U.S. Army Corps
of Engineers

Galveston District
Southwestern Division

Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers, and Galveston Counties, Texas

Engineering Appendix C

November 2019

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
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Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers, and Galveston Counties, Texas

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EXECUTIVE SUMMARY

Study Description

The purpose of this Feasibility Study is to evaluate Federal interest in alternative plans (including the No-Action Plan) for reducing transportation costs and addressing navigation safety issues on the Houston Ship Channel (HSC) system and assess the effects of the alternatives on the natural system and human environment, including the economic development of existing inefficiencies. The scope includes six segments of the HSC, which will be evaluated for current and projected vessel size and traffic. Beginning at the most seaward end of the HSC along Bolivar Roads at the Galveston Entrance Channel, the study examined possible moorings and bay widening to provide for safe meeting opportunities in the Bay Reach, as well as study the tributary channels at Bayport Ship Channel (BSC), and Barbours Cut Channel (BCC). Additionally, the study evaluated at the upper reach of the HSC between Boggy Bayou and the Main Turning Basin for deepening opportunities and widening where practicable. Dredged material placement is evaluated for upland confined placement, beneficial Use (BU) of dredged material, where practicable, and offshore placement at Ocean Dredged Material Disposal Sites (ODMDS). Figure 1-1 provides an overview of the study segments in the study scope.

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List of Acronyms

$/CY	Cost per cubic yard
AC	acres
AdH	Adaptive Hydraulics
AdH-SW3	Adaptive Hydraulics 3D shallow water module
ADM	Agency Decision Milestone
AM	advance maintenance
AO	allowable overdepth
AOM	Assumption of Maintenance
ASA	Assistant Secretary of the Army
ATON	Aids to Navigation
BC	base condition
BCC	Barbours Cut Channel
BCCT	Barbours Cut Container Terminal
BSC	Bayport Ship Channel
BU	beneficial use
BUG	Beneficial Uses Group
CDF	confined disposal facility
CO-OPS	Center for Operational Oceanographic Products and Services
CWCCIS	Civil Works Construction Cost Index System
CWRB	Civil Works Review Board
CY	cubic yards
CY/YR	cubic yards per year
DMMP	Dredged Material Management Plan
DO	dissolved oxygen
EA	Environmental Assessment
EEB	Estuarine Engineering Branch
EIS	Environmental Impact Statement
EOP	Environmental Operating Principles
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
ERDC	Engineer Research and Design Center
ERDC-CHL	Engineer Research and Design Center Coastal and Hydraulics Laboratory
ERGO	Environmental Review Guide for Operations
FWOP	future without project

FWP	future with project
FY	fiscal year
GBANC	Galveston Bay Area Navigation Channel
GIWW	Gulf Intracoastal Waterway
GLO	General Land Office
GNF	General Navigation Feature
HP	Houston Pilots
HSC	Houston Ship Channel
HSC ECIP	Houston Ship Channel Expansion Channel Improvement Project
HTRW	Hazardous, Toxic and Radioactive Waste
IFR-EIS	Integrated Feasibility Report and Environmental Assessment
JV	Joint Venture
LOA	length overall
LSF	local service facility
MCNP	Monitoring Completed Navigation Projects
MCY	million cubic yards
MLLW	mean lower low water
MLT	mean low tide
MSL	Mean Sea Level
MST	mooring service type
NAD83	North American Datum of 1983
NEPA	National Environmental Policy Act
NFS	Non-Federal Sponsor
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
O&M	operations and maintenance
ODMDS	Ocean Dredged Material Disposal Site
PA	placement area
PDR	Project Deficiency Report
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PHA	Port of Houston Authority
POA	period of analysis
PSI	pounds per square inch
PTM	partial tracking model
RSLC	relative sea level change
SJMTTC	San Jacinto Maritime Technology and Training Center

SMMP	Site Management and Monitoring Plan
TCEQ	Texas Commission on Environmental Quality
TCOON	Texas Coastal Ocean Observation Network
TPWD	Texas Parks and Wildlife Department
TSP	Tentatively Selected Plan
TWDB	Texas Water Development Board
UFC	United Facilities Criteria
USACE	United States Army Corps of Engineers
USACE-SWG	United States Army Corps of Engineers Southwestern Division Galveston District
USCG	United States Coast Guard
VF	vertical foot
VTS	Vessel traffic service

1 GENERAL

1.1 Introduction

The Joint Venture of Turner Collie & Braden Inc. and Gahagan & Bryant Associates, Inc. (JV) was retained by the Port of Houston Authority (PHA) to assist in the Houston Ship Channel Expansion Channel Improvement Project (HSC ECIP), in partnership with the U.S. Army Corps of Engineers (USACE). The study is being performed in response to the standing authority of Section 216 of the Flood Control Act of 1970, as amended, which authorizes studies to review the operation of completed Federal projects and recommend project modifications "…when found advisable due to significantly changed physical or economic conditions and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

The study focuses on six segments of HSC shown in Figure 1-1. Channel modifications evaluated in this study include widening, deepening, bend easings, multipurpose mooring facilities, turning basins, and shoaling attenuation features. The following sections outline the details of the study and do not include portions of the HSC system that are not studied for improvement/modification.

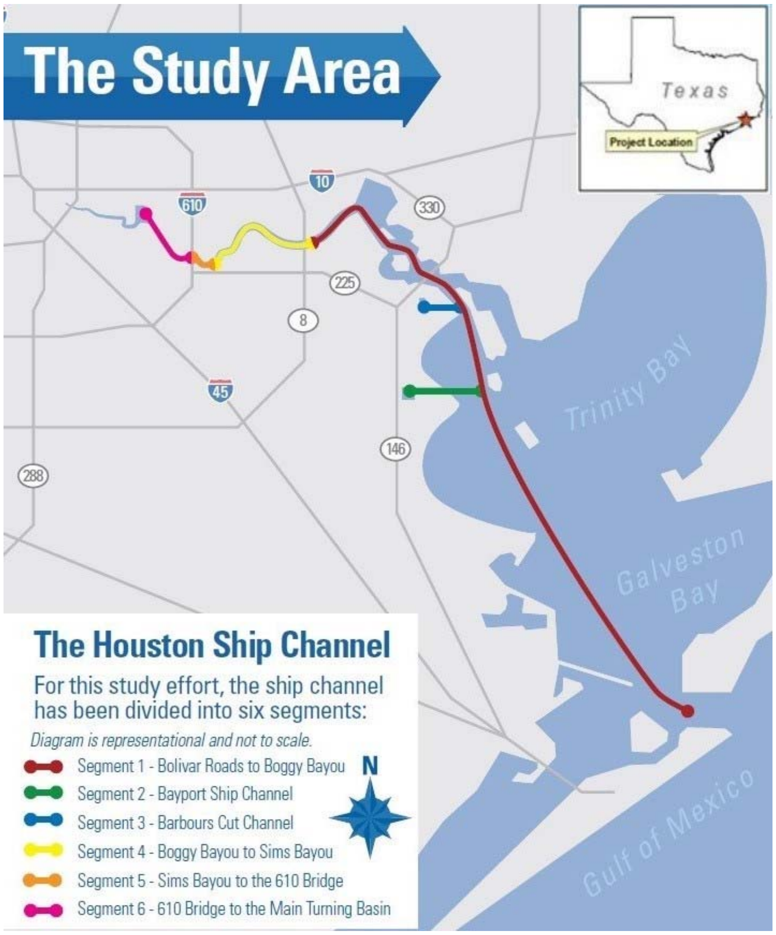


Figure 1-1: Six Study Segments of the HSC ECIP Feasilibity Study

1.1.1 Segment 1: Bay Reach

Segment 1, the 46.5-Foot Project, extends from Bolivar Roads to Boggy Bayou. Segment 1 is separated into two sections, each divided further into three reaches with an authorized depth of -46.5 feet MLLW.

1. The Bay Section – This section begins at mile 0 at Bolivar Roads and extends to mile 26.2 at Morgans Point and is generally 530 feet wide with 235 feet of navigable barge space on either side of the channel. The 235 feet includes the transition from the channel to the barge lane at -13 feet MLLW. This section is divided into three reaches at each channel bend.
    i. Lower Bay – Extends from Station 138+369 near Buoy 18 to Station 78+844 at Redfish Light 1, referred to as Bolivar Roads to Redfish.
    ii. Mid Bay – Extends from Station 78+844 to Beacon 75/76 at Station 28+605, referred to as Redfish to BSC. The reach was mined to -52.5 feet MLLW during the construction of the 46.5 Project.
    iii. Upper Bay – Extends from Station 28+605 to lower end Morgans Point Cut at Station 0+00, referred to as BSC to BCC. This reach was mined intermittently to depths ranging from -60 to -70 feet MLLW from Station 14+500 to 28+605 during construction of the PA 14/15 Expansion Project and construction of the Gorini Demonstration Marsh as part of the 46.5 Project.
2. The Bayou Section – This section begins at mile 26.2 at Morgans Point and extends to the end of Boggy Bayou at mile 38.5. The channel is approximately 530 feet wide and greater in the turns. The channel narrows to 400 feet for the last approximate 1.3 miles, west of the San Jacinto Monument to Boggy Bayou. This section is divided into three reaches. However, no improvements are proposed in this section of the channel as part of the study.
    i. Lower Bayou – Extends from Station 0+05 to Station 295+00, referred to as the BCC to Exxon.
    ii. Mid Bayou – Extends from Station 295+00 to 520+00, referred to as Exxon to Carpenters Bayou.
    iii. Upper Bayou – Extends from Station 520+00 to 684+03, referred to as Carpenters Bayou to Boggy Bayou.

The study evaluates the need of selectively widening the existing 530-foot wide HSC to approximately 700-feet wide in the Bay Section to facilitate two-way traffic meeting by large vessels as well as the easing of the channel bends and turns associated with transit restrictions, slowdowns, and additional tug assist. Barge lanes will be replaced in-kind to their existing dimensions to the outside of the channel widening.

1.1.2 Segment 2: Bayport Ship Channel

The 4.1-mile-long BSC is currently authorized to a 300-foot width and a depth of -41.5 feet MLLW. The PHA with authority under Sections 408 and 204(f) deepened the channel to -46.5 feet MLLW and widened the bay portions of the channel by 100 feet and widened the constricted portion of the channel within the land cut by 50 feet. The USACE recently assumed maintenance of the PHA improvements to the BSC Improvement Projects under Section 204 (f) of WRDA 86, as amended. The Feasibility Study analysis evaluates widening to a width of 455 feet. Other opportunities in this area include adding some form of jetty or structures to minimizing shoaling. The BSC was mined to -52.5 feet MLLW from Station 180+00 to the intersection of the HSC to provide construction materials for PAs 14 and 15 during the 46.5 Project.

One established safety issue was addressed under the HSC Project Deficiency Report (PDR), approved in May 2016, which recommended an interim corrective action at the HSC/BSC intersection with the ultimate fix requiring further evaluation as part of this Feasibility Study. During the study period the existing 3,000-foot radius flare was eased to a radius of 4,000 feet and ease the HSC bend transition from Mid Bay to Lower Bay under the HSC PDR approval. If the HSC is not widened, the BSC Flare requires additional easing to an approximate 5,375-foot radius and the HSC bend at Station 28+605 would require additional easing as discussed further in this appendix. Vessels entering the BSC typically do so with tug assistance due to the reduction in speed and the sharp turn necessary to safely enter the channel. This Feasibility Study considers a potential solution to improve this issue.

1.1.3 Segment 3: Barbours Cut Channel

The 1.6-mile-long BCC is currently authorized to a depth of -41.5 feet MLLW. The PHA with authority under Sections 408 and 204(f) deepened the channel to -46.5 feet MLLW and shifted the channel 75 feet north to accommodate a wider berthing area. To accommodate the shift, the channel was excavated 75 feet to the north between Station 20+13 and 65+43 to maintain a 300-foot channel bottom width. The USACE recently assumed maintenance of the PHA improvements to the BCC Improvement Projects under Section 204 (f) of WRDA 86, as amended. The Feasibility Study analysis evaluates widening the channel to 455 feet. Other opportunities in this area evaluate the need for open water turning basin and flare improvements. The BCC was mined to -55.5 feet MLLW as part of deferred environmental restoration on the 46.5 Project.

1.1.4 Segment 4: Boggy Bayou to Sims Bayou

This segment consists of two reaches. Boggy Bayou to Greens Bayou extends from channel Station 684+03 to Station 833+05. Greens Bayou to Sims Bayou extends from Station 833+05 to 1110+77. This analysis evaluates deepening the 8-mile portion of the HSC from Boggy Bayou to Sims Bayou to five feet beyond the existing -41.5 feet MLLW and widening between Boggy Bayou to Greens Bayou to a width of 530 feet. The portion of the channel between Boggy Bayou and Sims Bayou is a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other Port of Houston infrastructure.

1.1.5 Segment 5: Sims Bayou to I-610 Bridge

This analysis evaluates deepening the 1-mile portion of the HSC from Sims Bayou to the I-610 Bridge four feet beyond the existing -37.5 feet MLLW. Widening of the channel was not ultimately considered due to apparent constrictions from surrounding structures and industry. The portion of the channel between Sims Bayou and the I-610 Bridge is a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other Port of Houston infrastructure.

1.1.6 Segment 6: I-610 Bridge to Turning Basin

This analysis evaluates deepening of the 2.5-mile portion of the HSC from the I-610 Bridge through the Main Turning Basin to four feet beyond the existing -37.5 feet MLLW. Widening of the channel was not ultimately considered due to apparent constrictions from surrounding structures and industry. Study Segments 5 and 6 lies within the HSC channel reach known as Sims Bayou to Turning Basin from Station 1110+77 to Station 1266+48.

1.2 Physical Description of the Existing Project

The HSC provides access to various private and public docks and berthing areas associated with the Port of Houston. It is the longest major navigation channel of a larger system of navigation channels of the Galveston Bay Area (herein referred to as (GBANC) system) located in Harris, Chambers and Galveston Counties, Texas. Associated side channels of the HSC include the BSC, BCC, San Jacinto and Greens Bayou Channels. Other major channels included in the GBANC are the Galveston Harbor and Channels and the Texas City Ship Channel, which provide access to the Ports of Galveston and Texas City, respectively, as well as the Cedar Bayou Navigation Channel which provides shallow water access to Cedar Bayou.

The original authorization for the channels was relative to Mean Low Tide (MLT). Galveston District recently converted the HSC to the Mean Lower Low Water (MLLW) datum. See Section 2.1 Datums for a description of the conversion from MLT to MLLW. Depths in the report are referenced to MLLW unless otherwise stated. Table 1-1 provides the project depths in both datums and a summary of the channel dimensions (depth, width, and length) for the HSC, its tributary channels, and turning basins.

Table 1-1: Channel Dimensions for HSC and Tributaries

HSC Section of Waterway	**Authorized Dimensions**			
	Depth (feet)		**Width (feet)**	**Length (miles)**
	MLT	**MLLW**		
SEGMENT 1 – HSC-BAY REACH SAFETY AND EFFICIENCY ENHANCEMENTS				
-Bolivar Roads (Mile 0) to Morgans Point (Mile 26.2)[1]	45	46/46.5	530	26.2
-Barge Lanes (adjacent to and on each side from Mile 0 to Mile 26.2)	12	13	125	26
-Morgans Point (Mile 26.2) to Boggy Bayou (Mile 38.5)	45	46.5	530-600	12.3
-South Boaters Cut @ Mile 15.3	8	9	300	1.9
-North Boaters Cut @ Mile 18.7	8	9	100	2.1
-Five Mile Cut Channel @ Mile 20.9	8	9	125	1.9
SEGMENT 2 – BAYPORT SHIP CHANNEL				
-Bayport Ship Channel (Mile 21.4 at intersection with HSC)[3]	40	41.5	300	3.8
Turning Basin	40	41.5	300-1,600	0.3
SEGMENT 3 – BARBOURS CUT CHANNEL				
-Barbours Cut Channel (Miles 26.3 at intersection with HSC)[3]	40	41.5	300	1.1
Turning Basin	40	41.5	300-1,600	0.3
SEGMENT 4 –BOGGY BAYOU TO SIMS BAYOU				
-Boggy Bayou (Mile 38.5) to Greens Bayou (Mile 42.0)	40	41.5	300	3.5
-Jacintoport Channel	40	41.5	200	0.7
-Greens Bayou (Mile 42.0) to Sims Bayou (Mile 47.5)	40	41.5	300	5.5
Hunting Bayou Turning Basin	40	41.5	948-1,000[2]	0.3
Clinton Island Turning Basin	40	41.5	965-1,070[2]	0.3
-Greens Bayou Channel Mile 0.0 to Mile 0.36	40	41.5	175	0.4
-Greens Bayou Channel Mile 0.36 to Mile 1.65	15	16.5	100	1.3
SEGMENT 5 –SIMS BAYOU TO I-610 BRIDGE				
-Sims Bayou (Mile 47.5) to I-610 Bridge (Mile 48.3)	36	37.5	300	0.8
SEGMENT 6 –I-610 BRIDGE TO MAIN TURNING BASIN				
-I-610 Bridge (Mile 48.3) to Houston (Main) Turning Basin (Mile 50.2)	36	37.5	300	1.9
Houston (Main) Turning Basin	36	37.5	400-932	0.6
Upper Turning Basin	36	37.5	150-527	0.2
Brady Island Channel	10	11	60	0.9
Brady Island Turning Basin	36	37.5	300-722	0.2
Buffalo Bayou Light Draft Channel	10	11	60	4.1
Turkey Bend Channel	10	11	60	0.8

[1] *Per the MLT to MLLW Datum Conversion, the split occurs at Beacon 76.*

[2] *Includes 300-foot channel width*

[3] *PHA received approval to deepen channel to 46.5 feet MLLW and subsequent Federal Assumption of Maintenance (AOM) under Section 408/204(f). BSC deepening was completed in Fall of 2016 and BCC was completed in August 2015. Additionally, the BSC was widened from 300 feet to 400 feet from the BSC Flare to the land cut and from 300 feet to 350 feet from the land cut to the BSC Turning Basin.*

1.3 Current Channel Restrictions

The HSC system is currently suffering inefficiencies due to is current channel configuration. The system has constrained vessel sizes, draft restricted areas in the upper channel, inadequate channel configurations for vessels currently using the channel, and these inefficiencies are contributing to congestion along the waterway, especially with the high volume of barge and deep-draft vessel traffic on the HSC. The HSC is a high use channel and one of the busiest waterways in the United States with over 9,000 deep draft and over 200,000 barge calls per year. The Houston Pilots (HP) is the entity that provides for the safe navigation along the HSC and its tributaries. As such, the

HP has promulgated rules and restrictions regarding the transit of various deep draft vessels in the system.

A summary of the working rules as they impose travel restriction are indicated below. Figure 1-2 identifies the location of the markers referenced in the HP working rules. The latest full description of HP Working Rules were updated on April 10, 2019, and are available at the following website: http://houston-pilots.com/workingRules.pdf.

- Maximum vessel size from Bolivar Roads to Barbour's Cut is 1,000 feet length overall (LOA) x 138 feet in beam (without additional restriction).
- Wide-Body Rules – This rule is predicated on the 530-foot wide channel and the completed barge lanes.
    - A wide-body vessel is defined as any vessel with a beam of 120 feet and over.
    - Any wide-body vessel transiting above Buoy 18 will require two pilots at all times.
    - Any wide-body tanker proceeding with cargo will be daylight restricted above Buoy 18.
    - Any wide-body vessel over 150 feet in beam and/or over 900 feet in LOA will be daylight restricted above Buoy 18 at all times.
    - The maximum LOA above Morgans Point High Lines is 950 feet without prior approval from the Houston Pilots and the respective terminal.
    - The maximum beam of any vessel allowed to come to Houston is 166 feet without prior approval from HP and the respective terminal.
    - Two wide-body vessels meeting in the HSC between Buoy 18 and Beacons 75/76 shall be restricted to a combined beam width of 310 feet and shall be limited to a combined draft of 85 feet.
    - Two wide bodies meeting in the HSC between Beacons 75/76 and Boggy Bayou shall be restricted to a combined beam of 272 feet and shall be limited to a combined draft of 77 feet.
- Loaded Suezmax tankers will not meet any vessel with a beam above 106 feet above Buoy
- Upon completion of the dredging project to widen the BSC to 400' outside the land cut and 350' inside the land cut, and of relocation of aids to navigation to mark the new channel, the maximum non-tank vessels permitted to transit the BSC is 1,096 feet LOA x 143-foot beam.

- Upon completion of the dredging project to increase the radius of the BSC Flare from 3,000’ to 4,000’ and to widen the east side of the HSC in the vicinity of Beacons 75/76, the maximum non-tank vessels permitted to transit the BSC is 1,160 feet LOA x 150-foot beam.
- The maximum size of a tank vessel permitted to transit the BSC and BCC is 850 feet LOA x 145-foot beam.
- Container vessels with dimensions greater than 1,100 feet LOA will not be met by any other ships in the HSC above B-18. Container vessels with dimensions less than or equal to 1,110 feet LOA and beam less than or equal to 150 feet may meet other vessels with dimensions less than or equal to 601 feet x 106 feet and a draft of less than 35 feet.
- Loaded Aframax tankers, approximately 850 feet LOA x 135-foot beam will not meet a larger, loaded vessel.
- Maximum vessel size from Boggy Bayou to Simms Bayou is 750 feet LOA x 116-foot beam and draft restricted to 41.5 feet.
- Vessels with beam greater than 105 feet shall not meet any ship vessel of any size above Boggy Bayou.
- All vessels greater than 750 feet LOA and a draft greater than 39 feet are daylight restricted above the Beltway 8 Bridge.
- Maximum draft from Simms Bayou to the Main Turning Basin is 37.5 feet.
- No car carrier of any size or any other vessel of 625 feet LOA or longer will arrive/depart City Docks #20-32 when required to turn at Brady Island Turning Basin when there is a vessel docked or encroached into City Dock #27.
- No vessel 580 feet LOA or longer loaded to more than 30-foot draft when required to turn at Brady Island Turning Basin will arrive/depart City Dock #20-32 when there is a vessel docked or encroached into City Dock # 27.

Figure 1-2: Location of Markers Referenced in HP Working Rules

2 EXISTING CONDITIONS

2.1 Surveying, Mapping, and Other Geospatial Data Requirements

2.1.1 Surveys

Conditional hydrographic channel surveys from 2016 to 2018 from the USACE supplemented with hydrographic surveys from the JV and NOAA were used for this study. Methodology for calculating channel volumes and further details about survey locations and dates are discussed in more detail in Section 5.1. During the PED phase, updated hydrographic surveys will be performed to better define the quantity of materials to be dredged. Additionally, hydrographic surveys shall extend approximately 1000 feet beyond the channel and barge lane toes on 1,000 foot intervals to track changes in channel side slopes and adjacent bay bottom over time for monitoring of channel conditions that relate to shoaling analysis.

2.1.2 Mapping

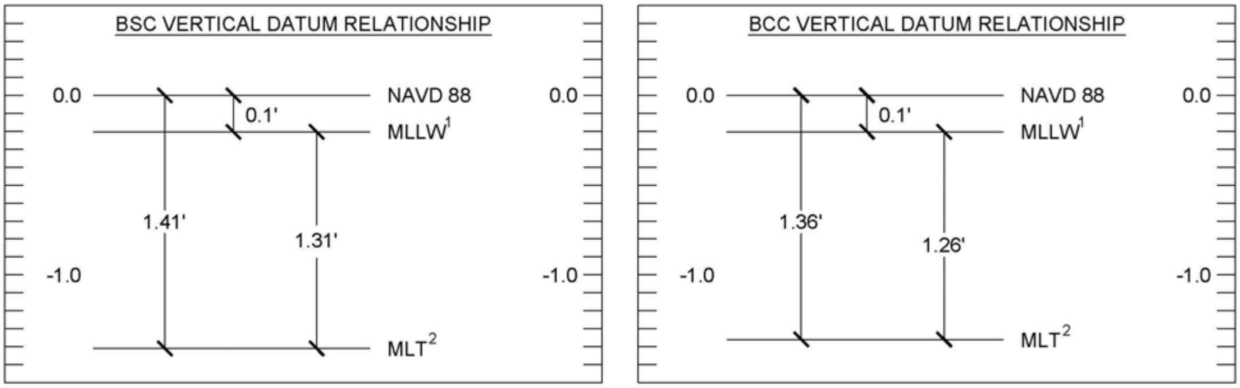
NOAA charts and aerial imagery from the Texas Natural Resources Information System of the vicinity was used during the initial and plan formulation phases. Planimetric CAD files of existing channel alignments and features were provided by the USACE and overlaid on to the background images.

2.1.3 Datum

The horizontal datum for the project is based on the Texas State Plane Coordinate System, South Central Zone 4204, North American Datum of 1983 (NAD83). The vertical datum is MLLW.

All prior projects in the Galveston District have used the USACE vertical datum MLT. The USACE has completed the process of converting the vertical datum for all navigation projects from MLT to MLLW (USACE, 2015a). From Bolivar Roads Station 138+369.011 to Beacon 76 at Station 28+605.055, MLLW is 1 foot above MLT, converting the -45-foot MLT project to -46 feet MLLW. From Station 28+605.055 to the termination of the HSC at the end of Main Turning Basin the conversion is 1.5 feet. The depths of the channels at -45, -40, -37 and -36 feet MLT are now -46.5, -41.5, -38.5 and -37.5 feet MLLW, respectively.

Separate from authorized channel depth conversions, actual survey data is converted between datums based on survey control monuments and not based on the channel conversions of 1 to 1.5 feet. Most all the survey data used in this Feasibility Study was provided by the USACE in MLLW. There were several instances in the BSC and BCC where surveys from previous projects in MLT were used to supplement gaps in the USACE data. To convert the survey data to MLLW the vertical datum relationships in Figure 2-1 were used.



NAVD 88 = NORTH AMERICAN VERTICAL DATUM 1988
MLLW = MEAN LOWER LOW WATER
MLT = MEAN LOW TIDE

NOTES:
[1] RELATIONSHIP BETWEEN MLLW AND NAVD88 IS FROM THE MORGANS POINT STATION 8770613
[2] RELATIONSHIP BETWEEN MLT AND NAVD88 PROVIDED BY THE USACE (MAY 2013)

Figure 2-1: BSC and BCC vertical datum relationship for converting survey data

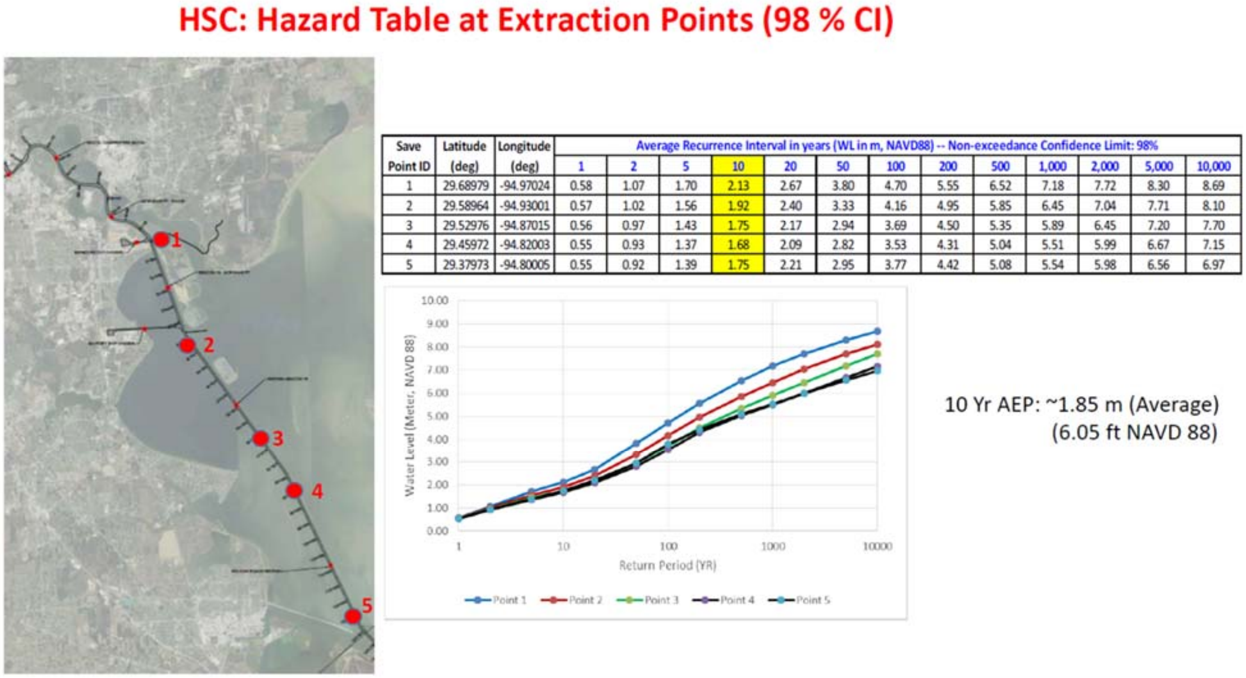
2.2 Tides, Currents, Wind, Waves, and Water Level

The project area experiences semi-diurnal tides where two high and two low tidal periods occur each daily tidal cycle, with an average mean tidal range of approximately 1 foot. Elevated tidal surge is experienced in Galveston Bay during storm conditions and high spring tide events. From May to September the Galveston Bay experiences increased precipitation which drives freshwater input from Buffalo Bayou and the two largest river drainages, the Trinity and San Jacinto Rivers. These increased freshwater inputs typically result in the formation of a fresh/saltwater wedge concentrated in the deeper areas of Galveston Bay as well as navigational channels such as the HSC and BSC.

Water circulation and currents in Galveston Bay can also be affected by prevailing wind conditions, especially within the relatively shallower areas. The prevailing south and southeastern winds, typically experienced from spring through fall, force water against the mainland and create countercurrent eddies within the nearshore areas while north and northwest winds in the winter months cause bay water to push against the barrier of Galveston Island and Bolivar Peninsula. Due to the low capacity to inflow ratio and small tidal range, water entering Galveston Bay has a relatively long residence time, with flushing times ranging from 75 to 280 days for the entire bay and from 16 to 28 days in the HSC (Sparr et al., 2010).

Although Galveston Bay is typically a low-energy environment protected on the seaward side by a chain of barrier islands and peninsula with limited inlets, the area experiences a high level of storm activity. Multiple hurricanes and tropical storms in recent years have had a dramatic effect on the location, composition, and function of shorelines throughout the bay. Coastal flooding from hurricanes occurs when the effects of storm surge, driven by cyclonic winds and low pressure, cause water to stack up at levels higher than normal ocean water-surface levels. Storm surge levels are highest when storm surge coincides with the astronomical high tide resulting in storm tide. Storm surge effects are greatest in shallower offshore waters. Therefore, the bathymetry that tends to exacerbate storm surge effects is that in shallower water.

Offshore surges were carried into various points around Galveston Bay. Surge levels for a variety of return periods were extracted at five locations along the HSC. The point locations and surge super-elevations are shown in Figure 2-2below.



HSC: Hazard Table at Extraction Points (98 % CI)

Save Point ID	Latitude (deg)	Longitude (deg)	Average Recurrence Interval in years (WL in m, NAVD88) -- Non-exceedance Confidence Limit: 98%												
			1	2	5	10	20	50	100	200	500	1,000	2,000	5,000	10,000
1	29.68979	-94.97024	0.58	1.07	1.70	2.13	2.67	3.80	4.70	5.55	6.52	7.18	7.72	8.30	8.69
2	29.58964	-94.93001	0.57	1.02	1.56	1.92	2.40	3.33	4.16	4.95	5.85	6.45	7.04	7.71	8.10
3	29.52976	-94.87015	0.56	0.97	1.43	1.75	2.17	2.94	3.69	4.50	5.35	5.89	6.45	7.20	7.70
4	29.45972	-94.82003	0.55	0.93	1.37	1.68	2.09	2.82	3.53	4.31	5.04	5.51	5.99	6.67	7.15
5	29.37973	-94.80005	0.55	0.92	1.39	1.75	2.21	2.95	3.77	4.42	5.08	5.54	5.98	6.56	6.97

10 Yr AEP: ~1.85 m (Average)
(6.05 ft NAVD 88)

Figure 2-2: HSC: Hazard Table at Extraction Points

2.3 Relative Sea Level Change

For navigation projects, the general impacts of rising sea level are (1) extra depth in the navigation channel (a benefit), (2) the eventual need for higher dikes around placement areas (a cost), and (3) drowning of some plant species, if sea level rises fast. Economic benefit analysis is not calculated for the potential extra depth of the navigation channel as there is no policy that requires or allows it. Additionally, the majority of the existing and planned dikes are above +10 MLLW and upwards of +30. This is well above the expected sea level rise. For the BU sites, periodic nourishment is part of the DMMP in Appendix R and the quantities for placement have been calculated to account for RSLC. Bird islands and BU sites will be assessed for RSLC impacts, and addressed via adaptive management techniques if necessary. RSLC is not expected to affect the air draft of the economic design vessels that cross below the Fred Hartman and BW 8 Bridges as there is already 15 feet of air draft available which is more than the estimated RSLC. Additionally, there are ways vessel operators can mitigate for any additional restrictions as a result of RSLC such as ballasting.

However, the clearance of the 610 Bridge is 135 feet which limits the draft of the vessels that navigate under it. The vessel size is the same in the FWP and FWOP. Issues relating to the navigability under and through the bridge are the same in the FWP and FWOP condition. TXDOT has plans for bridge replacement in their master plan.

Results are summarized below. For the complete report, see Attachment 3 "Sea-Level Rise Effects for the HSC ECIP Feasibility Study."

Rising sea levels due to changes induced by climate change are an impact of the environment on coastal project performance of increasing concern to the USACE. Relative Sea Level Change (RSLC) was evaluated using the current USACE guidance ER 1100-2-8162, *Incorporating Sea Level Change in Civil Works Programs* (USACE, 2013), and the Engineering Technical Letter ETL 1100-2-1, *Procedures to Evaluate Sea Level Change: Impacts, Responses, And Adaptation* (USACE, 2014). USACE guidance specifies evaluating alternatives using "low," "intermediate," and "high" rates of future sea level change.

- **Low** - Use the historic rate of local mean sea level change as the "low" rate (which is a straight line). The guidance further states that historic rates of sea level change are best determined by local tide records (preferably with at least a 40-year data record).
- **Intermediate** - Estimate the "intermediate" rate of local mean sea level change using the modified Nation Research Council's (NRC) Curve I. It is corrected for the local rate of vertical land movement.
- **High** - Estimate the "high" rate of local mean sea level change using the modified NRC Curve III. It is corrected for the local rate of vertical land movement.

ETL 1100-2-1 recommends an expansive approach to considering and incorporating RSLC into civil works projects. It is important to understand the difference between the period of analysis (POA) and planning horizon. Initially, USACE projects are typically justified over a 50-year POA. However, USACE projects can remain in service much longer than the POA. The climate for which the project was designed can change over the full lifetime of a project to the extent that stability, maintenance, and operations may be impacted. Given these factors and for consistency with ER 1110-2-8159, *Life Cycle Design and Performance* (USACE, 1997), the project planning horizon considered for analyzing RSLC is 100 years.

Historic rates from the Center for Operational Oceanographic Products and Services (CO-OPS) at the National Oceanic and Atmospheric Administration (NOAA), which has been measuring sea level for over 150 years, were used in the analysis. This is consistent with USACE guidance that changes in Mean Sea Level (MSL) should be computed using gages with a minimum 40-year span of observations. The longest-running (from 1908 to present) tide gage in Galveston Bay is at Pier 21 (NOAA 8771450) in Galveston and is still active. These measurements have been averaged by month to eliminate the effect of higher frequency phenomena such as storm surge, to compute an accurate linear sea level trend.

The MSL trends presented are local relative trends as opposed to the global (eustatic) sea level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is long-term vertical land motion occurring at that location such as subsidence, the relative MSL trend measured there is a combination of the global sea level rate and the local vertical land motion, also known as RSLC.

The Pier 21 tidal-gage data was utilized to determine the MSL trend from 1908 to 2013 which is estimated at 6.39 mm/year with a 95% confidence interval of ± 0.24 mm/year. NOAA estimates the MSL trend as 6.37 mm/year. Comparing the tide gauge change of RSLC with the network of subsidence gauges, it can be concluded that subsidence is about twice that of RSLC. The subsidence data also show that subside is decelerating slowly. It should be noted that the subsidence gauges are located on land in Harris County, while the tide gauge used for this analysis is located at Pier 21. Though these locations do not coincide, they are the best gauges available, so the assumption made is to apply the same respective trends in subsidence and RSLC from these two gauges throughout the Galveston region, and thus for this analysis.

In addition to the project period of analysis of 50 years and the RSLC planning horizon of 100 years, RSLC for the 25-year period was calculated, per ETL 1100-2-1. Table 2-1 presents the predicted level (MLLW) for the 25, 50 and 100-year periods.

Table 2-1: Summary of Relative Sea Level Change Estimates (Levels are relative to 1992 Zero)

Year	Low (feet)	Intermediate (feet)	High (feet)
2023	1.20	1.29	1.56
	The anticipated project construction start year		
2029 (0 years)	1.33	1.45	1.83
	The anticipated project construction completion year		
2054 (25 years)	1.85	2.19	3.28
2079 (50 years)	2.37	3.05	5.18
2129 (100 years)	3.42	5.09	10.38

Economic analysis did not assume any benefits from RSLC. It is still undetermined whether increased benefits in the channel from RSLC will be less than or more than the increased cost for PA dikes.

3 CHANNEL DESIGN CONSIDERATIONS

3.1 Design Vessels

The design vessels selected by the USACE were used to conduct an economic evaluation and to guide the engineering design of channel improvements. EM 1110-2-1613, *Hydraulic Design of Deep-Draft Navigation Projects* states "…the design ship or ships are selected on the basis of economic studies of the types and sizes of the ship fleet expected to use the proposed navigation channel over the project life…" (USACE, 2006). The design ship is defined as "…the largest ship of the major commodity movers expected to use the project improvements on a frequent and continuing basis…" For a full distribution and discussion of the current and future fleet forecasts of design vessels, consult Appendix B, Economics. As recommended in Appendix B, the following design vessels for each channel study segment are discussed below.

Eight design vessels were identified within the six study segments. The alternatives target improvements for those different design vessels throughout the HSC system. Ship simulations were conducted to determine the feasible dimensions of the channel after the Tentatively Selected Plan (TSP) per the 3x3x3 exemption approval for the HSC ECIP study. Final channel dimensions will be confirmed through more in-depth ship simulations during Preconstruction Engineering and Design (PED). Table 3-1 below provides the design vessels and study segments they are associated with.

Table 3-1: Design Vessels per Study Segment

Segment	Type	Class	LOA	Beam	Draft
1,2,3	Containership	Gen III	1,100	158	49
1,2,3	Containership	Gen III	1,200	140	49
1,2	Tanker	Suezmax	935	164	54
3,4	Tanker	Aframax	850	138	54
4	Bulk Carrier	Panamax	810	106	44
5	Tanker	Panamax size	610	106	44
5	Vehicle Carrier	Ro-Ro	640	106	34
6	Bulk Carrier	70k-110k Bulker	750	106	45

EM 1110-2-1613 defines design vessel as "A hypothetical or real ship with dimensions of the largest vessels that a navigation project is designed to accommodate" (USACE, 2006, Glossary-11). It further states "For project improvement studies, a thorough review and analysis of ships presently using the project should be included as a part of the study. Projections of ship fleet data, usually needed, account for expected ship construction trends" (p. 3-10). "The design ship is chosen as the maximum or near-maximum-size ship in the range of ship sizes from the vessel fleet. The design dimensions of the channel will be determined to accommodate the design ship(s) representative of the project forecasted user fleet" (p. 3-11).

The largest potential container ship size is a hybrid of the 1,000 feet LOA x 158-foot beam and a 1,200-foot LOA x 140-foot beam. Therefore, a hybrid container ship size was selected to evaluate design considerations. The contemplated hybrid container ship is 1,200 feet LOA x 158-foot beam for sizing the BSC and BCC and a hybrid of a 1,200 feet LOA x 164-foot beam was used to size the bend easing and widening of the HSC from Bolivar Roads to Morgans Point. The design vessels shown in Table 3-1 were considered for feasibility level ship simulation.

3.2 Channel Modifications

EM 1110-2-1613 provides guidelines to determine channel modifications based on average navigation conditions. Final design of channel improvements is typically confirmed with ship simulation. The basic requirements and guidelines used to determine the required channel improvements for bend easing, channel widening, mooring basins and turning basins are discussed further in this section. Section 4 provides more detailed calculations and design recommendations for these features and the measures developed to achieve them.

3.2.1 Bend Easings

The HP have expressed concerns with the ability to navigate vessels greater than 1,000 feet in length into and up the HSC to BSC and BCC. Of particular concern is the turns that the vessels make between each reach. Due to the ship length, vessels can cross from the red side to the green side when transiting inbound/outbound when making the turns. When returning from sea, heading upstream, or toward the origin/headwaters of a body of water, the right side of the channel will be marked with red aids-to-navigation (ATONS) and green on the left. The current channel and turn dimensions are not adequate for a containership greater than 1,000 feet in length.

EM 1110-2-1613 guidelines provided in Table 3-2 were consulted to determine channel bend requirements as a function of deflection angle, turn radius, and design ship length as shown in. Resulting channel configurations using these guidelines will be refined using ship simulation.

Table 3-2: Recommended Channel Turn Configurations

Turn Type	Deflection Angle, δ (Degrees)	Turn Radius/Ship Length (R/L)	Turn Width Increase Factor
Angle	0-10	0	0
Cutoff	10-25	3-5	2-1
Apex	25-35	5-7	1.0-0.7
Curved	35-50	7-10	0.7-0.5
Circular	>50	>10	0.5

3.2.2 Channel Widening

The existing width determinations were made through several decision points that include environmental considerations, expert consultations, engineering constraints, and simulation during the study phase of the Houston-Galveston Navigation Channel (HGNC) Project for deepening and widening.

Guidelines from EM 1110-2-1613 shown in Table 3-3 and Table 3-4 prescribes the following calculations for one-way and two-way traffic for design of channel widths as a function of channel type, current speeds, ATONS, channel cross-section, and design ship beam. Resulting channel configurations using these guidelines will be refined using ship simulation.

Table 3-3: One-Way Ship Traffic – Channel Width Design Criteria

Uniform Cross Section	Design Ship Beam Multipliers for Maximum Current		
	0.0 to 0.5 knots LOW	0.5 to 1.5 knots MED	1.5 to 3.0 knots HIGH
Constant Cross Sections - Best Aids to Navigation			
Canal	2.50	3.00	3.50
Shallow	3.00	4.00	5.00
Trench	2.75	3.25	4.00
Variable Cross Sections - Average Aids to Navigation			
Canal	3.00	3.50	4.00
Shallow	3.50	4.50	5.50
Trench	3.50	4.00	5.00

Table 3-4: Two-Way Ship Traffic – Channel Width Design Criteria

Uniform Cross Section	Design Ship Beam Multipliers for Maximum Current		
	0.0 to 0.5 knots LOW	0.5 to 1.5 knots MED	1.5 to 3.0 knots HIGH
Constant Cross Sections - Best Aids to Navigation			
Canal	4.00	4.50	5.50
Shallow	5.00	6.00	8.00
Trench	4.50	5.50	6.50

3.2.3 Turning Basins

Mooring facilities have been requested for multiple uses including vessel lay berthing/queueing and for a harbor of refuge. Additionally, turning basins are needed for ship turning movements to facilitate safe passages for both channel traffic as well as ingress/egress of considered mooring facilities. EM 1110-2-1613 prescribes minimum dimension requirements that can be applied to the needs of facilities on an individual basis (design vessel size and quantities).

For turning basins, circular areas are overlain into smooth geometric linear extensions of channel toes. Whether the turning circles are to include the channel width or be installed completely outside of the existing limits is a matter of design discretion based on traffic safety requirements. The required size of a turning circle is a function of the design ship length and predominant water currents of the area. Water currents vary between 0.5 knots to 1.5 knots throughout the project area. For this, the manual prescribes a multiplication factor of 1.5 times the ship length for the required turning circle size unless specifically verified by ship simulation.

3.3 Channel Slope Stability Analysis

The existing channel slopes for this project range from 2.5 horizontal to one vertical (2.5H:1V) to 5H:1V. For construction of channel modifications, the historic practice is to utilize a template with 3H:1V slopes. The maintenance templates are maintained on a 2.5H:1V slope. These slopes have been used for the HSC in all previous dredging contracts without any noted problems. During PED, additional geotechnical data will be gathered using various means and methods and detailed analyses will be performed to verify the stability of the side slopes due to the increased dredging depth and/or width.

An April 08, 2019 memo was released by the USACE-SWG regarding district policy on setting dredging templates for studies, new work construction projects, and channel maintenance. The updated policy follows guidance from ER 1130-2-520 and EP 1130-2-520, with the objective to standardize new work dredging templates and ensure that all new work material be removed from the future O&M template. Required depth will include authorized project depth, required advance maintenance, and required OD to include side slopes (Figure 3-1). Required OD and additional allowable OD will be based on the type of material encountered and can vary within the same channel. These modifications will be evaluated further in PED based on geotechnical properties.

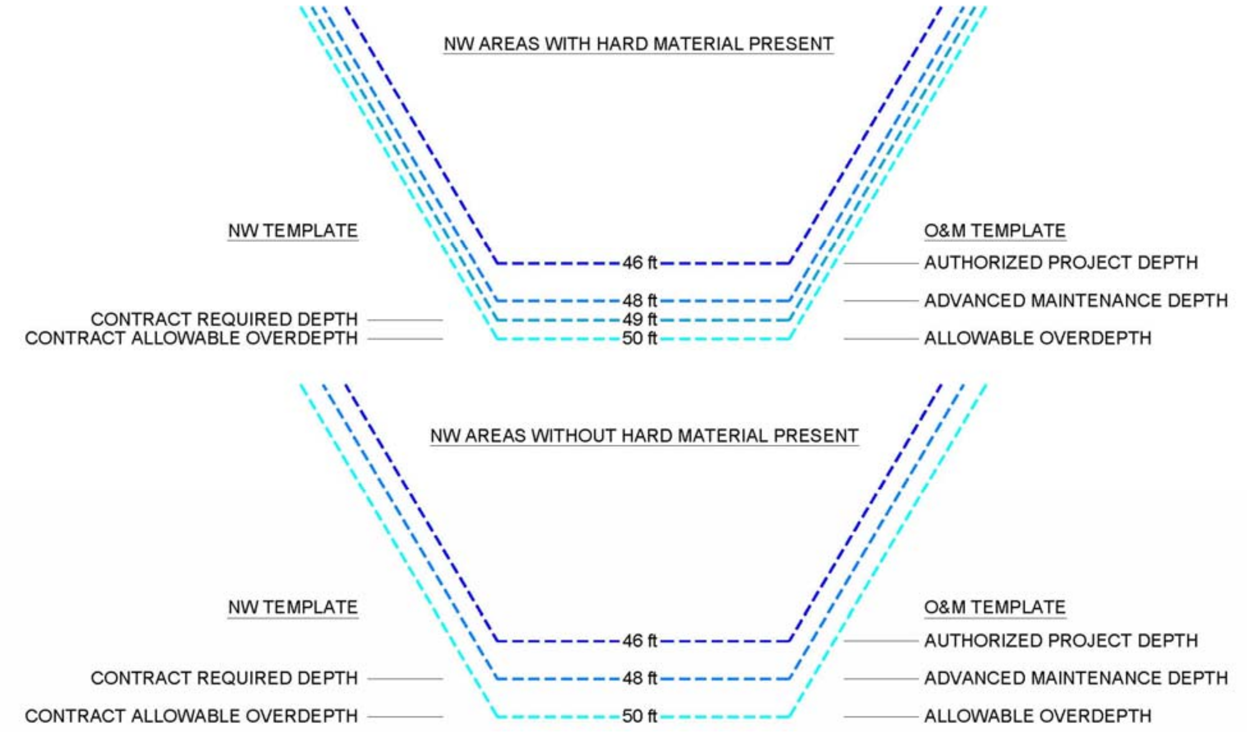


Figure 3-1: New work and O&M Dredging Templates Modified for SWG Policy.

4 MEASURES EVALUATED

The various channel modifications considered for the Recommended Plan (RP) are outlined in Table 4-1 and further detailed in the following sections. These include bend easings, channel widening and deepening, turning basins, and moorings. Measures evaluated for the TSP that were not carried forward to the RP are detailed in the Draft Engineering Appendix (USACE, 2017). Due to the large number of measures developed, an abbreviated designation was given to each type of measure along with the segment number, an approximate channel reference to the measure location, and a size of the measure (i.e. widened dimension, turning circle dimension, etc.). Descriptive designators were determined for the measures as follows:

[Measure Type][Segment]_[Location Information]_[Size (if applicable)]

The following nomenclatures are thus used for the measure designations discussed in subsequent sections:

- Measure Type:
    - BE – Bend Easing
    - CW – Channel Widening (includes deepening where applicable)
    - CD – Channel Deepening (deepening only, no widening)
    - TB – Turning Basin
    - SA – Sediment Attenuation
- Segment:
    - 1-6 for Study segments 1-6
- Location Information:
    - Denotes abbreviated reaches (i.e. BR-Redfish for Bolivar Roads to Redfish) or approximate channel reference station for mid-point locations of features for bends, turning basins, and mooring measures
- Size:
    - Where multiple sizes of features were considered (i.e. widening widths, turning basin circle diameters, etc.) the size evaluated was noted at the end of the measure designation. In text, where a measure is discussed in terms of generality, the size designator may or may not be listed.

Table 4-1: Measures Evaluated

Channel Segment	Channel Section	Bend Easings (Section 4.1)	Channel Widening (Section 4.2)	Channel Deepening (Section 4.3)	Turning Basin (Section 4.4)
1	1a - Bolivar Roads to Redfish	BE1_138+369 BE1_128+731	CW1_BR-Redfish_700		
	1b - Redfish to BSC	BE1_78+844	CW1_Redfish-BSC_700		
	1c - BSC to BCC	BE1_28+605	CW1_BSC-BCC_700		
2	BSC	BE2_BSCFlare	CW2_BSC_455		
3	BCC	BETB3_BCCFlare_1800NS	CW3_BCC_455		Combined with bend easing measure
4	Boggy Bayou to Greens Bayou		CW4_BB-GB_530 (Deepen 5FT) 46.5', +2 AM, +1AO		
	Greens Bayou to Sims Bayou			CD4_Whole (5FT) 46.5', +2 AM, +1AO	
5	Sims Bayou to I-610 Bridge			CD5_Whole (4-FT) 41.5', +2AM, +1AO	
6	I-610 Bridge to End Main Turning Basin			CD6_Whole (4-FT) 41.5', +2AM, +1AO	TB6_Brady_900

4.1 Bend Easings

Bend easing were developed based on EM requirements and design vessels as discussed in Section 3.2.1. The following calculations in Table 4-2 were made for each vessel type:

Table 4-2: Calculated Bend Easing Requirements by Vessel Type

Vessel Type	Vessel Length	Vessel Beam	L/B	Turn Type	Deflection Angle, δ (Degrees)	Turn Radius/Ship Length (R/L)		Turn Width Increase Factor (Ship Beam)		Channel Width	Design Turn Radius		Design Turn Width Increase	
Aframax	850	138	6.16	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	2550	4250	276	138
				Apex	25-35	5.0	7.0	1.0	0.7	530	4250	5950	138	96.6
				Curved	35-50	7.0	10.0	0.7	0.5	530	5950	8500	96.6	69
				Circular	>50	10.0		0.5		530	8500		69	
Suezmax	935	164	5.70	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	2805	4675	328	164
				Apex	25-35	5.0	7.0	1.0	0.7	530	4675	6545	164	114.8
				Curved	35-50	7.0	10.0	0.7	0.5	530	6545	9350	114.8	82
				Circular	>50	10.0		0.5		530	9350		82	
LPG	738	121	6.10	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	2214	3690	242	121
				Apex	25-35	5.0	7.0	1.0	0.7	530	3690	5166	121	84.7
				Curved	35-50	7.0	10.0	0.7	0.5	530	5166	7380	84.7	60.5
				Circular	>50	10.0		0.5		530	7380		60.5	
Tanker	610	106	5.75	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	1830	3050	212	106
				Apex	25-35	5.0	7.0	1.0	0.7	530	3050	4270	106	74.2
				Curved	35-50	7.0	10.0	0.7	0.5	530	4270	6100	74.2	53
				Circular	>50	10.0		0.5		530	6100		53	
Cargo	797	105	7.59	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	1830	3050	210	105
				Apex	25-35	5.0	7.0	1.0	0.7	530	3050	4270	105	73.5
				Curved	35-50	7.0	10.0	0.7	0.5	530	4270	6100	73.5	52.5
				Circular	>50	10.0		0.5		530	6100		52.5	
Container	1100	158	6.96	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	3300	5500	316	158
				Apex	25-35	5.0	7.0	1.0	0.7	530	5500	7700	158	110.6
				Curved	35-50	7.0	10.0	0.7	0.5	530	7700	11000	110.6	79
				Circular	>50	10.0		0.5		530	11000		79	
Container	1200	140	8.57	Angle	0-10	0.0		0		530	0		0	
				Cutoff	10-25	3.0	5.0	2.0	1.0	530	3300	5500	280	140
				Apex	25-35	5.0	7.0	1.0	0.7	530	5500	7700	140	98
				Curved	35-50	7.0	10.0	0.7	0.5	530	7700	11000	98	70
				Circular	>50	10.0		0.5		530	11000		70	

4.1.1 Segment 1

Potential design vessels include two different GEN III container vessels. The largest potential container ship size of 1,200 feet LOA x 158-foot beam is a hybrid of the 1,000 feet LOA x 158-foot beam and a 1,200-foot LOA x 140-foot beam. However, the widest beam ship is the Suezmax at 935 feet LOA x 164-foot beam. Both the length and beam factor into the design of the bends. The largest required bend easing is a minimum of 164 feet to a maximum of 328 feet as highlighted in Table 4-2. Ship simulations were conducted to determine the feasible dimensions of the channel after the TSP per the 3x3x3 exemption approval for the HSC ECIP study. Final channel dimensions will be confirmed through more in-depth ship simulations during PED. For screening purposes, the bend easing of 328 feet is used throughout the analysis for the bend easings in the Bay sections of the project.

As all the angles of deflection are greater than 10 degrees, less than 25 degrees turn type will be cutoff based on Suezmax vessel, according to the EM guidance bend easings should be in place in the current channel condition. It is recognized that the barge lanes will be relocated outside of the bend easings.

Using the EM guidance, cutoff bend easings to facilitate and ensure navigational safety were developed for Segment 1 at each of the bends that occur from the intersection of the HSC and Galveston Harbor to the BSC near Beacon 76 as shown in Figure 4-1. Bend easings at these locations were developed for the existing 530-foot channel and channel widening measures discussed in the following sections. The bend easing measures developed in the Bay reach include:

- BE1_138+369
- BE1_128+731
- BE1_78+844
- BE1_28+605

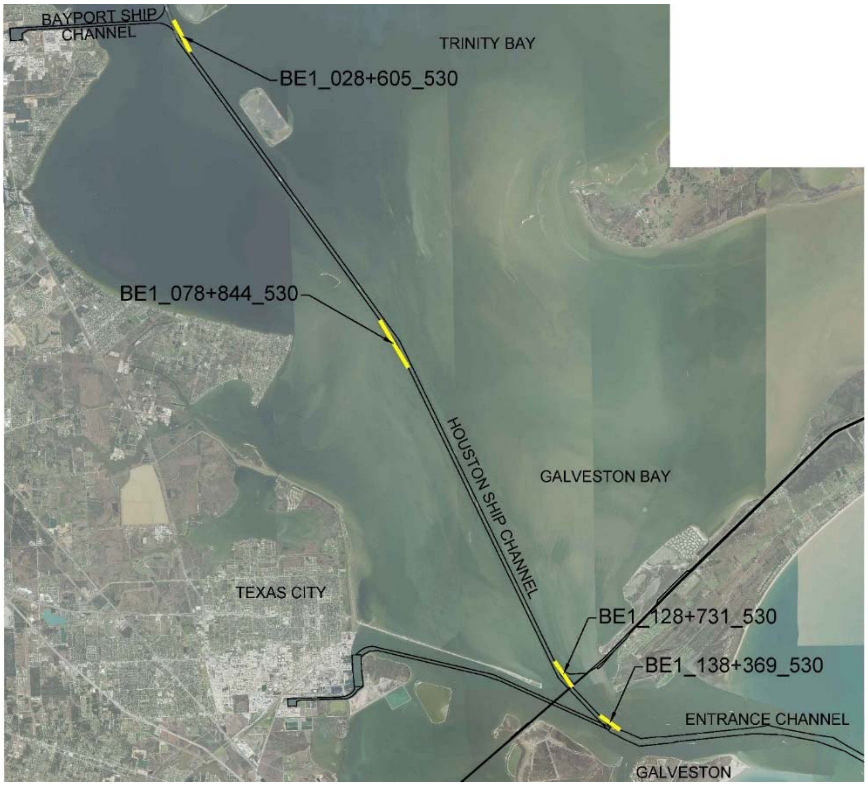


Figure 4-1: Segment 1 Bay Reach Bend Easing Measures for the Existing 530-foot channel

4.1.2 Segment 2

A bend easing was developed to widen the south side BSC flare at its intersection with the HSC. The measure, **BE2_BSCFlare** would ease the south flare from its existing radius of 4,000 feet to 5,375 feet as shown in Figure 4-2. Under a separate authority for the HSC PDR, the southern portion of the BSC Flare was eased to 4,000 feet, and the HSC adjacent to the Flare was widened by 235 feet to the east between HSC Station 26+484 and 30+090 as an interim fix. Further evaluation of this intersection was recommended as part of this study. Consultation with HP indicated that the 4,000-foot radius is efficient for a Maersk A type container ship (1,160 feet LOA x150-foot beam), which was evaluated for the PDR, but would also require other components such as a wider channel with larger turning basins, larger dog leg turns in the HSC, and the potential for an additional turning basin near the BSC RO/RO Terminal. The Maersk A type vessel is similar to the HSC-ECIP design vessels These additional considerations would allow for the largest expected container vessels to transit from the HSC to the BSC with minimal restriction and are considered in the formulation of alternative.

Based on the feedback from the HP, the 4,000-foot BSC flare with an additional modification to tie into the 700-foot HSC channel with 328-foot bend easings, and the BSC widening to 455 feet were simulated with the hybrid design vessel (1,200 feet LOA x 158-foot beam) and the Suezmax design vessel (935 feet LOA x 164-foot beam). Results of the ship simulation found that this combination would allow for the successful transit of the design containership, assist tugs, and normal HSC vessel traffic. With these modifications, the 5,375-foot BSC Flare would not be required, which would reduce the additional mitigation and the anticipated increase in maintenance dredging and placement area (PA) costs for a larger flare in an area with high shoaling. However, if the HSC is not widened to 700 feet, the Flare modification to the suggested 5,375-foot radius and a 328-foot bend easing at the existing 530-foot HSC bend at station 28+605 would be required. The additional turning basin at the BSC RO/RO was not economically justified and was eliminated from further study. The BE2_BSCFlare is further detailed in Engineering Plate No. 09.

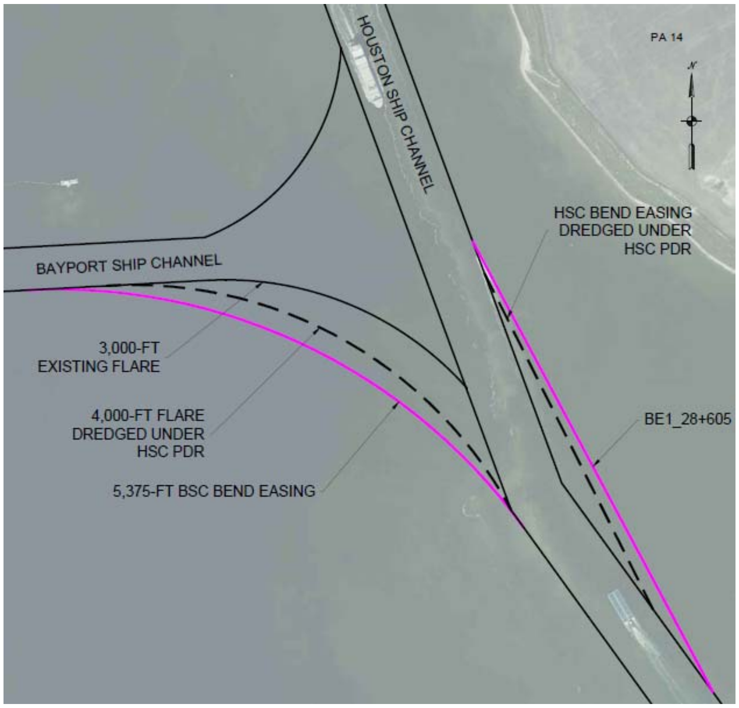


Figure 4-2: BSC Flare Easing 5,375 feet (BE2_BSCFlare)

4.1.3 Segment 3

The HP have requested the ability to completely turn a vessel at the entrance to the BCC to back larger container vessels into Docks 1 or 2. This would reduce issues with passage of moored vessels further down the narrow channel by allowing them to turn around at the entrance and immediately dock at the facility. Options were considered for increasing the existing flare on the north side as well as creating a flare on the south side. A combination bend easing/turning basin was developed for the BCC, to facilitate ingress between the channel and the HSC. This measure, **BETB3_BCCFlare_1800NS**, considers easing the flare on the north side of the BCC entrance and creating a flare to the south as shown in Figure 4-3. Currently, vessels entering the BCC from the south make a sharp tug assisted turn into the BCC using the north side flare to turn and enter the channel. To safely make the turn into the BCC, the entrance needs modification. To determine the size needed for the turns, the standard turning basin calculations were utilized. The typical current at the entrance to Morgan’s Point is approximately 1.5 feet/second (0.89 knots) using the NOAA Morgan’s Point gauge. A turning basin in a mid-current range would require an 1,800-foot diameter for vessels with 1,200 feet LOA. This increment would allow for safer transit from the HSC into the BCC as well as a turning basin at the mouth of the BCC for both the 1,100 feet and 1,200 feet LOA container vessels.

Ship simulation of the BCC Flare easing and 700-foot HSC widening allowed for the design containership to successfully turn at the entrance to BCC and back into the dock, and to successfully exit the BCC. Transit of Suezmax tankers inbound and outbound of the BCC were considered acceptable, however it is recommended that transitioning between facilities north of Morgans Point and BCC be evaluated further in PED. In all cases three tugs are considered required and wind limits of 15 knots maximum should be observed.

This increment does not require dredging on the east side of the HSC, however it could potentially impede future development of the PHA facilities on the south side of the channel at Morgan’s Point. In 1977, there were several mooring structures situated on the north side of the BCC flare that were cut at the mudline and removed. Any improvements to the north flare of the channel would require their total removal. The LASH dock on the southern side of the flare has been removed since the aerial photo was taken. Additionally, scattered oyster reef is located to the north as discussed Appendix P of the FSEIS. The BETB3_BCCFlare_1800NS is further detailed in Engineering Plate No. 10 and 26.

Figure 4-3: BETB3_BCCFlare_1800NS – BCC Flare Easing and 1,800-Foot Turning Basin

4.2 Channel Widening

Multiple channel widening scenarios have been evaluated to meet the needs of the existing and future shipping traffic. There are three different channel types defined in the EM 110-2-1613, canal, trench, and shallow. The HSC channel would be classified as a dredged channel trench as shown in Figure 4-4 (USACE, 2006, p. 8-3).

Typical current speeds in the area can be in the range of 0.5 to 1.5 knots (medium current speed range) as shown at observation stations located at the Fred Hartman Bridge and Morgan's Point. Using the design recommendation from EM 1110-2-1613 referenced in Table 4-4 for two-way traffic and assuming a best level of ATONS, vessel beam combinations were evaluated to make design recommendations for width of the channel using various sized ships anticipated to frequently transverse the HSC. Results of these four tests are shown in Table 4-3 and show the EM guidance channel widths based on the channel type, current speed, design vessel beam widths, one-way versus two-way traffic, and ATONS.

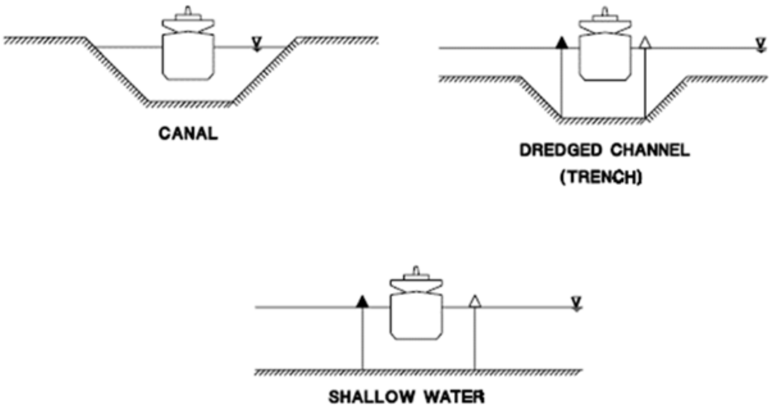


Figure 4-4: Channel Types Defined in EM 110-2-1613

Table 4-3: HSC Test Cases – Channel Width Design Criteria

	Channel Cross Section		Trench Type Channel Cross Section		**Current (ft/s)**		Medium Current Range 0.5 to 1.5 Knots	
	Bay Reach		**Bay Reach**		**Bay Reach**		**Bay Reach**	
	Beam (ft)	Description	Beam (ft)	Description	Beam (ft)	Description	Beam (ft)	Description
Vessel Beam$_{design}$ (ft)	164	**Suezmax1**	164	**Suezmax1**	164	**Suezmax1**	164	**Suezmax1**
Vessel Beam$_{traffic}$ (ft)	164	**Suezmax1**	158	**Container**	140	**Container**	138	**Aframax**
One-Way Best ATONS Multiplier Constant Cross Section	3.25		3.25		3.25		3.25	
Channel width (ft)	***533***		***523***		***494***		***491***	
One-Way Best ATONS Multiplier Variable Cross Section	4.00		4.00		4.00		4.00	
Channel width (ft)	***656***		***644***		***608***		***604***	
Two-Way Best ATONS Multiplier Uniform channel Cross Section	5.50		5.50		5.50		5.50	
Channel width (ft)	***902***		***886***		***836***		***831***	

4.2.1 Segment 1

Based on the results shown in Table 4-3 and discussions with the HP, channel widening scenarios ranging from 900 to 650 feet with 328-foot bend easings were evaluated for Segment 1. The 900 and 820-foot channels were not economically justified and were dropped at TSP and ADM. Ship simulations of the 650-foot channel widening concluded that the meeting of two design containerships would be a high-risk maneuver, and meetings between a design containership and tanker would be a risky maneuver. The meetings between any of the design ships for the 650-foot channel in the 328-foot bends were not simulated as the pilots considered such a maneuver unsafe. The same scenarios were simulated for the 700-foot HSC widening with the 328-foot bends and were considered to be acceptable. Therefore, a 700-foot-wide channel is carried forward for analysis. Details regarding specific ship simulation can be found in Attachment 5 of this Appendix. An example cross section of the channel template is shown in Figure 4-5.

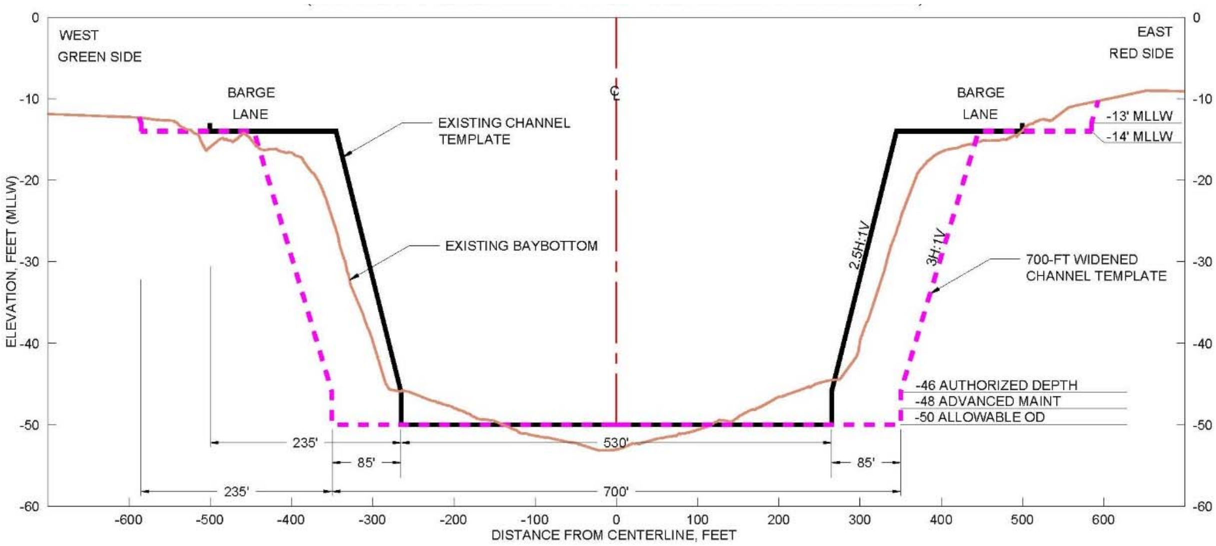


Figure 4-5: Bay Reach Widening 700 Feet from Bolivar Roads to BCC Cross Section

4.2.1.1 Bay Reach Widening 700 Feet from Bolivar Roads to BCC

The bay reach widening measures evaluated for the 700-foot-wide channel are **CW1_BR-Redfish_700**, **CW1_Redfish-BSC_700**, and **CW1_BSC-BCC_700**. These channel widening measures are detailed in Engineering Plate No. 15-23.

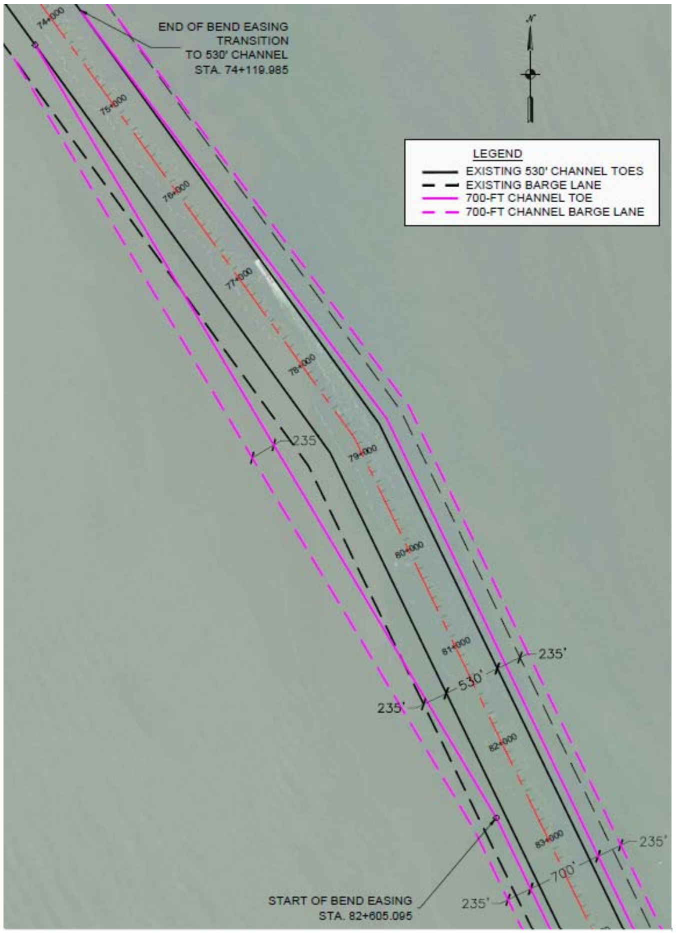


Figure 4-6: Transition at Station 78+844 from CW1_BR-Redfish_700 to existing 530-foot channel

If after evaluation of costs, economics, and mitigation requirements the channel could not be widened throughout the entire Bay, the HP suggested that widening the Lower Bay would provide the most benefit since the timing of the inbound ship meeting the outbound ship is easier to determine and manage. However, it is their assertion that the entire HSC artery through the Bay be widened to ensure navigational safety. This section is the longest straight section of the channel and could afford up to 4 vessel meetings assuming 2.5 mile spacing. To evaluate the potential for widening only the lower bay reach, measure CW1_BR-Redfish_700 was modified to transition from the bend easing at Station 78+844 to the existing 530-foot HSC at Station 74+119.99 as shown in Figure 4-6. This measure would not lift any other restrictions inbound or outbound further up the channel. This measure has been identified as the NED. CW1_BR-Redfish_700 under the NED plan is detailed in Engineering Plate No. 04-07.

4.2.2 Segment 2

The entrance of the BSC is near Beacon 76 at approximate HSC Station 25+466 where the two channel centerlines meet. The southern boundary of the BSC has a 4,000-foot radius. The current BSC is 46.5 feet deep and approximately 400 feet wide from the start of the BSC Flare at approximate Station 221+00 to the land cut at 112+00. The remaining channel is 350 feet wide from Station 112+00 to 25+58 and includes a 1,600-foot turning basin at its terminus. The HP have expressed concerns for sufficient room for tug assistance and the ability to efficiently navigate large container and wide tanker vessels through the land cut portions of the channel past moored vessels. Additionally, long vessels tend to “crab” (transit diagonally to their heading direction) from the transit between the HSC and the BSC land cut due to wind conditions. This can lead to channel restrictions.

The current forecasted range of container vessel sizes expected to frequently call at PHA range from 1,100 feet LOA x 158 feet in beam to 1,200 feet LOA by 140-foot beam. Additionally, tanker forecasted sizes are 935 feet LOA x 164-foot beam and 750 feet LOA x 138-foot beam. HP requested consideration of additional widening, ranging from 50 to 168 feet at the BSC.

Due to the container terminal berths to the south, widening of the channel to the south is not an option inside the land cut. Therefore, all channel widening considered is to the north. On the north side of the land cut a shore protection rock revetment would have to be removed and replaced for any additional widening scenario. It should be noted that intermittent wetlands are located between the rock revetment and the residential road that will require assessment and mitigation. Conversion of shallow water habitat to deep-water habitat will also need to be considered. Additionally, several pipelines are in the buffer zone between the existing channel top of slope and the adjacent road and residential neighborhood. Widening beyond 100-125 feet may require the relocation of these pipelines and is considered cost prohibitive. Therefore, this was considered as a constraint to the widening of the BSC. A sheet pile bulkhead would be required to protect and secure the north shoreline as discussed in Section 4.6 of this Appendix. From approximate Station 55+00 to 25+58, additional landside development has occurred, and is occurring, to include the San Jacinto Community College, LBC Tank Terminals, and Crosby Tug. The PHA currently has a development easement extending approximately 230 feet from the improved channel toe along the north side of the channel for future development. Any additional widening will require improvements and replacements to the current ATON systems for the BSC and it is assumed that these improvements will constitute the best ATONs assessment. Utilizing the EM design parameters, the range of possible channel widening is shown in Table 4-4. The BSC could be considered a hybrid channel between trench and canal types. The north side slope extends to daylight like that of a canal type channel. On the south side however, the toe ends at the start of the berthing areas, spans the wide berths, before sloping up underneath the docks. This would make the channel more closely resembling a trench type. Both configurations were evaluated with the EM design guidance and the trench type was found to yield a more conservative channel width requirement than the canal type, and was therefore held. Regarding the water current conditions, the BSC is a dead-end channel with little to no riverine inflow and the flow is thus dominated by tidal currents in the Bay. Bay tidal ebb and flood current velocities would max out at approximately 1 feet per second except under extreme circumstances, and in general would predominantly be under 2.5 feet per second, the upper bound of the middle current regime. Therefore, the mid-level current regime was selected for the BSC design criteria.

Table 4-4: BSC Design Widths by Vessel Size

	Trench Type Channel Cross Section				**Current Regime**
	158-foot Design Vessel		**140-foot Design Vessel**		**BSC (MID-CURRENT RANGE)**
	Beam (ft)	Description	Beam (ft)	Description	
Vessel Beam$_{\text{design}}$ (ft)	158	**Container**	140	**Container**	
Vessel Beam$_{\text{traffic}}$ (ft)	158	**Container**	140	**Container**	
One-Way Best ATONS Multiplier	3.25		3.25		
Channel width (ft)	***515***		***455***		
Two-Way Best ATONS Multiplier	5.50		5.50		
Channel width (ft)	***869***		***770***		
	Bayport Ship Channel		**Bayport Ship Channel**		**BSC (LOW-CURRENT RANGE)**
	Beam (ft)	Description	Beam (ft)	Description	
Vessel Beam$_{\text{design}}$ (ft)	158	**Container**	140	**Container**	
Vessel Beam$_{\text{traffic}}$ (ft)	158	**Container**	140	**Container**	
One-Way Best ATONS Multiplier	2.75		2.75		
Channel width (ft)	***435***		***385***		
Two-Way Best ATONS Multiplier	4.50		4.50		
Channel width (ft)	***711***		***630***		

A 455-foot channel measure, **CW2_BSC_455**, was developed for the BSC to meet the EM requirements of the 140-foot beam vessel utilizing the best ATON configuration for one-way traffic under a mid-current regime. This same considered width would meet the requirements of a 158-foot beam vessel during periods of low-current conditions. This would require an approximate 50-foot widening from Station 221+00 to 112+00 and approximately 100-foot widening from Station 112+00 to 25+58 as shown in Figure 4-7 and detailed in Engineering Plate No. 8-9 and 24-25. No deepening beyond the currently permitted 46.5-foot channel is being considered. However, the recent channel deepening and widening will be included in the documents for specific authorization pending the next WRDA legislation if additional improvements are not warranted by this study.

Ship maneuvering simulations of the BSC widening combined with the 4,000-foot BSC flare and 700-foot HSC channel with 328-foot bend easings were conducted. In all cases three tugs of the 3075 type were considered required and wind limits of 15 knots maximum should be observed. The option to widen the BSC within the land cut to 400 feet was found marginally acceptable, however due to the drift angle required with crosswinds, a 455-foot channel width throughout the channel was preferred.

Slope stability of the north shore of the channel with the proposed channel widening improvements and the installation of a bulkhead were evaluated using existing geotechnical and survey data and the minimum factors of safety were met. Results of the slope stability analysis can be found in Attachment 6 of this Appendix.

This measure would require oyster mitigation. Any widening from Station 112+00 to 25+58 will require the removal and relocation of existing rock revetment, have potential impacts to existing pipelines and cause impacts to development between Station 55+00 to 25+58. It is also assumed that the acreage for widening between Station 112+00 to 25+58 may require mitigation for the conversion of shallow water habitat to deep-water habitat and intermittent wetlands located landward of the rock revetment.

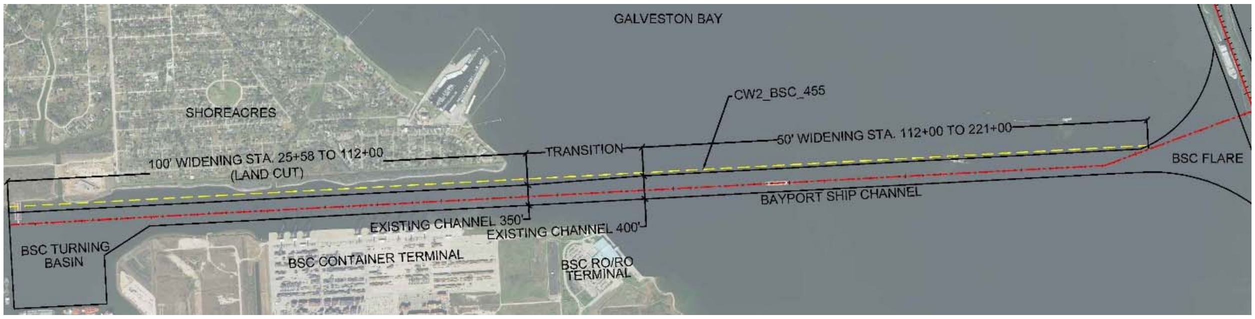


Figure 4-7: CW2_BSC_455 - BSC Widening 455 Feet

4.2.3 Segment 3

The HP have expressed concerns with the ability to navigate large containers vessels more than 1,100 feet in length into the BCC as well as through the channel past moored vessels. The entrance of the BCC is at Morgan’s Point and approximate HSC Station 6+00 where the two channel centerlines meet, just north of the entrance to the Cedar Bayou Navigation Channel. The BCC is a 1.6-mile channel approximately 300-feet wide, at a depth of -46.5 feet MLLW, and includes a turning basin at its terminus. The turning basin is approximately 2,000 x 1,900 feet in dimension. It is essentially land locked on both sides by berthing areas to the south and Spilmans Island PA to the north. The berthing areas are approximately 225 feet wide. The BCC channel is one-way traffic. Because the channel itself is land locked and short, it is considered to have a low current and thus low current calculations for the channel widening features were considered. The LASH dock between Stations 14+00 and 22+00 as well as the old RO/RO Dock on the southeast side of Dock 1 are currently being removed.

As with the BSC, HP have requested additional widening to allow for more space for tug assistance. The channel is 300 feet wide from approximate Station 68+00 to 33+00. Potential additional channel widths for BCC one-way traffic as described below. As noted above, the low current range values were used to calculate the needed widths of the channel. Due to the presence of the container terminal on the south side of the channel, widening to the south is not an option. Spilmans Island PA is located on the north side of the channel. Its current dikes are at approximately +30 feet MLT. Significant consideration to future slope stability along the south side of Spilmans Island will need to be evaluated along with the impact of long term dredged material placement capacity. ATONS constituting the best assessment would need to be installed; otherwise there is not sufficient area to widen the channel.

Table 4-5: BCC Design Widths by Vessel Size

	Trench Type Channel Cross Section				**Current Regime**
	158-foot Design Vessel		**140- foot Design Vessel**		**BCC (LOW-CURRENT RANGE)**
	Beam (ft)	Description	Beam (ft)	Description	
Vessel Beam$_{design}$ (ft)	158	**Container**	140	**Container**	
Vessel Beam$_{traffic}$ (ft)	158	**Container**	140	**Container**	
One-Way Best ATONS Multiplier	2.75		2.75		
Channel width (ft)	***435***		***385***		
One-Way Average ATONS Multiplier	3.50		3.50		
Channel width (ft)	***553***		***490***		

The BCC channel is similar to the BSC in terms of its existing configuration (i.e. docks to south, shoreline to the north, dead-end channel, etc.) Therefore, the same EM design parameter was held for a trench type channel. While it could be also considered a cut off channel, the requirements of the trench channel are more conservative. EM calculations for widening the BCC would require a channel width ranging from 385 to 553 feet wide depending on the ATONs utilized in a low current regime. The EM does not consider the short nature of a channel. Due the range of potential widening, the channel short distance, and the fact that the forecasted vessel sizes for containers vessels are the same as the BSC, a channel width of 455' was selected for evaluation. This measure, **CW3_BCC_455**, would require a 155-foot widening from approximate Station 24+75 to 67+11 as shown in Figure 4-8 and detailed in Engineering Plate No. 10 and 26. Input from the HP indicates that the same dimensions for both the BSC and BCC are desired.

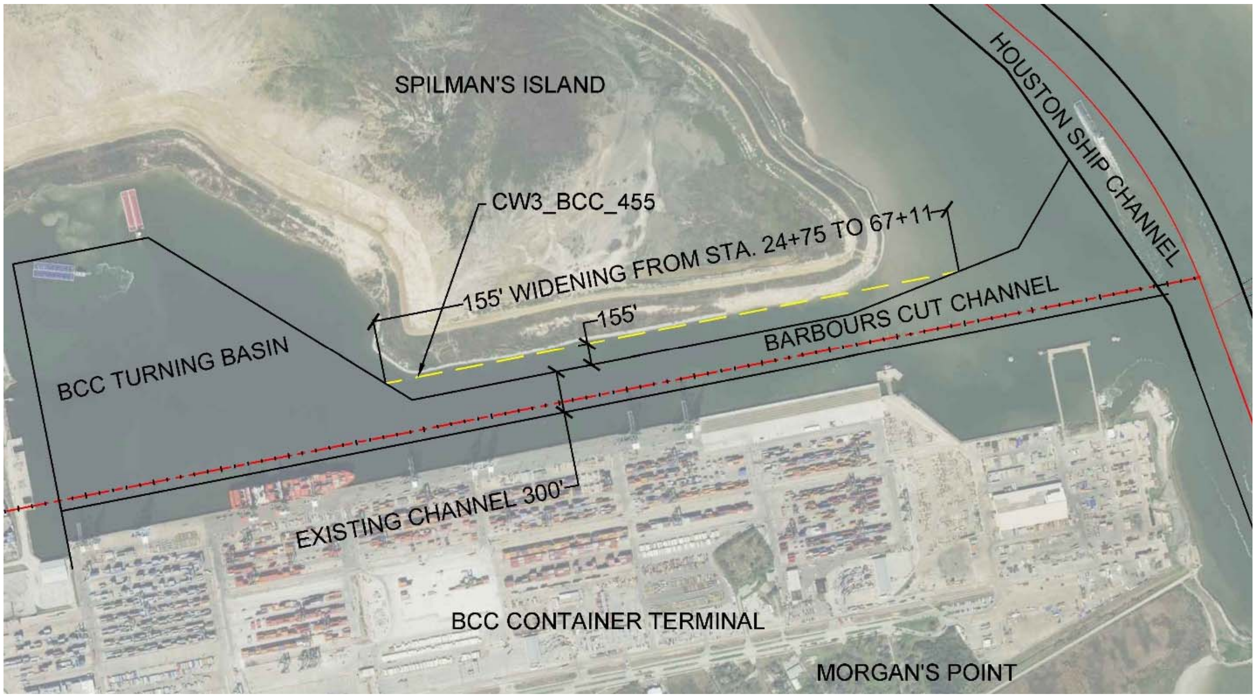


Figure 4-8: CW3_BCC_455 - BCC Widening 455 Feet

Ship simulations performed on the 455-foot BCC allowed the successful maneuvering of the design containership turning at the entrance to BCC, transit through the channel past berthed design containerships at the docks, turning in the turning basin, and exiting the BCC. The transit of the design tanker, both inbound and outbound of the BCC was considered acceptable with the 700-foot HSC widening and the easing of the BCC Flare. In all cases three tugs are considered required and wind limits of 15 knots maximum should be observed.

The projected toe of the channel does impact the emergent dikes of Spilmans Island PA. However, a sheet pile bulkhead may still be feasible without relocating any of the existing PA dikes. This increment would require the existing Spilmans Island PA dikes to be shifted to the north towards the interior if a sheet pile type bulkhead is not installed and would require the removal and replacement of the rock revetment shore protection. The dredging of this feature will likely need to be through mechanical dredging rather than the area standard practice of hydraulic dredging to allow for the installation of sheet pile prior to dredging and to reduce the potential for damage to the sheet pile. This will also affect long term maintenance costs. This increment would require exploration and potential removal of some of the historic mooring piles. Ship simulation will be utilized to determine the optimal width of the channel and slope stability analysis will be required along Spilmans Island PA in PED.

Slope stability of the north shore of the channel with the proposed channel widening improvements and the installation of a bulkhead were evaluated using existing geotechnical and survey data and the minimum factors of safety were met. Results of the slope stability analysis can be found in Attachment 5 of this Appendix.

4.2.4 Segment 4

The measure developed for Segment 4 considers deepening and widening approximately 8 miles of channel to alleviate current traffic restrictions for both draft and beam widths to allow for benefits to be realized for increased Aframax and Suezmax traffic in this region and to improve the current 116-foot beam restriction. Widening is envisioned through varying degrees to the north and south through meandering centerline shifts. Significant investment from multiple private entities is being made to upgrade, expand and/or develop new facilities regardless of improvements. This section of channel from approximate Station 684+00 to 850+00 is currently 300 feet wide at a depth of -41.5 feet MLLW and is predominantly bounded on both sides by petroleum and chemical industries. Measure, **CW4_BB-GB_530**, would widen the channel up to 530 feet from Boggy Bayou to Greens Bayou (Station 684+00 to 833+00) along the centerline and deepen to a depth of -46.5 feet MLLW as shown in Figure 4-9 and further detailed in Engineering Plate No. 11 and 27.

Since the location falls along a compound curve, its configuration is required to be evaluated through ship simulation. This assumes that the current dock setbacks are sufficient to meet HP guidelines and the projected design vessel at this time but should be reviewed in further analysis. As previously stated, HP require all existing dock facilities to be a minimum of 160 feet from the channel toe and a minimum of 225 feet for new facility construction. This measure allows for the petrochemical industry in this stretch of channel to realize the benefits from the downstream 46.5-foot project and would extend the widening up to 530 feet.

Ship simulation of the 530-foot channel from Boggy Bayou to Greens Bayou found it provided successful operations of Aframax and Suezmax vessels, two-way traffic of loaded vessels with a maximum combined ship beam of 246 feet, and the meeting of loaded Aframax and Panamax ships. The meeting of loaded Suezmax with Panamax vessels was problematic, however with further evaluation and training it could be possible. Discussions with the existing and planned LSFs is included in Section 5.3 of this Appendix.

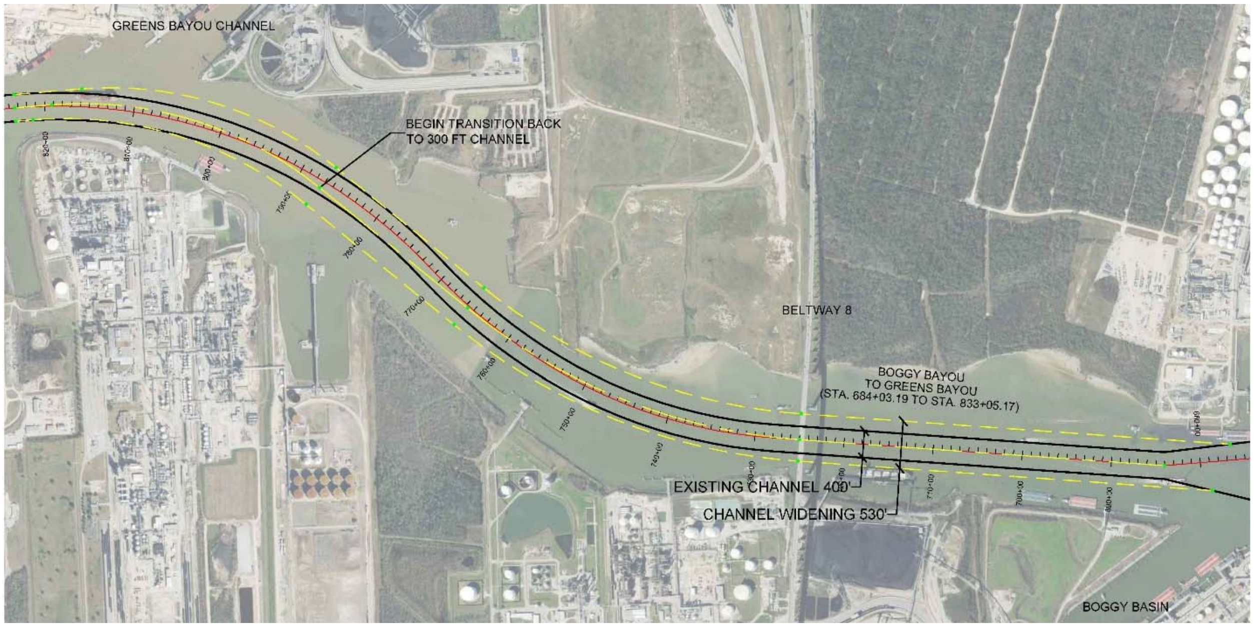


Figure 4-9: CW4_BB-GB_530 – Boggy Bayou to Greens Bayou Widening 530 Feet

4.3 Channel Deepening

Three measures were developed within Segments 4, 5 and 6 of the HSC that are currently at depths less than -46.5 feet MLLW.

4.3.1 Segment 4

The current depth of the HSC from Boggy Bayou to Sims Bayou is -41.5 feet MLLW. However, at the Washburn Tunnel crossing, the channel depth is maintained at -38.5 feet MLLW, with 2 feet AM, and 1-foot allowable overdepth (AO). Any improvements in this area would have to avoid impacts to the Washburn Tunnel at Station 974+07, a nationally registered historic place. Measure CD4_Whole proposes to deepen Segment 4 by approximately 5 feet between Boggy Bayou at Station 684+03 to the Hunting Turning Basin at Station 930+00 as detailed in Engineering Plate No. 11-12 and 27-28. This allows for the petrochemical industry in this stretch of channel to realize the benefits from the 46.5-foot project but would not lift current channel vessel beam restrictions. USACE Galveston District Surveys indicate that depths of this segment are already more than -41.5 feet MLLW. The majority of the facilities in this section are currently upgrading, constructing or permitted to upgrade or construct their facilities regardless of these channel improvements. The PHA met with many of the facilities to discuss channel improvements and acquire where possible CADD files and permit drawings of the proposed expansions. Based on the needs of the facilities, and existing pipeline locations, it is recommended that the deepening be stopped after Hunting Turning Basin at Station 930+00.

4.3.2 Segment 5

The HSC from Sims Bayou to the I-610 Bridge has an authorized depth of -37.5 feet MLLW. Measure **CD5_Whole** would deepen this section of channel by approximately 4 feet between Station 1110+77.54 to 1160+62.20 as shown in Engineering Plate No. 13 and 29. This measure would be subject to the same concerns regarding pipelines and dock facilities as CD4_Whole. No LSF improvements are currently considered in this analysis.

4.3.3 Segment 6

The HSC from the I-610 Bridge through the Main Turning Basin has an authorized depth of -37.5 feet MLLW. Measure **CD6_Whole** would deepen the section of channel by approximately 4 feet from Station 1160+62.20 to 30+95.06 at the Main Turning Basin as shown in Engineering Plate No. 14 and 30. This measure would be subject to similar concerns regarding pipelines and dock facilities as deepening measures in Segments 4 and 5. Deepening of City Dock 16 was the only LSF improvement currently considered in this analysis.

4.4 Turning Basins

Turning basins are an integral part of shipping channels, and are required where maneuverability of ship traffic between locations cannot be performed under ship power alone, and requires stopping and tug assisted turning. This situation occurs frequently in the HSC at intersections between channels and at docking facilitates.

4.4.1 Segment 3

The HP have requested the ability to completely turn a vessel at the entrance to the BCC to back larger container vessels into Docks 1 or 2. This would reduce issues with passage of moored vessels further down the narrow channel by allowing them to turn around at the entrance and immediately dock at the facility. Options were considered for increasing the existing flare on the north side as well as creating a flare on the south side. A combination bend easing/turning basin was developed for the BCC, to facilitate ingress between the channel and the HSC. This measure, **BETB3_BCCFlare_1800NS**, considers easing the flare on the north side of the BCC entrance and creating a flare to the south as shown in Figure 4-3 and previously discussed in Section 4.1.3. Refer to Engineering Plate No. 10 and 26. This measure serves a dual purpose; to allow sufficient turning radius for vessel ingress and egress, and to allow vessel turning and backing access to Berths 1 and 2 rather than passing moored vessels in this constrained channel.

4.4.2 Segment 4

The existing turning basin at Hunting Bayou was evaluated to accommodate turning of bulk carriers with a 750-foot LOA, the design vessel in this reach. In accordance with EM 1110-2-1613 and assuming a 0.5 to 1.5 knot current regime, measure **TB4_Hunting** has a 1,125-foot diameter turning basin. Assuming a less than 0.5 knot current regime, a 900-foot diameter turning circle is also shown for additional reference in Figure 4-10. Evaluation of the existing 900-foot diameter turning basin indicates it is currently of sufficient size and does not need further modification, however it will be deepened as part of CD4_Whole that will deepen this portion of the channel from the -41.5 feet MLLW to -46.5’ MLLW

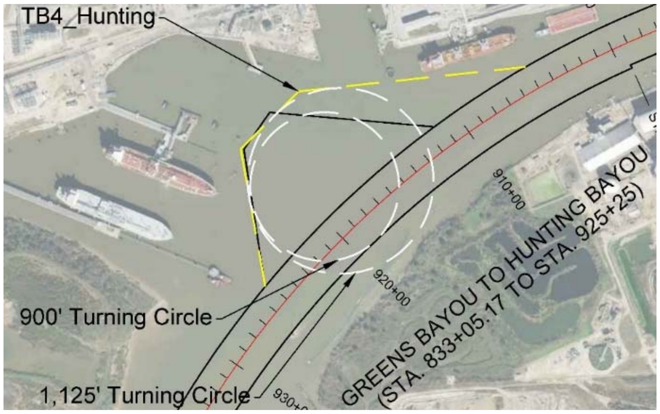


Figure 4-10: TB4_Hunting - Segment 4 Turning Basin at Hunting Bayou

4.4.3 Segment 6

The Brady Island Turning Basin at Station 1195+00 needs to be expanded to accommodate turning of bulk carriers, the design vessel in this reach. Measure **TB6_Brady_900**, as shown in Figure 4-11 has a 900-foot diameter turning basin. Ship simulations for an enlarged Brady Island Turning Basin had successful turning maneuvers of Panamax vessels with the assistance of tugs while Panamax vessels were berthed at Wharfs 26-28 and a bunkering barge alongside the ship at Wharf 27. This measure will require the installation of a bulkhead as discussed in Section 4.6 and detailed in Engineering Plate No. 14 and 30.

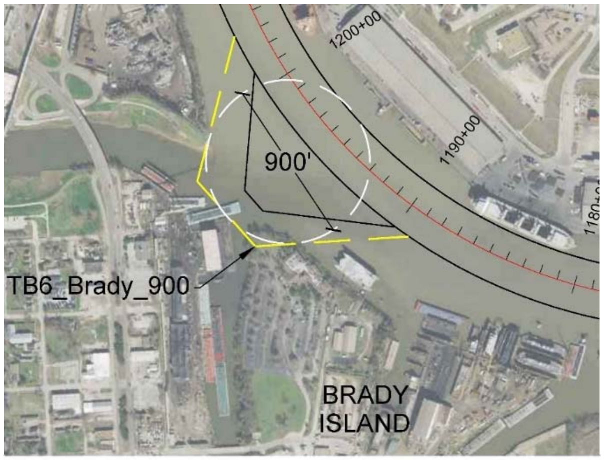


Figure 4-11: TB6_Brady – Segment 6 Brady Island Turning Basin

4.4.4 BSC Flare Sedimentation Attenuation Feature

The BSC Flare, located at the intersection of the HSC and BSC, has an existing high shoaling rate of approximately 788,000 CY per year. This has led to a maintenance dredging requirement of approximately every 9-12 months. If selected for further consideration, measure BE2_BSCFlare would widen the south side of the flare to a 5,375-foot radius. While providing navigational benefits, this measure would potentially increase the flare shoaling by an additional 308,000 CY per year and exacerbate maintenance dredging requirements.

Because of this, sedimentation attenuation feature options were investigated by a Texas A&M professor (Bert Sweetman) while on sabbatical in the USACE SWG office. Two options were developed to reduce the counter-clockwise circulation west of Atkinson Island that is carrying sediment into BSC.

The AdCirc numerical model of currents was applied to HSC by Engineer Research and Design Center (ERDC) (Jennifer McAlpin) which will be used in PED to test these two options.

After completion of the AdCirc model, an option was developed to largely close the circulation into BSC. The purpose of this feature would be to alter the existing sediment pathways currently leading to the flare and redirect them to a location that would decrease the amount of flare shoaling occurring now, while also not worsening channel shoaling elsewhere. This feature has been incorporated into this study conceptually as measure SA2_BSCFlare. Specific details and requirements of this measure are not known at this time and will be based upon hydrodynamic, salinity, and sediment transport modeling at ERDC during PED. An estimated location for this measure has been sited on the northwest side of the intersection of the BSC and HSC as shown in Engineering Plate No. 31. It would be constructed running along the north toe of the BSC, angle northward at the intersection, and then proceed north running parallel to the west toe of the HSC. The length of the measure is currently estimated to be approximately 9,400 linear feet. Both the length and/or overall configuration could change significantly following the completion of the ERDC study.

This measure is being assumed as a hardened structure at this time, consisting of an armored earthen dike. The dike would be constructed using hydraulically placed new work dredge materials, excavated as part of adjacent channel widening features. The dike would be armored with rip-rap quarry stone similar to adjacent shore protection features along the west side of Atkinson Island. Analysis of this feature is provided in Attachment 9.

Figure 4-12 shows a conceptual design cross-section of a dike of construction type typical to this region. This section was assumed for the length of the measure for cost estimation purposes.

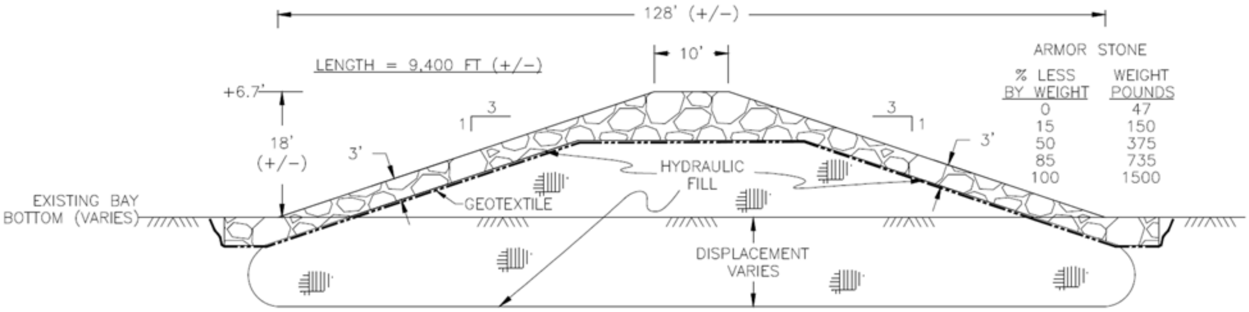


Figure 4-12: BSC Flare Sedimentation Attenuation Feature

Thus three options have been put forth as this feature (two by A&M and the third long straight option described in the preceding three paragraphs. Which of the options might be chosen is expected to be determined by a separate benefit/cost analysis comparing attenuation (prevention) and dredging (reaction).

4.5 Sheet piling

Measures requiring sheet piling are those where dredged side slopes (3H:1V) would potentially impact shore side constraints (existing infrastructure, PAs, development, wetlands etc.), making it necessary to provide a stabilizing structure. Sheet piling was assumed to be required where these conditions potentially exist.

The conceptual design for the sheet pile walls was based on similar designs that provided containment to -45 feet. Costs for sheet pile walls were extracted which included a combination of interlocking H-piles (king piles) and intermediate Type Z sheets.

The combined wall system consists of 1) the king pile, 2) intermediary sheet piles, and 3) connectors or tie-rods as shown in Figure 4-13. The design uses a tie-rod welded to or interlocked with the king pile to connect the king pile to the sheet pile, with each tie-rod secured to a sheet pile deadman. Horizontal bracing or walers are also incorporated for horizontal load transfer from the anchored sheet pile to the tie-rods. The conceptual design assumes that current soil conditions are adequate for sheet pile stability and that no backfilling would be required. No platforms or approach slabs are assumed in the design since the purpose of this structure is to retain soil and provide protection from ship wakes, but not for servicing vessels or barges. Sheet pile was not considered as its own measure but is included in the costs of applicable measures. Sheet piling will be required along the north shore of the BSC from Station 35+00 to 43+50 (Engineering Plate No. 08), along the shoreline of Morgans Point at the intersection of the HSC and BCC Flare at approximate HSC Station 0+000 to 0+400 (Engineering Plate No. 10), the north side of the BCC along Spilmans Island from Station 30+00 to 67+00 (Engineering Plate No. 10), and at the Brady Island Turning Basin (Engineering Plate No. 14).

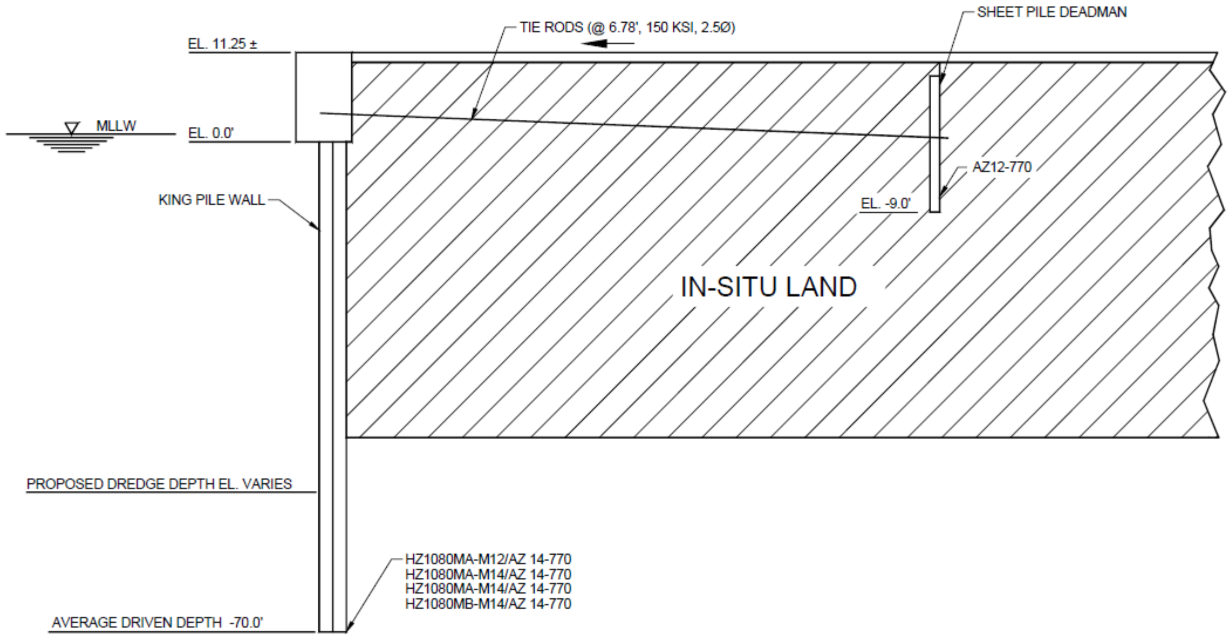


Figure 4-13: Typical Sheet Pile Section

4.6 Aids to Navigation

The relocation or addition of ATONs will be required to delineate the limits of the widened channel(s). Coordination with the United States Coast Guard (USCG) has been performed to evaluate the potential impacts to existing ATONs. In general, ATONs along the HSC between Bolivar Roads to Morgans Point are positioned at the outside toe of the existing barge lanes. These will all require relocation to the outside toe of the relocated barge lanes. In Segment 2, ATONs lying along widened areas will require relocation to maintain required offsets. Additionally, one junction light and one outer range front light will need to be moved. The remaining area impacted lies in Segment 4, at the area of proposed channel widening between Boggy Bayou to Greens Bayou. This area of the channel is proposed to be improved by widening the existing channel up to 530 feet and reconfiguring of the centerline to create smoother bend transitions. A list of ATONs requiring relocation was provided by USCG and is quantified in Table 4-6 in reference to the considered channel measure.

Table 4-6: ATONs for Relocation

Segment	Measure	ATON Qty.
1	CW1_BR-Redfish_700	31
	CW1_Redfish-BSC_700	26
	CW1_BSC-BCC_700	14
2	CW2_BSC_455	6
	CW2_BSCFlare	3
3	BETB3_BCCFlare_1800	2
4	CW4_BB-GB_530	4
	TOTAL	86

4.7 Typical Dredge Material Use Options

General engineering analysis was used to develop scenarios for the construction of new sites to either contain the new work materials as a result of the construction of the channel modifications and/or to create additional future O&M capacity where feasible. The placement measures for new work were generally sized to hydraulically construct dikes for the measure with the new work in Galveston Bay. There are no new non-Federal facility improvements in Galveston Bay. In Boggy Bayou in-situ earthen dikes were sized on the various PAs to contain the new work. The Boggy Bayou area of the channel is heavily constrained by existing industrial and residential developed property. Therefore, few opportunities for new dredged material placement options are available within reasonable proximity to the channel. A combination of upland confined PAs (UCPA) and BU PAs, their sizes and general engineering considerations are discussed below. The selected UCPA and BU PAs will undergo further geotechnical, surveying, and engineering analysis in PED and their sizes will be adjusted accordingly.

4.7.1 Beneficial Use

The Federal Government has placed considerable emphasis on using dredged material in a beneficial manner. Statutes such as the Water Resources Development Acts of 1992, 1996, 2000, and 2007 demonstrate that BU has been a Congressional priority. The USACE has emphasized the use of dredged material for BU through such regulations as 33 CFR Part 335, ER 1105-2-100, and ER 1130-2-520 and by Policy Guidance Letter No. 56. ER 1105-2-100 states that “all dredged material management studies include an assessment of potential BUs for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction” (USACE, 2000, E-69). Opportunities for BU of dredged material exist in the project vicinity. Meetings with the Beneficial Uses Group (BUG), consisting of Federal and state resource agencies (EPA, NMFS, NRCS, USFWS, TCEQ, TGLO, and TPWD) were conducted throughout the development of the Dredge Material Management Plan for the HSC ECIP to discuss potential BU options.

The BU components of the RP are considered general navigation features and the cost sharing is determined by WRDA 86, as amended. The BU components of this plan are considered general navigation features because the BU sites are part of the Federal Standard/Base Plan.

Typically, design of BU projects requires a grain size/compatibility analysis and potentially modeling of sediment transport and fate to be completed for these types of projects. To meet the goals of accelerating the schedule and reducing study costs, this work is scheduled for the PED phase. As a result, the measures are discussed in the Feasibility Report/EIS without detailed analysis, but with a commitment to perform additional analysis during the PED phase and re-coordinate all decisions with resource agencies to ensure environmental acceptability. Final designs, decisions to implement, and final environmental considerations/clearances would take place during the PED phase if significantly altered. Some of the engineering considerations and analyses to be conducted during the PED phase include but are not limited to:

- Grain size analysis and PSDDF consolidation testing of materials to be dredged by reach considered for BU marsh construction to determine the bulking and consolidation characteristics of the materials to be dredged and placed.
- Geotechnical probings and borings to determine foundation characteristics for stability and consolidation to determine construction and maintenance elevations.
- Site specific wind and wave analysis to determine optimal dike heights and shore protection features.
- Intertidal marsh elevation surveys would be conducted on neighboring marshes to the site selection to determine the optimal tidal elevation target range with consideration of RSLC. Surveys and conversions should be NAVD88.
- Natural and artificial reef surveys to determine optimal design elevations, contours, and monitoring strategies.
- Ground truthing of assumptions made for planting marshes and bird islands during the HGNC deepening and widening construction and maintenance

4.7.1.1 8-Acre Bird Island

The proposed 8-acre bird island as shown in Figure 4-14 and Figure 4-15 would be located in Lower Bay, east of the HSC as shown in Engineering Plate No. 33. The preliminary design uses the same project elevations used in the design of the existing bird island from the HGNC LRR and FSEIS (USACE, 1995). Estimated neatline quantity of material for construction is 546,000 CY. With a retainage rate of 60% the total new work material required is 910,000 CY. The retainage rate considers foundation displacement to -15 feet MLLW.

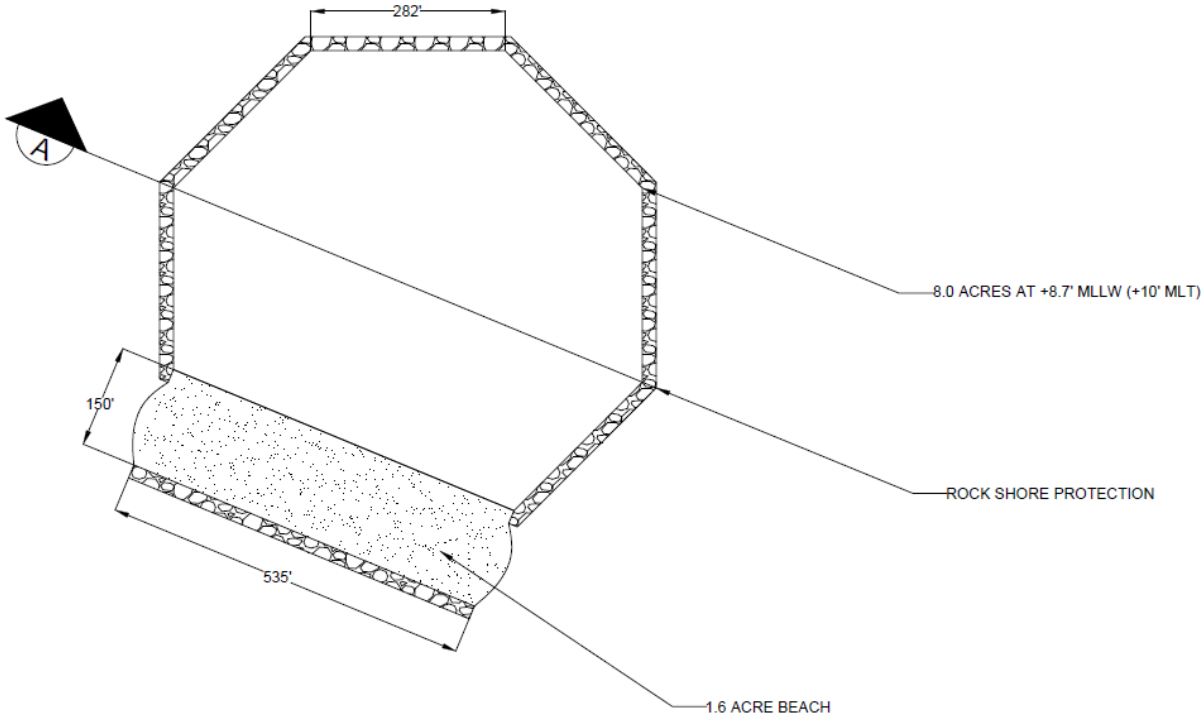


Figure 4-14: 8-Acre Bird Island Plan View

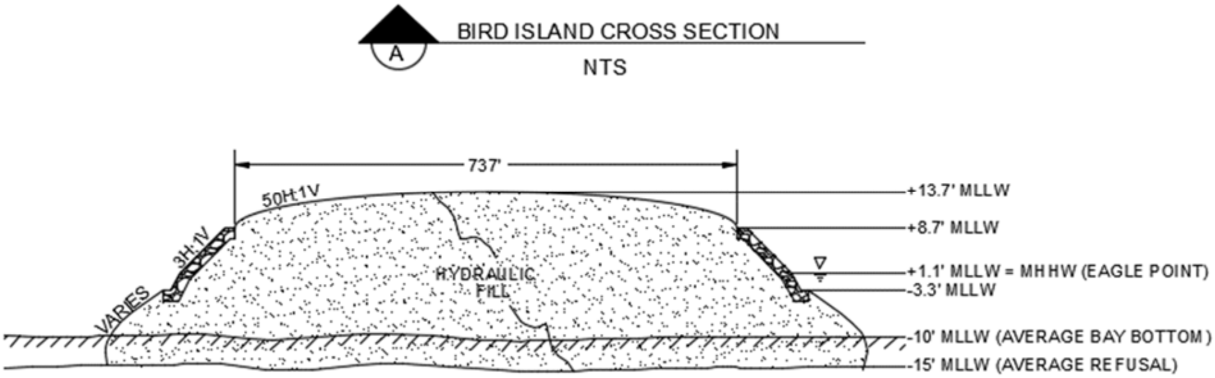


Figure 4-15: 8-Acre Bird Island Cross Section

4.7.1.2 Long Bird Island

The 6-acre bird island would be located in Lower Bay, east of the HSC as shown in Engineering Plate No. 31. A dike would be constructed along the channel side of the island to minimize wave impacts, and an oyster reef/wave trip along the back side as shown in Figure 4-16 and Figure 4-17 (Engineering Plate No. 34). The distance from the oyster reef/wave trip is approximate and will be defined post wind/wave calculations dependent on the final project location.

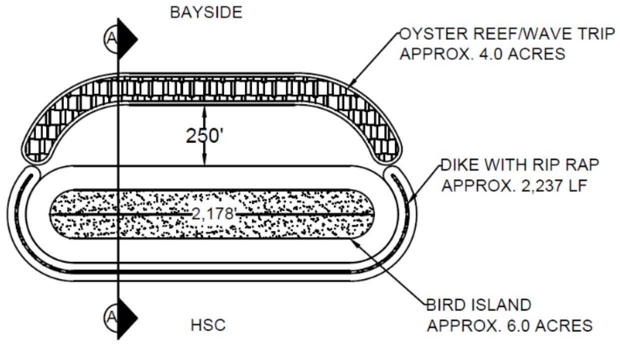


Figure 4-16: Long Bird Island Plan View

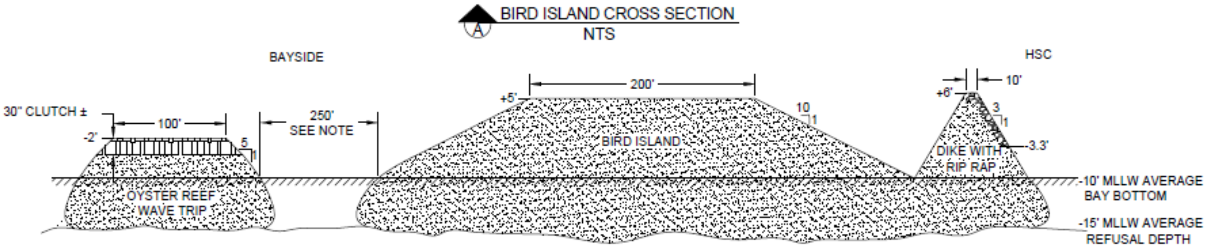


Figure 4-17: Long Bird Island Cross Section

Estimated neatline quantity of material for construction is 703,000 CY. With a retainage rate of 60% the total new work material required is 1,172,000 CY. The retainage rate considers foundation displacement to -15 feet MLLW. The intent of this bird island is for nesting habitat for skimmers. Natural habitat for the target species typically is barren ground devoid of vegetation and consisting of shell hash. During PED, habitat should be evaluated and coordinated with the resource agencies to determine if barren ground is sufficient or if placement of a shell substrate cap over all or some of the island is feasible and within budget. As shell hash is not typically readily available, a crushed limestone product known as DF blend can potentially be considered for and placement as a cap.

The DF blend is a crushed limestone product used in road base applications that generally matches the gradation of existing shell hash common in the region. While similar in gradation, the general shape of the graded rock is more rounded than that of shell hash. Despite this difference, it has been used in at least one recent regional project that has exhibited immediate successes (Figure 4-18). Current

Figure 4-18: Oyster Catcher nesting one day after completion of the Dickinson Bay Island Ground Nesting Habitat Enhancement Project (Source: Galveston Bay Foundation)

design and cost estimates for bird islands do not include these materials, however as part of a final design they would be evaluated with ultimate selection based on proven application, as well as prudent engineering design and judgment.

4.7.1.3 Bird Island Marsh

This BU area would be located in Trinity Bay along the Mid Bay Reach of the HSC as shown in Engineering Plate No. 31. The preliminary design includes three 2-acre bird islands positioned in a triangle. The islands are connected by an armored dike approximately 5,224-ft in length. The BUG members requested the dikes be bowed outward to create a round dike alignment versus a straight line between islands. An oyster reef/wave trip will be created outside the bird islands not protected by the dike structure to provide wading habitat for nesting and foraging birds.

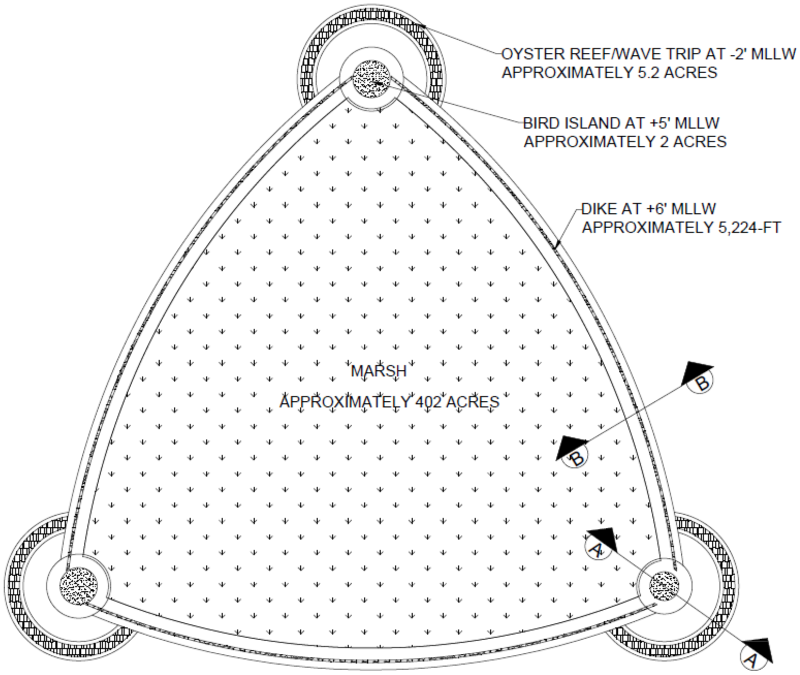


Figure 4-20: Bird Island Marsh Plan View

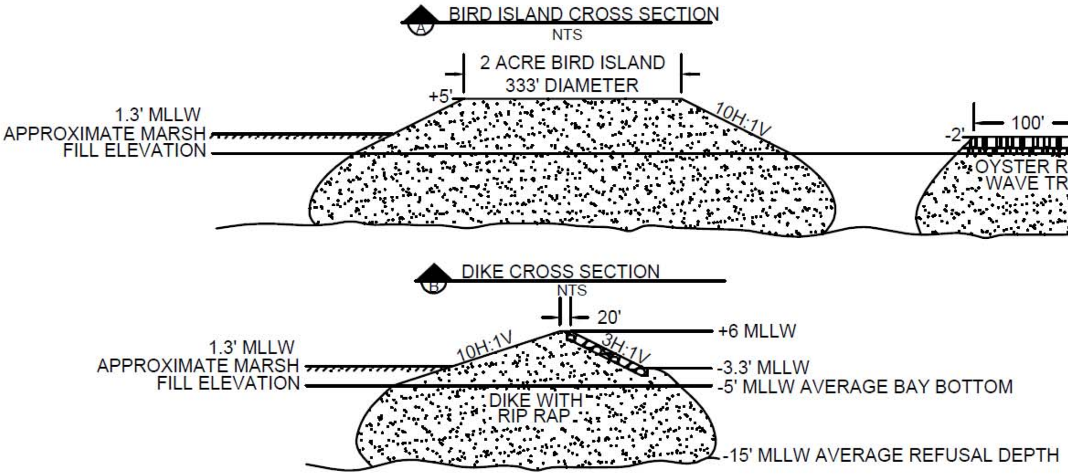


Figure 4-19: Bird Island Marsh Cross Section

Estimated neatline quantity of material for construction is 2.7 MCY CY. With a retainage rate of 60% the total new work material required is 4.5 MCY. The retainage rate considers foundation displacement to -15 feet MLLW. This BU area will create a 402-acre marsh with a neatline capacity of fill to +1.3 feet MLLW of 7.3 MCY, which is 11.2 MCY after 65% consolidation.

Future fill capacity due to RSLC is 2.5 MCY. Should more material become available, the bird island sizes will be increased to improve the upland habitat being provided to avian populations, up to 6 acres, and the marsh dikes lengths or widths could be increased. Should size reduction need to occur, the size of the inner marsh will be decreased, and bird island sizes will remain constant. Site detailed in Engineering Plate No. 32.

4.7.1.4 M11 & M12

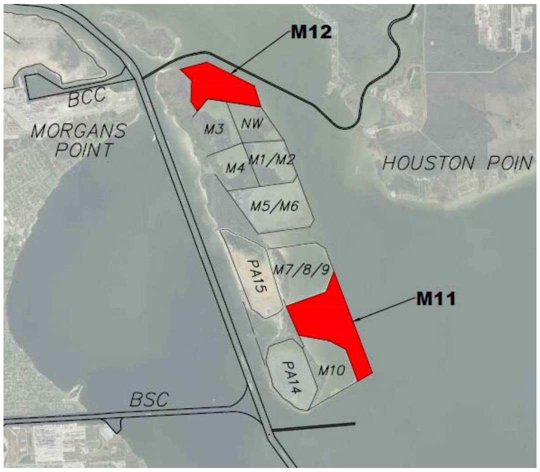


Figure 4-21: BU sites M11 & M12

Two new marsh cells were evaluated that would expand upon the existing BU sites at Atkinson Island as shown in Figure 4-21. M11 would be created with an approximate 1.8-mile dike between M7/8/9 and M10 and will be unarmored. A typical perimeter dike cross section is shown in Figure 4-22.Estimated neatline quantity of material for construction is 1.7 MCY. With a retainage rate of 60% the total new work material required is 2.8 MCY. The BU area will create approximately 445-acres of marsh with a neatline capacity of fill to +1.3 feet MLLW of 4.5 MCY, which is 6.9 MCY after 65% consolidation. Future fill capacity due to RSLC is 2.6 MCY (1.7 MCY neatline). The retainage rate considers foundation displacement to -15 feet MLLW. Access to existing wells will need to be coordinated during PED an may include construction of access pad, and permit renewals should be denied.

M12 is located on the north end of Atkinson Island and would require an approximate 1.5-mile dike. Estimated neatline quantity of material for construction is 1.4 MCY. With a retainage rate of 60% the total new work material required is 2.3 MCY. The BU area will create approximately 273-acres of marsh with a neatline capacity of fill to +1.3 feet MLLW of 2.8 MCY, which is 4.3 MCY after 65% consolidation. Future fill capacity due to RSLC is 1.7 MCY (1.1 MCY neatline). The retainage rate considers foundation displacement to -15 feet MLLW. An access corridor via an earthen pad or other will need to be considered in coordination with energy interests for well servicing in the future during PED.

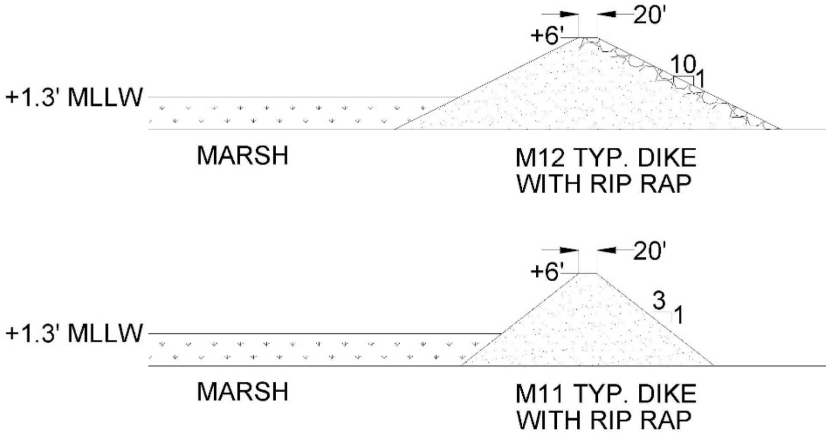


Figure 4-22: Typical perimeter dike cross section for M11 & M12

4.7.1.5 Bay Aquatic Beneficial Use Site

Bay aquatic BU sites (BABUS) located in Galveston Bay are proposed to provide storage for maintenance material volumes that exceed existing confined PA capacities. BABUS are confined aquatic disposal (CAD) cell excavated below existing bay bottom with an emergent dike constructed around the CAD cell using the excavated soils placed hydraulically to create BU or habitat areas. The estimated interior excavation elevation would be -70 feet MLLW and the dike crest elevation would be +6 feet MLLW for the purposes of this study. Actual elevations will be determined during design. The BABUS concept includes establishing submerged, intertidal, and emergent habitat on the dikes, with the interior area of each site raised to create intertidal marsh habitat once filled to capacity. The interior excavation will be performed using hydraulic cutter head dredge with the excavated material used to build the exterior dikes and the resulting habitat. The dikes will have 7H:1V inside side slopes. The exterior side slopes will be compound with 7H:1V from the dike crest down to elevation +3 feet, then 30H:1V side slopes below elevation +3 feet down to bay bottom to provide more habitat area and protection against erosion from the bay wave and current environment.

The BABUS would be constructed in Galveston Bay, south of Atkinson Island, north of Midbay PA, and east of the HSC as shown in Figure 4-23, with the intent to avoid oyster impacts and impacts to existing pipelines. Design and placement of the BABUS sites will take into consideration minimization of bay bottom area impacts by overlapping the outside toes of adjacent sites.

The BABUS sites would be utilized to provide storage for OM dredged material once the existing confined PAs have reached capacity. They would also be able to accept new work from expansion of either Federal channels or non-Federal facilities. The OM dredged material would be placed in the BABUS using bottom-dump scows and/or hopper dredges that would access the interior of the sites using the existing Five Mile Cut (widened and deepened as required) and then through access channels excavated into the Bay bottom and extending through gaps in the exterior dikes. Once the BABUS fill elevation prevents floatation inside each site, the exterior dike would be closed, and the interior would be filled to final marsh elevation using OM material dredged and hydraulically pumped into the sites. Estimated OM dredged material capacities

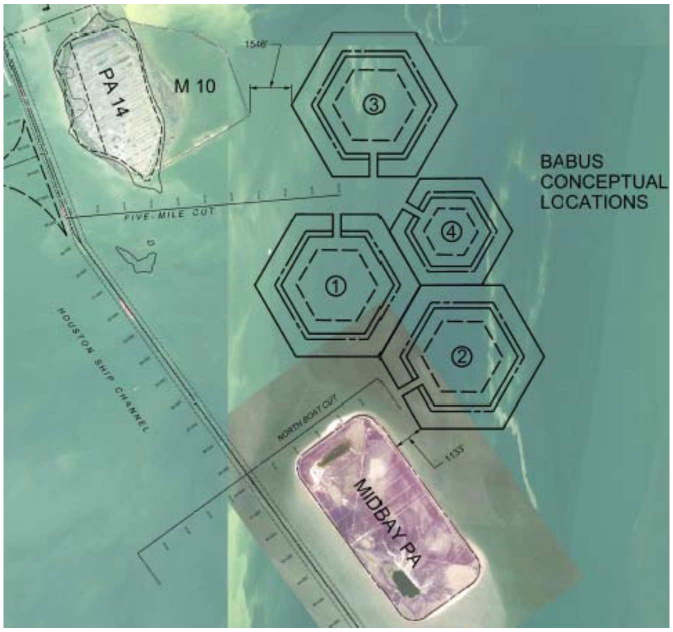
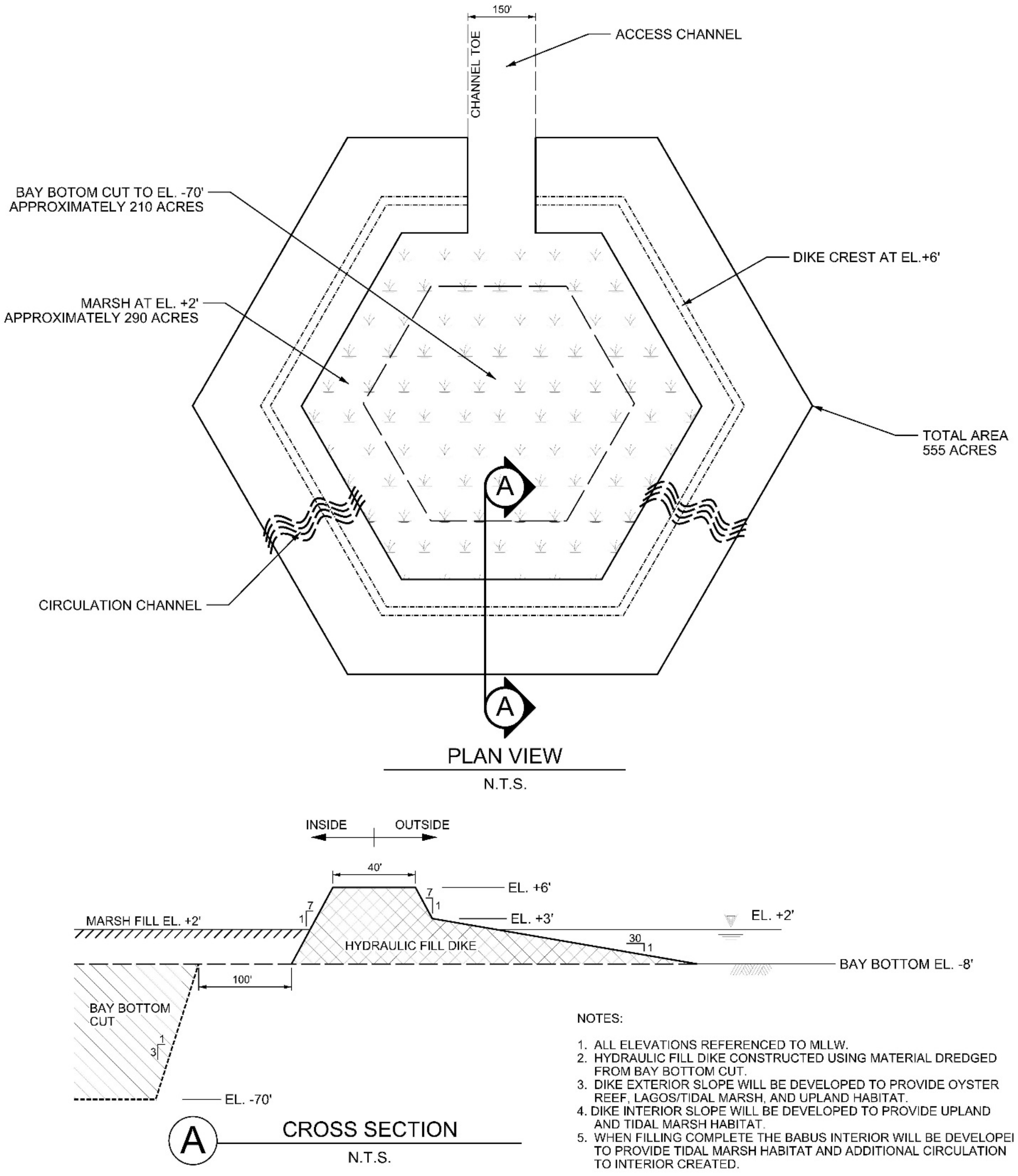


Figure 4-23: Conceptual layout of BABUS cells

for the BABUS sites are 29 MCY and 15 MCY for the 325-acre and 200-acre sites, respectively. For the FWOP DMMP, an estimated four (three 325-acre and one 200-acre) BABUS sites would be required to provide capacity for O&M (Federal and non-Federal) material dredged over the 50-year analysis period.

The BUG has requested that a longer flatter slope of approximately 50:1 be considered to provide for a greater footprint of fringe marsh and higher uplift associated with the project design and allow for a long-term approach to RSLS. Additionally, consideration of additional circulation through channeling of the BABUS dikes should be evaluated in the initial and final designs during PED. The conceptual design is provided in Figure 4-24.

Exact locations of the dikes will be adjusted during PED to avoid placing dikes on the oyster-mining holes dug in the mid 1900s, which are now filled with anoxic semi-fluid unconsolidated sediments.



NOTES:

1. ALL ELEVATIONS REFERENCED TO MLLW.
2. HYDRAULIC FILL DIKE CONSTRUCTED USING MATERIAL DREDGED FROM BAY BOTTOM CUT.
3. DIKE EXTERIOR SLOPE WILL BE DEVELOPED TO PROVIDE OYSTER REEF, LAGOS/TIDAL MARSH, AND UPLAND HABITAT.
4. DIKE INTERIOR SLOPE WILL BE DEVELOPED TO PROVIDE UPLAND AND TIDAL MARSH HABITAT.
5. WHEN FILLING COMPLETE THE BABUS INTERIOR WILL BE DEVELOPEI TO PROVIDE TIDAL MARSH HABITAT AND ADDITIONAL CIRCULATION TO INTERIOR CREATED.

Figure 4-24: Bay Aquatic Beneficial Use Site

4.7.2 Upland Confined Placement Areas

A UCPA, also known as confined disposal facilities (CDF), is an engineered structure for the containment of dredged material. UCPAs are bound by confinement dikes or structures to enclose the PA, thereby isolating the dredged material from its surrounding environment. The material is placed into the UCPA either hydraulically or mechanically. Hydraulically placed dredged material contains a large amount of additional water when it is introduced into the facility, causing it to occupy several times its original volume. To maximize the UCPA capacity, management measures for dewatering the sites must be followed, including ditching, drying, and draining of materials to allow for consolidation and increased capacity. Following these measures allows the dredged material to consolidate to 65-70 percent of its gross volume.

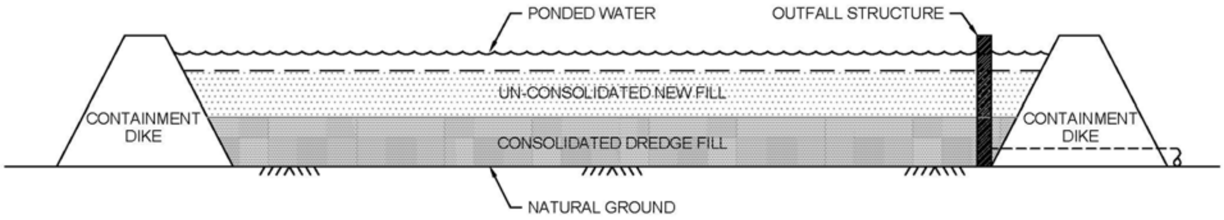


Figure 4-25: Typical Section of Hydraulic Fill at an Existing UCPA

The design of UCPAs shall follow EM 1110-2-5025, *Dredging and Dredged Material Management* (USACE, 2015). Steps to design the UCPAs in more detail during PED will generally include the following steps.

- Hydrographic and topographic surveys of the project areas to develop bay bottom and upland elevation contour data. These surfaces were used during the design of the dredging templates and the dike templates. Hydrographic data is used to estimate material quantities to be dredged.
- Analyze existing geotechnical data, including boring logs and material test results, and evaluate the need for additional investigations
- Geotechnical field investigations including borings and probings at candidate sites to determine the subsurface conditions of the existing foundations. Material testing of samples to include strength tests, sieve analysis, settling tests, Atterberg Limits and consolidation tests. Analysis of material testing results will identify material characteristics needed for the design of the proposed dikes.
- Classification of dredge material and quantity calculations of each material type available within the proposed dredge areas
- Perform slope stability analysis for dike template design

- Calculate material quantities required to construct containment dikes
- Determine corresponding required dredging quantities based upon expected cut/fill ratios
- Wind, tide, and current data and model outputs for the area should be collected and analyzed to evaluate design wave conditions for the design of the shore protection elements, and to consider future sea level change into the design process. Since future sea levels are unknown, dikes will be monitored and added to in a long-term "adaptive" approach.
- Identify project constraints and existing features that must be protected, e.g., gas and oil wells, pipelines, and other utilities.
- Slope stability analysis on existing UCPAs was conducted during the HSCPA and are included in Attachment 7 in this Appendix.

4.7.2.1 Mid Bay Upland Confined Placement Areas

Three UCPAs were evaluated in the Mid Bay reach of the HSC as shown in Figure 4-26, two expansions on the existing Mid Bay PA, and a stand-alone site called Upland Concept No. 1. Preliminary design of each site includes an initial dike construction to +20 feet MLLW with a 20-foot crown width and 3H:1V slopes to average depth of refusal at -15 feet MLLW, and an interior site fill to +18 feet MLLW. To estimate future capacity the dikes will be raised to +40 feet MLLW with material from within the site. Final site fill elevation will be +38 feet MLLW. Material quantities for the construction and continued O&M use of the sites is provided in Table 4-7. The retainage rate considers foundation displacement to -15 feet MLLW.

Figure 4-26: Mid Bay UCPAs

Table 4-7: Mid Bay UCPA Volumes

Mid Bay Expansion	Mid Bay Expansion North (292 Acres)	Mid Bay Expansion South (292 Acres)	Upland Concept #1 (334 Acres)
Construction +20' Dikes (Neatline)	1,700,000	1,700,000	2,700,000
NW Material From Cut	2,800,000	2,800,000	4,500,000
Site Fill To +18' MLLW (Neat Line)	10,400,000	10,400,000	19,000,000
Maint Required From Cut To +18' MLLW	16,000,000	16,000,000	29,200,000
Construction +40' Dikes (Neatline)	1,000,000	1,000,000	1,900,000
Borrow Material From Site	1,500,000	1,500,000	2,900,000
Site Fill To +38' MLLW (Neat Line)	10,600,000	10,600,000	19,500,000
Maint Required From Cut To +38' MLLW	16,300,000	16,300,000	30,000,000
Total NW	2,800,000	2,800,000	4,500,000
Total Maint	32,300,000	32,300,000	59,200,000

Note:
1. New Work Dike Construction Volumes Calculated To The Average Depth Of Refusal -15 feet MLLW.
2. Maintenance Fill Volumes Calculated To The Average Bay Bottom Of -5 feet MLLW.

4.7.2.2 Bayou Upland Confined Placement Areas

UCPAs were evaluated in the Upper Bayou reach of the HSC for the placement of new work and maintenance materials from Segments 4, 5 & 6 as shown in Figure 4-27. The Beltway 8 (BW-8) and E2 Clinton (E2C) tracts would be two new sites for one-time placement of new work materials from the Federal Channel. After material placement and grading at BW-8, the PHA plans to develop the site. The BW-8 is a former munitions storage facility that includes approximately 50 bunkers and is heavily wooded. The PHA is cleaning and grubbing the site and demolishing the bunkers. The site has been surveyed for unexploded ordnance clearance and has been environmentally cleared by TCEQ. See Section 7.5 for HTRW desicriptions. No future plans for E2C are considered at this time. The Rosa Allen Expansion (RAE) would expand upon the existing Rosa Allen PA to create a new cell for O&M maintenance materials in the future.

The Lynchburg tract was not considered for new work placement due to the site's distance of approximately 14 miles from the nearest new work dredging location. Segment 4, hydraulic dredging of the stiff clay new work materials in this area would be cost prohibitive if even possible. The site was additionally removed from screening consideration for maintenance material dredging. Additional increased costs would include expensive initial site construction, laying and maintenance of several miles of pipeline per dredging event, installation and upkeep of permanent culverts, and construction of over two miles of drainage ditching and culverts from the PA outfall. More importantly however, the FWOP condition includes the construction of BABUS PAs. With additional capacity already being provided by these BABUS sites, the development of the Lynchburg site for O&M was not considered further.”

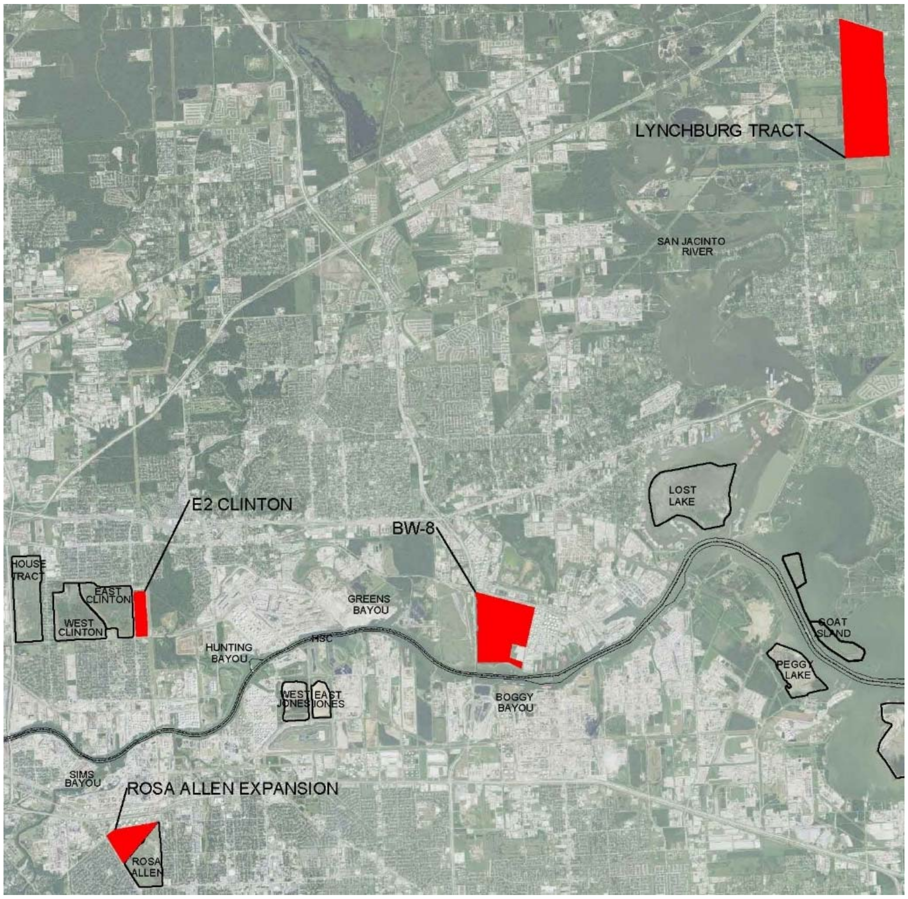


Figure 4-27: New Bayou Upland Confined Placement Areas

A typical dike section was developed to contain the anticipated fill. At BW-8 and E2C, the dike section was designed to contain the proposed new work materials. At RSE, the dike was designed to create an initial dike capable of containing maintenance materials and that future raising events would increase its height. In both cases, the dike initial construction consists of borrowing of interior materials to construct a dike to target elevation. The section would have a 20-foot crown and 3H:1V side slopes on both sides.

The dikes would be constructed mechanically and volumes account for 40% material losses during construction. Table 4-8 provides the measures and quantities relative to each location.

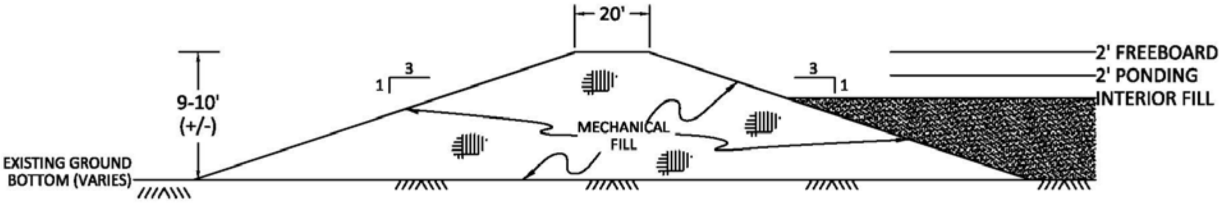


Figure 4-28: Typical Bayou UCPA Initial Dike Section

Following placement of new work materials on BW-8 and E2C, no further work would be done at these sites. Following the initial dike raising at RSE, the area could begin receiving maintenance materials. Dikes would be raised through normal construction general means during future years operations and maintenance. An ultimate dike elevation of 55 feet was assumed feasible for RSE, matching the USACE stability analyses for the adjacent Rosa Allen PA as part of the HSC Preliminary Assessment. Adjacent ground elevation was approximated at +26 feet.

Table 4-8: Bayou Confined UCPA Quantities

Placement Area	Acreage (AC)	Perimeter (FT)	Dike Ht. (FT)	Dike Qty. (CY)	Site Cap. (CY)	Ult. Cap. (CY)
BW-8	355	16,800	9.1	446,000	2,920,000*	NA
E2C	70	8,900	9.3	244,000	562,000*	NA
RAE	138	11,300	10.0**	349,000**	1,113,200**	10,760,000

Notes:
*BW-8 and E2C represent quantities and capacities to contain new work fill only.
**RAE quantities representing initial dike raising quantity to make site ready to receive maintenance materials, and initial maintenance material capacity. Future dike raising events provide increased capacity to achieve estimated ultimate capacity.

5 QUANTITY COMPUTATIONS

5.1 New Work Quantities

Volumes were calculated using USACE single beam survey data and supplemented with hydrographic surveys from the JV and NOAA where available. Survey data acquisition methods and dates of collection varied and can only be considered as indicating the general condition existing at that time. Refer to Table 5-1 for a summary of survey sources and dates used to calculate volumes. All survey data that was previously collected in MLT was converted to MLLW.

Table 5-1: Survey Data used to Calculate Material Quantity

Channel Section	Survey	Source	Date	Datum
Lower Bay	Single beam	USACE	3/2/2016 & 3/28-30/2016	MLLW
	Single beam	NOAA	1995-2013	MLLW
Mid Bay	Single beam	USACE	5/3/2016	MLLW
	Single beam	NOAA	1996	MLLW
	Single beam	USACE	06/01/2018	MLLW
Upper Bay	Single beam	USACE	5/6/2016	MLLW
	Single beam	NOAA	1995-1996	MLLW
Bayport Ship Channel	Multibeam	JV	10/18-20/2016 & 7/18/2016	MLT
	Single beam	JV	7/20/2016	MLT
	Single beam	USACE	04/30/2018	MLLW
Barbours Cut Channel	Single beam	USACE	4/1/2016 & 5/5/2016	MLLW
	Single beam	JV	06/12/2014 & 09/17/2015	MLT
	Multibeam	JV	09/14-15/2015	MLT
Bayou	Single beam	USACE	04/15/2016 & 05/2-11/2016	MLLW
	Single beam	JV	07/27/2018 (Sta. 676+53 – 825+00)	MLLW

Where no survey data was available, outward most points in the dataset were extended out to cover the limits of the dredging prisms. It should be noted that the provided volumes should be considered preliminary and approximate as true bottom conditions may differ from that used. The USACE typically only performs hydrographic surveys between the channel toes and does not cover the extents of the channel slopes. During PED the extents of the proposed channel toes along with a 500-foot buffer shall be surveyed to refine the quantities estimated and monitored post construction to capture channel sloughing for shoaling analysis. No topographical data was available in locations where dredging prisms extended above existing natural ground as shown from aerial photography. Additional survey data is required to determine full material volumes to be removed in these locations.

Volumes were calculated using Trimble Terramodel 10.61 by comparing survey data to the proposed measure templates. Mooring facilities, turning basins, and new spur channels were calculated by modeling the proposed measure and calculating DTM volumes through surface-to-modeled-surface comparisons. Proposed measures for modifications to existing channels were calculated by creating road jobs with design templates and computing average-end-area volumes for affected reaches.

Existing maintenance materials (materials existing within current authorized channel limits as shown in Figure 5-1) were excluded because only the new work material totals could be considered specific to the measures being evaluated. Maintenance materials would fall under current Federal O&M responsibilities and therefore not be applicable to alternatives screening.

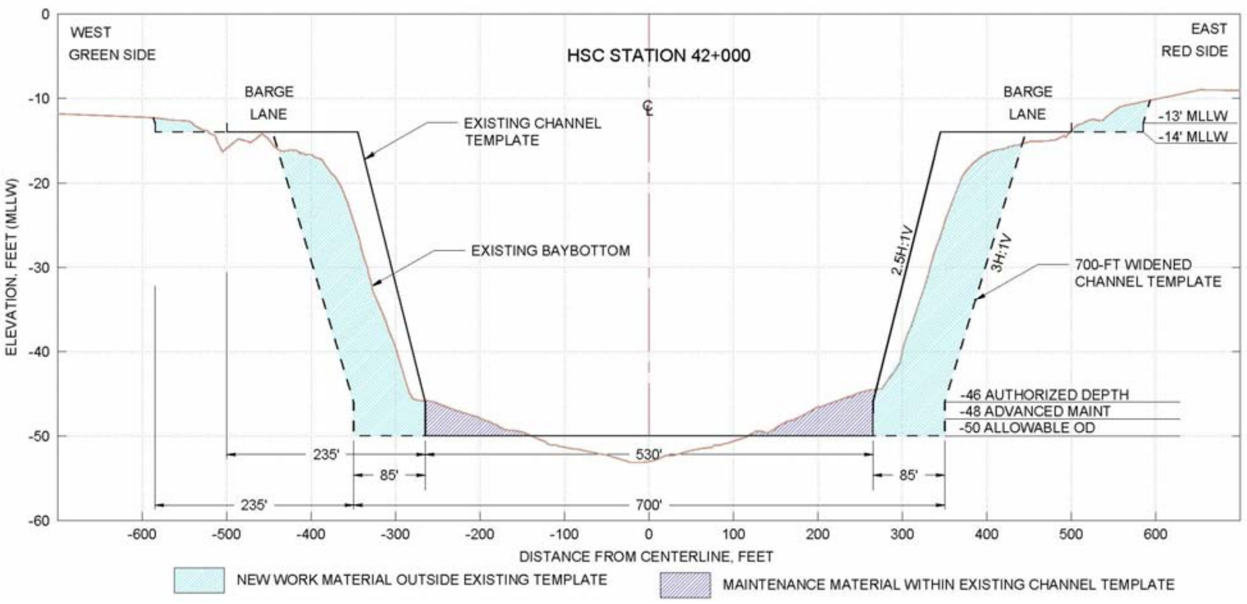


Figure 5-1: 700-FT Channel Widening Typical Template

Final design templates will be evaluated in PED based on geotechnical properties in accordance with Section 3.3.

5.1.1 Segment 1: Bay Reach

The HSC from Bolivar Roads to Morgans Point (BCC) is 530 feet wide. The remainder of Segment 1 from Morgans Point up through Carpenters Bayou varies from 530 to 600 feet wide and additionally along channel curves. The currently authorized depths for this segment of the HSC are provided in Table 5-2. The existing channel template was created with 2.5H:1V slope beginning at the authorized depth with a box cut down to allowable overdepth (AO). The Bay Reach is maintained with two feet of advanced maintenance (AM) and two feet of AO. All new work templates have 3H:1V slopes. Widening volumes in the HSC Bay sections from Bolivar Roads to BCC include the offset of the barge lanes 500 feet from the channel centerline as shown in Figure 5-1. All new work quantities calculated for the Segment 1 measures are provided in Table 5-3. Quantities for widening measures are incremental to (i.e. non-inclusive of) the bend measures provided for the existing channel width and are rounded to the nearest thousandth.

Table 5-2: Currently Authorized Depths for Segment 1

Channel Section	Start Station	End Station	Authorized Depth (MLLW)	Advanced Maintenance (MLLW)	Allowable Overdepth (MLLW)
Bolivar Roads to Redfish	138+369.011	78+844.001	46	48	50
Redfish to BSC	78+844.001	28+605.055	46	48	50
BSC to BCC	28+605.055	-0+003.944	46.5	48.5	50.5
BCC to Exxon	0+05	295+00	46.5	50.5	51.5
	280+05	295+00	46.5	48.5	49.5
Exxon to Carpenters Bayou	295+00	520+00	46.5	48.5	49.5
Carpenters Bayou to Boggy Bayou	520+00	684+03.19	46.5	48.5	49.5

Table 5-3: New Work Quantities for Segment 1

Measure	Description	New Work Quantity (CY)
Bolivar Roads to Redfish Station 138+369.011 - 78+844.001		
CW1_700_BR-RF (NED)	700-foot channel widening from Bolivar Roads to Redfish with 328-foot bend easings and transition to 530-foot existing channel at Sta. 74+119.99	5,031,000 (1,109,000 CY is in Mid Bay Segment from Sta 78+844 to 74+119)
Redfish To BSC Station 78+844.001 - 28+605.055		
CW1_700_RF-BSC (LPP)	700-foot channel widening from Redfish to BSC with 328-foot bend easings	7,685,000
BSC To BCC 28+605.055 - -0+003.944		
BE1_028+605_530 (NED)	328-foot bend on existing 530-foot channel at Sta. 28+605	425,000
CW1_700_BSC-BCC (LPP)	700-foot channel widening from BSC to BCC with 328-foot bend easings	5,341,000

5.1.2 Segment 2: Bayport Ship Channel

The current BSC is 46.5 feet deep and approximately 400 feet wide from the start of the BSC Flare at approximate Station 221+00 to the land cut at 112+00. The remaining channel is 350 feet wide from Station 112+00 to 25+58 and includes a 1,600-foot turning basin at its terminus. The maintenance template was created with 2.5H:1V slope beginning at -46.5 feet MLLW with a box cut down to AO of -50.5 feet MLLW. All new work templates have 3H:1V slopes. Volumes for the BSC Flare includes 7 feet of AM. The 2018 USACE single beam survey was added to the survey surface to more accurately determine NW dredging quantities after the recent dredging of the 4,000-foot BSC Flare. New work quantities calculated for the various BSC measures are provided in Table 5-4.

Table 5-4: New Work Quantities for Segment 2

Measure	Description	New Work Quantity (CY)
CW2_BSC_455 (NED)	Widen BSC to 455-FT	2,108,000
BE2_BSCFlare (NED not LPP)	Widen south BSC Flare to 5,375-FT radius (Includes 7 feet of AM)	1,925,000

5.1.3 Segment 3: Barbours Cut Channel

The entrance of the BCC is at Morgan's Point and approximate HSC Station 6+00 where the two channel centerlines meet, just north of the entrance to the Cedar Bayou Navigation Channel. The BCC is approximately 1.4 miles in length and approximately 300 feet wide, at a depth of -46.5 feet MLLW and includes a turning basin at its westernmost end. The turning basin is approximately 2,000 x 1,900 feet in dimension. The flare ranges from 300-feet-wide to 1,280-feet-wide at its intersection with the HSC. The BCC is bordered by Spilmans Island to the north, the Barbours Cut Container Terminal (BCCT), and Morgan's Point to the south.

The existing BCC template reflects the recent channel improvements that were completed in 2016 and discussed in Section 1.1.3. This includes a channel depth of -46.5 feet MLLW plus 2 feet of AM and 2 feet of AO. A portion of the north side of the channel from Station 20+13 to 65+43 was widened by 75 feet to maintain the 300-foot channel width. The authorized channel template was created with 2.5H:1V slope beginning at the authorized depth with a box cut down to AO. All new work templates have 3H:1V slopes. The BCC Flare is extended to the north and south to include an 1,800 foot diameter turning basin. Volumes for the BCC Flare includes 7 feet of AM . New work quantities calculated for the various BCC measures are provided in Table 5-5.

Table 5-5: New Work Quantities for Segment 3

Measure	Description	New Work Quantity (CY)
CW3_BCC_455 (NED)	Widen BCC to 455-FT	1,202,000
BETB3_BCCFlare_1800NS (NED)	Widen BCC N/S flare 1,800-FT diameter TB (Includes 7 feet AM)	1,623,000

5.1.4 Segment 4: Boggy Bayou to Sims Bayou

Most of Segment 4 is 300 feet wide except where turning basins are located and a few small stretches of channel that are reduced to 200 and 280 feet. The current authorized depths for this segment of the HSC are provided in Table 5-6. The existing channel template was created with 2.5H:1V slope beginning at the authorized depth with a box cut down to AO. All new work templates have 3H:1V slopes. New work volumes for Segment 4 measures are provided in Table 5-7. The channel is widened along centerline shifts up to 530 feet from Boggy Bayou to Greens Bayou and deepened from -41.5 feet MLLW to -46.5 fee MLLW from Boggy Bayou to Hunting Bayou.,

Table 5-6: Currently Authorized Depths for Segment 4

Channel Section	Start Station	End Station	Authorized Depth (MLLW)	Advanced Maintenance (MLLW)	Allowable Overdepth (MLLW)
Boggy Bayou to Greens Bayou	684+03.19	833+05.17	41.5	43.5	44.5
Greens Bayou to Sims Bayou[1]	833+05.17	1110+77.54	41.5	43.5	44.5
Note: [1]Washburn Tunnel from Station 977+92.5 to 974+07.5 is authorized to 41.5 feet, but is dredged to 38.5 feet, +2 feet AM, +1 foot AO.					

Table 5-7: New Work Quantities for Segment 4

Measure	Description	New Work Quantity (CY)
CW4_BB-GB_530 (NED)	Widen (530-FT)/Deepen (5-FT) Boggy Bayou to Greens Bayou	2,412,000[1]
CD4_Whole (NED)	Deepen (5-FT) Boggy Bayou to Hunting Turning Basin	860,000
Note: [1]Quantity excludes approximately 418,000 CY included with CD4_Whole		

5.1.5 Segment 5: Sims Bayou to I-610 Bridge

This segment of the channel is 300 feet wide and has an authorized depth of -37.5 feet MLLW with 2 feet of AM and 1 foot of AO. The existing channel template was created with 2.5H:1V slope beginning at the authorized depth with a box cut down to -40.5 feet MLLW. The new work template has 3H:1V slopes. The new work volume for the deepening of Segment 5 from -37.5 feet MLLW to -41.5 feet MLLW is provided in Table 5-8.

Table 5-8: New Work Quantities for Segment 5

Measure	Description	New Work Quantity (CY)
CD5_Whole (NED)	Deepen (4-FT) HSC Sims Bayou to I-610 Bridge	176,000

5.1.6 Segment 6: I-610 Bridge to Turning Basin

This segment of the channel has an authorized depth of -37.5 feet MLLW with 2 feet of AM and 1 foot of AO. Apart from the Brady Island Turning Basin, the channel width is 300 feet from the I-610 Bridge to the start of the Main Turning Basin at Station 1266+48.72, where it is reduced to 250 feet. The existing channel template was created with 2.5H:1V slope beginning at the authorized depth with a box cut down to -40.5 feet MLLW. All new work templates have 3H:1V slopes. New work volumes for the deepening of Segment 6 from -37.5 feet MLLW to -41.5 feet MLLW is provided in Table 5-9.

Table 5-9: New Work Quantities for Segment 6

Measure	Description	New Work Quantity (CY)
CD6_Whole (NED)	Deepen (4-FT) HSC I-610 Bridge thru Turning Basin	706,000
TB6_Brady_900 (NED)	Turning Basin at Brady Island Station 1195+00	294,000

5.2 Shoaling Rates

5.2.1 Existing Shoaling Rates

Existing shoaling rates for the HSC were compiled from various sources and are outlined in Table 5-10, and do not include non-federal shoaling.

The Draft HSC Sedimentation Study (JV, 2012) estimated the shoaling rate of the 46.5-foot channels using survey data dating back to 1999 and included non-pay volumes. During the BSC and BCC widening and deepening projects an evaluation to estimate the increased shoaling rate from the planned channel modifications was conducted (JV, 2013). The Draft HSC Integrated Dredged Material Management Plan and Environmental Assessment (DMMP/EA) (USACE, 2019) provides estimated shoaling rates for the entire HSC system. Several of the shoaling rates for the 46.5-foot channels estimated in the JV studies have been utilized in this DMMP. The shoaling rates for the 41.5-foot and 37.5-foot channels were derived from the USACE Dredging Histories Database and do not include non-pay volumes. The USACE has adjusted the BSC and BCC shoaling rates using recent survey and dredging data. Due to variable high shoaling rates in the BSC Flare that may be due to recent flooding, the contingency placed on dredging the BSC

Flare was raised from 21% to 30%. The BCC shoaling rate from the 2013 JV study will continue to be used in this evaluation to remain conservative as the rate in the DMMP is slightly less.

Table 5-10: Existing Federal Shoaling Rates

<table>
<tr><th>Channel Segment</th><th>Channel Section</th><th colspan="2">Existing Total Federal Shoaling Rates (CY/Year)</th><th>Average Dredging Cycle (Years)</th></tr>
<tr><td rowspan="6">1</td><td>Bolivar Roads to Redfish</td><td colspan="2">99,194[1]</td><td>4</td></tr>
<tr><td>Redfish to BSC</td><td colspan="2">1,468,925[1]</td><td>3</td></tr>
<tr><td>BSC to BCC</td><td colspan="2">771,433[1]</td><td>3</td></tr>
<tr><td>BCC to Exxon</td><td colspan="2">1,240,802[1]</td><td>3</td></tr>
<tr><td>Exxon to Carpenters Bayou</td><td colspan="2">454,759[2,4]</td><td>3</td></tr>
<tr><td>Carpenters Bayou to Boggy Bayou</td><td colspan="2">194,478[2,4]</td><td>4</td></tr>
<tr><td rowspan="2">2</td><td>BSC Flare</td><td colspan="2">788,415[2]</td><td>1</td></tr>
<tr><td>BSC Channel & TB</td><td colspan="2">498,500[2]</td><td>4</td></tr>
<tr><td rowspan="2">3</td><td>BCC Flare</td><td colspan="2">168,992[3]</td><td>3</td></tr>
<tr><td>BCC Channel & Flare</td><td colspan="2">113,152[3]</td><td>3</td></tr>
<tr><td rowspan="2">4</td><td>Boggy Bayou to Greens Bayou</td><td>113,709[2, 4]</td><td rowspan="2">329,371</td><td rowspan="2">4-5</td></tr>
<tr><td>Greens Bayou to Sims Bayou</td><td>215,662[2, 4]</td></tr>
<tr><td>5</td><td>Sims Bayou to I-610 Bridge</td><td colspan="2">38,751[2, 4, 5]</td><td>3</td></tr>
<tr><td>6</td><td>I-610 Bridge to End Main Turning Basin</td><td colspan="2">180,416[2, 4, 5]</td><td>3</td></tr>
<tr><td colspan="5">Notes:
[1]Existing shoaling rate from Draft HSC Sedimentation Study (JV, 2012), does not include non-Federal facilities.
[2]Existing shoaling rate from the Draft HSC Integrated Dredged Material Management Plan and Environmental Assessment (USACE, 2019)
[3]Estimated Shoaling rate post BSC and BCC Channel Improvement Projects (JV, 2013)
[4]Existing shoaling rates removed annual non-federal shoaling rate (gross volume) of the docks.
[5]The DMMP provides shoaling quantities for Sims Bayou to the Main Turning Basin, which are separated into two segments for the HSC-ECIP study. The shoaling rate was portioned between segments based on the area between channel toes.</td></tr>
</table>

5.2.2 Estimated Shoaling Rates

The existing shoaling rate and area of the nearest section of channel was used to determine the approximate shoaling rate for the various channel measures. The assumption was made that the existing shoaling rate will increase by the same rate as the increased project footprint. This method was used for all measures where there would be an alteration in the channel footprint from channel widening, bend easings, mooring facilities, and turning basins. Using this method, the assumption is made that shoaling occurs uniformly over the entire section of the existing channel and will continue to shoal at the same rate in the newly dredged area. Estimated shoaling for project measures is provided below in Table 5-11.

Table 5-11: Estimated Shoaling Rates

SEG.	Measure	(A)	(B)	(C)	(D) = (C/B)	(E) = (D x A)	(F) = (E - A)
		Existing Shoaling Rate (CY/Yr)	Area of Existing Channel (Sq Ft)	Increased Area with Measure (Sq Ft)	% Increase in Area	New Shoaling Rate (CY/Yr)	Incremental Shoaling (CY/Yr)
1	CW1_BR-Redfish_700	99,000	30,885,000	46,938,000	152%	151,000	52,000
	CW1_BR-Redfish_700[1]	99,000	30,885,000	42,223,000	137%	136,000	36,000
	CW1_Redfish-BSC_700	1,469,000	27,030,000	37,200,000	138%	2,022,000	553,000
	CW1_BSC-BCC_700	771,000	15,372,000	20,415,000	133%	1,025,000	253,0,00
	BE1_028+605_530[2]	771,000	15,372,000	15,887,000	103%	797,000	26,000
		1,469,000	27,030,000	28,295,000	104%	1,538,000	69,000
2	CW2_BSC_455	449,000	7,945,000	9,292,000	117%	583,000	84,000 (Channel)
		788,000	4,128,000	4,355,000	106%	832,000	44,000 (Flare)
	BE2_BSCFlare	788,000	4,128,000	5,737,000	139%	1,096,000	308,000
3	CW3_BCC_455	113,000	4,555,000	5,070,000	111%	126,000	13,000 (Channel)
		169,000	1,204,000	1,269,000	105%	178,000	9,000 (Flare)
	BETB3_BCCFlare_1800	169,000	1,204,000	2,556,000	212%	359,000	190,000
4	CW4_BB-GB_530	Refer to Table 5-12					
	CD4_Whole						
5	CD5_Whole	Refer to Table 5-12					
6	CD6_Whole	Refer to Table 5-12					
	TB6_Brady_900						

Notes:

[1] With the LPP the entire HSC Bay will be widened to 700-ft and will not require the transition back to the 530-ft channel.

[2] Measure BE1_028+605_530 falls between two bay sections of the HSC, Redfish-BSC and BSC-BCC.

The shoaling rate for channel deepening measures in Segments 4, 5, and 6 could not be determined from the percent increase in project area, as the footprint does not change. For these measures the "Volume of Cut" method was used to estimate the change in shoaling rate. The methodology used was that described in "Basics of Channel Deposition/Siltation" (van Rijn, 2013). Results are provided below in Table 5-12. More detailed analysis of the existing and projected shoaling rates will be conducted during PED and will incorporate the findings of the sediment transport modeling.

Table 5-12: Estimated Shoaling Rates using Volume of Cut Method

Segment	4		5	6	
Measure	CW4_BB-GB_530[1]	CD4_Whole	CD5_Whole	CD6_Whole (Includes TB6_Brady_900)	
Parts	BB-GB	GB-Hunting	SB-610	610-TB	TB
Station to Station	684+03.19	833+05.17	1110+77.54	1160+62.20	00+00.00
	833+05.17	974+07.50	1160+62.20	1266+48.00	30+95.00
Distance (FT)	14,902	14,102	4,985	10,586	3,095
$W_{existing}$ (FT)	300	300	300	300	300
$W_{proposed}$ (FT)	530	300	300	300	300
$D_{existing}$ (FT)	41.5	41.5	37.5	37.5	37.5
$D_{proposed}$ (FT)	46.5	46.5	41.5	41.5	41.5
$V_{old, cut}$ (CY)	6,871,000	6,503,000	2,077,000	4,782,000	2,073,000
$V_{new, cut}$ (CY)	12,586,000	7,286,000	2,298,000	5,748,000	2,294,000
I_{cut}	0.83	0.06	0.11	0.20	0.11
$V_{old, md}$ (CY/YR)	113,709	215,662	38,751	75,327	105,089
$V_{new, md}$ (CY/YR)	208,000	229,000	43,000	91,000	116,000
$R_{inc.}$ (CY/YR)	94,291	13,338	4,249	15,673	10,911

Note:

[1] The shoaling rate for the channel deepening measure CD4_Whole between Boggy Bayou and Greens Bayou is included in the channel widening and deepening measure CW4_BB-GB_530.

5.2.3 Shoaling Estimate from the Numerical Model

The sediment analysis is based on the historic dredge records from the USACE annual reports as done in the model validation (McAlpin et al. 2019a) as shown Houston Ship Chanel and Vicinity Three-Dimensional Adaptive Hydraulics (AdH) Numerical Model Calibration/ Validation Report included in Attachment 4a. These volumes are provided for several reaches of the HSC as noted in the dredge template shown in Figure 5-2. This template will be used to show how the alternative shoaling estimates from the numerical model compare to each other for each channel reach. The numerical model computed shoaling results are scaled based on the historic dredge records. For further information on this numerical model, please see the ERDC technical report (McAlpin et al., 2019b) Houston Ship Channel Expansion Channel Improvement Project (ECIP) Numerical Modeling Report included in Attachment 4b.

Figure 5-3 shows the model computed, scaled shoaling volume within each segment for the 2010 base condition and all four alternatives – present with project (PWP), present without project (PWOP), future with project (FWP), and future without project (FWOP). The with-project shoaling is larger for all segments except at the furthest upstream and downstream segments. Bolivar Roads to Redfish indicates a small decrease in the shoaling with the project changes in place likely due to the slight increase in the tidal prism which will generate some higher velocity magnitudes. The BSC area shows the largest increase in shoaling volume. The BSC Flare is already a sediment trap due to its present size and the project alternative of widening the BSC and to ease the bend further increase the footprint and therefore the tendency to trap sediment.

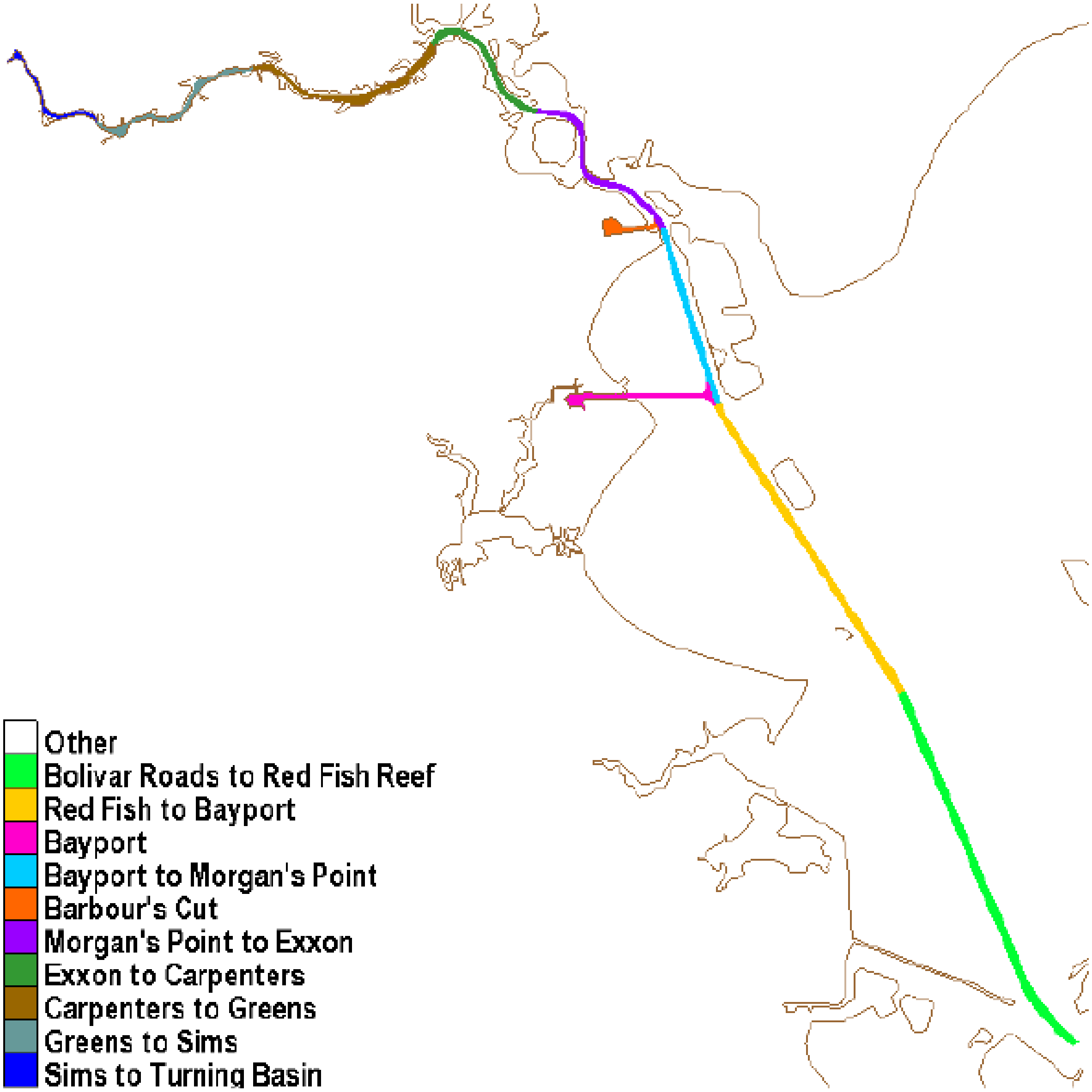


Figure 5-2: HSC dredge template for shoaling analysis

Figure 5-4 shows the model computed, unscaled bed displacement along the HSC from the Texas City Dike to the HSC Turning Basin. These results show a similar pattern to those in Figure 5-3, although no scaling has been done to ensure a correlation to historic data as in the shoaling volume plot. However, the comparison between with and without project will remain if scaled to replicate actual shoaling volumes/depths. The plot does show that the with project alternatives increase the deposition along most of the HSC. It also indicates a potential shift in the shoaling locations for the PWP alternative to areas upstream of Redfish and up-stream of BSC. The increase upstream of BSC may actually be a simple increase in shoaling as opposed to a shift since there are still peaks in the bed displacement at the BSC Flare. It is not uncommon for channel modifications to change the flow patterns such that the turbidity maximum (the location where the sediment tends to collect and often tied to the location of the salinity wedge) moves upstream, especially in the case of channel deepening. The future alternatives do not show this shift most likely because the sediment loads are reduced in the future condition simulations.

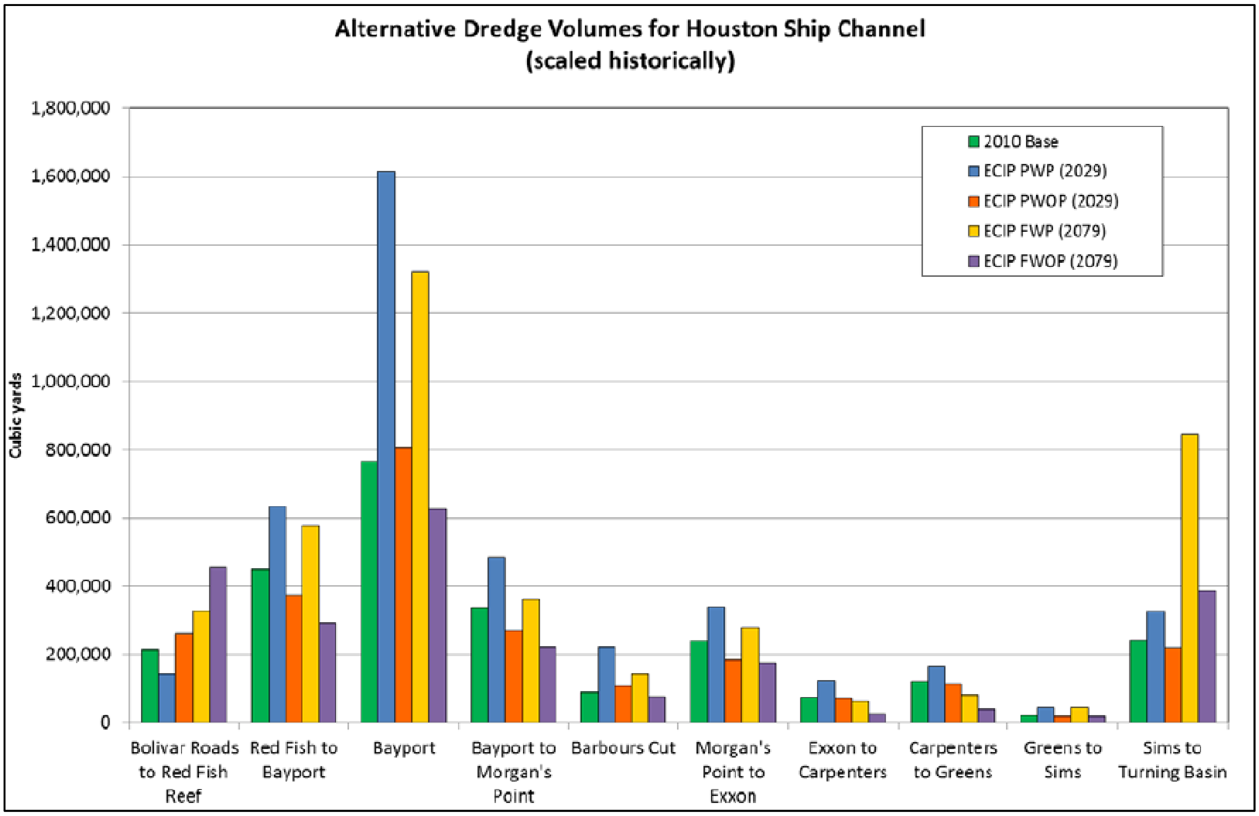


Figure 5-3. Shoaling results by reach for alternatives

The deepened portion of the HSC in the project alternatives is located up-stream of the San Jacinto River. Sediment loads from the bayous entering the HSC in the area of the deepening may have a tendency to migrate up-stream due to the salinity being pushed further upstream along the channel bottom; although the salinity change is less than 1 ppt for most of this area. This model does not include these bayou sediment loads because they are unknown and therefore is unable to predict this potential up-stream sediment migration.

Due to the increase in the with project cross sectional area (where the HSC is being widened or deepened), the same shoaling volume will equate to a reduced shoaling depth for the larger cross section. Figure 5-5 shows schematically how the shoaling volume can be interpreted for different channel modifications. A wider channel and the same shoaling depth or elevation will produce a larger shoaling volume. So the increased shoaling volume does not mean dredging must occur sooner, but it does indicate the dredging may cost more due to more volume. A constant shoaling volume will mean a lower shoaling depth for a channel widening condition; therefore, again, the dredging may not be required as often. For a deepened channel condition, the same results are true as in the widened condition; however, for a constant shoaling elevation, the shoaling volume and depth will be increased but dredging will only be required more often if the required dredging elevation is also deepened. These conditions should be considered when viewing the modeled shoaling volume and bed displacement changes for the various locations along the HSC due to the different areas of deepening and widening.

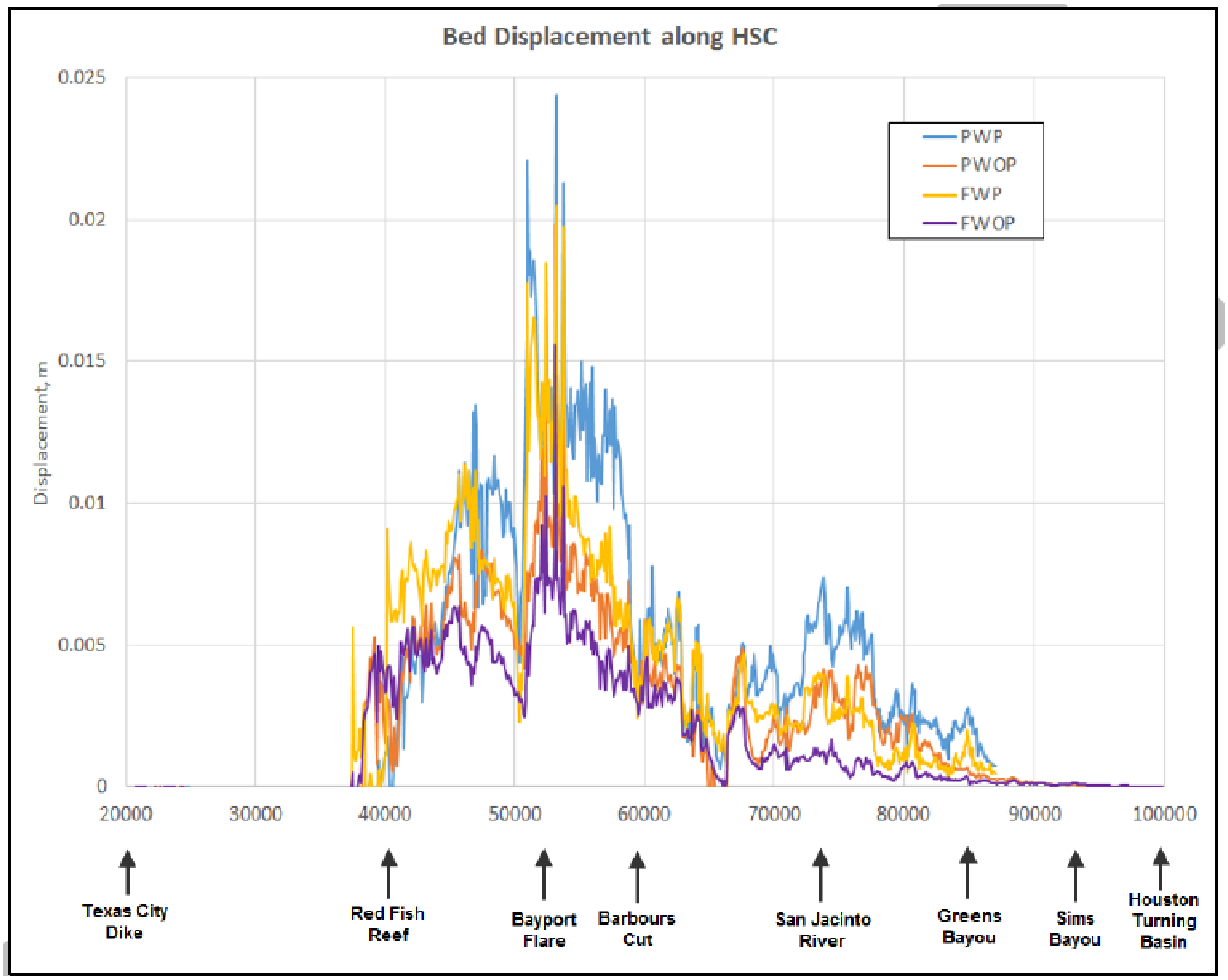


Figure 5-4. Modeled bed displacement along HSC (non-scaled, focus on the change; * Focus separately on changes between the present and future to isolate project impacts).

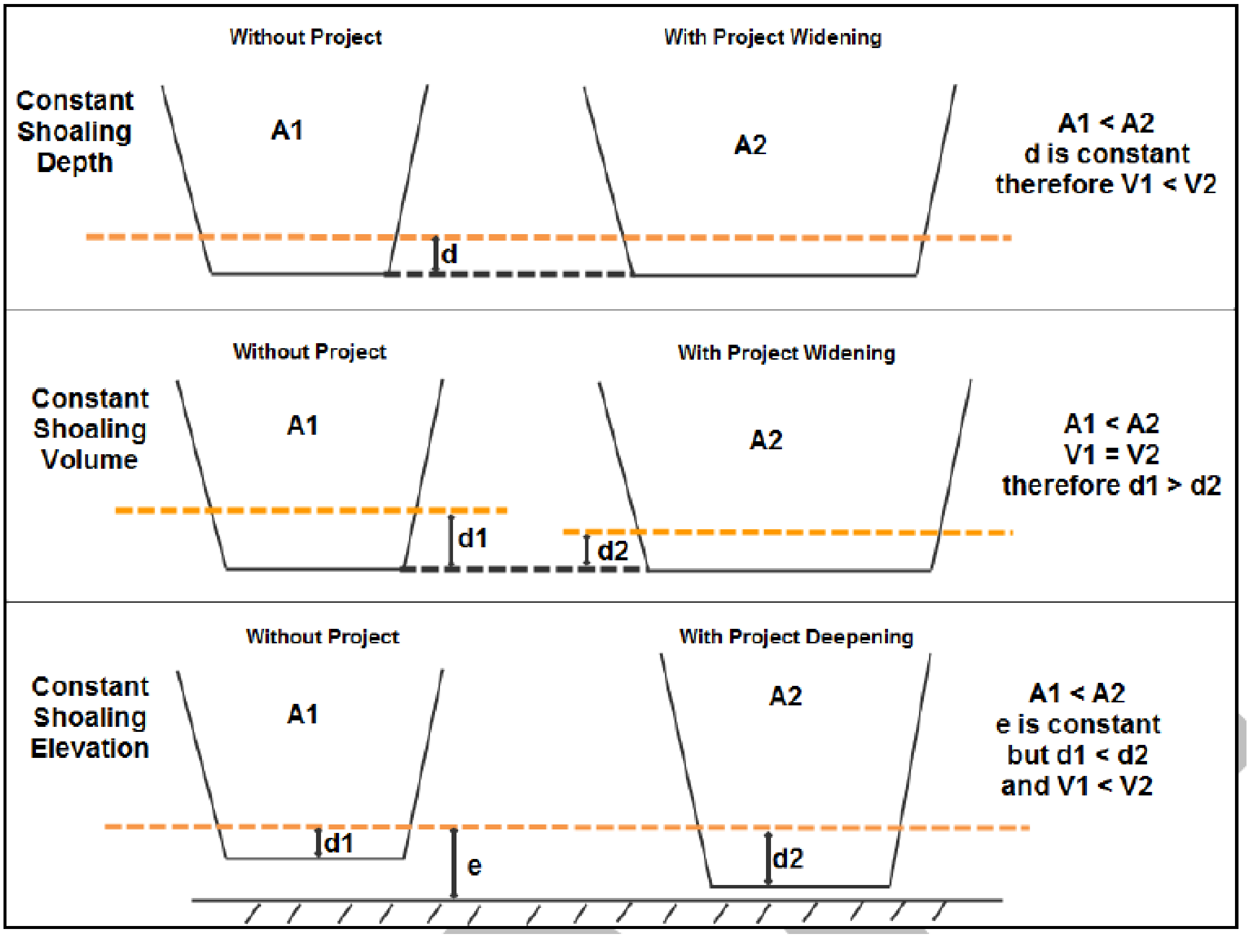


Figure 5-5. Shoaling impacts under various alternative conditions (*Focus separately on changes between the present and future to isolate project impacts)

5.2.4 Sediment Model Calibration to Corps Shoaling Analysis Tool (CSAT) Estimates

An additional sediment model calibration effort, is performed using the Corps Shoaling Analysis Tool (CSAT). This tool computes historic shoaling rates and provides estimates of future rates on a fine scale (10ft). This calibration effort provides shoaling estimates similar to those presented in the previous section but on a finer scale than the dredge template allows.

All previous sediment results with the numerical model has applied a historical scale factor based on seven years of dredge volumes (post 40x530 ft construction) provided in the USACE Annual Reports. These reports are best viewed over several years since some reaches are not dredged every year. The CSAT analysis was performed on data from 2011-2013. The USACE Annual Reports are not available beyond 2012. However, the total shoaling estimates for the entire HSC for 2011 and 2012 are comparable to the CSAT shoaling estimate for 2011-2013: although there are large differences in some of the reach shoaling volumes (see Table 5-13). (CSAT reaches were combined to match the analysis reaches shown in Figure 5-2). Presently there is no explanation as to why there are such large differences between the Annual Report reach volumes and the CSAT reach volumes.

Table 5-13: Comparisons by reach for Annual Report data and CSAT estimates of shoaling volume for the HSC

HSC Reach	2011 (CY)	2012 (CY)	**Avg (CY)/Yr**	**CSAT 2011-2013 Volume (CY)**
Bolivar Roads to Red Fish			**0**	**935,032**
Red Fish to Bayport		1,946,206	**973,103**	**926,405**
Bayport	741,492	176,916	**459,204**	**802,561**
Bayport to Morgan's Point	914,986		**457,493**	**231,949**
Barbours Cut	7,362		**3,681**	**169,650**
Morgan's Point to Exxon	2,024,913		**1,012,457**	**472,026**
Exxon to Carpenters	64,535	3,543,921	**1,804,228**	**228,338**
Carpenters to Greens			**0**	**192,423**
Greens to Sims		431,216	**215,608**	**377,957**
Sims to Turning Basin	130,347		**65,174**	**167,909**
SUM	3,883,635	6,098,259	**4,990,947**	**4,504,250**

The CSAT results were analyzed over the Annual Report reaches and a scale factor determined such that the numerical model results could be adjusted to better match the CSAT values. The average of the model shoaling results for 2005, 2010, and 2011 (the model validation years) for each reach were used to compare back to the CSAT results and a scale factor determined. Figure 5-6 shows the results of the various scaling options. The Annual Report volumes and the CSAT volume analysis results are considered "data". The numerical model computed results scaled in various ways are listed as "model". The green data sets are model shoaling volumes scaled by the 2005 historic Annual Report data as documented in Attachment 4a (McAlpin et al. 2019a). The pink data sets are the model shoaling volumes scaled by the CSAT to 2011 model shoaling results (the 2011 pink bar matches the red CSAT bar). The dark blue model data sets are model shoaling volumes scaled by the CSAT to 2005, 2010, and 2011 average model shoaling results. The 2011 scaling option produces extremely large shoaling volumes at reaches in the upper HSC which are likely incorrect since they are so much larger than the Annual Report values and CSAT values. However, the CSAT maximum values do reach some extremely large shoaling volumes. Scaled results that fall in the general range of the Annual Report data and the CSAT data are considered more reliable at this time.

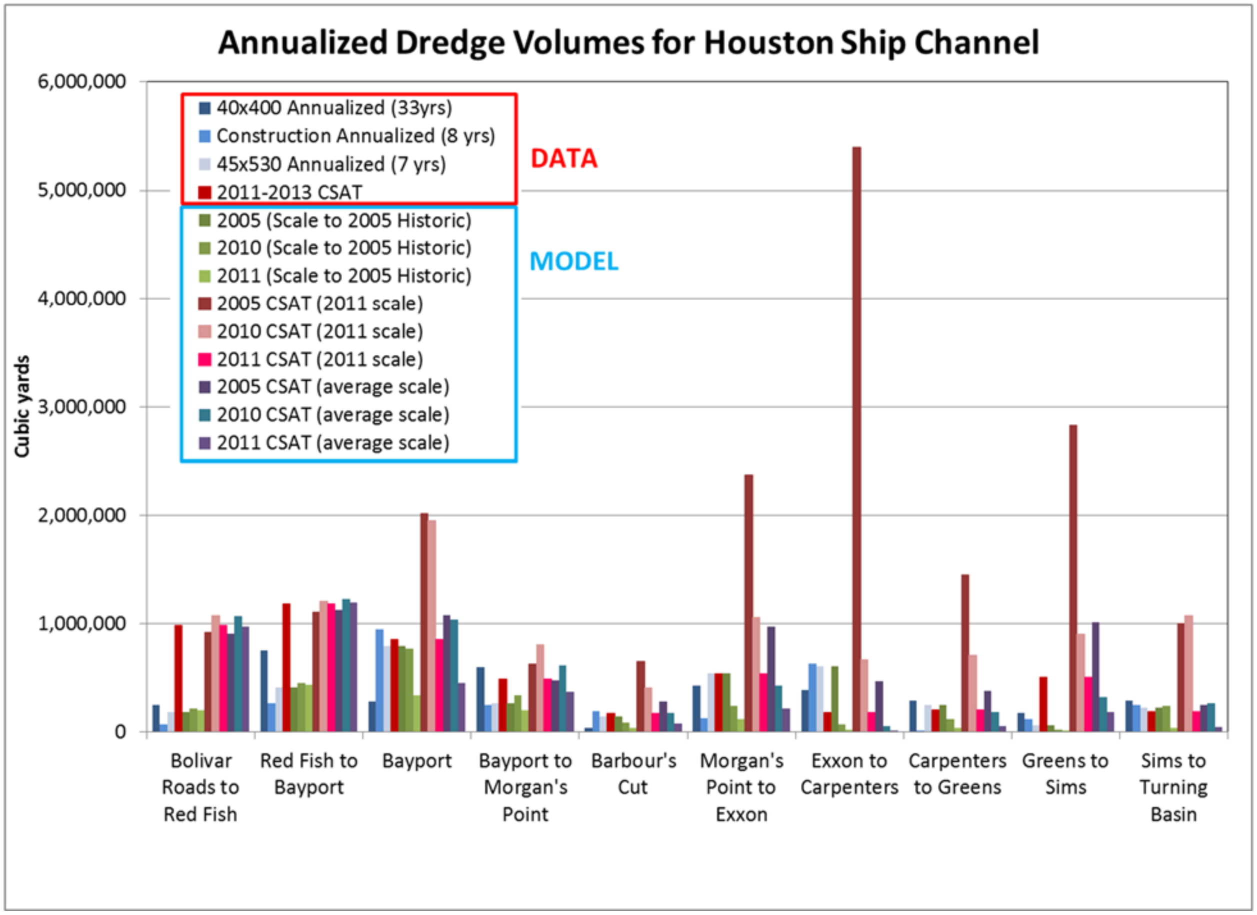


Figure 5-6: AdH Model Scaled Shoaling Results

The CSAT scaling of the numerical model results using the average shoaling of the three validation years is applied to the four ECIP alternatives – present with project (PWP), present without project (PWOP), future with project (FWP), and future without project (FWOP) – over the Annual Report reaches. The results for both the historic Annual Report scaling (as presented in the ECIP modeling report) and the CSAT scaling are shown in Figure 5-7 along with the CSAT computed volume for each reach (red). The CSAT scaling generates higher shoaling volumes than the Annual Report scaling although most reaches do not show extreme differences (more than double) except Bolivar Roads to Redfish and Greens Bayou to Sims Bayou.

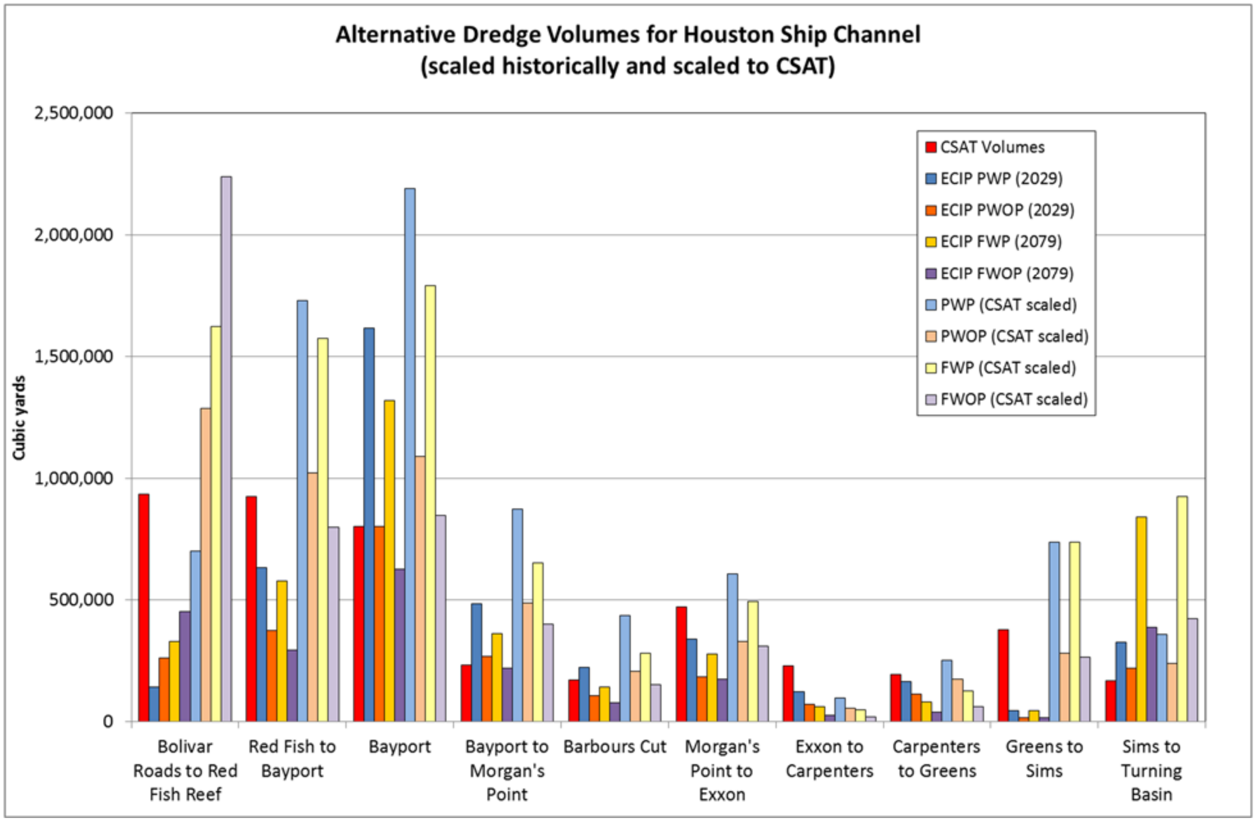


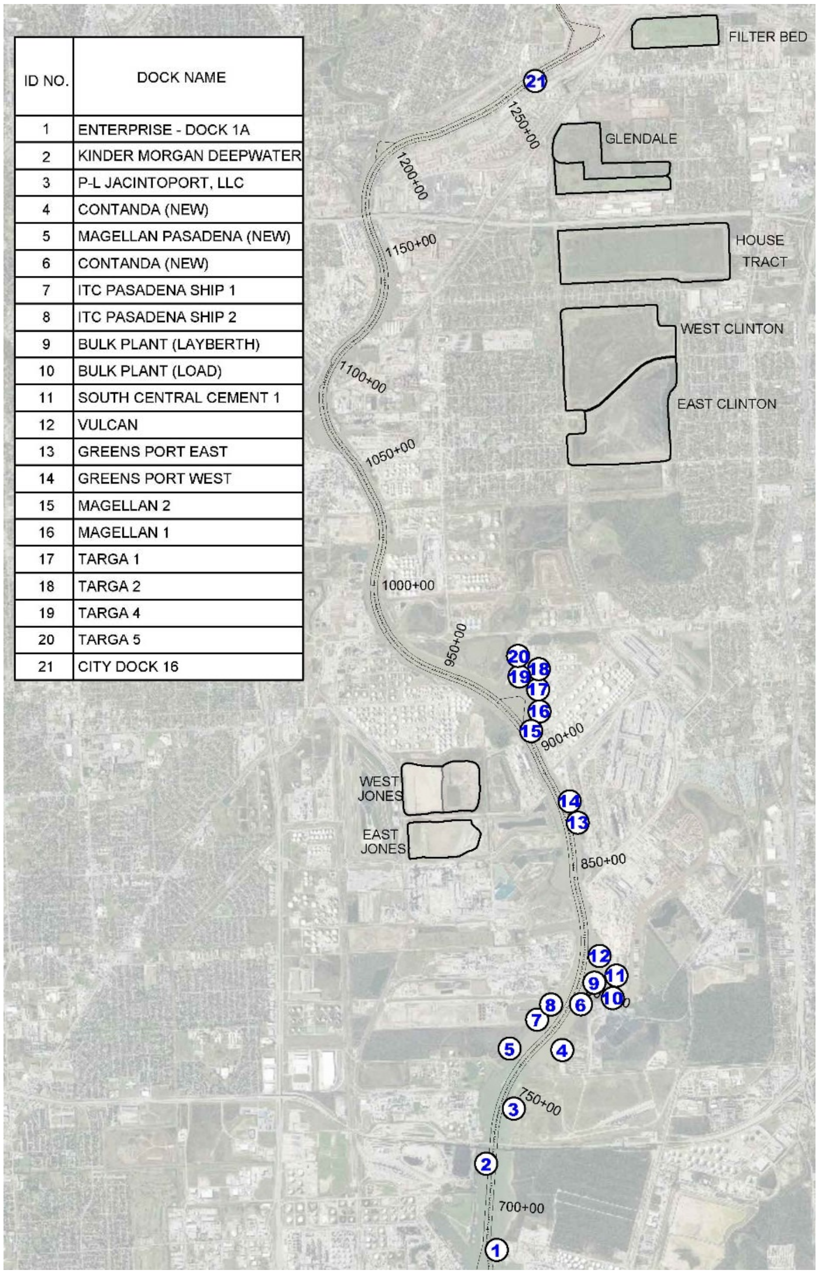
Figure 5-7: ECIP Alternative Scaled AdH Model Shoaling Volume Results for Annual Report reaches

The AdH shoaling validation effort using CSAT data provides a much larger range of possible shoaling results for the HSC reaches as compared to the USACE Annual Report validation effort presented in Attachment 4a (McAlpin et al. 2019a). The total shoaling for the HSC is comparable among the two data sources but the reach information varies drastically in some sections. The analysis years are not identical between the two methods which can present uncertainties given the variability of drought and flood years. Also creating discrepancies is the fact that the reaches are defined differently between the two data sources. However, the two methods present a possible range of shoaling to be expected along sections of the HSC under various flow conditions

5.2.5 Local Service Facilities

Economic analysis for the HSC ECIP has identified 21 Local Service Facilities (LSF) that would provide economic benefits from the channel modification/improvements as shown in Figure 5-8.

To estimate the total quantity of NW materials and 50-year maintenance quantities the area of each berthing facility was determined. CADD files were provided for the new Magellan, Contanda, and ITC facilities. The limits of the remaining facilities were approximated from permit documents, and/or NOAA charts. The footprint of each facility was limited to the toes of the 530-foot channel widening template from Boggy Bayou to Greens Bayou, and to the limits of the existing channel toes from Greens Bayou onward. This process is highlighted in Figure 5-9, with the dredging footprint of the Enterprise 1A facility in magenta limited to the proposed 530-foot channel toes in blue.



ID NO.	DOCK NAME
1	ENTERPRISE - DOCK 1A
2	KINDER MORGAN DEEPWATER
3	P-L JACINTOPORT, LLC
4	CONTANDA (NEW)
5	MAGELLAN PASADENA (NEW)
6	CONTANDA (NEW)
7	ITC PASADENA SHIP 1
8	ITC PASADENA SHIP 2
9	BULK PLANT (LAYBERTH)
10	BULK PLANT (LOAD)
11	SOUTH CENTRAL CEMENT 1
12	VULCAN
13	GREENS PORT EAST
14	GREENS PORT WEST
15	MAGELLAN 2
16	MAGELLAN 1
17	TARGA 1
18	TARGA 2
19	TARGA 4
20	TARGA 5
21	CITY DOCK 16

Figure 5-8: LSFs projected to benefit from the HSC ECIP

Existing berthing depths and proposed FWP deepening for existing facilities were provided by the PHA. The new facilities that were designed before the HSC ECIP and the proposed 5-foot channel deepening assume an existing FWOP and FWP depth as the adjacent channel to that facility.

Existing non-federal shoaling rates for the docks were held from the FWOP. These were listed as 0 CY/YR, 1,709 CY/YR, and 34,115 CY/YR for Boggy to Greens,

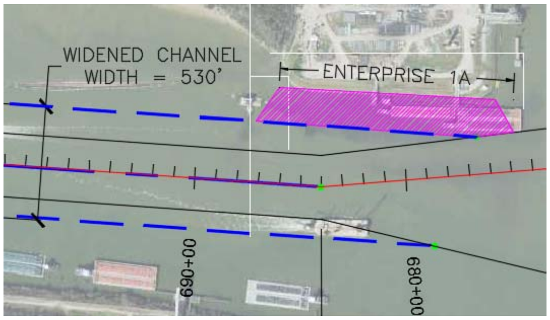


Figure 5-9: Estimating LSF footprint

Greens to Sims, and 610 to Main Turning Basin, respectively, for the 21 affected LSFs. In order to estimate shoaling rates for the FWP deepened docks, the Volume-of-Cut method was again used. In order to use this method theoretical shoaling rates for the existing condition were estimated by applying the existing channel shoaling rate per square foot to the footprint area of the LSFs. Once this rate was developed, the increased shoaling rate due to the 5-foot cut volume was determined. The shoaling quantities for the 21 affected LSFs are provided in the Tables 5-13 and 5-14.

Table 5-14: LSF New Work Quantities

			A	**B**	**A x B**
LSF	**FWOP Depth (MLLW)**	**FWP Depth (MLLW)**	**FWP Deepening (FEET)**	**Approximate Area Of Dock Footprint Outside 530-FT Widening (SQ FT)**	**NW (CY)**
Enterprise - Dock 1A	41.5’	46.5'	5	194,655	36,000
Kinder Morgan Deepwater	41.5'	46.5'	5	121,682	23,000
ITC Pasadena Ship 1	41.5'	46.5'	5	473,460	88,000
ITC Pasadena Ship 2	41.5'	46.5'	5	335,108	62,000
Bulk Plant (Lay Berth)	41.5'	46.5'	5	39,880	7,000
Bulk Plant (Load)	41.5'	46.5'	5	38,795	7,000
South Central Cement 1	41.5'	46.5'	5	159,787	30,000
Vulcan	41.5'	46.5'	5	292,191	54,000
Greens Port East	40.5'	46.5'	6	197,972	44,000
Greens Port West	39.5'	46.5'	7	273,460	71,000
Magellan 2	41.5'	46.5'	5	201,739	37,000
Magellan 1	41.5'	46.5'	5	398,703	74,000
Targa 1	41.5'	46.5'	5	189,457	35,000
Targa 2	41.5'	46.5'	5	157,725	29,000
Targa 4	41.5'	46.5'	5	334,904	62,000
Targa 5	41.5'	46.5'	5	472,252	87,000
City Dock 16	36.5'	37.5	1	36,816	1,000
				TOTAL	**747,000**

Table 5-15: LSF O&M Quantities

NAME	Area (SF)	FWOP Depth (MLLW)	$V_{old, cut}$ CY	FWP Deepening (FEET)	FWP DEPTH (MLLW)	$V_{new, cut}$ CY	I_{out}	Existing Channel Shoaling Adjacent (CY/YR)	Existing Adjacent Channel Area (SF)	FWOP Docks $V_{old, md}$ (CY/YR)	FWP Docks $V_{new, md}$ (CY/YR)	INCR. R_{inc} (CY/YR)
P-L Jacintoport, LLC (NEW)	1,548,626	41.5	2,380,000	5	46.5	2,667,000	0.12	113,709	4,470,594	39,389	44,139	4,750
CONTANDA (NEW)	1,239,504	41.5	1,905,000	5	46.5	2,135,000	0.12	113,709	4,470,594	31,527	35,333	3,806
MAGELLAN PASADENA (NEW)	1,733,641	41.5	2,665,000	5	46.5	2,986,000	0.12	113,709	4,470,594	44,095	49,406	5,311
CONTANDA (NEW)	772,363	41.5	1,187,000	5	46.5	1,330,000	0.12	113,709	4,470,594	19,645	22,012	2,367
ITC Pasadena Ship 1 EXPANSION	240,439	41.5	370,000	5	46.5	414,000	0.12	113,709	4,470,594	6,116	6,843	727
Kinder Morgan Deepwater	121,682	41.5	187,000	5	46.5	210,000	0.12	113,709	4,470,594	3,095	3,476	381
ITC Pasadena Ship 1 EXISTING	473,460	41.5	728,000	5	46.5	815,000	0.12	113,709	4,470,594	12,042	13,482	1,439
ITC Pasadena Ship 2	335,108	41.5	515,000	5	46.5	577,000	0.12	113,709	4,470,594	8,523	9,550	1,026
Bulk Plant (Lay Berth)	39,880	41.5	61,000	5	46.5	69,000	0.13	113,709	4,470,594	1,014	1,147	133
Bulk Plant (Load)	38,795	41.5	60,000	5	46.5	67,000	0.12	113,709	4,470,594	987	1,102	115
South Central Cement 1	159,787	41.5	246,000	5	46.5	275,000	0.12	113,709	4,470,594	4,064	4,543	479
Vulcan	292,191	41.5	449,000	5	46.5	503,000	0.12	215,662	4,470,594	14,095	15,791	1,695
Greens Port East	197,972	40.5	297,000	6	46.5	341,000	0.15	215,662	9,722,482	4,391	5,042	651
Greens Port West	273,460	39.5	400,000	7	46.5	471,000	0.18	215,662	9,722,482	6,066	7,143	1,077
Magellan 2	201,739	41.5	310,000	5	46.5	347,000	0.12	215,662	9,722,482	4,475	5,009	534
Magellan 1	398,703	41.5	613,000	5	46.5	687,000	0.12	215,662	9,722,482	8,844	9,912	1,068
Targa 1	189,457	41.5	291,000	5	46.5	326,000	0.12	215,662	9,722,482	4,202	4,708	505
Targa 2	157,725	41.5	242,000	5	46.5	272,000	0.12	215,662	9,722,482	3,499	3,932	434
Targa 4	334,904	41.5	515,000	5	46.5	577,000	0.12	215,662	9,722,482	7,429	8,323	894
Targa 5	472,252	41.5	726,000	5	46.5	813,000	0.12	215,662	9,722,482	10,475	11,731	1,255
City Dock 16	36,816	36.5	50,000	1	37.5	51,000	0.02	114,078	4,916,674	854	871	17

Table 5-16: LSF Non-Federal Shoaling Summary (21 Benefiting Docks)

LOCATION		FWOP USACE* CY/YR	FWP INCR. CY/YR	FWP TOTAL (CY/YR)
4	Boggy Bayou to Greens Bayou	0	22,230	22,230
	Greens Bayou to Sims Bayou	1,709	6,418	8,127
6	I-610 to Main TB	34,115	17	34,132

*USACE FWOP Non-Federal shoaling rate for affected reach

5.2.6 Channel Improvements Potential Effects on Existing and Planned Structures

5.2.6.1 Segment 1

The channel widening features in Segment 1 from Bolivar to Redfish and Redfish to BSC do not affect any existing or planned dock structures. In the BSC to BCC Reach, the channel widening modification/improvements will affect the shoreline at Morgans Point between Station 0+000 and 0+400. A sheet pile wall will be installed as discussed in Section 4.6. The main bridges that cross Segment 1 are the Fred Hartman & BW8), the air draft is 175 ft. The largest ships will transit under these two bridges are Aframax and Suezmax, which have max height above mast (sticking out of the water) under lightship condition of about 47.5 m to 48.5 (~156-159 ft) and less under normal ballast (~43 to 45m or 141-148 ft). The vessel size does not change.

5.2.6.2 Segment 2

Channel improvements on the BSC will not affect existing dock structures. The current dock setbacks are 225 feet from the dock face to the toe of the BSC. The dock facilities constructed and or planned contemplate a minimum design depth of 50 feet at the PHA BSC Container terminal, Odjfel and ITC. Channel widening will affect the north shore of the BSC as discussed in Section 4.6. Installation of sheet pile wall and relocation of the rock revetment are accounted for in the project costs and slope stability analysis using existing survey and geotechnical data is included as Attachment 5 of this Appendix.

5.2.6.3 Segment 3

Channel improvements on the BSC will not affect existing dock structures. The current dock setbacks are 225 feet from the dock face to the toe of the BSC. The dock facilities constructed and or currently being upgraded contemplate a minimum design depth of 50 feet at the PHA BCCT, and Enterprise. The LASH dock and RO/RO dock has been removed. Channel widening will affect the north shore of the BCC along Spilmans Island as discussed in Section 4.6. Installation of sheet pile wall and relocation of the rock revetment are accounted for in the project costs and slope stability analysis using existing survey and geotechnical data is included as Attachment 5 of this Appendix.

5.2.6.4 Segment 4

Measure, **CW4_BB-GB_530**, would widen the channel up to 530 feet from Boggy Bayou to Greens Bayou (Station 684+00 to 833+00) and deepen to a depth of -46.5 feet MLLW to Hunting Turning Basin at Station 930+00 as shown in Figure 4-9.

Several measures were taken to communicate and obtain information from the LSFs, particularly in the widening sections of Segment 4 and include public notices, public meetings, presentation to Waterways Utilization and Navigation Operations subcommittees of the Lone Star Harbor Safety Committee, coordination with HP, phone interviews by the PHA, and coordination with the engineers of record. On June 6, 2018, a meeting was held with several of the LSF representatives for Texas Deepwater/Pinto Lion, Magellan, ITC, Contanda, Inneos Phenol and Kinder Morgan.

This coordination indicates that the widening of the channel should occur on centerline shifts to the north and south allowing for required setbacks from the docks/berthing facilities. Representatives of the Texas Deepwater project expressed concerns with options to focus widening to the north. All others were taking the deepening and widening into account for their planned construction. This coordination also indicated that the Hunting Bayou Turning basin is of sufficient size and does not need improvement other than deepening. The planned new facilities have incorporated vessel turning into their dock designs.

Close and regular coordination during PED between the USACE, the non-Federal Sponsor, HP, and the LSFs must occur to ensure that the Federal interests and construction of the LSFs are aligned. Improvements to the existing facilities and new facilities are occurring in the FWOP condition and therefore no costs for actual dock construction other than dredging to the deepened depth of -46.5 feet MLLW are included in the associated costs.

The existing BW8 Bridge is located at the beginning of this reach and a new bridge is currently under construction. The footings for the new bridge are outside of the planned channel improvements and the bridge clearance is sufficient for the planned vessel traffic. The existing bridge and its respective footings will be removed by the Harris County Transit Authority by 2020.

5.2.6.5 Segment 5

This short section of channel scours and for the majority of the reach it is already at the proposed depth ss shown by the relatively minimal amount of new work dredging in this reach. Therefore, no impacts to existing facilities is contemplated. The 610 Bridge lies between Segments 5 and 6 with a clearance of 135 feet. The vessel sizes in the economic analysis do not change and currently have this limitation in the FWOP condition.

5.2.6.6 Segment 6

The facilities directly adjacent to the channel improvements other than the Brady Island Turning Basin are PHA City docks. The majority of these docks were constructed in the 1950s and are undergoing refurbishment or replacement as part of the PHA Master Plan in the FWOP condition. Therefore, other than costs to deepen them, no other associated costs are estimated. Sheet pile wall will be installed as described in Section 4.6 at the Brady Island Turning Basin improvements.

6 GEOTECHNICAL

All geotechnical data collected to date within Galveston Bay was reviewed to determine its relevance to the current project and to identify what new investigations would be necessary for project design. Existing borings are included in the Engineering Plates.

6.1 Existing Borings

A majority of the historical geotechnical data was collected between 1963 and 1993 and published in the HGNC LRR in November 1995. This included channel boring series 3ST, 72 and 93. The plans for HGNC 46.5-foot project published between 1998 and 2002 for various sections of the channel utilized most all the geotechnical data from the HGNC LRR and was supplemented with new borings during construction. In many instances, errors were found in the boring logs of the HGNC LRR, but had been corrected in the HGNC 46.5-foot project construction plans. Based on the observed revisions, plans for the HGNC 46.5-foot project were used as the main source for historical boring locations. For any boring that did not have a location identified in the logs, their approximate location was determined from the boring plan view sheet. An image of the plan view was aligned as best possible over existing channel lines and PA dikes and a point created at each boring location.

Geotechnical data in the Upper Bayou section of the HSC, from Station 700+00 to 1082+50 were collected from the Texas Coastal Sediments Geodatabase compiled by the Texas General Land Office (GLO). HSC channel borings were collected in 1963, Greens Bayou borings in 1967 and Brady Island borings in 1964 and 1976. All borings designated with prefix 3ST and were collected by the USACE. The boring logs downloaded from the GLO are handwritten and do not provide a station and range, however a Latitude and Longitude is identified for each data point in the map viewer. How the GLO determined the location of these data points is unknown and their location should be considered approximate.

No geotechnical data within the existing or proposed channel limits could be found between HSC Station 1082+50 and the end of the Main Turning Basin at Station 30+95.06. To aid with the new work dredge material classification in Segments 5 and 6, the PHA provided geotechnical data from borings collected along numerous dock facilities between 1961 and 2000; which were collected as part of dock facilities expansion and/or modification projects.

6.1.1 Segment 1: Bay Reach

Boring series 3ST, 72 and 93 run the extent of the channel segment starting at Bay Station 138+369.011 up through -0+003.944 and continuing through the Bayou from Station 0+05 to 684+03.19. The 3ST-series of borings were taken on an average 1,000-foot spacing, alternating between right and left sides of the channel. The 72 and 93-series of borings fill in the data gaps between the 3ST-series. As channel modifications and PA development continued project specific borings were acquired and include the following borings in Segment 1:

- 1992 (SC-series) Bay Station 5+000 - 25+000
- 1998 (AM-series) Bay Station 1+000 - 29+000
- 1998 (LB-series) Bay Station 79+000 - 120+000
- 2000 (MB-series) Bay Station 34+000 - 75+000
- 2001 (B-series) Bay Station 35+000 - 75+000
- 2001 (SJ01, GI01, LB01, BM01, and B-series) Bayou Station 360+00 - 470+00
- 2009 (HSC-09-series) Bay Station 15+000 - 38+000

6.1.2 Segment 2: Bayport Ship Channel

With every modification to the BSC there have been several rounds of geotechnical investigations. Borings within the footprints of the alternatives under review include the 1999 (B-series), 2000 (BF-series), 2004 (MB-series), 2009 (BC-series), and 2012 (12-series).

6.1.3 Segment 3: Barbours Cut Channel

The most recent borings at the BCC labeled with the prefix L, S and T were taken in 2012 for the widening and deepening project that was completed in 2015. The 04-series of borings was taken in 2006.

6.1.4 Segment 4: Boggy Bayou to Sims Bayou

The existing geotechnical data in this segment of the channel are the 3ST and 72-series borings taken prior to the 46.5-foot project. No existing geotechnical data was located above Station 1090+00.

6.1.5 Segment 5: Sims Bayou to I-610 Bridge

No existing geotechnical data was available within the existing channel limits. Borings collected in 2000 from dock facilities were provided by the PHA.

6.1.6 Segment 6: I-610 Bridge to Turning Basin

No existing geotechnical data was available within the existing channel limits. A series of borings were taken in the Brady Island Channel in 1964 that include one boring within the existing Brady Island Turning Basin. The PHA provided boring logs from samples collected along dock facilities between 1961 and 1969.

6.2 Future investigations/recommendation

Most of the HSC, BSC and BCC have ample existing geotechnical data that will be sufficient for material classification required at this stage of the study. Portions of the Bayou in Segments 4, 5, and 6, however, are lacking adequate geotechnical data. When determining where new geotechnical data is needed, the age of existing data, the depths to which the borings were taken and the footprint of the proposed alternatives were all factored in to the decision. Additional geotechnical data may be gathered through any or a combination of geotechnical borings, probings, acoustic subbottom profiling and other remote sensing surveys.

6.2.1 Segment 1: Bay Reach

This segment of the channel has an existing boring approximately every 1,000 feet or less, from 1963 through 2009. Existing data in this area should be sufficient for channel material classification for this stage of the study, however final engineering and design may require additional borings to be taken outside the existing channel toes to bolster the classification of new work dredge materials as much of the boring data is from 1963 to 2009.

For the associated PAs, borings shall be taken approximately every 500-1,000 feet along the dike and bird island alignments as well as borings representative of the interior to determine slope stability, foundation characteristics, settlement, and consolidation. Soft sediments are expected to be encountered and probings should also be taken to differentiate between soft soil layers.

Geotechnical hand and/or jet probing is a useful supplement to traditional geotechnical sampling in the aquatic environment and can be performed at a fraction of the cost of traditional geotechnical sample collection. Hand/jet probing should not be confused with other standardized probing methods such as Dynamic Probing (ISO 22476-2). Hand/jet probing is the practice of physically exploring substrate for determination of general material properties to a refusal stratum. No sample data for analysis or standardized strength test data is acquired. Both hand and jet probing involve lowering a graduated pipe to the bay bottom and pushing it through the substrate to determine material types through resistance and vibrations against the pipe. In both types, an auger is generally attached at the end of the pipe to assist with transitioning between sediment layers. Hand probing typically employs a ¾” galvanized steel pipe as shown in Figure 6-1. They are very useful in shallow water and can be done aboard a small vessel. Jet

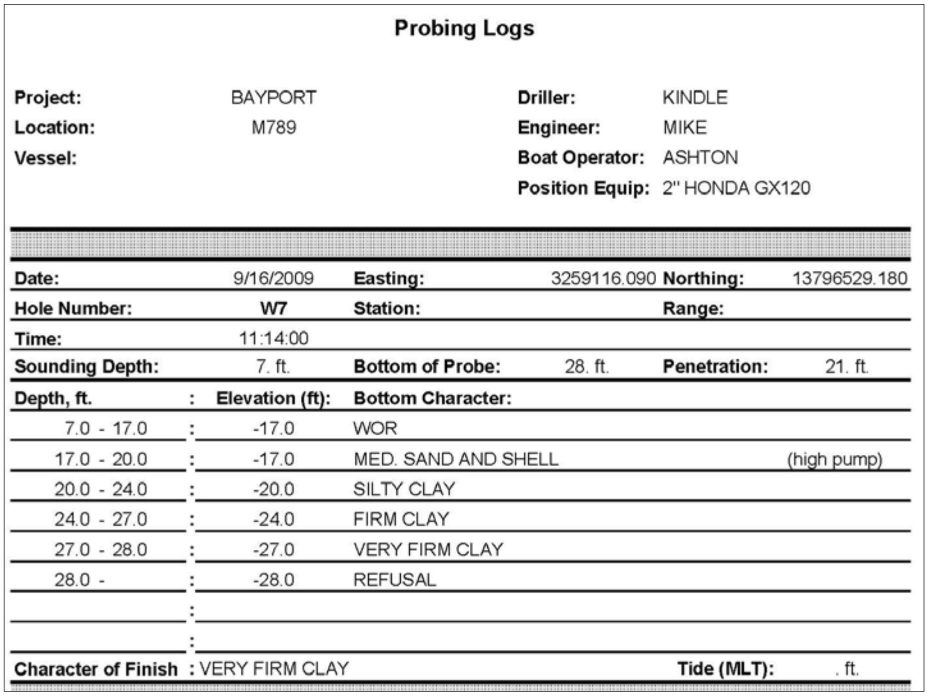
Figure 6-1: Hand Probing

Figure 6-2: Jet Probing

probings are similar with the addition of using a hose mounted water supply at the top of the pipe. This allows washing of the probing hole for increased depth measurements. Jet probes use a larger diameter rod (typically 1½ inch aluminum) and are performed aboard a larger vessel or drilling rig capable of supplying the water and raising the pipe. Typical probing data can be extremely useful for determining weight-of-rod material, soft clay, sand and shell layers, and a refusal layer, relating that information into foundation design. Refusal represents the stratum of resistant bearing or shear and for most areas usually represents thick oyster reef, medium to stiff clays, or densely packed sand. Navigation is typically performed with consumer grade GPS equipment; however tighter accuracy can be warranted. In dredging projects, probing data is used in order to supplement the traditional geotechnical data in between boring locations, and primarily to develop a spatial model of soft bay bottom sediments.

The strata to be determined are classified vertically to quantify the varying material types and to identify potential habitat impacts and soft foundations, at a minimum. A trained engineer, scientist, surveyor, or technician can perform probings and determine material types through resistance, touch, and sound. The probing pipe can also be turned at refusal to obtain a short plug sample of material on the auger tip for visual classification.

Probing data is processed, and tide corrected at each location. The data is plotted onto probing logs with locational information, and the vertical profile of layers observed. With this information, composite data sets can be created with surface linkage for volumetric analysis. A typical jet probing log is provided in Figure 6-3.



Probing Logs

Project:	BAYPORT	**Driller:**	KINDLE
Location:	M789	**Engineer:**	MIKE
Vessel:		**Boat Operator:**	ASHTON
		Position Equip:	2" HONDA GX120

Date:	9/16/2009	**Easting:**	3259116.090	**Northing:**	13796529.180
Hole Number:	W7	**Station:**		**Range:**	
Time:	11:14:00				
Sounding Depth:	7. ft.	**Bottom of Probe:**	28. ft.	**Penetration:**	21. ft.

Depth, ft.	**Elevation (ft):**	**Bottom Character:**	
7.0 - 17.0	-17.0	WOR	
17.0 - 20.0	-17.0	MED. SAND AND SHELL	(high pump)
20.0 - 24.0	-20.0	SILTY CLAY	
24.0 - 27.0	-24.0	FIRM CLAY	
27.0 - 28.0	-27.0	VERY FIRM CLAY	
28.0 -	-28.0	REFUSAL	

Character of Finish : VERY FIRM CLAY **Tide (MLT):** . ft.

Figure 6-3: Typical Probing Field Log

6.2.2 Segment 2: Bayport Ship Channel

There is currently sufficient existing geotechnical data from within the BSC alternatives to classify dredge materials. Final engineering and design could benefit from additional borings to fill gaps in the data for the flare widening as shown in Figure 6-4. Additionally, more borings may be needed during PED to validate slope stability and sheet pile wall requirements along the north slope of the BSC within the land cut. For the associated PAs, borings shall be taken approximately every 500-1,000 feet along the dike and bird island alignments, and include several borings within the interior of the site. The geotechnical data will be used to determine slope stability, foundation characteristics, settlement, and consolidation required for site design.

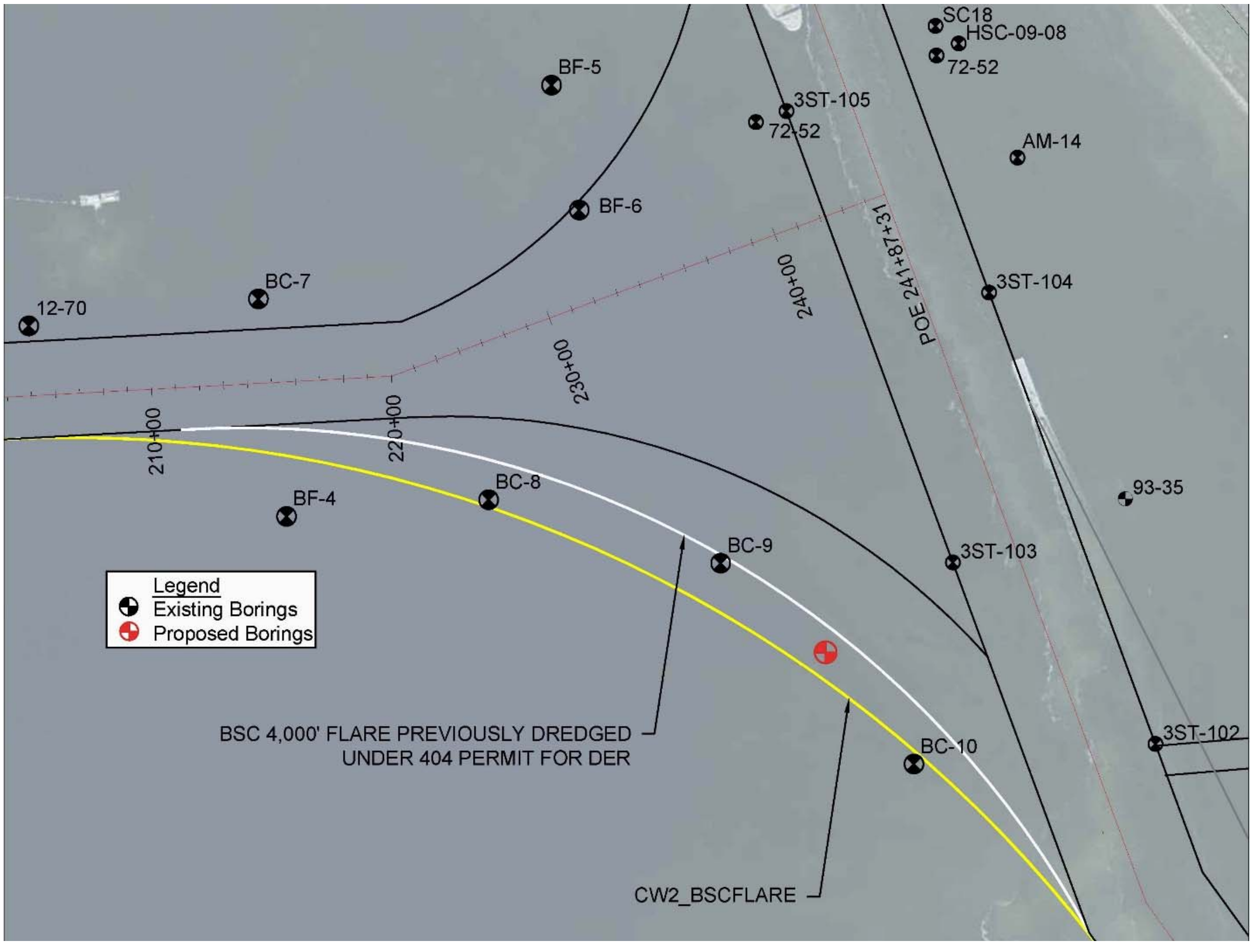


Figure 6-4: Proposed borings for CW2_BSCFlare

6.2.3 Segment 3: Barbours Cut Channel

There is currently sufficient existing geotechnical data from within the BCC alternatives to classify dredge materials. Final engineering and design could benefit from additional borings for the 1,800-foot BCC flare modification. Proposed boring locations are provided in Figure 6-5. Three borings in the south flare region, and two additional borings in the north flare are recommended to be taken during the PED phase. Additionally, more borings may be needed during PED to validate slope stability and sheet pile wall requirements along the south side of Spilmans Island. For the associated PAs, borings shall be taken approximately every 500-1,000 feet along the dike and bird island alignments and include several borings within the interior of the site.

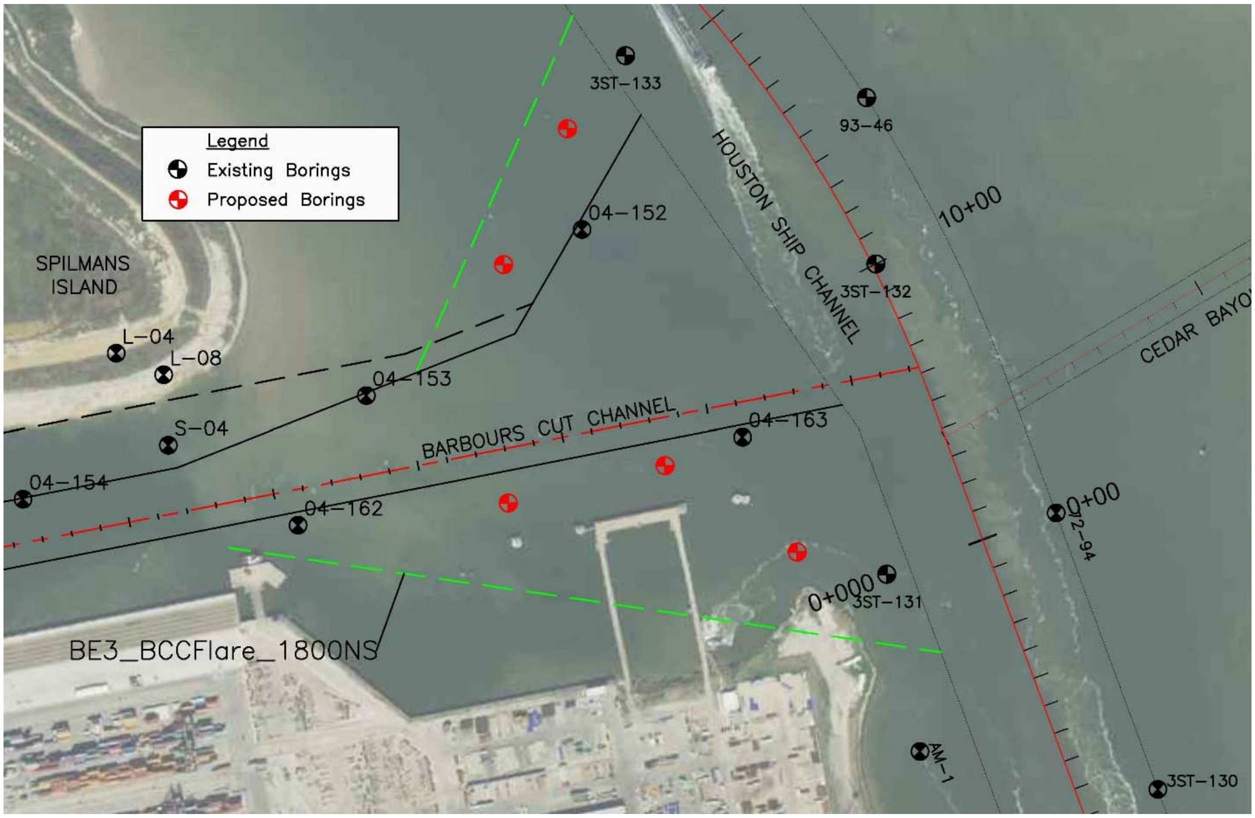


Figure 6-5: Proposed borings for BCC 1,800-foot Flare Easing and Turning Basin (BETB3_BCCFlare_1800NS)

6.2.4 Segment 4: Boggy Bayou to Sims Bayou

The existing geotechnical data in this segment of the channel is sparse, consisting of 3ST and 72-series borings. All 3ST borings in this section of the channel are from the Texas Coastal Sediments Geodatabase. Segment 4 includes a combination of widening and deepening from Boggy Bayou to Sims Bayou. The existing borings were used to classify materials, however new borings would be required for final engineering and design. It is recommended that new borings be taken every 1,000 feet along the proposed channel toe along alternating sides of the channel. This would result in 18 new borings in Segment 4. For PA sites BW-8 and E2C, borings shall be taken approximately every 500-1,000 feet along the dike alignment and include several borings within the interior of the sites.

6.2.5 Segment 5: Sims Bayou to I-610 Bridge

Geotechnical data collected from the dock facilities in 2000 was provided by the PHA and used to classify materials for the channel deepening in Segment 5. For final engineering and design, it is recommended that borings be acquired every 1,000 feet along the existing channel toe on alternating sides of the channel. This segment of the HSC is approximately 5,000 feet in length and would require 5 geotechnical borings. Borings shall be taken approximately every 500-1,000 feet along the dike alignment at E2C and include several borings within the interior of the site. Existing geotechnical data at Filterbed and Glendale will be used for preliminary assessment. Slope stability analysis on existing UCPAs was conducted during the HSCPA and are included in Attachment 7 in this Appendix.

6.2.6 Segment 6: I-610 Bridge to Turning Basin

Geotechnical data collected from the dock facilities between 1961 to 1969 was provided by the PHA and used to classify materials for the channel deepening in Segment 6. For final engineering and design, it is recommended that borings be acquired every 1,000 feet along the existing channel toe on alternating sides of the channel. This segment of the HSC is 13,700 feet in length and would require 14 geotechnical borings. Existing geotechnical data at Filterbed and Glendale will be used for preliminary assessment. Slope stability analysis on existing UCPAs was conducted during the HSCPA and are included in Attachment 7 in this Appendix.

6.3 New Work Materials

Historical boring logs were reviewed to determine the material types in accordance with Unified Soil Classification (ASTM D-2487-98) and categorize them into: Very Soft Silts & Clays, Soft Silts & Clays, Medium Clays, Stiff Clays, Very Stiff Clays, Hard Clays, Loose Sands, Medium Dense Sands, Very Dense Sands, and Medium to Dense Silt. Table 6-1 is provided to establish a point of reference for the categorization of the materials.

Table 6-1: Categorization of materials based on their consistency or relative density

Relative Density of Sand		Strength of Clay		
Penetration Resistance N (blows/ft)	Relative Density	Penetration Resistance N (blows/ft)	Unconfined Compressive Strength (tons/ft^2)	Consistency
0-4	Very loose	<2	<0.25	Verysoft
4-10	Loose	2-4	0.25-0.50	Soft
10-30	Medium	4-8	0.50-1.00	Medium
30-50	Dense	8-15	1.00-2.00	Stiff
>50	Very dense	15-30	2.00-4.00	Very stiff
		>30	>4.00	Hard

From Terzaghi and Peck, 1948 (Source: Soil Mechanics, T.W. Lambe và R.V. Whitman)

It should be noted that these material estimates are based on historic borings ranging from one to several decades old. Material types may additionally vary between the boring locations where data has been linearly interpolated. Additional information as collected and/or received may warrant revision of the material types and quantities provided herein.

Materials were then plotted in profile along the dredging reach and connected between like material types. Figure 6-6 through Figure 6-12 are plan-profile drawings identifying the historical borings used and the material profiles created therefrom. After generating the profiles, material layers were created in Trimble Terramodel v10.61 and material volumes by type were generated. Reaches are presented proceeding from south to north.

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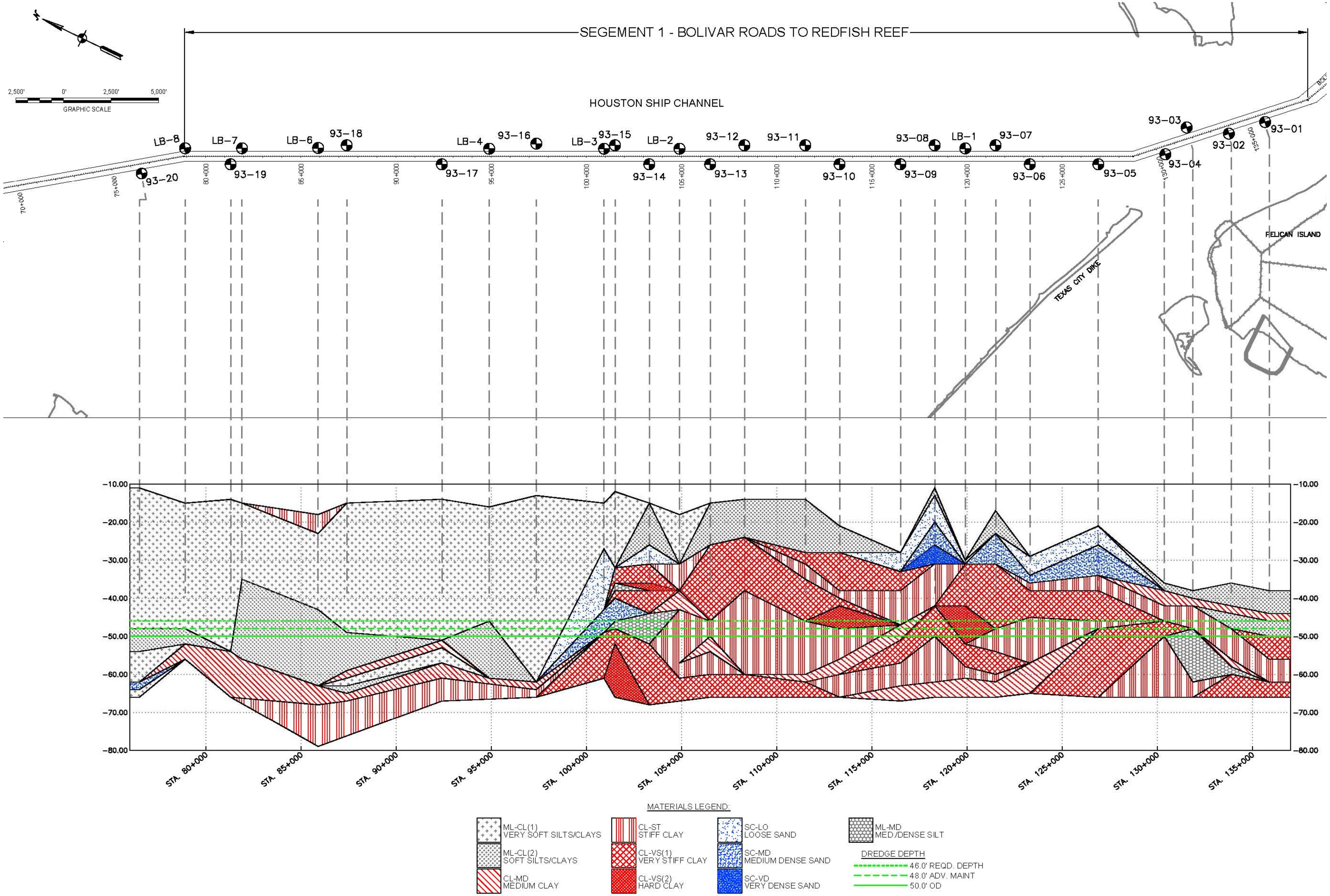

Figure 6-6: Geotechnical Profile Segment 1 - Lower Bay

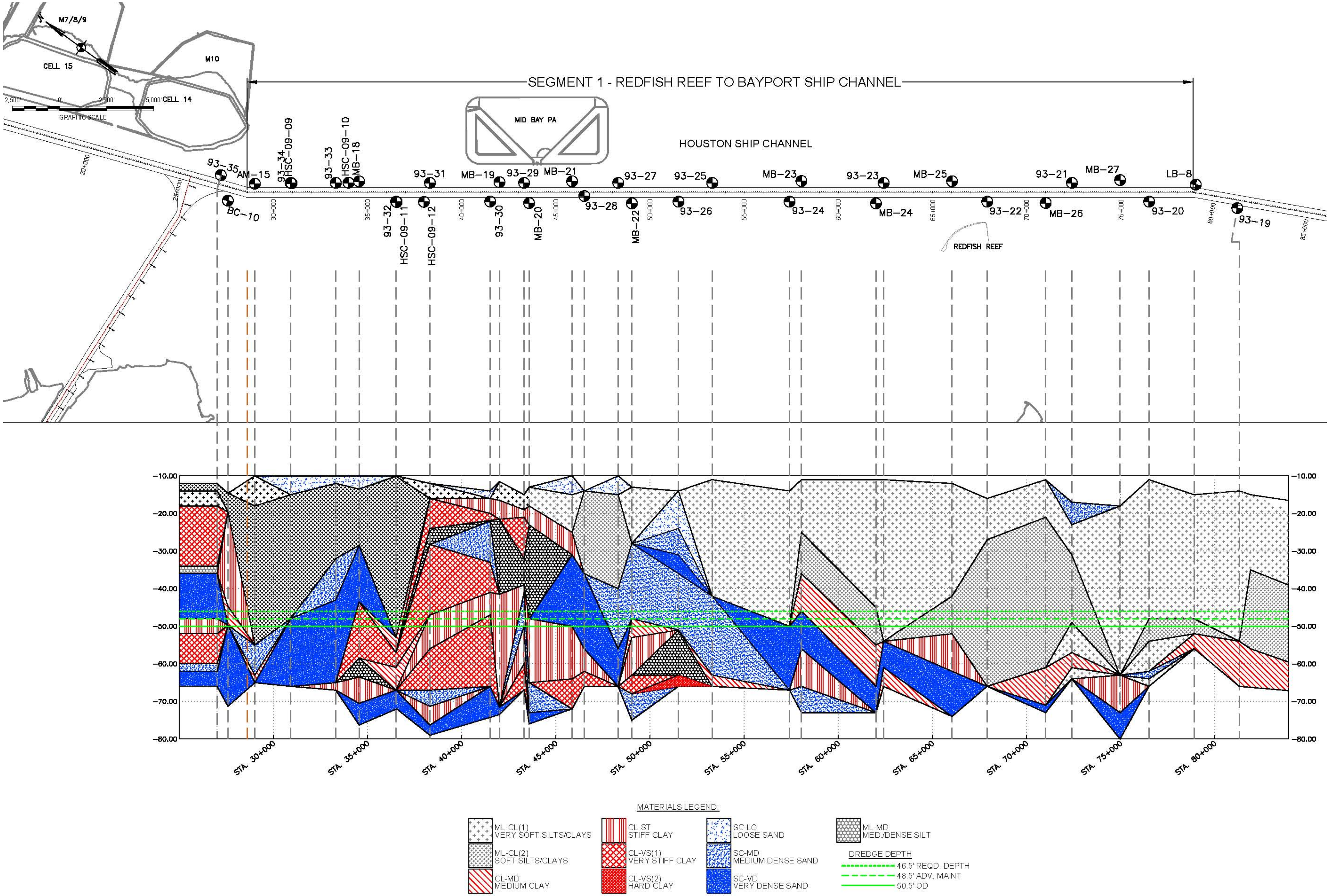

Figure 6-8: Geotechnical Profile Segment 1 - Mid Bay

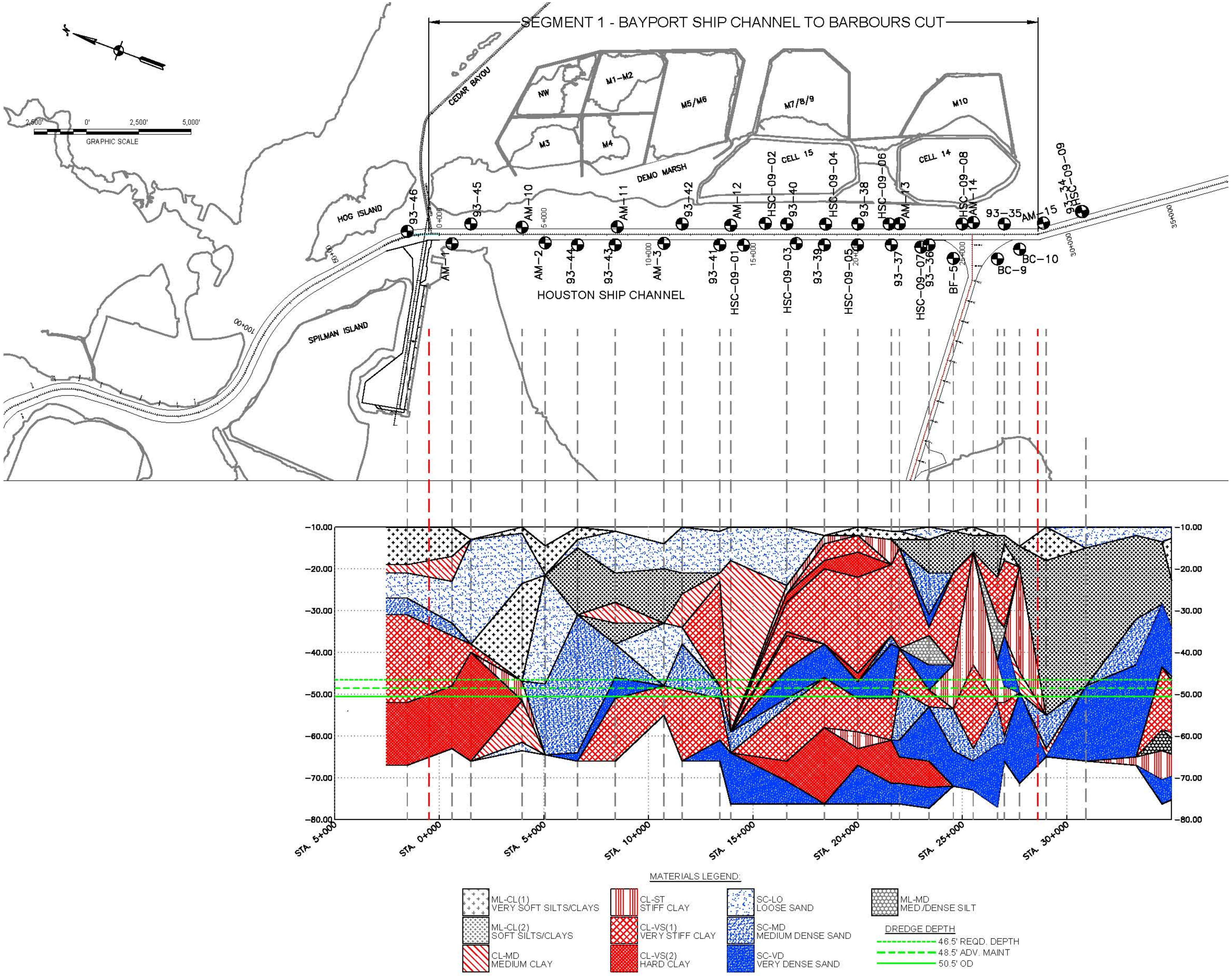

Figure 6-9: Geotechnical Profile Segment 1 - Upper Bay

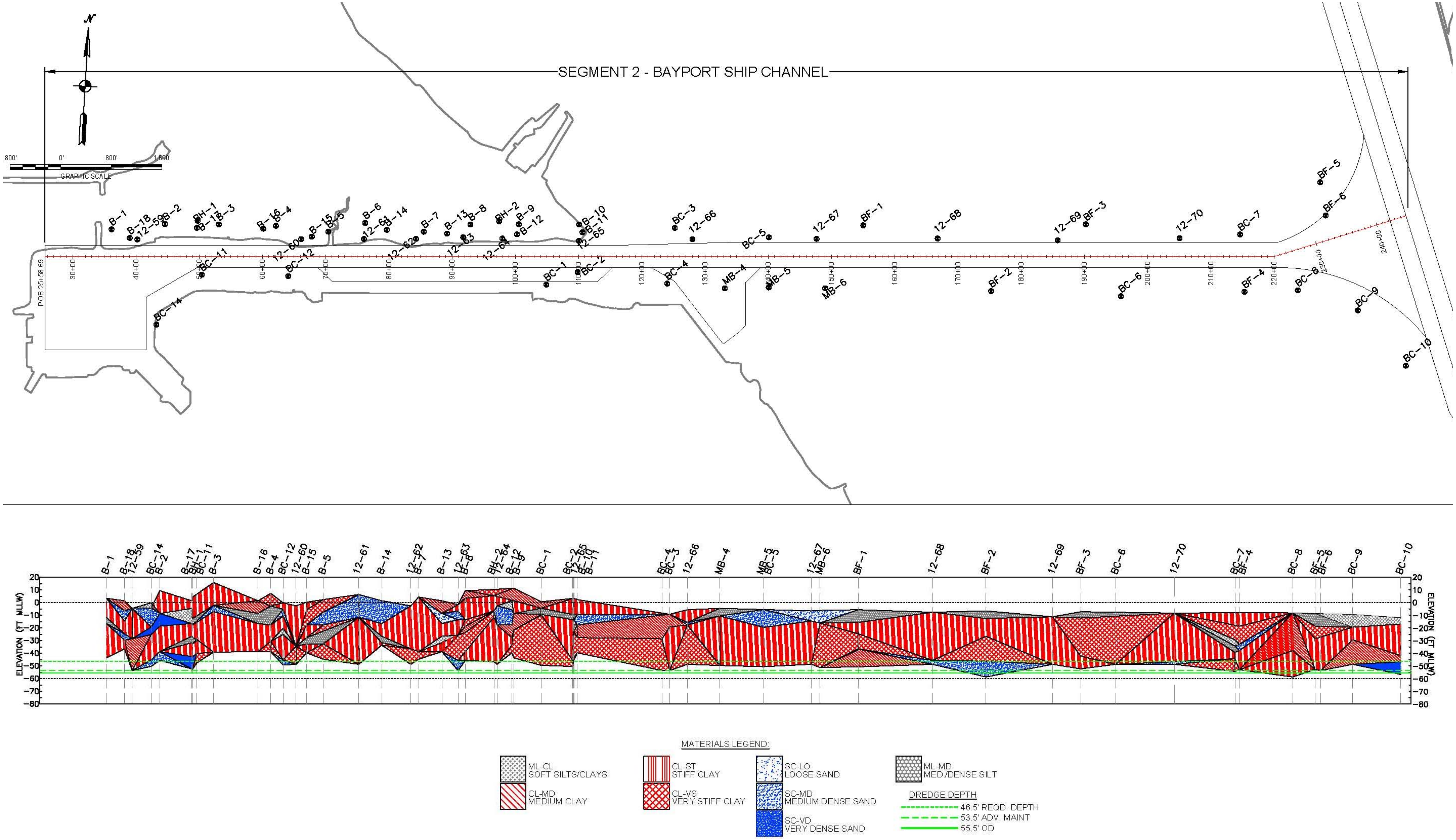

Figure 6-10: Geotechnical Profile Segment 2

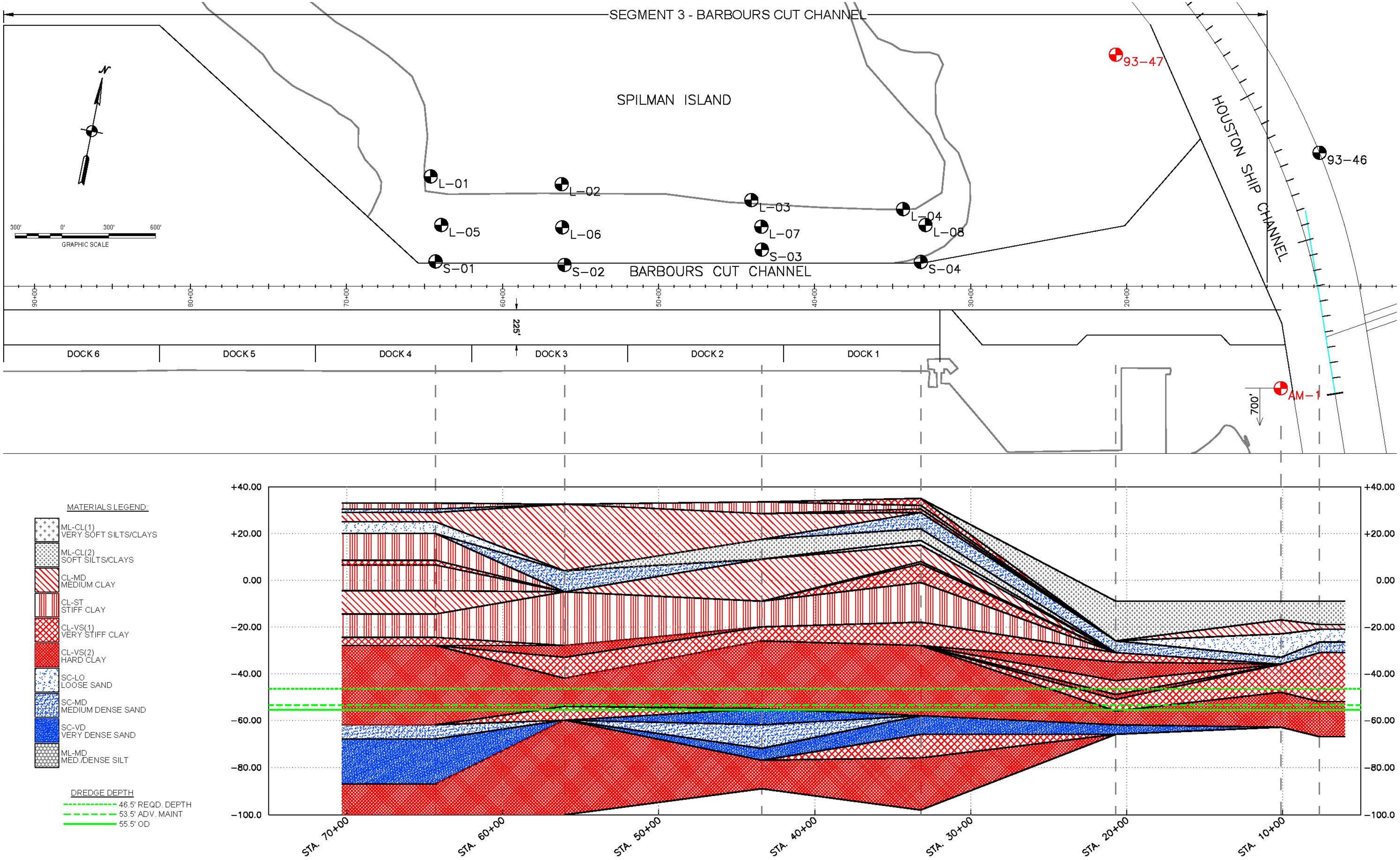

Figure 6-11: Geotechnical Profile Segment 3

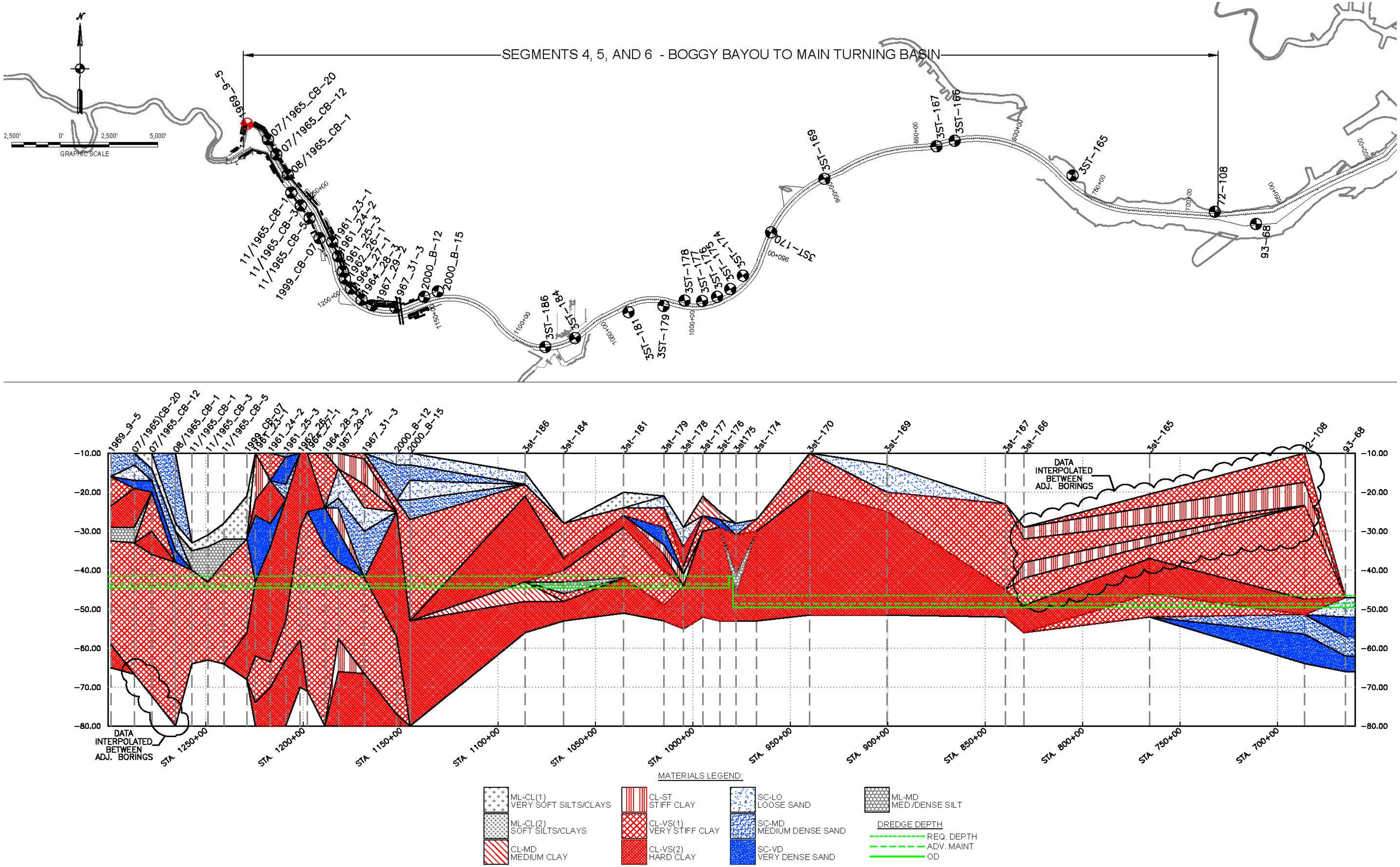

Figure 6-12: Geotechnical Profile Segment 4, 5, & 6

Table 6-2: HSC-ECIP NW Material Classification

Material Type	Segment 1 - CW1_BR-Redfish_700 (w/ Bends)		Segment 1 - CW1_Redfish-BSC_700 (w/Bends)		Segment 1 CW1_BSC-BCC_700 (w/Bends)		Segment 2 CW2_BSC_455		Segment 2 BE2_BSCFlare		Segment 3 CW3_BCC_455 & BETB3_BCCFlare_1800		Segment 4 CW4_BB-GB_530 & CD4_Whole		Segment 5 CD5_Whole		Segment 6 CD6_Whole	
	Bolivar to Redfish Reef (Station 138+369 to 78+844)		Redfish to BSC (Station 78+844 to 28+605)		BSC to BCC (Station 28+604 to -3.94)		BSC (Station 25+58 – 222+76)		BSC Flare (Station 203+66 – 239+78)		BCC + BETB3_BCCFlare_1800NS (Station 8+78 to 67+11)		Boggy Bayou to Sims Bayou (Station 684+03.19 – 974+07.50)		Sims Bayou to I-610 Bridge (Station 1110+77.54 – 1160+62.20)		I-610 Bridge to Main Turning Basin	
	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total	Quantity (CY)	% of Total
Very Soft Silts & Clays	1,637,380	41.75%	3,261,691	37.09%	488,605	9.15%	104,559	4.96%	95,469	4.96%	38,935	1.38%	434,108	12.47%	3	0.00%	818	0.08%
Soft Silts & Clays	415,493	10.59%	2,712,865	30.85%	604,469	11.32%	-	-	-	-	117,654	4.16%	-	-	-	-	-	-
Medium Clays	80,040	2.04%	165,984	1.89%	454,281	8.51%	120,983	5.74%	110,464	5.74%	200,561	7.10%	1,633	0.05%	11	0.01%	32	0.00%
Stiff Clays	631,947	16.11%	339,280	3.86%	528,675	9.90%	1,020,308	48.39%	931,601	48.39%	840,389	29.74%	322,369	9.26%	102	0.06%	2,555	0.26%
Very Stiff Clays	661,585	16.87%	463,883	5.28%	1,178,187	22.06%	539,883	25.61%	492,944	25.61%	487,349	17.25%	1,306,549	37.53%	126,817	72.04%	804,661	80.45%
Hard Clays	94,061	2.40%	0	0.00%	211,612	3.96%	-	-	-	-	776,343	27.48%	1,405,108	40.36%	40,591	23.06%	126,559	12.65%
Loose Sands	148,818	3.79%	193,693	2.20%	891,624	16.69%	56,843	2.70%	51,901	2.70%	146,458	5.18%	2,904	0.08%	2,393	1.36%	1,957	0.20%
Medium Dense Sands	157,293	4.01%	749,880	8.53%	509,163	9.53%	170,273	8.08%	155,469	8.08%	217,696	7.71%	1,781	0.05%	6,029	3.42%	9,157	0.92%
Dense to Very Dense Sands	414	0.01%	589,650	6.71%	406,245	7.61%	8,360	0.40%	7,633	0.40%	-	-	3,360	0.10%	72	0.04%	21,519	2.15%
Medium to Dense Silts	95,101	2.42%	316,945	3.60%	68,081	1.27%	87,277	4.14%	79,689	4.14%	-	-	3,504	0.10%	31	0.02%	32,943	3.29%
Total NW	3,922,130	100%	8,793,872	100%	5,340,943	100%	2,108,485	100.00%	1,925,170	100.00%	2,825,383	100.00%	3,481,316	100.00%	176,049	100.00%	1,000,200	100.00%

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6.4 Maintenance Materials

Maintenance sediments encountered in the HSC consist of mixtures of clay, silt, and sand of varying percentages. Actual grain size for individual dredging operations will vary based on climate conditions such as tropical storms, drought, and floods. Results of historic particle size analyses for maintenance sediment grab samples obtained from the HSC and tributary channels shown in Table 6-3, indicate the percentage of fines (clay and silt particle sizes) ranges from about 43 percent to 91 percent (USACE, 2016a). The balance of the maintenance sediment consists of sand-sized or larger particles.

To calculate short term volumes of dredged materials and estimate capacity in UCPAs a bulking factor of 1.3 will be used for the HSC, BSC, and BCC and 1.1 for the Light Draft Channel. Shrinkage factors (for long term storage) of 0.65 will be used for the HSC, BSC, and BCC and 0.80 for the Light Draft Channel.

Table 6-3: Maintenance Material Sediment Grain Size

Dredging Reach	**Reach Length (feet)**	**Particle Size Distribution**				
		Average Percent Sand	**Average Percent Silt**	**Average Percent Clay**	**Percent Silt & Clay**	**Average D_{50} (mm)**
Bolivar Roads to Redfish Reef	59,525	56.0	19.0	25.0	44.0	0.111
Redfish Reef to BSC	50,239	29.9	34.4	35.7	70.1	0.048
BSC to Morgans Point (BCC)	28,609	22.1	36.4	41.5	77.9	0.031
BSC	21,610	21.4	34.6	44.0	78.6	0.039
Morgans Point (BCC) to Exxon	29,500	20.4	41.4	38.2	79.6	0.038
BCC	8,432	9.0	37.7	53.3	91.0	0.013
Exxon to Carpenters Bayou	22,500	18.7	33.4	47.9	81.3	0.028
Carpenters Bayou to Greens Bayou	31,305	16.2	39.5	44.3	83.8	0.018
Greens Bayou to Sims Bayou	27,772	17.1	55.5	27.4	82.9	0.021
Greens Bayou Channel	10,824	33.0	36.8	30.2	67.0	0.068
Sims Bayou to Upper Turning Basin	15,572	21.4	54.7	23.9	78.6	0.029
Brady Island Channel	5,875	23.6	55.6	20.8	76.4	0.034
Buffalo Bayou Light Draft Channel	21,610	57.5	28.8	13.7	42.5	0.146
Turkey Bend Channel	4,026	50.6	35.8	13.6	49.4	0.088

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7 ENVIRONMENTAL CONSIDERATIONS

7.1 Environmental Engineering

7.1.1 Design of Positive Environmental Attributes into the Project

In citing new dredged material PAs, measures were taken to avoid impacting protected species and avoidance of wetlands and oyster habitat where feasible. If by chance oyster habitat or wetlands were impacted, they are mitigated. Environmental attributes of the project include increasing navigation efficiency and safety and beneficial use of dredge material for land reclamation, creation of bird islands and marshes.

7.1.2 Inclusion Of Environmentally Beneficial Operations And Management For The Project

O&M dredging of the newly created channel is an opportunity to positively benefit the environment. Dredging the channel and removing the sediment will reduce the risk of pilots moving off course. The O&M plan consisted of utilizing existing and newly created PAs.

7.1.3 Maintenance Of Ecological Continuity In The Project With The Surrounding Area And Within The Region

The ecological continuity in the project with the surrounding area and within the region should not be interrupted permanently with the current dredging and material placement plans.

7.1.4 Consideration of Indirect Environmental Costs and Benefits

Indirect environmental costs and benefits were considered in the preliminary layout of the proposed channel improvements and newly created PAs. The proposed measures were designed to avoid environmental habitats as much as possible. The water quality may be affected by turbidity and the exhaust from the dredge during construction and future maintenance may have a minor effect on the degradation of air quality. Improvements to the existing HSC-is not expected to significantly disrupt the environment. The proposed project does not impact Federally listed threated or endangered species or their designated critical habitat.

7.1.5 Integration of Environmental Sensitivity Into All Aspects Of The Project

Consideration has been given to environmental, social and economic effects of proposed project modifications in accordance with NEPA in all aspects of the project.

7.1.6 Perusal Of The Environmental Review Guide For Operations With Respect To Environmental Problems At Similar Existing Projects.

Lessons learned from similar projects by using the Environmental review Guide for Operations (ERGO) will be considered in this design. Environmental issues for this project will be addressed.

7.1.7 Incorporation if Environmental Compliance Measures Into The Project Design

USACE Environmental Operating Principles (EOP) were incorporated into the project design. The EOP principles ensure conservation, environmental preservation and restoration. Coordination with the USFWS and the NMFS under the Endangered Species Act will be done, thereby removing risks of impacts to endangered species or their habitats.

7.2 Mitigation

ER 1105-2-100 requires mitigation of significant unavoidable losses to significant ecological resources (USACE, 2000). Dredging to implement modifications to the channel for the TSP would result in removal of oyster reef and shell hash habitat that have been mapped within the project footprint. If not mitigated for, this would be a permanent impact to the local oyster reef habitat; however mitigation of these impacts will include restoration of healthy oyster reefs damaged by Hurricane Ike through construction of reef pads in Galveston Bay. Further details regarding mitigation is discussed in the Mitigation Plan provided in Appendix P.

7.3 Calculating Impacts to Mapped Oyster Reefs

Prior to 2011, the most recent and comprehensive reef mapping data for Galveston Bay was from a study published in 1994 by Powell et al. Texas Parks and Wildlife Department (TPWD) updated the data in 2011 from Station 2+500 to 52+300. In September 2018, the JV conducted sidescan surveys of the HSC from Station -03.94 to 3+000 and 52+000 to 101+500 to the limits of the proposed 700-foot channel widening. Additional areas surveyed included the project footprint of the BETB3_BCCFlare, and an 1,800-acre area between M10 and Mid Bay where BU areas may be constructed. The JV completed an oyster dredge survey to confirm and more accurately evaluate the results of the sidescan survey.

The 2011 TPWD data in was combined with the 2018 JV survey to create one layer of oyster habitat data. The footprint of each measure was overlaid on the data to calculate potential impacts from the proposed improvements. The optimum area for oyster growth along the HSC begins at the 20-foot depth contour and continues up the slope into shallower water (USACE, 1995). This depth was identified by resource agencies and used to determine impacts to oysters for the Galveston Bay Area Navigation Study for improvements to the HSC. Continuing with this assumption, boundaries for each channel widening measure were created using the 20-foot contour along the existing HSC and the point at which the widened channel daylights with the existing bay bottom. The 20-foot contour was originally in MLT and was converted to -21.31 feet MLLW to be consistent with the new project datum. These limits are identified in Figure 7-1. Where any reef boundary fell within the limits of potential impact the acreage was calculated and combined to estimate the total impact from each measure as provided inTable 7-1.

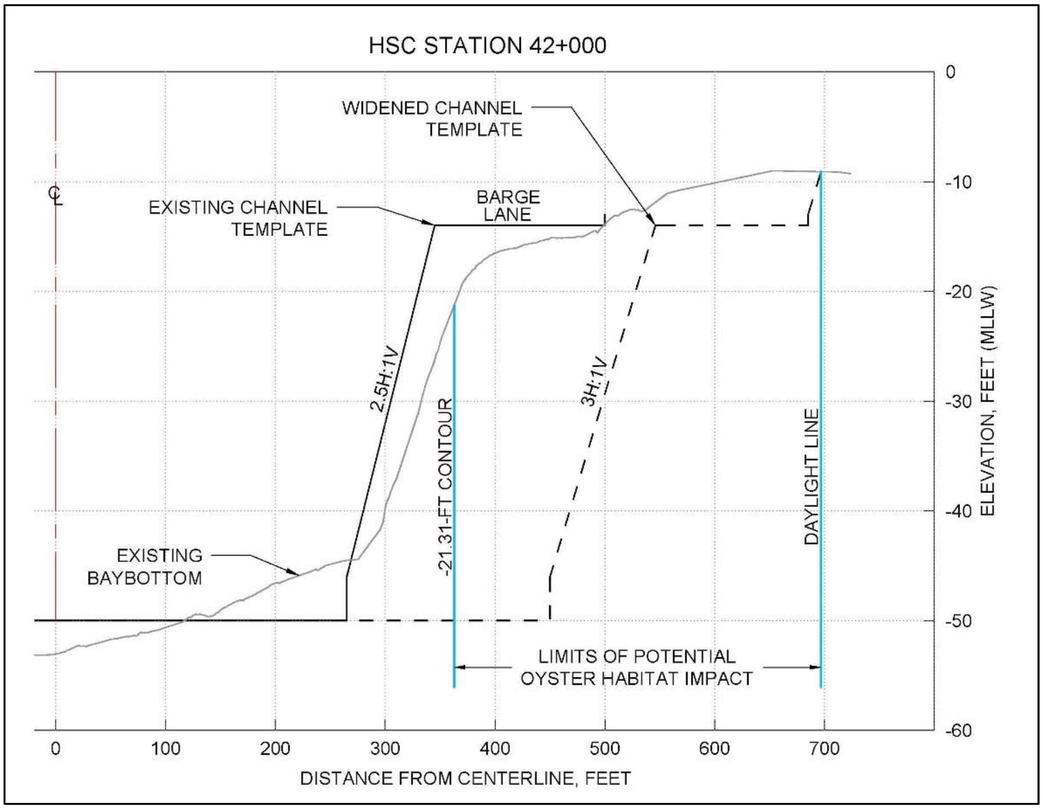

Figure 7-1: Potential Oyster Impact Limits

Table 7-1: Mitigation Requirements

Category	Project Component	Oyster Mitigation Required (Acres)	Bay Bottom Conversion Mitigation Required (Acres)
NED NW Dredging	CW1_BR-Redfish_700	53.9	-
	BE1_028+605_530	11	-
	CW2_BSC_455	3.9	-
	BE2_BSCFlare	10.6	-
	CW3_BCC_455 & BETB3_BCCFlare_1800	3.0	-
LPP NW Dredging	CW1_Redfish-BSC_700	184.5	-
	CW1_BSC-BCC_700	128.2	-
Potential New PA's	Mid Bay Expansion North	5.7	127.5
	Mid Bay Expansion South	32.1	127.5
	Upland Concept 1	0.3	151.9

7.4 Wetlands

Potential wetland areas totaling less than 6 acres are located in areas where sediment normally accumulates along the channel near the confluence of Sims Bayou and the HSC, just upstream and downstream of the BW-8 Bridge, adjacent to the Lynchburg ferry landing, southwest section of Alexander Island PA, and adjacent to the Fred Hartman Bridge. More detail on these areas are provided in Appendix P of the FSEIS. The RP channel improvements would not be expected to have adverse indirect effects to wetlands by inducing landside population growth or changes in land use. The RP would also not be expected to indirectly change the surface hydrology or reduce tidal inundation of wetlands. Another mitigation cost accounted for is for impacts to forest and herbaceous shrub at the BW-8 (30.0 acres) and E2C (6.3 acres) tracts. This mitigation is to be paid into an FCU mitigation bank as described in Appendix P of the FSEIS.

7.5 Hazardous and Toxic Materials

To complete a feasibility level hazardous, toxic, and radioactive waste (HTRW) evaluation for the HSC ECIP, following the rules and guidance of ER 1165-2-132, *HTRW Guidance for Civil Works Projects* (USACE, 1992), and ASTM E1527-13 *Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process* (ASTM International, 2013) was conducted and is provided in Appendix G. The proposed project occurs entirely in-water, so per civil works guidance, no HTRW sites are found within the project footprint. However, several HTRW sites can be found in near proximity to the proposed project footprint. These sites are listed below, along with the action recommendation.

Table 7-2: HTRW Sites Near Project Vacinity

Site	Location	REC	Action Recommendation
Patrick Bayou	1.8 mi E of BW-8 bridge, Harris County	NPL site, sediment contaminated with PAHs, metals, and PCBs	Avoidance of widening measures in this area to the HSC
San Jacinto Waste Pits	Immediately N of I10 bridge @ San Jacinto River, Channelview	NPL site, sediment contaminated with dioxin	Chemical sediment quality sampling within HSC portion of AOC, in accordance with 2009 EPA public notice
Pasadena Refining System	0.25 mi E of Washburn Tunnel, Pasadena	Past RCRA investigations and corrective actions, TSDF, active institutional controls	Avoidance of widening measures in this area to the HSC
South Coast Terminals	0.1 mi E of I-610 bridge, Houston	Past state enforcement orders, active VCP remediation ongoing, soil and GW contaminated with VOCs, BTEX, and PAHs	Avoidance of widening measures in this area of HSC
Lone Star Industries	0.1 mi E of Brady Island, Houston	Active VCP investigation ongoing, soil and GW contaminated with VOCs, SVOCs, metals, and TPH	Avoidance of widening measures in this area of HSC
Pasadena Terminal	0.4 mi S of Hunting Bayou, Pasadena	Past state enforcement orders, active institutional controls	Avoidance of widening measures in this area to the HSC
Oxid, LP	0.1 mi E of I-610 bridge, Houston	Active VCP remediation ongoing, soil and GW contaminated with solvents and metals	Avoidance of widening measures in this area of HSC

An HTRW evaluation was also conducted for the proposed new upland PAs, E2 Clinton, Rosa Allen Extension, and Beltway 8. Neither E2 Clinton nor Rosa Allen Extension had any HTRW concerns. The Beltway 8 property has an HTRW history, but discussion with the TCEQ indicated the site was safe for proposed use as an upland PA. Refer to Section 1.3.7.1 of Appendix G for further discussion of Beltway 8.

7.6 Salinity Modeling with AdH

This is abstracted from an ERDC Technical Report "Houston Ship Channel 45-Foot Expansion Channel Improvement Project (ECIP) Numerical Modeling Report" by Jennifer McAlpin, Cassandra Ross, and Jared McKnight, ERDC.

Hydrodynamic and salinity modeling of present conditions is complete. Initial runs were provided to SWG, feedback was returned, and models were rerun. Problems with matching model results and measurements of salinity in Trinity Bay were resolved on later runs by (a) adjusting diffusion and bed roughness that were unmeasured within the acceptable range and (b) rainfall and evaporation were added.

SWG provided a project alternative that includes channel widening, deepening, and bend easing. The model is run for "present" year zero (2029) and "future" year 50 (2079) with and without project.

The model shows that the salinity does not vary greatly when the project is in place. Changes to salinity are 2 ppt or less. The tidal prism increases by less than 2% when the project is included and the tidal amplitudes increase by no more than 0.01 m. The residual velocity vectors do vary in and around areas where project modifications are made – along the HSC, BSC, and BCC.

7.6.1 Model Results

SWG provided a project alternative that includes channel widening, deepening, and bend easing. The model is run for "present" year zero (2029) and "future" year 50 (2079) with and without project.

The model shows that the salinity does not vary greatly when the project is in place. Changes to salinity are 2 ppt or less. The tidal prism increases by less than 2% when the project is included and the tidal amplitudes increase by no more than 0.01 m. The residual velocity vectors do vary in and around areas where project modifications are made – along the HSC, BSC, and BCC.

The variation in salinity between present and future conditions is significant as expected. The rise in water surface elevation due to sea level changes as well as a reduction in freshwater inflow for future conditions generates very different salinity magnitudes throughout the analysis year. In most locations the mean salinity is larger for the future conditions. However, the variation in salinity between with and without project alternatives is quite small for most locations – generally less than 2 ppt. The largest variation in salinity between with and without project results is in the upstream locations of the HSC. The salinities are almost identical near the entrance but begin to diverge further into the system at Mid Bay Marsh, Morgan's Point, and locations further up the HSC. However, the change in the mean salinity between with and without project remains within 2 ppt. This behavior is visible in the point analysis as well as in the cross sectional analysis to be discussed in the next section. The time history of salinity includes dotted lines for 10 ppt and 15 ppt thresholds. The with project conditions generally maintains the pattern of the salinity over time but does increase above these thresholds for short periods of time at some locations.

7.6.2 Salinity Slice Analysis

A slice along the center of the HSC from the Gulf of Mexico to the HSC Turning Basin allows for the comparison of the salinity wedge migration along the ship channel. These results are for mean salinity over the year-long analysis period. Figure 7-2 shows the location of key features along the HSC for reference.

Figure 7-3 shows the mean salinity along the HSC for all four alternatives. Again, when viewing these results, focus on changes between the present with and without project separately from the future with and without project in order to isolate impacts due to the project.

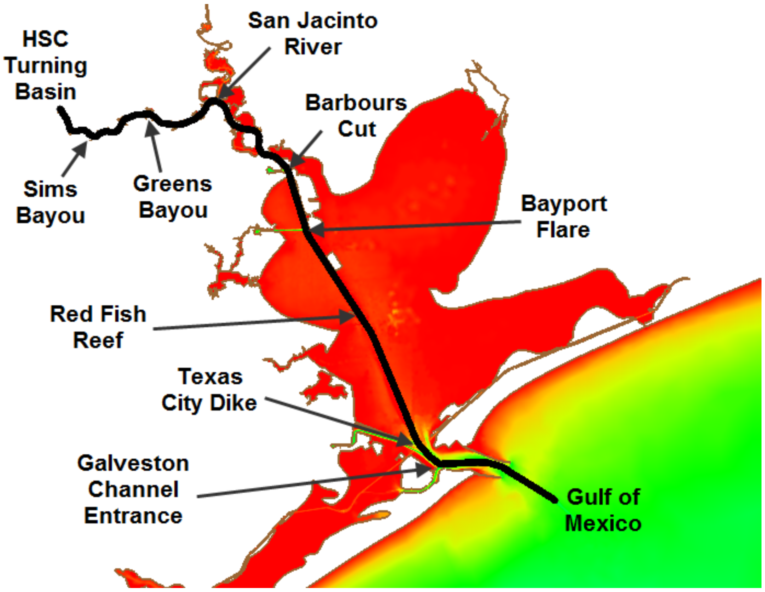

Figure 7-2: HSC key feature refecnce map

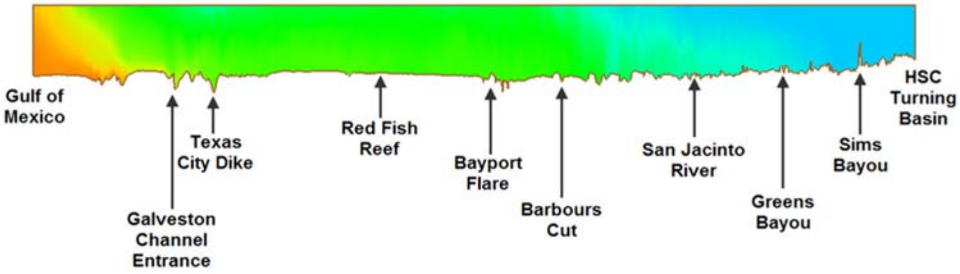

Figure 7-3: HSC slice analysis reference map

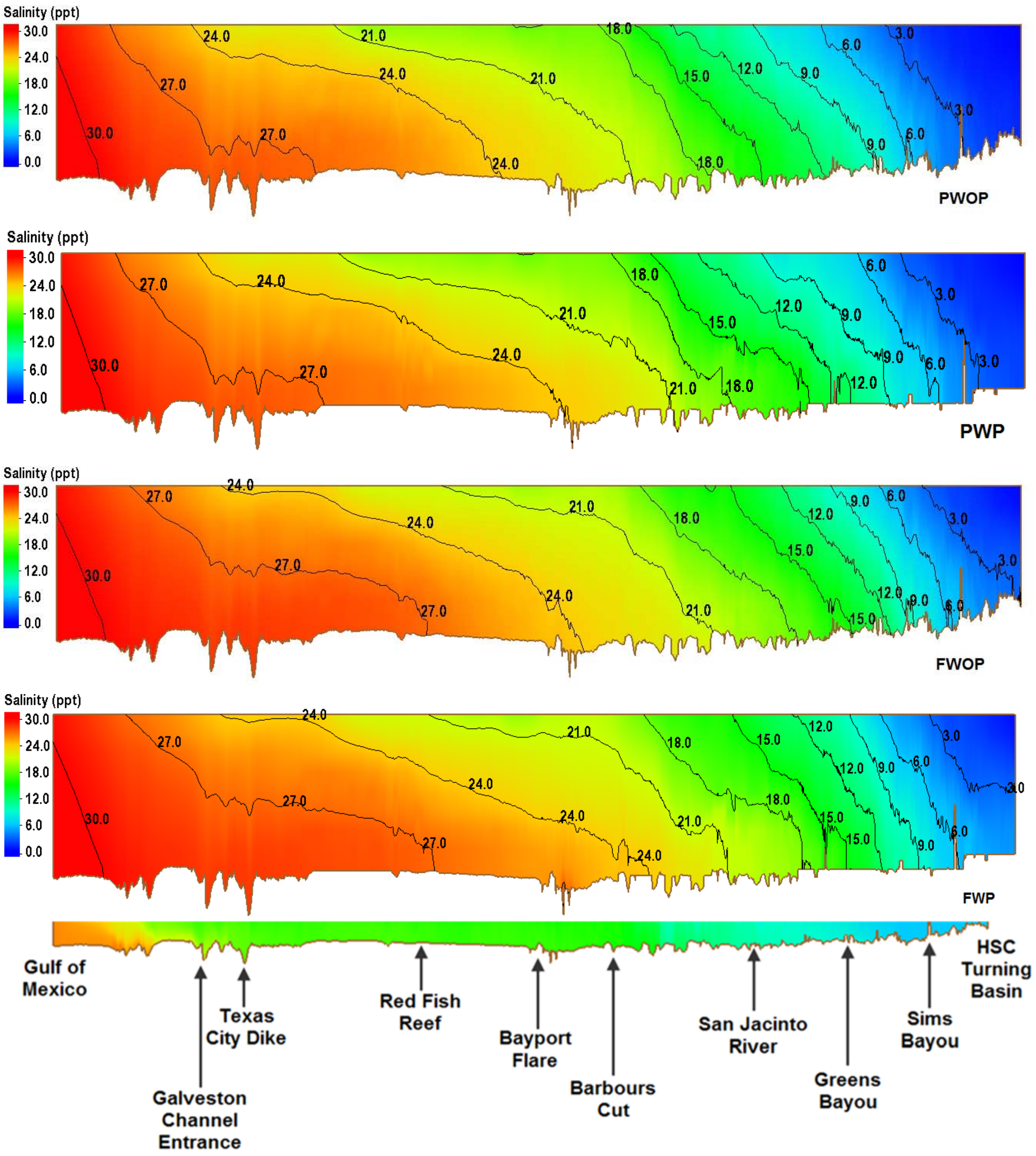

Figure 7-4: HSC average sality slice results

7.7 Dissolved Oxygen

Analysis of dissolved oxygen (DO) of the GBANC is discussed in detail in Appendix G.

8 REAL ESTATE

8.1 Real Estate Considerations

The NFS is responsible for acquiring and furnishing all lands, easements, rights-of-way, relocations (i.e., P.L. 91-646 relocations and utility/facility relocations), borrow material, and dredged or excavated material disposal areas (LERRD) for the project, if required. The real estate requirements for the Project must support construction as well as the continued operation and maintenance of the Project.

8.1.1 Lands, Easements, and Rights-of-Way

This channel improvement project will overlap the existing HSC project as discussed in the "Purpose" section of the Real Estate Plan (REP). The alignment of the NED Plan and LPP is located mostly on open waters of Galveston Bay and HSC. Portions of the additional submerged lands required over Galveston Bay are owned by TxGLO and would be utilized under navigational servitude. A total of 50 TxGLO submerged tracts were identified as being utilized under navigational servitude. These tracts are located These tracts are located from Bolivar Roads to Barbers Cut. A table of these tracts is shown in the REP, Exhibit D. A total of 45 Tracts were identified as NFS owned land via patent by the State of Texas. The PHA currently has a development easement extending approximately 230 feet from the improved channel toe along the north side of the BSC for future development. A table of these tracts is shown in the REP, Exhibit E. These submerged lands are located at the BSC and BCC through the upper bayou of this project.

Segment 6 will include turning basin improvements at Brady Island, which will require the land shaving of 0.096 acres requiring land acquisition in fee. As additional requirement for this feature is a one-acre staging/temporary work area easement on Brady Island situated adjacent to the Brady Island land shaving feature for the term of one year. Access to the staging area will utilize public roads leading into Brady Island.

9 UTILITIES AND FACILITIES

As the underlying property owner of most submerged lands in Harris County, the NFS licenses the use of these lands to third parties, such as pipeline owners. The NSF currently tracks over 1,000 pipeline licenses and easements across its properties. As such, the NFS conducted an analysis of pipelines crossing the channel where proposed improvements to the channel were stated at the TSP level. The data was derived from PHA license data, permit documents, as-built documents, and state and Federal databases. For the pipelines within Chambers and Galveston Counties, the NFS contacted the pipeline companies disclosed in State databases such as the Texas Railroad Commission and Texas General Land Office. PHA has assessed all available data for pipelines crossing the HSC and this report focuses efforts on the pipelines with potential impact. PAs, BU areas, and mitigation sites were located in such way to not impact pipelines or assumed to allow for a symbiotic coexistence.

Approximate locations of pipelines shown on Engineering Plates were downloaded from the Texas Railroad Commission. Pipeline locations are only as accurate as the data sources and must be verified by the construction designer Engineer-of-Record and the construction contractor prior to construction.

During TSP, 103 potential conflicts were evaluated. In post ADM analysis, this number was reduced to 58 potential pipeline conflicts. Of these 58 identified pipelines, 14 pipelines will require additional evaluation during PED, but have been slated for removal and relocation in this documentation for budgeting purposes. One pipeline in Segment 1 has been identified to have less than optimal cover after project completion and would require more detailed analysis during PED. The remaining 13 pipelines all are located in Segment 4. Nine pipelines have been targeted to having less than ten feet cover along parts of the pipeline after the channel has been deepened or widened with significant overdepth provided. Although presented within this documentation to be relocated, four of these pipelines are candidates to remain in place with additional anchoring to ensure no further future movement. The remaining five pipelines (two corridors) are expected to be relocated as the expected remaining cover along the edges are within construction instrumentation tolerance and risk of damage would be almost certain without relocation.

A few pipelines, usually abandoned in place, may predate documentation of such and present a risk of being discovered during construction. The full list of pipelines evaluated, and corresponding costs are located in Attachment 2 of this Appendix. Pipeline specific information is available upon request.

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10 COSTS

10.1 Introduction

10.1.1 General

The following section identifies the measures evaluated and assumptions used in development of the cost estimates for the HSC-ECIP. The cost components are broken out into categories that include dredging, earthwork, and ancillary. Costs have been developed for both the initial construction (1st costs) and for 50 years of operation and maintenance (O&M). Where practical, cost development was held consistent between various options in order to rapidly evaluate numerous scenarios; where distances, quantities, and materials are the changing variables affecting costs. For new work dredging, the costs only include the pay quantity costs of the required material to be removed. Non-pay over-dredging by the contractor was not considered in total prices, but rather incidental to the new work dredging. For O&M, the quantities used were those as described in Table 5-10, and include non-pay quantities.

10.1.2 Equipment & Labor

This report identifies the measures evaluated and assumptions used in development of the cost estimates for the HSC-ECIP. The cost components are broken out into categories that include dredging, earthwork, and ancillary. Costs have been developed for both the initial construction (1st costs) and for 50 years of operation and maintenance (O&M). Where practical, cost development was held consistent between various options in order to rapidly evaluate numerous scenarios; where distances, quantities, and materials are the changing variables affecting costs.

10.2 Project First Costs

10.2.1 General

The project measures include various options for improvements to the HSC, as well as the connected channels BSC and BCC. These measures require the dredging of new work (NW) materials. The study locations are broken up by segments. Segment 1 consists of three HSC reaches, Bolivar Roads to Redfish, Redfish to BSC, and BSC to BCC. Segment 2 is the BSC and Segment 3 is BCC. Segment 4 includes the HSC reaches of Boggy Bayou to Greens Bayou and Greens Bayou to Sims Bayou. Segment 5 is Sims Bayou to the I-610 Bridge and Segment 6 is between the I-610 Bridge through the Main Turning Basin. Dredging cost estimates are a function of the material to be dredged and where/how the material is to be placed. Additional criteria are derived therefrom and include the selected plant, shoreside costs, and costs of ancillary tasks.

The locations of dredging construction included in the study are provided below for both NED and LPP versions:

Table 10-1: HSC-ECIP Study Channel Measures

PLAN	SEG.	MEASURE	STATION(S)	DESCRIPTION
NED	1	CW1_BR-Redfish_700	138+369 – 078+844	Widen HSC between Bolivar to Redfish to 700-foot width. Includes bend easings.
			078+844 – 073+934	Bottleneck transition back to existing 530-foot channel.
		BE1_028+605_530	031+171 – 028+605	Bend easing within Redfish to BSC reach.
			028+605 – 026+028	Bend easing within BSC to BCC reach.
	2	CW2_BSC_455	025+58 – 222+76	Widen BSC on north side to 455-foot width.
		BE2_BSCFlare	203+66 – 239+78	Widen BSC south side flare radius to 5,375 feet.
	3	CW3_BCC_455	24+69 – 67+11	Widen BCC on north side to 455-foot width.
		BETB3_BCCFlare_1800	08+78 – 30+84	Widen BCC flare on north and south to create 1,800-foot diameter turning basin.
	4	CW4_BB-GB_530	684+03 – 833+05	Widen HSC between Boggy Bayou to Greens Bayou to 530-foot width.
		CD4_Whole (1)	684+03 – 974+08	Deepen HSC between Boggy Bayou to Hunting Turning Basin
	5	CD5_Whole	1110+78 – 1160+62	Deepen HSC between Sims Bayou to I-610 Bridge.
	6	CD6_Whole	1266+49=00+00 – 30+95	Deepen HSC between I-610 Bridge and Main Turning Basin.
		TB6_Brady_900	1189+15.688 – 1203+14.265	900-foot Turning Basin at Brady Island
LPP Add'l Work	1	CW1_Redfish-BSC_700(2)	073+934 – 028+605	Widen HSC between Redfish to BSC to 700-foot width. Includes bend easings.
		CW1_BSC-BCC_700(2)	028+605 – (-)3.94	Widen HSC between BSC to BCC to 700-foot width. Includes bend easings.

Notes:

1. For dredging/cost purposes these measures were separated as *Boggy to Greens* and *Greens to Sims*, where *Boggy to Greens* includes both the widening (where applicable) and deepening, and *Greens to Sims* includes only deepening (to Washburn Tunnel).
2. If full bay widening extended, eliminates need for BE2_BSCFlare

10.2.2 NW Materials to be Dredged

As detailed in Section 6.3, historical boring logs were reviewed to determine the material types for the proposed channel measures. This analysis found that parts of Bolivar to Redfish and Redfish to BSC have a higher than desired percentage of very soft to soft silts and clays. These materials are difficult, if not impossible, to build new sites with via hydraulic pumping as they generally do not fall out at the end of the dredge pipe, but rather run out with little to no retainage. Therefore, the alternative to using for construction would be to mechanically dredge the sections of predominantly softer material, and only use the sections with generally suitable material for new site construction projects. These reaches are re-presented broken out accordingly below.

Table 10-2: Segment 1 – Bolivar to Redfish Materials (Reach Separation by Quality)

Material Type:	Station 138+369 to 100+000		Station 100+000 to 78+844	
	Quantity (CY)	% of Total	Quantity (CY)	% of Total
Very Soft Silts & Clays	91,530	4.59%	1,545,850	80.15%
Soft Silts & Clays	79,101	3.97%	336,392	17.44%
Medium Clays	80,030	4.01%	10	0.00%
Stiff Clays	631,836	31.69%	111	0.01%
Very Stiff Clays	661,553	33.19%	32	0.00%
Hard Clays	94,050	4.72%	11	0.00%
Loose Sands	105,819	5.31%	42,999	2.23%
Medium Dense Sands	154,116	7.73%	3,176	0.16%
Dense to Very Dense Sands	404	0.02%	10	0.00%
Medium to Dense Silts	95,091	4.77%	10	0.00%
Total NW	1,993,531	100%	1,928,600	100%

Table 10-3: Segment 1 – Redfish to BSC Materials (Reach Separation by Quality)

Material Type:	Station 78+844 to 57+000		Station 57+000 to 28+604	
	Quantity (CY)	% of Total	Quantity (CY)	% of Total
Very Soft Silts & Clays	2,370,358	66.16%	891,335	17.10%
Soft Silts & Clays	1,048,646	29.27%	1,664,219	31.94%
Medium Clays	128,755	3.59%	37,229	0.71%
Stiff Clays	498	0.01%	338,781	6.50%
Very Stiff Clays	487	0.01%	463,396	8.89%
Hard Clays	0	0.00%	0	0.00%
Loose Sands	14,350	0.40%	179,344	3.44%
Medium Dense Sands	338	0.01%	749,573	14.38%
Dense to Very Dense Sands	18,988	0.53%	570,662	10.95%
Medium to Dense Silts	338	0.01%	316,607	6.08%
Total NW	3,582,727	100%	5,211,146	100%

In general, the south side of Bolivar to Redfish has materials in line with those typically used for new site construction. There is a large area within the north side of Bolivar to Redfish and the south side of Redfish to BSC (Stations 57+000 to 100+000) with a high concentration of soft and very soft silts and clays. The material gets again more suitable in the north side of Redfish to BSC and significantly better throughout BSC to BCC.

10.2.3 NW Placement Options

Potential options were developed to use the new work dredge materials from the proposed measures to determine options to develop the least cost plan. Not all of tese options are constructed. Options include new marshes and UCPAs for O&M capacity; and UCPAs for new work site fill only (bird islands, instant marshes, etc.) Each option includes its own assumptions applicable for dredging. Each channel segment and/or reach establishes discrete alternatives that utilize all the new work and maintenance for that segment and/or reach. Options may be constructed from multiple reaches as developed in options. I.e., options falling in vicinity of Redfish to BSC reach may ultimately be constructed from new work materials from BSC or BSC to BCC reach, etc. All options below and including BCC assume the use of a 30-inch hydraulic dredge. Options above BCC assume use of a 24-inch dredge. The potential options are provided below.

Table 10-4: NW Placement Options

Placement Option	Description	NW Qty. Req. (CY)
8-acre Bird Island	New apprx. 8-acre emergent bird island habitat • Assumes use of 30-inch hydraulic dredge • 2,227 feet of armored shoreline requiring 16,385 tons of armor stone • No new O&M capacity created	911,000
Long Bird Island	New apprx. 6-acre emergent bird island habitat with adjacent oyster reef/wave trip • Assumes use of 30-inch hydraulic dredge • 2,237 feet of armored shoreline requiring 13,528 tons of armor stone • 100-feet in width by 1,748 feet long oyster reef wave trip requiring 21,236 tons of cultch material • No new O&M capacity created • Creates apprx. 4-acre oyster mitigation credit	1,172,000
Bolivar New Marsh	New apprx. 37-acre marsh constructed to marsh grade (+1.3’ MLLW +/-) • Assumes use of 30-inch hydraulic dredge • 3,803 feet of armored shoreline requiring 24,290 tons of armor stone • Requires increased level of construction effort from shaping both constructed dike and interior fill elevations/channelization/etc. • No new O&M capacity created • Eliminated in screening	1,994,000
Mid Bay Expansion North	New 293-acre UCPA expansion on north side of existing Mid Bay DMPA • Assumes use of 30-inch hydraulic dredge • 10,297 feet of armored shoreline requiring 72,732 tons of armor stone • Requires relocation of Boaters Cut channel • Est. 32,300,000 CY O&M capacity created • Creates 5.7 acres of increased oyster impact • Creates 128 acres of bay bottom impact • Eliminated in screening	2,800,000
Mid Bay Expansion South	New 293-acre UCPA expansion on south side of existing Mid Bay DMPA • Assumes use of 30-inch hydraulic dredge • 10,297 feet of armored shoreline requiring 72,732 tons of armor stone • No required relocation of Boaters Cut channel • Est. 32,300,000 CY O&M capacity created • Creates 32.1 acres of increased oyster impact • Creates 128 acres of bay bottom impact • Eliminated in screening	2,800,000
Upland Concept 1	New 340-acre UCPA north east of existing Mid Bay DMPA • Assumes use of 30-inch hydraulic dredge • 16,824 feet of armored shoreline requiring 118,109 tons of armor stone • No required relocation of Boaters Cut channel • Est. 37,552,000 CY O&M capacity created • Creates 0.3 acres of increased oyster impact • Creates 152 acres of bay bottom impact • Eliminated in screening	4,500,000

Bird Island Marsh	New 402-acre marsh placement area with three attached bird islands, east of existing Mid Bay DMPA • Assumes use of 30-inch hydraulic dredge • 15,672 feet of armored shoreline requiring 94,774 tons of armor stone • 100-feet in width by 6,375 feet long oyster reef wave trip requiring 74,855 tons of cultch material • Est. 6,300,000 CY O&M capacity created • Creates apprx. 11.1-acre oyster mitigation credit	4,270,000
Atkinson Marsh Cell M11	New 445-acre marsh cell at Atkinson Island • Assumes use of 30-inch hydraulic dredge • 9,455 feet of wide unarmored dike with flat slope • Est. 9,500,000 CY O&M capacity created	2,800,000
Atkinson Marsh Cell M7/8/9	Repair/complete existing marsh cell at Atkinson Island • Assumes use of 30-inch hydraulic dredge • Completion of wide unarmored dike with flat slope • Est. 1,735,000 CY O&M capacity created	600,000
Atkinson Marsh Cell M12	New 273-acre marsh cell at Atkinson Island • Assumes use of 30-inch hydraulic dredge • 7,785 feet of armored shoreline requiring 49,723 tons of armor stone • Includes sweeping cedar bayou upon completion • Est. 6,000,000 CY O&M capacity created	4,500,000
BSC Sedimentation Attenuation Feature	New emergent dike for sedimentation diversion to decrease shoaling at BSC Flare • Assumes use of 30-inch hydraulic dredge • 9,400 feet of armored shoreline (all sides) requiring 318,773 tons of armor stone • No new O&M capacity created	800,000
Spilman Island NW Berm	New work placed into a berm along the interior side of existing dike to stockpile for future dike raise • Assumes use of 30-inch hydraulic dredge • No new O&M capacity created • Eliminated in screening	2,825,000
Alexander Island New Marsh	New apprx. 57-acre marsh constructed to marsh grade (+1.3’ MLLW +/-) • Assumes use of 30-inch hydraulic dredge • 3,854 feet of armored shoreline requiring 24,616 tons of armor stone • Requires increased level of construction effort from shaping both constructed dike and interior fill elevations/channelization/etc. • No new O&M capacity created • Eliminated in screening	2,825,000
Beltway 8 Tract	New work placed into even lifts onto PHA BW-8 Tract • Assumes use of 24-inch hydraulic dredge • Apprx. 5-foot of fill on property • Initial apprx. 9-foot dike creation to contain fill • Installation of one spillbox • No new O&M capacity created	2,920,000
E2 Clinton	New work placed into even lifts onto PHA E2Cn Tract • Assumes use of 24-inch hydraulic dredge • Apprx. 5-foot of fill on property • Initial apprx. 9-foot dike creation to contain fill • Installation of one spillbox • Includes real estate costs • No new O&M capacity created	562,000

Glendale	New work placed into even lifts onto existing Glendale PA • Assumes use of 24-inch hydraulic dredge • Apprx. 3-foot of fill on property • Initial apprx. 7-foot dike raise to contain fill • Assumes use of existing spillboxes • No new O&M capacity created	910,000
Filter Bed	New work placed into even lifts onto existing Glendale PA • Assumes use of 24-inch hydraulic dredge • Apprx. 2-foot of fill on property • Initial apprx. 6-foot dike raise to contain fill • Assumes use of existing spillboxes • No new O&M capacity created	267,000
Rosa Allen Expansion	New work placed into even lifts onto PHA Rosa Allen Expansion Tract • Assumes use of 24-inch hydraulic dredge • Apprx. 5-foot of fill on property • Initial apprx. 9-foot dike raise to contain fill • Installation of one spillbox • Includes real estate costs • No new O&M capacity created • Assumes site not used for future O&M	1,177,000

10.2.4 NW Production Variables

10.2.4.1 Pipeline Lengths

Production rates were developed for all dredging scenarios. For the NW dredging, the materials derived from the boring logs were used for each reach. The various proposed new sites for construction were used for development of lines and lengths. NW dredging by hydraulic methods was assumed pump limited. Clamshell dredging production rates were determined based predominantly on sail distances as well as equipment operating capacities.

Table 10-5: New Work Dredging Pipeline Lengths

Reach	Placement Location	PL Min. (FT)	PL Max. (FT)	PL Avg. (FT)
Bolivar - Redfish (100+000 to 138+369)	8-AC Bird Island	10,500	32,500	23,000
	Long Bird Island	10,500	42,000	23,000
	Bolivar Instant Marsh	13,000	37,000	26,000
Redfish - BSC (028+604 to 057+000)	Bird Island Marsh	20,500	45,000	30,000
	Mid Bay Exp. S	10,500	31,500	18,500
	Mid Bay Exp. N	10,500	29,000	20,000
	Upland Concept 1	23,500	42,000	33,000
	M11	17,500	46,000	31,500
BSC - BCC (-3.94 to 028+604)	Upland Concept 1	26,000	55,000	40,500
	Mid Bay Exp. N	17,000	46,000	31,500
	Mid Bay Exp. S	26,500	55,000	41,000
	M11	10,500	32,000	20,000
	M12	9,500	38,500	24,000
	Bird Island Marsh	33,000	61,500	47,000

BSC/BSC Flare (25+58 to 239+00)	Sedimentation Attenuation	1,500	26,000	11,500
	Upland Concept 1	21,000	43,000	32,000
	Mid Bay Exp. N	22,000	44,000	33,000
	Mid Bay Exp. S	36,000	58,000	47,000
	Bird Island Marsh	37,500	59,000	48,500
	M11	20,000	41,500	31,000
BCC/BCC Flare (8+78 to 67+11)	M12	12,000	18,000	15,000
	Spilman Island	1,000	12,500	10,000
	Alexander Marsh	26,000	30,000	28,000
Boggy - Greens (676+54 to 850+00)	BW-8 Tract	5,500	18,500	11,000
Greens – Sims (850+00 to 974+08)	E2C	13,500	21,500	18,000
Sims – 610 (1110+78 to 1160+62)	Glendale	7,000	21,000	12,000
610 – Turning Basin (1160+62 – 1266+48)	Glendale	5,000	8,000	6,000
Upper Bayou (00+00 – 30+95)	Filterbed	25,000	44,000	34,500

10.2.4.2 Haul Distances

As discussed previously, a portion of the new work materials that lie between Bolivar to Redfish and Redfish to BSC, between approximate Station 57+000 to 100+000, are considered unsuitable for new construction as per the available geotechnical data. This material will then be mechanically dredged and hauled offshore to ODMDS. Average production rates were developed for bucket dredging assuming a range of bucket sizes from 24 to 30 CY bucket sizes based on the materials, depths, haul distances, and standard equipment operating capabilities. For the reach, haul distances were determined as 18.1 nautical miles (nm) minimum, 25.1 nm maximum, and 21.6 nm average.

10.2.5 NW Cost Considerations

Costs were estimated at 2018 price levels and assume standard construction practices. Equipment rates were derived from dredging experience, industry contractors, and several construction and equipment vendors. Labor rates were based on current industry typical standards.

10.2.5.1 Mobilization

Mobilization and demobilization costs are difficult to estimate. This is in part due to industry growing more accustomed to rolling in additional profit and/or overhead costs and assumed risk into this line item. Additionally, it is impossible to determine the exact locations from where equipment will be mobilized. It is assumed that the necessary dredging plant to be mobilized is located within approximately 500 nautical miles of the project site. Mobilization costs vary due to several factors including pipe required, equipment, personnel, and difficulty/type of work. I.e. mobilization for NW construction is generally much greater than that for O&M. Therefore, in order to develop estimated mobilization/demobilization costs for these estimates, historical pricing was analyzed for numerous past NW projects. The values were averaged and then inflated from the mid-point year to the study price year (2018).

Mobilizations for ancillary tasks were determined on case by case basis and assumed estimated actual equipment/labor costs required for transportation and setup of equipment. These options assumed approximately two weeks for mobilization.

10.2.5.2 Dredging Prices

Production analyses were run for each placement option based upon the material properties, pipeline and/or hauling distances, and equipment. These rates vary by location. Dredging unit costs were developed by estimating monthly operating and ownership costs of the dredges and attendant plant. The monthly operating costs were determined by calculating payroll costs, usage, repairs and maintenance, wear costs, marine insurance, fuel, operating supplies and consumables, and engineering and supervision for the operation of the various pieces of plant. Fuel cost used for all estimates was $3.00/gallon. The operating costs for the various components vary in the dredge pipe requirements, energy costs, equipment, and personnel required for the work and to accommodate multiple placement sites and locations of work.

The operating costs are the costs of owning and maintaining the various pieces of dredging equipment and attendant plant. Estimated ownership costs provide for amortization (depreciation and interest on capital invested), periodic major repairs, the cost of an idle plant, the cost of yard facilities, and taxes and insurance. The operating and ownership costs are multiplied by the time required to perform the dredging based on the applied production rates and then summed. Additional cost percentages are added to this value to account for overhead, profit and bond. Finally, the cost of the work is divided by the dredge quantity to get a unit cost for the work.

10.2.5.3 Hydraulic Fill Shaping

This work item represents the landside work associated with new work dredging/new site construction. The operations are assumed to occur concurrently with the new work dredging, lasting for the duration of dredging, plus approximately 1 month for final shaping and grading. In the cases of new marsh construction (Bolivar New Marsh and Alexander New Marsh), where a marsh is to be constructed to grade, an additional month was added. This is to account for the 1 month required for final shaping and grading of the dikes, plus another month for shaping of the placed NW fill, circulation, channelization, etc.

10.2.5.4 Shore Protection

Typical sections were developed for the proposed dikes to be armored. These sections varied in dimensions. Total rock tonnages were calculated for each section for each placement area protected shoreline lengths assuming 165 PCF rock density with 38% voids. Based on a review of historical contract data, a rock price was developed and inflated to the study price year. The derived cost of $96.70/ton was then multiplied by the tonnage required.

10.2.5.5 Cultch Installation

Two of the proposed new work construction options include areas of proposed oyster promoting wave trip features. These include the Long Bird Island and Bird Island Marsh. Cultch rock tonnages were applied over the sections and include an assumed 35% voids and a rock density of 150 PCF. Based on a review of historical contract data, a cultch rock price was developed and inflated to 2018 dollars. The derived cost of $60/ton was then multiplied by the tonnage required.

10.2.5.6 Initial Dike Raising

This cost is applicable where new work materials are proposed to be placed onto upland tracts requiring an initial dike raise and includes the options at BW-8 Tract, E2C, RAE Tract, Filter Bed, and Glendale. For these considerations, an initial dike raise cost was developed for a raise height equal to the approximate fill height plus two feet of ponding and two feet of freeboard. The costs include initial dike raising heights of approximately 9-10 feet for BW-8, E2C, and RAE, 7 feet at Glendale, and 6 feet at Filter Bed. Quantities were developed assuming a 25-foot crown width, 3H:1V side slopes, and cut to fill loss percentage of 40% to account for losses and compaction. Additionally, included in dike raising are cost components for stripping, clearing, and grubbing prior to construction; as well as turfing post-construction.

10.2.5.7 Real Estate

Certain placement area options would contain associated real estate costs. These locations include the BW-8 Tract, E2C, and RAE. For estimating and screening purposes, real estate costs were retrieved from the Harris County Central Appraisal District (HCAD). USACE real estate costs are used in the final MCACES.

10.2.5.8 Spillboxes

New placement areas require installation of spillboxes. For these estimates, two new boxes were assumed for all newly constructed areas that would receive O&M material in the future. For BW-8 and E2C, as these areas are one time use sites for a single Federal dredging event of NW placement, only one spillbox was assumed. Historical prices were evaluated and averaged and inflated to the study pricing year, which was approximately $350,000/spill box. The spill box would be set in place and the dikes constructed around it. H-piles would not be necessary.

10.2.5.9 Mitigation

Due to environmental impacts resulting from the work, mitigation is required. There are two types of impacts considered in the Bay, oyster reef and bay bottom conversion. For impacted oyster reef, mitigation requirements are to construct new oyster reef in replacement. For bay bottom conversion where bay bottom is converted from underwater habitat to upland habitat (for example with new UCPA creation); mitigation can be a new environmentally beneficial feature, such as marsh creation.

For oyster mitigation, typical construction consists of cultch material placement. Pads are built of varying thickness (generally around 2.5 feet), with the constructed acreage being what meets the mitigation requirement. This is to be the case for mitigation required of the NED plan and would be constructed on a per contract/measure basis. For the LPP plan, a much larger mitigation acreage would be required. It was thus determined to perform all of its mitigation at one time, utilizing a portion of the new work materials to construct a base pad (at a dredging unit cost), thus requiring less rock to be placed to attain the necessary relief above the bay bottom. Depending on cultch thickness installed, oyster mitigation costs for the cultch vary from approximately $67K to $334K per acre. Depths surrounding the mitigation area are approximately -6 feet MLLW. Rock barges will be light loaded to reach the mitigation site.

For bay bottom conversion mitigation, historical pricing from a recent 288-acre marsh construction project was used to derive a cost per acre of marsh creation of about $68K/acre as inflated to 2018 pricing. Mitigation requirements for each project component, and for each type, are provided in Table 7-1.

Another mitigation cost accounted for is that for impacts to forest and herbaceous shrub at the Beltway 8 (30.0 acres) and E2C (6.3 acres) tracts. This mitigation is to be paid into an FCU mitigation bank.

Additionally, there are two measures when considered that provide an offset to the required mitigation. These are Bird Island Marsh (11.1 acres) and Long Bird Island (4.0 acres). These sites share in common a component of cultch installation, that counts towards fulfilling the greater mitigation requirements.

10.2.5.10 Boaters Cut Relocation

Applicable to the proposed Mid Bay Expansion North option, this cost includes the costs associated with dredging a new boater’s cut where the existing would be cut off by the proposed new placement area. This cost assumes the use of a 10-15 CY Clamshell dredge with material transport to ODMDS via dump scow.

10.2.5.11 Cedar Bayou Channel Sweeping

This cost component is included with construction new Atkinson Marsh Cell M12. As the site would be constructed adjacent to Cedar Bayou Navigation Channel, some infilling of the channel could occur from the dike filling operations. Therefore, the added task of sweeping the channel from its intersection with the HSC to the land cut has been added to the cost of construction of M12. This cost assumes the use of a 10-15 CY Clamshell dredge with material transport to ODMDS via dump scow.

10.2.6 Pipeline Relocations

Pipeline relocations and their costs were prepared by the PHA and provided in Attachment 2 of this Appendix. Pipeline specific information is available upon request.

10.2.7 Associated Costs

10.2.7.1 LSF New Work Dredging

Limited data was available for estimating new work dredging costs associated with LSF. As such, the new work quantities estimated as shown in Table were used as separated by study segment. Only the groupings for Segment 4, as separated between Boggy to Greens and Greens to Sims, were evaluated. (The quantity derived for City Dock 16 in Segment 6 was too small to prepare a realistic independent estimate, and therefore was considered to be an incidental inclusion to channel dredging in the vicinity.) For the two parts of Segment 4, dredging cost estimates were developed for four known private placement areas: East Jones, West Jones, Deepwater, and Adloy. Estimates for all but Adloy were assumed to be done by hydraulic dredging methods. Due to the distance of Adloy from the dock locations, only mechanical dredging was assumed feasible. There is now way to know when the docks will be dredged in terms of facility owners working together to share mobilization costs, therefore it was assumed that all of the docks would be dredged under one mobilization. Separate events would increase the costs of dredging to all facility owners and should be considered by same in terms mobilization costs and placement area tipping fees. Table 10-6 below provides the evaluated dredging distances for each of the locations.

Table 10-6: LSF Dredging Distances

Segment 4 Reach	East Jones			West Jones			Deepwater			Adloy
	Min. (FT)	Max. (FT)	Avg. (FT)	Min. (FT)	Max. (FT)	Avg. (FT)	Min. (FT)	Max. (FT)	Avg. (FT)	Avg. Haul (NM)
BB-GB	9,500	22,500	13,500	11,000	24,000	15,500	10,000	22,500	18,500	14.9
GB-SB	6,000	9,000	8,000	5,500	8,500	6,500	28,000	35,500	33,000	17.1

Materials were estimated to consist of the same types as those derived for their adjacent channel reaches. Similarly, the dredging spreads were also held consistent in terms of limiting the hydraulic methods to a 24-inch cutter suction dredge with attendant plant and required boosters. For the mechanical dredging work, a clamshell dredge with a heavy ten cubic yard bucket was assumed. Tipping fees (placement facility costs) were obtained for each placement area from the facility owner and/or manager. As of the dates of quotation, these were $18/CY for East and West Jones, $16/CY for Deepwater, and $8/CY for Adloy. Total cost estimates for each of the segments are shown in Table 10-7.

Table 10-7: LSF Cost Estimates

Segment 4 Reach	Docks	NW Qty. (CY)	Dredging Cost			
			East Jones	West Jones	Deepwater	Adloy
BB-GB	Enterprise, Kinder Morgan, P-L Jacintoport, Contanda, Magellan, ITC Pasadena, Bulk Plan, South Central Cement, Vulcan	1,332,000	$44,600,000	$45,300,000	$43,500,000	$47,500,000
GB-SB	Greensport East/West, Magellan, Targa	439,000	$16,800,000	$16,800,000	$18,500,000	$16,600,000

10.2.7.2 ATONS

ATON costs were prepared by USCG Aids to Navigation office in Galveston, TX. This location is additionally the source of labor and equipment that would be performing the relocations. The following cost Table 10-8 were provided by USCG for each of the previously noted 86 ATONs requiring relocation.

Table 10-8: Cost for ATON Relocation

LLNR	NAME	Cost	LLNR	NAME	Cost
23900	Houston Ship Channel Entrance Lighted Buoy 18	$ 14,772.00	24305	Houston Ship Channel Light 65	$ 13,452.50
23955	Houston Ship Channel Lighted Buoy 25	$ 14,772.00	24310	Houston Ship Channel Light 66	$ 13,452.50
23960	Houston Ship Channel Lighted Buoy 26	$ 14,772.00	24315	Houston Ship Channel Light 67	$ 13,452.50
23965	Houston Ship Channel Rock Pile Lighted Buoy 25A	$ 14,772.00	24320	Houston Ship Channel Light 68	$ 13,452.50
23985	Houston Ship Channel Lighted Buoy 27	$ 14,772.00	24325	Houston Ship Channel Light 69	$ 13,452.50
23990	Houston Ship Channel Lighted Buoy 28	$ 14,772.00	24330	Houston Ship Channel Light 70	$ 13,452.50
23995	Houston Ship Channel Lighted Buoy 29	$ 14,772.00	24365	Houston Ship Channel Light 71	$ 13,452.50
24000	Houston Ship Channel Lighted Buoy 30	$ 14,772.00	24370	Houston Ship Channel Light 72	$ 13,452.50
24005	Houston Ship Channel Lighted Buoy 31	$ 14,772.00	24375	Houston Ship Channel Light 73	$ 13,452.50

24010	Houston Ship Channel Lighted Buoy 32	$ 14,772.00	24380	Houston Ship Channel Light 74	$ 13,452.50
24015	Houston Ship Channel Lighted Buoy 33	$ 14,772.00	24382	HOUSTON SHIP CHANNEL LIGHT 74A	$ 13,452.50
24020	Houston Ship Channel Lighted Buoy 34	$ 14,772.00	24385	Houston Ship Channel Light 75	$ 13,452.50
24025	Houston Ship Channel Light 35	$ 13,452.50	24390	Houston Ship Channel Light 76	$ 13,452.50
24030	Houston Ship Channel Light 35A	$ 13,452.50	24392	HOUSTON SHIP CHANNEL LIGHT 76A	$ 13,452.50
24040	Houston Ship Channel Light 36	$ 13,452.50	24430	Bayport Ship Channel Outer Range Front Light	$ 167,928.00
24045	Houston Ship Channel Light 37	$ 13,452.50	24450	Bayport Ship Channel Light 1	$ 13,452.50
24050	Houston Ship Channel Light 38	$ 13,452.50	24455	Bayport Ship Channel Junction Light B	$ 13,452.50
24070	Houston Ship Channel Light 39	$ 13,452.50	24460	Bayport Ship Channel Light 2	$ 13,452.50
24075	Houston Ship Channel Light 40	$ 13,452.50	24475	Bayport Ship Channel Light 3	$ 13,452.50
24080	Houston Ship Channel Light 41	$ 13,452.50	24480	Bayport Ship Channel Light 4	$ 13,452.50
24085	Houston Ship Channel Light 42	$ 13,452.50	24485	Bayport Ship Channel Light 5	$ 13,452.50
24090	Houston Ship Channel Light 43	$ 13,452.50	24490	Bayport Ship Channel Light 6	$ 13,452.50
24095	Houston Ship Channel Light 44	$ 13,452.50	24500	Bayport Ship Channel Light 8	$ 13,452.50
24100	Houston Ship Channel Light 45	$ 13,452.50	24520	Houston Ship Channel Light 78	$ 13,452.50
24105	Houston Ship Channel Light 46	$ 13,452.50	24525	Houston Ship Channel Light 81	$ 13,452.50
24110	Houston Ship Channel Light 47	$ 13,452.50	24530	Houston Ship Channel Light 82	$ 13,452.50
24115	Houston Ship Channel Light 48	$ 13,452.50	24535	Houston Ship Channel Light 83	$ 13,452.50
24120	Houston Ship Channel Light 49	$ 13,452.50	24540	Houston Ship Channel Light 84	$ 13,452.50
24125	Houston Ship Channel Light 50	$ 13,452.50	24545	Houston Ship Channel Light 85	$ 13,452.50
24170	Houston Ship Channel Light 51	$ 13,452.50	24550	Houston Ship Channel Light 86	$ 13,452.50
24175	Houston Ship Channel Light 52	$ 13,452.50	24555	Houston Ship Channel Light 87	$ 13,452.50
24180	Houston Ship Channel Light 53	$ 13,452.50	24560	Houston Ship Channel Light 88	$ 13,452.50
24185	Houston Ship Channel Light 54	$ 13,452.50	24565	Houston Ship Channel Light 89	$ 13,452.50
24225	Houston Ship Channel Light 55	$ 13,452.50	24570	Houston Ship Channel Light 89A	$ 13,452.50

24230	Houston Ship Channel Light 56	$ 13,452.50	24575	Houston Ship Channel Light 90	$ 13,452.50
24235	Houston Ship Channel Light 57	$ 13,452.50	24580	Houston Ship Channel Light 90A	$ 13,452.50
24240	Houston Ship Channel Light 58	$ 13,452.50	24595	Houston Ship Channel Light 91	$ 13,452.50
24245	Houston Ship Channel Light 59	$ 13,452.50	24600	Houston Ship Channel Light 92	$ 13,452.50
24250	Houston Ship Channel Light 60	$ 13,452.50	24750	Barbours Cut Junction Light BC	$ 13,452.50
24255	Houston Ship Channel Light 61	$ 13,452.50	25780	Houston Ship Channel Light 144	$ 13,452.50
24260	Houston Ship Channel Light 62	$ 13,452.50	25785	Houston Ship Channel Lighted Buoy 145	$ 13,452.50
24295	Houston Ship Channel Light 63	$ 13,452.50	25790	Houston Ship Channel Light 146	$ 13,452.50
24300	Houston Ship Channel Light 64	$ 13,452.50	25810	Houston Ship Channel Light 152	$ 13,452.50
Total Cost					$1,327,224.50

10.3 50-Year O&M Costs

10.3.1 General

The study has to evaluate 50 years' worth of O&M costs resulting from the project. These are the costs to maintain the channel depth with maintenance dredging, as well as maintain the operational capabilities of the placement areas. As different construction options have been developed, numerous O&M options can exist, dependent on what gets built, when its used, and from where is it being used. In general, the methodology used assumed to follow the USACE Future Without Project (FWOP) usage and sequencing of existing placement areas, with new placement being used as various options would construct.

10.3.2 O&M Materials to be Dredged

Maintenance materials dredged during O&M dredging events were assumed to consist of Very Soft Silts & Clays, with a negligible content of loose sands and having an average in-situ density of approximately 95 pcf. For ultimate DMMP planning purposes, all reaches within the study location must be evaluated in terms of their existing shoaling and proposed increased shoaling. Increased O&M shoaling quantities due to proposed measures are dictated by the improvements constructed. For the HSC Bolivar Roads to BCC, quantities vary by the amount of increased footprint.

The O&M material quantities used for the estimates are provided below**.** These include shoaling rates as provided in the Draft HSC Sedimentation Study (JV, 2012), BSC and BCC Channel

Improvements Project (JV, 2013), and the HSC Preliminary Assessment (USACE, 2017). Increased shoaling rates for enlarged sections were determined by applying the existing shoaling rate in terms of cy/sf, to the increased footprint area. Shoaling increases from deepening only segments were determined by using the Volume of Cut Method, as discussed in Basics of Channel Deposition/Siltation (van Rijn, 2013).

The BSC Flare has recently seen an increase of shoaling beyond the 788,000 CY/Year. This may be due to significant flooding in the Houston/Galveston metroplex. The PDT has determined to utilize the precited shoaling rate and closely monitor the BSC Flare. However, the contingency placed on the dredging quantities and prices was increase from 21% to 30%.

Table 10-9: O&M Material Quantities

Plan	Seg.	Location/ Reach	Existing Fed. Shoaling Rate (KCY/YR)	Existing Non-Fed. Shoaling Rate (KCY/YR)	Proposed Measure Increased Shoaling Rate (KCY/YR)	Proposed Measure Non-Fed. Inc. Shoaling Rate (KCY/YR)	Avg. Dredge Freq. (YR)	Total O&M Dredge Per Cycle (KCY/Cycle)
NED	1	HSC – Bolivar to Redfish (S1/2)	49.6	-	19.0	-	4	274.4
		HSC – Bolivar to Redfish (N1/2)	49.6	-	24.2	-	4	295.2
		HSC – Redfish to BSC (S1/2)	734.5	-	8.4	-	3	2,228.5
		HSC – Redfish to BSC (N1/2)	734.5	-	67.2	-	3	2,404.9
		HSC – BSC to BCC (S1/2)	385.7	-	25.9	-	3	1,234.7
		HSC – BSC to BCC (N1/2)	385.7	-	-	-	3	1,157.1
	2	BSC – Channel	498.5	24.1	84.5	-	2	1,214.2
		BSC – Flare	788.4	-	350.8	-	1	1139.2
	3	BCC – Channel	113.2	109.3	21.9	-	3	733.0
		BCC – Flare	169.0	-	189.7	-	3	1,076.1
	4	HSC – Boggy to Greens	113.7	-	94.3	163.2	4	1,484.7
		HSC – Greens to Sims	215.7	1.7	13.3	51.9	5	1,413.2
	5	HSC – Sims to 610	38.8	9.1	4.2	-	6	312.4
	6	HSC – 610 to TB	75.3	34.1	15.7	1.6	6	760.3
		HSC – TB	105.1	-	10.9	-	3	348.0
LPP	1	HSC – Redfish to BSC (S1/2)	734.5	-	276.3	-	3	3,032.4
		HSC – Redfish to BSC (N1/2)	734.5	-	276.3	-	3	3,032.4
		HSC – BSC to BCC (S1/2)	385.7	-	126.5	-	3	1,536.8
		HSC – BSC to BCC (N1/2)	385.7	-	126.5	-	3	1,536.8

10.3.3 O&M Placement Options

All existing and potential new placement areas were considered for operations and maintenance (O&M) use. These include UCPA sites located in the Bayou segments, UCPA and BU sites in the bay, and USACE concept design for open bay semi-confined BU sites, called BABUS. New UCPA sites considered for maintenance material placement in the bayou include RAE. All PAs evaluated are provided below.

Table 10-10: O&M Placement Options

Placement Option	Description	Est. Cap. (CY)
Mid Bay	Existing UCPA	11,406,000
MB Exp. N	Potential new UCPA	32,300,000
MB Exp. S	Potential new UCPA	32,300,000
Upland Concept 1	Potential new UCPA	37,552,000
Bird Island Marsh	Potential new BU site	6,300,000
PA 14	Existing UCPA	9,031,000
PA 15	Existing UCPA	11,386,000
PA14/15 Connection	Potential new UCPA connecting existing PA's 14 and 15 • Initial dike raising to contain fill, 10-feet initial raise assumed • Two spillboxes installed	10,060,000
Atkinson Marsh Cell M7/8/9	Unfinished BU site Requires NW to be usable	1,735,000
Atkinson Marsh Cell M10	Existing BU site	1,305,000
Atkinson Marsh Cell M11	Potential new BU site	10,267,000
Atkinson Marsh Cell M12	Potential new BU site	6,298,000
Atkinson Marsh Cell M1/M2	Existing BU site Estimated capacity assumes additional fill required due to 2.28 feet of RSLC	1,392,000
Atkinson Marsh Cell M3	Existing BU site Estimated capacity assumes additional fill required due to 2.28 feet of RSLC	1,190,00
Atkinson Marsh Cell NW	Existing BU site Estimated capacity assumes additional fill required due to 2.28 feet of RSLC	1,110,000
Atkinson Marsh Cell M4	Existing BU site Estimated capacity assumes additional fill required due to 2.28 feet of RSLC	1,165,000
Atkinson Marsh Cell M5/M6	Existing BU site Estimated capacity assumes additional fill required due to 2.28 feet of RSLC	2,085,000
Spilman Island	Existing UCPA	14,244,000

Alexander Island	Existing UCPA	17,862,000
Lost Lake	Existing UCPA	6,225,000
Peggy Lake	Existing UCPA	6,296,000
Rosa Allen	Existing UCPA	2,934,000
East Clinton	Existing UCPA	6,290,000
West Clinton	Existing UCPA	5,651,000
House Tract	Existing UCPA	4,560,000
Rosa Allen Expansion	PA created on an existing apprx. 138-acre upland tract of land located west of existing placement area Rosa Allen • Initial dike raising to contain fill, 10-feet initial raise assumed • Two spillboxes installed • Includes real estate costs • Assumes site not used for NW placement	10,760,000
ODMDS	Existing offshore material disposal site	NEL

10.3.4 O&M Production Variables

10.3.4.1 Pipeline Lengths

Production rates were developed for all study reaches to each placement area. Lines and lengths to each placement area were developed. O&M dredging by hydraulic methods was assumed coverage limited (i.e. limited by walking speed of the dredge rather than pump capability). Clamshell dredging and hopper dredging production rates were determined based predominantly on sail distances as well as equipment operating capacities.

Table 10-11: O&M Dredging Pipeline Lengths

Reach	Placement Area	PL Min. (FT)	PL Max. (FT)	PL Avg. (FT)
South ½ Lower Bay (108+600 to 138+369)	N/A – (No pipeline dredging assumed for Lower Bay, Hopper dredging only)			
North ½ Lower Bay (078+844 to 108+600)				
South ½ Mid Bay (53+700 to 78+844)	Bird Island Marsh	19,000	44,000	31,500
	MB Expansion South	9,000	33,500	21,000
	Mid Bay	16,500	41,000	29,000
	Upland Concept 1	20,500	45,000	33,000
	MB Expansion North	16,500	41,000	29,000
	PA 14	36,000	62,000	49,000
	PA15	36,000	62,000	49,000
	PA14/15 Connection	36,000	62,000	49,000
North ½ Mid Bay (28+604 to 53+700)	Bird Island Marsh	16,500	34,500	25,500
	Mid Bay	2,500	16,500	11,000
	Upland Concept 1	11,500	31,000	20,000
	MB Expansion North	2,500	16,500	11,000
	MB Expansion South	2,500	21,500	11,000

	PA 14	11,000	36,000	23,500
	PA15	11,000	36,000	23,500
	PA14/15 Connection	11,000	36,000	23,500
South ½ Upper Bay (14+300 to 28+604)	M10	6,500	14,000	11,000
	M11	6,500	14,000	11,000
	M7/8/9	6,500	14,000	11,000
	M5/M6	22,000	24,000	23,000
	M1/M2	20,000	37,000	28,500
	M3	14,000	32,000	23,000
	M4	14,000	32,000	23,000
	NW	14,000	32,000	23,000
	M12	15,000	29,500	22,000
	PA 14	2,500	11,500	8,000
	PA 15	2,500	11,500	8,000
	Mid Bay	14,000	28,000	21,000
	Upland Concept 1	13,500	27,500	20,500
	MB Expansion North	14,000	28,500	21,000
	Spilman	18,500	33,000	25,500
	PA14/15 Connection	2,500	11,500	8,000
North ½ Upper Bay (-3.94 to 14+300)	M1/M2	10,000	23,000	16,000
	M10	13,000	27,000	20,000
	M11	13,000	27,000	20,000
	M12	4,500	15,000	11,500
	M3	3,500	17,500	11,500
	M4	3,500	17,500	11,500
	M5/M6	10,000	23,000	16,000
	M7/8/9	13,000	27,000	20,000
	NW	3,500	17,500	11,500
	Spilman	3,500	18,500	11,500
	PA 14	9,000	24,500	17,000
	PA 15	9,000	24,500	17,000
	Mid Bay	28,000	42,500	35,500
	Upland Concept 1	27,500	42,000	35,000
	MB Expansion North	28,000	42,500	35,500
	PA14/15 Connection	9,000	24,500	17,000
BSC – Channel (25+58 to 180+00)	M10	14,000	29,500	22,000
	M11	14,000	29,500	22,000
	M7/8/9	14,000	29,500	22,000
	M12	29,000	45,000	37,000
	MID BAY	19,000	34,500	27,000
	M5/M6	34,500	50,000	42,000

	PA 14	11,000	26,500	19,000
	PA 15	11,500	27,000	19,000
	MB Expansion North	18,500	34,000	26,000
	Upland Concept 1	22,000	37,500	30,000
	Bird Island Marsh	39,000	55,000	47,000
	MB Expansion South	26,000	41,500	34,000
	PA14/15 Connection	10,000	25,500	18,000
BSC – Flare (180+00 to 241+00)	M10	12,000	16,500	14,000
	M11	12,000	16,500	14,000
	M7/8/9	12,000	16,500	14,000
	M12	27,000	31,500	29,500
	M5/M6	32,500	37,000	34,500
	Bird Island Marsh	33,000	40,000	36,500
	Mid Bay	17,000	23,500	20,500
	Upland Concept 1	20,000	26,500	23,500
	PA 14	9,000	13,500	11,000
	MB Expansion North	16,500	23,000	19,500
	PA 15	9,500	11,500	11,500
	MB Expansion South	24,000	30,500	27,000
	PA14/15 Connection	8,000	12,000	10,000
BCC – Channel (33+00 to 91+98)	M12	7,500	13,500	10,500
	NW	14,500	20,500	17,500
	M1/M2	19,500	25,500	22,500
	M5/M6	17,000	23,000	20,000
	M4	13,000	19,000	16,000
	Spilman	1,000	6,000	3,500
	M3	11,000	16,500	14,000
	M10	30,500	36,500	33,500
	M11	30,500	36,500	33,500
	M7/8/9	30,500	36,500	33,500
	Alexander	22,000	26,000	24,000
	PA 14	26,500	34,000	30,000
	PA 15	26,500	34,000	30,000
	PA14/15 Connection	26,500	34,000	30,000
BCC – Flare (11+00 to 33+00)	M12	4,500	7,500	6,000
	M3	8,000	11,000	9,500
	Spilman	1,000	3,000	2,000
	M4	10,500	13,000	12,000
	M5/M6	14,500	17,000	15,500
	NW	12,000	14,500	13,500
	M1/M2	17,000	19,500	18,500

	M10	28,000	30,500	29,000
	M11	28,000	30,500	29,000
	M7/8/9	28,000	30,500	29,000
	Alexander	17,500	21,500	19,500
	PA 14	24,000	28,000	26,000
	PA 15	24,000	28,000	26,000
	PA14/15 Connection	24,000	28,000	26,000
HSC – Boggy to Greens (684+03 to 833+05)	Lost Lake	21,500	36,500	29,000
	East Clinton	22,500	37,500	30,000
	E3 Clinton	20,000	35,000	27,500
	Peggy Lake	33,500	48,500	41,000
	Rosa Allen Expansion	30,700	45,600	38,200
	Lynchburg	64,500	79,500	72,000
HSC – Greens to Sims (833+05 to 1110+77)	Glendale	18,000	42,500	27,500
	West Clinton	15,000	33,000	24,000
	East Clinton	13,000	31,000	22,000
	E3 Clinton	10,000	28,500	19,500
	House Tract	14,500	38,500	23,500
	Rosa Allen	24,500	48,500	33,500
	Lynchburg	79,500	107,500	93,500
	Rosa Allen Expansion	23,000	47,000	32,000
HSC – Sims to 610 & 610 to Turning Basin (1110+77 to 1266+48)	Glendale	3,000	17,000	8,000
	House Tract	6,500	20,500	12,000
	West Clinton	10,000	24,000	15,000
	East Clinton	15,000	29,000	20,000
	E3 Clinton	18,000	31,500	23,000
	Rosa Allen	28,000	43,500	35,500
	Lynchburg	107,500	123,000	115,500
	Rosa Allen Expansion	26,000	42,000	34,000
HSC - Turning Basin (00+00 to 30+95)	Glendale	4,500	8,000	6,000
	West Clinton	11,500	14,500	13,000
	House Tract	8,000	11,000	10,000
	East Clinton	16,500	20,000	18,000
	E3 Clinton	19,500	22,500	20,000
	Rosa Allen	43,500	46,500	45,000
	Lynchburg	123,500	127,000	125,500
	Rosa Allen Expansion	42,000	45,000	43,500

10.3.4.2 Haul Distances

O&M hopper dredging estimates were developed by studying historical contract daily production data for multiple projects. Production estimates for O&M dredging were then developed for 8KCY and 10KCY hopper dredges, using the assumed maintenance material density, the various reach distances to the ODMDS, and additional criteria such as two drag-arm digging, overflow allowed, hopper capacity loaded at 75%, and bottom dump out at the ODMDS. Production rates were determined for each dredging reach, for each of the two specified hopper dredge sizes. The developed production rates were inclusive of loading/turning, hauling, and dump, and were assumed over an operational time of 20 hours per day. Distances and cycle times are provided below.

Table 10-12: O&M Production Rates
(Sailing Speed Loaded 12.4-13.2 kts / Sailing Speed Unloaded 14.2-15.1 kts)

Reach	Avg. Dist. to ODMDS (NM)	Load Time (HR)	Turning Time (HR)	Travel Time (R/T) (HR)	Dump Time (HR)
South ½ Lower Bay (108+600-138+369)	14.2	2.2-2.8	0.2	2.0-2.1	0.1
North ½ Lower Bay (78+844 - 108+600)	19.0	2.2-2.8	0.2	2.7-2.9	0.1
South ½ Mid Bay (53+700 - 78+844)	23.5	2.2-2.8	0.2	3.3-3.5	0.1
North ½ Mid Bay (28+604 - 53+700)	27.7	2.2-2.8	0.2	3.9-4.2	0.1
South ½ Upper Bay (14+300 - 28+604)	30.9	2.2-2.8	0.2	4.4-4.6	0.1
North ½ Upper Bay (-3.94 - 14+300)	33.3	2.2-2.8	0.2	4.7-5.0	0.1
BSC – Flare	30.8	2.2-2.8	0.2	4.3-4.6	0.1
BSC – Channel	32.6	2.2-2.8	0.2	4.6-4.9	0.1
BCC – Flare	34.8	2.2-2.8	0.2	4.9-5.2	0.1
BCC – Channel	35.5	2.2-2.8	0.2	5.0-5.3	0.1
Boggy Bayou to Greens Bayou (684+03 - 833+05)	47.1	2.2-2.8	0.2	*7.5	0.1
Greens Bayou to Sims Bayou (833+05 - 1110+77)	50.6	2.2-2.8	0.2	*8.6	0.1
Sims Bayou to Turning Basin (1160+62-1266+48)	54.1	2.2-2.8	0.2	*9.6	0.1
Turning Basin (1266+48/00+00 – 30+95)	55.7	2.2-2.8	0.2	*10.1	0.1
Notes: *Sailing speeds reduced between Morgans Point to Boggy Bayou to 9.9 kts (loaded) and 10.8 kts (empty). Sailing speeds reduced between Boggy Bayou through Main Turning Basin to 6.5 kts (loaded and empty). **Hopper dredging estimates were limited to an 8KCY dredge north of BCC due to size restrictions					

O&M estimates for clamshell dredging considered mechanically dredging areas with a clamshell dredge and material transport scows. Clamshell production rates were developed assuming a 21 CY bucket over an average cut depth of 48.5 feet below the I-610 Bridge, and 44 feet upstream of the bridge. Rates were applied over 15 operational hours per day with tugs and 6,000 CY dump scows apportioned accordingly. Haul distances were held by reach as shown for hopper estimates. Travel speeds were set to 4.5 knots when loaded and 6.5 knots when empty. In general, two tugs and three scows were required in estimates from the Boggy Bayou to Greens Bayou reach and downstream. Three tugs and four scows were needed upstream of this reach.

10.3.5 O&M Cost Considerations

Costs were estimated at 2018 price levels and assume standard construction practices. Equipment rates were derived from dredging experience, industry contractors, and several construction and equipment vendors. Labor rates were based on current industry typical standards.

10.3.5.1 Mobilization

O&M work assumes less equipment and personnel due to minimal shoreside pipe and plant requirements and other atypical work required. Regarding O&M placement area improvements, it is assumed that these mobilizations would be from the surrounding general project area. However, many recent USACE bids for the HSC and tributaries show the costs for mobilization for dike construction and DAMP work also vary greatly. Historical costs were reviewed and averaged and inflated to the study pricing year for this item.

Mobilizations for ancillary tasks were determined on case by case basis and assumed estimated actual equipment/labor costs required for transportation and setup of equipment. These options assumed approximately two weeks for mobilization.

10.3.5.2 Dredging Prices

The costs for O&M dredging vary significantly from that of NW dredging since additional pipe, equipment and personnel are required for the NW construction versus the O&M work. O&M maintenance assumes less equipment and personnel due to minimal pipe movement and placement methods. Additionally, the material itself is much easier to move. Dredging prices are developed similarly to NW dredging though, in that the production analysis determines the required time and energy requirements. And the operating costs and ownership costs, plus extras are determined; and ultimately dividing by the dredge quantity to get the unit cost.

10.3.5.3 DAMP Costs

Based on historical experience in disposal area management, it is estimated that 500 LF of perimeter ditch (requiring two passes) or 700 LF of interior ditch (requiring one pass) can be excavated per day, per marsh hoe. Costs per DAMP event were developed using typical industry equipment spreads and production rates. The costs per DAMP event were multiplied by the calculated number of DAMPs that would conceivably be performed per placement location. The number of DAMPs was determined by dividing the total site capacity by an assumed fill height of four feet based on cut yards per DAMP. This cost was then divided by the total capacity cubic yardage to attain a unit cost of capacity resultant from DAMPing the sites. No DAMP costs were assumed applicable to marsh cells, only UCPA's.

10.3.5.4 Construction General Costs

O&M dike construction consists of raising the containment dike of a specific placement area. Estimates assume a typical five-foot dike raise with dimensions of common practice. Side slopes were estimated at 3H:1V, extending up from the interior crown edge of the existing dike. Raised dike crown width of 20-feet assumed. Interior slope at 3H:1V down five feet to an interior bench of 30-foot width. Bench sloped down at 3H:1V back to existing interior site grade. Losses for handling and compaction were assumed at 40%. With this and the dike perimeter, material quantities were developed for all placement areas to be considered for future dike raising. Production rates for dike construction assume two draglines side casting materials onto the existing crown from a minimum distance of 50-feet to the interior of the dike; and two dozers shaping the placed materials. Eight hours of operational time were estimated per day. Additional components of dike raising included stripping/clearing/grubbing and turfing.

The cost was determined like that of DAMPing in that the costs per raising event were determined from the developed spread and production rate. Dike raising events were assumed to occur at a frequency of every other DAMP event. Costs include those for stripping/clearing/grubbing pre-construction and turfing post-construction. The cost per raise was then multiplied by the quantity of dike raising events and this cost was then divided by the total capacity cubic yardage to attain a unit cost of capacity resultant from raising the dikes at the sites. No dike raising costs were assumed applicable to marsh cells, only UCPA's.

10.3.5.5 Upfront Dike Raising

Certain sites would require initial preparations in order to be capable of receiving fill. These include the considered new UCPA's E3 Clinton, Lynchburg Tract, 14/15 Connection, and RAE. For these locations, an initial 10-foot dike raise was assumed. Spread and production was held consistent with other dike raising considerations and was applied to the required material quantity. Costs include those for stripping/clearing/grubbing pre-construction and turfing post-construction.

10.3.5.6 BABUS Cell Construction Costs

This cost was provided by USACE and was given as $93,324,000 and $52,228,000 per 325-ac and 200-ac BABUS, respectively. Cost for capacity was given as $3.28/CY. For O&M mechanical dredging to a BABUS site, the dredging unit prices developed by USACE Operations were used. The USACE estimates assumed that for each BABUS, 60% of the dredging would be performed via bottom dump scow placement, and 40% would require hydraulic pump out into the cell at an increased cost. For all dredging costs to BABUS sites, the weighted unit cost was used for dredging, with the storage an added cost per cubic yard. These prices are provided in Table 10-13.

Table 10-13: BABUS Costs

Reach	60% Dump Scow Placement Cost per CY	40% Hydraulic Placement Cost per CY	Weighted Dredging Unit Cost per CY	BABUS Storage Cost per CY	Total Cost to Dredge and Place in BABUS per CY
Morgans Point to Exxon, Sta 0+00 to Sta 150+00	$6.64	$10.39	$8.14	$3.28	$11.42
Morgans Point to Exxon, Sta 150+00 to Sta 300+00	$5.32	$9.07	$6.82	$3.28	$10.10
Exxon to Carpenters Bayou, Sta 300+00 to Sta 530+00	$8.01	$11.76	$9.51	$3.28	$12.79
Carpenters Bayou to Boggy Bayou, Sta 530+00 to Sta 684.03	$11.13	$14.88	$12.63	$3.28	$15.91
Boggy Bayou to Greens Bayou, Sta 684+03 to Sta 833+06	$16.49	$20.24	$17.99	$3.28	$21.27
Greens Bayou	$11.00	$14.75	$12.50	$3.28	$15.78
Greens Bayou to Sims Bayou, Sta 833+05 to Sta 1110+78	$10.89	$14.64	$12.39	$3.28	$15.67
Sims Bayou to Turning Basin, Sta 1110+78 to Sta 1266+49	$17.27	$21.02	$18.77	$3.28	$22.05
Main and Upper Turning Basins	$17.50	$21.25	$19.06	$3.28	$22.28

10.4 LSF Maintenance

O&M costs for LSF were developed using the non-federal shoaling quantities for each standard O&M dredging reach. Non-federal dredging costs were determined in congruence with the channel federal O&M dredging and the same costs were held. I.e., in hydraulic dredging estimates for the channel, non-federal costs were assumed using the same unit prices and to occur during the same mobilization. This was also held for mechanical dredging to BABUS sites. Upon reaching maximum capacity at the Bayou UCPAs, all maintenance dredging goes to the BABUS sites at the unit costs provided by USACE.

At BCC however, when Spilman PA and M12 reach maximum capacity, all material except from the docks would go to ODMDS. The dock materials would be mechanically dredged to a BABUS at the unit price attributed to the Morgan’s to Exxon reach as shown above.

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11 RECOMMENDED PLAN

The project measures include various options for improvements to the HSC, as well as the connected channels BSC and BCC. Channel measures for the NED Plan and LPP (RP) are outlined below in Table 11-1 and placement options for new work and O&M is provided in Table 11-2.

Table 11-1: Recommended Plan Channel Measures

	NED PLAN			**LPP RECOMMENDED PLAN**		
SEG.	**MEASURE**	**STATION**	**DESCRIPTION**	**MEASURE**	**STATION**	**DESCRIPTION**
1	CW1_BR-Redfish_700	138+369 – 078+844	Widen HSC between Bolivar to Redfish to 700-foot width. Includes bend easings.	CW1_BR-Redfish_700	138+369 – 078+844	Widen HSC between Bolivar to Redfish to 700-foot width. Includes 328-foot bend easings.
		078+844 – 073+934	Bottleneck transition back to existing 530-foot channel.	CW1_Redfish-BSC	073+934 – 028+605	Widen HSC between Redfish to BSC to 700-foot width. Includes 328-foot bend easings.
	BE1_028+605_530	026+028 - 031+171	328-foot bend easing along the 530-foot existing channel	CW1_BSC-BCC	028+605 – (-)3.94	Widen HSC between BSC to BCC to 700-foot width. Includes 328-foot bend easings.
2	CW2_BSC_455	025+58 – 222+76	Widen BSC on north side to 455-foot width.	CW2_BSC_455	025+58 – 222+76	Widen BSC on north side to 455-foot width.
	BE2_BSCFlare	203+66 – 239+78	Widen BSC south side flare radius to 5,375 feet.			
3	CW3_BCC_455	24+69 – 67+11	Widen BCC on north side to 455-foot width.	NO CHANGE - SAME AS NED PLAN		
	BETB3_BCCFlare	08+78 – 30+84	Widen BCC flare on north and south to create 1,800-foot diameter turning basin.			
4	CD4_Whole	684+03 – 974+08	Deepen HSC between Boggy Bayou and Hunting Turning Bain	NO CHANGE - SAME AS NED PLAN		
	CW4_BB-GB_530	684+03 – 833+05	Widen HSC between Boggy Bayou to Greens Bayou to 530-foot width.			
5	CD5_Whole	1110+78 – 1160+62	Deepen HSC between Sims Bayou to I-610 Bridge.	NO CHANGE - SAME AS NED PLAN		
6	CD6_Whole	1266+49=00+00 – 30+95	Deepen HSC between I-610 Bridge and Main Turning Basin.			
	TB6_Brady_900	1189+15.688 – 1203+14.265	900-foot Turning Basin at Brady Island			

Table 11-2: Placement Options for New Work and O&M

	NED PLAN			LPP RECOMMENDED PLAN		
	New Work		**O&M**	**New Work**		**O&M**
SEG.	**To New BU/PAs**	**To Existing BU/PAs**		**To New BU/PAs**	**To Existing BU/PAs**	
1	8-Acre Bird Island Long Bird Island Bird Island Marsh	ODMDS	ODMDS Bird Island Marsh Mid Bay PA15	8-Acre Bird Island Long Bird Island BSC Sedimentation Attenuation Feature Oyster Pad Mitigation M11	ODMDS M7/8/9 Rehabilitation	ODMDS Bird Island Marsh MidBay PA15 M11 M7/8/9
2	Bird Island Marsh	N/A	PA14 P14/15 Connection ODMDS	NO CHANGE - SAME AS NED PLAN		PA14 P14/15 Connection ODMDS M7/8/9 M11
3	M12	N/A	M12 Spilman ODMDS BABUS	NO CHANGE - SAME AS NED PLAN		
4	BW-8 Tract E2 Clinton	N/A	Lost Lake BABUS Rosa Allen Rosa Allen Expansion	NO CHANGE - SAME AS NED PLAN		
5	N/A	Glendale PA	West Clinton BABUS	NO CHANGE - SAME AS NED PLAN		
6	N/A	Glendale PA Filterbed PA	West Clinton House Tract BABUS	NO CHANGE - SAME AS NED PLAN		

12 ADDITIONAL STUDIES

The following sections outline the additional studies that were conducted post ADM and will be further refined during the PED phase of the project to meet the goals of the accelerated schedule and reduce study costs. Additional studies include, but are not limited to, hydrodynamic modeling, ship simulation, geotechnical investigations and analysis, and review of current AM and AO practices.

12.1 Hydrodynamic Modeling

The AdH model was used to produce plots of currents, salinity, sediment concentrations, and shoaling. The currents modeling is described here. Salinity results are summarized in section 7.5 above. Complete modeling results will be in an ERDC Technical Report "Houston Ship Channel 45-Foot Expansion Channel Improvement Project (ECIP) Numerical Modeling Report" by Jennifer McAlpin, Cassandra Ross, and Jared McKnight, ERDC.

The Adaptive Hydraulics (AdH) model is being used to evaluate the potential impacts of proposed channel modifications (TSP) on the hydrodynamics, salinity and sediment behavior in the HSC. The objectives of this effort are to develop a fully calibrated and validated model of Galveston Bay, from the entrance at Bolivar Roads to the turning basin at the Port of Houston. The validated model will be used to establish base conditions against which the proposed project conditions will be evaluated. An analysis of the model results will be conducted to determine the potential impacts of the TSP on important environmental parameters such as salinity, water levels, the tidal prism, sediment transport, and shoaling. A summary of these modeling efforts is summarized below with further details provided in Attachment 4 "Engineering Data and Models."

A lot of environmental modeling work has been done in Galveston Bay in the past. In the early 1990's, the Estuarine Engineering Branch (EEB) at the ERDC Coastal and Hydraulics Laboratory (CHL) developed a 3D hydrodynamic and salinity model to evaluate proposed deepening and widening of the HSC in the Bay portion of the channel (Berger et al. 1995a, 1995b). Later work was focused on developing a sediment transport model of the area to investigate the causes of increased shoaling in the ship channel, again focusing on the Bay portion of the channel (Tate et al. 2006, 2008, 2009, and 2012). A Monitoring Completed Navigation Projects (MCNP) Program study was performed on the entrance channel area as well as the Bay portion of the channel to continue the investigation of the suspected increased shoaling (Tate et al. 2014). All the previous EEB modeling in the estuarine area (Bay and HSC) was performed using the TABS-MDS model. The TABS-MDS model is no longer supported by ERDC-CHL.

AdH is a mathematical model developed by ERDC-CHL for the numerical simulation of two-dimensional (2D) and three-dimensional (3D) hydrodynamics, water quality and particle transport. AdH replaces the TABS-MDS model. Demonstrations of the capabilities of the 3D shallow water module (AdH-SW3) have been carried for the Galveston Bay (Savant et al., 2014; Savant and Berger, 2015).

12.1.1 Model Setup

12.1.1.1 Bathymetry Update

The bathymetry in the existing Galveston Bay AdH model has been updated using data provided by USACE-SWG. The data sources include channel surveys, navigation charts and aerial imagery covering Galveston Bay, including Trinity Bay and West Bay, from the entrance channel to the upper HSC. This update adds horizontal resolution and additional detail, particularly in the upper portion of the HSC.

12.1.1.2 Other Model Input

The AdH model requires tidal, salinity and discharge boundary conditions, in addition to sediment loads, bed material composition, and surface wind fields. Field data are also needed for model calibration and validation. These data were obtained from USGS, NOAA, Texas Coastal Ocean Observation Network (TCOON), TCEQ, Texas Water Development Board (TWDB) and other sources. These were additionally augmented with data from USACE field measurements: discharge data were collected in the vicinity of the BSC Flare in 2010; velocity and salinity measurements were collected in the Bay in 2011; sediment data (suspended and bed material) were collected in the Bay in 2005 and 2006. Since there's no continuous record for all the required data sets, calibration and validation were performed over multiple time periods coincident with the available data. The sediment transport portion of the model is being validated using historical dredge records and historical channel surveys.

12.1.2 Planned Simulations

The validated model will be applied to calculate the currents, water levels, salinity, and sedimentation for specified plan conditions. This includes modeling a base condition (BC), one alternative channel condition, one future without project condition, and one future with project condition. The alternatives will be provided by USACE-SWG through consultation with ERDC-CHL.

12.1.2.1 Base Condition

The BC will be simulated as the present condition. This alternative will match the conditions (geometry and bathymetry) in the final validated model. A single year BC from those generated for the model/field comparisons will be simulated.

12.1.2.2 Alternative Channel Condition

The alternative channel condition specified by USACE-SWG will be incorporated into the model domain mesh as necessary to define the geometric influence on the hydrodynamics and transport conditions. A single year BC from those generated for the model/field comparisons will be simulated with the alternative channel condition to show the impact of the alternative for current conditions.

12.1.2.3 Future Without Project (FWOP)

The FWOP condition will include updated boundary conditions for the proposed future time. Future condition BCs information will be provided by USACE-SWG for river inflow, tidal elevation (including subsidence and sea level rise), salinity input, sediment loads, and wind fields. The model domain will be modified from the BC only to include tidal storage in the event of sea level rise. Additional ADCIRC and STWAVE simulations are required to obtain appropriate BCs for the future condition AdH simulation.

12.1.2.4 Future With Project (FWP)

The FWP condition will include mesh modification to combine the alternative channel condition mesh and the FWOP mesh. The same BCs (provided by USACE-SWG) used in the FWOP simulation will be used for this condition.

The models will be updated in PED to include a study regarding vessel sheer stresses and wakes of larger deeper drafted vessels transiting the channel and potential effects on side slopes, banks, and docks. The models should also be used to evaluate predicted sedimentation and update the shoaling rates.

12.2 Ship Simulation

On November 17, 2017, the USACE Galveston District and the PHA, in consortia with the HP and G&H Towing, concluded ship maneuvering simulations in support of a feasibility study for the HSC-ECIP. The full report is included in Attachment 5, a summary is provided below.

- CW1_650_BR-RF, CW1_650_RF-BSC, and CW1_650_BSC-BCC straight channel sections were simulated and found meetings between two design containerships were considered high-risk, and meetings between the design containerships and tankers were a risky maneuver. Meetings in the 328-foot bends were not simulated as the pilots considered such maneuvers unsafe.
- CW1_700_BR-RF, CW1_700_RF-BSC, and CW1_700_BSC-BCC channel widening measures were simulated and found that meetings between two design containerships and

between design containerships and tankers in both the straight reaches of the channel and in the 328-foot bends were considered acceptable.

- CW2_455_BSC: The design 455-foot channel in combination with the 4,000-foot BSC Flare, and 700-foot HSC widening was found to be acceptable. The BSC was simulated with a 400-foot wide channel within the landcut. This was marginally acceptable, however, due to the drift angle required with cross-winds, a 455-foot design for the land cut is preferred.
- TB2_BSCRORO_1800 was considered to be acceptable.
- CW3_455_BCC inclusive of the BCC Flare widening (BETB3_BCCFlare_1800NS) and the 700-foot HSC widening are feasible for the navigation of the design containership, assist tugs and normal HSC vessel traffic.
- CW4_BB-GB_530: This measure was found to provide for successful operations of Aframax and Suezmax vessels, which increases the size of ships allowed to operate in this reach above the existing LOA of 750 feet and beam of 106 feet. This allows for the successful implementation of two-way traffic of loaded vessels with a maximum combined ship beam of 246 feet.
- Meetings between a design Arfamax and Panamax was found acceptable both above and below the BW-8 Bridge. Meetings between a design Suezmax and Panamax was found acceptable both above and below the BW-8 Bridge.
- TB6_Brady_900: Turning the design Panamax with ships and bunkering barges alongside at Wharfs 26-28 was considered acceptable with sufficient room with the assistance of available tugs.

12.3 Advanced Maintenance and Allowable Overdepth

As noted above, the practices for AM and AO vary throughout the HSC system. The current practices have been used to estimate the current and future dredging needs. However, a more in-depth review of channel shoaling and durations will be conducted to validate or make recommendations to the current AM and AO practices. Additional design level ship simulations to verify dimensions of the channel widening and bend easings will be conducted in PED. In some high shoal areas the AM practice may need to be increased to reduce the frequency of dredging and allow for the PAs to be maintained. In areas of low shoaling the AM and AO practice may be reduced. Currently, the dredging quantities of the BSC Flare and BCC Flare reflect 7 feet of AM. No other changes to AM have been made. AM justification for 7 feet of AM at BSC and BCC is discussed in Section 7.6 of Appendix R.

13 SCHEDULE OF DESIGN AND CONSTRUCTION

The Contract Schedule contains the breakout of the contracts with the Dredging Sections pertaining to the new work. Refer to Cost Estimates Summary of Accounts for this information.

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14 OPERATION AND MAINTENANCE

The plan proposed for maintenance dredging is discussed in the DMMP located in Appendix R.

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15 ACCESS ROADS

Access roads are not required for channel dredging. Channel deepening will be accomplished by a floating plant. Access to existing and proposed upland placement areas will be from existing public streets. Access to existing and proposed placement sties in the bay would be accessible by water only.

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16 PROJECT SECURITY

This project consists mainly of channel dredging and levee work. A security plan will not be needed.

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PLATES

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ATTACHMENT 1

COST ESTIMATE (MII V4.2)/TPCS/CSRA

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ATTACHMENT 2

HSC PIPELINE RELOCATION EVALUATION

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ATTACHMENT 3

CLIMATE CHANGE AND SEA-LEVEL RISE EFFECTS FOR THE HSC ECIP FEASIBILITY STUDY

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ATTACHMENT 4a

ENGINEERING DATA AND MODELS – HOUSTON SHIP CHANNEL AND VICINITY TREE-DIMENSIONSAL ADAPTIVE HYDRAULICS (AdH) NUMERICAL MODEL

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ATTACHMENT 4b

HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (ECIP) NUMERICAL MODELING REPORT

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ATTACHMENT 5

SHIP MANEUVERING SIMULATION STUDY OF PROPOSED CHANNEL MODIFICATIONS; HSC-ECIP FEASIBILITY STUDY, TEXAS

(AVAILABLE UPON REQUEST TO THE GALVESTON DISTRICT PROJECT MANAGEMENT)

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ATTACHMENT 6

SLOPE STABILITY ANALYSIS FOR BSC AND BCC

(AVAILABLE UPON REQUEST TO THE GALVESTON DISTRICT PROJECT MANAGEMENT)

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ATTACHMENT 7

SLOPE STABILITY ANALYSIS OF EXISTING PLACEMENT AREAS

(AVAILABLE UPON REQUEST TO THE GALVESTON DISTRICT PROJECT MANAGEMENT)

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ATTACHMENT 8

CORPS SHOALING ANALYSIS TOOL (CSAT) REPORT

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ATTACHMENT 9

SEDIMENT TRAINING OPTIONS FOR THE BAYPORT FLARE IN THE HOUSTON SHIP CHANNEL

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ATTACHMENT 10

CHANNEL MEASURE VOLUME REPORTS

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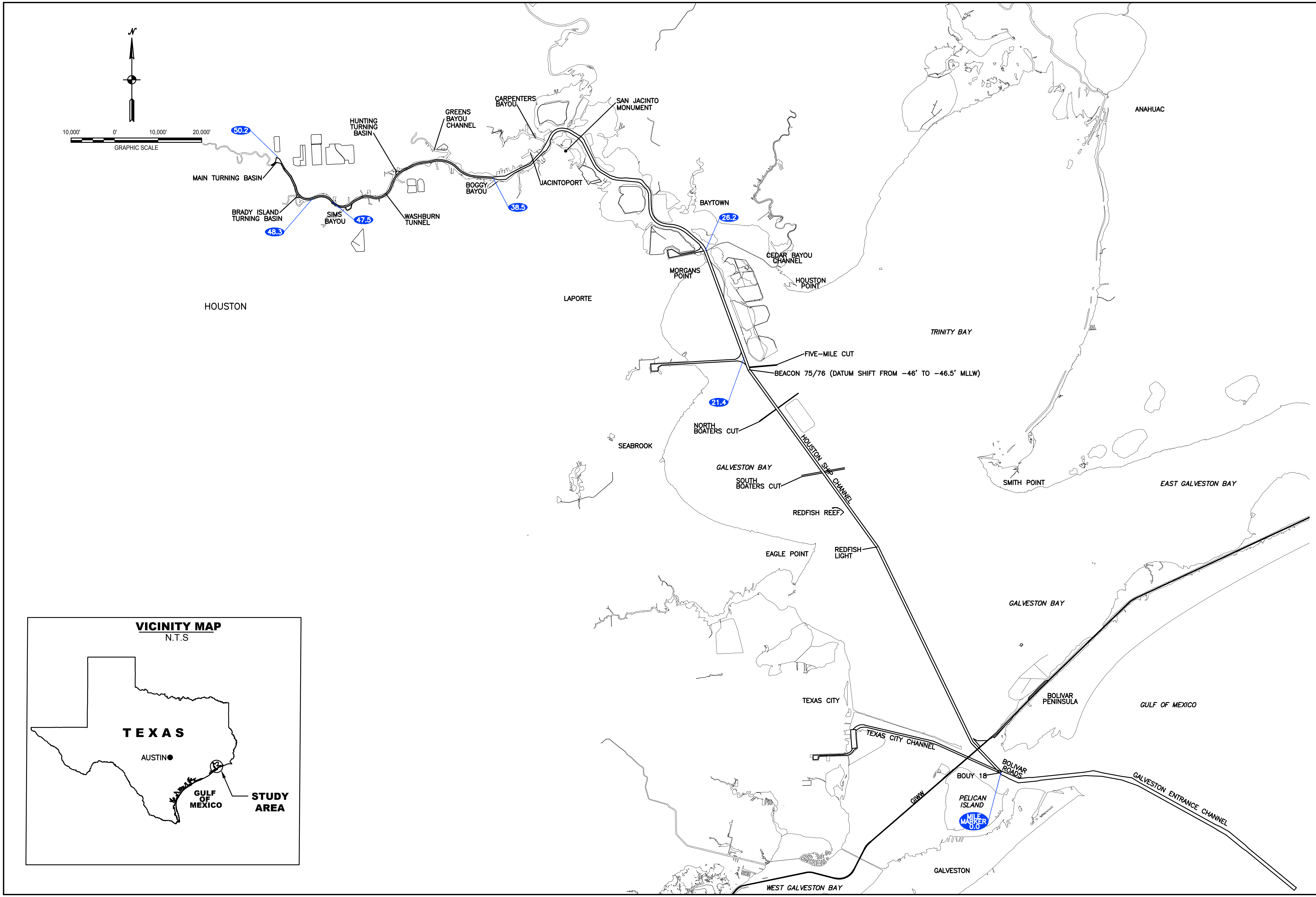

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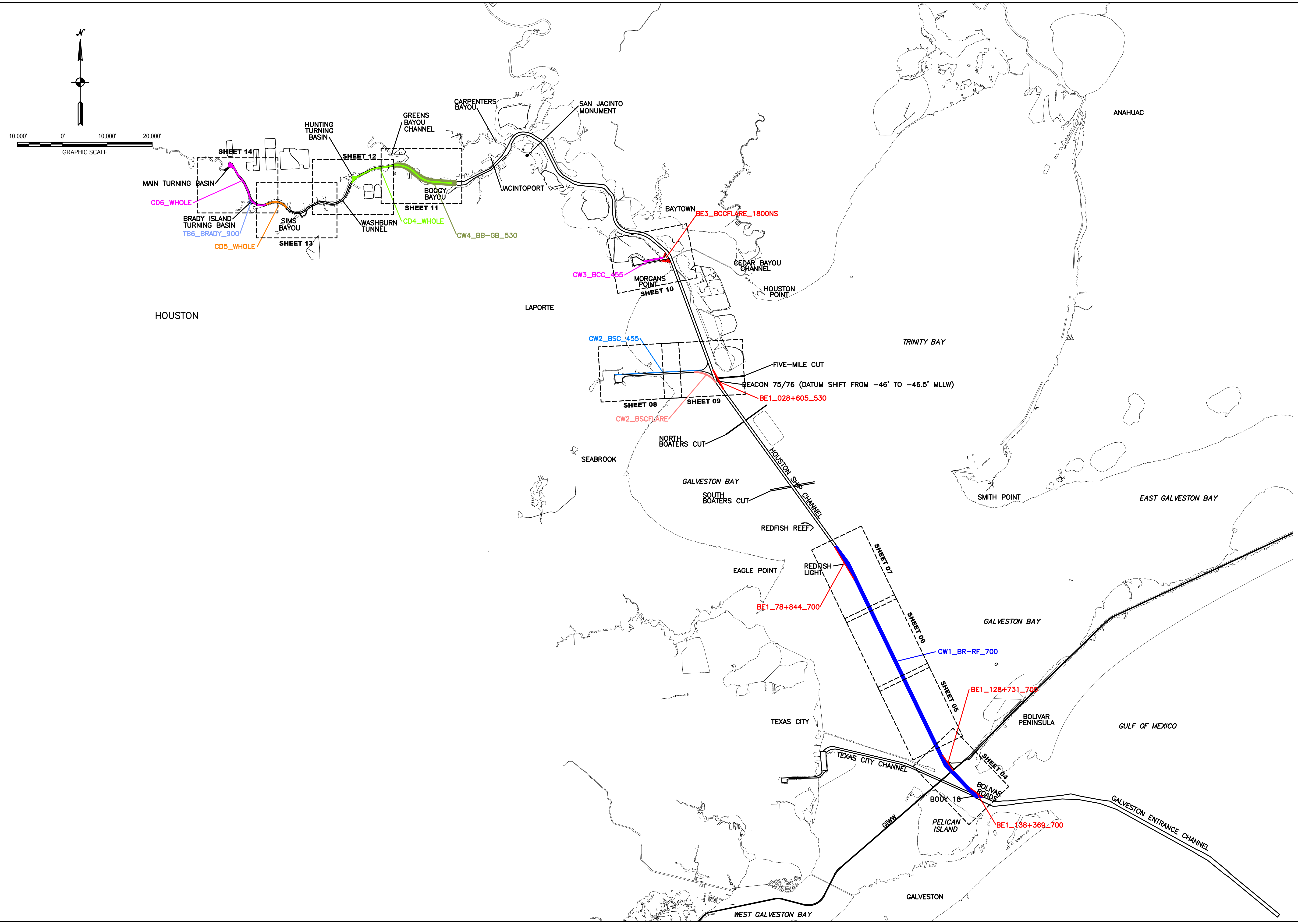
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

STUDY AREA

Plate No.:
01
Sheet 01 of 38



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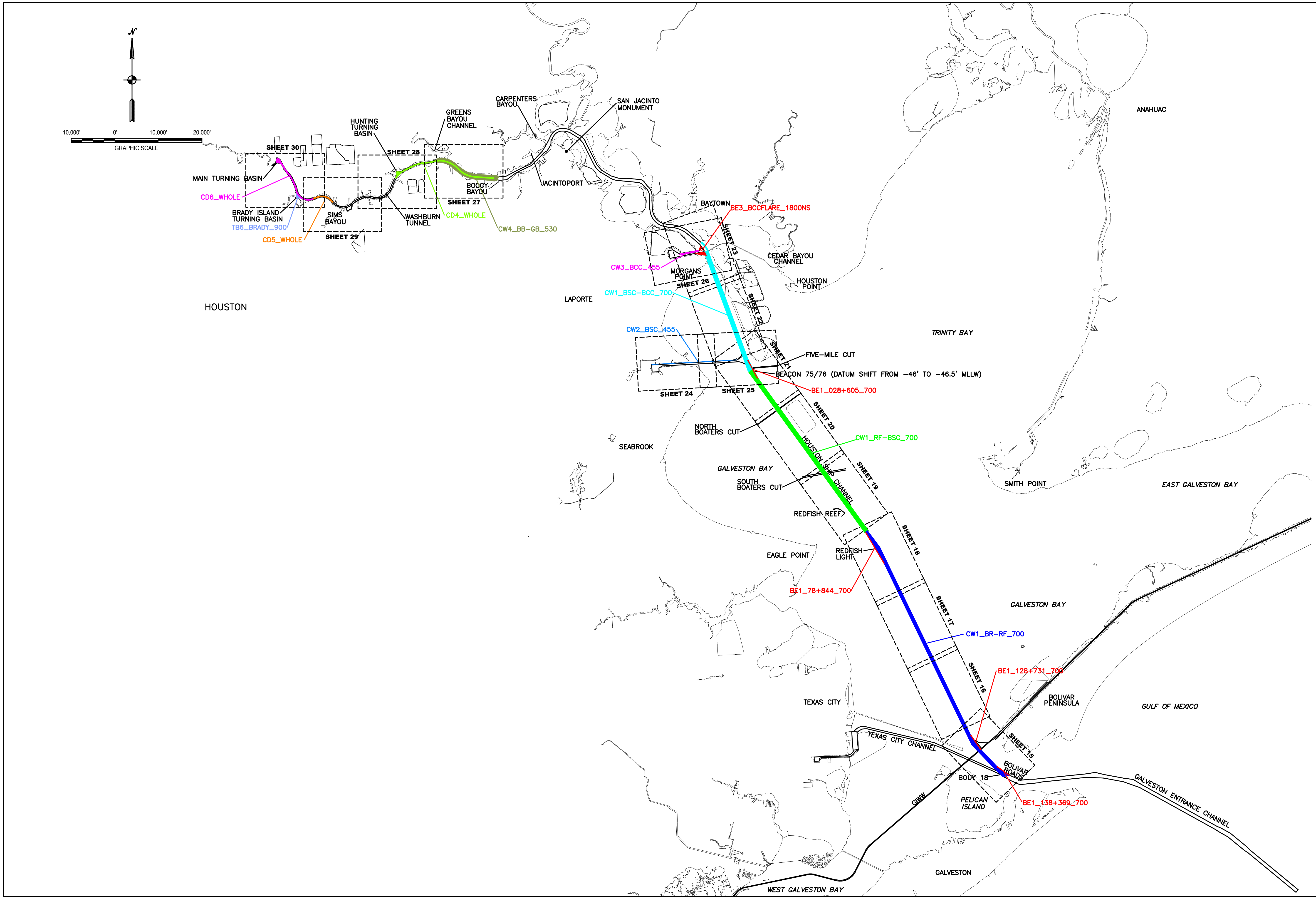
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN OVERVIEW

Plate No.:
02
Sheet 02 of 25



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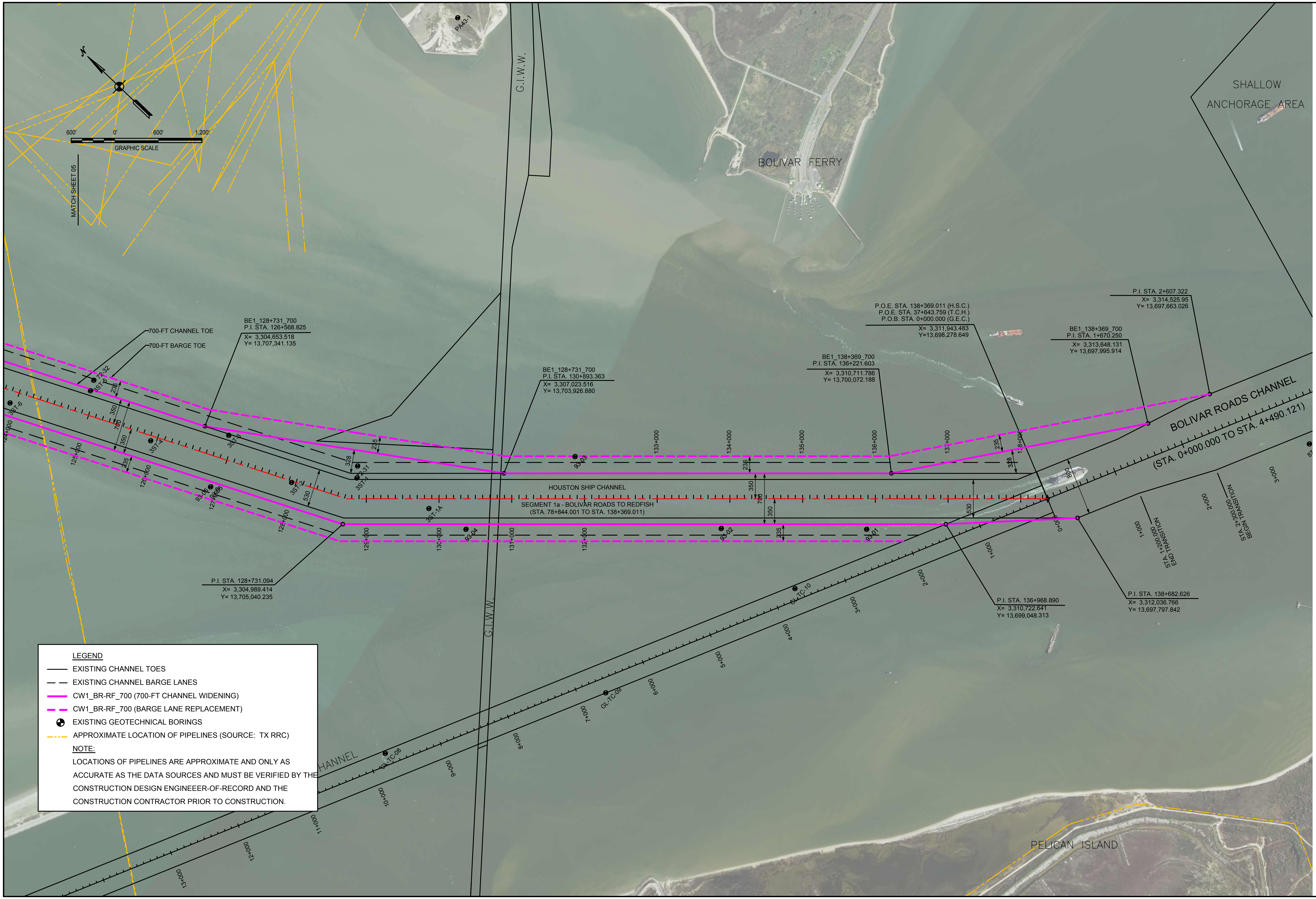
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

RECOMMENDED PLAN
LPP OVERVIEW

Plate No.:
03
Sheet 03 of 38



LEGEND

- EXISTING CHANNEL TOES
- EXISTING CHANNEL BARGE LANES
- CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
- CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
- ● EXISTING GEOTECHNICAL BORINGS
- APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

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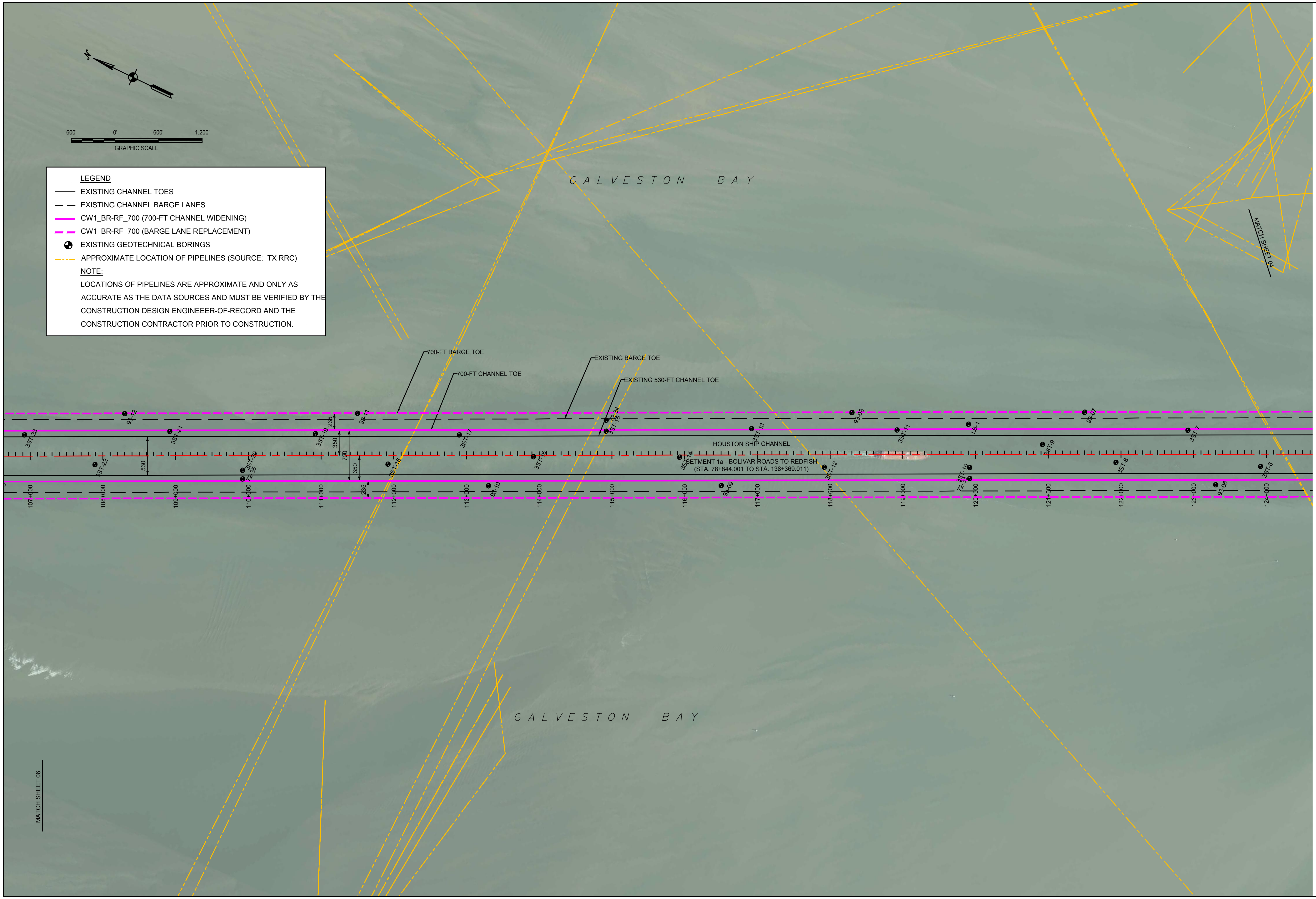
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

NED PLAN
SEGMENT 1a - BOLIVAR ROADS TO REDFISH

Plate No.:
04
Sheet 04 of 38



LEGEND

──	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
──	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
— —	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
— · —	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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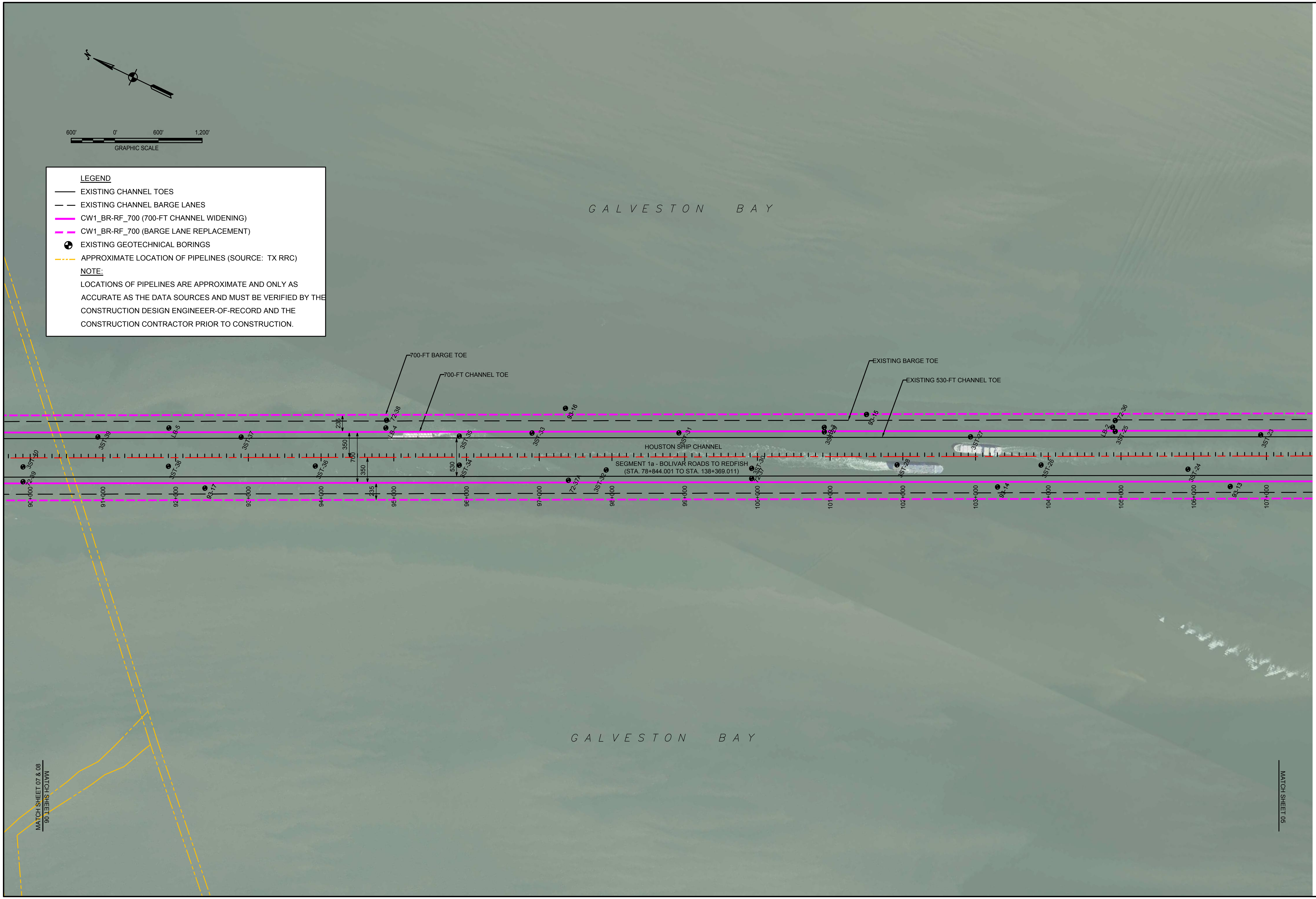
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

NED PLAN
SEGMENT 1a - BOLIVAR ROADS TO REDFISH

Plate No.:
05
Sheet 05 of 38



LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
—	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
— —	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
-·-	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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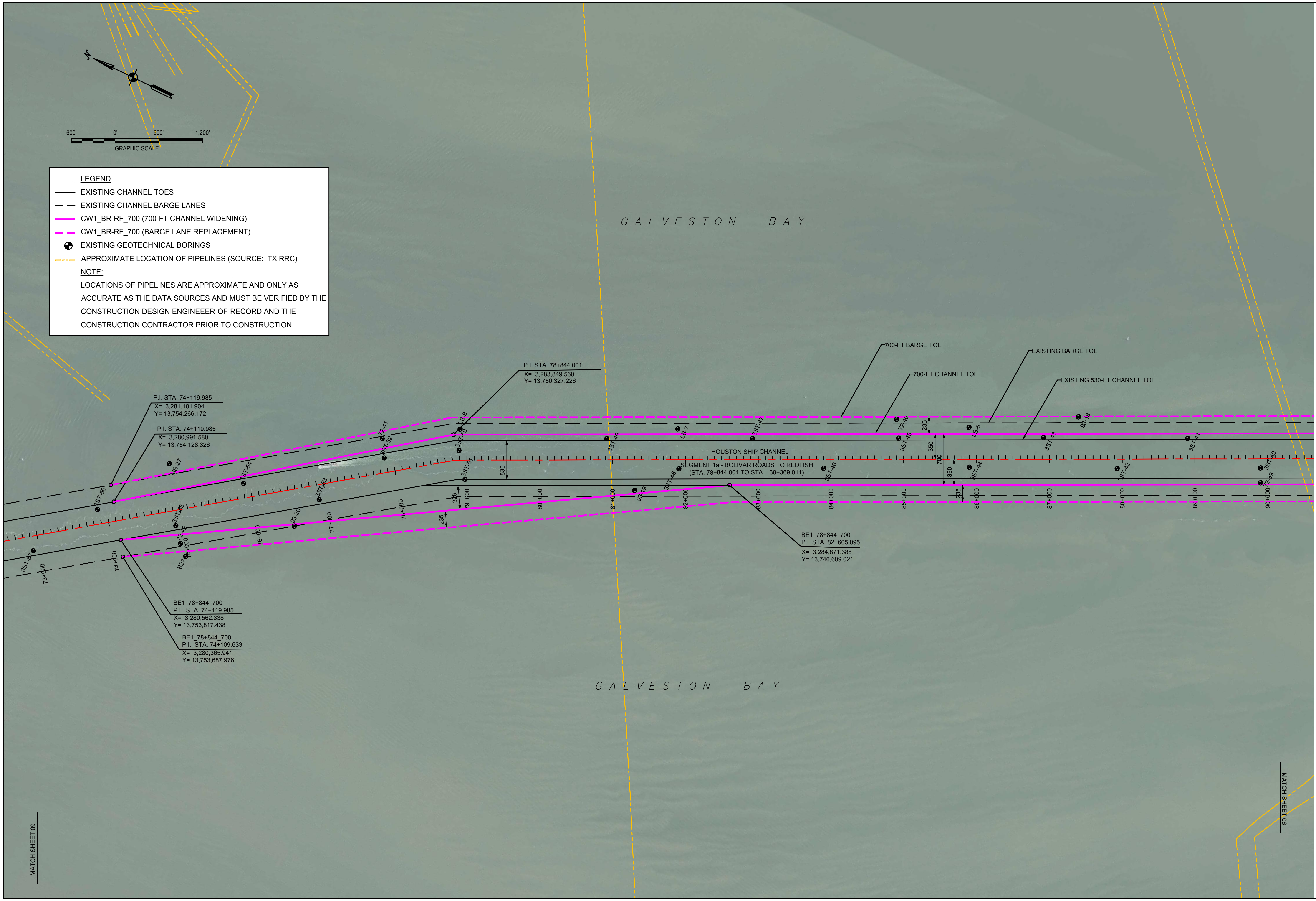
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 1a - ROADS TO REDFISH REEF

Plate No.:
06
Sheet 06 of 38



LEGEND

- — EXISTING CHANNEL TOES
- — — EXISTING CHANNEL BARGE LANES
- — CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
- — — CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
- ● EXISTING GEOTECHNICAL BORINGS
- -·- APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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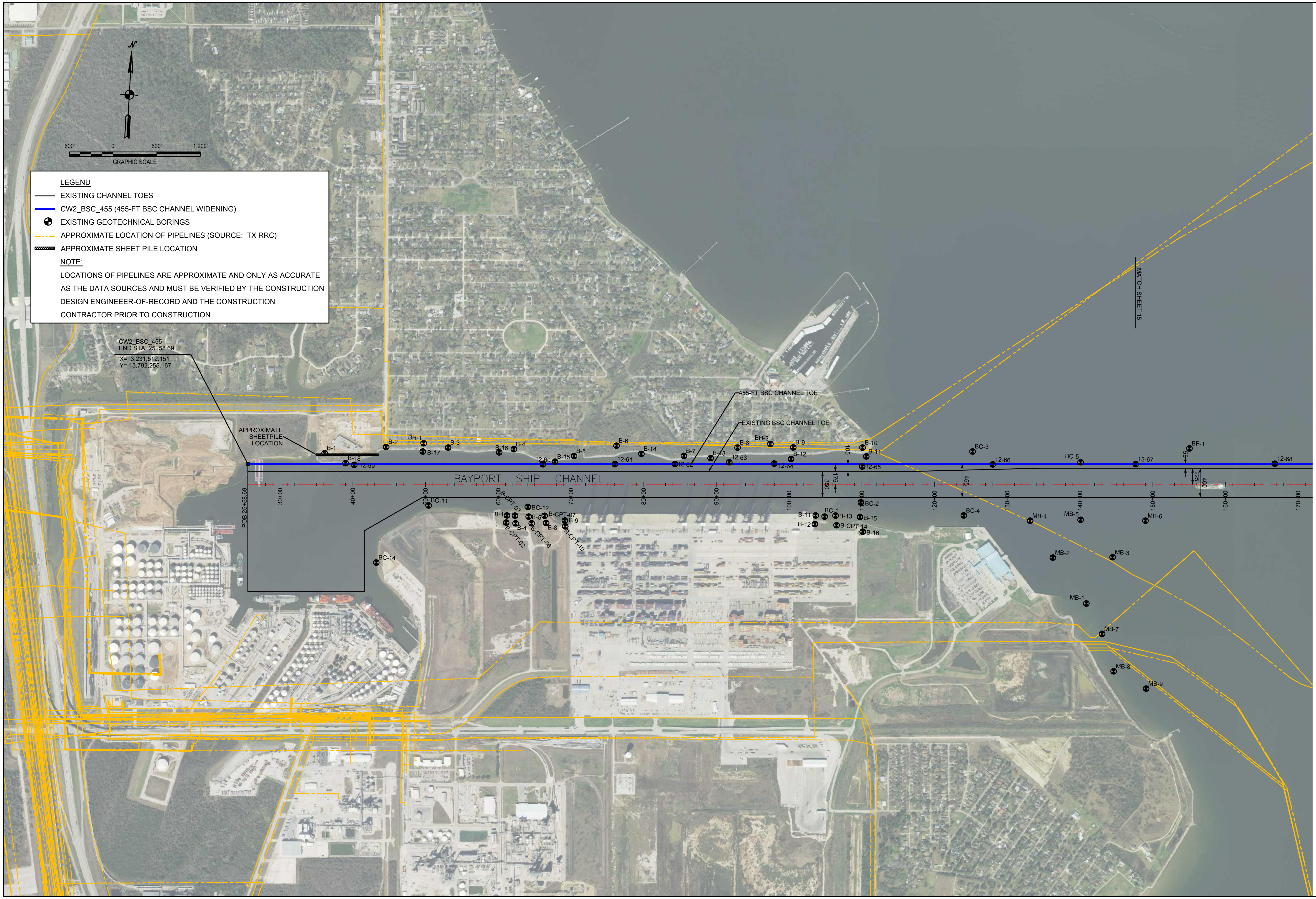
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 1a - BOLIVAR ROADS TO REDFISH

Plate No.:
07
Sheet 07 of 38



LEGEND

—	EXISTING CHANNEL TOES
—	CW2_BSC_455 (455-FT BSC CHANNEL WIDENING)
●	EXISTING GEOTECHNICAL BORINGS
-·-	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
▨	APPROXIMATE SHEET PILE LOCATION

NOTE:

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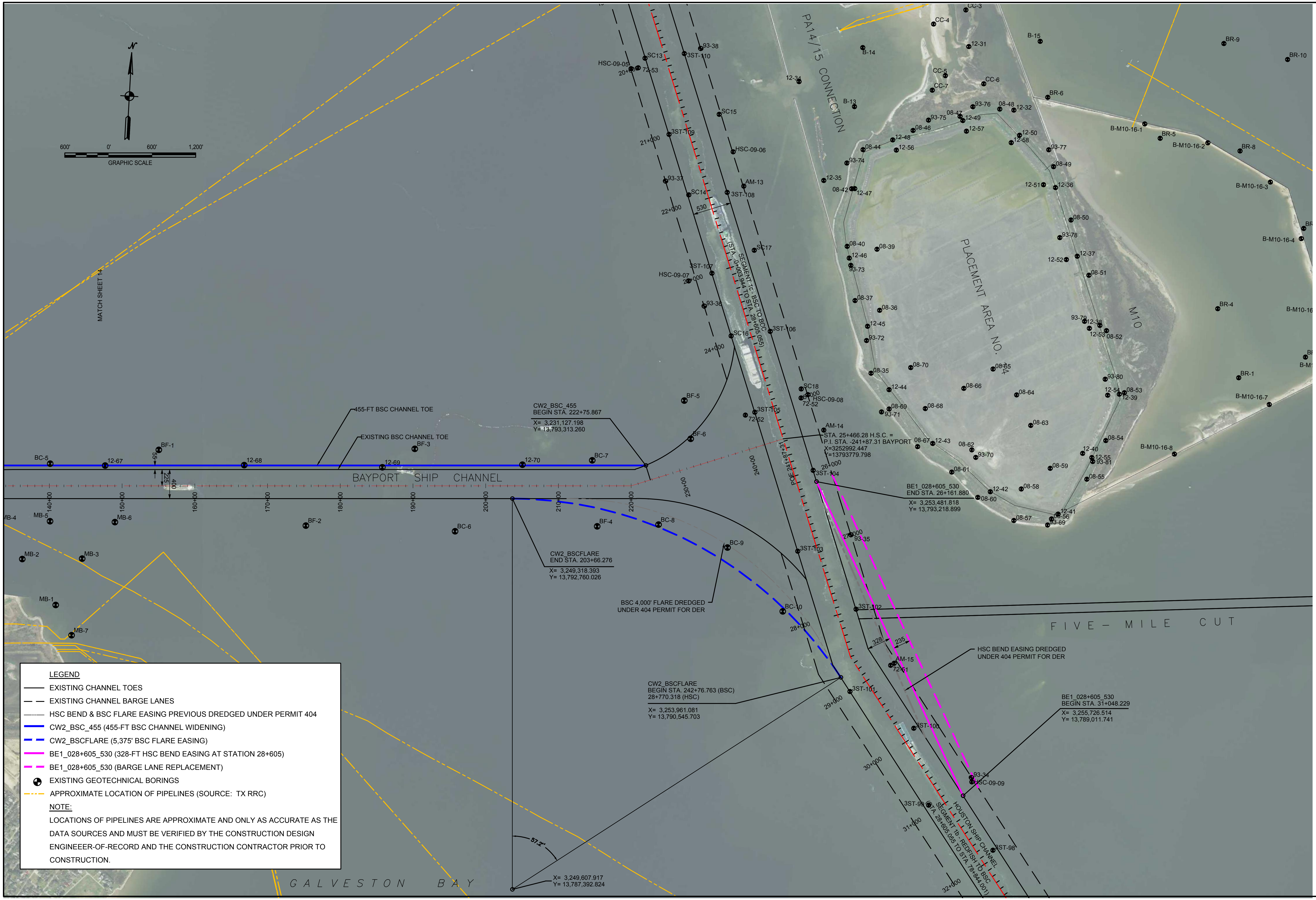
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 2 - BAYPORT SHIP CHANNEL

Plate No.:
08
Sheet 08 of 38



LEGEND

───	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
········	HSC BEND & BSC FLARE EASING PREVIOUSLY DREDGED UNDER PERMIT 404
───	CW2_BSC_455 (455-FT BSC CHANNEL WIDENING)
— —	CW2_BSCFLARE (5,375' BSC FLARE EASING)
───	BE1_028+605_530 (328-FT HSC BEND EASING AT STATION 28+605)
— —	BE1_028+605_530 (BARGE LANE REPLACEMENT)
⊗	EXISTING GEOTECHNICAL BORINGS
-·-·-	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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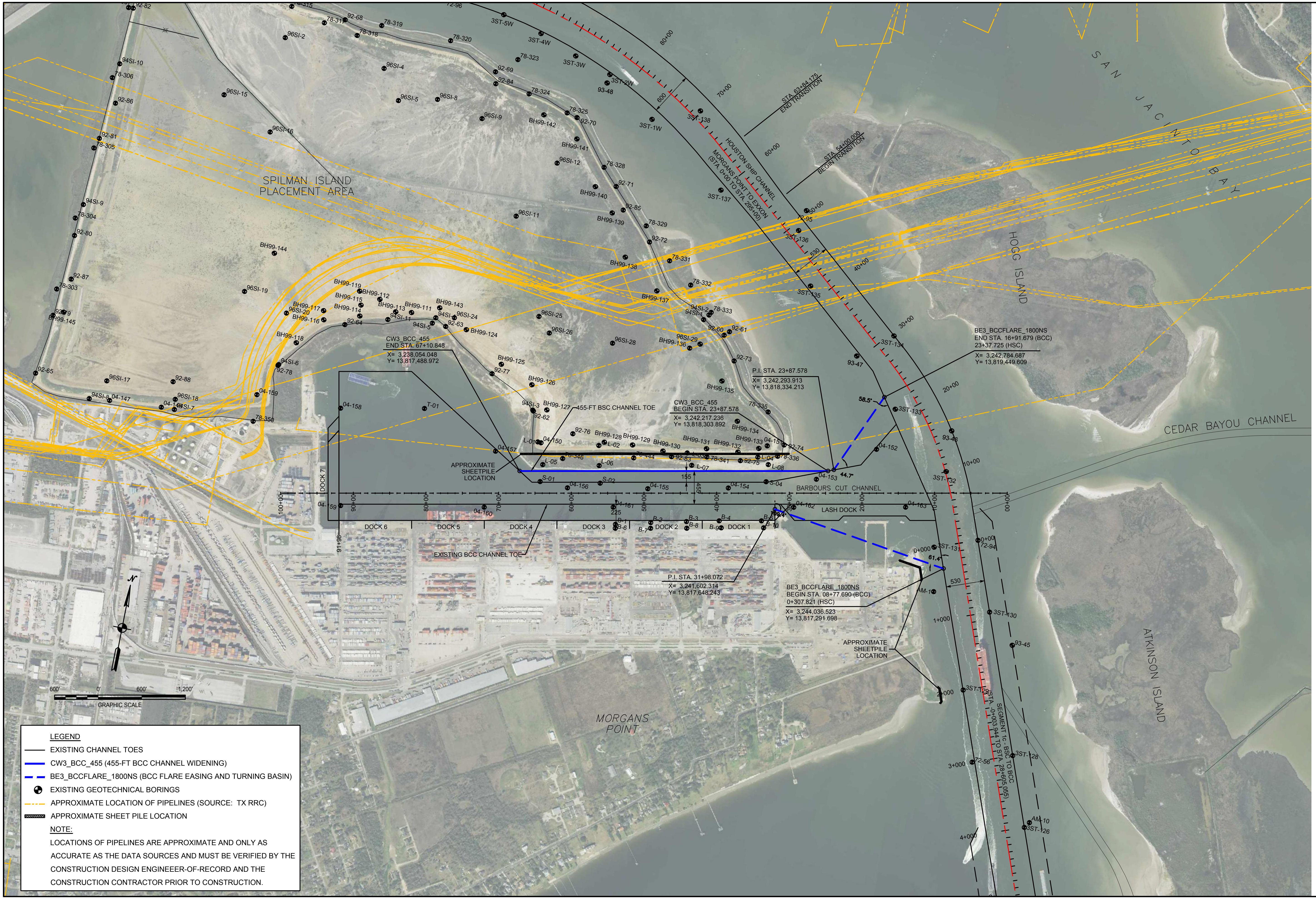
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 2 - BAYPORT SHIP CHANNEL

Plate No.:
09
Sheet 09 of 38



LEGEND

▬	EXISTING CHANNEL TOES
▬	CW3_BCC_455 (455-FT BCC CHANNEL WIDENING)
‒ ‒	BE3_BCCFLARE_1800NS (BCC FLARE EASING AND TURNING BASIN)
⊕	EXISTING GEOTECHNICAL BORINGS
‒ · ‒	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
▨	APPROXIMATE SHEET PILE LOCATION

NOTE:

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HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

NED PLAN
EGMENT 3 - BARBOURS CUT CHANNEL

Plate No.:
10
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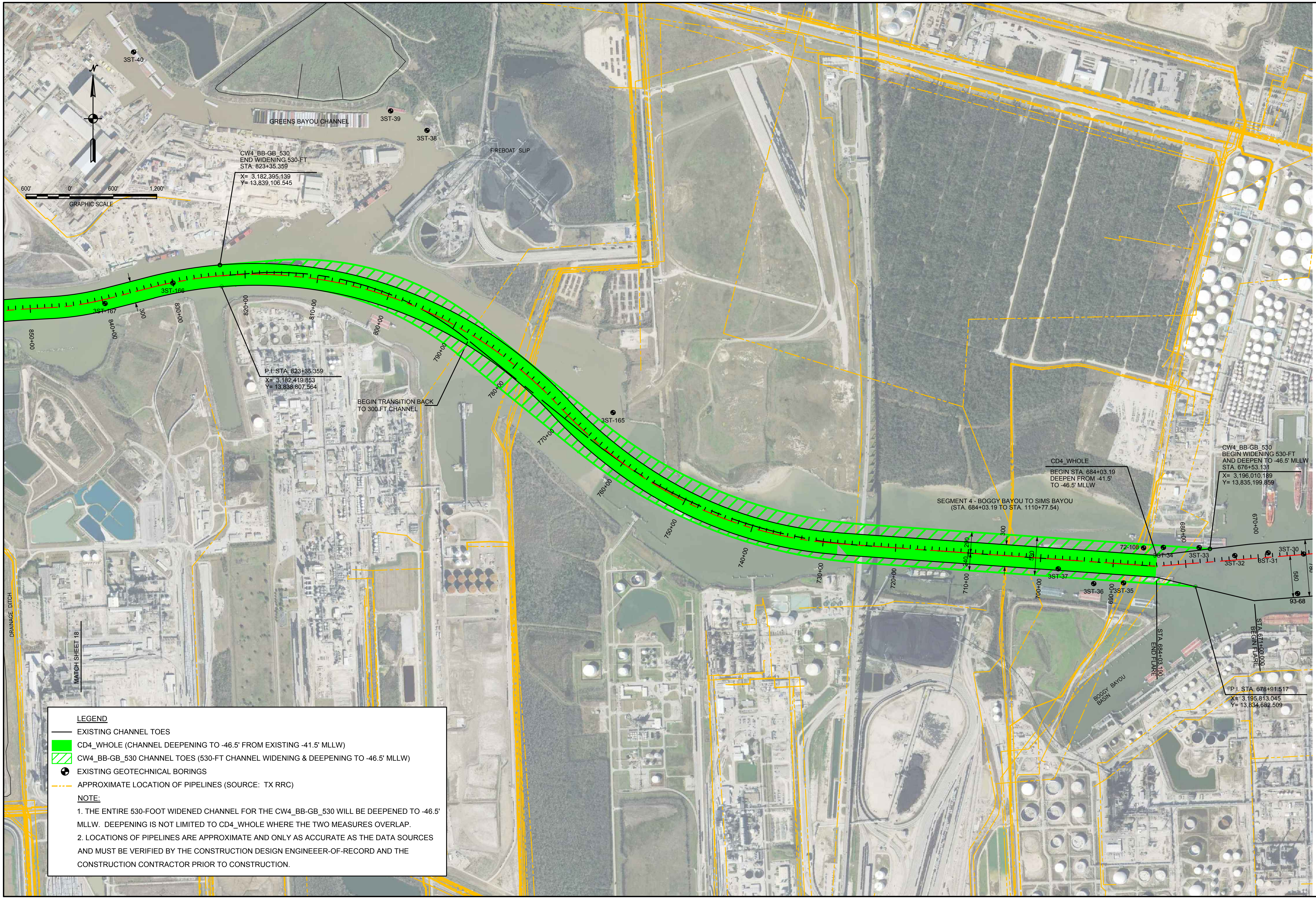

LEGEND

—	EXISTING CHANNEL TOES
🟩	CD4_WHOLE (CHANNEL DEEPENING TO -46.5' FROM EXISTING -41.5' MLLW)
▨	CW4_BB-GB_530 CHANNEL TOES (530-FT CHANNEL WIDENING & DEEPENING TO -46.5' MLLW)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

1. THE ENTIRE 530-FOOT WIDENED CHANNEL FOR THE CW4_BB-GB_530 WILL BE DEEPENED TO -46.5' MLLW. DEEPENING IS NOT LIMITED TO CD4_WHOLE WHERE THE TWO MEASURES OVERLAP.
2. LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

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HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

NED PLAN
SEGMENT 4 BOGGY BAYOU TO SIMS BAYOU

Plate No.:
11
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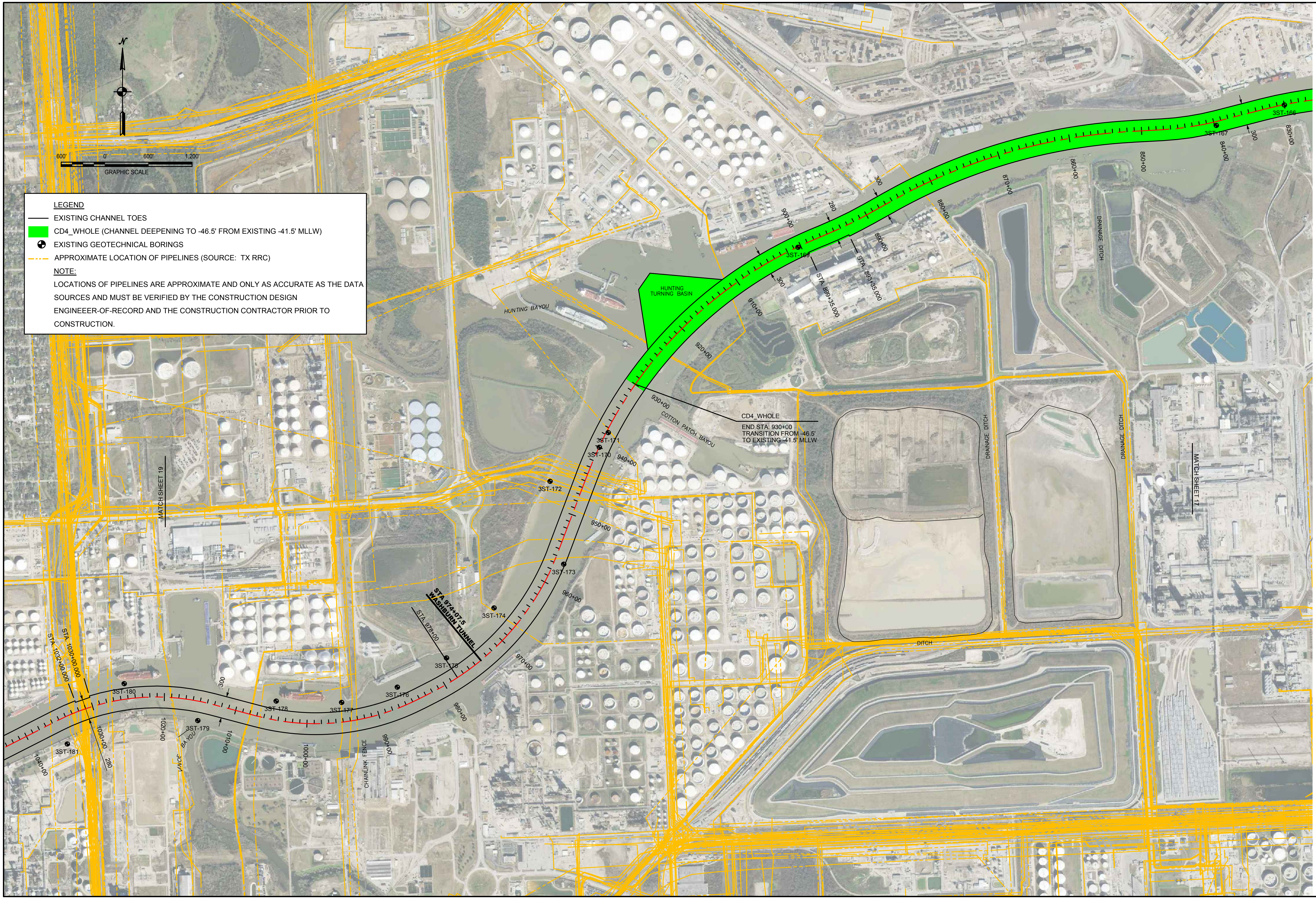

LEGEND

—	EXISTING CHANNEL TOES
🟩	CD4_WHOLE (CHANNEL DEEPENING TO -46.5' FROM EXISTING -41.5' MLLW)
◐	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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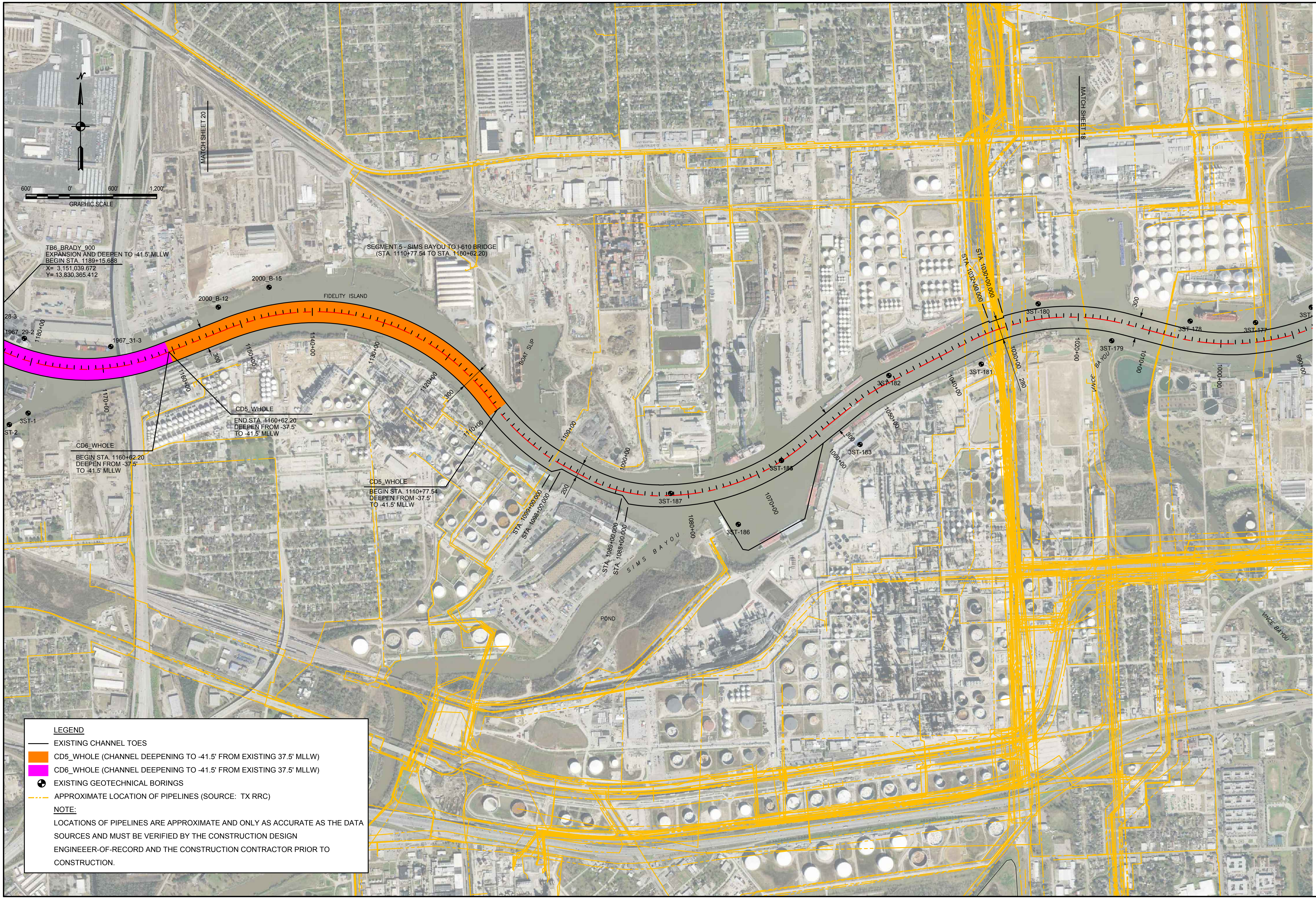
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 4 BOGGY BAYOU TO SIMS BAYOU

Plate No.:
12
Sheet 12 of 38



LEGEND

—	EXISTING CHANNEL TOES
🟧	CD5_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING 37.5' MLLW)
🟪	CD6_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING 37.5' MLLW)
●	EXISTING GEOTECHNICAL BORINGS
- - -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

NED PLAN
SEGMENT 5 SIMS BAYOU TO I-610-BRIDGE

Plate No.:

13

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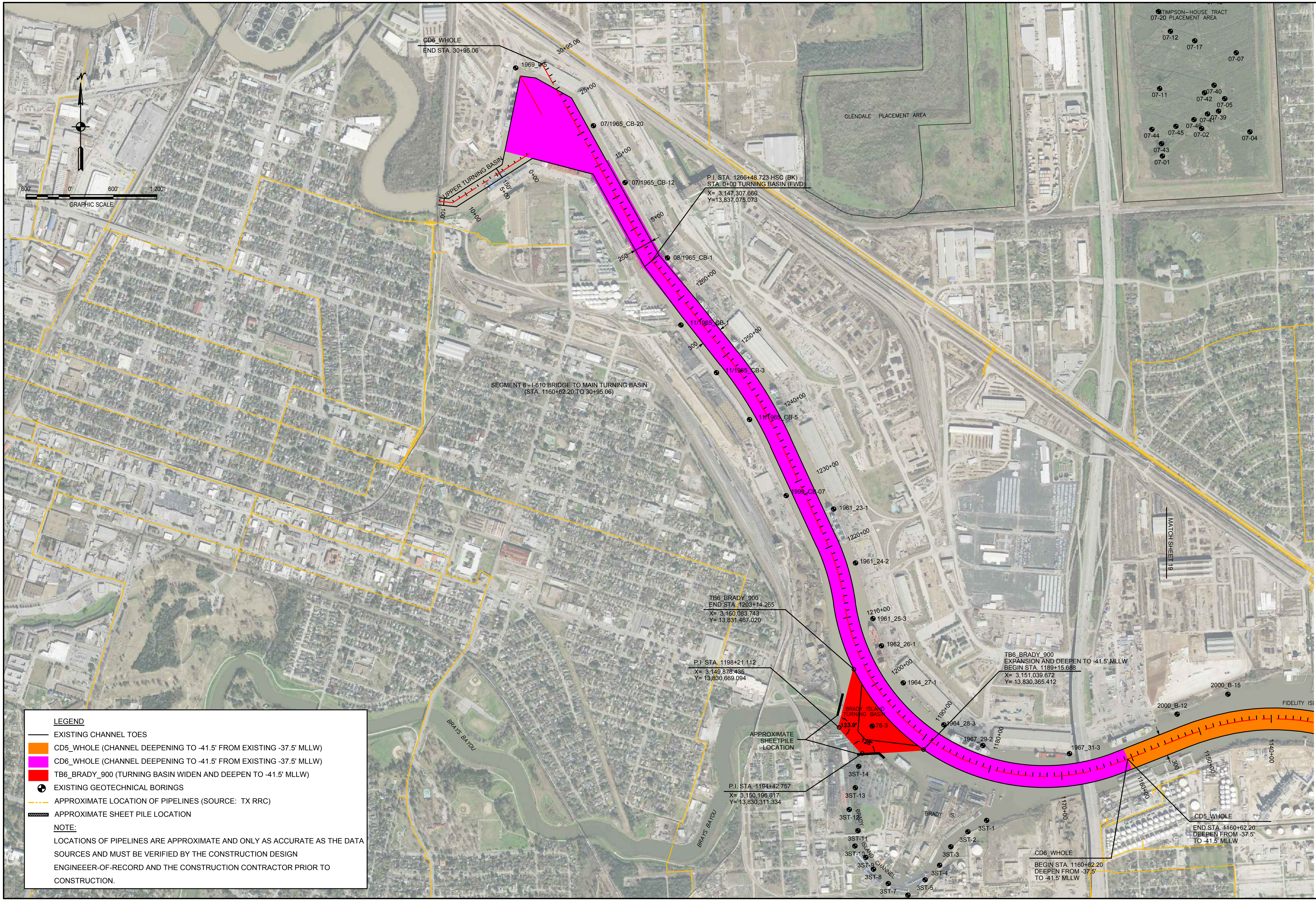

LEGEND

- EXISTING CHANNEL TOES
- 🟧 CD5_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING -37.5' MLLW)
- 🟪 CD6_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING -37.5' MLLW)
- 🟥 TB6_BRADY_900 (TURNING BASIN WIDEN AND DEEPEN TO -41.5' MLLW)
- ● EXISTING GEOTECHNICAL BORINGS
- APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
- ▨ APPROXIMATE SHEET PILE LOCATION

NOTE:

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HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

NED PLAN
SEGMENT 6 I-610 BRIDGE TO MAIN TB

Plate No.:

14

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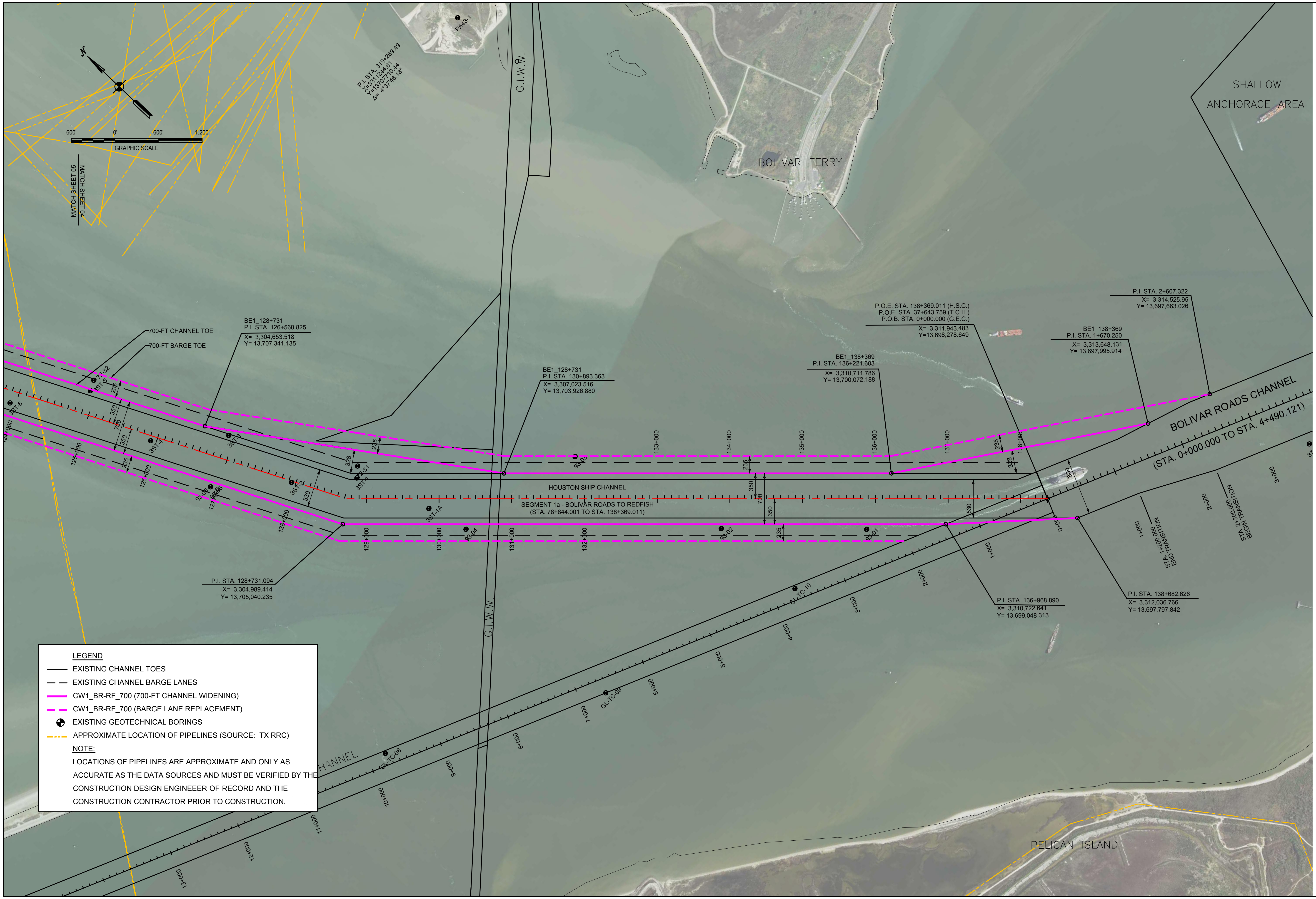

LEGEND

———	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
———	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
— —	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
— · —	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 1a - BOLIVAR ROADS TO REDFISH

Plate No.:
15
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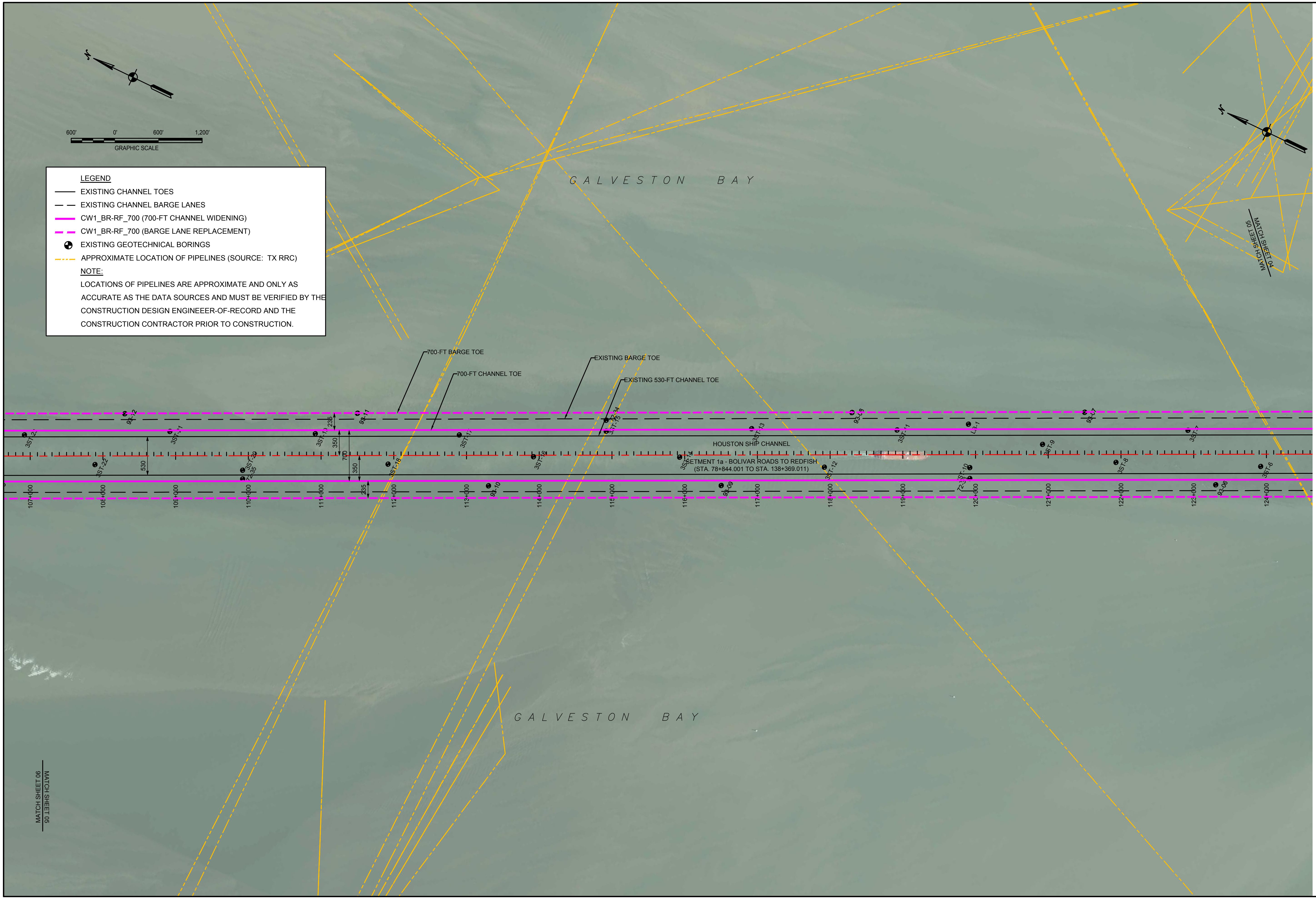

LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
—	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
— —	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
— · —	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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RECOMMENDED PLAN - LPP
SEGMENT 1a - BOLIVAR ROADS TO REDFISH

Plate No.:
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LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
—	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
— —	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
— · —	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

U.S. Army Corps
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Galveston District

Rev.	Description	Date	By

Drawn by: SAH
Designed by: --
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Submitted by:
Approved by:
Date: 08/22/2019
Rev.
Scale: AS SHOWN
Approval Recommended:

U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

Turner Collie & Braden Inc.
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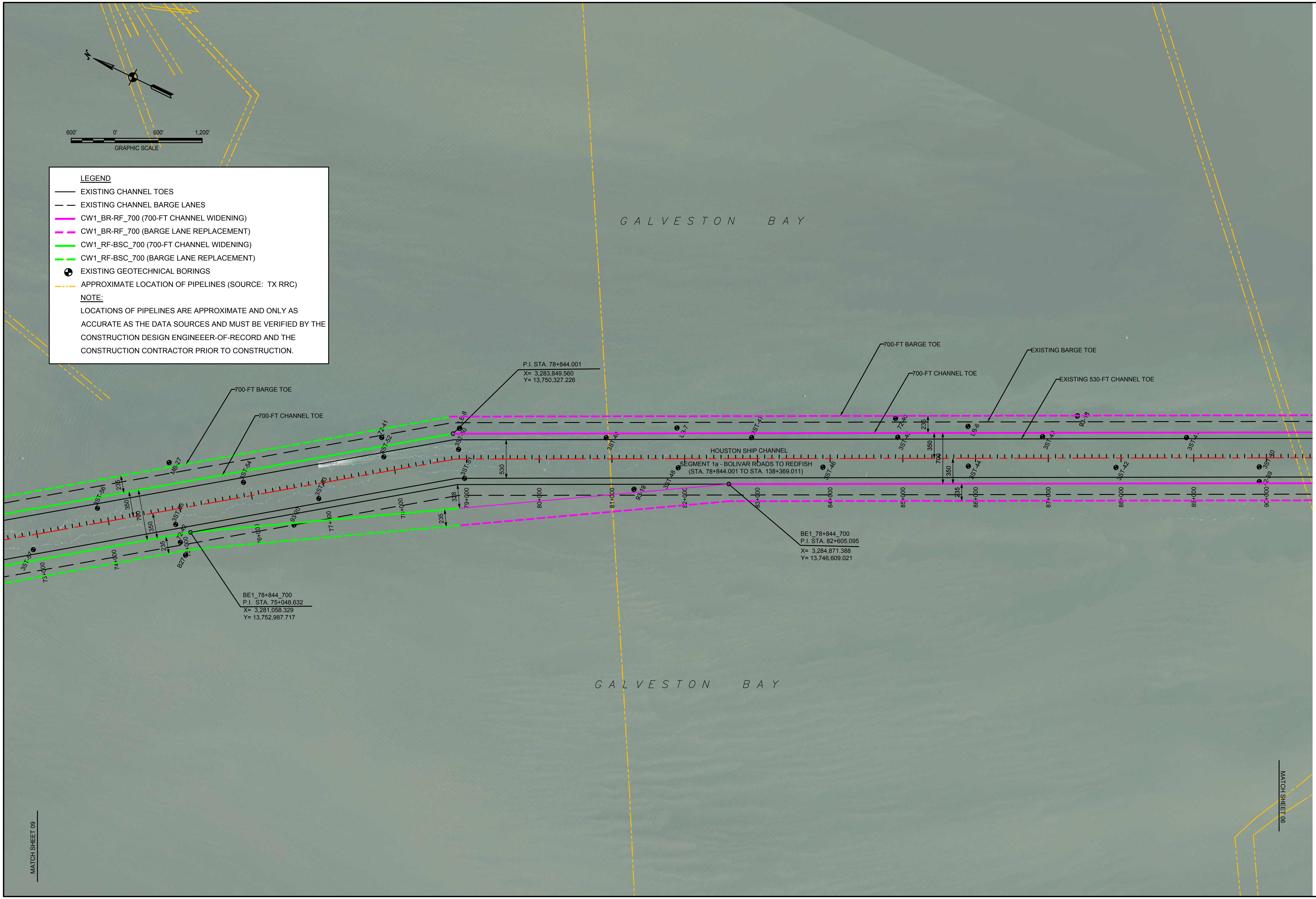
5444 WESTHEIMER RD. SUITE 200
HOUSTON, TX 77056

**HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)**

RECOMMENDED PLAN - LPP
SEGMENT 1a - ROADS TO REDFISH REEF

Plate No.:
17

Sheet 17 of 38



LEGEND

───	EXISTING CHANNEL TOES
─ ─	EXISTING CHANNEL BARGE LANES
───	CW1_BR-RF_700 (700-FT CHANNEL WIDENING)
─ ─	CW1_BR-RF_700 (BARGE LANE REPLACEMENT)
───	CW1_RF-BSC_700 (700-FT CHANNEL WIDENING)
─ ─	CW1_RF-BSC_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
─ · ─	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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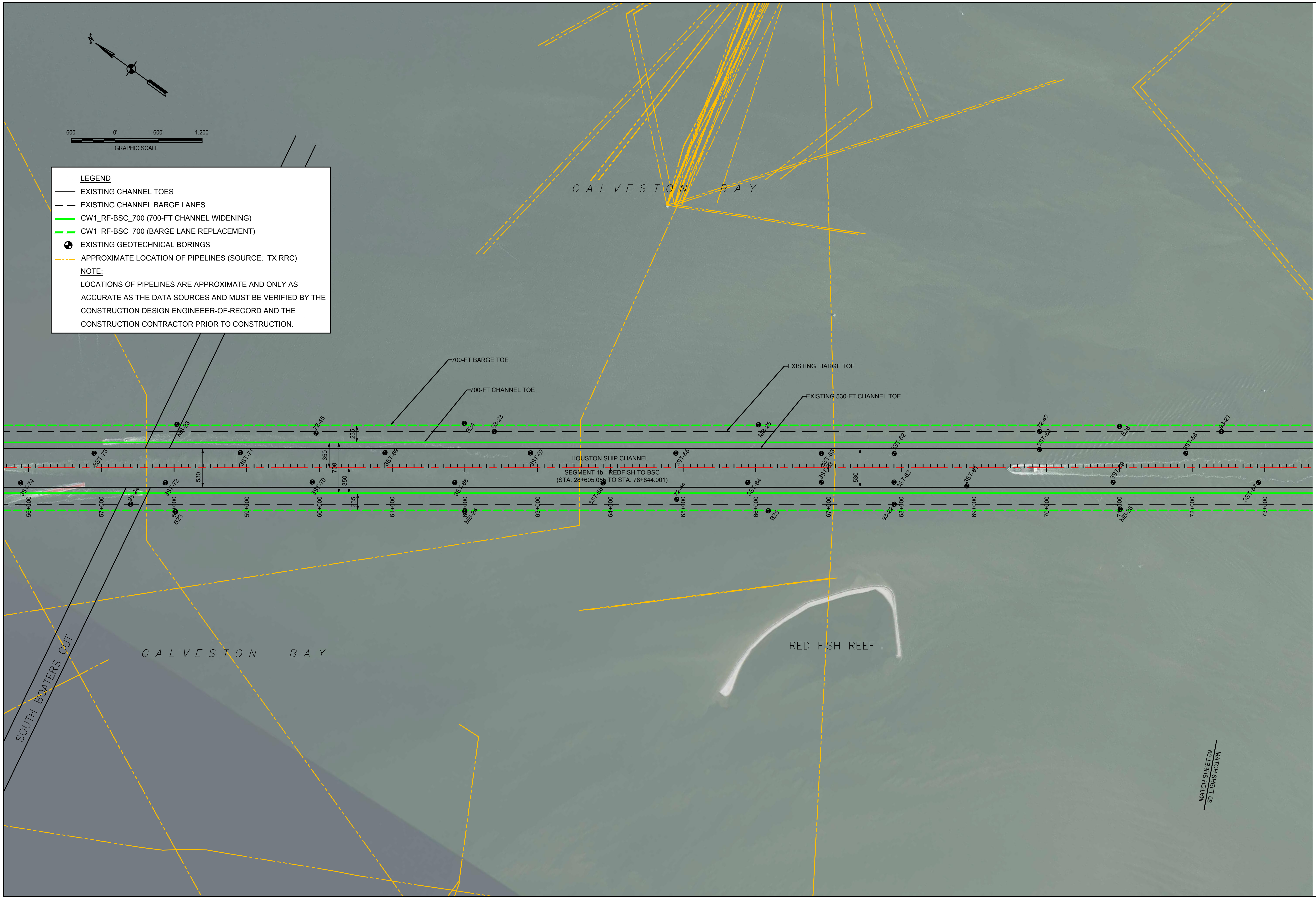
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 1a - BOLIVAR ROADS TO REDFISH
SEGMENT 1b - REDFISH TO BSC

Plate No.:
18
Sheet 18 of 38



LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
🟩	CW1_RF-BSC_700 (700-FT CHANNEL WIDENING)
🟩 🟩	CW1_RF-BSC_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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Approved by:
Chief, Engineering and Construction Division

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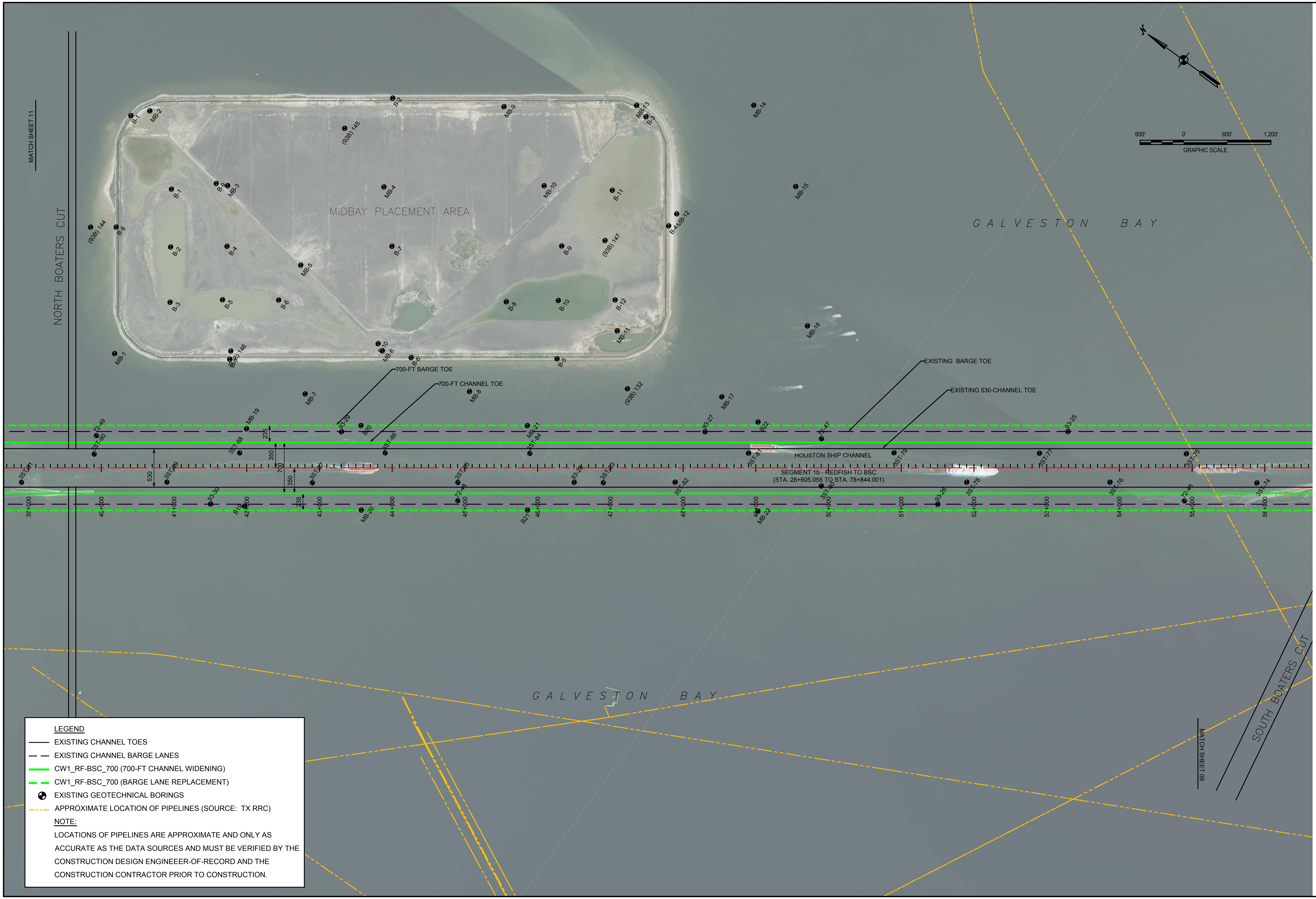
**HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)**

RECOMMENDED PLAN - LPP
SEGMENT 1b - REDFISH TO BSC

Plate No.:
19
Sheet 19 of 38



LEGEND

——	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
🟩	CW1_RF-BSC_700 (700-FT CHANNEL WIDENING)
🟩 🟩	CW1_RF-BSC_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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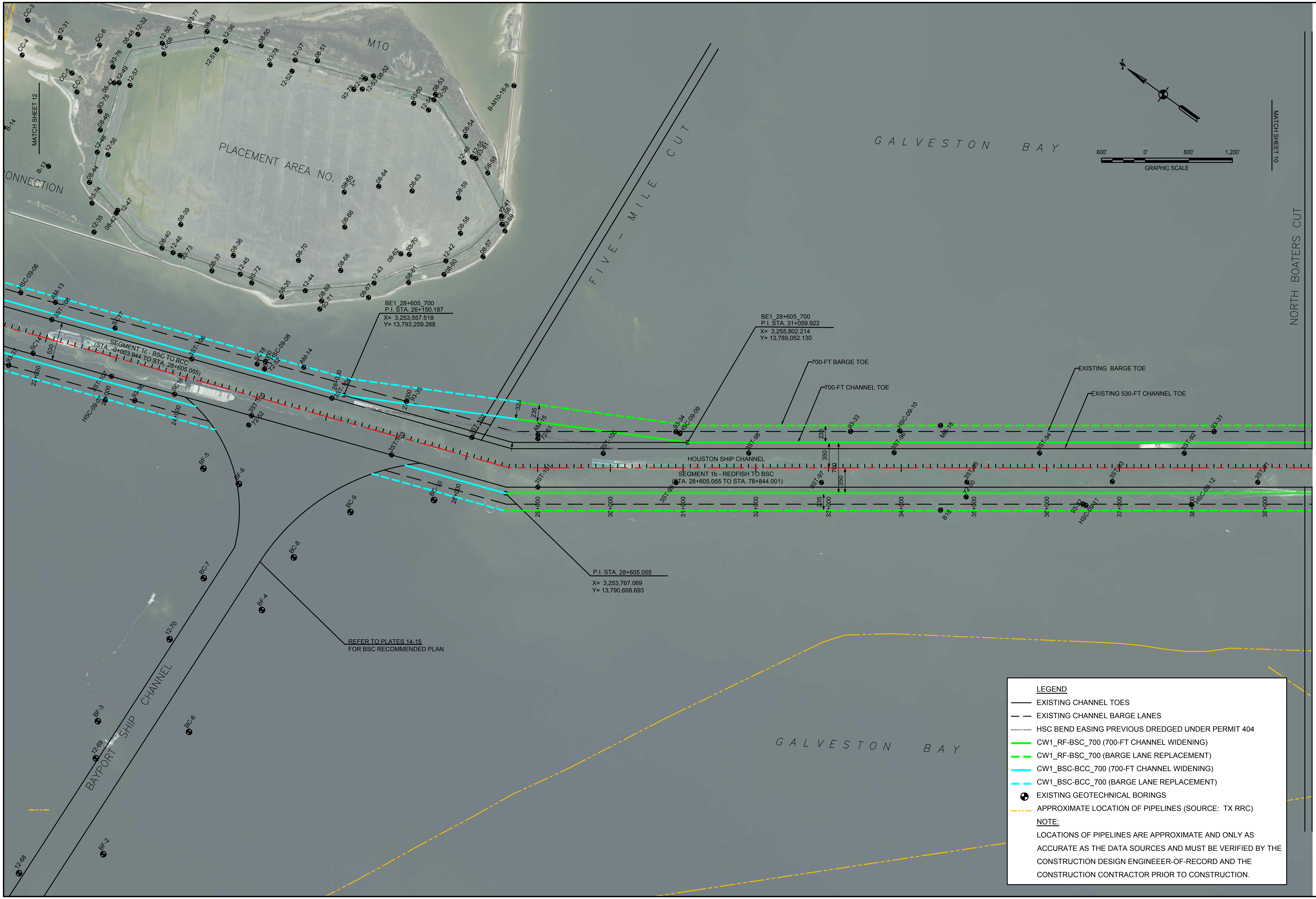
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 1b - REDFISH TO BSC

Plate No.:
20
Sheet 20 of 38



LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
-·-·-	HSC BEND EASING PREVIOUS DREDGED UNDER PERMIT 404
🟩 —	CW1_RF-BSC_700 (700-FT CHANNEL WIDENING)
🟩 — —	CW1_RF-BSC_700 (BARGE LANE REPLACEMENT)
—	CW1_BSC-BCC_700 (700-FT CHANNEL WIDENING)
— —	CW1_BSC-BCC_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
— · —	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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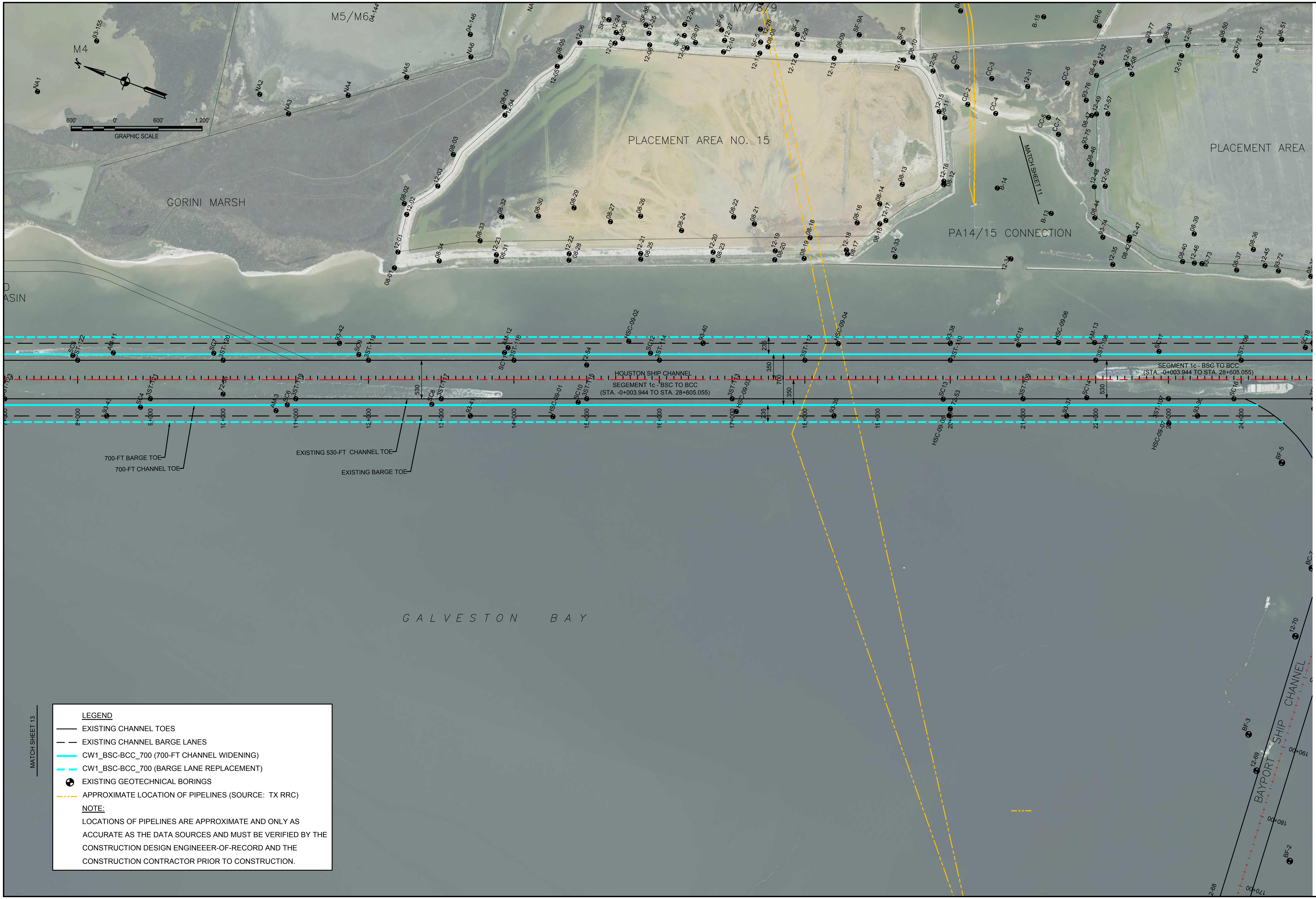
**HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)**

RECOMMENDED PLAN - LPP
SEGMENT 1b - REDFISH TO BSC
SEGMENT 1c - BSC TO BCC

Plate No.:
21
Sheet 21 of 38



LEGEND

- EXISTING CHANNEL TOES
- EXISTING CHANNEL BARGE LANES
- CW1_BSC-BCC_700 (700-FT CHANNEL WIDENING)
- CW1_BSC-BCC_700 (BARGE LANE REPLACEMENT)
- EXISTING GEOTECHNICAL BORINGS
- APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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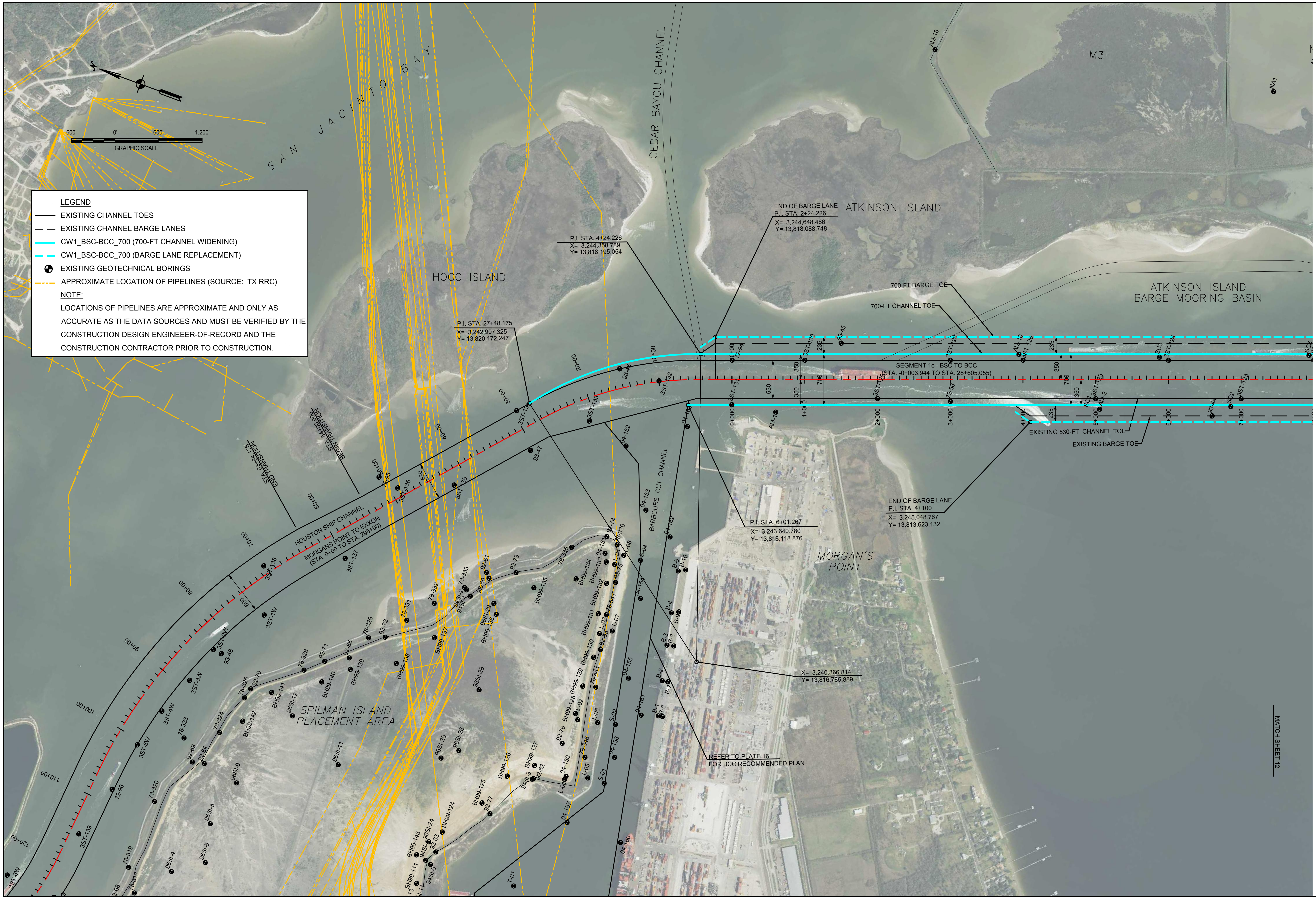
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 1c - BSC TO BCC

Plate No.:
22
Sheet 22 of 38



LEGEND

—	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
—	CW1_BSC-BCC_700 (700-FT CHANNEL WIDENING)
— —	CW1_BSC-BCC_700 (BARGE LANE REPLACEMENT)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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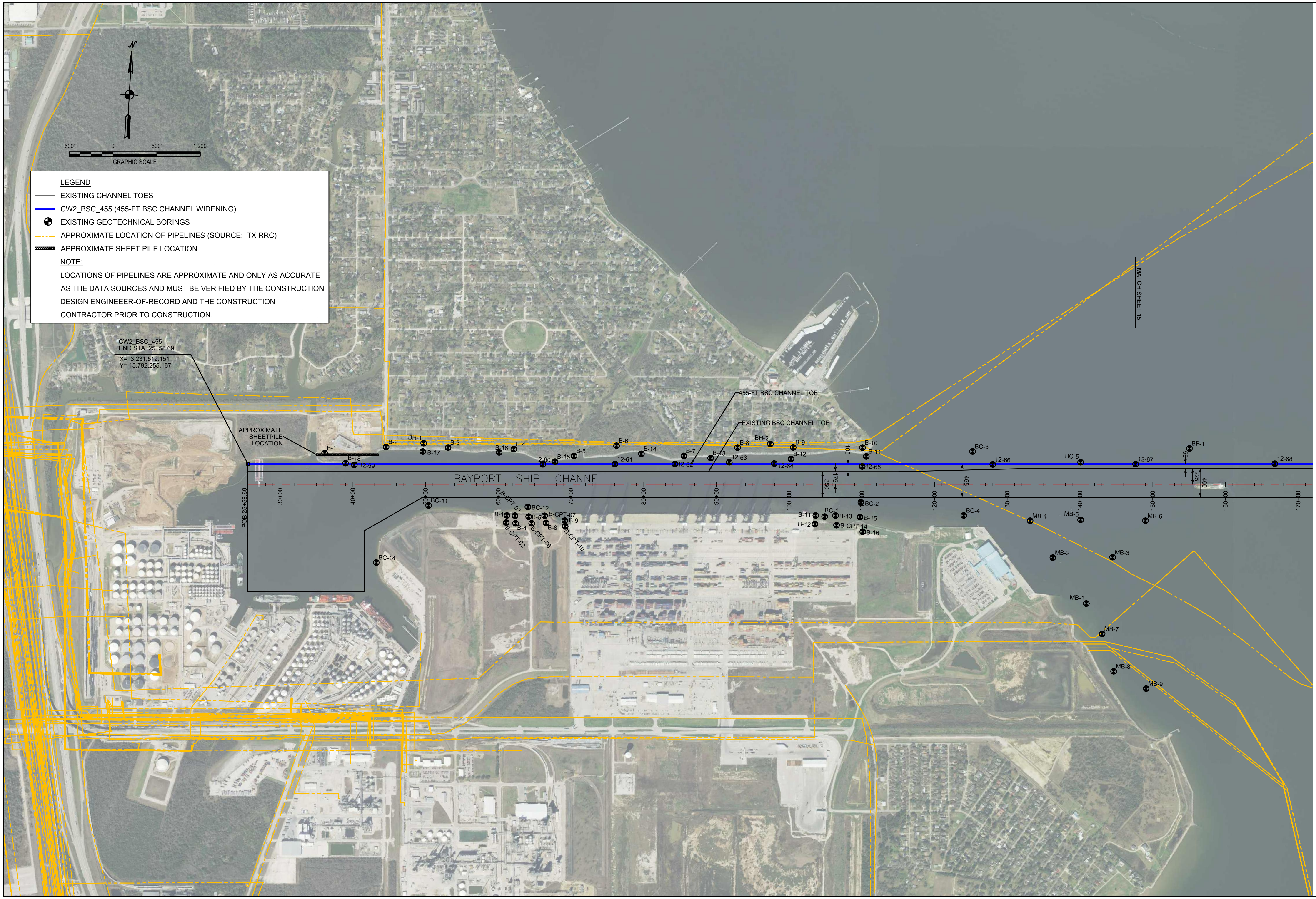
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 1c - BSC TO BCC

Plate No.:
23
Sheet 23 of 38



LEGEND

—	EXISTING CHANNEL TOES
—	CW2_BSC_455 (455-FT BSC CHANNEL WIDENING)
●	EXISTING GEOTECHNICAL BORINGS
-·-	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
▨	APPROXIMATE SHEET PILE LOCATION

NOTE:

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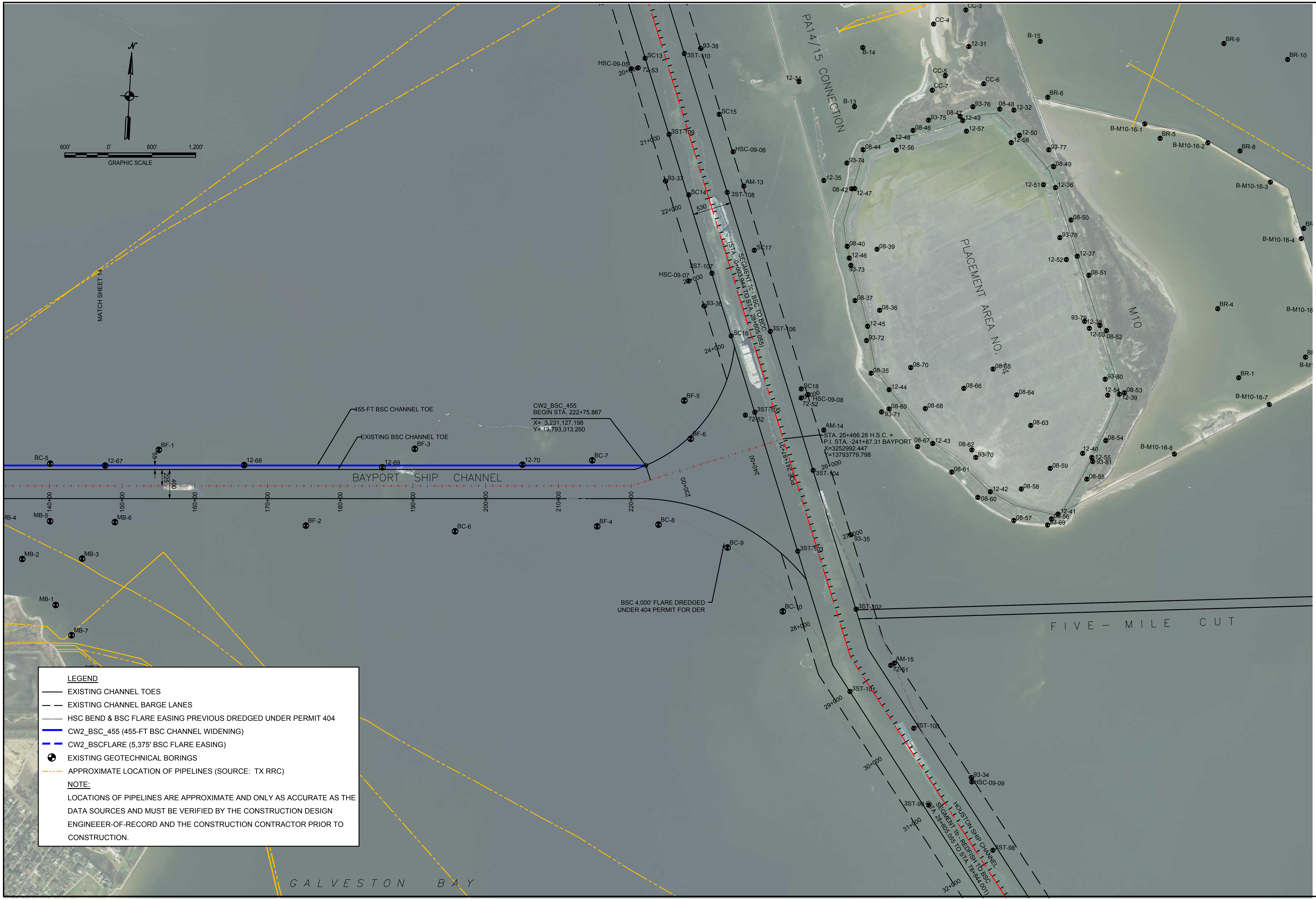
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 2 - BAYPORT SHIP CHANNEL

Plate No.:
24
Sheet 24 of 38



LEGEND

——	EXISTING CHANNEL TOES
— —	EXISTING CHANNEL BARGE LANES
----	HSC BEND & BSC FLARE EASING PREVIOUS DREDGED UNDER PERMIT 404
——	CW2_BSC_455 (455-FT BSC CHANNEL WIDENING)
— —	CW2_BSCFLARE (5,375' BSC FLARE EASING)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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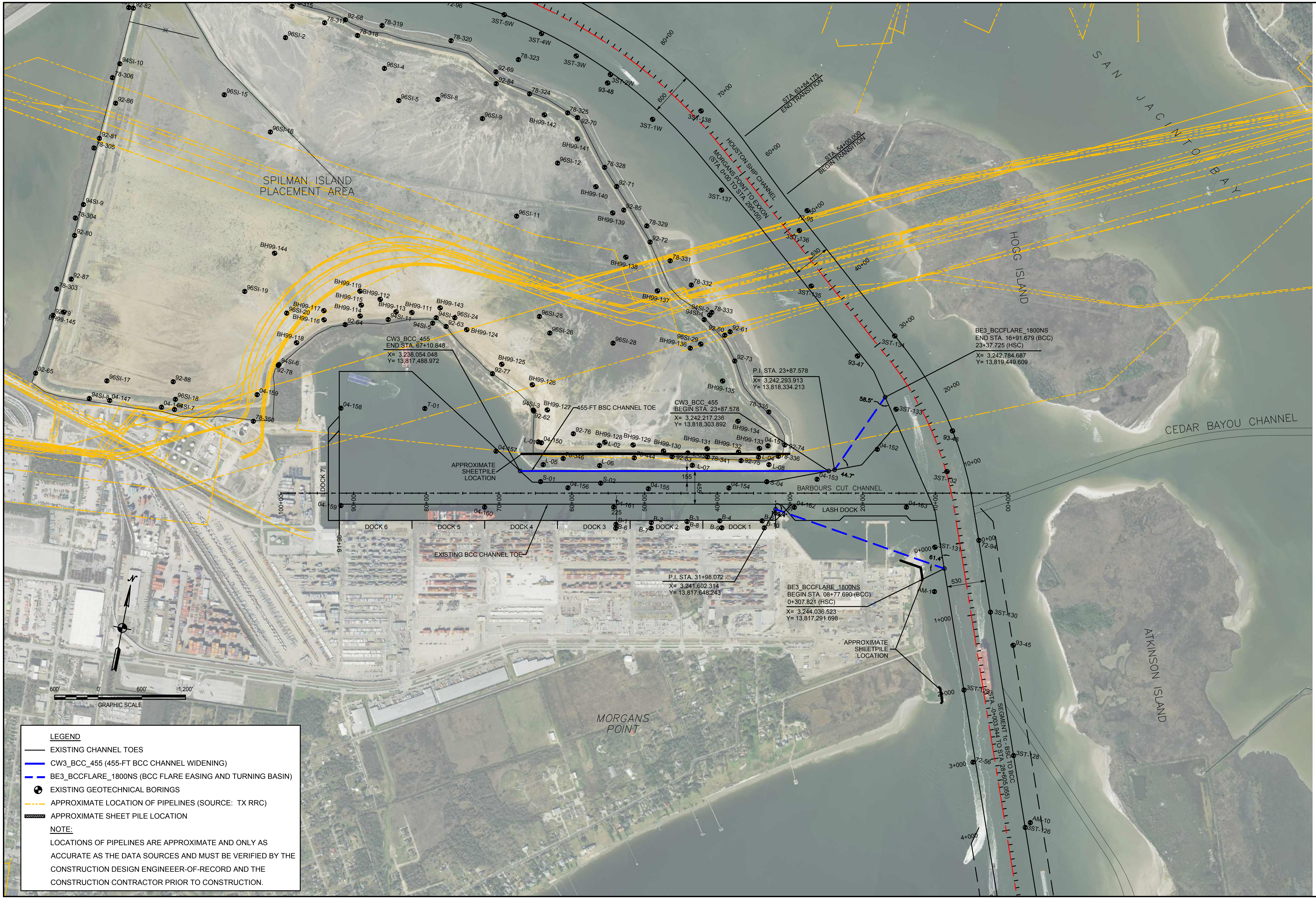
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 2 - BAYPORT SHIP CHANNEL

Plate No.:
25
Sheet 25 of 38



LEGEND

—	EXISTING CHANNEL TOES
—	CW3_BCC_455 (455-FT BCC CHANNEL WIDENING)
– –	BE3_BCCFLARE_1800NS (BCC FLARE EASING AND TURNING BASIN)
●	EXISTING GEOTECHNICAL BORINGS
– · –	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
▨	APPROXIMATE SHEET PILE LOCATION

NOTE:

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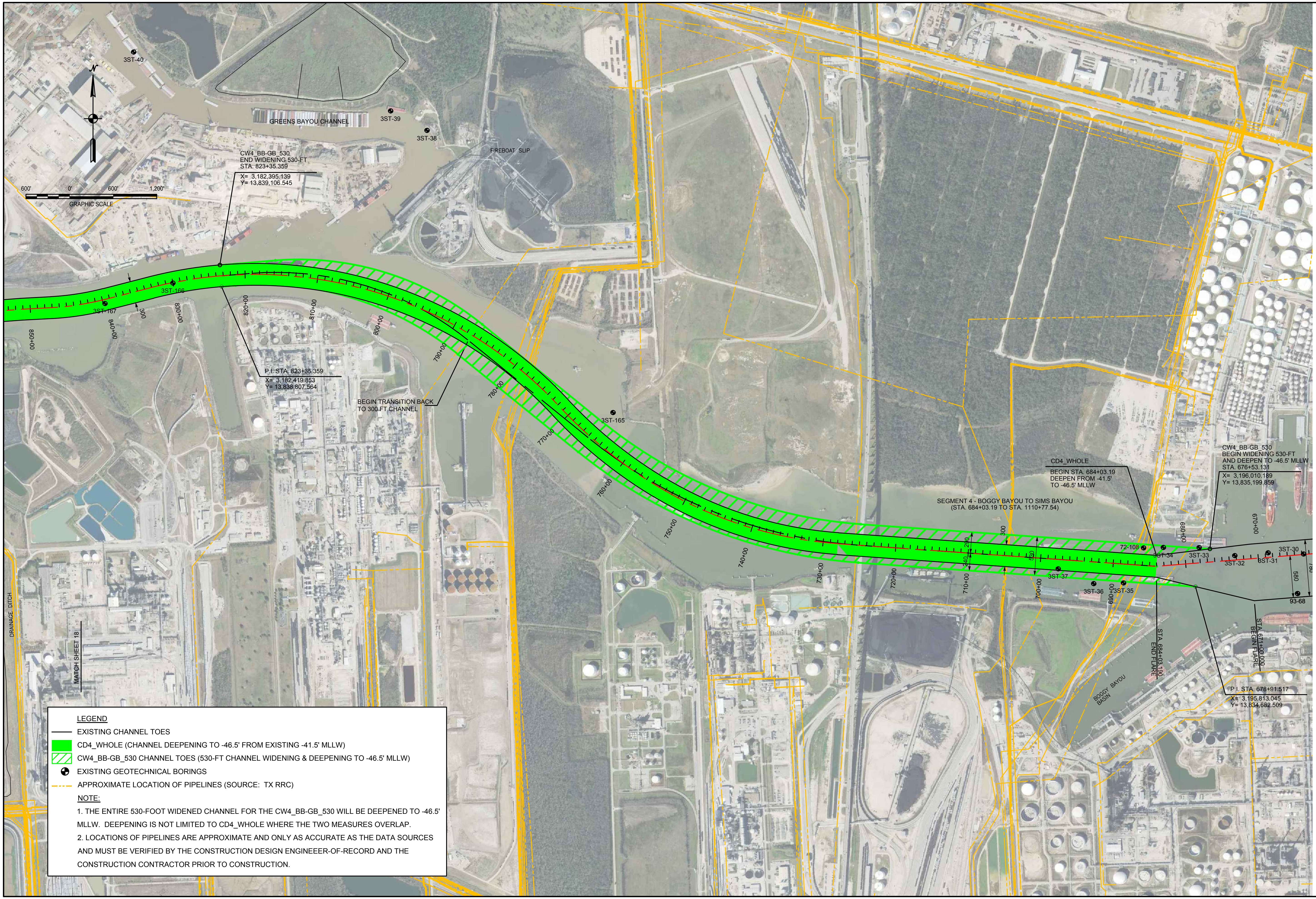
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 3 - BARBOURS CUT CHANNEL

Plate No.:
26
Sheet 26 of 38



LEGEND

—	EXISTING CHANNEL TOES
🟩	CD4_WHOLE (CHANNEL DEEPENING TO -46.5' FROM EXISTING -41.5' MLLW)
▨	CW4_BB-GB_530 CHANNEL TOES (530-FT CHANNEL WIDENING & DEEPENING TO -46.5' MLLW)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

1. THE ENTIRE 530-FOOT WIDENED CHANNEL FOR THE CW4_BB-GB_530 WILL BE DEEPENED TO -46.5' MLLW. DEEPENING IS NOT LIMITED TO CD4_WHOLE WHERE THE TWO MEASURES OVERLAP.
2. LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

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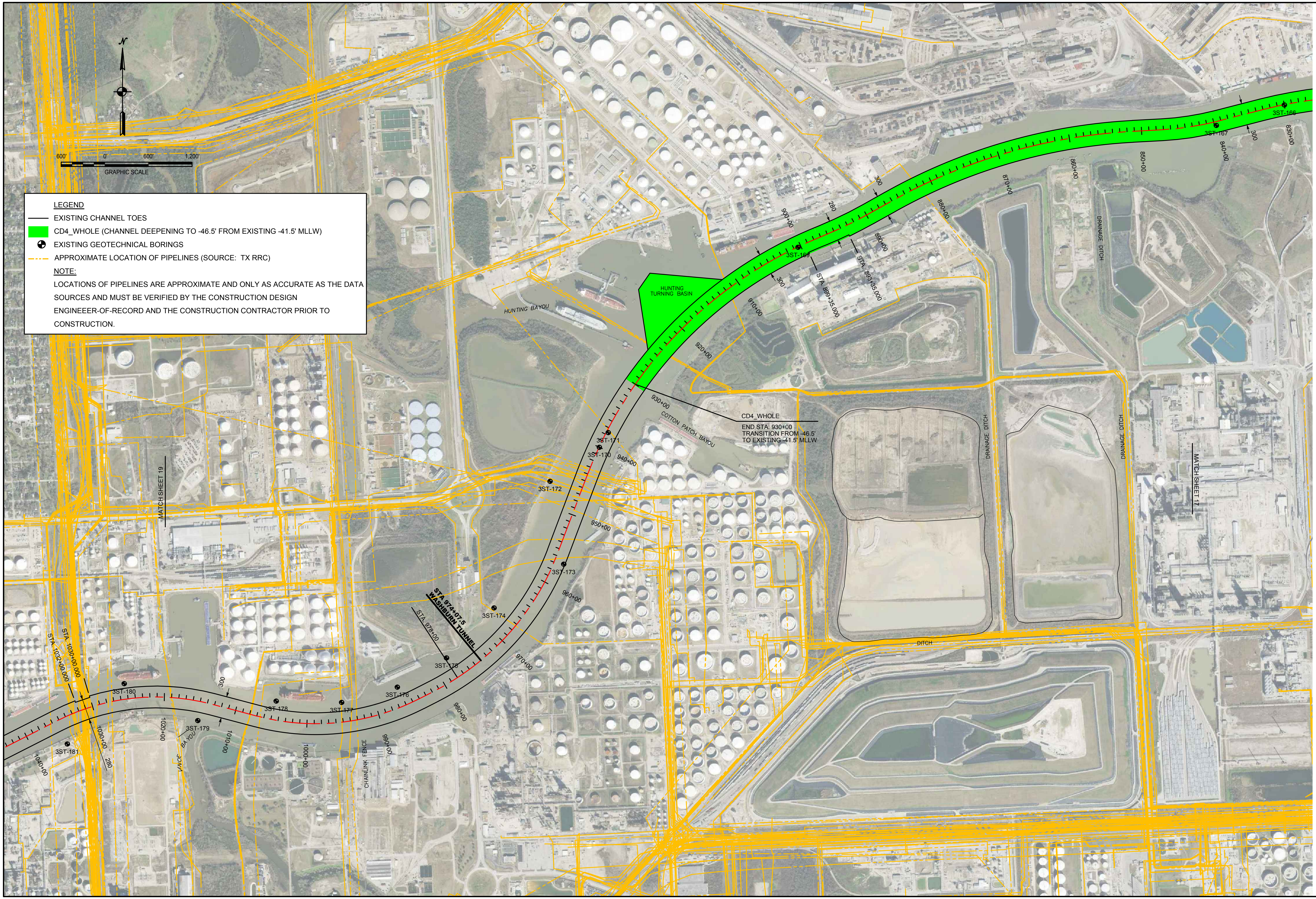
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 4 BOGGY BAYOU TO SIMS BAYOU

Plate No.:

27

Sheet 27 of 38



LEGEND

—	EXISTING CHANNEL TOES
🟩	CD4_WHOLE (CHANNEL DEEPENING TO -46.5' FROM EXISTING -41.5' MLLW)
●	EXISTING GEOTECHNICAL BORINGS
- - -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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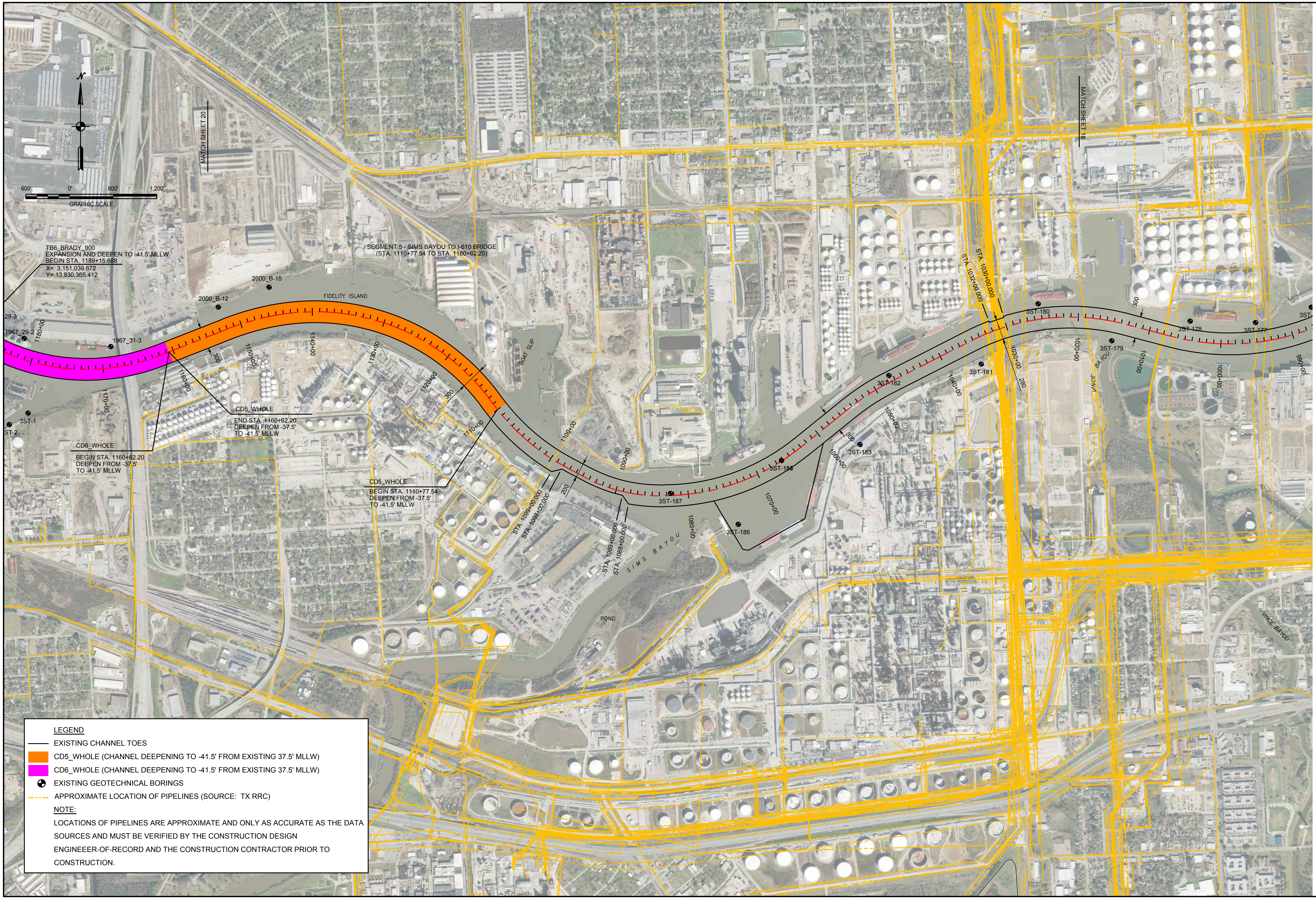
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 4 BOGGY BAYOU TO SIMS BAYOU

Plate No.:

28

Sheet 28 of 38



LEGEND

- EXISTING CHANNEL TOES
- 🟧 CD5_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING 37.5' MLLW)
- 🟪 CD6_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING 37.5' MLLW)
- ● EXISTING GEOTECHNICAL BORINGS
- APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

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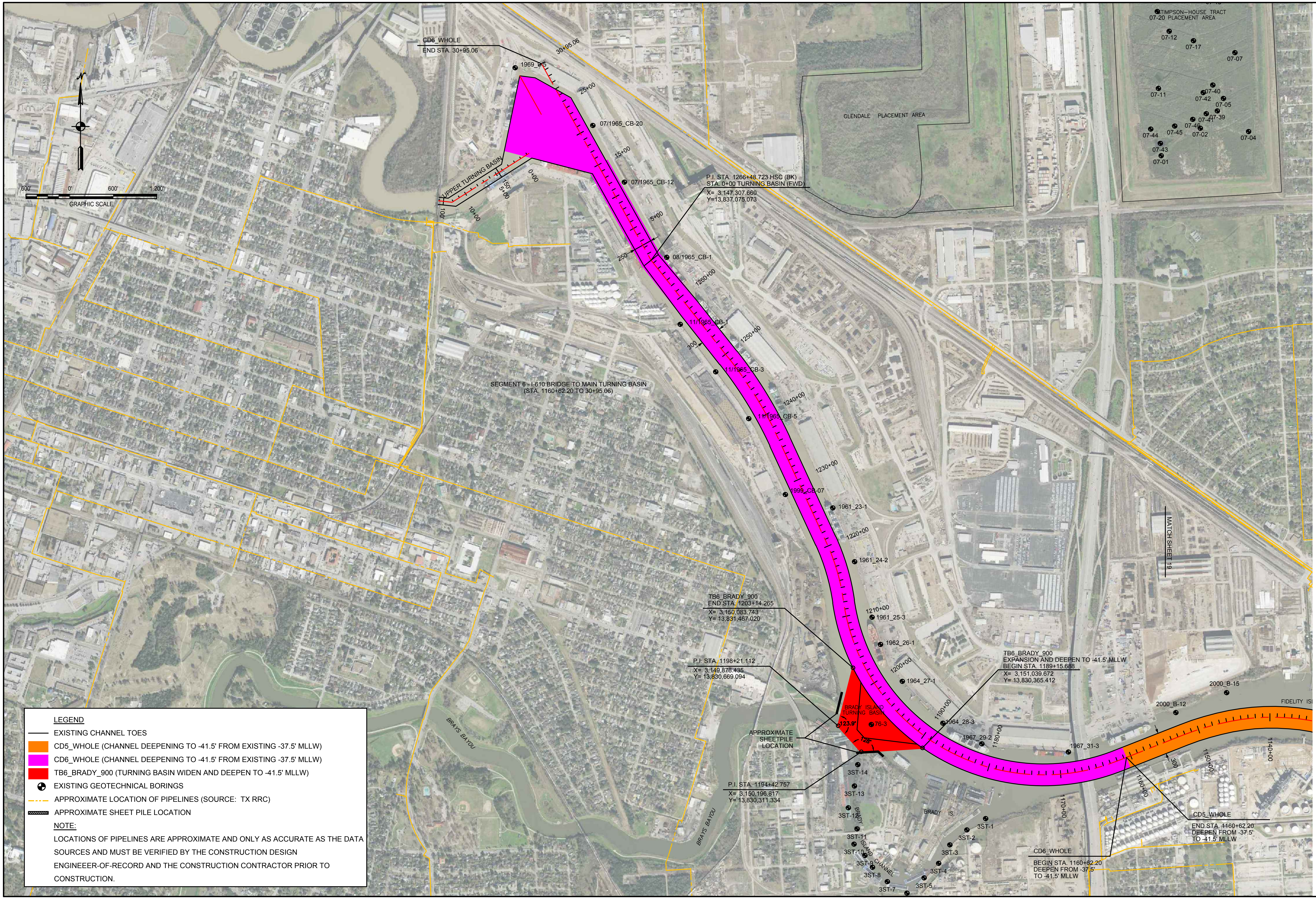
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 5 SIMS BAYOU TO I-610-BRIDGE

Plate No.:
29
Sheet 29 of 38



LEGEND

—	EXISTING CHANNEL TOES
🟧	CD5_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING -37.5' MLLW)
🟪	CD6_WHOLE (CHANNEL DEEPENING TO -41.5' FROM EXISTING -37.5' MLLW)
🟥	TB6_BRADY_900 (TURNING BASIN WIDEN AND DEEPEN TO -41.5' MLLW)
●	EXISTING GEOTECHNICAL BORINGS
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)
▨	APPROXIMATE SHEET PILE LOCATION

NOTE:

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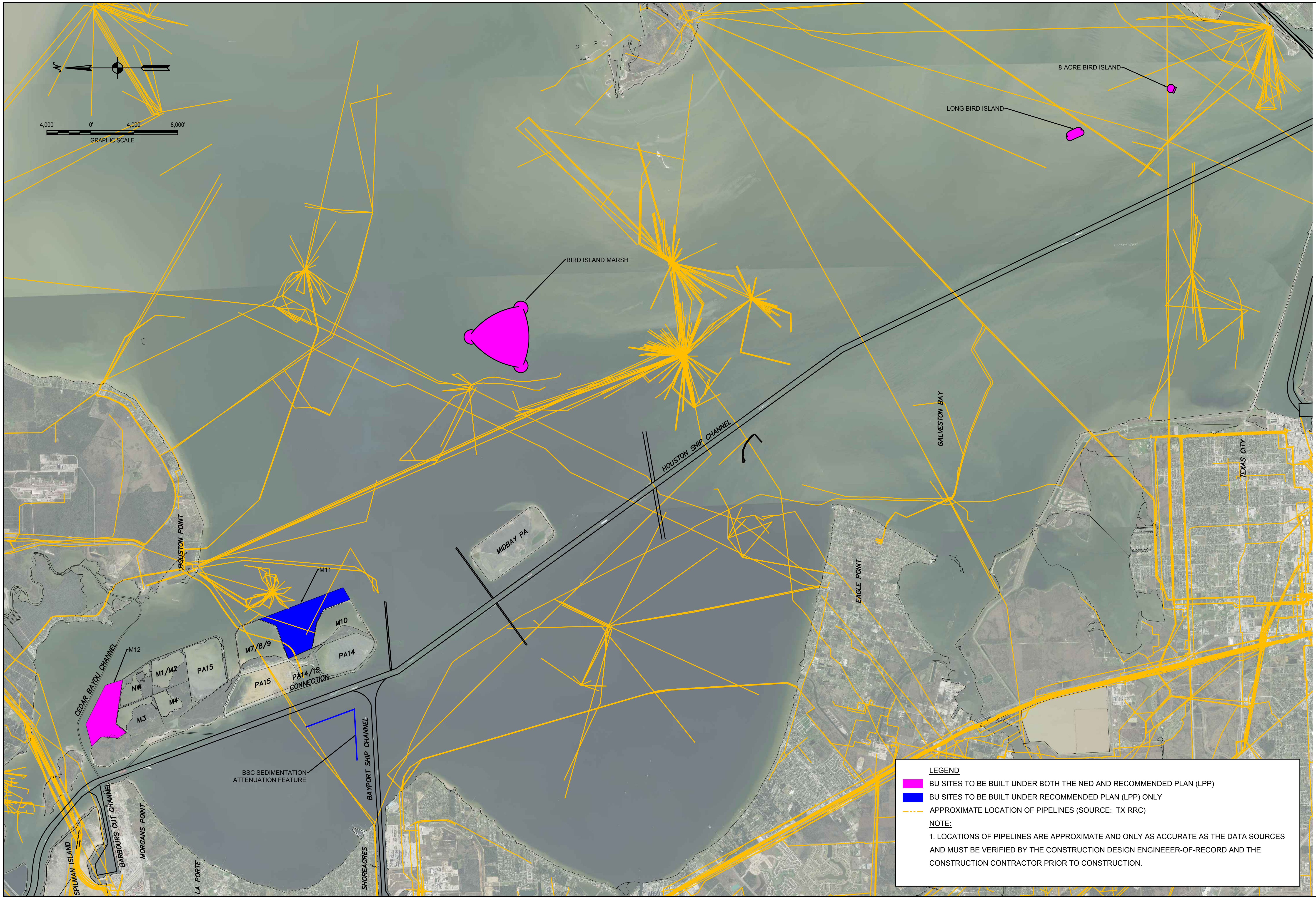
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - LPP
SEGMENT 6 I-610 BRIDGE TO MAIN TB

Plate No.:
30
Sheet 30 of 38



LEGEND

🟪	BU SITES TO BE BUILT UNDER BOTH THE NED AND RECOMMENDED PLAN (LPP)
🟦	BU SITES TO BE BUILT UNDER RECOMMENDED PLAN (LPP) ONLY
- · -	APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

1. LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

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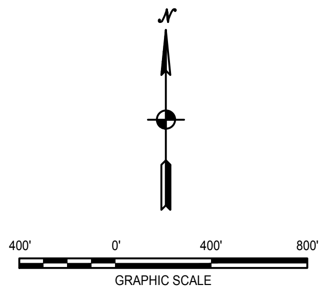
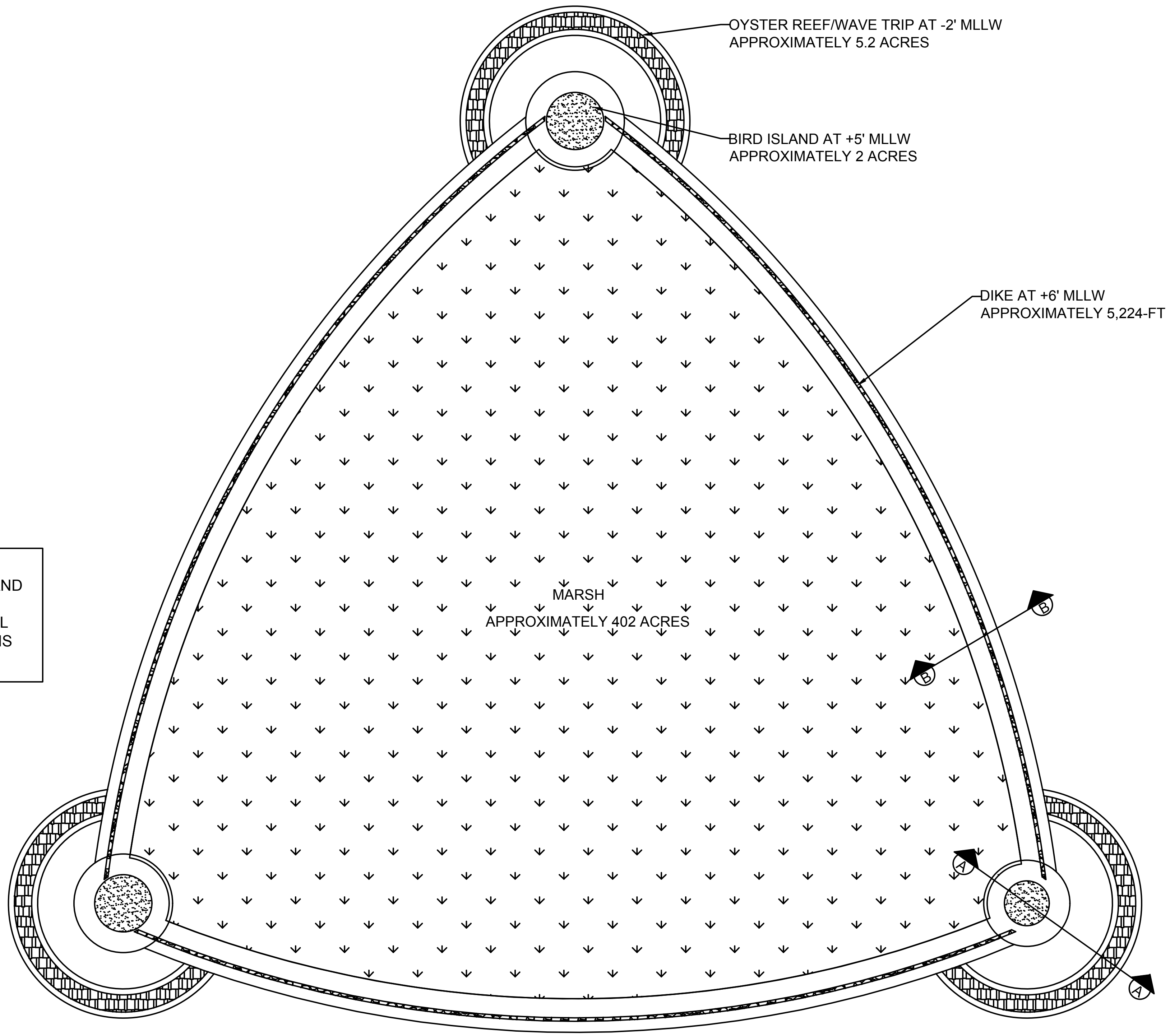
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

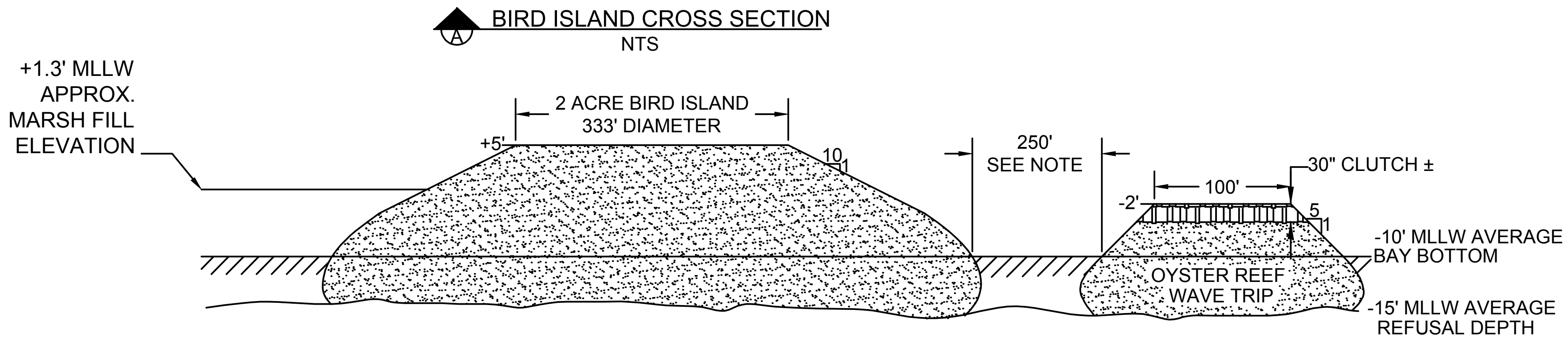
SEGMENT 1, 2, & 3
BENEFICIAL USE SITES

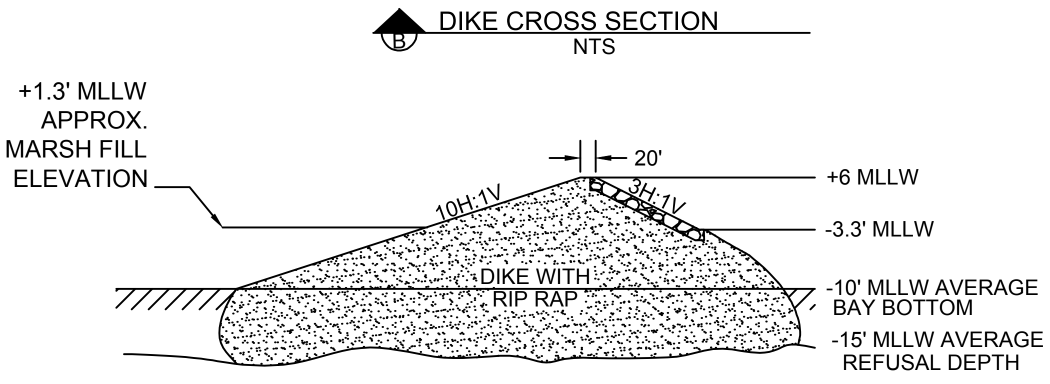
Plate No.:
31
Sheet 31 of 38



NOTE:
DISTANCE OF THE OYSTER REEF/WAVE TRIP AND THE SHORE PROTECTION DESIGN, LENGTHS, AND ELEVATIONS ARE APPROXIMATE AND WILL BE DEFINED POST WINDD/WAVE CALCULATIONS DEPENDENT ON FINAL PROJECT LOCATION.







U.S. Army Corps
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Galveston District

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Designed by: --
Checked by: ---
Submitted by:
Approved by:
Date: 08/22/2019
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Scale: AS SHOWN
Approval Recommended:

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GALVESTON, TEXAS

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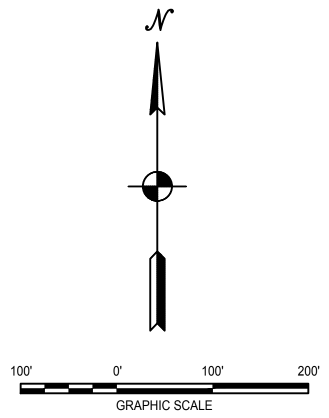
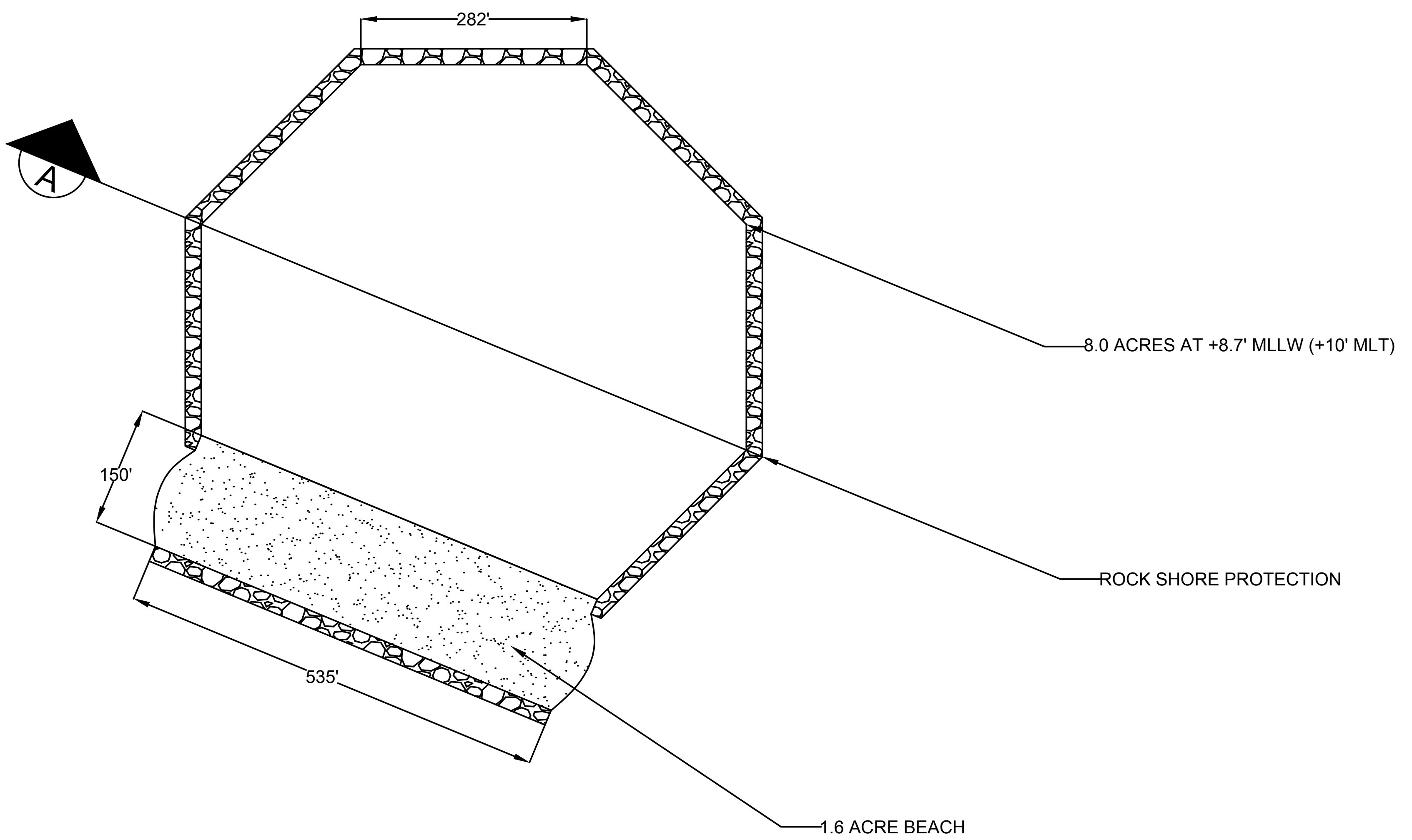
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

BIRD ISLAND MARSH
BENEFICIAL USE SITE

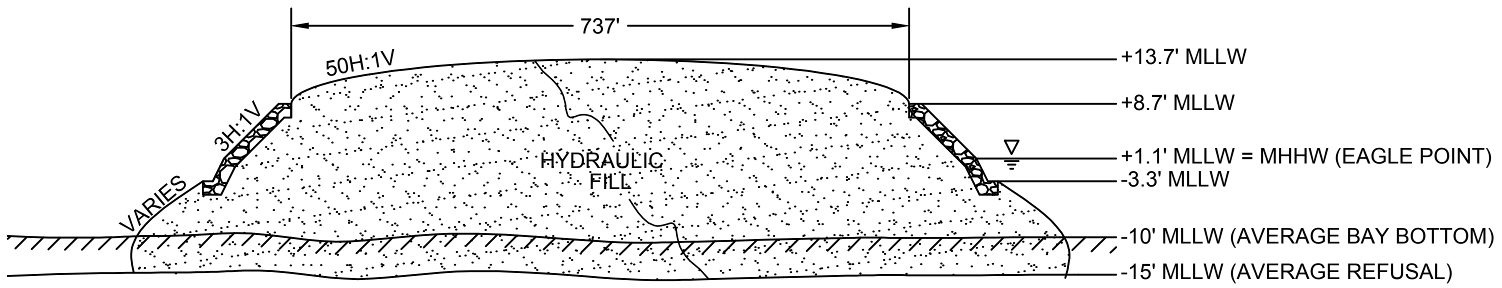
Plate No.:
32
Sheet 32 of 38





A BIRD ISLAND CROSS SECTION

NTS



NOTE:
SHORE PROTECTION DESIGN, LENGTHS, AND ELEVATIONS ARE APPROXIMATE AND WILL BE DEFINED POST WINDD/WAVE CALCULATIONS DEPENDENT ON FINAL PROJECT LOCATION.

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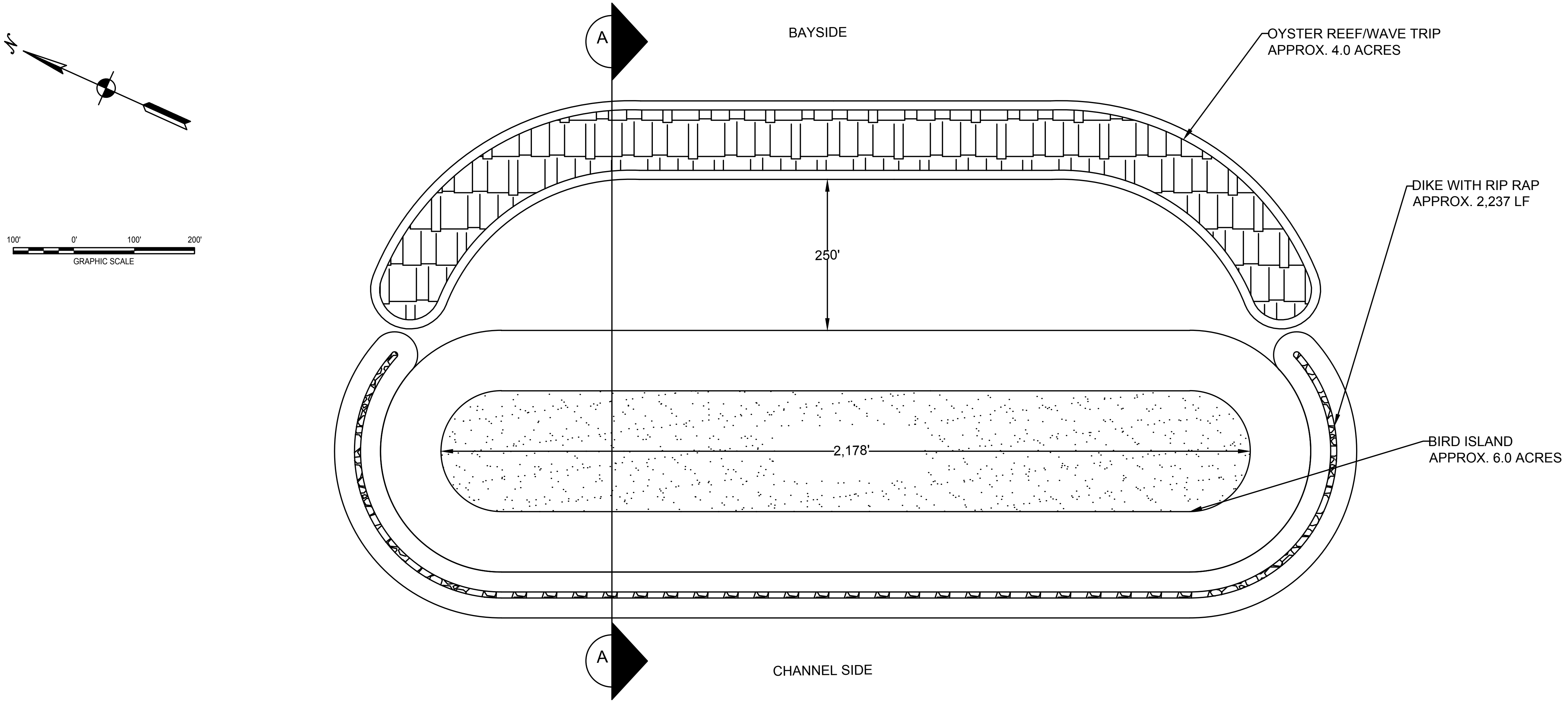
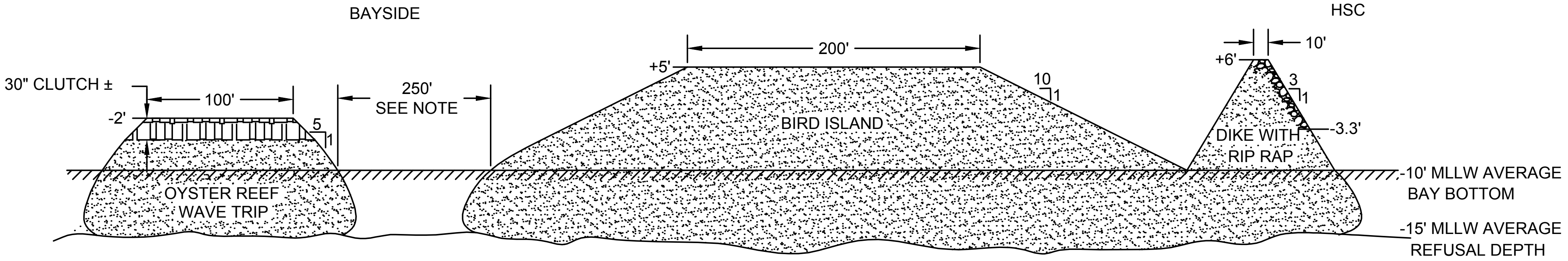
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

8-ACRE BIRD ISLAND
BENEFICIAL USE SITE

Plate No.:
33
Sheet 33 of 38



BIRD ISLAND CROSS SECTION
A
NTS



NOTE:
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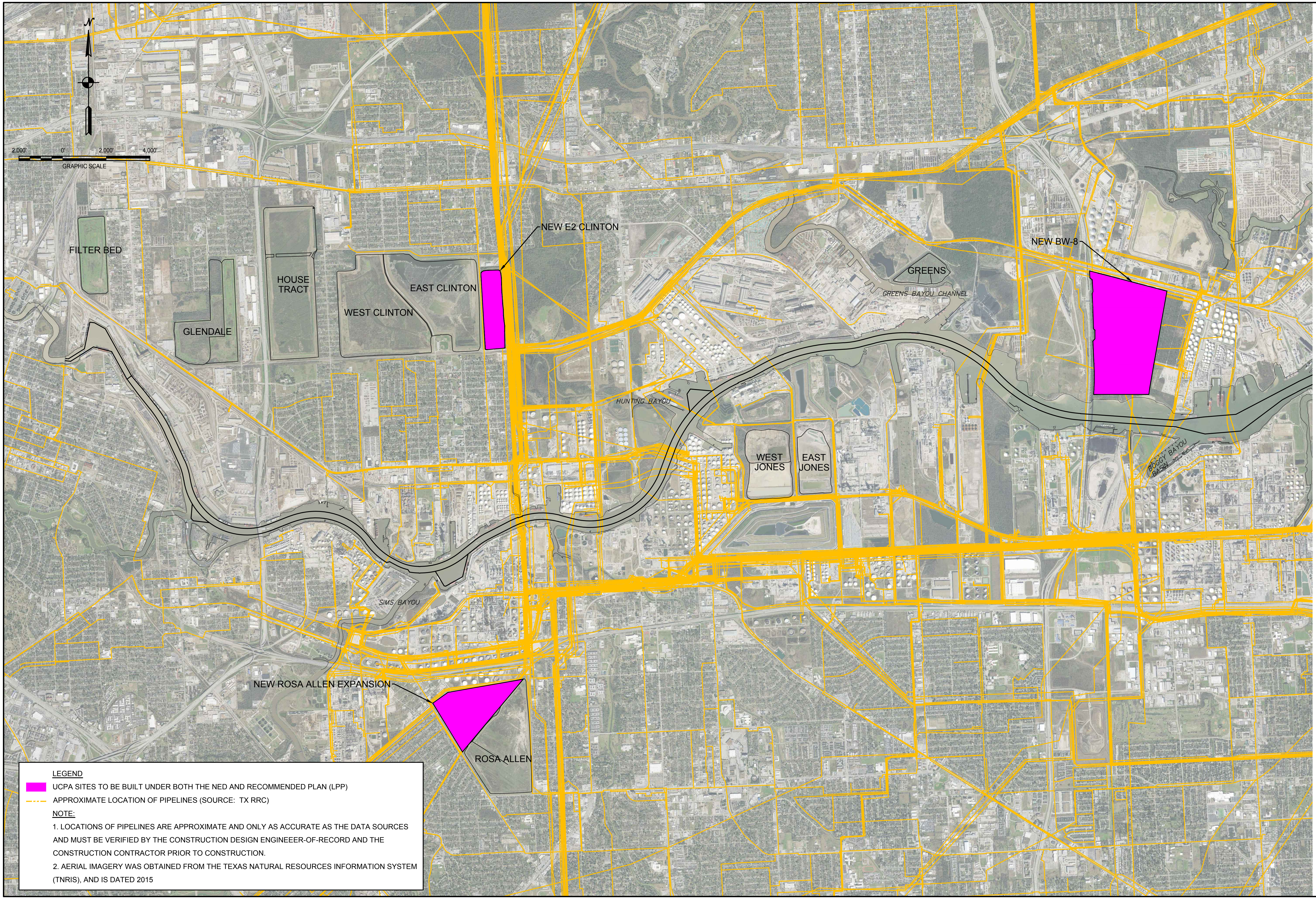
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

LONG BIRD ISLAND
BENEFICIAL USE SITE

Plate No.:
34
Sheet 34 of 38



LEGEND

🟪 UCPA SITES TO BE BUILT UNDER BOTH THE NED AND RECOMMENDED PLAN (LPP)

APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

NOTE:

1. LOCATIONS OF PIPELINES ARE APPROXIMATE AND ONLY AS ACCURATE AS THE DATA SOURCES AND MUST BE VERIFIED BY THE CONSTRUCTION DESIGN ENGINEEER-OF-RECORD AND THE CONSTRUCTION CONTRACTOR PRIOR TO CONSTRUCTION.

2. AERIAL IMAGERY WAS OBTAINED FROM THE TEXAS NATURAL RESOURCES INFORMATION SYSTEM (TNRIS), AND IS DATED 2015

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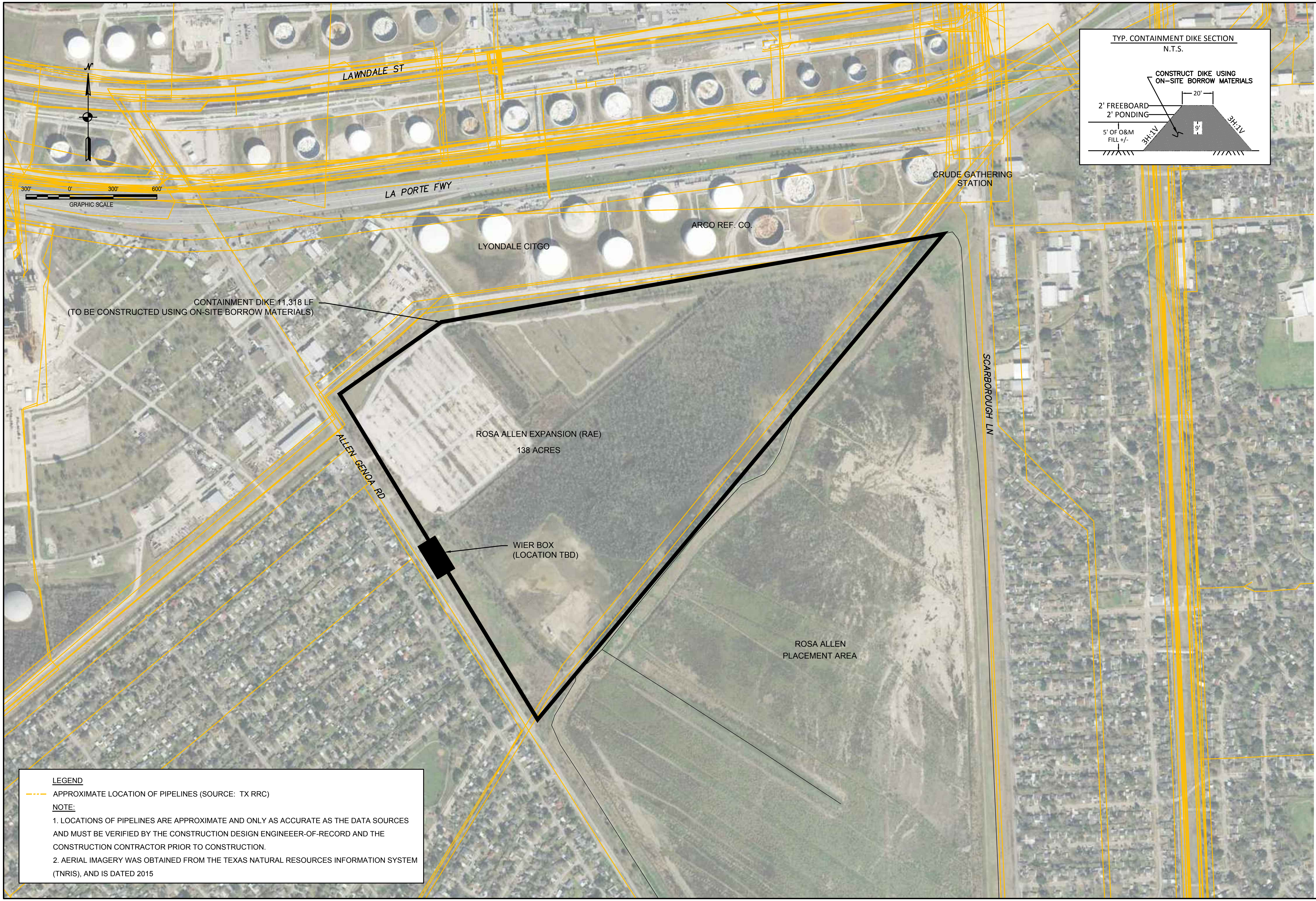
**HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENT
PROJECT (HSC ECIP)**

SEGMENT 4, 5 & 6
NEW UPLAND CONFINED PLACEMENT AREAS

Plate No.:

35

Sheet 35 of 38



LEGEND

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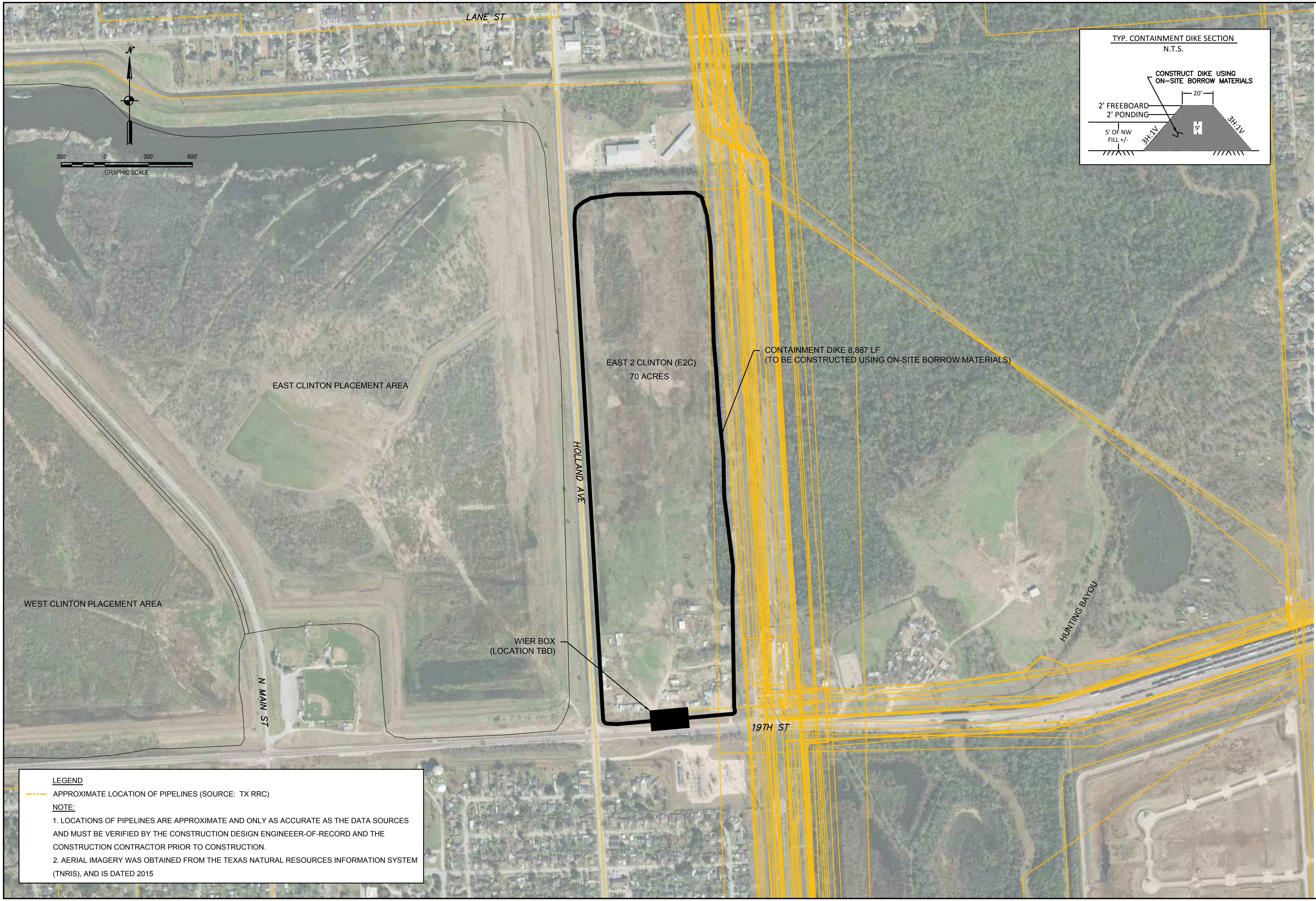
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN
ROSA ALLEN EXPANSION PLACEMENT AREA

Plate No.:
36



LEGEND

- - - APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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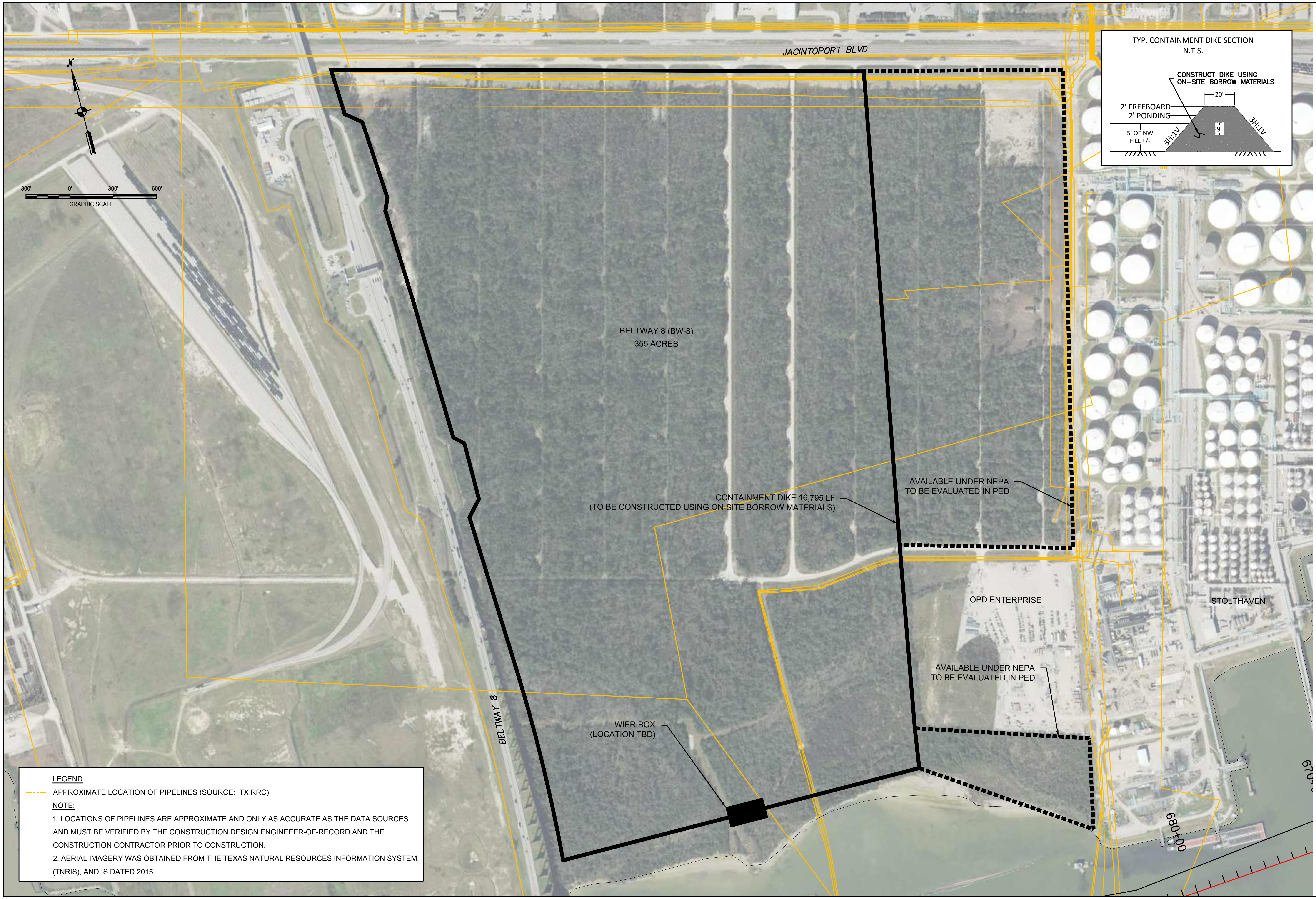
HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - NED
EAST 2 CLINTON PLACEMENT AREA

Plate No.:
37
Sheet 37 of 38



LEGEND

- - - APPROXIMATE LOCATION OF PIPELINES (SOURCE: TX RRC)

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HOUSTON SHIP CHANNEL EXPANSION CHANNEL IMPROVEMENT PROJECT (HSC ECIP)

RECOMMENDED PLAN - NED
BELTWAY 8 PLACEMENT AREA

Plate No.:
38
Sheet 38 of 38

ATTACHMENT 1

COST ESTIMATE (MII V4.4.2)/TPCS/CSRA

Proposed Modifications to Houston Ship Channel

Estimated by	Chester Hedderman, GBA
Designed by	GBA/AECOM/POH
Prepared by	G. Dale Williams, USACE
Preparation Date	12/4/2019
Effective Date of Pricing	12/4/2019
Estimated Construction Time	1,363 Days

[redacted]

Description	Quantity	UOM	DirectCost	ContractCost	ProjectCost
Project Cost Summary Report			**414,300,046**	**432,928,241**	**432,928,241**
Construction General - NED	**1.00**	**EA**	**414,300,046**	**432,928,241**	**432,928,241**
Segment 1	**1.00**	**EA**	**87,325,320**	**90,171,471**	**90,171,471**
01 Construction Year 01-02	**1.00**	**EA**	**75,565,813**	**78,180,986**	**78,180,986**
02 Construction Year 02-03	**1.00**	**EA**	**11,759,507**	**11,990,485**	**11,990,485**
Segment 2	**1.00**	**EA**	**104,936,094**	**112,082,953**	**112,082,953**
02 Construction Year 02-03	**1.00**	**EA**	**104,936,094**	**112,082,953**	**112,082,953**
Segment 3	**1.00**	**EA**	**97,414,396**	**99,743,251**	**99,743,251**
03 Construction Year 03-04	**1.00**	**EA**	**97,414,396**	**99,743,251**	**99,743,251**
Segment 4	**1.00**	**EA**	**91,295,165**	**95,415,294**	**95,415,294**
01 Construction Year 01-02	**1.00**	**EA**	**91,295,165**	**95,415,294**	**95,415,294**
Segment 5	**1.00**	**EA**	**3,981,995**	**4,216,305**	**4,216,305**
04 Construction Year 04-05	**1.00**	**EA**	**3,981,995**	**4,216,305**	**4,216,305**
Segment 6	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**
04 Construction Year 04-05	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**

Proposed Modifications to Houston Ship Channel

Estimated by	Chester Hedderman, GBA
Designed by	GBA/AECOM/POH
Prepared by	G. Dale Williams, USACE
Preparation Date	12/5/2019
Effective Date of Pricing	10/1/2019
Estimated Construction Time	1,830 Days

[redacted]

Description	Quantity	UOM	DirectCost	ContractCost	ProjectCost
Project Cost Summary Report			**532,842,750**	**557,028,037**	**557,028,037**
Construction General - LPP	**1.00**	**EA**	**532,842,750**	**557,028,037**	**557,028,037**
Segment 1	**1.00**	**EA**	**261,176,466**	**274,487,624**	**274,487,624**
01 Construction Year 01-02	**1.00**	**EA**	**77,132,593**	**79,747,766**	**79,747,766**
02 Construction Year 02-03	**1.00**	**EA**	**102,841,061**	**106,131,096**	**106,131,096**
03 Construction Year 03-05	**1.00**	**EA**	**81,202,813**	**88,608,762**	**88,608,762**
Segment 2	**1.00**	**EA**	**51,709,961**	**53,948,906**	**53,948,906**
02 Construction Year 02-03	**1.00**	**EA**	**51,709,961**	**53,948,906**	**53,948,906**
Segment 3	**1.00**	**EA**	**95,323,718**	**97,652,572**	**97,652,572**
03 Construction Year 03-05	**1.00**	**EA**	**95,323,718**	**97,652,572**	**97,652,572**
Segment 4	**1.00**	**EA**	**91,303,533**	**95,423,662**	**95,423,662**
01 Construction Year 01-02	**1.00**	**EA**	**91,303,533**	**95,423,662**	**95,423,662**
Segment 5	**1.00**	**EA**	**3,981,996**	**4,216,305**	**4,216,305**
04 Construction Year 05-06	**1.00**	**EA**	**3,981,996**	**4,216,305**	**4,216,305**
Segment 6	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**
04 Construction Year 05-06	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 451902

SWG – Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers and Galveston Counties

The Houston Ship Channel Expansion Channel Improvement Project, as presented by Galveston District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of December 6, 2019, the Cost MCX certifies the estimated total project cost:

National Economic Development (NED)

FY20 Project First Cost:	$666,265,000
Fully Funded Amount:	$767,138,000

Locally Preferred Plan (LPP)

FY20 Project First Cost:	$876,848,000
Fully Funded Amount:	$996,912,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal Participation.

HILL.DAVID.E.1384235731

Digitally signed by HILL.DAVID.E.1384235731
Date: 2019.12.09 08:38:58 -08'00'

Michael P. Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
PROJECT NO: P2 451902
LOCATION: Houston Ship Channel, Texas

DISTRICT: Galveston District
PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

This Estimate reflects the scope and schedule in report; HSC Feasibility

Program Year (Budget EC): 2020
Effective Price Level Date: 1 OCT 19

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 1-Oct-19 ($K)	TOTAL FIRST COST ($K) K	NFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
02	RELOCATIONS	$25,420	$9,151	36.0%	$34,571	0.0%	$25,420	$9,151	$34,571	$0	$34,571	9.5%	$27,832	$10,019	$37,851
06	FISH & WILDLIFE FACILITIES	$39,858	$14,349	36.0%	$54,207	0.0%	$39,858	$14,349	$54,207	$0	$54,207	12.5%	$44,823	$16,136	$60,960
12	NAVIGATION PORTS & HARBORS	$355,951	$128,142	36.0%	$484,094	0.0%	$355,951	$128,142	$484,094	$0	$484,094	15.8%	$412,191	$148,389	$560,580
	CONSTRUCTION ESTIMATE TOTALS:	$421,229	$151,642		$572,871	0.0%	$421,229	$151,642	$572,871	$0	$572,871	15.1%	$484,846	$174,545	$659,391
01	LANDS AND DAMAGES	$11,699	$2,925	25.0%	$14,624	0.0%	$11,699	$2,925	$14,624	$0	$14,624	9.7%	$12,832	$3,208	$16,040
30	PLANNING, ENGINEERING & DESIGN	$36,857.537	$13,269	36.0%	$50,126	0.0%	$36,858	$13,269	$50,126	$0	$50,126	15.1%	$42,430	$15,275	$57,704
31	CONSTRUCTION MANAGEMENT	$21,061	$7,582	36.0%	$28,644	0.0%	$21,061	$7,582	$28,644	$0	$28,644	18.7%	$25,002	$9,001	$34,003
	PROJECT COST TOTALS:	$490,847	$175,418	35.7%	$666,265		$490,847	$175,418	$666,265	$0	$666,265	15.1%	$565,110	$202,028	$767,138

REGNER.MARTIN.B.1367377794 Digitally signed by REGNER.MARTIN.B.1367377794 Date: 2019.12.09 10:48:02 -06'00'
CHIEF, COST ENGINEERING, Martin Regner, P.E.

Andrea Catanzaro
PROJECT MANAGER, Andrea Catanzaro

for
CHIEF, REAL ESTATE, Timothy Nelson

CHIEF, PLANNING, Robert Newman

CHIEF, ENGINEERING, Willie J. Honza, P.E.

CHIEF, OPERATIONS, Joe Hrametz. P.E.

CHIEF, CONSTRUCTION, Donald Carelock, P.E.

CHIEF, CONTRACTING,Jeffrey Neill

CHIEF, PM-PB, Valerie Miller

CHIEF, DPM, Edmund P. Russo, Jr., PHD, P.E., D.CE, D.NE.

ESTIMATED TOTAL PROJECT COST:	$767,138
ASSOCIATED COST:	$ 90,016
ESTIMATED TOTAL 50-Yr O&M COST:	$ 9,981,513
ESTIMATED TOTAL INCREASE IN 50-Yr O&M COST:	$ 1,883,123

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure			**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
			Estimate Prepared: Effective Price Level:			**4-Dec-19** 1-Oct-19	Program Year (Budget EC): Effective Price Level Date:			2020 1 OCT 19					
					RISK BASED										
WBS NUMBER *A*		Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
		Segment 1													
02		RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06		FISH & WILDLIFE FACILITIES	$22,010	$7,923	36.0%	$29,933	0.0%	$22,010	$7,923	$29,933	2023Q2	10.3%	$24,281	$8,741	$33,022
12		NAVIGATION PORTS & HARBORS	$68,106	$24,518	36.0%	$92,624	0.0%	$68,106	$24,518	$92,624	2023Q3	11.1%	$75,699	$27,252	$102,951
		CONSTRUCTION ESTIMATE TOTALS:	$90,115	$32,441	36.0%	**$122,557**		$90,115	$32,441	$122,557			$99,980	$35,993	$135,973
01		LANDS AND DAMAGES	$56	$14	25.0%	$70	0.0%	$56	$14	$70	2023Q3	11.1%	$63	$16	$78
30		PLANNING, ENGINEERING & DESIGN													
	0.8%	Project Management	$676	$243	36.0%	$919	0.0%	$676	$243	$919	2022Q3	9.9%	$743	$267	$1,010
	0.5%	Planning & Environmental Compliance	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
	3.0%	Engineering & Design	$2,703	$973	36.0%	$3,677	0.0%	$2,703	$973	$3,677	2022Q3	9.9%	$2,971	$1,070	$4,041
	0.5%	Reviews, ATRs, IEPRs, VE	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
	0.5%	Life Cycle Updates (cost, schedule, risks)	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
	0.5%	Contracting & Reprographics	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
	1.0%	Engineering During Construction	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
	0.5%	Planning During Construction	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
	0.5%	Adaptive Management & Monitoring	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2023Q1	12.0%	$505	$182	$686
	1.0%	Project Operations	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
31		CONSTRUCTION MANAGEMENT													
	3.0%	Construction Management	$2,703	$973	36.0%	$3,677	0.0%	$2,703	$973	$3,677	2022Q3	9.9%	$2,971	$1,070	$4,041
	1.0%	Project Operation:	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
	1.0%	Project Management	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
		CONTRACT COST TOTALS:	$102,562	$36,916		$139,479		$102,562	$36,916	**$139,479**			$113,670	$40,914	**$154,584**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT:	Houston Ship Channel Improvement Project (NED Plan)	DISTRICT:	Galveston District
LOCATION:	Houston Ship Channel, Texas	POC:	CHIEF, COST ENGINEERING, Martin Regner, P.E.

PREPARED: 12/5/2019

This Estimate reflects the scope and schedule in report; HSC Feasibility

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 2													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$3,718	$1,339	36.0%	$5,057	0.0%	$3,718	$1,339	$5,057	2024Q3	14.5%	$4,257	$1,532	$5,789
12	NAVIGATION PORTS & HARBORS	$108,327	$38,998	36.0%	$147,325	0.0%	$108,327	$38,998	$147,325	2025Q1	16.2%	$125,829	$45,299	$171,128
	CONSTRUCTION ESTIMATE TOTALS:	$112,045	$40,336	36.0%	**$152,382**		$112,045	$40,336	$152,382			$130,086	$46,831	$176,917
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2024Q3	14.5%	$43	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$840	$303	36.0%	$1,143	0.0%	$840	$303	$1,143	2023Q3	14.1%	$959	$345	$1,304
0.5%	Planning & Environmental Compliance	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
3.0%	Engineering & Design	$3,361	$1,210	36.0%	$4,571	0.0%	$3,361	$1,210	$4,571	2023Q3	14.1%	$3,835	$1,380	$5,215
0.5%	Reviews, ATRs, IEPRs, VE	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
0.5%	Life Cycle Updates (cost, schedule, risks)	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
0.5%	Contracting & Reprographics	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
1.0%	Engineering During Construction	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
0.5%	Planning During Construction	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2024Q3	18.4%	$664	$239	$902
0.5%	Adaptive Management & Monitoring	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
1.0%	Project Operations	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2023Q3	14.1%	$1,278	$460	$1,738
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$3,361	$1,210	36.0%	$4,571	0.0%	$3,361	$1,210	$4,571	2024Q3	18.4%	$3,981	$1,433	$5,415
1.0%	Project Operation:	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
1.0%	Project Management	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
	CONTRACT COST TOTALS:	$127,489	$45,892		$173,381		$127,489	$45,892	**$173,381**			$148,022	$53,283	**$201,306**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Segment 3													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$5,520	$1,987	36.0%	$7,507	0.0%	$5,520	$1,987	$7,507	2025Q3	17.9%	$6,509	$2,343	$8,852
12	NAVIGATION PORTS & HARBORS	$94,186	$33,907	36.0%	$128,093	0.0%	$94,186	$33,907	$128,093	2025Q4	18.8%	$111,893	$40,281	$152,174
	CONSTRUCTION ESTIMATE TOTALS:	$99,706	$35,894	36.0%	**$135,600**		$99,706	$35,894	$135,600			$118,402	$42,625	$161,026
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2025Q1	16.2%	$44	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$748	$269	36.0%	$1,017	0.0%	$748	$269	$1,017	2024Q3	18.4%	$886	$319	$1,205
0.5%	Planning & Environmental Compliance	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
3.0%	Engineering & Design	$2,991	$1,077	36.0%	$4,068	0.0%	$2,991	$1,077	$4,068	2024Q3	18.4%	$3,543	$1,275	$4,818
0.5%	Reviews, ATRs, IEPRs, VE	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
0.5%	Life Cycle Updates (cost, schedule, risks)	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
0.5%	Contracting & Reprographics	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
1.0%	Engineering During Construction	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
0.5%	Planning During Construction	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2025Q3	23.0%	$613	$221	$834
0.5%	Adaptive Management & Monitoring	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
1.0%	Project Operations	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2024Q3	18.4%	$1,181	$425	$1,606
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,991	$1,077	36.0%	$4,068	0.0%	$2,991	$1,077	$4,068	2025Q3	23.0%	$3,680	$1,325	$5,005
1.0%	Project Operation:	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
1.0%	Project Management	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
	CONTRACT COST TOTALS:	$113,453	$40,839		**$154,292**		$113,453	$40,839	**$154,292**			$134,981	$48,588	**$183,569**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Segment 4													
02	RELOCATIONS	$25,420	$9,151	36.0%	$34,571	0.0%	$25,420	$9,151	$34,571	2023Q1	9.5%	$27,832	$10,019	$37,851
06	FISH & WILDLIFE FACILITIES	$7,184	$2,586	36.0%	$9,771	0.0%	$7,184	$2,586	$9,771	2023Q4	12.0%	$8,045	$2,896	$10,941
12	NAVIGATION PORTS & HARBORS	$51,415	$18,509	36.0%	$69,924	0.0%	$51,415	$18,509	$69,924	2023Q4	12.0%	$57,574	$20,727	$78,301
	CONSTRUCTION ESTIMATE TOTALS:	$84,019	$30,247	36.0%	**$114,266**		$84,019	$30,247	$114,266			$93,451	$33,642	$127,094
01	LANDS AND DAMAGES	$11,396	$2,849	25.0%	$14,245	0.0%	$11,396	$2,849	$14,245	2023Q1	9.5%	$12,478	$3,119	$15,597
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$630	$227	36.0%	$857	0.0%	$630	$227	$857	2022Q4	10.9%	$699	$252	$951
0.5%	Planning & Environmental Compliance	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
3.0%	Engineering & Design	$2,521	$907	36.0%	$3,428	0.0%	$2,521	$907	$3,428	2022Q4	10.9%	$2,796	$1,007	$3,803
0.5%	Reviews, ATRs, IEPRs, VE	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
0.5%	Life Cycle Updates (cost, schedule, risks)	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
0.5%	Contracting & Reprographics	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
1.0%	Engineering During Construction	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
0.5%	Planning During Construction	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2024Q4	19.6%	$502	$181	$683
0.5%	Adaptive Management & Monitoring	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
1.0%	Project Operations	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2022Q4	10.9%	$932	$336	$1,268
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,521	$907	36.0%	$3,428	0.0%	$2,521	$907	$3,428	2024Q4	19.6%	$3,014	$1,085	$4,099
1.0%	Project Operation:	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
1.0%	Project Management	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
	CONTRACT COST TOTALS:	$106,968	$37,255		**$144,223**		$106,968	$37,255	**$144,223**			$119,218	$41,546	**$160,764**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 5													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$370	$133	36.0%	$503	0.0%	$370	$133	$503	2026Q3	21.5%	$450	$162	$611
12	NAVIGATION PORTS & HARBORS	$3,827	$1,378	36.0%	$5,205	0.0%	$3,827	$1,378	$5,205	2026Q3	21.5%	$4,649	$1,673	$6,322
	CONSTRUCTION ESTIMATE TOTALS:	$4,198	$1,511	36.0%	**$5,709**		$4,198	$1,511	$5,709			$5,098	$1,835	$6,934
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2026Q1	19.6%	$22	$6	$28
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$31	$11	36.0%	$43	0.0%	$31	$11	$43	2025Q3	23.0%	$39	$14	$53
0.5%	Planning & Environmental Compliance	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
3.0%	Engineering & Design	$126	$45	36.0%	$171	0.0%	$126	$45	$171	2025Q3	23.0%	$155	$56	$211
0.5%	Reviews, ATRs, IEPRs, VE	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
0.5%	Life Cycle Updates (cost, schedule, risks)	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
0.5%	Contracting & Reprographics	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
1.0%	Engineering During Construction	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
0.5%	Planning During Construction	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2026Q3	27.7%	$27	$10	$36
0.5%	Adaptive Management & Monitoring	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
1.0%	Project Operations	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2025Q3	23.0%	$52	$19	$70
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$126	$45	36.0%	$171	0.0%	$126	$45	$171	2026Q3	27.7%	$161	$58	$219
1.0%	Project Operation:	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
1.0%	Project Management	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
	CONTRACT COST TOTALS:	$4,793	$1,724		**$6,517**		$4,793	$1,724	**$6,517**			$5,843	$2,101	**$7,945**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure			**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
			Estimate Prepared: Effective Price Level:			**4-Dec-19** 1-Oct-19	Program Year (Budget EC): Effective Price Level Date:			2020 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER *A*		Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
		Segment 6													
02		RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06		FISH & WILDLIFE FACILITIES	$1,056	$380	36.0%	$1,436	0.0%	$1,056	$380	$1,436	2026Q3	21.5%	$1,282	$462	$1,744
12		NAVIGATION PORTS & HARBORS	$30,090	$10,833	36.0%	$40,923	0.0%	$30,090	$10,833	$40,923	2026Q3	21.5%	$36,547	$13,157	$49,704
		CONSTRUCTION ESTIMATE TOTALS:	$31,146	$11,213	36.0%	**$42,359**		$31,146	$11,213	$42,359			$37,829	$13,618	$51,447
01		LANDS AND DAMAGES	$153	$38	25.0%	$191	0.0%	$153	$38	$191	2026Q1	19.6%	$183	$46	$229
30		PLANNING, ENGINEERING & DESIGN													
	0.8%	Project Management	$234	$84	36.0%	$318	0.0%	$234	$84	$318	2025Q3	23.0%	$287	$103	$391
	0.5%	Planning & Environmental Compliance	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
	3.0%	Engineering & Design	$934	$336	36.0%	$1,271	0.0%	$934	$336	$1,271	2025Q3	23.0%	$1,150	$414	$1,563
	0.5%	Reviews, ATRs, IEPRs, VE	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
	0.5%	Life Cycle Updates (cost, schedule, risks)	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
	0.5%	Contracting & Reprographics	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
	1.0%	Engineering During Construction	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
	0.5%	Planning During Construction	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2026Q3	27.7%	$199	$72	$270
	0.5%	Adaptive Management & Monitoring	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
	1.0%	Project Operations	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2025Q3	23.0%	$383	$138	$521
31		CONSTRUCTION MANAGEMENT													
	3.0%	Construction Management	$934	$336	36.0%	$1,271	0.0%	$934	$336	$1,271	2026Q3	27.7%	$1,193	$430	$1,623
	1.0%	Project Operation:	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
	1.0%	Project Management	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
		CONTRACT COST TOTALS:	$35,582	$12,793		**$48,374**		$35,582	$12,793	**$48,374**			$43,376	$15,595	**$58,971**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Associated Costs													
12	NAVIGATION PORTS & HARBORS (Aids to Navigation)	$2,845	$1,024	36.0%	$3,869	0.0%	$2,845	$1,024	$3,869	2023Q4	12.0%	$3,186	$1,147	$4,332
12	NAVIGATION PORTS & HARBORS (Local Service Facilities)	$56,262	$20,254	36.0%	$76,516	0.0%	$56,262	$20,254	$76,516	2023Q4	12.0%	$63,002	$22,681	$85,683
	CONSTRUCTION ESTIMATE TOTALS:	$59,107	$21,278	36.0%	**$80,385**		$59,107	$21,278	$80,385			$66,188	$23,828	$90,016
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering & Design	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Adaptive Management & Monitoring	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
0.0%	Construction Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operation:	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$59,107	$21,278		**$80,385**		$59,107	$21,278	**$80,385**			$66,188	$23,828	**$90,016**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure			**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
			Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
			Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*		Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
		O&M Costs													
12		NAVIGATION PORTS & HARBORS Total 50-Yr O&M Costs	$3,121,567	$0	0.0%	$3,121,567	0.0%	$3,121,567	$0	$3,121,567	2054Q1	173.7%	$8,544,692	$0	$8,544,692
		CONSTRUCTION ESTIMATE TOTALS:	$3,121,567	$0	0.0%	**3,121,567**		$3,121,567	$0	$3,121,567			$8,544,692	$0	$8,544,692
01		LANDS AND DAMAGES	$0	$0	0.0%	$ -	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30		PLANNING, ENGINEERING & DESIGN													
	0.5%	Project Management	$16,321	$3,427	21.0%	$19,749	0.0%	$16,321	$3,427	$19,749	2053Q3	280.1%	$62,038	$13,028	$75,066
	0.3%	Planning & Environmental Compliance	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
	2.1%	Engineering & Design	$65,285	$13,710	21.0%	$78,995	0.0%	$65,285	$13,710	$78,995	2053Q3	280.1%	$248,151	$52,112	$300,262
	0.3%	Reviews, ATRs, IEPRs, VE	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
	0.3%	Life Cycle Updates (cost, schedule, risks)	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
	0.3%	Contracting & Reprographics	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
	0.7%	Engineering During Construction	$21,762	$4,570	21.0%	$26,332	0.0%	$21,762	$4,570	$26,332	2054Q1	288.0%	$84,436	$17,732	$102,167
	0.3%	Planning During Construction	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2054Q1	288.0%	$42,218	$8,866	$51,084
	0.3%	Adaptive Management & Monitoring	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2054Q1	288.0%	$42,218	$8,866	$51,084
	0.7%	Project Operations	$21,762	$4,570	21.0%	$26,332	0.0%	$21,762	$4,570	$26,332	2053Q3	280.1%	$82,717	$17,371	$100,087
31		CONSTRUCTION MANAGEMENT													
	2.3%	Construction Management	$71,172	$14,946	21.0%	86,118	0.0%	$71,172	$14,946	$86,118	2054Q1	288.0%	$276,147	$57,991	$334,138
	0.8%	Project Operation:	$23,724	$4,982	21.0%	28,706	0.0%	$23,724	$4,982	$28,706	2054Q1	288.0%	$92,049	$19,330	$111,379
	0.8%	Project Management	$23,724	$4,982	21.0%	28,706	0.0%	$23,724	$4,982	$28,706	2054Q1	288.0%	$92,049	$19,330	$111,379
		CONTRACT COST TOTALS:	$3,430,602	$64,897		**3,495,500**		$3,430,602	$64,897	**$3,495,500**			$9,732,148	$249,366	**$9,981,513**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Increase in 50-Yr O&M Costs	$499,180	$104,828	21.0%	$604,008	0.0%	$499,180	$104,828	$604,008	2054Q1	173.7%	$1,366,410	$286,946	$1,653,356
	CONSTRUCTION ESTIMATE TOTALS:	$499,180	$104,828	21.0%	**$604,008**		$499,180	$104,828	$604,008			$1,366,410	$286,946	$1,653,356
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$2,610	$548	21.0%	$3,158	0.0%	$2,610	$548	$3,158	2053Q3	280.1%	$9,921	$2,083	$12,004
0.3%	Planning & Environmental Compliance	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
2.1%	Engineering & Design	$10,440	$2,192	21.0%	$12,632	0.0%	$10,440	$2,192	$12,632	2053Q3	280.1%	$39,683	$8,333	$48,016
0.3%	Reviews, ATRs, IEPRs, VE	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.3%	Life Cycle Updates (cost, schedule, risks)	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.3%	Contracting & Reprographics	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.7%	Engineering During Construction	$3,480	$731	21.0%	$4,211	0.0%	$3,480	$731	$4,211	2054Q1	288.0%	$13,502	$2,836	$16,338
0.3%	Planning During Construction	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2054Q1	288.0%	$6,751	$1,418	$8,169
0.3%	Adaptive Management & Monitoring	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2054Q1	288.0%	$6,751	$1,418	$8,169
0.7%	Project Operations	$3,480	$731	21.0%	$4,211	0.0%	$3,480	$731	$4,211	2053Q3	280.1%	$13,228	$2,778	$16,005
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$11,381	$2,390	21.0%	$13,771	0.0%	$11,381	$2,390	$13,771	2054Q1	288.0%	$44,160	$9,274	$53,433
0.8%	Project Operation:	$3,794	$797	21.0%	$4,590	0.0%	$3,794	$797	$4,590	2054Q1	288.0%	$14,720	$3,091	$17,811
0.8%	Project Management	$3,794	$797	21.0%	$4,590	0.0%	$3,794	$797	$4,590	2054Q1	288.0%	$14,720	$3,091	$17,811
	CONTRACT COST TOTALS:	$548,599	$115,206		**$663,805**		$548,599	$115,206	**$663,805**			$1,556,300	$326,823	**$1,883,123**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
PROJECT NO: P2 451902
LOCATION: Houston Ship Channel, Texas

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: **12/5/2019**

This Estimate reflects the scope and schedule in report; HSC Feasibility

Program Year (Budget EC): 2020
Effective Price Level Date: 1 OCT 19

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	**TOTAL ($K) J**	Spent Thru: **1-Oct-19** ($K)	**TOTAL FIRST COST ($K) K**	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
02	RELOCATIONS	$26,870	$10,479	39.0%	$37,350	0.0%	$26,870	$10,479	$37,350	$0	$37,350	9.6%	$29,444	$11,483	$40,927
06	FISH & WILDLIFE FACILITIES	$58,819	$22,939	39.0%	$81,758	0.0%	$58,819	$22,939	$81,758	$0	$81,758	11.9%	$65,835	$25,676	$91,511
12	NAVIGATION PORTS & HARBORS	$459,613	$179,249	39.0%	$638,862	0.0%	$459,613	$179,249	$638,862	$0	$638,862	14.2%	$524,657	$204,616	$729,274
	CONSTRUCTION ESTIMATE TOTALS:	$545,302	$212,668		$757,969	0.0%	$545,302	$212,668	$757,969	$0	$757,969	13.7%	$619,937	$241,775	$861,712
01	LANDS AND DAMAGES	$11,726	$2,932	25.0%	$14,658	0.0%	$11,726	$2,932	$14,658	$0	$14,658	9.7%	$12,861	$3,215	$16,077
30	PLANNING, ENGINEERING & DESIGN	$47,714	$18,608	39.0%	$66,322	0.0%	$47,714	$18,608	$66,322	$0	$66,322	13.5%	$54,142	$21,115	$75,257
31	CONSTRUCTION MANAGEMENT	$27,265	$10,633	39.0%	$37,898	0.0%	$27,265	$10,633	$37,898	$0	$37,898	15.7%	$31,558	$12,308	$43,866
	PROJECT COST TOTALS:	$632,007	$244,841	38.7%	$876,848		$632,007	$244,841	**$876,848**	$0	**$876,848**	13.7%	$718,498	$278,414	$996,912

REGNER.MARTIN.B.1367377794 Digitally signed by REGNER.MARTIN.B.1367377794 Date: 2019.12.09 10:48:34 -06'00'
CHIEF, COST ENGINEERING, Martin Regner, P.E.

Andrea Catanzaro
PROJECT MANAGER, Andrea Catanzaro

CHIEF, REAL ESTATE, Timothy Nelson

CHIEF, PLANNING, Robert Newman

CHIEF, ENGINEERING, Willie J. Honza, P.E.

CHIEF, OPERATIONS, Joe Hrametz. P.E.

CHIEF, CONSTRUCTION, Donald Carelock, P.E.

CHIEF, CONTRACTING,Jeffrey Neill

CHIEF, PM-PB, Valerie Miller

CHIEF, DPM, Edmund P. Russo, Jr., PHD, P.E., D.CE, D.NE.

ESTIMATED TOTAL PROJECT COST:	**$996,912**
ASSOCIATED COSTS:	**$92,696**
ESTIMATED TOTAL 50 YR O&M Costs: Beginning 2029 and includes 21% contingency	**$10,331,048**
ESTIMATED TOTAL 50 YR O&M INCREASE : Beginning 2029 and includes 21% contingency	**$2,204,310**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	RISK BASED CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Segment 1													
02	RELOCATIONS	$1,451	$566	39.0%	$2,017	0.0%	$1,451	$566	$2,017	2023Q3	11.1%	$1,612	$629	$2,241
06	FISH & WILDLIFE FACILITIES	$46,172	$18,007	39.0%	$64,179	0.0%	$46,172	$18,007	$64,179	2023Q3	11.1%	$51,320	$20,015	$71,334
12	NAVIGATION PORTS & HARBORS	$226,763	$88,438	39.0%	$315,201	0.0%	$226,763	$88,438	$315,201	2023Q3	11.1%	$252,047	$98,298	$350,345
	CONSTRUCTION ESTIMATE TOTALS:	$274,386	$107,010	39.0%	**$381,396**		$274,386	$107,010	$381,396			$304,979	$118,942	$423,921
01	LANDS AND DAMAGES	$102	$26	25.0%	$128	0.0%	$102	$26	$128	2023Q3	11.1%	$113	$28	$142
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$2,058	$803	39.0%	$2,860	0.0%	$2,058	$803	$2,860	2022Q3	9.9%	$2,262	$882	$3,144
0.5%	Planning & Environmental Compliance	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
3.0%	Engineering & Design	$8,232	$3,210	39.0%	$11,442	0.0%	$8,232	$3,210	$11,442	2022Q3	9.9%	$9,047	$3,528	$12,575
0.5%	Reviews, ATRs, IEPRs, VE	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Life Cycle Updates (cost, schedule, risks)	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Contracting & Reprographics	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
1.0%	Engineering During Construction	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
0.5%	Planning During Construction	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Adaptive Management & Monitoring	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2023Q3	14.1%	$1,565	$610	$2,175
1.0%	Project Operations	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$8,232	$3,210	39.0%	$11,442	0.0%	$8,232	$3,210	$11,442	2022Q3	9.9%	$9,047	$3,528	$12,575
1.0%	Project Operation:	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
1.0%	Project Management	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
	CONTRACT COST TOTALS:	$312,216	$121,750		$433,965		$312,216	$121,750	**$433,965**			$346,615	$135,164	**$481,778**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 2													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$599	$234	39.0%	$833	0.0%	$599	$234	$833	2024Q3	14.5%	$686	$267	$953
12	NAVIGATION PORTS & HARBORS	$53,331	$20,799	39.0%	$74,130	0.0%	$53,331	$20,799	$74,130	2025Q1	16.2%	$61,948	$24,160	$86,107
	CONSTRUCTION ESTIMATE TOTALS:	$53,930	$21,033	39.0%	**$74,963**		$53,930	$21,033	$74,963			$62,633	$24,427	$87,061
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2024Q3	14.5%	$21	$5	$27
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$404	$158	39.0%	$562	0.0%	$404	$158	$562	2023Q3	14.1%	$461	$180	$641
0.5%	Planning & Environmental Compliance	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
3.0%	Engineering & Design	$1,618	$631	39.0%	$2,249	0.0%	$1,618	$631	$2,249	2023Q3	14.1%	$1,846	$720	$2,566
0.5%	Reviews, ATRs, IEPRs, VE	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
0.5%	Life Cycle Updates (cost, schedule, risks)	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
0.5%	Contracting & Reprographics	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
1.0%	Engineering During Construction	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
0.5%	Planning During Construction	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2024Q3	18.4%	$319	$125	$444
0.5%	Adaptive Management & Monitoring	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
1.0%	Project Operations	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2023Q3	14.1%	$615	$240	$855
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$1,618	$631	39.0%	$2,249	0.0%	$1,618	$631	$2,249	2024Q3	18.4%	$1,916	$747	$2,664
1.0%	Project Operation:	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
1.0%	Project Management	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
	CONTRACT COST TOTALS:	$61,364	$23,929		$85,294		$61,364	$23,929	**$85,294**			$71,267	$27,791	**$99,059**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Segment 3													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$3,429	$1,337	39.0%	$4,767	0.0%	$3,429	$1,337	$4,767	2025Q3	17.9%	$4,044	$1,577	$5,621
12	NAVIGATION PORTS & HARBORS	$94,186	$36,732	39.0%	$130,918	0.0%	$94,186	$36,732	$130,918	2025Q4	18.8%	$111,893	$43,638	$155,531
	CONSTRUCTION ESTIMATE TOTALS:	$97,615	$38,070	39.0%	**$135,685**		$97,615	$38,070	$135,685			$115,936	$45,215	$161,152
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2025Q1	16.2%	$44	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$732	$286	39.0%	$1,018	0.0%	$732	$286	$1,018	2024Q3	18.4%	$867	$338	$1,205
0.5%	Planning & Environmental Compliance	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
3.0%	Engineering & Design	$2,928	$1,142	39.0%	$4,071	0.0%	$2,928	$1,142	$4,071	2024Q3	18.4%	$3,469	$1,353	$4,821
0.5%	Reviews, ATRs, IEPRs, VE	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
0.5%	Life Cycle Updates (cost, schedule, risks)	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
0.5%	Contracting & Reprographics	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
1.0%	Engineering During Construction	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
0.5%	Planning During Construction	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2025Q3	23.0%	$600	$234	$835
0.5%	Adaptive Management & Monitoring	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
1.0%	Project Operations	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2024Q3	18.4%	$1,156	$451	$1,607
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,928	$1,142	39.0%	$4,071	0.0%	$2,928	$1,142	$4,071	2025Q3	23.0%	$3,603	$1,405	$5,008
1.0%	Project Operation:	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
1.0%	Project Management	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
	CONTRACT COST TOTALS:	$111,075	$43,314		**$154,389**		$111,075	$43,314	**$154,389**			$132,169	$51,540	**$183,709**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 4													
02	RELOCATIONS	$25,420	$9,914	39.0%	$35,333	0.0%	$25,420	$9,914	$35,333	2023Q1	9.5%	$27,832	$10,854	$38,686
06	FISH & WILDLIFE FACILITIES	$7,193	$2,805	39.0%	$9,998	0.0%	$7,193	$2,805	$9,998	2023Q4	12.0%	$8,055	$3,141	$11,196
12	NAVIGATION PORTS & HARBORS	$51,415	$20,052	39.0%	$71,467	0.0%	$51,415	$20,052	$71,467	2023Q4	12.0%	$57,574	$22,454	$80,028
	CONSTRUCTION ESTIMATE TOTALS:	$84,027	$32,771	39.0%	**$116,798**		$84,027	$32,771	$116,798			$93,461	$36,450	$129,910
01	LANDS AND DAMAGES	$11,396	$2,849	25.0%	$14,245	0.0%	$11,396	$2,849	$14,245	2023Q1	9.5%	$12,478	$3,119	$15,597
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$630	$246	39.0%	$876	0.0%	$630	$246	$876	2022Q4	10.9%	$699	$273	$972
0.5%	Planning & Environmental Compliance	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
3.0%	Engineering & Design	$2,521	$983	39.0%	$3,504	0.0%	$2,521	$983	$3,504	2022Q4	10.9%	$2,797	$1,091	$3,887
0.5%	Reviews, ATRs, IEPRs, VE	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
0.5%	Life Cycle Updates (cost, schedule, risks)	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
0.5%	Contracting & Reprographics	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
1.0%	Engineering During Construction	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
0.5%	Planning During Construction	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2024Q4	19.6%	$502	$196	$698
0.5%	Adaptive Management & Monitoring	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
1.0%	Project Operations	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2022Q4	10.9%	$932	$364	$1,296
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,521	$983	39.0%	$3,504	0.0%	$2,521	$983	$3,504	2024Q4	19.6%	$3,015	$1,176	$4,190
1.0%	Project Operation:	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
1.0%	Project Management	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
	CONTRACT COST TOTALS:	$106,977	$40,126		**$147,103**		$106,977	$40,126	**$147,103**			$119,228	$44,752	**$163,981**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 5													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$370	$144	39.0%	$515	0.0%	$370	$144	$515	2026Q3	21.5%	$450	$175	$625
12	NAVIGATION PORTS & HARBORS	$3,827	$1,493	39.0%	$5,320	0.0%	$3,827	$1,493	$5,320	2026Q3	21.5%	$4,649	$1,813	$6,462
	CONSTRUCTION ESTIMATE TOTALS:	$4,198	$1,637	39.0%	**$5,835**		$4,198	$1,637	$5,835			$5,098	$1,988	$7,086
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2026Q1	19.6%	$22	$6	$28
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$31	$12	39.0%	$44	0.0%	$31	$12	$44	2025Q3	23.0%	$39	$15	$54
0.5%	Planning & Environmental Compliance	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
3.0%	Engineering & Design	$126	$49	39.0%	$175	0.0%	$126	$49	$175	2025Q3	23.0%	$155	$60	$215
0.5%	Reviews, ATRs, IEPRs, VE	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
0.5%	Life Cycle Updates (cost, schedule, risks)	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
0.5%	Contracting & Reprographics	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
1.0%	Engineering During Construction	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
0.5%	Planning During Construction	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2026Q3	27.7%	$27	$10	$37
0.5%	Adaptive Management & Monitoring	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
1.0%	Project Operations	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2025Q3	23.0%	$52	$20	$72
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$126	$49	39.0%	$175	0.0%	$126	$49	$175	2026Q3	27.7%	$161	$63	$224
1.0%	Project Operation:	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
1.0%	Project Management	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
	CONTRACT COST TOTALS:	$4,793	$1,867		**$6,660**		$4,793	$1,867	**$6,660**			$5,843	$2,276	**$8,119**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Segment 6													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$1,056	$412	39.0%	$1,467	0.0%	$1,056	$412	$1,467	2026Q3	21.5%	$1,282	$500	$1,782
12	NAVIGATION PORTS & HARBORS	$30,090	$11,735	39.0%	$41,826	0.0%	$30,090	$11,735	$41,826	2026Q3	21.5%	$36,547	$14,253	$50,800
	CONSTRUCTION ESTIMATE TOTALS:	$31,146	$12,147	39.0%	**$43,293**		$31,146	$12,147	$43,293			$37,829	$14,753	$52,582
01	LANDS AND DAMAGES	$153	$38	25.0%	$191	0.0%	$153	$38	$191	2026Q1	19.6%	$183	$46	$229
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$234	$91	39.0%	$325	0.0%	$234	$91	$325	2025Q3	23.0%	$287	$112	$399
0.5%	Planning & Environmental Compliance	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
3.0%	Engineering & Design	$934	$364	39.0%	$1,299	0.0%	$934	$364	$1,299	2025Q3	23.0%	$1,150	$448	$1,598
0.5%	Reviews, ATRs, IEPRs, VE	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
0.5%	Life Cycle Updates (cost, schedule, risks)	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
0.5%	Contracting & Reprographics	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
1.0%	Engineering During Construction	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
0.5%	Planning During Construction	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2026Q3	27.7%	$199	$78	$276
0.5%	Adaptive Management & Monitoring	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
1.0%	Project Operations	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2025Q3	23.0%	$383	$149	$533
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$934	$364	39.0%	$1,299	0.0%	$934	$364	$1,299	2026Q3	27.7%	$1,193	$465	$1,659
1.0%	Project Operation:	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
1.0%	Project Management	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
	CONTRACT COST TOTALS:	$35,582	$13,855		**$49,437**		$35,582	$13,855	**$49,437**			$43,376	$16,891	**$60,266**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**4-Dec-19**	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Associated Costs													
12	NAVIGATION PORTS & HARBORS (Aids to Navigation)	$3,316	$1,293	39.0%	$4,609	0.0%	$3,316	$1,293	$4,609	2023Q3	11.1%	$3,685	$1,437	$5,122
12	NAVIGATION PORTS & HARBORS (Local Service Facilities)	$56,262	$21,942	39.0%	$78,204	0.0%	$56,262	$21,942	$78,204	2023Q4	12.0%	$63,002	$24,571	$87,573
	CONSTRUCTION ESTIMATE TOTALS:	$59,578	$23,235	39.0%	**$82,813**		$59,578	$23,235	$82,813			$66,688	$26,008	$92,696
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering & Design	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Adaptive Management & Monitoring	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
0.0%	Construction Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operation:	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$59,578	$23,235		**$82,813**		$59,578	$23,235	**$82,813**			$66,688	$26,008	**$92,696**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared: Effective Price Level:			**4-Dec-19** 1-Oct-19	Program Year (Budget EC): Effective Price Level Date:			2020 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Total O&M for 50 Years	$2,735,545	$574,464	21.0%	$3,310,009	0.0%	$2,735,545	$574,464	$3,310,009	2054Q1	173.7%	$7,488,030	$1,572,486	$9,060,516
	CONSTRUCTION ESTIMATE TOTALS:	$2,735,545	$574,464	21.0%	**3,310,009**		$2,735,545	$574,464	$3,310,009			$7,488,030	$1,572,486	$9,060,516
01	LANDS AND DAMAGES	$0	$0	0.0%	$ -	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$14,303	$3,004	21.0%	$17,307	0.0%	$14,303	$3,004	$17,307	2054Q1	288.0%	$55,496	$11,654	$67,150
0.3%	Planning & Environmental Compliance	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
2.1%	Engineering & Design	$57,212	$12,015	21.0%	$69,226	0.0%	$57,212	$12,015	$69,226	2054Q1	288.0%	$221,983	$46,616	$268,599
0.3%	Reviews, ATRs, IEPRs, VE	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Life Cycle Updates (cost, schedule, risks)	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Contracting & Reprographics	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.7%	Engineering During Construction	$19,071	$4,005	21.0%	$23,075	0.0%	$19,071	$4,005	$23,075	2054Q1	288.0%	$73,994	$15,539	$89,533
0.3%	Planning During Construction	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Adaptive Management & Monitoring	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2053Q3	280.1%	$36,244	$7,611	$43,855
0.7%	Project Operations	$19,071	$4,005	21.0%	$23,075	0.0%	$19,071	$4,005	$23,075	2054Q1	288.0%	$73,994	$15,539	$89,533
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$62,370	$13,098	21.0%	75,468	0.0%	$62,370	$13,098	$75,468	2054Q1	288.0%	$241,998	$50,820	$292,817
0.8%	Project Operation:	$20,790	$4,366	21.0%	25,156	0.0%	$20,790	$4,366	$25,156	2054Q1	288.0%	$80,666	$16,940	$97,606
0.8%	Project Management	$20,790	$4,366	21.0%	25,156	0.0%	$20,790	$4,366	$25,156	2054Q1	288.0%	$80,666	$16,940	$97,606
3.8%														
	CONTRACT COST TOTALS:	$3,006,364	$631,336		**3,637,700**		$3,006,364	$631,336	**$3,637,700**			$8,538,056	$1,792,992	**$10,331,048**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Increase in O&M for 50 Years	$613,620	$128,860	21.0%	$742,480	0.0%	$613,620	$128,860	$742,480	2054Q1	173.7%	$1,679,666	$352,730	$2,032,396
	CONSTRUCTION ESTIMATE TOTALS:	$613,620	$128,860	21.0%	**$742,480**		$613,620	$128,860	$742,480			$1,679,666	$352,730	$2,032,396
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$3,208	$674	21.0%	$3,882	0.0%	$3,208	$674	$3,882	2053Q3	280.1%	$12,195	$2,561	$14,756
0.3%	Planning & Environmental Compliance	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
2.1%	Engineering & Design	$12,833	$2,695	21.0%	$15,528	0.0%	$12,833	$2,695	$15,528	2053Q3	280.1%	$48,780	$10,244	$59,024
0.3%	Reviews, ATRs, IEPRs, VE	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.3%	Life Cycle Updates (cost, schedule, risks)	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.3%	Contracting & Reprographics	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.7%	Engineering During Construction	$4,278	$898	21.0%	$5,176	0.0%	$4,278	$898	$5,176	2020Q2	0.9%	$4,318	$907	$5,225
0.3%	Planning During Construction	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2020Q2	0.9%	$2,159	$453	$2,613
0.3%	Adaptive Management & Monitoring	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2022Q1	7.8%	$2,307	$484	$2,791
0.7%	Project Operations	$4,278	$898	21.0%	$5,176	0.0%	$4,278	$898	$5,176	2053Q3	280.1%	$16,260	$3,415	$19,675
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$13,991	$2,938	21.0%	$16,929	0.0%	$13,991	$2,938	$16,929	2020Q2	0.9%	$14,123	$2,966	$17,089
0.8%	Project Operation:	$4,664	$979	21.0%	$5,643	0.0%	$4,664	$979	$5,643	2020Q2	0.9%	$4,708	$989	$5,696
0.8%	Project Management	$4,664	$979	21.0%	$5,643	0.0%	$4,664	$979	$5,643	2020Q2	0.9%	$4,708	$989	$5,696
	CONTRACT COST TOTALS:	$674,368	$141,617		**$815,985**		$674,368	$141,617	**$815,985**			$1,821,744	$382,566	**$2,204,310**

US Army Corps of Engineers®

Houston Ship Channel DMMP
45’ Expansion Channel Improvement
Project Cost and Schedule Risk Analysis Report
NED Plan

Prepared for:

U.S. Army Corps of Engineers,
Galveston District

Prepared by:

U.S. Army Corps of Engineers, Walla Walla District
Engineering and Construction Division, Cost Engineering Branch

November 20, 2019

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Galveston District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Galveston District, Houston Ship Channel DMMP. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

The Houston Ship Channel (HSC) project purpose is to reduce transportation costs and address navigation safety issues on the Houston Ship Channel (HSC) system. The HSC consists of an existing 52 mile long deep-draft navigation channel, three deep-draft tributary channels and one shallow draft tributary channel. The primary HSC deep-draft channel has authorized depths ranging from 36 feet to 45 feet and widths ranging generally from 300 feet to 530 feet.

The DMMP documents the dredging and placement needs for the Federal project and associated non- Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel, Barbour’s Terminal Cut, Greens Bayou, Jacintoport, the light-draft channel, Turkey Bend, Turkey Bend Cut off, boater cuts, and barge lanes. The DMMP is developed as a stand-alone document for operations and management of future dredged material for the federal project.

The current and future placement plan for continued operation and maintenance of the existing HSC complex is outlined in the December 5, 2017 Preliminary Assessment (HSCPA) and conceptual 50-year DMMP dated December 18, 2018. This is considered the Future Without Project (FWOP) condition for the HSC ECIP Study. The study integrates changes to the FWOP conditions by identifying the base plan for placement needs for the increment of new work and maintenance dredging from the recommended modification which includes dredged material originating from the Federal channel for a period of 50-years. This is considered the Future With Project (FWP) condition for the HSC ECIP Study.

Specific to the Houston Ship Channel DMMP, the current project base cost estimate, pre-contingency, approximates $411M. This CSRA included study of estimated base construction, engineering and design and construction management. There are no spent costs and real estate costs are accounted for in the real estate appendix. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Cost MCX located in Walla Walla District) recommends a contingency value of $148M or approximately 36% of base project cost at an 80% confidence level of successful execution.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Estimate	**$410,607,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$542,001,000	32%
80%	**$558,425,000**	**36%**
90%	$570,744,000	39%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

A formal Cost Risk Analysis was performed on Houston Ship Channel Improvement Project with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works. The risks were quantified and a cost risk model developed to determine a contingency at 80% confidence level (CL). The key risk drivers identified through sensitivity analysis suggest a cost contingency of $148M at an 80% confidence level.

Cost Risks: From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction.

There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.

- PM-5: Scope Changes – Scope changes could add cost and delay the project. Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor – Inefficient contractor may delay the project and affect the quantities.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.
- PM-5: Scope Changes – Scope changes could add cost and delay the project.
- ES-5: Schedule Detail – Estimate and schedule assume 12 separate contracts and likely to change.

Recommendations: The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Within the authority of the US Army Corps of Engineers (USACE), Galveston District, this report presents the efforts and results of the cost and schedule risk analysis for the Houston Ship Channel DMMP. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The NED cost estimate of the project is divided into six segments, or reaches, each with a separate placement plan and placement areas. All dredging was assumed to be performed by a 30-inch cutter-head pipeline dredge, except for portions of Bolivar Roads to Redfish Reef segment and Redfish to BSC, for which a mechanical dredge will be used. Reaches include:
The NED plan includes widening the channel from 530 feet wide to 700 feet wide from Bolivar Roads to Redfish, four bend easings, and easing the Bayport Flare from a 4,000 foot to a 5,300 foot radius in Segment 1; widening the Bayport Ship Channel from 350 and 400 feet to 455 feet in Segment 2; widening the Barbour's Cut Ship Channel from 300 to 455 feet wide and extending the turning radius flare to 1,800 feet in Segment 3; widening from 400 to 530 feet and deepening from 41.5 to 46.5 feet Boggy Bayou to Greens Bayou and deepening from 41.5 to 46.5 from Greens Bayou to the Washburn Tunnel in Segment 4; deepening from Sims to 610 from 37.5 to 41.5 in Segment 5; and deepening from 37.5 to 41.5 from 610 to the Turning Basin in Segment 6.

Detailed descriptions of the various HSC segments and tributary channels included in this DMMP are presented in the Integrated Dredged Material Management Plan and Environmental Assessment Report.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.

- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in March 2015. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

A Risk meeting occurred in March 2015 with an update in December of 2015, resulting in a revision of the identified risks and the current known impacts. The cost and schedule risk analysis and cost certification was completed in January 2016. The project scope was changed and a cost and schedule risk analysis update was again completed in June 2019. Key PDT members included:

Attendance	Name	Office	Representing
Full	Dale Williams	CESWG-ECE-P	Cost Engineering
Full	T. Cheryl Jaynes	CESWF-PEC-PF	Plan Formulation
Full	Nancy C. Young	CESWF-EC-G	Civil Engineer
Full	David B. Boothby	CESWF-EC-S	Geotech Engineer
Full	Harmon Brown	CESWF-PEC-CC	Environmental
Full	Kenny Pablo	CESWG-RE	Real Estate
Full	Nichole Schlund	CESWG-RE	Real Estate
Full	A. Rashid Ali	CESWG-ECE-P	Cost Engineering
Full	Chester Hedderman	GBA/JV	PHA
Full	Richard Ruchoeft	PHA	PHA
Full	Ryan Harbor	CESWG-ECE-P	Cost Engineering
Full	Stephanie Nieves	CESWG-ECE-P	Cost Engineering
Full	Dana Cheney	GBA/JV	PHA
Full	Carl Sepulveda	AECOM/JV	Environmental

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Galveston District office for the purposes of identifying and assessing risk factors. The meeting conducted June 2019 included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for cost risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the project.

a. The Galveston District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) and CEDEP (Corps of Engineers Dredge Estimating Program) files electronically. The MII files transmitted and downloaded June 2019 were the basis for the initial cost and schedule risk analyses. These files were again updated in November 2019.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304. The risk analyses accounted for no escalation over and above the national average; however, recent experience in the past five years does indicate a construction inflation above the standard OMB rates published. This risk was considered with the delay impacts.

e. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

f. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for

implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks was quantified as approximately $148 Million at the P80 confidence.

Table 1. Construction Cost Contingency Summary

Base Case Estimate	**$411,070,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$542,001,000	32%
80%	**$558,425,000**	**36%**
90%	$570,744,000	39%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

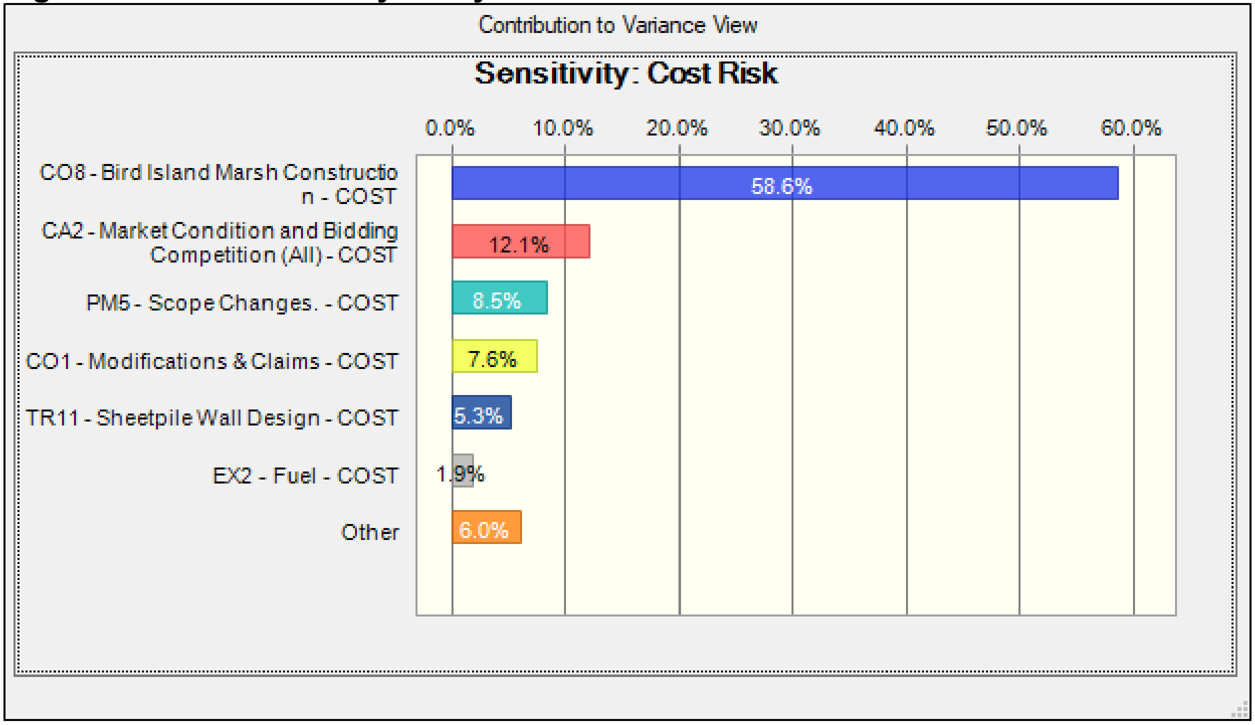
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule Risk Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

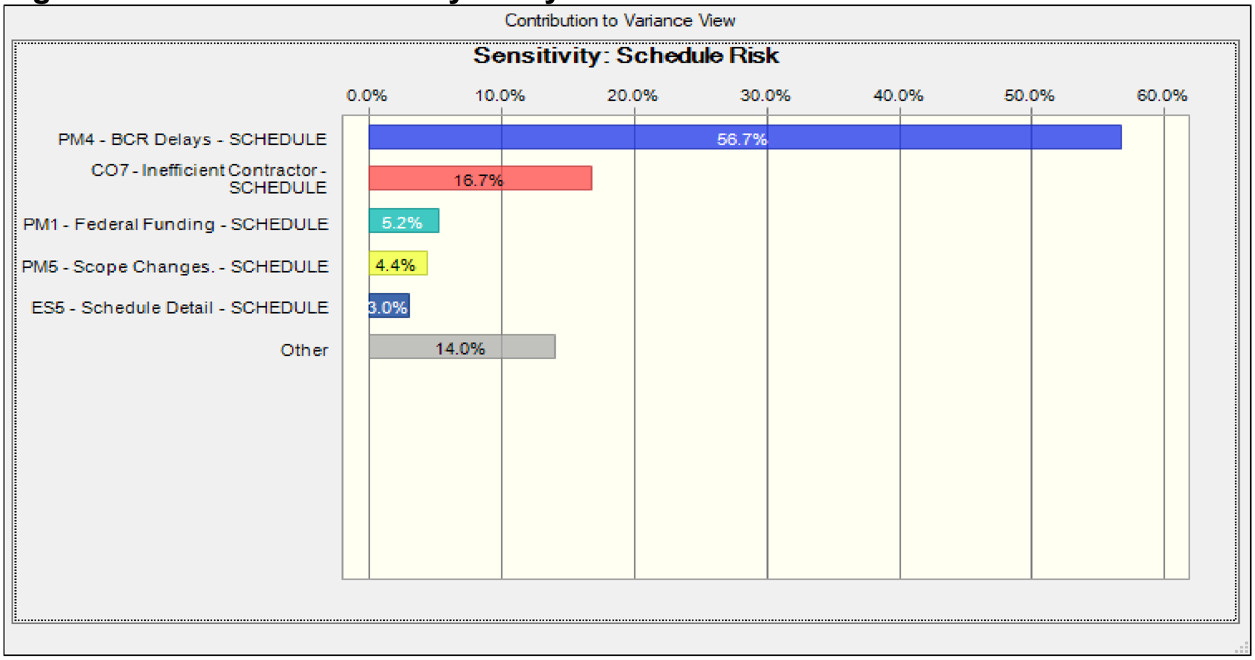
Schedule duration contingency was quantified as 22 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 40 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	58	18
80% Confidence	62	22
90% Confidence	64	24

Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 1. Additional major findings and observations of the risk analysis are listed below.

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in 2015. The cost and schedule risk analysis and cost certification was completed January 2016 and updated in August 2019. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $148M at an 80% confidence level.

Cost Risks: From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- PM-5: Scope Changes – Scope changes could add cost and delay the project. Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is

conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor – Inefficient contractor may delay the project and affect the quantities.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.
- PM-5: Scope Changes – Scope changes could add cost and delay the project.
- ES-5: Schedule Detail – Estimate and schedule assume 12 separate contracts and likely to change.

Table 2. Construction Cost Comparison Summary (Uncertainty Analysis)

	Percentile	**Baseline TPC**	**Baseline w/ Contingency**	**Contingency %**
PROJECT CONTINGENCY (BASELINE ESTIMATE)	0%	$410,606,921	**$476,304,028**	**16%**
	10%	$410,606,921	**$509,152,582**	**24%**
	20%	$410,606,921	**$521,470,789**	**27%**
	30%	$410,606,921	**$529,682,928**	**29%**
	40%	$410,606,921	**$533,788,997**	**30%**
	50%	$410,606,921	**$542,001,135**	**32%**
	60%	$410,606,921	**$546,107,205**	**33%**
	70%	$410,606,921	**$554,319,343**	**35%**
	80%	$410,606,921	**$558,425,412**	**36%**
	90%	$410,606,921	**$570,743,620**	**39%**
	100%	$410,606,921	**$632,334,658**	**54%**

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor, Railroad, and USACE is needed in areas of ROW, mobile home relocations, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

<u>Risk Management</u>: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

<u>Risk Analysis Updates</u>: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

CREF	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Likelihood ©	Impact ©	Risk Level ©	Likelihood (S)	Impact (S)	Risk Level (S)
Organizational and Project Management Risks (PM)									
PM1	Federal Funding	Annual appropriations for Design and Construction could be delayed.	Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.	Possible	Negligible	**Low**	Possible	Significant	**Medium**
PM2	Non Federal Funding	Non federal sponsor may not have the funds to cost share.	The port if committed to having the funding. The PPA is anticipated to be signed and the funding will be in place.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**
PM3	Labor Availability	There may be a shortage of manpower for the design of this project.	We expect to have enough people to work on this project with the Galveston district. The PHA will supplement any shortages with work in kind.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM4	BCR Delays	A low BCR ratio may delay a new start decision.	Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.	Unlikely	Negligible	**Low**	Likely	Marginal	**Medium**
PM5	Scope Changes.	Scope changes could add cost and delay the project.	Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.	Possible	Moderate	**Medium**	Possible	Marginal	**Low**
PM6	Coordination between Construction and Operations	O&M needs could impact new work dredging schedule.	O&M dredging could cause individual contract schedule coordination between construction and operations. This coordination could cause new work schedule changes. The total duration is not expected to change.	Possible	Marginal	**Low**	Unlikely	Negligible	**Low**
Contract Acquisition Risks (CA)									

CA1	Acquisition Strategy	Acquisition Strategy could change.	Contracts are generally separated by contract year and the team does not feel there is a risk of the acquisition changing. The order of the contracts could change but would not add to cost or delay the overall construction schedule.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CA2	Market Condition and Bidding Competition (All)	There is the possibility of having a limited number of contractors bid which would increase the cost.	Having limited competition would likely increase the cost. Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the hydraulic dredging. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.	Likely	Moderate	**Medium**	Unlikely	Negligible	**Low**
CA3	Small Business Goals	Small Business goals could add subcontracting costs.	Majority of dredging and placement area work is assumed for IFB large business. Small business could be added for PA site prep at Segment 4 , 5 and 6 adding marginal cost and schedule delays.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
General Technical Risks (TR)									
TR1	Mechanical Dredging Quantities	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes 3:1 slopes and the existing slopes are "flatter" and will require less dredging quantity due to the soft material. (Sta 57+000 to 100+000)	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR2	Hydraulic Dredging Quantities - Bay	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Likely	Moderate	**Medium**	Likely	Marginal	**Medium**

TR3	Hydraulic Dredging Quantities - Bayou	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. There is less Geo information for the Bayou than the bay. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Very Likely	Marginal	**Medium**	Very Likely	Marginal	**Medium**
TR4	Long bird Island and 8 Acre Bird Island PA Retainage	Conceptual Level Design and could change.	If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR5	3 Bird Island Marsh PA Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR7	M12 PA (NED) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. (M12 is significantly better foundation than M11) If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs. Sweeping of Cedar Bayou navigation channel material could increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR9	Oyster Mitigation Design (NED)	Conceptual Level Design and could change.	NED design is an established practice. 31.7 acre oyster reef mitigation for Boliver Roads to Redfish does not rely on berm. 30-inch layer of cultch is sufficient to account for settling.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

TR11	Sheetpile Wall Design	Initial Sheetpile Wall Design and could change.	Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,	Possible	Moderate	**Medium**	Possible	Negligible	**Low**
TR12	Beltway 8 Upland PA Design	The Beltway 8 Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR13	E2 Clinton Upland PA Design	The E2 Clinton Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR14	Glendale and Filter bed Upland PA Design	Conceptual Level Design and could change.	The estimate assumes onsite borrow but may require offsite import material.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR15	Revetment Rock Sizing	Revetment Rock Sizing could change.	Revetment rock sizing could change during PED. Sizing currently to 1500# stone and is conservative. If stone sizing decreased the total tonnage could increase. This risk is independent of the shoaling attenuation feature.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
Lands and Damages (LD)									
LD1	LERRDS	Additional LERRDS may be required.	ALL upland PA's owned by the Port of Houston. Bay PA's are on submerged lands. Oyster Mitigation reefs avoid tracts under 3rd party leases.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
LD2	Pipeline Relocations	Utility Relocation numbers and construction may change.	8 assumed in estimate and quantities could change. Actual depth are unknown.	Likely	Negligible	**Low**	Possible	Negligible	**Low**
Regulatory Environmental Risks (RG)									
RG1	Historical/Cultural Significance	Historical/Cultural Significance	No historical or cultural sites expected.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

RG2	Endangered Species	Bird avoidance and minimization	There is no beach disposal on this project. No endangered species concerns with the new work.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG3	Unexploded Ordinance	Beltway 8 was former army munitions depot facility.	Sweeps did not find any UXO's with 95% confidence.	Unlikely	Marginal	**Low**	Unlikely	Moderate	**Low**
RG4	Sea Level Rise	The implementation of estimating sea level rise in the design life of all ACOE projects could affect the project cost.	This risk could be eliminated during the design phase. This could decrease the project cost due to less required dredging. Less dredging would also decrease the project schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG5	Oyster Mitigation	Oyster mitigation quantity could change.	Oyster mitigation based on updated survey. The Bird island size cannot change and therefore the oyster mitigation acreage not anticipated to change. Additional quantity changes are captured in the technical risks (ADD Risk #). There could be a schedule delay to coordinate with other agencies.	Unlikely	Negligible	**Low**	Possible	Marginal	**Low**
RG6	Air Quality	Construction could be delayed to minimize air quality impacts.	Do not foresee having any issue with EPA. Could require Tier 2 equipment and lower fuel efficiency but it is possible.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
RG7	Contaminated Dredge Material	Contamination could lead to changing disposal location.	Segment 5 and 6 has the potential for contaminated material. Sediment testing has been done and no contamination was present in levels of significant concern. Current sediment sampling indicates this is a very low risk but if it occurred it could be a moderate cost. The design may require drainage of dredge effluent with onsite management. This would reduce the dredge production requiring the dredge to reduce time for 14 hours/day to 12 hours/day. The PDT feels this a possible risk for the project but has moderate cost risks.	Possible	Significant	**Medium**	Possible	Marginal	**Low**
RG8	Agency Reviews	Agency reviews could lead to delays.	There has been ongoing coordination with beneficial use group (BUG) and there are no delays anticipated. Sediment sampling and section 103 has been coordinated with the EPA.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

Construction Risks (CO)

CO1	Modifications & Claims	Construction contract modifications can impact construction cost and schedule growth.	Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc. Will impact costs, but little overall impact to larger project timeline.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
CO2	Labor Availability/Pricing	Gulf Labor rates are relatively low and estimate labor rate are conservative.	Gulf region labor rates are fairly low when compared to national rates. Busy economy may require paying extra for skilled labor. Estimate labor (Union Rates) conservative and typically higher than actual costs.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CO3	Navigation Traffic Conflicts	Traffic within the shipping channel could delay or halt construction.	Submerged pipeline required to mitigate navigation traffic interference. Estimate assumes decreased productivity to account for navigation channel traffic. 14 hours/day in Bayou and 16 hrs/day in the bay assumed in estimate. EWT accounted for in CEDEP estimate and is based on historical productivity. Additional cost and schedule risks are minimal.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO4	New Dredging	New work dredging could be lower productivity than estimated.	New work dredging estimates based on historical boring information and production estimate reflect the new work materials seen per segment.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO5	Material Availability	Rock material pricing is a concern.	Imported rock is assumed to be imported from Missouri. Rock and rip rap is readily available and conservatively priced based on common practice for the area.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
CO6	Sheetpile Wall Construction	Specialized Equipment may not be available	Giken "press in" method may be required for pile installation and require specialized equipment that may not be available	Possible	Marginal	**Low**	Possible	Marginal	**Low**

			(segment 2 only). This could add to the cost for the segment 2 pile installation.						
CO7	Inefficient Contractor	Inefficient contractor may delay the project and affect the quantities.	Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
CO8	Bird Island Marsh Construction	Low retainage may require 3 materials in order to construct Bird Island Marsh as designed.	The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.	Likely	Moderate	**Medium**	Possible	Moderate	**Medium**
Estimate and Schedule Risks (ES)									
ES1	Dredging Productivity	The types and classifications of materials for the purposes of estimating could present a risk to the project costs and schedule. Since future dredging in new work areas, there is some uncertainty about the types of material that will be encountered.	Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity.	Possible	Moderate	**Medium**	Unlikely	Moderate	**Low**
ES2	Dredge Mob/Demob	Actual Mob/Demob cost could vary	Mob/demob costs are based on average actual pricing. Actual mob costs could vary based on actual dredge plant location.	Possible	Marginal	**Low**	Unlikely	Moderate	**Low**

ES3	Relocation Pricing	Relocation costs may change.	Relocation costs based on historical costs. Actual costs may vary from escalated price included in estimate. Relocations based on land based equipment. Relocations need to be completed prior to work and could delay the contract. Relocation pricing modeled in LD2.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES4	Equip rates	The equipment rates are outdated	Equipment pricing is outdated in the properties but the rates were manually updated based on current data.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES5	Schedule Detail	Construction Schedule could change.	Estimate and schedule assume 12 separate contracts. Total dredging time, based on quantities, is 40 months. Schedule based on fiscal years but total schedule is unlikely to extend more than 3-6 months.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
ES6	Sheetpile Pricing	Sheetpile Pricing Parametric and may change.	Sheetpile pricing is parametric and could vary from the actual pricing. There is updated material pricing but the labor and equipment is likely to change. The labor and equipment risk is modeled in TR11.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
External Risks (EX)									
EX1	Adverse Weather	Location is subject to hurricanes.	Storms/hurricanes in other regions could limit number of dredges available close to project site during performance period, increasing distance to mobilize. This would be paid by another contract but could cause a schedule delay. A local storm could bring additional dredging quantities. Storms could damage existing placement area work.	Possible	Marginal	**Low**	Likely	Negligible	**Low**

EX2	Fuel	Fuel is a volatile cost and can greatly affect the cost of this project.	Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.	Possible	Moderate	**Medium**	Unlikely	Negligible	**Low**
EX3	Dredge Availability	The availability and number of quality dredges for this particular project is a potential concern.	There is concern in needing more dredges to complete dredging in a required timeframe. Dredges must be spaced a minimum distance, as per USCG (5 nautical miles). PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem.	Unlikely	Moderate	**Low**	Possible	Marginal	**Low**
EX4	Inflation	Inflation could exceed CWCCIS	Project is for 2023-2027 (2028 for LPP) and inflation could exceed CWCCIS tables. Since this is dredging the risks for fuel and labor have already been accounted and therefore this risk is not modeled.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
EX5	Upland Mitigation	Upland Mitigation	Bank credits are being used and if the project is delayed the credits could change (37 ac assumed). Bank credit cost could change. The bank credit costs covered in the estimate is conservative and therefore the cost risk has not been modeled.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**
EX6	Ship Accident/Oil Spill	Possible accident or oil spill in the channel.	A ship accident or oil spill within the channel could lead to standby costs and schedule delays.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

US Army Corps of Engineers®

Houston Ship Channel DMMP
45’ Expansion Channel Improvement
Project Cost and Schedule Risk Analysis Report
LPP Plan

Prepared for:

U.S. Army Corps of Engineers,
Galveston District

Prepared by:

U.S. Army Corps of Engineers, Walla Walla District
Engineering and Construction Division, Cost Engineering Branch

November 20, 2019

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Galveston District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Galveston District, Houston Ship Channel DMMP. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

The Houston Ship Channel (HSC) project purpose is to reduce transportation costs and address navigation safety issues on the Houston Ship Channel (HSC) system. The HSC consists of an existing 52 mile long deep-draft navigation channel, three deep-draft tributary channels and one shallow draft tributary channel. The primary HSC deep-draft channel has authorized depths ranging from 36 feet to 45 feet and widths ranging generally from 300 feet to 530 feet.

The DMMP documents the dredging and placement needs for the Federal project and associated non- Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel, Barbour’s Terminal Cut, Greens Bayou, Jacinto Port, the light-draft channel, Turkey Bend, Turkey Bend Cut off, boater cuts, and barge lanes. The DMMP is developed as a stand-alone document for operations and management of future dredged material for the federal project.

The current and future placement plan for continued operation and maintenance of the existing HSC complex is outlined in the December 5, 2017 Preliminary Assessment (HSCPA) and conceptual 50-year DMMP dated December 18, 2018. This is considered the Future Without Project (FWOP) condition for the HSC ECIP Study. The study integrates changes to the FWOP conditions by identifying the base plan for placement needs for the increment of new work and maintenance dredging from the recommended modification which includes dredged material originating from the Federal channel for a period of 50-years. This is considered the Future With Project (FWP) condition for the HSC ECIP Study.

Specific to the Houston Ship Channel DMMP, the current project base cost estimate, pre-contingency, approximates $531M. This CSRA included study of estimated base construction, engineering and design and construction management. There are no spent costs and real estate costs are accounted for in the real estate appendix. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Cost MCX located in Walla Walla District) recommends a contingency value of $209M or approximately 39% of base project cost at an 80% confidence level of successful execution.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Estimate	**$531,384,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$712,054,000	34%
80%	**$738,623,000**	**39%**
90%	$754,565,000	42%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

A formal Cost Risk Analysis was performed on Houston Ship Channel Improvement Project with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works. The risks were quantified and a cost risk model developed to determine a contingency at 80% confidence level (CL). The key risk drivers identified through sensitivity analysis suggest a cost contingency of $207M at an 80% confidence level.

Cost Risks: From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired.
- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope

growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.

- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30" hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- ES-1: Dredging Productivity – Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity. Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – Low retainage may require additional time in order to construct Bird Island Marsh as designed.
- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor - Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.
- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in Bay with a longer construction schedule. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired
- ES-6: Schedule Detail: Estimate and schedule assume 12 separate contracts and likely to change.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.

Recommendations: The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Within the authority of the US Army Corps of Engineers (USACE), Galveston District, this report presents the efforts and results of the cost and schedule risk analysis for the Houston Ship Channel DMMP. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The LPP cost estimate of the project is divided into six segments, or reaches, each with a separate placement plan and placement areas. All dredging was assumed to be performed by a 30-inch cutter-head pipeline dredge, except for portions of Boliver Roads to Redfish Reef segment and Redfish to BSC, for which a mechanical dredge will be used.

The NED plan includes widening the channel from 530 feet wide to 700 feet wide from Bolivar Roads to Redfish, four bend easings, and easing the Bayport Flare from a 4,000 foot to a 5,300 foot radius in Segment 1; widening the Bayport Ship Channel from 350 and 400 feet to 455 feet in Segment 2; widening the Barbour's Cut Ship Channel from 300 to 455 feet wide and extending the turning radius flare to 1,800 feet in Segment 3; widening from 400 to 530 feet and deepening from 41.5 to 46.5 feet Boggy Bayou to Greens Bayou and deepening from 41.5 to 46.5 from Greens Bayou to the Washburn Tunnel in Segment 4; deepening from Sims to 610 from 37.5 to 41.5 in Segment 5; and deepening from 37.5 to 41.5 from 610 to the Turning Basin in Segment 6.

The apparent LPP includes widening the channel from 530 feet to 700 feet wide from Redfish to Bayport and from Bayport to Barbour's Cut.

Detailed descriptions of the various HSC segments and tributary channels included in this DMMP are presented in the Integrated Dredged Material Management Plan and Environmental Assessment Report.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in March 2015. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

A Risk meeting occurred in March 2015 with an update in December of 2015, resulting in a revision of the identified risks and the current known impacts. The cost and schedule risk analysis and cost certification was completed in January 2016. The project scope was changed and a cost and schedule risk analysis update was again completed in June 2019. Key PDT members included:

Attendance	Name	Office	Representing
Full	Dale Williams	CESWG-ECE-P	Cost Engineering
Full	T. Cheryl Jaynes	CESWF-PEC-PF	Plan Formulation
Full	Nancy C. Young	CESWF-EC-G	Civil Engineer
Full	David B. Boothby	CESWF-EC-S	Geotech Engineer
Full	Harmon Brown	CESWF-PEC-CC	Environmental
Full	Kenny Pablo	CESWG-RE	Real Estate
Full	Nichole Schlund	CESWG-RE	Real Estate
Full	A. Rashid Ali	CESWG-ECE-P	Cost Engineering
Full	Chester Hedderman	GBA/JV	PHA
Full	Richard Ruchoeft	PHA	PHA
Full	Ryan Harbor	CESWG-ECE-P	Cost Engineering
Full	Stephanie Nieves	CESWG-ECE-P	Cost Engineering
Full	Dana Cheney	GBA/JV	PHA
Full	Carl Sepulveda	AECOM/JV	Environmental

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Galveston District office for the purposes of identifying and assessing risk factors. The meeting conducted June 2019 included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for cost risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the project.

a. The Galveston District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) and CEDEP (Corps of Engineers Dredge Estimating Program) files electronically. The MII files transmitted and downloaded June 2019 were the basis for the initial cost and schedule risk analyses. These files were again updated in November 2019.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304. The risk analyses accounted for no escalation over and above the national average; however, recent experience in the past five years does indicate a construction inflation above the standard OMB rates published. This risk was considered with the delay impacts.

e. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

f. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks was quantified as approximately $93.5 Million at the P80 confidence.

Table 1. Construction Cost Contingency Summary

Base Case Estimate	**$531,384,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$712,054,000	34%
80%	**$738,623,000**	**39%**
90%	$754,565,000	42%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

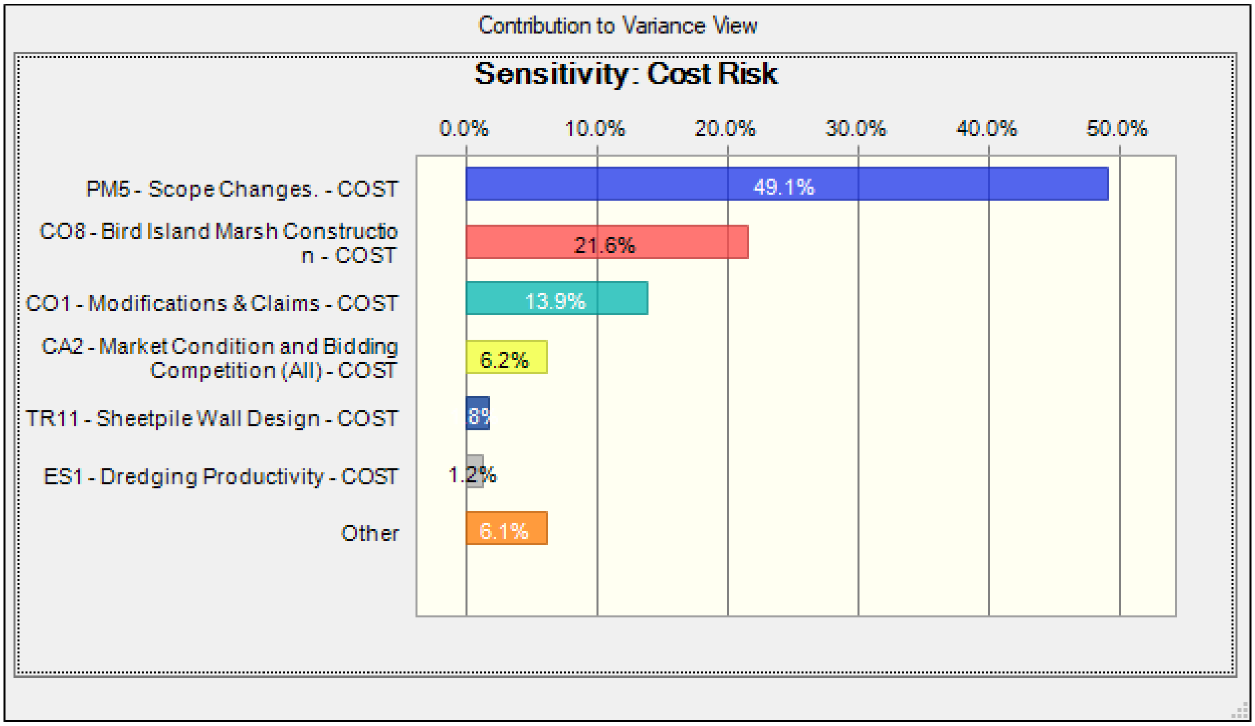
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule Risk Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

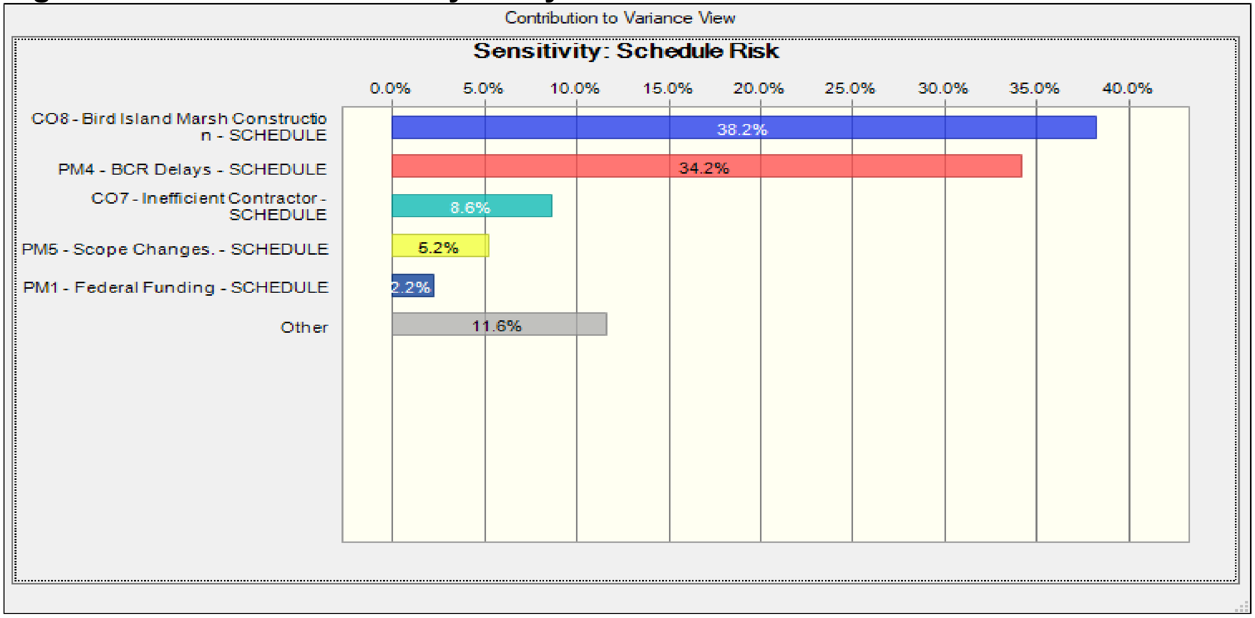
Schedule duration contingency was quantified as 23 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 52 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	71	19
80% Confidence	75	23
90% Confidence	78	26

Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 1. Additional major findings and observations of the risk analysis are listed below.

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in 2015. The cost and schedule risk analysis and cost certification was completed January 2016 and updated in August 2019. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $207M at an 80% confidence level.

Cost Risks: From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in the Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired.
- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- ES-1: Dredging Productivity – Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity. Lesser project risks can be referenced in the cost sensitivity forecast data.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – Low retainage may require additional time in order to construct Bird Island Marsh as designed.
- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor - Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.
- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in the Bay with a longer construction schedule. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired
- ES-6: Schedule Detail: Estimate and schedule assume 12 separate contracts and likely to change.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.

Table 2. Construction Cost Comparison Summary (Uncertainty Analysis)

	Percentile	**Baseline TPC**	**Baseline w/ Contingency**	**Contingency %**
PROJECT CONTINGENCY (BASELINE ESTIMATE)	0%	$531,384,000	**$627,032,838**	**18%**
	10%	$531,384,000	**$669,543,539**	**26%**
	20%	$531,384,000	**$680,171,215**	**28%**
	30%	$531,384,000	**$690,798,890**	**30%**
	40%	$531,384,000	**$701,426,565**	**32%**
	50%	$531,384,000	**$712,054,240**	**34%**
	60%	$531,384,000	**$717,368,078**	**35%**
	70%	$531,384,000	**$727,995,753**	**37%**
	80%	$531,384,000	**$738,623,428**	**39%**
	90%	$531,384,000	**$754,564,941**	**42%**
	100%	$531,384,000	**$807,703,317**	**52%**

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor, Railroad, and USACE is needed in areas of ROW, mobile home relocations, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

CREF	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Likelihood ©	Impact ©	Risk Level ©	Likelihood (S)	Impact (S)	Risk Level (S)
Organizational and Project Management Risks (PM)									
PM1	Federal Funding	Annual appropriations for Design and Construction could be delayed.	Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.	Possible	Negligible	**Low**	Possible	Significant	**Medium**
PM2	Non Federal Funding	Non federal sponsor may not have the funds to cost share.	The port if committed to having the funding. The PPA is anticipated to be signed and the funding will be in place.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**
PM3	Labor Availability	There may be a shortage of manpower for the design of this project.	We expect to have enough people to work on this project with the Galveston district. The PHA will supplement any shortages with work in kind.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM4	BCR Delays	A low BCR ratio may delay a new start decision.	Multiple separable element that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.	Unlikely	Negligible	**Low**	Likely	Marginal	**Medium**
PM5	Scope Changes.	Scope changes could add cost and delay the project.	Additional ship simulations could result in wider channel recommended in Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired. Additional pipelines could be identified and be added at the time of construction.	Possible	Significant	**Medium**	Unlikely	Negligible	**Low**
PM6	Coordination between Construction and Operations	O&M needs could impact new work dredging schedule.	O&M dredging could cause individual contract schedule coordination between construction and operations. This coordination could cause new work schedule changes. The total duration is not expected to change.	Possible	Marginal	**Low**	Unlikely	Negligible	**Low**
Contract Acquisition Risks (CA)									

CA1	Acquisition Strategy	Acquisition Strategy could change.	Contracts are generally separated by contract year and the team does not feel there is a risk of the acquisition changing. The order of the contracts could change but would not add to cost or delay the overall construction schedule.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CA2	Market Condition and Bidding Competition (All)	There is the possibility of having a limited number of contractors bid, due to increased work advertised, which would increase the cost.	Having limited competition would likely increase the cost. Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the hydraulic dredging. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.	Likely	Moderate	**Medium**	Unlikely	Negligible	**Low**
CA3	Small Business Goals	Small Business goals could add subcontracting costs.	Majority of dredging and placement area work is assumed for IFB large business. Small business could be added for PA site prep at Segment 4 , 5 and 6 adding marginal cost and schedule delays.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
General Technical Risks (TR)									
TR1	Mechanical Dredging Quantities	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes 3:1 slopes and the existing slopes are "flatter" and will require less dredging quantity due to the soft material. (Sta 57+000 to 100+000)	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR2	Hydraulic Dredging Quantities - Bay	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Likely	Moderate	**Medium**	Likely	Marginal	**Medium**

TR3	Hydraulic Dredging Quantities - Bayou	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. There is less Geo information for the Bayou than the bay. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Very Likely	Marginal	**Medium**	Very Likely	Marginal	**Medium**
TR4	Long bird Island and 8 Acre Bird Island PA Retainage	Conceptual Level Design and could change.	If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR5	3 Bird Island Marsh PA Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR6	M7/8/9 and M11 PA (LPP) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping and grading. Oil and gas stakeholders may require access to the site.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR7	M12 PA (NED) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. (M12 is significantly better foundation than M11) If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs. Sweeping of Cedar Bayou navigation channel material could increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

TR8	Shoaling Attenuation Feature Design (LPP Only)	Conceptual Level Design and could change.	Highly conceptual level design will change after hydrodynamic modeling in PED. Size, length, position and orientation anticipated to change.	Very Likely	Moderate	**High**	Possible	Marginal	**Low**
TR9	Oyster Mitigation Design (NED)	Conceptual Level Design and could change.	NED design is an established practice.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR10	Oyster Mitigation Design (LPP)	Conceptual Level Design and could change.	LPP Oyster design is new in Galveston Bay (357.9 AC for the LPP vs. 88 AC for the NED). Berm for San Leon oyster reef may require additional cultch if berm does not provide firm foundation. 2,030,000 CY hydraulically dredged to San Leon oyster reef (177 acres) to construct berm. If berm aborted, some material would be mechanically dredged.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR11	Sheetpile Wall Design	Initial Sheetpile Wall Design and could change.	Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,	Possible	Moderate	**Medium**	Possible	Negligible	**Low**
TR12	Beltway 8 Upland PA Design	The Beltway 8 Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR13	E2 Clinton Upland PA Design	The E2 Clinton Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR14	Glendale and Filter bed Upland PA Design	Conceptual Level Design and could change.	The estimate assumes onsite borrow but may require offsite import material.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR15	Revetment Rock Sizing	Revetment Rock Sizing could change.	Revetment rock sizing could change during PED. Sizing currently to 1500# stone and is conservative. If stone sizing decreased the total tonnage could increase. This risk is independent of the shoaling attenuation feature.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

Lands and Damages (LD)

LD1	LERRDS	Additional LERRDS may be required.	ALL upland PA's owned by the Port of Houston. Bay PA's are on submerged lands. Oyster Mitigation reefs avoid tracts under 3rd party leases.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
LD2	Pipeline Relocations	Utility Relocation numbers and construction may change.	8 assumed in estimate and quantities could change. Actual depth are unknown.	Likely	Negligible	**Low**	Possible	Negligible	**Low**
Regulatory Environmental Risks (RG)									
RG1	Historical/Cultural Significance	Historical/Cultural Significance	No historical or cultural sites expected.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG2	Endangered Species	Bird avoidance and minimization	There is no beach disposal on this project. No endangered species concerns with the new work.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG3	Unexploded Ordinance	Beltway 8 was former army munitions depot facility.	Sweeps did not find any UXO's with 95% confidence.	Unlikely	Marginal	**Low**	Unlikely	Moderate	**Low**
RG4	Sea Level Rise	The implementation of estimating sea level rise in the design life of all ACOE projects could affect the project cost.	This risk could be eliminated during the design phase. This could decrease the project cost due to less required dredging. Less dredging would also decrease the project schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG5	Oyster Mitigation	Oyster mitigation quantity could change.	Oyster mitigation based on updated survey. The Bird island size cannot change and therefore the oyster mitigation acreage not anticipated to change. Additional quantity changes are captured in the technical risks (ADD Risk #). There could be a schedule delay to coordinate with other agencies.	Unlikely	Negligible	**Low**	Possible	Marginal	**Low**
RG6	Air Quality	Construction could be delayed to minimize air quality impacts.	Do not foresee having any issue with EPA. Could require Tier 2 equipment and lower fuel efficiency but it is possible.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**

RG7	Contaminated Dredge Material	Contamination could lead to changing disposal location.	Segment 5 and 6 has the potential for contaminated material. Sediment testing has been done and no contamination was present in levels of significant concern. Current sediment sampling indicates this is a very low risk but if it occurred it could be a moderate cost. The design may require drainage of dredge effluent with onsite management. This would reduce the dredge production requiring the dredge to reduce time for 14 hours/day to 12 hours/day. The PDT feels this a possible risk for the project but has moderate cost risks.	Possible	Significant	**Medium**	Possible	Marginal	**Low**
RG8	Agency Reviews	Agency reviews could lead to delays.	There has been ongoing coordination with beneficial use group (BUG) and there are no delays anticipated. Sediment sampling and section 103 has been coordinated with the EPA.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
Construction Risks (CO)									
CO1	Modifications & Claims	Construction contract modifications can impact construction cost and schedule growth.	Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc. Will impact costs, but little overall impact to larger project timeline.	Possible	Moderate	**Medium**	Unlikely	Marginal	**Low**
CO2	Labor Availability/Pricing	Gulf Labor rates are relatively low and estimate labor rate are conservative.	Gulf region labor rates are fairly low when compared to national rates. Busy economy may require paying extra for skilled labor. Estimate labor (Union Rates) conservative and typically higher than actual costs.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CO3	Navigation Traffic Conflicts	Traffic within the shipping channel could delay or halt construction.	Submerged pipeline required to mitigate navigation traffic interference. Estimate assumes decreased productivity to account for navigation channel traffic. 14 hours/day in Bayou and 16 hrs/day in the bay assumed in estimate. EWT accounted for in CEDEP estimate and is based on historical productivity. Additional cost and schedule risks are minimal.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

CO4	New Dredging	New work dredging could be lower productivity than estimated.	New work dredging estimates based on historical boring information and production estimate reflect the new work materials seen per segment.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO5	Material Availability	Rock material pricing is a concern.	Imported rock is assumed to be imported from Missouri. Rock and rip rap is readily available and conservatively priced based on common practice for the area.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
CO6	Sheetpile Wall Construction	Specialized Equipment may not be available	Giken "press in" method may be required for pile installation and require specialized equipment that may not be available (segment 2 only). This could add to the cost for the segment 2 pile installation.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO7	Inefficient Contractor	Inefficient contractor may delay the project and affect the quantities.	Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
CO8	Bird Island Marsh Construction	Low retainage may require additional material in order to construct Bird Island Marsh as designed.	The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.	Likely	Moderate	**Medium**	Possible	Moderate	**Medium**
Estimate and Schedule Risks (ES)									

ES1	Dredging Productivity	The types and classifications of materials for the purposes of estimating could present a risk to the project costs and schedule. Since future dredging in new work areas, there is some uncertainty about the types of material that will be encountered.	Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity.	Possible	Moderate	**Medium**	Unlikely	Moderate	**Low**
ES2	Dredge Mob/Demob	Actual Mob/Demob cost could vary	Mob/demob costs are based on average actual pricing. Actual mob costs could vary based on actual dredge plant location.	Possible	Marginal	**Low**	Unlikely	Moderate	**Low**
ES3	Relocation Pricing	Relocation costs may change.	Relocation costs based on historical costs. Actual costs may vary from escalated price included in estimate. Relocations based on land based equipment. Relocations need to be completed prior to work and could delay the contract. Relocation pricing modeled in LD2.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES4	Equip rates	The equipment rates are outdated	Equipment pricing is outdated in the properties but the rates were manually updated based on current data.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES5	Schedule Detail	Construction Schedule could change.	Estimate and schedule assume 12 separate contracts. Total dredging time, based on quantities, is 40 months. Schedule based on fiscal years but total schedule is unlikely to extend more than 3-6 months.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
ES6	Sheetpile Pricing	Sheetpile Pricing Parametric and may change.	Sheetpile pricing is parametric and could vary from the actual pricing. There is updated material pricing but the labor and equipment is likely to change. The labor and equipment risk is modeled in TR11.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**

External Risks (EX)

EX1	Adverse Weather	Location is subject to hurricanes.	Storms/hurricanes in other regions could limit number of dredges available close to project site during performance period, increasing distance to mobilize. This would be paid by another contract but could cause a schedule delay. A local storm could bring additional dredging quantities. Storms could damage existing placement area work.	Possible	Marginal	**Low**	Likely	Negligible	**Low**
EX2	Fuel	Fuel is a volatile cost and can greatly affect the cost of this project.	Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal or a decrease of $0.50/gal based price fluctuation in the past years.	Possible	Moderate	**Medium**	Unlikely	Negligible	**Low**
EX3	Dredge Availability	The availability and number of quality dredges for this particular project is a potential concern.	There is concern in needing more dredges to complete dredging in a required timeframe. Dredges must be spaced a minimum distance, as per USCG (5 nautical miles). PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem.	Unlikely	Moderate	**Low**	Possible	Marginal	**Low**
EX4	Inflation	Inflation could exceed CWCCIS	Project is for 2023-2027 (2028 for LPP) and inflation could exceed CWCCIS tables. Since this is dredging the risks for fuel and labor have already been accounted and therefore this risk is not modeled.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
EX5	Upland Mitigation	Upland Mitigation	Bank credits are being used and if the project is delayed the credits could change (37 ac assumed). Bank credit cost could change. The bank credit costs covered in the estimate is conservative and therefore the cost risk has not been modeled.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**

EX6	Ship Accident/Oil Spill	Possible accident or oil spill in the channel.	A ship accident or oil spill within the channel could lead to standby costs and schedule delays.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

ATTACHMENT 2

HSC PIPELINE RELOCATION EVALUATION

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
1a. Bollivar Roads to Redfish	135+000	A.1	Cameron Highway Oil Pipeline	24	-80	-46	34	Yes	
1a. Bollivar Roads to Redfish	122+000	B.1	Williams Pipeline (Black Marlin)	16	-75.26	-46	29.26	Yes	
1a. Bollivar Roads to Redfish	117+000	C.1	Denbury (Kinder Morgan)	18	-82	-46	36	Yes	
1b. Redfish to Bayport	90+000	D.1	Florida Gas	24	-78	-46	32	Yes	
1b. Redfish to Bayport	71+500	E.1	Layton Products	10.75	-74.42	-46	28.42	Yes	
1c. Bayport to Barbours Cut	21+000	F.1	Davis Petroleum (abandoned in place)	10	-66	-46	20	No	$4,392,500
Total:									**$ 4,392,500.00**

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
2. Bayport Channel	N/A[6]	N/A	Davis Petroleum (abandoned in place)	10	-5	N/A	N/A	N/A	
Total:									**$ -**

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
3. Barbours Cut Channel	N/A[7]	N/A	HSC 24" NGL Pipeline	24	-100.66	-46.5	54.16	Yes	
Total:									**$ -**

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
4. Boggy Bayou to Greens	687+75.06	1.1	Enterprise Houston Ship Channel, L.P.	16	-130	-46	84	Yes	
4. Boggy Bayou to Greens	687+75.06	1.1	Enterprise Houston Ship Channel, L.P.	12	-130	-46	84	Yes	
4. Boggy Bayou to Greens	687+75.06	1.1	Enterprise Houston Ship Channel, L.P.	Fiber	-130	-46	84	Yes	
4. Boggy Bayou to Greens	687+75	1.2.11.2.2	HFOTCO LLC	24	-125	-46	79	Yes	
4. Boggy Bayou to Greens	690+01.85	1.3.1	Shell Oil Company	16	-105	-46	59	Yes	
4. Boggy Bayou to Greens	687+75	1.4.11.4.2	Enterprise Houston Ship Channel, L.P.	30	-195	-46	149	Yes	
4. Boggy Bayou to Greens	705+81	2.1	Kinder Morgan Texas Pipeline LP	2-12	-50	-46	4	No	$2,384,500
4. Boggy Bayou to Greens	705+81	2.2	Howell	6	-60	-46	14	No	$1,380,500
4. Boggy Bayou to Greens	705+81	2.2	Natural Gas Pipeline Company	6	-60	-46	14	No	
4. Boggy Bayou to Greens	705+81	2.3	Olin Corporation	3-10	-50	-46	4	No	$2,196,250
4. Boggy Bayou to Greens	705+81	2.3	Olin Corporation	10	-50	-46	4	No	$2,196,250
4. Boggy Bayou to Greens	705+81	2.3	Olin Corporation	10	-50	-46	4	No	$2,196,250
4. Boggy Bayou to Greens	705+81	2.4.1 2.4.2	HSC Pipeline Partnership, LLC	12	-82	-46	36	Yes	
4. Boggy Bayou to Greens	705+81	2.5.1	Enterprise Houston Ship	24	-100.5	-46	54.5	Yes	
4. Boggy Bayou to Greens	705+81	2.6.1 2.6.2 2.6.3	HSC Pipeline Partnership, LLC	8	-80	-46	34	Yes	
4. Boggy Bayou to Greens	722+00	3.1	Air Products LLC	6	-72 [1]	-46	26	Yes	
4. Boggy Bayou to Greens	722+00	3.1	Air Products LLC	6	-72 [1]	-46	26	Yes	
4. Boggy Bayou to Greens	722+00	3.2	Kinder Morgan Crude and Condensate LLC	24	-108.9	-46	62.9	Yes	
4. Boggy Bayou to Greens	779+98	4.1	HSC Pipeline Partnership, LLC	8	-60 [2]	-46	14	No	$1,601,380

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
4. Boggy Bayou to Greens	779+98	4.2	INEOS Pipeline Investment Company	16	-75	-46	29	Yes	
4. Boggy Bayou to Greens	779+35	4.3	Colonial Pipeline Company	40	-72 [1]	-46	26	Yes	
4. Boggy Bayou to Greens		4.4	HFOTCO LLC	24	-120	-46	74	Yes	
4. Boggy Bayou to Greens	779+98	4.7	Seminole Pipeline Company LLC (Colonial)	20	-55	-46	9	No	$2,208,800
4. Boggy Bayou to Greens	777+34.63	4.5	Southtex 66 Pipeline Company Ltd	8	-90	-46	44	Yes	
4. Boggy Bayou to Greens	778+83	4.6	Explorer Pipeline Company	28	-60	-46	14	No	$3,915,600
4. Boggy Bayou to Greens	779+98	4.7	Colonial Pipeline Company	36	-55	-46	9	No	$5,490,625
4. Greens to Sims Deepening	940+00	5.1	Targa	6	-72	-46	26	Yes	
4. Greens to Sims Deepening	940+00	5.2	Chevron Phillips Chemical LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	940+00	5.2	Chevron Phillips Chemical LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	940+00	5.2	Targa Downstream LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	940+00	5.2	Targa Downstream LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	940+00	5.2	Targa Downstream LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	940+00	5.2	Targa Downstream LP	8	-75	-46	29	Yes	
4. Greens to Sims Deepening	922+70	5.3	Magellan Terminal Holdings, L.P.	36	-72.31 [3]	-46	26.31	Yes	
4. Greens to Sims Deepening	922+70	5.3	Magellan Terminal Holdings, L.P.	36	-72.31 [3]	-46	26.31	Yes	
4. Greens to Sims Deepening	922+70	5.3	Magellan Terminal Holdings, L.P.	14	-72.11 [3]	-46	26.11	Yes	
4. Greens to Sims Deepening	922+70	5.3	Magellan Terminal Holdings, L.P.	14	-72.11 [3]	-46	26.11	Yes	

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
4. Greens to Sims Deepening	922+70	5.3	Magellan Terminal Holdings, L.P.	4	-72.11 [3]	-46	26.11	Yes	
4. Greens to Sims Deepening	892+58.8	5.4	Praxair Inc.	12	-55	-46	9	No	$1,807,200
4. Greens to Sims Deepening	892+58.8	5.4	Praxair Inc.	12	-55	-46	9	No	$1,807,200
4. Greens to Sims Deepening	953+93	6.1	Kinder Morgan Liquids Terminal LLC	16	-60 [4]	-41	19	Yes	
4. Greens to Sims Deepening	954+33.51	6.2	Explorer Pipeline Company	10	-90 [4]	-41	49	Yes	
4. Greens to Sims Deepening	954+74.7	6.3	KM Liquids Terminals LLC	20	-68 [4]	-41	27	Yes	
4. Greens to Sims Deepening	954+74.7	6.3	KM Liquids Terminals LLC	6	-68 [4]	-41	27	Yes	
4. Greens to Sims Deepening	956+52.33	6.4	Phillips 66 Carrier LLC	20	-93 [4]	-41	52	Yes	
4. Greens to Sims Deepening	957+25.5	6.5	KM Liquids Terminals LLC	16	-100 [4]	-41	59	Yes	
4. Greens to Sims Deepening	957+25.5	6.5	KM Liquids Terminals LLC	16	-100 [4]	-41	59	Yes	
4. Greens to Sims Deepening	958+92.8	6.6	Kinder Morgan Liquids Terminal LLC	20	-130 [4]	-41	89	Yes	
4. Greens to Sims Deepening	958+92.8	6.6	Kinder Morgan Liquids Terminal LLC	20	-130 [4]	-41	89	Yes	
4. Greens to Sims Deepening	958+92.8	6.7	KM Liquids Terminals LLC	16	-80 [4]	-41	39	Yes	
4. Greens to Sims Deepening	958+92.8	6.7	Valero Refining-Texas, L.P.	16	-80 [4]	-41	39	Yes	

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
4. Greens to Sims Deepening	979+22.6	7.1	Enterprise Houston Ship Channel, L.P.	24	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	980+00	---	Precint 2 Washburn Tunnel	---	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1020+00	7.2	City of Houston	60	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1020+00	7.2	City of Houston	60	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1020+00	7.2	City of Houston	60	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1018+39	7.3	Shell Pipeline Company LP	12	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1018+39	7.3	Shell Pipeline Company LP	12	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.3	Magellan Pipeline Company LP	24	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.5	Enterprise TE Products Pipeline Company LLC	18	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.6	BridgeTex Pipeline Company LLC	24	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.7	KM Liquids Terminals LLC	20	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.7	KM Liquids Terminals LLC	20	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1089+00	7.7	KM Liquids Terminals LLC	3	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Williams Tunnel with multiple pipelines	96	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.2.3	Enterprise Texas Pipeline LLC	12	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.2.1	KM Liquids Terminals LLC	16	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.2.2	Cowboy Pipeline Service Company	10	No Changes to the Federal Channel Proposed				

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
4. Greens to Sims Deepening	1043+00	8.5	DL Propylene LLC	4	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.4	Enterprise Texas Pipeline LLC	12	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.6	Seaway Crude Pipeline Company LLC	30	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.7	Magellan Pipeline Company, LP	8	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Kinder Morgan Liquid Terminals	3	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Kinder Morgan Liquid Terminals	24	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Kinder Morgan Liquid Terminals	24	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	4	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	6	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	8	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Equistar Chemicals, LP	16	No Changes to the Federal Channel Proposed				
4. Greens to Sims Deepening	1043+00	8.1	Magellan Pipeline Holdings, LP	20	No Changes to the Federal Channel Proposed				
Total:									**$ 27,184,555.00**

Study Segment Description	HSC Station (approx)	Study Index	Pipeline Descriptor	Size (in)	Minimum Depth[1]	Prop Channel Depth (MLLW)	Minimum Cover (feet)	Sufficient Cover?	Relocation Cost
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
5. Sims to Turning Basin	1099+50	9.01	Valero Refining-Texas, L.P.		No Changes to the Federal Channel Proposed				
Total:									$ -

[1] Minimum depth, unless otherwise indicated is in MLT per record drawing. Depth of pipeline is established at a horizontal offset of 50-feet from the new toe of slope when widening the channel (Basis of evaluation: Regional General Permit SWG-1998-02413 (Installation of Pipelines by Directional Drilling).

[2] Recommend additional investigation. At this time, assumed widening of channel. Final design may be depening only, with sufficient depth (90-feet).

[3] Elevation with least cover at the edge of usuable channel and potential Turning Basin extension. As of 7 Feb 2019, Turning Basin not in NED.

[4] No proposed deepening. Minimal deepening may be rquired to minimize hydraulic impacts in the channel. No impact to pipelines.

[5] No proposed deepening. Minimal deepening may be rquired to minimize hydraulic impacts in the channel. No impact to pipelines.

[6] Pipeline runs parallel to BSC in defined 50-foot easement. Top of bank of BSC does not encroach easement, but is less than 50-feet horizontal of pipeline (abandoned in place)

[7] Pipeline runs parallel to BCSC and crosses BCSC in Turning Basin. No planned work in Turning Basin.

ATTACHMENT 3

CLIMATE CHANGE AND SEA-LEVEL RISE EFFECTS FOR THE HSC ECIP FEASIBILITY STUDY

October 2019

3.1 Climate Change in Coastal Texas

The specific aspect of climate change that is sea level is a complex subject addressed separately in the H&H Attachment (Relative Sea Level Rise) to the H&H Engineering Appendix. This section discusses other future climate changes (mainly precipitation) based on current scientific evidence and studies. Climate change is expected to pose several challenges along the Texas coast. It is expected to vary greatly along the extensive Texas coast from the Mexican border to the Louisiana border. These challenges will unfold against a backdrop that includes a growing urban population, incentives for energy production, and advances in technology.

For the current study area, the primary climatic forces with potential to affect the project are changes in temperature, sea and inland water levels, precipitation, storminess, ocean acidity, and ocean circulation. Air temperatures in the Houston-Galveston mean statistical area, on average, increased about 1 degree Centigrade over the past 20 years, a pattern that is expected to continue. Sea surface temperatures have risen and are expected to rise at a faster rate over the next few decades. Global average sea level is rising and has been doing so for more than 100 years. Greater rates of sea-level rise are expected in the future (Parris 2012). Higher sea levels cause more coastal erosion, changes in sediment transport and tidal flows, more frequent flooding from higher storm surges, and saltwater intrusion into aquifers and estuaries.

Patterns of precipitation change are affecting coastal areas in complex ways. The Texas coast saw a 10 to 15 percent increase in annual precipitation between 1991 and 2012 compared to the 1901-1960 average, Figure 1. Texas coastal areas are predicted to experience heavier runoff from inland areas, with the already observed trend toward more intense rainfall events continuing to increase the risk of extreme runoff, flooding, and possibly creating safety issues.

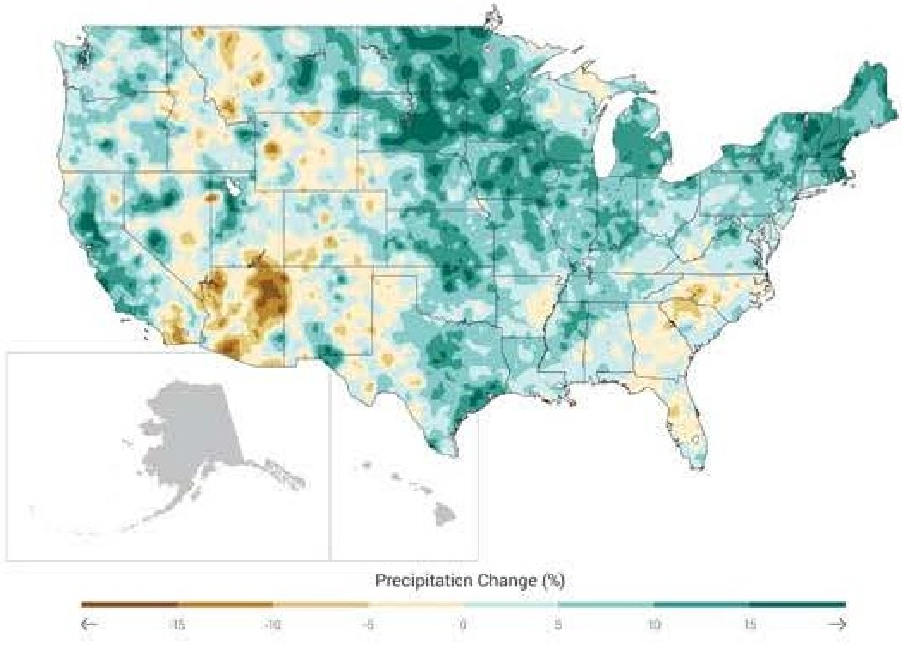


Figure 1: Percent Change in Annual Precipitation for 1991-2012 Compared to 1901-1960 (adapted from Peterson et al. 2013)

Texas' Gulf Coast historically averages three tropical storms or hurricanes every four years (annual probability of 75%), generating coastal storm surges and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. The estimated rise in sea level will result in an effective increase in storm surge along the Texas Gulf coast and miles inland. Tropical storms have increased in intensity in the last few decades. Future projections suggest increases in hurricane rainfall and intensity (with a greater number of the strongest - Category 4 and 5 - hurricanes) (Melillo 2014).

As the concentration of carbon dioxide in the atmosphere increases, the oceans will continue to absorb CO_2, resulting in increased ocean acidification. This threatens coral reefs and shellfish (Hoegh-Guldberg 2007). Coastal fisheries are also affected by rising water temperatures and climate-related changes in oceanic circulation. Wetlands and other coastal habitats are threatened by sea-level change, especially in areas of limited sediment supply or where barriers prevent onshore migration. The combined effects of saltwater intrusion, reduced precipitation, and increased evapotranspiration will elevate soil salinities and lead to an increase in salt-tolerant vegetation (Craft 2009). For additional information, reference the Environmental section of the FIFR-EIS. None of these changes operate in isolation. The combined effects of climate changes with other human-induced stresses make predicting the effects of climate change on coastal systems challenging. However, it is certain that these factors will create increasing hazards to the Texas coast. Heavily industrialized cities and ports containing critical infrastructure along the Texas coast, including Freeport, Port Arthur, Galveston, Corpus Christi, Matagorda, Brazos Island Harbor, Houston, Port Orange, and additional areas will be adversely affected by climate change.

The projected change in sea level will result in the potential for greater damage from storm surge along the Texas coast. About a third of the GDP for the state of Texas is generated in coastal counties. Coastal areas in Alabama, Mississippi, Louisiana, and Texas already face losses that annually average $14 billion from hurricane winds, land subsidence, and sea-level change. According to a recent study, projected sea-level change increases average annual losses from hurricanes and other coastal storms (Building 2010).

Diminishing water supplies and rapid population growth are critical issues in Texas. Along the coast, climate change-related saltwater intrusion into aquifers and estuaries poses a serious risk to local populations. In 2011, many locations in Texas experienced more than 100 days over 100°F, as the state set high temperature records. Rates of water loss were double the long-term average, depleting water resources. This contributed to more than $10 billion in direct losses to agriculture alone (Melillo 2014). Typically, many of the water shortages occur in the drier west parts of Texas.

The agricultural economy along the Texas coast, including livestock, rice, cotton, and citrus cultivation, is threatened by the combination of salt or brackish water from sea-level change and reduced freshwater levels from changes in temperature and precipitation. Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human interventions creating additional stresses. Climate change will result in further reduction or loss of functions these ecosystems provide.

Successful adaptation of human and natural systems to climate change will require commitment to addressing these challenges. Regional-scale planning and local-to-regional implementation will prove beneficial. Finding a way to mainstream climate planning into existing processes will save time and money. It is important that information be continually shared among decision-makers to facilitate the alignment of goals.

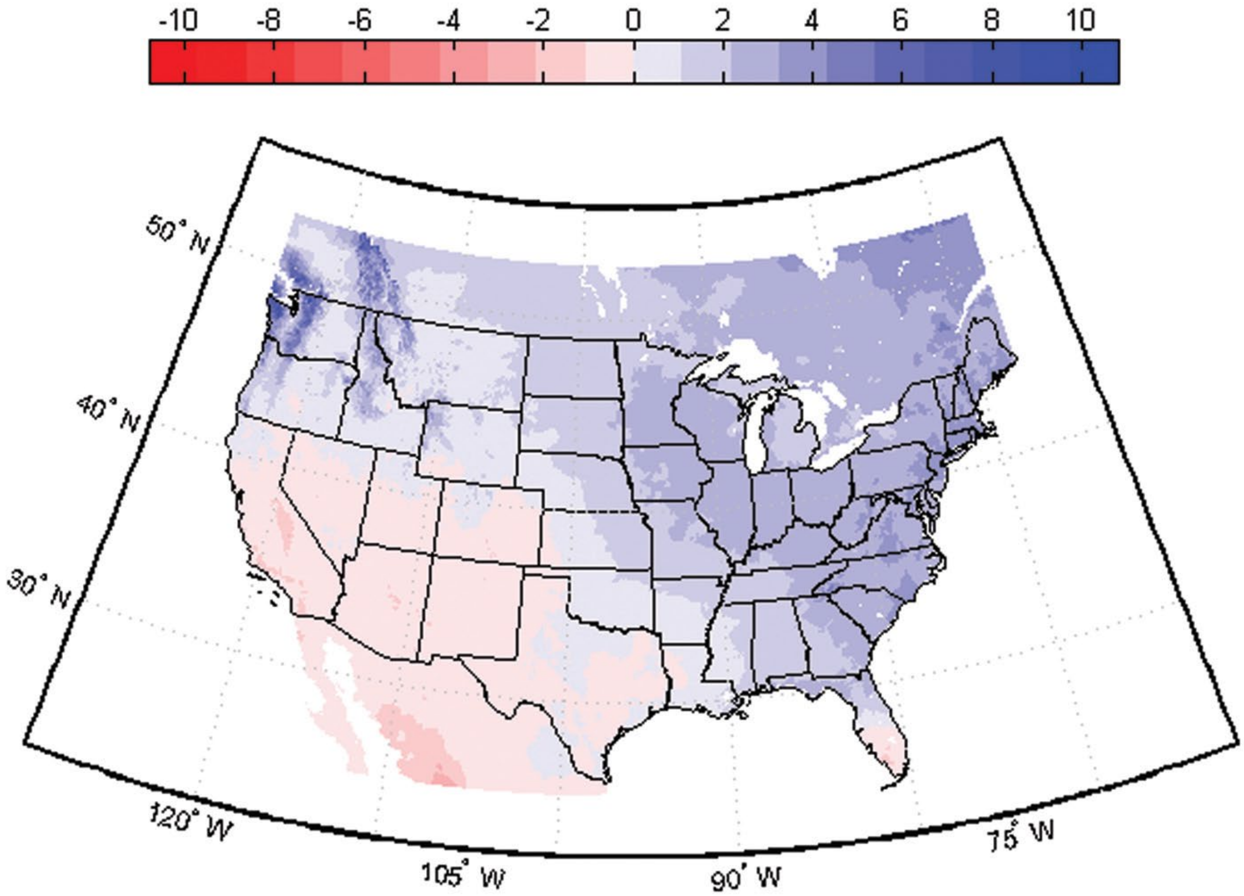


Figure 2: Change in 30-year mean annual precipitation, measured in centimeters per year (cm/year). The median difference between 1971–2000 and 2041–2070 is based on 112 projections obtained from "Statistically Downscaled WCRP CMIP3 Climate Projections" (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections).

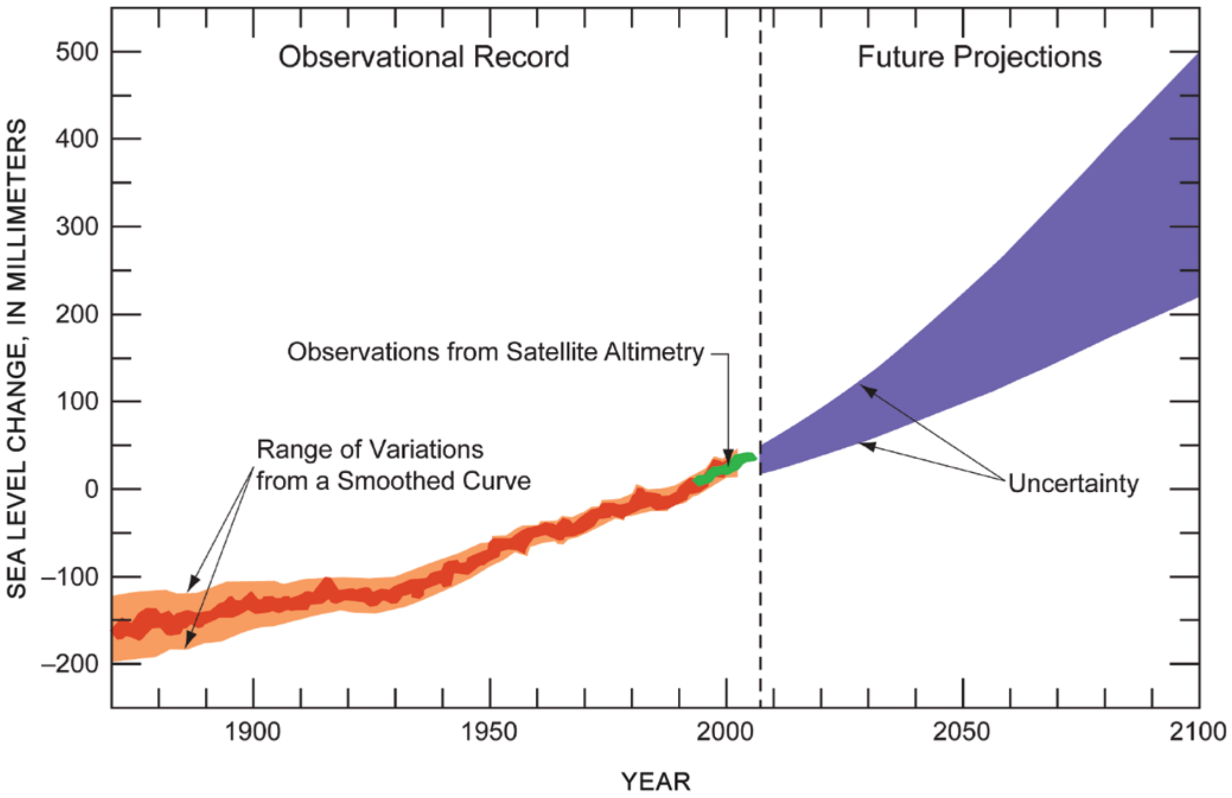


Figure 3: Global mean sea level (GMSL) observed since 1870 and projected for the future (deviation from the 1980–1999 mean). [For illustrative purposes only, from U.S. Army Corps of Engineers (2008); Intergovernmental Panel on Climate Change (2007, FAQ 5.1, fig. 1).]

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3.2 Sea Level Rise

Report on Sea-Level Rise Effects on the Houston Ship Channel's Deepening and Widening Project

General guidance by Galveston District's Hydrology and Hydraulics Branch

ABSTRACT

This report summarizes guidance for incorporating sea-level rise (SLR) into a navigation project. Specific SLR projections have been included for Houston Ship Channel.

"Present Condition" sea levels for the Bay relative to Local Mean Sea Level (LMSL) are 0.44 ft in 2013 (the end year for USACE sea-level analysis), 0.52 ft in 2017 (the year of economic modeling for this project), and 0.65 ft in 2023 (the anticipated project construction year). (Levels are relative to 1992 Zero.)

Projected sea-level rise has been computed for project durations of 25-year, 50-year, and 100-year timeframes. As a conservative approach, USACE's Low Sea-Level Curve should be used for this navigation project (since it provides deeper water and less dredging than other curves).

When considering channel depths (for dredging computations), both sea-level rise and subsidence are relevant. (Subsidence is more than twice the sea-level rise rate.) Under this scenario the 50-year design life channel depth will increase an additional 1.70 feet above the 2023 level. The 100-year planning life channel depth will rise 2.75 feet above the 2023 level.

Conversely, SLC effects on the non-federal sponsor's infrastructure will largely be detrimental. They should carefully consider which sea-level to plan for, and more importantly, what their adaptation measures should be (Table 11).

Some deleterious effects due to sea-level rise may also occur within the federal project, such as:

Increased erosion at islands
Increased ship wakes in barge lanes and mooring areas
Increased wind waves, especially in shallow areas (but not in the main channel)
Changes in water chemistry (salinity, dissolved oxygen)

For the first three items in the list above, some simple spreadsheet calculations can be performed to indicate a level-of-concern. For all four categories, the numerical model and ship simulation runs should help quantify the effects. One decision the team will have to make is which scenarios are to be run in the model and in the simulations. There are not likely to be sufficient funds to run all possible combinations of: Low, Intermediate, and High SLR; their effects on multiple ship sizes; and runs both with and without project.

The primary federal structures for HSC are the entrance jetties. Therefore in the numerical model runs and in the with-project ship simulations, it will be important to study the effects of "with sea-level rise" on the jettied entrance.

1.0 Summary of Official Guidance on Sea-Level Change

General guidance for "Incorporating Sea-Level Change in Civil Works Programs" is given in the 3-pages plus appendices of ER 1100-2-8162. General concepts and analyses are expected to be applied to "every coastal activity as far inland as the extent of estimated tidal influence", which describes the Houston Ship Channel.

Relevant characteristics of the analyses may be summarized as:

- Consider SLR effects on the designs over the project life cycle (SLR analysis performed for both 50 years and 100 years from project construction completion year).
- Evaluate effects on the project for the three USACE sea-level curves: Low, Intermediate, and High. A sea-level calculator is at http://www.corpsclimate.us/ccaceslcurves.cfm
- Analyze effects for "With Project" and "Without Project".
- Evaluate how sensitive the alternatives and the selected design are to the different SLRs.
- List and describe the Risks due to SLR, estimate uncertainties, and plan measures to adapt to the rise: "decisions allowing for adaption based on evidence as the future unfolds."
- Sea level curve "selection should be tailored to each situation." However, guidance for navigation projects is to generally use the Low SLC, since it is the conservative choice (results in the least improvement to channel depth). (ref: Climate-Change CoP Subject

Matter Expert, Patrick O'Brien, briefing to SWG H&H Branch on 10/21/2016)

2.0 Relative Sea-Level Change

This report uses current USACE guidance to assess relative sea-level change (RSLC). Current USACE guidance (ER 1100-2-8162, December 2013, and ETL 1100-2-1, June 2014) specify the procedures for incorporating climate change and RSLC into planning studies and engineering design projects. Projects must consider alternatives that are formulated and evaluated for the entire range of possible future rates of RSLC for both existing and proposed projects. USACE guidance specifies evaluating alternatives using "low," "intermediate," and "high" rates of future sea level change.

- Low - Use the historic rate of local mean sea-level change as the "low" rate. The guidance further states that historic rates of sea-level change are best determined by local tide records (preferably with at least a 40-year data record).

- Intermediate - Estimate the "intermediate" rate of local mean sea-level change using the modified NRC Curve I. It is corrected for the local rate of vertical land movement.

- High - Estimate the "high" rate of local mean sea-level change using the modified NRC Curve III. It is corrected for the local rate of vertical land movement.

USACE (ETL 1100-2-1, 2014) recommends an expansive approach to considering and incorporating RSLC into civil works projects. It is important to understand the difference between the period of analysis (POA) and planning horizon. Initially, USACE projects are justified over a period of analysis, typically 50 years. However, USACE projects can remain in service much longer than the POA. The climate for which the project was designed can change over the full lifetime of a project to the extent that stability, maintenance, and operations may be impacted, possibly with serious consequences, but also potentially with beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic period of analysis) should be 100 years, consistent with ER 1110-2-8159. Current guidance considers both short- and long-term planning horizons and helps to better quantify RSLC. RSLC must be included in plan formulation and the economic analysis, along with USACE expectations of climate change and RSLC, and their impacts. Some key expectations include:

- At minimum 25-, 50-, and 100-year planning horizons should be considered in the analysis. (ETL 1100-2-1, p. C-3)
- A thorough physical understanding of the project area and purpose is required to effectively assess the project's sensitivity to RSLC.

- Identification of thresholds by the project delivery team and tipping points within the impacted project area will inform both the selection of anticipatory/adaptive/reactive options and the timing strategies.

- Rather than attempt to predict climate change, it is more important to "provide a method to address uncertainty, describing a sequence of decisions allowing for adaptation based on evidence as the future unfolds." (ER 1100-2-8162)

3.0 Historic RSLC for Galveston Bay

Historic rates are taken from the Center for Operational Oceanographic Products and Services (CO-OPS) at NOAA, which has been measuring sea level for over 150 years. Guidance is that changes in MSL should be computed using gages with a minimum 40-year span of observations. The Bay-side gage relied on for this project is the Pier 21 tide gage with 106 years of recording. These measurements have been averaged by month to eliminate the effect of higher frequency phenomena such as storm surge, in order to compute an accurate linear sea-level trend.

The MSL trends presented are local relative trends as opposed to the global (eustatic) sea-level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long-term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea-level rate and the local vertical land motion, also known as RSLC.

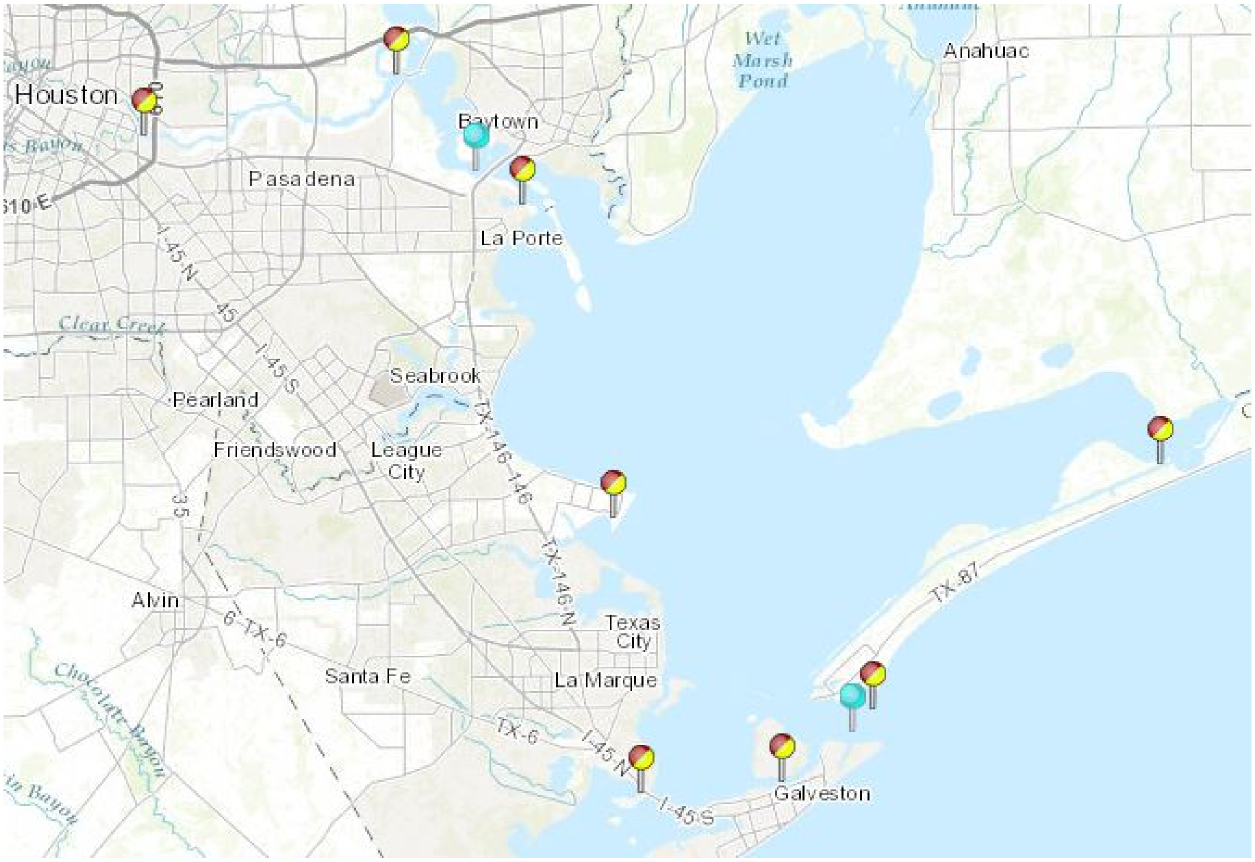
Galveston Bay has the following active gages. All but the two current-meter stations have both water-level and meteorological data. Three of the gages are well away from the navigation channel:

- Rollover Pass (the easternmost gage)
- Galveston Railroad Bridge (TCOON's gage at Tiki Island), shown at bottom left

The remaining 8 gages, starting at the jetties and working up the Channel,

- Galveston Bay Entrance, North Jetty
- Galveston Bay Entrance Channel LB 11 (currents only)
- Galveston Pier 21 (the ONLY gage with sea-level computations)
- Eagle Point
- Morgan's Point
- Fred Hartman Bridge, HSC (currents only)
- Lynchburg Landing (TCOON)
- Manchester (TCOON)

These 10 gages are shown on the following map, with the two current-meter gages shown in light blue and the water-level/meteorological gages in red-and-yellow circles.



Map 1: Active gages in Galveston Bay from https://www.tidesandcurrents.noaa.gov/map/

3.1 Galveston Bay Side (Pier 21)

The longest-running (106 years) tide gage in Galveston Bay is at Pier 21 in Galveston and is still active (unlike the Gulf side gage at Galveston Pleasure Pier). Therefore this gage will be used for all sea-level computations for this HSC Project, since it is the only Bay gage with those computations. The USACE calculation for NOAA gage 8771450's (Galveston Pier 21 computed from 1908 to 2013) has a mean sea-level trend of 6.39 mm/yr with a 95% confidence interval of ± 0.24 mm/yr. (The NOAA site shows 6.37 mm/yr, whereas the Corps site shows 6.39 mm/yr, presumably because the NOAA data are computed through 2015, whereas the Corps data are through 2013.) If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be 4.69 mm/yr (6.39 mm/yr - 1.70 mm/yr), but that subsidence is decelerating at the rate of (6.39mm/yr – 6.37mm/yr)/2yrs = 0.01 mm/yr^2. However, this deceleration is based on only a two-year period of difference in computations and may not be reliable long term. Whether to include decelerating subsidence in final sea levels for the project will be determined in final design phase after more recent sea-level data accumulate.

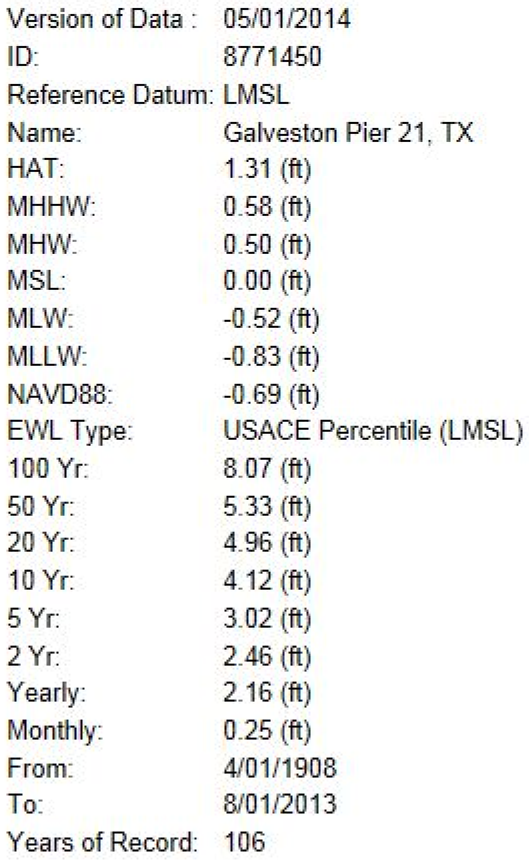
3.2 HSC "Project Present Condition"

Numerical modeling must use the best available data. Unfortunately, these are a combination from datasets and previous model runs in three different years: 2005, 2010, and 2011.

The present conditions for the project, for purposes of modeling (ship simulations) are as follows, from the Pier 21 gage, as computed from the USACE sea-level calculator, all referenced to Local Mean Sea Level (LMSL):

Year	Still Water Elevation (ft MSL)	Event
1992	0.00	NOAA-defined start point (midpoint of tidal epoch)
2013	0.44	Measured data used by calculator ends at 8/01/2013.
2017	0.52	Year of numerical and economics modeling in this Study
2023	0.65	Anticipated project construction
2073	1.70	End of project 50-year "lifetime"
2123	2.75	End of 100-year planning period

The first half of the following table may be used for conversion between datums.
The second half shows Extreme Water Levels (EWLs) in construction year 2023 by return period.



Version of Data :	05/01/2014
ID:	8771450
Reference Datum:	LMSL
Name:	Galveston Pier 21, TX
HAT:	1.31 (ft)
MHHW:	0.58 (ft)
MHW:	0.50 (ft)
MSL:	0.00 (ft)
MLW:	-0.52 (ft)
MLLW:	-0.83 (ft)
NAVD88:	-0.69 (ft)
EWL Type:	USACE Percentile (LMSL)
100 Yr:	8.07 (ft)
50 Yr:	5.33 (ft)
20 Yr:	4.96 (ft)
10 Yr:	4.12 (ft)
5 Yr:	3.02 (ft)
2 Yr:	2.46 (ft)
Yearly:	2.16 (ft)
Monthly:	0.25 (ft)
From:	4/01/1908
To:	8/01/2013
Years of Record:	106

COASTAL GAGES

The following gages on the open coast are listed for comparison purposes. The conclusions are:

- On the open coast sea-level rise is faster than in the Bay (6.84 mm/yr vs. 6.39 mm/yr).
- Sea-level rise at Galveston's coast (6.84 mm/yr) is faster than either southwest at Freeport (4.35 mm/yr) or northeast of Galveston at Sabine (5.66 mm/yr).
- A comparison of USACE sea-level rise rates and NOAA rates, based on the same data set, but over different periods of years, suggests that subsidence is decelerating in Galveston, at a rate of 0.01 mm/yr^2.

3.3 Galveston Gulf Side (Pleasure Pier)

The tide gage with sea level trend information nearest to the Galveston coast region, with over 40 years of record, is at the Galveston Pleasure Pier, which is on the Gulf of Mexico coast side of Galveston Island (NOAA Gage #8771510). The NOAA MSL trend (from the Corps' calculator) at this site (from 1957 to 2008) is equal to 6.84 mm/yr with a 95 percent confidence interval of ± 0.74 mm/yr. If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be 5.14 mm/yr (6.84 mm/yr - 1.70 mm/yr).

3.4 Sabine Pass (Upcoast or NE of Galveston)

USACE calculations from NOAA gage #8770570, near the junction of the Sabine River and the Gulf of Mexico, show a sea-level rise of 5.66 ± 0.79 mm/yr computed over 57 years (1958 to 2014). If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be 3.96 mm/yr (5.66 mm/yr - 1.70 mm/yr).

3.5 Freeport (Downcoast or SW of Galveston)

The tide gage with sea level trend information nearest to the Brazos River system, with over 40 years of record, is located at Freeport, TX Island (NOAA Gage 8772447). The NOAA MSL trend (from the Corps' calculator) at this site (from 1954 to 2014) is equal to 4.35 mm/yr with a 95 percent confidence interval of ± 1.12 mm/yr. If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be 2.65 mm/yr (4.35 mm/yr - 1.70 mm/yr).

4.0 Predicted Future SLR

The Pier 21 tide gage will be used to compute sea level rise for this project, since it is the only one in Galveston Bay with reported sea-level trends, and also has the longest record. In addition to the project design period of 50 years and the project planning period of 100 years, the 25-year period will be calculated, per ETL 1100-2-1, p. C-3.

4.1 Predicted Future Rates of RSLC for 25-Year Period of Analysis

The computed future rates of RSLC in this section give the predicted change between the years 2023 (estimated project start date) and 2048 for Galveston Bay. RSLC values for this 25-year period are summarized in Figure 1. For comparison, both NOAA and ACE curves are shown (for this first example only). The rate that will be used in this navigation project is the ACE and NOAA low curve, which are identical since they use the same historic rate. However, the computed elevations from the two calculators differ slightly, since the periods of analysis differ by two years. All curve plots and data tables in this report use the USACE analysis of the NOAA Pier 21 tide gage.

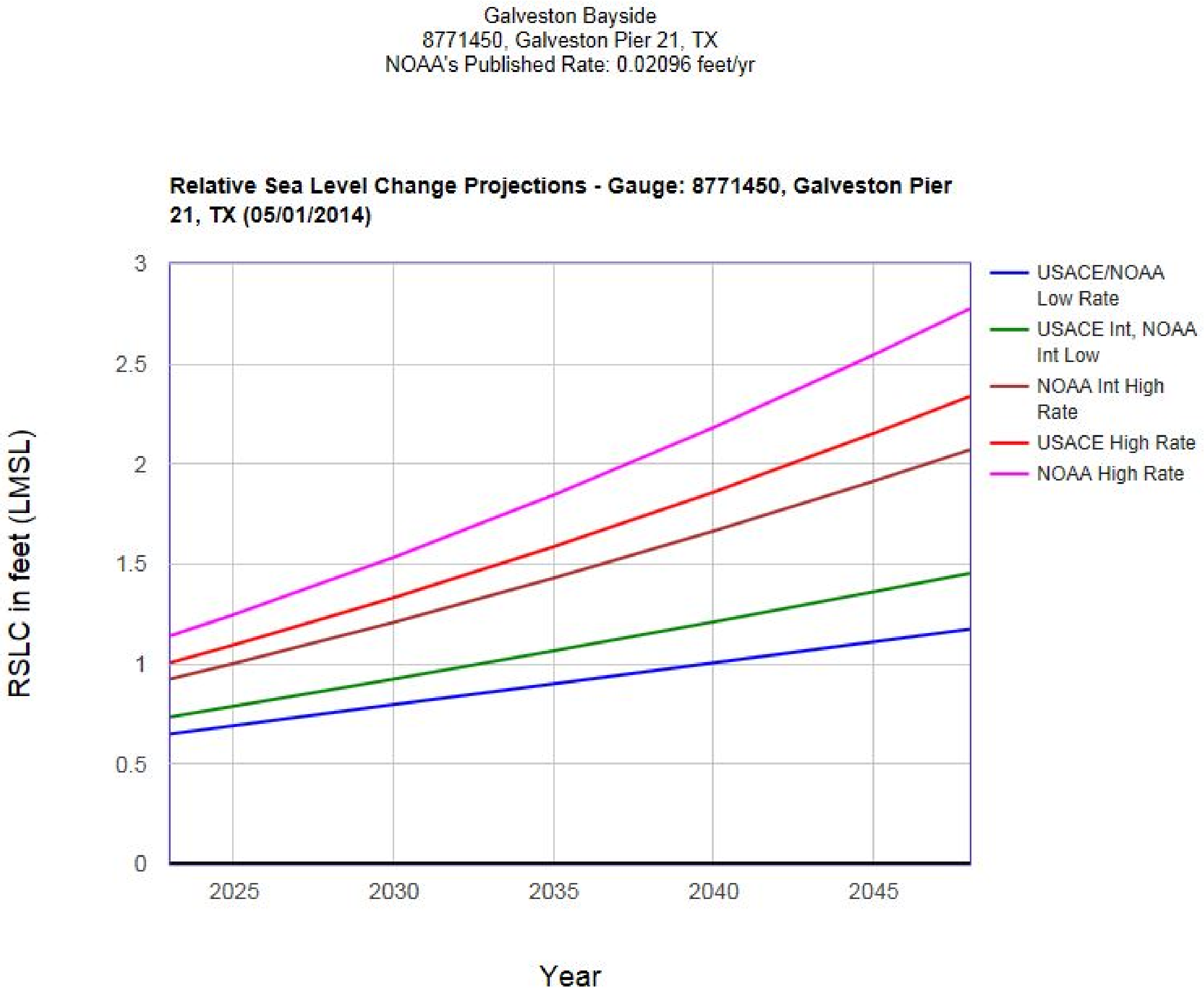
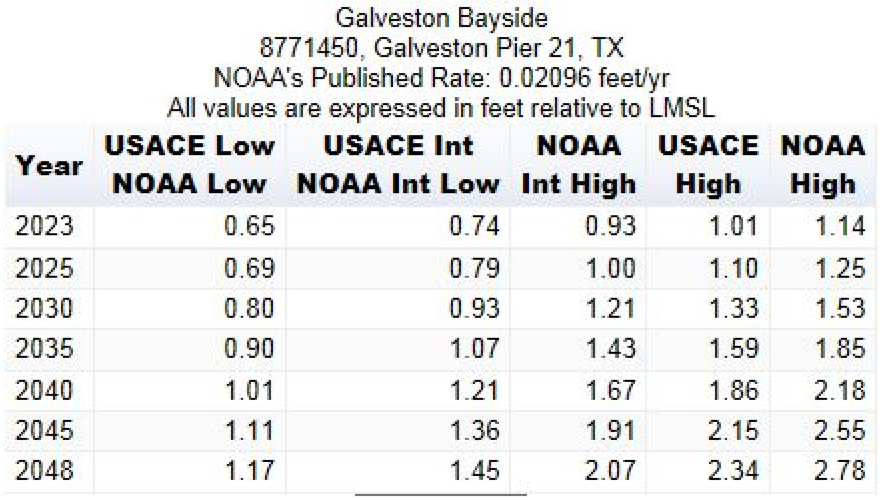


Figure 1: Estimated SLR over the First 25 Years of the Project Life (2023 - 2048) from both NOAA and Corps of Engineers Curves (Levels are relative to 1992 Zero.)

Table 1: Estimated SLR over the First 25 Years of the Project Life (2023 - 2048)
(Levels are relative to 1992 Zero.)



Galveston Bayside
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low NOAA Low	USACE Int NOAA Int Low	NOAA Int High	USACE High	NOAA High
2023	0.65	0.74	0.93	1.01	1.14
2025	0.69	0.79	1.00	1.10	1.25
2030	0.80	0.93	1.21	1.33	1.53
2035	0.90	1.07	1.43	1.59	1.85
2040	1.01	1.21	1.67	1.86	2.18
2045	1.11	1.36	1.91	2.15	2.55
2048	1.17	1.45	2.07	2.34	2.78

For ease of comparison with the 50-year and 100-year periods of analysis, the data from the ACE curves only are plotted here in Figure 2 and listed in Table 2.

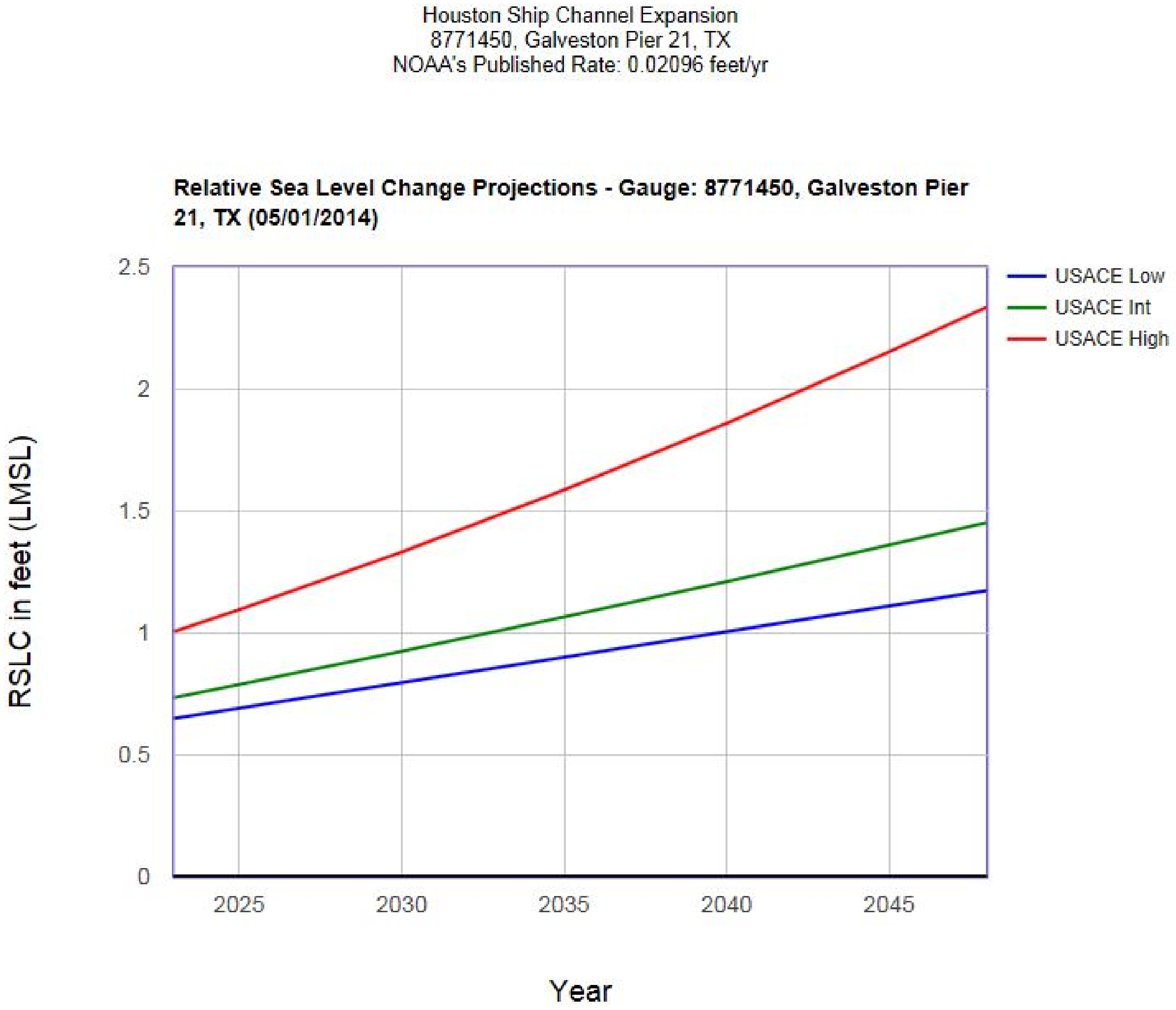
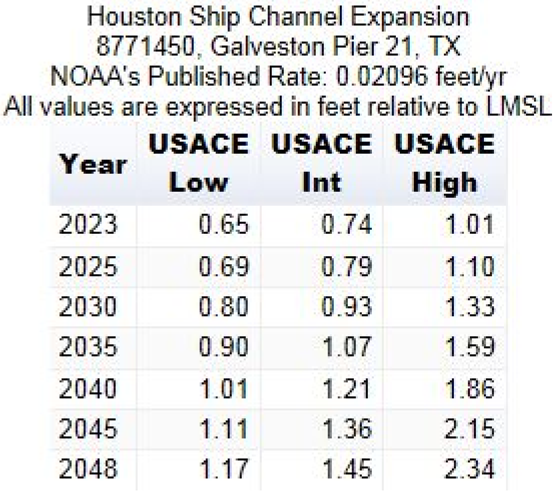


Figure 2: Estimated SLR over the First 25 Years of the Project Life (2023 - 2048) Corps of Engineers Curves Only

Table 2. SLR for the 25-Year Period of Analysis (Levels are relative to 1992 Zero.)



Houston Ship Channel Expansion
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2023	0.65	0.74	1.01
2025	0.69	0.79	1.10
2030	0.80	0.93	1.33
2035	0.90	1.07	1.59
2040	1.01	1.21	1.86
2045	1.11	1.36	2.15
2048	1.17	1.45	2.34

4.2 Predicted Future Rates of RSLC for 50-Year (Project Design) Period of Analysis

The computed future rates of RSLC given here assume a 50-year period of analysis, and give the predicted change between the years 2023 and 2073 for Galveston Bay. Relative sea level change values for the 50-year period are shown in Figure 3 and Table 3.

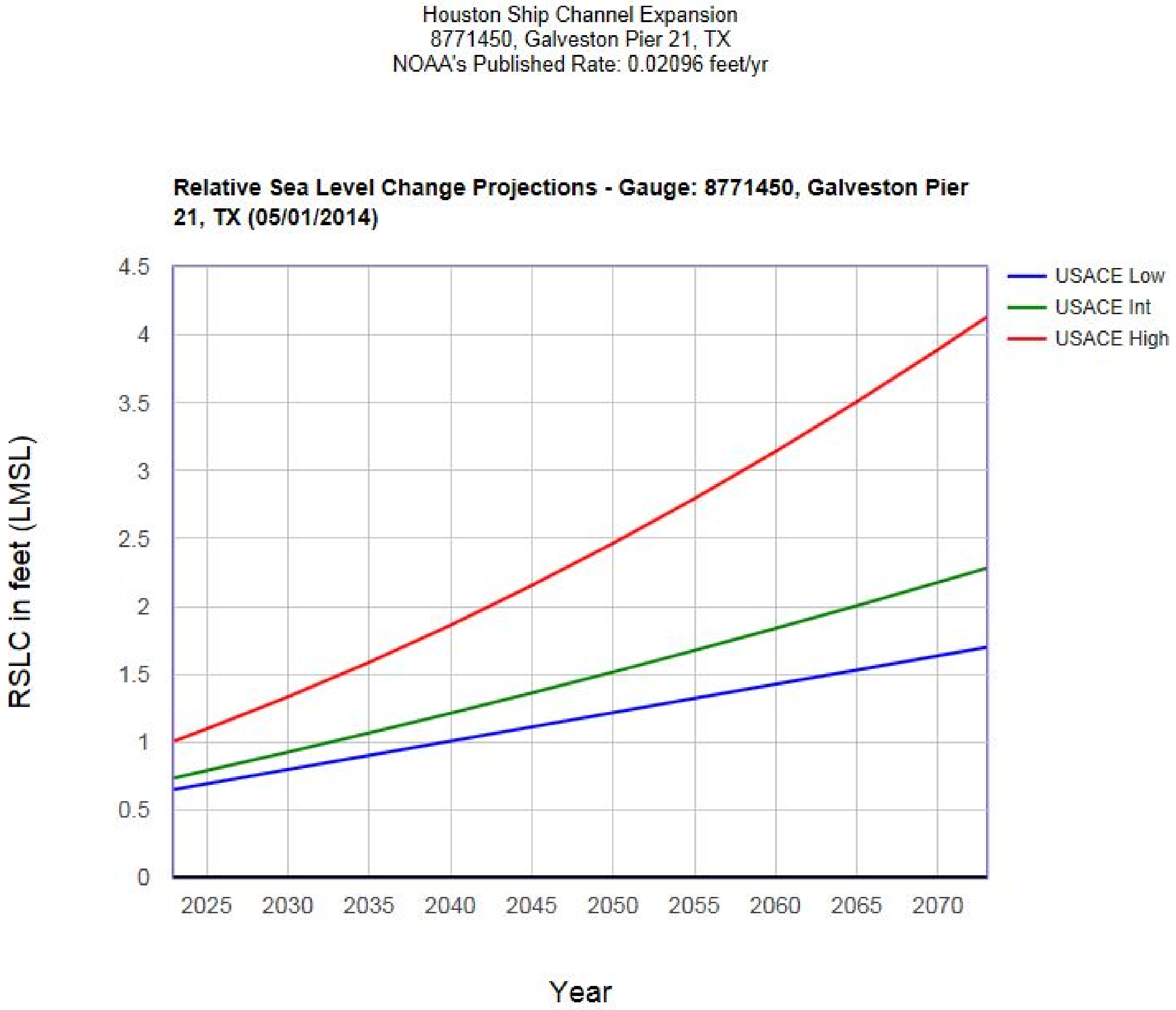
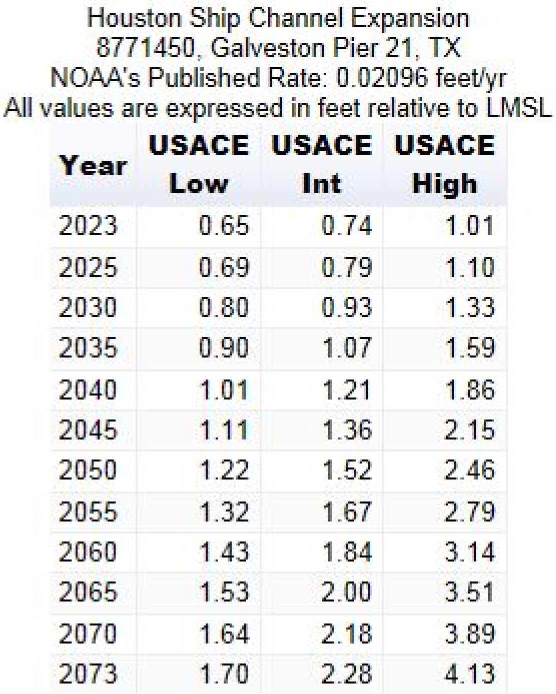


Figure 3: Estimated SLR over the First 50 Years of the Project Life (2023 - 2073) Corps of Engineers Curves Only (Levels are relative to 1992 Zero.)

Table 3. SLR for the 50-Year Period of Analysis
(Levels are relative to 1992 Zero.)



Houston Ship Channel Expansion
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2023	0.65	0.74	1.01
2025	0.69	0.79	1.10
2030	0.80	0.93	1.33
2035	0.90	1.07	1.59
2040	1.01	1.21	1.86
2045	1.11	1.36	2.15
2050	1.22	1.52	2.46
2055	1.32	1.67	2.79
2060	1.43	1.84	3.14
2065	1.53	2.00	3.51
2070	1.64	2.18	3.89
2073	1.70	2.28	4.13

4.3 Predicted Future Rates of RSLC – 100-year Sea-Level Change (Planning Period)

The planning, design, and construction of a large water project can take decades. Though initially justified over a 50-year economic period of analysis, USACE projects often remain in service much longer. The climate for which the project was designed can change over the full lifetime of the project to the extent that stability, maintenance, and operations may be affected. These changes can cause detrimental or beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic period of analysis) should be 100 years, consistent with ETL-1110-2-1.

The period of economic analysis for USACE projects has generally been limited to 50 years because economic forecasts beyond that time frame were not considered reliable. However, the potential impacts of SLC over a 100-year period can be used in the formulation of alternatives and for robustness and resiliency comparisons. ETL 1100-2-1 recommends that predictions of how the project or system might perform, as well as its ability to adapt beyond the typical 50-year economic analysis period, be considered in the decision-making process.

The initial assessment that evaluates the exposure and vulnerability of the project area over the 100-year planning horizon was used to assist planners and engineers in determining the long-term approach that best balances risks for the project. The three (3) general approaches are anticipatory, adaptive, and reactive strategies. These strategies can be combined, or they can change over the life cycle of the project. Key factors in determining the approach include consequences, the cost, and risk. This consideration is particularly important under a climate-change condition, where loading and response mechanisms are likely to transition over the life of the project. Projected sea-level curves and levels are shown here in Figure 4 and Table 4.

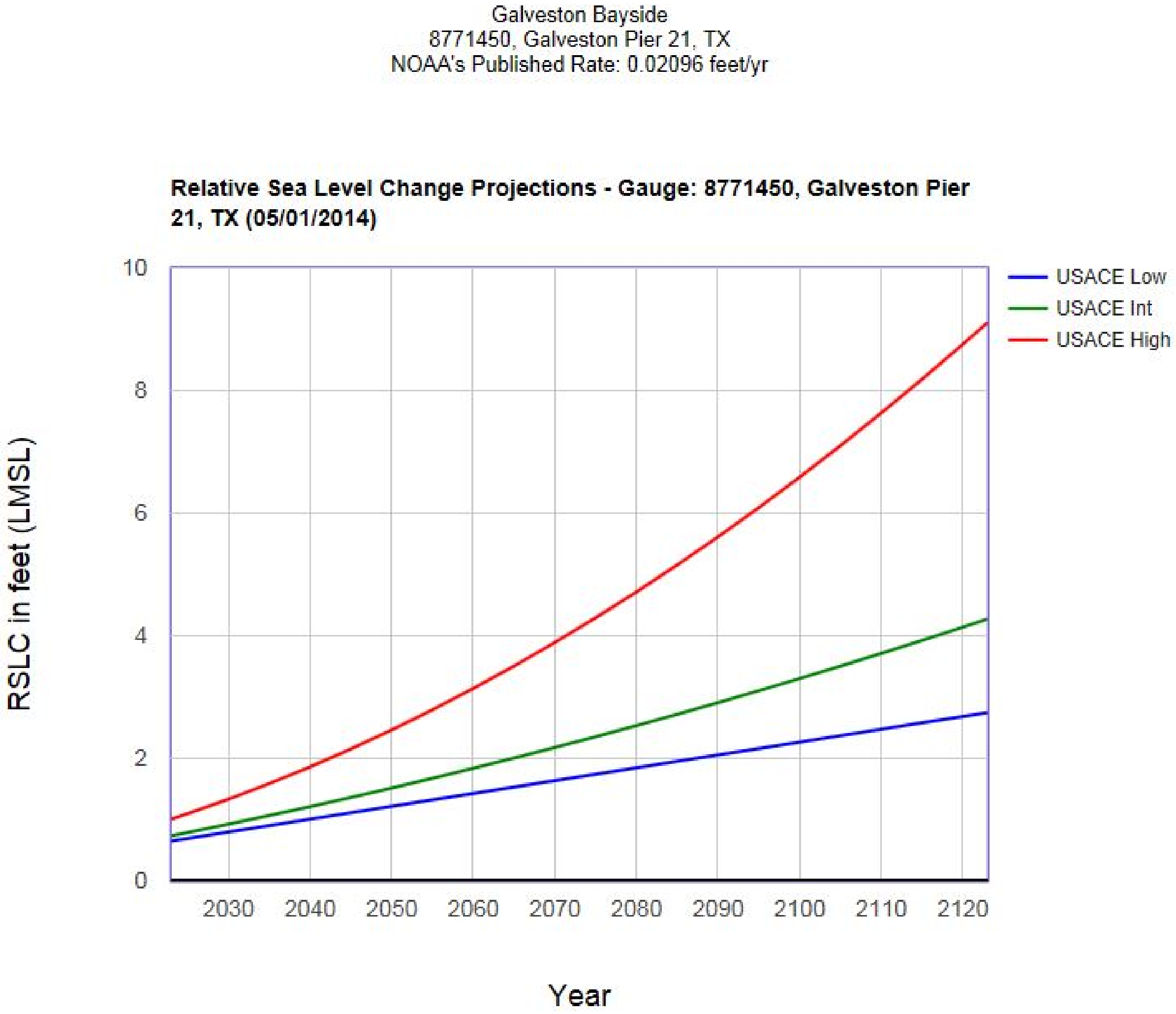
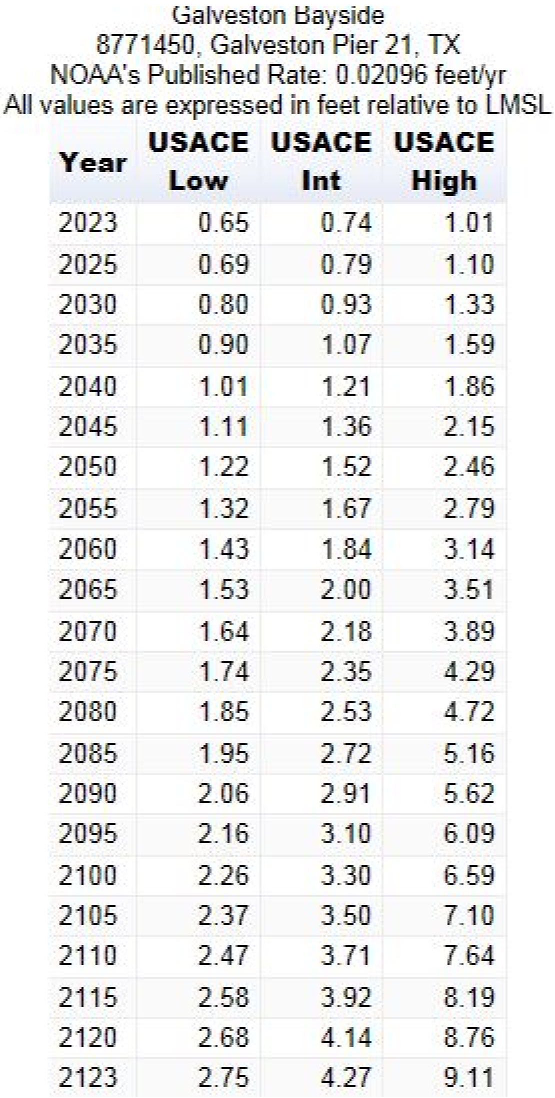


Figure 4: Estimated SLR over the First 100 Years of the Project Life (2023 - 2123) Corps of Engineers Curves Only (Levels are relative to 1992 Zero.)

Table 4. SLR for the 100-Year Period of Analysis
(Levels are relative to 1992 Zero.)

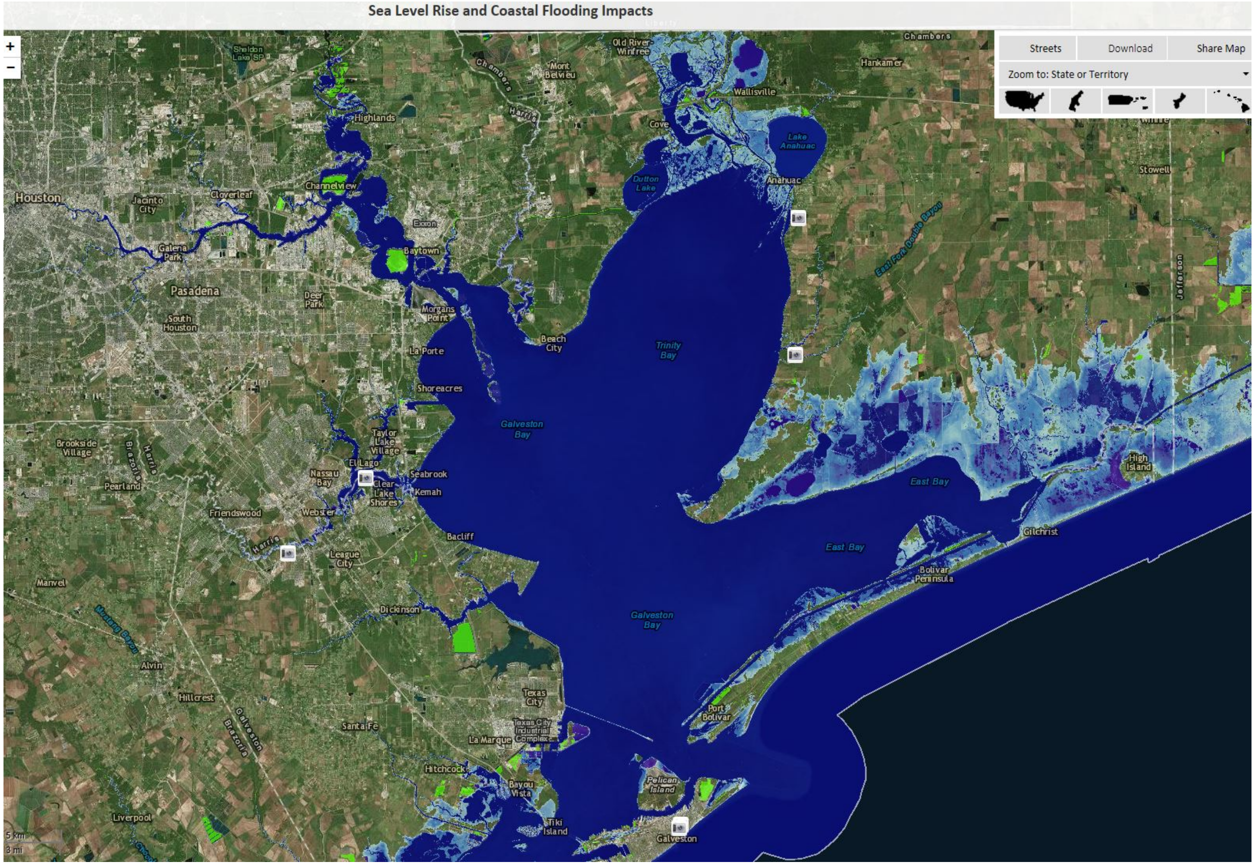


Galveston Bayside
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2023	0.65	0.74	1.01
2025	0.69	0.79	1.10
2030	0.80	0.93	1.33
2035	0.90	1.07	1.59
2040	1.01	1.21	1.86
2045	1.11	1.36	2.15
2050	1.22	1.52	2.46
2055	1.32	1.67	2.79
2060	1.43	1.84	3.14
2065	1.53	2.00	3.51
2070	1.64	2.18	3.89
2075	1.74	2.35	4.29
2080	1.85	2.53	4.72
2085	1.95	2.72	5.16
2090	2.06	2.91	5.62
2095	2.16	3.10	6.09
2100	2.26	3.30	6.59
2105	2.37	3.50	7.10
2110	2.47	3.71	7.64
2115	2.58	3.92	8.19
2120	2.68	4.14	8.76
2123	2.75	4.27	9.11

5.0 Planning for Sea-Level Rise

Note that during the project's planning period (near the Year 2088), sea level has risen about 2 feet. (NOAA's inundation plotter will only plot integral numbers of feet of inundation. The 2 ft level happens to occur in year 2088 for this site.) NOAA's "Sea Level Rise and Coastal Flooding Impacts Viewer" can be used to view the inundation occurring in whole numbers of feet. As seen below in Map 2, it is apparent that much of the land around the East Bay and Trinity Bay is low-lying and therefore inundated.

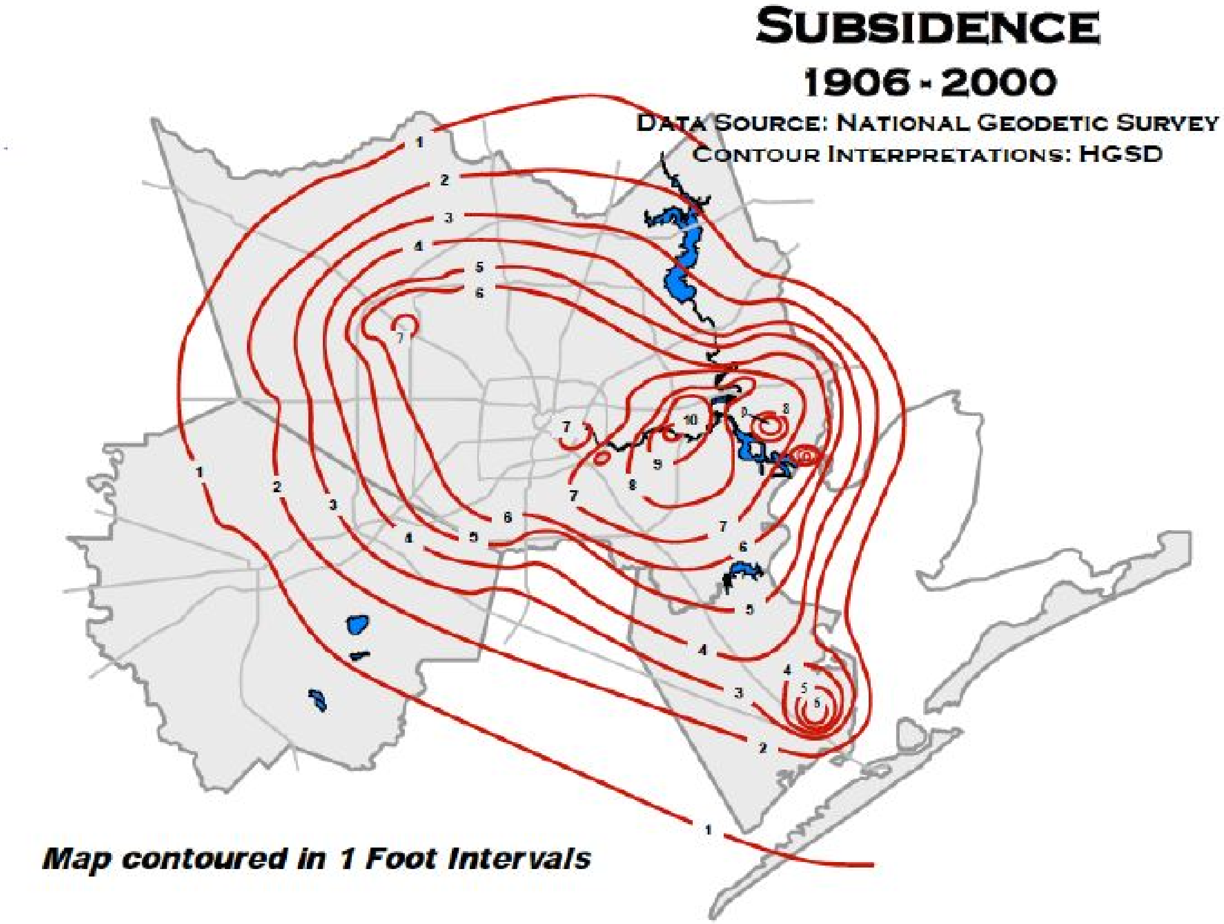


Map 2: Extent of Inundation (light blue) with 2-foot Rise (in year 2088)
Shown in bright green are low-lying areas that are occasionally inundated even before the project start.

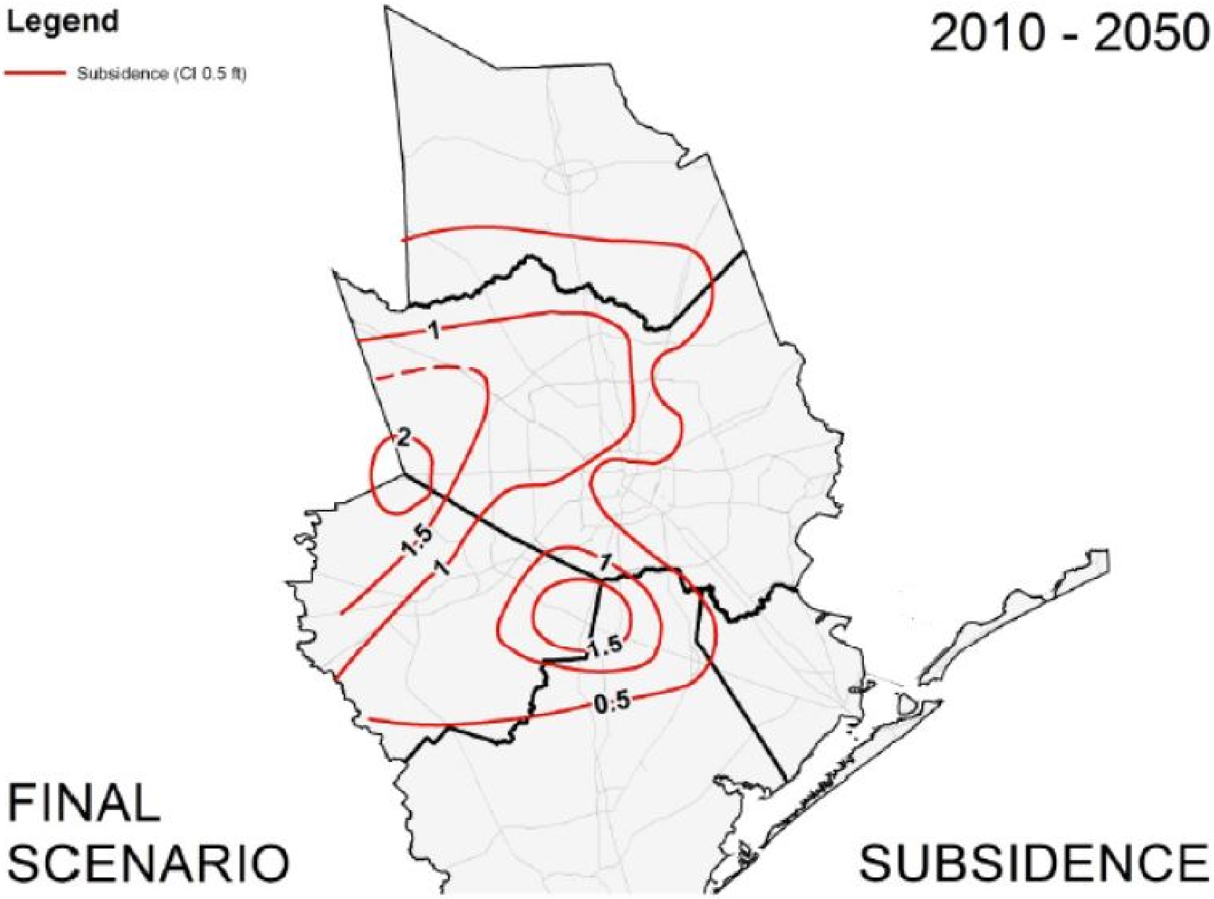
6.0 Subsidence

Land subsidence in the past has been much higher than in surrounding areas, as shown in Map 3. The main reason is thought to be groundwater extraction, and as a result the Harris-Galveston Subsidence District (HGSD) was formed to monitor and regulate further extraction. As supporting groundwater is removed, sediments compact. There is subsidence of at least a foot throughout this project's study area. Subsidence has ranged to over 10 feet, and the largest values seem to follow the Houston Ship Channel, from the Turning Basin to the Fred Hartman Bridge (or something similar).

Since the Houston Ship Channel Deepening and Widening Project will occur in the future and uses topography that has already been subjected to this historical subsidence, of more concern to this project is future subsidence. Based on HGSD's planned amounts of future extraction, they have modeled expected future subsidence, plotted here as Map 4. Significantly high values of 0.5 to 1.0 foot are only anticipated significantly far from the Houston Ship Channel. For the channel itself, the effect will be largely beneficial, by deepening the channel. Of more concern are effects on docks and other support facilities.



Map 3: Past Subsidence in Galveston and Harris Counties
(from GCCPRD Phase 2 Report, 02/23/2016)



Map 4: Anticipated Future Subsidence in Galveston and Harris Counties (from GCCPRD Phase 2 Report, 02/23/2016)
The river in the lower part of the figure (where subsidence can exceed 1.5 ft) is Clear Creek. The river in the upper portion is Houston Ship Channel (where subsidence is between 0.5 and 1 ft).

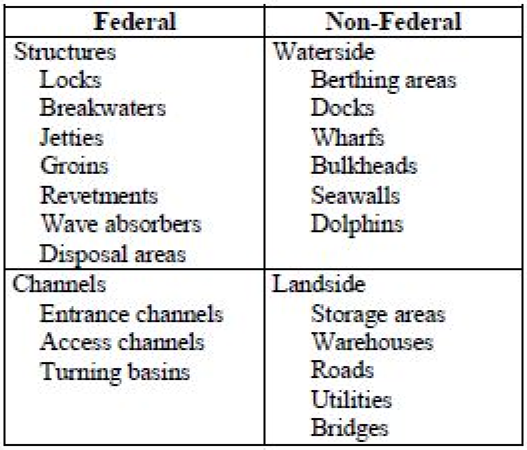
7.0 SLR Guidance Specific to Navigation Projects (ETL 1100-2-1's Appendix C)

Appendix C of the ETL "Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation" is titled "Navigation Projects" and specifically addresses only those. The general conclusion about sea-level rise effects on navigation projects is that it is a benefit to the project itself (providing deeper channel water), but is a potential threat or cost to related infrastructure. For federal projects, it is important to know which mitigations or adaptations can be made with federal funds and which cannot. Table 5 below provides general guidance on these two categories.

The primary federal structure for HSC is the entrance jetties. Therefore in the numerical model runs and in the with-project ship simulations, it will be important to study the "with sea-level rise" runs effects on the jettied entrance.

Deleterious effects on the navigation channel itself can occur however, and three of those areas are listed in the bottom left corner of Table 5. Physically the effect is primarily due to higher waves being able to form and propagate in the deeper channel. Since the deepening planned for HSC will be a relatively small portion of the entire depth, it is expected that this will have little effect and thus not become a risk that the project need address. A clearer quantitative answer to this question should be available when comparing the numerical-model and ship-simulation runs between the "no rise" and "sea-level rise" scenarios.

Table 5: Federal and non-Federal navigation project features at risk from sea-level change (from ETL 1100-2-1 Table C-1)



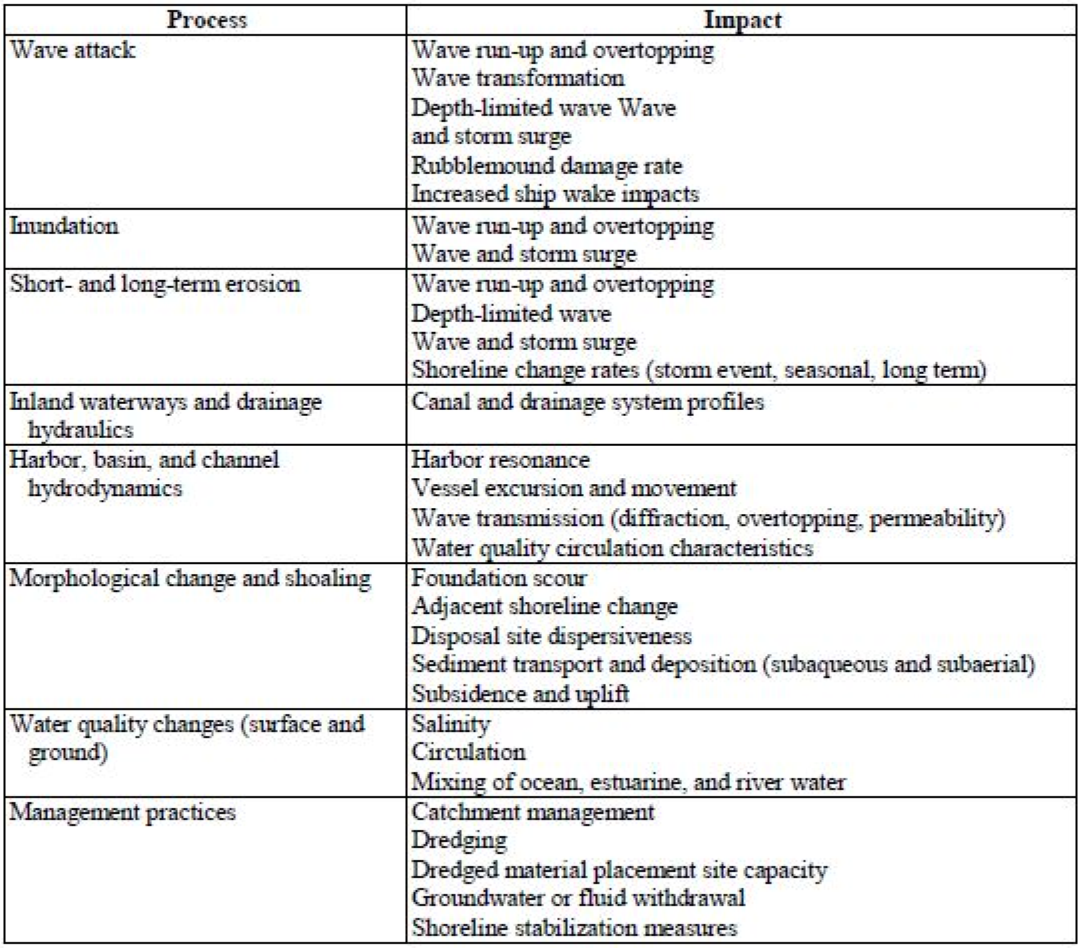
Federal	Non-Federal
Structures	Waterside
Locks	Berthing areas
Breakwaters	Docks
Jetties	Wharfs
Groins	Bulkheads
Revetments	Seawalls
Wave absorbers	Dolphins
Disposal areas	
Channels	Landside
Entrance channels	Storage areas
Access channels	Warehouses
Turning basins	Roads
	Utilities
	Bridges

Table 6 below lists the various physical processes that sea-level rise can affect in navigation projects. The impacts (on the right side of the Table) that are most likely to affect specifically Houston Ship Channel are:

1. Increased ship-wake impacts
2. Vessel excursion and movement
3. Adjacent shoreline change (due to increased propagation of ship wakes)
4. Less dredging needed to maintain the same depth (a benefit)
5. Dredged material placement site capacity

The first three of these should be addressed by the numerical model and ship simulations. The last two should be quantifiable with simpler spreadsheet computations, once this report's sea-level numbers have been agreed to by the team.

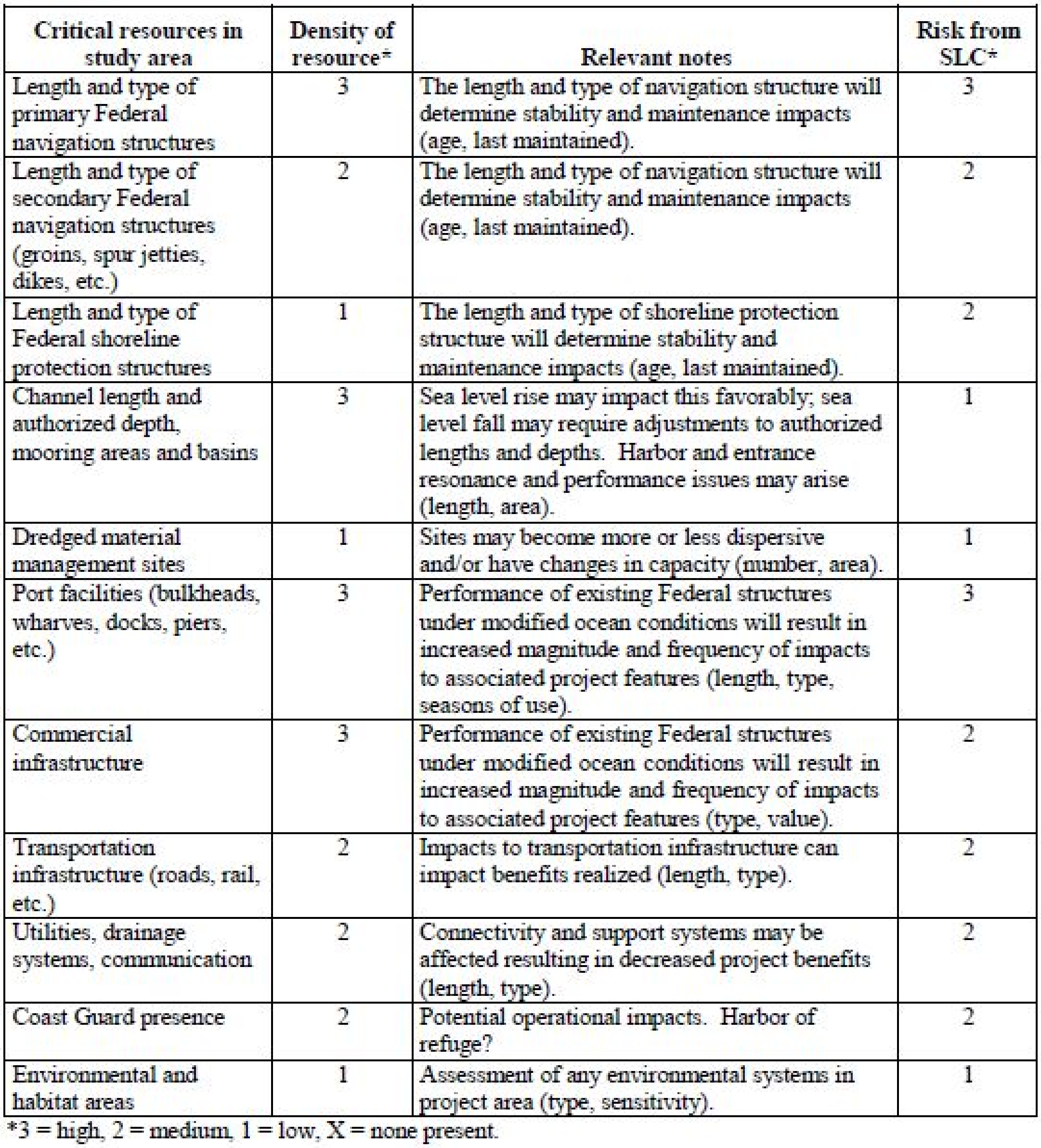
Table 6: Physical Processes Sensitive to Sea-Level Rise in Navigation Projects (from ETL 1100-2-1 Table C-3)



Process	Impact
Wave attack	Wave run-up and overtopping Wave transformation Depth-limited wave Wave and storm surge Rubblemound damage rate Increased ship wake impacts
Inundation	Wave run-up and overtopping Wave and storm surge
Short- and long-term erosion	Wave run-up and overtopping Depth-limited wave Wave and storm surge Shoreline change rates (storm event, seasonal, long term)
Inland waterways and drainage hydraulics	Canal and drainage system profiles
Harbor, basin, and channel hydrodynamics	Harbor resonance Vessel excursion and movement Wave transmission (diffraction, overtopping, permeability) Water quality circulation characteristics
Morphological change and shoaling	Foundation scour Adjacent shoreline change Disposal site dispersiveness Sediment transport and deposition (subaqueous and subaerial) Subsidence and uplift
Water quality changes (surface and ground)	Salinity Circulation Mixing of ocean, estuarine, and river water
Management practices	Catchment management Dredging Dredged material placement site capacity Groundwater or fluid withdrawal Shoreline stabilization measures

Table 7 below is a qualitative matrix for evaluating the level of risk of sea-level rise to a navigation project. The numerical scores on the left indicate the relative importance of density of each resource in a navigation project. The scores on the right indicate how at-risk that resource is to sea-level rise. Note that the two scores are different. For example, channel dimensions (length, depth, mooring areas) are of high importance or density in the project, but are expected to suffer little impact from sea-level rise. Note that the non-federal port facilities (wharves, docks, etc.) have both a high density and may be at high-risk from sea-level rise. Unfortunately for the local sponsor, sea-level rise scenarios may have much more impact on port facilities than on federal channel dimensions.

Table 7: Qualitative Matrix for Determining Risk Level (from ETL 1100-2-1 Table C-4)



Critical resources in study area	Density of resource*	Relevant notes	Risk from SLC*
Length and type of primary Federal navigation structures	3	The length and type of navigation structure will determine stability and maintenance impacts (age, last maintained).	3
Length and type of secondary Federal navigation structures (groins, spur jetties, dikes, etc.)	2	The length and type of navigation structure will determine stability and maintenance impacts (age, last maintained).	2
Length and type of Federal shoreline protection structures	1	The length and type of shoreline protection structure will determine stability and maintenance impacts (age, last maintained).	2
Channel length and authorized depth, mooring areas and basins	3	Sea level rise may impact this favorably; sea level fall may require adjustments to authorized lengths and depths. Harbor and entrance resonance and performance issues may arise (length, area).	1
Dredged material management sites	1	Sites may become more or less dispersive and/or have changes in capacity (number, area).	1
Port facilities (bulkheads, wharves, docks, piers, etc.)	3	Performance of existing Federal structures under modified ocean conditions will result in increased magnitude and frequency of impacts to associated project features (length, type, seasons of use).	3
Commercial infrastructure	3	Performance of existing Federal structures under modified ocean conditions will result in increased magnitude and frequency of impacts to associated project features (type, value).	2
Transportation infrastructure (roads, rail, etc.)	2	Impacts to transportation infrastructure can impact benefits realized (length, type).	2
Utilities, drainage systems, communication	2	Connectivity and support systems may be affected resulting in decreased project benefits (length, type).	2
Coast Guard presence	2	Potential operational impacts. Harbor of refuge?	2
Environmental and habitat areas	1	Assessment of any environmental systems in project area (type, sensitivity).	1

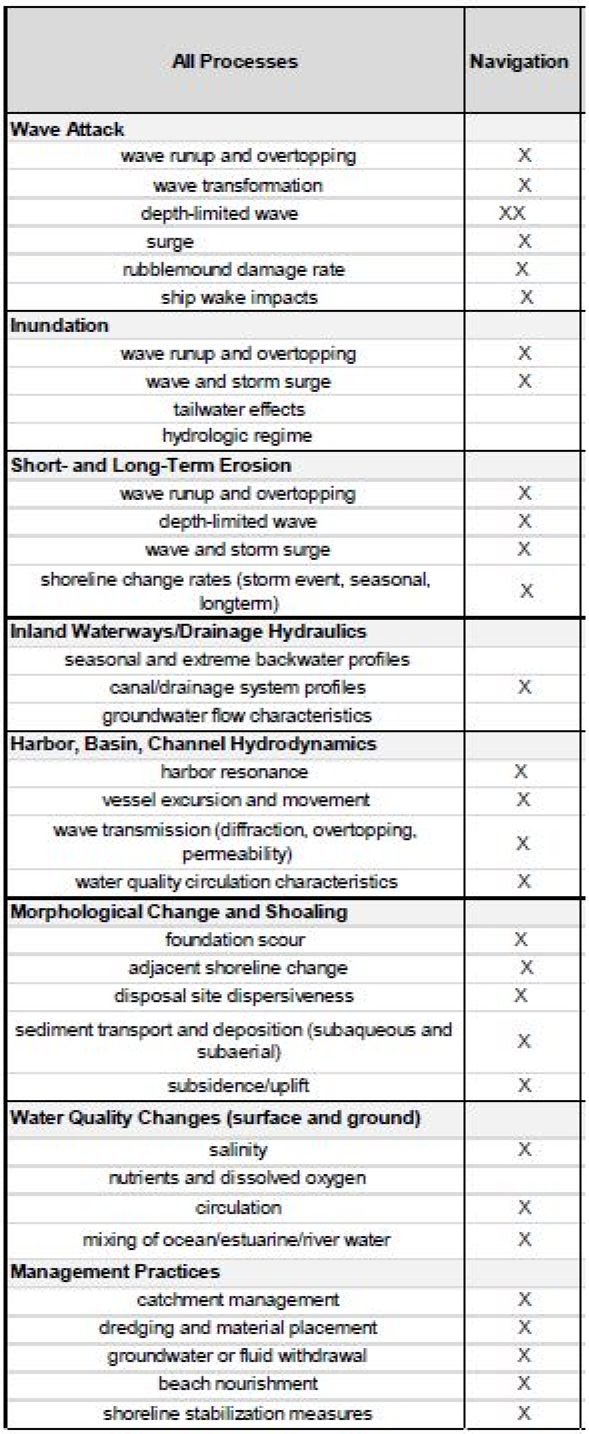
*3 = high, 2 = medium, 1 = low, X = none present.

7.1 Physical Processes at Navigation Projects affected by Sea-Level Rise (ETL 1100-2-1's Tables 6 and 8)

In deciding which processes should be evaluated for their effects on the project, due to sea-level rise, the following Table 8 provides a checklist to apply to specific projects. Note that the only doubly important marking is for "depth-limited waves", which means that wave heights can be expected to increase.

Within the main channel, the depth increase caused by sea-level rise will be small compared to the total depth, so this effect will be small. However, this is NOT the case with barge lanes and mooring basins, where sea-level rise will be a much larger percentage of the total depth, and where it is known that waves are "depth limited". (For background information, wave heights are determined by wind speed, but can be limited in three ways: depth, fetch length, and wind duration. There is usually only one of these three factors which controls or "limits" the wave height. In Galveston Bay, waves are usually depth limited.)

Table 8: Physical Processes Affected by Sea-Level Rise in Navigation Projects (from ETL 1100-2-1's Table 6)

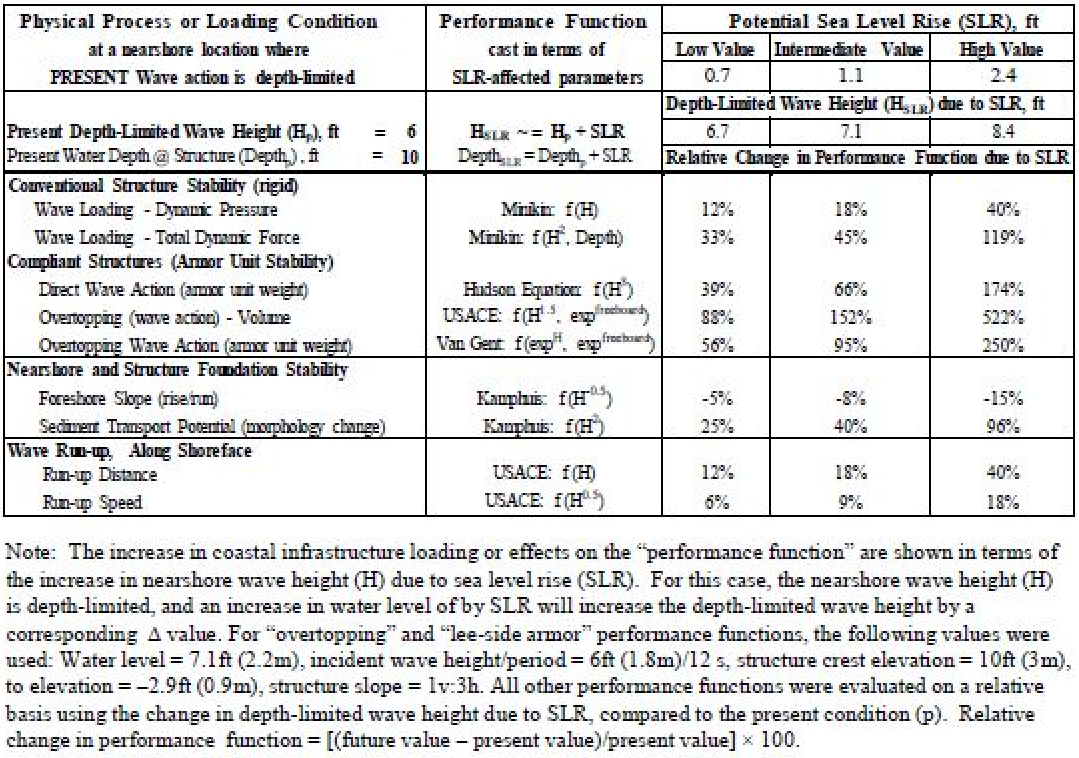


All Processes	Navigation
Wave Attack	
wave runup and overtopping	X
wave transformation	X
depth-limited wave	XX
surge	X
rubblemound damage rate	X
ship wake impacts	X
Inundation	
wave runup and overtopping	X
wave and storm surge	X
tailwater effects	
hydrologic regime	
Short- and Long-Term Erosion	
wave runup and overtopping	X
depth-limited wave	X
wave and storm surge	X
shoreline change rates (storm event, seasonal, longterm)	X
Inland Waterways/Drainage Hydraulics	
seasonal and extreme backwater profiles	
canal/drainage system profiles	X
groundwater flow characteristics	
Harbor, Basin, Channel Hydrodynamics	
harbor resonance	X
vessel excursion and movement	X
wave transmission (diffraction, overtopping, permeability)	X
water quality circulation characteristics	X
Morphological Change and Shoaling	
foundation scour	X
adjacent shoreline change	X
disposal site dispersiveness	X
sediment transport and deposition (subaqueous and subaerial)	X
subsidence/uplift	X
Water Quality Changes (surface and ground)	
salinity	X
nutrients and dissolved oxygen	
circulation	X
mixing of ocean/estuarine/river water	X
Management Practices	
catchment management	X
dredging and material placement	X
groundwater or fluid withdrawal	X
beach nourishment	X
shoreline stabilization measures	X

To quantify the effect of sea-level rise on depth-limited wave heights and other factors, Table 9 below provides a useful matrix of specific quantifiable effects. Most of the Table applies to structures. Except possibly at the jetties, the only significant relevance of this Table for this HSC project is that wave height increases in depth-limited (shallow) areas. (The Table's example shows that the depth-limited wave height increases by the same amount as the sea-level rise, in this case from 6 ft to 6.7 ft.)

Corresponding to three different values of sea-level rise, percentage changes are computed for various forces used to compute damaging effects such as wave attack, armor-unit stability, morphology change, and wave run-up on structures and shores.

Table 9: Quantified Changes in Loading Conditions due to Sea-Level Rise
(From ETL 1100-2-1's Table 8)



Physical Process or Loading Condition at a nearshore location where PRESENT Wave action is depth-limited	Performance Function cast in terms of SLR-affected parameters	Potential Sea Level Rise (SLR), ft		
		Low Value	Intermediate Value	High Value
		0.7	1.1	2.4
		Depth-Limited Wave Height (H_{SLR}) due to SLR, ft		
Present Depth-Limited Wave Height (H_p), ft = 6	$H_{SLR} \sim= H_p + SLR$	6.7	7.1	8.4
Present Water Depth @ Structure ($Depth_p$), ft = 10	$Depth_{SLR} = Depth_p + SLR$	Relative Change in Performance Function due to SLR		
Conventional Structure Stability (rigid)				
Wave Loading - Dynamic Pressure	Minikin: f(H)	12%	18%	40%
Wave Loading - Total Dynamic Force	Minikin: f(H^2, Depth)	33%	45%	119%
Compliant Structures (Armor Unit Stability)				
Direct Wave Action (armor unit weight)	Hudson Equation: f(H^3)	39%	66%	174%
Overtopping (wave action) - Volume	USACE: f($H^{1.5}$, $exp^{freeboard}$)	88%	152%	522%
Overtopping Wave Action (armor unit weight)	Van Gent: f(exp^H, $exp^{freeboard}$)	56%	95%	250%
Nearshore and Structure Foundation Stability				
Foreshore Slope (rise/run)	Kamphuis: f($H^{-0.5}$)	-5%	-8%	-15%
Sediment Transport Potential (morphology change)	Kamphuis: f(H^2)	25%	40%	96%
Wave Run-up, Along Shoreface				
Run-up Distance	USACE: f(H)	12%	18%	40%
Run-up Speed	USACE: f($H^{0.5}$)	6%	9%	18%

Note: The increase in coastal infrastructure loading or effects on the "performance function" are shown in terms of the increase in nearshore wave height (H) due to sea level rise (SLR). For this case, the nearshore wave height (H) is depth-limited, and an increase in water level of by SLR will increase the depth-limited wave height by a corresponding Δ value. For "overtopping" and "lee-side armor" performance functions, the following values were used: Water level = 7.1ft (2.2m), incident wave height/period = 6ft (1.8m)/12 s, structure crest elevation = 10ft (3m), to elevation = –2.9ft (0.9m), structure slope = 1v:3h. All other performance functions were evaluated on a relative basis using the change in depth-limited wave height due to SLR, compared to the present condition (p). Relative change in performance function = [(future value – present value)/present value] × 100.

The numerical model and ship simulations that compare "with sea-level rise" to "without (or present-day)" scenarios should provide quantitative results for estimating the project's risk to sea-level rise.

7.2 SLR Risks and Adaptations for Navigation Projects (ETL 1100-2-1's Tables 1 and 7)

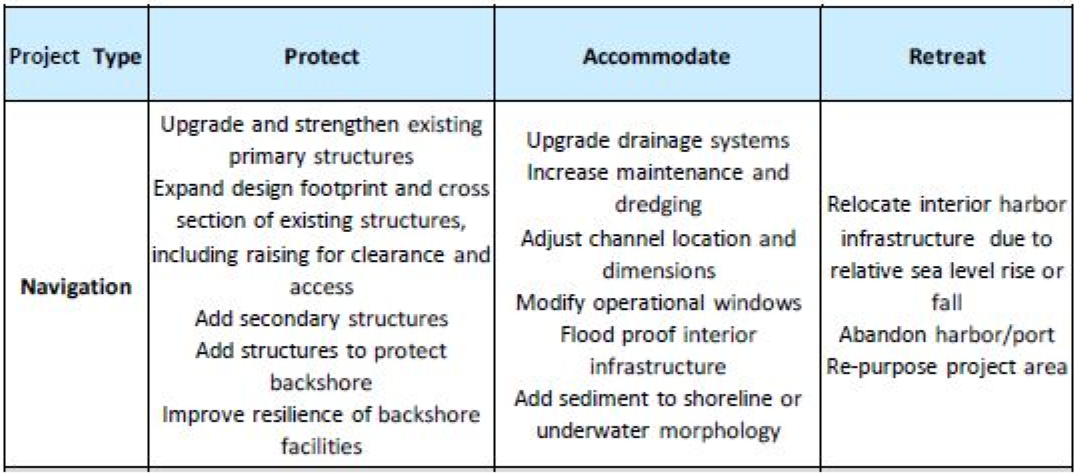
An essential element of developing a good understanding of the project area's exposure and vulnerability is assessing how quickly the individual scenarios might necessitate an action due to thresholds and tipping points. It is important to identify key milestones in the project timeline when impacts are expected. This involves inputs from all members of the PDT, since the threshold or tipping point could be a variety of different items or combinations of items.

Response strategies for the project planning horizon range from a conservative anticipatory approach, which constructs a resilient project at the beginning to last the entire life cycle (and possibly beyond), to a reactive approach, which would simply be to do nothing until impacts are experienced. Between these extremes is an adaptive management strategy, which incorporates new assessments and actions throughout the project life based on timeframes, thresholds and triggers. A plan may include multiple measures adaptable over a range of SLC conditions and over the entire timeline, with different measures being executed as necessitated.

For a feasibility-level design, it is important to identify potential cost-risk items and adaptation costs to the stakeholders and decision makers. Further detailed design and analysis may be undertaken during the pre-construction engineering and design phase to optimize project features sensitive to relative sea level change. In this phase, the question of further adaptability beyond the 50-year economic analysis period may be addressed as part of the design optimization. The economic and cost formulation for the project should account for uncertainty in critical design items.

Hard structures (rock or concrete) are difficult to alter to accommodate changing conditions, unless they have been designed with that in mind from the beginning. Examples of the three types of approaches are listed below in Table 10. Since this navigation project does not include improvements to hard structures (in the federal part of the project), then it will be relatively easy to design protections and solutions. In contrast, it is difficult to accommodate hard structures that have not been designed from the beginning with adaptation in mind. For example, a dock that has been designed from the beginning with the intention that it will eventually need to be jacked up is much cheaper in the long-run than a dock that has to be torn down and rebuilt. So again, this planning for an adaptive strategy will be much more important to the non-federal part of the project.

Table 10: Adaptive Approaches to Navigation Projects
(From ETL 1100-2-1's Table 1)

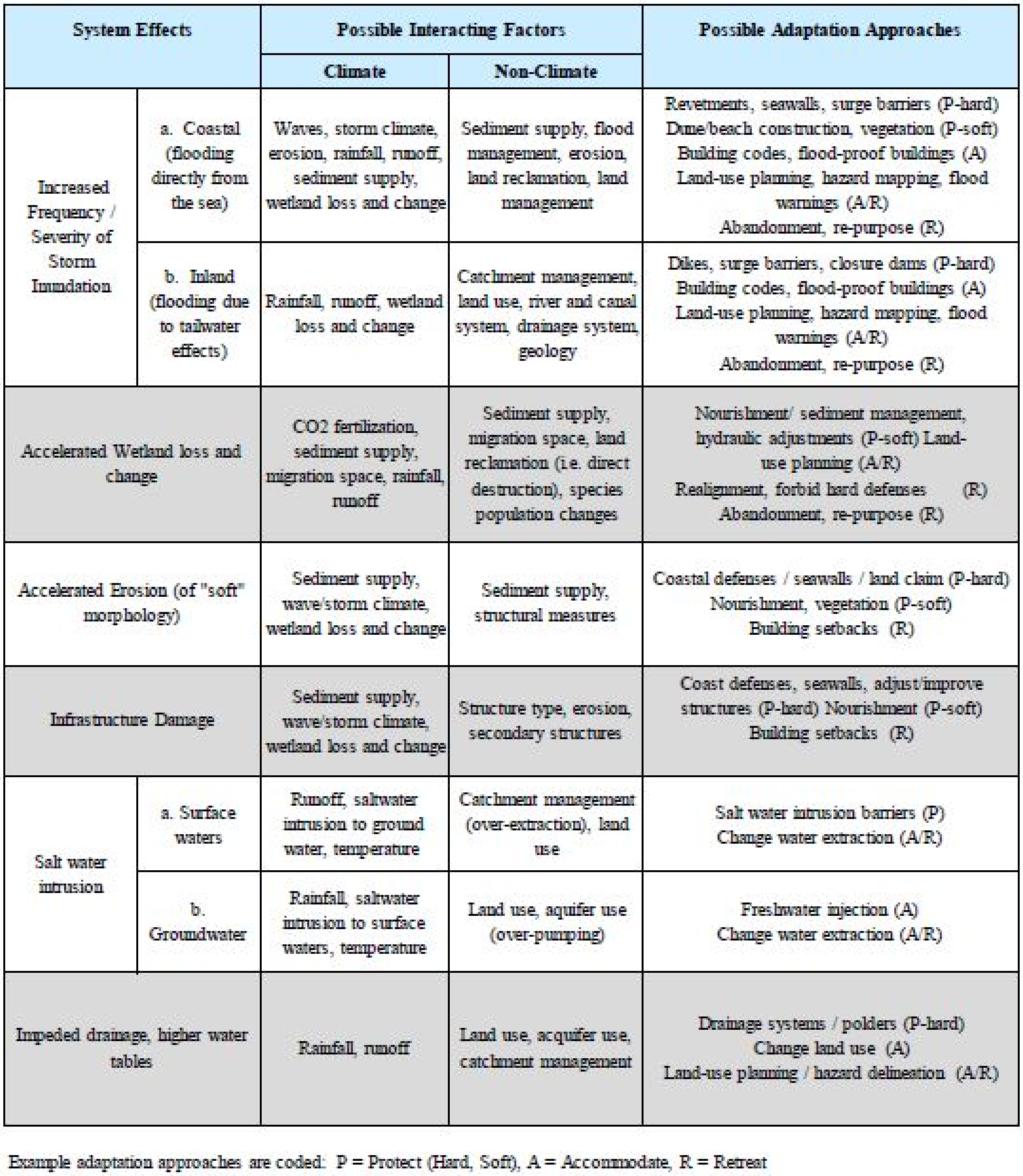


Project Type	Protect	Accommodate	Retreat
Navigation	Upgrade and strengthen existing primary structures Expand design footprint and cross section of existing structures, including raising for clearance and access Add secondary structures Add structures to protect backshore Improve resilience of backshore facilities	Upgrade drainage systems Increase maintenance and dredging Adjust channel location and dimensions Modify operational windows Flood proof interior infrastructure Add sediment to shoreline or underwater morphology	Relocate interior harbor infrastructure due to relative sea level rise or fall Abandon harbor/port Re-purpose project area

In planning an adaptation strategy, Table 11 below provides a useful method of selecting the kind of adaptation to use (P = Protect, A = Accommodate, R = Retreat) and also provides a list of specific solutions to pick from. Both the kind of adaptation and specific solutions are shown in the right-most column.

The two categories of sea-level effects in the left-most column that are more likely to affect this project are "wetland loss" (federal) and "infrastructure damage" (non-federal). Therefore both the entire team and the non-federal team should plan their adaptation strategies.

Table 11: Systems Affected by Sea-Level Rise and Adaptation Approaches (From ETL 1100-2-1's Table 7)



System Effects		Possible Interacting Factors		Possible Adaptation Approaches
		Climate	Non-Climate	
Increased Frequency / Severity of Storm Inundation	a. Coastal (flooding directly from the sea)	Waves, storm climate, erosion, rainfall, runoff, sediment supply, wetland loss and change	Sediment supply, flood management, erosion, land reclamation, land management	Revetments, seawalls, surge barriers (P-hard) Dune/beach construction, vegetation (P-soft) Building codes, flood-proof buildings (A) Land-use planning, hazard mapping, flood warnings (A/R) Abandonment, re-purpose (R)
	b. Inland (flooding due to tailwater effects)	Rainfall, runoff, wetland loss and change	Catchment management, land use, river and canal system, drainage system, geology	Dikes, surge barriers, closure dams (P-hard) Building codes, flood-proof buildings (A) Land-use planning, hazard mapping, flood warnings (A/R) Abandonment, re-purpose (R)
Accelerated Wetland loss and change		CO2 fertilization, sediment supply, migration space, rainfall, runoff	Sediment supply, migration space, land reclamation (i.e. direct destruction), species population changes	Nourishment/ sediment management, hydraulic adjustments (P-soft) Land-use planning (A/R) Realignment, forbid hard defenses (R) Abandonment, re-purpose (R)
Accelerated Erosion (of "soft" morphology)		Sediment supply, wave/storm climate, wetland loss and change	Sediment supply, structural measures	Coastal defenses / seawalls / land claim (P-hard) Nourishment, vegetation (P-soft) Building setbacks (R)
Infrastructure Damage		Sediment supply, wave/storm climate, wetland loss and change	Structure type, erosion, secondary structures	Coast defenses, seawalls, adjust/improve structures (P-hard) Nourishment (P-soft) Building setbacks (R)
Salt water intrusion	a. Surface waters	Runoff, saltwater intrusion to ground water, temperature	Catchment management (over-extraction), land use	Salt water intrusion barriers (P) Change water extraction (A/R)
	b. Groundwater	Rainfall, saltwater intrusion to surface waters, temperature	Land use, aquifer use (over-pumping)	Freshwater injection (A) Change water extraction (A/R)
Impeded drainage, higher water tables		Rainfall, runoff	Land use, acquifer use, catchment management	Drainage systems / polders (P-hard) Change land use (A) Land-use planning / hazard delineation (A/R)

Example adaptation approaches are coded: P = Protect (Hard, Soft), A = Accommodate, R = Retreat

8.0 Recommendations

As a conservative approach (not exaggerating benefits from sea-level rise), USACE's Low Sea-Level Curve should be used for the navigation portion of this project.

Including sea-level rise and subsidence in the project design will result in **less dredging** than otherwise anticipated, since the channel depth is increasing due to both of these factors. At the end of the 50-year project life, channel depth will have increased (since construction) by:

1.70 ft (in 2073) – 0.65 ft (in 2023) = 1.05 ft.

At the end of the 100-year planning period, channel depth will have increased (since construction) by: 2.75 ft (in 2123) – 0.65 ft (in 2023) = 2.10 ft.

If sea level rises faster than the historic "Low" rate, then channel depth will increase even more.

Conversely, SLC effects on the non-federal sponsor's infrastructure will largely be detrimental. They should carefully consider which sea level to plan for, and more importantly, what their adaptation measures should be (Table 11).

Some deleterious effects due to sea-level rise may also occur within the federal project. Many of the general categories of effects listed in the Tables will not apply to this project, but most likely there will be some deleterious effects in some of the following categories:

Increased erosion at islands
Increased ship wakes in barge lanes and mooring areas
Increased wind waves, especially in shallow areas (but not in the main channel)
Changes in water chemistry (salinity, dissolved oxygen)

For the first three items in the list above, some simple spreadsheet calculations can be performed to indicate a level-of-concern. For all four categories, the numerical model and ship simulation runs should help quantify the effects. One decision the team will have to make is which scenarios are to be run in the model and in the simulations. There are not likely to be sufficient funds to run all possible combinations of: Low, Intermediate, and High SLR; their effects on multiple ship sizes; and runs both with and without project. The current plan is to make four runs: Present Condition, Project TSP, Project Alternative, and Future with TSP.

The primary federal structures for HSC are the entrance jetties. Therefore in the numerical model runs and in the with-project ship simulations, it will be important to study the effects of "with sea-level rise" on the jettied entrance.

References

ER (Engineering Regulation) 1100-2-8162, “Incorporating Sea Level Change in Civil Works Programs”, 31 Dec 2013, 3 pp + 2 Appendices.

ETL (Engineering Technical Letter) 1100-2-1, “Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation,” 30 Jun 2014, 5 Chapters + Appendices A-G.

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ATTACHMENT 4A

ENGINEERING DATA AND MODELS

ERDC/CHL TR-19-10

Coastal and Hydraulics Laboratory

US Army Corps
of Engineers®
Engineer Research and
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Houston Ship Channel and Vicinity Three-Dimensional Adaptive Hydraulics (AdH) Numerical Model Calibration/Validation Report

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Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers, Galveston District
P.O. Box 1229
Galveston, TX 77553-1229

Under Work Unit 145745; Coastal Texas Region 1 Protect and Restore and Work Unit 451902 HSC Feasibility Study

Abstract

The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate larger vessels as needed. The U.S. Army Engineer District, Galveston, requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, perform hydrodynamic, salinity, and sediment transport modeling of proposed modifications along the Houston Ship Channel from its connection to the Gulf of Mexico to the Port of Houston as well as alterations for storm protection. The modeling results are necessary to provide data for salinity and sediment transport analysis as well as a ship simulation investigation to determine the navigational impacts of the proposed alternatives. The model setup and validation are presented in this report. The model proved to match field data for water surface elevation, velocity, and shoaling in the ship channel over three simulation years — 2005, 2010, and 2011.

Contents

Figures and Tables

Figures

Tables

Preface

The model investigation presented in this report was authorized and funded by the U.S. Army Corps of Engineers, Galveston District, under Work Unit 145745; Coastal Texas Region 1 Protect and Restore and Work Unit 451902 HSC Feasibility Study.

The work was performed at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL), Vicksburg, MS. At the time of publication of this report, Dr. Ty V. Wamsley was Director, and Mr. Jeffrey R. Eckstein was Deputy Director, ERDC-CHL. Direct supervision was provided by Dr. Cary Talbot, Chief, Flood and Storm Protection Division, and Mr. Keith Flowers, Chief, River and Estuarine Engineering Branch.

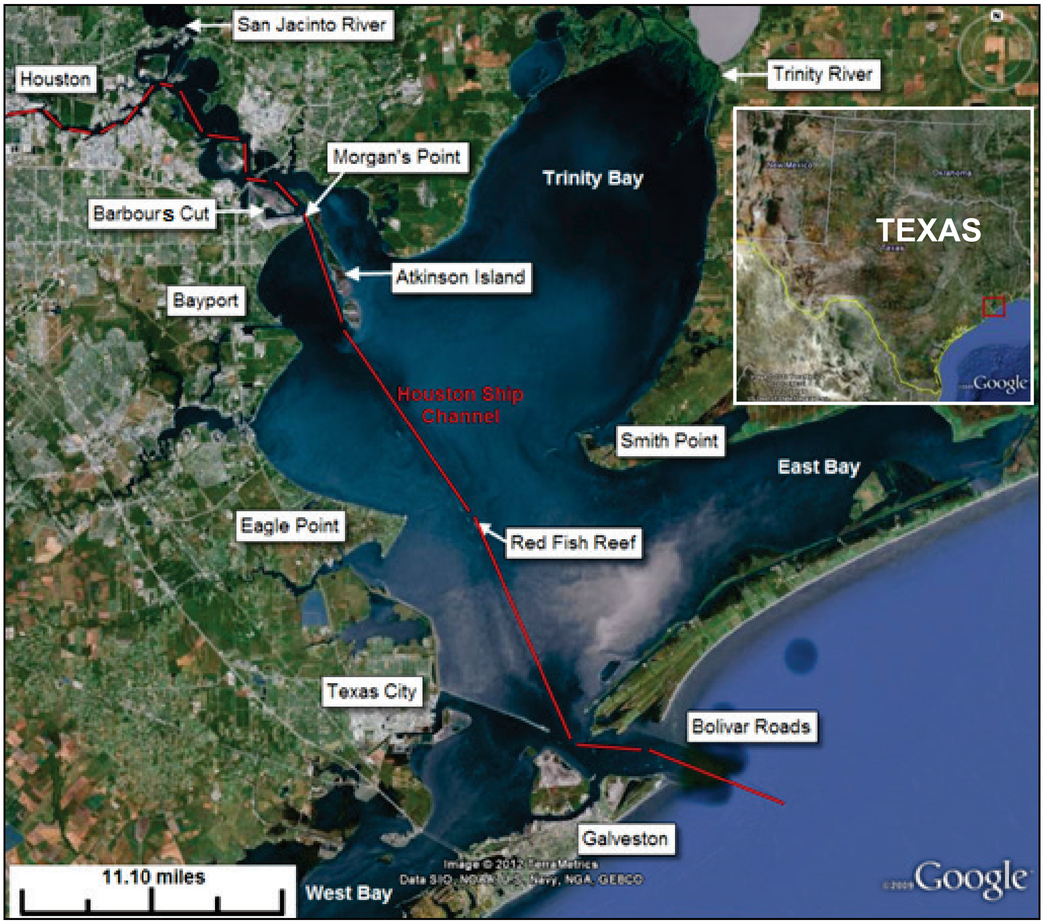
COL Ivan P. Beckman was Commander of ERDC, and Dr. David W. Pittman was Director.

1 Introduction

Background

Since the early 1800s, vessels have transited Galveston Bay both to and from Galveston and Houston (Galveston Bay Estuary Program 2002). Galveston Bay is a tidal estuary such that the effect of the tide on the water surface elevation is observed from the Gulf of Mexico to locations near Houston, TX. The Houston Ship Channel (HSC) is a deep-draft navigation channel that allows for vessel passage from the Gulf to the city of Houston, approximately 53 miles upstream. Since 1903, Operations and Maintenance dredging has been conducted in the bay to maintain authorized channel dimensions. Figure 1 shows the HSC as it passes through Galveston Bay from its entrance at Bolivar Roads to the Port of Houston.

Figure 1. HSC area map.



The navigation channel acts as a flow pathway for salinity to travel upstream since high-saline water is heavier than fresh water and tends to flow up-channel along the channel bottom. The net drift in the bottom of the water column is flood in much of the channel (Tate and Berger 2006) (i.e., the tendency is for suspended material to move upstream into the bay). The velocity magnitudes drop in the Atkinson Island reach due to tidal reflections from the bay boundary. The flow tends to stratify more as a result in this reach, and material from farther downstream in the estuary tends to collect near Atkinson Island.

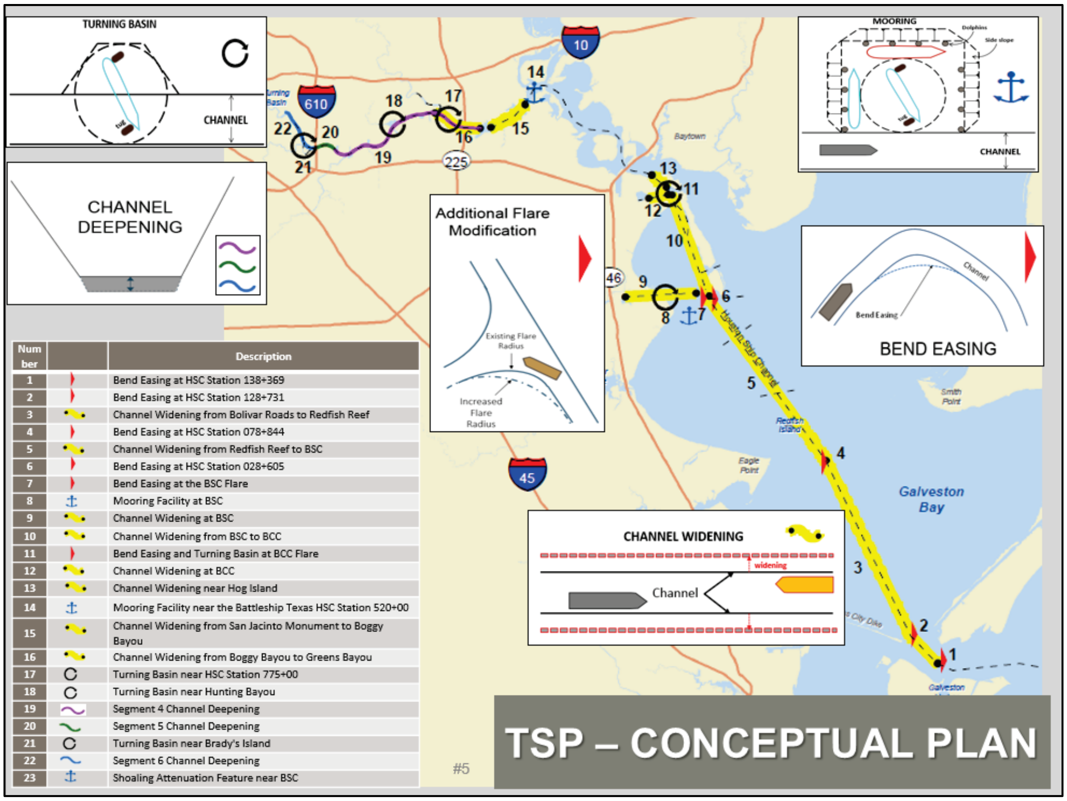
The behavior of the salinity and hydrodynamics in Galveston Bay during May through June is different than the remainder of the year due to a salinity drop in the northern Gulf of Mexico as the Mississippi, Sabine-Neches, and Atchafalaya Rivers and other northern Gulf river systems provide a significant influx of fresh water. When the salinity in the Gulf of Mexico drops, the salt water tends to evacuate from the bay. A reduction in bay salinity results in different suspended concentration patterns and fresh deposit characteristics during this time period compared to data collected at other times during the year. During this period, sediment would tend to collect farther down the channel toward Red Fish Reef (Tate and Berger 2006).

The U.S. Army Corps of Engineers (USACE), Galveston District (SWG) recently enlarged the Houston Ship Channel from a 12.2-meters (m) (40-foot [ft]) depth by 122 m (400 ft) width to a 13.7 m (45 ft) depth by 162 m (530 ft) width. Previously, a three-dimensional (3D) numerical model study was implemented at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL), to evaluate the salinity and circulation impact of this enlargement.

Objective

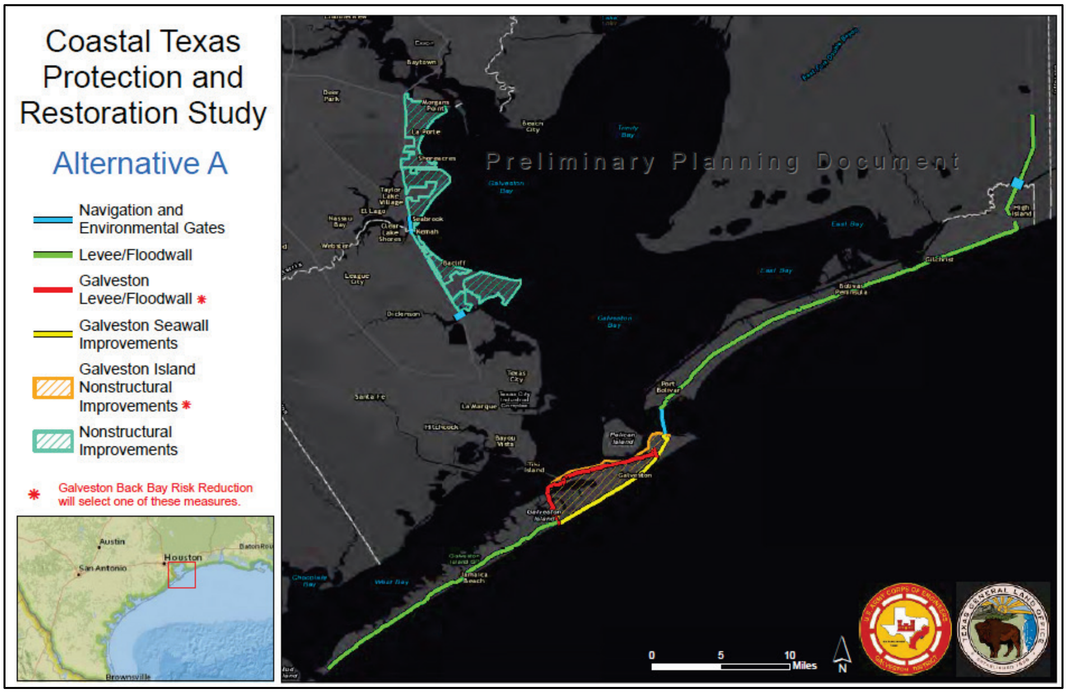
In 2016, SWG requested the ERDC-CHL perform hydrodynamic, salinity and sediment modeling of proposed modifications along the HSC from its connection to the Gulf of Mexico to the Port of Houston for both improved navigation and storm protection (Figure 2 and Figure 3). The modeling results are necessary to provide data for salinity and sediment transport analysis as well as ship simulation studies in which pilots test the navigational effects of the modifications. The model setup and validation are presented in this report.

Figure 2. Proposed modifications to the HSC (figure from SWG).



Number		Description
1	▶	Bend Easing at HSC Station 138+369
2	▶	Bend Easing at HSC Station 128+731
3	~	Channel Widening from Bolivar Roads to Redfish Reef
4	▶	Bend Easing at HSC Station 078+844
5	~	Channel Widening from Redfish Reef to BSC
6	▶	Bend Easing at HSC Station 028+605
7	▶	Bend Easing at the BSC Flare
8	⚓	Mooring Facility at BSC
9	~	Channel Widening at BSC
10	~	Channel Widening from BSC to BCC
11	▶	Bend Easing and Turning Basin at BCC Flare
12	~	Channel Widening at BCC
13	~	Channel Widening near Hog Island
14	⚓	Mooring Facility near the Battleship Texas HSC Station 520+00
15	~	Channel Widening from San Jacinto Monument to Boggy Bayou
16	~	Channel Widening from Boggy Bayou to Greens Bayou
17	↻	Turning Basin near HSC Station 775+00
18	↻	Turning Basin near Hunting Bayou
19	∼	Segment 4 Channel Deepening
20	∼	Segment 5 Channel Deepening
21	↻	Turning Basin near Brady's Island
22	∼	Segment 6 Channel Deepening
23	⚓	Shoaling Attenuation Feature near BSC

Figure 3. Proposed coastal protection (figure from SWG).



Approach

A 3D Adaptive Hydraulics (AdH) model was developed and validated for simulation of hydrodynamics, salinity, and sediment transport. Previous modeling efforts used TABS-MDS as the finite element code (Berger et al. 1995; Carrillo et al. 2002; Tate and Berger 2006; Tate et al. 2008; Tate and Ross 2012). The present effort necessitates the development of a new model utilizing the latest technology and updated to present conditions. The model was validated to available field data for all parameters and then utilized to test project alternatives for present and future conditions.

Chapter 2 discusses the model development and boundary condition definitions for the hydrodynamic, salinity, and sediment transport model. Chapter 3 documents the model to field data comparisons for hydrodynamics, salinity, and HSC dredge volumes. Chapter 4 provides the conclusions of this numerical model validation.

2 Model Development

A numerical model was developed to analyze alternative plans for the HSC and to provide hydrodynamic data for ship simulation studies. The model was developed such that the natural driving forces of the system are included — winds, tides, salinity, freshwater inflows, friction effects, and sediment behavior. The model is compared to field data collected during the simulation period to ensure an accurate representation of nature. This model is validated using data from 2010 and 2011; 2005 is used as the model calibration period.

Numerical code

AdH is the numerical model code applied for the simulations in this study (Savant et al. 2014; Savant and Berger 2015). AdH is a finite element code that is capable of simulating 3D Navier-Stokes equations, two-dimensional (2D) and 3D shallow water equations, and groundwater equations. It can be used in a serial or multiprocessor mode on personal computers and high-performance computing systems. AdH can refine the domain mesh in areas where more resolution is needed at certain times due to changes in the flow conditions and then remove the added resolution when it is no longer needed, to minimize computational burden. The code also includes automatic time-step adaption, as needed. AdH can simulate the transport of conservative constituents, such as dye clouds, as well as simulate sediment transport, when used with SEDLIB, that is coupled to bed and hydrodynamic changes. This code has been applied to model riverine flow (Bell et al. 2017; Clifton et al. 2017) estuarine circulation (Tate et al. 2009; McAlpin et al. 2013), and sediment transport (Sharp et al. 2013; Heath et al. 2015; Letter et al. 2015).

SEDLIB is a sediment transport code that allows for the simulation of non-cohesive (sand), cohesive (silt and clay), and mixed sediments. Each grain class is tracked separately yet allowed to mix as necessary in multiple bed layers. SEDLIB calculates erosion and deposition simultaneously and includes bed processes such as armoring, consolidation, and discrete depositional layer evolution.

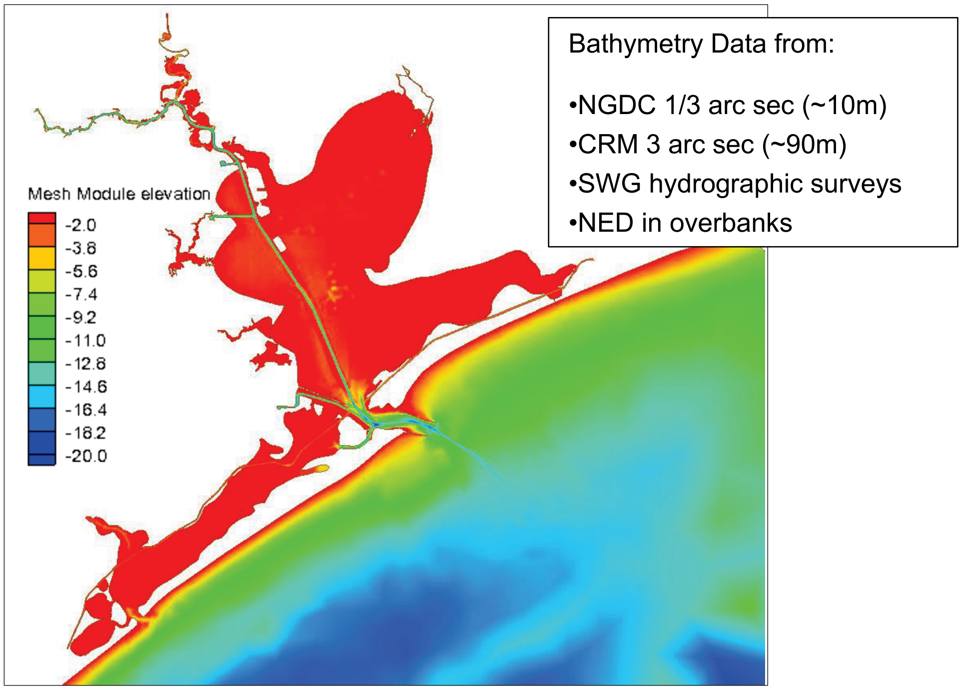
For this study, the 3D shallow water module of AdH is applied for all simulations. This code solves for depth and velocity throughout the model domain. (More details of the 3D shallow water module of AdH and its computational philosophy and equations are available in Savant et al. 2014 and Savant and Berger 2015.) AdH version 4.6 was applied for this study.

Mesh development

The model domain was determined using aerial images and bathymetry/topographic data for the area. The Surface Water Modeling System was used to generate a 2D surface mesh and define material regions for applying specific model features, such as bed roughness. The domain is defined horizontally in Universal Transverse Mercator, zone 15 coordinates with units of meters. Vertically it is based on North American Vertical Datum of 1988 (NAVD88) with units of meters. All data applied to the model are shifted to this datum and coordinate system.

Bathymetry data for the model were obtained from several sources: the National Geophysical Data Center, the Coastal Relief Model, sponsor-collected hydrographic surveys, and the National Elevation Dataset. These data sets were combined such that the latest data were made a priority as well as data collected at finer resolution. The 3D AdH code cannot include areas that wet/dry; therefore, elevations above -2 m NAVD88 were set to -2 m to ensure the domain remains wet throughout the simulation period. Figure 4 shows most of the model domain and bathymetry.

Figure 4. Model domain bathymetry.

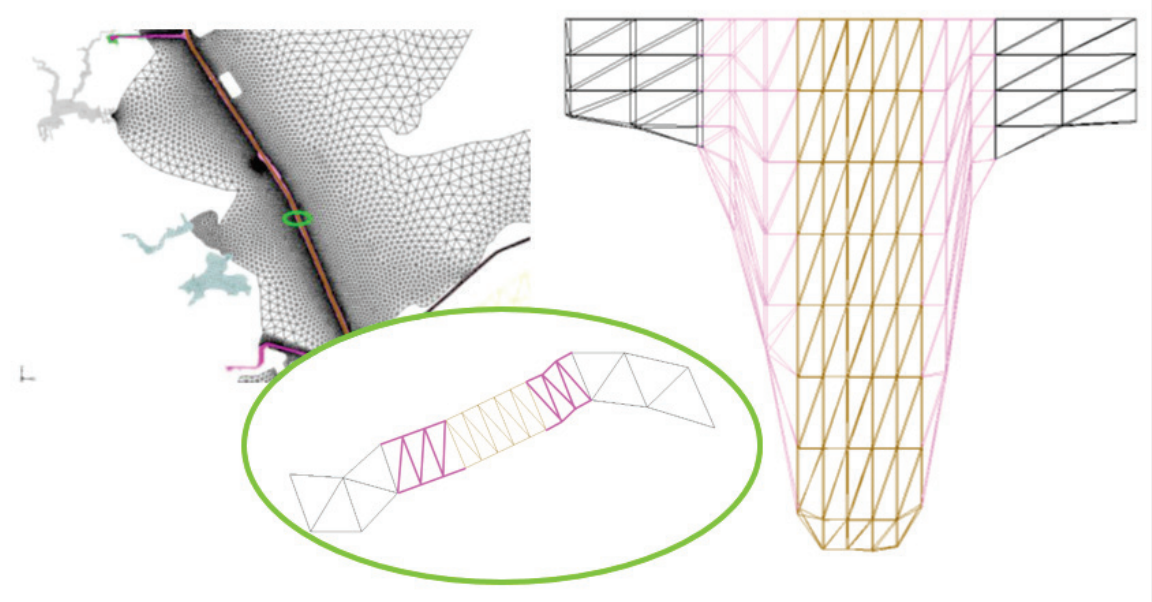


Bathymetry Data from:

- •NGDC 1/3 arc sec (~10m)
- •CRM 3 arc sec (~90m)
- •SWG hydrographic surveys
- •NED in overbanks

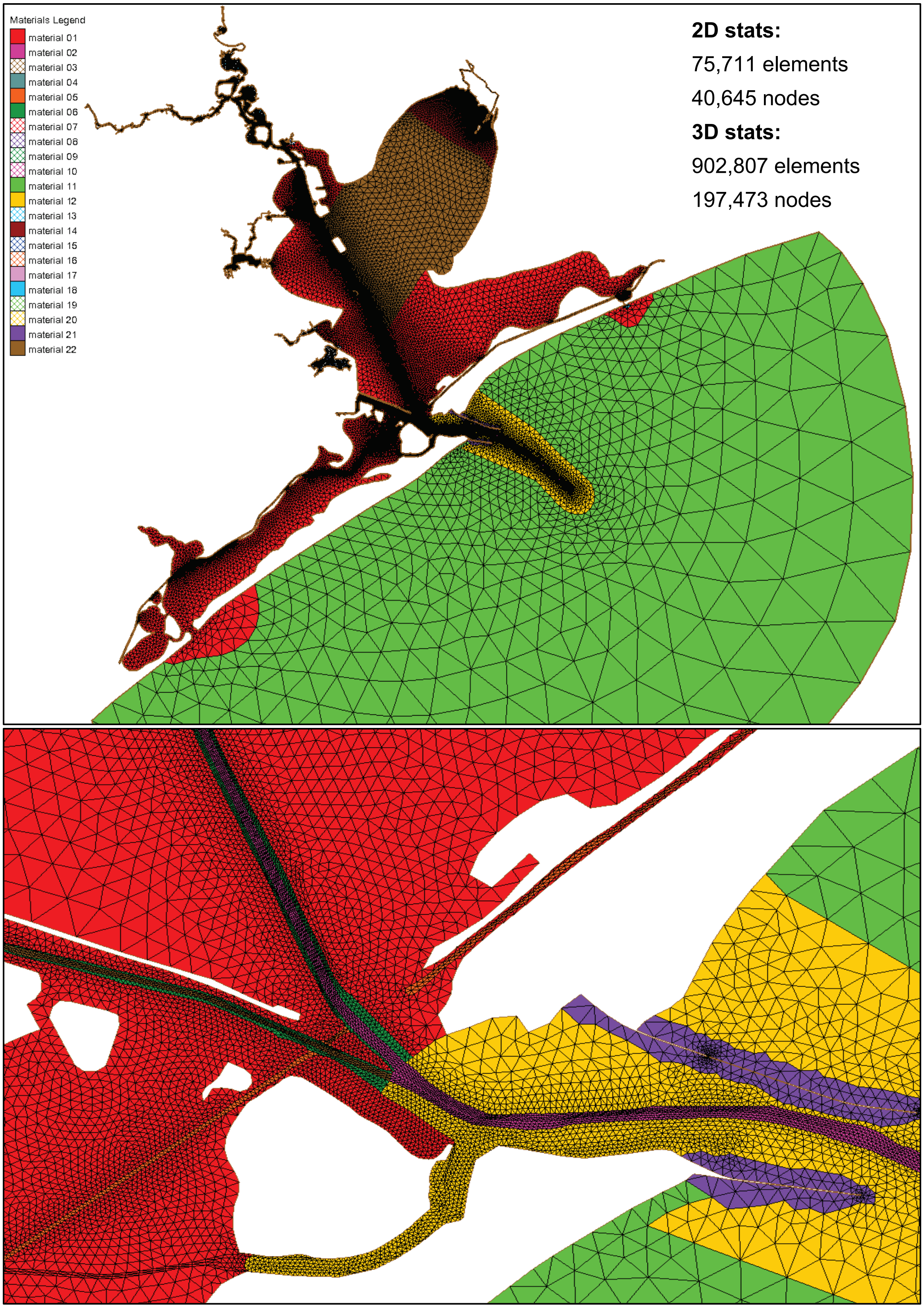
The 2D mesh was then extruded to a 3D mesh using a utility code designed specifically for use with AdH. The vertical layers are defined by elevation. All areas have at least two vertical layers with most locations having a new layer every 2 m. The Gulf of Mexico has less vertical resolution with a new layer every 5 m. Figure 5 shows the vertical layering in a cross section of the HSC.

Figure 5. Vertical mesh resolution in HSC mesh. Colors represent AdH 3D material regions.



The model domain extends over 3,200 square miles from the Gulf of Mexico to Houston, TX, and includes areas from San Louis Pass on the west to Rollover Pass on the east. The 3D mesh contains over 900,000 elements and nearly 200,000 nodes. Figure 6 shows the horizontal mesh resolution for the model domain with a close-up image on the HSC at the entrance at Bolivar Roads. Resolution is finest in the HSC to accurately capture the salinity wedge that moves along the bottom of the water column in this deep channel. Finer resolution is also seen in areas where geometric features need to be defined accurately, such as in the break in the north jetty.

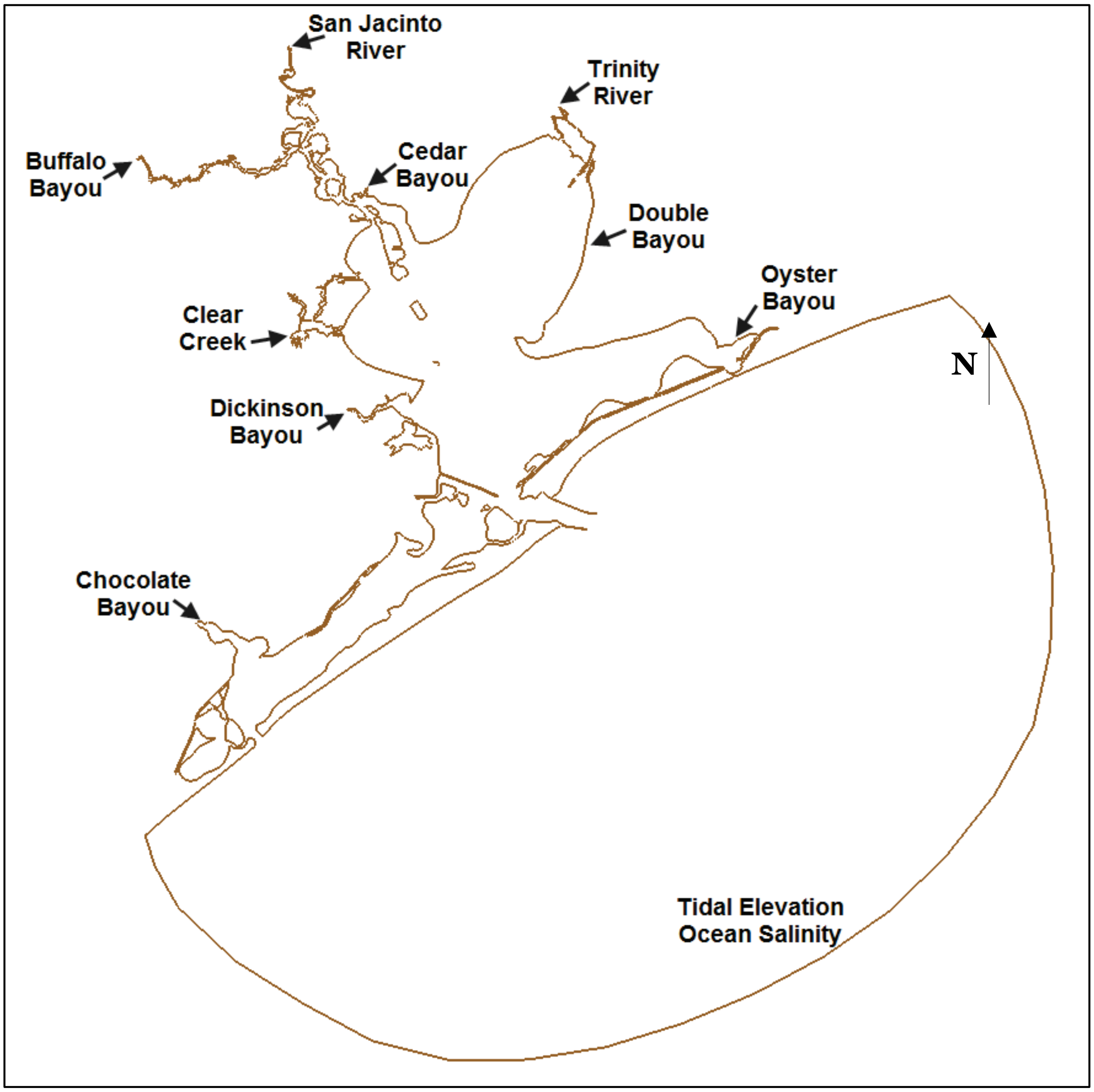
Figure 6. Horizontal mesh resolution.



Boundary conditions

The boundary conditions for this study are set up in the same manner as the previous work performed for this model domain (Tate et al. 2008). Tidal water surface elevations and salinity are applied at the ocean boundary. Winds are included throughout the model domain. Freshwater inflow is applied for the Trinity River and the San Jacinto River, as well as at other inflow locations to account for ungaged flows in the area. All inflow locations are labeled in Figure 7.

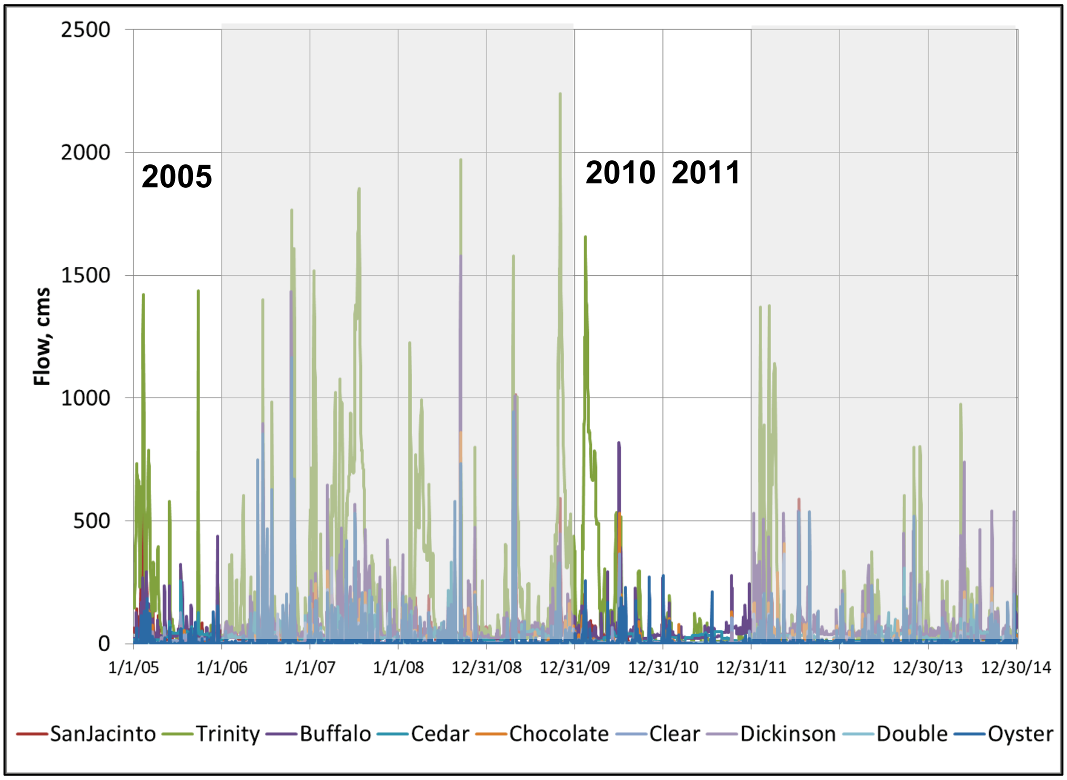
Figure 7. Inflow locations.



Freshwater inflows

Figure 8 shows the inflow discharge for the two major rivers entering the bay — Trinity River and San Jacinto River — as well as the ungaged inflows at the seven remaining locations specified in Figure 7. These flows are computed through a hydrology model maintained by the Texas Water Development Board (Schoenbaechler and Guthrie 2012). All data are provided for calendar years 2005 through 2014 to show how validation years compare.

Figure 8. River and ungaged inflows for all simulation years (2005, 2010, 2011).



Tidal boundary conditions

Water surface elevation

In addition to freshwater inflows, a tidal boundary is applied at the ocean boundary of the mesh. The tidal water surface elevation is based on harmonics for the area and measured data from National Oceanic and Atmospheric Administration (NOAA) gages at Freeport (8772447) and Sabine Pass (8770822), Texas (Figure 9). The harmonic constituents and the nonpredicted, or subtidal, signal (the difference between the predicted value based on tidal constituents and the observed value, which includes winds and other factors) for each station are used to generate a tidal forcing or water surface elevation at each node along the tidal boundary for the simulation time period. The values for each node are determined by performing a linear interpolation of the gage amplitude and phase for each tidal constituent as well as for the nonpredicted signal. The tide is then reconstituted at each location along the boundary using these interpolated parameters. The time series for the east and west endpoints of the tidal boundary is shown in Figure 10 along with the tide boundary condition at the boundary midpoint. The variation along the tidal boundary is typically less than 0.1 m.

Initially, the water surface elevation is set to the average along the tidal boundary and is a flat surface throughout the model domain. A 1-year spin-up period is executed, and the variable water surface from the end of that simulation is used as the initial condition for the analysis period model simulation.

Figure 9. Tidal water surface elevation data locations.

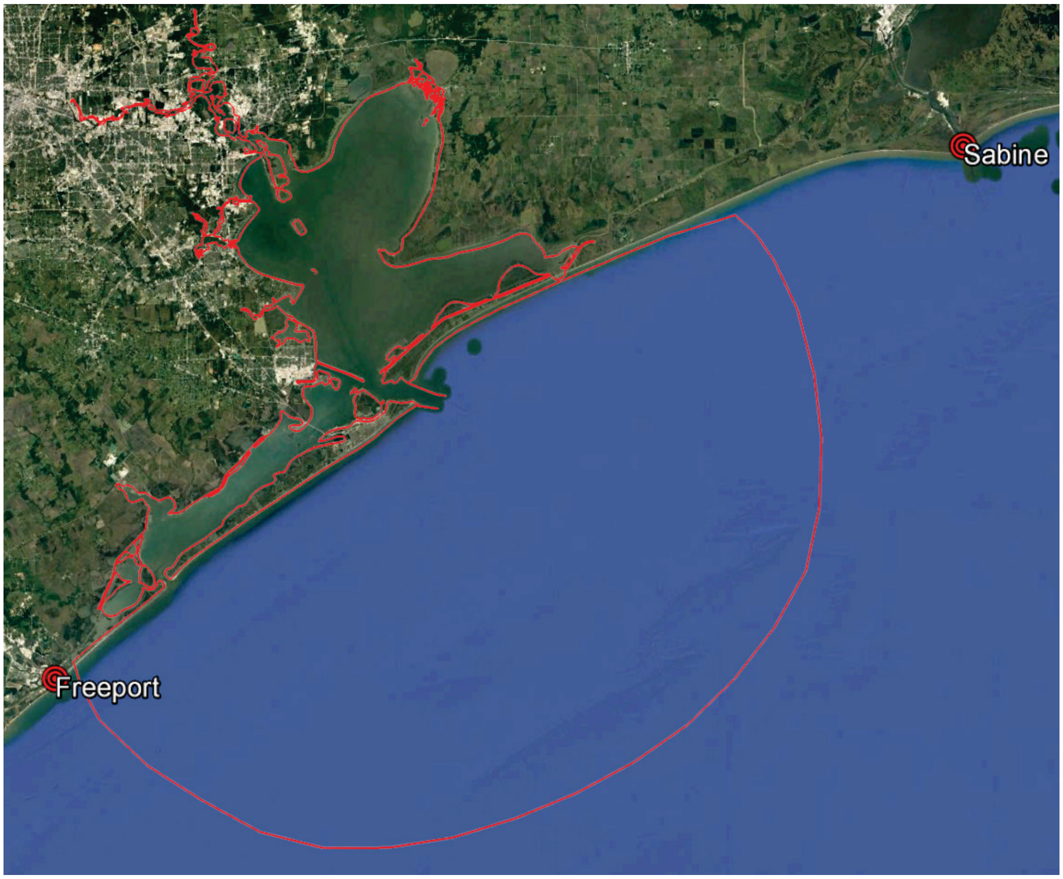
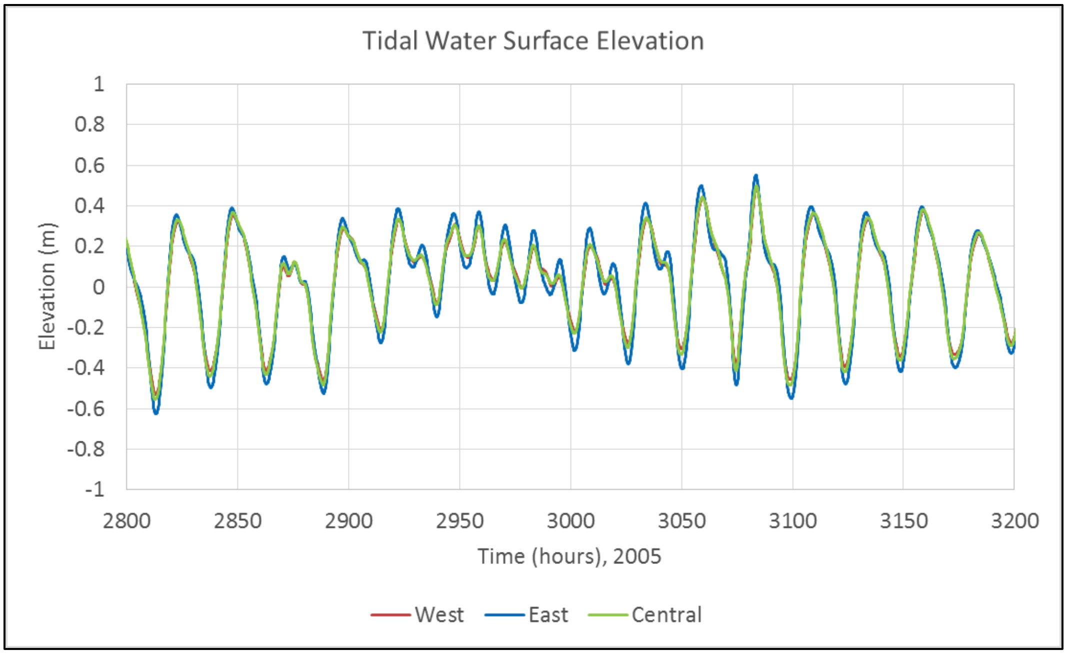


Figure 10. Water surface elevation for a section of 2005.



Salinity

Salinity is also applied at the model's Gulf of Mexico tidal boundary. A Texas Automated Buoy System (TABS) salinity gage (GERG_B) is maintained by the Texas General Land Office and the Geochemical and Environmental Research Group (GERG) at Texas A&M University and shown as the red dot in Figure 11. This gage, however, experiences biofouling and malfunctions regularly making it un-usable as a model boundary condition. Figure 12 shows plots of several years of GERG_B data – 2006 and 2008–2015. Included in the plot is a data set based on monthly averages over a 15-year period (red line) (Cochrane and Kelly 1986) as well as a data set based on salinity correlations to Mississippi River and Atchafalaya River flows (yellow line). Since the monthly average data set tends to follow the GERG_B data, where it appears to be accurate, the monthly average data set (red line in Figure 12) is used as the Gulf of Mexico salinity boundary condition. This data set is used for all calibration/validation years.

Initially, the salinity is set to an average time period throughout the model domain. A 1-year spin-up period is executed for each simulation year (typically using input data for the prior calendar year), and the salinity field from the end of that simulation is used as the initial conditions for the complete model simulation.

Figure 11. Location of GERG_B.

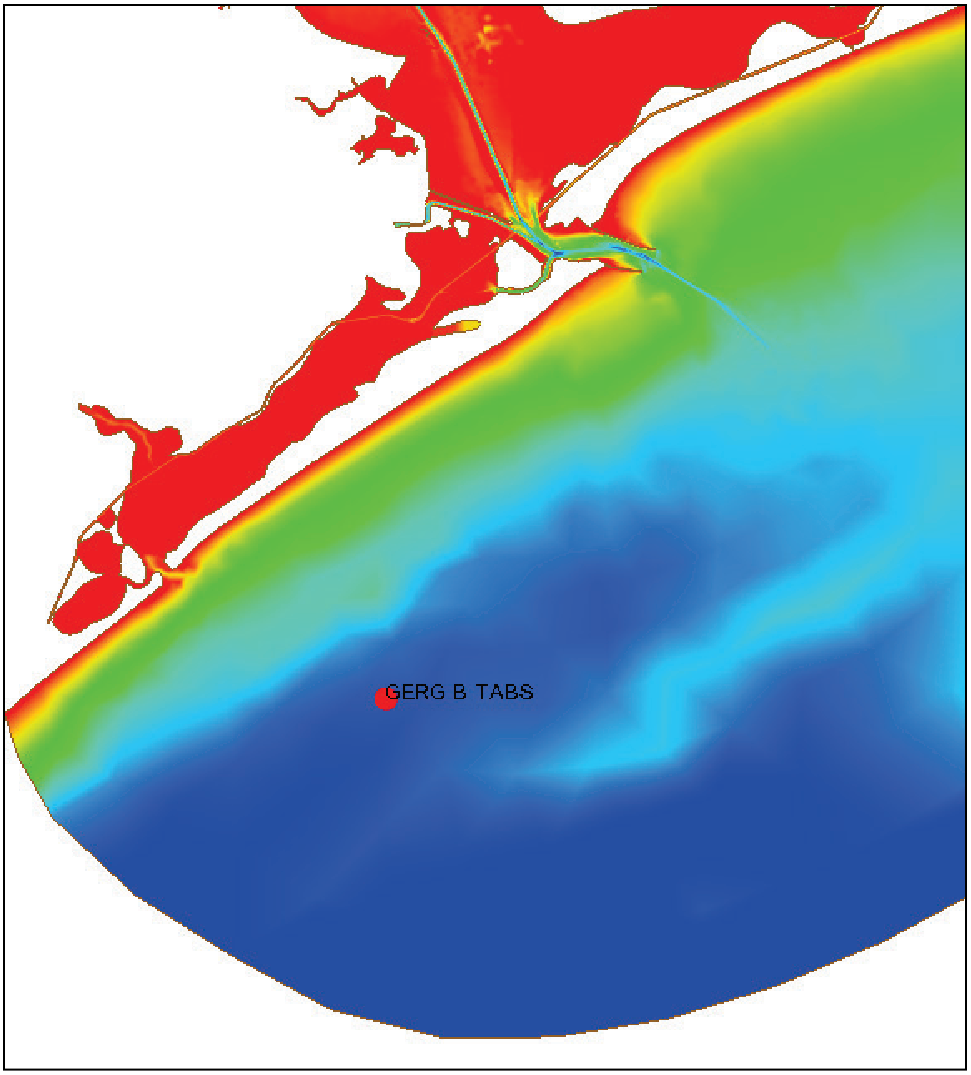
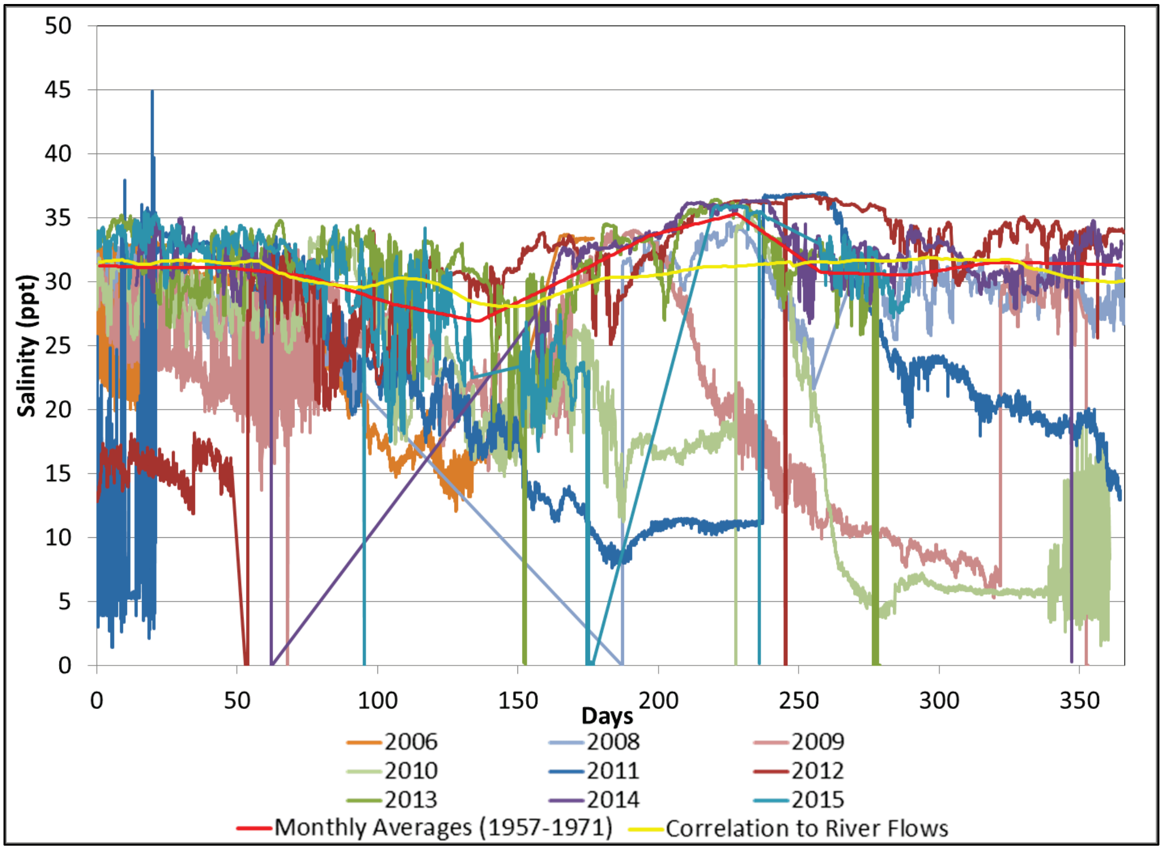


Figure 12. Gulf of Mexico salinity.



Wind conditions

The wind conditions applied to the model are obtained from the Wave Information Studies (WIS) computed wind field for points that lie in the vicinity of the model domain (Hubertz 1992). There are 26 WIS sites for this model (see Figure 13). The WIS model is validated against measurement sites where applicable, and these wind data allow for variable wind conditions across the domain. The wind data are supplied to the AdH model as time series of x- and y-velocities. These wind components are then converted to a shear stress dependent on conditions set for each material — deeper water uses a Wu formulation (Wu 1969, 1982) and shallow regions use a Teeter formulation (Teeter 2002). The wind rose for each data site for all three calibration/validation years is shown in Figure 14 through Figure 16.

Figure 13. Wind data boundary condition locations.

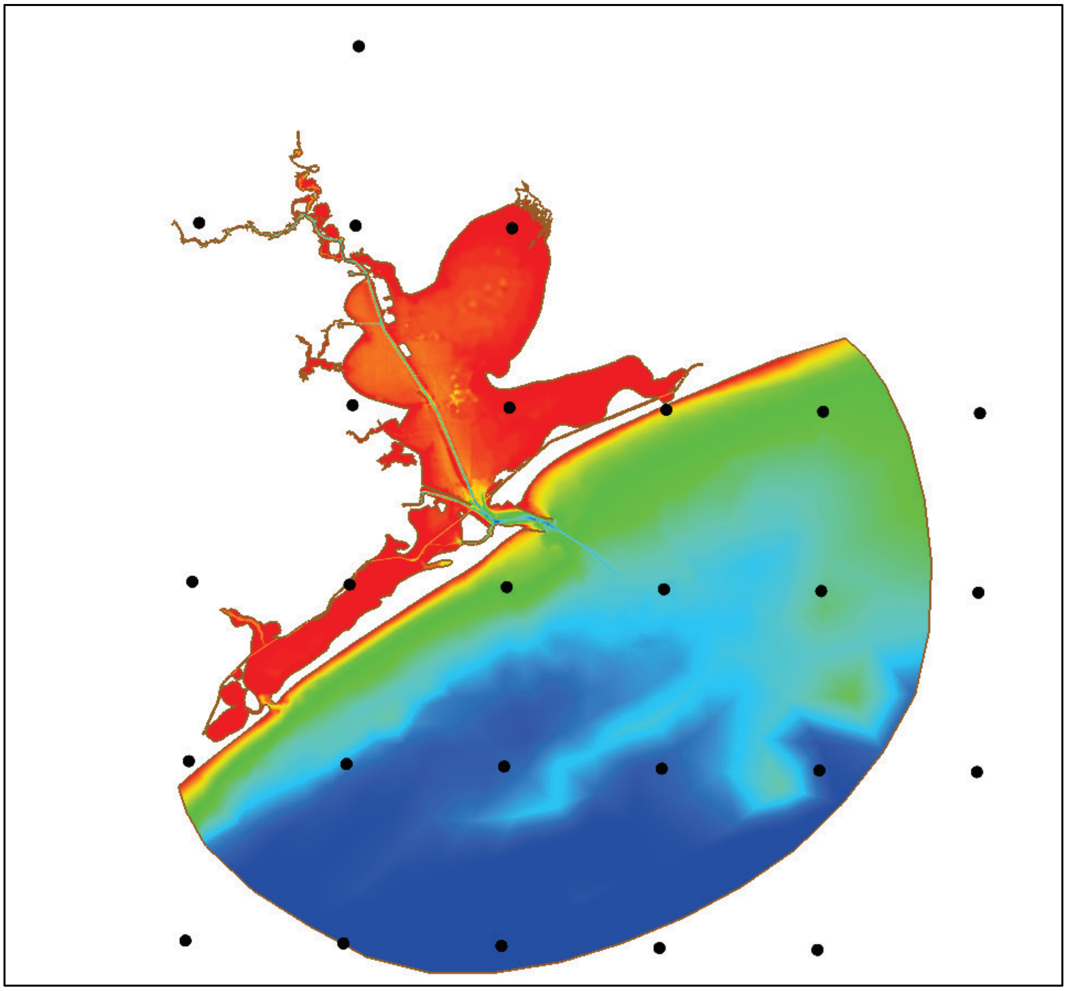


Figure 14. 2005 wind rose for all sites.

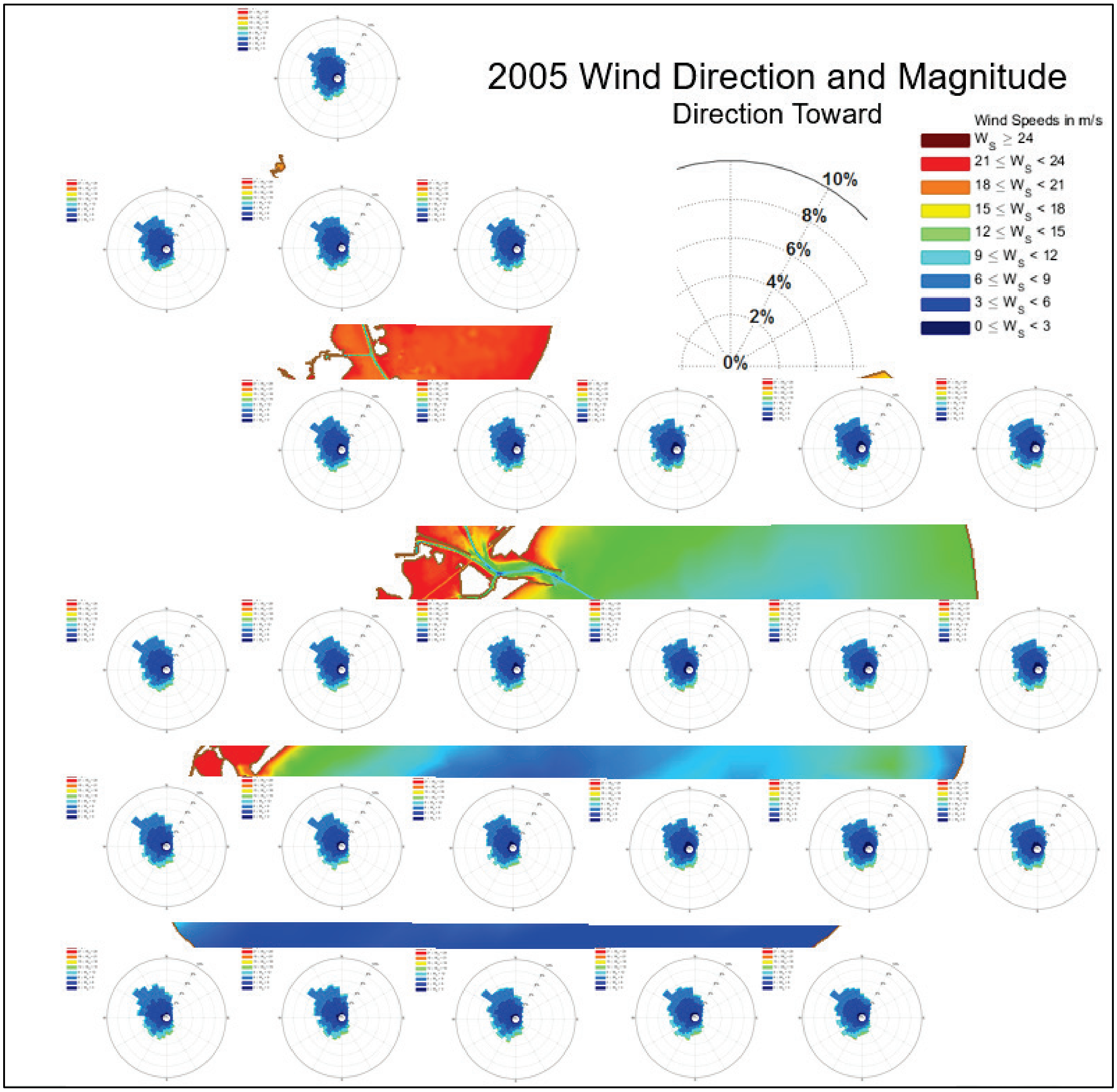


Figure 15. 2010 wind rose for all sites.

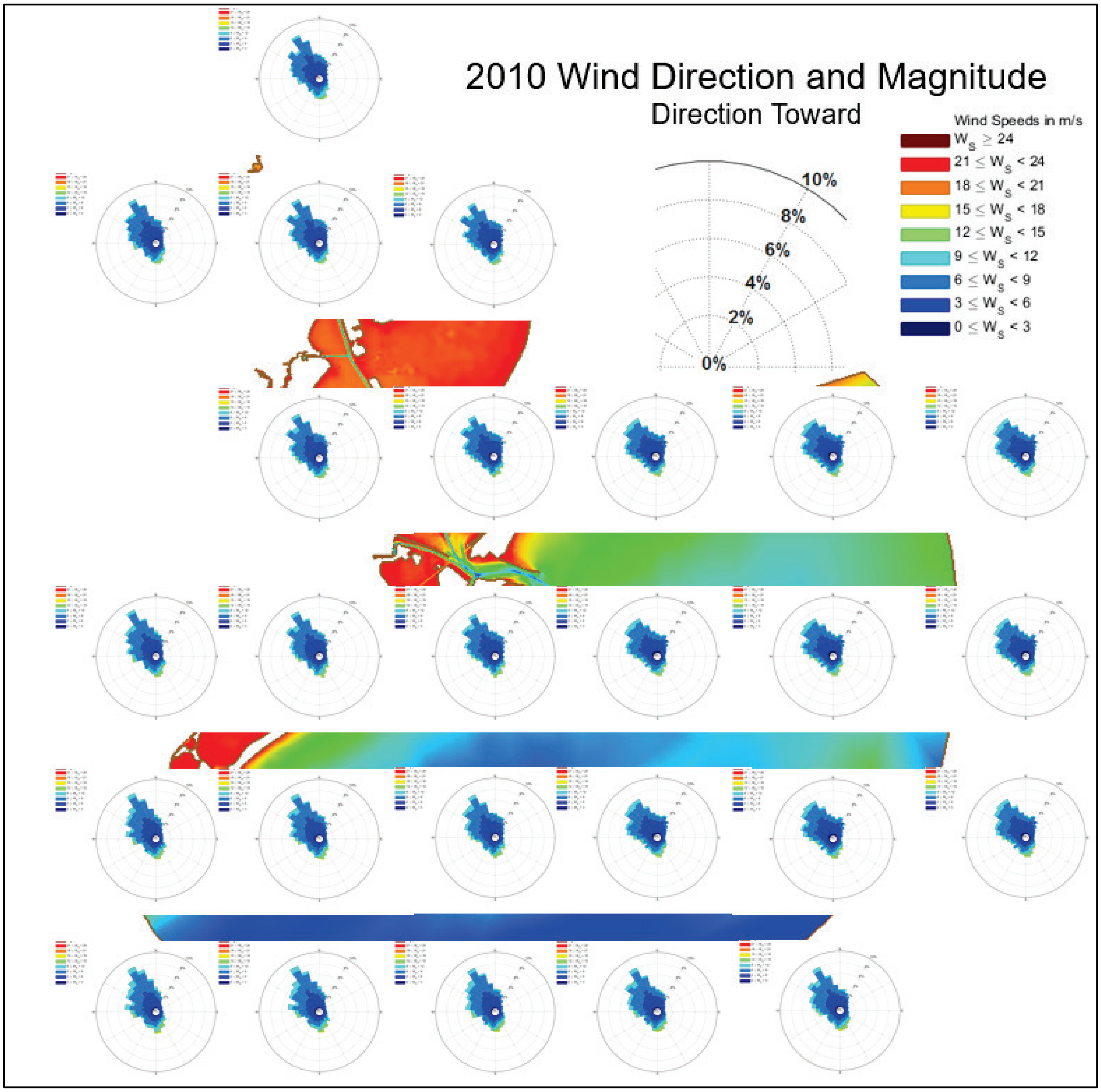
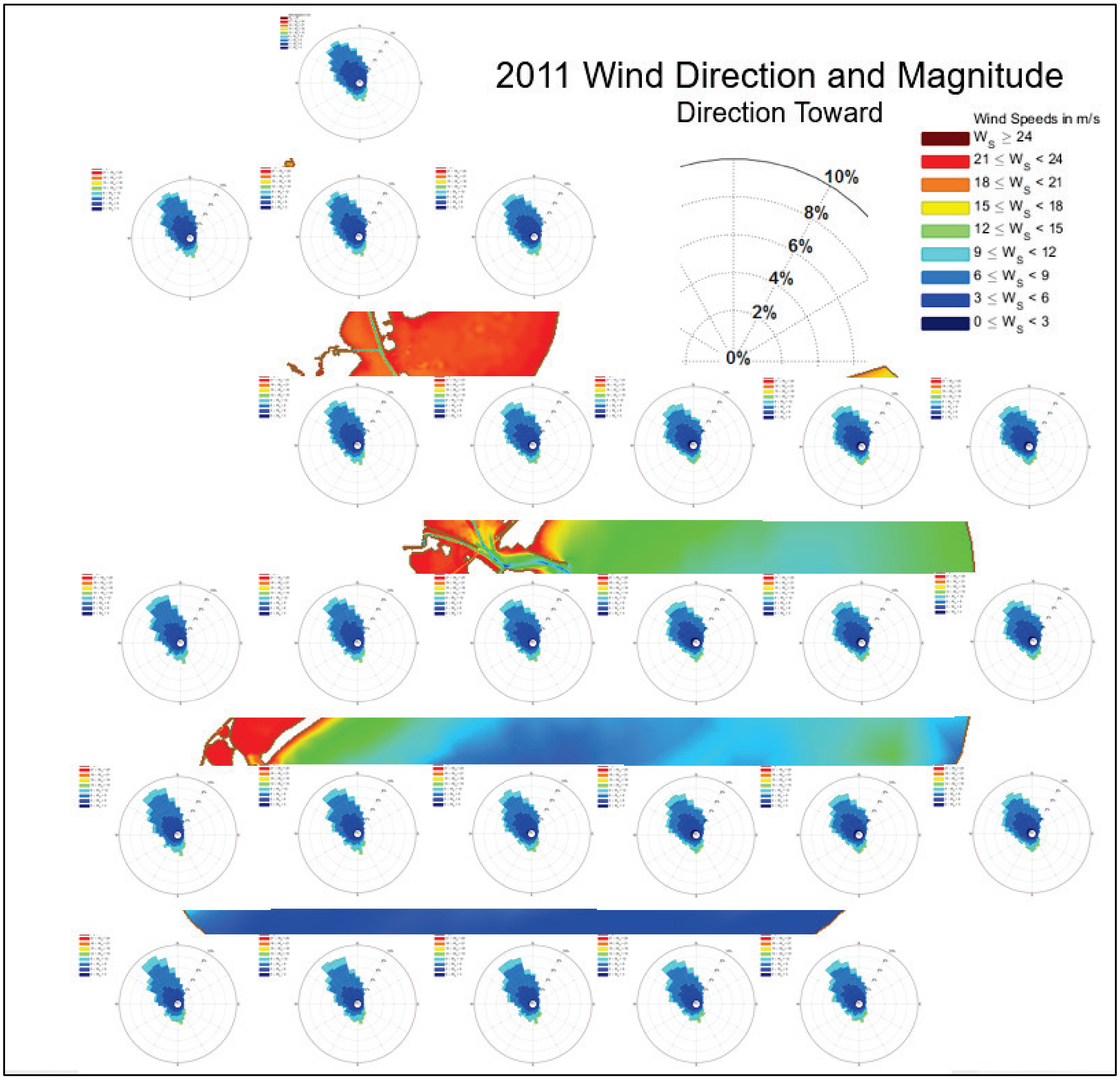


Figure 16. 2011 wind rose for all sites.



Meteorological conditions

To accurately reproduce salinity values in Trinity Bay, it was determined that rainfall and precipitation should be included in the model. These data (shown in Figure 17 through Figure 19) were also obtained from the Texas Water Development Board (TWDB), and the data are based on wind and temperature computations validated to several measurement locations using the Texas Rainfall Runoff Model. The combination of precipitation (rainfall only in south Texas) and evaporation is applied equally over the model domain. The drought conditions of 2011 are visible in the meteorological data.

Figure 17. 2005 meteorological conditions.

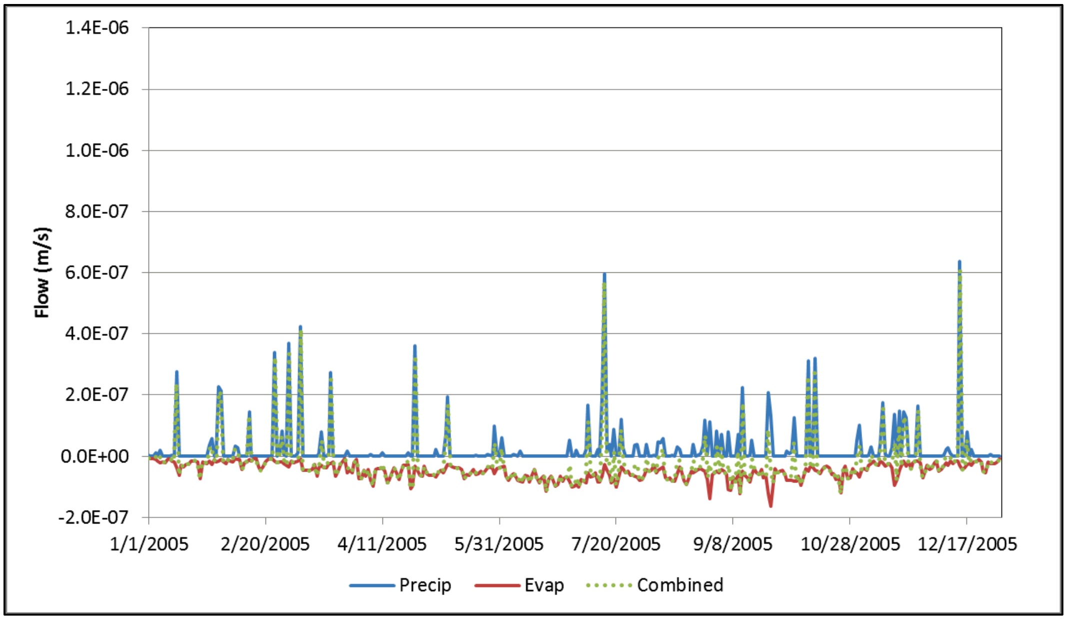


Figure 18. 2010 meteorological conditions.

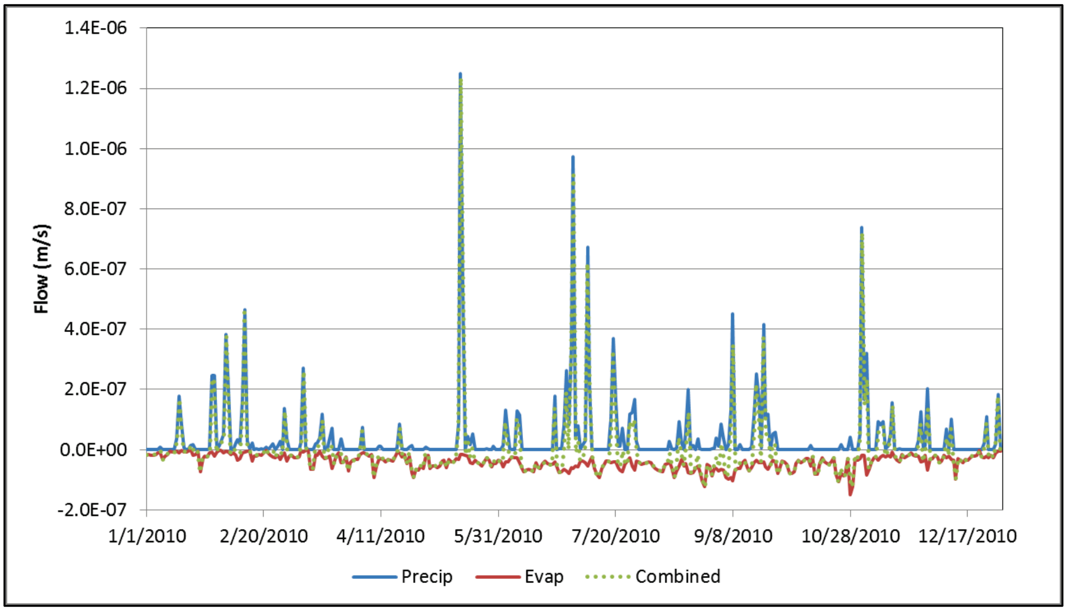
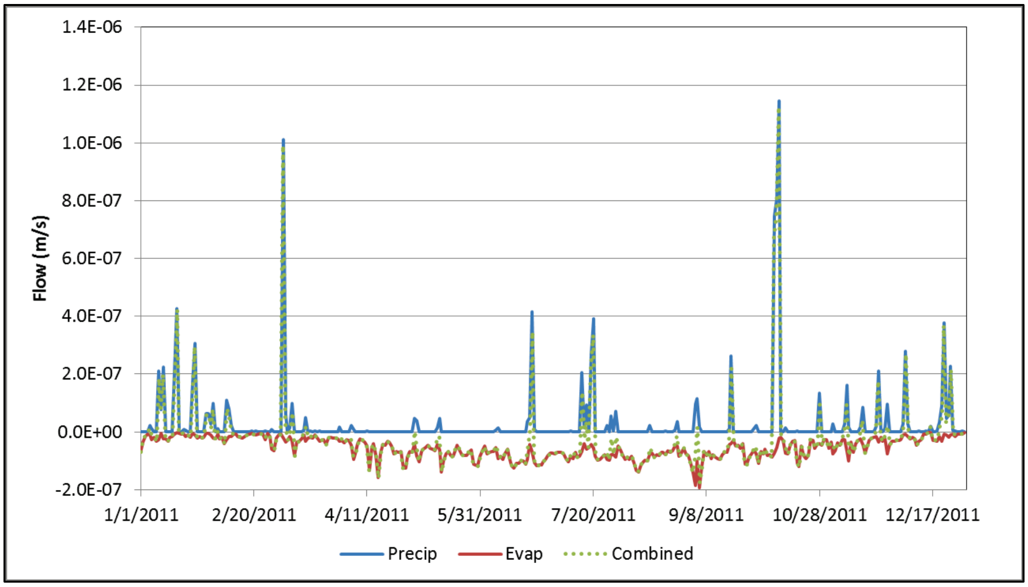


Figure 19. 2011 meteorological conditions.



Sediment model boundary conditions

The sediment model is fully coupled with the hydrodynamic model when simulating AdH with SEDLIB. The boundary conditions for the sediment model include grain characteristics, bed definitions, and sediment loads. The conditions established from the previous sediment model validation (Tate et al. 2008) were determined from field samples (although a small sample set) in Trinity and Galveston Bays, and these parameters were used as initial parameters for the present AdH/SEDLIB sediment model. This model includes five fine sediment classes (sizes defined by the American Geophysical Union [AGU]), which encompasses the majority of the sediment present in the domain. Sand is dominant at the entrance at Bolivar Roads, but it primarily remains in that area and therefore is not included in these simulations. The sediment-specific parameters are given in Table 1. These parameters are utilized for suspended and newly deposited grains.

Table 1. Sediment parameters and values.

Grain Class (AGU)	Diameter (mm)	Specific Gravity	Density (kg/m^3)	Critical Shear for Erosion (Pa)	Erosion Rate Constant	Critical Shear for Deposition (Pa)	Settling Velocity (mm/s)
Clay	0.003	2.65	1275	0.1	0.0000384	0.05	0.009
Very Fine Mud	0.006	2.65	1275	0.2	0.0000384	0.06	0.036
Fine Mud	0.011	2.65	1275	0.3	0.0000384	0.07	0.121
Medium Mud	0.023	2.65	1275	0.4	0.0000384	0.08	0.529
Coarse Mud	0.045	2.65	1275	0.6	0.0000384	0.10	2.025

Since the data available to define the sediment bed throughout the full model domain are limited (most is only in the HSC) and many years old (URS Group Inc. 2009; Buczkowski et al. 2006), the hydrodynamics of the system are used to sort the bed prior to validation and alternative simulations. This step is performed by setting the top-most defined bed layer to equal fractions for all of the grains (0.2 for all five grains). This layer is also defined as 0.2 m thick — selected because erosion beyond this value during the course of the simulation year is likely prevented due to bed armoring or nonedible material; it is known that the bay system is not eroding at a significant rate (Nichols 1989). Three additional bed layers are defined to track deposition events and help define bed features that may change the erosion/deposition potential. The cohesive bed properties that help determine erosion potential of a bed layer are defined with bulk density of 1400 kilograms per cubic meter, critical shear stress for erosion of 1.0 Pascal, erosion rate constant of 0.000062, and erosion rate exponent of 1.0.

As the model runs and the bed begins to sort and change, the bed properties vary from these initially defined parameters. An initial 1-year simulation is performed with no bed displacement allowed so that the bed can sort based on the erosion and deposition tendencies in each area. The results of this spin-up simulation are then used as the initial conditions for the analysis model run with the bed allowed to change due to computed erosion and deposition.

The sediment entrainment algorithm used in this model is Wright-Parker (Wright and Parker 2004), and the hiding factor algorithm is Egiazaroff (Egiazaroff 1965). Flocculation properties are not included in the AdH code and should be considered when defining the sediment grain properties. There is no bedload in the present 3D Shallow Water AdH code, and cohesive bed consolidation is not included in this model due to the short simulation time of 1 year for each analysis model run.

Sediment loads are applied to the two major rivers in the area: the Trinity River and the San Jacinto River. These loads are determined from a rating curve correlating discharge with concentration generated using data from the U.S. Geological Survey as documented in Tate et al. (2008).

$$C_{Trinity} = 0.7704*Q_{Trinity}^{0.5716}$$

$$C_{SanJacinto} = 7.1547*Q_{SanJacinto}^{\ 0.3234}$$

These load estimates are not ideal. The Trinity River load is based on 2 years of data collected at the Wallisville lock, which is the upstream model boundary for this river. The San Jacinto River load is based on limited data from Conroe, TX, which is located on the Western fork of the river and upstream of Lake Houston. The sediment loads applied at each river for each of the validation years are shown in Figure 20 through Figure 22. The total load is divided equally among the five grain classes. The load information for the ungaged inflows is unknown and therefore set to zero.

Figure 20. 2005 total sediment load for Trinity and San Jacinto Rivers.

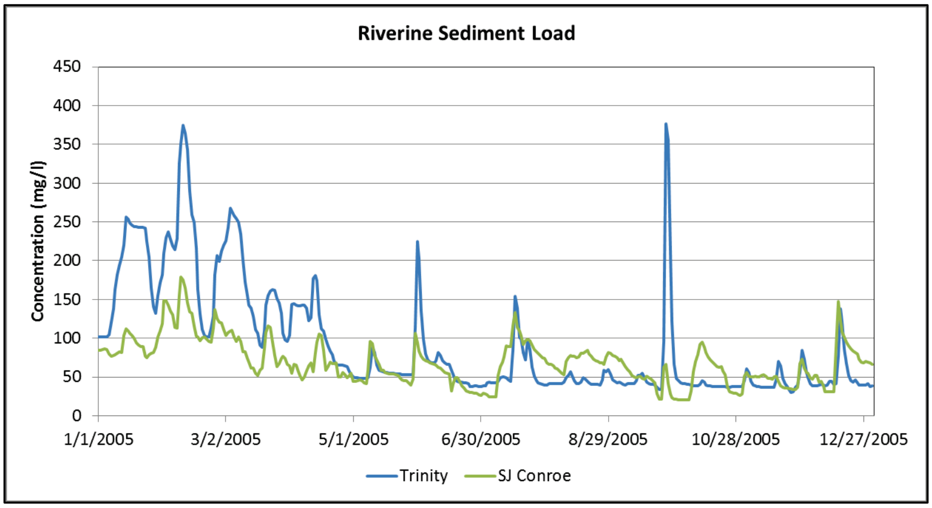


Figure 21. 2010 total sediment load for the Trinity and San Jacinto Rivers.

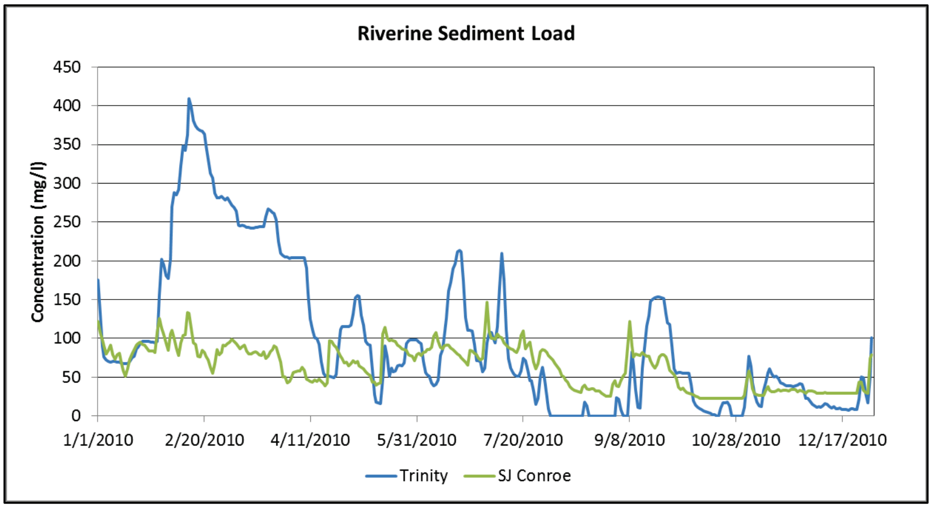
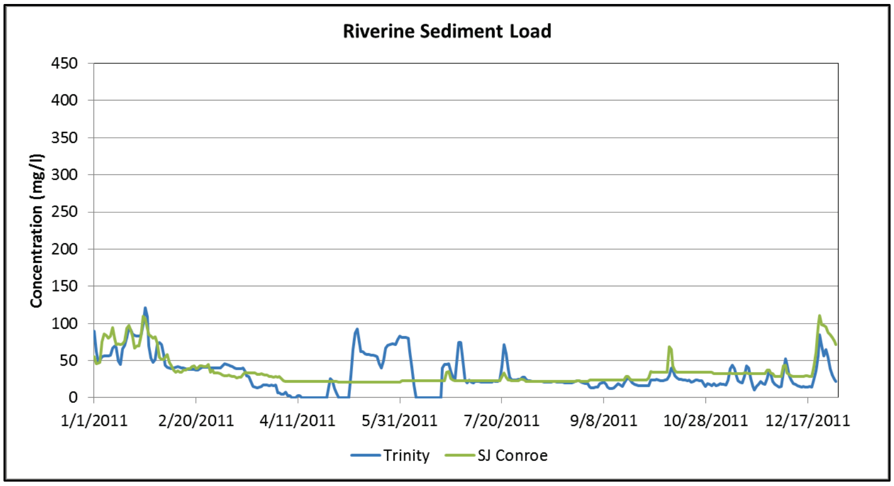
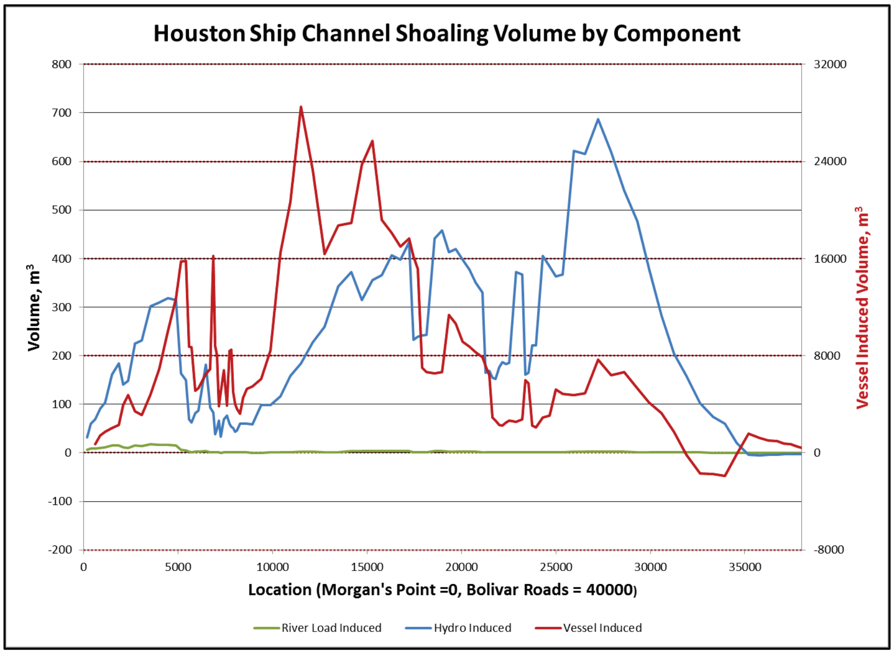


Figure 22. 2011 total sediment load for Trinity and San Jacinto Rivers.



The sedimentation in the HSC and Trinity and Galveston Bays is influenced greatly by deep-draft vessel passages in the area (Tate et al. 2008, 2014). Figure 23 shows model-computed results indicating that vessel induced shoaling can produce 4 times more shoaled volume in the HSC than other factors such as tidally driven sedimentation and river sediment loads. The model presented in this report does not include vessel impacts indicating an expectation to underpredict the sediment volumes. Shoaling drivers not specifically in the model are incorporated as part of a scaling process performed during model calibration/validation.

Figure 23. Influences on HSC shoaling.



AdH model parameters

The parameters used by AdH to achieve the validated model (discussed in the following sections) are provided in Table 2. This table provides the specific or range of values used for various model properties such as bed roughness, diffusion, eddy viscosity, and turbulence. The values vary by location (material designation) and sediment grain class. Large values of diffusion, viscosity, and turbulence coefficients (increased generally to maintain model stability) are associated with larger grain sizes and locations away from the immediate study area.

Table 2. Model parameters.

Parameter	Value
Turbulent Diffusion of Salinity	0.00005 – 0.1 m^2/s
Turbulent Diffusion of Cohesive Sediment	0.001 – 10.0 m^2/s
Eddy Viscosity	0.0001 – 1.5 m^2/s
Turbulence (Smagorinsky Coefficient)	0.2 – 0.8
Bed Roughness (Manning's Coefficient)	0.015
Time Stepping	Second Order
Time-Step Maximum	150 s
Convergence	0.01 (Increment Norm)

3 Model/Field Comparison – Calibration and Validation

The model is calibrated/validated by comparing to measured field data over 3 different years — 2005, 2010, and 2011. These 3 years were used to take advantage of various data sets for hydrodynamics, salinity, and sediment transport as well as provide a wide range of conditions over which the model is considered accurate. Year 2005 served as a calibration period such that parameters — such as bed roughness, salinity diffusion, viscosity, and sediment properties — were adjusted, within a physically reasonable range, to get the best match to the field data. Those parameters were then unchanged when the model was simulated and compared to the field (validated) for 2010 and 2011. Most data were obtained from publicly accessible data websites. For all comparison types — hydrodynamic, salinity, and sediment — a subset of the sites are provided in the body of the report with all site comparisons provided in the appendices.

Hydrodynamic calibration

The model is compared to water surface elevation and velocity at several locations during the 2005 calibration period. Water surface elevation data were obtained from the NOAA Co-Ops and the National Data Buoy Center. Velocity data were obtained from NOAA PORTS.

Water surface elevation

Water surface elevation results are compared to the field at six locations. Figure 24 shows the location of the water surface elevation comparison sites. Statistical comparisons are provided in Table 3. Time history and box plot comparisons at Manchester, Morgans Point, and Eagle Point are shown in this section (see Figure 25 through Figure 27 and Figure 28 through Figure 30). The full set of comparisons is provided in Appendix A.

For the time history plots, the green line represents the measured field data, and the blue line represents the model computed values. Each comparison location also includes a box plot showing the relationship between the measured field data (*x*-axis) and the modeled data (*y*-axis). A perfect match would yield points on the black 1:1 line.

Figure 24. Water surface elevation comparison locations.

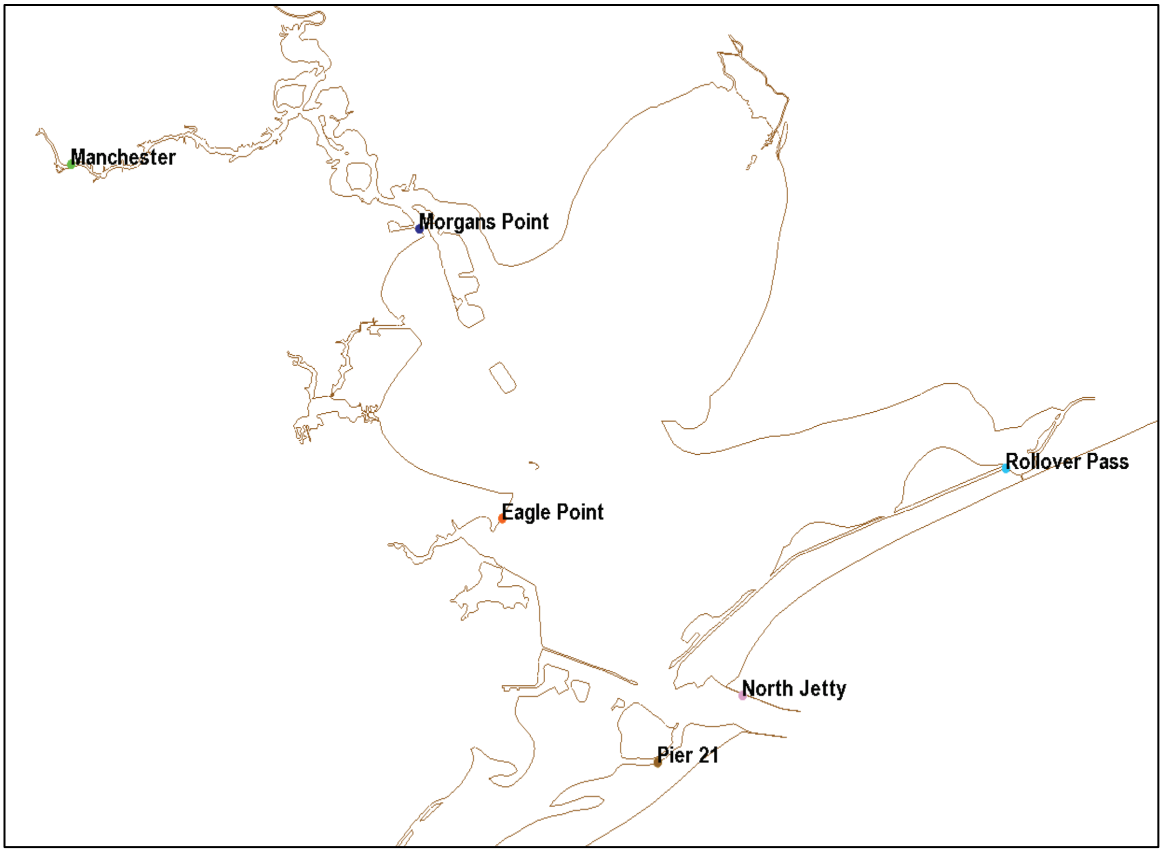


Table 3. Statistical model/field calibration comparison of water surface elevation.

	2005 Root Mean Square Error	2005 Correlation Coefficient
Manchester	0.12	0.90
Morgan's Point	0.07	0.96
Eagle Point	0.06	0.97
Pier 21	0.07	0.97
North Jetty	0.05	0.98
Rollover Pass	0.12	0.85

Figure 25. Water surface elevation calibration comparisons over time for Manchester.

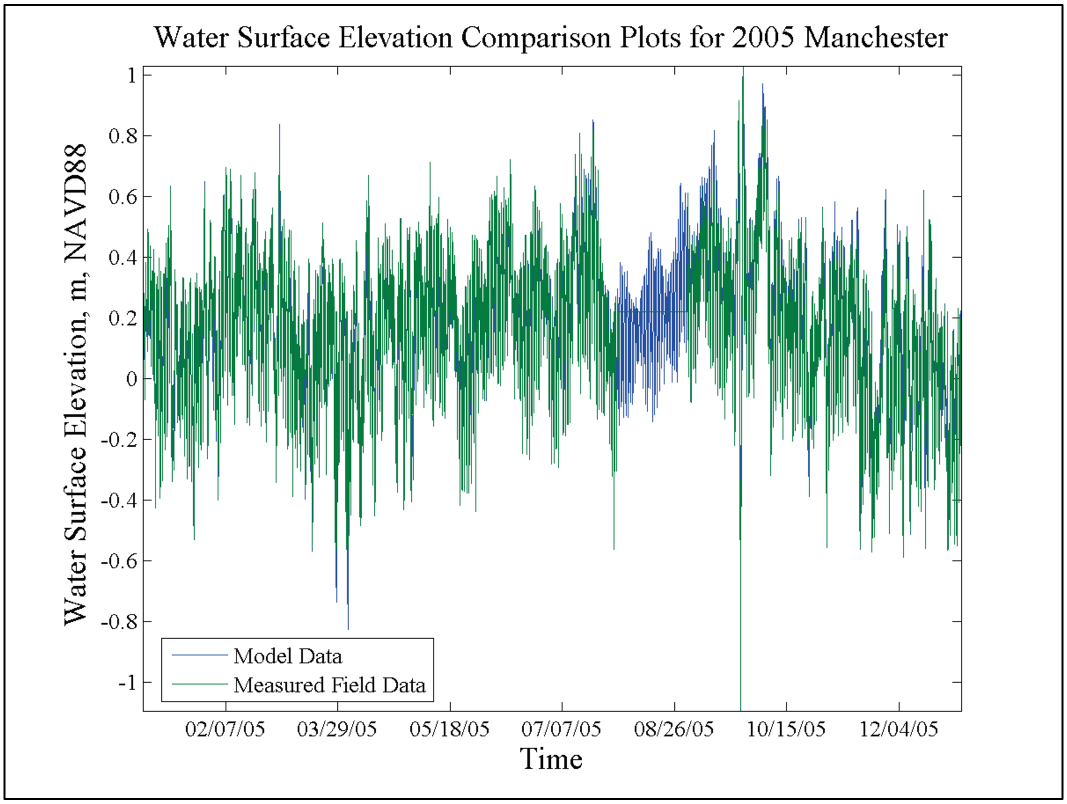


Figure 26. Water surface elevation calibration comparisons over time for Morgans Point.

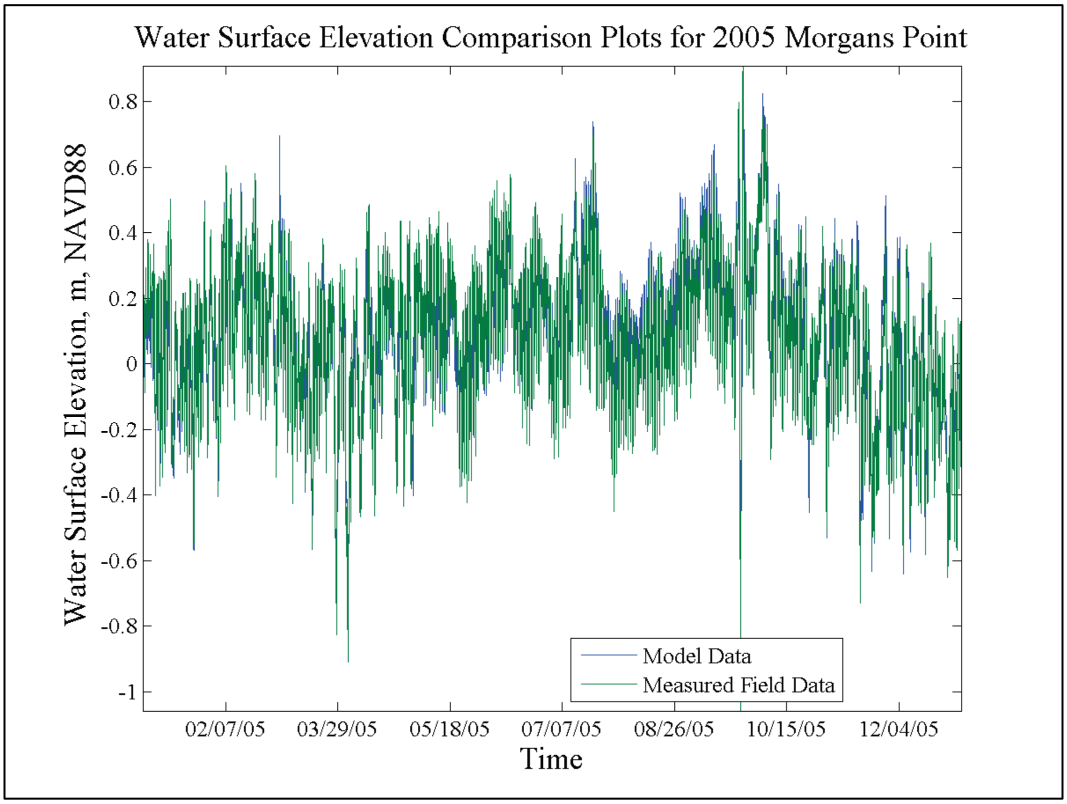


Figure 27. Water surface elevation calibration comparisons over time for Eagle Point.

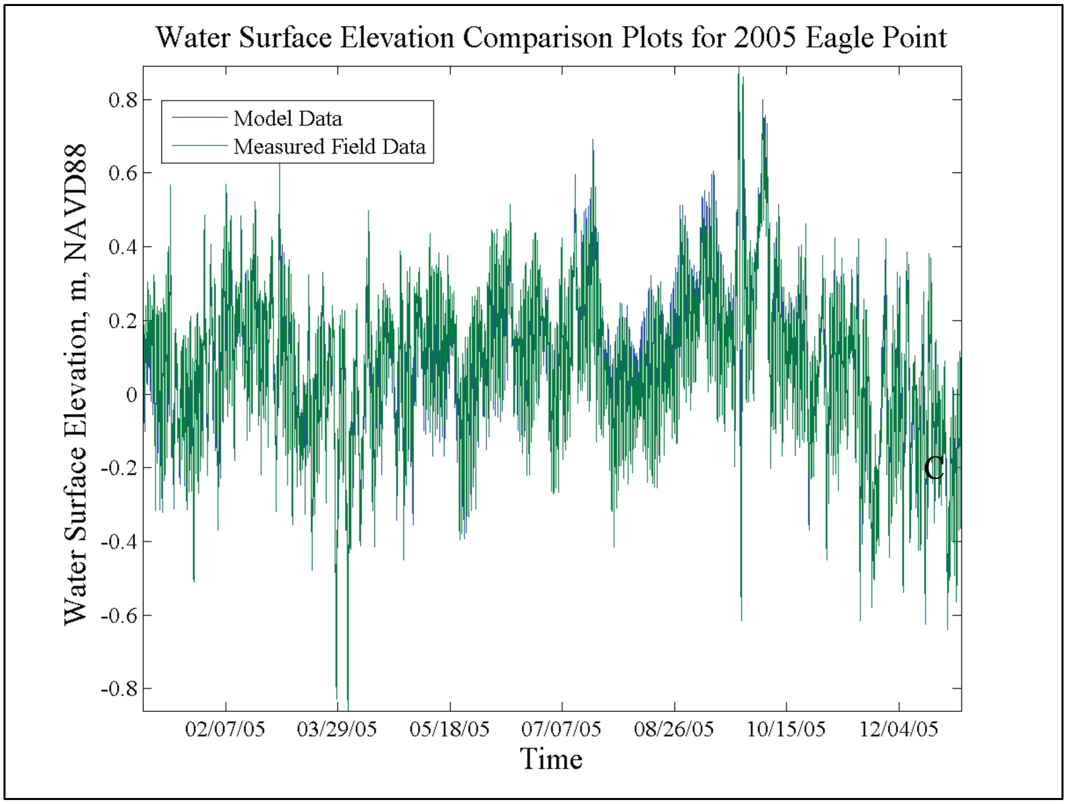


Figure 28. Water surface elevation calibration comparison box plot for Manchester.

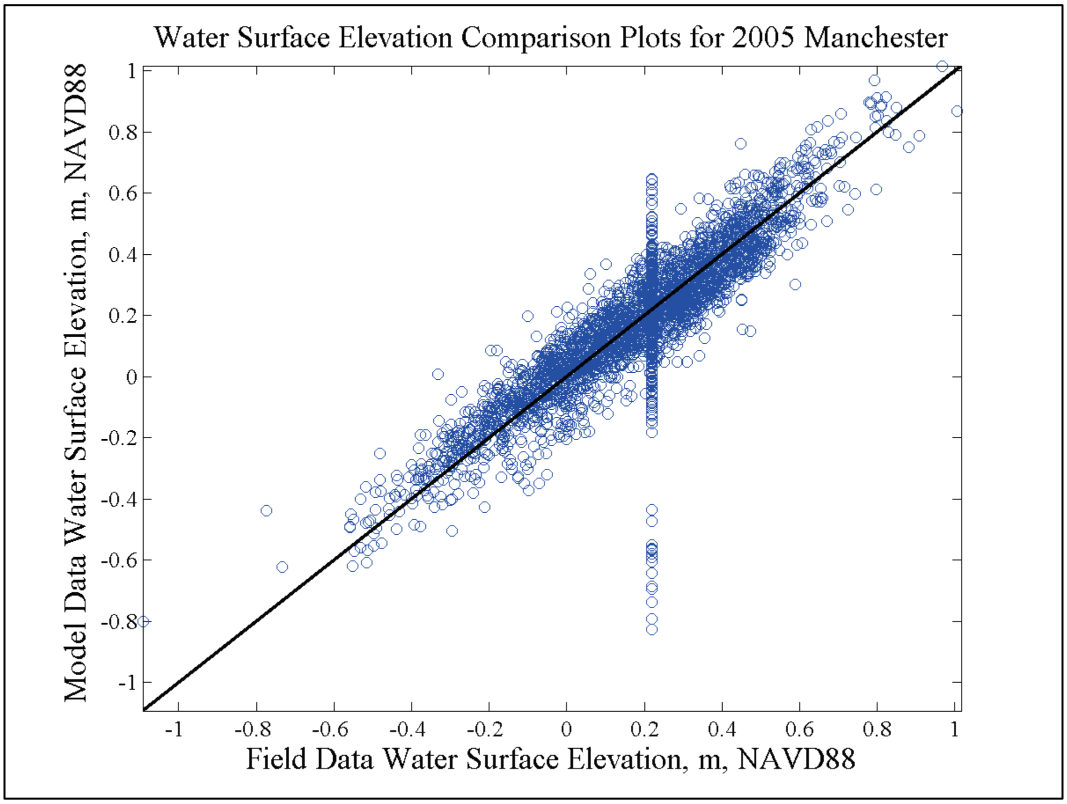


Figure 29. Water surface elevation calibration comparison box plot for Morgans Point.

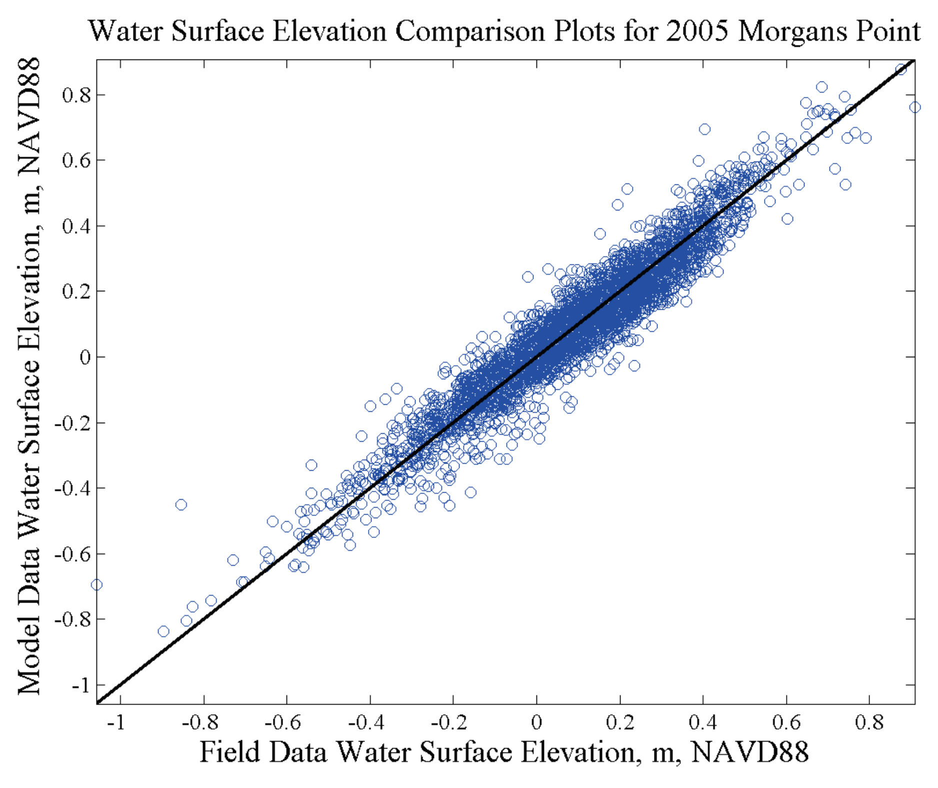
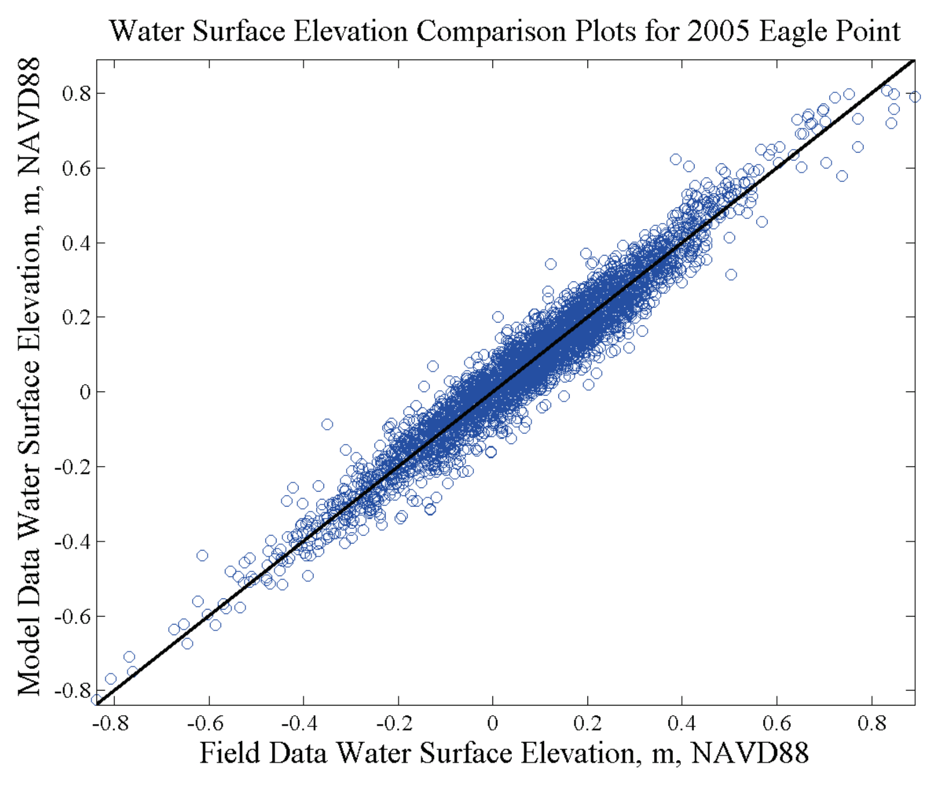


Figure 30. Water surface elevation calibration comparison box plot for Eagle Point.



Velocity

Velocity calibration comparisons are made at one location from NOAA PORTS (Figure 31) - Morgan’s Point. Additional sites are available for comparison of the validation years. Figure 32 shows the time history velocity magnitude and direction (positive: flood; negative: ebb) for this location. The overall pattern of the surface velocity signal is reproduced by the model, and the comparison of the magnitude is also good.

Figure 31. Velocity calibration comparison locations.

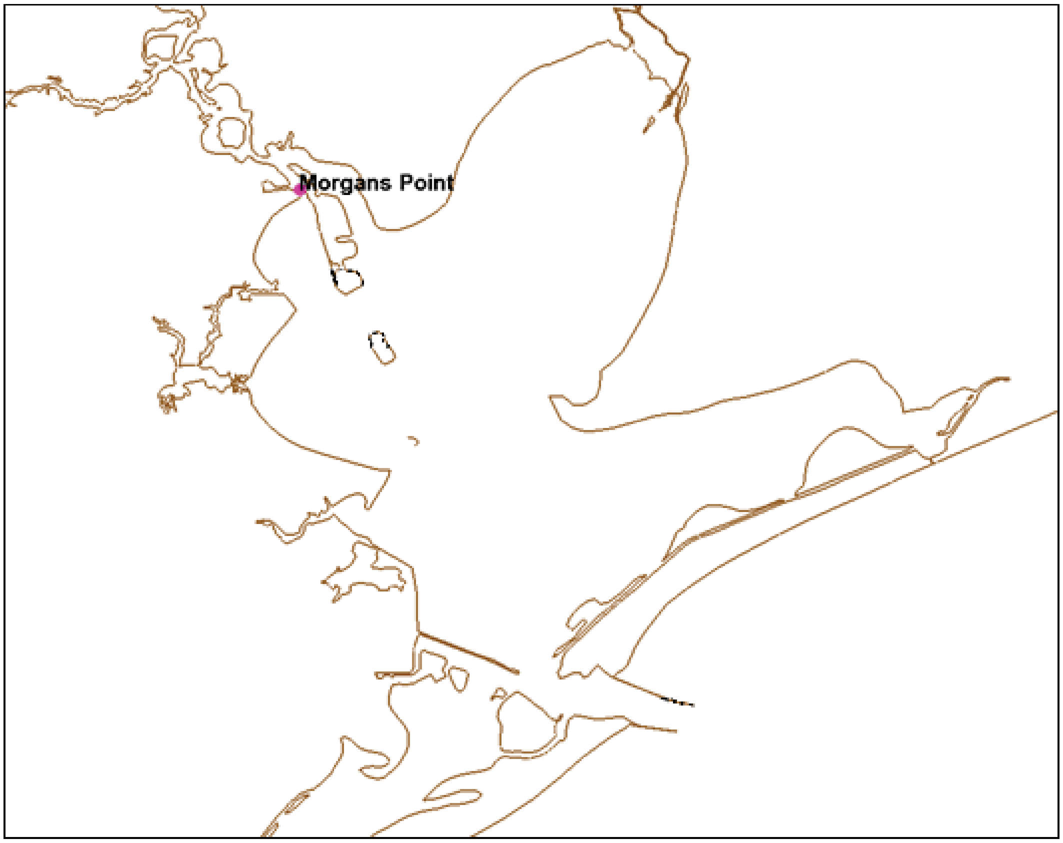
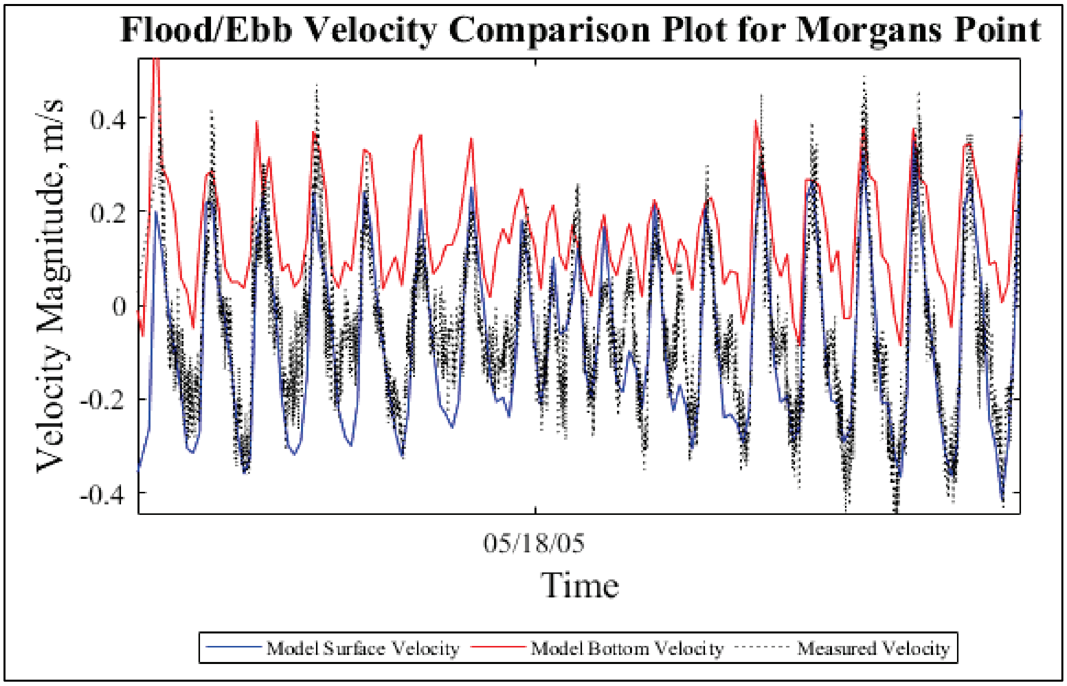


Figure 32. 2005 Morgan's Point velocity comparison (positive: flood; negative: ebb).



Salinity calibration

The 2005 field salinity data for model calibration were obtained from TWDB (Figure 33), Texas Commission on Environmental Quality (TCEQ) (Figure 34), and Houston Advanced Research Center (HARC) (Figure 35). There are 24 total salinity calibration sites throughout the HSC and the surrounding bays.

Time-history comparisons at selected locations are shown in this section. The field data are represented by stars where data are sparse and smaller black dots where data are numerous whereas the model data are shown in blue for surface salinity and in red for bottom salinity. In deep, stratified regions, the bottom salinity is larger than the surface salinity. In well-mixed regions the two should be approximately equal. The field-measured salinity is typically measured at the surface, but it is not specified for all data. A subset of comparisons is provided with the full set of comparisons provided in Appendix B.

Figure 33. TWDB 2005 salinity calibration sites.

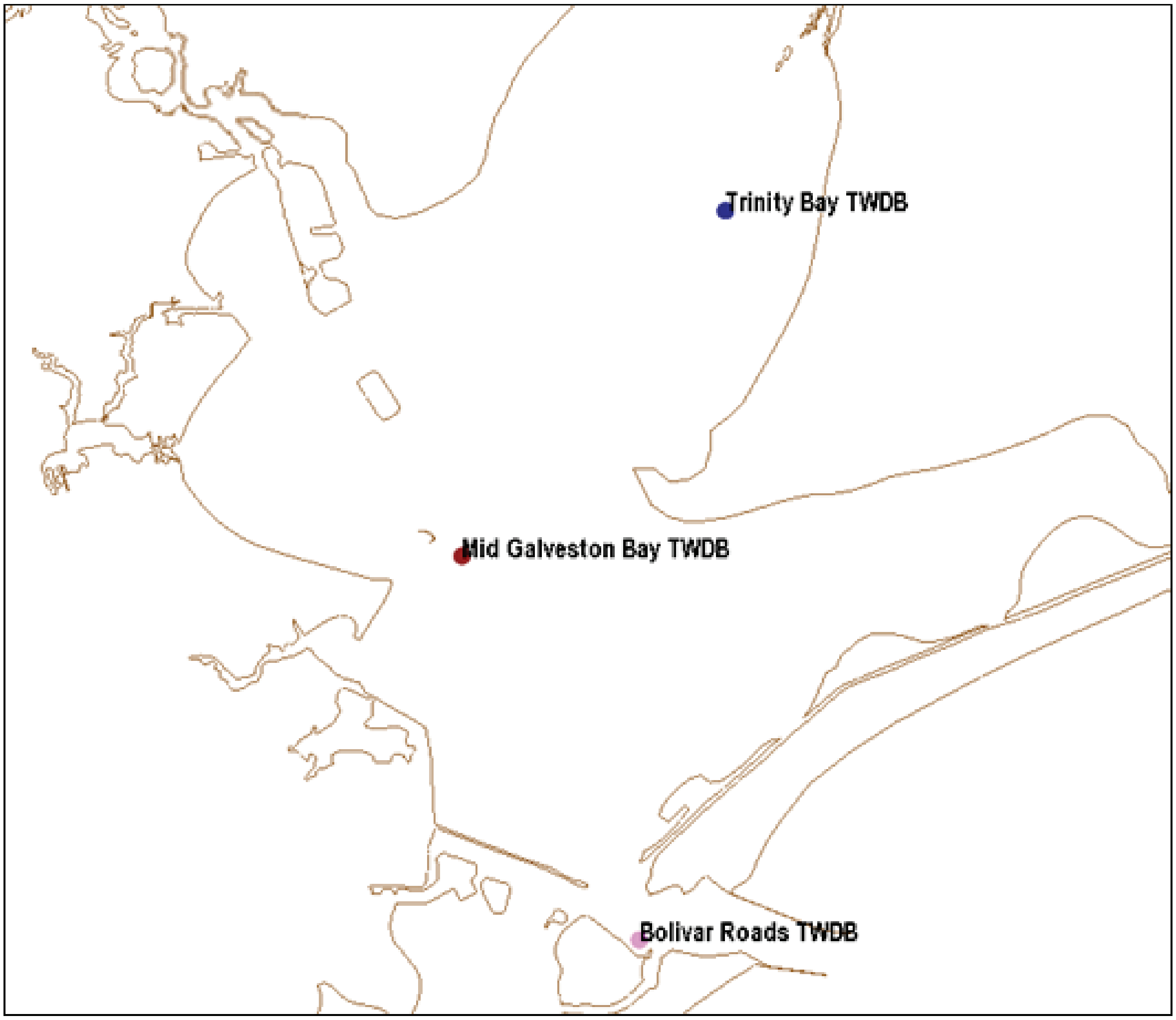


Figure 34. TCEQ 2005 salinity calibration sites.

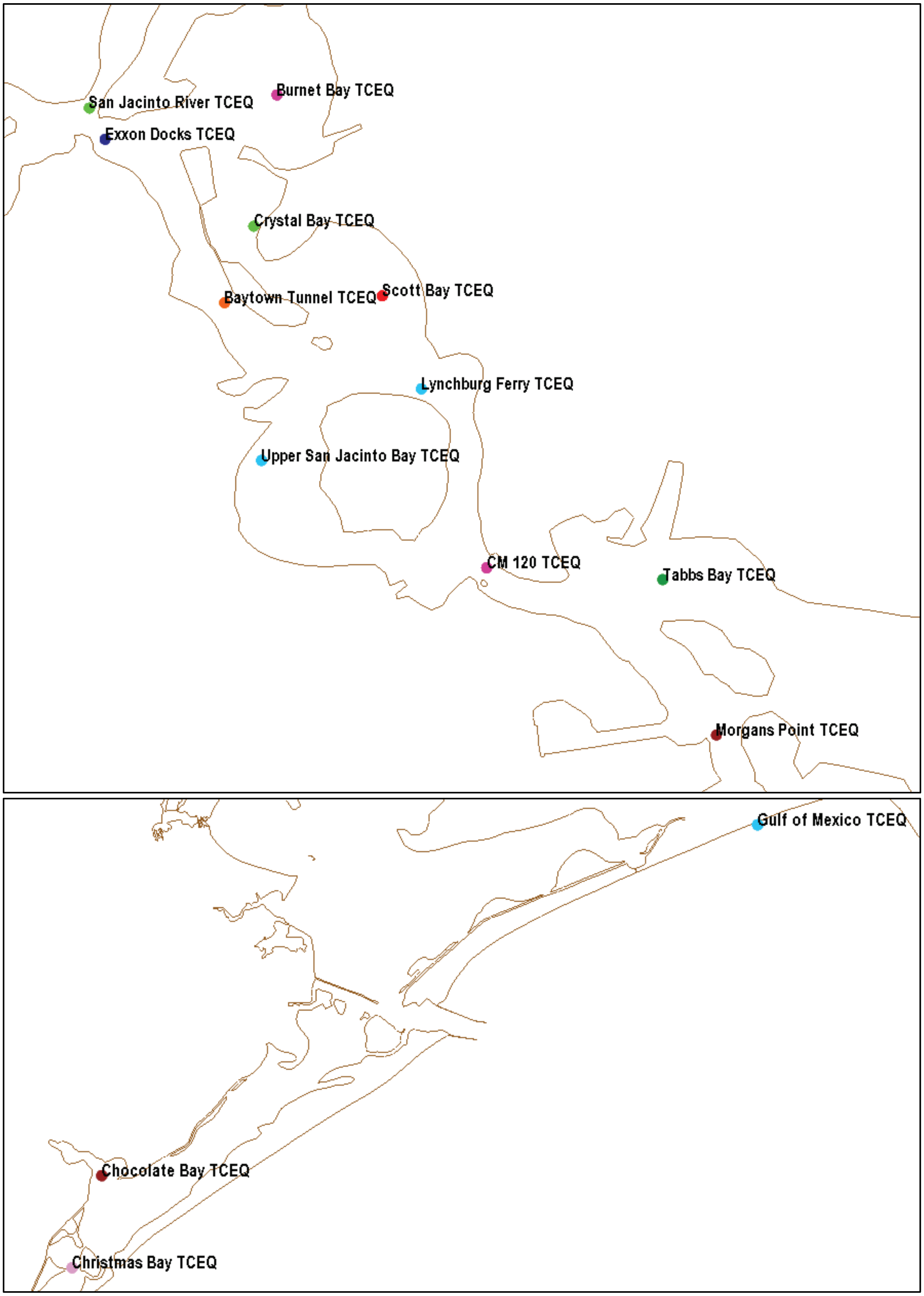
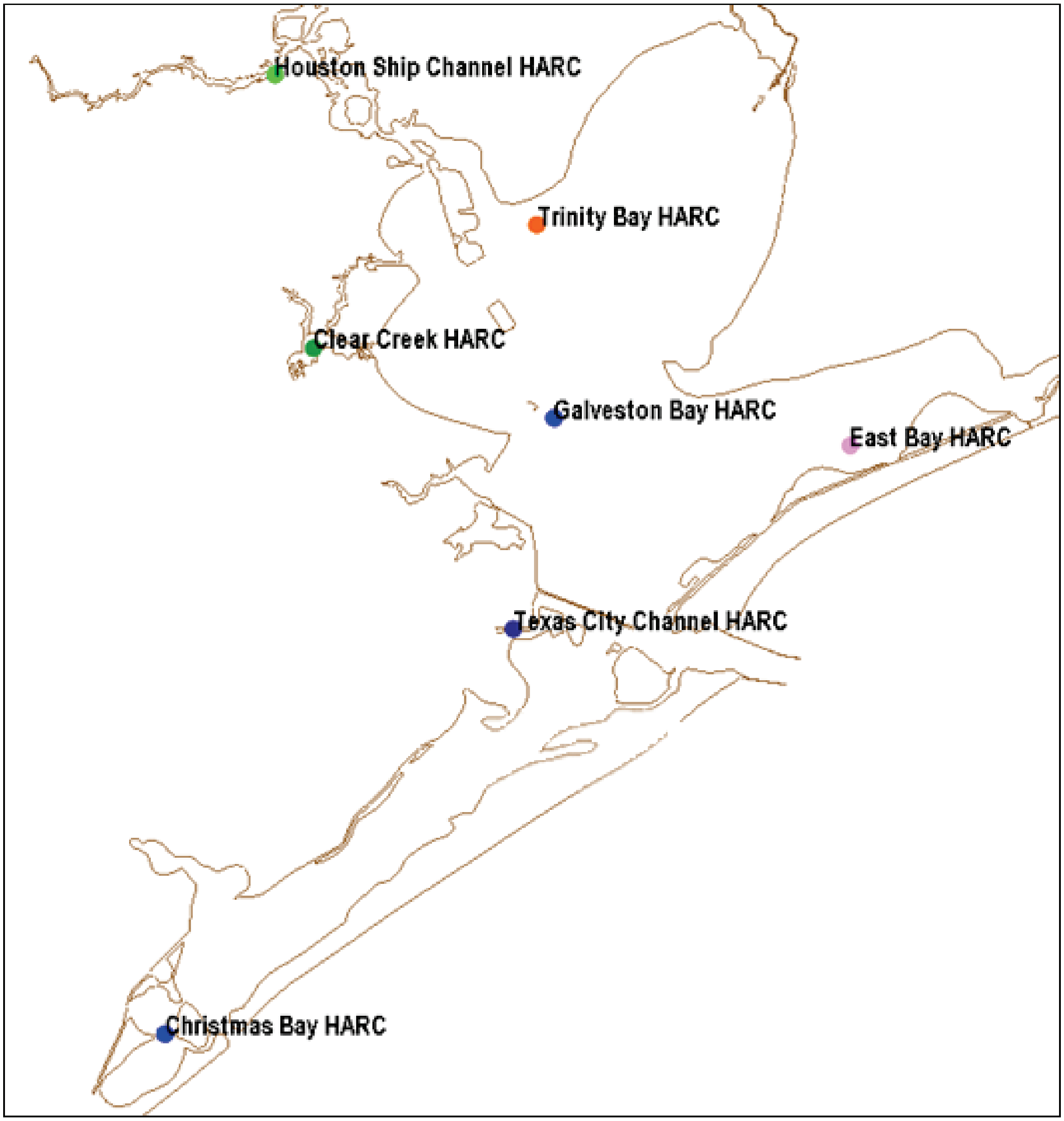


Figure 35. HARC 2005 salinity calibration sites.



Field data for points in the upper HSC are primarily limited to 2005 in the TCEQ data set. Model/field comparisons, from upstream to downstream, at Exxon Docks, Baytown Tunnel, Lynchburg Ferry, CM120, and Morgan's Point are shown in the following plots (Figure 36 through Figure 40).

Figure 36. Exxon Docks salinity calibration comparison.

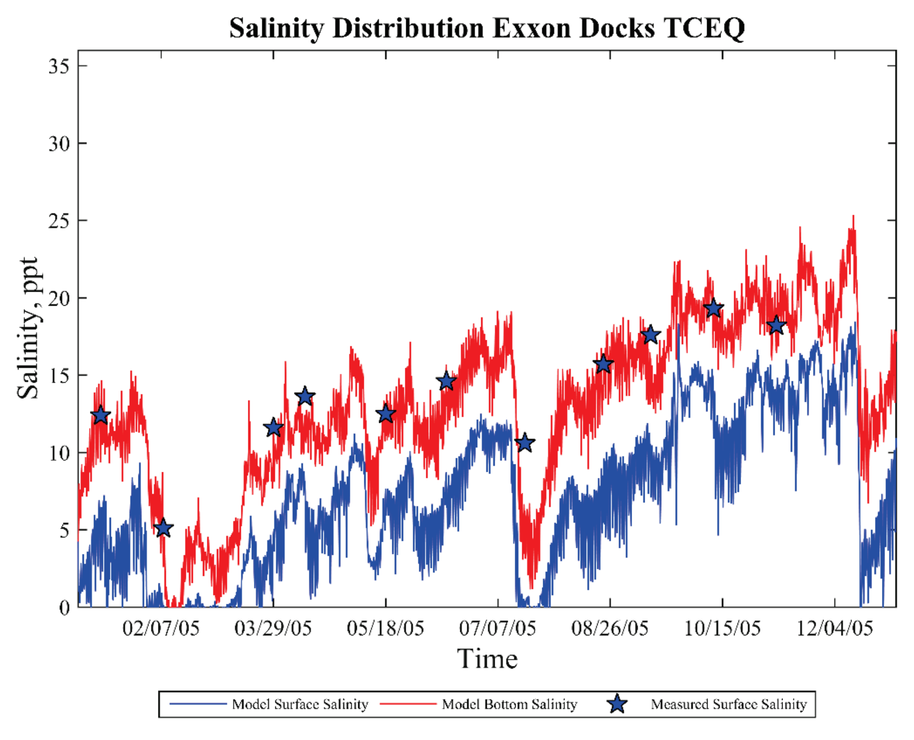


Figure 37. Baytown Tunnel salinity calibration comparisons.

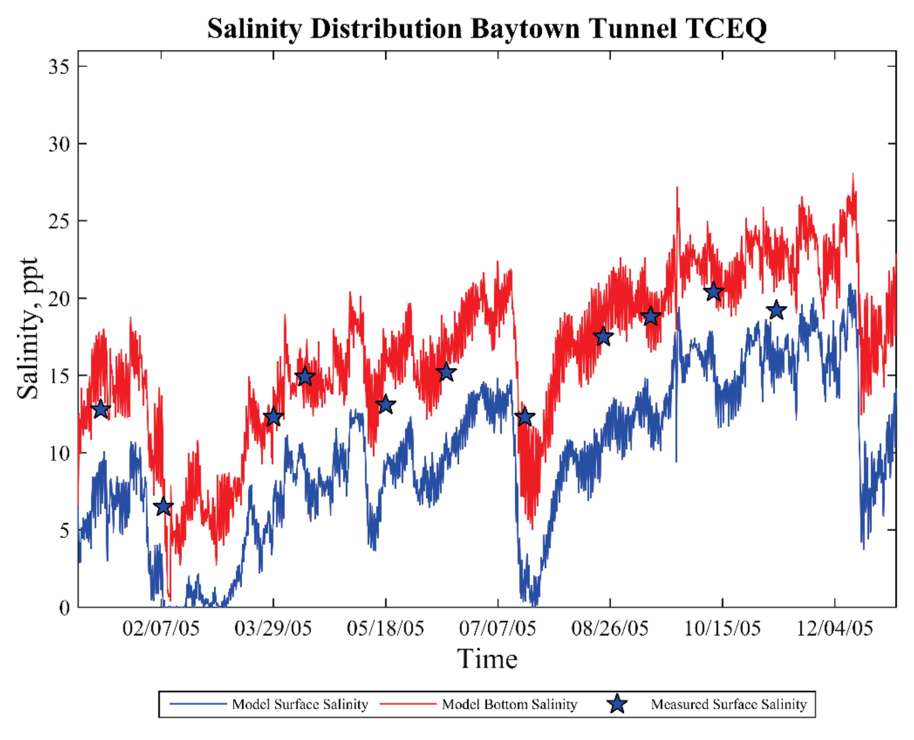


Figure 38. Lynchburg Ferry salinity calibration comparisons.

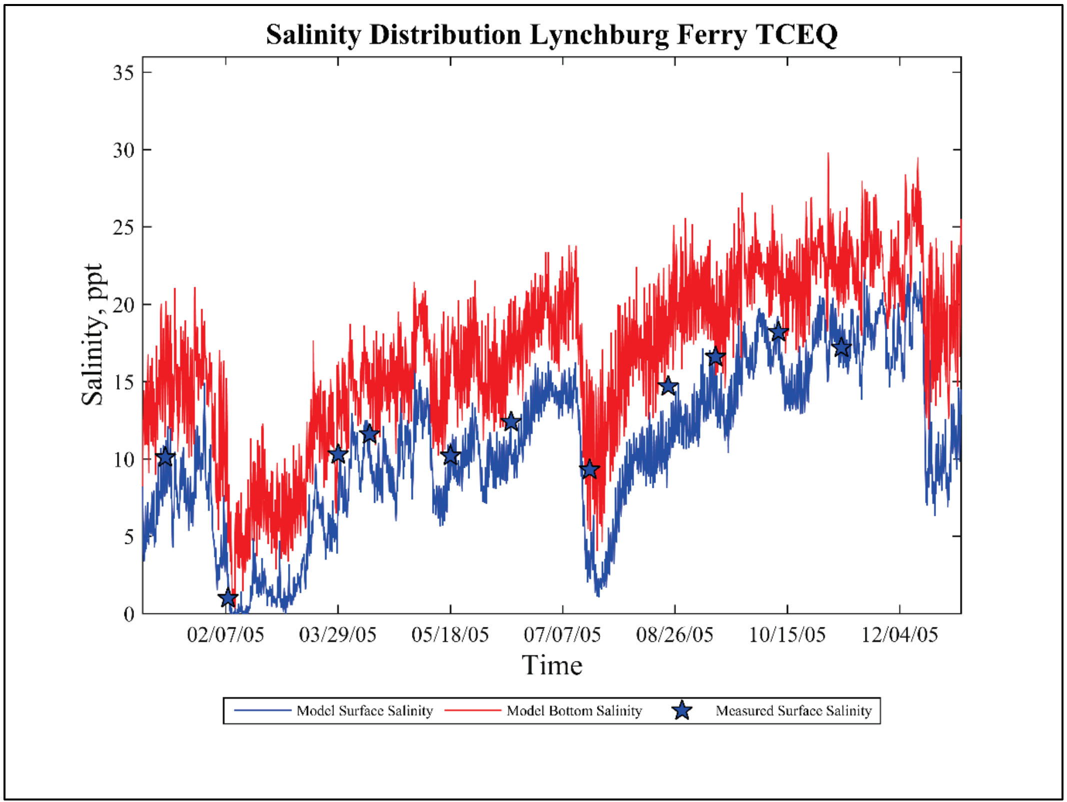


Figure 39. CM120 salinity calibration comparisons.

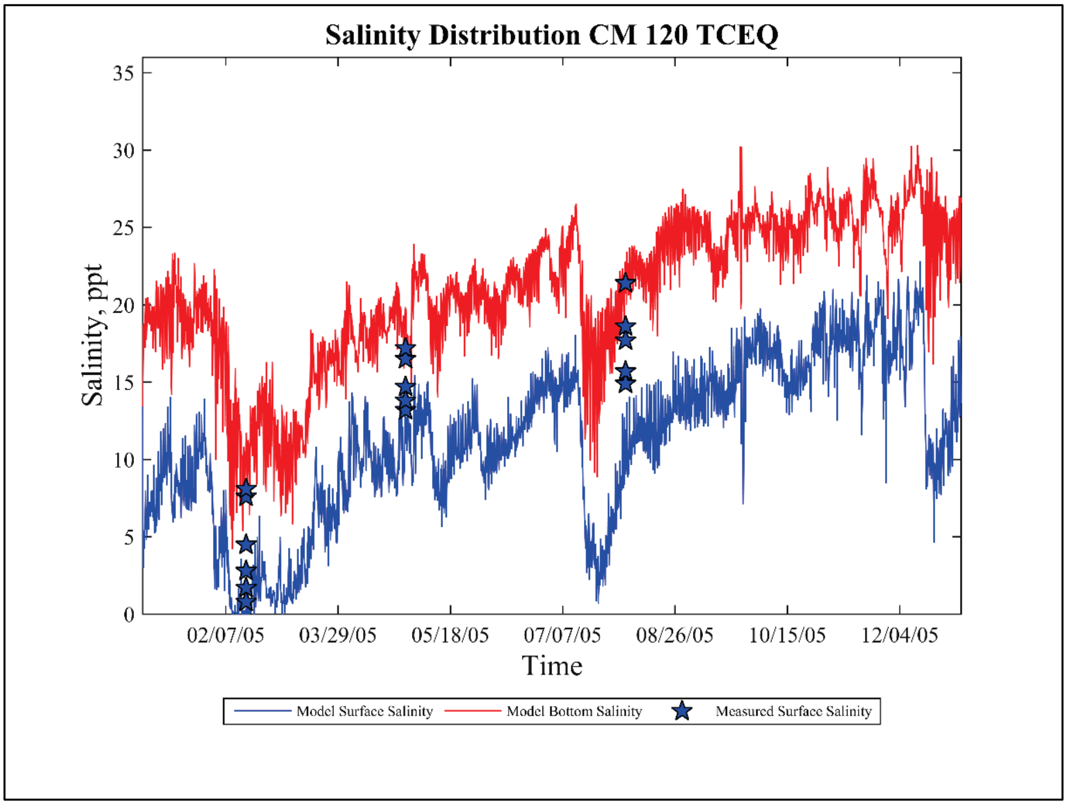
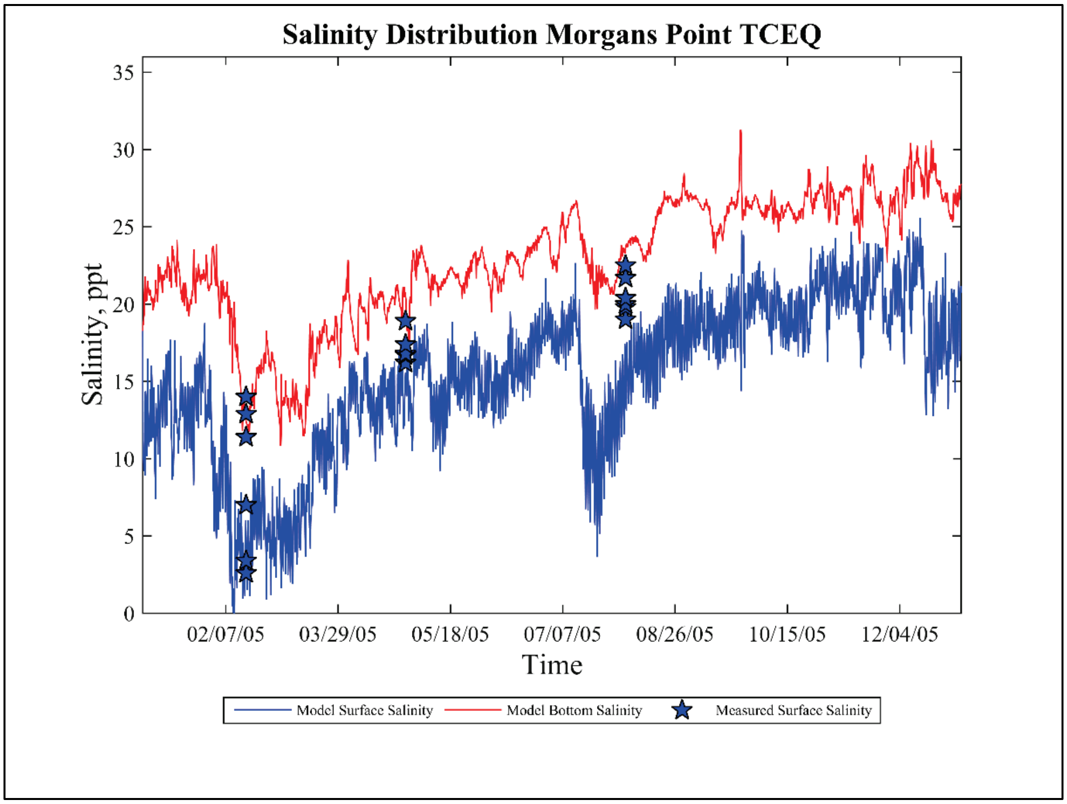


Figure 40. Morgan's Point salinity calibration comparisons.



Salinity impacts in Trinity Bay are of primary concern when analyzing project changes for impacts on aquatic habitat. The model/field calibration comparisons of salinity at Mid Galveston Bay and two Trinity Bay sites – HARC on the northwest side of the bay (Figure 35) and TWDB on the southeast side of the bay (Figure 33) – are shown for 2005 in Figure 41 through Figure 43.

Overall, the salinity patterns and values are replicated in the model. There are periods in the field data where it appears the field instrument malfunctions; the model and field behavior diverges during these periods. The TWDB Trinity Bay (southeast) location comparisons indicate that the model is providing lower salinity values than the field, sometimes by as much as 8 parts per thousand (ppt). This area may be more heavily influenced by shallow depths and wind wave impacts (not included in this model) that are not impacting the salinity comparisons at the other comparison locations. Given the physics that are presently included in this AdH model and the overall good comparisons at other locations, these differences are noted but will not result in additional model calibration.

Figure 41. 2005 Mid Galveston Bay salinity calibration comparisons.

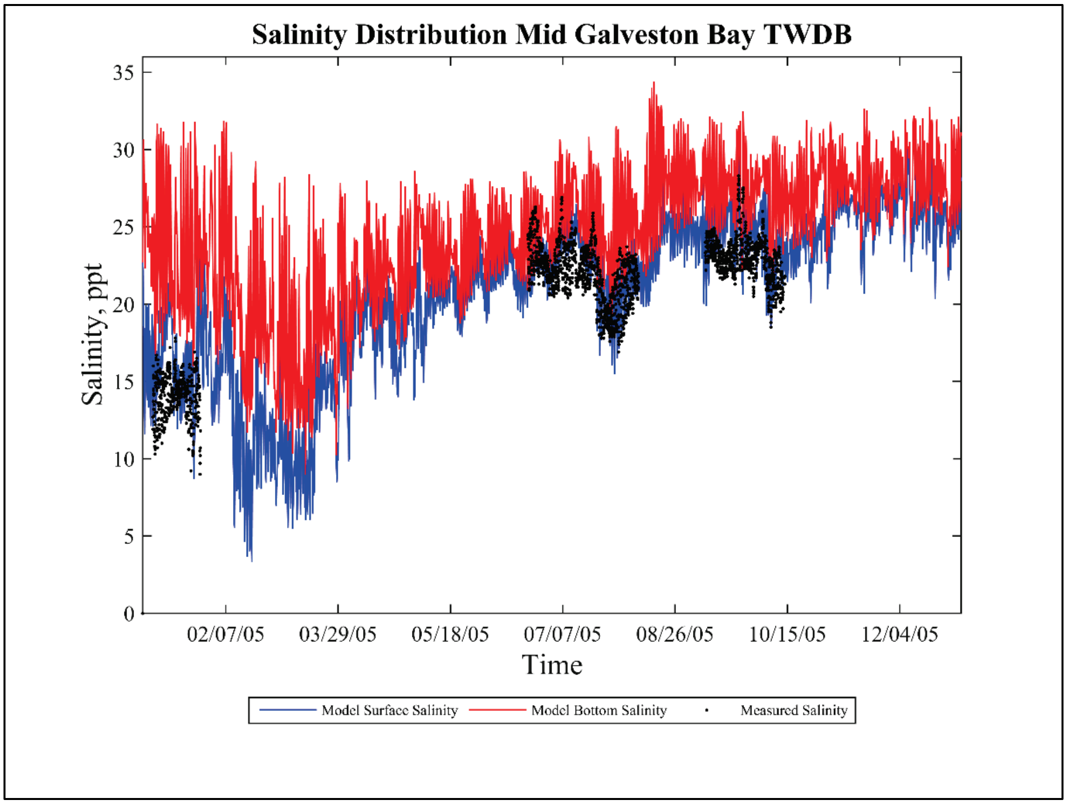


Figure 42. 2005 Trinity Bay HARC salinity calibration comparisons (northwest).

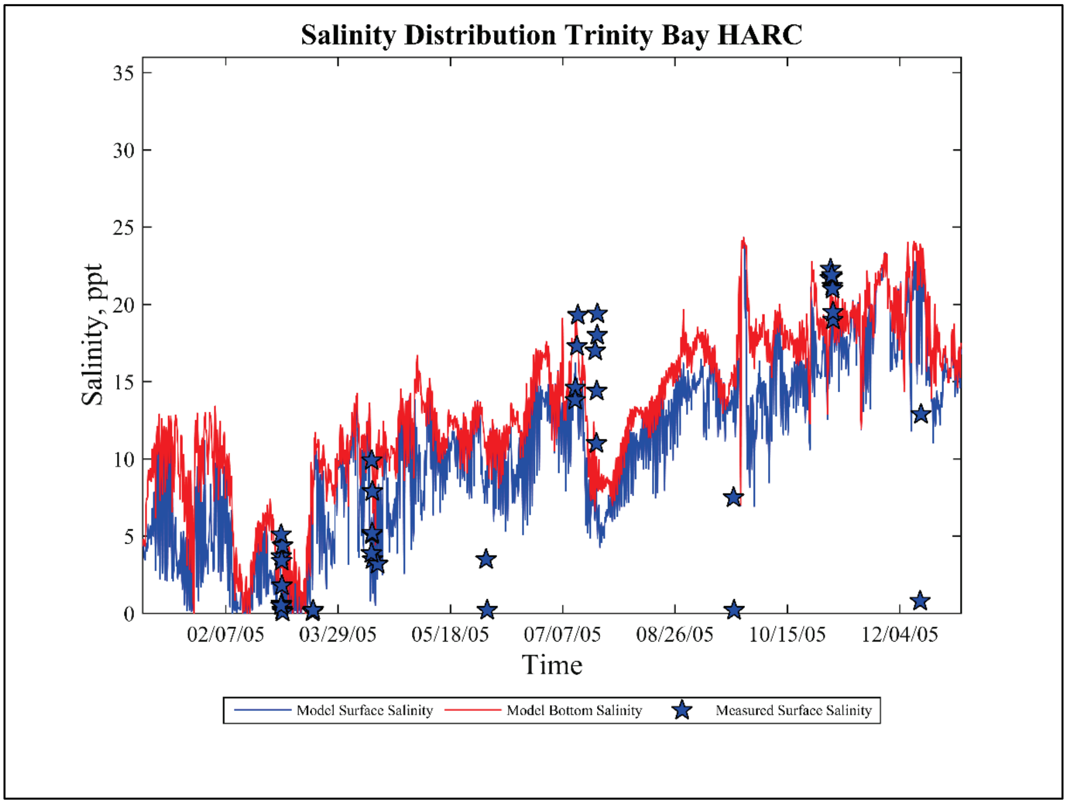
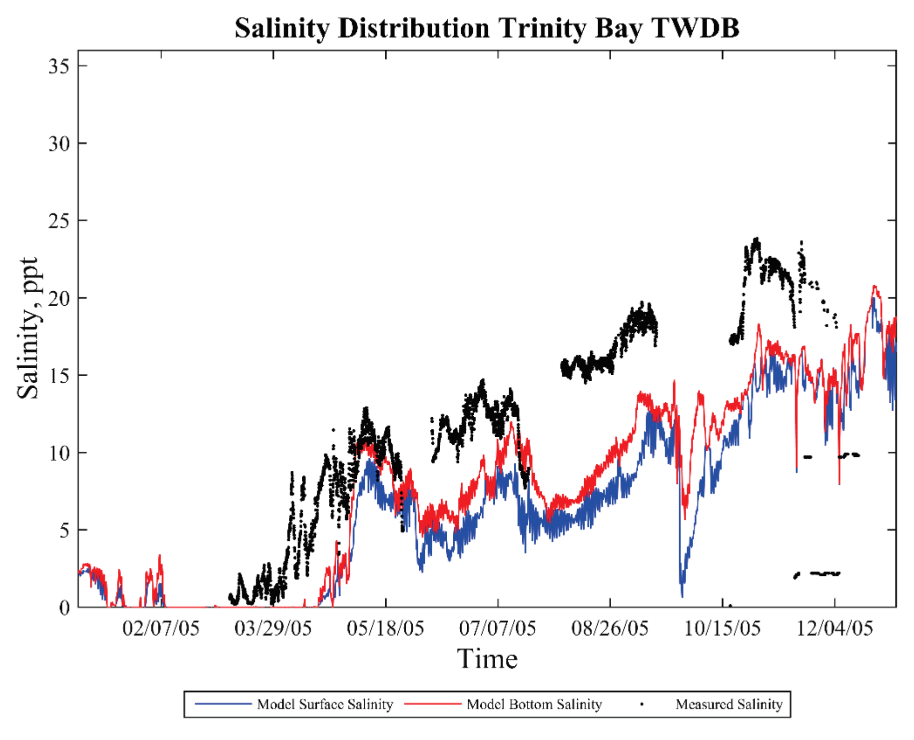


Figure 43. 2005 Trinity Bay TWDB salinity calibration comparisons (southeast).



Sediment calibration

The sediment model is calibrated based on historic maintenance dredge records for the HSC. Previous research has indicated that several sources of dredge records are available — contract records, pre and post surveys, USACE annual reports, etc. — but the various sources often provide very different total volumes (Tate et al. 2014). For this study, the data provided in the USACE annual reports are used for model calibration and validation. This data set covers over 55 years and is reported by channel segments. From the data, three time periods as defined by the channel dimensions can be specified and annualized to determine an average yearly shoaling amount by reach (Table 4). No data were available to analyze sedimentation changes in the bay or bayou shallows over single-year time periods.

Table 4. Annualized shoaling periods.

Dimensions	Years
40 x 400 ft	1660 - 1997
Construction	1998 – 2005
45 x 530 ft	2006 - 2016

A dredge template (Figure 44) was produced to match the HSC reaches as reported in the USACE annual report shoaling records. These sections were defined based on the HSC channel station map and the USACE channel survey sections. There is uncertainty where the Bayport and Barbours Cut channels join the HSC. Figure 45 shows the reported maintenance dredge records annualized over each time period for each channel segment.

Figure 44. HSC dredge template.

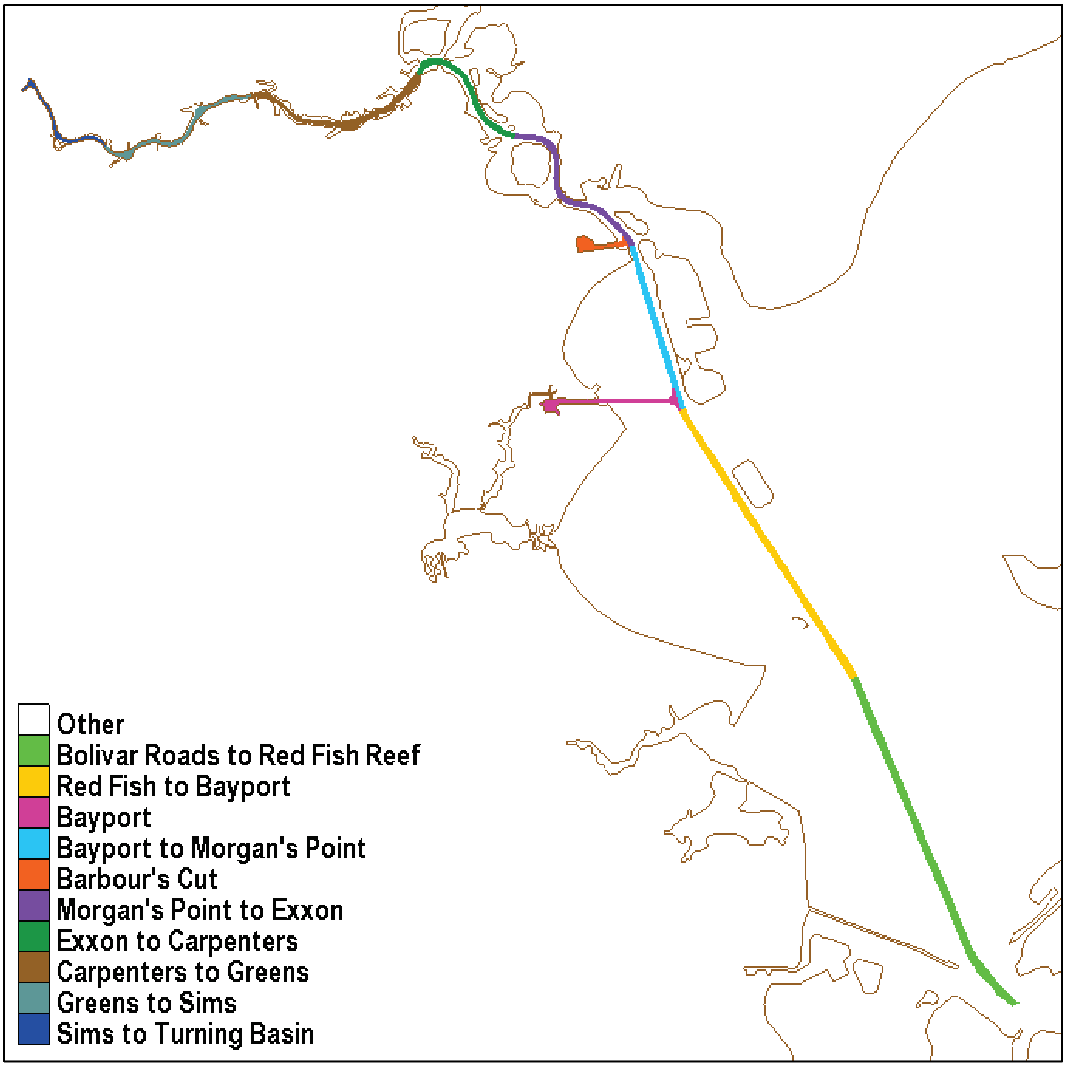
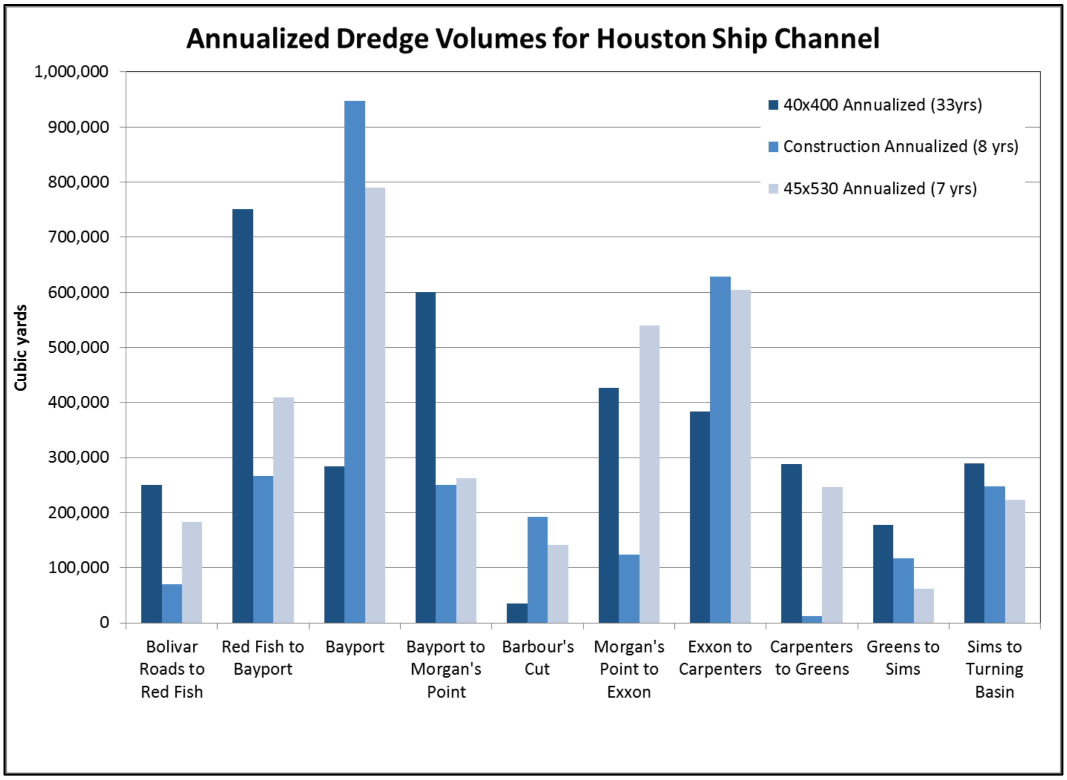


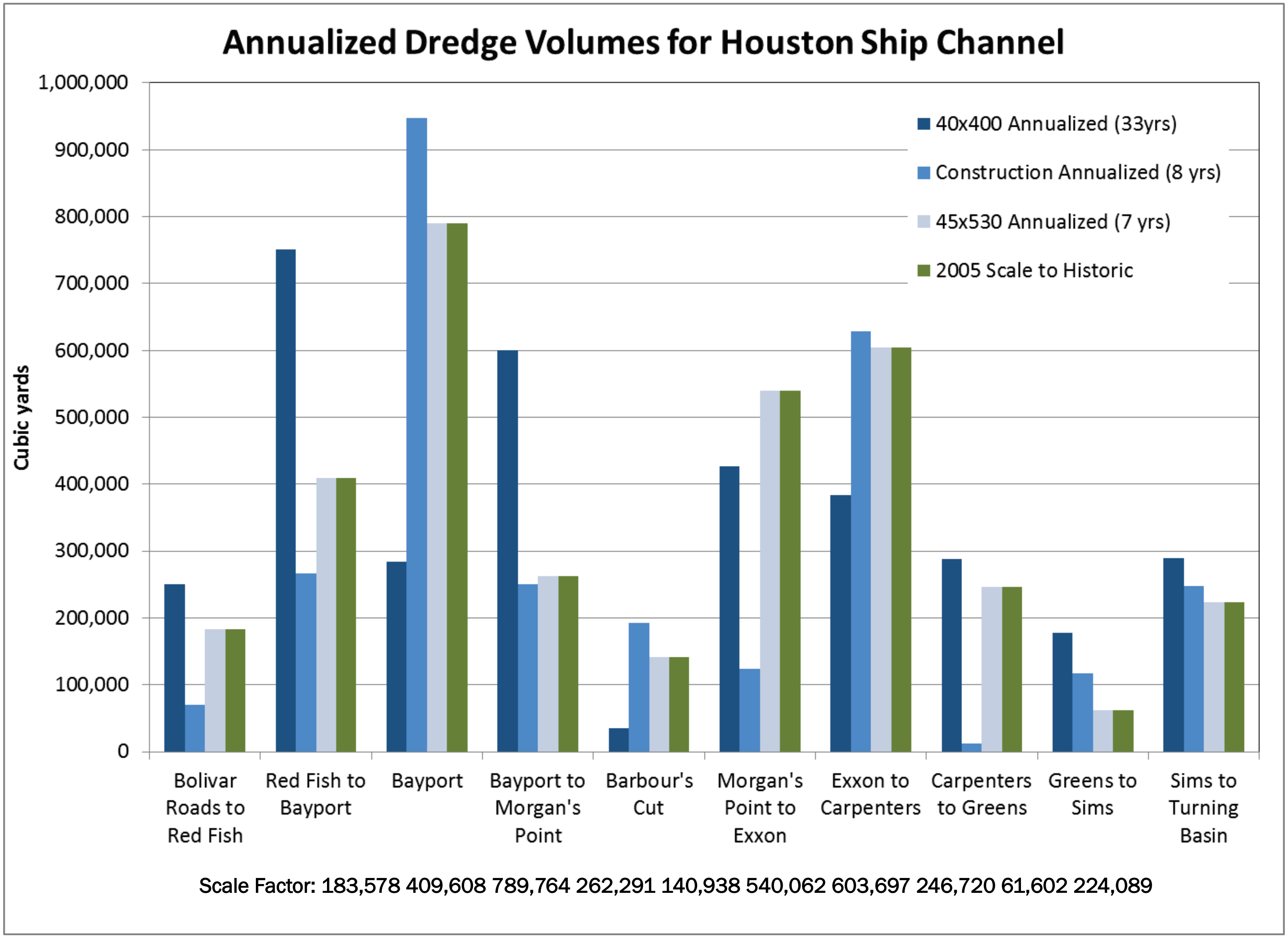
Figure 45. Annualized maintenance dredge volumes based on USACE annual reports.



This dredge template is then used to determine the model computed shoaling volume over each 1-year simulation period. Since it is known that sediment loads are unaccounted for from the ungaged freshwater inflows, from wind-generated wave erosion along the shallows, and from vessel-induced erosion in the bays, several methods to account for these missing sources were tested. A historical scaling method for each channel segment was determined to be the best option to account for the combined effect of the various unknown loads. The 2005 model-computed shoaling for each segment was scaled to match the annualized historic records for the 45 × 530 ft channel as a means of calibration. A scale factor for each segment was determined and applied accordingly for the 2010 and 2011 validation years.

Figure 46 shows the shoaling calibration results for 2005 as compared to the annualized historic maintenance dredging records as well as the computed scale factor for each reach.

Figure 46. Model/field HSC shoaling calibration comparison.



Scale Factor: 183,578 409,608 789,764 262,291 140,938 540,062 603,697 246,720 61,602 224,089

Hydrodynamic validation

The model is compared to water surface elevation and velocity at several locations during the 2010 and 2011 validation period. Water surface elevation data were obtained from the NOAA Co-Ops and the National Data Buoy Center. Velocity data were obtained from NOAA PORTS and from a 2011 CHL collection effort in Trinity Bay.

Water surface elevation

Water surface elevation validation results are compared to the field at six locations — some years have fewer locations depending on the data availability. Figure 24 shows the location of the water surface elevation comparison sites. Statistical comparisons are provided in Table 5. Time-history and box-plot comparisons at Manchester, Morgans Point, and Eagle Point are shown in his section (Figure 47 through Figure 49 and Figure 50 through Figure 52). The full set of comparisons is provided in Appendix A.

For the time-history plots, the green line represents the measured field data, and the blue line represents the model-computed values. Each comparison location also includes a box plot showing the relationship between the measured field data (*x*-axis) and the modeled data (*y*-axis). A perfect match would yield points on the black 1:1 line.

Table 5. Statistical model/field validation comparison of water surface elevation.

	Root Mean Square Error		Correlation Coefficient	
	2010	2011	2010	2011
Manchester		0.12		0.89
Morgan's Point	0.07	0.05	0.97	0.98
Eagle Point	0.07	0.04	0.96	0.98
Pier 21	0.07	0.05	0.96	0.98
North Jetty		0.05		0.98
Rollover Pass		0.07		0.95

Figure 47. Water surface elevation validation comparisons over time for Manchester 2011.

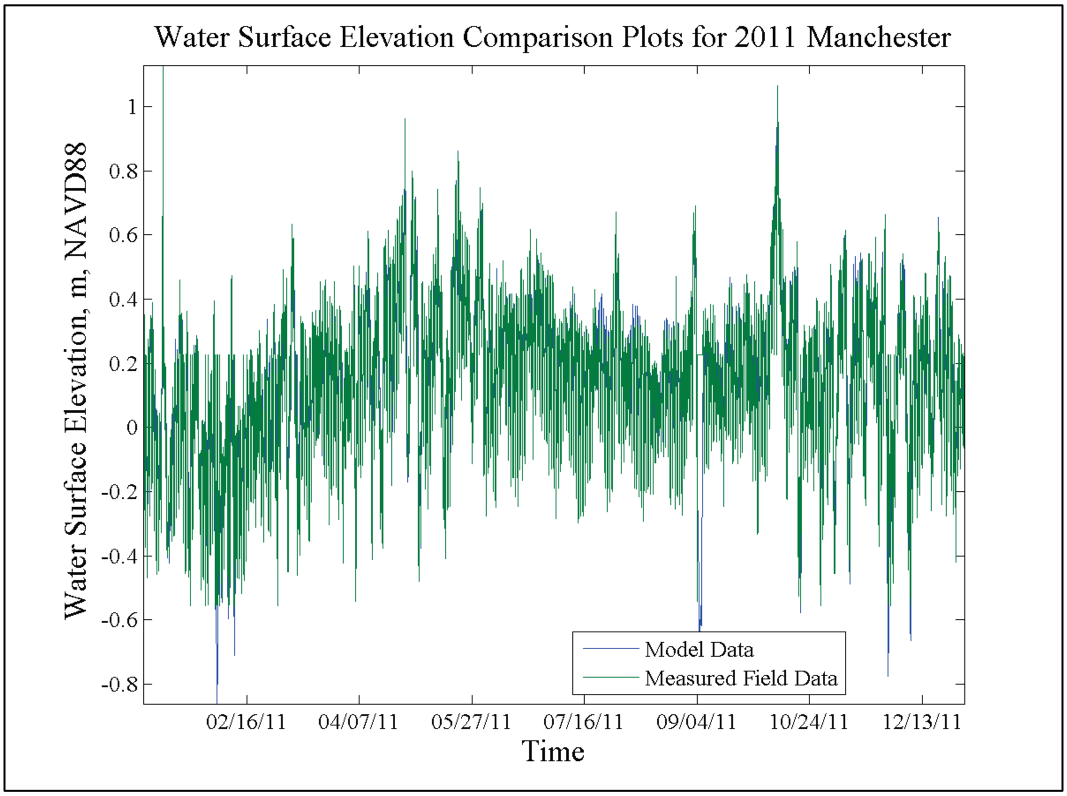


Figure 48. Water surface elevation validation comparisons over time for Morgans Point.

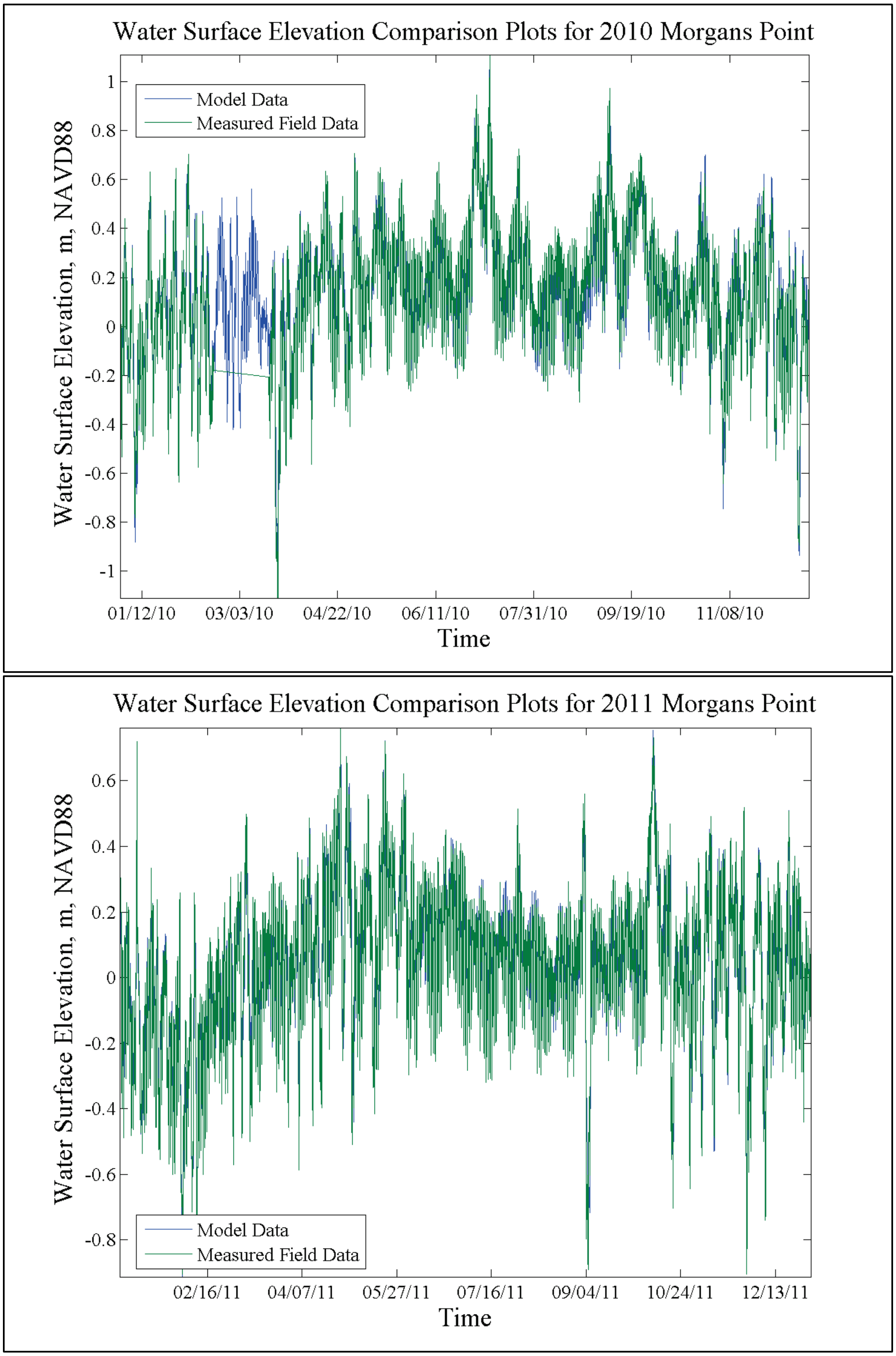


Figure 49. Water surface elevation validation comparisons over time for Eagle Point.

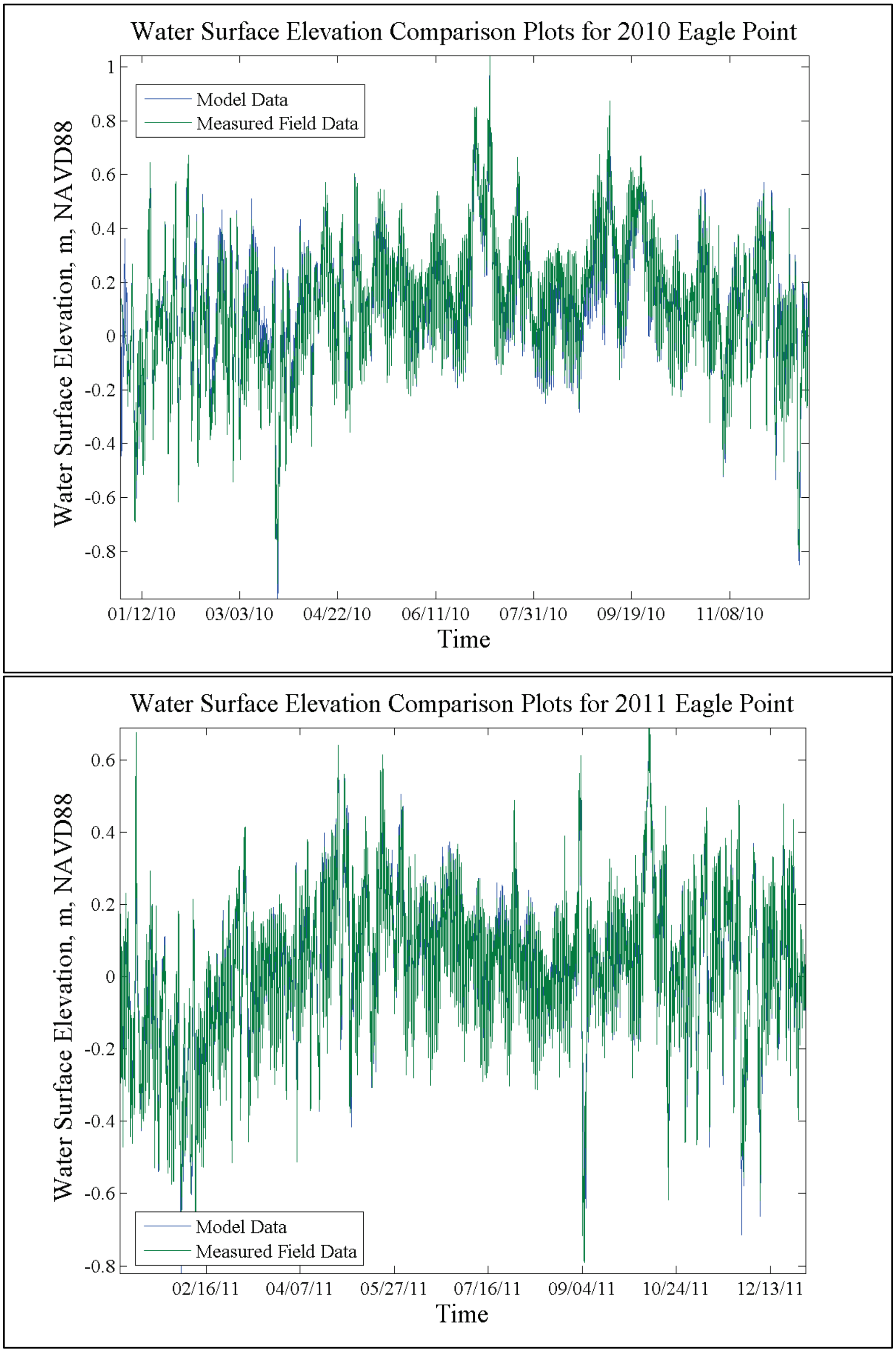


Figure 50. Water surface elevation validation comparison box plot for Manchester.

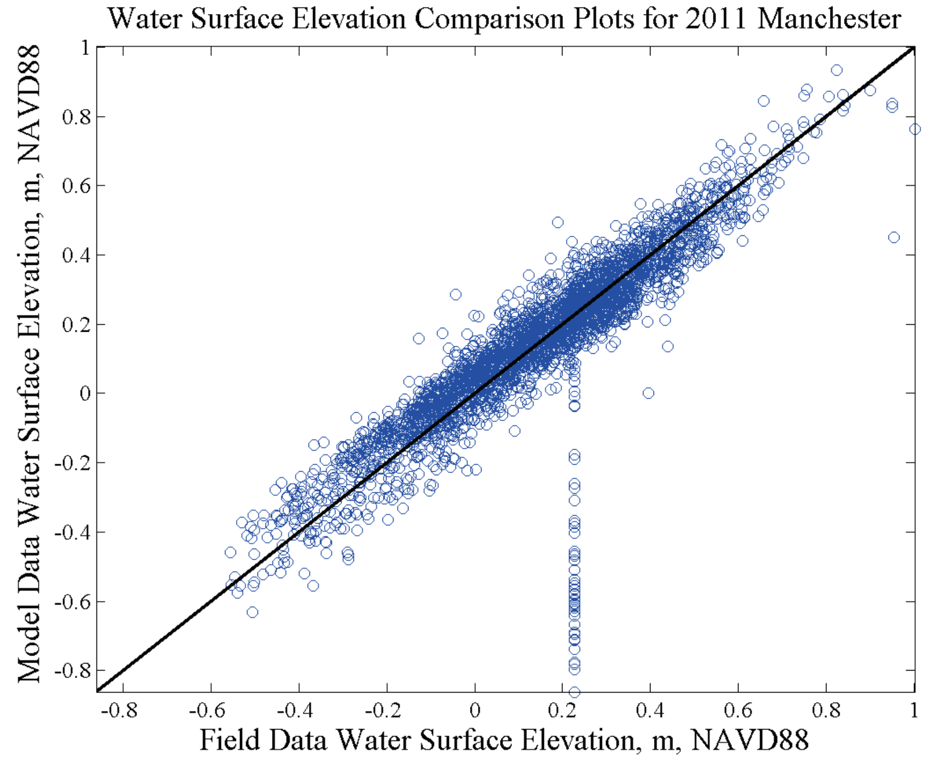
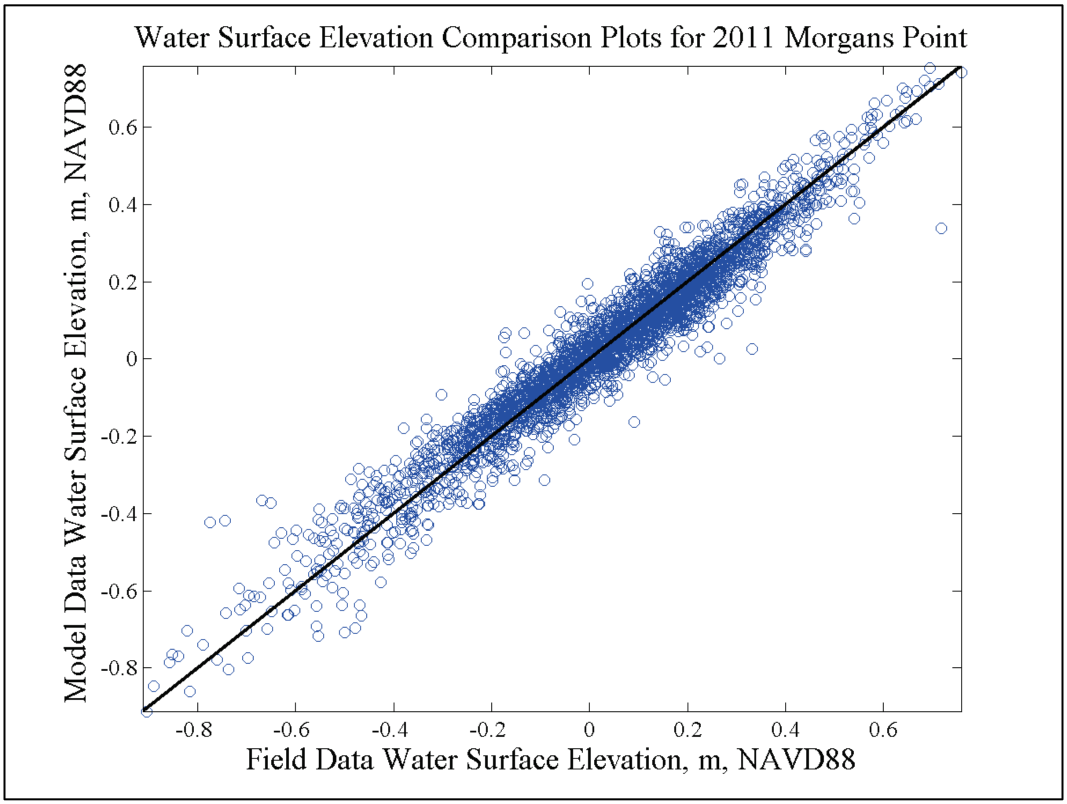


Figure 51. Water surface elevation validation comparison box plots for Morgans Point.



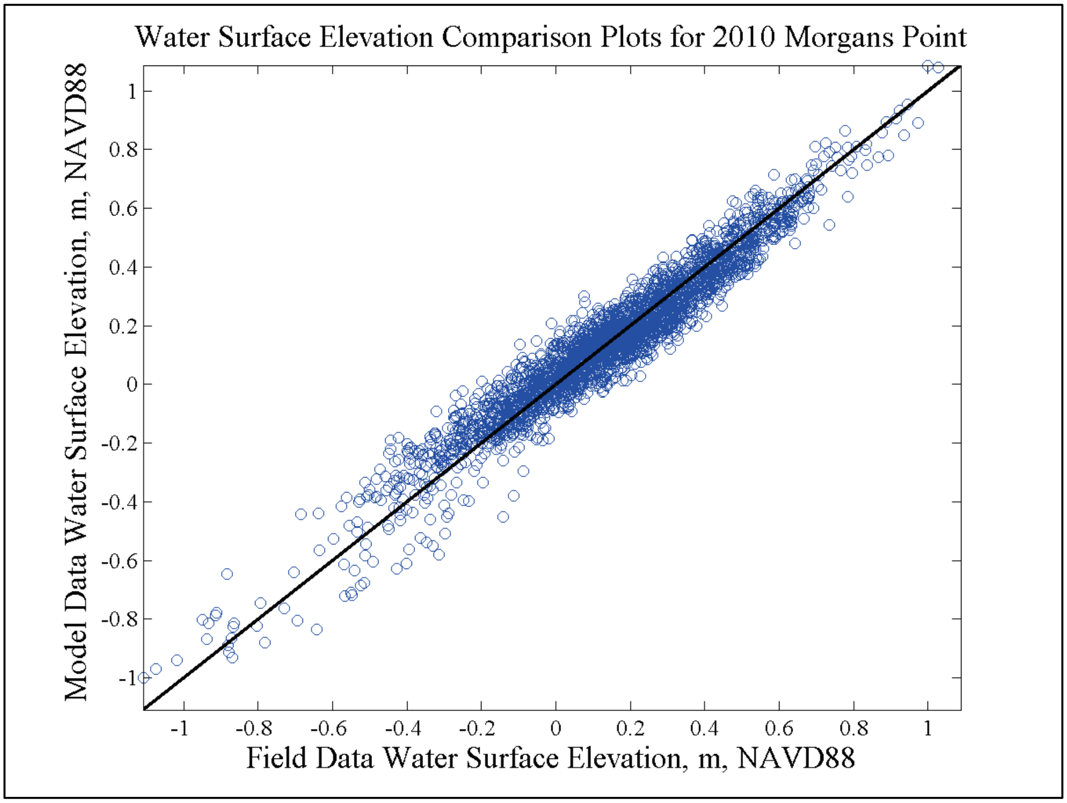
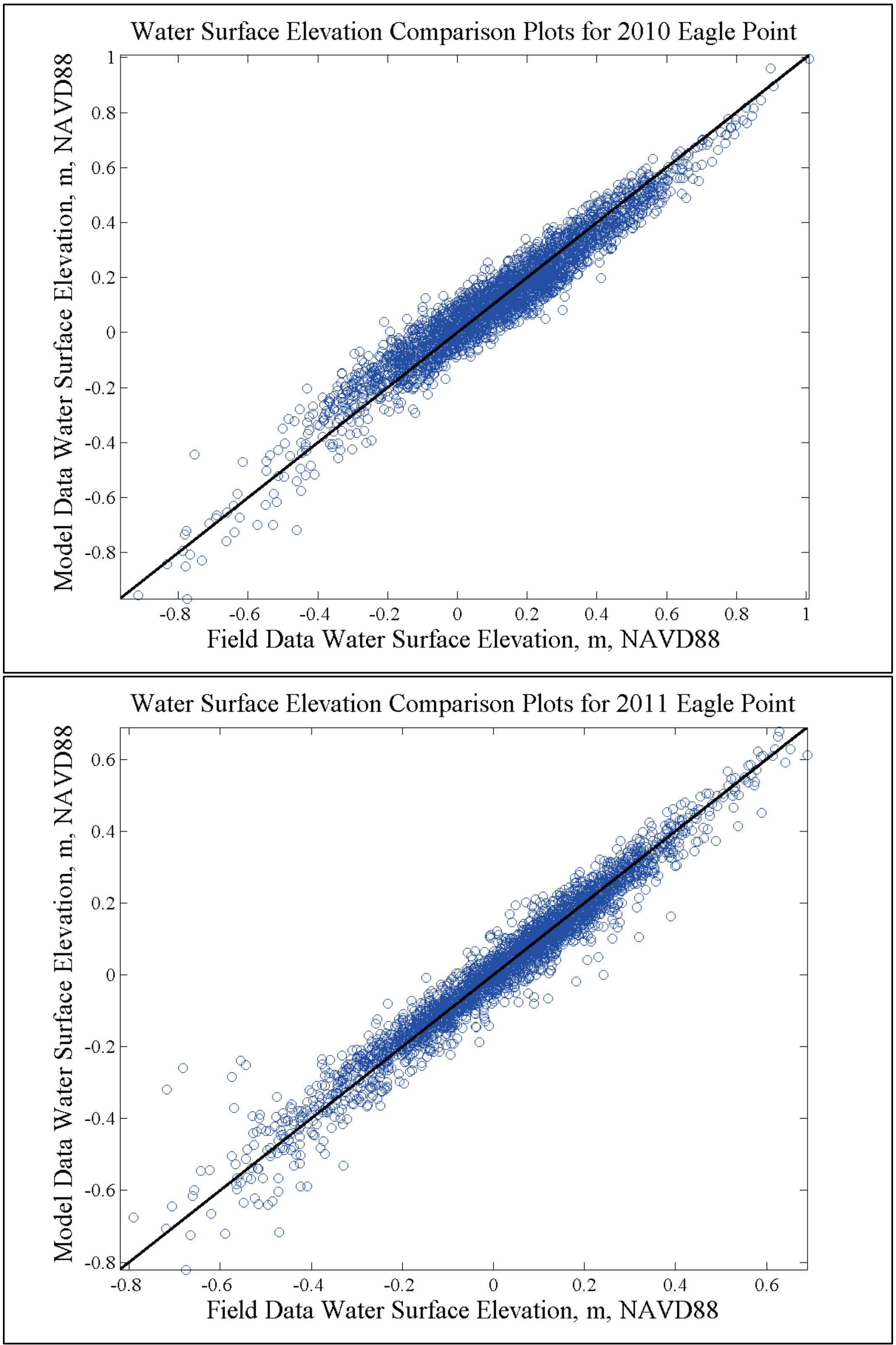


Figure 52. Water surface elevation validation comparison box plots for Eagle Point.



Velocity

Velocity validation comparisons are made at four locations — one from NOAA PORTS and three from a 2011 CHL data collection effort (Acoustic Wave and Current profiler [AWAC]) (Figure 53). The time available for comparison is limited for these data sets. Year 2010 only has field data for the Galveston Entrance. Year 2011 has field data for all validation locations. Figure 32 through Figure 58 show the time-history velocity magnitude and direction (positive: flood; negative: ebb) for these locations. The model/field velocity comparison is better in the ship channel locations than in the bay where there is an approximate 0.1 m shift in the model mean as compared to the field. The larger differences in the shallow bay are not unexpected since the velocities in the bay are impacted by smaller disturbances such as passing vessels and local winds, which can easily skew the flood/ebb magnitude. The magnitude of the velocity in the bay is also much smaller, and therefore the data can be impacted more by instrument *noise*. The comparisons at AWAC 1 and 2 show that the model is approximately half the magnitude of the field. This difference in magnitude may be due to the location of the gages in the barge lanes or side slope of the ship channel where the bathymetry changes rapidly and the mesh may not be most accurate. The overall pattern in the velocity signal is reproduced by the model for all locations.

Figure 53. Velocity validation comparison locations.

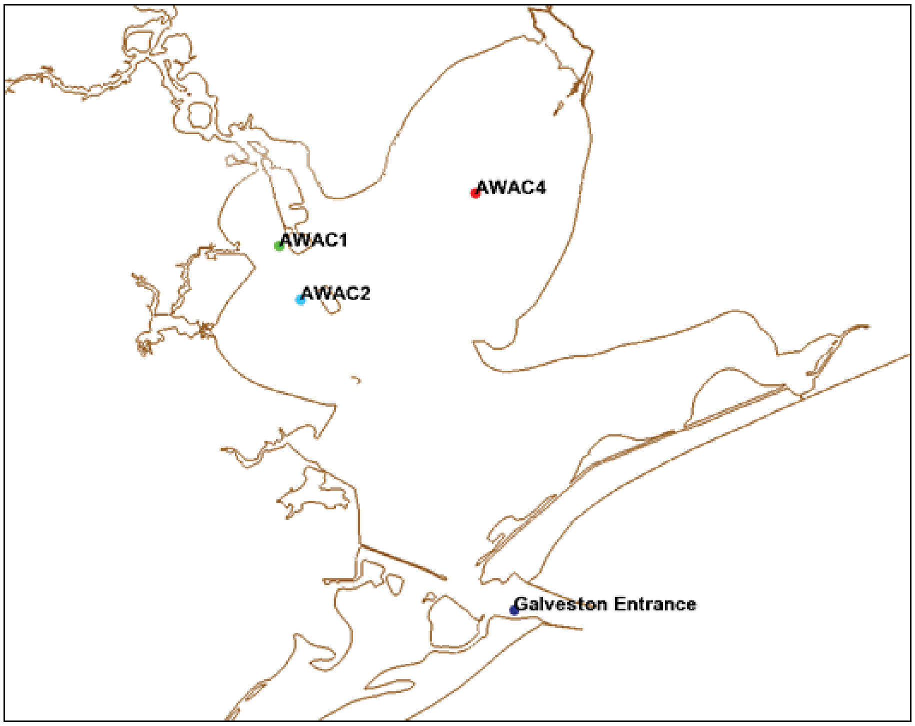


Figure 54. 2010 Galveston Entrance velocity comparison (positive: flood; negative: ebb).

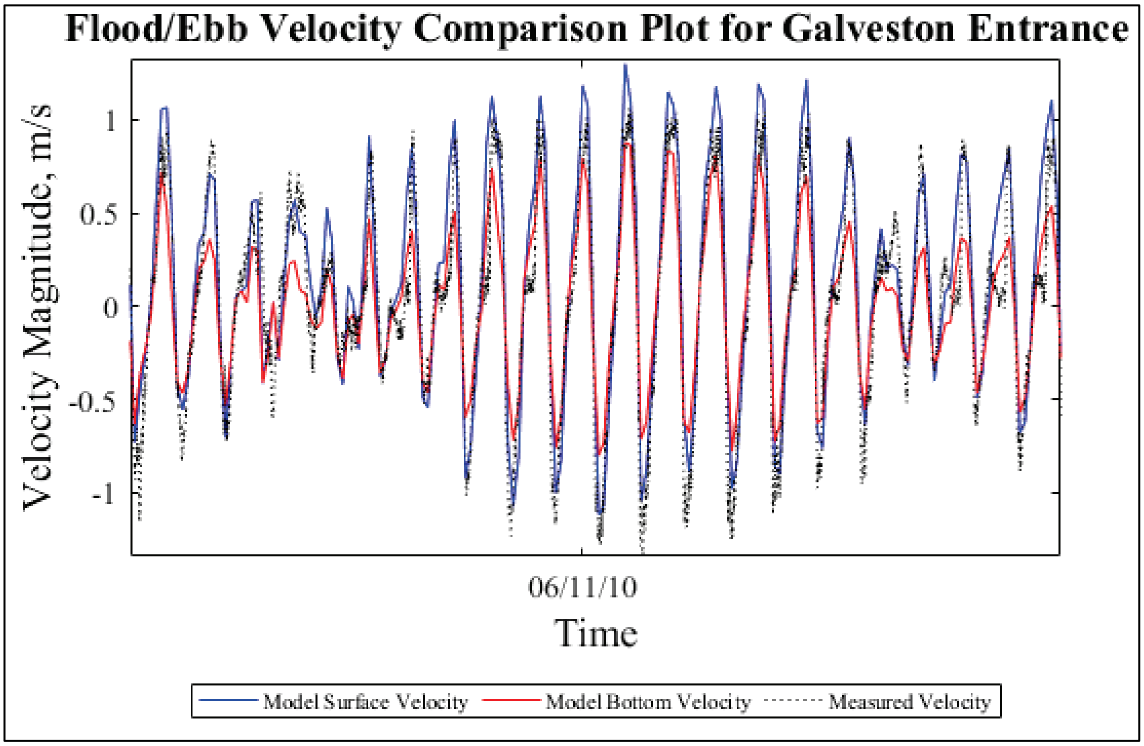


Figure 55. 2011 CHL AWAC 1 velocity comparison (positive: flood; negative: ebb).

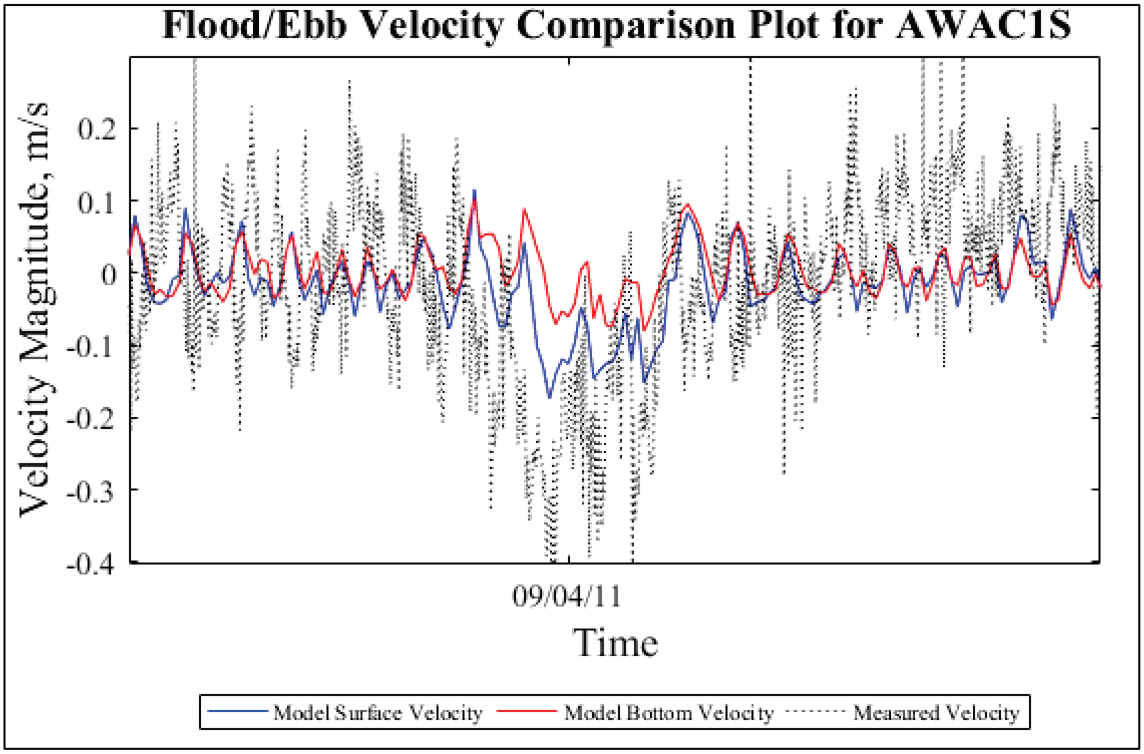


Figure 56. 2011 CHL AWAC 2 velocity comparison (positive: flood; negative: ebb).

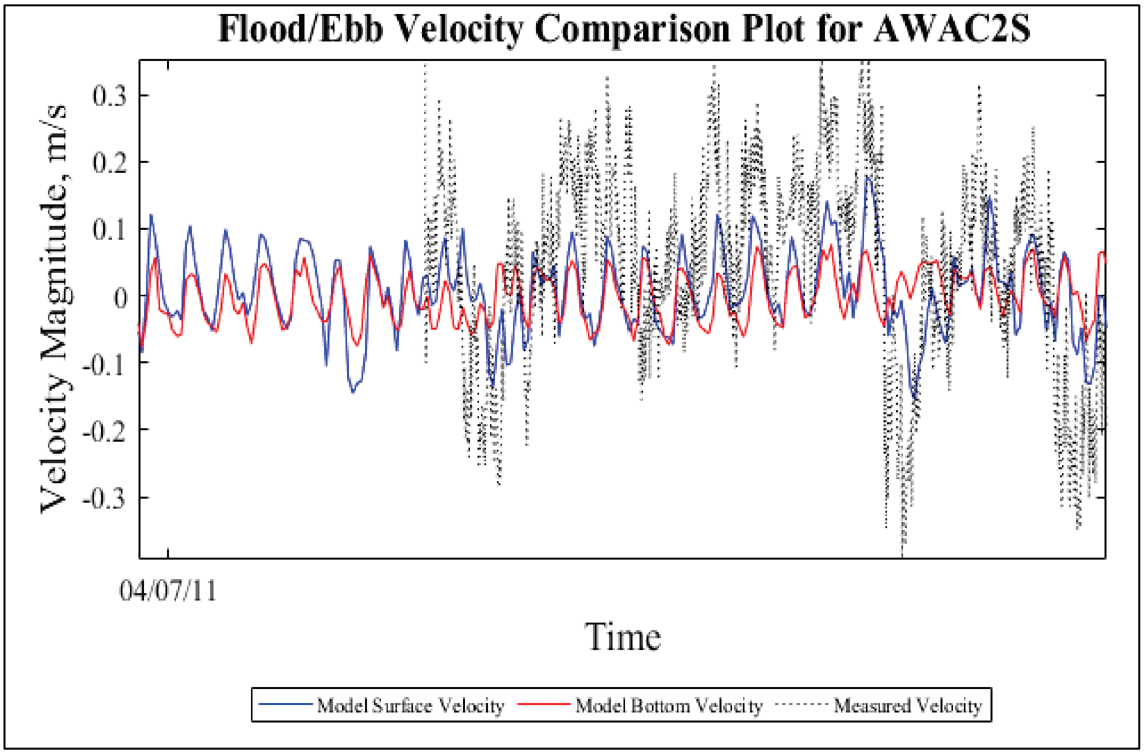


Figure 57. 2011 CHL AWAC 3 velocity comparison (positive: flood; negative: ebb).

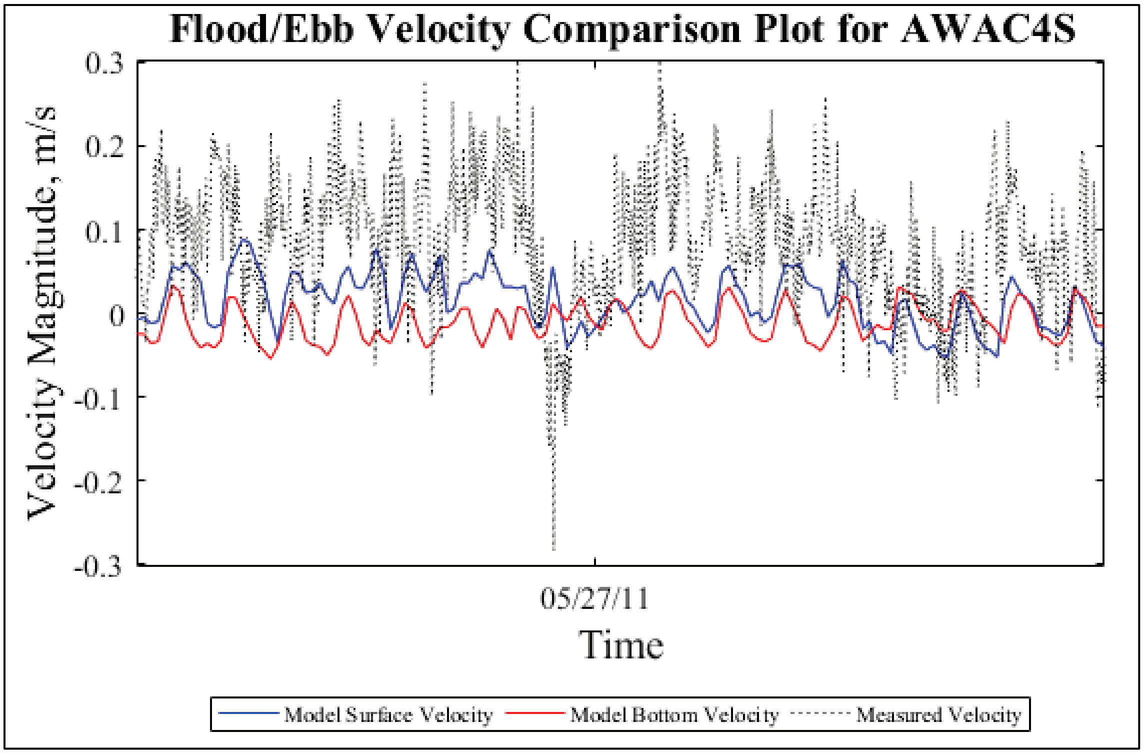
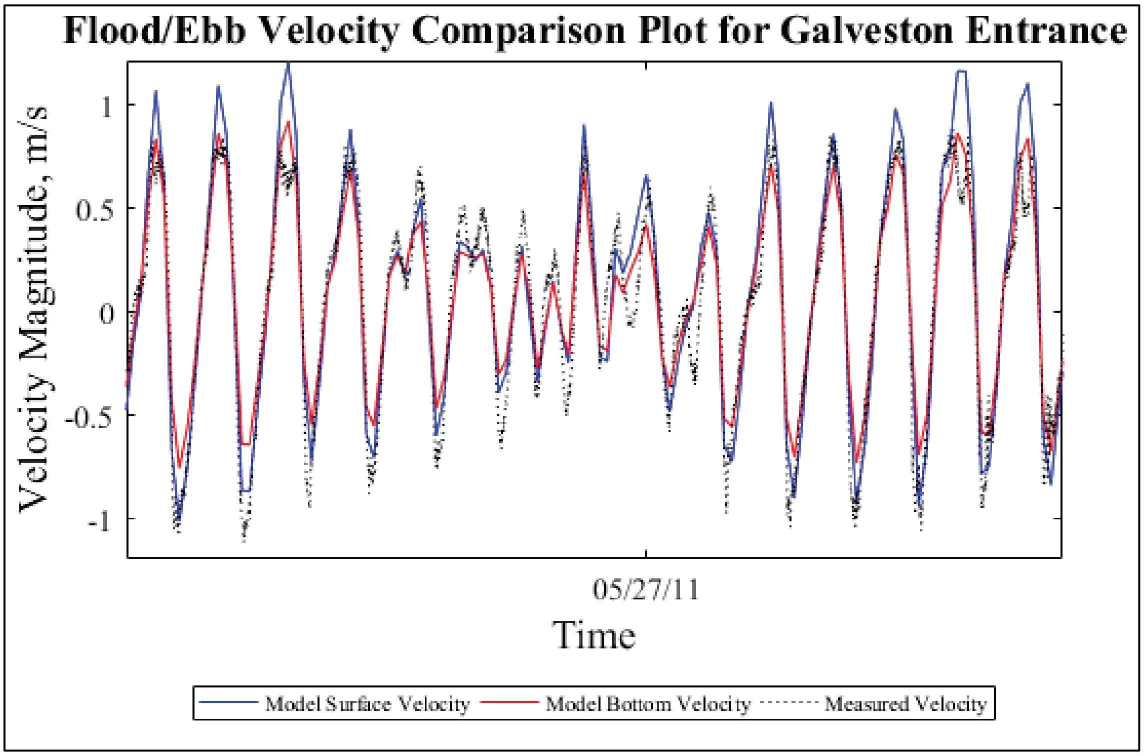


Figure 58. 2011 Galveston Entrance velocity comparison (positive: flood; negative: ebb).



Salinity validation

Field salinity data were obtained for model validation from TWDB (Figure 59), TCEQ (Figure 60), HARC (Figure 61), and TABS (Figure 62). There are 23 total salinity validation comparison sites throughout the HSC and the surrounding bays. As with the previous data comparisons, some sites do not have data for all of the simulation periods.

Time-history comparisons at selected locations are shown in this section. The field data are represented by stars where data are sparse and smaller black dots where data are numerous whereas the model data are shown in blue for surface salinity and in red for bottom salinity. In deep, stratified regions, the bottom salinity is larger than the surface salinity. In well-mixed regions the two should be approximately equal. The field-measured salinity is typically measured at the surface, but it is not specified for all data. A subset of comparisons is provided with the full set of comparisons provided in Appendix B.

Figure 59. TWDB salinity validation comparison sites.

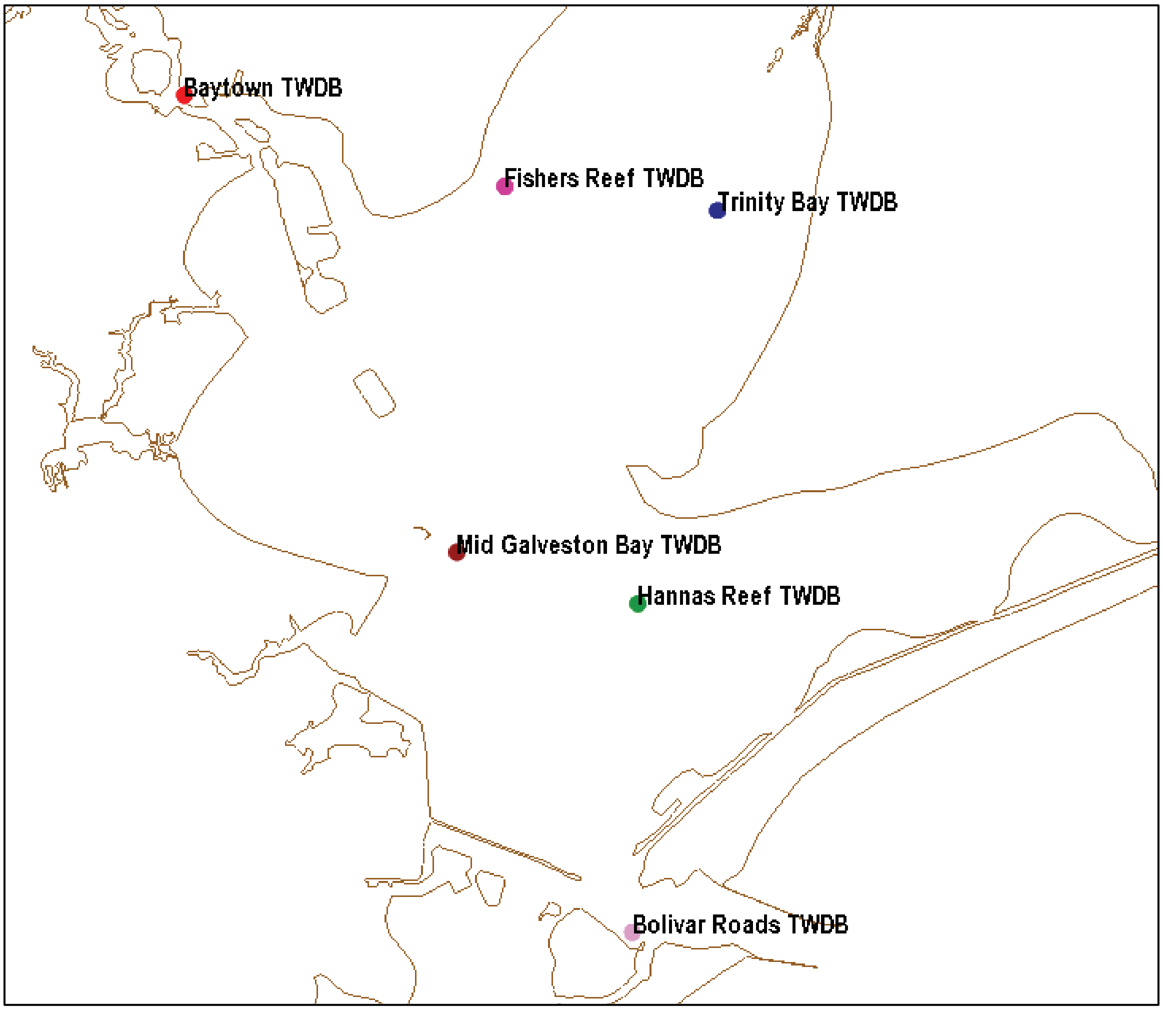


Figure 60. TCEQ salinity validation comparison sites.

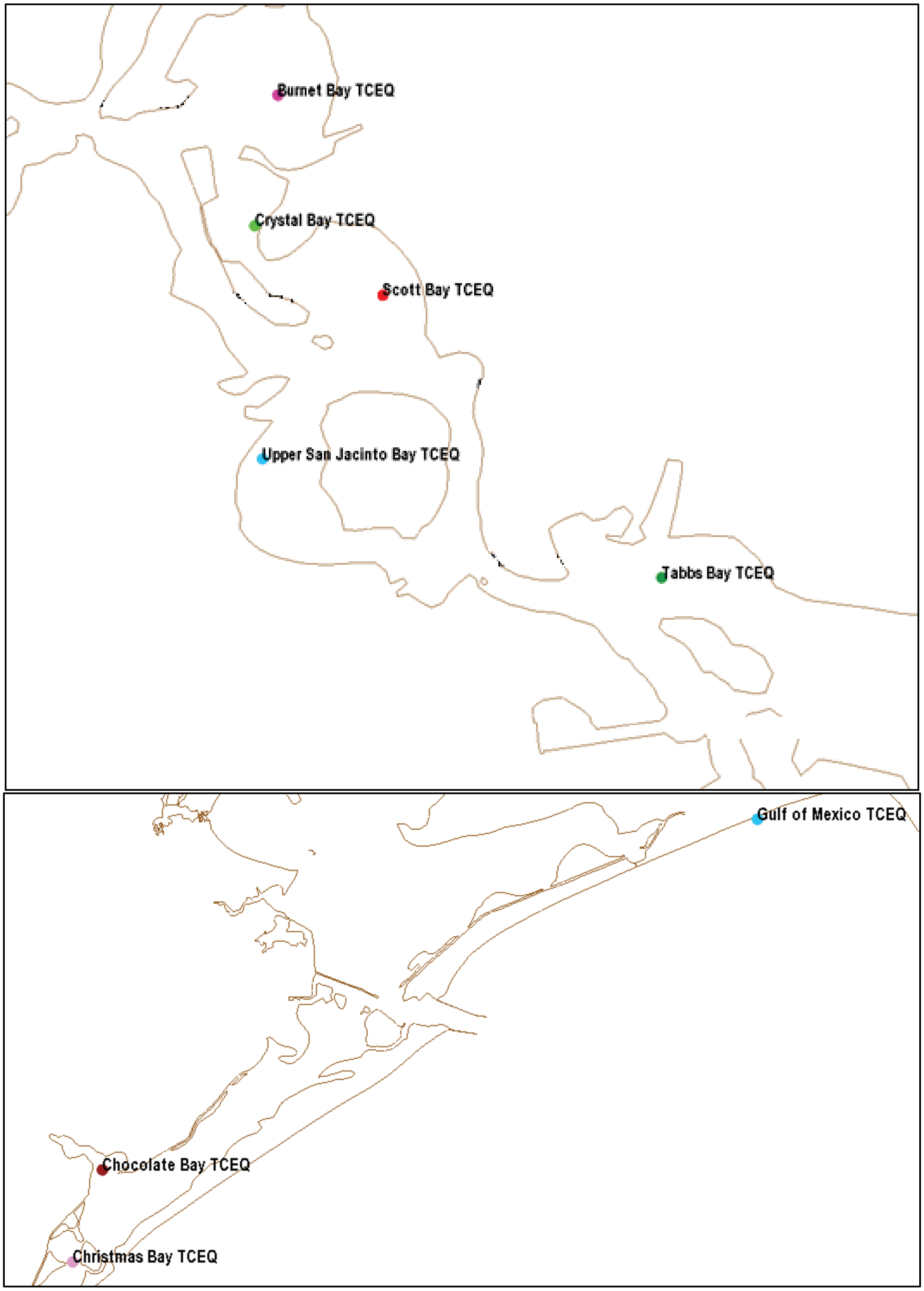


Figure 61. HARC salinity validation comparison sites.

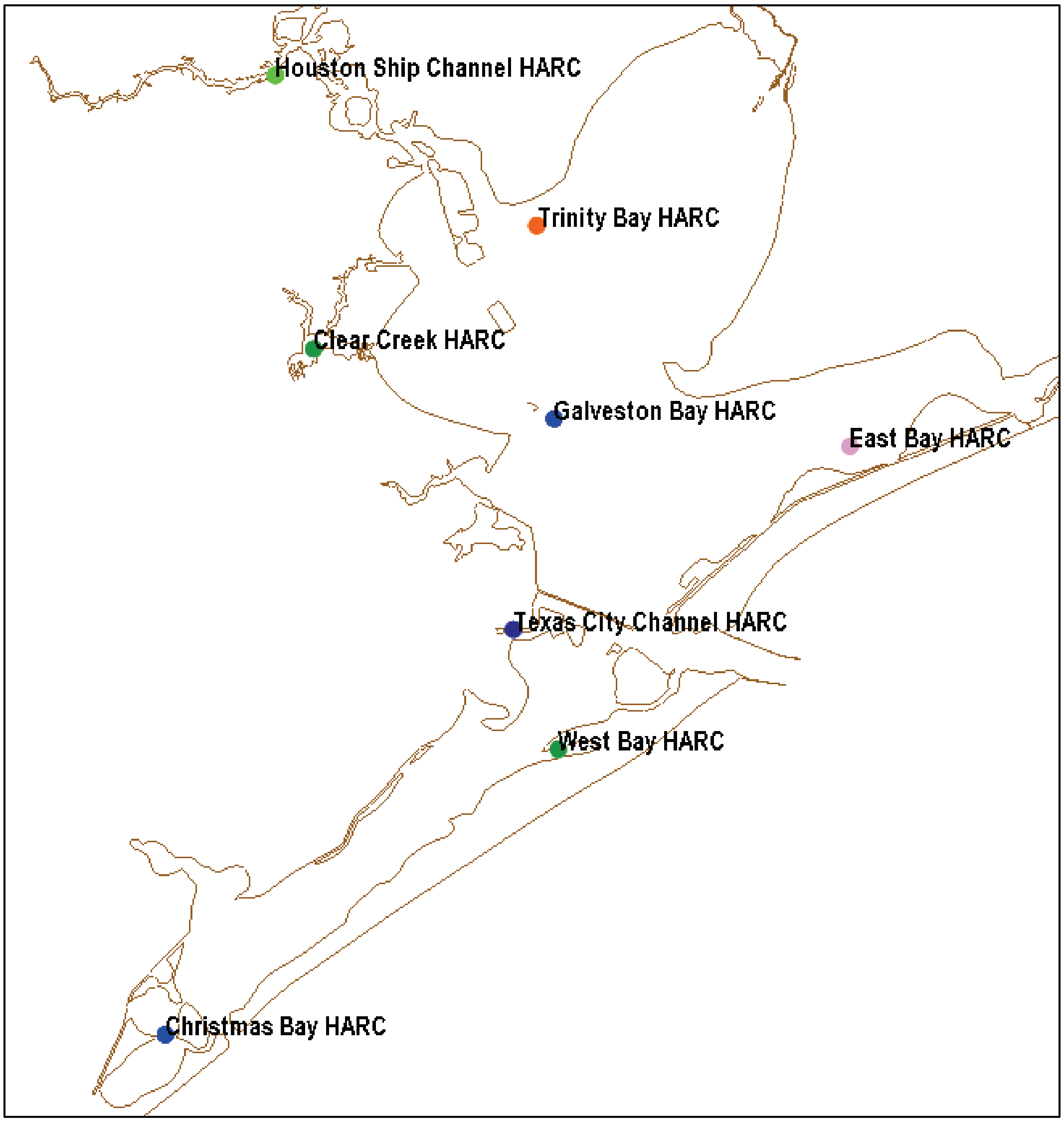
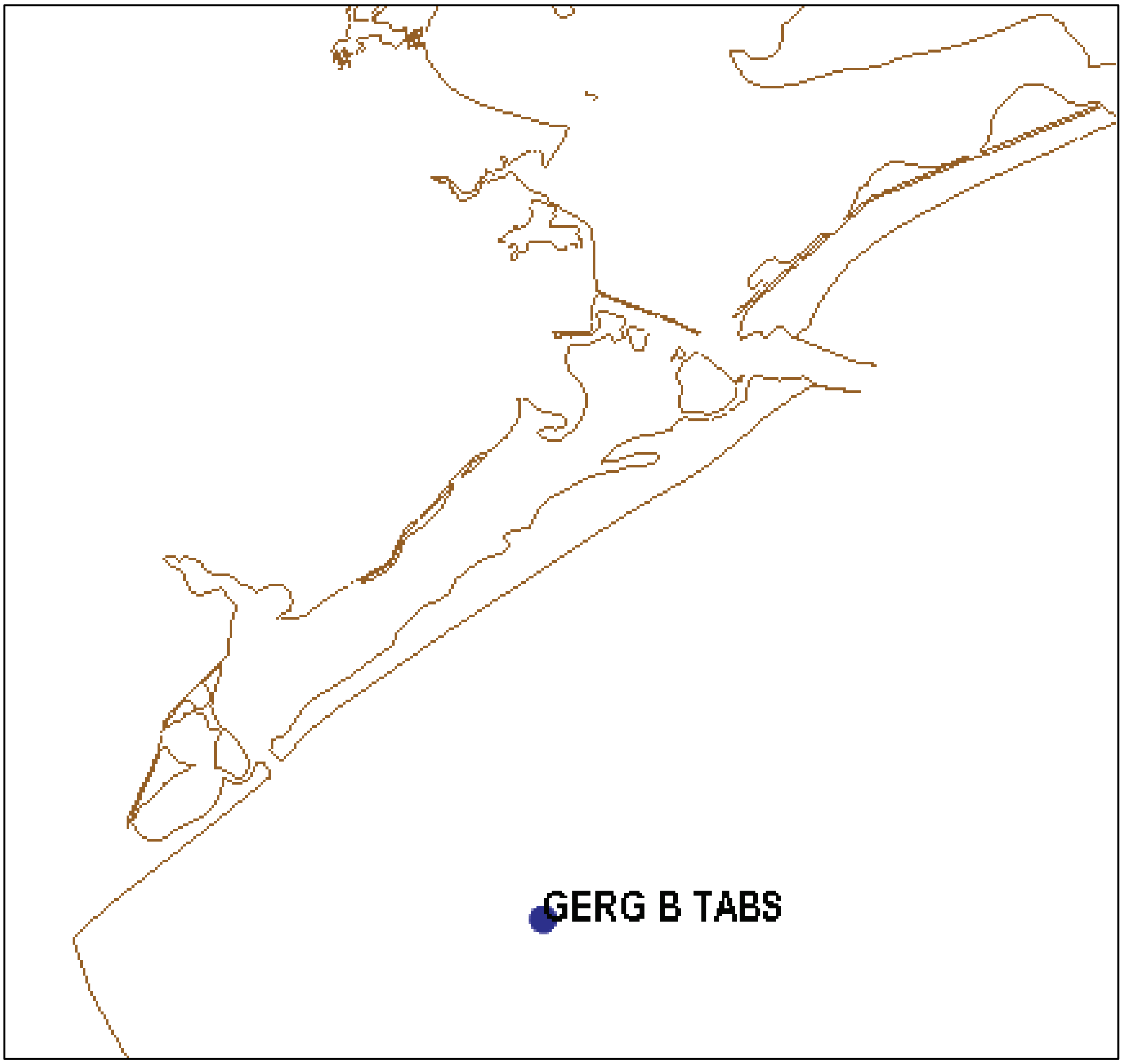


Figure 62. TABS salinity validation comparison site.



The upper HSC validation sites are primarily located in shallow regions outside of the ship channel. Model/field comparisons for the 2010 and 2011 validation period, from upstream to downstream, at HSC, Burnet Bay, Scott Bay, Baytown, and Upper San Jacinto Bay are shown in the following plots (Figure 63 through Figure 70).

Figure 63. 2010 HSC salinity validation comparisons.

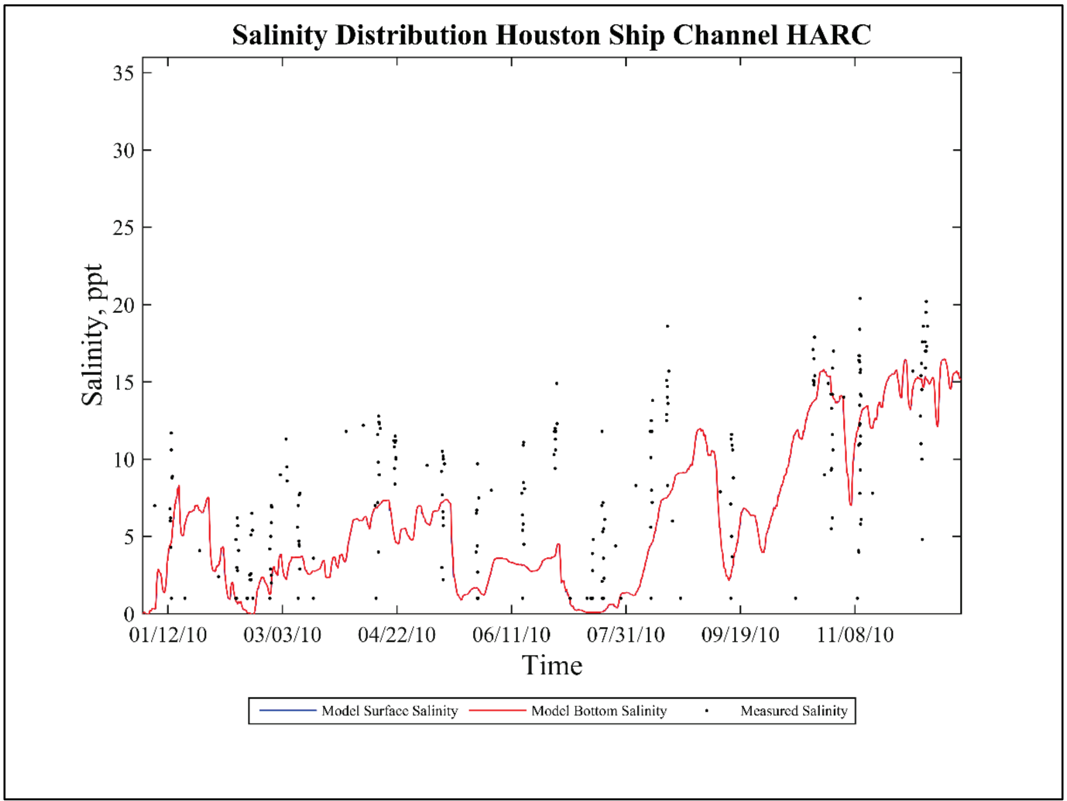


Figure 64. 2011 Burnet Bay salinity validation comparisons.

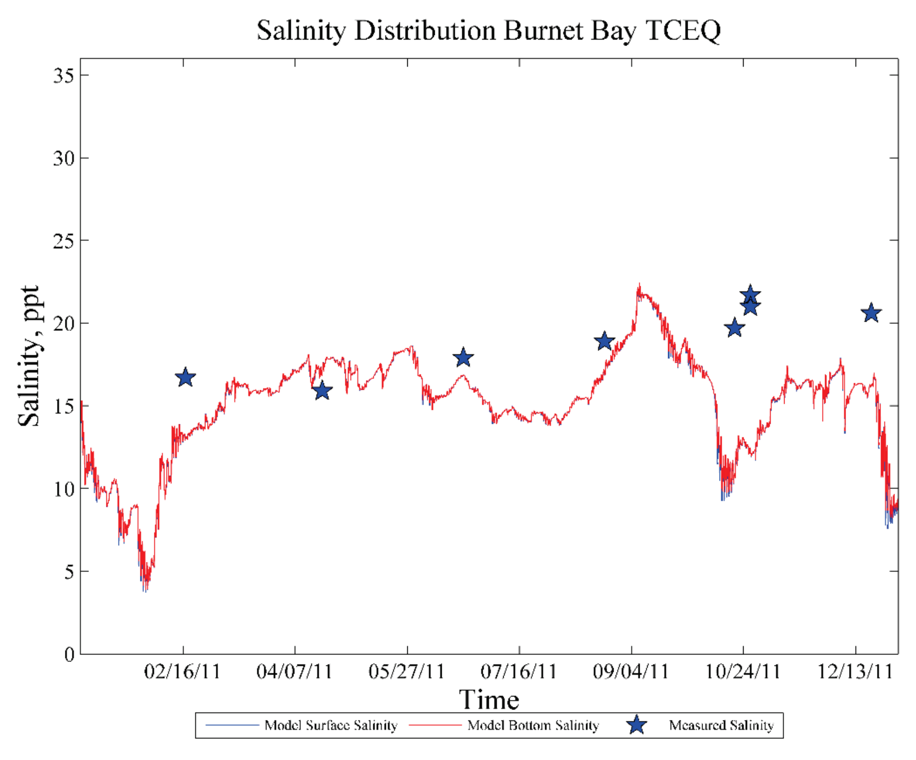


Figure 65. 2010 Scott Bay salinity validation comparisons.

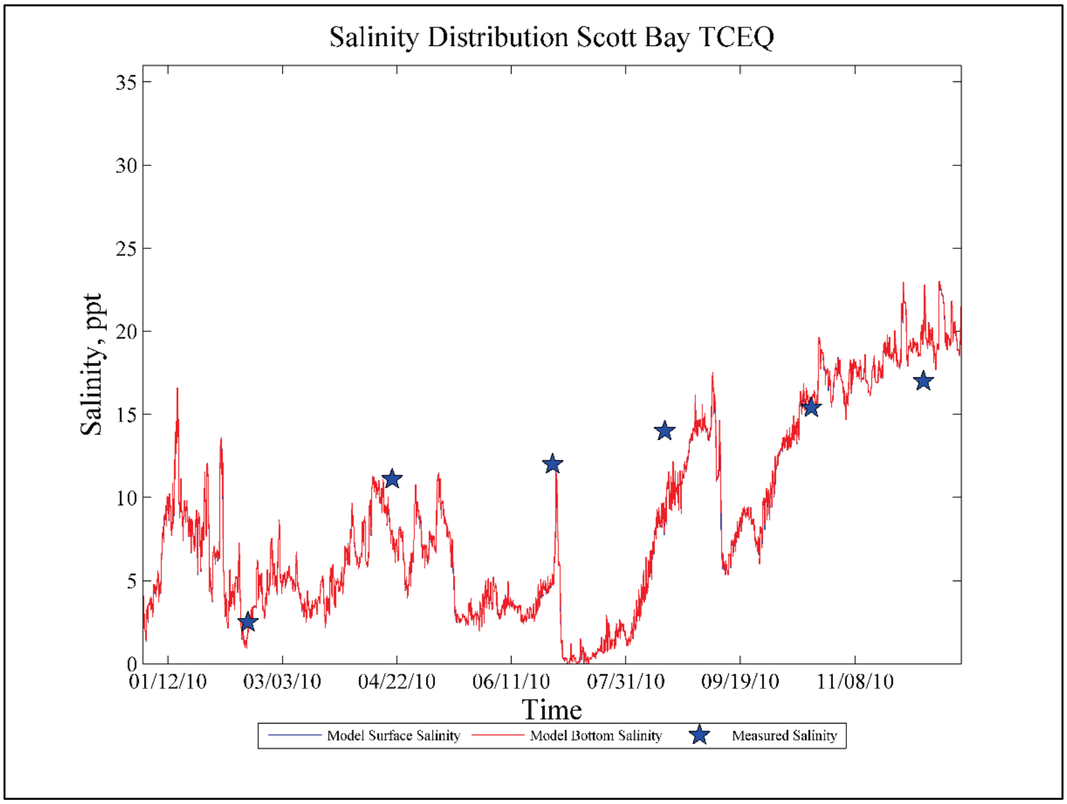


Figure 66. 2011 Scott Bay salinity validation comparisons.

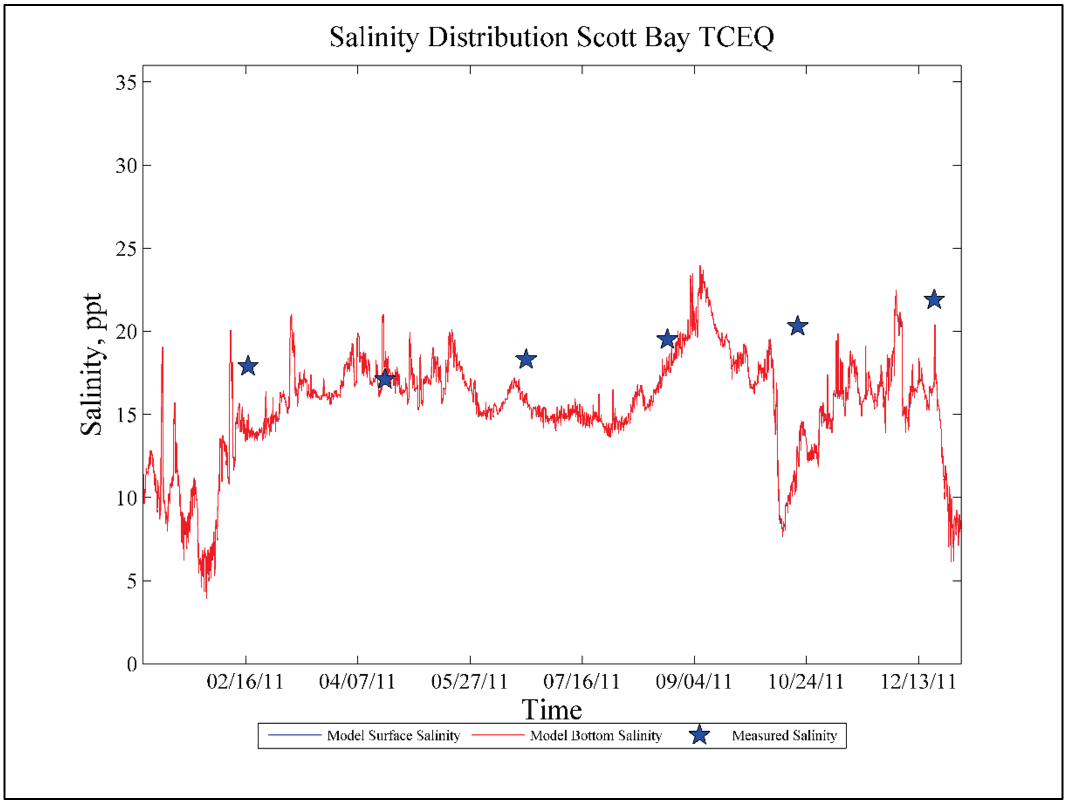


Figure 67. 2010 Baytown salinity validation comparisons.

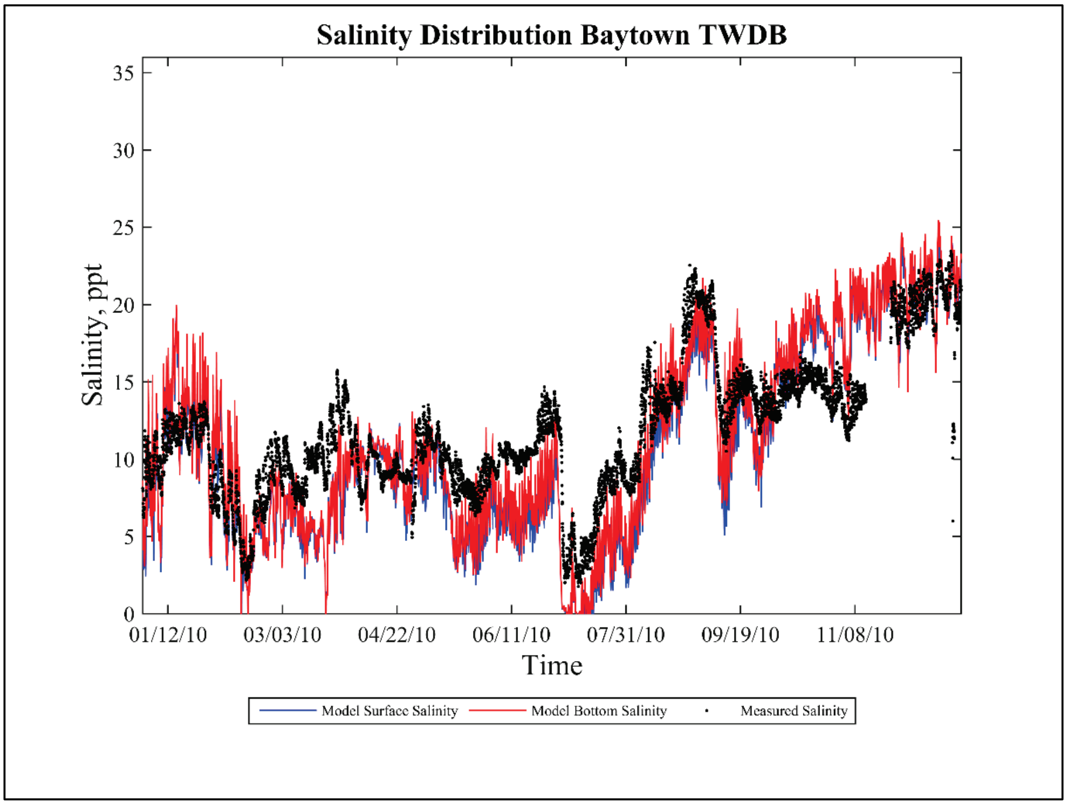


Figure 68. 2011 Baytown salinity validation comparisons.

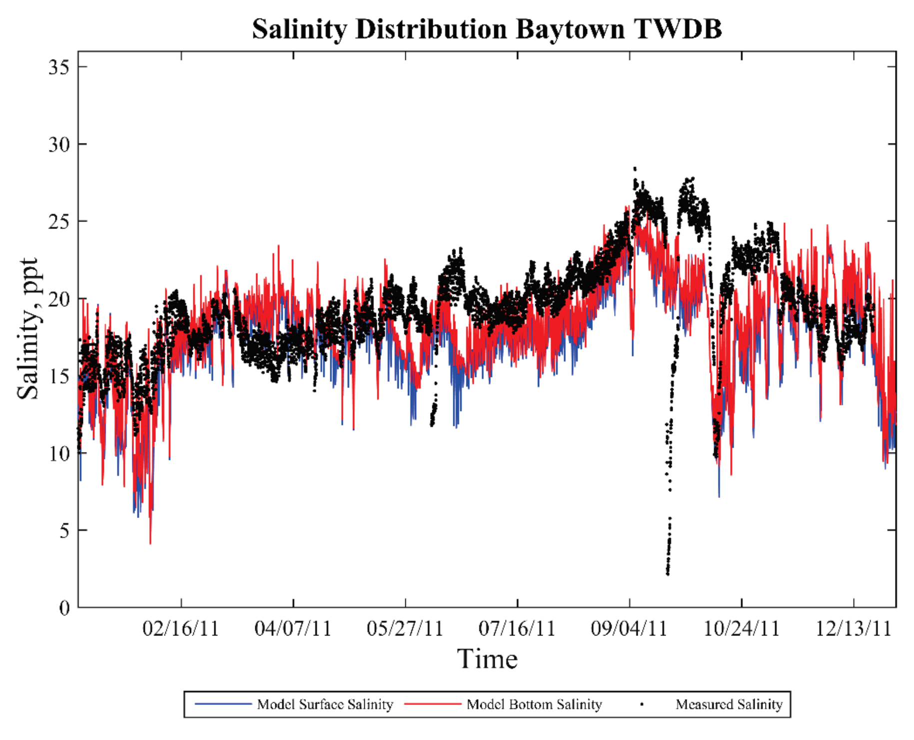


Figure 69. 2010 Upper San Jacinto Bay salinity validation comparisons.

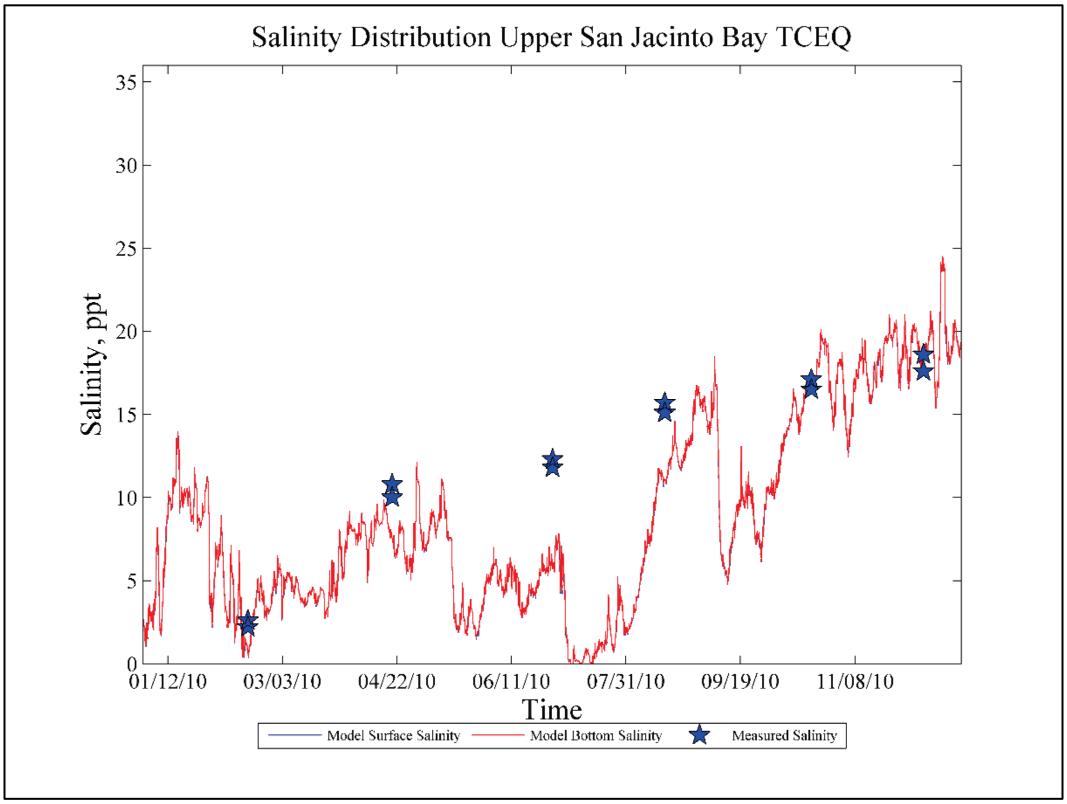
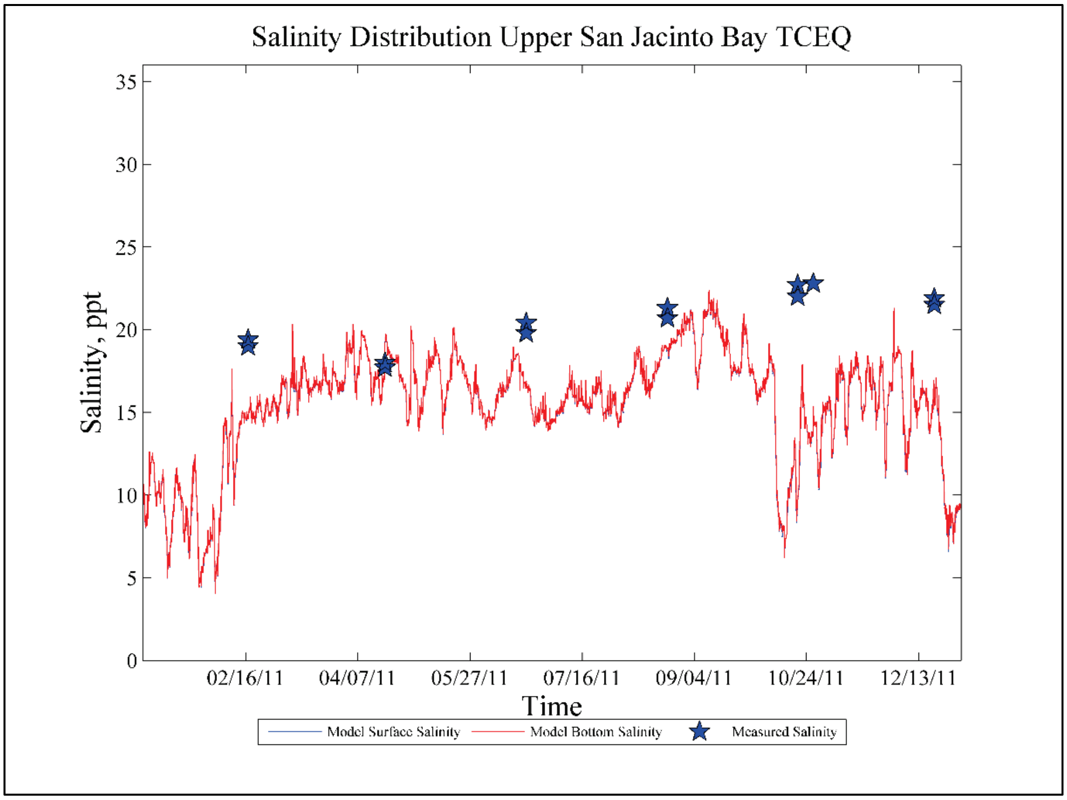


Figure 70. 2011 Upper San Jacinto Bay salinity validation comparisons.



Salinity impacts in Trinity Bay are of primary concern when analyzing project changes for impacts on aquatic habitat. The model/field validation comparisons of salinity at Mid Galveston Bay and two Trinity Bay sites — HARC on the northwest side of the bay (Figure 61) and TWDB on the southeast side of the bay (Figure 59) — are shown for 2010 and 2011 (except for Trinity Bay HARC) in Figure 71 through Figure 75.

Overall, the salinity patterns are replicated in the model. There are periods in the field data where it appears the field instrument malfunctions, but the general patterns are observable over the year-long simulation periods. The TWDB Trinity Bay (southeast) location comparisons indicate that the model is providing lower salinity values than the field, sometimes by as much as 8 ppt. This is expected because the model-computed velocities in these locations did not compare favorably to those observed in the field (Figure 55 through Figure 57). This area may be more heavily influenced by shallow depths and wind wave impacts (not included in this model) that are not impacting the salinity comparisons at the other comparison locations or due to neglected tidal prism due to model domain restrictions. Given the physics that are presently included in this AdH model and the overall good validation comparisons at other locations, these differences are noted but will not result in additional model calibration/validation.

Figure 71. 2010 Mid Galveston Bay salinity validation comparisons.

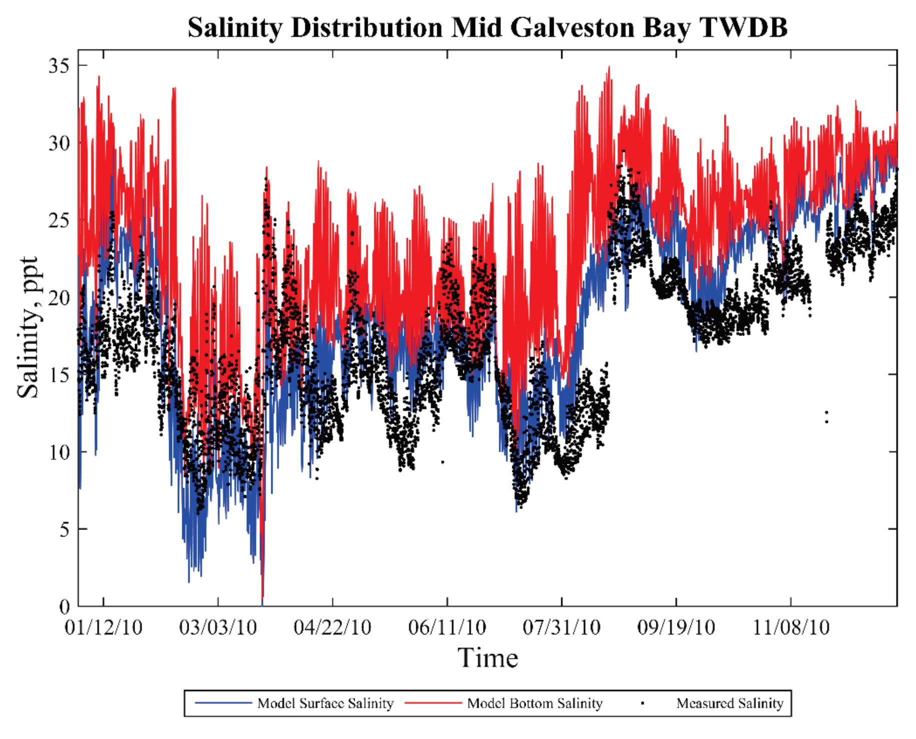


Figure 72. 2011 Mid Galveston Bay salinity validation comparisons.

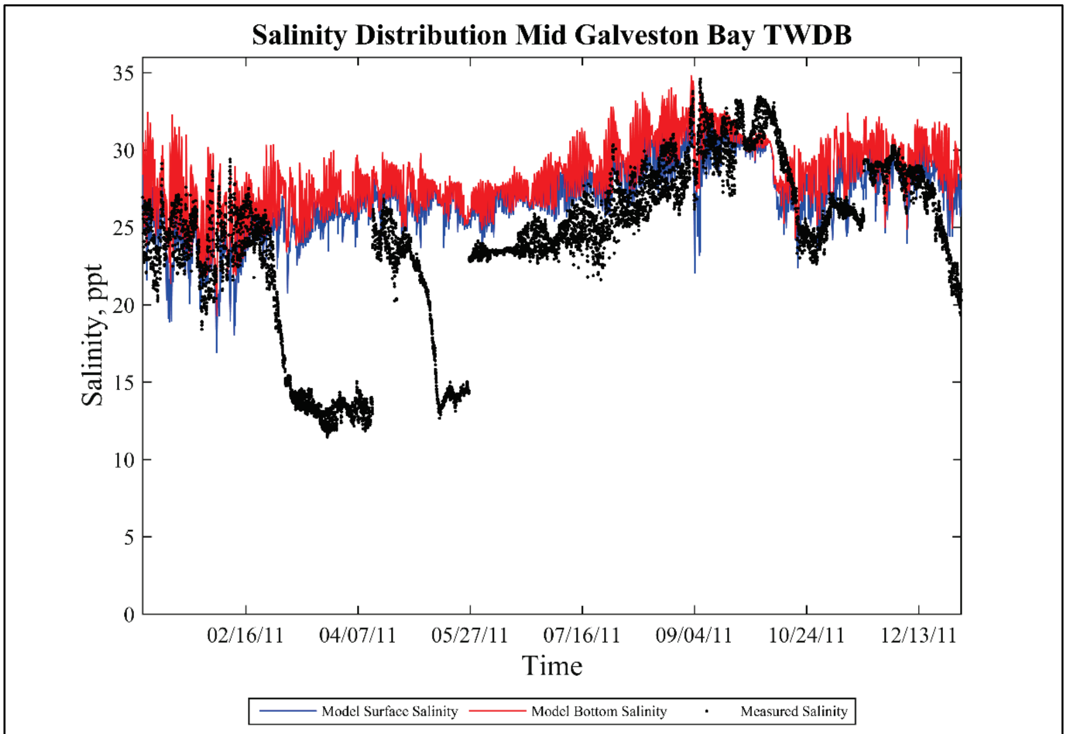


Figure 73. 2010 Trinity Bay HARC salinity validation comparisons (northwest).

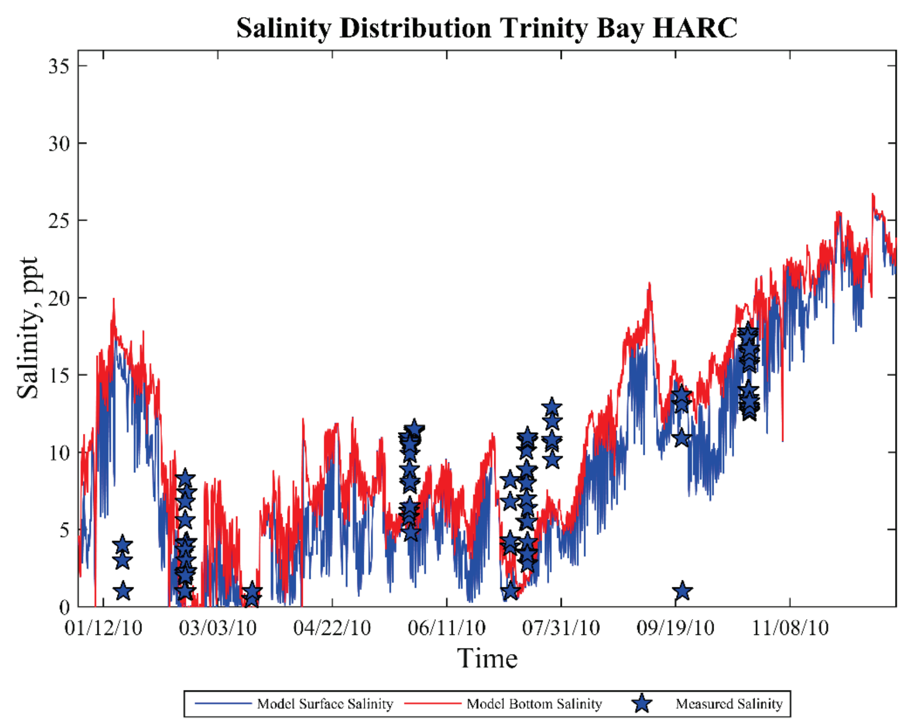


Figure 74. 2010 Trinity Bay TWDB salinity validation comparisons (southeast).

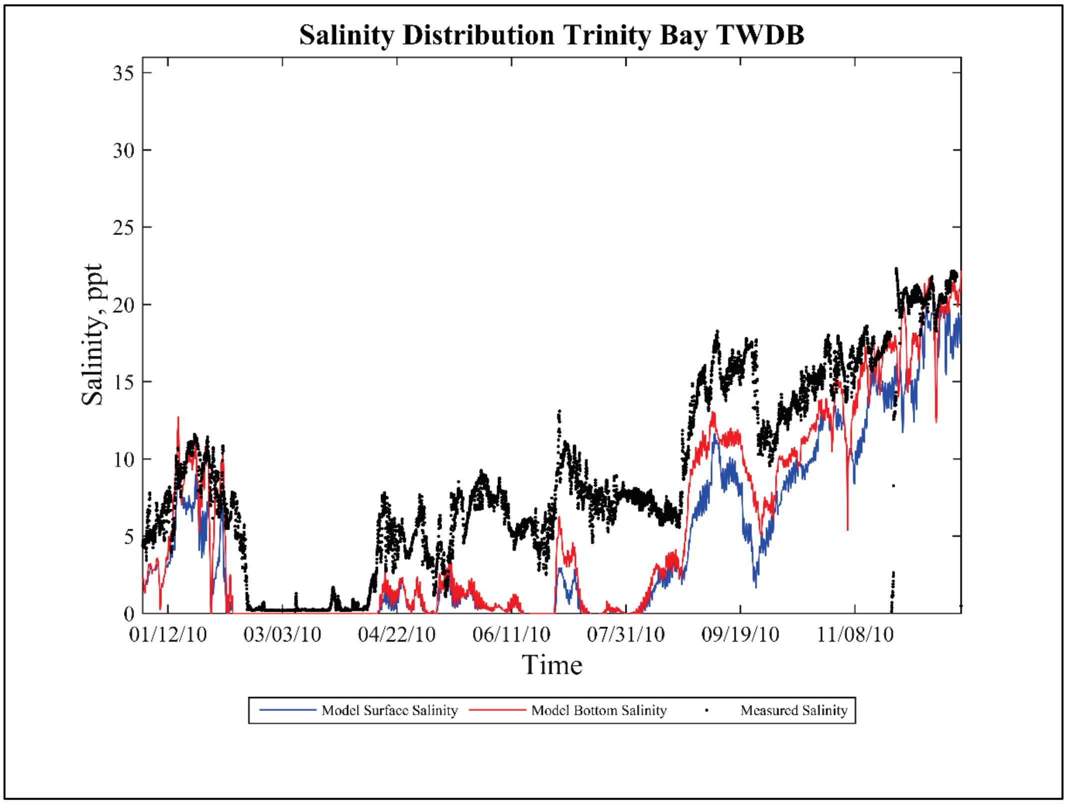
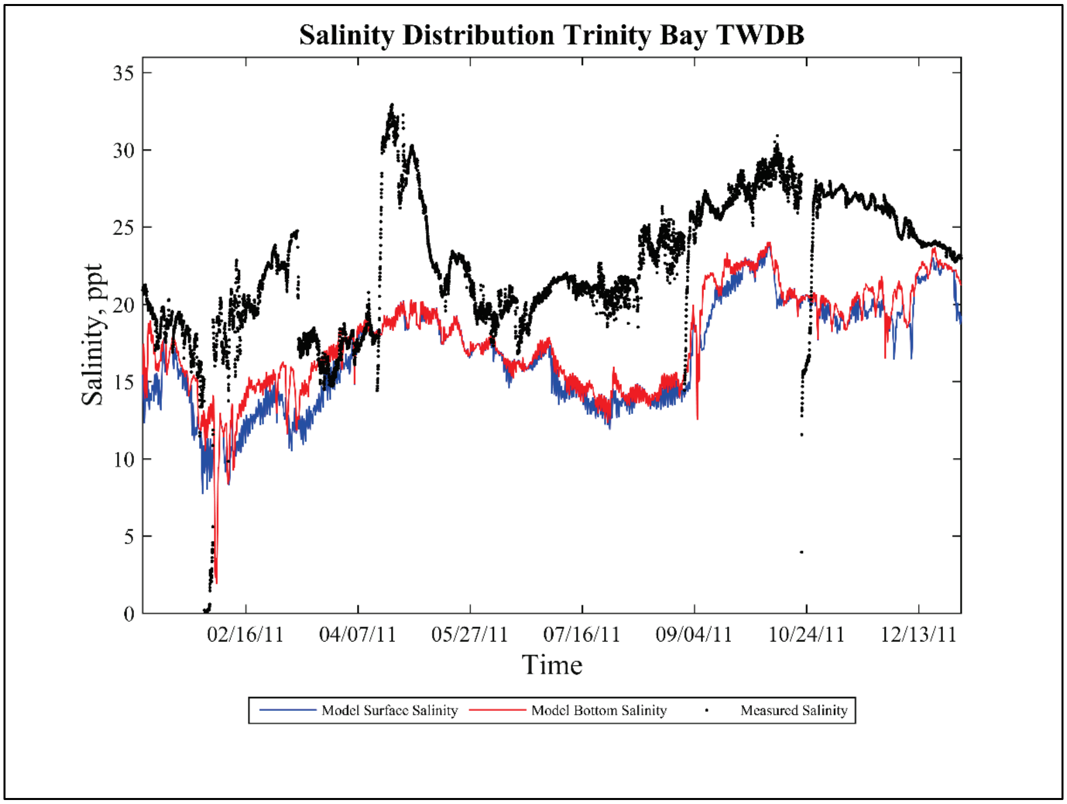


Figure 75. 2011 Trinity Bay TWDB salinity validation comparisons (southeast).

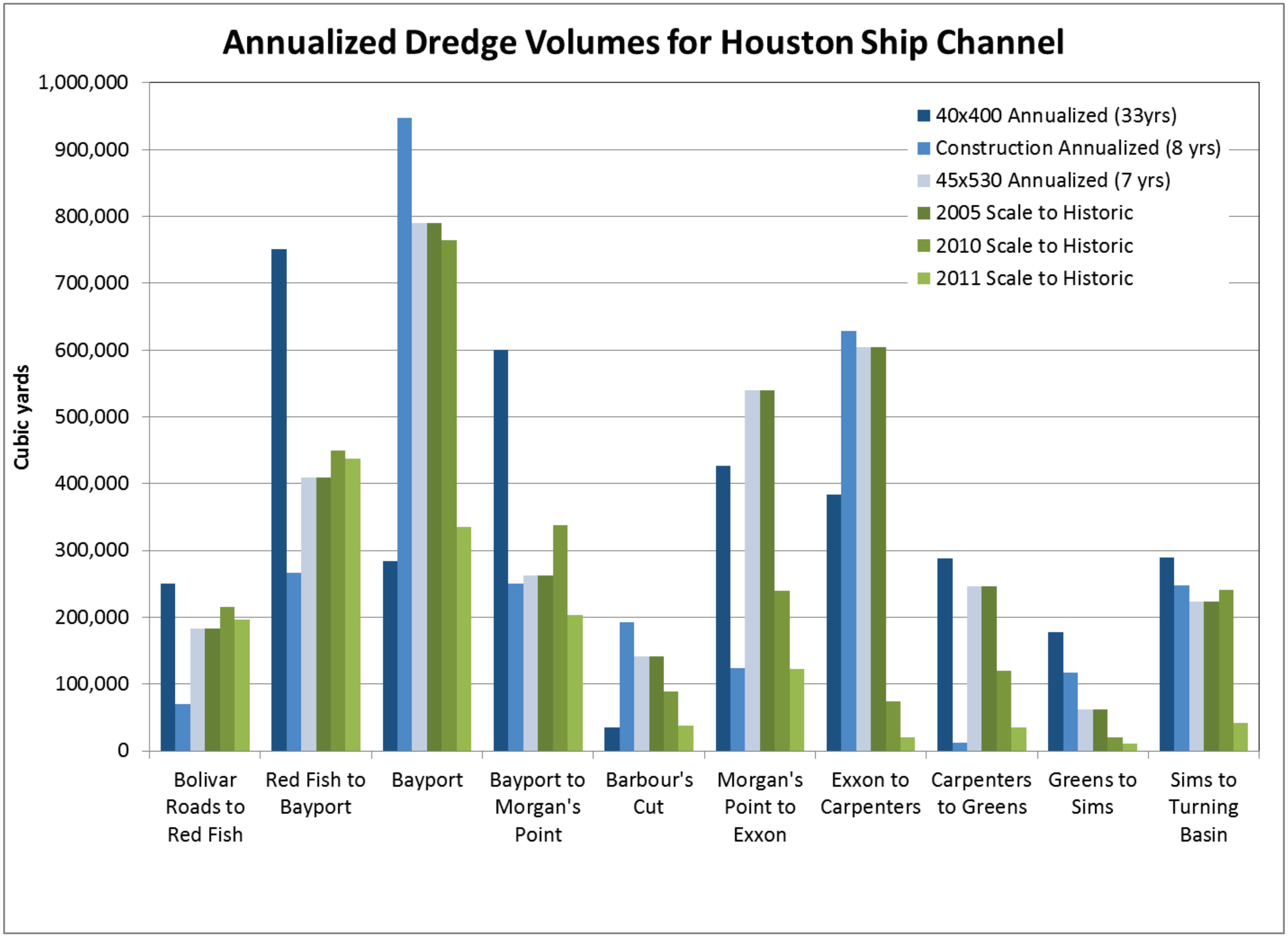


Sediment validation

The sediment model is validated based on historic maintenance dredging records for the HSC and a historic scaling method using the 2005 calibration year. The scale factor for each segment determined during the sediment model calibration was applied accordingly for the 2010 and 2011 validation years.

Figure 76 shows the shoaling validation results for 2010 and 2011 as compared to the annualized historic maintenance dredging records. The range of the shoaling results over the 2 validation years (green shades) lies within the range of the historic records (blue shades), and the large reduction in shoaling for 2011 is logical due to the drought and extremely low flow during that year. These results indicate that the model shoaling results, when scaled based on the 2005 data, should be appropriate for any base/plan comparisons made with the sediment model assuming the unaccounted for processes will not change with the plan alternative.

Figure 76. Model/field HSC shoaling validation comparison.



4 Conclusions

The 3D AdH model of the HSC and surrounding bays and bayous presented in this report has been developed based on the available data and known primary influences on the physics within the system. The model includes freshwater inflows, tides, salinity, wind, and sediment loads in an effort to reproduce the field for water surface elevation, velocity magnitude and direction, salinity, and HSC shoaling over a wide range of conditions. The model was compared to field data for 2005, 2010, and 2011 due to the availability of various data sets over wet and dry years. Calendar year 2005 was used for model calibration, and 2010 and 2011 were used for model validation.

Based on the AdH model definition as stated in Chapter 2 and the model/field comparisons for water surface elevation, velocity, salinity, and shoaling along the HSC as presented in Chapter 3, this model is available to simulate present and proposed future conditions, with and without project. Water surface elevation comparisons show good agreement between the model and the field over the 3 simulation years. The velocity comparisons are very good in the HSC but show much variation in Trinity Bay. It is possible that high-frequency events in the wind signal are generating some of these differences or that the field data are being influenced by local vessel traffic such as pleasure craft or fishing vessels. The model reproduces the salinity intrusion up the HSC as well as provides a reasonable representation of salinity stratification along the HSC as indicated by the available field data and historic documentation. The model also shows salinity intrusion into Trinity Bay; although comparisons in this area are not as good, the model generally replicates the salinity patterns over time.

The model does not directly include specified inputs of sediment loads from the ungaged freshwater inflows or the physics to compute wind-generated wave erosion along the shallows and vessel-induced erosion in the bays (which is known to be a significant source of HSC shoaling). Although the sediment model calibration attempts to account for these processes, there is a large range in the shoaling estimates for the validation period. This variability is also observed in the field data over time and indicates the sensitivity of the HSC shoaling to the variability of the forcing conditions. One-to-one comparison of the shoaling along the HSC is difficult to verify when scaling is based on a single year of data but is the only means available unless large quantities of sediment bed and load data are available for model calibration. Therefore, the model-predicted shoaling results should be viewed only in terms of relative changes and never used to predict total volume, especially if modifications to the system cause vessel traffic to change (i.e., faster and/or larger ships will likely generate an increase in the erosion potential they create in the area causing the model to underpredict the possible increase in HSC shoaling).

Although proven to match field conditions over a range of conditions, this model is intended to be used to reasonably forecast behavior assuming events do not occur that change the physics of the system. Hurricanes, severe storms, and anthropogenic influences (among other forces) over time can generate changes to the system that will require model updates or re-validation. The model is best used for determining trends and impacts in a percentage change and range of results type of analyses. Note that this model should not be used to predict actual values for any future parameters as the future is unknown, and it is extremely unlikely that the future will mimic exactly what is modeled.

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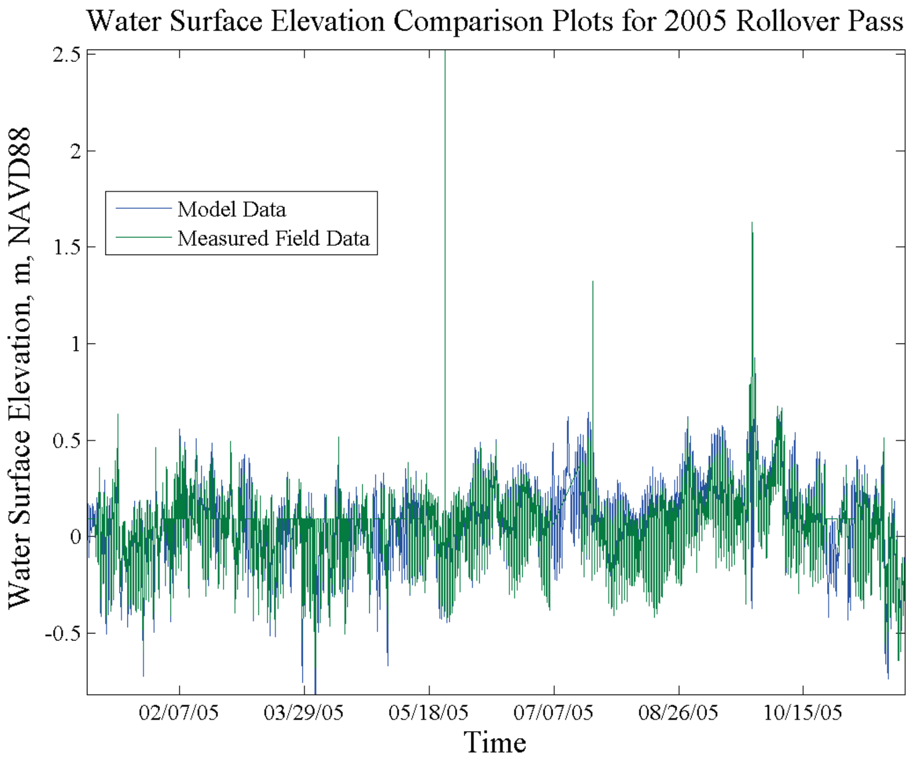
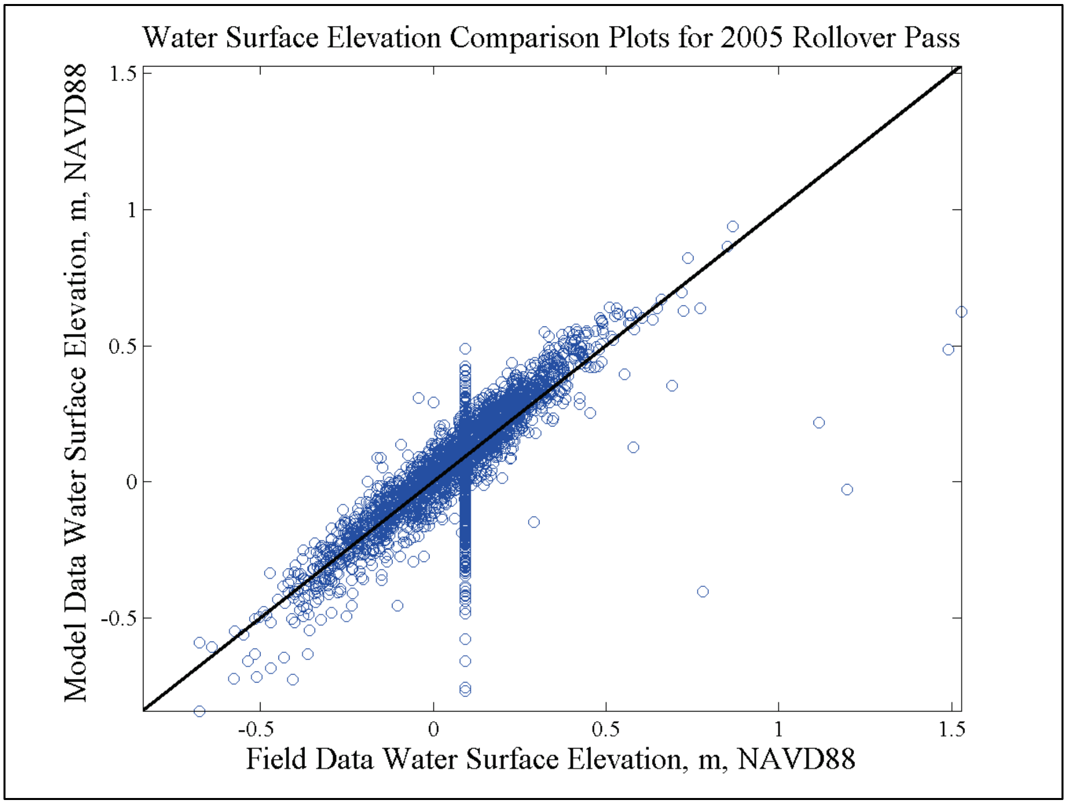
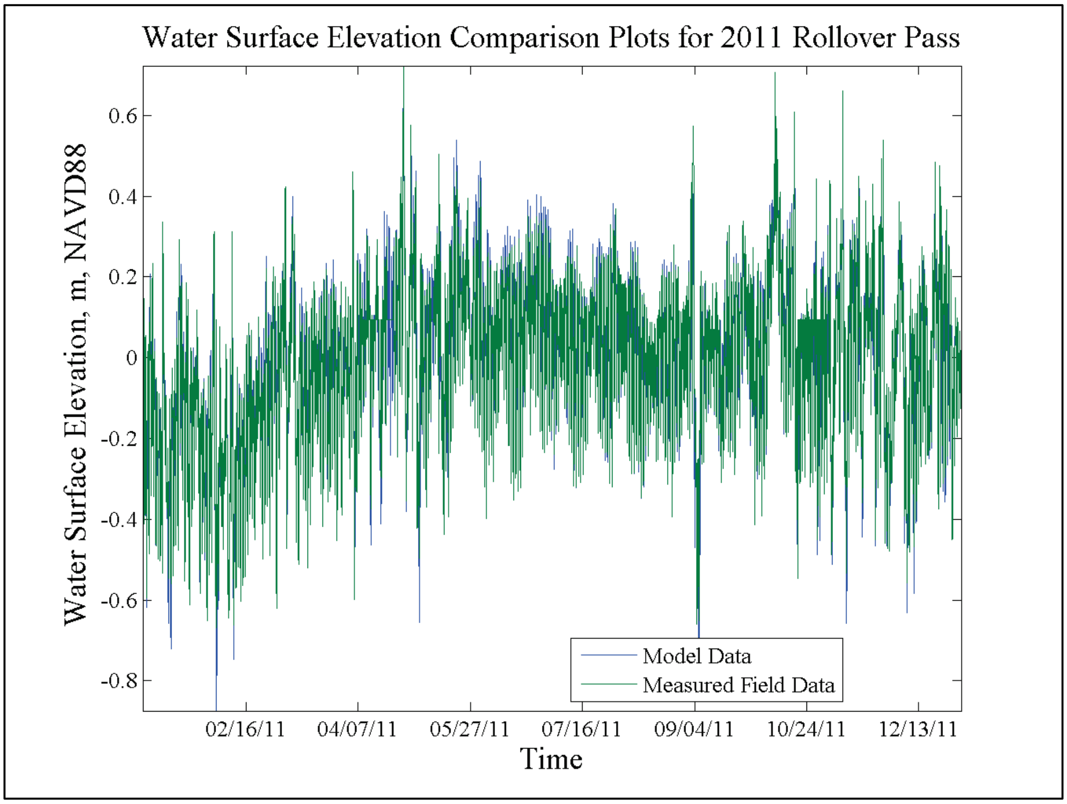
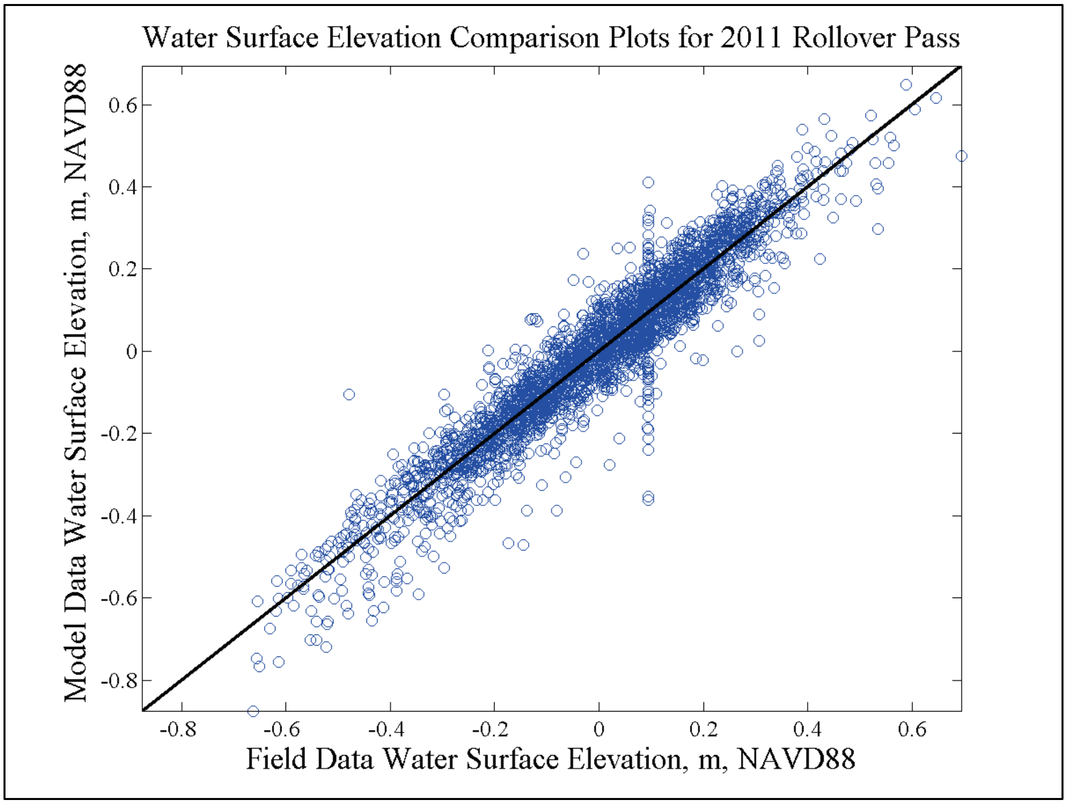
Appendix A: Water Surface Elevation Comparisons

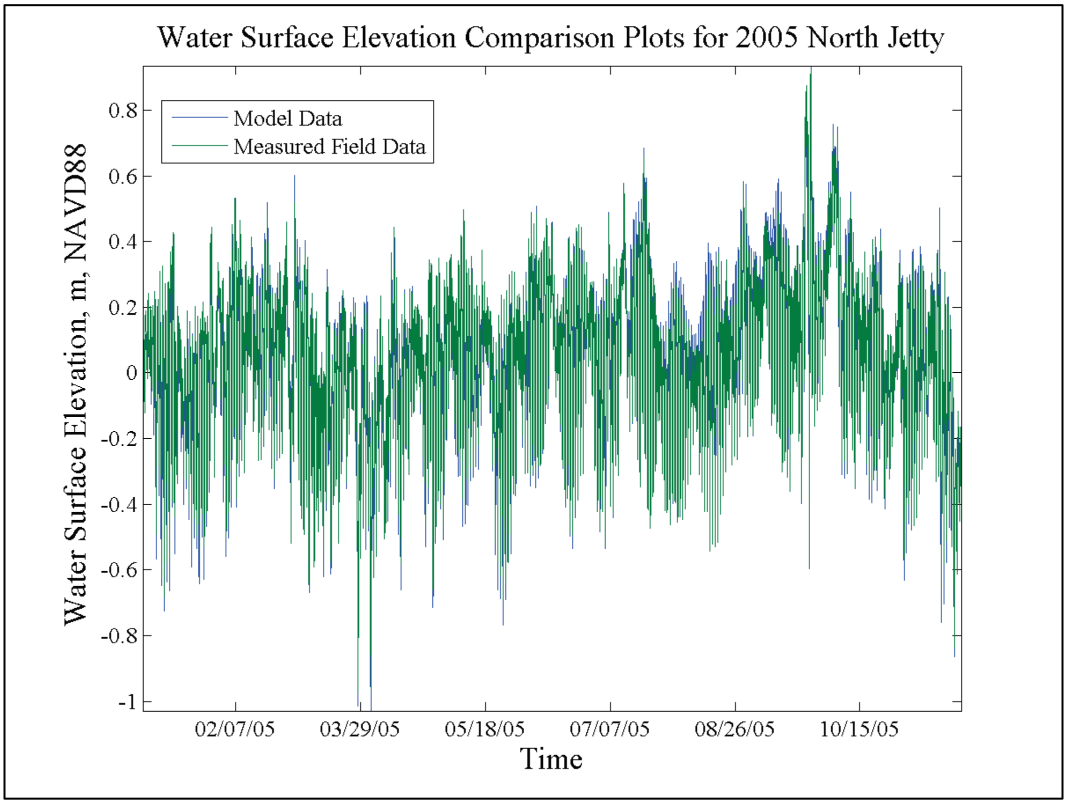
The following plots include all of the model/field water surface elevation comparisons for the available field data during the 3 calibration/validation years – 2005, 2010, and 2011. Data are not available for all 3 years at all sites. Figure 24 in the main text shows the locations of all water surface elevation comparison sites. For the time-history plots, the green line represents the measured field data, and the blue line represents the model-computed values. Each comparison location also includes a box plot showing the relationship between the measured field data (*x*-axis) and the modeled data (*y*-axis). A perfect match at all times would yield points on the black 1:1 line.

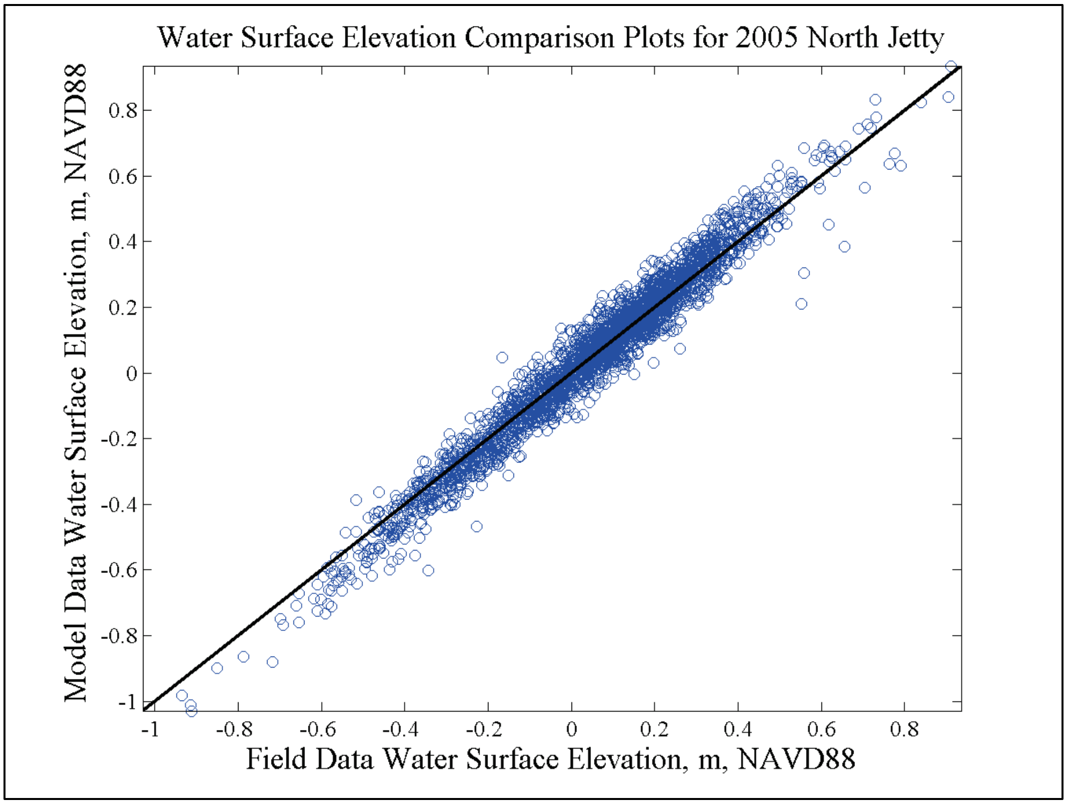


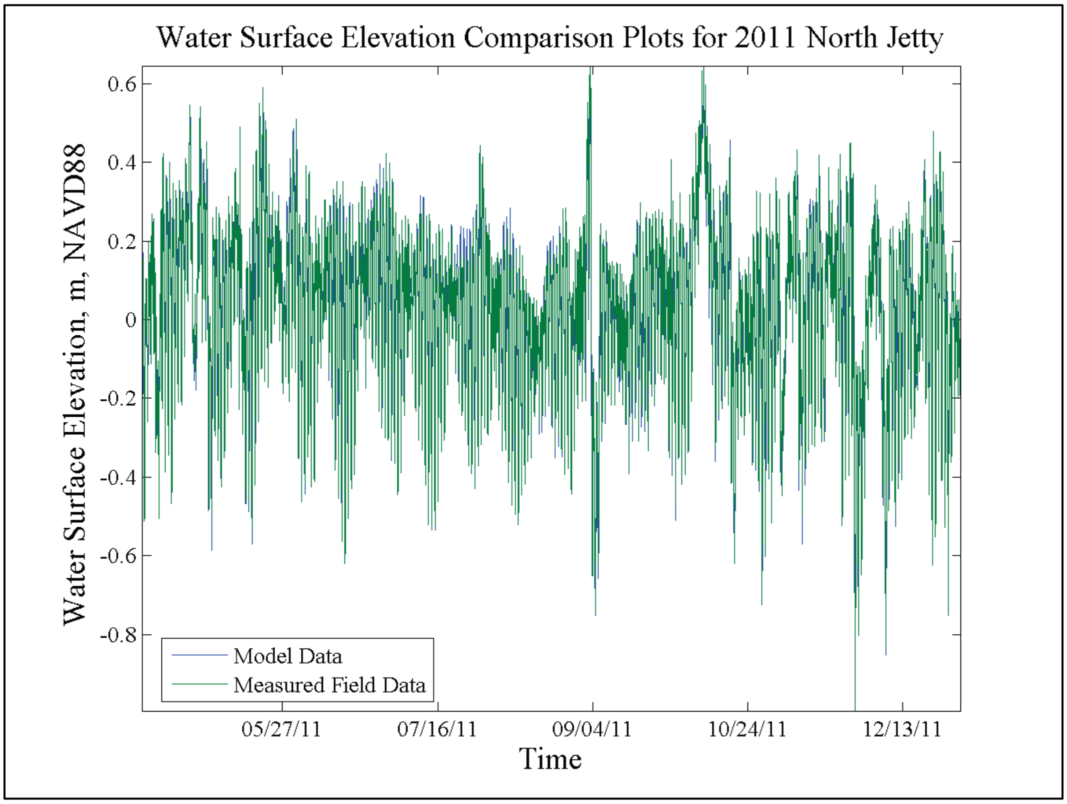

Water Surface Elevation Comparison Plots for 2005 Rollover Pass
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
1.5
1
0.5
0
-0.5
-0.5
0
0.5
1
1.5

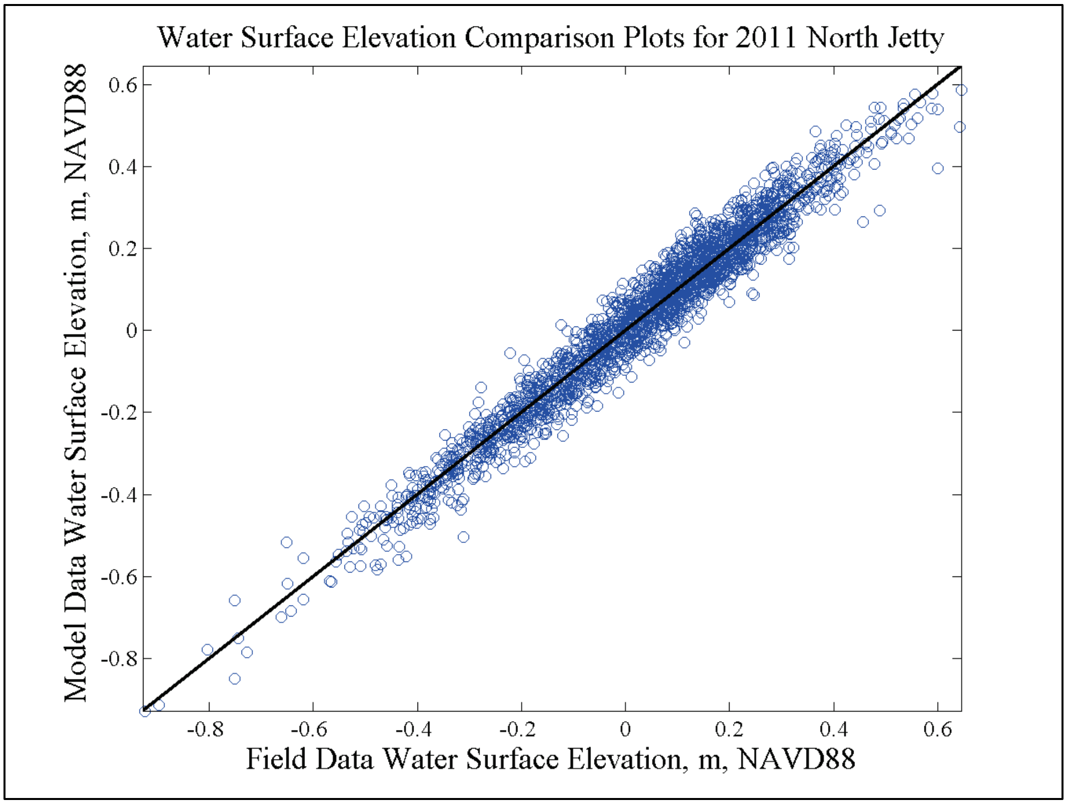

Water Surface Elevation Comparison Plots for 2011 Rollover Pass
Water Surface Elevation, m, NAVD88
Time
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Model Data
Measured Field Data

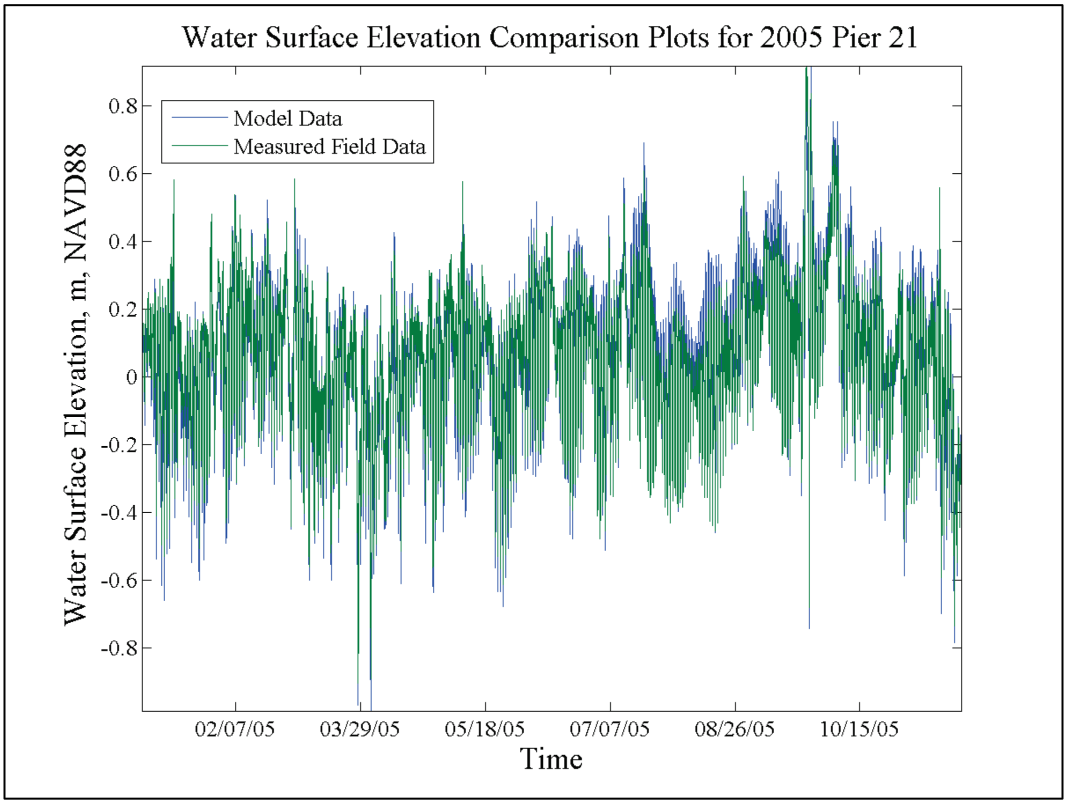

Water Surface Elevation Comparison Plots for 2011 Rollover Pass
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

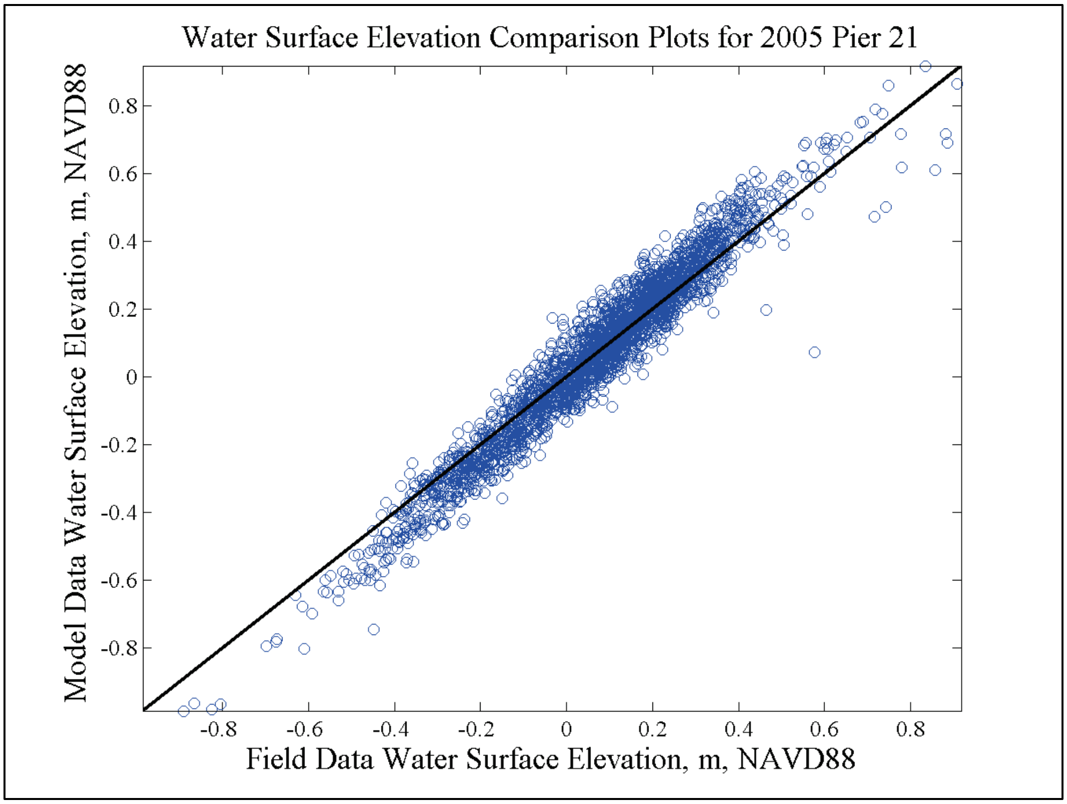

Water Surface Elevation Comparison Plots for 2005 North Jetty
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
Time
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05

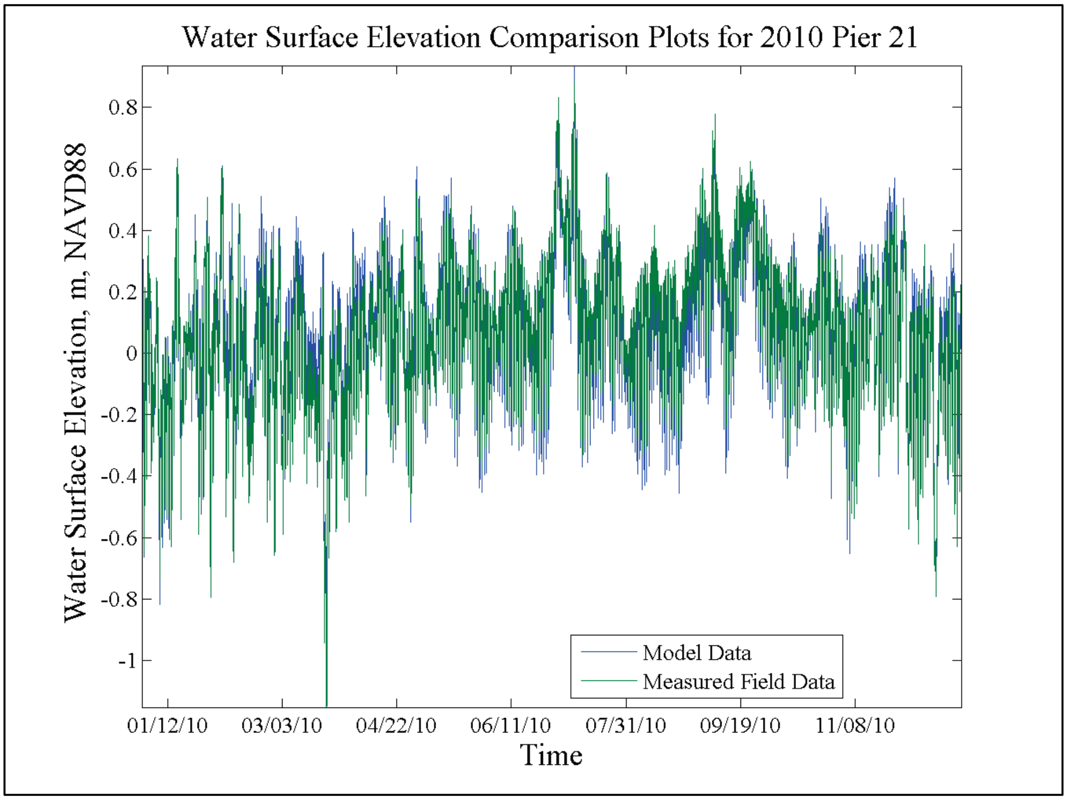

Water Surface Elevation Comparison Plots for 2005 North Jetty
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

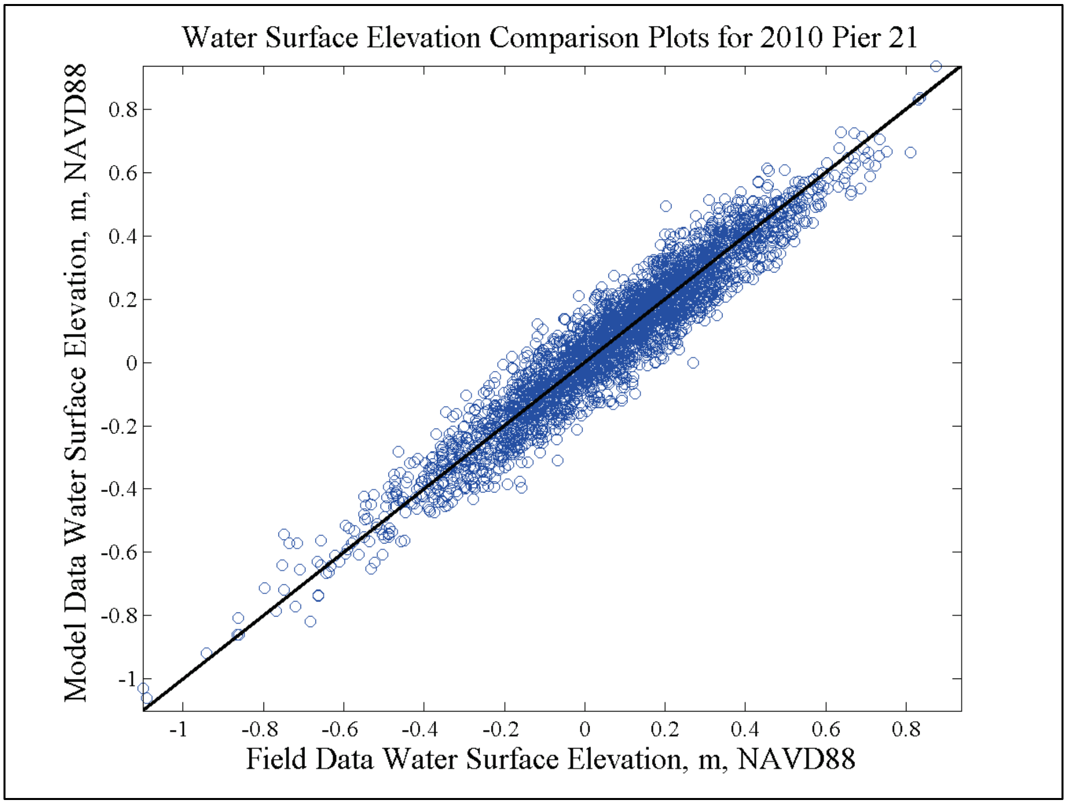

Water Surface Elevation Comparison Plots for 2011 North Jetty
Water Surface Elevation, m, NAVD88
Time
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Model Data
Measured Field Data

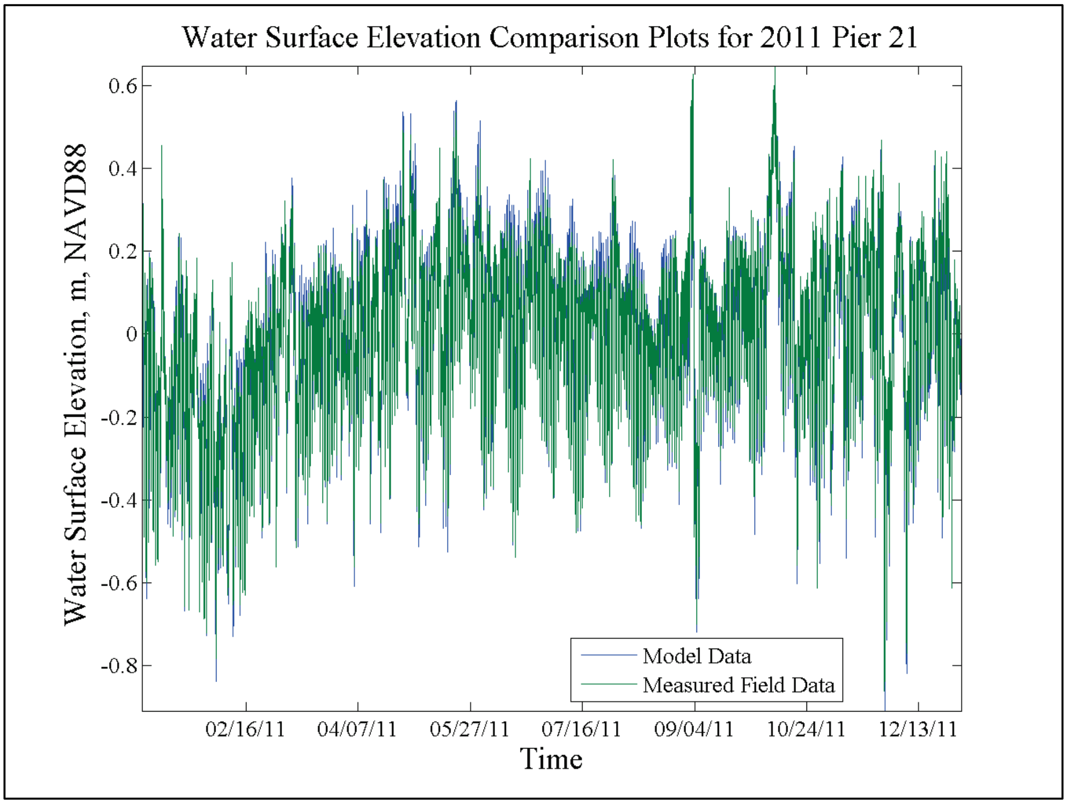

Water Surface Elevation Comparison Plots for 2011 North Jetty
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

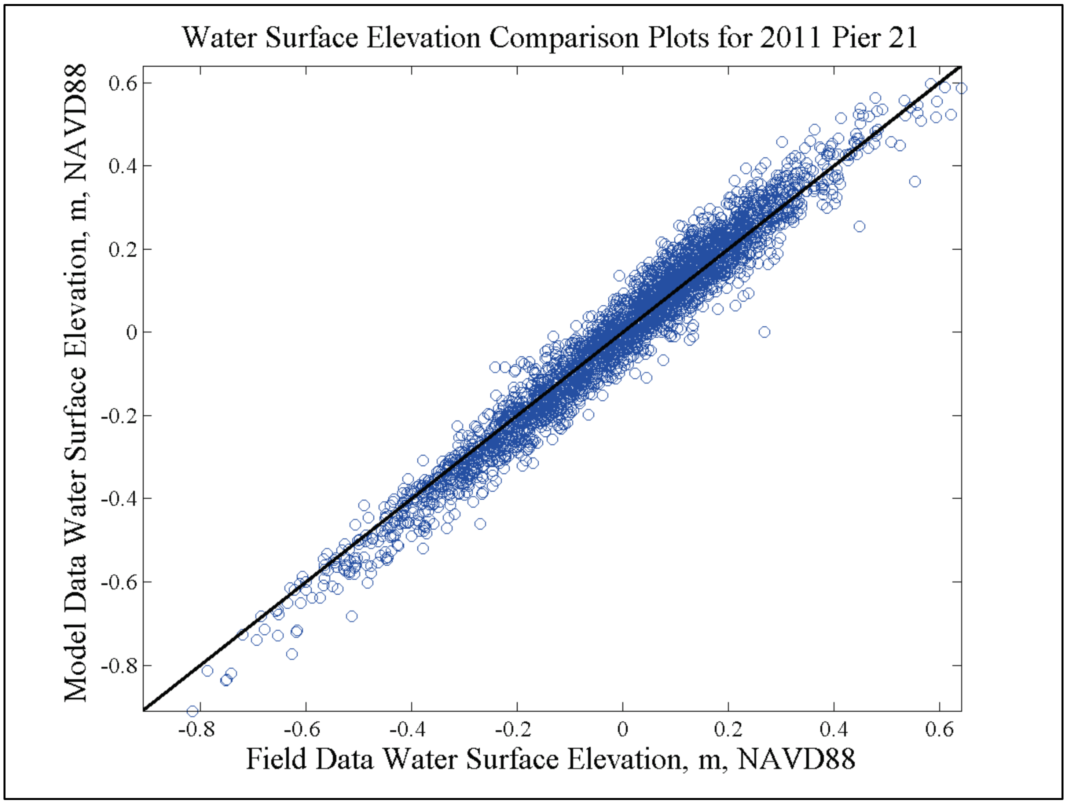

Water Surface Elevation Comparison Plots for 2005 Pier 21
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
Time
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05

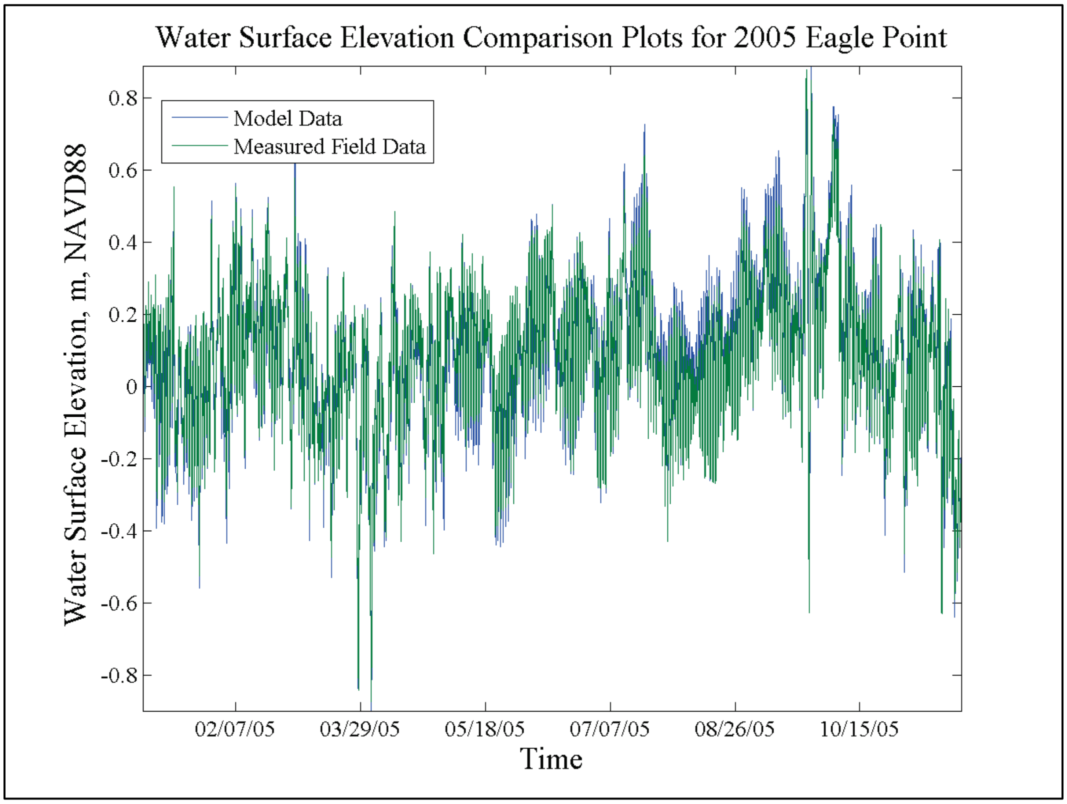

Water Surface Elevation Comparison Plots for 2005 Pier 21
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

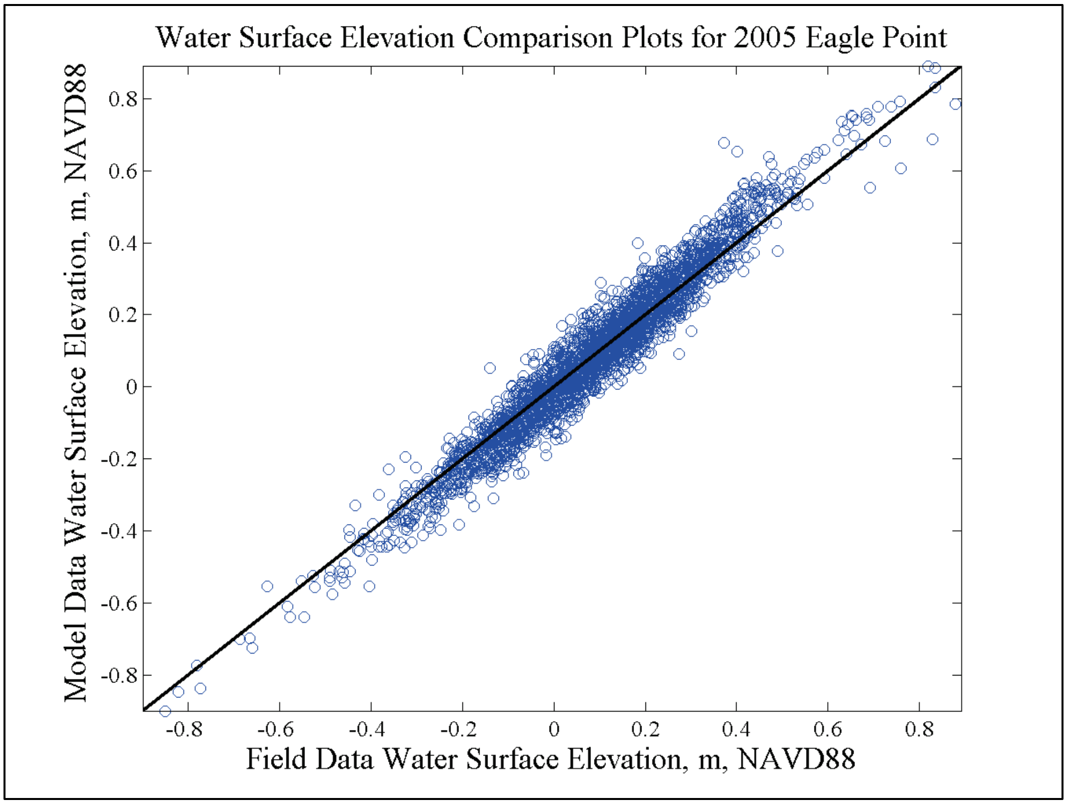

Water Surface Elevation Comparison Plots for 2010 Pier 21
Water Surface Elevation, m, NAVD88
Time
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Model Data
Measured Field Data

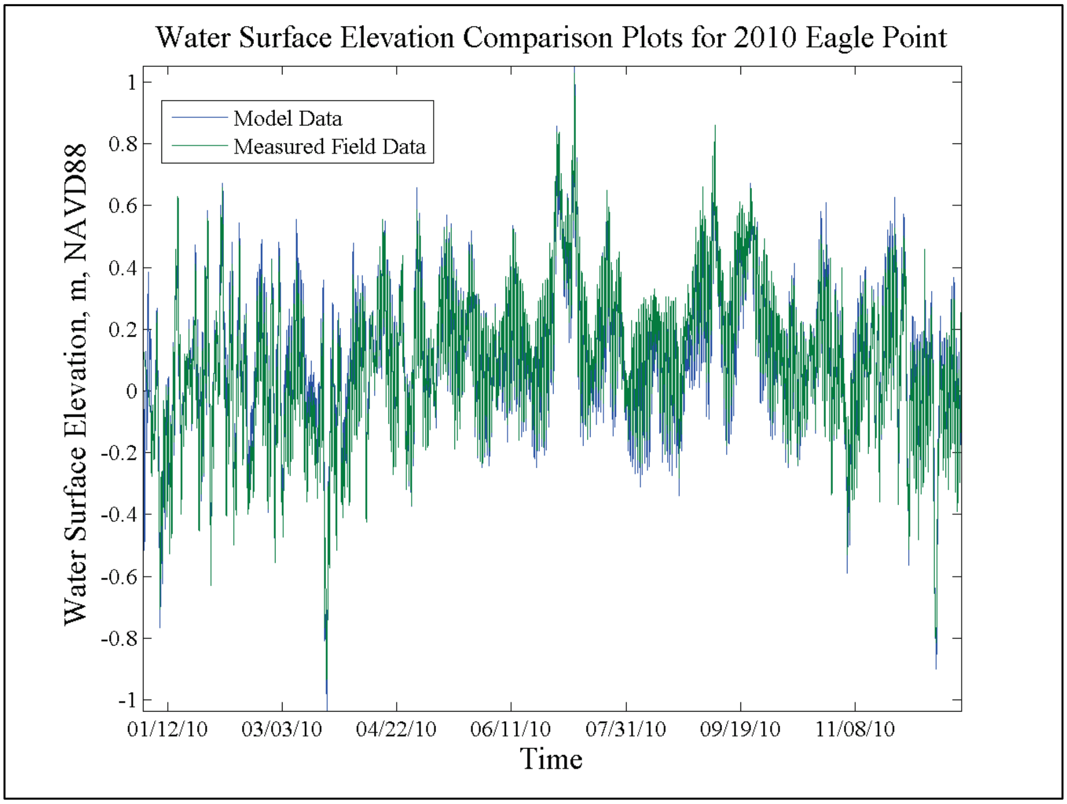

Water Surface Elevation Comparison Plots for 2010 Pier 21
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

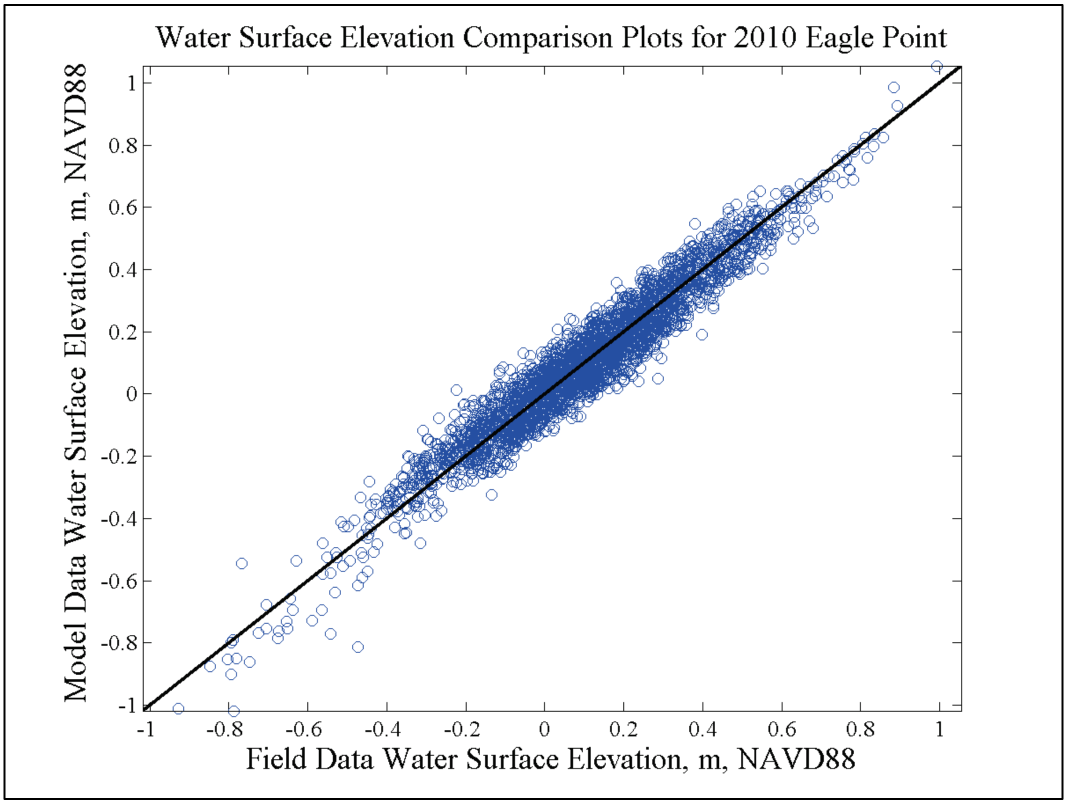

Water Surface Elevation Comparison Plots for 2011 Pier 21
Water Surface Elevation, m, NAVD88
Time
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Model Data
Measured Field Data

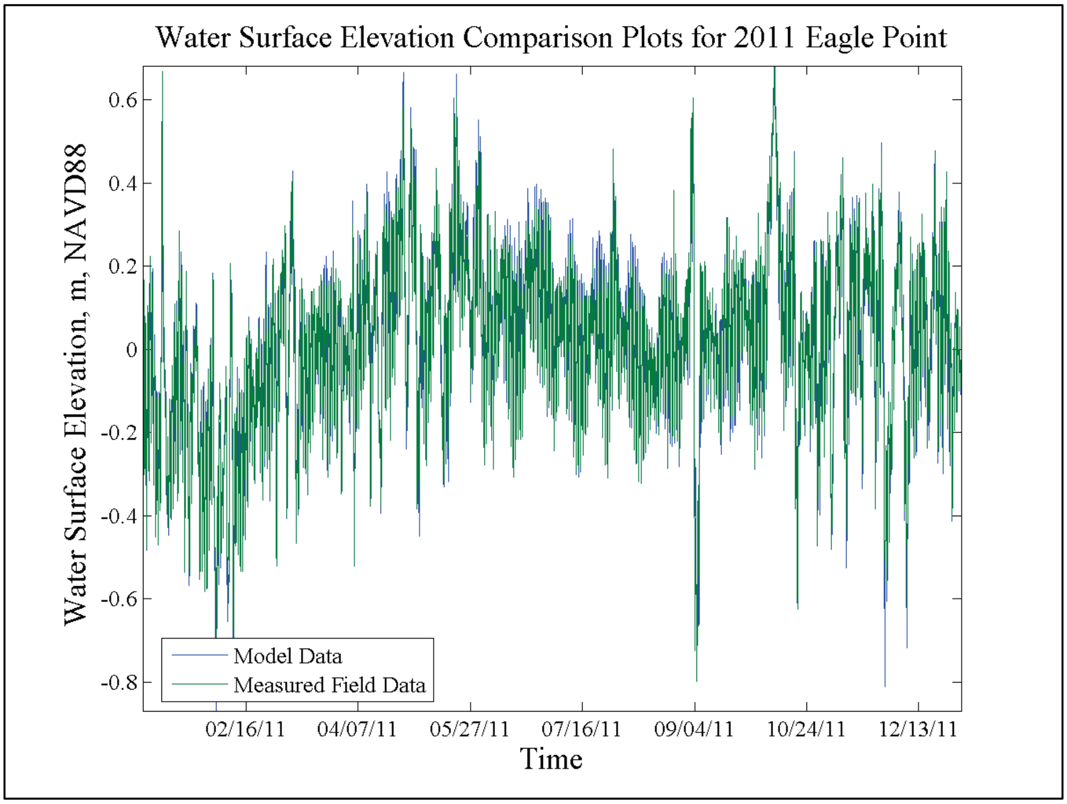

Water Surface Elevation Comparison Plots for 2011 Pier 21
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

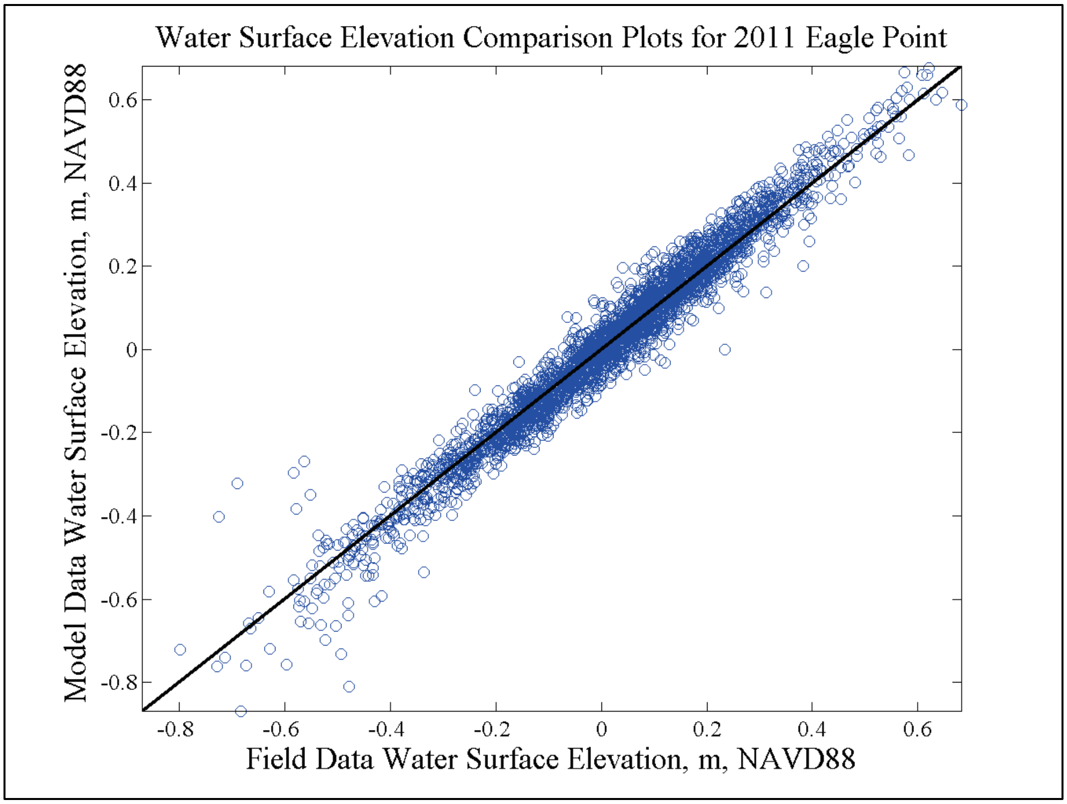

Water Surface Elevation Comparison Plots for 2005 Eagle Point
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
Time
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05

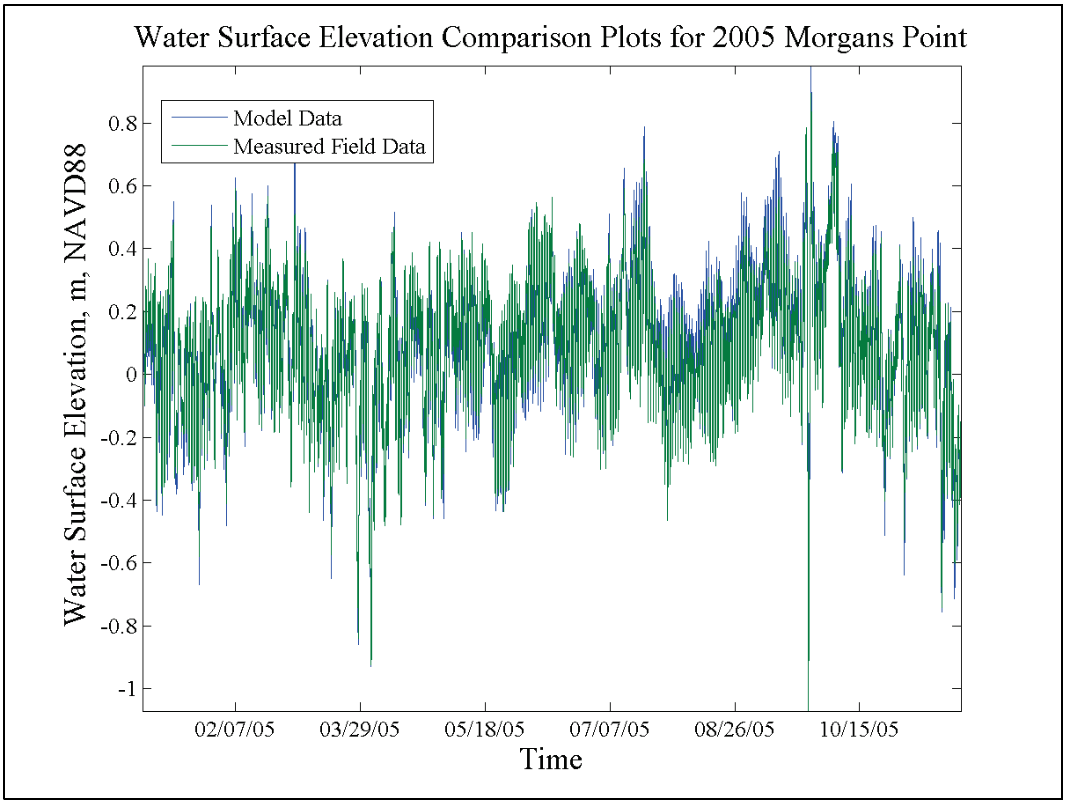

Water Surface Elevation Comparison Plots for 2005 Eagle Point
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8

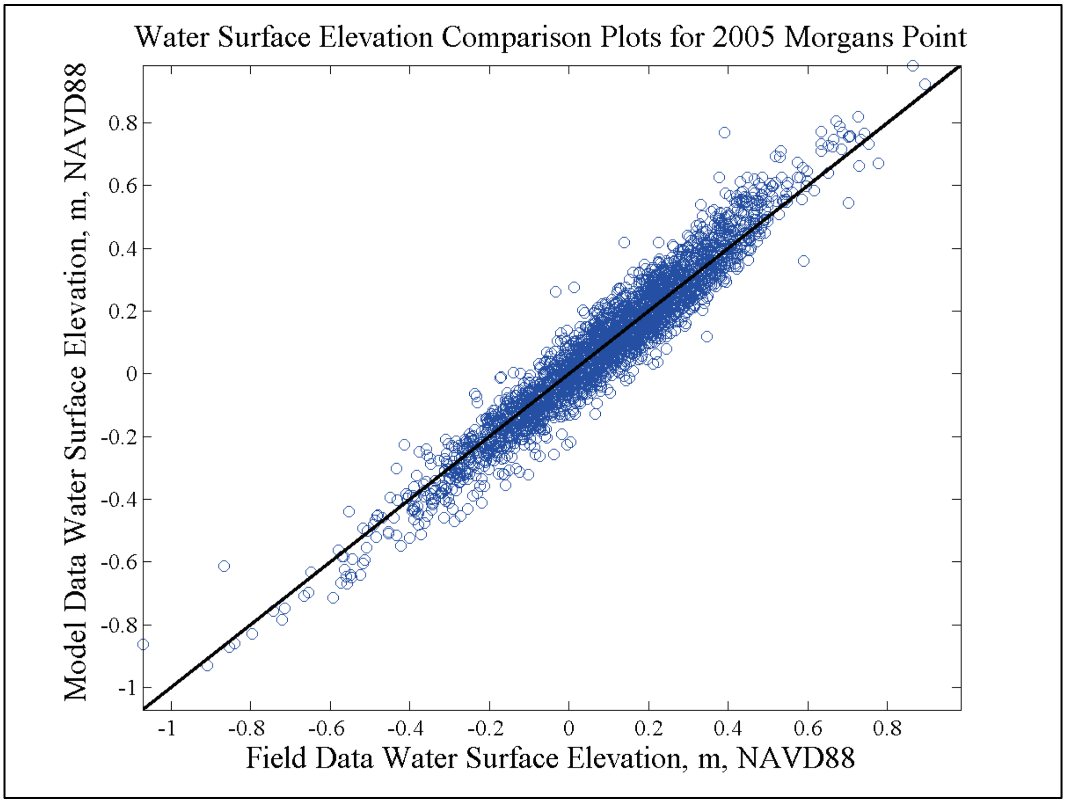

Water Surface Elevation Comparison Plots for 2010 Eagle Point
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10

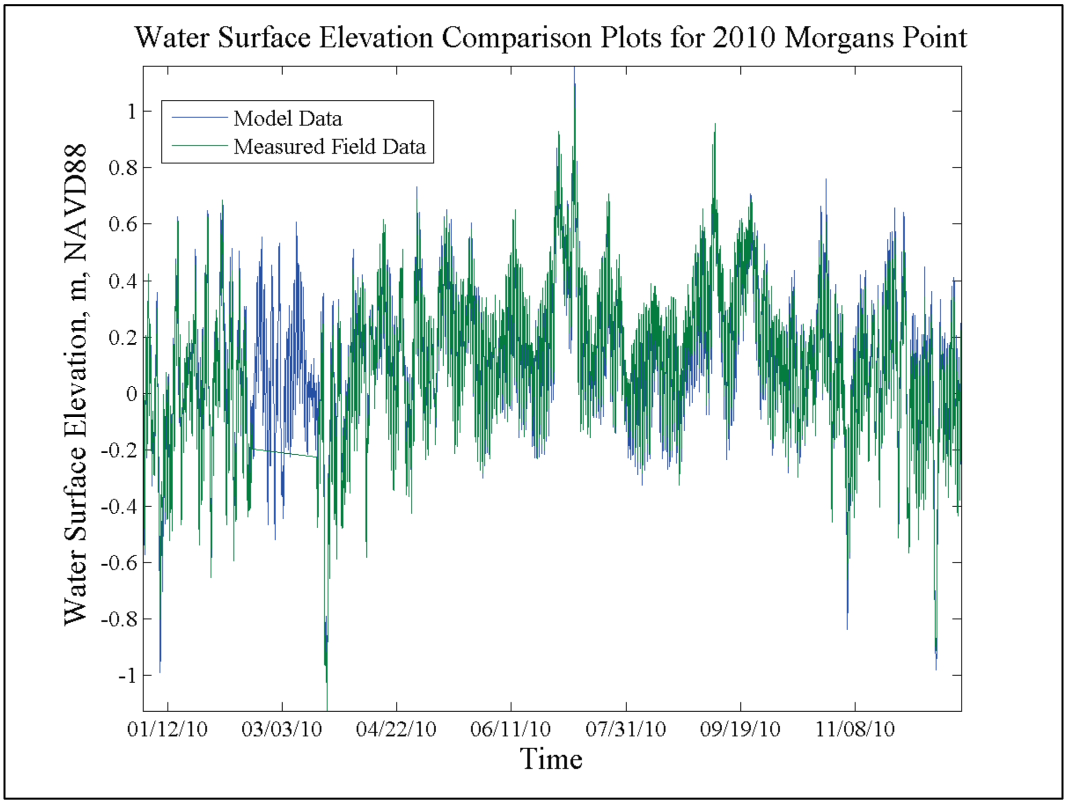

Water Surface Elevation Comparison Plots for 2010 Eagle Point
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

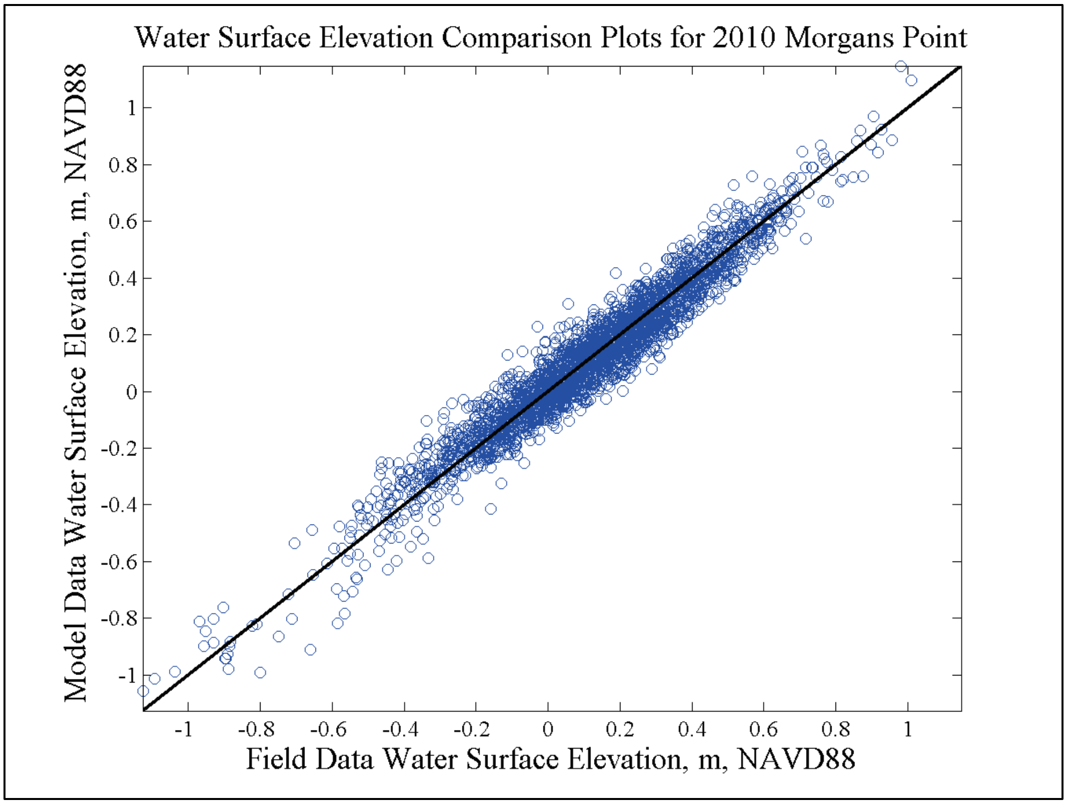

Water Surface Elevation Comparison Plots for 2011 Eagle Point
Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Model Data
Measured Field Data
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time

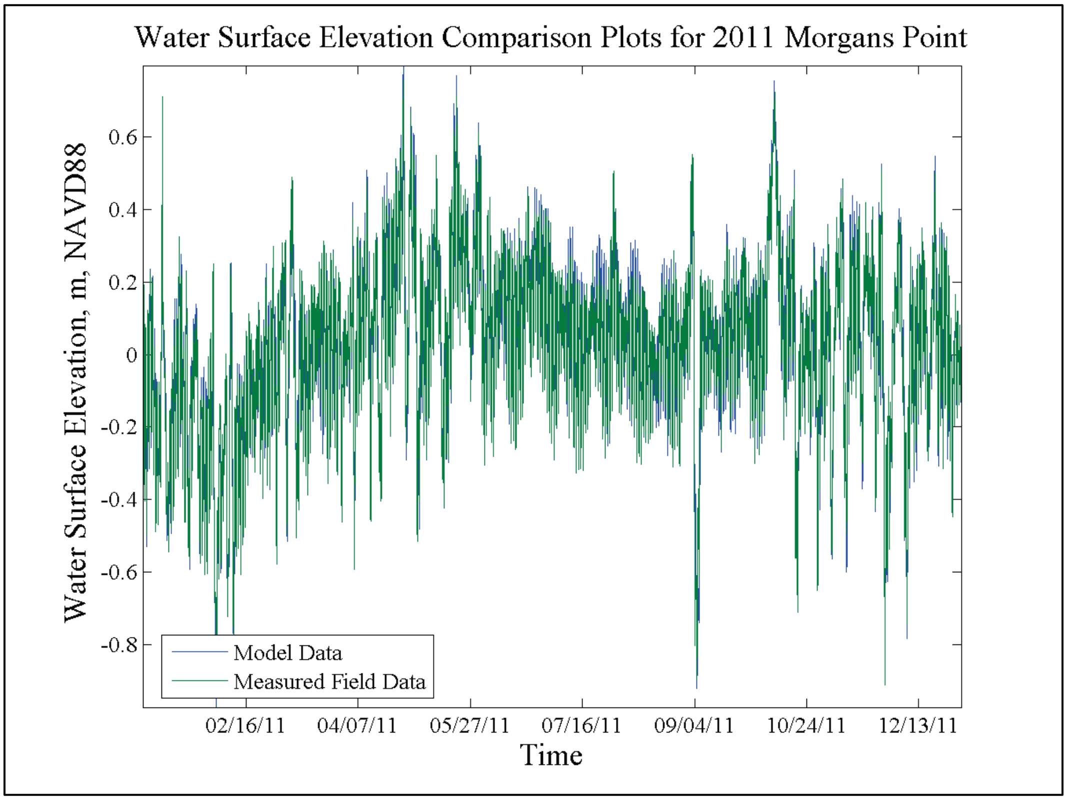

Water Surface Elevation Comparison Plots for 2011 Eagle Point
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

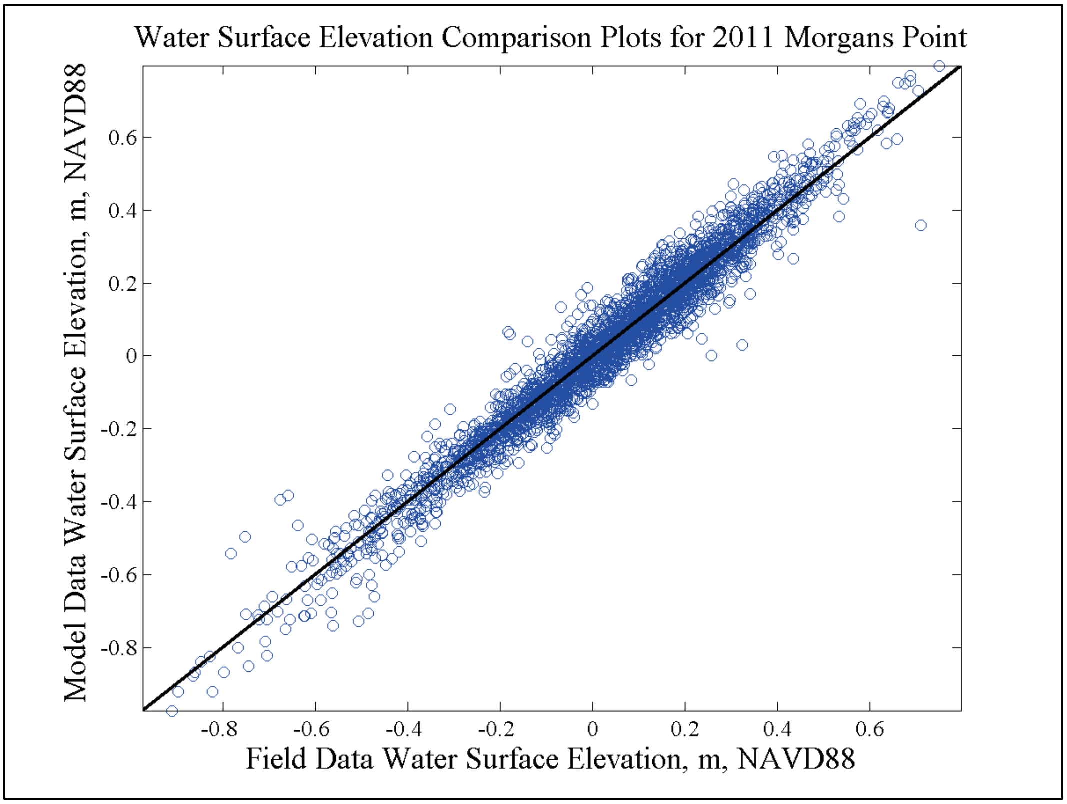

Water Surface Elevation Comparison Plots for 2005 Morgans Point
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
Time
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05

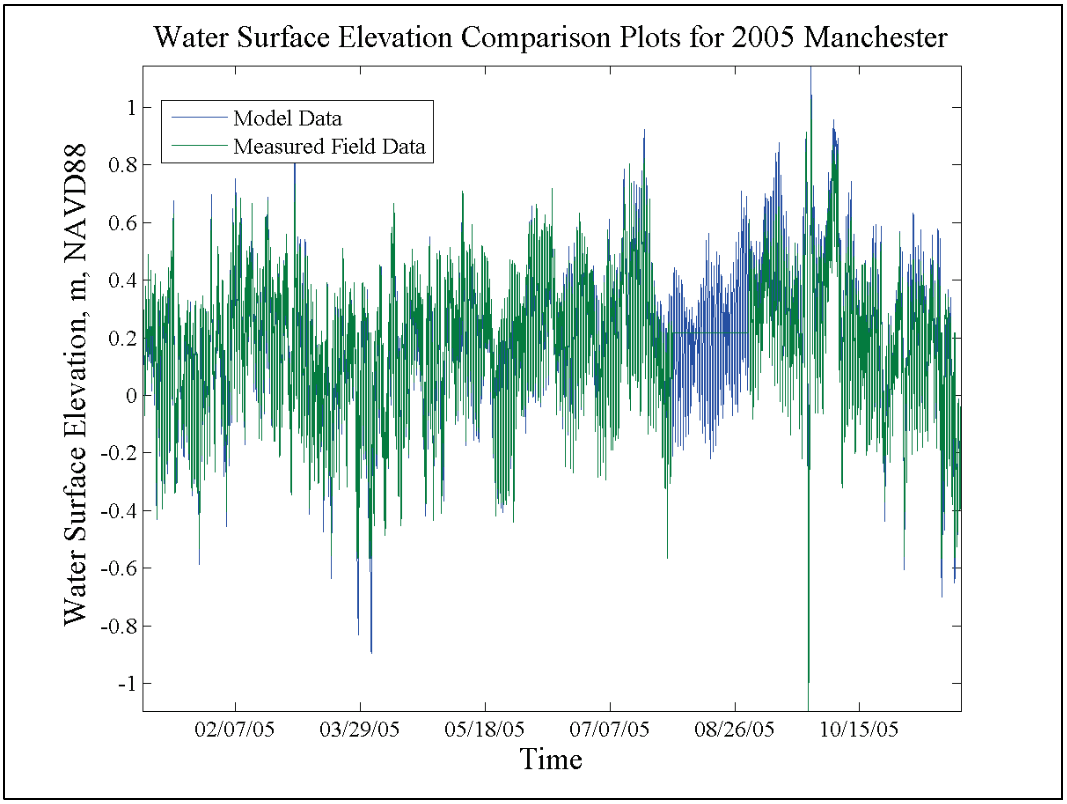

Water Surface Elevation Comparison Plots for 2005 Morgans Point
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

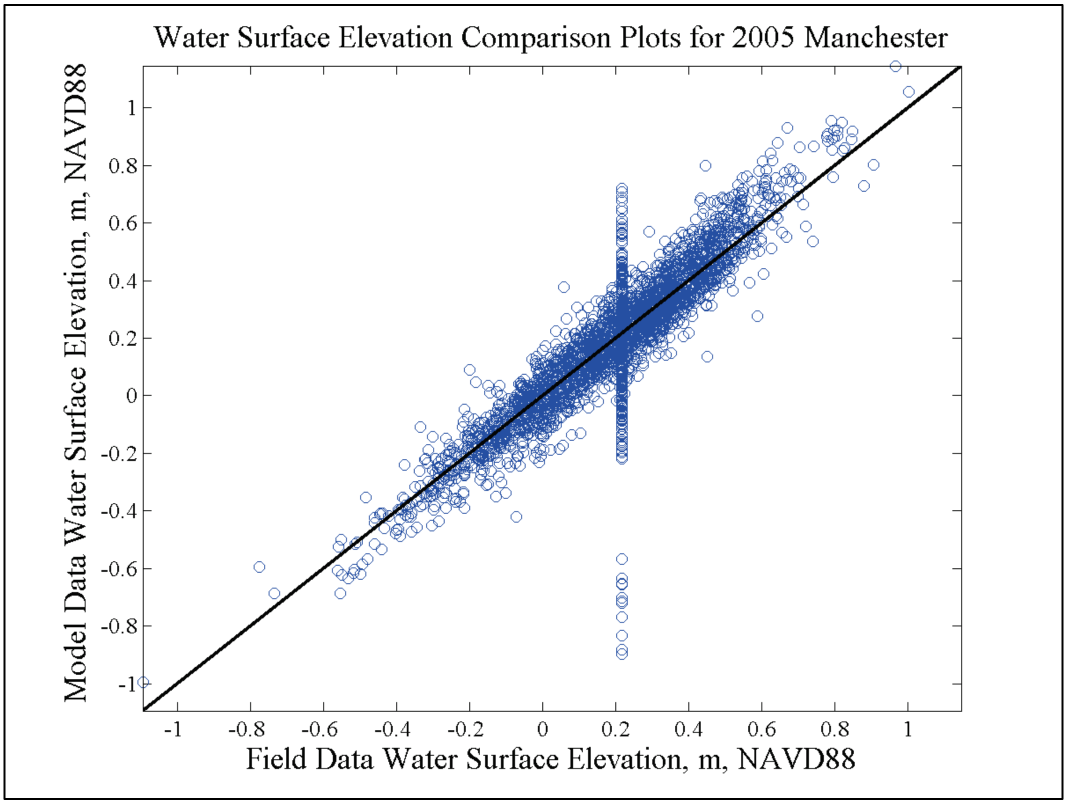

Water Surface Elevation Comparison Plots for 2010 Morgans Point
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time

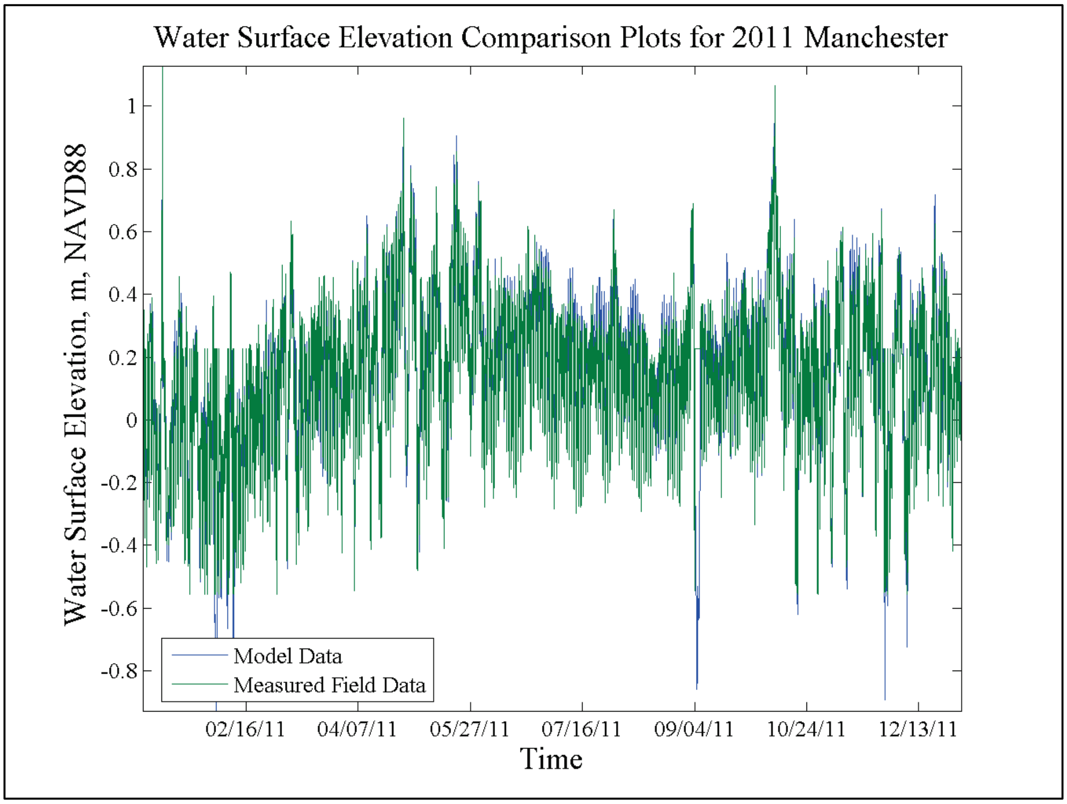

Water Surface Elevation Comparison Plots for 2010 Morgans Point
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

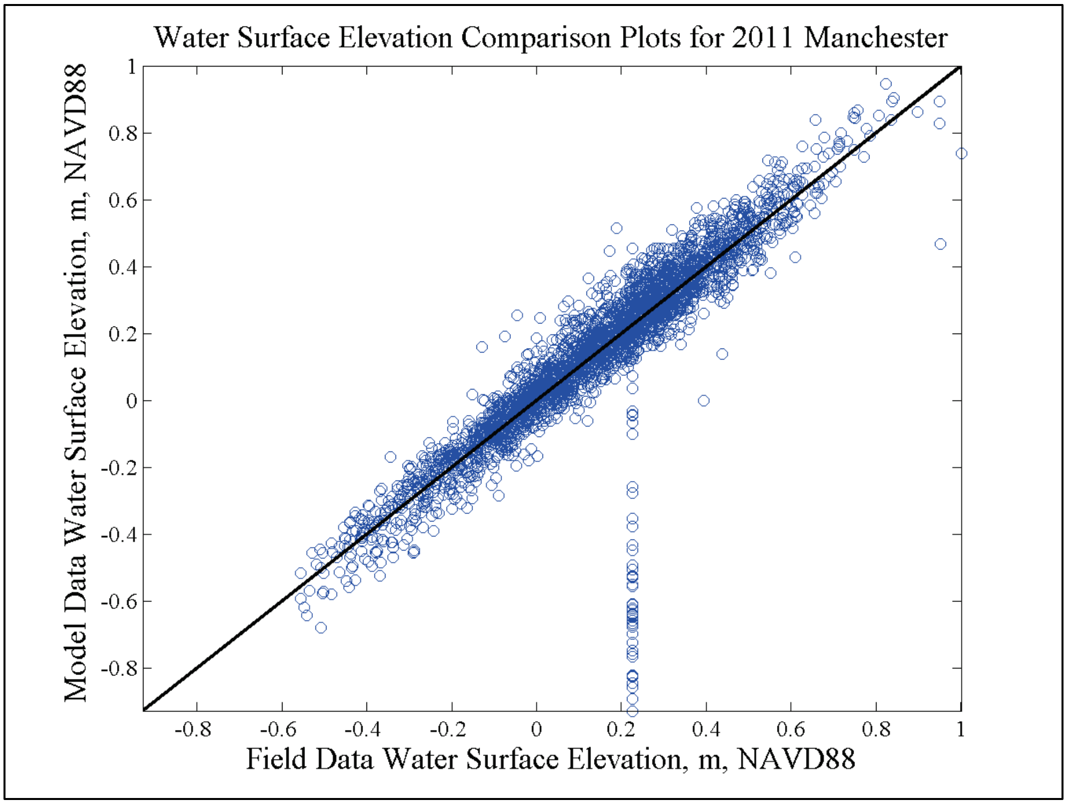

Water Surface Elevation Comparison Plots for 2011 Morgans Point
Water Surface Elevation, m, NAVD88
Time
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Model Data
Measured Field Data


Water Surface Elevation Comparison Plots for 2011 Morgans Point
Model Data Water Surface Elevation, m, NAVD88
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Field Data Water Surface Elevation, m, NAVD88


Water Surface Elevation Comparison Plots for 2005 Manchester
Model Data
Measured Field Data
Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time

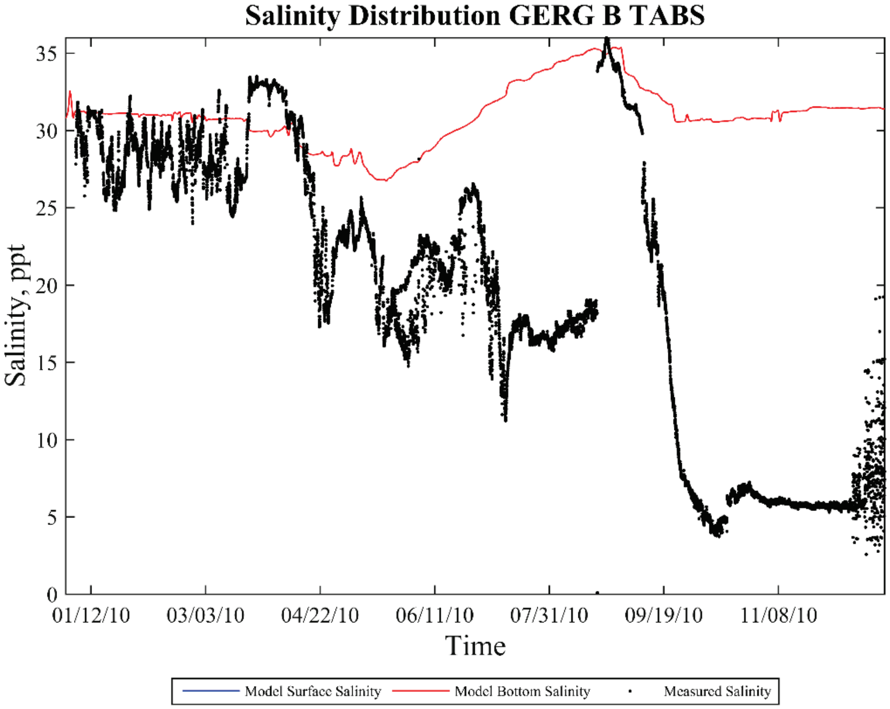

Water Surface Elevation Comparison Plots for 2005 Manchester
Model Data Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Field Data Water Surface Elevation, m, NAVD88

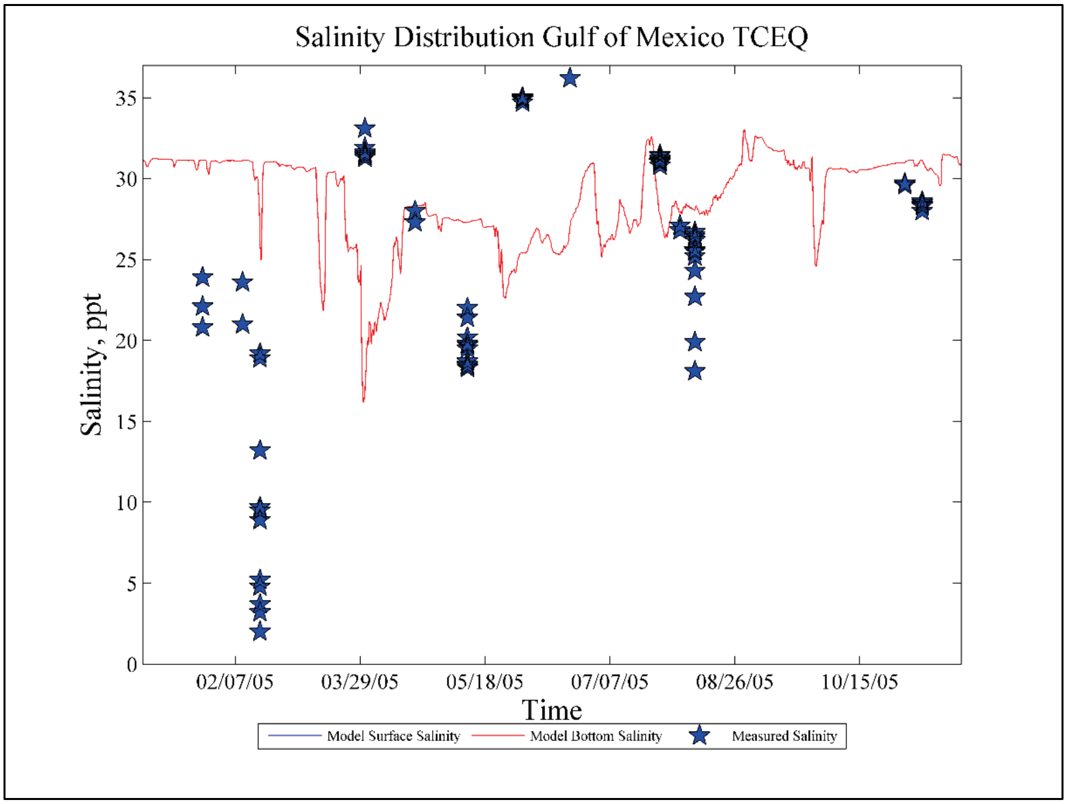

Water Surface Elevation Comparison Plots for 2011 Manchester
Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Model Data
Measured Field Data
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time

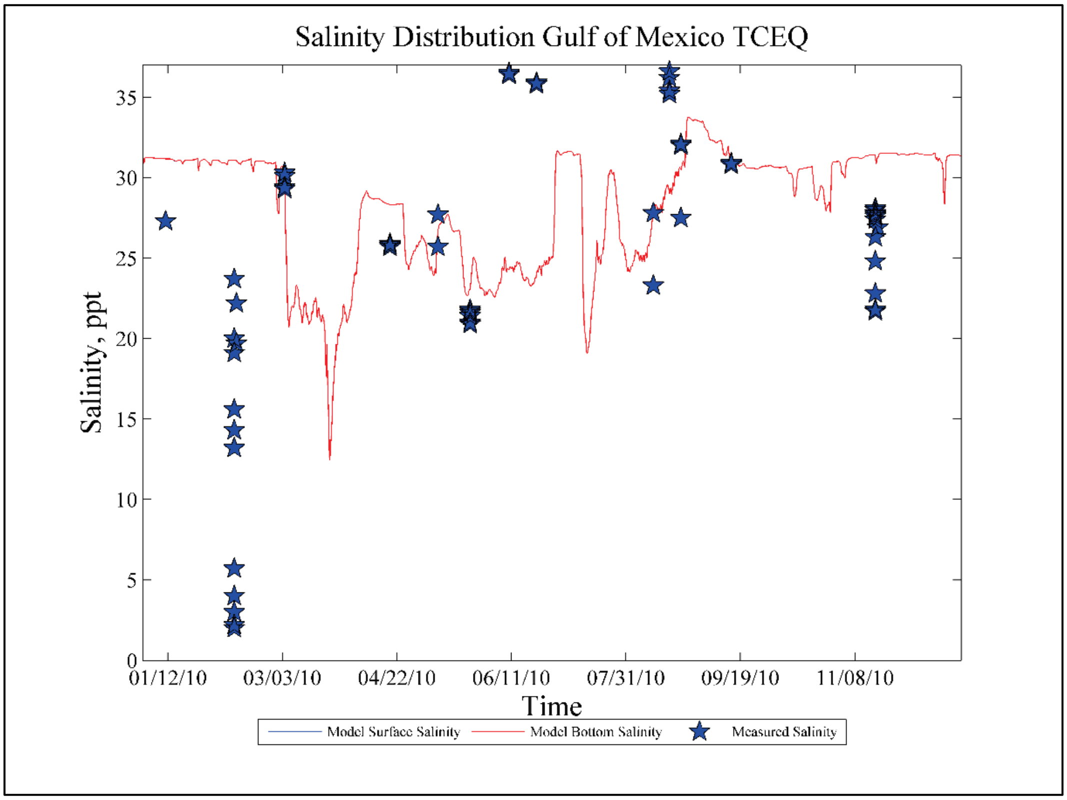

Water Surface Elevation Comparison Plots for 2011 Manchester
Model Data Water Surface Elevation, m, NAVD88
Field Data Water Surface Elevation, m, NAVD88
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

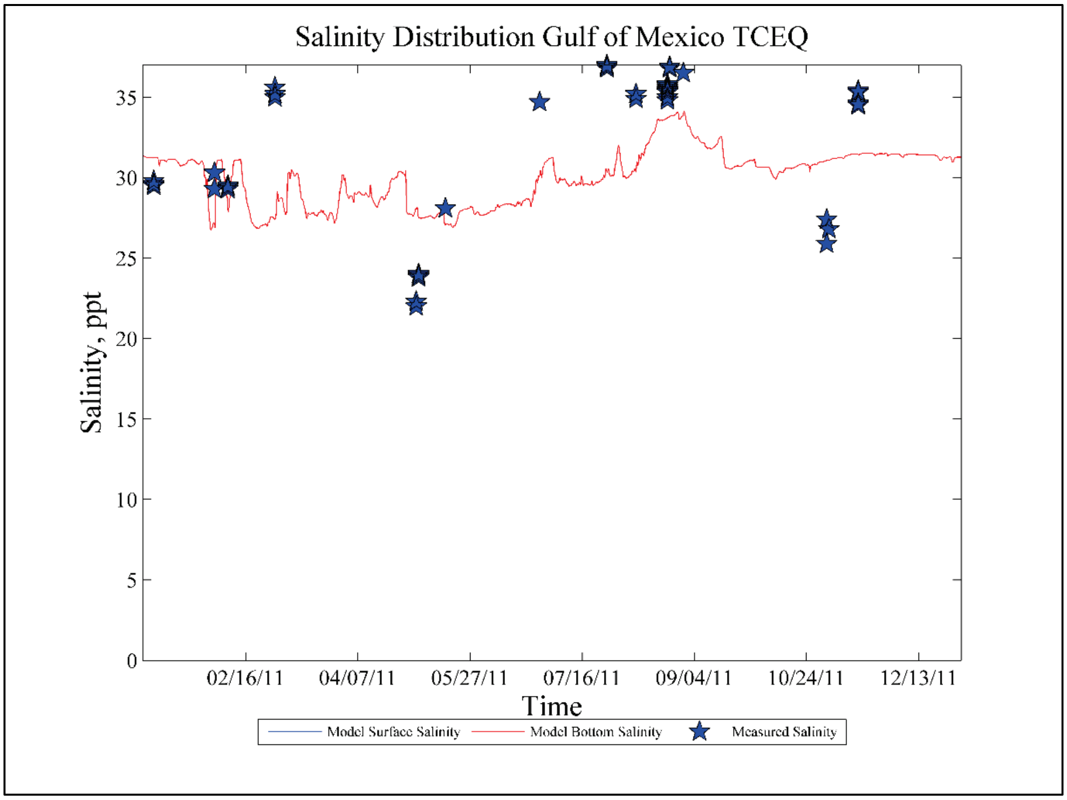
Appendix B: Salinity Comparisons

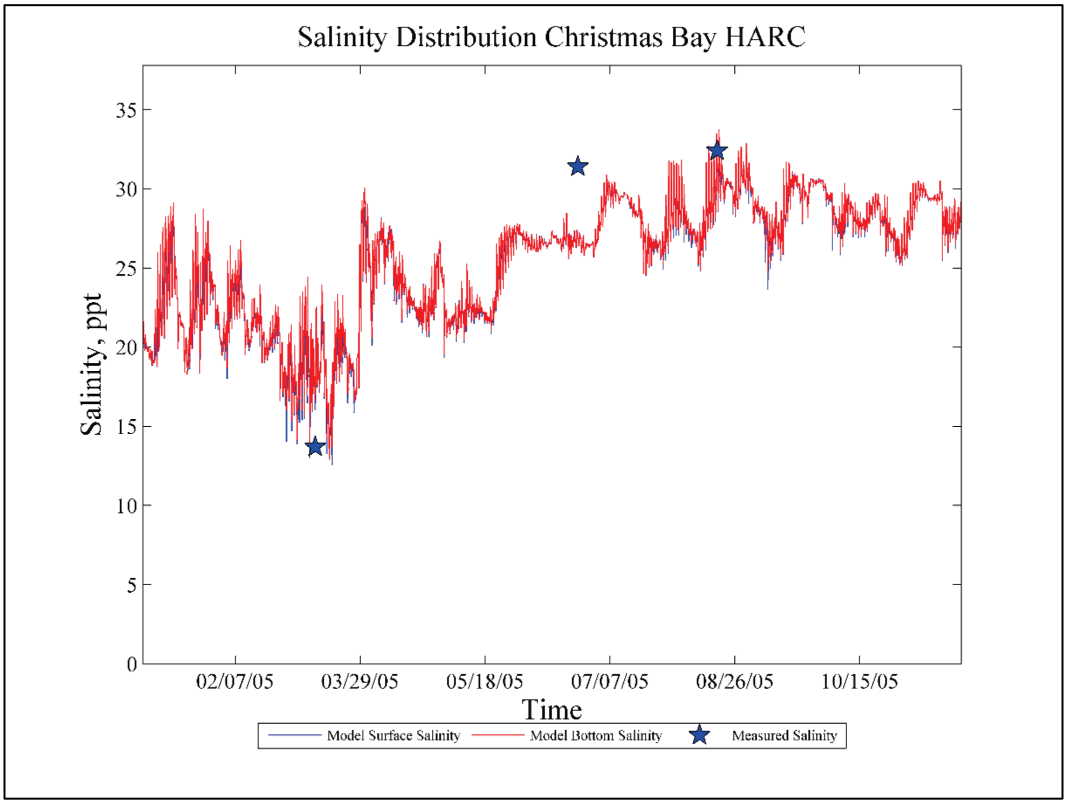
The following plots include all of the model/field comparisons for the available field data during the 3 calibration/validation years – 2005, 2010, and 2011. Data are not available for all 3 years at all sites. Figure 33 through Figure 35 and Figure 59 through Figure 62 in the main text show the locations of all salinity comparison sites. The blue stars (where data are sparse) and smaller black dots (where data are numerous) represent the measured field data. These data are defined as near surface for several of the sites, but many others do not define the vertical location of the samples. The model-computed surface salinity is given by the blue line, and the model-computed bottom salinity by the red line. In deep, stratified regions, the bottom salinity is larger than the surface salinity. In well-mixed regions, the two should be approximately equal.

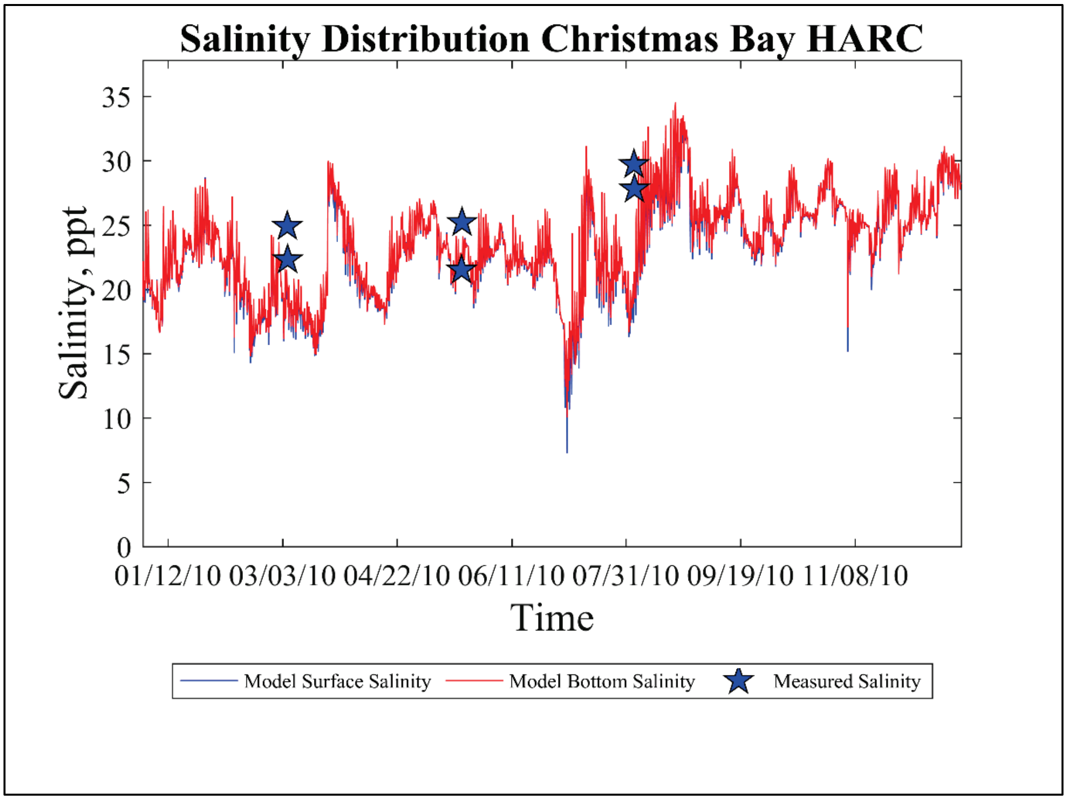


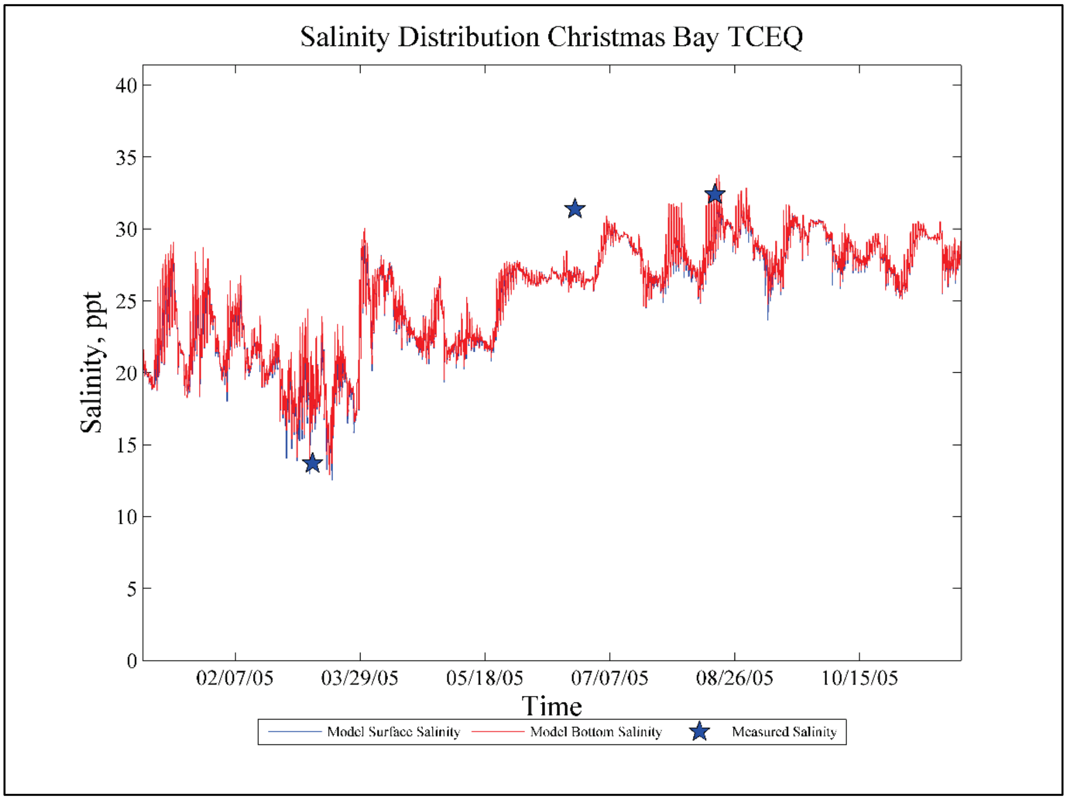

Salinity Distribution Gulf of Mexico TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

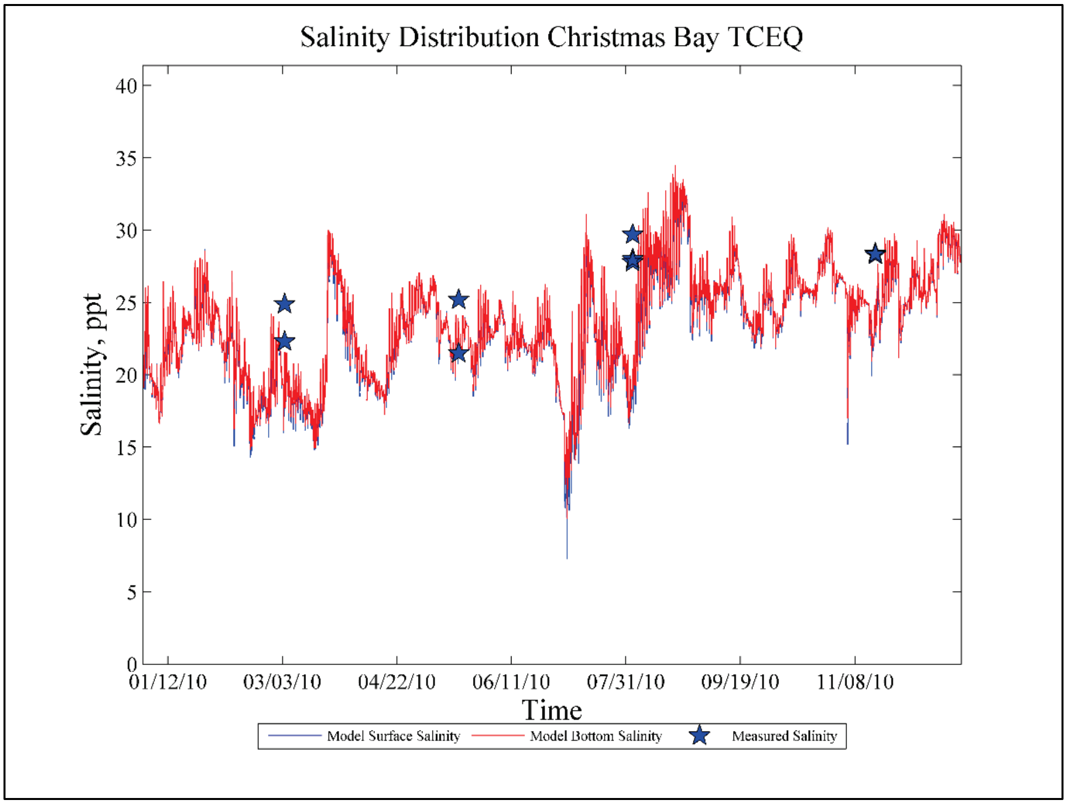

Salinity Distribution Gulf of Mexico TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

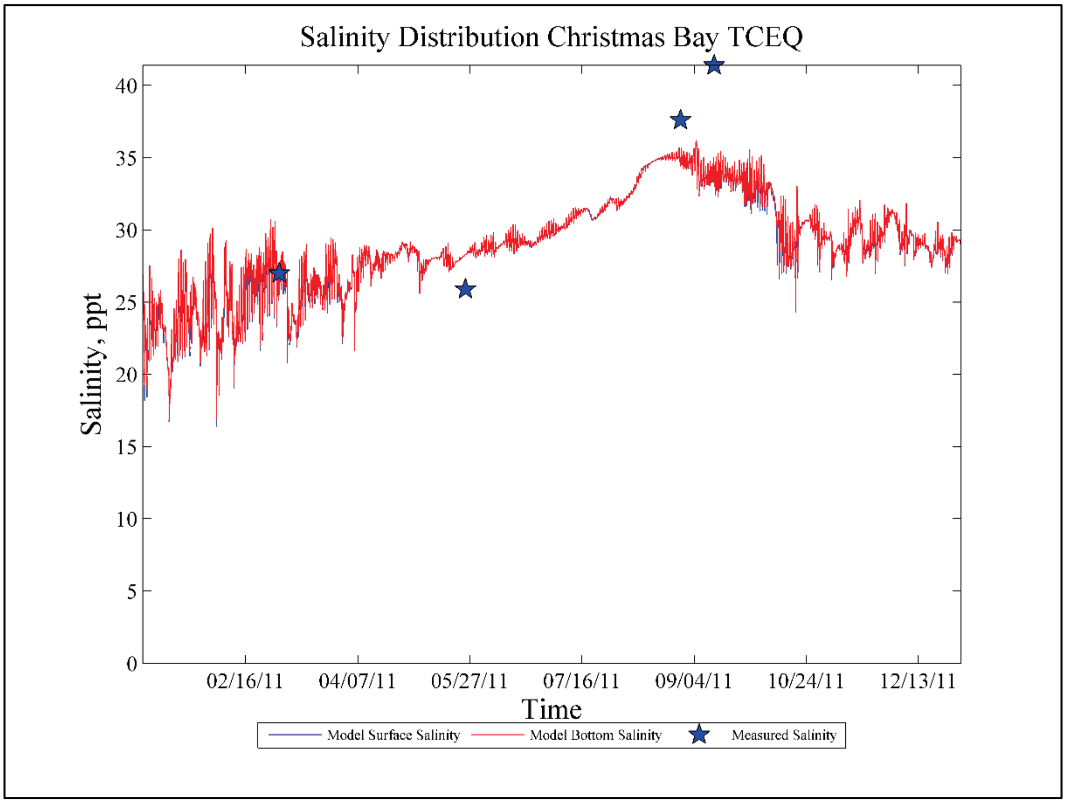

Salinity Distribution Gulf of Mexico TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

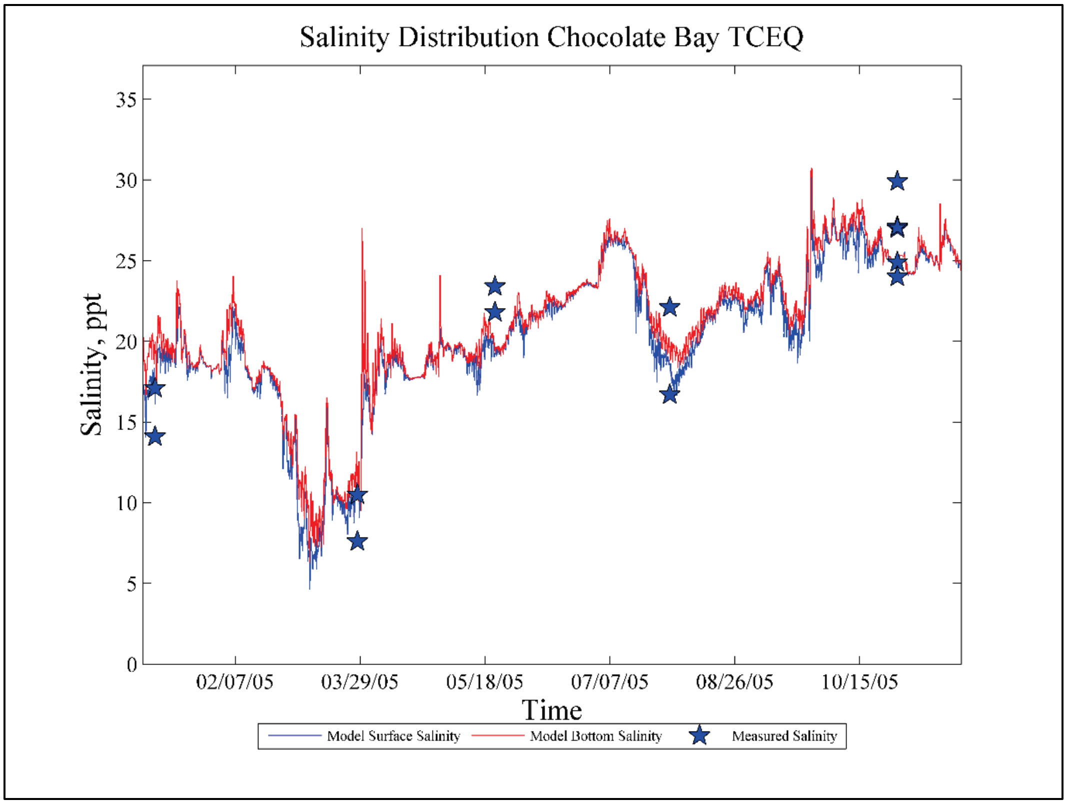

Salinity Distribution Christmas Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

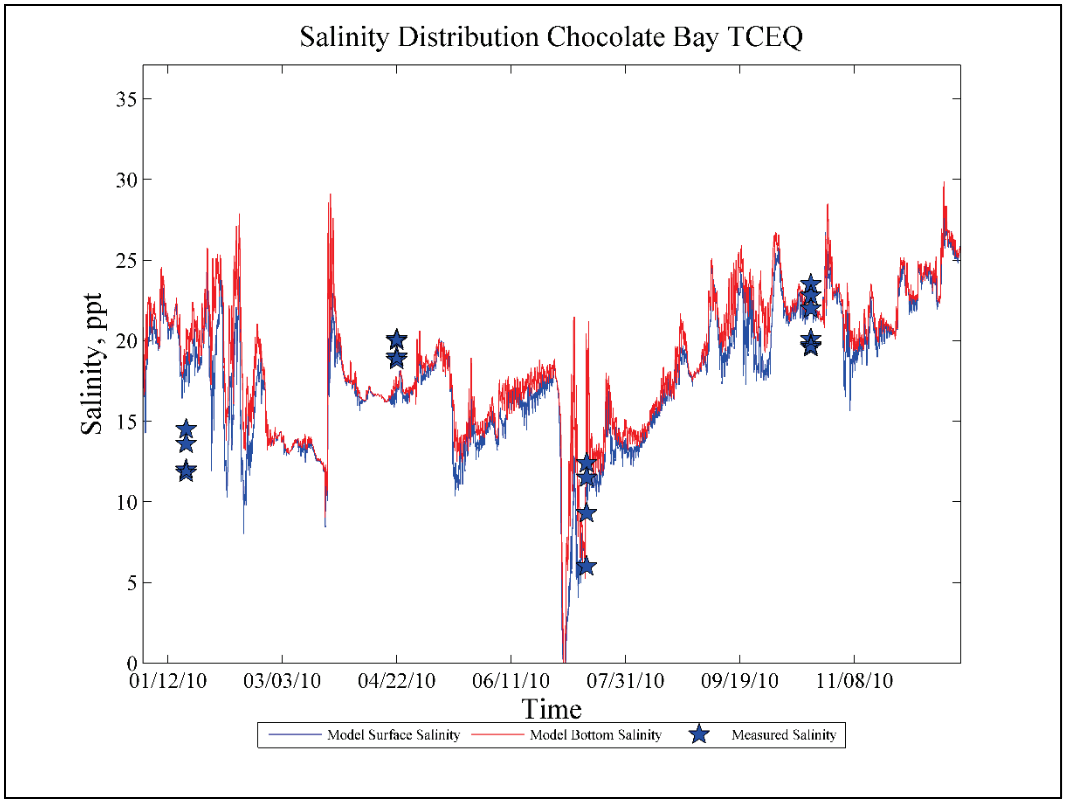

Salinity Distribution Christmas Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

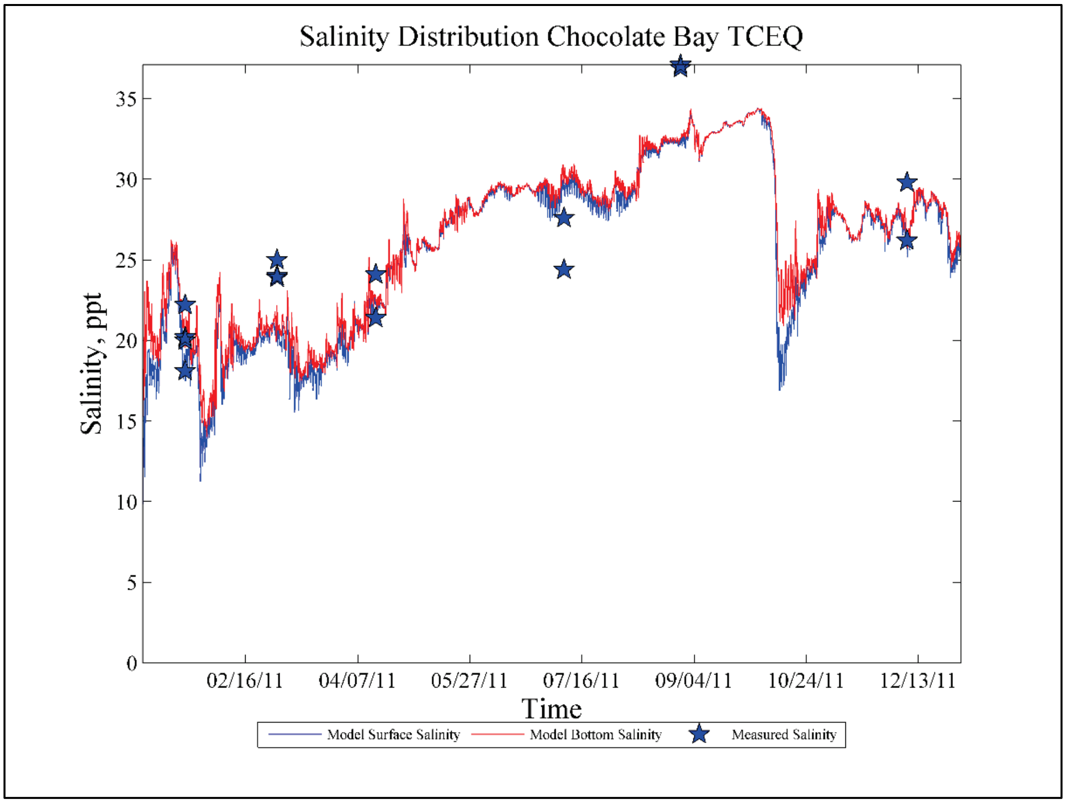

Salinity Distribution Christmas Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
40
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

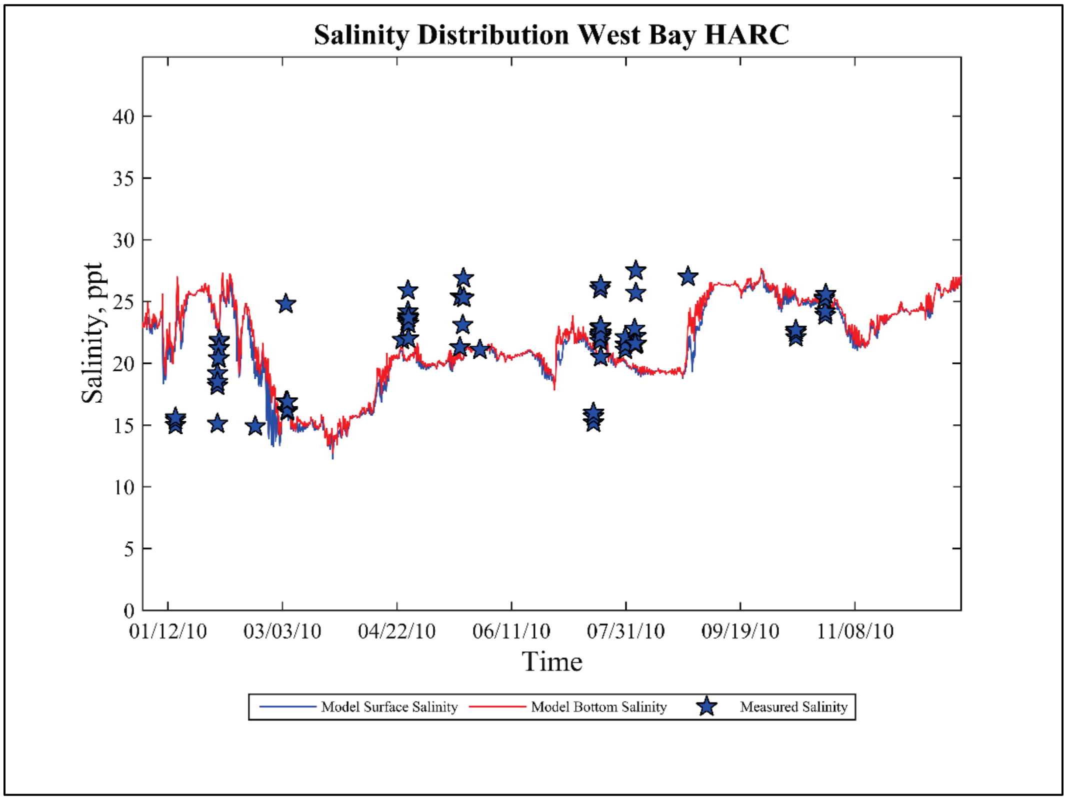

Salinity Distribution Christmas Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
40
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

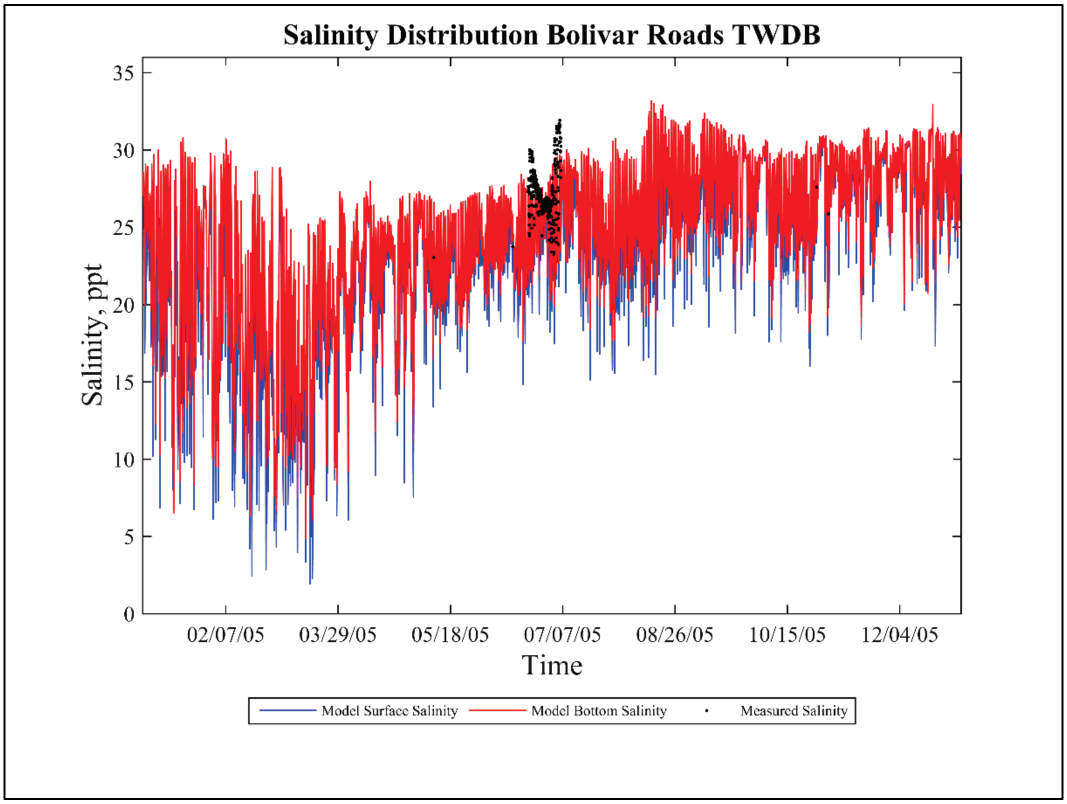

Salinity Distribution Christmas Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
40
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

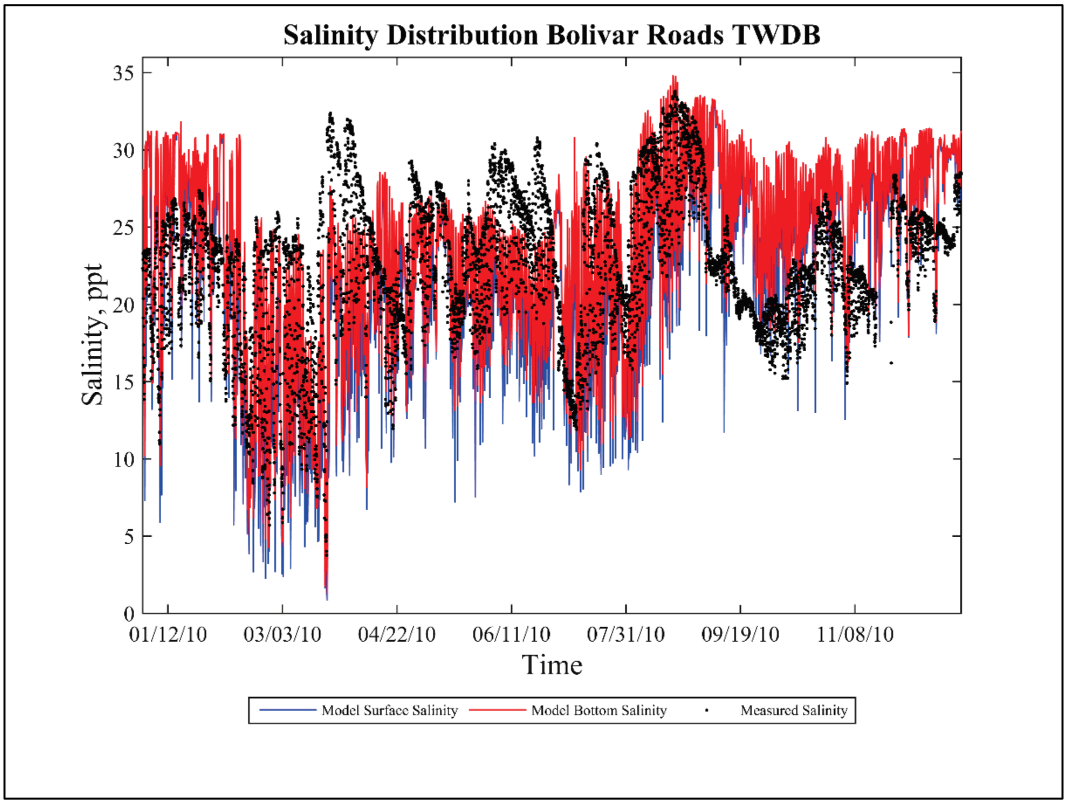

Salinity Distribution Chocolate Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

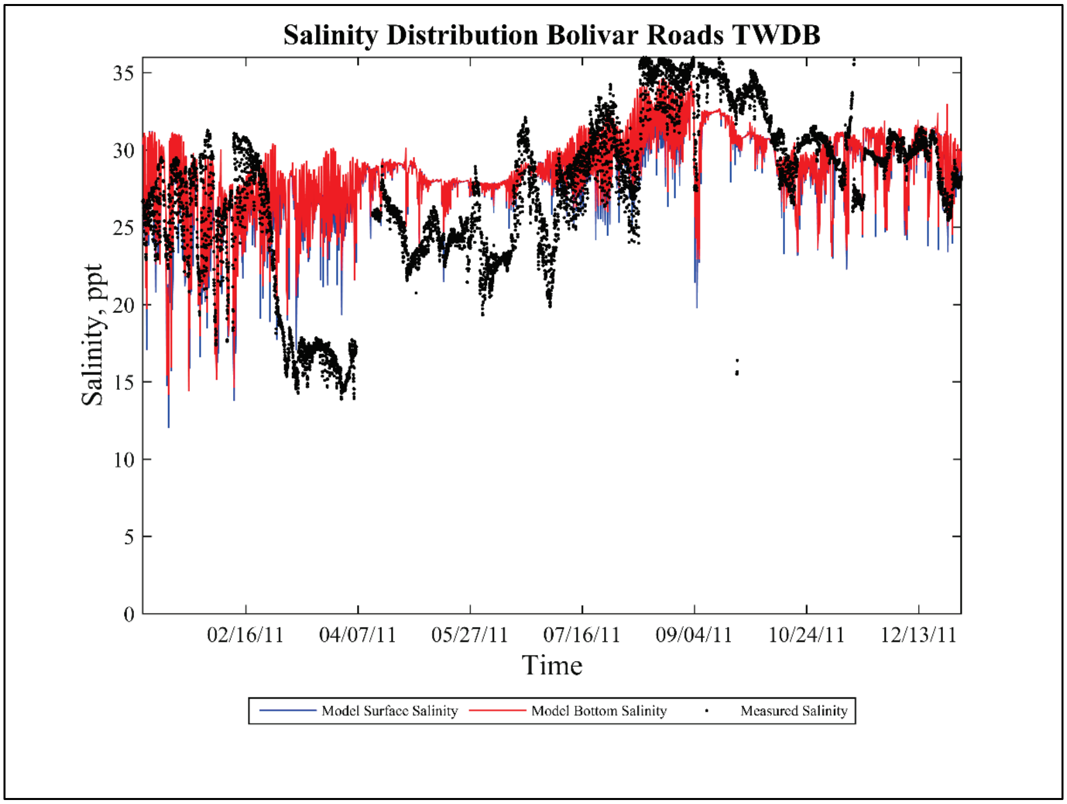

Salinity Distribution Chocolate Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

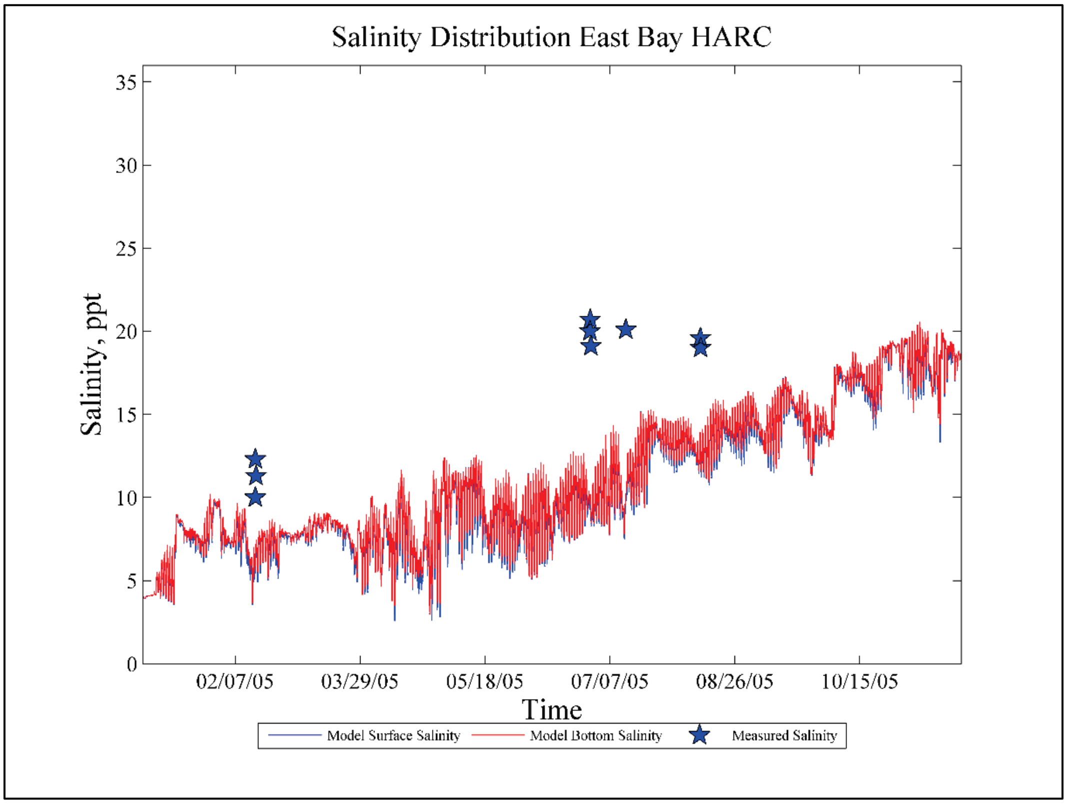

Salinity Distribution Chocolate Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

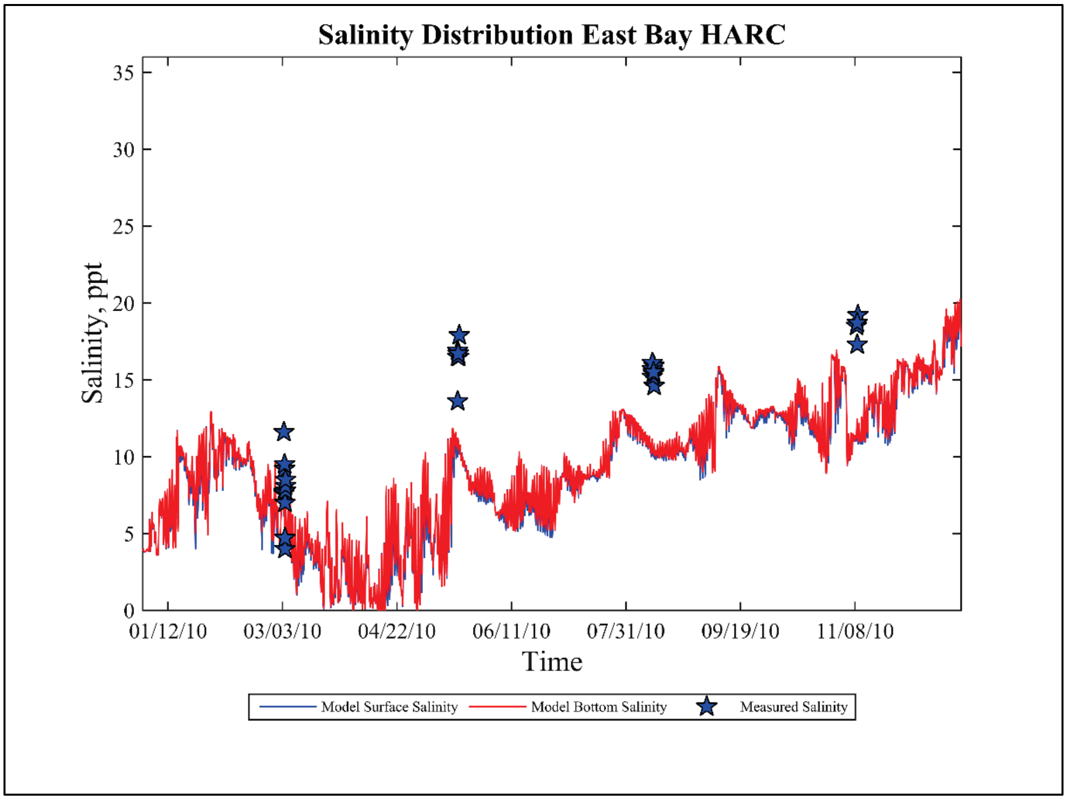

Salinity Distribution West Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
40
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

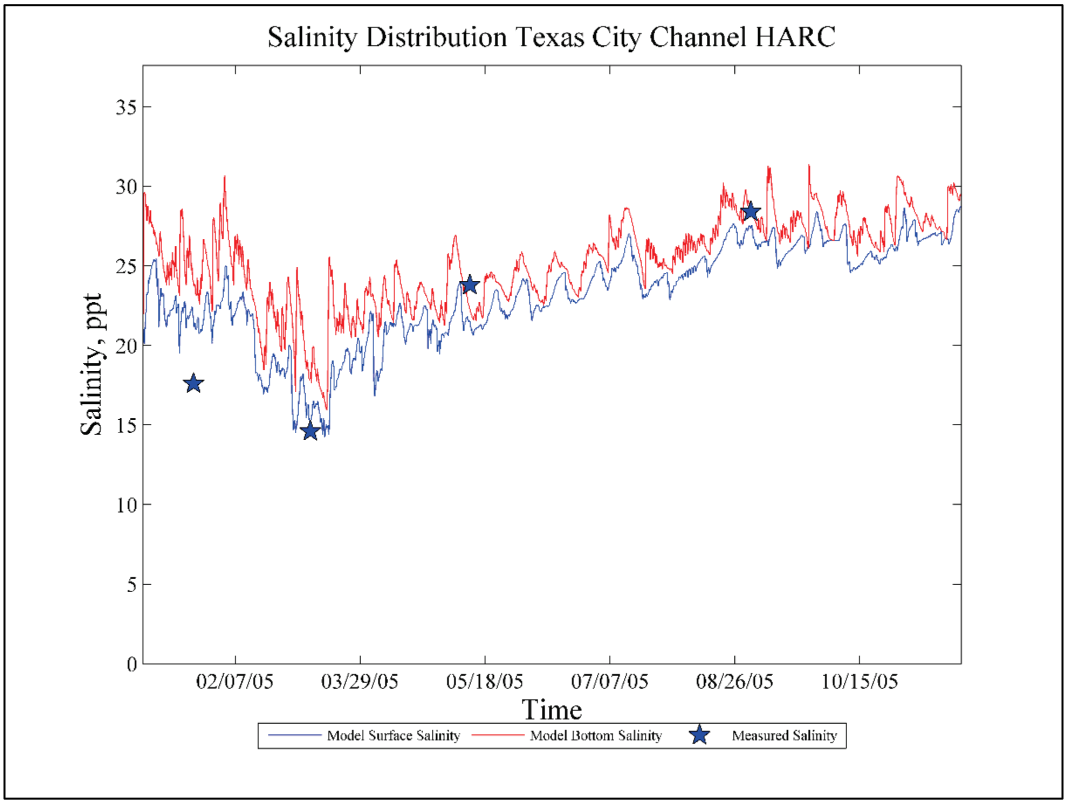

Salinity Distribution Bolivar Roads TWDB
Salinity, ppt
35
30
25
20
15
10
5
0
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
12/04/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

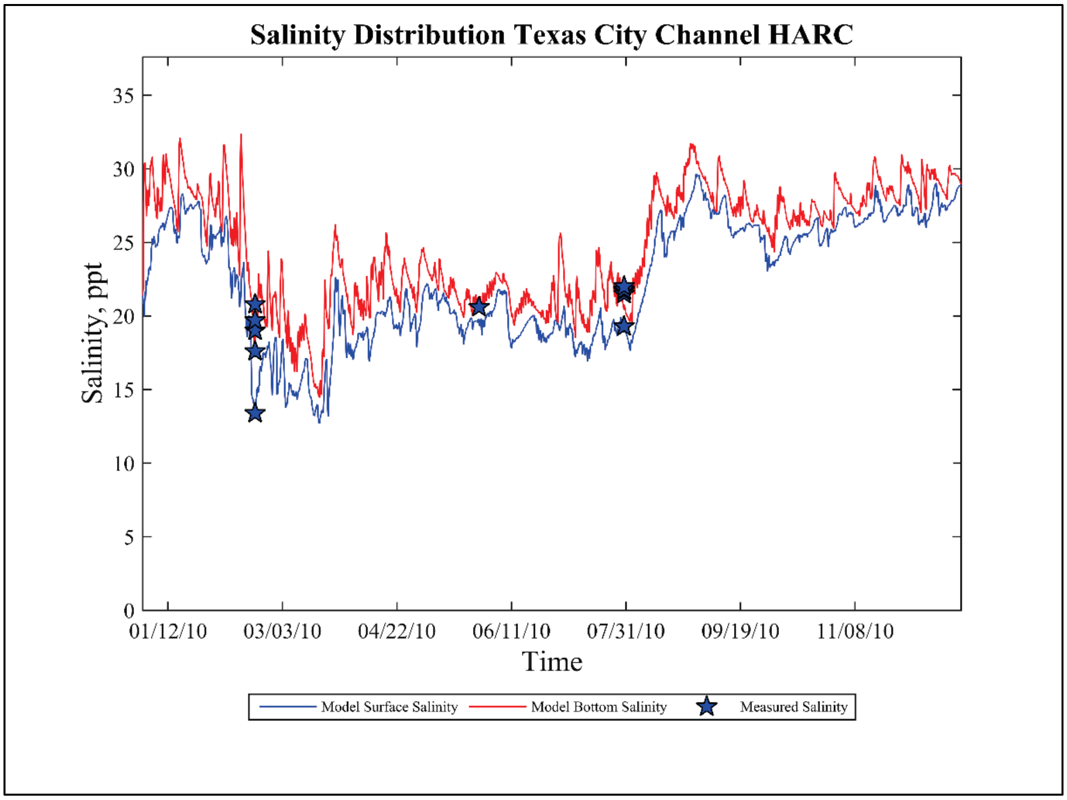

Salinity Distribution Bolivar Roads TWDB
Salinity, ppt
35
30
25
20
15
10
5
0
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

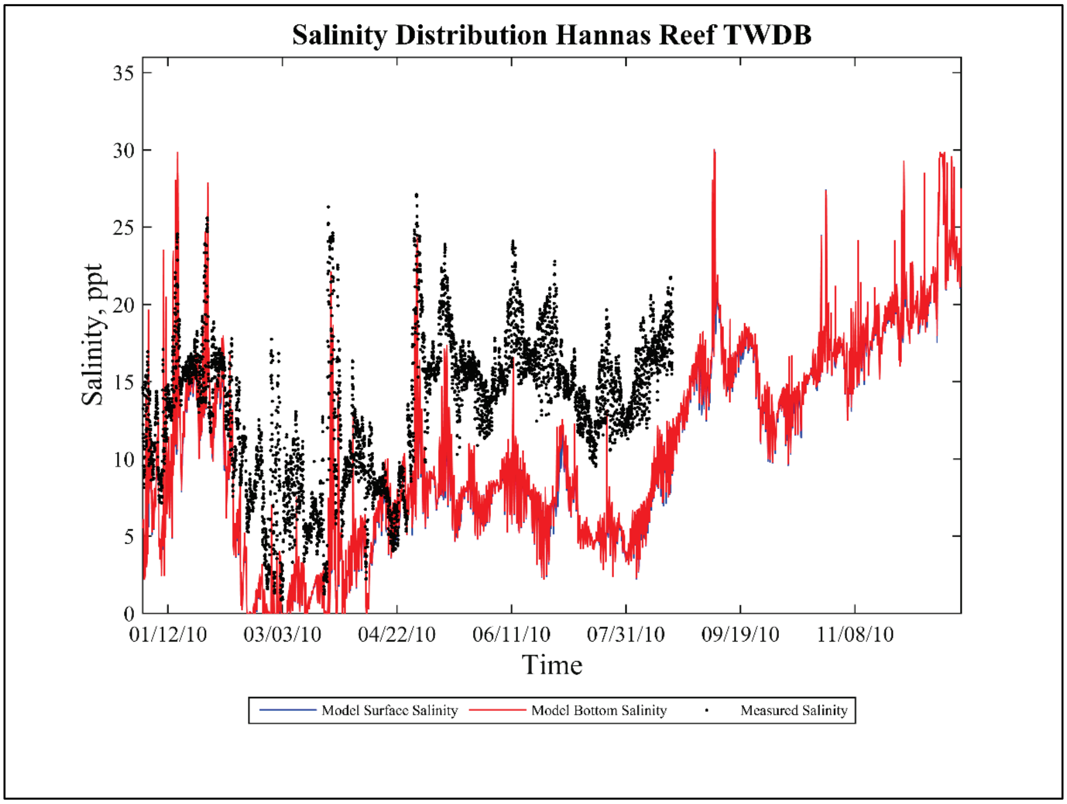

Salinity Distribution Bolivar Roads TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

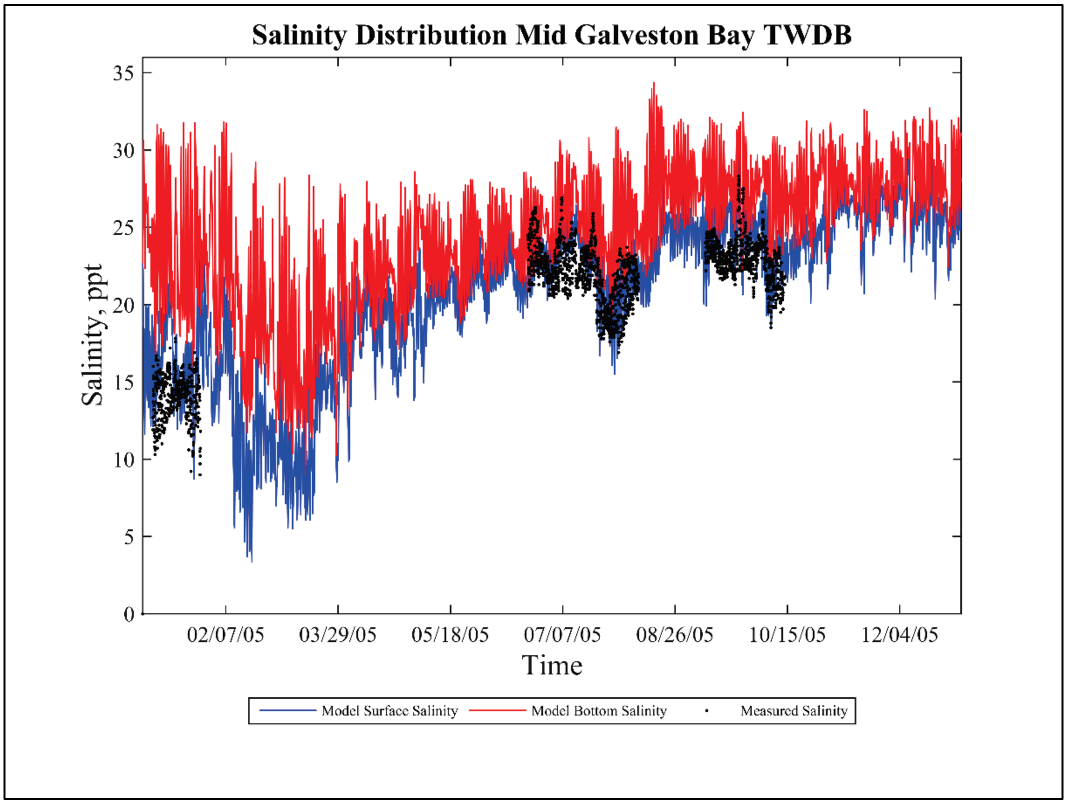

Salinity Distribution East Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

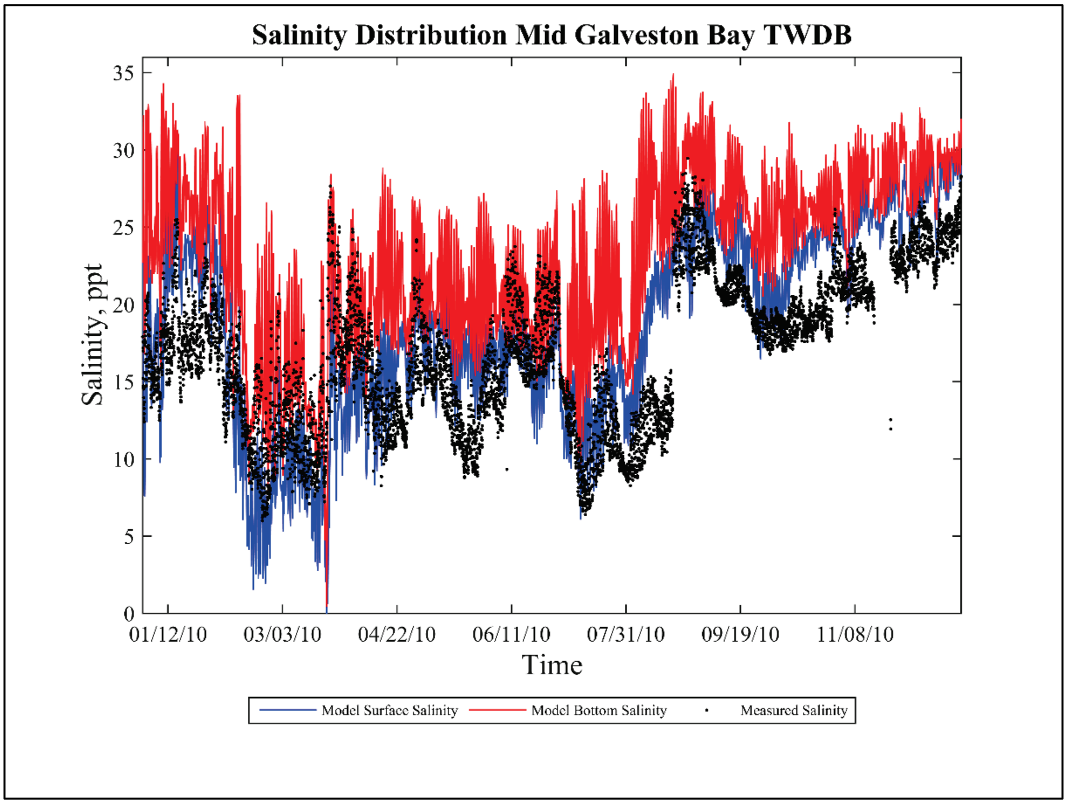

Salinity Distribution East Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

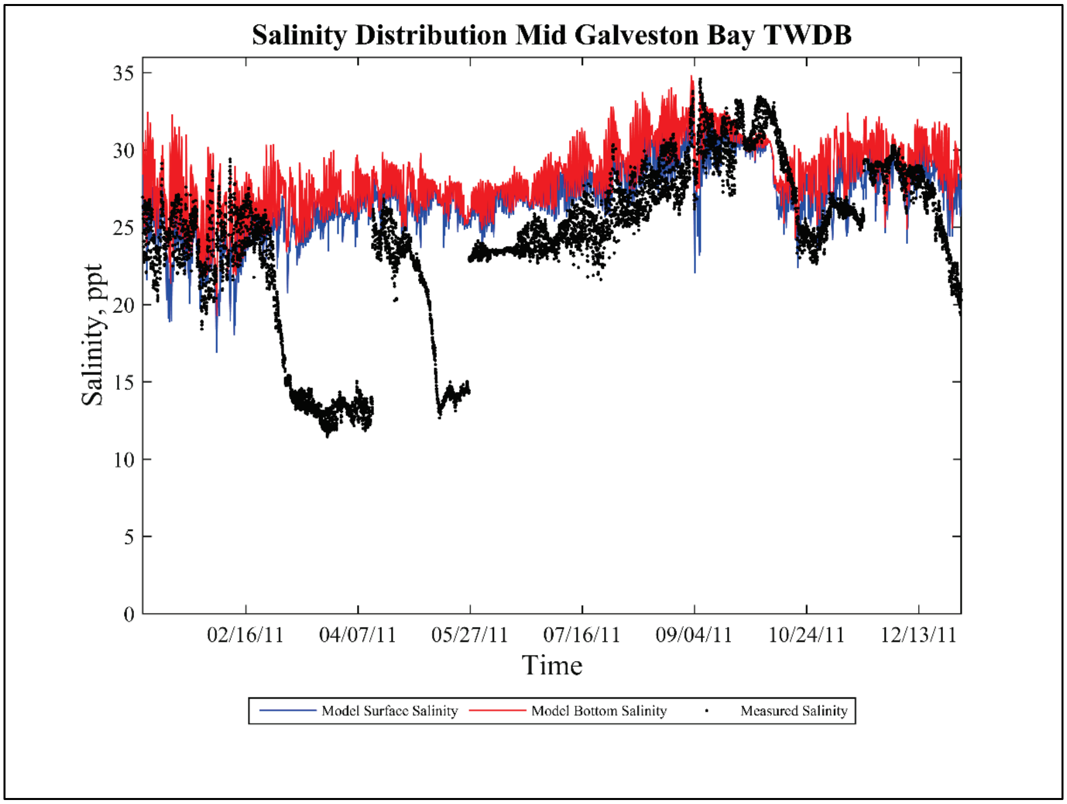

Salinity Distribution Texas City Channel HARC
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

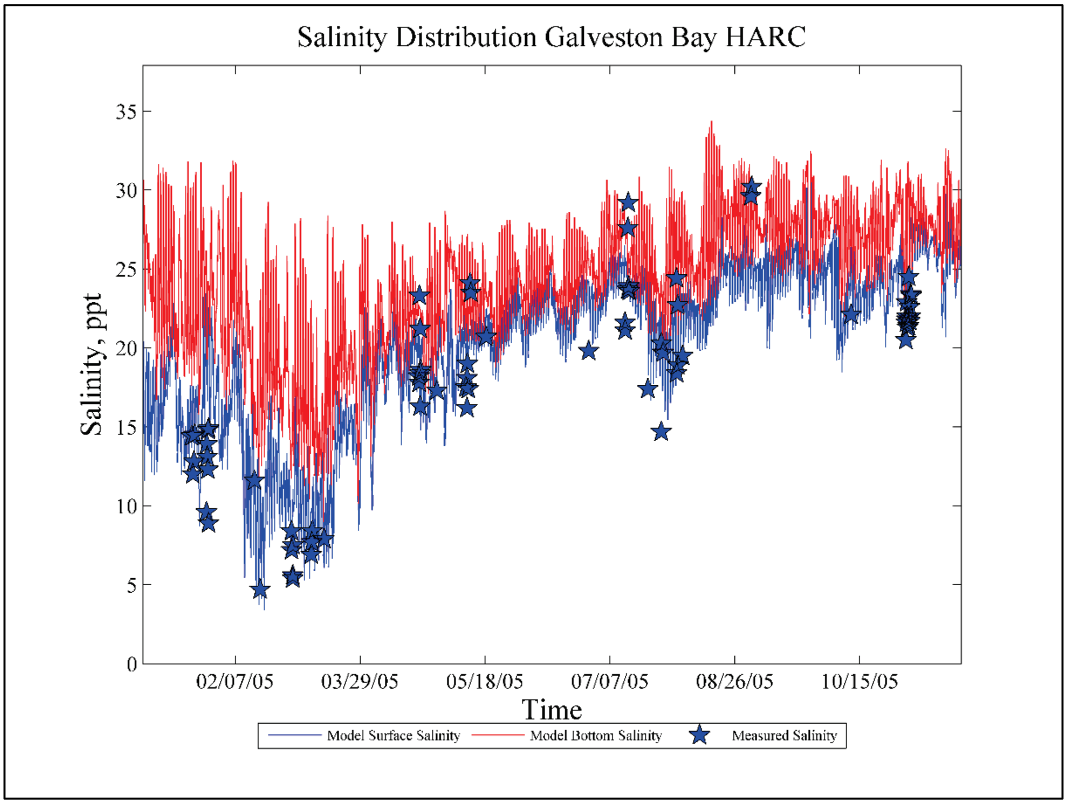

Salinity Distribution Texas City Channel HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

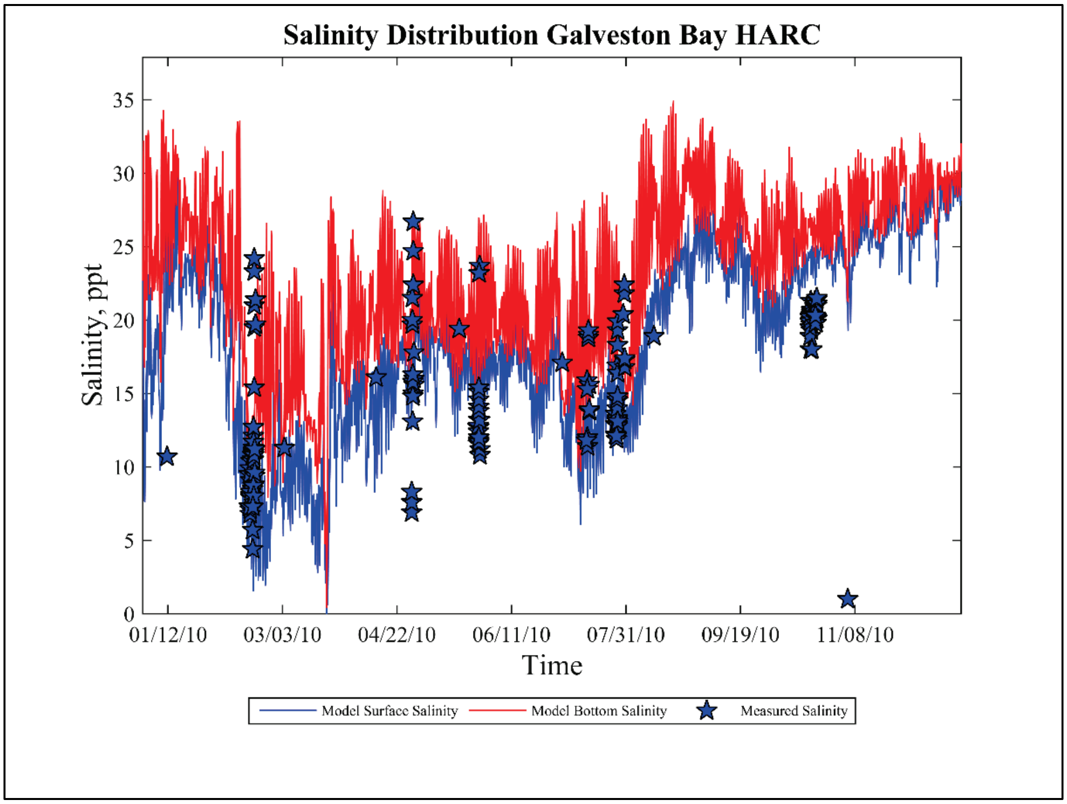

Salinity Distribution Hannas Reef TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

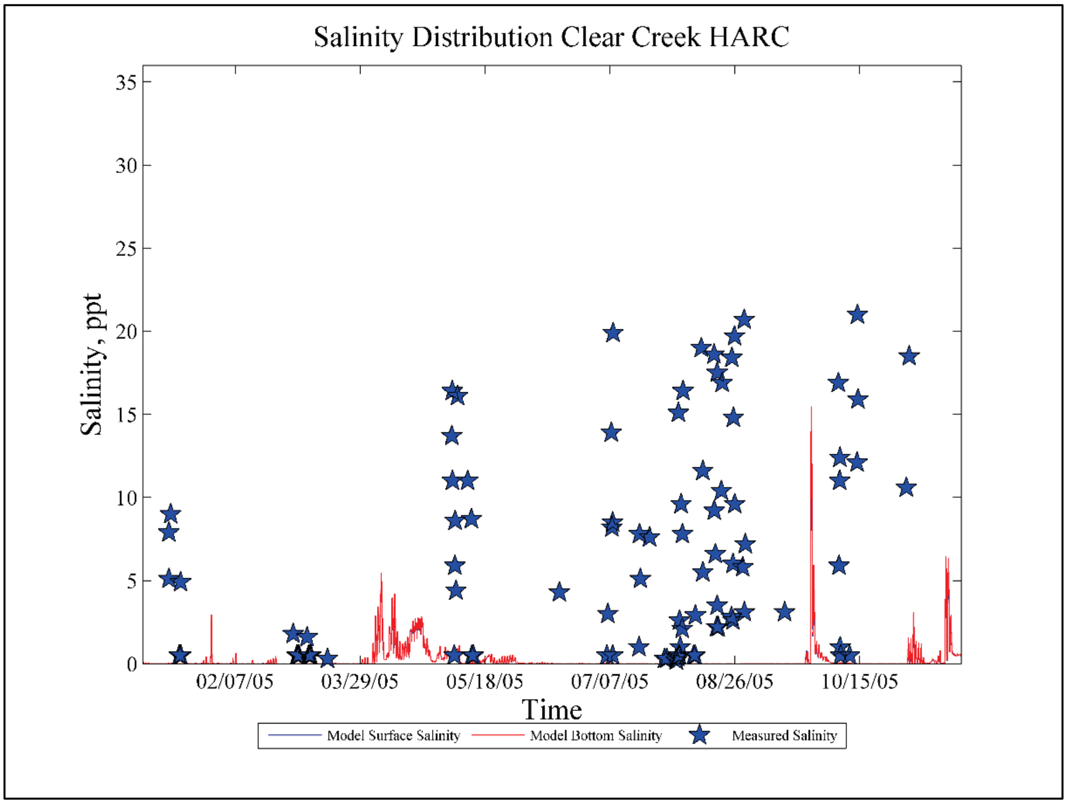

Salinity Distribution Mid Galveston Bay TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
12/04/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

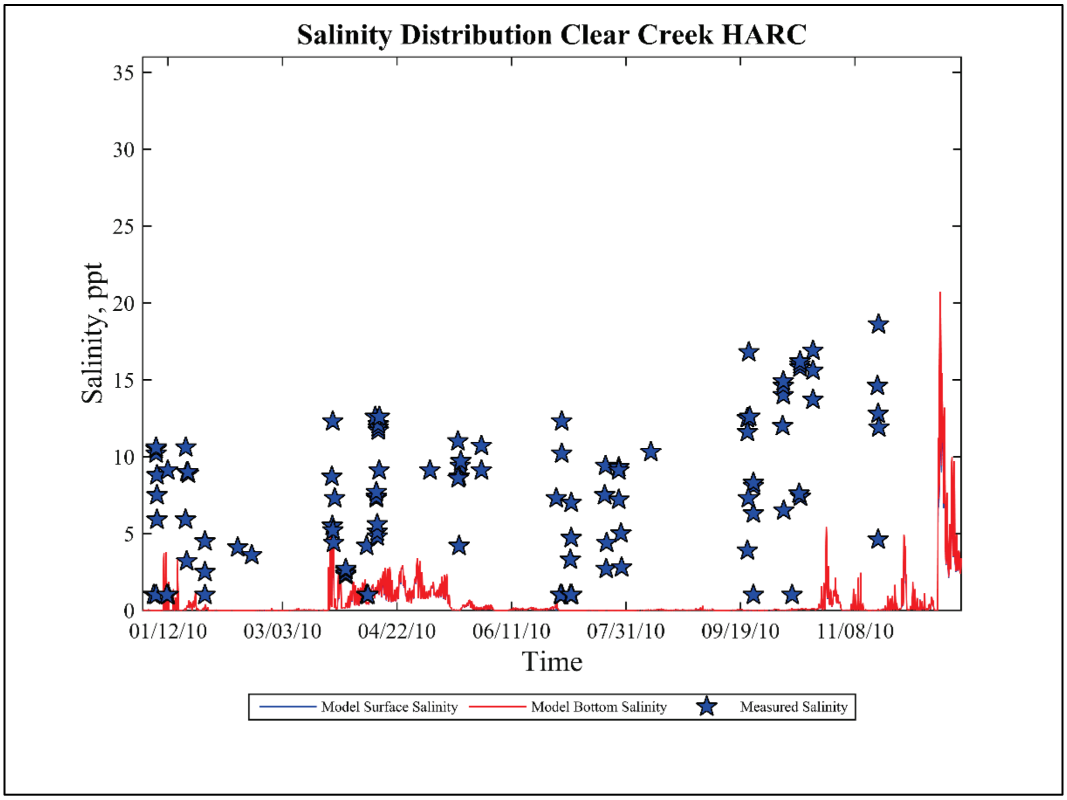

Salinity Distribution Mid Galveston Bay TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

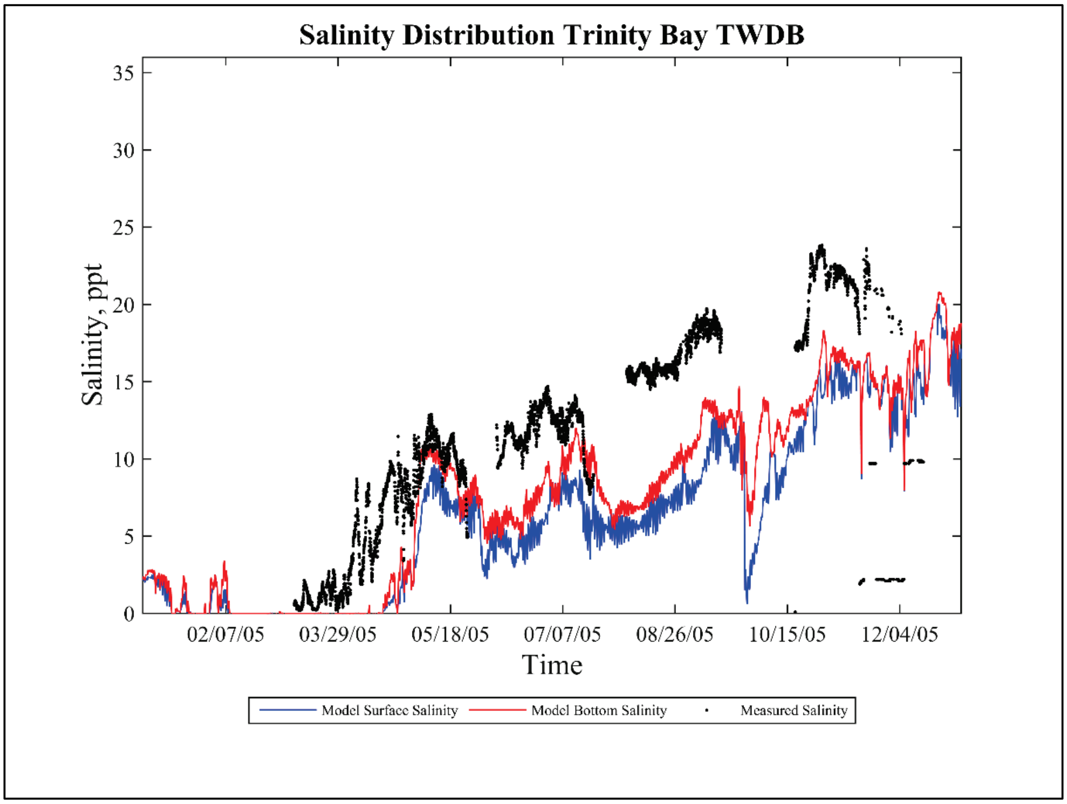

Salinity Distribution Mid Galveston Bay TWDB
Salinity, ppt
35
30
25
20
15
10
5
0
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

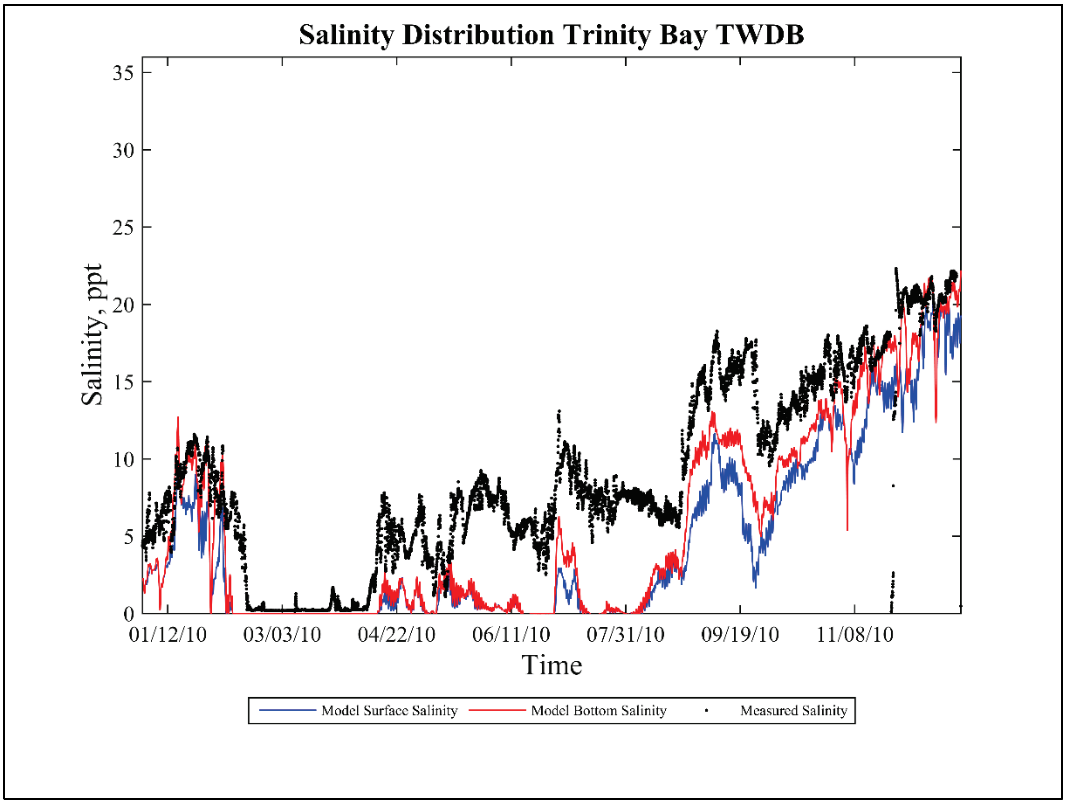

Salinity Distribution Galveston Bay HARC
Salinity, ppt
35
30
25
20
15
10
5
0
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

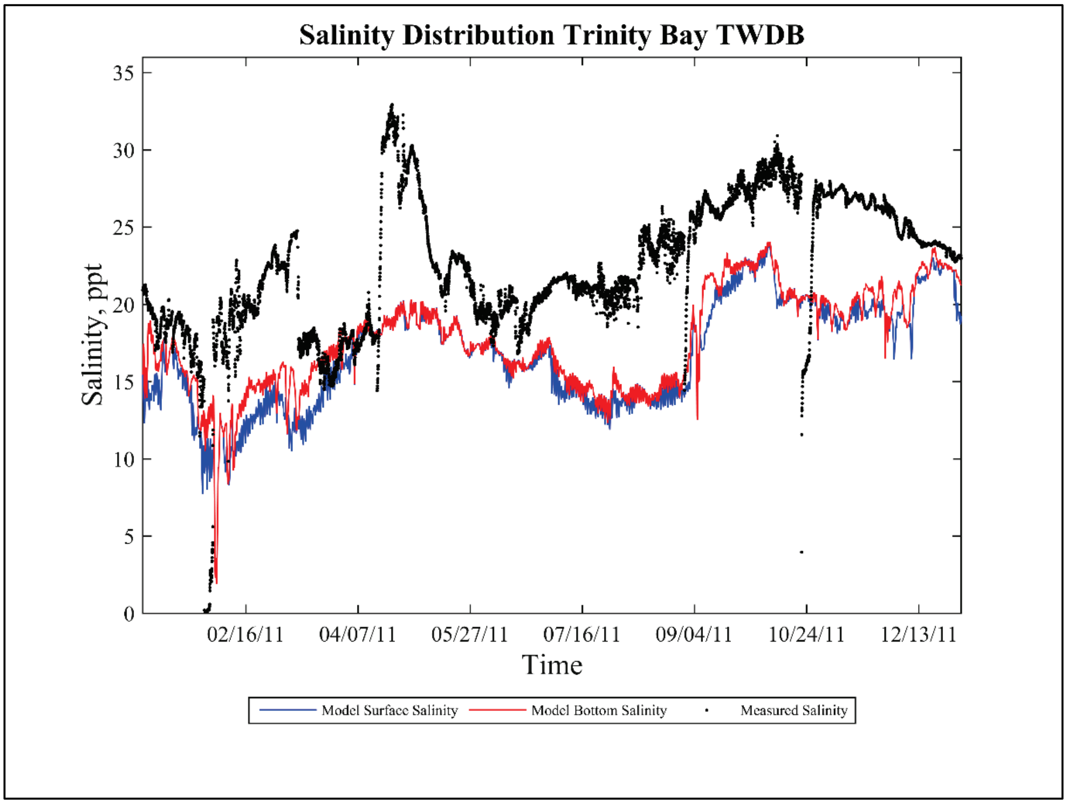

Salinity Distribution Galveston Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

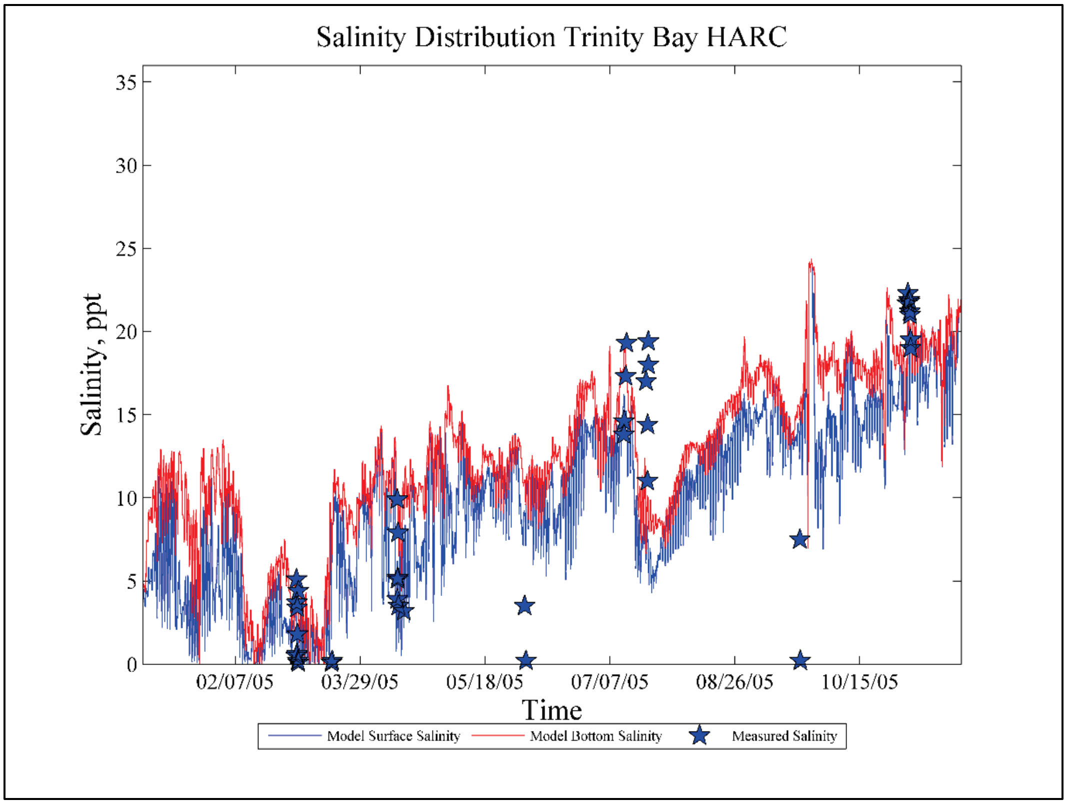

Salinity Distribution Clear Creek HARC
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

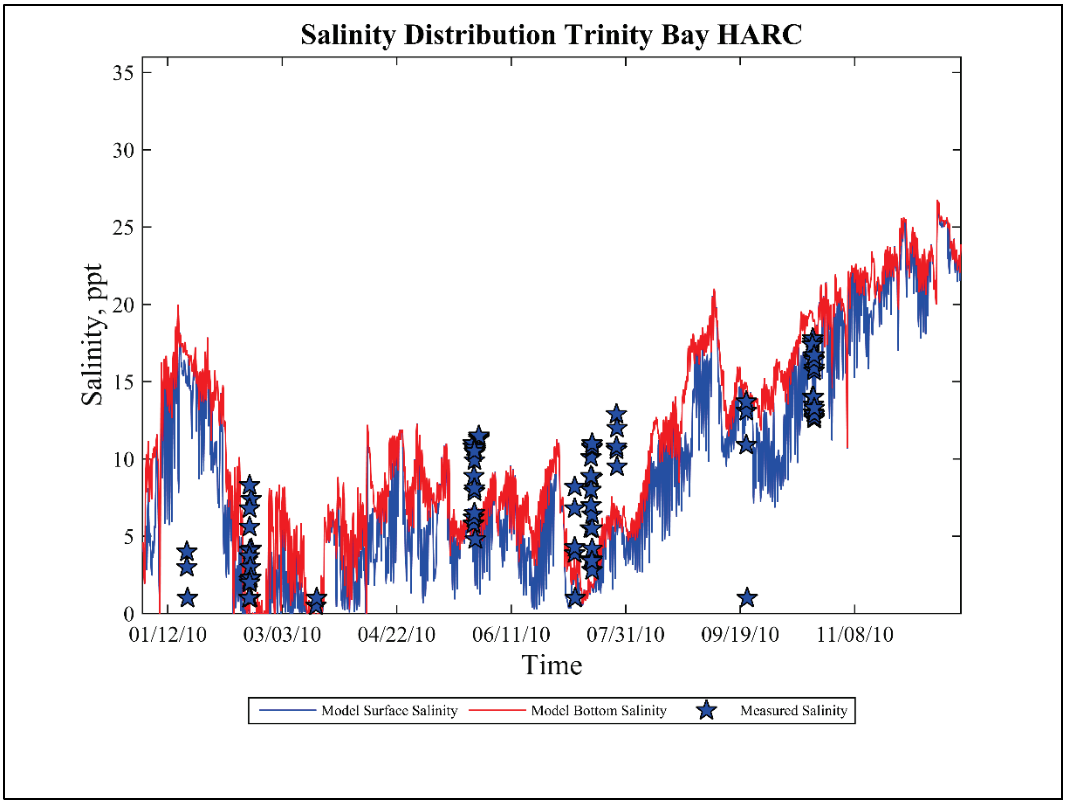

Salinity Distribution Clear Creek HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

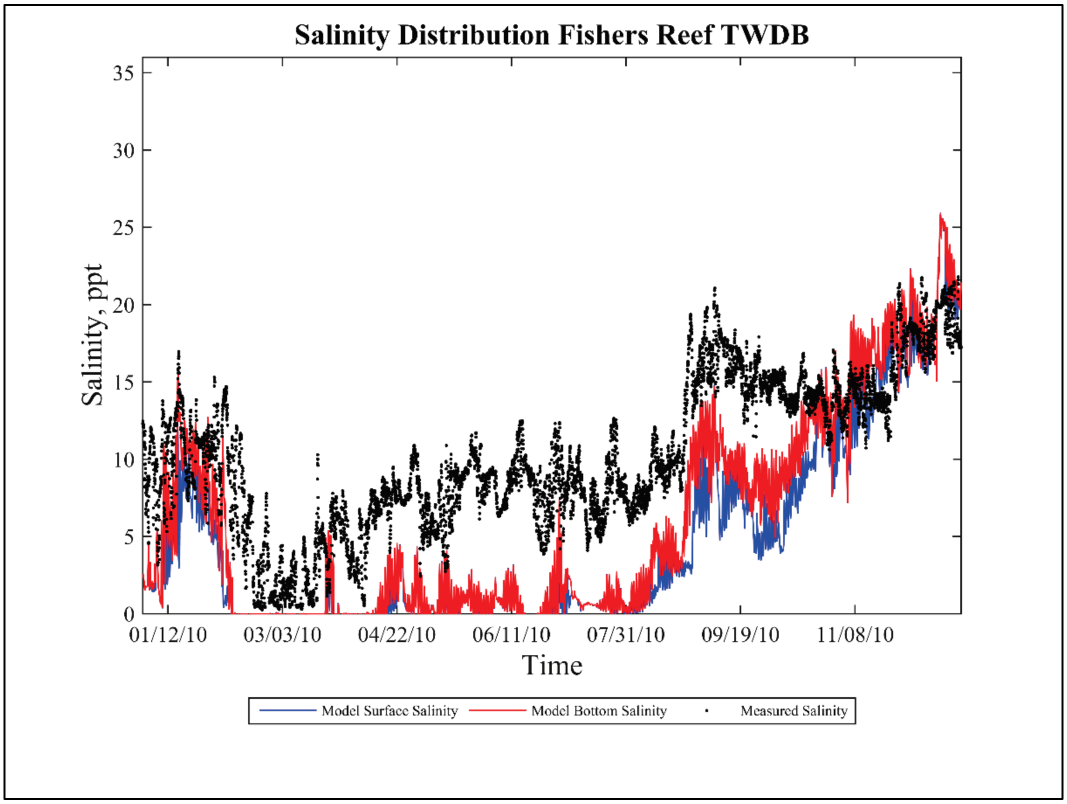

Salinity Distribution Trinity Bay TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
12/04/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

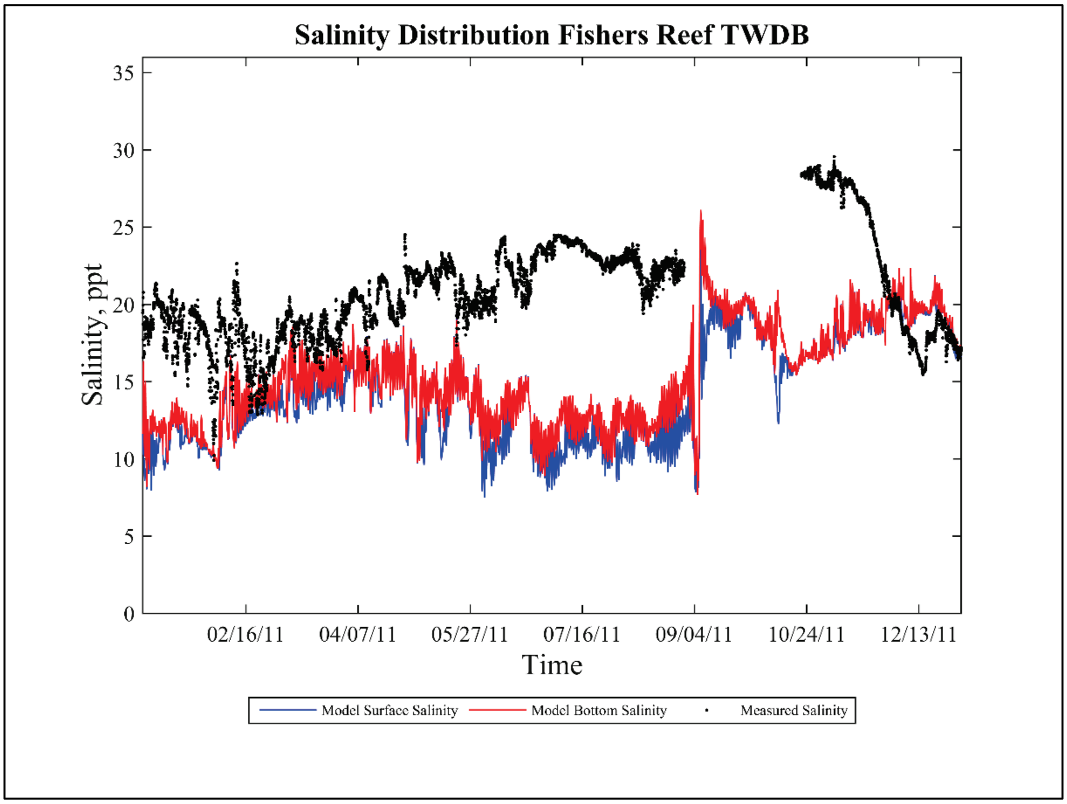

Salinity Distribution Trinity Bay TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

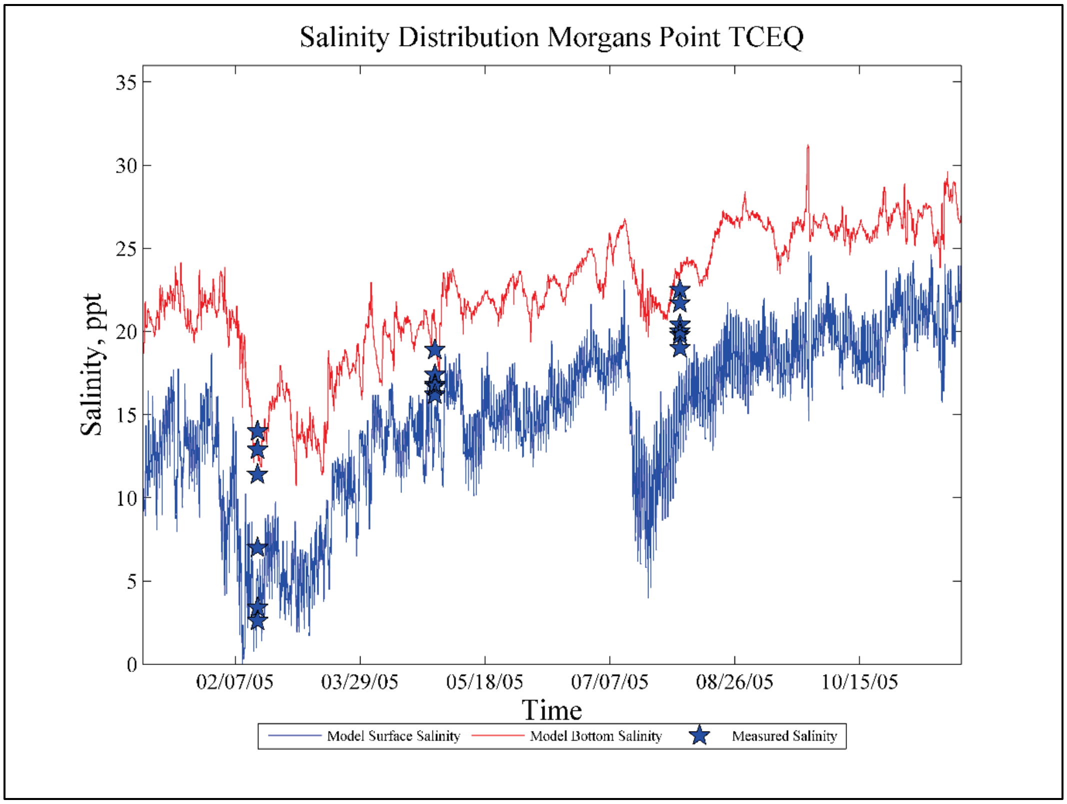

Salinity Distribution Trinity Bay TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

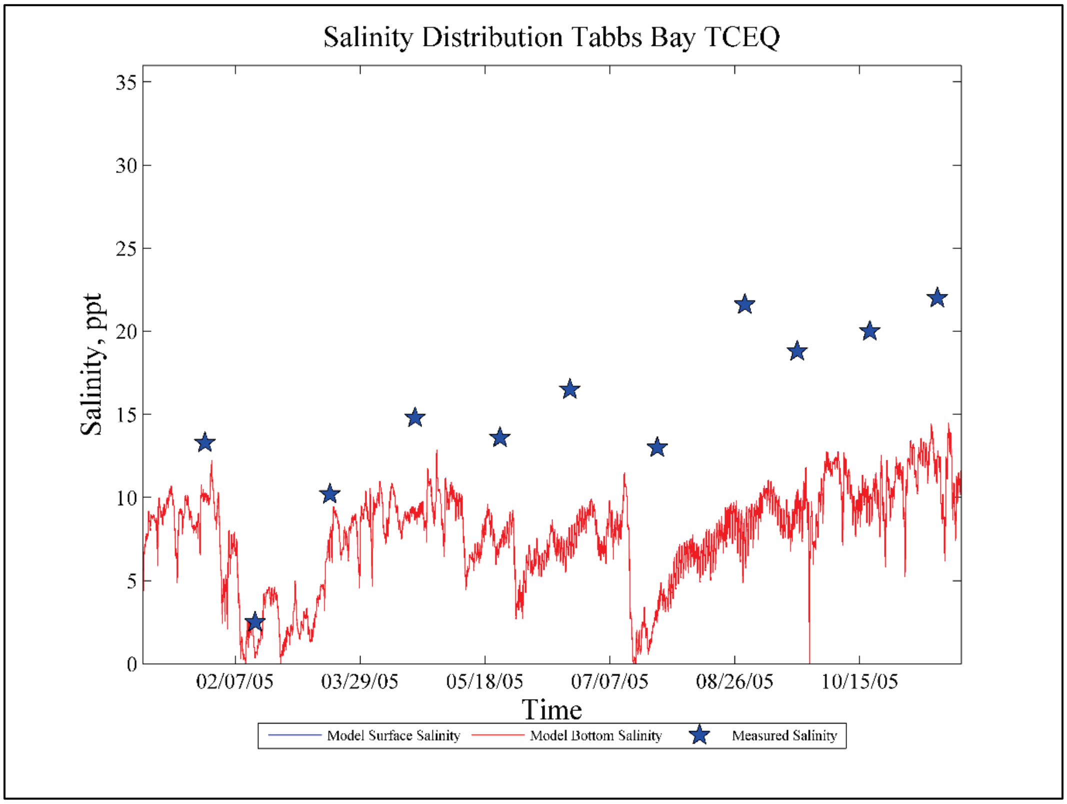

Salinity Distribution Trinity Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

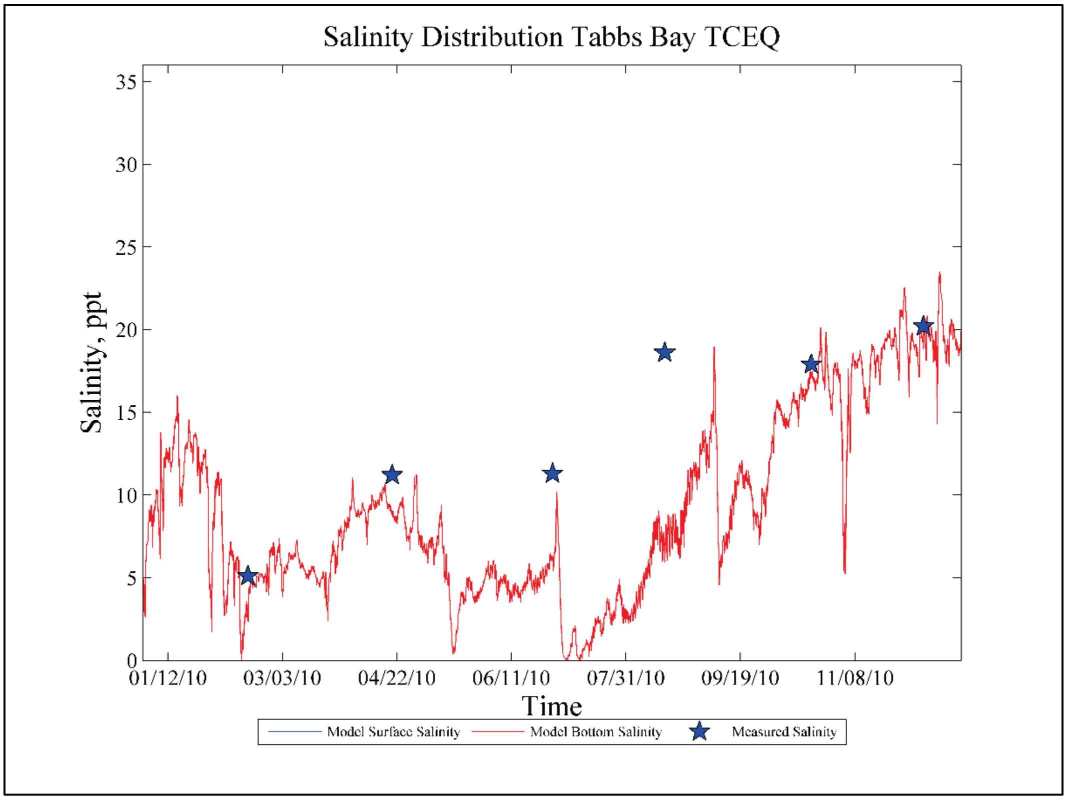

Salinity Distribution Trinity Bay HARC
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

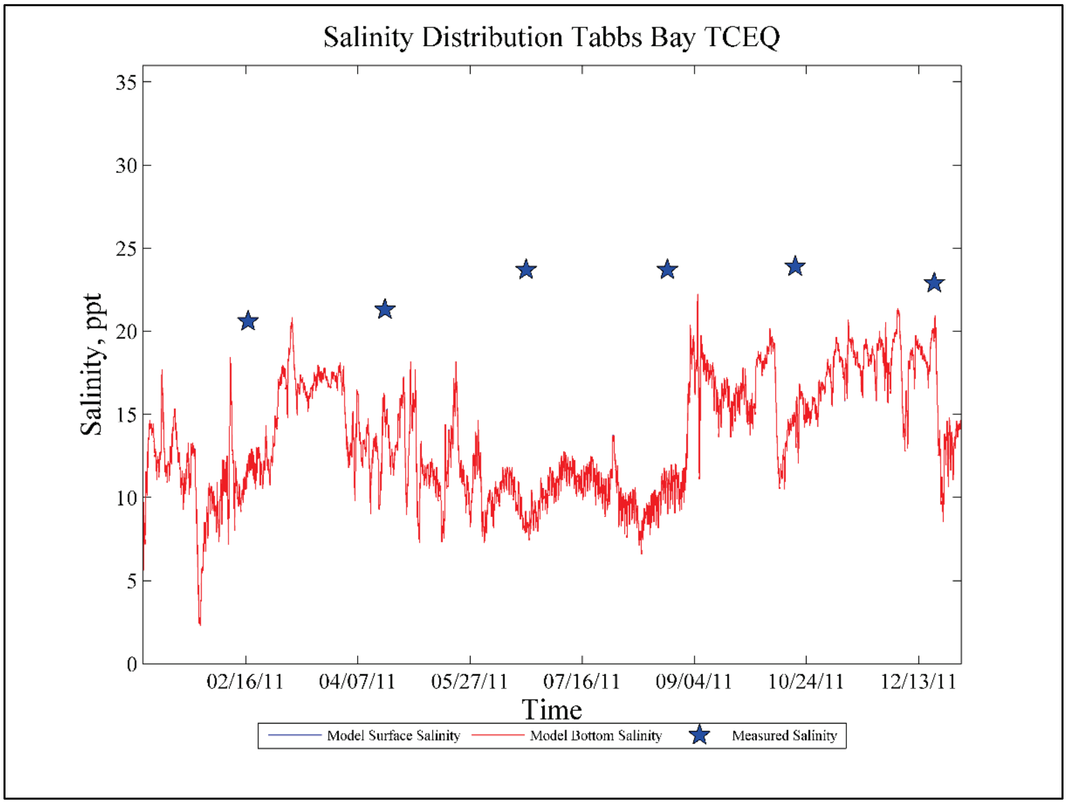

Salinity Distribution Fishers Reef TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

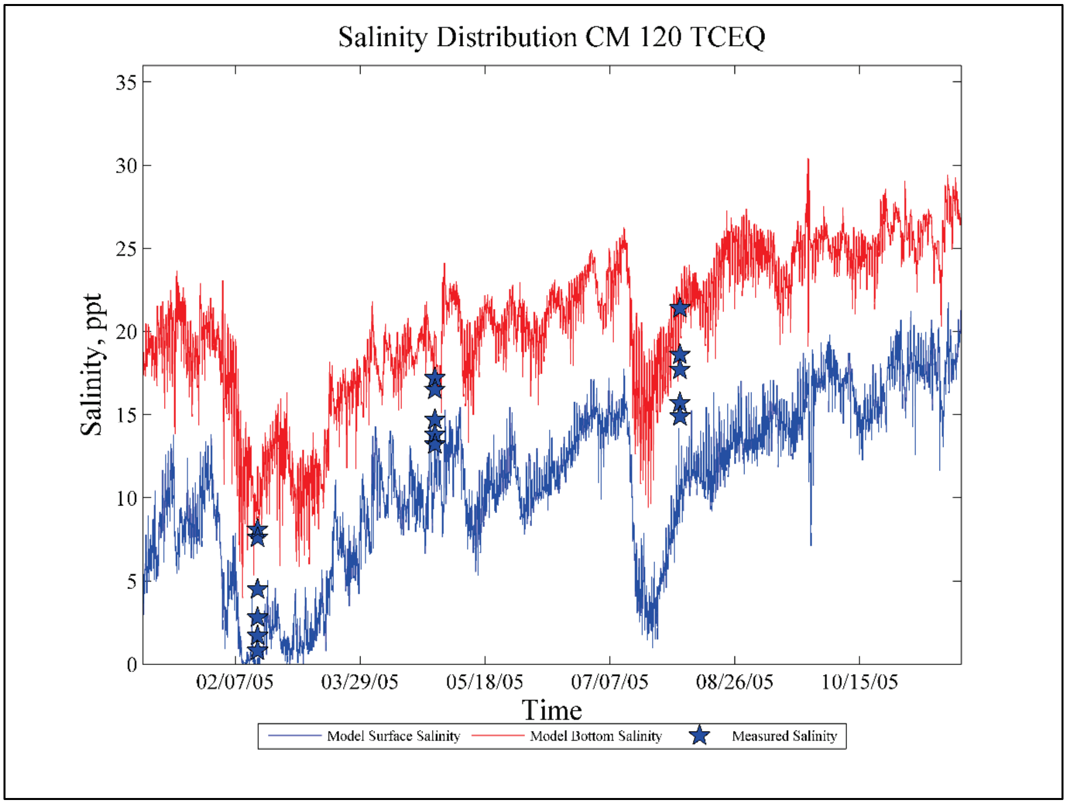

Salinity Distribution Fishers Reef TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

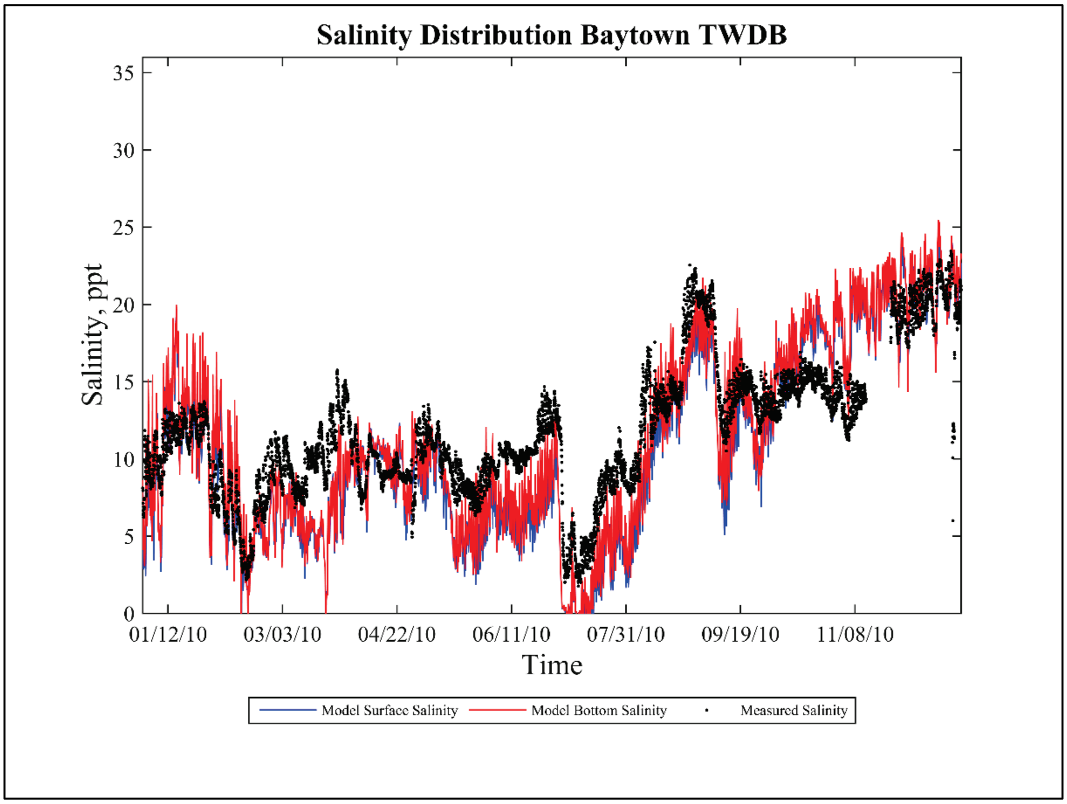

Salinity Distribution Morgans Point TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

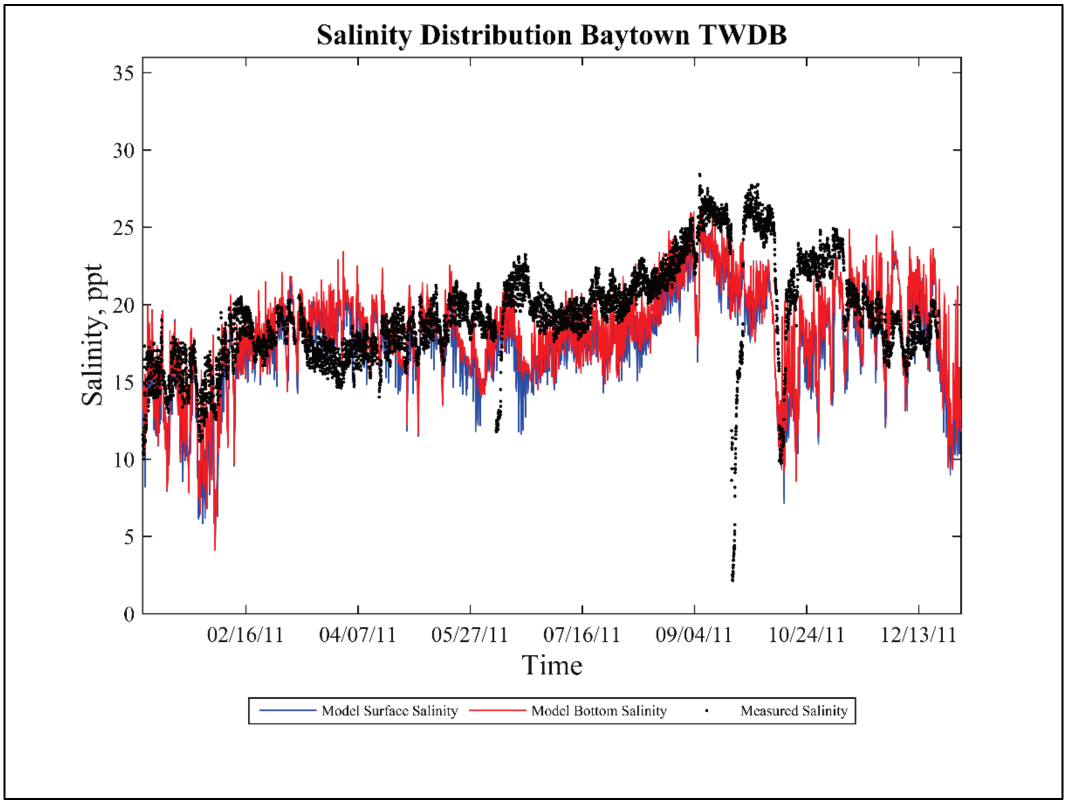

Salinity Distribution Tabbs Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity

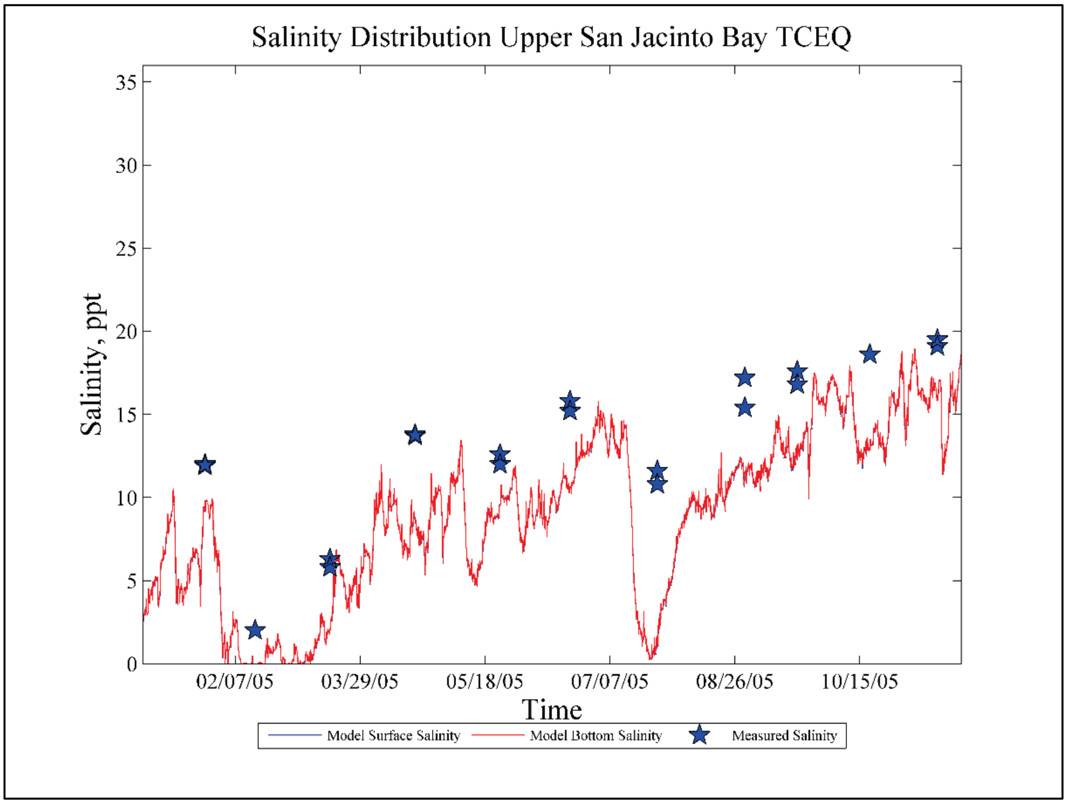

Salinity Distribution Tabbs Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity


Salinity Distribution Tabbs Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity


Salinity Distribution CM 120 TCEQ
Salinity, ppt
35
30
25
20
15
10
5
0
02/07/05
03/29/05
05/18/05
07/07/05
08/26/05
10/15/05
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity


Salinity Distribution Baytown TWDB
Salinity, ppt
35
30
25
20
15
10
5
0
01/12/10
03/03/10
04/22/10
06/11/10
07/31/10
09/19/10
11/08/10
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity


Salinity Distribution Baytown TWDB
Salinity, ppt
0
5
10
15
20
25
30
35
02/16/11
04/07/11
05/27/11
07/16/11
09/04/11
10/24/11
12/13/11
Time
Model Surface Salinity
Model Bottom Salinity
Measured Salinity


Salinity Distribution Upper San Jacinto Bay TCEQ
Salinity, ppt
0
5
10
15
20
25
30
35
02/07/05
03/29/05
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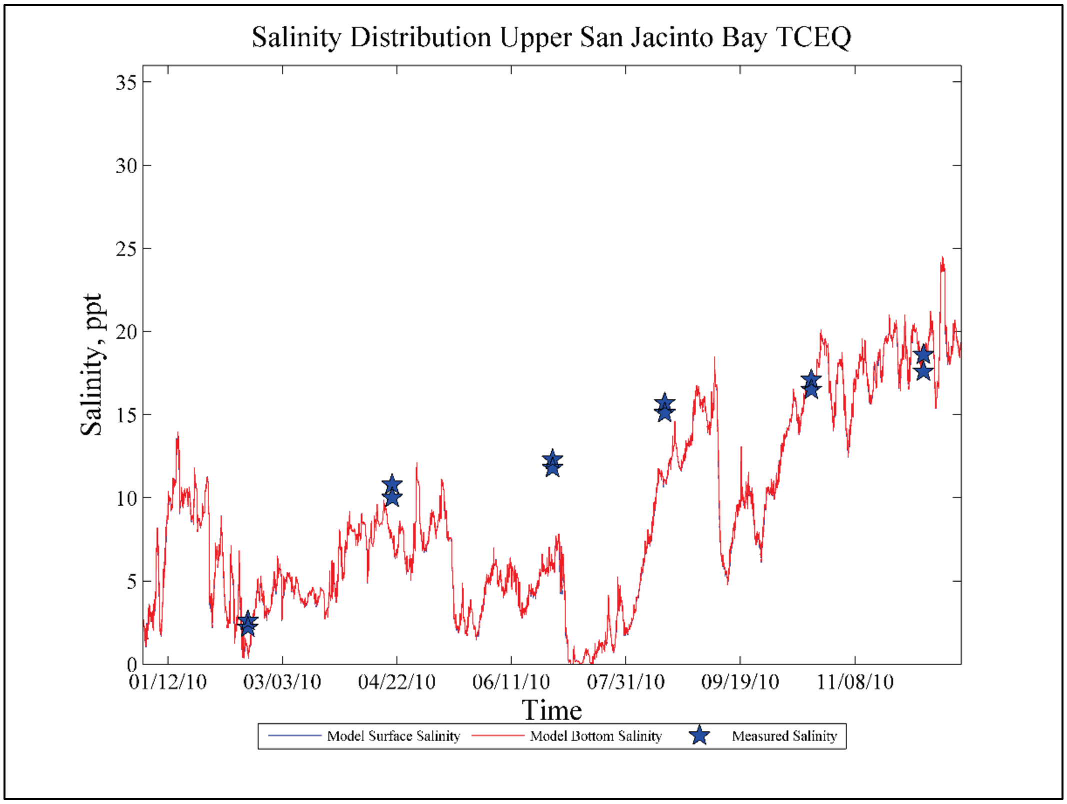
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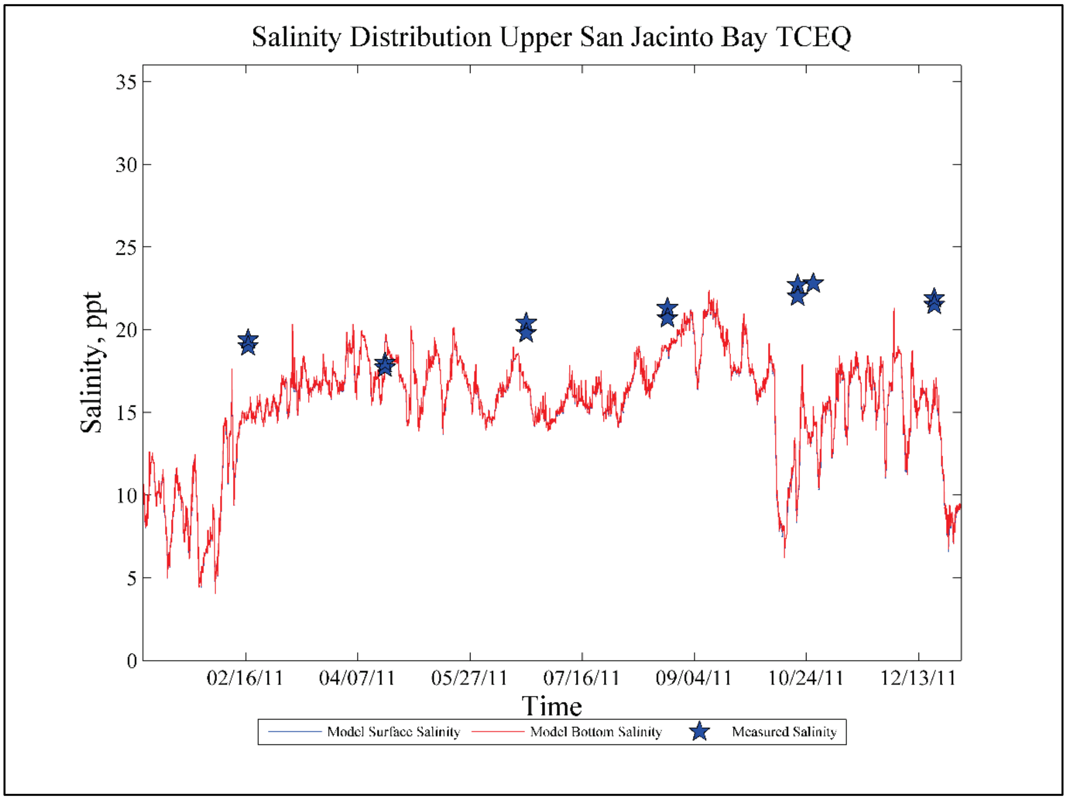
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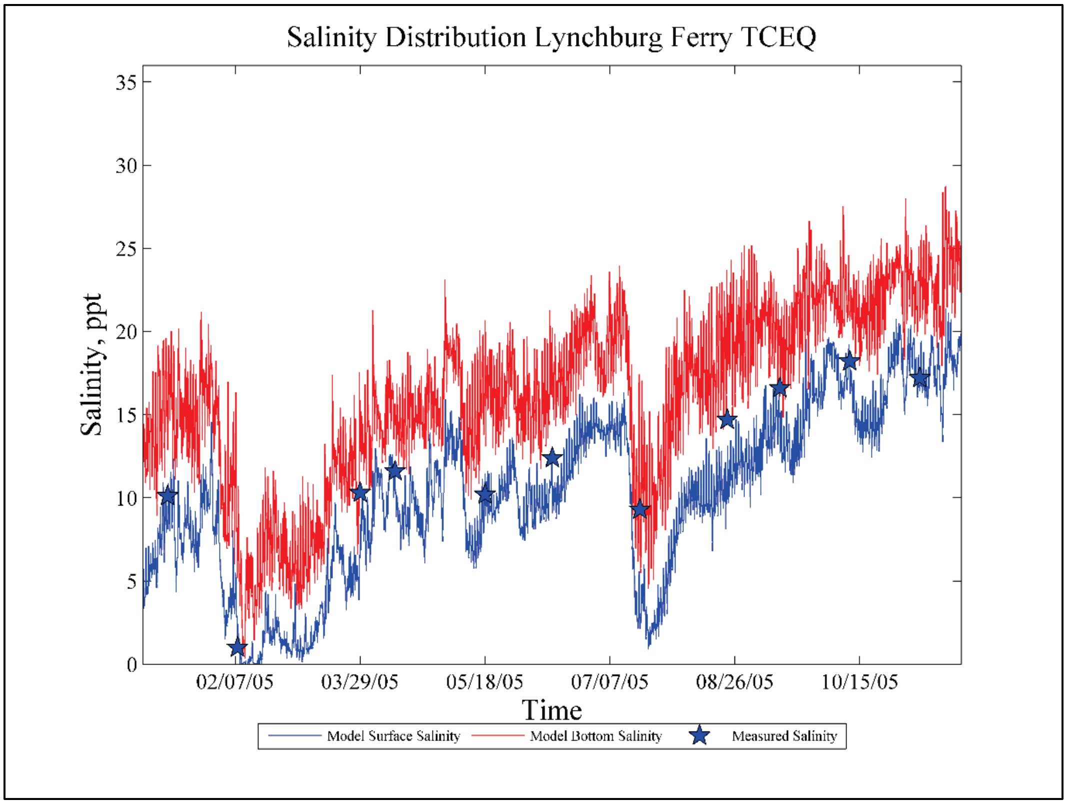
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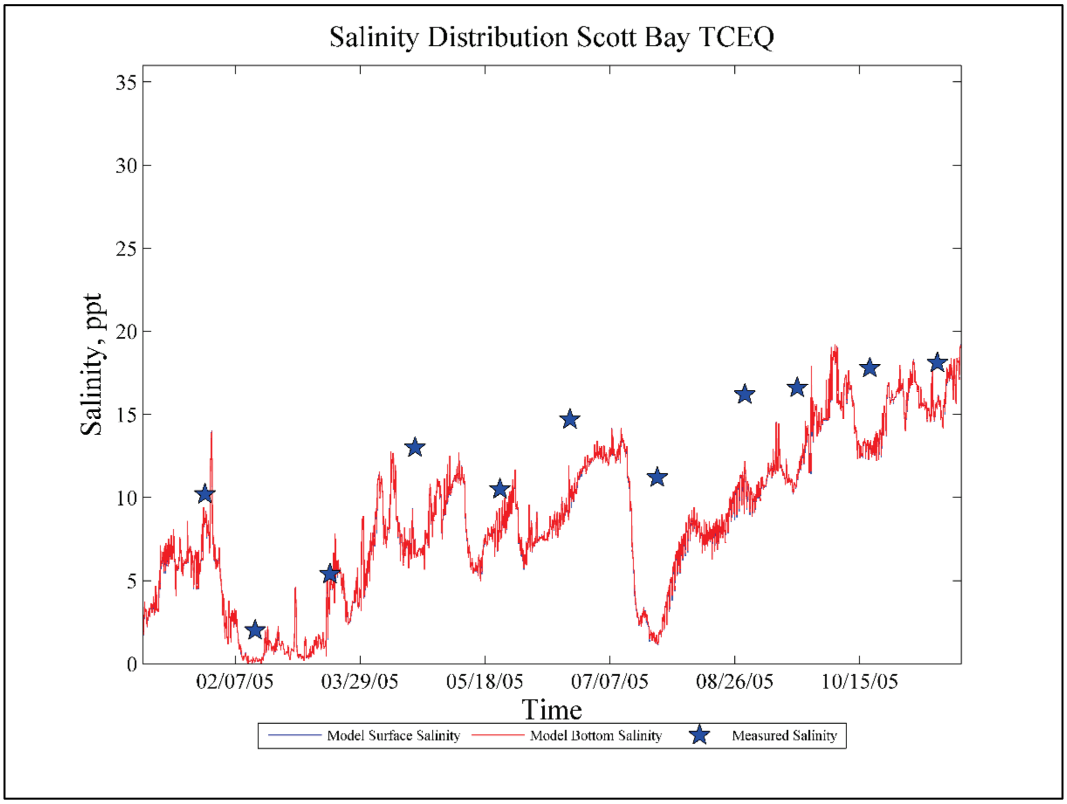
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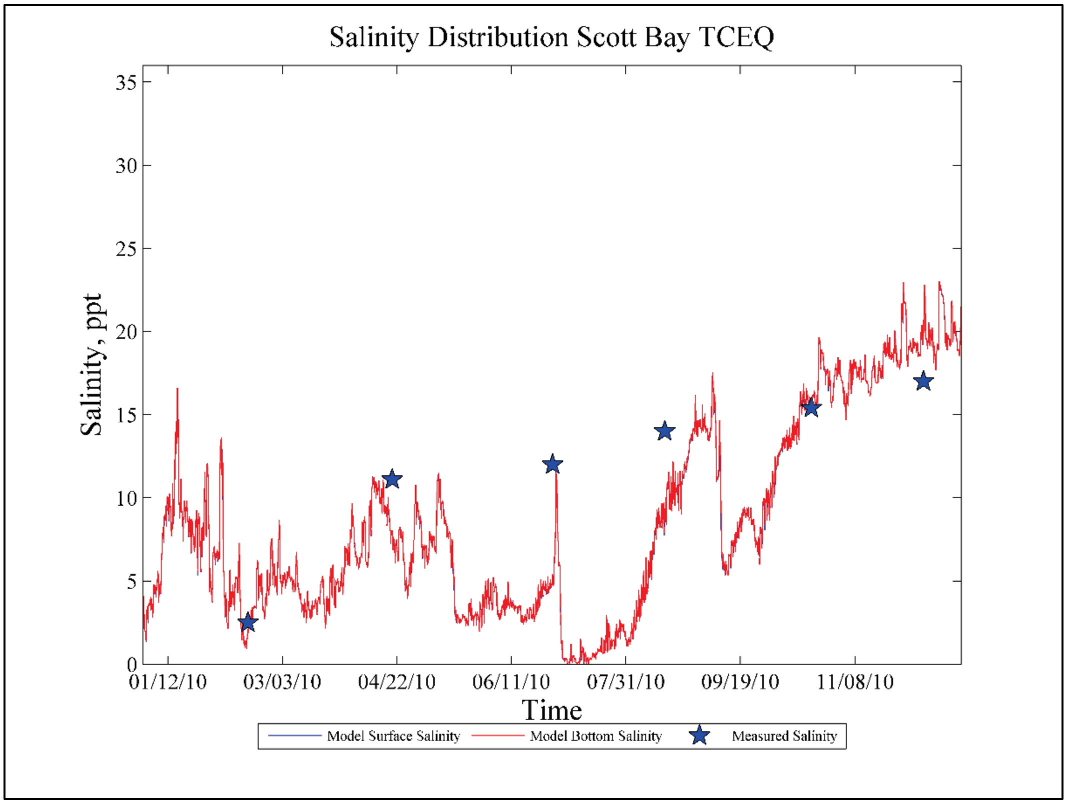
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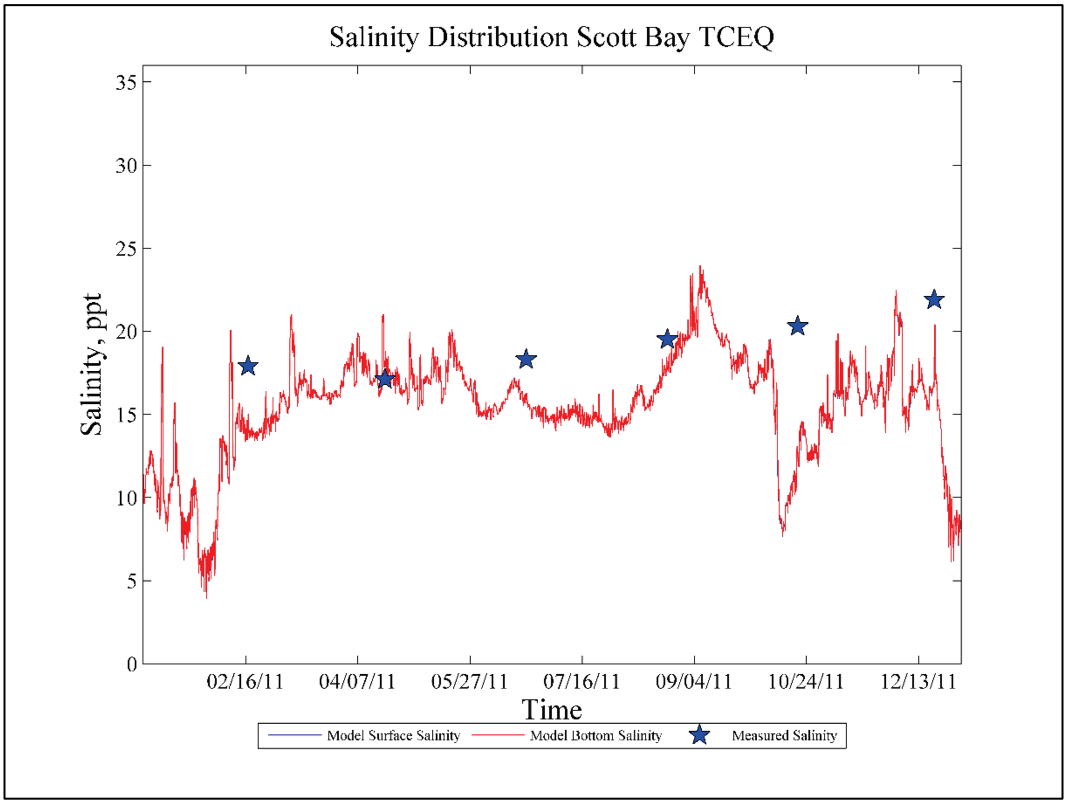
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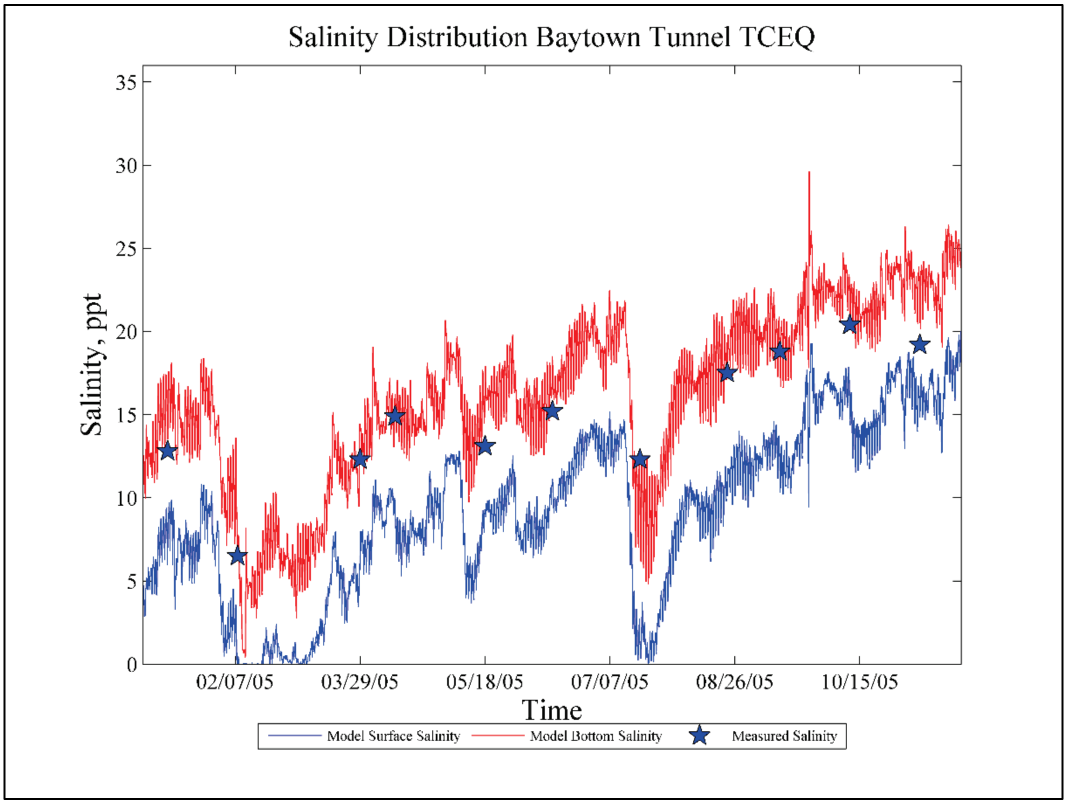
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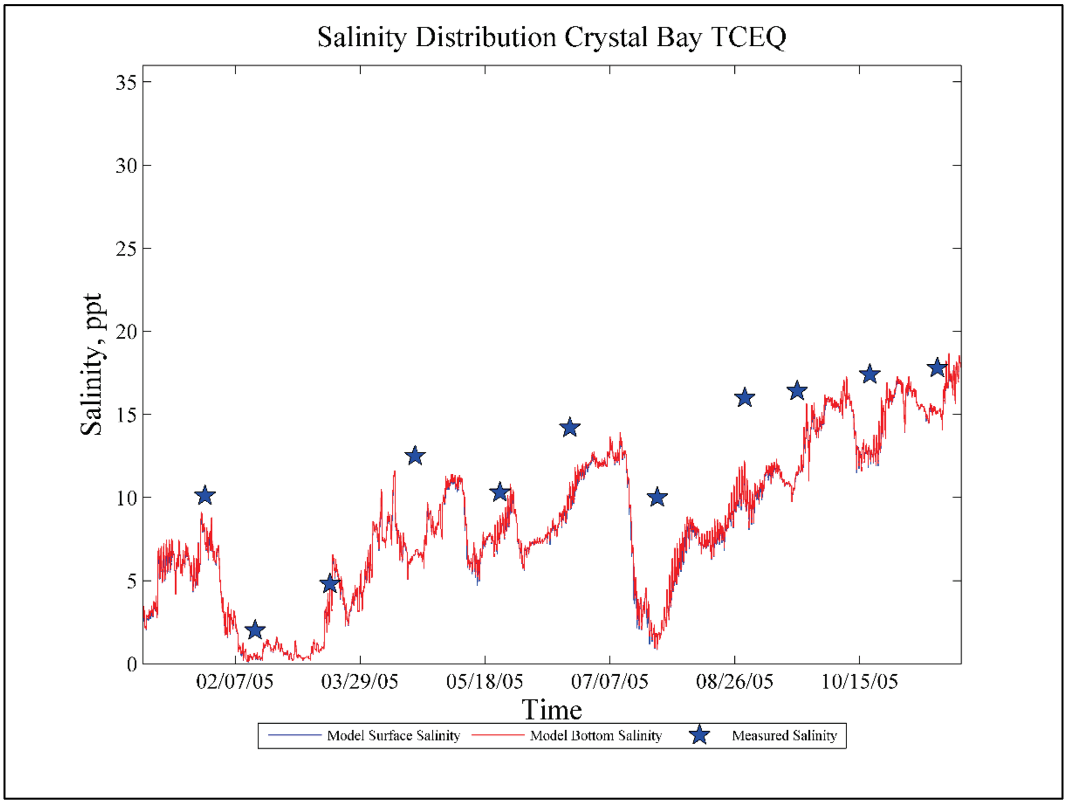
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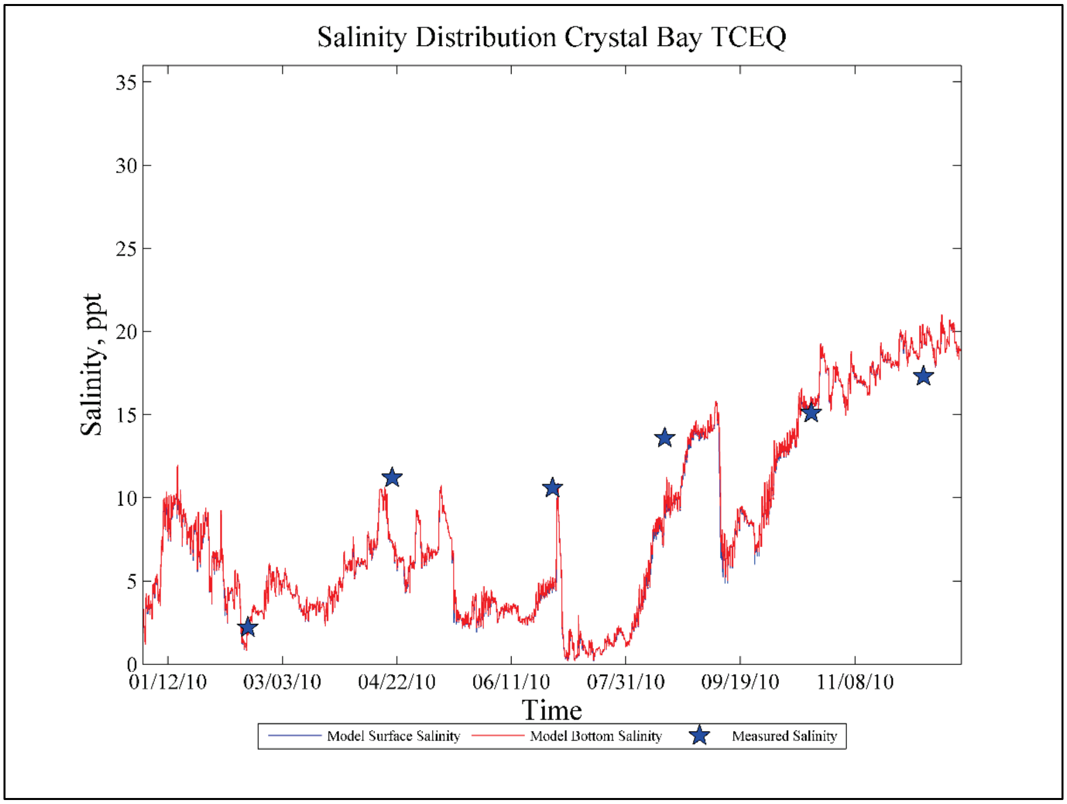
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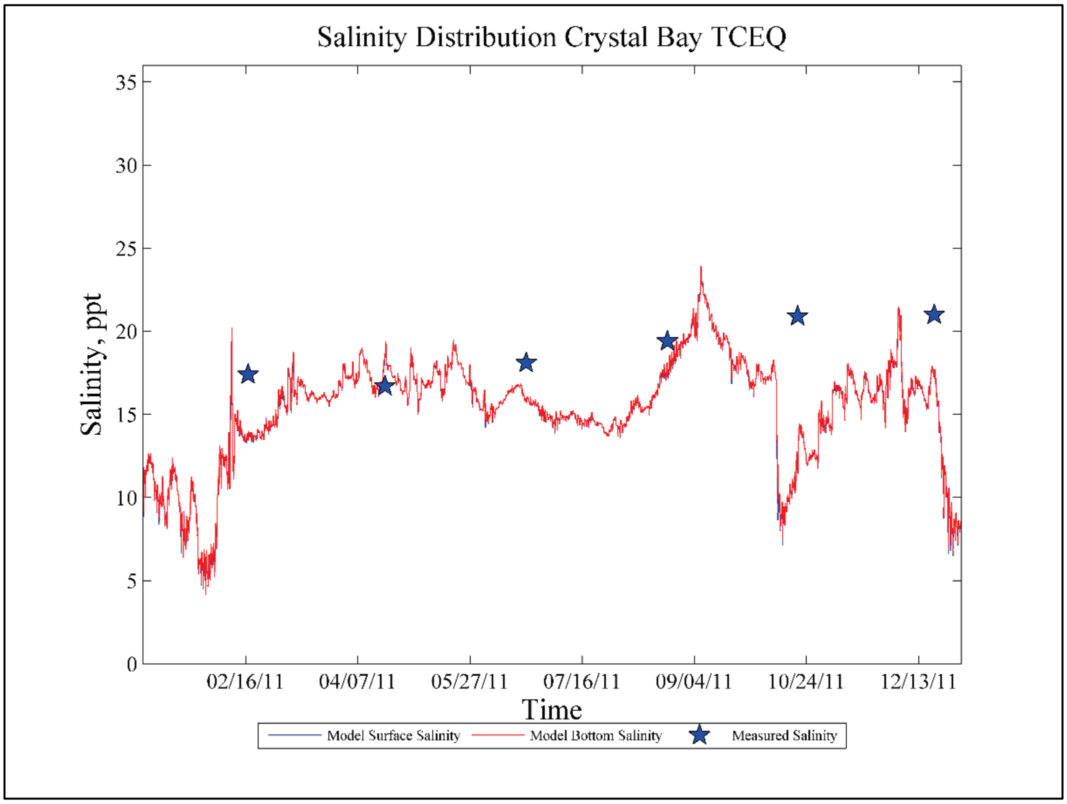
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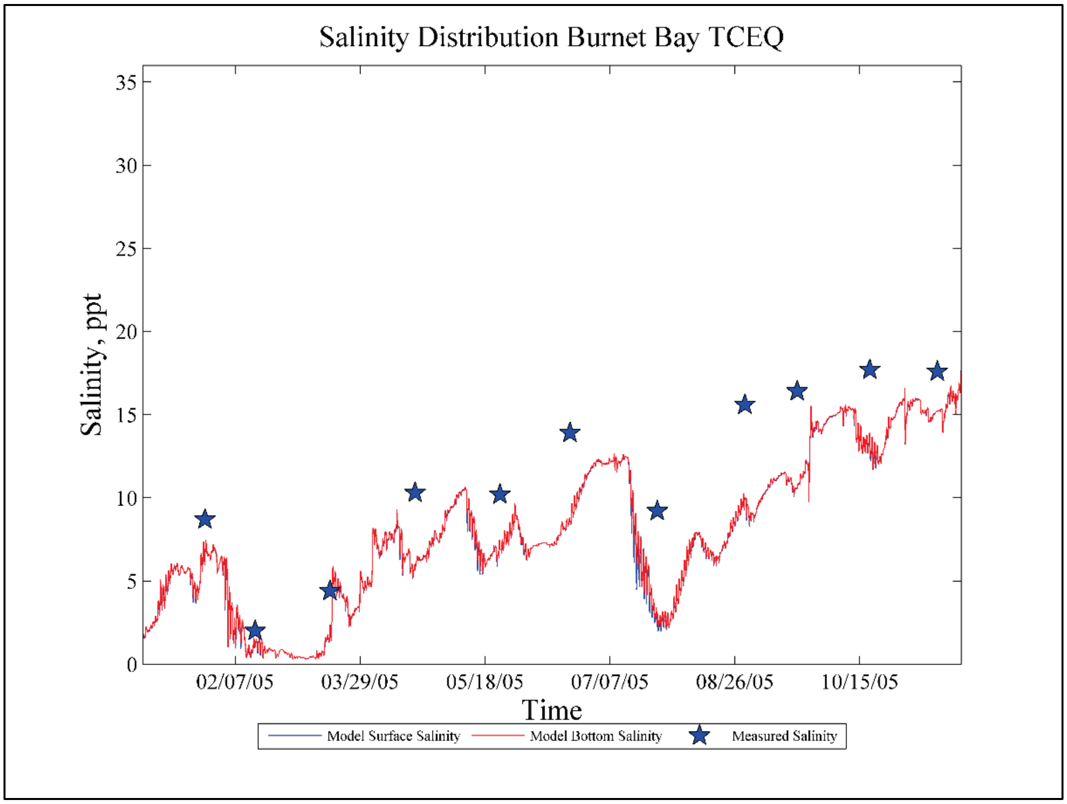
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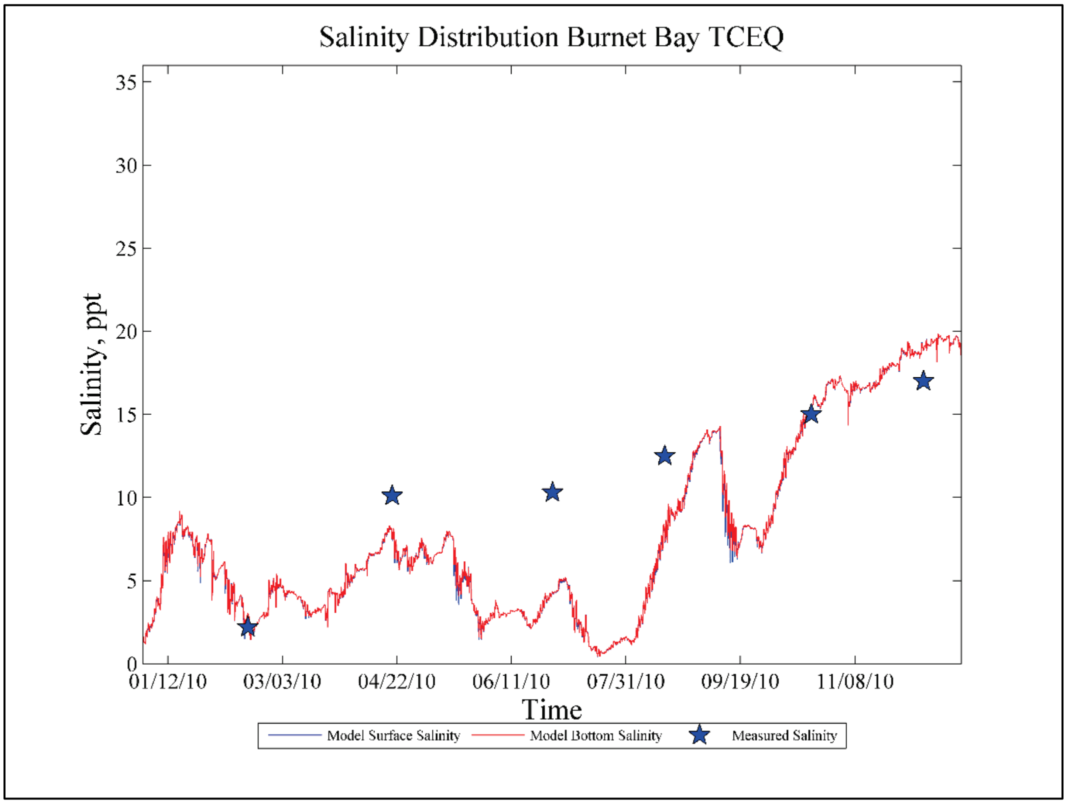
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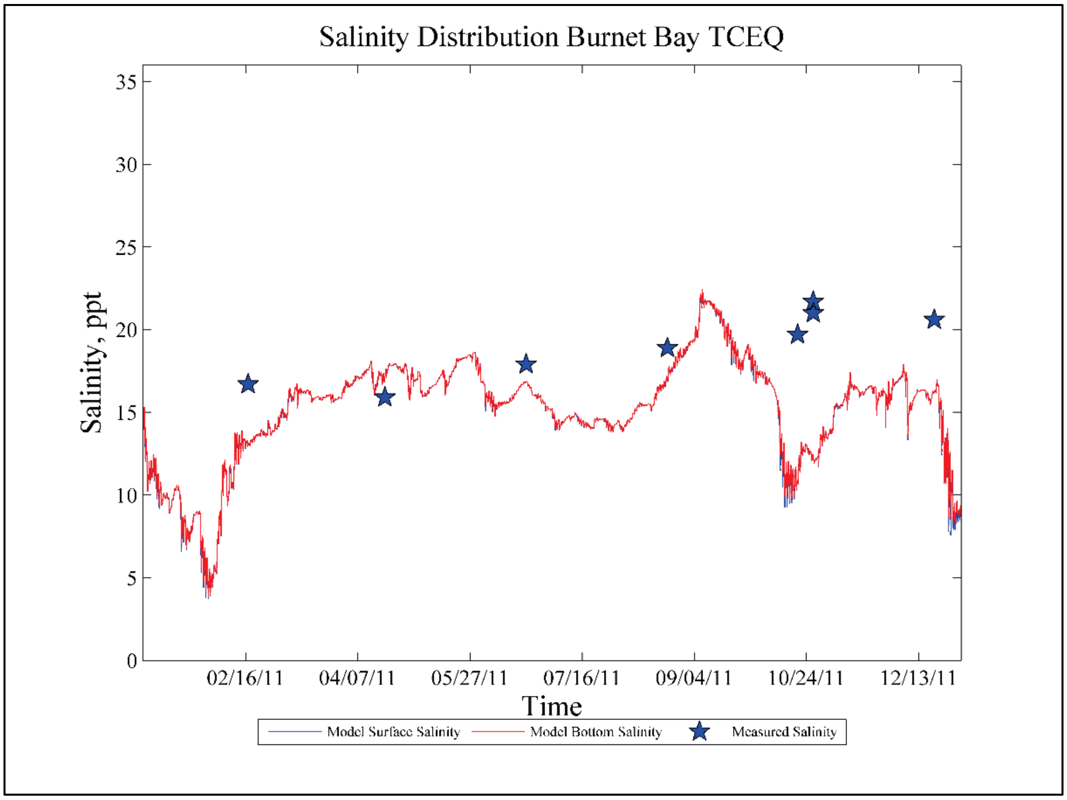
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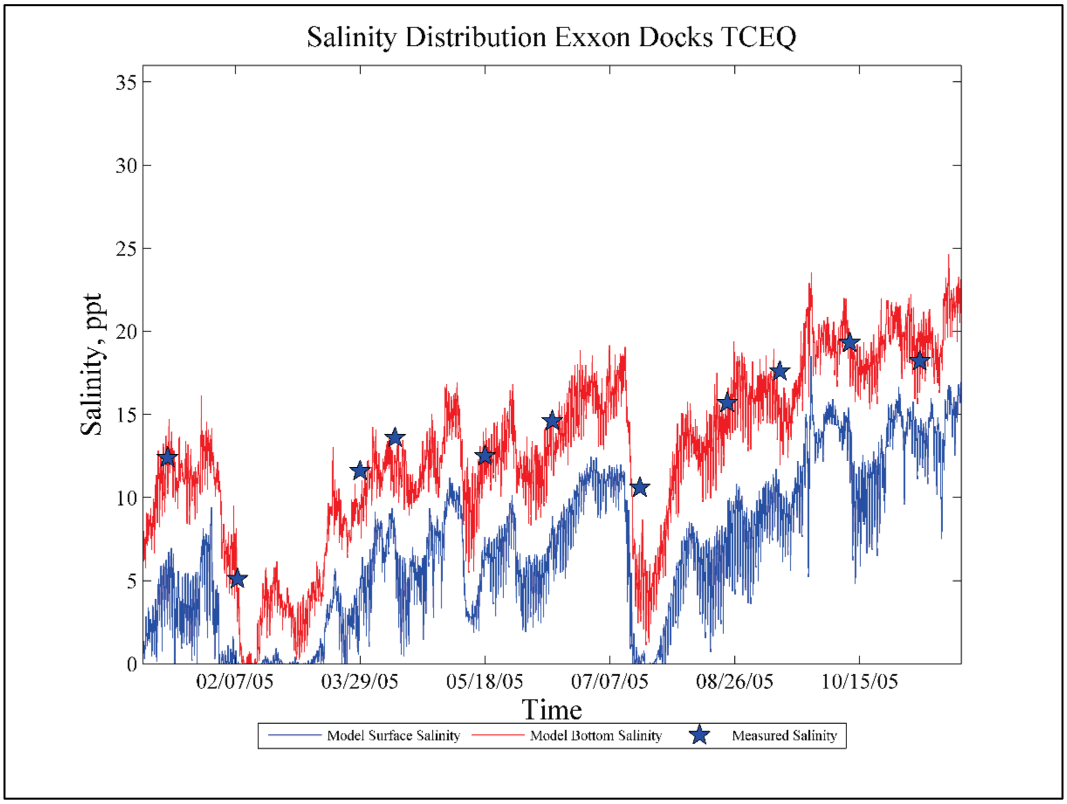
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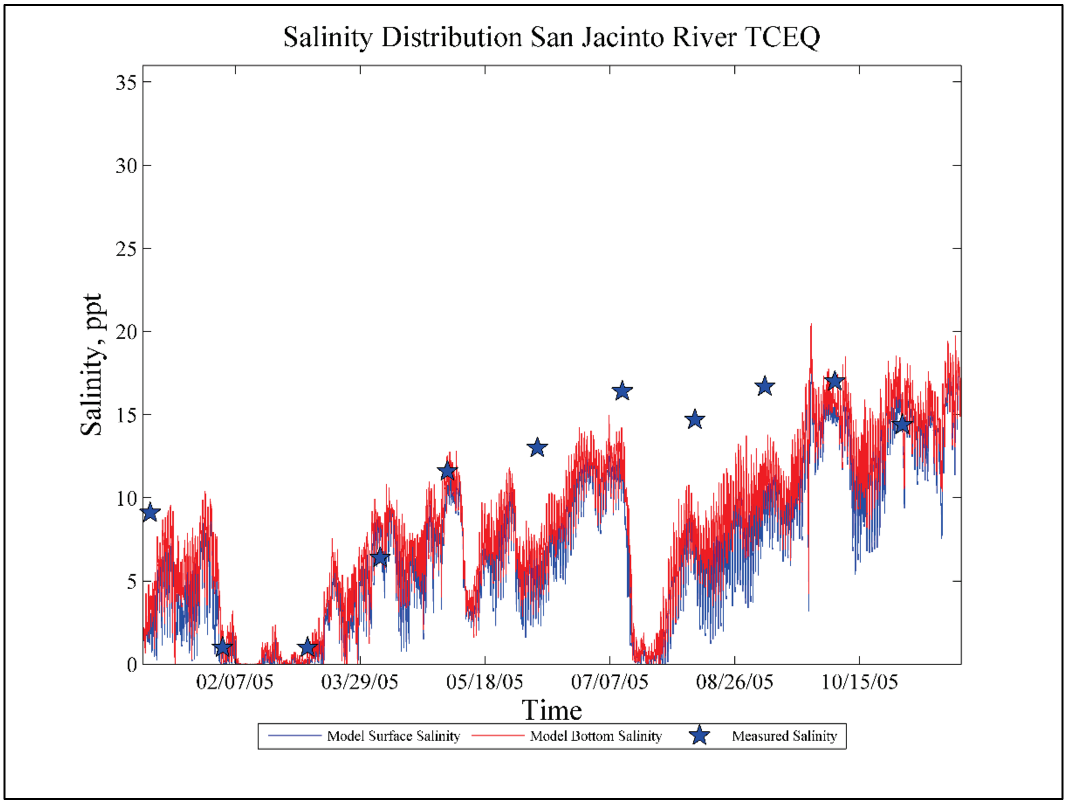
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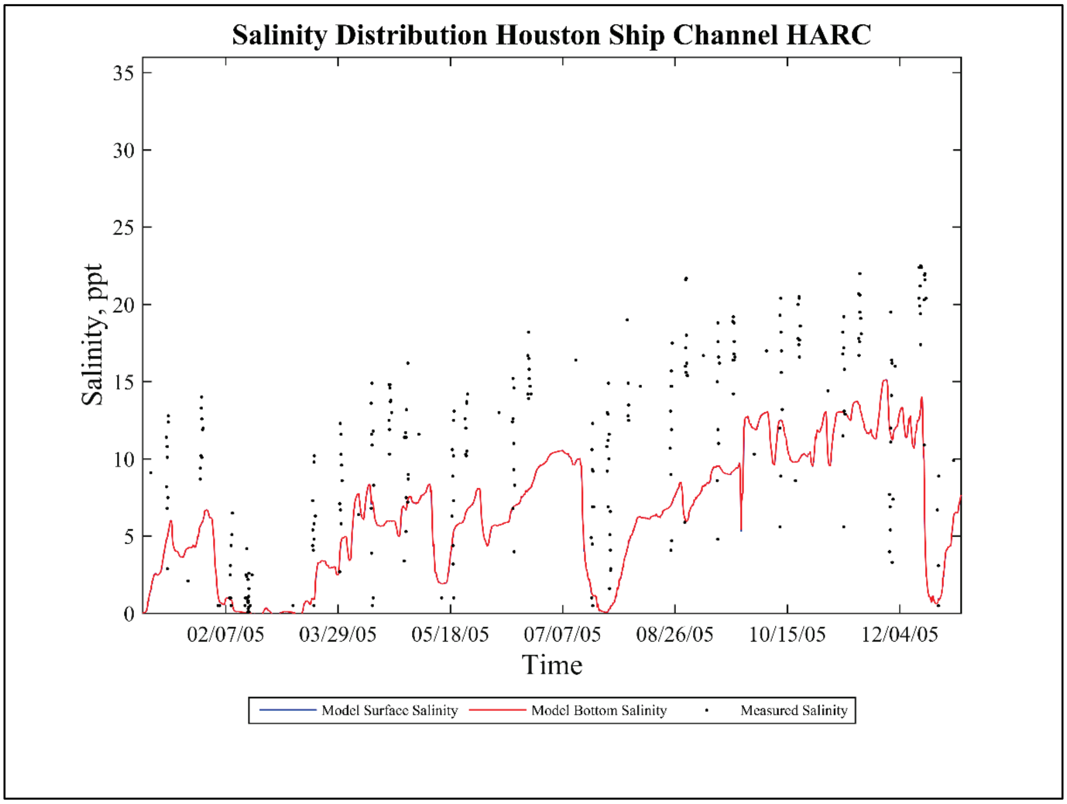
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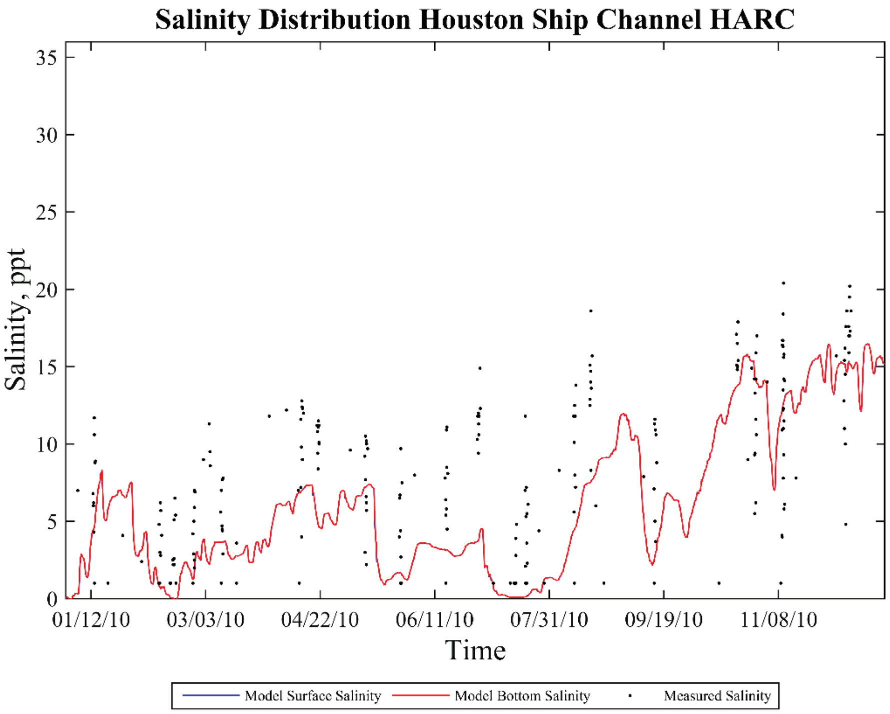
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Model Surface Salinity
Model Bottom Salinity
Measured Salinity

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	0.0254	meters
knots	0.5144444	meters per second
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

List of Abbreviations

AdH	Adaptive Hydraulics
AGU	American Geophysical Union
AWAC	Acoustic Wave and Current Profiler
CTR1	Coastal Texas Region 1
ERDC-CHL	Engineer Research and Development Center, Coastal and Hydraulics Laboratory
FWP	Future With Project
FWOP	Future Without Project
GERG	Geochemical and Environmental Research Group
HARC	Houston Advanced Research Center
HSC	Houston Ship Channel
MLLW	Mean Lower Low Water
NAVD88	North American Vertical Datum 1988
NOAA	National Oceanic and Atmospheric Administration
PWP	Present With Project
PWOP	Present Without Project
SLR	Sea Level Rise
SMS	Surface Water Modeling System
SWG	US Army Engineer District, Galveston
TABS	Texas Automated Buoy System
TCEQ	Texas Commission on Environmental Quality
TSP	Tentatively selected plan
TWDB	Texas Water Development Board
TxRR	Texas Rainfall Runoff Model
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WIS	Wave Information Studies
2D	Two-dimensional
3D	Three-dimensional

List of Unit Abbreviations

ft	feet
m	meters
m^3	cubic meters
cms	cubic meters per second
m/s	meters per second
mg/l	milligrams per liter
ppt	parts per thousand

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Jennifer McAlpin, Cassandra Ross, and Jared McKnight

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Vicksburg, MS 39180-6199

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P.O. Box 1229
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14. ABSTRACT

The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate larger vessels as needed. The U.S. Army Engineer District, Galveston, requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, perform hydrodynamic, salinity, and sediment transport modeling of proposed modifications along the Houston Ship Channel from its connection to the Gulf of Mexico to the Port of Houston as well as alterations for storm protection. The modeling results are necessary to provide data for salinity and sediment transport analysis as well as a ship simulation investigation to determine the navigational impacts of the proposed alternatives. The model setup and validation are presented in this report. The model proved to match field data for water surface elevation, velocity, and shoaling in the ship channel over three simulation years — 2005, 2010, and 2011.

15. SUBJECT TERMS
Coastal engineering—Numerical, Houston Ship Channel (Tex.), Inland navigation, Hydrodynamics, Salinity, Sedimentation and deposition, Sediment transport

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			
Unclassified	Unclassified	Unclassified	SAR	133	**19b. TELEPHONE NUMBER** *(Include area code)* 601-634-2511

ATTACHMENT 4

ENGINEERING DATA AND MODELS

ERDC/CHL TR-19-12

Coastal and Hydraulics Laboratory

US Army Corps
of Engineers®
Engineer Research and
Development Center

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

Houston Ship Channel Expansion Channel Improvement Project (ECIP) Numerical Modeling Report

Jennifer McAlpin, Jared McKnight, and Cassandra Ross

June 2019

ERDC/CHL TR-19-12
June 2019

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Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
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Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers, Galveston District
P.O. Box 1229
Galveston, TX 77553-1229

Under Work Unit 451902; HSC Feasibility Study

Abstract

The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate larger vessel dimensions over time. The U.S. Army Engineer District, Galveston (SWG), requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, perform hydrodynamic and sediment modeling of proposed modifications along the Houston Ship Channel from its connection to the Gulf of Mexico to the Port of Houston. The modeling results are necessary to provide data for salinity and sediment transport analysis as well as ship simulation studies.

SWG provided a project alternative that includes channel widening, deepening, and bend easing. The model is run for *present* year zero (2029) and *future* year 50 (2079) with and without project.

The model shows that the salinity does not vary greatly with project. Changes to salinity are 2 parts per thousand or less. The tidal prism increases by less than 2% when the project is included, and the tidal amplitudes increase by no more than 0.01 meter. The residual velocity vectors do vary in and around areas where project modifications are made — along the Houston Ship Channel, Bayport Channel, and Barbours Cut Channel. The model also indicates an increase in the shoaling along the ship channel when compared to the without project results, the largest increases being in the Bayport channel and flare.

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Figures and Tables

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Tables

Preface

The model investigation presented in this report was authorized and funded by the U.S. Army Corps of Engineers, Galveston District, Work Unit 451902; HSC Feasibility Study.

The work was performed at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL), Vicksburg, MS, under the general direction of Mr. José E. Sánchez, Director, and Mr. Jeffrey R. Eckstein, Deputy Director, ERDC-CHL. Direct supervision was provided by Dr. Cary Talbot, Chief, Flood and Storm Protection Division, and Mr. Keith Flowers, Chief, River and Estuarine Engineering Branch.

At the time of publication of this report, Mr. Jeffrey R. Eckstein was the Deputy Director of CHL, and Dr. Ty V. Wamsley was the Director.

COL Ivan P. Beckman was Commander of ERDC, and Dr. David W. Pittman was Director.

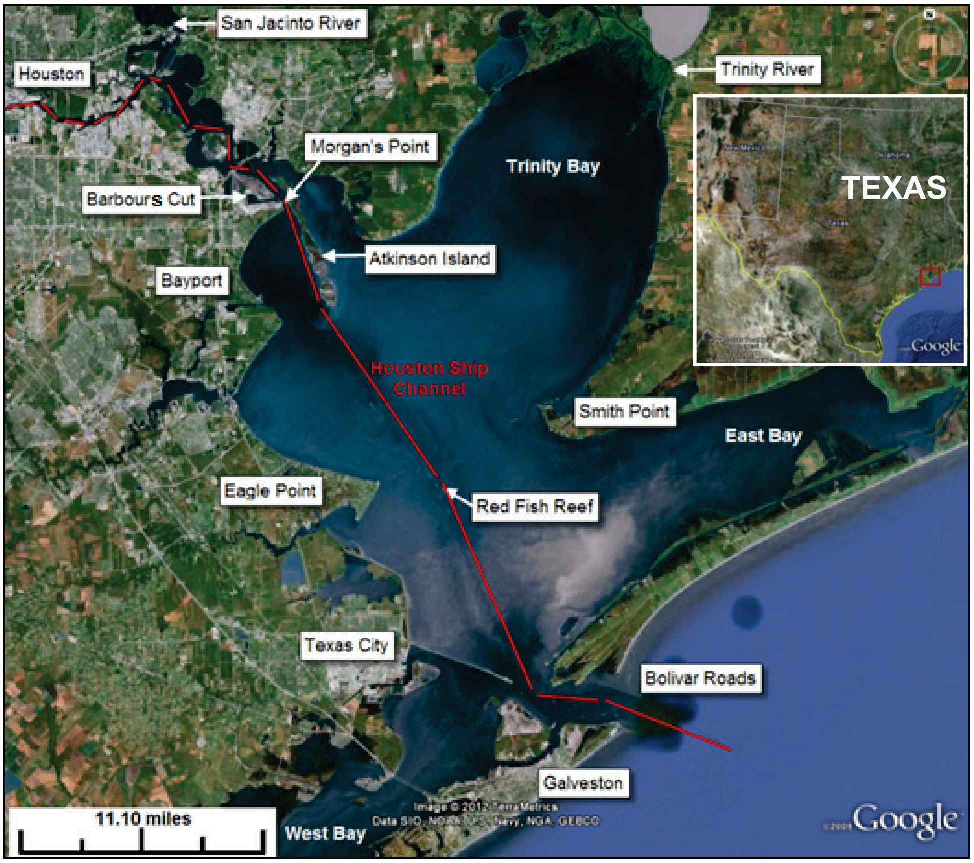
1 Introduction

Background

Since the early 1800s, vessels have transited Galveston Bay both to and from Galveston and Houston (Galveston Bay Estuary Program 2002).

Galveston Bay is a tidal estuary such that the effect of the tide on the water surface elevation is observed from the Gulf of Mexico to locations near Houston, TX. The Houston Ship Channel (HSC) is a deep-draft navigation channel that allows for vessel passage from the Gulf to the city of Houston, approximately 53 miles upstream. Since 1903, Operations and Maintenance dredging has been conducted in the bay portion to maintain authorized channel dimensions. Figure 1 shows the HSC as it passes through Galveston Bay from its entrance at Bolivar Roads to the Port of Houston.

Figure 1. HSC area map.



The U.S. Army Corps of Engineers (USACE), Galveston District (SWG), recently enlarged the HSC from a 12.2-meter (m) (40-foot [ft]) depth by 122 m (400-ft) width to a 13.7 m (45 ft) depth by 162 m (530 ft) width. Previously, a three-dimensional (3D) numerical model study was implemented at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), to evaluate the salinity and circulation impact of this enlargement. In Berger et al. (1995a) the model was shown to represent the salinity and circulation in the earlier channel configuration. Berger et al. (1995b) used the model to predict the impact of the enlarged channel. Carrillo et al. (2002) used the model to evaluate the addition of barge lanes along the ship channel flanks. Tate and Berger (2006) looked into possible reasons for increased shoaling in the ship channel by analyzing vessel effects and sediment properties in the area. In Tate et al. (2008), the sediment model was validated using the same hydrodynamic model, and the results included the effects of vessel transport on the sedimentation patterns. The model was utilized again to investigate proposed changes to the Bayport Flare (Tate and Ross 2012).

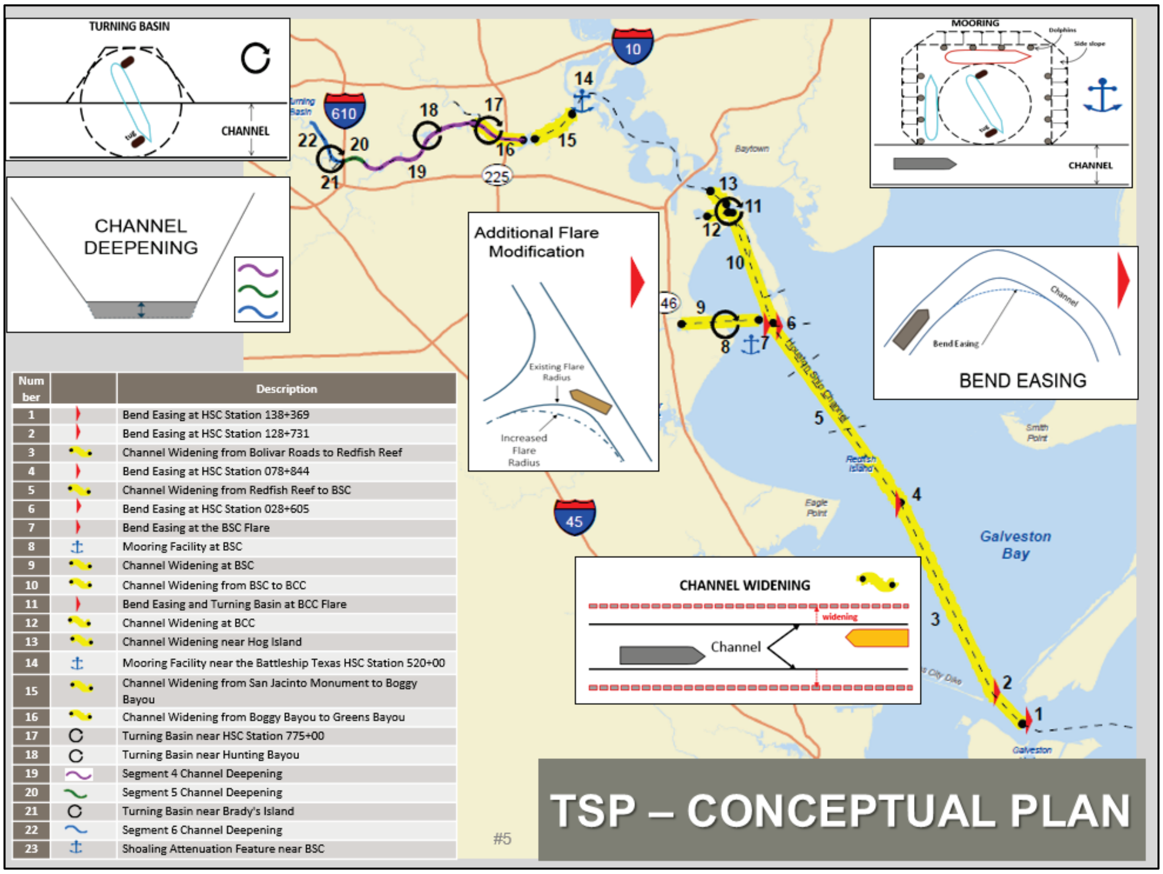
The deep navigation channel acts as a natural pathway for salinity to travel upstream since high-saline water is heavier than fresh water and tends to flow up-channel along the channel bottom. The residual velocity, or net drift, is flood in much of the channel (Tate and Berger 2006) (i.e., the tendency is for suspended material to move upstream into the Galveston Bay.) The velocity magnitudes drop in the Atkinson Island reach due to tidal reflections from the bay boundaries. More stratification occurs as a result in this reach, and material from farther downstream in the estuary will tend to collect near Atkinson Island.

The behavior of the salinity and hydrodynamics in Galveston Bay during May through June is different than the remainder of the year due to a salinity drop in the northern Gulf of Mexico as the Mississippi, Sabine-Neches, and Atchafalaya Rivers and other northern Gulf river systems provide a significant influx of fresh water. When the salinity in the Gulf of Mexico drops, the salt water tends to evacuate from the bays. A reduction in bay salinity is hypothesized to result in different suspended concentrations. Therefore fresh deposit characteristics may change during this time period when compared to data collected at other times during the year. If this is the case, sediment would tend to collect farther down the channel toward Red Fish Reef during this period.

Objective

In 2016, SWG requested the ERDC-CHL to perform hydrodynamic and sediment modeling of proposed modifications along the HSC from its connection to the Gulf of Mexico to the Port of Houston (see Figure 2). The modeling results are necessary to provide data for salinity and sediment transport analysis as well as ship simulation studies in which pilots test the navigational effects of the modifications. The model results of project year zero (2029) and project year 50 (2079) with and without project results will be documented.

Figure 2. Proposed modifications to the HSC (figure from SWG).



Number		Description
1	▶	Bend Easing at HSC Station 138+369
2	▶	Bend Easing at HSC Station 128+731
3	∼	Channel Widening from Bolivar Roads to Redfish Reef
4	▶	Bend Easing at HSC Station 078+844
5	∼	Channel Widening from Redfish Reef to BSC
6	▶	Bend Easing at HSC Station 028+605
7	▶	Bend Easing at the BSC Flare
8	⚓	Mooring Facility at BSC
9	∼	Channel Widening at BSC
10	∼	Channel Widening from BSC to BCC
11	▶	Bend Easing and Turning Basin at BCC Flare
12	∼	Channel Widening at BCC
13	∼	Channel Widening near Hog Island
14	⚓	Mooring Facility near the Battleship Texas HSC Station 520+00
15	∼	Channel Widening from San Jacinto Monument to Boggy Bayou
16	∼	Channel Widening from Boggy Bayou to Greens Bayou
17	○	Turning Basin near HSC Station 775+00
18	○	Turning Basin near Hunting Bayou
19	∼	Segment 4 Channel Deepening
20	∼	Segment 5 Channel Deepening
21	○	Turning Basin near Brady's Island
22	∼	Segment 6 Channel Deepening
23	⚓	Shoaling Attenuation Feature near BSC

Approach

A 3D Adaptive Hydraulics (AdH) model will be developed and validated for simulation of hydrodynamics, salinity, and sediment transport. Previous modeling efforts used the TABS-MDS finite element code. This code is no longer supported by CHL, requiring a new model to be built utilizing the latest technology and updated to represent present conditions. The model will be validated to available field data for all parameters and then utilized to test project alternatives for present and future conditions. For all simulations, the model will be set up to run for 2 years — the first year being a spin-up period to obtain an accurate initial salinity field as well as an accurate sediment bed, and the second year will be used for all analyses.

The model development and boundary condition definitions for the hydrodynamic, salinity, and sediment transport model as well as the model to field data comparisons, including water surface elevation, velocity, salinity, and HSC dredge volumes are documented in a separate report (McAlpin et al. 2019). Chapter 2 focuses on the plan alternatives and simulation periods. Chapter 3 focuses on the comparisons of these modifications to the present condition for hydrodynamics, salinity, and sedimentation. Chapter 4 provides the conclusions of this numerical model study.

2 Plan Alternatives

Documentation of the plan alternatives will include the geometric modifications to the system, defined as *project*, as well as the input conditions for the *present* project year zero (2029) and *future* project year 50 (2079). Therefore, there will be four alternatives — present without project (PWOP), present with project (PWP), future without project (FWOP), and future with project (FWP).

Project modifications

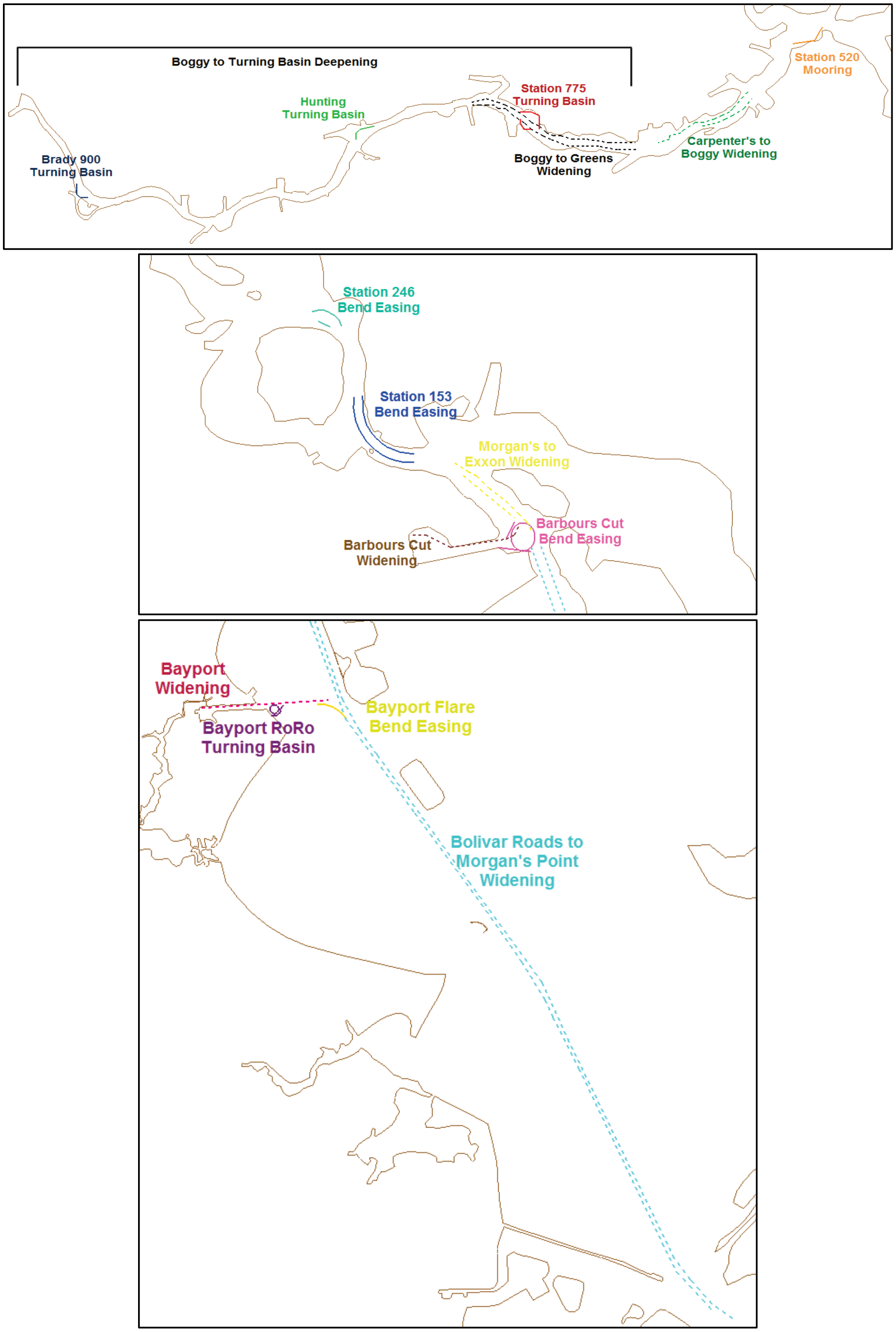
SWG along with the Port of Houston developed several potential channel modification plans. These plans were analyzed for cost/benefit based on labor for dredging, mitigation for habitat adjustment, and other factors. The final tentatively selected plan (TSP) was alternative 8, otherwise known as the *everything plan*. This plan includes widening the bay portion of the HSC to a width between 650 ft to 820 ft, widening and deepening several sections of the bayou portion of the HSC, as well as bend easings, mooring facilities, and turning basins. Figure 2 is a schematic of this alternative.

Details of the TSP, or project, are provided in Table 1 and Figure 3. Deepening segments are not included in Figure 3. All depths given in the table are based on Mean Lower Low Water and include advanced maintenance (AM) and allowable overdepth (AO) where specified. The width of the bay portion of the HSC from Bolivar Roads to Morgan’s Point was modeled at 650 ft as requested by SWG knowing that later ship simulation may require a wider channel dimension.

Table 1. Details of TSP. Dimensions in feet.

HSC Segment	Widening	Deepening	Bend Easing	Mooring Facility	Turning Basin
Bolivar Roads to Red Fish Light 1	650				
Redfish Light 1 to Beacon 76	650				
Beacon 76 to Lower End Morgan's Point Cut	650				
Morgan's Point to Exxon	600		Station 153+06 Station 246+54		
Exxon to Carpenter's Bayou					
Carpenter's Bayou to Boggy Bayou	530			Station 520+00 41.5	
Bayport Ship Channel	455		Flare		RoRo 46.5
Barbours Cut Ship Channel	455		Flare		
Boggy Bayou to Greens Bayou	530	46.5 +2 AM +1 AO			Station 775+00 46.5
Greens Bayou to Sims Bayou[1]		46.5 +2 AM +1 AO			Hunting 46.5
Sims Bayou to I-610 Bridge		41.5 +2 AM +1 AO			
I-610 Bridge to End Main Turning Basin		41.5 +2 AM +1 AO			Brady 900 46.5

Figure 3. TSP location map.



Input conditions

Most USACE design projects require a 50-year project life span; therefore, analysis at some year zero and year 50 are required. This type of analysis requires projecting future inputs to the numerical model. Sea level rise (SLR) curves are available to determine the adjustments necessary for potential changes to the tidal elevation. Predictions of future freshwater inflows are often available and primarily include urban growth projections. However, future wind conditions, sediment loads, and rainfall/evaporation are much more difficult to determine. For this project, the 2010 validation year was determined suitable by SWG as a base or starting point for the year zero (present) and year 50 (future) model inputs. (For details of the 2010 model boundary conditions, see McAlpin et al. [2019]). The tidal water surface elevation, freshwater inputs, and sediment loads (because they are based on the freshwater input) are the only model inputs that will vary from the 2010 base condition. All simulations will be made for a 2-year period with the first year-long simulation serving to generate an accurate initial salinity field and initial sediment bed. Data availability for each input parameter determines if consecutive years of data are used for the 2-year simulations or if a single year of data is repeated.

Given the variability in several input parameters for the present and future conditions, great care should be taken when reviewing the model results. Changes from present to future must be understood with no project in place to understand the project impacts. In other words, comparison of with and without project should be done on the present conditions and the future conditions separately and only mixed when well understood.

Sea level rise (SLR)

The tidal boundary condition at the Gulf of Mexico is based on harmonics and measured data from National Oceanic and Atmospheric Administration gages at Freeport (8772447) and Sabine Pass (8770822), Texas. To account for potential SLR at year zero (2029) and year 50 (2079), guidance defined in USACE EC 1165-2-212, *Sea-Level Change Considerations for Civil Works Programs*, was used (USACE 2011). The 2010 data applied for the model validation were adjusted to 2017 based on the low SLR curve to obtain present conditions. The intermediate SLR projection curve was then applied to the 2017 adjusted elevations. Table 2 provides the elevation shift applied to the 2010 tide elevation for the year

2029 and year 2079 model scenarios. The elevation shift was constant over the length of the model boundary and the time of the model simulation for each year.

Table 2. SLR adjustment for model tidal boundary conditions.

Adjustment Period	SLR Curve	Elevation Shift
2010 to 2017	Low	0.148 ft (0.045 m)
2017 to 2029	Intermediate	0.322 ft (0.098 m)
2017 t0 2079	Intermediate	1.914 ft (0.583 m)

Freshwater inflow

Freshwater inflow into the model domain was applied at the two major rivers — Trinity River and San Jacinto River — and at seven ungaged flow locations. These flow values were obtained from the Texas Water Development Board (TWDB) hydrology model which computes flows for the area from the 1970s to present (Schoenbaechler and Guthrie 2012). SWG determined that years 1985 and 1986 were typical flow conditions for the region and would be a good estimate of future flow patterns. Based on findings by SWG in coordination with TWDB, the freshwater flow into the Trinity and Galveston Bay system will decline by approximately 12% over the 50-year project life. This reduction is primarily due to projections of increased water needs for the surrounding municipalities, meaning that more volume will be diverted for local water supply and less will be available to enter the bay system.

For year 2029 (present) conditions, 2009 (spin-up year) and 2010 (analysis year) inflows are used for all freshwater inflow locations. Figure 4 shows the year 2029 inflows. For year 2079 (future) conditions, 88% of the 1985 (spin-up year) and 1986 (analysis year) freshwater inflows are used for the Trinity River and San Jacinto River, and 88% of the 2009 and 2010 inflows are used at the ungaged locations. Figure 5 shows the 2079 inflows.

Figure 4. Year 2029 (present) freshwater inflows.

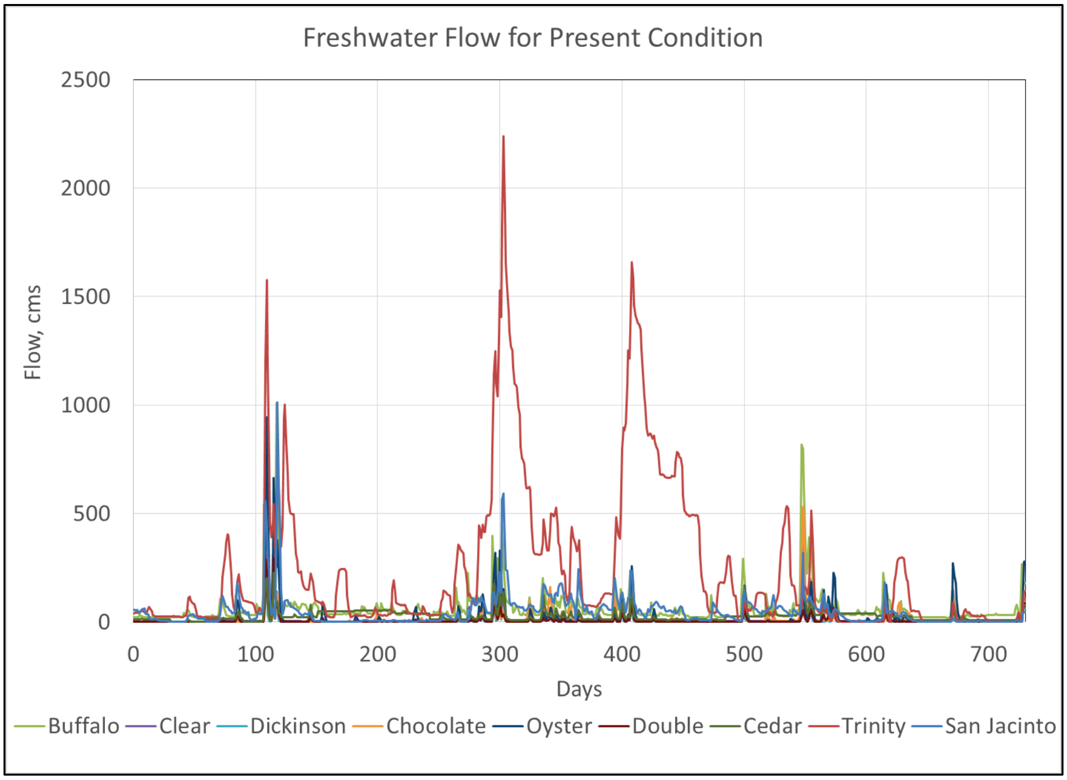
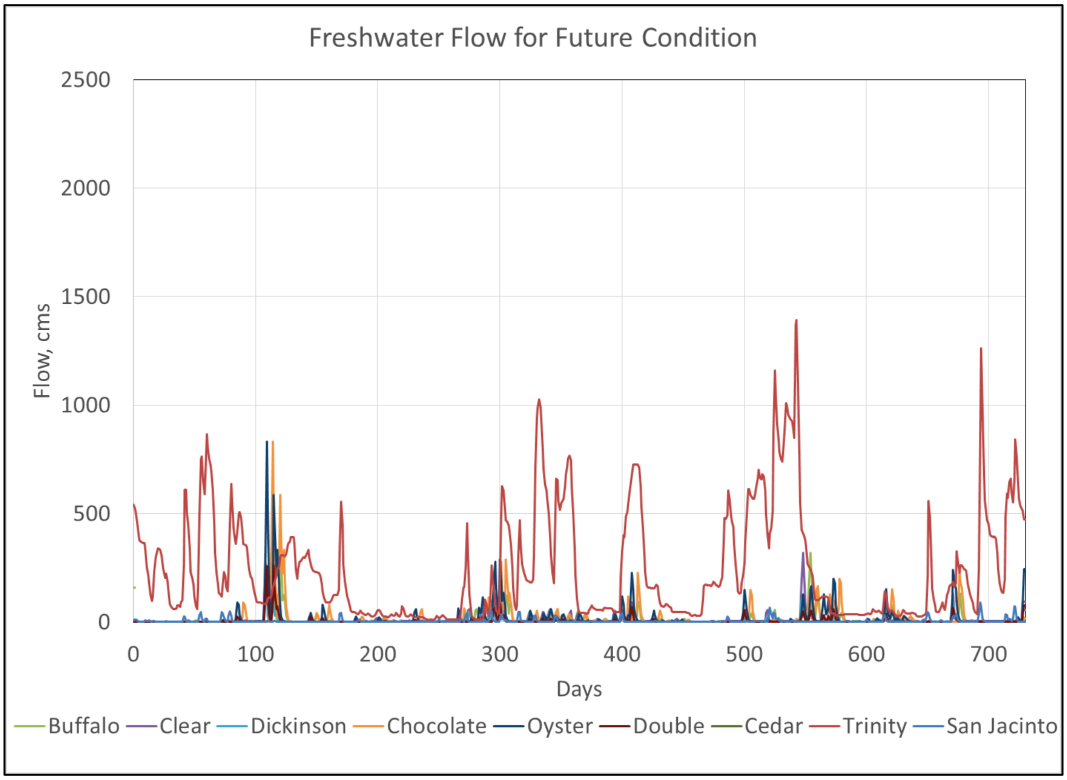


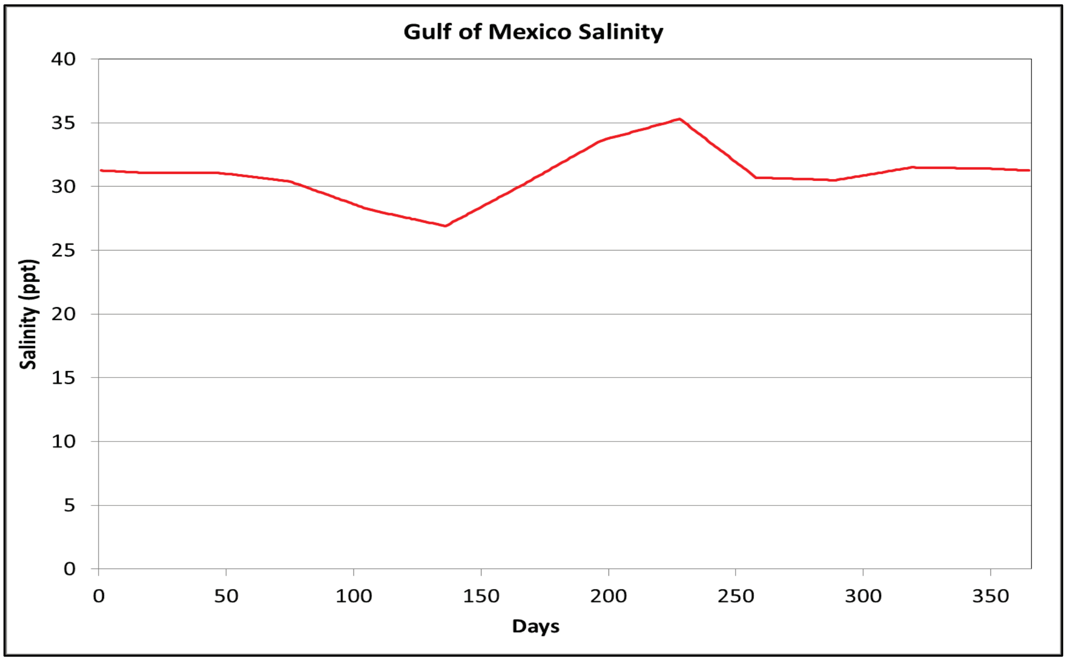
Figure 5. Year 2079 (future) freshwater inflows.



Salinity

The salinity input at the model's ocean boundary is unchanged from the model validation and shown in Figure 6 (McAlpin et al. 2019). The time-varying boundary condition is based on monthly averages over a 15-year period. The single year of data was repeated such that the same input was applied for the spin-up year and the analysis year.

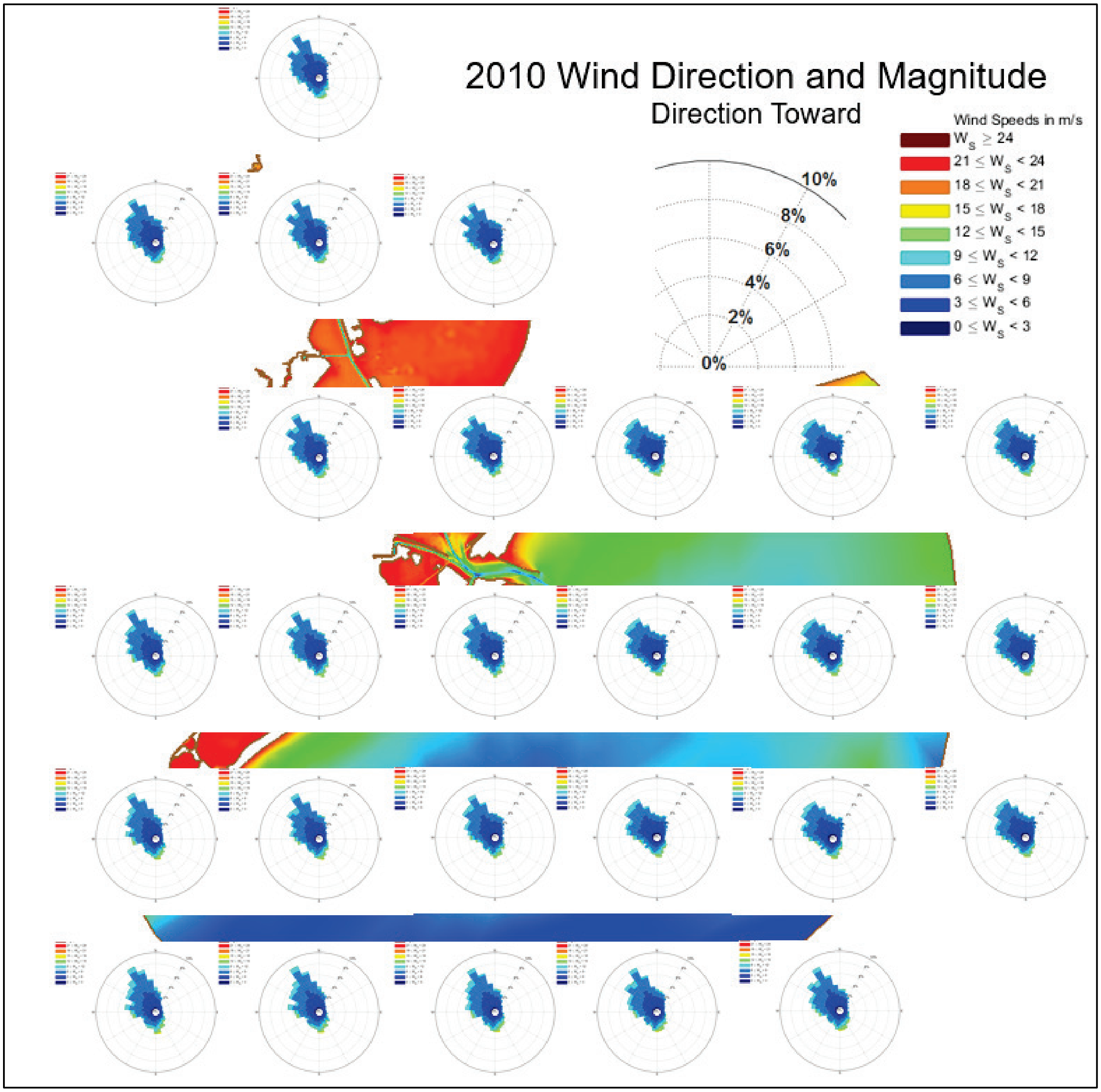
Figure 6. Salinity boundary condition for present and future conditions.



Wind

The 2010 wind data set was obtained from the Wave Information Studies computed wind field at 26 points in the vicinity of the model domain. This data set was maintained from the model validation (McAlpin and Ross et al. 2019). This wind data set was unchanged and repeated for the spin up and analysis years for both the present and future conditions. Figure 7 shows the 2010 wind rose for the 26 computed wind series locations.

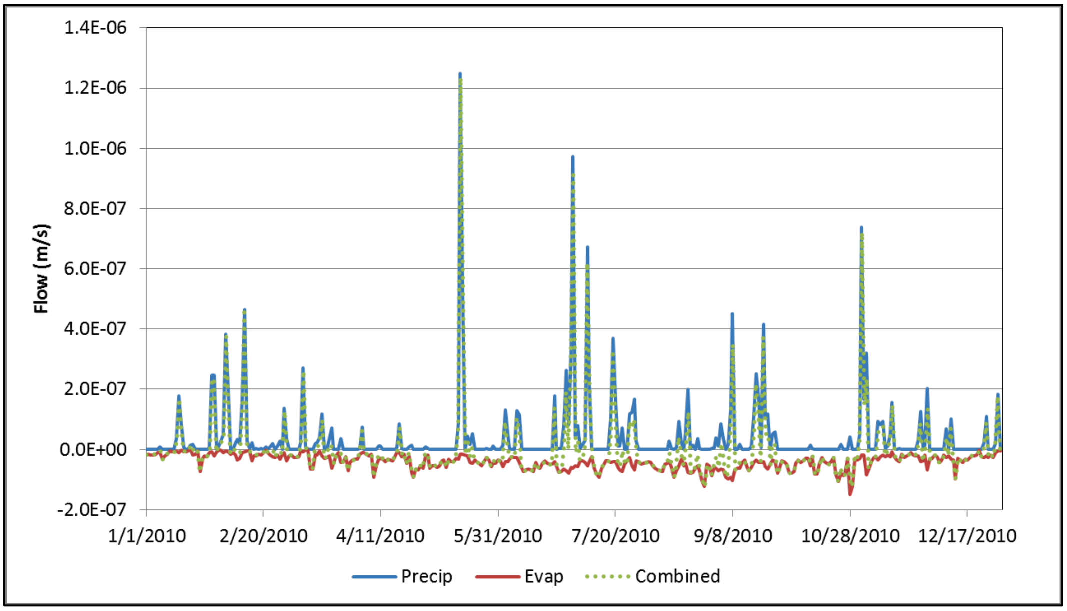
Figure 7. 2010 wind rose at all sites for 2029 (present) and 2079 (future) alternatives.



Meteorological conditions

Precipitation and evaporation were included in the alternative conditions as in the model validation (McAlpin et al. 2019). The 2010 data from the TWDB were applied equally over the model domain. The data were unchanged and repeated for the spin-up and analysis years for the present and future conditions. Figure 8 shows the time series of the meteorological data.

Figure 8. 2010 meteorological conditions for 2029 (present) and 2079 (future) alternatives.



Sediment

The sediment grain and bed parameters are maintained from the validation effort (McAlpin et al. 2019). The loads are applied to the two major rivers in the same manner as in the model validation — by applying a rating curve that correlates river discharge with the total concentration.

Figure 9 shows the 2029 sediment loads, which are based on 2009 and 2010 inflow data. Figure 10 shows the 2079 loads, which are based on the reduced 1985 and 1986 inflow data. These total loads are divided equally among the five simulated grain classes when applied in the model. No sediment is applied at the ungaged inflow locations, as done in the model validation.

The model validation (McAlpin et al. 2019) details sediment loads that are not included in this model. These include unaccounted sediment loads from the ungaged freshwater inflows, from wind-generated wave erosion along the shallows, and from vessel-induced erosion in the bays. A historical scaling method for each channel segment was determined to be the best option to account for the combined effect of the various unknown loads.

Figure 9. Year 2029 (present) total sediment load.

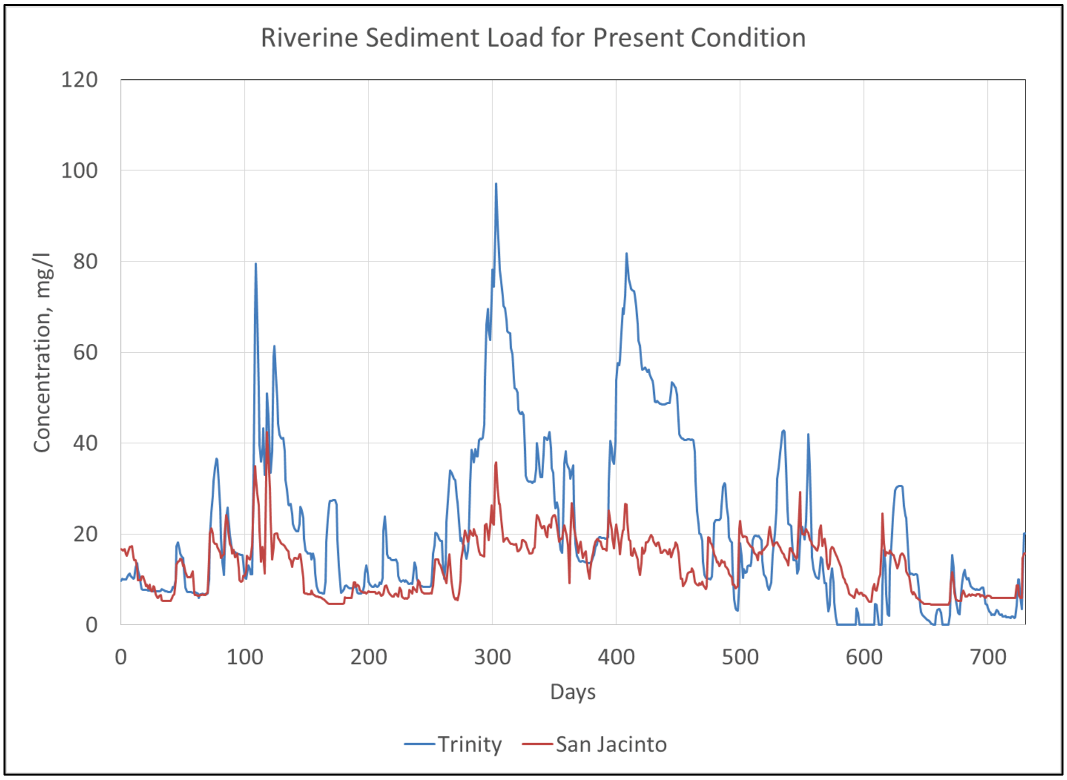
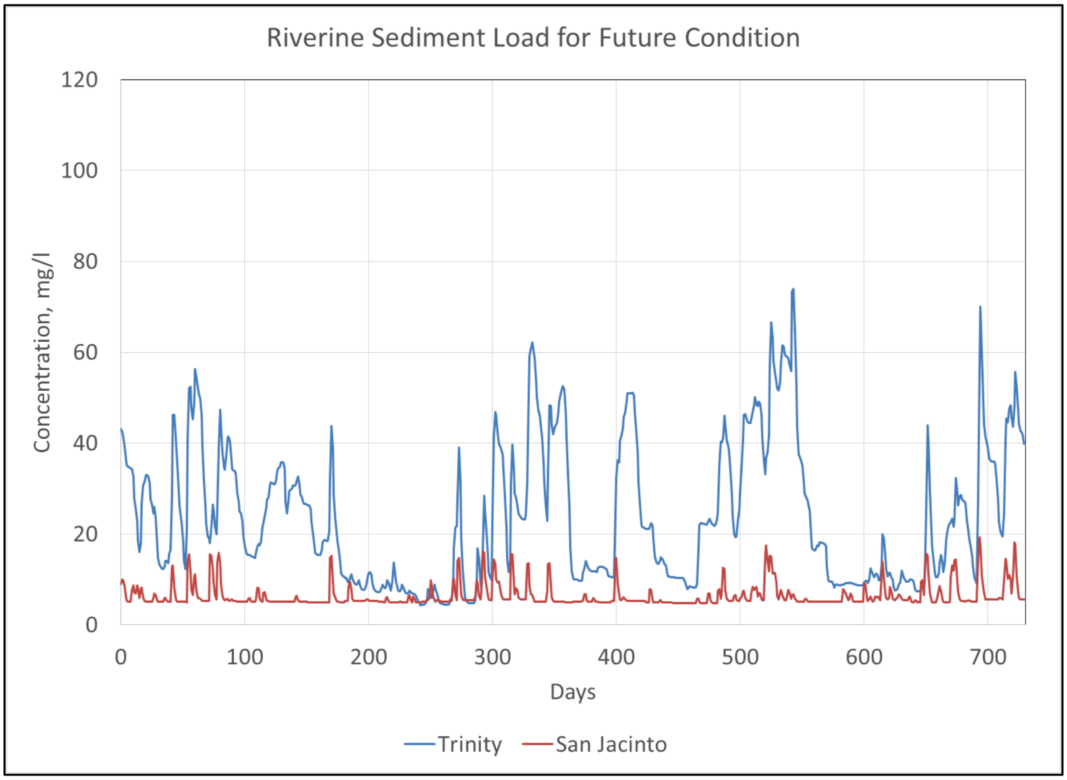


Figure 10. Year 2079 (future) total sediment load.



3 Model Results and Discussion

The four alternatives —PWOP, PWP, FWOP, and FWP — were simulated using 3D AdH as stated in the previous chapters. Present is year 2029 and future is 2079 assuming a 50-year project lifespan. The results will include changes in salinity and velocity throughout the model domain under the various alternative conditions. Additionally, changes to the shoaling in the HSC and sedimentation patterns in the surrounding bays will be observed.

Comparison of with and without project should be done on the present conditions and the future conditions separately to isolate impacts due to the project alone. Given the variability in several input parameters for the present and future conditions, it is not recommended to compare present and future results directly unless careful consideration is given to understanding the difference in the present and future input parameters.

Salinity

Salinity point analysis

Several locations were identified for specific analysis such as time history, percent-less-than, and maximum/minimum/average computations of salinity. These locations are shown in Figure 11 and labeled in Table 3. A subset of these locations, circled in red in Figure 11 and the shaded rows in Table 3, will be included and discussed in the text. All analysis plots and images will be included in the appendix.

Figure 11. Point analysis locations. Circled locations discussed in this section.

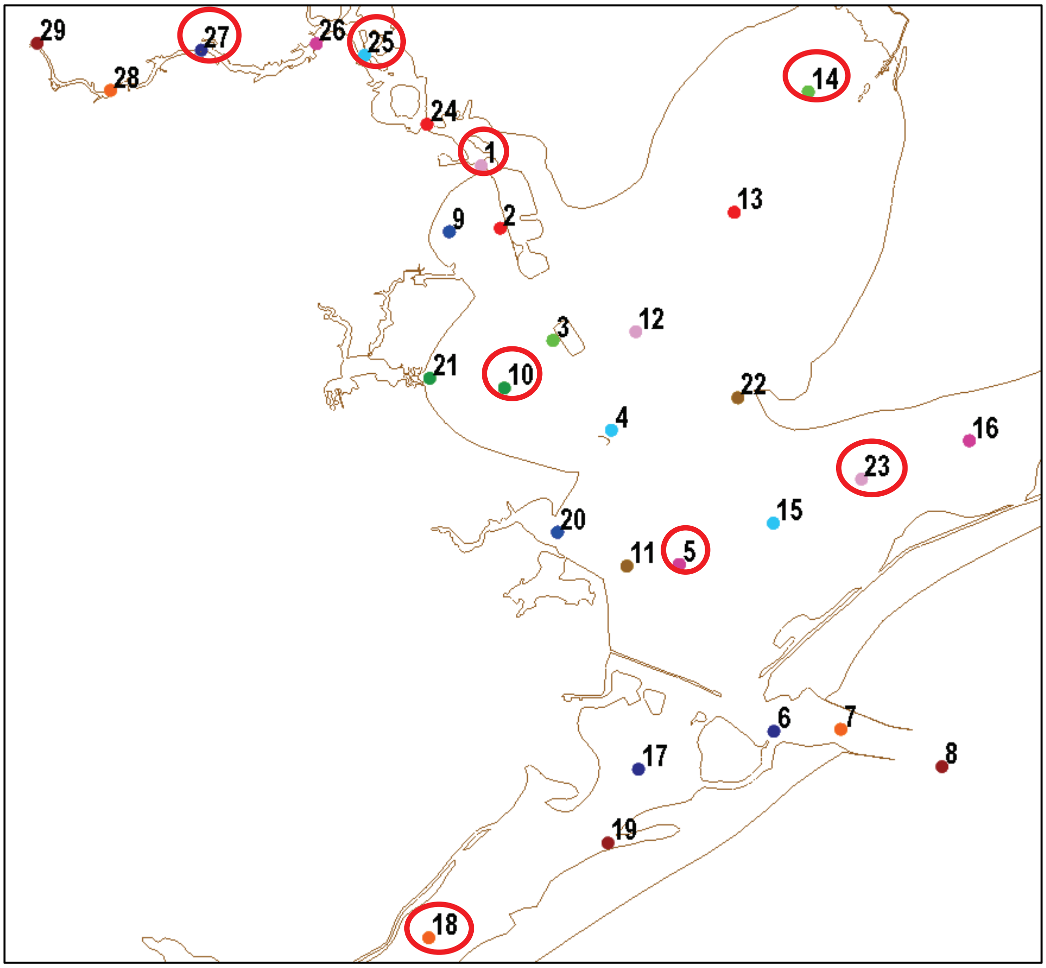


Table 3. Point analysis location names. Highlighted locations discussed in this section.

Point #	Name	Point #	Name
1	HSC at Morgan's Point	16	Eastern East Bay
2	HSC at Atkinson Island	17	Eastern West Bay
3	HSC at Mid Bay Marsh	18	Mid West Bay
4	HSC at Red Fish Reef	19	Offatts Bayou
5	HSC at Lower Galveston Bay	20	Dickinson
6	HSC at Bolivar Roads	21	Clear Creek
7	HSC at Entrance	22	Smith Point
8	HSC at Gulf	23	Mid East Bay
9	Upper Galveston Bay 1	24	HSC at Fred Hartman Bridge
10	Upper Galveston Bay 2	25	HSC at Goat Island

Point #	Name
11	Lower Galveston Bay
12	Lower Trinity Bay
13	Mid Trinity Bay
14	Upper Trinity Bay
15	Western East Bay
26	HSC at Carpenters Bayou
27	HSC at Greens Bayou
28	HSC at Sims Bayou
29	HSC at Turning Basin

Time history of salinity is shown for several points within the HSC and several in the bays. Also provided are plots showing the maximum, average, and minimum salinity at each location for the year-long analysis period. The salinity shown in the plots is bottom values, which will be larger than or equal in magnitude to the surface values due to the density stratification of salt water. For all plots of salinity, PWP is blue, PWOP is red, FWP is yellow, and FWOP is purple.

Additionally, percent-less-than plots are provided to show how the bottom salinity varies over the analysis period. The maximum salinity value is given at 100% and the minimum value at 0%. The 50% salinity value indicates that the salinity is less than this value for 50% of the analysis time and greater than this value for 50% of the time.

Vertical salinity profiles are also included for all of the salinity analysis points.

To isolate impacts due to the project, when viewing these results, focus on changes between the present with and without project separately from the future with and without project. The future conditions have changes in the input conditions that make comparisons between present and future results harder to interpret.

Figures 12 – 43 show the point salinity analysis at the eight selected locations. The results for all 29 locations are provided in the appendix.

The variation in salinity between present and future conditions is significant as expected. The rise in water surface elevation due to sea level changes as well as a reduction in freshwater inflow for future conditions generates very different salinity magnitudes throughout the analysis year. In most locations the mean salinity is larger for the future conditions. However, the variation in salinity between with and without project alternatives is quite small for most locations — generally less than 2 parts per thousand (ppt). The largest variation in salinity between with and without project results is in the upstream locations of the HSC. The salinities are almost identical near the entrance but begin to diverge farther into the system at Mid Bay Marsh, Morgan's Point, and locations farther up the HSC. However, the change in the mean salinity between with and without project remains within 2 ppt. This behavior is visible in the point analysis as well as in the cross-sectional analysis to be discussed in the next section. The time history of salinity includes dotted lines for 10 ppt and 15 ppt thresholds. The with project conditions generally maintain the pattern of the salinity over time but do increase above these thresholds for short periods of time at some locations.

Point salinity analysis

Figure 12. Salinity time history at HSC at Greens Bayou.

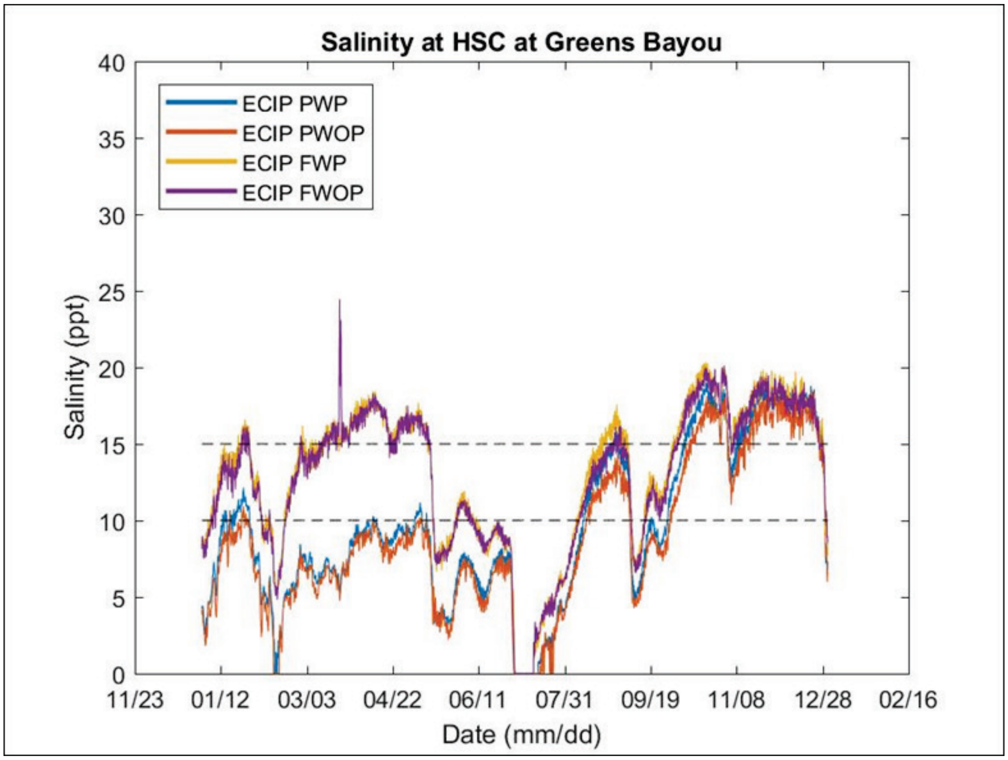


Figure 13. Maximum, minimum, and mean salinity at HSC at Greens Bayou.

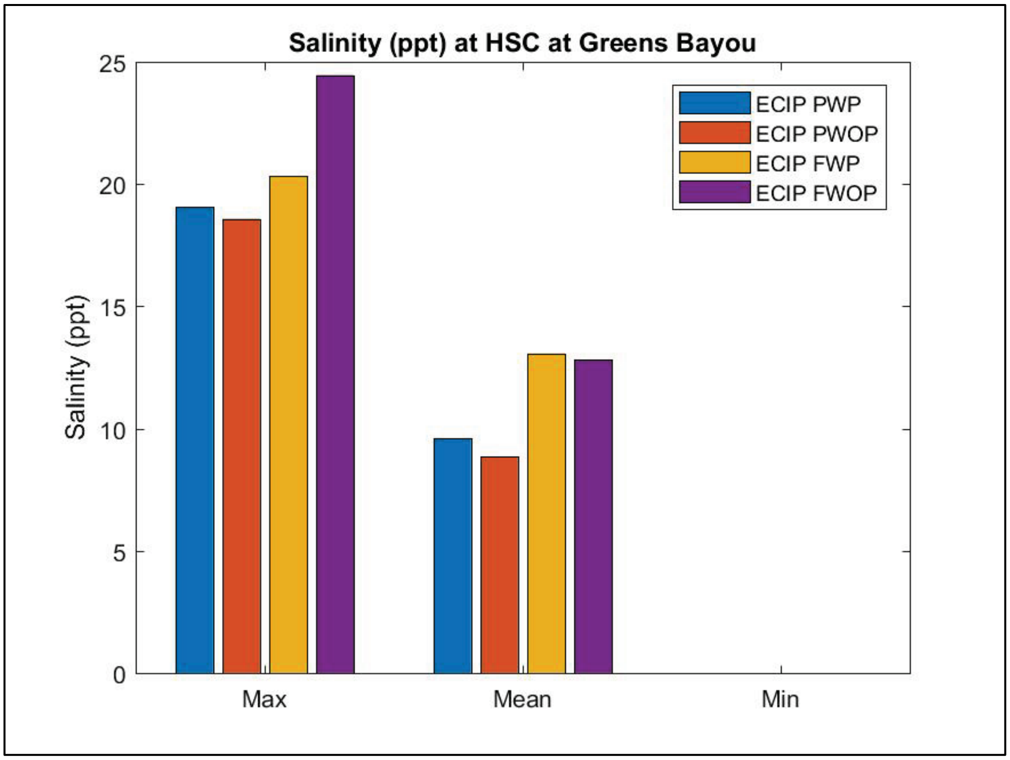


Figure 14. Percent-less-than salinity at HSC at Greens Bayou.

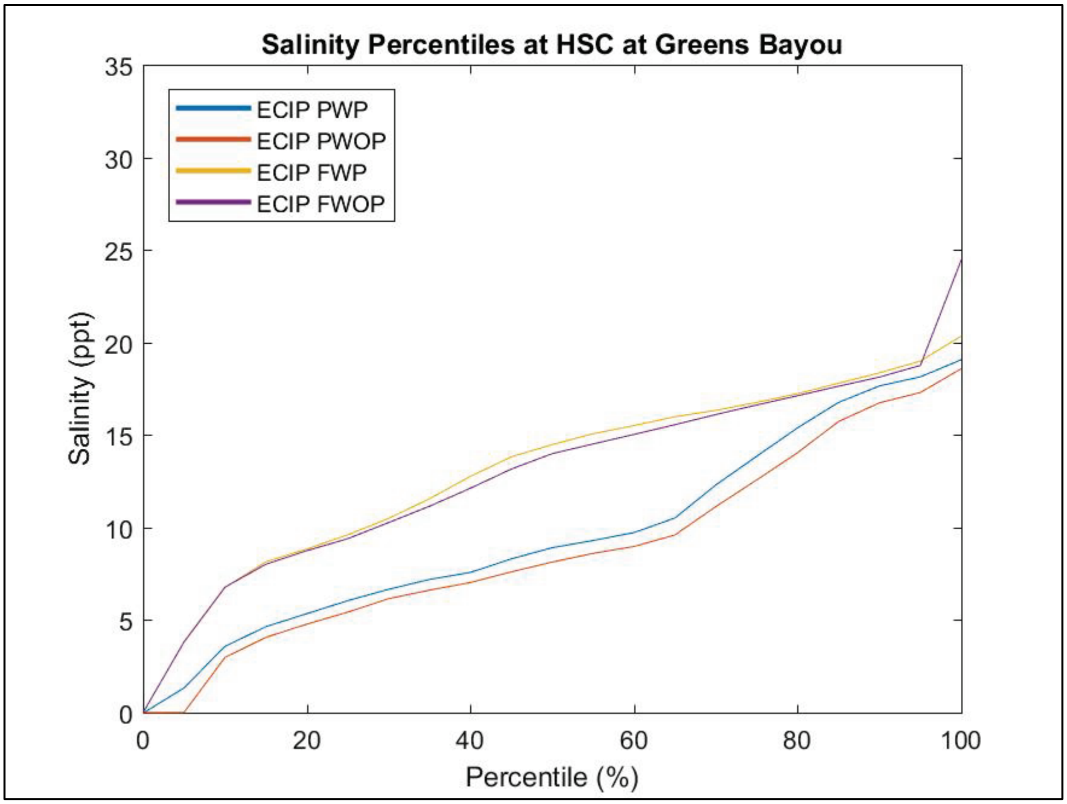


Figure 15. Vertical salinity profile at HSC at Greens Bayou.

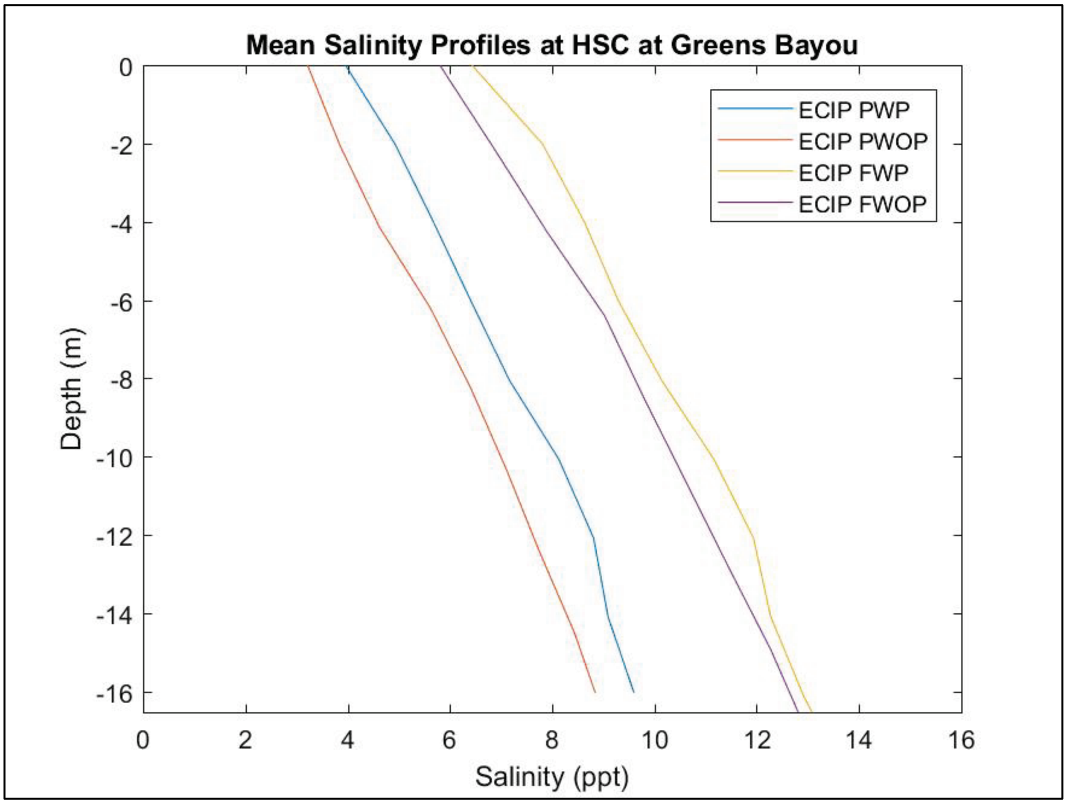


Figure 16. Salinity time history at HSC at Goat Island.

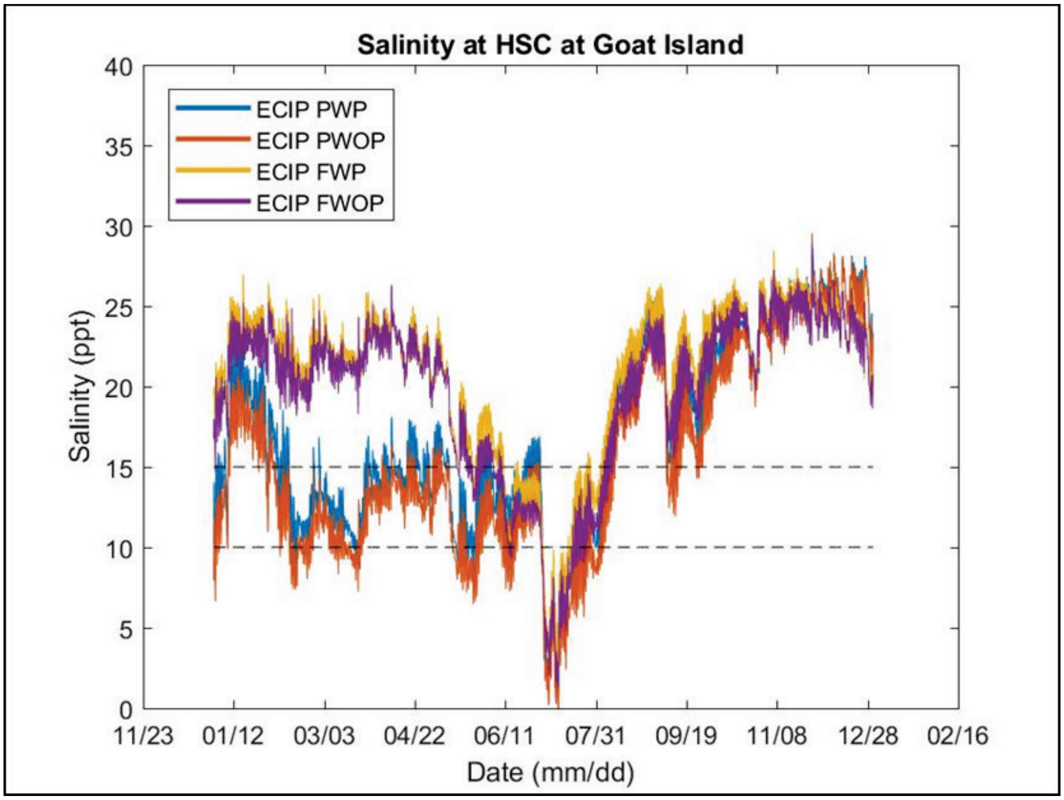


Figure 17. Maximum, minimum, and mean salinity at HSC at Goat Island.

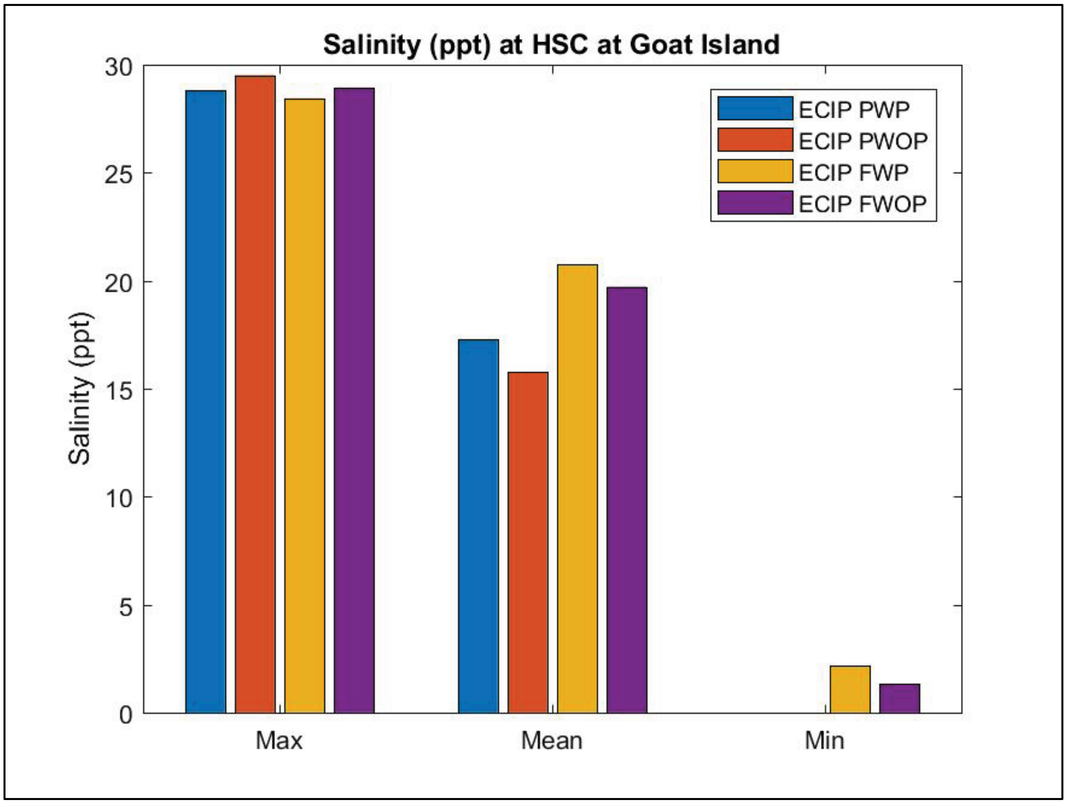


Figure 18. Percent-less-than salinity at HSC at Goat Island.

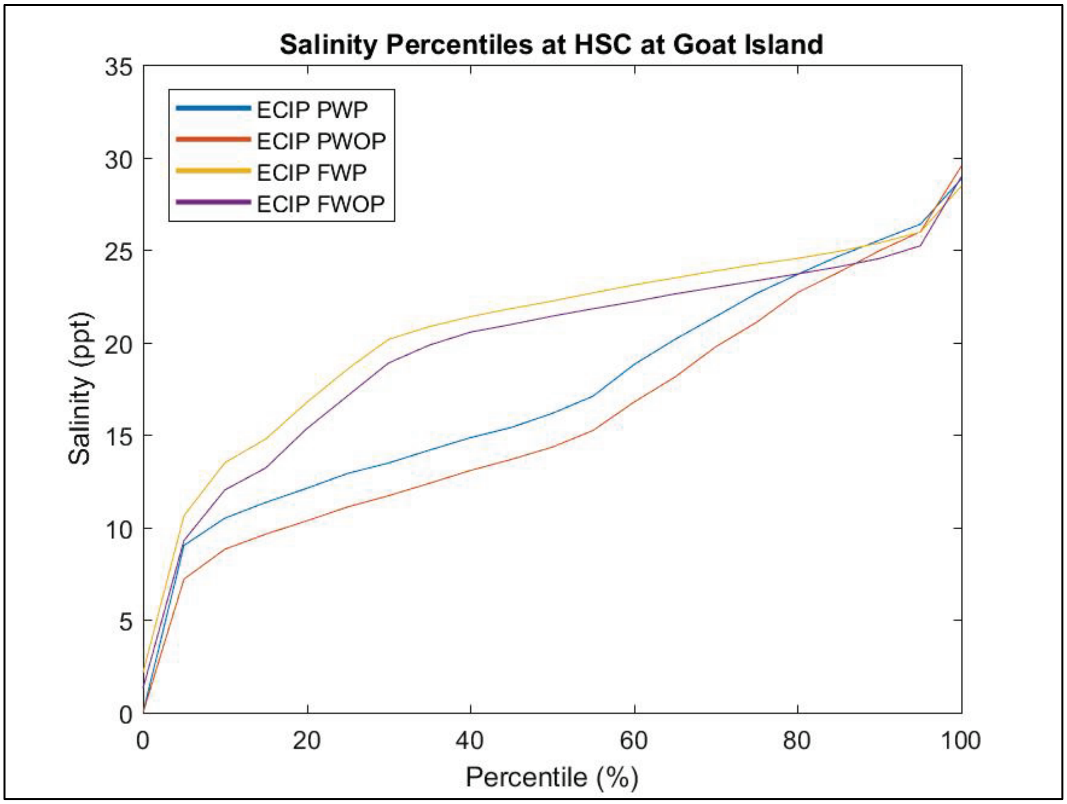


Figure 19. Vertical salinity profile at HSC at Goat Island.

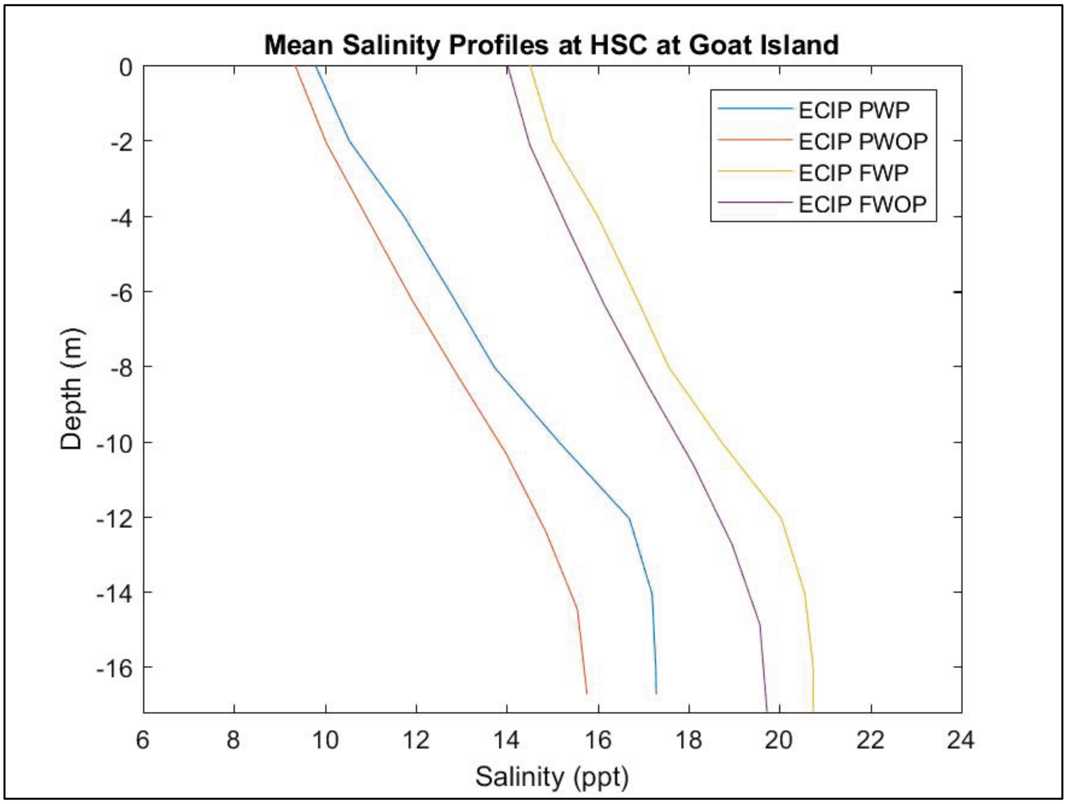


Figure 20. Salinity time history at HSC at Morgan's Point.

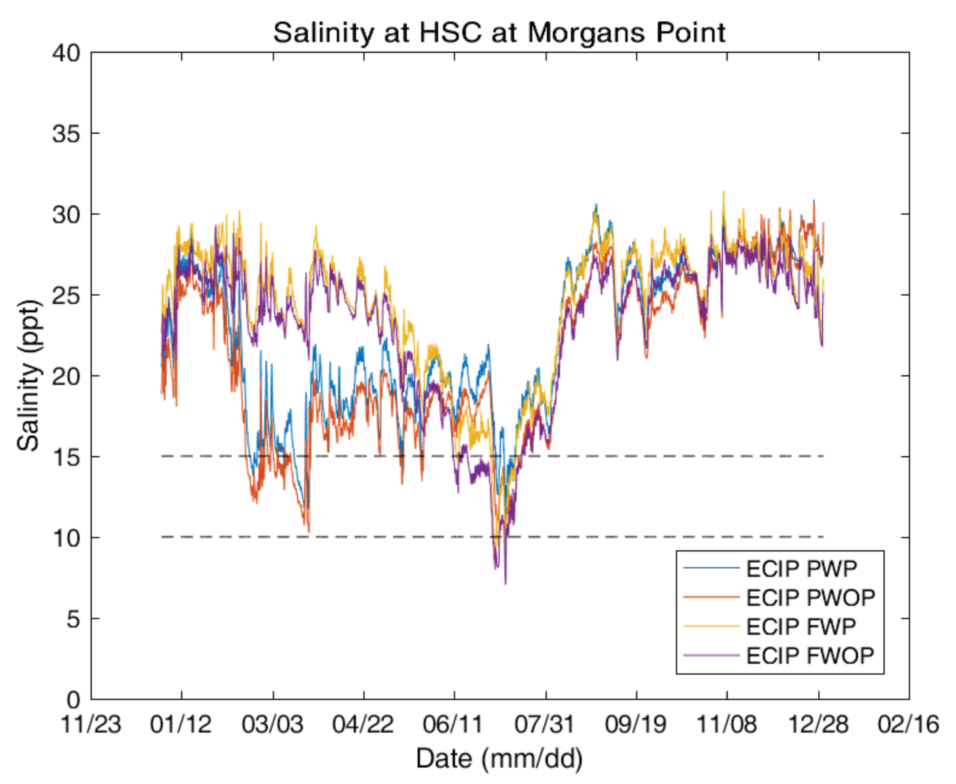


Figure 21. Maximum, minimum, and mean salinity at HSC at Morgan's Point.

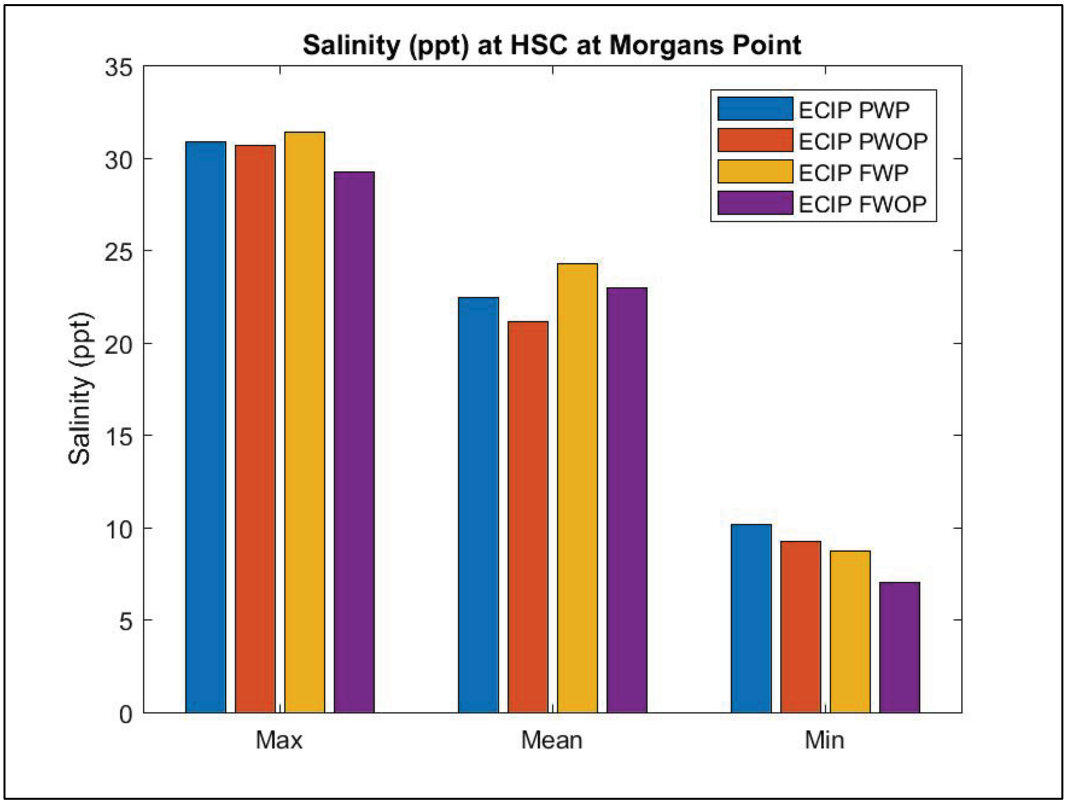


Figure 22. Percent-less-than salinity at HSC at Morgan's Point.

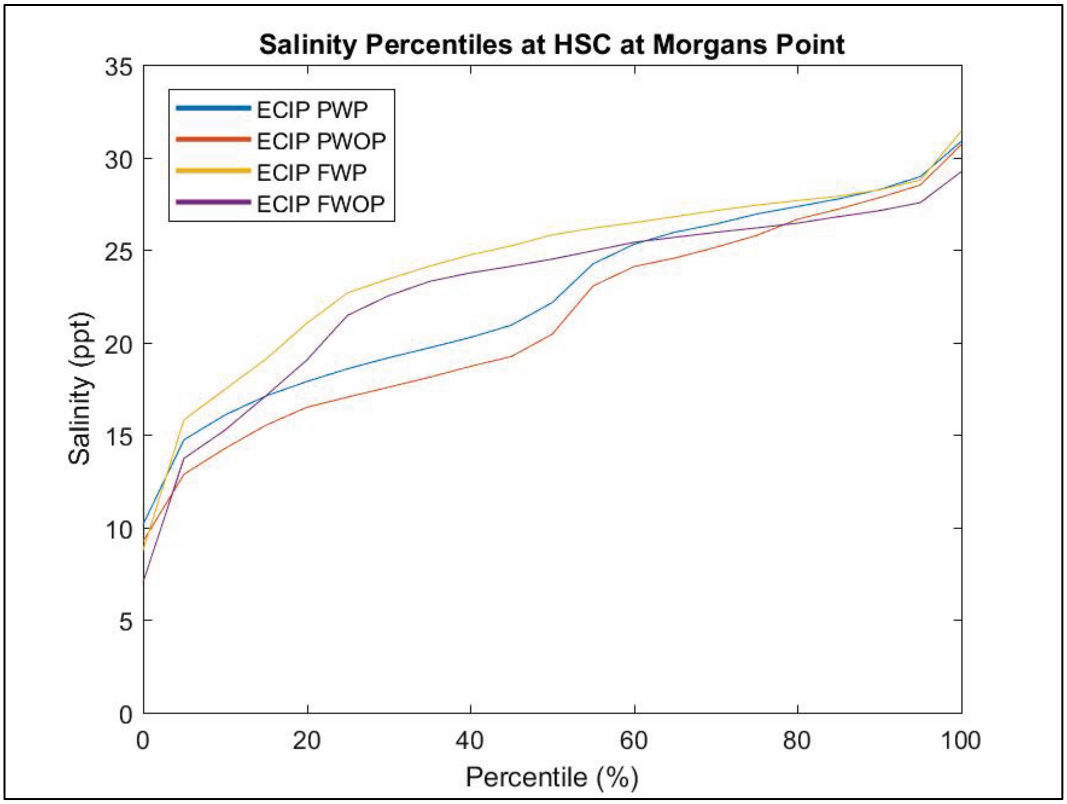


Figure 23. Vertical salinity profile at HSC at Morgan's Point.

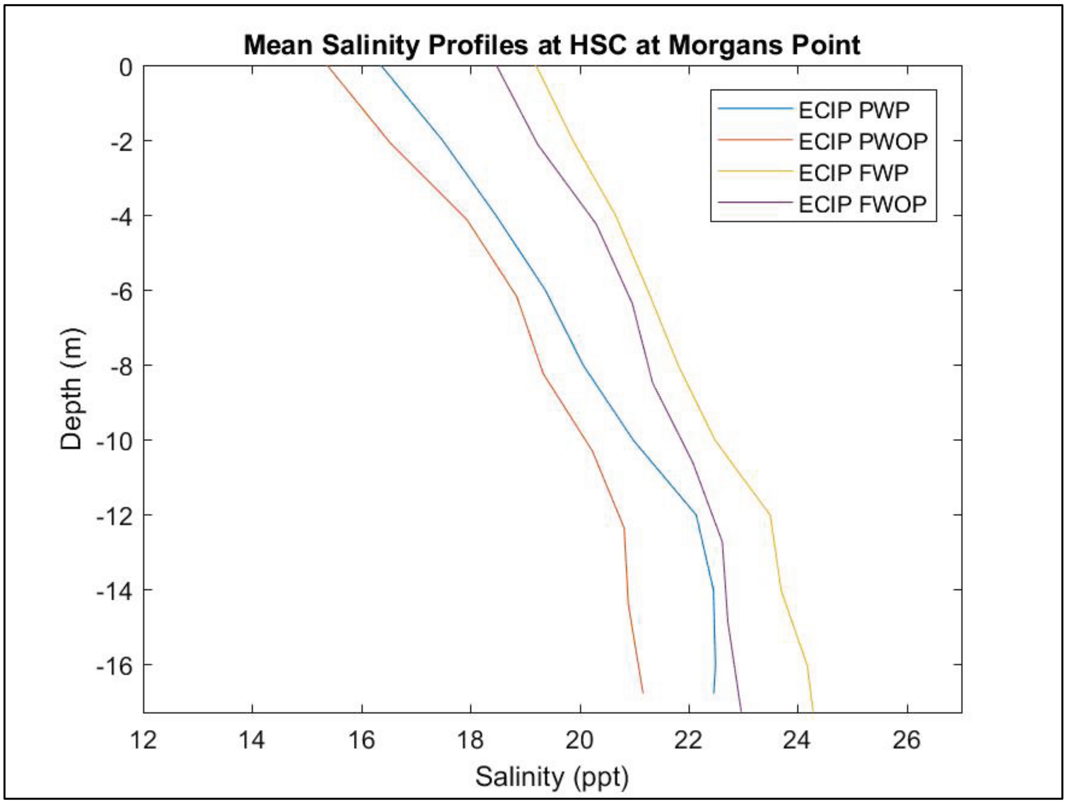


Figure 24. Salinity time history at HSC at Lower Galveston Bay.

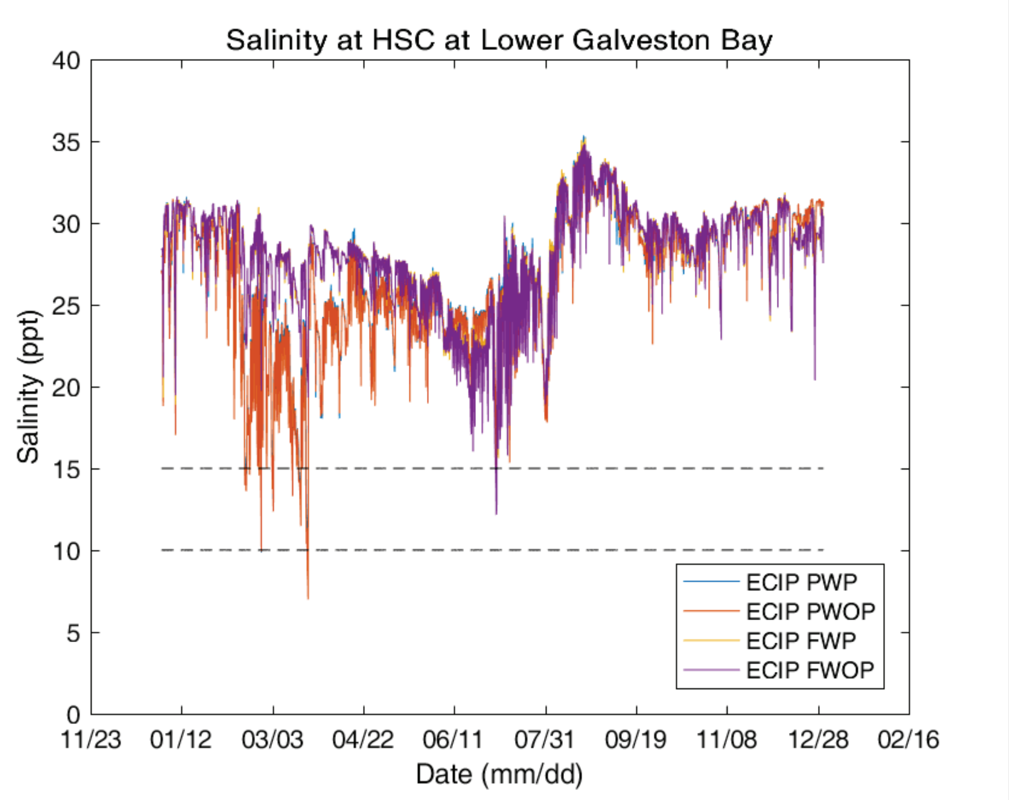


Figure 25. Maximum, minimum, and mean salinity at HSC at Lower Galveston Bay.

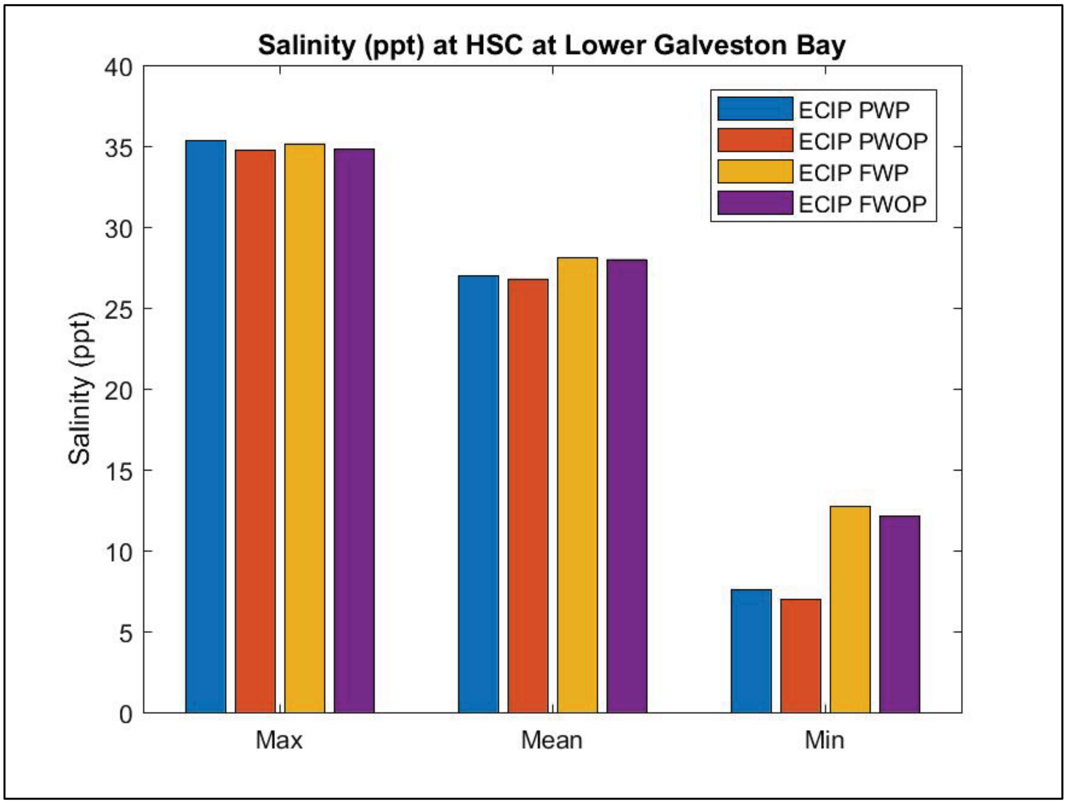


Figure 26. Percent-less-than salinity at HSC at Lower Galveston Bay.

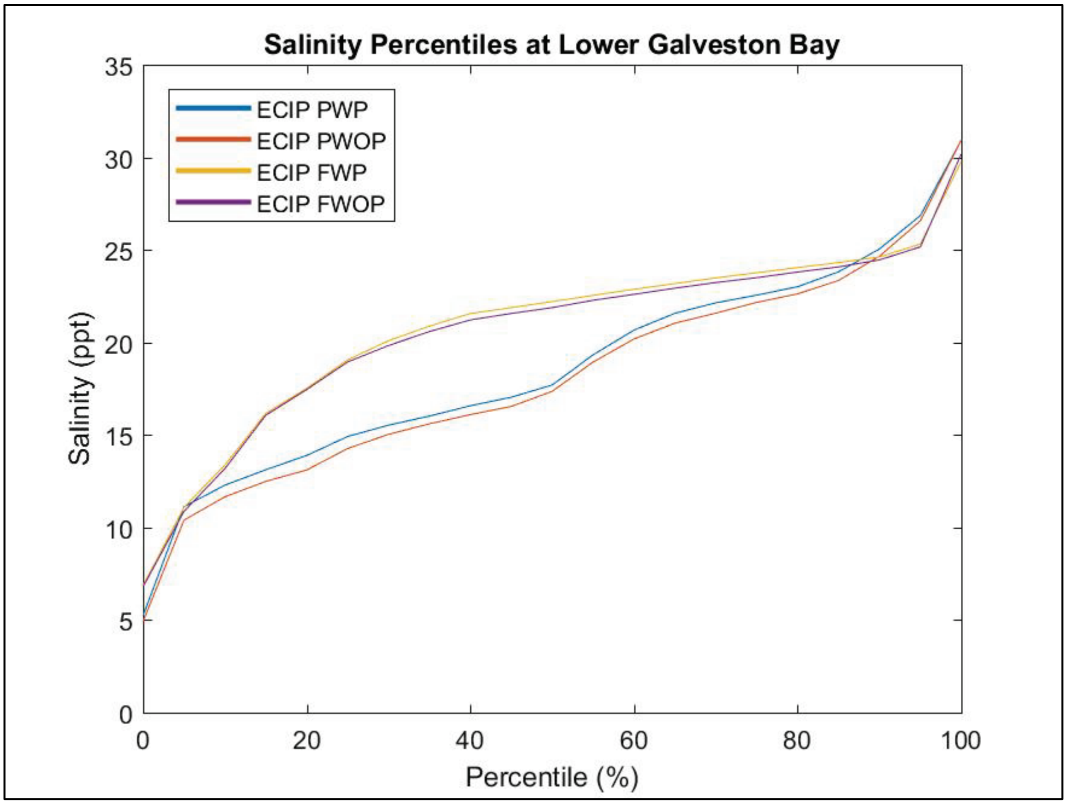


Figure 27. Vertical salinity profile at HSC at Lower Galveston Bay.

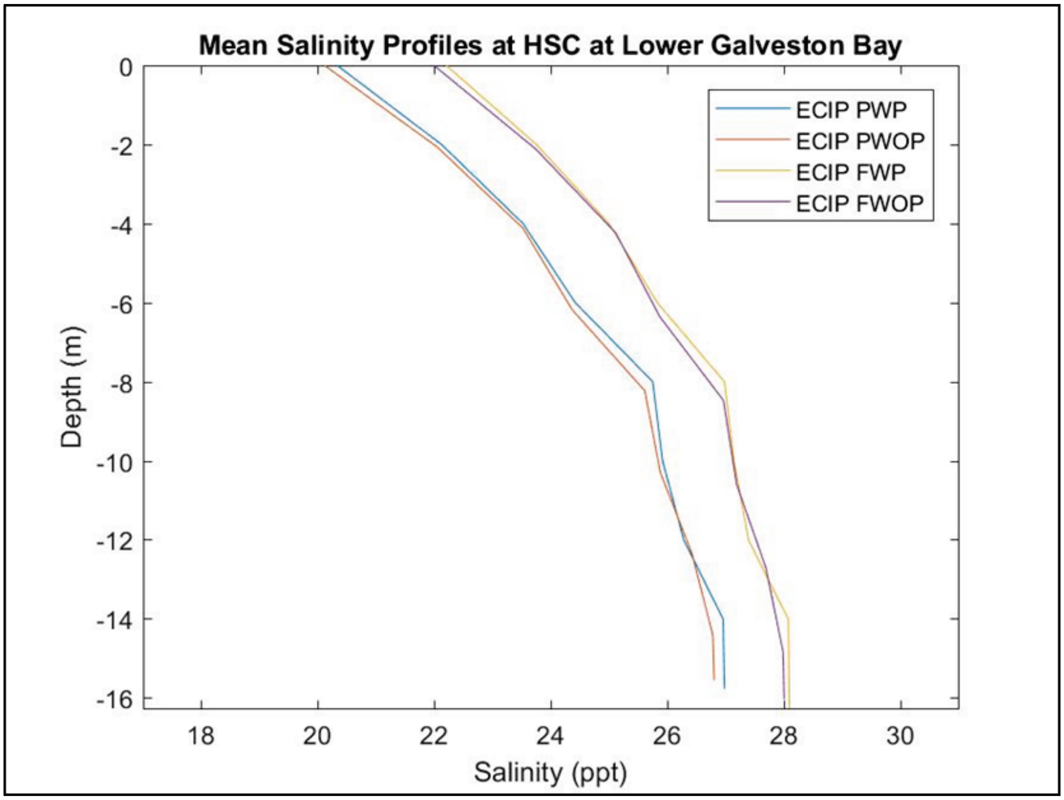


Figure 28. Salinity time history at Upper Galveston Bay 2.

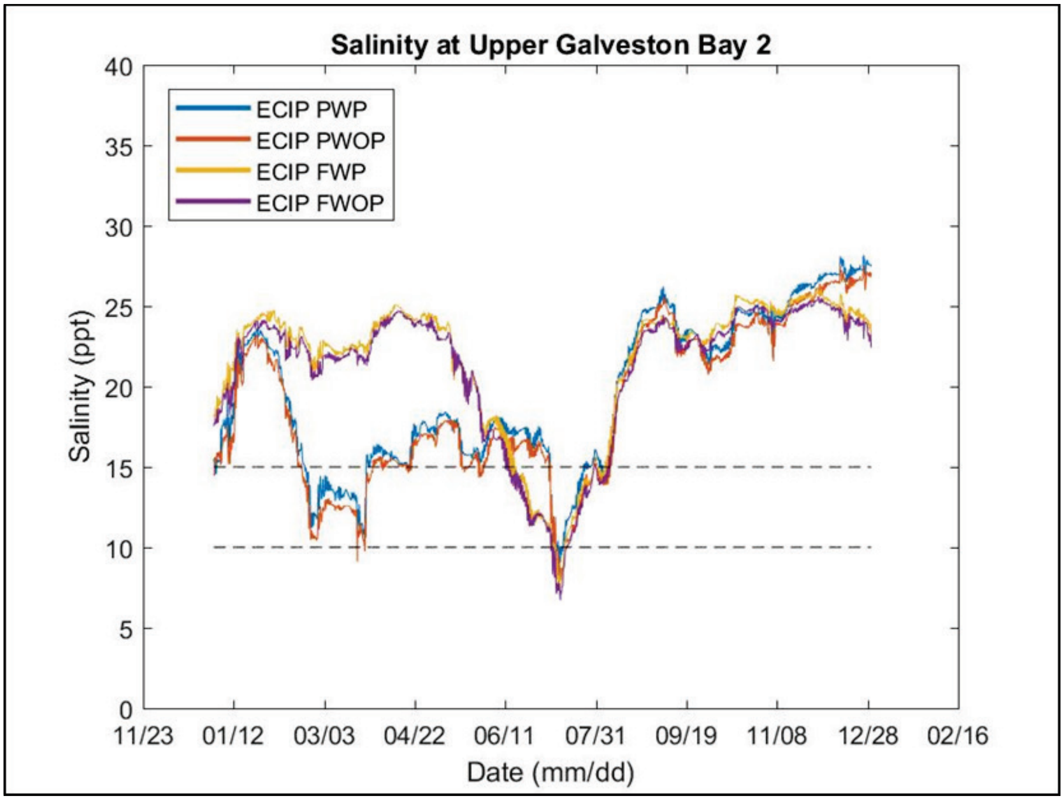


Figure 29. Maximum, minimum, and mean salinity at Upper Galveston Bay 2.

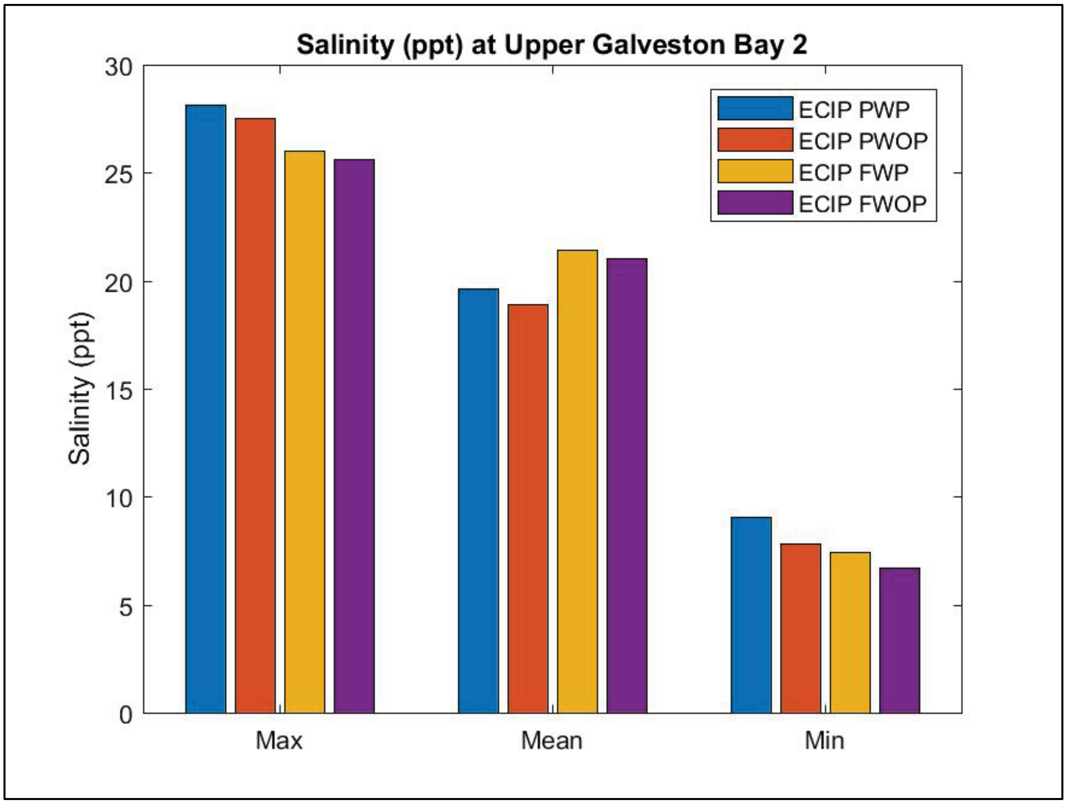


Figure 30. Percent-less-than salinity at Upper Galveston Bay 2.

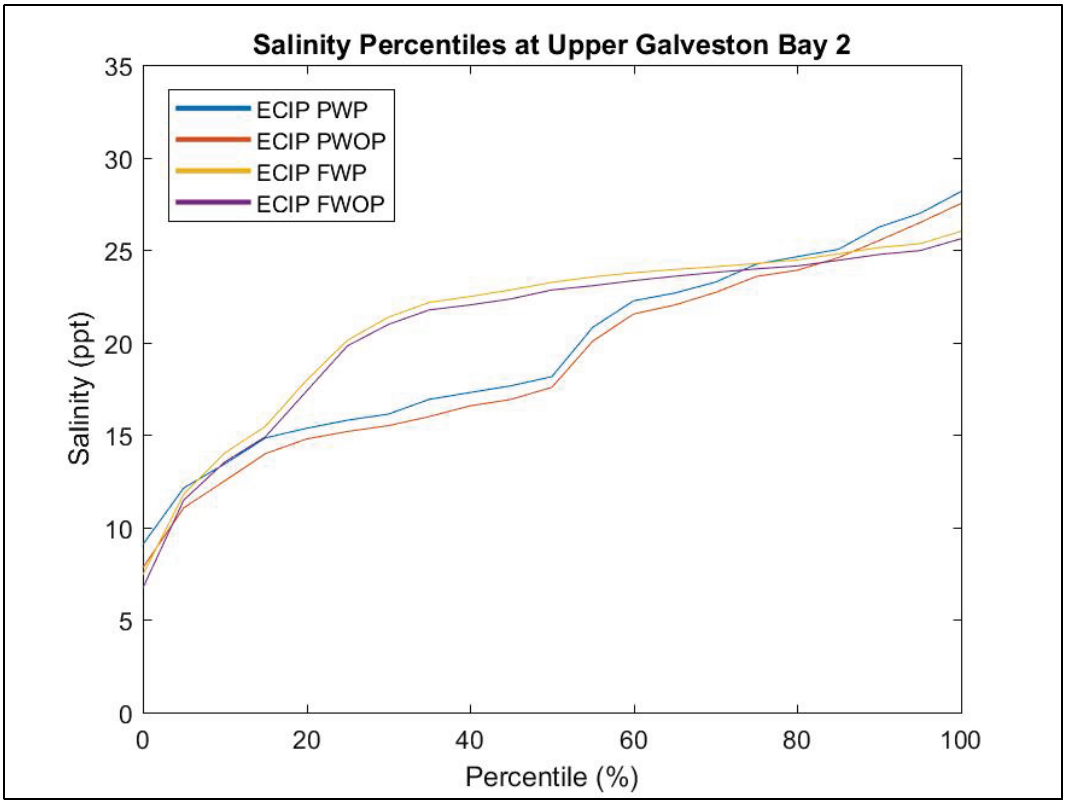


Figure 31. Vertical salinity profile at Upper Galveston Bay 2.

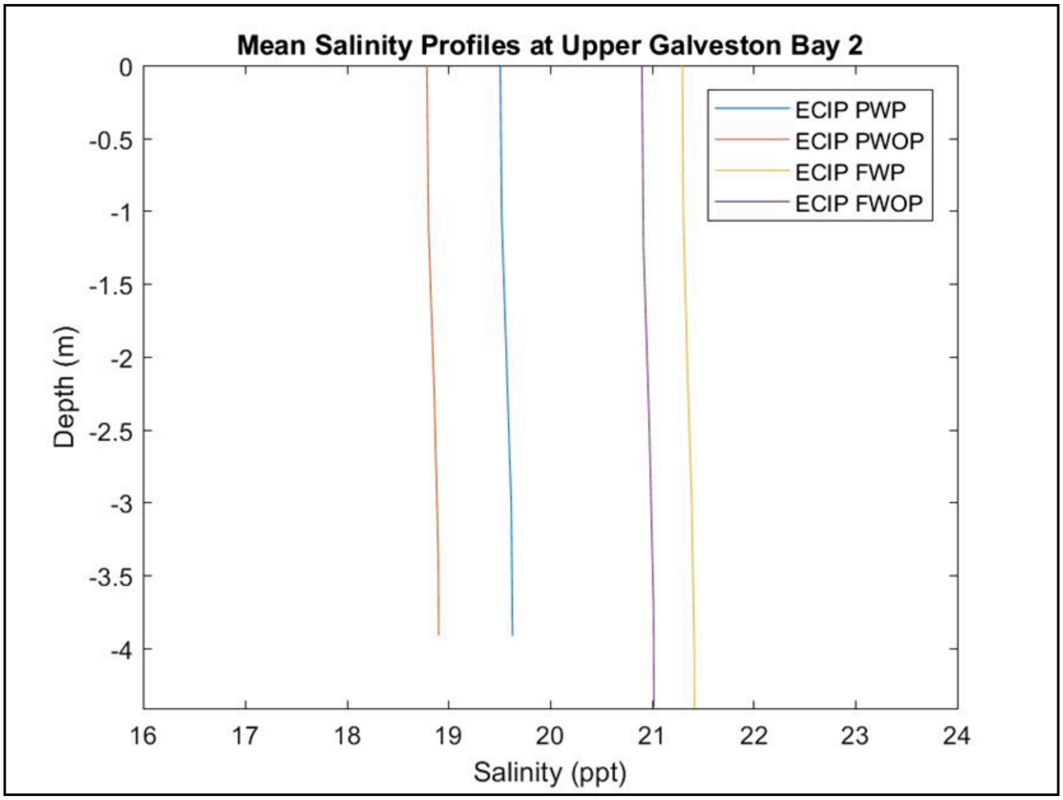


Figure 32. Salinity time history at Upper Trinity Bay.

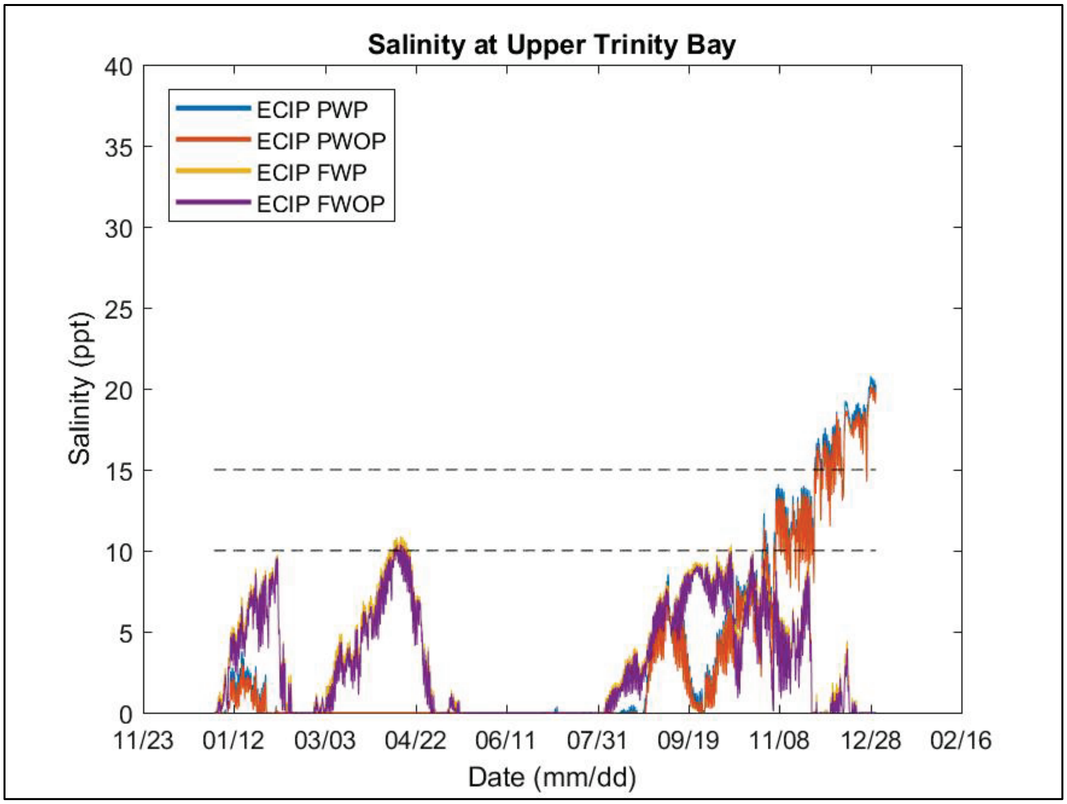


Figure 33. Maximum, minimum, and mean salinity at Upper Trinity Bay.

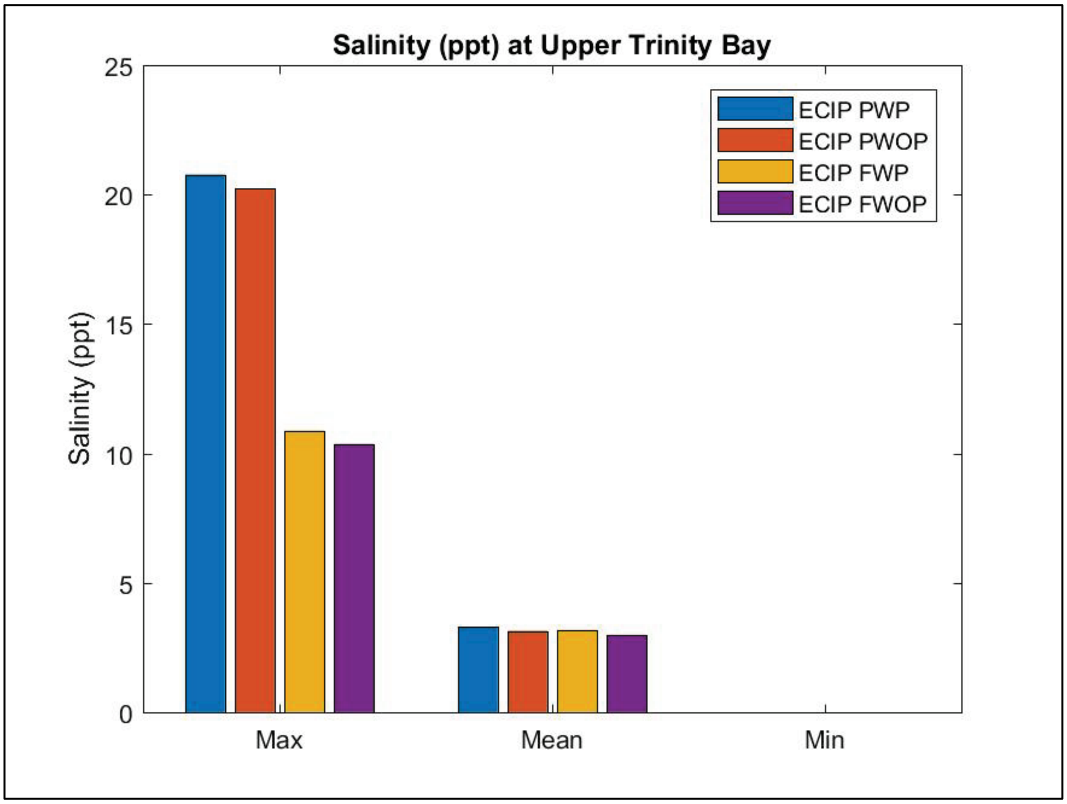


Figure 34. Percent-less-than salinity at Upper Trinity Bay.

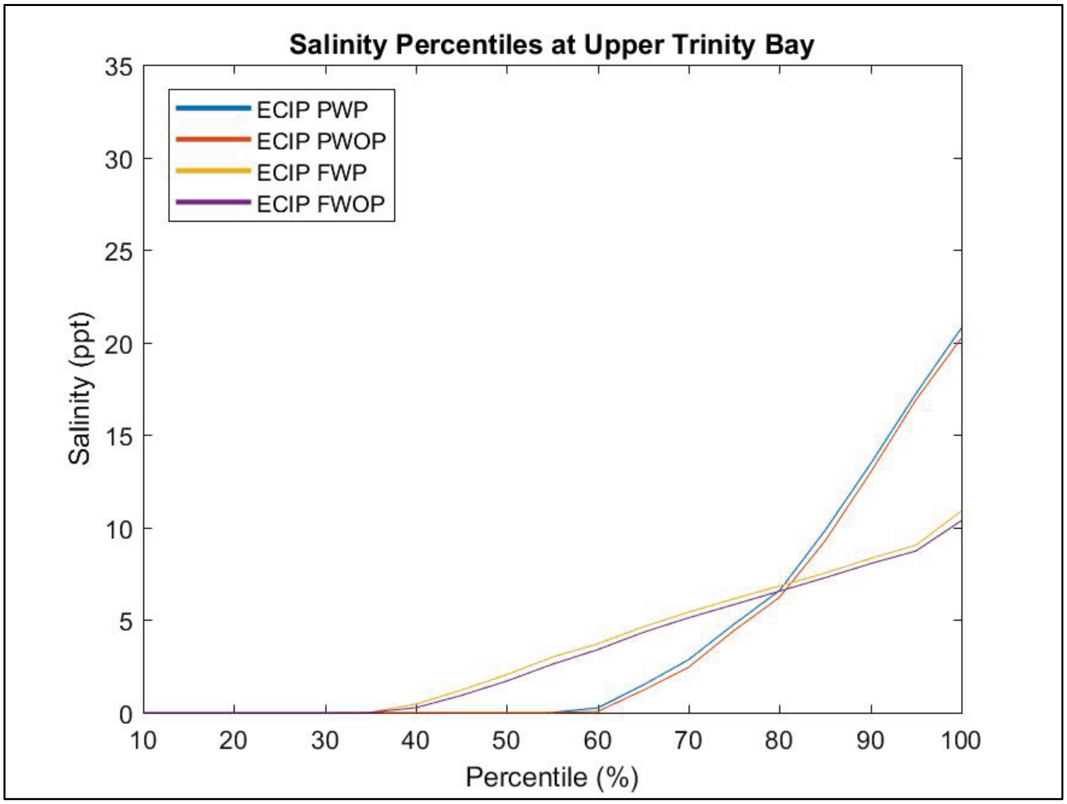


Figure 35. Vertical salinity profile at Upper Trinity Bay.

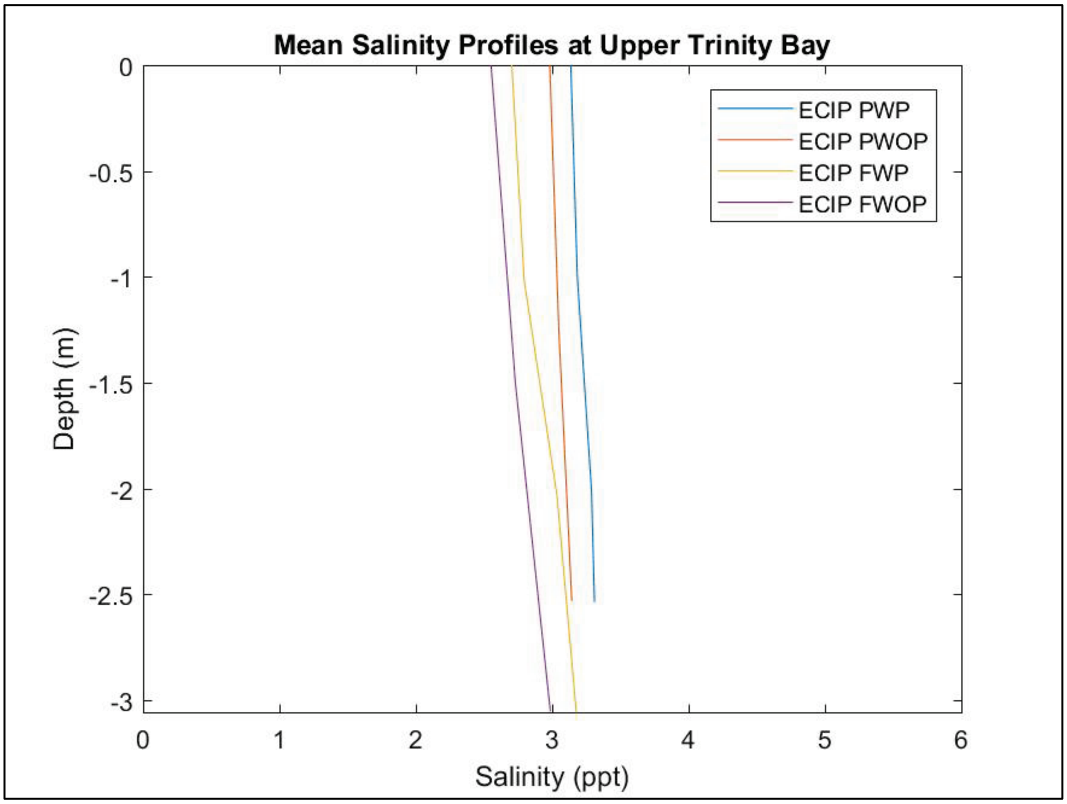


Figure 36. Salinity time history at Mid West Bay.

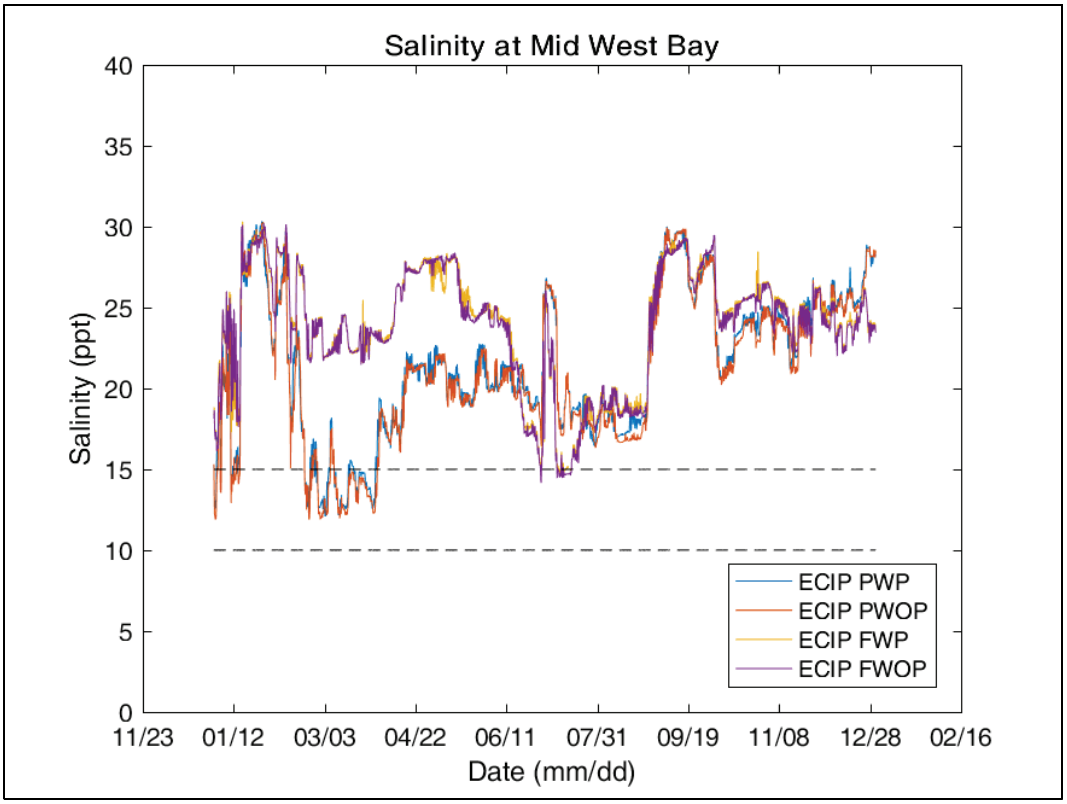


Figure 37. Maximum, minimum, and mean salinity at Mid West Bay.

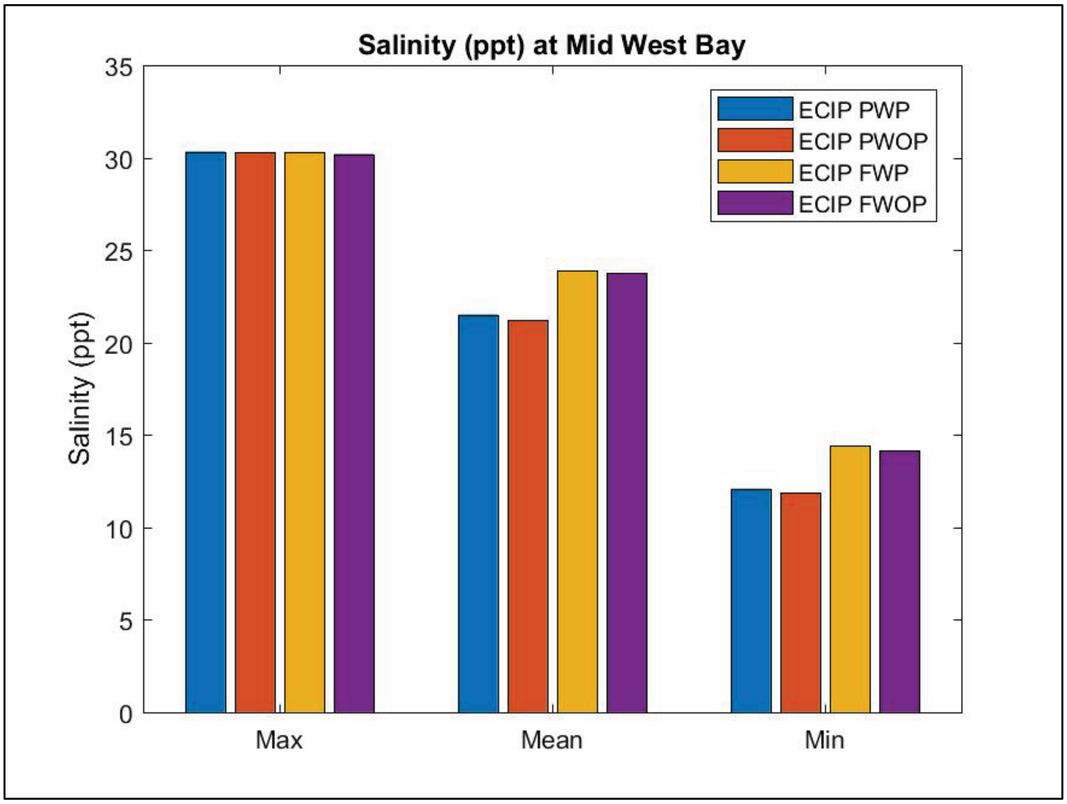


Figure 38. Percent-less-than salinity at Mid West Bay.

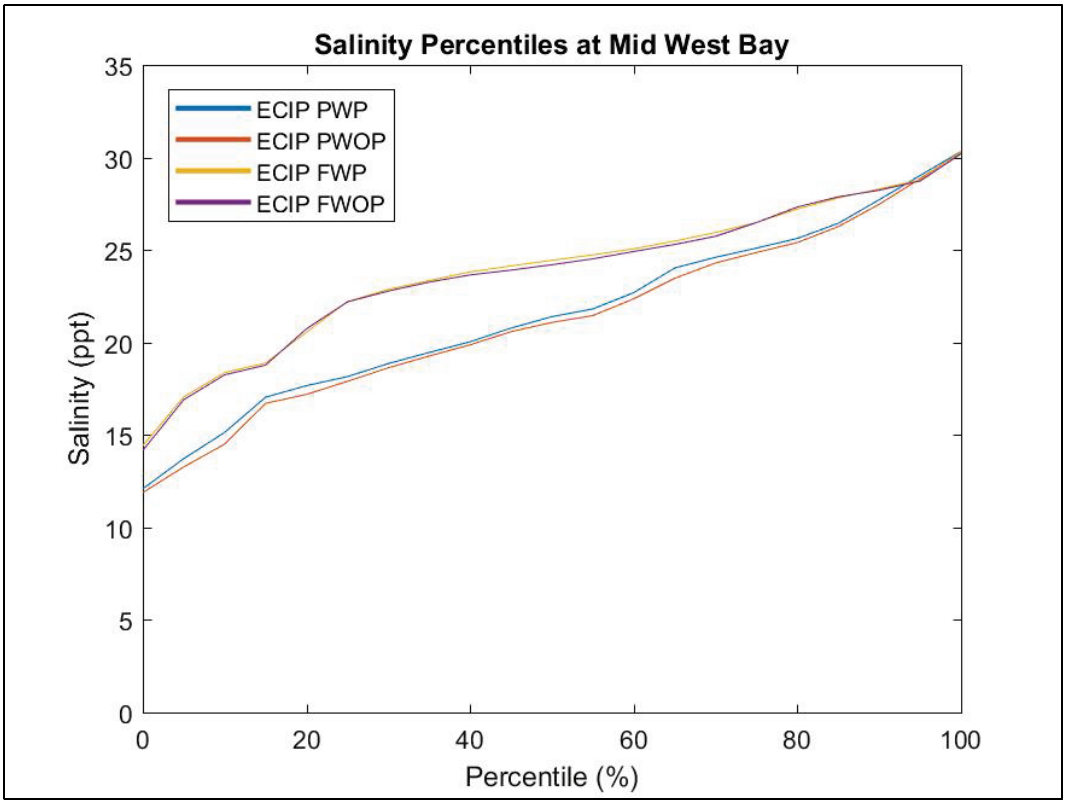


Figure 39. Vertical salinity profile at Mid West Bay.

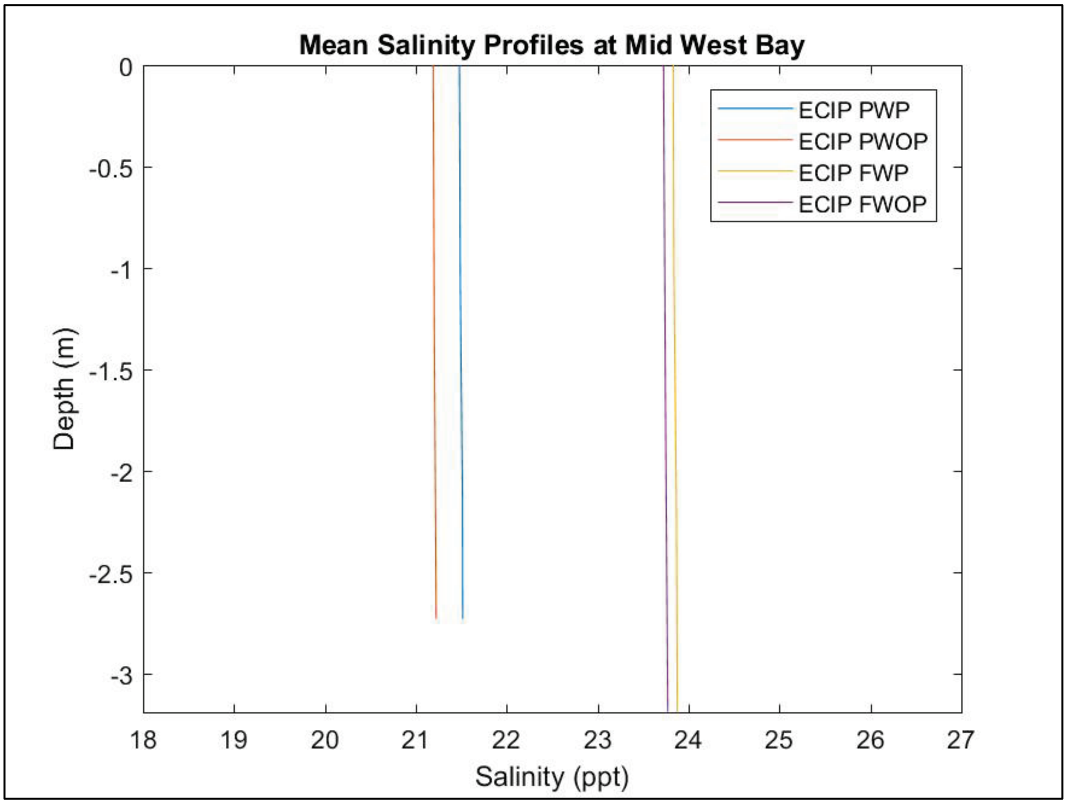


Figure 40. Salinity time history at Mid East Bay.

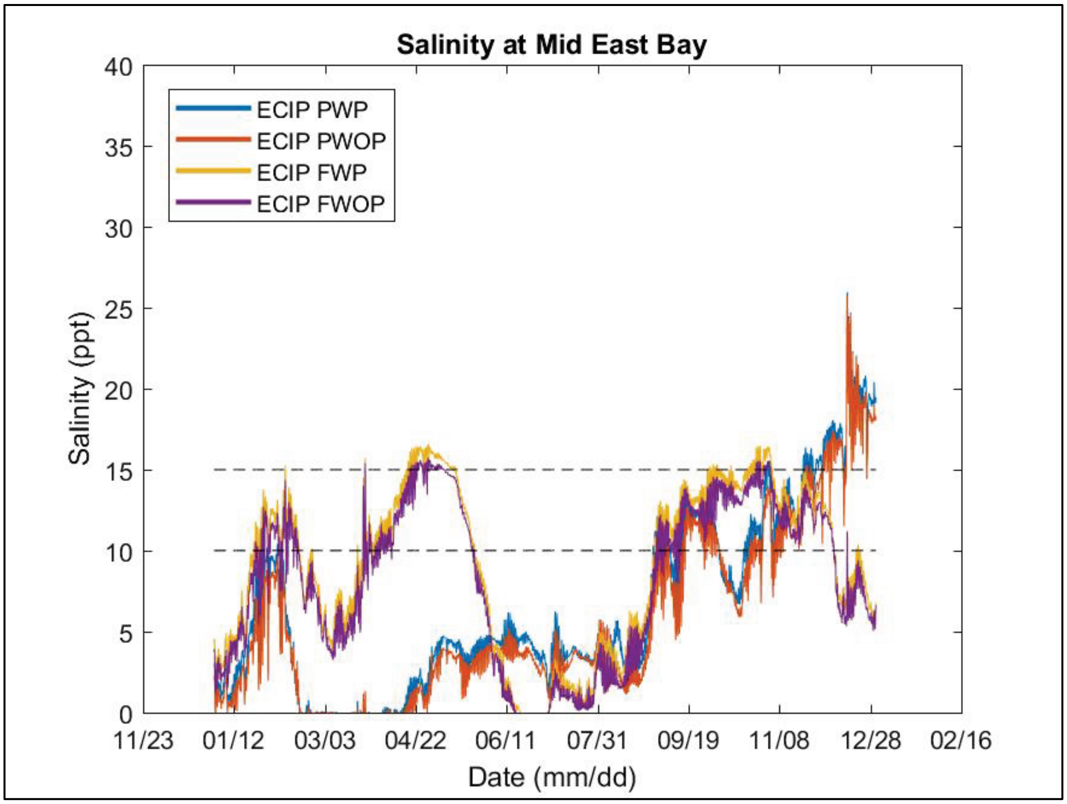


Figure 41. Maximum, minimum, and mean salinity at Mid East Bay.

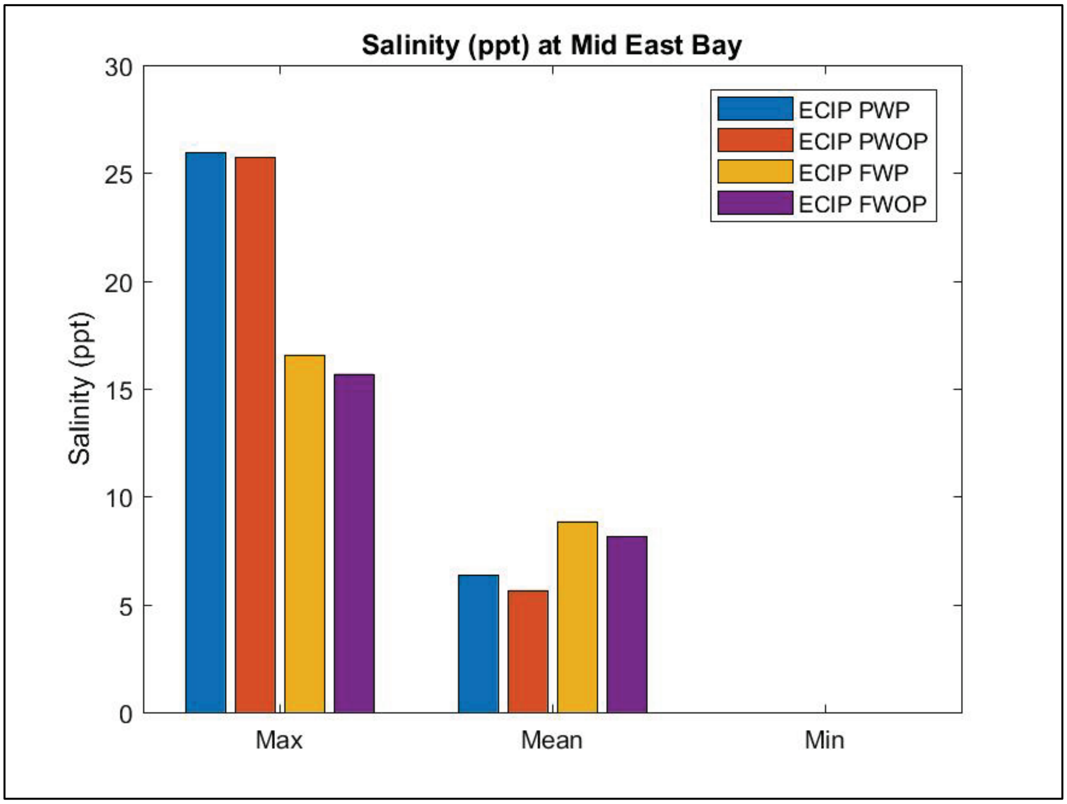


Figure 42. Percent-less-than salinity at Mid East Bay.

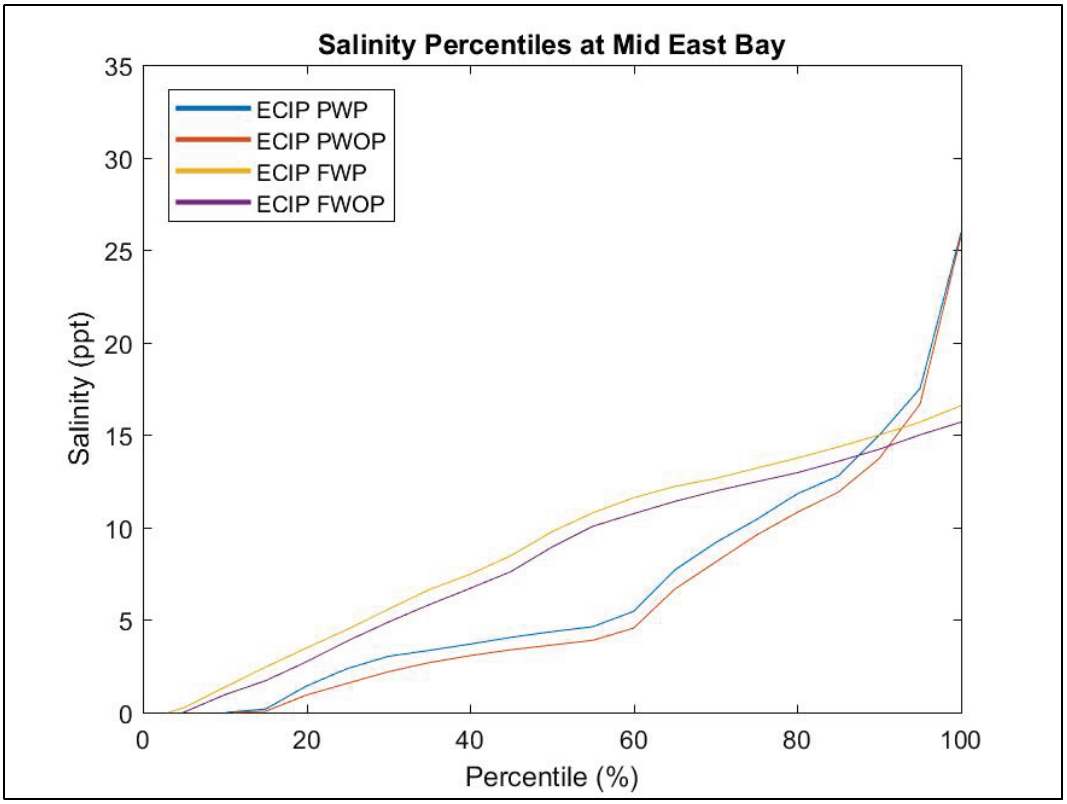
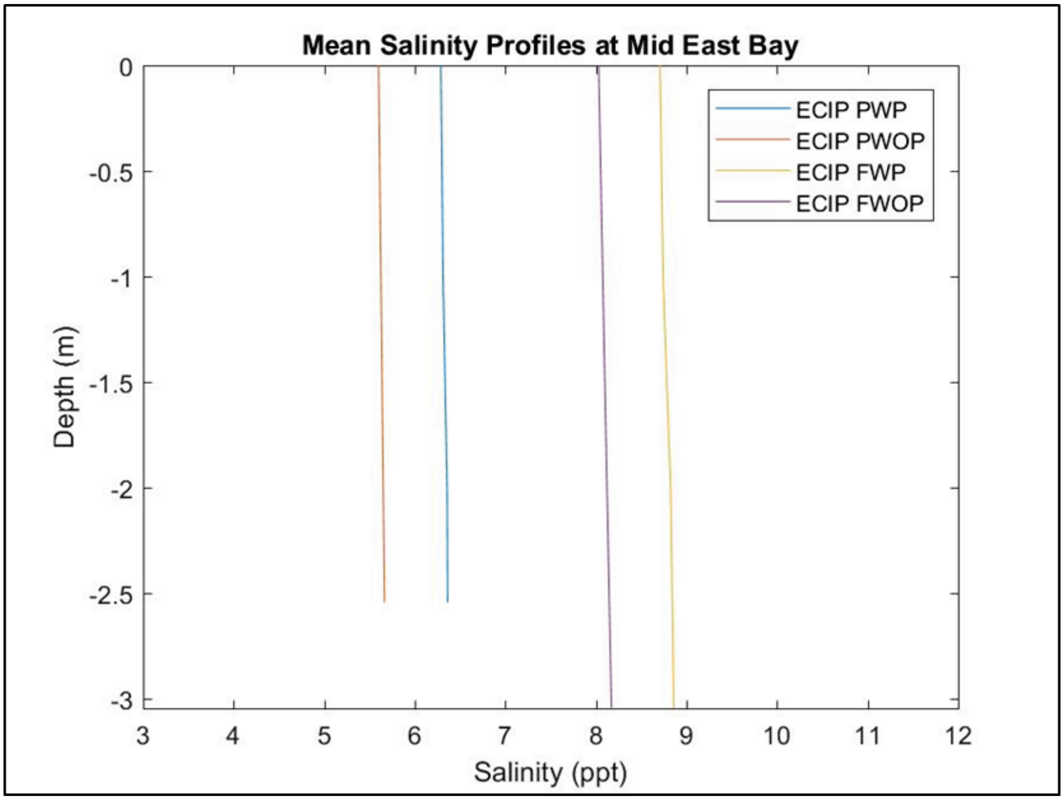


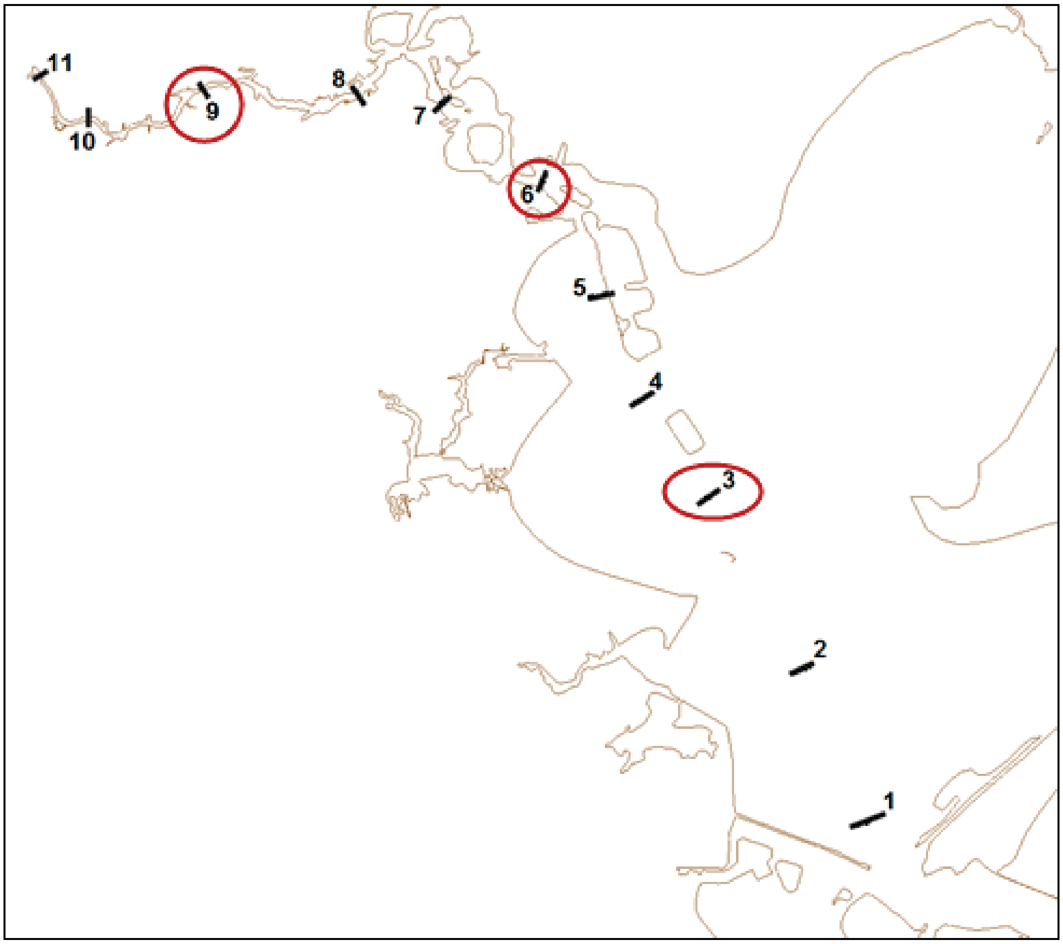
Figure 43. Vertical salinity profile at Mid East Bay.



Cross-sectional salinity analysis

Cross-sectional analysis of mean salinity along the HSC is provided for 11 cross sections beginning near the Texas City Dike and ending near the Houston turning basin. Figure 44 shows the location of these cross sections. Again, a subset of these cross sections (Figure 45 – Figure 47) — those circled in red in Figure 44 — will be provided in the text with all locations included in the appendices.

Figure 44. HSC cross sectional analysis locations. Circled locations discussed in this section.



Again, when viewing these results, focus on changes between the present with and without project separately from the future with and without project to isolate impacts due to the project. The future conditions have changes in the input conditions that make comparisons between present and future results harder to interpret.

Figure 45. Cross section 3 salinity.

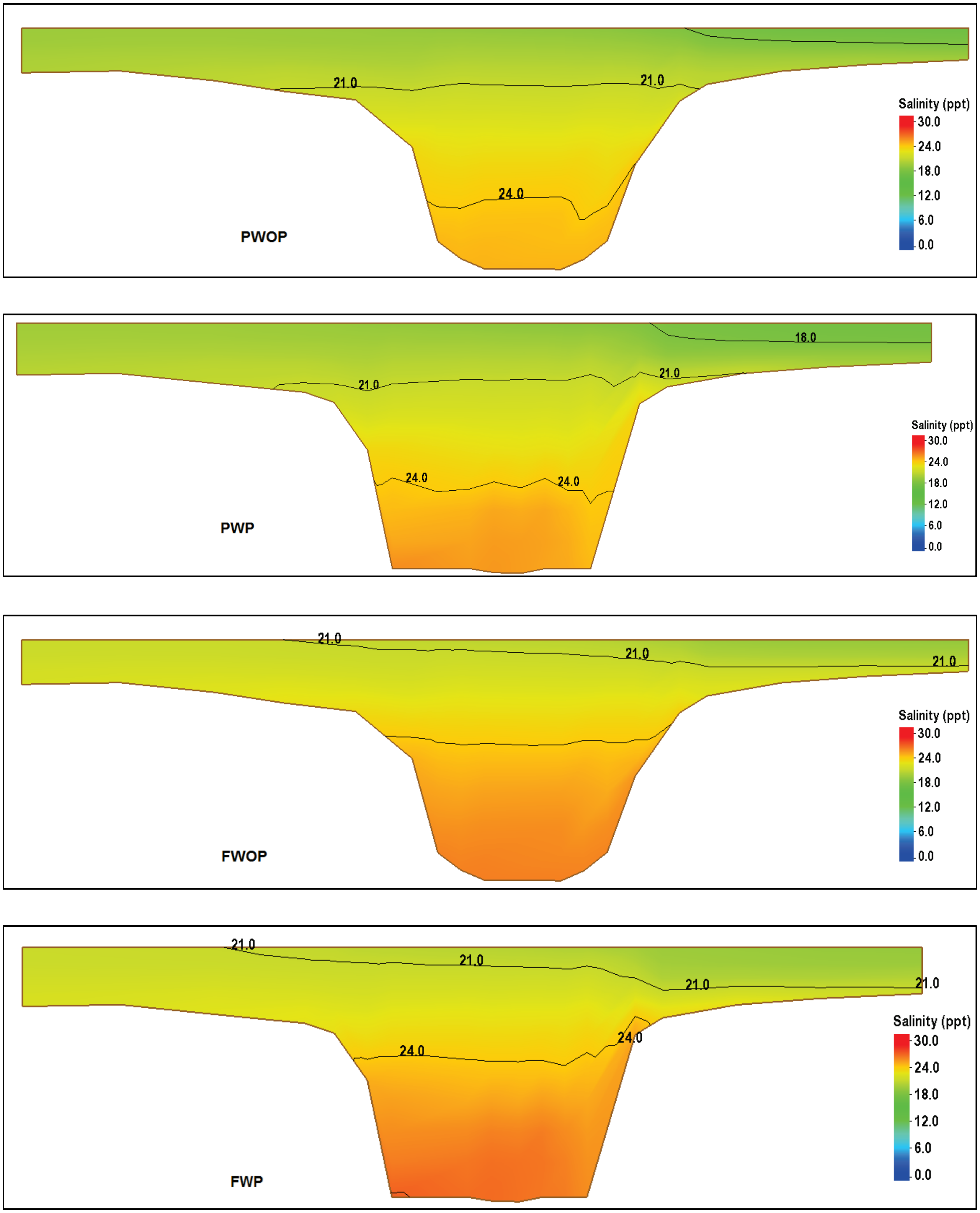


Figure 46. Cross section 6 salinity.

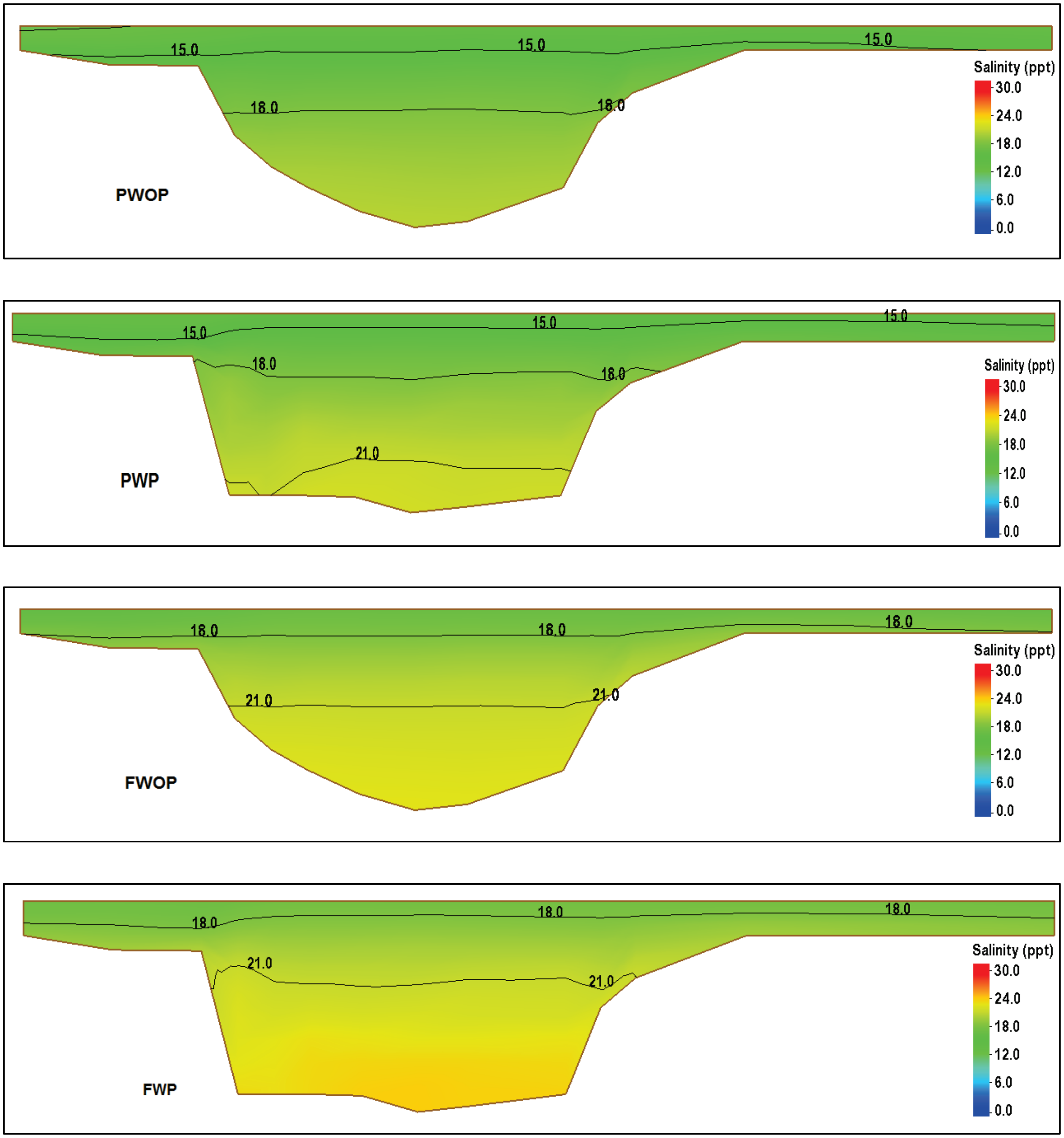
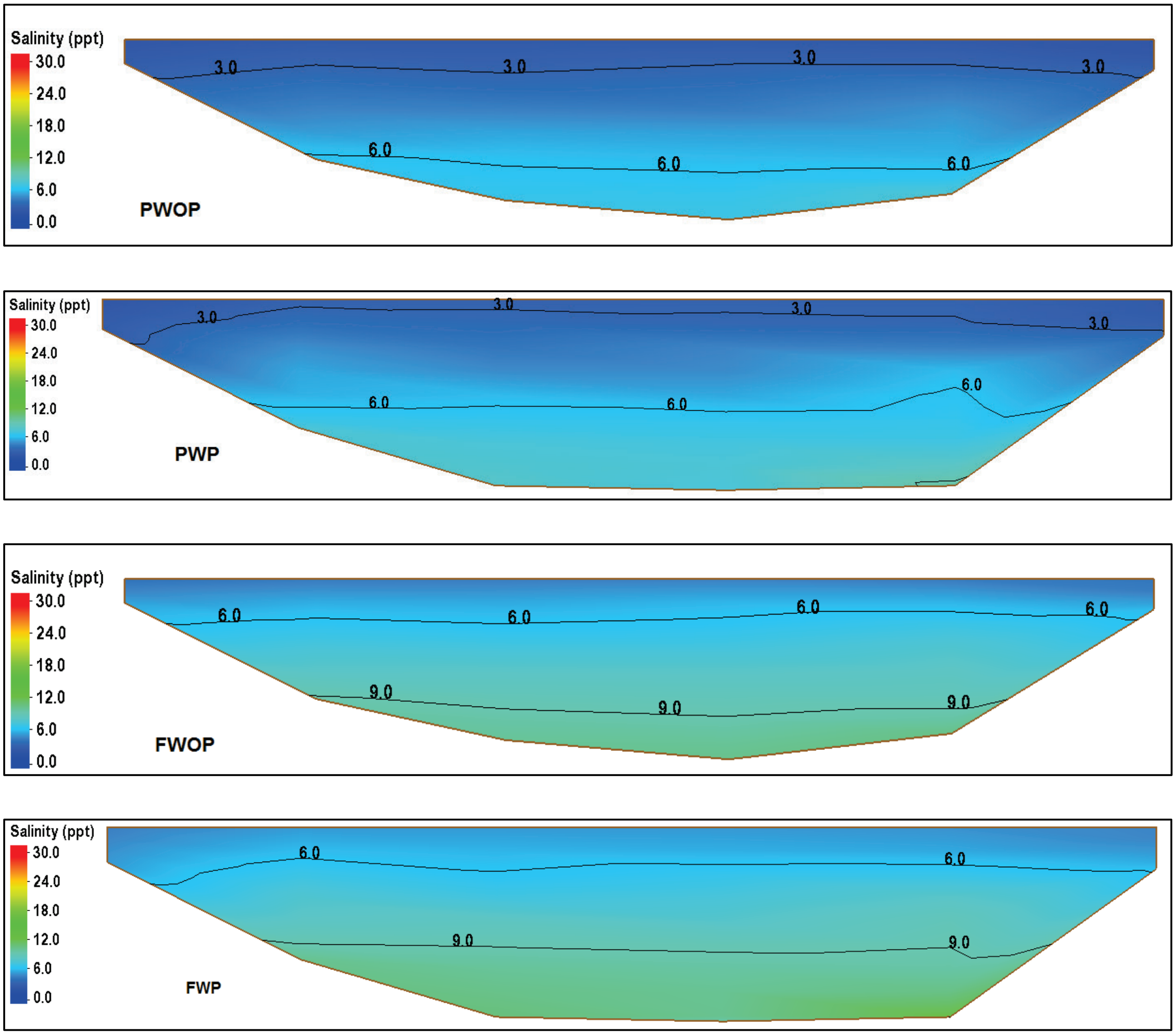


Figure 47. Cross section 9 salinity.



Salinity HSC slice analysis

A slice along the center of the HSC from the Gulf of Mexico to the HSC Turning Basin allows for the comparison of the salinity wedge migration along the ship channel. These results are for mean salinity over the year-long analysis period. Figure 48 shows the location of key features along the HSC for reference. Figure 49 shows the mean salinity along the HSC for all four alternatives. Again, when viewing these results, focus on changes between the present with and without project separately from the future with and without project to isolate impacts due to the project.

Figure 48. HSC slice analysis reference map.

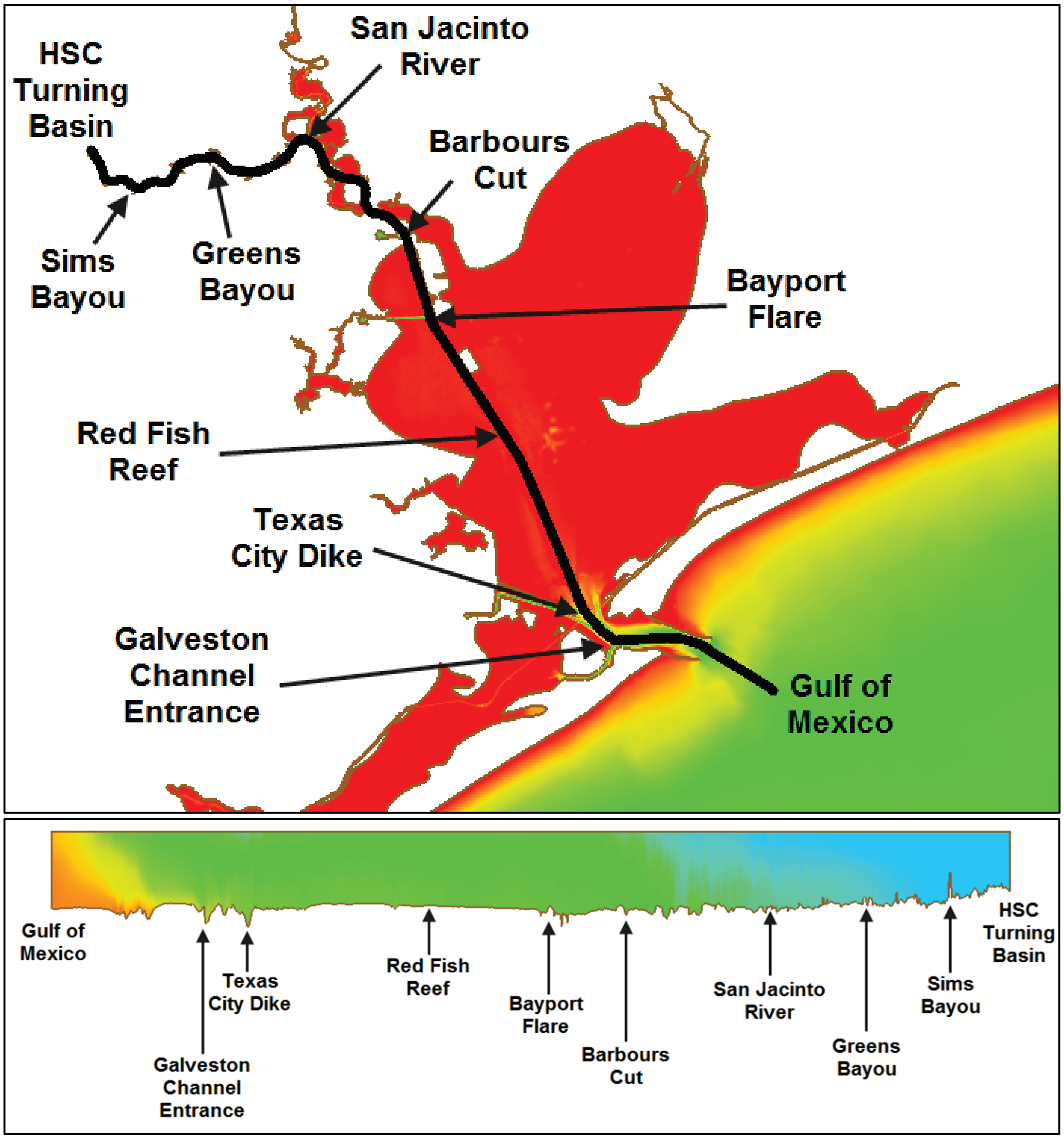
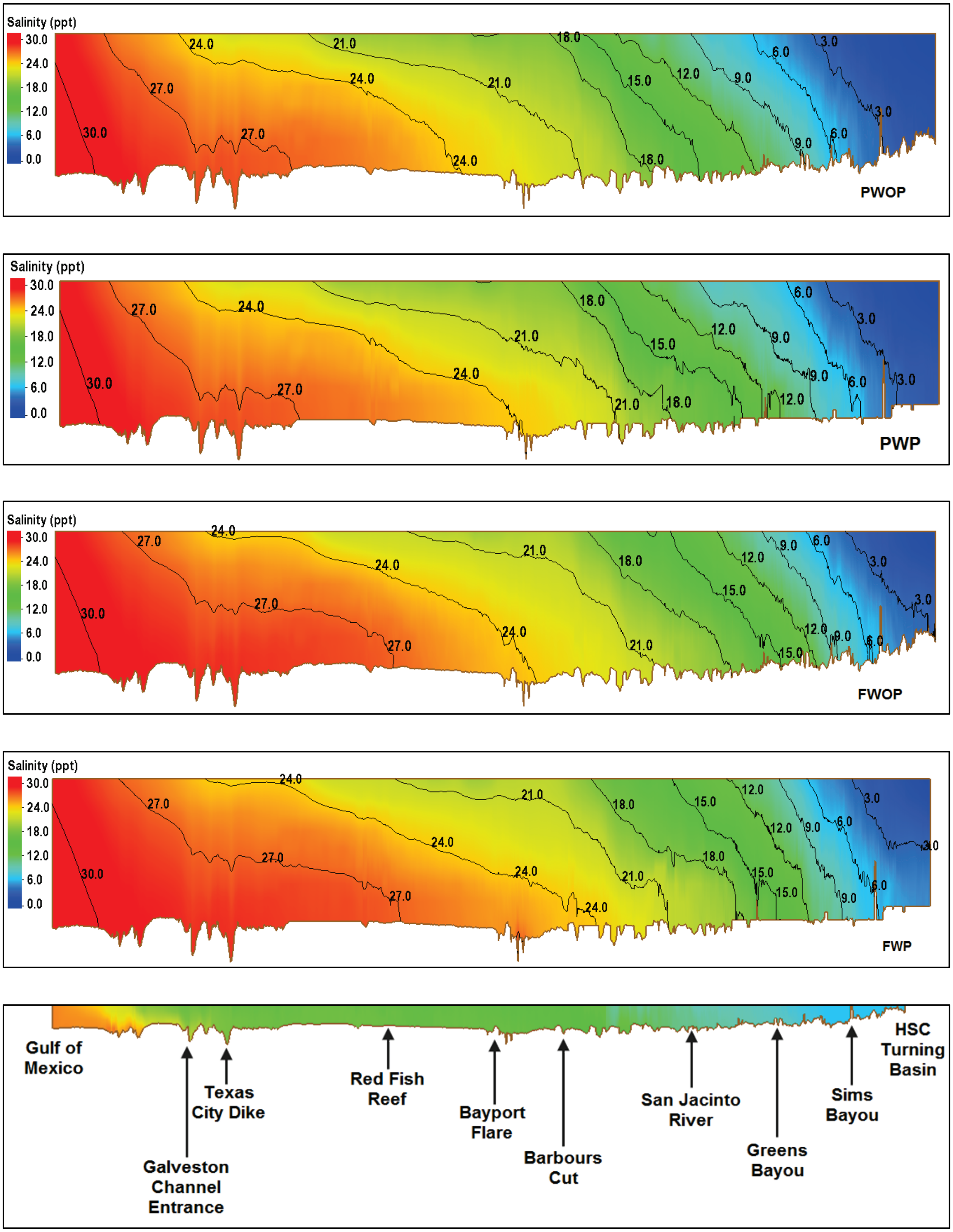


Figure 49. HSC average salinity slice results.



Tidal prism and amplitude

Changes to the system geometry can impact the tidal exchange into a bay environment such as Galveston and Trinity Bays. Although the entrance into the bay area is not modified in these alternatives, the HSC channel depth and width are modified and will allow for changes in the volume of flow being exchanged through the inlets. The tidal prism is a calculation of the volume of water that enters and leaves through the inlets with each tide. This volume was computed for all tides over the analysis year, and the average tidal prism was determined. Table 4 shows the volume of the average tidal prism for each alternative as well as the percentage change in the with project alternative as compared to the without project alternative for present and future conditions. The change is less than 2%, which indicates that the modifications to the HSC do not greatly impact the volume of water entering and leaving the system.

Table 4. Average tidal prism volume for analysis year and percent change of the with project from the without project alternative for present and future conditions.

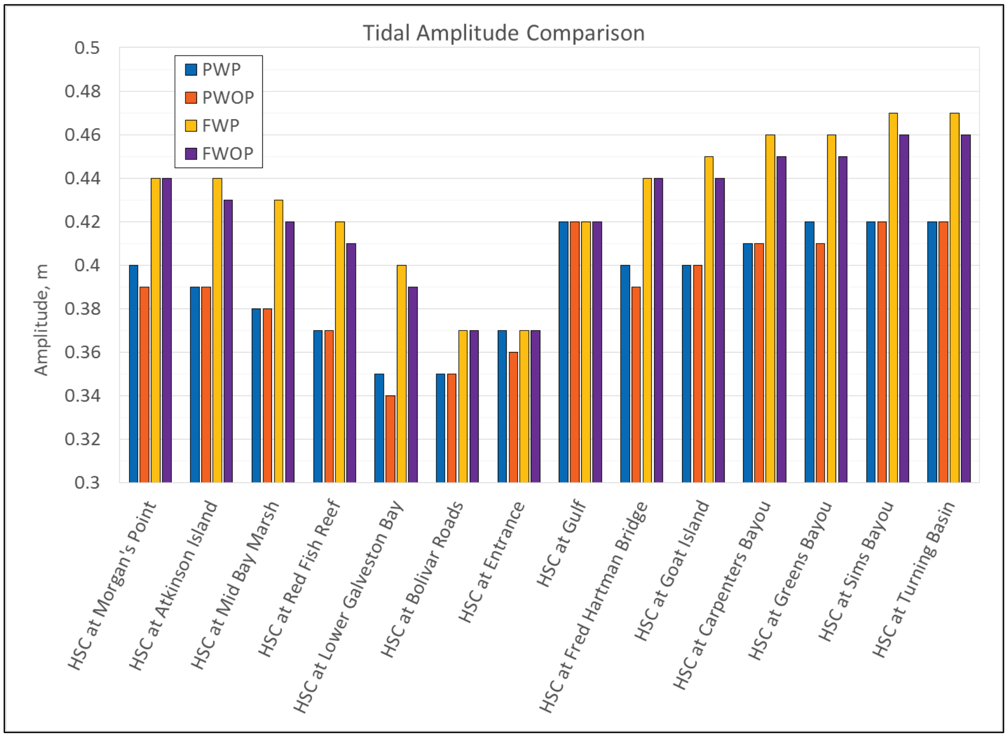
	PWP (m^3)	PWOP (m^3)	PWP % change from PWOP	FWP (m^3)	FWOP (m^3)	FWP % change from FWOP
Average	532,306,623	527,608,754	0.89	587,213,984	578,371,465	1.53

The tidal amplitude is the change in the water level from low-tide to high tide and vice versa. The tidal prism gives an overall impact on the water exchange whereas the tidal amplitude may vary at locations depending on where the system modifications are made and changes in the flow patterns within the system. Table 5 shows the percentage change between present without and with project alternatives and future without and with project alternatives. Locations (labeled in Figure 11 and Table 3) where both present and future changes were zero have been removed from the list. All locations see less than a 3% increase in the tidal amplitude when the project modifications are included. Figure 50 and Figure 51 show the tidal amplitudes for all alternatives for the HSC locations and bay locations, respectively. There is very little impact on the tidal amplitude when the present and future with project conditions are compared to the without project conditions — no more than 0.01 m at any location.

Table 5. Percent change in tidal amplitude of the with project from the without project alternative for present and future conditions.

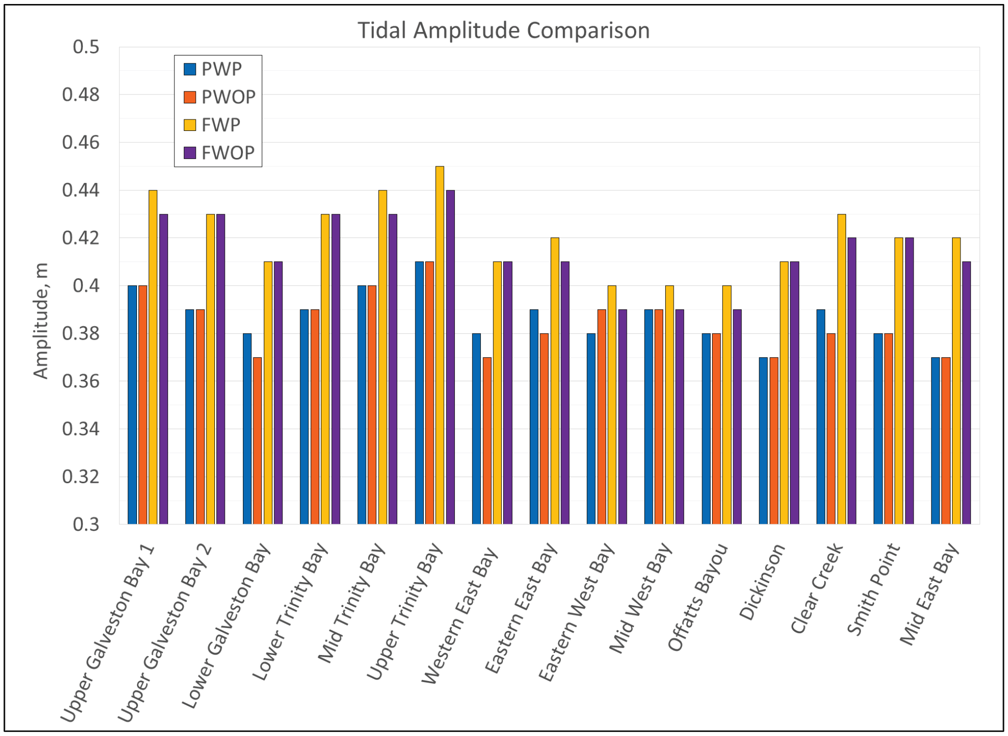
	PWP % change from PWOP	FWP % change from FWOP
HSC at Morgan's Point	2.56	0.00
HSC at Atkinson Island	0.00	2.33
HSC at Mid Bay Marsh	0.00	2.38
HSC at Red Fish Reef	0.00	2.44
HSC at Lower Galveston Bay	2.94	2.56
HSC at Entrance	2.78	0.00
Upper Galveston Bay 1	0.00	2.33
Lower Galveston Bay	2.70	0.00
Mid Trinity Bay	0.00	2.33
Upper Trinity Bay	0.00	2.27
Western East Bay	2.70	0.00
Eastern East Bay	2.63	2.44
Eastern West Bay	-2.56	2.56
Mid West Bay	0.00	2.56
Offatts Bayou	0.00	2.56
Clear Creek	2.63	2.38
Mid East Bay	0.00	2.44
HSC at Fred Hartman Bridge	2.56	0.00
HSC at Goat Island	0.00	2.27
HSC at Carpenters Bayou	0.00	2.22
HSC at Greens Bayou	2.44	2.22
HSC at Sims Bayou	0.00	2.17
HSC at Turning Basin	0.00	2.17

Figure 50. Tidal amplitude comparison at HSC points for all alternatives.



* Focus separately on changes between the present and future to isolate project impacts.

Figure 51. Tidal amplitude comparison at bay points for all alternatives.



* Focus separately on changes between the present and future to isolate project impacts.

Velocity

The velocity comparisons among the alternatives will focus on residual velocity vectors. Residual velocity is the velocity that remains when the tidally varying velocity has been averaged out. This vector defines the predominant flow direction and speed of a particle of water. Although the tide will cause the particle to move back and forth, there is generally a flow direction that is dominant, allowing for a particle to migrate along a certain path. Typically, in a tidally driven environment with a deep navigation channel such as the HSC, the predominant flow direction is upstream along the channel bottom and downstream along the channel surface. The surface and bottom velocity comparisons for with project and without project are shown in Figure 52 through Figure 55. The red vectors indicate the direction of the with project residual velocity and the black vectors, the without project. The contours represent the difference in the velocity magnitudes — with project minus without project such that positive values (reds/yellows) indicate the with project residual velocity magnitude is greater, and negative values (blues) indicate that the without project residual velocity magnitude is greater.

The comparisons show that the residual vector directions are very similar for with and without project alternatives. There are locations where they vary, but the general flow patterns are maintained. The area of the most variation is along western Galveston Bay, primarily between Red Fish Reef and Morgan’s Point. There is widening of the HSC, bend easing, and turning basins added to this area, so the variation is not unexpected. The change in the residual velocity magnitudes are less than 0.1 meter per second (m/s). The impact of the project is greater along the HSC upstream of Barbours Cut. The residual velocity magnitudes vary more there than in the bay portion of the project, although the variation from the without project magnitude remains in the range of 0.1 m/s or less. The vector directions also show more variation in the upper HSC area. Again, this is an area of many modifications, such as channel widening and additional turning basins and moorings — all of which are going to modify the velocity patterns.

Figure 52. Surface average residual velocity comparison for present conditions.
(red vectors – with project; black vectors – without project)

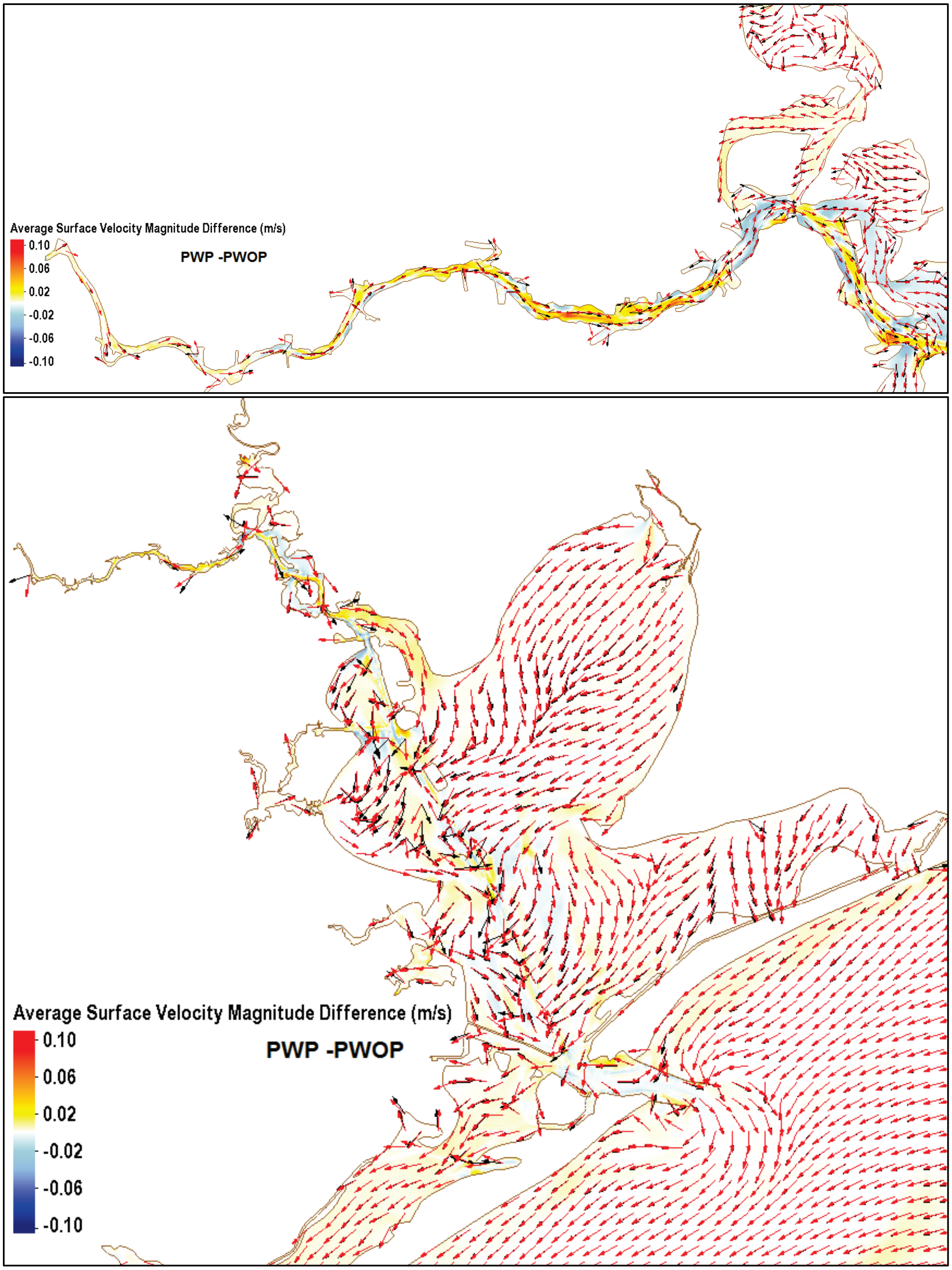


Figure 53. Bottom average residual velocity comparison for present conditions. (red vectors – with project; black vectors – without project)

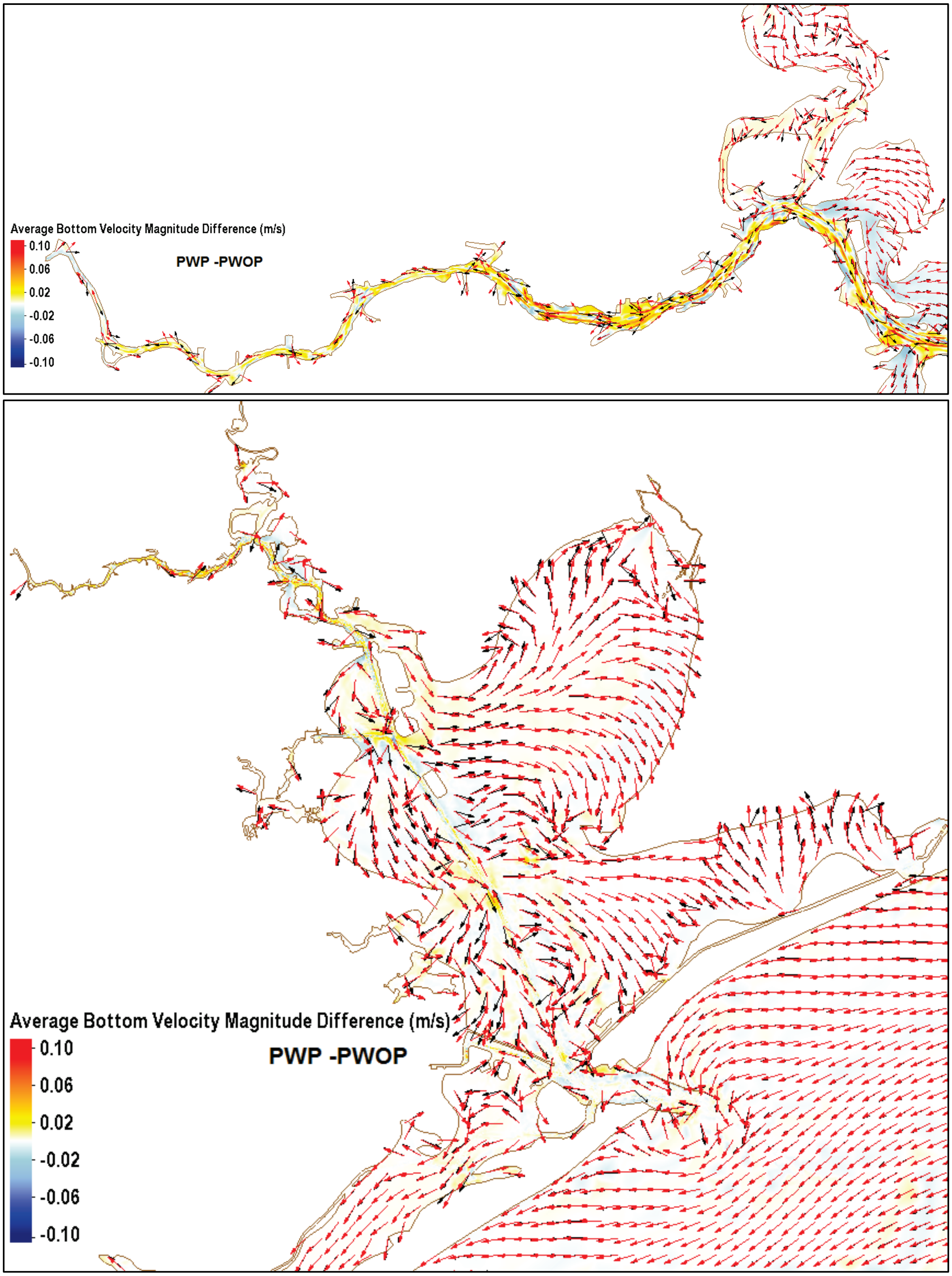


Figure 54. Surface average residual velocity comparison for future conditions.
(red vectors – with project; black vectors – without project)

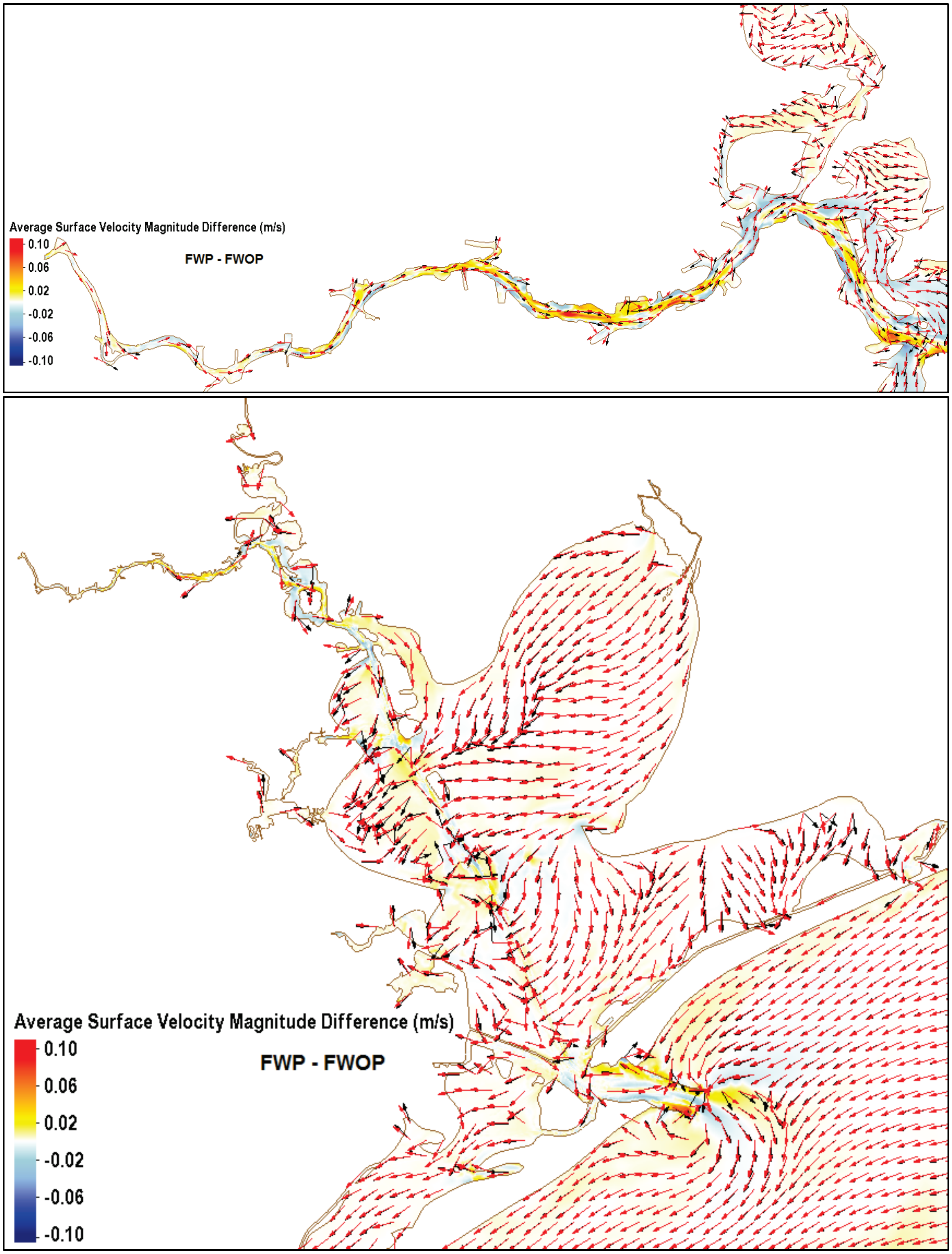
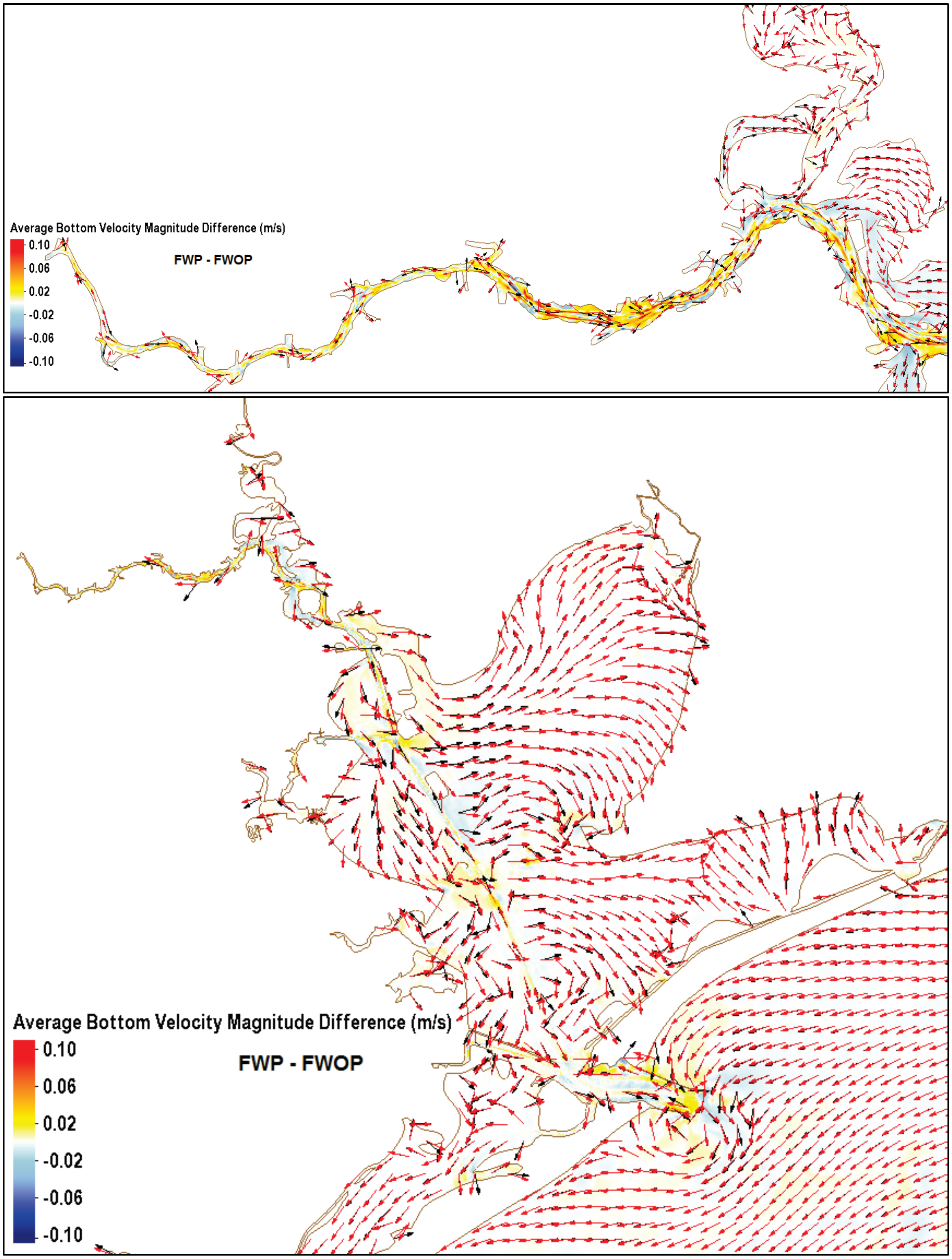


Figure 55. Bottom average residual velocity comparison for future conditions.
(red vectors – with project; black vectors – without project)



Shoaling

The sediment analysis is based on the historic dredge records from the USACE annual reports as done in the model validation (McAlpin et al. 2019). These volumes are provided for several reaches of the HSC as noted in the dredge template shown in Figure 56. This template will be used to show how the alternative shoaling estimates from the numerical model compare to each other for each channel reach.

Figure 56. HSC dredge template for shoaling analysis.

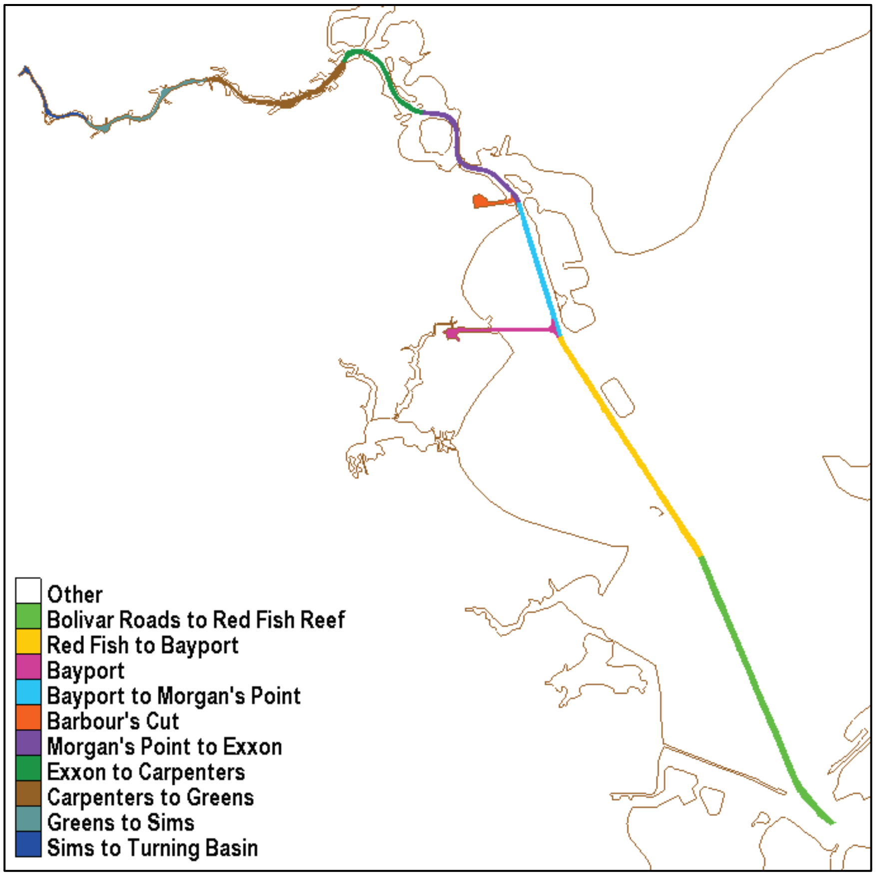


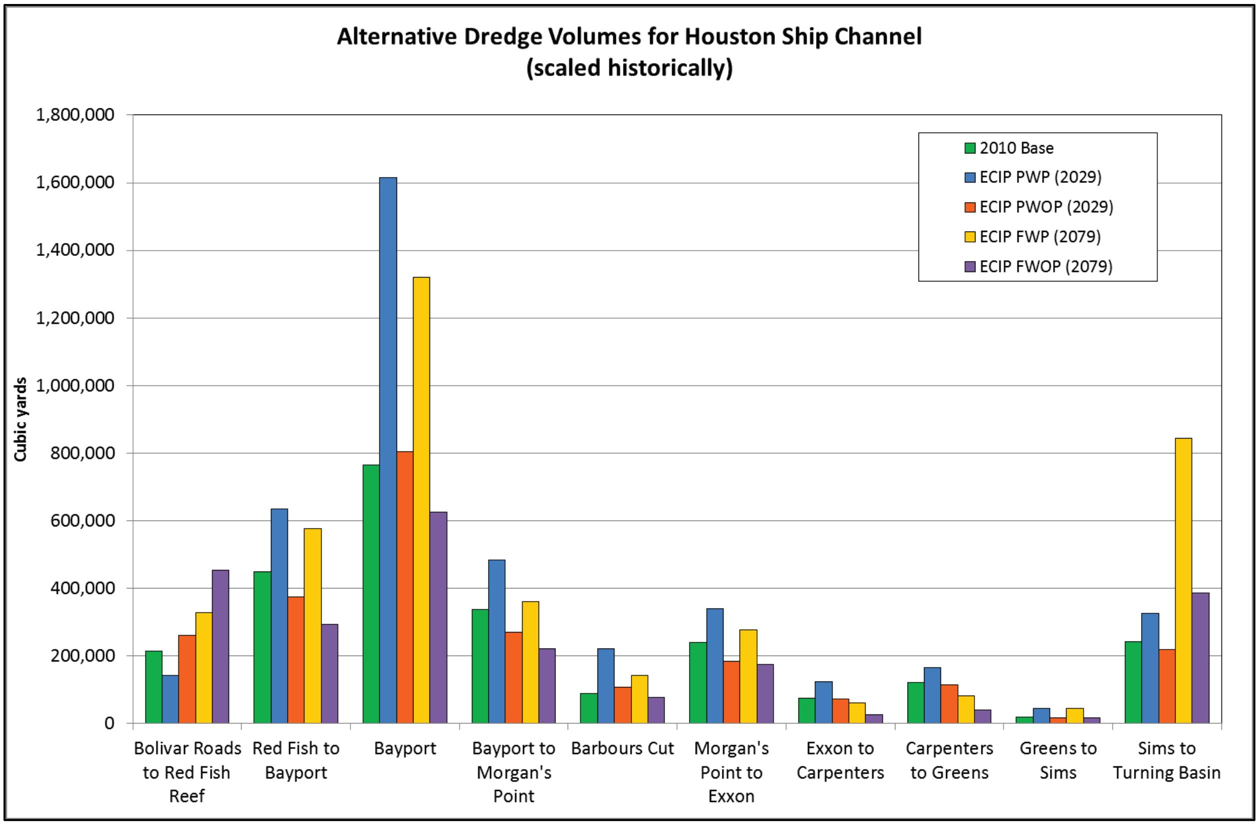
Figure 57 shows the scaled shoaling volume within each segment for the 2010 base condition and all four alternatives — PWP, PWOP, FWP, and FWOP. The with project shoaling is larger for all segments except at the farthest upstream and downstream segments. Bolivar Roads to Red Fish Reef indicates a small decrease in the shoaling with the project changes in place likely due to the slight increase in the tidal prism, which will generate some higher velocity magnitudes. The Bayport area shows the largest increase in shoaling volume. The flare is already a sediment trap due to its present size, and the project alternative of widening the Bayport channel and to ease the bend further increase the footprint and therefore the tendency to trap sediment. Figure 58 shows the model-computed, unscaled bed displacement along the HSC from the Texas City Dike to the Houston Turning Basin. These results show a similar pattern to those in Figure 57, although no scaling has been done to ensure a correlation to historic data as in the shoaling volume plot. However, the comparison between with and without project will remain if scaled to replicate actual shoaling volumes/depths. The plot does show that the with project alternatives increase the deposition along most of the HSC. It also indicates a potential shift in the shoaling locations for the PWP alternative to areas upstream of Red Fish Reef and upstream of Bayport. The increase upstream of Bayport may actually be a simple increase in shoaling as opposed to a shift since there are still peaks in the bed displacement at the Bayport Flare. It is not uncommon for channel modifications to change the flow patterns such that the turbidity maximum (the location where the sediment tends to collect and often tied to the location of the salinity wedge) moves upstream, especially in the case of channel deepening. The future alternatives do not show this shift most likely because the sediment loads are reduced in the future condition simulations.

The deepened portion of the HSC in the project alternatives is located upstream of the San Jacinto River. Sediment loads from the bayous entering the HSC in the area of the deepening may have a tendency to migrate upstream due to the salinity being pushed farther upstream along the channel bottom, although the salinity change is less than 1 ppt for most of this area. This model does not include these bayou sediment loads because they are unknown and therefore is unable to predict this potential upstream sediment migration.

Due to the increase in the with project cross-sectional area (where the HSC is being widened or deepened), the same shoaling volume will equate to a reduced shoaling depth for the larger cross section. Figure 59 shows schematically how the shoaling volume can be interpreted for different channel modifications. A wider channel and the same shoaling depth or elevation will produce a larger shoaling volume. Therefore, the increased shoaling volume does not mean dredging must occur sooner, but it does indicate the dredging may cost more due to more volume. A constant shoaling volume will mean a lower shoaling depth for a channel widening condition; therefore, again, the dredging may not be required as often. For a deepened channel condition, the same results are true as in the widened condition; however, for a constant shoaling elevation, the shoaling volume and depth will be increased, but dredging will only be required more often if the required dredging elevation is also deepened. These conditions should be considered when viewing the modeled shoaling volume and bed displacement changes for the various locations along the HSC due to the different areas of deepening and widening.

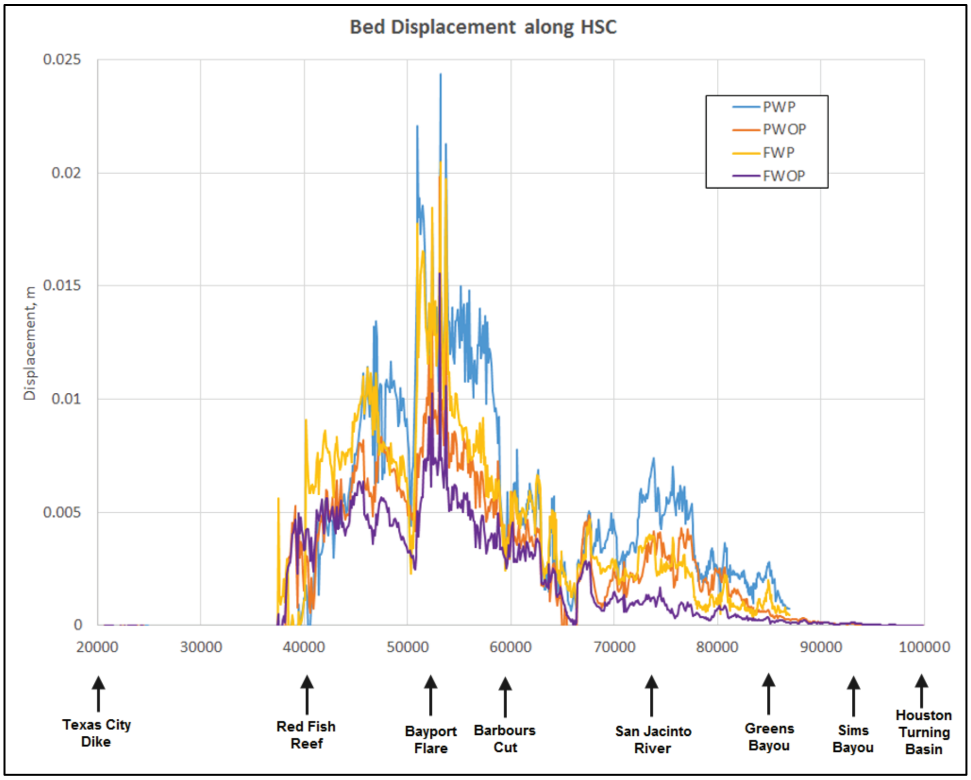
An additional sediment model calibration effort will be performed using the Corps Shoaling Analysis Tool. This tool computes historic shoaling rates and provides estimates of future rates on a fine scale (5–10 m). This calibration effort will be documented in McAlpin et al. (2019) and will provide shoaling estimates similar to those presented in this chapter but on a finer scale than the dredge template allows.

Figure 57. Shoaling results by reach for all alternatives.



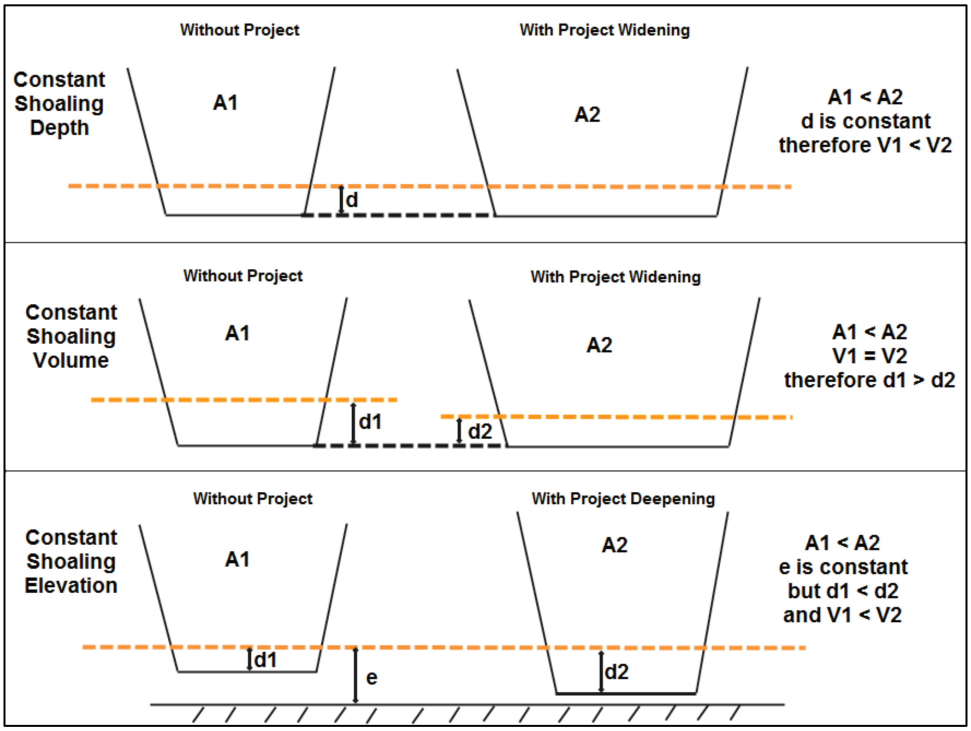
* Focus separately on changes between the present and future to isolate project impacts.

Figure 58. Modeled bed displacement along HSC (non-scaled, focus on the change).



*Focus separately on changes between the present and future to isolate project impacts.

Figure 59. Shoaling impacts under various alternative conditions.



4 Conclusions

Overall, the proposed alternative has little effect on salinity, but it does generate larger shoaling and localized changes in velocity patterns.

Comparison of with and without project should be done on the present conditions and the future conditions separately to isolate impacts due to the project alone. Comparing present and future results directly means that the impact of the project is included with the impact of modified input parameters since several were adjusted for the future condition and therefore difficult to determine which change is generating the difference between alternatives.

The salinity was analyzed at 29 locations along the HSC and in the surrounding bays and on average, did not vary by more than 2 ppt between with and without project conditions at any location. At some locations the maximum or minimum salinity values varied by more but these are extreme values and likely only occur a couple of times throughout the simulation year. The percent-less-than plots of salinity show the range of salinity values for all locations over the simulation period and again, show little variation between with and without project results. The salinity wedge does have a tendency to migrate a bit farther upstream due to the channel widening and deepening, but that distance is small which supports the 2 ppt or less increase for the with project condition.

The average tidal prism and average tidal amplitudes also remained fairly consistent between with and without project over the simulation year. The tidal prism change with the project alternative in place is less than 2% for both present and future conditions. The tidal amplitudes varied by no more than 0.01 m at any of the 29 locations.

The residual velocity indicates the predominant flow direction and magnitude when the tide is removed from the velocity throughout the model domain. The change from the without project condition is limited to areas in and immediately around where the modifications are made. Significant differences in residual velocity direction and magnitude are visible around Bayport as well as in the upper HSC area where widening and deepening occur, but these changes are less than 0.1 m/s. There are impacts to velocity magnitude into the bay areas, but they are much smaller than the impacts at the locations of the modifications.

The alternative condition does indicate an increase in the shoaling along the HSC when compared to the without project results. The largest increases are in the Bayport channel and flare. This is not unexpected since this area is presently a sediment trap due to its large, deep footprint, and the alternative condition increases the channel and flare area. The shoaling volume results should be reviewed in connection with shoal height to determine the overall impacts of the channel shoaling analysis and how they relate to the proposed modifications. A widened channel with an increased shoal volume may mean that although more volume must be removed when dredged, the number of dredging occurrences may be reduced.

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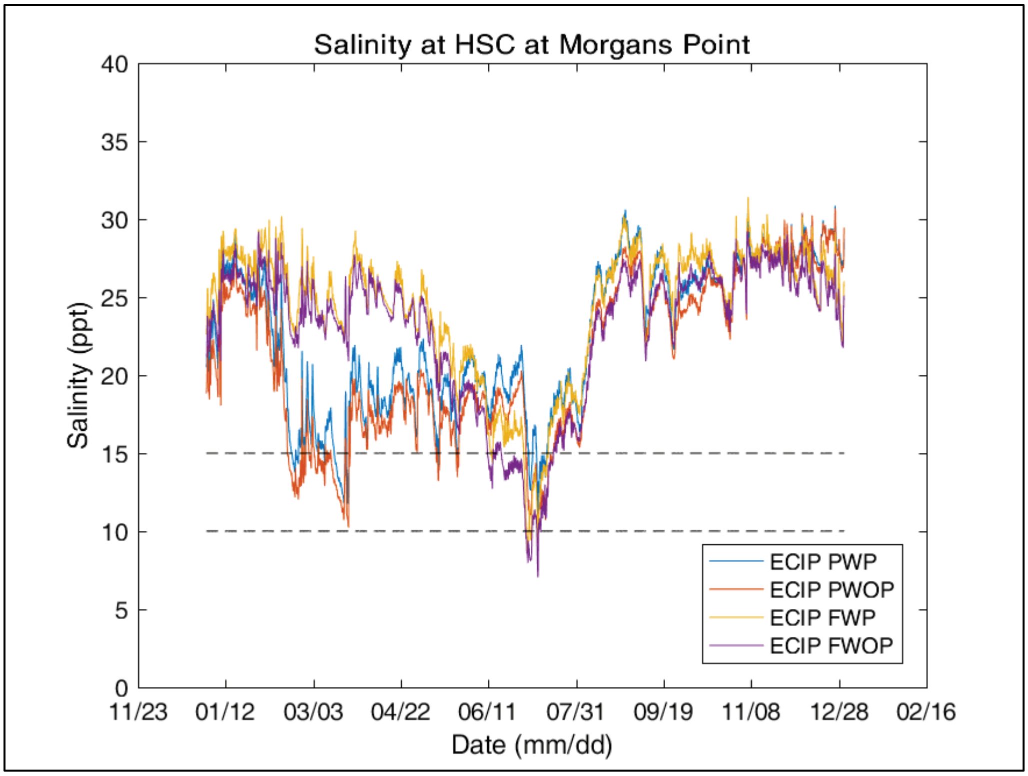
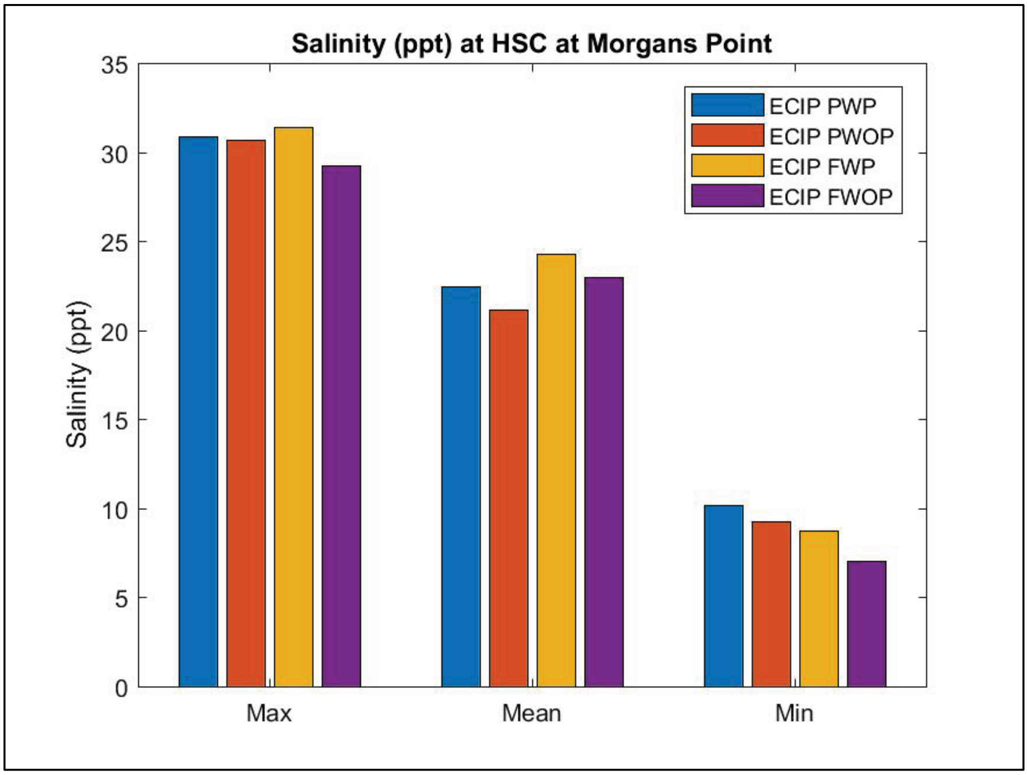
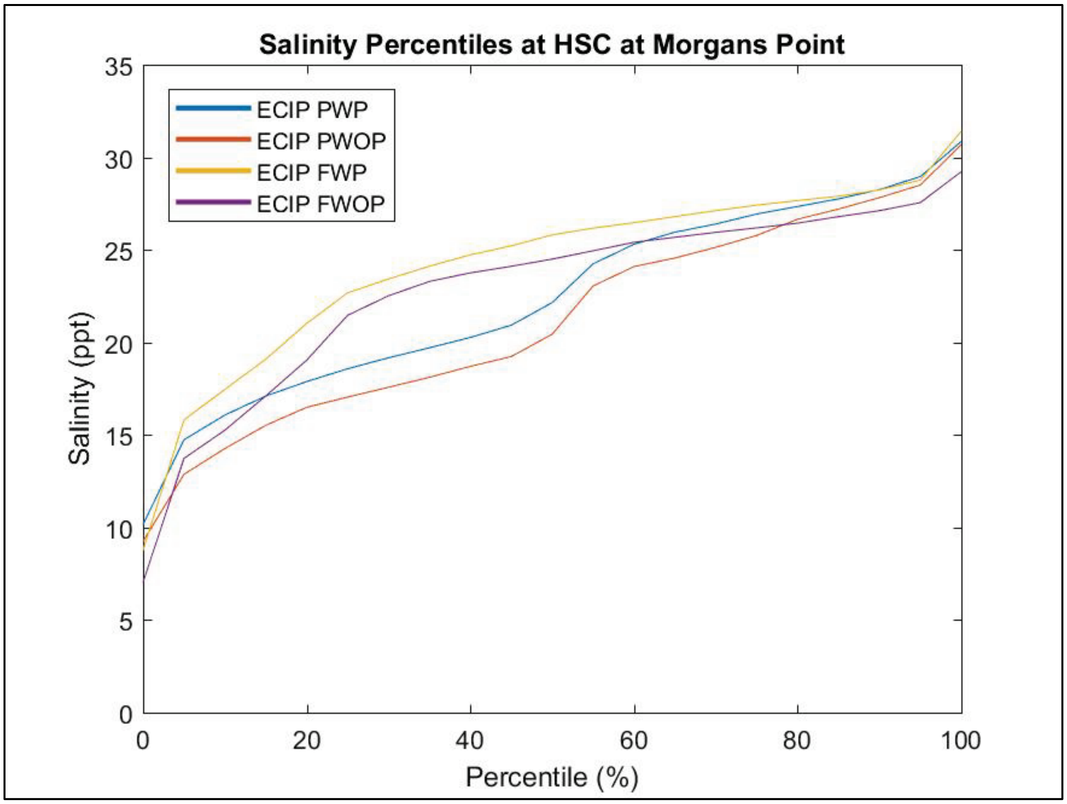
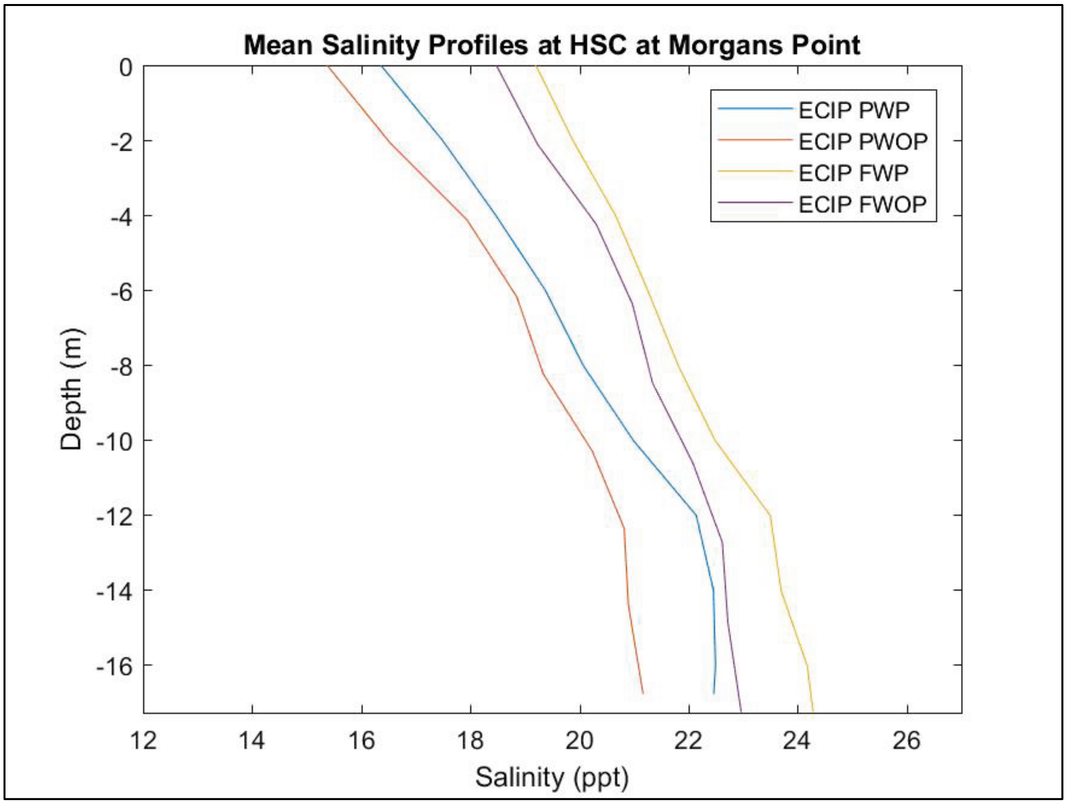
Appendix

Point salinity analysis






Salinity Percentiles at HSC at Morgans Point
Salinity (ppt)
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Morgans Point
Depth (m)
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
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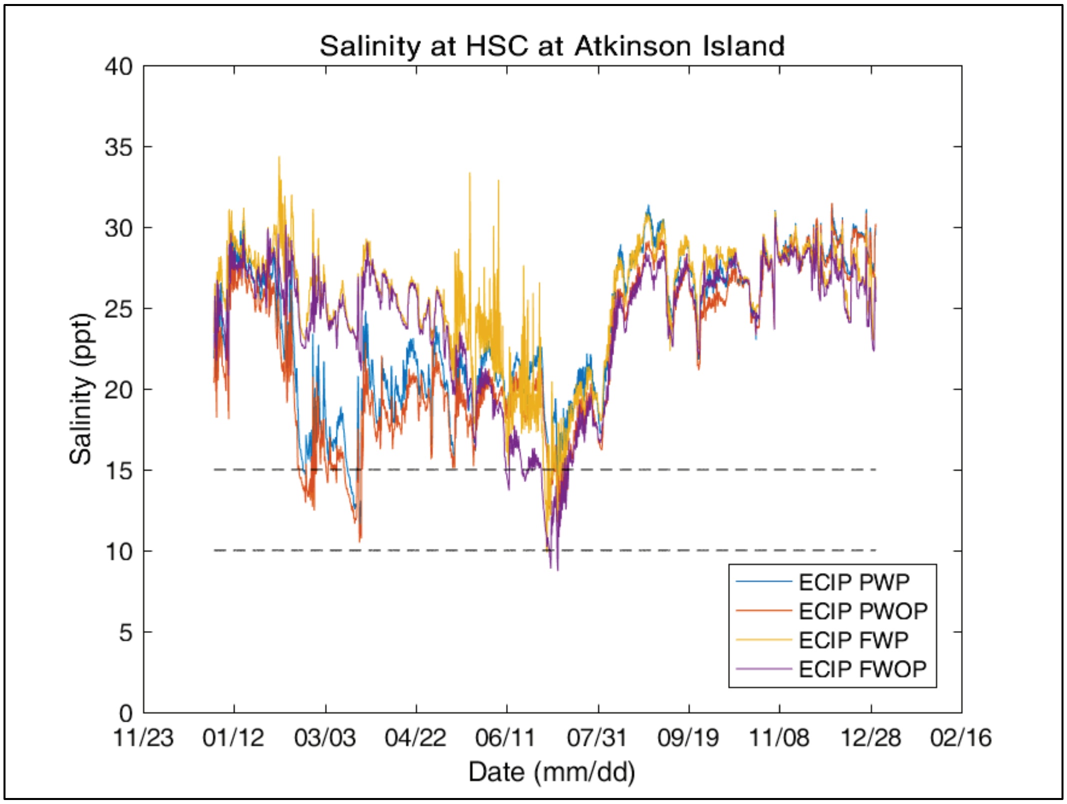
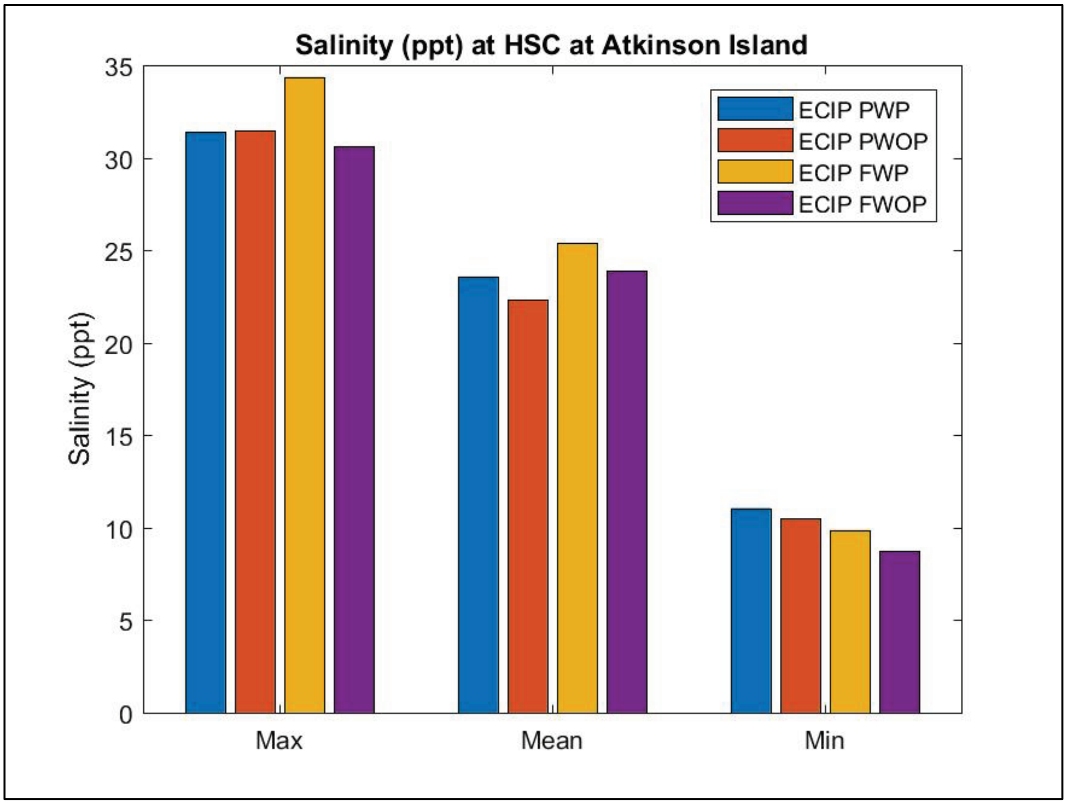
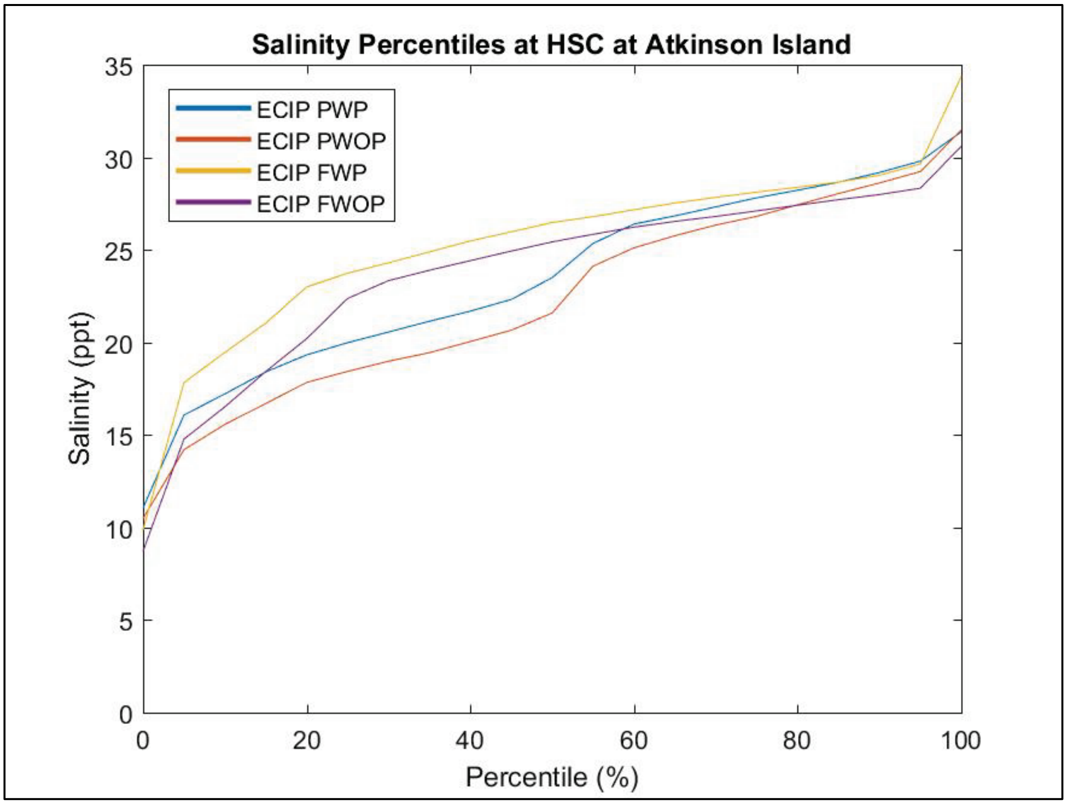
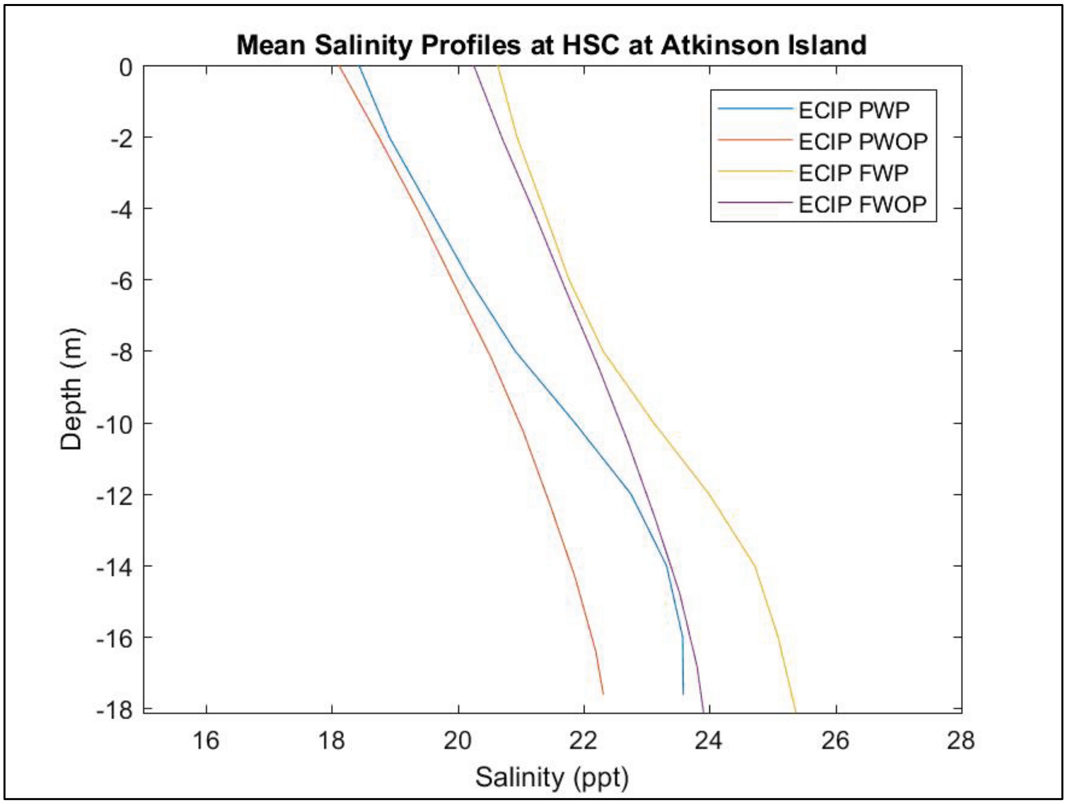
-4
-6
-8
-10
-12
-14
-16
12
14
16
18
20
22
24
26


Salinity at HSC at Atkinson Island
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP


Salinity (ppt) at HSC at Atkinson Island
Salinity (ppt)
0
5
10
15
20
25
30
35
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP


Salinity Percentiles at HSC at Atkinson Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100


Mean Salinity Profiles at HSC at Atkinson Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
Salinity (ppt)
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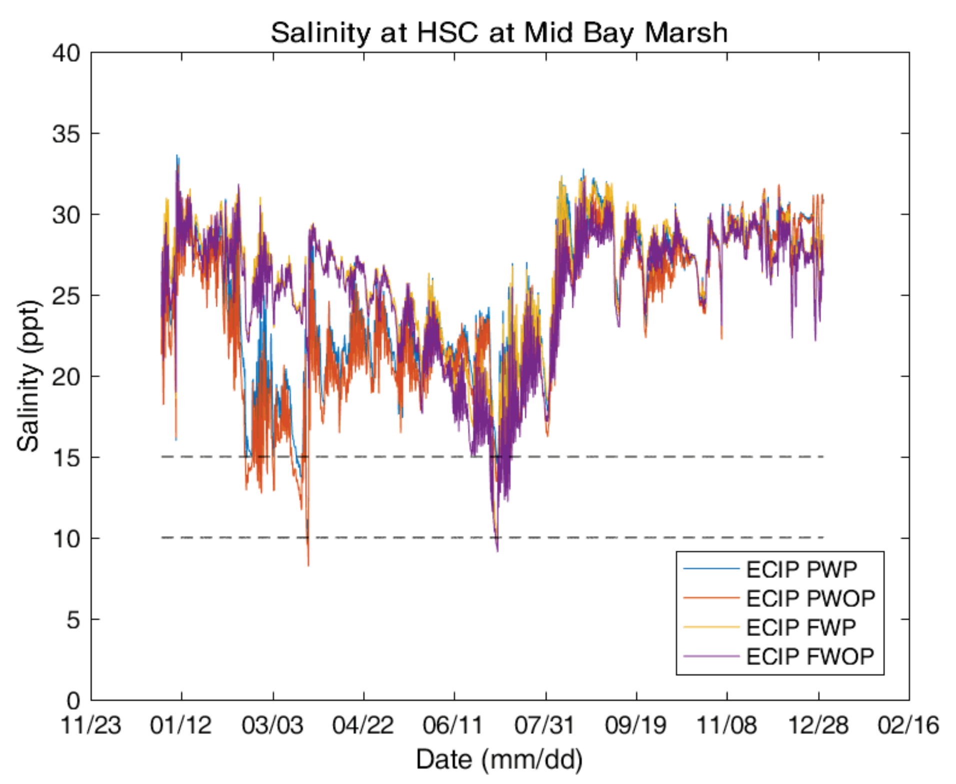
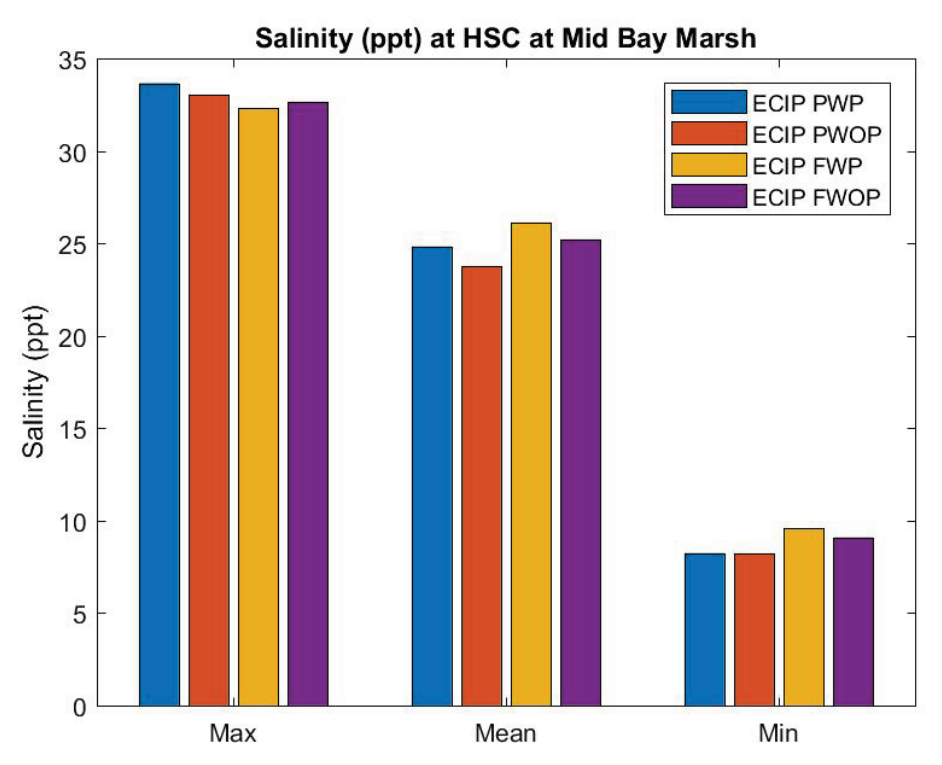
18
20
22
24
26
28


Salinity at HSC at Mid Bay Marsh
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP


Salinity (ppt) at HSC at Mid Bay Marsh
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
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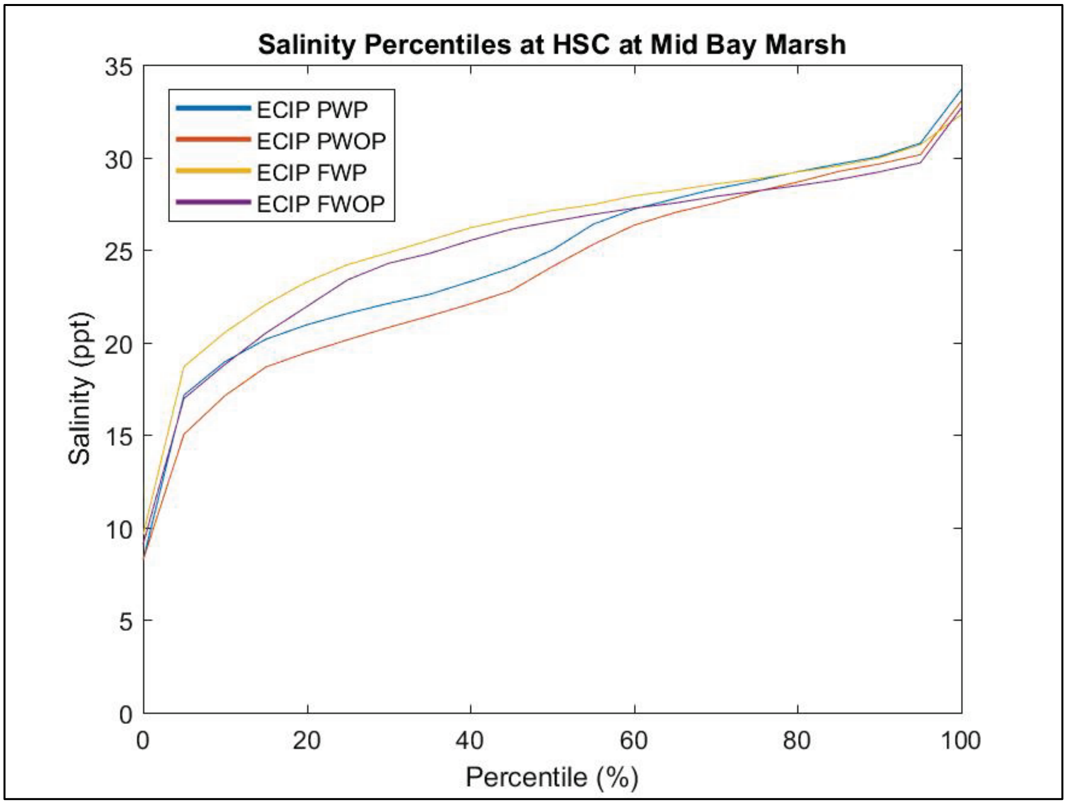
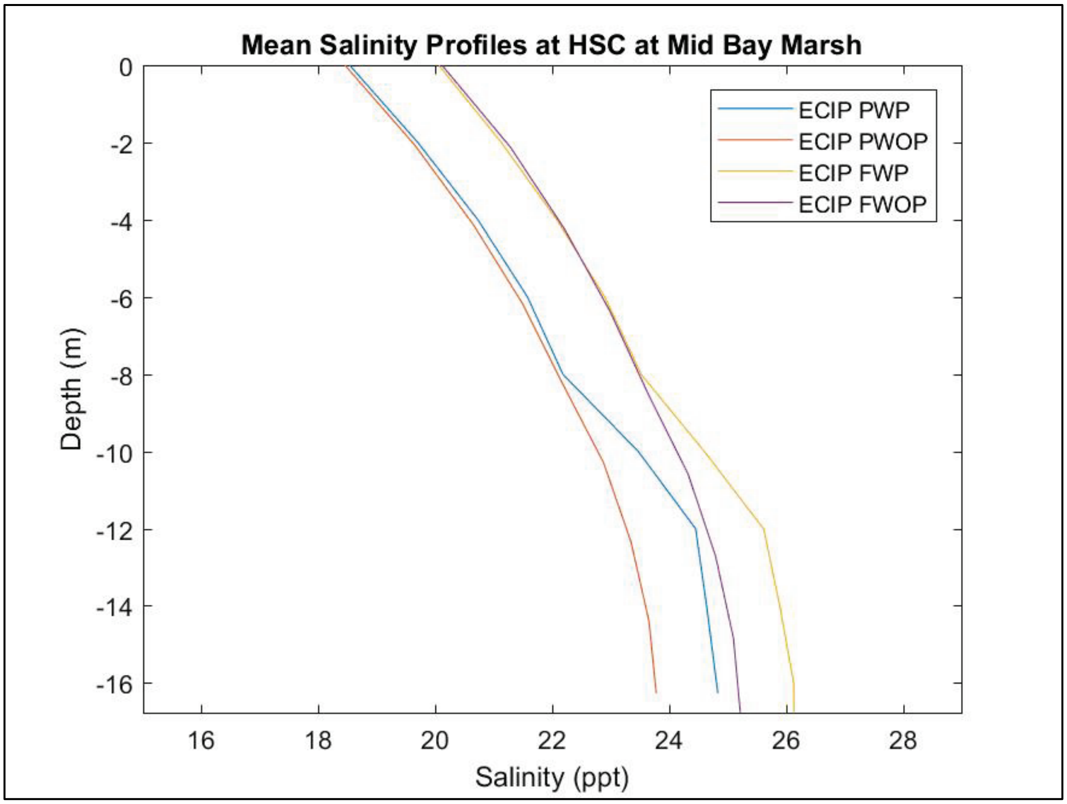
ECIP PWOP
ECIP FWP
ECIP FWOP


Salinity Percentiles at HSC at Mid Bay Marsh
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)


Mean Salinity Profiles at HSC at Mid Bay Marsh
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-2
-4
-6
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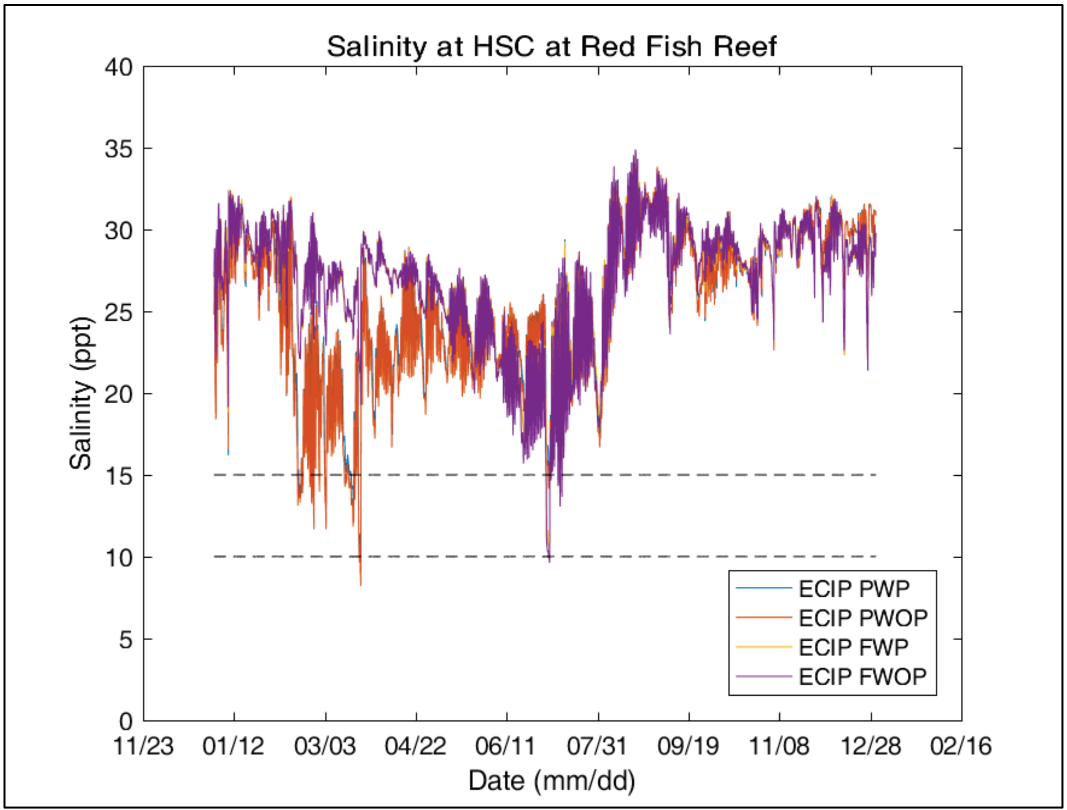
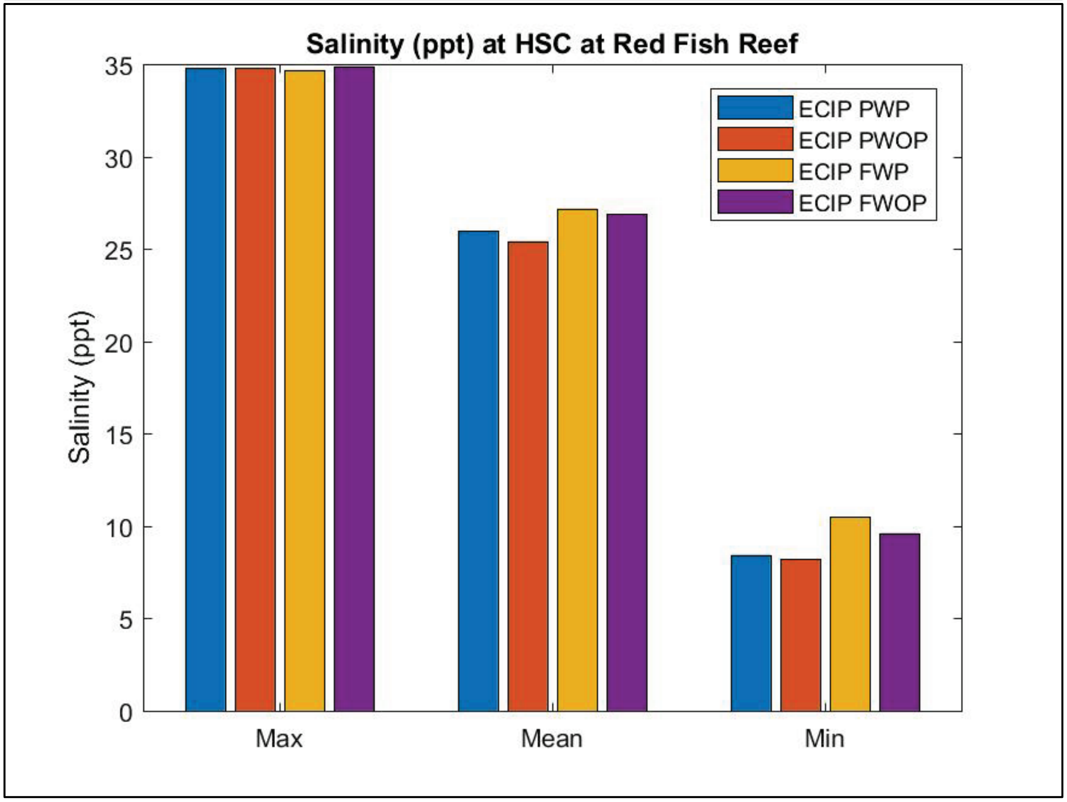
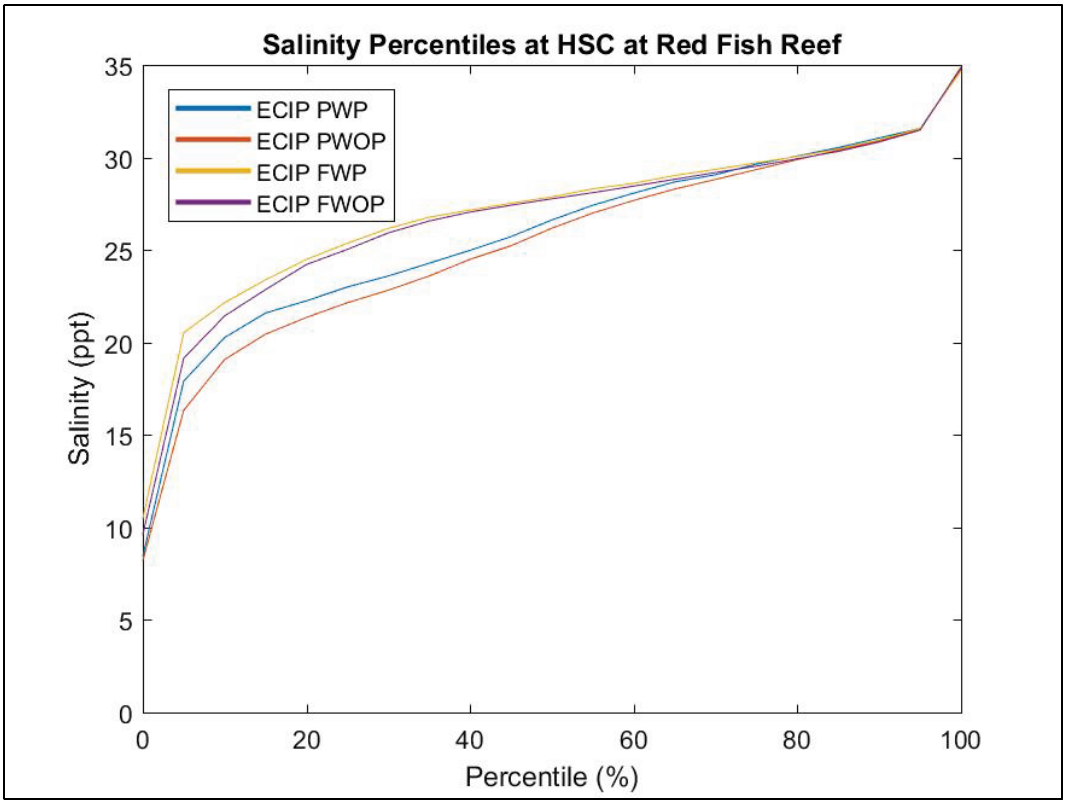
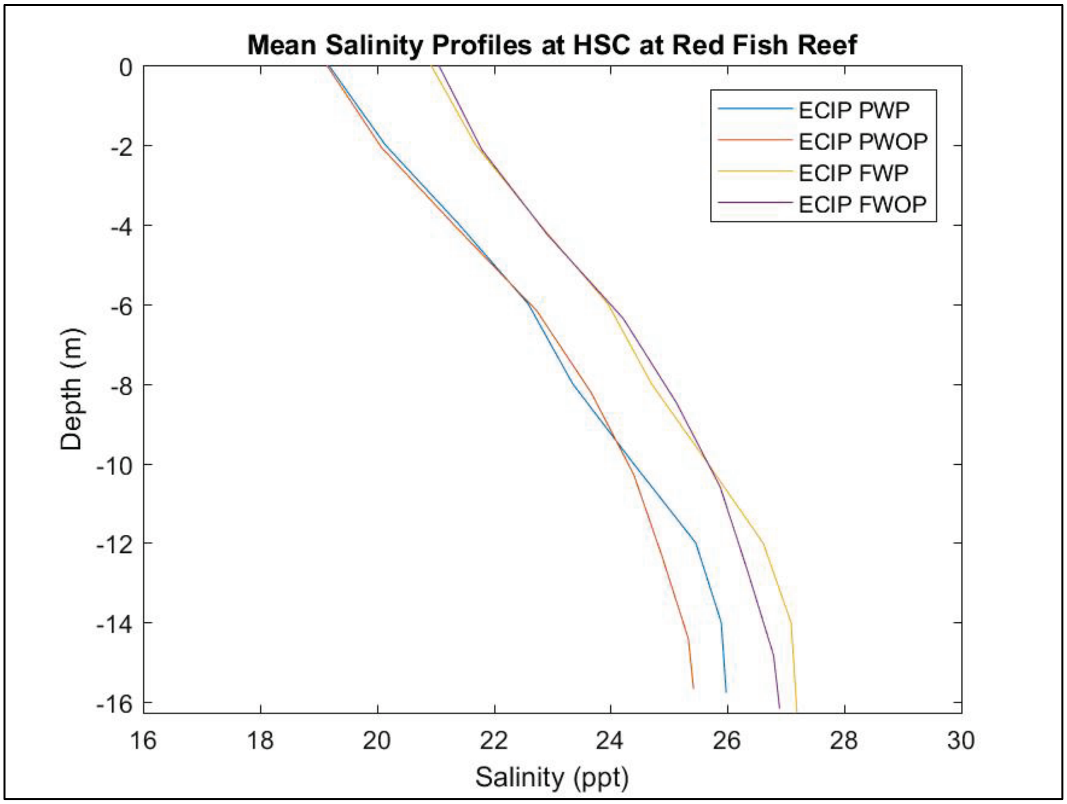
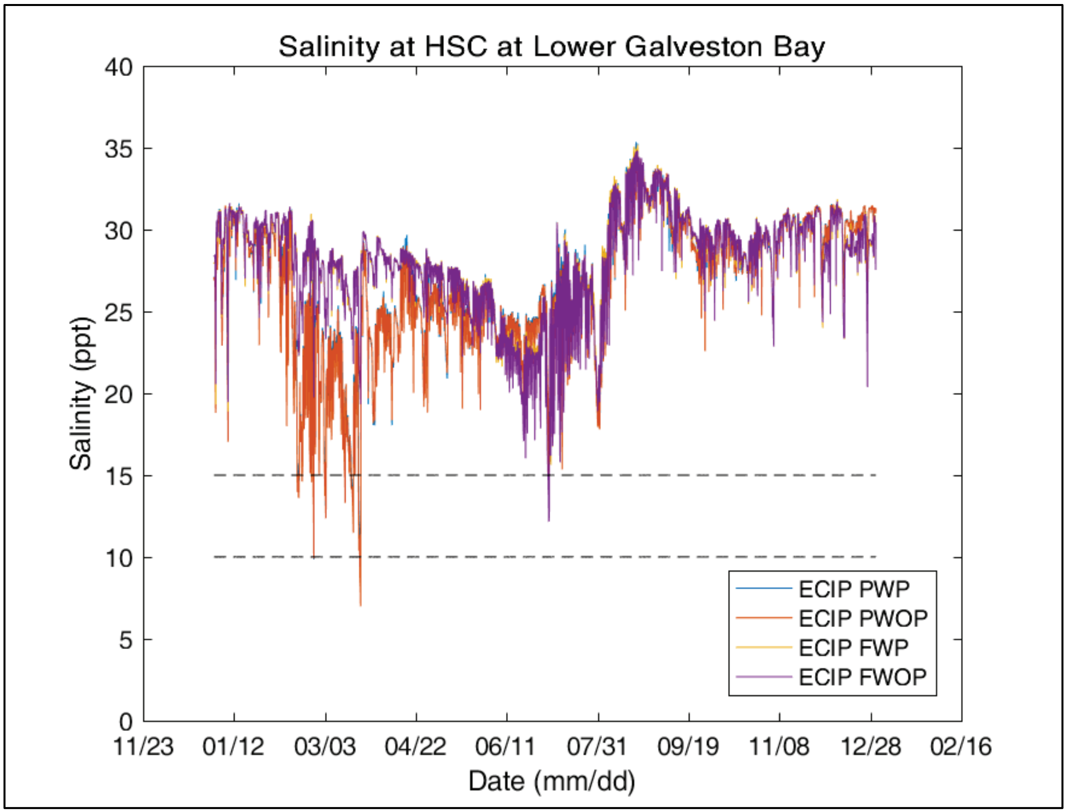
-14
-16
16
18
20
22
24
26
28
Salinity (ppt)

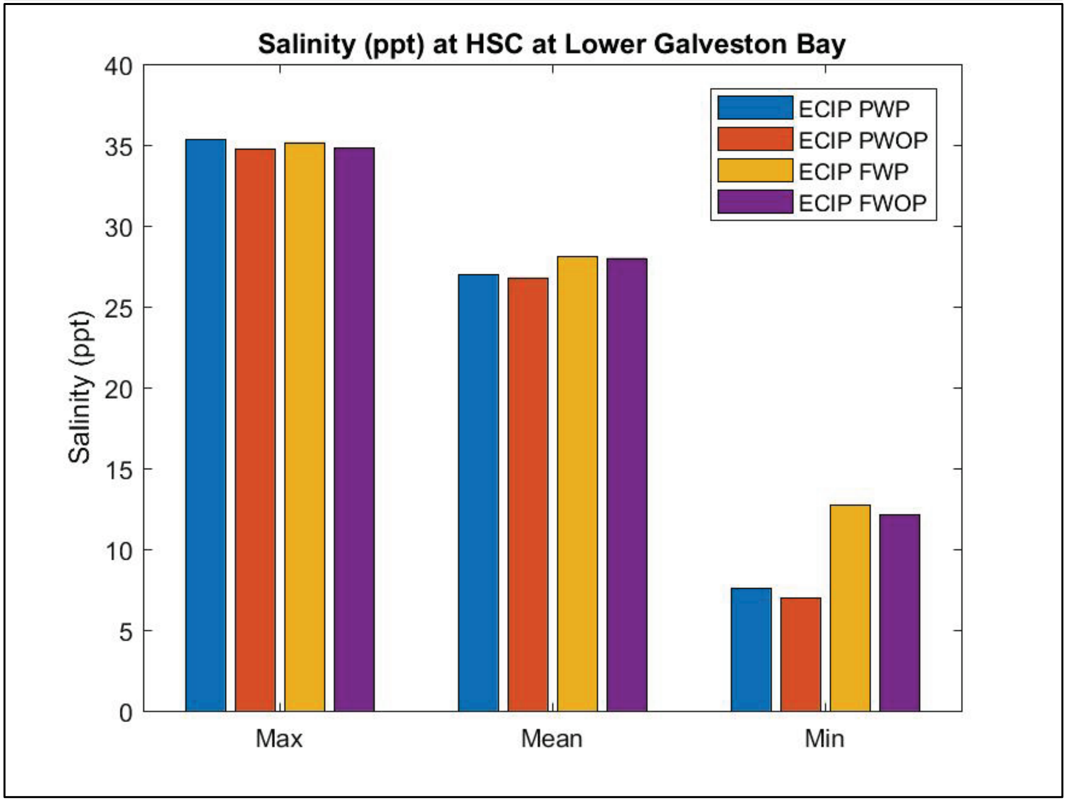

Salinity at HSC at Red Fish Reef
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

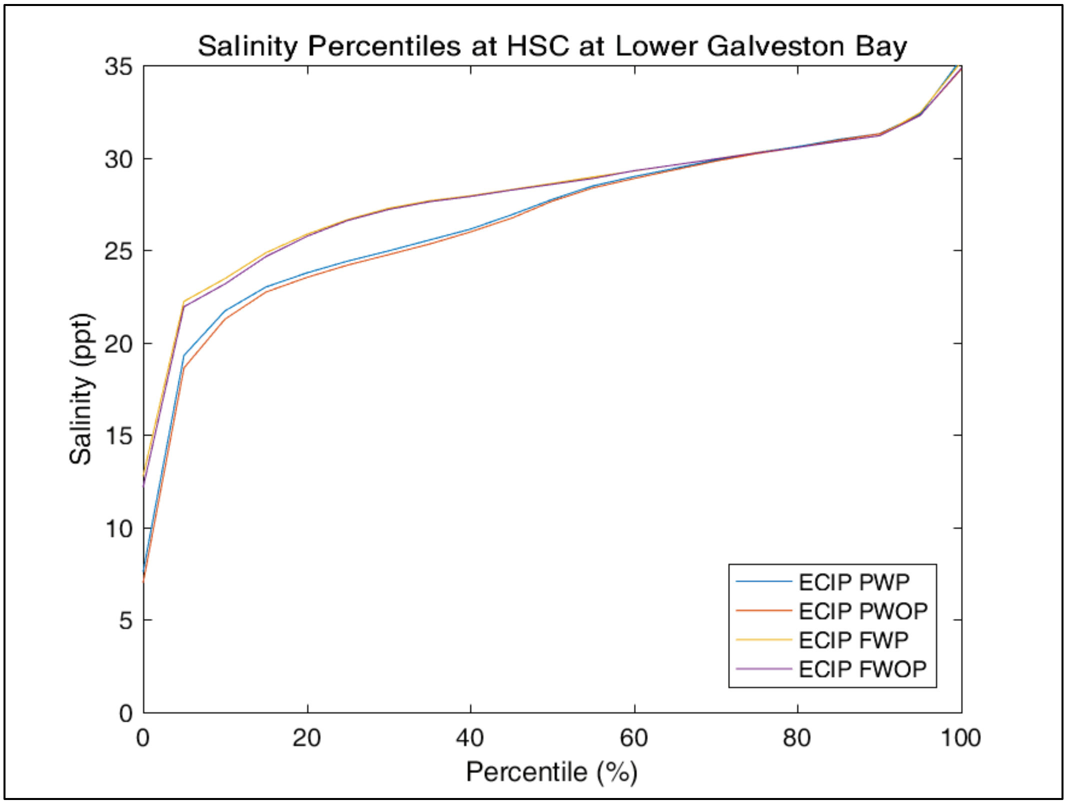

Salinity (ppt) at HSC at Red Fish Reef
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

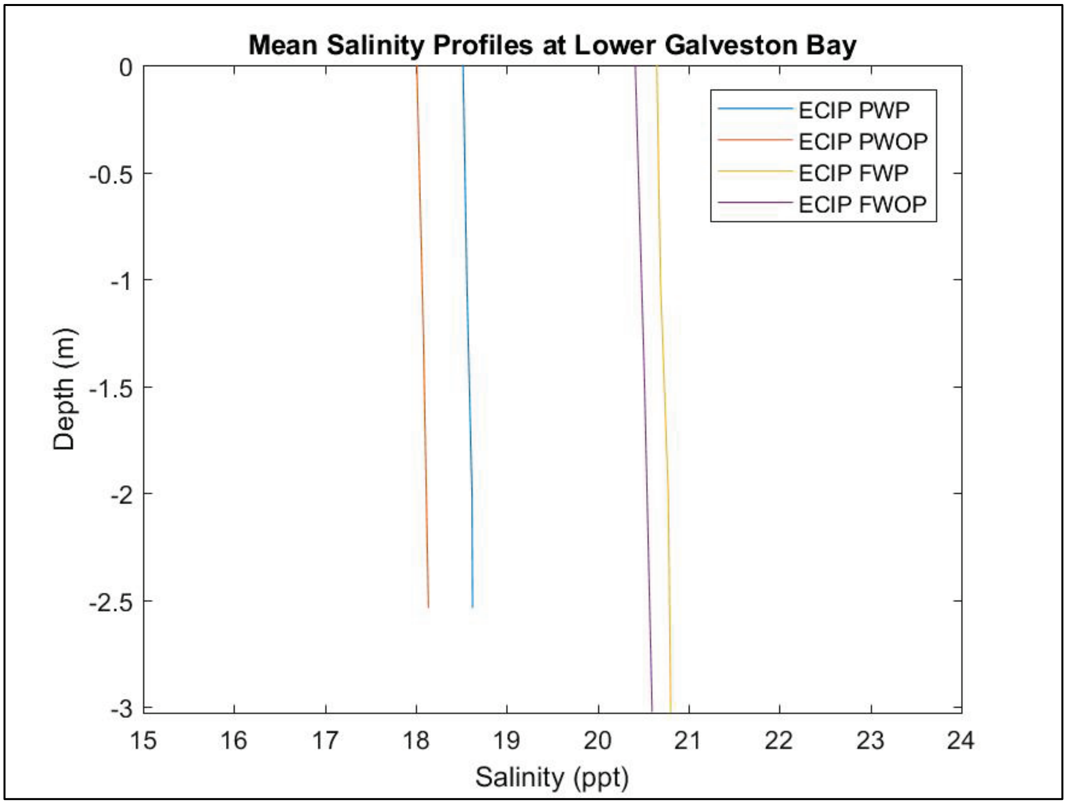

Salinity Percentiles at HSC at Red Fish Reef
Salinity (ppt)
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
0
5
10
15
20
25
30
35
0
20
40
60
80
100

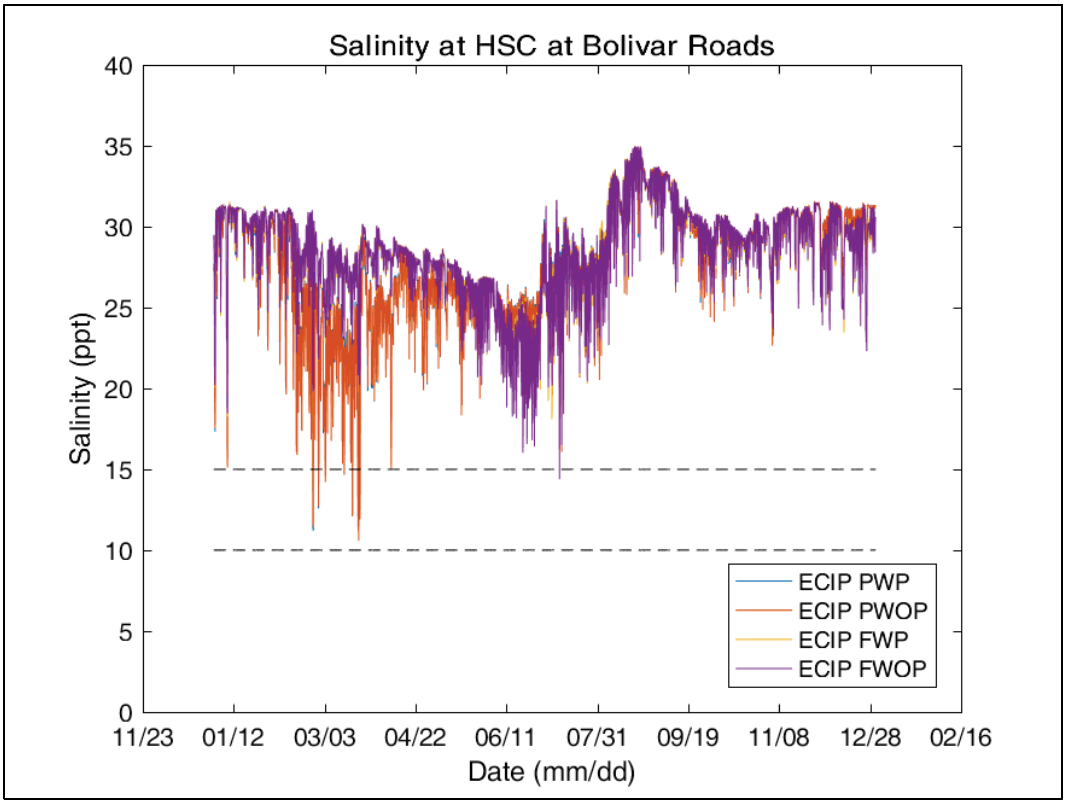

Mean Salinity Profiles at HSC at Red Fish Reef
Depth (m)
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
0
-2
-4
-6
-8
-10
-12
-14
-16
16
18
20
22
24
26
28
30

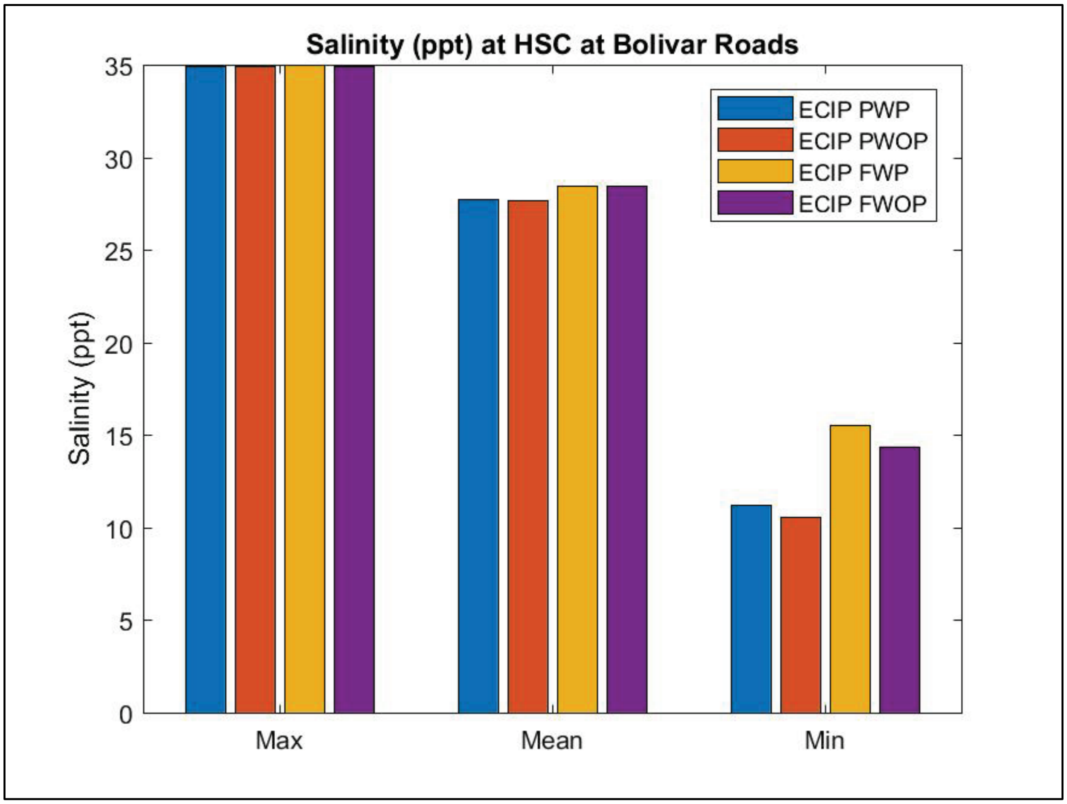

Salinity at HSC at Lower Galveston Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

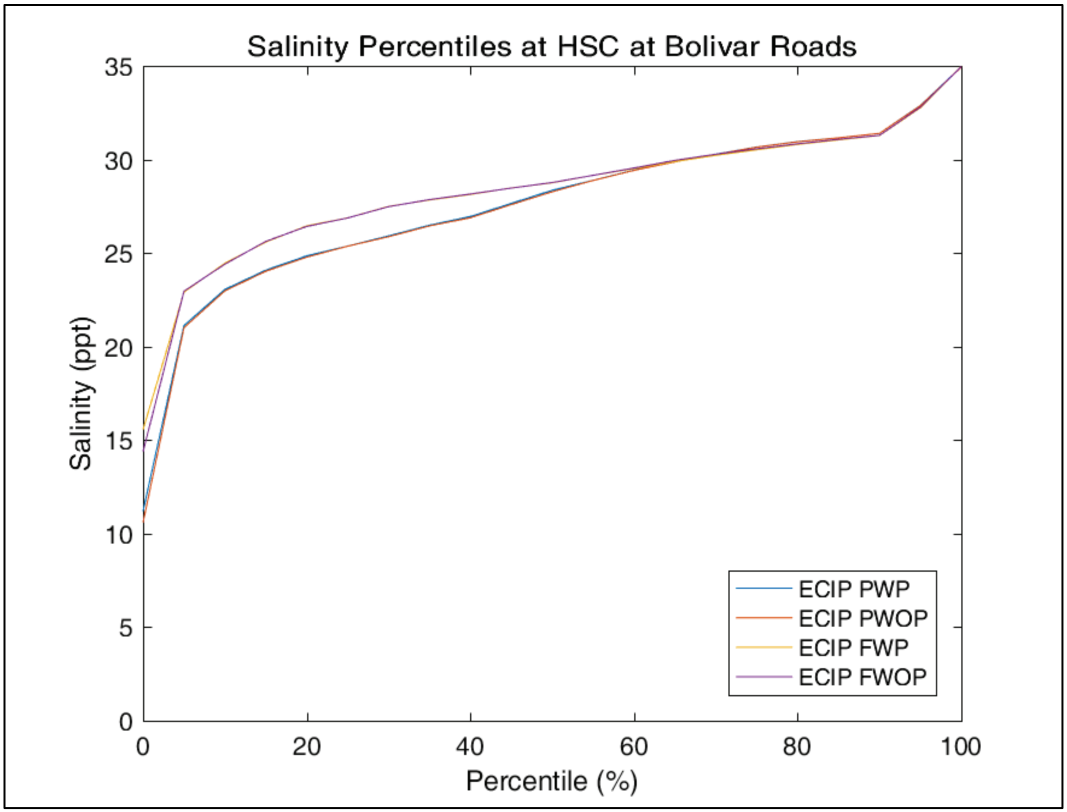

Salinity (ppt) at HSC at Lower Galveston Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

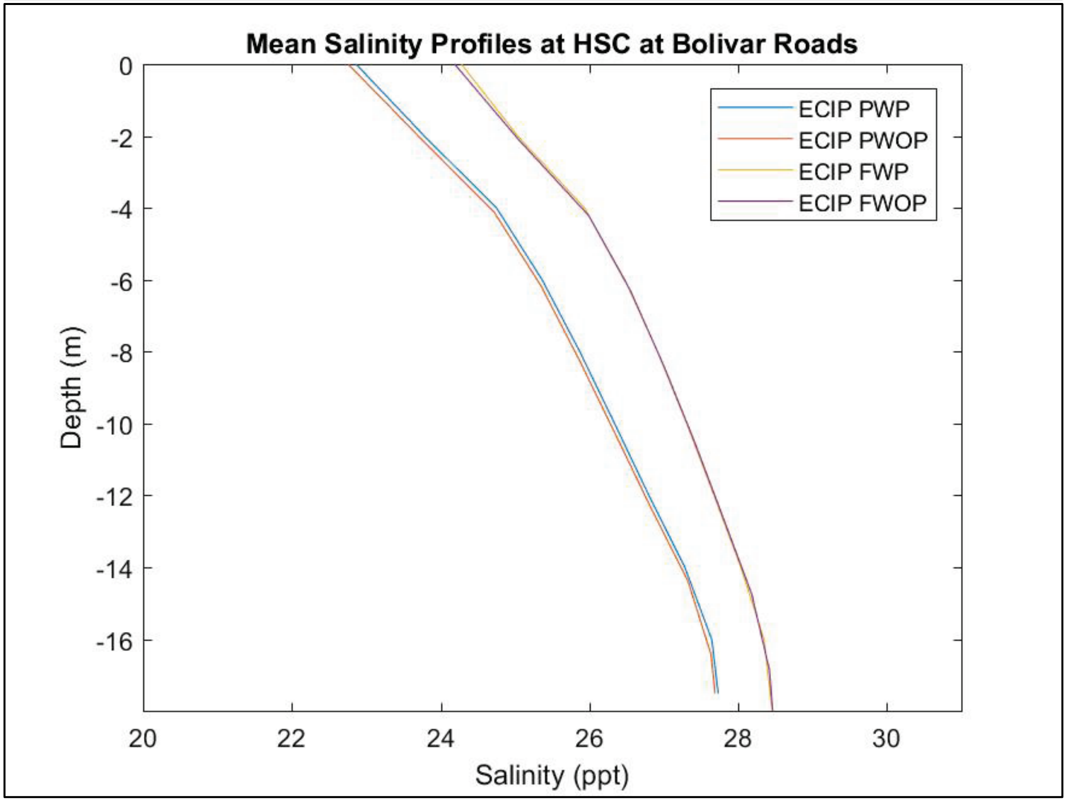

Salinity Percentiles at HSC at Lower Galveston Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

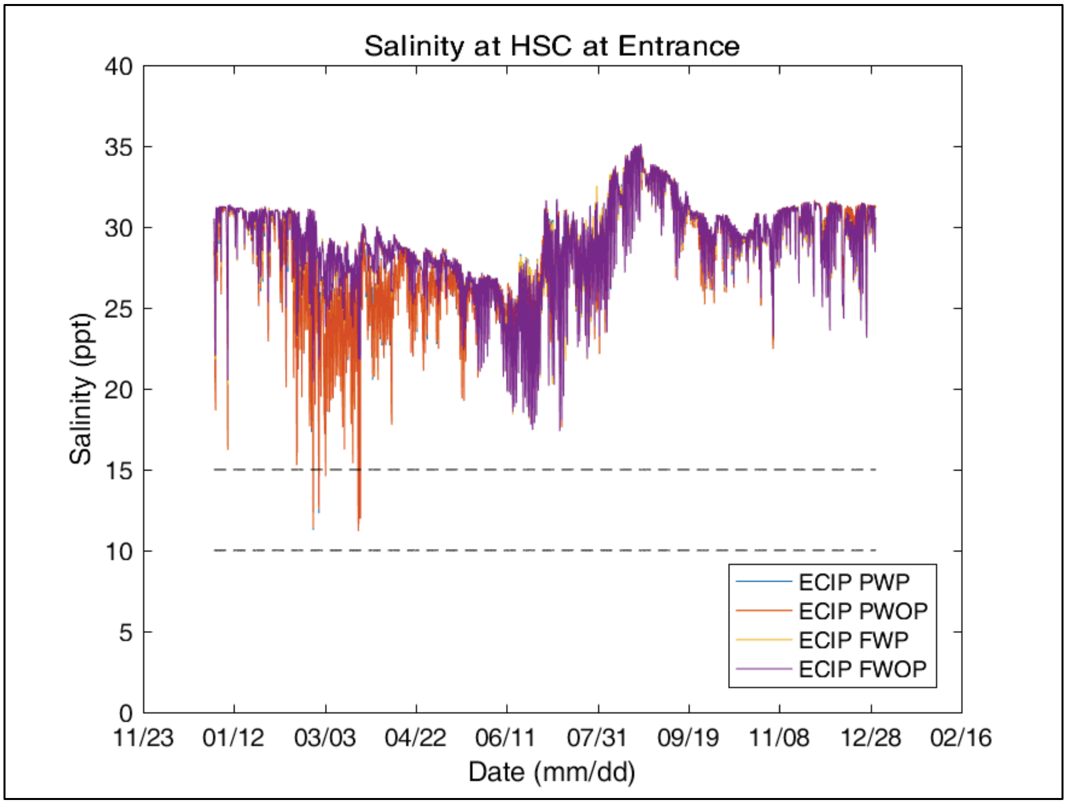

Mean Salinity Profiles at Lower Galveston Bay
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
15
16
17
18
19
20
21
22
23
24
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

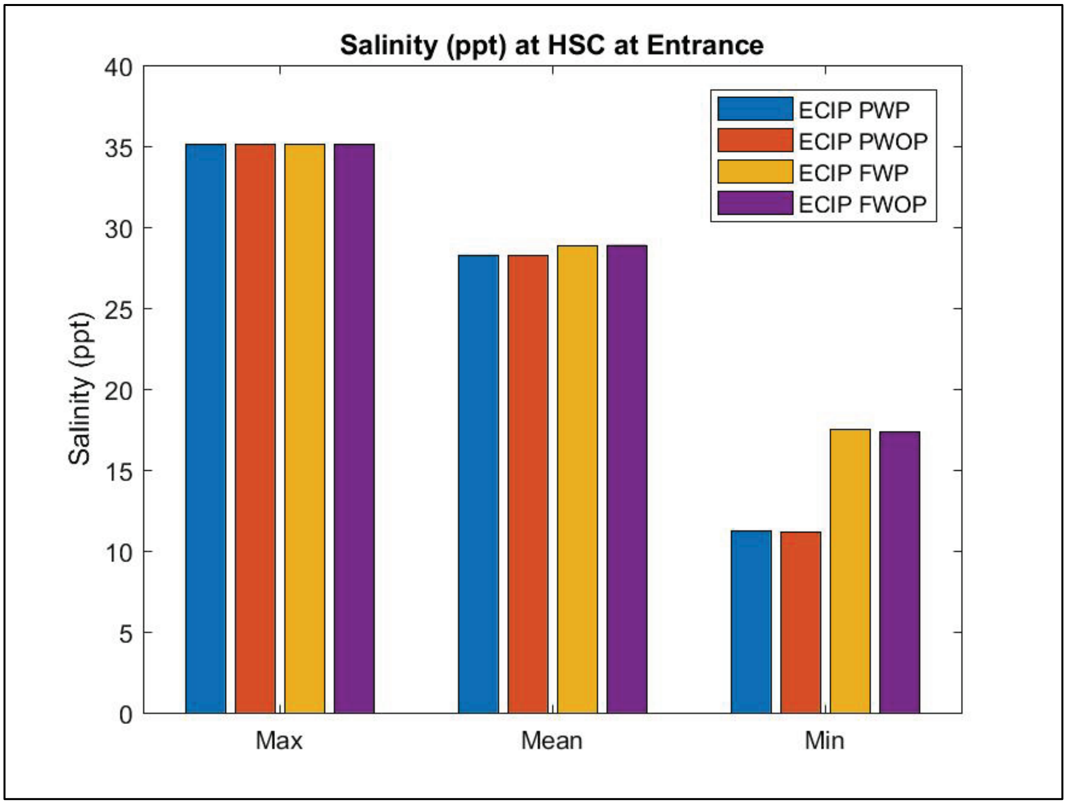

Salinity at HSC at Bolivar Roads
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

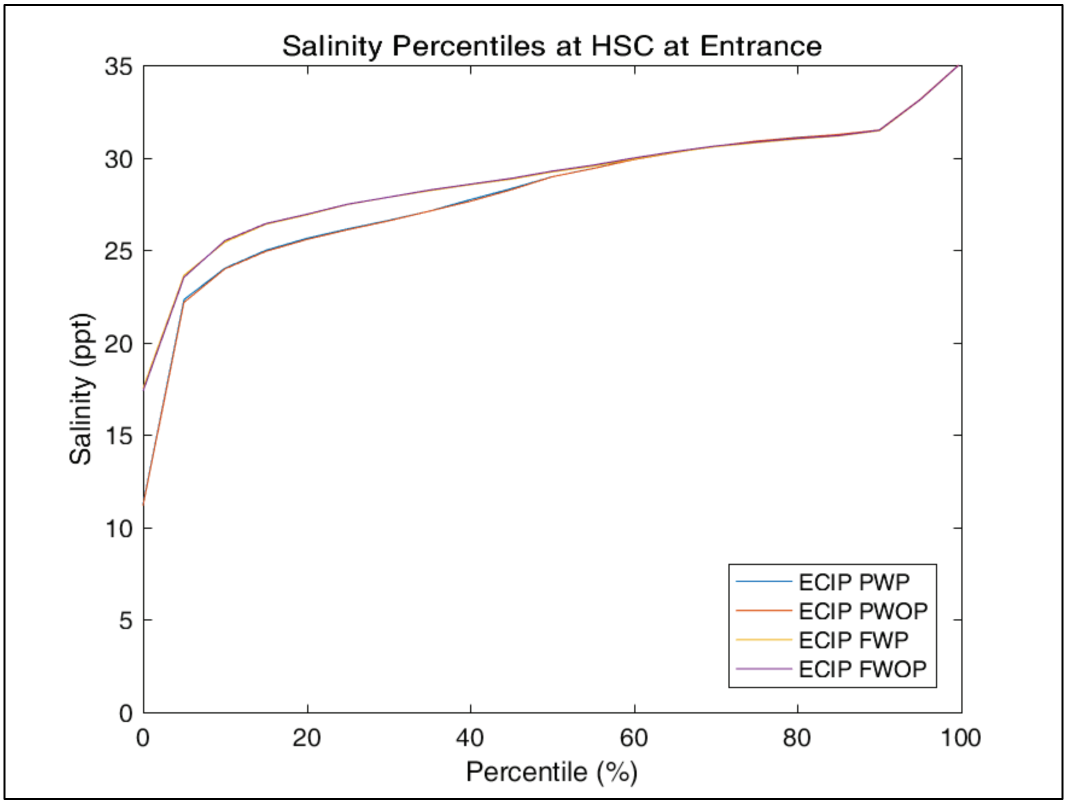

Salinity (ppt) at HSC at Bolivar Roads
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

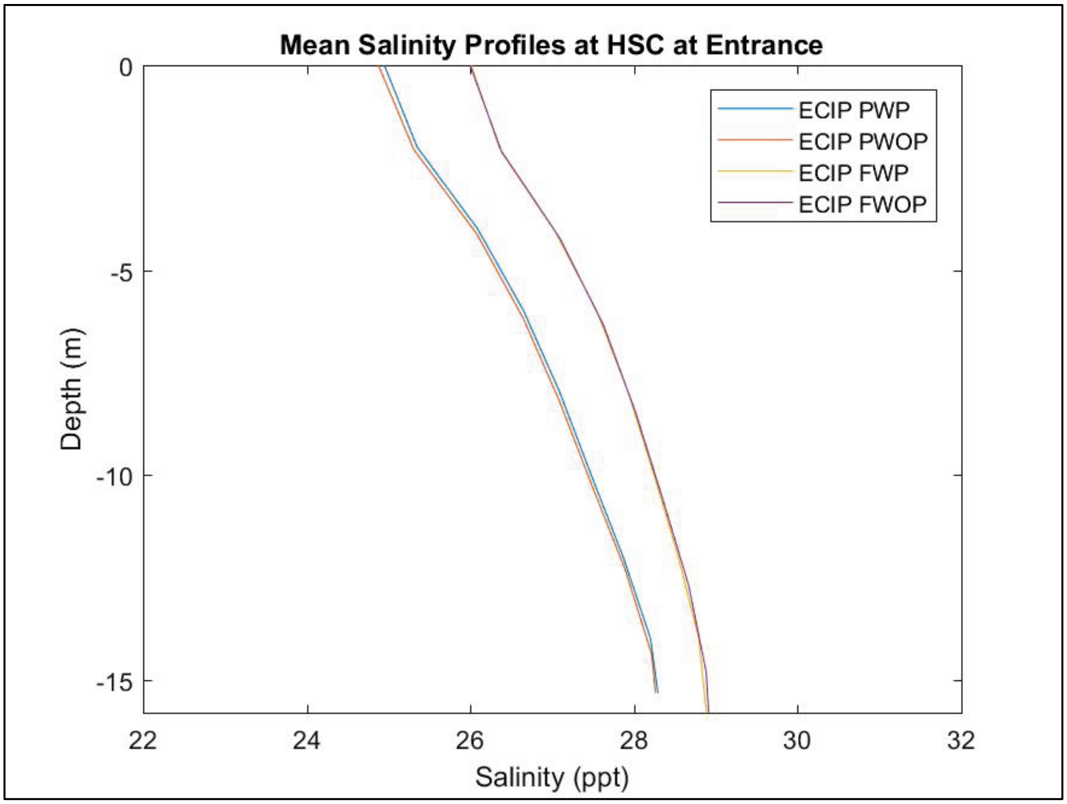

Salinity Percentiles at HSC at Bolivar Roads
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

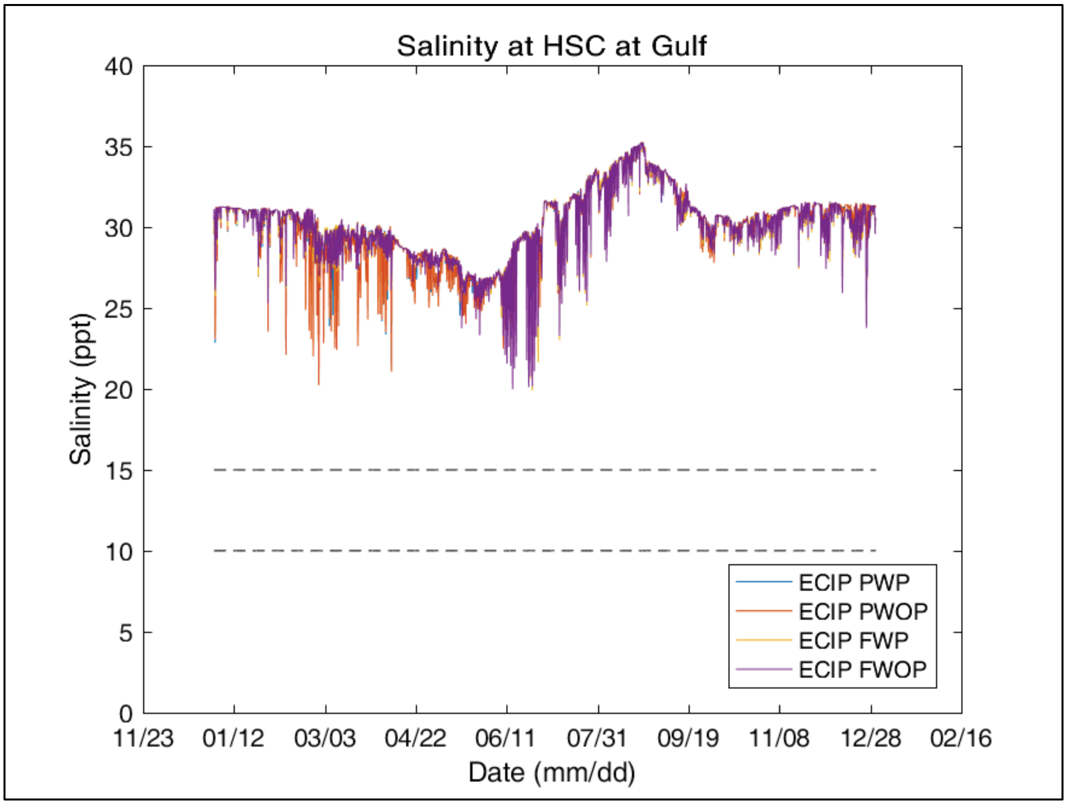

Mean Salinity Profiles at HSC at Bolivar Roads
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
20
22
24
26
28
30
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

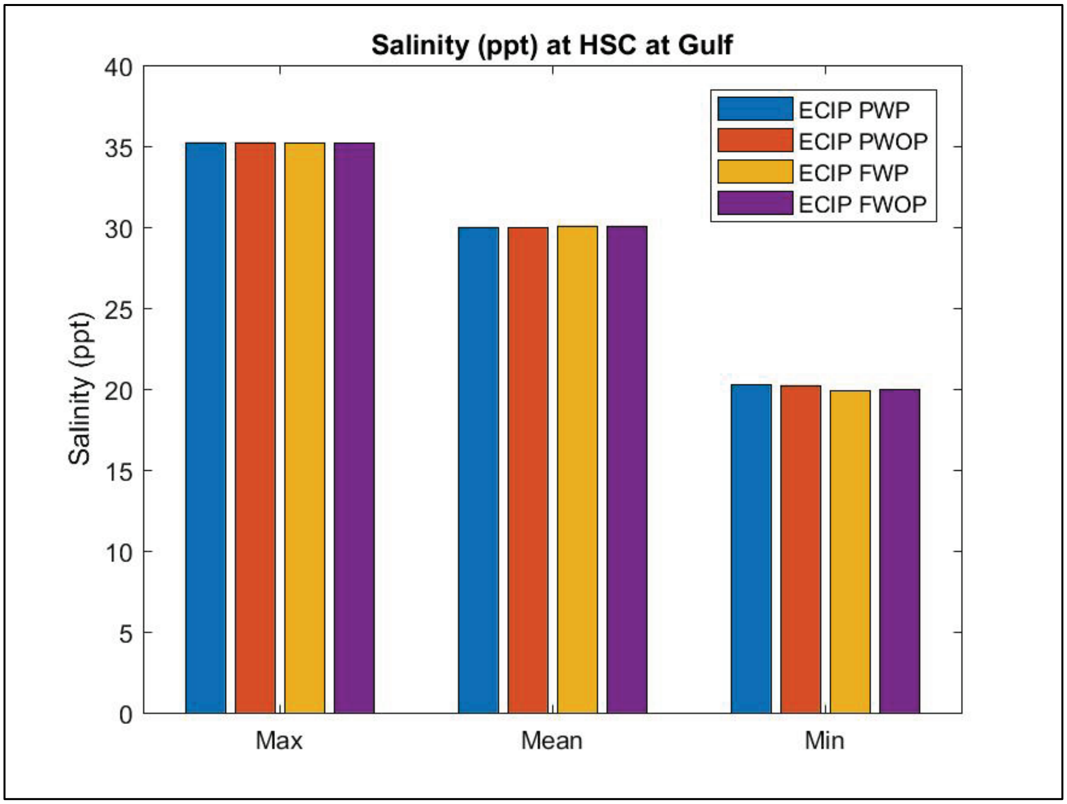

Salinity at HSC at Entrance
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

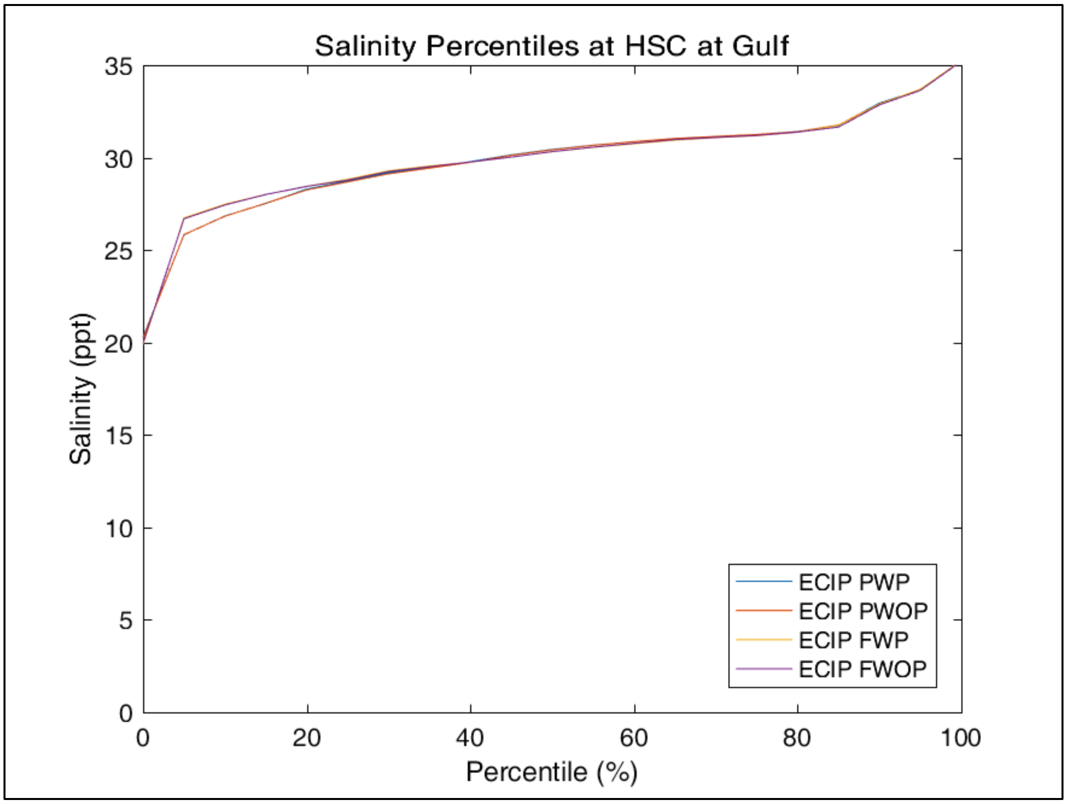

Salinity (ppt) at HSC at Entrance
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

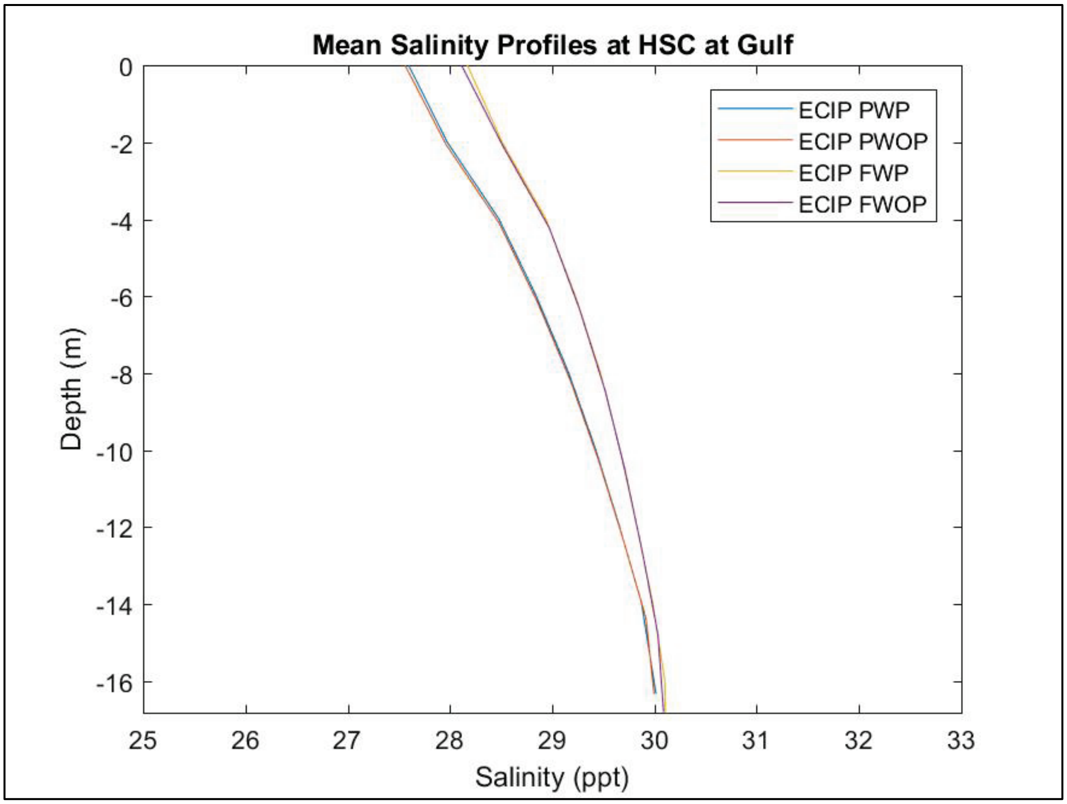

Salinity Percentiles at HSC at Entrance
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

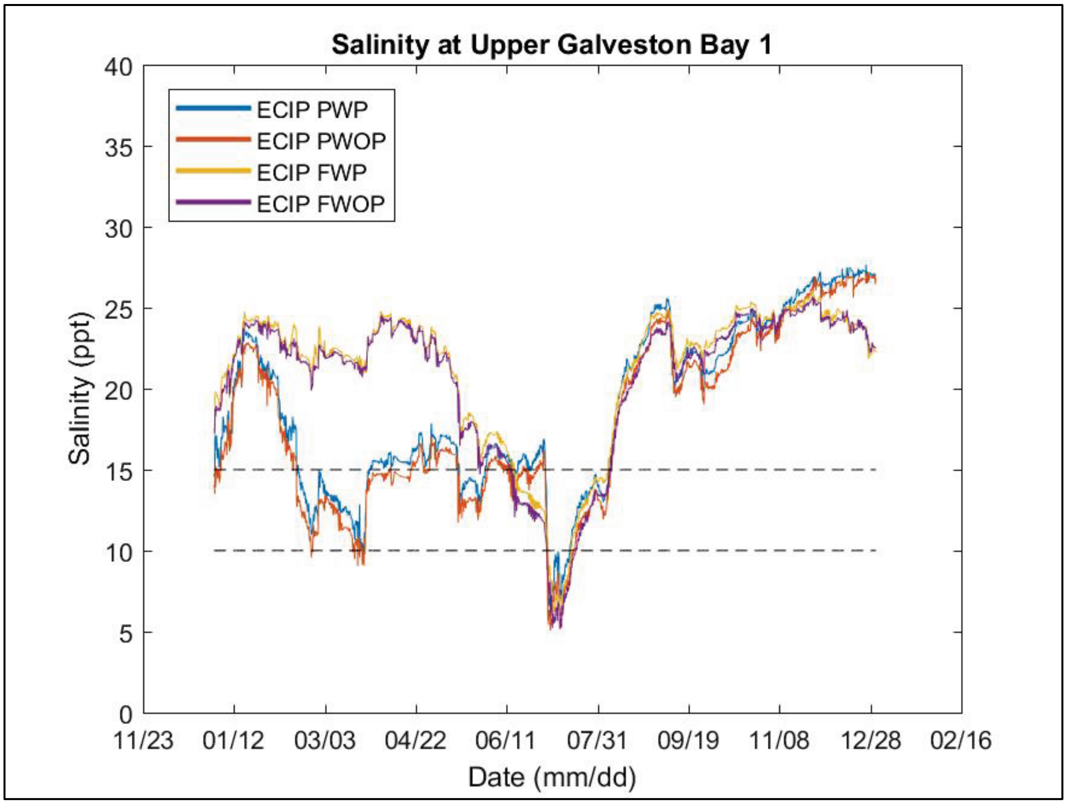

Mean Salinity Profiles at HSC at Entrance
Depth (m)
Salinity (ppt)
0
-5
-10
-15
22
24
26
28
30
32
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

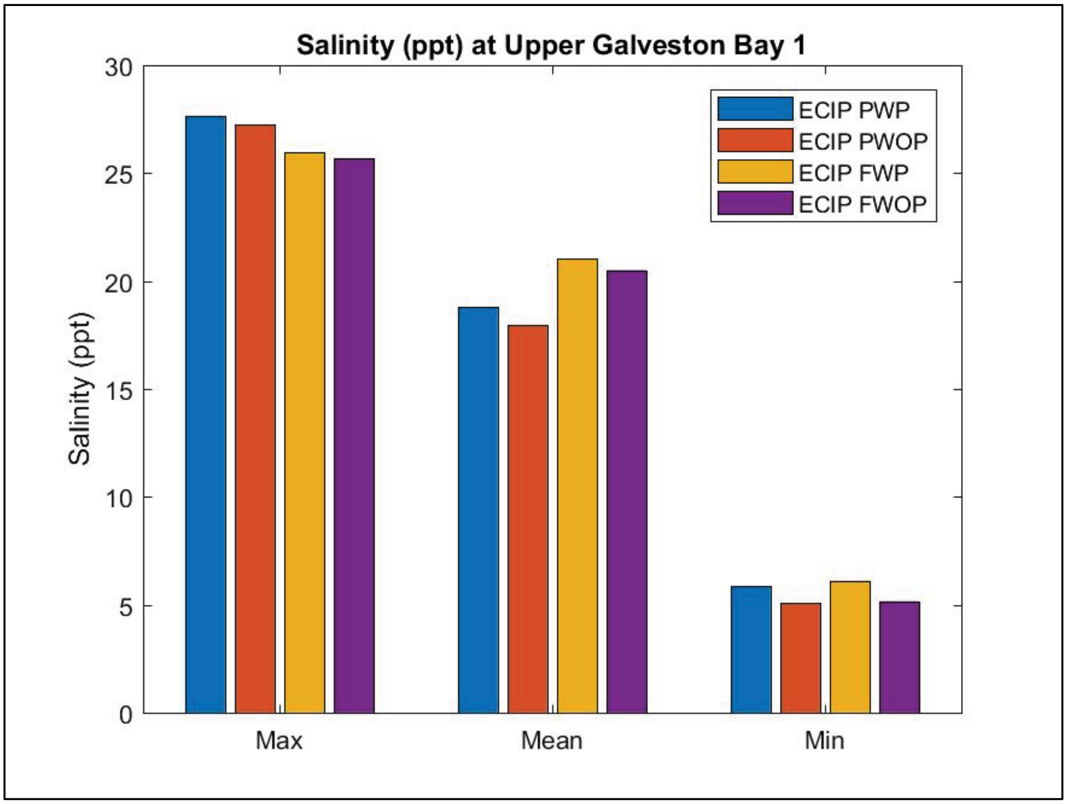

Salinity at HSC at Gulf
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

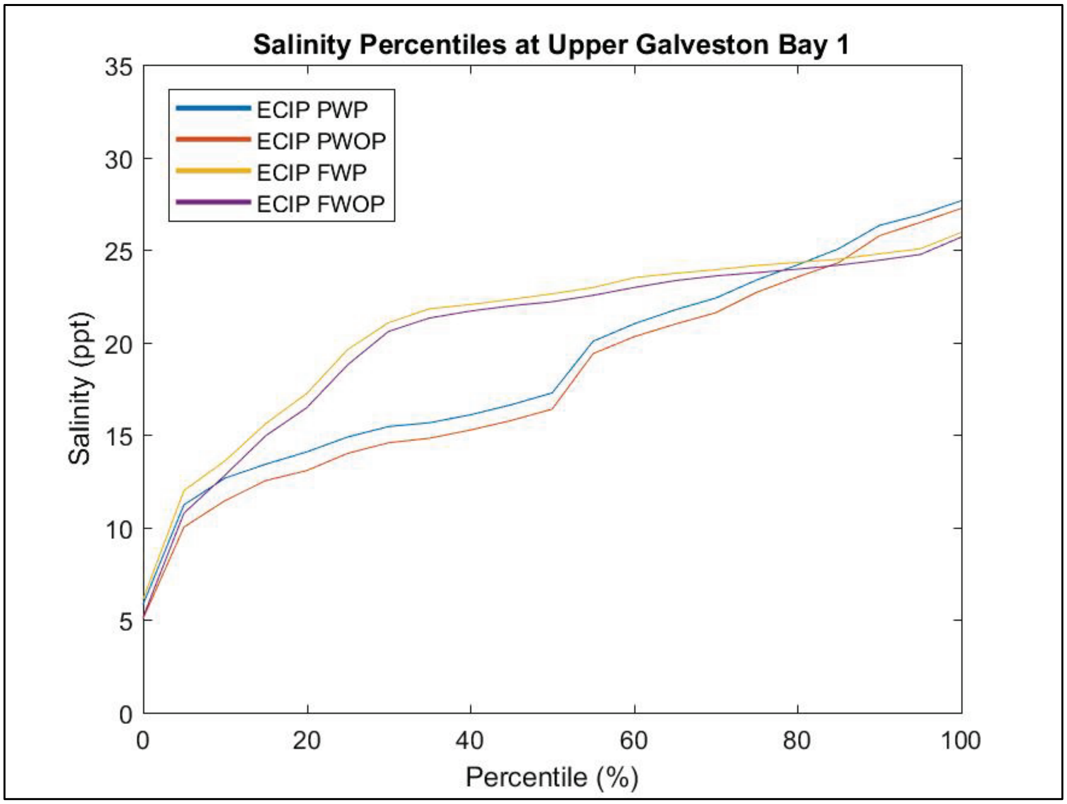

Salinity (ppt) at HSC at Gulf
Salinity (ppt)
40
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

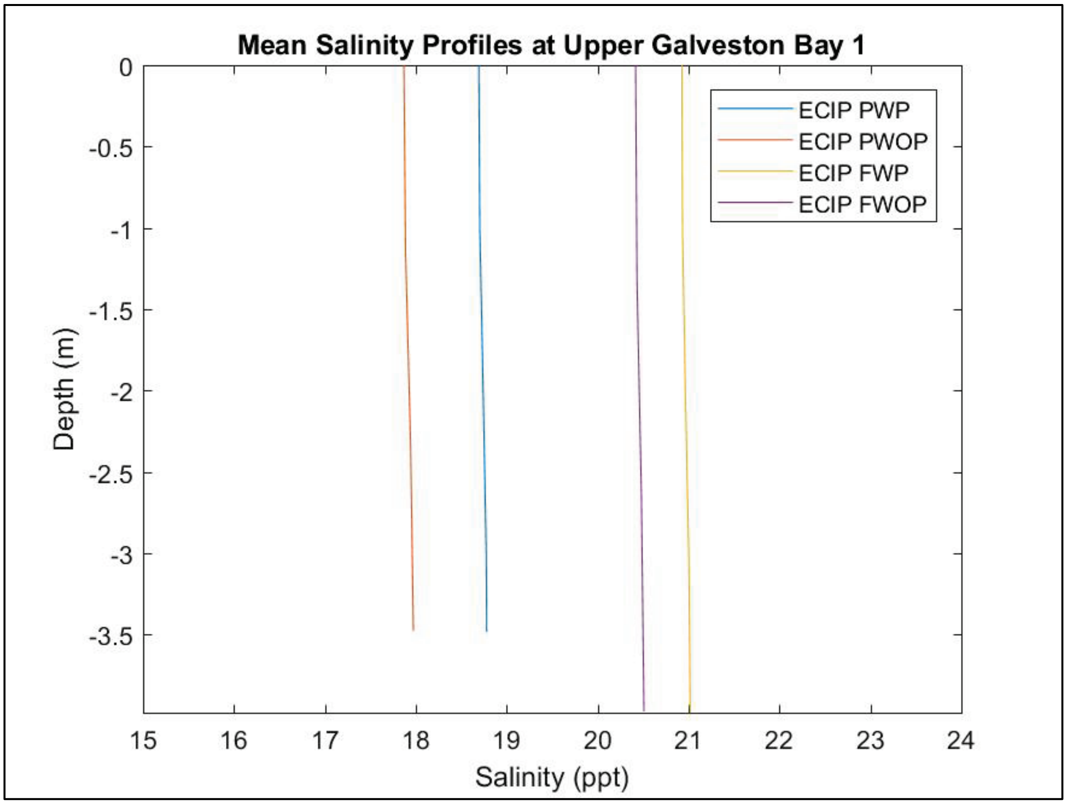

Salinity Percentiles at HSC at Gulf
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

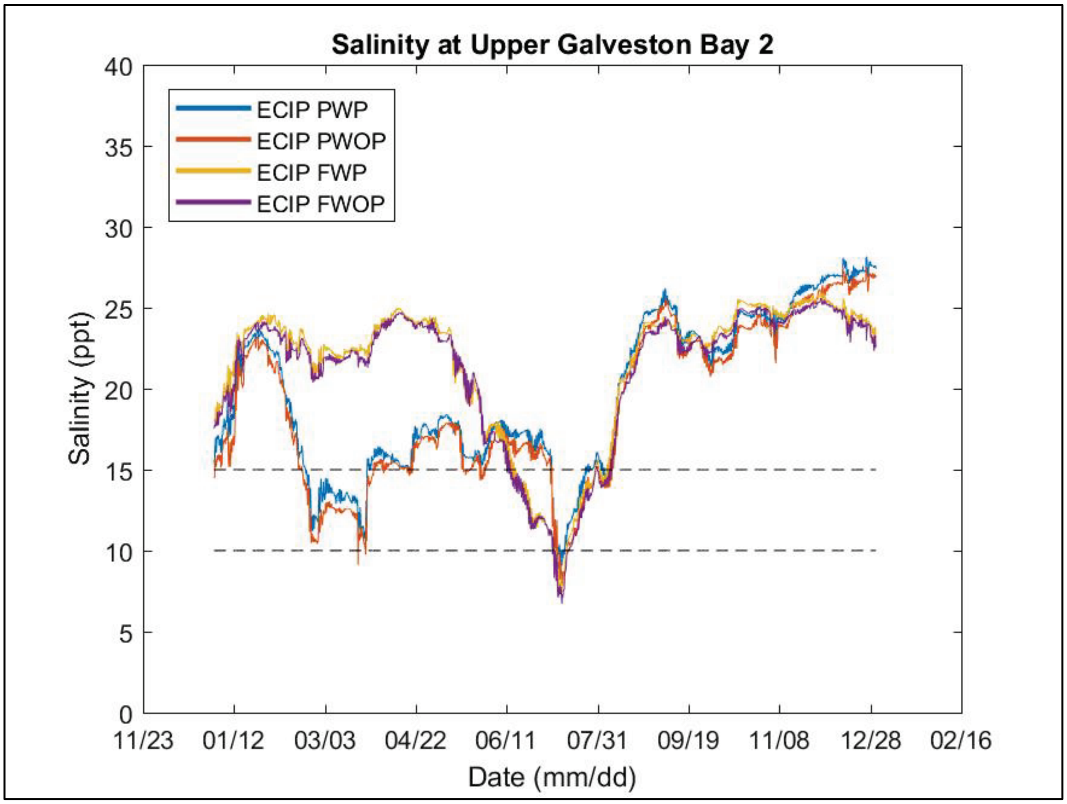

Mean Salinity Profiles at HSC at Gulf
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
25
26
27
28
29
30
31
32
33
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

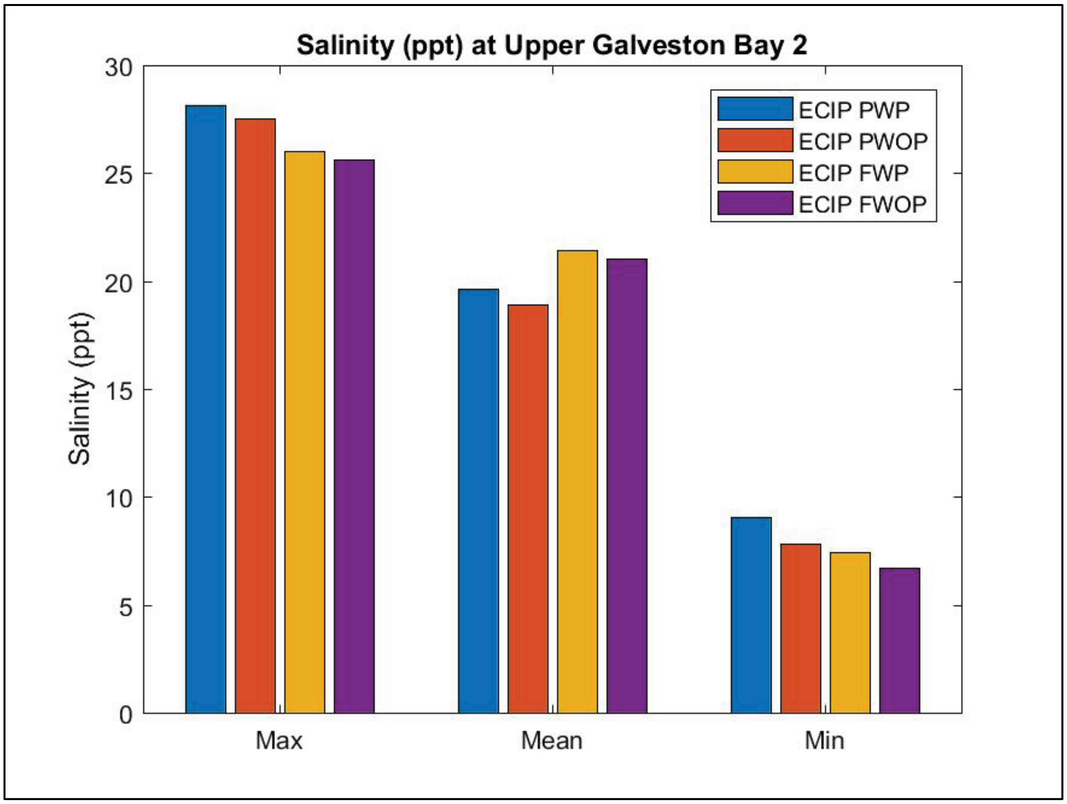

Salinity at Upper Galveston Bay 1
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

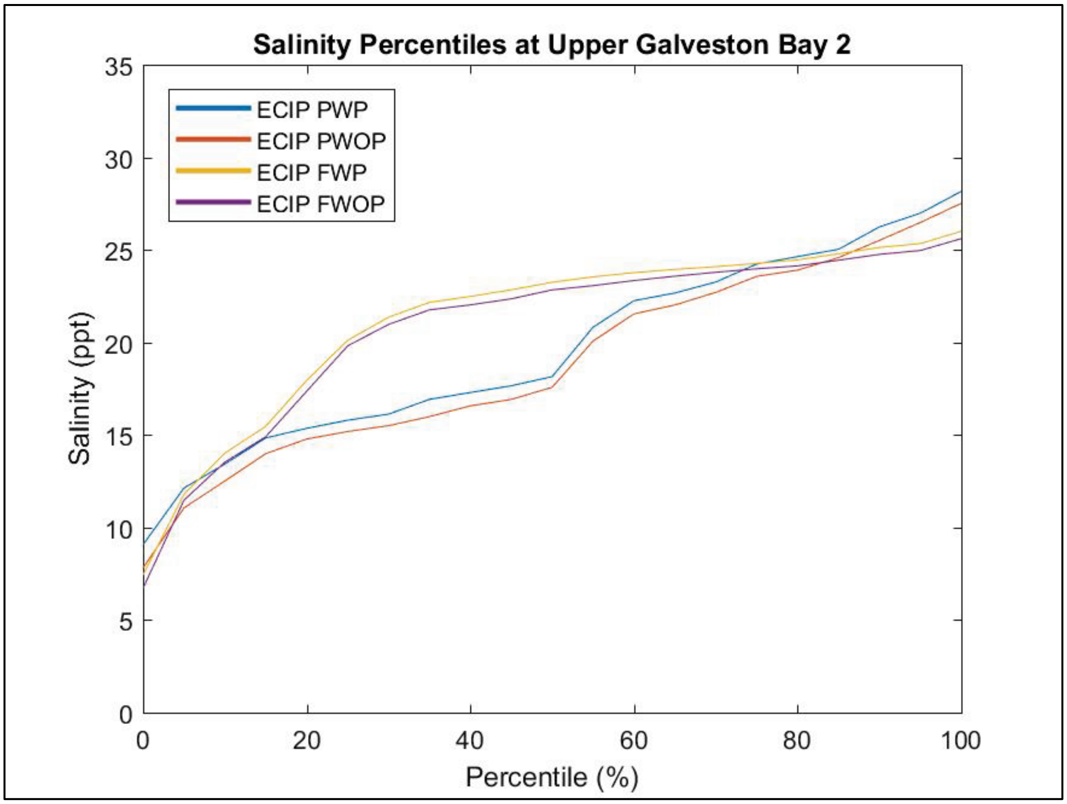

Salinity (ppt) at Upper Galveston Bay 1
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

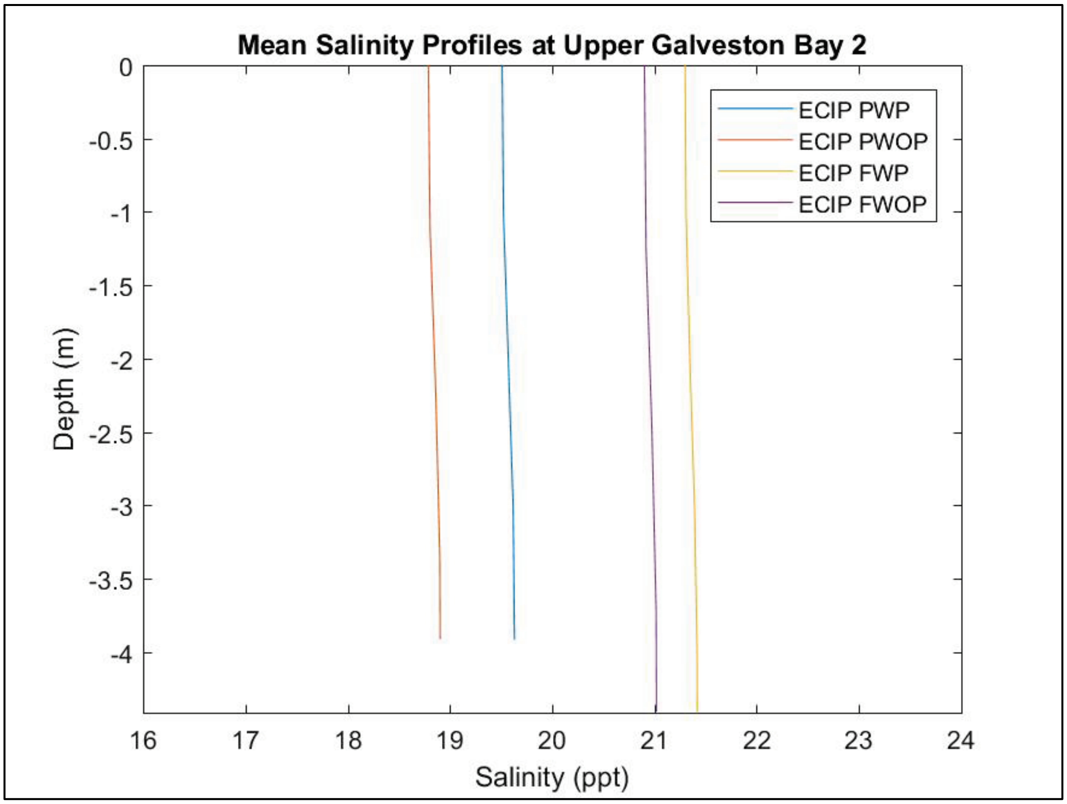

Salinity Percentiles at Upper Galveston Bay 1
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
Percentile (%)
0
20
40
60
80
100

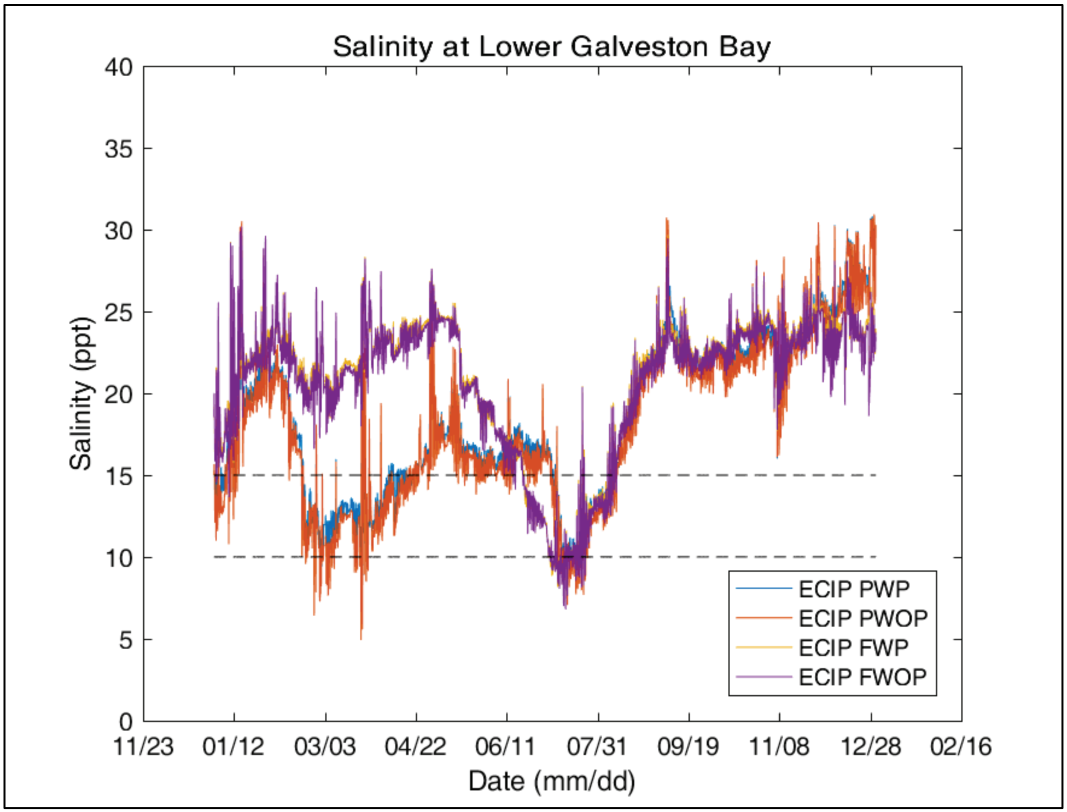

Mean Salinity Profiles at Upper Galveston Bay 1
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Salinity (ppt)
15
16
17
18
19
20
21
22
23
24

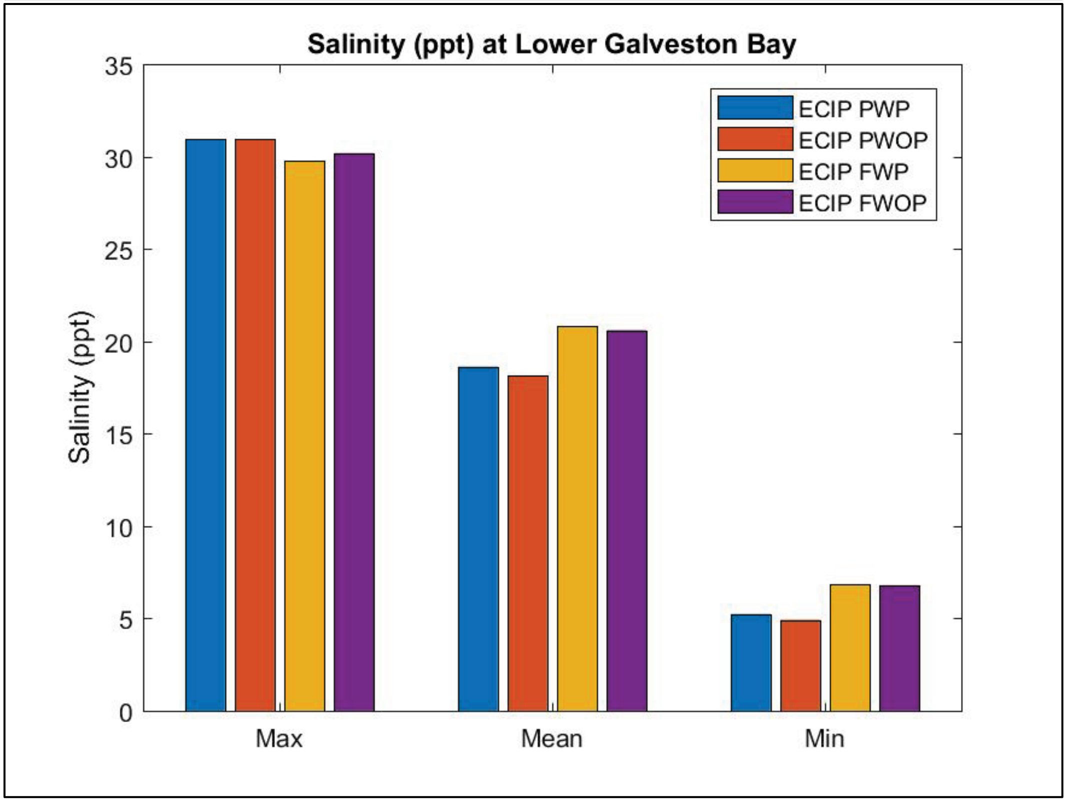

Salinity at Upper Galveston Bay 2
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

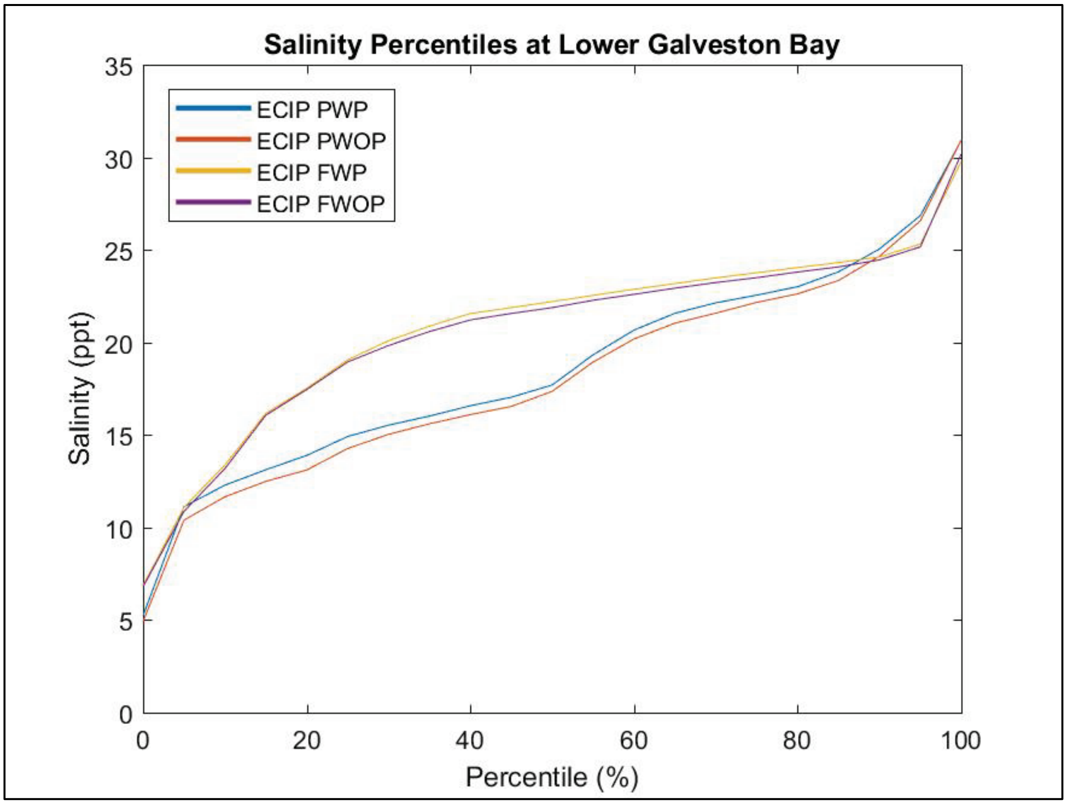

Salinity (ppt) at Upper Galveston Bay 2
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

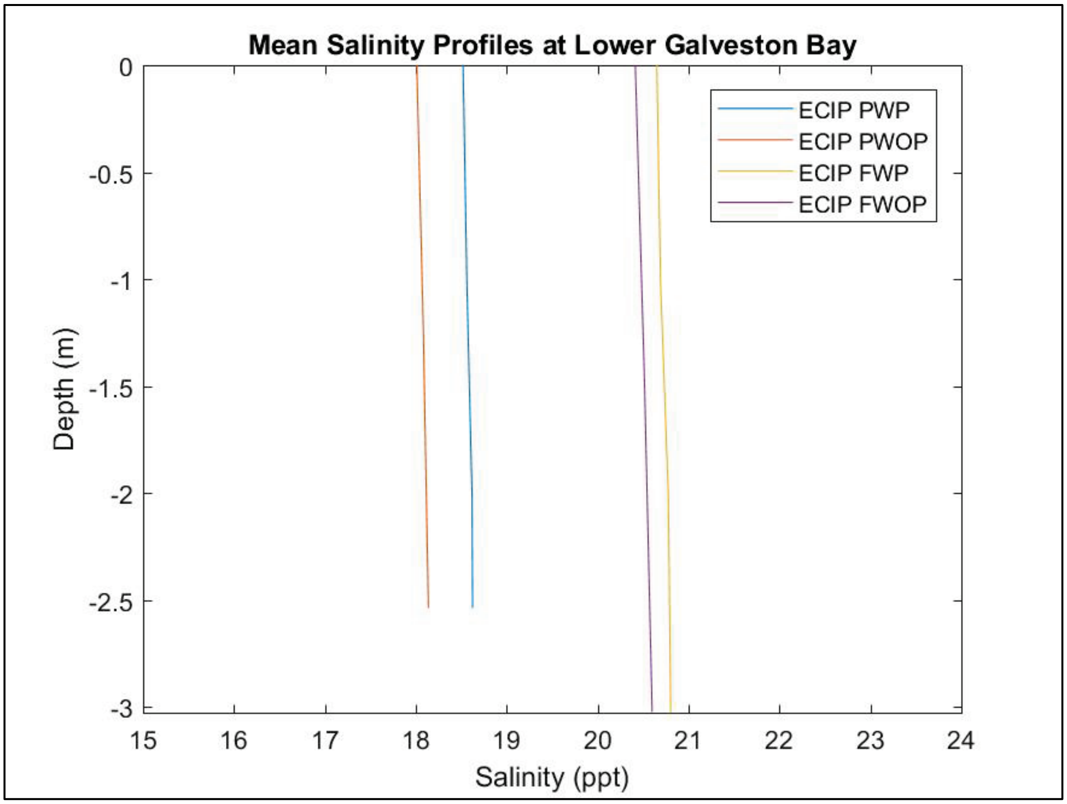

Salinity Percentiles at Upper Galveston Bay 2
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Percentile (%)
0
20
40
60
80
100

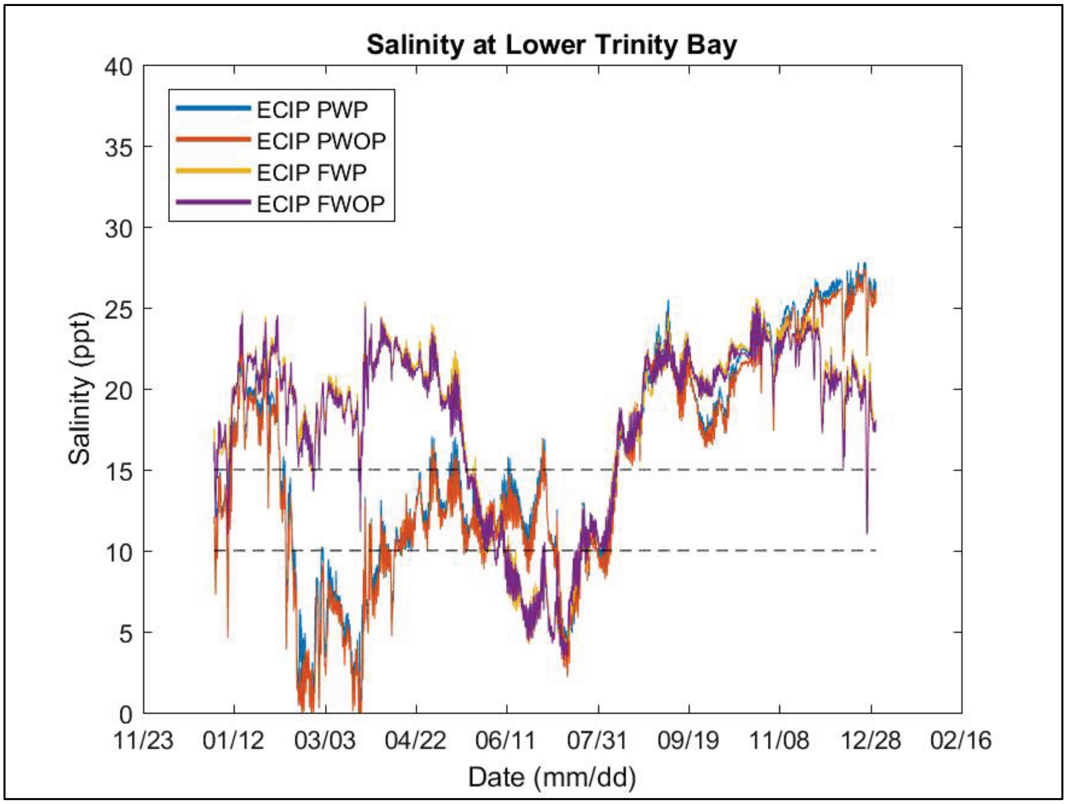

Mean Salinity Profiles at Upper Galveston Bay 2
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
Salinity (ppt)
16
17
18
19
20
21
22
23
24

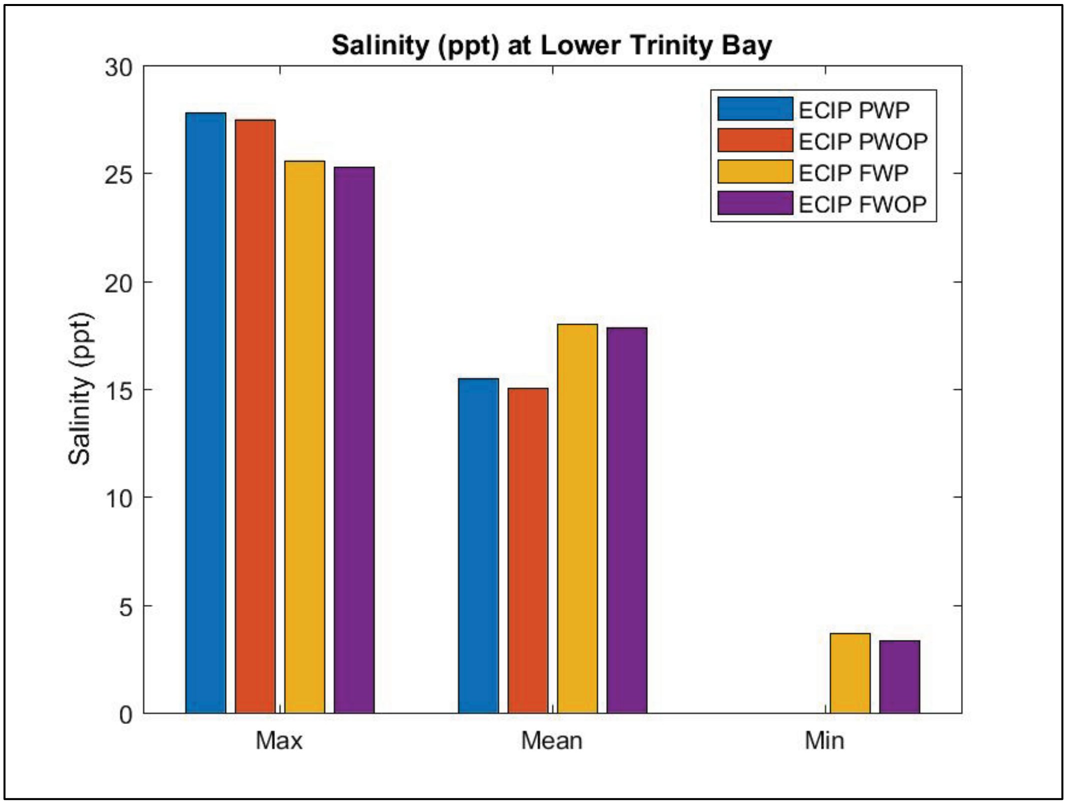

Salinity at Lower Galveston Bay
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

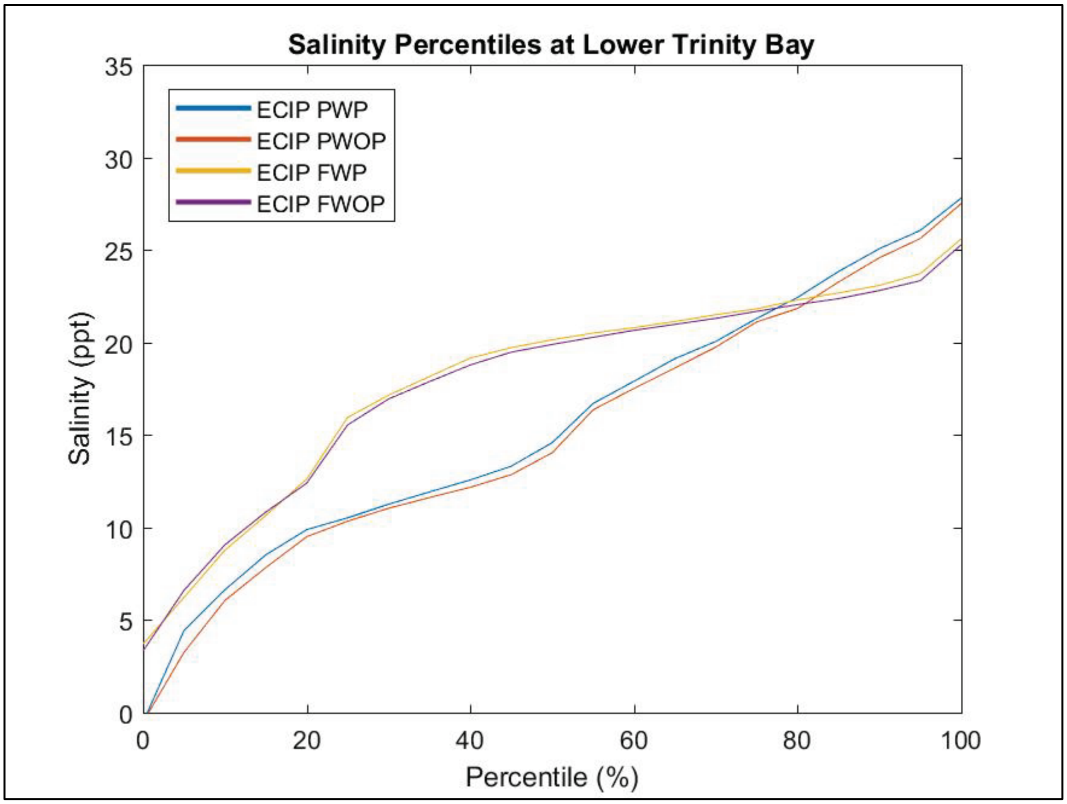

Salinity (ppt) at Lower Galveston Bay
Salinity (ppt)
0
5
10
15
20
25
30
35
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

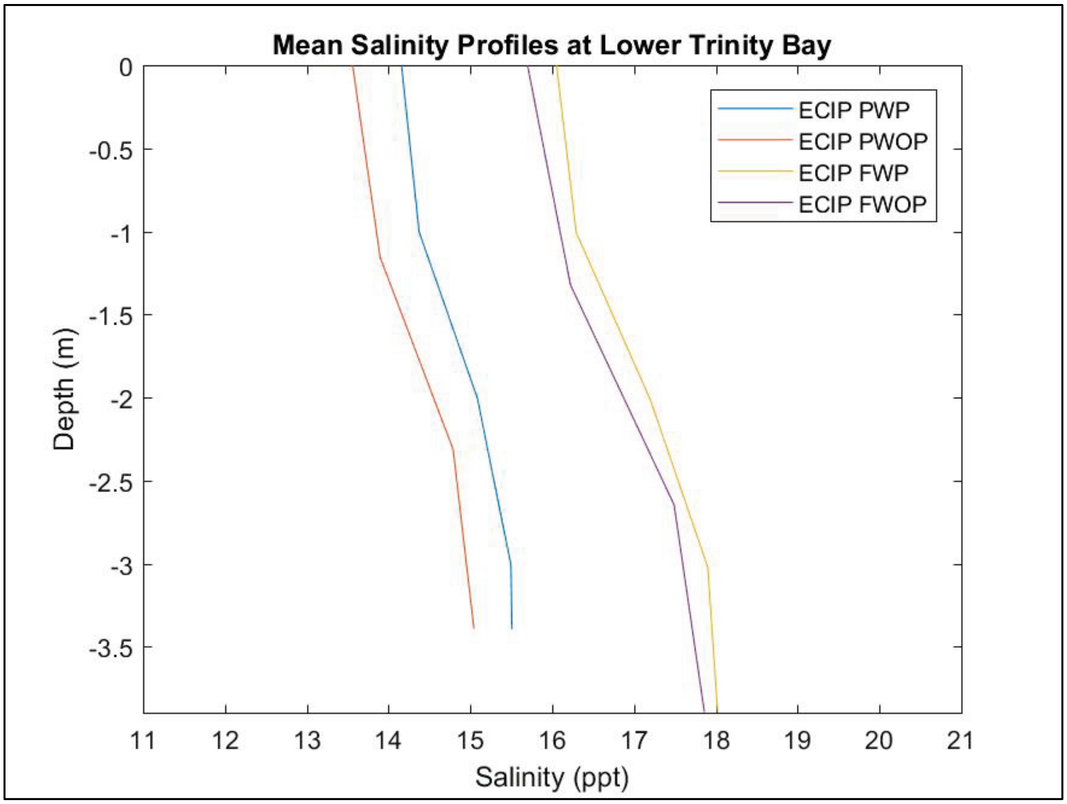

Salinity Percentiles at Lower Galveston Bay
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

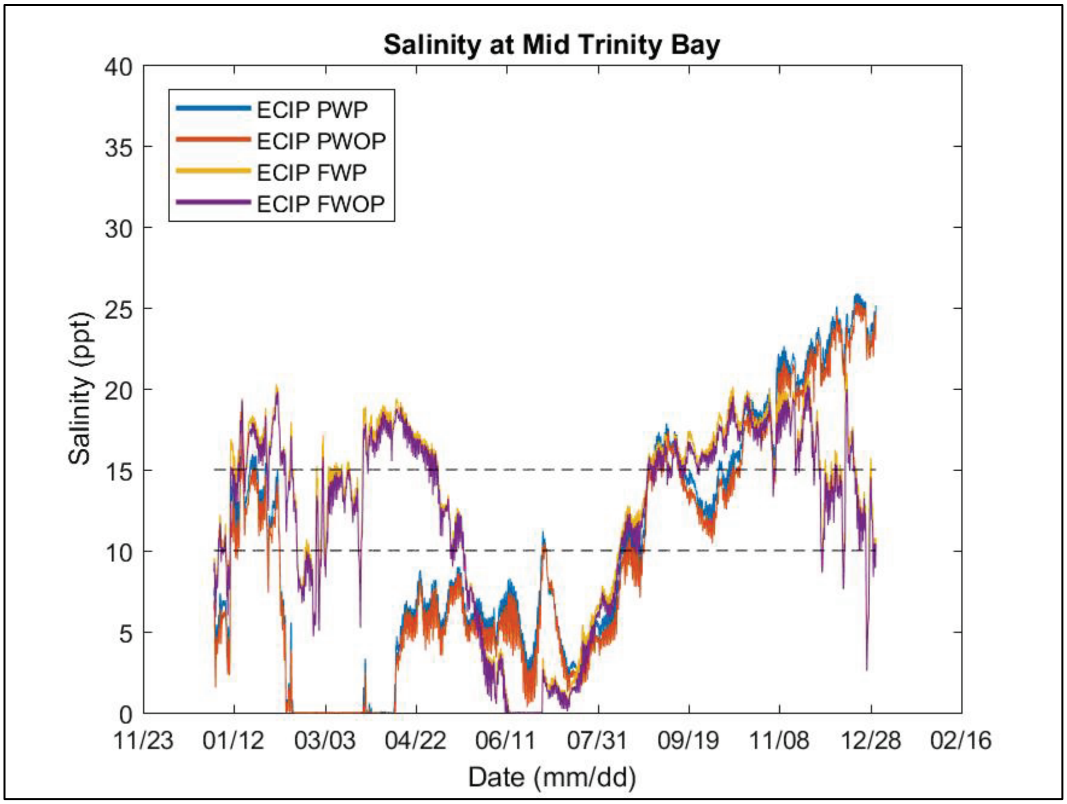

Mean Salinity Profiles at Lower Galveston Bay
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
15
16
17
18
19
20
21
22
23
24
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

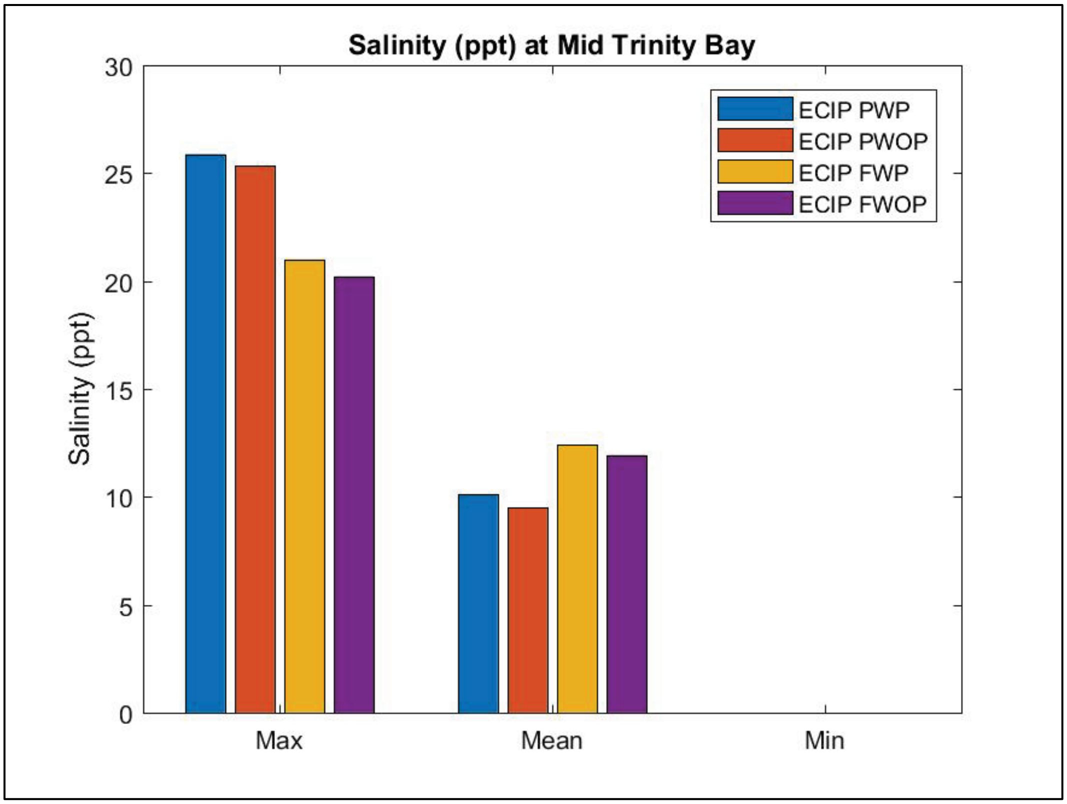

Salinity at Lower Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

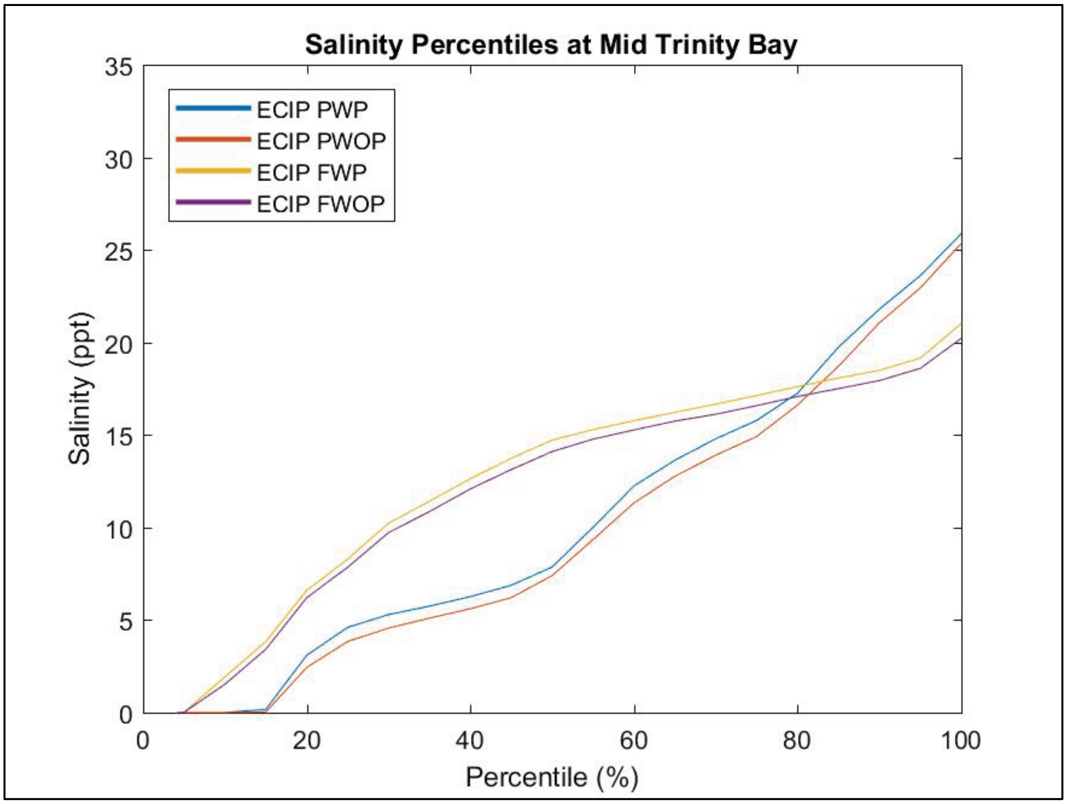

Salinity (ppt) at Lower Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

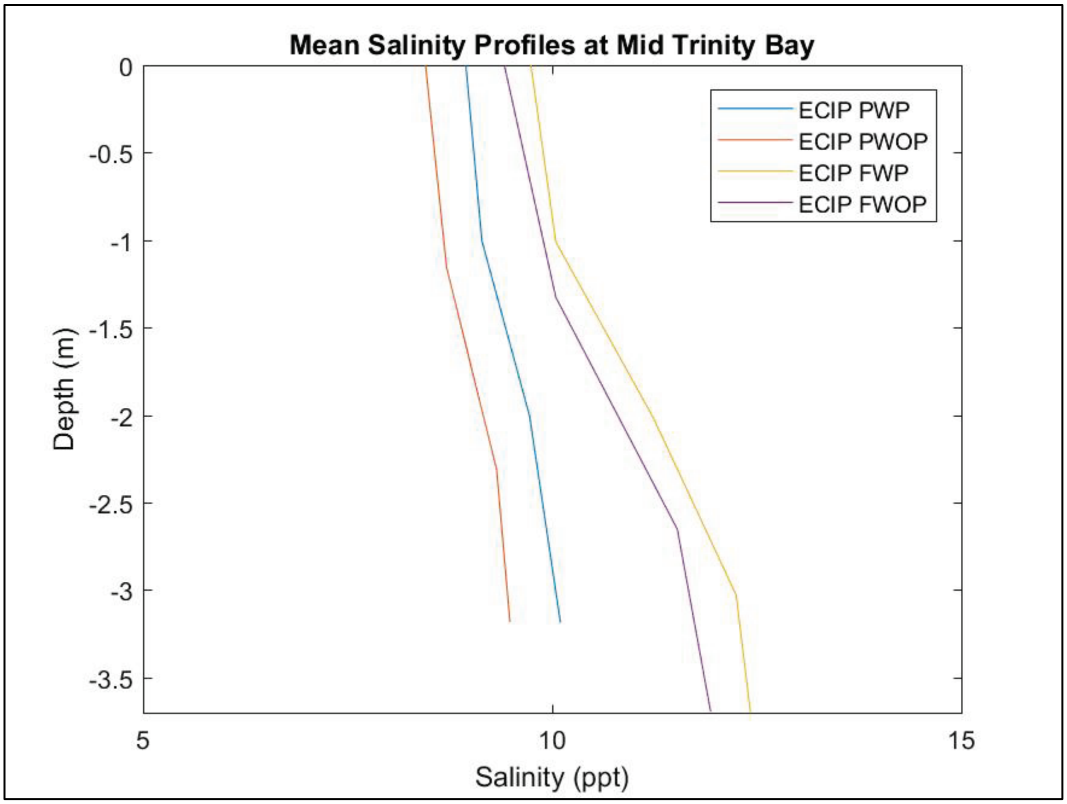

Salinity Percentiles at Lower Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

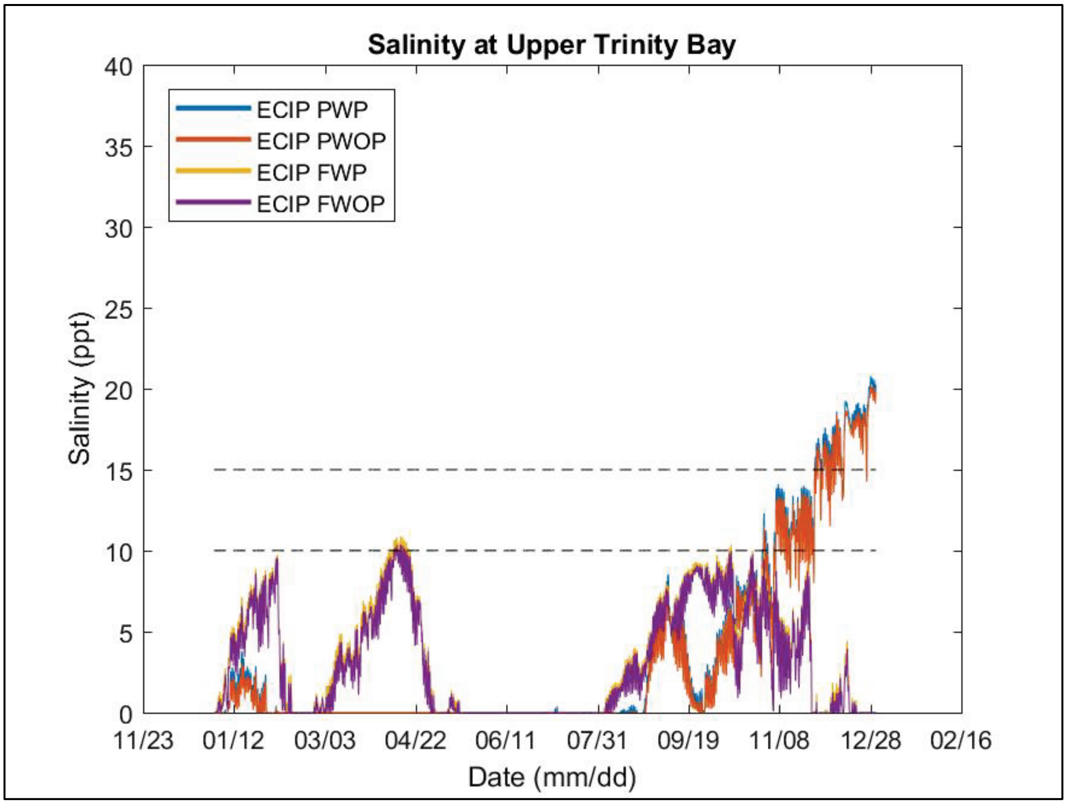

Mean Salinity Profiles at Lower Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
11
12
13
14
15
16
17
18
19
20
21
Salinity (ppt)

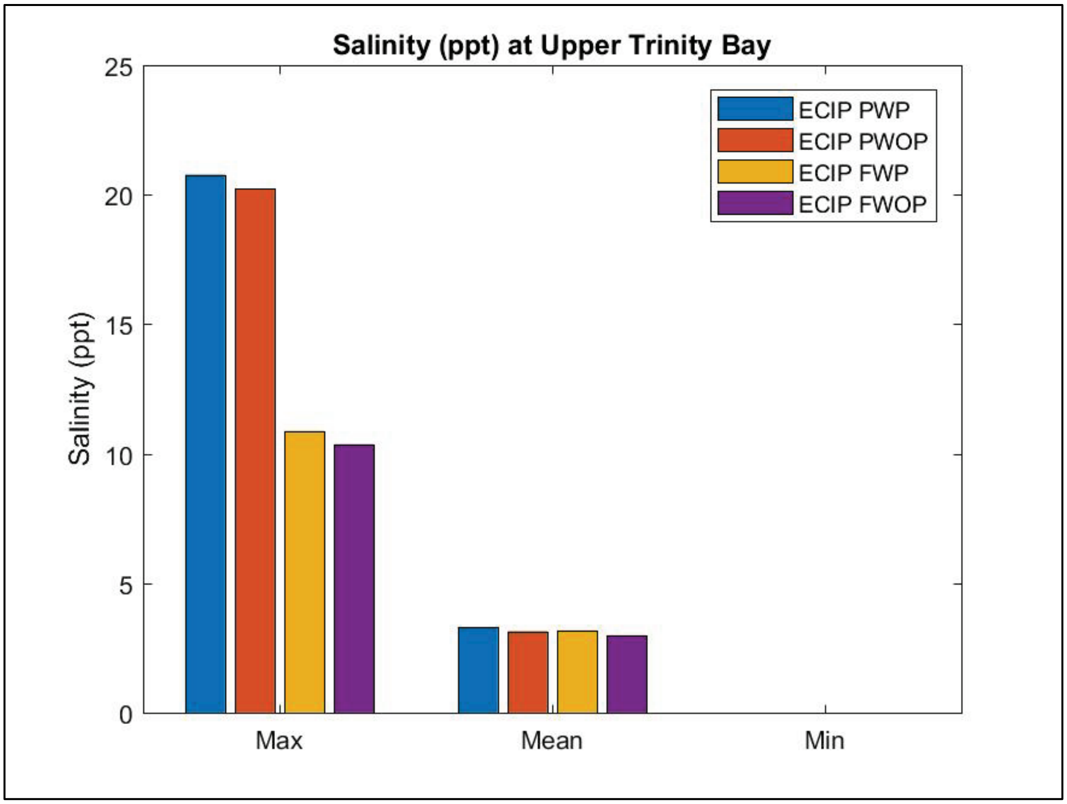

Salinity at Mid Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

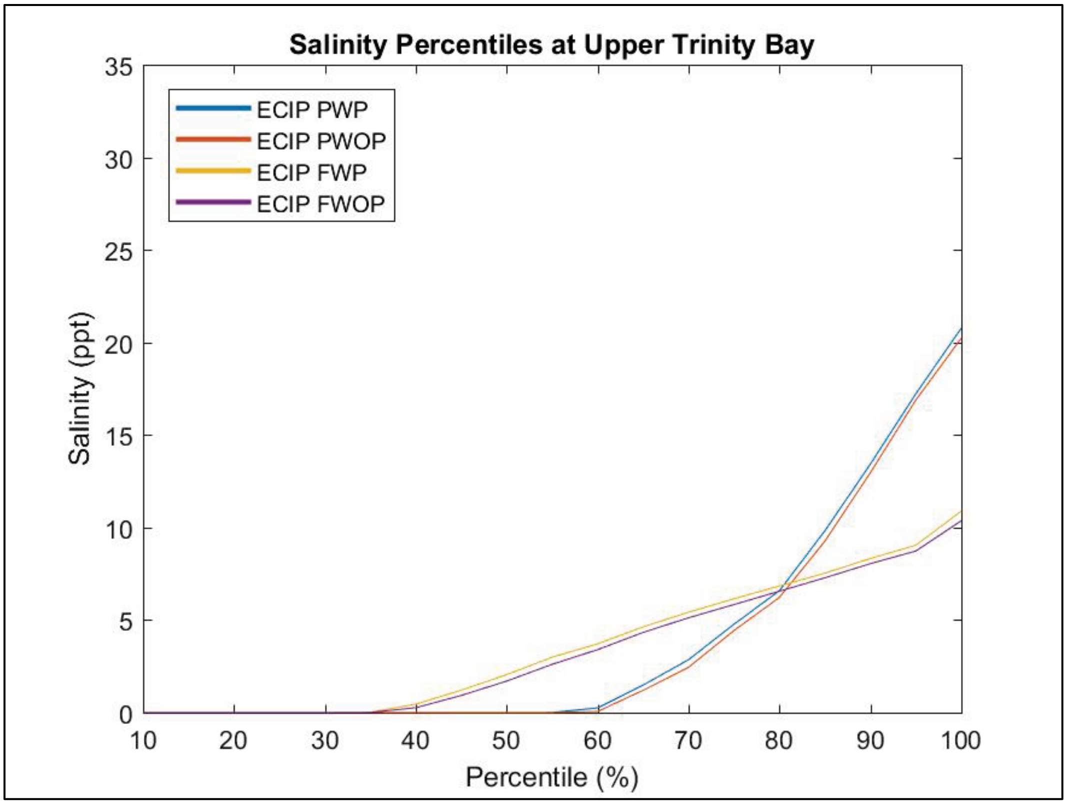

Salinity (ppt) at Mid Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min

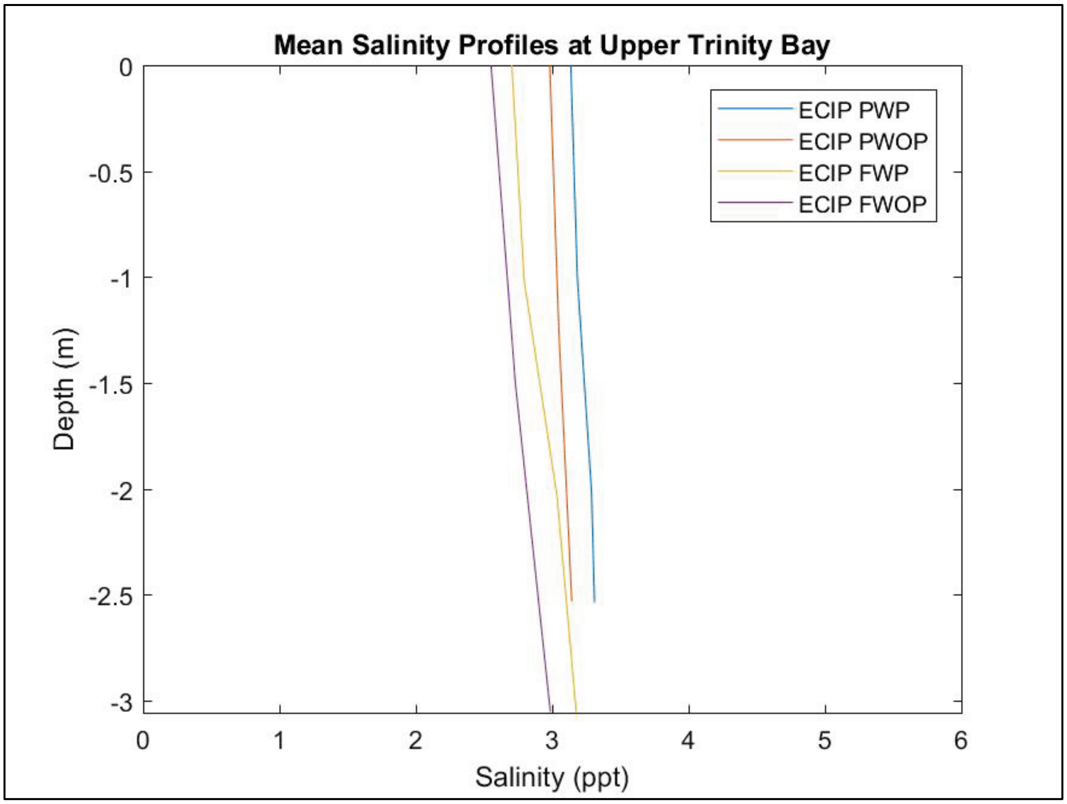

Salinity Percentiles at Mid Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

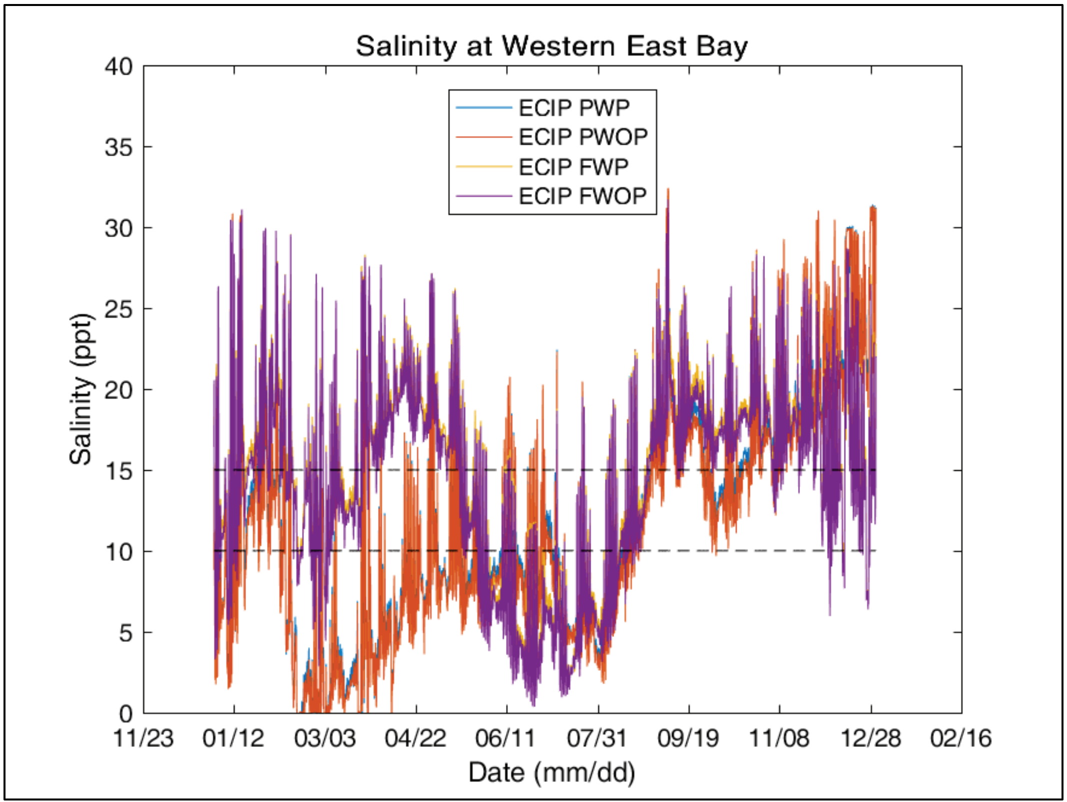

Mean Salinity Profiles at Mid Trinity Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
5
10
15
Salinity (ppt)

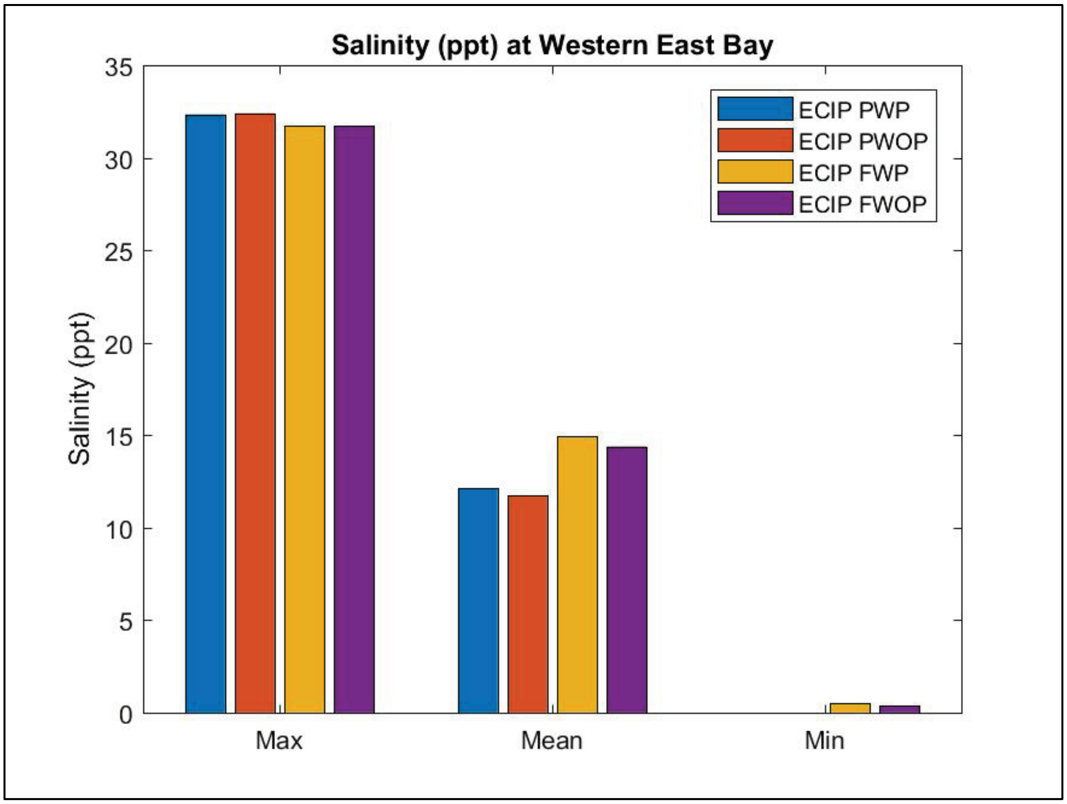

Salinity at Upper Trinity Bay
Salinity (ppt)
0
5
10
15
20
25
30
35
40
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

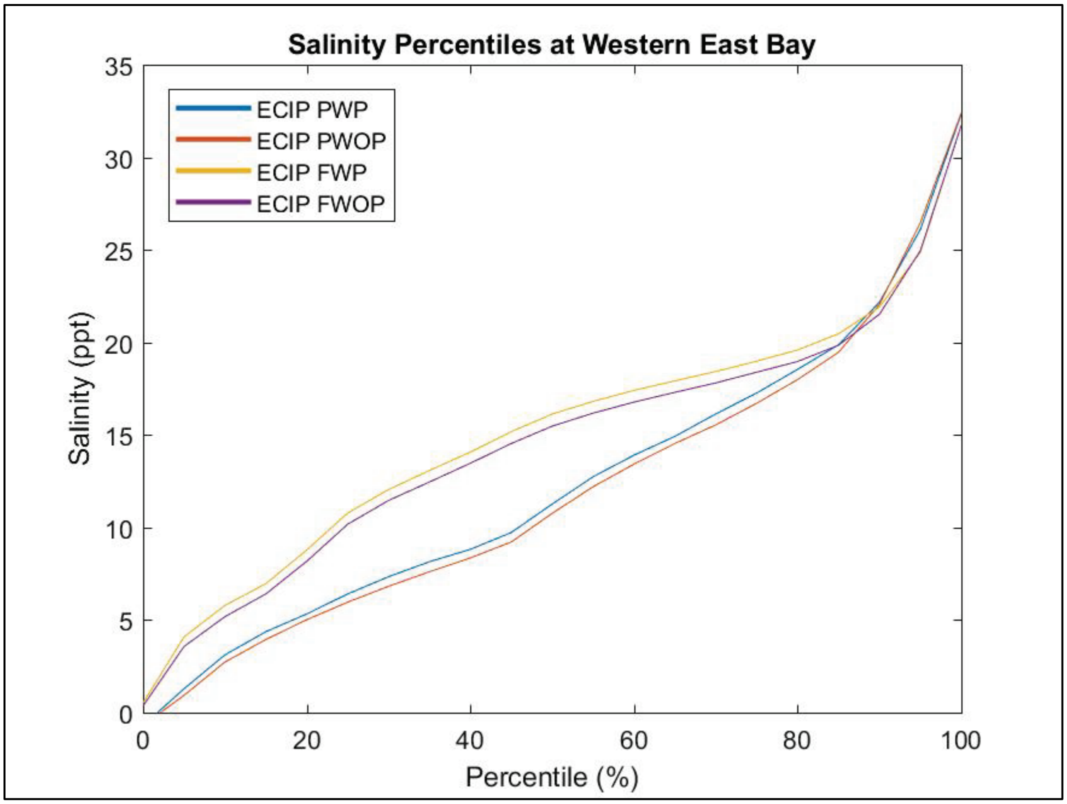

Salinity (ppt) at Upper Trinity Bay
Salinity (ppt)
0
5
10
15
20
25
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Max
Mean
Min

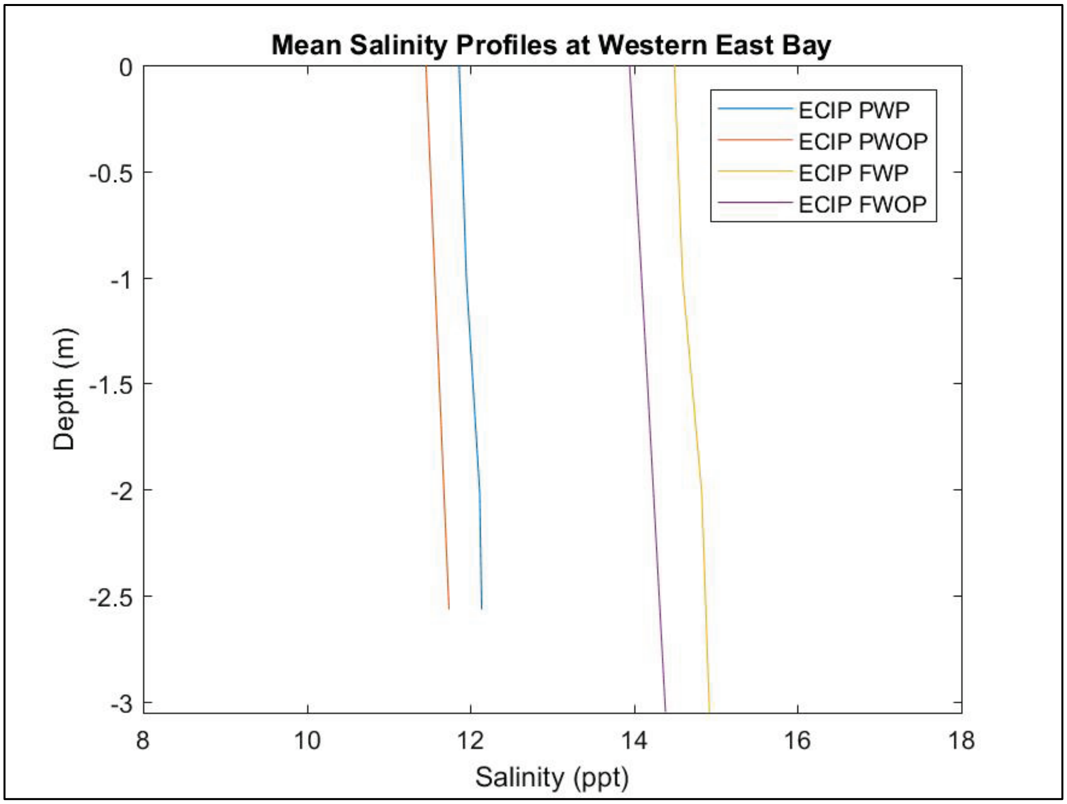

Salinity Percentiles at Upper Trinity Bay
Salinity (ppt)
Percentile (%)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
0
5
10
15
20
25
30
35
10
20
30
40
50
60
70
80
90
100

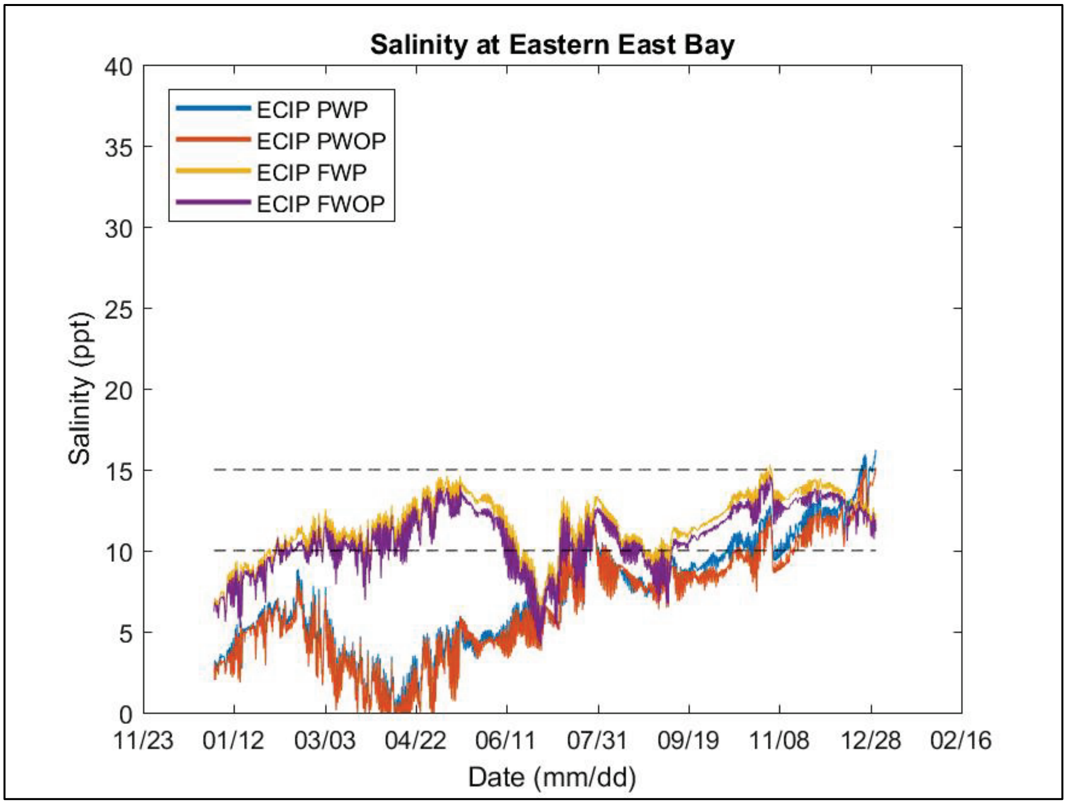

Mean Salinity Profiles at Upper Trinity Bay
Depth (m)
Salinity (ppt)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
0
-0.5
-1
-1.5
-2
-2.5
-3
0
1
2
3
4
5
6

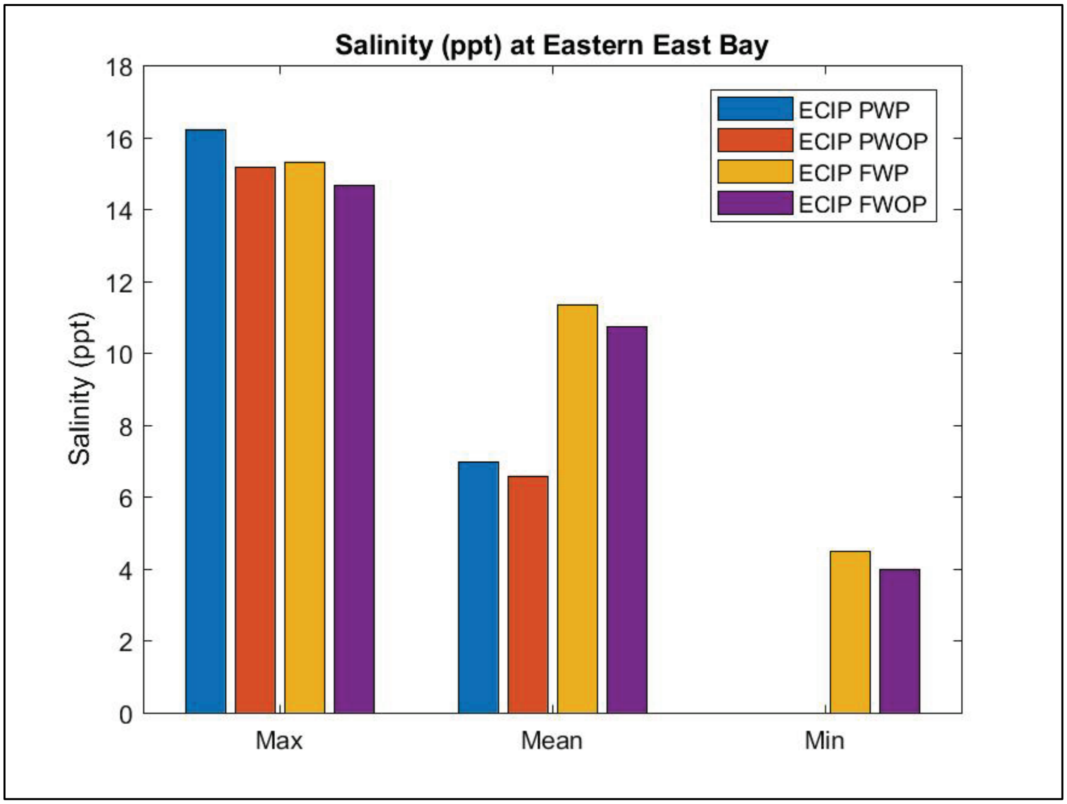

Salinity at Western East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

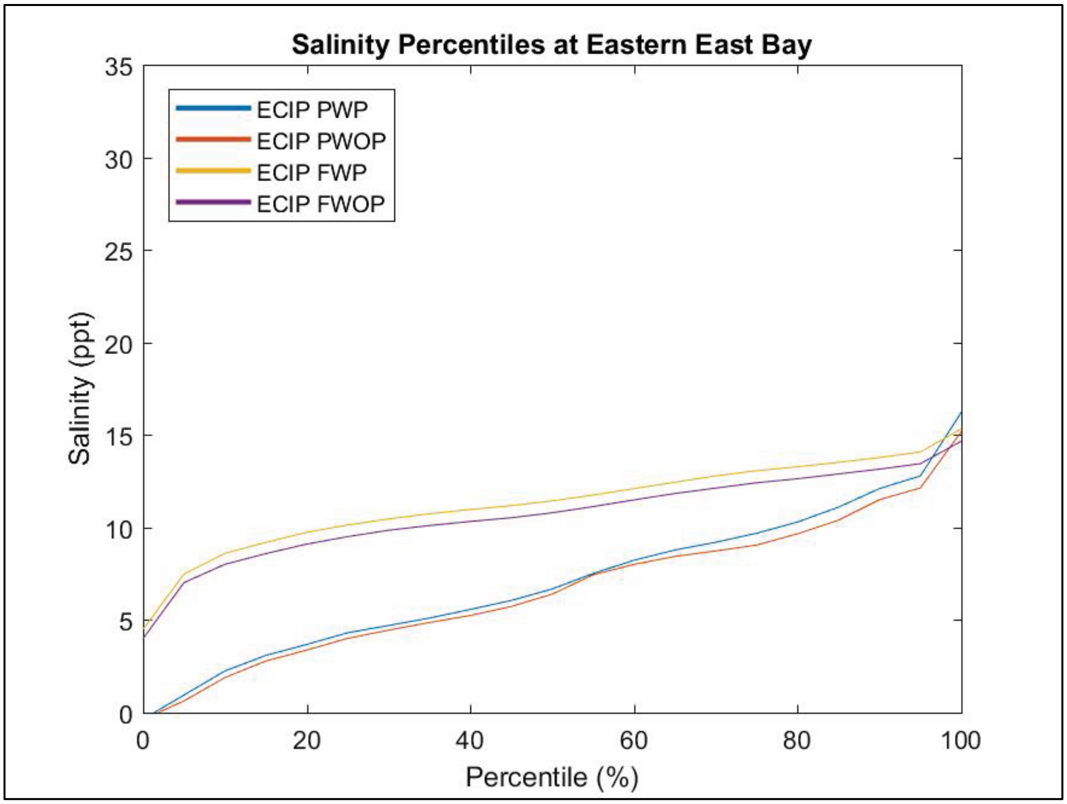

Salinity (ppt) at Western East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Max
Mean
Min

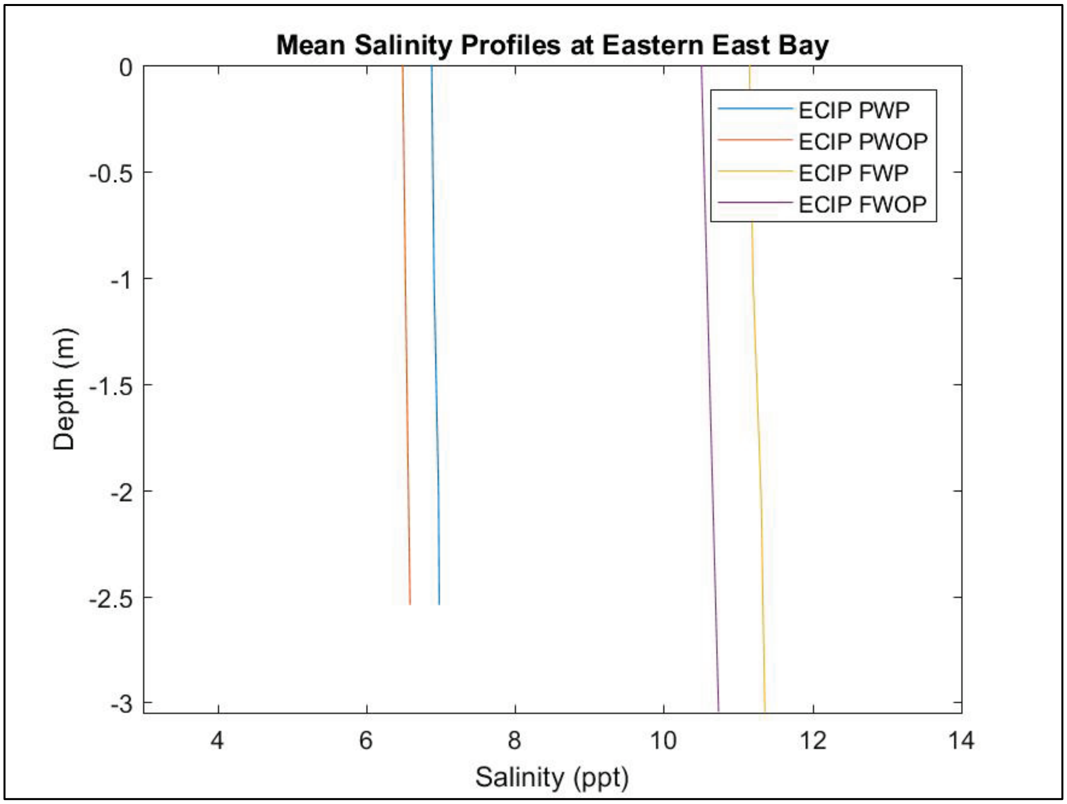

Salinity Percentiles at Western East Bay
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

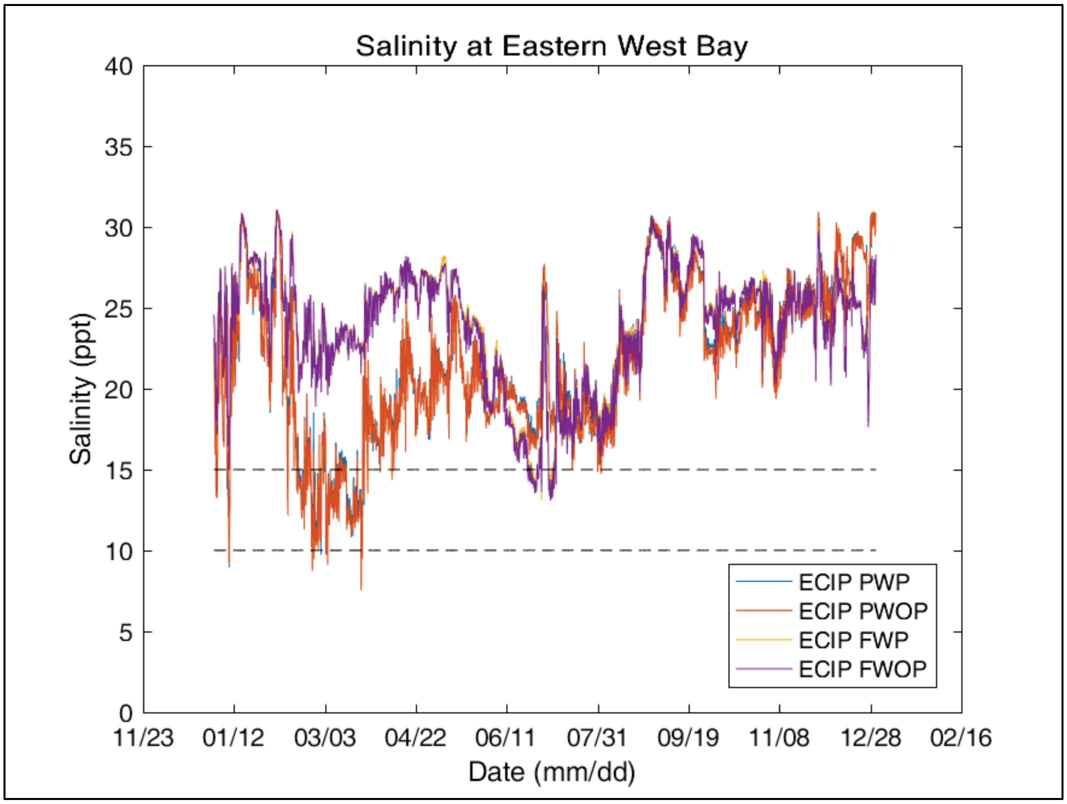

Mean Salinity Profiles at Western East Bay
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
8
10
12
14
16
18
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

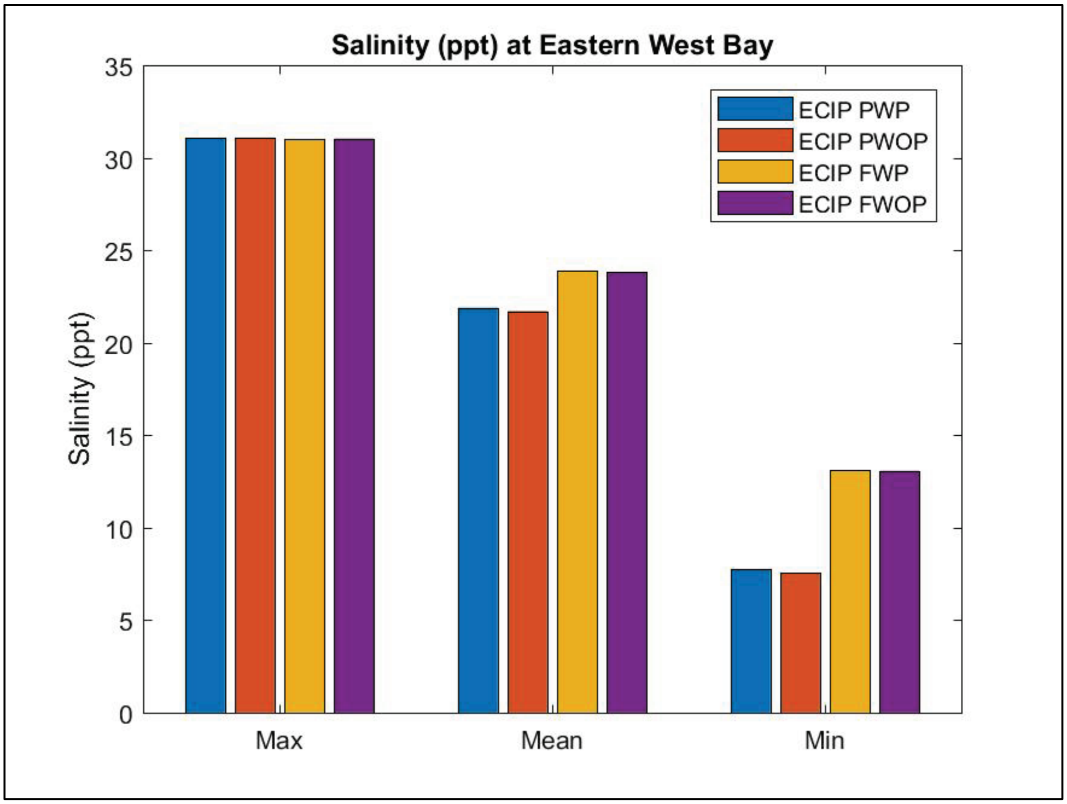

Salinity at Eastern East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

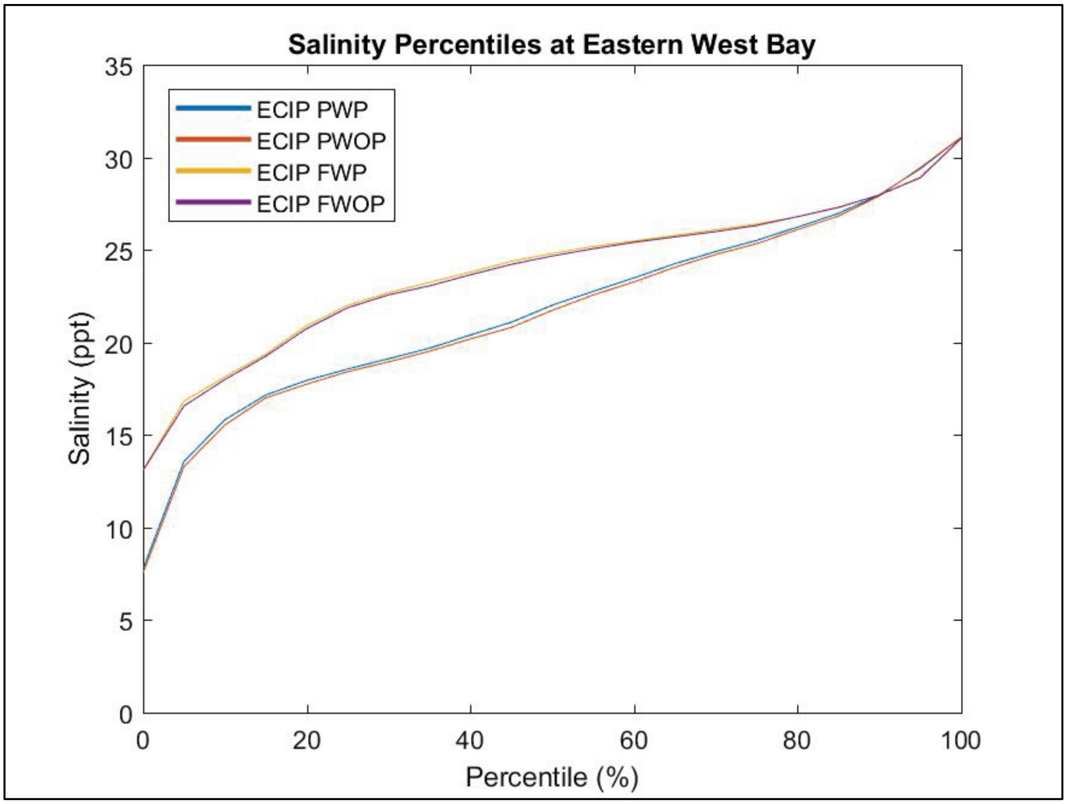

Salinity (ppt) at Eastern East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
2
4
6
8
10
12
14
16
18
Max
Mean
Min

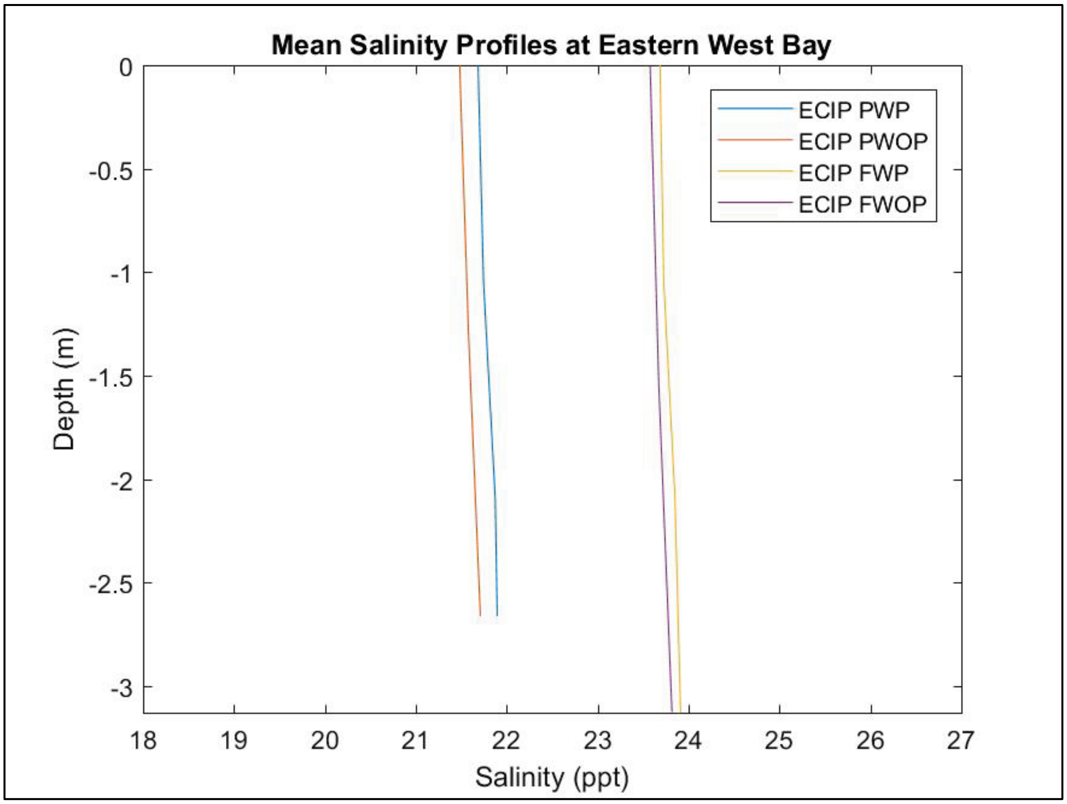

Salinity Percentiles at Eastern East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Percentile (%)
0
20
40
60
80
100

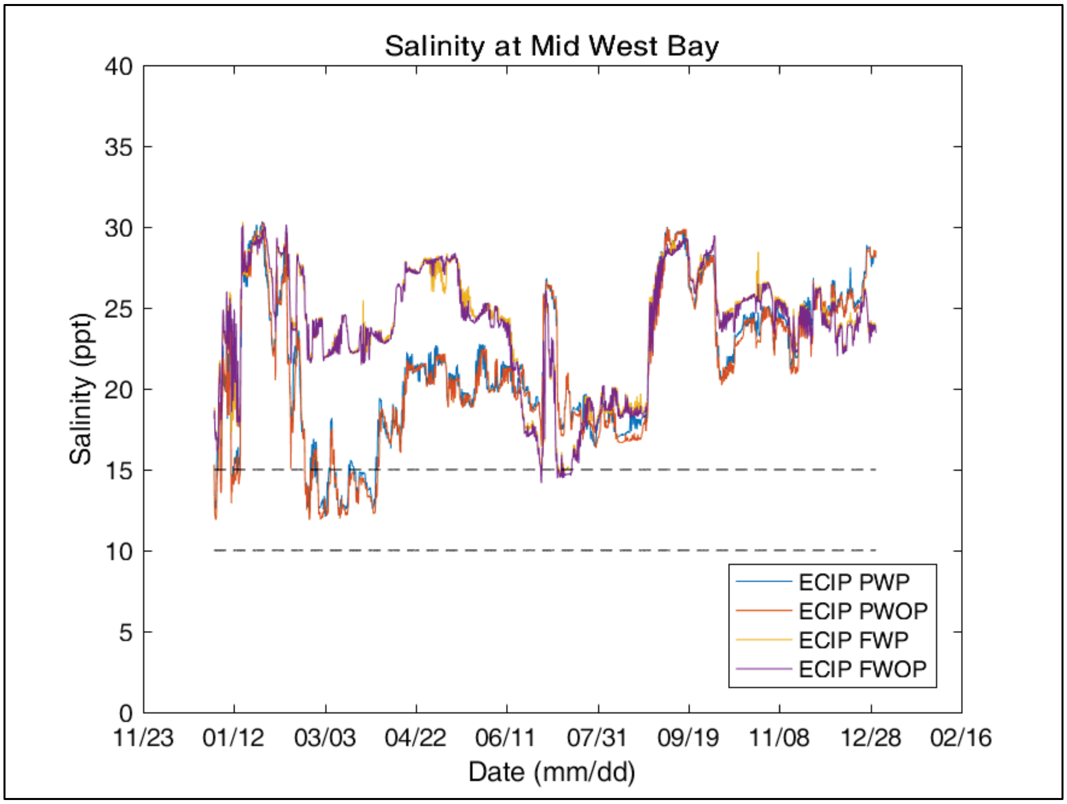

Mean Salinity Profiles at Eastern East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
Salinity (ppt)
4
6
8
10
12
14

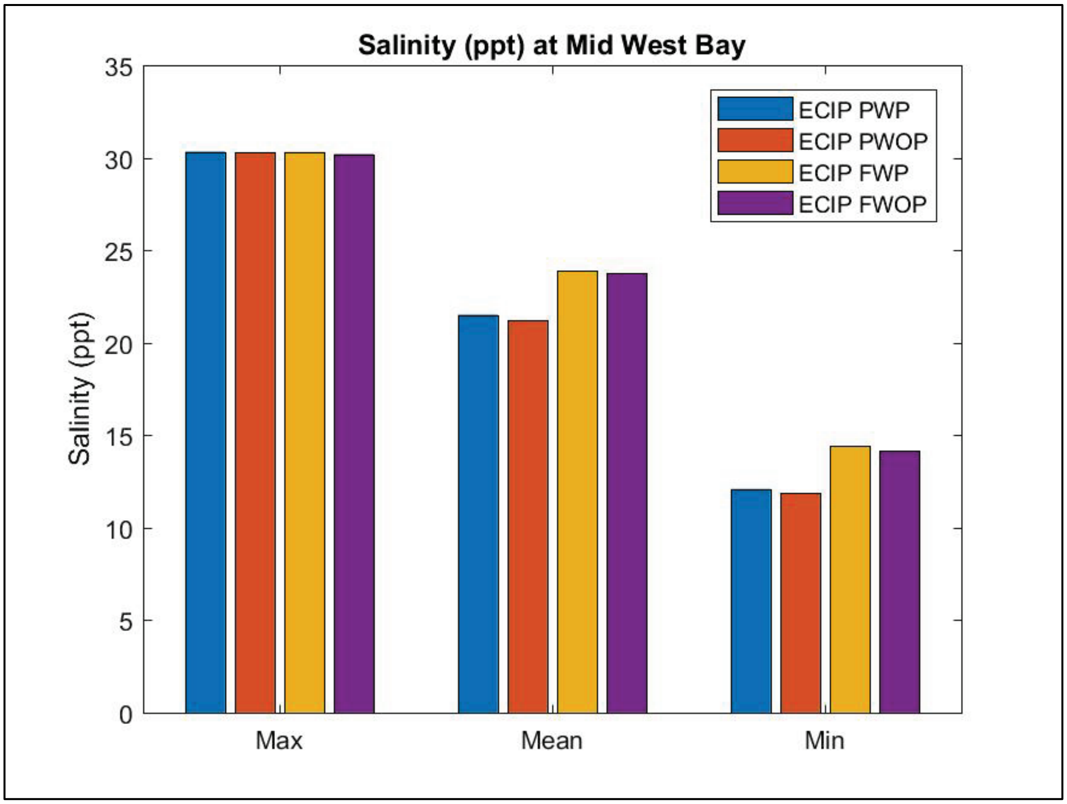

Salinity at Eastern West Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

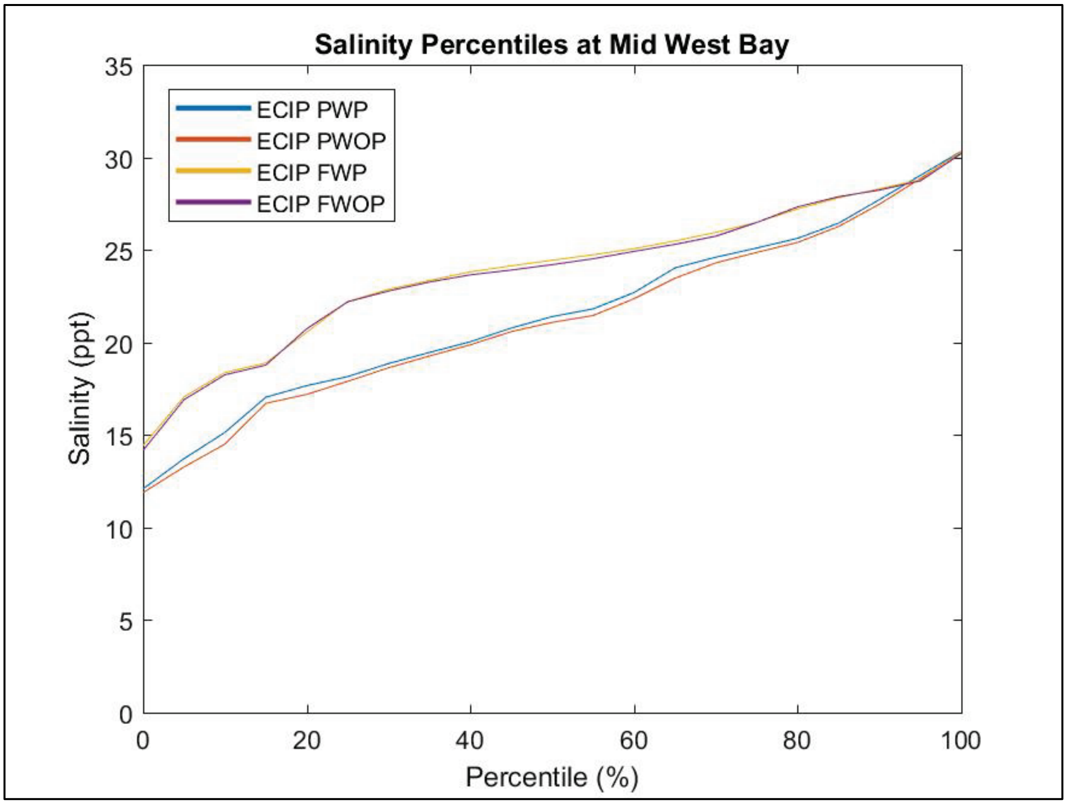

Salinity (ppt) at Eastern West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

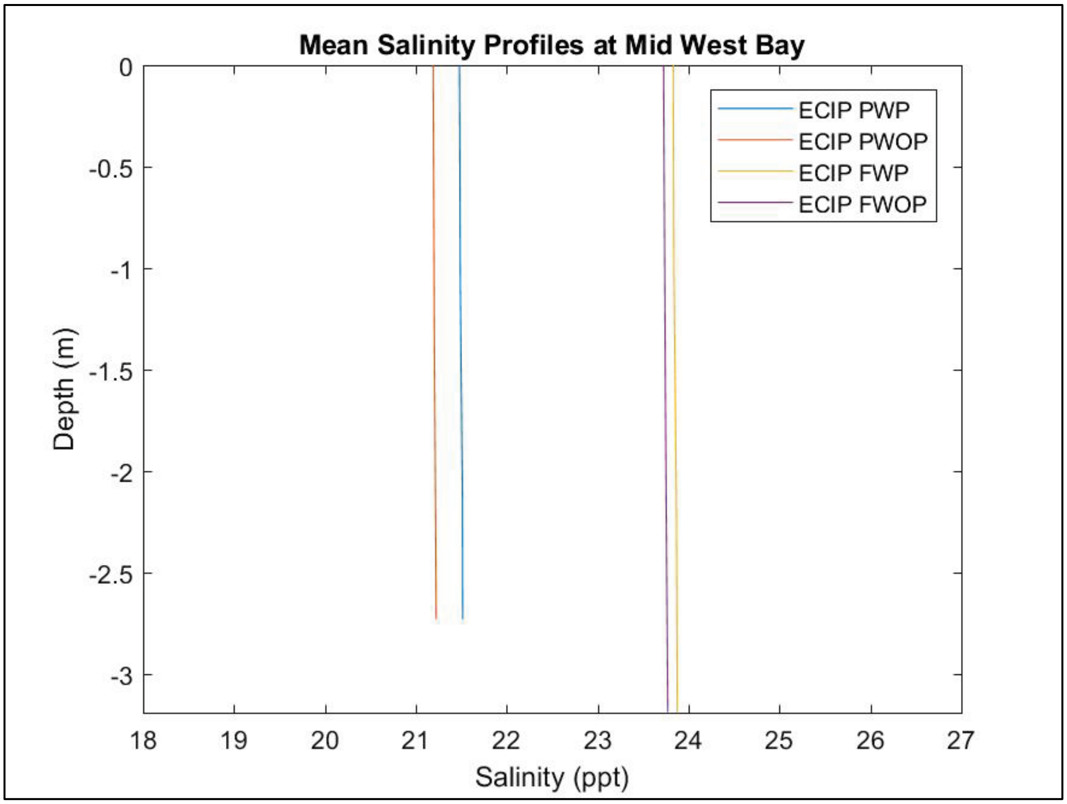

Salinity Percentiles at Eastern West Bay
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

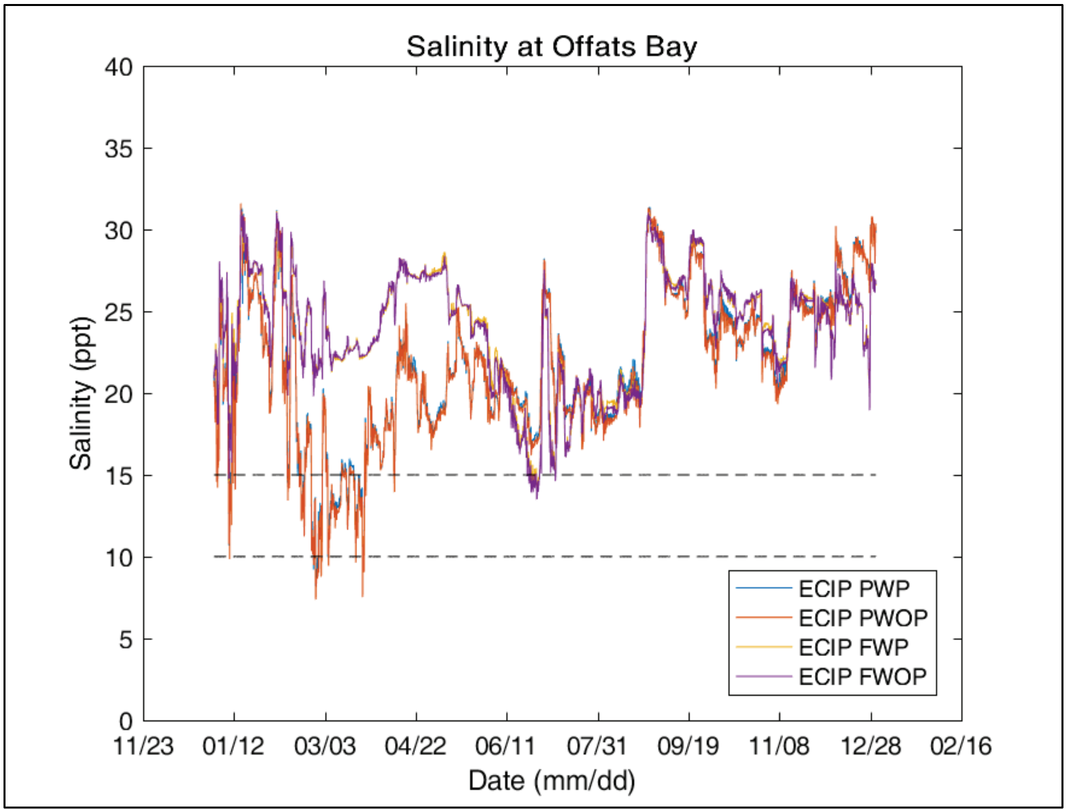

Mean Salinity Profiles at Eastern West Bay
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
18
19
20
21
22
23
24
25
26
27
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

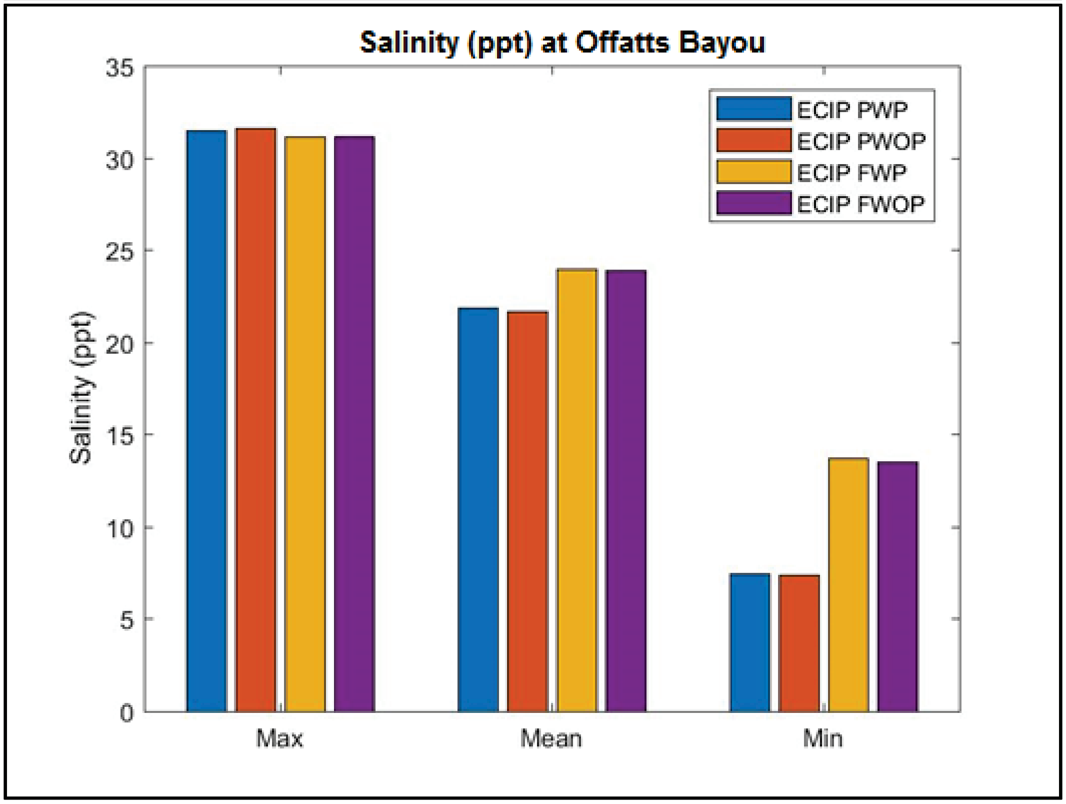

Salinity at Mid West Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

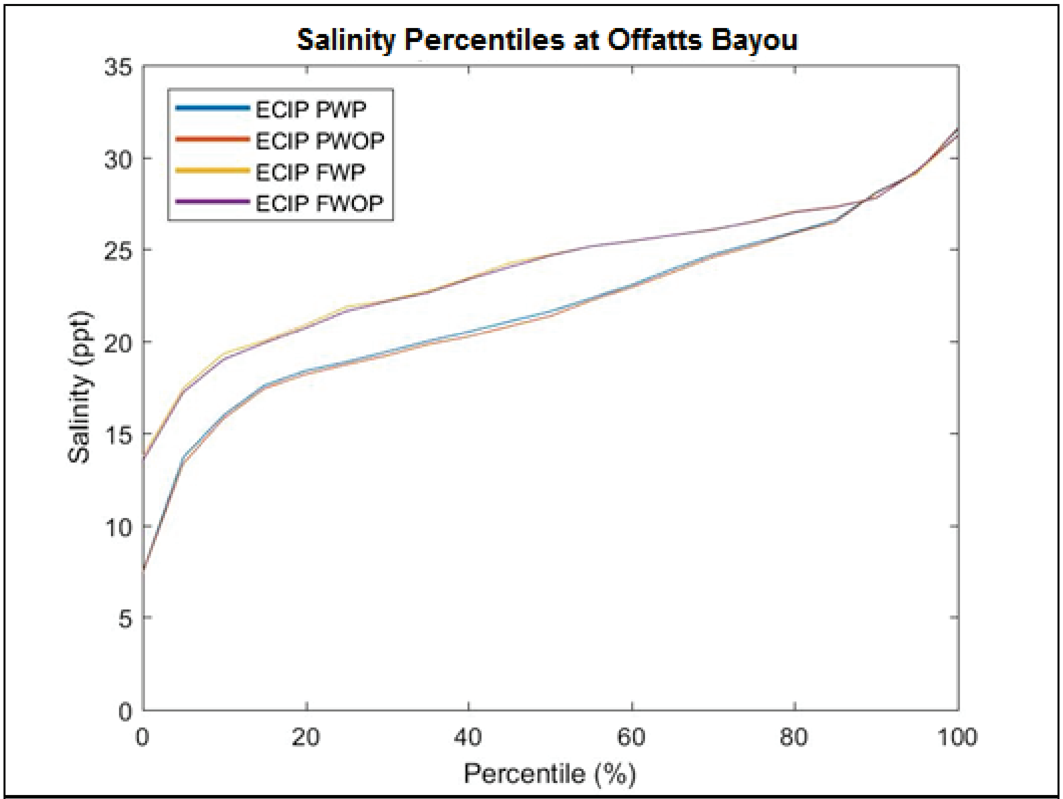

Salinity (ppt) at Mid West Bay
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

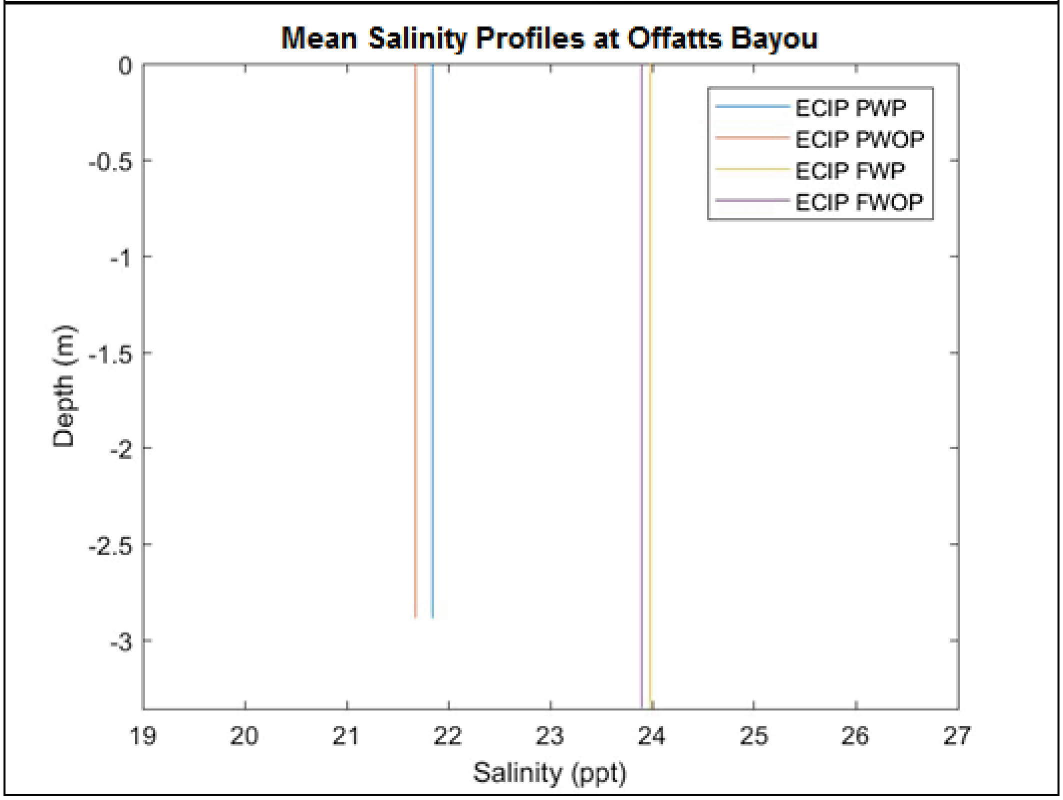

Salinity Percentiles at Mid West Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
Percentile (%)

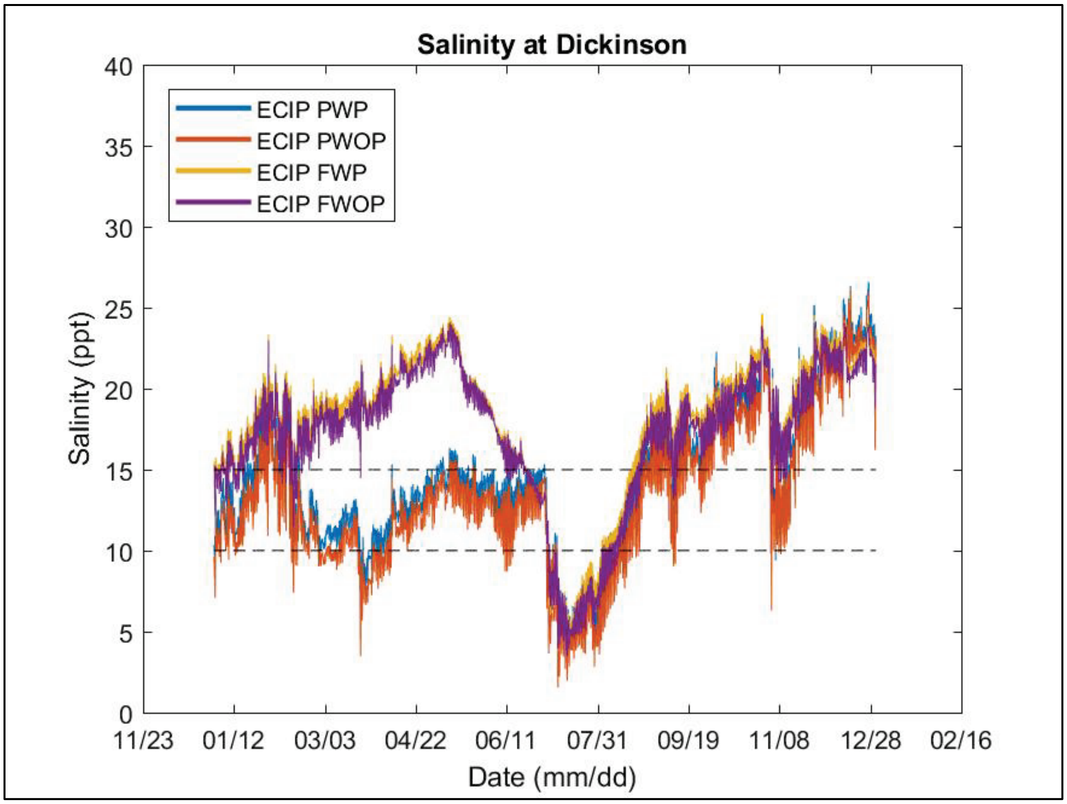

Mean Salinity Profiles at Mid West Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
18
19
20
21
22
23
24
25
26
27
Salinity (ppt)

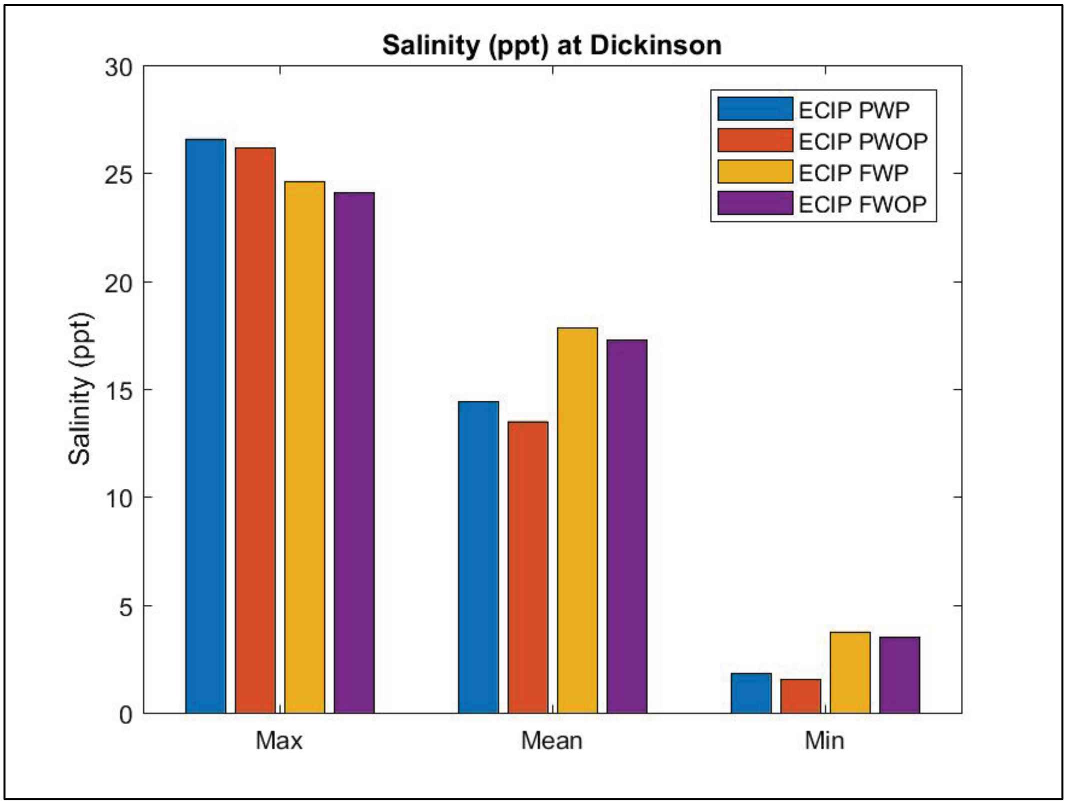

Salinity at Offats Bay
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

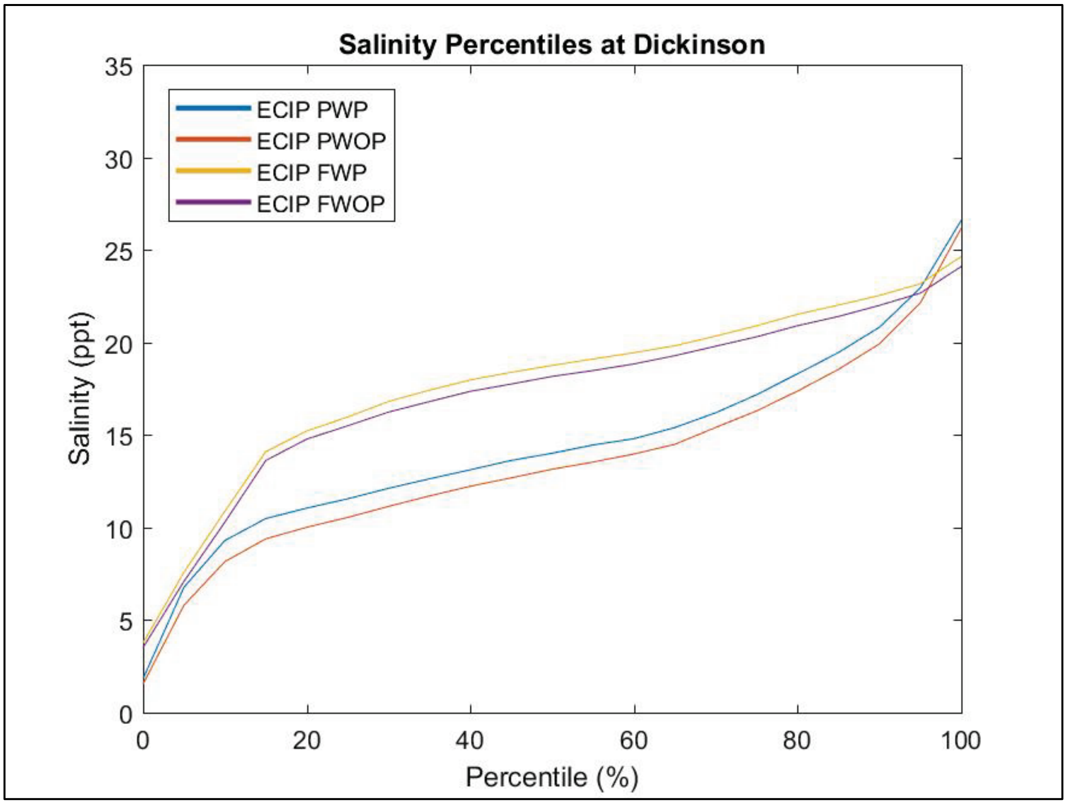

Salinity (ppt) at Offatts Bayou
Salinity (ppt)
35
30
25
20
15
10
5
0
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

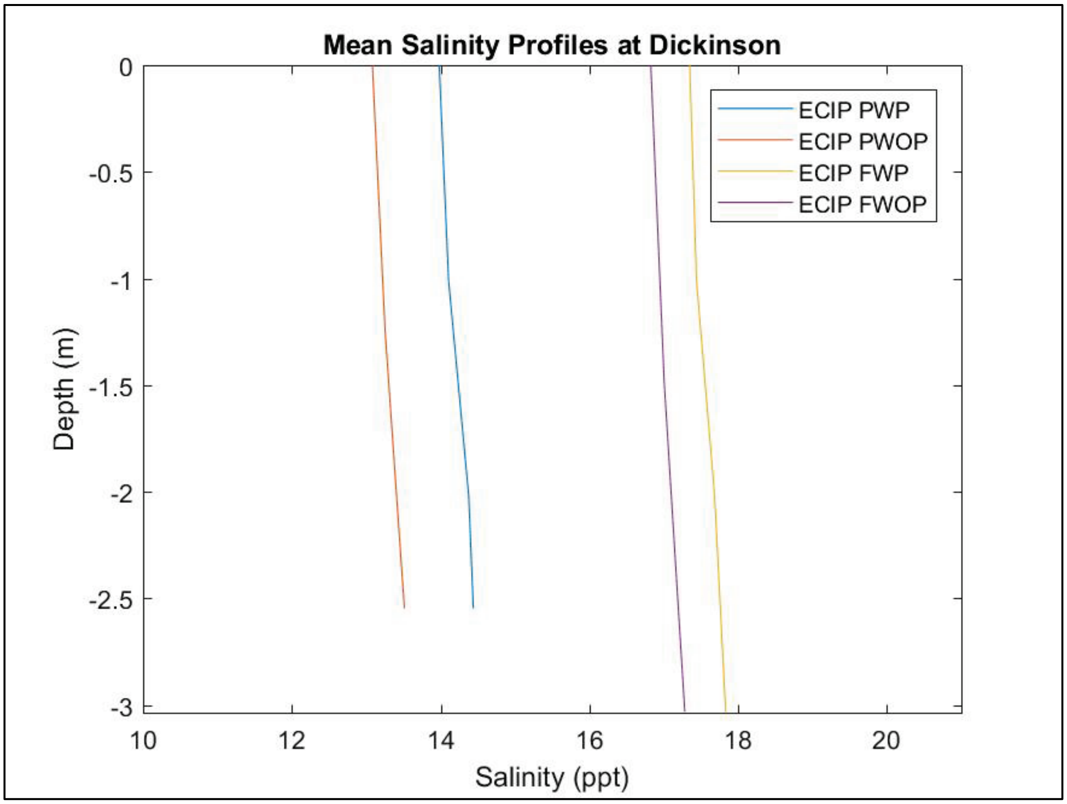

Salinity Percentiles at Offatts Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

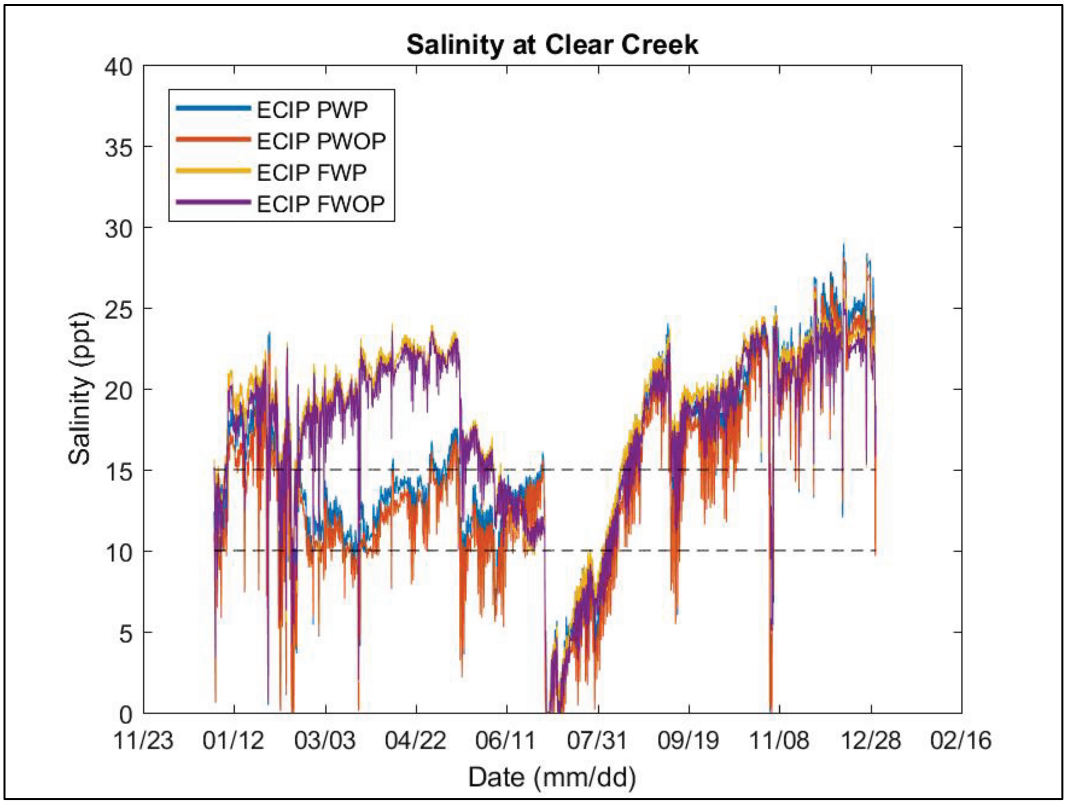

Mean Salinity Profiles at Offatts Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
19
20
21
22
23
24
25
26
27
Salinity (ppt)

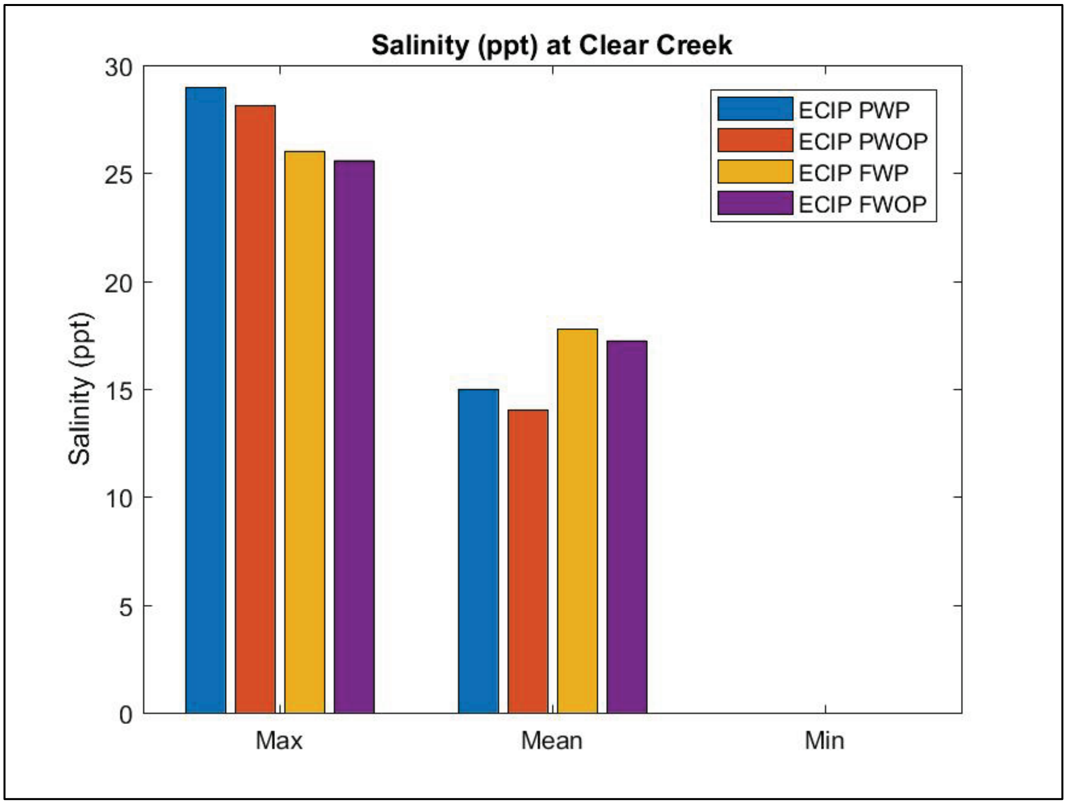

Salinity at Dickinson
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

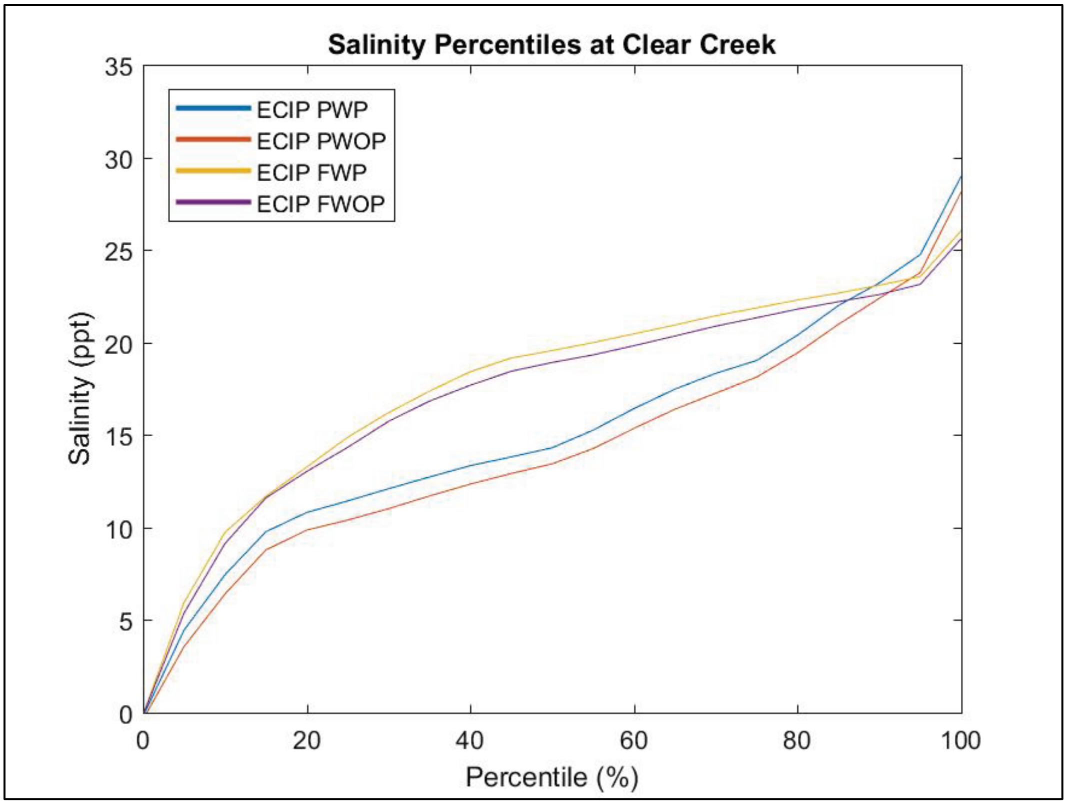

Salinity (ppt) at Dickinson
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

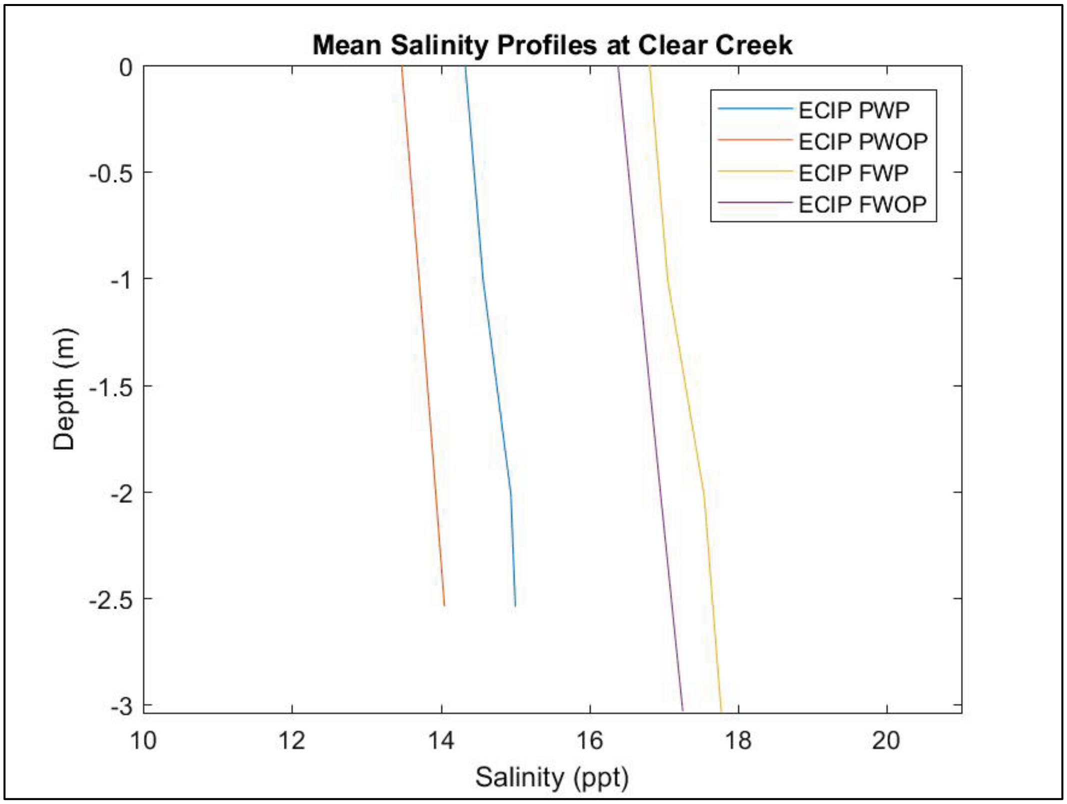

Salinity Percentiles at Dickinson
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

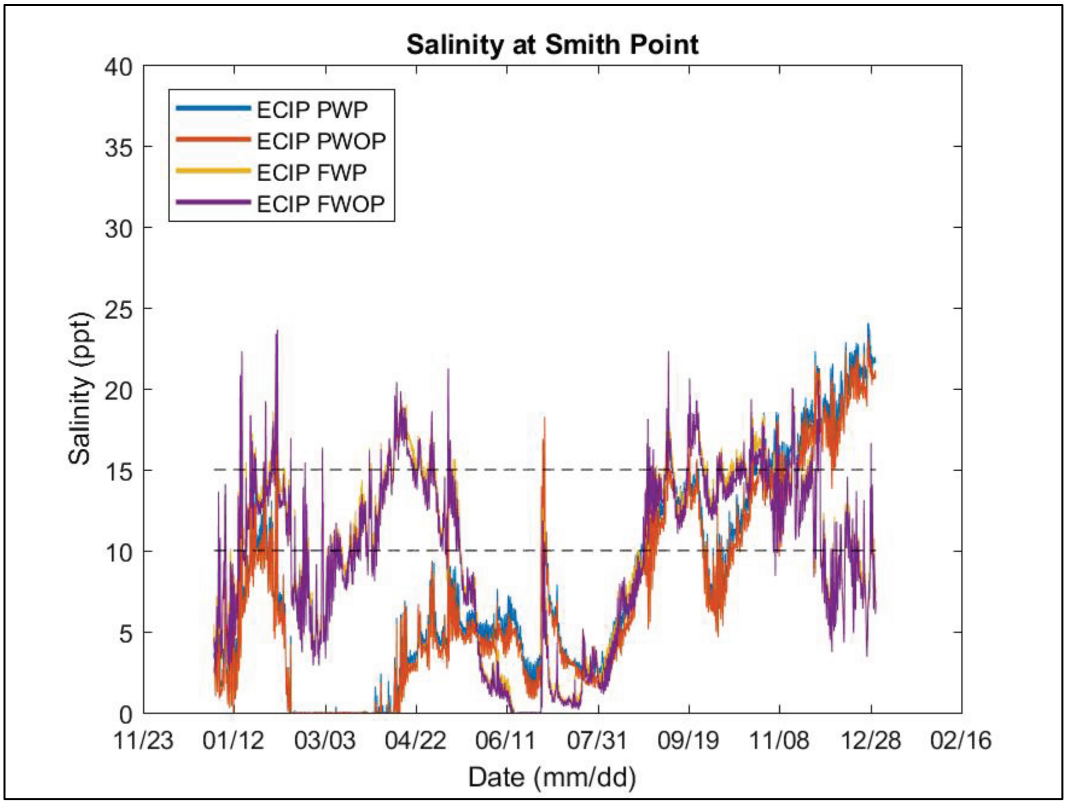

Mean Salinity Profiles at Dickinson
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
10
12
14
16
18
20
Salinity (ppt)

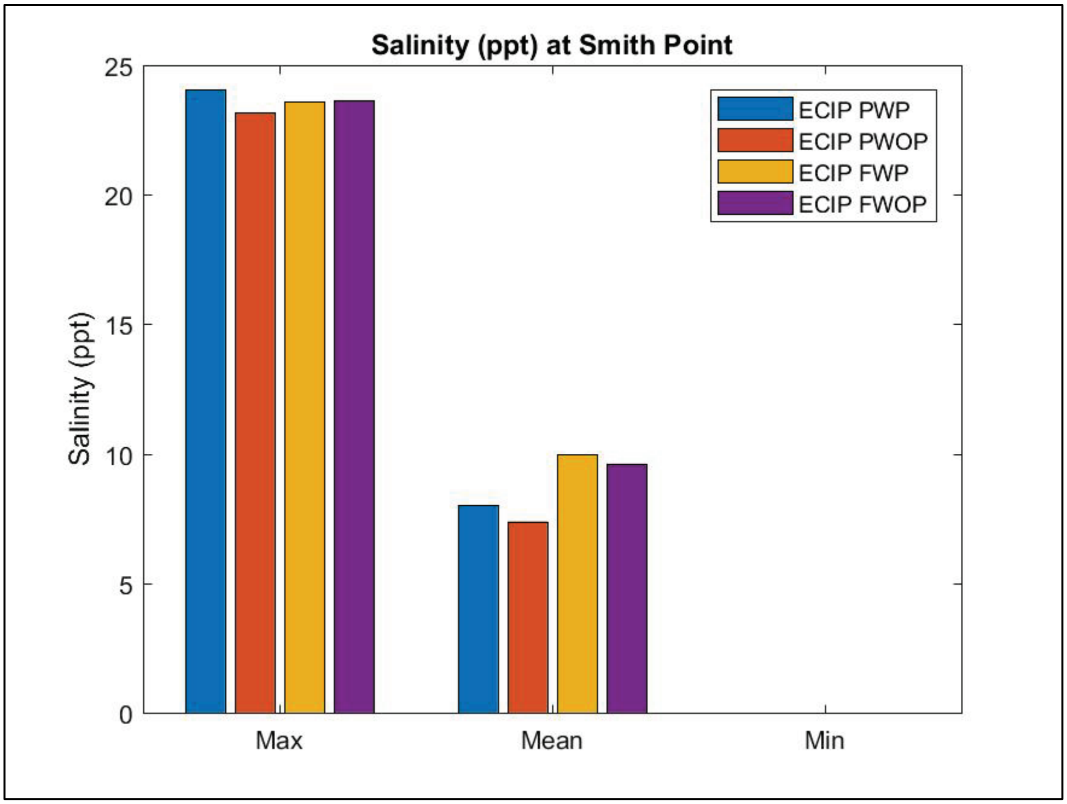

Salinity at Clear Creek
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

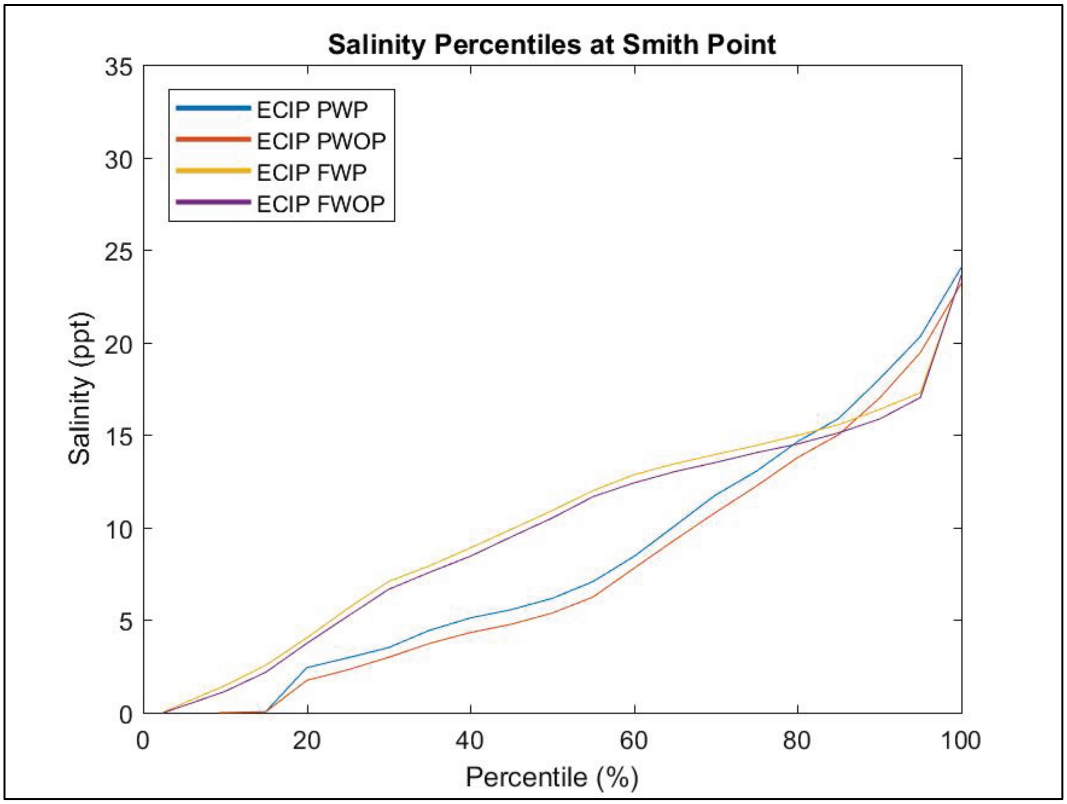

Salinity (ppt) at Clear Creek
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

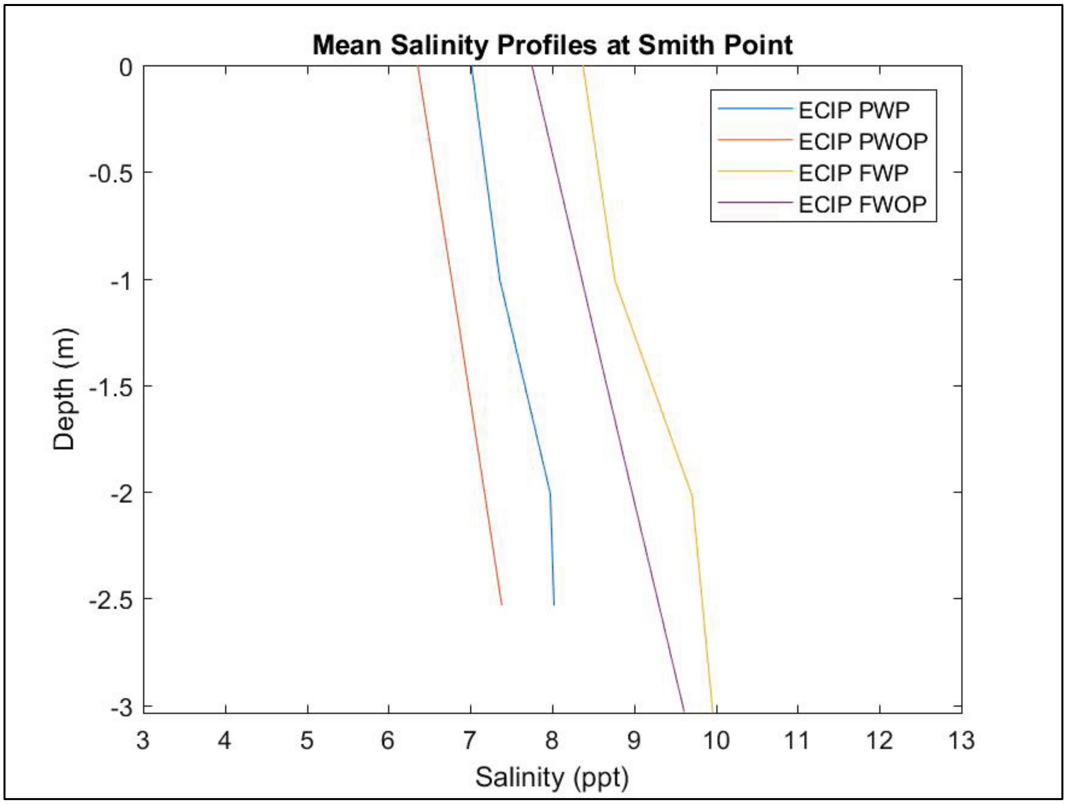

Salinity Percentiles at Clear Creek
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

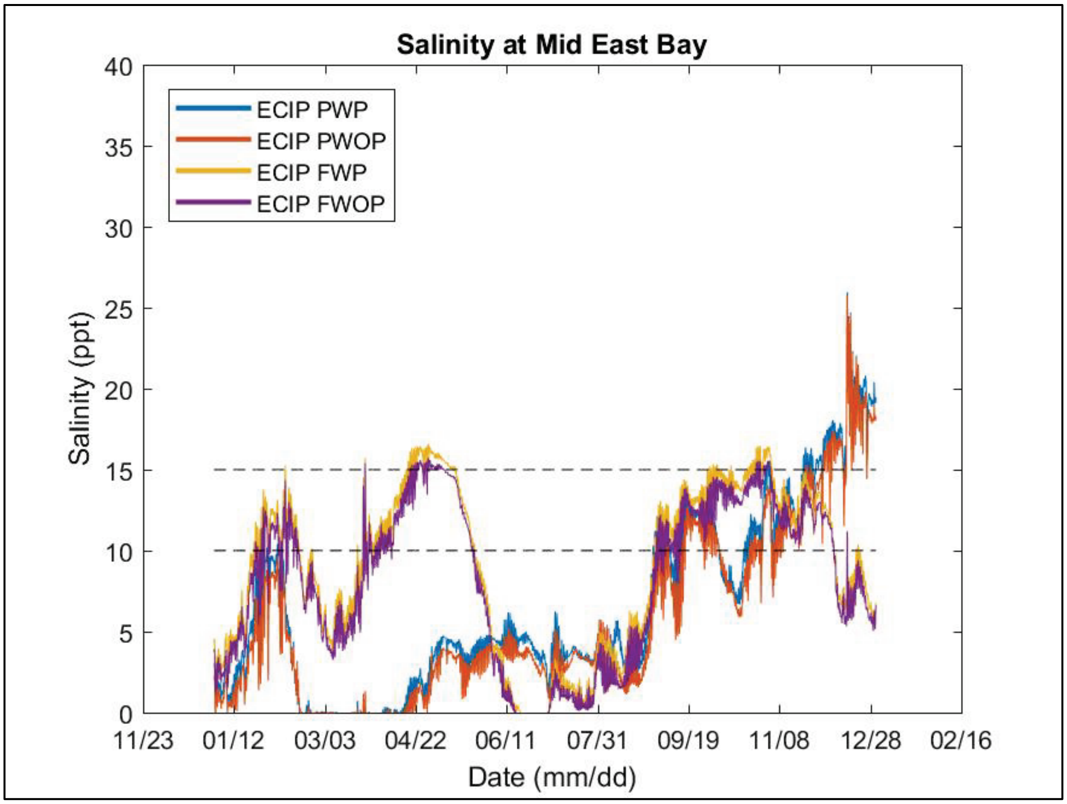

Mean Salinity Profiles at Clear Creek
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
10
12
14
16
18
20
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

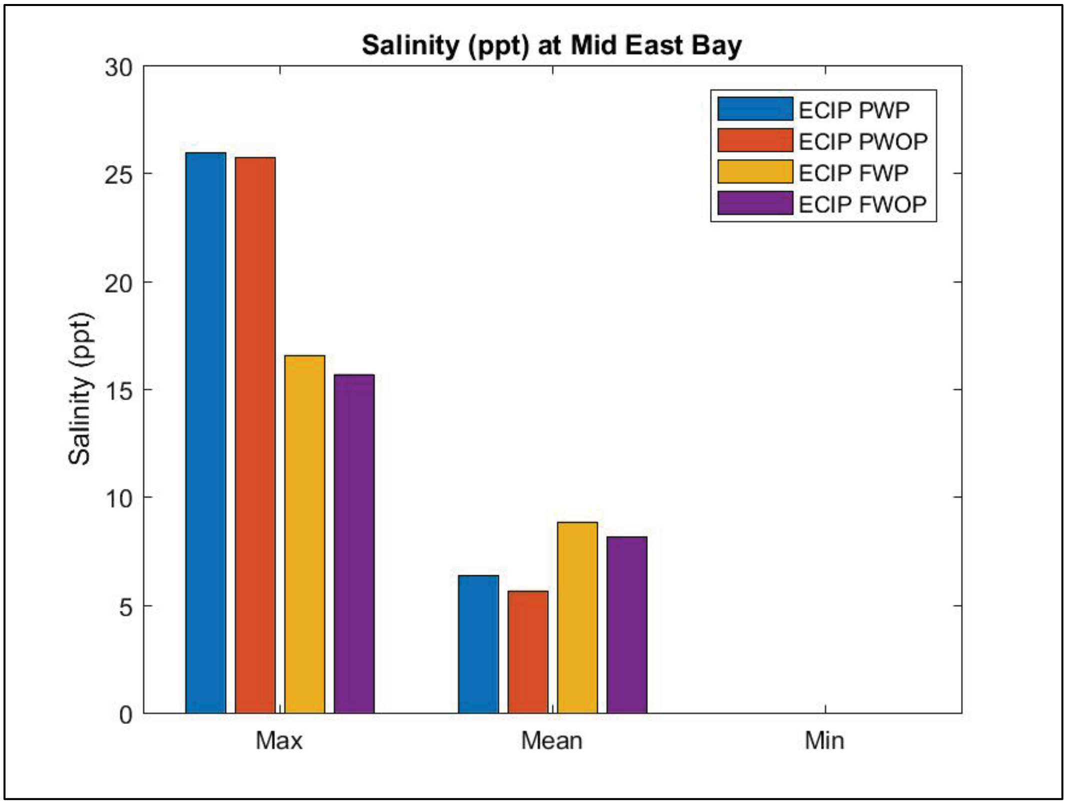

Salinity at Smith Point
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

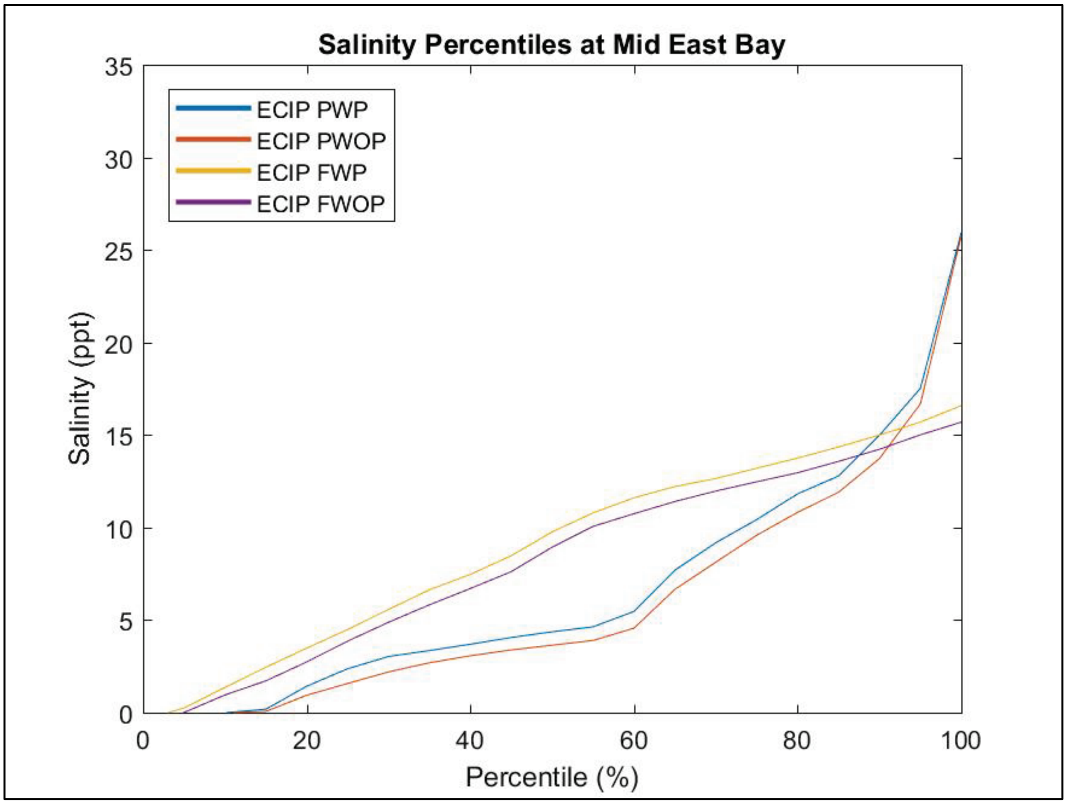

Salinity (ppt) at Smith Point
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
25
20
15
10
5
0
Max
Mean
Min

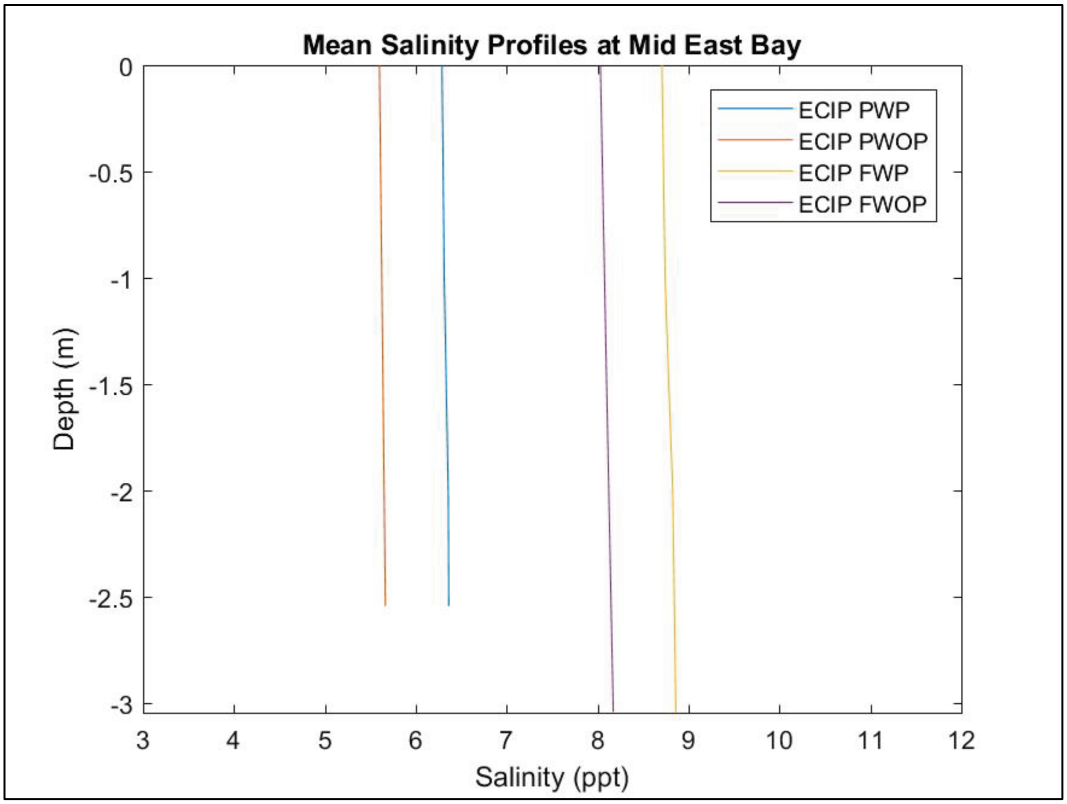

Salinity Percentiles at Smith Point
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

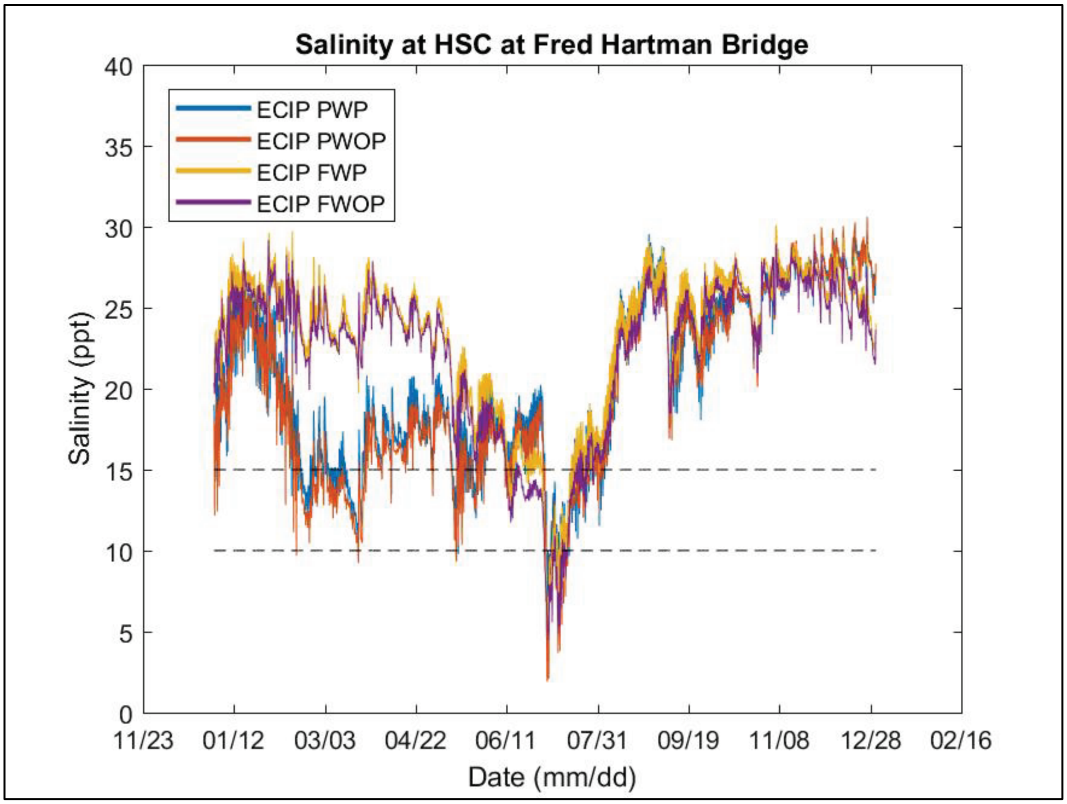

Mean Salinity Profiles at Smith Point
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
3
4
5
6
7
8
9
10
11
12
13
Salinity (ppt)

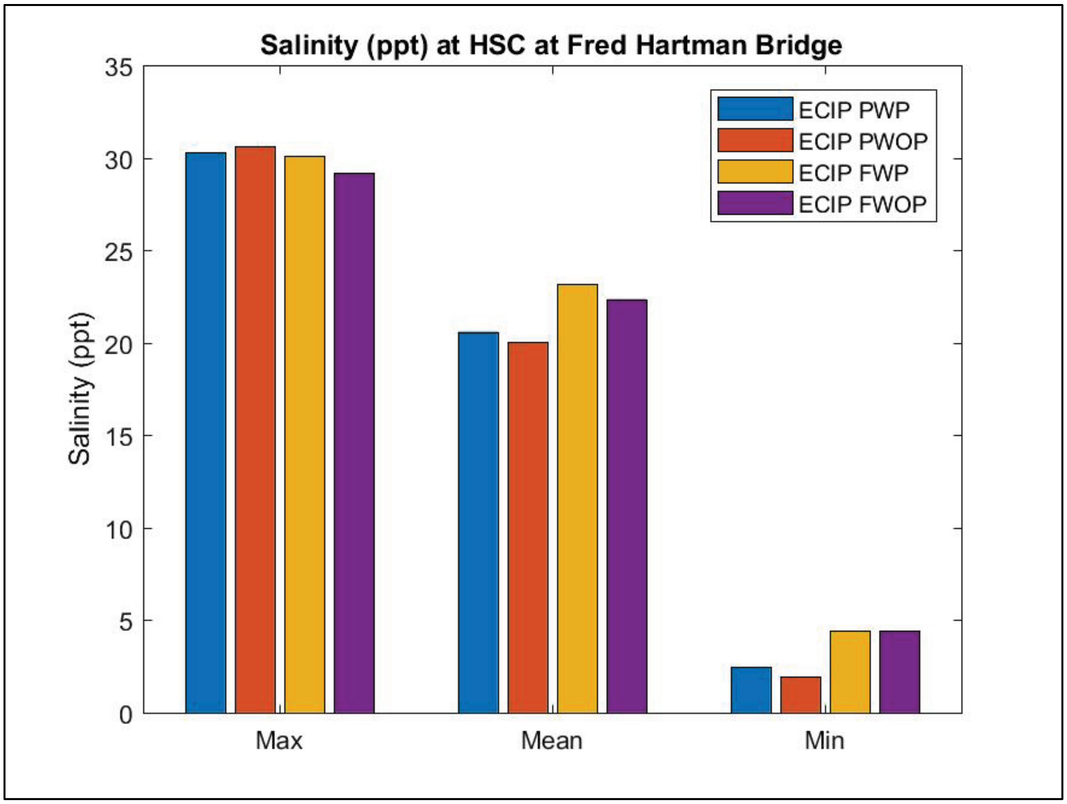

Salinity at Mid East Bay
Salinity (ppt)
Date (mm/dd)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

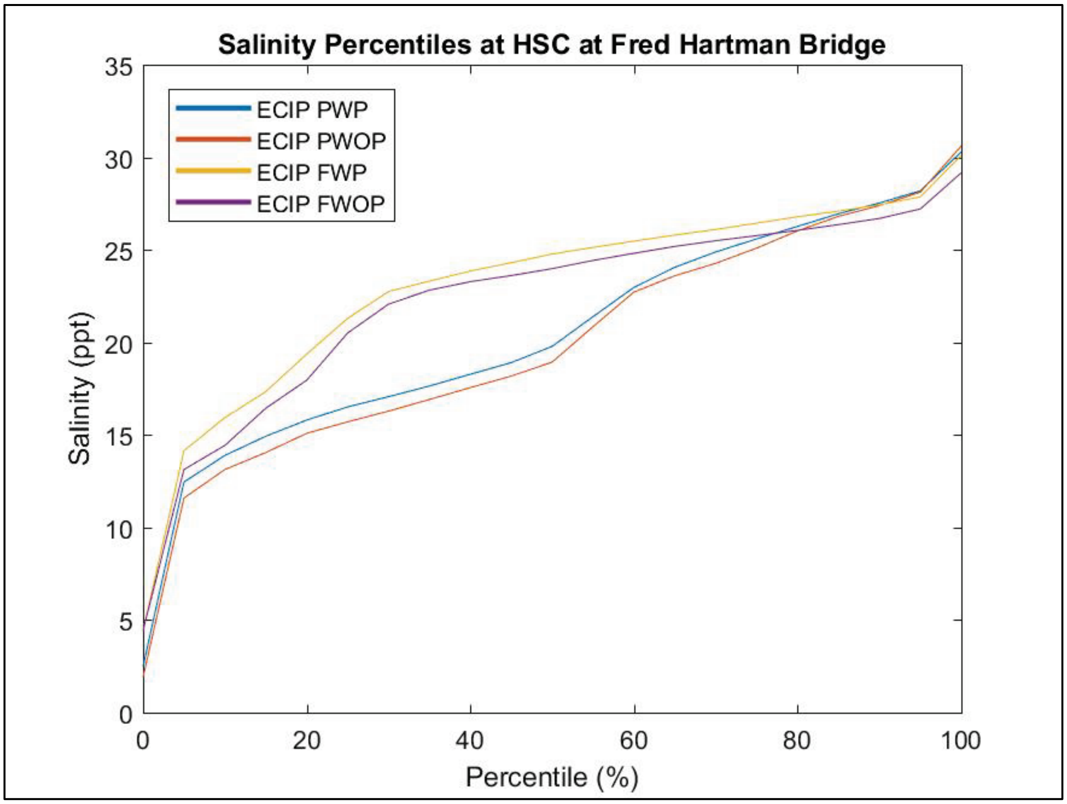

Salinity (ppt) at Mid East Bay
Salinity (ppt)
0
5
10
15
20
25
30
Max
Mean
Min
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP

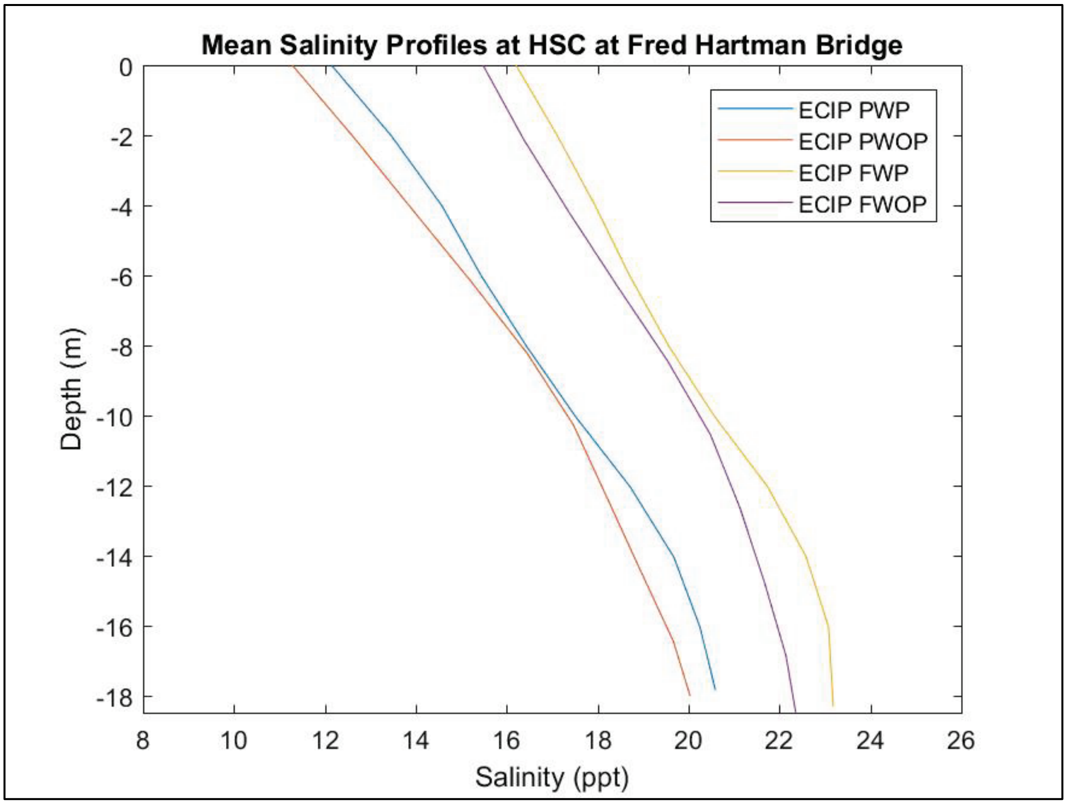

Salinity Percentiles at Mid East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100

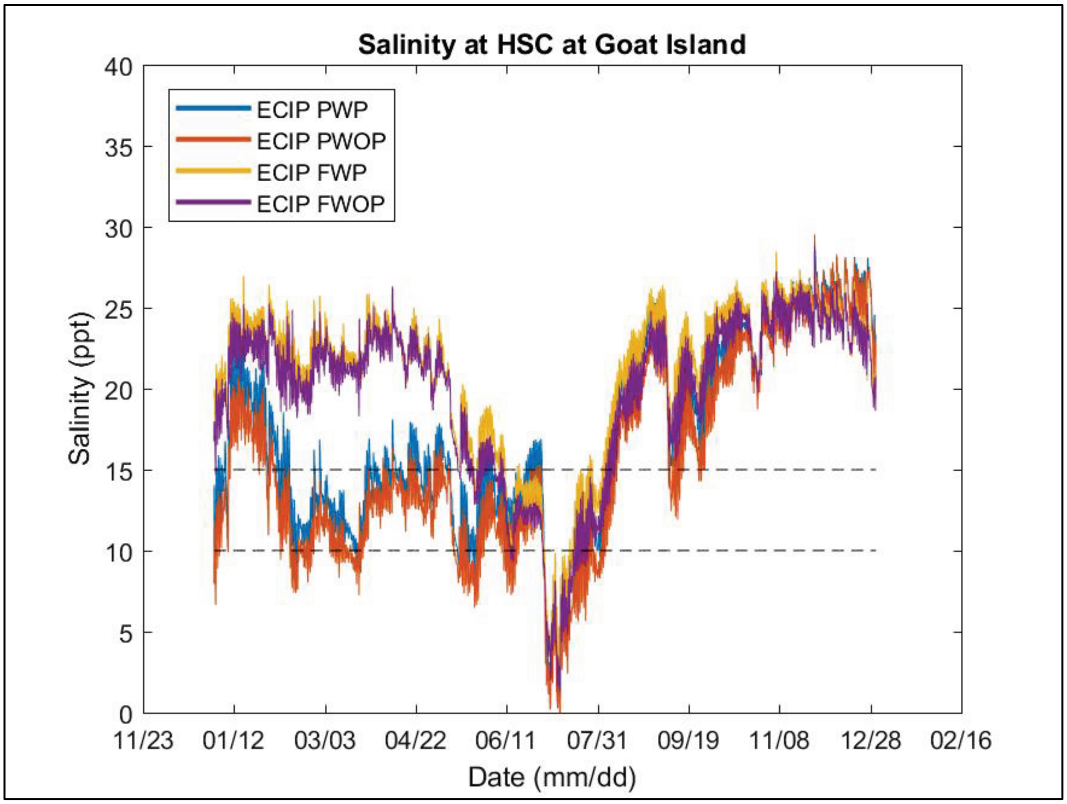

Mean Salinity Profiles at Mid East Bay
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
Salinity (ppt)
0
-0.5
-1
-1.5
-2
-2.5
-3
3
4
5
6
7
8
9
10
11
12

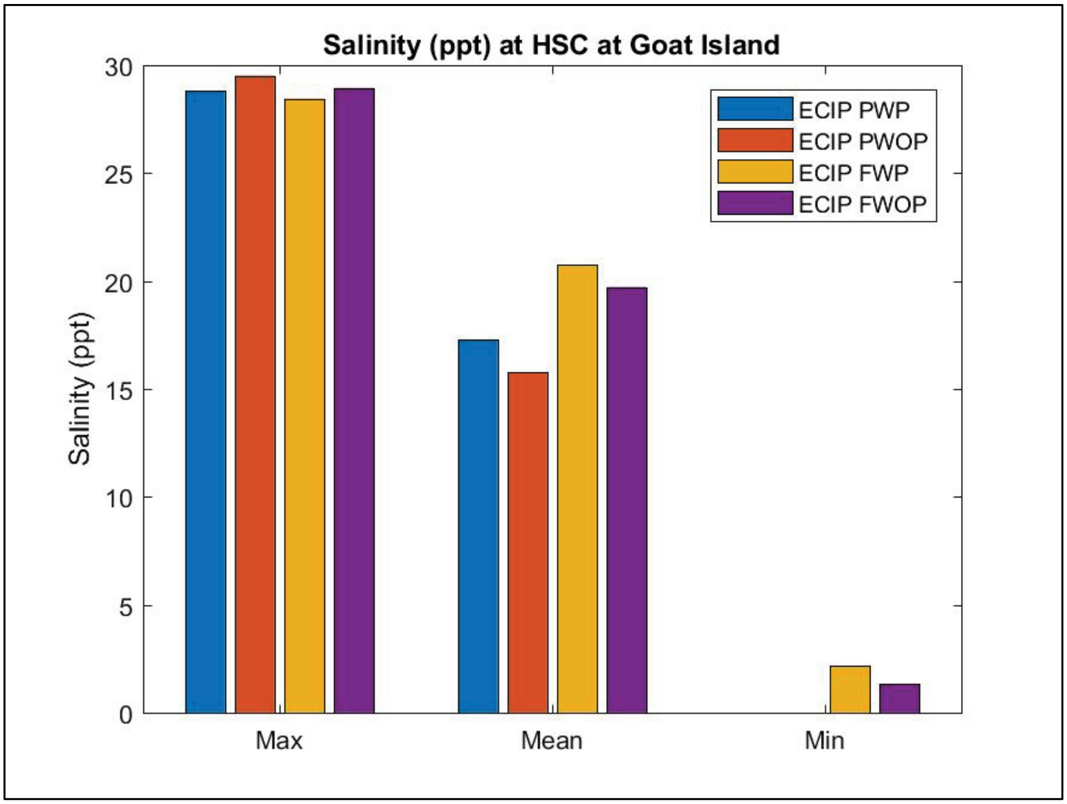

Salinity at HSC at Fred Hartman Bridge
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

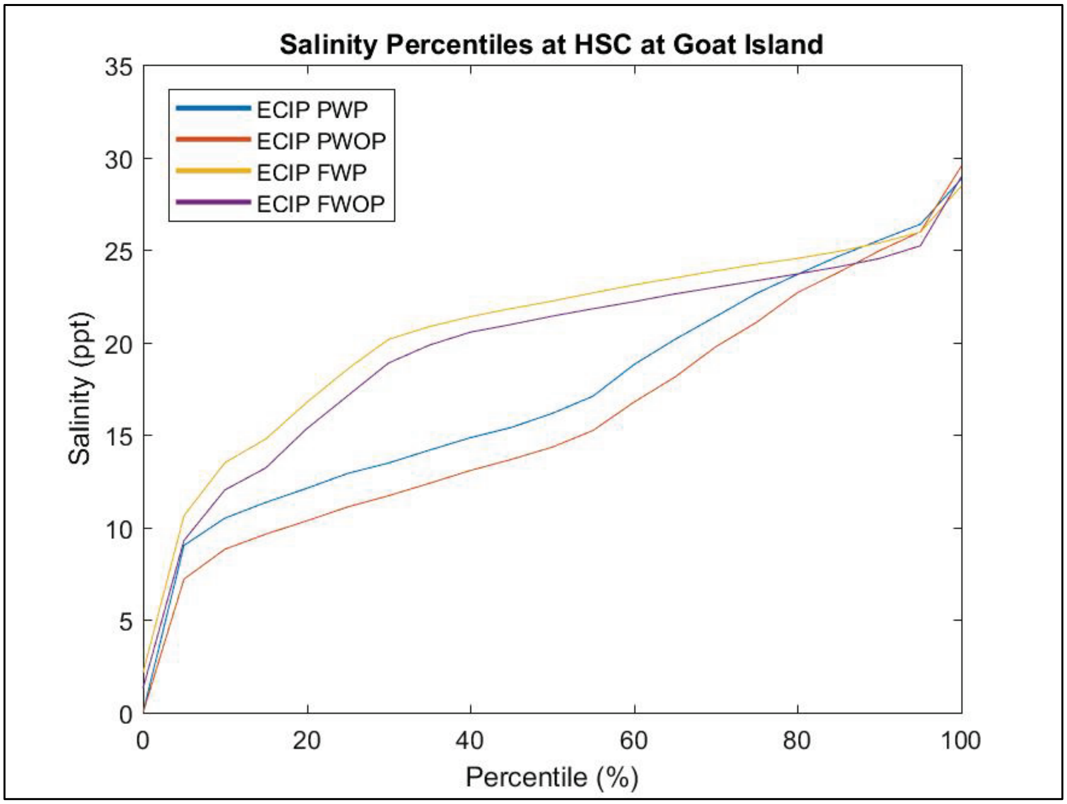

Salinity (ppt) at HSC at Fred Hartman Bridge
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Max
Mean
Min

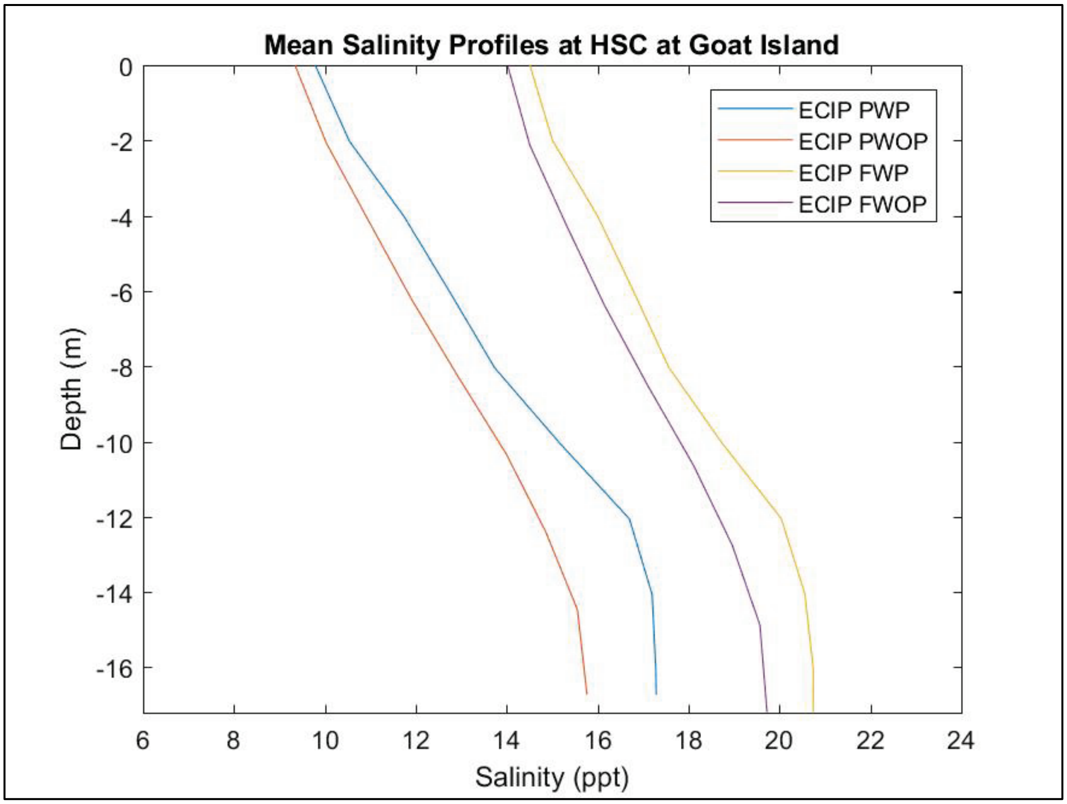

Salinity Percentiles at HSC at Fred Hartman Bridge
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
0
20
40
60
80
100
Percentile (%)

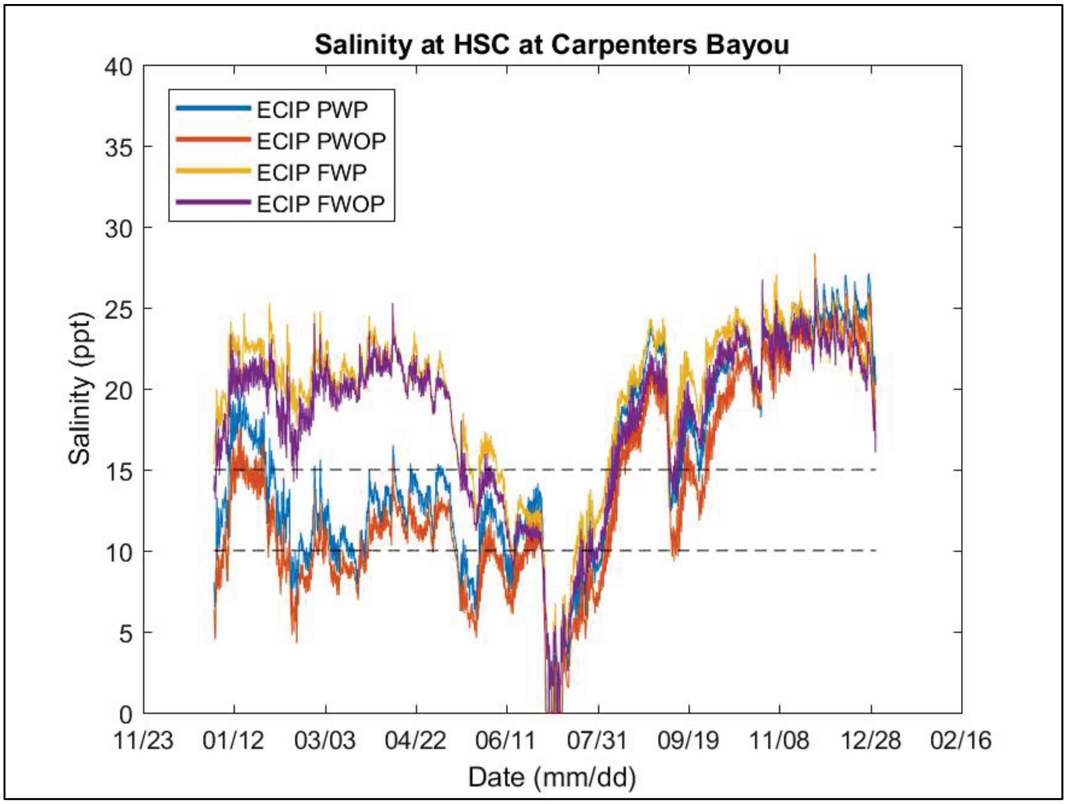

Mean Salinity Profiles at HSC at Fred Hartman Bridge
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
8
10
12
14
16
18
20
22
24
26
Salinity (ppt)

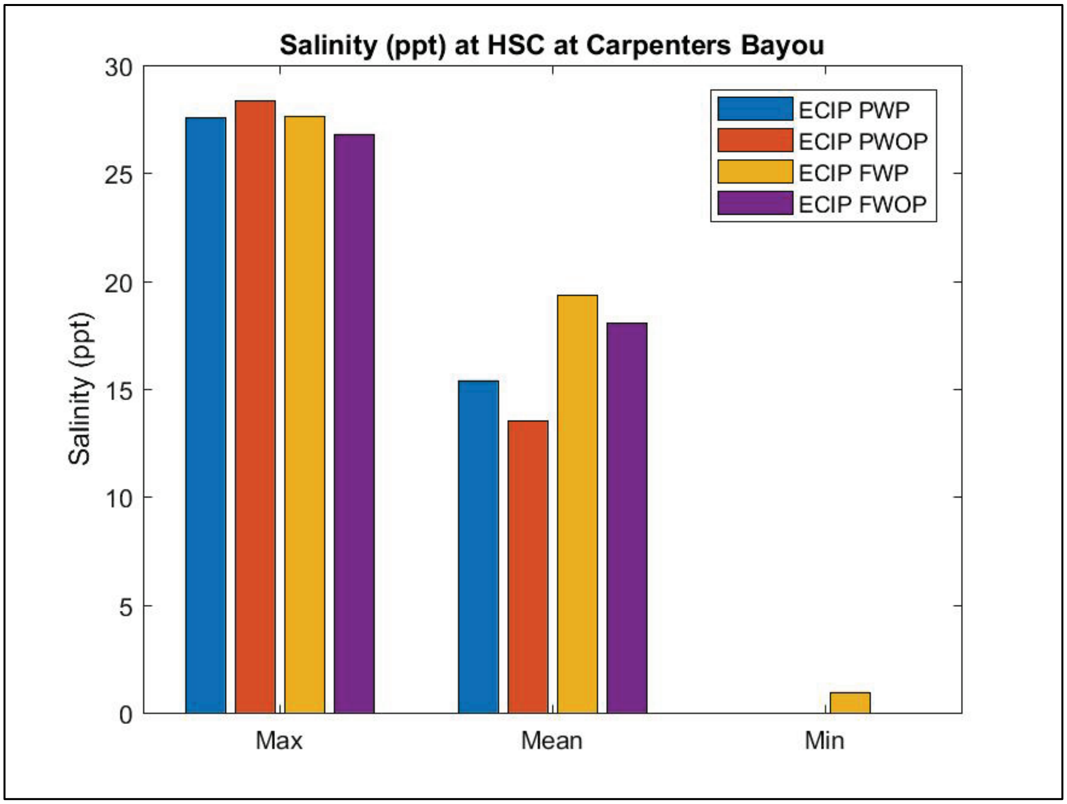

Salinity at HSC at Goat Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

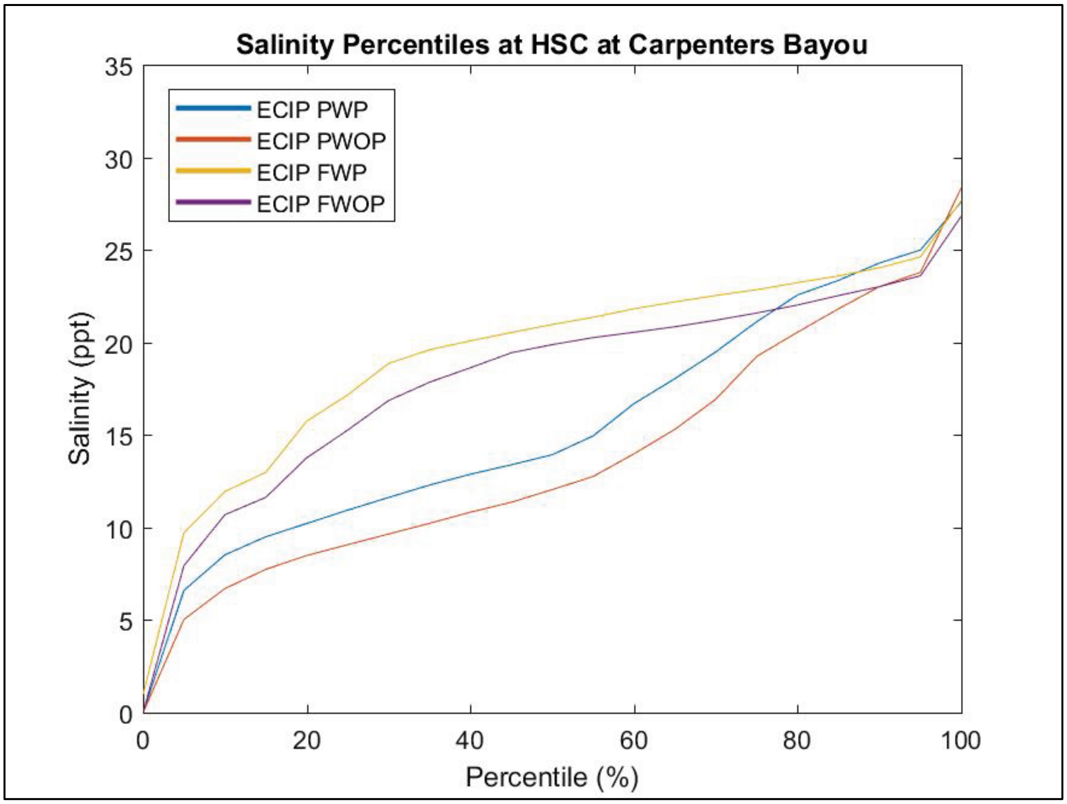

Salinity (ppt) at HSC at Goat Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

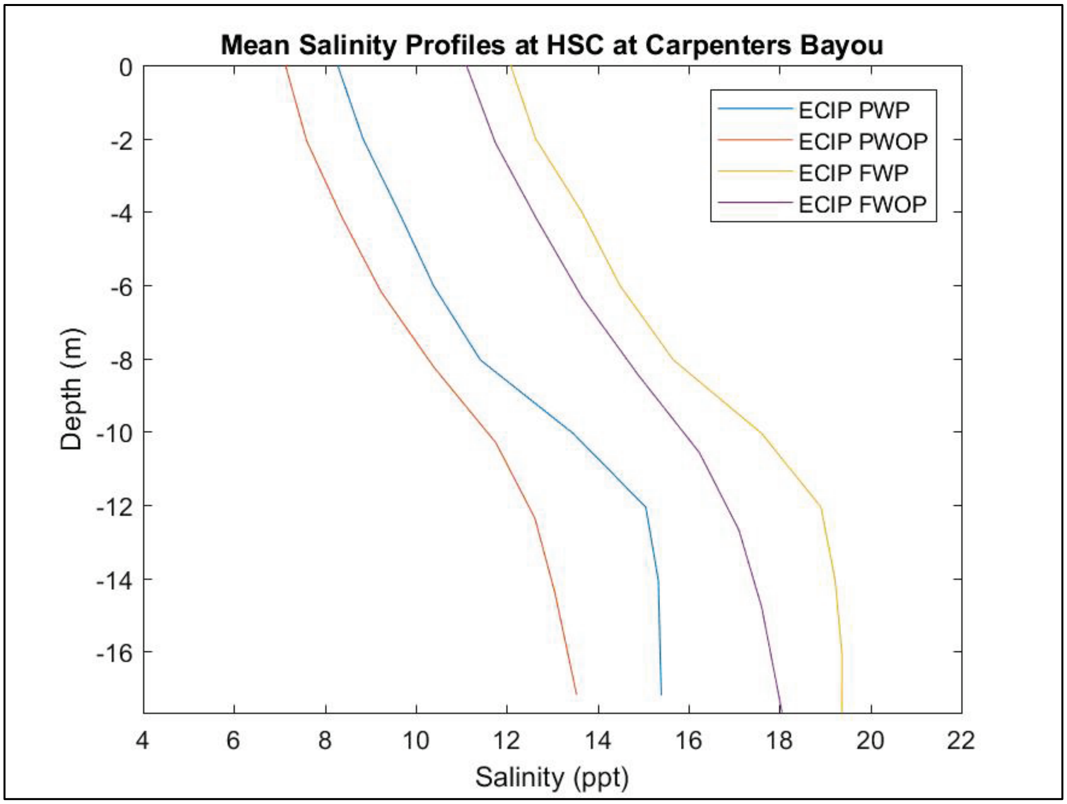

Salinity Percentiles at HSC at Goat Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
Percentile (%)
0
20
40
60
80
100

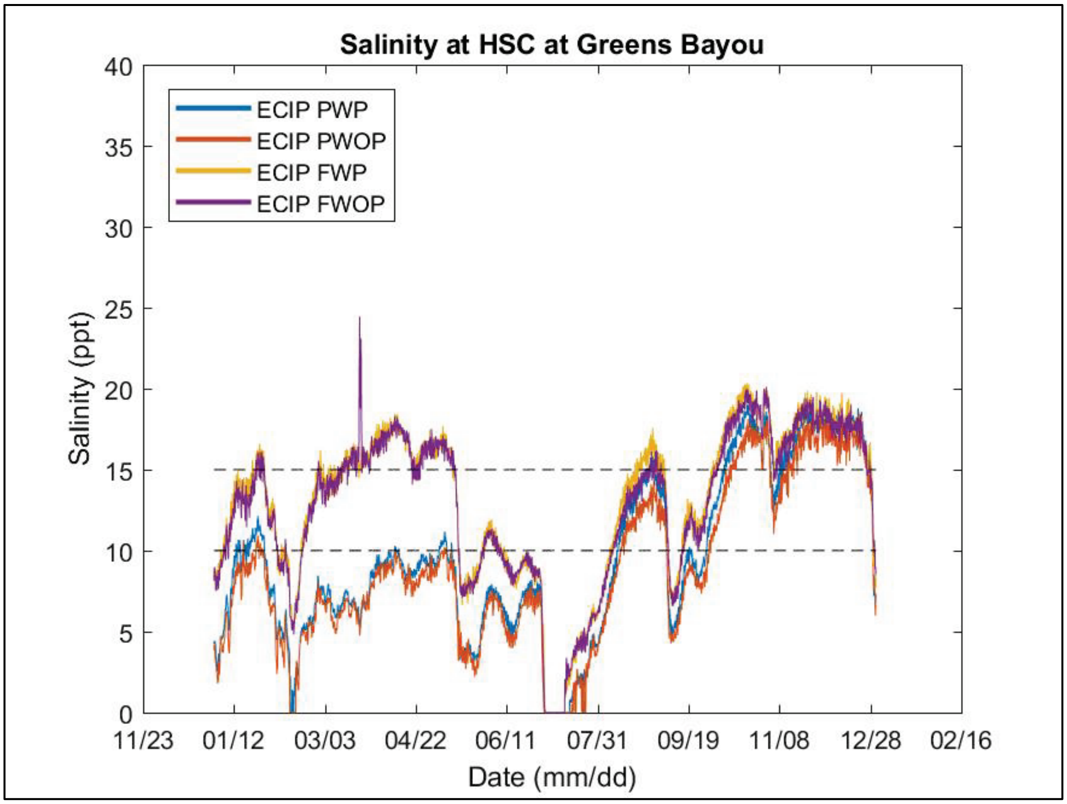

Mean Salinity Profiles at HSC at Goat Island
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
Salinity (ppt)
6
8
10
12
14
16
18
20
22
24

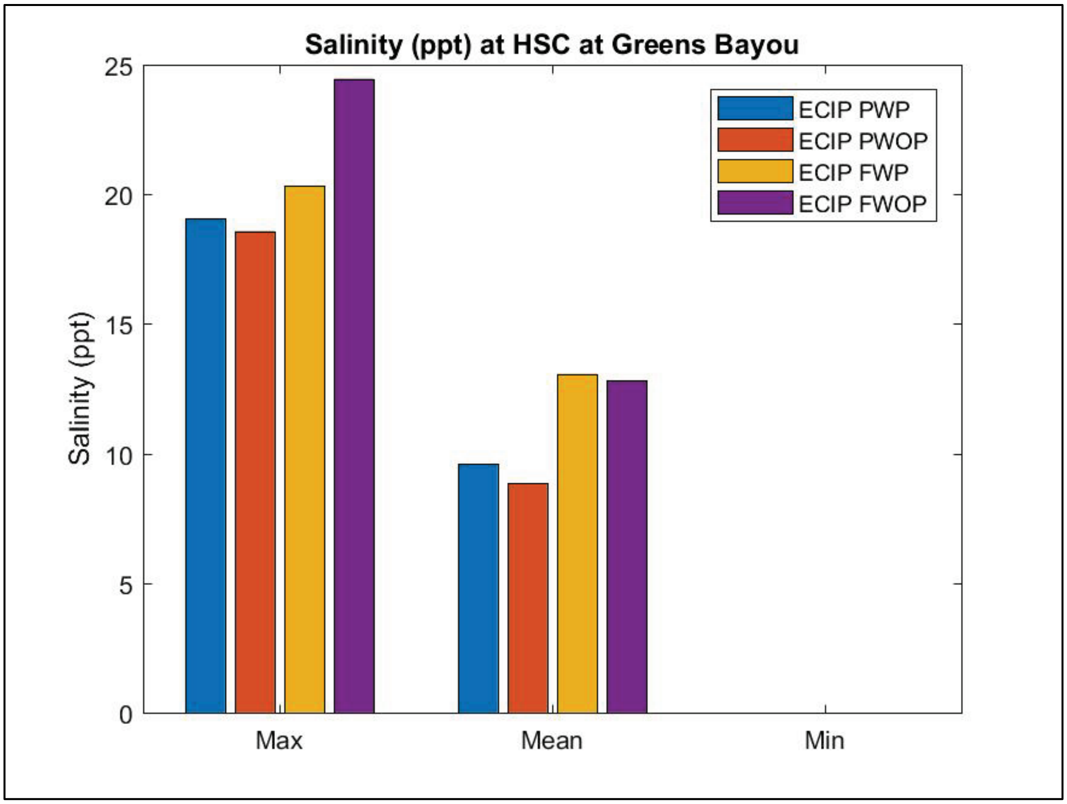

Salinity at HSC at Carpenters Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

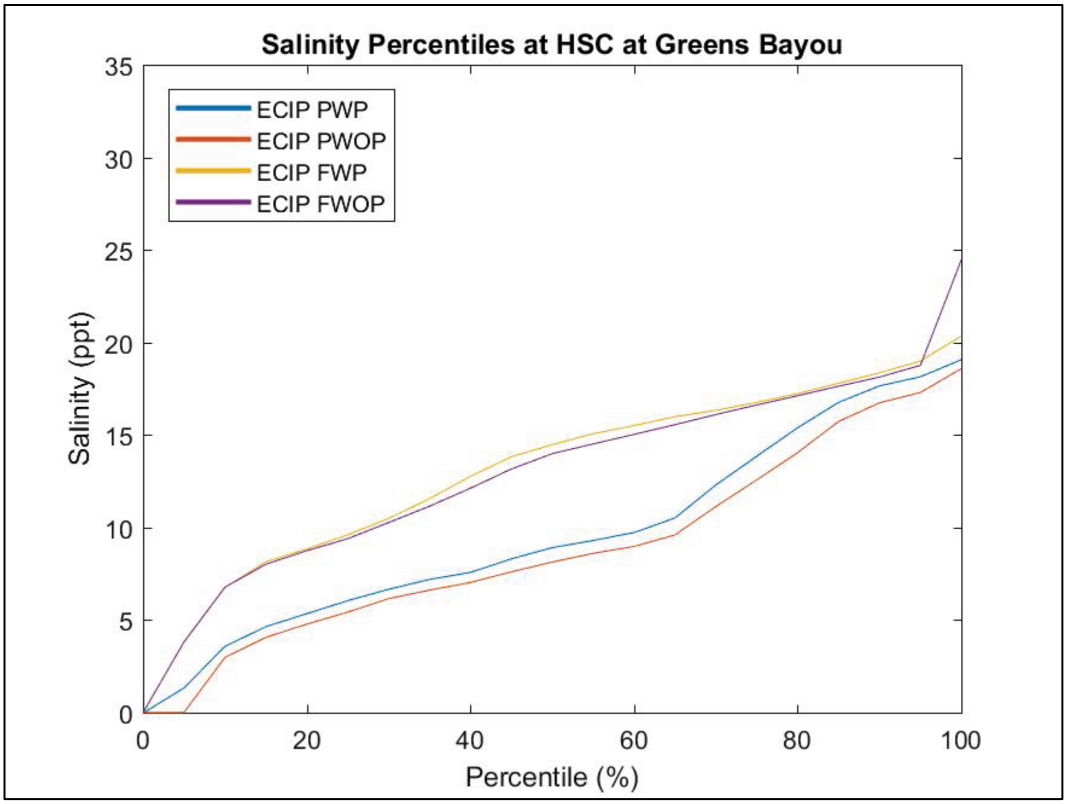

Salinity (ppt) at HSC at Carpenters Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
30
25
20
15
10
5
0
Max
Mean
Min

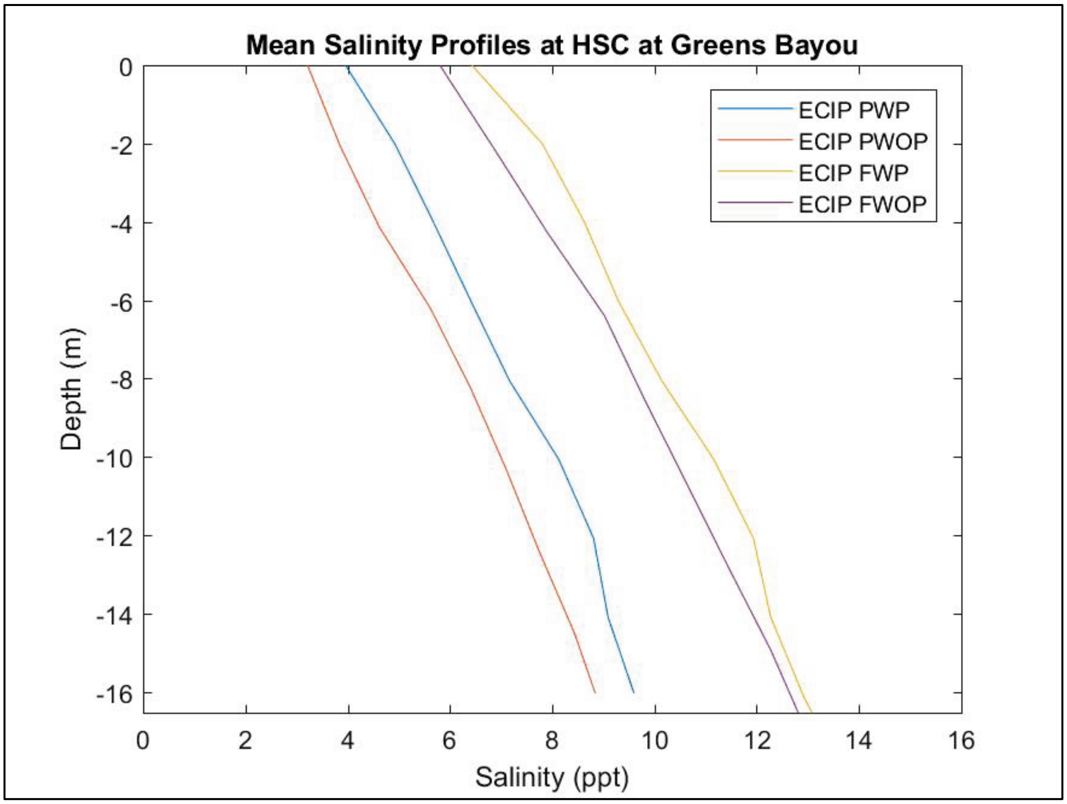

Salinity Percentiles at HSC at Carpenters Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
Percentile (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100

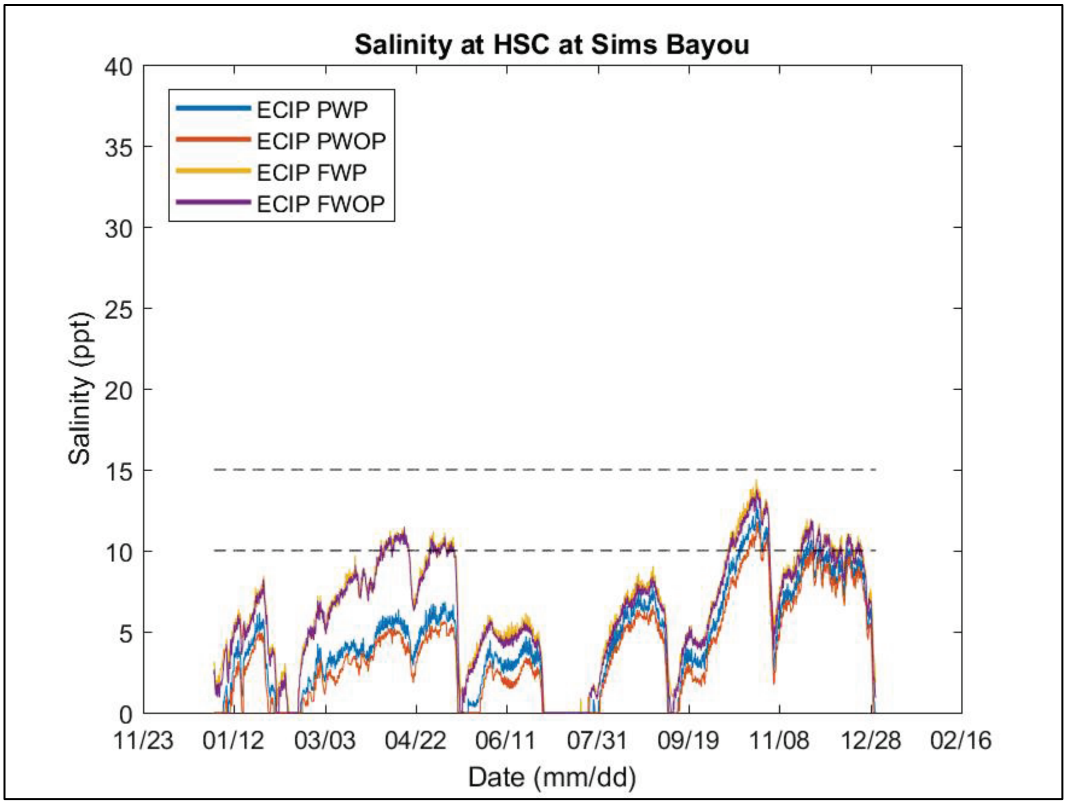

Mean Salinity Profiles at HSC at Carpenters Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
Salinity (ppt)
0
-2
-4
-6
-8
-10
-12
-14
-16
4
6
8
10
12
14
16
18
20
22

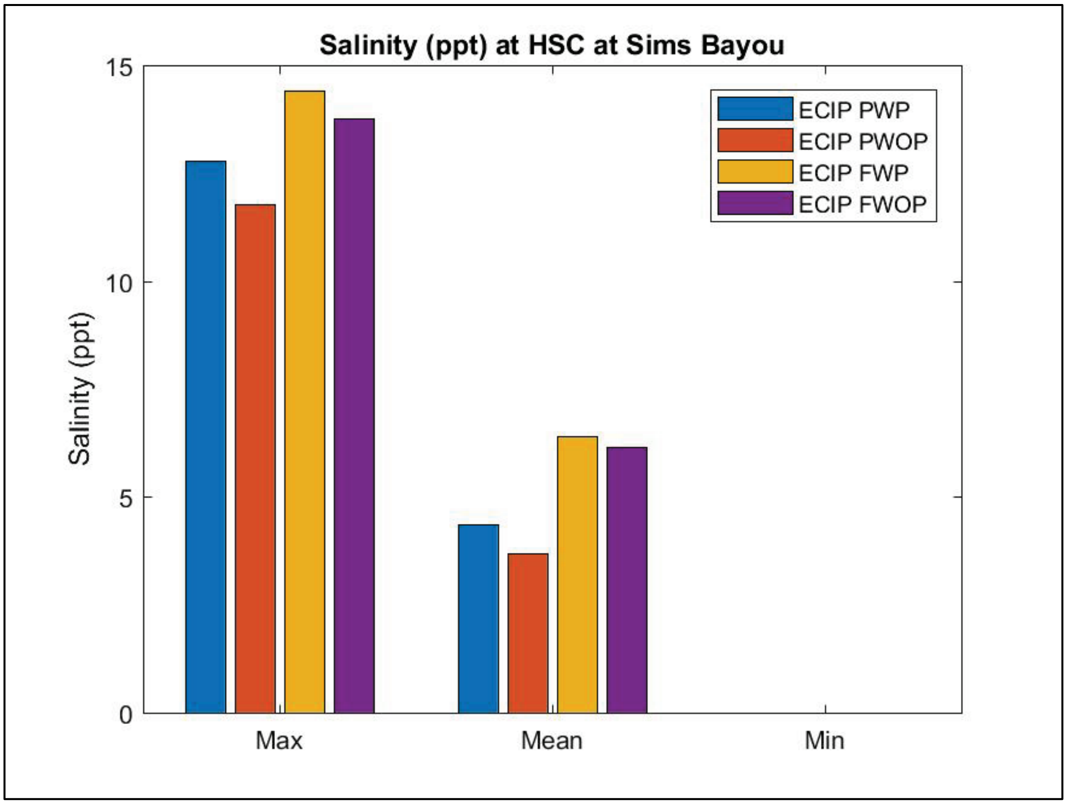

Salinity at HSC at Greens Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
40
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

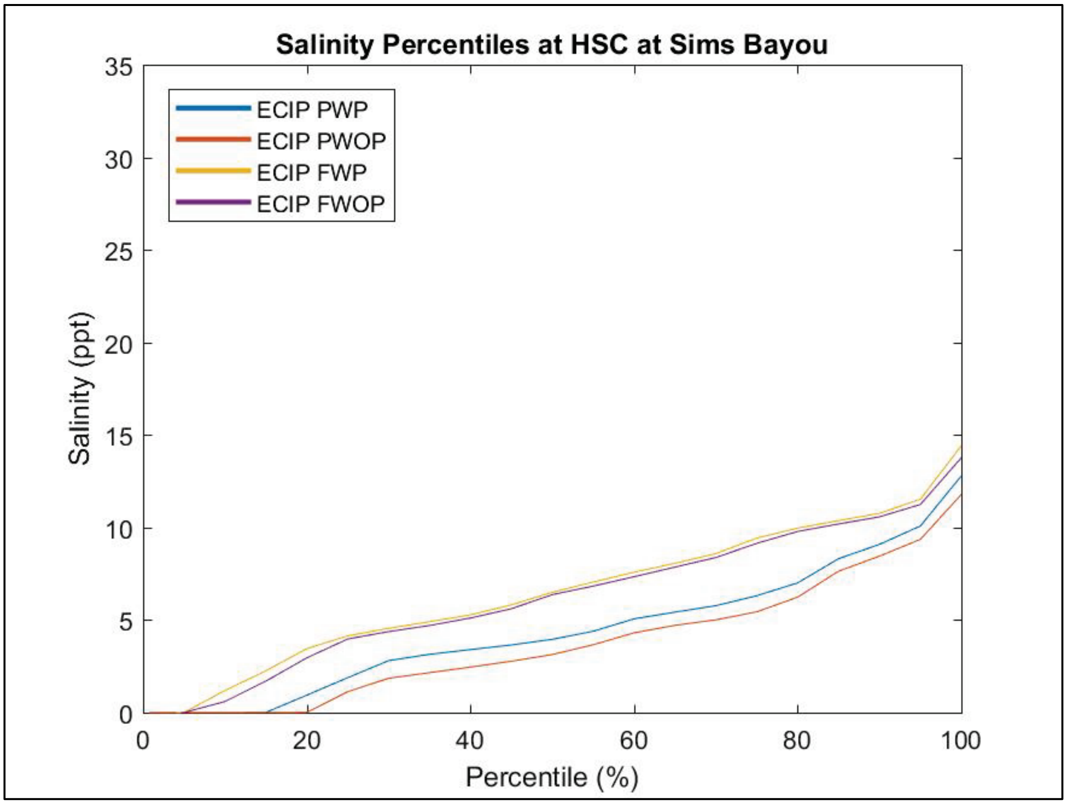

Salinity (ppt) at HSC at Greens Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
Max
Mean
Min

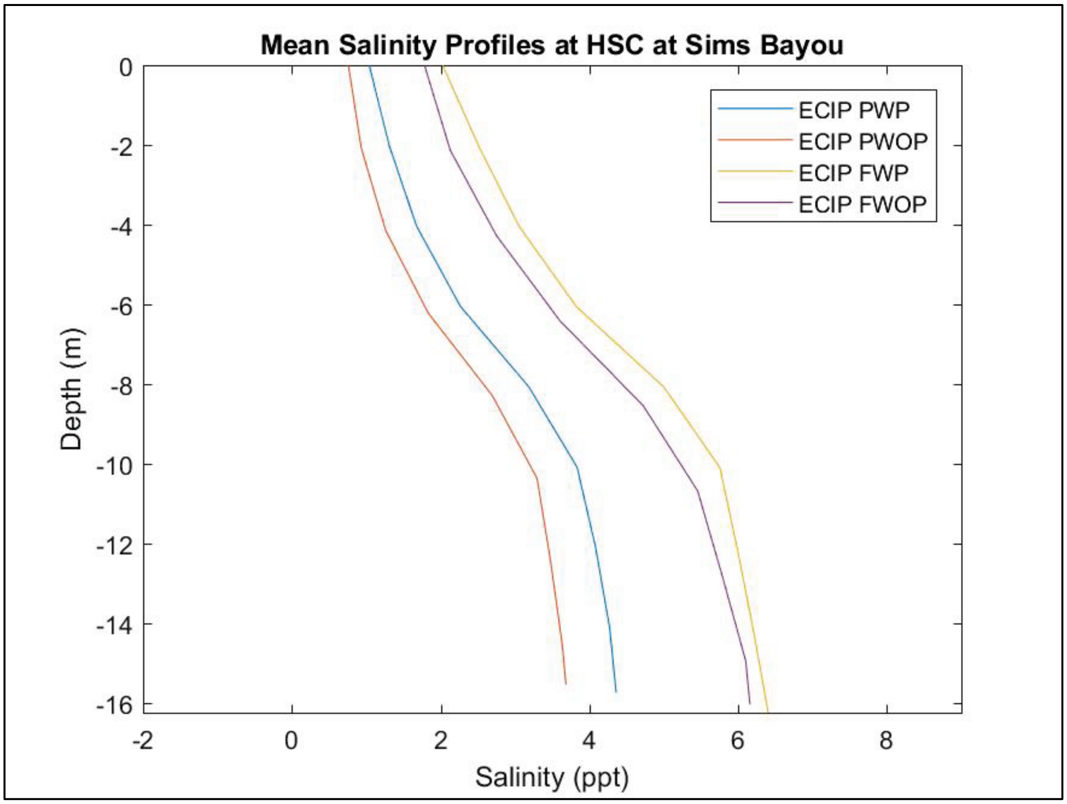

Salinity Percentiles at HSC at Greens Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Percentile (%)

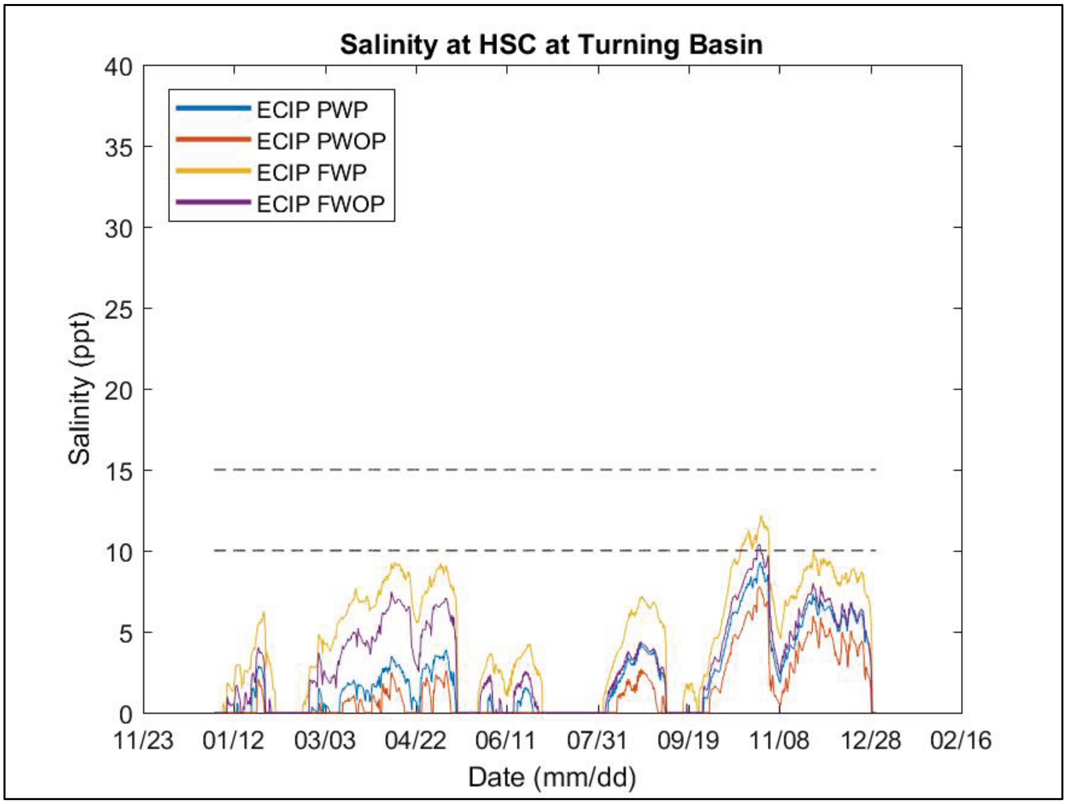

Mean Salinity Profiles at HSC at Greens Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
0
2
4
6
8
10
12
14
16
Salinity (ppt)

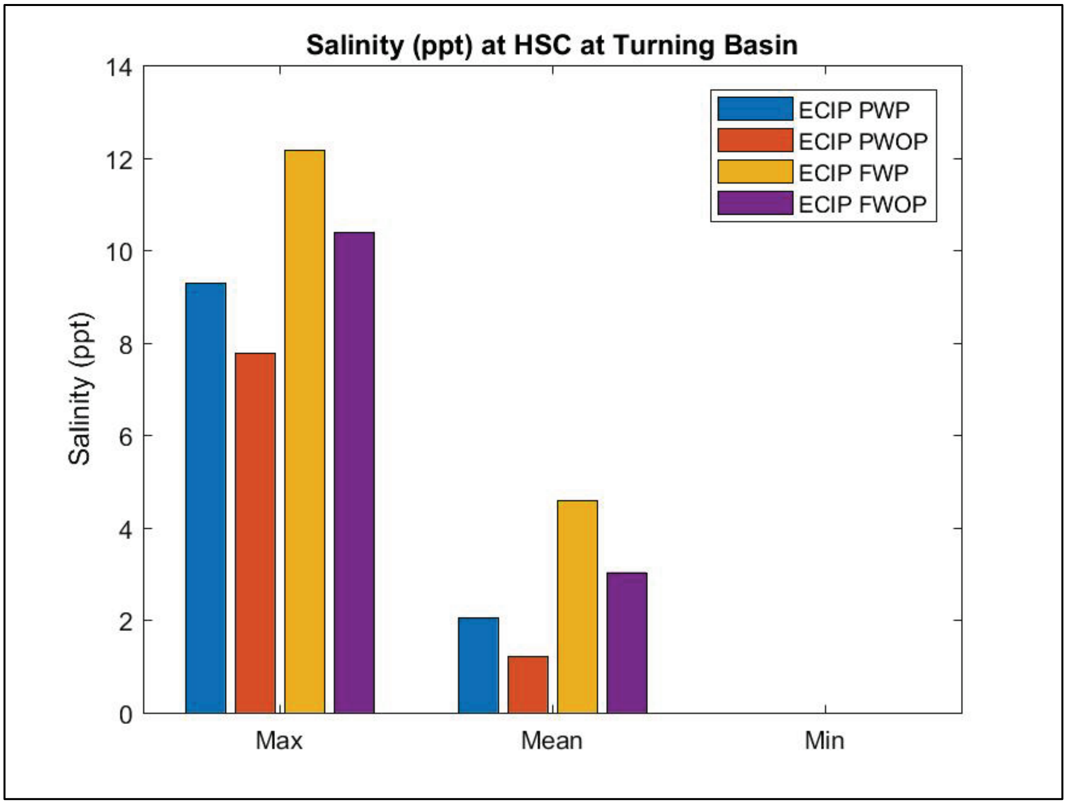

Salinity at HSC at Sims Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

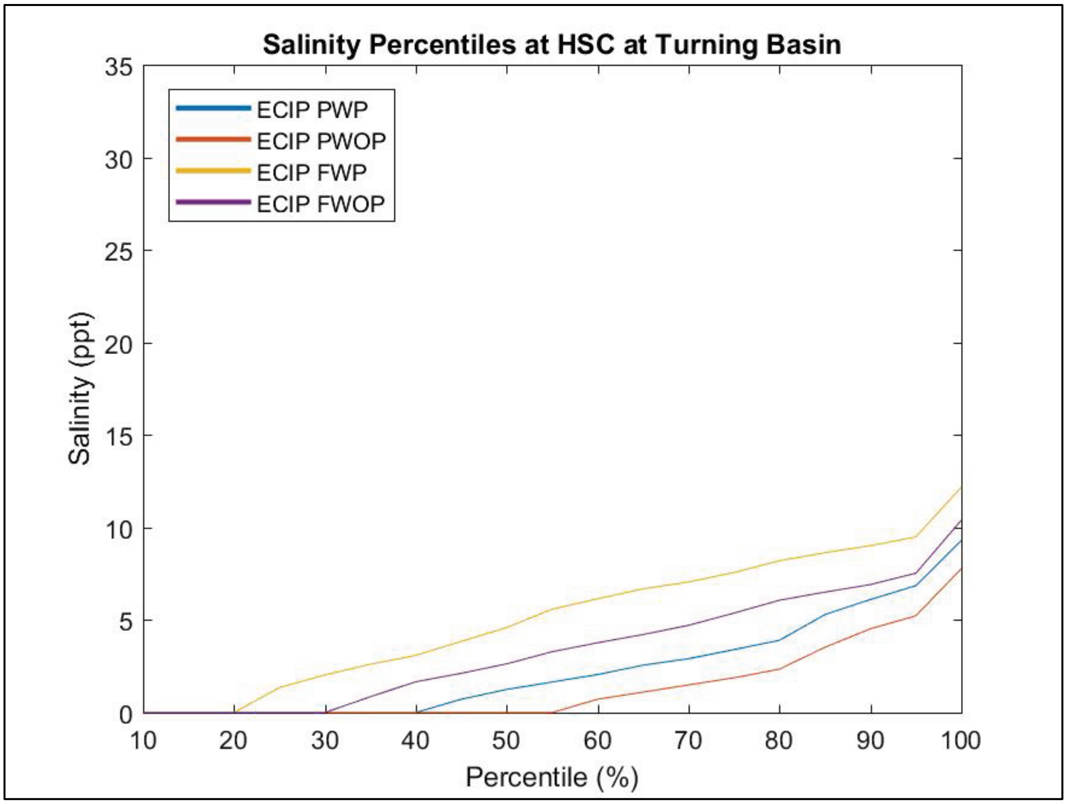

Salinity (ppt) at HSC at Sims Bayou
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
15
10
5
0
Max
Mean
Min

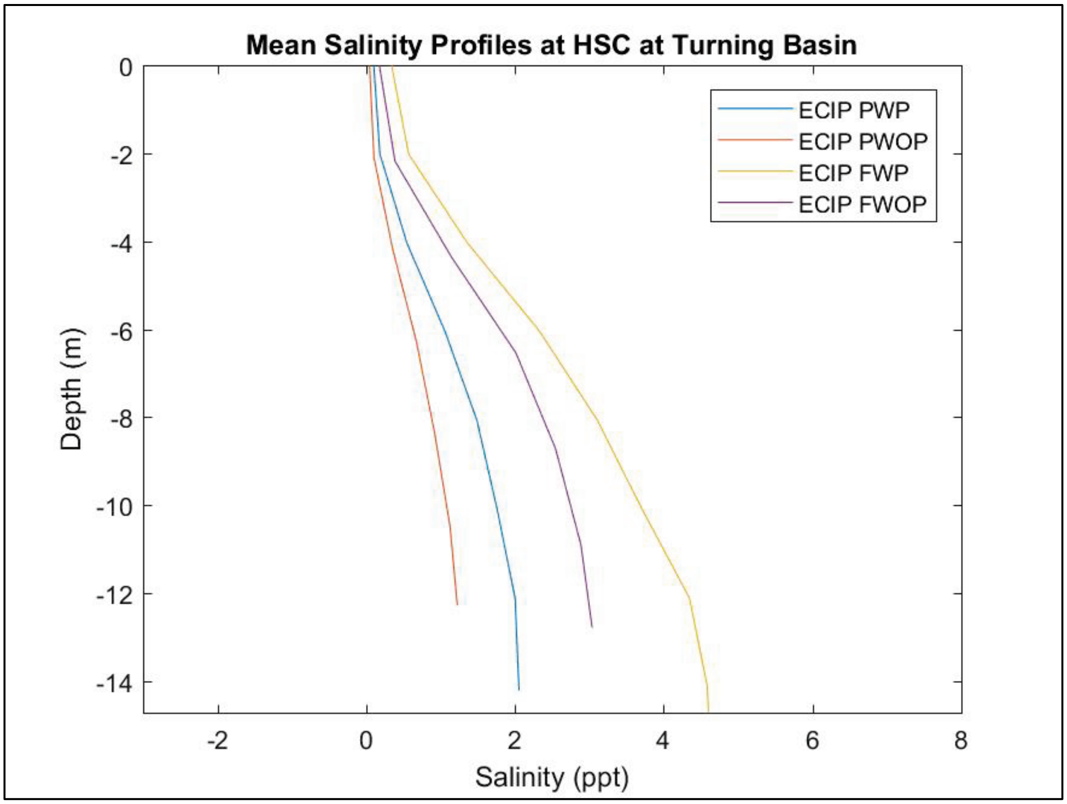

Salinity Percentiles at HSC at Sims Bayou
Salinity (ppt)
35
30
25
20
15
10
5
0
Percentile (%)
0
20
40
60
80
100
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP


Mean Salinity Profiles at HSC at Sims Bayou
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
Salinity (ppt)
-2
0
2
4
6
8
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP


Salinity at HSC at Turning Basin
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
40
35
30
25
20
15
10
5
0
11/23
01/12
03/03
04/22
06/11
07/31
09/19
11/08
12/28
02/16
Date (mm/dd)

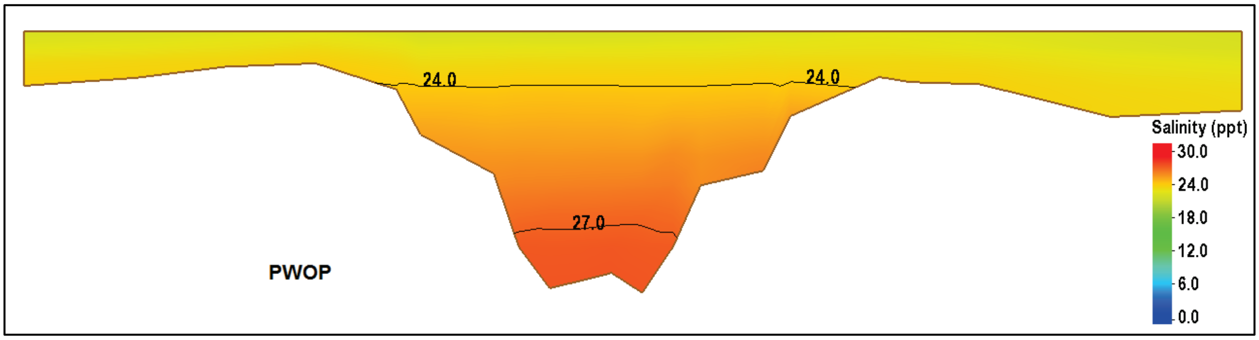

Salinity (ppt) at HSC at Turning Basin
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
14
12
10
8
6
4
2
0
Max
Mean
Min

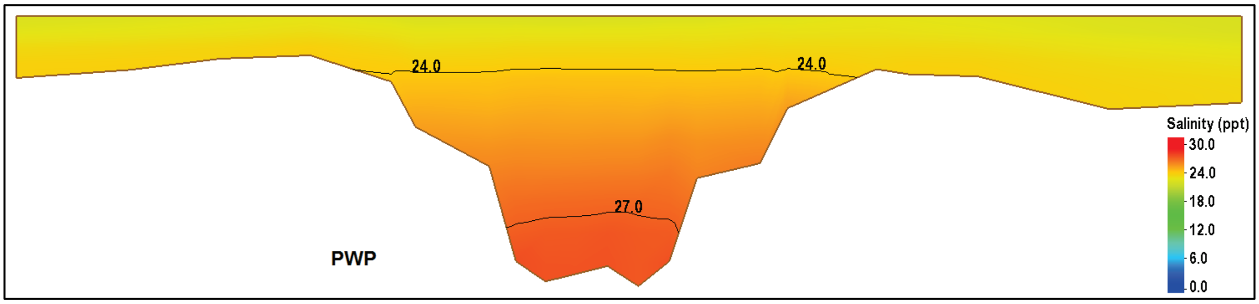

Salinity Percentiles at HSC at Turning Basin
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Salinity (ppt)
0
5
10
15
20
25
30
35
10
20
30
40
50
60
70
80
90
100
Percentile (%)

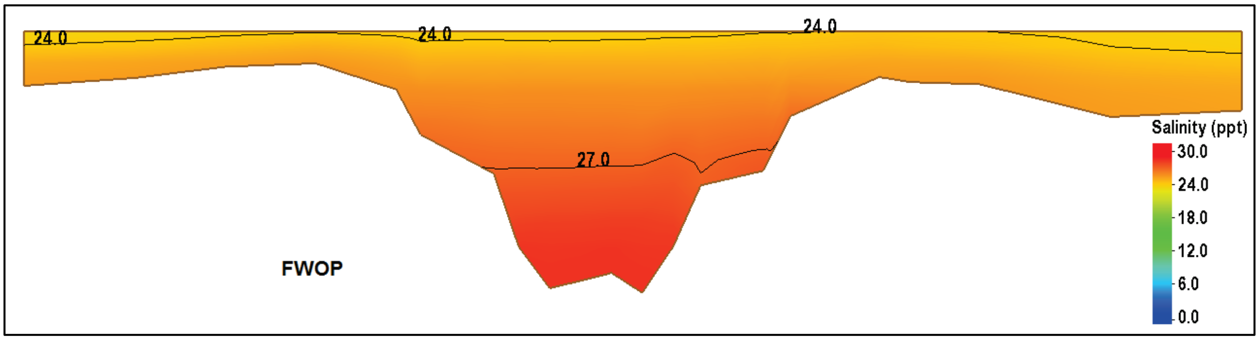

Mean Salinity Profiles at HSC at Turning Basin
ECIP PWP
ECIP PWOP
ECIP FWP
ECIP FWOP
Depth (m)
0
-2
-4
-6
-8
-10
-12
-14
-2
0
2
4
6
8
Salinity (ppt)

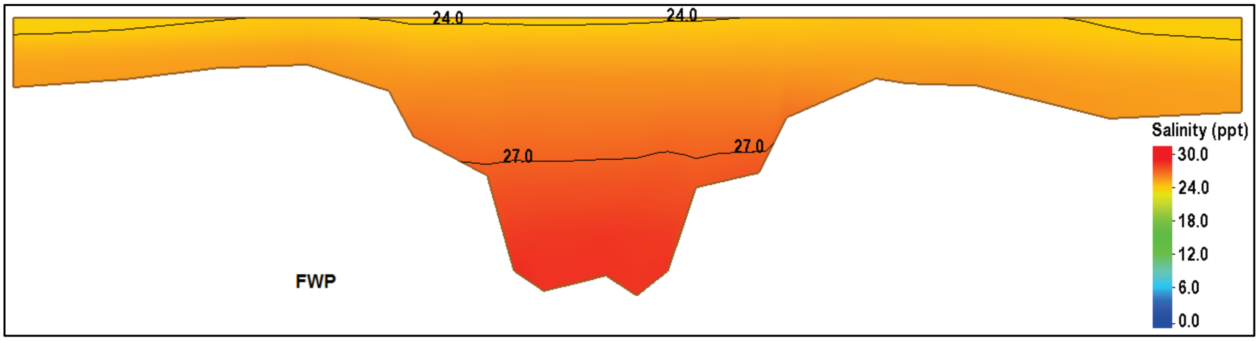
Cross-sectional salinity analysis

Cross section 1

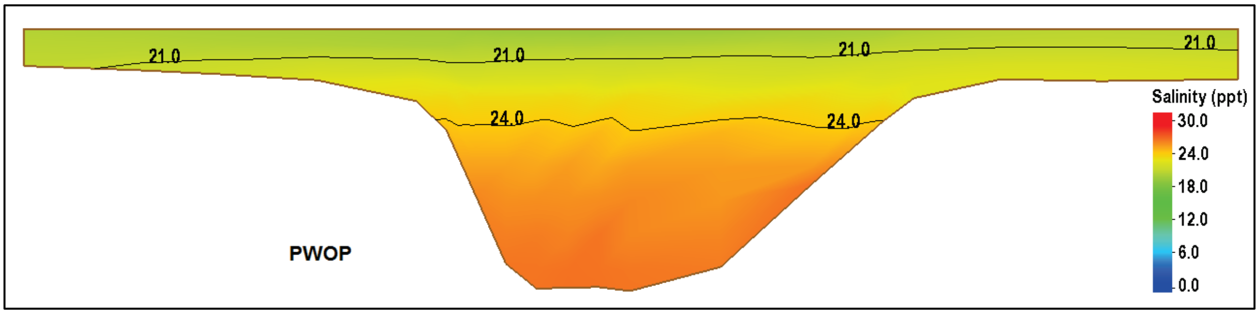


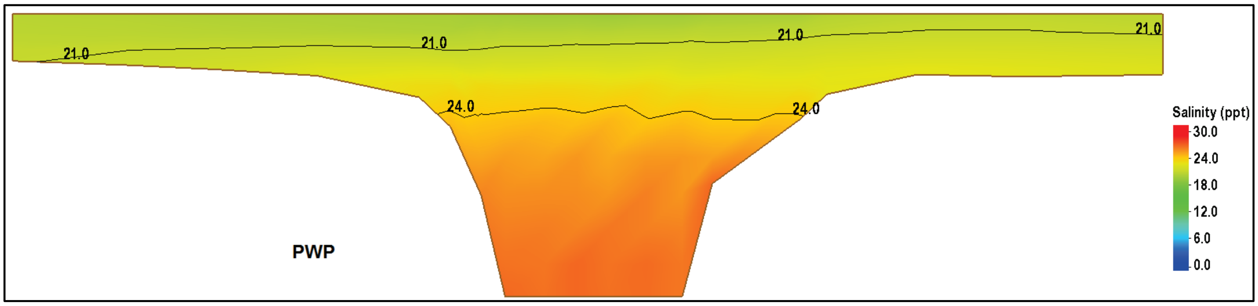


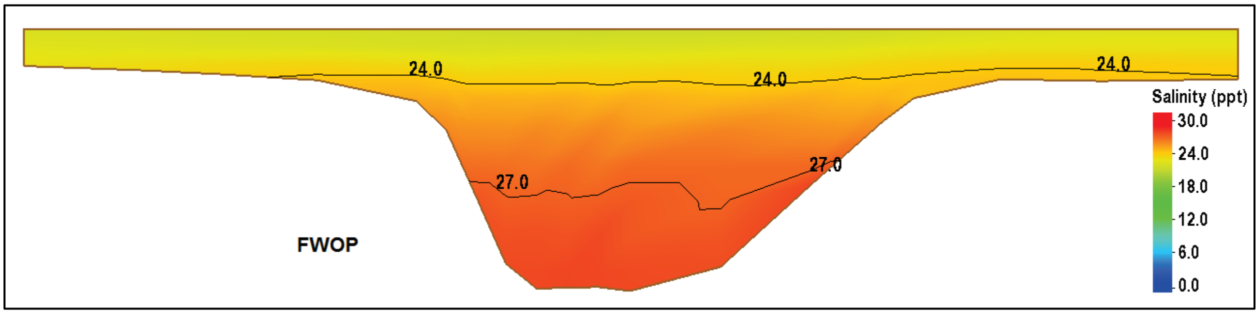


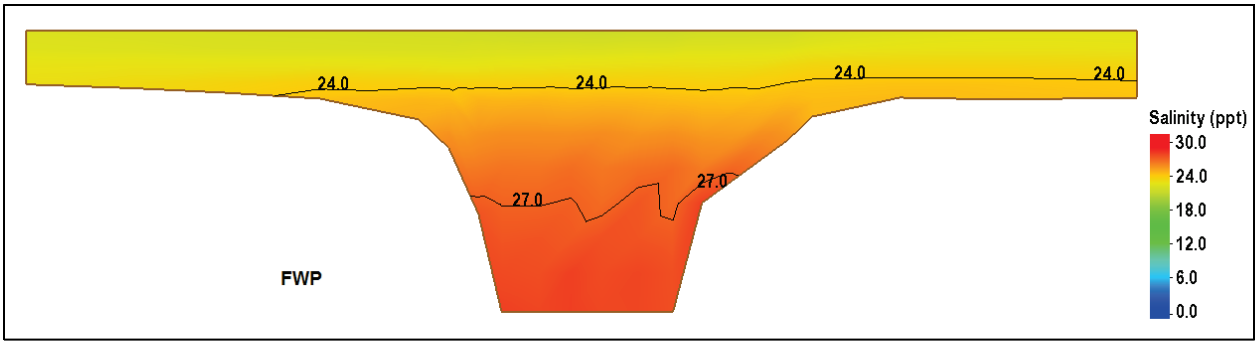


Cross section 2

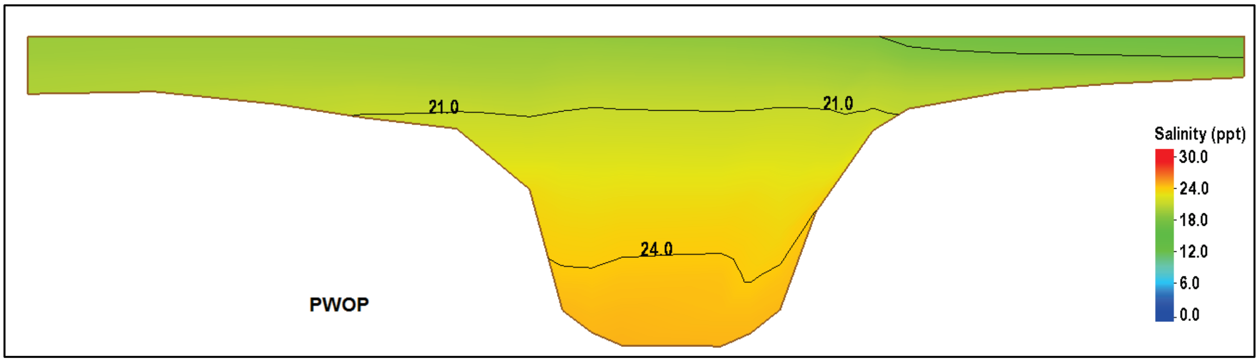


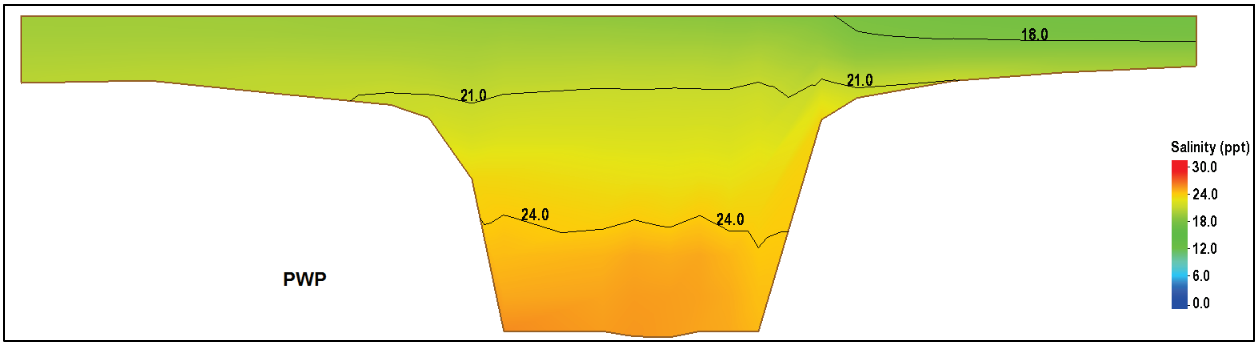


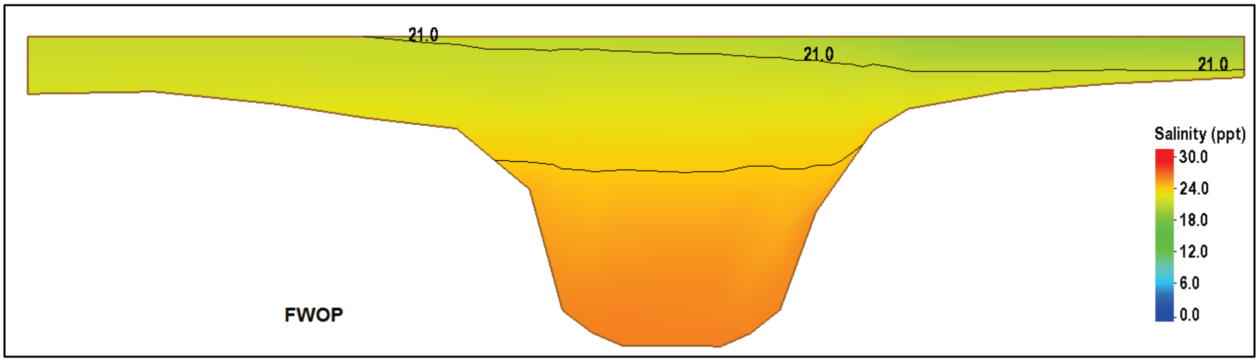


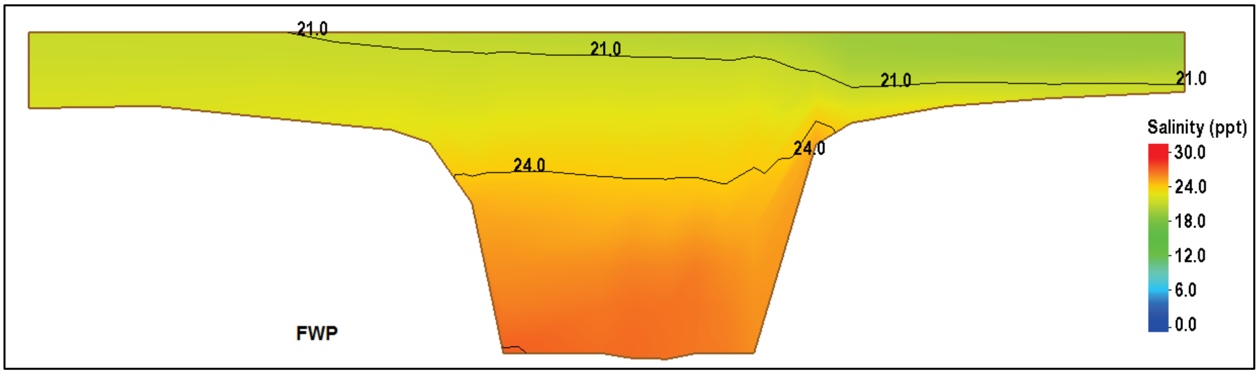


Cross section 3

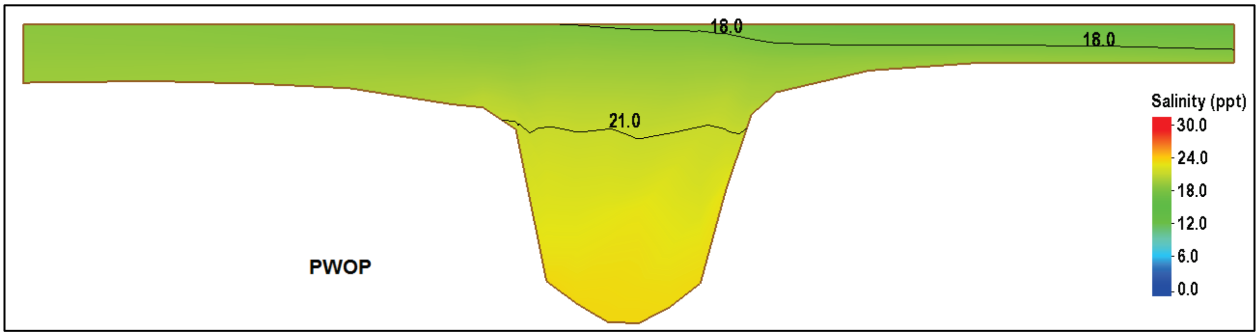


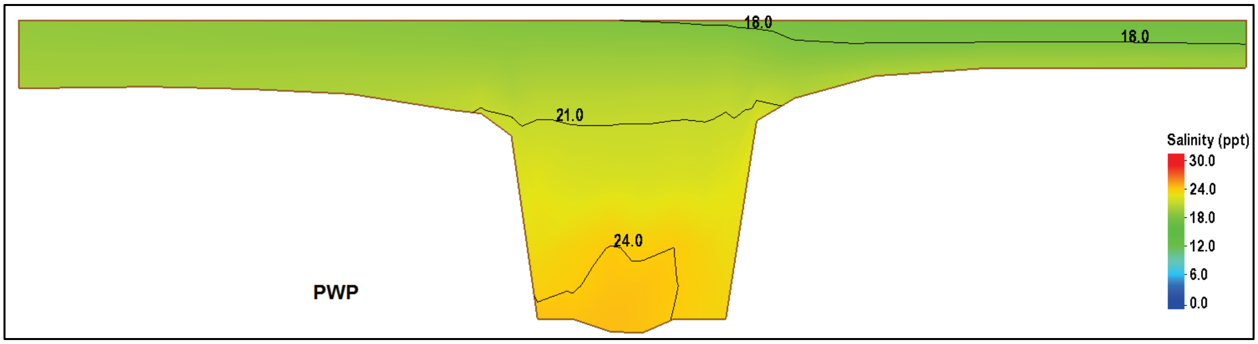


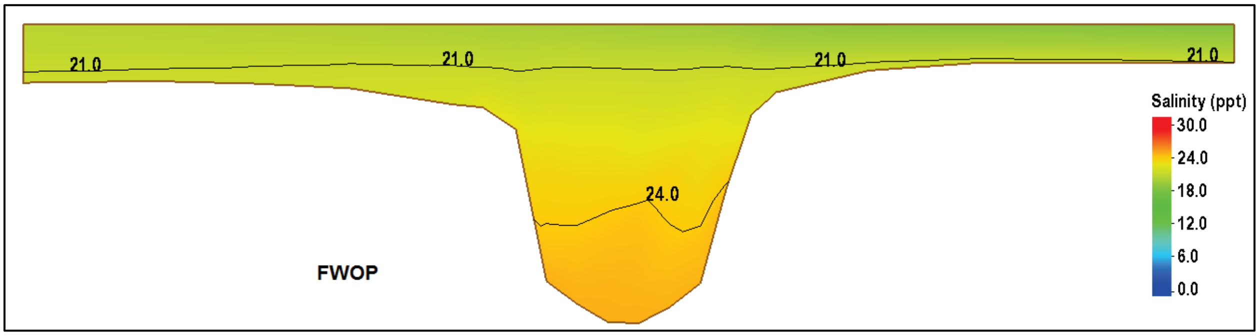


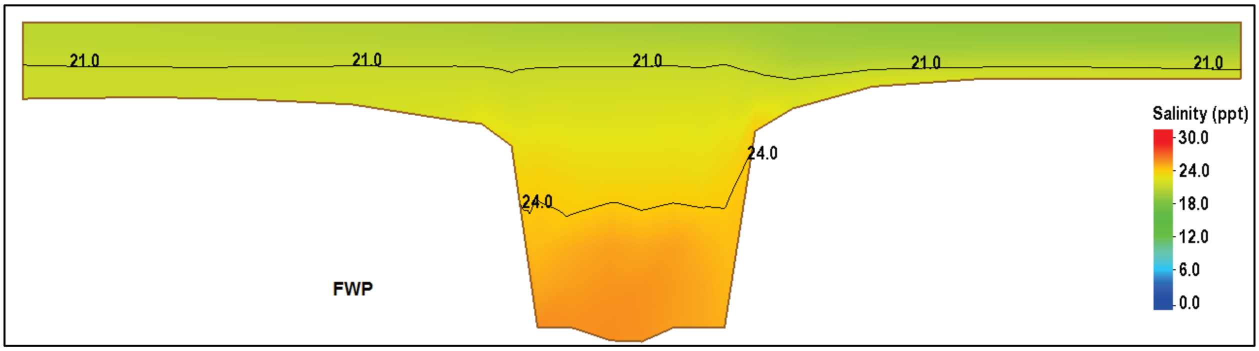


Cross section 4

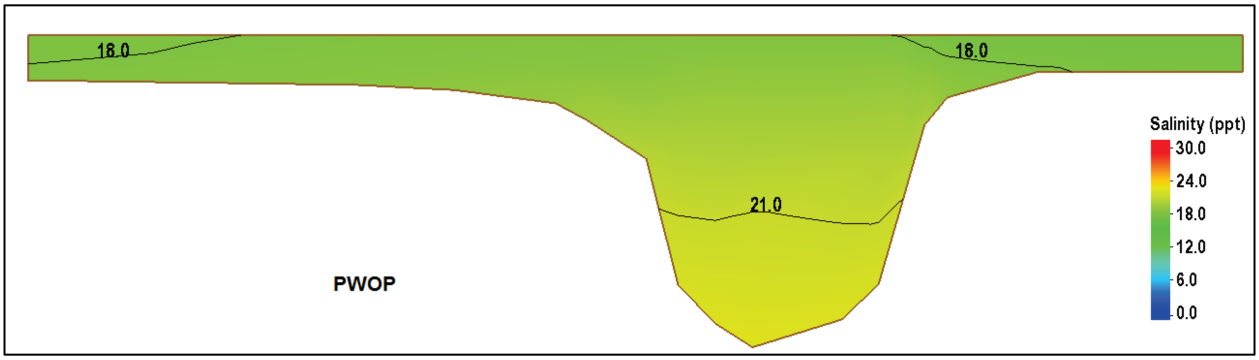


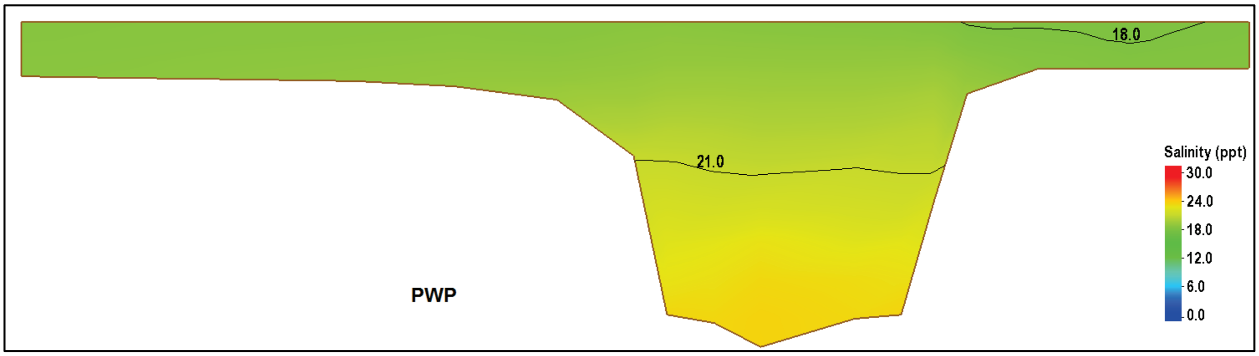


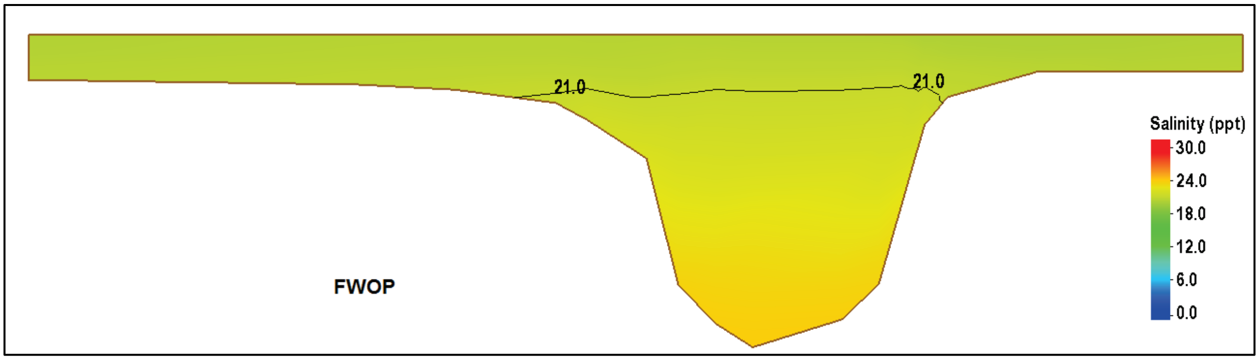


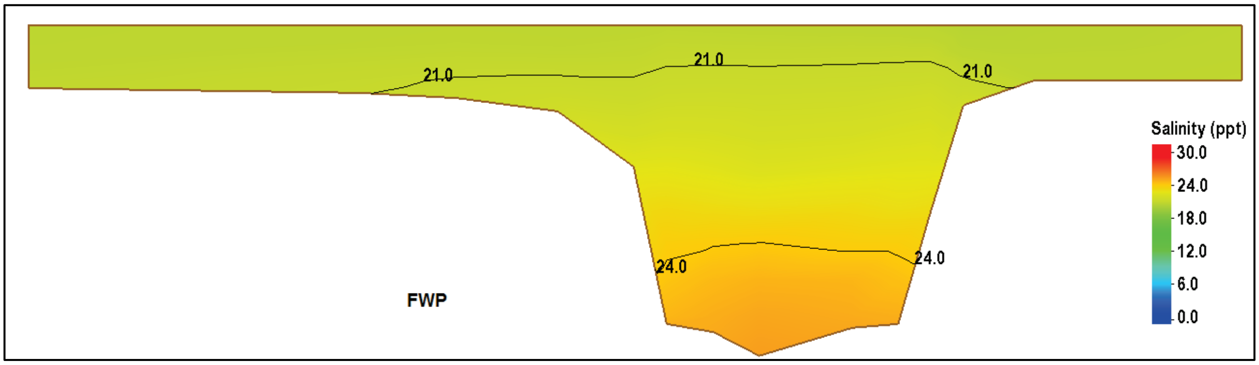


Cross section 5

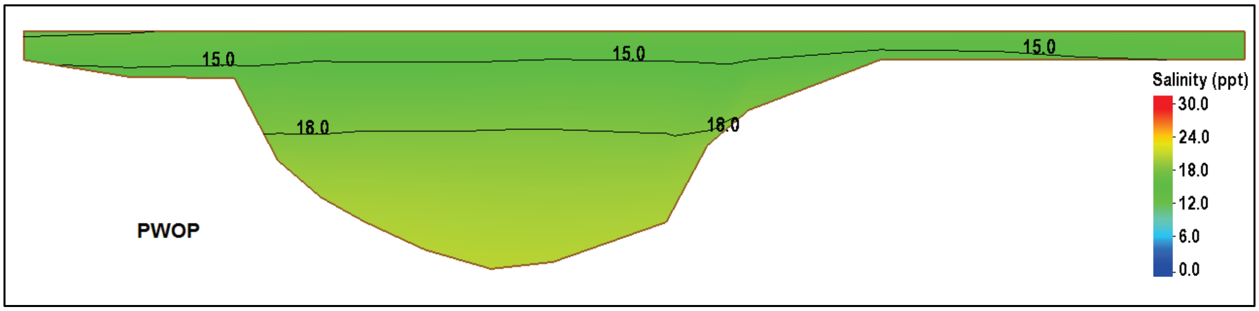


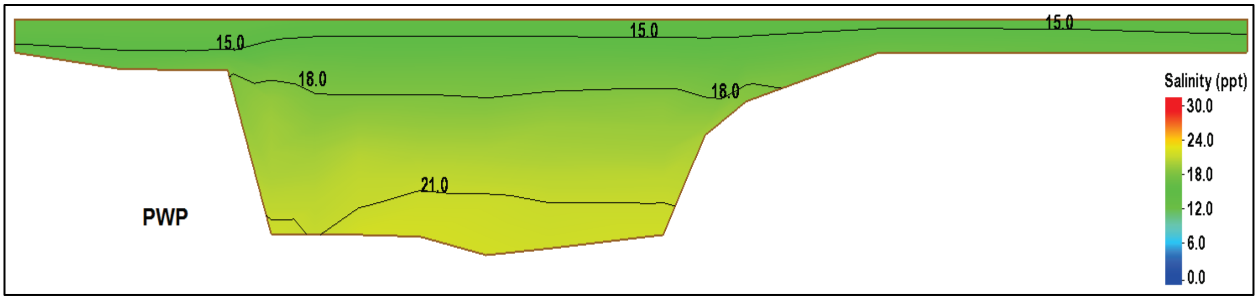


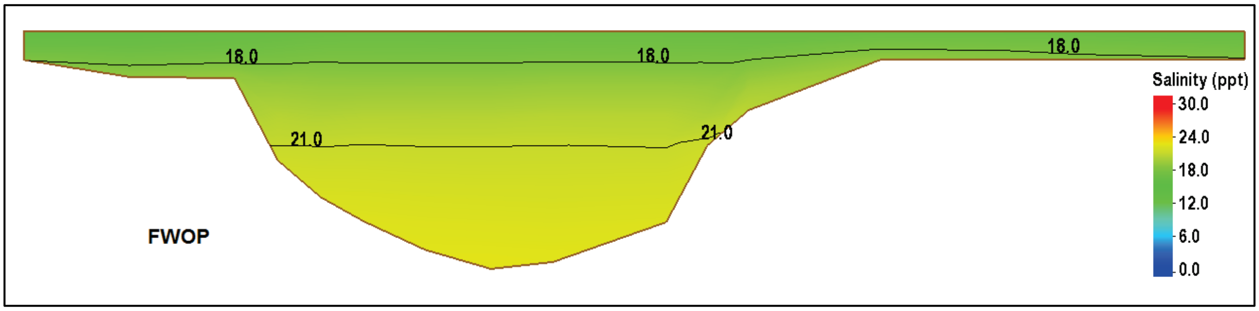


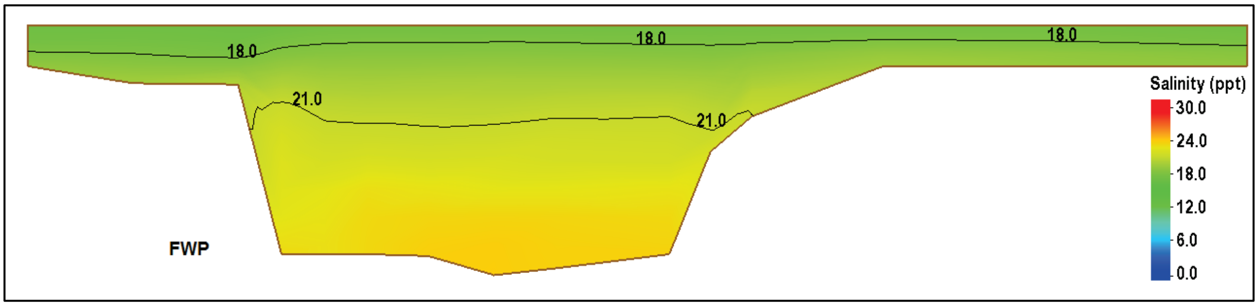


Cross section 6

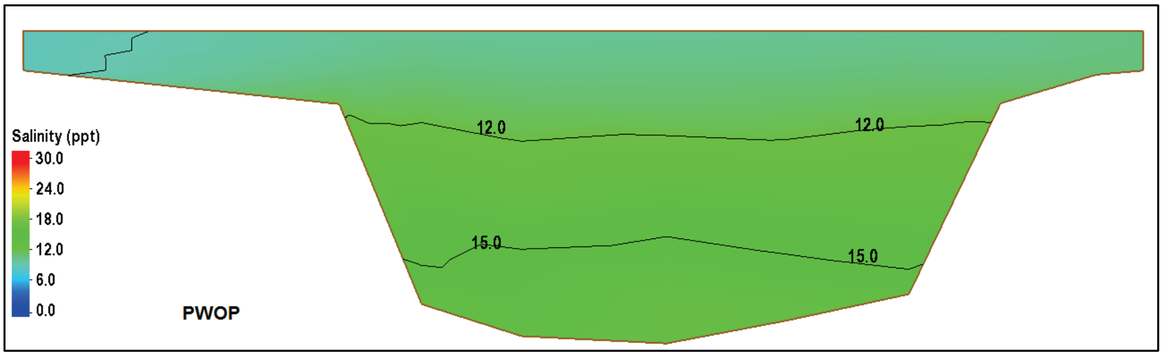


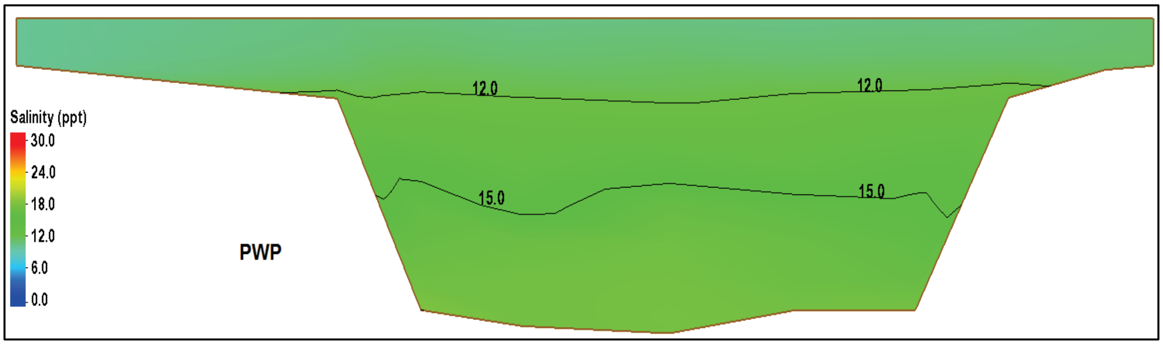


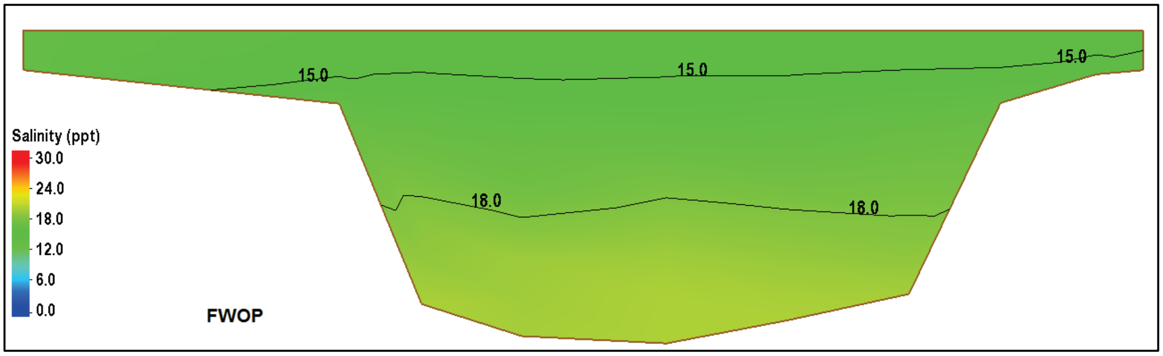




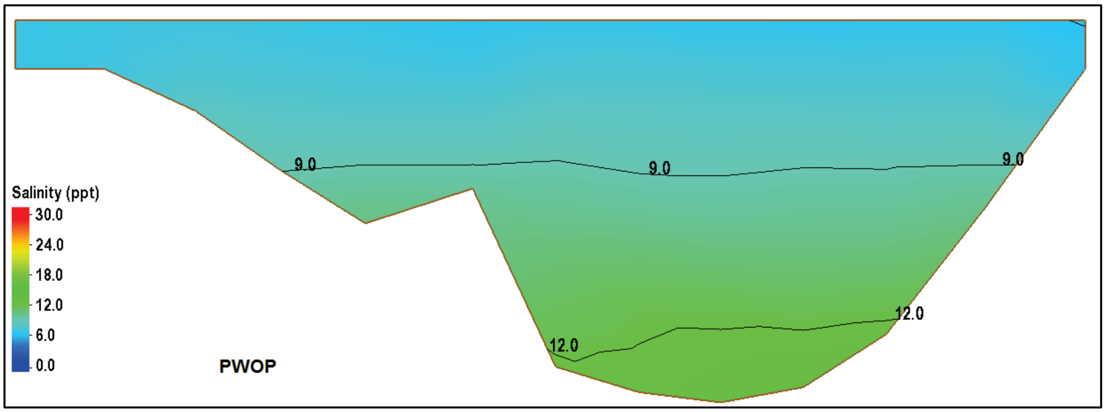
Cross section 7

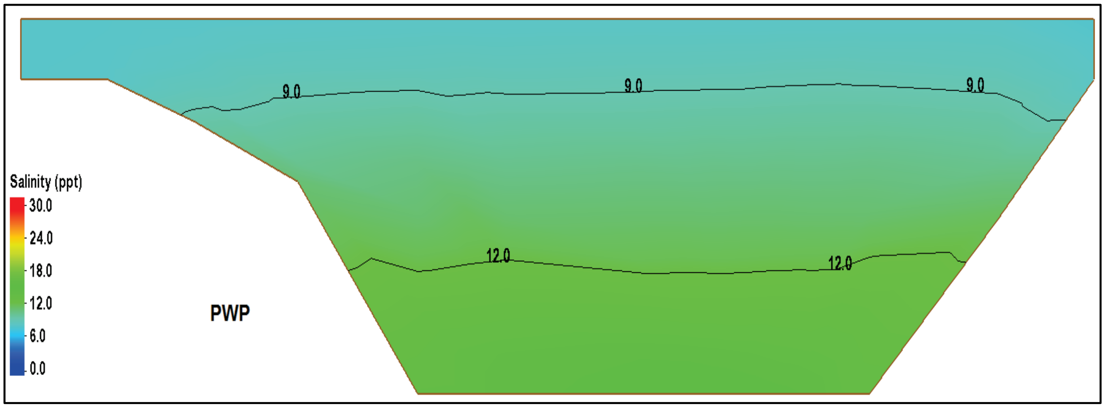


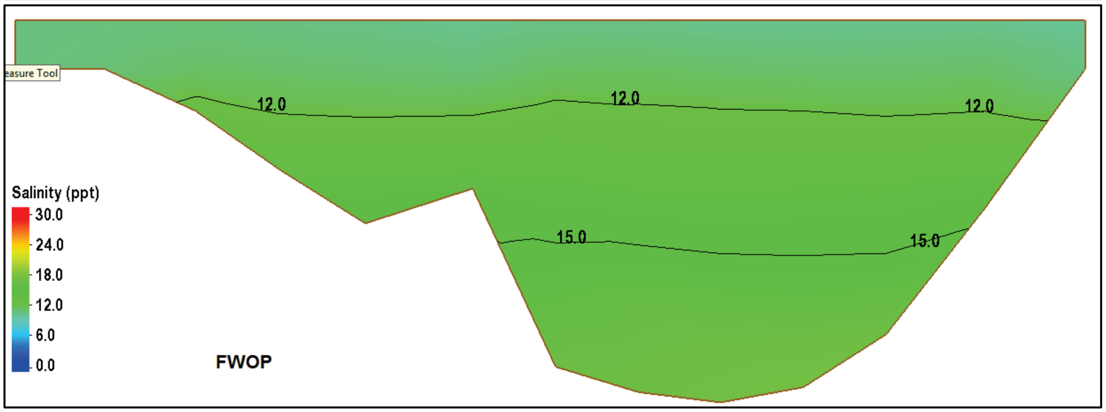




Cross section 8







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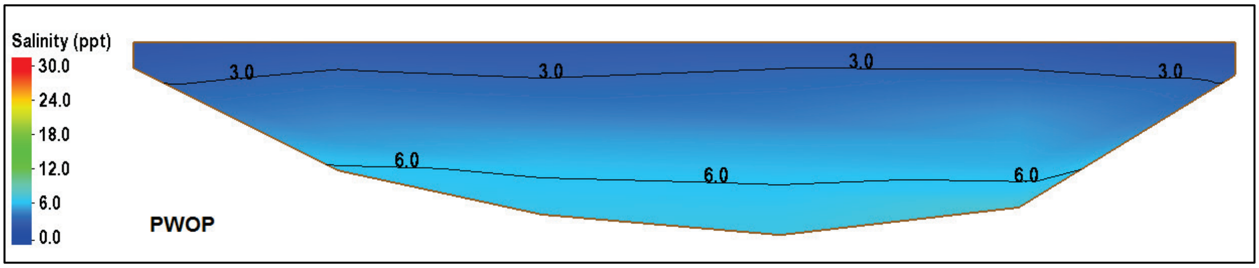

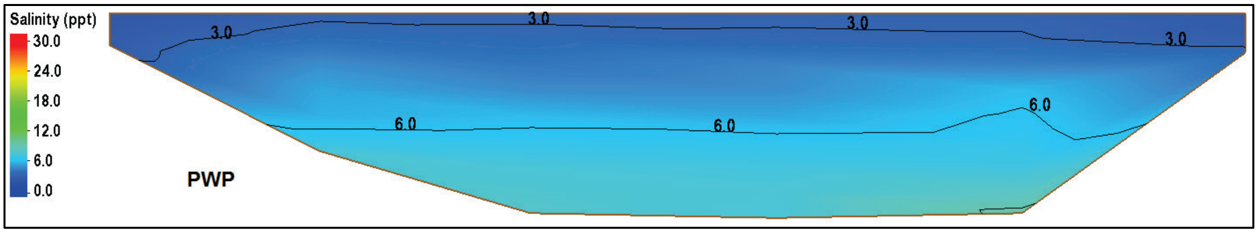

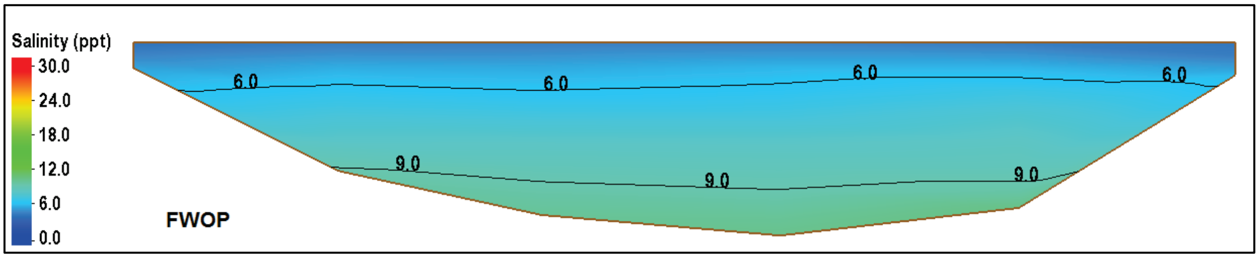

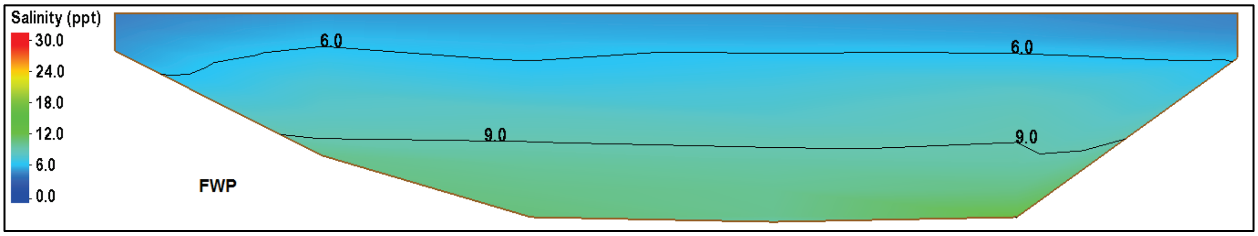

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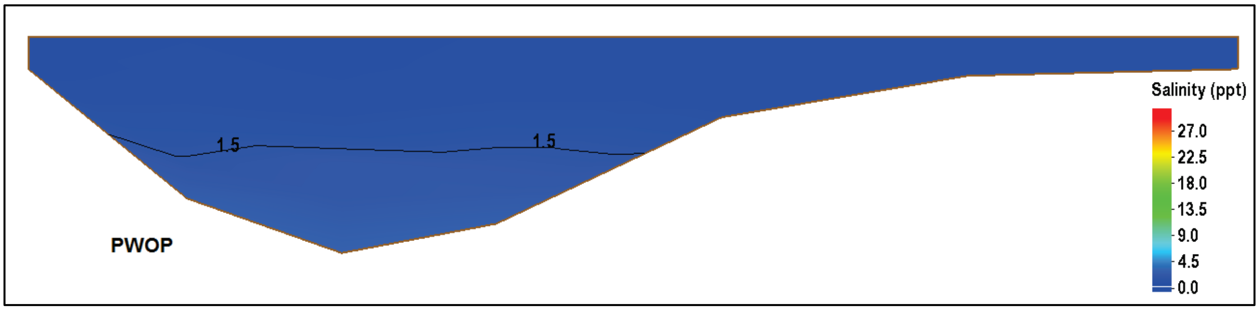

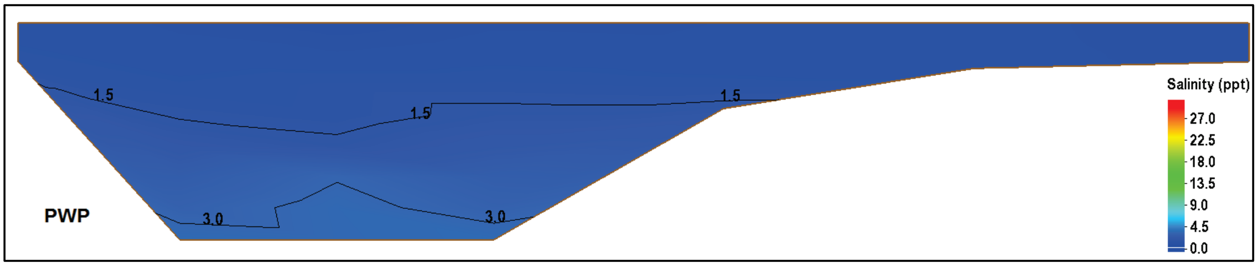

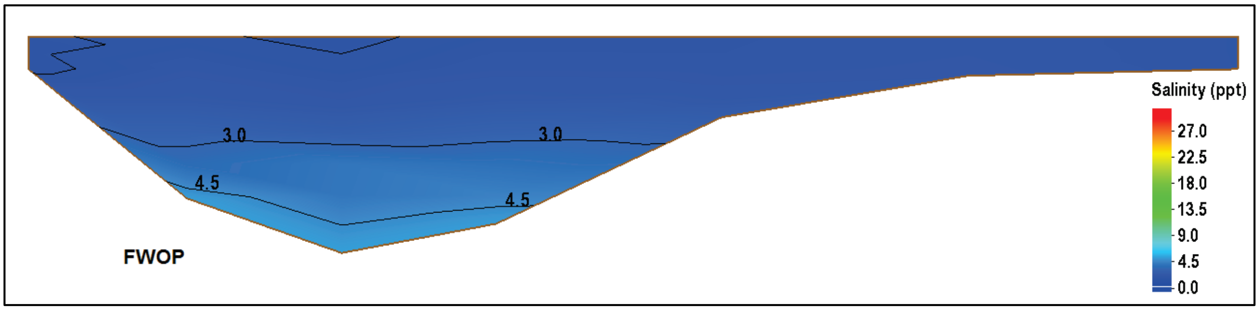

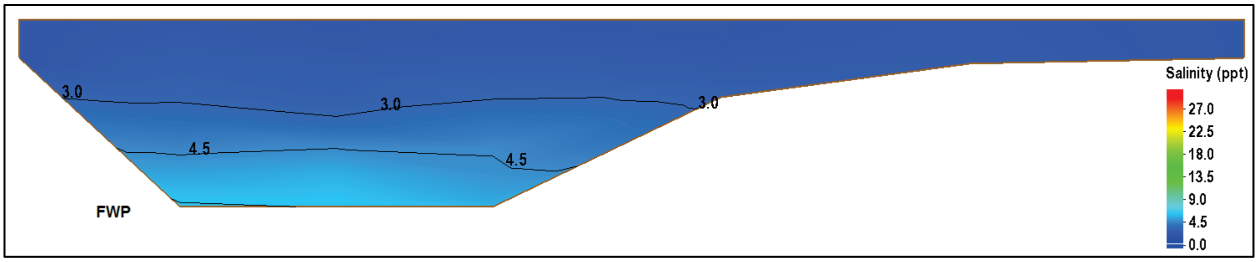

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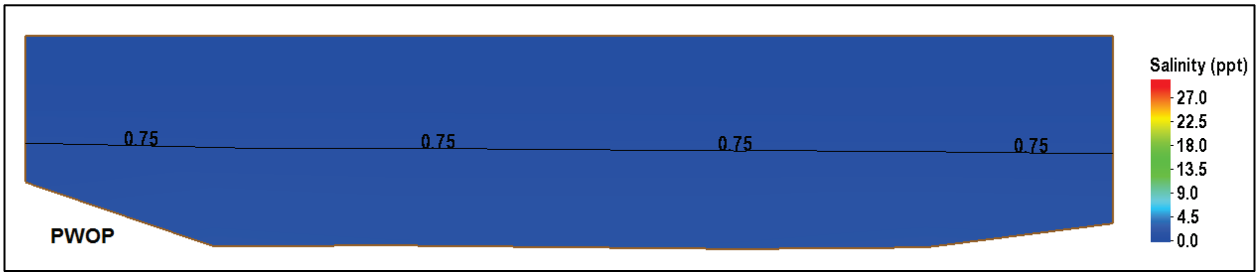

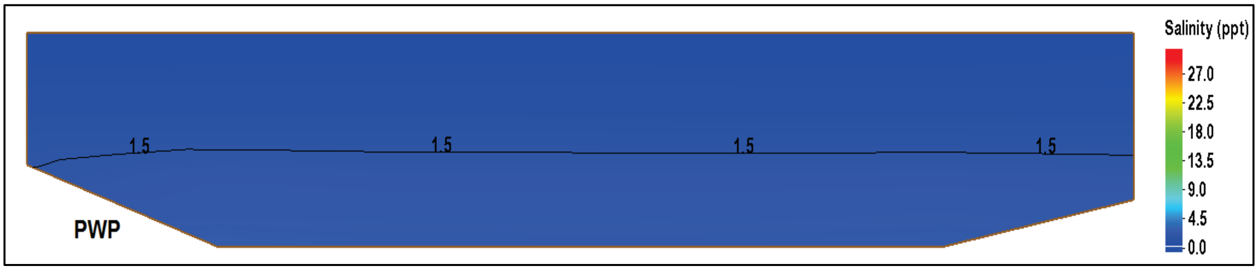

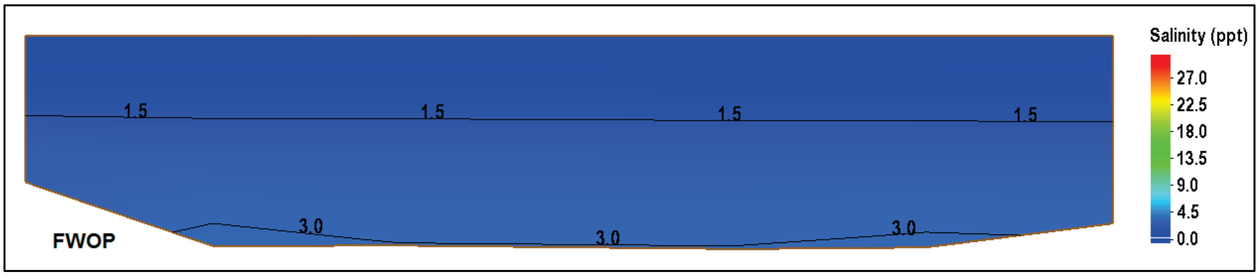

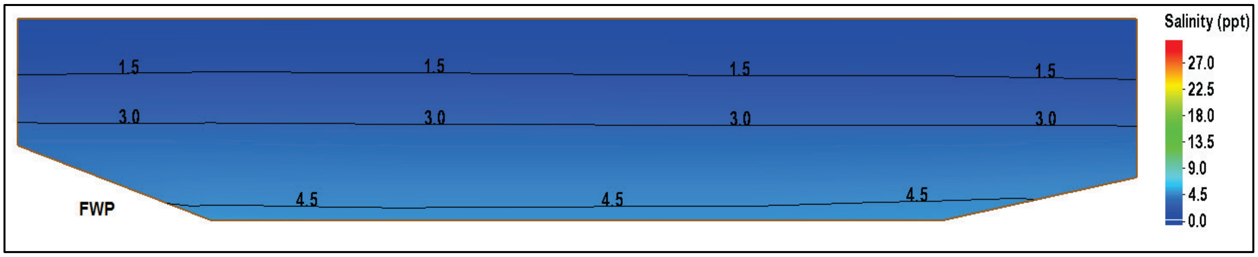

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic feet per second	0.02831685	cubic meters per second
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	0.0254	meters
knots	0.5144444	meters per second
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

List of Abbreviations

HSC	Houston Ship Channel
AdH	Adaptive Hydraulics
AM	Advanced Maintenance
AO	Allowable Overdepth
CSAT	Corps Shoaling Analysis Tool
ECIP	Expansion Channel Improvement Project
ERDC-CHL	Engineer Research and Development Center, Coastal and Hydraulics Laboratory
FWP	Future With Project
FWOP	Future Without Project
MLLW	Mean Lower Low Water
NOAA	National Oceanic and Atmospheric Administration
PWP	Present With Project
PWOP	Present Without Project
SLR	Sea Level Rise
SWG	US Army Engineer District, Galveston
TSP	Tentatively selected plan
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
WIS	Wave Information Studies
3D	Three-dimensional

List of Unit Abbreviations

ft	feet
m	meters
m^3	cubic meters
cms	cubic meters per second
m/s	meters per second
mg/l	milligrams per liter
ppt	parts per thousand

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14. ABSTRACT
The Houston Ship Channel is one of the busiest deep-draft navigation channels in the United States and must be able to accommodate larger vessel dimensions over time. The U.S. Army Engineer District, Galveston (SWG), requested the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, perform hydrodynamic and sediment modeling of proposed modifications along the Houston Ship Channel from its connection to the Gulf of Mexico to the Port of Houston. The modeling results are necessary to provide data for salinity and sediment transport analysis as well as ship simulation studies. SWG provided a project alternative that includes channel widening, deepening, and bend easing. The model is run for present year zero (2029) and future year 50 (2079) with and without project. The model shows that the salinity does not vary greatly with project. Changes to salinity are 2 parts per thousand or less. The tidal prism increases by less than 2% when the project is included, and the tidal amplitudes increase by no more than 0.01 meter. The residual velocity vectors do vary in and around areas where project modifications are made — along the Houston Ship Channel, Bayport Channel, and Barbours Cut Channel. The model also indicates an increase in the shoaling along the ship channel when compared to the without project results, the largest increases being in the Bayport channel and flare.

15. SUBJECT TERMS
Coastal engineering—Numerical analysis, Dredging, Houston Ship Channel (Tex.), Hydrodynamics, Inland navigation, Salinity, Sedimentation and deposition, Sediment transport

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ATTACHMENT 5

SHIP MANEUVERING SIMULATION STUDY OF PROPOSED CHANNEL MODIFICATIONS; HSC-ECIP FEASIBILITY STUDY, TEXAS

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Ship Maneuvering Simulation Study of Proposed Channel Modifications; Houston Ship Channel Expansion Channel Improvement Project Feasibility Study, Texas

FINAL REPORT

April 13, 2018
Revised June 25 2019
Performed for
Port of Houston Authority
By
Waterway Simulation Technology, Inc.
&
Maritime Pilots Institute

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Executive Summary

On November 17, 2017, the USACE Galveston District and the Port of Houston, in consortia with the Houston Pilots and G&H Towing, concluded ship maneuvering simulations in support of a feasibility study for the US Army Corps of Engineers (USACE) Houston Ship Channel Expansion Channel Improvement Project (HSC ECIP). This overall study is evaluating potential channel improvements for the Houston Ship Channel (HSC) considering changing demands for admitting ships larger than the existing project and increasing efficiency of navigation for the existing vessel fleet. The study formulated to improve safety and efficiency of maritime operations on the HSC and related projects.

Project participants included the Port of Houston, the Houston Pilots, with the USACE in attendance as oversight. Simulations were conducted using the Kongsberg Polaris Full-Bridge Ship and Tug Simulators located at the San Jacinto Maritime College Maritime Technology and Training Center (SJMCMTTC) in LaPorte, Texas. The simulation study was conducted with cooperation between Waterway Simulation Technology (WST) and LOCUS. The project analyzed a number of proposed design alternatives aimed at increasing safety and efficiency of navigation by widening the navigation channel, easing bends, enlarging turning basins, and generally improving navigable space for the Houston Ship Channel (HSC), Bayport Ship Channel (BSC), and Barbours Cut Channel (BCC) based on specific design test vessels.

This feasibility-level assessment entailed two months of technical development, one week of simulation model vetting and one week of simulation-based testing which involved conducting 64 simulation runs using the various design alternatives. The simulation test runs performed are documented in Appendix C.

The ship and simulation model data bases, including data bases of the proposed project for the Portable Pilots Unit (PPU), were developed jointly by WST and LOCUS. The Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi provided three-dimensional hydrodynamic current model output that was used by WST to generate depth-averaged current vector fields in ebb and flood conditions for the ship maneuvering simulations. Ship models were existing models available at the SJMCMTTC. Wind was provided as a global condition with directions of north and southeast at 10-20 knots. Simulations were conducted with Houston Ship Pilots and G&H Towing operators conning and operating the design vessels and tugs, respectively.

This report is provided with the understanding that it is a feasibility-level assessment of proposed design alternatives of the HSC in support of USACE 216 processes. This feasibility-level assessment was arrived at using simulations with ideal situations of visibility, simplicity in the simulated navigation channels in the Galveston Bay, predicted vessel traffic, available ship and tug models, and known piloting conditions. This project evaluation is a preliminary assessment by the project participants of the safety of navigation for pilotage in the proposed channel alternatives for the HSC. The results were evaluated using Houston Pilots Simulation-Based Evaluation Standards of Care included in Appendix I. The following summarizes results from the five areas of the HSC tested during the Houston 216 simulation study, see Figure 1.

Figure 1. Six Study Segments for the HSC ECIP Feasibility Study

A final debriefing was conducted following the completion of the simulations. A summary of the results of this debriefing is provided below. Specific simulated situations and conditions, locations, and ship models used are described in the full report.

Results of Two-way Traffic in the Proposed HSC Improvements

The results of two-way meeting situations in the Galveston Bay reaches of the HSC are summarized in this section. This includes meetings that took place in all three straight reaches of the HSC Bay Channels and the bends between the three reaches; i.e., Bolivar Roads to Redfish Bar (Channel Markers 51-52), Redfish Bar to Channel Markers 75-76 (Bayport), Channel Markers 75-76 to Morgan's Point (Barbors Cut).

- Meetings involving two design containerships in a straight reach of the 650-ft design channel were considered to be a high-risk maneuver.
- Meetings between the design containerships and tankers in a straight reach of the 650-ft design channel were considered to be a risky maneuver.
- No meetings between any of the design ships in the 650-ft design channel bends were simulated as the pilots considered such maneuvers unsafe.
- Meetings between two design containerships and between a design containership and tanker in both 700-ft design channel straight reaches and in 1030-ft Apex Cutoff Bends were considered to be acceptable.
- Design ships overtaking tows in the 700-ft design channel affected the tows as expected; this situation needs further analysis.
- It is acceptable for a design containership may meet another ship below Channel Markers 75-76 and then turn into the Bayport Ship Channel design as tested.

Results of Barbours Cut Channel Simulations

The results of the design containership conducting various maneuvers between Barbours Cut Channel and the HSC are reported in this section. In addition, tests of the design tanker were also conducted for a design widener at Barbours Cut for in- and out-bound transits. These results are also reported in this section. In all cases three tugs are considered required and wind limits of 15 knots maximum should be observed. For tug operations, the standards of care should be observed which requires a maximum speed of the ship of 7 knots when using a stern tug.

- The turning at the entrance to the Barbours Cut Channel and backing to a terminal berth of a design containership could be accomplished with good room and the design tested is acceptable.
- The transit of a design containership through the Barbours Cut Channel was considered acceptable.
- For a design containership exiting the Barbours Cut Channel and turning into the HSC there was good room and the design was acceptable.
- The design containership was able to turn with good room in the design turning basin and the basin design was considered acceptable.
- The transit of a design tanker, both inbound and outbound, between the Barbours Cut Channel and the HSC was considered acceptable with the design widener in place.

Results of Bayport Ship Channel Simulations

The results of the ship maneuvering simulations in the Bayport Ship Channel and between the Bayport Ship Channel and the HSC are reported in this section. In all cases three tugs of the 3075 type were considered required and wind limits of 15 knots maximum should be observed. For tug operations, the standards of care should be observed which requires a maximum speed of the ship of 7 knots when using a stern tug.

- The turning, both inbound and outbound, through the design 4,000-ft radius flared entrance of a design containership was considered to be acceptable.
- The meeting of another design ship below the entrance to the design Bayport Ship Channel with the design 4,000-ft radius and then making the turn into the Bayport Ship Channel by a design containership was considered to be acceptable.
- Use of the design “RO/RO Turning Basin near the land entrance of the Bayport Ship Channel was preferred for use when approaching the terminal’s Berths 1-3. This would allow two inbound

ships to approach the container terminal at the same time with one going to Berths 4-6 and the other bound for Berths 1-3 with the full benefit of four daylight inbound transits per day.
- The design 455-ft bay channel was found to be acceptable.
- The design 400-ft land channel section was marginally acceptable; however, due to the drift angle required with cross-winds, a 455-ft design for the land channel is preferred.
- The inner Turning Basin was considered to be acceptable.

Results of Meetings in the Improved Boggy Bayou to Greens Bayou Sections of the HSC

The results of the simulated meetings of design ships in the widened HSC and deepened channel section between Boggy Bayou and Greens Bayou are reported in this section.

- Meetings between a design Aframax and design Panamax in the design HSC Channel was found acceptable both below the Texas 8 Highway Bridge and above that bridge.
- Meetings between a design Suezmax and design Panamax in the design HSC Channel was found acceptable both below the Texas 8 Highway Bridge and above that bridge.

Results of Ship Turning in the Enlarged Brady Island Turning Basin

The results of turning the design Panamax ship in the design 900-ft turning basin was considered acceptable with sufficient room when two tugs of the 2460 class assisted the turn. This includes turning the design ship in the design turning basin with ships and bunkering barges alongside are at Wharfs 26-28. No wind restrictions were considered necessary.

Summary

As a result, the findings from the ship maneuvering simulation feasibility study are:

- Widen the HSC navigation channels to a width of 700 ft
- Widen the HSC bay bends as proposed as Cutoff Bends with 1030 ft Apex
- Widen the BSC bay channel from the intersection with the HSC to the proposed RO/RO Turning Basin with a 4,000 ft radius flare on the south edge at the intersection of the HSC.
- Construct the proposed RO/RO Turning Basin on the BSC
- Widen the BSC land channel to 400 ft with a taper on the north side of the channel from the RO/RO Turning Basin to the Land Cut
- Flare the entrance to the BCC as proposed with the widener transitioning from the 700 ft HSC channel to the existing channel at Markers 83-84
- Widen the BCC to 455 ft
- Widen and deepen the HSC from Boggy Bayou to Greens Bayou as proposed to 530 ft and 46.5 ft below MLLW
- Enlarge the Brady Island Turning Basin as proposed.

Introduction

The ongoing feasibility study under the Houston Ship Channel Expansion Channel Improvement Project, Texas (HSC ECIP), has identified a need to conduct feasibility level ship maneuvering simulations in order to determine if the proposed channel design layout and dimensions for the projected design vessel classes are feasible and, where there is uncertainity about the required dimension, assist to identify the dimension needed. Of particular interest is the admission of Post- and Neo-Panamax container ships (now commonly referred to as Ultra Large Container Carriers or ULCC) that transit and, therefore, are limited to the maximum dimensions of the expanded Panama Canal. Since the terminals that would admit these vessels are both in the Galveston Bay below Morgans Point at the Bayport Ship Channel (BSC) and the Barbours Cut Channel (BCC), the design container test vessel (design containership) for Bay reaches and BSC and BCC have dimensions of an overall length of 1200 ft or less and a beam of 158 ft or less - and a Suezmax tanker with an overall length of 935 ft or less and a beam of 164 ft. The longer and wider containerships cannot meet any other vessels in the existing 530 ft HSC channel widths or the existing channel widths of the BSC and BCC; nor can they currently safely transit the existing unwidened bends of the HSC bay channels.

In addition, new and expanded turning basins are being considered with some of these requiring ship maneuvering simulation.

Finally, there is consideration of widening and deepening the HSC navigation channel between Boggy Bayou and Greens Bayou to accommodate developments along this reach of the HSC. Since the target design is to allow Aframax and Suezmax vessels to operate in this reach (this is not allowed under current pilot rules) and also a desire to determine the allowable limits for two-way traffic in this reach, simulations were recommended for this section of the HSC. An Aframax model was used for this purpose with the dimensions of LOA of 243.8m (799.9 ft), a beam of 42m (137.8 ft) and a draft of 12.2m (40.0 ft) even keel.

The navigation channel and turning basin designs to be tested were provided by the Project Delivery Team (PDT) consisting of members from the USACE and Port of Houston Authority (PHA). The ship maneuvering simulations study was conducted by the Waterway Simulation Technology, Inc. (WST) and Maritime Pilot Institute (MPI) with the Houston Pilots providing the piloting expertise.

It is understood that since these simulations were done as a part of a feasibility study, they were conducted as a limited set of tests, as quickly as possible and with minimum effort and cost, to refine feasible channel dimensions. Therefore, the testing program was designed to quickly assess a particular proposed design and to move to an alternate design based on the results of that test. The acceptability of the design was based on the participating Houston Pilot's opinions and the judgment of the team conducting the simulations using an accepted set of evaluation criteria.

Finally, the simulations were conducted at the SJCMTTC using their Kongsberg Polaris simulators. These simulators are similar to the simulator at the U.S. Army Engineering Research and Development Center (ERDC) at Vicksburg, MS.

Simulation matrices and scope were coordinated with ERDC in August and September and included fifty-five (55) simulation runs in the HSC, HSC/BCS, HSC/BCC, Boggy Bayou to Green's Bayou, and the Brady Island Turning Basin (this approved test matrix and the proposed scope of work are included as Appendix H). At the direction of the PDT, additional simulation of a Suezmax tanker was added to the simulations planned from Boggy to Greens and simulation of modifications to the Brady Island Turning Basin if time allowed.

Purpose

The primary purpose of this feasibility level simulation study was to determine the feasibility of the proposed channel improvements and to refine the proposed range of widening improvements in Galveston Bay. The Tentatively Selected Plan (TSP), provided a range of widening in the Galveston Bay sections of the HSC from the current 530-foot-wide channel to a 650 to 820 foot-wide channel. Due to the length of the transit in the Bay, the navigation channel in this reach is currently considered to allow two-way traffic. The existing channel widths and bend designs do not allow safe transits of the design containership, primarily due to the *length* and beam of these vessels. Therefore, two-way meeting simulations were required to refine the channel and bend width.

Since it is necessary for the new design containerships to enter and exit the channels leading to the container terminals from the HSC, simulations of the design containership maneuvering into and through the proposed navigation channels and turning basins for the BSC and BCC container terminals was required to determine if the proposed channel and turning basin designs are feasible.

Admission of Aframax and Suezmax vessels into the reaches above the East Sam Houston Tollway Bridge (Texas 8) from Boggy Bayou to Greens Bayou is being considered and transits of these vessels were simulated with the proposed channel width of 530 ft and deepening to -46.5 ft MLLW. Tests were conducted to determine the feasible limits of two-way traffic meetings of the design vessels in this improved reach.

Finally, an expansion of the Brady Island Turning Basin is being proposed in order to relieve an operational constraint prohibiting turning of Panamax vessels while other vessels are berthed at the Wharfs 26-28 docks and especially while bunkering operations are ongoing at these locations. Simulated turning operations of a Panamax ship (700 ft LOA by 104 ft beam) were performed with Panamax vessels at these docks with a bunkering barge alongside one of the vessels to confirm the turning basin design.

Approach

Ship Models

The Maritime Pilot's Institute (MPI) had a ship model of the *MAERSK EDINBURG* with a Length Over All (LOA) of 354m (1161.4 ft) and a beam of 48m (157.5 ft). Therefore, it was recommended that this model be modified to a length of 1200 ft and used as the representative design containership. MPI provided the maneuvering characteristics of this model based on observations of operating containerships. Houston Pilots vetted the model as described in a Memorandum for the Record[1] included in Appendix J.

A partially loaded Suezmax tanker model (*ORION VOYAGER*) that has been used extensively by the Houston Pilots on the San Jacinto simulator was used in these simulations. This tanker had dimensions

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[1] Memorandum for the Record, Subject Houston Ship Channel (HSC) 216 Ship Simulation Model Setup and Verification, Waterway Simulation Technology, Inc., October 20, 2017

of 274m (900.4 ft) LOA, 50.0m (164 ft) beam and a draft aft of 13.79m (45.2 ft) and draft forward of 11.22m (36.8 ft.). This model was used as the representative Suezmax design vessel.

The PDT requested that combinations of vessels meeting in the deepened and widened reach of the HSC from Boggy Bayou to Greens Bayou be included in the ship maneuvering tests. This reach was widened from 300 ft to 530 ft and deepened to a depth of 46.5 ft MLLW from 41.5 ft MLLW. The goal of the design change was to allow Aframax and Suezmax vessels to use this reach of the HSC, which is currently restricted for these vessels. In addition, the simulation was to determine what combination of these vessels could meet in this reach to provide for feasible two-way traffic conditions; thereby increasing efficiency. The models used included a Suezmax VLCC model (*ORION VOYAGER*) with an LOA of 902ft, a beam of 164ft, and a draft of 45ft; a Aframax tanker model (*EAGLE KANGAR*) with an LOA of 800ft, a beam of 138ft, and a draft of 40ft; and a Panamax bulk carrier (*M/S MAGITOGORSK*) with an LOA of 707ft, a beam of 104ft, and a draft of 38ft.

Additionally, the PDT requested that the proposed improvements to the Brady Island Turning Basin be tested if time allowed. For the turning basin tests at Brady Island, a typical Panamax vessel (*M/S MAGITOGORSK*) was used. The preferred LOA for such a vessel was 750 ft as this is the maximum length allowed in this reach of the HSC. However, the only acceptable model available was a Panamax bulk carrier with a LOA of 707 ft, a beam of 104 ft and a draft of 38 ft. This vessel was used with available tug support for the turning tests at Brady Island.

In summary, the ship class, model name, and dimensions used for each vessel are included in Table 1 below:

Table 1: Ship Models Used in the HSC Feasibility Ship Maneuvering Simulation Study

Model Name	Ships Name	Dead Weight	DRAFT		Displacement	Length Overall	Breath
		Tons	AFT (ft)	FWD (ft)	Tons	(ft)	(ft)
BULKC06L	*M/S Magnitogorsk*	22691	37.7	37.6	60920	706.5	104.3
TANK23L	*EAGLE KANGAR*	107481	40.0	40.0	99250	799.7	137.8
BULKC16	*FRAISER RIVER*	75000	41.0	41.0	85005	869.2	105.9
VLCC13X	*ORION VOYAGER*	156500	45.2	36.8	122400	900.4	164.0
MULCV14T	*MAERSK EDINBURGH*	133500	45.0	45.0	157281	1202.1	158.1

Pilot Cards for each of the vessel models used in these stimulations are presented in Appendix A.

Model Databases

A basic model of the HSC navigation channels was available on the San Jacinto simulator. Widening is proposed for the HSC Bay Channels above Bolivar Roads to Morgans Point to a width greater than the existing 530 ft. channel widths being considered for the simulation effort included 650 ft, 700 ft, and 750 ft. Bend wideners for each of four bends are also being considered for this channel segment of Galveston Bay. No deepening is being considered at this time. Therefore, modifications of these model databases (visual, radar and ECDIS, channel, currents) were required to account for the channel improvements being tested. WST assisted MPI in this development.

Currents were input as data. The currents for the HSC ECIP simulation were obtained from a 3D hydrodynamic model of the existing HSC developed at USACE Engineer Research and Development Center (ERDC). WST converted the three-dimensional data from this model to two-dimensional depth-averaged data for simulation model input. Maximum ebb and flood currents for the Redfish Bend and the Bayport Channel sections were independently extracted from the model data to provide a range of water flow conditions for the simulations. Current data were also extracted from the model for the Bayou section simulations; although, current magnitudes in this region were very low.

Since the emphasis of this study was to determine the feasible navigation channel width for the larger design vessels, it was recommended that the proposed alternative navigation channel width for the bay channels be input based on agreement with the USACE and the Houston Pilots. It was anticipated that the initial testing would begin with a 650 ft wide channel from Bouy 18 to Morgans Point and a cutoff bend easing of 980ft at each of the channel bends at HSC stations 138+369 (Buoy 18), 128+731, 78+844 (Redfish), and 28+605 (Beacons 75/76). Simulations with vessel meetings were developed for all three channel sections of Galveston Bay. Based on discussions with the Houston Pilots and with approval from the Corps representatives during the simulation validation, meetings of the design vessels in the improved bends were also included. Emphasis was placed on meeting before and after the bends at Redfish, at HSC Beacons 75 and 76 below the intersection with the Bayport Ship Channel and then up to (Beacons 81-82). Other channel widths were prepared at 700 ft and 750 ft in anticipation of the need to test such alternatives. These channel cross-sections were constructed to be representative of typical cross-sections observed in the existing ship channels and to be representative of the typical conditions the ships would experience in the future after the channel has been used and shaped by the ship traffic. An example of the type of cross-section to be used in building the widened channels is shown in Figure 2. It was anticipated that barge shelves would be included to represent the bank conditions with these present in any future project expansion. Consideration was given to including operating tows on the barge shelf to observe the effects of deep-draft ships transiting the deep navigation channel.

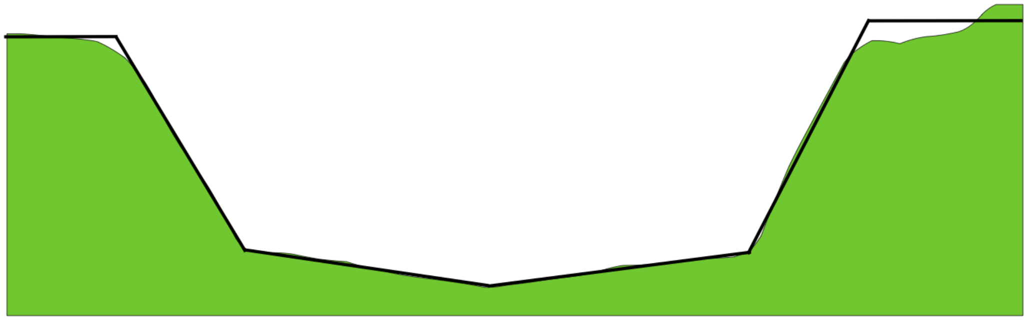


Figure 2. Typical Cross-section

Similarly, the proposed navigation channels in the HSC above the Texas 8 Bridge from Boggy Bayou to Greens Bayou were developed based on the existing hydrographic survey data modified to represent the proposed improvements to the channel with a nominal channel width of 530 ft and depth of 46.5 ft MLLW. Modifications to the channel were made based on the results of transits of the largest permitted vessels (LOA<= 750 ft) in this reach at the present time.

The Bayport Ship Channel was widened on the north side of the ship channel from a width of 400 ft to 455 ft from the entrance near the bend at channel markers 75-76. A turning basin, identified as the RO/RO Turning Basin, was included in the modified Bayport project. Beginning at this turning basin, the simulated channel was tapered to a 400 ft width near the entrance to the land cut through the remainder of the ship channel and the turning basin. The simulated channel was also developed with a 455 ft width through the entire channel including the turning basin; however, this was not tested. Both ship channels were also developed with a 4,000 ft and 5,735 ft radius flare on the south side of the

Bayport Ship Channel connecting with the apex of the bend near channel marker 75 for each of the HSC navigation channel model databases.

The Barbours Cut Channel was modified to include a widening of the ship channel from 300 ft to 455 ft with offsets from the container terminal to the north. Straight-line flare designs on the north and south sides of the entrance were provided by the PDT and included in the simulated test channels. A transition from the eastern side of the widened HSC channel starting at channel marker 90A to the existing channel near channel marker 94 were also included and tested for traffic transiting between points north of Morgans Point and Barbours Cut.

Finally, a simulation database was developed for the proposed enlarged Brady Island Turning Basin. This enlargement was to enable the maximum sized Panamax vessels allowed to operate in the upper reaches of the HSC above Boggy Bayou to turn in the turning basin while vessels are berthed at the docks at Wharfs 26-27; especially while receiving bunker fuel from barges alongside the vessels. Therefore, Panamax vessels with a length of 750 ft and a beam of 106 ft were berthed at Wharfs 6-8 such as to restrict the turning area to test the relaxation of the current operating restrictions for this turning basin and a bunkering barge with length of 195 ft by 35 ft was placed adjacent to the tanker berthed at Wharf 27.

Simulated Project Improvement Databases for the Houston Pilot Portable Pilot Units (Raven PPUs)

The Houston Pilots provided three computers used as Portable Pilot Units (PPUs) for use during these simulation tests and arranged for *myppu.com* to work with WST and MPI to develop databases of the proposed project improvements for use with the PPUs during the ship maneuvering simulation tests. The Houston Pilots regularly utilize PPUs to help them navigate vessel transits on the HSC system. Personnel from myppu.com were able to provide these databases with short lead times.

Ship and Waterway Model Validation and Adjustments

During the period from October 13-15, 2017, MPI, San Jacinto Maritime, Houston Pilots, and WST installed the simulation model databases for the reaches of the HSC, tested and adjusted the ship models until they were verified by the Houston Pilots, checked out the simulation databases, and discussed the project, feasibility study objectives, and testing program with the pilots, representatives from ERDC, the Galveston District, and Port of Houston Authority. A Memorandum for Record dated October 20, 2018 was prepared to document the results of this effort and is included in Appendix J.

Ship Maneuvering Simulation Tests

Ship maneuvering simulation tests were conducted at the San Jacinto Maritime Center Ship Simulator during the period November 13-17, 2017. The list of participants is provided in Appendix B. The simulations conducted as a part of this study and the conditions of each simulated transit are documented in Appendix C. The results of the simulations are presented below.

Results of the Ship Maneuvering Simulations

A brief description of each principal simulation test area is presented in this section of the report. In addition, the basic findings and recommendations derived from those test sections are presented. The entire set of track plots for all simulations conducted are included in Appendix K-P.

Galveston Bay Channel of the HSC

Figure 3 through Figure 5 show representative track plots of the HSC tested during the simulation study. The HSC bay channels tested stretched from Bolivar Roads to just below BCC and were considered to represent three segments. The entire set of track plots for all simulations conducted are included in Appendix L. The proposed 650-ft widening of the Houston Ship Channel in the Galveston Bay was tested extensively and found to be unacceptable for two-way traffic operations (see Figure 3). The 700-foot-wide channel was tested next. The design vessel for this study segment was a representative design containership with dimensions of 1,200ft x 158ft x 45ft. The primary design operation was a meeting maneuver of two of these vessels. Additionally, meeting and passing maneuvers were simulated between the design containership and a Suezmax-class tanker (900ft x 170.6ft x 45.3ft/36.8ft). A few simulations also included traffic tows transiting the HSC along the barge lanes during the meeting/passing operations. The proposed 700-ft widening was found to be acceptable (see Figure 4). Also, meetings of the design containership in bends, which were widened to an apex of 1,030 ft and with the 700-ft channel, were found to be acceptable (see Figure 5). Below are the findings for simulations in the bay section of the HSC.

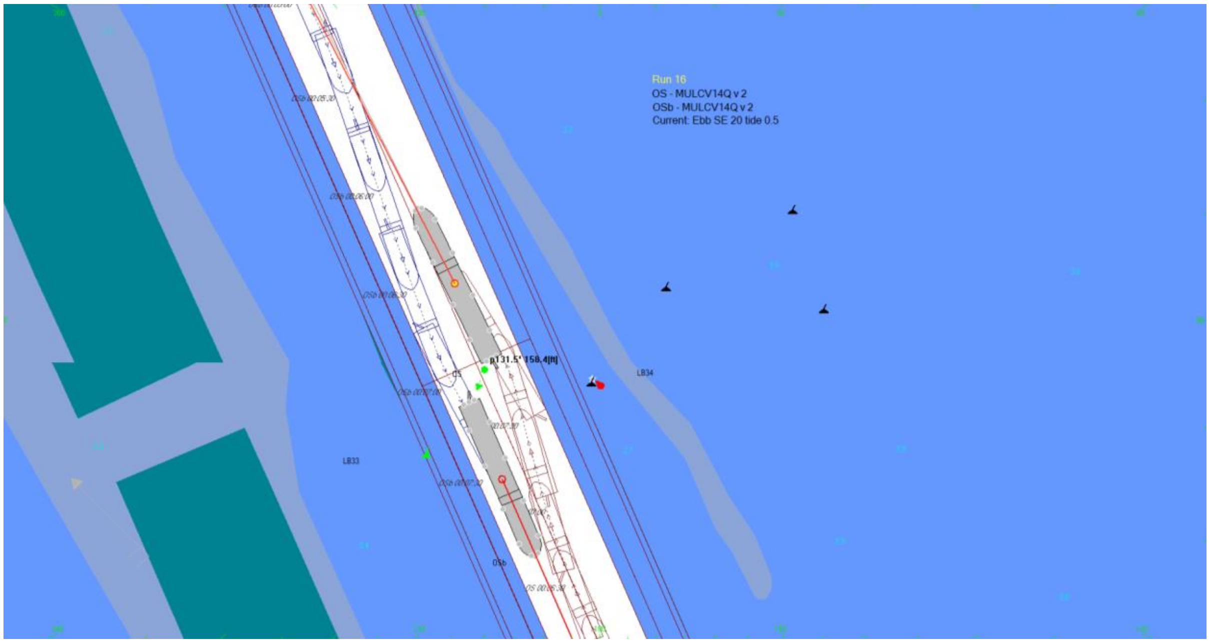


Figure 3. Two Design Containerships Meeting in the Proposed 650 ft Wide Houston Ship Channel

Figure 4. Two Design Containerships Meeting in the Proposed 700 ft Wide Houston Ship Channel

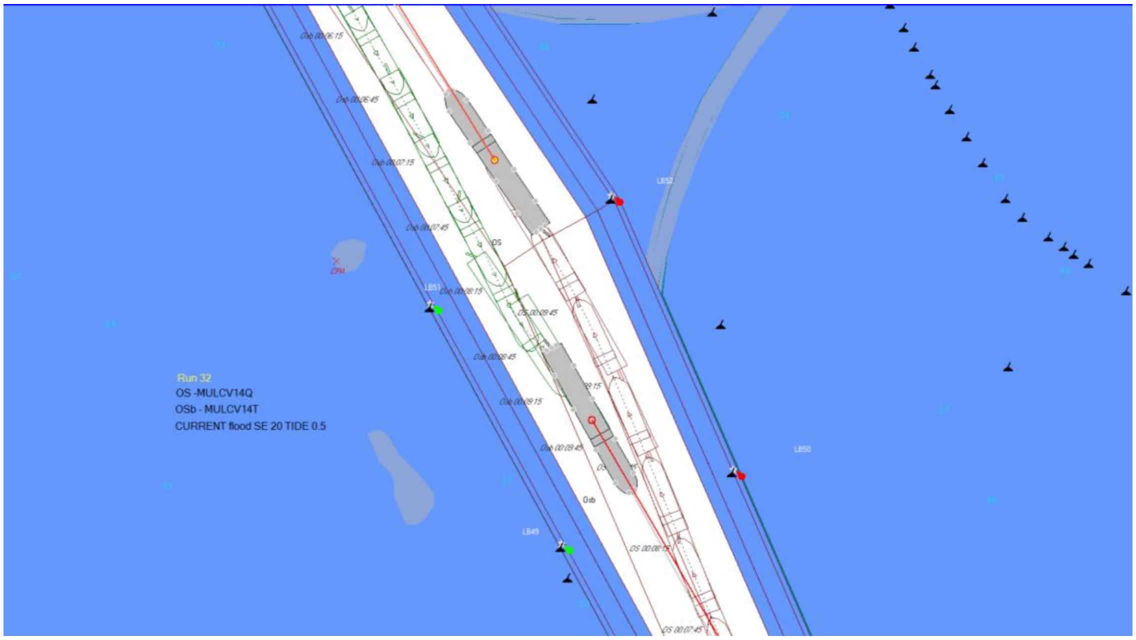


Figure 5. Two Design Containerships Meeting in Red Fish Bend

Findings for Bay Reach of the Houston Ship Channel

1. The design containership had better piloting success in the 700’ channel than the 650’ channel.
2. The design containership was able to meet another design containership in the 700’ test channel while maintaining adequate separation between each vessel and the test channel toe.
3. The design containership was able to safely meet Suezmax (secondary design test vessel with dimensions of 900ft x 164ft x 45ft) vessels in the 700’ channel of the HSC.
4. The design containership was able to meet another design containership and a Suezmax vessel in the widened design bends under current and wind conditions (20 knots SE) tested.

5. Tow vessels navigating in the deeper water alongside the channel toeline, on the margin of the barge lanes, *may* lose control of their vessel and/or tow units due to passing ship forces from the design containership. .
6. The channel widening provided in the 700’ channel is feasible for two-way traffic meetings of an inbound and outbound design containership, Suezmax vessels, and a design containership and a Suezmax vessel.

Recommendations for the Bay Reach of the Houston Ship Channel

1. Consideration could be given to evaluating a reduction of the proposed 1,030-foot apex bend widening such that safe meeting operations may be maintained and further evaluated in Project Engineering and Design (PED).
2. Further analysis of ship and tow interaction in the 700’ alternative is recommended to better understand the risk posed by the design containership as well as Suezmax vessels to tug and tow vessels transiting in the barge lanes alongside the 700’ channel.

Bayport Channel

The design containership was successfully piloted in simulations in and out of Bayport Channel. Figure 6 - Figure 8 show representative track plots of the Bayport Channel. The entire set of track plots for all simulations conducted are included in Appendix N. A modification to the existing BSC southern flare is underway that will create a 4,000 ft radius. ERDC previously evaluated a flare modification up to a 5,375 ft radius. Discussions with the Houston Pilots indicated that the 5,375 foot radius may not be necessary for the southern side of the channel at the intersection of the BSC and HSC at beacon 75/76 when the HSC is widened to 700 feet, therefore, only the 4,000 ft radius with an additional modification to tie it into the proposed 700 ft wide HSC was simulated. The channel design tested was 455 ft wide from the 4000 ft-radius flare intersection with the HSC, westward to the proposed RO/RO Turning Basin and, from thence, tapering to 400 ft wide at the beginning of the land cut and past the container docks to the existing turning basin. A proposed new turning basin (RO/RO) on the south side of the channel at the beginning of the land-cut was also included in the simulation tests (Figure 7). The following findings for the Bayport Channel simulation are presented.

Figure 6. Design Containership Inbound to Bayport Container Terminal at Channel Intersection with HSC

Figure 7. Design Containership Turning in the RO/RO Turning Basin and Backing to the Bayport Container Terminal

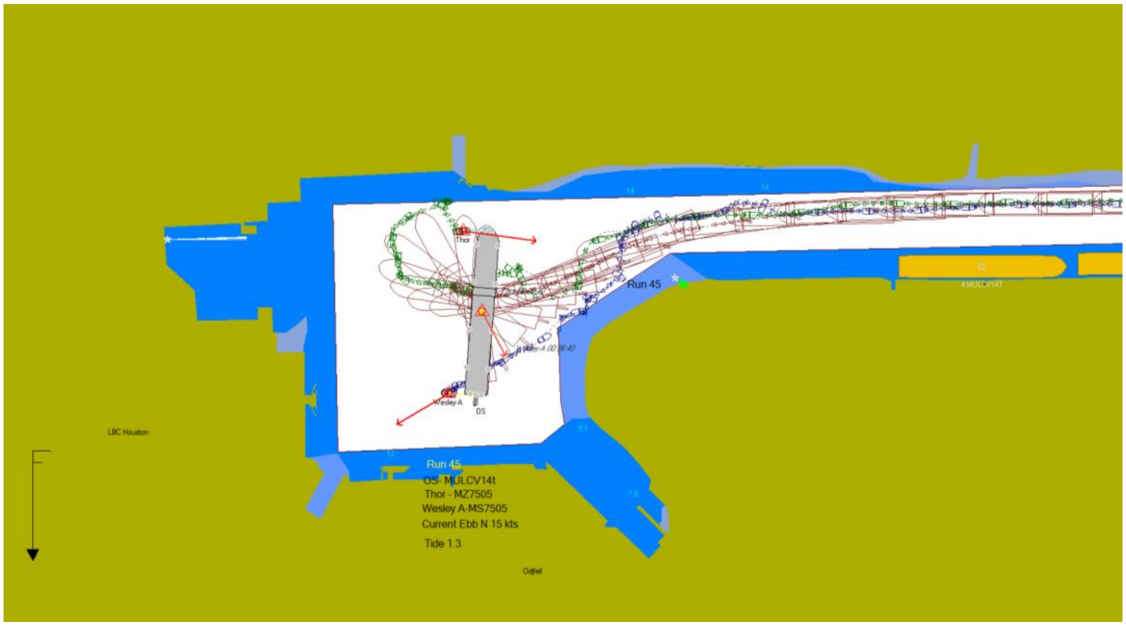


Figure 8. Design Containership Transiting the Bayport Container Terminal and Turning in the Existing Turning Basin which was Expanded by 400ft to the North

Bayport Ship Channel Findings

1. The design containership and ship assist tugs providing escort towing services to the design containership were able to maintain position in water considered safe by the pilots and tug masters during approaches and departures to Bayport container terminal using the additional space provided in the 700’ HSC design, proposed bend wideners, 4000’ flare at the entrance, and the widening of the Bayport Ship Channel to 455ft from the flare to the land cut.
2. The proposed widening of the Bayport Ship Channel open bay reach to 455’, the approved and anticipated 4,000’ radius flare at the entrance, and the proposed bend widener at the bend at Beacon 75/76 allowed successful entrance into and departure from the Bayport Ship Channel in accordance with the Houston Pilots Simulation-Based Evaluation Standards of Care even following the meeting with another vessel immediately below the bend at Beacons 75/76.
3. The Houston Pilots stated that the availability and use of the RO/RO Turning Basin would allow more efficient marine operations by allowing ships to move to the main turning basin followed by ships that would use the RO/RO Turning Basin; thus making effective use of 8 hours of daylight operations at the Bayport Terminals.
4. The proposed RO/RO Turning Basin near BSC Markers 6-7 allowed successful turning with the assistance of available escort tugs prior to entrance into the land cut of the BSC by backing to the eastern berths of the Bayport terminal in accordance with the Houston Pilots Simulation-Based Evaluation Standards of Care.
5. The proposed design of the Bayport Ship Channel widening to a 455 ft width tapers from the RO/RO Turning Basin to the entrance of the land cut at the eastern end of the container terminal to a 400 ft ship channel width along the terminal to the turning basin at the end of the channel. This increase in width from 350 ft provides for a successful transit of the design containership with available tug escort up to the wind limits of 15 knots.
6. The Houston Pilots stated that with the 400’ land cut Bayport Ship Channel width would still require one-way traffic with the design containership and would limit bunkering operation in the channel and holding of barges along the channel.

7. The Houston Pilots stated that they believed this design would require three tugs to control the design containership with the upper wind limits of 15 knots.
8. The Houston Pilots prefer a width in the land cut of 455 ft.
9. The channel improvements proposed for the 455'/400' navigation channel for the approaches to the Bayport Terminals, inclusive of the 4,000 ft flare and channel improvements, are feasible for the successful transit of the design containership, assist tugs and normal HSC vessel traffic.

Recommendations for Bayport Ship Channel

1. The proposed RO/RO Turning Basin near the land cut in the Bayport Ship Channel is recommended by the Houston Pilots for consideration as this will provide for more efficient ship maneuvering operations to the eastern berths at the Bayport Container Terminal and allow optimal use of the channel during daylight restriction.

Barbours Cut Channel

Figure 9 through Figure 11 show representative track plots in the 455ft widened design channel for Barbours Cut Container Terminal near Morgans Point, Texas. In addition, design widenings and flares at the intersection of the Barbours Cut channel with the 700 ft design HSC are shown. The entire set of track plots for all simulations conducted are included in Appendix M. In order to successfully transition from the widened channel in Galveston Bay to the existing 530-wide channel above Morgans Point as well as the north bound turns out of BCC, slight widening and tapering of the channel transition was approximated. The following findings for the simulations of Barbours Cut Channel are presented.

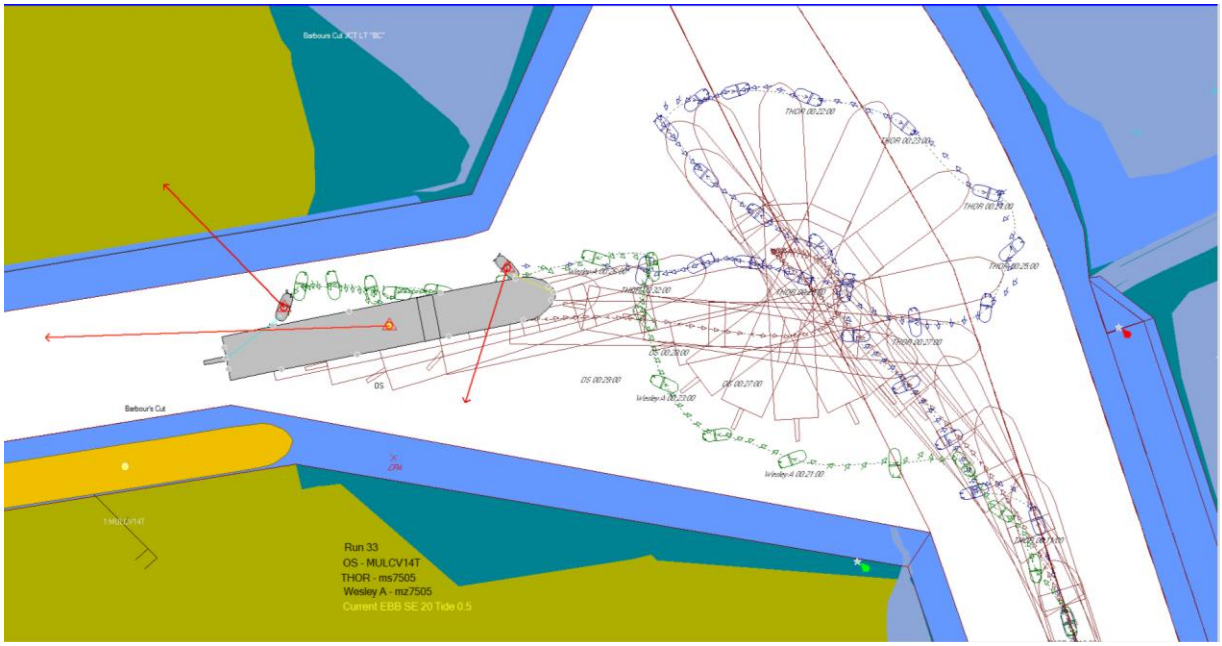


Figure 9. Design Containership Turning and Backing into Barbours Cut Container Terminal

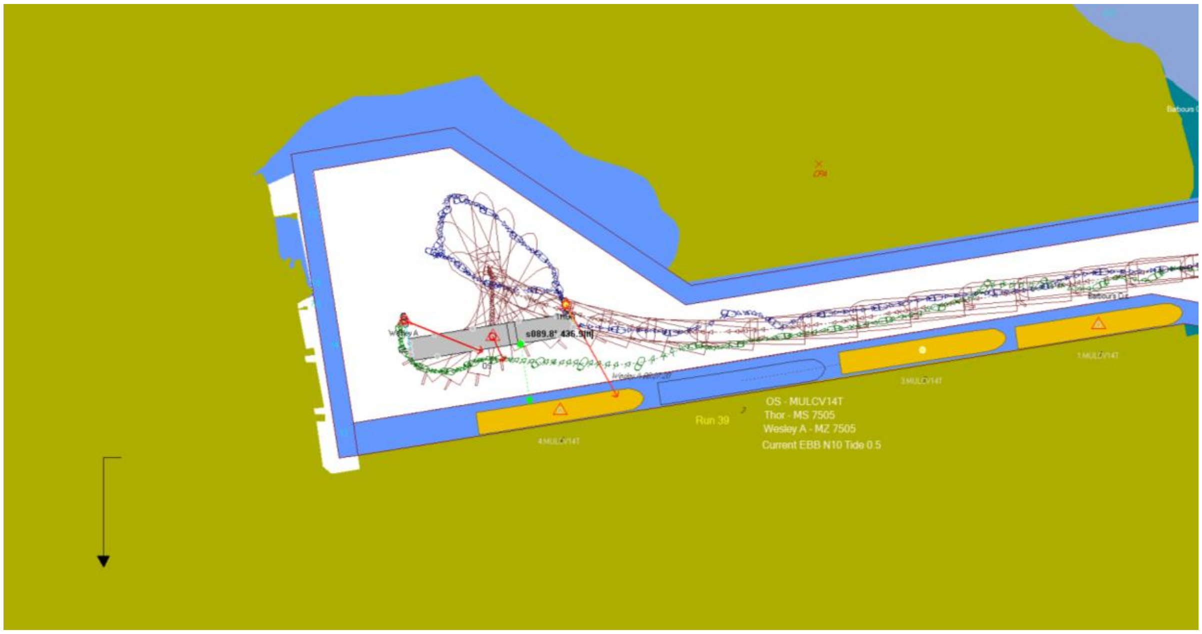


Figure 10. Design Containership Transiting the Widened 455ft Channel at Barbours Cut Container Terminal and Turning in the Existing Turning Basin

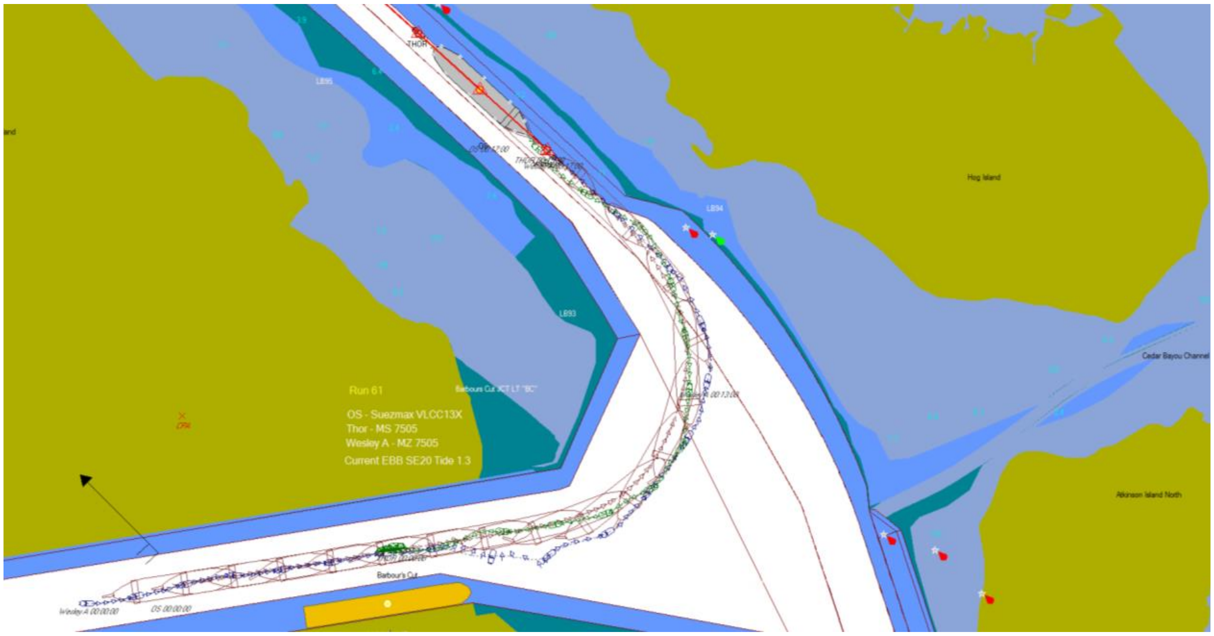


Figure 11. Suezmax Exiting the Barbours Cut Container Terminal Channel and Turning Up-channel Using the Widening Flare and East Houston Ship Channel Widener at Markers 83-84

Findings for Barbours Cut Channel

1. The widening of the BCC to 455' allowed the successful maneuvering of the design containership through the terminal past berthed design containerships at the terminal berths with tug support with both the ship and tugs maintaining Houston Pilots Simulation-Based Evaluation Standards of Care (see I).
2. The design containership was able to sucessfully turn and maintain Houston Pilots Simulation-Based Evaluation Standards of Care while turning in the BCC Turning Basin with assistance of the available tug escort and maneuvering assistance.

3. Transit of Suezmax-class vessels to and from the proposed BCC improvements into and from the proposed 700 ft HSC north of BCC was found to be successful with assistance of available tugs.
4. The channel improvements proposed for the 455' channel for the approaches to BCC, inclusive of the flare and HSC channel improvements, are feasible for the navigation of the design containership, assist tugs and normal HSC vessel traffic.

Recommendations for Proposed Barbours Cut Channel

1. The channel improvements at the entrance of the BCC and the widening of the Houston Ship Channel between channel markers 91 to 93-94 provided successful maneuvering of Suezmax tankers transiting between terminals north of Morgans Point and Barbours Cut. However, this transition should be specifically evaluated further in PED.

HSC from Boggy Bayou to Greens Bayou

Figure 11 shows a representative track plot of the simulations between Boggy Bayou to Greens Bayou. The entire set of track plots for all simulations conducted are included in Appendix P. In the Bayou section of the HSC, the proposed design tested was widening the section from Boggy Bayou to Greens Bayou from a width of 300ft to 530ft and deepening to a depth of 46.5ft MLLW (Figure 12). Meetings of various combinations of Suezmax, Aframax, and Panamax vessels were simulated to evaluate the limits of vessel meetings that could feasibly be accomplished. Since these meetings were a completely new maneuver for the Houston Pilots, they were establishing the ship handling technique that was required to meet this size of vessel in this improved reach. Even though many of these meetings were close to the proposed channel toelines, the Houston Pilots stated that they consider these were safe meetings and within the pilots' standard of care as there is deep water outside the proposed channel toelines, which they routinely use.

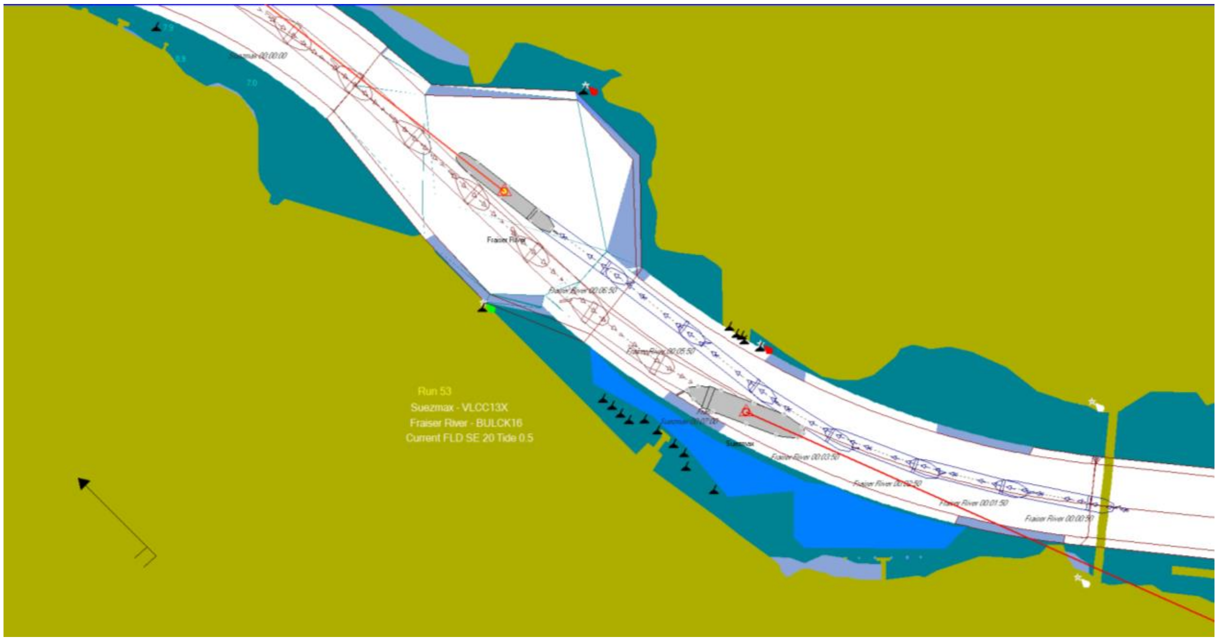


Figure 12. Meeting of Suezmax and Panamax Vessels in the Widened and Deepened Houston Ship Channel Between Boggy Bayou and Greens Bayou

Findings for the Houston Ship Channel from Boggy Bayou to Greens Bayou

1. The proposed widening and deepening of the HSC reach between Boggy Bayou and Greens Bayou was found to provide for successful operations of Aframax and Suezmax vessels, which increases the size of ships allowed to operate in this reach above the existing LOA of 750 ft and beam of 106 ft.
2. The proposed widening and deepening for this reach was found to allow successful implementation of two-way traffic of loaded vessels with a maximum combined ship beam of 246’.
3. The proposed widening and deepening allowed the meeting of loaded Aframax and Panamax ships in this improved reach of the HSC.
4. The meetings of loaded vessels of Suezmax size with loaded vessels of Panamax size were problematic during the simulation tests; however, there is a possibility with a more realistic database considering the channel conditions along the navigation channel and additional training, two-way operations between these vessels could be possible.
5. The channel improvements provided in the proposed 530’ channel widening and deepening to 46.5 MLLW for the upper Houston Ship Channel between Boggy Bayou (Shell) to Greens Bayou the deepening area are feasible.

Recommendations for the Houston Ship Channel from Boggy Bayou to Greens Bayou

1. During PED, additional testing with a channel database representing the proposed design along with terminals that will be constructed to service these larger vessels may demonstrate the feasibility of relaxing the combined beam restriction cited in item 4 above.

Brady Island Turning Basin

The proposed enlargement of the Brady Island Turning Basin is shown in Figure 13. Simulations are shown of Panamax vessels turning in the enlarged Brady Island Turning Basin with Panamax vessels berthed at the docks at Wharfs 26-28 and a bunkering barge alongside the ship at Wharf 27. The entire set of track plots for all simulations conducted are included in Appendix O.

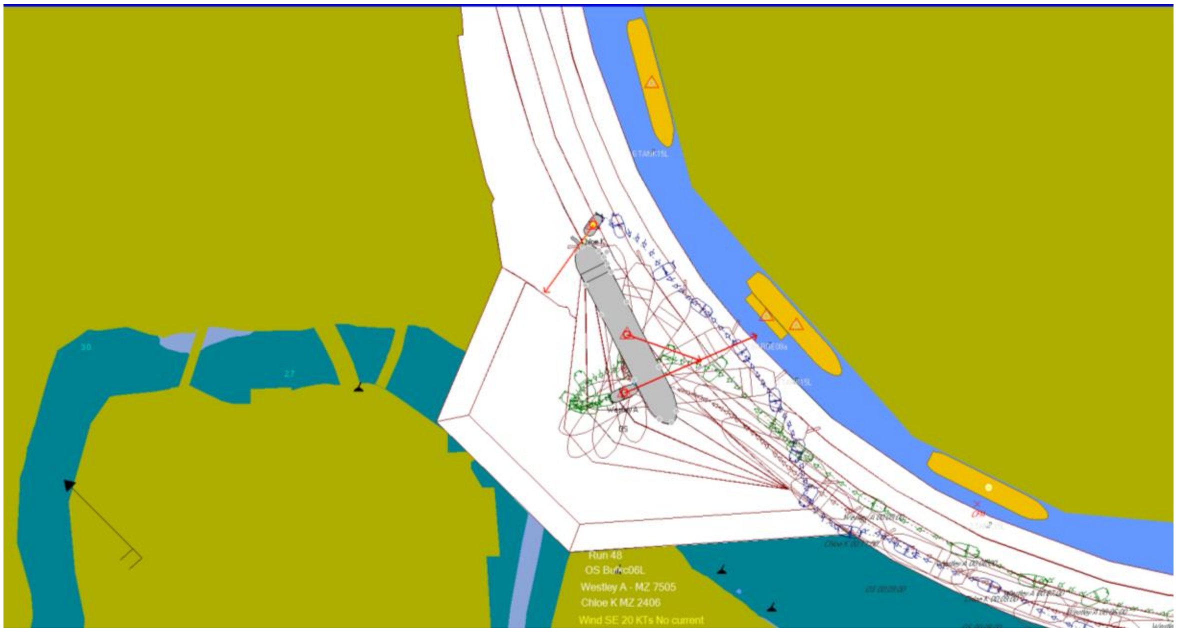


Figure 13. Panamax Turning in the Enlarged Brady Island Turning Basin

Findings for the Enlarged Brady Island Turning Basin

1. Successful turning maneuvers of the representative design test Panamax vessel with the assistance of available tugs in this enlarged turning basin with Panamax vessels at Wharfs 26, 27, and 28 and bunkering operations at these vessels can be accomplished in compliance with the Houston Pilots Simulation-Based Evaluation Standards of Care.

Appendix A: Pilot Cards for the Ship Models Used in the Simulations

PILOT CARD

MULCV14Q
Version 6

Ship's name MPI 14000 TEU ULCV **Date**

Call Sign MPI1 **Deadweight** 133500 tonnes **Year built** 2017

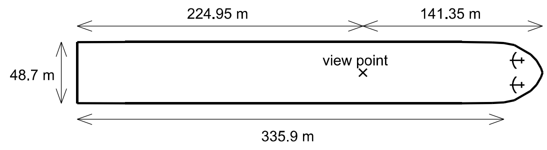
Draught aft 13.716 m / 45 ft 0 in **Forward** 13.716 m / 45 ft 0 in **Displacement** 157281 tonnes

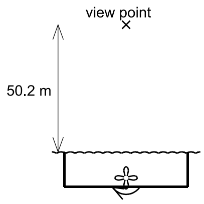
SHIP'S PARTICULARS

Length overall 365.7 m **Anchor chain:** **Port** 28.0 shackles **Starboard** 28.0 shackles

Breadth 48.7 m **Stern** shackles

Bulbous bow Yes **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 67699 kW (92045 hp)

Manoeuvring engine order		**RPM**	**Pitch**	**Speed (knots)**	
				Loaded	**Ballast**
Full sea speed	**1**	101.7			24.8
Full Ahead	**0.8**	89.8			22.4
Half Ahead	**0.5**	59.9			15.3
Slow Ahead	**0.25**	31.0			7.3
Dead Slow Ahead	**0.125**	20.0			4.9
Dead Slow Astern	**-0.125**	-20.0			
Slow Astern	**-0.25**	-31.0			
Half Astern	**-0.5**	-50.9			
Full Astern	**-1**	-66.9			

Time limit astern min:sec

Full ahead to full astern min:sec

Max. No. of consecutive starts

Minimum RPM knots

Astern power % ahead

PILOT CARD

VLCC13X
Version 5

Ship's name Orion Voyager

Call Sign ______ **Deadweight** 156400 tonnes **Year built** ______

Draught aft 13.79 m / 45 ft 3 in **Forward** 11.22 m / 36 ft 10 in **Displacement** 122400 tonnes

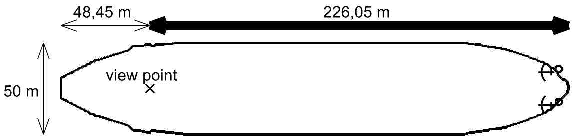
SHIP'S PARTICULARS

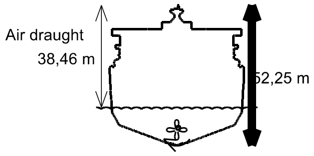
Length overall 274.5 m **Anchor chain:** **Port** 14.0 shackles **Starboard** 14.0 shackles

Breadth 50 m

Bulbous bow No

(1 shackle = 27,432 m = 15 fathoms)





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 14872 kW (20220 hp)

Manoeuvring engine order		**RPM**	**Pitch**	**Speed (knots)**	
				Loaded	**Ballast**
Full sea speed	**1**	91.0	N/A	N/A	16.4
Full Ahead	**0.8**	57.0	N/A	N/A	10.4
Half Ahead	**0.5**	46.0	N/A	N/A	8.4
Slow Ahead	**0.25**	35.0	N/A	N/A	6.4
Dead Slow Ahead	**0.125**	27.0	N/A	N/A	4.9
Dead Slow Astern	**-0.125**	-27.0	N/A		
Slow Astern	**-0.25**	-35.0	N/A		
Half Astern	**-0.5**	-46.0	N/A		
Full Astern	**-1**	-91.0	N/A		

PILOT CARD

TANK23L
Version 5

Ship's name Eagle Kangar

Call Sign 9V8472 **Deadweight** 107481 tonnes **Year built** 2010

Draught aft 12.2 m / 40 ft 0 in **Forward** 12.2 m / 40 ft 0 in **Displacement** 99250 tonnes

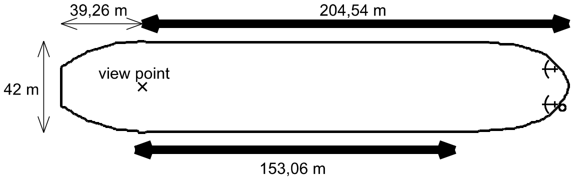
SHIP'S PARTICULARS

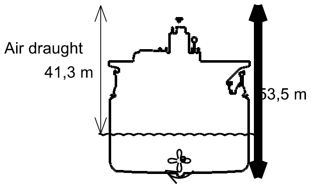
Length overall 243.8 m **Anchor chain:** **Port** 13.0 shackles **Starboard** 13.0 shackles

Breadth 42 m

Bulbous bow Yes

(1 shackle = 27,432 m = 15 fathoms)





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 13557 kW (18432 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	101.0	N/A	15.0	N/A
Full Ahead	**0.8**	75.0	N/A	11.2	N/A
Half Ahead	**0.5**	62.0	N/A	9.2	N/A
Slow Ahead	**0.25**	42.0	N/A	6.2	N/A
Dead Slow Ahead	**0.125**	35.0	N/A	5.1	N/A
Dead Slow Astern	**-0.125**	-35.0	N/A		
Slow Astern	**-0.25**	-42.0	N/A		
Half Astern	**-0.5**	-62.0	N/A		
Full Astern	**-1**	-75.0	N/A		

PILOT CARD

BULKC16
Version 1

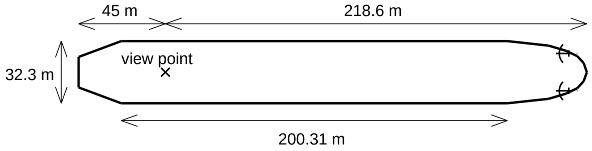
Ship's name Fraiser River **Date**

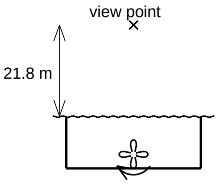
Call Sign V7NS1 **Deadweight** 75000 tonnes **Year built** 1982

Draught aft 12.5 m / 41 ft 0 in **Forward** 12.5 m / 41 ft 0 in **Displacement** 85005 tonnes

SHIP'S PARTICULARS

Length overall 265 m	**Anchor chain:**	**Port** 25.1 shackles	**Starboard** 25.1 shackles	
Breadth 32.3 m		**Stern** shackles		
Bulbous bow Yes			**(1 shackle = 27.432 m = 15 fathoms)**	





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 10860 kW (14564 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots) Loaded	Speed (knots) Ballast
Full sea speed	**1**	94.0		14.5	
Full Ahead	**0.8**	81.0		12.6	
Half Ahead	**0.5**	60.0		9.3	
Slow Ahead	**0.25**	40.0		6.1	
Dead Slow Ahead	**0.125**	28.0		4.2	
Dead Slow Astern	**-0.125**	-28.0			
Slow Astern	**-0.25**	-40.0			
Half Astern	**-0.5**	-54.0			
Full Astern	**-1**	-81.0			

Time limit astern min:sec

Full ahead to full astern min:sec

Max. No. of consecutive starts

Minimum RPM knots

Astern power % ahead

PILOT CARD

BULKC06L
Version 15

Ship's name M/S Magnitogorsk

Call Sign A8IS3 **Deadweight** 22691 tonnes **Year built** 1976

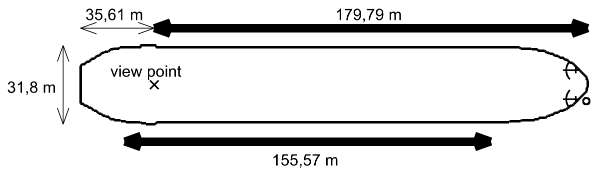
Draught aft 11.5 m / 37 ft 9 in **Forward** 11.5 m / 37 ft 9 in **Displacement** 60920 tonnes

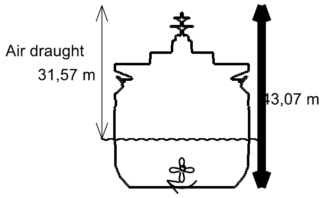
SHIP'S PARTICULARS

Length overall 215.4 m **Anchor chain:** **Port** 10.9 shackles **Starboard** 10.9 shackles

Breadth 31.8 m

Bulbous bow No **(1 shackle = 27,432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 9180 kW (12481 hp)

Manoeuvring engine order		**RPM**	**Pitch**	**Speed (knots)**	
				Loaded	**Ballast**
Full sea speed	**1**	120.0	N/A	16.0	N/A
Full Ahead	**0.8**	108.6	N/A	14.4	N/A
Half Ahead	**0.5**	96.0	N/A	12.8	N/A
Slow Ahead	**0.25**	76.2	N/A	10.1	N/A
Dead Slow Ahead	**0.125**	45.0	N/A	6.0	N/A
Dead Slow Astern	**-0.125**	-45.0	N/A		
Slow Astern	**-0.25**	-70.2	N/A		
Half Astern	**-0.5**	-89.4	N/A		
Full Astern	**-1**	-96.0	N/A		

PILOT CARD

TUGBA21
Version 4

Ship's name MTY Tow 21

Call Sign ______ **Deadweight** 0 tonnes **Year built** 2002

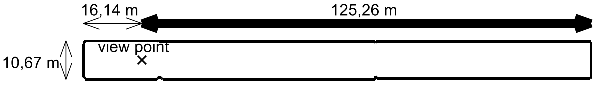
Draught aft 2.28 m / 7 ft 6 in **Forward** 0.46 m / 1 ft 6 in **Displacement** 790 tonnes

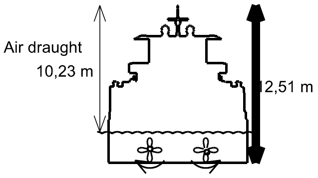
SHIP'S PARTICULARS

Length overall 141.4 m **Anchor chain:** **Port** ______ shackles **Starboard** ______ shackles

Breadth 10.67 m

Bulbous bow No **(1 shackle = 27,432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 1177 kW (1600 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	268.0	N/A	N/A	8.0
Full Ahead	**0.8**	237.8	N/A	N/A	7.3
Half Ahead	**0.5**	192.6	N/A	N/A	6.2
Slow Ahead	**0.25**	120.0	N/A	N/A	4.2
Dead Slow Ahead	**0.125**	32.0	N/A	N/A	1.1
Dead Slow Astern	**-0.125**	-32.0	N/A		
Slow Astern	**-0.25**	-120.0	N/A		
Half Astern	**-0.5**	-192.6	N/A		
Full Astern	**-1**	-268.0	N/A		

PILOT CARD

MS7505
Version 5

Ship's name THOR

Call Sign WDD8608 **Deadweight** 189 tonnes **Year built:** 2007

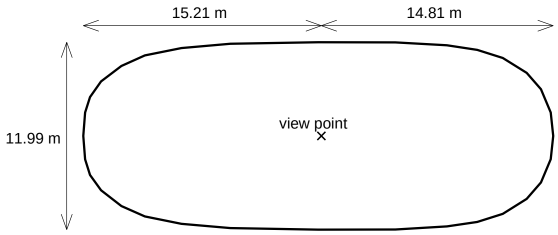
Draught aft 5.99 m / 19 ft 8 in **Forward** 5.85 m / 19 ft 2 in **Displacement** 733 tonnes

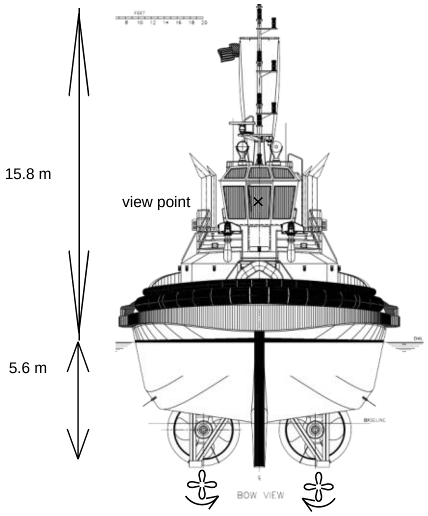
SHIP'S PARTICULARS

Length overall 30.02 m **Anchor chain:** **Port** ______ shackles **Starboard** ______ shackles

Breadth 11.99 m **Stern** ______ shackles

Bulbous bow No **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 4633 kW (6299 hp)

Manoeuvring engine order		RPM Shaft	RPM Engine	Speed (knots)	
				Loaded	Ballast
Full speed	**1**	200.0	1800	12.2	
Ahead	**0.8**	168.0	1500	10.5	
Half Ahead	**0.5**	130.0	1200	8.7	
Quarter Ahead	**0.25**	100.0	950	6.5	
Slow Ahead	**0.125**	70.0	650	5.3	

Time limit astern ______ min:sec

Full ahead to full astern ______ min:sec

Max. No. of consecutive starts ______

Minimum RPM ______ ______ knots

Astern power ______ % ahead

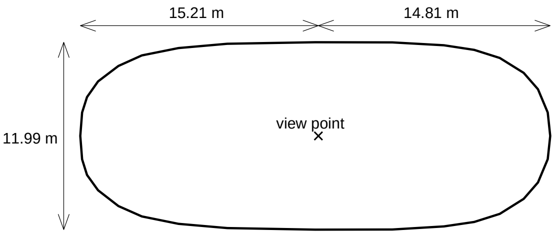
PILOT CARD

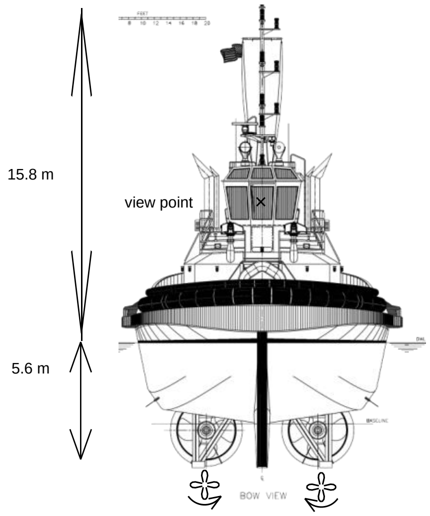
MZ7505
Version 5

Ship's name WESLEY A
Call Sign WDE 2433 **Deadweight** 189 tonnes **Year built:** 2007
Draught aft 5.99 m / 19 ft 8 in **Forward** 5.85 m / 19 ft 2 in **Displacement** 733 tonnes

SHIP'S PARTICULARS

Length overall 30.02 m **Anchor chain:** **Port** shackles **Starboard** shackles
Breadth 11.99 m **Stern** shackles
Bulbous bow No **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 4633 kW (6299 hp)

Manoeuvring engine order		RPM Shaft	RPM Engine	Speed (knots)	
				Loaded	Ballast
Full speed	**1**	200.0	1800	12.2	
Ahead	**0.8**	168.0	1500	10.5	
Half Ahead	**0.5**	130.0	1200	8.7	
Quarter Ahead	**0.25**	100.0	950	6.5	
Slow Ahead	**0.125**	70.0	650	5.3	

Time limit astern min:sec
Full ahead to full astern min:sec
Max. No. of consecutive starts
Minimum RPM knots
Astern power % ahead

Appendix B: Study Participants and Attendees

A partial list of participants of the ship maneuvering simulation study is provided below:

U.S. Army Corps of Engineers
- Dennis Webb
- Mario Sanchez
- Tim Shelton
- Tomas White

Gahagan & Bryant Associates, Inc.
- Dana Chaney
- Ashley Judith

Maritime Pilots Institute
- George Burkley
- Fernando Lagunes

Houston Pilots
- Capt. Tom Goodwin
- Capt. Gregg Brown
- Capt. John Bratcher
- Capt. Sean Arbogast
- Capt. Jason Briones
- Capt. Brandon Bass

San Jacinto Maritime Simulator
- Renee Hendrix
- John Gregg

G&H Towing
- Capt. Robin Sarvis
- Capt. Bobby Pytka
- Capt. Bobby Pytka

Waterway Simulation Technology
- Larry Daggett
- Chris Hewlett

Appendix C. Simulation Runs Performed in Support of the HSC 216 Study

Run No.	Channel Condition	Inbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Outbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Tide	Wind Direction/ Speed (knts)	Tugs	Notes	Run Comments
		Type	Draft (ft)				Type	Draft (ft)								
1 - Testing HSC Widened to 650 ft with Bend Wideners																
1a	650 ft	Container	45	10	18	B	Suezmax	45	10	57-58	A	Flood	SE/20	0	Meeting Below Red Fish	1st Run with environment - Familiarization - !st Meeting good; With only 2 pilots, the setup of the second run was problematic.
1b	650 ft	Container	45	10	Continue	B	Container	45	10	63-64	A	Flood	SE/20	0	Meeting Below Red Fish	2nd meeting very tight – outbound ship aground.
2	650 ft	Container	45	266/10	Bolivar Roads	B	Container	45	156/10	45-46	A	0.5/Fld	SE/20	0	Meeting Below Red Fish	Run to allow Pilot B to rerun previous run. Outbound ship over-steered in anticipation of bow wave - stern-to-stern collision.
3	650 ft	Container	45	336/10	31-32	B	Container	45	156/10	37-39	A	0	0	0	2 ship meeting in straight reach - no environmentals	B broke too soon and had too much drift angle..
4	650 ft	Container	45	336/10	31-32	B	Container	45	156/10	37-38	A	0	0	0	Trying a slower speed- limit break angle to 3 degrees. No enviornmentals	Large angle/LOA creates stern section & turn to port - recovery crosses C//L.
5	650 ft	Container	45	336/10	31-32	B	Tanker	45	156/10	37-38	A	0	0	0	Meeting with Suzmax/Neo-Panamax. No environmentals	Good Run
6	650 ft	Suezmax	45	336/10	31-32	B	Tanker	45	156/10	37-38	A	0.5/Ebb	SE/20	0	Add Environment	Suezmax Grounded
7	650 ft	Container	45	326/10	65-66	A	Tanker	45	146/10	73/74	B	0.5/Fld	SE/20	0	Move Up-bay	ULCV Grounded
8	650 ft	Container	45	326/10	65-66	A	Tanker	45	146/10	73-74	B	0.5/Fld	SE/20	0	Repeat run	Good run
9	650 ft	Container	45	326/10	65-66	A	Container	45	146/10	73-74	B	0.5/Fld	SE/20	0	Container to Container	Both vessels grounded
10	650 ft	Tanker	45	326/10	65-66	A	Tanker	45	146/10	73-74	B	0.5/Fld	SE/20	0	VLCC/VLCC	Good run
11	700 ft	Container	45	326/10	63-64	A	Container	45	146/10	71-72	B	0.5/Fld	SE/20	0	Check effects of a wider channel	Inbound vessel aground
12	700 ft	Container	45	326/10	63-64	A	Tanker	45	146/10	71-72	B	0.5/Fld	SE/20	0	Check effects of a wider channel - VLCC/VLCC	ULCV grounded
13	700 ft	Container	45	326/10	63-64	A	Container	45	146/10	71-72	B	0.5/Fld	SE/20	0	Reduce Containership (red) bank moment	Vessels passed, but very tight on channel toe
14	700 ft	Container	45	326/10	63-64	A	Container	45	146/10	71-72	B	0.5/Fld	SE/20	0	New vessel model with reduced bank moment & bow effect in ship/ship interaction	Good run. Pilots confirm Containership model is acceptable
15	650 ft	Container	45	326/10	63-64	A	Container	45	146/10	71-72	B	0.5/Fld	SE/20	0	Repeat #9	Good Run
16	650 ft	Container	45	336.5/10	29-30	B	Container	45	156/10	39-40	A	0.5/Ebb	SE/20	0	Clean Passing	Run with inbound @ 10 knts & outbound @ 14 knts
17	650 ft	Container	45	336.5/10	29-30	C	Tanker	45	156.3/10	39-40	D	0.5/Ebb	SE/20	0	2 new pilots - Start Suezmax meeting	Inbound ship grounded after meeting
18	650 ft	Container	45	336.5/10	29-30	C	Tanker	45	156.3/10	39-40	D	0.5/Ebb	SE/20	0	2 new pilots - Suezmax/Containership	Good meeting
19	650 ft	Container	45	336.5/10	29-30	D	Tanker	45	156.3/10	39-40	C	0.5/Ebb	SE/20	0	Switch Bridges	Containership close to bank
20	650 ft	Container	45	336.5/10	29-30	C	Container	45	156.3/10	37-38	D	0.5/Ebb	SE/20	0	2 Containerships meeting	Inbound container close to bank

Run No.	Channel Condition	Inbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Outbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Tide	Wind Direction/ Speed (knts)	Tugs	Notes	Run Comments
		Type	Draft (ft)				Type	Draft (ft)								
2 - Testing HSC Widened to 700 ft with Bend Wideners																
21	700 ft	Container	45	326.2/10	63-64	B	Container	45	146.5/10	71-72	C	0.5/Fld	SE/20	0	Wider channel - mid-bay reach	Successful Passing, but outbound ship rotated clockwise after passing
22	700 ft	Container	45	326.2/10	63-64	D	Container	45	146.5/10	71-72	A	0.5/Fld	SE/20	0	"	Good meeting
23	700 ft	Container	45	326.2/10	63-64	C	Container	45	146.5/10	71-72	B	0.5/Ebb	SE/20	0	Change currents	Good meeting
24	700 ft	Container	45	326.2/10	63-64	A	Container	45	146.5/10	71-72	D	0.5/Ebb	SE/20	0	Set up traffic meetings	Good meeting
							Tanker	45	161.8/10	81-82	B					Good meeting
25	700 ft	Container	45	326.2/10	65-66	B	Container	45	146.5/10	73-74	D	0.5/Fld	SE/20	0	Shorten Traffic separation	High speed 13.5 - Heeled & soft grounding
							Tanker	45	161.8/10	81-82	A					Stopped model - lost tanker model - no evaluation
26	700 ft	Container	45	326.2/10	65-66	B	Container	45	146.5/10	73-74	D	0.5/Fld	SE/20	0	Shorten Traffic separation	Rudder stuck at port after meeting on outbound ship; grounded on red side of channel
							Tanker	45	161.8/10	81-82	A					Meeting OK; passed grounded ship successfully
27	700 ft	Container	45	326.2/10	73-74	C	Container	45	161.8/10	81-82	D	0.5/Fld	SE/20	0	Meet in Red Fish Bend	Changed rudder to azipods on Bridges B & C
							Tanker	45	161.8/10	85-86	A				Meet above Bayport Ship Channel	
28	700 ft	Container	45	326.2/10	63-64	C	Container	45	146.5/10	73-74	D	1.3/Ebb	SE/20	0	Meeting with tow in barge channel - TUGBA21 conned by Pilot A	Inbound tow difficult to control during overtaking
29	700 ft	Container	45	326.2/10	65-66	A	Container	45	146.5/10	73-74	D	0.5/Ebb	SE/20	0	Repeat run 28 – Pilot E on Tow	Inbound tow difficult to control during overtaking
30	700 ft	Container	45	336.5/10	43-44	A	Container	45	146.5/10	53-54	D	0.5/Fld	SE/20	0	Meetings @ Red Fish	
							Tanker	45	146.5/10	57-58	E/D					
31	700 ft	Container	45	336.5/10	43-44	A	Tanker	45	146.5/10	55-56	D	0.5/Fld	SE/20	0	Meeting in Red Fish Bend	Inbound ship turned late; ended on red bank toeline
32	700 ft	Container	45	326.2/10	43-44	A	Container	45	146.5/10	55-56	D	0.5/Fld	SE/20	0	Meeting in Red Fish Bend / Change pilot visibility on Outbound ULCV	
3. Testing Widened HSC Channel (700 ft) - Entrance to Babours Cut Channel @ 455 ft Width																
33	700ft / 455 ft	Container	45	342/7	87-88	D						0.5/Ebb	SE/20	2	Tugs = Thor@C/L Aft-C; Wesley A@C/L Bow-I	Time clear of channel 29:20 into simulation
34	700ft / 455 ft	Container	45	342/7	87-88	I						0.5/Ebb	SE/20	2	Tugs = Thor@PB- H; Wesley A@C/L Aft- G	Time clear of channel 34 min. into simulation; Wesely went out of channel; Max wind limits for this ship are 15 knots; New pilot disregard run - No Evaluation
35	700ft / 455 ft	Container	45	342/3	89A-90A	C						0.5/Ebb	N/10	2	Tugs = Thor@PB- G; Wesley A@C/L Aft- H	Bow clear of channel @ 20 min., Tug clear @20:36
36	700ft / 455 ft						Container	45	080/0	Berth 2	A	0.5/Ebb	N/10	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Grounded on the Point/Turned too early
37	700ft / 455 ft						Container	45	080/0	Berth 2	A	0.5/Ebb	N/10	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Good

Run No.	Channel Condition	Inbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Outbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Tide	Wind Direction/ Speed (knts)	Tugs	Notes	Run Comments
		Type	Draft (ft)				Type	Draft (ft)								
38	700ft / 455 ft						Container	45	080/0	Berth 2	D	0.5/Ebb	SE/10	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Good
39	700ft / 455 ft	Container	45	342/3	89A-90A	C						0.5/Ebb	N/10	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Good
4. Testing Widened HSC Channel (700 ft) - Entrance to Bayport Ship Channel @ 455 ft Width																
40	700ft / 455-400ft	Container	45	328/8	73-74	A						0.5/Ebb	N/15	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Used RO/RO Turning Basin
41	700ft / 455-400ft	Container	45	328/8	73-74	C						0.5/Fld	SE/15	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H	Used RO/RO Turning Basin
42	700ft / 455-400ft						Container	45	089/4	Berth 2	D	0.5/Fld	SE/15	1	Tugs = Wesley A@C/L Aft- H	Simulation Stopped/Paused and restarted/finished OK
43	700ft / 455-400ft						Container	45	080/0	Berth 2	A	0.5/Ebb	N/15	0		
44	700ft / 455-400ft	Container	45	268/7	BSC 6-7	A					A	1.3/Ebb	N/15	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H; Transit through the terminal	Note: Channel ranges and C/L for 350' channel- visual and Raven; Drifted to South with wind forces
45	700ft / 455-400ft	Container	45	268/7	BSC 6-7	C						1.3/Ebb	N/15	2	Tugs = Thor@C/L B- G; Wesley A@C/L Aft- H; Transit through the terminal	Changed the tug use per tug mater's advice; used power indirect
5. Testing Enlarged Brady Island Turning Basin																
46	400ft x 41.5 ft	Bulker	37.7	250.5/4	Wharf 32	A						0/Ebb	N/15	2	Tugs= Wesley A@SS - H;Chloe K@C/L Aft- G	Panamax ships berthed at Wharfs 26-28 with bunker barge at Wharf 27
47	400ft x 41.5 ft	Bulker	37.7	250.5/4	Wharf 32	C						0/0	0	2	Tugs= Wesley A@SS - H;Chloe K@C/L Aft- G	Panamax ships berthed at Wharfs 26-28 with bunker barge at Wharf 27
48	400ft x 41.5 ft	Bulker	37.7	250.5/4	Wharf 32	A						0/0	SE/20	2	Tugs= Wesley A@SS - H;Chloe K@C/L Aft- G	Panamax ships berthed at Wharfs 26-28 with bunker barge at Wharf 27
6. Testing Widened and Deepened San Jacinto to Greens Bayou Channel (530 ft Wide x 46.5 ft Deep MLLW) (Texas 8 Bridge - to be replaced with a bridge spanning the navigation channel)																
49	530ft x 46.5 ft	Aframax	40	241.3/6.5	Shell	A	Suezmax	45	130.1/6.5	Greens Bayou	C	0.5/Ebb	SE20	0	Transit through Boggy Bayou - Greens Bayou	Grounded - do not meet 2 loaded ships in 530 ft channels with this combined beam
50	530ft x 46.5 ft	Aframax	40	241.3/6.5	Shell	A	Suezmax	45	130.1/6.5	Greens Bayou	C	0.5/Ebb	SE20	0	Transit through Boggy Bayou - Greens Bayou	Grounded
51	530ft x 46.5 ft	Aframax	28.2	241.3/6.5	Shell	A	Suezmax	45	095.6/5	Bridge	D	0.5/Fld	SE20	0	Transit through Boggy Bayou - Greens Bayou	Meet Light Aframax Tanker
52	530ft x 46.5 ft	Aframax	28.2	281.3/6	Bridge	A	Suezmax	45	126.9/5.5	Greens Bayou	C	0.5/Fld	SE20	0	Transit through Boggy Bayou - Greens Bayou	Meet Light Aframax Tanker
54	530ft x 46.5 ft	Suezmax	45	281.1/6.5	Bridge	C	Bulker	40	126.9/6	Greens Bayou	A	0.5/Fld	SE20	0	Transit through Boggy Bayou - Greens Bayou	

Run No.	**Channel Condition**	**Inbound Ship**		**Heading (deg) Initial Speed (knts)**	**Initial Position**	**Pilot**	**Outbound Ship**		**Heading (deg) Initial Speed (knts)**	**Initial Position**	**Pilot**	**Tide**	**Wind Direction/ Speed (knts)**	**Tugs**	**Notes**	Run Comments
		Type	**Draft (ft)**				**Type**	**Draft (ft)**								
55	530ft x 46.5 ft	Suezmax	45	242.4/5.5	Shell	C	Bulker	40	095.7/6	Bridge	A	0.5/Fld	SE20	0	Transit through Boggy Bayou - Greens Bayou	
56	530ft x 46.5 ft	Aframax	40	260/6	Shell	A	Bulker	37.7	107.1/6	Ammonia	D	1.3/Ebb	N20	0	Transit through Boggy Bayou - Greens Bayou	
57	530ft x 46.5 ft	Aframax	40	260/6	Shell	A	Bulker	37.7	107.1/6	Ammonia	K	1.3/Ebb	N20	0	Transit through Boggy Bayou - Greens Bayou	
58	530ft x 46.5 ft	Aframax	40	275/5.2	Kinder Morgan	A	Bulker	37.7	129.8/6	Greens Bayou	D	1.3/Ebb	N20	0	Transit through Boggy Bayou - Greens Bayou	
59	530ft x 46.5 ft	Bullker	37.7	275/6	Bridge	D	Aframax	40	131.4/6	Greens Bayou	A	1.3/Ebb	N20	0	Transit through Boggy Bayou - Greens Bayou	
60	530ft x 46.5 ft	Bullker	37.7	275/6	Bridge	K	Aframax	40	131.4/6	Greens Bayou	A	1.3/Ebb	SE20	0	Transit through Boggy Bayou - Greens Bayou	
63	530ft x 46.5 ft	Bullker	37.7	267.8/6	Shell	D	Suezmax	45	099.2/6	Bridge	A	1.3/Ebb	SE20	0	Transit through Boggy Bayou - Greens Bayou	
3. Testing Widened HSC Channel (700 ft) - Entrance to Barbours Cut Channel @ 455 ft Width																
61	700ft / 455 ft						Suezmax	45	081/3.5	Berth 2	A	1.3/Ebb	SE20	2	Tugs = Thor@C/L B- K; Wesley A@C/L Aft- D	Suezmax turn to North out of Barbours Cut; Two Houston Pilots handling the tugs
62	700ft / 455 ft						Suezmax	45	132.7/4.3	83-84	A	1.3/Ebb	SE20	2	Tugs = Thor@C/L B- K; Wesley A@C/L Aft- D	Suezmax inbound from the North to Barbours Cut; Two Houston Pilots handling the tugs

Ship Models Used in the HSC 216 Ship Maneuvering Simulation Study

					DRAFT					Length Overall		Breadth	
Model Name	Version	Ships Name	Dead Weight	Year Built	AFT M	A FT	FWD M	F FT	Displacement	Meters	Feet	Meters	Feet
BULKC06L	13	M/S Magnitogorsk	22691	1976	11.5	37.7	11.45	37.6	60920	215.4	706.5	31.8	104.3
TANK23L	5	EAGLE KANGAR	107481	2010	12.2	40.0	12.2	40.0	99250	244	799.7	42.0	137.8
BULKC16	1	FRAISER RIVER	75000	1982	12.5	41.0	12.5	41.0	85005	265	869.2	32.3	105.9
VLCC13X	5	ORION VOYAGER	156500	1994	13.8	45.2	11.2	36.8	122400	275	900.4	50.0	164.0
MULCV14T	2	MAERSK EDINBURGH	133500	2010	13.7	45.0	13.7	45.0	157281	367	1202.1	48.2	158.1

Pilot	**Name**	**Tug Master**	**Name**
A	**Capt. Tom Goodwin**	**F**	**Capt. Robin Sarvis**
B	**Capt. Gregg Brown**	**G**	**Capt. Bobby Pytka**
C	**Capt. John Bratcher**	**H**	**Capt. Shawn Elmore**
D	**Capt. Sean Arbogast**	**F**	**Capt. Robin Sarvis**
E	**Capt. George Burkley**	**G**	**Capt. Bobby Pytka**
I	**Capt. Jason Briones**	**H**	**Capt. Shawn Elmore**

Run No.	Channel Condition	Inbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Outbound Ship		Heading (deg) Initial Speed (knts)	Initial Position	Pilot	Tide	Wind Direction/ Speed (knts)	Tugs	Notes	Run Comments
		Type	Draft (ft)				Type	Draft (ft)								
K	Capt. Brandon Bass															

Appendix D: A Sample Pilot Questionnaire

Run #:	**Date:**	**Simulator/Operator:**
Pilot:		**Ship's Initial Heading/Speed:**
Run Start Time:	**Run End Time:**	**HSC Bay Width:**
Start Location:		**End Location:**
Ship Model Used	**Container**	**Suezmax**
Travel Direction	**Inbound**	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
Notes:		

1st Meeting (a)

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

3 Comment(s)

2nd Meeting (b)

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

6 Comment(s)

3rd Meeting (c)

7 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

9 Comment(s)

Appendix E: Pilot Questionnaire Responses

The completed questionnaires by the conning pilot for each of the ship maneuvering simulated transits are provided in this appendix. The questionnaires included are the ones completed following runs after the final adjustments were made to the ship models. These questionnaires are published separately to conserve space in the main body of the report but are available on request.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 14	**Date:** 11-13-17	**Simulator/Operator:**	
Pilot: B		**Ship's Initial Heading/Speed:** 146/10	
Run Start Time: 1641	**Run End Time:**	**HSC Bay Width:** 706	
Start Location: 72-71		**End Location:**	
Ship Model Used	[✓ ULCV]	Suezmax	
Travel Direction	Inbound	[✓ Outbound]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/120	0.5/Fld	
Notes: 14a New Model red bank red bow moment			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 15	**Date:** 11-13-17	**Simulator/Operator:**
Pilot: B		**Ship's Initial Heading/Speed:** 146/10
Run Start Time: 1659	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 73-74		**End Location:**

Ship Model Used	[✓ **ULCV**]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/ Fld

Notes: New Model 14Q
Red. bank effect
Red. Bow Effect Ship/Ship Interaction

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 ~~4~~ 5 [✓ 6] 7 8 9 10

3 Comment(s)

More stable response of the meeting & rudder response much improved.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 15	**Date:** 11-13-17	**Simulator/Operator:**
Pilot: A		**Ship's Initial Heading/Speed:** 326/110
Run Start Time: 1659	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 65-66		**End Location:**

Ship Model Used	[✓ **ULCV**]	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes: New model 14Q
Red. bank effect
Red. Bow effect Ship/ship interaction

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) REACTED NATURALLY AS TO REAL LIFE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 16	**Date:** 11-14-17	**Simulator/Operator:** SIMC A / Renee Hendrix	
Pilot: B		**Ship's Initial Heading/Speed:** 336.5/10	
Run Start Time: 0827	**Run End Time:**	**HSC Bay Width:** 650	
Start Location: 29-30		**End Location:**	
Ship Model Used	[✓ ULCV] QVZ	**Suezmax**	
Travel Direction	[✓ Inbound]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	0.5/Ebb	
Notes: ULCV QVZ			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓ 6] 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s)

Sluggish Rudder response during meeting, bordering on Not being in absolute Control.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 16	**Date:** 11-14-17	**Simulator/Operator:** JJMC C/ Renee Hendrix
Pilot: A		**Ship's Initial Heading/Speed:** 156.3/10
Run Start Time: 0827	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 39-4		**End Location:**

Ship Model Used	[✓ **ULCV**] Q UZ	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) I FELT THE SPEED WAS UNREALISTIC IN PRACTICE BUT VESSEL PREFORMED AS EXPECTED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 17	**Date:** 11-14-17	**Simulator/Operator:**	
Pilot: D		**Ship's Initial Heading/Speed:** 156.3/10	
Run Start Time: 0850	**Run End Time:**	**HSC Bay Width:** 650	
Start Location: 39-40		**End Location:**	
Ship Model Used	ULCV	[✓ Suezmax]	
Travel Direction	Inbound	[✓ Outbound]	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	SE/10	0.5/Ebb	
Notes: First Run			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

~~650~~ 325 500

Felt safe squat was significant but not realistic for our channel.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 17	**Date:** 11-14-17	**Simulator/Operator:**
Pilot: C		**Ship's Initial Heading/Speed:** 336.5/10
Run Start Time: 0850	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 29-30		**End Location:**
Ship Model Used	ULCV	[✓ Suezmax]
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

MY SPEED WAS A LITTLE TOO FAST
OTHERWISE SEEMED FAIRLY "NORMAL"

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 18	**Date:** 11-14-17	**Simulator/Operator:**
Pilot: D		**Ship's Initial Heading/Speed:** 156.3/10
Run Start Time: 0918	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 39-46		**End Location:**

Ship Model Used	**ULCV**	[✓ **Suezmax**]
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb

Notes: ~~Pilot stated he broke late~~ -

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

Very Comfortable

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 18	**Date:** 11-14-17	**Simulator/Operator:**
Pilot: C		**Ship's Initial Heading/Speed:** 336.5/10
Run Start Time: 0918	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 29-30		**End Location:**
Ship Model Used	[✓ **ULCV**] QVZ	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

FELT NORMAL
SPEED GOOD
GAVE A "KICK" TO MAINTAIN CONTROL COMING BACK
TO CENTER AFTER MTG

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 19	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: ~~E~~ D		**Ship's Initial Heading/Speed:** ~~156.3/10~~ 336.5/10
Run Start Time: 0935	**Run End Time:**	**HSC Bay Width:** 650
Start Location: ~~39-40~~ 29-30		**End Location:**

Ship Model Used	[✓ ULCV]	~~Suezmax~~
Travel Direction	[✓ Inbound]	~~Outbound~~
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5 / Ebb

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 [✓ 6] 7 8 9 10

3 Comment(s)

still getting use to maneuvering characteristics of design vessel.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 19	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: ~~B~~ C		**Ship's Initial Heading/Speed:** ~~331.5/10~~ 156.3/10
Run Start Time: 0935	**Run End Time:**	**HSC Bay Width:** 650
Start Location: ~~29-30~~ 39-40		**End Location:**

Ship Model Used	~~ULCV~~	[✓ **Suezmax**]
Travel Direction	~~Inbound~~	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓ 6] 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓] 5 6 7 8 9 10

3 Comment(s)

STEERING FAILURE CAUSED A HIGH LEVEL OF DISCOMFORT
SLIGHTLY SLUGGISH
SLOWER RUDDER

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 20	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 156.3/10
Run Start Time: 0955	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 39-40		**End Location:**
Ship Model Used	[✓ **ULCV** Q V2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓] 4 5 6 7 8 9 10

3 Comment(s)

NOT SURE OF THE REALISM OF THE RECOVERY/ SWING/ANGLE
HAD A HARD SWING BACK TO PORT AFTER MEETING THEN
SHIP "SNAPPED" BACK TO STARBOARD - USED A LOT OF
HARD OVER COMMANDS TO CHECK SHIP
IF THIS IS ACURATE THEN WE'RE RUNNING AT THE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 20	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 356.5/10
Run Start Time: 0955	**Run End Time:**	**HSC Bay Width:** 650
Start Location: 29-30		**End Location:**
Ship Model Used	[✓ ULCV QVZ]	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 [✓ 7] 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s)

Ship ran a little was worried about overcorrection and sterns colliding but recovered in significant time

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 21	**Date:** 11-14-17	**Simulator/Operator:**	
Pilot: C		**Ship's Initial Heading/Speed:** 146.5/10	
Run Start Time: 1031	**Run End Time:**	**HSC Bay Width:** 706	
Start Location: 71-72		**End Location:**	
Ship Model Used	[✓ ULCV]	Suezmax	
Travel Direction	Inbound	[✓ Outbound]	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	SE/20	0.5/Fld	
Notes:			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 [✓ 7] 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s)

DECENT RUN
SPEED GOOD
QUESTIONABLE REACTION OF SHIP AFTER MEETING
SHIP COMES BACK TOWARD CENTER AFTER MEETING
AND THEN TAKES HARD RUN BACK TO PORT (UNREALISTIC)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 21	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: B		**Ship's Initial Heading/Speed:** 3263/10
Run Start Time: 1031	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 63-64		**End Location:**

Ship Model Used	[✓ **ULCV**]	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/[redacted]Fld

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓ 6] 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s)

Vessel responded to Rudder
Very well, distance on stb qtr
close still. Rudder response

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 22	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 146.5/10
Run Start Time: 1053	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 71-72		**End Location:**

Ship Model Used	[✓ **ULCV**] Q2	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) VESSEL BEHAVED AS EXPECTED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 22	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: D		**Ship's Initial Heading/Speed:** 326.2/10
Run Start Time: 1053	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 63-64		**End Location:**
Ship Model Used	[✓ ULCV] Q2	**Suezmax**
Travel Direction	[✓ Inbound]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/120	0.5/Fld
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓ 6] 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s) still getting use to size of ship

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 23	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 326.2/10
Run Start Time: 1106	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 63-64		**End Location:**
Ship Model Used	[✓ ULCV] Q2	Suezmax
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

SEEMED LIKE EVERYTHING SET UP WELL
GOOD SPD
GOOD DISTANCE
MUCH BETTER WITH WIDER CHANNEL

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 23	**Date:** 11-14-17	**Simulator/Operator:** B	
Pilot: B		**Ship's Initial Heading/Speed:** 146.5/	
Run Start Time: 1106	**Run End Time:**	**HSC Bay Width:** 706	
Start Location: 71-72		**End Location:**	
Ship Model Used	[✓ ULCVQ2]		**Suezmax**
Travel Direction	**Inbound**		[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**		**Tide/Flow**
	SE/20		0.5/Ebb
Notes:			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 [✓ 6] 7 8 9 10

3 Comment(s)

Meeting + Recovery went well. P > S meeting was again somewhat unrealistic.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 221	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 326.2 /10
Run Start Time: 1157	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 63-64		**End Location:**
Ship Model Used	[✓ ULCVQ2]	**Suezmax**
Travel Direction	[✓ Inbound]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes: Traffic Test		

1st Meeting (a)

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) As Expected

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

2nd Meeting (6)

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

12 Comment(s) AS EXPECTED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 24a	**Date:** 11-14-17	**Simulator/Operator:**
Pilot: D		**Ship's Initial Heading/Speed:** 146.5/10
Run Start Time: 1157	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 71-72		**End Location:**
Ship Model Used	[✓ **ULCV** Q2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) Getting Use to Model

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 246	**Date:** 11-14-17	**Simulator/Operator:**	
Pilot: B		**Ship's Initial Heading/Speed:** 161.8/10	
Run Start Time: 1157	**Run End Time:**	**HSC Bay Width:** 700	
Start Location: 81-82		**End Location:**	
Ship Model Used	ULCV	[✓ Suezmax]	
Travel Direction	Inbound	[✓ Outbound]	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	SE/20	0.5/Ebb	
Notes: Transit Bend then meet			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s)

Good Run, Suez reacted
very well in this simulation.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 25	**Date:** 11-14-17	**Simulator/Operator:** A	
Pilot: B		**Ship's Initial Heading/Speed:** 326.2/10	
Run Start Time: ~~1250~~ 1306 restart	**Run End Time:**	**HSC Bay Width:** 700	
Start Location: 65-66		**End Location:**	
Ship Model Used	[✓ ULCV]	Suezmax	
Travel Direction	[✓ Inbound]	Outbound	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	SE/20	0.5/Fld	
Notes:			

1st Meeting (a)

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

Meeting went well, Rudder response better before & after meetings?

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HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

4th Meeting (4)

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

12 Comment(s)

Turn into Bayport at 11 kts
Slow ROT at start of turn
but did achieve 24° ROT
for successful turn – but
grounding then occured,
unexplained!!

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 266	**Date:** 11-14-17	**Simulator/Operator:** B
Pilot: A		**Ship's Initial Heading/Speed:** 161.8/10
Run Start Time: 1306 restart ~~1250~~	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 81-82		**End Location:**

Ship Model Used	ULCV	[✓ Suezmax]
Travel Direction	Inbound	[✓ Outbound]
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	0.5/Fld

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) As Expected

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 25a	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 146.5/10
Run Start Time: 1306 ~~1259~~ ~~restart~~	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 73-74		**End Location:**

Ship Model Used	[✓ **ULCV**] 22	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/10	0.5/Fld

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 27	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 376.2/10
Run Start Time: 1417	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 73-74		**End Location:**

Ship Model Used	[✓ **ULCV**] Q2	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3 ~~0.5~~/ Ebb

Notes:

1st Meeting (a)

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 [✓ 10]

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

FAIRLY UNREALISTIC IN TERMS OF DIST. BETWEEN SHIPS - MADE IT WORK - TRIED TO KEEP SPD DOWN - NOT SURE IN REAL LIFE IF I WOULD HAVE BEEN ABLE TO KEEP SHIP ON BANK TO MEET 2ND SHIP

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

~~4th~~ 2nd Meeting (~~d~~ b)

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 [✓ 9] 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 27a	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 161.8/10
Run Start Time: 1417	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 81-82		**End Location:**

Ship Model Used	[✓ **ULCV**Q2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20.	1.3 ~~[illegible]~~/Ebb

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 27 b	**Date:** 11-14-17	**Simulator/Operator:** 1	
Pilot: A		**Ship's Initial Heading/Speed:** 161.8/10	
Run Start Time: 1417	**Run End Time:**	**HSC Bay Width:** 706	
Start Location: 85-86		**End Location:**	
Ship Model Used	**ULCV**	[✓ **Suezmax**]	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**~~Tide~~/Flow**	
	SE/140	1.3/Ebb	
Notes:			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) VESSEL HANDLED THE MANUVER AS EXPECTED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 28	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 326.2/10
Run Start Time: 1453	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 65-66		**End Location:**

Ship Model Used	[✓ ULCVQ2]	Suezmax
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	1.3/Ebb

Notes: Mtg with Tows

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 [✓ 9] 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

I CALL THIS ONE A FAILURE DUE TO BANK TO BANK DRIVING

TOWS WERE NOT A CONCERN - THE CONCERN FOR ME WAS THE 'RUN' THE SHIP TOOK TO PORT

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 28	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 146.5/10
Run Start Time: 1453	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 73-74		**End Location:**

Ship Model Used	[✓ **ULCV**Q2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3/Ebb

Notes: Mtg with Tows

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 [✓ 7] 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

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HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 28	**Date:** 11-14-17	**Simulator/Operator:** B
Pilot: A		**Ship's Initial Heading/Speed:** 326.2/5
Run Start Time: 1453	**Run End Time:**	**HSC Bay Width:** 700
Start Location:		**End Location:**

Ship Model Used	~~ULCV~~ TugBAZ1	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3/Ebb

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s) VESSEL INTERACTION WAS MUCH LIKE REAL LIFE

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 29	**Date:** 11-14.	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 326.2/10
Run Start Time: 1519	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 63-64		**End Location:**

Ship Model Used	[✓ **ULCV** Q2]	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb

Notes:

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s) As EXPECTED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 29	**Date:** 11-14-19	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 146.5/10
Run Start Time: 1519	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 73-74		**End Location:**
Ship Model Used	[✓ **ULCV** Q2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 29	**Date:** 11-14-17	**Simulator/Operator:** B
Pilot: E		**Ship's Initial Heading/Speed:** 326.2/5
Run Start Time:	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 65-66		**End Location:**
Ship Model Used	ULCV	~~Suezmax~~ TugBA21
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	0.5/Ebb
Notes:		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 [✓ 10]

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

I DROVE THE TOWBOAT Along THE TOE of THE CHANNEL AT 5Kn AND THE Head of THE TOW WAS slightly To THE left AND INSIDE THE channel EDGE. THE overtaking SHIP @ 9Kn Dragged THE HEAD of THE barge INTO THE CHANNEL. I could not Control THE TOW.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 30	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 336.5/10
Run Start Time: 1540	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 43-44		**End Location:**

Ship Model Used	[✓ **ULCV**] Q2	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. ~~(from)~~ / Speed**	**Tide/Flow**
	SE/140	0.5/Fld

Notes: Mtgs around Red Fish

1st Meeting (a)

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) As EXPECTED

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HSC 216 Feasibility Simulation Study
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~~4th~~ 2nd Meeting (~~d~~ b)

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

12 Comment(s) THE WIDENER MADE IT DIFFICULT TO ~~[illegible]~~ BE IN POSITION FOR THE MEETING

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 30	**Date:** 11-14-17	**Simulator/Operator:** C	
Pilot: D		**Ship's Initial Heading/Speed:** 146.3/10	
Run Start Time: 1540	**Run End Time:**	**HSC Bay Width:** 700	
Start Location: 53-54		**End Location:**	
Ship Model Used	[✓ ULCVQ2]	Suezmax	
Travel Direction	Inbound	[✓ Outbound]	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	SE/20	0.5/Fld	
Notes: Mtg below Red Fish			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 30	**Date:** 11-14-17	**Simulator/Operator:** B	
Pilot: E/D		**Ship's Initial Heading/Speed:** 146.3/10	
Run Start Time: 1540	**Run End Time:**	**HSC Bay Width:** 700	
Start Location: 57-58		**End Location:**	
Ship Model Used	**ULCV**	[✓ **Suezmax**]	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	0.5/Fld	
Notes: Mtg above Red Fish			

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 31	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 336.1/10
Run Start Time: 1604	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 43-46		**End Location:**
Ship Model Used	[✓ ULCVG2]	Suezmax
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	0.5/Fld
Notes: Mtg in Red Fish		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s) MEETING HAD NO ISSUES WIDENER IS ALITTLE EXCESSIVE IN MY OPINION

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 31	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 146.6/10
Run Start Time: 1604	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 55-56		**End Location:**
Ship Model Used	**ULCV**	[✓ **Suezmax**]
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**~~Tide~~/Flow**
	SE/20	0.5/Fld
Notes: Mtg in Red Fish		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 32	**Date:** 11-14-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 336.1 / 10
Run Start Time: 1621	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 43-46		**End Location:**

Ship Model Used	[✓ **ULCV**Q2]	**Suezmax**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes: Mtg in Redfish

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) WIDENER DOES INCREASE MARGIN OF SAFETY, BUT MY OPINION STILL NOT NEEDED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 32	**Date:** 11-14-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 146.6/10
Run Start Time: 1621	**Run End Time:**	**HSC Bay Width:** 700
Start Location: 55-56		**End Location:**
Ship Model Used	[✓ ULCV T2]	Suezmax
Travel Direction	Inbound	[✓ Outbound]
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	SE/20	0.5/Fld
Notes: Mtg in Red Fish		

Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
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Run #: 33	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: D		**Ship's Initial Heading/Speed:** 342 / 7	
Run Start Time: 0840	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: 87-8B		**End Location:** Berth 1	

Ship Model Used	[✓ ULCV]	Tug MS7505 - 2 ~~Suezmax~~
Travel Direction	[✓ Inbound]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Ebb

Notes: Tugs Thor - I stern & Wesely A - A bow ℄
Time Clear of Channel - 29:20 into Simulation

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

Difficulty is the large ship, Getting it slowed + turned

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s)

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HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
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Transit Channel

4 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty ⟶ — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe — Increasing Safety ⟶ — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

6 Comment(s)

Turn in __________ Turning ~~Basin~~ B-Cut FLARE

7 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty ⟶ — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe — Increasing Safety ⟶ — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
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Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

12 Comment(s)

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Run 33

Tom wench easy
Jason safe

@ 2kts Stern push to pull to all stop maintain difficult to
backing control
could do better if on port bow

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Pilot Evaluation of Simulation Run
November 2017

Run #: 34	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: I		**Ship's Initial Heading/Speed:** 342/7	
Run Start Time: 0928	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: 87-88		**End Location:**	
Ship Model Used	[✓ ULCV]	Tugs MS78 cs ~~Suezmax~~	
Travel Direction	[✓ Inbound]	**Outbound**	
Environmental Conditions	**Wind Dir. ~~(from)~~ / Speed**	**Tide/Flow**	
	SE/20	0.5/Ebb	

Notes: ~~Thor~~ Wesley A. stern ℄ - H ~~Bow~~ ~~Wesley~~ A- Port Bow - G
Thor to Port Shoulder
Time Clear of Channel 34 min Wesely-out of Channel
Wind above limit of of 15 knts
New Pilot - disregard - No Eval

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult
1 2 3 4 5 6 7 8 [✓ 9] 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe
1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

FIRST TIME IN SIMULATOR.
ISSUE WAS PILOT ERROR.

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

~~**Transit Channel**~~

~~4 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.~~

~~Easy Increasing Difficulty → Difficult~~
~~1 2 3 4 5 6 7 8 9 10~~

~~5 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.~~

~~Unsafe Increasing Safety → Safe~~
~~1 2 3 4 5 6 7 8 9 10~~

~~6 Comment(s)~~

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 [✓ 3] 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 [✓ 8] 9 10

9 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 35	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 342/3	
Run Start Time: 1010	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: 89A-90A		**End Location:**	
Ship Model Used	[✓ ULCV TZ]	Thor ℄B 7606 - G **Suezmax** Wesely A ℄A 7505 - H	
Travel Direction	[✓ Inbound]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	N/10	0.5/Ebb	

Notes: Bow clear of channel @ 20 min
Bow tug " " " @ 20:36 min

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 [✓ 7] 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

GOOD DISTANCE TO ENTER FLARE

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 [✓ 7] 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

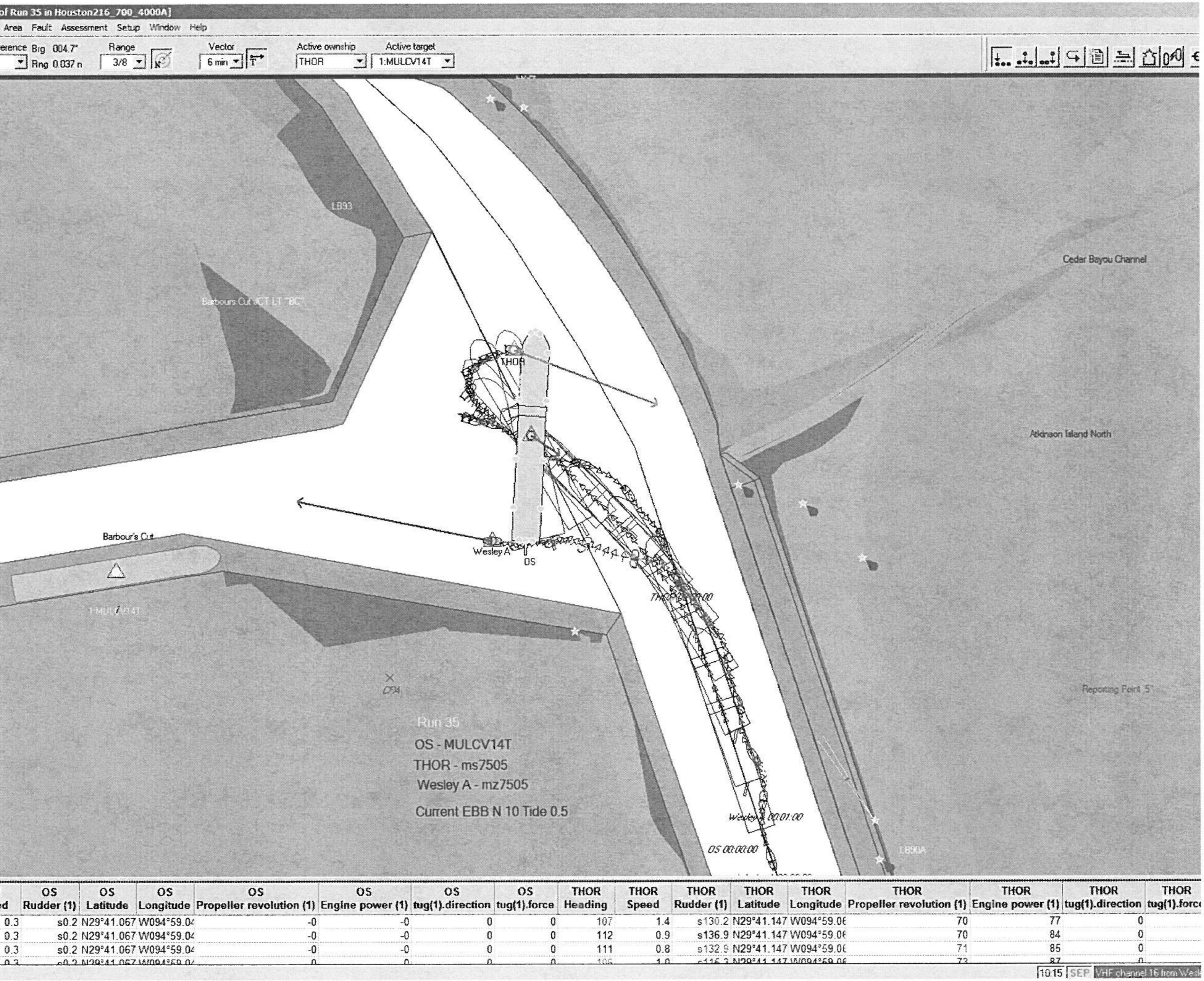
Unsafe Increasing Safety → Safe

1 2 3 4 [✓] 5 6 7 8 9 10

12 Comment(s)

GOOD SPACING BETWEEN SHIP / DOCKS
AND NORTH SIDE
THIS DISTANCE IS GOOD AND SHOULD BE
THE MIN - SHOULD NOT LESSEN THE DISTANCE

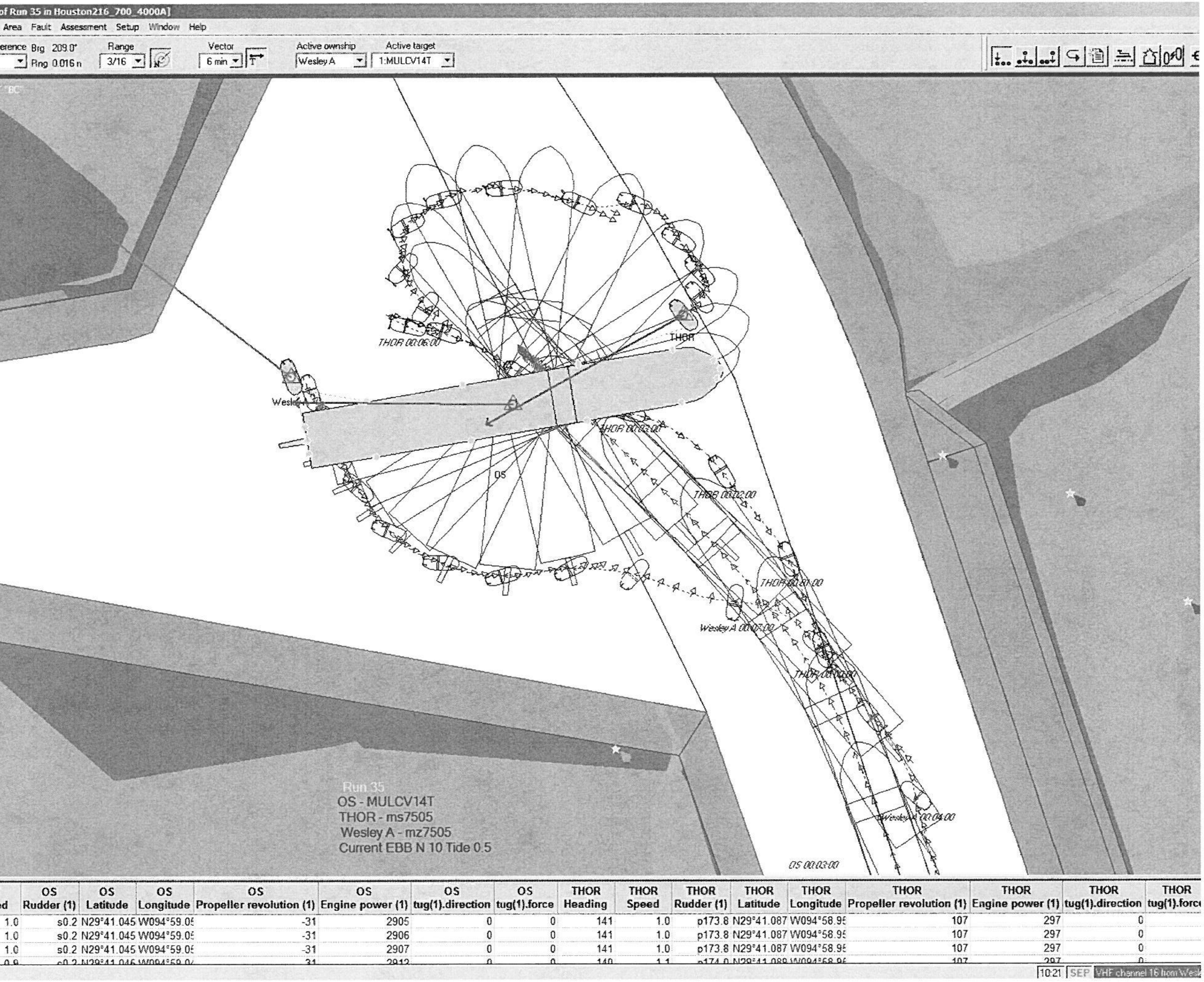
August 22, 2017



Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

ed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).forc
0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	107	1.4	s130.2	N29°41.147	W094°59.06	70	77	0	
0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	112	0.9	s136.9	N29°41.147	W094°59.06	70	84	0	
0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	111	0.8	s132.9	N29°41.147	W094°59.06	71	85	0	
0.3	s0.2	N29°41.067	W094°59.04	0	0	0	0	106	1.0	s116.3	N29°41.147	W094°59.06	73	87	0	

August 22, 2017



of Run 35 in Houston216_700_4000A]

erence Brg 209.0° Rng 0.016 n

Range 3/16

Vector 6 min

Active ownship Wesley A

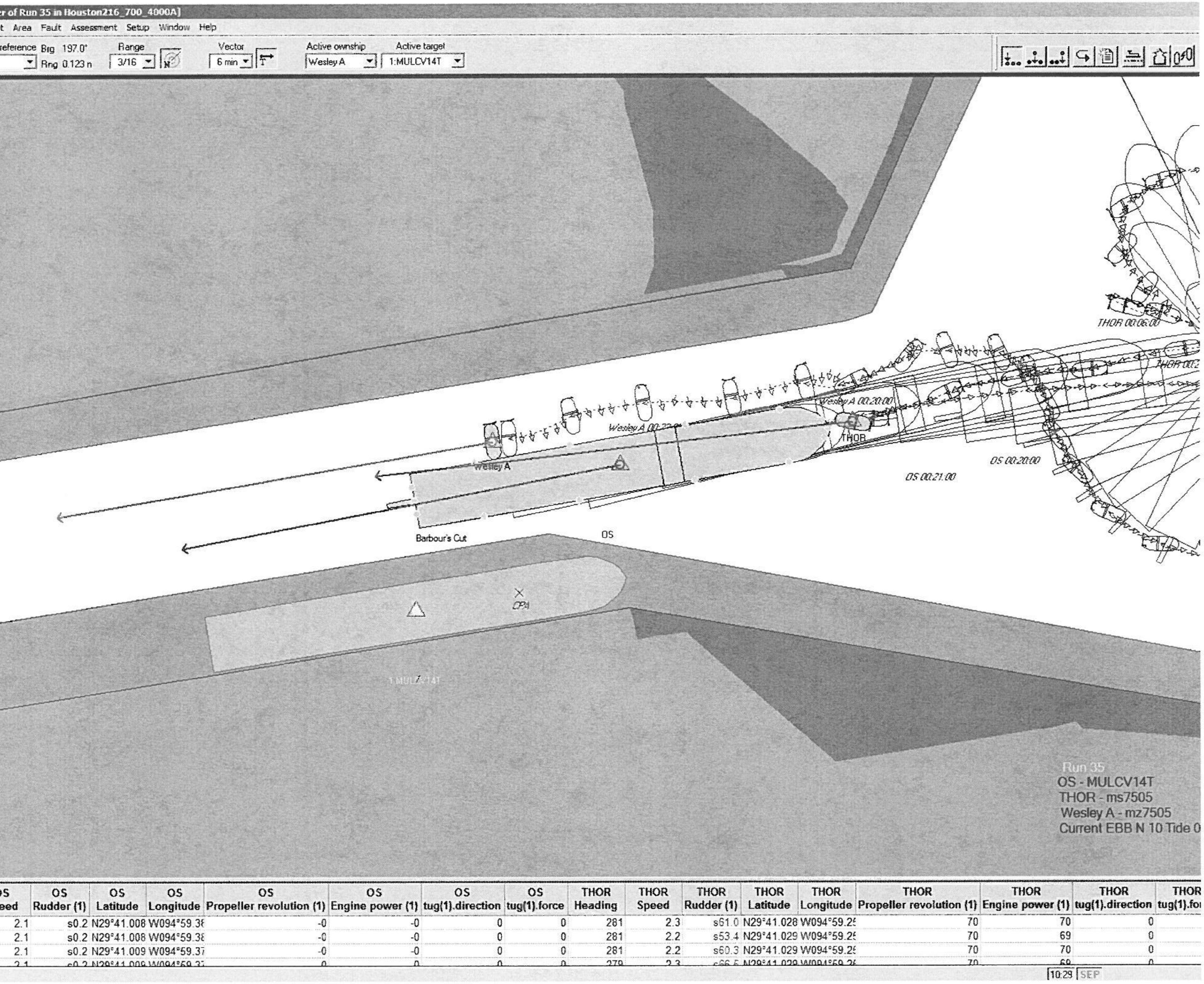
Active target 1:MULCV14T

Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

d	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).forc
1.0	s0.2	N29°41.045	W094°59.0	-31	2905	0	0	141	1.0	p173.8	N29°41.087	W094°58.9	107	297	0	
1.0	s0.2	N29°41.045	W094°59.0	-31	2906	0	0	141	1.0	p173.8	N29°41.087	W094°58.9	107	297	0	
1.0	s0.2	N29°41.045	W094°59.0	-31	2907	0	0	141	1.0	p173.8	N29°41.087	W094°58.9	107	297	0	
0.9	s0.2	N29°41.046	W094°59.0	-31	2912	0	0	140	1.1	p174.0	N29°41.089	W094°58.9	107	297	0	

10:21 SEP VHF channel 16 from Wes

August 22, 2017



Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0

S eed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).fo
2.1	s0.2	N29°41.008	W094°59.3	-0	-0	0	0	281	2.3	s61.0	N29°41.028	W094°59.2	70	70	0	0
2.1	s0.2	N29°41.008	W094°59.3	-0	-0	0	0	281	2.2	s53.4	N29°41.029	W094°59.2	70	69	0	0
2.1	s0.2	N29°41.009	W094°59.3	-0	-0	0	0	281	2.2	s60.3	N29°41.029	W094°59.2	70	70	0	0
2.1	s0.2	N29°41.009	W094°59.3	0	0	0	0	279	2.3	s66.5	N29°41.029	W094°59.2	70	69	0	0

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 36	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 080/0	
Run Start Time: 1052	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: Berth 2		**End Location:**	

Ship Model Used	[✓ ULCVT2]	Tug Thor - CLB 7505 G ~~Suezmax~~ WesleyA-CLA 7505 F
Travel Direction	Inbound	[✓ Outbound]
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	N/10	0.5/Ebb

Notes:

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s) UNDERESTIMATED THE ROT SPEED AT TURN

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

6 Comment(s)

Turn in _________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 37	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 080/0	
Run Start Time: 1110	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: Berth 2		**End Location:**	

Ship Model Used	[✓ **ULCV**T2]	**Suezmax**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/10	0.5/Ebb

Notes:

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 [✓ 7] 8 9 10

3 Comment(s) WAS ABLE TO MAKE THE MANUVER WITH MINIMUM EXTERNAL FORCE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

6 Comment(s)

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 38	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 080/0	
Run Start Time: 1211	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: Berth Z		**End Location:**	

Ship Model Used	[✓ ULCVT2]	Thor - ¢B G ~~Suezmax~~ 7505 Wesley - ¢A H 7505
Travel Direction	Inbound	[✓ Outbound]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/10	0.5/Fld

Notes:

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 [✓ 2] 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 [✓ 8] 9 10

6 Comment(s)

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 39	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 342.1/3	
Run Start Time: 1133	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: 89A-90A		**End Location:**	

Ship Model Used	[✓ ULCVT2]	**Suezmax**
Travel Direction	[✓ Inbound]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/10	0.5/Ebb

Notes:

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

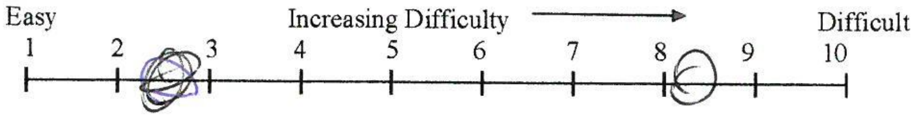
NICE SAFE TURN WITH WIDE FLARE

August 22, 2017

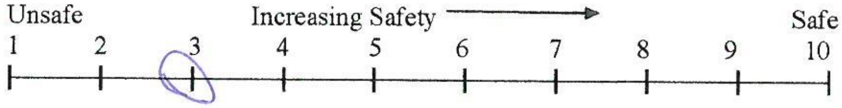
HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.



5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

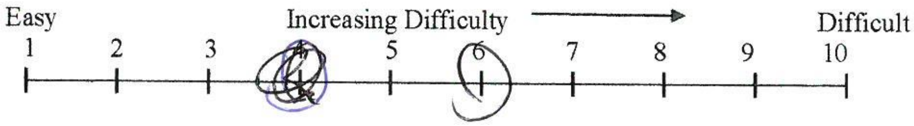


6 Comment(s)

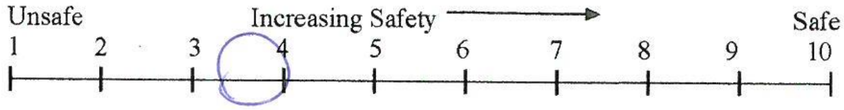
WITH ONLY 10KTS OF WIND - SHIP WANTED TO 'FALL' DOWN ON SHIPS - HAVE TO KEEP SPD DOWN SO WIND HAS GREATER EFFECT - I BELIEVE AT MAX LIMIT WITH WIND - OTHERWISE YOU HAVE TO CARRY MORE SPD

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.



8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.



9 Comment(s)

HAVE TO MAKE SURE YOU USE THE WEST SIDE OF T.B. OTHERWISE YOU WILL RUN OUT OF ROOM ON BOW AS YOU TURN

WILL BE VERY TIGHT WITH NORTH WIND AND

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 [✓ 4] 5 [✓ 6] 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

12 Comment(s)

WILL BE TIGHT WITH NORTH WIND WITH SHIP AT 4 AND POINT AT ENTRY TO T.B.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 40	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 326/8	
Run Start Time: 1331	**Run End Time:**	**HSC Bay Width:** 700	**BSC Flare:**
Start Location: 73-74		**End Location:**	

Ship Model Used	[✓ ULCVT2]	Thor BC-G ~~Suezmax~~ 7566 Wesley LA-H 7505
Travel Direction	[✓ Inbound]	Outbound
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow
	N/15	0.5/Ebb

Notes:

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) DESIGN OF FLARE IS A DESIRABLE LEVEL OF SAFETY

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

6 Comment(s) NO ISSUES

Turn in FWD BAYPORT BASIN Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

9 Comment(s) BASIN ~~WAS~~ SAFETY MARGINS WERE ACCEPTABLE

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 [✓ 4] 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

12 Comment(s) DOCKING EVOLUTION WAS UNDER CONTROL. MORE WATER COULD HAVE BEEN UTILIZED, TO CREATE MORE DISTANCE SKIN TO SKIN, BUT THE MANUVER WAS INDICITIVE OF MY NORMAL DOCKING APPROACH

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 41	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: G		**Ship's Initial Heading/Speed:** 326.1 /1[illegible]8	
Run Start Time: 1436	**Run End Time:**	**HSC Bay Width:** 700	**BOC Flare:**
Start Location: 73-74		**End Location:**	
Ship Model Used	[✓ ULCVT2]	Thor ℄B − G ~~Suezmax~~ 7505 Wesley ℄A − H 7505	
Travel Direction	[✓ Inbound]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/15	0.5/Fld	
Notes:			

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s)

GOOD ROOM FOR A SAFE ENTRY INTO FLARE

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

6 Comment(s)

KEPT MY SPD A LITTLE FASTER THAN I NORMALLY WOULD BECAUSE OF STRONG WIND - ONLY PROBLEM WAS SHIP HAD A HARD TIME SLOWING DOWN AS WE WERE APPROACHING THE T.B.

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓] 4 5 6 7 8 9 10

9 Comment(s)

LOTS OF ROOM BUT AGAIN - NEED TO MAKE SURE TO DRIVE FURTHER TO WEST INTO LARGER PORTION OF T.B.

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

12 Comment(s)

A TIGHT BUT VERY DOABLE MANEUVER THATS MORE DIFFICULT DUE TO THE WIND I WAS USING THE TUGS UP TO THEIR LIMIT TO MAKE SURE THE SHIP STAYED ON TRACK

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 42	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: D		**Ship's Initial Heading/Speed:** 089/4	
Run Start Time: 1529	**Run End Time:**	**HSC Bay Width:**	**BOC Flare:**
Start Location: Berth Z		**End Location:**	
Ship Model Used	[✓ **ULCV** TZ]	Wesely A-H ~~**Suezmax**~~ 7505	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/15	0.5/Ebb	

Notes: Simulation stopped @ 12:40 - paused & restarted

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

6 Comment(s)

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 10

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
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Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy   Increasing Difficulty →   Difficult
1 2 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe   Increasing Safety →   Safe
1 2 3 4 5 6 7 8 [✓ 9] 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 43	**Date:** 11-15-17	**Simulator/Operator:** A	
Pilot: A ~~B~~		**Ship's Initial Heading/Speed:** 089/4.5	
Run Start Time: 1601	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:** 4000
Start Location: Bertha Z		**End Location:**	

Ship Model Used	[✓ ULCVTZ]	~~Worley A-H 7565~~ ~~Suezmax~~ 0 Tugs
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/15	0.5 / Fld

Notes: ~~Sim Stopped 12:46 paused rebooted & restarted~~

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s) WORKED AS DESIGNED

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Transit Channel

4 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

5 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

6 Comment(s) VESSEL PREFORMED AS EXPECTED

Turn in __________ Turning Basin

7 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 10

N/A

8 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 10

9 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Approach to Terminal

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 10

N/A

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 10

12 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 44	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 268/7	
Run Start Time: 0829	**Run End Time:**	**HSC Bay Width:** 700	**B~~O~~SC Flare:** 4000
Start Location: 6-7		**End Location:**	

Ship Model Used	[✓ ULCV T2]	Thor B℄-H ~~Suezmax~~ Wesely A℄-G
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/15	1.3 / Ebb

Notes:

Transit Past Terminals
~~**Entry at Flare**~~

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s) LACK OF NEEDED TUG HORSEPOWER

FELT THAT WIND EFFECT WAS UNREALISTIC

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 45	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 268/7	
Run Start Time:	**Run End Time:**	**HSC Bay Width:** 700	**BSC Flare:** 4000
Start Location: BSC 6-7		**End Location:**	
Ship Model Used	[✓ ULCVT2]	**Suezmax**	
Travel Direction	[✓ **Inbound**]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	N/10	1.3/Ebb	
Notes:			

Transit thru terminal
~~**Entry at Flare**~~

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

STRONG WIND - HAVE TO STAY ON NORTH SIDE OTHERWISE STERN WILL BE TOO CLOSE TO SHIPS ON DOCK

~~MAXED OUT ON~~

3-4 TUGS RECOMMENDED

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 45	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 268/7	
Run Start Time:	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:** 4000
Start Location: BSC 6-7		**End Location:**	
Ship Model Used	[✓ ULCV TZ]	Thor B℄ Worely A℄ ~~Suezmax~~	
Travel Direction	[✓ Inbound]	Outbound	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	N/15	1.3/Ebb	

Notes: Discussed how to work with Rawen image
>4 5K - Dead zone hard to do direct pull - do inline direct more eff.
& control speed.

Transit through terminal
~~**Entry at Flare**~~

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult
1 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe
1 2 3 4 5 6 7 8 9 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 16	**Date:** 11-16-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 250.5/4
Run Start Time: 1043	**Run End Time:**	**Vessels at 26&27&28** 3 @ 750 x 106 Barge on 27
Start Location: Below Wharf 32		**End Location:**

Ship Model Used/ Wesely	[illegible] - 55 - A **Aframax** 7605 Chloe K - [illegible] A - G 2406	[✓ **Panamax Bulker** 06]
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/[illegible] 15	0.0/Ebb

Notes: Problems with Simulator

Turn in Improved Turning Basin

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) TURNING ROOM WAS ADAQUATE FOR THE MANUVER

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 47	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 250.5/4	
Run Start Time: 1242	**Run End Time:**	**Vessels at 26&27&28** 3 @ ~~750x106~~ 473x 75.5 Barge on 27	
Start Location: ~~Below~~ Wharf 32		**End Location:**	
Ship Model Used Wesely	~~Zeus~~ -55-H-7505 ~~Aframax~~ Chloek-EA-G 2A06		[✓ Panamax Buiker 06]
Travel Direction	[✓ Inbound]		Outbound
Environmental Conditions	Wind Dir. (from) / Speed		Tide/Flow
	SE/20 0		0.0/Ebb 0
Notes:			

Turn in Improved Turning Basin

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 [✓ 6] 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s)

ROOM FOR THIS SIZE SHIP IS GOOD

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 48	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 250.5 / 4	
Run Start Time: 1312	**Run End Time:**	**Vessels at 26&27~~&~~28** 3@ ~~750~~ 473 x 75.5 Barge @ 27	
Start Location: Wharf 32		**End Location:**	
Ship Model Used	Wesely -SS-H 7505 ~~Aframax~~ Chole K-CA-G 2406	[✓ **Panamax Buiker** 06]	
Travel Direction	[✓ **Inbound**]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	0/0	
Notes:			

Turn in Improved Turning Basin

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s) BASIN SIZE WORKED WELL

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 49	**Date:** 11-16-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 130.1/~~74~~6.5
Run Start Time: 1616	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: below Shell		**End Location:**

Ship Model Used	**Aframax**	Suez ~~**Panamax/Bulker**~~
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 8 9 [✓ 10]

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

[✓ 1] 2 3 4 5 6 7 8 9 10

3 Comment(s)

TWO WIDE BEAM LOADED TANKERS MEETING THERE IS UNREALISTIC

THE ROOM APPEARS TO BE THERE BUT VERY LITTLE ROOM FOR ERROR

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 49	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 241.3/~~6.9~~6.5
Run Start Time: 1616	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Greens Bayou		**End Location:**
Ship Model Used	[✓ **Aframax**]	**Panamax Bulker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s) VESSEL NEEDED TO HAVE ALL AVAILABLE WATER THAT IS USE IN REAL LIFE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 50	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: D		**Ship's Initial Heading/Speed:** 130.1 / 6.5	
Run Start Time:	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Greens Bayou		**End Location:**	
Ship Model Used	**Aframax**	Suez ~~**Panamax Bulker**~~	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE 20	0.5/Fld	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

Under Bridge Bad spot

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

KMDN bad spot to meet.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 50	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 241.3/16.5
Run Start Time:	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Shell		**End Location:**
Ship Model Used	[✓ **Aframax**]	**Panamax Bulker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 [✓ 5] 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 [✓ 5] 6 7 8 9 10

3 Comment(s) MEETING CAN BE DONE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 51	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: [redacted] A		**Ship's Initial Heading/Speed:** 241.3/5
Run Start Time: 1455	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: below Shell		**End Location:**

Ship Model Used	[✓ **Aframax**]	**Panamax Bulker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) MEETING WENT WELL.

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 51	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: D		**Ship's Initial Heading/Speed:** 095.6/5	
Run Start Time: 1455	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Bridge		**End Location:**	
Ship Model Used	**Aframax**	~~**Panamax Bulker**~~ Suezmax	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	0.5/Fld	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 53	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 281.3/6
Run Start Time: 1533	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: TX 8 Bridge		**End Location:**
Ship Model Used	Panamax Bulk ~~Aframax~~	**Panamax Buiker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) SAFE MANU.VER !

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 53	**Date:** 11-16-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 126.9/5.5
Run Start Time: 1533	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Greens Bayou		**End Location:**

Ship Model Used	**Aframax**	~~**Panamax Bulker**~~ Suez Max
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

GOOD MEETING
GOOD ROOM/POSITION
SHIP DID WANT TO 'RUN' TO PORT (TO LEFT)
AFTER MEETING SHIP BUT I WAS ABLE TO
CHECK SHIP

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 52	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 231.3/6
Run Start Time: 1516	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Bridge TX 8		**End Location:**

Ship Model Used	[✓ **Aframax**]	**Panamax Bulker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) NORMAL PRACTICE MEETING SUCCESS

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 52	**Date:** 11-16-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 126.8 /5.5
Run Start Time: 1516	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Greens Bayou		**End Location:**
Ship Model Used	**Aframax**	~~**Panamax Bulker**~~ Suezmax
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 [✓ 9] 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe
1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

VERY GOOD MEETING
GOOD POSITION
MAIN CONCERN WAS INABILITY TO CHECK SHIP UP AFTER MEETING INBOUND SHIP

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 54	**Date:** 11-16-17	**Simulator/Operator:** C	
Pilot: A		**Ship's Initial Heading/Speed:** 127 /16	
Run Start Time: 1545	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Greens Bayou		**End Location:** 5	
Ship Model Used	**Aframax**	[✓ **Panamax Buiker**]	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	0.5/ Fld	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 [✓ 3] 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) SAFE AND CONTROLED

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 54	**Date:** 11-16-17	**Simulator/Operator:** A
Pilot: C		**Ship's Initial Heading/Speed:** 281. /16.5
Run Start Time: 1545	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: TX 8 Bridge		**End Location:**

Ship Model Used	[✓ Suez ~~Afra~~max]	**Panamax Buiker**
Travel Direction	**Inbound**	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	5E/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 [✓ 3] 4 5 6 7 8 9 10

3 Comment(s)

~~MAEET~~ AT THE MOST NARROW PART OF CHANNEL.
MET

IT WORKED BUT WAS TIGHT.

THIS WOULD HAVE BEEN CONSIDERED

A SUCCESS IN MY BOOK ALTHOUGH I TRY NOT

TO MEET ANY SHIP AT THAT SPOT IN REAL LIFE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 55	**Date:** 11-16-17	**Simulator/Operator:** C
Pilot: A		**Ship's Initial Heading/Speed:** 095.7/6
Run Start Time:	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: TX8 Bridge		**End Location:**
Ship Model Used	**Aframax**	[✓ **Panamax Buiker**]
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	0.5/Fld
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 55	**Date:** 11-16-17	**Simulator/Operator:** A	
Pilot: C		**Ship's Initial Heading/Speed:** 242.4/5.5	
Run Start Time:	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Shell ~~TX 8 Bridge~~		**End Location:**	
Ship Model Used	[✓ Suez ~~Afra~~max]	**Panamax Buiker**	
Travel Direction	[✓ **Inbound**]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed** SE/20	**Tide/Flow** 0.5/Fld	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 2 3 4 5 6 7 [✓ 8] 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 [✓ 4] 5 6 7 8 9 10

3 Comment(s)

GOOD MEETING

GOOD SPACE

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 56	**Date:** 11-17-17	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 107.1 / 6
Run Start Time: 0812	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Ammonia		**End Location:**

Ship Model Used	**Aframax**	[✓ **Panamax ~~Bulker~~**] Tank 10L
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/20	1.3/Ebb
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 56	**Date:** 11-17-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 260/6	
Run Start Time: 0812	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Shell		**End Location:**	
Ship Model Used	[✓ **Aframax** 23L]		**Panamax Bulker**
Travel Direction	[✓ **Inbound**]		**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**		**Tide/Flow**
	N[illegible]/20		1,3 / Ebb
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) MET WITH NO ISSUES

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 57	**Date:** 11-17-17	**Simulator/Operator:** C	
Pilot: BK		**Ship's Initial Heading/Speed:** 107.1/6	
Run Start Time: 0856	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Ammonia		**End Location:**	
Ship Model Used	**Aframax**	[✓ **Panamax ~~Bulker~~** Tank 10L]	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	N/20	1.3/Ebb	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 57	**Date:** 11-17-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 260/6
Run Start Time: 0836	**Run End Time:**	**Bayou Channel Width:**
Start Location: Shell		**End Location:**
Ship Model Used	[✓ **Aframax** 23L]	**Panamax Bulker**
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/20	1.3/Ebb
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 58	**Date:** 11-17-17	**Simulator/Operator:** C
Pilot: [redacted] D		**Ship's Initial Heading/Speed:** 129.8/6
Run Start Time: 0902 [redacted]	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Greens Bayou		**End Location:**

Ship Model Used	**Aframax**	[✓ **Panamax Buiker** CW6L]
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	N/20	1.3/Ebb
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 58	**Date:** 11-17-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 275/5.2	
Run Start Time: 0902 ~~0834~~	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Below TX 8 Bridge		**End Location:**	
Ship Model Used	[✓ Aframax 23L]	**Panamax Buiker**	
Travel Direction	[✓ Inbound]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	N/20	1.3/Ebb	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 [✓ 8] 9 10

3 Comment(s) SUCCESSFUL!!!

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 59	**Date:** 11-17-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 131.4/6	
Run Start Time: 0918	**Run End Time:**	**Bayou Channel Width:** 530	
Start Location: Greens Bayou		**End Location:**	
Ship Model Used	[✓ **Aframax** L]	**Panamax Bulker**	
Travel Direction	**Inbound**	[✓ **Outbound**]	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	N/20	1.3/Ebb	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s) GREAT RUN!

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 59	**Date:** 11-17-17	**Simulator/Operator:** C	
Pilot: D		**Ship's Initial Heading/Speed:** 275.7/6	
Run Start Time: 0918	**Run End Time:**	**Bayou Channel Width:**	
Start Location: Below TX 8 Bridge		**End Location:**	
Ship Model Used	Aframax	[✓ Panamax Buiker CD6L]	
Travel Direction	[✓ Inbound]	Outbound	
Environmental Conditions	Wind Dir. (from) / Speed	Tide/Flow	
	N/20	1.3 / Ebb	
Notes:			

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 60	**Date:** 11-17-17	**Simulator/Operator:** C
Pilot: K		**Ship's Initial Heading/Speed:** 275.7/6
Run Start Time: 0931	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Below TX 8		**End Location:**

Ship Model Used	**Aframax**	[✓ **Panamax Bulker**] CO6L
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3/Ebb

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s)

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 60	**Date:** 11-17-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 131.4/6
Run Start Time: 0931	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Greens Bayou		**End Location:**

Ship Model Used	[✓ **Aframax**]	~~**Panamax Bulker** [illegible]~~
Travel Direction	~~**Inbound**~~	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3 /Ebb

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s)

August 22, 2017

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 61	**Date:** 11-17-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 081 / 3.5	
Run Start Time: 0954	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: Berth 2		**End Location:**	
Ship Model Used	Tugs Thor & B – K – B Wesley K & A ~~ULCV~~ D – C		[✓ **Suezmax**]
Travel Direction	**Inbound**		[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**		**Tide/Flow**
	SE / 20		1.3 / Ebb
Notes: Turn to North from Barbours Cut			

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy [✓ 1] 2 3 4 5 6 7 8 9 10 Difficult

Increasing Difficulty →

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe 1 2 3 4 5 6 7 8 9 [✓ 10] Safe

Increasing Safety →

3 Comment(s) MOST OF TURN DONE WITH RUDDER ONLY!

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 6R	**Date:** 11-17-17	**Simulator/Operator:** A	
Pilot: A		**Ship's Initial Heading/Speed:** 132.7/4.3	
Run Start Time:	**Run End Time:**	**HSC Bay Width:** 700	**BCC Flare:**
Start Location: 83-84		**End Location:**	
Ship Model Used	Thor ℄B - D - B ~~ULCV~~ Wesely ℄A - K - C	[✓ **Suezmax**]	
Travel Direction	[✓ **Inbound**]	**Outbound**	
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**	
	SE/20	1.3/Ebb	
Notes:			

Entry at Flare

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) ADEQUATE ROOM FOR MANUVER

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 63	**Date:** 11-17-17	**Simulator/Operator:** A
Pilot: A		**Ship's Initial Heading/Speed:** 099.2/6
Run Start Time: 1049	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Above Bridge		**End Location:**

Ship Model Used	~~**Aframax**~~ Suezmax	**Panamax Buiker**
Travel Direction	**Inbound**	[✓ **Outbound**]
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1,3/Ebb

Notes:

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

1 [✓ 2] 3 4 5 6 7 8 9 10

2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

1 2 3 4 5 6 7 8 [✓ 9] 10

3 Comment(s) PERFECT

HSC 216 Feasibility Simulation Study
Pilot Evaluation of Simulation Run
November 2017

Run #: 63	**Date:**	**Simulator/Operator:** C
Pilot: D		**Ship's Initial Heading/Speed:** 267.8/6
Run Start Time: 1049	**Run End Time:**	**Bayou Channel Width:** 530
Start Location: Shell		**End Location:**

Ship Model Used	**Aframax**	[✓ **Panamax Bulker** 006L]
Travel Direction	[✓ **Inbound**]	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
	SE/20	1.3/Ebb
Notes:		

Transit and Meeting

1 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy — Increasing Difficulty → — Difficult

[✓ 1] 2 3 4 5 6 7 8 9 10

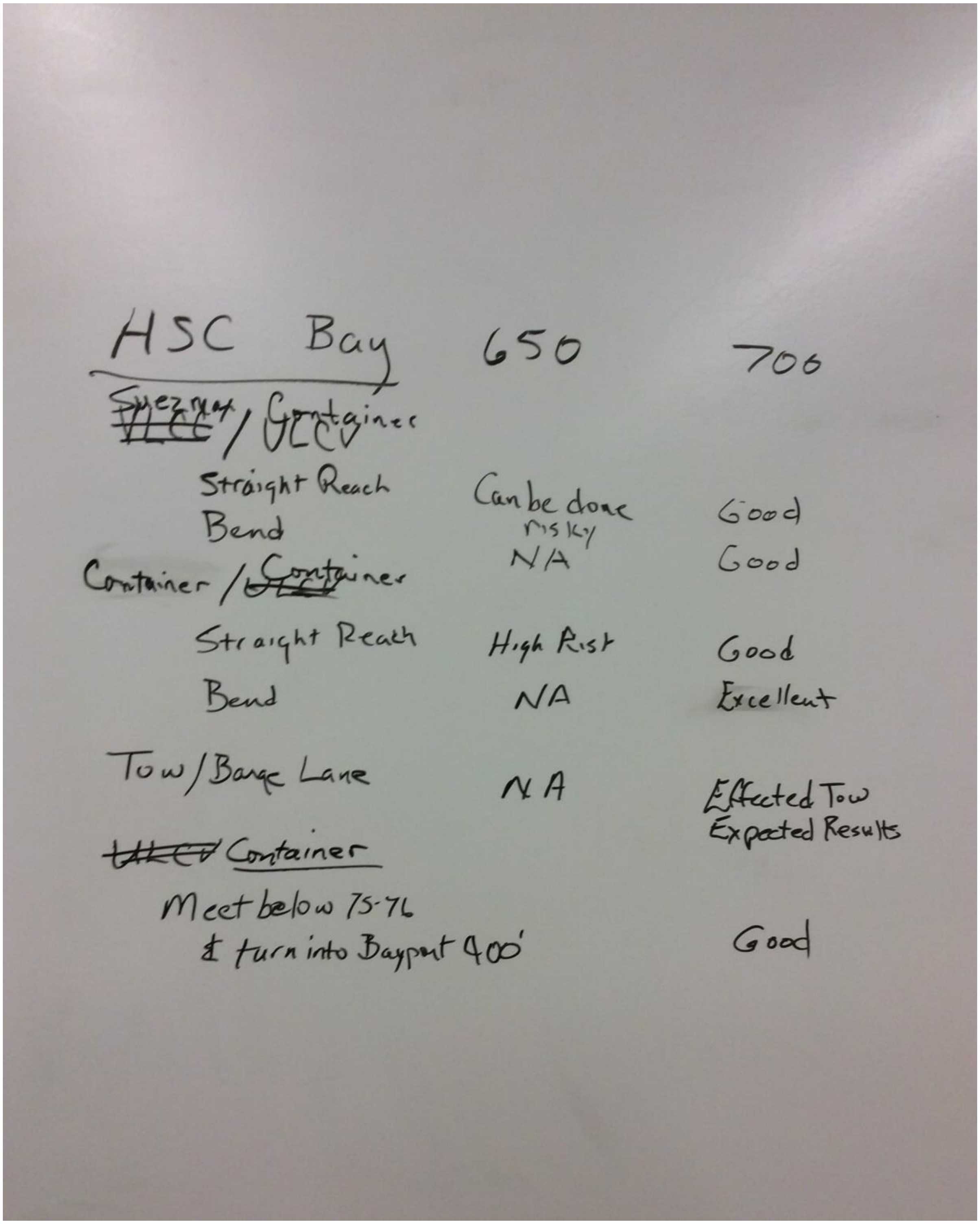
2 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe — Increasing Safety → — Safe

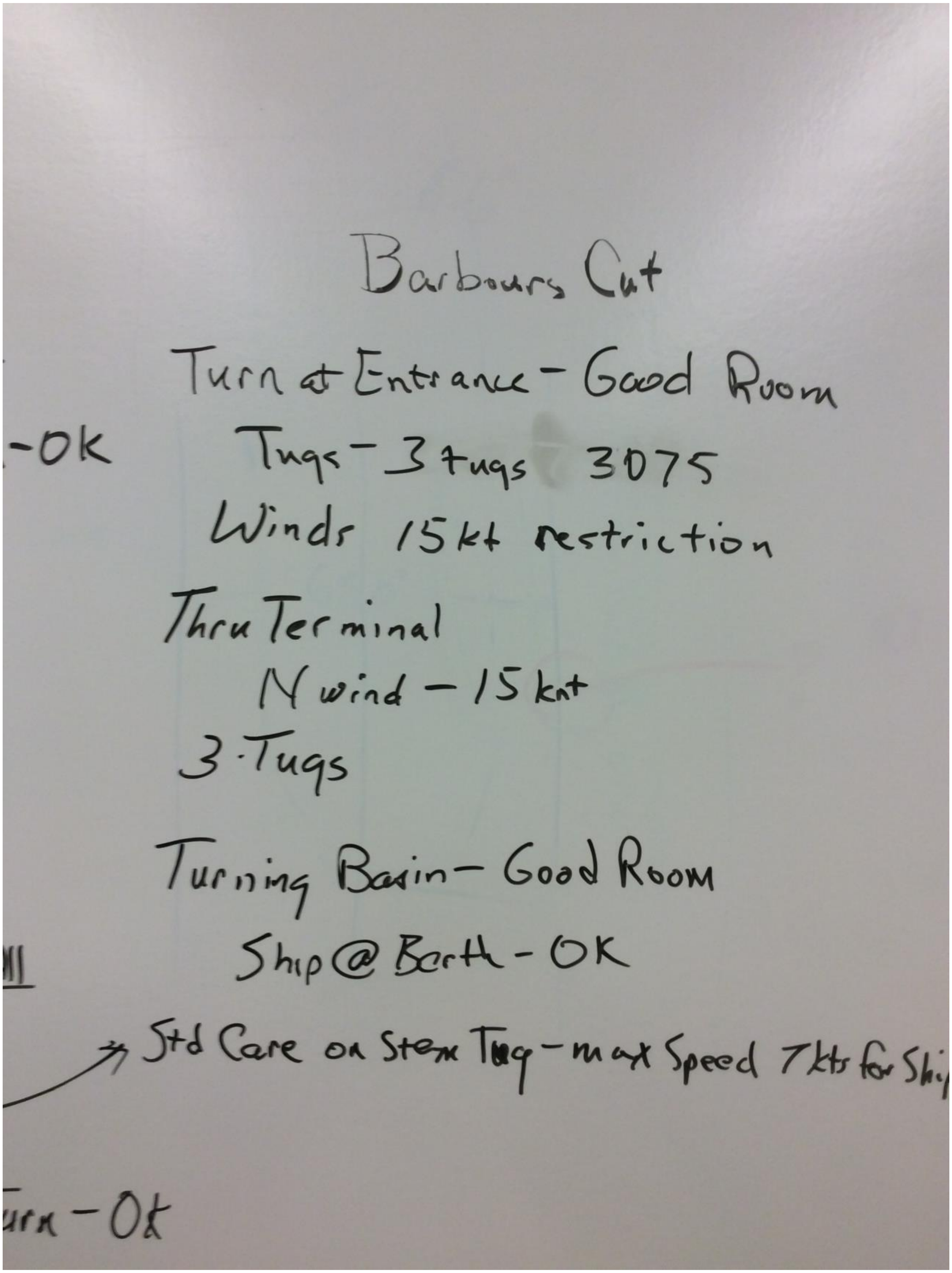
1 2 3 4 5 6 7 8 9 [✓ 10]

3 Comment(s)

Appendix F: Final Debriefing Agreements Based on the Completed Ship Maneuvering Simulation Tests



HSC Bay	650	700
~~VLCC~~ Suezmax / ULCV Container		
Straight Reach	Can be done risky	Good
Bend	NA	Good
Container / ~~ULCV~~ Container		
Straight Reach	High Risk	Good
Bend	NA	Excellent
Tow / Barge Lane	NA	Effected Tow Expected Results
~~ULCV~~ Container		
Meet below 75-76 & turn into Bayport 400'		Good



Barbours Cut

Turn at Entrance - Good Room

-OK

Tugs - 3 tugs 3075

Winds 15kt restriction

Thru Terminal

N wind - 15 knt

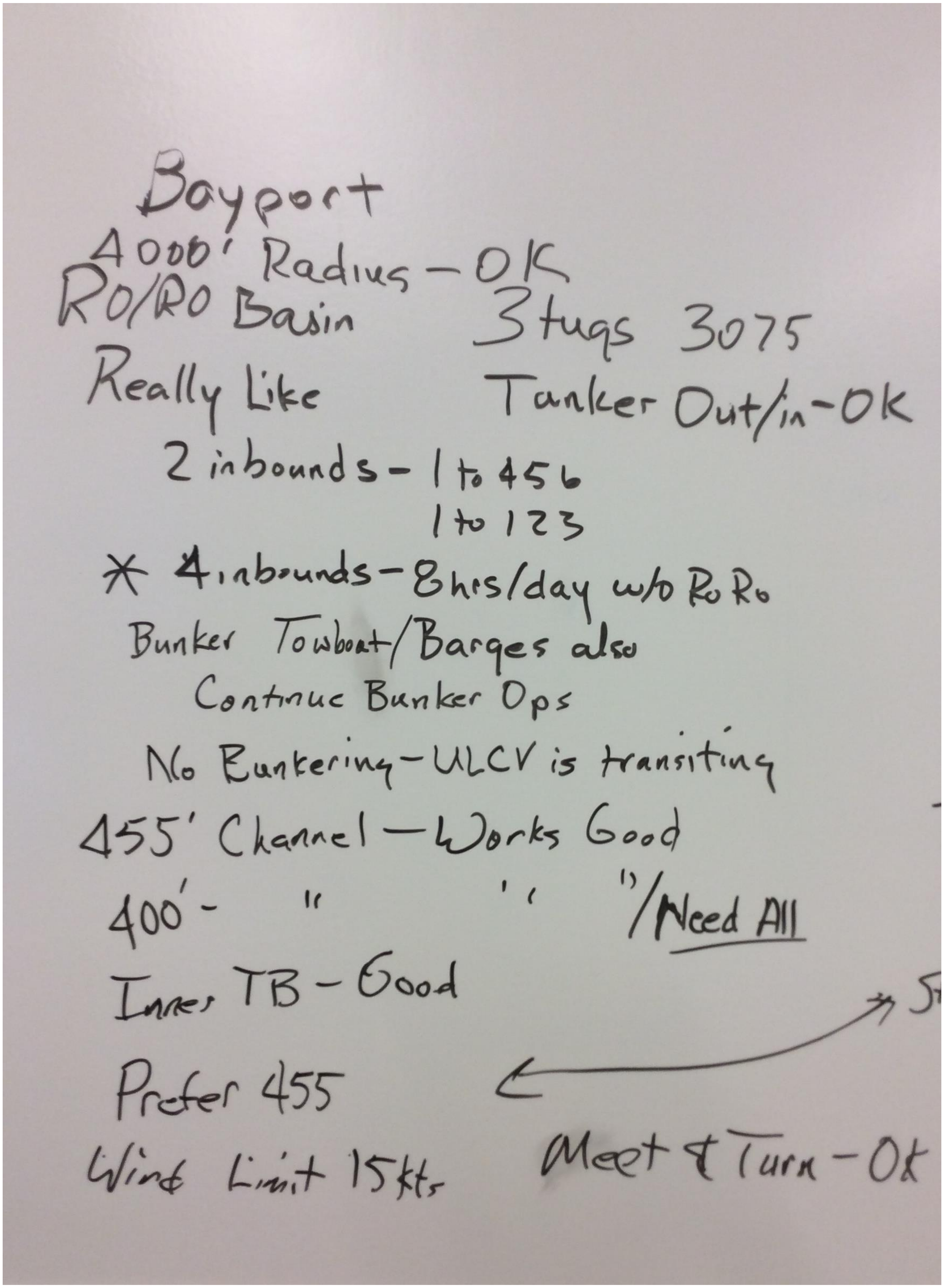
3 Tugs

Turning Basin - Good Room

Ship @ Berth - OK

→ Std Care on Stern Tug - max Speed 7kts for Shi

urn - Ok



Bayport

4000' Radius - OK

RO/RO Basin

3 tugs 3075

Really Like

Tanker Out/in - OK

2 inbounds - 1 to 456
1 to 123

* 4 inbounds - 8 hrs/day w/o Ro Ro

Bunker Towboat/Barges also
Continue Bunker Ops

No Bunkering - ULCV is transiting

455' Channel - Works Good

400' - " " "/<u>Need All</u>

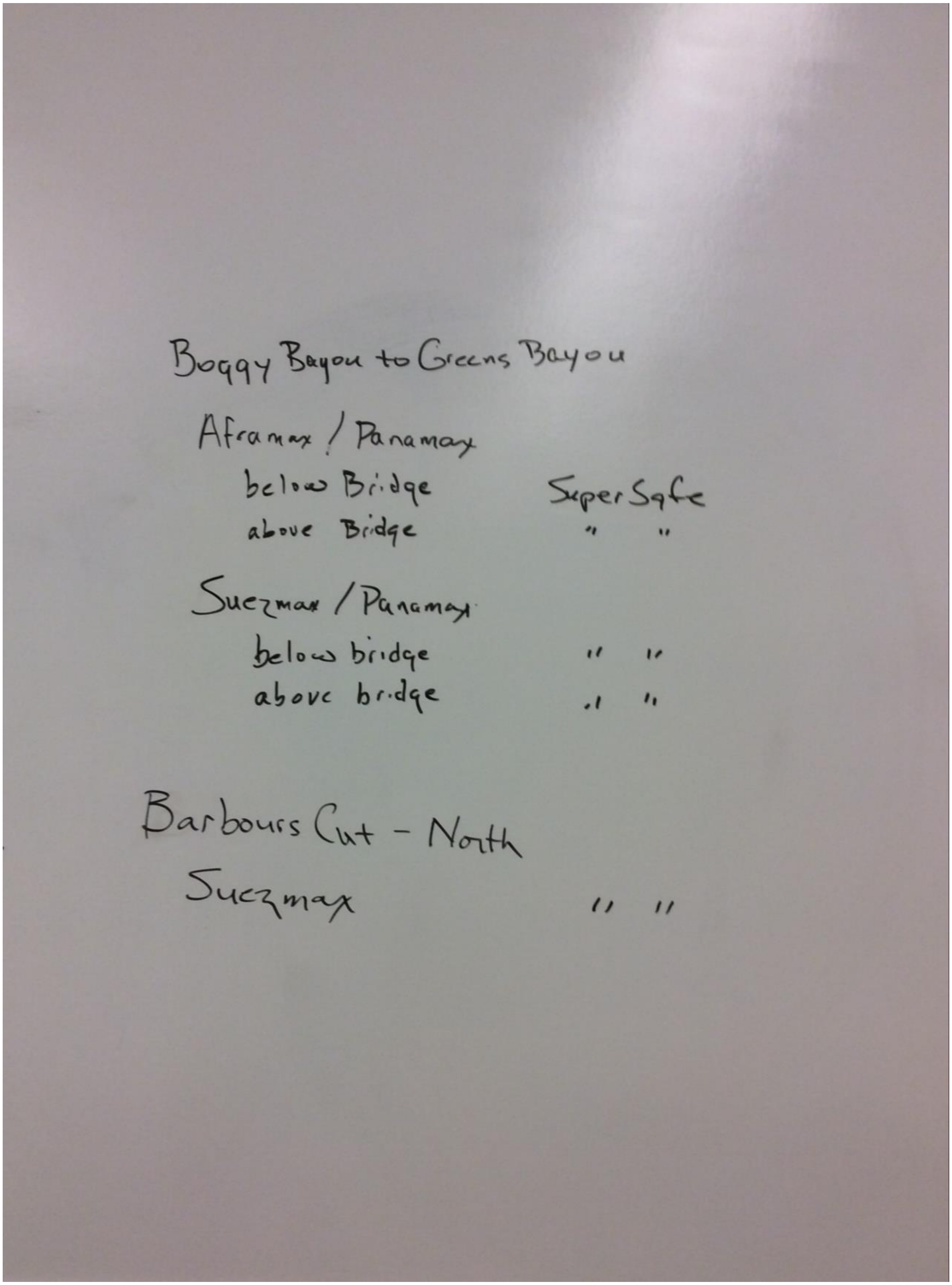
Inner TB - Good

Prefer 455

S

Wind Limit 15 kts

Meet & Turn - Ok

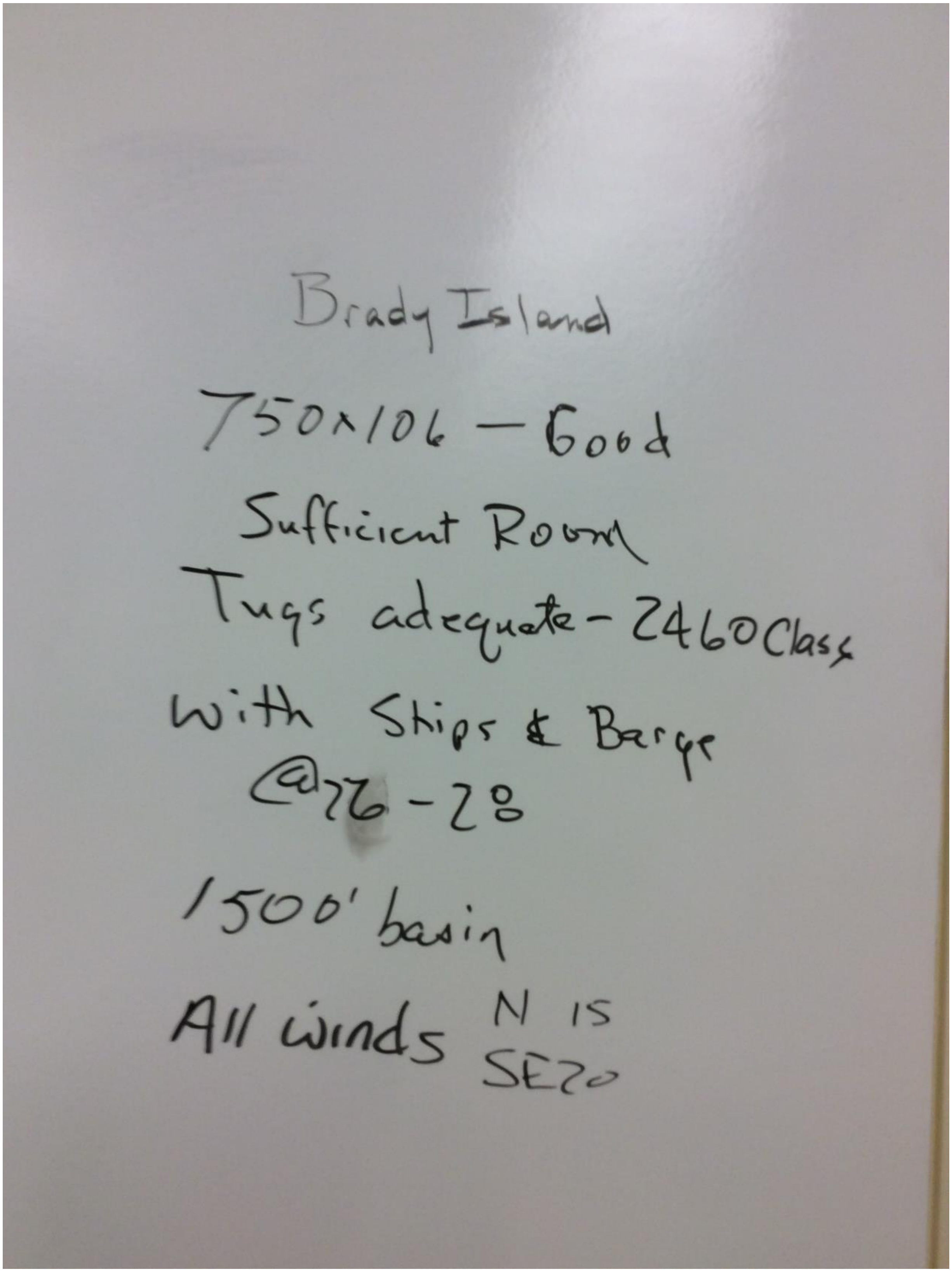


Boggy Bayou to Greens Bayou

Aframax / Panamax
below Bridge SuperSafe
above Bridge " "

Suezmax / Panamax
below bridge " "
above bridge " "

Barbours Cut - North
Suezmax " "



Brady Island

750x106 – Good

Sufficient Room

Tugs adequate – 2460 Class

with Ships & Barge

@26-28

1500' basin

All winds N 15
SE20

Appendix G: Description of San Jacinto College Maritime Technology and Training Center Ship and Tug Simulators

A preview of the San Jacinto College Maritime Technology and Training Center

03.03.2014 | By Jeannie Peng-Armao

Capt. John Kessler, maritime instructor, demonstrates how mariners train using the bridge simulators at the San Jacinto College maritime program. *Photo credit: Jeannie Peng-Armao, San Jacinto College marketing, public relations, and government affairs department.*

As San Jacinto College prepares to break ground to build the region's newest maritime training facility, some of the industry's most sought after training technology has arrived and is awaiting its new home.

The College recently received three interactive, full-mission, ship bridge simulators, thanks to a collaborative agreement with the Houston Pilots. They will be moved to the College's 45,000-square-foot Maritime Technology and Training Center once it opens, projected for mid 2015.

“For our new, waterfront maritime campus, we did our homework and traveled across the country to research exactly what we needed to provide in our new facility in order to be certain that we are offering today's maritime professionals the best training available anywhere in the country” said Capt. Mitch Schacter, director of the San Jacinto College maritime program.

The simulators are room-sized replicas of ship control bridges, each with a 270-degree view and life-like graphics displayed on fourteen 65-inch monitors. They are equipped with the newest versions Kongsberg’s Polaris 7.2 ship simulation software. They allow trainees to experience different sea conditions from flat calm water to 30-foot high waves, from zero wind to hurricane winds, from clear blue skies to rain, snow, sleet, fog, and sand storms, and include day and night operations.

"This technology allows trainees from almost any type of vessel to experience wind, current and wave action from any direction and at any level of magnitude as well as close quarters interaction with other vessels operating in the same scenario, without ever putting anyone’s life or property in peril," said Bryan Elliot, maritime instructor and simulator operator. "It provides a very safe and very realistic experience."

The three simulators are currently operating at the San Jacinto College maritime training center off Highway 225 in Pasadena. Once the new Maritime Technology and Training Center is built along the Port of Houston, the simulators will become a part of a 3,748 square-foot simulation suite with instructor stations, debrief classrooms, and development stations.

In addition, the new facility will house engineering simulators to train maritime engineers for hydraulic, electric, pump control, motor control, heating and air conditioning, and refrigeration. Also planned is a full-mission engine room simulator, which will be interactive and interconnected with the bridge simulators to allow vessel management exercises to accommodate deck and engineering officers and crew at the same time, in the same scenario.

Other features will include a 2,000 square-foot multipurpose space for industry conferences and corporate partner meetings along with a fully equipped commercial kitchen to support those functions. The entire building will sit 14 feet above ground and will house 15 classrooms, and administrative support offices. The ground level will showcase a training dock with lifeboats, davits, and fast rescue craft, and a separate industry dock for crew changes. It will also allow vessel specific training for local maritime companies and have an aquatic training facility for sea survival and life raft training, complete with men’s and women’s locker rooms.

“The Center will serve as the premier training facility for regional industry and new maritime technology associate degree program," said Schacter. "It will house the very latest technology and U.S. Coast Guard-approved curriculum to allow us to continue and to offer much training for captains, mates, deckhands, tankermen and engineers in a safe, professional and productive training environment."

For more information about the San Jacinto College maritime program, visit http://www.sjcd.edu/continuing-professional-development/corporate-and-workforce/maritime.

About San Jacinto College

Surrounded by monuments of history, industries and maritime enterprises of today, and the space age of tomorrow, San Jacinto College has been serving the citizens of East Harris County, Texas, for more than 50 years. The Achieving the Dream Leader College is committed to the goals and aspirations of a diverse population of 30,000 students in more than 200 degree and certificate options, including university transfer and career preparation. Students also benefit from the College’s job training programs, renowned for meeting the needs of growing industries in the region. San Jacinto College graduates contribute nearly $630 million each year to the Texas workforce. San Jacinto College. Your Goals. Your College.

For more information about San Jacinto College, please call 281-998-6150, visit www.sanjac.edu, or follow us on Facebook at www.facebook.com/SanJacintoCollege.

Appendix H: Approved Study Scope and Test Matrix

August 22, 2017

Waterway Simulation Technology, Inc.

❖❖❖

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Attn: Larry L. Daggett

MEMO FOR RECORD

Subject: Proposal to Conduct Ship Simulations for the Houston Ship Channel, Texas, Expansion Feasibility Study – Section 216 of the Flood Control Act of 1970, as Amended.

Introduction

The ongoing feasibility study of potential needs for improvement and possible expansion of the Houston Ship Channel (HSC), Texas, has identified a need to conduct feasibility level ship maneuvering simulations in order to refine safe and efficient channel dimension assumptions for the design vessel classes. This MFR presents a proposal for addressing the identified navigation issues.

Assumptions

One issue that has been identified is to define the required deep-water navigation channel width to provide safe and efficient transits of the design ships. It is understood that the primary area of concern is the existing 530 ft wide x 46.5 (MLLW) ft deep Bay Reaches; especially with the growing demand for admitting Post- and Neo-Panamax container ships, i.e. ULCVs. Of particular interest is admitting those ULCVs that transit and, therefore, are limited to the maximum dimensions of the expanded Panama Canal. Since the terminals that would be considered to admit these vessels are both in the Galveston Bay below Morgan Point (Bayport and Barbours Cut), the design ships for Bay reaches should be a ULCV with overall length of 1200 ft or less and a beam of 160 ft or less and a Suezmax tanker. ULVCs are being considered as possible vessels requesting admittance and request are expected to grow in the future.

Due to the length of the transit in the Bay, the width of the navigation channel in these reaches must consider two-way traffic. It is not recommended to evaluate passing lanes since it is so difficult to ensure that a meeting between two design ships will occur in the passing lane; this requires extremely accurate traffic control and could cause at least one of the meeting ships to slow to a dangerous speed. Therefore, two-way meeting simulations will be required to define the channel width.

In addition to the channel widths in the straight reaches of the Bay, simulation testing of potential bend widening should be examined. The length of the design vessels will most likely require extra widening in the four bends in the Bay from Buoy 18 to Morgans Point.
Finally, for the Bay channels, it will be advised to conduct simulations of the design container ships maneuvering into and through the navigation channels and turning basins to the Bayport and Barbers Cut container terminals. These simulations may require testing of specific designs being considered for these terminals; e.g., a docking facility may be used near the entrance of the Barbours Cut terminal.

It is understood that no simulations are being considered for the Bayou Sections of the 46.5 foot remainder of HSC. Therefore, this section of the HSC is not discussed in this MFR.

Consideration of admitting Aframax tankers and bulk carriers into the reaches above the East Sam Houston Tollway Bridge (Texas 8) has been discussed. Simulation tests of this channel should be considered to define the required channel widths, particularly in the bends of this reach and to provide guidance on the ship speeds and safe clearances of berths along this channel. Many of the bends in the lower reaches of this section of the HSC are relatively gentle; however, the bends above HSC Light 162 or Buffalo Bayou may require study.

It is understood that since these simulations are being done a part of a feasibility study, they are to be conducted as a limited set of tests to, as quickly as possible and with minimum effort and cost, to refine the acceptable channel dimensions. Therefore, the testing program should be designed to quickly assess a particular proposed design and move to an alternate design based on the results of that test. The acceptability of the design will be based on the participating Houston Pilot's opinions and the judgment of the team conducting the simulations using a accepted set of evaluation criteria.

Finally, it is understood that a requirement for the conduct of the simulations is the use of the local-area ship simulator, owned by the Houston Pilots, managed by the Maritime Pilot's Institute, and located at the San Jacinto Maritime Technology and Training Center. This is a Kongsberg simulator, similar to the simulator at the U.S. Army Engineering Research and Development Center (ERDC) at Vicksburg, MS.

Approach

Ship Models

The first requirement for conduct of the ship maneuvering simulations is to define the design ships and identify models for the HSC test reaches.

Previous simulation studies of admitting ULCVs to the Bayport Container terminal tested A-class Maersk containerships and a Neo-Panamax containerships at Maritime Institute of Technology and Graduate Studies (MITAGS) simulator facility. These ship models included 9,000 TEU, 14,000 TEU, and 15,000 TEU ULCVs. The 14,000 TEU ULCV was a model of the MSC Beatrice with a length overall (LOA) of 366m (1,200 ft) and a beam of 50.9m (166.7 ft) with a draft of 13.4m (44 ft). These ship models have been well vetted.

While this beam is larger than the suggested beam for transit through the third set of Panama Canal locks, i.e. beam of 160 ft, it is anticipated that this beam width will eventually be permitted as usage of the locks grows in a similar manner in which pressure from shipping companies narrowed the free space in the older locks. The width of the third lock chambers is 180 ft.

Later tests were conducted at MITAGS in January 2014 sponsored by the Maersk shipping company using a model of an A-Class containership. Maersk requested these simulations because they were requesting the pilots to agree to admit these ships into the HSC. Dimensions of this ship model are 352.2m (1,155.2 ft) LOA, 42.8m (140.4 ft) beam, and a loaded draft of 12.2m (40.0 ft).

An analysis of the largest 110 containerships in the world fleet shows that 88 of these ships, or 80%, would fit into the third set of Panama Canal locks, see Table 1.

The Maritime Pilot's Institute has a ship model of the MAERSK EDINBURG with an LOA of 354m (1161.4 ft) and a beam of 48m (157.5 ft). Therefore, it is recommended that this model be used as the design containership. MPI will be working on improving the maneuvering characteristics of this model based on observations of operating containerships. Maneuvering characteristics of the above mentioned ship models used in previous studies and vetted by pilots are also available to guide this model adjustment.

A loaded Suezmax tanker model was used in the MITAGS simulation tests of Bayport. This tanker had dimensions of 280m (918.6 ft) LOA, 49.9m (163.7 ft) beam and 12.2m (40.0 ft) draft. It is recommended that a ship model of this or similar size be used as the other design vessel for the Bay channel simulations. Again, if a vetted and acceptable model is not available on the San Jacinto simulator, then acceptable models from either Kongsberg or ERDC should be considered for use and should be vetted by the Houston Pilots.

An Aframax tanker was developed and vetted by the Houston Pilots for tests of a proposed terminal immediately above the Texas 8 bridge. This tanker was used in loaded and ballast conditions to test the approach, turning, and movement to the terminal and did not transit through the navigation channels. However, these tests were conducted on the San Jacinto simulator and the model developed could be used to conduct simulation runs through the HSC channels from Boggy Bayou to the upper turning basin. There should be a recheck of the model to assure that the model is still considered appropriate for these specific tests.

Model Databases

A basic model of the HSC navigation channels is available on the San Jacinto simulator. However, modifications of these model databases (visual, radar and ECDIS, channel, currents) will be required to account for the channel improvements being tested. WST will assist in this development.

Currents can be input as data. The best procedure is to use currents computed with numerical hydrodynamic models of the alternative channel dimensions during a spring tide. Generally it is best to test with maximum flood and ebb currents. It is understood that ERDC is computing the hydrodynamic currents for alternative channel widths in the Bay. However, if these are not available, WST can compute the currents. In this proposal it is assumed that ERDC will furnish the currents and an estimate of this work is not included in WST's estimate.

The existing Bay channels can be constructed based on the most recent hydrographic survey data recorded by the Galveston District Corps of Engineers. However, since the emphasis of this study is to define the navigation channel width that will provide safe and efficient transits, it is recommended that the proposed alternative navigation channel width be input based on agreement with the Corps of Engineers and the Houston Pilots. At this point it is anticipated that the initial testing would begin with a 650 ft wide channel with widening at the Redfish bend and the bend at HSC Lights 75 and 76 below the intersection with the Bayport Ship Channel. Other channel widths may be prepared at 600 ft, 700 ft ,and 750 ft in anticipation of the need to test such alternatives. These channel cross-sections will be constructed to be representative of typical cross-sections observed in the existing ship channels to be representative of the typical conditions the ships would experience in the future after the channel has been used and shaped by the ship traffic. It is anticipated that barge shelves would be included to represent the bank conditions with these present in any future project expansion. Consideration will be given to including operating tows on the barge shelf to observe the effects of deep-draft ships operating in the deep navigation channel.

Similarly, the navigation channels in the HSC above the Texas 8 Bridge would be developed based on the existing hydrographic survey data modified to represent the proposed improvements to the channel with a nominal channel width of 530 ft and depth of 45 ft. Modifications to the channel would be made based on the results of the Aframax tanker transits.

Simulations

It is proposed that each test run in the Bay navigation channels accomplish multiple purposes. Simulation runs should be conducted with Houston Pilots conning the deep-draft vessels and G&H tug masters handling the tug simulators. Tug models to be used will be based on the advice of the pilots and G&H.

For example, inbound simulation runs in the Bay could begin HSC Lights 41-42 and proceed to HSC Lights 85-86; a distance of 13.5 nm. During that run a meeting situation could be introduced below the bend at Redfish, transit through the bend widener at Redfish, another meeting between HSC Lights 51-52 and HSC Lights 75-76, transit through the bend widener at HSC Lights 75-76 below the Bayport Ship Channel, and then a final meeting above Bayport Ship Channel. If the inbound ship transits at approximately 10 knots, that transit would take approximately an hour and 20 minutes. But there would be three meetings and each bend would be evaluated. Outbound runs would be similar.

A draft proposed test matrix is provided in Table 2.

Special runs would be conducted to evaluate the turns from the widened HSC navigation channel into both the Bayport Ship Channel and the Barbours Cut Terminal. The Bayport transits would be conducted from HSC Light 65-66 into the Bayport Turning Basin. This would be a distance of approximately 6.8 nm and would require a transit time of less than one hour. It would be a test of traffic to include an outbound tanker to meet the inbound container ship just below the bend at HSC Lights 75-76 prior to making the turn into the Bayport Ship Channel. Similarly, runs can be conducted from HSC Lights 85-86 into the Barbers Cut Terminal to the berth prepared for the ULCVs; from previous inquiries it is understood that consideration has been given to assigning the first berth from the HSC to the ULCVs, thus, avoiding a full transit through the Barbours Cut Ship Channel and use of the turning basin at the end of that channel.

At this point it is recommended that transits with the Aframax through the navigation channels above the Texas 8 Bridge be initially conducted with the proposed channel width up to 530 ft and depth of 45 ft. Conducting several inbound and outbound transits would identify any issues with the bends and terminals along the channel. If problems are identified, then modifications to the simulated navigation channels could be made and retested.

The proposed simulation approaches are recommendations and are subject to approval and modification based on discussions with the Corps of Engineers, Port of Houston Authority, and Houston Pilots.

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Table 2. List of 110 Largest Containerships in the World Fleet

Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2017	OOCL Hong Kong[1]	399.87	1,311.90	58.8	193	21413	OOCL (Hong Kong)	210,890
2017	OOCL Germany	399.87	1,311.90	58.8	193	21413	OOCL (Hong Kong)	210,890
2017	Madrid Maersk[2]	399	1,309	58.6	192	20568	Maersk Line	214,286
2017	Munich Maersk	399	1,309	58.6	192	20568	Maersk Line	214,286[3]
2017	Moscow Maersk	399	1,309	58.6	192	20568	Maersk Line	214,286[4]
2017	MOL Triumph[5]	400	1,312.30	58.8	193	20170	Mitsui O.S.K. Lines	199,000
2017	MOL Trust	400	1,312.30	58.8	193	20170	Mitsui O.S.K. Lines	199,000
2017	MOL Tribute	400	1,312.30	58.8	193	20170	Mitsui O.S.K. Lines	199,000
2016	MSC Jade[6]	398.45	1,307.30	59.07	193.8	19224	Mediterranean Shipping Company	194,308
2016	MSC Ditte[7]	398.43	1,307.20	59.08	193.8	19224	Mediterranean Shipping Company	194,308
2016	MSC Reef	398.43	1,307.20	59.08	193.8	19224	Mediterranean Shipping Company	194,308
2016	MSC Mirja	398.43	1,307.20	59.08	193.8	19224	Mediterranean Shipping Company	194,308
2016	MSC Erica	398.43	1,307.20	59.08	193.8	19224	Mediterranean Shipping Company	194,308
2017	MSC Tina	398.43	1,307.20	59.08	193.8	19224	Mediterranean Shipping Company	194,308
2016	MSC Diana[8]	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2016	MSC Ingy	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2016	MSC Eloane	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2016	MSC Mirjan	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2017	MSC Rifaya	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2017	MSC Leanne	399.994	1,312.32	58.839	193.04	19224	Mediterranean Shipping Company	193,489
2015	MSC Oscar[9]	395.4	1,297	59	194	19224	MSC (Switzerland)	192,237
2015	MSC Oliver[10]	395.4	1,297	59	194	19224	MSC (Switzerland)	192,237
2015	MSC Zoe[11]	395.4	1,297	59	194	19224	MSC (Switzerland)	192,237

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Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2015	MSC Maya[12]	395.4	1,297	59	194	19224	MSC (Switzerland)	192,237
2014	CSCL Globe[13]	399.67	1,311.30	58.6	192	19100	CSCL (China)	187,541
2014	CSCL Pacific Ocean[14]	399.67	1,311.30	58.6	192	19100	CSCL (China)	187,541
2015	CSCL Indian Ocean[15]	399.67	1,311.30	58.6	192	19100	CSCL (China)	187,541
2015	CSCL Atlantic Ocean[16]	399.67	1,311.30	58.6	192	19100	CSCL (China)	187,541
2015	CSCL Arctic Ocean[17]	399.67	1,311.30	58.6	192	19100	CSCL (China)	187,541
2015	Barzan[18]	400	1,312.30	58.6	192	18800	UASC (Kuwait)	195,636
2013	*Magleby Maersk*[19]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2014	MSC New York[20]	399	1,309	54	177	18270	MSC (Switzerland)	176,490
2013	*Madison Maersk*[21]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2013	*Mærsk Mc-Kinney Møller*[22]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2013	*Majestic Mærsk*[23]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2013	*Mary Mærsk*[24]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2013	*Marie Mærsk*[25]	400	1,312.30	59	194	18270	Maersk (Denmark)	194,849
2015	CMA CGM Georg Forster[26]	398	1,306	54	177	18000	CMA CGM (France)	175,688
2015	CMA CGM Bougainville	398	1,306	54	177	17722	CMA CGM (France)	175,688
2015	*CMA CGM Kerguelen*[27]	398	1,306	54	177	17722	CMA CGM (British)	175,688
2015	CMA CGM Vasco de Gama	399	1,309	54	177	17859	CMA CGM (France)	178,228
2015	CMA CGM Zheng He	399	1,309	54	177	17859	CMA CGM (France)	178,228
2015	*CMA CGM Benjamin Franklin*[28]	399	1,309	54	177	17859	CMA CGM (France)	178,228
2012	*CMA CGM Marco Polo*[29]	396	1,299	54	177	16020	CMA CGM (France)	175,343
2013	*CMA CGM Alexander von Humboldt*[30]	396	1,299	54	177	16020	CMA CGM (France)	175,343
2013	*CMA CGM Jules Verne*[31]	396	1,299	54	177	16020	CMA CGM (France)	175,368
2006	*Emma Mærsk*[32]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794

Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2006	*Estelle Mærsk*[33]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2007	*Eleonora Mærsk*[34]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2007	*Evelyn Mærsk*[35]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2007	*Ebba Mærsk*[36]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2007	*Elly Mærsk*[37]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2007	*Edith Mærsk*[38]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2008	*Eugen Mærsk*[39]	397.7	1,305	56.4	185	15500	Maersk (Denmark)	170,794
2010	CSCL Star[40]	366	1,201	52	171	14074	CSCL (China)	150,853
2011	CSCL Saturn[41]	366	1,201	52	171	14074	CSCL (China)	150,853
2011	CSCL Mercury[42]	366	1,201	52	171	14074	CSCL (China)	150,853
2011	CSCL Mars[43]	366	1,201	51.2	168	14074	CSCL (China)	150,853
2012	CSCL Uranus[44]	366	1,201	52	171	14074	CSCL (China)	150,853
2012	CSCL Neptune[45]	366	1,201	52	171	14074	CSCL (China)	150,853
2011	CSCL Jupiter[46]	365.5	1,199	52	171	14074	CSCL (China)	150,853
2013	MOL Quest[47]	368	1,207	51	167	14000	Mitsui (Japan)	151,963
2013	APL Temasek[48]	368	1,207	51	167	14000	APL (Singapore)	151,963
2010	MSC Savona[49]	366	1,201	51	167	14000	MSC (Switzerland)	153,115
2010	MSC Genova[50]	366	1,201	51	167	14000	MSC (Switzerland)	153,115
2012	MSC Deila[51]	366	1,201	51	167	14000	MSC (Switzerland)	153,115
2012	MSC Valeria[52]	366	1,201	51	167	14000	MSC (Switzerland)	153,115
2011	MSC Fillippa[53]	366	1,201	48	157	14000	MSC (Switzerland)	140,259
2009	*MSC Danit*[54]	366	1,201	51	167	14000	MSC (Switzerland)	153,092
2009	*MSC Camille*[55]	366	1,201	51	167	14000	MSC (Switzerland)	153,092
2010	*MSC Melatilde*[56]	366	1,201	51	167	14000	MSC (Switzerland)	151,559
2010	*MSC Paloma*[57]	366	1,201	51	167	14000	MSC (Switzerland)	153,092

Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2011	MSC Ravenna[58]	366	1,201	51	167	14000	MSC (Switzerland)	153,115
2011	CSCL Venus[59]	365.5	1,199	51.2	168	14000	CSCL (China)	150,853
2010	MSC Alexandra[60]	365.5	1,199	52	171	14000	MSC (Switzerland)	153,115
2010	MSC Rosa M[61]	365.5	1,199	51	167	14000	MSC (Switzerland)	153,115
2010	MSC La Spezia[62]	365.5	1,199	51	167	14000	MSC (Switzerland)	153,115
2011	MSC Taranto[63]	365.5	1,199	51	167	14000	MSC (Switzerland)	153,115
2013	*APL Raffles*[64]	368.5	1,209	51	167	13900	APL (Singapore)	151,963
2015	Manchester Bridge[65]	366	1,201	51	167	13870	K Line (Japan)	150,709
2009	*CMA CGM Laperouse*[66]	366	1,201	52	171	13830	CMA CGM (France)	150,269
2010	*CMA CGM Corte Real*[67]	366	1,201	52	171	13830	CMA CGM (France)	150,269
2010	*CMA CGM Amerigo Vespucci*[68]	366	1,201	52	171	13800	CMA CGM (France)	152,991
2010	*CMA CGM Christophe Colomb*[69]	365	1,198	52	171	13800	CMA CGM (France)	153,022
2008	*MSC Daniela*[70]	366	1,201	45.6	150	13798	MSC (Switzerland)	151,559
2009	*MSC Kalina*[71]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2009	*MSC Bettina*[72]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2009	*MSC Irene*[73]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2009	*MSC Emanuela*[74]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2009	*MSC Eva*[75]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2010	*MSC Beatrice*[76]	366	1,201	51	167	13798	MSC (Switzerland)	151,559
2010	MSC Sonia[77]	365.5	1,199	51	167	13798	MSC (Switzerland)	153,092
2010	MSC Livorno[78]	365.5	1,199	51	167	13798	MSC (Switzerland)	153,115
2009	*MSC Gaia*[79]	365.5	1,199	45.6	150	13798	MSC (Switzerland)	151,559
2010	*UMM Salal*[80]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Ain Snan[81]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077

Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2012	Unayzah[82]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Alula[83]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Tayma[84]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Malik Al Ashtar[85]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Al Riffa[86]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Al Qibla[87]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2012	Jebel Ali[88]	365.5	1,199	48	157	13500	UASC (Kuwait)	141,077
2013	COSCO France[89]	366	1,201	52	171	13386	COSCO (China)	153,666
2013	COSCO Belgium[90]	366	1,201	51	167	13386	COSCO (China)	153,666
2010	*CMA CGM Magellan*[91]	365.5	1,199	51.2	168	13830	CMA CGM (France)	150,269
2013	OOCL Brussels[92]	366.5	1,202	48.2	158	13208	OOCL (Hong Kong)	141,003
2013	OOCL Berlin[93]	366.5	1,202	48.2	158	13208	OOCL (Hong Kong)	141,003
2013	OOCL Chongqing[94]	366.5	1,202	48.2	158	13208	OOCL (Hong Kong)	141,003
2013	NYK Helios[95]	365.5	1,199	48.4	159	13208	NYK (Japan)	141,003
2013	NYK Hercules[96]	365.5	1,199	48.4	159	13208	NYK (Japan)	141,003
2012	Hamburg Express[97]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2012	New York Express[98]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2012	Basle Express[99]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2013	*Hong Kong Express*[100]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2013	Shanghai Express[101]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2013	Essen Express[102]	366	1,201	48.2	158	13169	Hapag Lloyd (Germany)	142,295
2011	*COSCO Glory*[103]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2011	*COSCO Development*[104]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2011	*COSCO Pride*[105]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2011	*COSCO Harmony*[106]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823

Built	Name	Length overall (m)	Length overall (ft)	Beam (m)	Beam (ft)	Maximum TEU	Owner	gt (tn)
2012	*COSCO Faith*[107]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2012	*COSCO Hope*[108]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2012	*COSCO Excellence*[109]	366.45	1,202.30	48.2	158	13114	Seaspan Corp. (HK)	141,823
2012	Hanjin Sooho[110]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2012	Hanjin Europe[111]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2012	Hanjin Africa[112]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2012	Hanjin America[113]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2013	Hanjin Harmony[114]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2013	Hanjin Gold[115]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2013	Hanjin Green Earth[116]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2011	MSC Cristina[117]	366	1,201	48	157	13102	MSC (Switzerland)	141,635
2012	MSC Altair[118]	366	1,201	48	157	13102	MSC (Switzerland)	141,635
2012	Hanjin Asia[119]	366	1,201	48	157	13102	Hanjin (South Korea)	141,754
2012	Hyundai Together[120]	366	1,201	48.2	158	13100	Danaos (Greece)	141,770
2012	Hyundai Tenacity[121]	366	1,201	48.2	158	13100	Danaos (Greece)	141,770
2012	Hyundai Smart[122]	366	1,201	48.2	158	13100	Danaos (Greece)	141,770
2012	Hyundai Speed[123]	366	1,201	48.2	158	13100	Danaos (Greece)	141,770
2012	Hyundai Ambition[124]	366	1,201	48.2	158	13100	Danaos (Greece)	141,770
2011	Maersk Evora[125]	366.47	1,202.30	48.2	158	13092	Maersk (Denmark)	141,716
2011	CMA CGM Alaska[126]	366	1,201	48	157	13092	CMA CGM (France)	140,259
2011	CMA CGM Nevada[127]	366	1,201	48	157	13092	CMA CGM (France)	140,259

Table 3. Proposed Test Matrix for Sec 216 Houston Ship Channel Expansion Ship Simulation

		Inbound Ship				Outbound Ship										
Run No.	Channel Condition	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Tide/ Current Speed	Wind Direction / Speed	Tugs	Estimated Transit Time (min)	Notes
1 - Testing HSC Widened to 650 ft with Bend Wideners																
1a	650 ft	Container	44/13.4	12	41-42		Suezmax	44/13.4	10	53-54		Flood	SE/20	0		Meeting Below Red Fish
1b	650 ft	Container	44/13.4	12	Continue							Flood	SE/20	0		Navigating Bend
1c	650 ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	81-82		Flood	SE/20	0		Meeting near 65-66
1d	650 ft	Container	44/13.4	12	Continue							Flood	SE/20	0		Navigating Bend
1e	650 ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	85-86		Flood	SE/20	0	90	Meeting Near 81-82
2a	650 ft	Container	44/13.4	12	41-42		Suezmax	44/13.4	10	53-54		Ebb	SE/20	0		Meeting Below Red Fish
2b	650 ft	Container	44/13.4	12	Continue							Ebb	SE/20	0		Navigating Bend
2c	650 ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	81-82		Ebb	SE/20	0		Meeting near 65-66
2d	650 ft	Container	44/13.4	12	Continue							Ebb	SE/20	0		Navigating Bend
2e	650 ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	85-86		Ebb	SE/20	0	90	Meeting Near 81-82
3a	650 ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	12	85+86		Flood	SE/20	0		Meeting Below Red Fish
3b	650 ft						Container	44/13.4	12	Continue		Flood	SE/20	0		Navigating Bend
3c	650 ft	Suezmax	44/13.4	10	45-46		Container	44/13.4	12	Continue		Flood	SE/20	0		Meeting near 65-66
3d	650 ft						Container	44/13.4	12	Continue		Flood	SE/20	0		Navigating Bend
3e	650 ft	Suezmax	44/13.4	10	41-42		Container	44/13.4	12	Continue		Flood	SE/20	0	90	Meeting Below Red Fish
4a	650 ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	12	85+86		Ebb	SE/20	0		Meeting Below Red Fish
4b	650 ft						Container	44/13.4	12	Continue		Ebb	SE/20	0		Navigating Bend
4c	650 ft	Suezmax	44/13.4	10	45-46		Container	44/13.4	12	Continue		Ebb	SE/20	0		Meeting near 65-66
4d	650 ft						Container	44/13.4	12	Continue		Ebb	SE/20	0		Navigating Bend
4e	650 ft	Suezmax	44/13.4	10	41-42		Container	44/13.4	12	Continue		Ebb	SE/20	0	90	Meeting Below Red Fish

		Inbound Ship					**Outbound Ship**									
Run No.	**Channel Condition**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Tide/ Current Speed**	**Wind Direction / Speed**	**Tugs**	**Estimated Transit Time (min)**	**Notes**
Total Time														**min**	**360**	
														hrs	**6**	
2 - Testing HSC Widened to xxx ft with Bend Wideners - Width Depending on Results of Previous Set of Tests																
1a	ft	Container	44/13.4	12	41-42		Suezmax	44/13.4	10	53-54		Flood	SE/20	0		Meeting Below Red Fish
1b	ft	Container	44/13.4	12	Continue							Flood	SE/20	0		Navigating Bend
1c	ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	81-82		Flood	SE/20	0		Meeting near 65-66
1d	ft	Container	44/13.4	12	Continue							Flood	SE/20	0		Navigating Bend
1e	ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	85-86		Flood	SE/20	0	90	Meeting Near 81-82
2a	ft	Container	44/13.4	12	41-42		Suezmax	44/13.4	10	53-54		Ebb	SE/20	0		Meeting Below Red Fish
2b	ft	Container	44/13.4	12	Continue							Ebb	SE/20	0		Navigating Bend
2c	ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	81-82		Ebb	SE/20	0		Meeting near 65-66
2d	ft	Container	44/13.4	12	Continue							Ebb	SE/20	0		Navigating Bend
2e	ft	Container	44/13.4	12	Continue		Suezmax	44/13.4	10	85-86		Ebb	SE/20	0	90	Meeting Near 81-82
3a	ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	12	85+86		Flood	SE/20	0		Meeting Below Red Fish
3b	ft						Container	44/13.4	12	Continue		Flood	SE/20	0		Navigating Bend
3c	ft	Suezmax	44/13.4	10	45-46		Container	44/13.4	12	Continue		Flood	SE/20	0		Meeting near 65-66
3d	ft						Container	44/13.4	12	Continue		Flood	SE/20	0		Navigating Bend
3e	ft	Suezmax	44/13.4	10	41-42		Container	44/13.4	12	Continue		Flood	SE/20	0	90	Meeting Below Red Fish
4a	ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	12	85+86		Ebb	SE/20	0		Meeting Below Red Fish
4b	ft						Container	44/13.4	12	Continue		Ebb	SE/20	0		Navigating Bend
4c	ft	Suezmax	44/13.4	10	45-46		Container	44/13.4	12	Continue		Ebb	SE/20	0		Meeting near 65-66

		Inbound Ship				Outbound Ship										
Run No.	**Channel Condition**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Tide/ Current Speed**	**Wind Direction / Speed**	**Tugs**	**Estimated Transit Time (min)**	**Notes**
4d	ft						Container	44/13.4	12	Continue		Ebb	SE/20	0		Navigating Bend
4e	ft	Suezmax	44/13.4	10	41-42		Container	44/13.4	12	Continue		Ebb	SE/20	0	90	Meeting Below Red Fish
Total Time														**min**	**360**	
														hrs	**6**	
3. Testing Widened HSC Channel (xxx ft) - Entrance to Barbours Cut (width depending on results of Runs 1-4)																
5	ft	Container	44/13.4	12	85-86		Suezmax	44/13.4	10	53-54		Flood	SE/20	2	45	Meeting Approaching Barbours Cut and Berthing in Barbours Cut
6	ft	Container	44/13.4	12	85-86		Suezmax	44/13.4	10	53-54		Ebb	SE/20	2	45	Meeting Approaching Barbours Cut and Berthing in Barbours Cut
7	ft	Suezmax	44/13.4	10	85-86		Container	44/13.4	12	Berth		Flood	SE/20	2	45	Departing Barbours Cut and Meeting below Barbours Cut
8	ft	Suezmax	44/13.4	10	85-86		Container	44/13.4	12	Berth		Ebb	SE/20	2	45	Departing Barbours Cut and Meeting below Barbours Cut
9	ft	Container	44/13.4	12	71-72		Suezmax	44/13.4	10	83-84		Flood	SE/20	2	60	Meeting Approaching Bayport and Enter Bayport
10	ft	Container	44/13.4	12	71-72		Suezmax	44/13.4	10	83-84		Ebb	SE/20	2	60	Meeting Approaching Bayport and Enter Bayport
11	ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	0	Berth		Flood	SE/20	2	45	Departing Bayport and Meeting below 75-76
12	ft	Suezmax	44/13.4	10	71-72		Container	44/13.4	0	Berth		Ebb	SE/20	2	45	Departing Bayport and Meeting below 75-76

		Inbound Ship				Outbound Ship										
Run No.	**Channel Condition**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Type**	**Draft (ft/m)**	**Initial Speed (knts)**	**Initial Position**	**Pilot**	**Tide/ Current Speed**	**Wind Direction / Speed**	**Tugs**	**Estimated Transit Time (min)**	**Notes**
Total Time														**min**	**390**	
														hrs	**6.5**	
4. Testing Widened Upper HSC Channel (Above Texas 8 Bridge - to be replaced with a bridge spanning the navigation channel)																
13	400 (?) ft x 45 (?) ft	Aframax	44/13.4	6	160							0	SE20	2	30	Transit through Boggy Bayou - Greens Bayou
14	400 (?) ft x 45 (?) ft	Aframax	44/13.4	6	160							0	SE20	2	30	Transit through Boggy Bayou - Greens Bayou
15	400 (?) ft x 45 (?) ft						Aframax	44/13.4	0	Berth		0	SE20	2	30	Transit through Boggy Bayou - Greens Bayou
16	400 (?) ft x 45 (?) ft						Aframax	44/13.4	0	Berth		0	SE20	2	30	Transit through Boggy Bayou - Greens Bayou
13	400 (?) ft x 45 (?) ft	Aframax	44/13.4	6	160							0	N20	2	30	Transit through Boggy Bayou - Greens Bayou
14	400 (?) ft x 45 (?) ft	Aframax	44/13.4	6	160							0	N20	2	30	Transit through Boggy Bayou - Greens Bayou
15	400 (?) ft x 45 (?) ft						Aframax	44/13.4	0	Berth		0	N20	2	30	Transit through Boggy Bayou - Greens Bayou
16	400 (?) ft x 45 (?) ft						Aframax	44/13.4	0	Berth		0	N20	2	30	Transit through Boggy Bayou - Greens Bayou
Total Time														**min**	**240**	
														hrs	**4**	

Appendix I: Houston Pilots Association Simulation-Based Evaluation Standards of Care

Houston Pilots Association

Simulation-Based Evaluation Standards of Care

Date: Thursday, 24 July, 2017
Document Version: 4

Pilot in Charge: Capt. Sean Arbogast, HPA Pilots

Edited by: George B. Burkley, LOCUS LLC, Maritime Pilots Institute

Disclaimer
The standards and methods documented herein are intended only for use in simulation-based research. These standards are designed to inform a research process and in no way apply to actual piloting or relate to the piloting operations of the Houston Ship Pilots Association or their members.

Contents

Update Log

Change Date	**Change Made**	**By**
19 JAN 2016	Document initiation	George Burkley
27 JAN 2016	Editorial revisions from initial safety committee review of document, added values to measurement metrics	George Burkley
20 APR 2016	Editorial edits to ship model evaluation, upgraded run evaluation form to include quantitative grading criteria	George Burkley
24 July 2017	Edited Pilot Eval Form to improve grading criteria logic. Added unsafe tug maneuver " no running in front of a ship while tethered at speeds above 8kn)	George Burkley

Simulation-Based Evaluation Standards of Care

Description:
The HPA simulation-based Evaluation Standards of Care are a set of standards developed by the Houston Pilots designed to guide pilots and researchers during evaluations when using a ship simulator. The standards are set out in three parts:

1. Standards for simulation databases and ship models
2. Standards for the conduct of simulation-based evaluation
3. Standards for documentation and reporting

Standards for simulation databases and ship models

a) Simulation databases
   i) Simulation databases used for test and evaluation shall be vetted and approved for use by the HPA Pilots prior to use of the simulation for testing using the **HPA Simulation Vetting Form**.
   ii) The following items will be vetted
      (1) Distances and measurements: If special docks or new structures are provided in the simulation the structures and their setbacks must be measured and validated against the agreed design measurements.
      (2) Shore and cultural features necessary for navigation and piloting landmarks.
      (3) Depths vetted either to the hydrographic chart in use or to custom data as per the direction of the HPA Pilot in Charge. The process is to move a ship through the areas to be used in the testing at piloting speeds and to ensure that no unusual grounding occurs. Occasionally, a random polygon can appear in a database that will cause a grounding in a testing area.
      (4) Currents vetted and tested
         (a) Current drift test: Place a large ship dead in the water in an area of constant, even current, and observe the motion of the vessel. Allow the vessel to reach maximum drift velocity due to the current. Then oppose the drift forces using two tugs in opposition to the forces. Note the required power needed by the tugs to oppose the forces. The Pilot in Charge should observe these forces and concur that the vessel drifts at current speed and the tug arrest forces seems reasonable for the conditions and under keel clearance provided.
      (5) Wind vetting: Wind shadowing should be provided by landmass and structures. Test this by partially hiding the ship behind an object then slowly move the vessel into the wind field and observe the wind force acting on the model as it projects into the wind area.
         (a) Wind can be either steady force wind or provided by a variance model which will surge the wind speeds and direction based on a simulation formula.
      (6) Fendering: Check the fendering at the docks, if used, to ensure the vessel will moor correctly in the fendering. Ensure the fendering effect is coincident with the provided visual image of the dock.
      (7) Lights and shapes: Ensure that navigation lights and their corresponding ATON shapes, especially ranges and range lights are clearly visible to the pilot.

Ship Model Standards and Evaluation Methods

General Standards

1) Ships used in simulation modelling will be six-degree of freedom, high fidelity ownships modeled using data from actual vessels.
2) Models will be provided with Pilot Card, Maneuvering Card and full IMO recognized sea trial data, with the trials conducted in simulation, deep water and zero environmental conditions. Sea trial data will be assumed as a baseline for the behavior of the vessel in deep water.
3) Shallow water testing: All ship models used in testing will be evaluated for shallow water effects prior to simulation using the **HPA Simulation Ship Model Evaluation Form.** This form is designed to test the behavior of the vessel in the Houston ship channel, with particular interest in the vessels squat, bank effect, suction, stern suction, bow cushion and ship to ship interaction.

Standards for the Conduct of Simulation-based Evaluation

Simulation Run Standards

1. All simulation-based testing will be conducted with vetted databases, vetted shipmodels with vetted tug effects.
2. Simulation runs will be run according to the following pattern:
    a. Run prebrief:
        i. Testing objective
        ii. Hypothesis of what the test pilot thinks will be the likely outcome
        iii. Double check of simulation setup, model, environmental conditions and tug setup
        iv. Communication with the operator of the intended tug use and maneuvers
    b. Runtime
        i. Data will be kept in a spreadsheet record of the simulation runs, typically be a researcher in the control room area.
        ii. Screenshots of the run will be taken a various intervals to support the spreadsheet data
        iii. A record file of the run will be maintained so that the run can be replayed on the simulator.
        iv. The Pilot in Charge or their designate has full control over the simulation start, stop, pause and conduct of the system.
    c. Debrief
        i. Pilots conducting tests will fill out a survey form (see **HPA Pilot Simulation Run Evaluation Form**) after every run to document their opinions and findings from the simulation.

Vessel Maneuvering Standards

3. Standards for vessel maneuvers
    a. Vessels will be maneuvered and piloted with good seamanship in a conservative fashion to a typical standard of care with the aim of success following the axiom **“ The proposed or tested maneuver can be reliably completed by an average pilot on an average day achieving consistent above-average results”**
    b. Simulation maneuvers that are reckless, lucky or otherwise non-professional will not be considered valid for testing. If there is question about whether a maneuver is valid, it will be decided by the Pilot in Charge with appeal to the HPA Safety Committee.
    c. All standards and requirements documented and used in these standards are intended only for use in simulation-based research purposes. The standards use herein are designed to inform a research process and in no way apply to actual piloting or relate to piloting operations in the Houston Ship Channel.

Vessel Load and Trim Conditions

4. Standards for vessel load and trim conditions
    a. Vessels used in simulation evaluation will normally be in even-keel configuration or in drag condition whereby the stern of the vessel is lower in the water than the bow.
    b. Vessels that are down-by-the-head, whereby the bow is lower in the water than the stern, will be considered a special-condition vessel, with known unusual maneuvering behaviors, and will not be used as a general comparator to normal load condition vessels.

Meeting and Overtaking

5. Standards for clearances when meeting, overtaking
    a. The main Houston Ship Channel will be assumed to be 530’ wide with two barge lanes on either side of the main channel measuring 235’ wide each. The toe of the main channel extends at a 3:1 slope towards the barge lane.
    b. Ownship will maintain **90 feet** of lateral distance between two ships during meeting and overtaking maneuvers in the ship channel.

   c. Ownship will maintain **100’ feet** of lateral distance between tows with barges during meeting and overtaking maneuvers in the ship channel.

Passing Moored Vessels

6. Standards for clearances and speeds when passing moored vessels
   a. Ownship shall maintain **119** feet of distance to other ships when passing a vessel that is berthed.
   b. Unless otherwise informed of by approved surge analysis study results, ownship shall not exceed **4.5** knots through the water speed when passing another berthed vessel when that vessel is within **119 feet** of distance from ownship.

Turning Basins and Confined Channels

7. Standards for maneuvering in turning basins and confined channels
   a. Ownship hull perimeter or outermost structure shall maintain **50 feet** of distance, and attached tugs shall maintain **25 feet** from fixed objects or moored vessels while maneuvering in turning basins.
   b. Ownship wash must be minimized when maneuvering in turning basins. Maneuvering bells of greater than half ahead or half astern will be considered non-standard emergency actions.

Drafts and Air-drafts

8. Standards for clearances with overhead and bottom structure
   a. Ownship shall maintain **2 feet** of distance between the uppermost part of the ship and any overhead structure (ex. bridge, crane)
   b. In a static condition, ownship shall maintain **1 foot** of distance between the bottom-most part of the ship and the project depth of the waterway.
   c. In a dynamic (moving) condition, ownship shall maintain **½ foot (.5’**) of distance between the bottom-most part of the ship and the project depth waterway.
      i. This safety clearance accounts for vessel “squat” effects of a moving vessel in a waterway.
      ii. It is understood that vessels navigating in confined muddy waterways with an indeterminate bottom composition have varying behavior to squat conditions.
      iii. It is agreed that all vessels navigating in near-bottom conditions, typically at speeds **above 5 knots**, will suffer a loss of speed and display an impairment in maneuvering, to include piloting requirements for greater rudder inputs to maintain courses and track stability of the vessel.

Assist Tugs

9. Tug clearances when engaged in ship assist maneuvers while at a dock or slip
   a. Assist tugs engaged in ship assistance at a dock or slip, whether attached or alongside, shall maintain **25 feet** of clearance from the extreme end of the tug and any man-made structure.
10. Tug clearance in the main channel
    a. Assist tugs engaged in ship assistance, whether attached or alongside, shall not allow the center-point of the tug’s wheelhouse to cross the 25 foot channel contour (outer toe of the ship channel)
11. Tug clearance when passing other ships in the channel
    a. Assist tugs engaged in ship assistance with a vessel underway in the HSC, whether attached or alongside, shall maintain **25 feet** of distance from any other vessel in the channel.
12. Tug clearance when passing moored vessels
    a. Assist tugs engaged in ship assistance, whether attached or alongside, shall not allow the perimeter fendering of the tug to come closer than **25 feet** to manmade structure or other vessels. (source, G&H Towing)
13. Tug reposition times
    a. Unless otherwise agreed to by the Pilot in Charge, the following re-position times will be used for assist tugs during simulation.

Tug Maneuver	Reposition Time
Running free alongside to "Put a line up and make fast"	2 minutes
Tied-up alongside - to shift one chock to another chock on the same side of the vessel	3 minutes
Tied-up alongside - to shift to a chock on the other side and tie up.	4 minutes
From center-lead aft - to drop line and shift to any chock forward of amidships	3 minutes
From center-lead aft – to keep line up and get into push-pull position on the quarter	1 minute

14. Tug bollard pull
    a. Unless otherwise agreed to by the Pilot in Charge, or accurate data is provided for actual tugs in the working area, the following tug bollard pull assumptions will be used for Azimuth Stern Drive (ASD) Tractor Tugs.
    b. Note: 1 long ton = 2240 pounds, 1 short ton = 2000 pounds, 1 metric ton = 2204.62 pounds
    c. Assist Tug Assumed Bollard Pull Table

Tug Type	Horsepower	Ahead Long Tons	Ahead Short Tons	Astern Long Tons	Astern Short Tons
ASD	6000	74	82.8	67	75
ASD	5000	56	62.7	52	58.2
ASD	4000	48	53.6	44	49.2
Twin Screw	3900	56	62.7	43	48.2

15. Tug polars for direct pull maneuvers
    a. Unless otherwise agreed to by the Pilot in Charge, the following direct pull tug polars will be used in simulation evaluation maneuvering

Direct Pull Table (Assumed)

Ship speed through the water (knots)	Tug angle to the ship (degrees)	Effective power (%)
0-2	Any	100% (full power)
2-4	0-90	50%
4+	0-90	0

16. Tug polars for powered indirect maneuvers
    a. Unless otherwise agreed to by the Pilot in Charge, the following powered-indirect pull tug polars will be used in simulation evaluation maneuvering

Powered Indirect Table

Ship speed through the water (knots)	Tug angle to the ship (degrees)	Effective power multiplier over direct pull power (%)
0-5	Any	none
5-8	90	125%

17. Tug polars for indirect pull maneuvers
    a. Unless otherwise agreed to by the Pilot in Charge, the following indirect pull tug polars will be used in simulation evaluation maneuvering

Indirect Pull Table

Ship speed through the water (knots)	Tug angle to the ships' stern (degrees)	Effective power multiplier (%)
0-7	Any	None
7-9	Inline (0) to 30 degrees	150%
7 - 10	Greater than 30 degrees	None (not possible)

Transverse Arrest Maneuver

18. For the purposes of simulation it will be assumed that transverse arrest maneuvers are emergency maneuvers only.
    a. The validity of the effective bollard pull multiplier for this maneuver is not validated. For the purposes of simulation, and until better data is available, it will be assumed that transverse arrest maneuvers are no more effective than an inline direct pull maneuver.
    b. The transverse arrest maneuver is also known to be unacceptably rough on tug equipment due to excess vibration, and is thus not considered a normal practice.

19. Unsafe tug maneuvers
    b. The following tug maneuvers will be considered unsafe
        i. Running ahead of a ship while tethered at speeds above 8kn.

Standards for Documentation and Reporting

The following standards will be followed for documentation and reporting

Privacy of Information

1. Participating pilots and researchers will document their work in the simulations using forms, notes, and recordings, both written and electronic. This information will be shared with persons designated by the Pilot in Charge.
    a. Participating pilots and researchers agree that no information will be shared with any other party regarding the conduct or outcomes of simulation research.

Documentation

2. The Pilot in Charge will approve the documentation protocol to be used for the evaluation and will be responsible for the safe keeping of such information.
3. Any changes to information contained in evaluation reports will be with the notice and consent of the Pilot in Charge and will be clearly noted in change logs in the preface of all reports.

HPA Simulation Database Vetting Form

HPA Vetting Pilot:___________________________ Database accepted: _______
Date:_____________ Database not accepted:______
Simulation Database Name/ Build Date:

#	Vetting Item	Accepted	Unacceptable
1.	**Distances and measurements**: If docks or new structures are provided in the simulation the structures and their setbacks to shallow water must be measured and validated against the agreed design measurements.		
2.	**Shore and cultural features** necessary for navigation and piloting landmarks		
3.	**Depths** vetted either to the hydrographic chart in use or to custom data as per the direction of the HPA Pilot in Charge. Process is to move a ship through the areas to be used in the testing at piloting speeds and to ensure that no unusual grounding occurs.		
4.	**Current drift test**: Place a large ship DIW in an area of constant, even current. Note that the vessel drifts at current speed and motion seem reasonable for the conditions/UKC. For eddy currents, place ship in current eddy and observe correct behavior		
5.	**Wind vetting:** Wind shadowing should be provided by landmass and structures.		
6.	**Fendering:** Check the fendering at the docks to ensure the vessel will moor correctly in the fendering. Ensure the fendering effect is coincident with the provided visual image of the dock.		
7.	**Lights and shapes:** lights, ATON shapes, are clearly visible		
8.	**Any other items noted by vetting pilot:**		

Signed: ______________________________

**Note: Attach screenshots of simulation instructor chart view of an unacceptable condition and other special findings from the vetting tests.*

HPA Simulation Ship Model Evaluation Form

HPA Vetting Pilot:__________________________ Model accepted: _______
Date:_____________ Model not accepted: _______

Simulation Model Name/Description:
Length: **Beam:** **Draft:** **Load Condition:**

Please attach pilot card and screenshots of maneuver to this form as a record of the testing
The intention of these test are to validate shallow water behavior of the model in the Houston Ship Channel. Model tests must be conducted in a validated and approved simulation model of the Houston Ship Channel. This form is documents the behavior of the vessel in the Houston ship channel for vessel squat, bank effect, suction, stern suction, bow cushion and ship to ship interaction. Feel free to make special notes and attach them to this record.

#	Vetting Item	Accepted	Unacceptable
1.	**Deep water sea trial** documentation, Pilot card and maneuvering poster are provided		
2.	**Squat behavior:** Model starts from DIW in the channel and accelerates to maximum transit speed consistent with future testing needs. Note the speed incident with onset of squat effects. Document if the vessel grounds due to squat in the speed range of future intended tests. Ensure the simulator is using the charted depth database and not a fictitious arbitrary depth “hard bottom”.		
3.	**Bank effect, neutral steering line:** Start model at a slow maneuvering speed in the center of the channel and accelerates to normal transit speeds. Document if the vessel will achieve a balanced position in the channel between the two opposing bank forces, ie: the “neutral steering line”. Document this effect.		
4.	**Bank effect, interaction:** While in the neutral steering line, pilot the vessel out of the “neutral steering line” and towards the starboard bank in easy increments until the model begins to interact with the bank. Note the speed and general angle and if it feels correct to your experience. If vessel consistently grounds and will not interact with the bank this is unacceptable.		
5.	**Bank effect departure:** Slowly move the vessel farther towards the bank observing greater need for counter-rudder. Achieve “departure” whereby the ship shears away from the bank with full counter-rudder. If departure is unattainable this unacceptable. Determine at which speed and angle this departure behavior will occur. If grounding occurs, document the situation referencing the grounding speeds and angle to the bank and if it is stern or bow grounding		
6.	**Ship to ship interaction test setup** (tests 6-12): 1. Tests will be run in a vetted and approved straight section of the HSC. 2. Bank effect testing must be completed first prior to validating ship to ship interactions. 3. Recommend a mid-bay location. 4. Vessels in the test should be of the exact same model type 5. Setup is, break at .6nm and 4 degrees (this setup is at the discretion of the test pilot)		
6.	**Ship to ship interaction, meeting conditions, onset behavior:** Document and evaluate if the bow surge effect is consistent with		

#	Vetting Item	Accepted	Unacceptable
	your experience. No effect noticed is grounds for an unacceptable rating.		
7.	**Ship to ship interaction, meeting conditions, alongside behavior**: Document and evaluate if the alongside effect and counter-rudder needed is consistent with your experience. No effect noticed is grounds for an unacceptable rating.		
8.	**Ship to ship interaction, meeting conditions, recovery behavior**: Document and evaluate if the recovery behavior is consistent with your experience. The vessel should turn in to the wake of the other ship and require piloting inputs to maintain safe clearance and control in the channel. No effect noticed is grounds for an unacceptable rating.		
9.	**Ship to ship interaction, overtaking conditions, onset behavior:** Note distance and effect of bow when approaching the stern of the other ship. Typically, this will be a weak effect in a ship simulator.		
10.	**Ship to ship interaction, overtaking conditions, alongside behavior:** Note the counter-rudder needed to maintain safe clearances while alongside the other vessel. This is a strong effect in ship simulators, if no effect is noted this is unacceptable.		
11.	**Ship to ship interaction, overtaking conditions, recovery behavior:** Note recovery effects as stern passes the other vessels bow, if any. (rare to feel in a ship simulator)		
12.	**Any other items noted by vetting pilot:**		

Signed: ______________________________

**Note: Attach screenshots of simulation instructor chart view of an unacceptable condition and other special findings from the vetting tests.*

Pilot Simulation Run Evaluation Form

Pilot Name:_______________________
Date:_______________________
Run #: _______________________

Overall Assessment: Satisfactory ____ Marginal ____ Unsatisfactory____

Run Objective: ____

Special Conditions (tugs, traffic, wind, current, setup, etc.):_______________________________

Pilot Opinion of Simulation Outcome: ____

Quantitative Grading Criteria:
For marks above a level 4 please provide comment

	Safe				***Unsafe***					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Safety										

Comment:

	Easy				***Challenging***					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Degree of Difficulty										

Comment:

	High Degree of Reserve Power				***Reduced Reserve Tug Power***					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Reserve Tug Power										

Comment:

Please use reverse for additional comments

Appendix J: Documentation of the HSC EPIFS Simulation Database Validation

June 26, 2019

Waterway Simulation Technology, Inc.

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Attn: Larry L. Daggett

MEMO FOR RECORD

Subject: Houston Ship Channel (HSC) 216 Ship Simulation Model Setup and Verification

Introduction

During the period from October 13-15, 2017, MPI, San Jacinto Maritime, Houston Pilots, and WST installed the simulation model databases for the reaches of the HSC, tested and adjusted the ship models until they were verified by the Houston Pilots, checked out the simulation databases, and discussed the project, feasibility study objectives, and testing program with the pilots, representatives from ERDC, the Galveston District, and Port of Houston Authority. This MFR has been prepared to document the results of this effort. Those in attendance during this period were:

- Marcus Maher, Tom Goodwin – Houston Pilots
- George Berkley, Fernando Lagunes – MPI
- Keith Martin, Dennis Webb – ERDC
- Larry Daggett, Chris Hewlett – WST
- Dana Chaney – Gahagan Bryant
- Richard Ruchhoeft – Port of Houston Authority
- Tomas White – Galveston District, Corps of Engineers

Ship model adjustment/verification

The ship model checkout and verification concentrated on the modified design ship, the Ultra Large Container Vessel (ULCV) (MV EDINBURG). This model was modified to make the ship more responsive to rudder commands in line with measurement that MPI made while observing a similar containership maneuvering in Norfolk Harbor. Maneuvers in deep unrestricted water and in the 650’ widened HSC channel were conducted by the Houston Pilots. Maneuvers were focused on responsiveness of the containership’s rudders to commands, the ship’s response to the rudder positions, and the response of the containership to the shallow water and banks in the channel. The pilots were satisfied with the ship’s performance in these circumstances.

Following the acceptance of the containership model, the verification focused on the modeling of ship/ship interactions within a shallow water restricted channel. This involved two Houston Pilots performing their normal meeting maneuvers with the design ULVC and Suezmax ship models in the shallow restricted proposed navigation channel (650ft x 46.5ft). Adjustments were made to the channel modeling resolution to enhance the bank effects and to the ship/ship interaction function of the ULCV in order to achieve ship model pilot acceptance.

Initial plans for modeling two-way traffic in the upper HSC were to involve an Aframax meeting a Panamax vessel. Discussions with the Houston Pilots noted that gas ships (LPG Carriers) involved vessels with a wider beam (120ft vs 106ft). Therefore, meeting situations with an LPGC model from the SJC library were performed which proved to be unsatisfactory. Further testing showed that the LPGC model had little, if any, bank effects response and was very sluggish in response to rudder commands. Therefore, the inclusion of the LPGC in the upper HSC tests was dropped. Testing of the performance of the design Aframax tanker meeting the design Panamax bulk carrier proved to be acceptable to the Houston Pilots. Although the bulk carrier has a smaller beam than the LPGC (106ft vs 120ft), the length of the Panamax bulk carrier was longer than the LPGC by 128ft. This will prove to be significant in maneuvers in the curved channel in the upper HSC.

Following the meeting tests, which were done without wind and/or currents, drift tests were performed on these ship models to demonstrated that the effects of wind and currents impacted the ship models in a realistic way.

Therefore, all ship models were accepted by the Houston Pilots and are ready for use in testing the channel design widths. The approval forms for the ULCV and Suezmax are attached as Enclosure 1. The selected ship principal characteristics are attached as Enclosure 2.

Test Procedures

The original development of the model of the Boggy to Greens Bayou widening was going to modify the Texas Beltway 8 bridge was going to be done by moving the piers of the bridge to the bank since the bridge replacement plans were not available. MPI was made aware that the proposed bridge would be of the cable stay design similar to the bridge at Baytown. Therefore, the modeled bridge was modified to have a similar design.

There was confusion on the proposed authorized channel depth to be used in the lower HSC and the Boggy Bayou to Greens Bayou. It was agreed that the design-authorized depth should be 46.5 MLLW. Therefore, all channels up to Greens Bayou were modified to that depth.

The proposed approach involved modeling meetings of Suezmax and ULCV in the bay channels with each vessel type transiting the bends in one-way mode. The Houston Pilots expressed concern that, as much as they would try to prevent meetings in the bends, such meetings were unavoidable. They strongly encouraged performing meetings in the bends.

In addition to meetings in the bends, the Houston Pilots noted that when one ULCV is approaching the container terminals another one would normally be departing. Therefore, they were concerned that the meetings should also include meetings of two ULCVs. It was agreed that such meetings would be included in the testing program.

The Houston Pilots noted that they do not presently allow the meeting of two Aframax vessels above Morgans Point, e.g. above the straight bay reaches. Therefore, it was recommended and agreed that the tests in the upper HSC widened and deepened reaches between Boggy Bayou and Greens Bayou would only involve two-way traffic of a Panamax and an Aframax vessel.

There was a discussion about which radius flare should be included in the testing program. There was a concern that the 5375ft radius that was presently programmed into the model databases would result in excessive dredging and maintenance volumes and mitigation costs. There was a discussion about whether the 4000ft radius would be adequate. The training that the pilots have been doing has been with the 4000ft radius flare; however, this may have been with a smaller ULCV. Results of the tests to determine the widening requirement for the Bayport Ship Channel were reviewed and found that transits were being made with the 4000ft radius. With the increased HSC width and the bend flare, it was agreed that the 4000ft radius should be included in the testing program. Concern was expressed over the extension of the channel toeline on the southwest end of the flare when the HSC was widened; thus making a point that had to be navigated around rather than a smooth curve transition to the apex of the west point of the Five-mile Cutoff Bend (markers 75-76). It was agreed that the simulation databases would be modified to include both the 4000ft radius and 5375ft radius flare into the Bayport Ship Channel for both the 650ft and 750ft HSC channel widths with testing of the 4000ft radius flare initially.

The Houston Pilots expressed a desire to conduct the turning operation in the Bayport Ship Channel in the proposed RO/RO turning basin. This would allow them to turn prior to entering the land portion of the channel and back into the terminals under tug control. They would prefer this operation instead of proceeding down the entire terminal channel between berthed containerships and the land and back again after turning in the turning basin at the end of the channel.

A draft pilot questionnaire was developed by WST and presented to ERDC for approval. That approval was received. The questionnaire is attached as Enclosure 3. This questionnaire was based on the initially presented test matrix.

Finally, the initial positions of the ships for each of the proposed test matrix were discussed using the NOAA navigation charts. The proposed test matrix for the Bay channels included long transits of the ULCV with multiple meetings of a Suezmax tanker in each of the straight reaches with no meetings in the bends. With the addition of meetings in the bends and meetings of the both the Suezmax and ULCV, this test matrix had to be revised. The Houston Pilots recommended a separation distance of 2 miles between ships in convoy. It was recommended that consideration be given to having the ship bridge be the long transiting ULCV and the two tug bridges be the meeting vessels. The simulation would be started at the lower end of the reach between Red Fish and Bolivar Roads with the ships beginning their transit below or above a bend so that the pilots could get a feel for the ship responses to the maneuvering commands.

Following the meetings of the two ships, the simulation could be paused and the tug bridges be reassigned or moved to a new location in the channel and the simulation restarted.

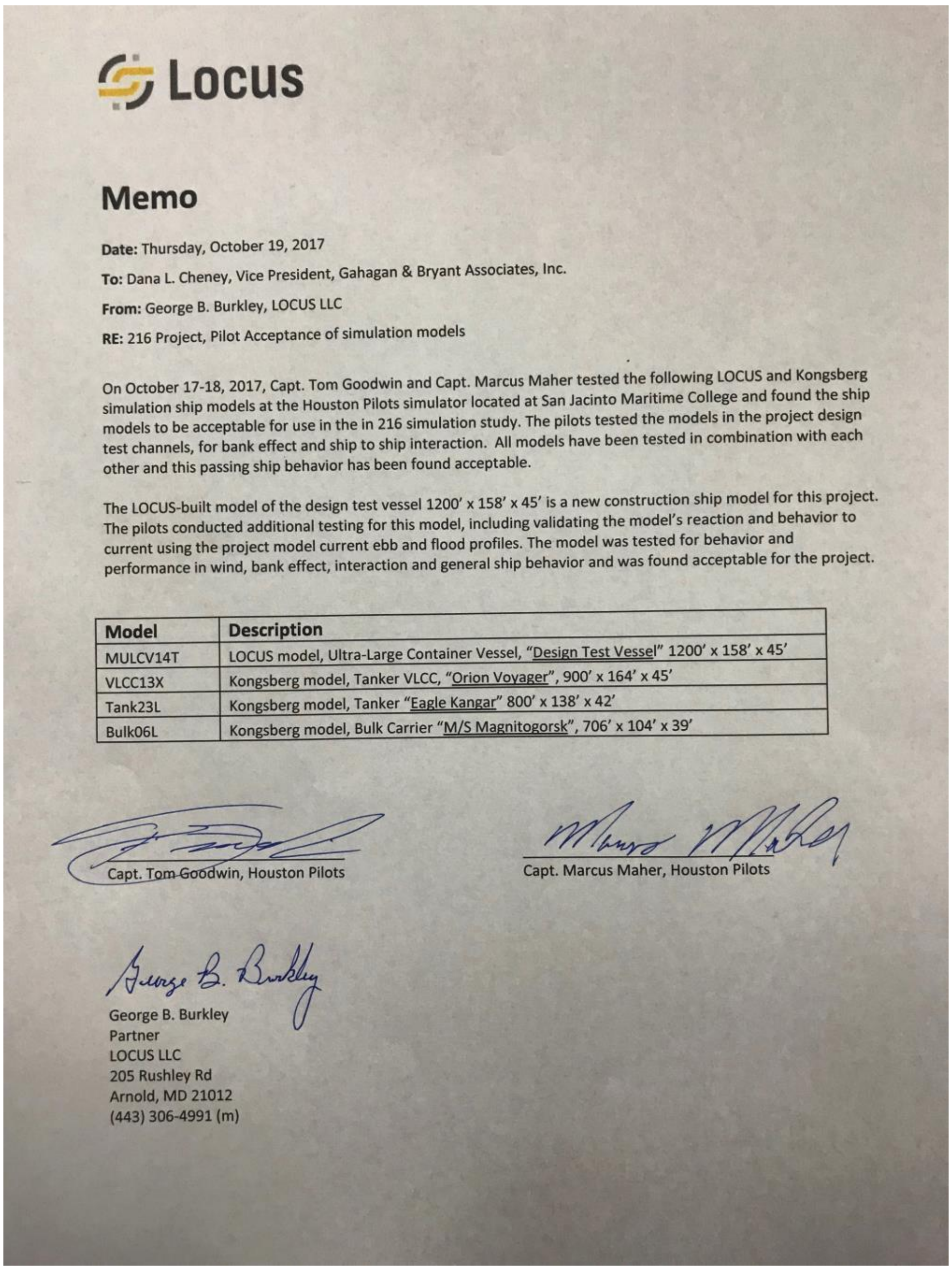
Based on these discussions, the test matrix was revised and is attached as Enclosure 4. The test program was modified to reduce the total time for the Bay channel runs. This test matrix is submitted for review and comments/suggestions.

Conclusions

The simulation modeling components were reviewed, evaluated and approved as modified. Changes were suggested that benefited the program and will make it more fully meet the objectives of the simulations. The benefit of having all parties involved participating, especially obtaining the input of the pilots to bring reality to the program, was especially beneficial.

Larry L Daggett

Larry L. Daggett, Engineer



LOCUS

Memo

Date: Thursday, October 19, 2017

To: Dana L. Cheney, Vice President, Gahagan & Bryant Associates, Inc.

From: George B. Burkley, LOCUS LLC

RE: 216 Project, Pilot Acceptance of simulation models

On October 17-18, 2017, Capt. Tom Goodwin and Capt. Marcus Maher tested the following LOCUS and Kongsberg simulation ship models at the Houston Pilots simulator located at San Jacinto Maritime College and found the ship models to be acceptable for use in the in 216 simulation study. The pilots tested the models in the project design test channels, for bank effect and ship to ship interaction. All models have been tested in combination with each other and this passing ship behavior has been found acceptable.

The LOCUS-built model of the design test vessel 1200′ x 158′ x 45′ is a new construction ship model for this project. The pilots conducted additional testing for this model, including validating the model's reaction and behavior to current using the project model current ebb and flood profiles. The model was tested for behavior and performance in wind, bank effect, interaction and general ship behavior and was found acceptable for the project.

Model	**Description**
MULCV14T	LOCUS model, Ultra-Large Container Vessel, "Design Test Vessel" 1200′ x 158′ x 45′
VLCC13X	Kongsberg model, Tanker VLCC, "Orion Voyager", 900′ x 164′ x 45′
Tank23L	Kongsberg model, Tanker "Eagle Kangar" 800′ x 138′ x 42′
Bulk06L	Kongsberg model, Bulk Carrier "M/S Magnitogorsk", 706′ x 104′ x 39′

Capt. Tom Goodwin, Houston Pilots

Marcus Maher

Capt. Marcus Maher, Houston Pilots

George B. Burkley

George B. Burkley
Partner
LOCUS LLC
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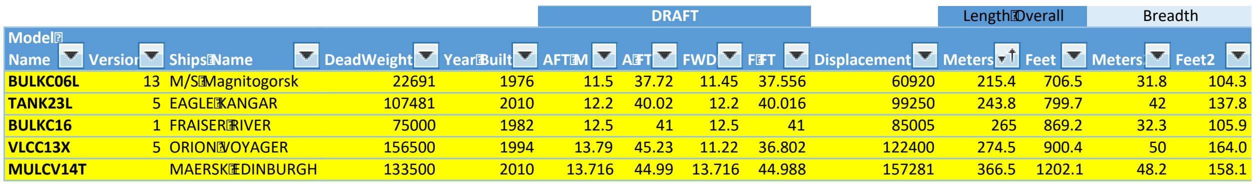
Enclosure 1



					DRAFT					Length Overall		Breadth	
Model Name	**Versior**	**Ships Name**	**DeadWeight**	**Year Built**	**AFT M**	**A FT**	**FWD**	**F FT**	**Displacement**	**Meters**	**Feet**	**Meters**	**Feet2**
BULKC06L	13	M/S Magnitogorsk	22691	1976	11.5	37.72	11.45	37.556	60920	215.4	706.5	31.8	104.3
TANK23L	5	EAGLE KANGAR	107481	2010	12.2	40.02	12.2	40.016	99250	243.8	799.7	42	137.8
BULKC16	1	FRAISER RIVER	75000	1982	12.5	41	12.5	41	85005	265	869.2	32.3	105.9
VLCC13X	5	ORION VOYAGER	156500	1994	13.79	45.23	11.22	36.802	122400	274.5	900.4	50	164.0
MULCV14T		MAERSK EDINBURGH	133500	2010	13.716	44.99	13.716	44.988	157281	366.5	1202.1	48.2	158.1

Enclosure 2

Run #:	**Date:**	**Simulator/Operator:**
Pilot:		**Ship's Initial Heading/Speed:**
Run Start Time:	**Run End Time:**	
Start Location:		**End Location:**
Ship Model Used	**ULCV**	**Suezmax**
Travel Direction	**Inbound**	**Outbound**
Environmental Conditions	**Wind Dir. (from) / Speed**	**Tide/Flow**
Notes:		

Reach 1 Meeting (27-28 to 47-48)

10 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

11 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

12 Comment(s)

Red Fish Bend (47-48 to 53-54)

13 Rate the difficulty of this run with the number "5" indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

14 Rate the overall safety of this run. Use "1" as unsafe and "5" as indicating average.

Unsafe Increasing Safety → Safe

1 2 3 4 5 6 7 8 9 10

15 Comment(s)

Reach 2 Meeting (53-54 to 73-74)

16 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

17 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

18 Comment(s)

Bayport Bend (73-74 to B-78)

19 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult
1 2 3 4 5 6 7 8 9 10

20 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

21 Comment(s)

Reach 3 Meeting (B-78 to 89A-90A)

22 Rate the difficulty of this run with the number “5” indicating the difficulty level of an average transit in real-world pilotage conditions.

Easy Increasing Difficulty → Difficult

1 2 3 4 5 6 7 8 9 10

23 Rate the overall safety of this run. Use “1” as unsafe and “5” as indicating average.

Unsafe Increasing Safety → Safe
1 2 3 4 5 6 7 8 9 10

24 Comment(s)

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
1 - Testing HSC Widened to 650 ft with Bend Wideners																
1a	650 ft	Container	44/13.4	10	18		Suezmax	44/13.4	10	57-58		Flood	SE/20	0		Meeting Below Red Fish
1b	650 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	63-64		Flood	SE/20	0	45	Meeting Below Red Fish
2a	650 ft	Suezmax	44/13.4	10	29-30		Container	44/13.4	10	57-58		Ebb	SE/20	0		Meeting Below Red Fish
2b	650 ft	Container	44/13.4	10	18		Container	44/13.4	10	Continue		Ebb	SE/20	0	45	Meeting Below Red Fish
3a	650 ft	Container	44/13.4	10	43-44		Suezmax	44/13.4	10	59-60		Flood	SE/20	0		Meeting Red Fish Bend
3b	650 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	75-76		Flood	SE/20	0		Meeting near 65-66
3c	650 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	B-92		Flood	SE/20	0		Meeting at 5-Mile Bend
3d	650 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	B-92		Flood	SE/20	0	75	Meeting near 83-84
4a	650 ft	Container	44/13.4	10	43-44		Container	44/13.4	10	59-60		Ebb	SE/20	0		Meeting Red Fish Bend
4b	650 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	75-76		Ebb	SE/20	0		Meeting near 65-66
4c	650 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	B-92		Ebb	SE/20	0		Meeting at 5-Mile Bend

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
4d	650 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	B-92		Ebb	SE/20	0	75	Meeting near 83-84
5a	650 ft	Container	44/13.4	10	73-74		Container	44/13.4	10	B-92		Flood	SE/20	0		Meet near 83-84
5b	650 ft	Suezmax	44/13.4	10	65-66		Container	44/13.4	10	Continue		Flood	SE/20	0		Meeting in 5-mile Bend
5c	650 ft	Container	44/13.4	10	53-54		Container	44/13.4	10	Continue		Flood	SE/20	0		Meeting near 66-68
5d	650 ft	Suezmax	44/13.4	10	29-30		Container	44/13.4	10	Continue		Flood	SE/20	0	75	Meet in Red Fish Bend
6a	650 ft	Suezmax	44/13.4	10	73-74		Container	44/13.4	10	B-92		Ebb	SE/20	0		Meet near 83-84
6b	650 ft	Container	44/13.4	10	65-66		Container	44/13.4	10	Continue		Ebb	SE/20	0		Meeting in 5-mile Bend
6c	650 ft	Suezmax	44/13.4	10	53-54		Container	44/13.4	10	Continue		Ebb	SE/20	0		Meeting near 66-68
6d	650 ft	Container	44/13.4	10	29-30		Container	44/13.4	10	Continue		Ebb	SE/20	0	75	Meet in Red Fish Bend
Total Time														**minutes**	**390**	
														hours	**6.5**	
2 - Testing HSC Widened to xxx ft with Bend Wideners - Width Depending on Results of Previous Set of Tests																
7a	750 ft	Container	44/13.4	10	18		Suezmax	44/13.4	10	57-58		Flood	SE/20	0		Meeting Below Red Fish

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
7b	750 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	63-64		Flood	SE/20	0	45	Meeting Below Red Fish
8a	750 ft	Suezmax	44/13.4	10	29-30		Container	44/13.4	10	57-58		Ebb	SE/20	0		Meeting Below Red Fish
8b	750 ft	Container	44/13.4	10	18		Container	44/13.4	10	Continue		Ebb	SE/20	0	45	Meeting Below Red Fish
9a	750 ft	Container	44/13.4	10	43-44		Suezmax	44/13.4	10	59-60		Flood	SE/20	0		Meeting Red Fish Bend
9b	750 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	75-76		Flood	SE/20	0		Meeting near 65-66
9c	750 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	B-92		Flood	SE/20	0		Meeting at 5-Mile Bend
9d	750 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	B-92		Flood	SE/20	0	75	Meeting near 83-84
10a	750 ft	Container	44/13.4	10	43-44		Container	44/13.4	10	59-60		Ebb	SE/20	0		Meeting Red Fish Bend
10b	750 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	75-76		Ebb	SE/20	0		Meeting near 65-66
10c	750 ft	Container	44/13.4	10	Continue		Container	44/13.4	10	B-92		Ebb	SE/20	0		Meeting at 5-Mile Bend
10d	750 ft	Container	44/13.4	10	Continue		Suezmax	44/13.4	10	B-92		Ebb	SE/20	0	75	Meeting near 83-84

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
11a	750 ft	Container	44/13.4	10	73-74		Container	44/13.4	10	B-92		Flood	SE/20	0		Meet near 83-84
11b	750 ft	Suezmax	44/13.4	10	65-66		Container	44/13.4	10	Continue		Flood	SE/20	0		Meeting in 5-mile Bend
11c	750 ft	Container	44/13.4	10	53-54		Container	44/13.4	10	Continue		Flood	SE/20	0		Meeting near 66-68
11d	750 ft	Suezmax	44/13.4	10	29-30		Container	44/13.4	10	Continue		Flood	SE/20	0	75	Meet in Red Fish Bend
12a	750 ft	Suezmax	44/13.4	10	73-74		Container	44/13.4	10	B-92		Ebb	SE/20	0		Meet near 83-84
12b	750 ft	Container	44/13.4	10	65-66		Container	44/13.4	10	Continue		Ebb	SE/20	0		Meeting in 5-mile Bend
12c	650 ft	Suezmax	44/13.4	10	53-54		Container	44/13.4	10	Continue		Ebb	SE/20	0		Meeting near 66-68
12d	650 ft	Container	44/13.4	10	29-30		Container	44/13.4	10	Continue		Ebb	SE/20	0	75	Meet in Red Fish Bend
Total Time														**minutes**	**390**	
														hours	**6.5**	
3. Testing Widened HSC Channel (xxx ft) - Entrance to Barbours Cut (width depending on results of Runs 1-4)																
13	xxx ft	Container	44/13.4	5	87-88							Flood	SE/20	2	45	Enter Barbpurs Cut and Turn in Turning Basin
14	xxx ft	Container	44/13.4	5	867-88							Ebb	N/20	2	45	Enter Barbpurs Cut and Turn in Turning Basin

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
15	xxx ft						Container	44/13.4	0	Berth		Flood	SE/20	2	30	Departing Barbours Cut
16	xxx ft						Container	44/13.4	0	Berth		Ebb	N/20	2	30	Departing Barbours Cut
17	xxx ft / 4000 ft Flare	Container	44/13.4	8	71-72							Flood	SE/20	2	60	Enter Bayport and Turn in Turning Basin
18	xxx ft / 4000 ft Flare	Container	44/13.4	8	71-72							Ebb	N/20	2	60	Enter Bayport and Turn in Turning Basin
19	xxx ft / 4000 ft Flare						Container	44/13.4	0	Berth		Flood	SE/20	2	45	Departing Bayport
20	xxx ft / 4000 ft Flare						Container	44/13.4	0	Berth		Ebb	N/20	2	45	Departing Bayport
Total Time														**minutes**	**360**	
														hours	**6**	
4. Testing Widened Upper HSC Channel (Above Texas 8 Bridge - to be replaced with a bridge spanning the navigation channel)																
21	530ft x 46.5 ft	Aframax	44/13.4	5	Oil Tanking		Bulker	37.7	5	Greens Bayou		Ebb	SE20	0	30	Transit through Boggy Bayou - Greens Bayou

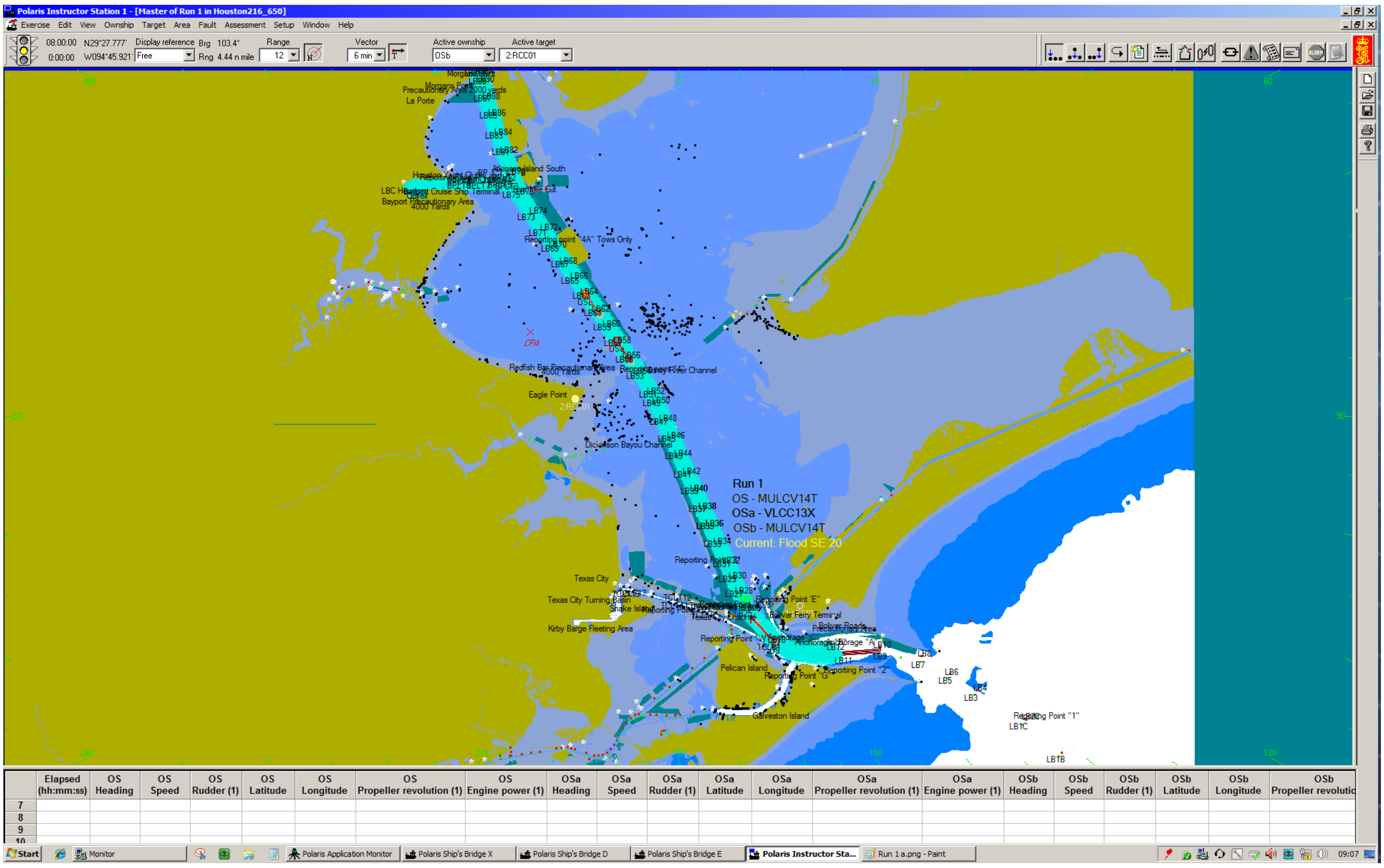
Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
22	530ft x 46.5 ft	Aframax	44/13.4	5	Oil Tanking		Bulker	37.7	5	Greens Bayou		Ebb	SE20	0	30	Transit through Boggy Bayou - Greens Bayou
23	530ft x 46.5 ft	Bulker	37.7	5	Greens Bayou		Aframax	44/13.4	0	Oil Tanking		Ebb	SE20	0	30	Transit through Boggy Bayou - Greens Bayou
24	530ft x 46.5 ft	Bulker	37.7	5	Greens Bayou		Aframax	44/13.4	0	Oil Tanking		Ebb	SE20	0	30	Transit through Boggy Bayou - Greens Bayou
25	530ft x 46.5 ft	Aframax	44/13.4	5	Oil Tanking		Bulker	37.7	5	Greens Bayou		Ebb	N20	0	30	Transit through Boggy Bayou - Greens Bayou
26	530ft x 46.5 ft	Aframax	44/13.4	5	Oil Tanking		Bulker	37.7	5	Greens Bayou		Ebb	N20	0	30	Transit through Boggy Bayou - Greens Bayou
27	530ft x 46.5 ft	Bulker	37.7	5	Greens Bayou		Aframax	44/13.4	0	Oil Tanking		Ebb	N20	0	30	Transit through Boggy Bayou - Greens Bayou
28	530ft x 46.5 ft	Bulker	37.7	5	Greens Bayou		Aframax	44/13.4	0	Oil Tanking		Ebb	N20	0	30	Transit through Boggy Bayou - Greens Bayou
Total Time														**minutes**	**240**	
														hours	**4**	
5. Brady Island Tests																

Run No.	Channel Condition	Inbound Ship					Outbound Ship					Tide	Wind Direction/ Speed (knts)	Tugs	Estimated Transit Time	Notes
		Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot	Type	Draft (ft/m)	Initial Speed (knts)	Initial Position	Pilot					
29	400'x41.5'	Bulkc06L	37.7	5	CG							Ebb	SE/20	2	45	Turn In Brady Island TB
30	400'x41.5'	Bulkc06L	37.7	5	CG							Ebb	N/20	2	45	Turn In Brady Island TB
Total Time														**minutes**	**90**	
														hours	**1.5**	
Total Hours															**24.5**	
Total Days															**4**	

Appendix K: Validation Simulation Tests

June 26, 2019

Run 1



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:00:00 N29°27.777' Display reference Free Brg 103.4° Rng 4.44 n mile Range 12 Vector 6 min Active ownship OSb Active target 2:RCC01

0:00:00 W094°45.921

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7																					
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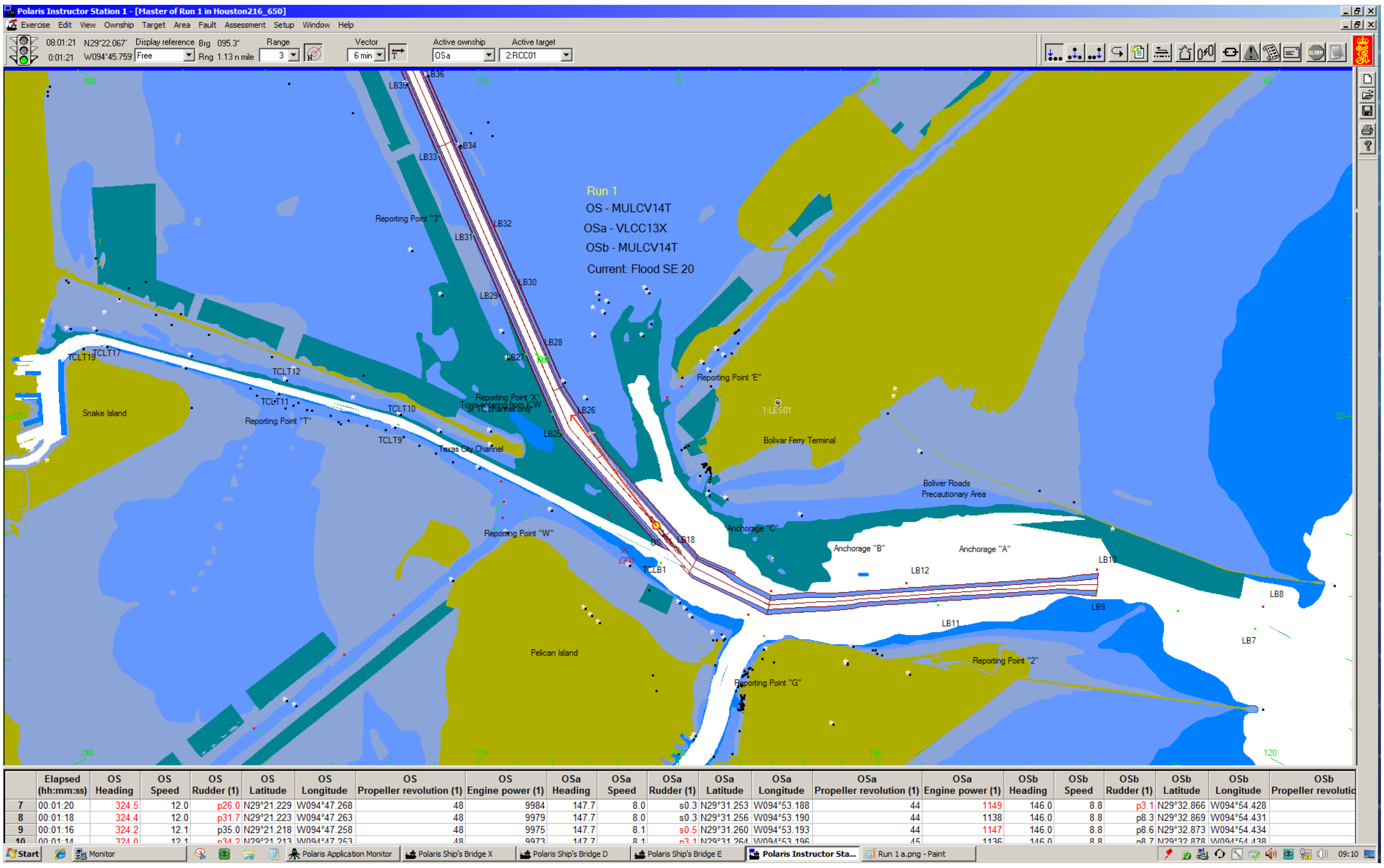

Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:01:21 N29°22.067' Display reference Free Brg 095.3° Rng 1.13 n mile Range 3 Vector 6 min Active ownship OSa Active target 2:RCC01

0:01:21 W094°45.759

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:01:20	324.5	12.0	p26.0	N29°21.229	W094°47.268	48	9984	147.7	8.0	s0.3	N29°31.253	W094°53.188	44	1149	146.0	8.8	p3.1	N29°32.866	W094°54.428	
8	00:01:18	324.4	12.0	p31.7	N29°21.223	W094°47.263	48	9979	147.7	8.0	s0.3	N29°31.256	W094°53.190	44	1138	146.0	8.8	p8.3	N29°32.869	W094°54.431	
9	00:01:16	324.2	12.1	p35.0	N29°21.218	W094°47.258	48	9975	147.7	8.1	s0.5	N29°31.260	W094°53.193	44	1147	146.0	8.8	p8.6	N29°32.873	W094°54.434	
10	00:01:14	324.0	12.1	p34.2	N29°21.213	W094°47.253	48	9973	147.7	8.1	p3.1	N29°31.264	W094°53.196	45	1136	146.0	8.8	p8.7	N29°32.878	W094°54.438	

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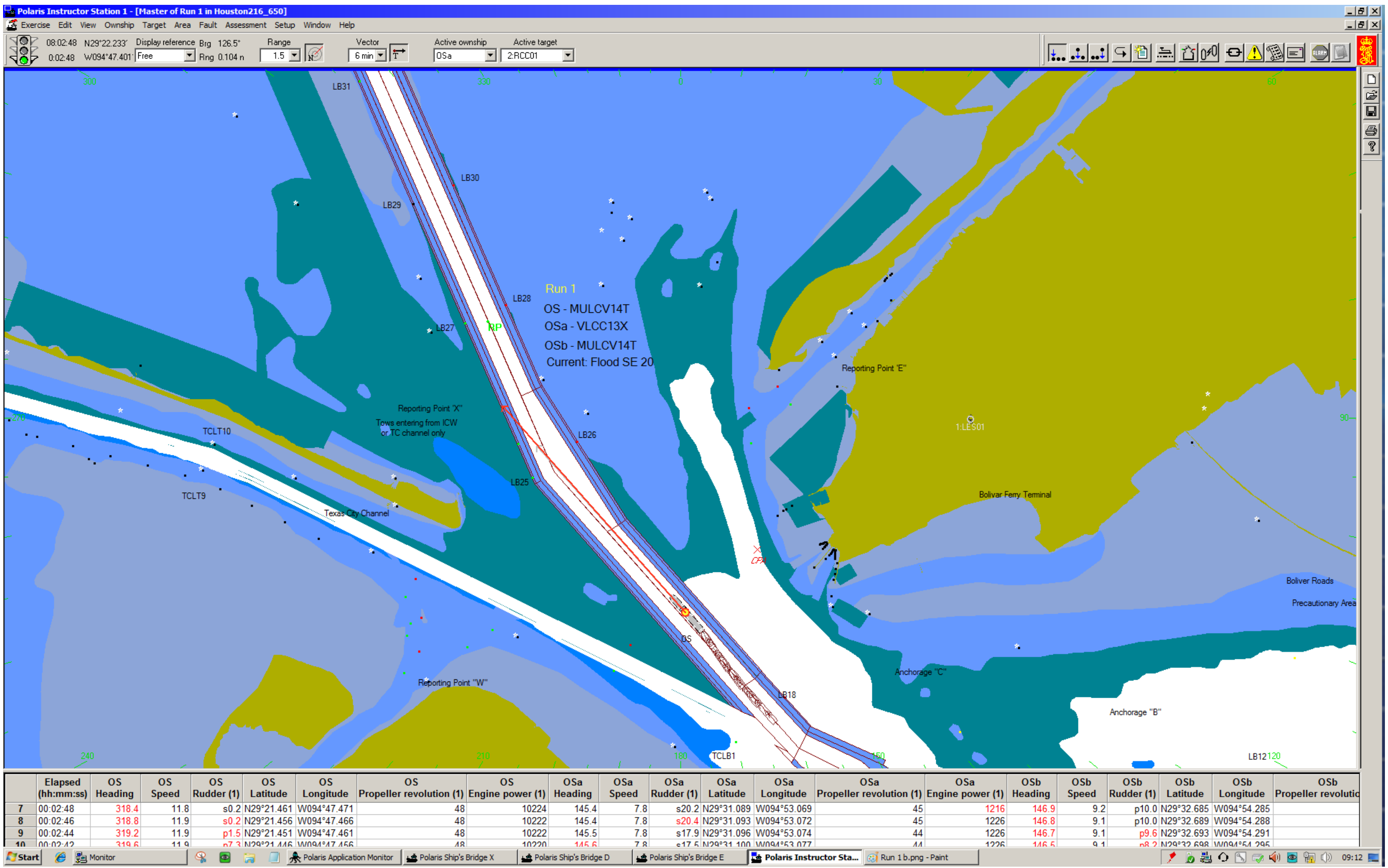
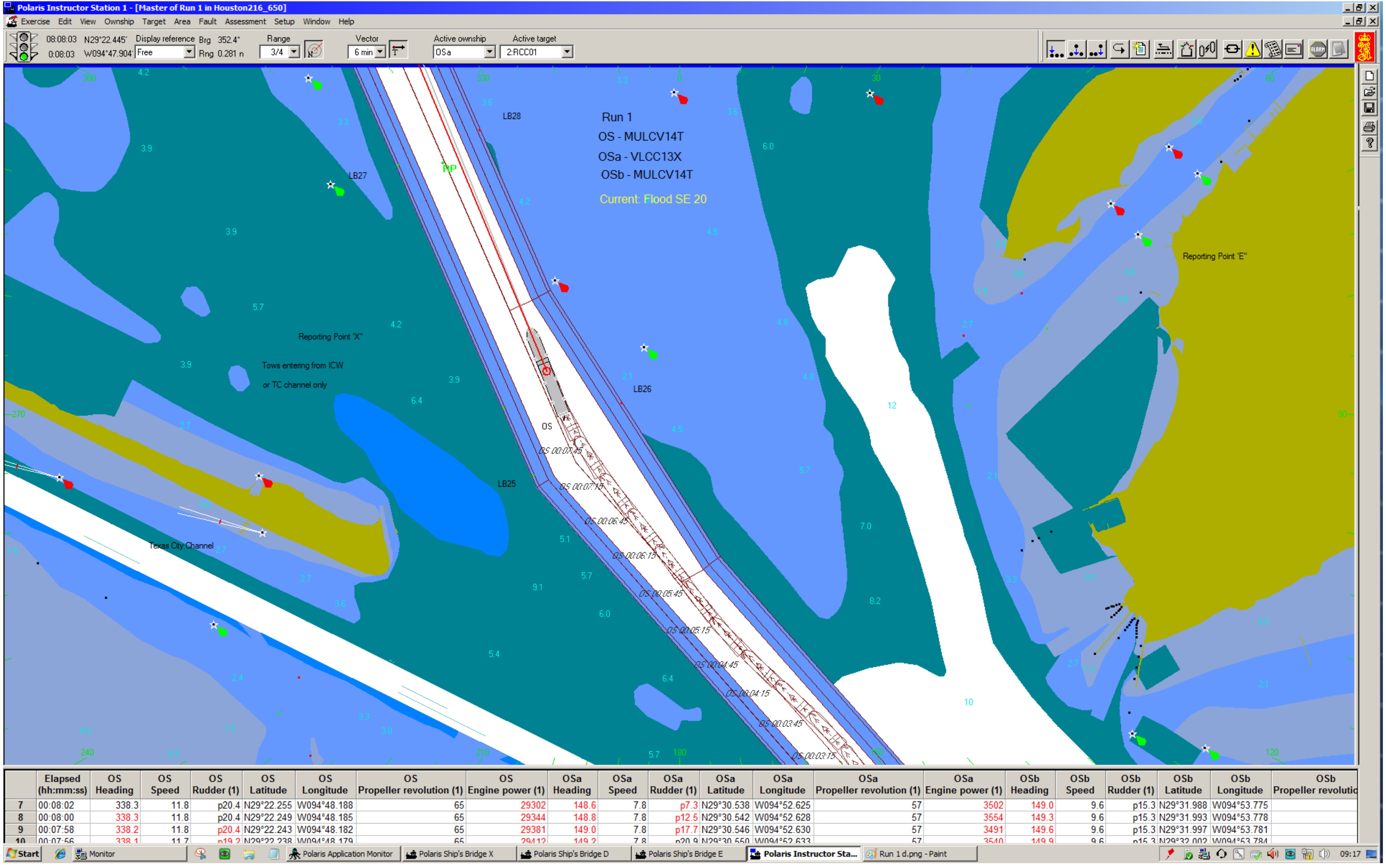


Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:02:48 N29°22.233' Display reference: Free Brg 126.5° Rng 0.104 n
0:02:48 W094°47.401'
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutic
7	00:02:48	318.4	11.8	s0.2	N29°21.461	W094°47.471	48	10224	145.4	7.8	s20.2	N29°31.089	W094°53.069	45	1216	146.9	9.2	p10.0	N29°32.685	W094°54.285	
8	00:02:46	318.8	11.9	s0.2	N29°21.456	W094°47.466	48	10222	145.4	7.8	s20.4	N29°31.093	W094°53.072	45	1226	146.8	9.1	p10.0	N29°32.689	W094°54.288	
9	00:02:44	319.2	11.9	p1.5	N29°21.451	W094°47.461	48	10222	145.5	7.8	s17.9	N29°31.096	W094°53.074	44	1226	146.7	9.1	p9.6	N29°32.693	W094°54.291	
10	00:02:42	319.6	11.9	p7.3	N29°21.446	W094°47.456	48	10220	145.6	7.8	s17.5	N29°31.100	W094°53.077	44	1226	146.5	9.1	p8.2	N29°32.698	W094°54.295	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:08:03 N29°22.445' Display reference: Free Brg 352.4° Rng 0.281 n
0:08:03 W094°47.904'
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutic
7	00:08:02	338.3	11.8	p20.4	N29°22.255	W094°48.188	65	29302	148.6	7.8	p7.3	N29°30.538	W094°52.625	57	3502	149.0	9.6	p15.3	N29°31.988	W094°53.775	
8	00:08:00	338.3	11.8	p20.4	N29°22.249	W094°48.185	65	29344	148.8	7.8	p12.5	N29°30.542	W094°52.628	57	3554	149.3	9.6	p15.3	N29°31.993	W094°53.778	
9	00:07:58	338.2	11.8	p20.4	N29°22.243	W094°48.182	65	29381	149.0	7.8	p17.7	N29°30.546	W094°52.630	57	3491	149.6	9.6	p15.3	N29°31.997	W094°53.781	
10	00:07:56	338.1	11.7	p19.2	N29°22.238	W094°48.179	65	29412	149.2	7.8	p20.9	N29°30.550	W094°52.633	57	3540	149.9	9.6	p15.3	N29°32.002	W094°53.784	

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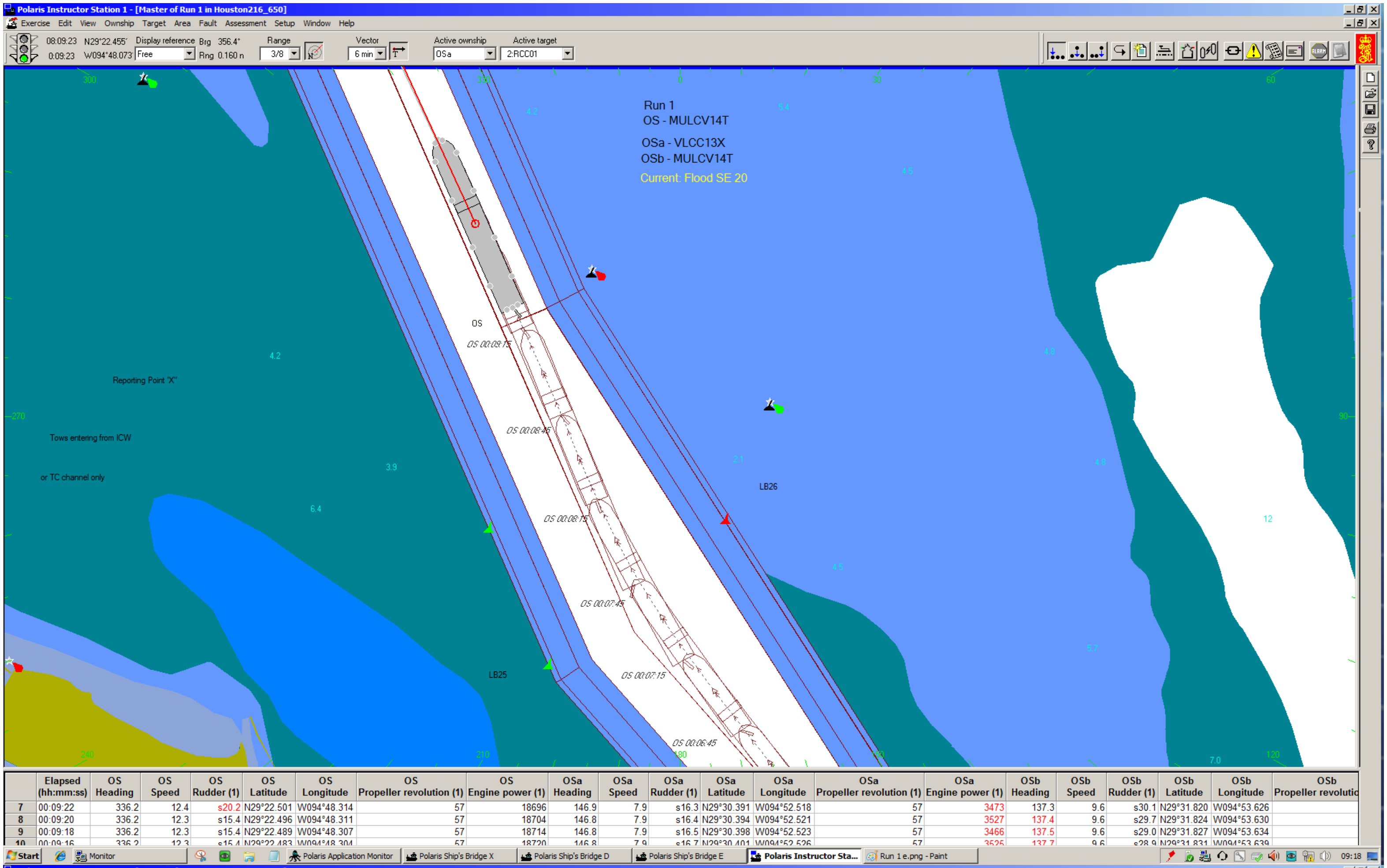
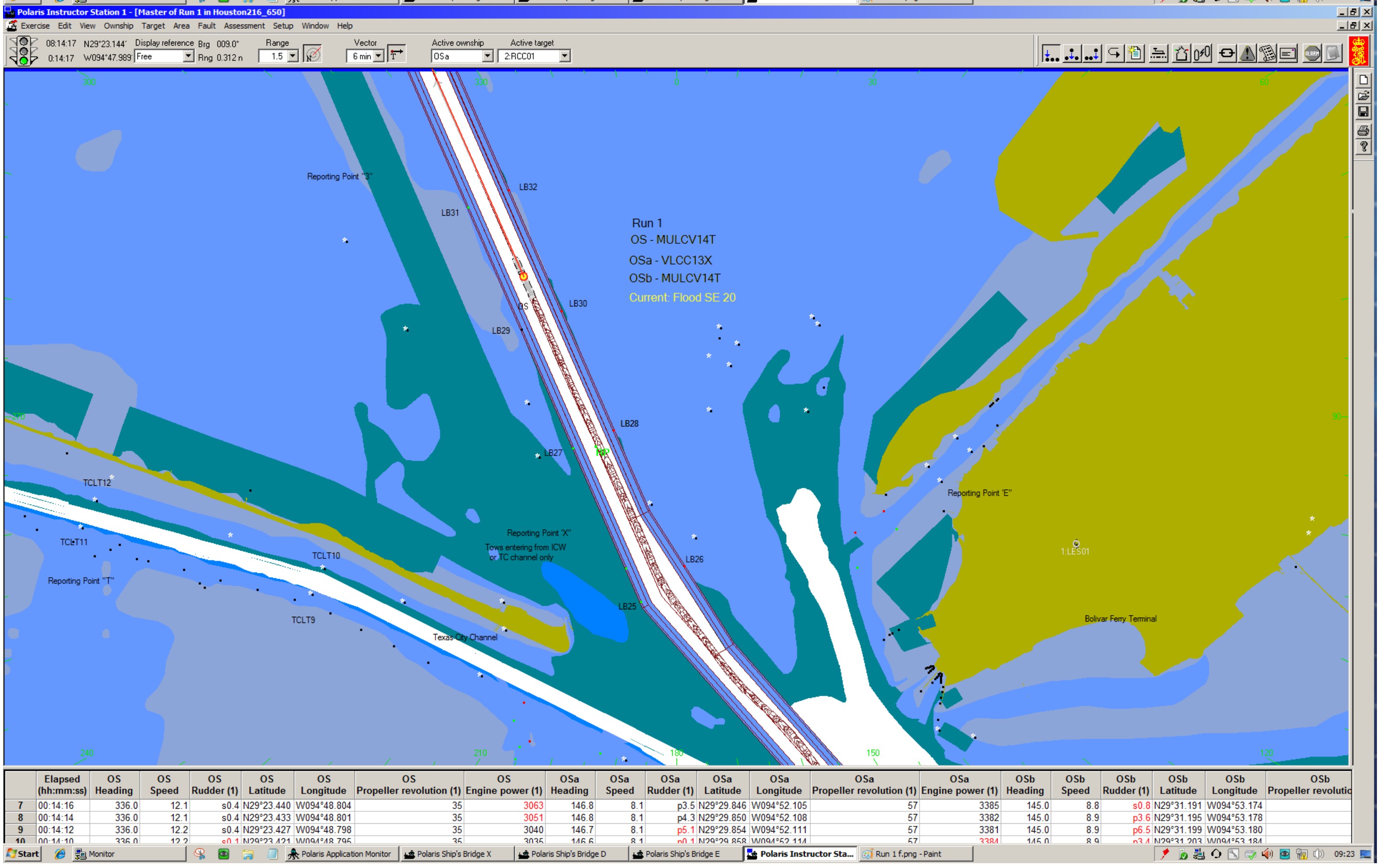


Run 1
OS - MULCV14T

OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:09:22	336.2	12.4	s20.2	N29°22.501	W094°48.314	57	18696	146.9	7.9	s16.3	N29°30.391	W094°52.518	57	3473	137.3	9.6	s30.1	N29°31.820	W094°53.626	
8	00:09:20	336.2	12.3	s15.4	N29°22.496	W094°48.311	57	18704	146.8	7.9	s16.4	N29°30.394	W094°52.521	57	3527	137.4	9.6	s29.7	N29°31.824	W094°53.630	
9	00:09:18	336.2	12.3	s15.4	N29°22.489	W094°48.307	57	18714	146.8	7.9	s16.5	N29°30.398	W094°52.523	57	3466	137.5	9.6	s29.0	N29°31.827	W094°53.634	
10	00:09:16	336.2	12.3	s15.4	N29°22.483	W094°48.304	57	18720	146.8	7.9	s16.7	N29°30.401	W094°52.526	57	3525	137.7	9.6	s28.9	N29°31.831	W094°53.639	



Run 1
OS - MULCV14T

OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:14:16	336.0	12.1	s0.4	N29°23.440	W094°48.804	35	3063	146.8	8.1	p3.5	N29°29.846	W094°52.105	57	3385	145.0	8.8	s0.8	N29°31.191	W094°53.174	
8	00:14:14	336.0	12.1	s0.4	N29°23.433	W094°48.801	35	3051	146.8	8.1	p4.3	N29°29.850	W094°52.108	57	3382	145.0	8.9	p3.6	N29°31.195	W094°53.178	
9	00:14:12	336.0	12.2	s0.4	N29°23.427	W094°48.798	35	3040	146.7	8.1	p5.1	N29°29.854	W094°52.111	57	3381	145.0	8.9	p6.5	N29°31.199	W094°53.180	
10	00:14:10	336.0	12.2	s0.1	N29°23.421	W094°48.795	35	3035	146.6	8.1	p0.1	N29°29.858	W094°52.114	57	3384	145.0	8.9	p3.4	N29°31.203	W094°53.184	

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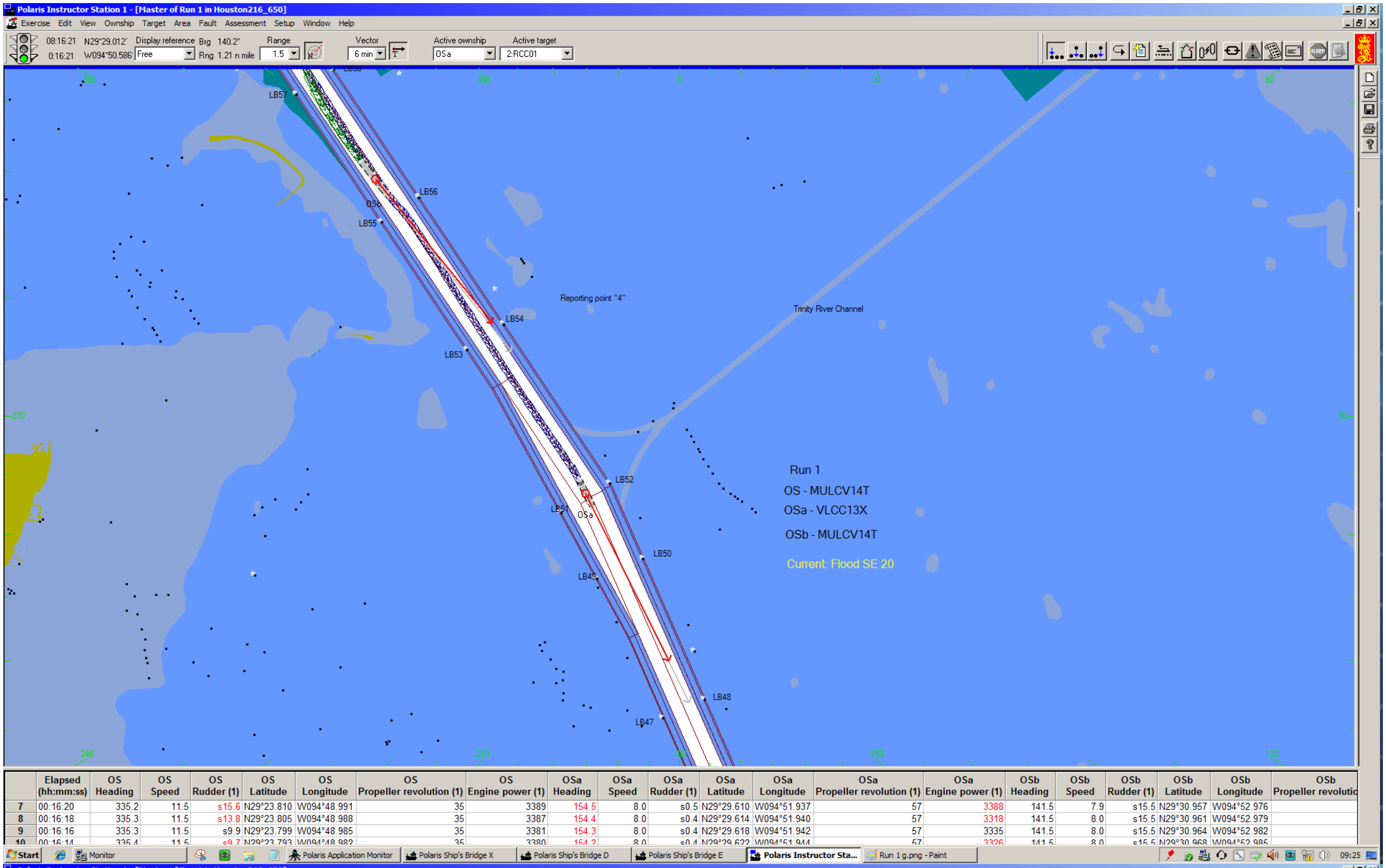
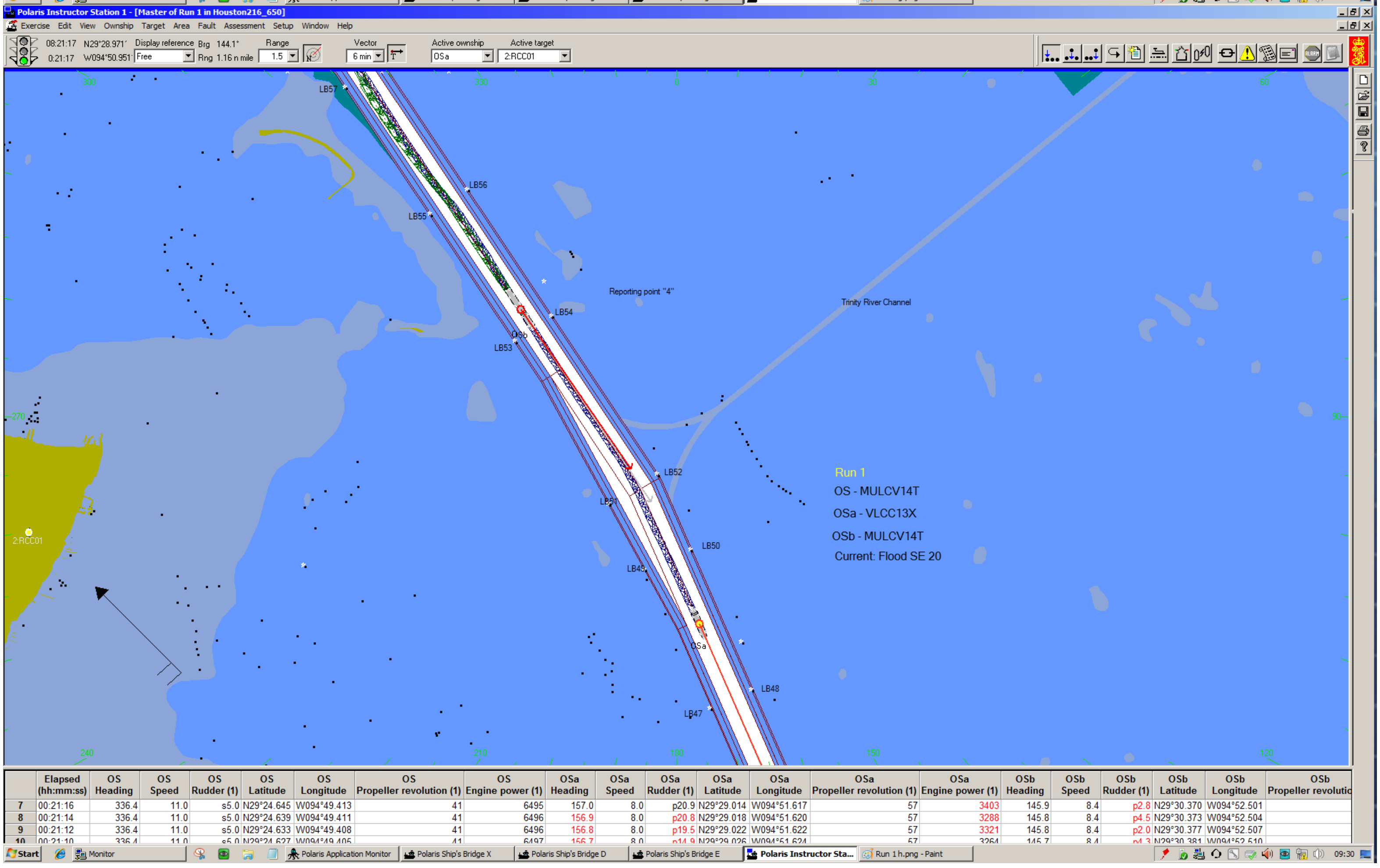


Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:16:21 N29°29.012' 0:16:21 W094°50.586'
Display reference: Free
Brg 140.2°
Rng 1.21 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:16:20	335.2	11.5	s15.6	N29°23.810	W094°48.991	35	3389	154.5	8.0	s0.5	N29°29.610	W094°51.937	57	3388	141.5	7.9	s15.5	N29°30.957	W094°52.976	
8	00:16:18	335.3	11.5	s13.8	N29°23.805	W094°48.988	35	3387	154.4	8.0	s0.4	N29°29.614	W094°51.940	57	3318	141.5	8.0	s15.5	N29°30.961	W094°52.979	
9	00:16:16	335.3	11.5	s9.9	N29°23.799	W094°48.985	35	3381	154.3	8.0	s0.4	N29°29.618	W094°51.942	57	3335	141.5	8.0	s15.5	N29°30.964	W094°52.982	
10	00:16:14	335.4	11.5	s9.7	N29°23.793	W094°48.982	35	3380	154.2	8.0	s0.4	N29°29.622	W094°51.944	57	3326	141.5	8.0	s15.5	N29°30.968	W094°52.985	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:21:17 N29°28.971' 0:21:17 W094°50.951'
Display reference: Free
Brg 144.1°
Rng 1.16 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:21:16	336.4	11.0	s5.0	N29°24.645	W094°49.413	41	6495	157.0	8.0	p20.9	N29°29.014	W094°51.617	57	3403	145.9	8.4	p2.8	N29°30.370	W094°52.501	
8	00:21:14	336.4	11.0	s5.0	N29°24.639	W094°49.411	41	6496	156.9	8.0	p20.8	N29°29.018	W094°51.620	57	3288	145.8	8.4	p4.5	N29°30.373	W094°52.504	
9	00:21:12	336.4	11.0	s5.0	N29°24.633	W094°49.408	41	6496	156.8	8.0	p19.5	N29°29.022	W094°51.622	57	3321	145.8	8.4	p2.0	N29°30.377	W094°52.507	
10	00:21:10	336.4	11.0	s5.0	N29°24.627	W094°49.405	41	6497	156.7	8.0	p14.9	N29°29.026	W094°51.624	57	3264	145.7	8.4	p4.3	N29°30.381	W094°52.510	

Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:25:51 N29°29.663' Display reference: Free Brg 079.4°
0:25:51 W094°51.550' Rng 0.287 n
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1

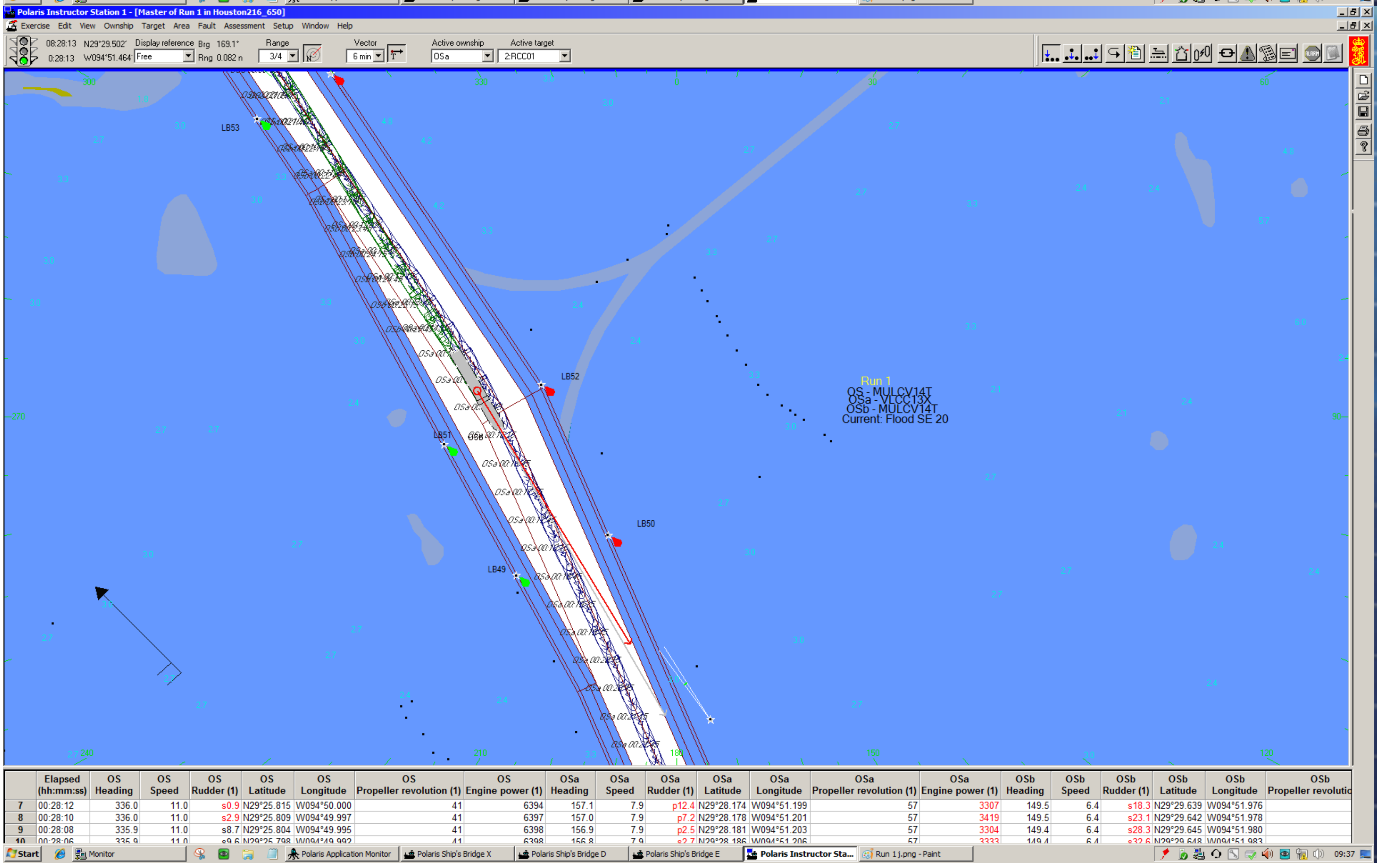
OS - MULCV14T

OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:25:50	336.3	11.1	s0.2	N29°25.415	W094°49.802	41	6397	156.7	7.9	s12.2	N29°28.460	W094°51.342	57	3300	147.4	7.2	s0.4	N29°29.860	W094°52.139	
8	00:25:48	336.3	11.1	s0.2	N29°25.410	W094°49.799	41	6398	156.7	7.9	s17.4	N29°28.464	W094°51.344	57	3285	147.4	7.2	s0.5	N29°29.864	W094°52.141	
9	00:25:46	336.2	11.1	s0.2	N29°25.404	W094°49.796	41	6399	156.6	7.9	s21.3	N29°28.468	W094°51.347	57	3281	147.4	7.2	s0.5	N29°29.867	W094°52.143	
10	00:25:44	336.2	11.1	s0.2	N29°25.398	W094°49.793	41	6397	156.6	7.9	s18.8	N29°28.472	W094°51.349	57	3398	147.5	7.3	s0.5	N29°29.870	W094°52.146	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:28:13 N29°29.502' Display reference: Free Brg 169.1°
0:28:13 W094°51.464' Rng 0.082 n
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:28:12	336.0	11.0	s0.9	N29°25.815	W094°50.000	41	6394	157.1	7.9	p12.4	N29°28.174	W094°51.199	57	3307	149.5	6.4	s18.3	N29°29.639	W094°51.976	
8	00:28:10	336.0	11.0	s2.9	N29°25.809	W094°49.997	41	6397	157.0	7.9	p7.2	N29°28.178	W094°51.201	57	3419	149.5	6.4	s23.1	N29°29.642	W094°51.978	
9	00:28:08	335.9	11.0	s8.7	N29°25.804	W094°49.995	41	6398	156.9	7.9	p2.5	N29°28.181	W094°51.203	57	3304	149.4	6.4	s28.3	N29°29.645	W094°51.980	
10	00:28:06	335.9	11.0	s9.6	N29°25.798	W094°49.992	41	6398	156.8	7.9	s2.7	N29°28.186	W094°51.206	57	3333	149.4	6.4	s32.6	N29°29.648	W094°51.983	

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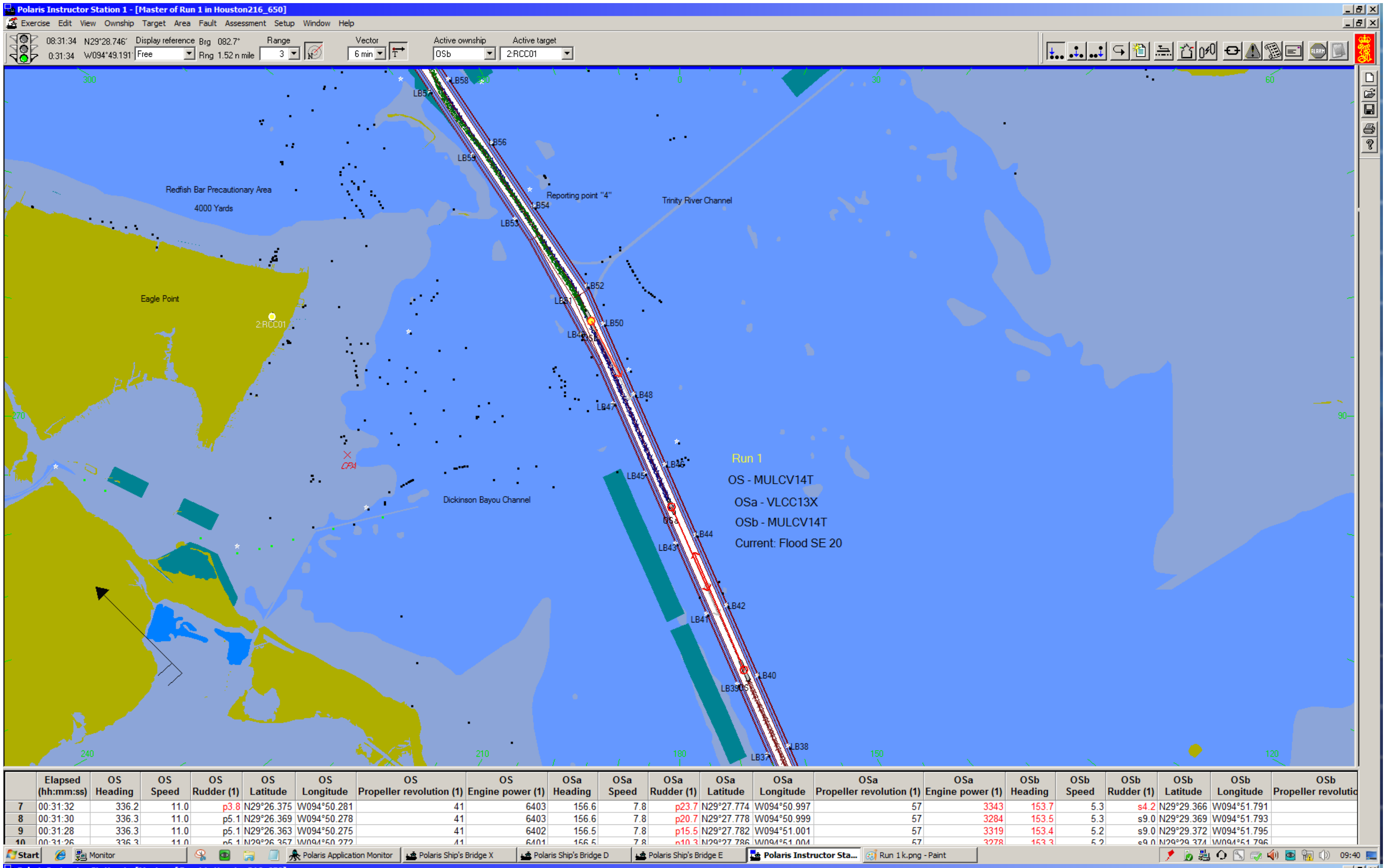


Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:31:34 N29°28.746´
0:31:34 W094°49.191´
Display reference: Free
Brg 082.7°
Rng 1.52 n mile
Range: 3
Vector: 6 min
Active ownship: OSb
Active target: 2:RCC01

Run 1

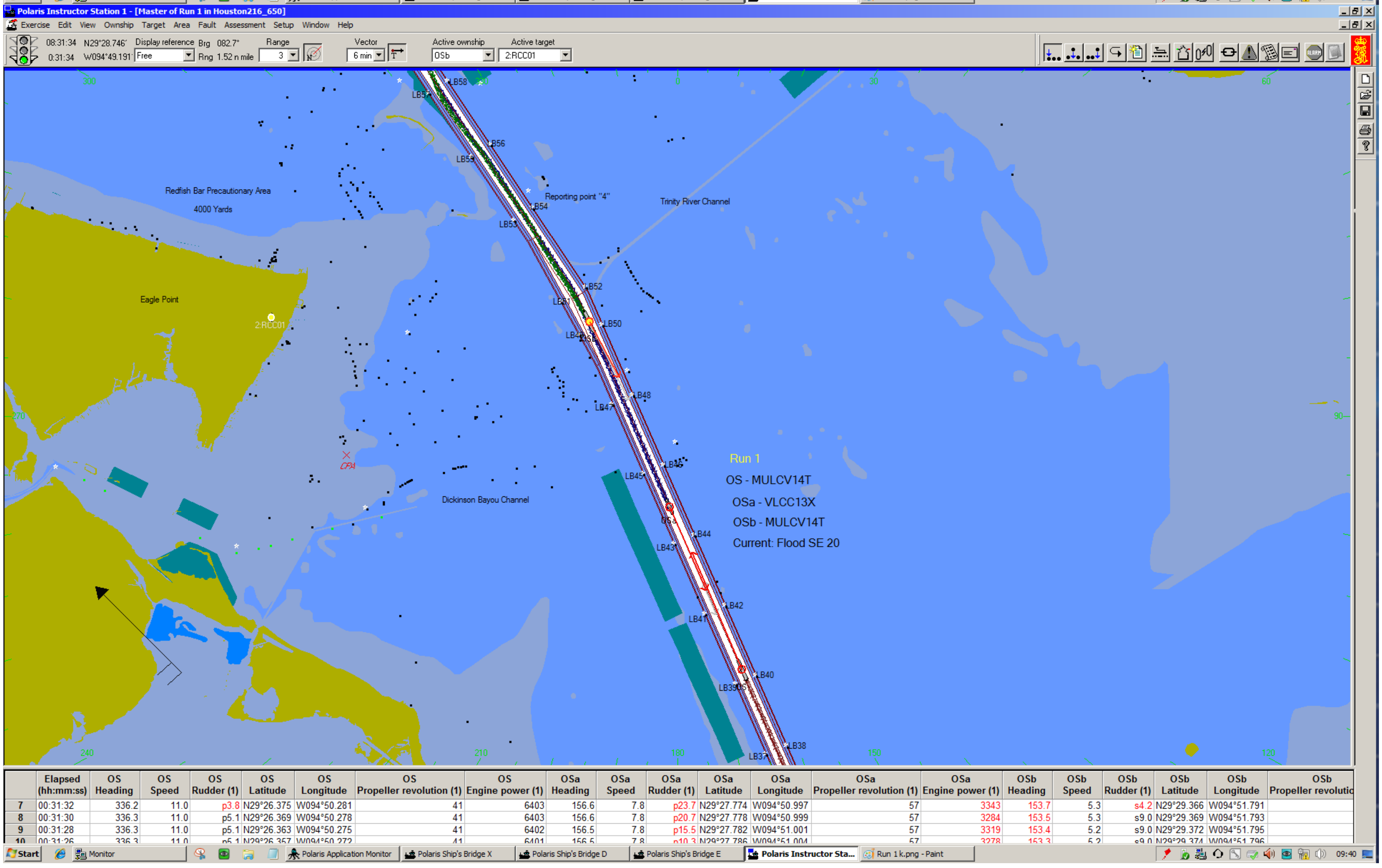
OS - MULCV14T

OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:31:32	336.2	11.0	p3.8	N29°26.375	W094°50.281	41	6403	156.6	7.8	p23.7	N29°27.774	W094°50.997	57	3343	153.7	5.3	s4.2	N29°29.366	W094°51.791	
8	00:31:30	336.3	11.0	p5.1	N29°26.369	W094°50.278	41	6403	156.6	7.8	p20.7	N29°27.778	W094°50.999	57	3284	153.5	5.3	s9.0	N29°29.369	W094°51.793	
9	00:31:28	336.3	11.0	p5.1	N29°26.363	W094°50.275	41	6402	156.5	7.8	p15.5	N29°27.782	W094°51.001	57	3319	153.4	5.2	s9.0	N29°29.372	W094°51.795	
10	00:31:26	336.3	11.0	p5.1	N29°26.357	W094°50.272	41	6401	156.5	7.8	p10.3	N29°27.786	W094°51.004	57	3278	153.3	5.2	s9.0	N29°29.374	W094°51.796	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:31:34 N29°28.746´
0:31:34 W094°49.191´
Display reference: Free
Brg 082.7°
Rng 1.52 n mile
Range: 3
Vector: 6 min
Active ownship: OSb
Active target: 2:RCC01

Run 1

OS - MULCV14T

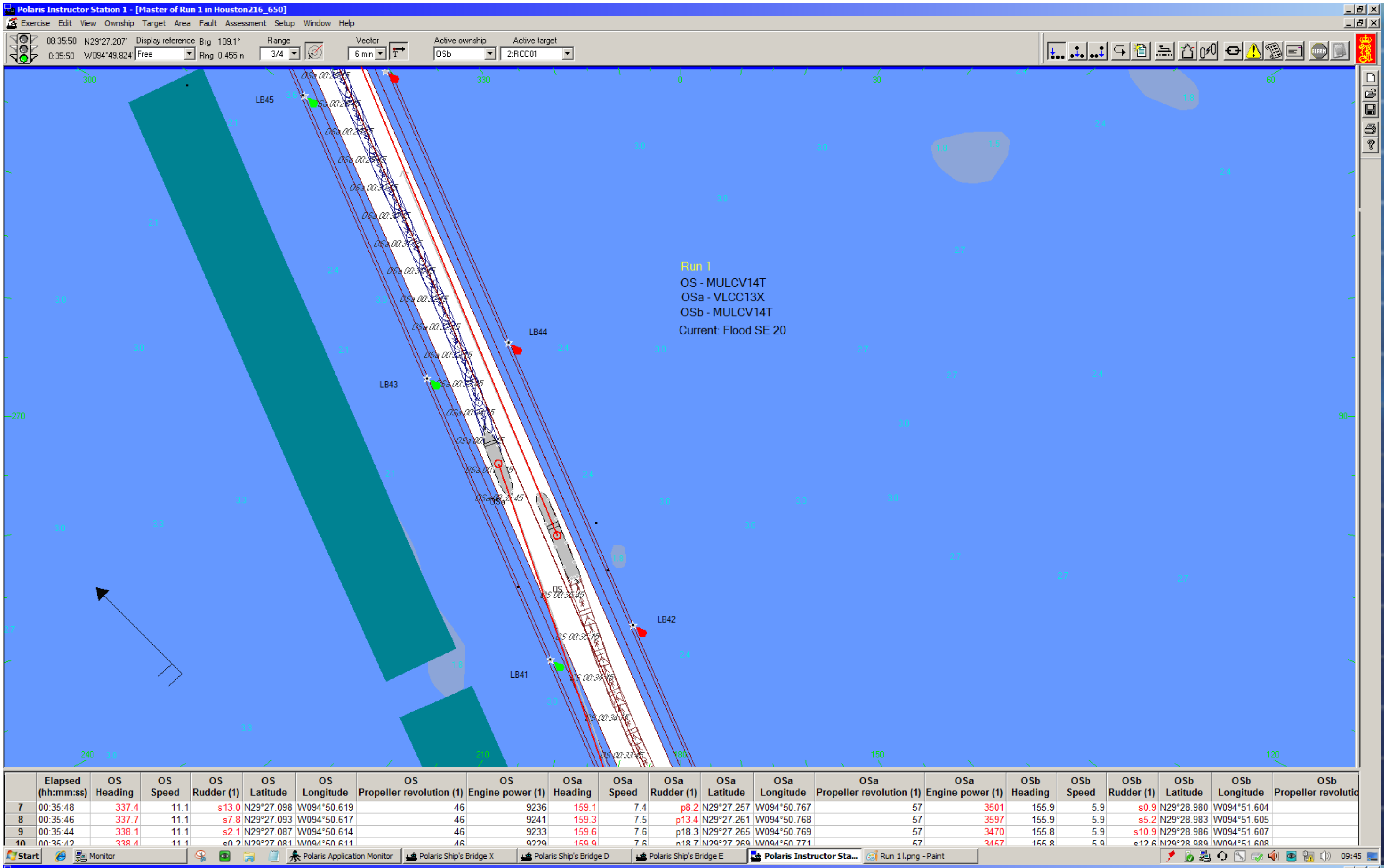
OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

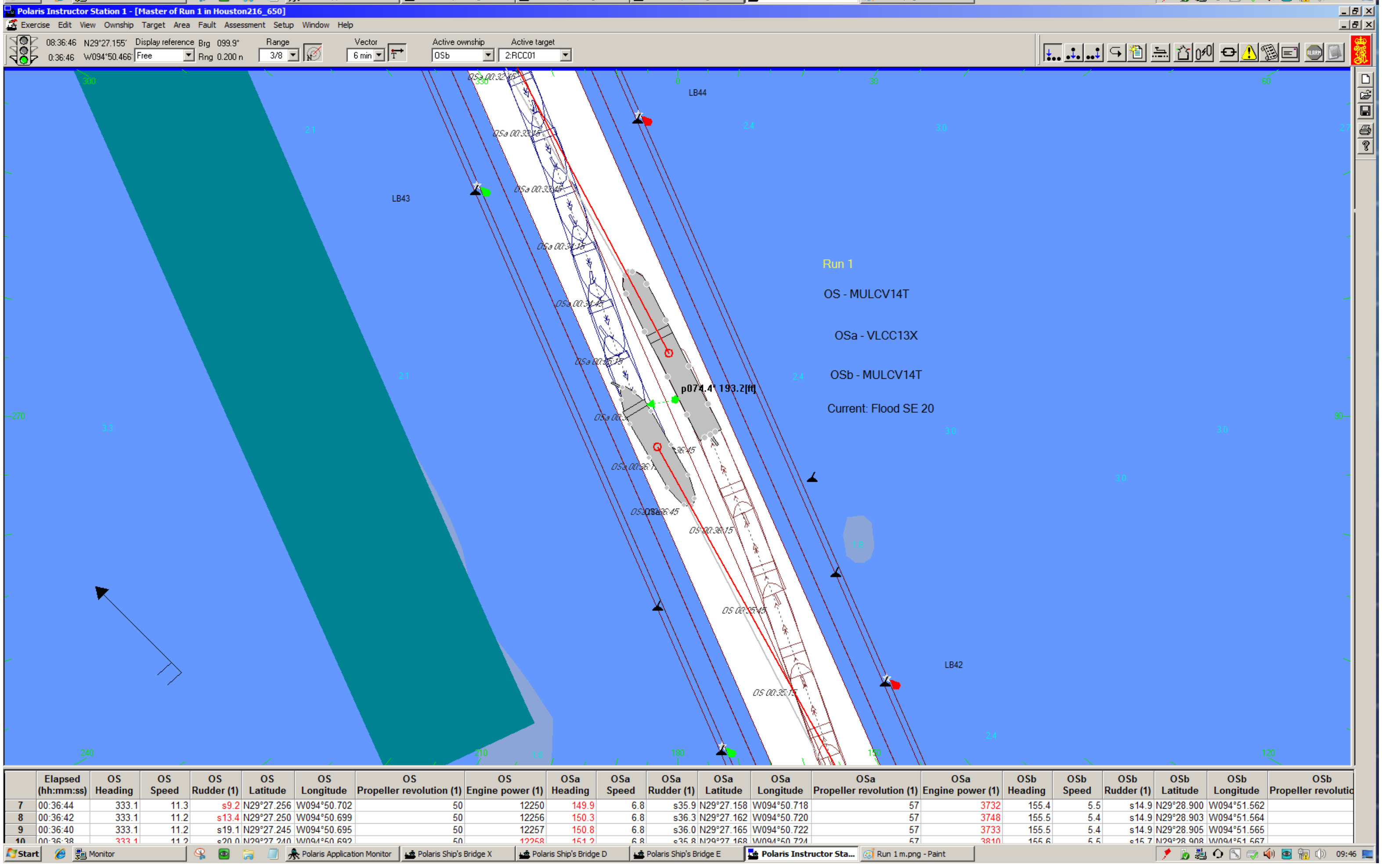
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:31:32	336.2	11.0	p3.8	N29°26.375	W094°50.281	41	6403	156.6	7.8	p23.7	N29°27.774	W094°50.997	57	3343	153.7	5.3	s4.2	N29°29.366	W094°51.791	
8	00:31:30	336.3	11.0	p5.1	N29°26.369	W094°50.278	41	6403	156.6	7.8	p20.7	N29°27.778	W094°50.999	57	3284	153.5	5.3	s9.0	N29°29.369	W094°51.793	
9	00:31:28	336.3	11.0	p5.1	N29°26.363	W094°50.275	41	6402	156.5	7.8	p15.5	N29°27.782	W094°51.001	57	3319	153.4	5.2	s9.0	N29°29.372	W094°51.795	
10	00:31:26	336.3	11.0	p5.1	N29°26.357	W094°50.272	41	6401	156.5	7.8	p10.3	N29°27.786	W094°51.004	57	3278	153.3	5.2	s9.0	N29°29.374	W094°51.796	

June 26, 2019



Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:35:48	337.4	11.1	s13.0	N29°27.098	W094°50.619	46	9236	159.1	7.4	p8.2	N29°27.257	W094°50.767	57	3501	155.9	5.9	s0.9	N29°28.980	W094°51.604	
8	00:35:46	337.7	11.1	s7.8	N29°27.093	W094°50.617	46	9241	159.3	7.5	p13.4	N29°27.261	W094°50.768	57	3597	155.9	5.9	s5.2	N29°28.983	W094°51.605	
9	00:35:44	338.1	11.1	s2.1	N29°27.087	W094°50.614	46	9233	159.6	7.6	p18.3	N29°27.265	W094°50.769	57	3470	155.8	5.9	s10.9	N29°28.986	W094°51.607	
10	00:35:42	338.4	11.1	s0.2	N29°27.081	W094°50.611	46	9229	159.9	7.6	p18.7	N29°27.269	W094°50.771	57	3457	155.8	5.9	s12.6	N29°28.989	W094°51.608	



Run 1

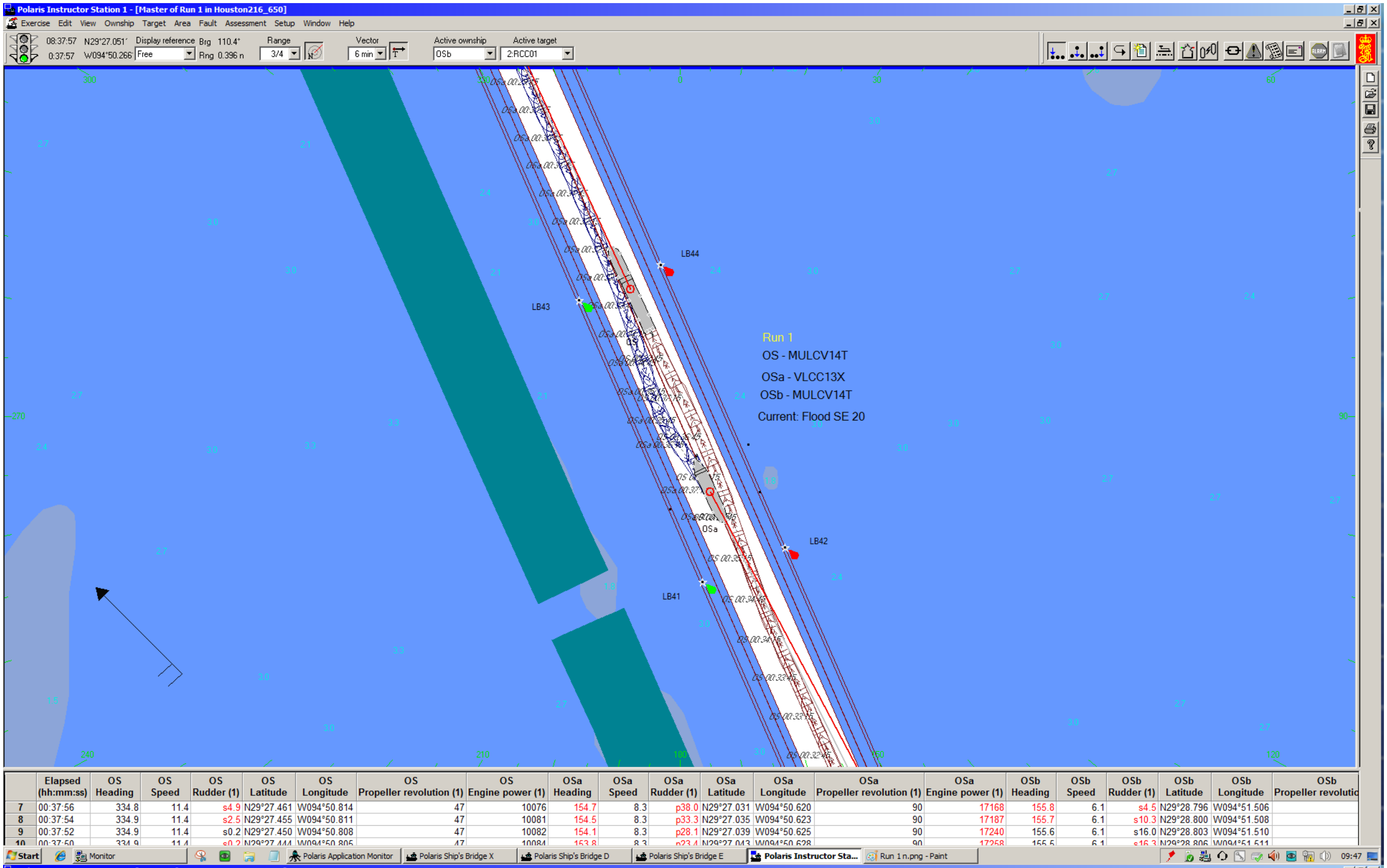
OS - MULCV14T

OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:36:44	333.1	11.3	s9.2	N29°27.256	W094°50.702	50	12250	149.9	6.8	s35.9	N29°27.158	W094°50.718	57	3732	155.4	5.5	s14.9	N29°28.900	W094°51.562	
8	00:36:42	333.1	11.2	s13.4	N29°27.250	W094°50.699	50	12256	150.3	6.8	s36.3	N29°27.162	W094°50.720	57	3748	155.5	5.4	s14.9	N29°28.903	W094°51.564	
9	00:36:40	333.1	11.2	s19.1	N29°27.245	W094°50.695	50	12257	150.8	6.8	s36.0	N29°27.165	W094°50.722	57	3733	155.5	5.4	s14.9	N29°28.905	W094°51.565	
10	00:36:38	333.1	11.2	s20.0	N29°27.240	W094°50.692	50	12258	151.2	6.8	s35.8	N29°27.168	W094°50.724	57	3810	155.6	5.5	s15.7	N29°28.908	W094°51.567	



08:37:57 N29°27.051′ Display reference: Free Brg 110.4° Range: 3/4 Vector: 6 min Active ownship: OSb Active target: 2:RCC01

0:37:57 W094°50.266′ Rng 0.396 n

Run 1

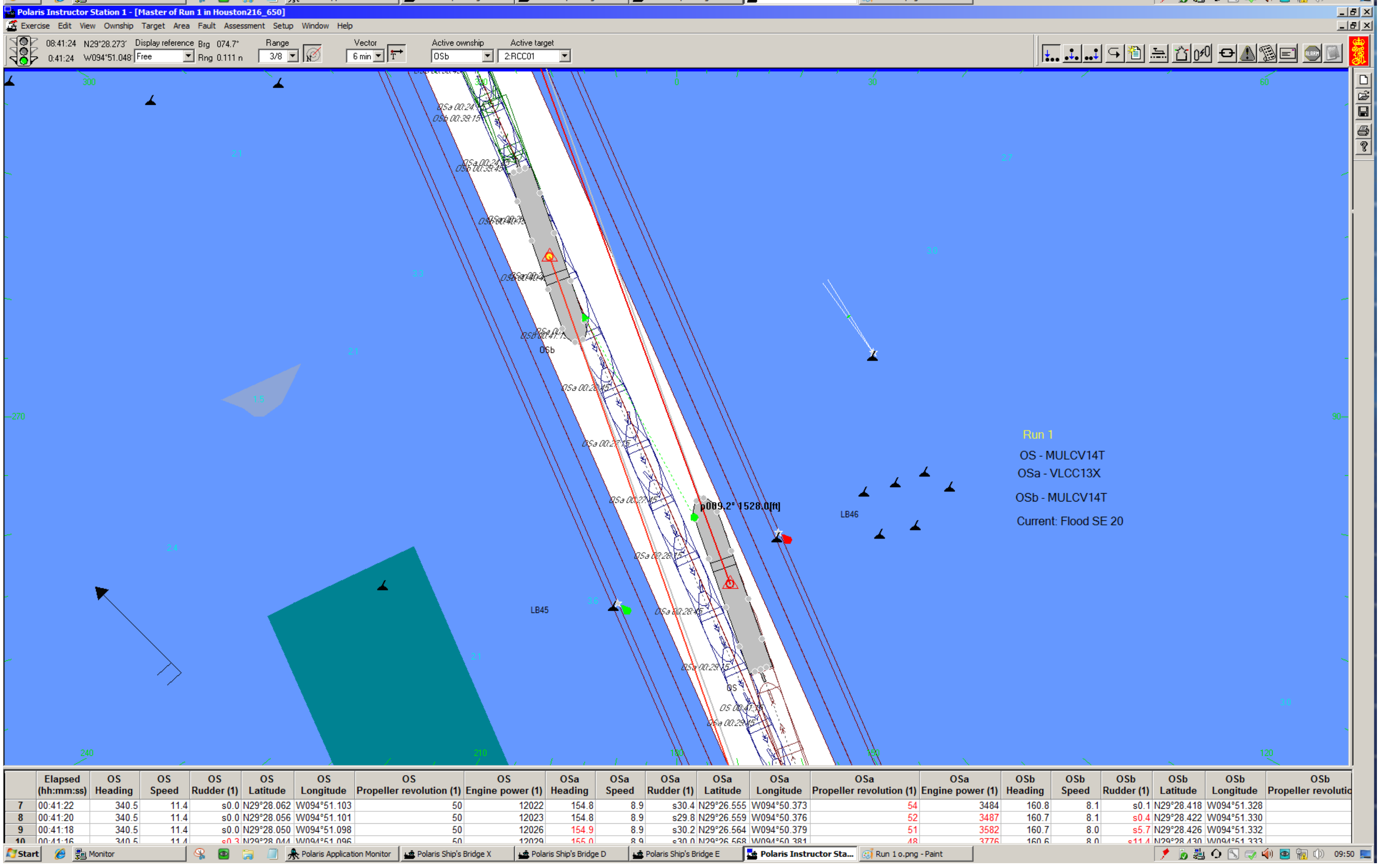
OS - MULCV14T

OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:37:56	334.8	11.4	s4.9	N29°27.461	W094°50.814	47	10076	154.7	8.3	p38.0	N29°27.031	W094°50.620	90	17168	155.8	6.1	s4.5	N29°28.796	W094°51.506	
8	00:37:54	334.9	11.4	s2.5	N29°27.455	W094°50.811	47	10081	154.5	8.3	p33.3	N29°27.035	W094°50.623	90	17187	155.7	6.1	s10.3	N29°28.800	W094°51.508	
9	00:37:52	334.9	11.4	s0.2	N29°27.450	W094°50.808	47	10082	154.1	8.3	p28.1	N29°27.039	W094°50.625	90	17240	155.6	6.1	s16.0	N29°28.803	W094°51.510	
10	00:37:50	334.9	11.4	s0.2	N29°27.444	W094°50.805	47	10084	153.8	8.3	p23.4	N29°27.043	W094°50.628	90	17258	155.5	6.1	s16.3	N29°28.806	W094°51.511	



08:41:24 N29°28.273′ Display reference: Free Brg 074.7° Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 2:RCC01

0:41:24 W094°51.048′ Rng 0.111 n

Run 1

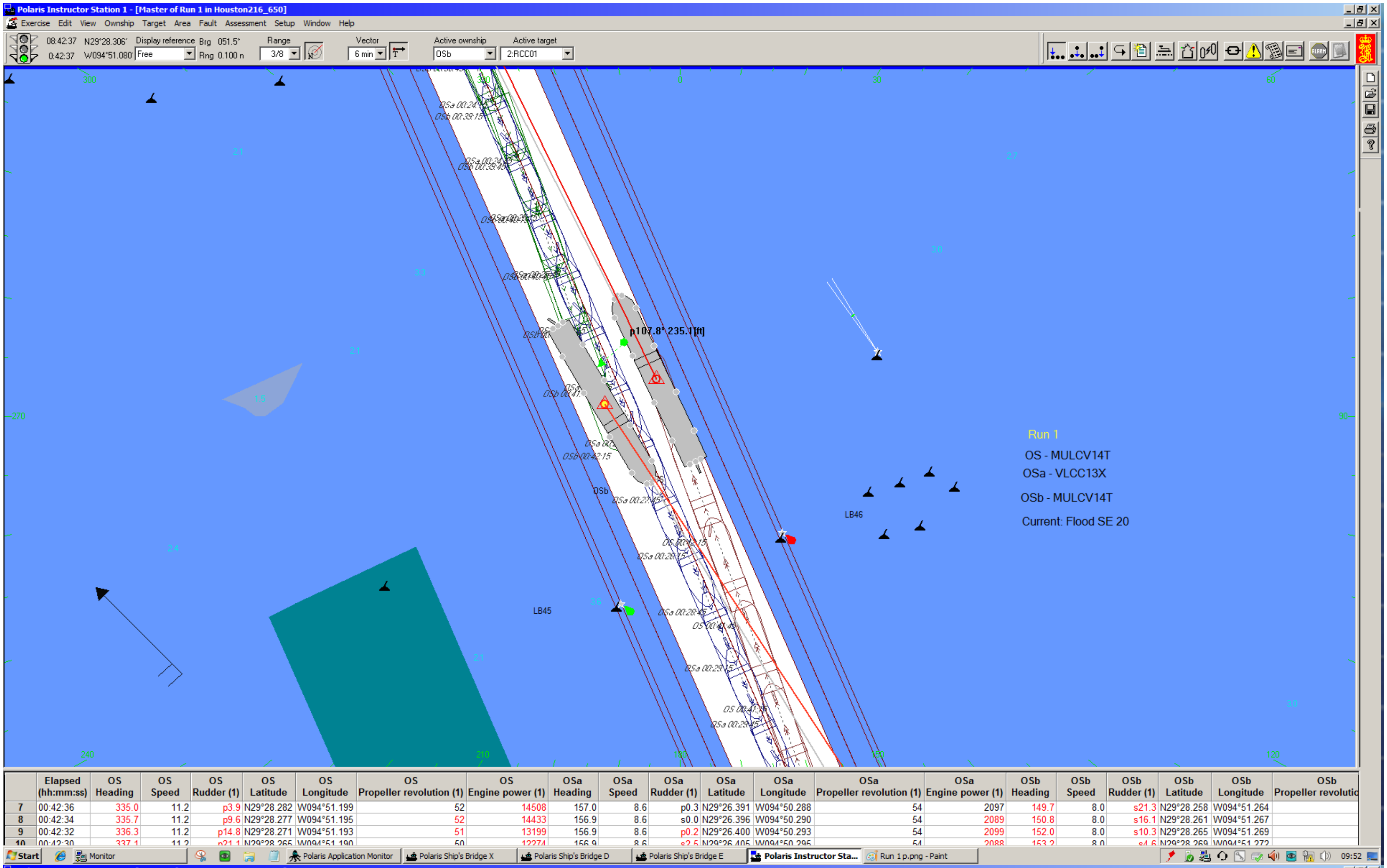
OS - MULCV14T

OSa - VLCC13X

OSb - MULCV14T

Current: Flood SE 20

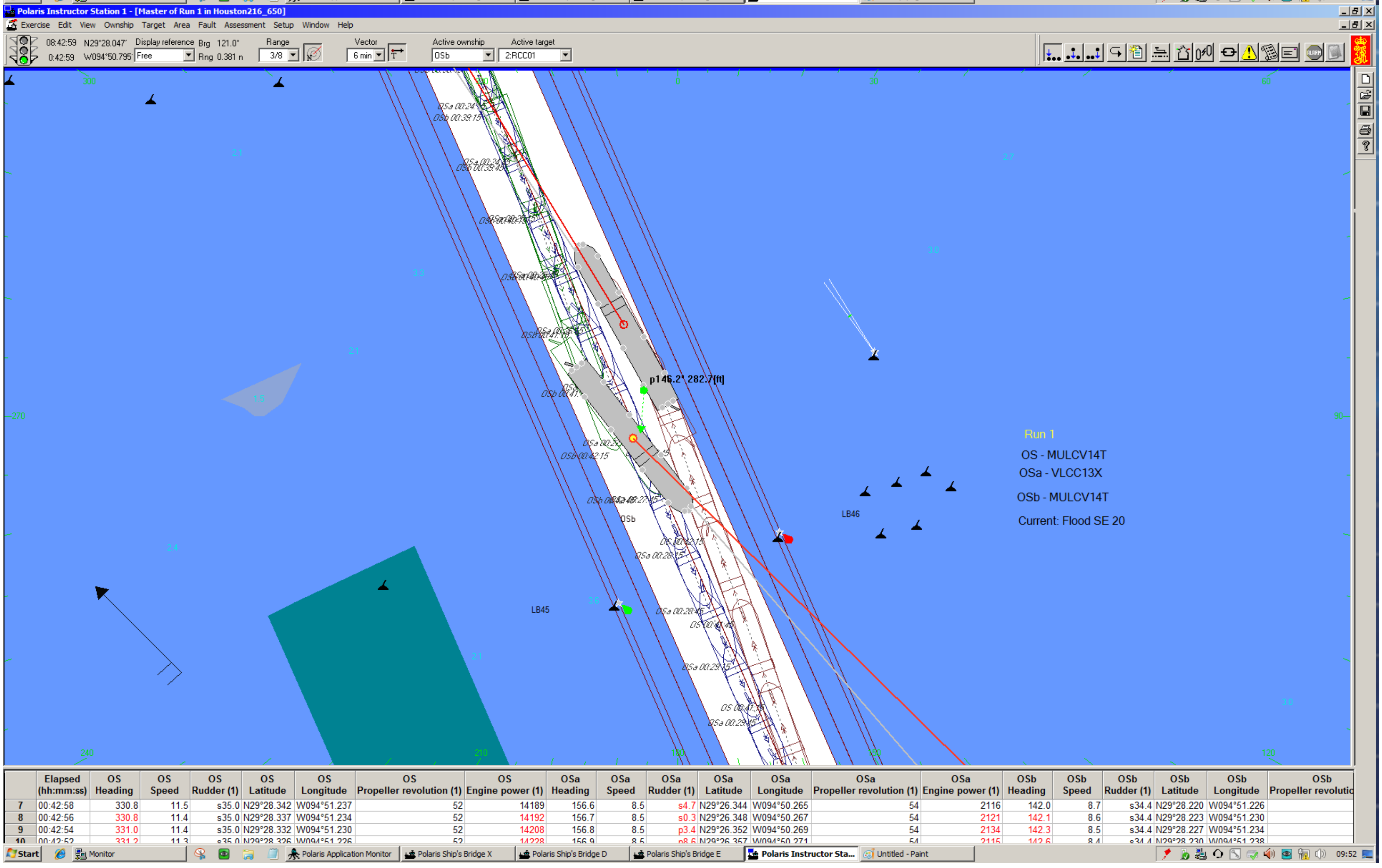
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:41:22	340.5	11.4	s0.0	N29°28.062	W094°51.103	50	12022	154.8	8.9	s30.4	N29°26.555	W094°50.373	54	3484	160.8	8.1	s0.1	N29°28.418	W094°51.328	
8	00:41:20	340.5	11.4	s0.0	N29°28.056	W094°51.101	50	12023	154.8	8.9	s29.8	N29°26.559	W094°50.376	52	3487	160.7	8.1	s0.4	N29°28.422	W094°51.330	
9	00:41:18	340.5	11.4	s0.0	N29°28.050	W094°51.098	50	12026	154.9	8.9	s30.2	N29°26.564	W094°50.379	51	3582	160.7	8.0	s5.7	N29°28.426	W094°51.332	
10	00:41:16	340.5	11.4	s0.3	N29°28.044	W094°51.096	50	12029	155.0	8.9	s30.0	N29°26.568	W094°50.381	48	3776	160.6	8.0	s11.4	N29°28.430	W094°51.333	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:42:37 N29°28.306′ Display reference Free Brg 051.5° Rng 0.100 n Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01
0:42:37 W094°51.080′

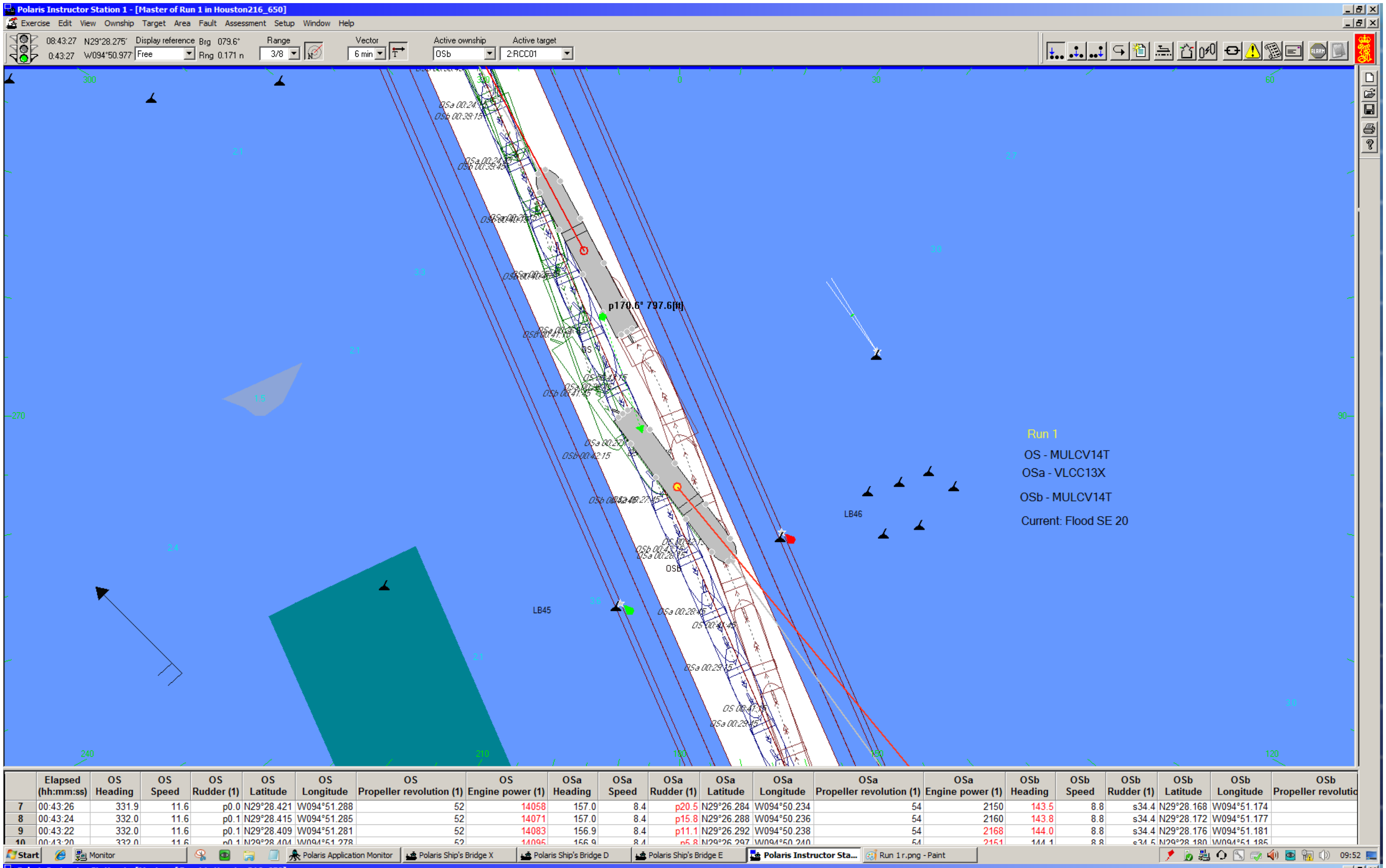
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutic
7	00:42:36	335.0	11.2	p3.9	N29°28.282	W094°51.199	52	14508	157.0	8.6	p0.3	N29°26.391	W094°50.288	54	2097	149.7	8.0	s21.3	N29°28.258	W094°51.264	
8	00:42:34	335.7	11.2	p9.6	N29°28.277	W094°51.195	52	14433	156.9	8.6	s0.0	N29°26.396	W094°50.290	54	2089	150.8	8.0	s16.1	N29°28.261	W094°51.267	
9	00:42:32	336.3	11.2	p14.8	N29°28.271	W094°51.193	51	13199	156.9	8.6	p0.2	N29°26.400	W094°50.293	54	2099	152.0	8.0	s10.3	N29°28.265	W094°51.269	
10	00:42:30	337.1	11.2	p21.1	N29°28.265	W094°51.190	50	12274	156.9	8.6	s2.5	N29°26.405	W094°50.295	54	2088	153.2	8.0	s4.6	N29°28.269	W094°51.272	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:42:59 N29°28.047′ Display reference Free Brg 121.0° Rng 0.381 n Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01
0:42:59 W094°50.795′

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutic
7	00:42:58	330.8	11.5	s35.0	N29°28.342	W094°51.237	52	14189	156.6	8.5	s4.7	N29°26.344	W094°50.265	54	2116	142.0	8.7	s34.4	N29°28.220	W094°51.226	
8	00:42:56	330.8	11.4	s35.0	N29°28.337	W094°51.234	52	14192	156.7	8.5	s0.3	N29°26.348	W094°50.267	54	2121	142.1	8.6	s34.4	N29°28.223	W094°51.230	
9	00:42:54	331.0	11.4	s35.0	N29°28.332	W094°51.230	52	14208	156.8	8.5	p3.4	N29°26.352	W094°50.269	54	2134	142.3	8.5	s34.4	N29°28.227	W094°51.234	
10	00:42:52	331.2	11.3	s35.0	N29°28.326	W094°51.226	52	14228	156.9	8.5	p8.6	N29°26.357	W094°50.271	54	2115	142.6	8.4	s34.4	N29°28.230	W094°51.238	

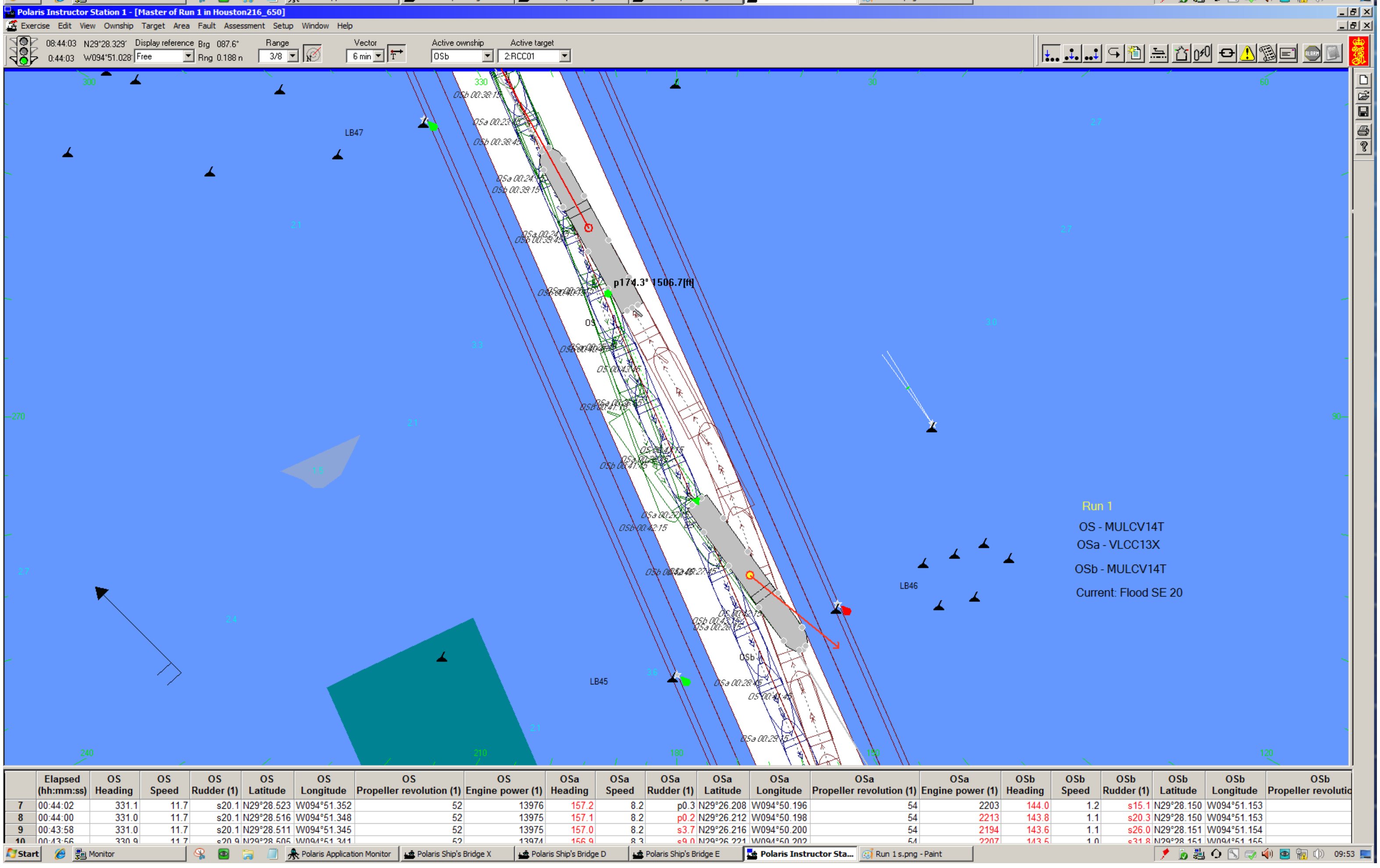


Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:43:27 N29°28.275′ Display reference Free Brg 079.6° Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01
0:43:27 W094°50.977′ Rng 0.171 n

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:43:26	331.9	11.6	p0.0	N29°28.421	W094°51.288	52	14058	157.0	8.4	p20.5	N29°26.284	W094°50.234	54	2150	143.5	8.8	s34.4	N29°28.168	W094°51.174	
8	00:43:24	332.0	11.6	p0.1	N29°28.415	W094°51.285	52	14071	157.0	8.4	p15.8	N29°26.288	W094°50.236	54	2160	143.8	8.8	s34.4	N29°28.172	W094°51.177	
9	00:43:22	332.0	11.6	p0.1	N29°28.409	W094°51.281	52	14083	156.9	8.4	p11.1	N29°26.292	W094°50.238	54	2168	144.0	8.8	s34.4	N29°28.176	W094°51.181	
10	00:43:20	332.0	11.6	p0.1	N29°28.404	W094°51.278	52	14095	156.9	8.4	p5.8	N29°26.297	W094°50.240	54	2151	144.1	8.8	s34.5	N29°28.180	W094°51.185	

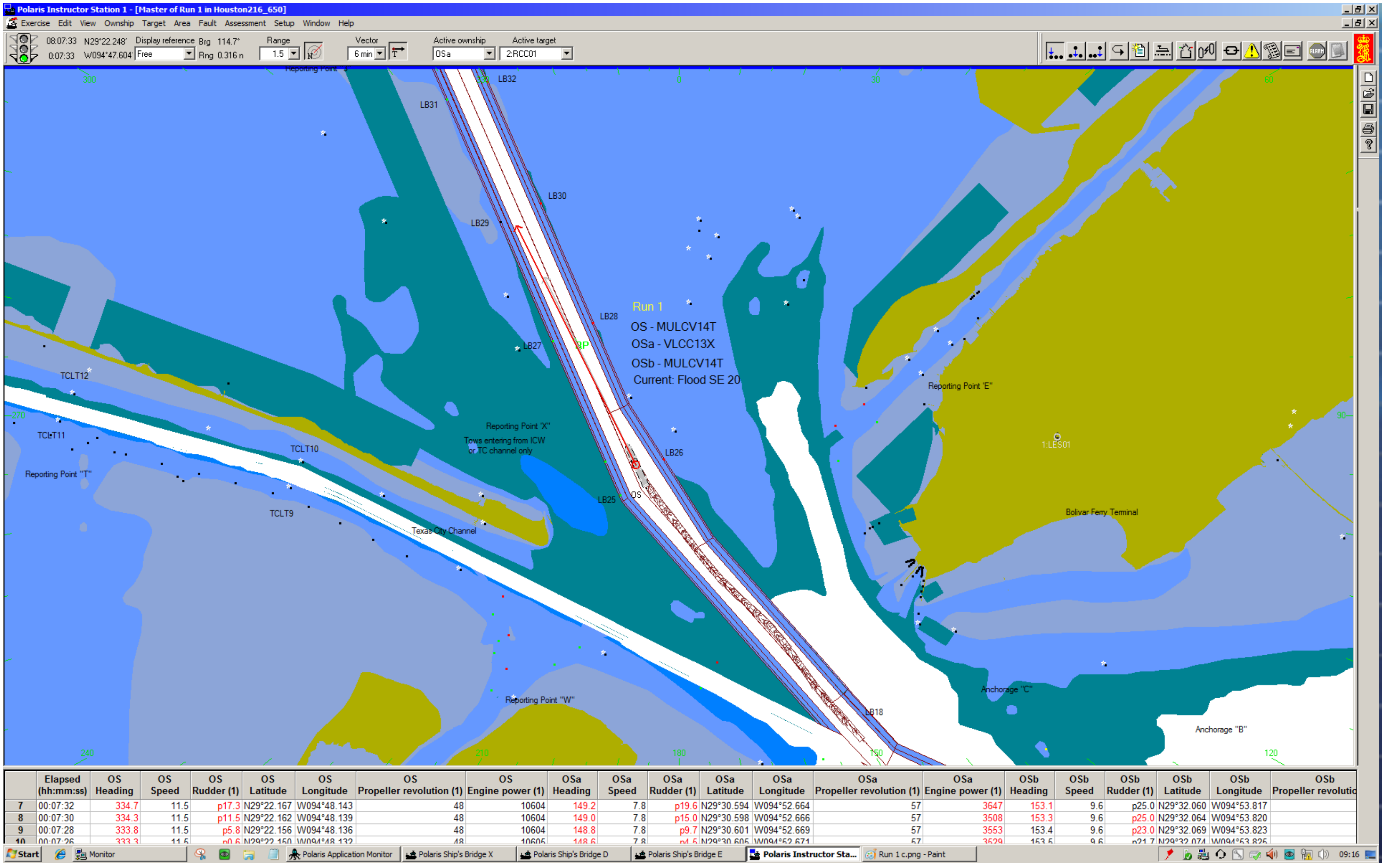


Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

08:44:03 N29°28.329′ Display reference Free Brg 087.6° Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01
0:44:03 W094°51.028′ Rng 0.188 n

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:44:02	331.1	11.7	s20.1	N29°28.523	W094°51.352	52	13976	157.2	8.2	p0.3	N29°26.208	W094°50.196	54	2203	144.0	1.2	s15.1	N29°28.150	W094°51.153	
8	00:44:00	331.0	11.7	s20.1	N29°28.516	W094°51.348	52	13975	157.1	8.2	p0.2	N29°26.212	W094°50.198	54	2213	143.8	1.1	s20.3	N29°28.150	W094°51.153	
9	00:43:58	331.0	11.7	s20.1	N29°28.511	W094°51.345	52	13975	157.0	8.2	s3.7	N29°26.216	W094°50.200	54	2194	143.6	1.1	s26.0	N29°28.151	W094°51.154	
10	00:43:56	330.9	11.7	s20.9	N29°28.505	W094°51.341	52	13974	156.9	8.3	s9.0	N29°26.221	W094°50.202	54	2207	143.5	1.0	s31.8	N29°28.151	W094°51.155	



Polaris Instructor Station 1 - [Master of Run 1 in Houston216_650]

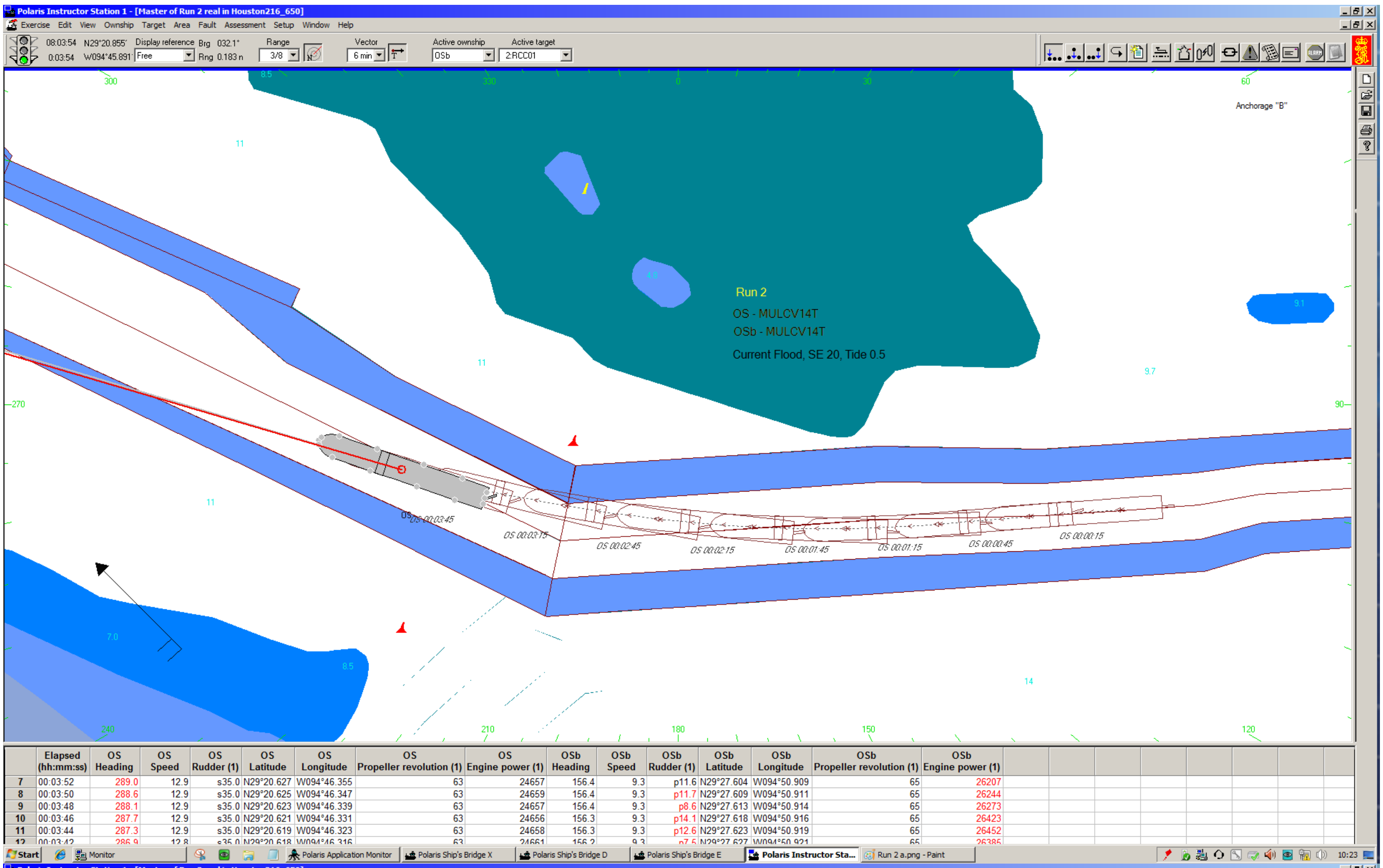
08:07:33 N29°22.248' Display reference: Free Brg 114.7° Range: 1.5 Vector: 6 min Active ownship: OSa Active target: 2:RCC01
0:07:33 W094°47.604' Rng 0.316 n

Run 1
OS - MULCV14T
OSa - VLCC13X
OSb - MULCV14T
Current: Flood SE 20

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolutio
7	00:07:32	334.7	11.5	p17.3	N29°22.167	W094°48.143	48	10604	149.2	7.8	p19.6	N29°30.594	W094°52.664	57	3647	153.1	9.6	p25.0	N29°32.060	W094°53.817	
8	00:07:30	334.3	11.5	p11.5	N29°22.162	W094°48.139	48	10604	149.0	7.8	p15.0	N29°30.598	W094°52.666	57	3508	153.3	9.6	p25.0	N29°32.064	W094°53.820	
9	00:07:28	333.8	11.5	p5.8	N29°22.156	W094°48.136	48	10604	148.8	7.8	p9.7	N29°30.601	W094°52.669	57	3553	153.4	9.6	p23.0	N29°32.069	W094°53.823	
10	00:07:26	333.3	11.5	p0.6	N29°22.150	W094°48.132	48	10605	148.6	7.8	p4.5	N29°30.605	W094°52.671	57	3529	153.5	9.6	p21.7	N29°32.074	W094°53.825	

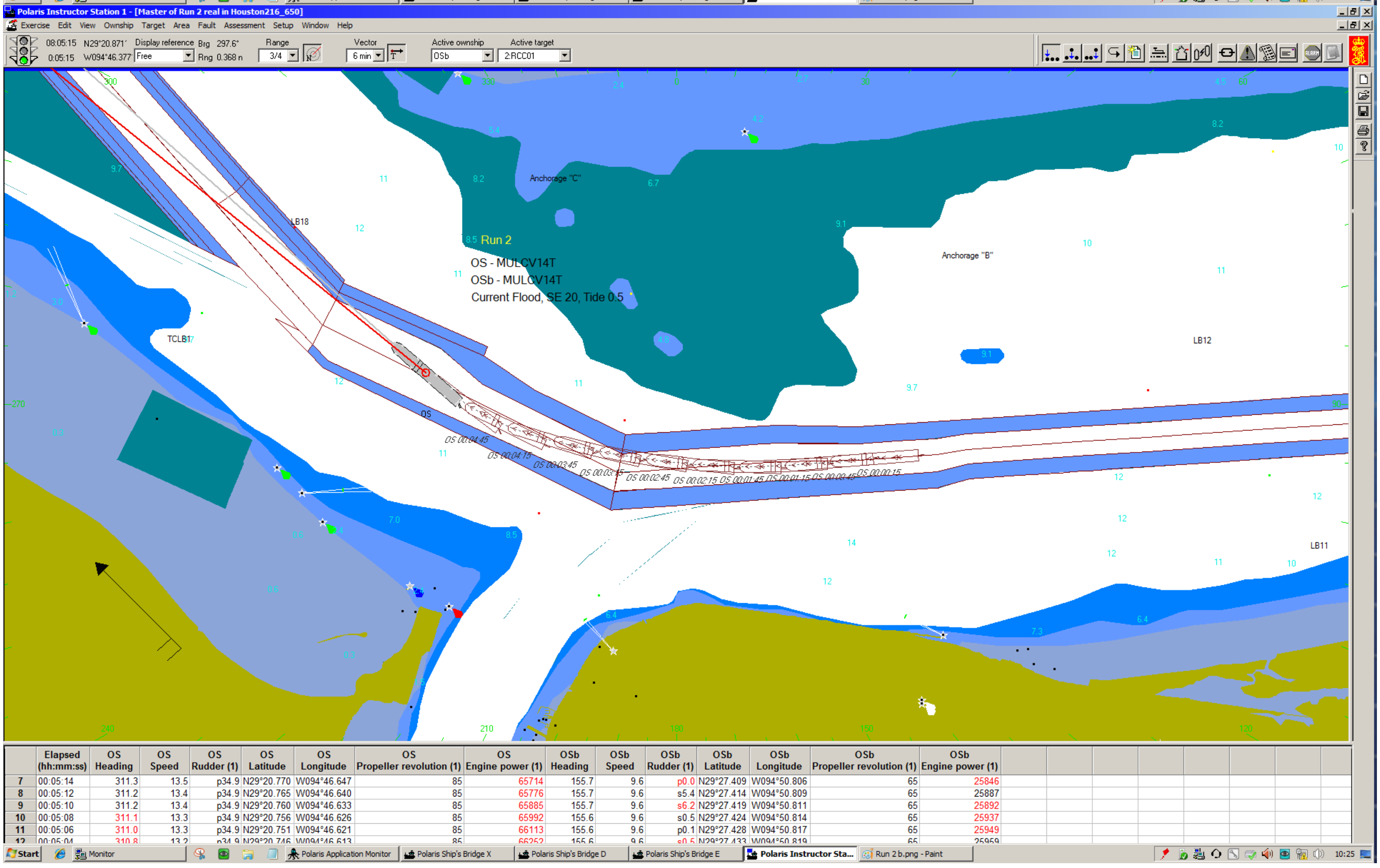
June 26, 2019

Run 2


Polaris Instructor Station 1 - [Master of Run 2 real in Houston216_650]

Run 2
OS - MULCV14T
OSb - MULCV14T
Current Flood, SE 20, Tide 0.5

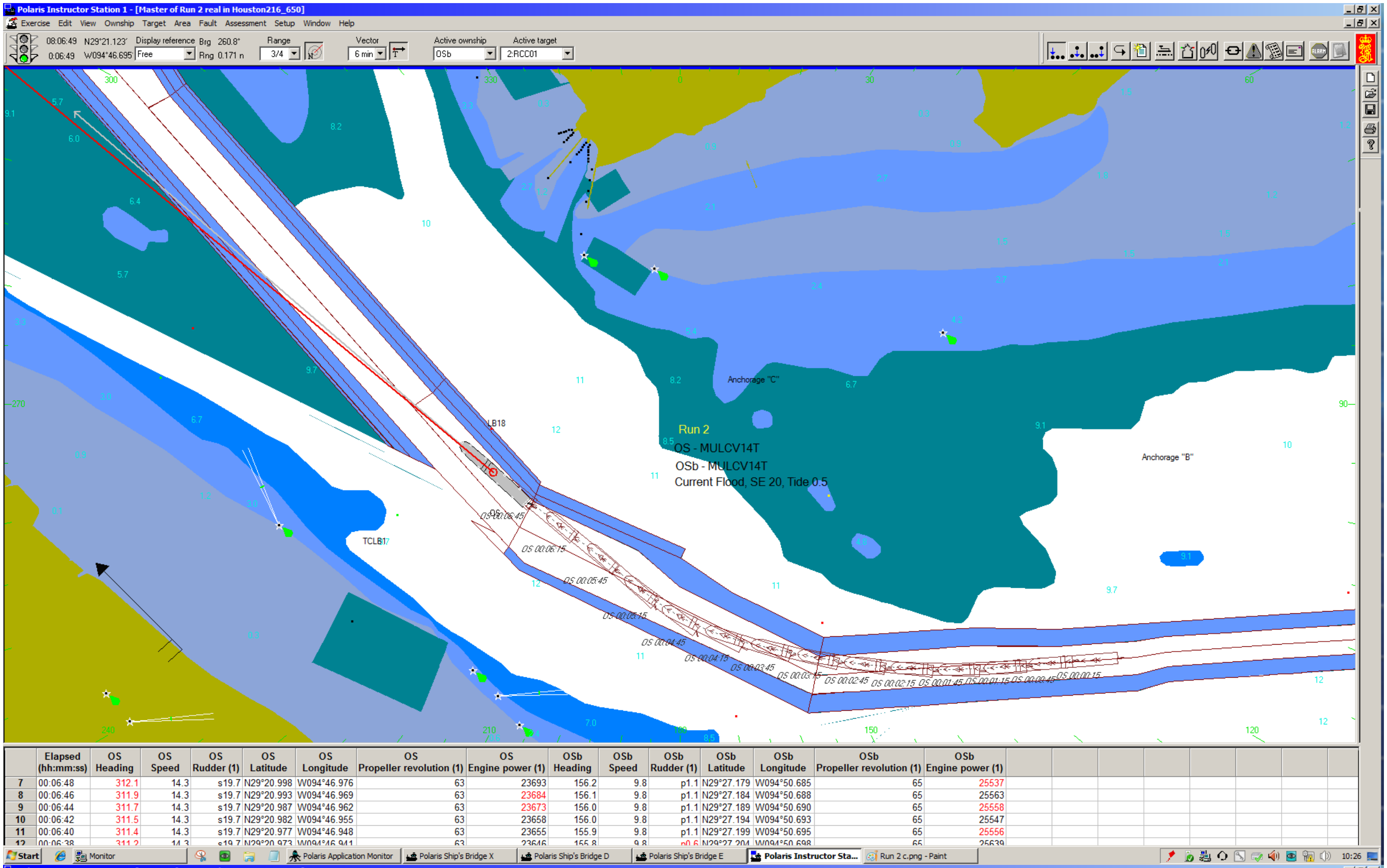
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:52	289.0	12.9	s35.0	N29°20.627	W094°46.355	63	24657	156.4	9.3	p11.6	N29°27.604	W094°50.909	65	26207
8	00:03:50	288.6	12.9	s35.0	N29°20.625	W094°46.347	63	24659	156.4	9.3	p11.7	N29°27.609	W094°50.911	65	26244
9	00:03:48	288.1	12.9	s35.0	N29°20.623	W094°46.339	63	24657	156.4	9.3	p8.6	N29°27.613	W094°50.914	65	26273
10	00:03:46	287.7	12.9	s35.0	N29°20.621	W094°46.331	63	24656	156.3	9.3	p14.1	N29°27.618	W094°50.916	65	26423
11	00:03:44	287.3	12.9	s35.0	N29°20.619	W094°46.323	63	24658	156.3	9.3	p12.6	N29°27.623	W094°50.919	65	26452
12	00:03:42	286.9	12.8	s35.0	N29°20.618	W094°46.316	63	24661	156.2	9.3	p7.5	N29°27.627	W094°50.921	65	26385


Polaris Instructor Station 1 - [Master of Run 2 real in Houston216_650]

Run 2
OS - MULCV14T
OSb - MULCV14T
Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:14	311.3	13.5	p34.9	N29°20.770	W094°46.647	85	65714	155.7	9.6	p0.0	N29°27.409	W094°50.806	65	25846
8	00:05:12	311.2	13.4	p34.9	N29°20.765	W094°46.640	85	65776	155.7	9.6	s5.4	N29°27.414	W094°50.809	65	25887
9	00:05:10	311.2	13.4	p34.9	N29°20.760	W094°46.633	85	65885	155.7	9.6	s6.2	N29°27.419	W094°50.811	65	25892
10	00:05:08	311.1	13.3	p34.9	N29°20.756	W094°46.626	85	65992	155.6	9.6	s0.5	N29°27.424	W094°50.814	65	25937
11	00:05:06	311.0	13.3	p34.9	N29°20.751	W094°46.621	85	66113	155.6	9.6	p0.1	N29°27.428	W094°50.817	65	25949
12	00:05:04	310.8	13.2	p34.9	N29°20.746	W094°46.613	85	66252	155.6	9.6	s0.5	N29°27.433	W094°50.819	65	25959

June 26, 2019

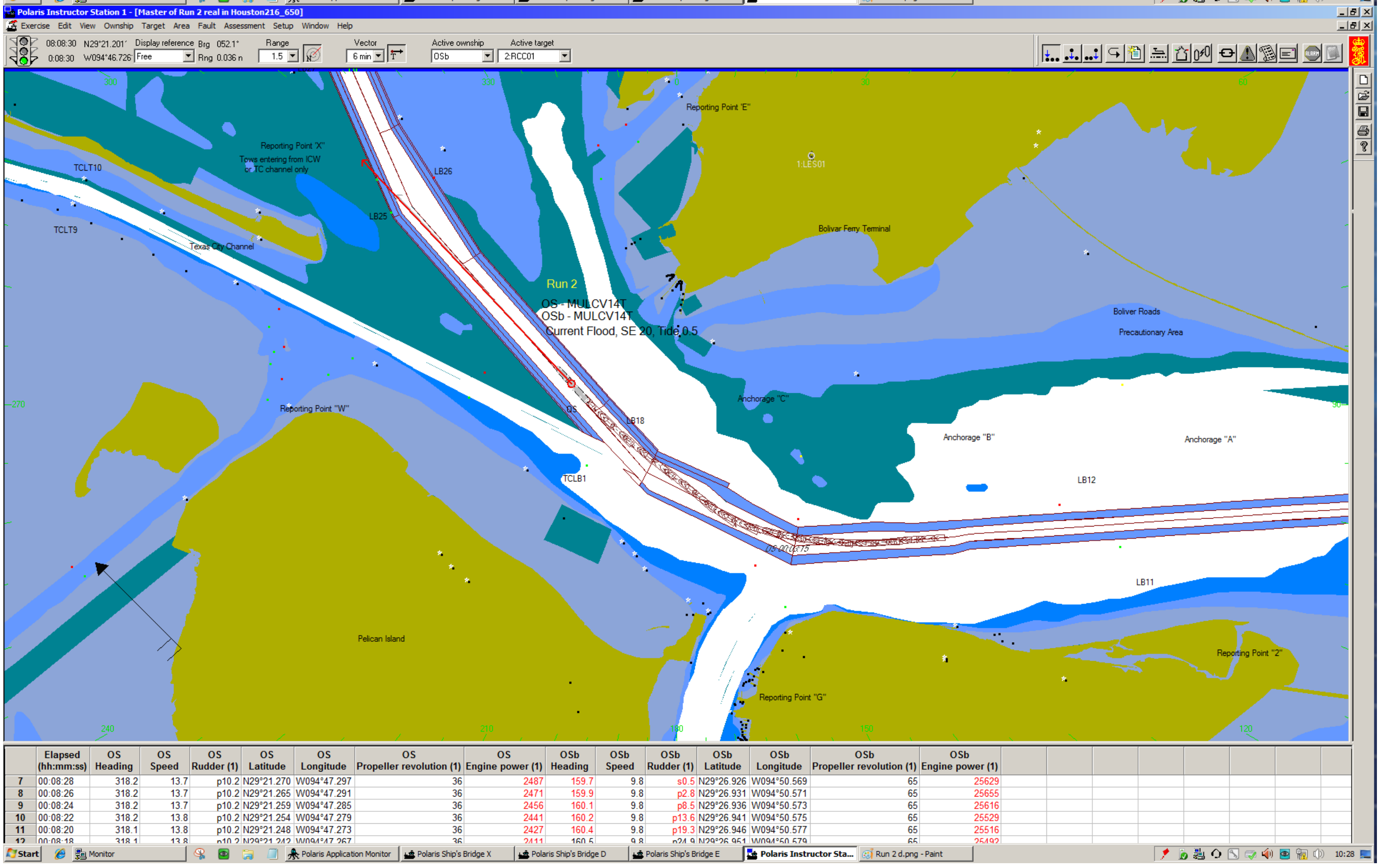


Polaris Instructor Station 1 - [Master of Run 2 real in Houston216_650]

08:06:49 N29°21.123' Display reference: Free Brg 260.8° Rng 0.171 n
0:06:49 W094°46.695'
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 2:RCC01

Run 2
OS - MULCV14T
OSb - MULCV14T
Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:48	312.1	14.3	s19.7	N29°20.998	W094°46.976	63	23693	156.2	9.8	p1.1	N29°27.179	W094°50.685	65	25537
8	00:06:46	311.9	14.3	s19.7	N29°20.993	W094°46.969	63	23684	156.1	9.8	p1.1	N29°27.184	W094°50.688	65	25563
9	00:06:44	311.7	14.3	s19.7	N29°20.987	W094°46.962	63	23673	156.0	9.8	p1.1	N29°27.189	W094°50.690	65	25558
10	00:06:42	311.5	14.3	s19.7	N29°20.982	W094°46.955	63	23658	156.0	9.8	p1.1	N29°27.194	W094°50.693	65	25547
11	00:06:40	311.4	14.3	s19.7	N29°20.977	W094°46.948	63	23655	155.9	9.8	p1.1	N29°27.199	W094°50.695	65	25556
12	00:06:38	311.2	14.3	s19.7	N29°20.973	W094°46.941	63	23646	155.8	9.8	p0.6	N29°27.204	W094°50.698	65	25639

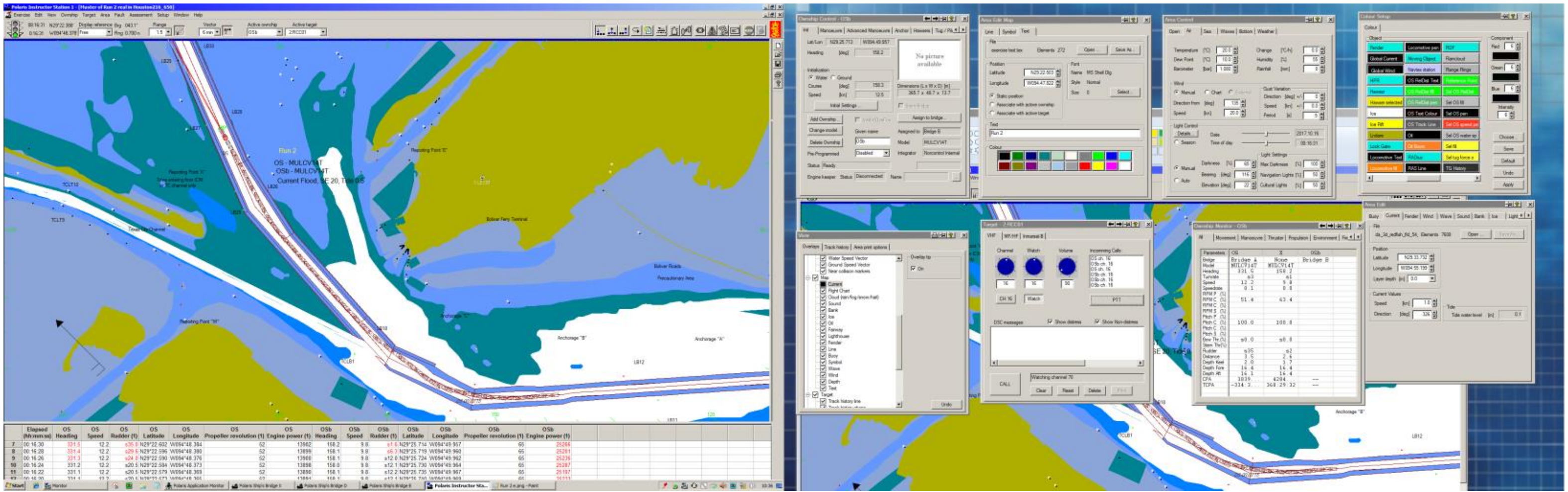


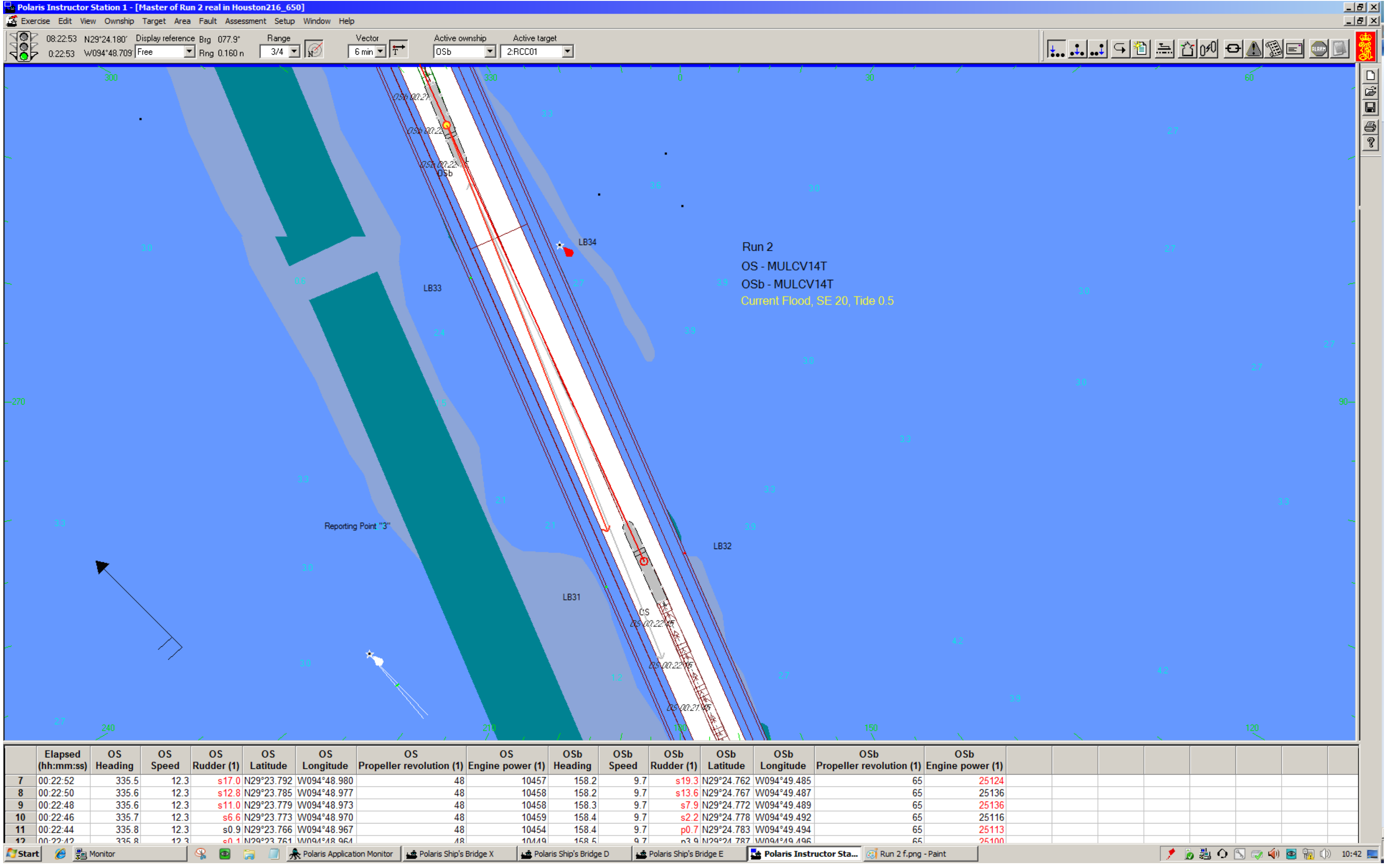
Polaris Instructor Station 1 - [Master of Run 2 real in Houston216_650]

08:08:30 N29°21.201' Display reference: Free Brg 052.1° Rng 0.036 n
0:08:30 W094°46.726'
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 2:RCC01

Run 2
OS - MULCV14T
OSb - MULCV14T
Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:28	318.2	13.7	p10.2	N29°21.270	W094°47.297	36	2487	159.7	9.8	s0.5	N29°26.926	W094°50.569	65	25629
8	00:08:26	318.2	13.7	p10.2	N29°21.265	W094°47.291	36	2471	159.9	9.8	p2.8	N29°26.931	W094°50.571	65	25655
9	00:08:24	318.2	13.7	p10.2	N29°21.259	W094°47.285	36	2456	160.1	9.8	p8.5	N29°26.936	W094°50.573	65	25616
10	00:08:22	318.2	13.8	p10.2	N29°21.254	W094°47.279	36	2441	160.2	9.8	p13.6	N29°26.941	W094°50.575	65	25529
11	00:08:20	318.1	13.8	p10.2	N29°21.248	W094°47.273	36	2427	160.4	9.8	p19.3	N29°26.946	W094°50.577	65	25516
12	00:08:18	318.1	13.8	p10.2	N29°21.242	W094°47.267	36	2411	160.5	9.8	p24.9	N29°26.951	W094°50.579	65	25492



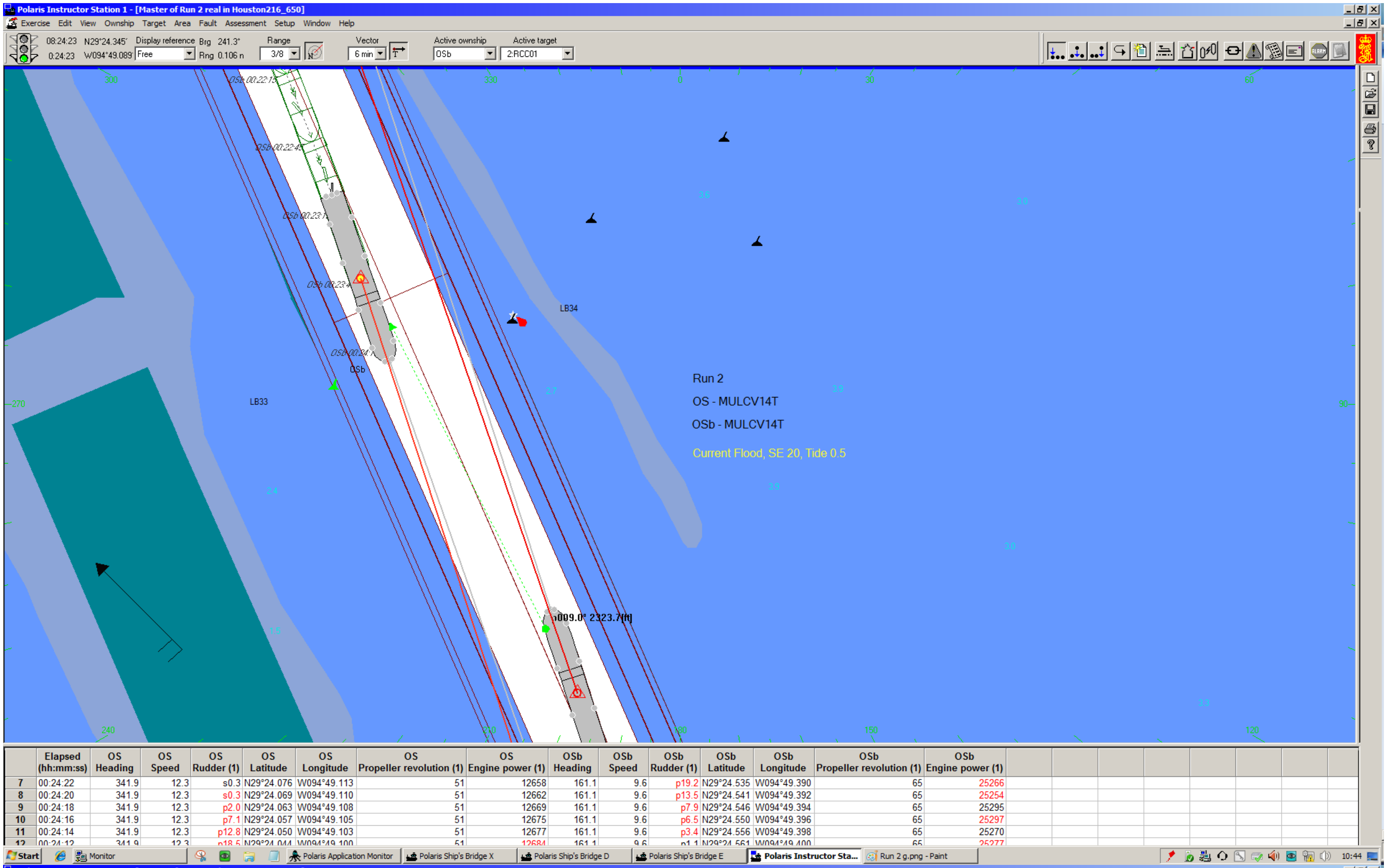


Polaris Instructor Station 1 - [Master of Run 2 real in Houston216_650]

08:22:53 N29°24.180'
0:22:53 W094°48.709'
Display reference: Free
Brg 077.9°
Rng 0.160 n
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 2:RCC01

Run 2
OS - MULCV14T
OSb - MULCV14T
Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:22:52	335.5	12.3	s17.0	N29°23.792	W094°48.980	48	10457	158.2	9.7	s19.3	N29°24.762	W094°49.485	65	25124
8	00:22:50	335.6	12.3	s12.8	N29°23.785	W094°48.977	48	10458	158.2	9.7	s13.6	N29°24.767	W094°49.487	65	25136
9	00:22:48	335.6	12.3	s11.0	N29°23.779	W094°48.973	48	10458	158.3	9.7	s7.9	N29°24.772	W094°49.489	65	25136
10	00:22:46	335.7	12.3	s6.6	N29°23.773	W094°48.970	48	10459	158.4	9.7	s2.2	N29°24.778	W094°49.492	65	25116
11	00:22:44	335.8	12.3	s0.9	N29°23.766	W094°48.967	48	10454	158.4	9.7	p0.7	N29°24.783	W094°49.494	65	25113
12	00:22:42	335.8	12.3	s0.1	N29°23.761	W094°48.964	48	10449	158.5	9.7	p3.9	N29°24.787	W094°49.496	65	25100



08:24:23 N29°24.345′ Display reference Free Brg 241.3° Rng 0.106 n Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01

0:24:23 W094°49.089′

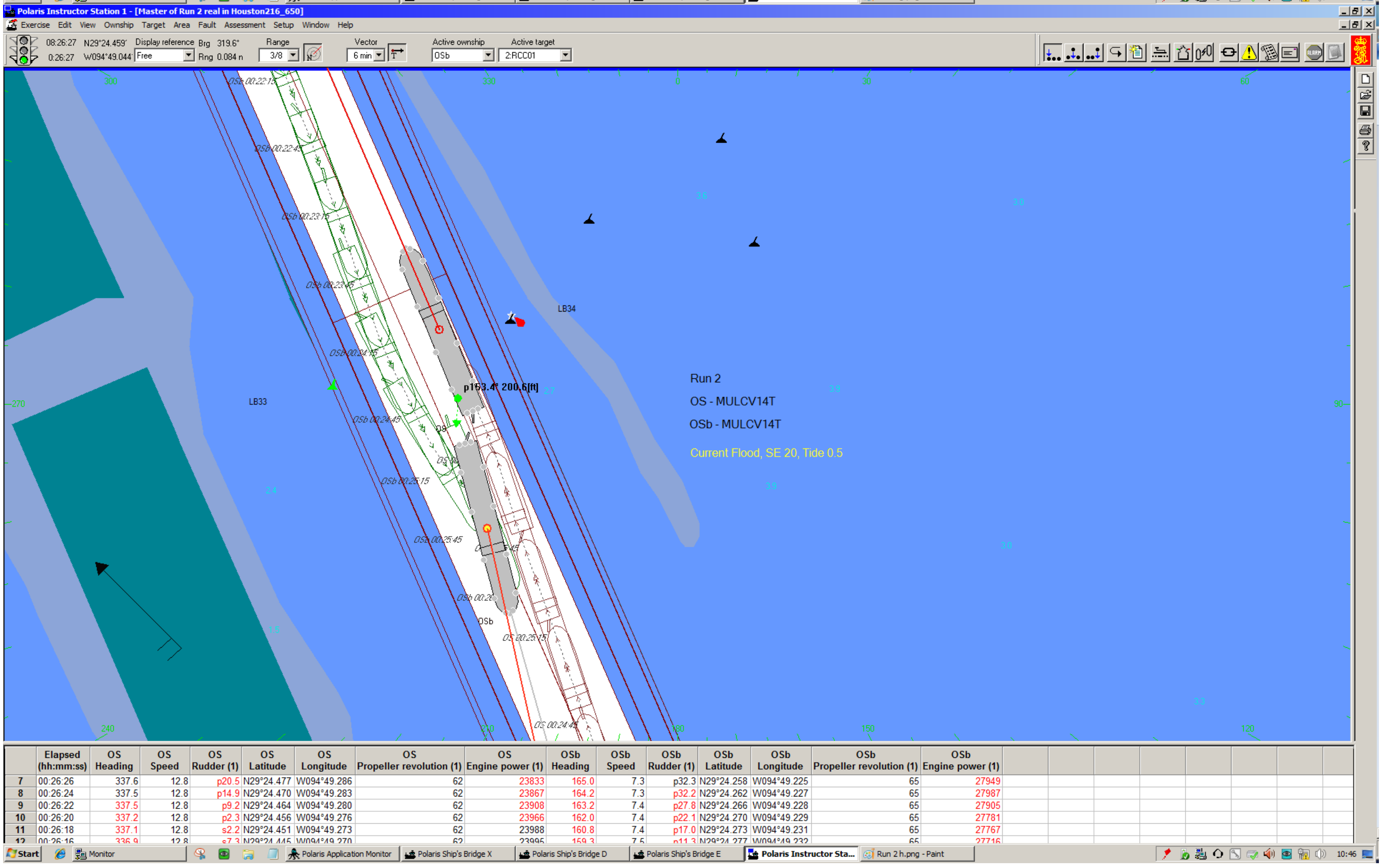
Run 2

OS - MULCV14T

OSb - MULCV14T

Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:24:22	341.9	12.3	s0.3	N29°24.076	W094°49.113	51	12658	161.1	9.6	p19.2	N29°24.535	W094°49.390	65	25266
8	00:24:20	341.9	12.3	s0.3	N29°24.069	W094°49.110	51	12662	161.1	9.6	p13.5	N29°24.541	W094°49.392	65	25254
9	00:24:18	341.9	12.3	p2.0	N29°24.063	W094°49.108	51	12669	161.1	9.6	p7.9	N29°24.546	W094°49.394	65	25295
10	00:24:16	341.9	12.3	p7.1	N29°24.057	W094°49.105	51	12675	161.1	9.6	p6.5	N29°24.550	W094°49.396	65	25297
11	00:24:14	341.9	12.3	p12.8	N29°24.050	W094°49.103	51	12677	161.1	9.6	p3.4	N29°24.556	W094°49.398	65	25270
12	00:24:12	341.9	12.3	p18.5	N29°24.044	W094°49.100	51	12684	161.1	9.6	p1.1	N29°24.561	W094°49.400	65	25277



08:26:27 N29°24.459′ Display reference Free Brg 319.6° Rng 0.084 n Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01

0:26:27 W094°49.044′

Run 2

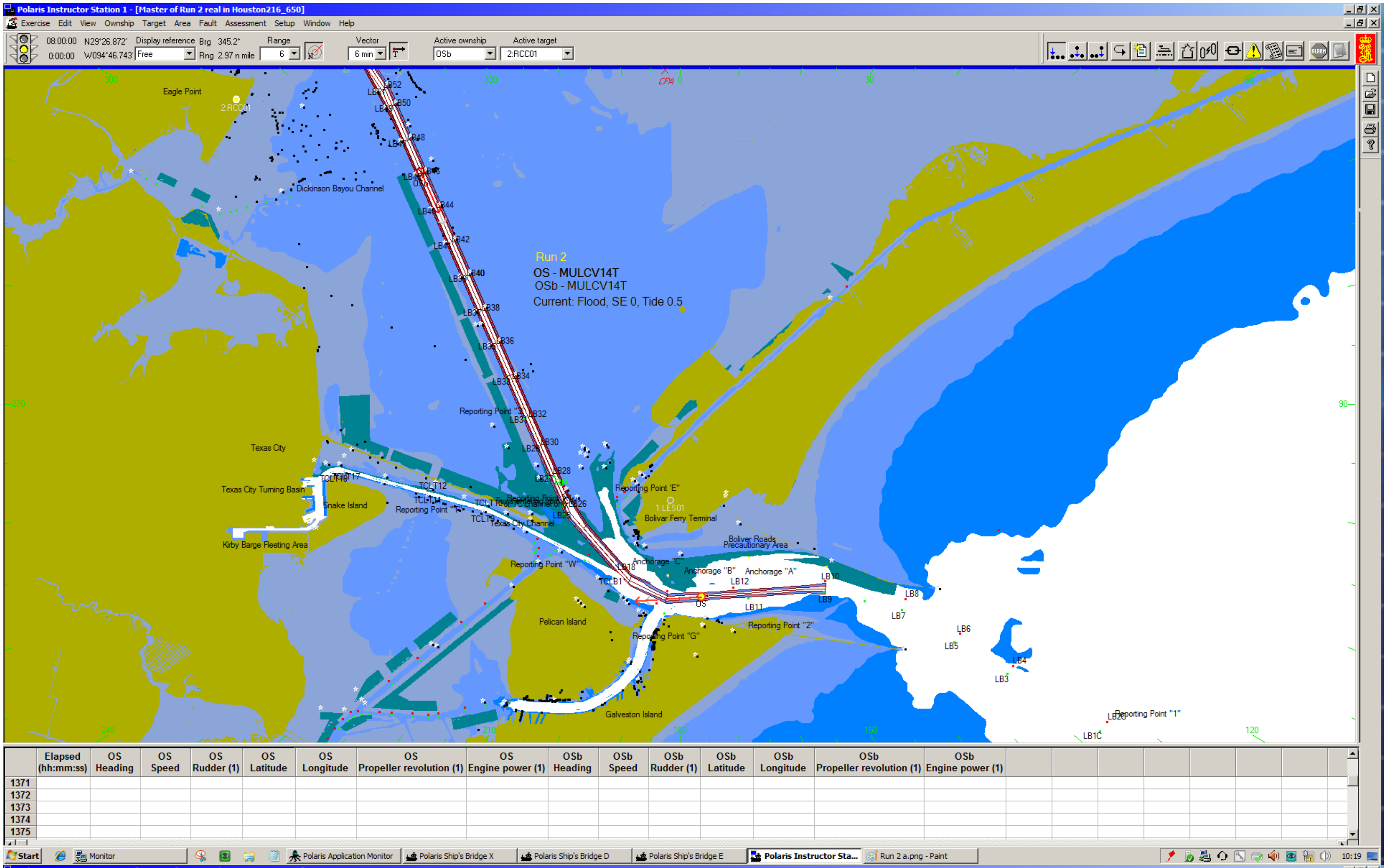
OS - MULCV14T

OSb - MULCV14T

Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:26:26	337.6	12.8	p20.5	N29°24.477	W094°49.286	62	23833	165.0	7.3	p32.3	N29°24.258	W094°49.225	65	27949
8	00:26:24	337.5	12.8	p14.9	N29°24.470	W094°49.283	62	23867	164.2	7.3	p32.2	N29°24.262	W094°49.227	65	27987
9	00:26:22	337.5	12.8	p9.2	N29°24.464	W094°49.280	62	23908	163.2	7.4	p27.8	N29°24.266	W094°49.228	65	27905
10	00:26:20	337.2	12.8	p2.3	N29°24.456	W094°49.276	62	23966	162.0	7.4	p22.1	N29°24.270	W094°49.229	65	27781
11	00:26:18	337.1	12.8	s2.2	N29°24.451	W094°49.273	62	23988	160.8	7.4	p17.0	N29°24.273	W094°49.231	65	27767
12	00:26:16	336.9	12.8	s7.3	N29°24.445	W094°49.270	62	23995	159.3	7.5	p11.3	N29°24.277	W094°49.232	65	27716

June 26, 2019



08:00:00 N29°26.872′ Display reference Free Brg 345.2° Rng 2.97 n mile Range 6 Vector 6 min Active ownship OSb Active target 2:RCC01

0:00:00 W094°46.743′

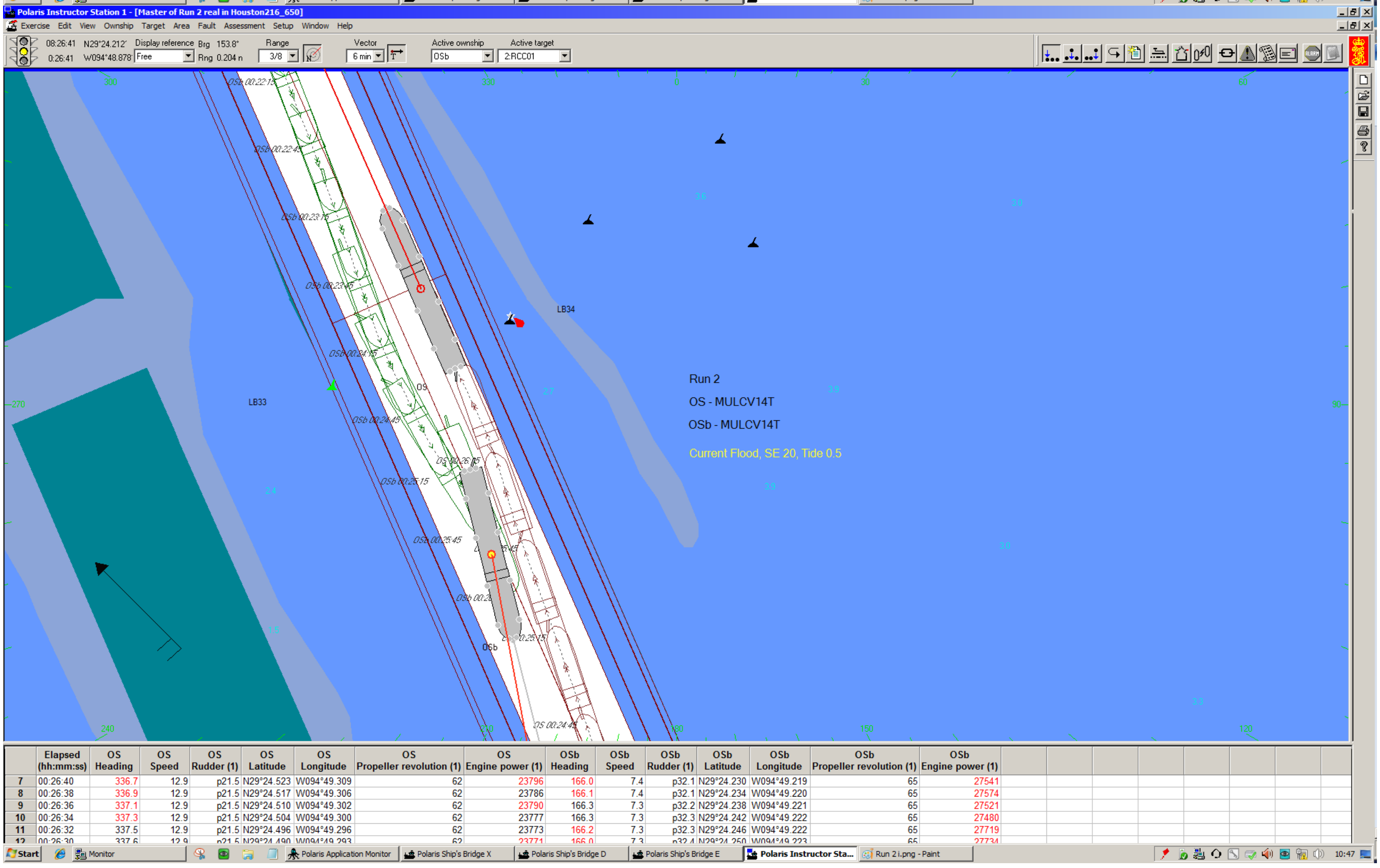
Run 2

OS - MULCV14T

OSb - MULCV14T

Current: Flood, SE 0, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
1371															
1372															
1373															
1374															
1375															



08:26:41 N29°24.212′ Display reference Free Brg 153.8° Rng 0.204 n Range 3/8 Vector 6 min Active ownship OSb Active target 2:RCC01

0:26:41 W094°48.878′

Run 2

OS - MULCV14T

OSb - MULCV14T

Current Flood, SE 20, Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:26:40	336.7	12.9	p21.5	N29°24.523	W094°49.309	62	23796	166.0	7.4	p32.1	N29°24.230	W094°49.219	65	27541
8	00:26:38	336.9	12.9	p21.5	N29°24.517	W094°49.306	62	23786	166.1	7.4	p32.1	N29°24.234	W094°49.220	65	27574
9	00:26:36	337.1	12.9	p21.5	N29°24.510	W094°49.302	62	23790	166.3	7.3	p32.2	N29°24.238	W094°49.221	65	27521
10	00:26:34	337.3	12.9	p21.5	N29°24.504	W094°49.300	62	23777	166.3	7.3	p32.3	N29°24.242	W094°49.222	65	27480
11	00:26:32	337.5	12.9	p21.5	N29°24.496	W094°49.296	62	23773	166.2	7.3	p32.3	N29°24.246	W094°49.222	65	27719
12	00:26:30	337.6	12.9	p21.5	N29°24.490	W094°49.293	62	23771	166.0	7.3	p32.4	N29°24.250	W094°49.223	65	27734

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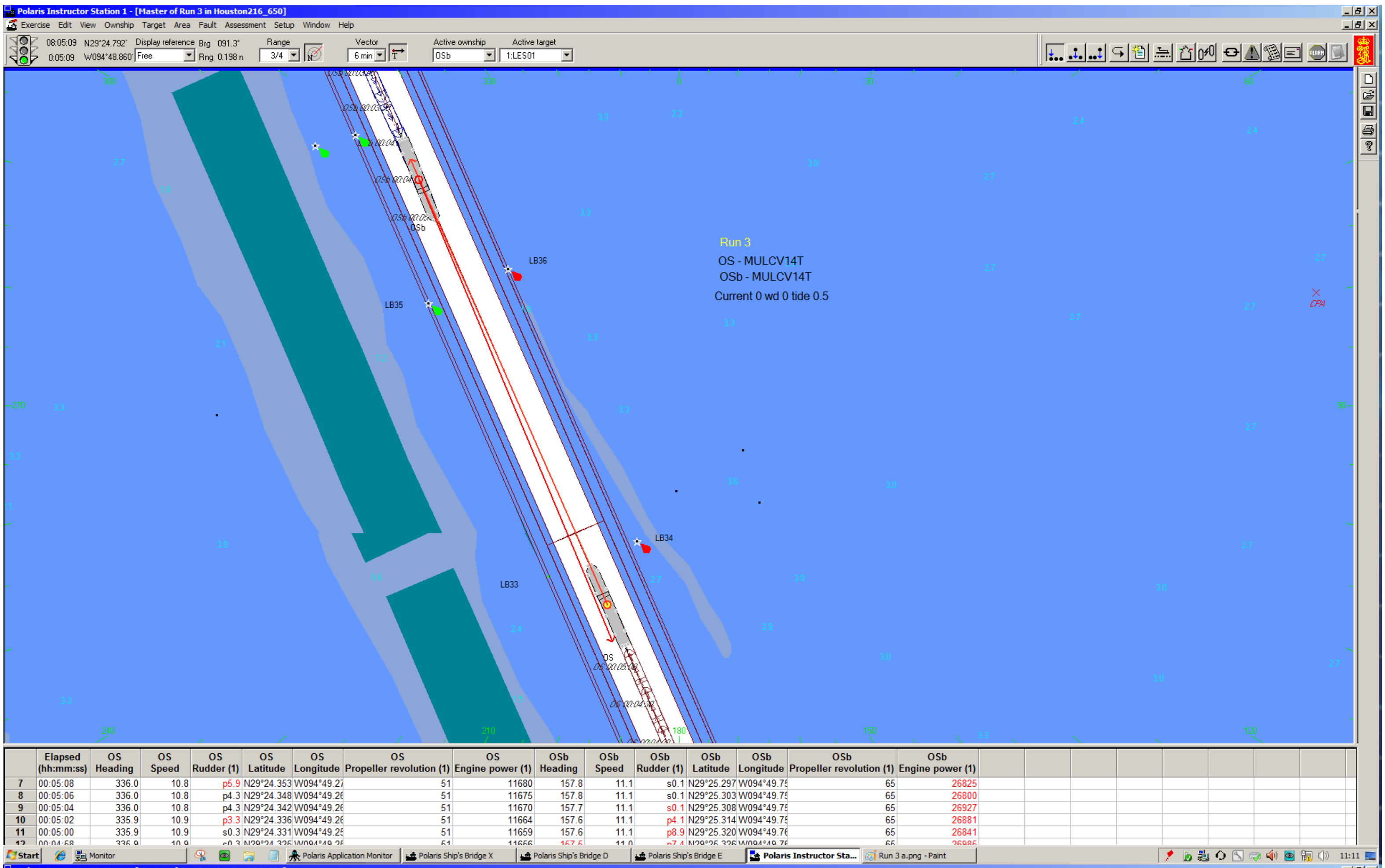
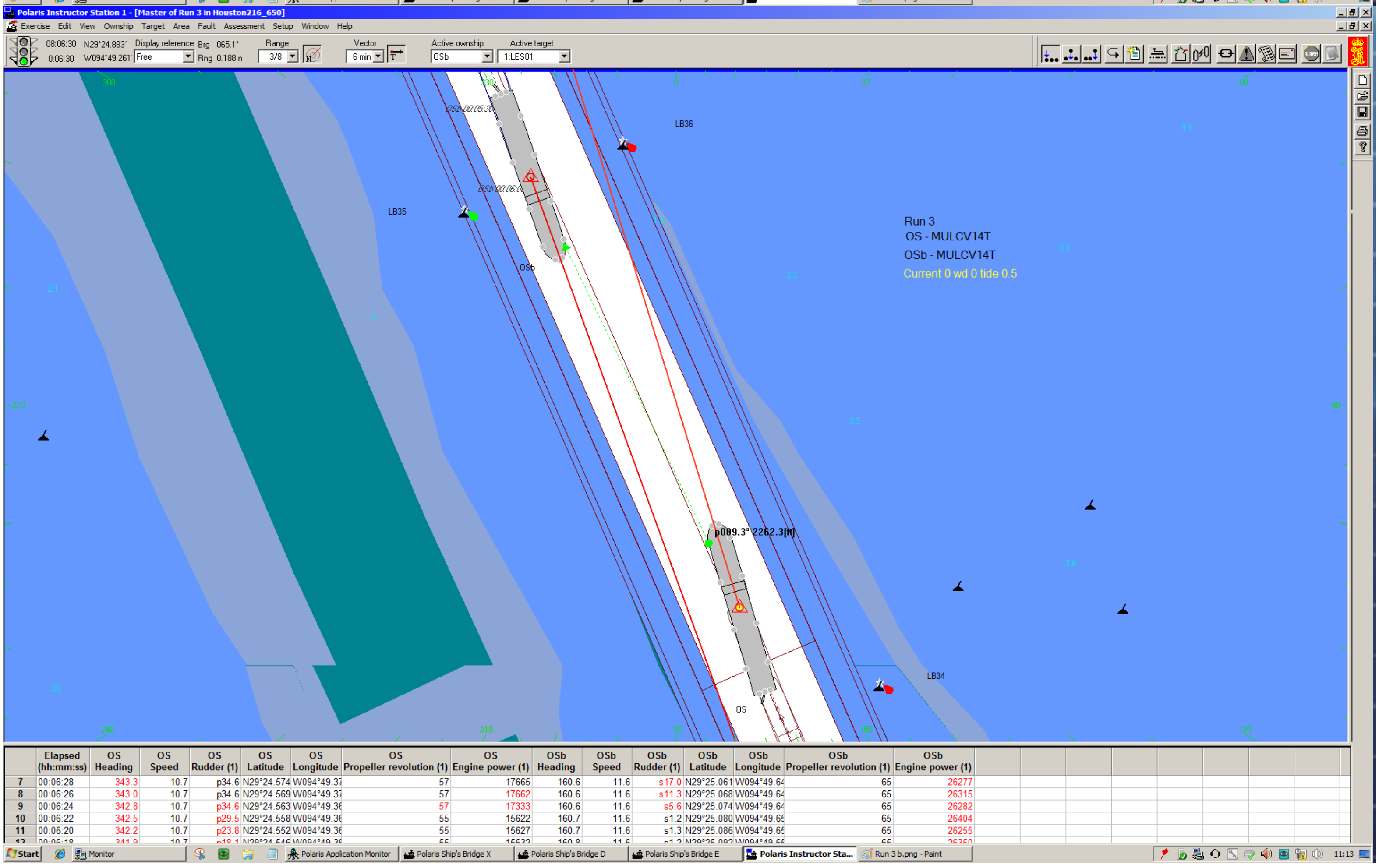
Run 3



08:05:09 N29°24.792′ Display reference: Free Brg 091.3° Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:05:09 W094°48.860′ Rng 0.198 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:08	336.0	10.8	p5.9	N29°24.353	W094°49.27	51	11680	157.8	11.1	s0.1	N29°25.297	W094°49.75	65	26825
8	00:05:06	336.0	10.8	p4.3	N29°24.348	W094°49.26	51	11675	157.8	11.1	s0.1	N29°25.303	W094°49.75	65	26800
9	00:05:04	336.0	10.8	p4.3	N29°24.342	W094°49.26	51	11670	157.7	11.1	s0.1	N29°25.308	W094°49.75	65	26927
10	00:05:02	335.9	10.9	p3.3	N29°24.336	W094°49.26	51	11664	157.6	11.1	p4.1	N29°25.314	W094°49.75	65	26881
11	00:05:00	335.9	10.9	s0.3	N29°24.331	W094°49.25	51	11659	157.6	11.1	p8.9	N29°25.320	W094°49.76	65	26841



08:06:30 N29°24.883′ Display reference: Free Brg 065.1° Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:06:30 W094°49.261′ Rng 0.188 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:28	343.3	10.7	p34.6	N29°24.574	W094°49.37	57	17665	160.6	11.6	s17.0	N29°25.061	W094°49.64	65	26277
8	00:06:26	343.0	10.7	p34.6	N29°24.569	W094°49.37	57	17662	160.6	11.6	s11.3	N29°25.068	W094°49.64	65	26315
9	00:06:24	342.8	10.7	p34.6	N29°24.563	W094°49.36	57	17333	160.6	11.6	s5.6	N29°25.074	W094°49.64	65	26282
10	00:06:22	342.5	10.7	p29.5	N29°24.558	W094°49.36	55	15622	160.7	11.6	s1.2	N29°25.080	W094°49.65	65	26404
11	00:06:20	342.2	10.7	p23.8	N29°24.552	W094°49.36	55	15627	160.7	11.6	s1.3	N29°25.086	W094°49.65	65	26255

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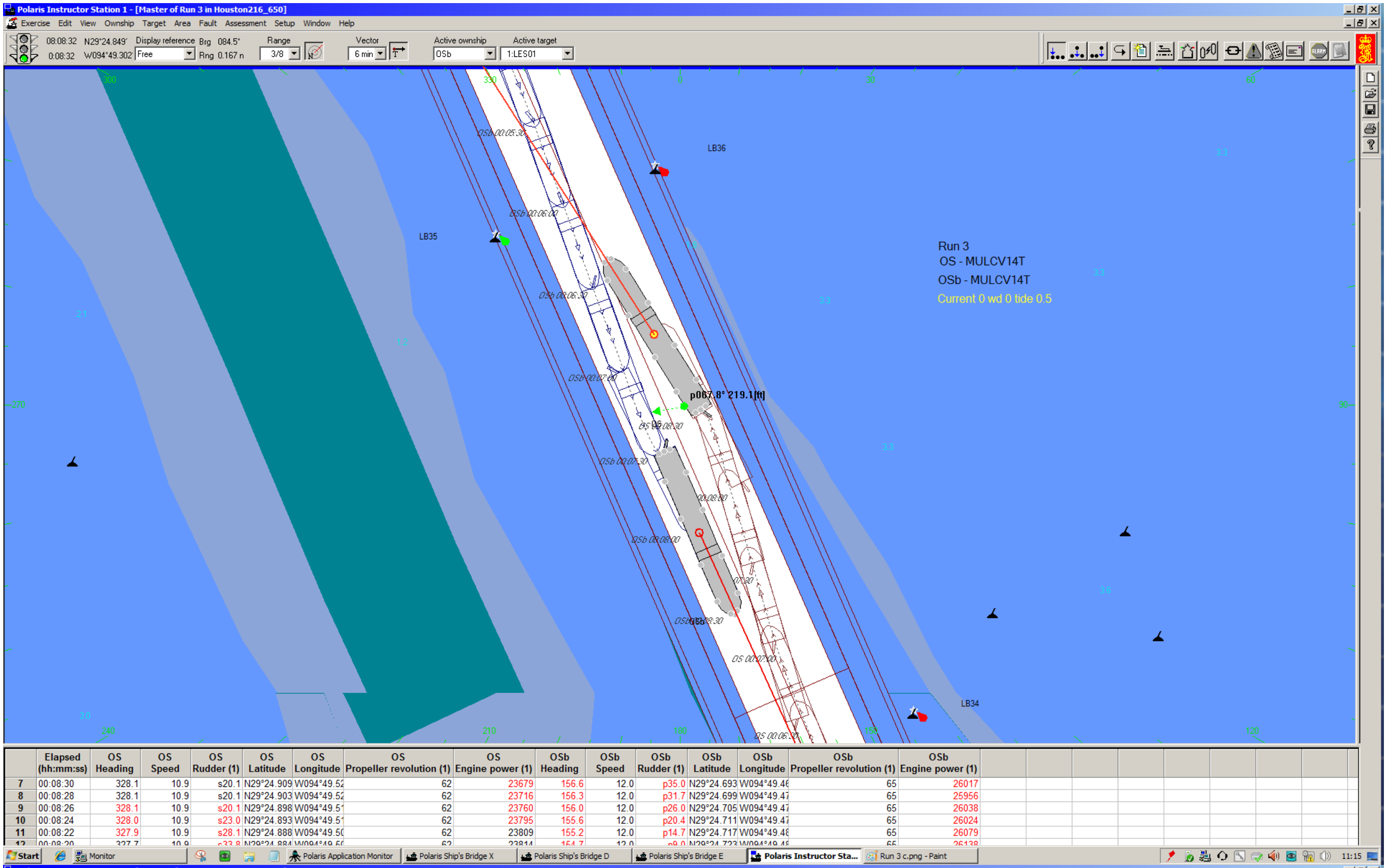
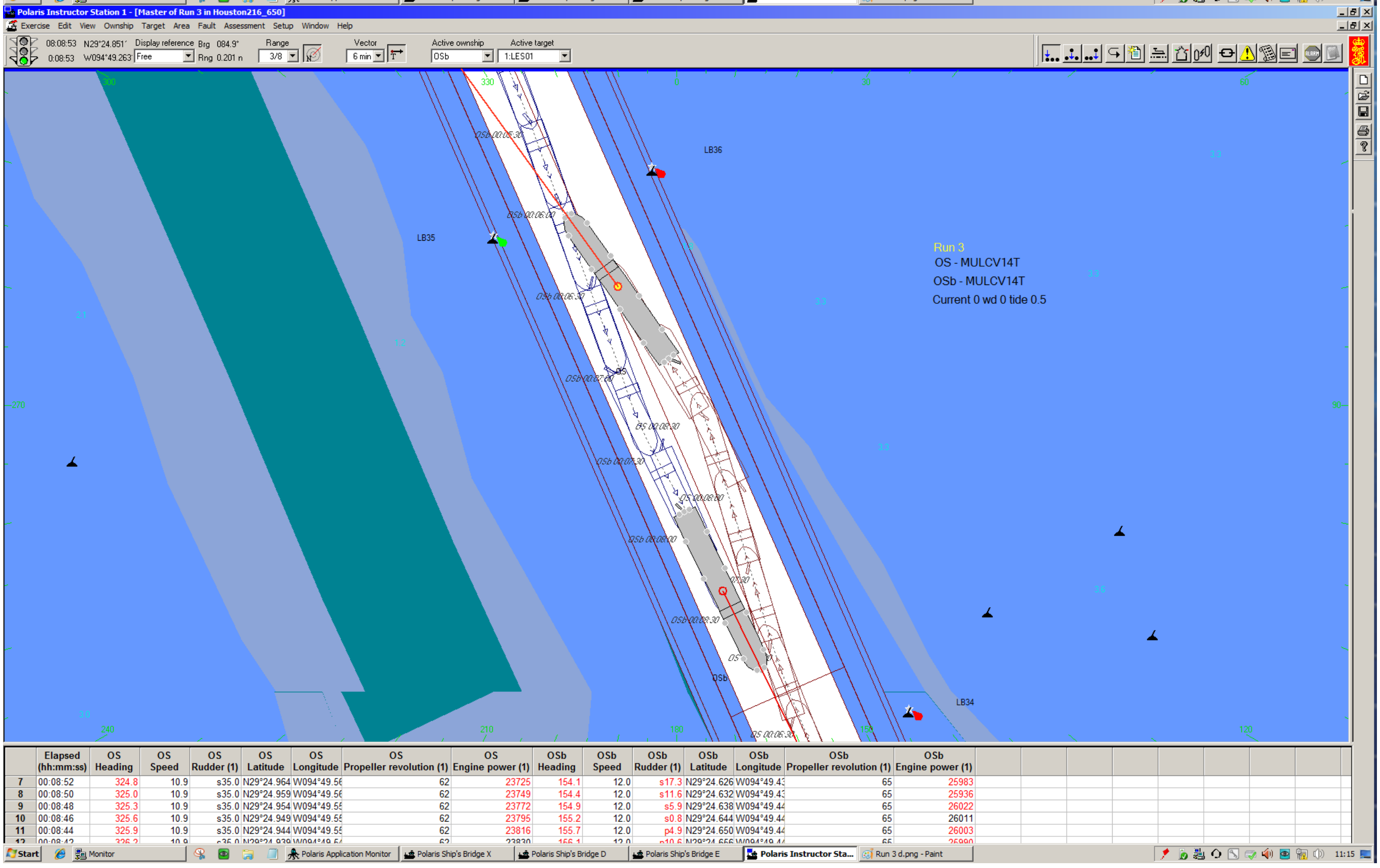


Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:08:32 N29°24.849' Display reference: Free Brg 084.5° Rng 0.167 n
0:08:32 W094°49.302
Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:30	328.1	10.9	s20.1	N29°24.909	W094°49.52	62	23679	156.6	12.0	p35.0	N29°24.693	W094°49.46	65	26017
8	00:08:28	328.1	10.9	s20.1	N29°24.903	W094°49.52	62	23716	156.3	12.0	p31.7	N29°24.699	W094°49.47	65	25956
9	00:08:26	328.1	10.9	s20.1	N29°24.898	W094°49.51	62	23760	156.0	12.0	p26.0	N29°24.705	W094°49.47	65	26038
10	00:08:24	328.0	10.9	s23.0	N29°24.893	W094°49.51	62	23795	155.6	12.0	p20.4	N29°24.711	W094°49.47	65	26024
11	00:08:22	327.9	10.9	s28.1	N29°24.888	W094°49.50	62	23809	155.2	12.0	p14.7	N29°24.717	W094°49.48	65	26079

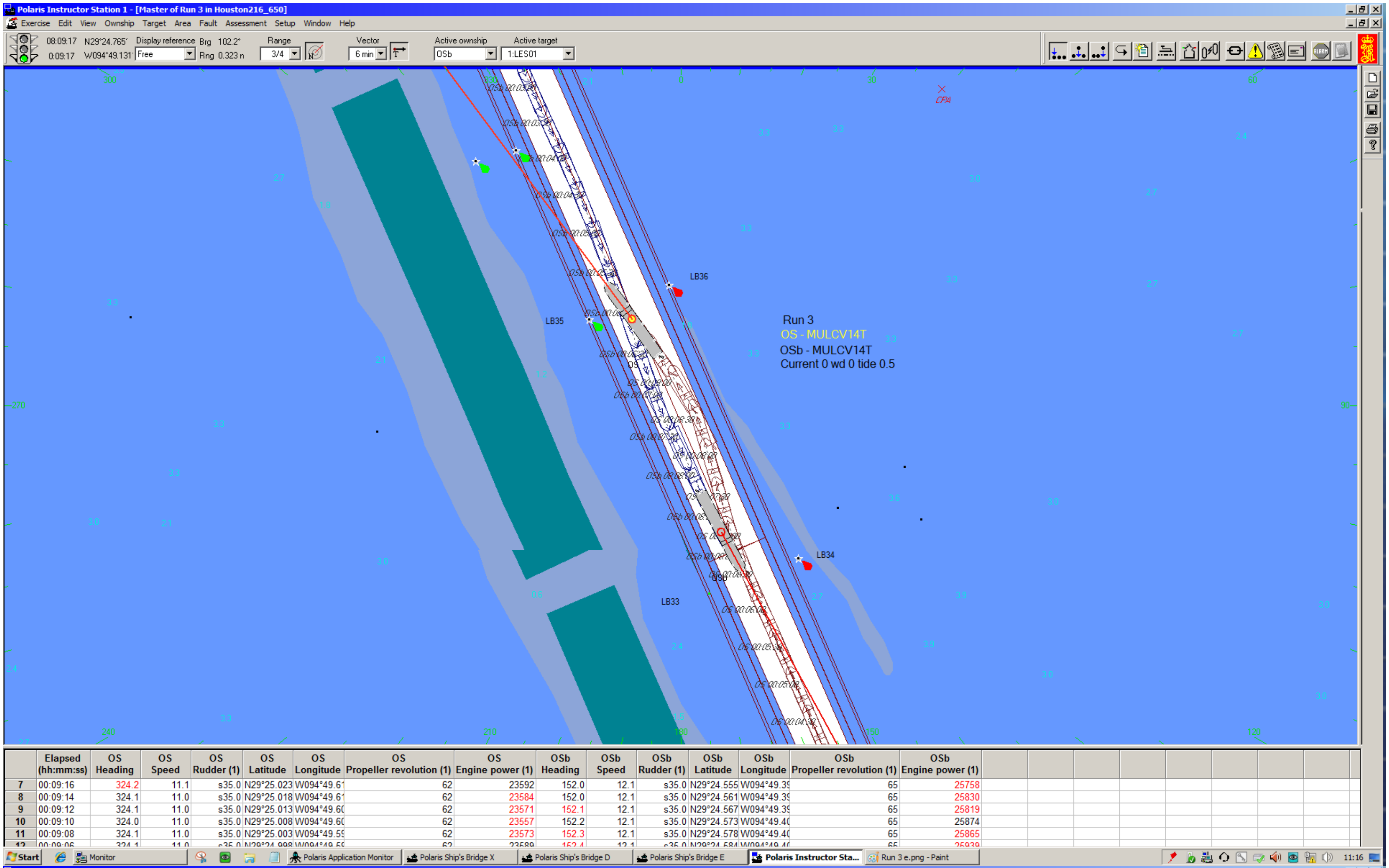


Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:08:53 N29°24.851' Display reference: Free Brg 084.9° Rng 0.201 n
0:08:53 W094°49.263
Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

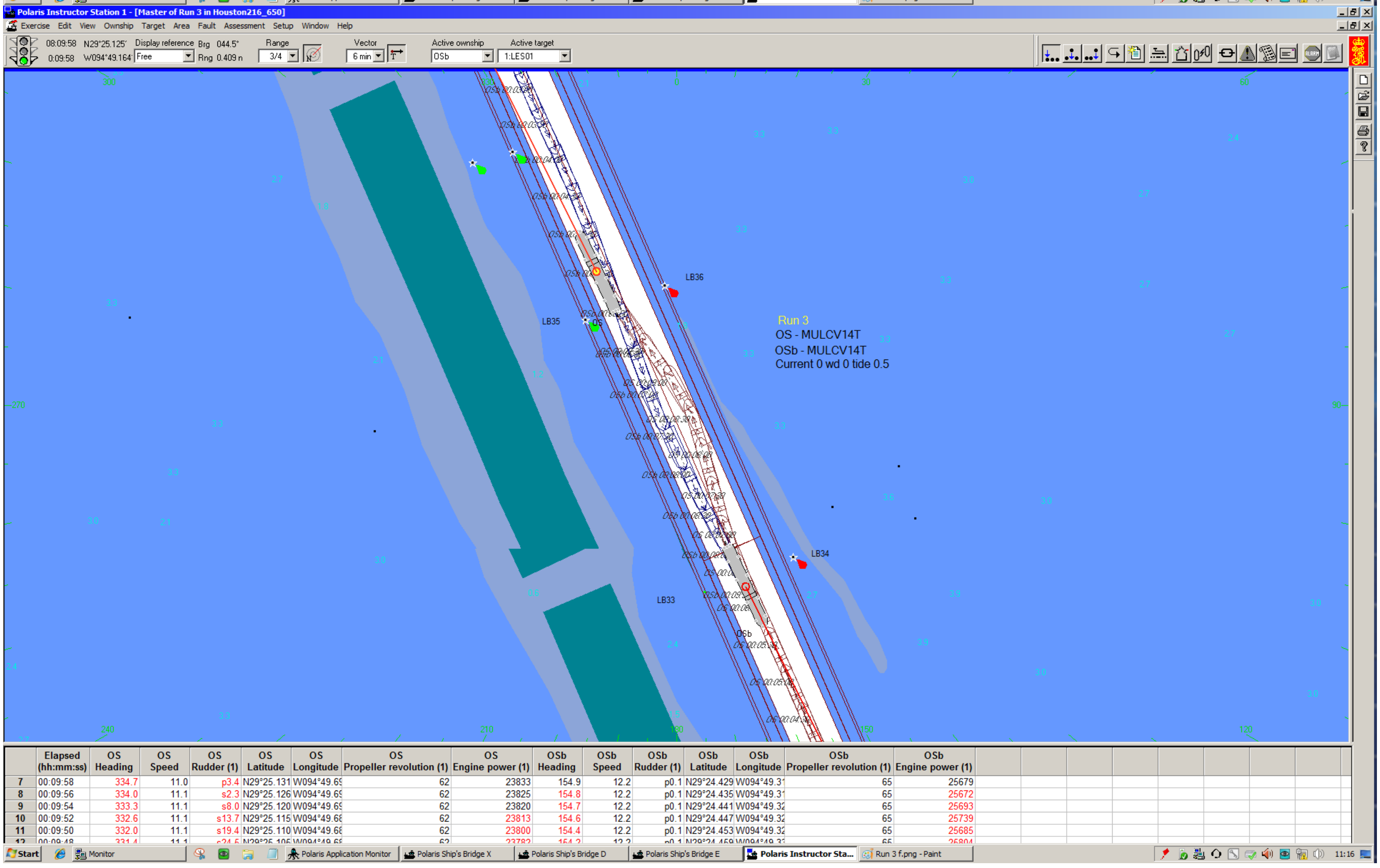
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:52	324.8	10.9	s35.0	N29°24.964	W094°49.56	62	23725	154.1	12.0	s17.3	N29°24.626	W094°49.43	65	25983
8	00:08:50	325.0	10.9	s35.0	N29°24.959	W094°49.56	62	23749	154.4	12.0	s11.6	N29°24.632	W094°49.43	65	25936
9	00:08:48	325.3	10.9	s35.0	N29°24.954	W094°49.55	62	23772	154.9	12.0	s5.9	N29°24.638	W094°49.44	65	26022
10	00:08:46	325.6	10.9	s35.0	N29°24.949	W094°49.55	62	23795	155.2	12.0	s0.8	N29°24.644	W094°49.44	65	26011
11	00:08:44	325.9	10.9	s35.0	N29°24.944	W094°49.55	62	23816	155.7	12.0	p4.9	N29°24.650	W094°49.44	65	26003



Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:09:17 N29°24.765' Display reference: Free Brg 102.2° Rng 0.323 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:09:17 W094°49.131'

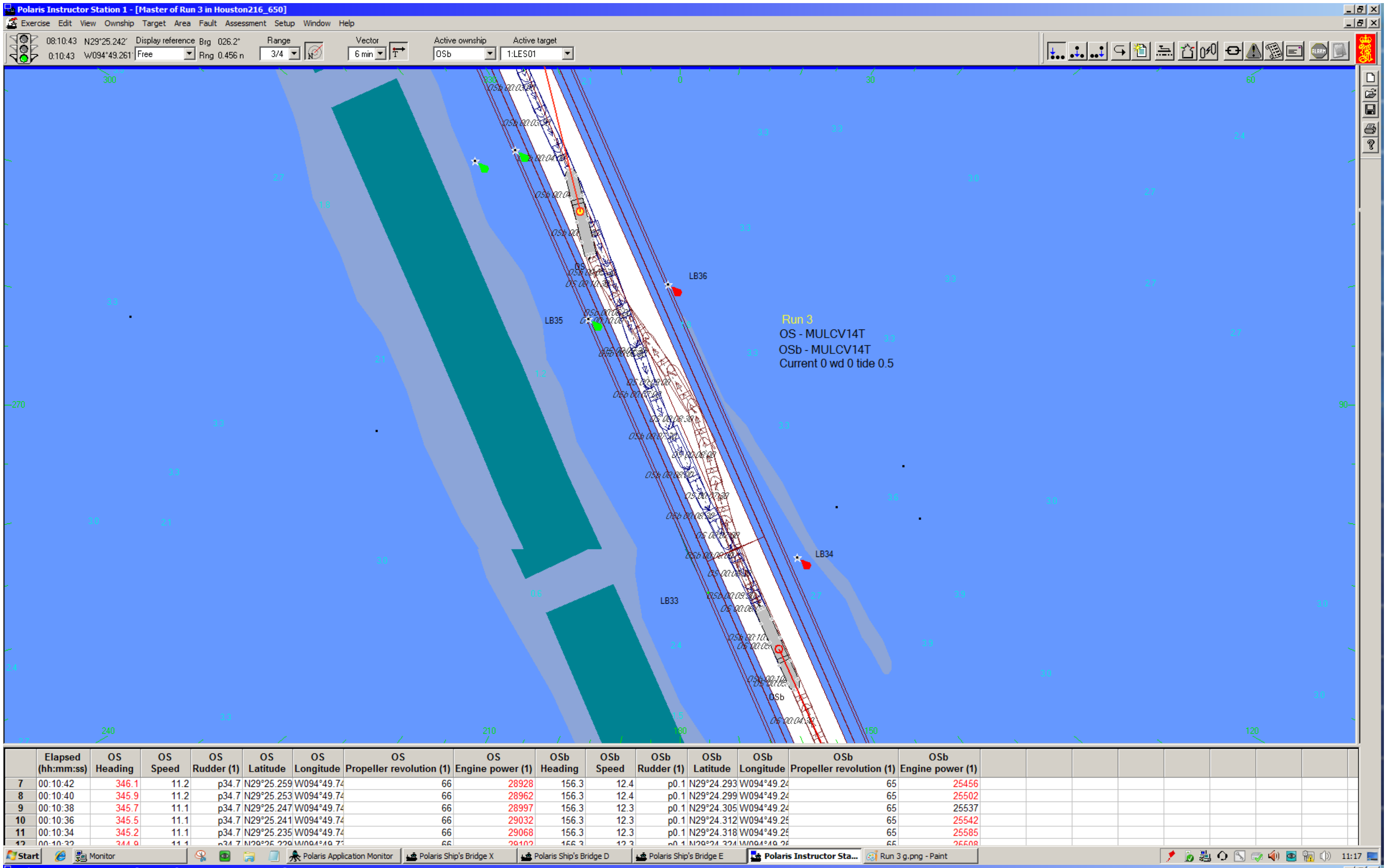
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:16	324.2	11.1	s35.0	N29°25.023	W094°49.6	62	23592	152.0	12.1	s35.0	N29°24.555	W094°49.3	65	25758
8	00:09:14	324.1	11.0	s35.0	N29°25.018	W094°49.6	62	23584	152.0	12.1	s35.0	N29°24.561	W094°49.3	65	25830
9	00:09:12	324.1	11.0	s35.0	N29°25.013	W094°49.6	62	23571	152.1	12.1	s35.0	N29°24.567	W094°49.3	65	25819
10	00:09:10	324.0	11.0	s35.0	N29°25.008	W094°49.6	62	23557	152.2	12.1	s35.0	N29°24.573	W094°49.4	65	25874
11	00:09:08	324.1	11.0	s35.0	N29°25.003	W094°49.5	62	23573	152.3	12.1	s35.0	N29°24.578	W094°49.4	65	25865



Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:09:58 N29°25.125' Display reference: Free Brg 044.5° Rng 0.409 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:09:58 W094°49.164'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:58	334.7	11.0	p3.4	N29°25.131	W094°49.6	62	23833	154.9	12.2	p0.1	N29°24.429	W094°49.3	65	25679
8	00:09:56	334.0	11.1	s2.3	N29°25.126	W094°49.6	62	23825	154.8	12.2	p0.1	N29°24.435	W094°49.3	65	25672
9	00:09:54	333.3	11.1	s8.0	N29°25.120	W094°49.6	62	23820	154.7	12.2	p0.1	N29°24.441	W094°49.3	65	25693
10	00:09:52	332.6	11.1	s13.7	N29°25.115	W094°49.6	62	23813	154.6	12.2	p0.1	N29°24.447	W094°49.3	65	25739
11	00:09:50	332.0	11.1	s19.4	N29°25.110	W094°49.6	62	23800	154.4	12.2	p0.1	N29°24.453	W094°49.3	65	25685

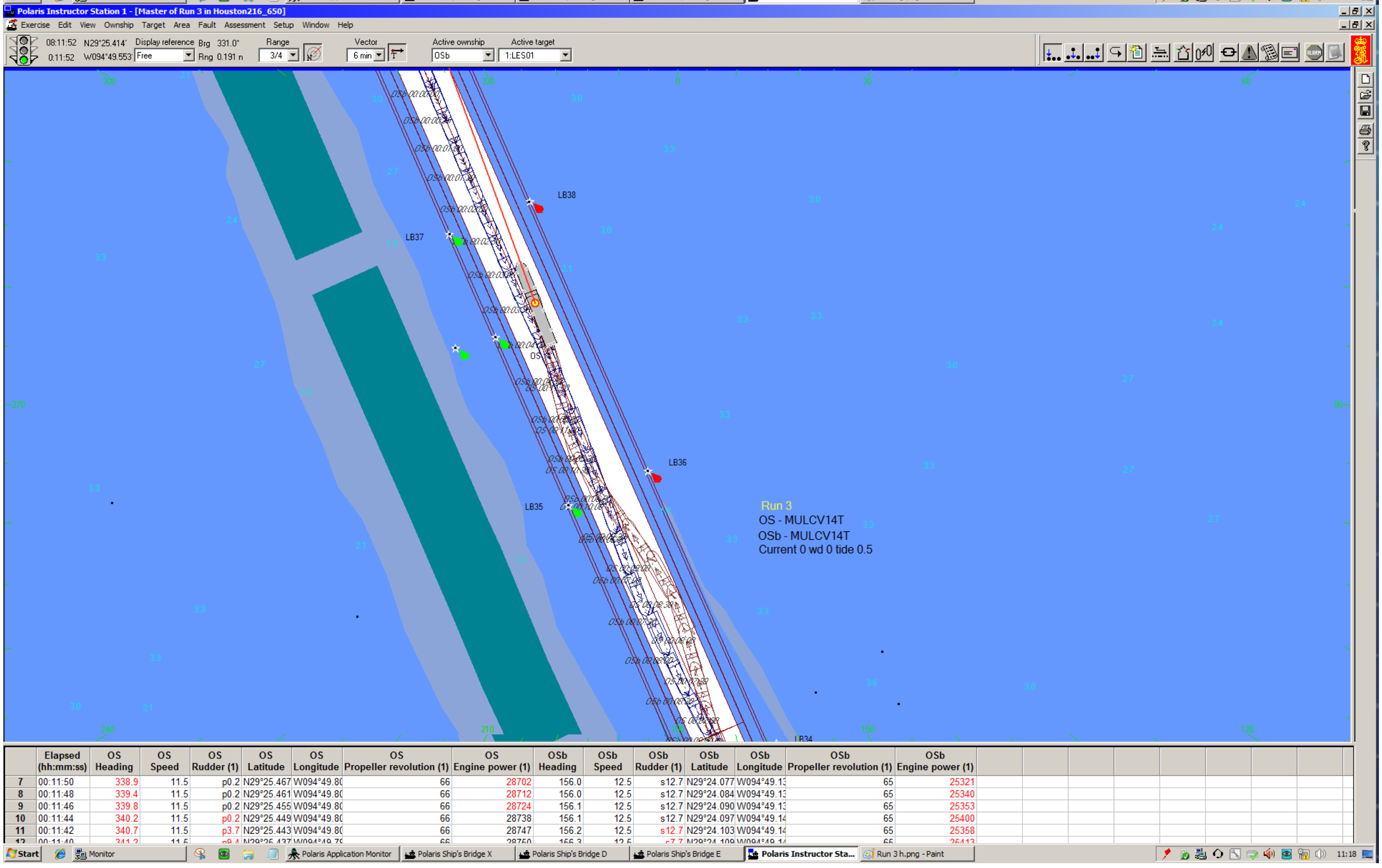


Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:10:43 N29°25.242' Display reference Brg 026.2°
0:10:43 W094°49.261' Free Rng 0.456 n
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:10:42	346.1	11.2	p34.7	N29°25.259	W094°49.74	66	28928	156.3	12.4	p0.1	N29°24.293	W094°49.24	65	25456
8	00:10:40	345.9	11.2	p34.7	N29°25.253	W094°49.74	66	28962	156.3	12.4	p0.1	N29°24.299	W094°49.24	65	25502
9	00:10:38	345.7	11.1	p34.7	N29°25.247	W094°49.74	66	28997	156.3	12.3	p0.1	N29°24.305	W094°49.24	65	25537
10	00:10:36	345.5	11.1	p34.7	N29°25.241	W094°49.74	66	29032	156.3	12.3	p0.1	N29°24.312	W094°49.25	65	25542
11	00:10:34	345.2	11.1	p34.7	N29°25.235	W094°49.74	66	29068	156.3	12.3	p0.1	N29°24.318	W094°49.25	65	25585

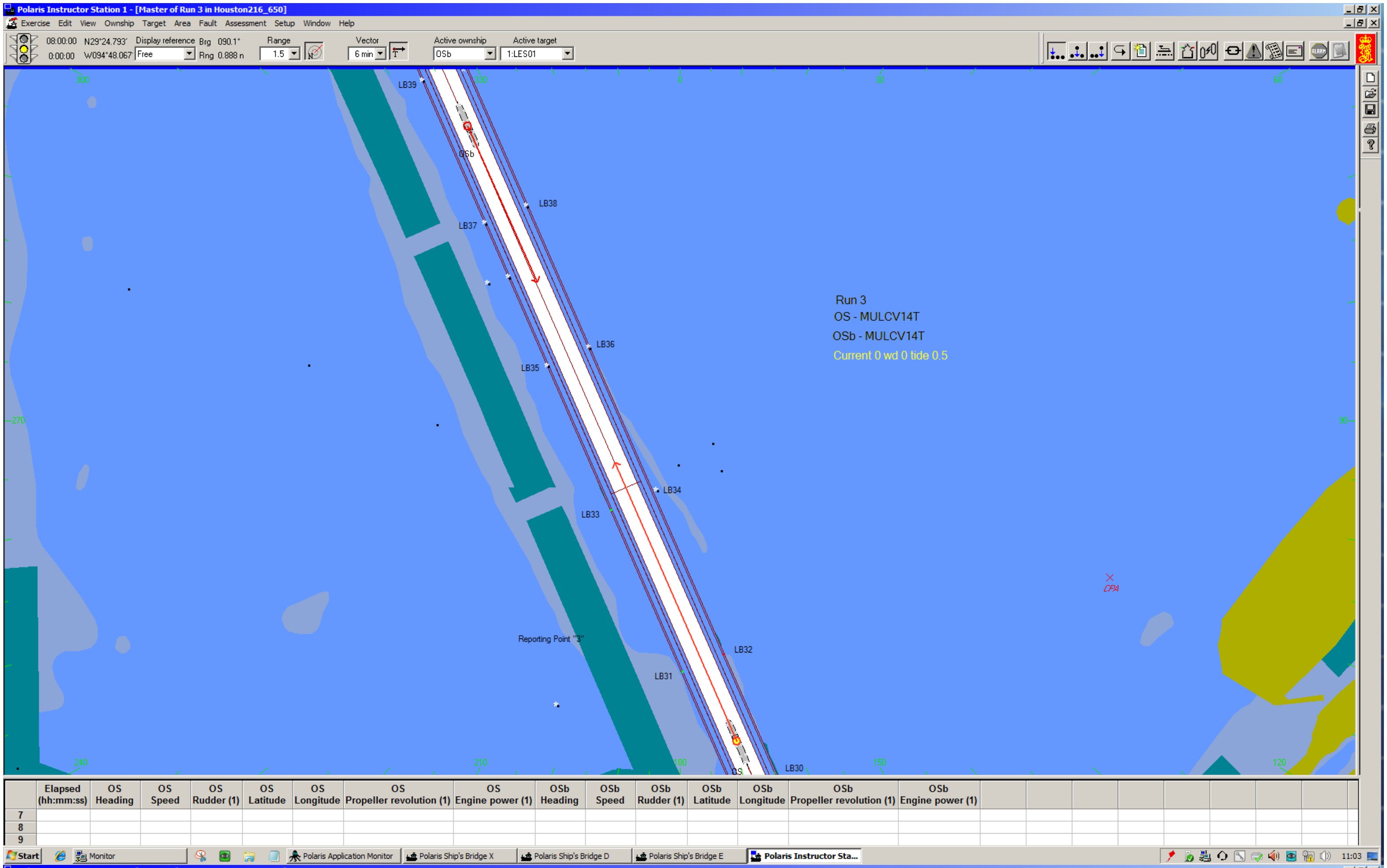


Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:11:52 N29°25.414' Display reference Brg 331.0°
0:11:52 W094°49.553' Free Rng 0.191 n
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:11:50	338.9	11.5	p0.2	N29°25.467	W094°49.80	66	28702	156.0	12.5	s12.7	N29°24.077	W094°49.13	65	25321
8	00:11:48	339.4	11.5	p0.2	N29°25.461	W094°49.80	66	28712	156.0	12.5	s12.7	N29°24.084	W094°49.13	65	25340
9	00:11:46	339.8	11.5	p0.2	N29°25.455	W094°49.80	66	28724	156.1	12.5	s12.7	N29°24.090	W094°49.13	65	25353
10	00:11:44	340.2	11.5	p0.2	N29°25.449	W094°49.80	66	28738	156.1	12.5	s12.7	N29°24.097	W094°49.14	65	25400
11	00:11:42	340.7	11.5	p3.7	N29°25.443	W094°49.80	66	28747	156.2	12.5	s12.7	N29°24.103	W094°49.14	65	25358

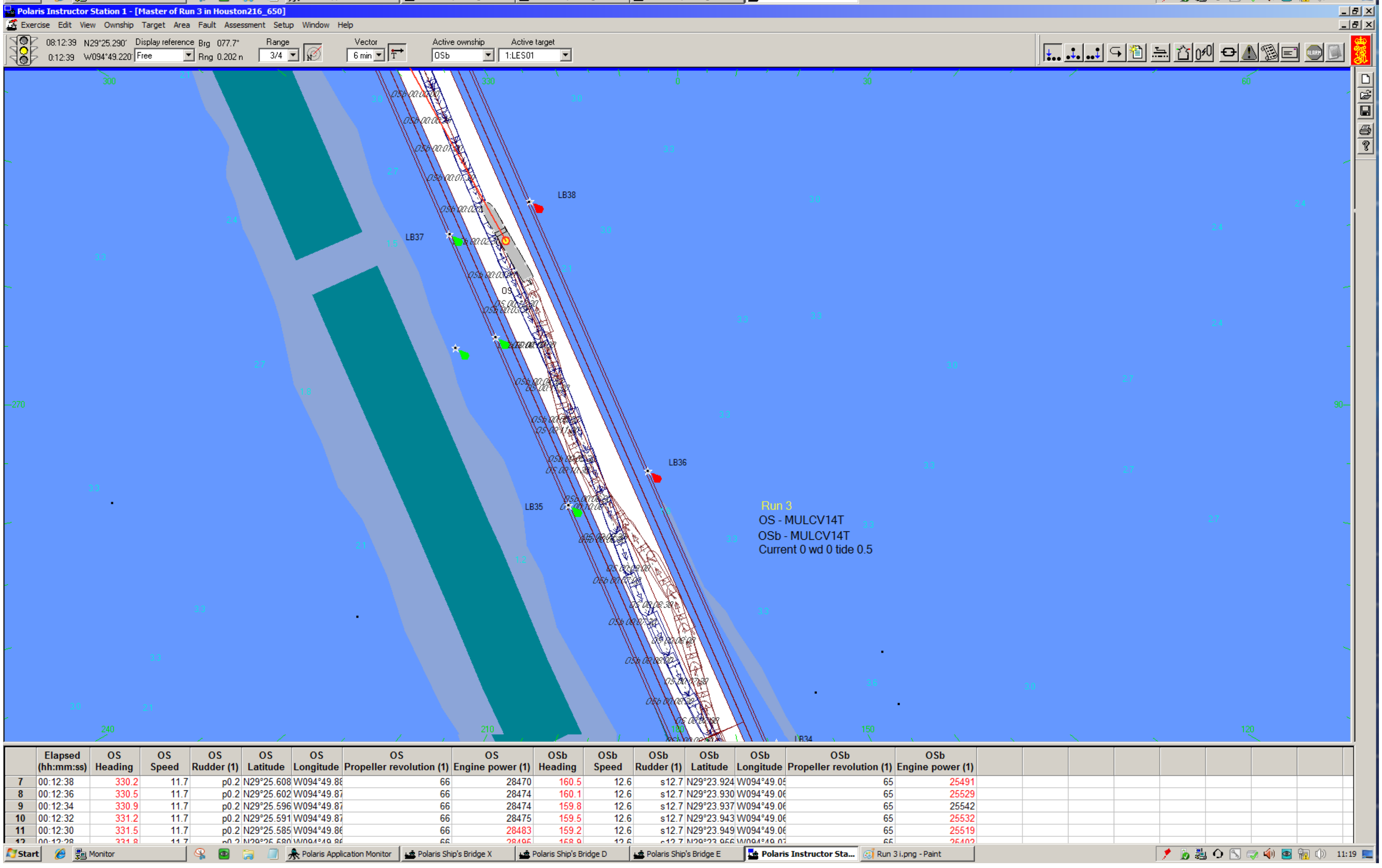


Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:00:00 N29°24.793' Display reference Free Brg 090.1° Rng 0.888 n Range 1.5 Vector 6 min Active ownship OSb Active target 1:LES01
0:00:00 W094°48.067

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7															
8															
9															



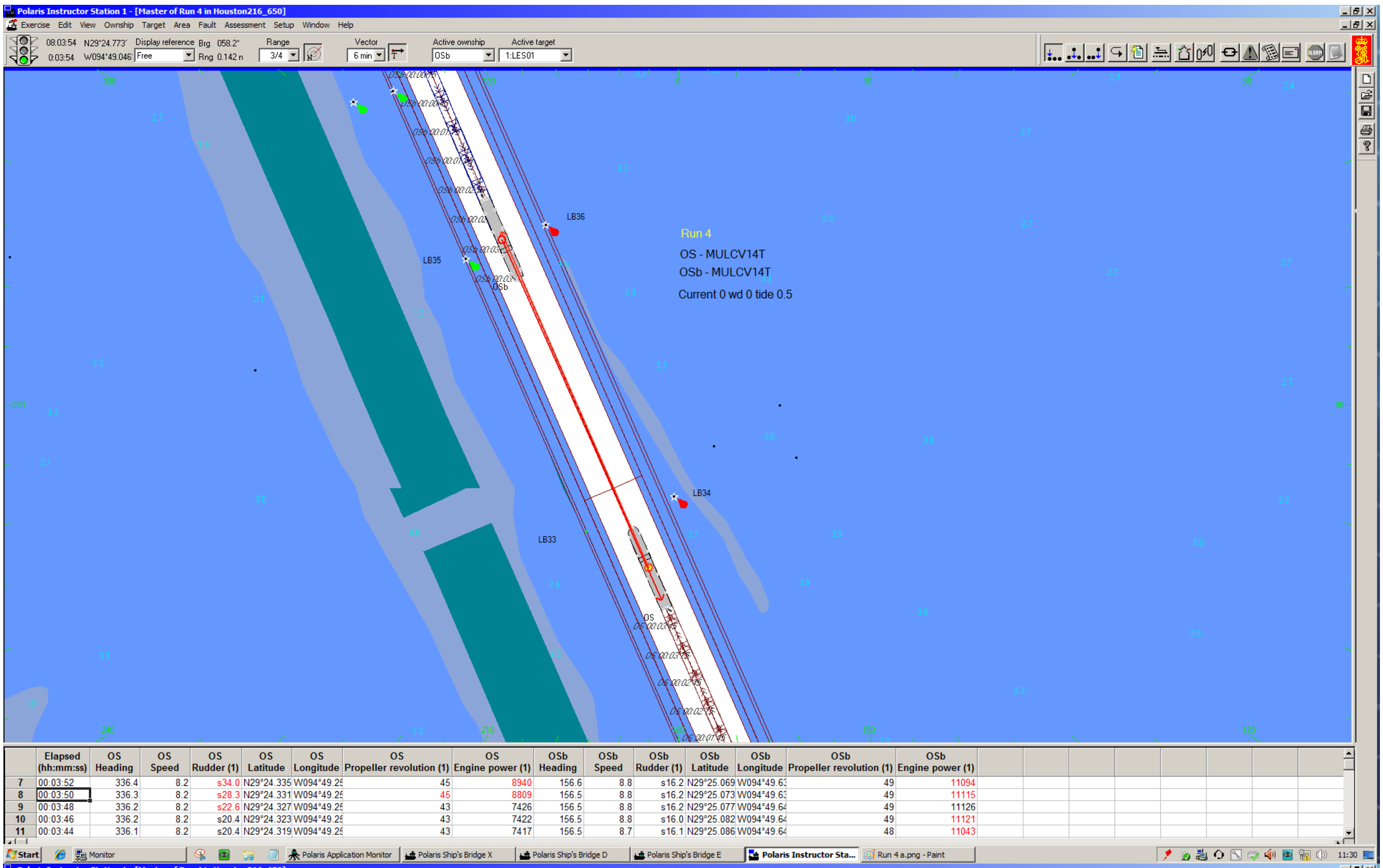
Polaris Instructor Station 1 - [Master of Run 3 in Houston216_650]

08:12:39 N29°25.290' Display reference Free Brg 077.7° Rng 0.202 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:12:39 W094°49.220

Run 3
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:12:38	330.2	11.7	p0.2	N29°25.608	W094°49.88	66	28470	160.5	12.6	s12.7	N29°23.924	W094°49.05	65	25491
8	00:12:36	330.5	11.7	p0.2	N29°25.602	W094°49.87	66	28474	160.1	12.6	s12.7	N29°23.930	W094°49.06	65	25529
9	00:12:34	330.9	11.7	p0.2	N29°25.596	W094°49.87	66	28474	159.8	12.6	s12.7	N29°23.937	W094°49.06	65	25542
10	00:12:32	331.2	11.7	p0.2	N29°25.591	W094°49.87	66	28475	159.5	12.6	s12.7	N29°23.943	W094°49.06	65	25532
11	00:12:30	331.5	11.7	p0.2	N29°25.585	W094°49.86	66	28483	159.2	12.6	s12.7	N29°23.949	W094°49.06	65	25519

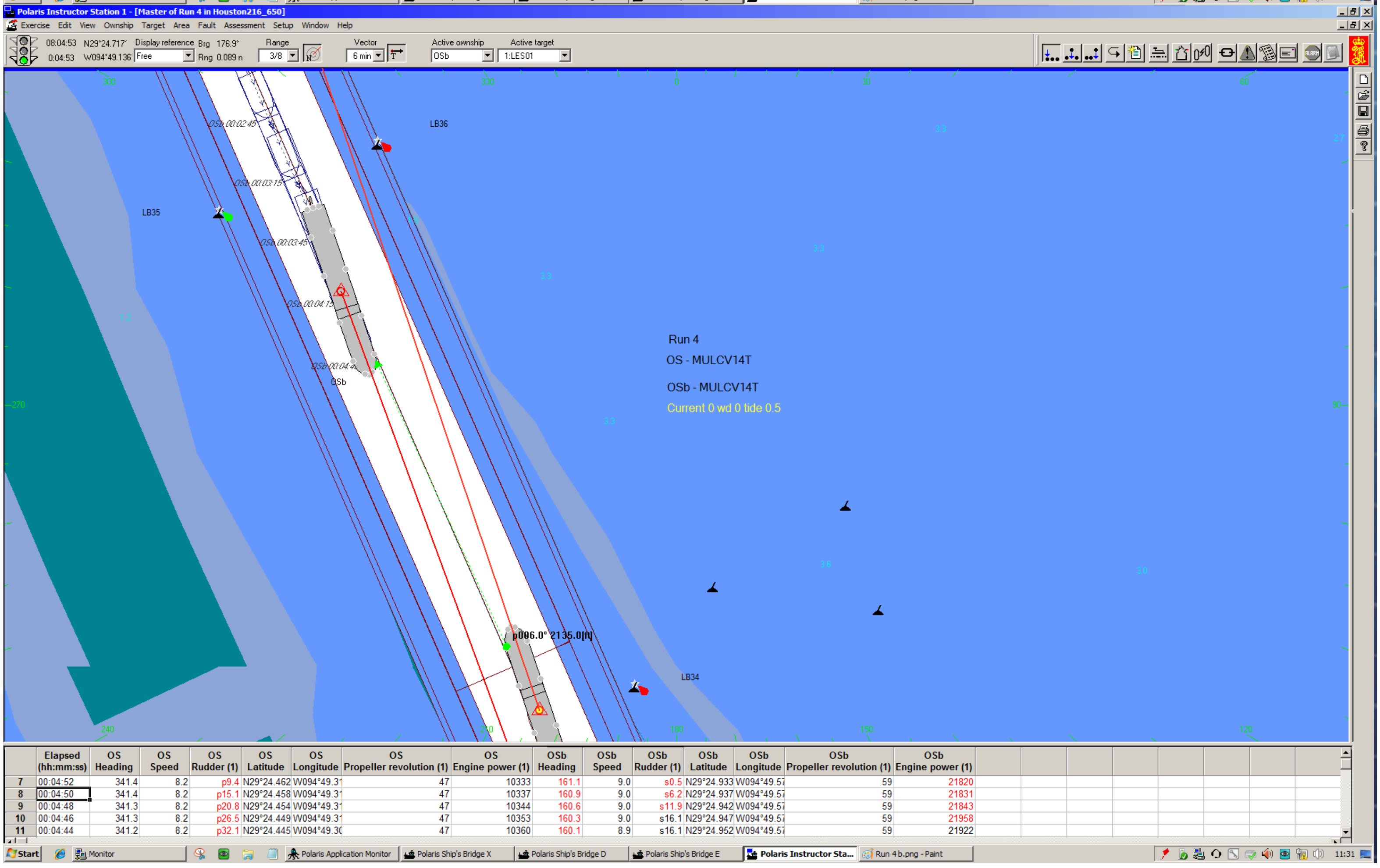
Run 4



08:03:54 N29°24.773' Display reference: Free Brg 058.2° Range: 3/4 Vector: 6 min Active ownship: OSb Active target: 1:LES01
0:03:54 W094°49.046' Rng 0.142 n

Run 4
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

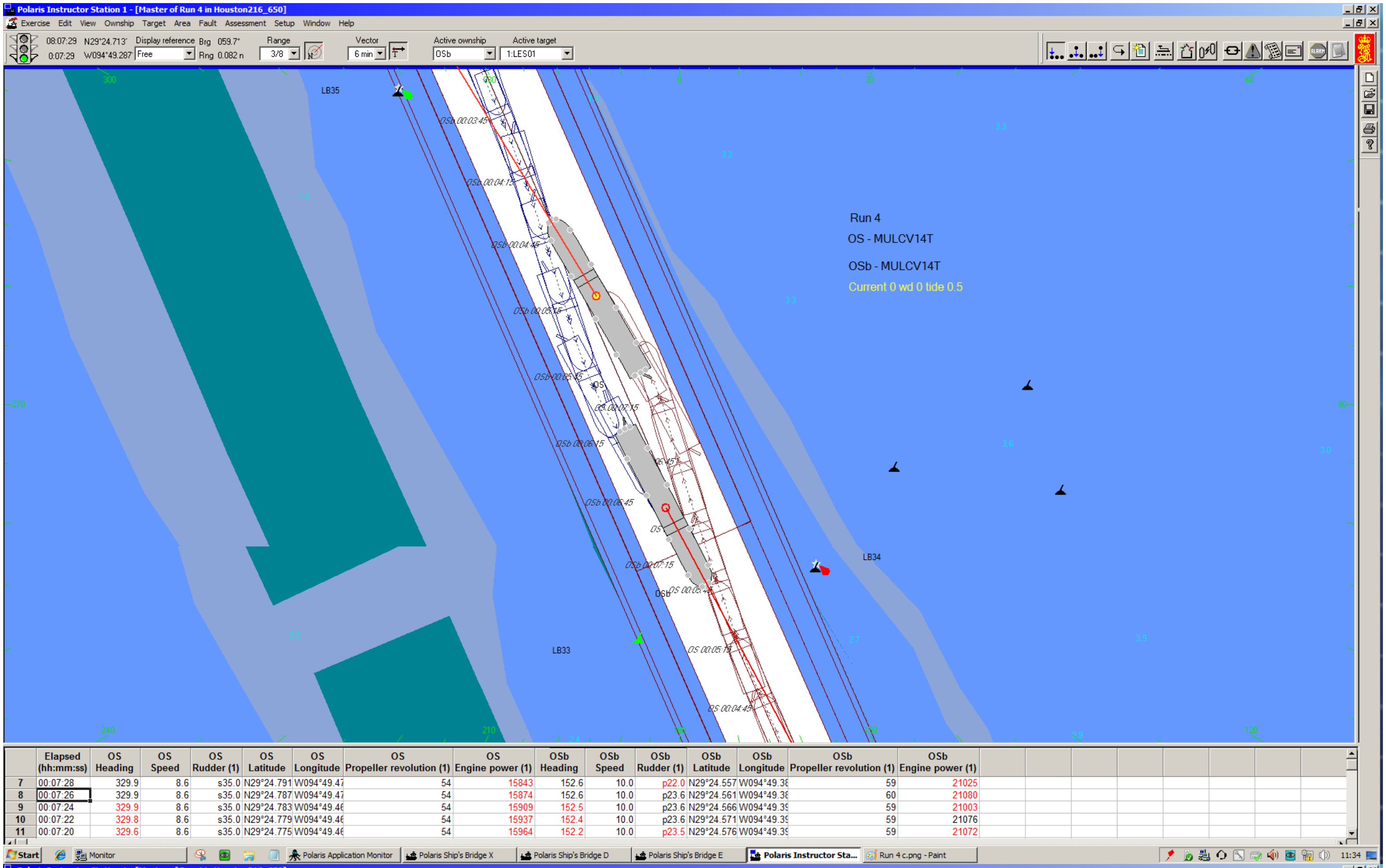
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:52	336.4	8.2	s34.0	N29°24.335	W094°49.25	45	8940	156.6	8.8	s16.2	N29°25.069	W094°49.63	49	11094
8	00:03:50	336.3	8.2	s28.3	N29°24.331	W094°49.25	45	8809	156.5	8.8	s16.2	N29°25.073	W094°49.63	49	11115
9	00:03:48	336.2	8.2	s22.6	N29°24.327	W094°49.25	43	7426	156.5	8.8	s16.2	N29°25.077	W094°49.64	49	11126
10	00:03:46	336.2	8.2	s20.4	N29°24.323	W094°49.25	43	7422	156.5	8.8	s16.0	N29°25.082	W094°49.64	49	11121
11	00:03:44	336.1	8.2	s20.4	N29°24.319	W094°49.25	43	7417	156.5	8.7	s16.1	N29°25.086	W094°49.64	48	11043



08:04:53 N29°24.717' Display reference: Free Brg 176.9° Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01
0:04:53 W094°49.136' Rng 0.089 n

Run 4
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:04:52	341.4	8.2	p9.4	N29°24.462	W094°49.31	47	10333	161.1	9.0	s0.5	N29°24.933	W094°49.57	59	21820
8	00:04:50	341.4	8.2	p15.1	N29°24.458	W094°49.31	47	10337	160.9	9.0	s6.2	N29°24.937	W094°49.57	59	21831
9	00:04:48	341.3	8.2	p20.8	N29°24.454	W094°49.31	47	10344	160.6	9.0	s11.9	N29°24.942	W094°49.57	59	21843
10	00:04:46	341.3	8.2	p26.5	N29°24.449	W094°49.31	47	10353	160.3	9.0	s16.1	N29°24.947	W094°49.57	59	21958
11	00:04:44	341.2	8.2	p32.1	N29°24.445	W094°49.30	47	10360	160.1	8.9	s16.1	N29°24.952	W094°49.57	59	21922



Polaris Instructor Station 1 - [Master of Run 4 in Houston216_650]

08:07:29 N29°24.713' Display reference Free Brg 059.7° Rng 0.082 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01

0:07:29 W094°49.287'

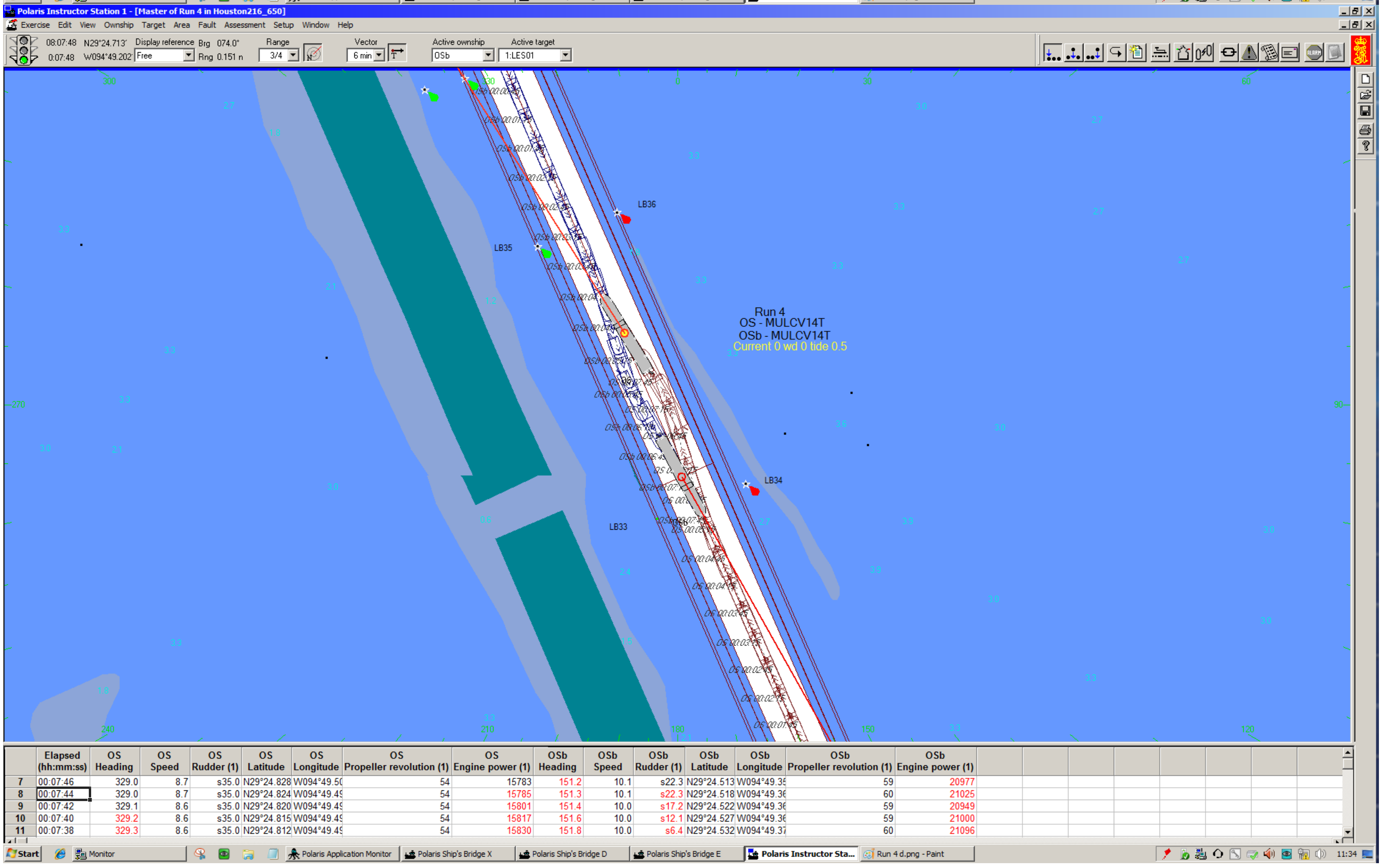
Run 4

OS - MULCV14T

OSb - MULCV14T

Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:28	329.9	8.6	s35.0	N29°24.791	W094°49.47	54	15843	152.6	10.0	p22.0	N29°24.557	W094°49.38	59	21025
8	00:07:26	329.9	8.6	s35.0	N29°24.787	W094°49.47	54	15874	152.6	10.0	p23.6	N29°24.561	W094°49.38	60	21080
9	00:07:24	329.9	8.6	s35.0	N29°24.783	W094°49.46	54	15909	152.5	10.0	p23.6	N29°24.566	W094°49.39	59	21003
10	00:07:22	329.8	8.6	s35.0	N29°24.779	W094°49.46	54	15937	152.4	10.0	p23.6	N29°24.571	W094°49.39	59	21076
11	00:07:20	329.6	8.6	s35.0	N29°24.775	W094°49.46	54	15964	152.2	10.0	p23.5	N29°24.576	W094°49.39	59	21072



Polaris Instructor Station 1 - [Master of Run 4 in Houston216_650]

08:07:48 N29°24.713' Display reference Free Brg 074.0° Rng 0.151 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01

0:07:48 W094°49.202'

Run 4

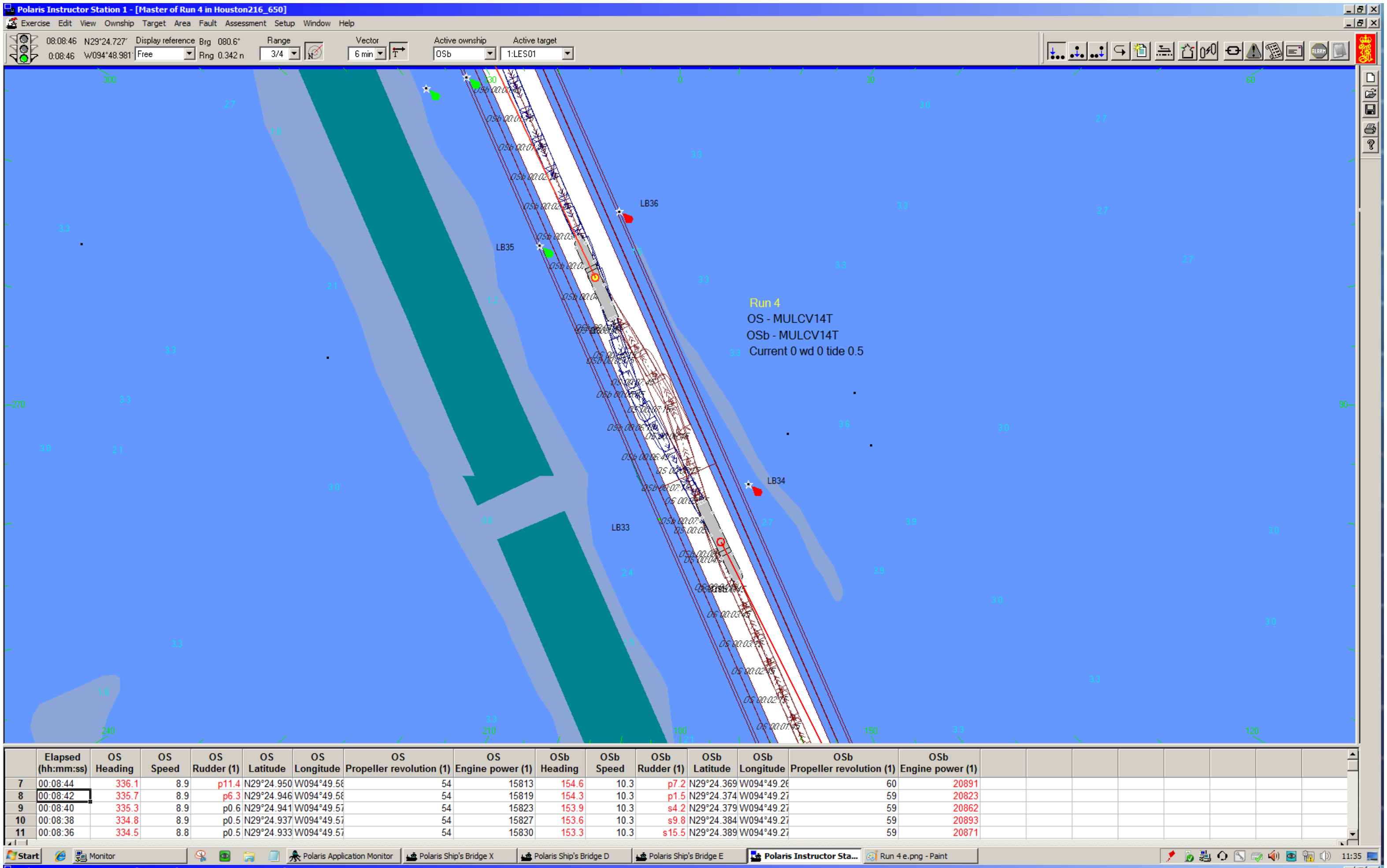
OS - MULCV14T

OSb - MULCV14T

Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:46	329.0	8.7	s35.0	N29°24.828	W094°49.50	54	15783	151.2	10.1	s22.3	N29°24.513	W094°49.35	59	20977
8	00:07:44	329.0	8.7	s35.0	N29°24.824	W094°49.49	54	15785	151.3	10.1	s22.3	N29°24.518	W094°49.36	60	21025
9	00:07:42	329.1	8.6	s35.0	N29°24.820	W094°49.49	54	15801	151.4	10.0	s17.2	N29°24.522	W094°49.36	59	20949
10	00:07:40	329.2	8.6	s35.0	N29°24.815	W094°49.49	54	15817	151.6	10.0	s12.1	N29°24.527	W094°49.36	59	21000
11	00:07:38	329.3	8.6	s35.0	N29°24.812	W094°49.49	54	15830	151.8	10.0	s6.4	N29°24.532	W094°49.37	60	21096

June 26, 2019

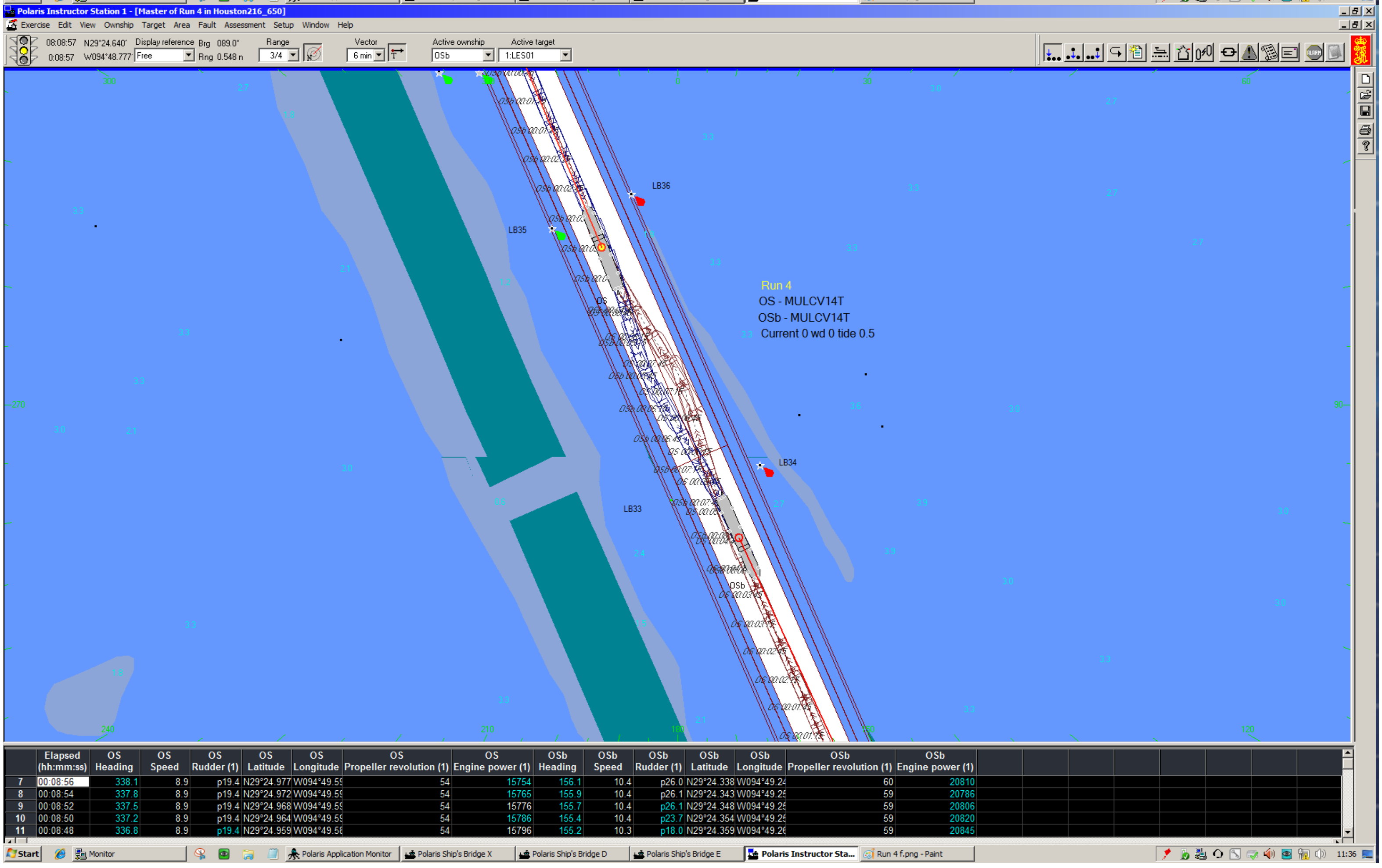


Polaris Instructor Station 1 - [Master of Run 4 in Houston216_650]

08:08:46 N29°24.727′ Display reference Free Brg 080.6° Rng 0.342 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:46 W094°48.981′

Run 4
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:44	336.1	8.9	p11.4	N29°24.950	W094°49.58	54	15813	154.6	10.3	p7.2	N29°24.369	W094°49.26	60	20891
8	00:08:42	335.7	8.9	p6.3	N29°24.946	W094°49.58	54	15819	154.3	10.3	p1.5	N29°24.374	W094°49.27	59	20823
9	00:08:40	335.3	8.9	p0.6	N29°24.941	W094°49.57	54	15823	153.9	10.3	s4.2	N29°24.379	W094°49.27	59	20862
10	00:08:38	334.8	8.9	p0.5	N29°24.937	W094°49.57	54	15827	153.6	10.3	s9.8	N29°24.384	W094°49.27	59	20893
11	00:08:36	334.5	8.8	p0.5	N29°24.933	W094°49.57	54	15830	153.3	10.3	s15.5	N29°24.389	W094°49.27	59	20871

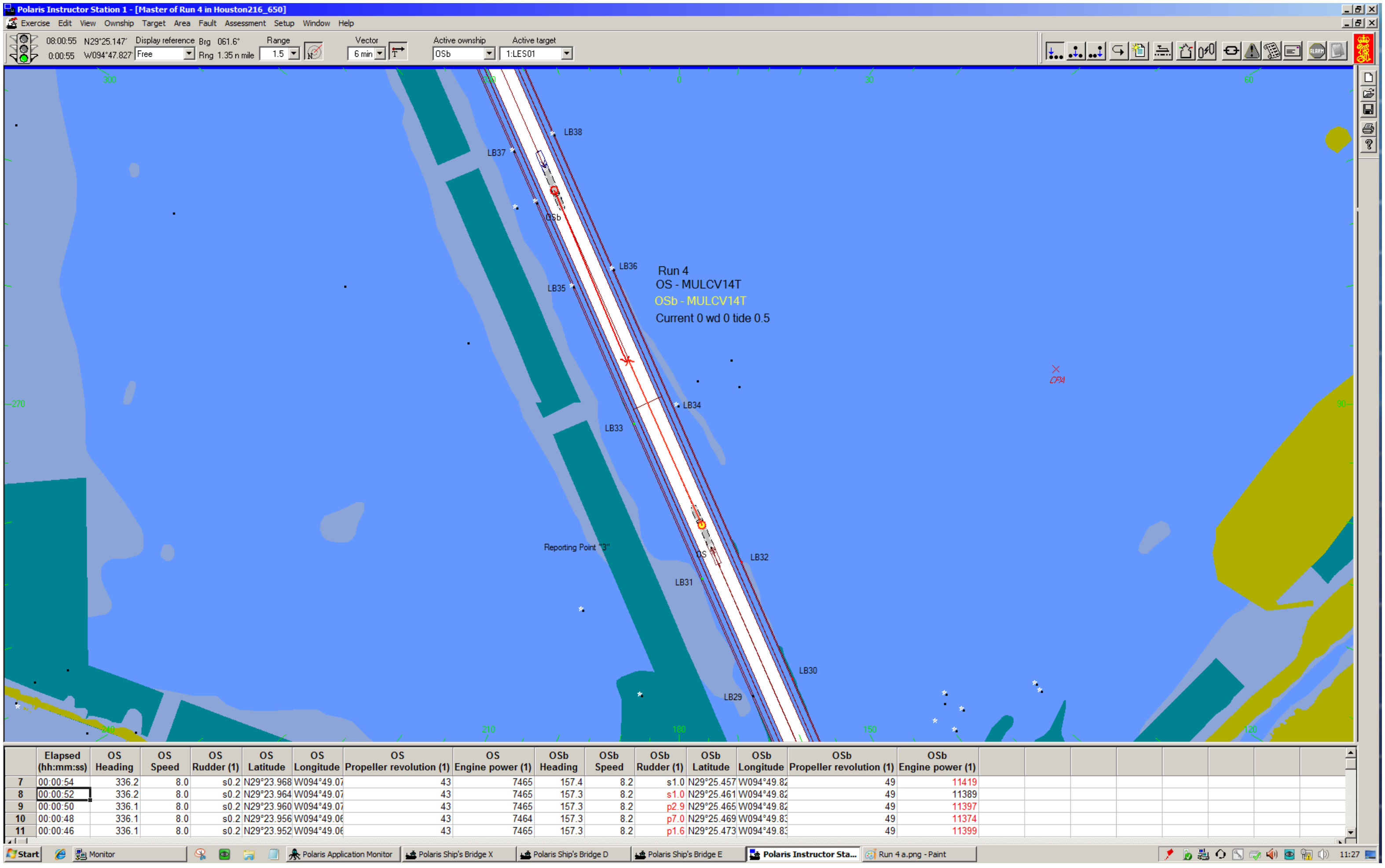


Polaris Instructor Station 1 - [Master of Run 4 in Houston216_650]

08:08:57 N29°24.640′ Display reference Free Brg 089.0° Rng 0.548 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:57 W094°48.777′

Run 4
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:56	338.1	8.9	p19.4	N29°24.977	W094°49.59	54	15754	156.1	10.4	p26.0	N29°24.338	W094°49.24	60	20810
8	00:08:54	337.8	8.9	p19.4	N29°24.972	W094°49.59	54	15765	155.9	10.4	p26.1	N29°24.343	W094°49.25	59	20786
9	00:08:52	337.5	8.9	p19.4	N29°24.968	W094°49.59	54	15776	155.7	10.4	p26.1	N29°24.348	W094°49.25	59	20806
10	00:08:50	337.2	8.9	p19.4	N29°24.964	W094°49.59	54	15786	155.4	10.4	p23.7	N29°24.354	W094°49.25	59	20820
11	00:08:48	336.8	8.9	p19.4	N29°24.959	W094°49.58	54	15796	155.2	10.3	p18.0	N29°24.359	W094°49.26	59	20845



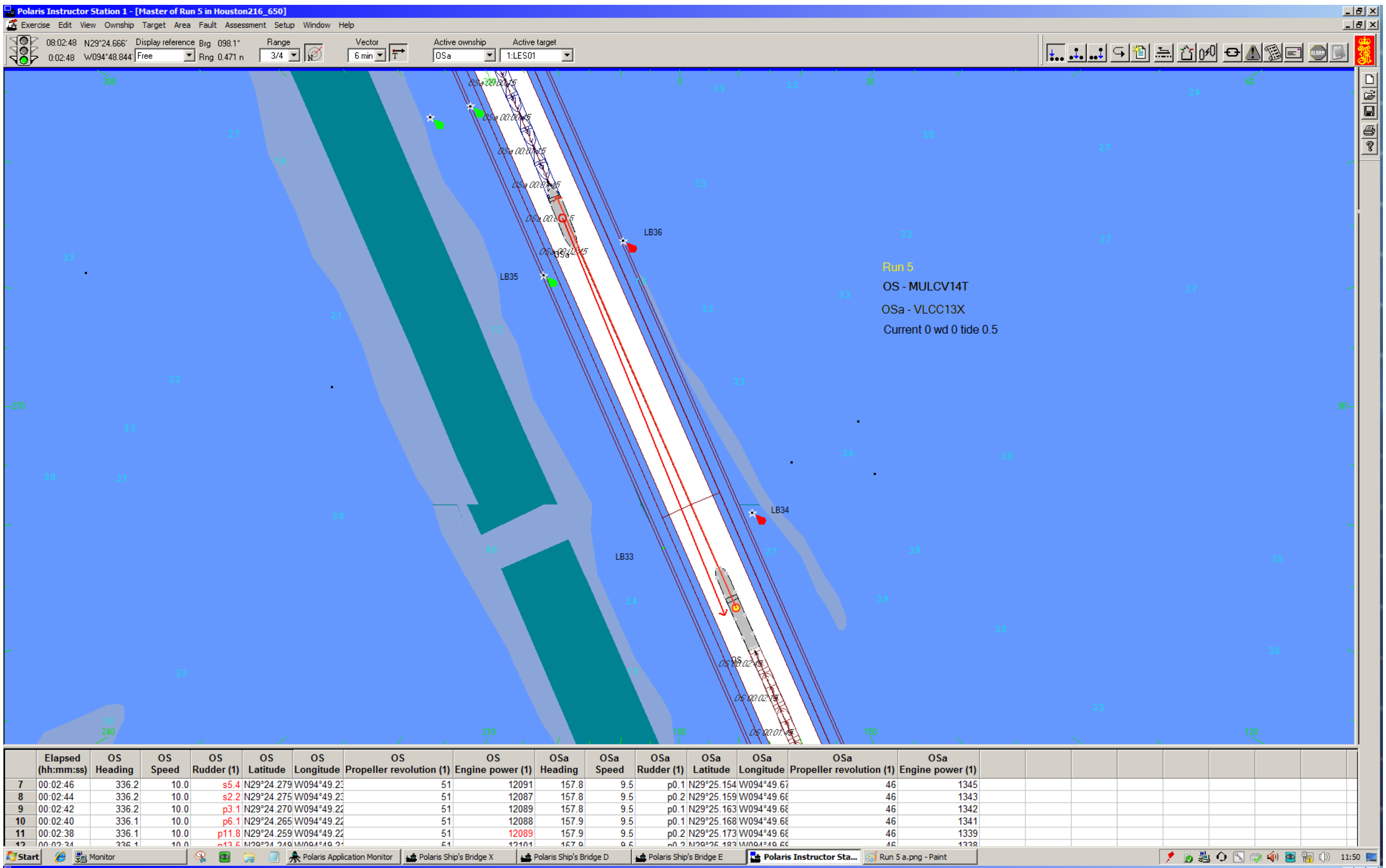
Polaris Instructor Station 1 - [Master of Run 4 in Houston216_650]

08:00:55 N29°25.147'
0:00:55 W094°47.827'
Display reference: Free
Brg 061.6°
Rng 1.35 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 4
OS - MULCV14T
OSb - MULCV14T
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:00:54	336.2	8.0	s0.2	N29°23.968	W094°49.07	43	7465	157.4	8.2	s1.0	N29°25.457	W094°49.82	49	11419
8	00:00:52	336.2	8.0	s0.2	N29°23.964	W094°49.07	43	7465	157.3	8.2	s1.0	N29°25.461	W094°49.82	49	11389
9	00:00:50	336.1	8.0	s0.2	N29°23.960	W094°49.07	43	7465	157.3	8.2	p2.9	N29°25.465	W094°49.82	49	11397
10	00:00:48	336.1	8.0	s0.2	N29°23.956	W094°49.06	43	7464	157.3	8.2	p7.0	N29°25.469	W094°49.83	49	11374
11	00:00:46	336.1	8.0	s0.2	N29°23.952	W094°49.06	43	7465	157.3	8.2	p1.6	N29°25.473	W094°49.83	49	11399

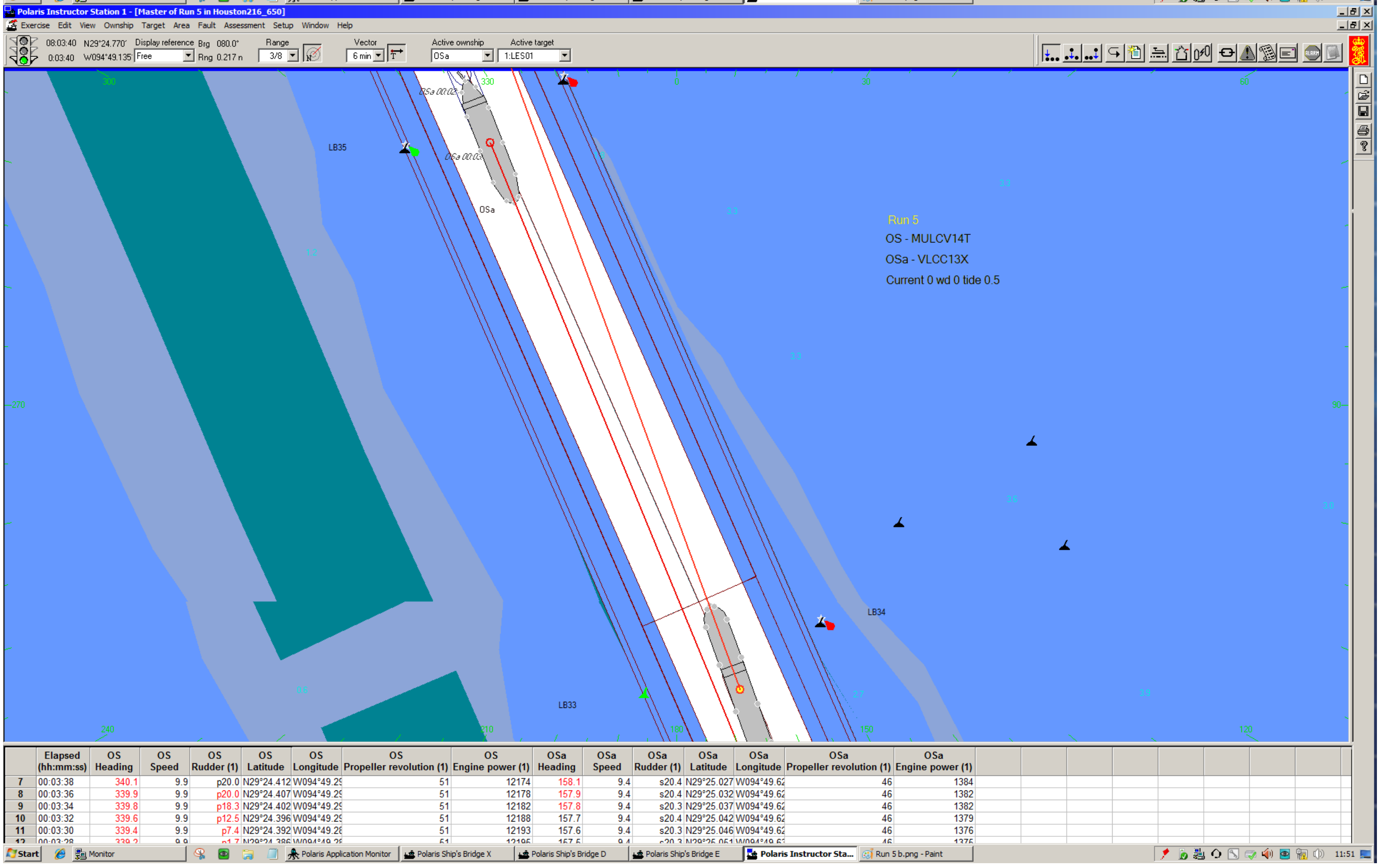
Run 5



08:02:48 N29°24.666' Display reference Brg 098.1°
0:02:48 W094°48.844' Free Rng 0.471 n
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

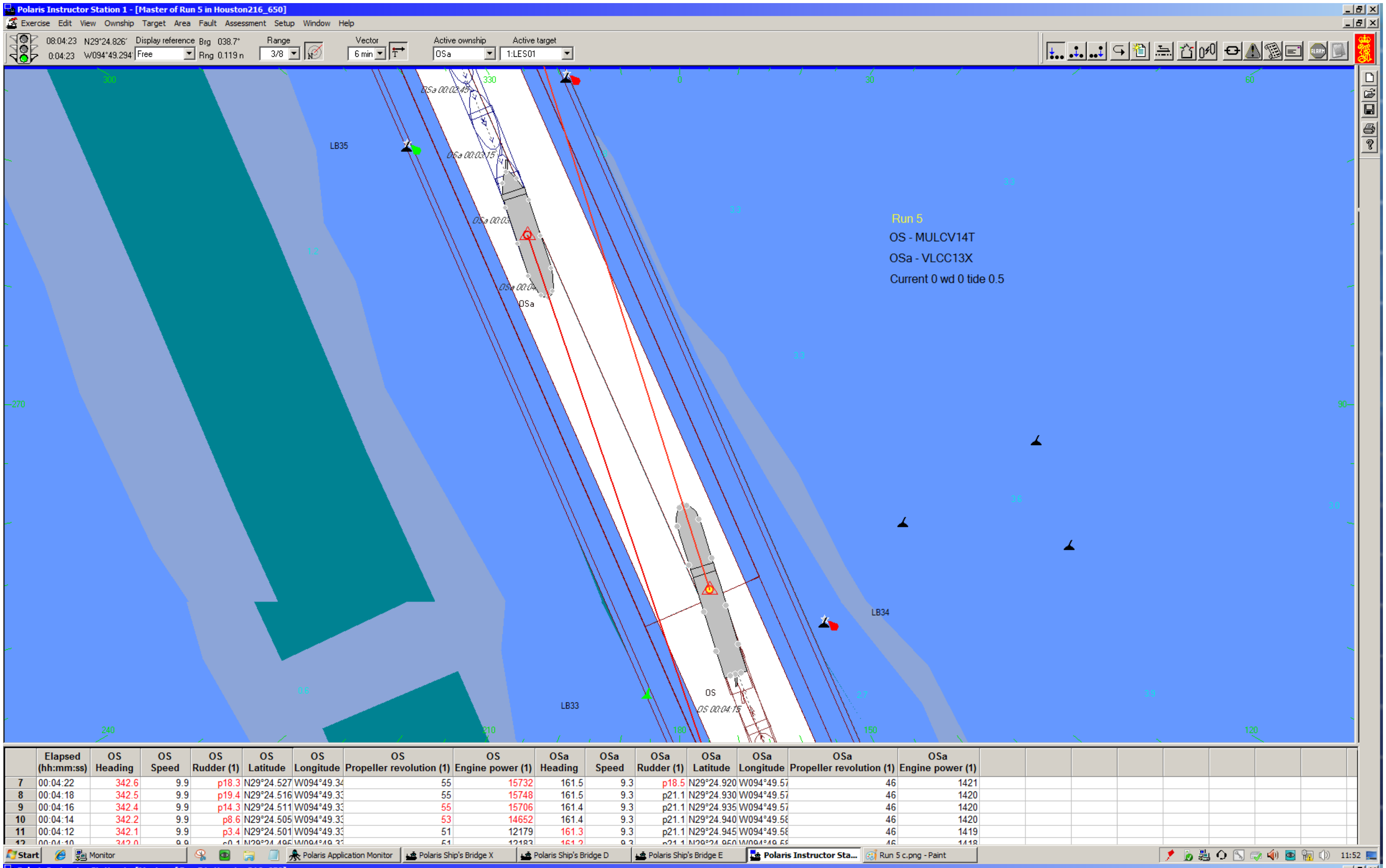
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:02:46	336.2	10.0	s5.4	N29°24.279	W094°49.23	51	12091	157.8	9.5	p0.1	N29°25.154	W094°49.67	46	1345
8	00:02:44	336.2	10.0	s2.2	N29°24.275	W094°49.23	51	12087	157.8	9.5	p0.2	N29°25.159	W094°49.68	46	1343
9	00:02:42	336.2	10.0	p3.1	N29°24.270	W094°49.22	51	12089	157.8	9.5	p0.1	N29°25.163	W094°49.68	46	1342
10	00:02:40	336.1	10.0	p6.1	N29°24.265	W094°49.22	51	12088	157.9	9.5	p0.1	N29°25.168	W094°49.68	46	1341
11	00:02:38	336.1	10.0	p11.8	N29°24.259	W094°49.22	51	12089	157.9	9.5	p0.2	N29°25.173	W094°49.68	46	1339



08:03:40 N29°24.770' Display reference Brg 080.0°
0:03:40 W094°49.135' Free Rng 0.217 n
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

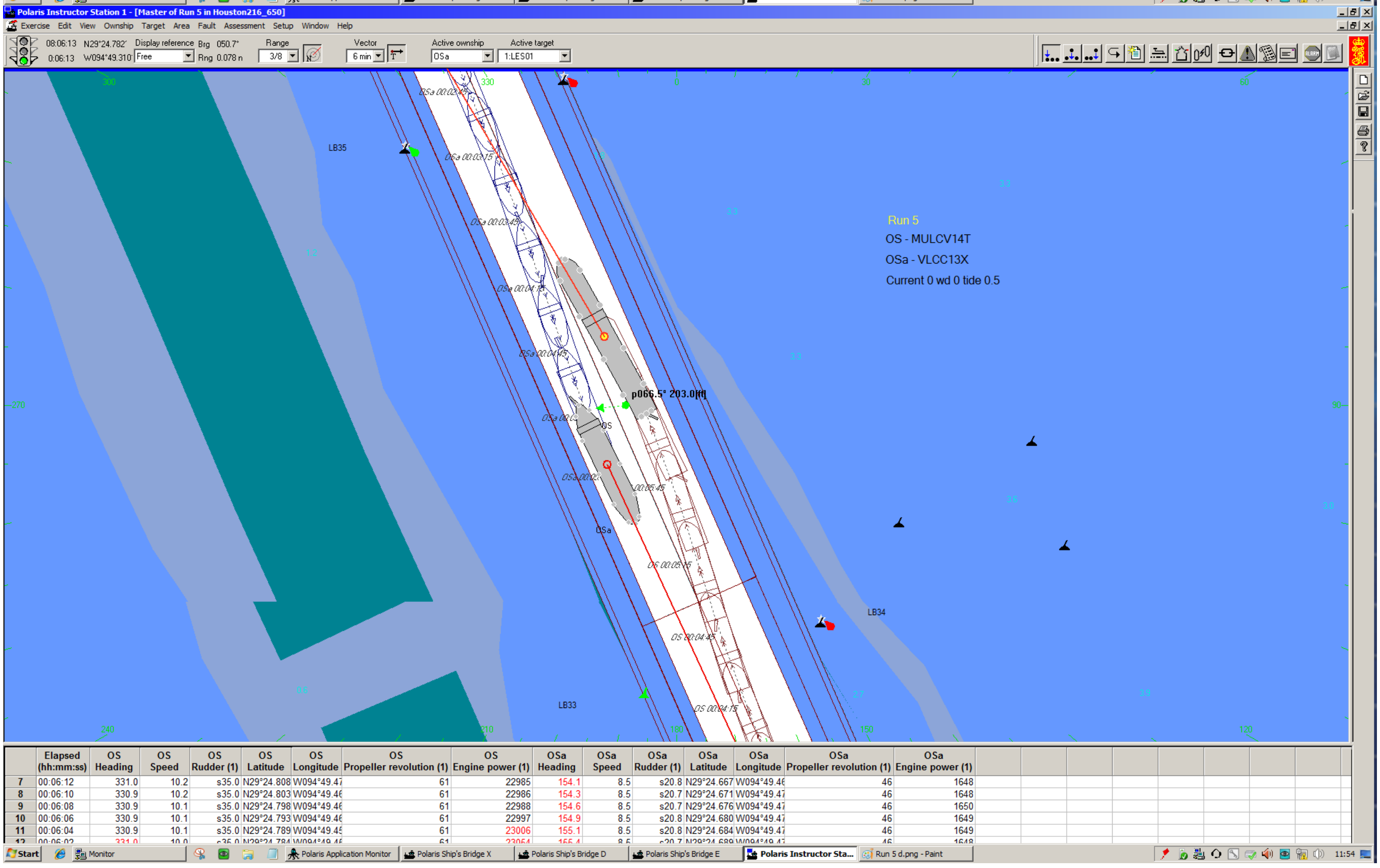
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:03:38	340.1	9.9	p20.0	N29°24.412	W094°49.29	51	12174	158.1	9.4	s20.4	N29°25.027	W094°49.62	46	1384
8	00:03:36	339.9	9.9	p20.0	N29°24.407	W094°49.29	51	12178	157.9	9.4	s20.4	N29°25.032	W094°49.62	46	1382
9	00:03:34	339.8	9.9	p18.3	N29°24.402	W094°49.29	51	12182	157.8	9.4	s20.3	N29°25.037	W094°49.62	46	1382
10	00:03:32	339.6	9.9	p12.5	N29°24.396	W094°49.29	51	12188	157.7	9.4	s20.4	N29°25.042	W094°49.62	46	1379
11	00:03:30	339.4	9.9	p7.4	N29°24.392	W094°49.28	51	12193	157.6	9.4	s20.3	N29°25.046	W094°49.62	46	1376



08:04:23 N29°24.826′ Display reference: Free Brg 038.7° Rng 0.119 n
0:04:23 W094°49.294′ Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

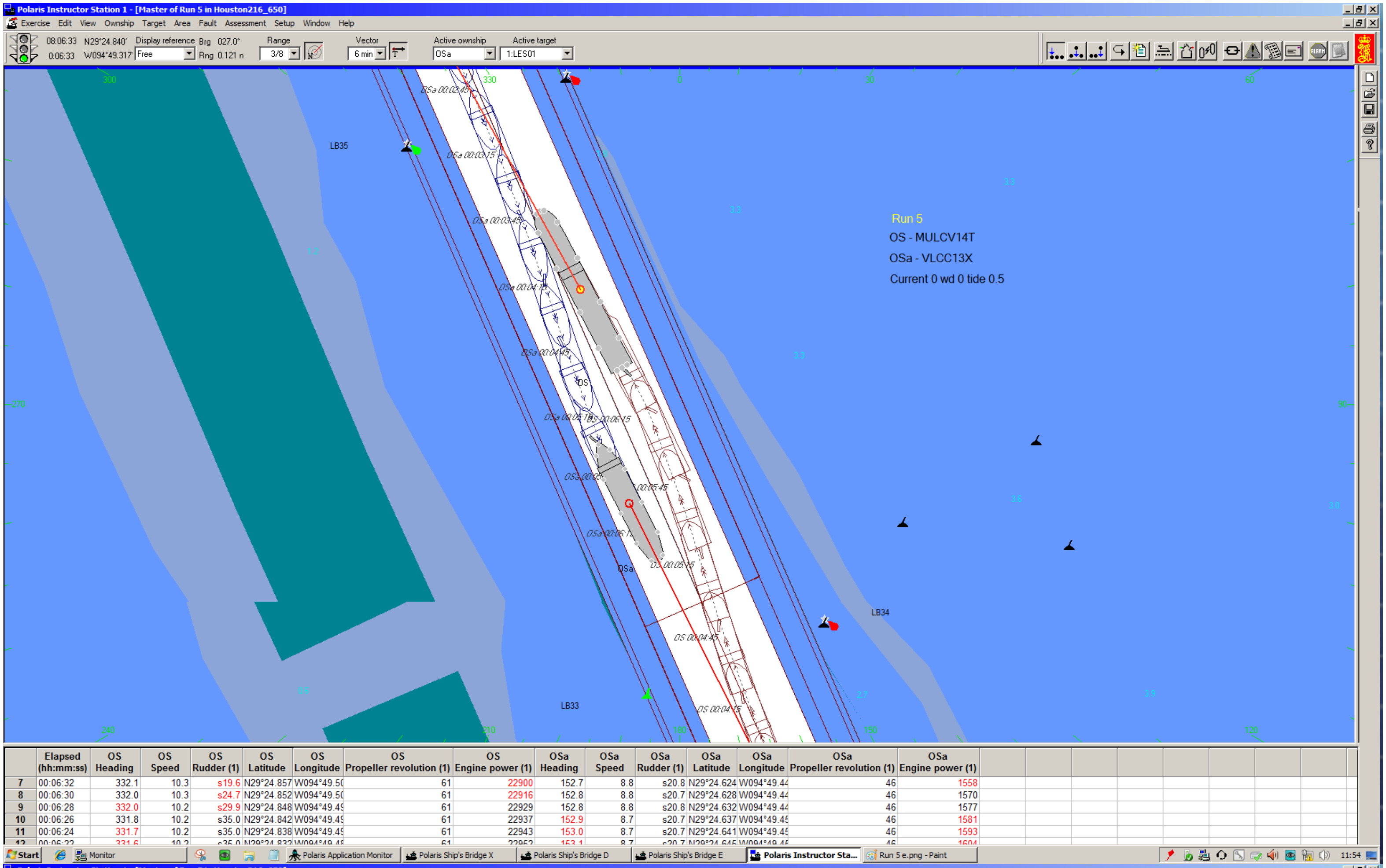
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:22	342.6	9.9	p18.3	N29°24.527	W094°49.34	55	15732	161.5	9.3	p18.5	N29°24.920	W094°49.57	46	1421
8	00:04:18	342.5	9.9	p19.4	N29°24.516	W094°49.33	55	15748	161.5	9.3	p21.1	N29°24.930	W094°49.57	46	1420
9	00:04:16	342.4	9.9	p14.3	N29°24.511	W094°49.33	55	15706	161.4	9.3	p21.1	N29°24.935	W094°49.57	46	1420
10	00:04:14	342.2	9.9	p8.6	N29°24.505	W094°49.33	53	14652	161.4	9.3	p21.1	N29°24.940	W094°49.58	46	1420
11	00:04:12	342.1	9.9	p3.4	N29°24.501	W094°49.33	51	12179	161.3	9.3	p21.1	N29°24.945	W094°49.58	46	1419



08:06:13 N29°24.782′ Display reference: Free Brg 050.7° Rng 0.078 n
0:06:13 W094°49.310′ Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:12	331.0	10.2	s35.0	N29°24.808	W094°49.47	61	22985	154.1	8.5	s20.8	N29°24.667	W094°49.46	46	1648
8	00:06:10	330.9	10.2	s35.0	N29°24.803	W094°49.46	61	22986	154.3	8.5	s20.7	N29°24.671	W094°49.47	46	1648
9	00:06:08	330.9	10.1	s35.0	N29°24.798	W094°49.46	61	22988	154.6	8.5	s20.7	N29°24.676	W094°49.47	46	1650
10	00:06:06	330.9	10.1	s35.0	N29°24.793	W094°49.46	61	22997	154.9	8.5	s20.8	N29°24.680	W094°49.47	46	1649
11	00:06:04	330.9	10.1	s35.0	N29°24.789	W094°49.45	61	23006	155.1	8.5	s20.8	N29°24.684	W094°49.47	46	1649

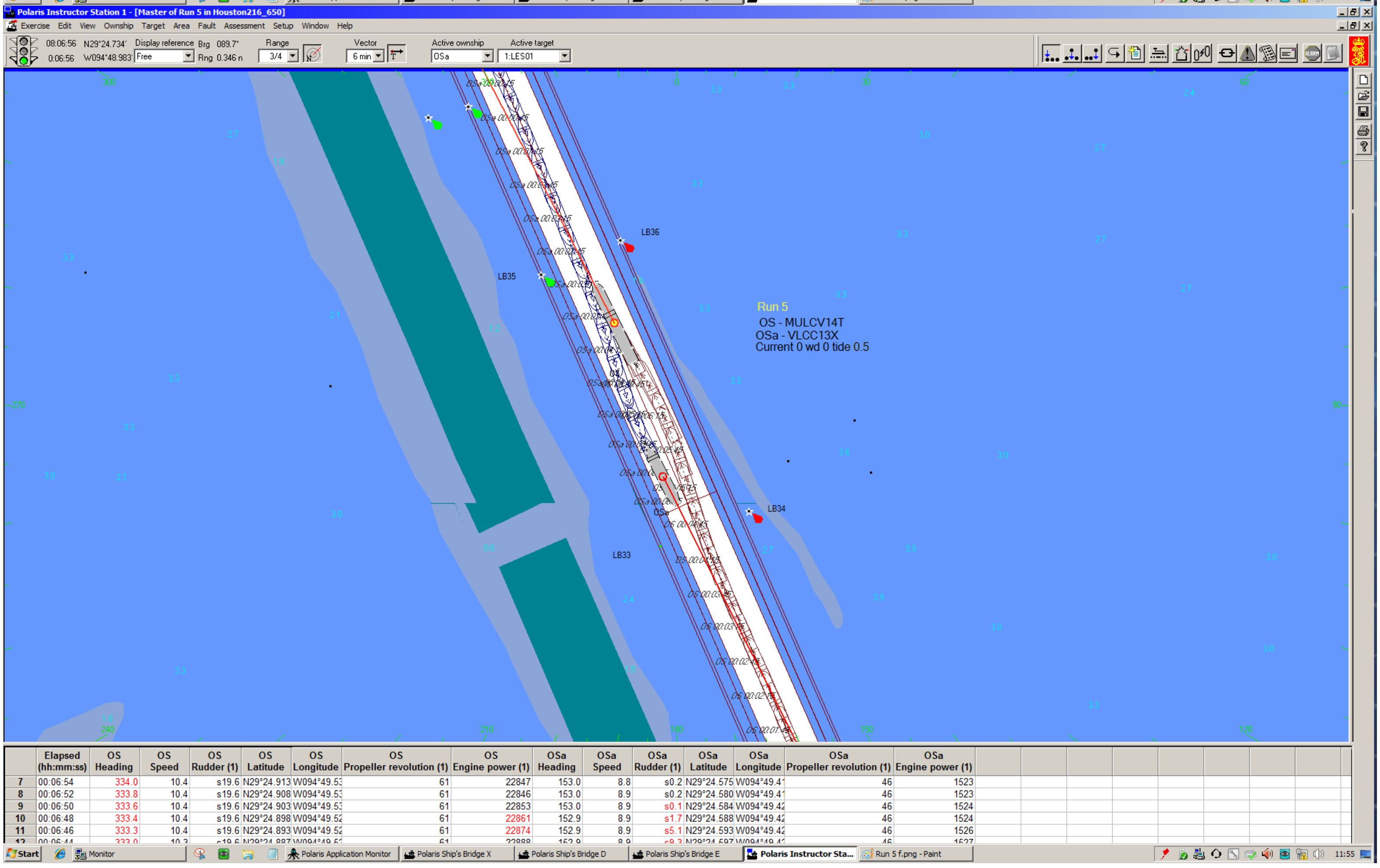


Polaris Instructor Station 1 - [Master of Run 5 in Houston216_650]

08:06:33 N29°24.840' Display reference Free Brg 027.0° Rng 0.121 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:06:33 W094°49.317'

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:32	332.1	10.3	s19.6	N29°24.857	W094°49.50	61	22900	152.7	8.8	s20.8	N29°24.624	W094°49.44	46	1558
8	00:06:30	332.0	10.3	s24.7	N29°24.852	W094°49.50	61	22916	152.8	8.8	s20.7	N29°24.628	W094°49.44	46	1570
9	00:06:28	332.0	10.2	s29.9	N29°24.848	W094°49.49	61	22929	152.8	8.8	s20.8	N29°24.632	W094°49.44	46	1577
10	00:06:26	331.8	10.2	s35.0	N29°24.842	W094°49.49	61	22937	152.9	8.7	s20.7	N29°24.637	W094°49.45	46	1581
11	00:06:24	331.7	10.2	s35.0	N29°24.838	W094°49.49	61	22943	153.0	8.7	s20.7	N29°24.641	W094°49.45	46	1593



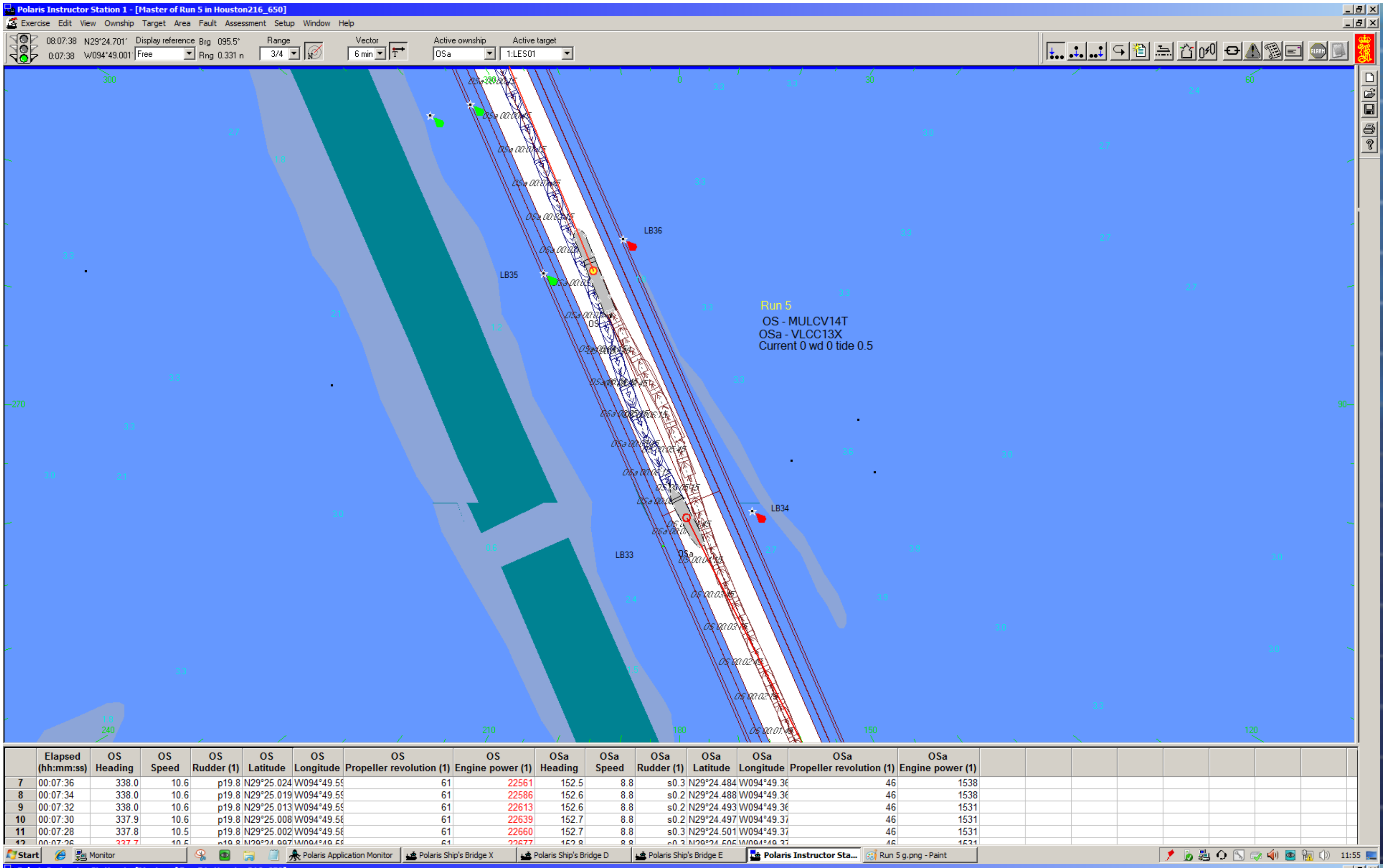
Polaris Instructor Station 1 - [Master of Run 5 in Houston216_650]

08:06:56 N29°24.734' Display reference Free Brg 089.7° Rng 0.346 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:06:56 W094°48.983'

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:54	334.0	10.4	s19.6	N29°24.913	W094°49.53	61	22847	153.0	8.8	s0.2	N29°24.575	W094°49.41	46	1523
8	00:06:52	333.8	10.4	s19.6	N29°24.908	W094°49.53	61	22846	153.0	8.9	s0.2	N29°24.580	W094°49.41	46	1523
9	00:06:50	333.6	10.4	s19.6	N29°24.903	W094°49.53	61	22853	153.0	8.9	s0.1	N29°24.584	W094°49.42	46	1524
10	00:06:48	333.4	10.4	s19.6	N29°24.898	W094°49.52	61	22861	152.9	8.9	s1.7	N29°24.588	W094°49.42	46	1524
11	00:06:46	333.3	10.4	s19.6	N29°24.893	W094°49.52	61	22874	152.9	8.9	s5.1	N29°24.593	W094°49.42	46	1526

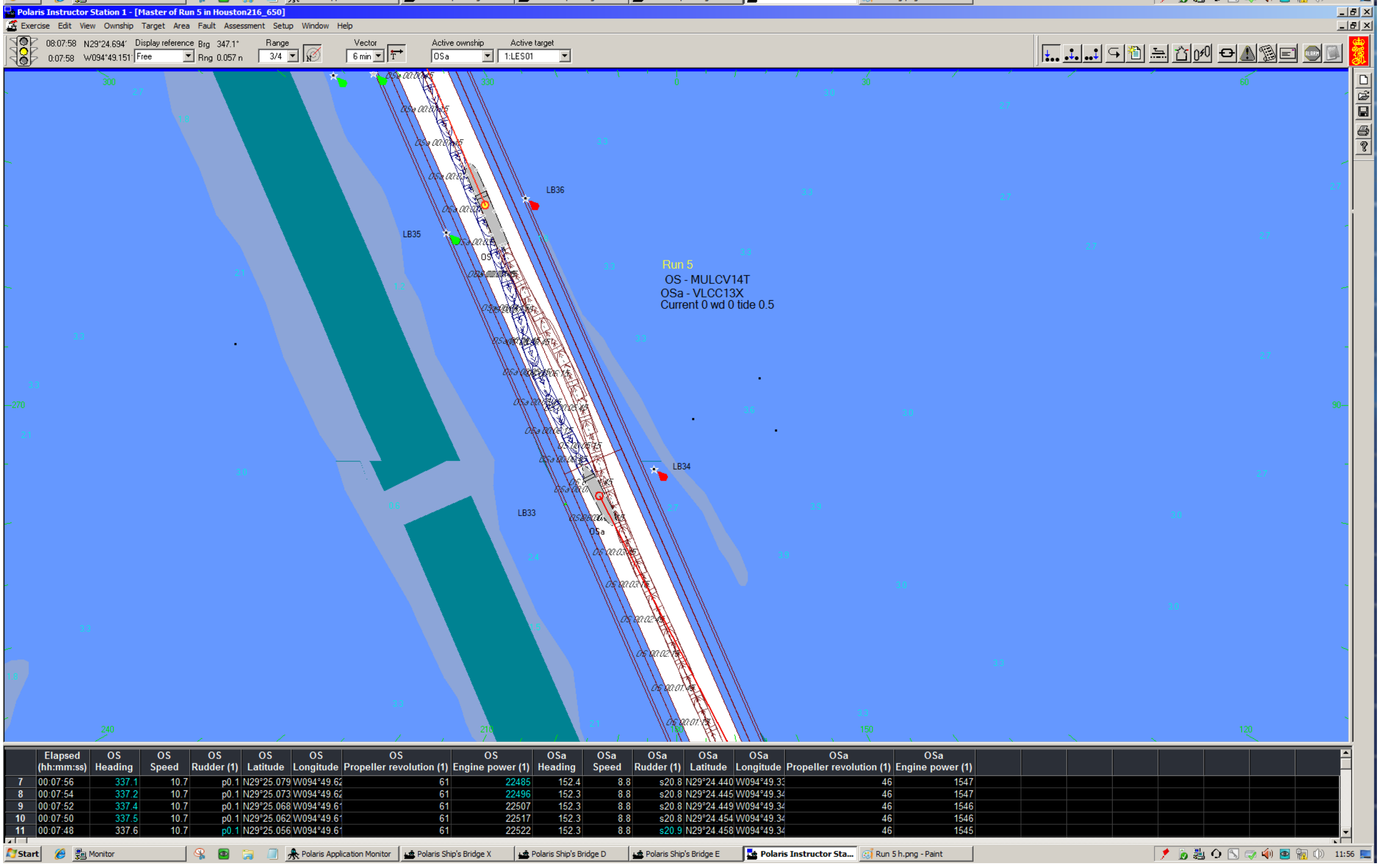
June 26, 2019



08:07:38 N29°24.701′ Display reference Free Brg 095.5° Rng 0.331 n
0:07:38 W094°49.001′
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

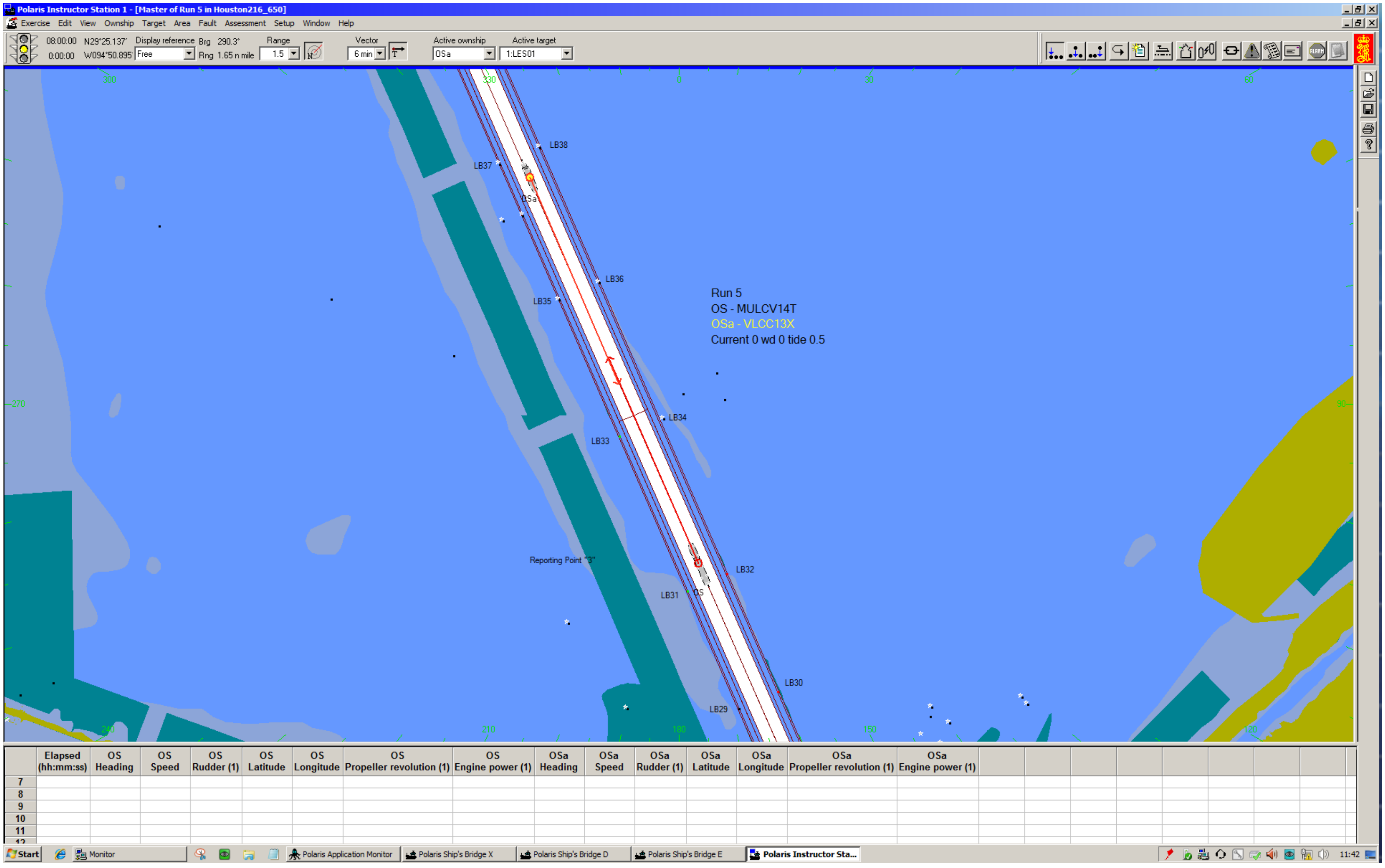
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:36	338.0	10.6	p19.8	N29°25.024	W094°49.59	61	22561	152.5	8.8	s0.3	N29°24.484	W094°49.36	46	1538
8	00:07:34	338.0	10.6	p19.8	N29°25.019	W094°49.59	61	22586	152.6	8.8	s0.2	N29°24.488	W094°49.36	46	1538
9	00:07:32	338.0	10.6	p19.8	N29°25.013	W094°49.59	61	22613	152.6	8.8	s0.2	N29°24.493	W094°49.36	46	1531
10	00:07:30	337.9	10.6	p19.8	N29°25.008	W094°49.58	61	22639	152.7	8.8	s0.2	N29°24.497	W094°49.37	46	1531
11	00:07:28	337.8	10.5	p19.8	N29°25.002	W094°49.58	61	22660	152.7	8.8	s0.3	N29°24.501	W094°49.37	46	1531
12	00:07:26	337.7	10.5	p19.8	N29°24.997	W094°49.58	61	22677	152.8	8.8	s0.3	N29°24.505	W094°49.37	46	1531



08:07:58 N29°24.694′ Display reference Free Brg 347.1° Rng 0.057 n
0:07:58 W094°49.151′
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:56	337.1	10.7	p0.1	N29°25.079	W094°49.62	61	22485	152.4	8.8	s20.8	N29°24.440	W094°49.33	46	1547
8	00:07:54	337.2	10.7	p0.1	N29°25.073	W094°49.62	61	22496	152.3	8.8	s20.8	N29°24.445	W094°49.34	46	1547
9	00:07:52	337.4	10.7	p0.1	N29°25.068	W094°49.61	61	22507	152.3	8.8	s20.8	N29°24.449	W094°49.34	46	1546
10	00:07:50	337.5	10.7	p0.1	N29°25.062	W094°49.61	61	22517	152.3	8.8	s20.8	N29°24.454	W094°49.34	46	1546
11	00:07:48	337.6	10.7	p0.1	N29°25.056	W094°49.61	61	22522	152.3	8.8	s20.9	N29°24.458	W094°49.34	46	1545



Polaris Instructor Station 1 - [Master of Run 5 in Houston216_650]

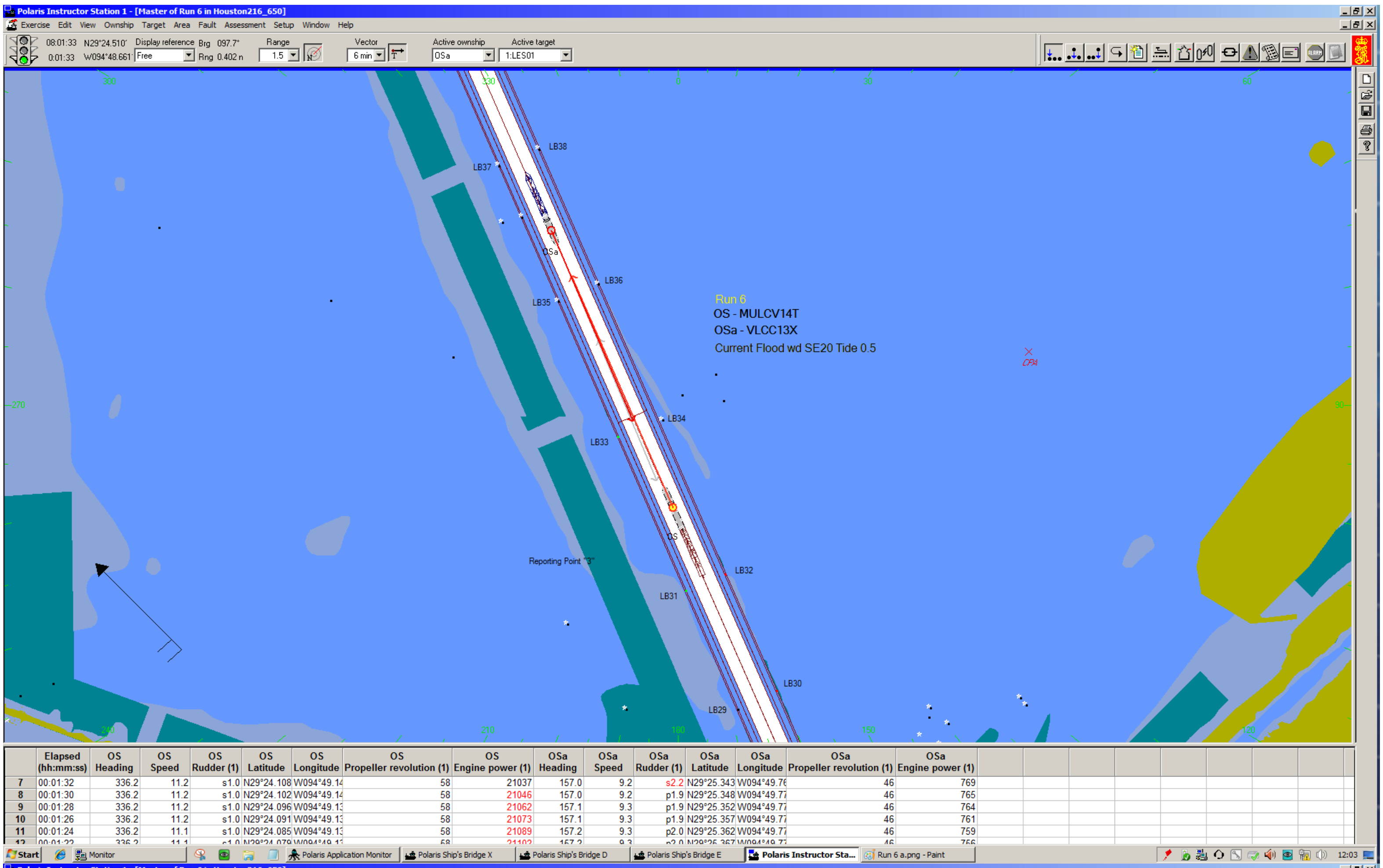
08:00:00 N29°25.137' Display reference Free Brg 290.3° Range 1.5 Vector 6 min Active ownship OSa Active target 1:LES01
0:00:00 W094°50.895' Rng 1.65 n mile

Run 5
OS - MULCV14T
OSa - VLCC13X
Current 0 wd 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
10															
11															

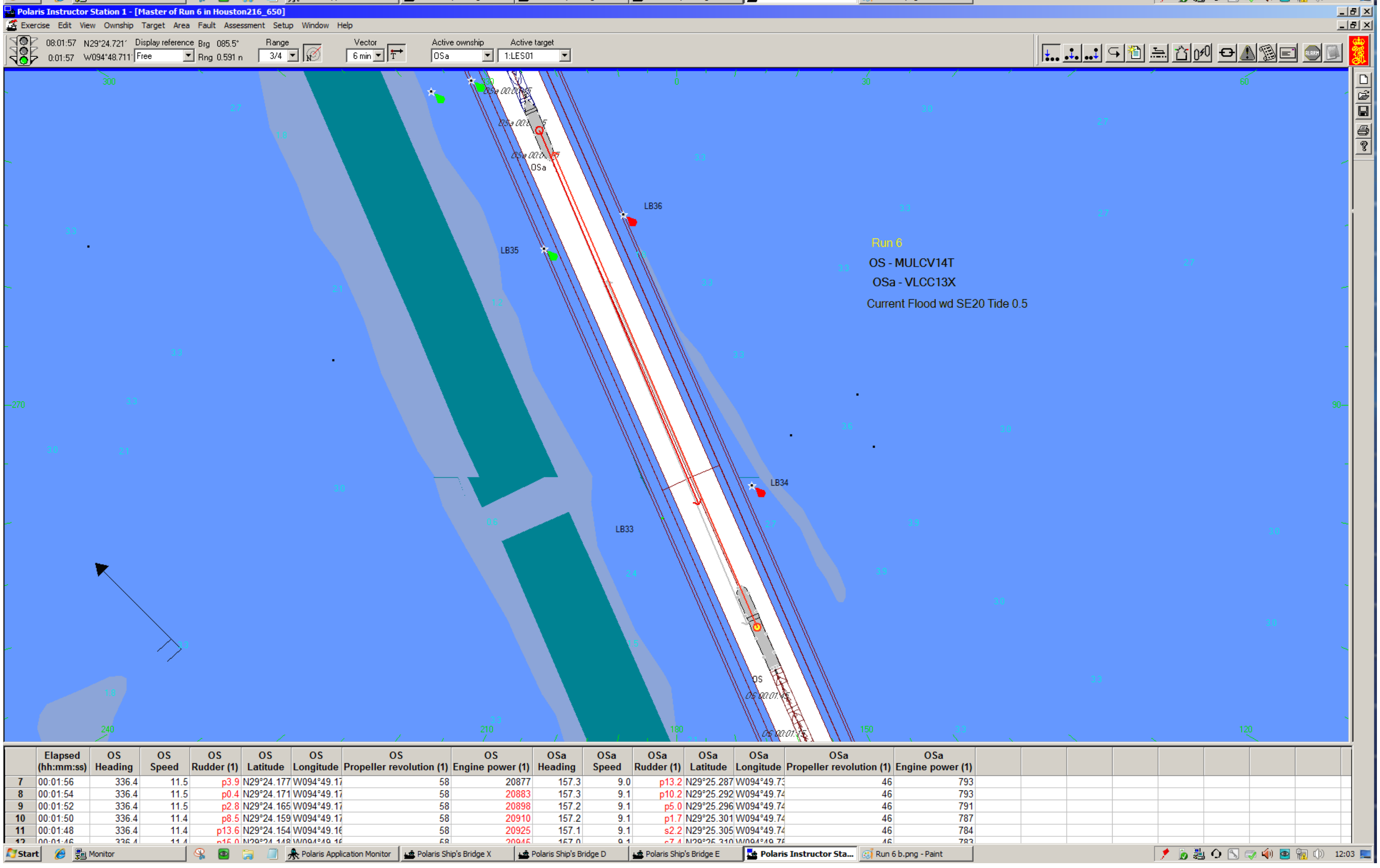
June 26, 2019

Run 6



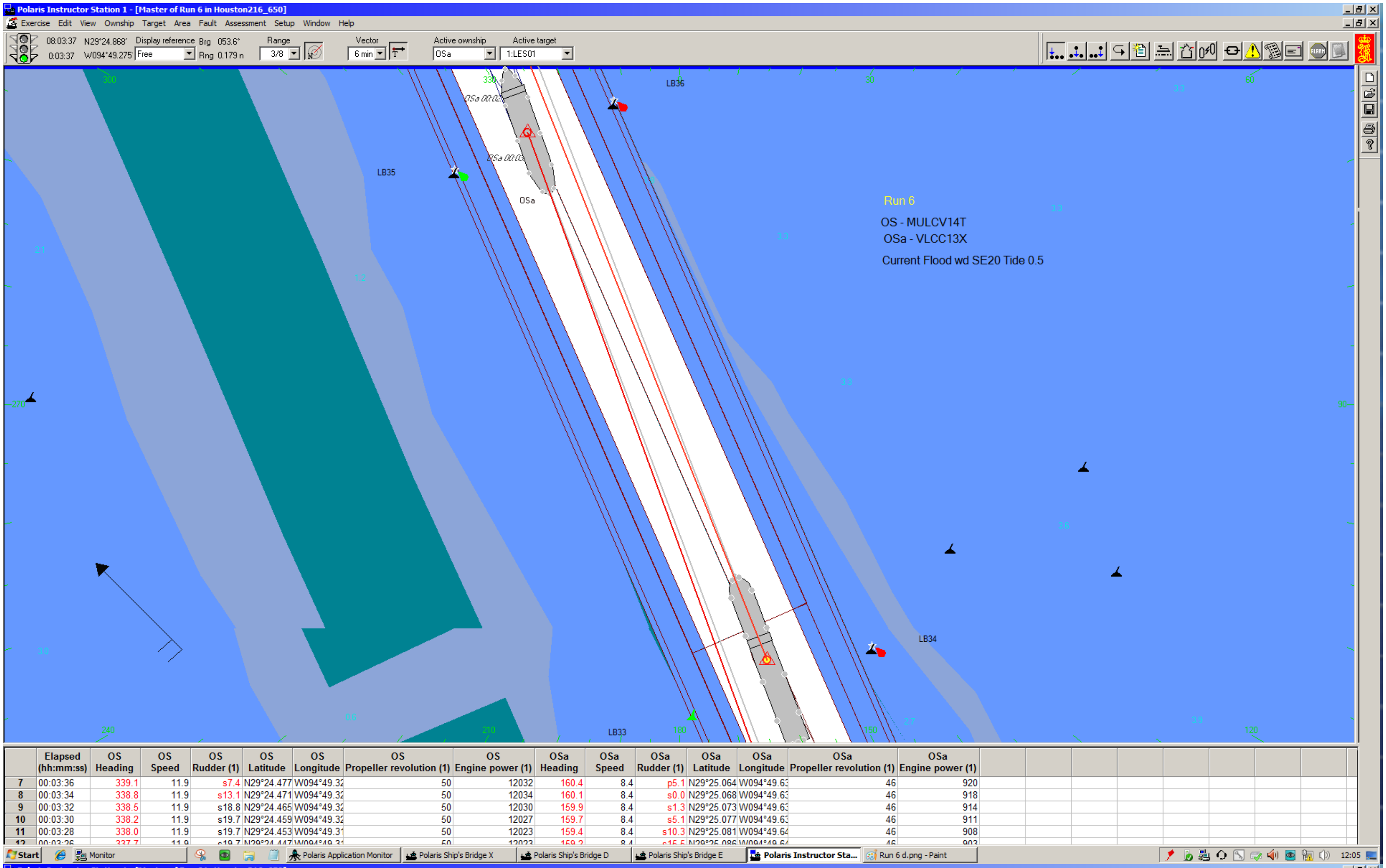
Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:01:32	336.2	11.2	s1.0	N29°24.108	W094°49.14	58	21037	157.0	9.2	s2.2	N29°25.343	W094°49.76	46	769
8	00:01:30	336.2	11.2	s1.0	N29°24.102	W094°49.14	58	21046	157.0	9.2	p1.9	N29°25.348	W094°49.77	46	765
9	00:01:28	336.2	11.2	s1.0	N29°24.096	W094°49.13	58	21062	157.1	9.3	p1.9	N29°25.352	W094°49.77	46	764
10	00:01:26	336.2	11.2	s1.0	N29°24.091	W094°49.13	58	21073	157.1	9.3	p1.9	N29°25.357	W094°49.77	46	761
11	00:01:24	336.2	11.1	s1.0	N29°24.085	W094°49.13	58	21089	157.2	9.3	p2.0	N29°25.362	W094°49.77	46	759



Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:01:56	336.4	11.5	p3.9	N29°24.177	W094°49.17	58	20877	157.3	9.0	p13.2	N29°25.287	W094°49.73	46	793
8	00:01:54	336.4	11.5	p0.4	N29°24.171	W094°49.17	58	20883	157.3	9.1	p10.2	N29°25.292	W094°49.74	46	793
9	00:01:52	336.4	11.5	p2.8	N29°24.165	W094°49.17	58	20898	157.2	9.1	p5.0	N29°25.296	W094°49.74	46	791
10	00:01:50	336.4	11.4	p8.5	N29°24.159	W094°49.17	58	20910	157.2	9.1	p1.7	N29°25.301	W094°49.74	46	787
11	00:01:48	336.4	11.4	p13.6	N29°24.154	W094°49.16	58	20925	157.1	9.1	s2.2	N29°25.305	W094°49.74	46	784



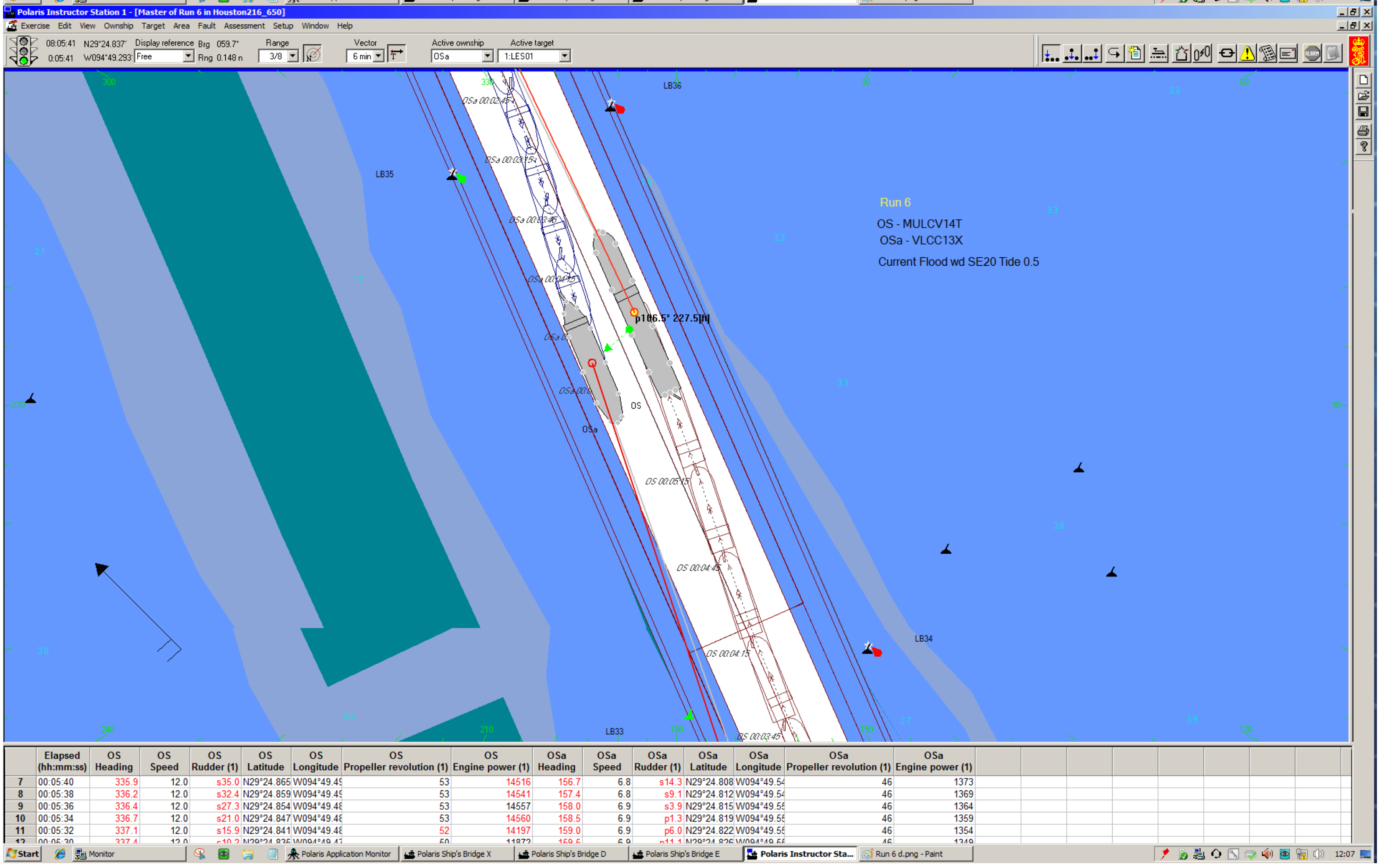
Run 6

OS - MULCV14T

OSa - VLCC13X

Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:03:36	339.1	11.9	s7.4	N29°24.477	W094°49.32	50	12032	160.4	8.4	p5.1	N29°25.064	W094°49.63	46	920
8	00:03:34	338.8	11.9	s13.1	N29°24.471	W094°49.32	50	12034	160.1	8.4	s0.0	N29°25.068	W094°49.63	46	918
9	00:03:32	338.5	11.9	s18.8	N29°24.465	W094°49.32	50	12030	159.9	8.4	s1.3	N29°25.073	W094°49.63	46	914
10	00:03:30	338.2	11.9	s19.7	N29°24.459	W094°49.32	50	12027	159.7	8.4	s5.1	N29°25.077	W094°49.63	46	911
11	00:03:28	338.0	11.9	s19.7	N29°24.453	W094°49.31	50	12023	159.4	8.4	s10.3	N29°25.081	W094°49.64	46	908



Run 6

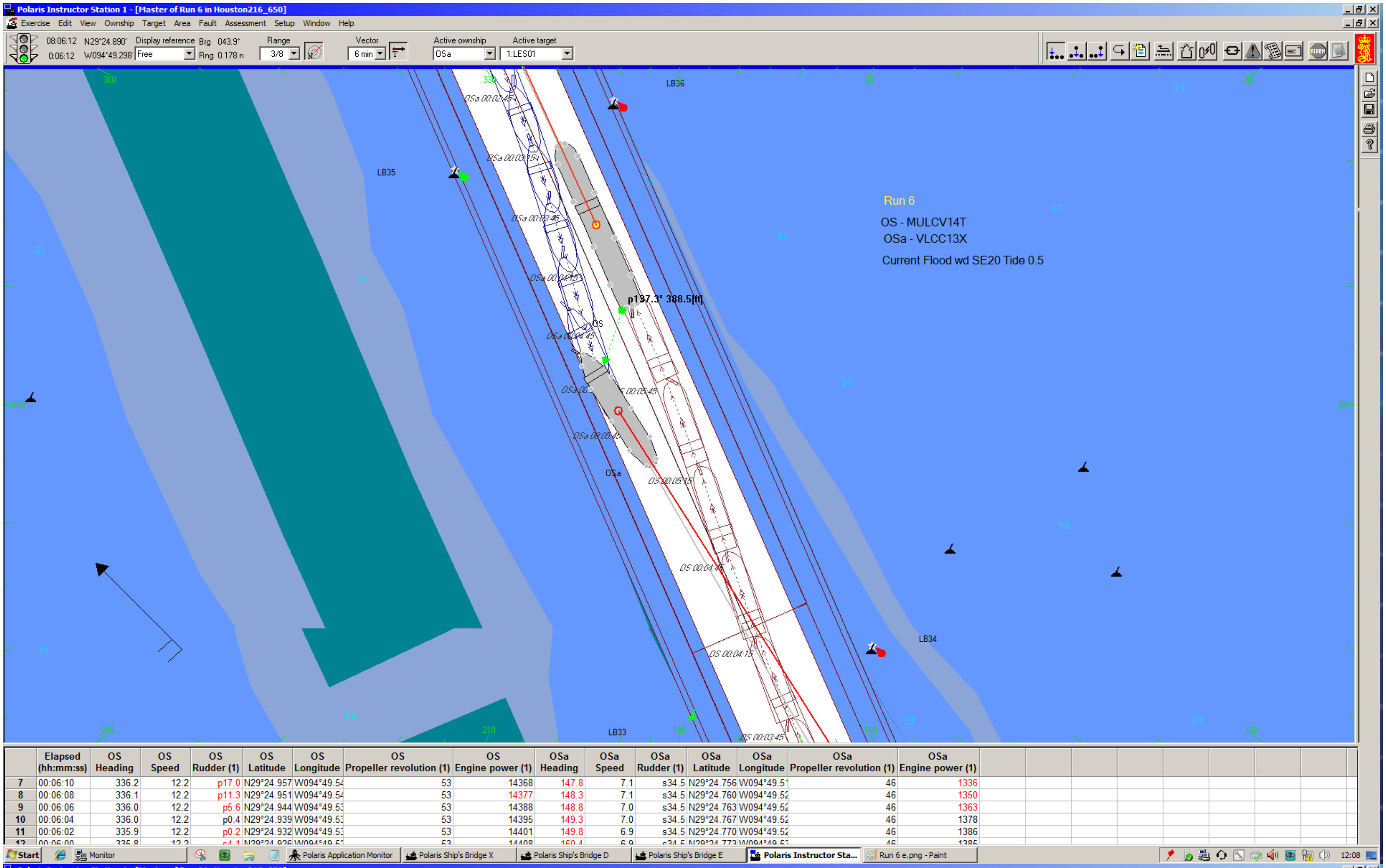
OS - MULCV14T

OSa - VLCC13X

Current Flood wd SE20 Tide 0.5

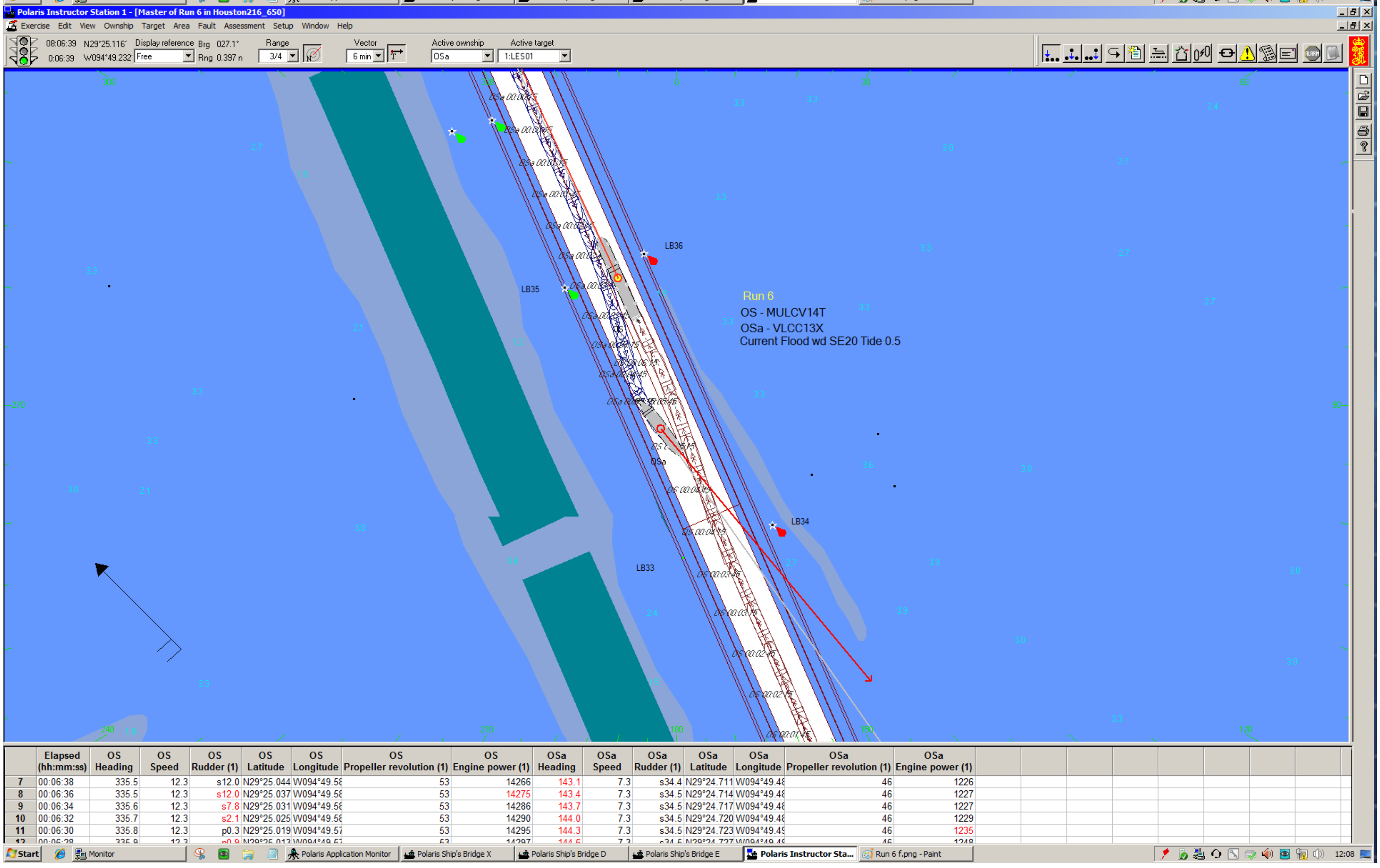
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:05:40	335.9	12.0	s35.0	N29°24.865	W094°49.49	53	14516	156.7	6.8	s14.3	N29°24.808	W094°49.54	46	1373
8	00:05:38	336.2	12.0	s32.4	N29°24.859	W094°49.49	53	14541	157.4	6.8	s9.1	N29°24.812	W094°49.54	46	1369
9	00:05:36	336.4	12.0	s27.3	N29°24.854	W094°49.48	53	14557	158.0	6.9	s3.9	N29°24.815	W094°49.55	46	1364
10	00:05:34	336.7	12.0	s21.0	N29°24.847	W094°49.48	53	14560	158.5	6.9	p1.3	N29°24.819	W094°49.55	46	1359
11	00:05:32	337.1	12.0	s15.9	N29°24.841	W094°49.48	52	14197	159.0	6.9	p6.0	N29°24.822	W094°49.55	46	1354

June 26, 2019



Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:10	336.2	12.2	p17.0	N29°24.957	W094°49.54	53	14368	147.8	7.1	s34.5	N29°24.756	W094°49.51	46	1336
8	00:06:08	336.1	12.2	p11.3	N29°24.951	W094°49.54	53	14377	148.3	7.1	s34.5	N29°24.760	W094°49.52	46	1350
9	00:06:06	336.0	12.2	p5.6	N29°24.944	W094°49.53	53	14388	148.8	7.0	s34.5	N29°24.763	W094°49.52	46	1363
10	00:06:04	336.0	12.2	p0.4	N29°24.939	W094°49.53	53	14395	149.3	7.0	s34.5	N29°24.767	W094°49.52	46	1378
11	00:06:02	335.9	12.2	p0.2	N29°24.932	W094°49.53	53	14401	149.8	6.9	s34.5	N29°24.770	W094°49.52	46	1386



Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:38	335.5	12.3	s12.0	N29°25.044	W094°49.58	53	14266	143.1	7.3	s34.4	N29°24.711	W094°49.48	46	1226
8	00:06:36	335.5	12.3	s12.0	N29°25.037	W094°49.58	53	14275	143.4	7.3	s34.5	N29°24.714	W094°49.48	46	1227
9	00:06:34	335.6	12.3	s7.8	N29°25.031	W094°49.58	53	14286	143.7	7.3	s34.5	N29°24.717	W094°49.48	46	1227
10	00:06:32	335.7	12.3	s2.1	N29°25.025	W094°49.58	53	14290	144.0	7.3	s34.5	N29°24.720	W094°49.48	46	1229
11	00:06:30	335.8	12.3	p0.3	N29°25.019	W094°49.57	53	14295	144.3	7.3	s34.5	N29°24.723	W094°49.49	46	1235

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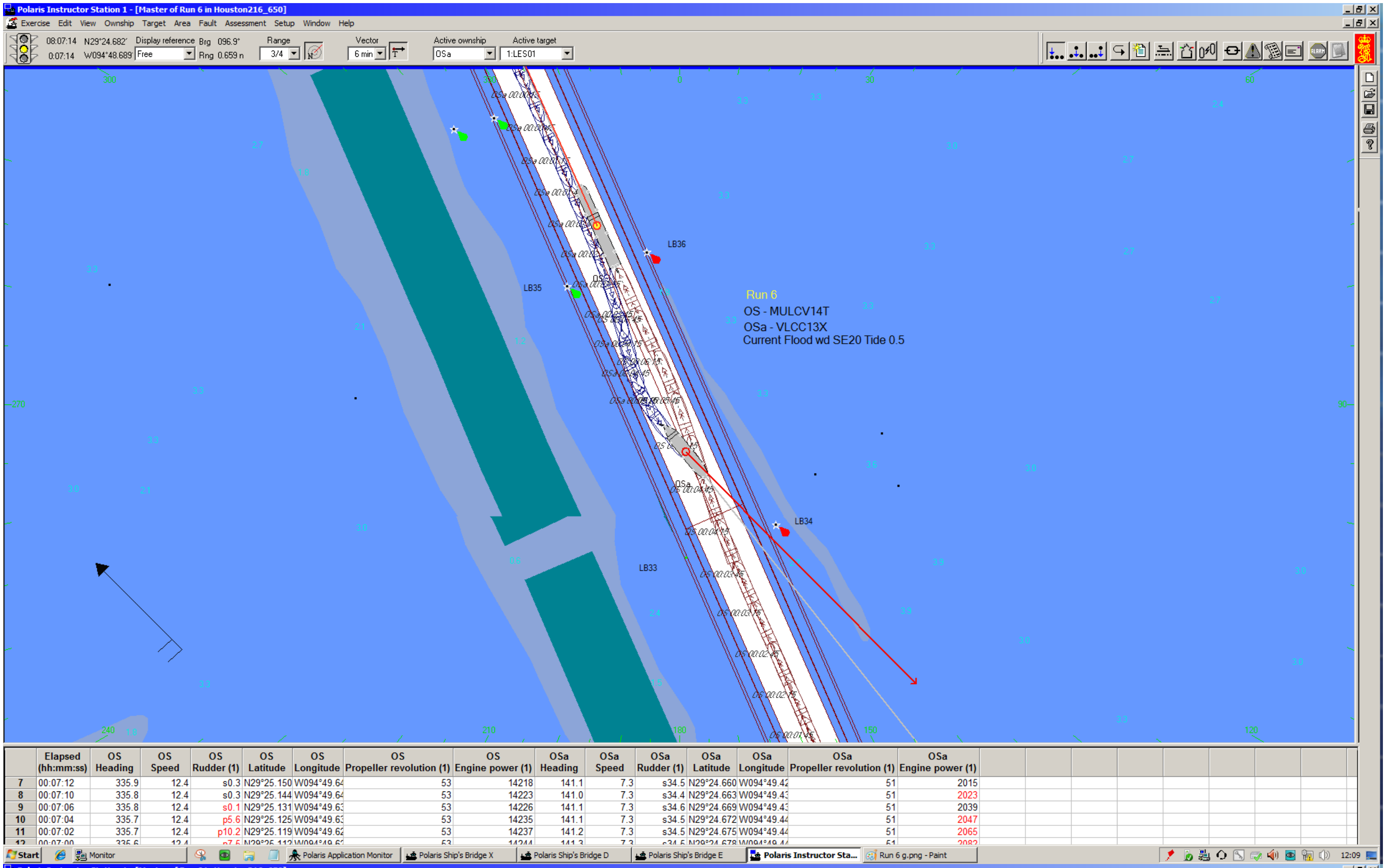
June 26, 2019


Polaris Instructor Station 1 - [Master of Run 6 in Houston216_650]

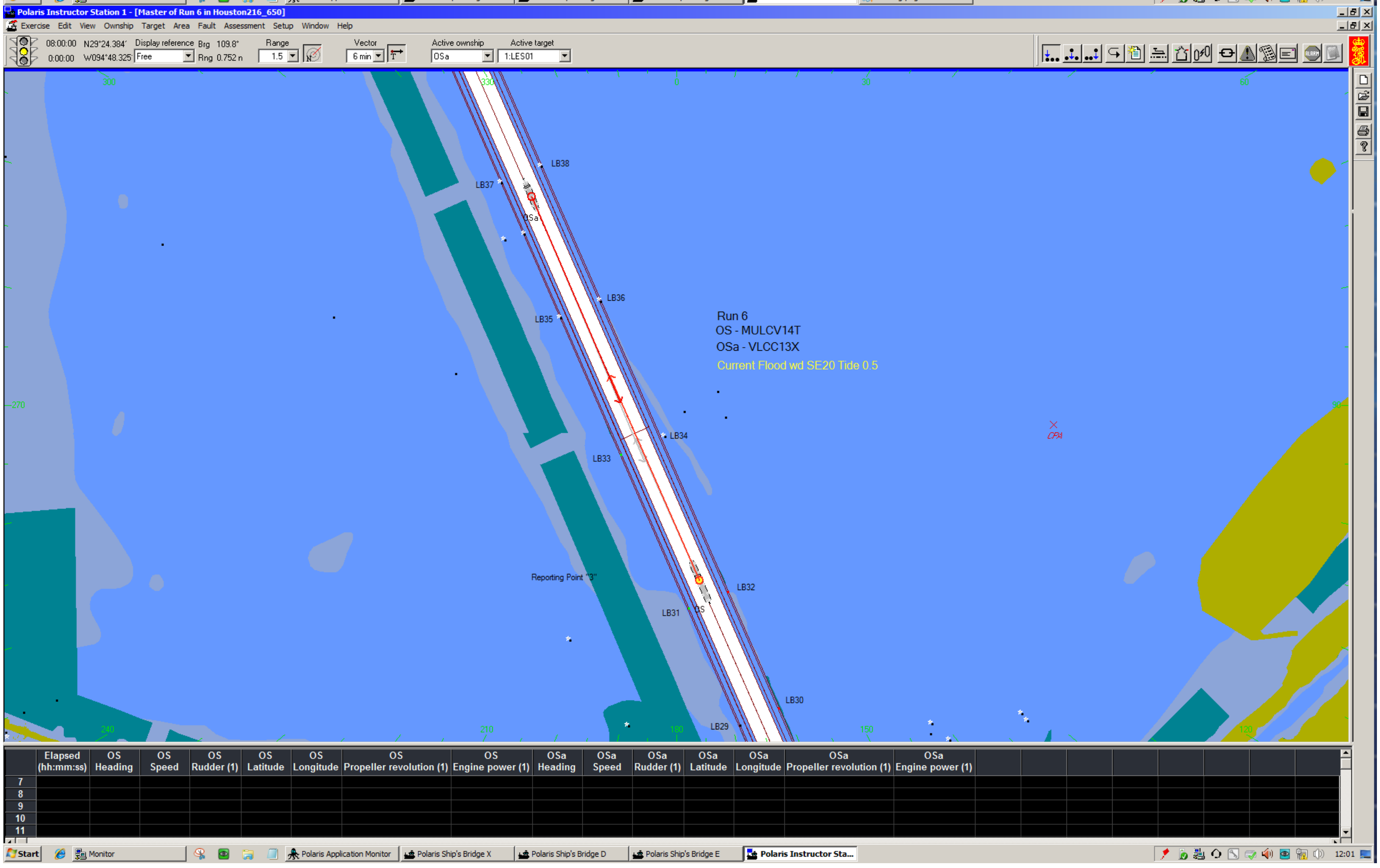
Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:07:14 N29°24.682' Display reference: Free Brg 096.9° Rng 0.659 n Range: 3/4 Vector: 6 min Active ownship: OSa Active target: 1:LES01

0:07:14 W094°48.689'

Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:12	335.9	12.4	s0.3	N29°25.150	W094°49.64	53	14218	141.1	7.3	s34.5	N29°24.660	W094°49.42	51	2015
8	00:07:10	335.8	12.4	s0.3	N29°25.144	W094°49.64	53	14223	141.0	7.3	s34.4	N29°24.663	W094°49.43	51	2023
9	00:07:06	335.8	12.4	s0.1	N29°25.131	W094°49.63	53	14226	141.1	7.3	s34.6	N29°24.669	W094°49.43	51	2039
10	00:07:04	335.7	12.4	p5.6	N29°25.125	W094°49.63	53	14235	141.1	7.3	s34.5	N29°24.672	W094°49.44	51	2047
11	00:07:02	335.7	12.4	p10.2	N29°25.119	W094°49.62	53	14237	141.2	7.3	s34.5	N29°24.675	W094°49.44	51	2065


Polaris Instructor Station 1 - [Master of Run 6 in Houston216_650]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:00:00 N29°24.384' Display reference: Free Brg 109.8° Rng 0.752 n Range: 1.5 Vector: 6 min Active ownship: OSa Active target: 1:LES01

0:00:00 W094°48.325'

Run 6
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
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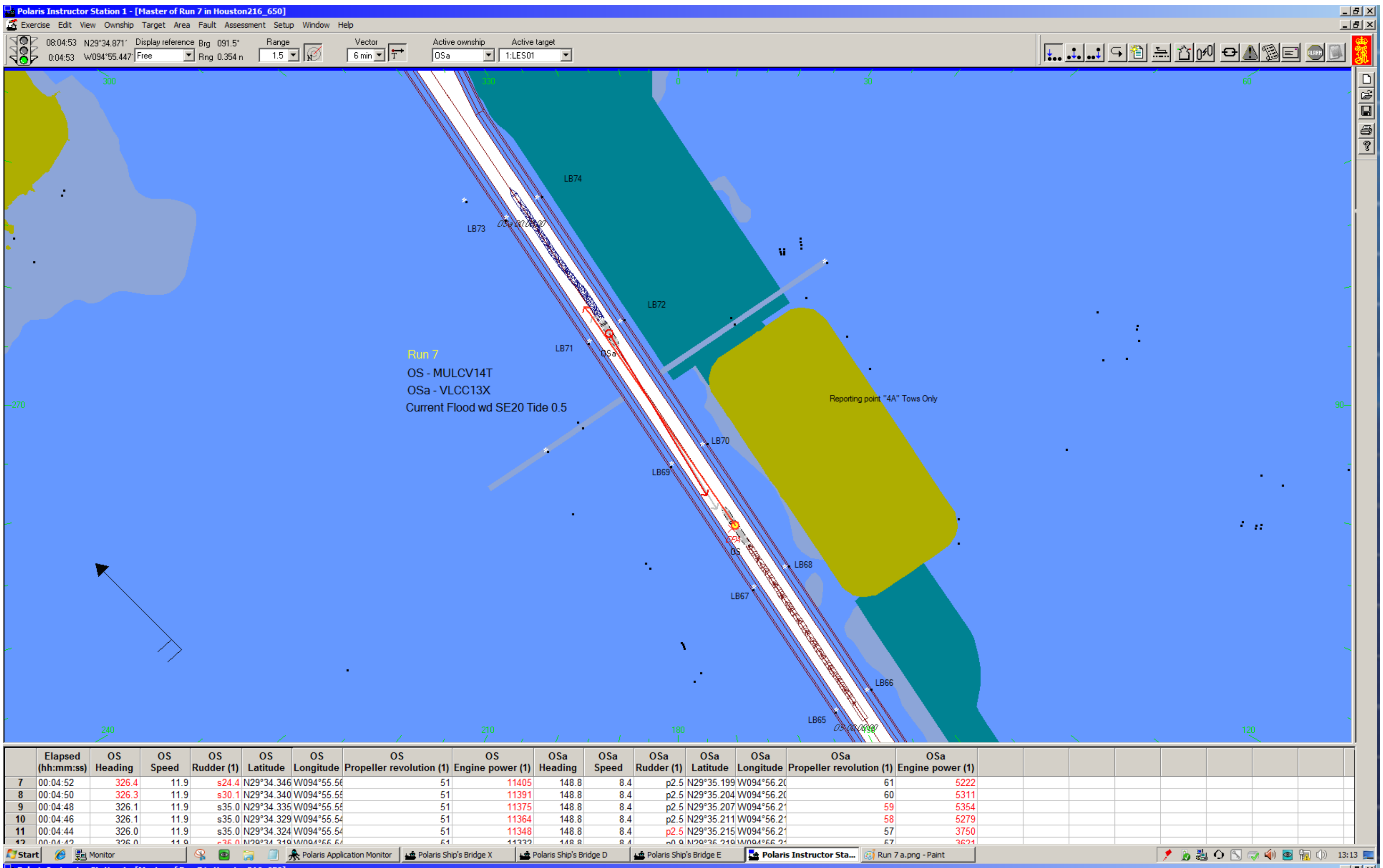
11															

Run 7

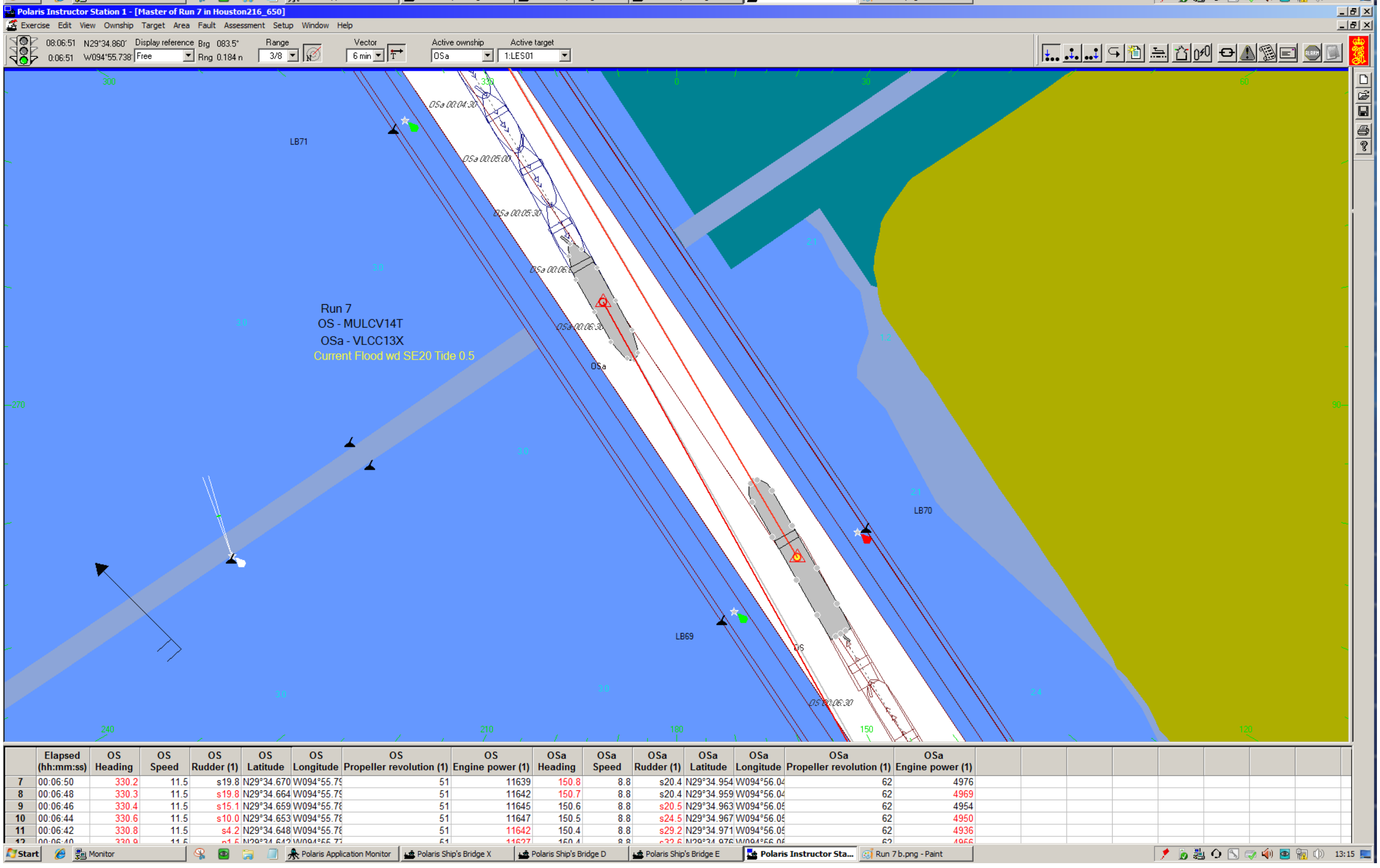


Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:04:53 N29°34.871' 0:04:53 W094°55.447 Display reference Free Brg 091.5° Rng 0.354 n Range 1.5 Vector 6 min Active ownship OSa Active target 1:LES01

Run 7
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:52	326.4	11.9	s24.4	N29°34.346	W094°55.5	51	11405	148.8	8.4	p2.5	N29°35.199	W094°56.2	61	5222
8	00:04:50	326.3	11.9	s30.1	N29°34.340	W094°55.5	51	11391	148.8	8.4	p2.5	N29°35.204	W094°56.2	60	5311
9	00:04:48	326.1	11.9	s35.0	N29°34.335	W094°55.5	51	11375	148.8	8.4	p2.5	N29°35.207	W094°56.2	59	5354
10	00:04:46	326.1	11.9	s35.0	N29°34.329	W094°55.5	51	11364	148.8	8.4	p2.5	N29°35.211	W094°56.2	58	5279
11	00:04:44	326.0	11.9	s35.0	N29°34.324	W094°55.5	51	11348	148.8	8.4	p2.5	N29°35.215	W094°56.2	57	3750
12	00:04:42	326.0	11.9	s35.0	N29°34.319	W094°55.5	51	11332	148.8	8.4	p0.9	N29°35.219	W094°56.2	57	3621



Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:06:51 N29°34.860' 0:06:51 W094°55.738 Display reference Free Brg 083.5° Rng 0.184 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

Run 7
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:50	330.2	11.5	s19.8	N29°34.670	W094°55.7	51	11639	150.8	8.8	s20.4	N29°34.954	W094°56.04	62	4976
8	00:06:48	330.3	11.5	s19.8	N29°34.664	W094°55.7	51	11642	150.7	8.8	s20.4	N29°34.959	W094°56.04	62	4969
9	00:06:46	330.4	11.5	s15.1	N29°34.659	W094°55.7	51	11645	150.6	8.8	s20.5	N29°34.963	W094°56.0	62	4954
10	00:06:44	330.6	11.5	s10.0	N29°34.653	W094°55.7	51	11647	150.5	8.8	s24.5	N29°34.967	W094°56.0	62	4950
11	00:06:42	330.8	11.5	s4.2	N29°34.648	W094°55.7	51	11642	150.4	8.8	s29.2	N29°34.971	W094°56.0	62	4936
12	00:06:40	330.9	11.5	p1.6	N29°34.642	W094°55.7	51	11627	150.4	8.8	s32.6	N29°34.976	W094°56.0	62	4966

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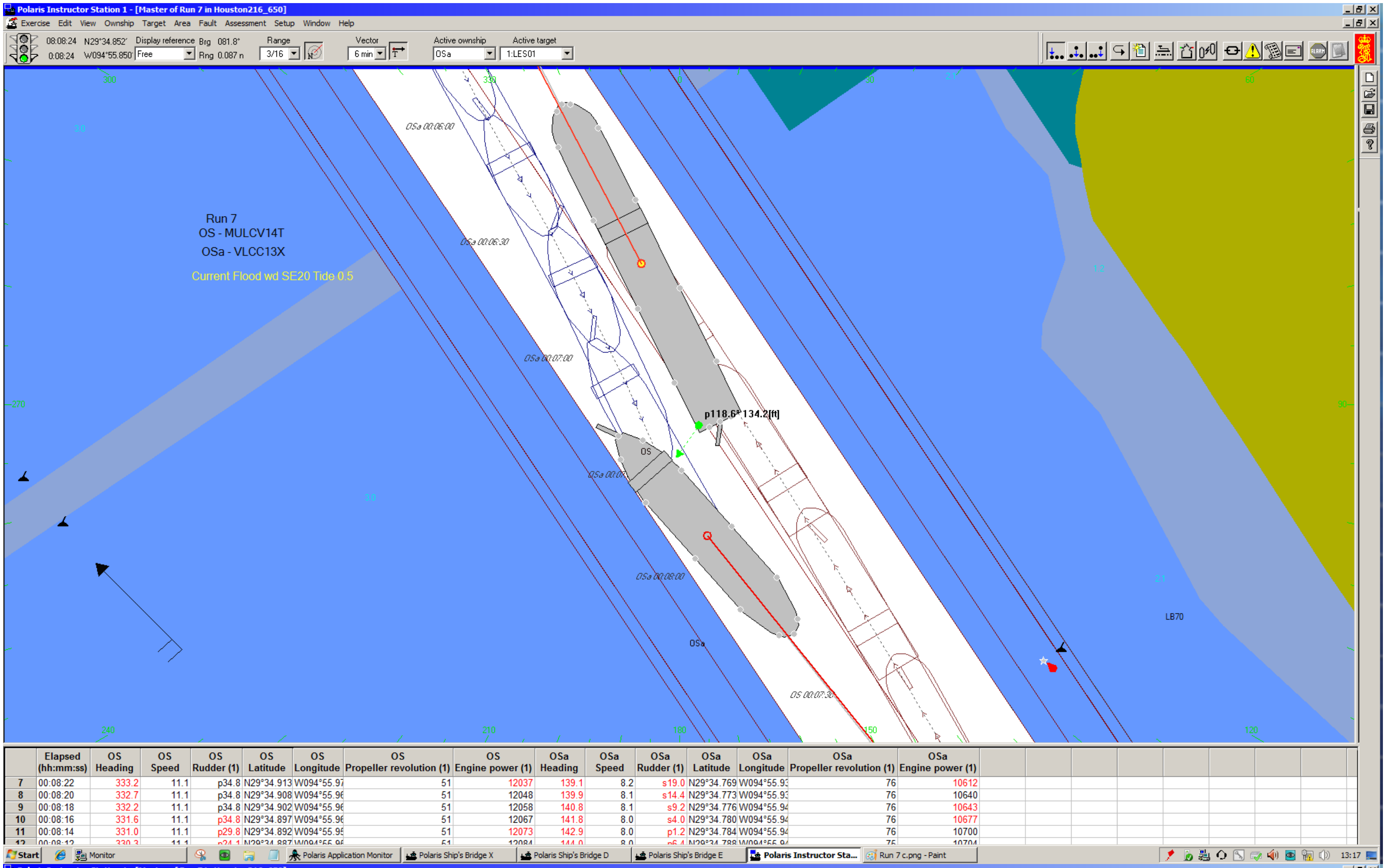
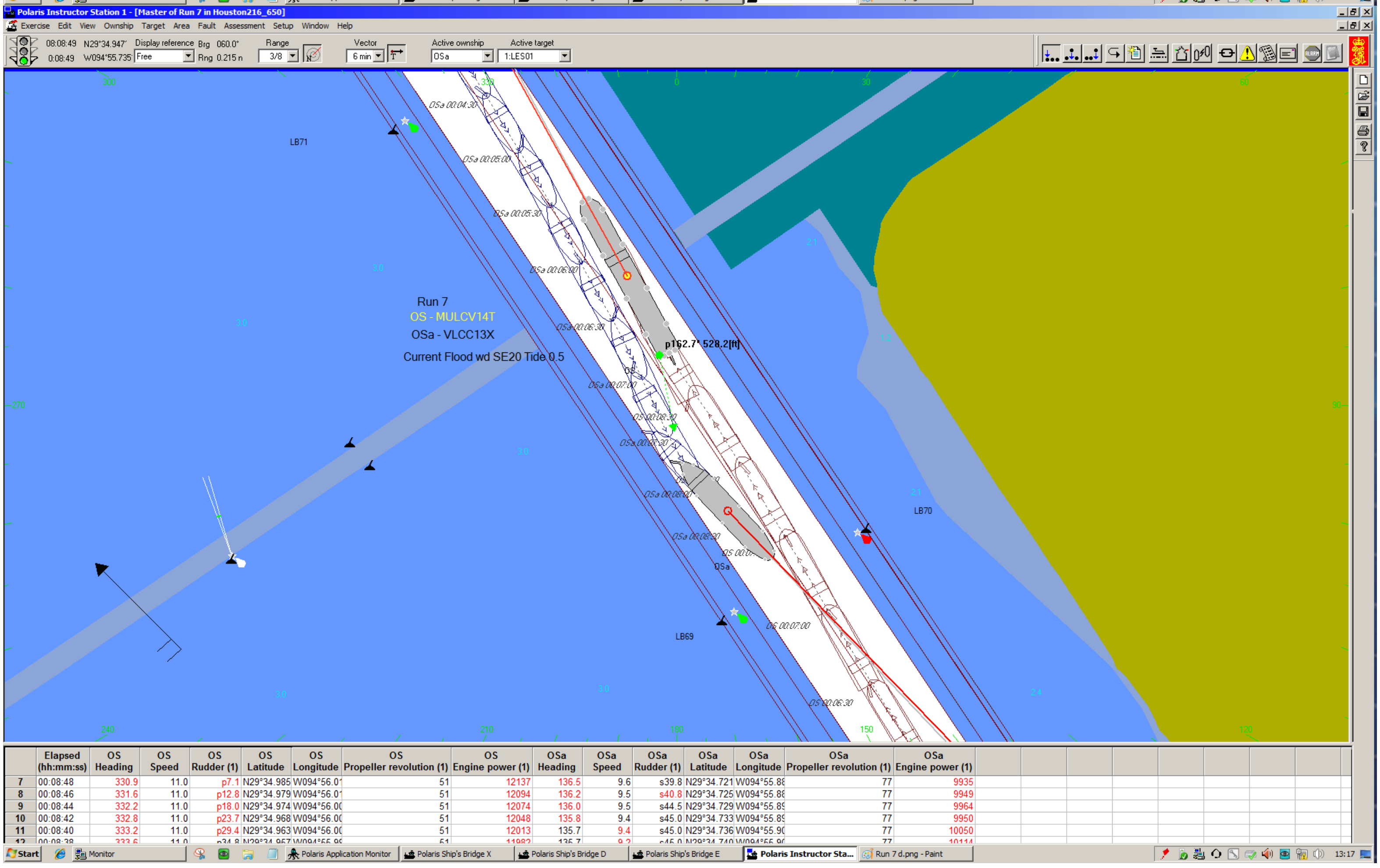
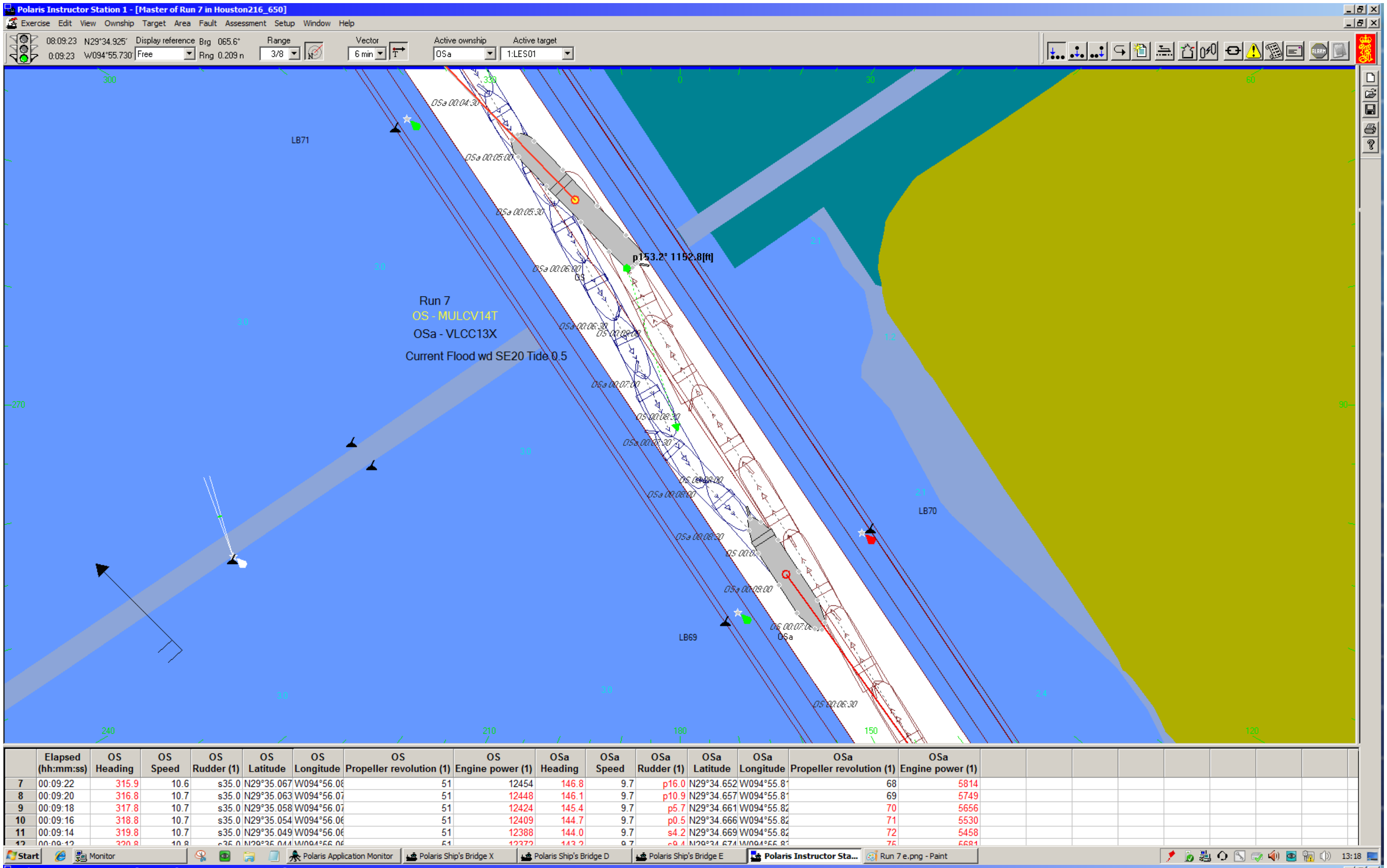


	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:22	333.2	11.1	p34.8	N29°34.913	W094°55.97	51	12037	139.1	8.2	s19.0	N29°34.769	W094°55.93	76	10612
8	00:08:20	332.7	11.1	p34.8	N29°34.908	W094°55.96	51	12048	139.9	8.1	s14.4	N29°34.773	W094°55.93	76	10640
9	00:08:18	332.2	11.1	p34.8	N29°34.902	W094°55.96	51	12058	140.8	8.1	s9.2	N29°34.776	W094°55.94	76	10643
10	00:08:16	331.6	11.1	p34.8	N29°34.897	W094°55.96	51	12067	141.8	8.0	s4.0	N29°34.780	W094°55.94	76	10677
11	00:08:14	331.0	11.1	p29.8	N29°34.892	W094°55.95	51	12073	142.9	8.0	p1.2	N29°34.784	W094°55.94	76	10700



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:48	330.9	11.0	p7.1	N29°34.985	W094°56.0	51	12137	136.5	9.6	s39.8	N29°34.721	W094°55.88	77	9935
8	00:08:46	331.6	11.0	p12.8	N29°34.979	W094°56.0	51	12094	136.2	9.5	s40.8	N29°34.725	W094°55.88	77	9949
9	00:08:44	332.2	11.0	p18.0	N29°34.974	W094°56.00	51	12074	136.0	9.5	s44.5	N29°34.729	W094°55.89	77	9964
10	00:08:42	332.8	11.0	p23.7	N29°34.968	W094°56.00	51	12048	135.8	9.4	s45.0	N29°34.733	W094°55.89	77	9950
11	00:08:40	333.2	11.0	p29.4	N29°34.963	W094°56.00	51	12013	135.7	9.4	s45.0	N29°34.736	W094°55.90	77	10050



Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:09:23 N29°34.925' 0:09:23 W094°55.730'

Display reference: Free

Brg 065.6° Rng 0.209 n

Range: 3/8

Vector: 6 min

Active ownship: OSa

Active target: 1:LES01

Run 7

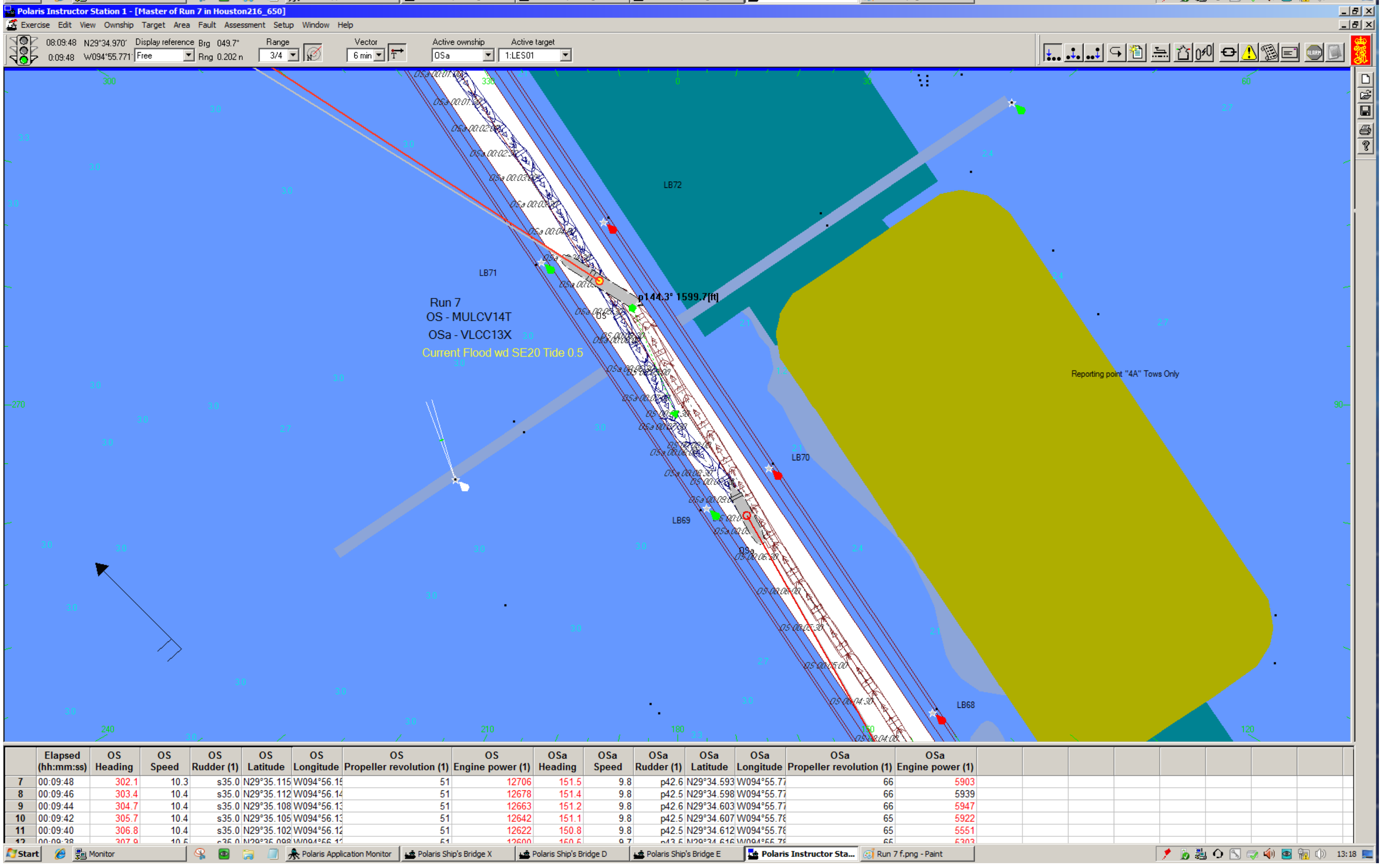
OS - MULCV14T

OSa - VLCC13X

Current Flood wd SE20 Tide 0.5

p153.2° 1152.8[ft]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:22	315.9	10.6	s35.0	N29°35.067	W094°56.08	51	12454	146.8	9.7	p16.0	N29°34.652	W094°55.81	68	5814
8	00:09:20	316.8	10.7	s35.0	N29°35.063	W094°56.07	51	12448	146.1	9.7	p10.9	N29°34.657	W094°55.81	69	5749
9	00:09:18	317.8	10.7	s35.0	N29°35.058	W094°56.07	51	12424	145.4	9.7	p5.7	N29°34.661	W094°55.82	70	5656
10	00:09:16	318.8	10.7	s35.0	N29°35.054	W094°56.06	51	12409	144.7	9.7	p0.5	N29°34.666	W094°55.82	71	5530
11	00:09:14	319.8	10.7	s35.0	N29°35.049	W094°56.06	51	12388	144.0	9.7	s4.2	N29°34.669	W094°55.82	72	5458



Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:09:48 N29°34.970' 0:09:48 W094°55.771'

Display reference: Free

Brg 049.7° Rng 0.202 n

Range: 3/4

Vector: 6 min

Active ownship: OSa

Active target: 1:LES01

Run 7

OS - MULCV14T

OSa - VLCC13X

Current Flood wd SE20 Tide 0.5

p144.3° 1599.7[ft]

Reporting point "4A" Tows Only

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:48	302.1	10.3	s35.0	N29°35.115	W094°56.15	51	12706	151.5	9.8	p42.6	N29°34.593	W094°55.77	66	5903
8	00:09:46	303.4	10.4	s35.0	N29°35.112	W094°56.14	51	12678	151.4	9.8	p42.5	N29°34.598	W094°55.77	66	5939
9	00:09:44	304.7	10.4	s35.0	N29°35.108	W094°56.13	51	12663	151.2	9.8	p42.6	N29°34.603	W094°55.77	66	5947
10	00:09:42	305.7	10.4	s35.0	N29°35.105	W094°56.13	51	12642	151.1	9.8	p42.5	N29°34.607	W094°55.78	65	5922
11	00:09:40	306.8	10.4	s35.0	N29°35.102	W094°56.12	51	12622	150.8	9.8	p42.5	N29°34.612	W094°55.78	65	5551

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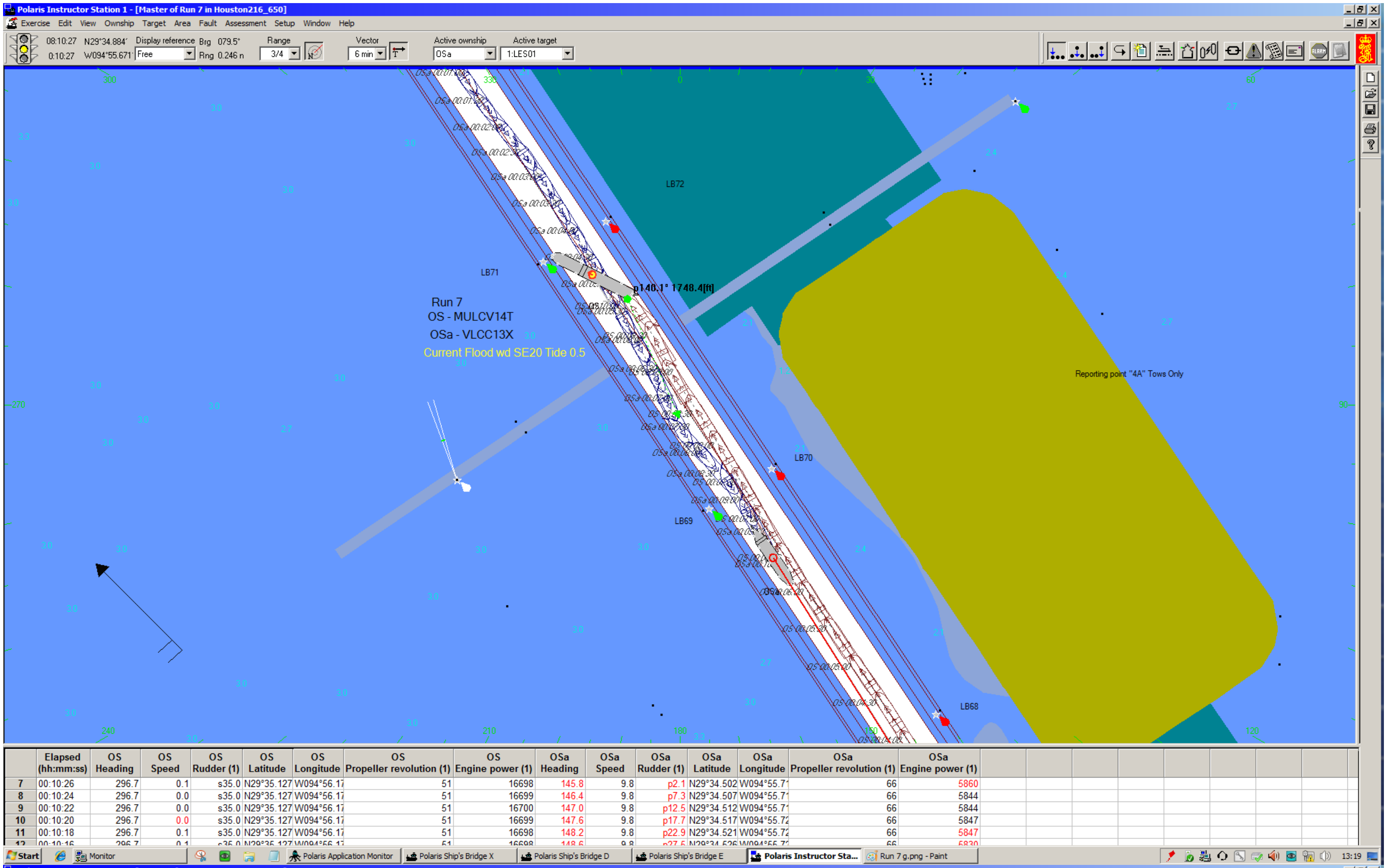


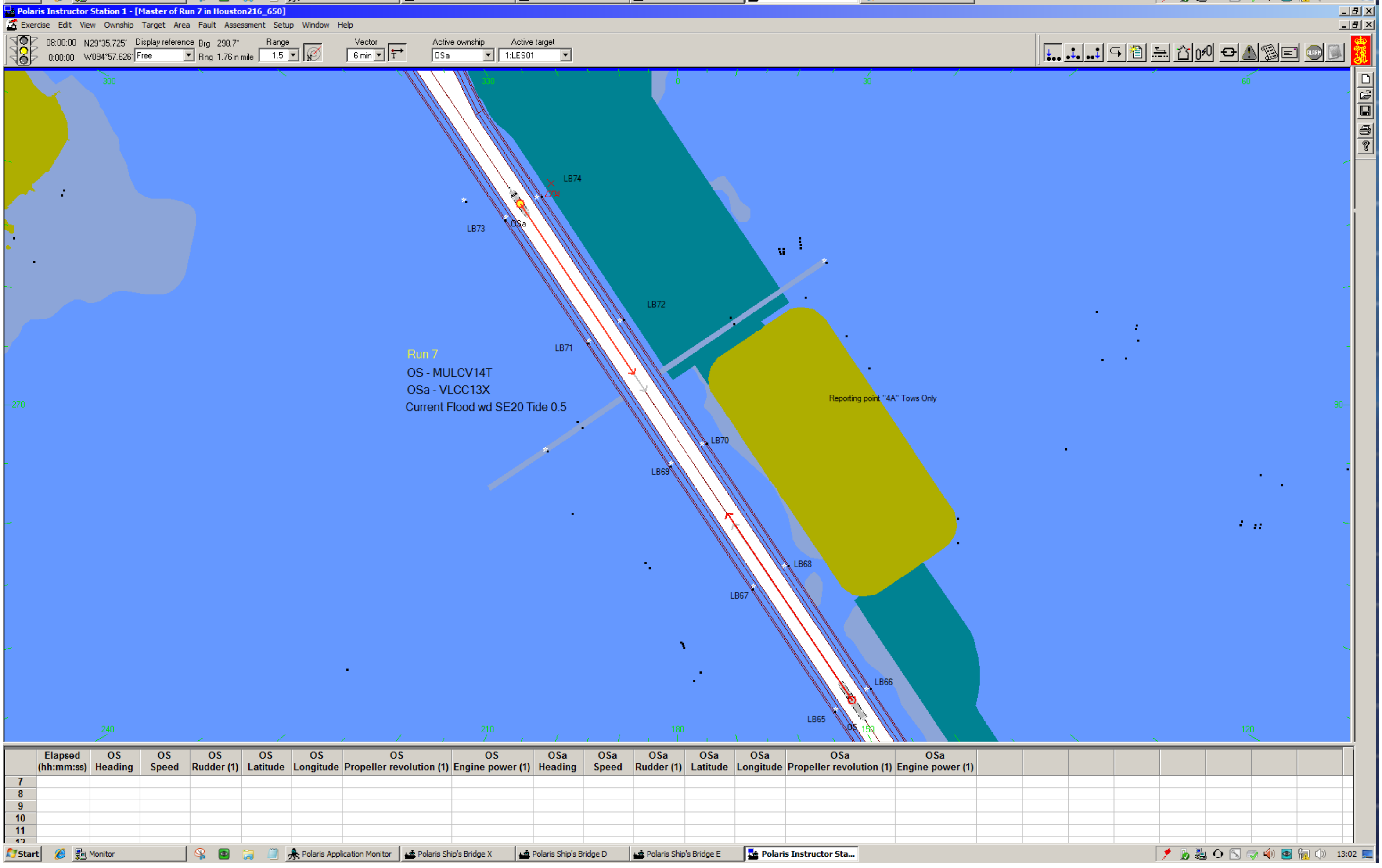
Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:10:27 N29°34.884′ Display reference Free Brg 079.5° Rng 0.246 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01

0:10:27 W094°55.671′

Run 7
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:10:26	296.7	0.1	s35.0	N29°35.127	W094°56.17	51	16698	145.8	9.8	p2.1	N29°34.502	W094°55.71	66	5860
8	00:10:24	296.7	0.0	s35.0	N29°35.127	W094°56.17	51	16699	146.4	9.8	p7.3	N29°34.507	W094°55.71	66	5844
9	00:10:22	296.7	0.0	s35.0	N29°35.127	W094°56.17	51	16700	147.0	9.8	p12.5	N29°34.512	W094°55.71	66	5844
10	00:10:20	296.7	0.0	s35.0	N29°35.127	W094°56.17	51	16699	147.6	9.8	p17.7	N29°34.517	W094°55.72	66	5847
11	00:10:18	296.7	0.1	s35.0	N29°35.127	W094°56.17	51	16698	148.2	9.8	p22.9	N29°34.521	W094°55.72	66	5847
12	00:10:16	296.7	0.1	s35.0	N29°35.127	W094°56.17	51	16698	148.6	9.8	p27.5	N29°34.526	W094°55.72	66	6830



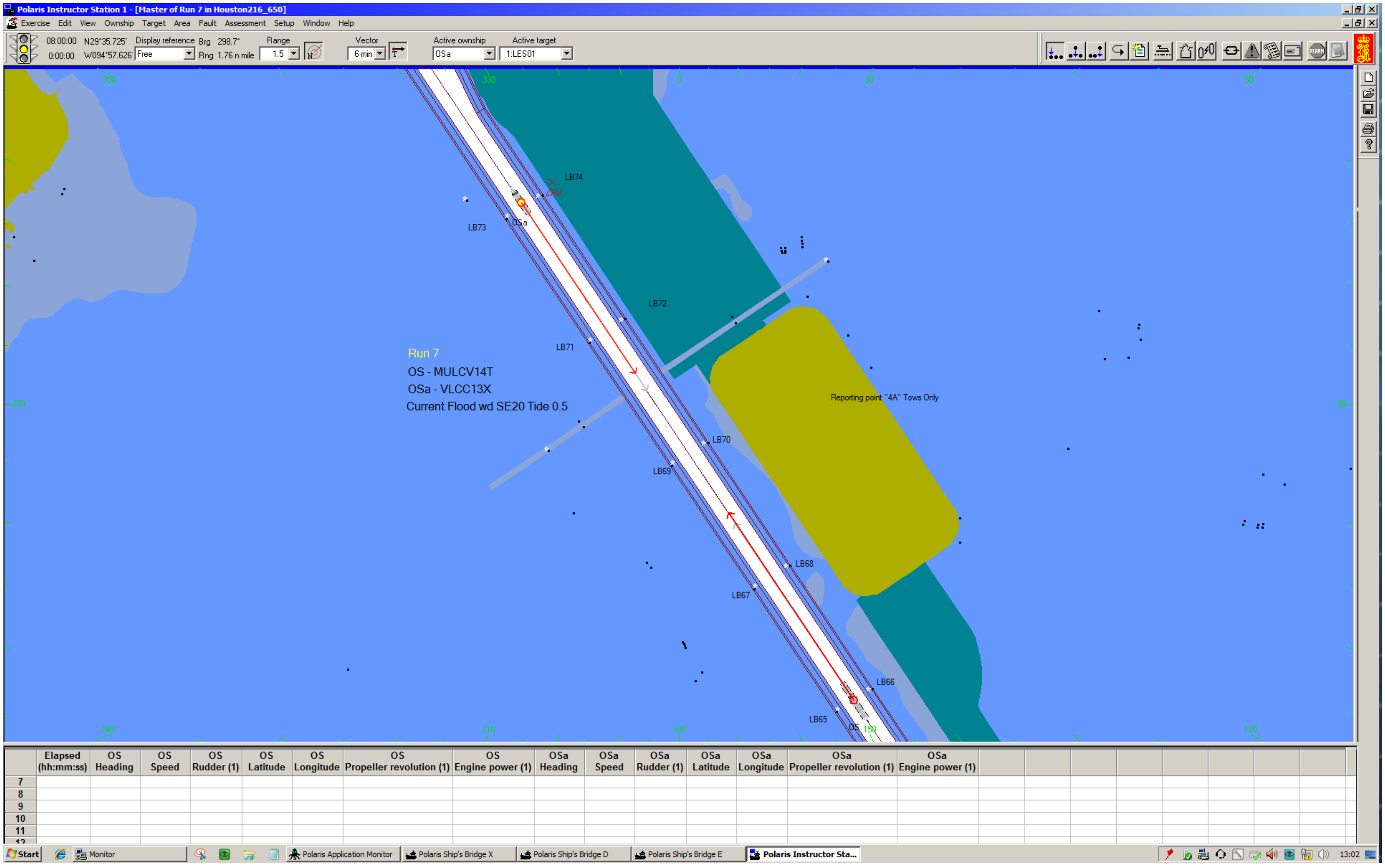
Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

08:00:00 N29°35.725′ Display reference Free Brg 298.7° Rng 1.76 n mile Range 1.5 Vector 6 min Active ownship OSa Active target 1:LES01

0:00:00 W094°57.626′

Run 7
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
10															
11															



Polaris Instructor Station 1 - [Master of Run 7 in Houston216_650]

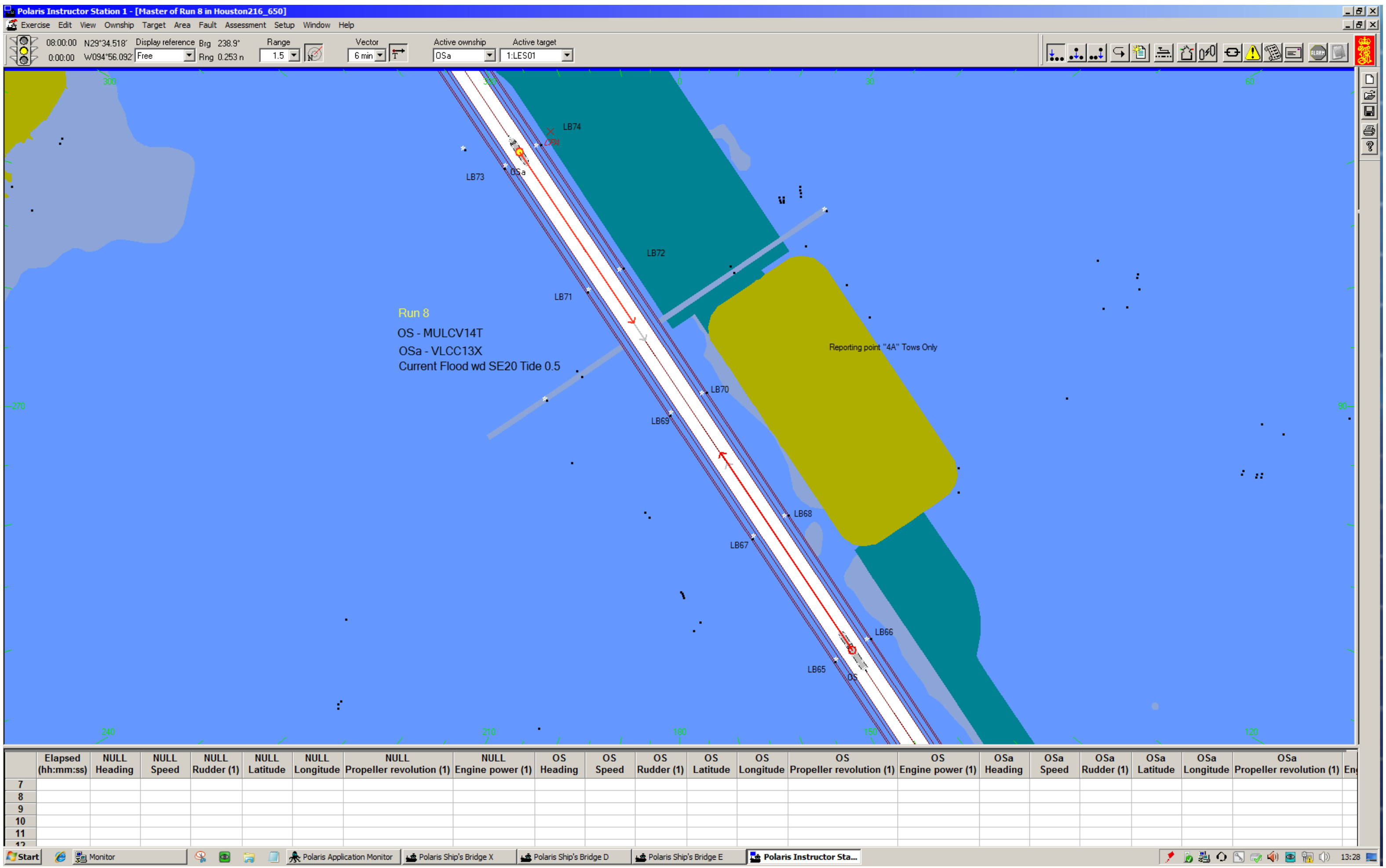
08:00:00 N29°35.725'
0:00:00 W094°57.626'
Display reference: Free
Brg 298.7°
Rng 1.76 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

Run 7
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

Reporting point "4A" Tows Only

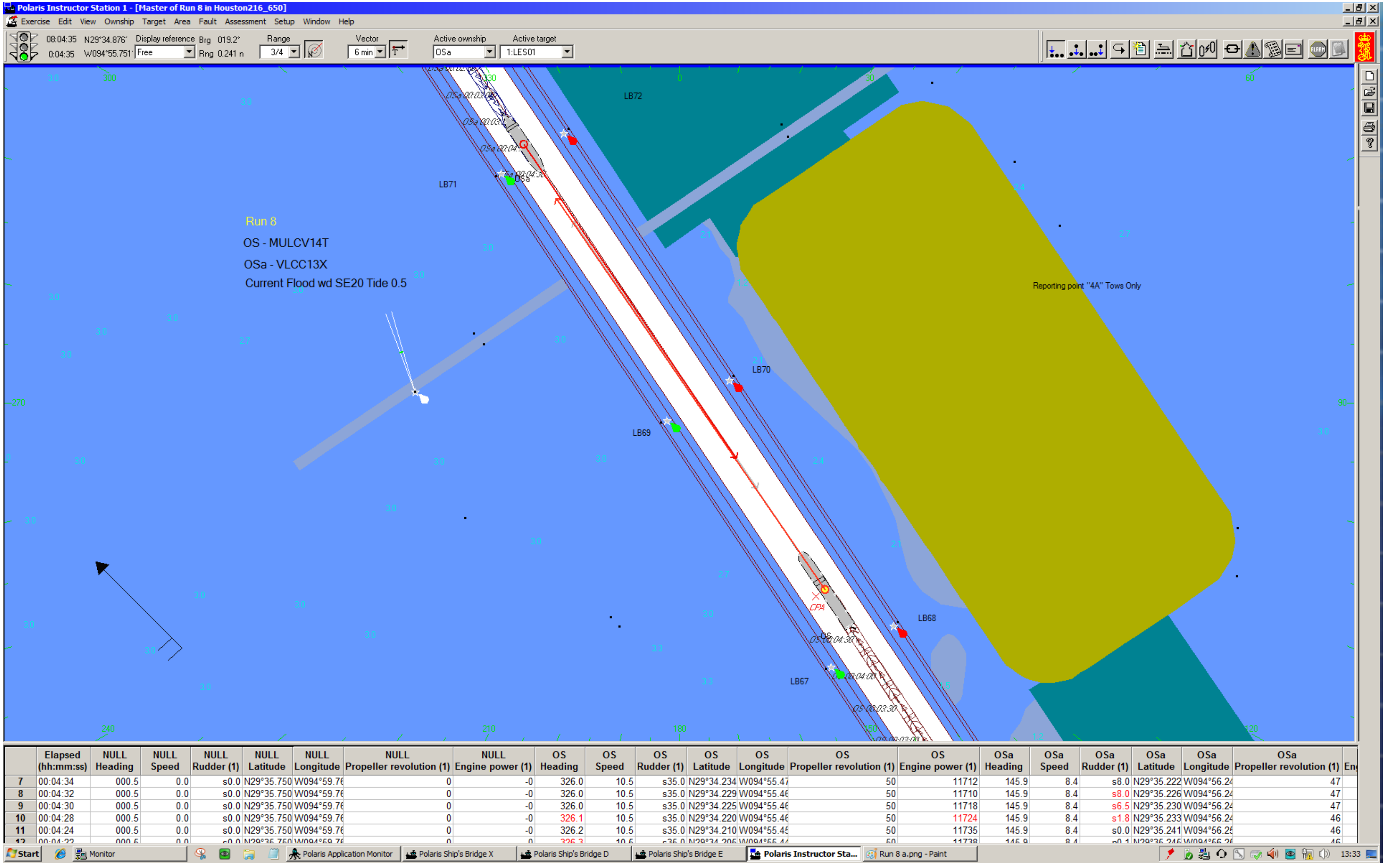
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
10															
11															

Run 8



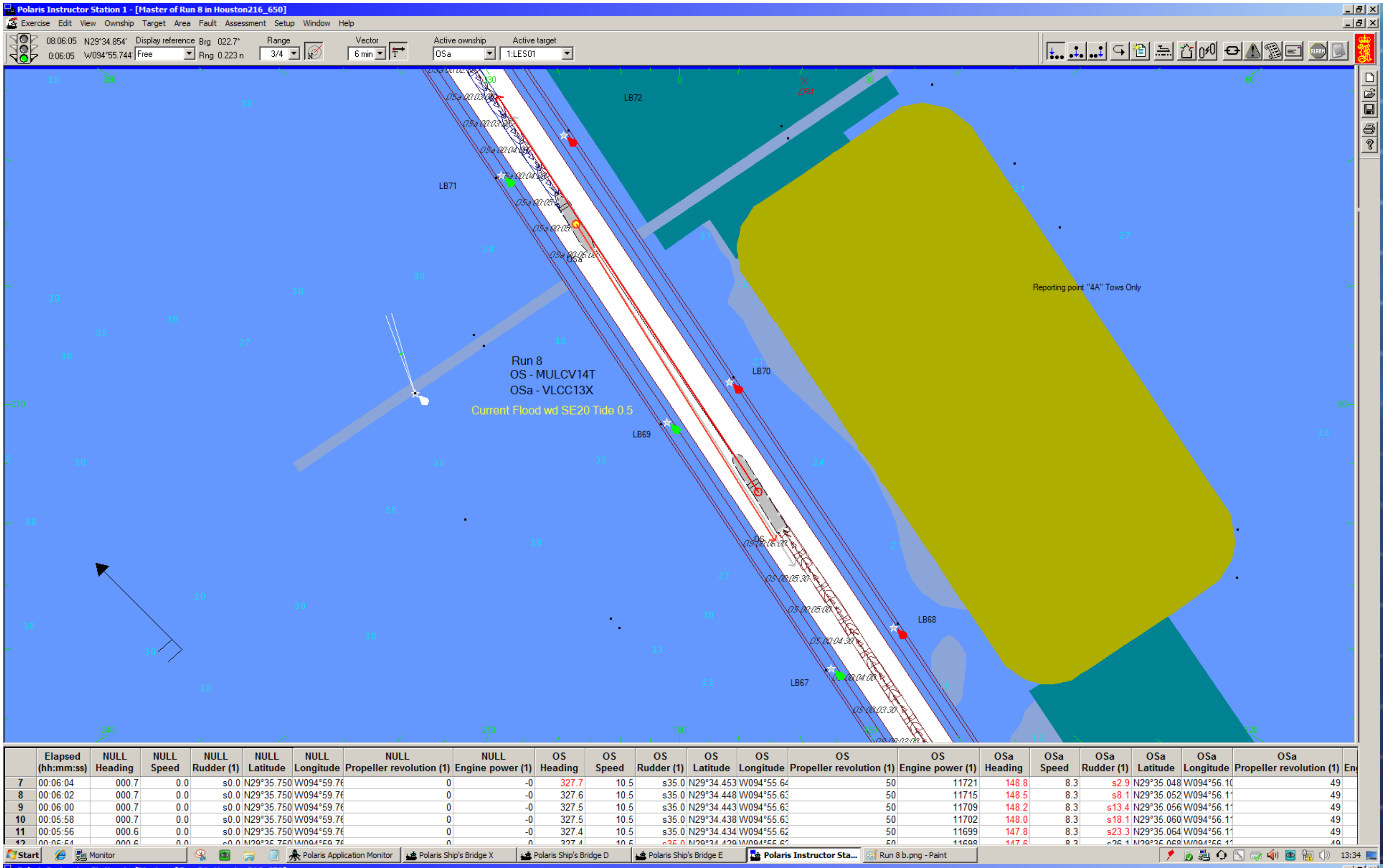
Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7																					
8																					
9																					
10																					
11																					



Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

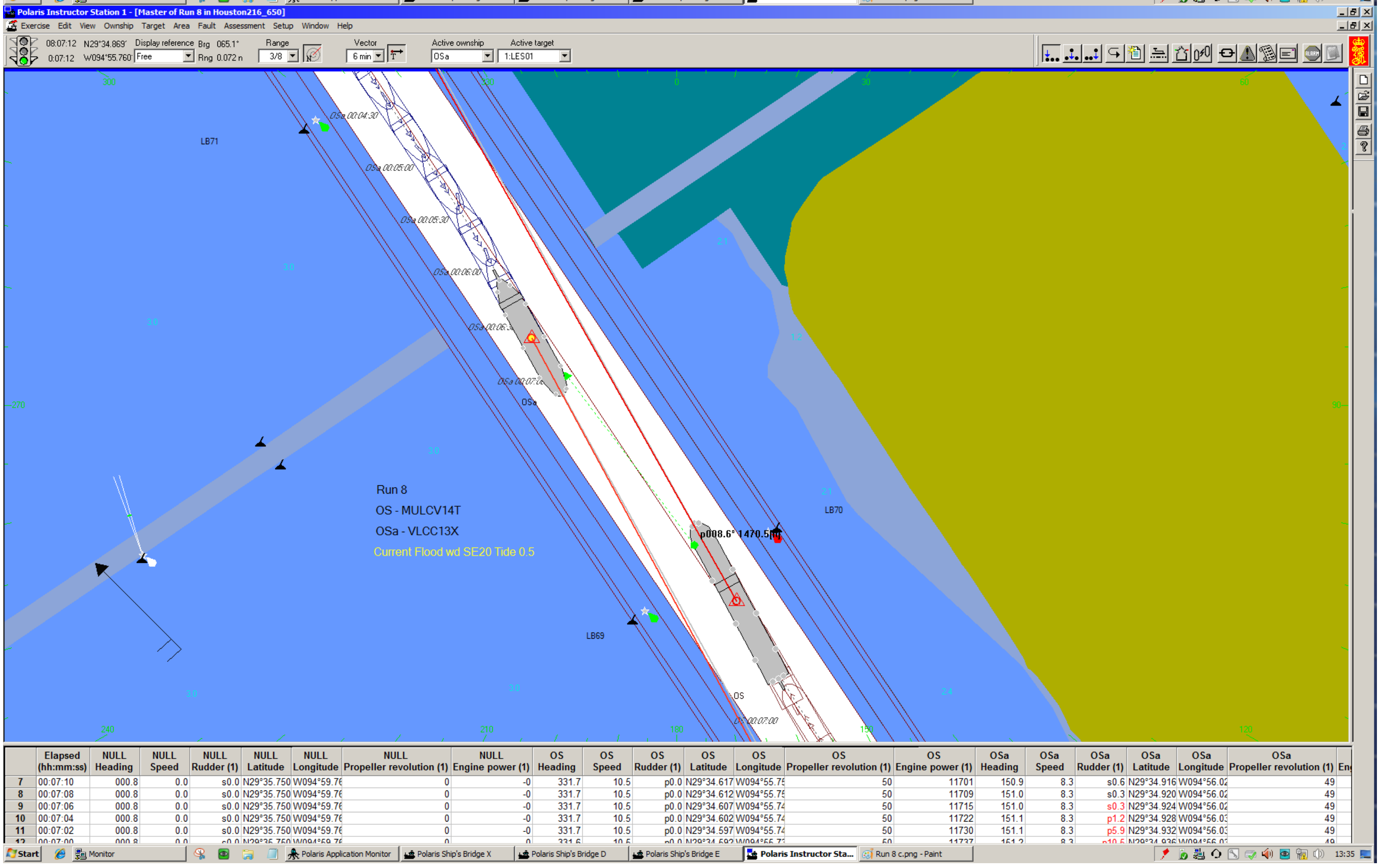
	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:04:34	000.5	0.0	s0.0	N29°35.750	W094°59.76	0	-0	326.0	10.5	s35.0	N29°34.234	W094°55.47	50	11712	145.9	8.4	s8.0	N29°35.222	W094°56.24	47
8	00:04:32	000.5	0.0	s0.0	N29°35.750	W094°59.76	0	-0	326.0	10.5	s35.0	N29°34.229	W094°55.46	50	11710	145.9	8.4	s8.0	N29°35.226	W094°56.24	47
9	00:04:30	000.5	0.0	s0.0	N29°35.750	W094°59.76	0	-0	326.0	10.5	s35.0	N29°34.225	W094°55.46	50	11718	145.9	8.4	s6.5	N29°35.230	W094°56.24	47
10	00:04:28	000.5	0.0	s0.0	N29°35.750	W094°59.76	0	-0	326.1	10.5	s35.0	N29°34.220	W094°55.46	50	11724	145.9	8.4	s1.8	N29°35.233	W094°56.24	46
11	00:04:24	000.5	0.0	s0.0	N29°35.750	W094°59.76	0	-0	326.2	10.5	s35.0	N29°34.210	W094°55.45	50	11735	145.9	8.4	s0.0	N29°35.241	W094°56.25	46



08:06:05 N29°34.854' 0:06:05 W094°55.744' Display reference: Free Brg 022.7° Rng 0.223 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01

Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

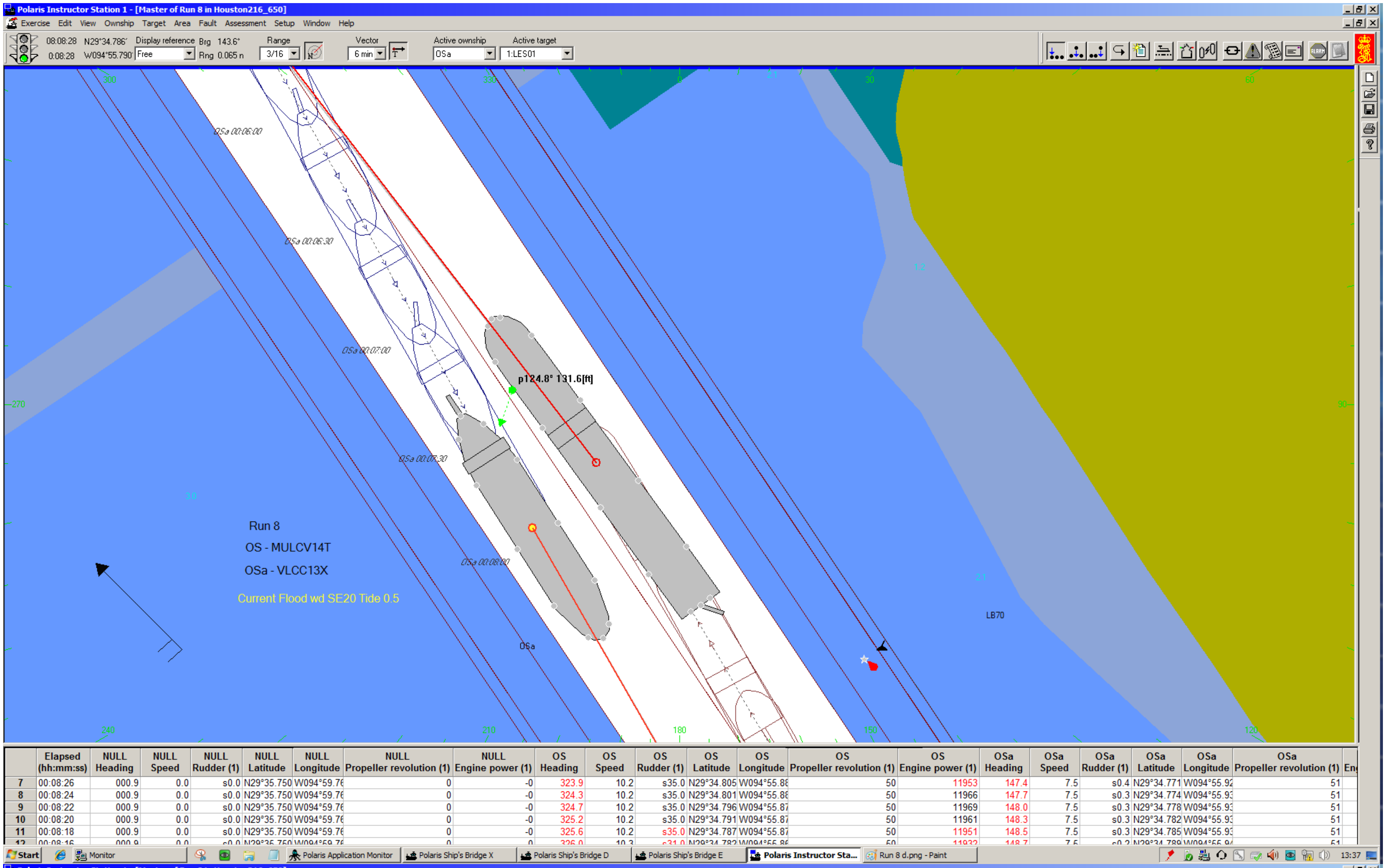
	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:06:04	000.7	0.0	s0.0	N29°35.750	W094°59.76	0	-0	327.7	10.5	s35.0	N29°34.453	W094°55.64	50	11721	148.8	8.3	s2.9	N29°35.048	W094°56.10	49
8	00:06:02	000.7	0.0	s0.0	N29°35.750	W094°59.76	0	-0	327.6	10.5	s35.0	N29°34.448	W094°55.63	50	11715	148.5	8.3	s8.1	N29°35.052	W094°56.11	49
9	00:06:00	000.7	0.0	s0.0	N29°35.750	W094°59.76	0	-0	327.5	10.5	s35.0	N29°34.443	W094°55.63	50	11709	148.2	8.3	s13.4	N29°35.056	W094°56.11	49
10	00:05:58	000.7	0.0	s0.0	N29°35.750	W094°59.76	0	-0	327.5	10.5	s35.0	N29°34.438	W094°55.63	50	11702	148.0	8.3	s18.1	N29°35.060	W094°56.11	49
11	00:05:56	000.6	0.0	s0.0	N29°35.750	W094°59.76	0	-0	327.4	10.5	s35.0	N29°34.434	W094°55.62	50	11699	147.8	8.3	s23.3	N29°35.064	W094°56.11	49



08:07:12 N29°34.869' 0:07:12 W094°55.760' Display reference: Free Brg 065.1° Rng 0.072 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:07:10	000.8	0.0	s0.0	N29°35.750	W094°59.76	0	-0	331.7	10.5	p0.0	N29°34.617	W094°55.75	50	11701	150.9	8.3	s0.6	N29°34.916	W094°56.02	49
8	00:07:08	000.8	0.0	s0.0	N29°35.750	W094°59.76	0	-0	331.7	10.5	p0.0	N29°34.612	W094°55.75	50	11709	151.0	8.3	s0.3	N29°34.920	W094°56.02	49
9	00:07:06	000.8	0.0	s0.0	N29°35.750	W094°59.76	0	-0	331.7	10.5	p0.0	N29°34.607	W094°55.74	50	11715	151.0	8.3	s0.3	N29°34.924	W094°56.02	49
10	00:07:04	000.8	0.0	s0.0	N29°35.750	W094°59.76	0	-0	331.7	10.5	p0.0	N29°34.602	W094°55.74	50	11722	151.1	8.3	p1.2	N29°34.928	W094°56.03	49
11	00:07:02	000.8	0.0	s0.0	N29°35.750	W094°59.76	0	-0	331.7	10.5	p0.0	N29°34.597	W094°55.74	50	11730	151.1	8.3	p5.9	N29°34.932	W094°56.03	49



08:08:28 N29°34.786'
0:08:28 W094°55.790'

Display reference: Free

Brg 143.6°
Rng 0.065 n

Range: 3/16

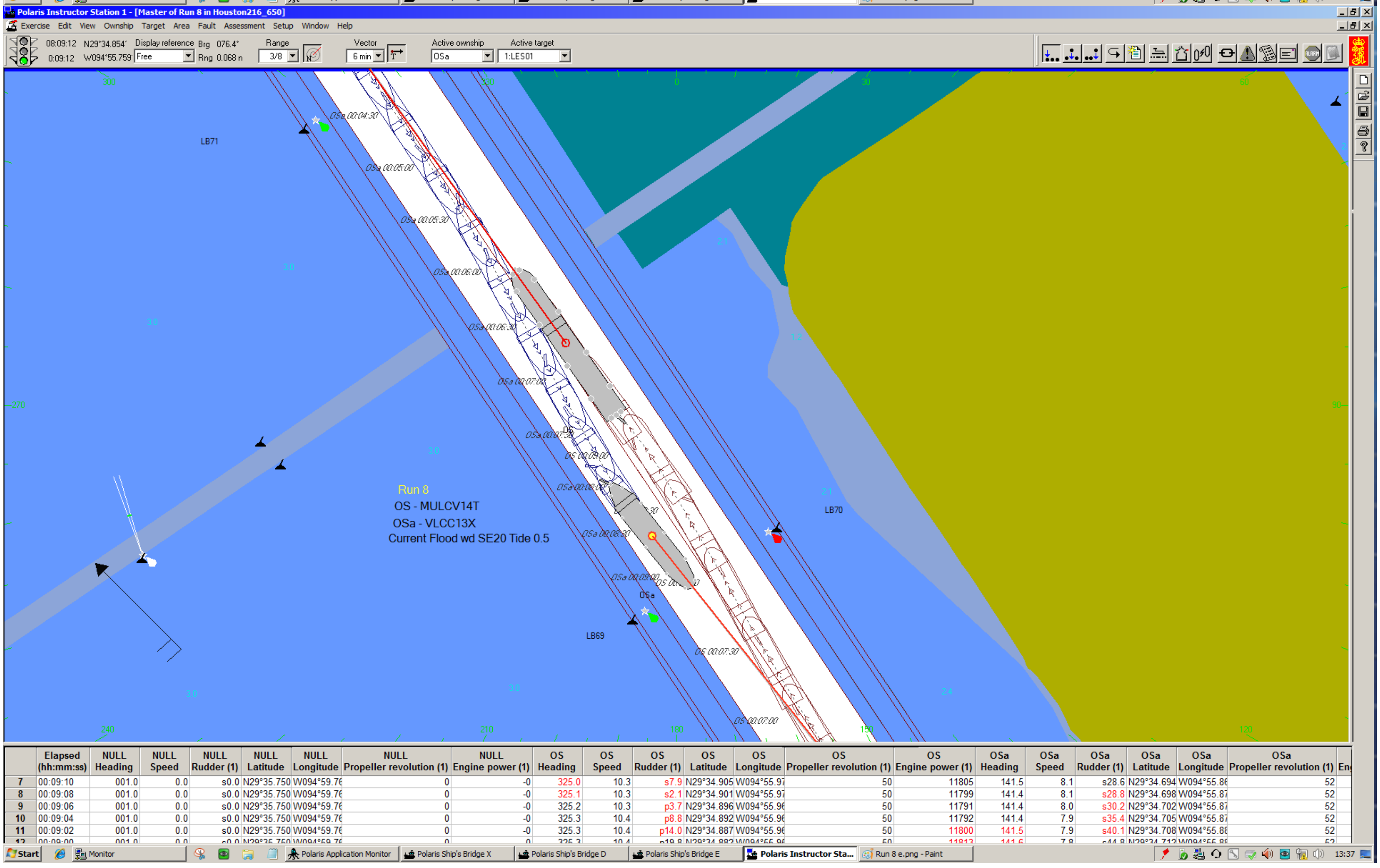
Vector: 6 min

Active ownship: OSa

Active target: 1:LES01

Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:08:26	000.9	0.0	s0.0	N29°35.750	W094°59.76	0	-0	323.9	10.2	s35.0	N29°34.805	W094°55.88	50	11953	147.4	7.5	s0.4	N29°34.771	W094°55.92	51
8	00:08:24	000.9	0.0	s0.0	N29°35.750	W094°59.76	0	-0	324.3	10.2	s35.0	N29°34.801	W094°55.88	50	11966	147.7	7.5	s0.3	N29°34.774	W094°55.93	51
9	00:08:22	000.9	0.0	s0.0	N29°35.750	W094°59.76	0	-0	324.7	10.2	s35.0	N29°34.796	W094°55.87	50	11969	148.0	7.5	s0.3	N29°34.778	W094°55.93	51
10	00:08:20	000.9	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.2	10.2	s35.0	N29°34.791	W094°55.87	50	11961	148.3	7.5	s0.3	N29°34.782	W094°55.93	51
11	00:08:18	000.9	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.6	10.2	s35.0	N29°34.787	W094°55.87	50	11951	148.5	7.5	s0.3	N29°34.785	W094°55.93	51



08:09:12 N29°34.854'
0:09:12 W094°55.759'

Display reference: Free

Brg 076.4°
Rng 0.068 n

Range: 3/8

Vector: 6 min

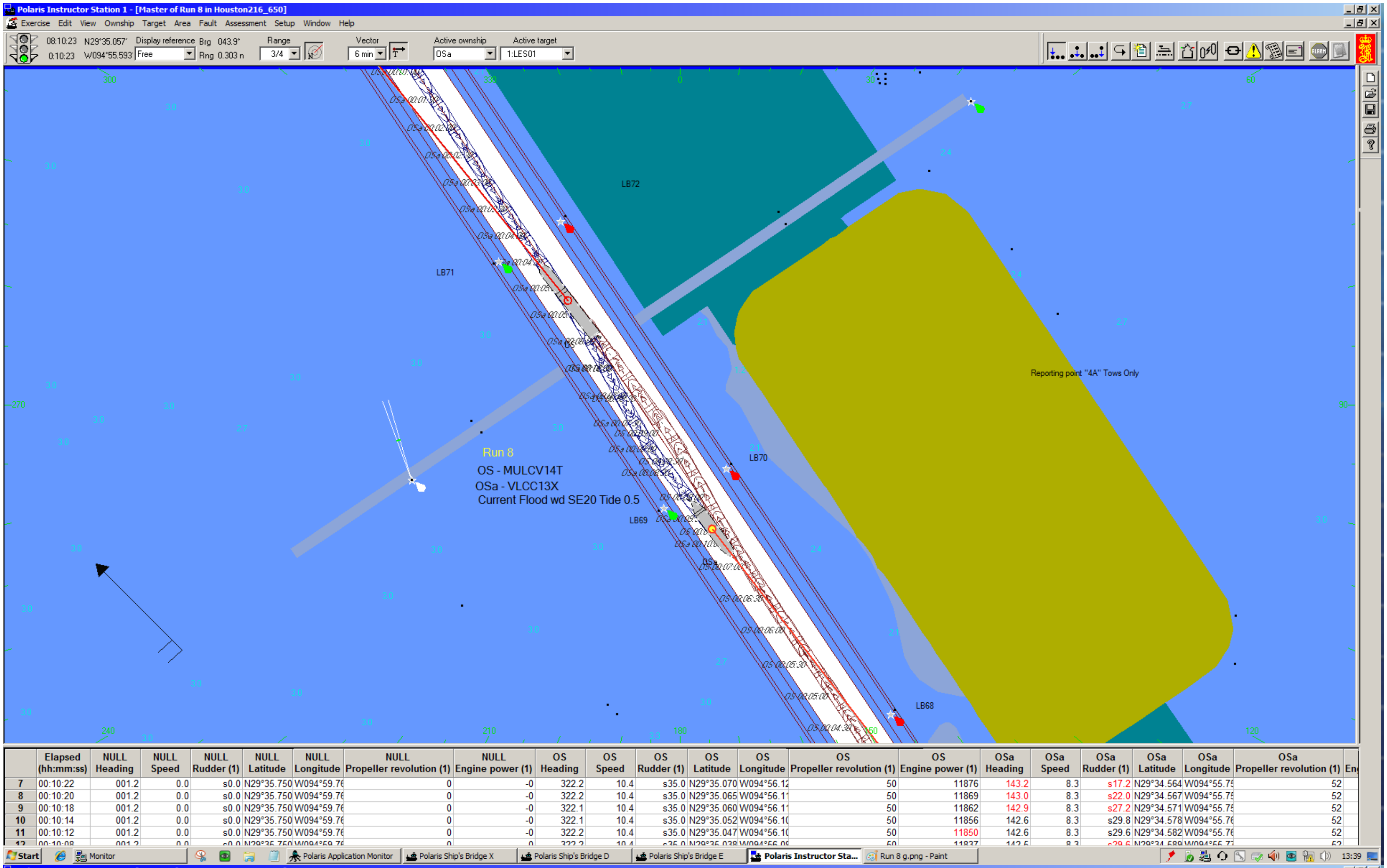
Active ownship: OSa

Active target: 1:LES01

Run 8
OS - MULCV14T
OSa - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:09:10	001.0	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.0	10.3	s7.9	N29°34.905	W094°55.97	50	11805	141.5	8.1	s28.6	N29°34.694	W094°55.86	52
8	00:09:08	001.0	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.1	10.3	s2.1	N29°34.901	W094°55.97	50	11799	141.4	8.1	s28.8	N29°34.698	W094°55.87	52
9	00:09:06	001.0	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.2	10.3	p3.7	N29°34.896	W094°55.96	50	11791	141.4	8.0	s30.2	N29°34.702	W094°55.87	52
10	00:09:04	001.0	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.3	10.4	p8.8	N29°34.892	W094°55.96	50	11792	141.4	7.9	s35.4	N29°34.705	W094°55.87	52
11	00:09:02	001.0	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.3	10.4	p14.0	N29°34.887	W094°55.96	50	11800	141.5	7.9	s40.1	N29°34.708	W094°55.88	52

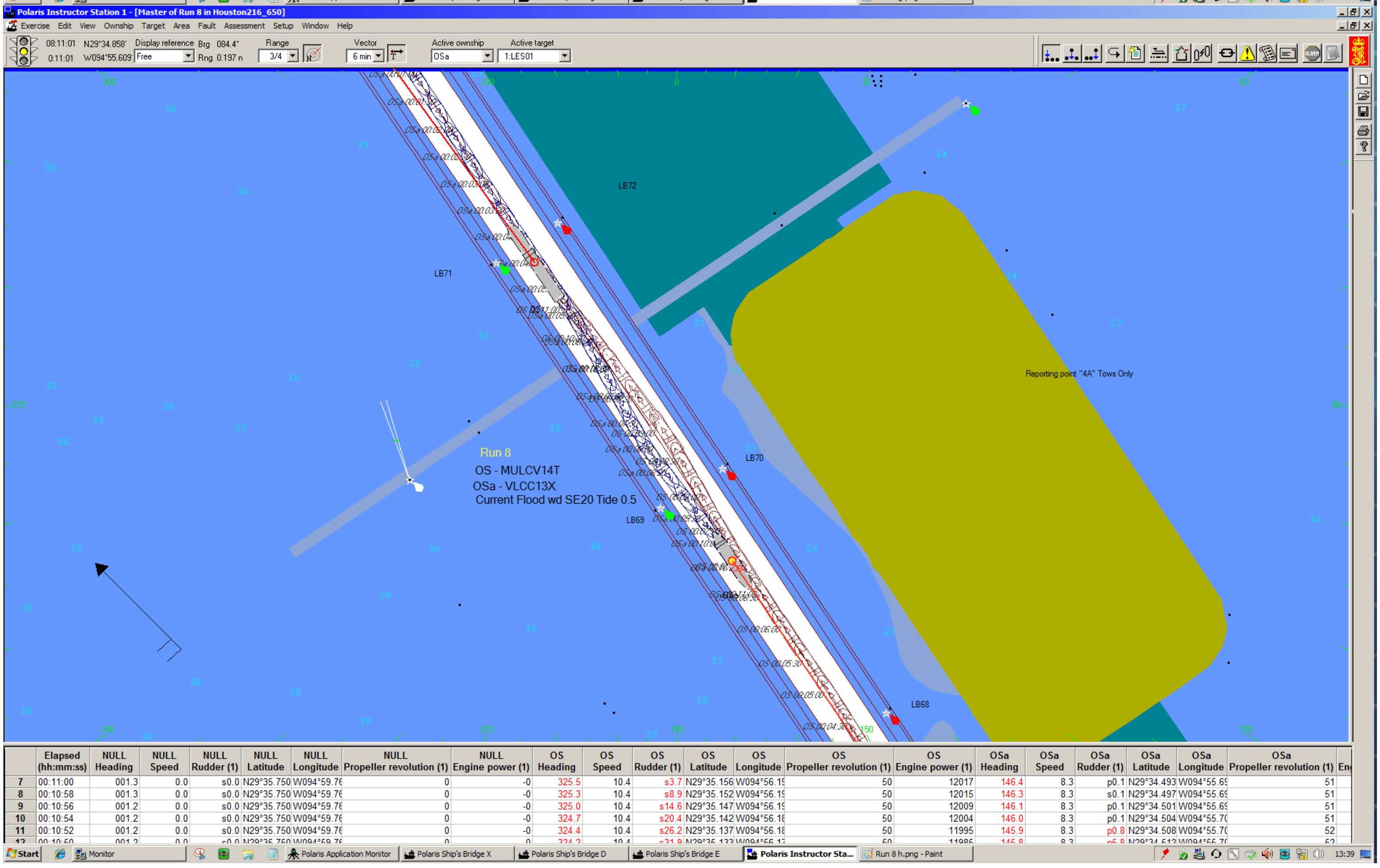
June 26, 2019



Polaris Instructor Station 1 - [Master of Run 8 in Houston216_650]

08:10:23 N29°35.057′ Display reference Free Brg 043.9° Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:10:23 W094°55.593′ Rng 0.303 n

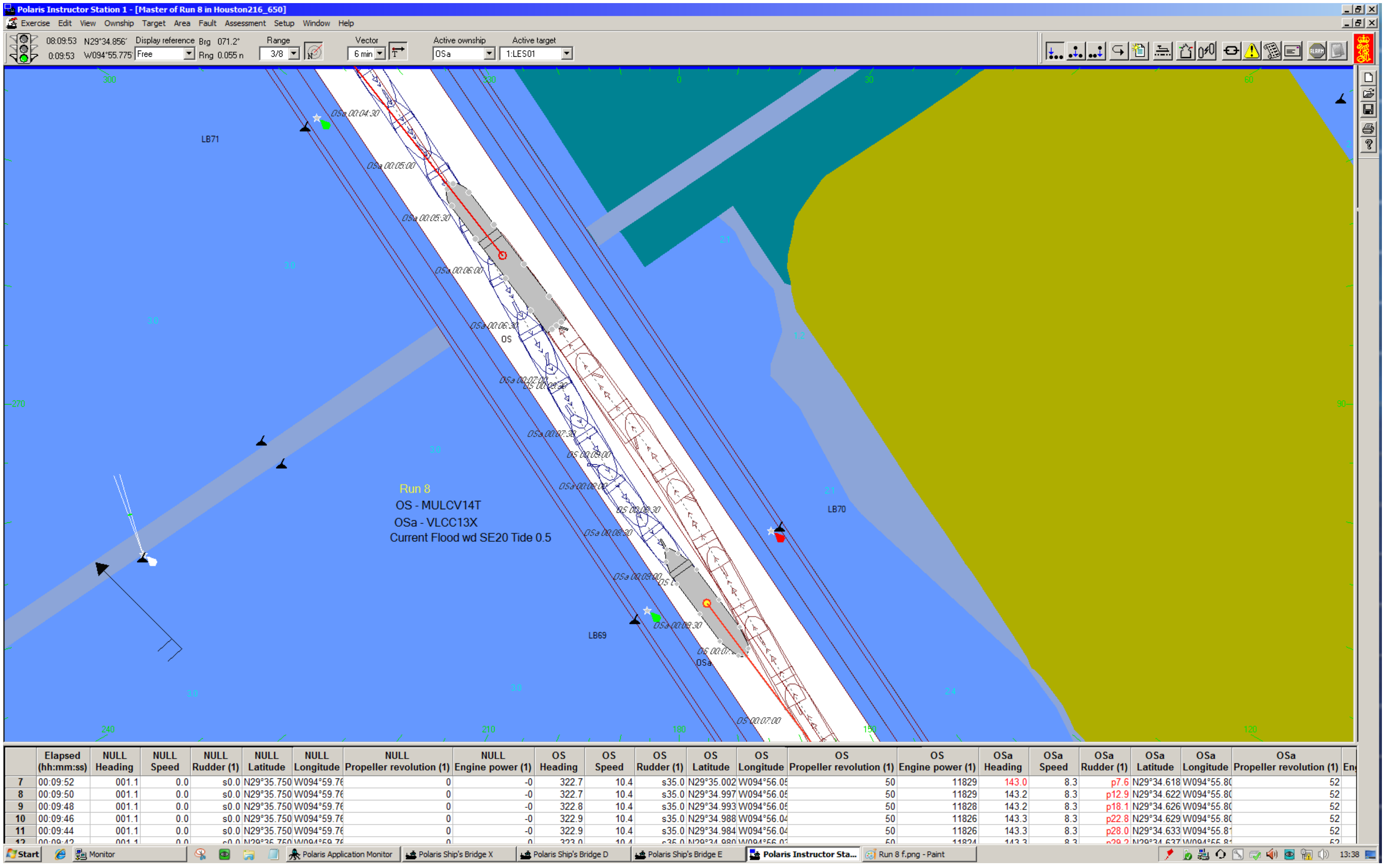
	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:10:22	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.2	10.4	s35.0	N29°35.070	W094°56.12	50	11876	143.2	8.3	s17.2	N29°34.564	W094°55.75	52
8	00:10:20	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.2	10.4	s35.0	N29°35.065	W094°56.11	50	11869	143.0	8.3	s22.0	N29°34.567	W094°55.75	52
9	00:10:18	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.1	10.4	s35.0	N29°35.060	W094°56.11	50	11862	142.9	8.3	s27.2	N29°34.571	W094°55.75	52
10	00:10:14	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.1	10.4	s35.0	N29°35.052	W094°56.10	50	11856	142.6	8.3	s29.8	N29°34.578	W094°55.76	52
11	00:10:12	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.2	10.4	s35.0	N29°35.047	W094°56.10	50	11850	142.6	8.3	s29.6	N29°34.582	W094°55.76	52



Polaris Instructor Station 1 - [Master of Run 8 in Houston216_650]

08:11:01 N29°34.858′ Display reference Free Brg 084.4° Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:11:01 W094°55.609′ Rng 0.197 n

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)
7	00:11:00	001.3	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.5	10.4	s3.7	N29°35.156	W094°56.19	50	12017	146.4	8.3	p0.1	N29°34.493	W094°55.69	51
8	00:10:58	001.3	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.3	10.4	s8.9	N29°35.152	W094°56.19	50	12015	146.3	8.3	s0.1	N29°34.497	W094°55.69	51
9	00:10:56	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	325.0	10.4	s14.6	N29°35.147	W094°56.19	50	12009	146.1	8.3	p0.1	N29°34.501	W094°55.69	51
10	00:10:54	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	324.7	10.4	s20.4	N29°35.142	W094°56.18	50	12004	146.0	8.3	p0.1	N29°34.504	W094°55.70	51
11	00:10:52	001.2	0.0	s0.0	N29°35.750	W094°59.76	0	-0	324.4	10.4	s26.2	N29°35.137	W094°56.18	50	11995	145.9	8.3	p0.8	N29°34.508	W094°55.70	52



Polaris Instructor Station 1 - [Master of Run 8 in Houston216_650]

08:09:53 N29°34.856′ Display reference Free Brg 071.2° Rng 0.055 n

0:09:53 W094°55.775′

Range 3/8

Vector 6 min

Active ownship OSa

Active target 1:LES01

Run 8

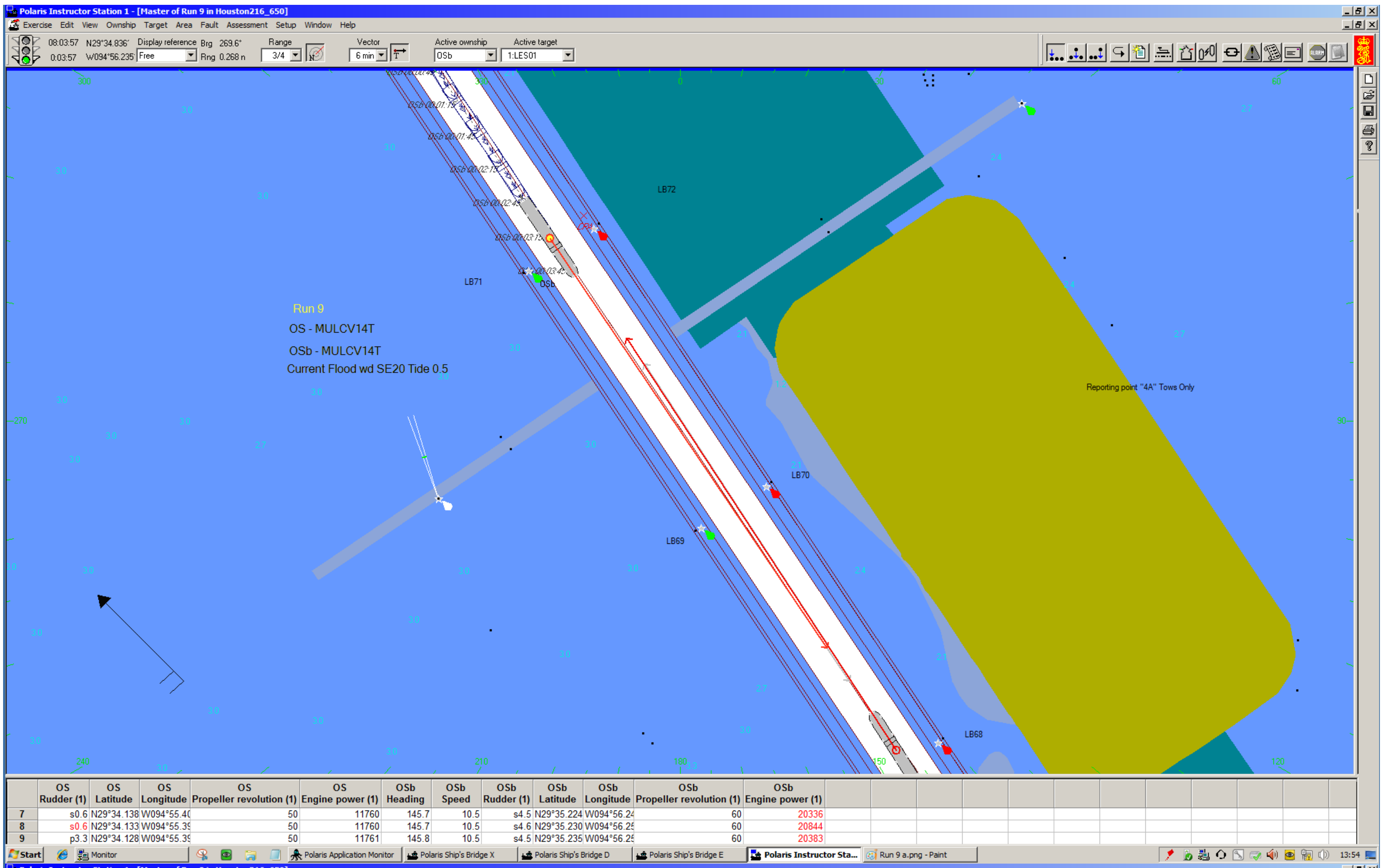
OS - MULCV14T

OSa - VLCC13X

Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	NULL Heading	NULL Speed	NULL Rudder (1)	NULL Latitude	NULL Longitude	NULL Propeller revolution (1)	NULL Engine power (1)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	En
7	00:09:52	001.1	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.7	10.4	s35.0	N29°35.002	W094°56.05	50	11829	143.0	8.3	p7.6	N29°34.618	W094°55.80	52	
8	00:09:50	001.1	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.7	10.4	s35.0	N29°34.997	W094°56.05	50	11829	143.2	8.3	p12.9	N29°34.622	W094°55.80	52	
9	00:09:48	001.1	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.8	10.4	s35.0	N29°34.993	W094°56.05	50	11828	143.2	8.3	p18.1	N29°34.626	W094°55.80	52	
10	00:09:46	001.1	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.9	10.4	s35.0	N29°34.988	W094°56.04	50	11826	143.3	8.3	p22.8	N29°34.629	W094°55.80	52	
11	00:09:44	001.1	0.0	s0.0	N29°35.750	W094°59.76	0	-0	322.9	10.4	s35.0	N29°34.984	W094°56.04	50	11826	143.3	8.3	p28.0	N29°34.633	W094°55.81	52	

Run 9

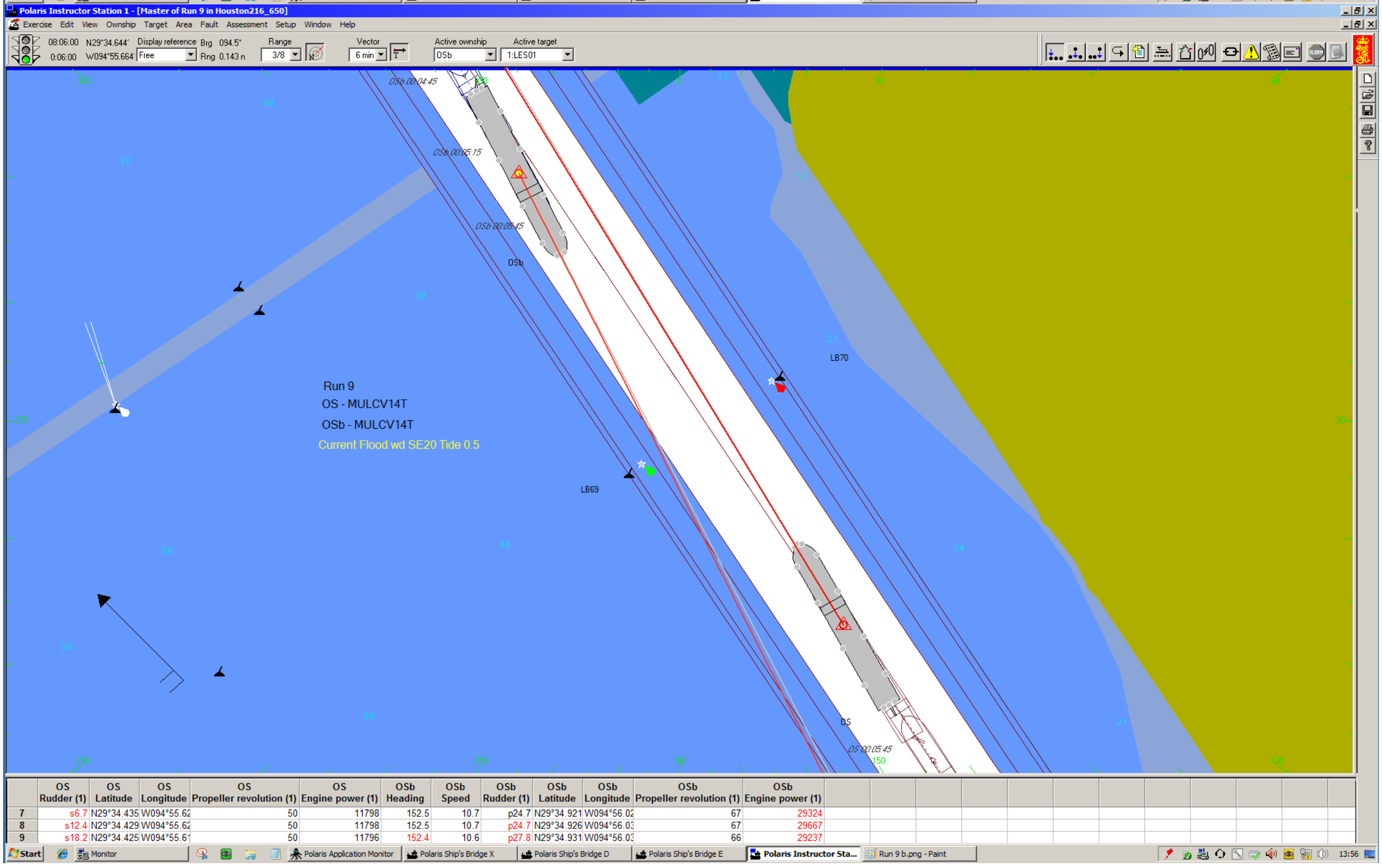


Polaris Instructor Station 1 - [Master of Run 9 in Houston216_650]

08:03:57 N29°34.836′ Display reference Brg 269.6°
0:03:57 W094°56.235′ Free Rng 0.268 n
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 9
OS - MULCV14T
OSb - MULCV14T
Current Flood wd SE20 Tide 0.5

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	s0.6	N29°34.138	W094°55.40	50	11760	145.7	10.5	s4.5	N29°35.224	W094°56.24	60	20336
8	s0.6	N29°34.133	W094°55.39	50	11760	145.7	10.5	s4.6	N29°35.230	W094°56.25	60	20844
9	p3.3	N29°34.128	W094°55.39	50	11761	145.8	10.5	s4.5	N29°35.235	W094°56.25	60	20383

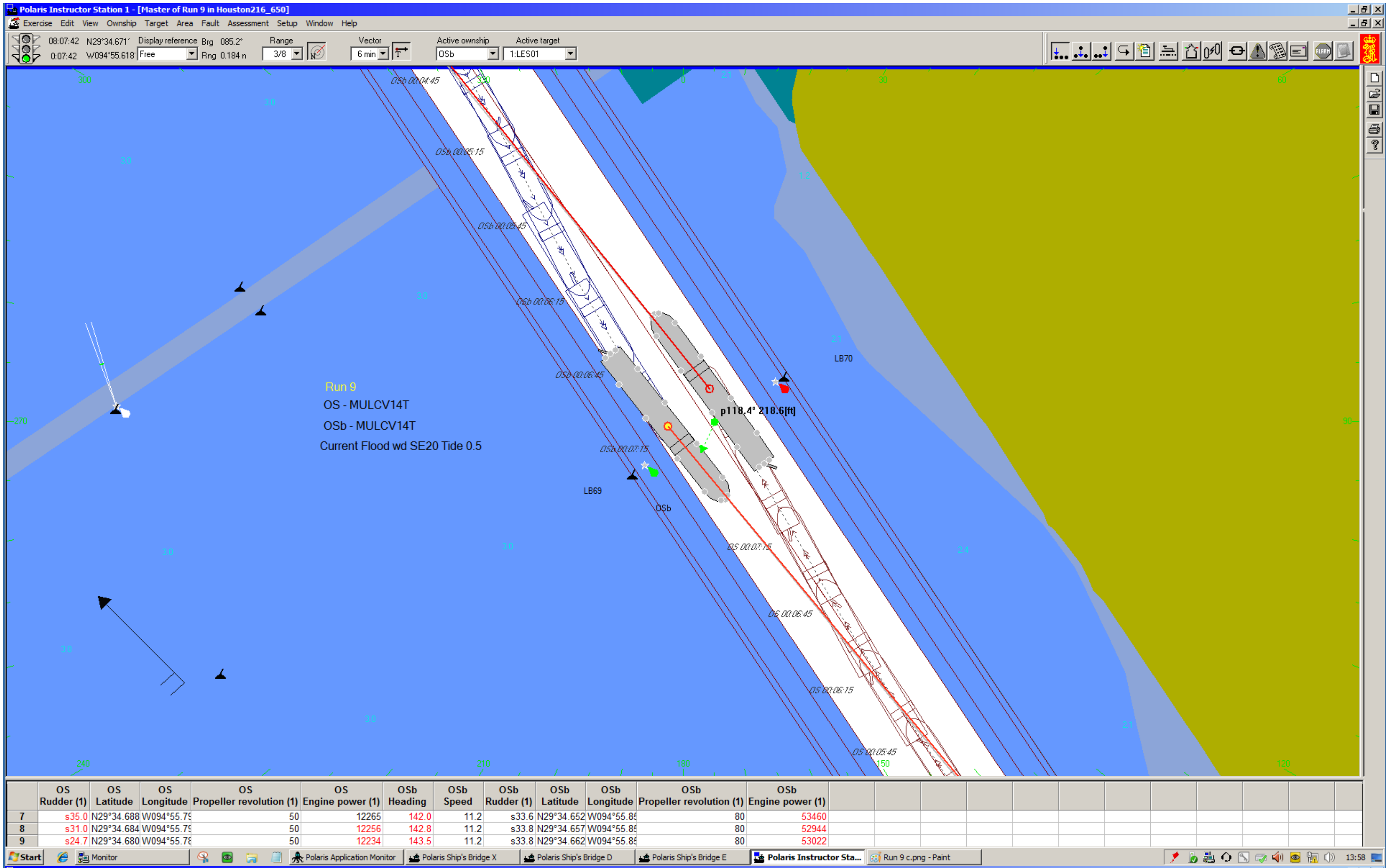


Polaris Instructor Station 1 - [Master of Run 9 in Houston216_650]

08:06:00 N29°34.644′ Display reference Brg 094.5°
0:06:00 W094°55.664′ Free Rng 0.143 n
Range 3/8
Vector 6 min
Active ownship OSb
Active target 1:LES01

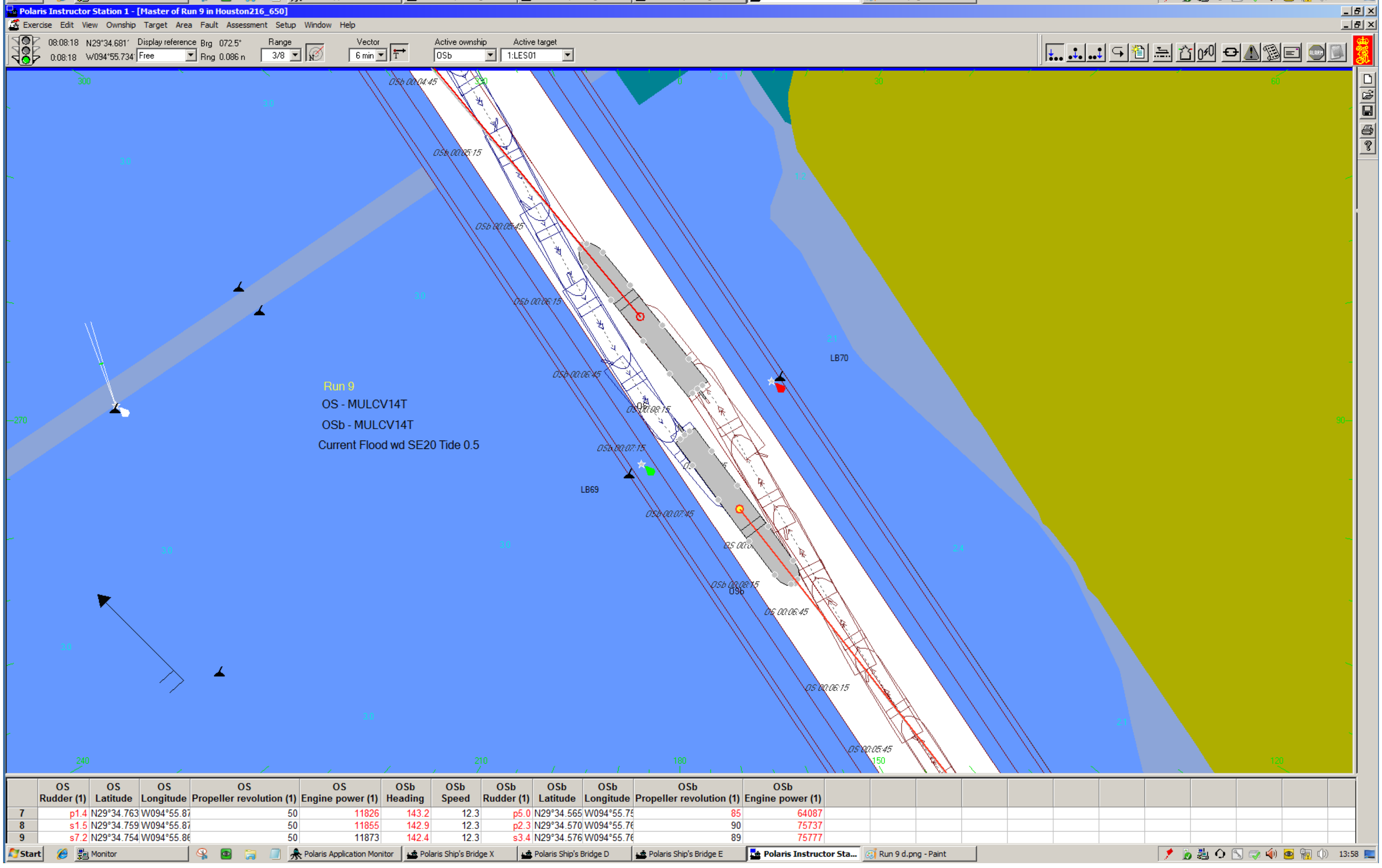
Run 9
OS - MULCV14T
OSb - MULCV14T
Current Flood wd SE20 Tide 0.5

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	s6.7	N29°34.435	W094°55.62	50	11798	152.5	10.7	p24.7	N29°34.921	W094°56.02	67	29324
8	s12.4	N29°34.429	W094°55.62	50	11798	152.5	10.7	p24.7	N29°34.926	W094°56.03	67	29667
9	s18.2	N29°34.425	W094°55.61	50	11796	152.4	10.6	p27.8	N29°34.931	W094°56.03	66	29237



08:07:42 N29°34.671´ Display reference: Free Brg 085.2° Rng 0.184 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:07:42 W094°55.618´

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	s35.0	N29°34.688	W094°55.79	50	12265	142.0	11.2	s33.6	N29°34.652	W094°55.85	80	53460
8	s31.0	N29°34.684	W094°55.79	50	12256	142.8	11.2	s33.8	N29°34.657	W094°55.85	80	52944
9	s24.7	N29°34.680	W094°55.78	50	12234	143.5	11.2	s33.8	N29°34.662	W094°55.85	80	53022



08:08:18 N29°34.681´ Display reference: Free Brg 072.5° Rng 0.086 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:18 W094°55.734´

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	p1.4	N29°34.763	W094°55.87	50	11826	143.2	12.3	p5.0	N29°34.565	W094°55.75	85	64087
8	s1.5	N29°34.759	W094°55.87	50	11855	142.9	12.3	p2.3	N29°34.570	W094°55.76	90	75737
9	s7.2	N29°34.754	W094°55.86	50	11873	142.4	12.3	s3.4	N29°34.576	W094°55.76	89	75777

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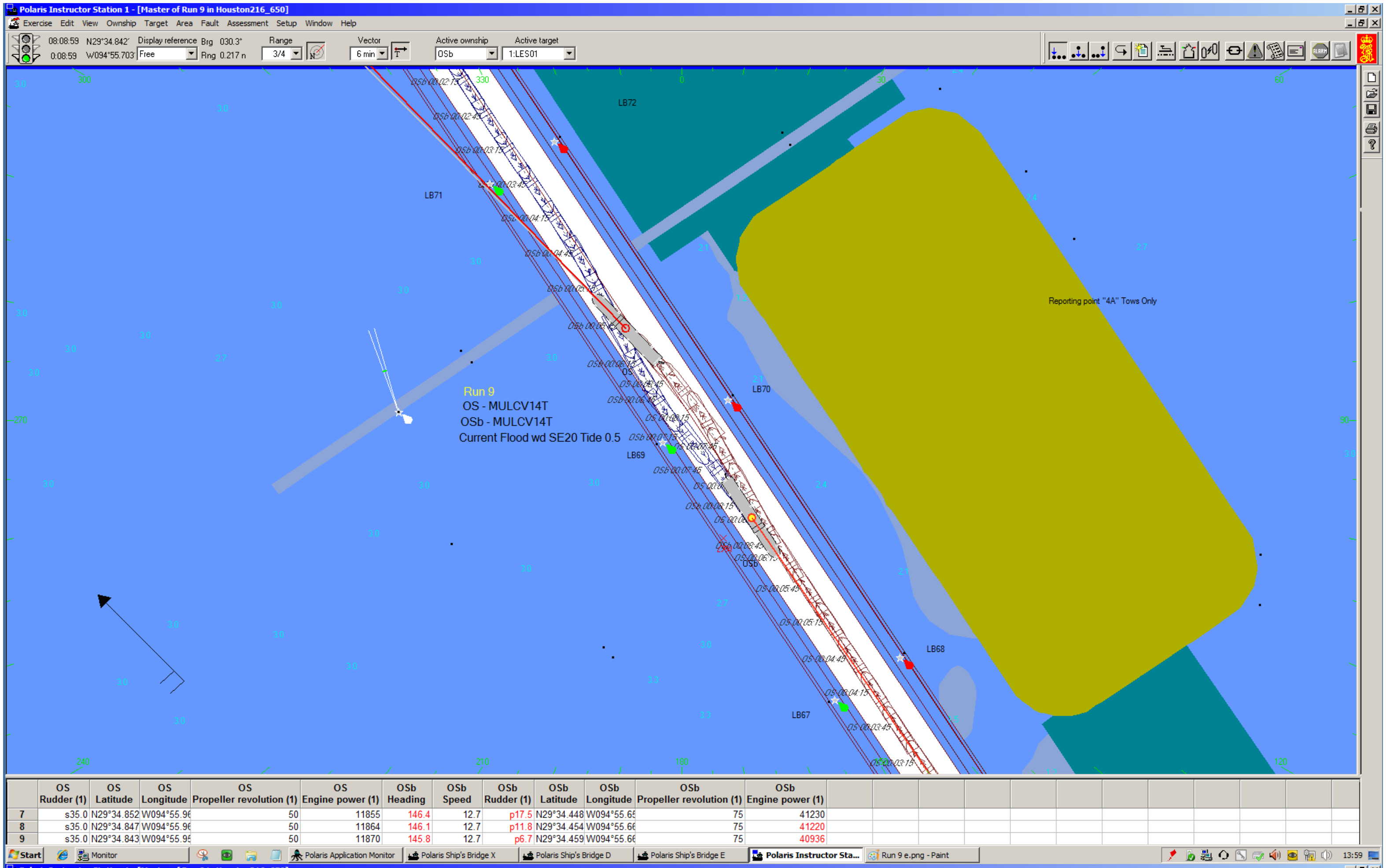
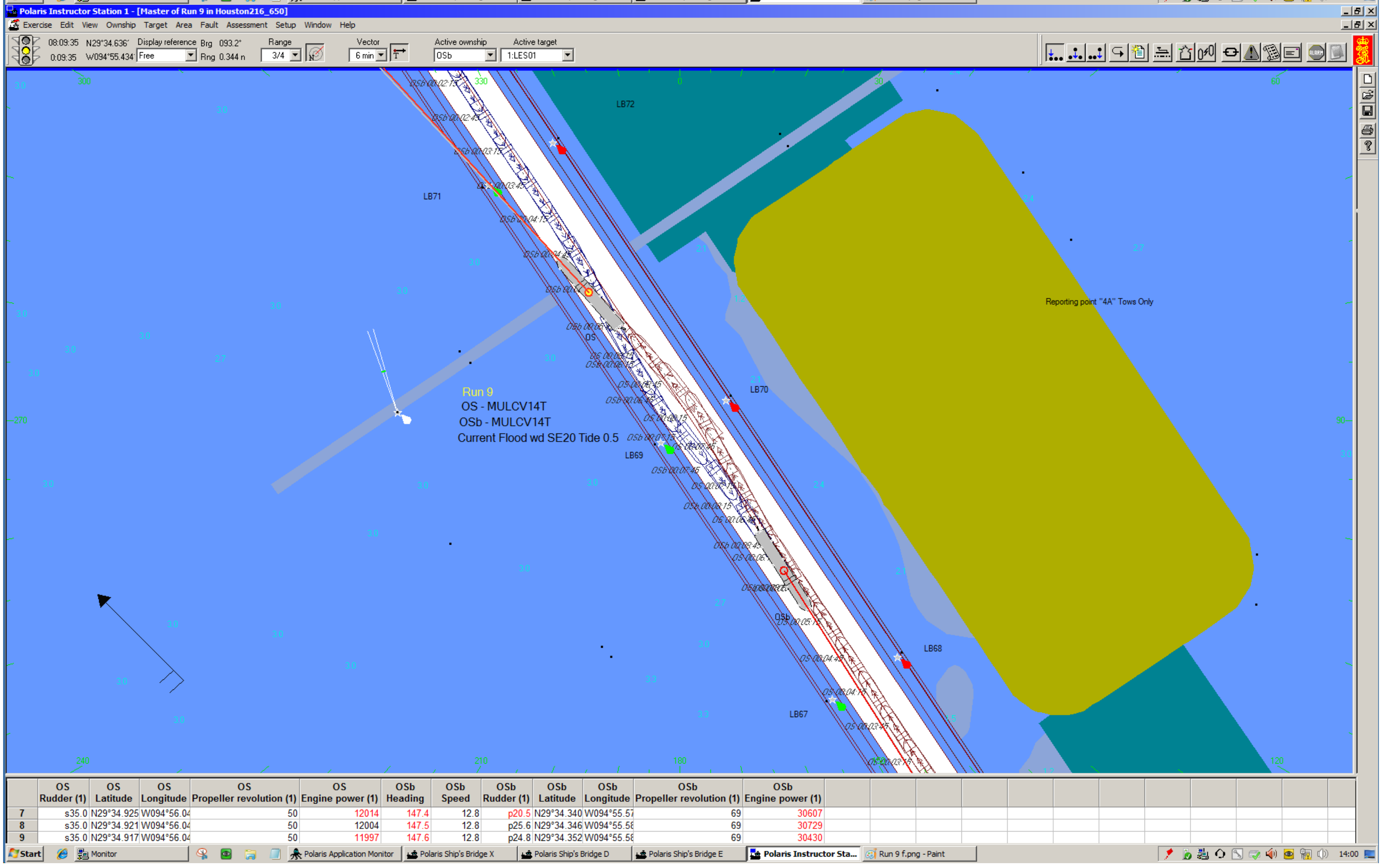


Polaris Instructor Station 1 - [Master of Run 9 in Houston216_650]

08:08:59 N29°34.842' Display reference Free Brg 030.3° Rng 0.217 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:59 W094°55.703'

Run 9
OS - MULCV14T
OSb - MULCV14T
Current Flood wd SE20 Tide 0.5

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	s35.0	N29°34.852	W094°55.96	50	11855	146.4	12.7	p17.5	N29°34.448	W094°55.65	75	41230
8	s35.0	N29°34.847	W094°55.96	50	11864	146.1	12.7	p11.8	N29°34.454	W094°55.66	75	41220
9	s35.0	N29°34.843	W094°55.95	50	11870	145.8	12.7	p6.7	N29°34.459	W094°55.66	75	40936



Polaris Instructor Station 1 - [Master of Run 9 in Houston216_650]

08:09:35 N29°34.636' Display reference Free Brg 093.2° Rng 0.344 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:09:35 W094°55.434'

Run 9
OS - MULCV14T
OSb - MULCV14T
Current Flood wd SE20 Tide 0.5

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	s35.0	N29°34.925	W094°56.04	50	12014	147.4	12.8	p20.5	N29°34.340	W094°55.57	69	30607
8	s35.0	N29°34.921	W094°56.04	50	12004	147.5	12.8	p25.6	N29°34.346	W094°55.58	69	30729
9	s35.0	N29°34.917	W094°56.04	50	11997	147.6	12.8	p24.8	N29°34.352	W094°55.58	69	30430

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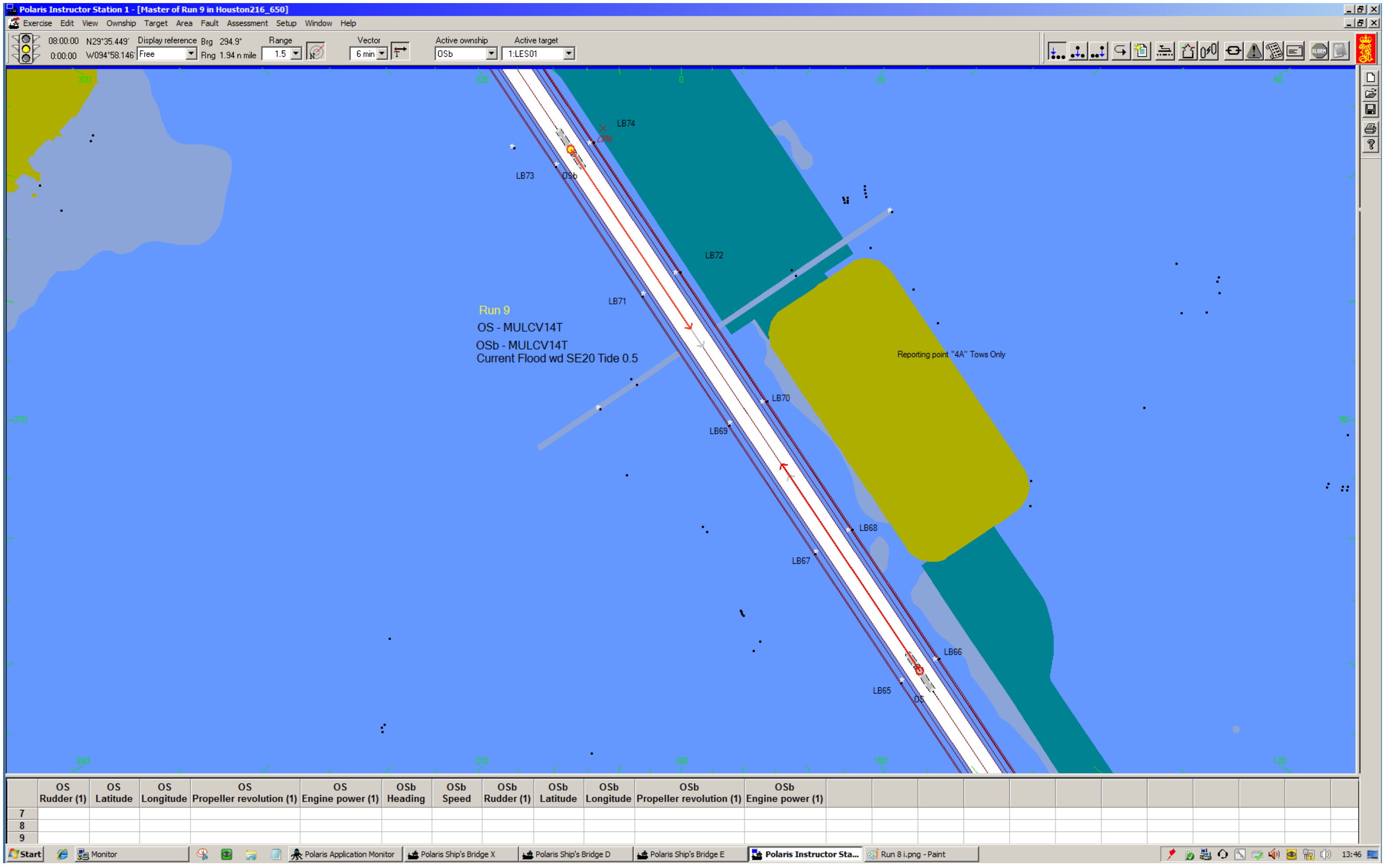


Polaris Instructor Station 1 - [Master of Run 9 in Houston216_650]

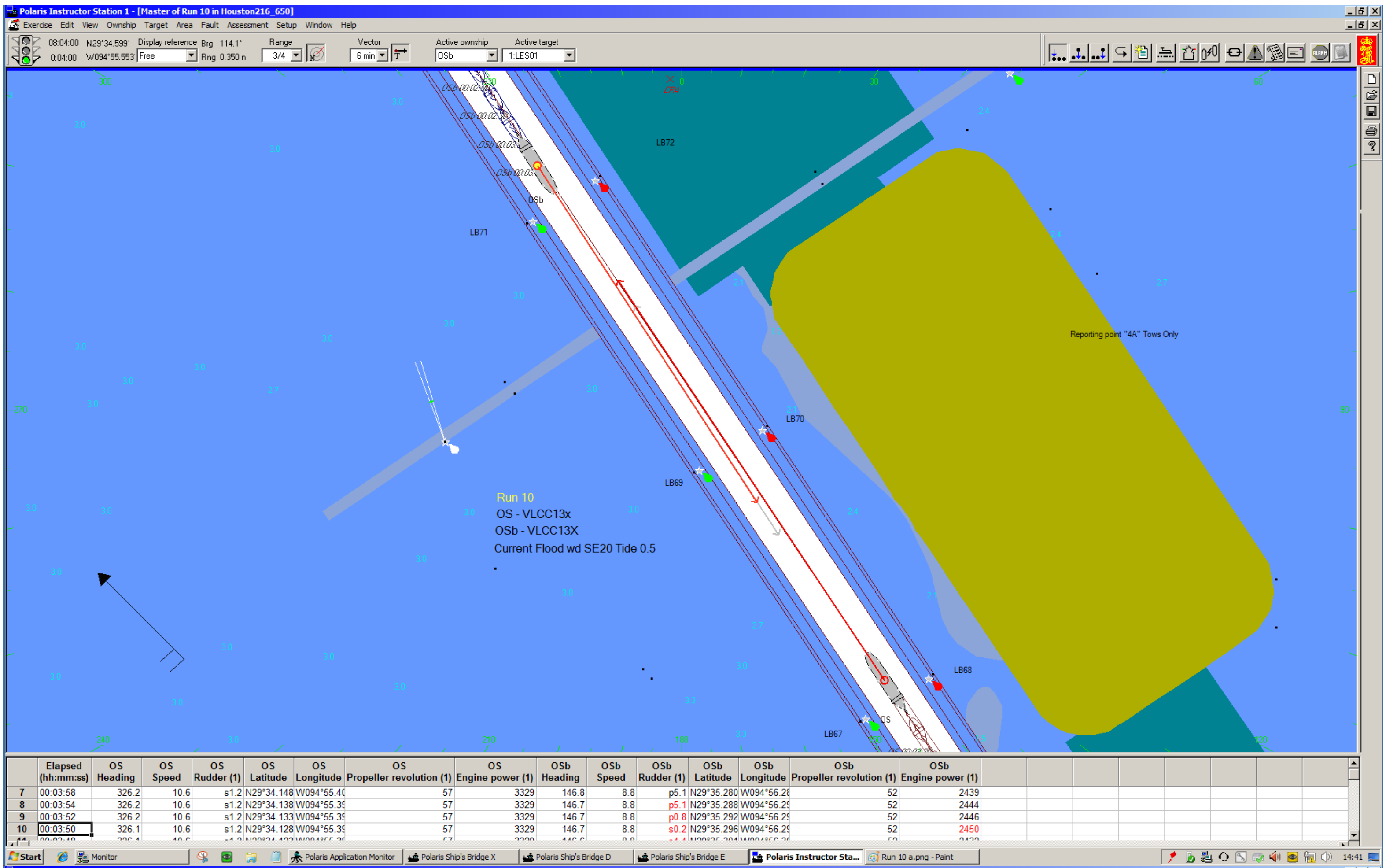
08:00:00 N29°35.449′
0:00:00 W094°58.146′
Display reference: Free
Brg 294.9°
Rng 1.94 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 9
OS - MULCV14T
OSb - MULCV14T
Current Flood wd SE20 Tide 0.5

Reporting point "4A" Tows Only

	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7												
8												
9												

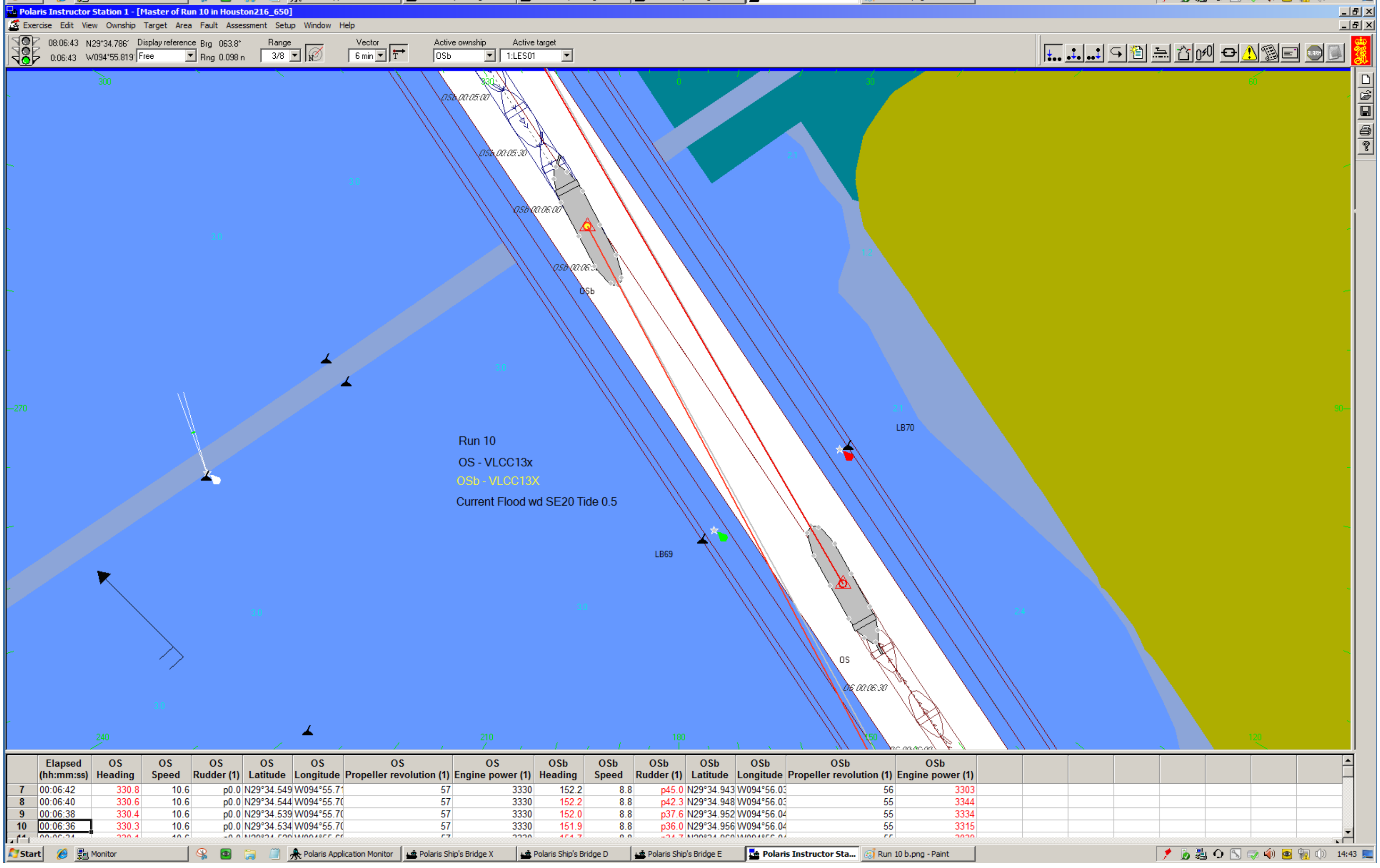
Run 10



08:04:00 N29°34.599′ Display reference: Free Brg 114.1° Rng 0.350 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:04:00 W094°55.553′

Run 10
OS - VLCC13x
OSb - VLCC13X
Current Flood wd SE20 Tide 0.5

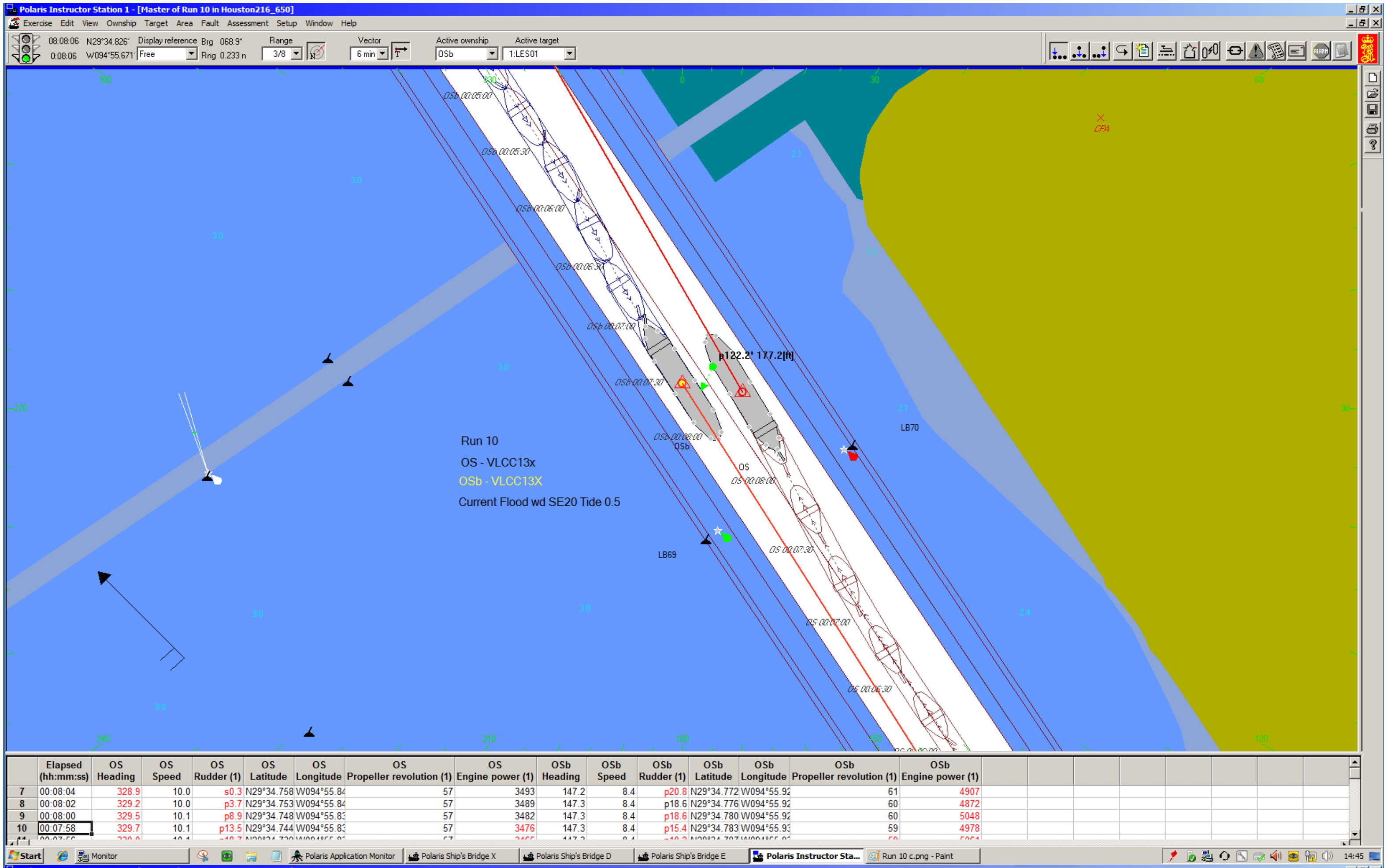
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:58	326.2	10.6	s1.2	N29°34.148	W094°55.4	57	3329	146.8	8.8	p5.1	N29°35.280	W094°56.2	52	2439
8	00:03:54	326.2	10.6	s1.2	N29°34.138	W094°55.3	57	3329	146.7	8.8	p5.1	N29°35.288	W094°56.2	52	2444
9	00:03:52	326.2	10.6	s1.2	N29°34.133	W094°55.3	57	3329	146.7	8.8	p0.8	N29°35.292	W094°56.2	52	2446
10	00:03:50	326.1	10.6	s1.2	N29°34.128	W094°55.3	57	3329	146.7	8.8	s0.2	N29°35.296	W094°56.2	52	2450



08:06:43 N29°34.786′ Display reference: Free Brg 063.8° Rng 0.098 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:06:43 W094°55.819′

Run 10
OS - VLCC13x
OSb - VLCC13X
Current Flood wd SE20 Tide 0.5

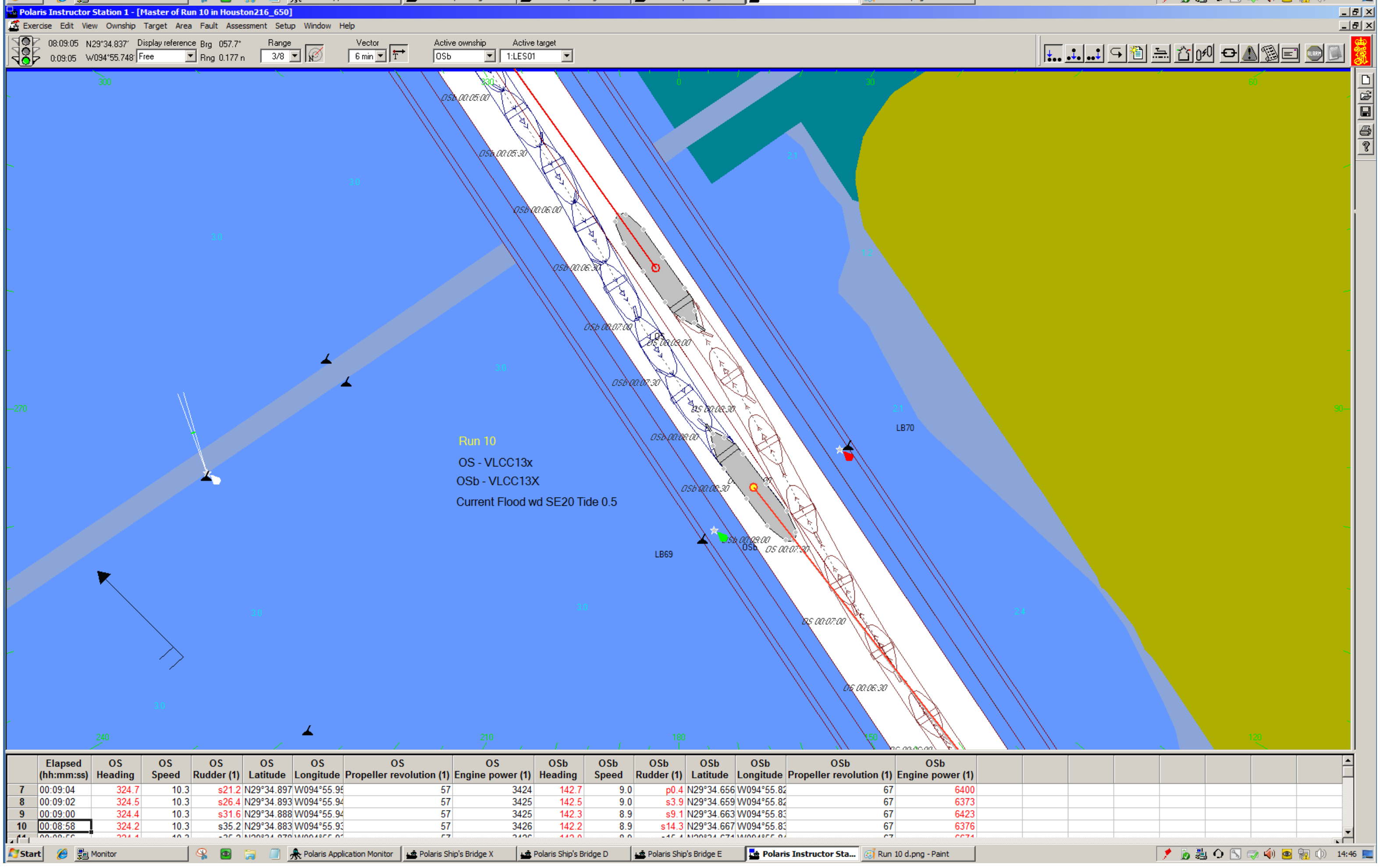
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:42	330.8	10.6	p0.0	N29°34.549	W094°55.7	57	3330	152.2	8.8	p45.0	N29°34.943	W094°56.0	56	3303
8	00:06:40	330.6	10.6	p0.0	N29°34.544	W094°55.7	57	3330	152.2	8.8	p42.3	N29°34.948	W094°56.0	55	3344
9	00:06:38	330.4	10.6	p0.0	N29°34.539	W094°55.7	57	3330	152.0	8.8	p37.6	N29°34.952	W094°56.0	55	3334
10	00:06:36	330.3	10.6	p0.0	N29°34.534	W094°55.7	57	3330	151.9	8.8	p36.0	N29°34.956	W094°56.0	55	3315



Polaris Instructor Station 1 - [Master of Run 10 in Houston216_650]

08:08:06 N29°34.826′ Display reference Free Brg 068.9° Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:06 W094°55.671′ Rng 0.233 n

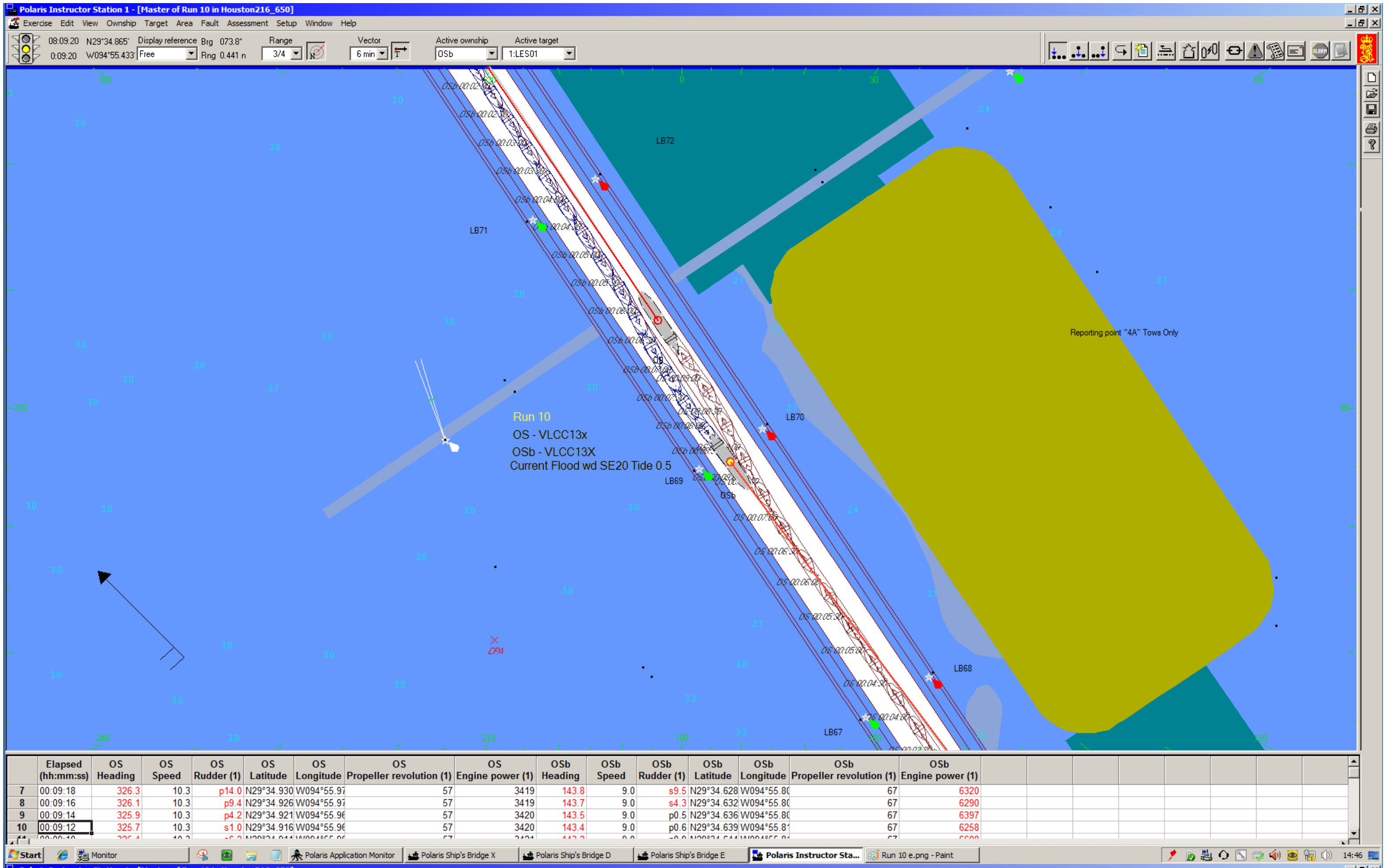
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:04	328.9	10.0	s0.3	N29°34.758	W094°55.84	57	3493	147.2	8.4	p20.8	N29°34.772	W094°55.92	61	4907
8	00:08:02	329.2	10.0	p3.7	N29°34.753	W094°55.84	57	3489	147.3	8.4	p18.6	N29°34.776	W094°55.92	60	4872
9	00:08:00	329.5	10.1	p8.9	N29°34.748	W094°55.83	57	3482	147.3	8.4	p18.6	N29°34.780	W094°55.92	60	5048
10	00:07:58	329.7	10.1	p13.5	N29°34.744	W094°55.83	57	3476	147.3	8.4	p15.4	N29°34.783	W094°55.93	59	4978



Polaris Instructor Station 1 - [Master of Run 10 in Houston216_650]

08:09:05 N29°34.837′ Display reference Free Brg 057.7° Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:09:05 W094°55.748′ Rng 0.177 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:04	324.7	10.3	s21.2	N29°34.897	W094°55.95	57	3424	142.7	9.0	p0.4	N29°34.656	W094°55.82	67	6400
8	00:09:02	324.5	10.3	s26.4	N29°34.893	W094°55.94	57	3425	142.5	9.0	s3.9	N29°34.659	W094°55.82	67	6373
9	00:09:00	324.4	10.3	s31.6	N29°34.888	W094°55.94	57	3425	142.3	8.9	s9.1	N29°34.663	W094°55.83	67	6423
10	00:08:58	324.2	10.3	s35.2	N29°34.883	W094°55.93	57	3426	142.2	8.9	s14.3	N29°34.667	W094°55.83	67	6376



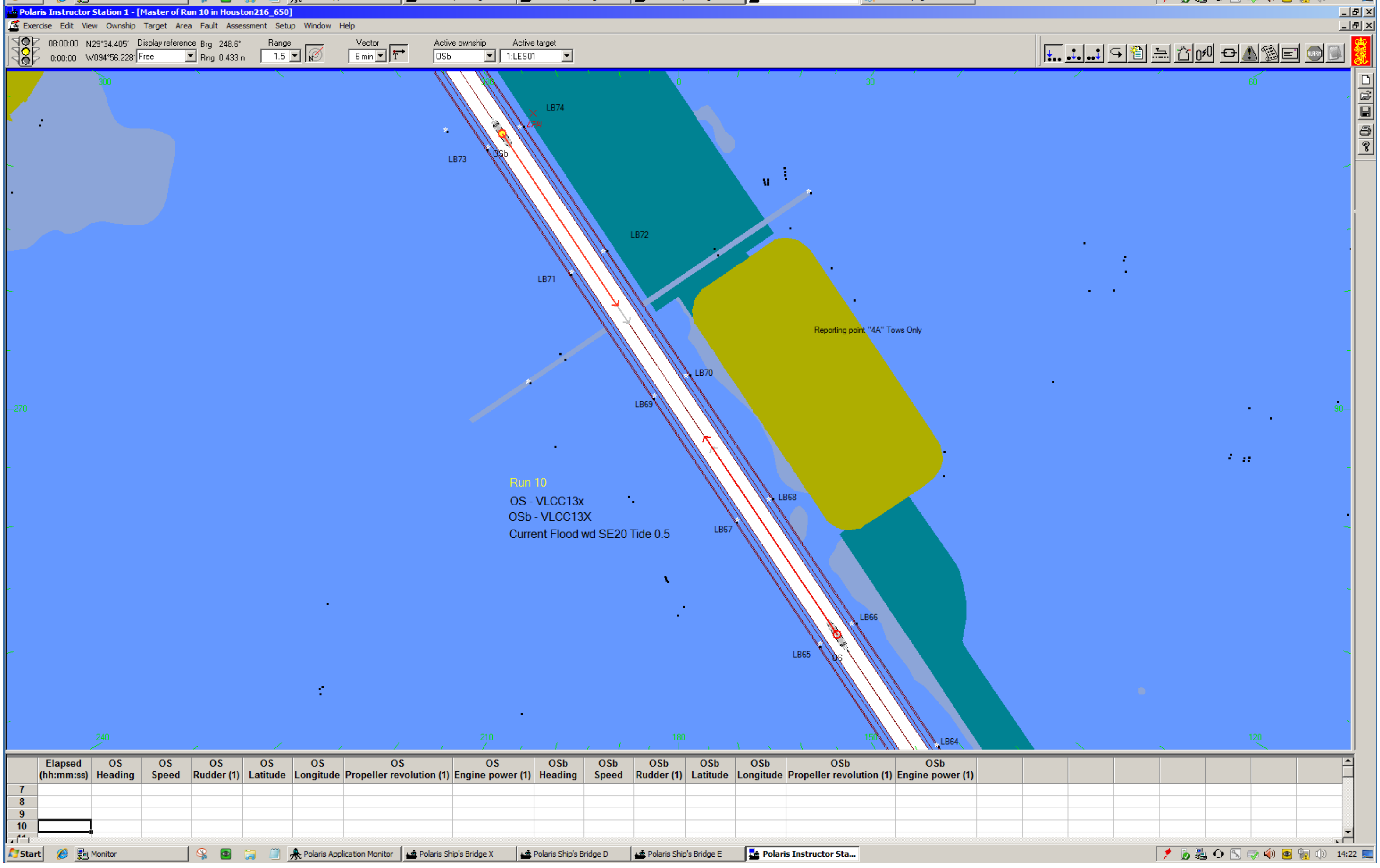
Polaris Instructor Station 1 - [Master of Run 10 in Houston216_650]

08:09:20 N29°34.865′ Display reference: Free Brg 073.8° Rng 0.441 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01

0:09:20 W094°55.433′

Run 10
OS - VLCC13x
OSb - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:18	326.3	10.3	p14.0	N29°34.930	W094°55.97	57	3419	143.8	9.0	s9.5	N29°34.628	W094°55.80	67	6320
8	00:09:16	326.1	10.3	p9.4	N29°34.926	W094°55.97	57	3419	143.7	9.0	s4.3	N29°34.632	W094°55.80	67	6290
9	00:09:14	325.9	10.3	p4.2	N29°34.921	W094°55.96	57	3420	143.5	9.0	p0.5	N29°34.636	W094°55.80	67	6397
10	00:09:12	325.7	10.3	s1.0	N29°34.916	W094°55.96	57	3420	143.4	9.0	p0.6	N29°34.639	W094°55.81	67	6258



Polaris Instructor Station 1 - [Master of Run 10 in Houston216_650]

08:00:00 N29°34.405′ Display reference: Free Brg 248.6° Rng 0.433 n Range 1.5 Vector 6 min Active ownship OSb Active target 1:LES01

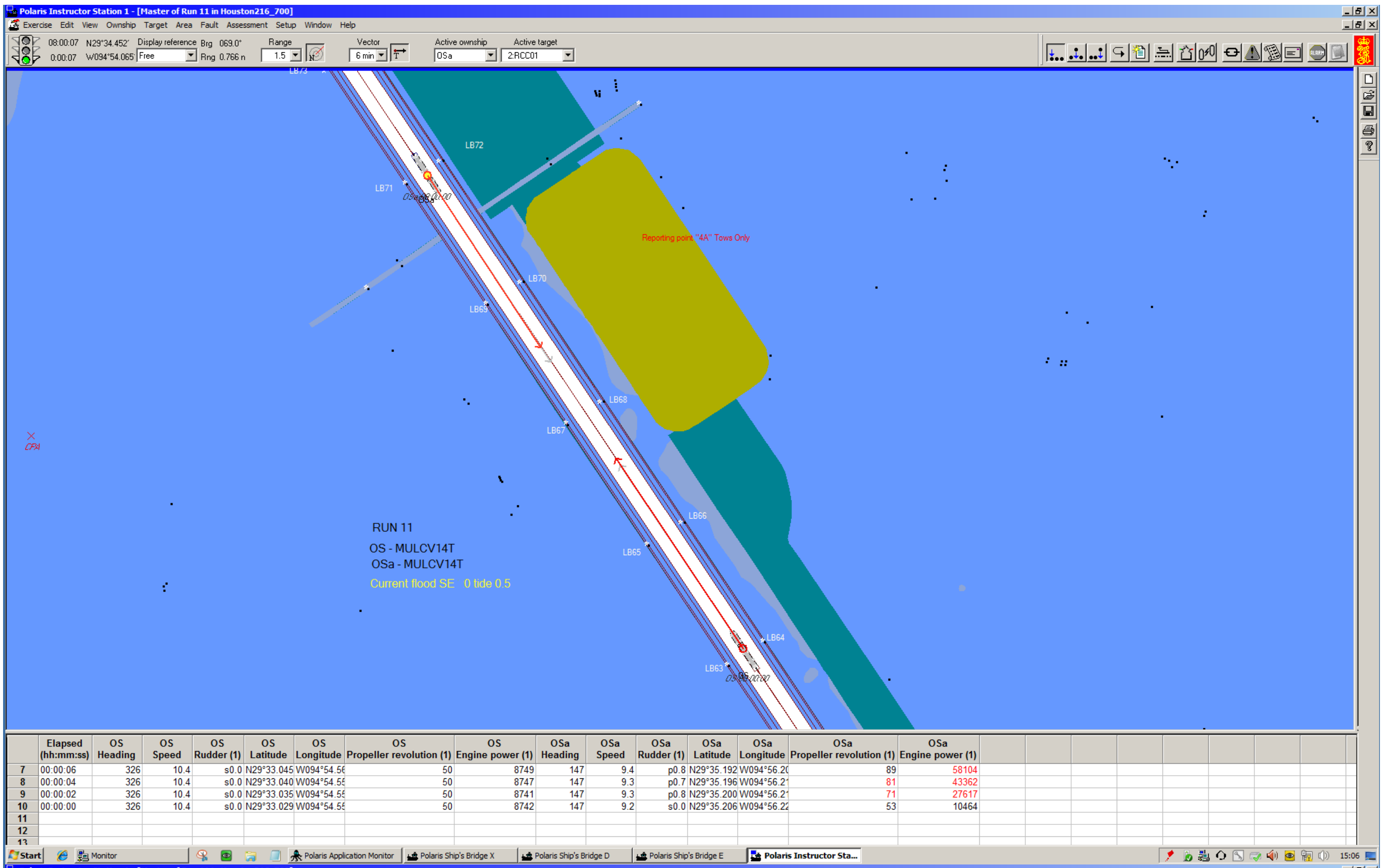
0:00:00 W094°56.228′

Run 10
OS - VLCC13x
OSb - VLCC13X
Current Flood wd SE20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7															
8															
9															
10															

June 26, 2019

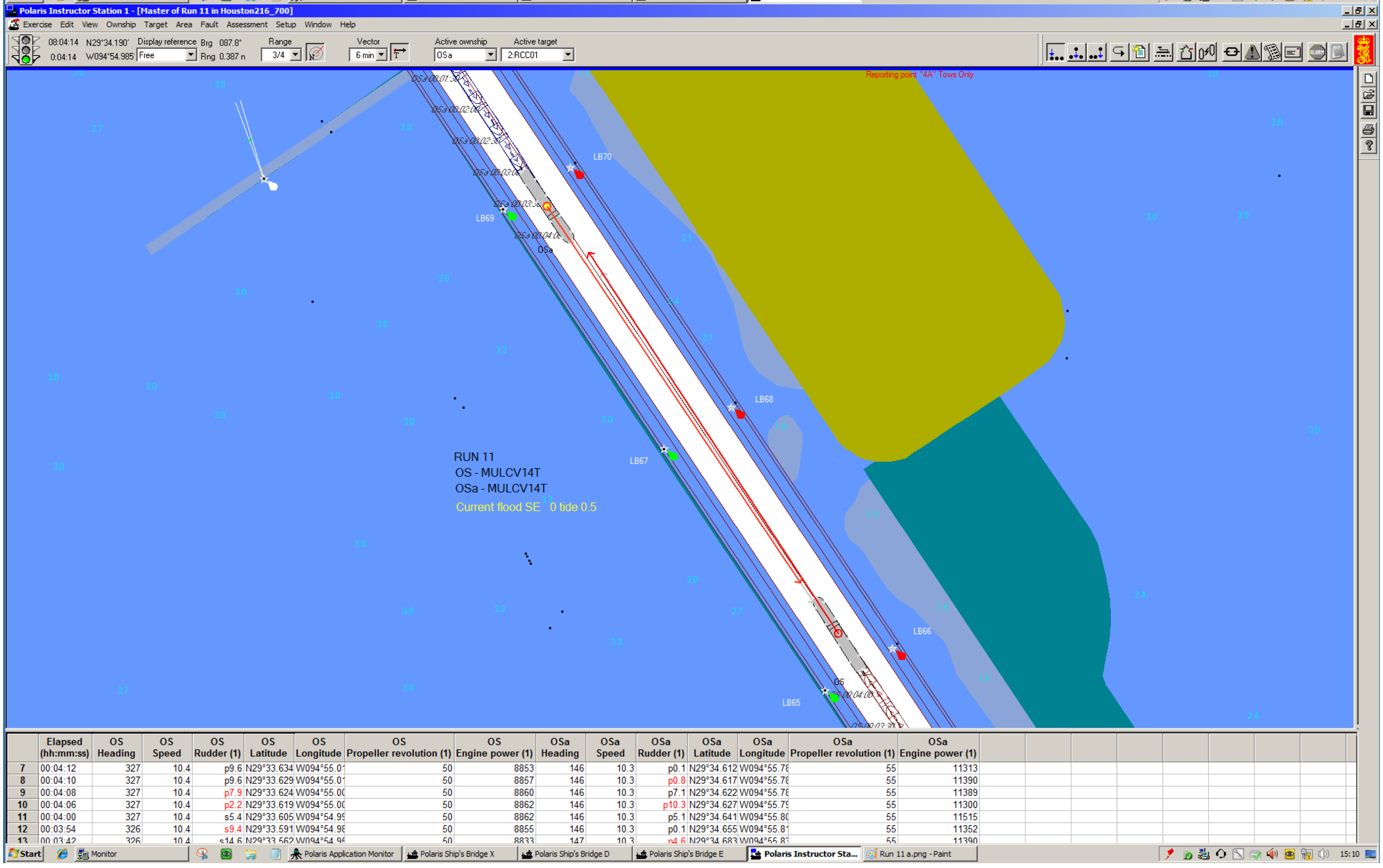
Run 11



RUN 11
OS - MULCV14T
OSa - MULCV14T
Current flood SE 0 tide 0.5

08:00:07 N29°34.452' Display reference Free Brg 069.0°
0:00:07 W094°54.065 Rng 0.766 n
Range 1.5
Vector 6 min
Active ownship OSa
Active target 2:RCC01

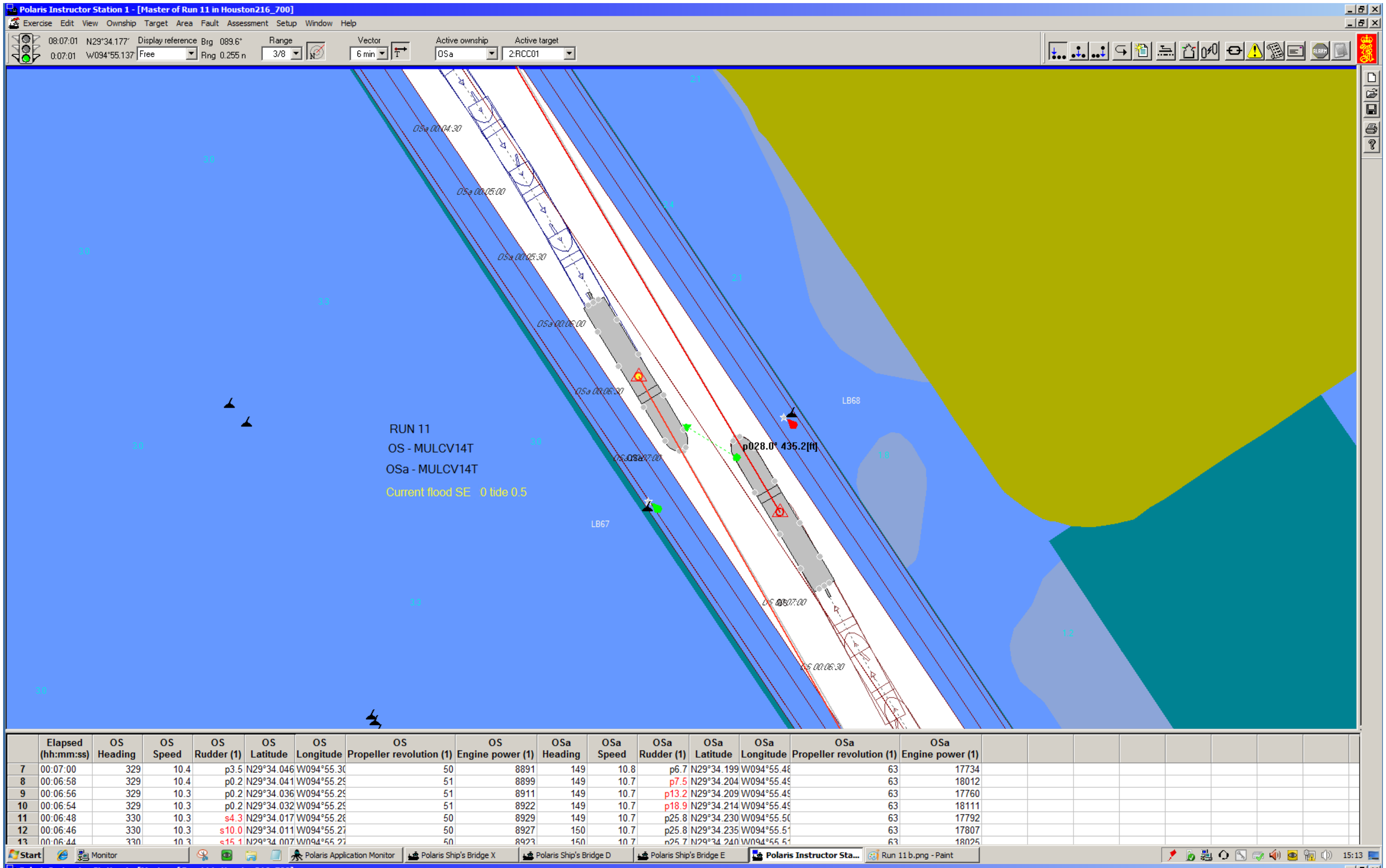
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:00:06	326	10.4	s0.0	N29°33.045	W094°54.56	50	8749	147	9.4	p0.8	N29°35.192	W094°56.20	89	58104
8	00:00:04	326	10.4	s0.0	N29°33.040	W094°54.55	50	8747	147	9.3	p0.7	N29°35.196	W094°56.21	81	43362
9	00:00:02	326	10.4	s0.0	N29°33.035	W094°54.55	50	8741	147	9.3	p0.8	N29°35.200	W094°56.21	71	27617
10	00:00:00	326	10.4	s0.0	N29°33.029	W094°54.55	50	8742	147	9.2	s0.0	N29°35.206	W094°56.22	53	10464
11															
12															
13															



RUN 11
OS - MULCV14T
OSa - MULCV14T
Current flood SE 0 tide 0.5

08:04:14 N29°34.190' Display reference Free Brg 087.8°
0:04:14 W094°54.985 Rng 0.387 n
Range 3/4
Vector 6 min
Active ownship OSa
Active target 2:RCC01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:12	327	10.4	p9.6	N29°33.634	W094°55.01	50	8853	146	10.3	p0.1	N29°34.612	W094°55.78	55	11313
8	00:04:10	327	10.4	p9.6	N29°33.629	W094°55.01	50	8857	146	10.3	p0.8	N29°34.617	W094°55.78	55	11390
9	00:04:08	327	10.4	p7.9	N29°33.624	W094°55.00	50	8860	146	10.3	p7.1	N29°34.622	W094°55.78	55	11389
10	00:04:06	327	10.4	p2.2	N29°33.619	W094°55.00	50	8862	146	10.3	p10.3	N29°34.627	W094°55.79	55	11300
11	00:04:00	327	10.4	s5.4	N29°33.605	W094°54.99	50	8862	146	10.3	p5.1	N29°34.641	W094°55.80	55	11515
12	00:03:54	326	10.4	s9.4	N29°33.591	W094°54.98	50	8855	146	10.3	p0.1	N29°34.655	W094°55.81	55	11352
13	00:03:42	326	10.4	s14.6	N29°33.562	W094°54.96	50	8833	147	10.3	p4.6	N29°34.683	W094°55.83	55	11390

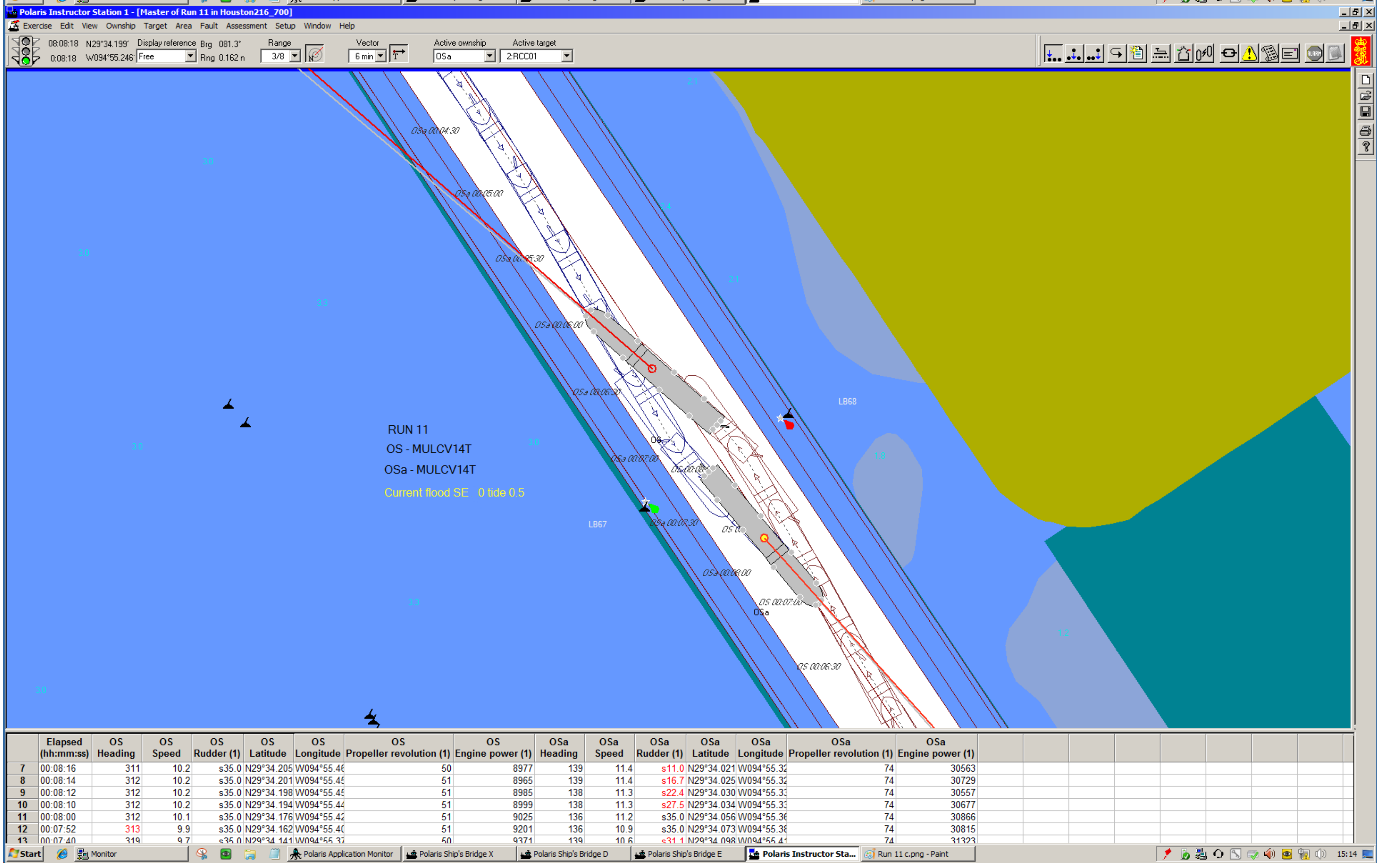


Polaris Instructor Station 1 - [Master of Run 11 in Houston216_700]

08:07:01 N29°34.177′ W094°55.137′ 0:07:01
Display reference: Free
Brg 089.6°
Rng 0.255 n
Range: 3/8
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

RUN 11
OS - MULCV14T
OSa - MULCV14T
Current flood SE 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:00	329	10.4	p3.5	N29°34.046	W094°55.30	50	8891	149	10.8	p6.7	N29°34.199	W094°55.48	63	17734
8	00:06:58	329	10.4	p0.2	N29°34.041	W094°55.29	51	8899	149	10.7	p7.5	N29°34.204	W094°55.49	63	18012
9	00:06:56	329	10.3	p0.2	N29°34.036	W094°55.29	51	8911	149	10.7	p13.2	N29°34.209	W094°55.49	63	17760
10	00:06:54	329	10.3	p0.2	N29°34.032	W094°55.29	51	8922	149	10.7	p18.9	N29°34.214	W094°55.49	63	18111
11	00:06:48	330	10.3	s4.3	N29°34.017	W094°55.28	50	8929	149	10.7	p25.8	N29°34.230	W094°55.50	63	17792
12	00:06:46	330	10.3	s10.0	N29°34.011	W094°55.27	50	8927	150	10.7	p25.8	N29°34.235	W094°55.51	63	17807
13	00:06:44	330	10.3	s15.1	N29°34.007	W094°55.27	50	8923	150	10.7	p25.7	N29°34.240	W094°55.51	63	18025



Polaris Instructor Station 1 - [Master of Run 11 in Houston216_700]

08:08:18 N29°34.199′ W094°55.246′ 0:08:18
Display reference: Free
Brg 081.3°
Rng 0.162 n
Range: 3/8
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

RUN 11
OS - MULCV14T
OSa - MULCV14T
Current flood SE 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:16	311	10.2	s35.0	N29°34.205	W094°55.46	50	8977	139	11.4	s11.0	N29°34.021	W094°55.32	74	30563
8	00:08:14	312	10.2	s35.0	N29°34.201	W094°55.45	51	8965	139	11.4	s16.7	N29°34.025	W094°55.32	74	30729
9	00:08:12	312	10.2	s35.0	N29°34.198	W094°55.45	51	8985	138	11.3	s22.4	N29°34.030	W094°55.33	74	30557
10	00:08:10	312	10.2	s35.0	N29°34.194	W094°55.44	51	8999	138	11.3	s27.5	N29°34.034	W094°55.33	74	30677
11	00:08:00	312	10.1	s35.0	N29°34.176	W094°55.42	51	9025	136	11.2	s35.0	N29°34.056	W094°55.36	74	30866
12	00:07:52	313	9.9	s35.0	N29°34.162	W094°55.40	51	9201	136	10.9	s35.0	N29°34.073	W094°55.38	74	30815
13	00:07:40	319	9.7	s35.0	N29°34.141	W094°55.37	50	9371	139	10.6	s31.1	N29°34.098	W094°55.41	74	31323

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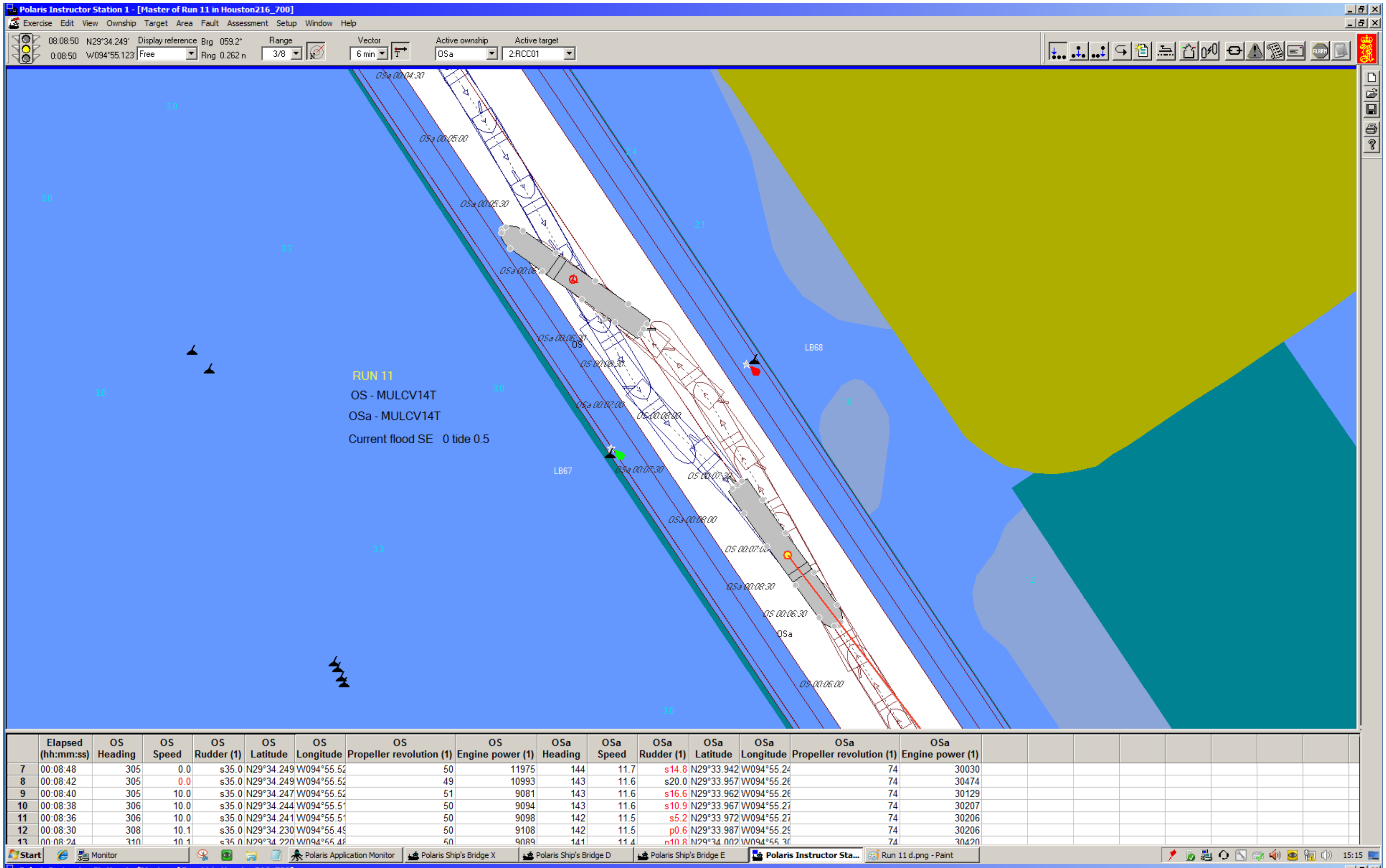
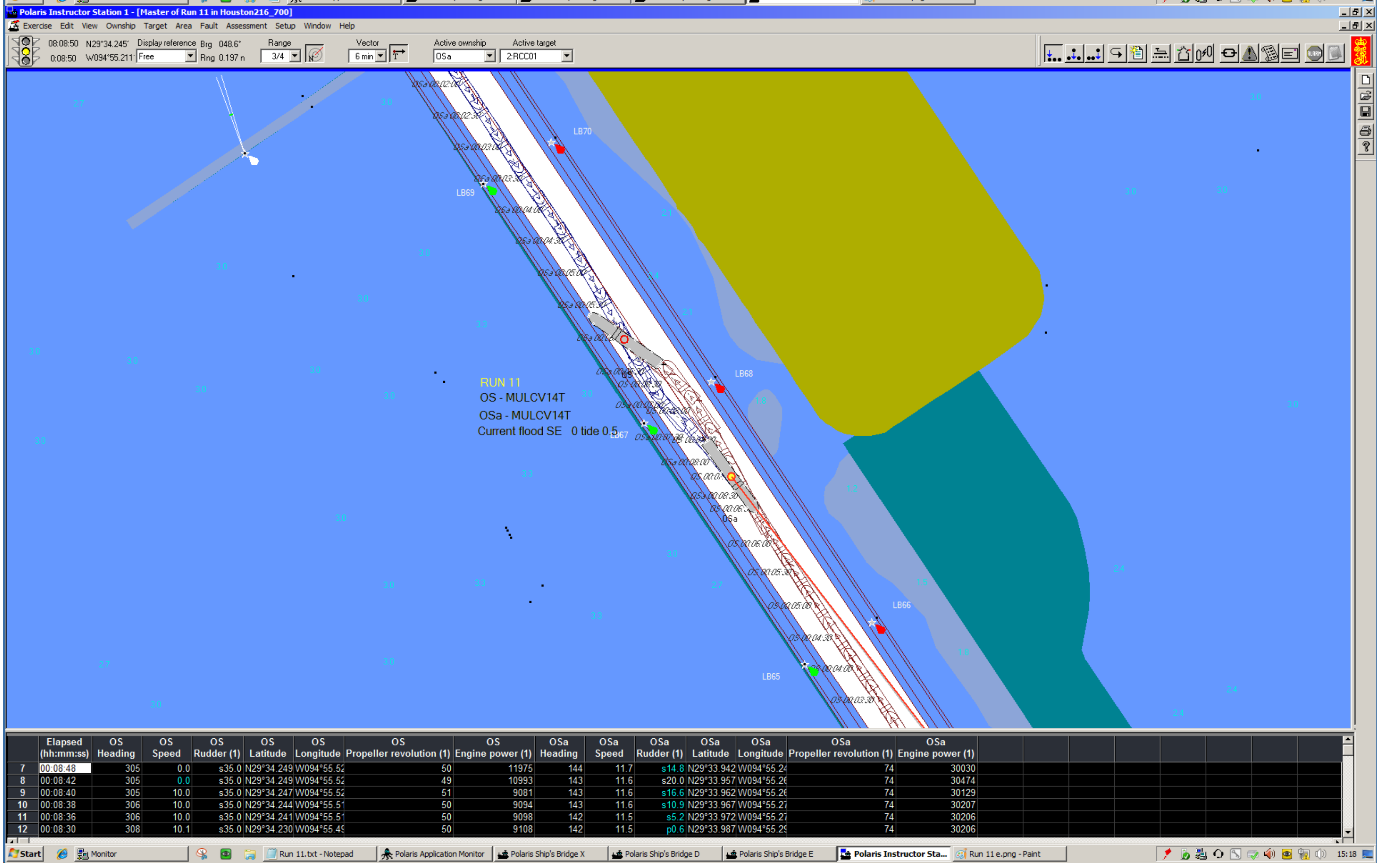


Polaris Instructor Station 1 - [Master of Run 11 in Houston216_700]

08:08:50 N29°34.249′ 0:08:50 W094°55.123′ Display reference Free Brg 059.2° Rng 0.262 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:48	305	0.0	s35.0	N29°34.249	W094°55.52	50	11975	144	11.7	s14.8	N29°33.942	W094°55.24	74	30030
8	00:08:42	305	0.0	s35.0	N29°34.249	W094°55.52	49	10993	143	11.6	s20.0	N29°33.957	W094°55.26	74	30474
9	00:08:40	305	10.0	s35.0	N29°34.247	W094°55.52	51	9081	143	11.6	s16.6	N29°33.962	W094°55.26	74	30129
10	00:08:38	306	10.0	s35.0	N29°34.244	W094°55.51	50	9094	143	11.6	s10.9	N29°33.967	W094°55.27	74	30207
11	00:08:36	306	10.0	s35.0	N29°34.241	W094°55.51	50	9098	142	11.5	s5.2	N29°33.972	W094°55.27	74	30206
12	00:08:30	308	10.1	s35.0	N29°34.230	W094°55.49	50	9108	142	11.5	p0.6	N29°33.987	W094°55.29	74	30206
13	00:08:24	310	10.1	s35.0	N29°34.220	W094°55.4	50	9089	141	11.4	p10.8	N29°34.002	W094°55.30	74	30420



Polaris Instructor Station 1 - [Master of Run 11 in Houston216_700]

08:08:50 N29°34.245′ 0:08:50 W094°55.211′ Display reference Free Brg 048.6° Rng 0.197 n Range 3/4 Vector 6 min Active ownship OSa Active target 2:RCC01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:48	305	0.0	s35.0	N29°34.249	W094°55.52	50	11975	144	11.7	s14.8	N29°33.942	W094°55.24	74	30030
8	00:08:42	305	0.0	s35.0	N29°34.249	W094°55.52	49	10993	143	11.6	s20.0	N29°33.957	W094°55.26	74	30474
9	00:08:40	305	10.0	s35.0	N29°34.247	W094°55.52	51	9081	143	11.6	s16.6	N29°33.962	W094°55.26	74	30129
10	00:08:38	306	10.0	s35.0	N29°34.244	W094°55.51	50	9094	143	11.6	s10.9	N29°33.967	W094°55.27	74	30207
11	00:08:36	306	10.0	s35.0	N29°34.241	W094°55.51	50	9098	142	11.5	s5.2	N29°33.972	W094°55.27	74	30206
12	00:08:30	308	10.1	s35.0	N29°34.230	W094°55.49	50	9108	142	11.5	p0.6	N29°33.987	W094°55.29	74	30206

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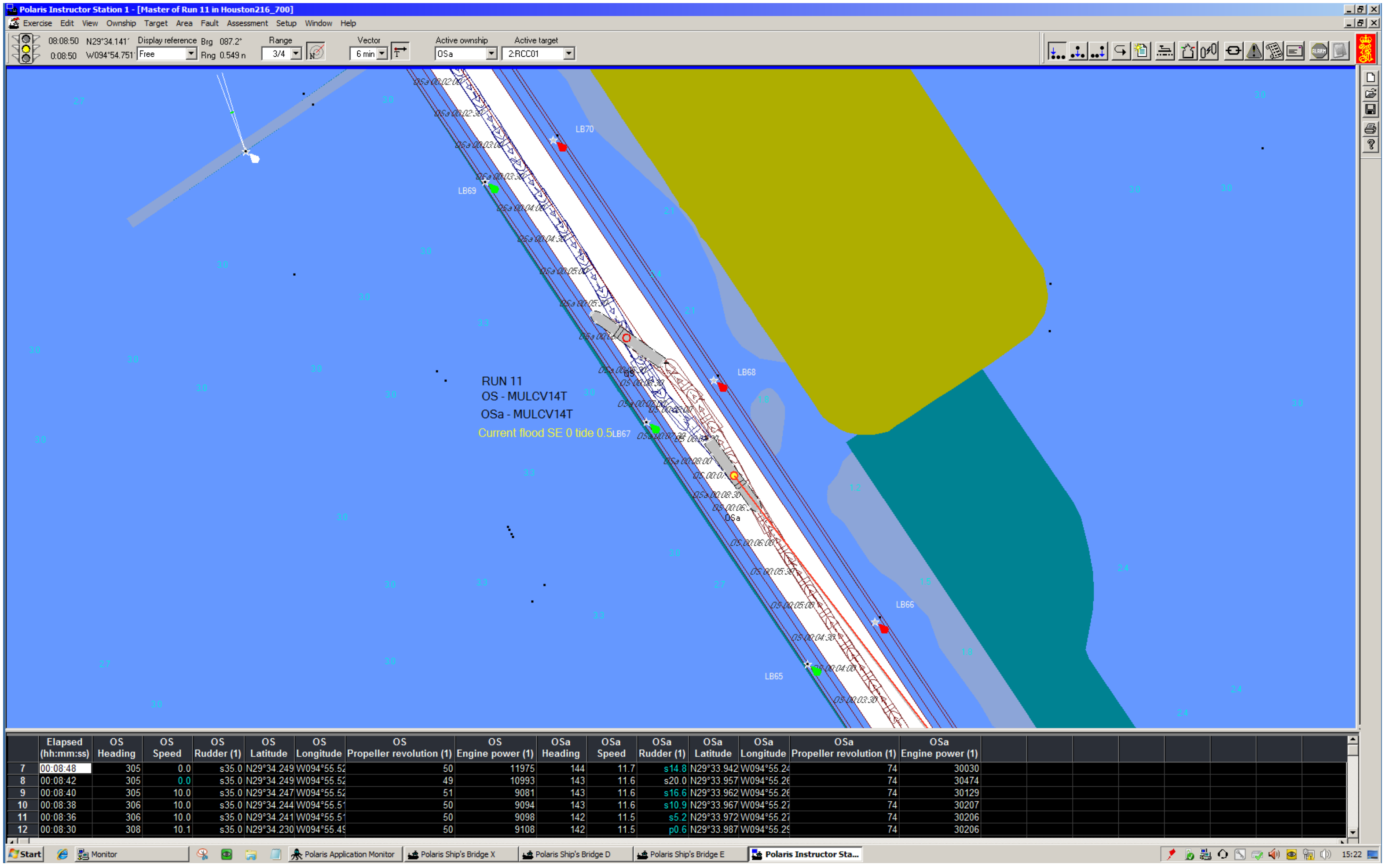


Polaris Instructor Station 1 - [Master of Run 11 in Houston216_700]

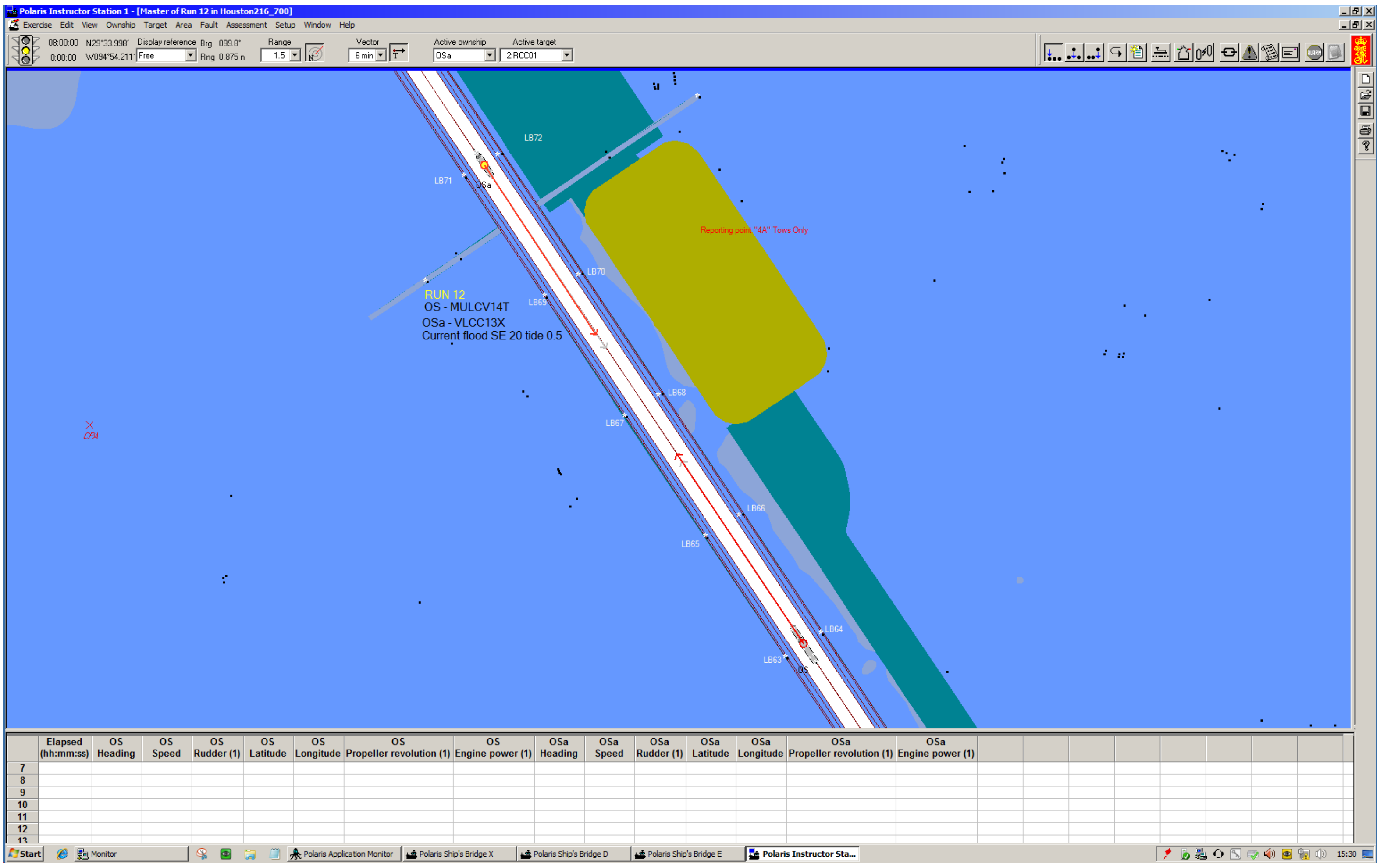
08:08:50 N29°34.141′
0:08:50 W094°54.751′
Display reference: Free
Brg 087.2°
Rng 0.549 n
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 2:RCC01

RUN 11
OS - MULCV14T
OSa - MULCV14T
Current flood SE 0 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:48	305	0.0	s35.0	N29°34.249	W094°55.52	50	11975	144	11.7	s14.8	N29°33.942	W094°55.24	74	30030
8	00:08:42	305	0.0	s35.0	N29°34.249	W094°55.52	49	10993	143	11.6	s20.0	N29°33.957	W094°55.26	74	30474
9	00:08:40	305	10.0	s35.0	N29°34.247	W094°55.52	51	9081	143	11.6	s16.6	N29°33.962	W094°55.26	74	30129
10	00:08:38	306	10.0	s35.0	N29°34.244	W094°55.51	50	9094	143	11.6	s10.9	N29°33.967	W094°55.27	74	30207
11	00:08:36	306	10.0	s35.0	N29°34.241	W094°55.51	50	9098	142	11.5	s5.2	N29°33.972	W094°55.27	74	30206
12	00:08:30	308	10.1	s35.0	N29°34.230	W094°55.49	50	9108	142	11.5	p0.6	N29°33.987	W094°55.29	74	30206

June 26, 2019

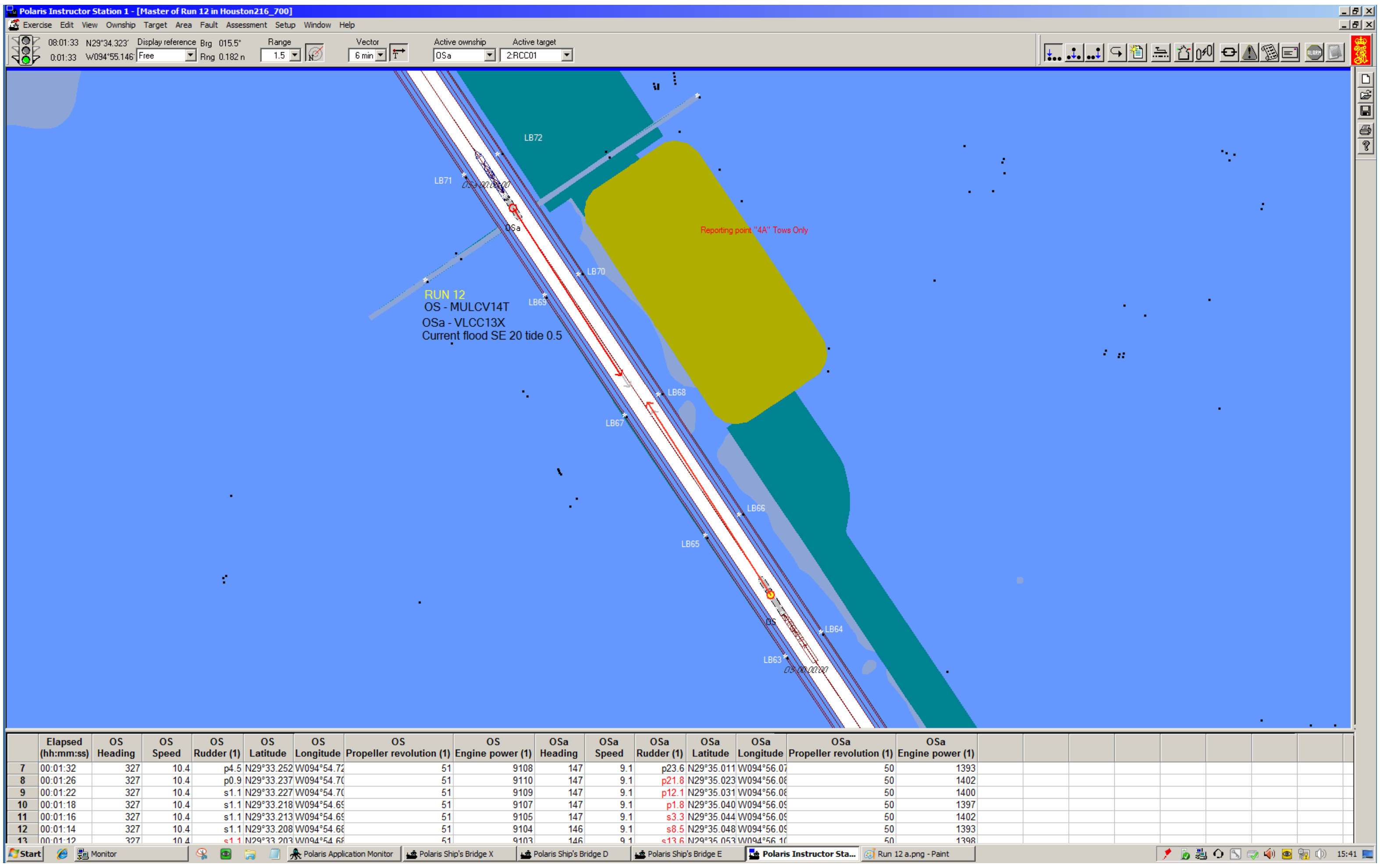
Run 12



RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

Reporting point "4A" Tows Only

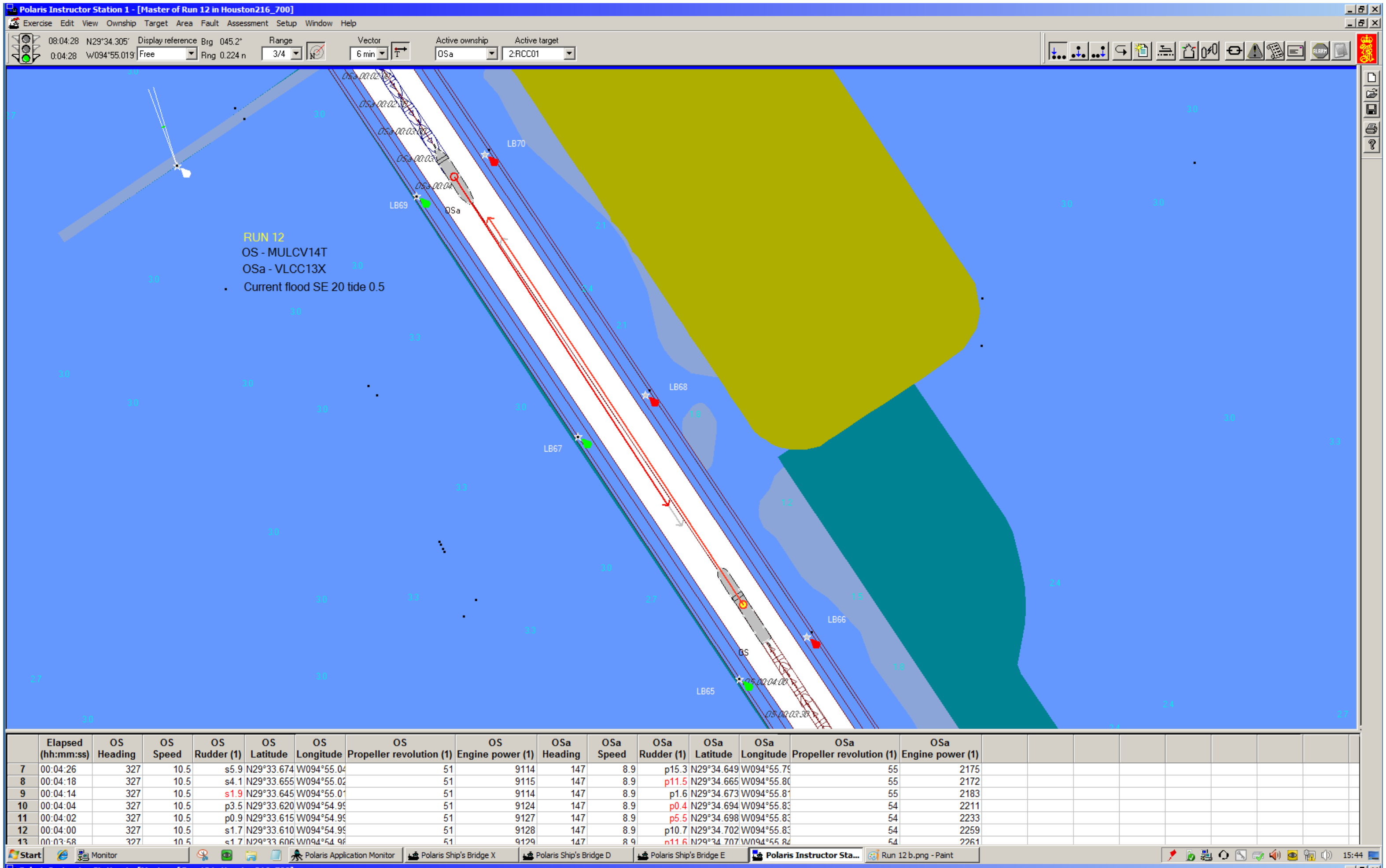
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
10															
11															
12															



RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

Reporting point "4A" Tows Only

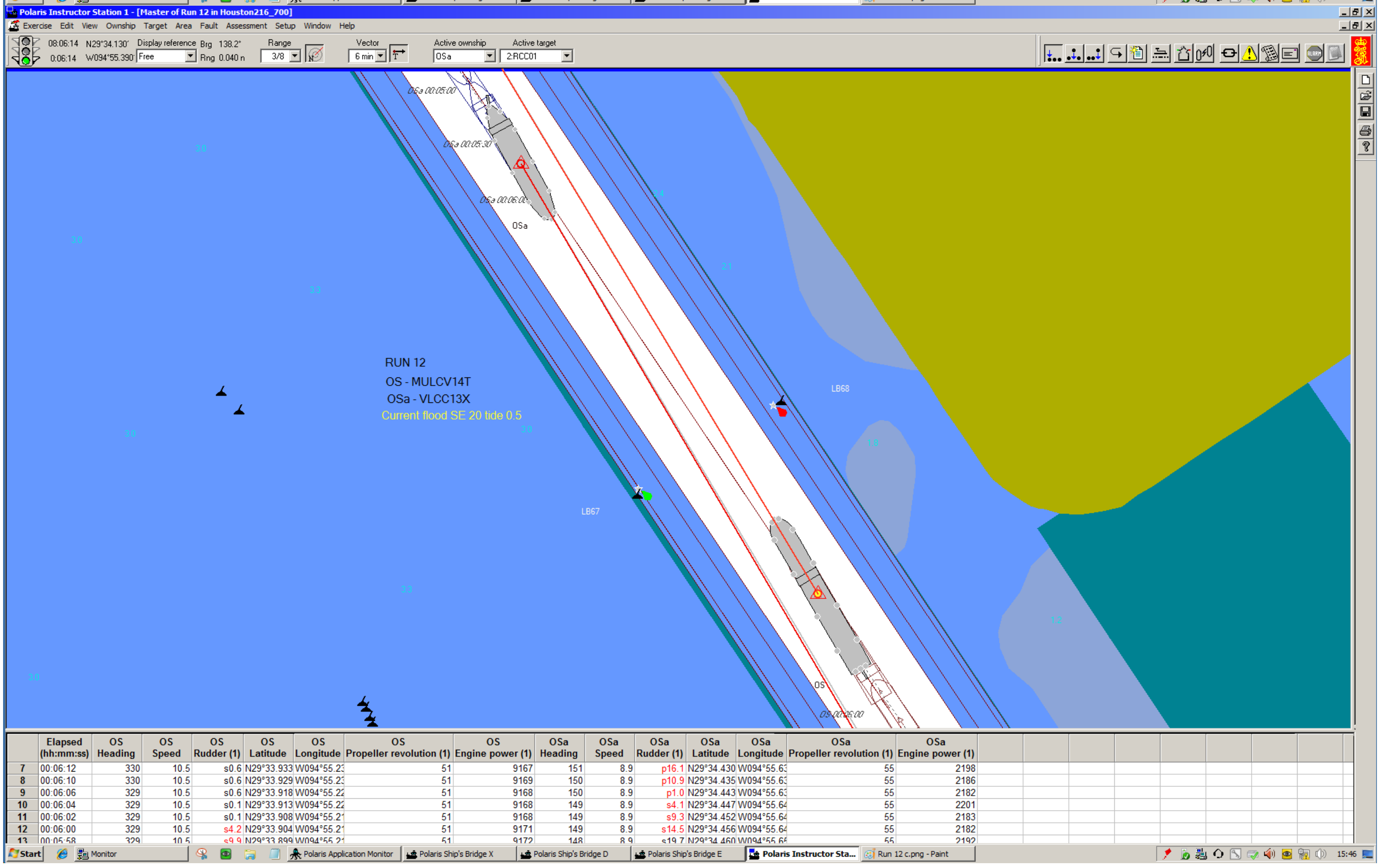
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:01:32	327	10.4	p4.5	N29°33.252	W094°54.72	51	9108	147	9.1	p23.6	N29°35.011	W094°56.07	50	1393
8	00:01:26	327	10.4	p0.9	N29°33.237	W094°54.70	51	9110	147	9.1	p21.8	N29°35.023	W094°56.08	50	1402
9	00:01:22	327	10.4	s1.1	N29°33.227	W094°54.70	51	9109	147	9.1	p12.1	N29°35.031	W094°56.08	50	1400
10	00:01:18	327	10.4	s1.1	N29°33.218	W094°54.69	51	9107	147	9.1	p1.8	N29°35.040	W094°56.09	50	1397
11	00:01:16	327	10.4	s1.1	N29°33.213	W094°54.69	51	9105	147	9.1	s3.3	N29°35.044	W094°56.09	50	1402
12	00:01:14	327	10.4	s1.1	N29°33.208	W094°54.68	51	9104	146	9.1	s8.5	N29°35.048	W094°56.09	50	1393
13	00:01:12	327	10.4	s1.1	N29°33.203	W094°54.68	51	9103	146	9.1	s13.6	N29°35.053	W094°56.10	50	1398



08:04:28 N29°34.305′ Display reference: Free Brg 045.2° Rng 0.224 n Range 3/4 Vector 6 min Active ownship OSa Active target 2:RCC01
0:04:28 W094°55.019′

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

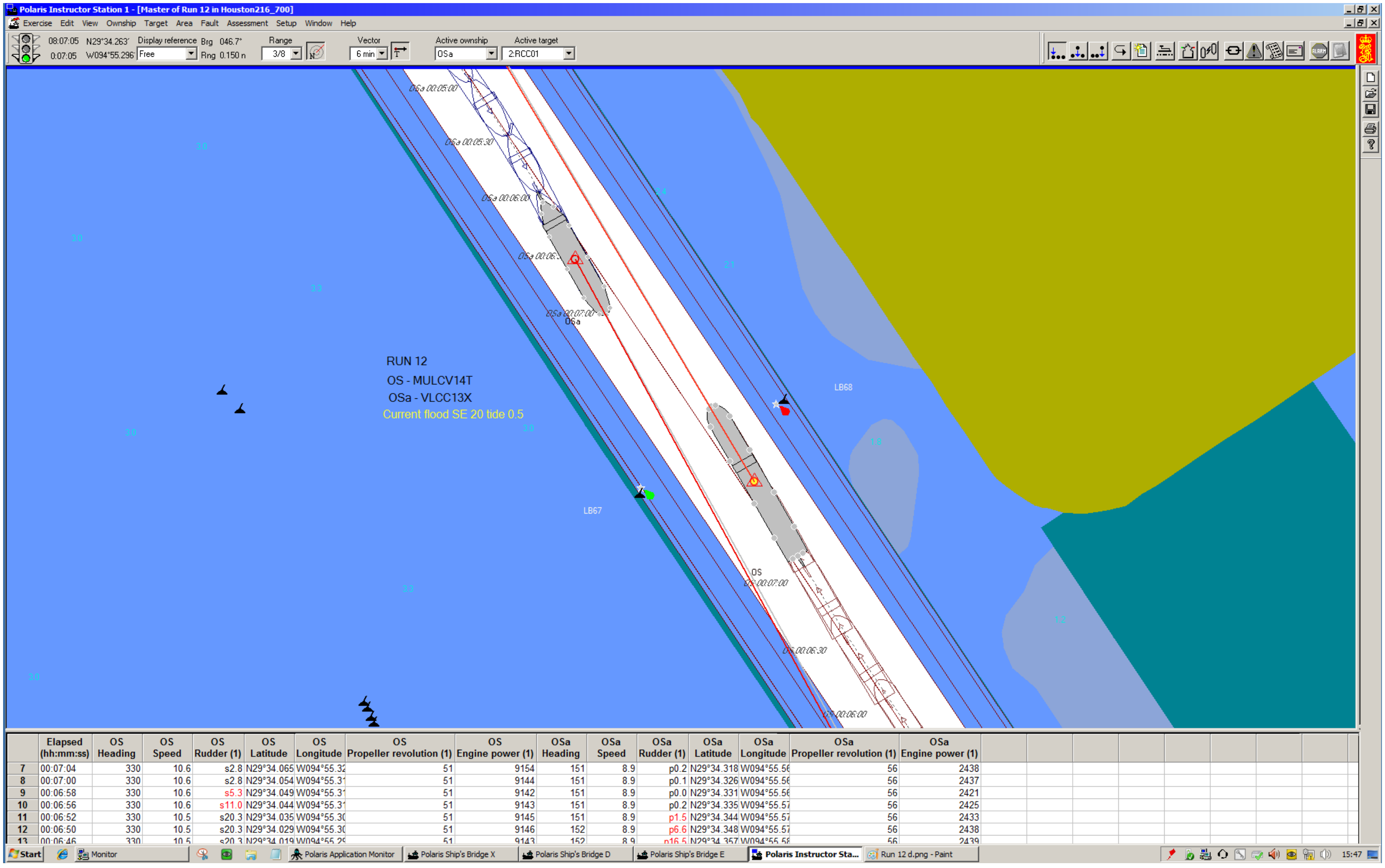
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:26	327	10.5	s5.9	N29°33.674	W094°55.04	51	9114	147	8.9	p15.3	N29°34.649	W094°55.79	55	2175
8	00:04:18	327	10.5	s4.1	N29°33.655	W094°55.02	51	9115	147	8.9	p11.5	N29°34.665	W094°55.80	55	2172
9	00:04:14	327	10.5	s1.9	N29°33.645	W094°55.01	51	9114	147	8.9	p1.6	N29°34.673	W094°55.81	55	2183
10	00:04:04	327	10.5	p3.5	N29°33.620	W094°54.99	51	9124	147	8.9	p0.4	N29°34.694	W094°55.83	54	2211
11	00:04:02	327	10.5	p0.9	N29°33.615	W094°54.99	51	9127	147	8.9	p5.5	N29°34.698	W094°55.83	54	2233
12	00:04:00	327	10.5	s1.7	N29°33.610	W094°54.99	51	9128	147	8.9	p10.7	N29°34.702	W094°55.83	54	2259
13	00:03:58	327	10.5	s1.7	N29°33.606	W094°54.98	51	9129	147	8.9	p11.6	N29°34.707	W094°55.84	54	2261



08:06:14 N29°34.130′ Display reference: Free Brg 138.2° Rng 0.040 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01
0:06:14 W094°55.390′

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:12	330	10.5	s0.6	N29°33.933	W094°55.23	51	9167	151	8.9	p16.1	N29°34.430	W094°55.63	55	2198
8	00:06:10	330	10.5	s0.6	N29°33.929	W094°55.23	51	9169	150	8.9	p10.9	N29°34.435	W094°55.63	55	2186
9	00:06:06	329	10.5	s0.6	N29°33.918	W094°55.22	51	9168	150	8.9	p1.0	N29°34.443	W094°55.63	55	2182
10	00:06:04	329	10.5	s0.1	N29°33.913	W094°55.22	51	9168	149	8.9	s4.1	N29°34.447	W094°55.64	55	2201
11	00:06:02	329	10.5	s0.1	N29°33.908	W094°55.21	51	9168	149	8.9	s9.3	N29°34.452	W094°55.64	55	2183
12	00:06:00	329	10.5	s4.2	N29°33.904	W094°55.21	51	9171	149	8.9	s14.5	N29°34.456	W094°55.64	55	2182
13	00:05:58	329	10.5	s9.9	N29°33.899	W094°55.21	51	9172	148	8.9	s19.7	N29°34.460	W094°55.65	55	2192



Polaris Instructor Station 1 - [Master of Run 12 in Houston216_700]

08:07:05 N29°34.263′ 0:07:05 W094°55.296′

Display reference: Free

Brg 046.7° Rng 0.150 n

Range: 3/8

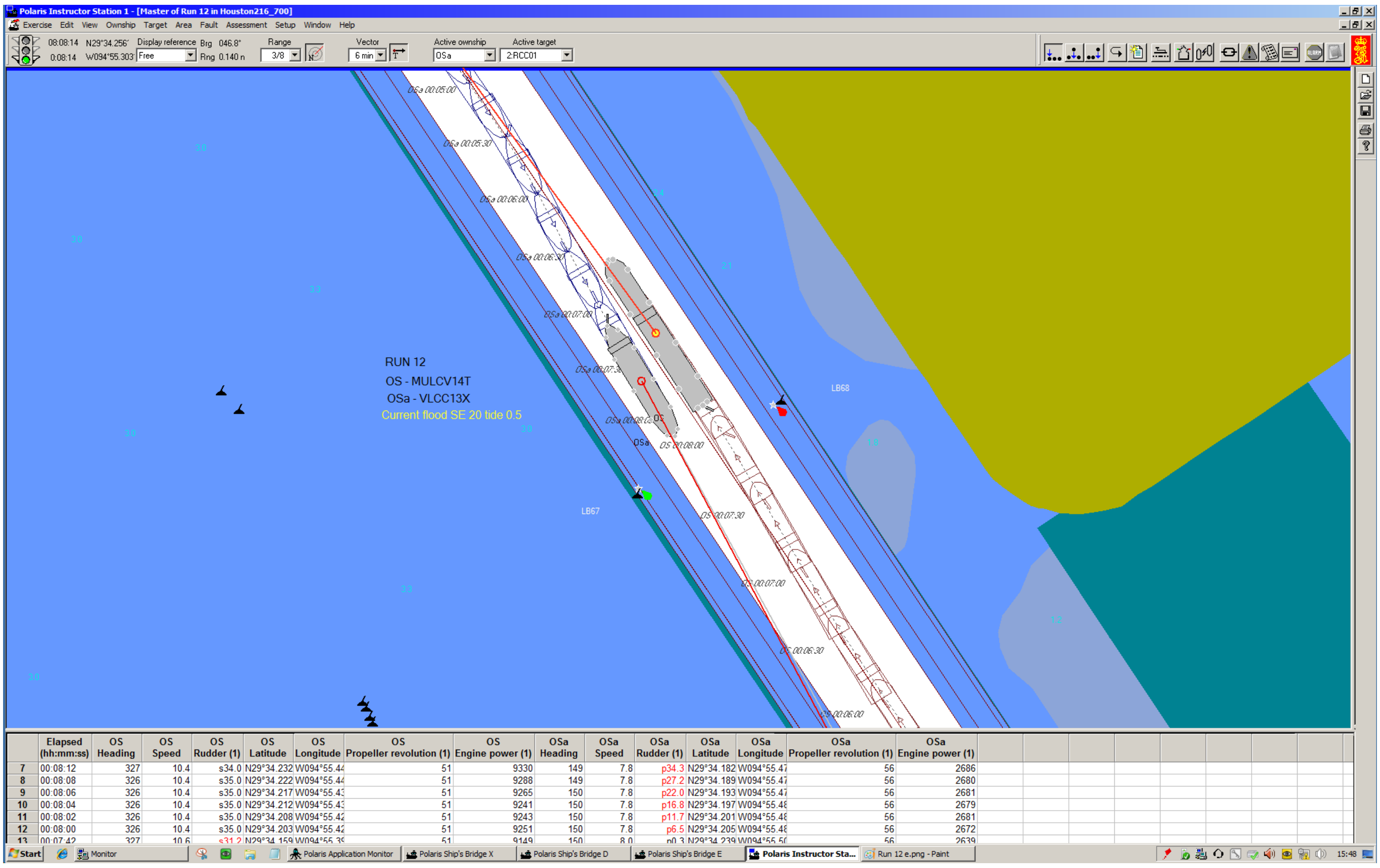
Vector: 6 min

Active ownship: OSa

Active target: 2:RCC01

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:04	330	10.6	s2.8	N29°34.065	W094°55.32	51	9154	151	8.9	p0.2	N29°34.318	W094°55.56	56	2438
8	00:07:00	330	10.6	s2.8	N29°34.054	W094°55.31	51	9144	151	8.9	p0.1	N29°34.326	W094°55.56	56	2437
9	00:06:58	330	10.6	s5.3	N29°34.049	W094°55.31	51	9142	151	8.9	p0.0	N29°34.331	W094°55.56	56	2421
10	00:06:56	330	10.6	s11.0	N29°34.044	W094°55.31	51	9143	151	8.9	p0.2	N29°34.335	W094°55.57	56	2425
11	00:06:52	330	10.5	s20.3	N29°34.035	W094°55.30	51	9145	151	8.9	p1.5	N29°34.344	W094°55.57	56	2433
12	00:06:50	330	10.5	s20.3	N29°34.029	W094°55.30	51	9146	152	8.9	p6.6	N29°34.348	W094°55.57	56	2438
13	00:06:46	330	10.5	s20.3	N29°34.019	W094°55.29	51	9143	152	8.9	p16.5	N29°34.357	W094°55.58	56	2439



Polaris Instructor Station 1 - [Master of Run 12 in Houston216_700]

08:08:14 N29°34.256′ 0:08:14 W094°55.303′

Display reference: Free

Brg 046.8° Rng 0.140 n

Range: 3/8

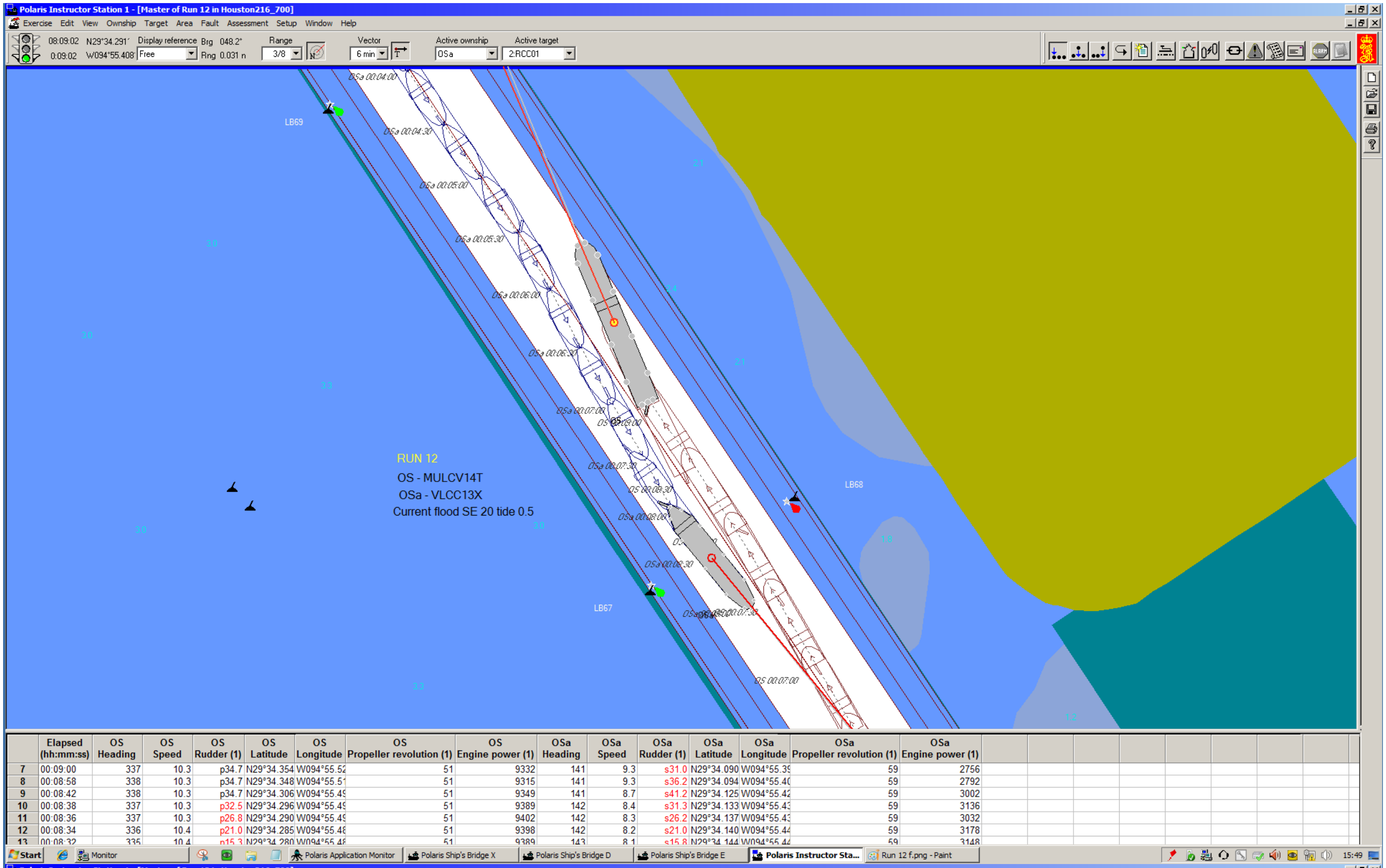
Vector: 6 min

Active ownship: OSa

Active target: 2:RCC01

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

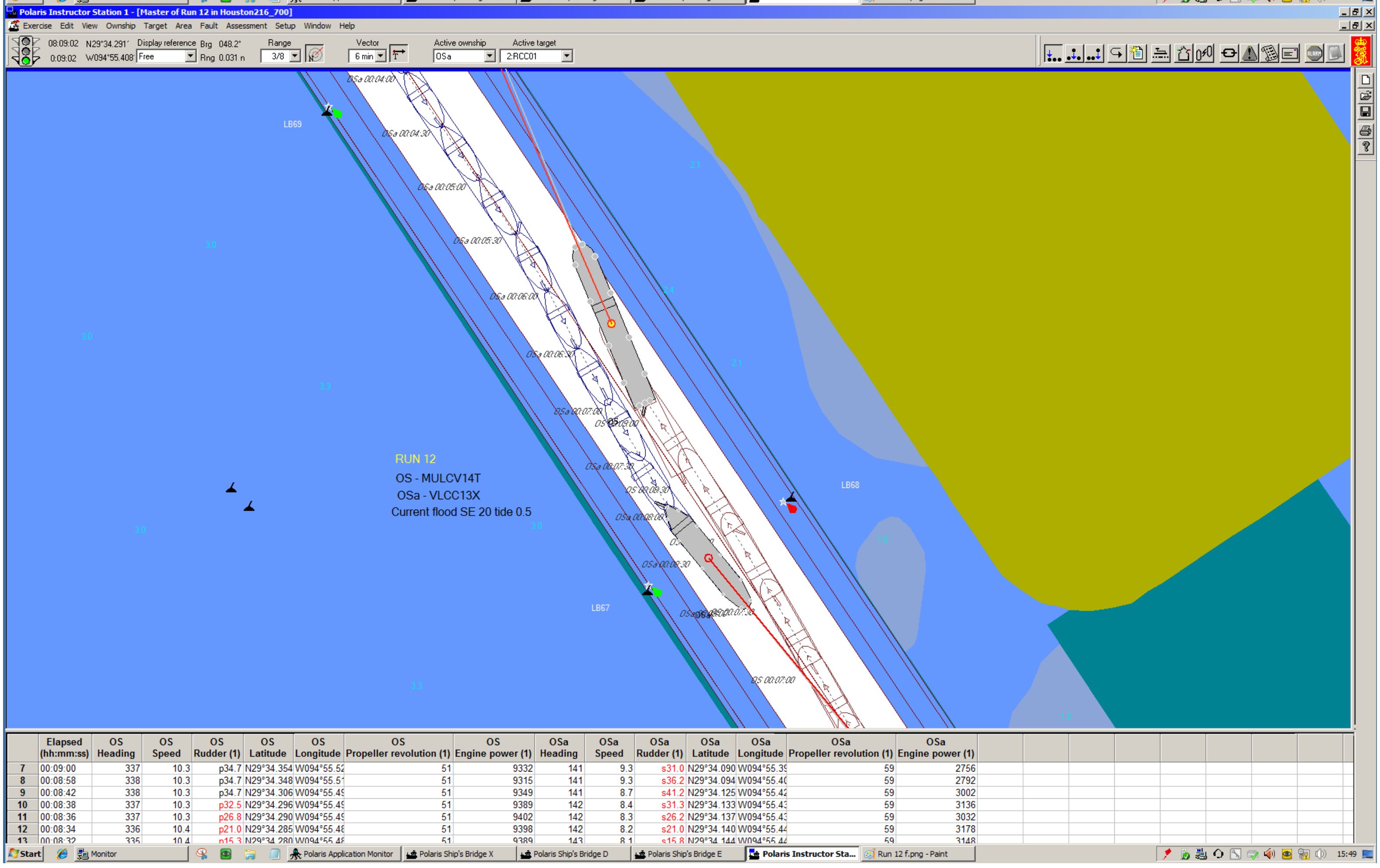
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:12	327	10.4	s34.0	N29°34.232	W094°55.44	51	9330	149	7.8	p34.3	N29°34.182	W094°55.47	56	2686
8	00:08:08	326	10.4	s35.0	N29°34.222	W094°55.44	51	9288	149	7.8	p27.2	N29°34.189	W094°55.47	56	2680
9	00:08:06	326	10.4	s35.0	N29°34.217	W094°55.43	51	9265	150	7.8	p22.0	N29°34.193	W094°55.47	56	2681
10	00:08:04	326	10.4	s35.0	N29°34.212	W094°55.43	51	9241	150	7.8	p16.8	N29°34.197	W094°55.48	56	2679
11	00:08:02	326	10.4	s35.0	N29°34.208	W094°55.42	51	9243	150	7.8	p11.7	N29°34.201	W094°55.48	56	2681
12	00:08:00	326	10.4	s35.0	N29°34.203	W094°55.42	51	9251	150	7.8	p6.5	N29°34.205	W094°55.48	56	2672
13	00:07:42	327	10.6	s31.2	N29°34.159	W094°55.39	51	9149	150	8.0	p0.3	N29°34.239	W094°55.50	56	2639



08:09:02 N29°34.291′ 0:09:02 W094°55.408′ Display reference: Free Brg 048.2° Rng 0.031 n Range: 3/8 Vector: 6 min Active ownship: OSa Active target: 2:RCC01

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

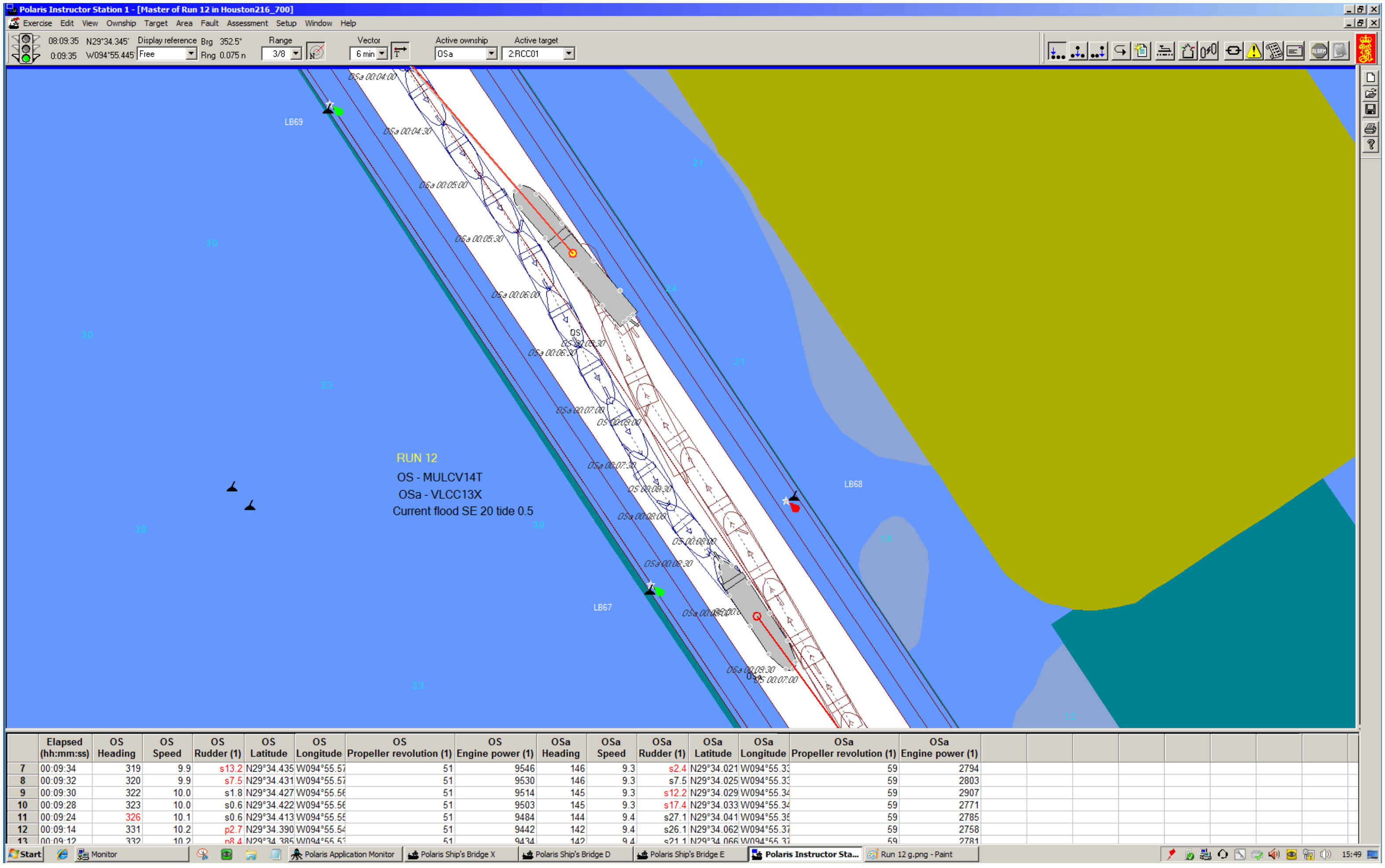
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:00	337	10.3	p34.7	N29°34.354	W094°55.52	51	9332	141	9.3	s31.0	N29°34.090	W094°55.39	59	2756
8	00:08:58	338	10.3	p34.7	N29°34.348	W094°55.51	51	9315	141	9.3	s36.2	N29°34.094	W094°55.40	59	2792
9	00:08:42	338	10.3	p34.7	N29°34.306	W094°55.49	51	9349	141	8.7	s41.2	N29°34.125	W094°55.42	59	3002
10	00:08:38	337	10.3	p32.5	N29°34.296	W094°55.49	51	9389	142	8.4	s31.3	N29°34.133	W094°55.43	59	3136
11	00:08:36	337	10.3	p26.8	N29°34.290	W094°55.49	51	9402	142	8.3	s26.2	N29°34.137	W094°55.43	59	3032
12	00:08:34	336	10.4	p21.0	N29°34.285	W094°55.48	51	9398	142	8.2	s21.0	N29°34.140	W094°55.44	59	3178
13	00:08:32	335	10.4	p15.3	N29°34.280	W094°55.48	51	9389	143	8.1	s15.8	N29°34.144	W094°55.44	59	3148


Polaris Instructor Station 1 - [Master of Run 12 in Houston216_700]

08:09:02 N29°34.291′ 0:09:02 W094°55.408′ Display reference: Free Brg 048.2° Rng 0.031 n Range: 3/8 Vector: 6 min Active ownship: OSa Active target: 2:RCC01

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:00	337	10.3	p34.7	N29°34.354	W094°55.52	51	9332	141	9.3	s31.0	N29°34.090	W094°55.39	59	2756
8	00:08:58	338	10.3	p34.7	N29°34.348	W094°55.51	51	9315	141	9.3	s36.2	N29°34.094	W094°55.40	59	2792
9	00:08:42	338	10.3	p34.7	N29°34.306	W094°55.49	51	9349	141	8.7	s41.2	N29°34.125	W094°55.42	59	3002
10	00:08:38	337	10.3	p32.5	N29°34.296	W094°55.49	51	9389	142	8.4	s31.3	N29°34.133	W094°55.43	59	3136
11	00:08:36	337	10.3	p26.8	N29°34.290	W094°55.49	51	9402	142	8.3	s26.2	N29°34.137	W094°55.43	59	3032
12	00:08:34	336	10.4	p21.0	N29°34.285	W094°55.48	51	9398	142	8.2	s21.0	N29°34.140	W094°55.44	59	3178
13	00:08:32	335	10.4	p15.3	N29°34.280	W094°55.48	51	9389	143	8.1	s15.8	N29°34.144	W094°55.44	59	3148

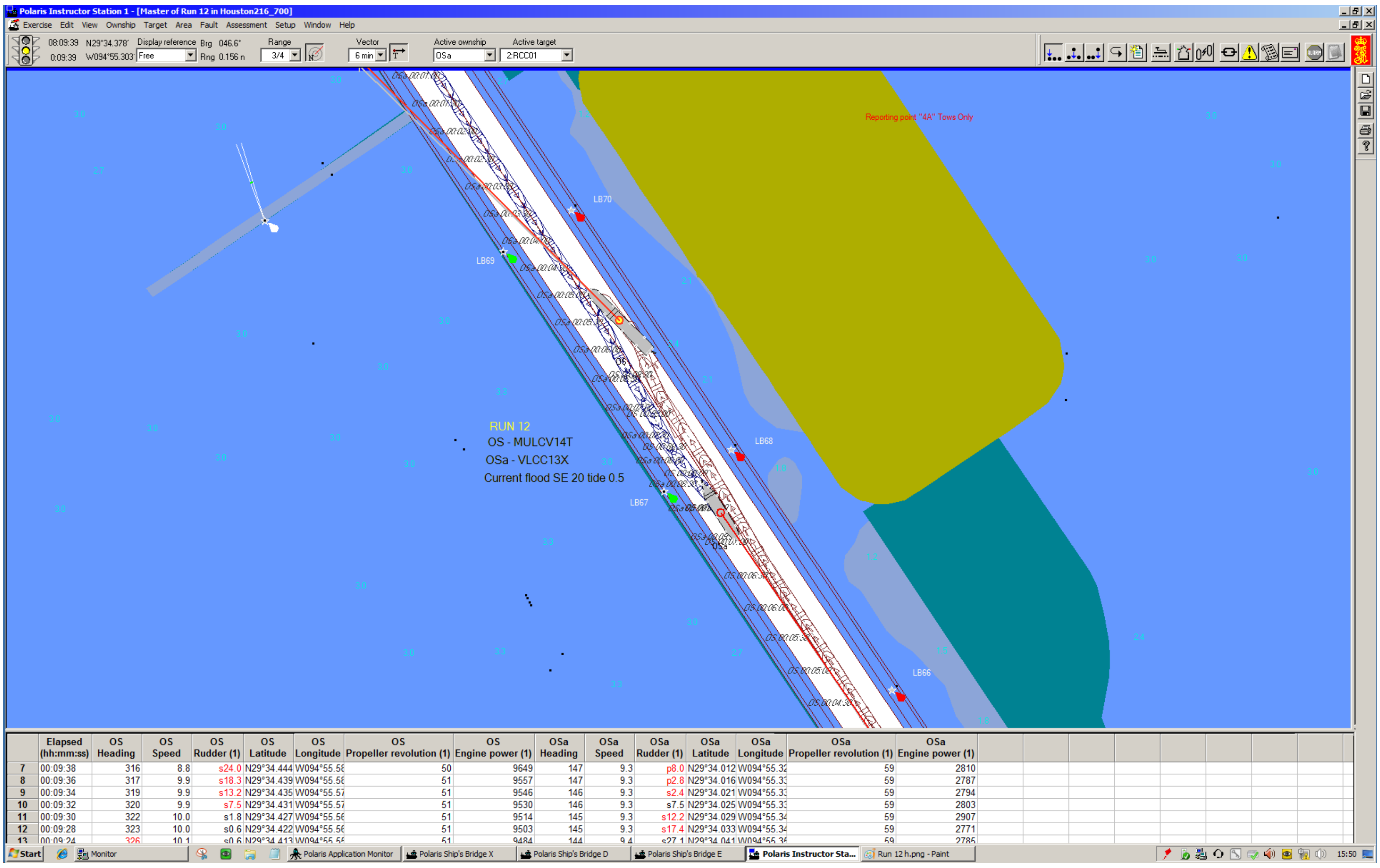


08:09:35 N29°34.345′ Display reference Free Brg 352.5° Rng 0.075 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01

0:09:35 W094°55.445′

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:34	319	9.9	s13.2	N29°34.435	W094°55.57	51	9546	146	9.3	s2.4	N29°34.021	W094°55.33	59	2794
8	00:09:32	320	9.9	s7.5	N29°34.431	W094°55.57	51	9530	146	9.3	s7.5	N29°34.025	W094°55.33	59	2803
9	00:09:30	322	10.0	s1.8	N29°34.427	W094°55.56	51	9514	145	9.3	s12.2	N29°34.029	W094°55.34	59	2907
10	00:09:28	323	10.0	s0.6	N29°34.422	W094°55.56	51	9503	145	9.3	s17.4	N29°34.033	W094°55.34	59	2771
11	00:09:24	326	10.1	s0.6	N29°34.413	W094°55.55	51	9484	144	9.4	s27.1	N29°34.041	W094°55.35	59	2785
12	00:09:14	331	10.2	p2.7	N29°34.390	W094°55.54	51	9442	142	9.4	s26.1	N29°34.062	W094°55.37	59	2758
13	00:09:12	332	10.2	p8.4	N29°34.385	W094°55.53	51	9434	142	9.4	s21.1	N29°34.066	W094°55.37	59	2781



08:09:39 N29°34.378′ Display reference Free Brg 046.6° Rng 0.156 n Range 3/4 Vector 6 min Active ownship OSa Active target 2:RCC01

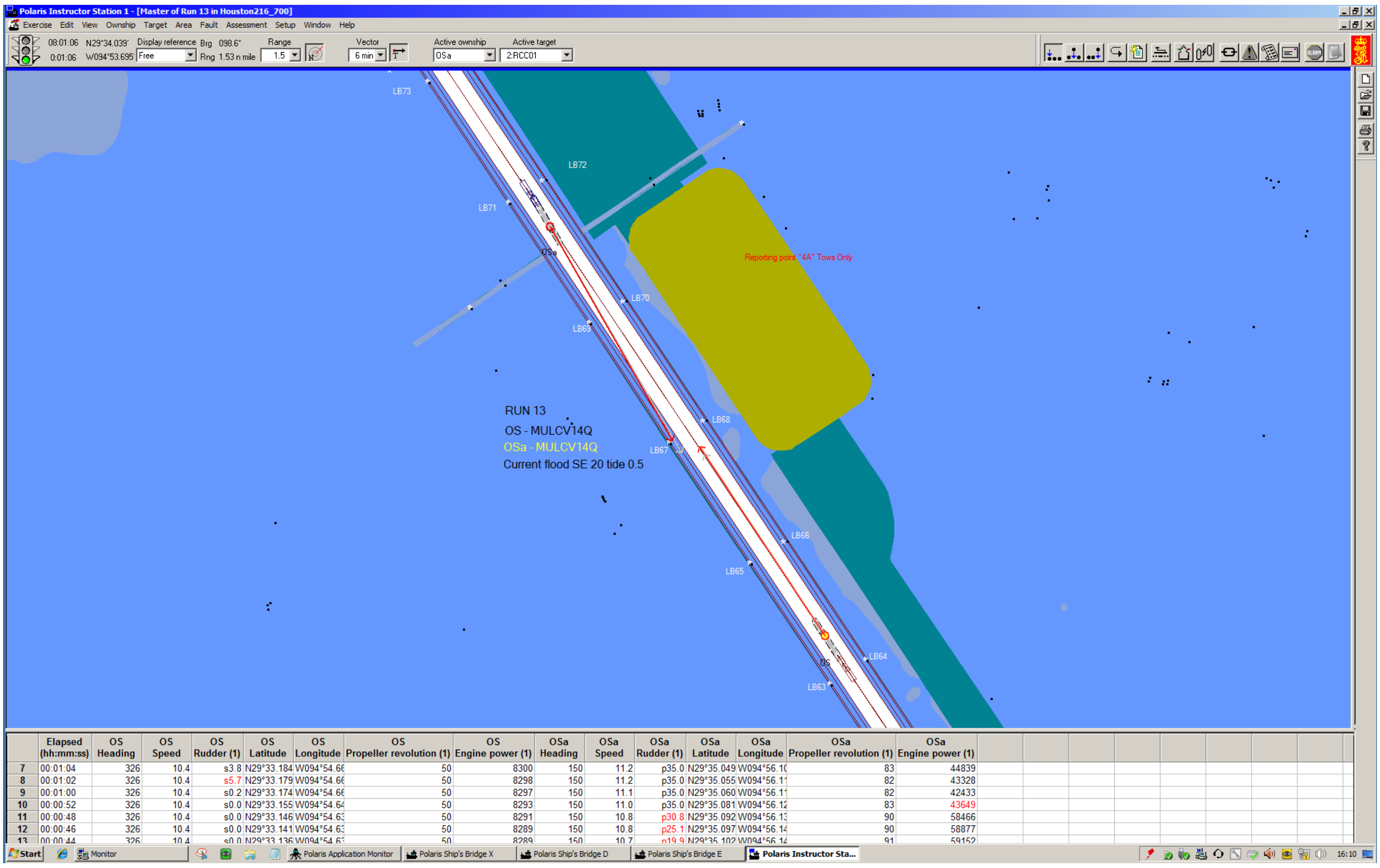
0:09:39 W094°55.303′

RUN 12
OS - MULCV14T
OSa - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:38	316	8.8	s24.0	N29°34.444	W094°55.58	50	9649	147	9.3	p8.0	N29°34.012	W094°55.32	59	2810
8	00:09:36	317	9.9	s18.3	N29°34.439	W094°55.58	51	9557	147	9.3	p2.8	N29°34.016	W094°55.33	59	2787
9	00:09:34	319	9.9	s13.2	N29°34.435	W094°55.57	51	9546	146	9.3	s2.4	N29°34.021	W094°55.33	59	2794
10	00:09:32	320	9.9	s7.5	N29°34.431	W094°55.57	51	9530	146	9.3	s7.5	N29°34.025	W094°55.33	59	2803
11	00:09:30	322	10.0	s1.8	N29°34.427	W094°55.56	51	9514	145	9.3	s12.2	N29°34.029	W094°55.34	59	2907
12	00:09:28	323	10.0	s0.6	N29°34.422	W094°55.56	51	9503	145	9.3	s17.4	N29°34.033	W094°55.34	59	2771
13	00:09:24	326	10.1	s0.6	N29°34.413	W094°55.55	51	9484	144	9.4	s27.1	N29°34.041	W094°55.35	59	2785

June 26, 2019

Run 13



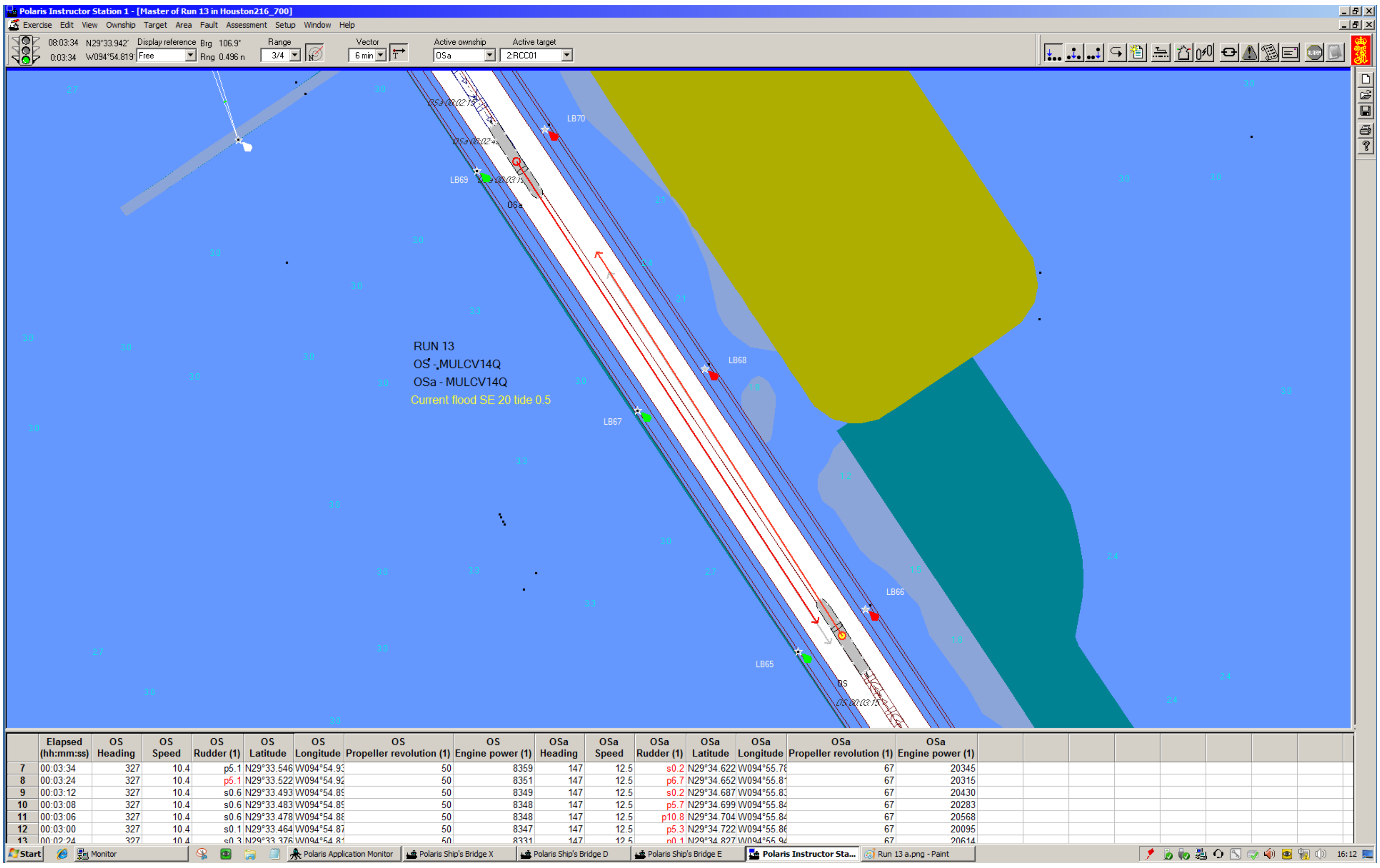
Polaris Instructor Station 1 - [Master of Run 13 in Houston216_700]

08:01:06 N29°34.039' Display reference Free Brg 098.6° Range 1.5
0:01:06 W094°53.695 Rng 1.53 n mile
Vector 6 min
Active ownship OSa
Active target 2:RCC01

Reporting point "4A" Tows Only

RUN 13
OS - MULCV14Q
OSa - MULCV14Q
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:01:04	326	10.4	s3.8	N29°33.184	W094°54.66	50	8300	150	11.2	p35.0	N29°35.049	W094°56.10	83	44839
8	00:01:02	326	10.4	s5.7	N29°33.179	W094°54.66	50	8298	150	11.2	p35.0	N29°35.055	W094°56.11	82	43328
9	00:01:00	326	10.4	s0.2	N29°33.174	W094°54.66	50	8297	150	11.1	p35.0	N29°35.060	W094°56.11	82	42433
10	00:00:52	326	10.4	s0.0	N29°33.155	W094°54.64	50	8293	150	11.0	p35.0	N29°35.081	W094°56.12	83	43649
11	00:00:48	326	10.4	s0.0	N29°33.146	W094°54.63	50	8291	150	10.8	p30.8	N29°35.092	W094°56.13	90	58466
12	00:00:46	326	10.4	s0.0	N29°33.141	W094°54.63	50	8289	150	10.8	p25.1	N29°35.097	W094°56.14	90	58877
13	00:00:44	326	10.4	s0.0	N29°33.136	W094°54.63	50	8289	150	10.7	p19.9	N29°35.102	W094°56.14	91	59152



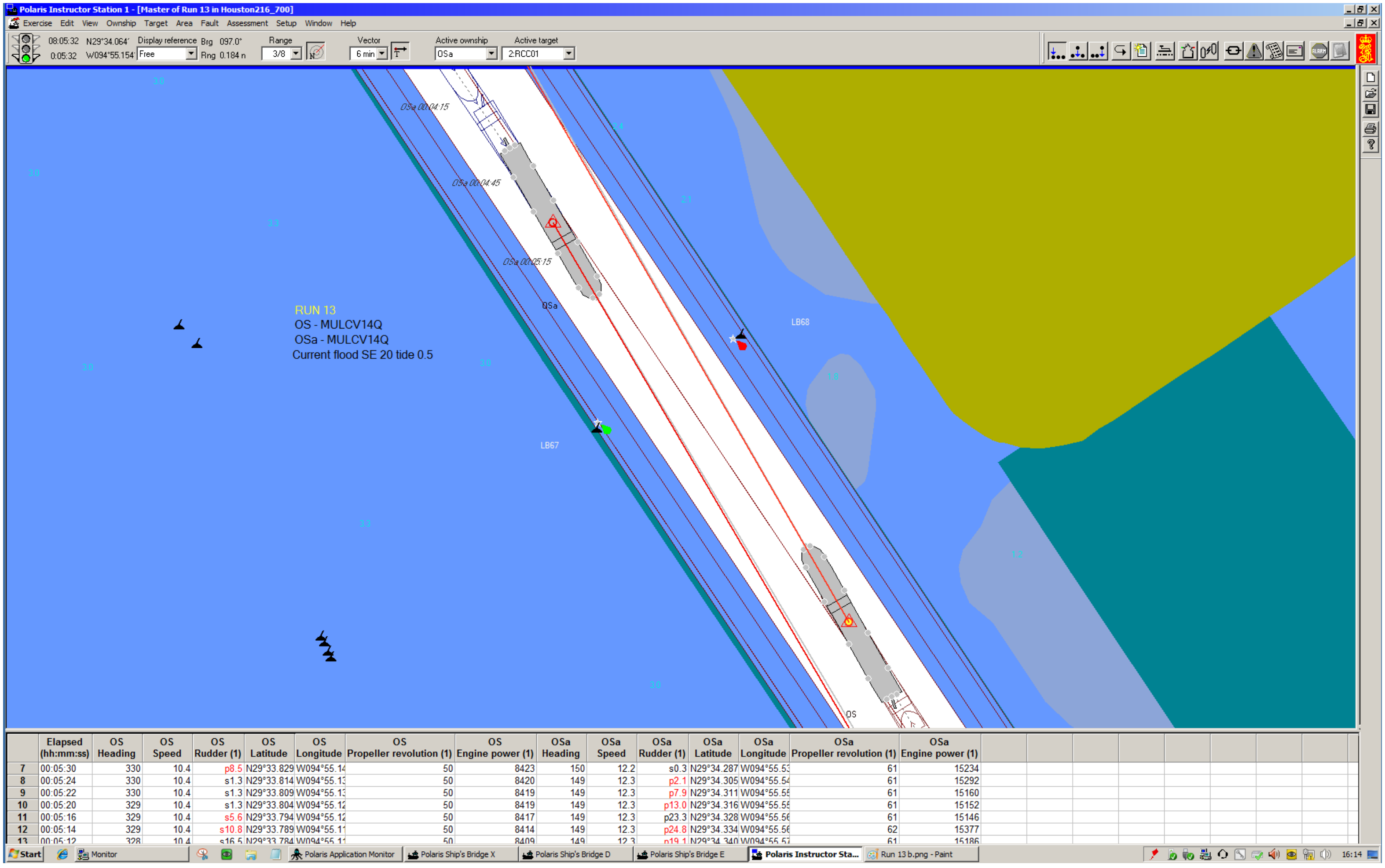
Polaris Instructor Station 1 - [Master of Run 13 in Houston216_700]

08:03:34 N29°33.942' Display reference Free Brg 106.9° Range 3/4
0:03:34 W094°54.819 Rng 0.496 n
Vector 6 min
Active ownship OSa
Active target 2:RCC01

RUN 13
OS - MULCV14Q
OSa - MULCV14Q
Current flood SE 20 tide 0.5

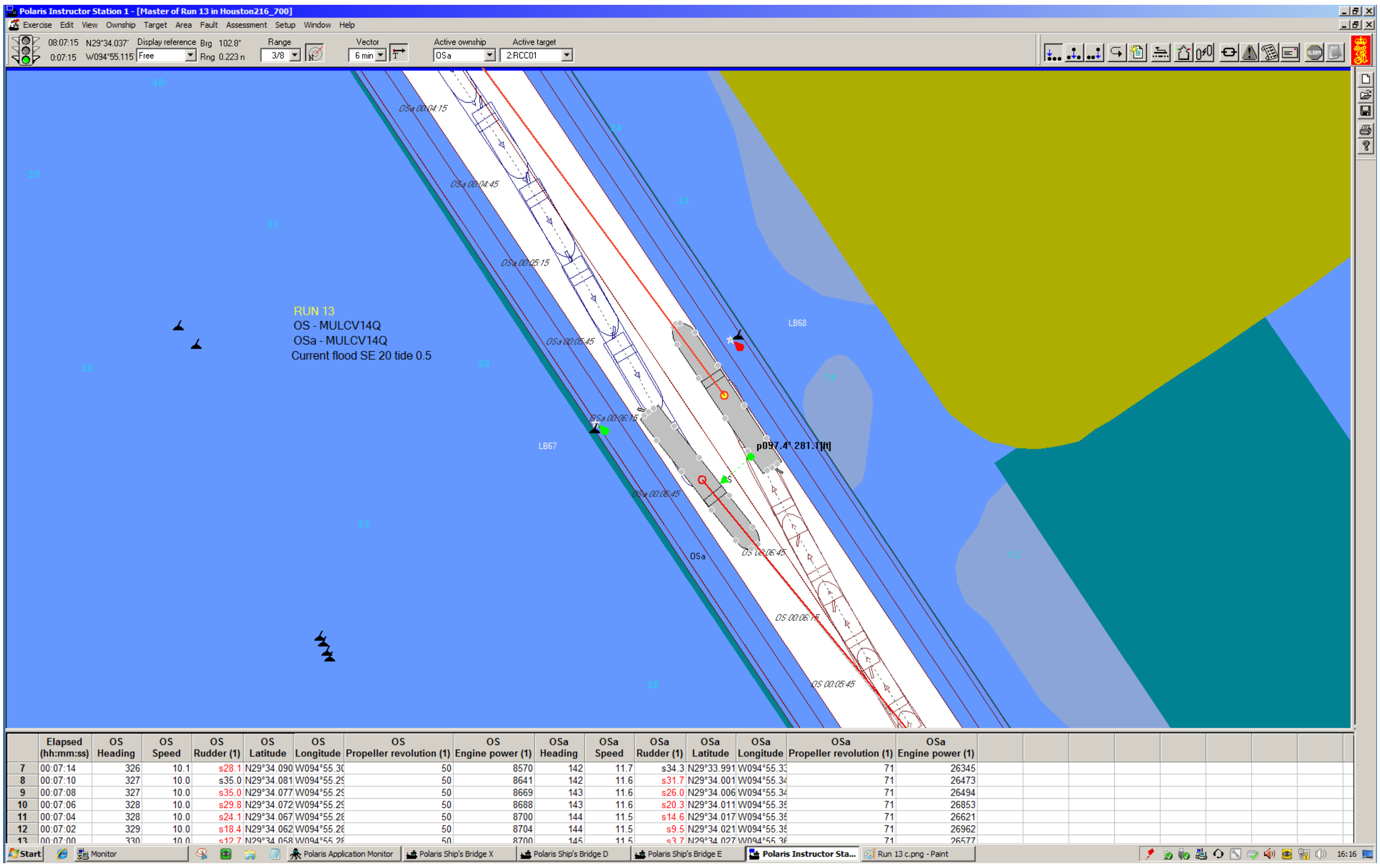
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:03:34	327	10.4	p5.1	N29°33.546	W094°54.93	50	8359	147	12.5	s0.2	N29°34.622	W094°55.78	67	20345
8	00:03:24	327	10.4	p5.1	N29°33.522	W094°54.92	50	8351	147	12.5	p6.7	N29°34.652	W094°55.81	67	20315
9	00:03:12	327	10.4	s0.6	N29°33.493	W094°54.89	50	8349	147	12.5	s0.2	N29°34.687	W094°55.83	67	20430
10	00:03:08	327	10.4	s0.6	N29°33.483	W094°54.89	50	8348	147	12.5	p5.7	N29°34.699	W094°55.84	67	20283
11	00:03:06	327	10.4	s0.6	N29°33.478	W094°54.88	50	8348	147	12.5	p10.8	N29°34.704	W094°55.84	67	20568
12	00:03:00	327	10.4	s0.1	N29°33.464	W094°54.87	50	8347	147	12.5	p5.3	N29°34.722	W094°55.86	67	20095
13	00:02:24	327	10.4	s0.3	N29°33.376	W094°54.81	50	8331	147	12.5	p0.1	N29°34.827	W094°55.94	67	20614

June 26, 2019



08:05:32 N29°34.064' Display reference Free Brg 097.0° Rng 0.184 n
0:05:32 W094°55.154'
Range 3/8
Vector 6 min
Active ownship OSa
Active target 2:RCC01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:05:30	330	10.4	p8.5	N29°33.829	W094°55.14	50	8423	150	12.2	s0.3	N29°34.287	W094°55.53	61	15234
8	00:05:24	330	10.4	s1.3	N29°33.814	W094°55.13	50	8420	149	12.3	p2.1	N29°34.305	W094°55.54	61	15292
9	00:05:22	330	10.4	s1.3	N29°33.809	W094°55.13	50	8419	149	12.3	p7.9	N29°34.311	W094°55.55	61	15160
10	00:05:20	329	10.4	s1.3	N29°33.804	W094°55.12	50	8419	149	12.3	p13.0	N29°34.316	W094°55.55	61	15152
11	00:05:16	329	10.4	s5.6	N29°33.794	W094°55.12	50	8417	149	12.3	p23.3	N29°34.328	W094°55.56	61	15146
12	00:05:14	329	10.4	s10.8	N29°33.789	W094°55.11	50	8414	149	12.3	p24.8	N29°34.334	W094°55.56	62	15377
13	00:05:12	328	10.4	s16.5	N29°33.784	W094°55.11	50	8409	149	12.3	p19.1	N29°34.340	W094°55.57	61	15186



08:07:15 N29°34.037' Display reference Free Brg 102.8° Rng 0.223 n
0:07:15 W094°55.115'
Range 3/8
Vector 6 min
Active ownship OSa
Active target 2:RCC01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:14	326	10.1	s28.1	N29°34.090	W094°55.30	50	8570	142	11.7	s34.3	N29°33.991	W094°55.33	71	26345
8	00:07:10	327	10.0	s35.0	N29°34.081	W094°55.29	50	8641	142	11.6	s31.7	N29°34.001	W094°55.34	71	26473
9	00:07:08	327	10.0	s35.0	N29°34.077	W094°55.29	50	8669	143	11.6	s26.0	N29°34.006	W094°55.34	71	26494
10	00:07:06	328	10.0	s29.8	N29°34.072	W094°55.29	50	8688	143	11.6	s20.3	N29°34.011	W094°55.35	71	26853
11	00:07:04	328	10.0	s24.1	N29°34.067	W094°55.28	50	8700	144	11.5	s14.6	N29°34.017	W094°55.35	71	26621
12	00:07:02	329	10.0	s18.4	N29°34.062	W094°55.28	50	8704	144	11.5	s9.5	N29°34.021	W094°55.35	71	26962
13	00:07:00	330	10.0	s12.7	N29°34.058	W094°55.28	50	8700	145	11.5	s3.7	N29°34.027	W094°55.36	71	26577

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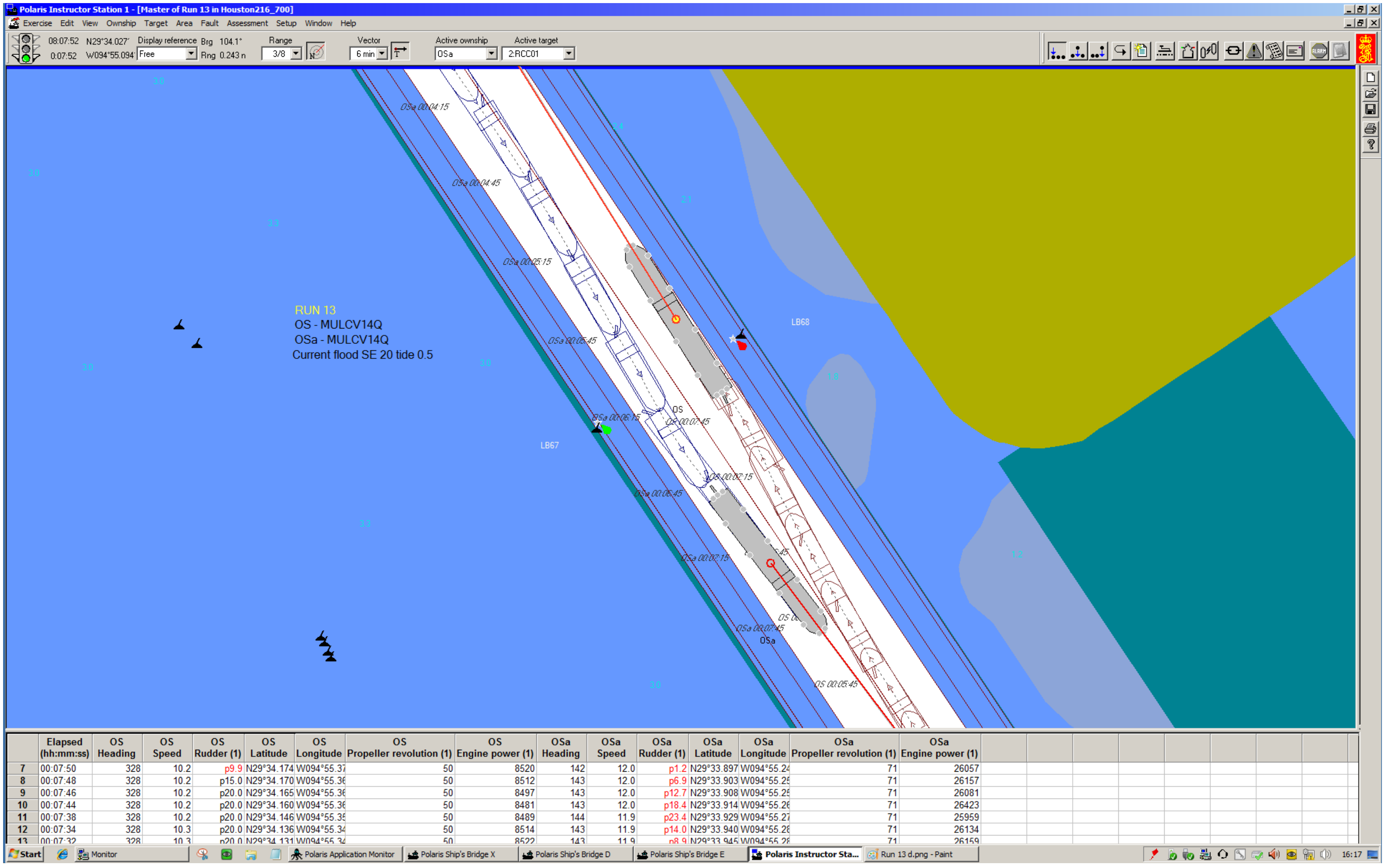
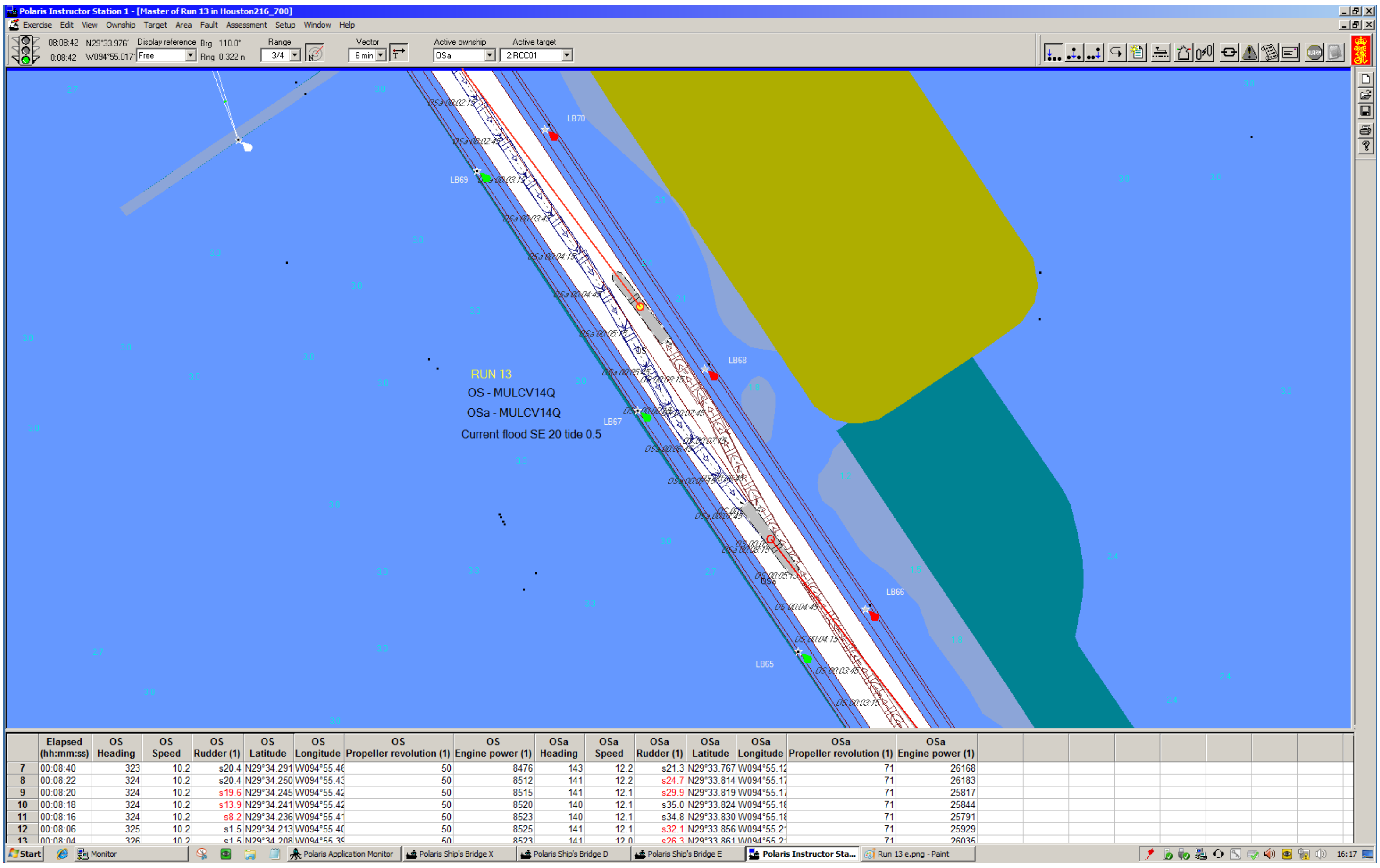


Polaris Instructor Station 1 - [Master of Run 13 in Houston216_700]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:50	328	10.2	p9.9	N29°34.174	W094°55.37	50	8520	142	12.0	p1.2	N29°33.897	W094°55.24	71	26057
8	00:07:48	328	10.2	p15.0	N29°34.170	W094°55.36	50	8512	143	12.0	p6.9	N29°33.903	W094°55.25	71	26157
9	00:07:46	328	10.2	p20.0	N29°34.165	W094°55.36	50	8497	143	12.0	p12.7	N29°33.908	W094°55.25	71	26081
10	00:07:44	328	10.2	p20.0	N29°34.160	W094°55.36	50	8481	143	12.0	p18.4	N29°33.914	W094°55.26	71	26423
11	00:07:38	328	10.2	p20.0	N29°34.146	W094°55.35	50	8489	144	11.9	p23.4	N29°33.929	W094°55.27	71	25959
12	00:07:34	328	10.3	p20.0	N29°34.136	W094°55.34	50	8514	143	11.9	p14.0	N29°33.940	W094°55.28	71	26134
13	00:07:32	328	10.3	p20.0	N29°34.131	W094°55.34	50	8522	143	11.9	p8.9	N29°33.945	W094°55.28	71	26159



Polaris Instructor Station 1 - [Master of Run 13 in Houston216_700]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:40	323	10.2	s20.4	N29°34.291	W094°55.46	50	8476	143	12.2	s21.3	N29°33.767	W094°55.12	71	26168
8	00:08:22	324	10.2	s20.4	N29°34.250	W094°55.43	50	8512	141	12.2	s24.7	N29°33.814	W094°55.17	71	26183
9	00:08:20	324	10.2	s19.6	N29°34.245	W094°55.42	50	8515	141	12.1	s29.9	N29°33.819	W094°55.17	71	25817
10	00:08:18	324	10.2	s13.9	N29°34.241	W094°55.42	50	8520	140	12.1	s35.0	N29°33.824	W094°55.18	71	25844
11	00:08:16	324	10.2	s8.2	N29°34.236	W094°55.41	50	8523	140	12.1	s34.8	N29°33.830	W094°55.18	71	25791
12	00:08:06	325	10.2	s1.5	N29°34.213	W094°55.40	50	8525	141	12.1	s32.1	N29°33.856	W094°55.21	71	25929
13	00:08:04	326	10.2	s1.5	N29°34.208	W094°55.39	50	8523	141	12.0	s26.3	N29°33.861	W094°55.21	71	26035

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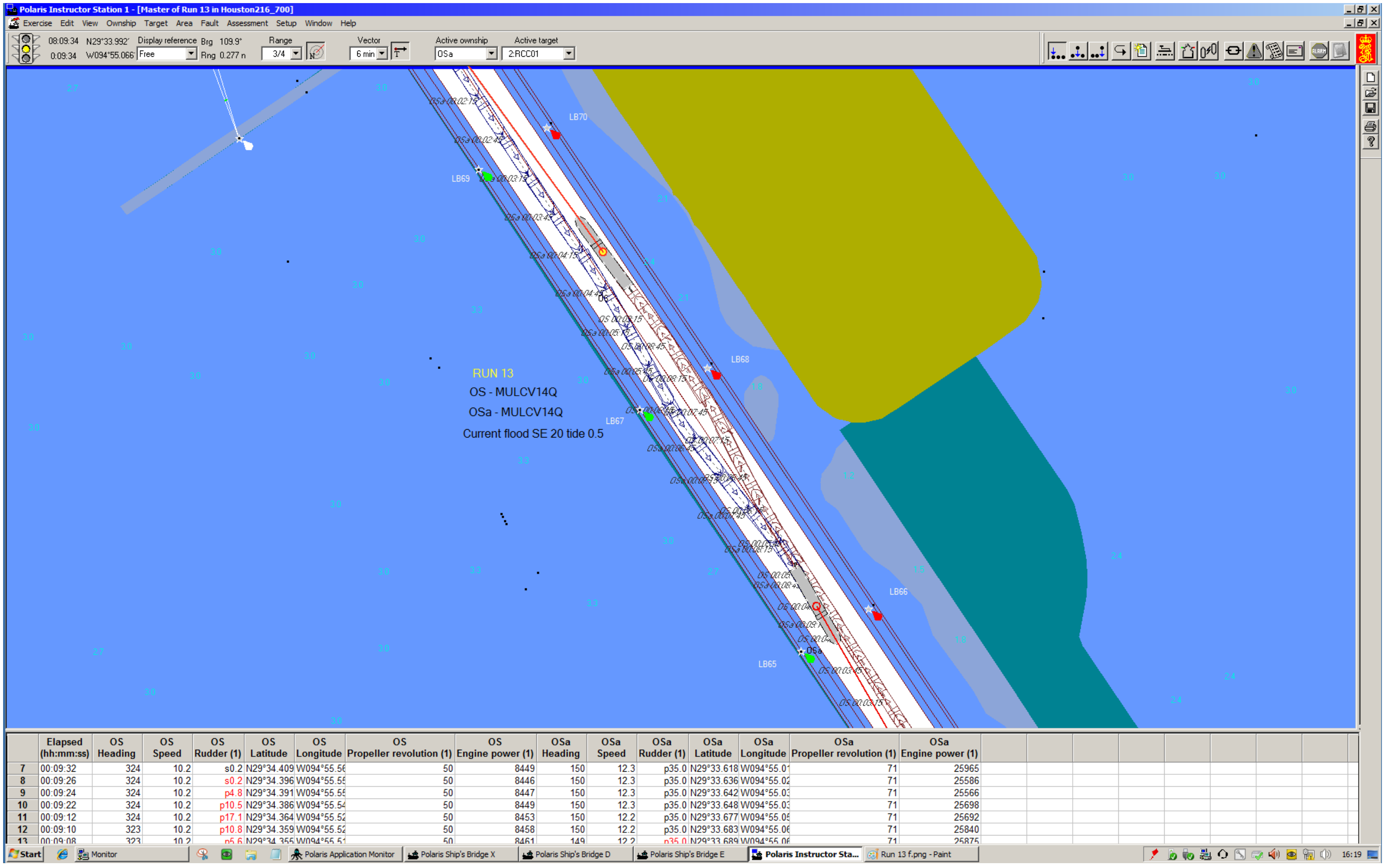


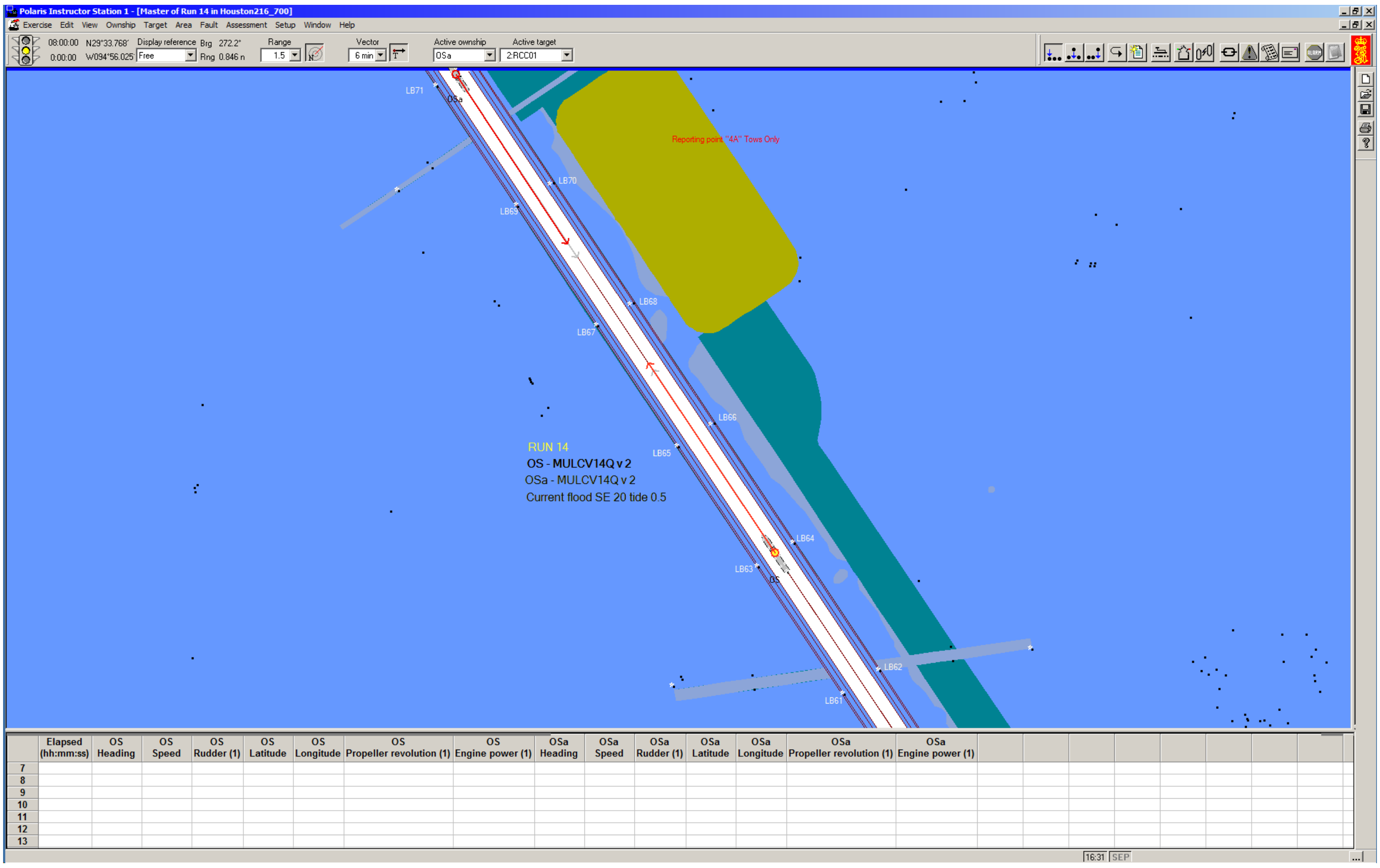
Polaris Instructor Station 1 - [Master of Run 13 in Houston216_700]

08:09:34 N29°33.992′ Display reference Free Brg 109.9° Range 3/4 Vector 6 min Active ownship OSa Active target 2:RCC01
0:09:34 W094°55.066′ Rng 0.277 n

RUN 13
OS - MULCV14Q
OSa - MULCV14Q
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:32	324	10.2	s0.2	N29°34.409	W094°55.56	50	8449	150	12.3	p35.0	N29°33.618	W094°55.01	71	25965
8	00:09:26	324	10.2	s0.2	N29°34.396	W094°55.55	50	8446	150	12.3	p35.0	N29°33.636	W094°55.02	71	25586
9	00:09:24	324	10.2	p4.8	N29°34.391	W094°55.55	50	8447	150	12.3	p35.0	N29°33.642	W094°55.03	71	25566
10	00:09:22	324	10.2	p10.5	N29°34.386	W094°55.54	50	8449	150	12.3	p35.0	N29°33.648	W094°55.03	71	25698
11	00:09:12	324	10.2	p17.1	N29°34.364	W094°55.52	50	8453	150	12.2	p35.0	N29°33.677	W094°55.05	71	25692
12	00:09:10	323	10.2	p10.8	N29°34.359	W094°55.52	50	8458	150	12.2	p35.0	N29°33.683	W094°55.06	71	25840
13	00:09:08	323	10.2	p5.6	N29°34.355	W094°55.51	50	8461	149	12.2	p35.0	N29°33.689	W094°55.06	71	25875

Run 14



08:00:00 N29°33.768′ Display reference Free Brg 272.2° Rng 0.846 n Range 1.5 Vector 6 min Active ownship OSa Active target 2:RCC01

0:00:00 W094°56.025′

RUN 14

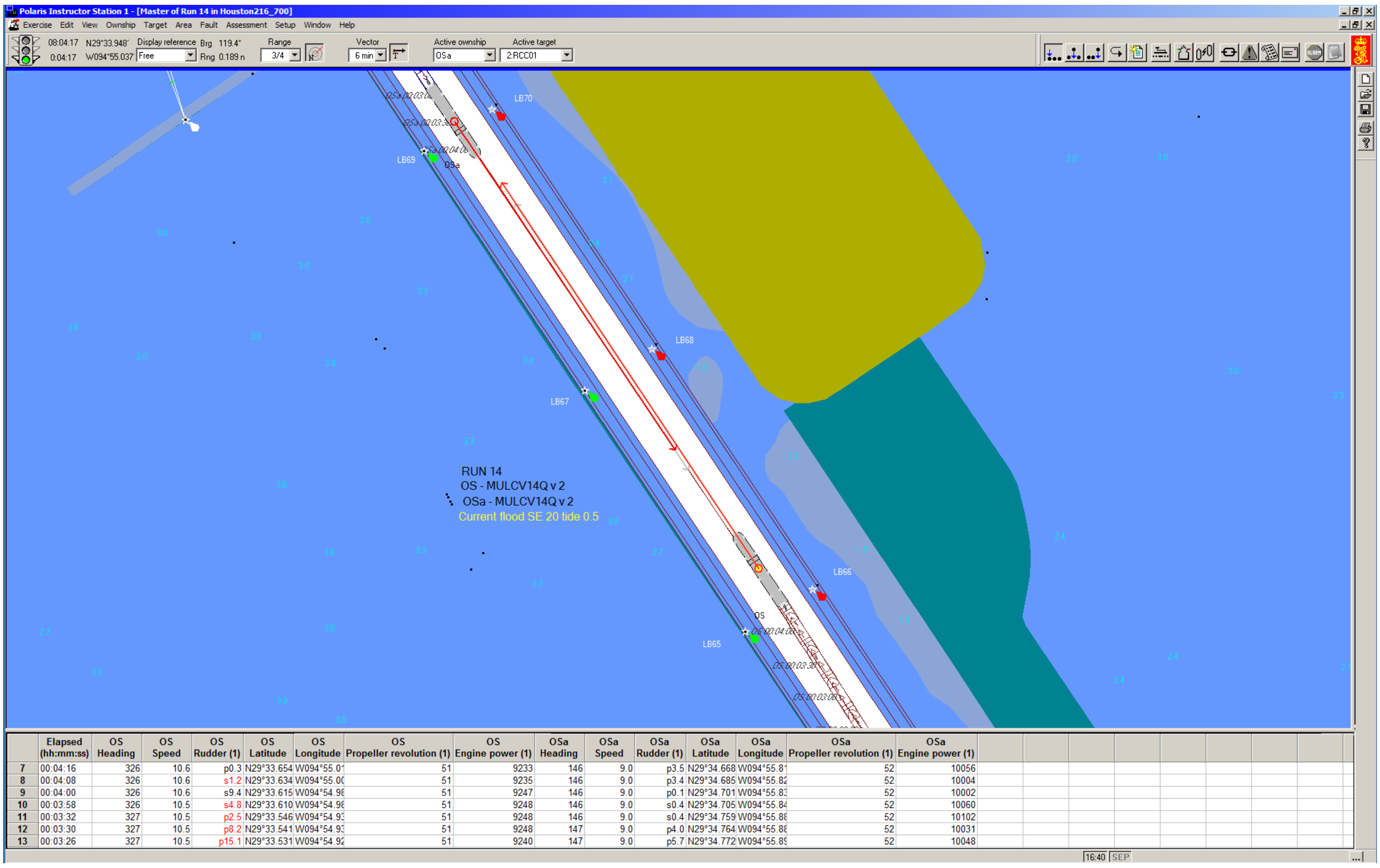
OS - MULCV14Q v 2

OSa - MULCV14Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															
9															
10															
11															
12															
13															

16:31 SEP



08:04:17 N29°33.948′ Display reference Free Brg 119.4° Rng 0.189 n Range 3/4 Vector 6 min Active ownship OSa Active target 2:RCC01

0:04:17 W094°55.037′

RUN 14

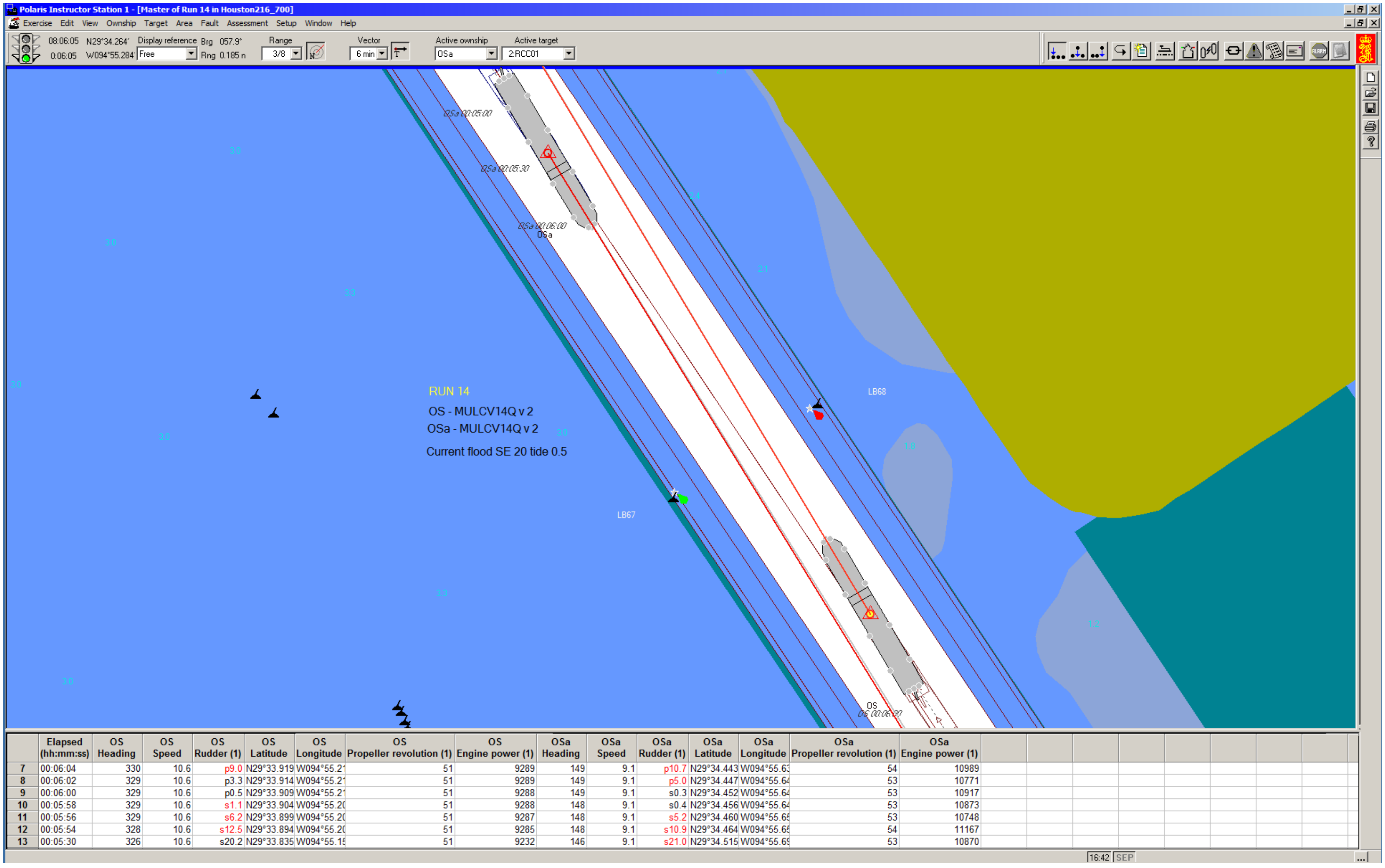
OS - MULCV14Q v 2

OSa - MULCV14Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:16	326	10.6	p0.3	N29°33.654	W094°55.0	51	9233	146	9.0	p3.5	N29°34.668	W094°55.8	52	10056
8	00:04:08	326	10.6	s1.2	N29°33.634	W094°55.0	51	9235	146	9.0	p3.4	N29°34.685	W094°55.8	52	10004
9	00:04:00	326	10.6	s9.4	N29°33.615	W094°54.9	51	9247	146	9.0	p0.1	N29°34.701	W094°55.8	52	10002
10	00:03:58	326	10.5	s4.8	N29°33.610	W094°54.9	51	9248	146	9.0	s0.4	N29°34.705	W094°55.8	52	10060
11	00:03:32	327	10.5	p2.5	N29°33.546	W094°54.9	51	9248	146	9.0	s0.4	N29°34.759	W094°55.8	52	10102
12	00:03:30	327	10.5	p8.2	N29°33.541	W094°54.9	51	9248	147	9.0	p4.0	N29°34.764	W094°55.8	52	10031
13	00:03:26	327	10.5	p15.1	N29°33.531	W094°54.9	51	9240	147	9.0	p5.7	N29°34.772	W094°55.8	52	10048

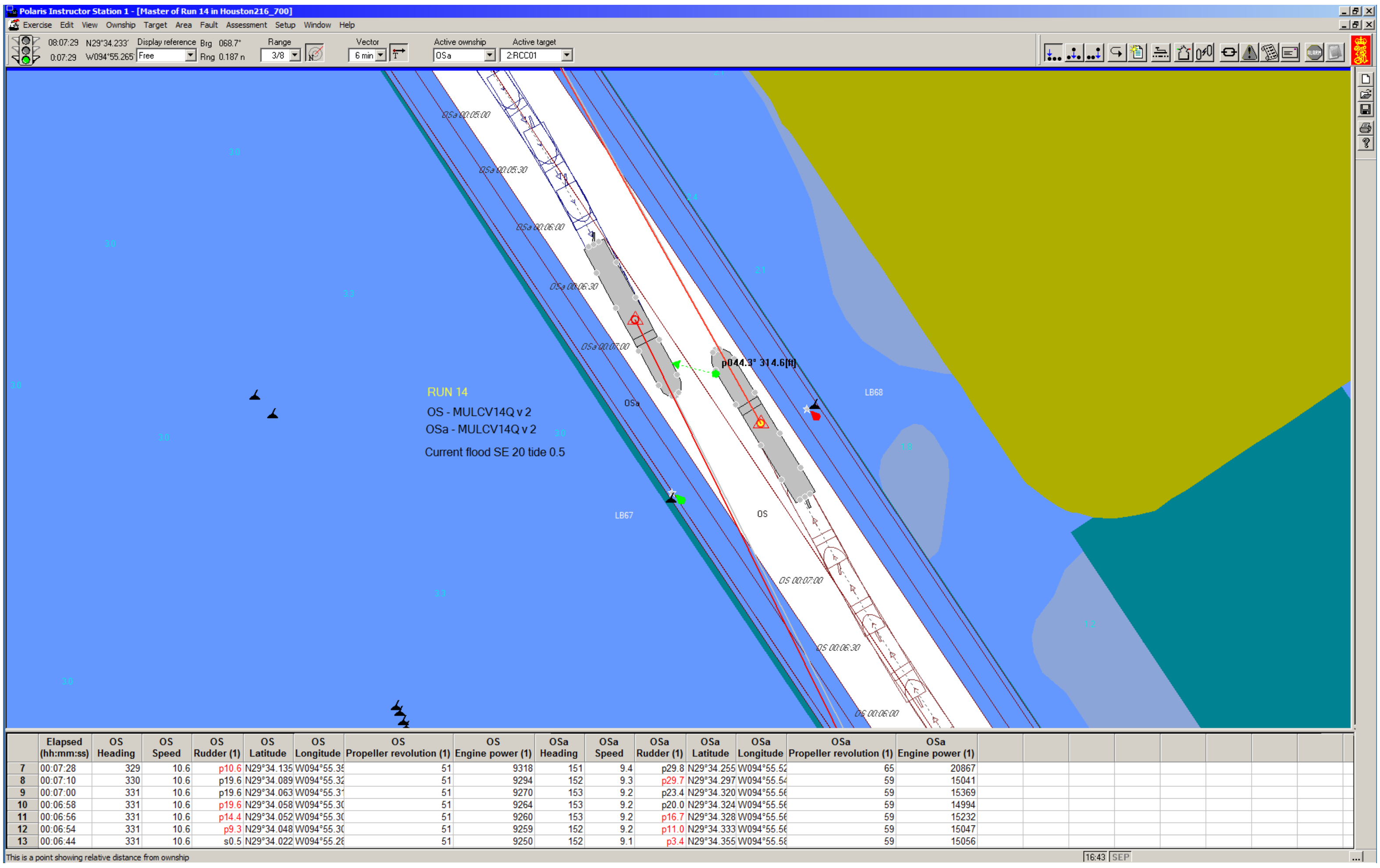
16:40 SEP



08:06:05 N29°34.264' Display reference Free Brg 057.9° Rng 0.185 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01

0:06:05 W094°55.284'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:06:04	330	10.6	p9.0	N29°33.919	W094°55.2	51	9289	149	9.1	p10.7	N29°34.443	W094°55.63	54	10989
8	00:06:02	329	10.6	p3.3	N29°33.914	W094°55.2	51	9289	149	9.1	p5.0	N29°34.447	W094°55.64	53	10771
9	00:06:00	329	10.6	p0.5	N29°33.909	W094°55.2	51	9288	149	9.1	s0.3	N29°34.452	W094°55.64	53	10917
10	00:05:58	329	10.6	s1.1	N29°33.904	W094°55.2	51	9288	148	9.1	s0.4	N29°34.456	W094°55.64	53	10873
11	00:05:56	329	10.6	s6.2	N29°33.899	W094°55.2	51	9287	148	9.1	s5.2	N29°34.460	W094°55.65	53	10748
12	00:05:54	328	10.6	s12.5	N29°33.894	W094°55.2	51	9285	148	9.1	s10.9	N29°34.464	W094°55.65	54	11167
13	00:05:30	326	10.6	s20.2	N29°33.835	W094°55.1	51	9232	146	9.1	s21.0	N29°34.515	W094°55.6	53	10870



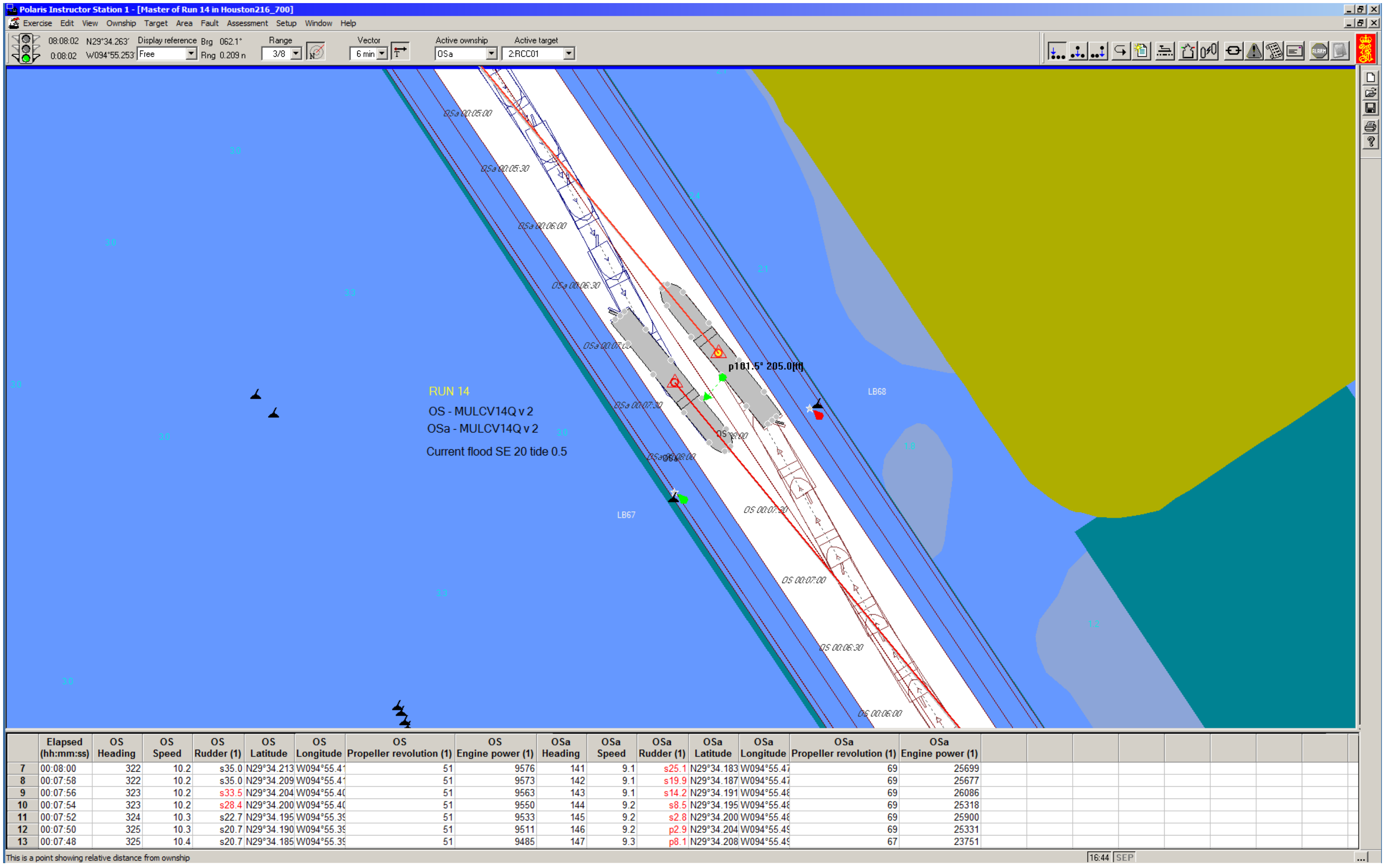
08:07:29 N29°34.233' Display reference Free Brg 068.7° Rng 0.187 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01

0:07:29 W094°55.265'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:28	329	10.6	p10.6	N29°34.135	W094°55.3	51	9318	151	9.4	p29.8	N29°34.255	W094°55.52	65	20867
8	00:07:10	330	10.6	p19.6	N29°34.089	W094°55.3	51	9294	152	9.3	p29.7	N29°34.297	W094°55.54	59	15041
9	00:07:00	331	10.6	p19.6	N29°34.063	W094°55.3	51	9270	153	9.2	p23.4	N29°34.320	W094°55.5	59	15369
10	00:06:58	331	10.6	p19.6	N29°34.058	W094°55.3	51	9264	153	9.2	p20.0	N29°34.324	W094°55.5	59	14994
11	00:06:56	331	10.6	p14.4	N29°34.052	W094°55.3	51	9260	153	9.2	p16.7	N29°34.328	W094°55.5	59	15232
12	00:06:54	331	10.6	p9.3	N29°34.048	W094°55.3	51	9259	152	9.2	p11.0	N29°34.333	W094°55.5	59	15047
13	00:06:44	331	10.6	s0.5	N29°34.022	W094°55.2	51	9250	152	9.1	p3.4	N29°34.355	W094°55.5	59	15056

This is a point showing relative distance from ownship

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 14 in Houston216_700]

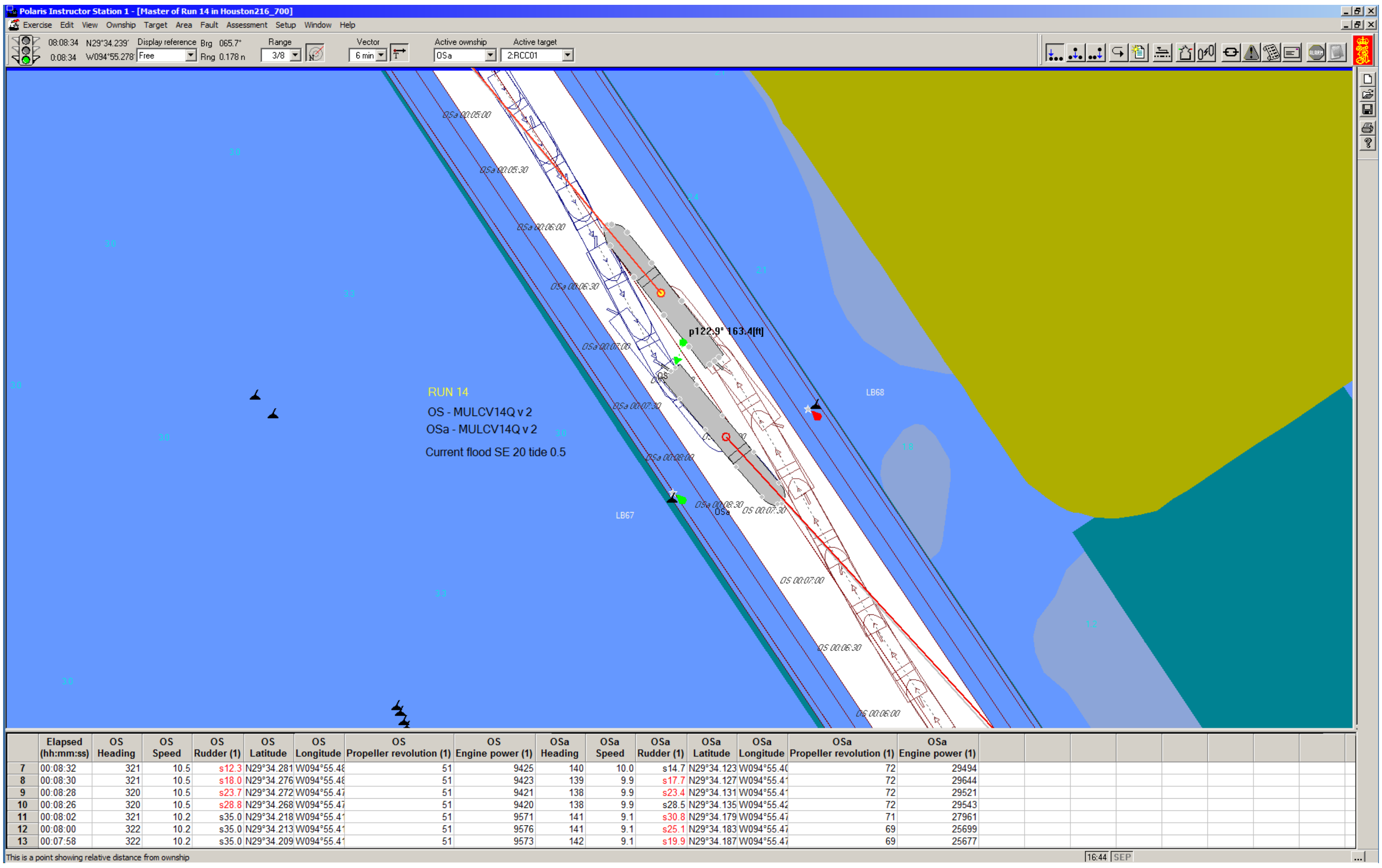
08:08:02 N29°34.263' Display reference Free Brg 062.1° Rng 0.209 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01
0:08:02 W094°55.253'

RUN 14
OS - MULCV14Q v 2
OSa - MULCV14Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:00	322	10.2	s35.0	N29°34.213	W094°55.41	51	9576	141	9.1	s25.1	N29°34.183	W094°55.47	69	25699
8	00:07:58	322	10.2	s35.0	N29°34.209	W094°55.41	51	9573	142	9.1	s19.9	N29°34.187	W094°55.47	69	25677
9	00:07:56	323	10.2	s33.5	N29°34.204	W094°55.40	51	9563	143	9.1	s14.2	N29°34.191	W094°55.48	69	26086
10	00:07:54	323	10.2	s28.4	N29°34.200	W094°55.40	51	9550	144	9.2	s8.5	N29°34.195	W094°55.48	69	25318
11	00:07:52	324	10.3	s22.7	N29°34.195	W094°55.39	51	9533	145	9.2	s2.8	N29°34.200	W094°55.48	69	25900
12	00:07:50	325	10.3	s20.7	N29°34.190	W094°55.39	51	9511	146	9.2	p2.9	N29°34.204	W094°55.49	69	25331
13	00:07:48	325	10.4	s20.7	N29°34.185	W094°55.39	51	9485	147	9.3	p8.1	N29°34.208	W094°55.49	67	23751

This is a point showing relative distance from ownship

16:44 SEP



Polaris Instructor Station 1 - [Master of Run 14 in Houston216_700]

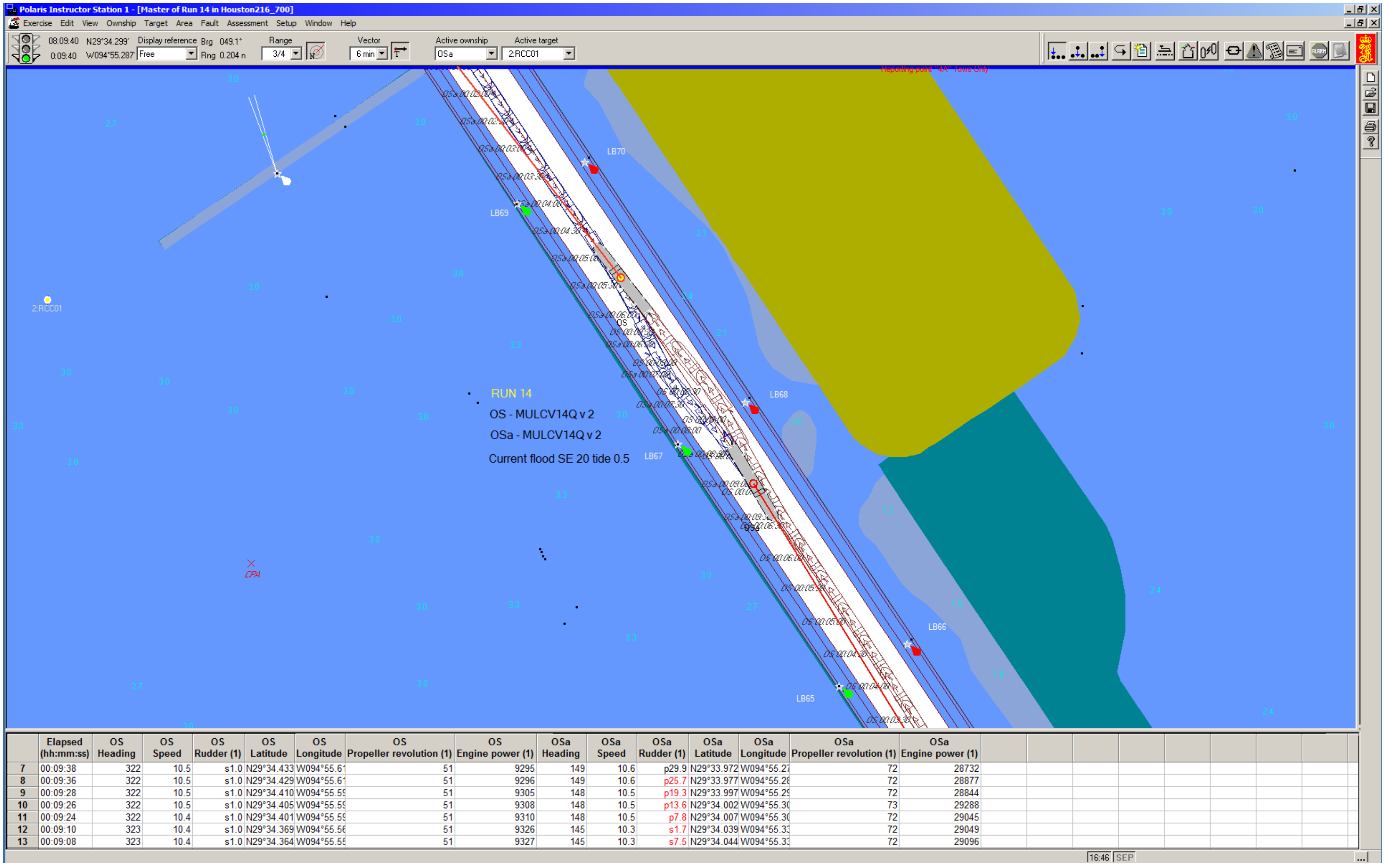
08:08:34 N29°34.239' Display reference Free Brg 065.7° Rng 0.178 n Range 3/8 Vector 6 min Active ownship OSa Active target 2:RCC01
0:08:34 W094°55.278'

RUN 14
OS - MULCV14Q v 2
OSa - MULCV14Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:32	321	10.5	s12.3	N29°34.281	W094°55.48	51	9425	140	10.0	s14.7	N29°34.123	W094°55.40	72	29494
8	00:08:30	321	10.5	s18.0	N29°34.276	W094°55.48	51	9423	139	9.9	s17.7	N29°34.127	W094°55.41	72	29644
9	00:08:28	320	10.5	s23.7	N29°34.272	W094°55.47	51	9421	138	9.9	s23.4	N29°34.131	W094°55.41	72	29521
10	00:08:26	320	10.5	s28.8	N29°34.268	W094°55.47	51	9420	138	9.9	s28.5	N29°34.135	W094°55.42	72	29543
11	00:08:02	321	10.2	s35.0	N29°34.218	W094°55.41	51	9571	141	9.1	s30.8	N29°34.179	W094°55.47	71	27961
12	00:08:00	322	10.2	s35.0	N29°34.213	W094°55.41	51	9576	141	9.1	s25.1	N29°34.183	W094°55.47	69	25699
13	00:07:58	322	10.2	s35.0	N29°34.209	W094°55.41	51	9573	142	9.1	s19.9	N29°34.187	W094°55.47	69	25677

This is a point showing relative distance from ownship

16:44 SEP



Polaris Instructor Station 1 - [Master of Run 14 in Houston216_700]

08:09:40 N29°34.299' Display reference: Free Brg 049.1° Range: 3/4 Vector: 6 min Active ownship: OSa Active target: 2:RCC01

0:09:40 W094°55.287' Rng 0.204 n

RUN 14

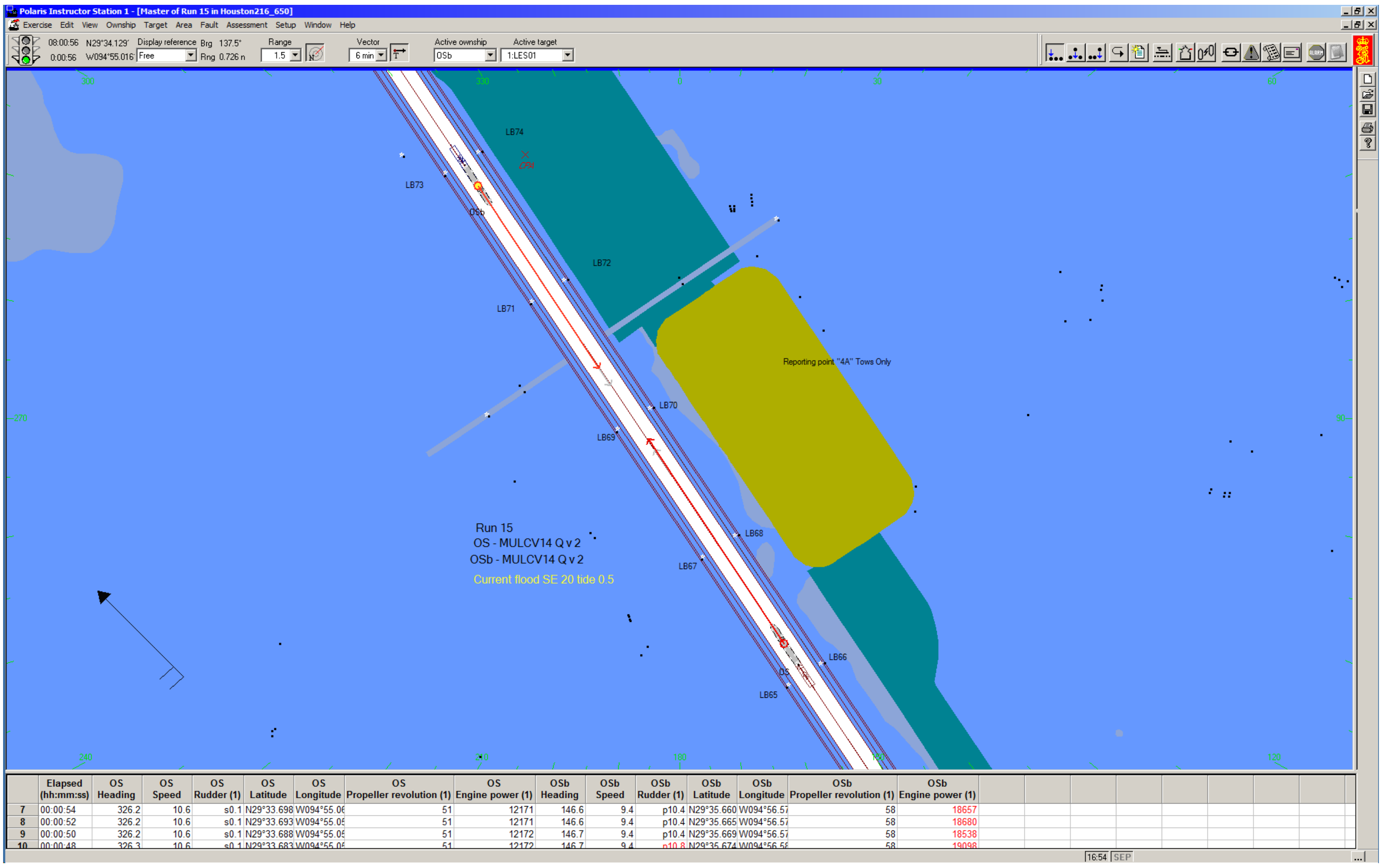
OS - MULCV14Q v 2

OSa - MULCV14Q v 2

Current flood SE 20 tide 0.5

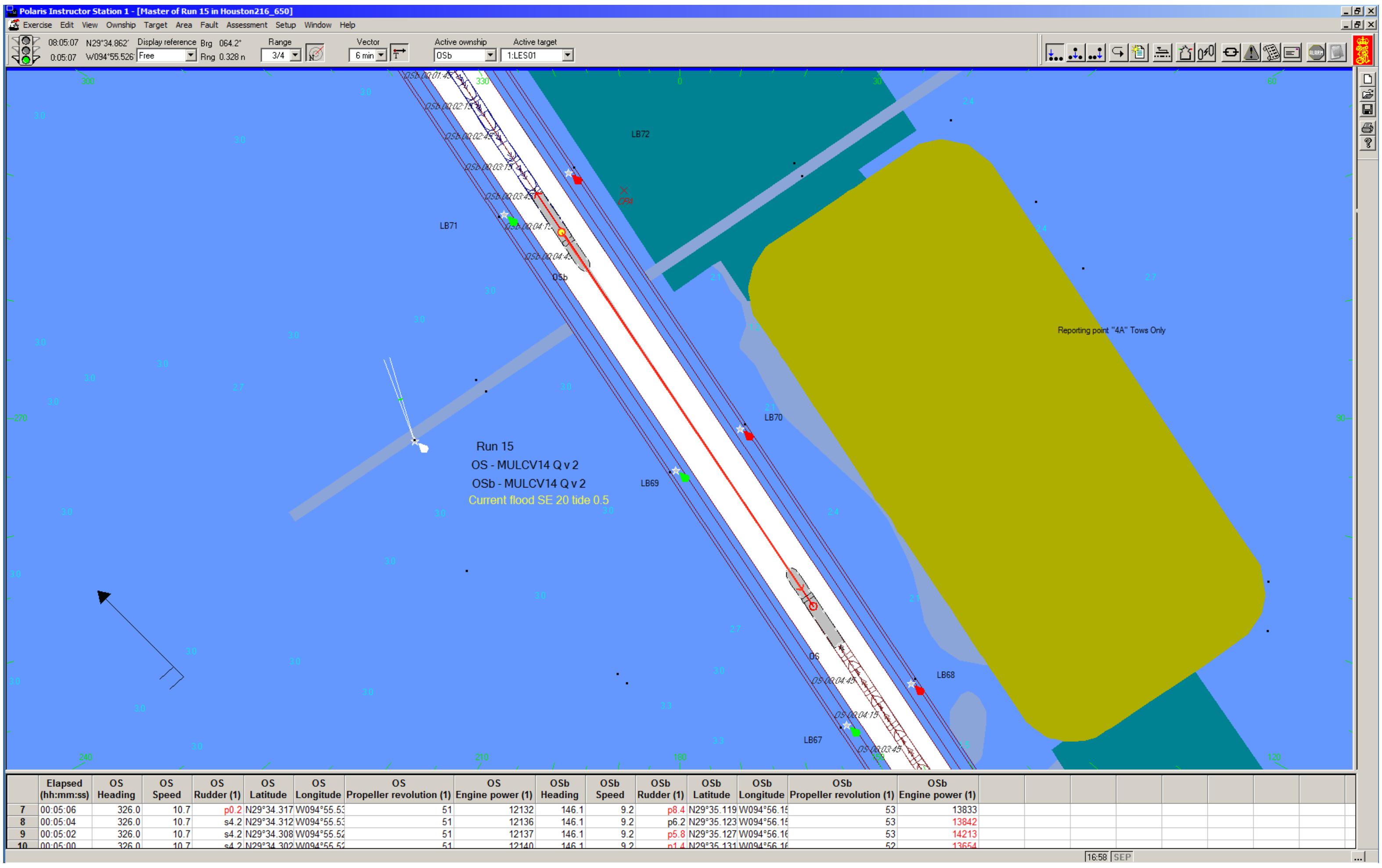
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:38	322	10.5	s1.0	N29°34.433	W094°55.61	51	9295	149	10.6	p29.9	N29°33.972	W094°55.27	72	28732
8	00:09:36	322	10.5	s1.0	N29°34.429	W094°55.61	51	9296	149	10.6	p25.7	N29°33.977	W094°55.28	72	28877
9	00:09:28	322	10.5	s1.0	N29°34.410	W094°55.59	51	9305	148	10.5	p19.3	N29°33.997	W094°55.29	72	28844
10	00:09:26	322	10.5	s1.0	N29°34.405	W094°55.59	51	9308	148	10.5	p13.6	N29°34.002	W094°55.30	73	29288
11	00:09:24	322	10.4	s1.0	N29°34.401	W094°55.59	51	9310	148	10.5	p7.8	N29°34.007	W094°55.30	72	29045
12	00:09:10	323	10.4	s1.0	N29°34.369	W094°55.56	51	9326	145	10.3	s1.7	N29°34.039	W094°55.33	72	29049
13	00:09:08	323	10.4	s1.0	N29°34.364	W094°55.55	51	9327	145	10.3	s7.5	N29°34.044	W094°55.33	72	29096

Run 15



08:00:56 N29°34.129′ Display reference: Free Brg 137.5° Rng 0.726 n
0:00:56 W094°55.016′
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:00:54	326.2	10.6	s0.1	N29°33.698	W094°55.06	51	12171	146.6	9.4	p10.4	N29°35.660	W094°56.57	58	18657
8	00:00:52	326.2	10.6	s0.1	N29°33.693	W094°55.05	51	12171	146.6	9.4	p10.4	N29°35.665	W094°56.57	58	18680
9	00:00:50	326.2	10.6	s0.1	N29°33.688	W094°55.05	51	12172	146.7	9.4	p10.4	N29°35.669	W094°56.57	58	18538
10	00:00:48	326.3	10.6	s0.1	N29°33.683	W094°55.05	51	12172	146.7	9.4	p10.8	N29°35.674	W094°56.58	58	19098



08:05:07 N29°34.862′ Display reference: Free Brg 064.2° Rng 0.328 n
0:05:07 W094°55.526′
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:06	326.0	10.7	p0.2	N29°34.317	W094°55.53	51	12132	146.1	9.2	p8.4	N29°35.119	W094°56.15	53	13833
8	00:05:04	326.0	10.7	s4.2	N29°34.312	W094°55.53	51	12136	146.1	9.2	p6.2	N29°35.123	W094°56.15	53	13842
9	00:05:02	326.0	10.7	s4.2	N29°34.308	W094°55.52	51	12137	146.1	9.2	p5.8	N29°35.127	W094°56.16	53	14213
10	00:05:00	326.0	10.7	s4.2	N29°34.302	W094°55.52	51	12140	146.1	9.2	p1.4	N29°35.131	W094°56.16	52	13654

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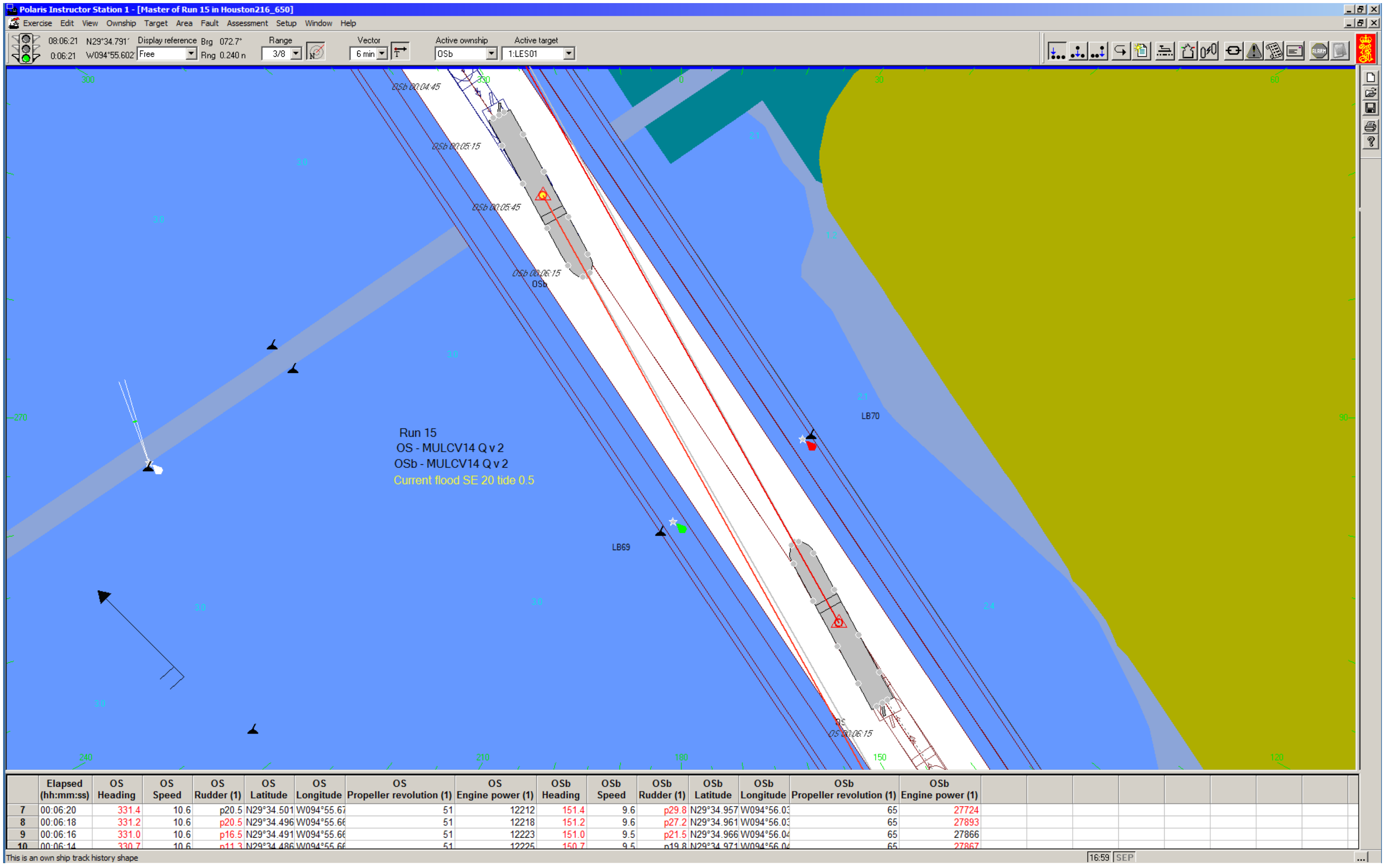
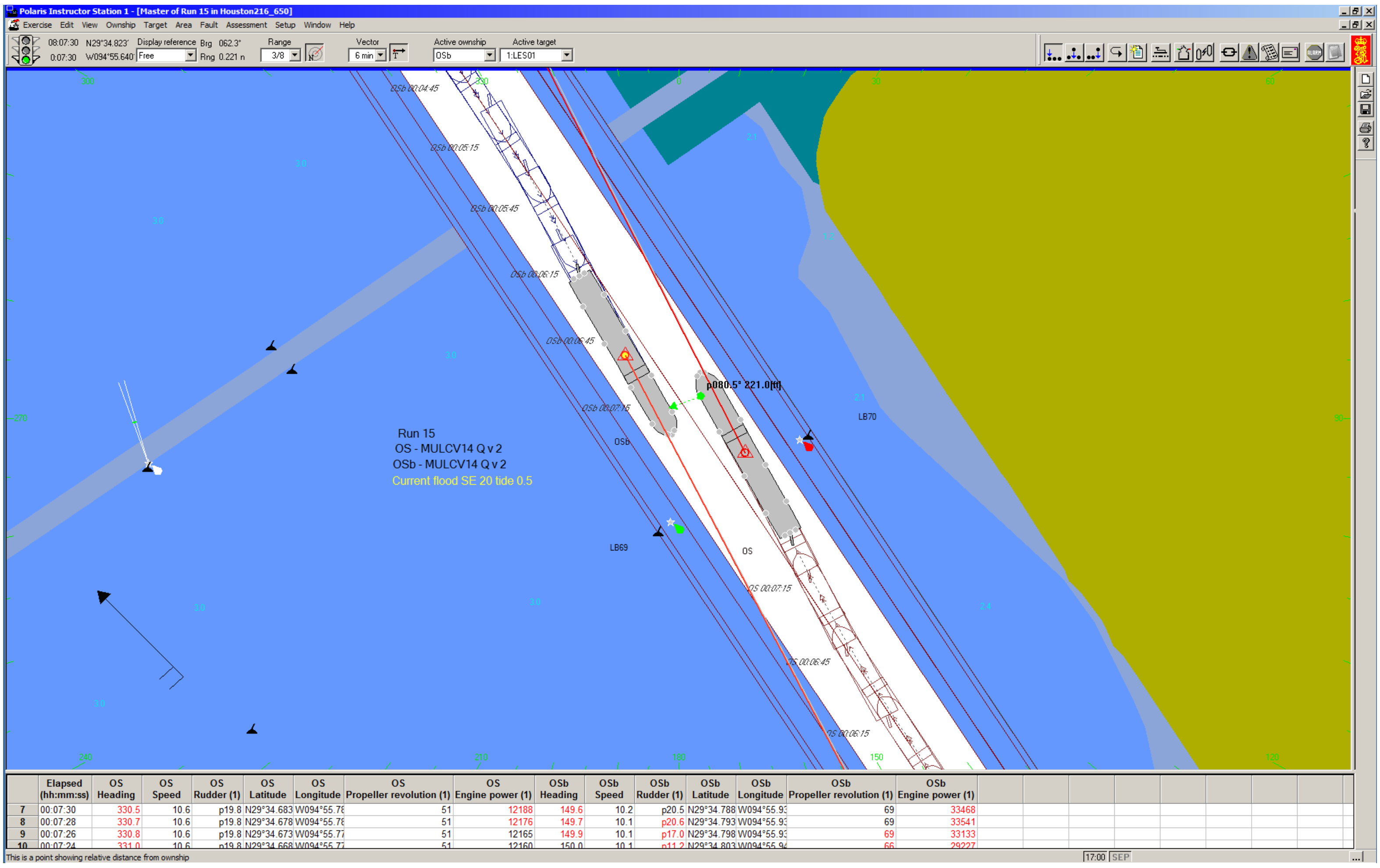


08:06:21 N29°34.791′ Display reference: Free Brg 072.7° Rng 0.240 n
0:06:21 W094°55.602′ Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:20	331.4	10.6	p20.5	N29°34.501	W094°55.67	51	12212	151.4	9.6	p29.8	N29°34.957	W094°56.03	65	27724
8	00:06:18	331.2	10.6	p20.5	N29°34.496	W094°55.66	51	12218	151.2	9.6	p27.2	N29°34.961	W094°56.03	65	27893
9	00:06:16	331.0	10.6	p16.5	N29°34.491	W094°55.66	51	12223	151.0	9.5	p21.5	N29°34.966	W094°56.04	65	27866
10	00:06:14	330.7	10.6	p11.3	N29°34.486	W094°55.66	51	12225	150.7	9.5	p19.8	N29°34.971	W094°56.04	65	27867

This is an own ship track history shape



08:07:30 N29°34.823′ Display reference: Free Brg 062.3° Rng 0.221 n
0:07:30 W094°55.640′ Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:30	330.5	10.6	p19.8	N29°34.683	W094°55.78	51	12188	149.6	10.2	p20.5	N29°34.788	W094°55.93	69	33468
8	00:07:28	330.7	10.6	p19.8	N29°34.678	W094°55.78	51	12176	149.7	10.1	p20.6	N29°34.793	W094°55.93	69	33541
9	00:07:26	330.8	10.6	p19.8	N29°34.673	W094°55.77	51	12165	149.9	10.1	p17.0	N29°34.798	W094°55.93	69	33133
10	00:07:24	331.0	10.6	p19.8	N29°34.668	W094°55.77	51	12160	150.0	10.1	p11.2	N29°34.803	W094°55.94	66	29227

This is a point showing relative distance from ownship

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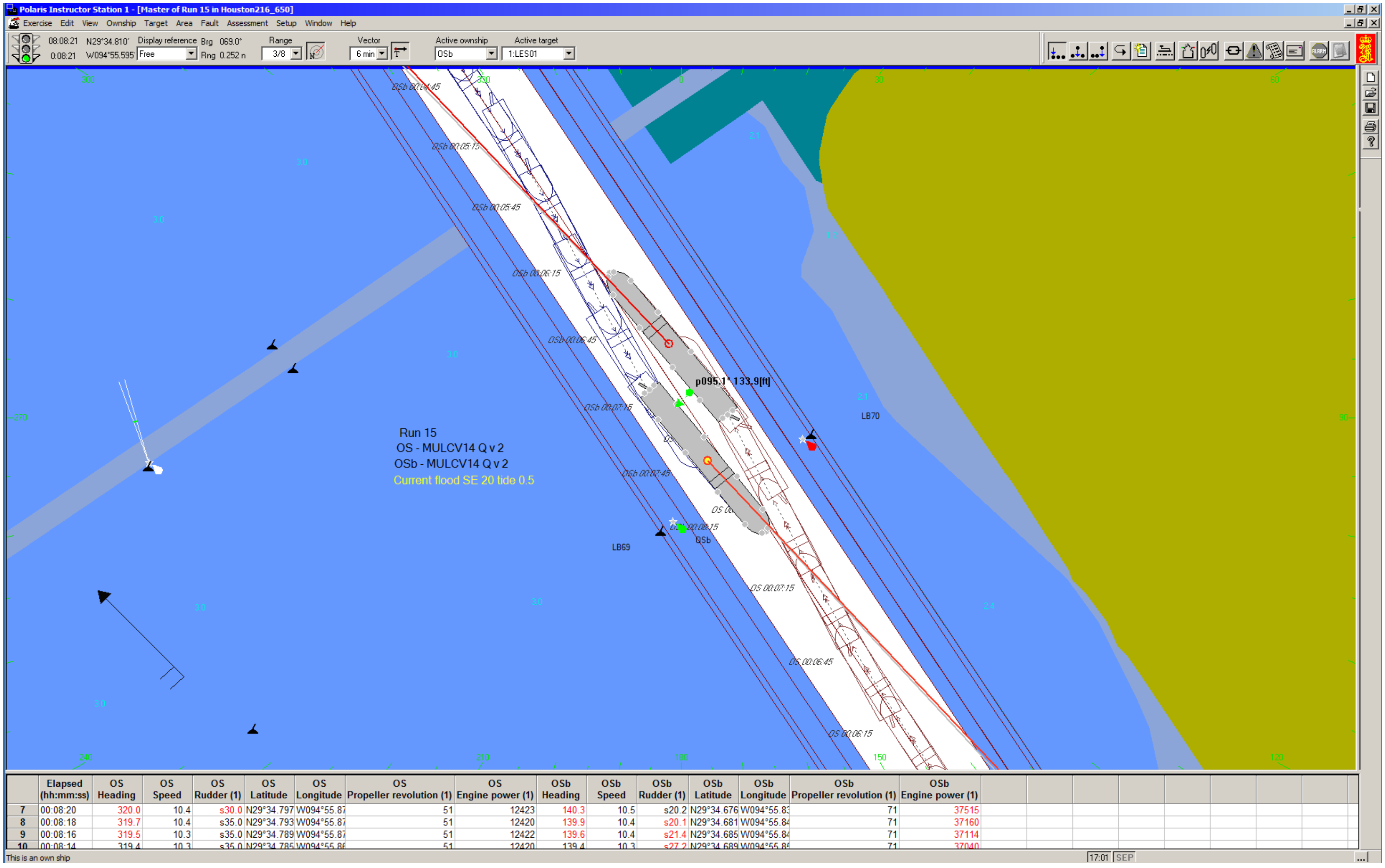


Polaris Instructor Station 1 - [Master of Run 15 in Houston216_650]

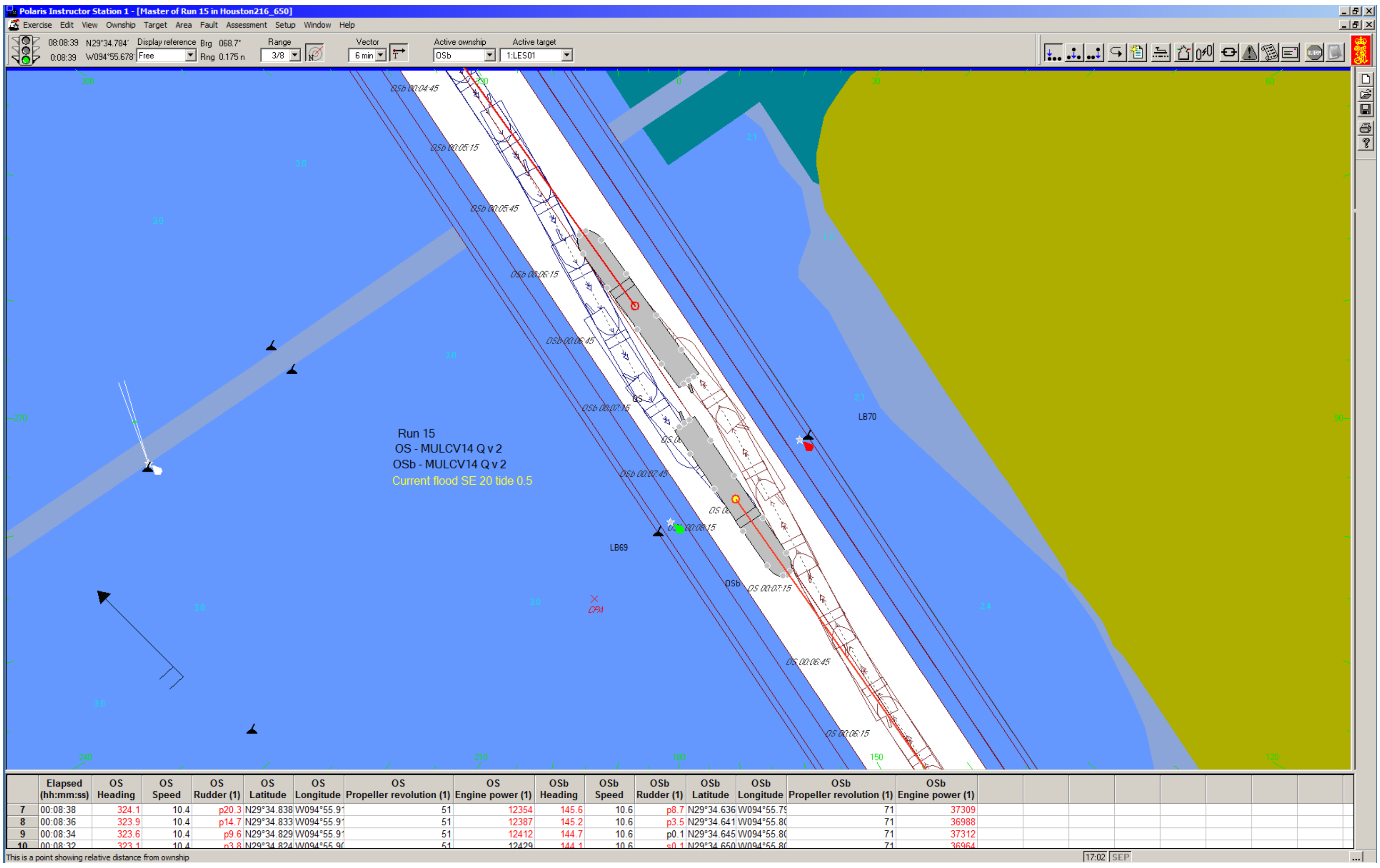
08:08:21 N29°34.810′
0:08:21 W094°55.595′
Display reference: Free
Brg 069.0°
Rng 0.252 n
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:20	320.0	10.4	s30.0	N29°34.797	W094°55.87	51	12423	140.3	10.5	s20.2	N29°34.676	W094°55.83	71	37515
8	00:08:18	319.7	10.4	s35.0	N29°34.793	W094°55.87	51	12420	139.9	10.4	s20.1	N29°34.681	W094°55.84	71	37160
9	00:08:16	319.5	10.3	s35.0	N29°34.789	W094°55.87	51	12422	139.6	10.4	s21.4	N29°34.685	W094°55.84	71	37114
10	00:08:14	319.4	10.3	s35.0	N29°34.785	W094°55.86	51	12420	139.4	10.3	s27.2	N29°34.689	W094°55.85	71	37040

This is an own ship

17:01 SEP



Polaris Instructor Station 1 - [Master of Run 15 in Houston216_650]

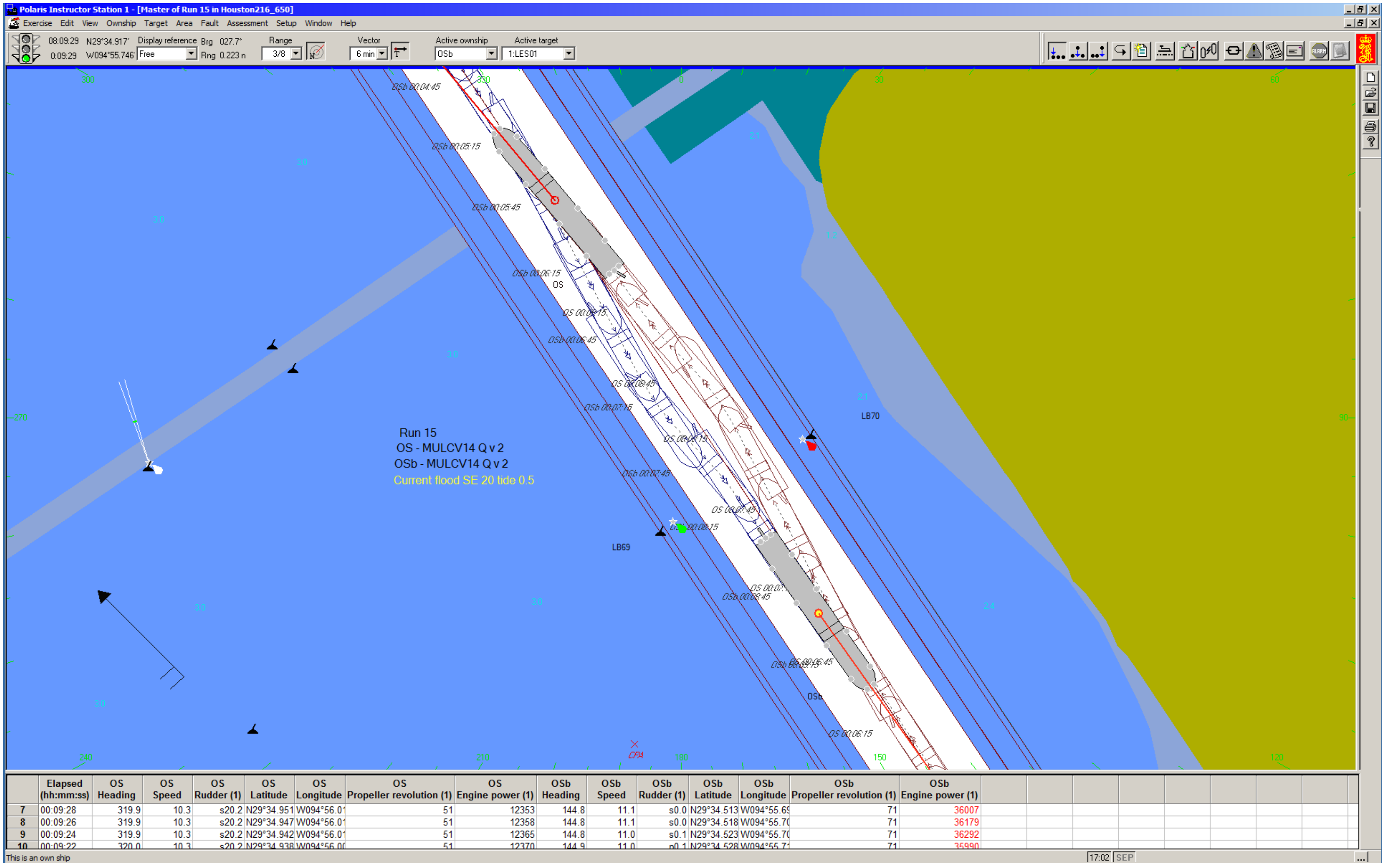
08:08:39 N29°34.784′
0:08:39 W094°55.678′
Display reference: Free
Brg 068.7°
Rng 0.175 n
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:38	324.1	10.4	p20.3	N29°34.838	W094°55.91	51	12354	145.6	10.6	p8.7	N29°34.636	W094°55.79	71	37309
8	00:08:36	323.9	10.4	p14.7	N29°34.833	W094°55.91	51	12387	145.2	10.6	p3.5	N29°34.641	W094°55.80	71	36988
9	00:08:34	323.6	10.4	p9.6	N29°34.829	W094°55.91	51	12412	144.7	10.6	p0.1	N29°34.645	W094°55.80	71	37312
10	00:08:32	323.1	10.4	p3.8	N29°34.824	W094°55.90	51	12429	144.1	10.6	s0.1	N29°34.650	W094°55.80	71	36964

This is a point showing relative distance from ownship

17:02 SEP



Polaris Instructor Station 1 - [Master of Run 15 in Houston216_650]

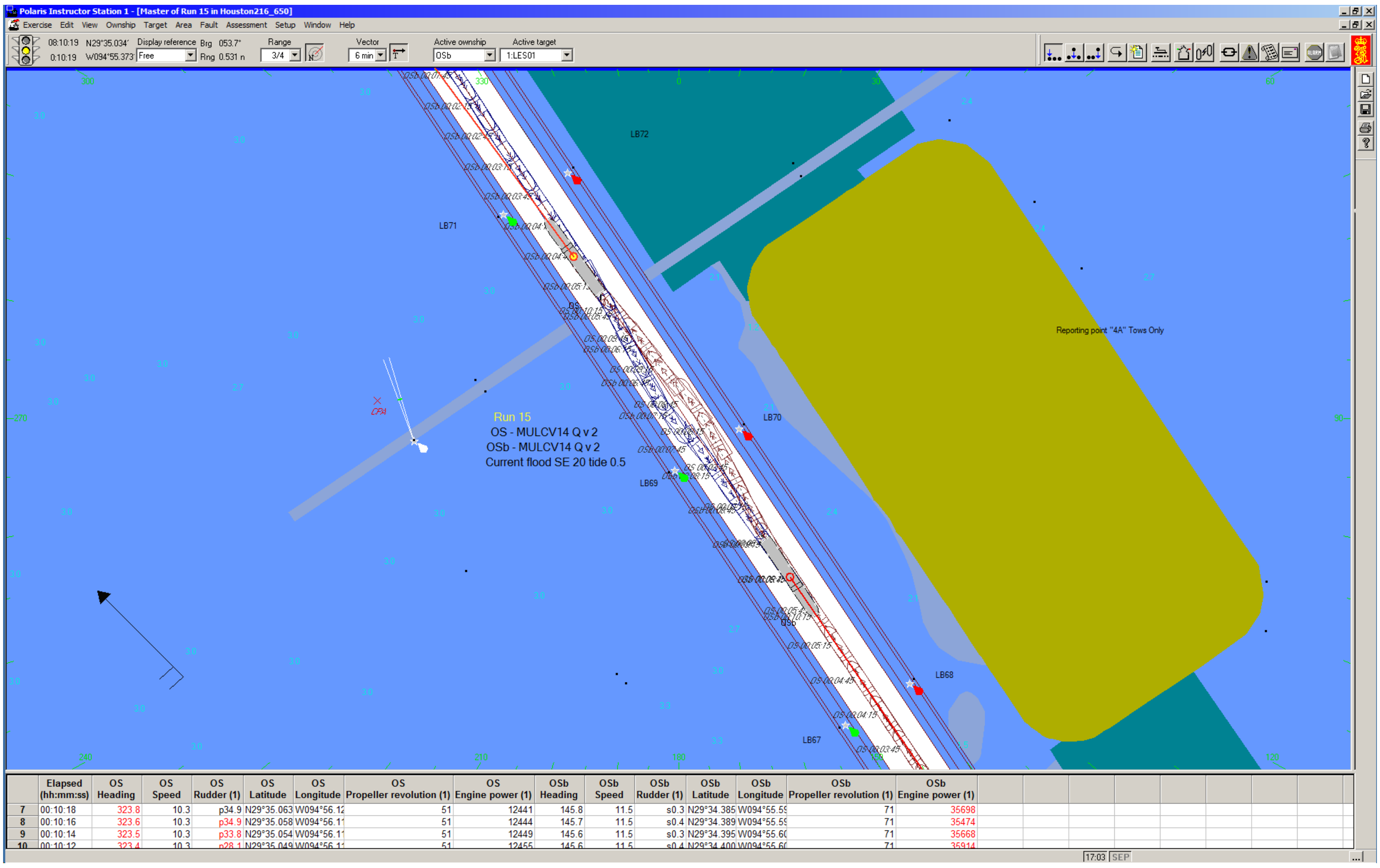
08:09:29 N29°34.917′ Display reference: Free Brg 027.7° Rng 0.223 n
0:09:29 W094°55.746′
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:28	319.9	10.3	s20.2	N29°34.951	W094°56.0	51	12353	144.8	11.1	s0.0	N29°34.513	W094°55.6	71	36007
8	00:09:26	319.9	10.3	s20.2	N29°34.947	W094°56.0	51	12358	144.8	11.1	s0.0	N29°34.518	W094°55.7	71	36179
9	00:09:24	319.9	10.3	s20.2	N29°34.942	W094°56.0	51	12365	144.8	11.0	s0.1	N29°34.523	W094°55.7	71	36292
10	00:09:22	320.0	10.3	s20.2	N29°34.938	W094°56.0	51	12370	144.9	11.0	p0.1	N29°34.528	W094°55.7	71	35990

This is an own ship

17:02 SEP



Polaris Instructor Station 1 - [Master of Run 15 in Houston216_650]

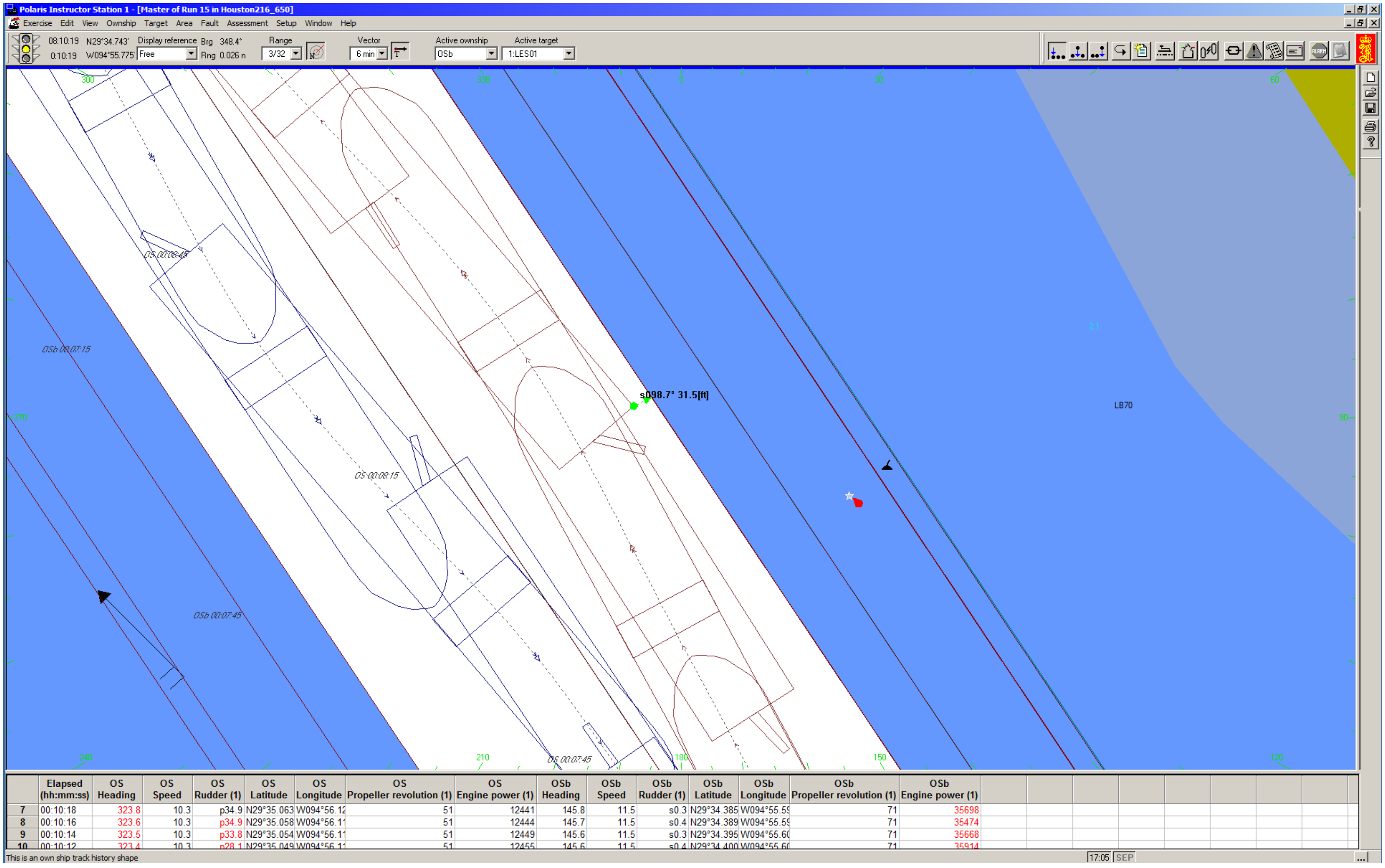
08:10:19 N29°35.034′ Display reference: Free Brg 053.7° Rng 0.531 n
0:10:19 W094°55.373′
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 15
OS - MULCV14 Q v 2
OSb - MULCV14 Q v 2
Current flood SE 20 tide 0.5

Reporting point "4A" Tows Only

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:10:18	323.8	10.3	p34.9	N29°35.063	W094°56.1	51	12441	145.8	11.5	s0.3	N29°34.385	W094°55.5	71	35698
8	00:10:16	323.6	10.3	p34.9	N29°35.058	W094°56.1	51	12444	145.7	11.5	s0.4	N29°34.389	W094°55.5	71	35474
9	00:10:14	323.5	10.3	p33.8	N29°35.054	W094°56.1	51	12449	145.6	11.5	s0.3	N29°34.395	W094°55.6	71	35668
10	00:10:12	323.4	10.3	p28.1	N29°35.049	W094°56.1	51	12455	145.6	11.5	s0.4	N29°34.400	W094°55.6	71	35914

17:03 SEP

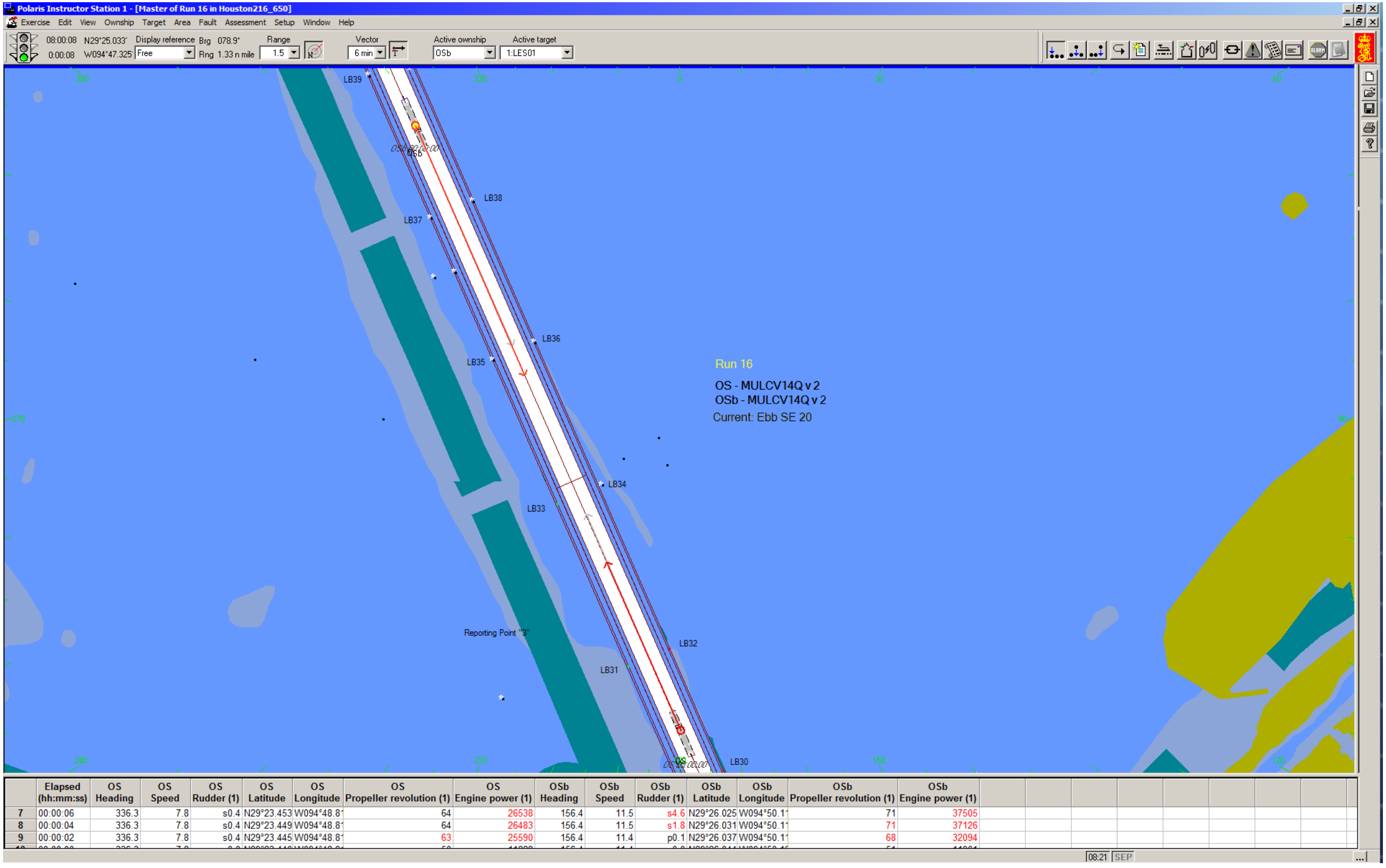

Polaris Instructor Station 1 - [Master of Run 15 in Houston216_650]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:10:18	323.8	10.3	p34.9	N29°35.063	W094°56.12	51	12441	145.8	11.5	s0.3	N29°34.385	W094°55.5	71	35698
8	00:10:16	323.6	10.3	p34.9	N29°35.058	W094°56.1	51	12444	145.7	11.5	s0.4	N29°34.389	W094°55.5	71	35474
9	00:10:14	323.5	10.3	p33.8	N29°35.054	W094°56.1	51	12449	145.6	11.5	s0.3	N29°34.395	W094°55.6	71	35668
10	00:10:12	323.4	10.3	p28.1	N29°35.049	W094°56.1	51	12455	145.6	11.5	s0.4	N29°34.400	W094°55.6	71	35914

This is an own ship track history shape

Appendix L: Houston Ship Channel Bay Sections Simulations

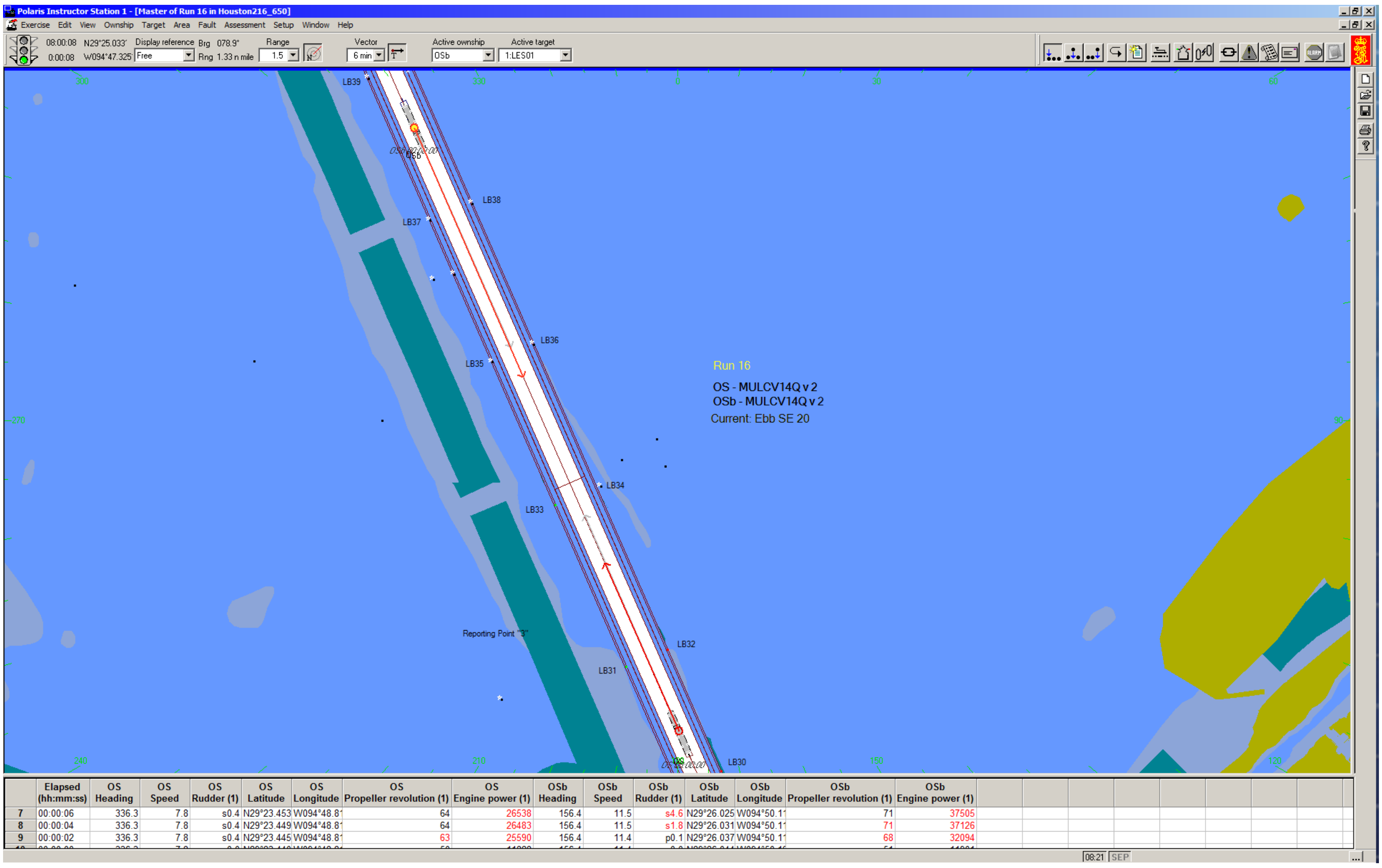
Run 16 – Begin 650 ft HSC Widening with Bend Widening



Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:00:08 N29°25.033′ Display reference: Free Brg 078.9°
0:00:08 W094°47.325′ Rng 1.33 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

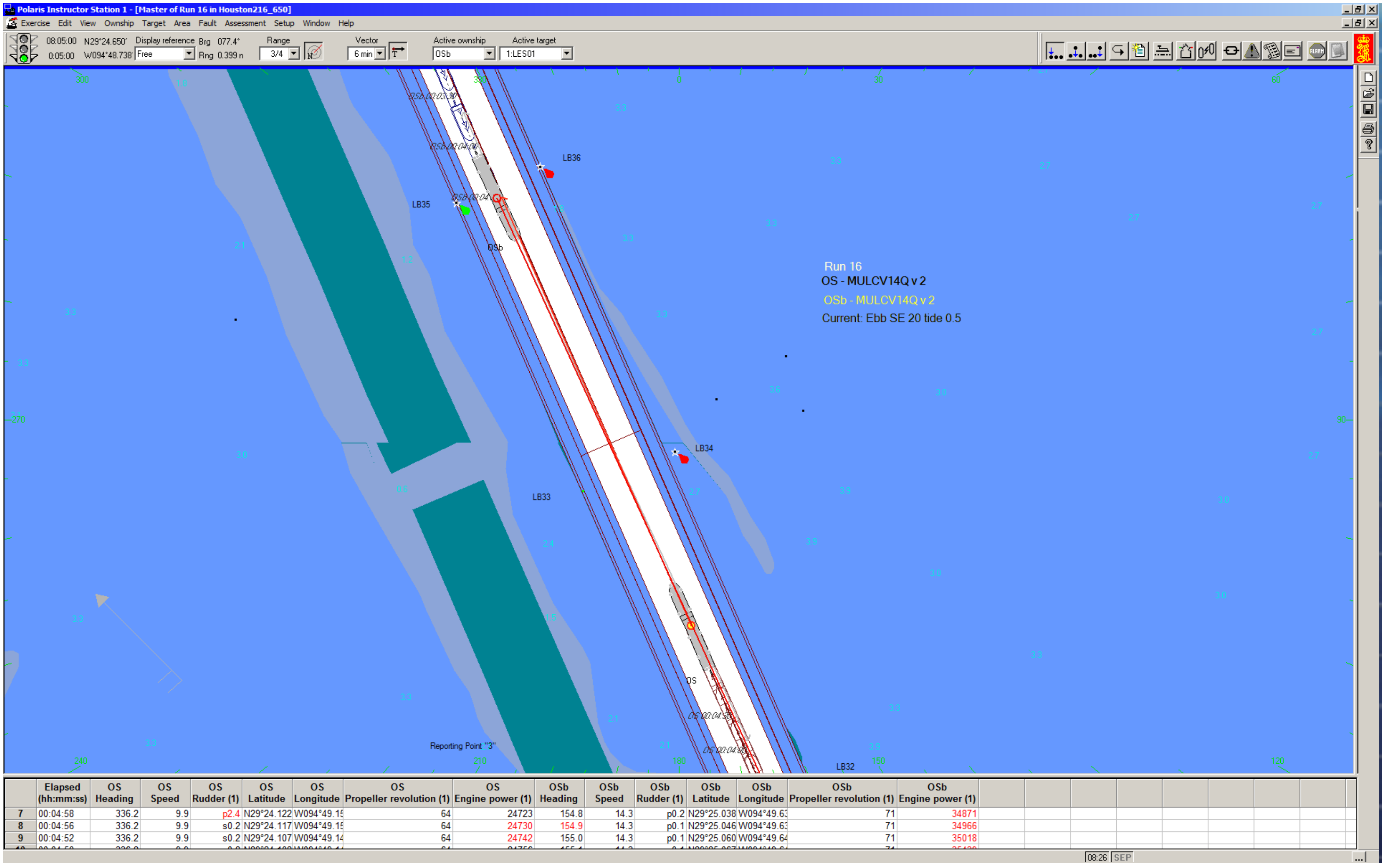
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:00:06	336.3	7.8	s0.4	N29°23.453	W094°48.8	64	26538	156.4	11.5	s4.6	N29°26.025	W094°50.1	71	37505
8	00:00:04	336.3	7.8	s0.4	N29°23.449	W094°48.8	64	26483	156.4	11.5	s1.8	N29°26.031	W094°50.1	71	37126
9	00:00:02	336.3	7.8	s0.4	N29°23.445	W094°48.8	63	25590	156.4	11.4	p0.1	N29°26.037	W094°50.1	68	32094



Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:00:08 N29°25.033′ Display reference: Free Brg 078.9°
0:00:08 W094°47.325′ Rng 1.33 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:00:06	336.3	7.8	s0.4	N29°23.453	W094°48.8	64	26538	156.4	11.5	s4.6	N29°26.025	W094°50.1	71	37505
8	00:00:04	336.3	7.8	s0.4	N29°23.449	W094°48.8	64	26483	156.4	11.5	s1.8	N29°26.031	W094°50.1	71	37126
9	00:00:02	336.3	7.8	s0.4	N29°23.445	W094°48.8	63	25590	156.4	11.4	p0.1	N29°26.037	W094°50.1	68	32094

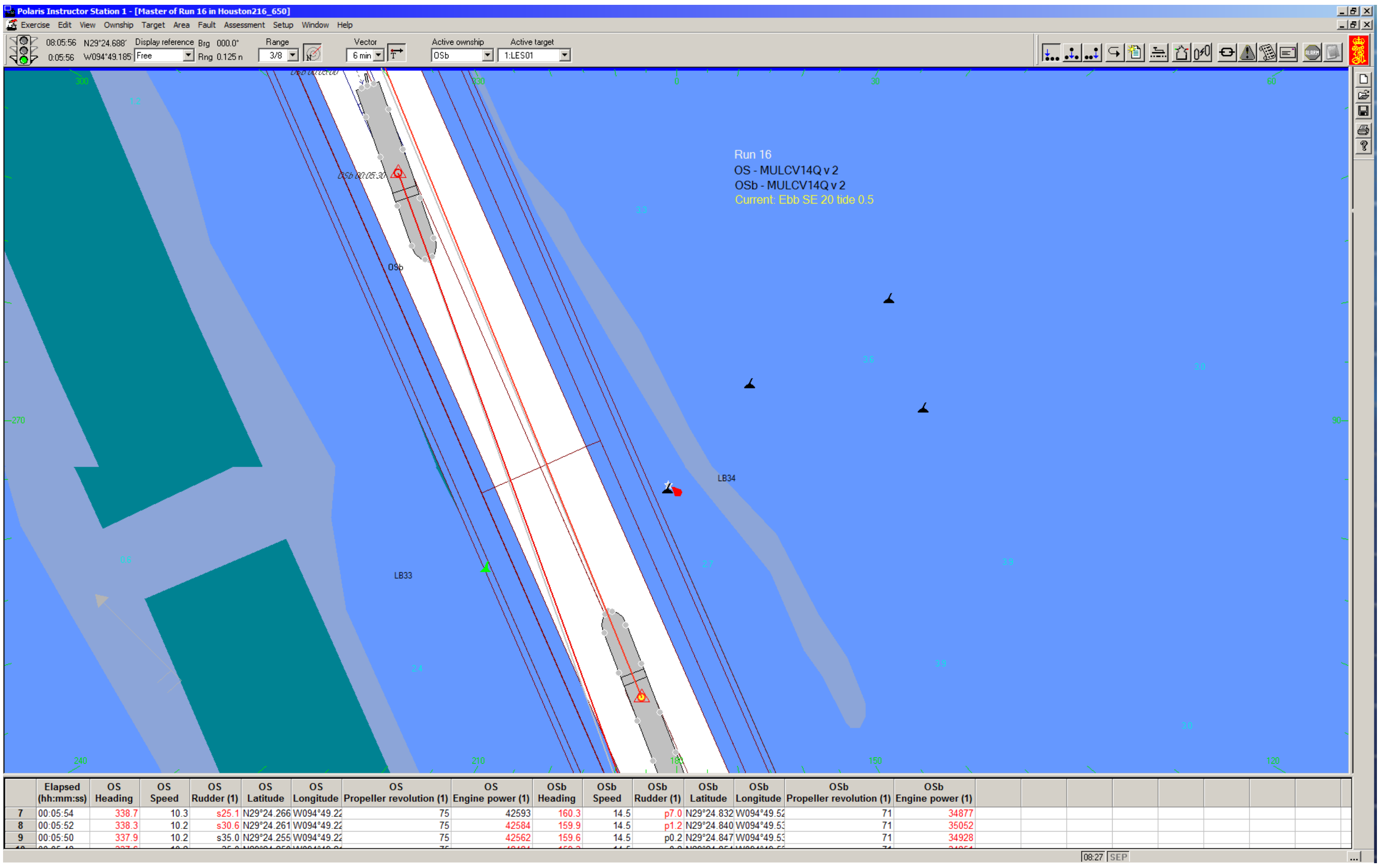


Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:05:00 N29°24.650' W094°48.738'
0:05:00
Display reference: Free
Brg 077.4°
Rng 0.399 n
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 16
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:04:58	336.2	9.9	p2.4	N29°24.122	W094°49.15	64	24723	154.8	14.3	p0.2	N29°25.038	W094°49.63	71	34871
8	00:04:56	336.2	9.9	s0.2	N29°24.117	W094°49.15	64	24730	154.9	14.3	p0.1	N29°25.046	W094°49.63	71	34966
9	00:04:52	336.2	9.9	s0.2	N29°24.107	W094°49.14	64	24742	155.0	14.3	p0.1	N29°25.060	W094°49.64	71	35018



Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:05:56 N29°24.688' W094°49.185'
0:05:56
Display reference: Free
Brg 000.0°
Rng 0.125 n
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 16
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:54	338.7	10.3	s25.1	N29°24.266	W094°49.22	75	42593	160.3	14.5	p7.0	N29°24.832	W094°49.52	71	34877
8	00:05:52	338.3	10.2	s30.6	N29°24.261	W094°49.22	75	42584	159.9	14.5	p1.2	N29°24.840	W094°49.53	71	35052
9	00:05:50	337.9	10.2	s35.0	N29°24.255	W094°49.22	75	42562	159.6	14.5	p0.2	N29°24.847	W094°49.53	71	34928

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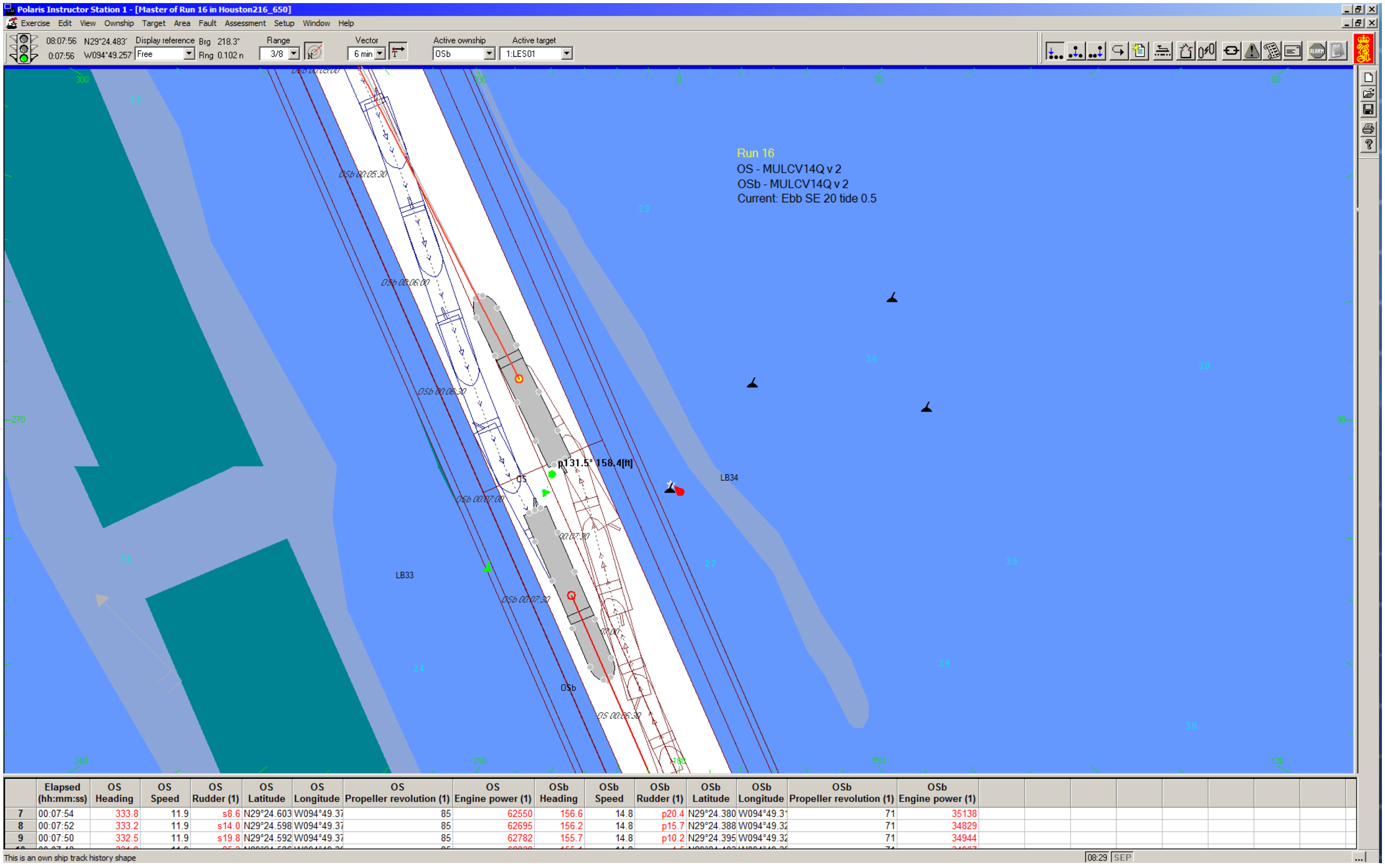
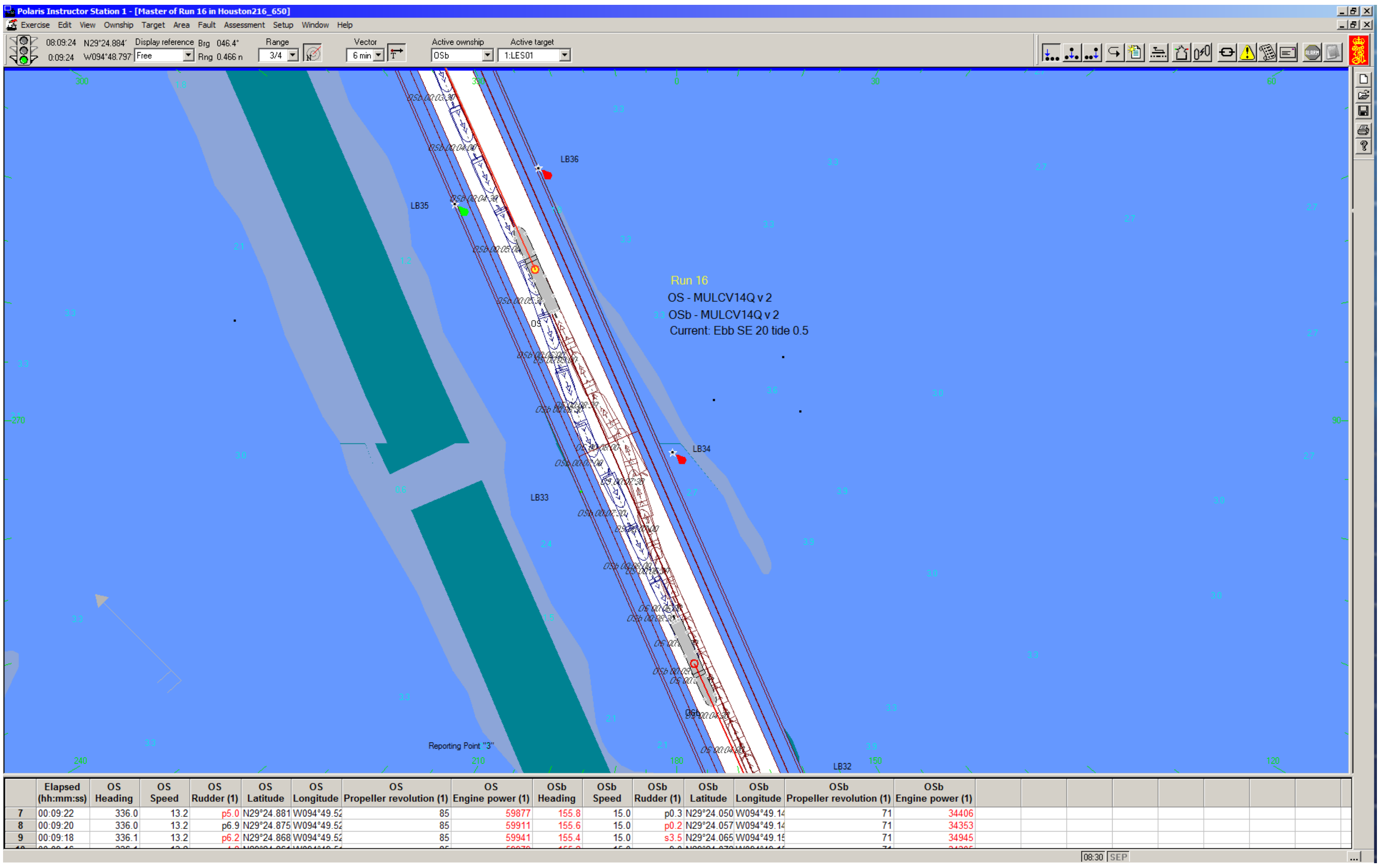

Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:07:56 N29°24.483' Display reference: Free Brg 218.3° Rng 0.102 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:07:56 W094°49.257

Run 16
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:54	333.8	11.9	s8.6	N29°24.603	W094°49.37	85	62550	156.6	14.8	p20.4	N29°24.380	W094°49.31	71	35138
8	00:07:52	333.2	11.9	s14.0	N29°24.598	W094°49.37	85	62695	156.2	14.8	p15.7	N29°24.388	W094°49.32	71	34829
9	00:07:50	332.5	11.9	s19.8	N29°24.592	W094°49.37	85	62782	155.7	14.8	p10.2	N29°24.395	W094°49.32	71	34944

This is an own ship track history shape


Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

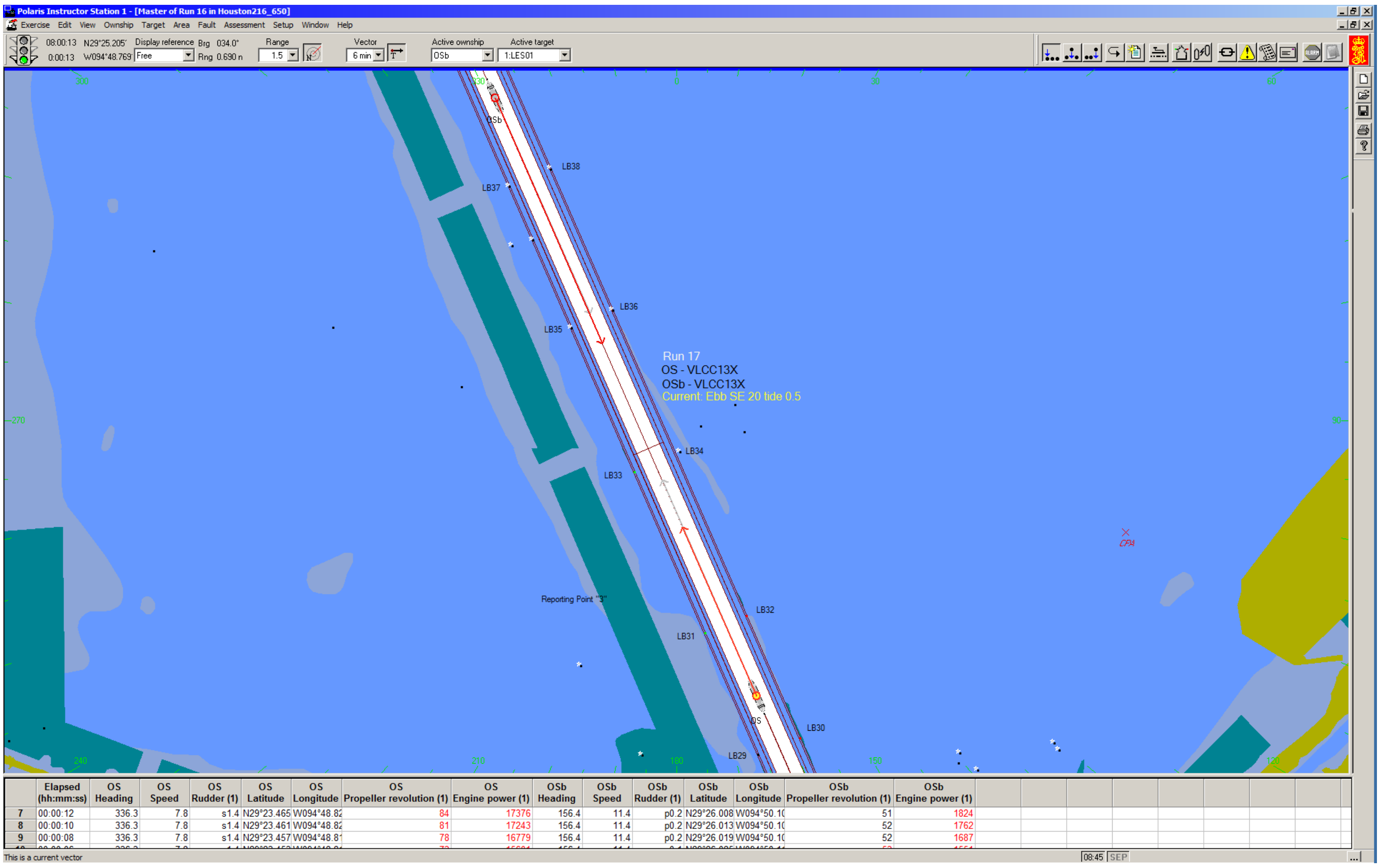
08:09:24 N29°24.884' Display reference: Free Brg 046.4° Rng 0.466 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:09:24 W094°48.797

Run 16
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:22	336.0	13.2	p5.0	N29°24.881	W094°49.52	85	59877	155.8	15.0	p0.3	N29°24.050	W094°49.14	71	34406
8	00:09:20	336.0	13.2	p6.9	N29°24.875	W094°49.52	85	59911	155.6	15.0	p0.2	N29°24.057	W094°49.14	71	34353
9	00:09:18	336.1	13.2	p6.2	N29°24.868	W094°49.52	85	59941	155.4	15.0	s3.5	N29°24.065	W094°49.15	71	34945

June 26, 2019

Run 17


Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

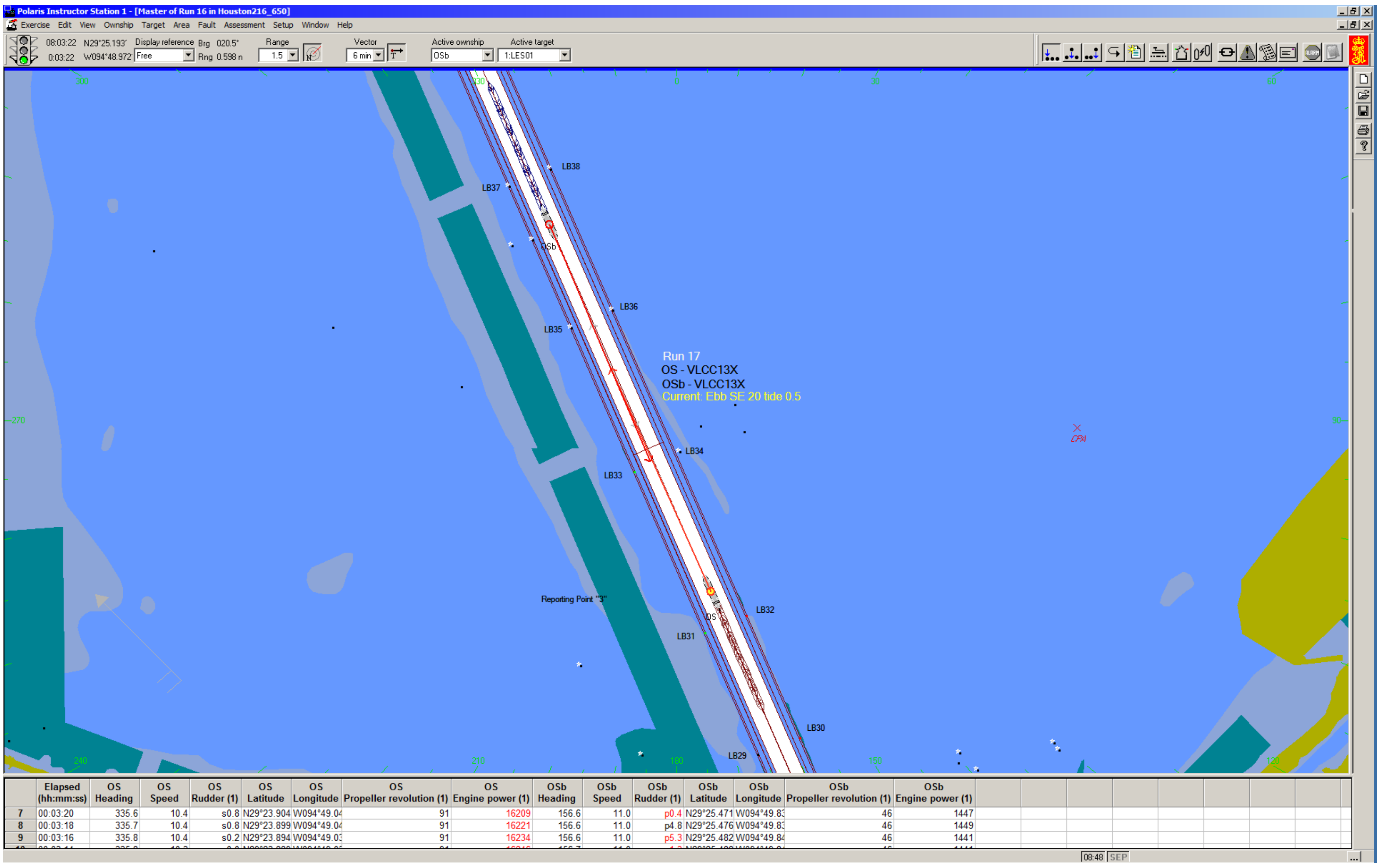
08:00:13 N29°25.205′ Display reference: Free Brg 034.0° Range 1.5 Vector 6 min Active ownship OSb Active target 1:LES01

0:00:13 W094°48.769′ Rng 0.690 n

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:00:12	336.3	7.8	s1.4	N29°23.465	W094°48.82	84	17376	156.4	11.4	p0.2	N29°26.008	W094°50.1	51	1824
8	00:00:10	336.3	7.8	s1.4	N29°23.461	W094°48.82	81	17243	156.4	11.4	p0.2	N29°26.013	W094°50.1	52	1762
9	00:00:08	336.3	7.8	s1.4	N29°23.457	W094°48.81	78	16779	156.4	11.4	p0.2	N29°26.019	W094°50.1	52	1687

This is a current vector

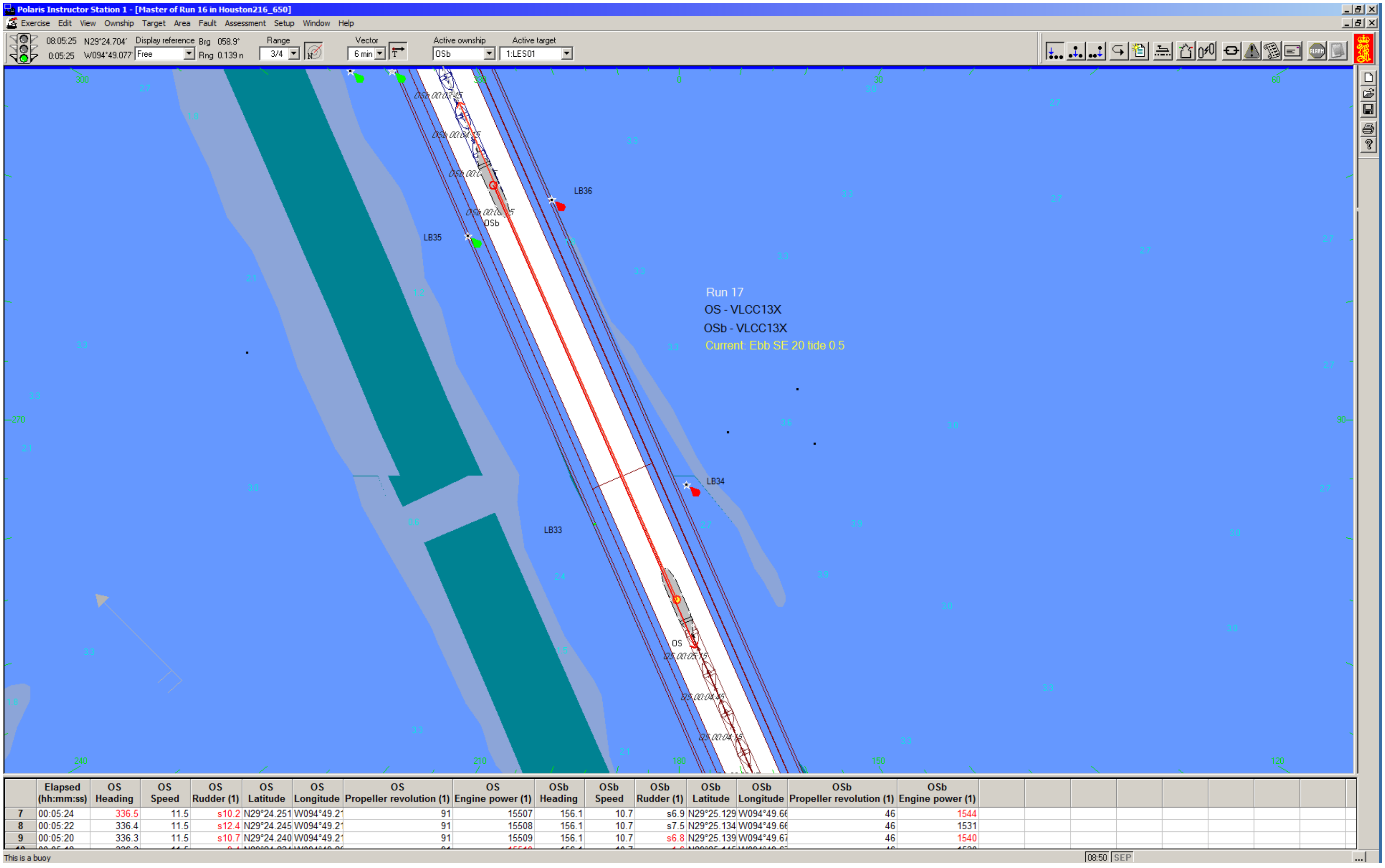

Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:03:22 N29°25.193′ Display reference: Free Brg 020.5° Range 1.5 Vector 6 min Active ownship OSb Active target 1:LES01

0:03:22 W094°48.972′ Rng 0.598 n

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:20	335.6	10.4	s0.8	N29°23.904	W094°49.04	91	16209	156.6	11.0	p0.4	N29°25.471	W094°49.83	46	1447
8	00:03:18	335.7	10.4	s0.8	N29°23.899	W094°49.04	91	16221	156.6	11.0	p4.8	N29°25.476	W094°49.83	46	1449
9	00:03:16	335.8	10.4	s0.2	N29°23.894	W094°49.03	91	16234	156.6	11.0	p5.3	N29°25.482	W094°49.84	46	1441

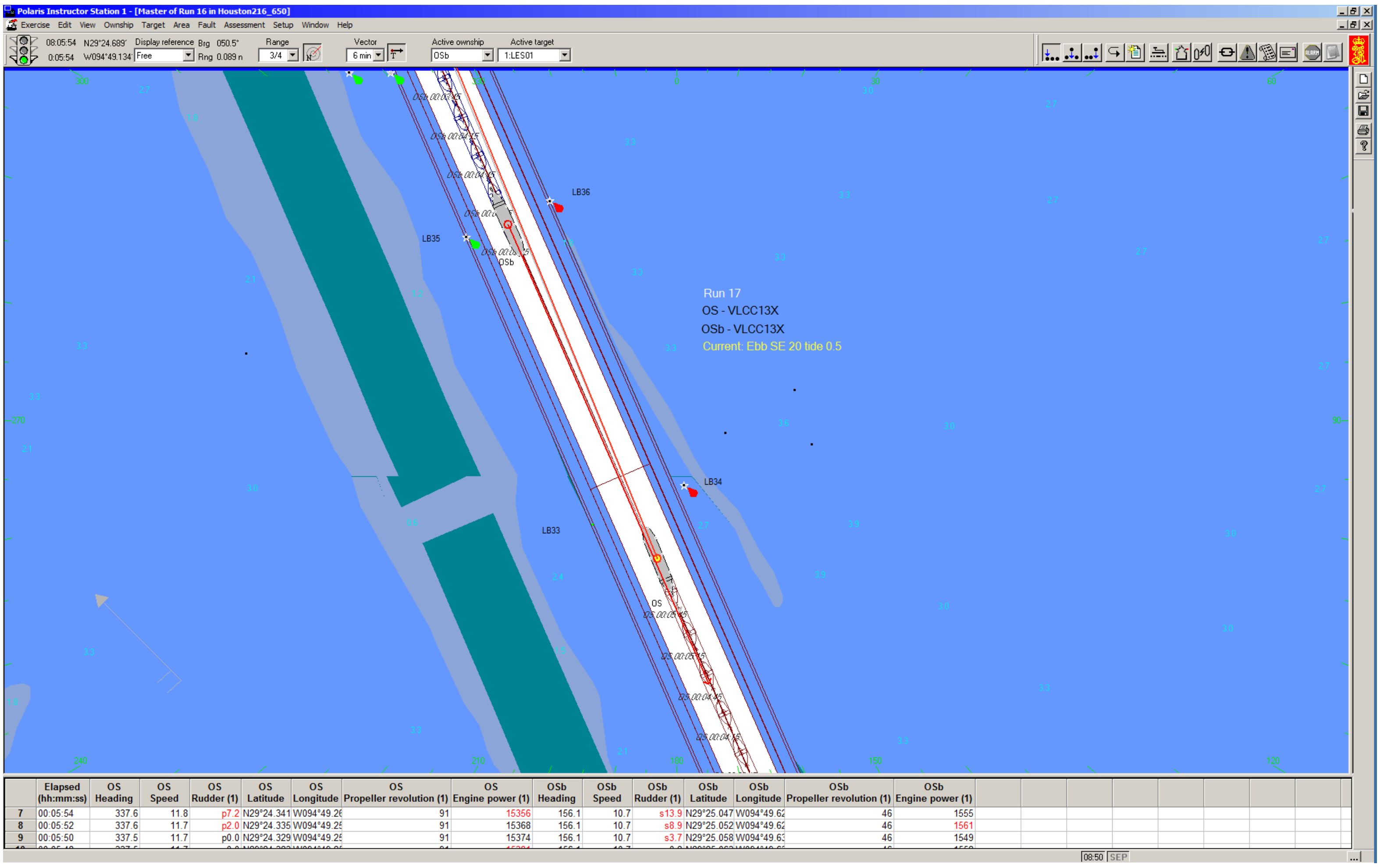


08:05:25 N29°24.704' Display reference Free Brg 058.9° Rng 0.139 n
0:05:25 W094°49.077'
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:24	336.5	11.5	s10.2	N29°24.251	W094°49.21	91	15507	156.1	10.7	s6.9	N29°25.129	W094°49.66	46	1544
8	00:05:22	336.4	11.5	s12.4	N29°24.245	W094°49.21	91	15508	156.1	10.7	s7.5	N29°25.134	W094°49.66	46	1531
9	00:05:20	336.3	11.5	s10.7	N29°24.240	W094°49.21	91	15509	156.1	10.7	s6.8	N29°25.139	W094°49.67	46	1540

This is a buoy



08:05:54 N29°24.689' Display reference Free Brg 050.5° Rng 0.089 n
0:05:54 W094°49.134'
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:05:54	337.6	11.8	p7.2	N29°24.341	W094°49.26	91	15356	156.1	10.7	s13.9	N29°25.047	W094°49.62	46	1555
8	00:05:52	337.6	11.7	p2.0	N29°24.335	W094°49.25	91	15368	156.1	10.7	s8.9	N29°25.052	W094°49.62	46	1561
9	00:05:50	337.5	11.7	p0.0	N29°24.329	W094°49.25	91	15374	156.1	10.7	s3.7	N29°25.058	W094°49.63	46	1549

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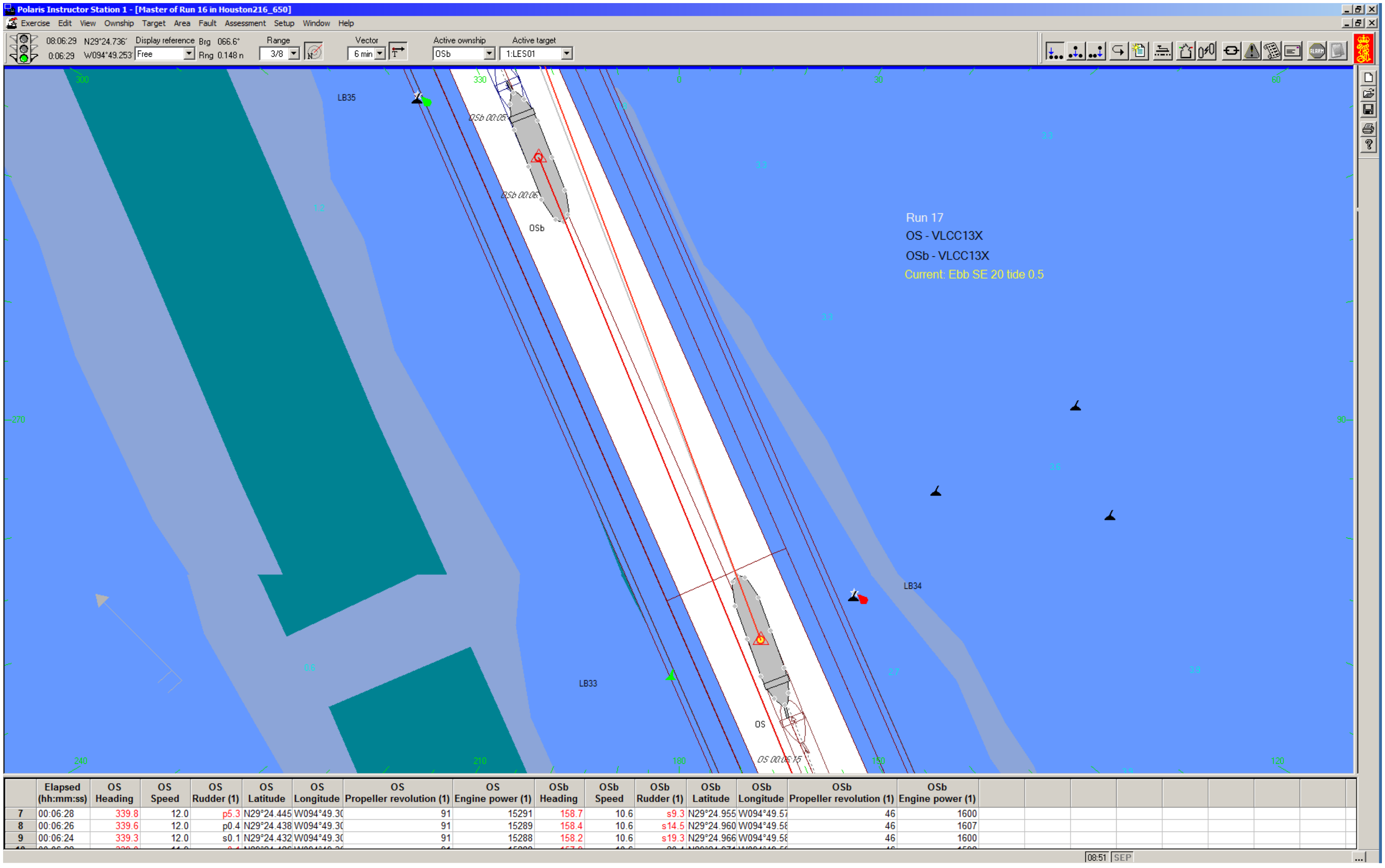


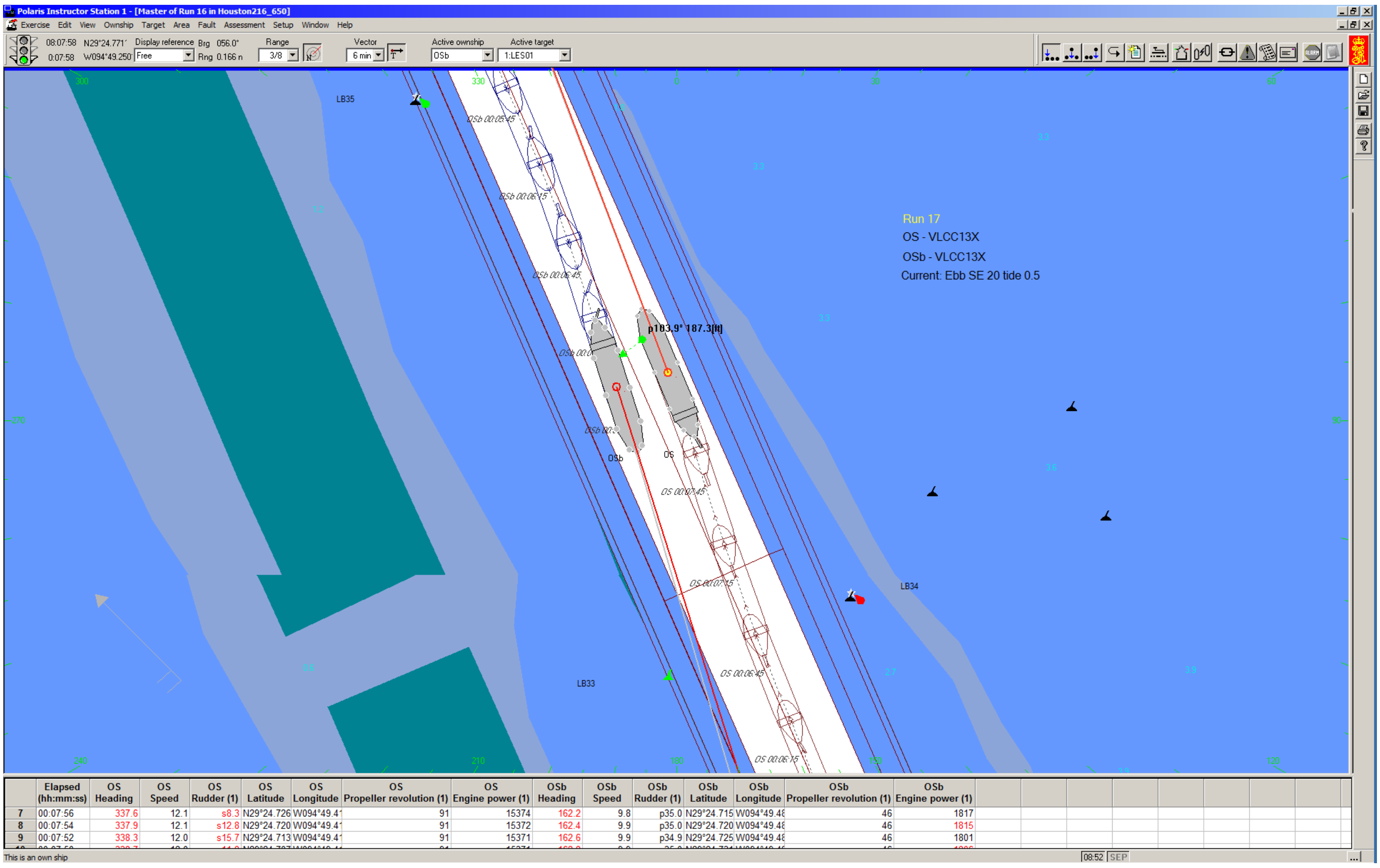
Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:06:29 N29°24.736' Display reference Free Brg 066.6° Rng 0.148 n
0:06:29 W094°49.253'

Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:28	339.8	12.0	p5.3	N29°24.445	W094°49.30	91	15291	158.7	10.6	s9.3	N29°24.955	W094°49.57	46	1600
8	00:06:26	339.6	12.0	p0.4	N29°24.438	W094°49.30	91	15289	158.4	10.6	s14.5	N29°24.960	W094°49.58	46	1607
9	00:06:24	339.3	12.0	s0.1	N29°24.432	W094°49.30	91	15288	158.2	10.6	s19.3	N29°24.966	W094°49.58	46	1600



Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

08:07:58 N29°24.771' Display reference Free Brg 056.0° Rng 0.166 n
0:07:58 W094°49.250'

Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01

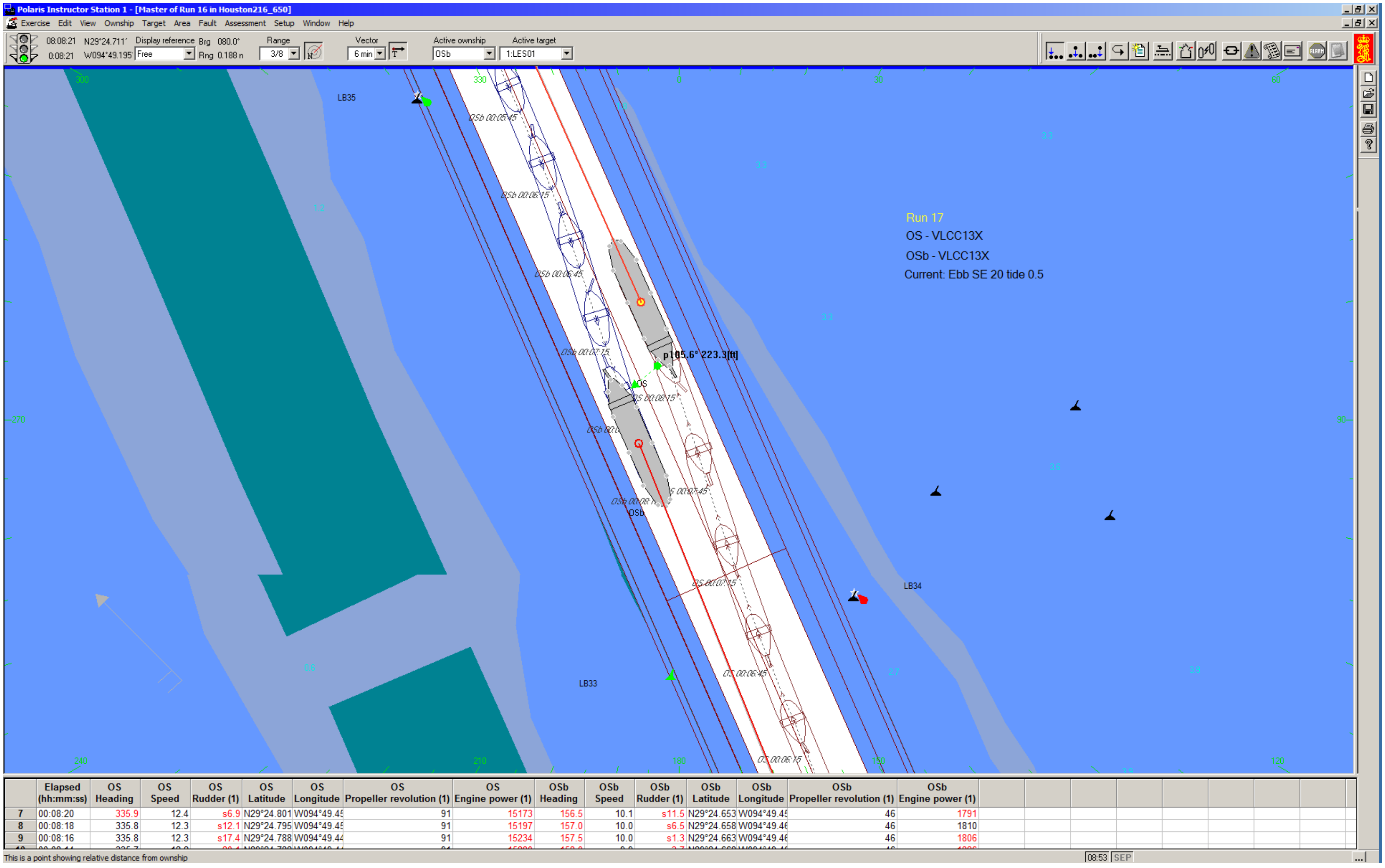
Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

p103.9° 187.3[ft]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:56	337.6	12.1	s8.3	N29°24.726	W094°49.41	91	15374	162.2	9.8	p35.0	N29°24.715	W094°49.48	46	1817
8	00:07:54	337.9	12.1	s12.8	N29°24.720	W094°49.41	91	15372	162.4	9.9	p35.0	N29°24.720	W094°49.48	46	1815
9	00:07:52	338.3	12.0	s15.7	N29°24.713	W094°49.41	91	15371	162.6	9.9	p34.9	N29°24.725	W094°49.48	46	1801

This is an own ship

June 26, 2019


Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

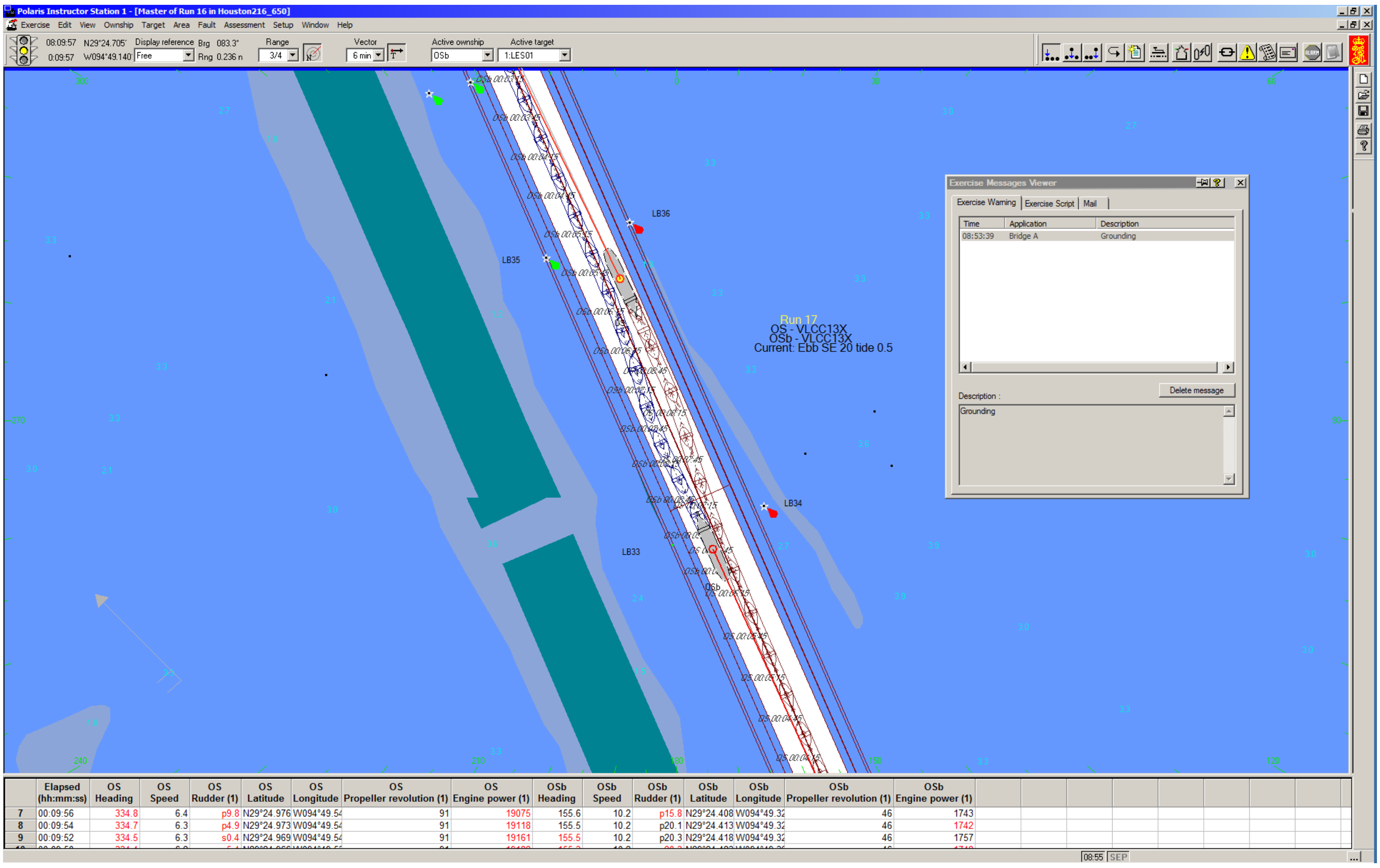
08:08:21 N29°24.711′ Display reference Brg 080.0°
0:08:21 W094°49.195′ Free Rng 0.188 n
Range 3/8
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:20	335.9	12.4	s6.9	N29°24.801	W094°49.45	91	15173	156.5	10.1	s11.5	N29°24.653	W094°49.45	46	1791
8	00:08:18	335.8	12.3	s12.1	N29°24.795	W094°49.45	91	15197	157.0	10.0	s6.5	N29°24.658	W094°49.46	46	1810
9	00:08:16	335.8	12.3	s17.4	N29°24.788	W094°49.44	91	15234	157.5	10.0	s1.3	N29°24.663	W094°49.46	46	1806

This is a point showing relative distance from ownship

08:53 SEP


Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:09:57 N29°24.705′ Display reference Brg 083.3°
0:09:57 W094°49.140′ Free Rng 0.236 n
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

Exercise Messages Viewer

Exercise Warning | Exercise Script | Mail

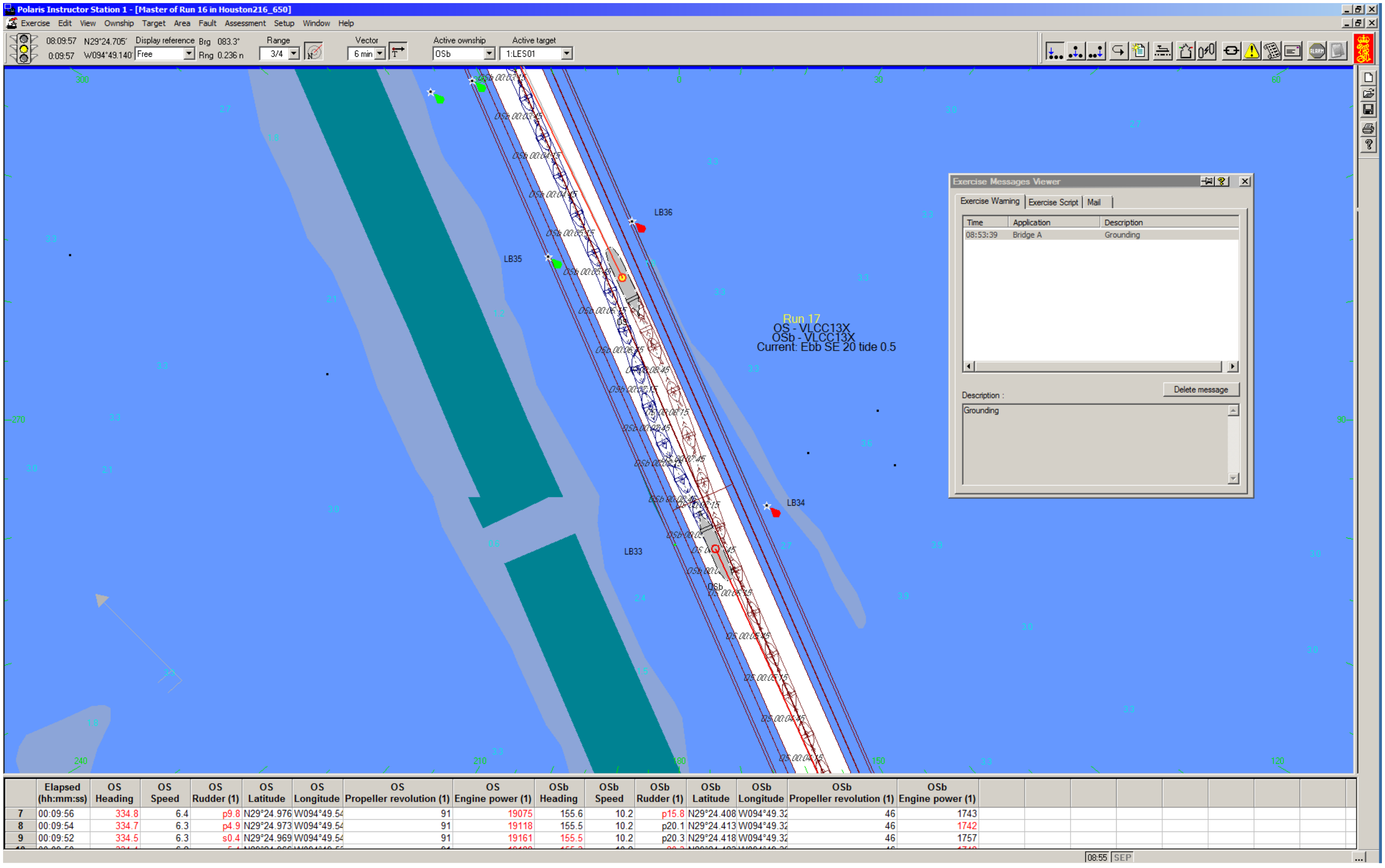
Time	Application	Description
08:53:39	Bridge A	Grounding

Description :
Grounding

Delete message

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:56	334.8	6.4	p9.8	N29°24.976	W094°49.54	91	19075	155.6	10.2	p15.8	N29°24.408	W094°49.32	46	1743
8	00:09:54	334.7	6.3	p4.9	N29°24.973	W094°49.54	91	19118	155.5	10.2	p20.1	N29°24.413	W094°49.32	46	1742
9	00:09:52	334.5	6.3	s0.4	N29°24.969	W094°49.54	91	19161	155.5	10.2	p20.3	N29°24.418	W094°49.32	46	1757

08:55 SEP



08:09:57 N29°24.705′ Display reference: Free Brg 083.3° Rng 0.236 n

0:09:57 W094°49.140′

Range: 3/4

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 17
OS - VLCC13X
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

Exercise Messages Viewer

Exercise Warning | Exercise Script | Mail

Time	Application	Description
08:53:39	Bridge A	Grounding

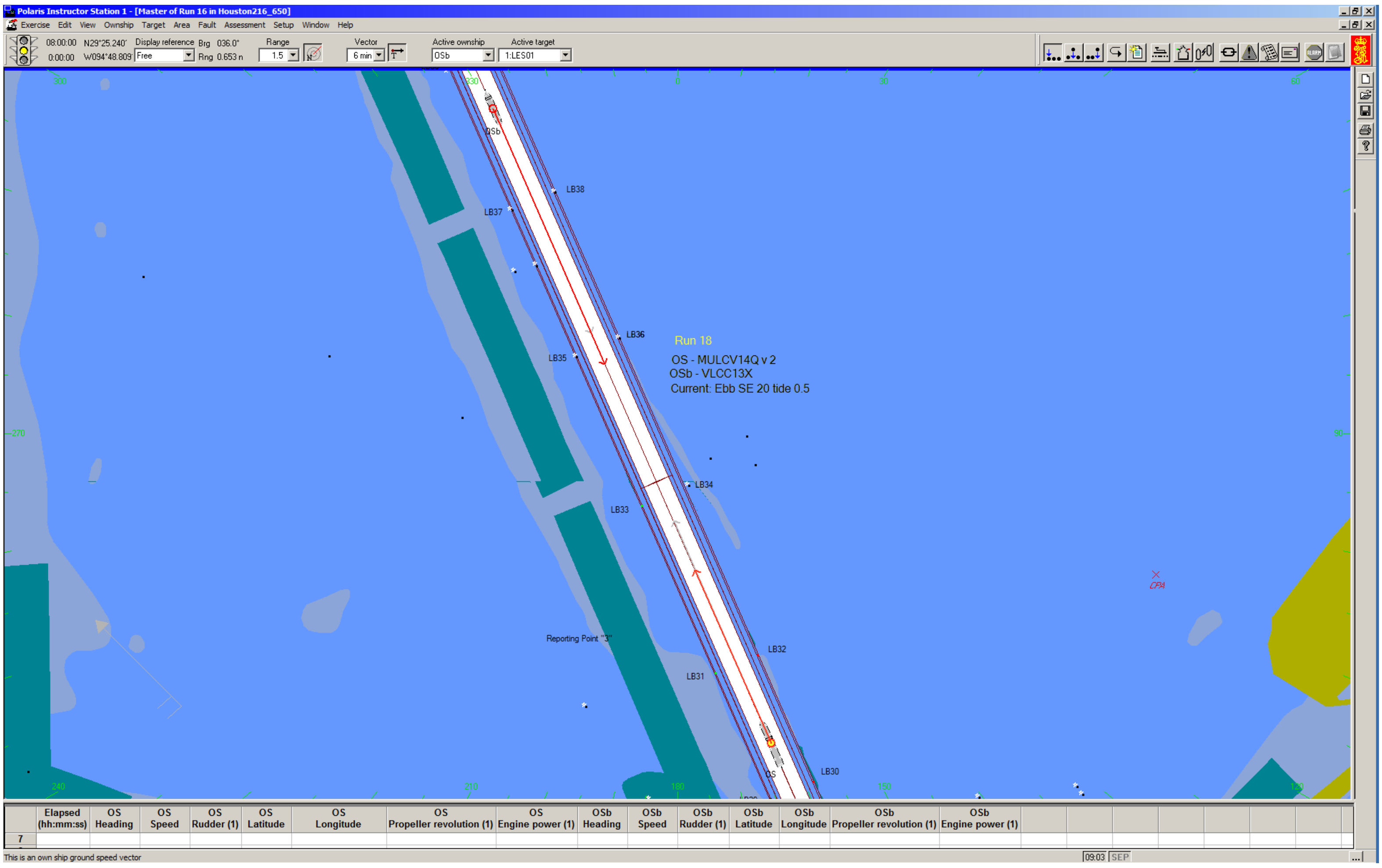
Description :

Grounding

Delete message

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:56	334.8	6.4	p9.8	N29°24.976	W094°49.54	91	19075	155.6	10.2	p15.8	N29°24.408	W094°49.32	46	1743
8	00:09:54	334.7	6.3	p4.9	N29°24.973	W094°49.54	91	19118	155.5	10.2	p20.1	N29°24.413	W094°49.32	46	1742
9	00:09:52	334.5	6.3	s0.4	N29°24.969	W094°49.54	91	19161	155.5	10.2	p20.3	N29°24.418	W094°49.32	46	1757

Run 18



Polaris Instructor Station 1 - [Master of Run 16 in Houston216_650]

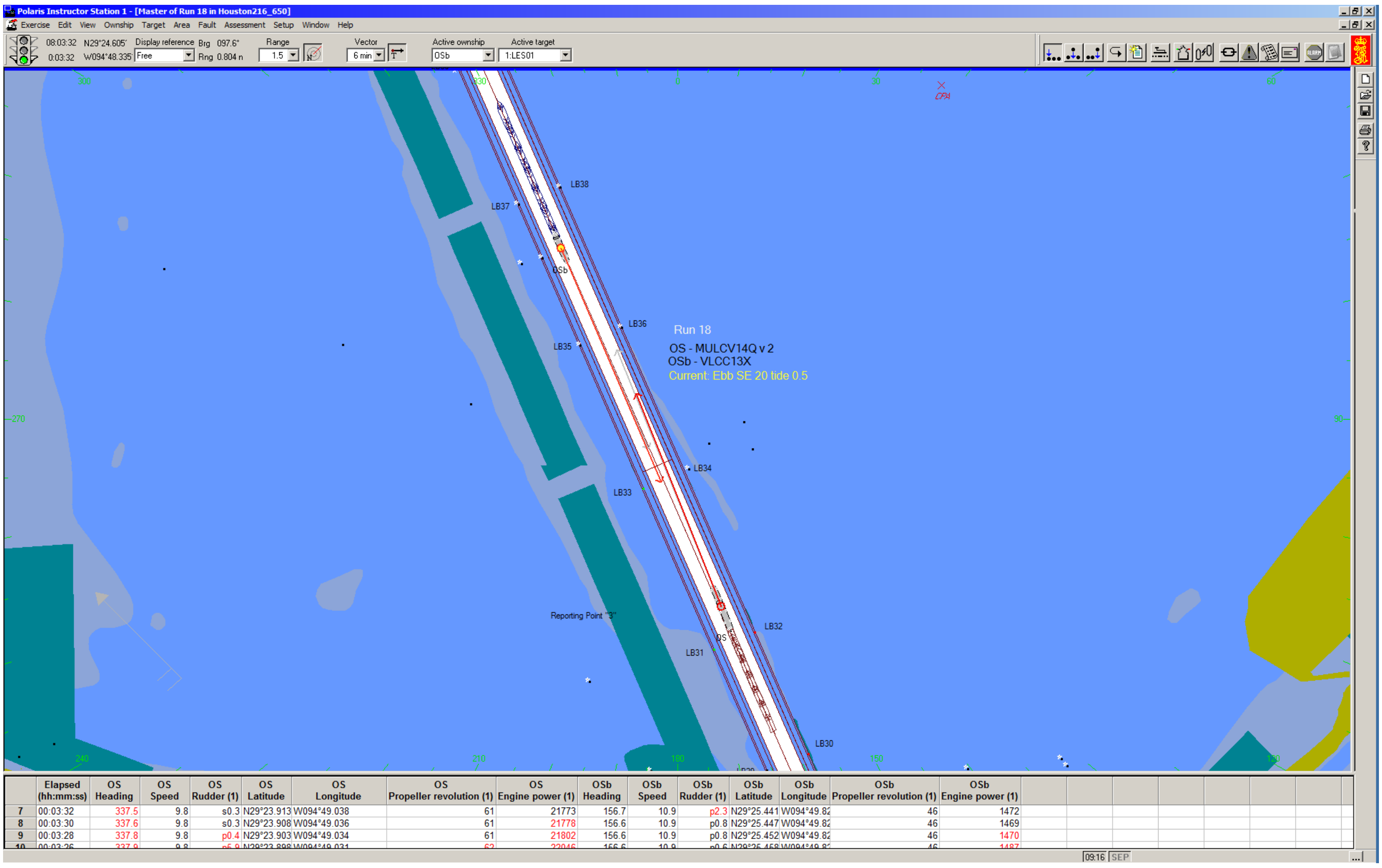
Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:00:00 N29°25.240' Display reference Free Brg 036.0° Rng 0.653 n
0:00:00 W094°48.809'
Range 1.5
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7															

This is an own ship ground speed vector



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

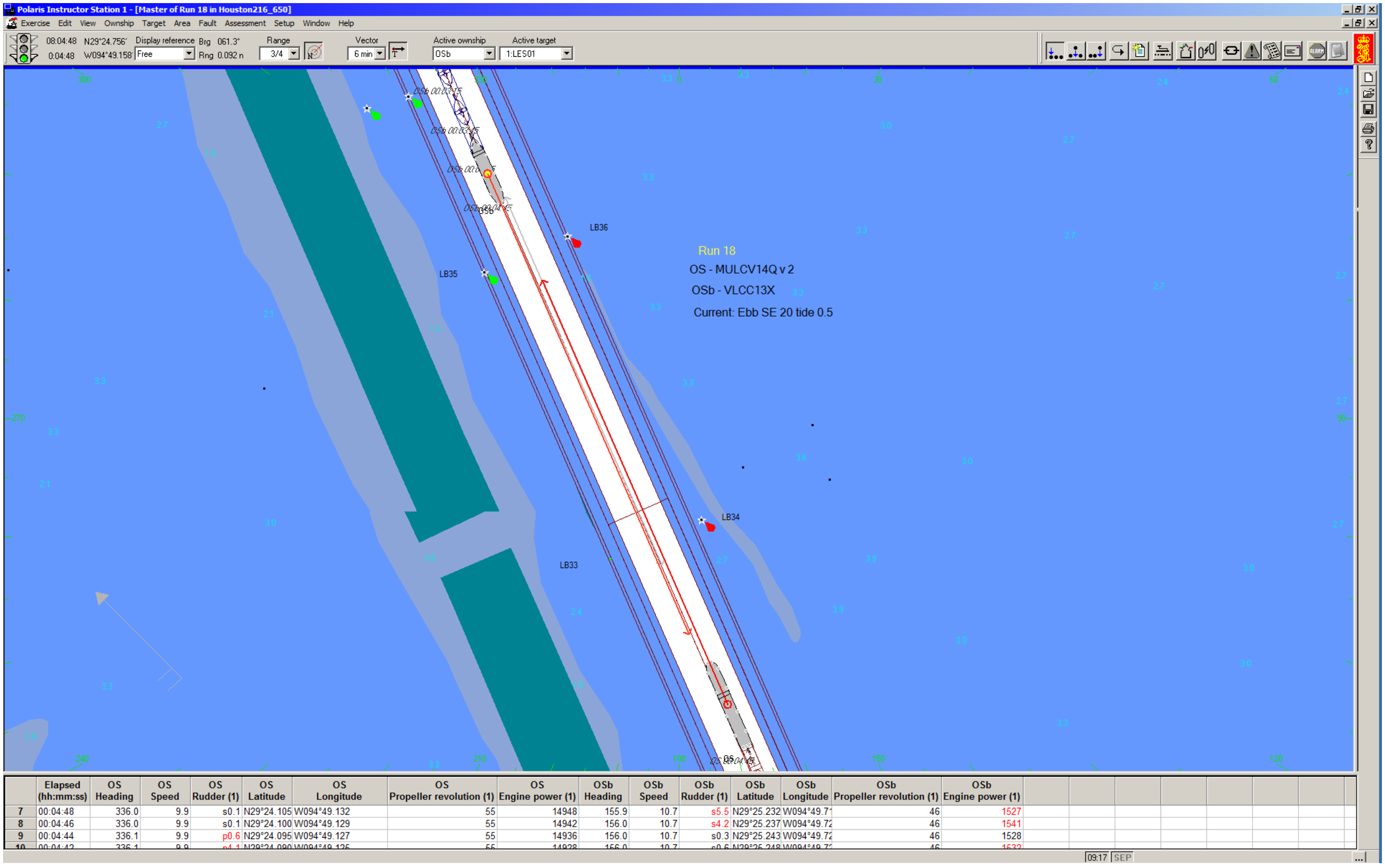
Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:03:32 N29°24.605' Display reference Free Brg 097.6° Rng 0.804 n
0:03:32 W094°48.335'
Range 1.5
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:32	337.5	9.8	s0.3	N29°23.913	W094°49.038	61	21773	156.7	10.9	p2.3	N29°25.441	W094°49.82	46	1472
8	00:03:30	337.6	9.8	s0.3	N29°23.908	W094°49.036	61	21778	156.6	10.9	p0.8	N29°25.447	W094°49.82	46	1469
9	00:03:28	337.8	9.8	p0.4	N29°23.903	W094°49.034	61	21802	156.6	10.9	p0.8	N29°25.452	W094°49.82	46	1470
10	00:03:26	337.9	9.8	p5.9	N29°23.898	W094°49.031	62	22046	156.6	10.9	p0.6	N29°25.458	W094°49.8	46	1487

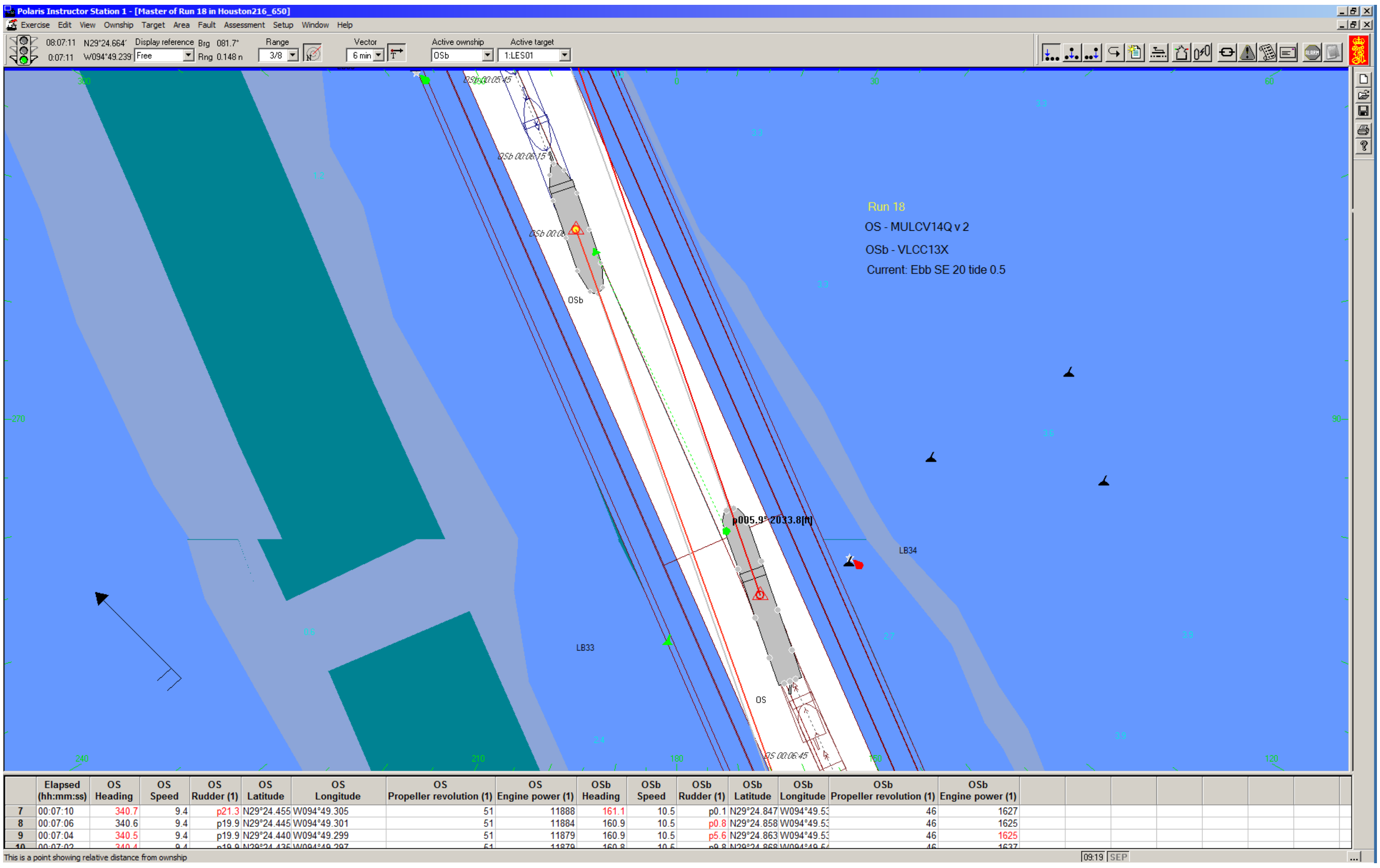
June 26, 2019



08:04:48 N29°24.756′
0:04:48 W094°49.158′
Display reference: Free
Brg 061.3°
Rng 0.092 n
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:04:48	336.0	9.9	s0.1	N29°24.105	W094°49.132	55	14948	155.9	10.7	s5.5	N29°25.232	W094°49.71	46	1527
8	00:04:46	336.0	9.9	s0.1	N29°24.100	W094°49.129	55	14942	156.0	10.7	s4.2	N29°25.237	W094°49.72	46	1541
9	00:04:44	336.1	9.9	p0.6	N29°24.095	W094°49.127	55	14936	156.0	10.7	s0.3	N29°25.243	W094°49.72	46	1528
10	00:04:42	336.1	9.9	p4.1	N29°24.090	W094°49.125	55	14928	156.0	10.7	s0.6	N29°25.248	W094°49.7	46	1532



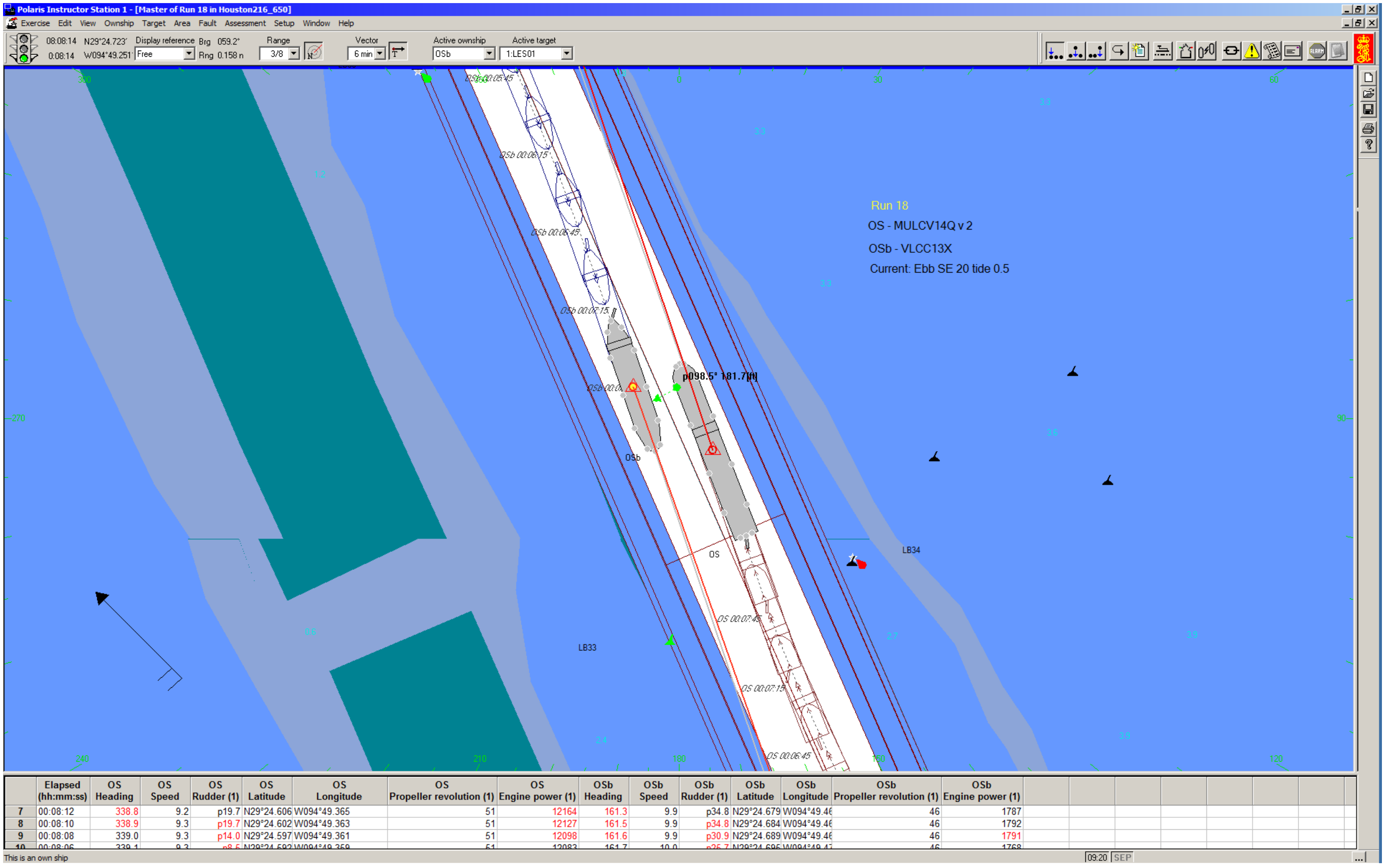
08:07:11 N29°24.664′
0:07:11 W094°49.239′
Display reference: Free
Brg 081.7°
Rng 0.148 n
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:10	340.7	9.4	p21.3	N29°24.455	W094°49.305	51	11888	161.1	10.5	p0.1	N29°24.847	W094°49.53	46	1627
8	00:07:06	340.6	9.4	p19.9	N29°24.445	W094°49.301	51	11884	160.9	10.5	p0.8	N29°24.858	W094°49.53	46	1625
9	00:07:04	340.5	9.4	p19.9	N29°24.440	W094°49.299	51	11879	160.9	10.5	p5.6	N29°24.863	W094°49.53	46	1625
10	00:07:02	340.4	9.4	p19.9	N29°24.435	W094°49.297	51	11879	160.8	10.5	p9.8	N29°24.868	W094°49.54	46	1637

This is a point showing relative distance from ownship

June 26, 2019

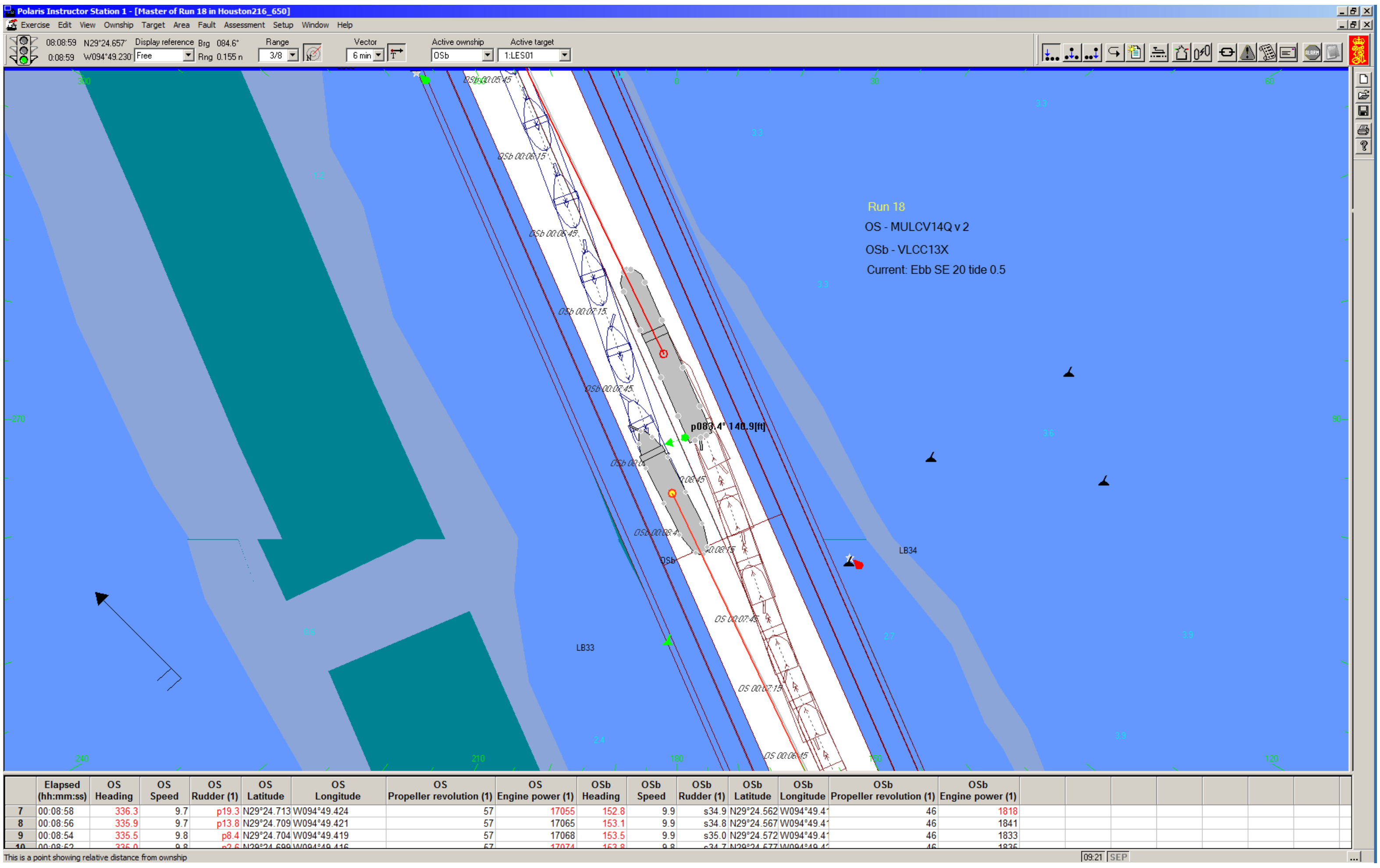

Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:08:14 N29°24.723' Display reference: Free Brg 059.2° Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:14 W094°49.251' Rng 0.158 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:12	338.8	9.2	p19.7	N29°24.606	W094°49.365	51	12164	161.3	9.9	p34.8	N29°24.679	W094°49.46	46	1787
8	00:08:10	338.9	9.3	p19.7	N29°24.602	W094°49.363	51	12127	161.5	9.9	p34.8	N29°24.684	W094°49.46	46	1792
9	00:08:08	339.0	9.3	p14.0	N29°24.597	W094°49.361	51	12098	161.6	9.9	p30.9	N29°24.689	W094°49.46	46	1791
10	00:08:06	339.1	9.3	p8.5	N29°24.592	W094°49.359	51	12083	161.7	10.0	p25.7	N29°24.696	W094°49.47	46	1768

This is an own ship

09:20 SEP


Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

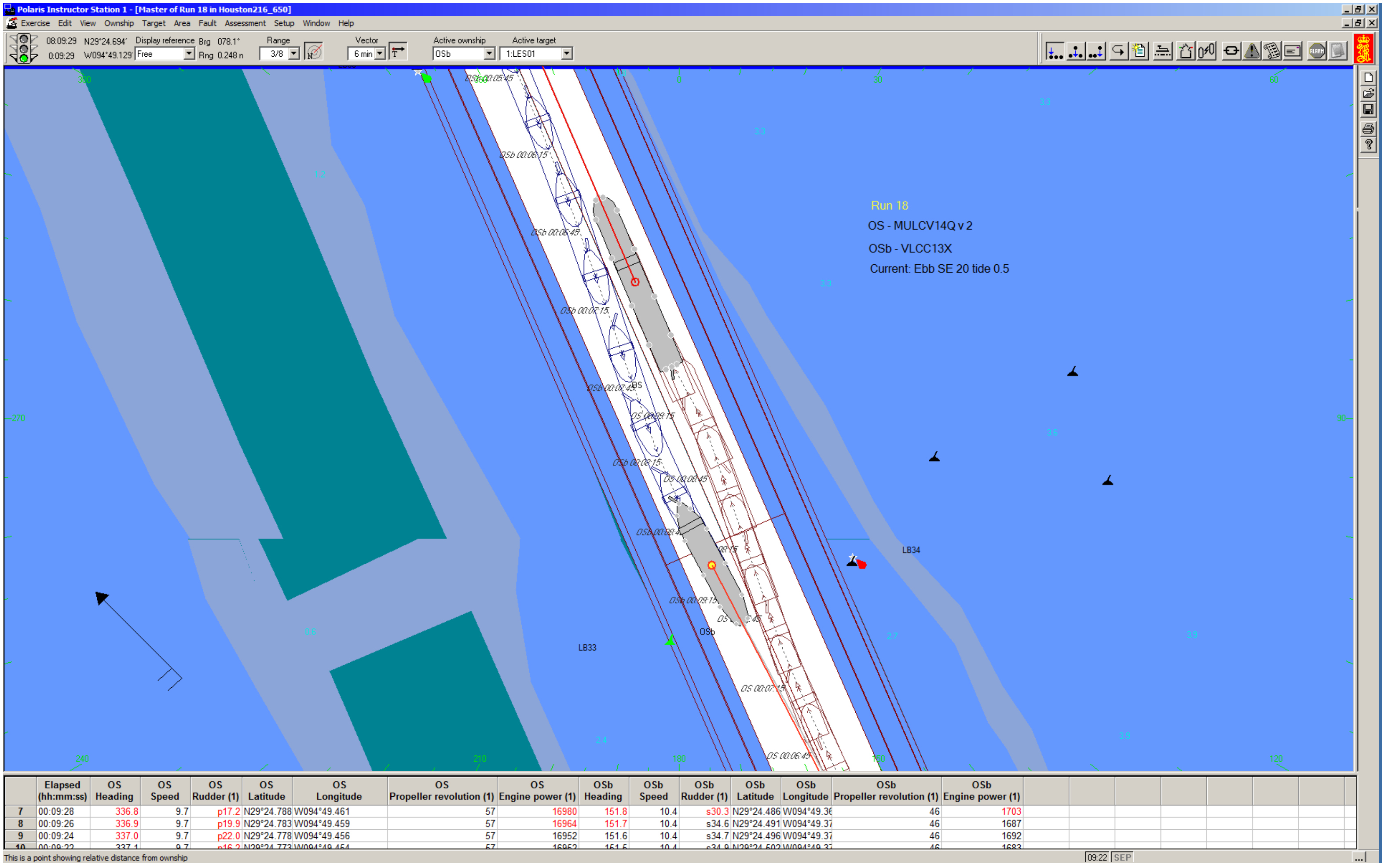
08:08:59 N29°24.657' Display reference: Free Brg 084.6° Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:59 W094°49.230' Rng 0.155 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:58	336.3	9.7	p19.3	N29°24.713	W094°49.424	57	17055	152.8	9.9	s34.9	N29°24.562	W094°49.4	46	1818
8	00:08:56	335.9	9.7	p13.8	N29°24.709	W094°49.421	57	17065	153.1	9.9	s34.8	N29°24.567	W094°49.4	46	1841
9	00:08:54	335.5	9.8	p8.4	N29°24.704	W094°49.419	57	17068	153.5	9.9	s35.0	N29°24.572	W094°49.4	46	1833
10	00:08:52	335.0	9.8	p2.6	N29°24.699	W094°49.416	57	17074	153.8	9.8	s34.7	N29°24.577	W094°49.4	46	1835

This is a point showing relative distance from ownship

09:21 SEP

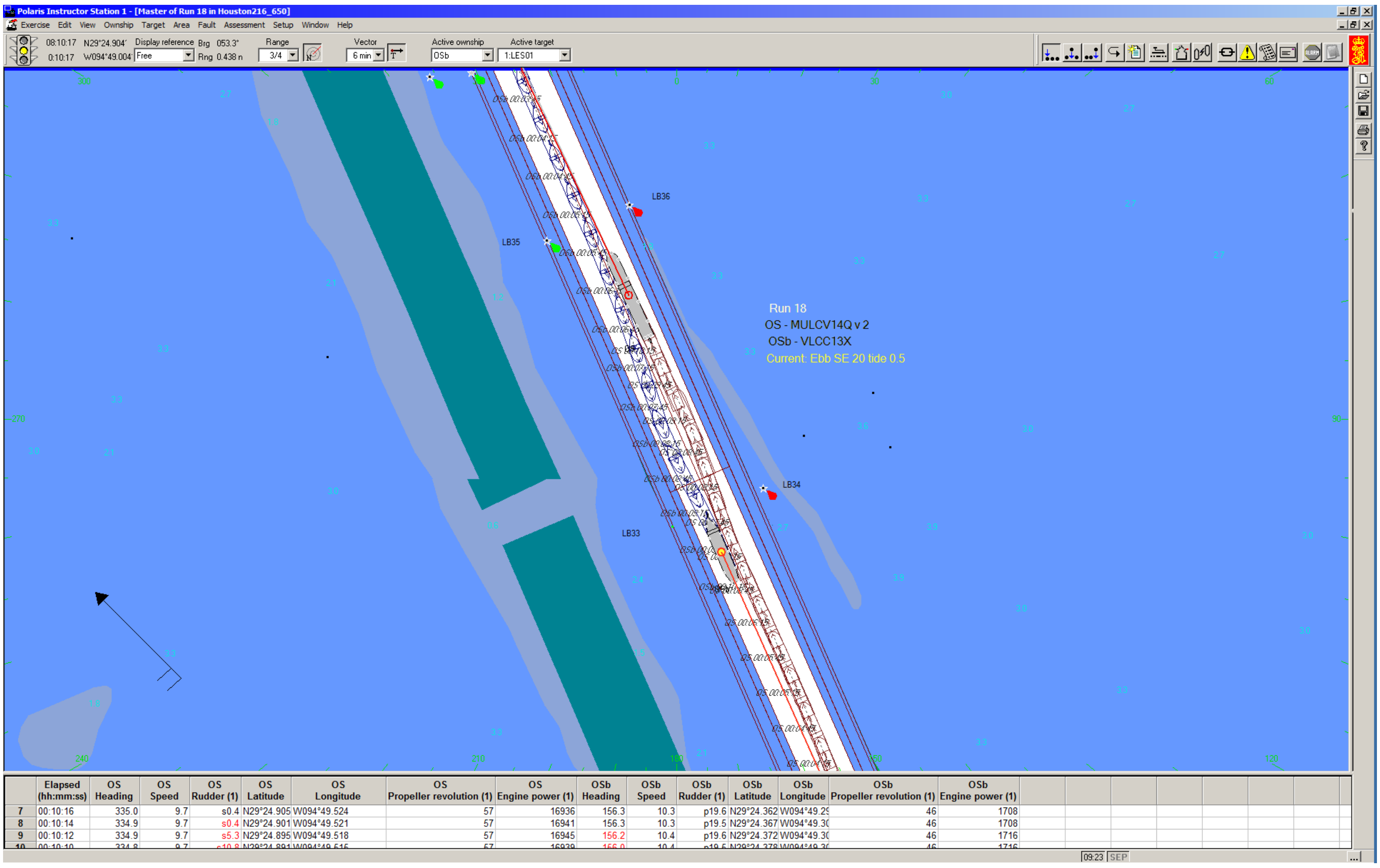
June 26, 2019



Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:28	336.8	9.7	p17.2	N29°24.788	W094°49.461	57	16980	151.8	10.4	s30.3	N29°24.486	W094°49.36	46	1703
8	00:09:26	336.9	9.7	p19.9	N29°24.783	W094°49.459	57	16964	151.7	10.4	s34.6	N29°24.491	W094°49.37	46	1687
9	00:09:24	337.0	9.7	p22.0	N29°24.778	W094°49.456	57	16952	151.6	10.4	s34.7	N29°24.496	W094°49.37	46	1692

This is a point showing relative distance from ownship

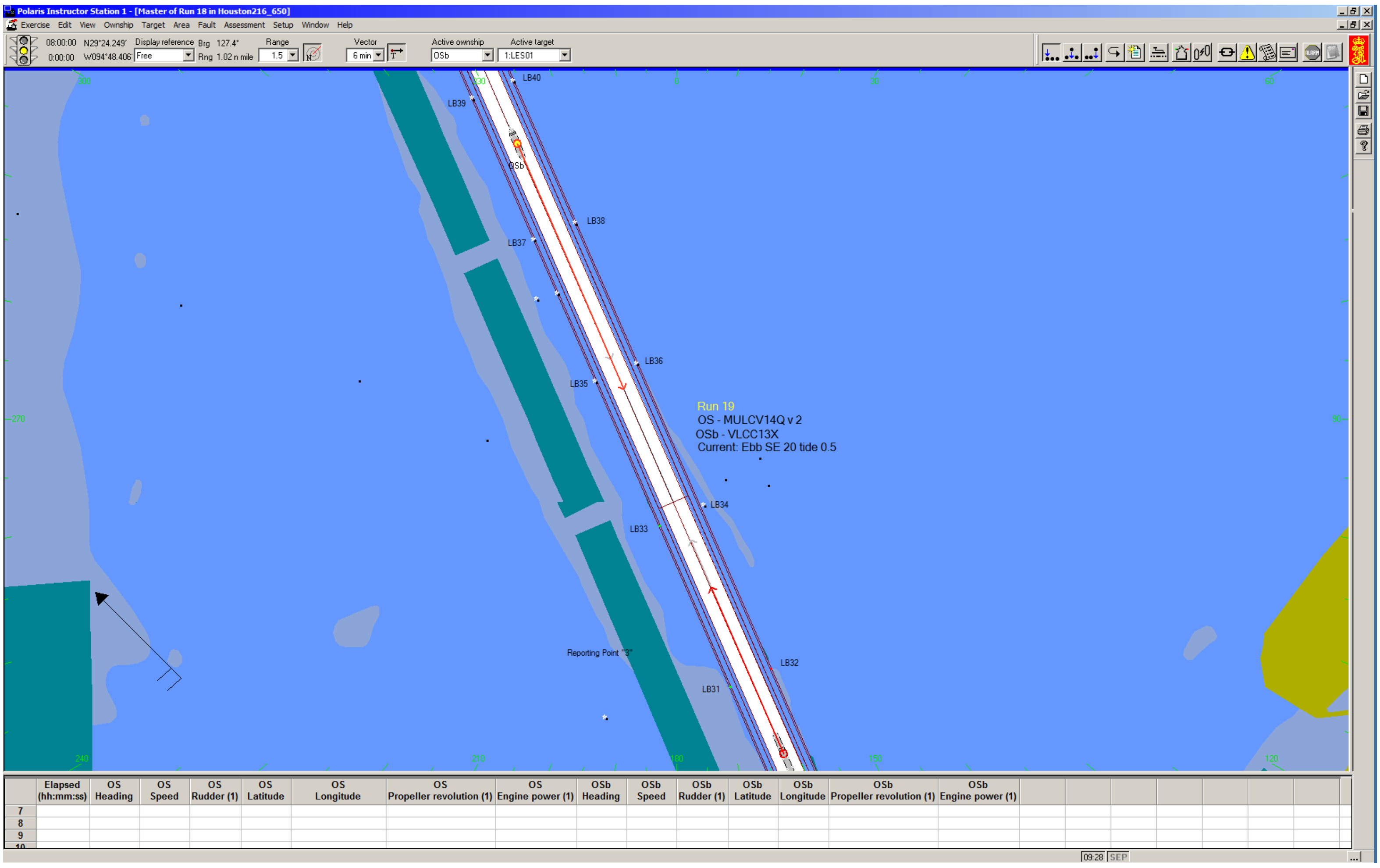


Run 18
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:10:16	335.0	9.7	s0.4	N29°24.905	W094°49.524	57	16936	156.3	10.3	p19.6	N29°24.362	W094°49.29	46	1708
8	00:10:14	334.9	9.7	s0.4	N29°24.901	W094°49.521	57	16941	156.3	10.3	p19.5	N29°24.367	W094°49.30	46	1708
9	00:10:12	334.9	9.7	s5.3	N29°24.895	W094°49.518	57	16945	156.2	10.4	p19.6	N29°24.372	W094°49.30	46	1716

June 26, 2019

Run 19



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:00:00 N29°24.249' W094°48.406 0:00:00

Display reference: Free

Brg 127.4° Rng 1.02 n mile

Range: 1.5

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

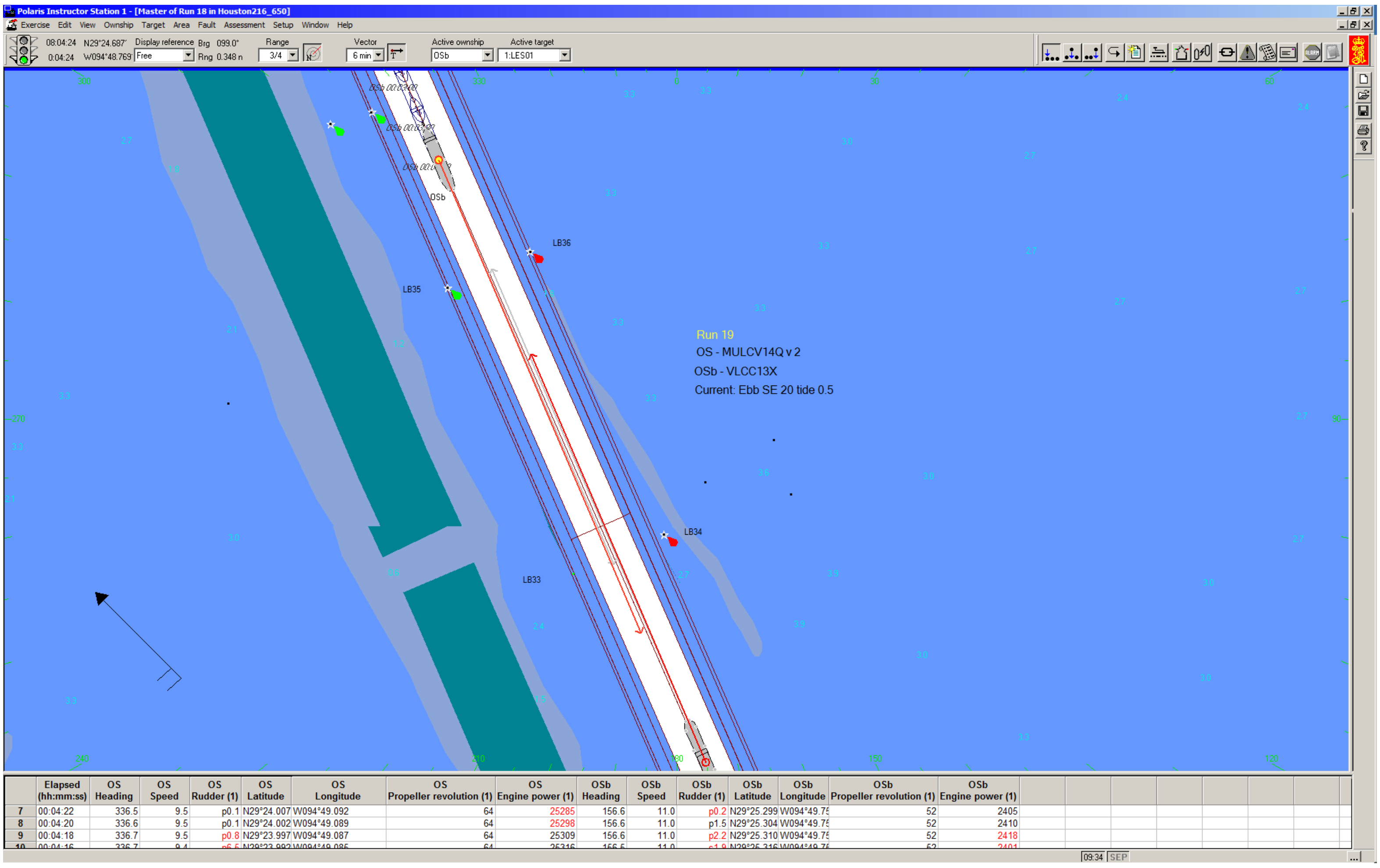
Run 19

OS - MULCV14Q v 2

OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7															
8															
9															



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:04:24 N29°24.687' W094°48.769' 0:04:24

Display reference: Free

Brg 099.0° Rng 0.348 n

Range: 3/4

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 19

OS - MULCV14Q v 2

OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:04:22	336.5	9.5	p0.1	N29°24.007	W094°49.092	64	25285	156.6	11.0	p0.2	N29°25.299	W094°49.75	52	2405
8	00:04:20	336.6	9.5	p0.1	N29°24.002	W094°49.089	64	25298	156.6	11.0	p1.5	N29°25.304	W094°49.75	52	2410
9	00:04:18	336.7	9.5	p0.8	N29°23.997	W094°49.087	64	25309	156.6	11.0	p2.2	N29°25.310	W094°49.75	52	2418

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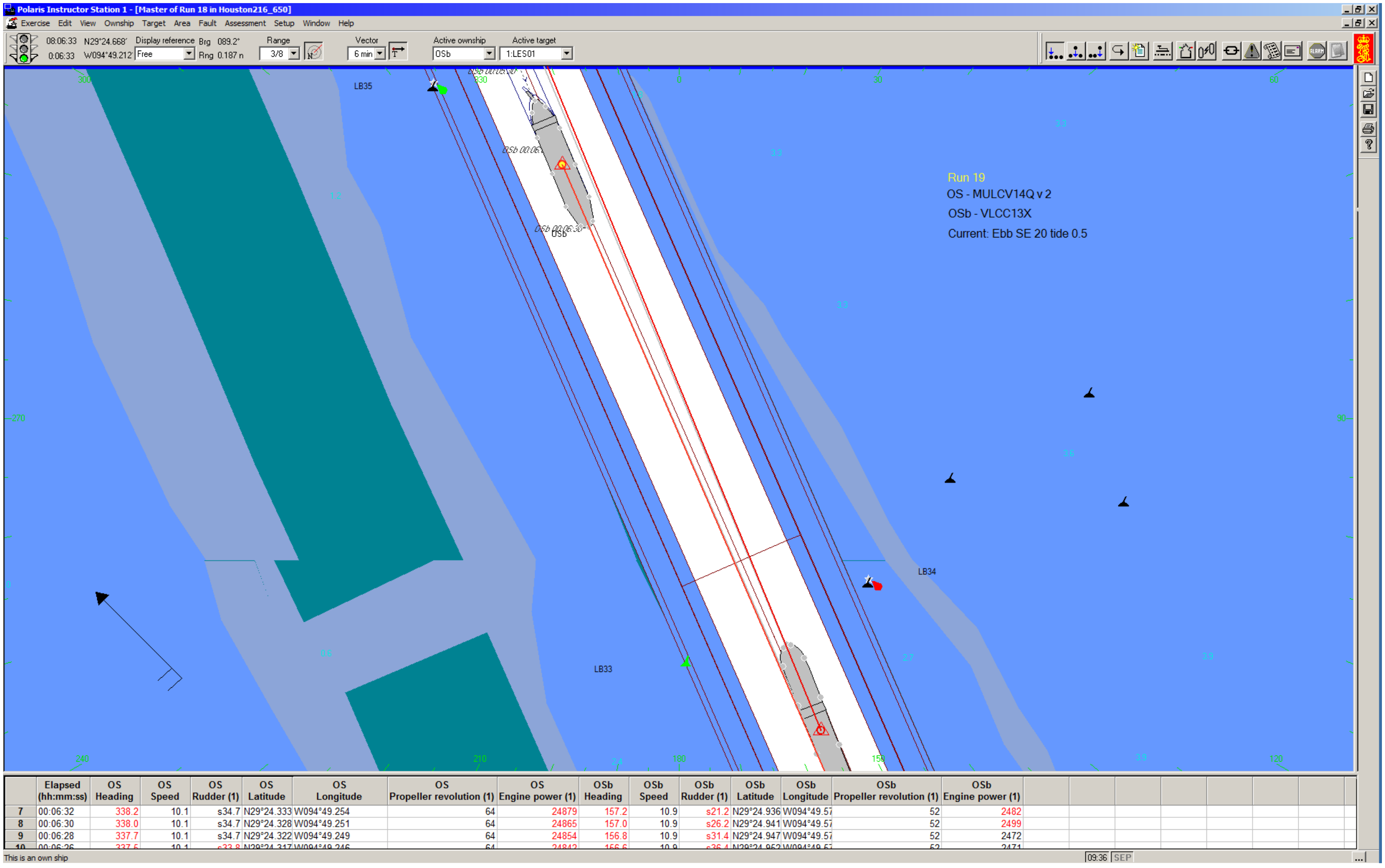


Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:06:33 N29°24.668′ Display reference Free Brg 089.2° Rng 0.187 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01

0:06:33 W094°49.212′

Run 19

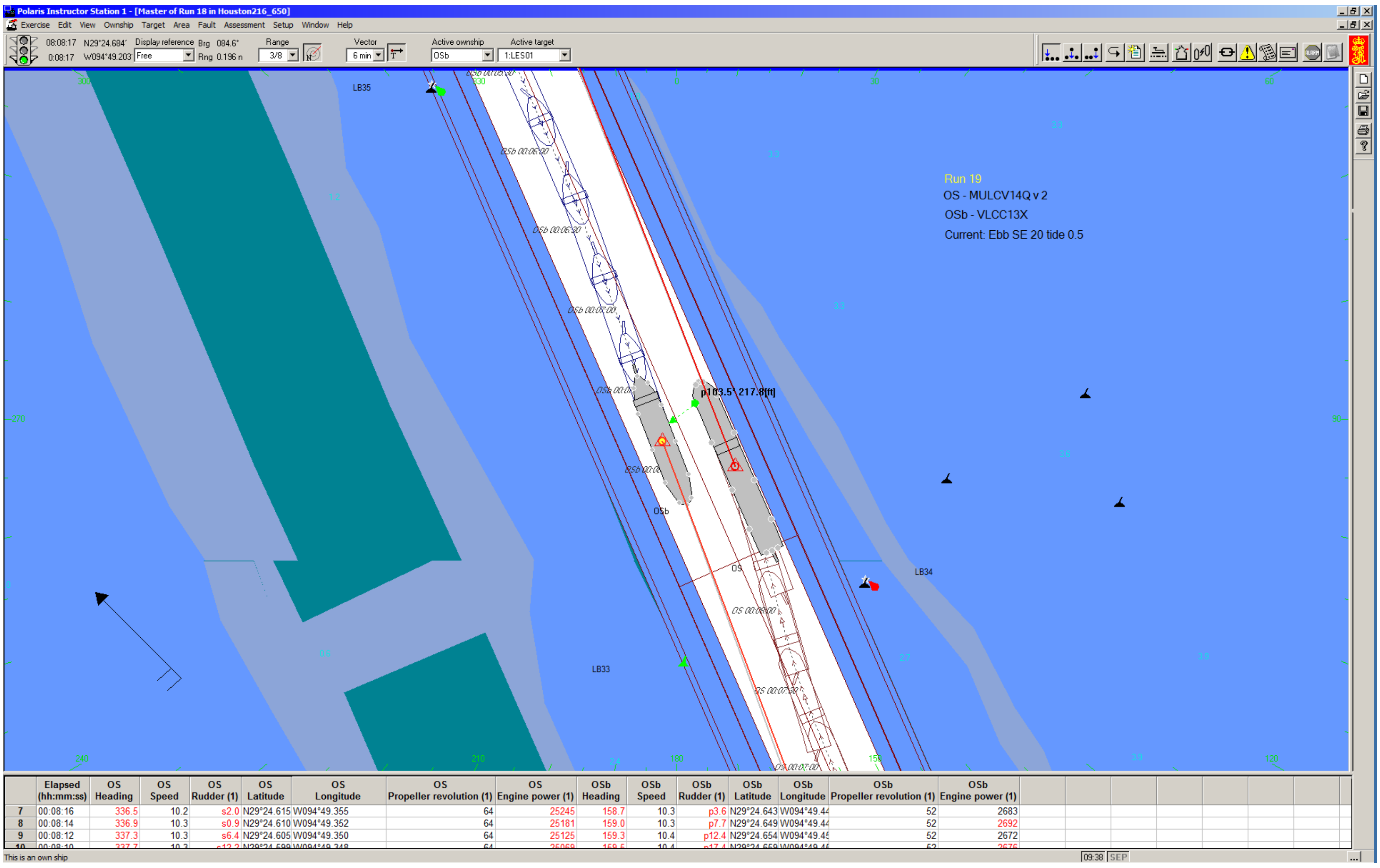
OS - MULCV14Q v 2

OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:32	338.2	10.1	s34.7	N29°24.333	W094°49.254	64	24879	157.2	10.9	s21.2	N29°24.936	W094°49.57	52	2482
8	00:06:30	338.0	10.1	s34.7	N29°24.328	W094°49.251	64	24865	157.0	10.9	s26.2	N29°24.941	W094°49.57	52	2499
9	00:06:28	337.7	10.1	s34.7	N29°24.322	W094°49.249	64	24854	156.8	10.9	s31.4	N29°24.947	W094°49.57	52	2472

This is an own ship



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:08:17 N29°24.684′ Display reference Free Brg 084.6° Rng 0.196 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01

0:08:17 W094°49.203′

Run 19

OS - MULCV14Q v 2

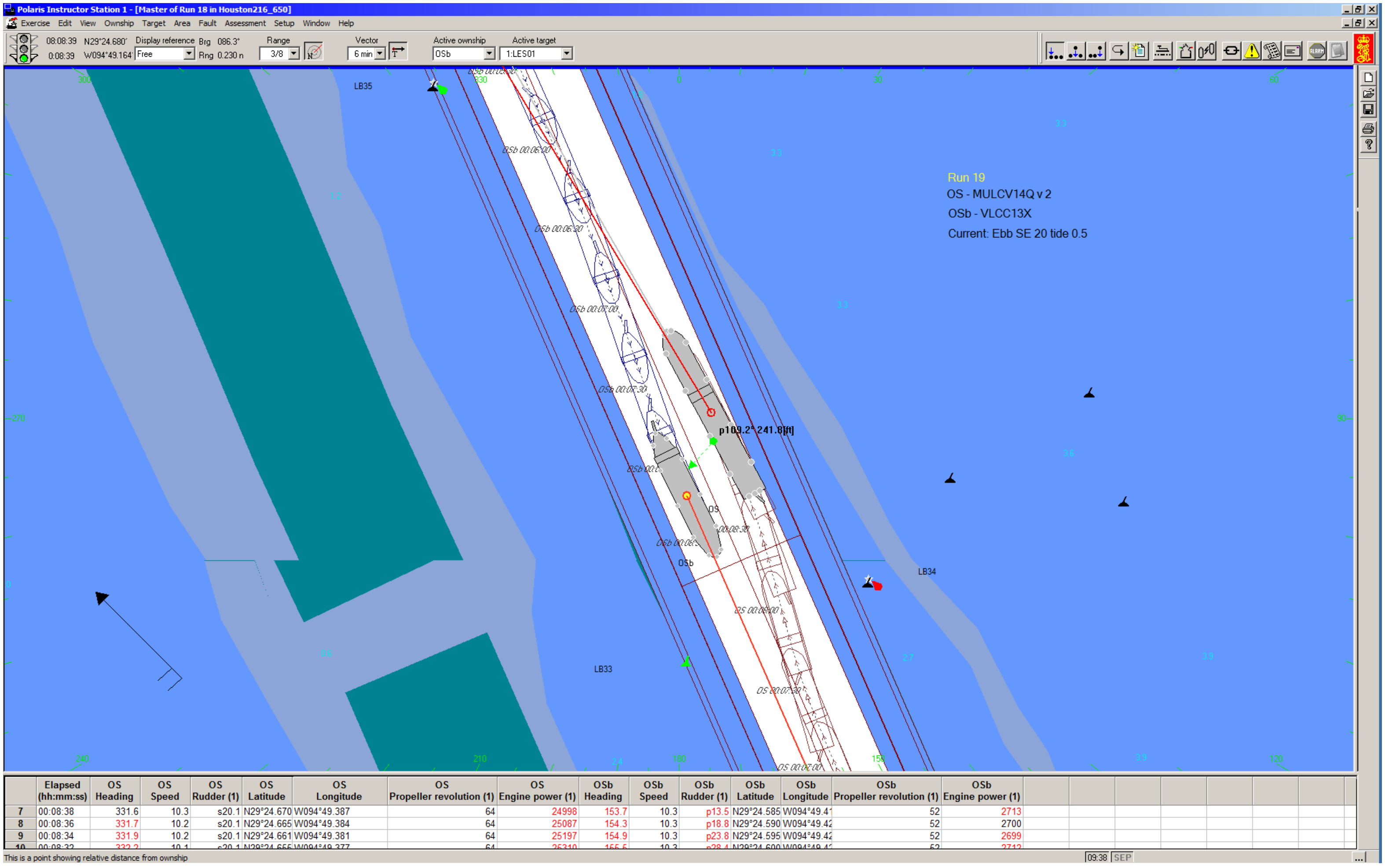
OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

p103.5° 217.8[ft]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:16	336.5	10.2	s2.0	N29°24.615	W094°49.355	64	25245	158.7	10.3	p3.6	N29°24.643	W094°49.44	52	2683
8	00:08:14	336.9	10.3	s0.9	N29°24.610	W094°49.352	64	25181	159.0	10.3	p7.7	N29°24.649	W094°49.44	52	2692
9	00:08:12	337.3	10.3	s6.4	N29°24.605	W094°49.350	64	25125	159.3	10.4	p12.4	N29°24.654	W094°49.45	52	2672

This is an own ship



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:08:39 N29°24.680' 0:08:39 W094°49.164'

Display reference: Free

Brg 086.3° Rng 0.230 n

Range: 3/8

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 19

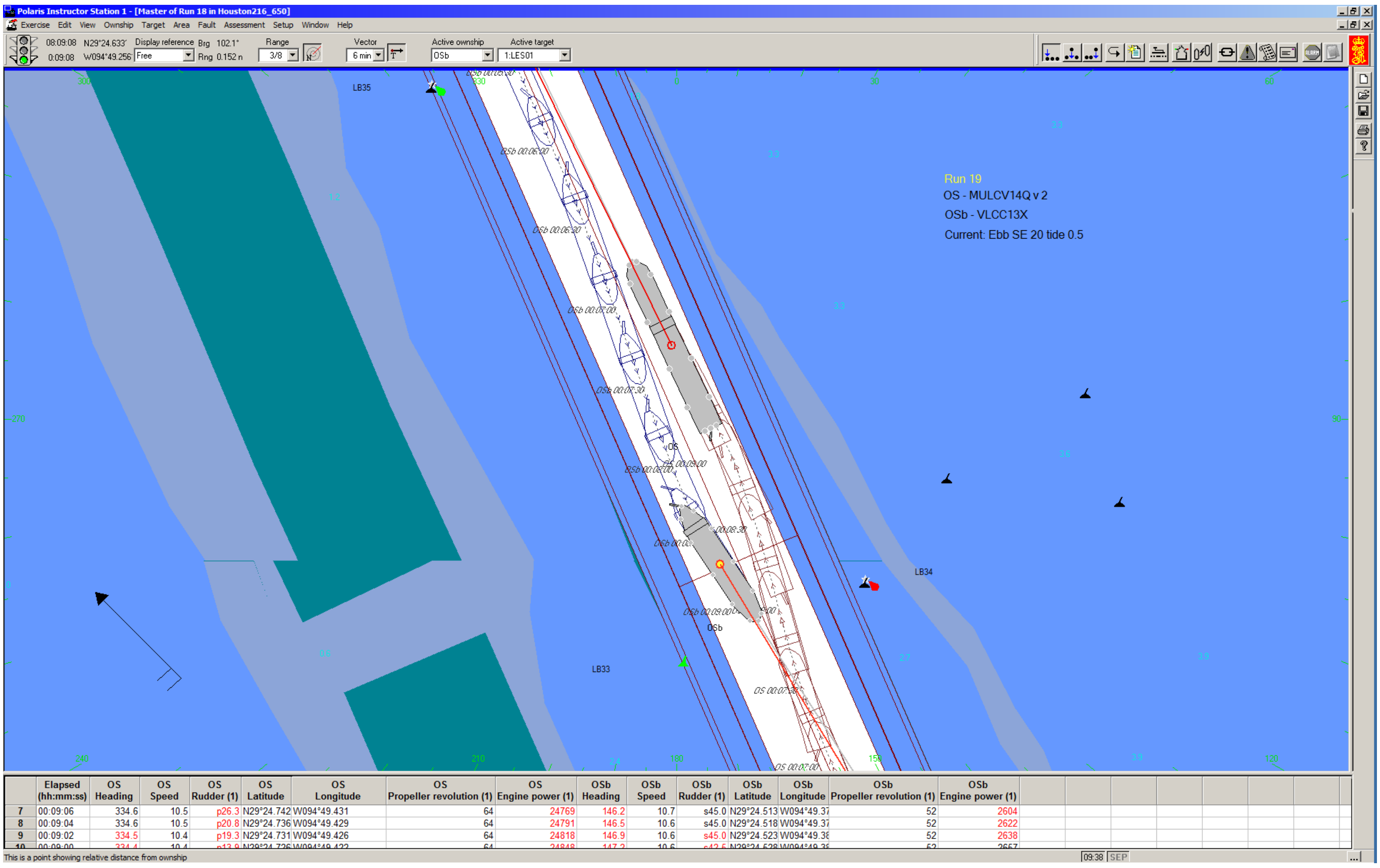
OS - MULCV14Q v 2

OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:38	331.6	10.3	s20.1	N29°24.670	W094°49.387	64	24998	153.7	10.3	p13.5	N29°24.585	W094°49.41	52	2713
8	00:08:36	331.7	10.2	s20.1	N29°24.665	W094°49.384	64	25087	154.3	10.3	p18.8	N29°24.590	W094°49.42	52	2700
9	00:08:34	331.9	10.2	s20.1	N29°24.661	W094°49.381	64	25197	154.9	10.3	p23.8	N29°24.595	W094°49.42	52	2699

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:09:08 N29°24.633' 0:09:08 W094°49.256'

Display reference: Free

Brg 102.1° Rng 0.152 n

Range: 3/8

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 19

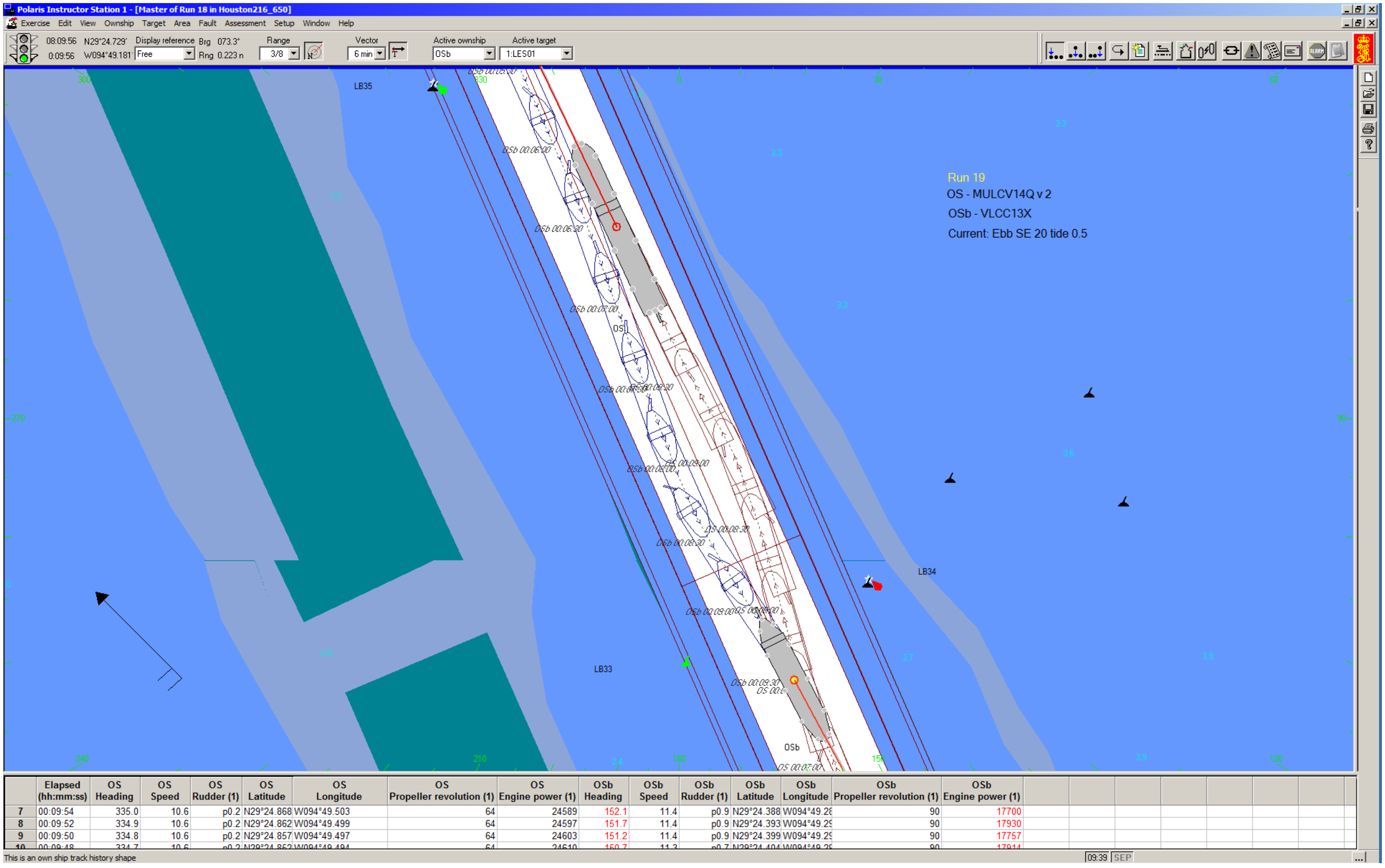
OS - MULCV14Q v 2

OSb - VLCC13X

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:06	334.6	10.5	p26.3	N29°24.742	W094°49.431	64	24769	146.2	10.7	s45.0	N29°24.513	W094°49.37	52	2604
8	00:09:04	334.6	10.5	p20.8	N29°24.736	W094°49.429	64	24791	146.5	10.6	s45.0	N29°24.518	W094°49.37	52	2622
9	00:09:02	334.5	10.4	p19.3	N29°24.731	W094°49.426	64	24818	146.9	10.6	s45.0	N29°24.523	W094°49.38	52	2638

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

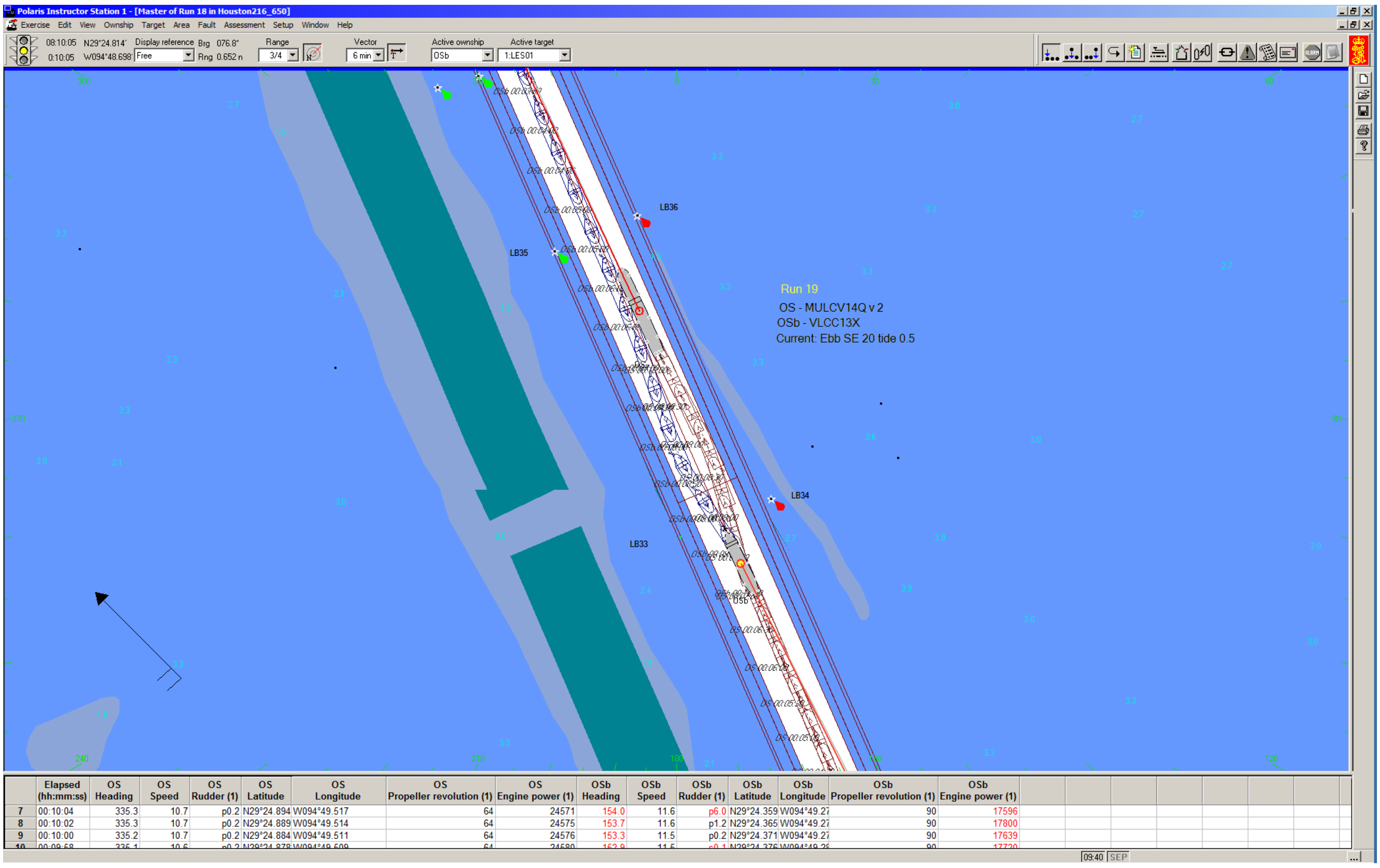
08:09:56 N29°24.729' Display reference Free Brg 073.3° Rng 0.223 n
0:09:56 W094°49.181'
Range 3/8
Vector 6 min
Active ownship OSb
Active target 1:LES01

Run 19
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:54	335.0	10.6	p0.2	N29°24.868	W094°49.503	64	24589	152.1	11.4	p0.9	N29°24.388	W094°49.28	90	17700
8	00:09:52	334.9	10.6	p0.2	N29°24.862	W094°49.499	64	24597	151.7	11.4	p0.9	N29°24.393	W094°49.29	90	17930
9	00:09:50	334.8	10.6	p0.2	N29°24.857	W094°49.497	64	24603	151.2	11.4	p0.9	N29°24.399	W094°49.29	90	17757

This is an own ship track history shape

09:39 SEP



Polaris Instructor Station 1 - [Master of Run 18 in Houston216_650]

08:10:05 N29°24.814' Display reference Free Brg 076.8° Rng 0.652 n
0:10:05 W094°48.698'
Range 3/4
Vector 6 min
Active ownship OSb
Active target 1:LES01

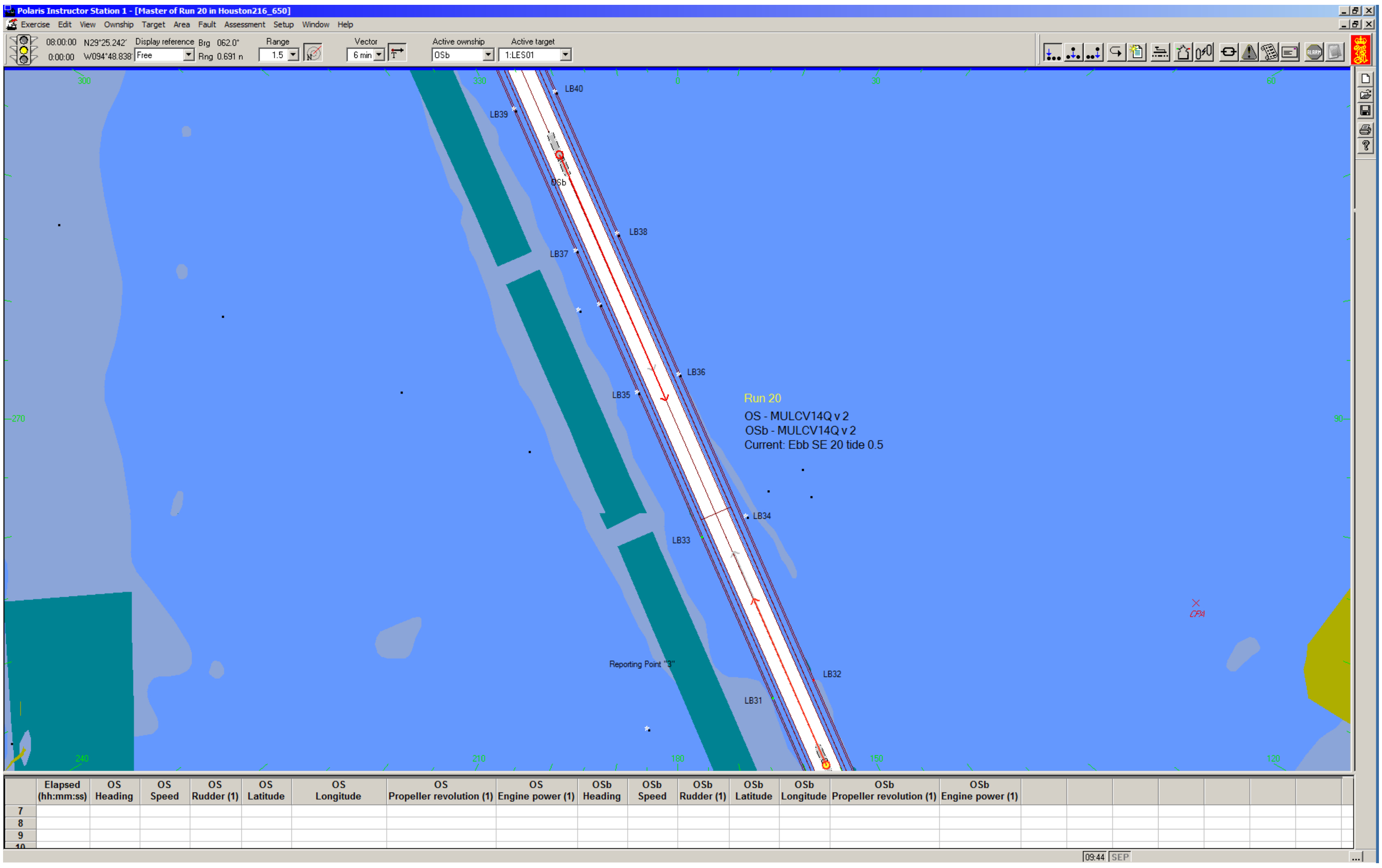
Run 19
OS - MULCV14Q v 2
OSb - VLCC13X
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:10:04	335.3	10.7	p0.2	N29°24.894	W094°49.517	64	24571	154.0	11.6	p6.0	N29°24.359	W094°49.27	90	17596
8	00:10:02	335.3	10.7	p0.2	N29°24.889	W094°49.514	64	24575	153.7	11.6	p1.2	N29°24.365	W094°49.27	90	17800
9	00:10:00	335.2	10.7	p0.2	N29°24.884	W094°49.511	64	24576	153.3	11.5	p0.2	N29°24.371	W094°49.27	90	17639

09:40 SEP

June 26, 2019

Run 20

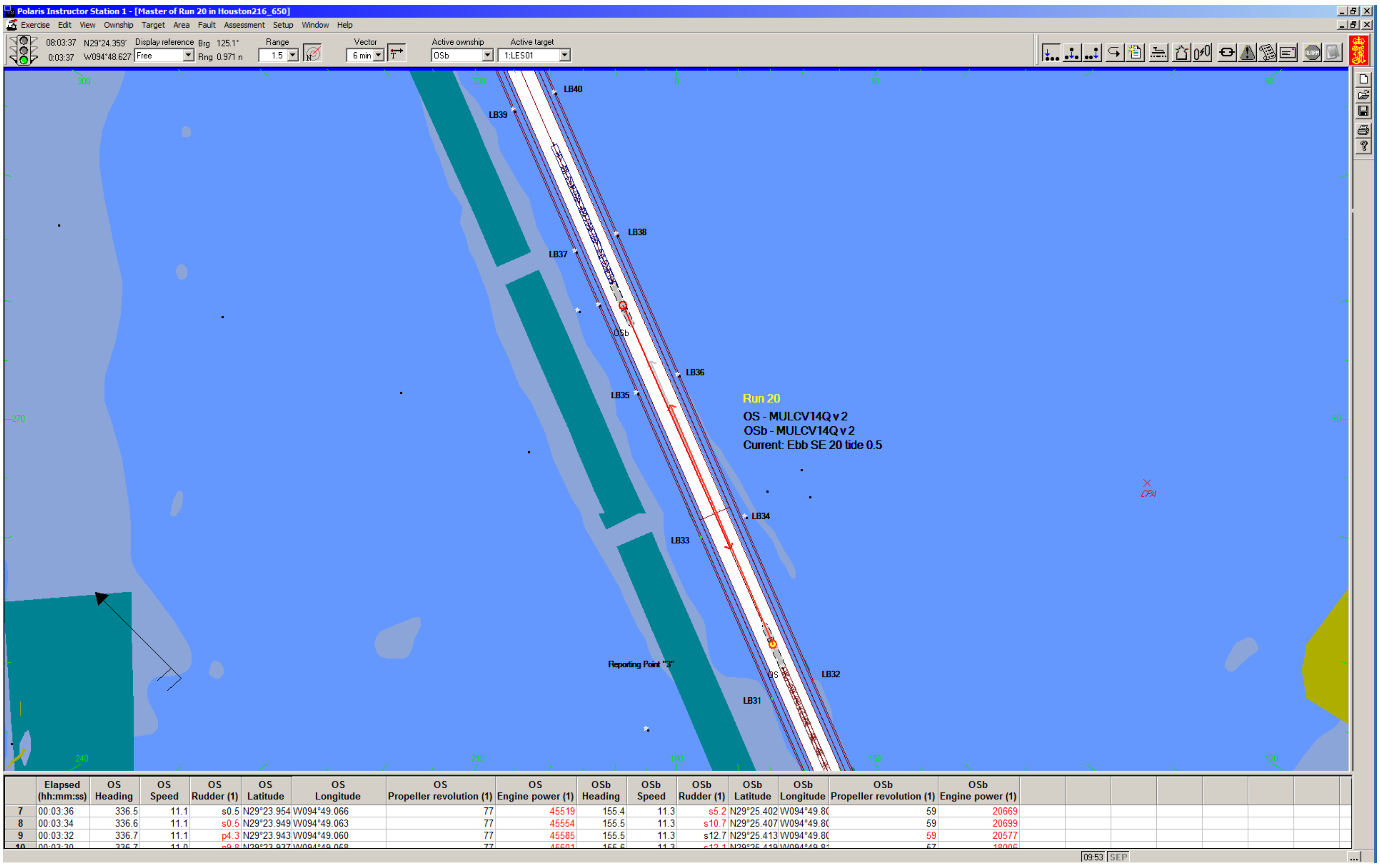


Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:00:00 N29°25.242'
0:00:00 W094°48.838'
Display reference: Free
Brg 062.0°
Rng 0.691 n
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7															
8															
9															
10															



Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:03:37 N29°24.359'
0:03:37 W094°48.627'
Display reference: Free
Brg 125.1°
Rng 0.971 n
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:03:36	336.5	11.1	s0.5	N29°23.954	W094°49.066	77	45519	155.4	11.3	s5.2	N29°25.402	W094°49.80	59	20669
8	00:03:34	336.6	11.1	s0.5	N29°23.949	W094°49.063	77	45554	155.5	11.3	s10.7	N29°25.407	W094°49.80	59	20699
9	00:03:32	336.7	11.1	p4.3	N29°23.943	W094°49.060	77	45585	155.5	11.3	s12.7	N29°25.413	W094°49.80	59	20577
10	00:03:30	336.7	11.0	p9.8	N29°23.937	W094°49.058	77	45601	155.6	11.3	s12.1	N29°25.419	W094°49.81	57	18006

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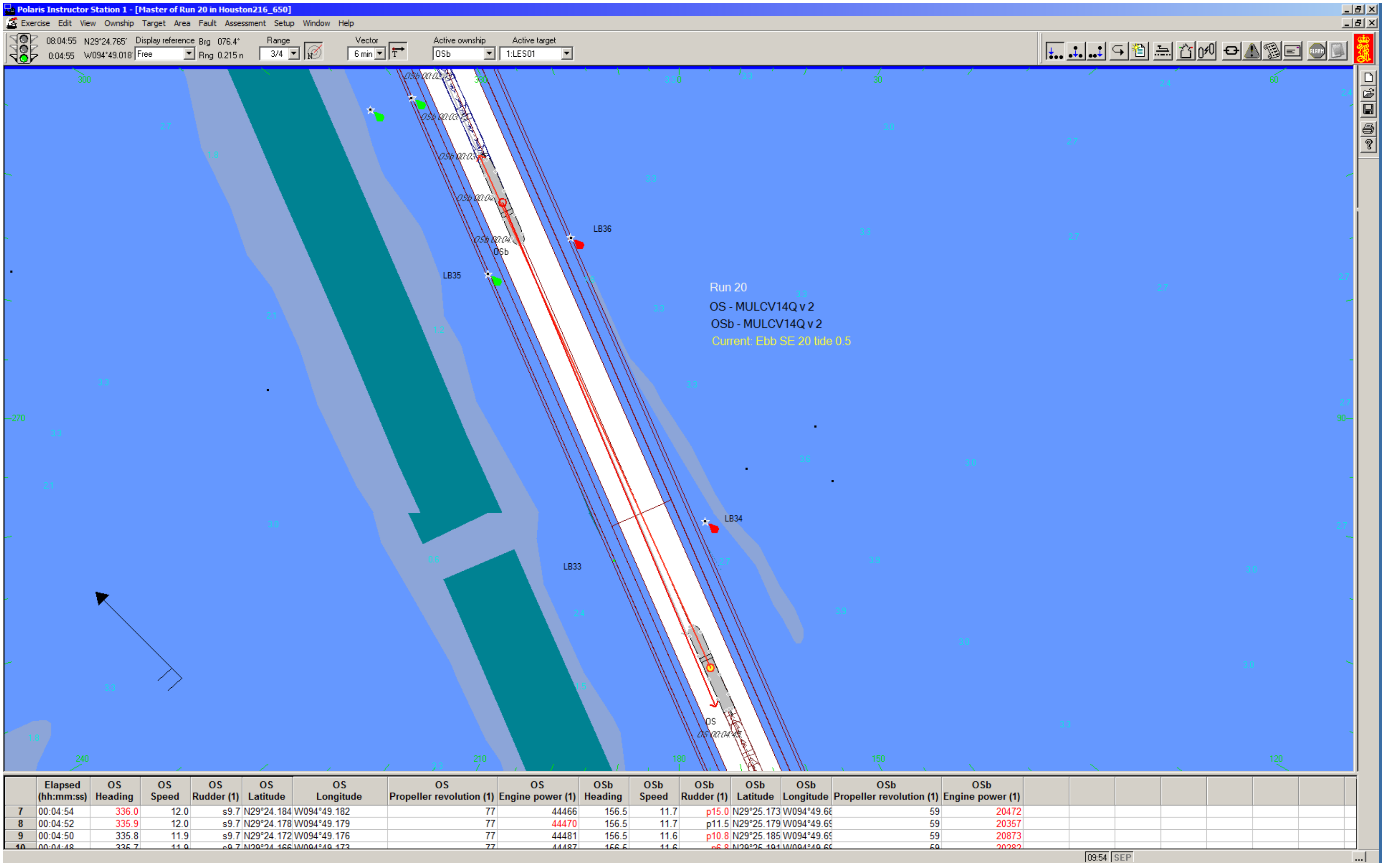


Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

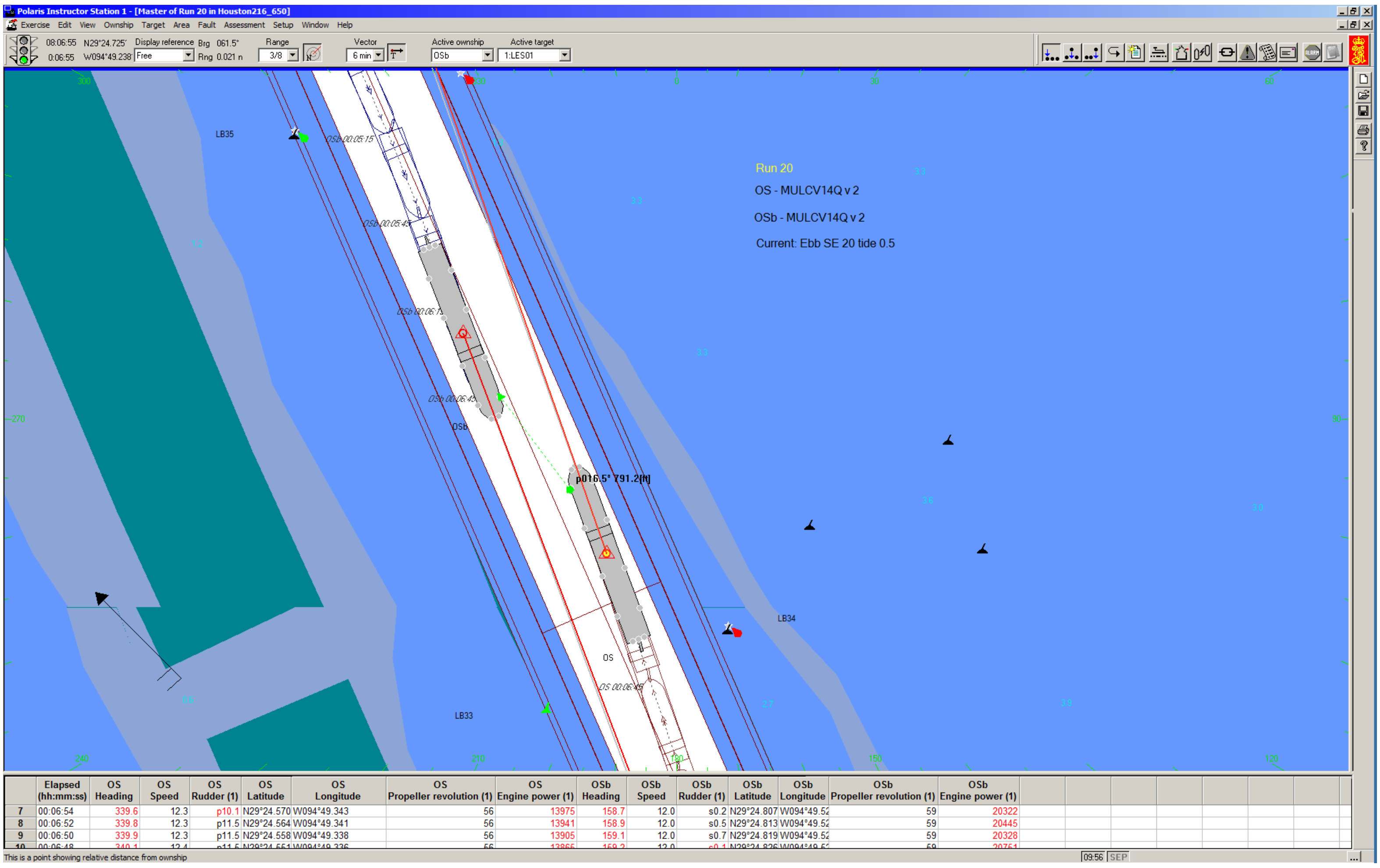
Run 20

OS - MULCV14Q v 2

OSb - MULCV14Q v 2

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:04:54	336.0	12.0	s9.7	N29°24.184	W094°49.182	77	44466	156.5	11.7	p15.0	N29°25.173	W094°49.68	59	20472
8	00:04:52	335.9	12.0	s9.7	N29°24.178	W094°49.179	77	44470	156.5	11.7	p11.5	N29°25.179	W094°49.69	59	20357
9	00:04:50	335.8	11.9	s9.7	N29°24.172	W094°49.176	77	44481	156.5	11.6	p10.8	N29°25.185	W094°49.69	59	20873
10	00:04:48	335.7	11.9	s9.7	N29°24.166	W094°49.173	77	44487	156.5	11.6	p6.8	N29°25.191	W094°49.69	59	20282



Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

Run 20

OS - MULCV14Q v 2

OSb - MULCV14Q v 2

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:06:54	339.6	12.3	p10.1	N29°24.570	W094°49.343	56	13975	158.7	12.0	s0.2	N29°24.807	W094°49.52	59	20322
8	00:06:52	339.8	12.3	p11.5	N29°24.564	W094°49.341	56	13941	158.9	12.0	s0.5	N29°24.813	W094°49.52	59	20445
9	00:06:50	339.9	12.3	p11.5	N29°24.558	W094°49.338	56	13905	159.1	12.0	s0.7	N29°24.819	W094°49.52	59	20328
10	00:06:48	340.1	12.4	p11.5	N29°24.551	W094°49.336	56	13866	159.2	12.0	s0.1	N29°24.826	W094°49.52	59	20751

This is a point showing relative distance from ownship

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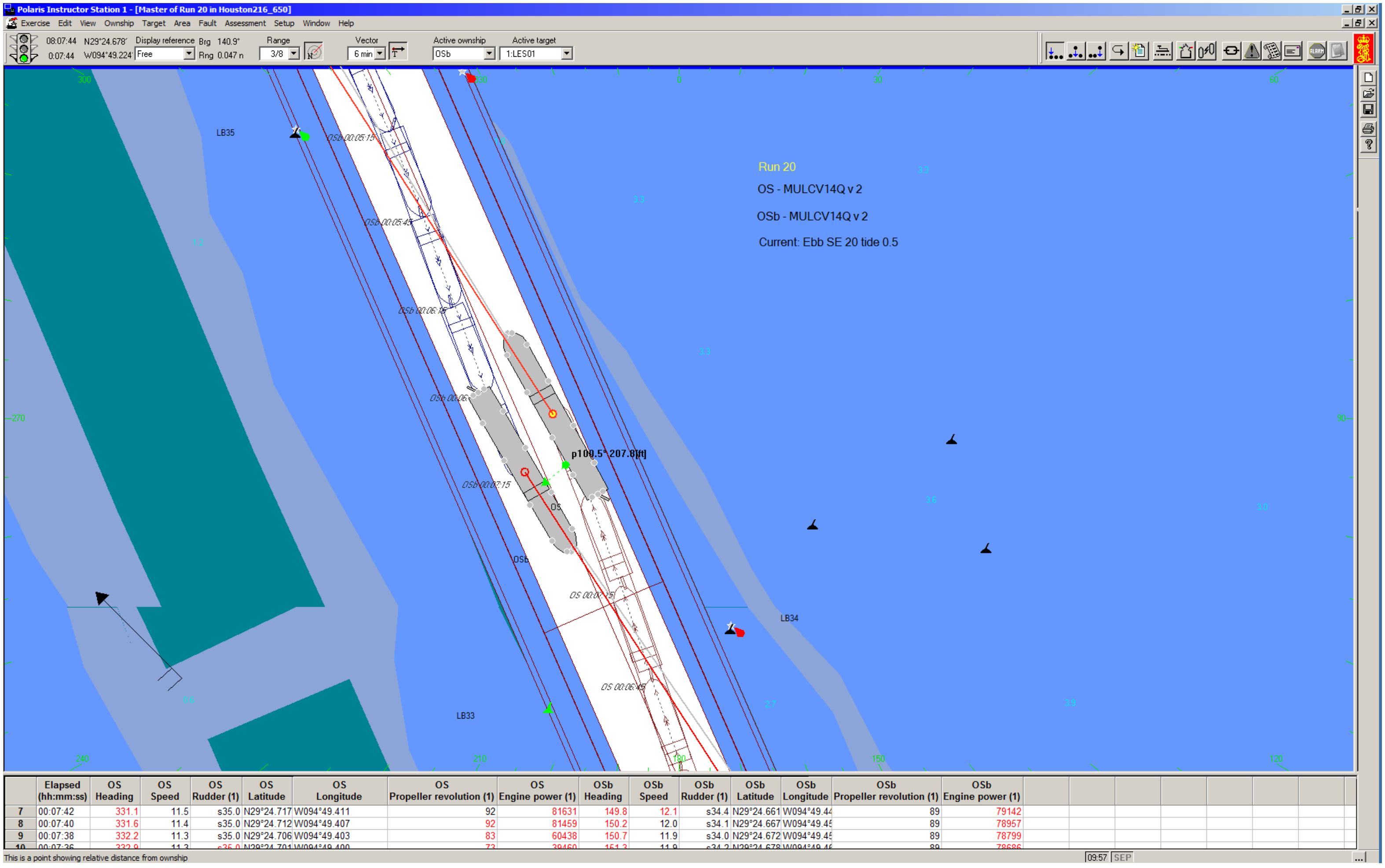


Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:07:44 N29°24.678' Brg 140.9°
0:07:44 W094°49.224' Rng 0.047 n

Display reference: Free
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20

OS - MULCV14Q v 2

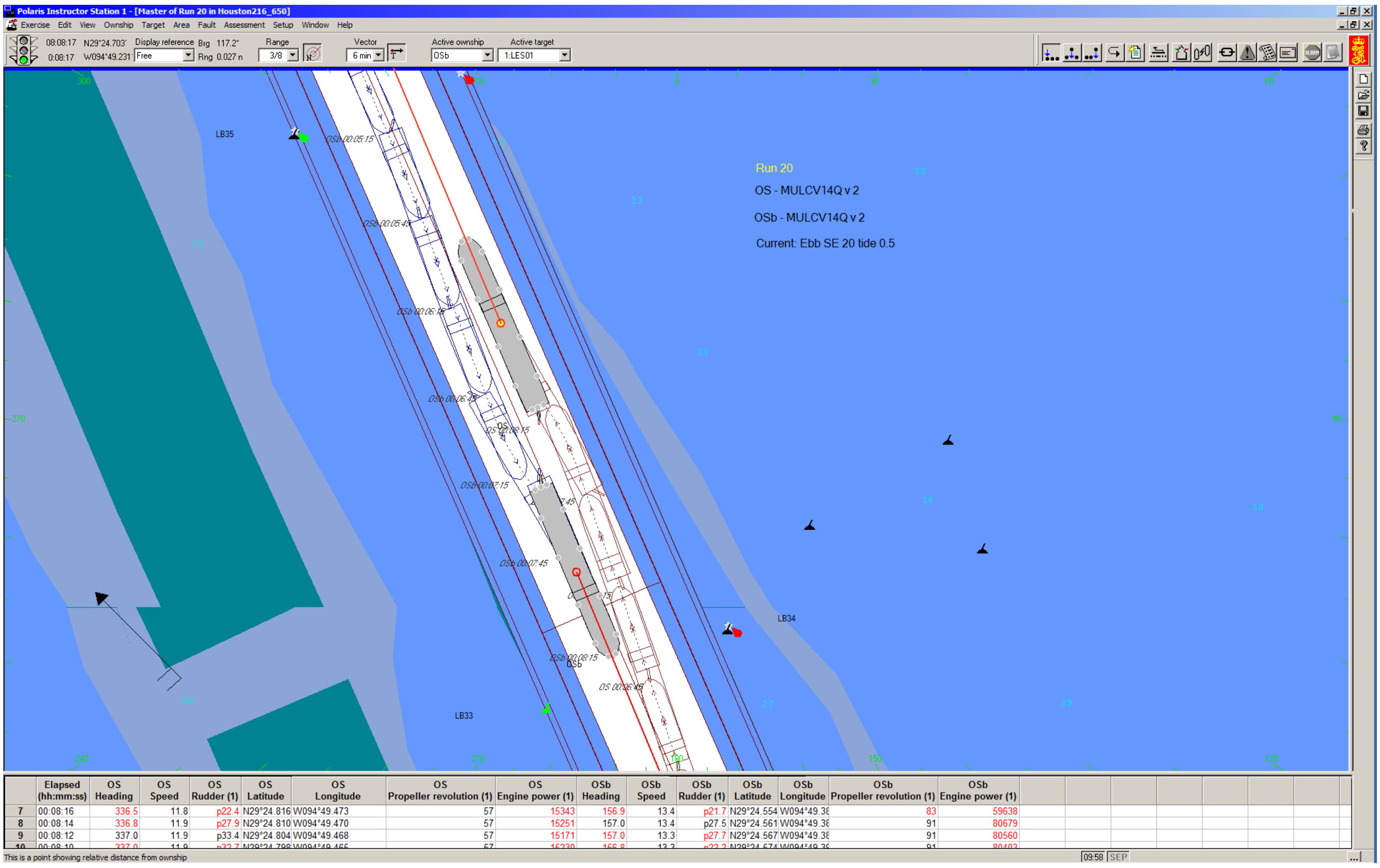
OSb - MULCV14Q v 2

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:07:42	331.1	11.5	s35.0	N29°24.717	W094°49.411	92	81631	149.8	12.1	s34.4	N29°24.661	W094°49.44	89	79142
8	00:07:40	331.6	11.4	s35.0	N29°24.712	W094°49.407	92	81459	150.2	12.0	s34.1	N29°24.667	W094°49.4	89	78957
9	00:07:38	332.2	11.3	s35.0	N29°24.706	W094°49.403	83	60438	150.7	11.9	s34.0	N29°24.672	W094°49.4	89	78799

This is a point showing relative distance from ownship

09:57 SEP



Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:08:17 N29°24.703' Brg 117.2°
0:08:17 W094°49.231' Rng 0.027 n

Display reference: Free
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20

OS - MULCV14Q v 2

OSb - MULCV14Q v 2

Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:08:16	336.5	11.8	p22.4	N29°24.816	W094°49.473	57	15343	156.9	13.4	p21.7	N29°24.554	W094°49.3	83	59638
8	00:08:14	336.8	11.9	p27.9	N29°24.810	W094°49.470	57	15251	157.0	13.4	p27.5	N29°24.561	W094°49.3	91	80679
9	00:08:12	337.0	11.9	p33.4	N29°24.804	W094°49.468	57	15171	157.0	13.3	p27.7	N29°24.567	W094°49.3	91	80560

This is a point showing relative distance from ownship

09:58 SEP

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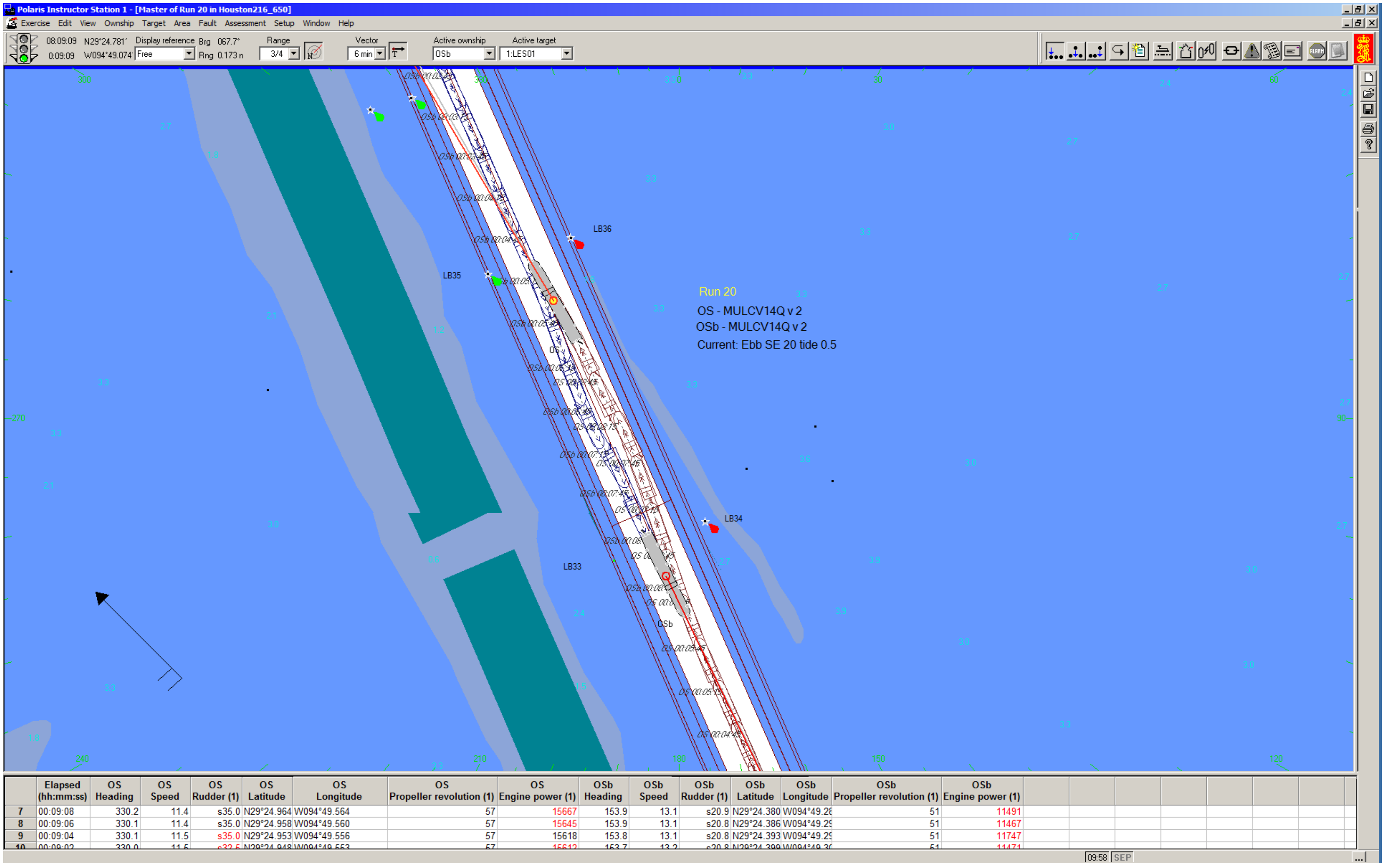


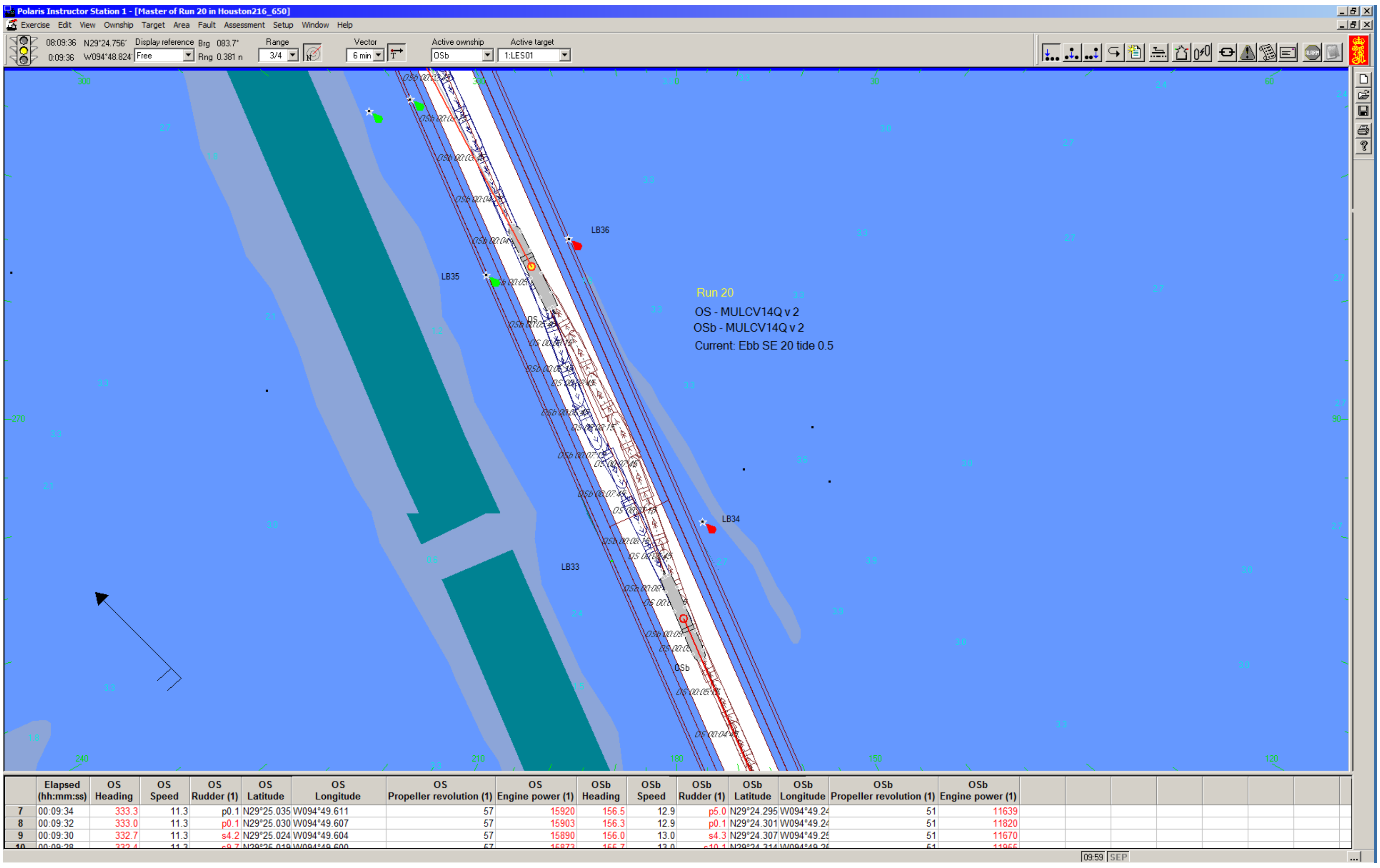
Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:09:09 N29°24.781′ Display reference: Free Brg 067.7°
0:09:09 W094°49.074′ Rng 0.173 n
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:08	330.2	11.4	s35.0	N29°24.964	W094°49.564	57	15667	153.9	13.1	s20.9	N29°24.380	W094°49.2	51	11491
8	00:09:06	330.1	11.4	s35.0	N29°24.958	W094°49.560	57	15645	153.9	13.1	s20.8	N29°24.386	W094°49.2	51	11467
9	00:09:04	330.1	11.5	s35.0	N29°24.953	W094°49.556	57	15618	153.8	13.1	s20.8	N29°24.393	W094°49.2	51	11747

09:58 SEP



Polaris Instructor Station 1 - [Master of Run 20 in Houston216_650]

08:09:36 N29°24.756′ Display reference: Free Brg 083.7°
0:09:36 W094°48.824′ Rng 0.381 n
Range: 3/4
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 20
OS - MULCV14Q v 2
OSb - MULCV14Q v 2
Current: Ebb SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	OSb Engine power (1)
7	00:09:34	333.3	11.3	p0.1	N29°25.035	W094°49.611	57	15920	156.5	12.9	p5.0	N29°24.295	W094°49.2	51	11639
8	00:09:32	333.0	11.3	p0.1	N29°25.030	W094°49.607	57	15903	156.3	12.9	p0.1	N29°24.301	W094°49.2	51	11820
9	00:09:30	332.7	11.3	s4.2	N29°25.024	W094°49.604	57	15890	156.0	13.0	s4.3	N29°24.307	W094°49.2	51	11670

09:59 SEP

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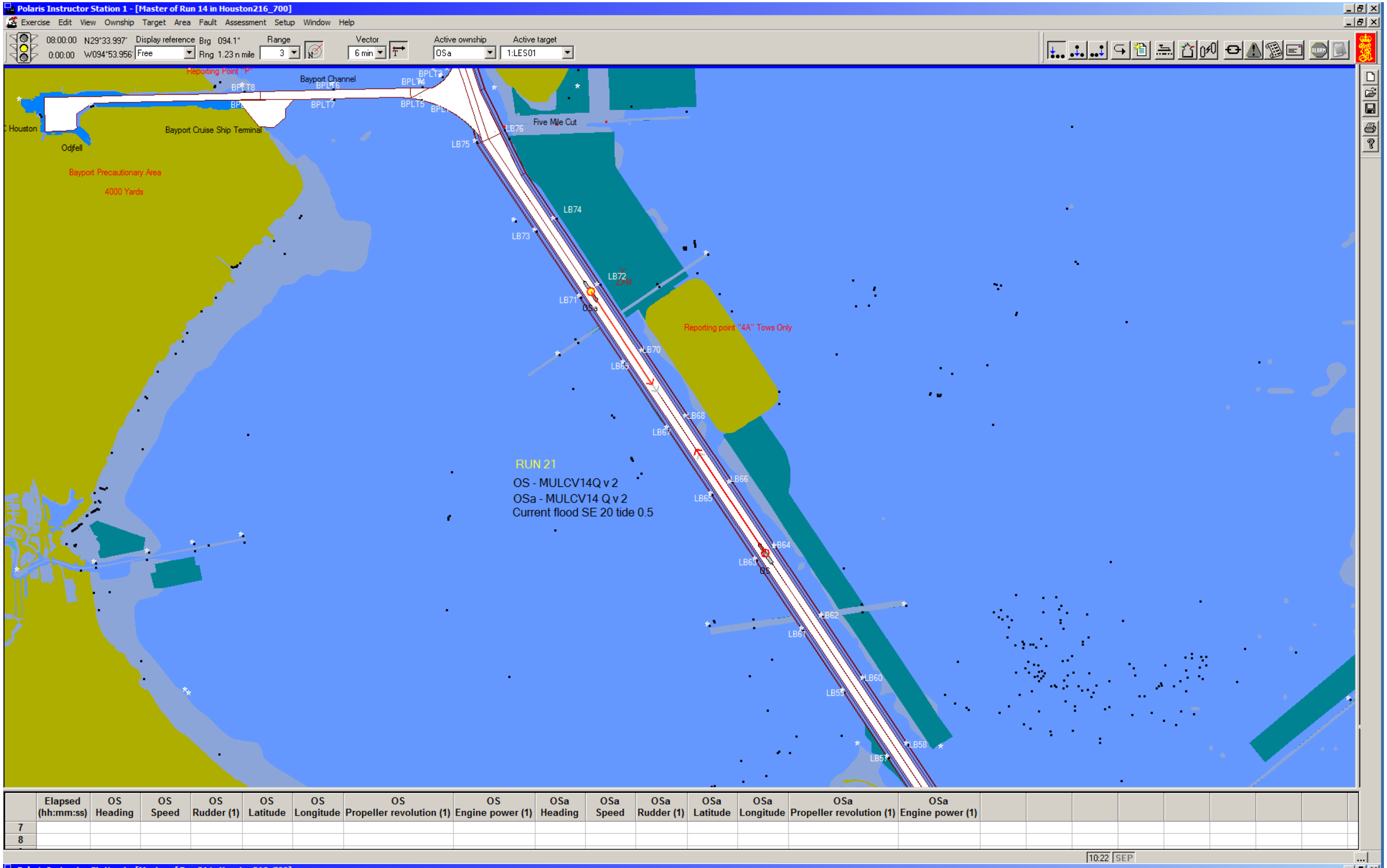
Run 21 – Begin 700 ft HSC Widening with Bend Widening



Polaris Instructor Station 1 - [Master of Run 14 in Houston216_700]

08:00:00 N29°33.997′ W094°53.956′ 0:00:00

Display reference: Free

Brg 094.1°

Rng 1.23 n mile

Range: 3

Vector: 6 min

Active ownship: OSa

Active target: 1:LES01

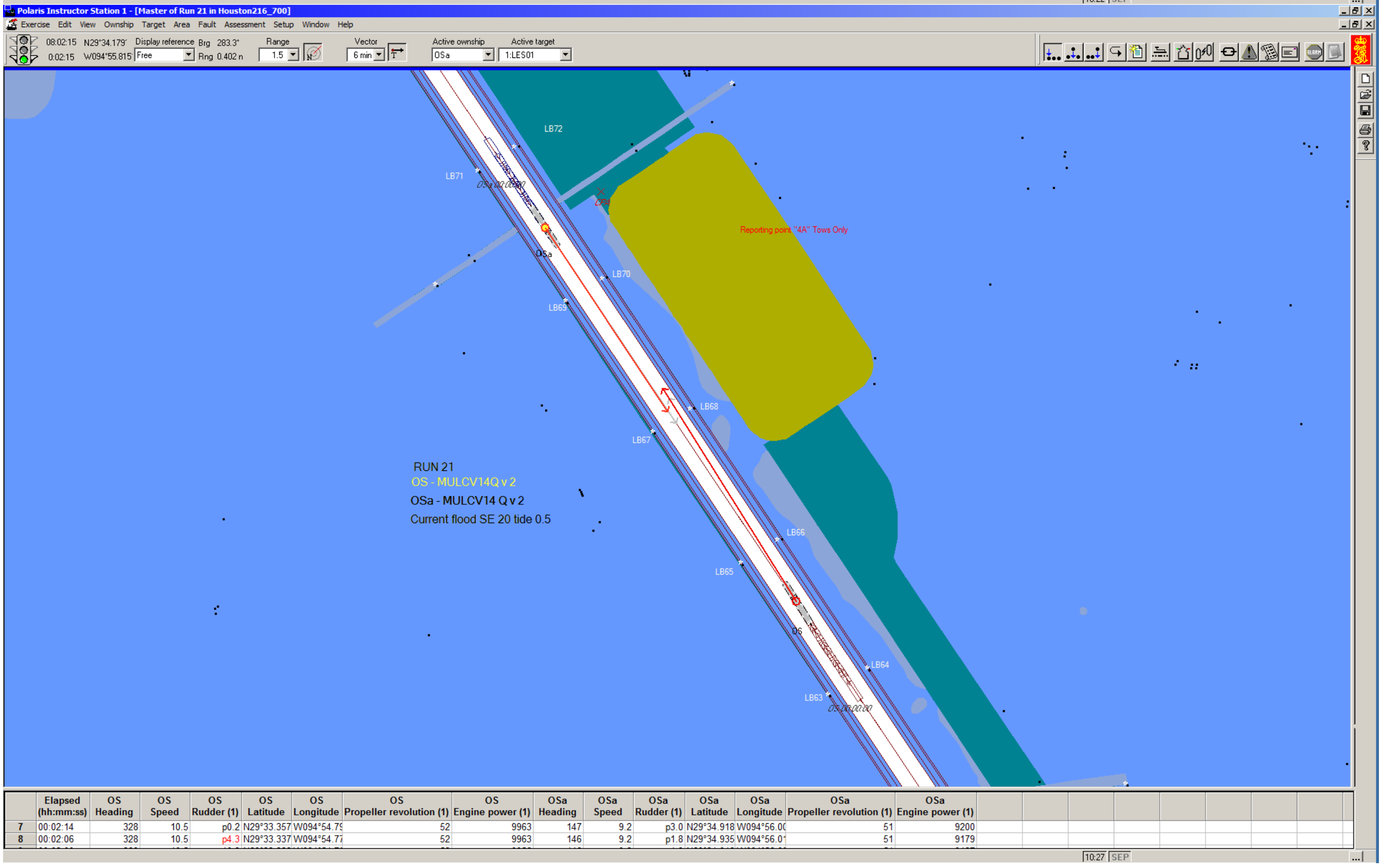
RUN 21

OS - MULCV14Q v 2

OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:02:15 N29°34.179′ W094°55.815′ 0:02:15

Display reference: Free

Brg 283.3°

Rng 0.402 n

Range: 1.5

Vector: 6 min

Active ownship: OSa

Active target: 1:LES01

RUN 21

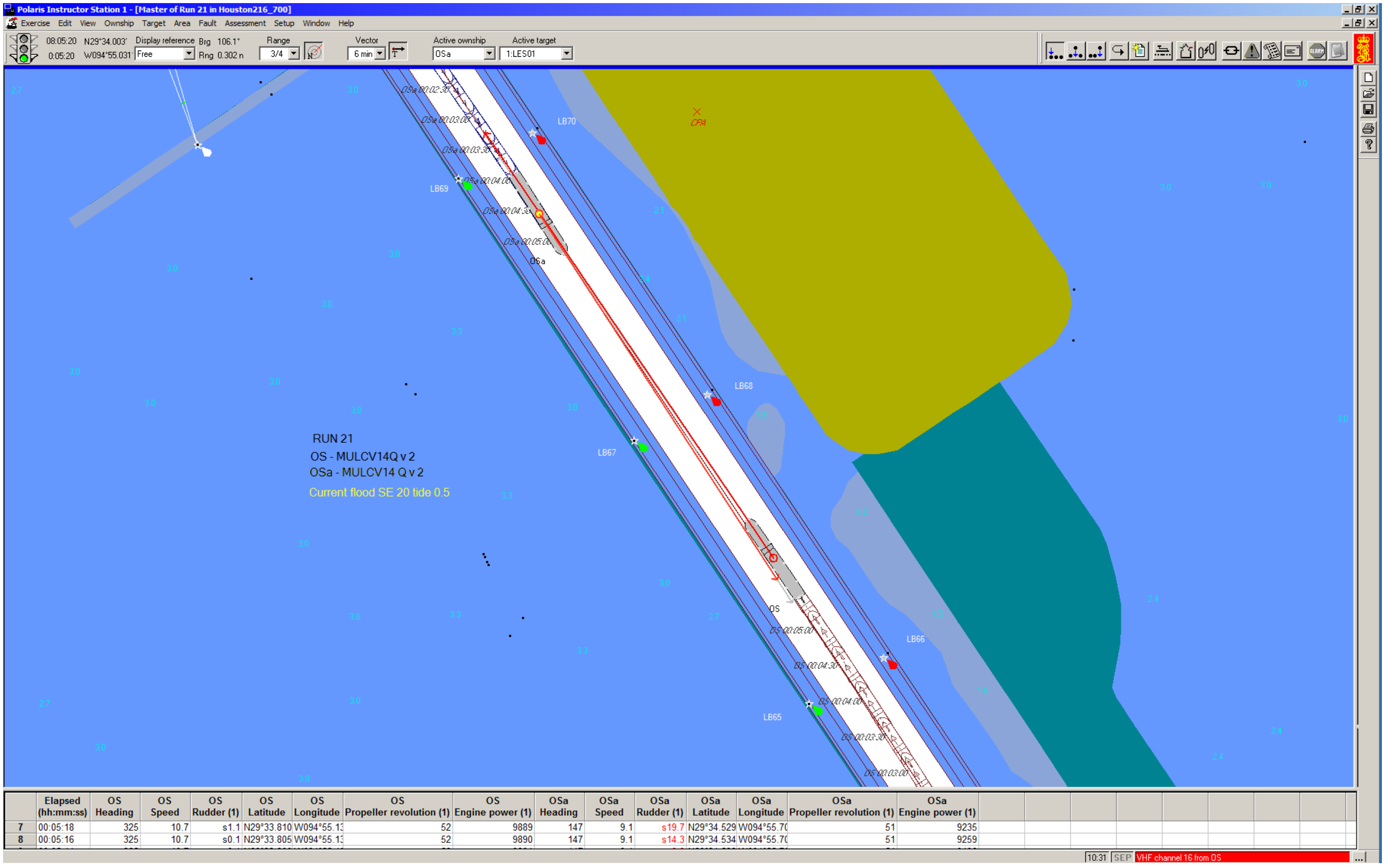
OS - MULCV14Q v 2

OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:02:14	328	10.5	p0.2	N29°33.357	W094°54.79	52	9963	147	9.2	p3.0	N29°34.918	W094°56.00	51	9200
8	00:02:06	328	10.5	p4.3	N29°33.337	W094°54.77	52	9963	146	9.2	p1.8	N29°34.935	W094°56.01	51	9179

June 26, 2019



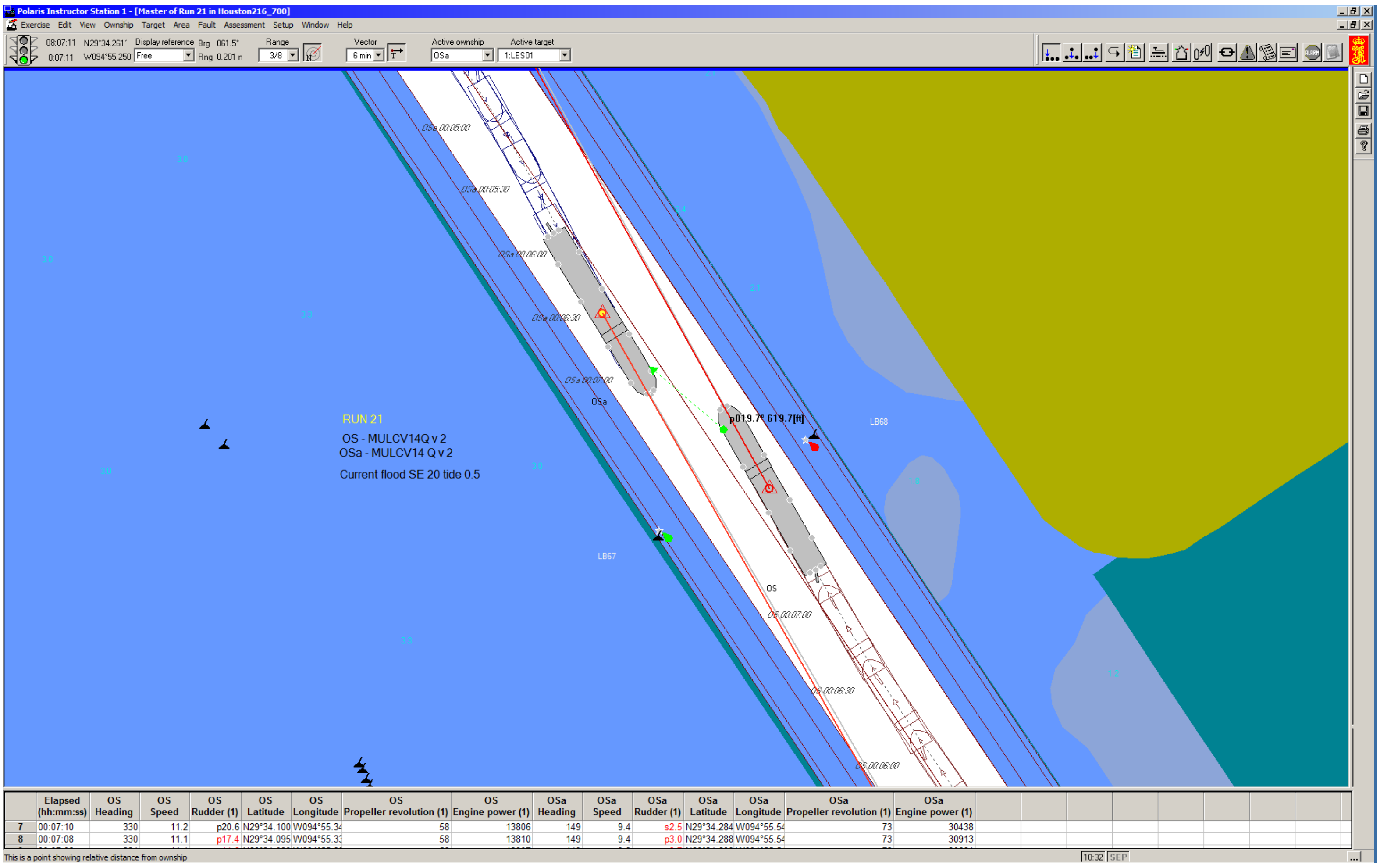
Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:05:20 N29°34.003' Display reference Free Brg 106.1° Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:05:20 W094°55.031' Rng 0.302 n

RUN 21
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:05:18	325	10.7	s1.1	N29°33.810	W094°55.13	52	9889	147	9.1	s19.7	N29°34.529	W094°55.70	51	9235
8	00:05:16	325	10.7	s0.1	N29°33.805	W094°55.13	52	9890	147	9.1	s14.3	N29°34.534	W094°55.70	51	9259

10:31 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:07:11 N29°34.261' Display reference Free Brg 061.5° Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:07:11 W094°55.250' Rng 0.201 n

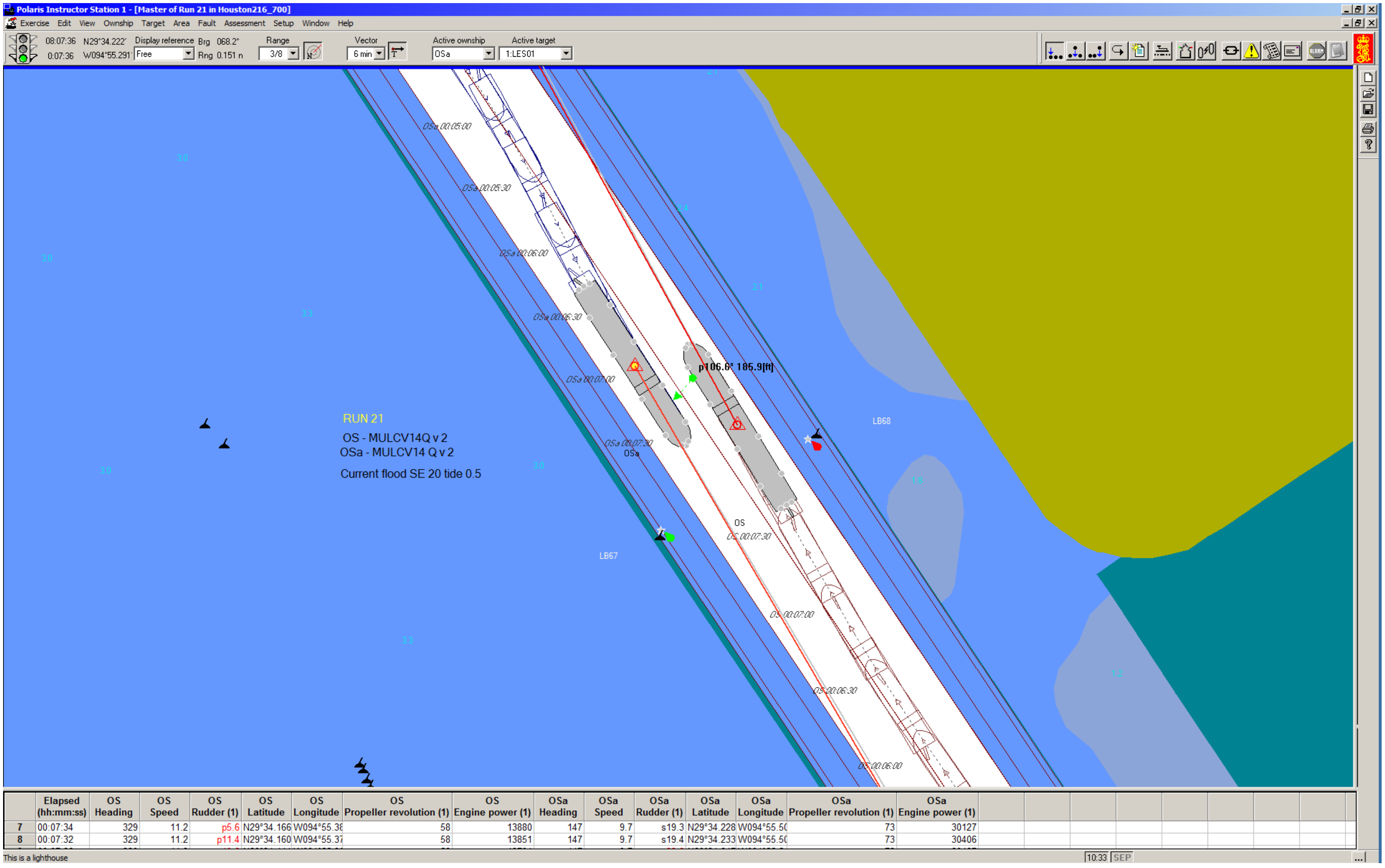
RUN 21
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:10	330	11.2	p20.6	N29°34.100	W094°55.34	58	13806	149	9.4	s2.5	N29°34.284	W094°55.54	73	30438
8	00:07:08	330	11.1	p17.4	N29°34.095	W094°55.33	58	13810	149	9.4	p3.0	N29°34.288	W094°55.54	73	30913

This is a point showing relative distance from ownship

10:32 SEP

June 26, 2019


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

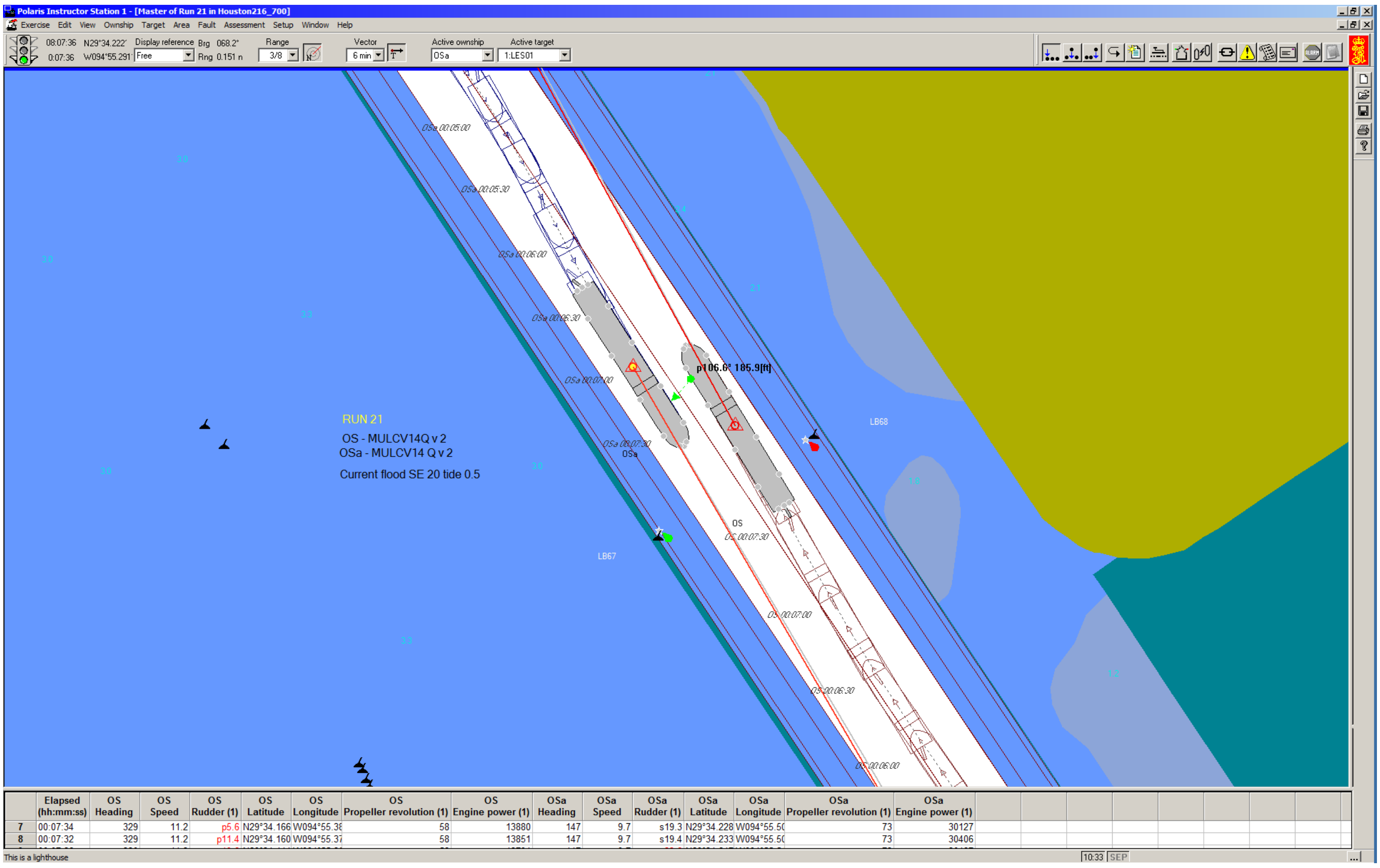
RUN 21

OS - MULCV14Q v 2
OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:34	329	11.2	p5.6	N29°34.166	W094°55.38	58	13880	147	9.7	s19.3	N29°34.228	W094°55.50	73	30127
8	00:07:32	329	11.2	p11.4	N29°34.160	W094°55.37	58	13851	147	9.7	s19.4	N29°34.233	W094°55.50	73	30406

This is a lighthouse


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

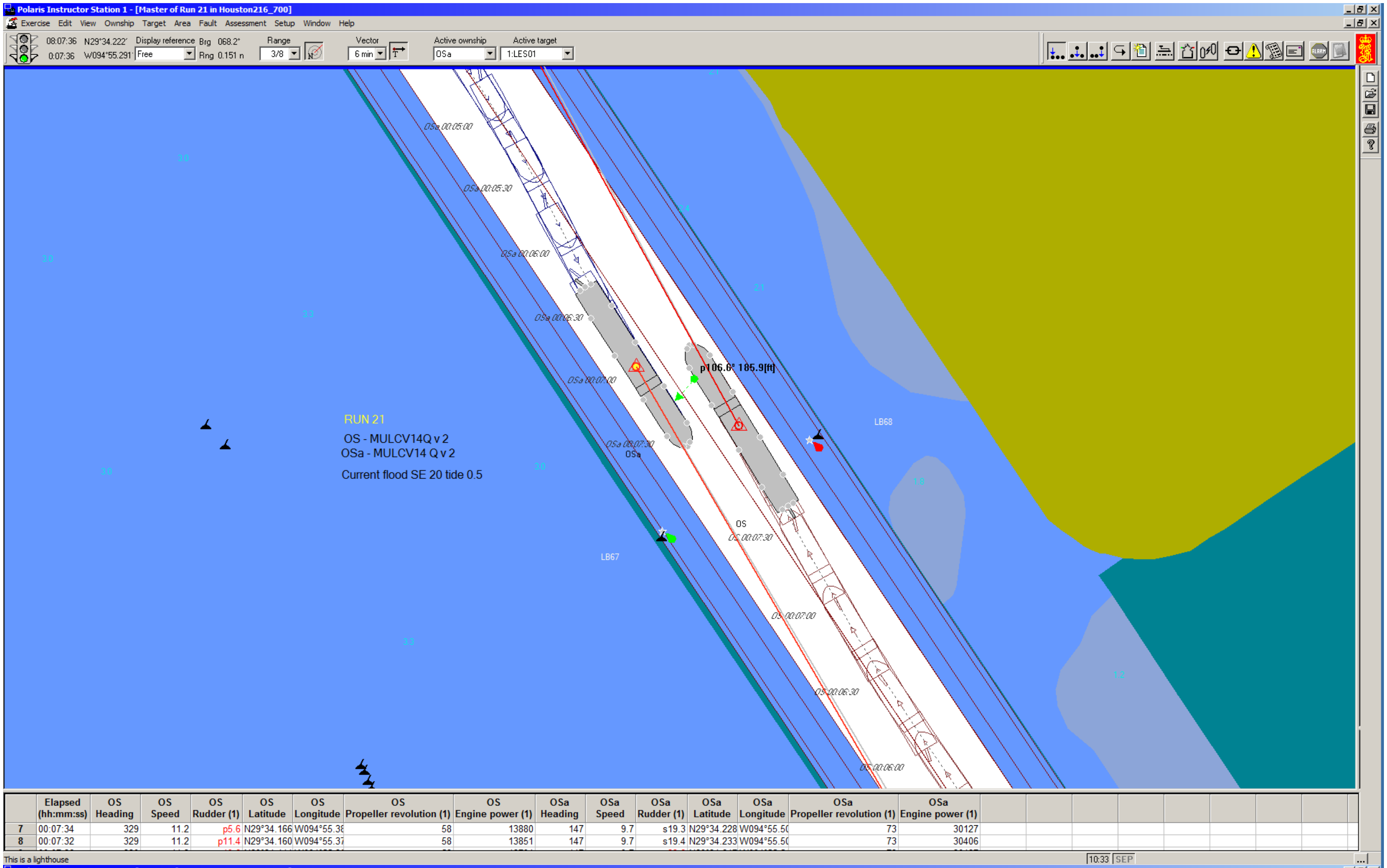
RUN 21

OS - MULCV14Q v 2
OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:34	329	11.2	p5.6	N29°34.166	W094°55.38	58	13880	147	9.7	s19.3	N29°34.228	W094°55.50	73	30127
8	00:07:32	329	11.2	p11.4	N29°34.160	W094°55.37	58	13851	147	9.7	s19.4	N29°34.233	W094°55.50	73	30406

This is a lighthouse



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:07:36 N29°34.222' Display reference Free Brg 068.2° Rng 0.151 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

0:07:36 W094°55.291'

RUN 21

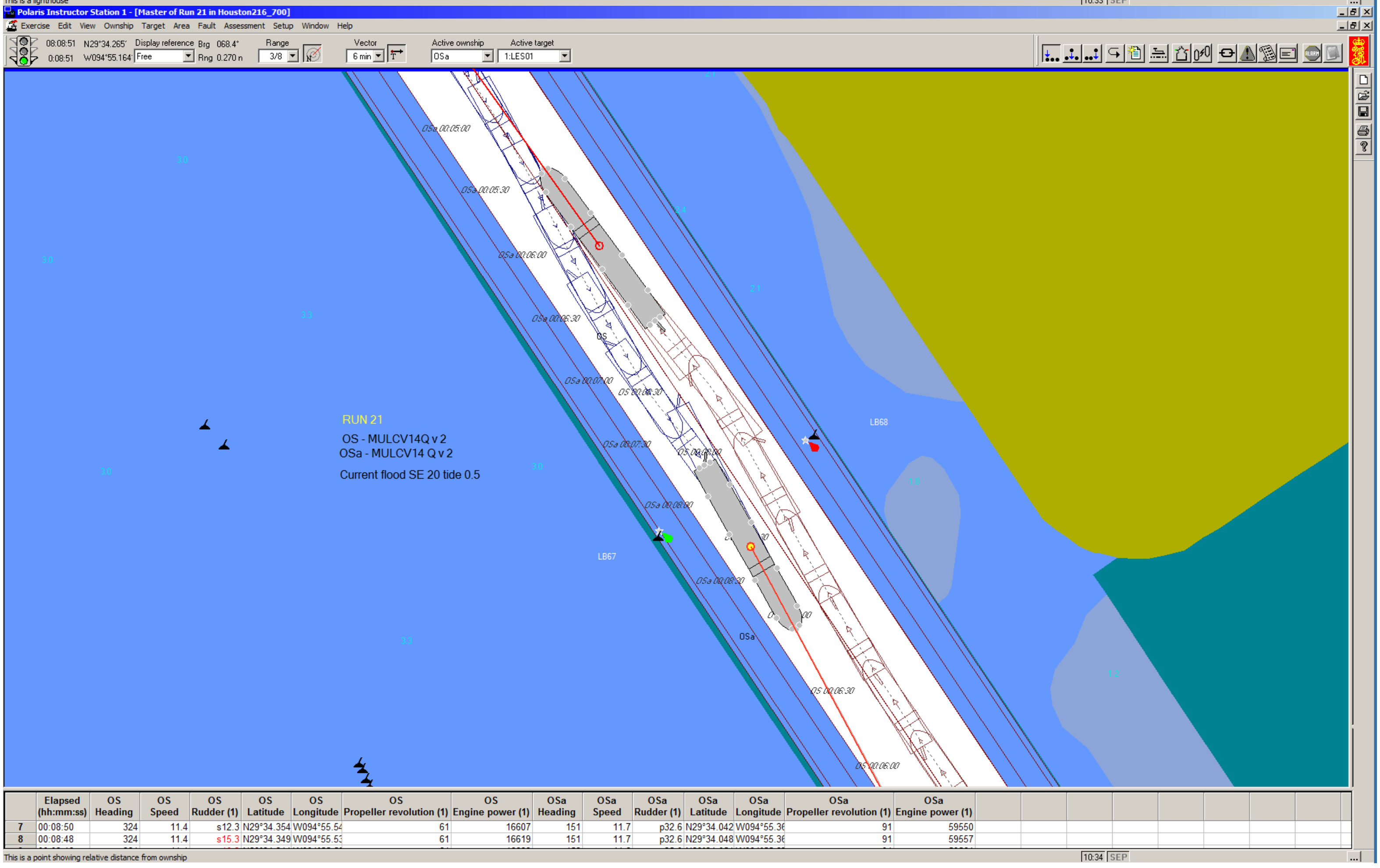
OS - MULCV14Q v 2

OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:34	329	11.2	p5.6	N29°34.166	W094°55.38	58	13880	147	9.7	s19.3	N29°34.228	W094°55.50	73	30127
8	00:07:32	329	11.2	p11.4	N29°34.160	W094°55.37	58	13851	147	9.7	s19.4	N29°34.233	W094°55.50	73	30406

This is a lighthouse



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:08:51 N29°34.265' Display reference Free Brg 068.4° Rng 0.270 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

0:08:51 W094°55.164'

RUN 21

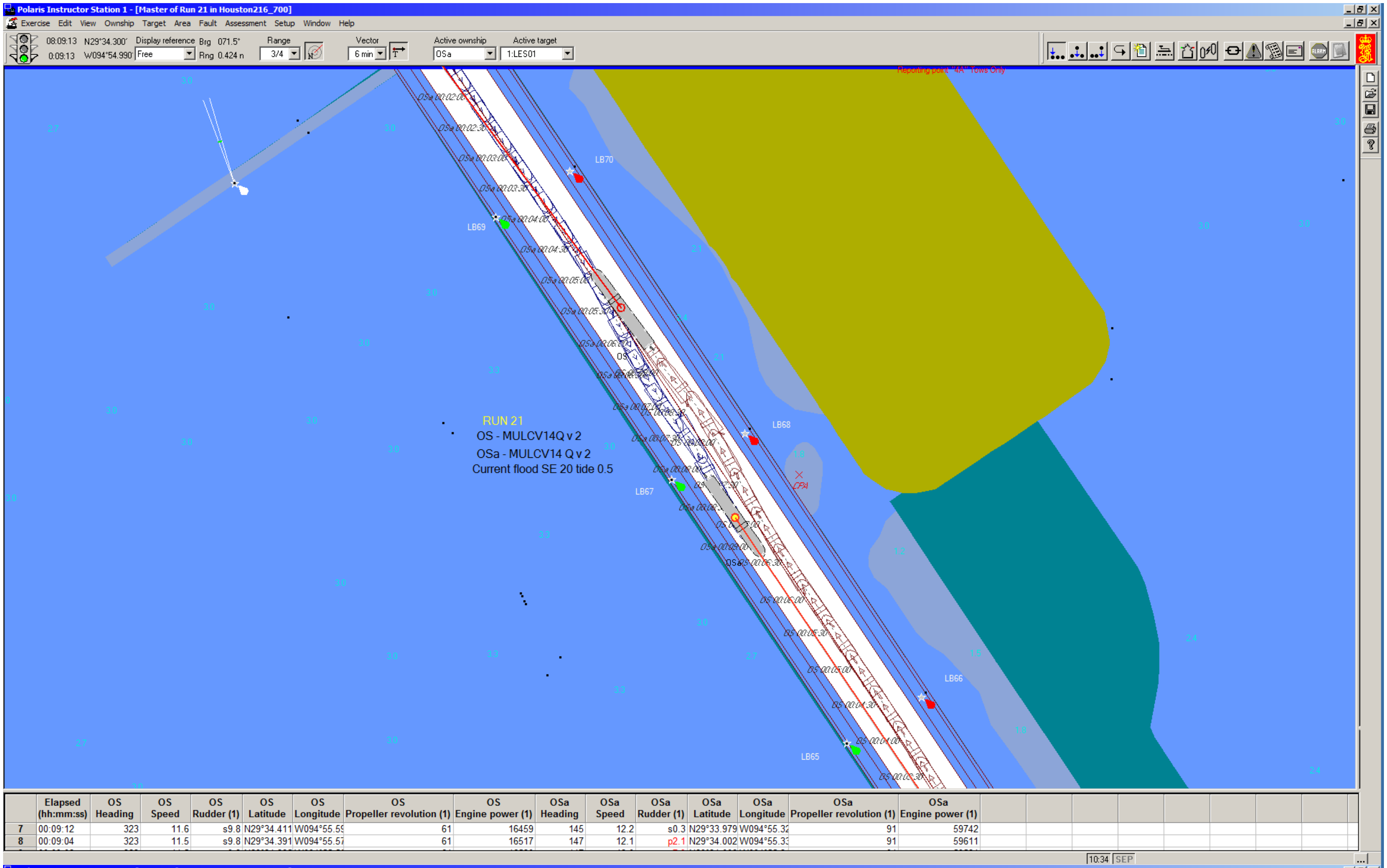
OS - MULCV14Q v 2

OSa - MULCV14 Q v 2

Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:50	324	11.4	s12.3	N29°34.354	W094°55.54	61	16607	151	11.7	p32.6	N29°34.042	W094°55.36	91	59550
8	00:08:48	324	11.4	s15.3	N29°34.349	W094°55.53	61	16619	151	11.7	p32.6	N29°34.048	W094°55.36	91	59557

This is a point showing relative distance from ownship

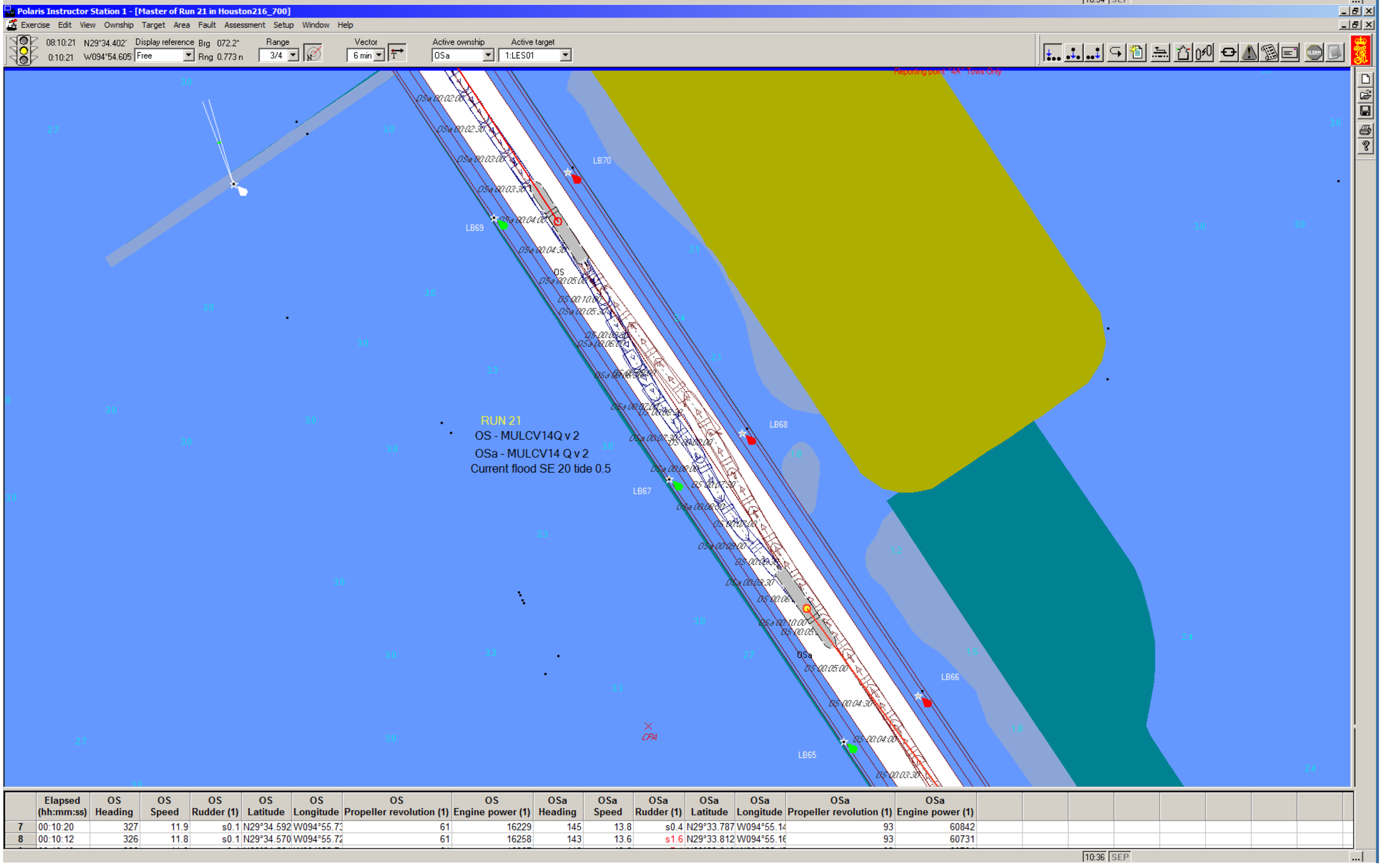


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:09:13 N29°34.300' Display reference Free Brg 071.5° Rng 0.424 n
0:09:13 W094°54.990'
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 21
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:12	323	11.6	s9.8	N29°34.411	W094°55.59	61	16459	145	12.2	s0.3	N29°33.979	W094°55.32	91	59742
8	00:09:04	323	11.5	s9.8	N29°34.391	W094°55.57	61	16517	147	12.1	p2.1	N29°34.002	W094°55.33	91	59611

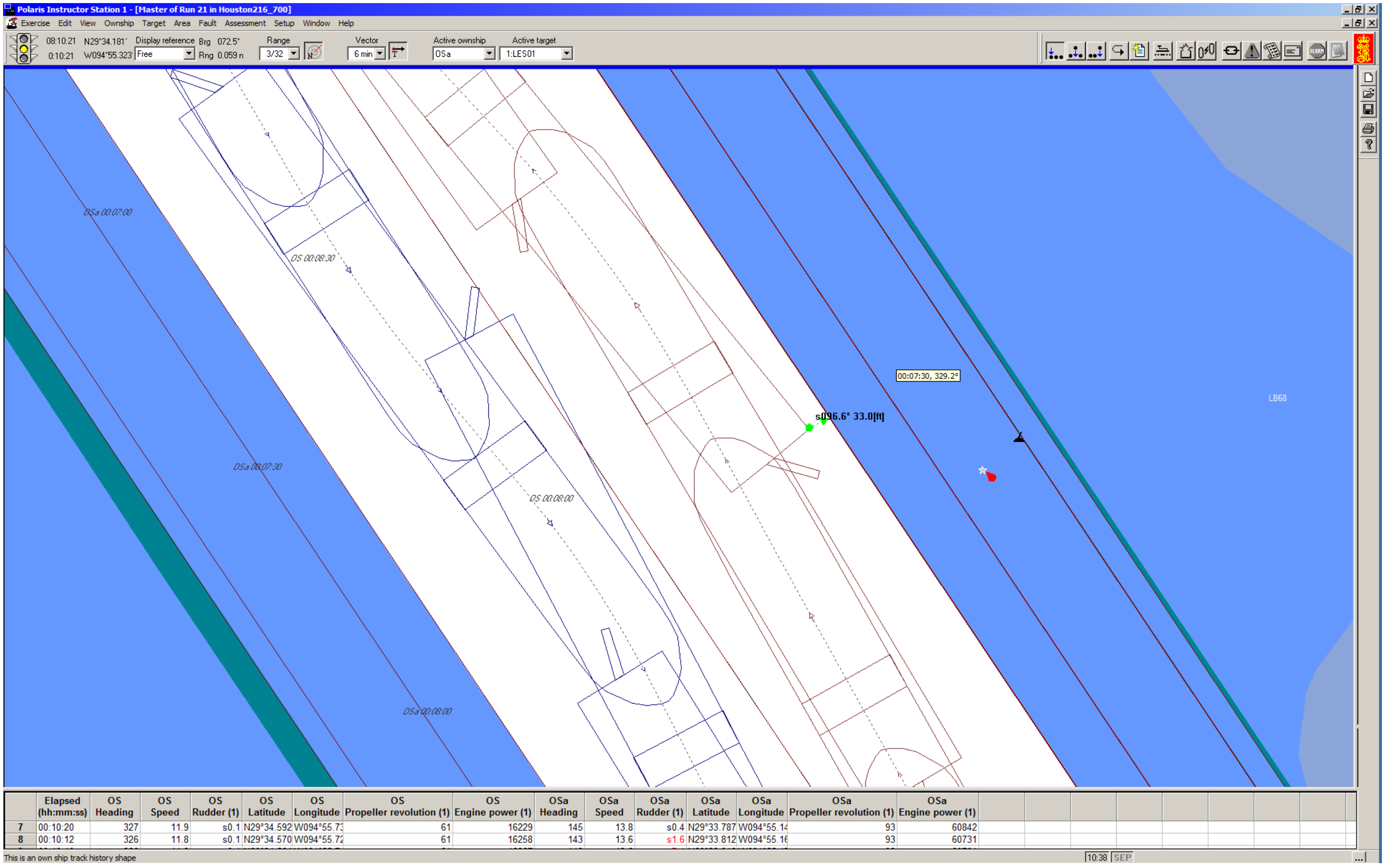


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:10:21 N29°34.402' Display reference Free Brg 072.2° Rng 0.773 n
0:10:21 W094°54.605'
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 21
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:10:20	327	11.9	s0.1	N29°34.592	W094°55.73	61	16229	145	13.8	s0.4	N29°33.787	W094°55.14	93	60842
8	00:10:12	326	11.8	s0.1	N29°34.570	W094°55.72	61	16258	143	13.6	s1.6	N29°33.812	W094°55.16	93	60731



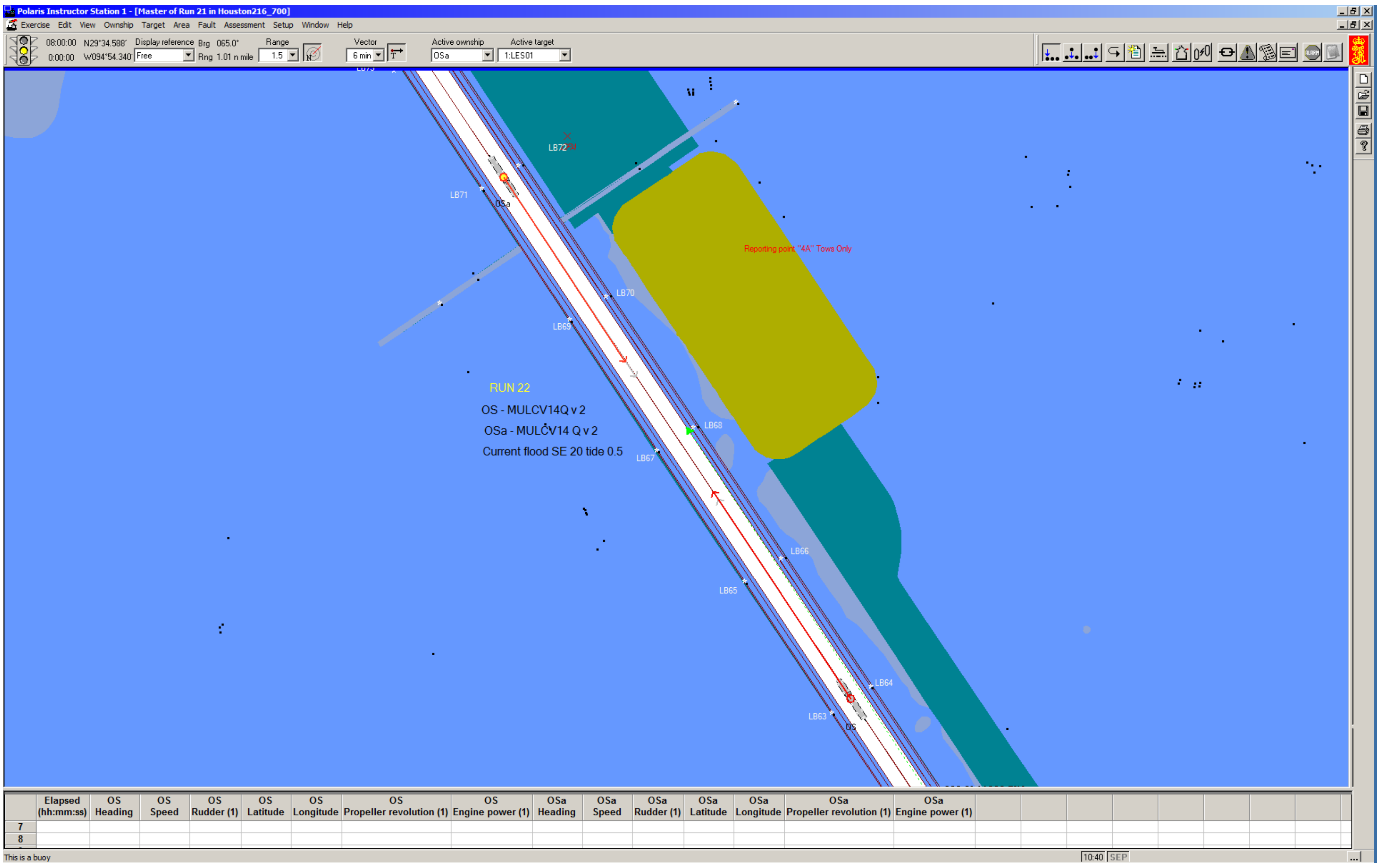
08:10:21 N29°34.181′ Display reference Free Brg 072.5° Range 3/32 Vector 6 min Active ownship OSa Active target 1:LES01

0:10:21 W094°55.323′ Rng 0.059 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:10:20	327	11.9	s0.1	N29°34.592	W094°55.73	61	16229	145	13.8	s0.4	N29°33.787	W094°55.14	93	60842
8	00:10:12	326	11.8	s0.1	N29°34.570	W094°55.72	61	16258	143	13.6	s1.6	N29°33.812	W094°55.16	93	60731

This is an own ship track history shape

Run 22



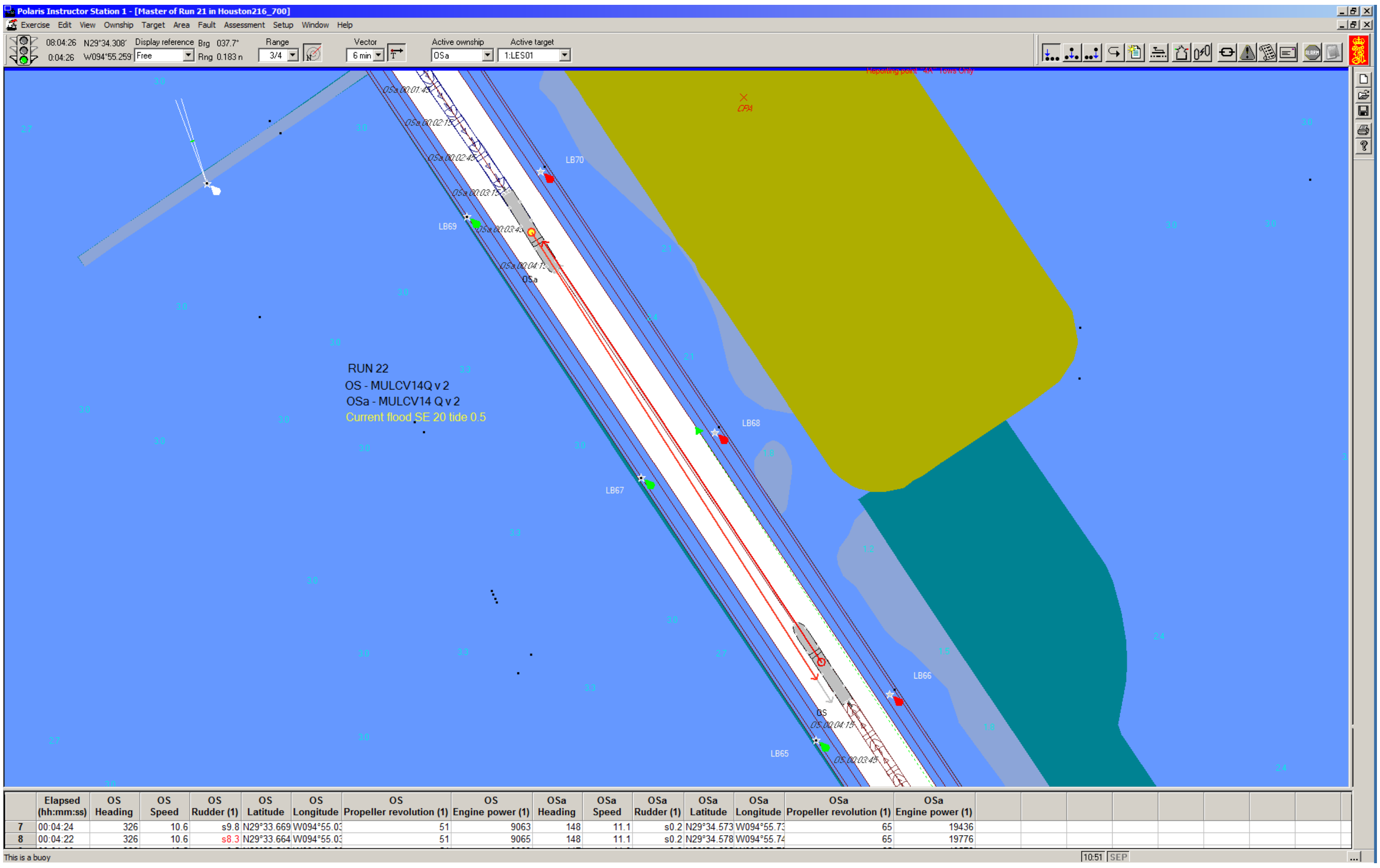
Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:00:00 N29°34.588′ Display reference: Free Brg 065.0° Rng 1.01 n mile
0:00:00 W094°54.340′
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															
8															

This is a buoy



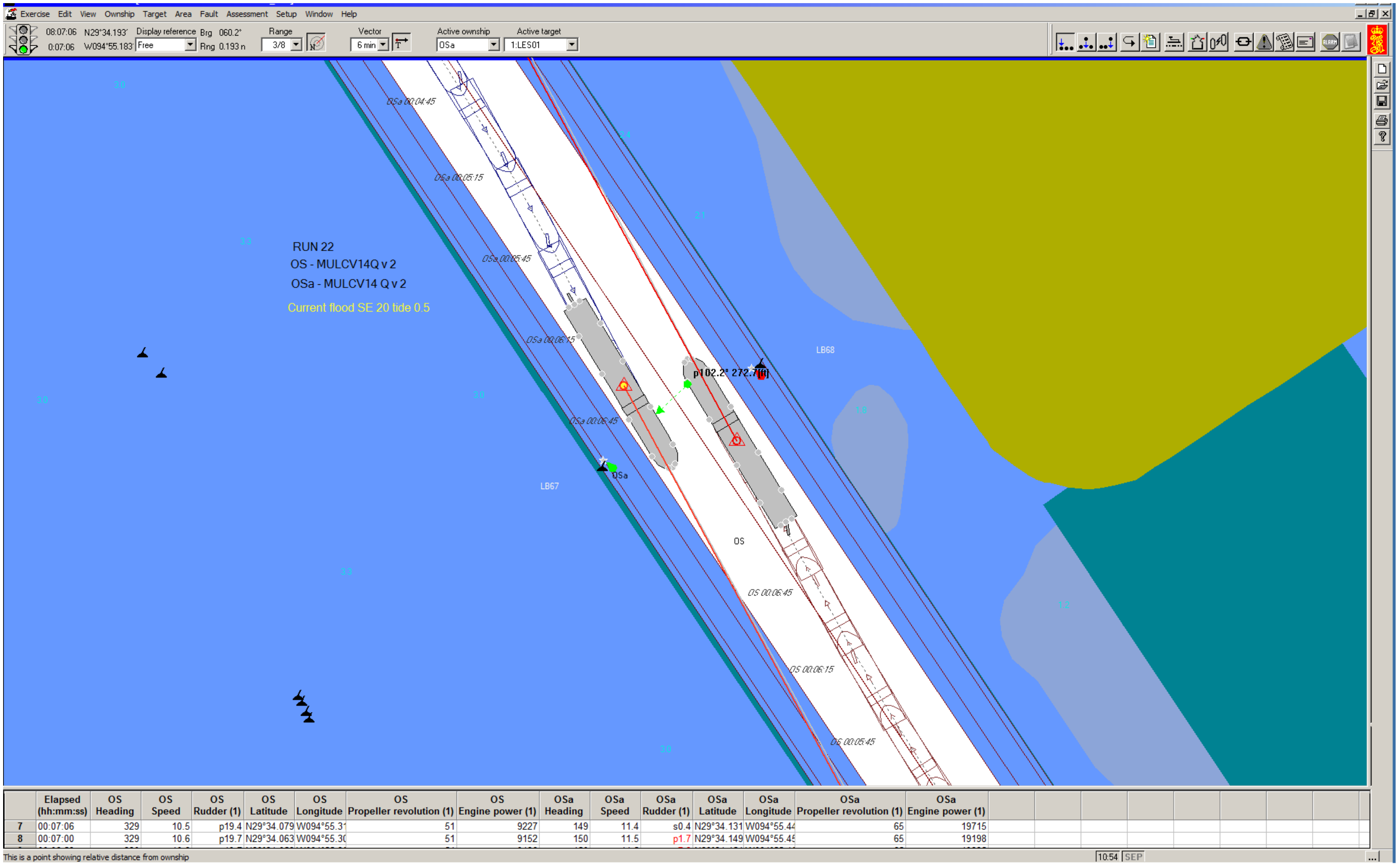
Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:04:26 N29°34.308′ Display reference: Free Brg 037.7° Rng 0.183 n
0:04:26 W094°55.259′
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:24	326	10.6	s9.8	N29°33.669	W094°55.03	51	9063	148	11.1	s0.2	N29°34.573	W094°55.73	65	19436
8	00:04:22	326	10.6	s8.3	N29°33.664	W094°55.03	51	9065	148	11.1	s0.2	N29°34.578	W094°55.74	65	19776

This is a buoy

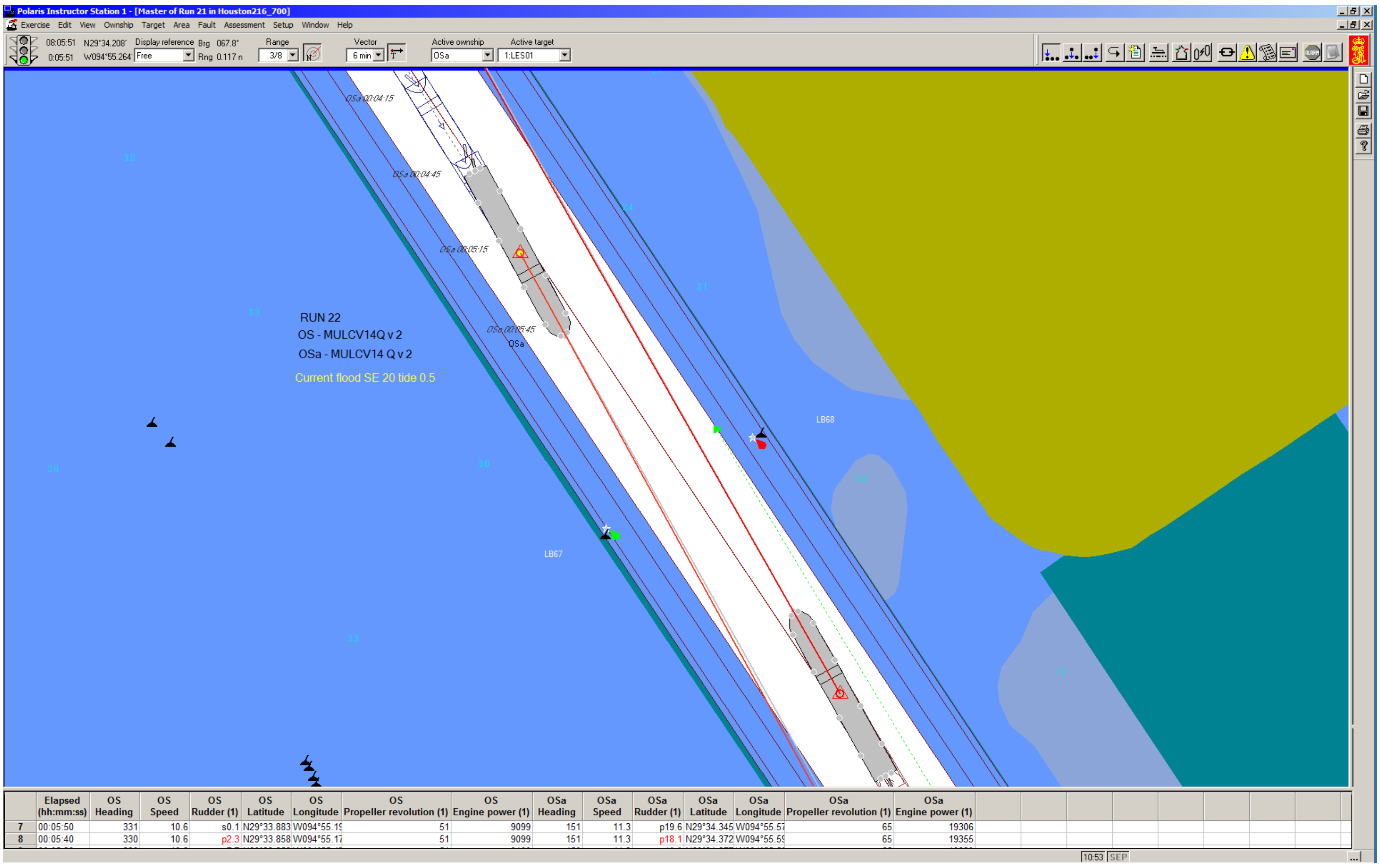


08:07:06 N29°34.193′ Display reference Free Brg 060.2° Rng 0.193 n
0:07:06 W094°55.183′
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:06	329	10.5	p19.4	N29°34.079	W094°55.31	51	9227	149	11.4	s0.4	N29°34.131	W094°55.44	65	19715
8	00:07:00	329	10.6	p19.7	N29°34.063	W094°55.30	51	9152	150	11.5	p1.7	N29°34.149	W094°55.45	65	19198

This is a point showing relative distance from ownship

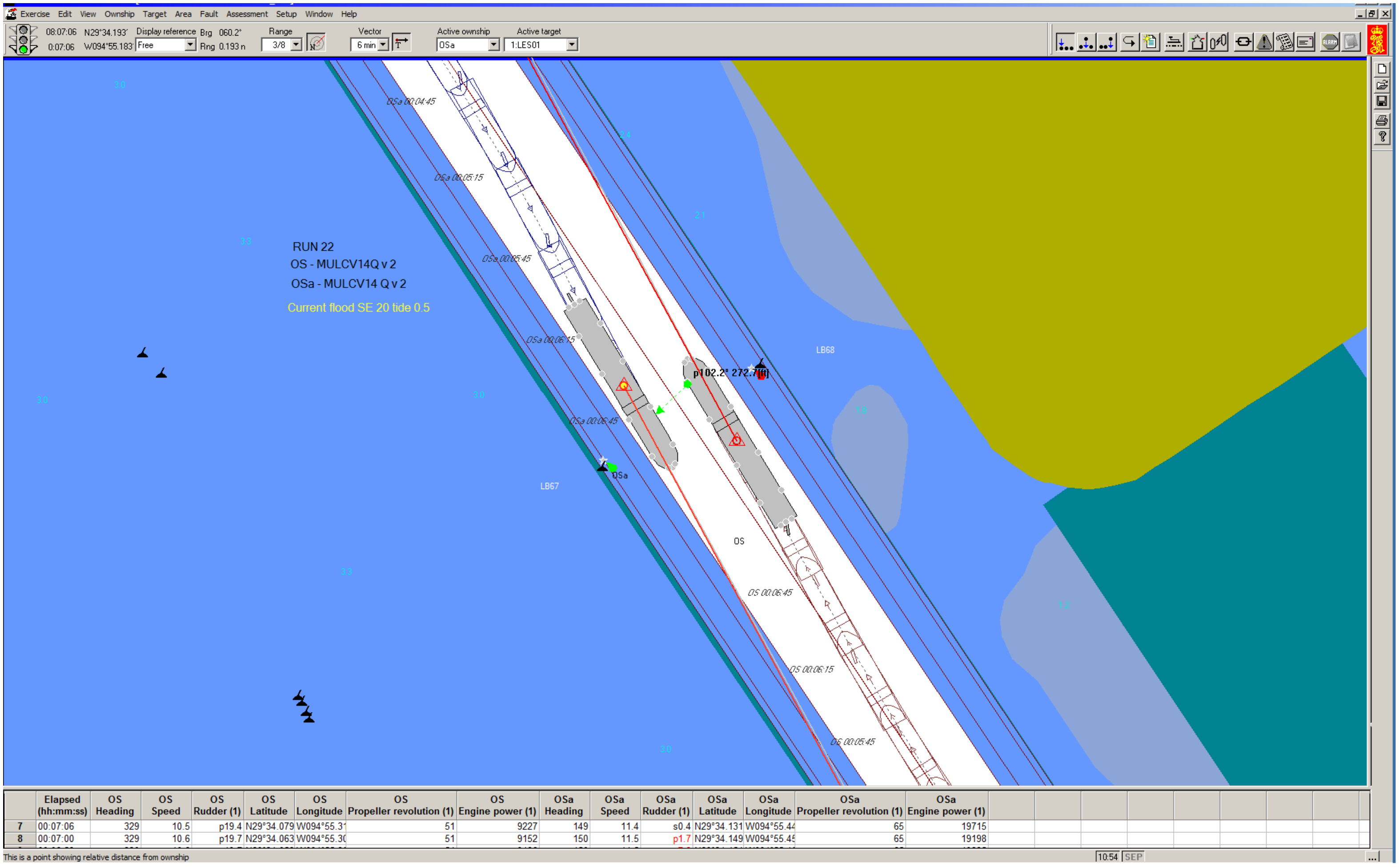


08:05:51 N29°34.208′ Display reference Free Brg 067.8° Rng 0.117 n
0:05:51 W094°55.264′
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:05:50	331	10.6	s0.1	N29°33.883	W094°55.19	51	9099	151	11.3	p19.6	N29°34.345	W094°55.57	65	19306
8	00:05:40	330	10.6	p2.3	N29°33.858	W094°55.17	51	9099	151	11.3	p18.1	N29°34.372	W094°55.59	65	19355

June 26, 2019

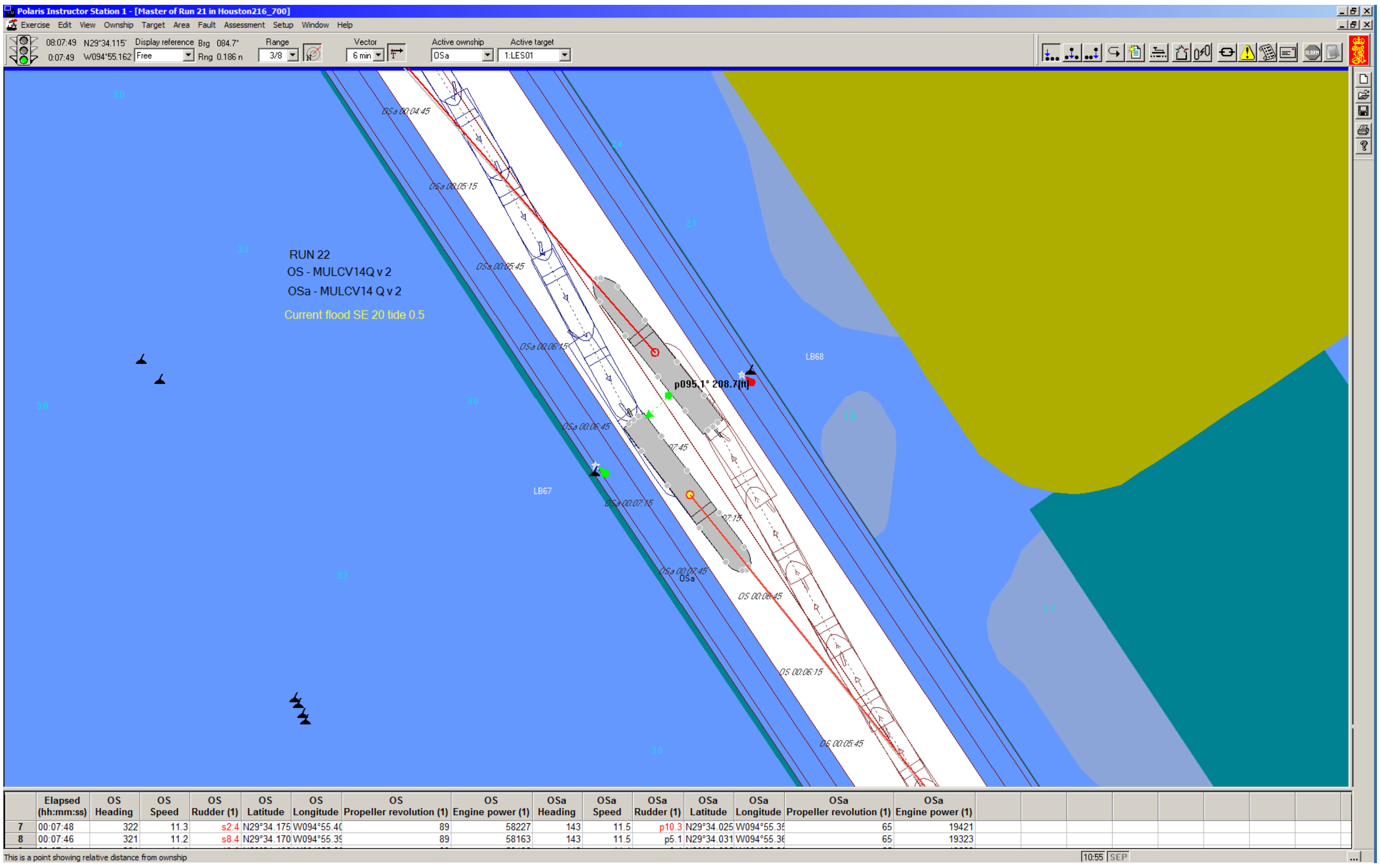


08:07:06 N29°34.193′ Display reference Free Brg 060.2°
0:07:06 W094°55.183′ Rng 0.193 n
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:06	329	10.5	p19.4	N29°34.079	W094°55.31	51	9227	149	11.4	s0.4	N29°34.131	W094°55.44	65	19715
8	00:07:00	329	10.6	p19.7	N29°34.063	W094°55.30	51	9152	150	11.5	p1.7	N29°34.149	W094°55.45	65	19198

This is a point showing relative distance from ownship
10:54 SEP



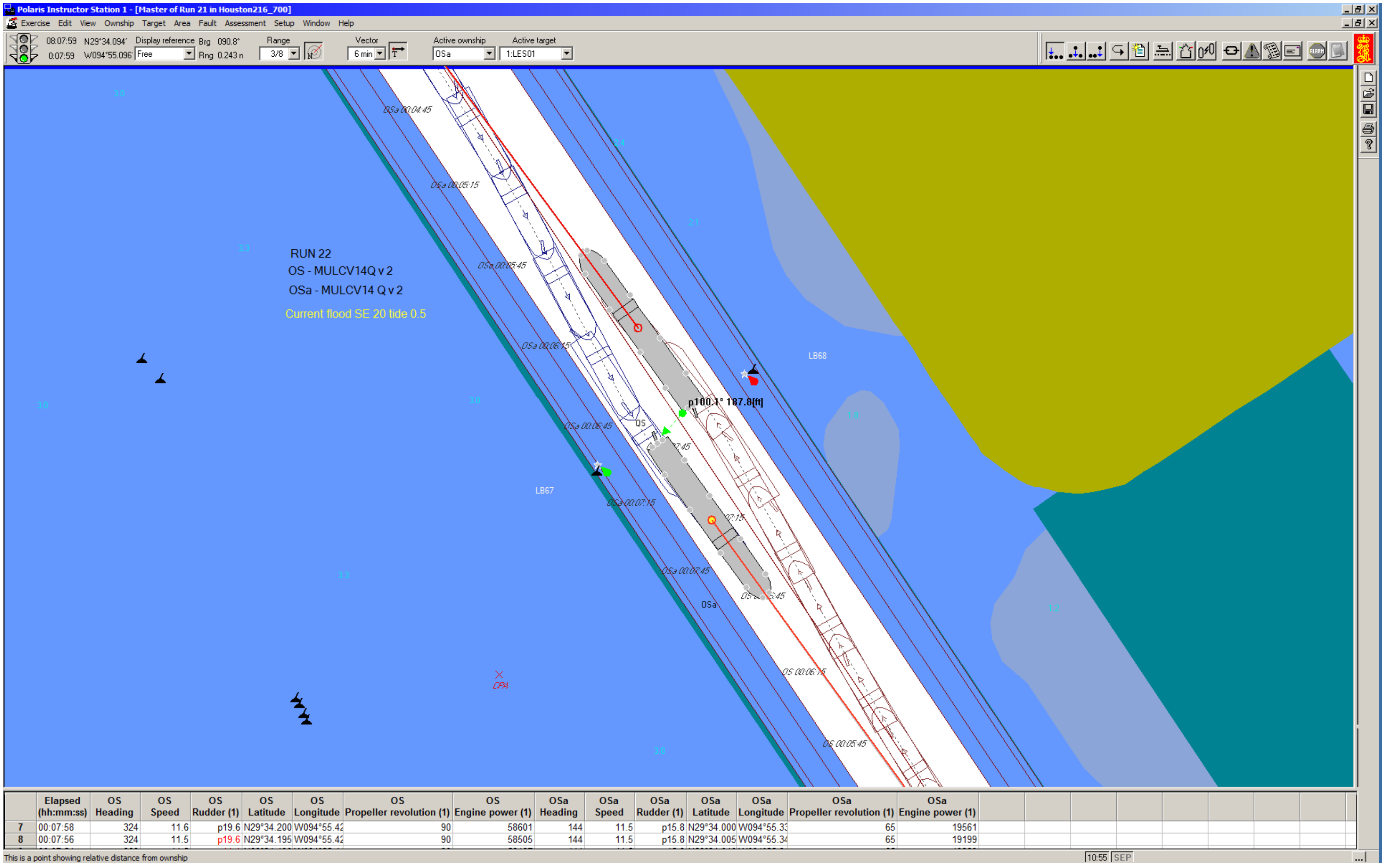
Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:07:49 N29°34.115′ Display reference Free Brg 084.7°
0:07:49 W094°55.162′ Rng 0.186 n
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:48	322	11.3	s2.4	N29°34.175	W094°55.40	89	58227	143	11.5	p10.3	N29°34.025	W094°55.35	65	19421
8	00:07:46	321	11.2	s8.4	N29°34.170	W094°55.39	89	58163	143	11.5	p5.1	N29°34.031	W094°55.36	65	19323

This is a point showing relative distance from ownship
10:55 SEP



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

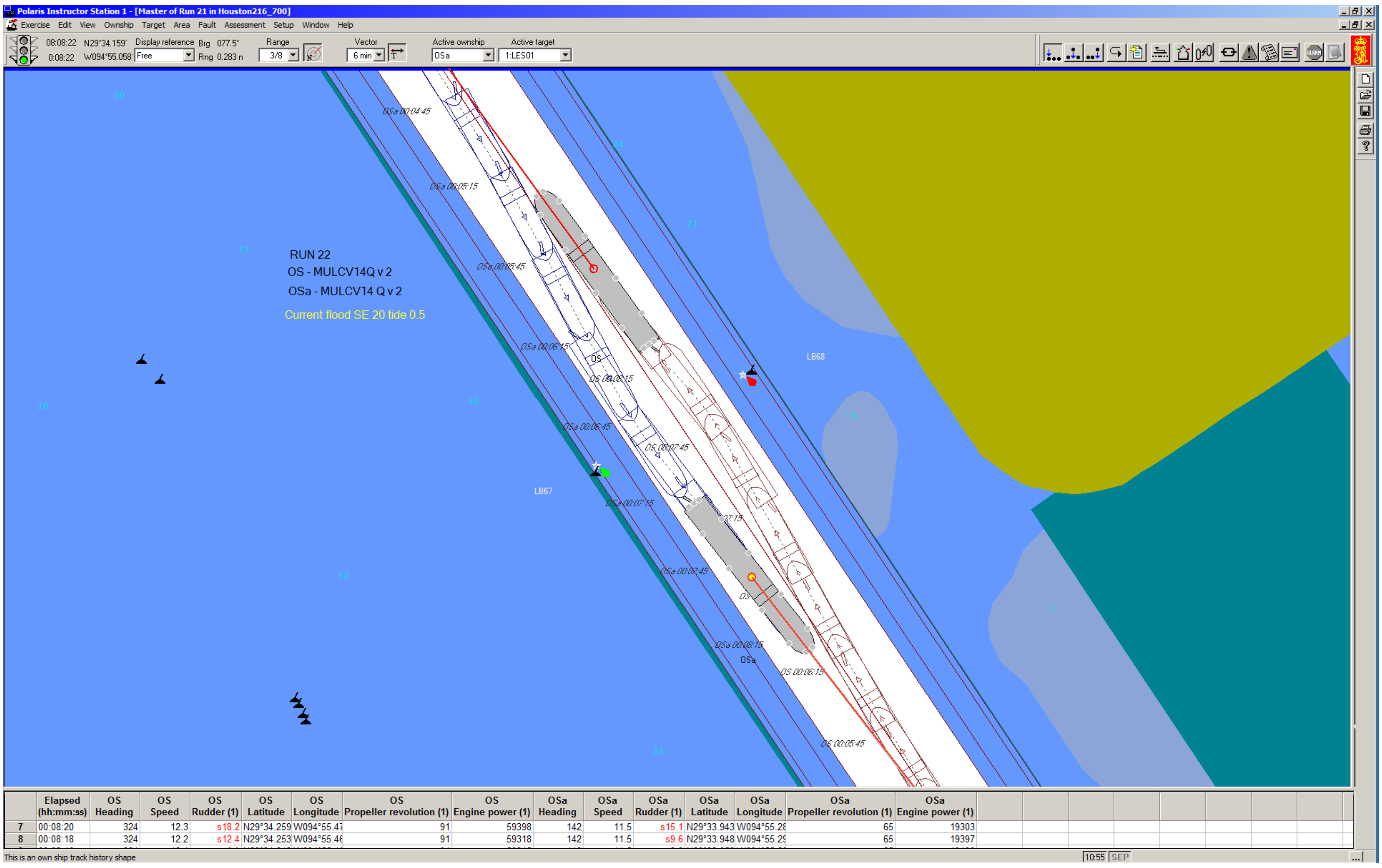
08:07:59 N29°34.094′ Display reference Brg 090.8°
0:07:59 W094°55.096′ Free Rng 0.243 n
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:58	324	11.6	p19.6	N29°34.200	W094°55.42	90	58601	144	11.5	p15.8	N29°34.000	W094°55.33	65	19561
8	00:07:56	324	11.5	p19.6	N29°34.195	W094°55.42	90	58505	144	11.5	p15.8	N29°34.005	W094°55.34	65	19199

This is a point showing relative distance from ownship

10:55 SEP



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:08:22 N29°34.159′ Display reference Brg 077.5°
0:08:22 W094°55.058′ Free Rng 0.283 n
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

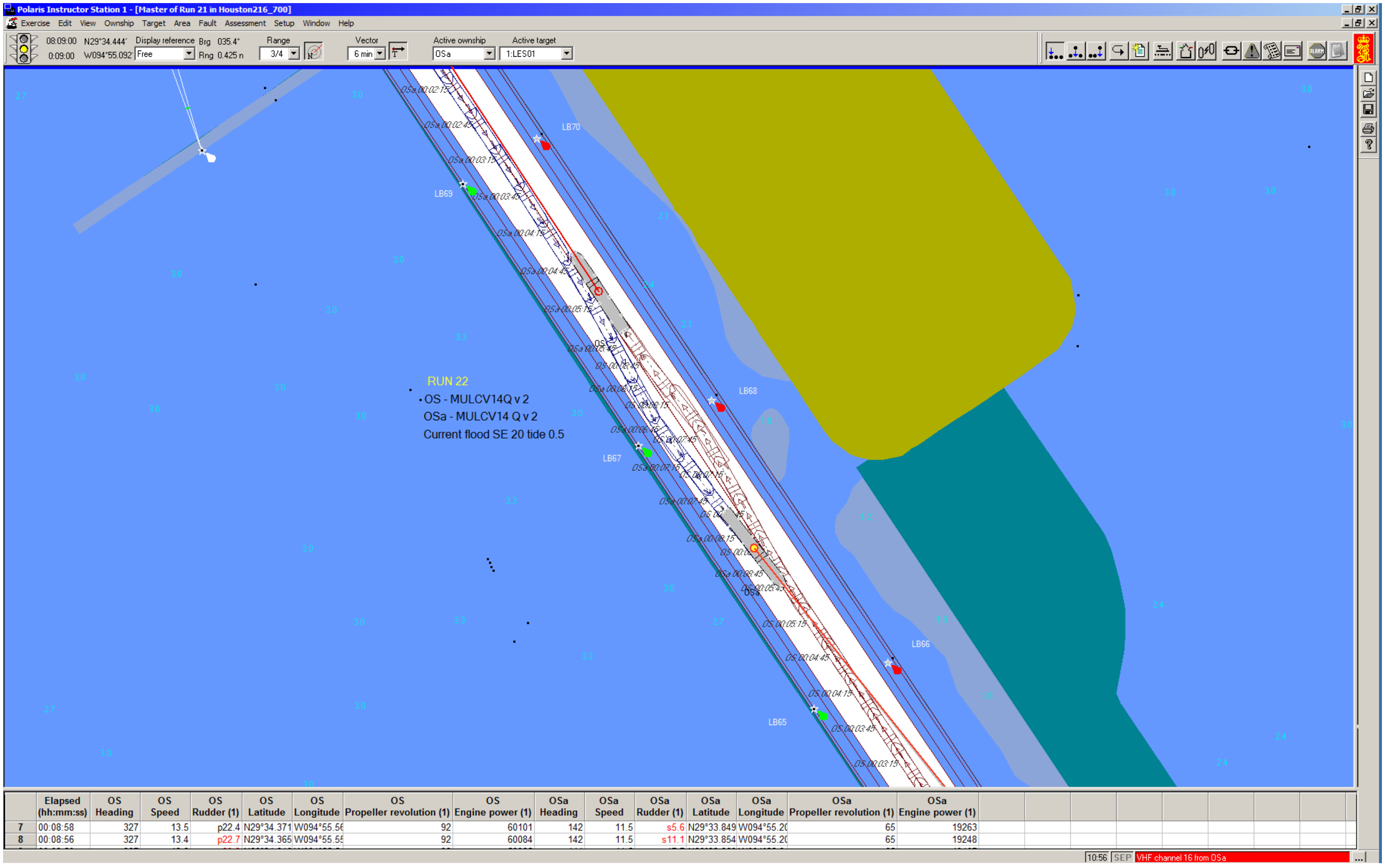
RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:20	324	12.3	s18.2	N29°34.259	W094°55.47	91	59398	142	11.5	s15.1	N29°33.943	W094°55.28	65	19303
8	00:08:18	324	12.2	s12.4	N29°34.253	W094°55.46	91	59318	142	11.5	s9.6	N29°33.948	W094°55.29	65	19397

This is an own ship track history shape

10:55 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

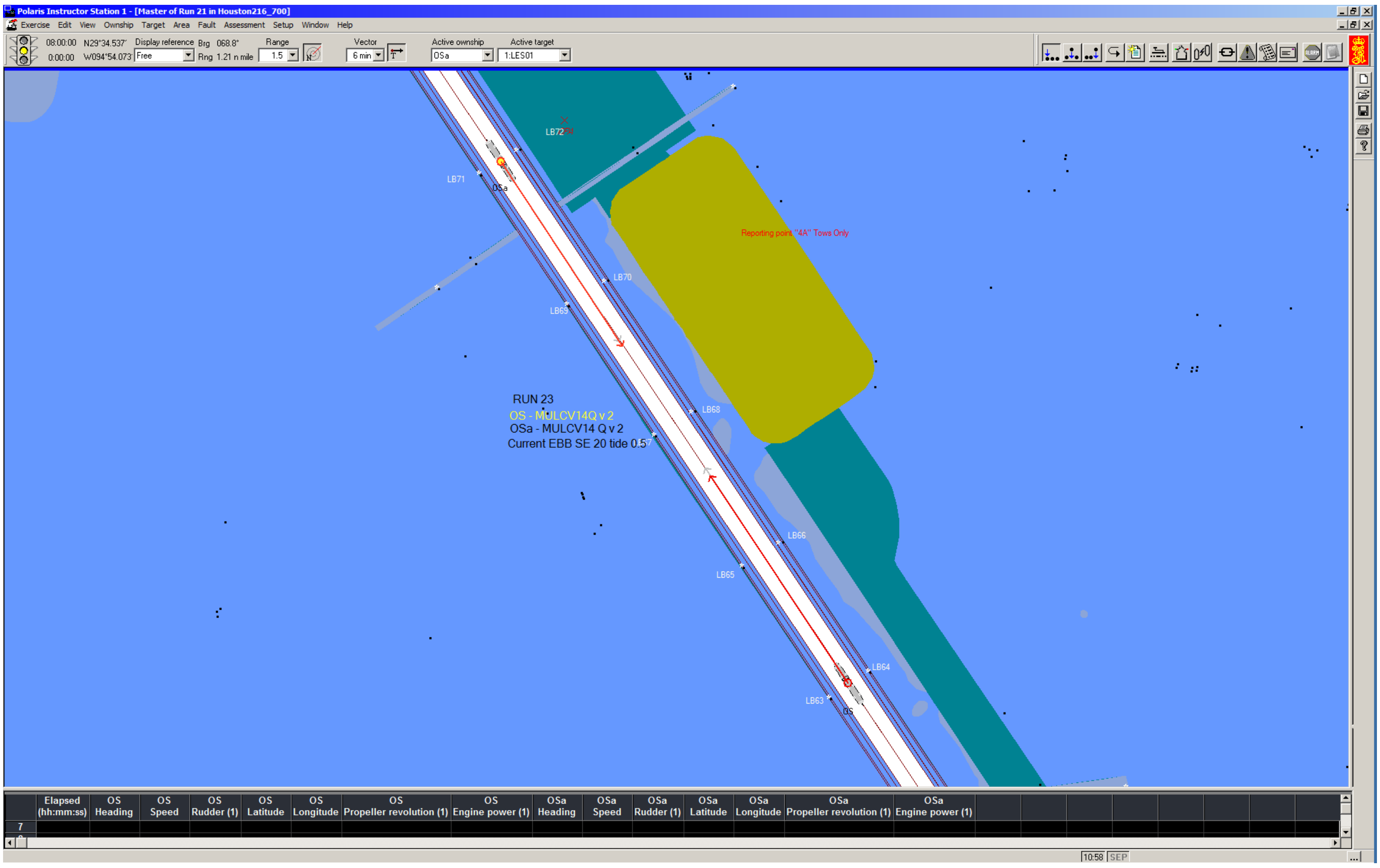
08:09:00 N29°34.444′
0:09:00 W094°55.092′
Display reference: Free
Brg 035.4°
Rng 0.425 n
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

RUN 22
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:58	327	13.5	p22.4	N29°34.371	W094°55.56	92	60101	142	11.5	s5.6	N29°33.849	W094°55.20	65	19263
8	00:08:56	327	13.4	p22.7	N29°34.365	W094°55.55	92	60084	142	11.5	s11.1	N29°33.854	W094°55.20	65	19248

10:56 SEP VHF channel 16 from OSa

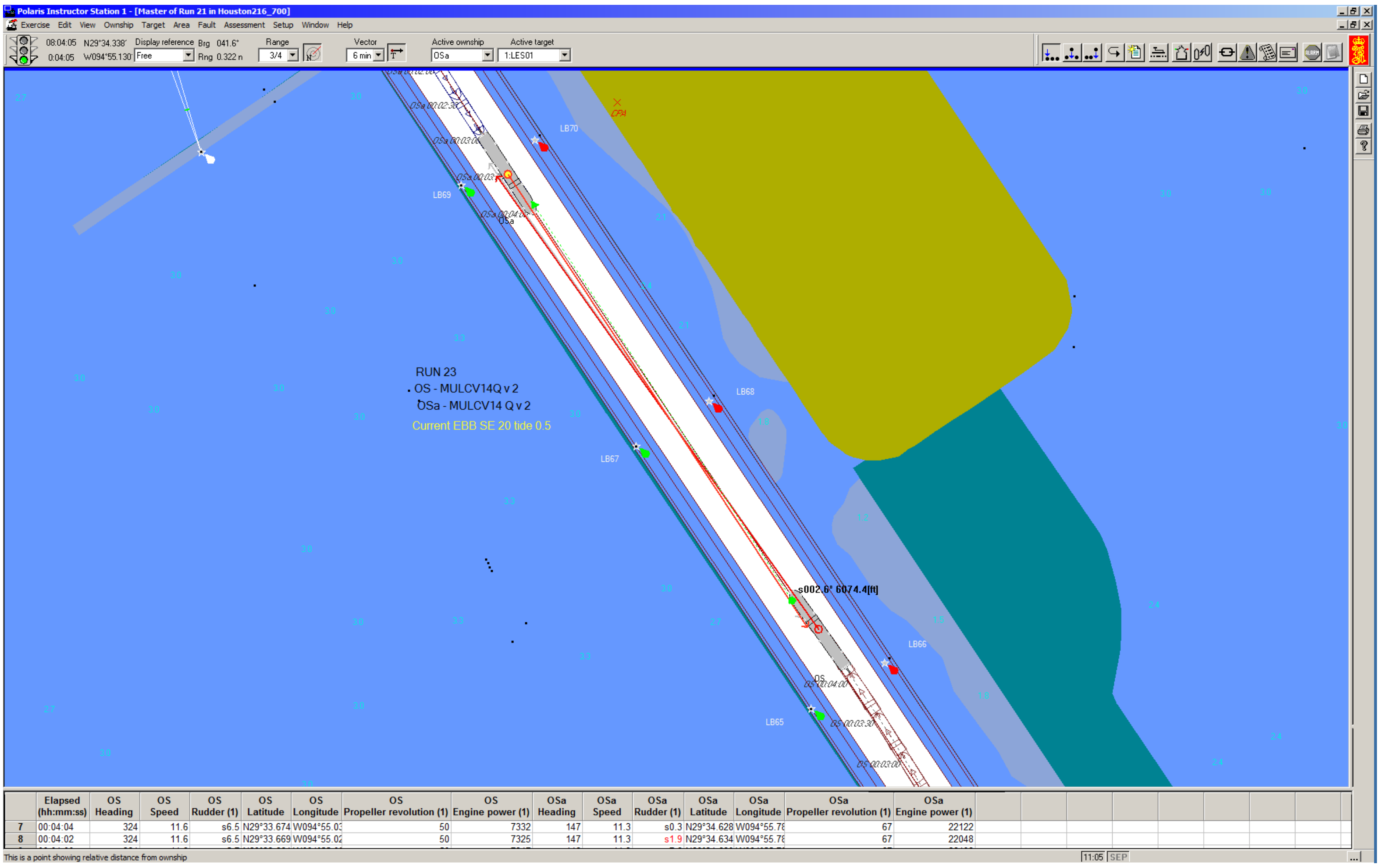
Run 23


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:00:00 N29°34.537' W094°54.073
0:00:00
Display reference: Free
Brg 068.8°
Rng 1.21 n mile
Range: 1.5
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7															


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:04:05 N29°34.338' W094°55.130'
0:04:05
Display reference: Free
Brg 041.6°
Rng 0.322 n
Range: 3/4
Vector: 6 min
Active ownship: OSa
Active target: 1:LES01

RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:04:04	324	11.6	s6.5	N29°33.674	W094°55.03	50	7332	147	11.3	s0.3	N29°34.628	W094°55.78	67	22122
8	00:04:02	324	11.6	s6.5	N29°33.669	W094°55.02	50	7325	147	11.3	s1.9	N29°34.634	W094°55.78	67	22048

This is a point showing relative distance from ownship

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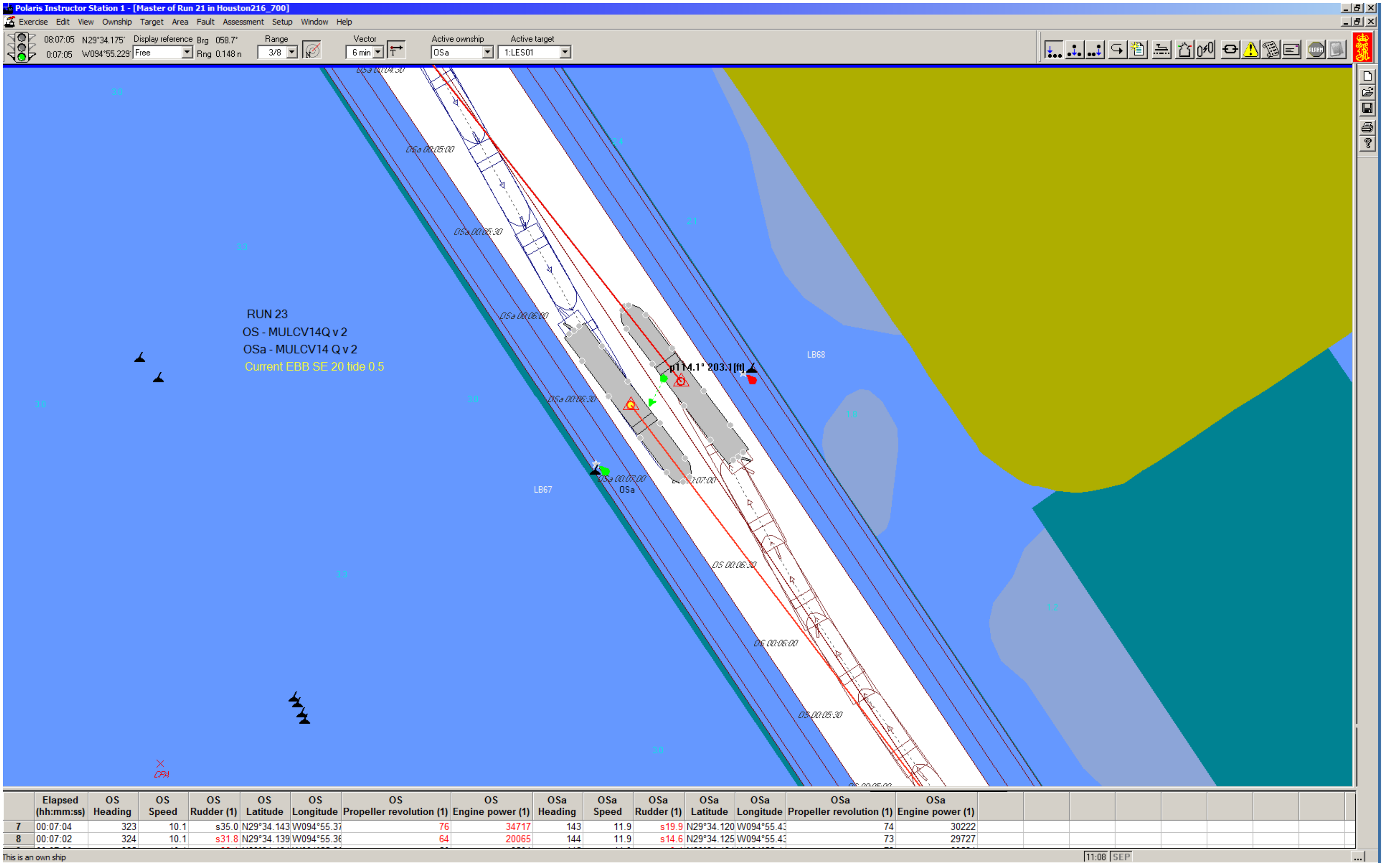


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:07:05 N29°34.175′ Display reference: Free Brg 058.7° Rng 0.148 n Range: 3/8 Vector: 6 min Active ownship: OSa Active target: 1:LES01
0:07:05 W094°55.229′

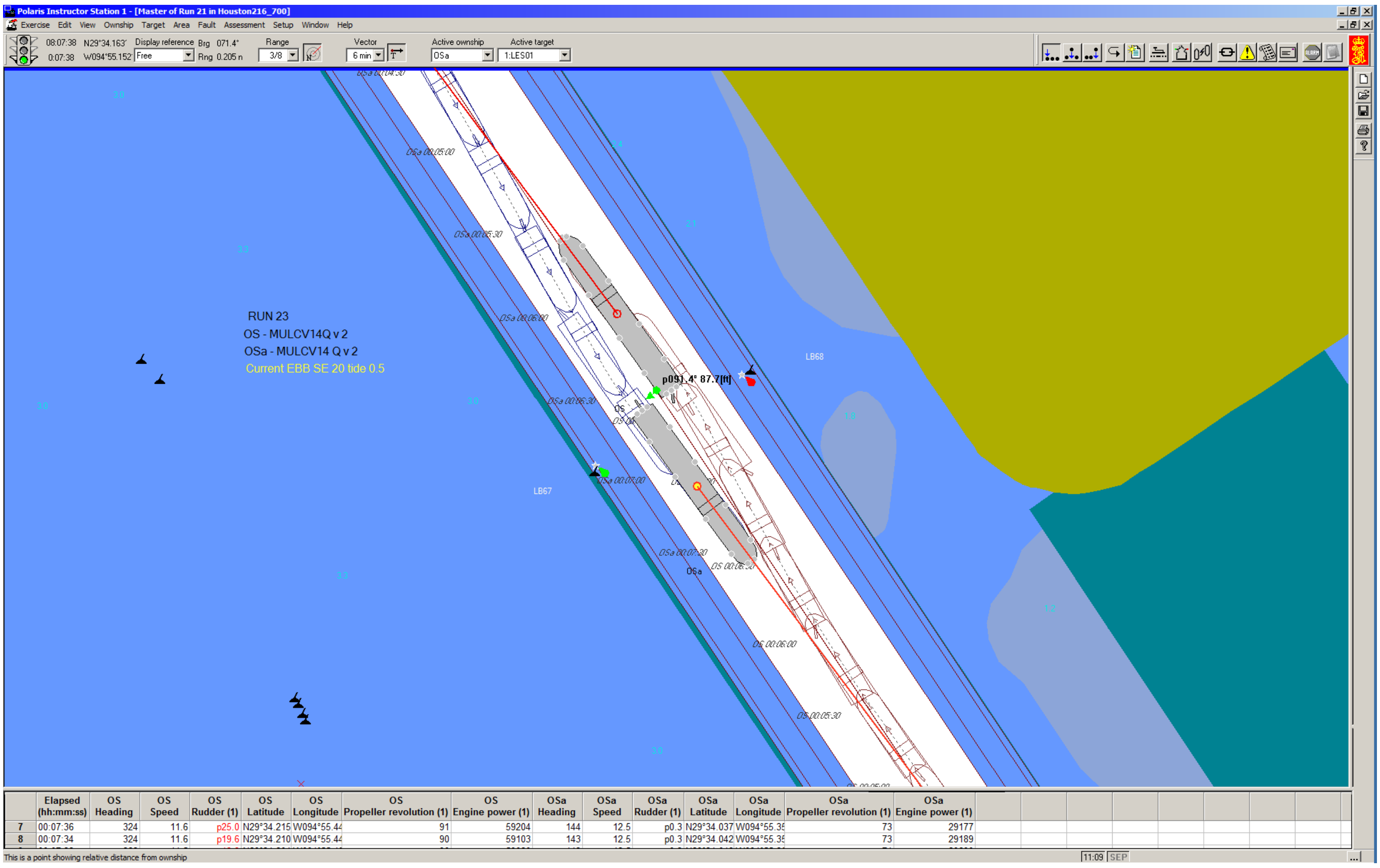
RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

p114.1° 203.1[ft]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:04	323	10.1	s35.0	N29°34.143	W094°55.37	76	34717	143	11.9	s19.9	N29°34.120	W094°55.43	74	30222
8	00:07:02	324	10.1	s31.8	N29°34.139	W094°55.36	64	20065	144	11.9	s14.6	N29°34.125	W094°55.43	73	29727

This is an own ship

11:08 SEP



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:07:38 N29°34.163′ Display reference: Free Brg 071.4° Rng 0.205 n Range: 3/8 Vector: 6 min Active ownship: OSa Active target: 1:LES01
0:07:38 W094°55.152′

RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

p091.4° 87.7[ft]

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:07:36	324	11.6	p25.0	N29°34.215	W094°55.44	91	59204	144	12.5	p0.3	N29°34.037	W094°55.35	73	29177
8	00:07:34	324	11.6	p19.6	N29°34.210	W094°55.44	90	59103	143	12.5	p0.3	N29°34.042	W094°55.35	73	29189

This is a point showing relative distance from ownship

11:09 SEP

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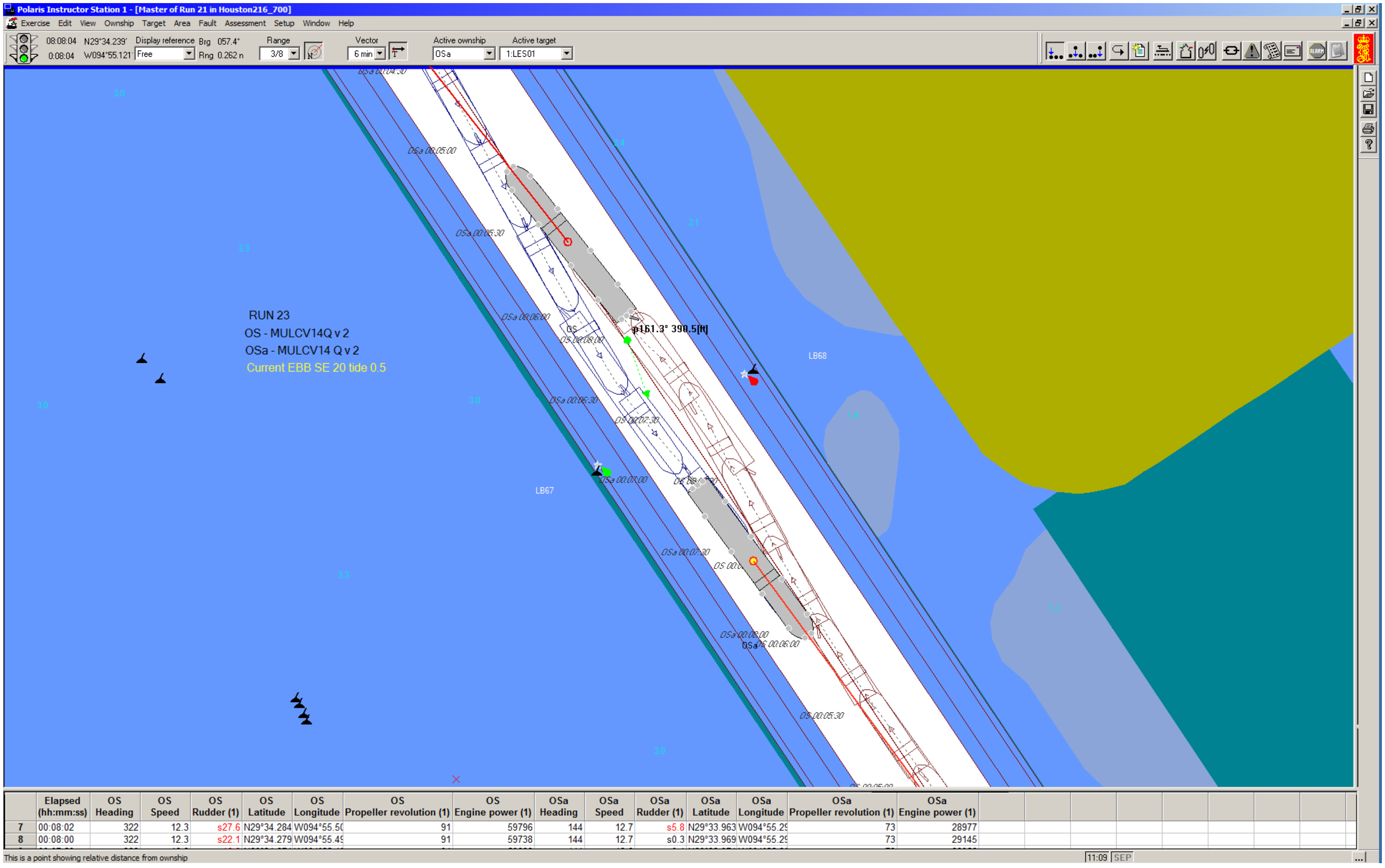


Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:08:04 N29°34.239′ Display reference Free Brg 057.4° Rng 0.262 n
0:08:04 W094°55.121′

Range 3/8

Vector 6 min

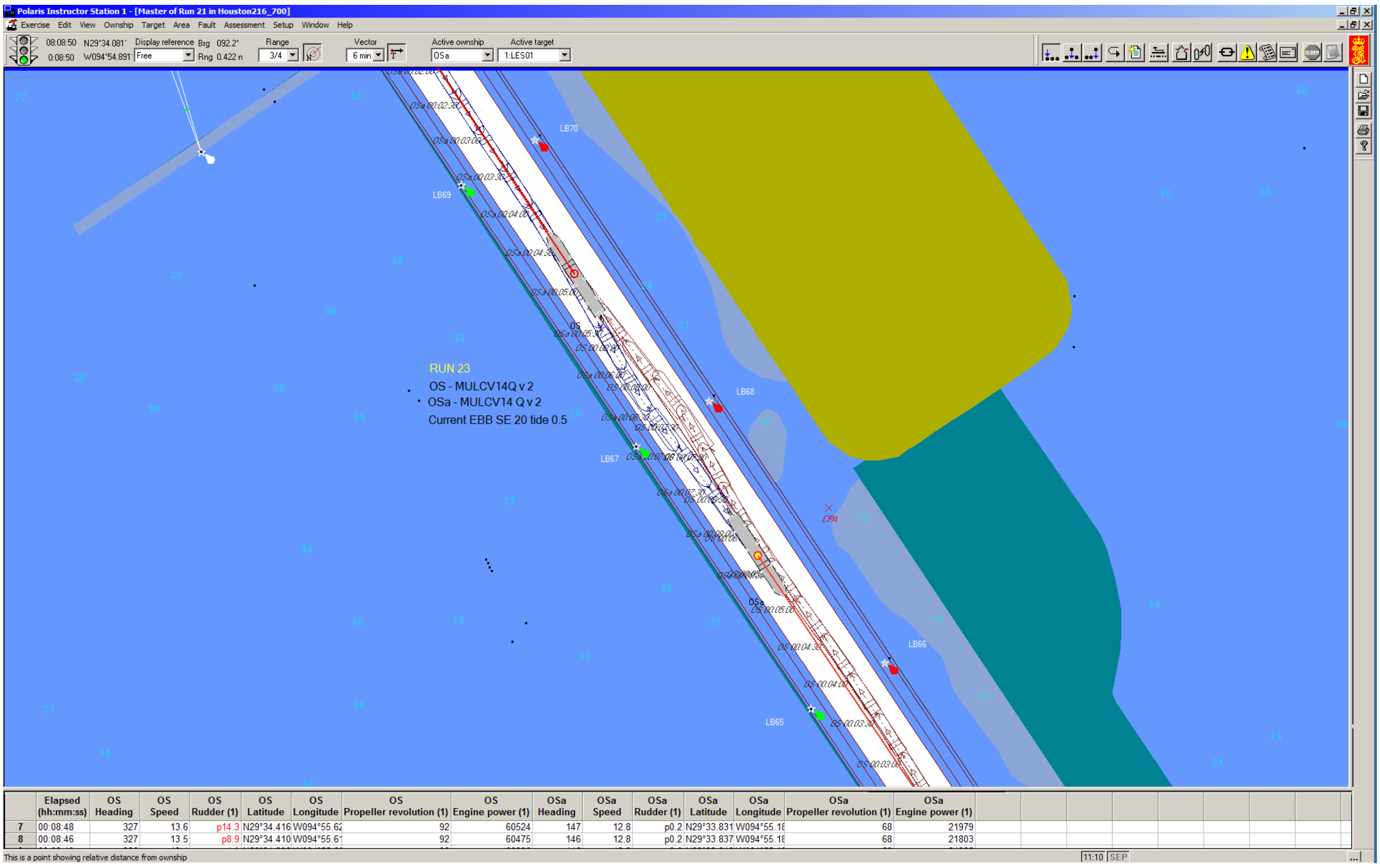
Active ownship OSa

Active target 1:LES01

RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:02	322	12.3	s27.6	N29°34.284	W094°55.50	91	59796	144	12.7	s5.8	N29°33.963	W094°55.29	73	28977
8	00:08:00	322	12.3	s22.1	N29°34.279	W094°55.49	91	59738	144	12.7	s0.3	N29°33.969	W094°55.29	73	29145

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:08:50 N29°34.081′ Display reference Free Brg 092.2° Rng 0.422 n
0:08:50 W094°54.891′

Range 3/4

Vector 6 min

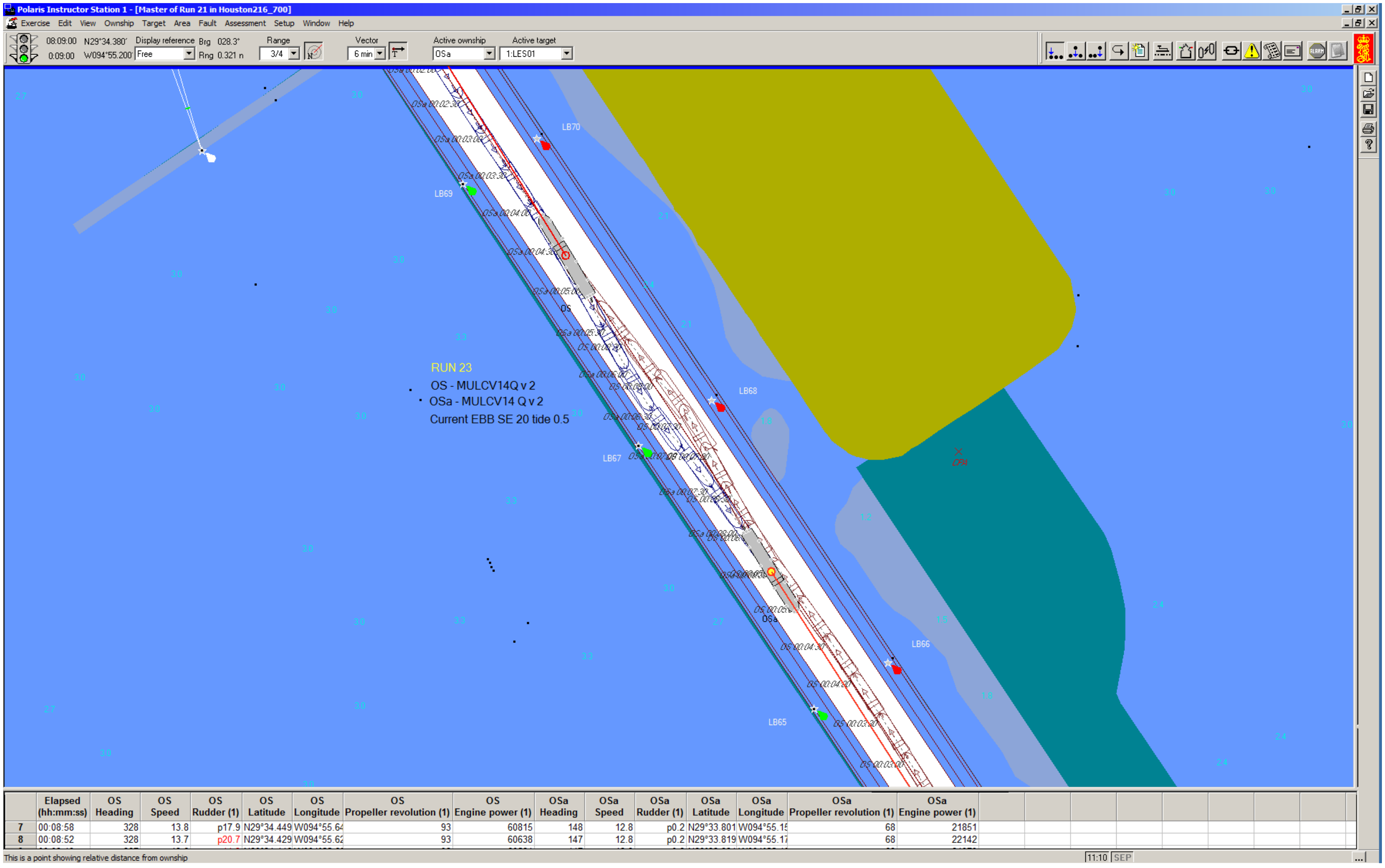
Active ownship OSa

Active target 1:LES01

RUN 23
OS - MULCV14Q v 2
OSa - MULCV14 Q v 2
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:48	327	13.6	p14.3	N29°34.416	W094°55.62	92	60524	147	12.8	p0.2	N29°33.831	W094°55.18	68	21979
8	00:08:46	327	13.5	p8.9	N29°34.410	W094°55.61	92	60475	146	12.8	p0.2	N29°33.837	W094°55.18	68	21803

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:09:00 N29°34.380' Display reference: Free Brg 028.3° Rng 0.321 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01

0:09:00 W094°55.200'

RUN 23

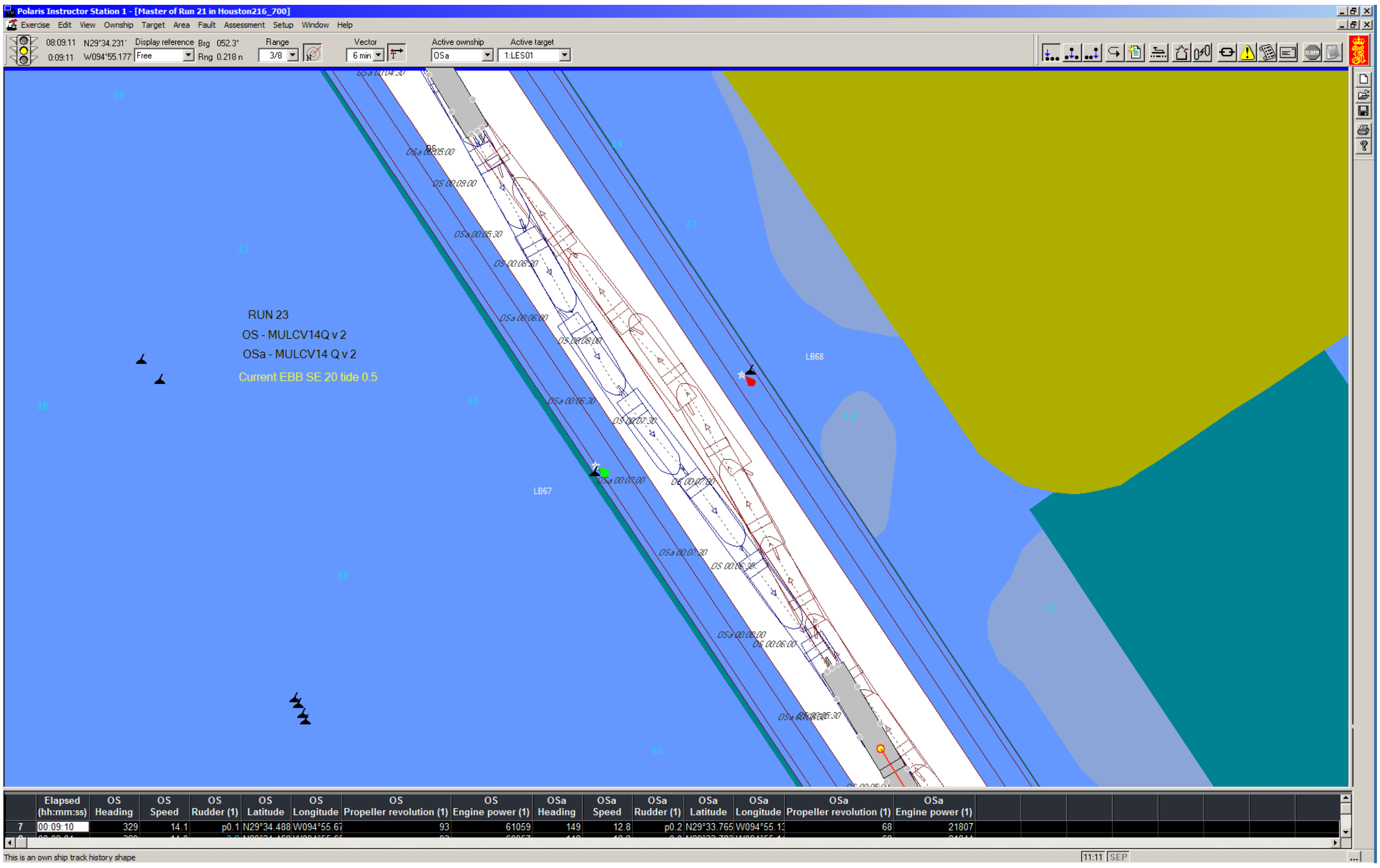
OS - MULCV14Q v 2

OSa - MULCV14 Q v 2

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:08:58	328	13.8	p17.9	N29°34.449	W094°55.64	93	60815	148	12.8	p0.2	N29°33.801	W094°55.15	68	21851
8	00:08:52	328	13.7	p20.7	N29°34.429	W094°55.62	93	60638	147	12.8	p0.2	N29°33.819	W094°55.17	68	22142

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 21 in Houston216_700]

08:09:11 N29°34.231' Display reference: Free Brg 052.3° Rng 0.218 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

0:09:11 W094°55.177'

RUN 23

OS - MULCV14Q v 2

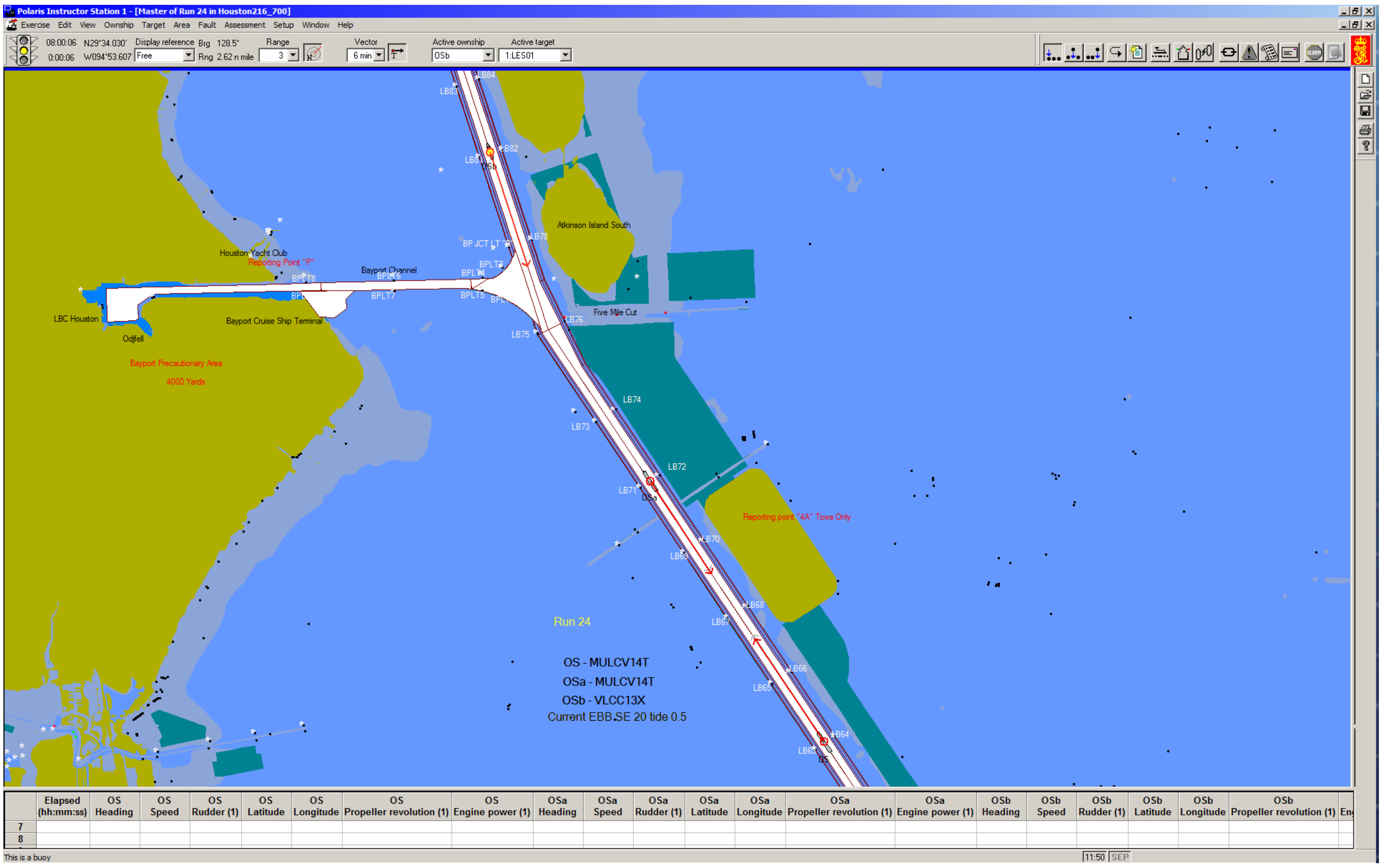
OSa - MULCV14 Q v 2

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)
7	00:09:10	329	14.1	p0.1	N29°34.488	W094°55.67	93	61059	149	12.8	p0.2	N29°33.765	W094°55.13	68	21807

This is an own ship track history shape

Run 24

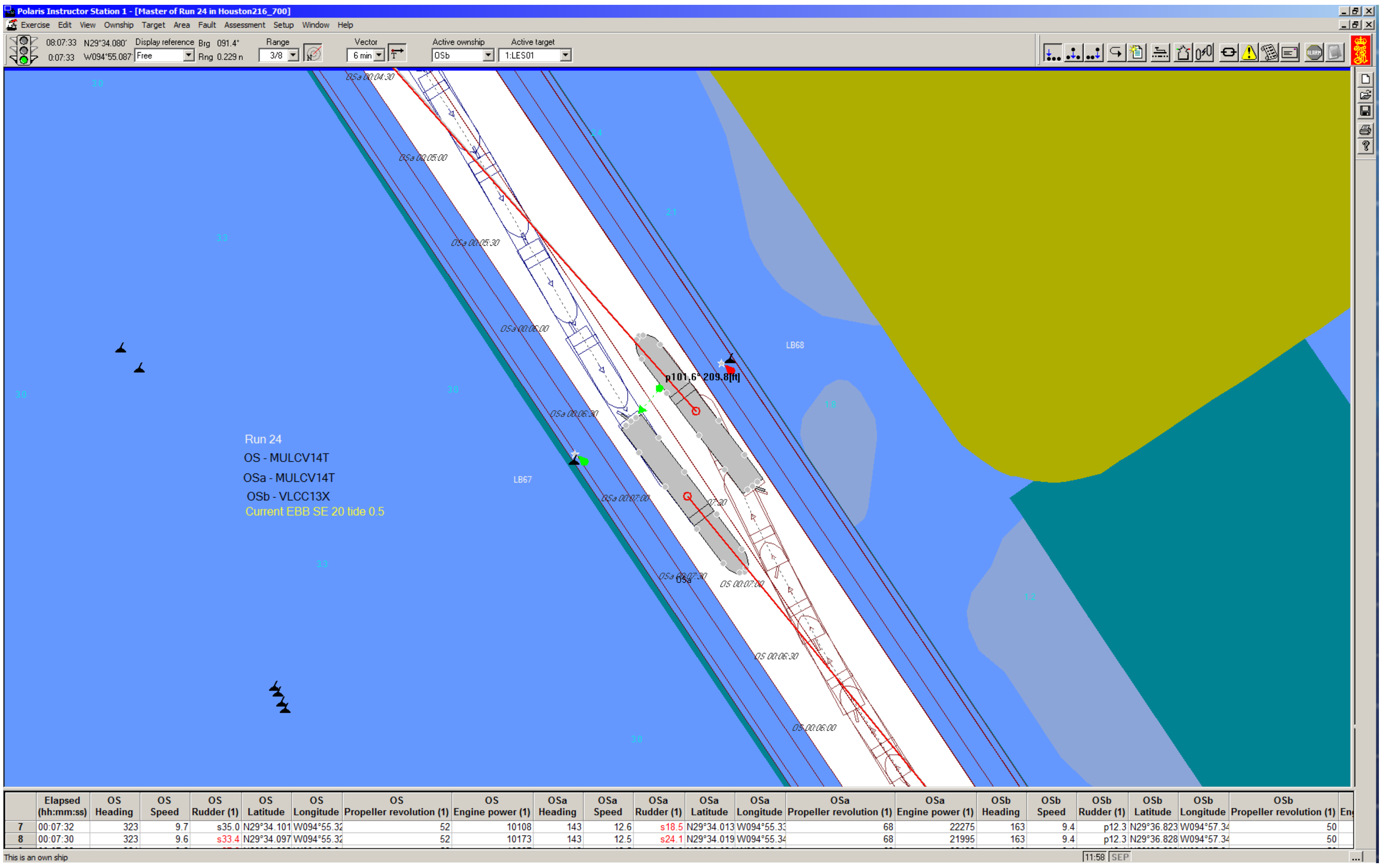


08:00:06 N29°34.030' Display reference: Free Brg 128.5° Range: 3 Vector: 6 min Active ownship: OSb Active target: 1:LES01
0:00:06 W094°53.607' Rng 2.62 n mile

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7																						
8																						

This is a buoy 11:50 SEP



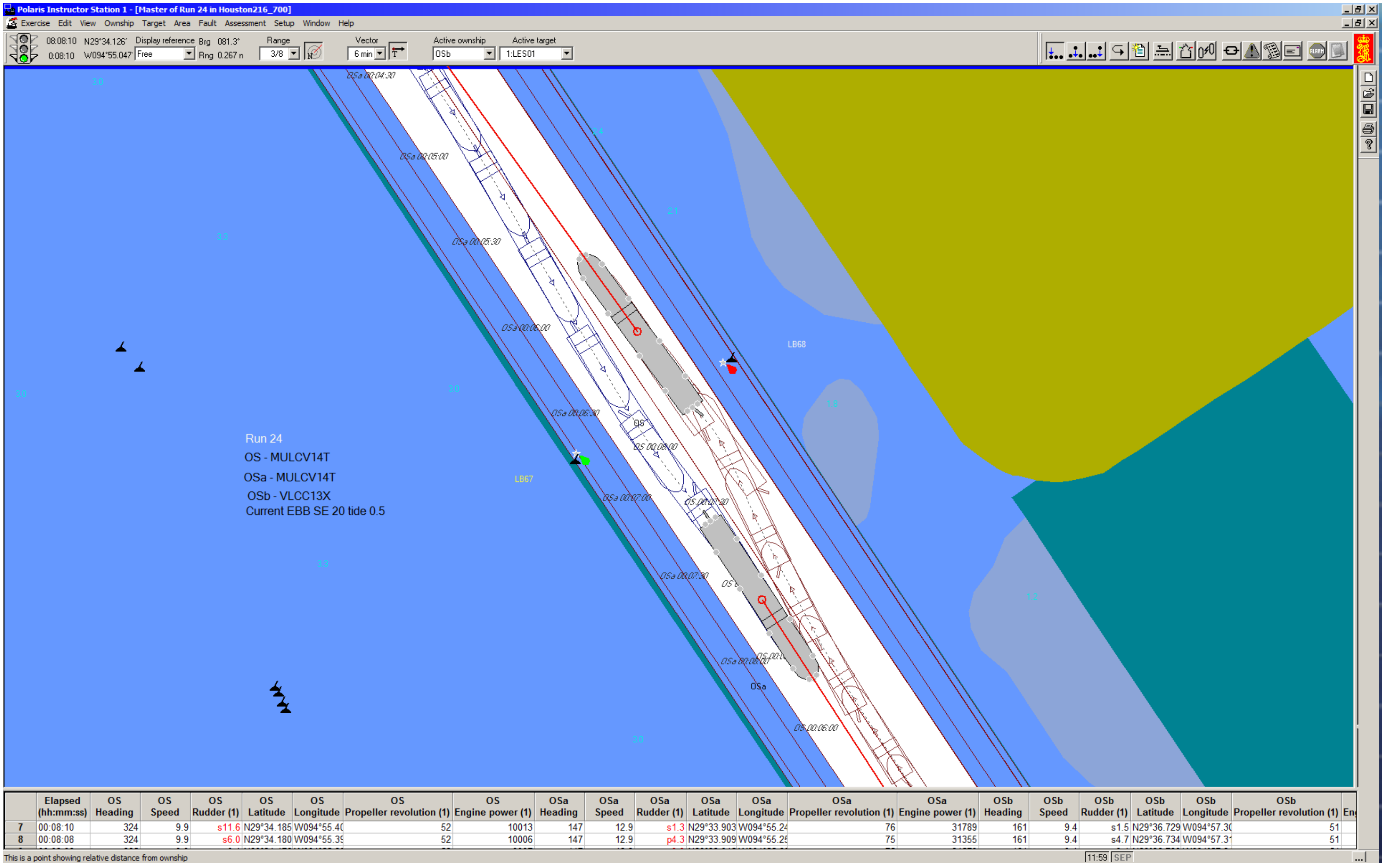
08:07:33 N29°34.080' Display reference: Free Brg 091.4° Range: 3/8 Vector: 6 min Active ownship: OSb Active target: 1:LES01
0:07:33 W094°55.087' Rng 0.229 n

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:07:32	323	9.7	s35.0	N29°34.101	W094°55.32	52	10108	143	12.6	s18.5	N29°34.013	W094°55.33	68	22275	163	9.4	p12.3	N29°36.823	W094°57.34	50	
8	00:07:30	323	9.6	s33.4	N29°34.097	W094°55.32	52	10173	143	12.5	s24.1	N29°34.019	W094°55.34	68	21995	163	9.4	p12.3	N29°36.828	W094°57.34	50	

This is an own ship 11:58 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

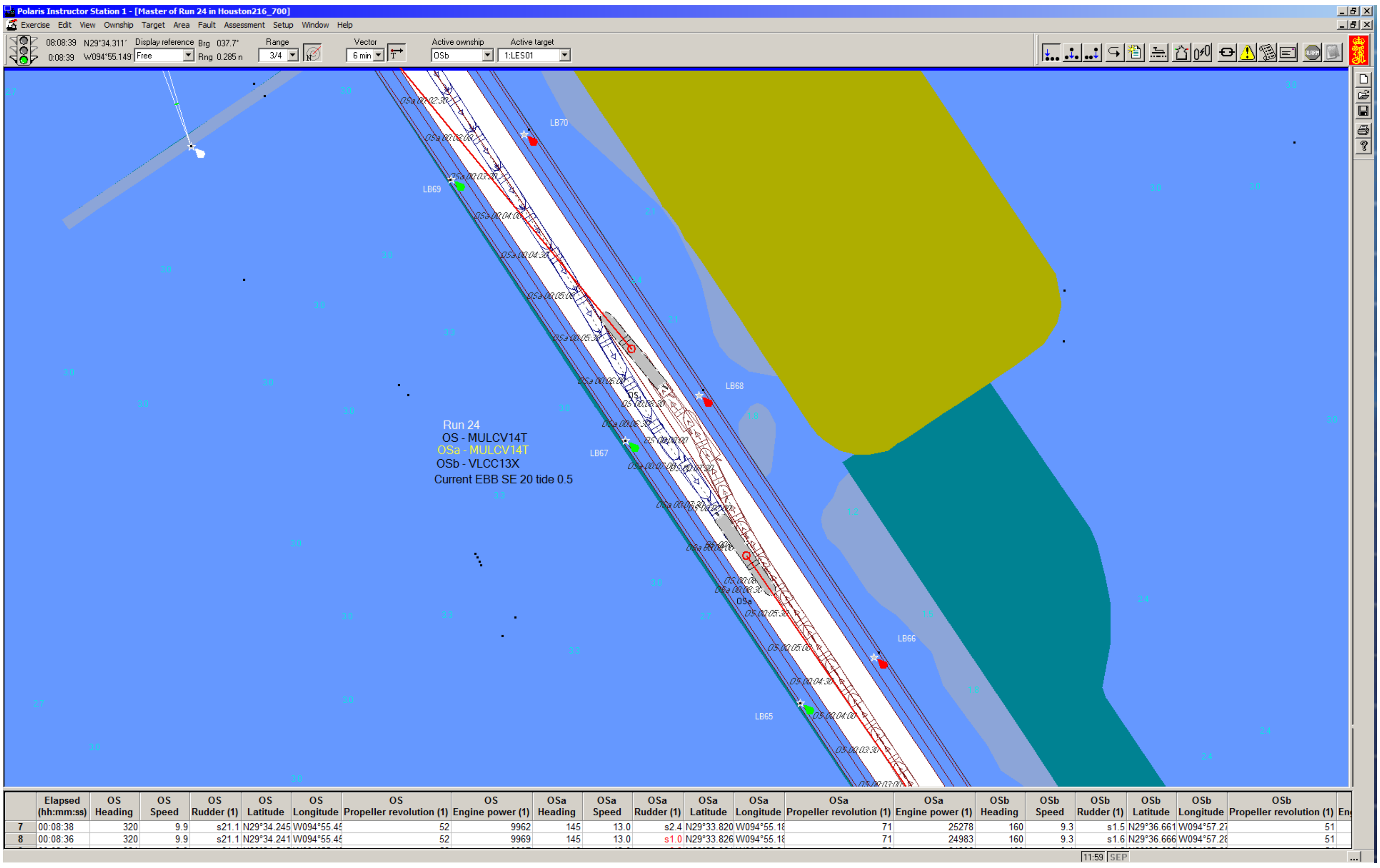
08:08:10 N29°34.126' Display reference Free Brg 081.3° Rng 0.267 n Range 3/8 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:10 W094°55.047'

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:08:10	324	9.9	s11.6	N29°34.185	W094°55.40	52	10013	147	12.9	s1.3	N29°33.903	W094°55.24	76	31789	161	9.4	s1.5	N29°36.729	W094°57.30	51	
8	00:08:08	324	9.9	s6.0	N29°34.180	W094°55.39	52	10006	147	12.9	p4.3	N29°33.909	W094°55.25	75	31355	161	9.4	s4.7	N29°36.734	W094°57.31	51	

This is a point showing relative distance from ownship

11:59 SEP



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:08:39 N29°34.311' Display reference Free Brg 037.7° Rng 0.285 n Range 3/4 Vector 6 min Active ownship OSb Active target 1:LES01
0:08:39 W094°55.149'

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:08:38	320	9.9	s21.1	N29°34.245	W094°55.45	52	9962	145	13.0	s2.4	N29°33.820	W094°55.18	71	25278	160	9.3	s1.5	N29°36.661	W094°57.27	51	
8	00:08:36	320	9.9	s21.1	N29°34.241	W094°55.45	52	9969	145	13.0	s1.0	N29°33.826	W094°55.18	71	24983	160	9.3	s1.6	N29°36.666	W094°57.28	51	

11:59 SEP

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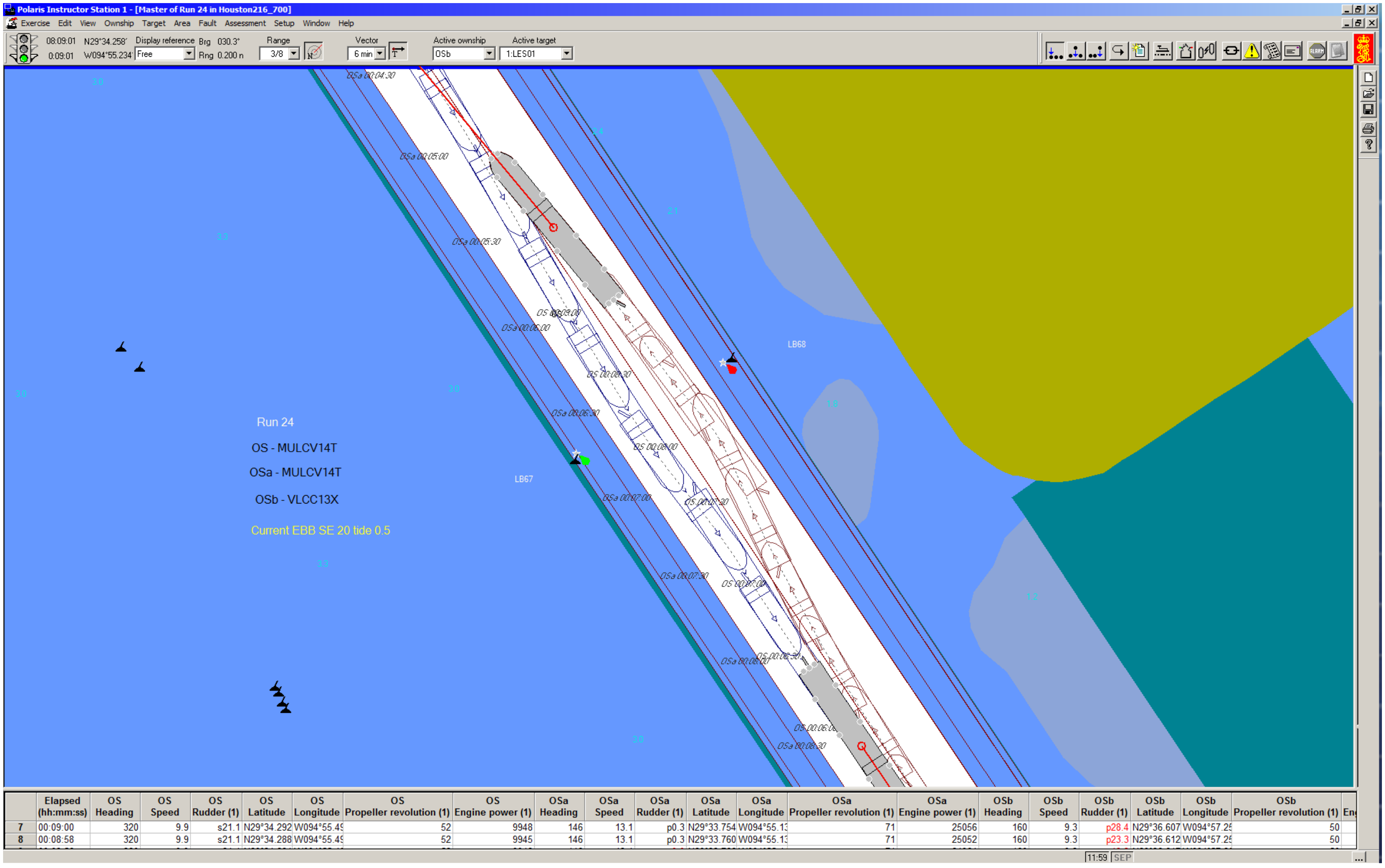


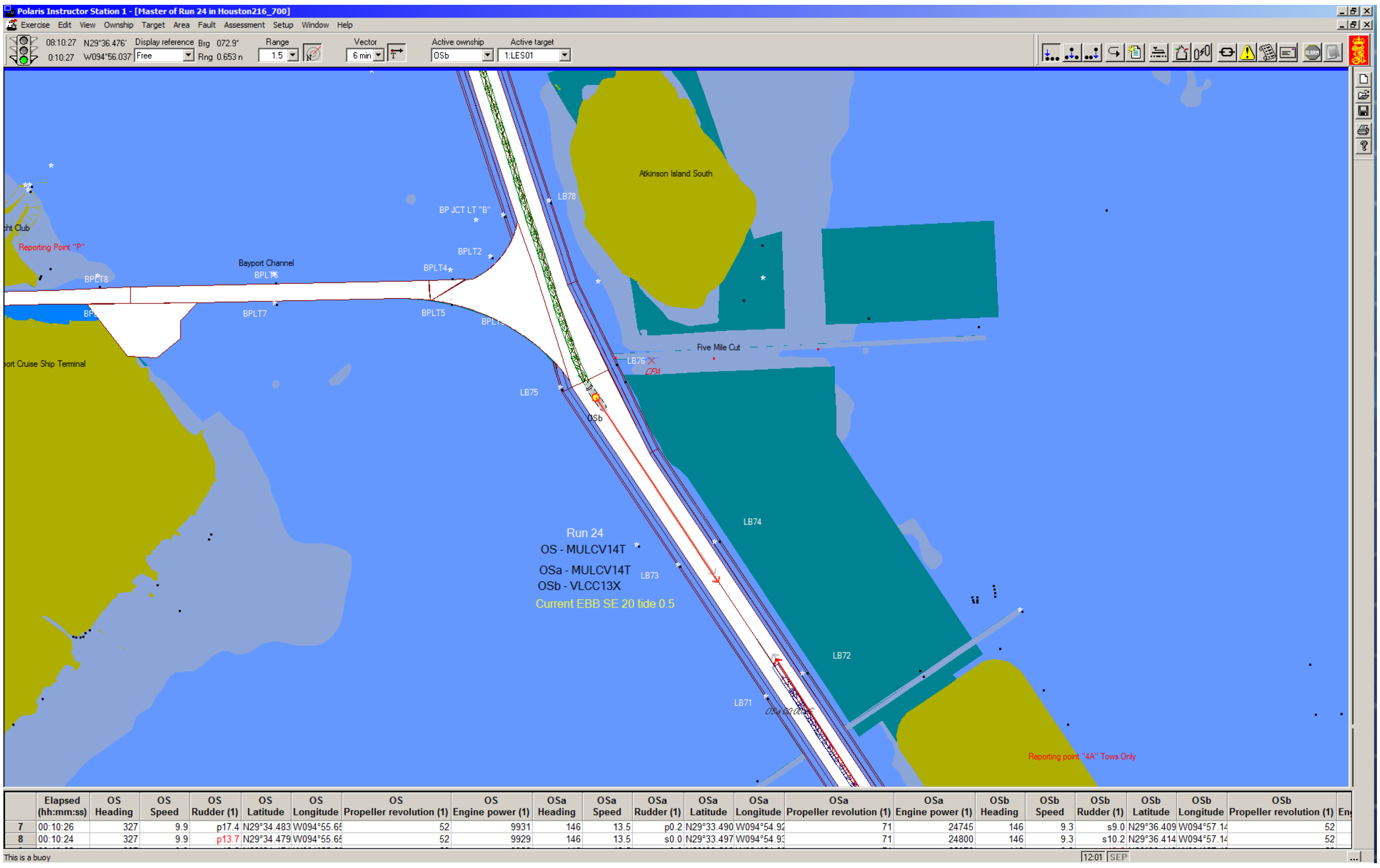
Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:09:01 N29°34.258'
0:09:01 W094°55.234'
Display reference: Free
Brg 030.3°
Rng 0.200 n
Range: 3/8
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)
7	00:09:00	320	9.9	s21.1	N29°34.292	W094°55.49	52	9948	146	13.1	p0.3	N29°33.754	W094°55.13	71	25056	160	9.3	p28.4	N29°36.607	W094°57.25	50
8	00:08:58	320	9.9	s21.1	N29°34.288	W094°55.49	52	9945	146	13.1	p0.3	N29°33.760	W094°55.13	71	25052	160	9.3	p23.3	N29°36.612	W094°57.25	50

11:59 SEP



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

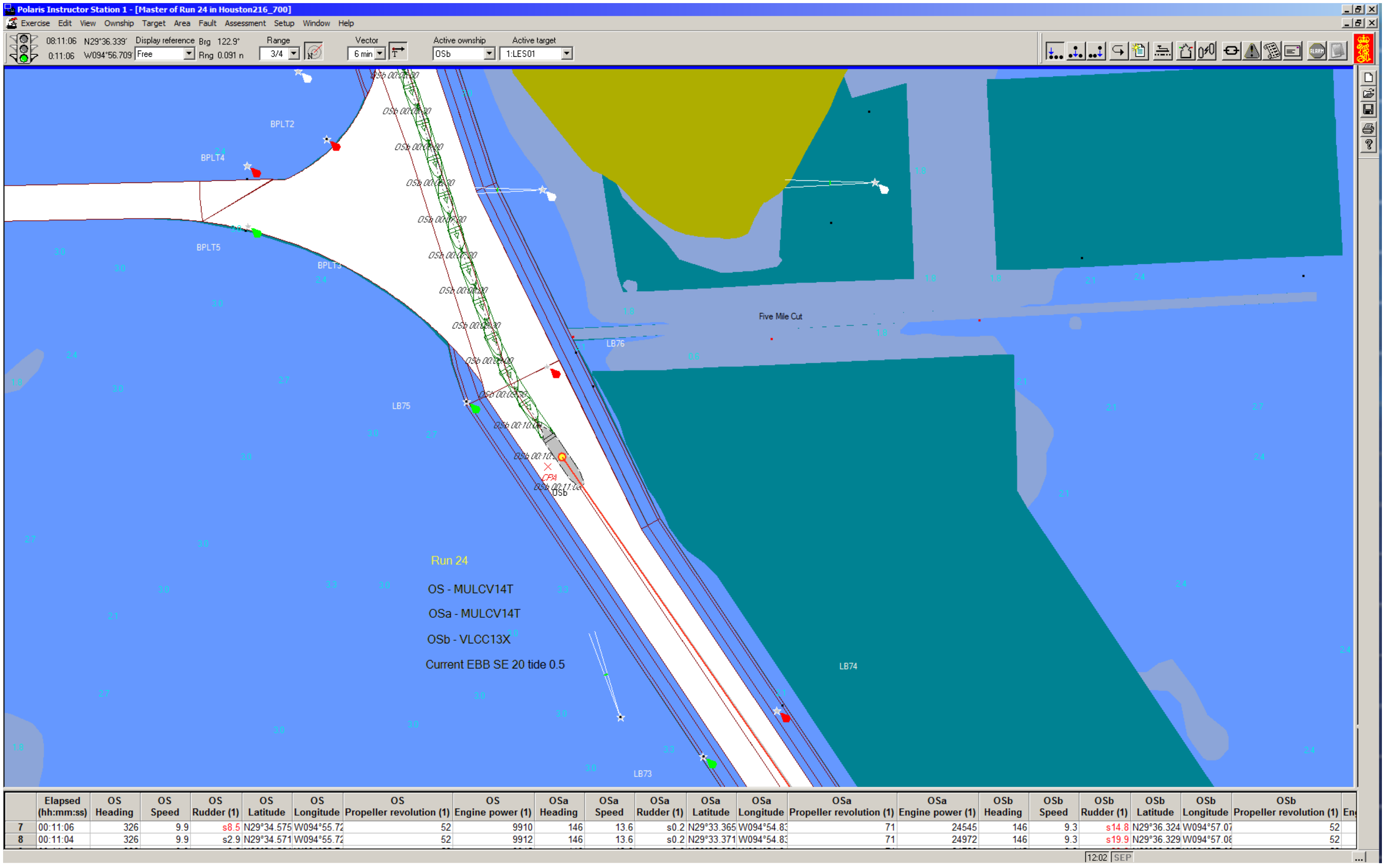
08:10:27 N29°36.476'
0:10:27 W094°56.037'
Display reference: Free
Brg 072.9°
Rng 0.653 n
Range: 1.5
Vector: 6 min
Active ownship: OSb
Active target: 1:LES01

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)
7	00:10:26	327	9.9	p17.4	N29°34.483	W094°55.65	52	9931	146	13.5	p0.2	N29°33.490	W094°54.92	71	24745	146	9.3	s9.0	N29°36.409	W094°57.14	52
8	00:10:24	327	9.9	p13.7	N29°34.479	W094°55.65	52	9929	146	13.5	s0.0	N29°33.497	W094°54.93	71	24800	146	9.3	s10.2	N29°36.414	W094°57.14	52

This is a buoy

12:01 SEP



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:11:06 N29°36.339' 0:11:06 W094°56.709'

Display reference: Free

Brg 122.9° Rng 0.091 n

Range: 3/4

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 24

OS - MULCV14T

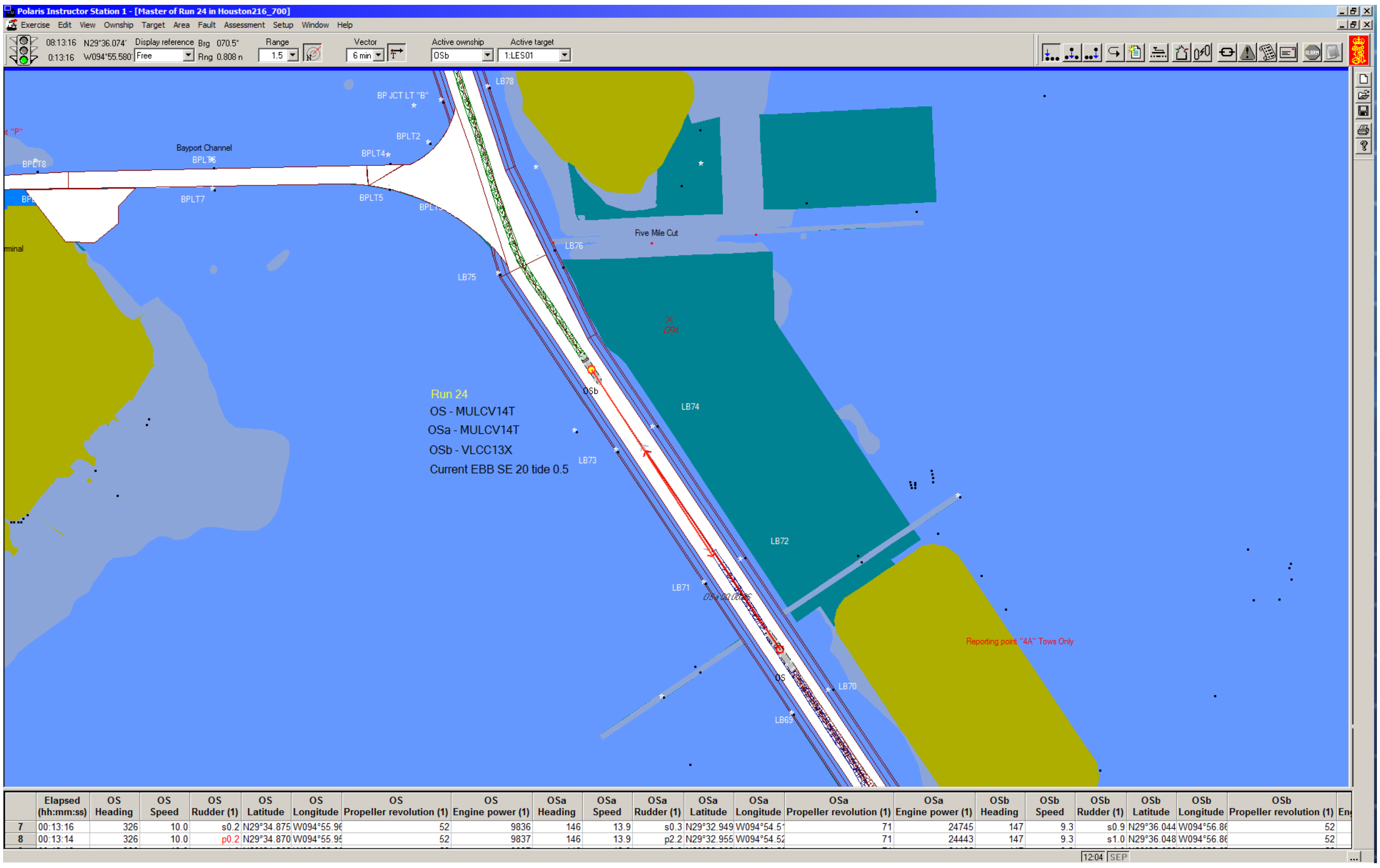
OSa - MULCV14T

OSb - VLCC13X

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:11:06	326	9.9	s8.5	N29°34.575	W094°55.72	52	9910	146	13.6	s0.2	N29°33.365	W094°54.83	71	24545	146	9.3	s14.8	N29°36.324	W094°57.07	52	
8	00:11:04	326	9.9	s2.9	N29°34.571	W094°55.72	52	9912	146	13.6	s0.2	N29°33.371	W094°54.83	71	24972	146	9.3	s19.9	N29°36.329	W094°57.08	52	

12:02 SEP



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:13:16 N29°36.074' 0:13:16 W094°55.580'

Display reference: Free

Brg 070.5° Rng 0.808 n

Range: 1.5

Vector: 6 min

Active ownship: OSb

Active target: 1:LES01

Run 24

OS - MULCV14T

OSa - MULCV14T

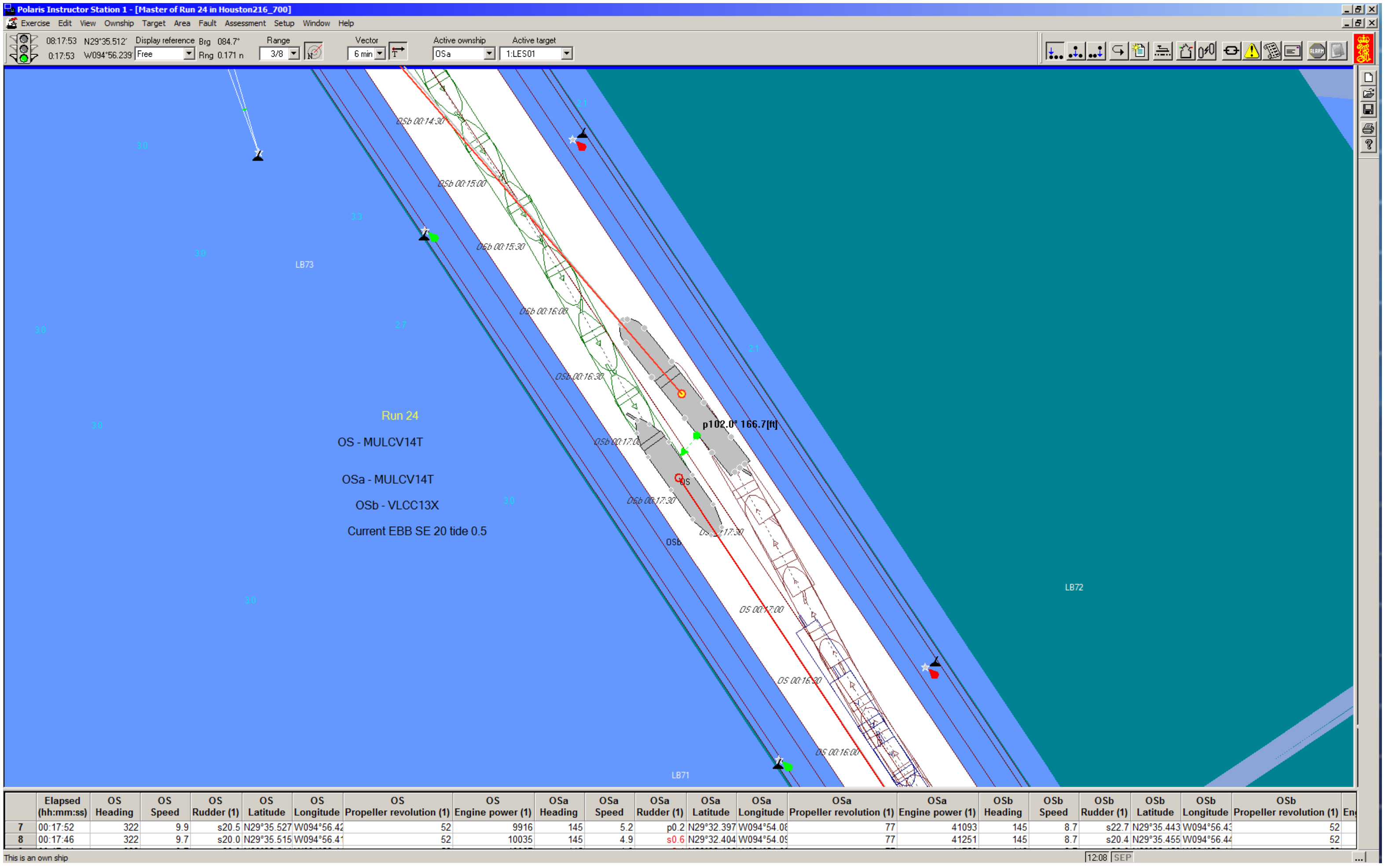
OSb - VLCC13X

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:13:16	326	10.0	s0.2	N29°34.875	W094°55.96	52	9836	146	13.9	s0.3	N29°32.949	W094°54.51	71	24745	147	9.3	s0.9	N29°36.044	W094°56.86	52	
8	00:13:14	326	10.0	p0.2	N29°34.870	W094°55.95	52	9837	146	13.9	p2.2	N29°32.955	W094°54.52	71	24443	147	9.3	s1.0	N29°36.048	W094°56.86	52	

12:04 SEP

June 26, 2019



Run 24

OS - MULCV14T

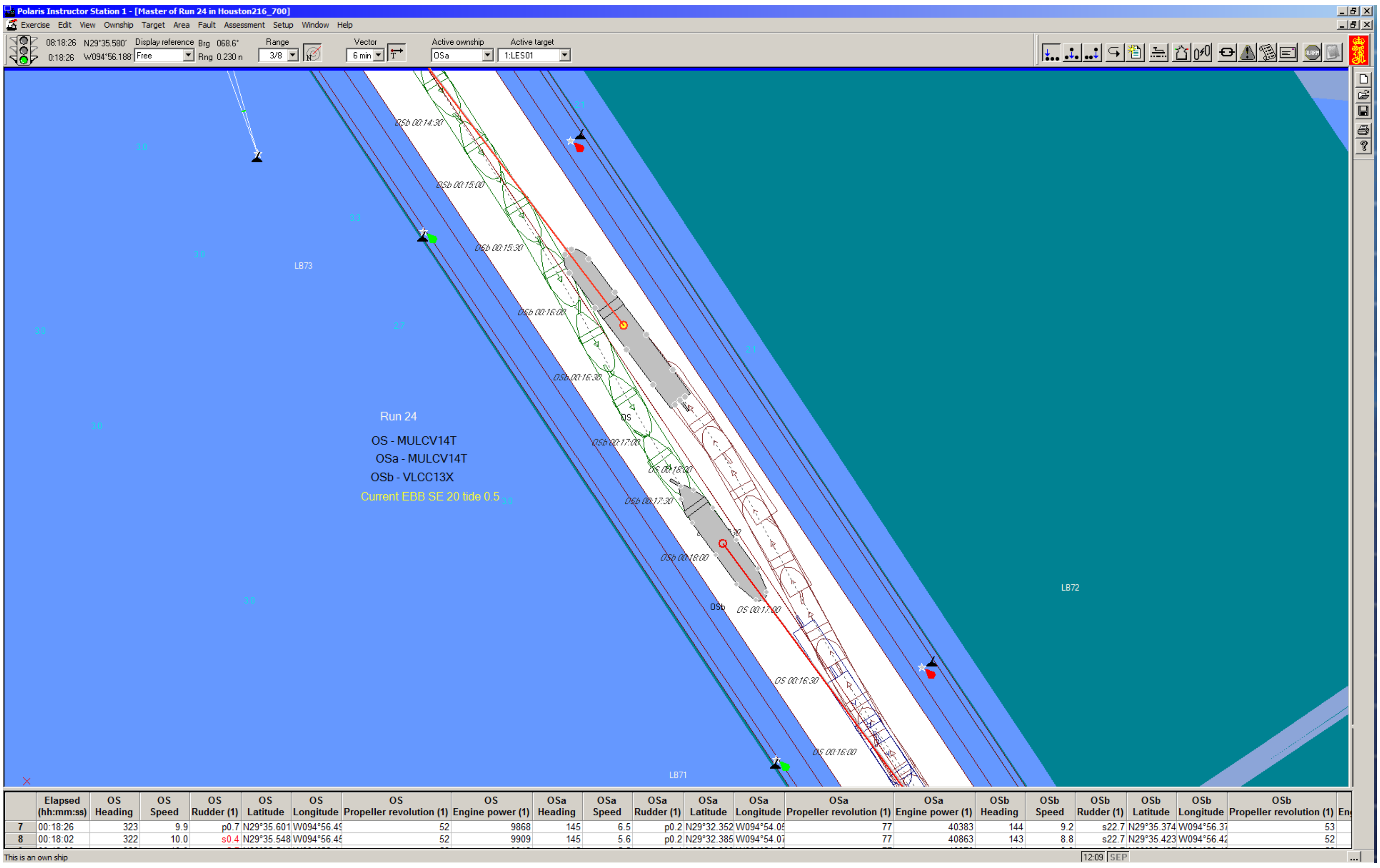
OSa - MULCV14T

OSb - VLCC13X

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:17:52	322	9.9	s20.5	N29°35.527	W094°56.42	52	9916	145	5.2	p0.2	N29°32.397	W094°54.08	77	41093	145	8.7	s22.7	N29°35.443	W094°56.43	52	
8	00:17:46	322	9.7	s20.0	N29°35.515	W094°56.41	52	10035	145	4.9	s0.6	N29°32.404	W094°54.09	77	41251	145	8.7	s20.4	N29°35.455	W094°56.44	52	

This is an own ship



Run 24

OS - MULCV14T

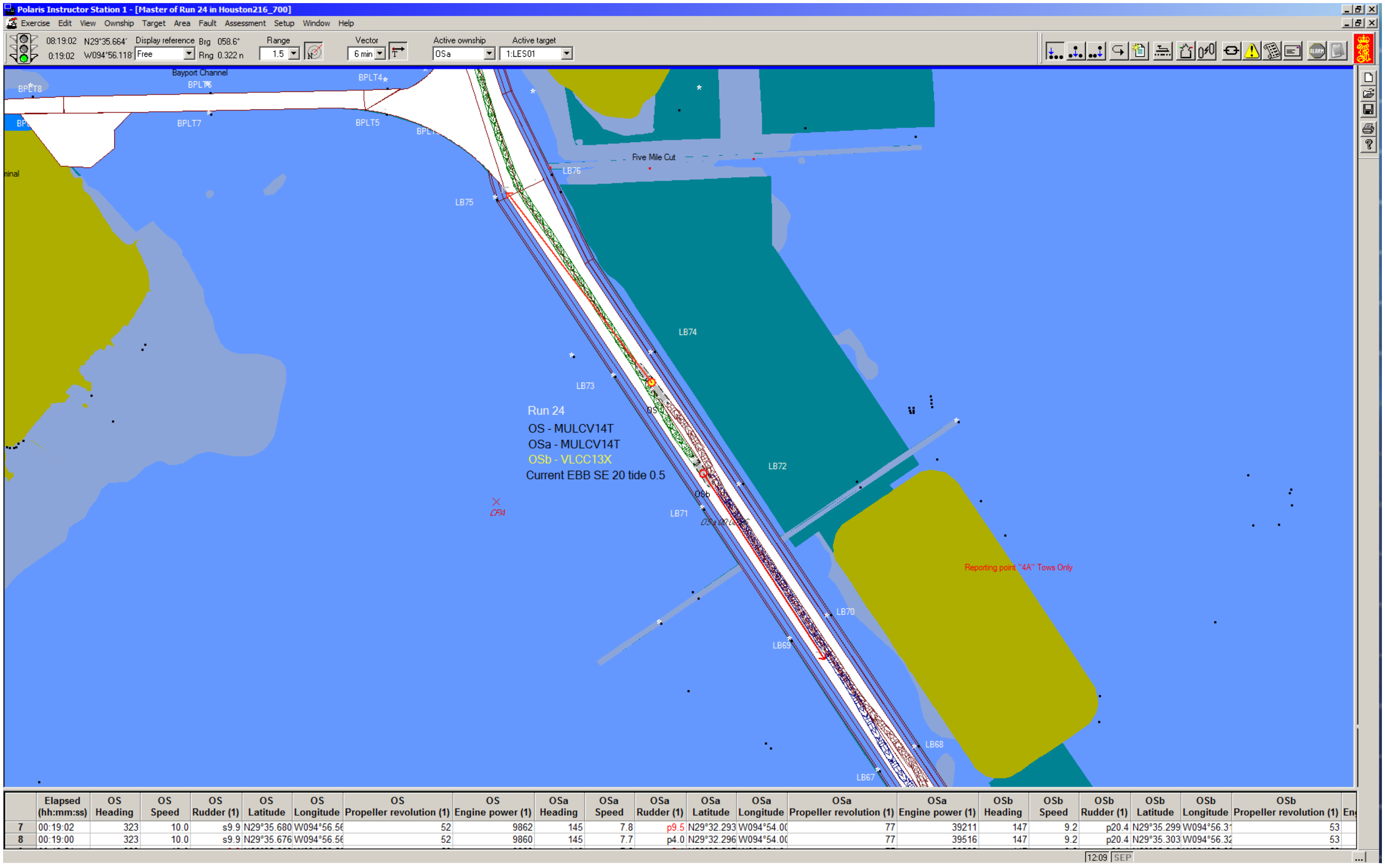
OSa - MULCV14T

OSb - VLCC13X

Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:18:26	323	9.9	p0.7	N29°35.601	W094°56.49	52	9868	145	6.5	p0.2	N29°32.352	W094°54.05	77	40383	144	9.2	s22.7	N29°35.374	W094°56.37	53	
8	00:18:02	322	10.0	s0.4	N29°35.548	W094°56.45	52	9909	145	5.6	p0.2	N29°32.385	W094°54.07	77	40863	143	8.8	s22.7	N29°35.423	W094°56.42	52	

This is an own ship



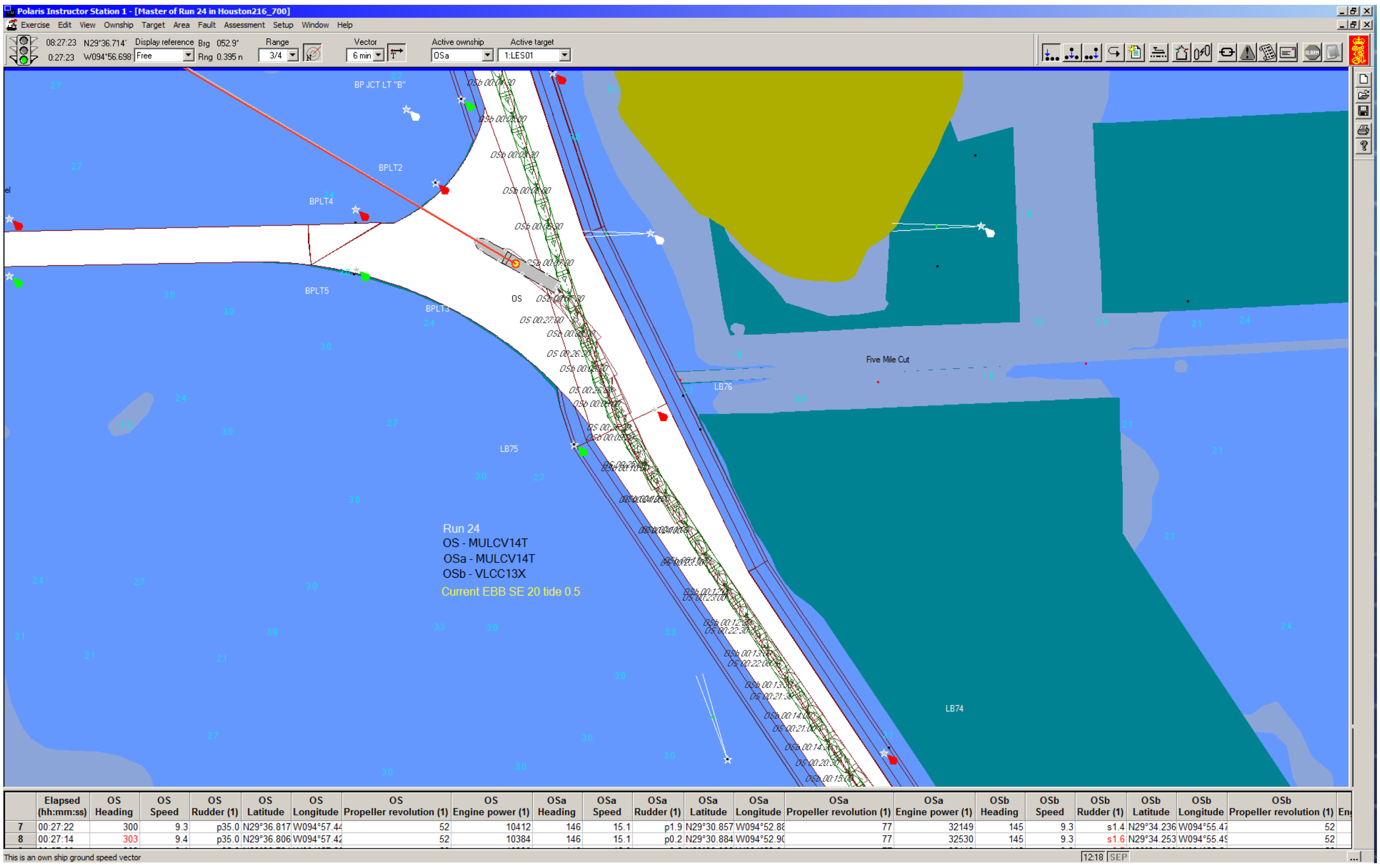
Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:19:02 N29°35.664' Display reference Free Brg 058.6°
0:19:02 W094°56.118' Rng 0.322 n
Range 1.5
Vector 6 min
Active ownship OSa
Active target 1:LES01

Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:19:02	323	10.0	s9.9	N29°35.680	W094°56.5	52	9862	145	7.8	p9.5	N29°32.293	W094°54.0	77	39211	147	9.2	p20.4	N29°35.299	W094°56.3	53	
8	00:19:00	323	10.0	s9.9	N29°35.676	W094°56.5	52	9860	145	7.7	p4.0	N29°32.296	W094°54.0	77	39516	147	9.2	p20.4	N29°35.303	W094°56.3	53	

12:09 SEP



Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:27:23 N29°36.714' Display reference Free Brg 052.9°
0:27:23 W094°56.698' Rng 0.395 n
Range 3/4
Vector 6 min
Active ownship OSa
Active target 1:LES01

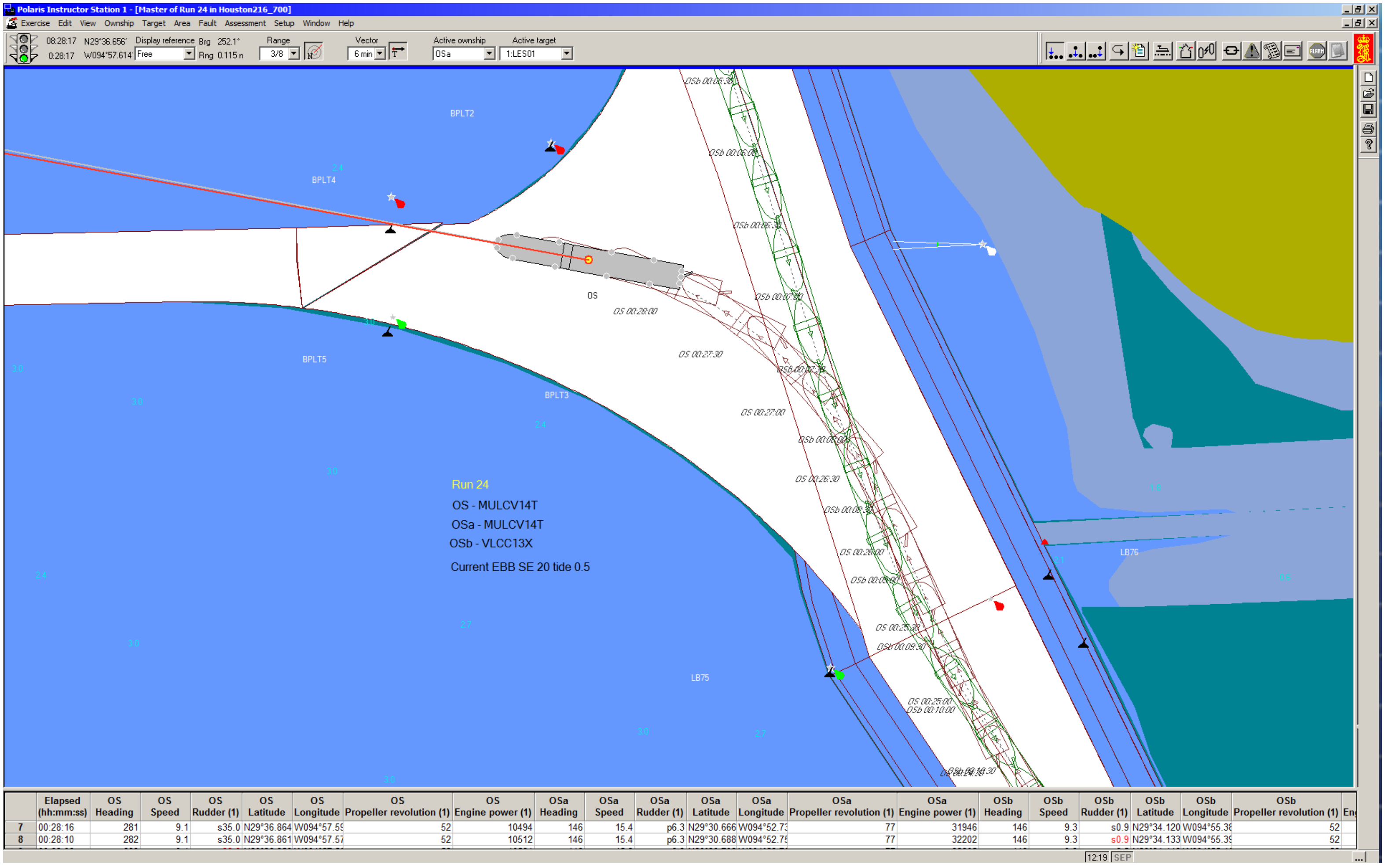
Run 24
OS - MULCV14T
OSa - MULCV14T
OSb - VLCC13X
Current EBB SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:27:22	300	9.3	p35.0	N29°36.817	W094°57.4	52	10412	146	15.1	p1.9	N29°30.857	W094°52.8	77	32149	145	9.3	s1.4	N29°34.236	W094°55.4	52	
8	00:27:14	303	9.4	p35.0	N29°36.806	W094°57.4	52	10384	146	15.1	p0.2	N29°30.884	W094°52.9	77	32530	145	9.3	s1.6	N29°34.253	W094°55.4	52	

This is an own ship ground speed vector

12:18 SEP

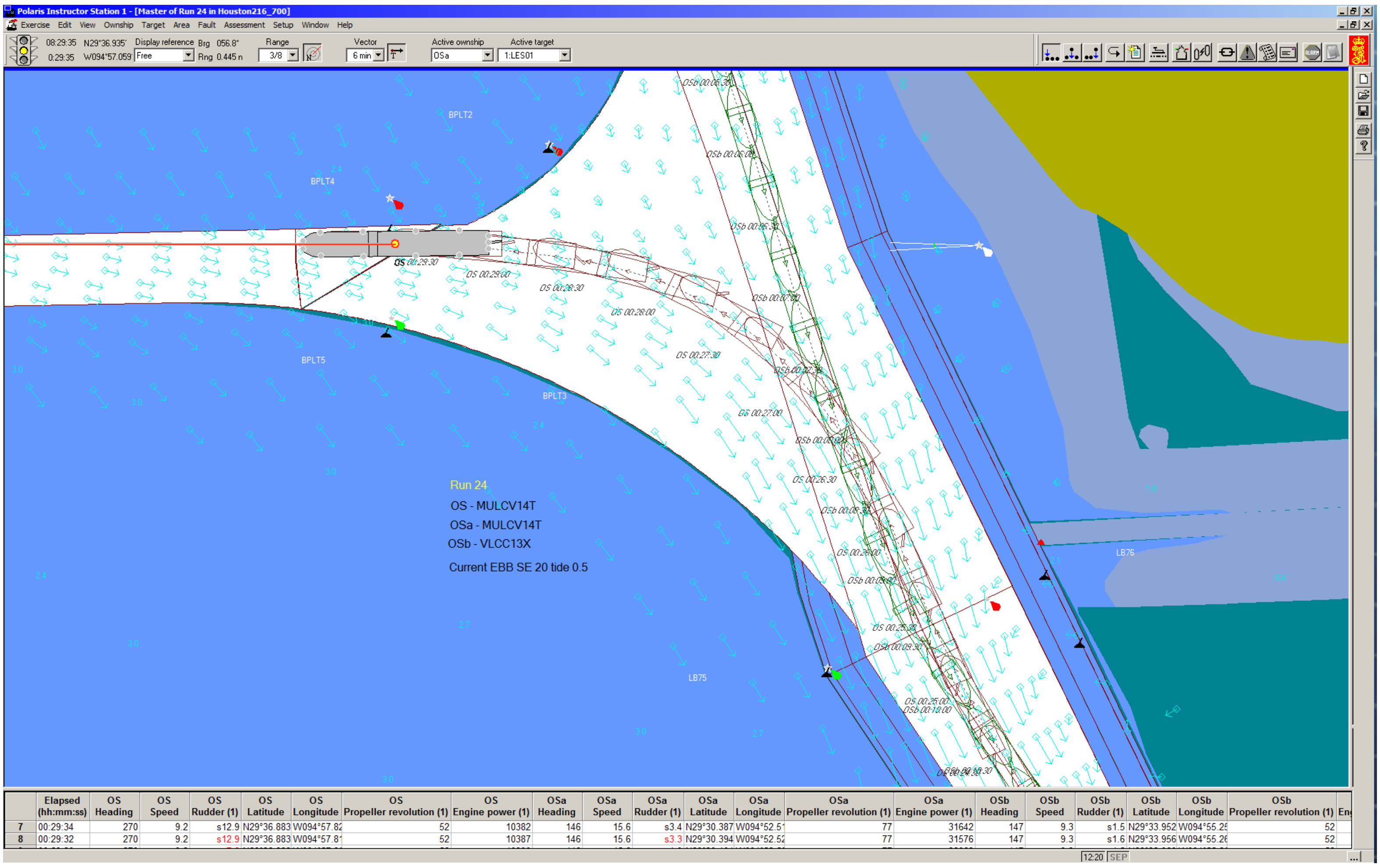
June 26, 2019


Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:28:17 N29°36.656' Display reference Free Brg 252.1° Rng 0.115 n
0:28:17 W094°57.614' Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:28:16	281	9.1	s35.0	N29°36.864	W094°57.59	52	10494	146	15.4	p6.3	N29°30.666	W094°52.73	77	31946	146	9.3	s0.9	N29°34.120	W094°55.38	52	
8	00:28:10	282	9.1	s35.0	N29°36.861	W094°57.57	52	10512	146	15.4	p6.3	N29°30.688	W094°52.75	77	32202	146	9.3	s0.9	N29°34.133	W094°55.39	52	

12:19 SEP


Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:29:35 N29°36.935' Display reference Free Brg 056.8° Rng 0.445 n
0:29:35 W094°57.059' Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:29:34	270	9.2	s12.9	N29°36.883	W094°57.82	52	10382	146	15.6	s3.4	N29°30.387	W094°52.51	77	31642	147	9.3	s1.5	N29°33.952	W094°55.25	52	
8	00:29:32	270	9.2	s12.9	N29°36.883	W094°57.81	52	10387	146	15.6	s3.3	N29°30.394	W094°52.52	77	31576	147	9.3	s1.6	N29°33.956	W094°55.26	52	

12:20 SEP

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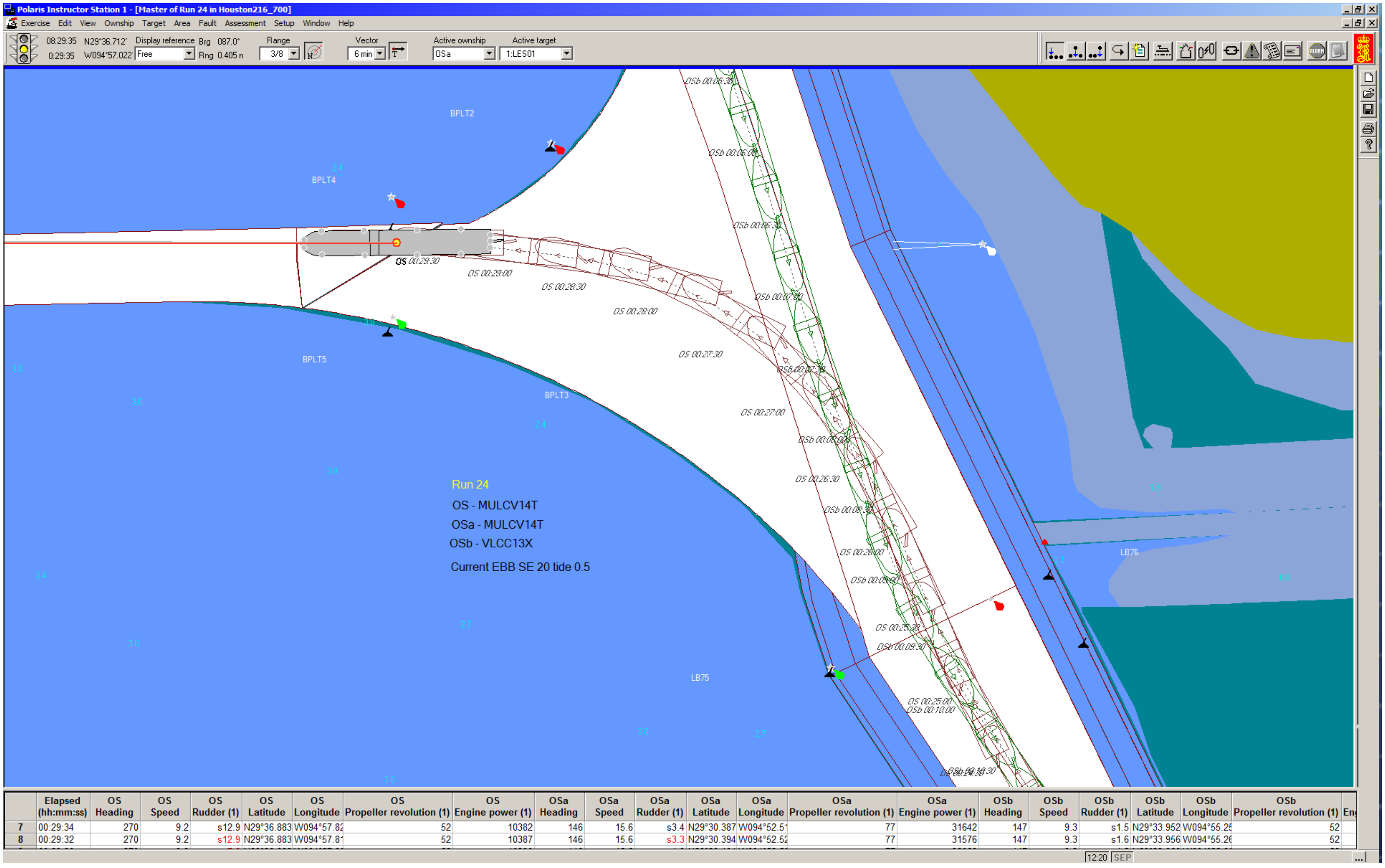
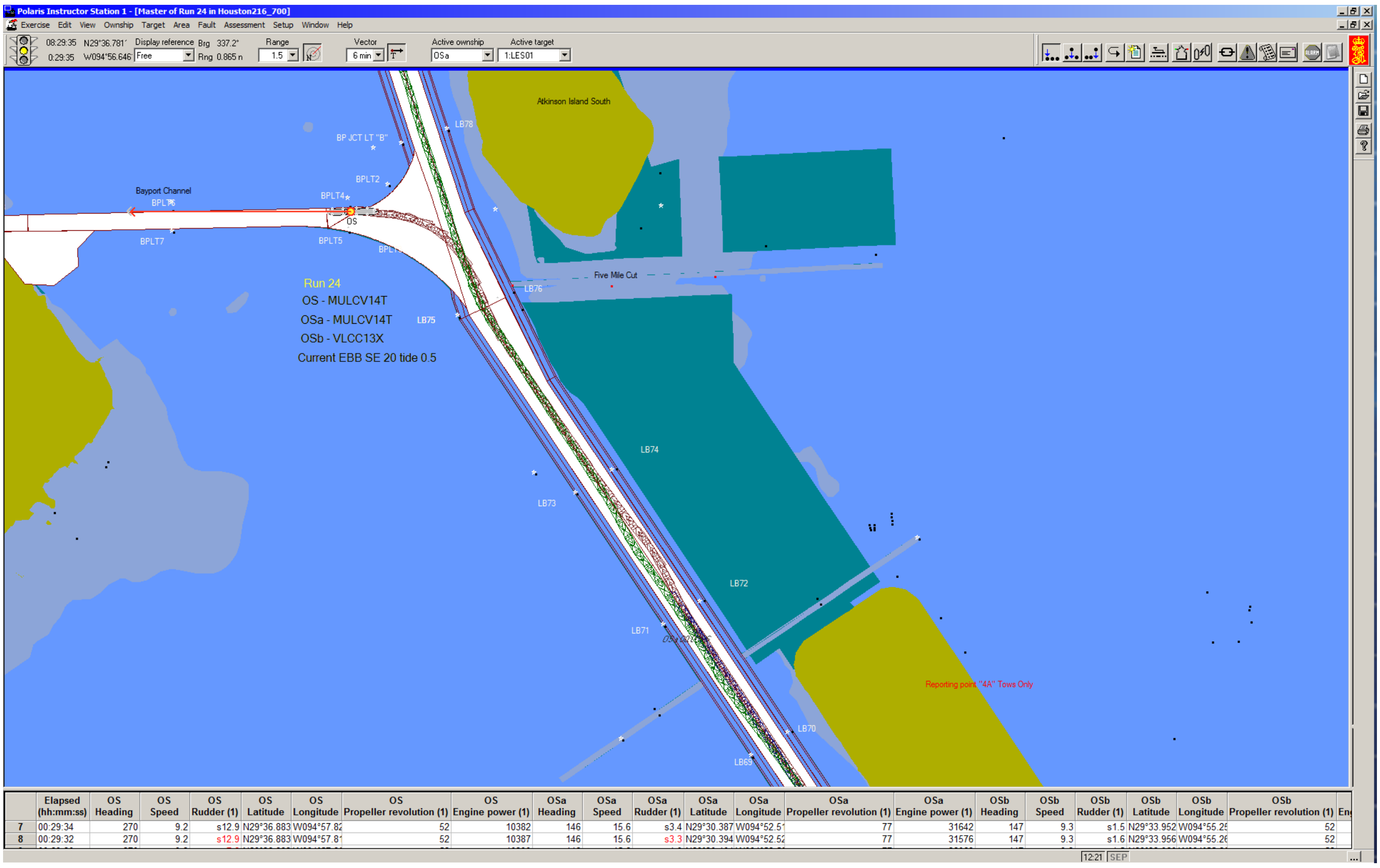
June 26, 2019


Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

08:29:35 N29°36.712′ 0:29:35 W094°57.022′ Display reference Free Brg 087.0° Rng 0.405 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01

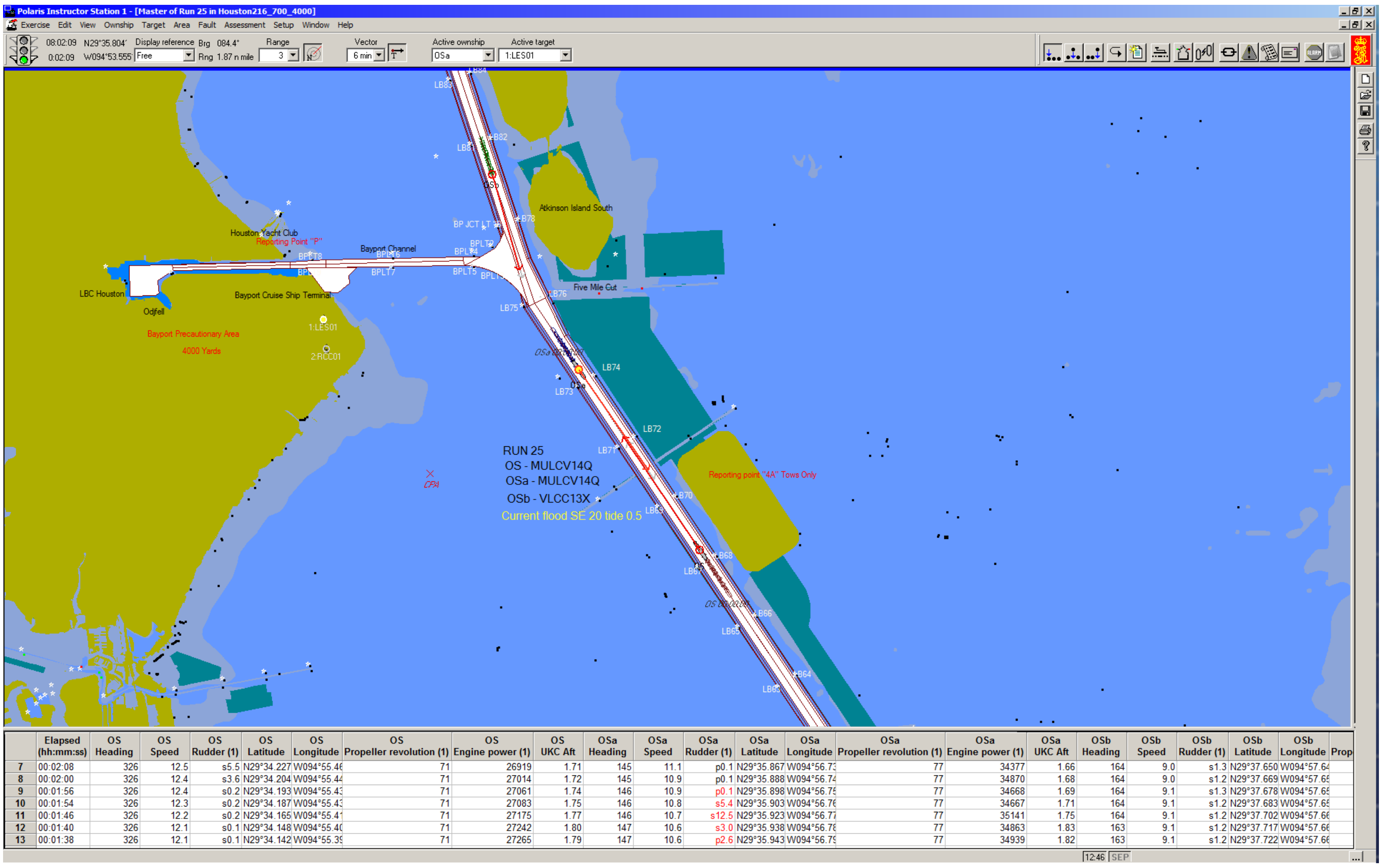
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:29:34	270	9.2	s12.9	N29°36.883	W094°57.82	52	10382	146	15.6	s3.4	N29°30.387	W094°52.51	77	31642	147	9.3	s1.5	N29°33.952	W094°55.25	52	
8	00:29:32	270	9.2	s12.9	N29°36.883	W094°57.81	52	10387	146	15.6	s3.3	N29°30.394	W094°52.52	77	31576	147	9.3	s1.6	N29°33.956	W094°55.26	52	


Polaris Instructor Station 1 - [Master of Run 24 in Houston216_700]

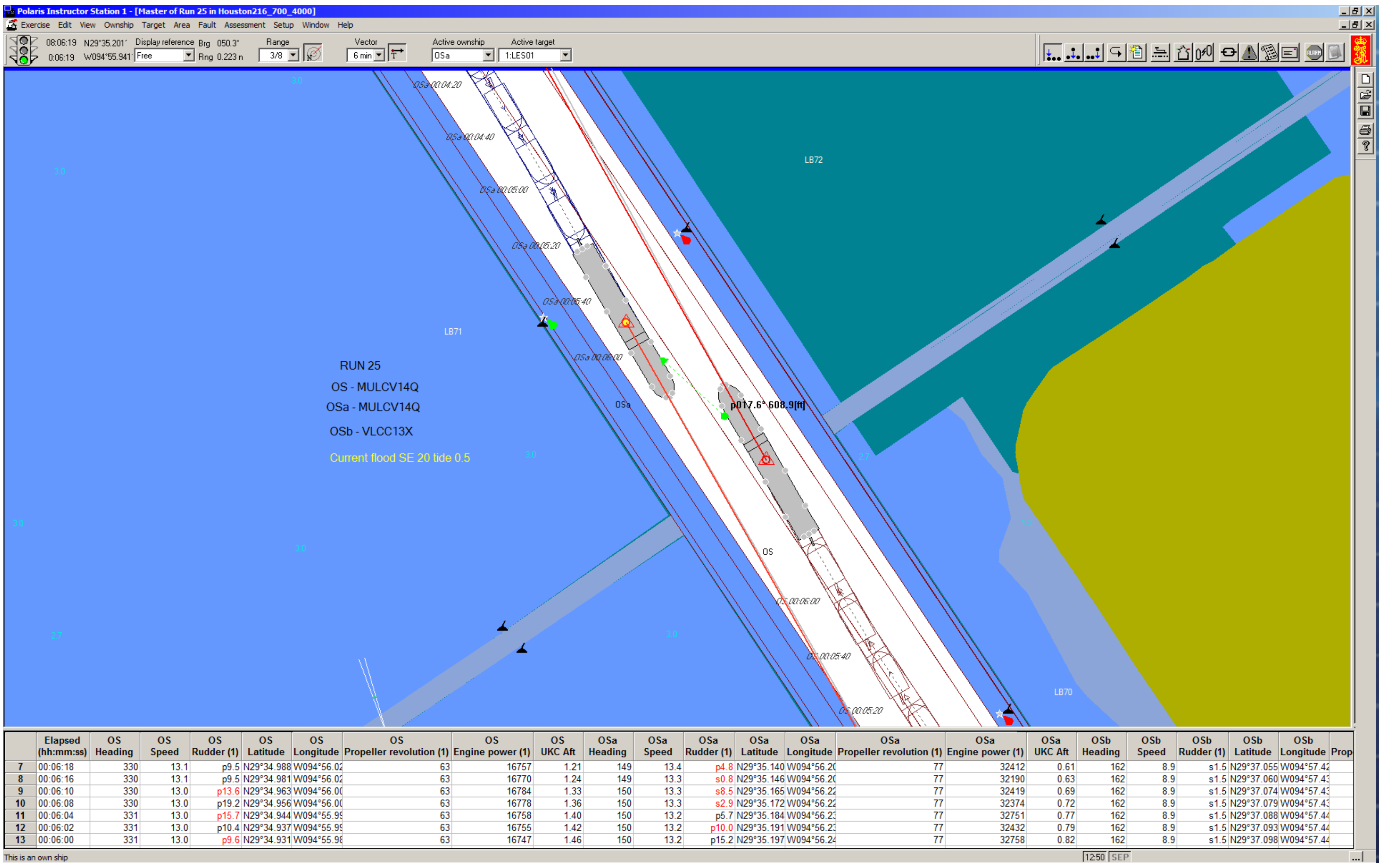
08:29:35 N29°36.781′ 0:29:35 W094°56.646′ Display reference Free Brg 337.2° Rng 0.865 n Range 1.5 Vector 6 min Active ownship OSa Active target 1:LES01

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	OSb Propeller revolution (1)	En
7	00:29:34	270	9.2	s12.9	N29°36.883	W094°57.82	52	10382	146	15.6	s3.4	N29°30.387	W094°52.51	77	31642	147	9.3	s1.5	N29°33.952	W094°55.25	52	
8	00:29:32	270	9.2	s12.9	N29°36.883	W094°57.81	52	10387	146	15.6	s3.3	N29°30.394	W094°52.52	77	31576	147	9.3	s1.6	N29°33.956	W094°55.26	52	

Run 25

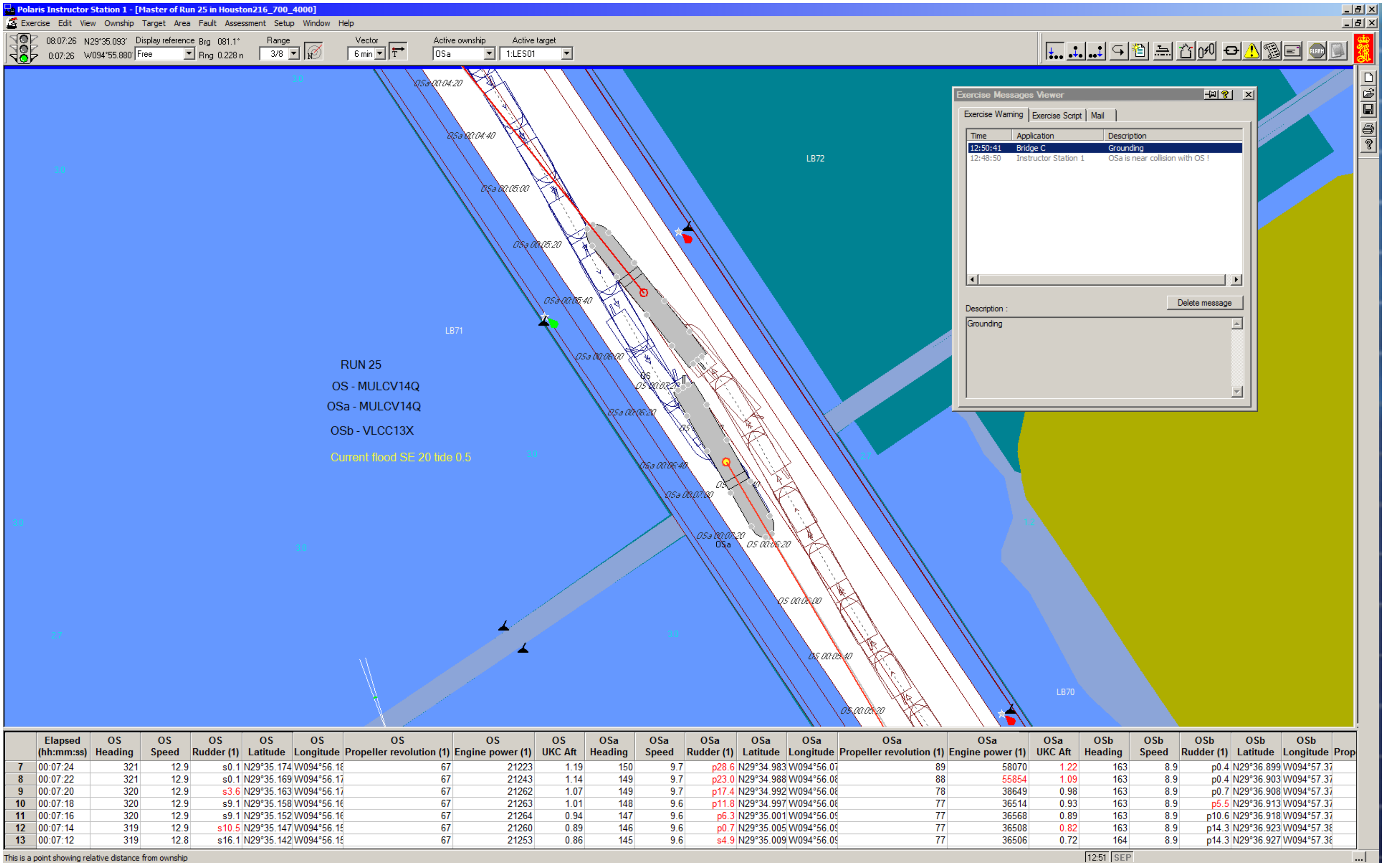


	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:02:08	326	12.5	s5.5	N29°34.227	W094°55.46	71	26919	1.71	145	11.1	p0.1	N29°35.867	W094°56.73	77	34377	1.66	164	9.0	s1.3	N29°37.650	W094°57.64	
8	00:02:00	326	12.4	s3.6	N29°34.204	W094°55.44	71	27014	1.72	145	10.9	p0.1	N29°35.888	W094°56.74	77	34870	1.68	164	9.0	s1.2	N29°37.669	W094°57.65	
9	00:01:56	326	12.4	s0.2	N29°34.193	W094°55.43	71	27061	1.74	146	10.9	p0.1	N29°35.898	W094°56.75	77	34668	1.69	164	9.1	s1.3	N29°37.678	W094°57.65	
10	00:01:54	326	12.3	s0.2	N29°34.187	W094°55.43	71	27083	1.75	146	10.8	s5.4	N29°35.903	W094°56.76	77	34667	1.71	164	9.1	s1.2	N29°37.683	W094°57.65	
11	00:01:46	326	12.2	s0.2	N29°34.165	W094°55.41	71	27175	1.77	146	10.7	s12.5	N29°35.923	W094°56.77	77	35141	1.75	164	9.1	s1.2	N29°37.702	W094°57.66	
12	00:01:40	326	12.1	s0.1	N29°34.148	W094°55.40	71	27242	1.80	147	10.6	s3.0	N29°35.938	W094°56.78	77	34863	1.83	163	9.1	s1.2	N29°37.717	W094°57.66	
13	00:01:38	326	12.1	s0.1	N29°34.142	W094°55.39	71	27265	1.79	147	10.6	p2.6	N29°35.943	W094°56.79	77	34939	1.82	163	9.1	s1.2	N29°37.722	W094°57.66	



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:06:18	330	13.1	p9.5	N29°34.988	W094°56.02	63	16757	1.21	149	13.4	p4.8	N29°35.140	W094°56.20	77	32412	0.61	162	8.9	s1.5	N29°37.055	W094°57.42	
8	00:06:16	330	13.1	p9.5	N29°34.981	W094°56.02	63	16770	1.24	149	13.3	s0.8	N29°35.146	W094°56.20	77	32190	0.63	162	8.9	s1.5	N29°37.060	W094°57.43	
9	00:06:10	330	13.0	p13.6	N29°34.963	W094°56.00	63	16784	1.33	150	13.3	s8.5	N29°35.165	W094°56.22	77	32419	0.69	162	8.9	s1.5	N29°37.074	W094°57.43	
10	00:06:08	330	13.0	p19.2	N29°34.956	W094°56.00	63	16778	1.36	150	13.3	s2.9	N29°35.172	W094°56.22	77	32374	0.72	162	8.9	s1.5	N29°37.079	W094°57.43	
11	00:06:04	331	13.0	p15.7	N29°34.944	W094°55.99	63	16758	1.40	150	13.2	p5.7	N29°35.184	W094°56.23	77	32751	0.77	162	8.9	s1.5	N29°37.088	W094°57.44	
12	00:06:02	331	13.0	p10.4	N29°34.937	W094°55.99	63	16755	1.42	150	13.2	p10.0	N29°35.191	W094°56.23	77	32432	0.79	162	8.9	s1.5	N29°37.093	W094°57.44	
13	00:06:00	331	13.0	p9.6	N29°34.931	W094°55.98	63	16747	1.46	150	13.2	p15.2	N29°35.197	W094°56.24	77	32758	0.82	162	8.9	s1.5	N29°37.098	W094°57.44	

This is an own ship



Polaris Instructor Station 1 - [Master of Run 25 in Houston216_700_4000]

08:07:26 N29°35.093′ Display reference Free Brg 081.1° Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:07:26 W094°55.880′ Rng 0.228 n

RUN 25
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

Exercise Messages Viewer

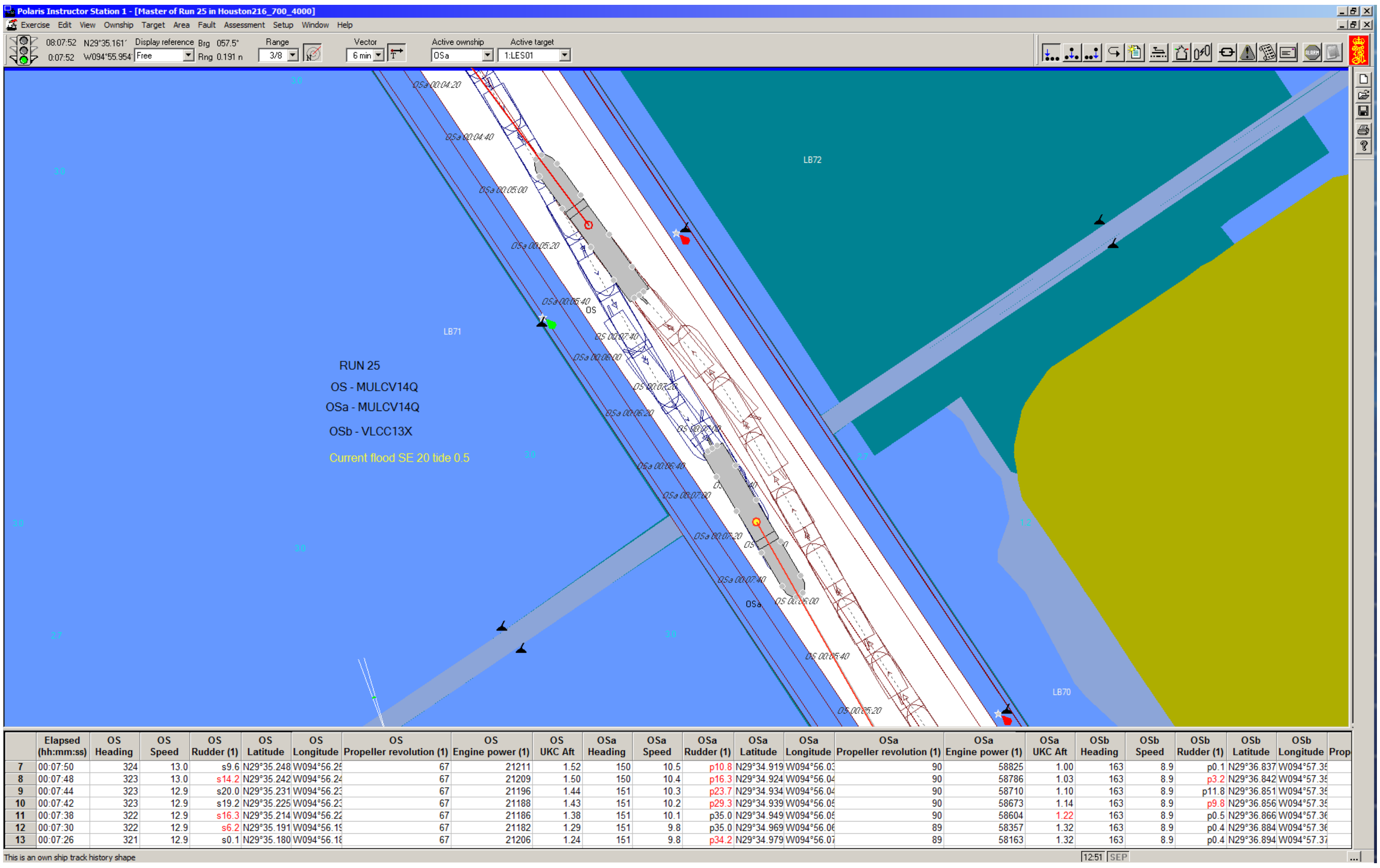
Time	Application	Description
12:50:41	Bridge C	Grounding
12:48:50	Instructor Station 1	OSa is near collision with OS !

Description :
Grounding

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:07:24	321	12.9	s0.1	N29°35.174	W094°56.1	67	21223	1.19	150	9.7	p28.6	N29°34.983	W094°56.0	89	58070	1.22	163	8.9	p0.4	N29°36.899	W094°57.3	
8	00:07:22	321	12.9	s0.1	N29°35.169	W094°56.1	67	21243	1.14	149	9.7	p23.0	N29°34.988	W094°56.0	88	55854	1.09	163	8.9	p0.4	N29°36.903	W094°57.3	
9	00:07:20	320	12.9	s3.6	N29°35.163	W094°56.1	67	21262	1.07	149	9.7	p17.4	N29°34.992	W094°56.0	78	38649	0.98	163	8.9	p0.7	N29°36.908	W094°57.3	
10	00:07:18	320	12.9	s9.1	N29°35.158	W094°56.1	67	21263	1.01	148	9.6	p11.8	N29°34.997	W094°56.0	77	36514	0.93	163	8.9	p5.5	N29°36.913	W094°57.3	
11	00:07:16	320	12.9	s9.1	N29°35.152	W094°56.1	67	21264	0.94	147	9.6	p6.3	N29°35.001	W094°56.0	77	36568	0.89	163	8.9	p10.6	N29°36.918	W094°57.3	
12	00:07:14	319	12.9	s10.5	N29°35.147	W094°56.1	67	21260	0.89	146	9.6	p0.7	N29°35.005	W094°56.0	77	36508	0.82	163	8.9	p14.3	N29°36.923	W094°57.3	
13	00:07:12	319	12.8	s16.1	N29°35.142	W094°56.1	67	21253	0.86	145	9.6	s4.9	N29°35.009	W094°56.0	77	36506	0.72	164	8.9	p14.3	N29°36.927	W094°57.3	

This is a point showing relative distance from ownship

12:51 SEP



Polaris Instructor Station 1 - [Master of Run 25 in Houston216_700_4000]

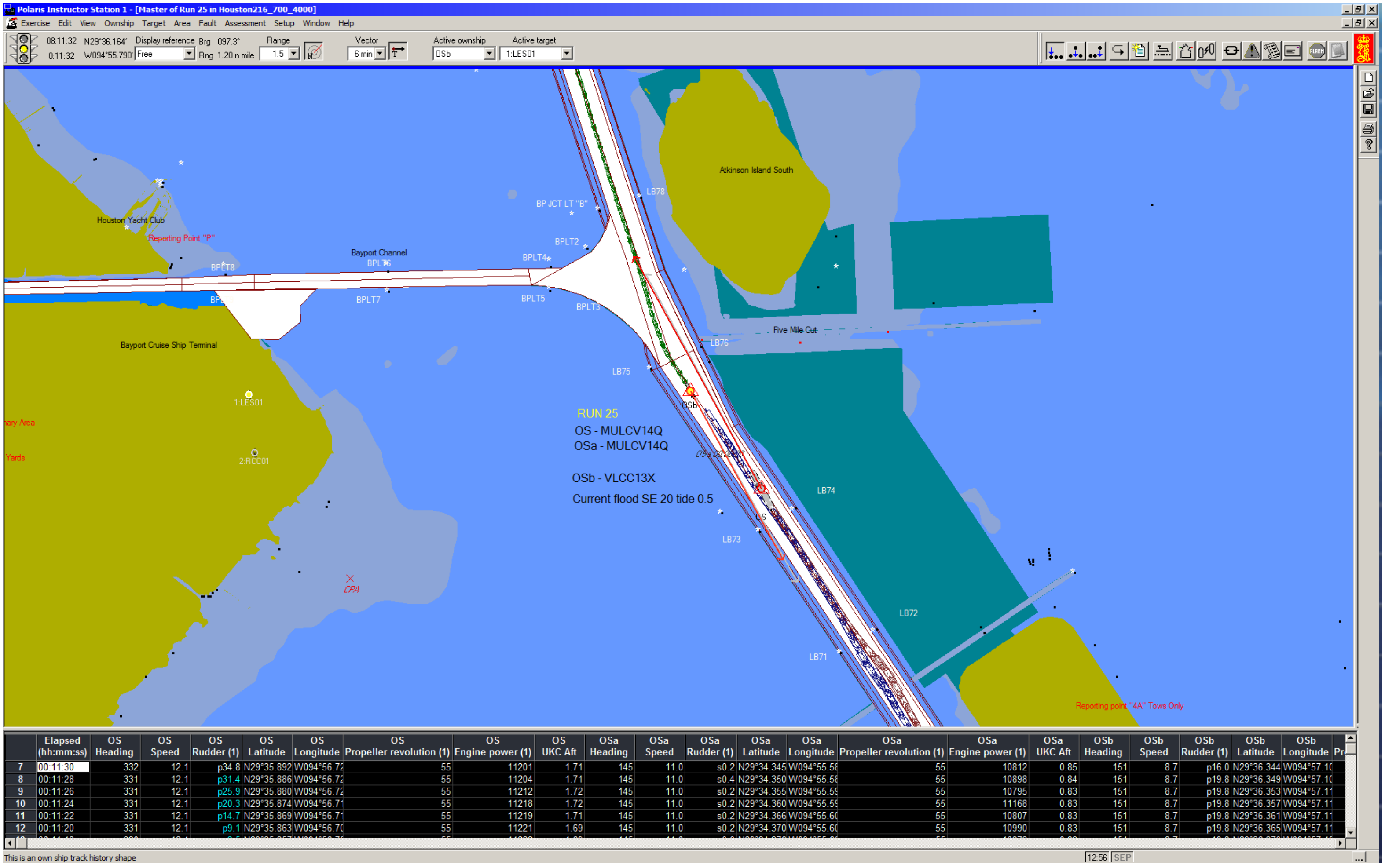
08:07:52 N29°35.161′ Display reference Free Brg 057.5° Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:07:52 W094°55.954′ Rng 0.191 n

RUN 25
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:07:50	324	13.0	s9.6	N29°35.248	W094°56.2	67	21211	1.52	150	10.5	p10.8	N29°34.919	W094°56.0	90	58825	1.00	163	8.9	p0.1	N29°36.837	W094°57.3	
8	00:07:48	323	13.0	s14.2	N29°35.242	W094°56.2	67	21209	1.50	150	10.4	p16.3	N29°34.924	W094°56.0	90	58786	1.03	163	8.9	p3.2	N29°36.842	W094°57.3	
9	00:07:44	323	12.9	s20.0	N29°35.231	W094°56.2	67	21196	1.44	151	10.3	p23.7	N29°34.934	W094°56.0	90	58710	1.10	163	8.9	p11.8	N29°36.851	W094°57.3	
10	00:07:42	323	12.9	s19.2	N29°35.225	W094°56.2	67	21188	1.43	151	10.2	p29.3	N29°34.939	W094°56.0	90	58673	1.14	163	8.9	p9.8	N29°36.856	W094°57.3	
11	00:07:38	322	12.9	s16.3	N29°35.214	W094°56.2	67	21186	1.38	151	10.1	p35.0	N29°34.949	W094°56.0	90	58604	1.22	163	8.9	p0.5	N29°36.866	W094°57.3	
12	00:07:30	322	12.9	s6.2	N29°35.191	W094°56.1	67	21182	1.29	151	9.8	p35.0	N29°34.969	W094°56.0	89	58357	1.32	163	8.9	p0.4	N29°36.884	W094°57.3	
13	00:07:26	321	12.9	s0.1	N29°35.180	W094°56.1	67	21206	1.24	151	9.8	p34.2	N29°34.979	W094°56.0	89	58163	1.32	163	8.9	p0.4	N29°36.894	W094°57.3	

This is an own ship track history shape

12:51 SEP



Polaris Instructor Station 1 - [Master of Run 25 in Houston216_700_4000]

08:11:32 N29°36.164' Display reference Free Brg 097.3° Rng 1.20 n mile Range 1.5 Vector 6 min Active ownship OSb Active target 1:LES01
0:11:32 W094°55.790'

RUN 25
OS - MULCV14Q
OSa - MULCV14Q

OSb - VLCC13X

Current flood SE 20 tide 0.5

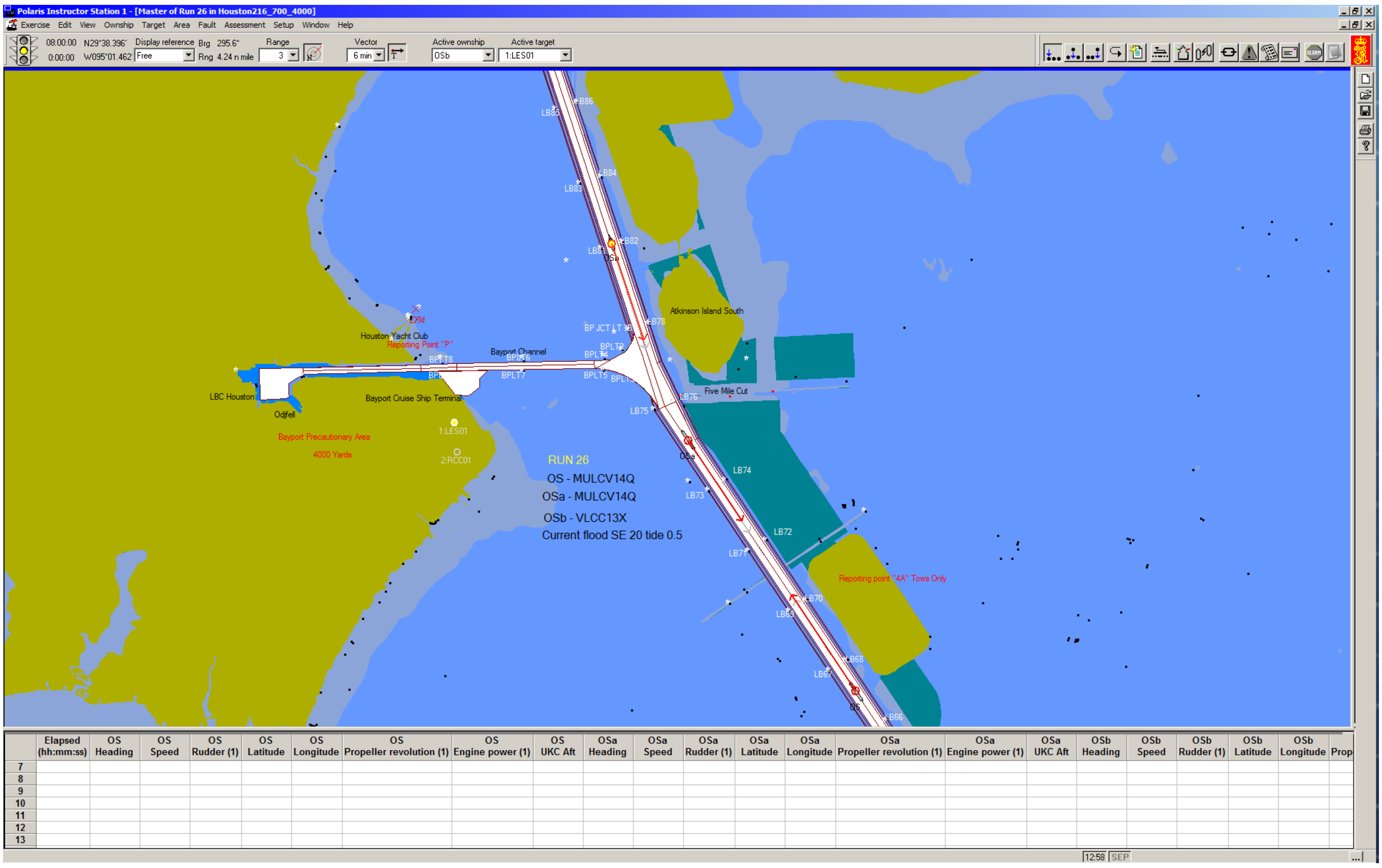
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude
7	00:11:30	332	12.1	p34.8	N29°35.892	W094°56.72	55	11201	1.71	145	11.0	s0.2	N29°34.345	W094°55.58	55	10812	0.85	151	8.7	p16.0	N29°36.344	W094°57.10
8	00:11:28	331	12.1	p31.4	N29°35.886	W094°56.72	55	11204	1.71	145	11.0	s0.4	N29°34.350	W094°55.58	55	10898	0.84	151	8.7	p19.8	N29°36.349	W094°57.10
9	00:11:26	331	12.1	p25.9	N29°35.880	W094°56.72	55	11212	1.72	145	11.0	s0.2	N29°34.355	W094°55.59	55	10795	0.83	151	8.7	p19.8	N29°36.353	W094°57.11
10	00:11:24	331	12.1	p20.3	N29°35.874	W094°56.71	55	11218	1.72	145	11.0	s0.2	N29°34.360	W094°55.59	55	11168	0.83	151	8.7	p19.8	N29°36.357	W094°57.11
11	00:11:22	331	12.1	p14.7	N29°35.869	W094°56.71	55	11219	1.71	145	11.0	s0.2	N29°34.366	W094°55.60	55	10807	0.83	151	8.7	p19.8	N29°36.361	W094°57.11
12	00:11:20	331	12.1	p9.1	N29°35.863	W094°56.70	55	11221	1.69	145	11.0	s0.2	N29°34.370	W094°55.60	55	10990	0.83	151	8.7	p19.8	N29°36.365	W094°57.11

This is an own ship track history shape

12:56 SEP

June 26, 2019

Run 26

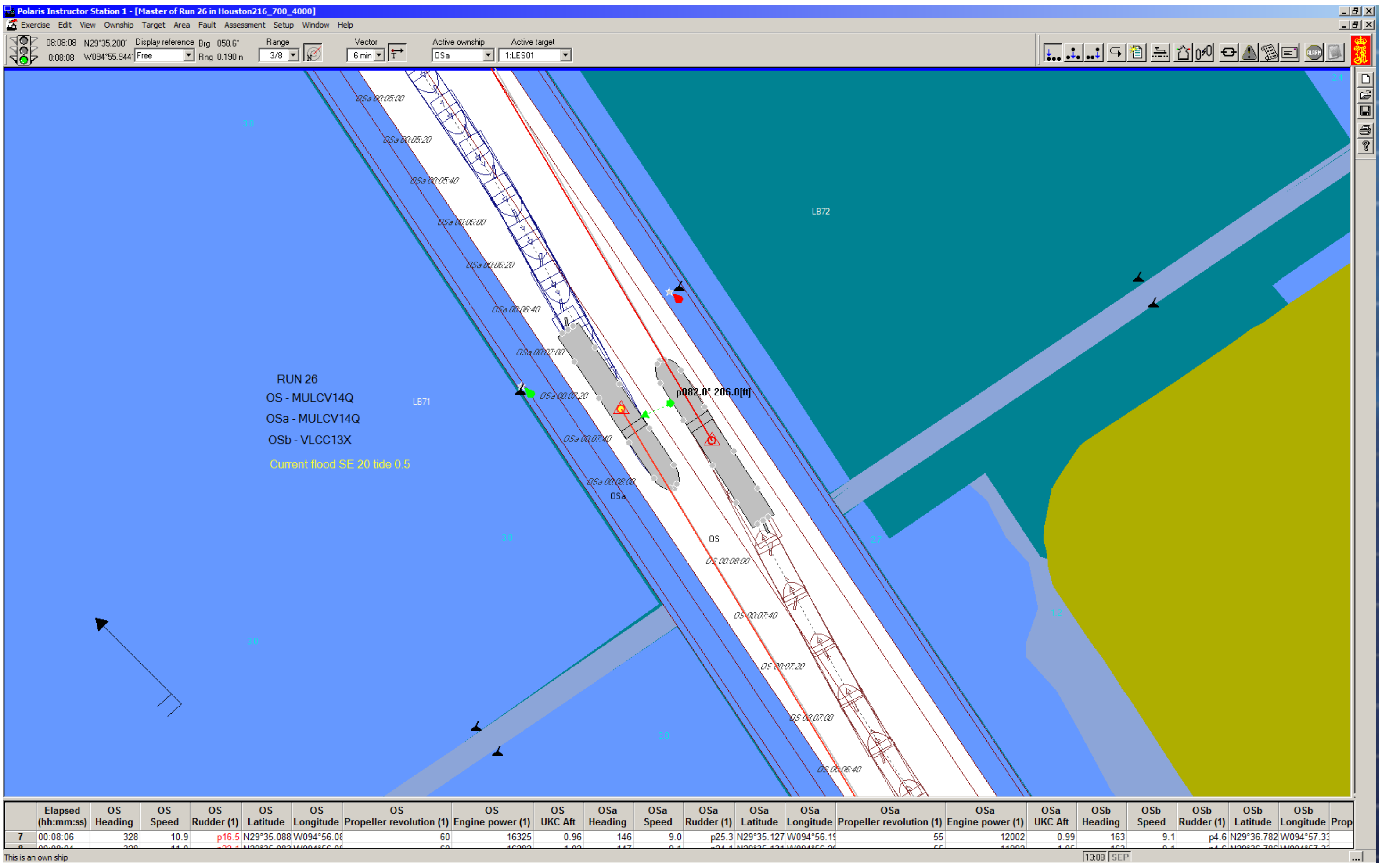

Polaris Instructor Station 1 - [Master of Run 26 in Houston216_700_4000]

08:00:00 N29°38.396′ Display reference Free Brg 295.6° Rng 4.24 n mile
0:00:00 W095°01.462′
Range 3
Vector 6 min
Active ownship OSb
Active target 1:LES01

RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7																							
8																							
9																							
10																							
11																							
12																							
13																							

12:58 SEP


Polaris Instructor Station 1 - [Master of Run 26 in Houston216_700_4000]

08:08:08 N29°35.200′ Display reference Free Brg 058.6° Rng 0.190 n
0:08:08 W094°55.944′
Range 3/8
Vector 6 min
Active ownship OSa
Active target 1:LES01

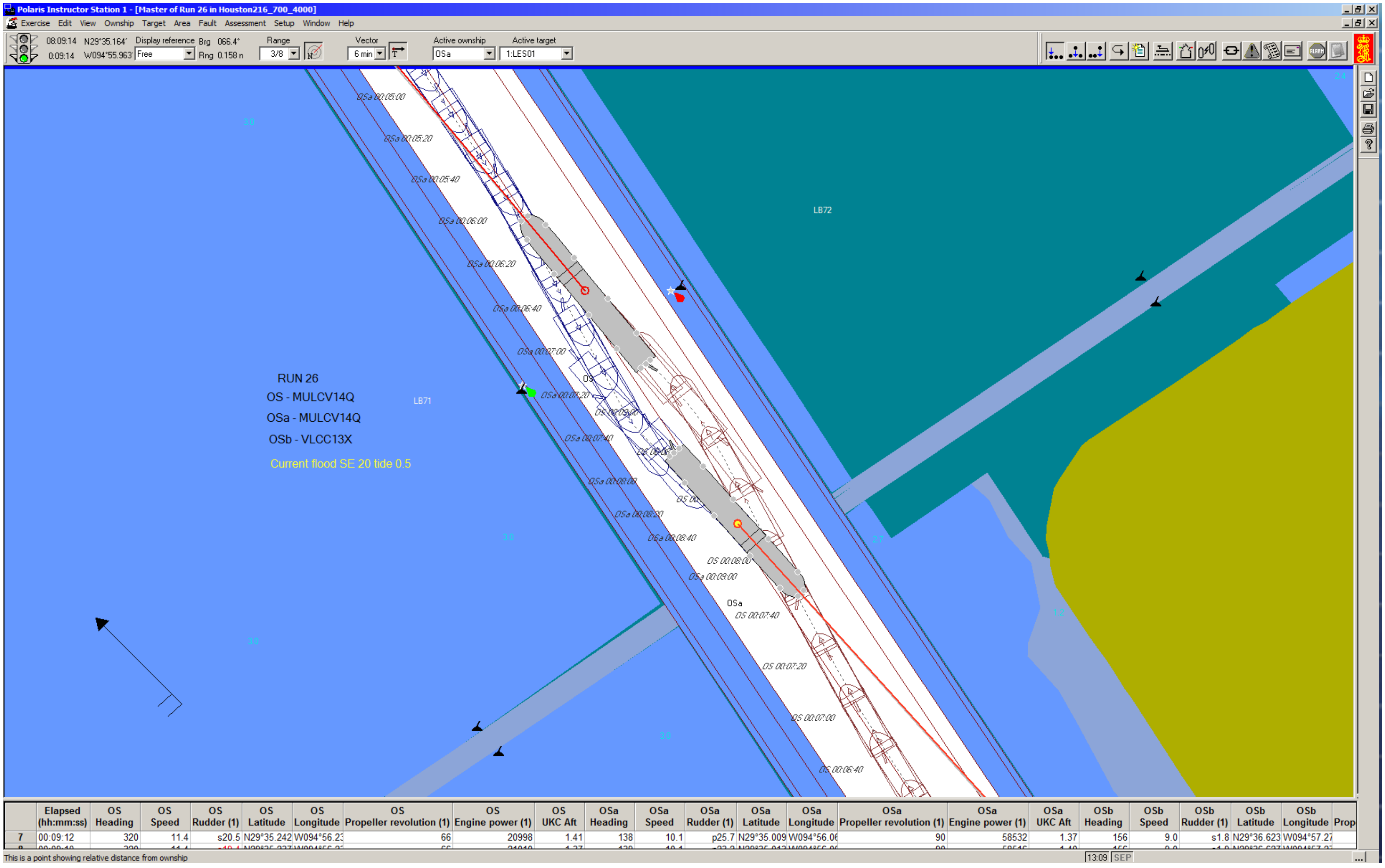
RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:08:06	328	10.9	p16.5	N29°35.088	W094°56.08	60	16325	0.96	146	9.0	p25.3	N29°35.127	W094°56.19	55	12002	0.99	163	9.1	p4.6	N29°36.782	W094°57.33	

This is an own ship

13:08 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 26 in Houston216_700_4000]

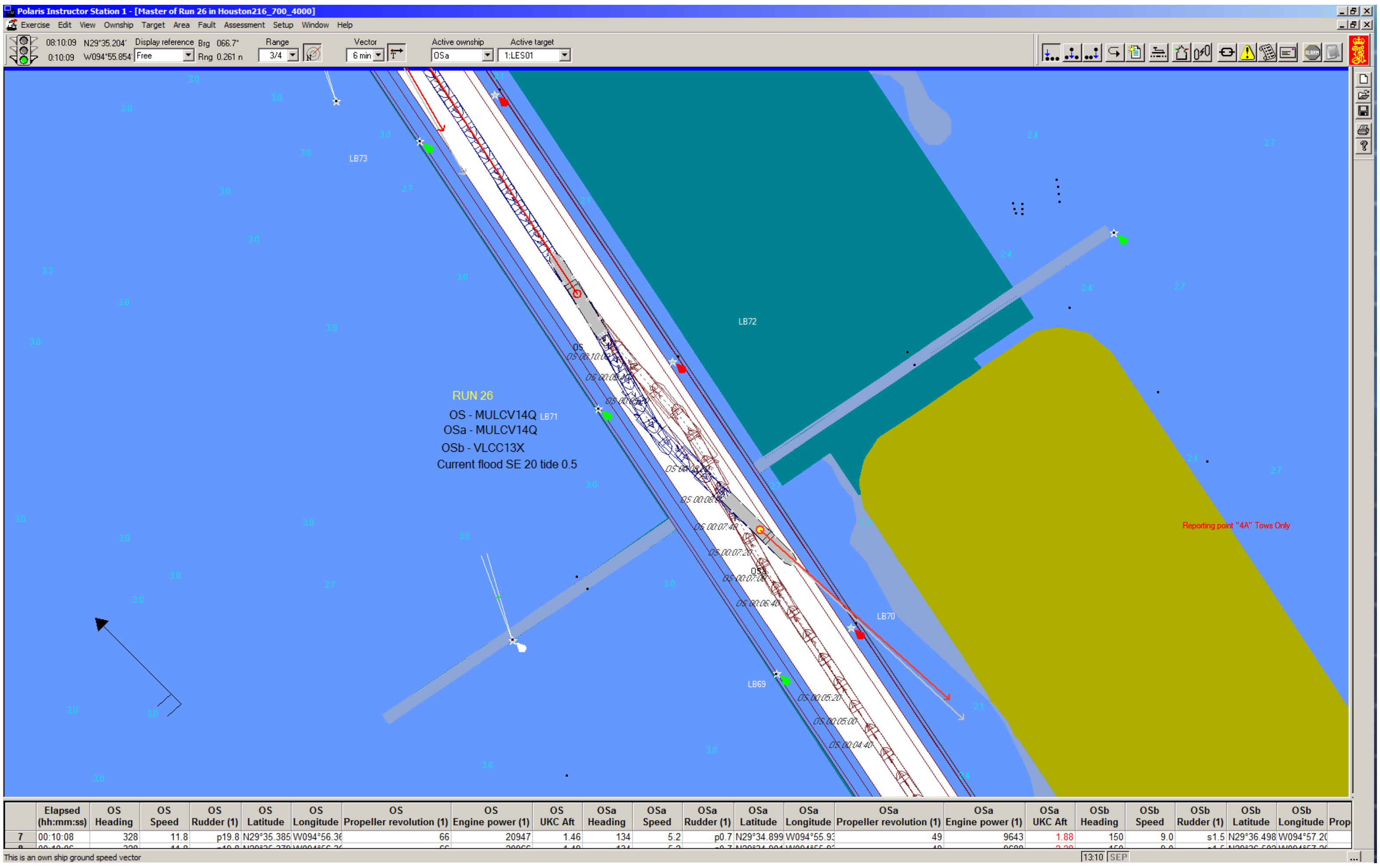
08:09:14 N29°35.164' Display reference Free Brg 066.4° Rng 0.158 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:09:14 W094°55.963'

RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:09:12	320	11.4	s20.5	N29°35.242	W094°56.23	66	20998	1.41	138	10.1	p25.7	N29°35.009	W094°56.06	90	58532	1.37	156	9.0	s1.8	N29°36.623	W094°57.27	

This is a point showing relative distance from ownship

13:09 SEP



Polaris Instructor Station 1 - [Master of Run 26 in Houston216_700_4000]

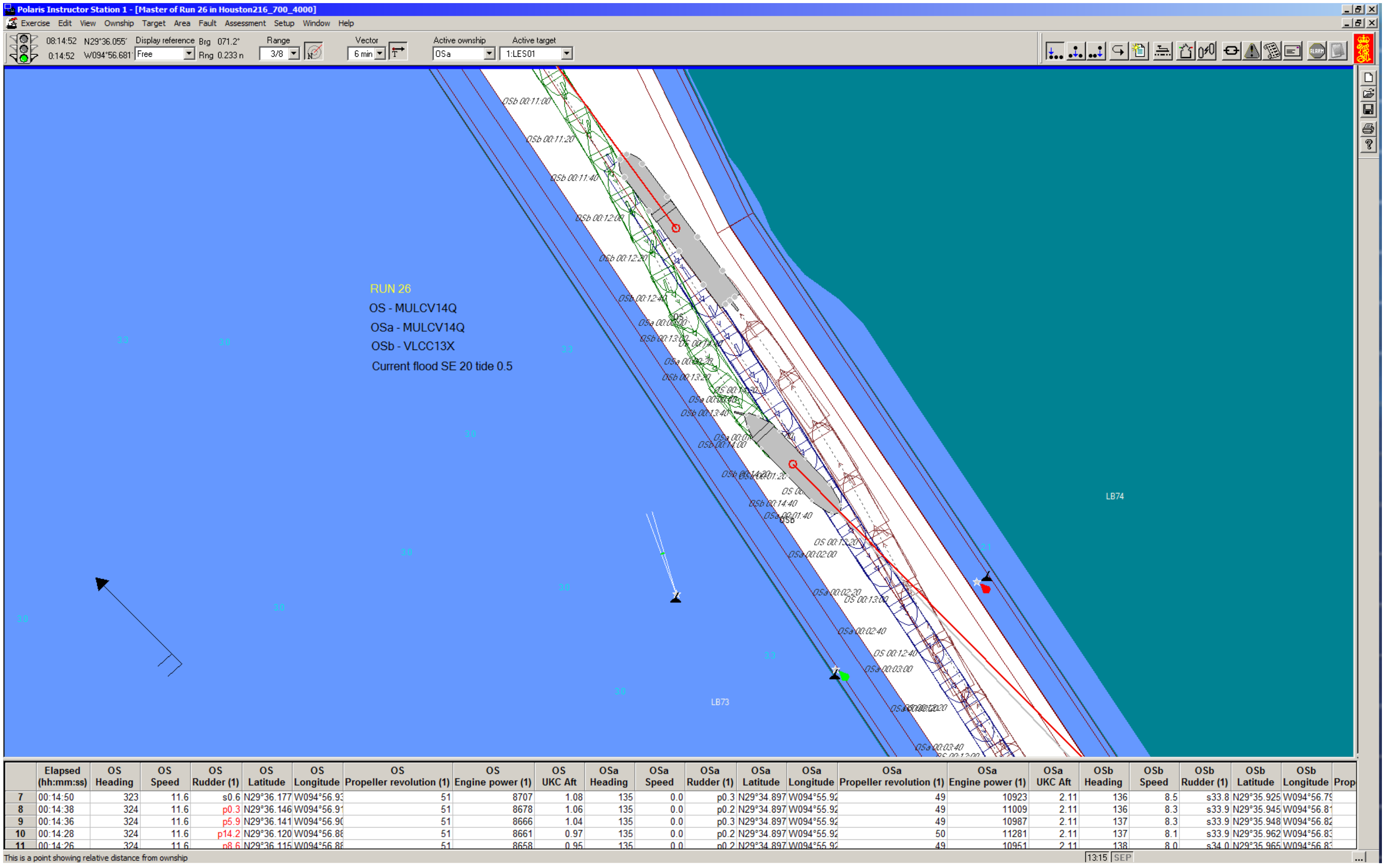
08:10:09 N29°35.204' Display reference Free Brg 066.7° Rng 0.261 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:10:09 W094°55.854'

RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:10:08	328	11.8	p19.8	N29°35.385	W094°56.36	66	20947	1.46	134	5.2	p0.7	N29°34.899	W094°55.93	49	9643	1.88	150	9.0	s1.5	N29°36.498	W094°57.20	

This is an own ship ground speed vector

13:10 SEP



08:14:52 N29°36.055′ Display reference Free Brg 071.2° Rng 0.233 n Range 3/8 Vector 6 min Active ownship OSa Active target 1:LES01
0:14:52 W094°56.681′

RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:14:50	323	11.6	s0.6	N29°36.177	W094°56.93	51	8707	1.08	135	0.0	p0.3	N29°34.897	W094°55.92	49	10923	2.11	136	8.5	s33.8	N29°35.925	W094°56.79	
8	00:14:38	324	11.6	p0.3	N29°36.146	W094°56.91	51	8678	1.06	135	0.0	p0.2	N29°34.897	W094°55.92	49	11009	2.11	136	8.3	s33.9	N29°35.945	W094°56.81	
9	00:14:36	324	11.6	p5.9	N29°36.141	W094°56.90	51	8666	1.04	135	0.0	p0.3	N29°34.897	W094°55.92	49	10987	2.11	137	8.3	s33.9	N29°35.948	W094°56.82	
10	00:14:28	324	11.6	p14.2	N29°36.120	W094°56.88	51	8661	0.97	135	0.0	p0.2	N29°34.897	W094°55.92	50	11281	2.11	137	8.1	s33.9	N29°35.962	W094°56.83	
11	00:14:26	324	11.6	p8.6	N29°36.115	W094°56.88	51	8658	0.95	135	0.0	p0.2	N29°34.897	W094°55.92	49	10951	2.11	138	8.0	s34.0	N29°35.965	W094°56.83	

This is a point showing relative distance from ownship

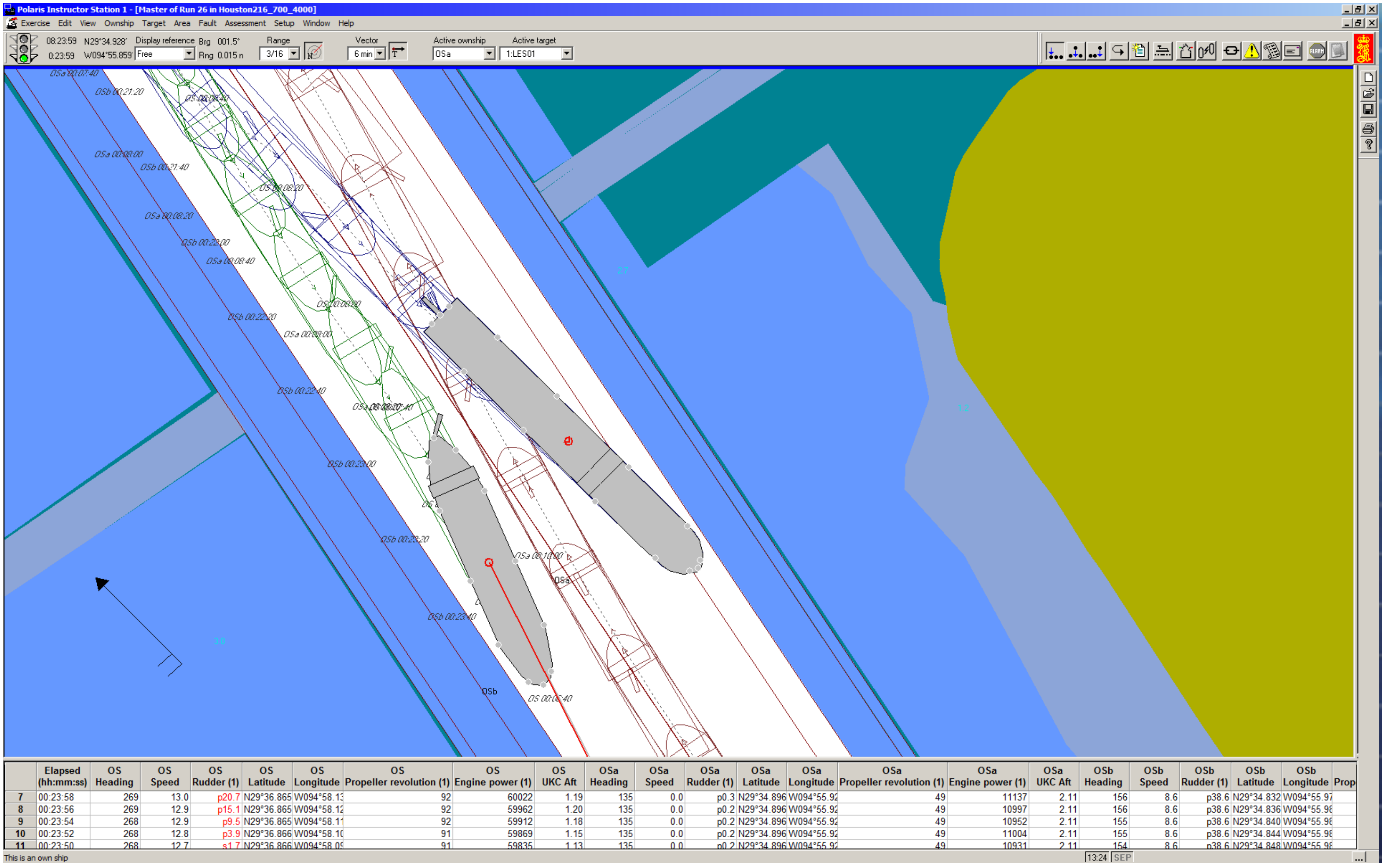
08:16:06 N29°35.871′ Display reference Free Brg 223.7° Rng 0.151 n Range 3/4 Vector 6 min Active ownship OSa Active target 1:LES01
0:16:06 W094°57.055′

RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:16:04	323	11.3	s35.0	N29°36.366	W094°57.09	46	6074	1.64	135	0.0	p0.2	N29°34.897	W094°55.92	49	10913	2.11	146	8.5	p6.2	N29°35.793	W094°56.66	
8	00:16:00	323	11.3	s35.0	N29°36.356	W094°57.08	46	6062	1.61	135	0.0	p0.2	N29°34.897	W094°55.92	49	10948	2.11	146	8.5	p10.1	N29°35.800	W094°56.66	
9	00:15:58	323	11.3	s29.5	N29°36.351	W094°57.08	46	6057	1.61	135	0.0	p0.3	N29°34.897	W094°55.92	49	11054	2.11	145	8.5	p11.1	N29°35.804	W094°56.67	
10	00:15:56	323	11.3	s23.9	N29°36.346	W094°57.08	46	6050	1.60	135	0.0	p0.2	N29°34.897	W094°55.92	49	10913	2.11	145	8.5	p11.1	N29°35.808	W094°56.67	
11	00:15:50	323	11.4	s18.7	N29°36.331	W094°57.06	46	6030	1.55	135	0.0	p0.2	N29°34.897	W094°55.92	49	10944	2.11	144	8.5	p8.6	N29°35.819	W094°56.68	

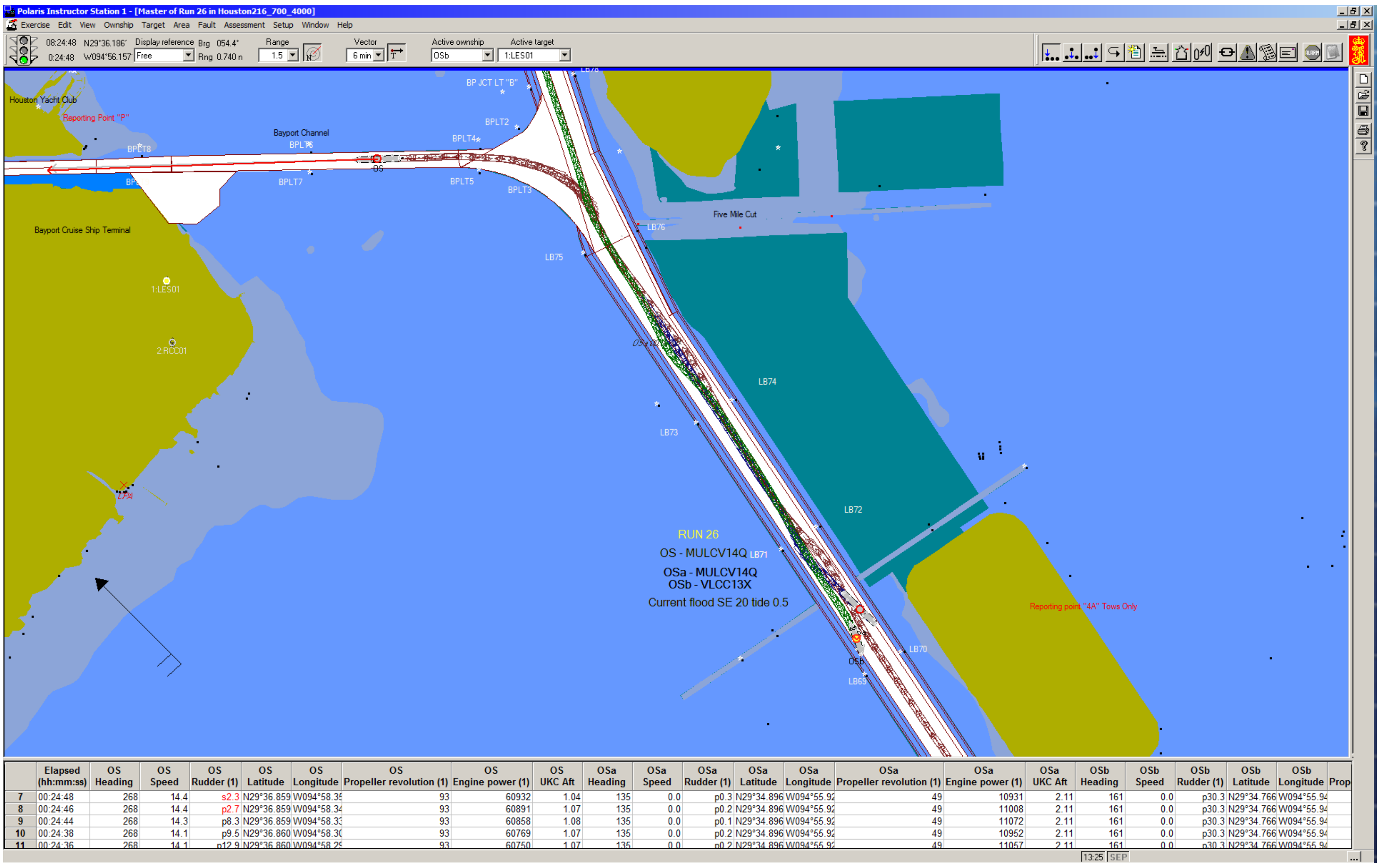
This is an own ship

June 26, 2019



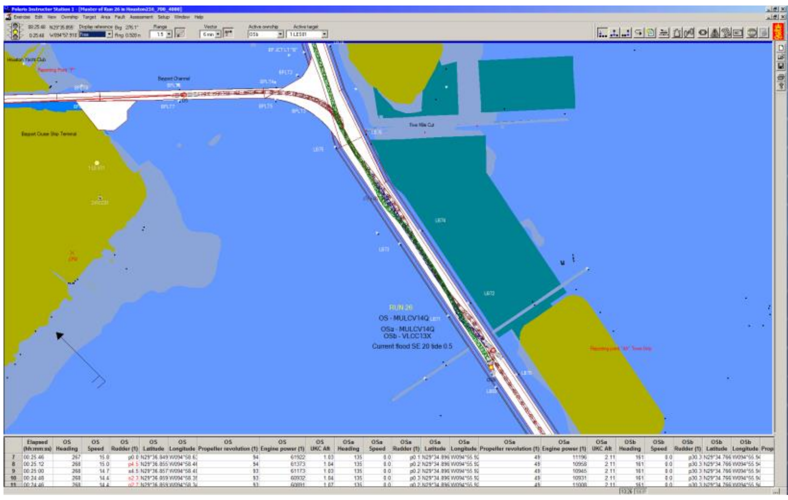
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:23:58	269	13.0	p20.7	N29°36.865	W094°58.13	92	60022	1.19	135	0.0	p0.3	N29°34.896	W094°55.92	49	11137	2.11	156	8.6	p38.6	N29°34.832	W094°55.97	
8	00:23:56	269	12.9	p15.1	N29°36.865	W094°58.12	92	59962	1.20	135	0.0	p0.2	N29°34.896	W094°55.92	49	10997	2.11	156	8.6	p38.6	N29°34.836	W094°55.98	
9	00:23:54	268	12.9	p9.5	N29°36.865	W094°58.11	92	59912	1.18	135	0.0	p0.2	N29°34.896	W094°55.92	49	10952	2.11	155	8.6	p38.6	N29°34.840	W094°55.98	
10	00:23:52	268	12.8	p3.9	N29°36.866	W094°58.10	91	59869	1.15	135	0.0	p0.2	N29°34.896	W094°55.92	49	11004	2.11	155	8.6	p38.6	N29°34.844	W094°55.98	
11	00:23:50	268	12.7	s1.7	N29°36.866	W094°58.09	91	59835	1.13	135	0.0	p0.2	N29°34.896	W094°55.92	49	10931	2.11	154	8.6	p38.6	N29°34.848	W094°55.98	

This is an own ship

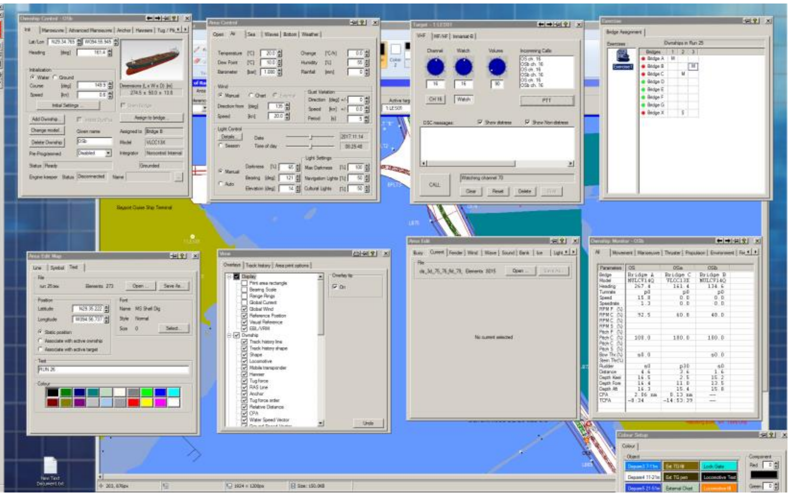


RUN 26
OS - MULCV14Q
OSa - MULCV14Q
OSb - VLCC13X
Current flood SE 20 tide 0.5

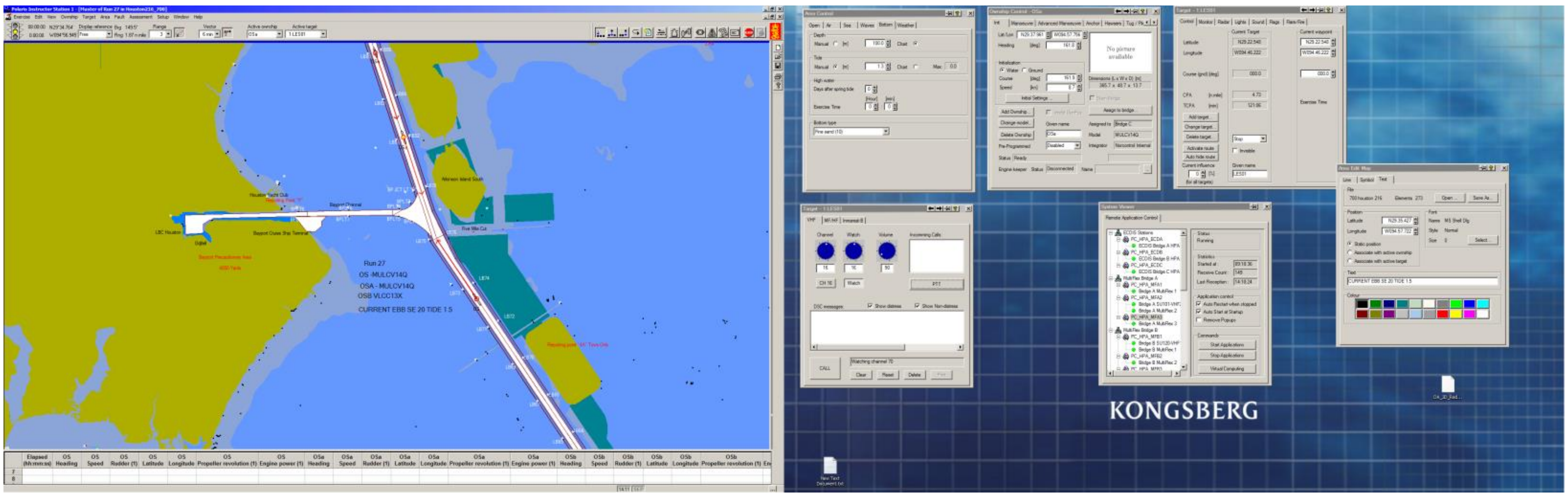
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:24:48	268	14.4	s2.3	N29°36.859	W094°58.35	93	60932	1.04	135	0.0	p0.3	N29°34.896	W094°55.92	49	10931	2.11	161	0.0	p30.3	N29°34.766	W094°55.94	
8	00:24:46	268	14.4	p2.7	N29°36.859	W094°58.34	93	60891	1.07	135	0.0	p0.2	N29°34.896	W094°55.92	49	11008	2.11	161	0.0	p30.3	N29°34.766	W094°55.94	
9	00:24:44	268	14.3	p8.3	N29°36.859	W094°58.33	93	60858	1.08	135	0.0	p0.1	N29°34.896	W094°55.92	49	11072	2.11	161	0.0	p30.3	N29°34.766	W094°55.94	
10	00:24:38	268	14.1	p9.5	N29°36.860	W094°58.30	93	60769	1.07	135	0.0	p0.2	N29°34.896	W094°55.92	49	10952	2.11	161	0.0	p30.3	N29°34.766	W094°55.94	
11	00:24:36	268	14.1	p12.9	N29°36.860	W094°58.29	93	60750	1.07	135	0.0	p0.2	N29°34.896	W094°55.92	49	11057	2.11	161	0.0	p30.3	N29°34.766	W094°55.94	

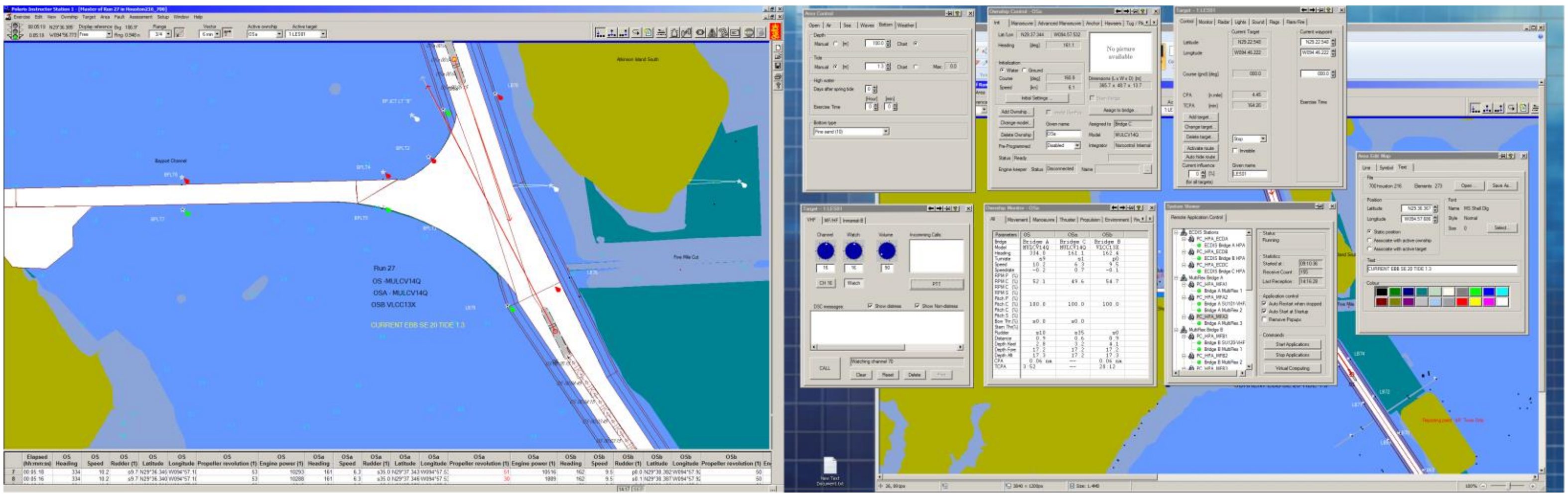


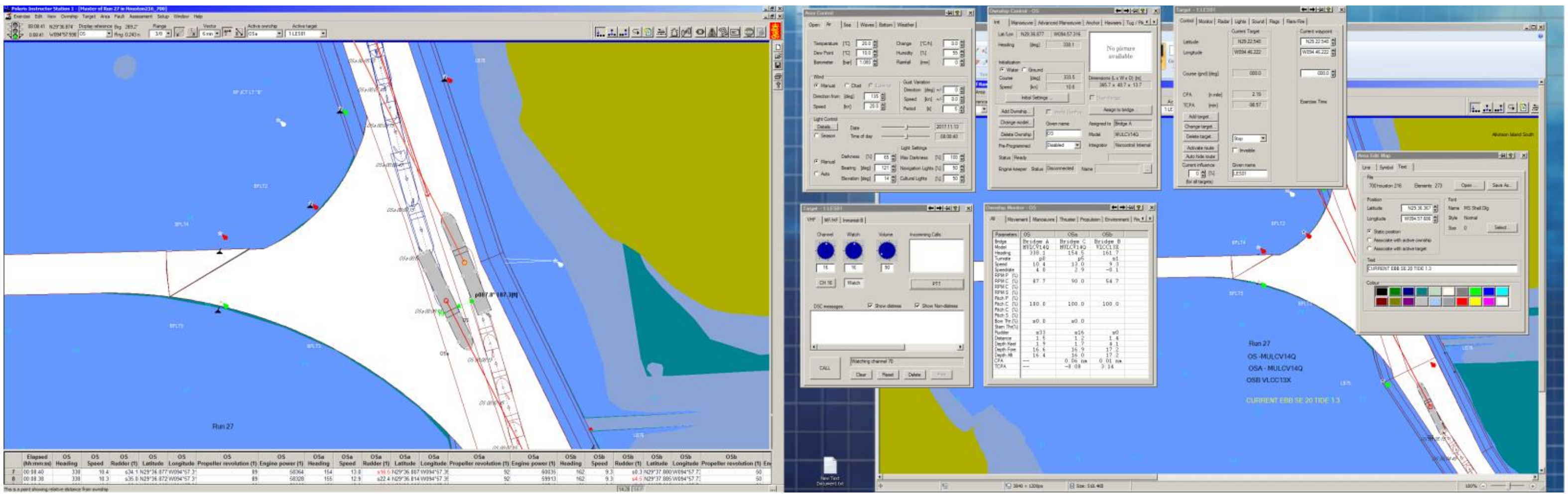
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS UKC Aft	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	OSa UKC Aft	OSb Heading	OSb Speed	OSb Rudder (1)	OSb Latitude	OSb Longitude	Prop
7	00:25:46	267	15.8	p0.0	N29°36.849	W094°58.6	94	61922	1.03	135	0.0	p0.1	N29°34.896	W094°55.9	49	11196	2.11	161	0.0	p30.3	N29°34.766	W094°55.9	
8	00:25:12	268	15.0	p4.5	N29°36.855	W094°58.4	94	61373	1.04	135	0.0	p0.2	N29°34.896	W094°55.9	49	10958	2.11	161	0.0	p30.3	N29°34.766	W094°55.9	
9	00:25:00	268	14.7	s4.5	N29°36.857	W094°58.4	93	61173	1.03	135	0.0	p0.2	N29°34.896	W094°55.9	49	10945	2.11	161	0.0	p30.3	N29°34.766	W094°55.9	
10	00:24:48	268	14.4	s2.3	N29°36.859	W094°58.3	93	60932	1.04	135	0.0	p0.3	N29°34.896	W094°55.9	49	10931	2.11	161	0.0	p30.3	N29°34.766	W094°55.9	
11	00:24:46	268	14.4	s2.7	N29°36.859	W094°58.3	93	60891	1.07	135	0.0	p0.2	N29°34.896	W094°55.9	49	11008	2.11	161	0.0	p30.3	N29°34.766	W094°55.9	

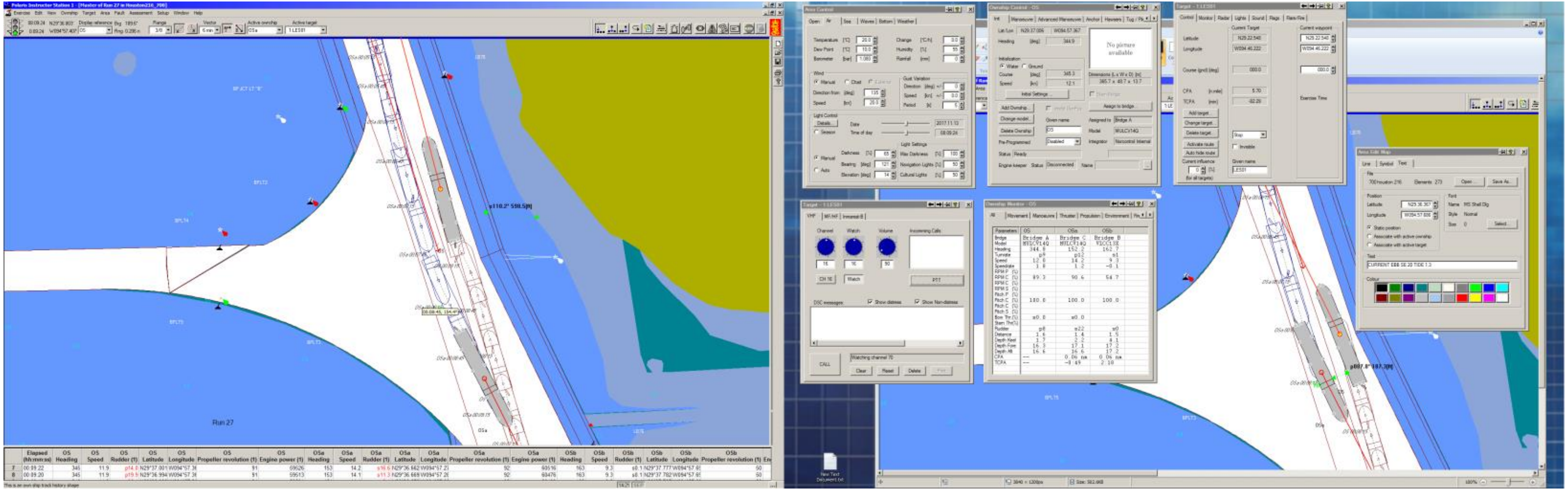


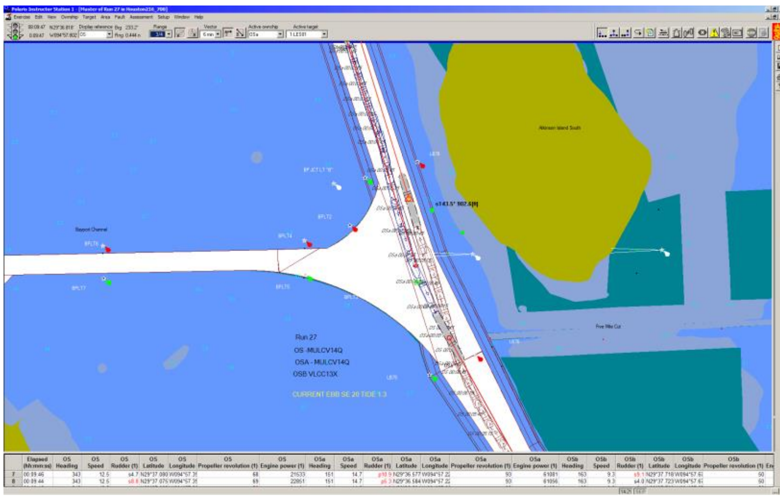
Run 27

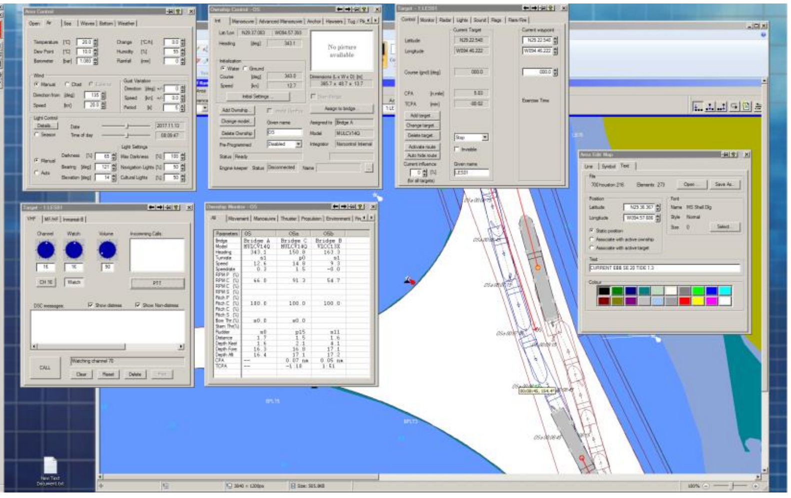

Bayport Channel
Atkinson Island South
Five Mile Cut
Run 27
OS -MULCV14Q
OSA - MULCV14Q
OSB VLCC13X
CURRENT EBB SE 20 TIDE 1.5
KONGSBERG

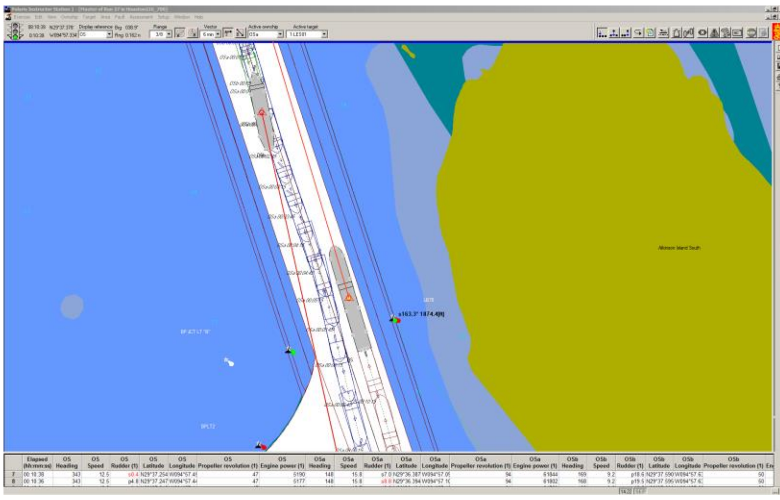

Bayport Channel
Atkinson Island South
Five Mile Cut
Run 27
OS -MULCV14Q
OSA - MULCV14Q
OSB VLCC13X
CURRENT EBB SE 20 TIDE 1.5

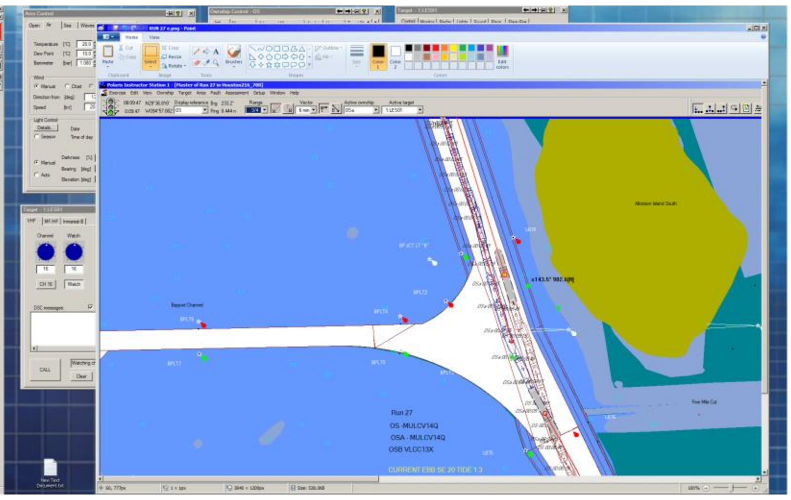

Run 27
OS -MULCV14Q
OSA - MULCV14Q
OSB VLCC13X
CURRENT EBB SE 20 TIDE 1.5

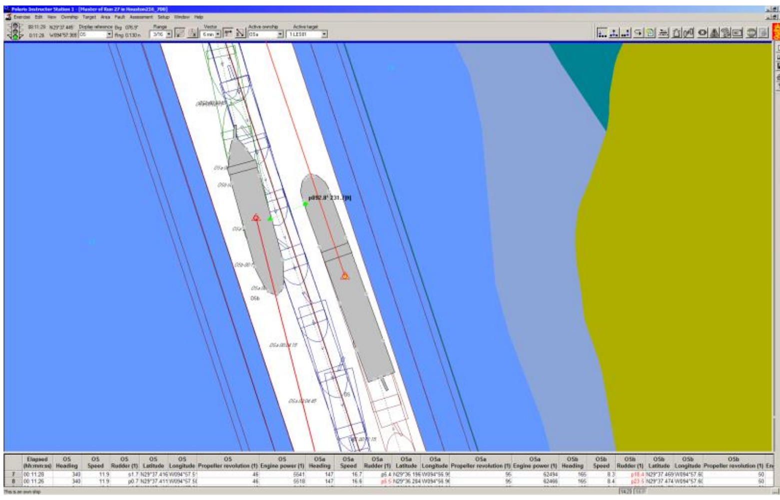

Run 27

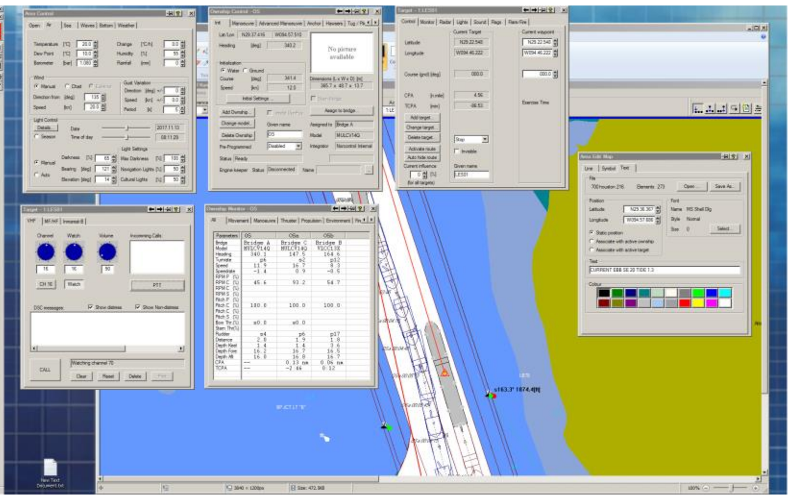

Morgans Island South
Bayport Channel
Five Mile Cut
s143.5° 902.6[ft]
Run 27
OS -MULCV14Q
OSA - MULCV14Q
OSB VLCC13X
CURRENT EBB SE 20 TIDE 1.3

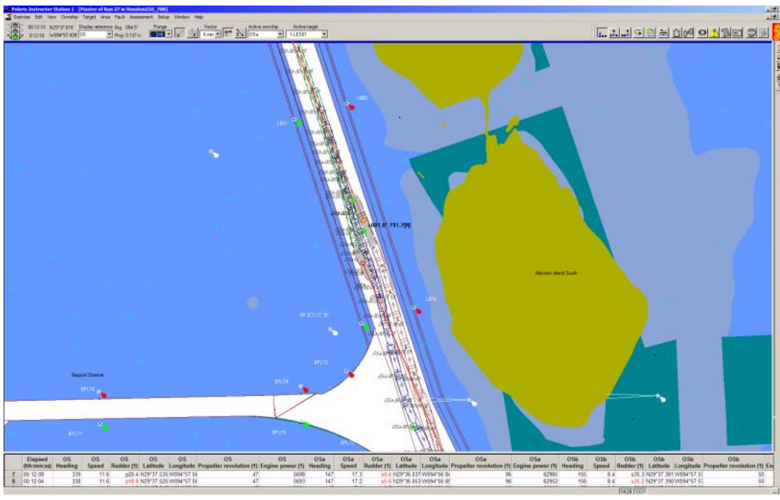


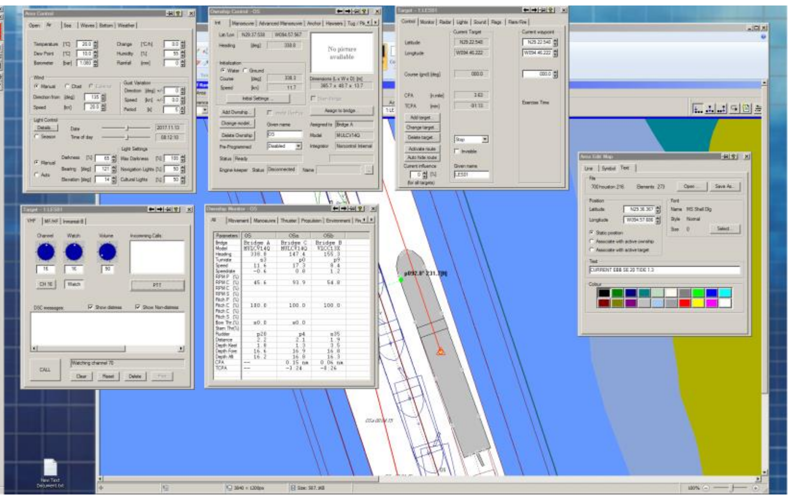

s163.3° 1674.4[ft]


Bayport Channel
Five Mile Cut
Run 27
OS -MULCV14Q
OSA - MULCV14Q
OSB VLCC13X
CURRENT EBB SE 20 TIDE 1.3

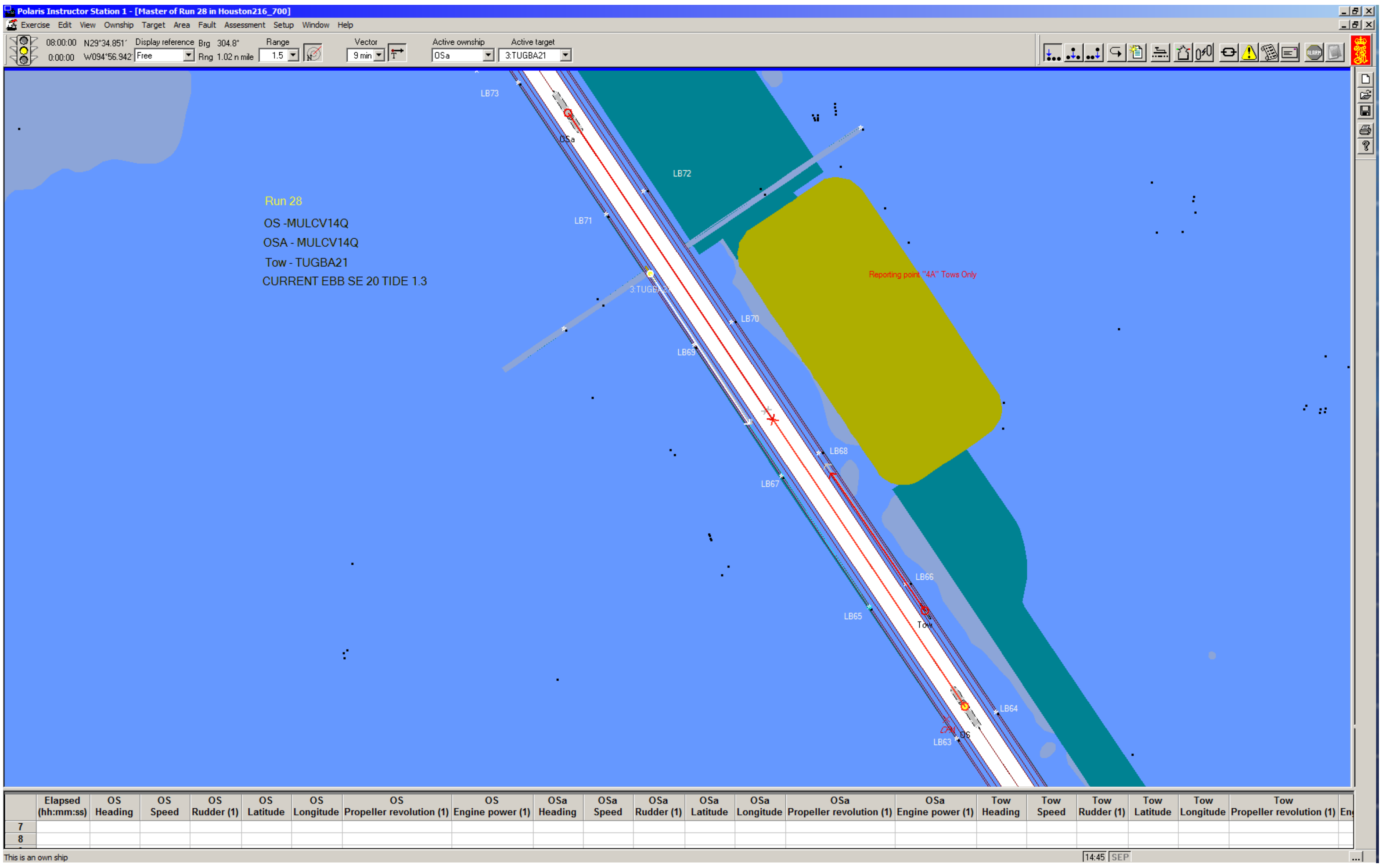





Bayport Channel



Run 28



Run 28

OS -MULCV14Q

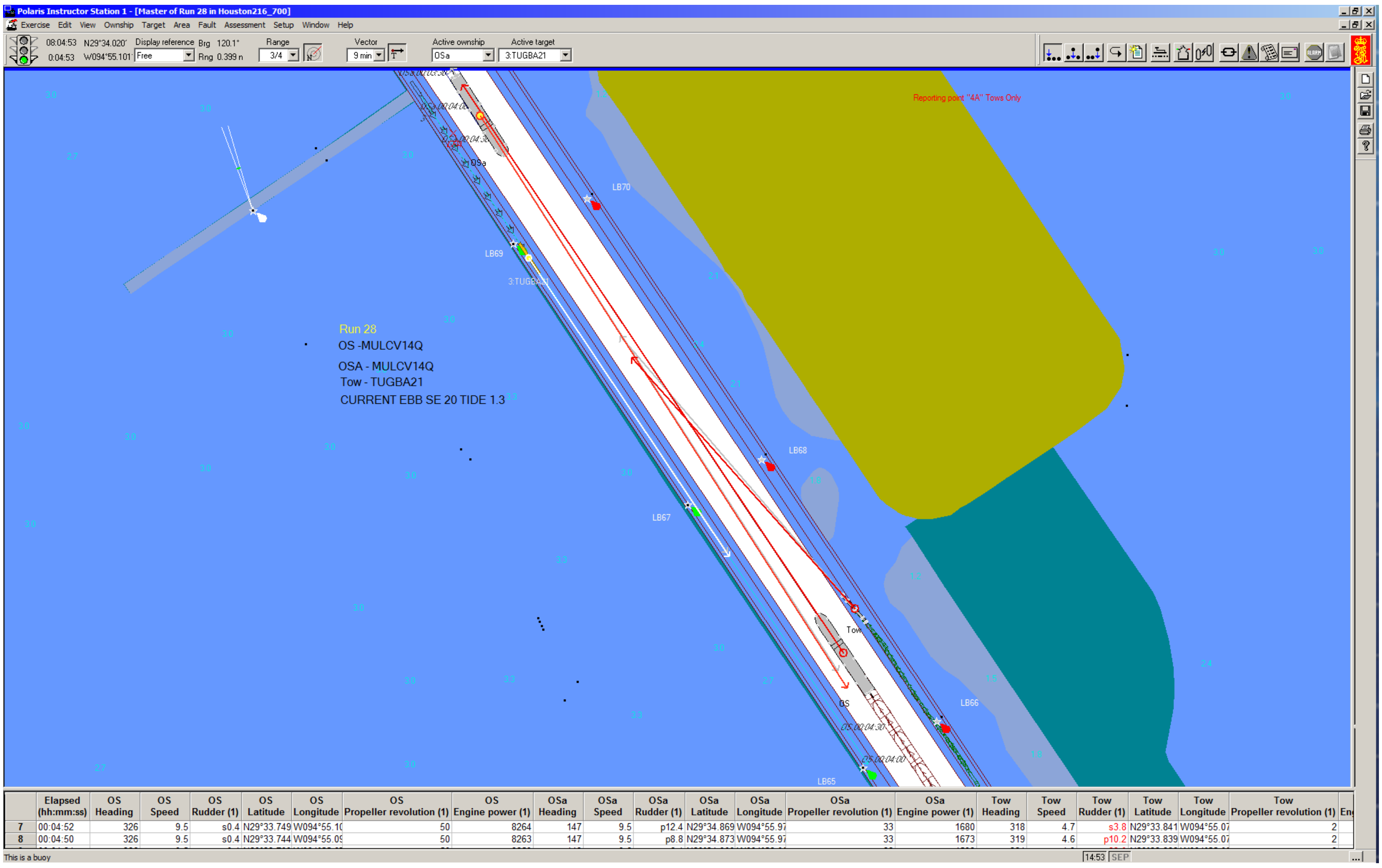
OSA - MULCV14Q

Tow - TUGBA21

CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7																						
8																						

This is an own ship



Run 28

OS -MULCV14Q

OSA - MULCV14Q

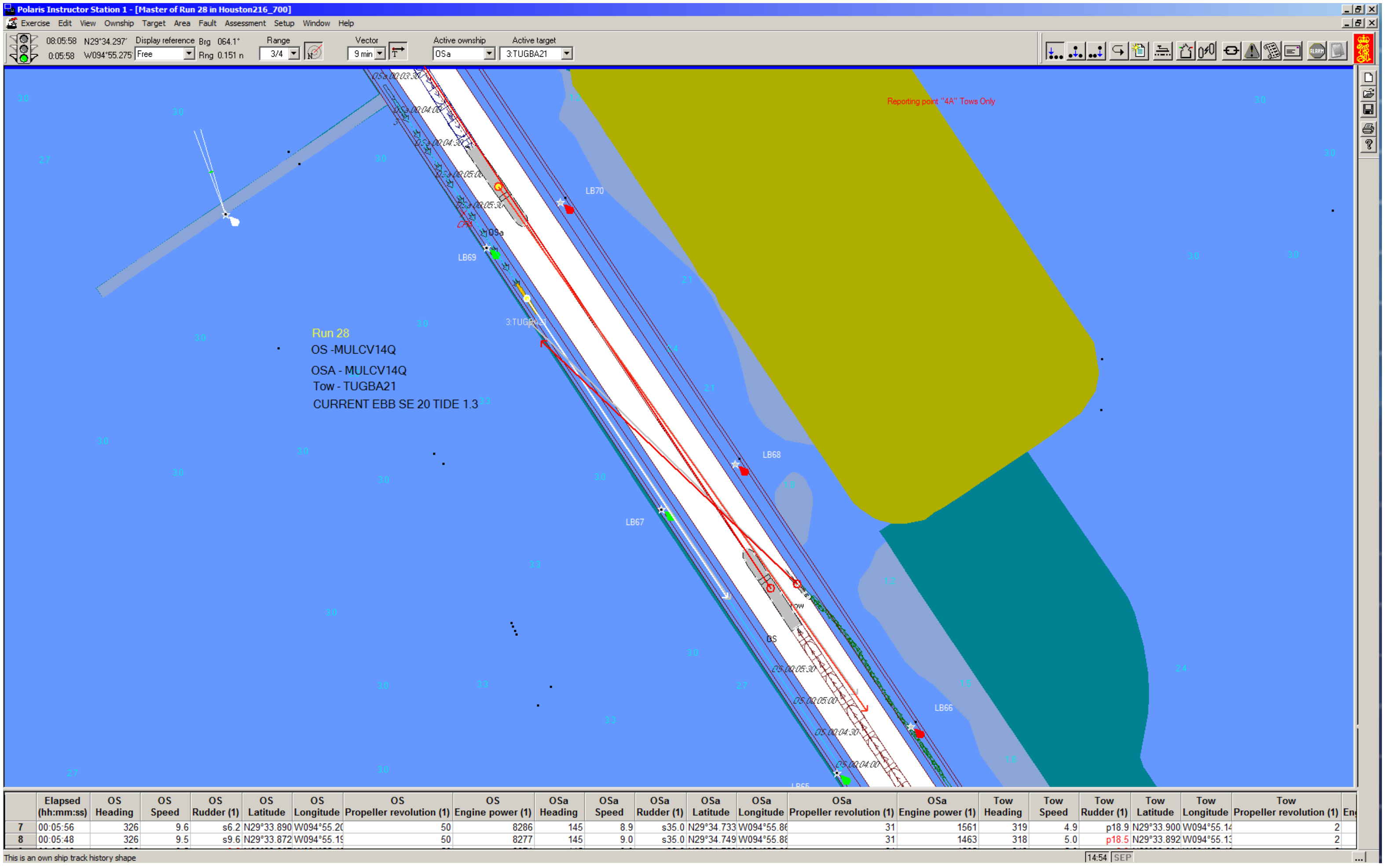
Tow - TUGBA21

CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:04:52	326	9.5	s0.4	N29°33.749	W094°55.10	50	8264	147	9.5	p12.4	N29°34.869	W094°55.97	33	1680	318	4.7	s3.8	N29°33.841	W094°55.07	2	
8	00:04:50	326	9.5	s0.4	N29°33.744	W094°55.09	50	8263	147	9.5	p8.8	N29°34.873	W094°55.97	33	1673	319	4.6	p10.2	N29°33.839	W094°55.07	2	

This is a buoy

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

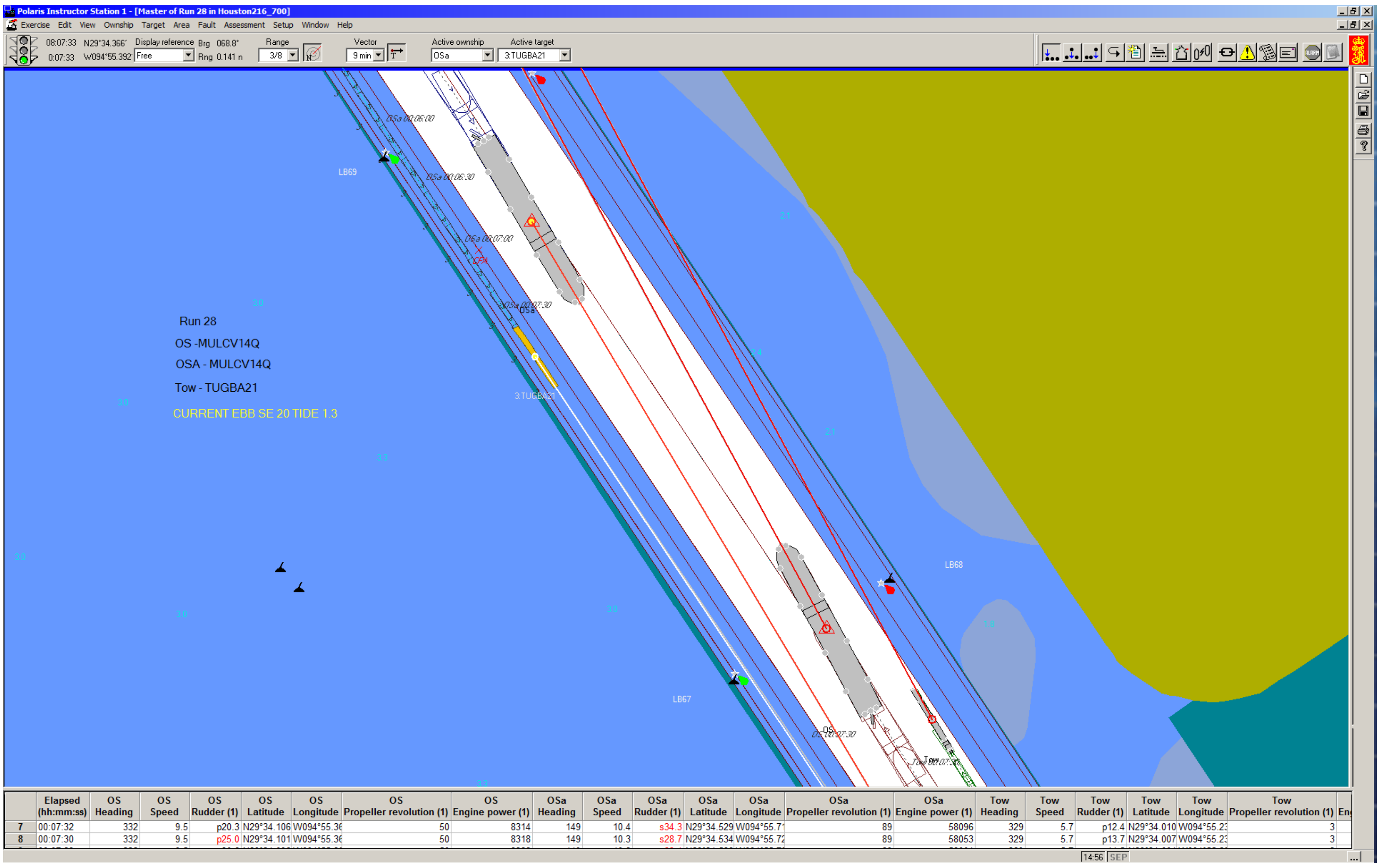
08:05:58 N29°34.297′ Display reference Free Brg 064.1° Rng 0.151 n Range 3/4 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:05:58 W094°55.275′

Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)
7	00:05:56	326	9.6	s6.2	N29°33.890	W094°55.2	50	8286	145	8.9	s35.0	N29°34.733	W094°55.8	31	1561	319	4.9	p18.9	N29°33.900	W094°55.1	2
8	00:05:48	326	9.5	s9.6	N29°33.872	W094°55.1	50	8277	145	9.0	s35.0	N29°34.749	W094°55.8	31	1463	318	5.0	p18.5	N29°33.892	W094°55.1	2

This is an own ship track history shape

14:54 SEP



Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

08:07:33 N29°34.366′ Display reference Free Brg 068.8° Rng 0.141 n Range 3/8 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:07:33 W094°55.392′

Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)
7	00:07:32	332	9.5	p20.3	N29°34.106	W094°55.3	50	8314	149	10.4	s34.3	N29°34.529	W094°55.7	89	58096	329	5.7	p12.4	N29°34.010	W094°55.2	3
8	00:07:30	332	9.5	p25.0	N29°34.101	W094°55.3	50	8318	149	10.3	s28.7	N29°34.534	W094°55.7	89	58053	329	5.7	p13.7	N29°34.007	W094°55.2	3

14:56 SEP

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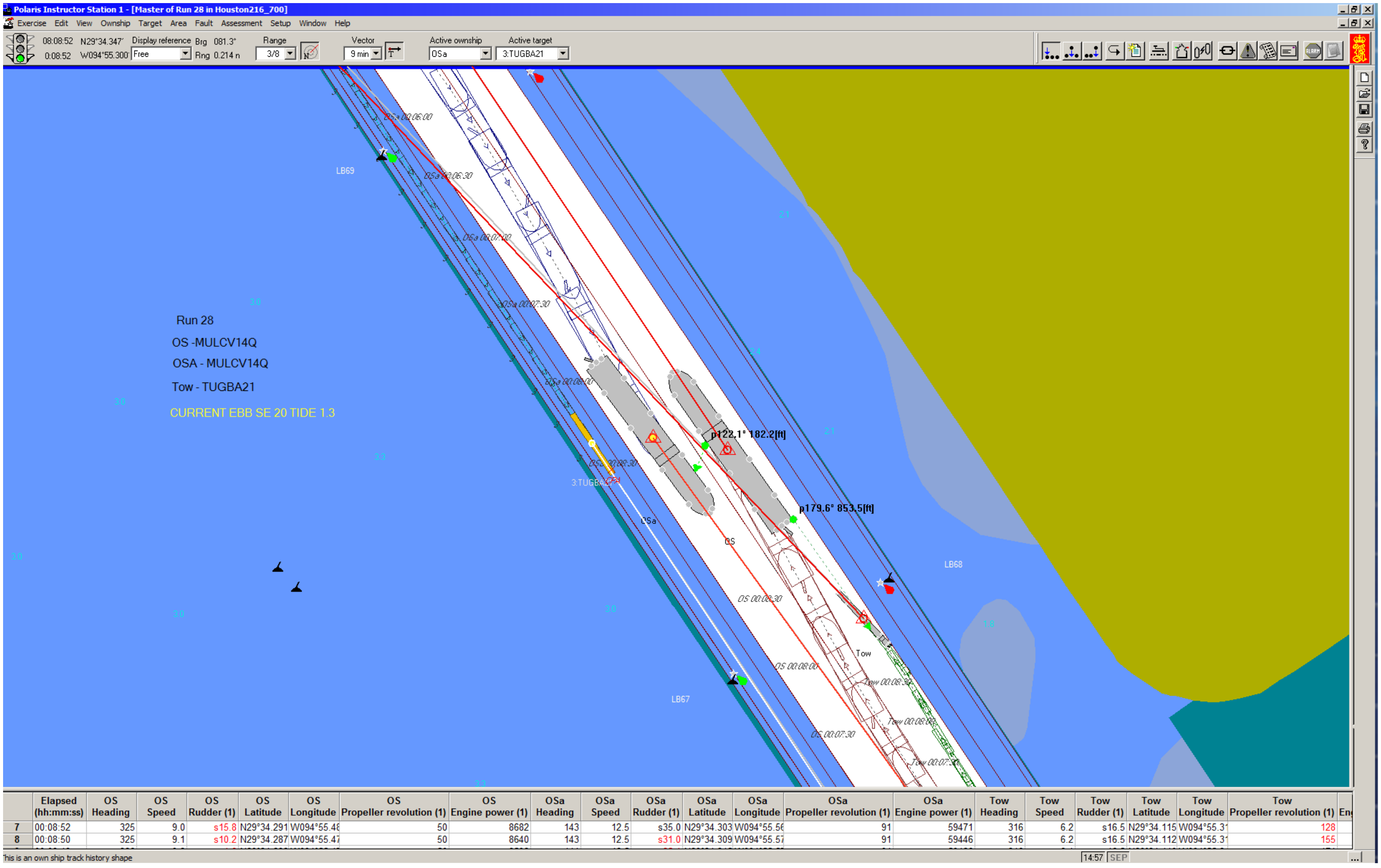


Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

08:08:52 N29°34.347′ Display reference: Free Brg 081.3° Rng 0.214 n Range 3/8 Vector 9 min Active ownship OSa Active target 3:TUGBA21

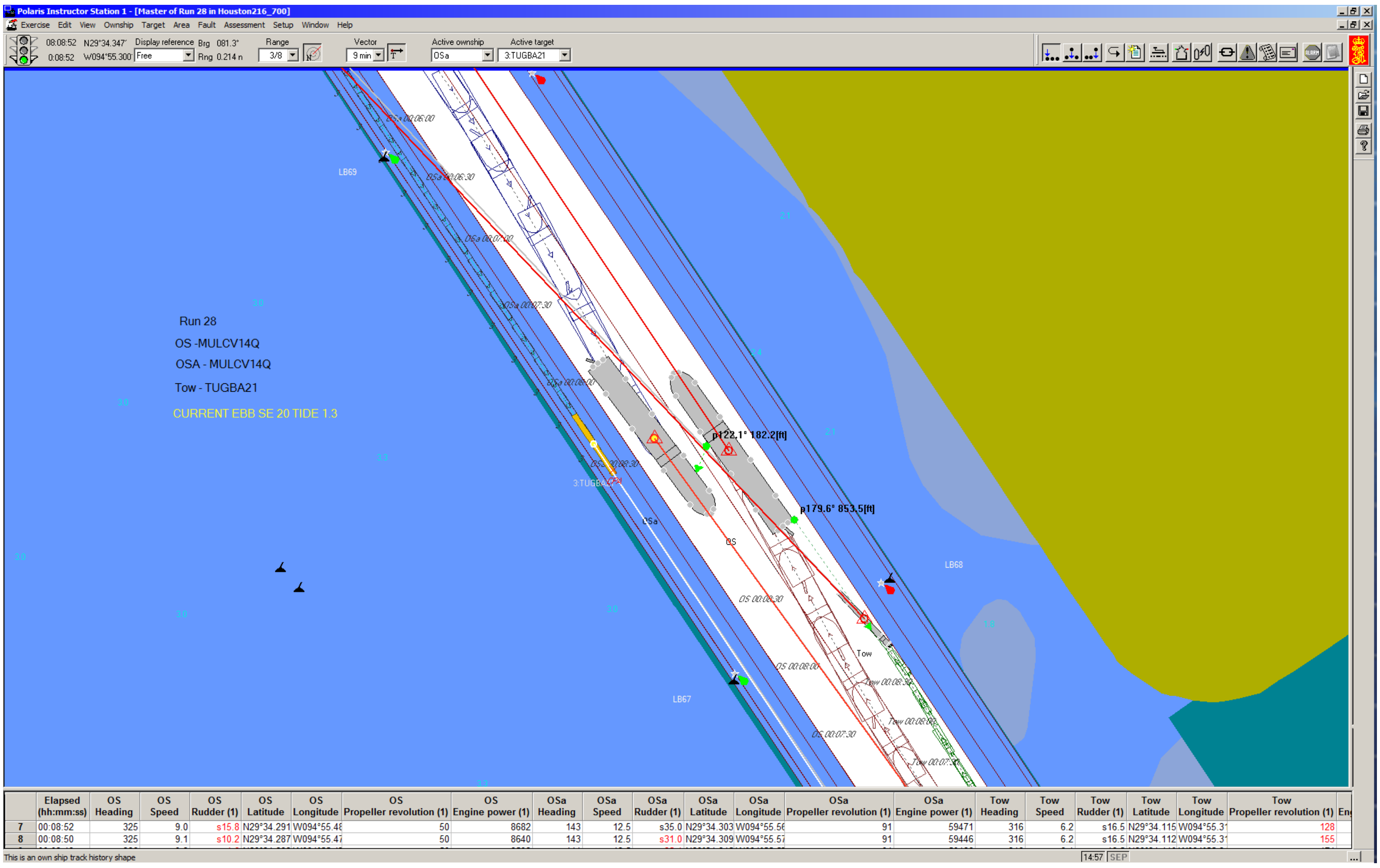
0:08:52 W094°55.300′

Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)
7	00:08:52	325	9.0	s15.8	N29°34.291	W094°55.48	50	8682	143	12.5	s35.0	N29°34.303	W094°55.56	91	59471	316	6.2	s16.5	N29°34.115	W094°55.31	128
8	00:08:50	325	9.1	s10.2	N29°34.287	W094°55.47	50	8640	143	12.5	s31.0	N29°34.309	W094°55.57	91	59446	316	6.2	s16.5	N29°34.112	W094°55.31	155

This is an own ship track history shape

14:57 SEP



Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

08:08:52 N29°34.347′ Display reference: Free Brg 081.3° Rng 0.214 n Range 3/8 Vector 9 min Active ownship OSa Active target 3:TUGBA21

0:08:52 W094°55.300′

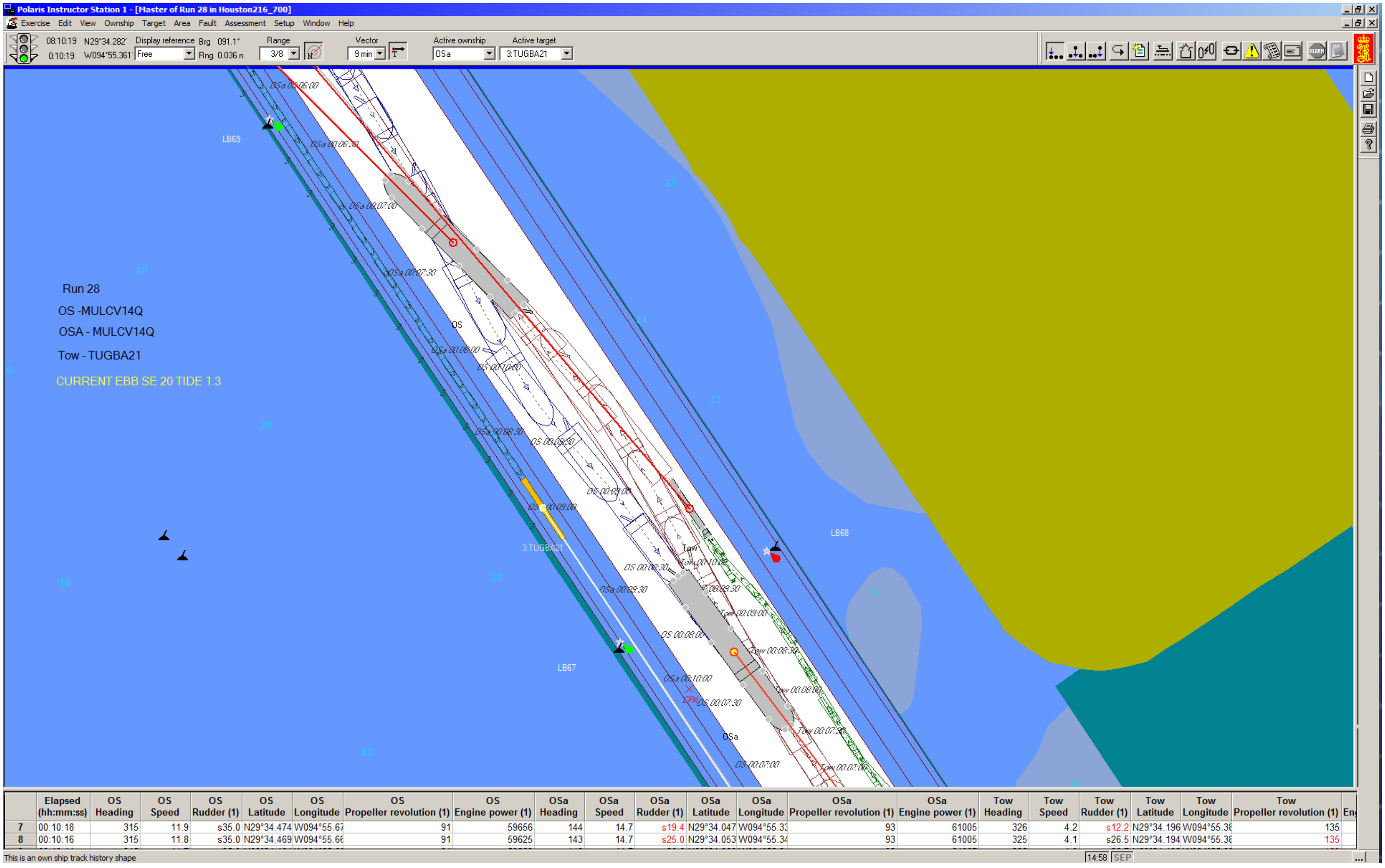
Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)
7	00:08:52	325	9.0	s15.8	N29°34.291	W094°55.48	50	8682	143	12.5	s35.0	N29°34.303	W094°55.56	91	59471	316	6.2	s16.5	N29°34.115	W094°55.31	128
8	00:08:50	325	9.1	s10.2	N29°34.287	W094°55.47	50	8640	143	12.5	s31.0	N29°34.309	W094°55.57	91	59446	316	6.2	s16.5	N29°34.112	W094°55.31	155

This is an own ship track history shape

14:57 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

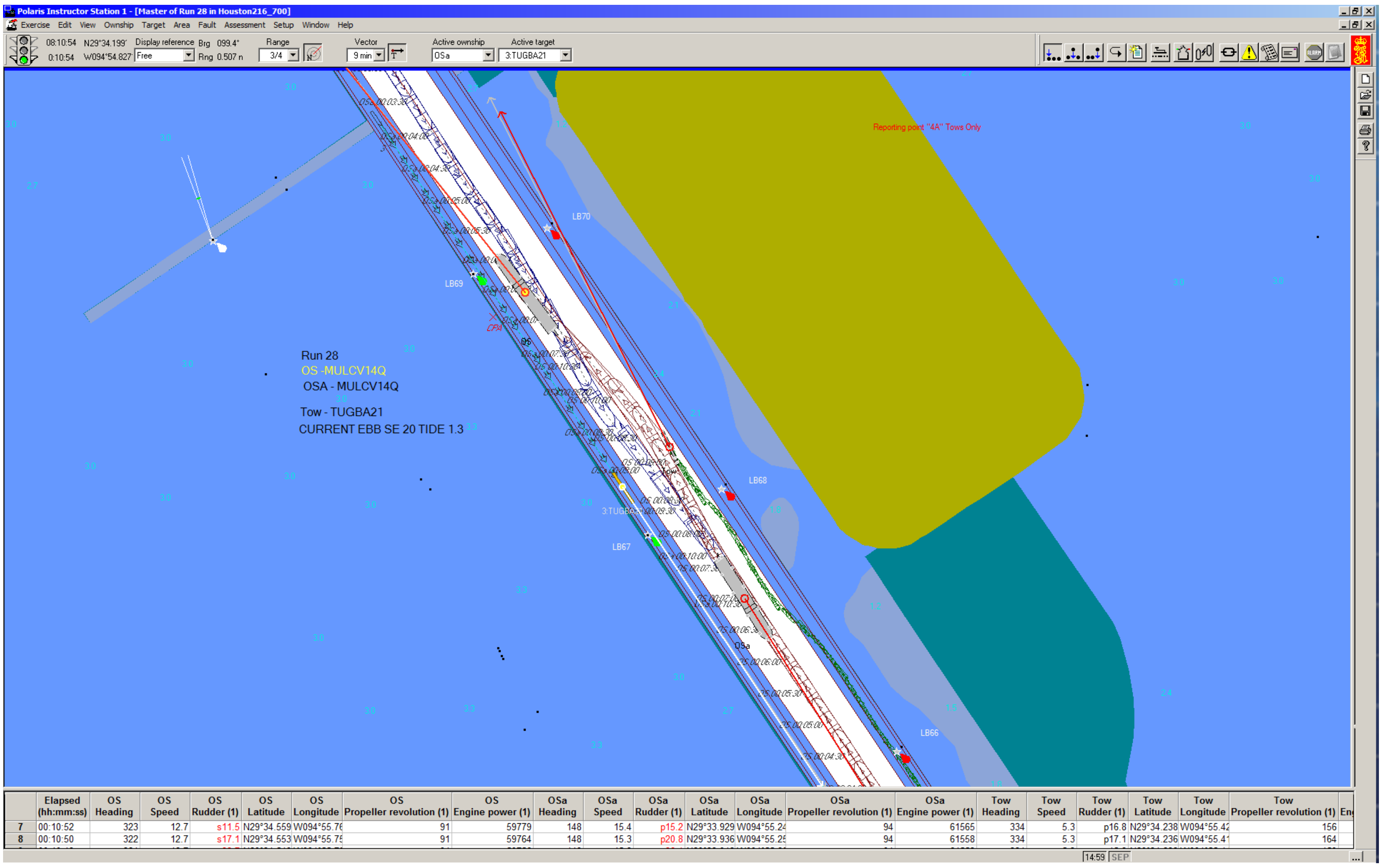
08:10:19 N29°34.282' Display reference: Free Brg 091.1° Rng 0.036 n Range 3/8 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:10:19 W094°55.361'

Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:10:18	315	11.9	s35.0	N29°34.474	W094°55.67	91	59656	144	14.7	s19.4	N29°34.047	W094°55.33	93	61005	326	4.2	s12.2	N29°34.196	W094°55.38	135	
8	00:10:16	315	11.8	s35.0	N29°34.469	W094°55.66	91	59625	143	14.7	s25.0	N29°34.053	W094°55.34	93	61005	325	4.1	s26.5	N29°34.194	W094°55.38	135	

This is an own ship track history shape

14:58 SEP



Polaris Instructor Station 1 - [Master of Run 28 in Houston216_700]

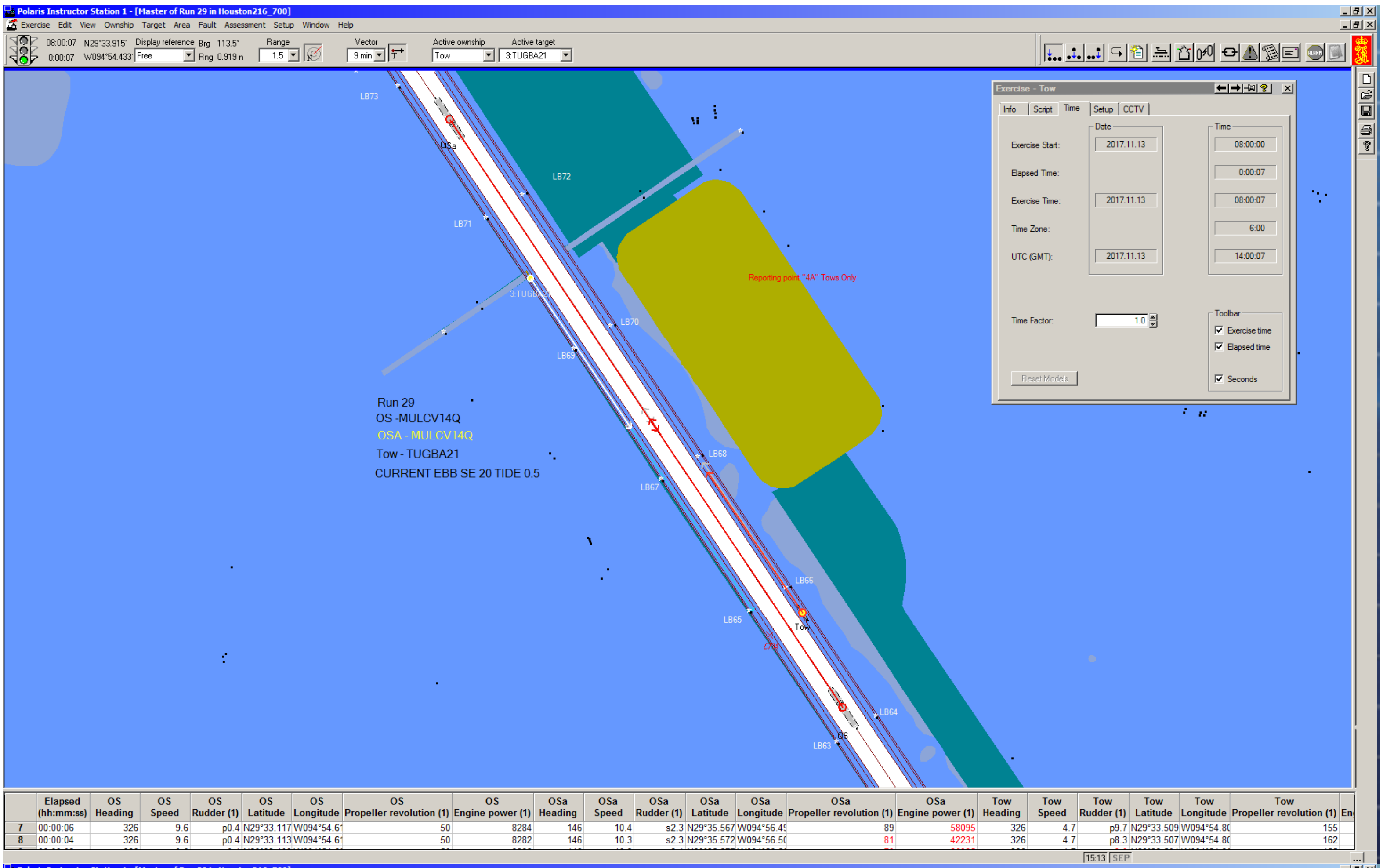
08:10:54 N29°34.199' Display reference: Free Brg 099.4° Rng 0.507 n Range 3/4 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:10:54 W094°54.827'

Run 28
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:10:52	323	12.7	s11.5	N29°34.559	W094°55.76	91	59779	148	15.4	p15.2	N29°33.929	W094°55.24	94	61565	334	5.3	p16.8	N29°34.238	W094°55.42	156	
8	00:10:50	322	12.7	s17.1	N29°34.553	W094°55.75	91	59764	148	15.3	p20.8	N29°33.936	W094°55.25	94	61558	334	5.3	p17.1	N29°34.236	W094°55.41	164	

14:59 SEP

Run 29



08:00:07 N29°33.915′ Display reference Free Brg 113.5° Rng 0.919 n Range 1.5 Vector 9 min Active ownship Tow Active target 3:TUGBA21
0:00:07 W094°54.433′

Run 29
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 0.5

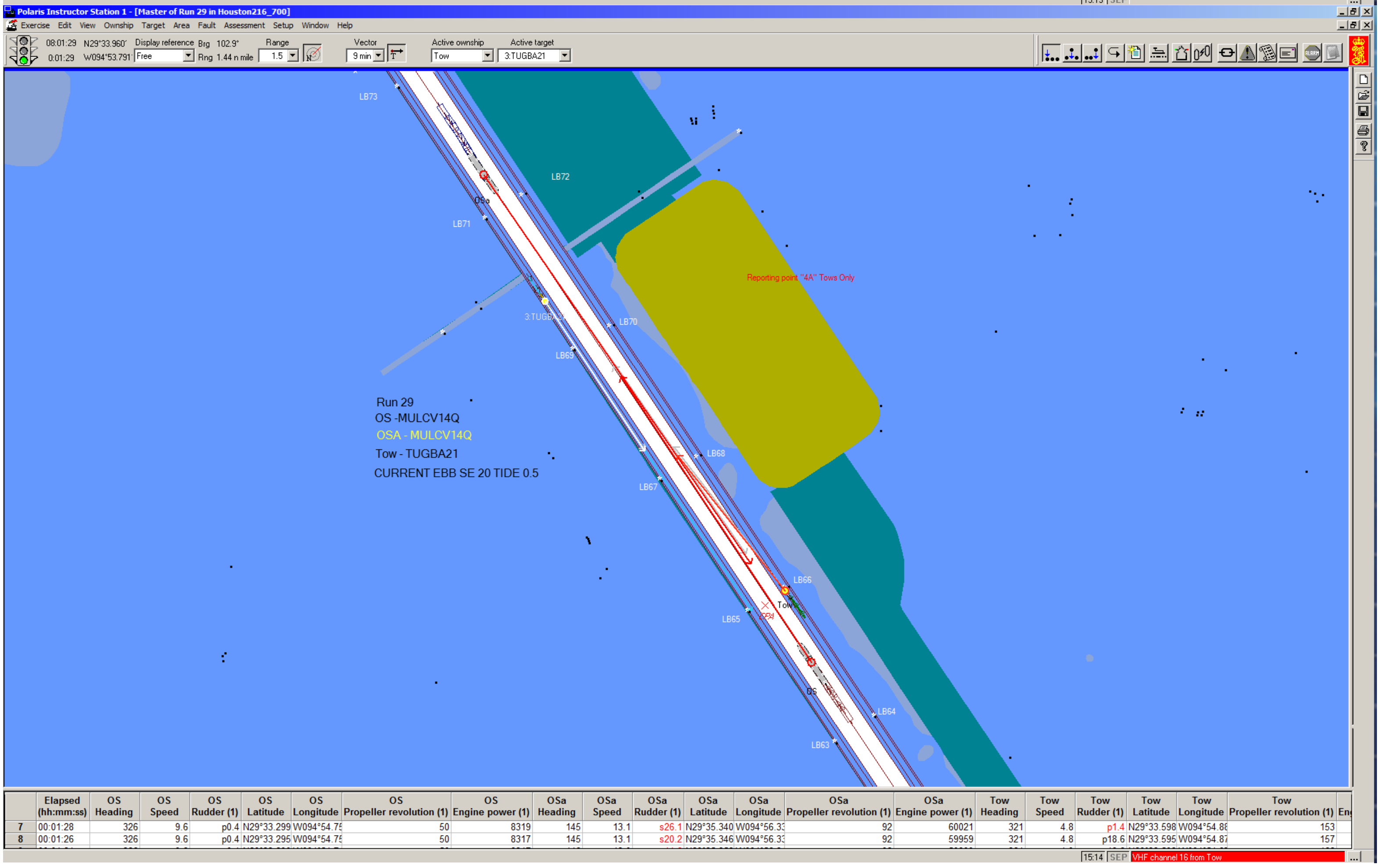
	Date	Time
Exercise Start:	2017.11.13	08:00:00
Elapsed Time:		0:00:07
Exercise Time:	2017.11.13	08:00:07
Time Zone:		6:00
UTC (GMT):	2017.11.13	14:00:07

Time Factor: 1.0

Toolbar
☑ Exercise time
☑ Elapsed time
☑ Seconds

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:00:06	326	9.6	p0.4	N29°33.117	W094°54.6	50	8284	146	10.4	s2.3	N29°35.567	W094°56.4	89	58095	326	4.7	p9.7	N29°33.509	W094°54.8	155	
8	00:00:04	326	9.6	p0.4	N29°33.113	W094°54.6	50	8282	146	10.3	s2.3	N29°35.572	W094°56.5	81	42231	326	4.7	p8.3	N29°33.507	W094°54.8	162	

15:13 SEP

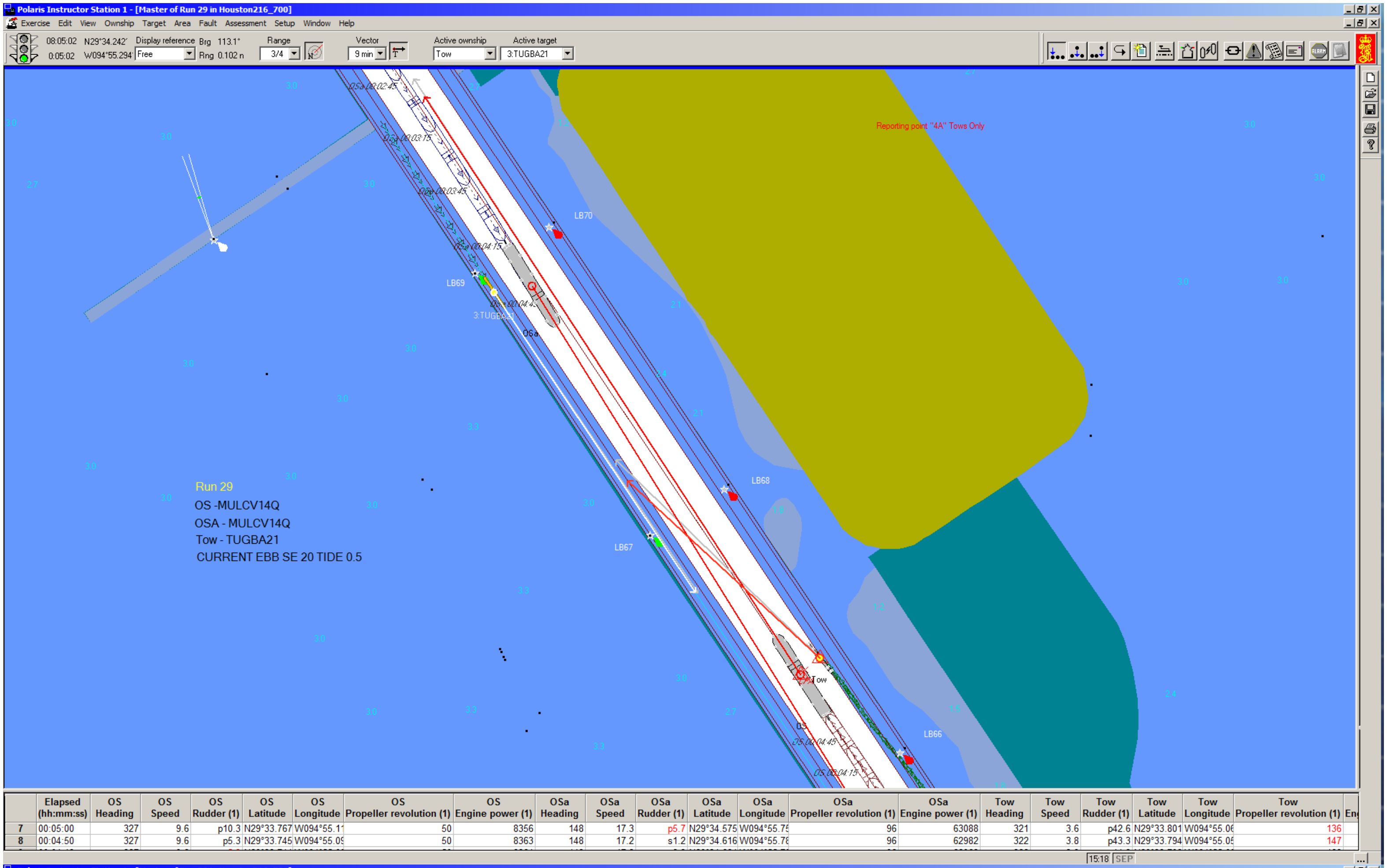


08:01:29 N29°33.960′ Display reference Free Brg 102.9° Rng 1.44 n mile Range 1.5 Vector 9 min Active ownship Tow Active target 3:TUGBA21
0:01:29 W094°53.791′

Run 29
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:01:28	326	9.6	p0.4	N29°33.299	W094°54.7	50	8319	145	13.1	s26.1	N29°35.340	W094°56.3	92	60021	321	4.8	p1.4	N29°33.598	W094°54.8	153	
8	00:01:26	326	9.6	p0.4	N29°33.295	W094°54.7	50	8317	145	13.1	s20.2	N29°35.346	W094°56.3	92	59959	321	4.8	p18.6	N29°33.595	W094°54.8	157	

15:14 SEP VHF channel 16 from Tow



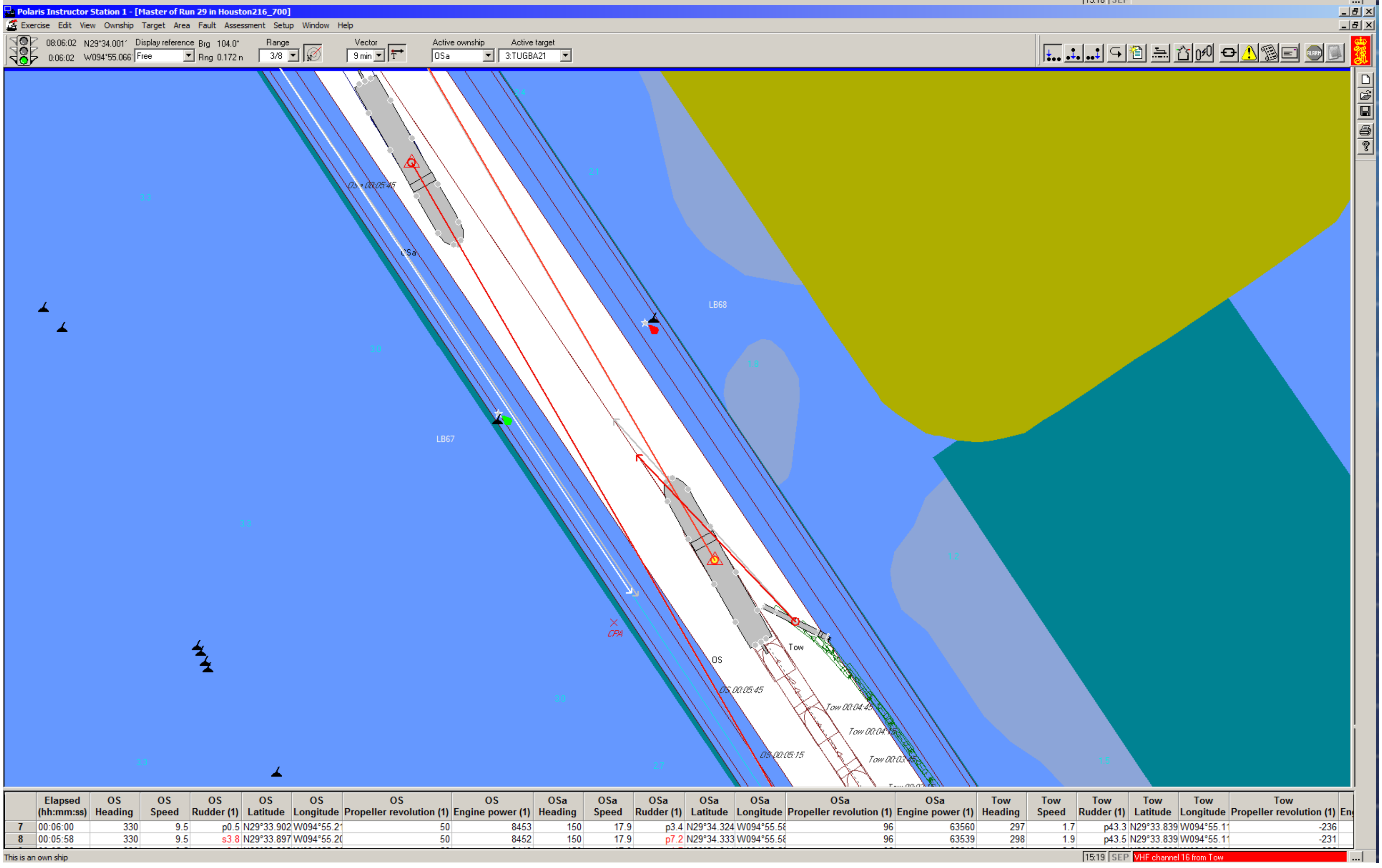
Polaris Instructor Station 1 - [Master of Run 29 in Houston216_700]

08:05:02 N29°34.242′
0:05:02 W094°55.294′
Display reference: Free
Brg 113.1°
Rng 0.102 n
Range: 3/4
Vector: 9 min
Active ownship: Tow
Active target: 3:TUGBA21

Run 29
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	Eng
7	00:05:00	327	9.6	p10.3	N29°33.767	W094°55.1	50	8356	148	17.3	p5.7	N29°34.575	W094°55.75	96	63088	321	3.6	p42.6	N29°33.801	W094°55.06	136	
8	00:04:50	327	9.6	p5.3	N29°33.745	W094°55.09	50	8363	148	17.2	s1.2	N29°34.616	W094°55.78	96	62982	322	3.8	p43.3	N29°33.794	W094°55.05	147	

15:18 SEP



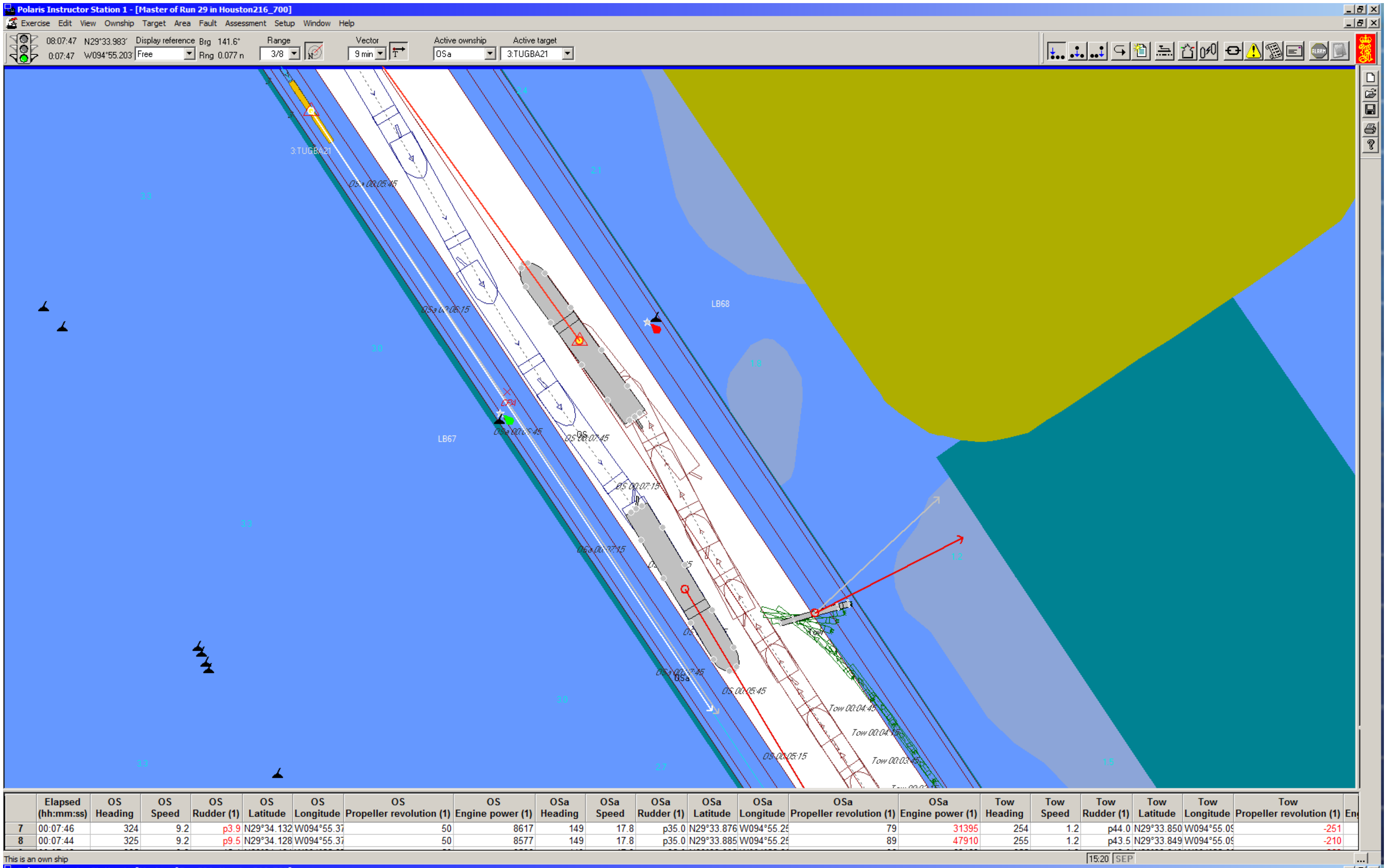
Polaris Instructor Station 1 - [Master of Run 29 in Houston216_700]

08:06:02 N29°34.001′
0:06:02 W094°55.066′
Display reference: Free
Brg 104.0°
Rng 0.172 n
Range: 3/8
Vector: 9 min
Active ownship: OSa
Active target: 3:TUGBA21

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	Eng
7	00:06:00	330	9.5	p0.5	N29°33.902	W094°55.2	50	8453	150	17.9	p3.4	N29°34.324	W094°55.58	96	63560	297	1.7	p43.3	N29°33.839	W094°55.1	-236	
8	00:05:58	330	9.5	s3.8	N29°33.897	W094°55.20	50	8452	150	17.9	p7.2	N29°34.333	W094°55.58	96	63539	298	1.9	p43.5	N29°33.839	W094°55.1	-231	

This is an own ship

15:19 SEP VHF channel 16 from Tow

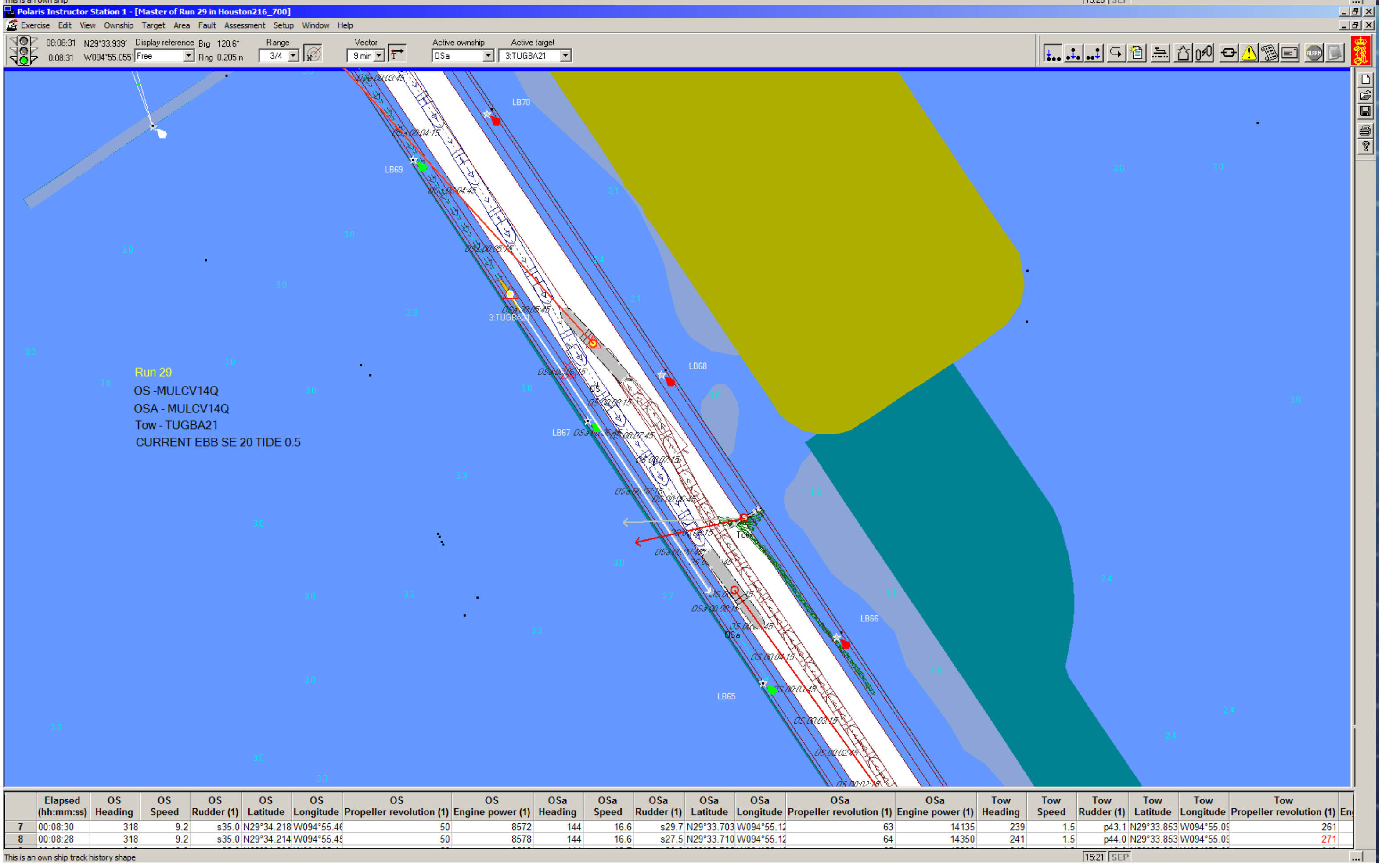


08:07:47 N29°33.983' Display reference Free Brg 141.6° Rng 0.077 n Range 3/8 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:07:47 W094°55.203'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:07:46	324	9.2	p3.9	N29°34.132	W094°55.37	50	8617	149	17.8	p35.0	N29°33.876	W094°55.25	79	31395	254	1.2	p44.0	N29°33.850	W094°55.09	-251	
8	00:07:44	325	9.2	p9.5	N29°34.128	W094°55.37	50	8577	149	17.8	p35.0	N29°33.885	W094°55.25	89	47910	255	1.2	p43.5	N29°33.849	W094°55.09	-210	

This is an own ship

15:20 SEP



08:08:31 N29°33.939' Display reference Free Brg 120.6° Rng 0.205 n Range 3/4 Vector 9 min Active ownship OSa Active target 3:TUGBA21
0:08:31 W094°55.055'

Run 29
OS -MULCV14Q
OSA - MULCV14Q
Tow - TUGBA21
CURRENT EBB SE 20 TIDE 0.5

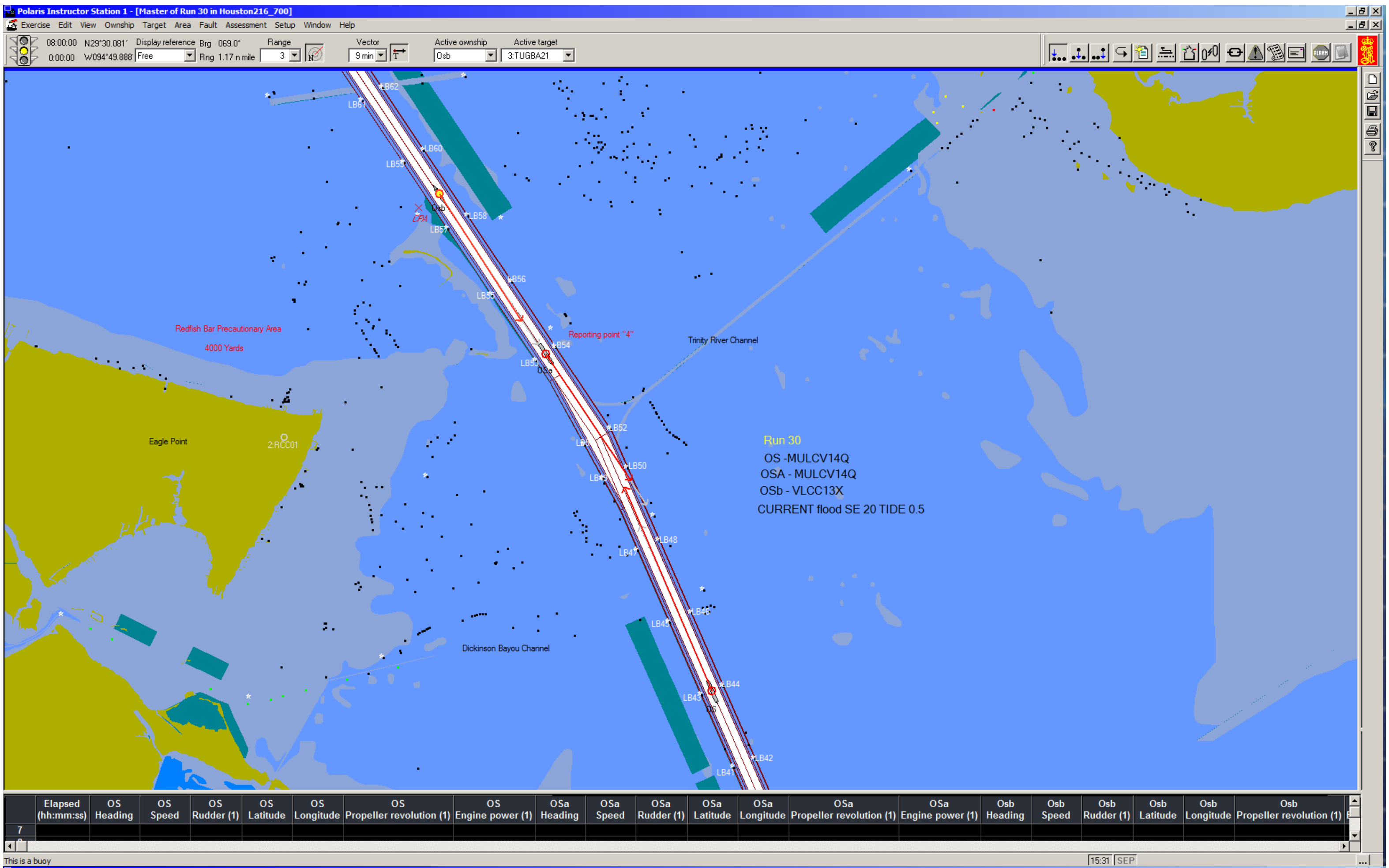
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Tow Heading	Tow Speed	Tow Rudder (1)	Tow Latitude	Tow Longitude	Tow Propeller revolution (1)	En
7	00:08:30	318	9.2	s35.0	N29°34.218	W094°55.46	50	8572	144	16.6	s29.7	N29°33.703	W094°55.12	63	14135	239	1.5	p43.1	N29°33.853	W094°55.09	261	
8	00:08:28	318	9.2	s35.0	N29°34.214	W094°55.45	50	8578	144	16.6	s27.5	N29°33.710	W094°55.12	64	14350	241	1.5	p44.0	N29°33.853	W094°55.09	271	

This is an own ship track history shape

15:21 SEP

June 26, 2019

Run 30



Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

08:00:00 N29°30.081' Display reference Brg 069.0° Range 3 Vector 9 min Active ownship Osb Active target 3:TUGBA21
0:00:00 W094°49.888 Free Rng 1.17 n mile

Run 30
OS -MULCV14Q
OSA - MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7																					

This is a buoy 15:31 SEP

Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

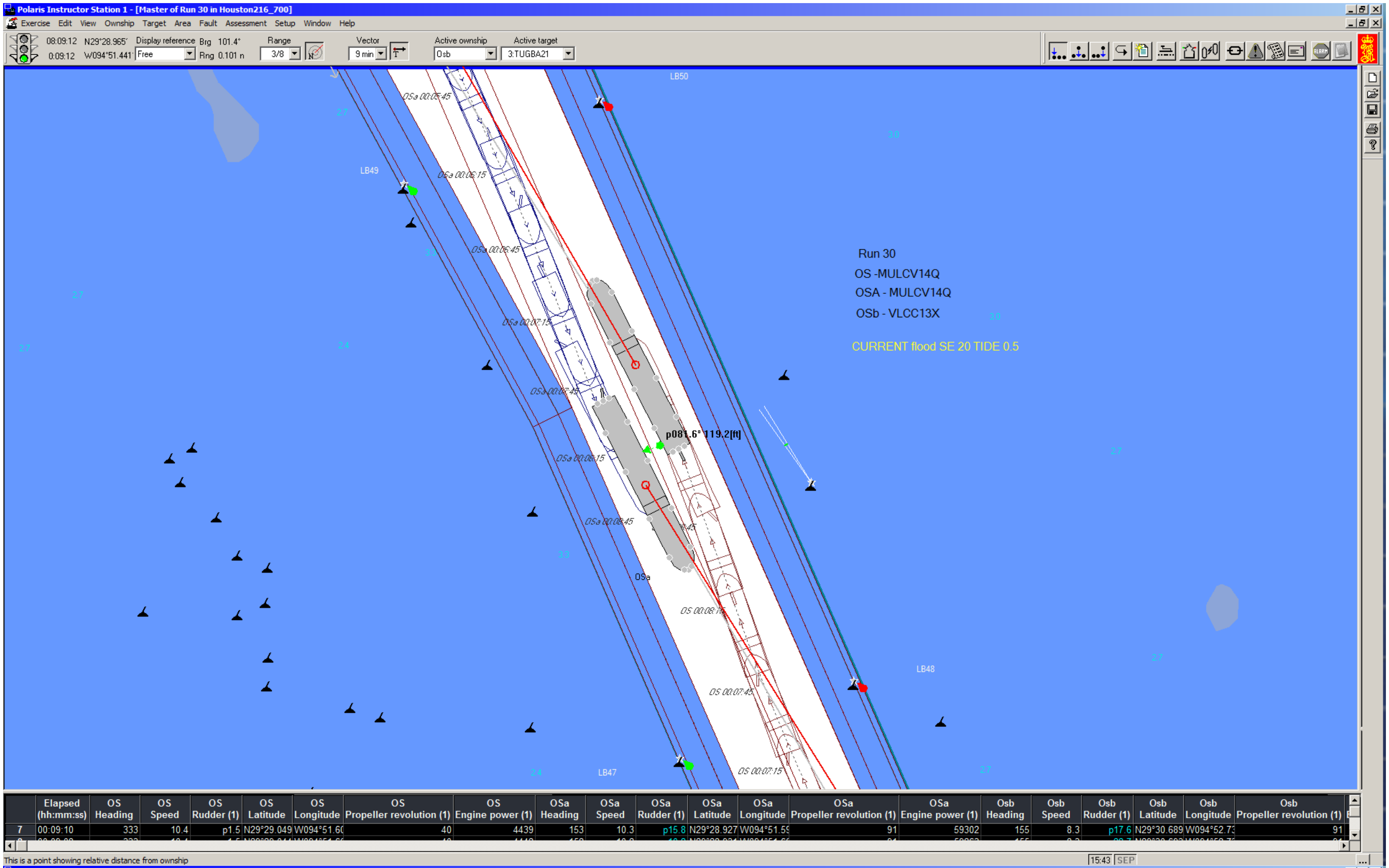
08:05:45 N29°29.007' Display reference Brg 076.0° Range 3/4 Vector 9 min Active ownship Osb Active target 3:TUGBA21
0:05:45 W094°50.897 Free Rng 0.497 n

Run 30
OS -MULCV14Q
OSA - MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:05:44	336	10.8	s0.1	N29°28.490	W094°51.34	40	4215	156	11.0	p8.6	N29°29.429	W094°51.86	37	1554	143	6.8	s4.8	N29°31.018	W094°53.0	39

15:40 SEP

- Page 350



Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

08:09:12 N29°28.965' Display reference Free Brg 101.4° Rng 0.101 n Range 3/8 Vector 9 min Active ownship Osb Active target 3:TUGBA21
0:09:12 W094°51.441'

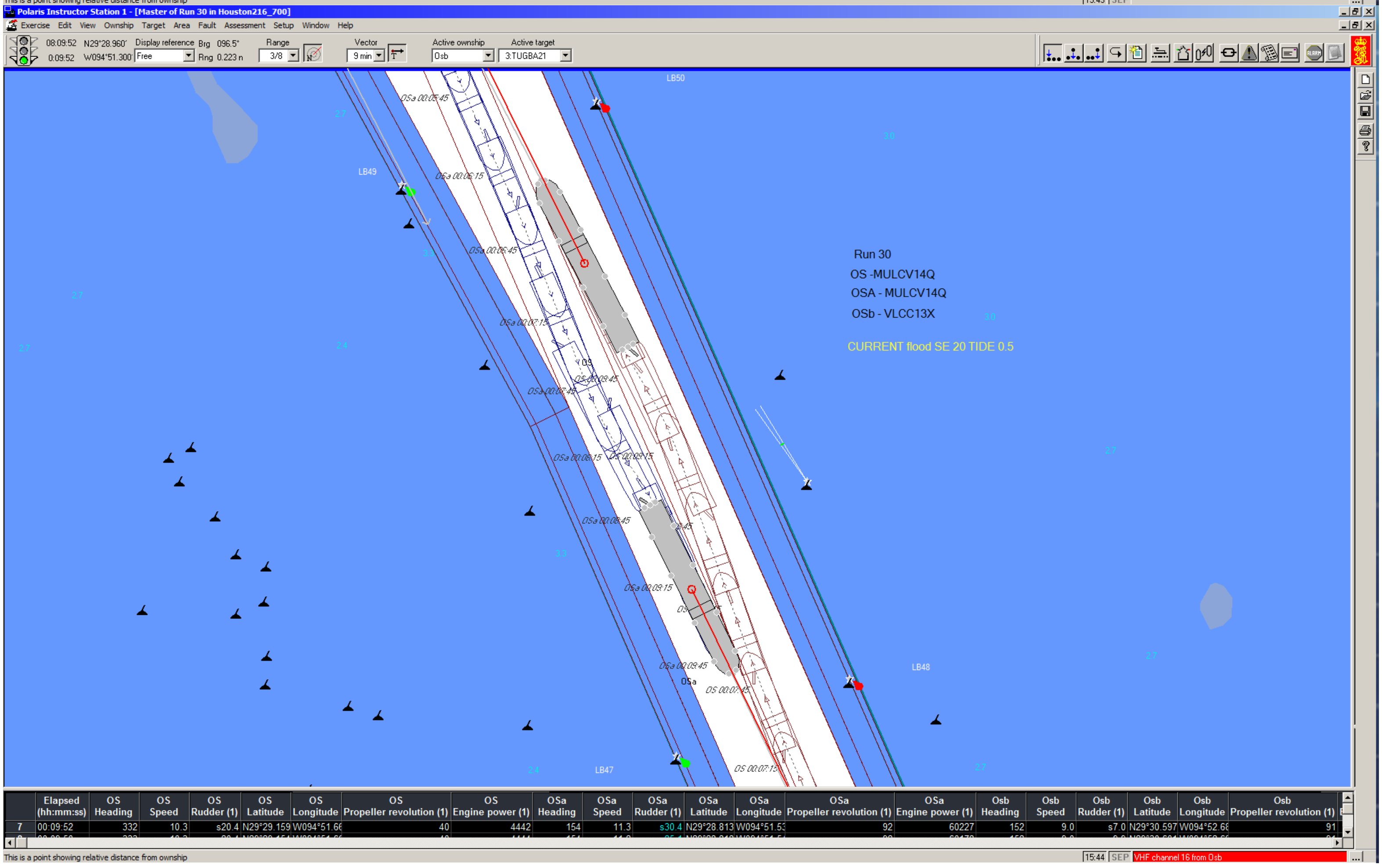
Run 30
OS -MULCV14Q
OSA - MULCV14Q
OSb - VLCC13X

CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:09:10	333	10.4	p1.5	N29°29.049	W094°51.60	40	4439	153	10.3	p15.8	N29°28.927	W094°51.59	91	59302	155	8.3	p17.6	N29°30.689	W094°52.73	91

This is a point showing relative distance from ownship

15:43 SEP



Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

08:09:52 N29°28.960' Display reference Free Brg 096.5° Rng 0.223 n Range 3/8 Vector 9 min Active ownship Osb Active target 3:TUGBA21
0:09:52 W094°51.300'

Run 30
OS -MULCV14Q
OSA - MULCV14Q
OSb - VLCC13X

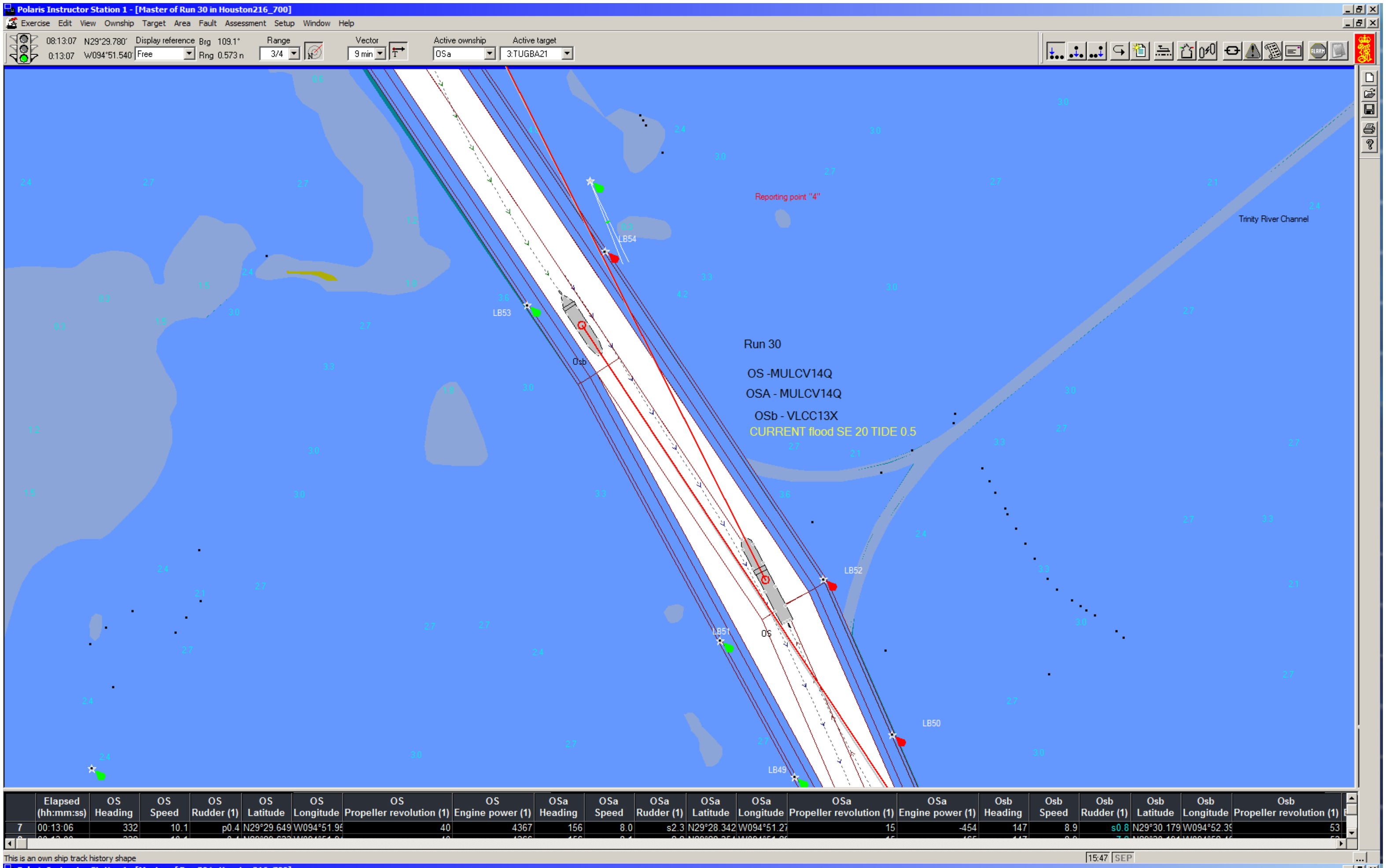
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:09:52	332	10.3	s20.4	N29°29.159	W094°51.66	40	4442	154	11.3	s30.4	N29°28.813	W094°51.53	92	60227	152	9.0	s7.0	N29°30.597	W094°52.68	91

This is a point showing relative distance from ownship

15:44 SEP VHF channel 16 from Osb

June 26, 2019

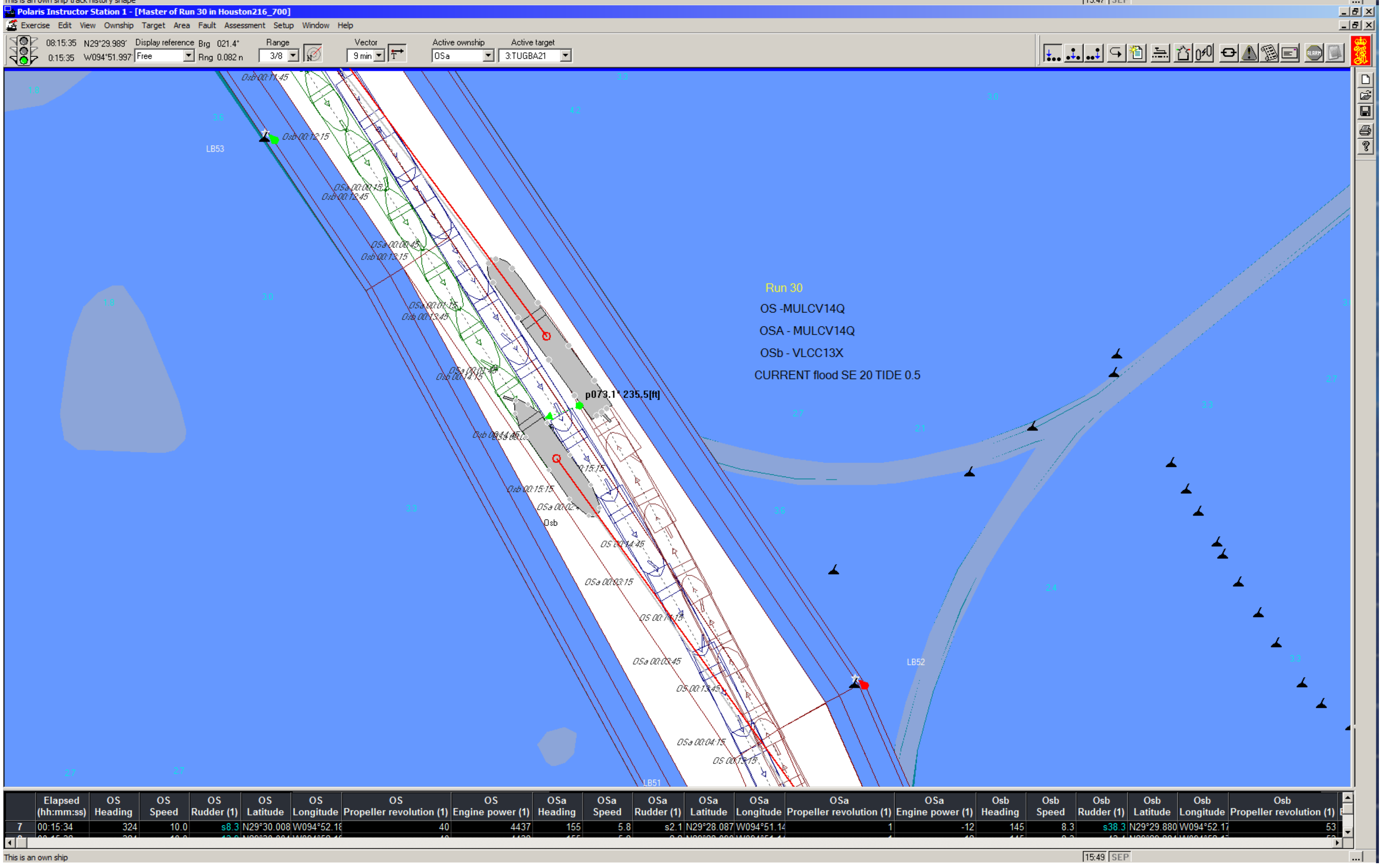

Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

08:13:07 N29°29.780' Display reference Brg 109.1°
0:13:07 W094°51.540' Free Rng 0.573 n
Range 3/4
Vector 9 min
Active ownship OSa
Active target 3:TUGBA21

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:13:06	332	10.1	p0.4	N29°29.649	W094°51.95	40	4367	156	8.0	s2.3	N29°28.342	W094°51.27	15	-454	147	8.9	s0.8	N29°30.179	W094°52.39	53

This is an own ship track history shape

15:47 SEP

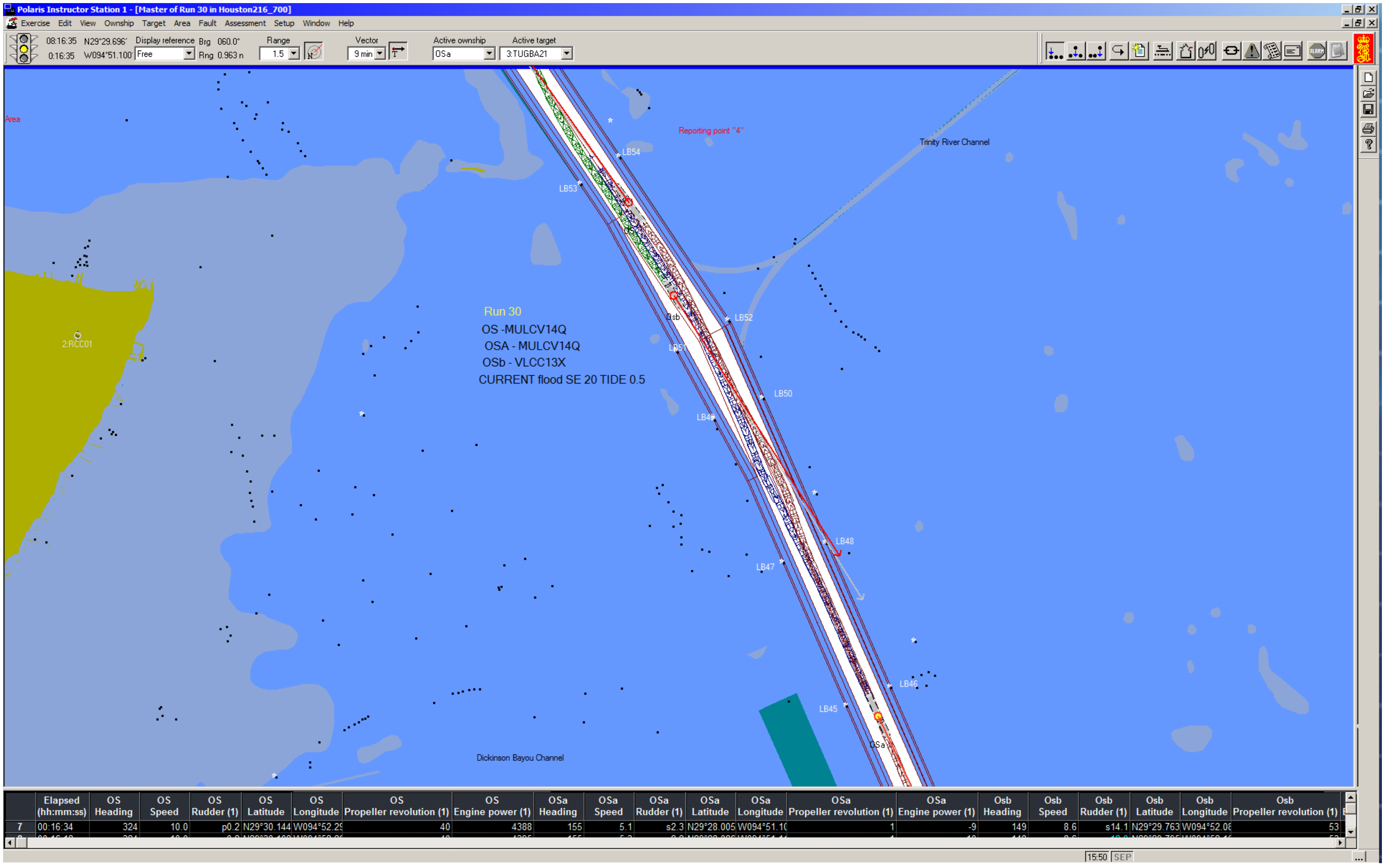

Polaris Instructor Station 1 - [Master of Run 30 in Houston216_700]

08:15:35 N29°29.989' Display reference Brg 021.4°
0:15:35 W094°51.997' Free Rng 0.082 n
Range 3/8
Vector 9 min
Active ownship OSa
Active target 3:TUGBA21

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:15:34	324	10.0	s8.3	N29°30.008	W094°52.18	40	4437	155	5.8	s2.1	N29°28.087	W094°51.14	1	-12	145	8.3	s38.3	N29°29.880	W094°52.17	53

This is an own ship

15:49 SEP

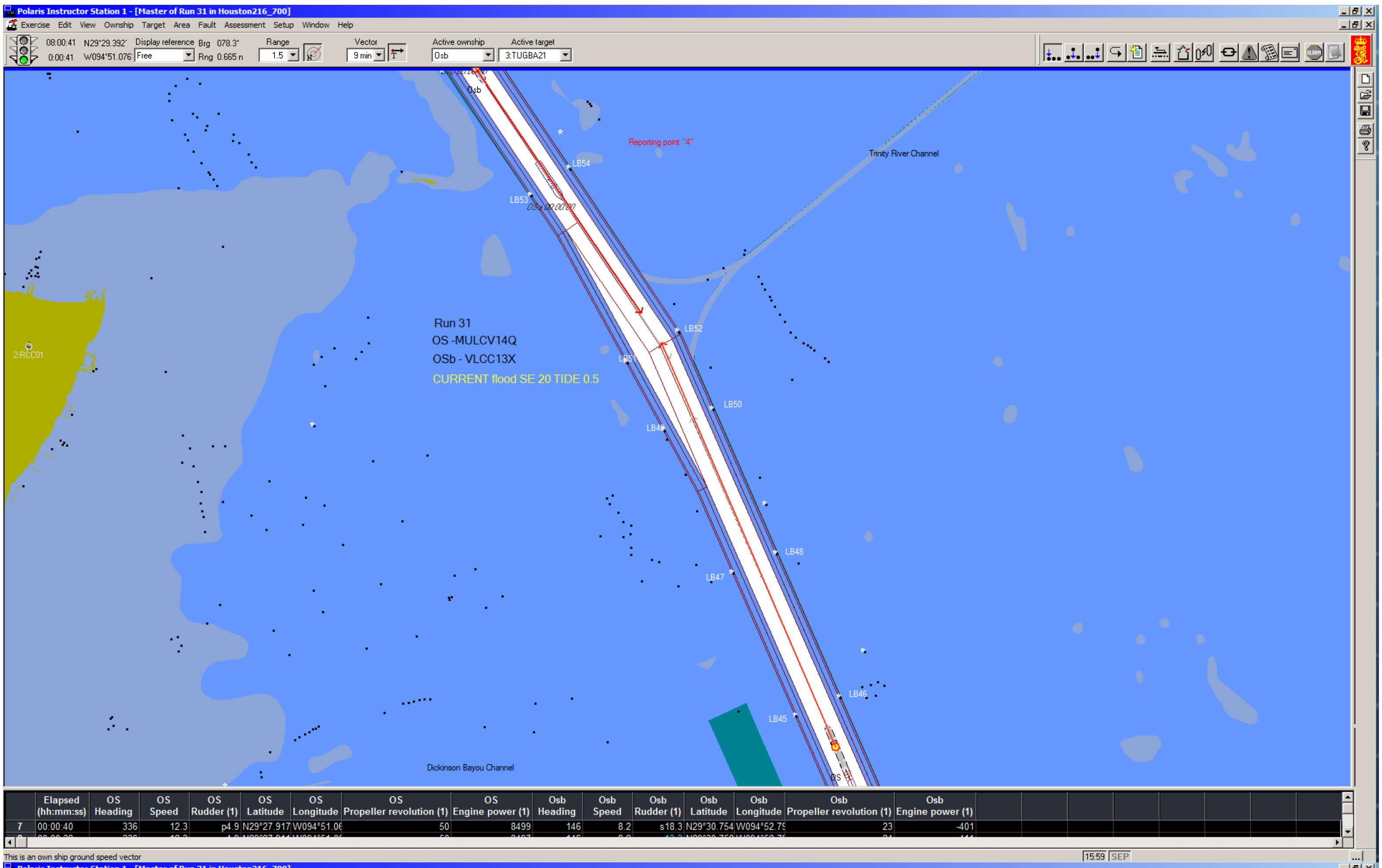


08:16:35 N29°29.696'
0:16:35 W094°51.100'
Display reference: Free
Brg 060.0°
Rng 0.963 n
Range: 1.5
Vector: 9 min
Active ownship: OSa
Active target: 3:TUGBA21

Run 30
OS -MULCV14Q
OSA - MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OSa Heading	OSa Speed	OSa Rudder (1)	OSa Latitude	OSa Longitude	OSa Propeller revolution (1)	OSa Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)
7	00:16:34	324	10.0	p0.2	N29°30.144	W094°52.29	40	4388	155	5.1	s2.3	N29°28.005	W094°51.10	1	-9	149	8.6	s14.1	N29°29.763	W094°52.08	53

Run 31



Polaris Instructor Station 1 - [Master of Run 31 in Houston216_700]

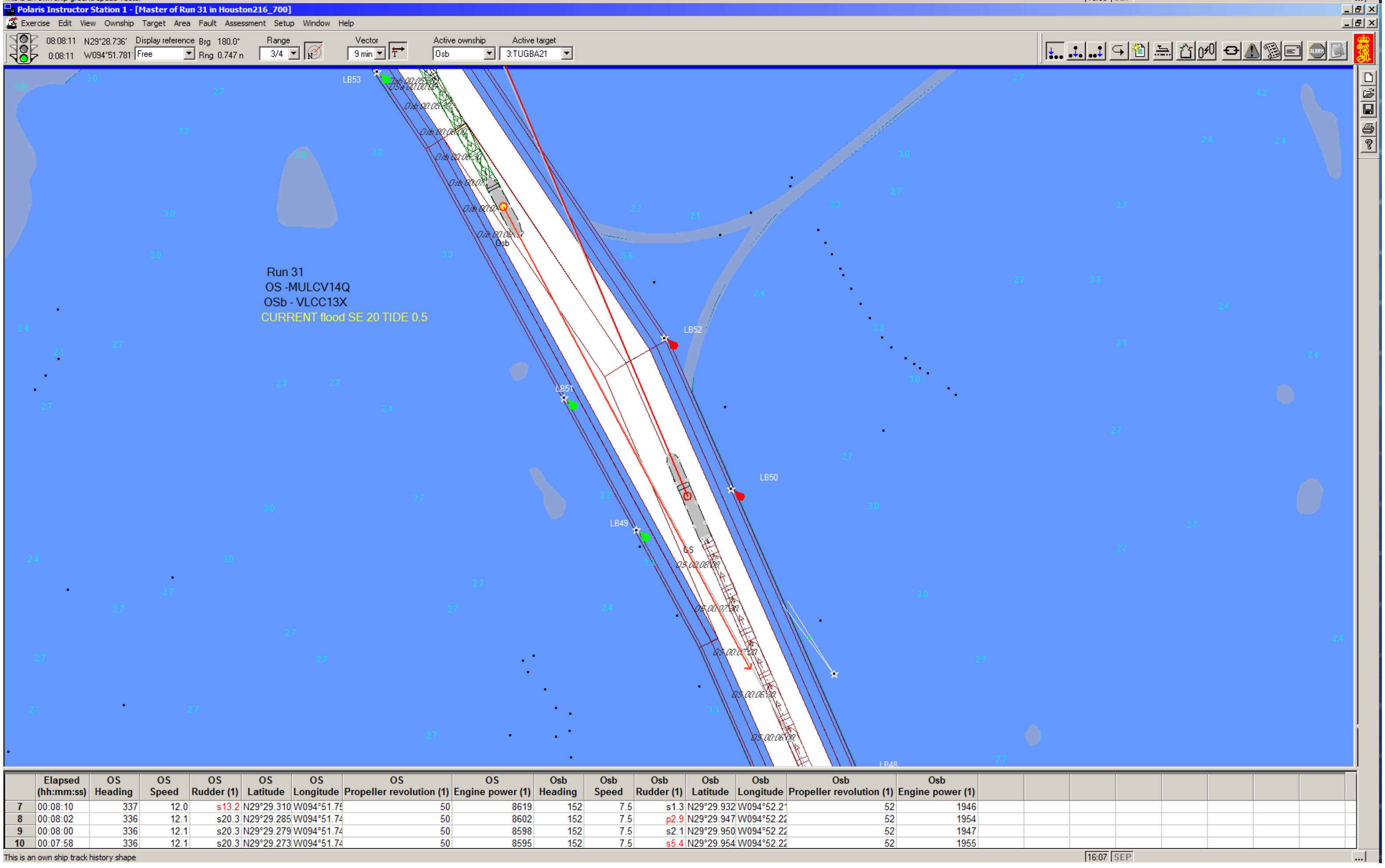
08:00:41 N29°29.392'
0:00:41 W094°51.076'
Display reference: Free
Brg 078.3°
Rng 0.665 n
Range: 1.5
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:00:40	336	12.3	p4.9	N29°27.917	W094°51.06	50	8499	146	8.2	s18.3	N29°30.754	W094°52.79	23	-401

This is an own ship ground speed vector

15:59 SEP



Polaris Instructor Station 1 - [Master of Run 31 in Houston216_700]

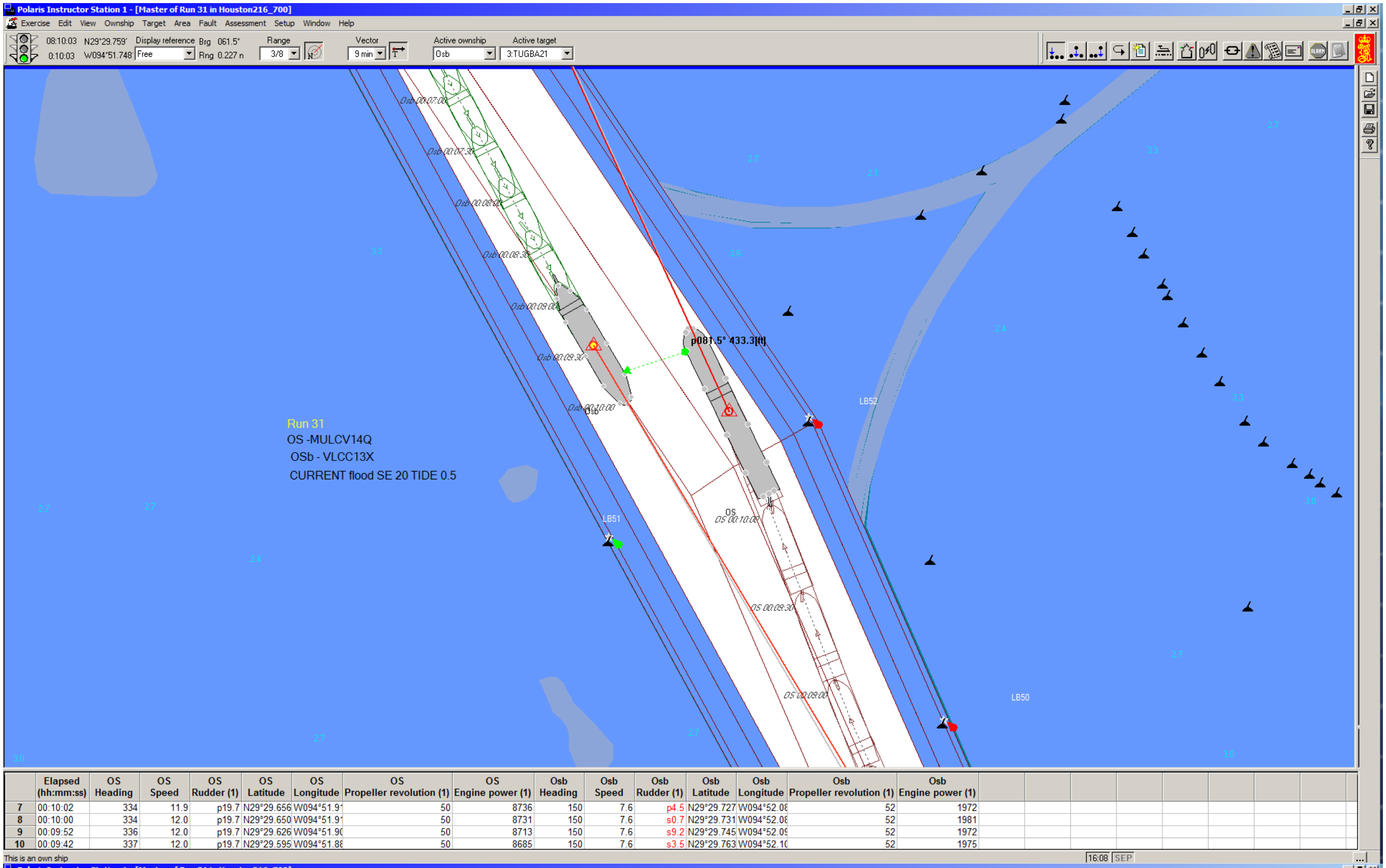
08:08:11 N29°28.736'
0:08:11 W094°51.781'
Display reference: Free
Brg 180.0°
Rng 0.747 n
Range: 3/4
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:08:10	337	12.0	s13.2	N29°29.310	W094°51.75	50	8619	152	7.5	s1.3	N29°29.932	W094°52.21	52	1946
8	00:08:02	336	12.1	s20.3	N29°29.285	W094°51.74	50	8602	152	7.5	p2.9	N29°29.947	W094°52.22	52	1954
9	00:08:00	336	12.1	s20.3	N29°29.279	W094°51.74	50	8598	152	7.5	s2.1	N29°29.950	W094°52.22	52	1947
10	00:07:58	336	12.1	s20.3	N29°29.273	W094°51.74	50	8595	152	7.5	s5.4	N29°29.954	W094°52.22	52	1955

This is an own ship track history shape

16:07 SEP



Polaris Instructor Station 1 - [Master of Run 31 in Houston216_700]

08:10:03 N29°29.759′ 0:10:03 W094°51.748′

Display reference: Free

Brg 061.5° Rng 0.227 n

Range: 3/8

Vector: 9 min

Active ownship: Osb

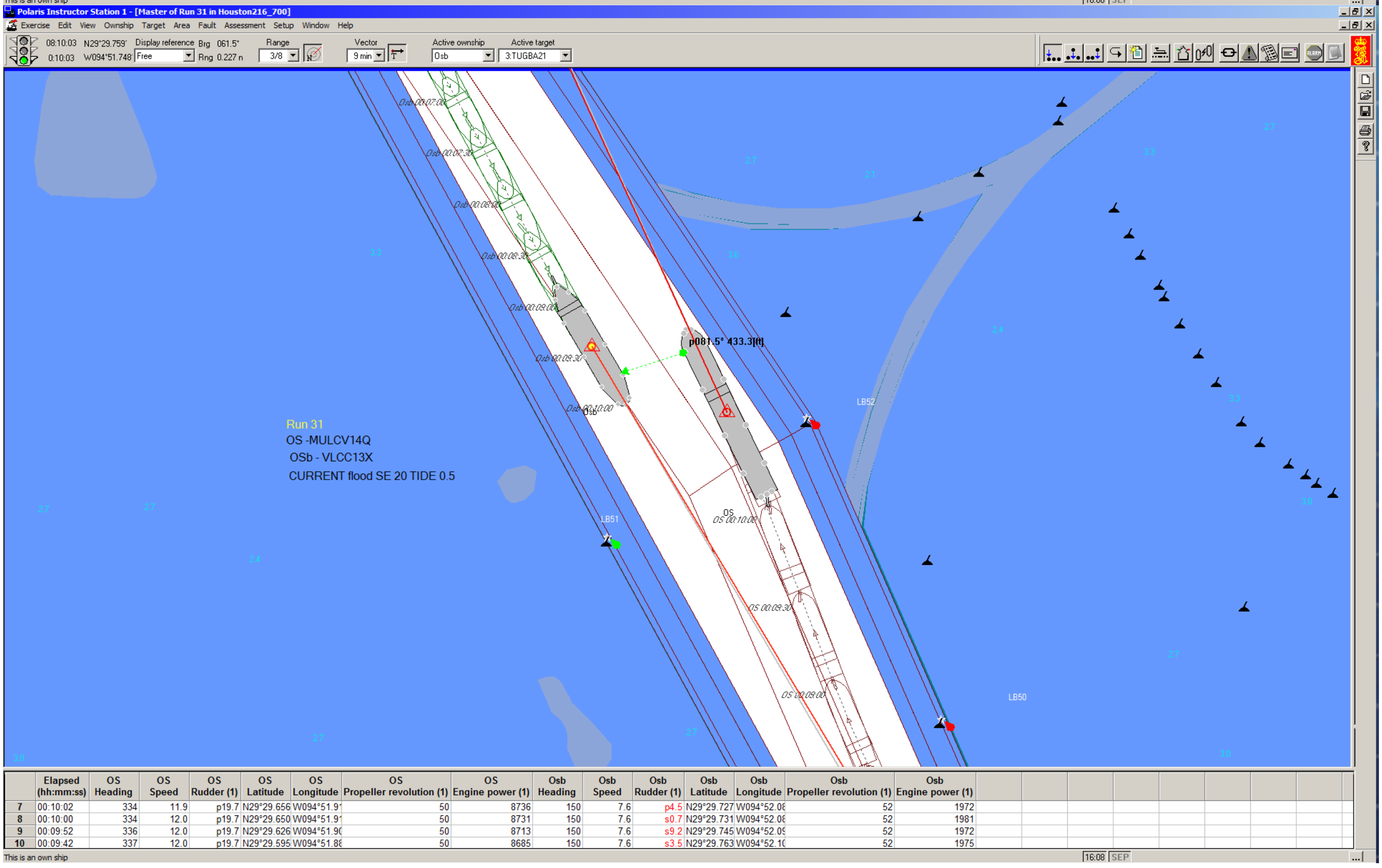
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:10:02	334	11.9	p19.7	N29°29.656	W094°51.9	50	8736	150	7.6	p4.5	N29°29.727	W094°52.0	52	1972
8	00:10:00	334	12.0	p19.7	N29°29.650	W094°51.9	50	8731	150	7.6	s0.7	N29°29.731	W094°52.0	52	1981
9	00:09:52	336	12.0	p19.7	N29°29.626	W094°51.9	50	8713	150	7.6	s9.2	N29°29.745	W094°52.0	52	1972
10	00:09:42	337	12.0	p19.7	N29°29.595	W094°51.8	50	8685	150	7.6	s3.5	N29°29.763	W094°52.1	52	1975

This is an own ship

16:08 SEP



Polaris Instructor Station 1 - [Master of Run 31 in Houston216_700]

08:10:03 N29°29.759′ 0:10:03 W094°51.748′

Display reference: Free

Brg 061.5° Rng 0.227 n

Range: 3/8

Vector: 9 min

Active ownship: Osb

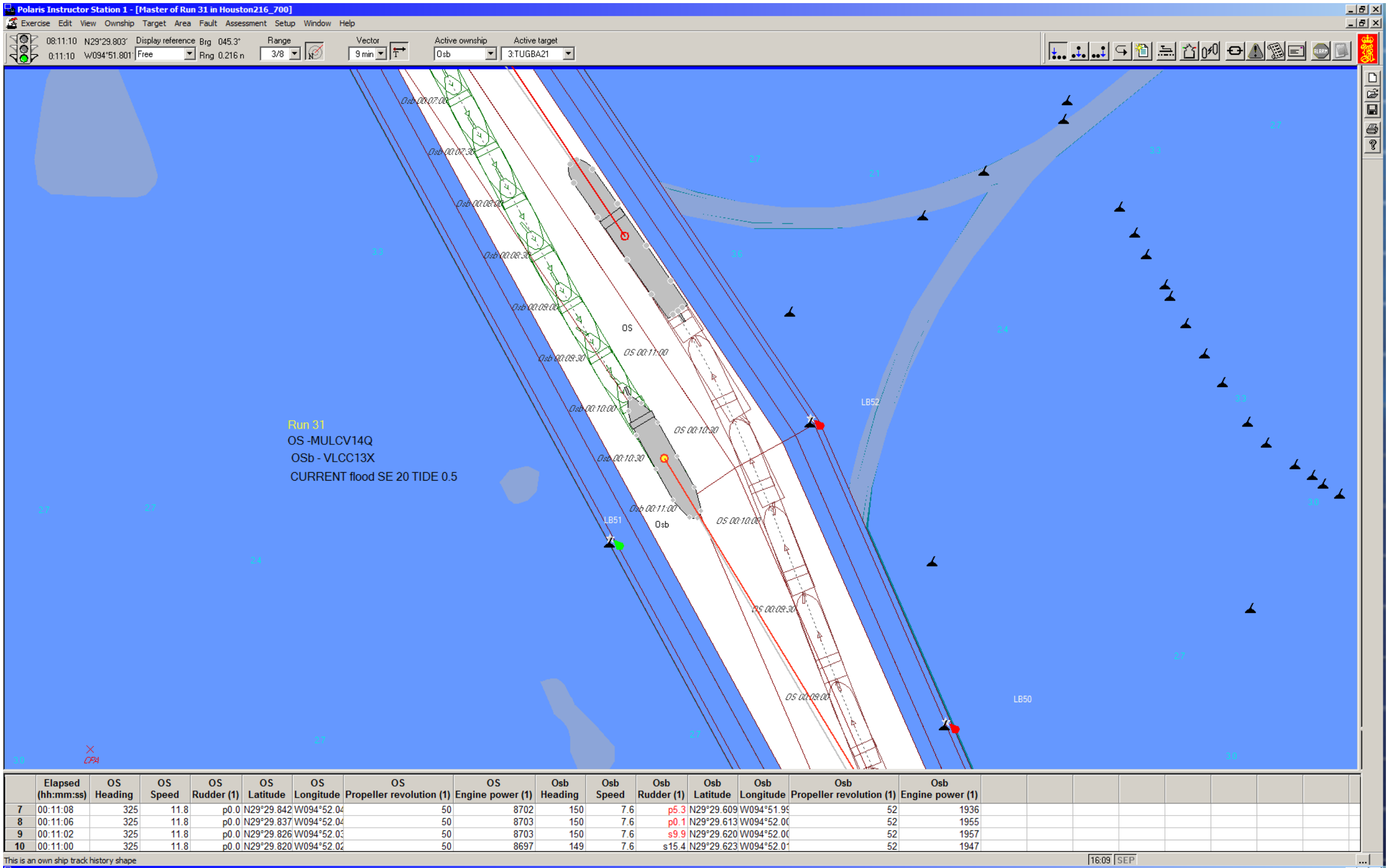
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:10:02	334	11.9	p19.7	N29°29.656	W094°51.9	50	8736	150	7.6	p4.5	N29°29.727	W094°52.0	52	1972
8	00:10:00	334	12.0	p19.7	N29°29.650	W094°51.9	50	8731	150	7.6	s0.7	N29°29.731	W094°52.0	52	1981
9	00:09:52	336	12.0	p19.7	N29°29.626	W094°51.9	50	8713	150	7.6	s9.2	N29°29.745	W094°52.0	52	1972
10	00:09:42	337	12.0	p19.7	N29°29.595	W094°51.8	50	8685	150	7.6	s3.5	N29°29.763	W094°52.1	52	1975

This is an own ship

16:08 SEP



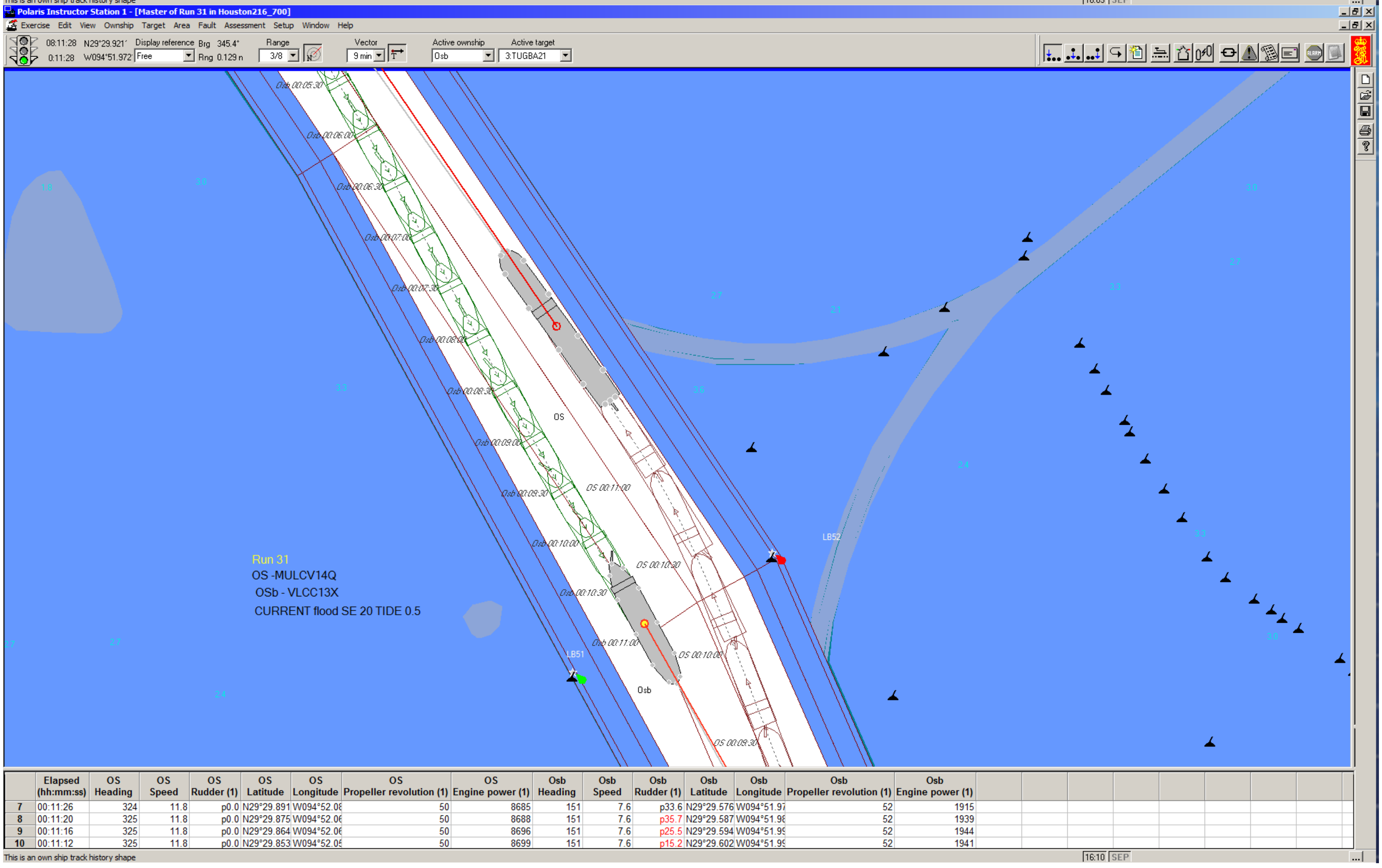
08:11:10 N29°29.803′ Display reference: Free Brg 045.3° Rng 0.216 n
0:11:10 W094°51.801′
Range: 3/8
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:11:08	325	11.8	p0.0	N29°29.842	W094°52.04	50	8702	150	7.6	p5.3	N29°29.609	W094°51.9	52	1936
8	00:11:06	325	11.8	p0.0	N29°29.837	W094°52.04	50	8703	150	7.6	p0.1	N29°29.613	W094°52.0	52	1955
9	00:11:02	325	11.8	p0.0	N29°29.826	W094°52.0	50	8703	150	7.6	s9.9	N29°29.620	W094°52.0	52	1957
10	00:11:00	325	11.8	p0.0	N29°29.820	W094°52.0	50	8697	149	7.6	s15.4	N29°29.623	W094°52.0	52	1947

This is an own ship track history shape

16:09 SEP



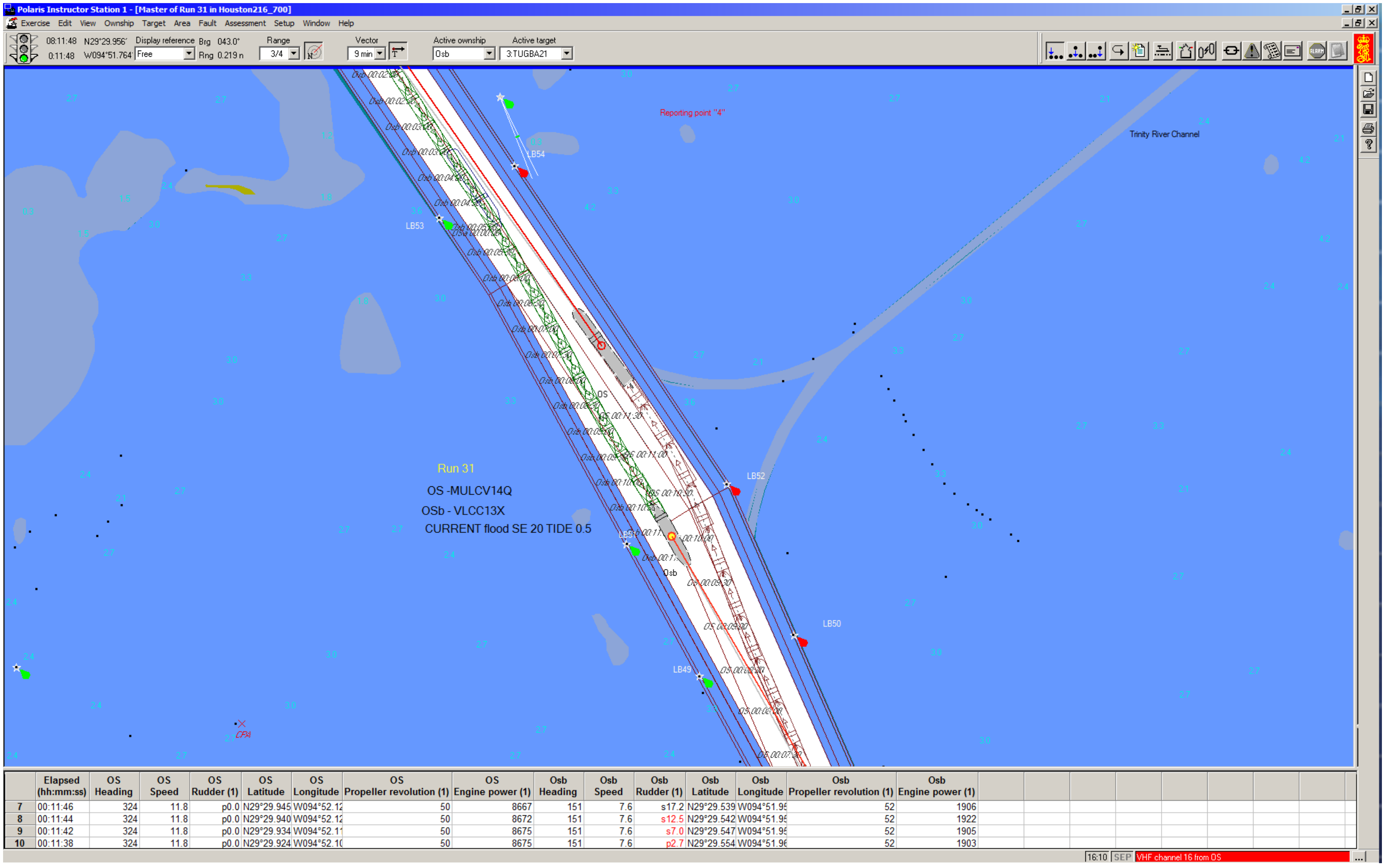
08:11:28 N29°29.921′ Display reference: Free Brg 345.4° Rng 0.129 n
0:11:28 W094°51.972′
Range: 3/8
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 31
OS -MULCV14Q
OSb - VLCC13X
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:11:26	324	11.8	p0.0	N29°29.891	W094°52.0	50	8685	151	7.6	p33.6	N29°29.576	W094°51.9	52	1915
8	00:11:20	325	11.8	p0.0	N29°29.875	W094°52.0	50	8688	151	7.6	p35.7	N29°29.587	W094°51.9	52	1939
9	00:11:16	325	11.8	p0.0	N29°29.864	W094°52.0	50	8696	151	7.6	p25.5	N29°29.594	W094°51.9	52	1944
10	00:11:12	325	11.8	p0.0	N29°29.853	W094°52.0	50	8699	151	7.6	p15.2	N29°29.602	W094°51.9	52	1941

This is an own ship track history shape

16:10 SEP



Polaris Instructor Station 1 - [Master of Run 31 in Houston216_700]

08:11:48 N29°29.956'
0:11:48 W094°51.764'
Display reference: Free
Brg 043.0°
Rng 0.219 n
Range: 3/4
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 31

OS -MULCV14Q

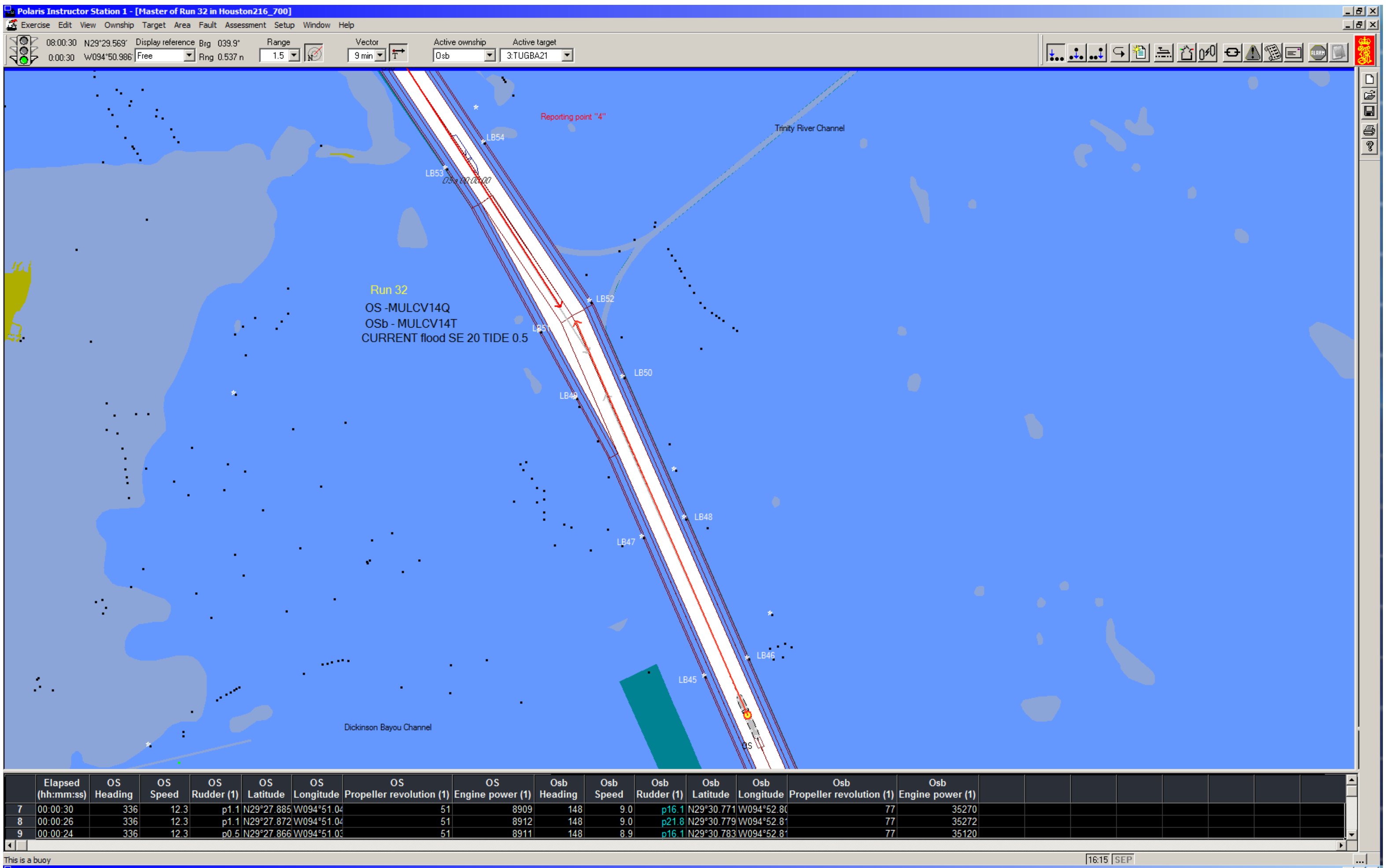
OSb - VLCC13X

CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:11:46	324	11.8	p0.0	N29°29.945	W094°52.12	50	8667	151	7.6	s17.2	N29°29.539	W094°51.95	52	1906
8	00:11:44	324	11.8	p0.0	N29°29.940	W094°52.12	50	8672	151	7.6	s12.5	N29°29.542	W094°51.95	52	1922
9	00:11:42	324	11.8	p0.0	N29°29.934	W094°52.11	50	8675	151	7.6	s7.0	N29°29.547	W094°51.95	52	1905
10	00:11:38	324	11.8	p0.0	N29°29.924	W094°52.10	50	8675	151	7.6	p2.7	N29°29.554	W094°51.96	52	1903

16:10 SEP VHF channel 16 from OS

Run 32



Polaris Instructor Station 1 - [Master of Run 32 in Houston216_700]

08:00:30 N29°29.569′ W094°50.986′ 0:00:30

Display reference: Free

Brg 039.9° Rng 0.537 n

Range: 1.5

Vector: 9 min

Active ownship: Osb

Active target: 3:TUGBA21

Run 32

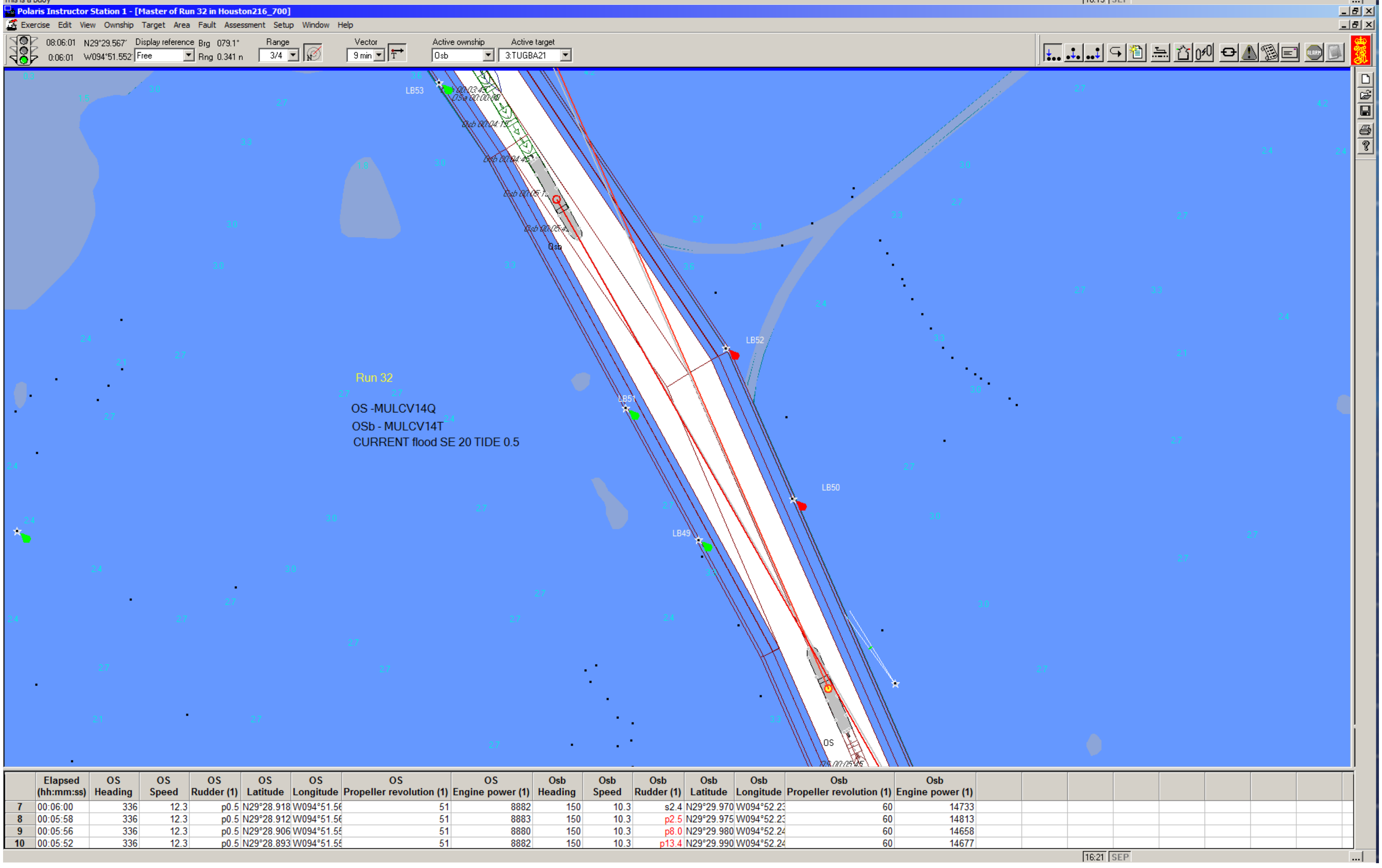
OS -MULCV14Q

OSb - MULCV14T

CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:00:30	336	12.3	p1.1	N29°27.885	W094°51.04	51	8909	148	9.0	p16.1	N29°30.771	W094°52.80	77	35270
8	00:00:26	336	12.3	p1.1	N29°27.872	W094°51.04	51	8912	148	9.0	p21.8	N29°30.779	W094°52.81	77	35272
9	00:00:24	336	12.3	p0.5	N29°27.866	W094°51.03	51	8911	148	8.9	p16.1	N29°30.783	W094°52.81	77	35120

This is a buoy



Polaris Instructor Station 1 - [Master of Run 32 in Houston216_700]

08:06:01 N29°29.567′ W094°51.552′ 0:06:01

Display reference: Free

Brg 079.1° Rng 0.341 n

Range: 3/4

Vector: 9 min

Active ownship: Osb

Active target: 3:TUGBA21

Run 32

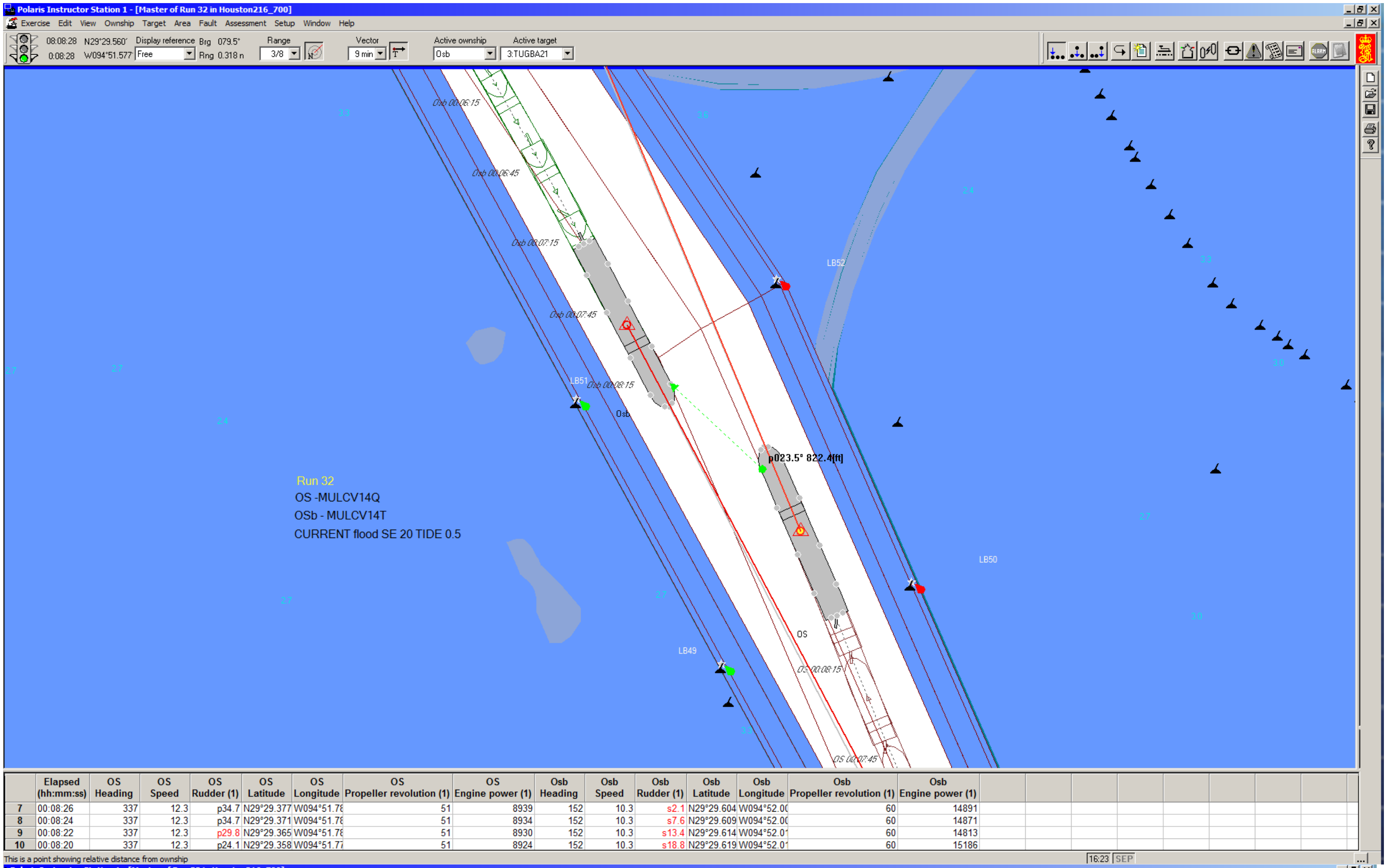
OS -MULCV14Q

OSb - MULCV14T

CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:06:00	336	12.3	p0.5	N29°28.918	W094°51.56	51	8882	150	10.3	s2.4	N29°29.970	W094°52.23	60	14733
8	00:05:58	336	12.3	p0.5	N29°28.912	W094°51.56	51	8883	150	10.3	p2.5	N29°29.975	W094°52.23	60	14813
9	00:05:56	336	12.3	p0.5	N29°28.906	W094°51.55	51	8880	150	10.3	p8.0	N29°29.980	W094°52.24	60	14658
10	00:05:52	336	12.3	p0.5	N29°28.893	W094°51.55	51	8882	150	10.3	p13.4	N29°29.990	W094°52.24	60	14677

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 32 in Houston216_700]

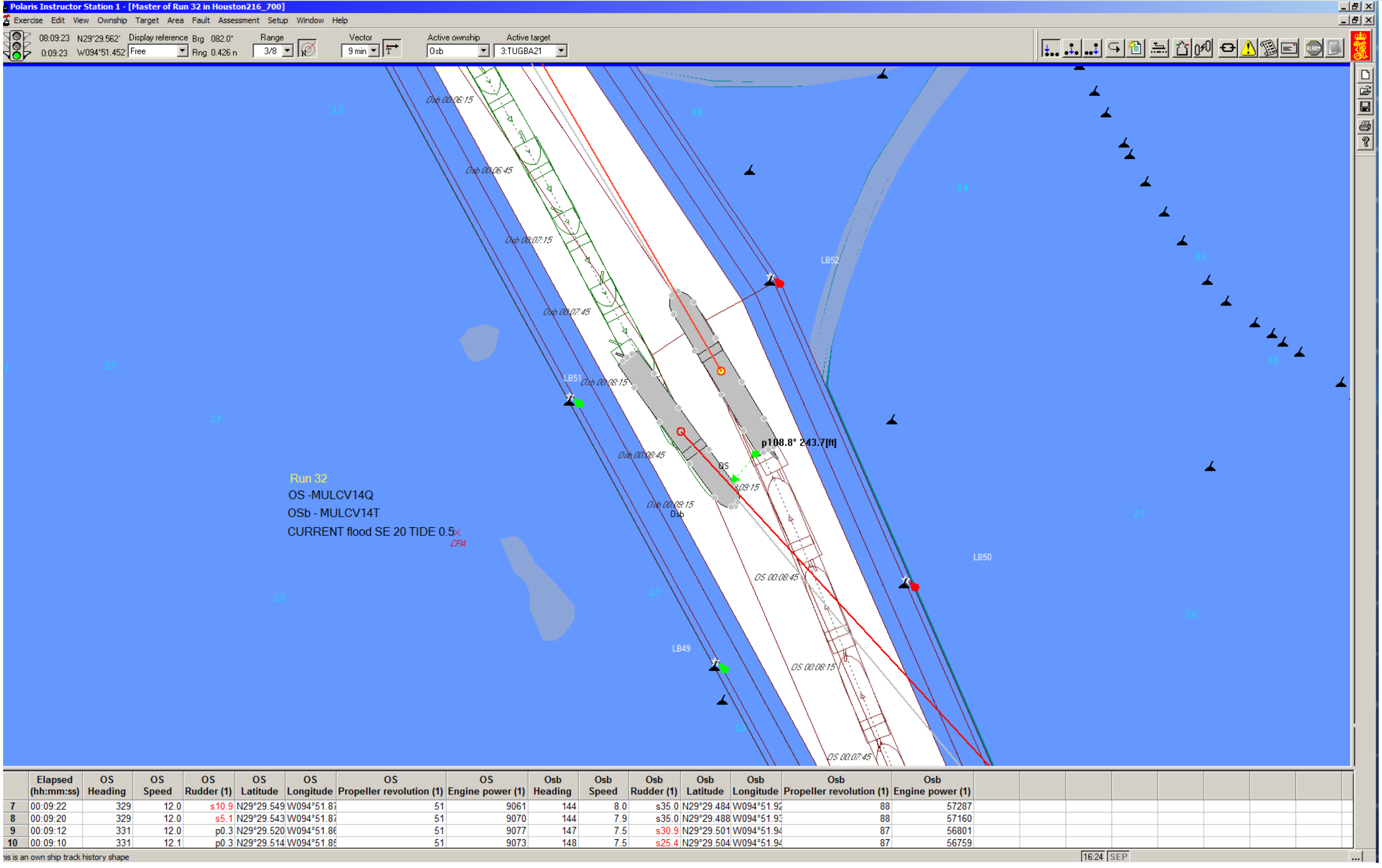
08:08:28 N29°29.560' Display reference: Free Brg 079.5°
0:08:28 W094°51.577' Rng 0.318 n
Range: 3/8
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 32
OS -MULCV14Q
OSb - MULCV14T
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:08:26	337	12.3	p34.7	N29°29.377	W094°51.78	51	8939	152	10.3	s2.1	N29°29.604	W094°52.00	60	14891
8	00:08:24	337	12.3	p34.7	N29°29.371	W094°51.78	51	8934	152	10.3	s7.6	N29°29.609	W094°52.00	60	14871
9	00:08:22	337	12.3	p29.8	N29°29.365	W094°51.78	51	8930	152	10.3	s13.4	N29°29.614	W094°52.01	60	14813
10	00:08:20	337	12.3	p24.1	N29°29.358	W094°51.77	51	8924	152	10.3	s18.8	N29°29.619	W094°52.01	60	15186

This is a point showing relative distance from ownship

16:23 SEP



Polaris Instructor Station 1 - [Master of Run 32 in Houston216_700]

08:09:23 N29°29.562' Display reference: Free Brg 082.0°
0:09:23 W094°51.452' Rng 0.426 n
Range: 3/8
Vector: 9 min
Active ownship: Osb
Active target: 3:TUGBA21

Run 32
OS -MULCV14Q
OSb - MULCV14T
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:09:22	329	12.0	s10.9	N29°29.549	W094°51.87	51	9061	144	8.0	s35.0	N29°29.484	W094°51.92	88	57287
8	00:09:20	329	12.0	s5.1	N29°29.543	W094°51.87	51	9070	144	7.9	s35.0	N29°29.488	W094°51.93	88	57160
9	00:09:12	331	12.0	p0.3	N29°29.520	W094°51.86	51	9077	147	7.5	s30.9	N29°29.501	W094°51.94	87	56801
10	00:09:10	331	12.1	p0.3	N29°29.514	W094°51.85	51	9073	148	7.5	s25.4	N29°29.504	W094°51.94	87	56759

his is an own ship track history shape

16:24 SEP

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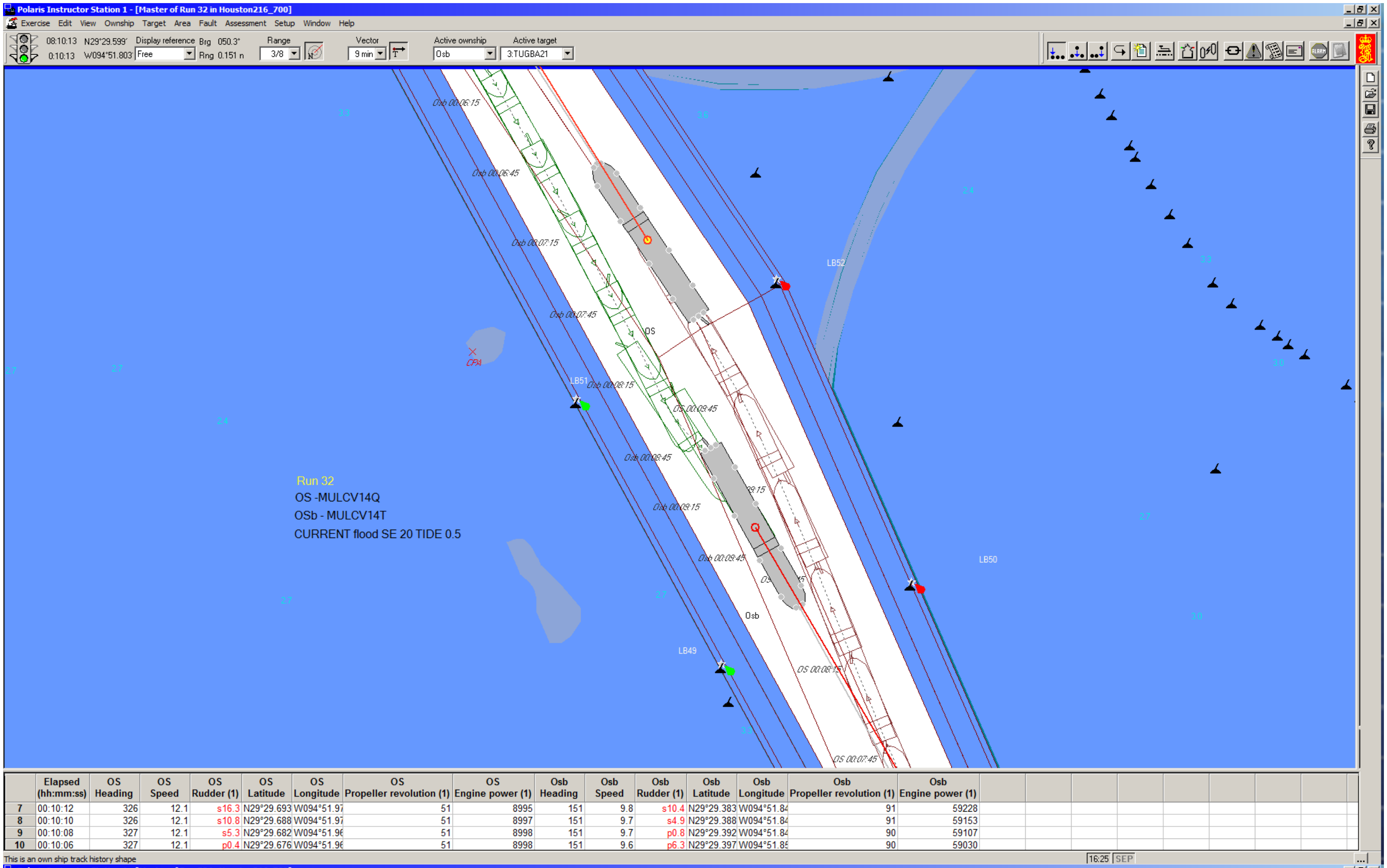
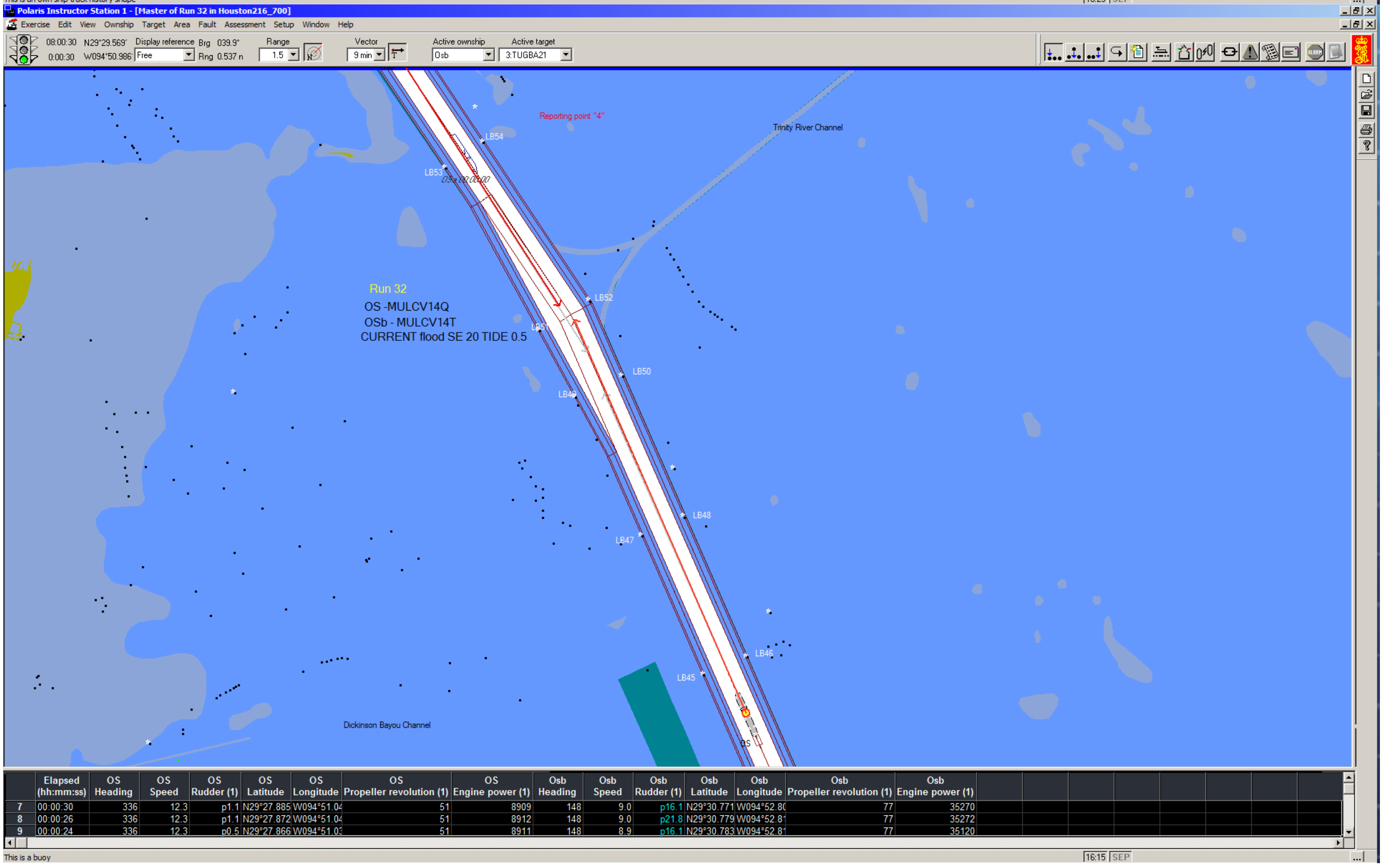


08:10:13 N29°29.599' Display reference Free Brg 050.3° Rng 0.151 n
0:10:13 W094°51.803'
Range 3/8
Vector 9 min
Active ownship Osb
Active target 3:TUGBA21

Run 32
OS -MULCV14Q
OSb - MULCV14T
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:10:12	326	12.1	s16.3	N29°29.693	W094°51.97	51	8995	151	9.8	s10.4	N29°29.383	W094°51.84	91	59228
8	00:10:10	326	12.1	s10.8	N29°29.688	W094°51.97	51	8997	151	9.7	s4.9	N29°29.388	W094°51.84	91	59153
9	00:10:08	327	12.1	s5.3	N29°29.682	W094°51.96	51	8998	151	9.7	p0.8	N29°29.392	W094°51.84	90	59107
10	00:10:06	327	12.1	p0.4	N29°29.676	W094°51.96	51	8998	151	9.6	p6.3	N29°29.397	W094°51.85	90	59030

This is an own ship track history shape



08:00:30 N29°29.569' Display reference Free Brg 039.9° Rng 0.537 n
0:00:30 W094°50.986'
Range 1.5
Vector 9 min
Active ownship Osb
Active target 3:TUGBA21

Run 32
OS -MULCV14Q
OSb - MULCV14T
CURRENT flood SE 20 TIDE 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	Osb Heading	Osb Speed	Osb Rudder (1)	Osb Latitude	Osb Longitude	Osb Propeller revolution (1)	Osb Engine power (1)
7	00:00:30	336	12.3	p1.1	N29°27.885	W094°51.04	51	8909	148	9.0	p16.1	N29°30.771	W094°52.80	77	35270
8	00:00:26	336	12.3	p1.1	N29°27.872	W094°51.04	51	8912	148	9.0	p21.8	N29°30.779	W094°52.81	77	35272
9	00:00:24	336	12.3	p0.5	N29°27.866	W094°51.03	51	8911	148	8.9	p16.1	N29°30.783	W094°52.81	77	35120

This is a buoy

Appendix M: HSC – Barbours Cut Channel Simulations

June 26, 2019

Run 33

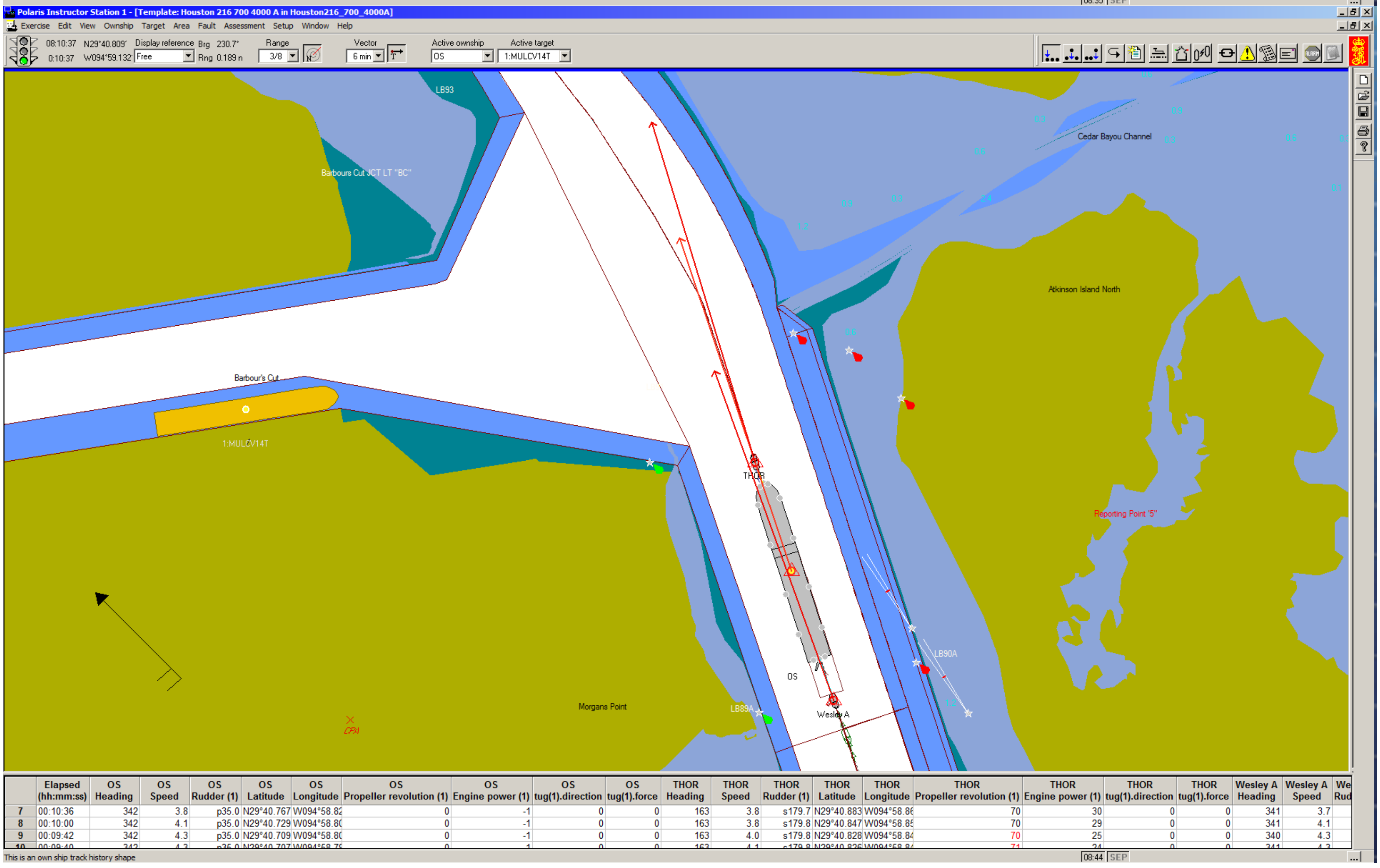
Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:01:03 N29°40.257' Display reference Brg 105.6°
0:01:03 W094°58.036 Free Rng 0.476 n
Range 1.5
Vector 18 min
Active ownship OS
Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:01:02	342	6.8	p11.7	N29°39.891	W094°58.4	33	2471	0	0	165	7.8	s179.5	N29°40.015	W094°58.5	141	247	0	0	338	6.6	
8	00:01:00	342	6.8	p11.7	N29°39.888	W094°58.4	33	2471	0	0	165	7.8	s175.4	N29°40.010	W094°58.5	141	241	0	0	344	6.7	
9	00:00:58	342	6.8	p8.2	N29°39.884	W094°58.4	33	2472	0	0	165	7.9	s178.5	N29°40.006	W094°58.5	141	234	0	0	349	6.9	
10	00:00:56	342	6.8	p2.6	N29°39.881	W094°58.4	33	2472	0	0	164	8.0	s176.9	N29°40.002	W094°58.5	141	220	0	0	355	7.1	
11	00:00:54	342	6.8	p1.0	N29°39.877	W094°58.4	33	2471	0	0	164	8.0	s177.1	N29°39.997	W094°58.5	141	211	0	0	360	7.2	
12	00:00:50	342	6.8	p9.6	N29°39.870	W094°58.4	33	2472	0	0	165	8.3	s179.6	N29°39.989	W094°58.5	142	189	0	0	004	7.2	
13	00:00:48	342	6.8	p12.0	N29°39.866	W094°58.4	33	2472	0	0	165	8.5	s179.6	N29°39.984	W094°58.5	143	176	0	0	004	7.2	
14	00:00:46	342	6.8	p10.5	N29°39.863	W094°58.4	33	2472	0	0	166	8.6	s179.7	N29°39.980	W094°58.5	145	180	0	0	002	7.2	

08:35 SEP



Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:10:37 N29°40.809' Display reference Brg 230.7°
0:10:37 W094°59.132 Free Rng 0.189 n
Range 3/8
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:10:36	342	3.8	p35.0	N29°40.767	W094°58.8	0	-1	0	0	163	3.8	s179.7	N29°40.883	W094°58.8	70	30	0	0	341	3.7	
8	00:10:00	342	4.1	p35.0	N29°40.729	W094°58.8	0	-1	0	0	163	3.8	s179.8	N29°40.847	W094°58.8	70	29	0	0	341	4.1	
9	00:09:42	342	4.3	p35.0	N29°40.709	W094°58.8	0	-1	0	0	163	4.0	s179.8	N29°40.828	W094°58.8	70	25	0	0	340	4.3	
10	00:09:40	342	4.3	p35.0	N29°40.707	W094°58.7	0	-1	0	0	163	4.1	s179.8	N29°40.826	W094°58.8	71	24	0	0	341	4.3	

This is an own ship track history shape

08:44 SEP

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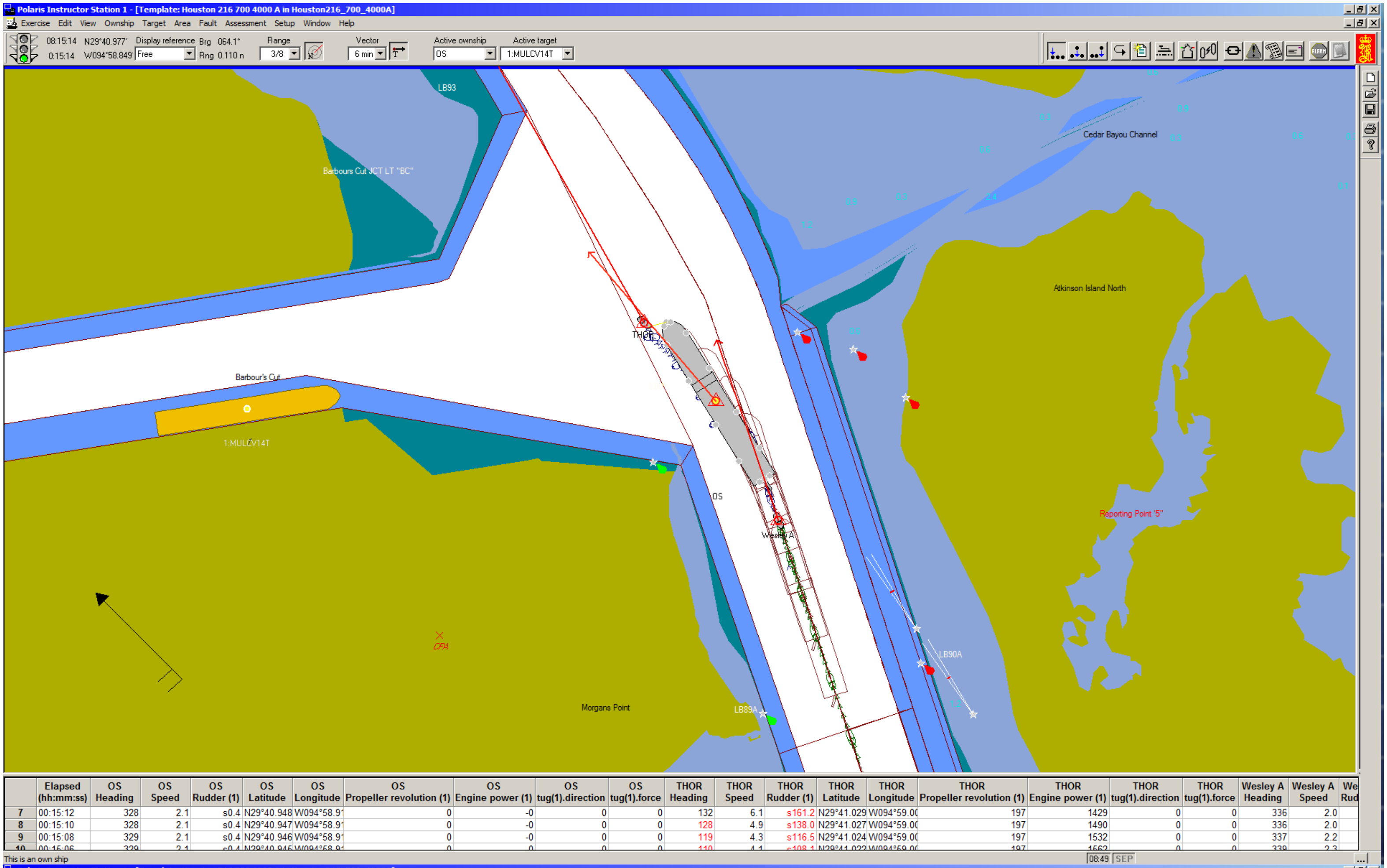
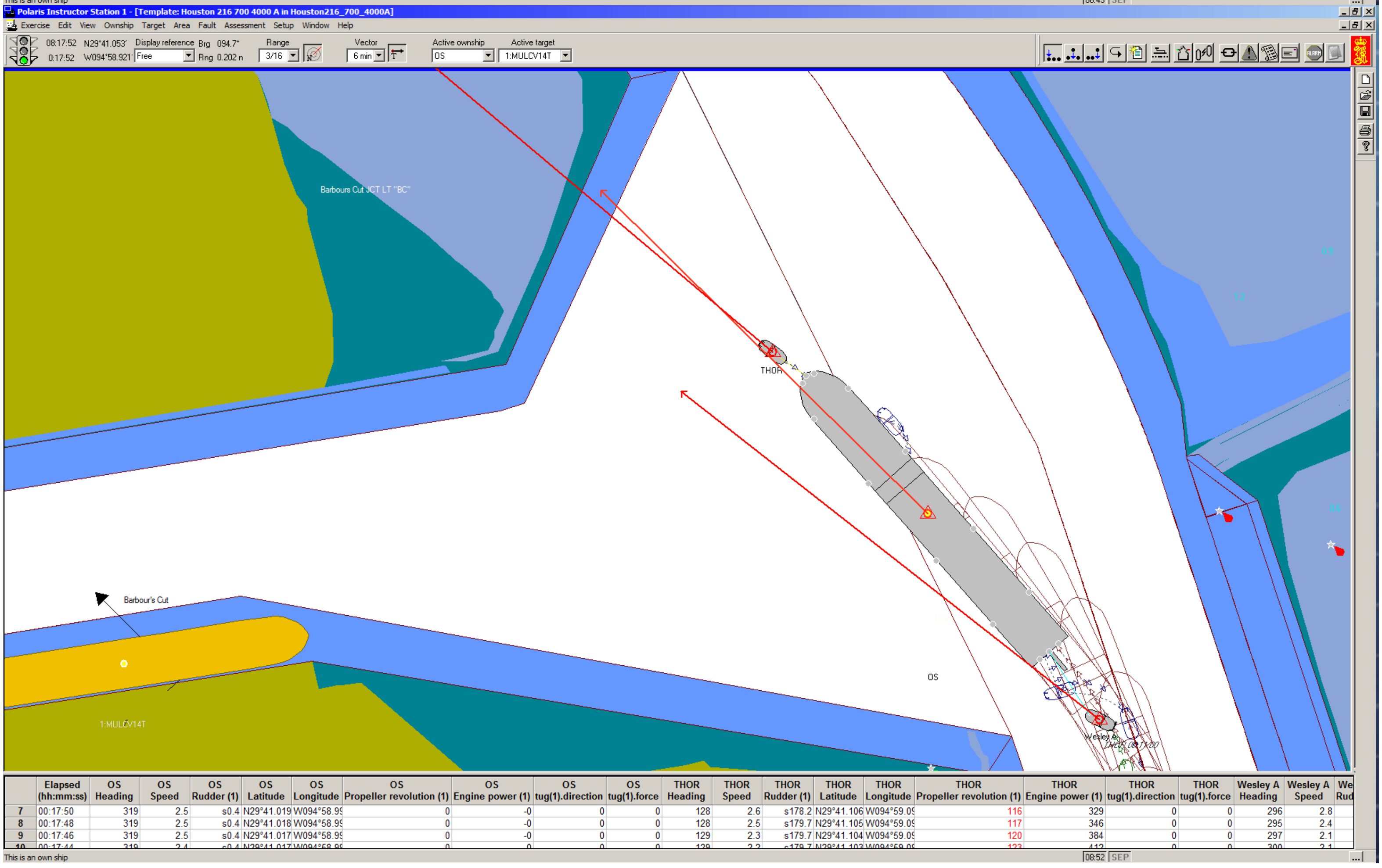


Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:15:14 N29°40.977' Display reference: Free Brg 064.1° Rng 0.110 n
0:15:14 W094°58.849'
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:15:12	328	2.1	s0.4	N29°40.948	W094°58.91	0	-0	0	0	132	6.1	s161.2	N29°41.029	W094°59.00	197	1429	0	0	336	2.0	
8	00:15:10	328	2.1	s0.4	N29°40.947	W094°58.91	0	-0	0	0	128	4.9	s138.0	N29°41.027	W094°59.00	197	1490	0	0	336	2.0	
9	00:15:08	329	2.1	s0.4	N29°40.946	W094°58.91	0	-0	0	0	119	4.3	s116.5	N29°41.024	W094°59.00	197	1532	0	0	337	2.2	
10	00:15:06	329	2.1	s0.4	N29°40.945	W094°58.91	0	-0	0	0	110	4.1	s108.1	N29°41.022	W094°59.00	197	1562	0	0	339	2.3	

This is an own ship

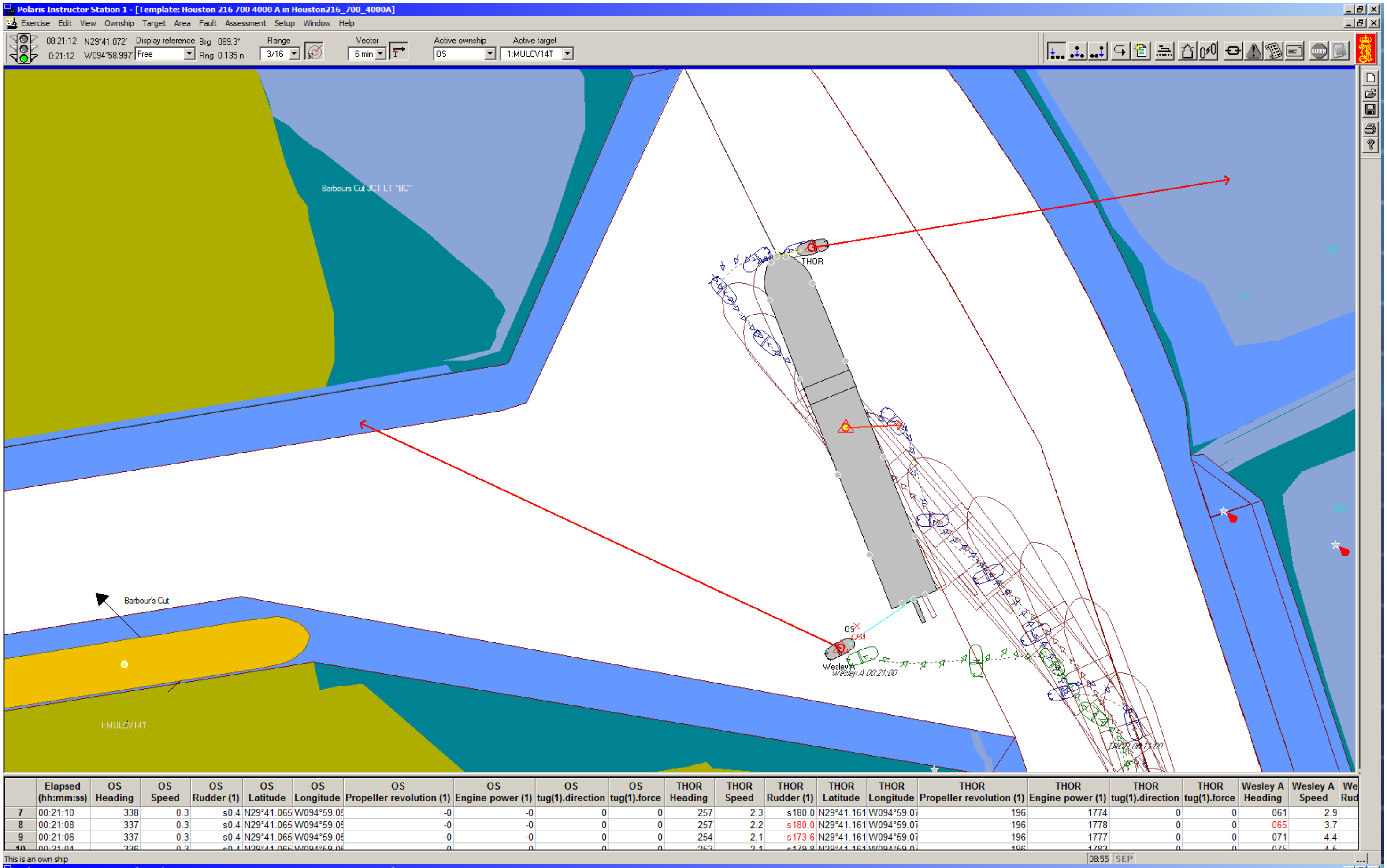


Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:17:52 N29°41.053' Display reference: Free Brg 094.7° Rng 0.202 n
0:17:52 W094°58.921'
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:17:50	319	2.5	s0.4	N29°41.019	W094°58.99	0	-0	0	0	128	2.6	s178.2	N29°41.106	W094°59.09	116	329	0	0	296	2.8	
8	00:17:48	319	2.5	s0.4	N29°41.018	W094°58.99	0	-0	0	0	128	2.5	s179.7	N29°41.105	W094°59.09	117	346	0	0	295	2.4	
9	00:17:46	319	2.5	s0.4	N29°41.017	W094°58.99	0	-0	0	0	129	2.3	s179.7	N29°41.104	W094°59.09	120	384	0	0	297	2.1	
10	00:17:44	319	2.4	s0.4	N29°41.017	W094°58.99	0	-0	0	0	129	2.2	s179.7	N29°41.103	W094°59.09	123	412	0	0	300	2.1	

This is an own ship



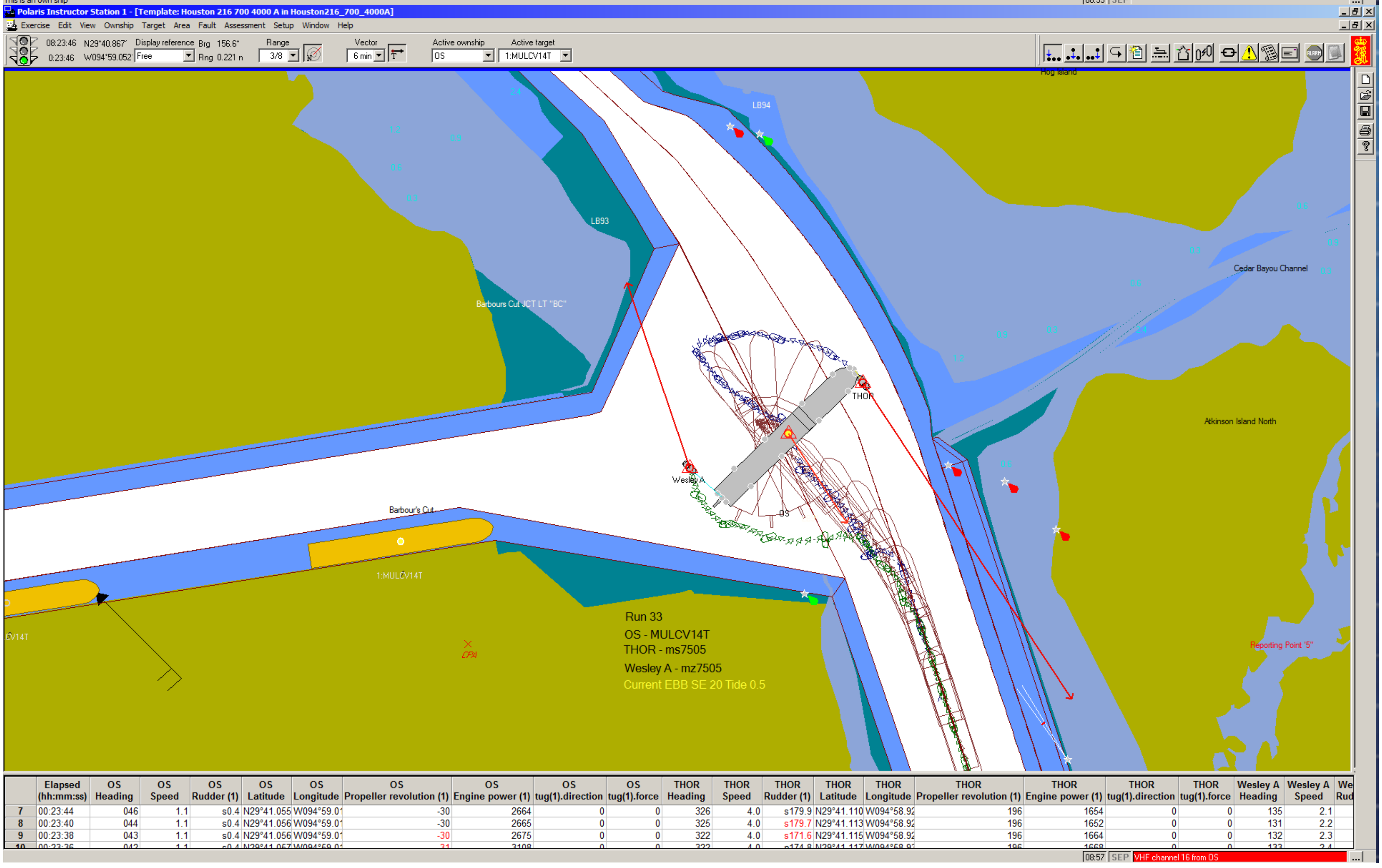
Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:21:12 N29°41.072' Display reference Free Brg 089.3° Rng 0.135 n
0:21:12 W094°58.997'
Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:21:10	338	0.3	s0.4	N29°41.065	W094°59.05	-0	-0	0	0	257	2.3	s180.0	N29°41.161	W094°59.07	196	1774	0	0	061	2.9	
8	00:21:08	337	0.3	s0.4	N29°41.065	W094°59.05	-0	-0	0	0	257	2.2	s180.0	N29°41.161	W094°59.07	196	1778	0	0	065	3.7	
9	00:21:06	337	0.3	s0.4	N29°41.065	W094°59.05	-0	-0	0	0	254	2.1	s173.6	N29°41.161	W094°59.07	196	1777	0	0	071	4.4	

This is an own ship

08:55 SEP



Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

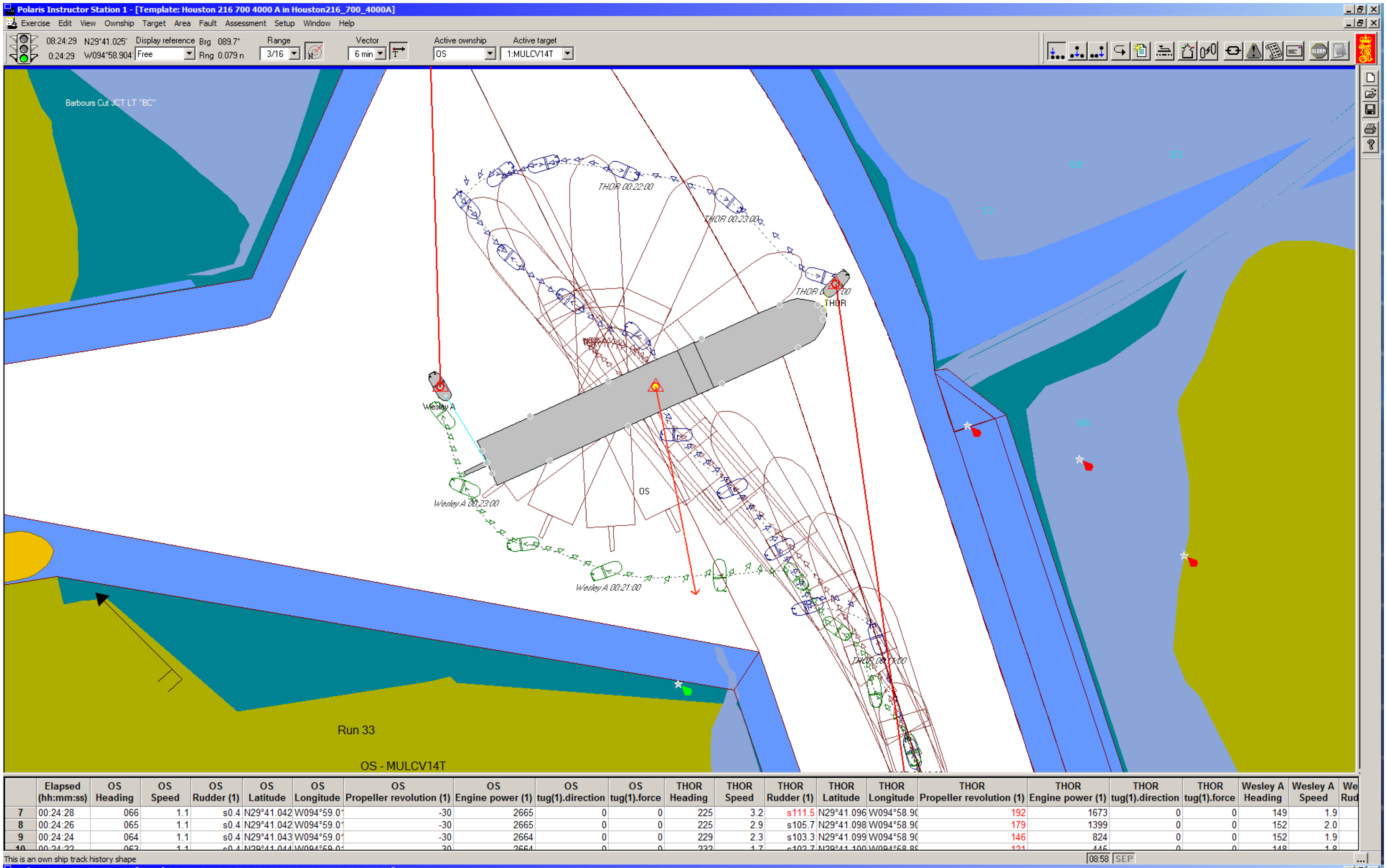
08:23:46 N29°40.867' Display reference Free Brg 156.6° Rng 0.221 n
0:23:46 W094°59.052'
Range 3/8 Vector 6 min Active ownship OS Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:23:44	046	1.1	s0.4	N29°41.055	W094°59.01	-30	2664	0	0	326	4.0	s179.9	N29°41.110	W094°58.92	196	1654	0	0	135	2.1	
8	00:23:40	044	1.1	s0.4	N29°41.056	W094°59.01	-30	2665	0	0	325	4.0	s179.7	N29°41.113	W094°58.92	196	1652	0	0	131	2.2	
9	00:23:38	043	1.1	s0.4	N29°41.056	W094°59.01	-30	2675	0	0	322	4.0	s171.6	N29°41.115	W094°58.92	196	1664	0	0	132	2.3	

08:57 SEP VHF channel 16 from OS

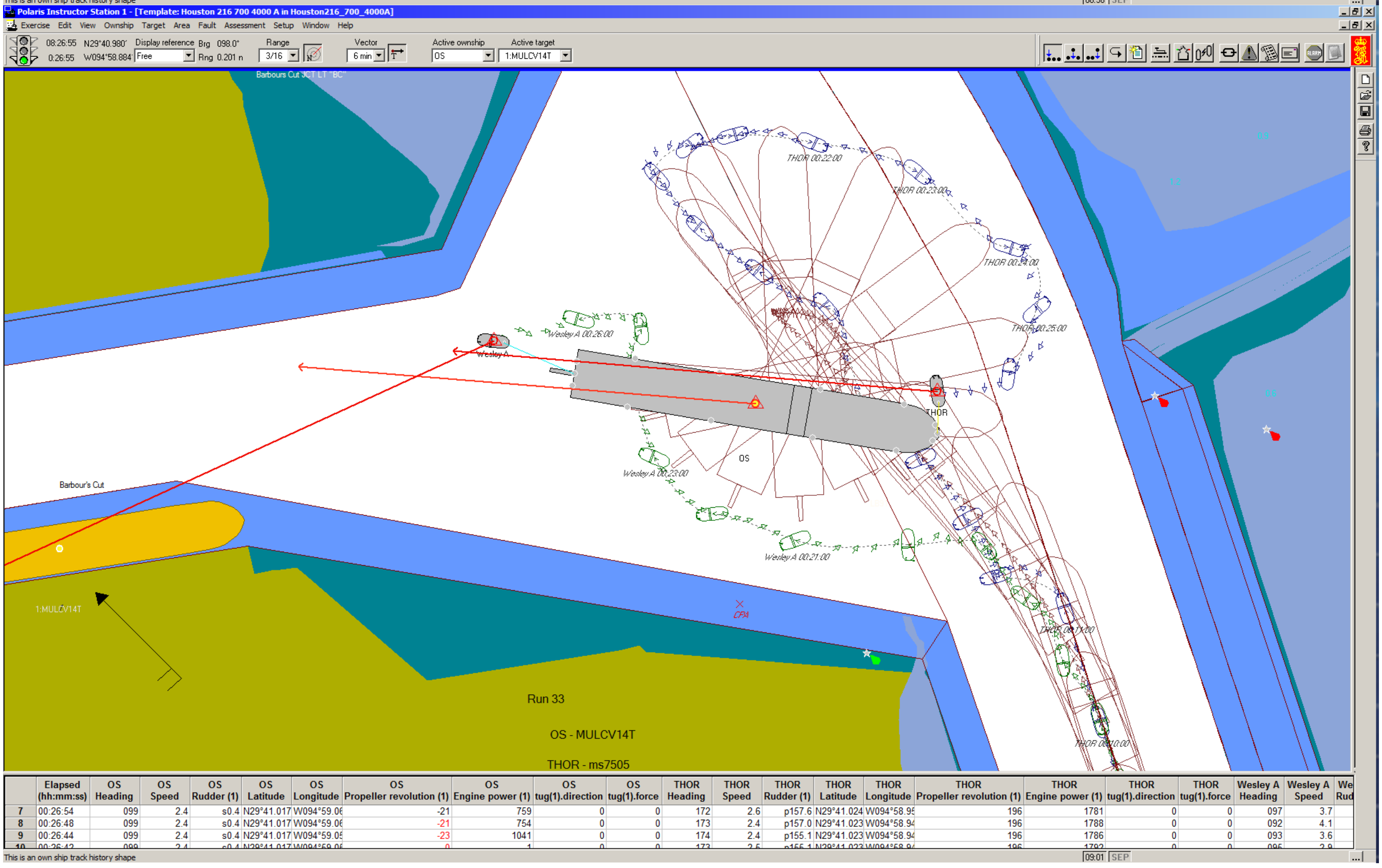
June 26, 2019



08:24:29 N29°41.025' Display reference Brg 089.7° Range Vector Active ownship Active target
0:24:29 W094°58.904' Free Rng 0.079 n 3/16 6 min OS 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:24:28	066	1.1	s0.4	N29°41.042	W094°59.0	-30	2665	0	0	225	3.2	s111.5	N29°41.096	W094°58.90	192	1673	0	0	149	1.9	
8	00:24:26	065	1.1	s0.4	N29°41.042	W094°59.0	-30	2665	0	0	225	2.9	s105.7	N29°41.098	W094°58.90	179	1399	0	0	152	2.0	
9	00:24:24	064	1.1	s0.4	N29°41.043	W094°59.0	-30	2664	0	0	229	2.3	s103.3	N29°41.099	W094°58.90	146	824	0	0	152	1.9	

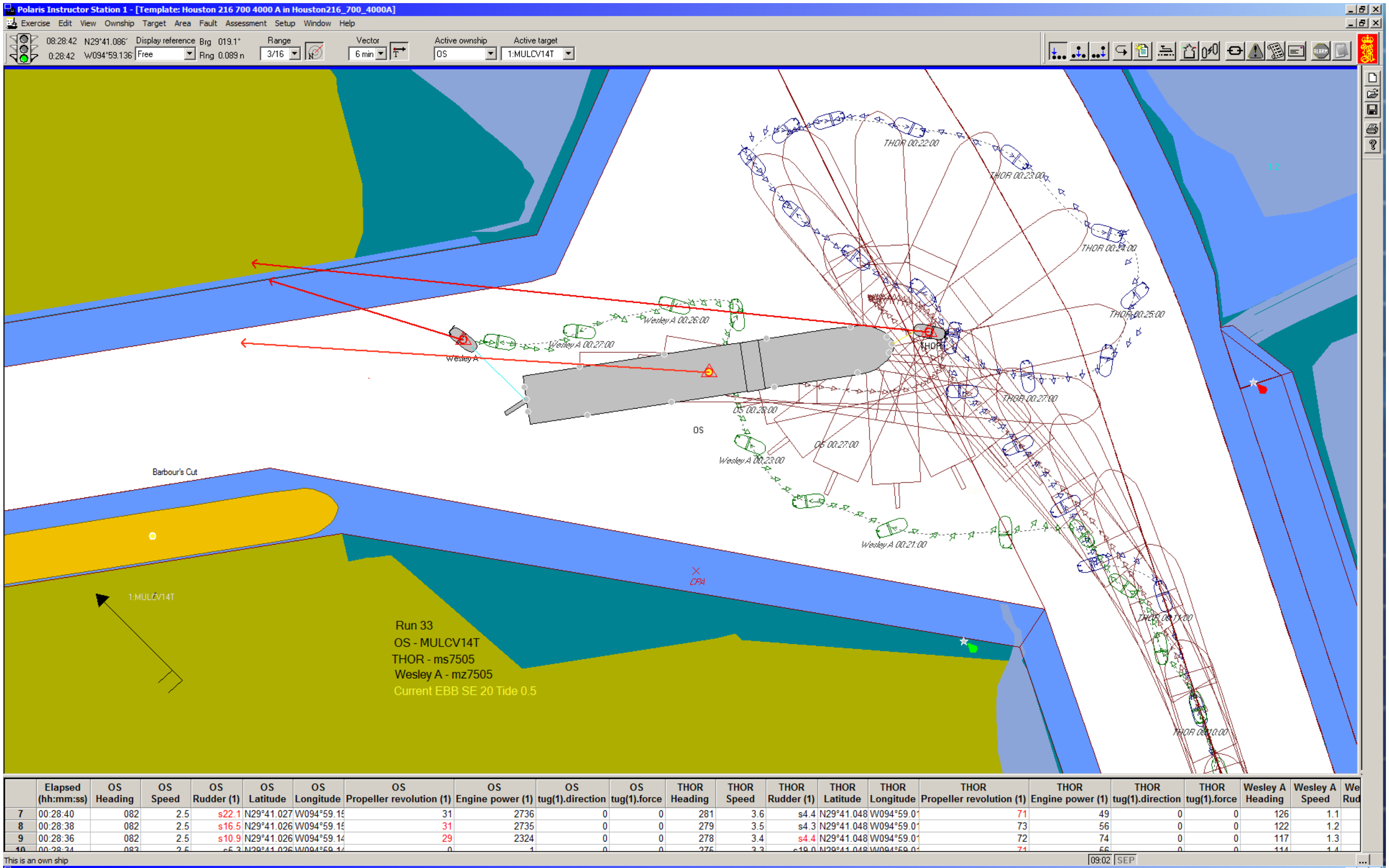
This is an own ship track history shape



08:26:55 N29°40.980' Display reference Brg 098.0° Range Vector Active ownship Active target
0:26:55 W094°58.884' Free Rng 0.201 n 3/16 6 min OS 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:26:54	099	2.4	s0.4	N29°41.017	W094°59.06	-21	759	0	0	172	2.6	p157.6	N29°41.024	W094°58.95	196	1781	0	0	097	3.7	
8	00:26:48	099	2.4	s0.4	N29°41.017	W094°59.06	-21	754	0	0	173	2.4	p157.0	N29°41.023	W094°58.94	196	1788	0	0	092	4.1	
9	00:26:44	099	2.4	s0.4	N29°41.017	W094°59.05	-23	1041	0	0	174	2.4	p155.1	N29°41.023	W094°58.94	196	1786	0	0	093	3.6	

This is an own ship track history shape



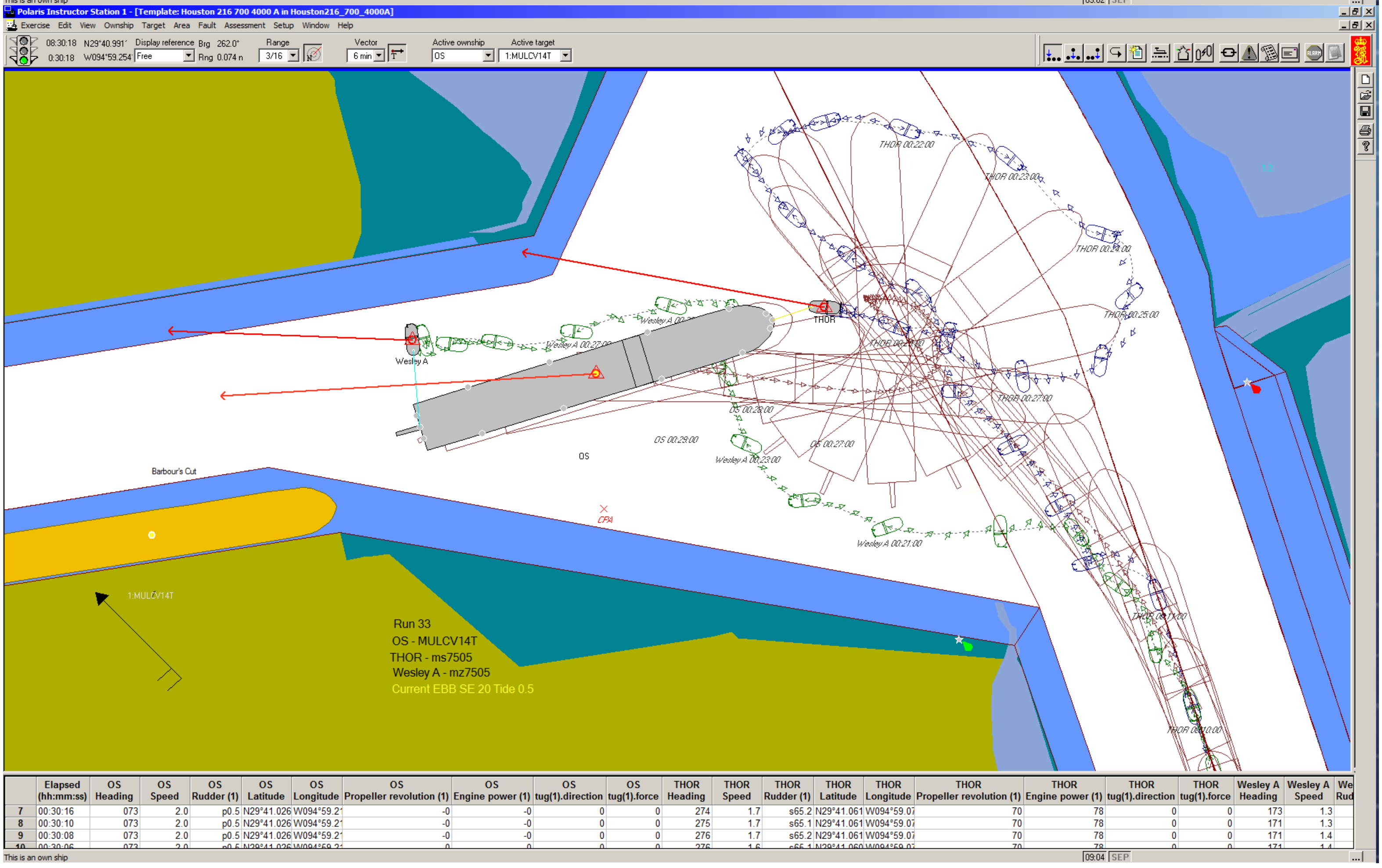
Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:28:42 N29°41.086′ Display reference Brg 019.1°
0:28:42 W094°59.136′ Free Rng 0.089 n
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:28:40	082	2.5	s22.1	N29°41.027	W094°59.15	31	2736	0	0	281	3.6	s4.4	N29°41.048	W094°59.01	71	49	0	0	126	1.1
8	00:28:38	082	2.5	s16.5	N29°41.026	W094°59.15	31	2735	0	0	279	3.5	s4.3	N29°41.048	W094°59.01	73	56	0	0	122	1.2
9	00:28:36	082	2.5	s10.9	N29°41.026	W094°59.14	29	2324	0	0	278	3.4	s4.4	N29°41.048	W094°59.01	72	74	0	0	117	1.3

This is an own ship



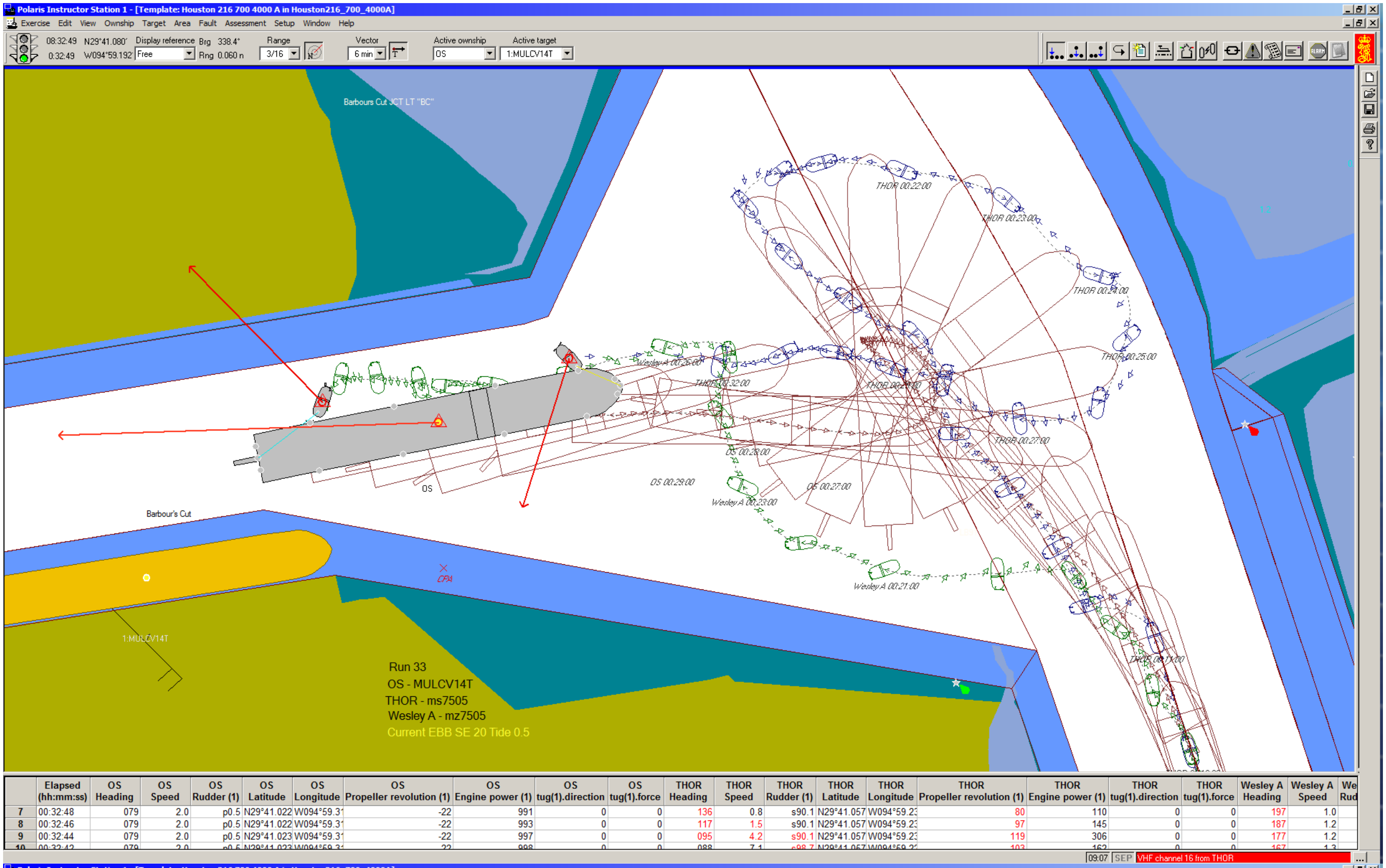
Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:30:18 N29°40.991′ Display reference Brg 262.0°
0:30:18 W094°59.254′ Free Rng 0.074 n
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:30:16	073	2.0	p0.5	N29°41.026	W094°59.21	-0	-0	0	0	274	1.7	s65.2	N29°41.061	W094°59.07	70	78	0	0	173	1.3
8	00:30:10	073	2.0	p0.5	N29°41.026	W094°59.21	-0	-0	0	0	275	1.7	s65.1	N29°41.061	W094°59.07	70	78	0	0	171	1.3
9	00:30:08	073	2.0	p0.5	N29°41.026	W094°59.21	-0	-0	0	0	276	1.7	s65.2	N29°41.061	W094°59.07	70	78	0	0	171	1.4

This is an own ship



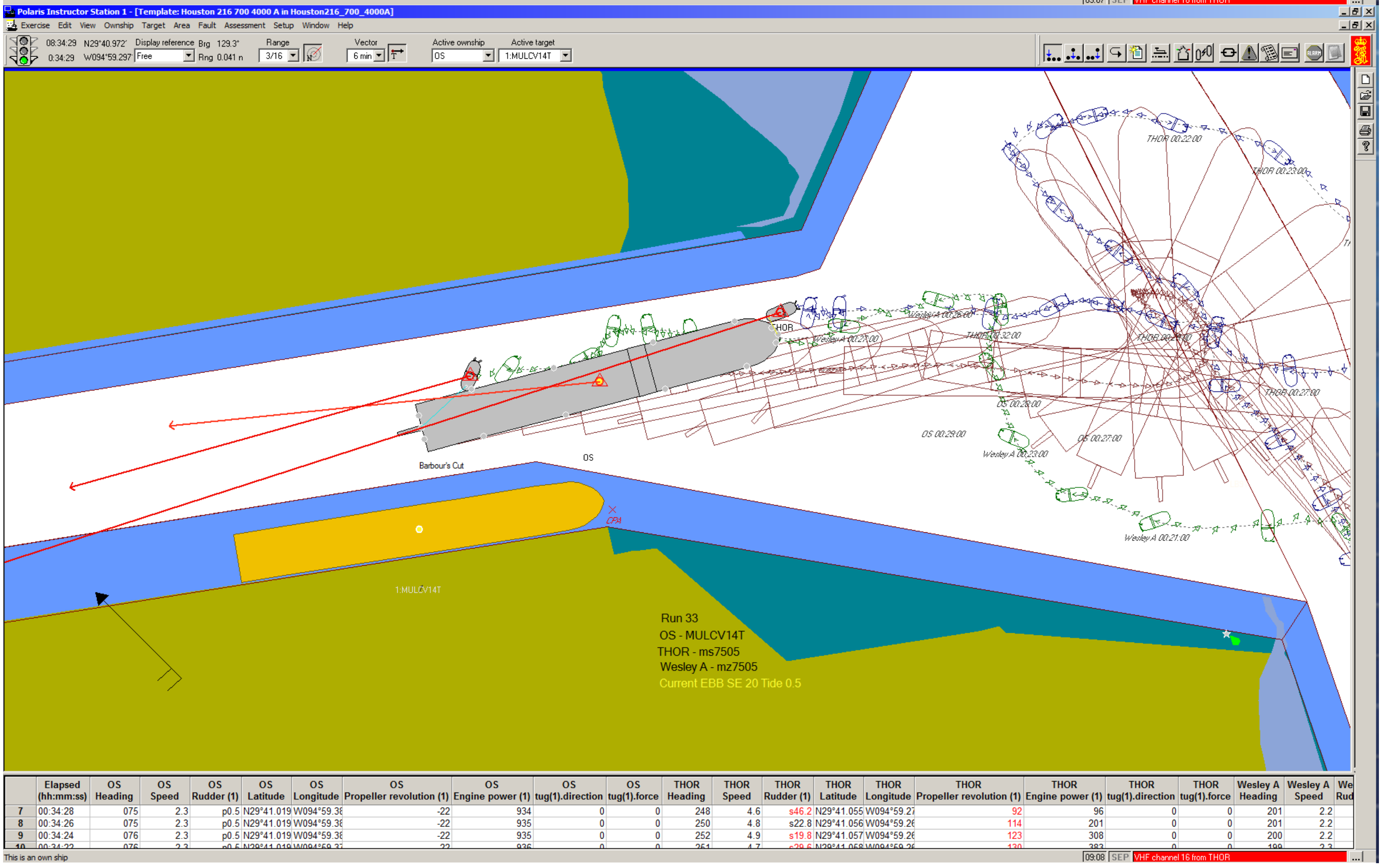
Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:32:49 N29°41.080' Display reference Free Brg 338.4° Rng 0.060 n
0:32:49 W094°59.192'
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:32:48	079	2.0	p0.5	N29°41.022	W094°59.31	-22	991	0	0	136	0.8	s90.1	N29°41.057	W094°59.23	80	110	0	0	197	1.0	
8	00:32:46	079	2.0	p0.5	N29°41.022	W094°59.31	-22	993	0	0	117	1.5	s90.1	N29°41.057	W094°59.23	97	145	0	0	187	1.2	
9	00:32:44	079	2.0	p0.5	N29°41.023	W094°59.31	-22	997	0	0	095	4.2	s90.1	N29°41.057	W094°59.23	119	306	0	0	177	1.2	
10	00:32:42	079	2.0	p0.5	N29°41.023	W094°59.31	-22	998	0	0	088	7.1	s98.7	N29°41.057	W094°59.23	103	162	0	0	167	1.3	

09:07 SEP VHF channel 16 from THOR



Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

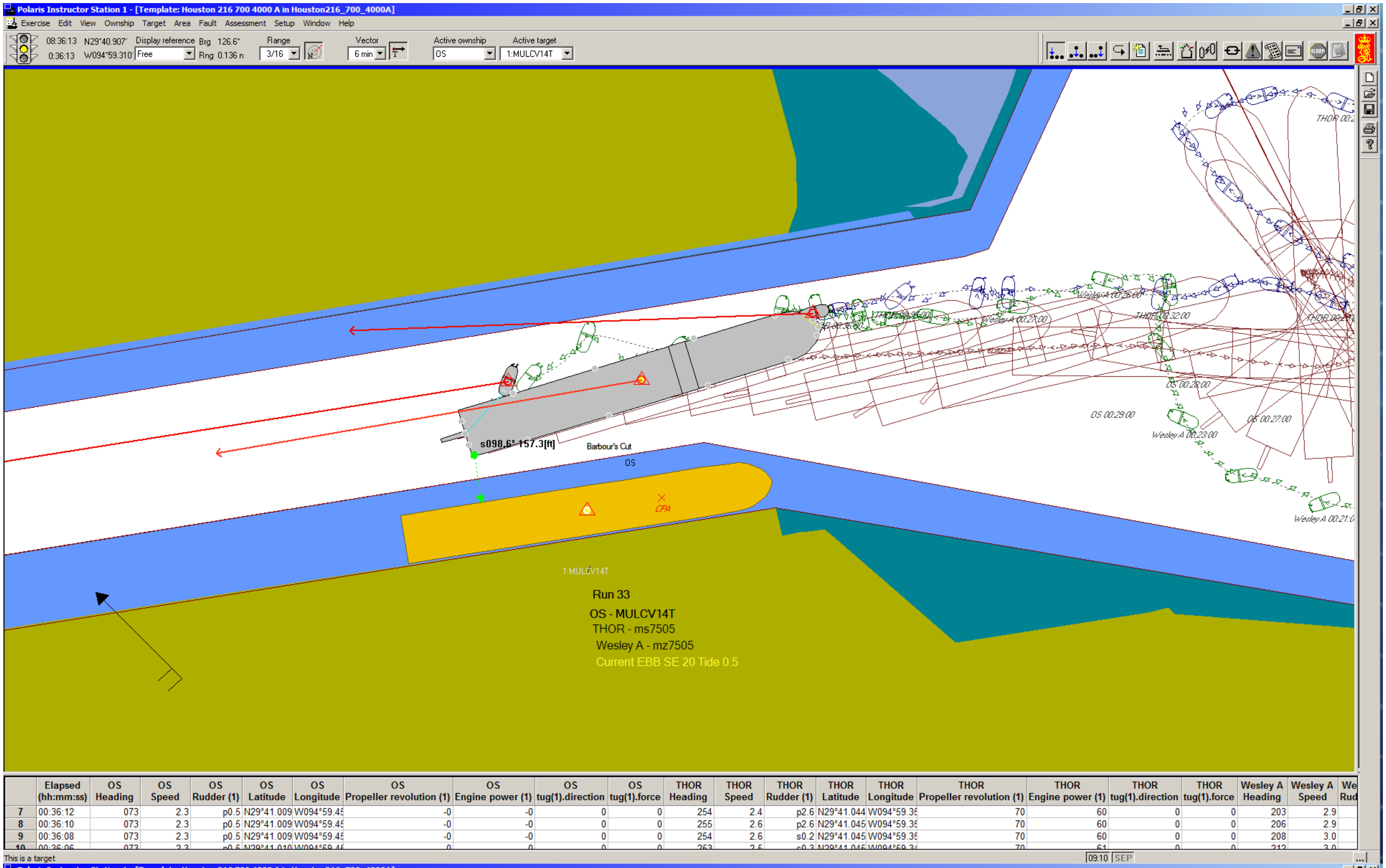
08:34:29 N29°40.972' Display reference Free Brg 129.3° Rng 0.041 n
0:34:29 W094°59.297'
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:34:28	075	2.3	p0.5	N29°41.019	W094°59.38	-22	934	0	0	248	4.6	s46.2	N29°41.055	W094°59.27	92	96	0	0	201	2.2	
8	00:34:26	075	2.3	p0.5	N29°41.019	W094°59.38	-22	935	0	0	250	4.8	s22.8	N29°41.056	W094°59.26	114	201	0	0	201	2.2	
9	00:34:24	076	2.3	p0.5	N29°41.019	W094°59.38	-22	935	0	0	252	4.9	s19.8	N29°41.057	W094°59.26	123	308	0	0	200	2.2	
10	00:34:22	076	2.3	p0.5	N29°41.019	W094°59.37	-22	936	0	0	251	4.7	s29.6	N29°41.058	W094°59.26	130	383	0	0	199	2.3	

This is an own ship

09:08 SEP VHF channel 16 from THOR



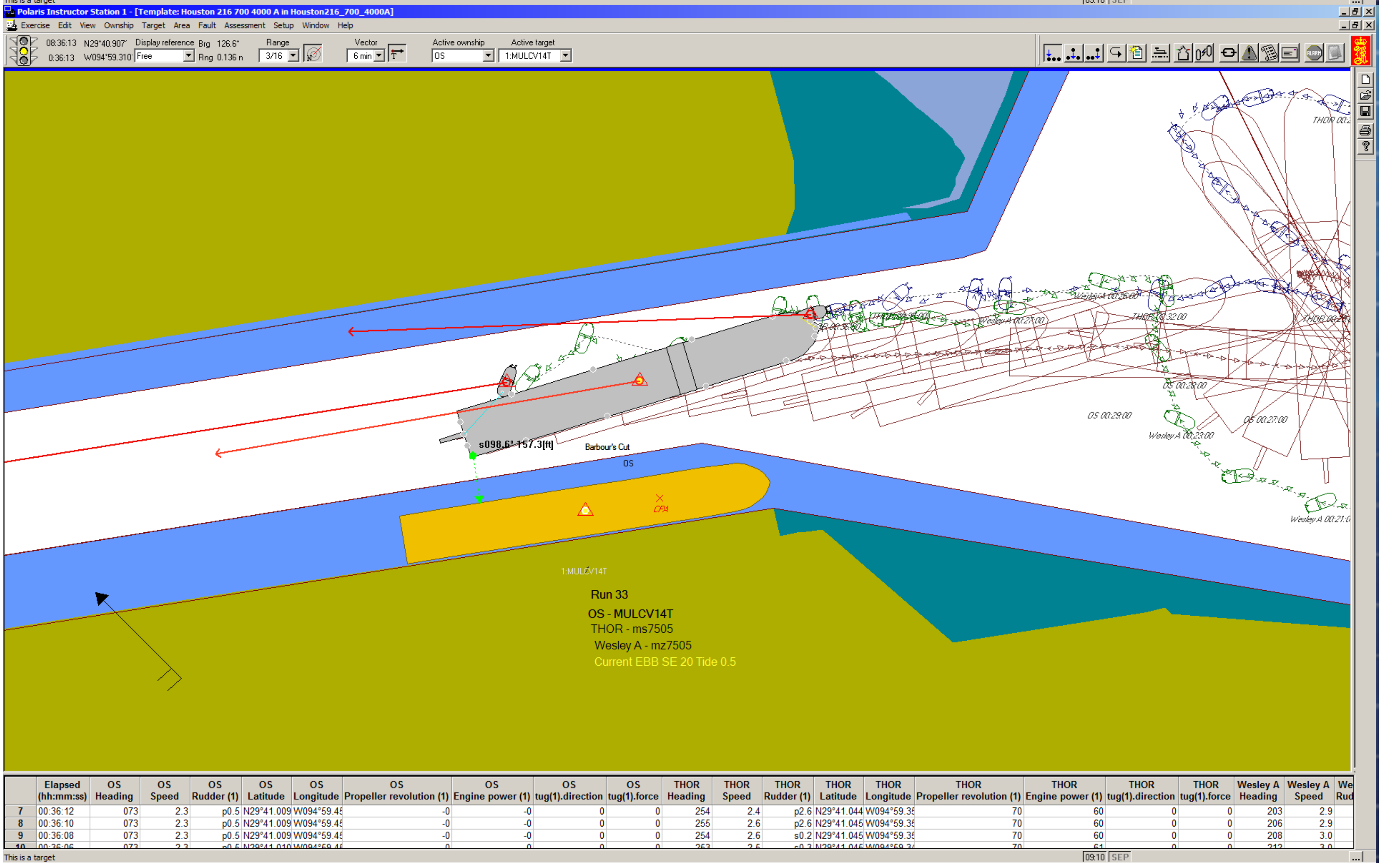
08:36:13 N29°40.907′ Display reference: Free Brg 126.6° Range: 3/16 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:36:13 W094°59.310′ Rng 0.136 n

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:36:12	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.4	p2.6	N29°41.044	W094°59.35	70	60	0	0	203	2.9
8	00:36:10	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	255	2.6	p2.6	N29°41.045	W094°59.35	70	60	0	0	206	2.9
9	00:36:08	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.6	s0.2	N29°41.045	W094°59.35	70	60	0	0	208	3.0

This is a target

09:10



Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

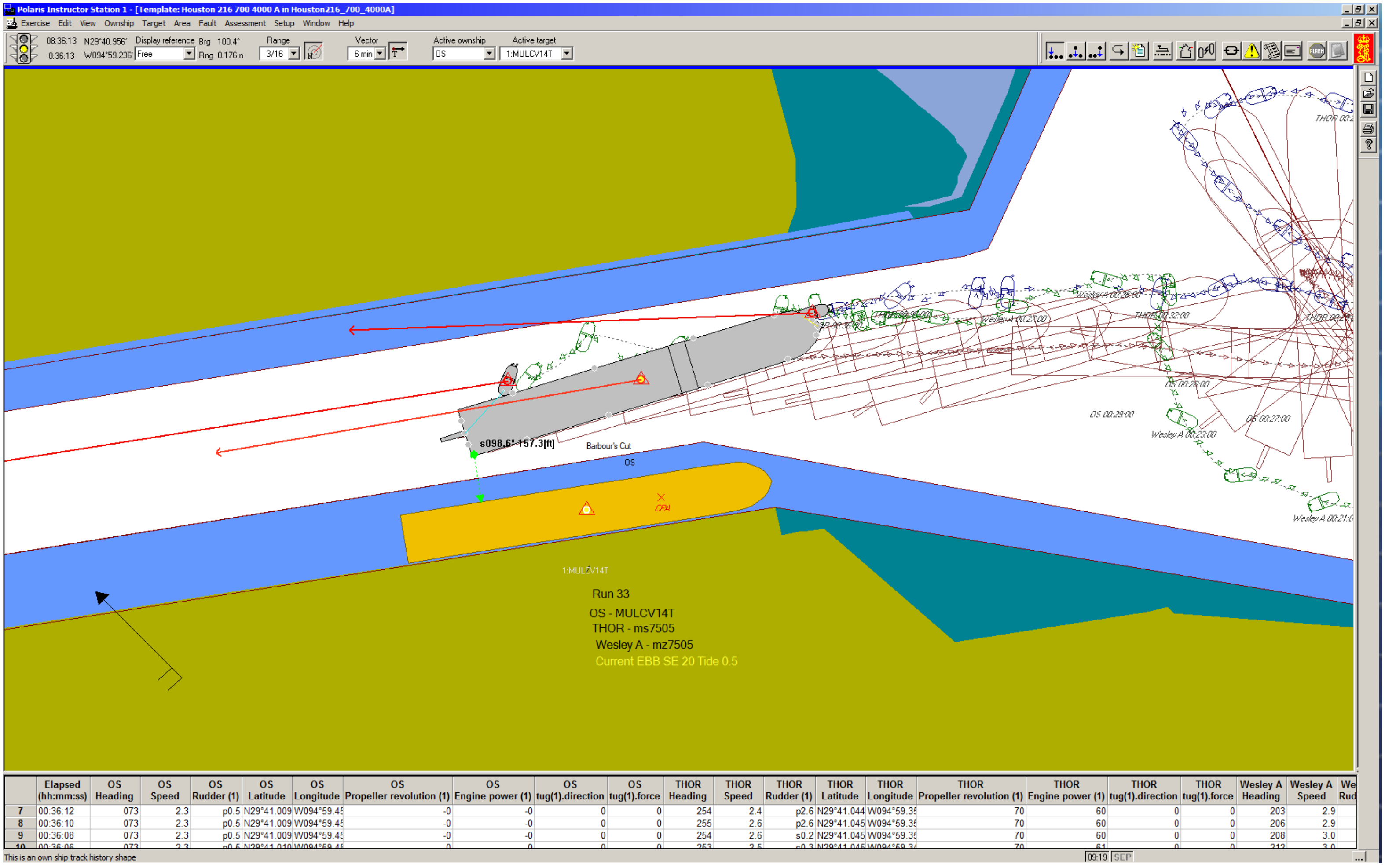
08:36:13 N29°40.907′ Display reference: Free Brg 126.6° Range: 3/16 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:36:13 W094°59.310′ Rng 0.136 n

Run 33
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:36:12	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.4	p2.6	N29°41.044	W094°59.35	70	60	0	0	203	2.9
8	00:36:10	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	255	2.6	p2.6	N29°41.045	W094°59.35	70	60	0	0	206	2.9
9	00:36:08	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.6	s0.2	N29°41.045	W094°59.35	70	60	0	0	208	3.0

This is a target

09:10



Polaris Instructor Station 1 - [Template: Houston 216 700 4000 A in Houston216_700_4000A]

08:36:13 N29°40.956'
0:36:13 W094°59.236'
Display reference: Free
Brg 100.4°
Rng 0.176 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 33

OS - MULCV14T

THOR - ms7505

Wesley A - mz7505

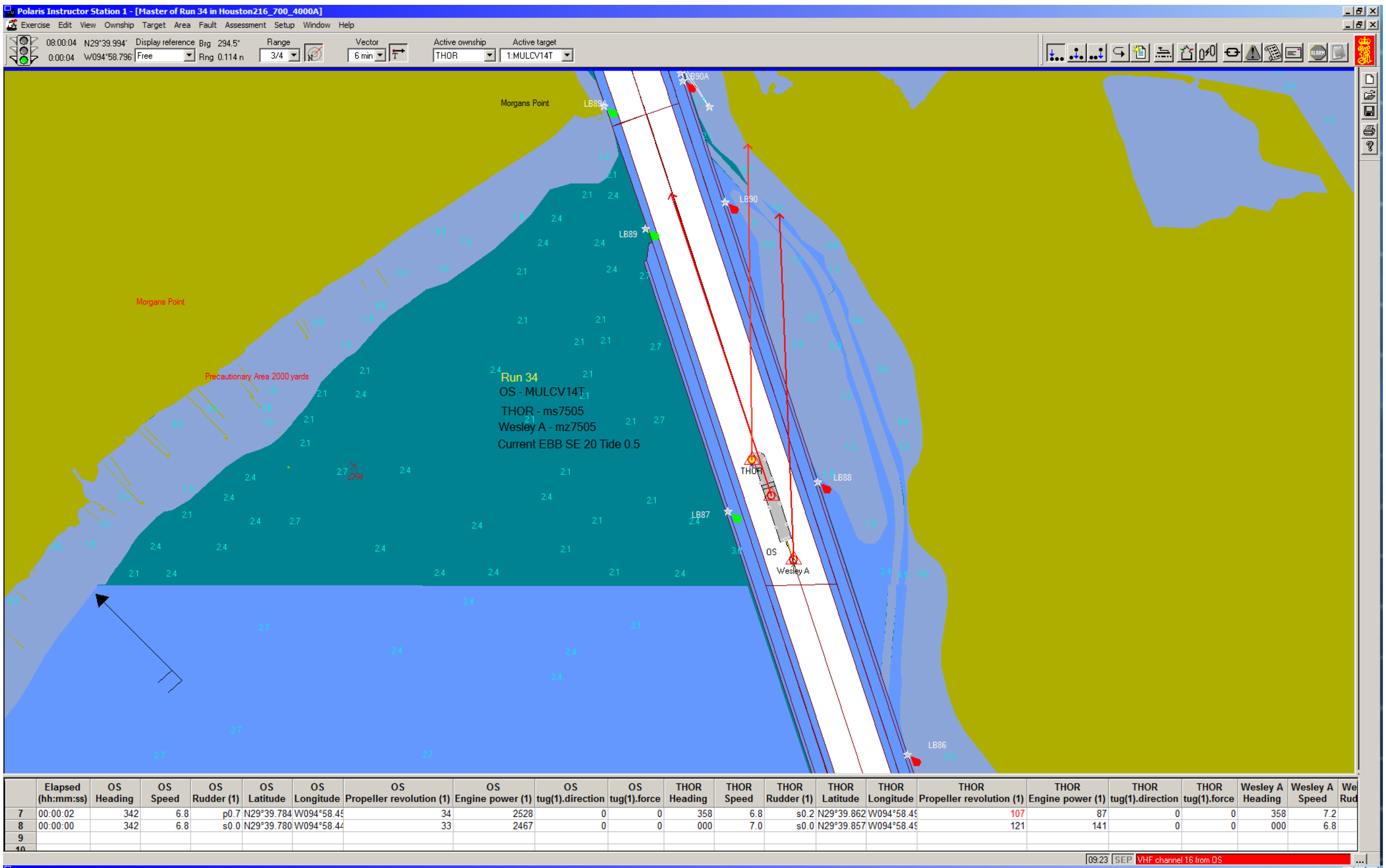
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:36:12	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.4	p2.6	N29°41.044	W094°59.35	70	60	0	0	203	2.9	
8	00:36:10	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	255	2.6	p2.6	N29°41.045	W094°59.35	70	60	0	0	206	2.9	
9	00:36:08	073	2.3	p0.5	N29°41.009	W094°59.45	-0	-0	0	0	254	2.6	s0.2	N29°41.045	W094°59.35	70	60	0	0	208	3.0	
10	00:36:06	073	2.3	p0.5	N29°41.010	W094°59.45	0	0	0	0	253	2.5	s0.3	N29°41.045	W094°59.34	70	61	0	0	212	3.0	

This is an own ship track history shape

09:19 SEP

Run 34



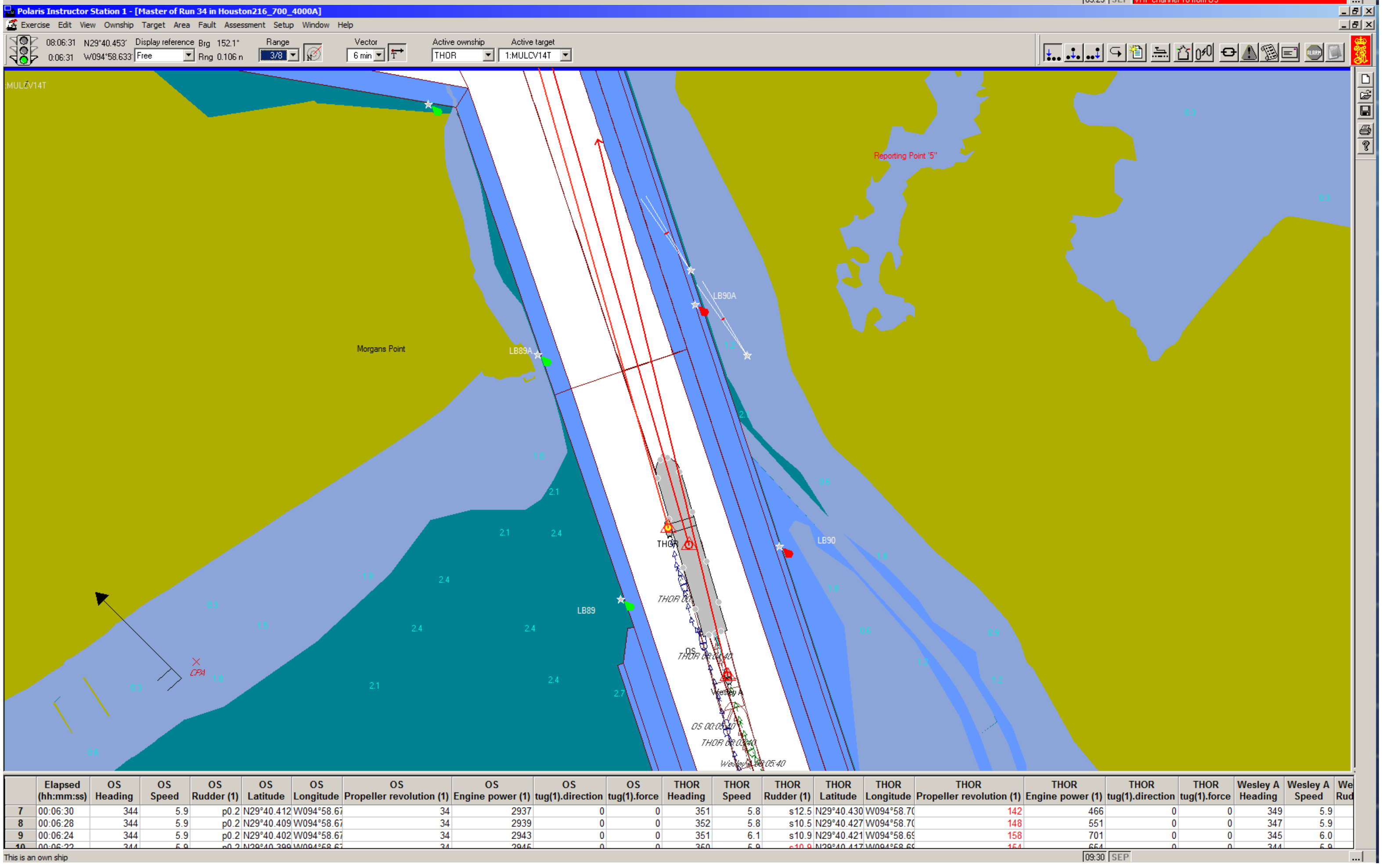
Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

08:00:04 N29°39.994′ Display reference Brg 294.5°
0:00:04 W094°58.796′ Free Rng 0.114 n
Range 3/4
Vector 6 min
Active ownship THOR
Active target 1:MULCV14T

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:00:02	342	6.8	p0.7	N29°39.784	W094°58.45	34	2528	0	0	358	6.8	s0.2	N29°39.862	W094°58.49	107	87	0	0	358	7.2	
8	00:00:00	342	6.8	s0.0	N29°39.780	W094°58.44	33	2467	0	0	000	7.0	s0.0	N29°39.857	W094°58.49	121	141	0	0	000	6.8	
9																						
10																						

09:23 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

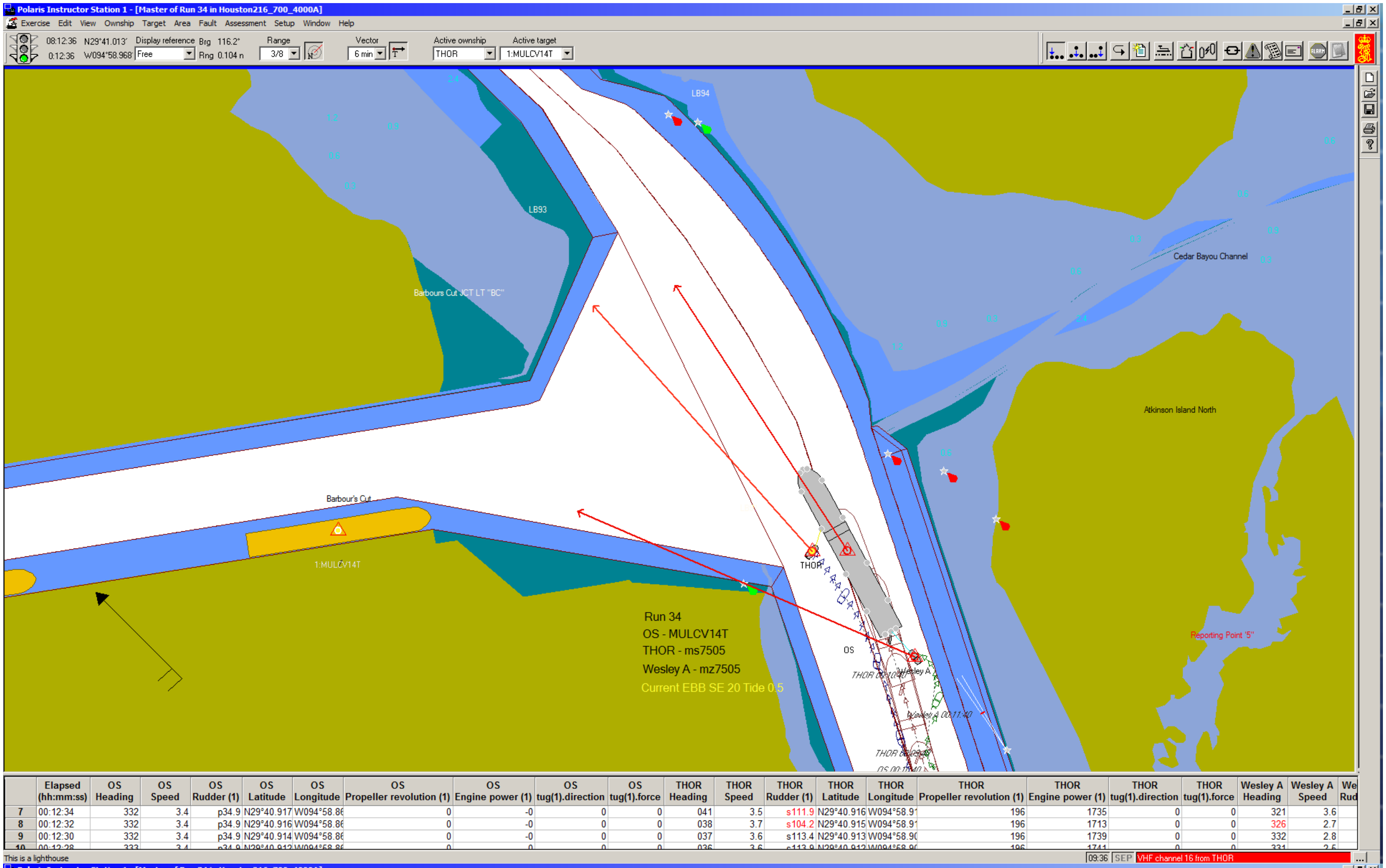
08:06:31 N29°40.453′ Display reference Brg 152.1°
0:06:31 W094°58.633′ Free Rng 0.106 n
Range 3/8
Vector 6 min
Active ownship THOR
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:06:30	344	5.9	p0.2	N29°40.412	W094°58.67	34	2937	0	0	351	5.8	s12.5	N29°40.430	W094°58.70	142	466	0	0	349	5.9	
8	00:06:28	344	5.9	p0.2	N29°40.409	W094°58.67	34	2939	0	0	352	5.8	s10.5	N29°40.427	W094°58.70	148	551	0	0	347	5.9	
9	00:06:24	344	5.9	p0.2	N29°40.402	W094°58.67	34	2943	0	0	351	6.1	s10.9	N29°40.421	W094°58.69	158	701	0	0	345	6.0	
10	00:06:22	344	5.9	p0.2	N29°40.399	W094°58.67	34	2945	0	0	350	5.9	s10.9	N29°40.417	W094°58.69	154	654	0	0	344	5.9	

This is an own ship

09:30 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

08:12:36 N29°41.013' Display reference: Free Brg 116.2° Rng 0.104 n Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T

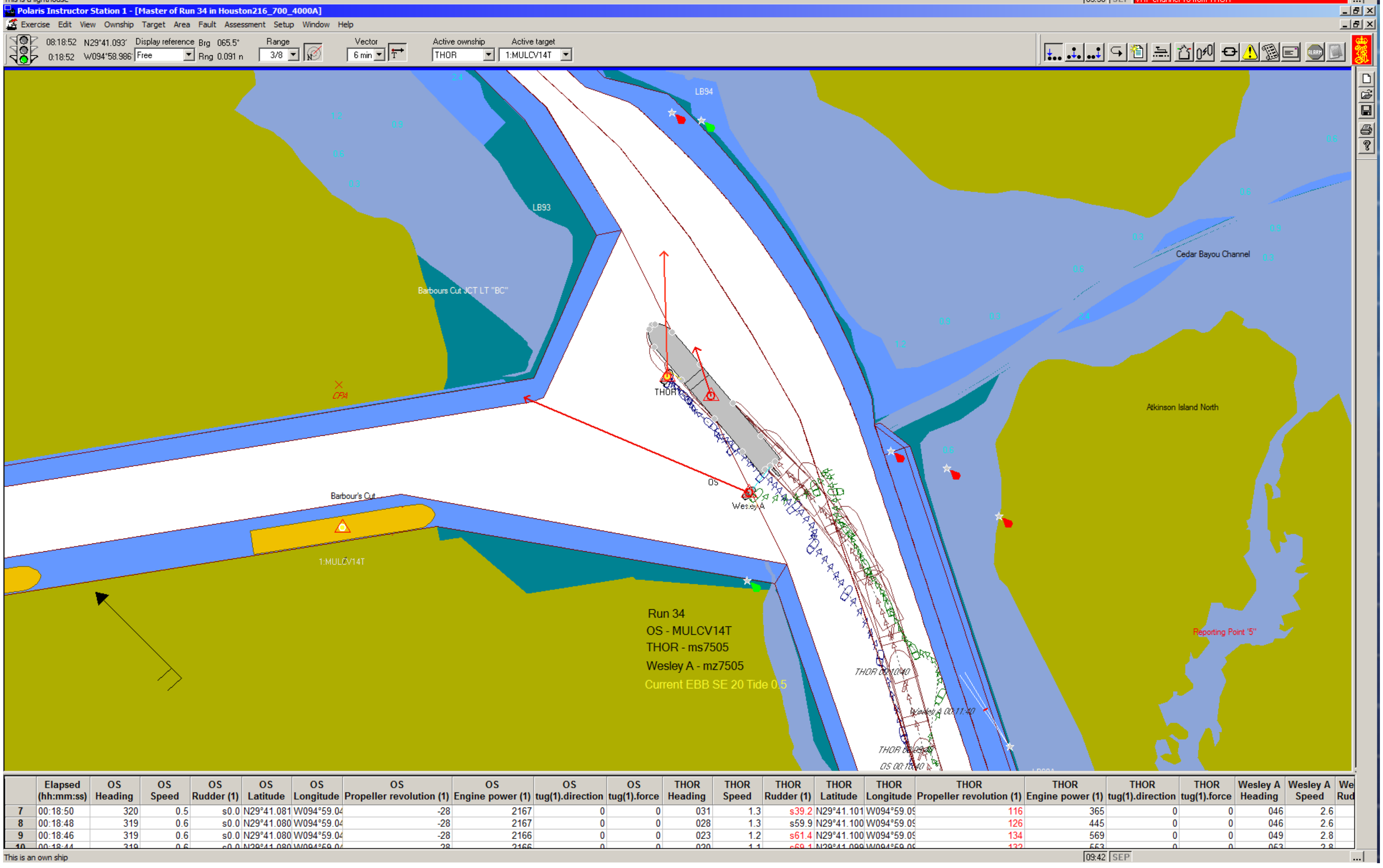
0:12:36 W094°58.968'

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:12:34	332	3.4	p34.9	N29°40.917	W094°58.86	0	-0	0	0	041	3.5	s111.9	N29°40.916	W094°58.91	196	1735	0	0	321	3.6
8	00:12:32	332	3.4	p34.9	N29°40.916	W094°58.86	0	-0	0	0	038	3.7	s104.2	N29°40.915	W094°58.91	196	1713	0	0	326	2.7
9	00:12:30	332	3.4	p34.9	N29°40.914	W094°58.86	0	-0	0	0	037	3.6	s113.4	N29°40.913	W094°58.90	196	1739	0	0	332	2.8

This is a lighthouse

09:36 SEP VHF channel 16 from THOR



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

08:18:52 N29°41.093' Display reference: Free Brg 065.5° Rng 0.091 n Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T

0:18:52 W094°58.986'

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:18:50	320	0.5	s0.0	N29°41.081	W094°59.04	-28	2167	0	0	031	1.3	s39.2	N29°41.101	W094°59.09	116	365	0	0	046	2.6
8	00:18:48	319	0.6	s0.0	N29°41.080	W094°59.04	-28	2167	0	0	028	1.3	s59.9	N29°41.100	W094°59.09	126	445	0	0	046	2.6
9	00:18:46	319	0.6	s0.0	N29°41.080	W094°59.04	-28	2166	0	0	023	1.2	s61.4	N29°41.100	W094°59.09	134	569	0	0	049	2.8

This is an own ship

09:42 SEP

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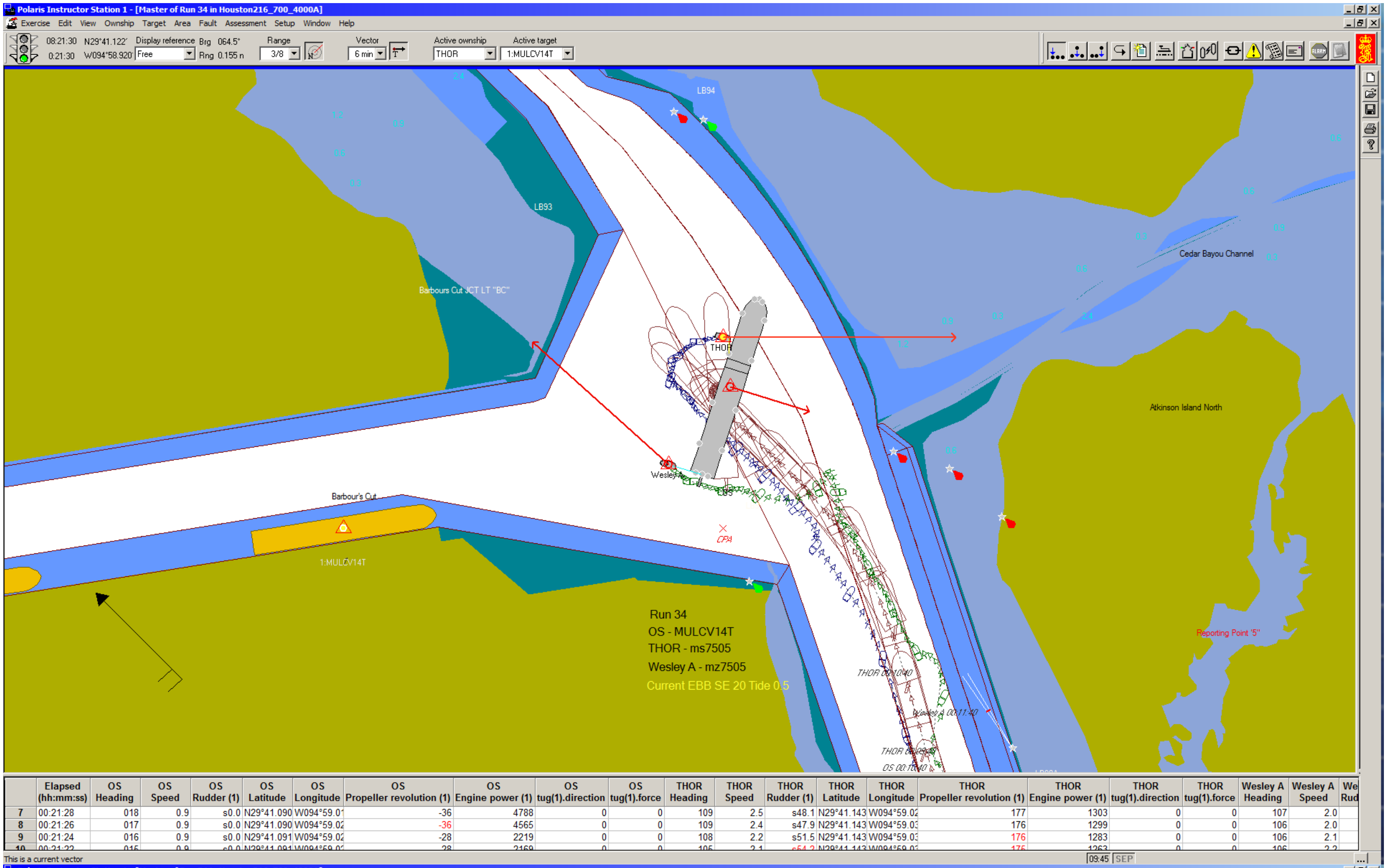
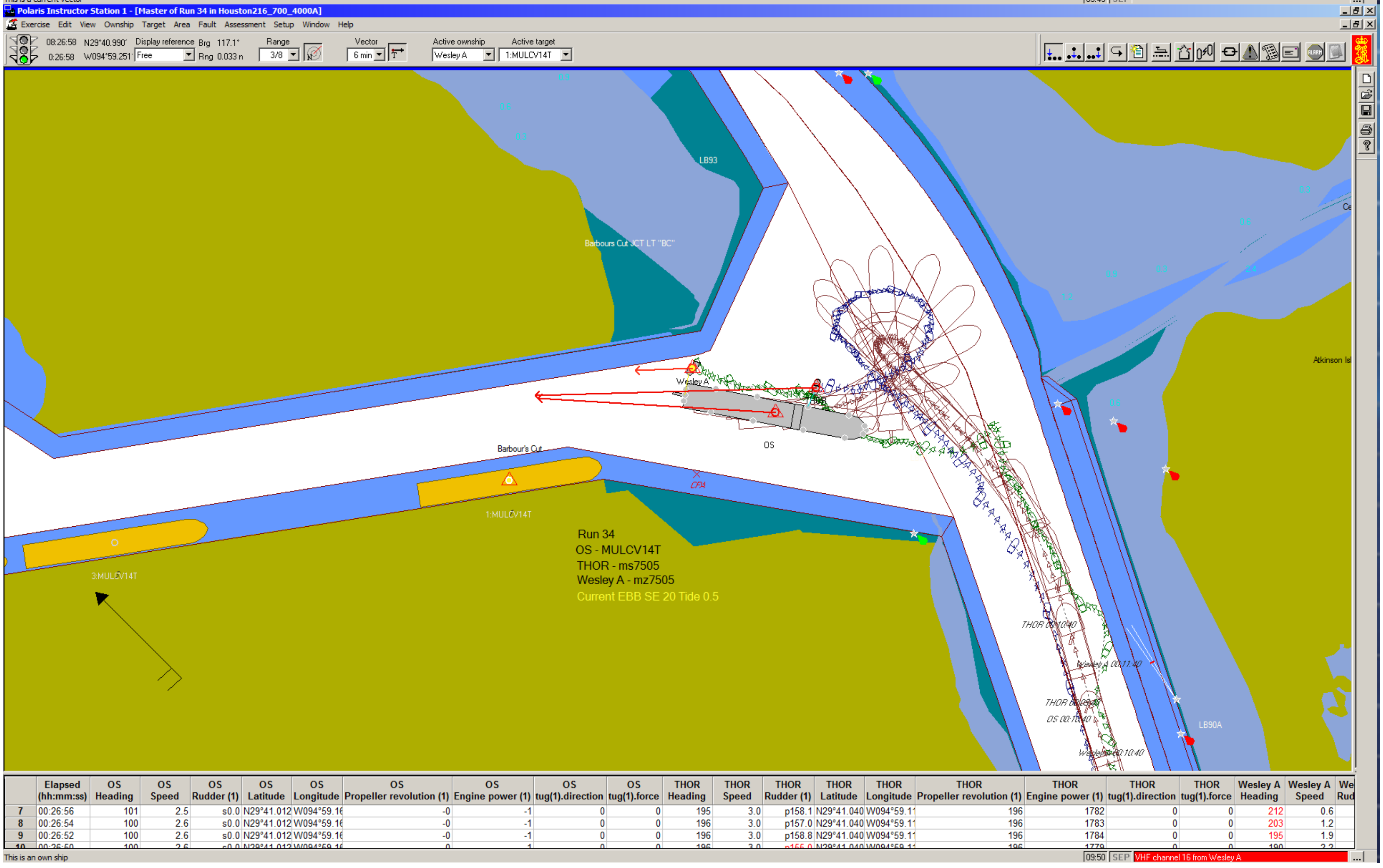


08:21:30 N29°41.122′ Display reference: Free Brg 064.5° Rng 0.155 n
0:21:30 W094°58.920′
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:21:28	018	0.9	s0.0	N29°41.090	W094°59.0	-36	4788	0	0	109	2.5	s48.1	N29°41.143	W094°59.02	177	1303	0	0	107	2.0	
8	00:21:26	017	0.9	s0.0	N29°41.090	W094°59.02	-36	4565	0	0	109	2.4	s47.9	N29°41.143	W094°59.0	176	1299	0	0	106	2.0	
9	00:21:24	016	0.9	s0.0	N29°41.091	W094°59.02	-28	2219	0	0	108	2.2	s51.5	N29°41.143	W094°59.0	176	1283	0	0	106	2.1	
10	00:21:22	015	0.9	s0.0	N29°41.091	W094°59.0	28	2169	0	0	105	2.1	s54.2	N29°41.143	W094°59.0	175	1263	0	0	106	2.2	

This is a current vector



08:26:58 N29°40.990′ Display reference: Free Brg 117.1° Rng 0.033 n
0:26:58 W094°59.251′
Range: 3/8
Vector: 6 min
Active ownship: Wesley A
Active target: 1:MULCV14T

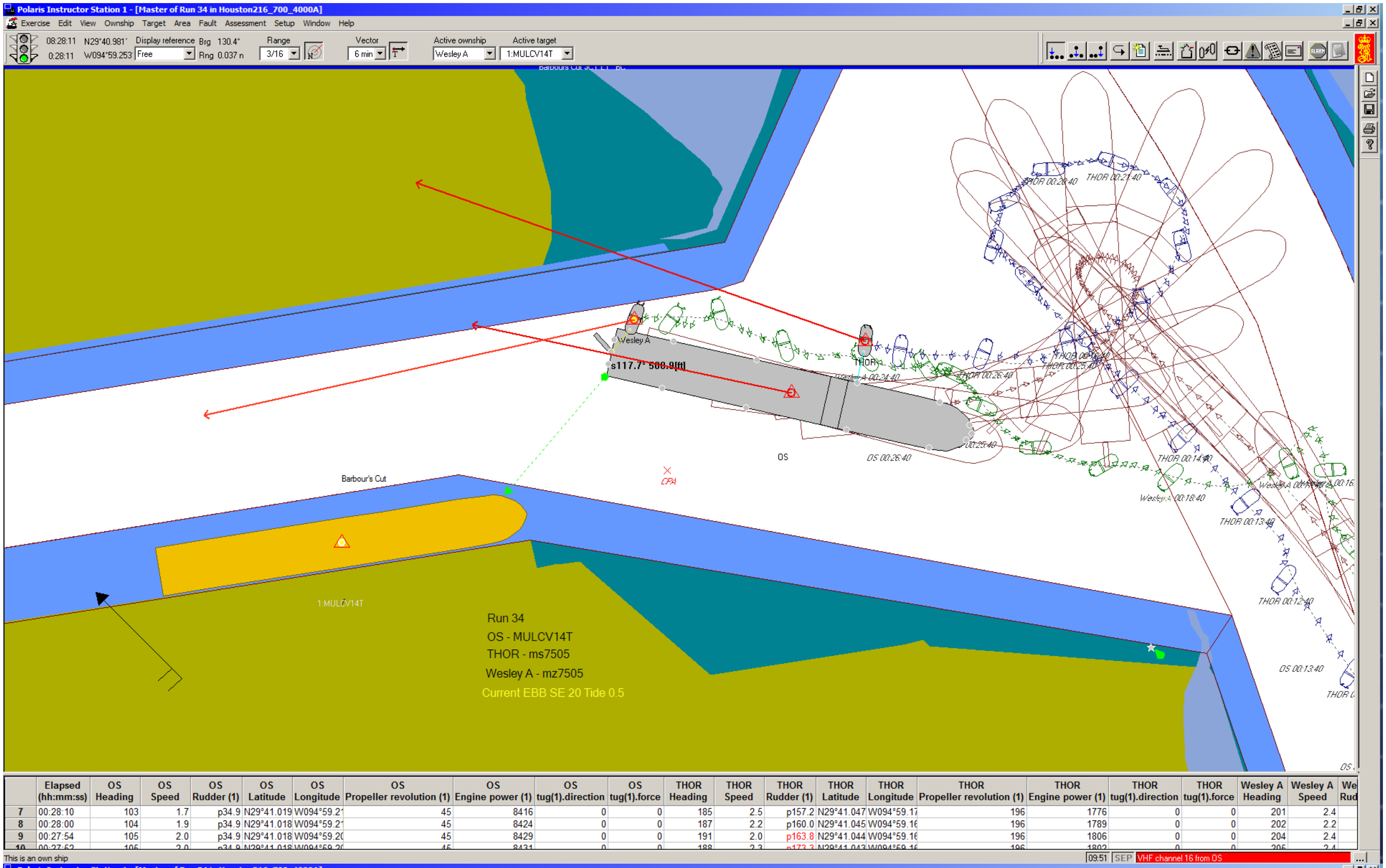
Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:26:56	101	2.5	s0.0	N29°41.012	W094°59.16	-0	-1	0	0	195	3.0	p158.1	N29°41.040	W094°59.1	196	1782	0	0	212	0.6	
8	00:26:54	100	2.6	s0.0	N29°41.012	W094°59.16	-0	-1	0	0	196	3.0	p157.0	N29°41.040	W094°59.1	196	1783	0	0	203	1.2	
9	00:26:52	100	2.6	s0.0	N29°41.012	W094°59.16	-0	-1	0	0	196	3.0	p158.8	N29°41.040	W094°59.1	196	1784	0	0	195	1.9	
10	00:26:50	100	2.6	s0.0	N29°41.012	W094°59.16	0	1	0	0	196	3.0	p155.0	N29°41.040	W094°59.1	196	1779	0	0	190	2.2	

This is an own ship

VHF channel 16 from Wesley A

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

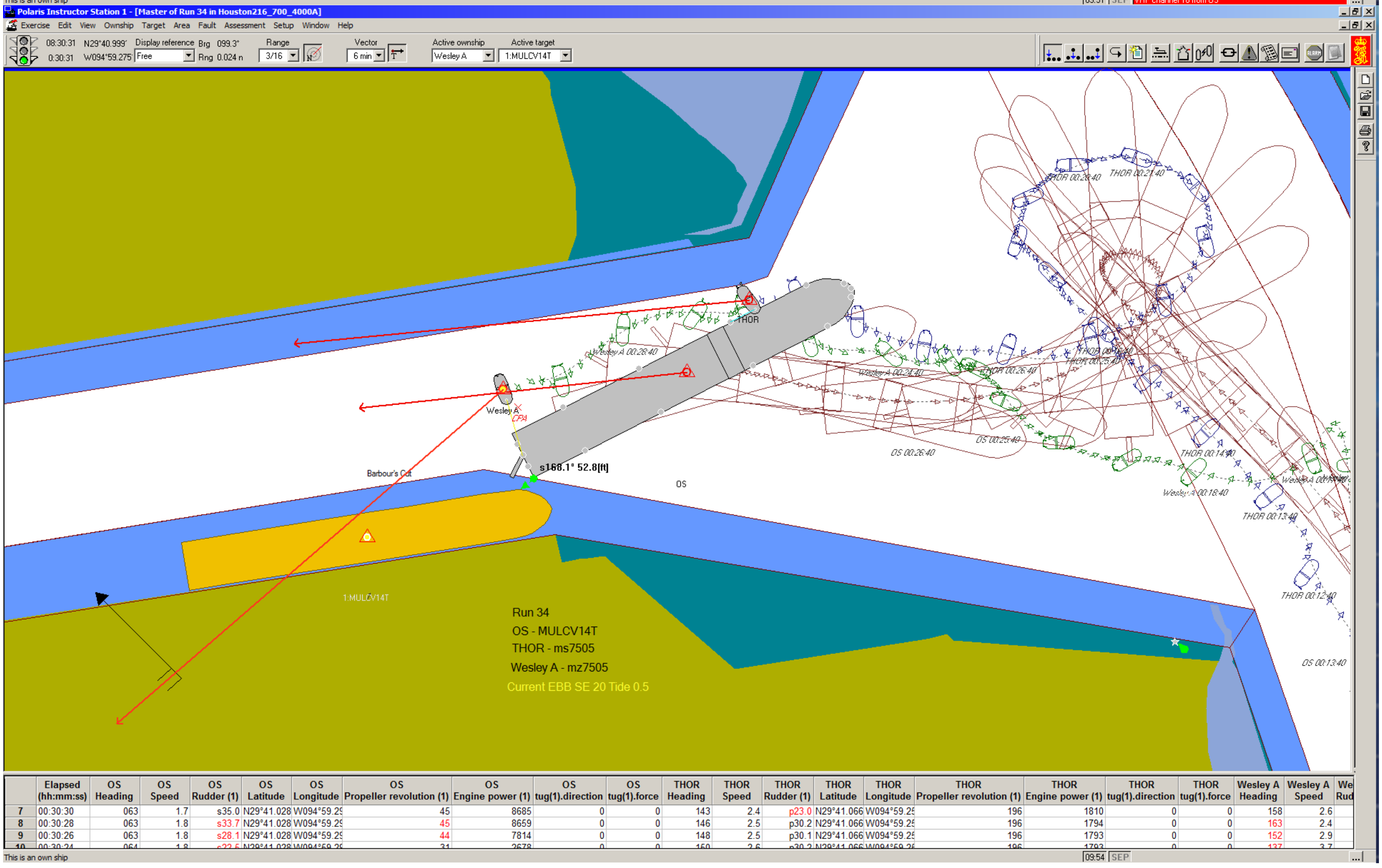
08:28:11 N29°40.981′ Display reference Free Brg 130.4° Rng 0.037 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T
0:28:11 W094°59.253′

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:28:10	103	1.7	p34.9	N29°41.019	W094°59.21	45	8416	0	0	185	2.5	p157.2	N29°41.047	W094°59.17	196	1776	0	0	201	2.4	
8	00:28:00	104	1.9	p34.9	N29°41.018	W094°59.21	45	8424	0	0	187	2.2	p160.0	N29°41.045	W094°59.16	196	1789	0	0	202	2.2	
9	00:27:54	105	2.0	p34.9	N29°41.018	W094°59.20	45	8429	0	0	191	2.0	p163.8	N29°41.044	W094°59.16	196	1806	0	0	204	2.4	

This is an own ship

09:51 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

08:30:31 N29°40.999′ Display reference Free Brg 099.3° Rng 0.024 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T
0:30:31 W094°59.275′

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:30:30	063	1.7	s35.0	N29°41.028	W094°59.29	45	8685	0	0	143	2.4	p23.0	N29°41.066	W094°59.25	196	1810	0	0	158	2.6	
8	00:30:28	063	1.8	s33.7	N29°41.028	W094°59.29	45	8659	0	0	146	2.5	p30.2	N29°41.066	W094°59.25	196	1794	0	0	163	2.4	
9	00:30:26	063	1.8	s28.1	N29°41.028	W094°59.29	44	7814	0	0	148	2.5	p30.1	N29°41.066	W094°59.25	196	1793	0	0	152	2.9	

This is an own ship

09:54 SEP

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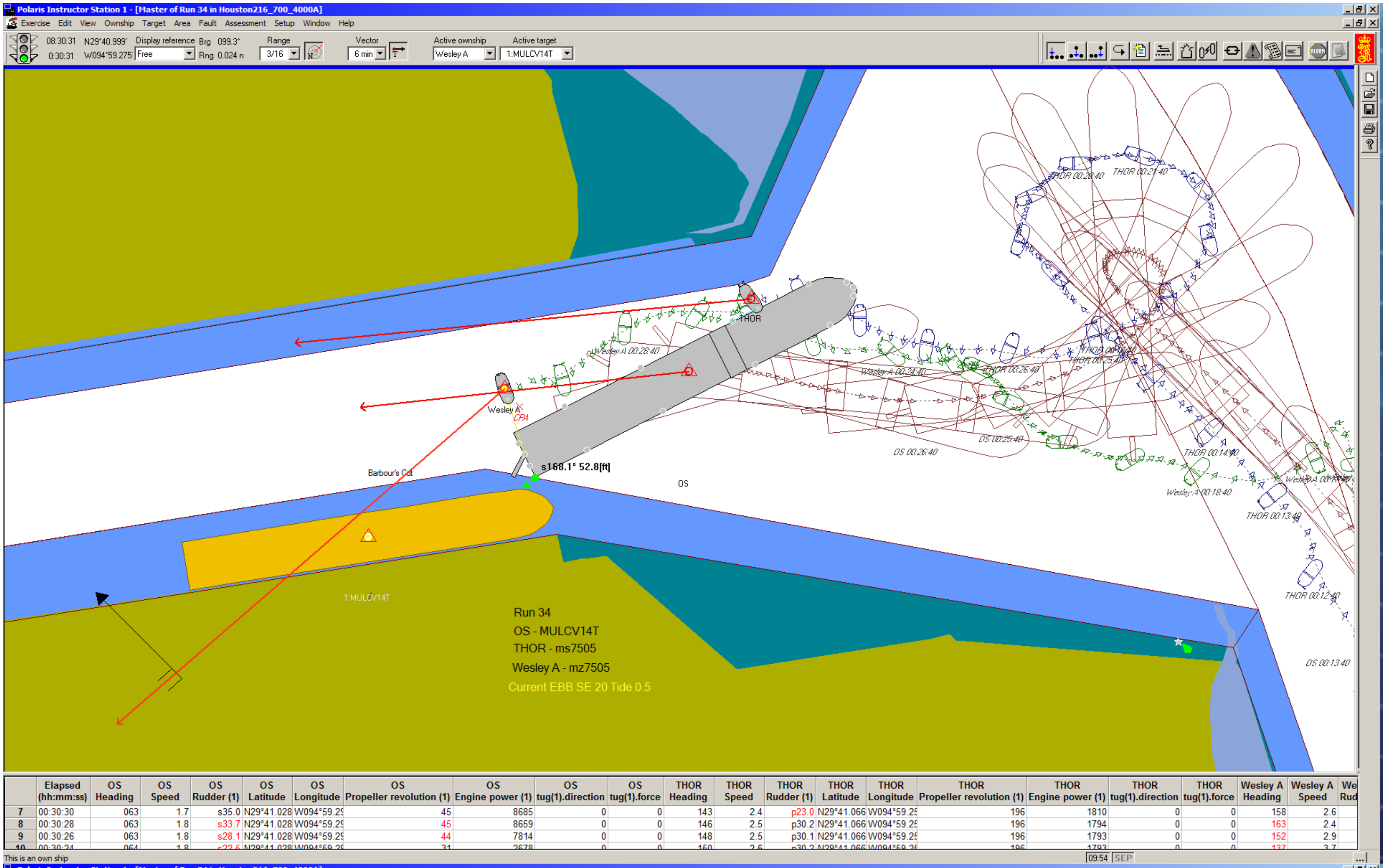


Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

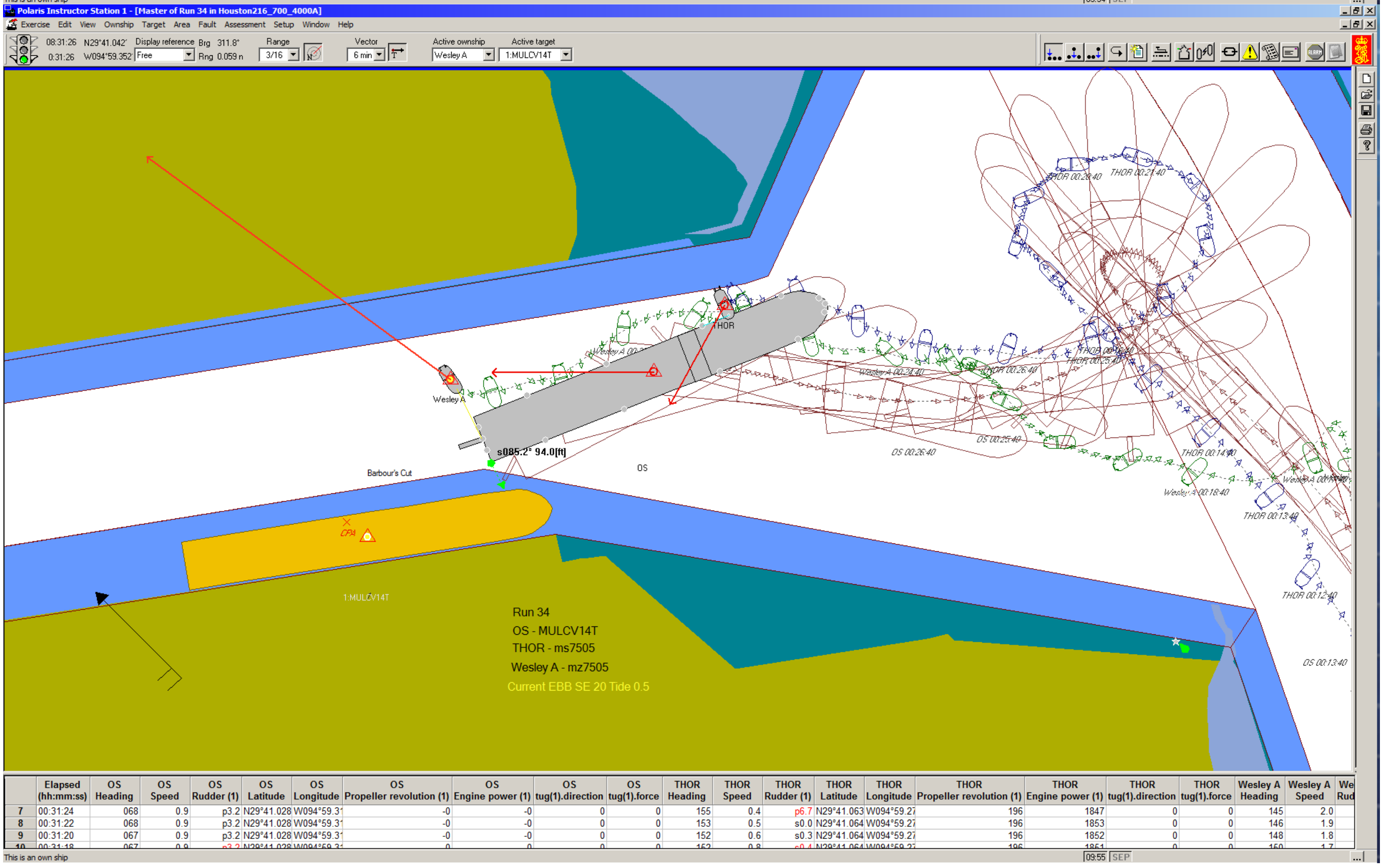
08:30:31 N29°40.999' Display reference Free Brg 099.3° Rng 0.024 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:30:30	063	1.7	s35.0	N29°41.028	W094°59.29	45	8685	0	0	143	2.4	p23.0	N29°41.066	W094°59.25	196	1810	0	0	158	2.6	
8	00:30:28	063	1.8	s33.7	N29°41.028	W094°59.29	45	8659	0	0	146	2.5	p30.2	N29°41.066	W094°59.25	196	1794	0	0	163	2.4	
9	00:30:26	063	1.8	s28.1	N29°41.028	W094°59.29	44	7814	0	0	148	2.5	p30.1	N29°41.066	W094°59.25	196	1793	0	0	152	2.9	
10	00:30:24	064	1.8	s22.5	N29°41.028	W094°59.29	31	2678	0	0	150	2.6	p30.2	N29°41.066	W094°59.26	196	1793	0	0	137	3.7	

This is an own ship

09:54 SEP



Polaris Instructor Station 1 - [Master of Run 34 in Houston216_700_4000A]

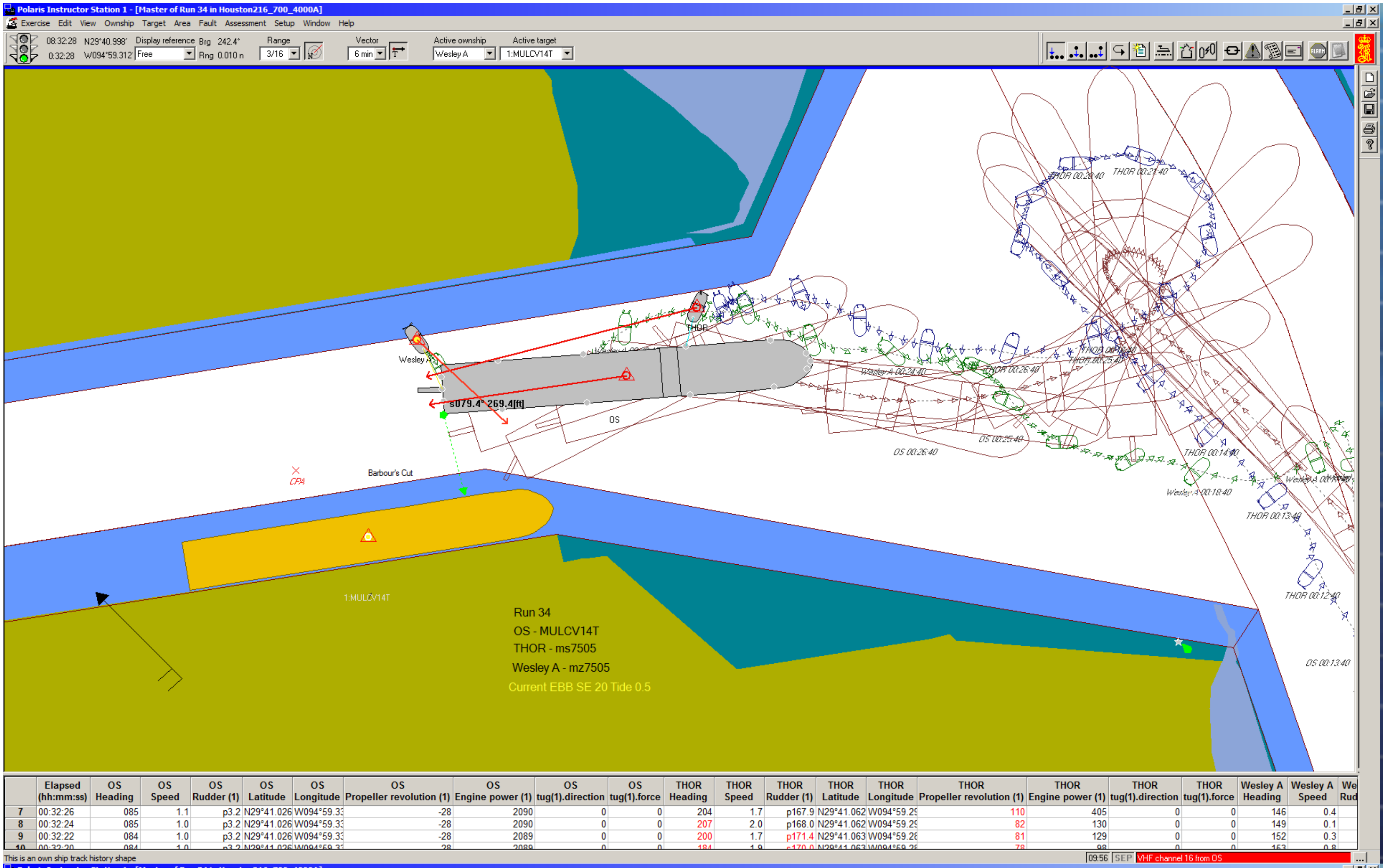
08:31:26 N29°41.042' Display reference Free Brg 311.8° Rng 0.059 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:31:24	068	0.9	p3.2	N29°41.028	W094°59.31	-0	-0	0	0	155	0.4	p6.7	N29°41.063	W094°59.27	196	1847	0	0	145	2.0	
8	00:31:22	068	0.9	p3.2	N29°41.028	W094°59.31	-0	-0	0	0	153	0.5	s0.0	N29°41.064	W094°59.27	196	1853	0	0	146	1.9	
9	00:31:20	067	0.9	p3.2	N29°41.028	W094°59.31	-0	-0	0	0	152	0.6	s0.3	N29°41.064	W094°59.27	196	1852	0	0	148	1.8	
10	00:31:18	067	0.9	p3.2	N29°41.028	W094°59.31	0	0	0	0	152	0.8	s0.4	N29°41.064	W094°59.27	196	1851	0	0	150	1.7	

This is an own ship

09:55 SEP



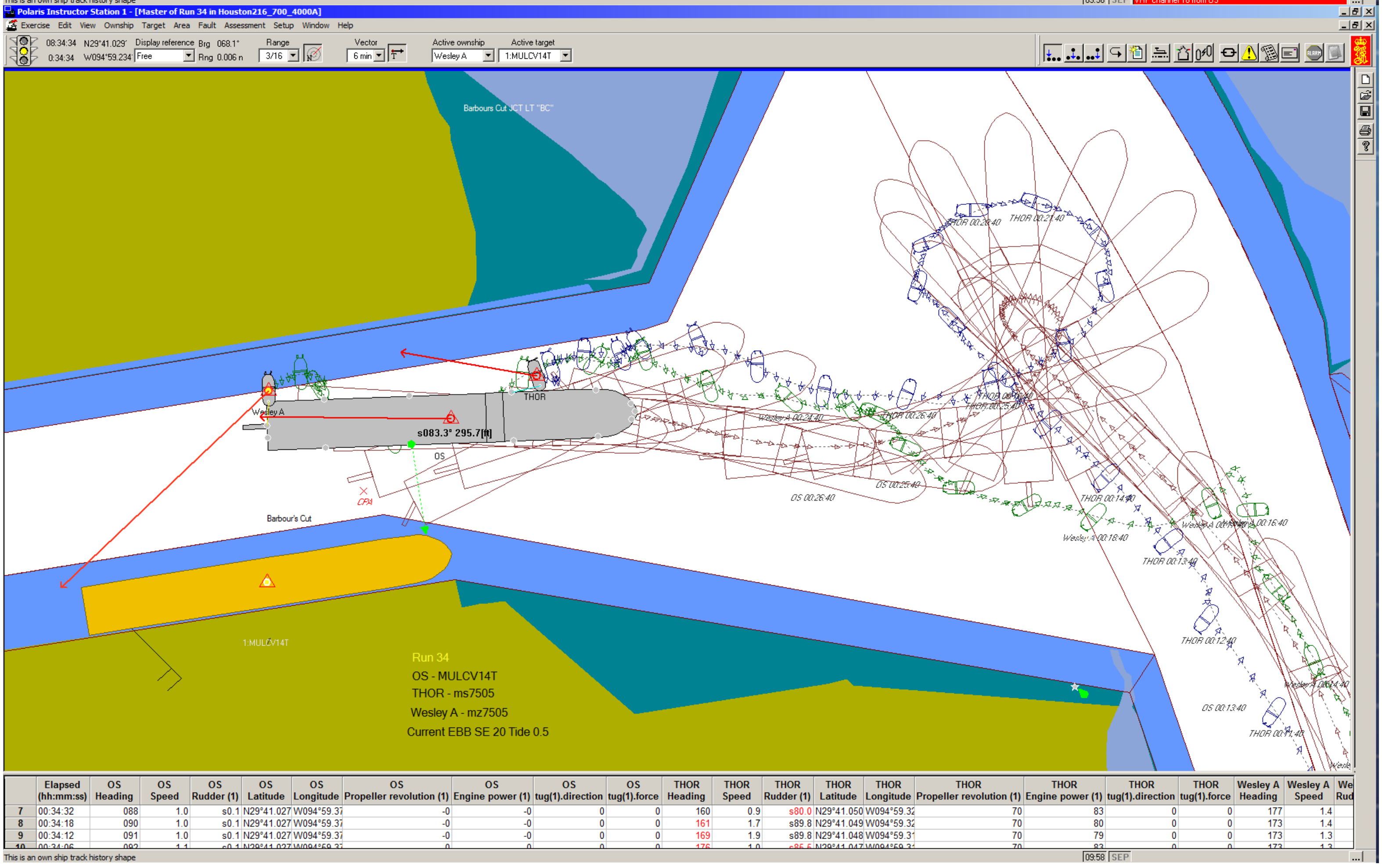
08:32:28 N29°40.998' Display reference Free Brg 242.4° Rng 0.010 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T
0:32:28 W094°59.312'

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:32:26	085	1.1	p3.2	N29°41.026	W094°59.33	-28	2090	0	0	204	1.7	p167.9	N29°41.062	W094°59.29	110	405	0	0	146	0.4	
8	00:32:24	085	1.0	p3.2	N29°41.026	W094°59.33	-28	2090	0	0	207	2.0	p168.0	N29°41.062	W094°59.29	82	130	0	0	149	0.1	
9	00:32:22	084	1.0	p3.2	N29°41.026	W094°59.33	-28	2089	0	0	200	1.7	p171.4	N29°41.063	W094°59.28	81	129	0	0	152	0.3	
10	00:32:20	084	1.0	p3.2	N29°41.026	W094°59.33	-28	2089	0	0	184	1.9	s170.0	N29°41.063	W094°59.28	78	98	0	0	153	0.8	

This is an own ship track history shape

09:56 SEP VHF channel 16 from OS



08:34:34 N29°41.029' Display reference Free Brg 068.1° Rng 0.006 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T
0:34:34 W094°59.234'

Run 34
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB SE 20 Tide 0.5

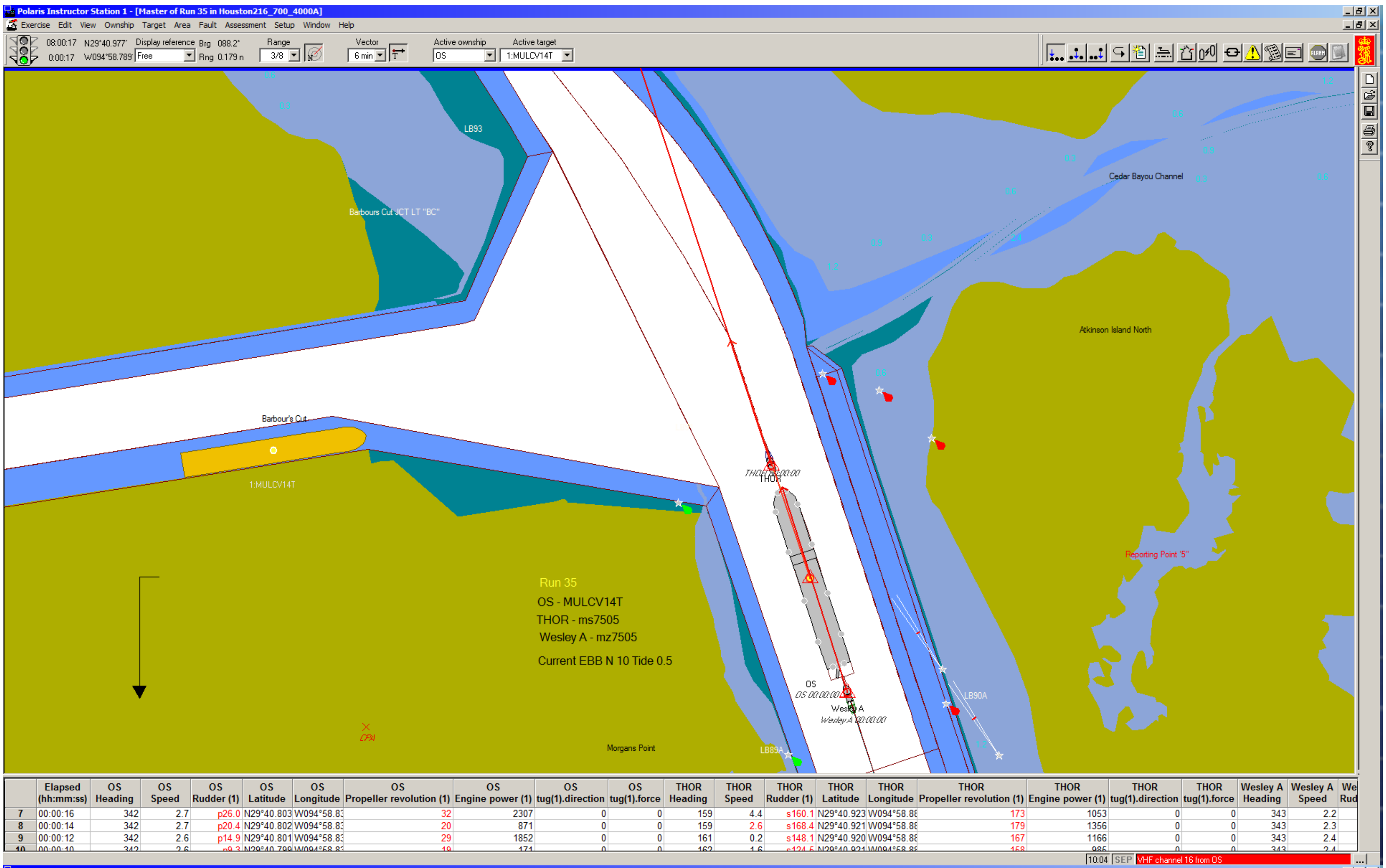
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:34:32	088	1.0	s0.1	N29°41.027	W094°59.37	-0	-0	0	0	160	0.9	s80.0	N29°41.050	W094°59.32	70	83	0	0	177	1.4	
8	00:34:18	090	1.0	s0.1	N29°41.027	W094°59.37	-0	-0	0	0	161	1.7	s89.8	N29°41.049	W094°59.32	70	80	0	0	173	1.4	
9	00:34:12	091	1.0	s0.1	N29°41.027	W094°59.37	-0	-0	0	0	169	1.9	s89.8	N29°41.048	W094°59.31	70	79	0	0	173	1.3	
10	00:34:06	092	1.1	s0.1	N29°41.027	W094°59.37	0	0	0	0	176	1.0	s85.5	N29°41.047	W094°59.31	70	83	0	0	173	1.3	

This is an own ship track history shape

09:58 SEP

June 26, 2019

Run 35



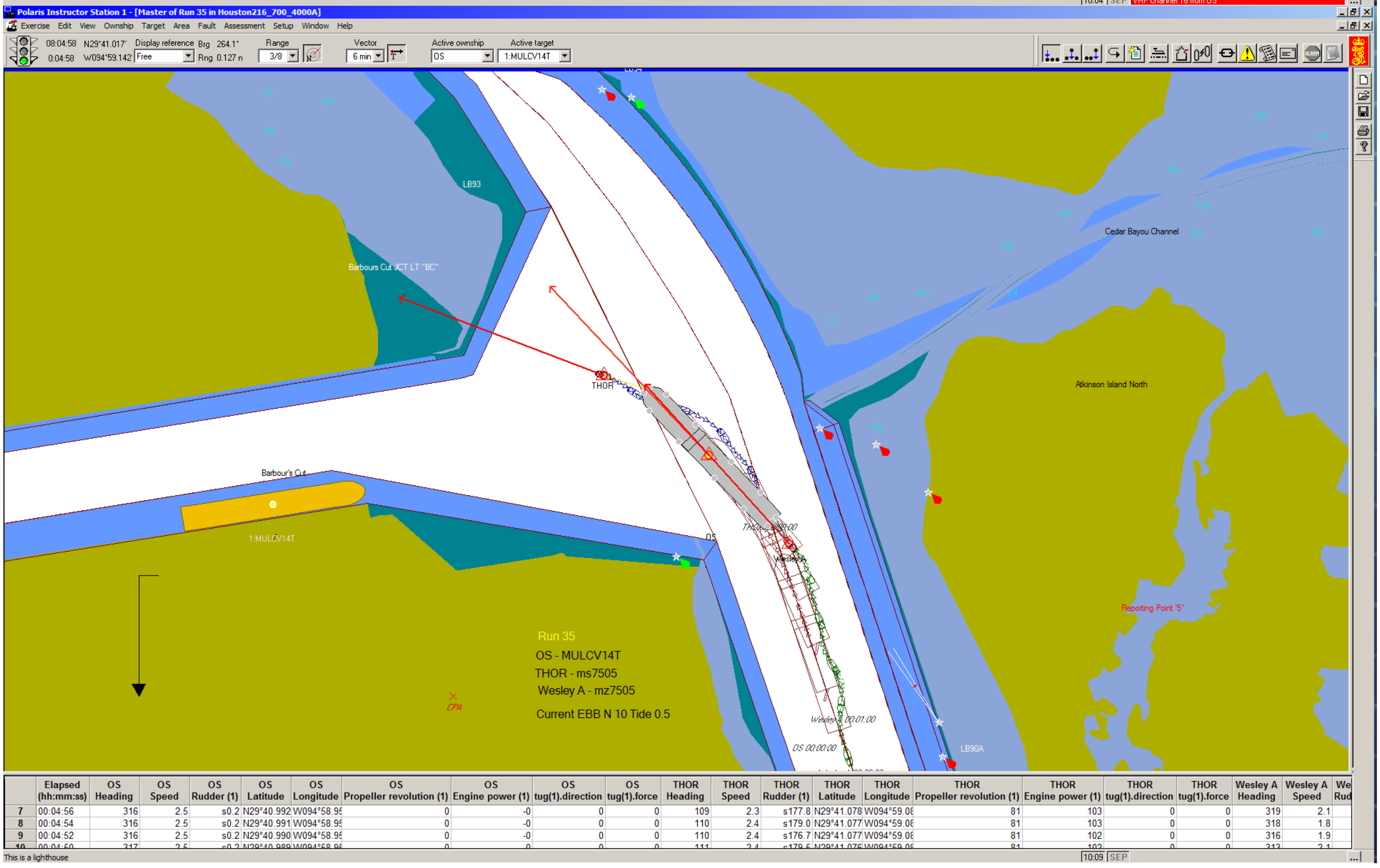
08:00:17 N29°40.977′ Display reference: Free Brg 088.2° Rng 0.179 n
0:00:17 W094°58.789′
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

THOR 00:00:00
OS 00:00:00
Wesley A 00:00:00

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:00:16	342	2.7	p26.0	N29°40.803	W094°58.83	32	2307	0	0	159	4.4	s160.1	N29°40.923	W094°58.88	173	1053	0	0	343	2.2	
8	00:00:14	342	2.7	p20.4	N29°40.802	W094°58.83	20	871	0	0	159	2.6	s168.4	N29°40.921	W094°58.88	179	1356	0	0	343	2.3	
9	00:00:12	342	2.6	p14.9	N29°40.801	W094°58.83	29	1852	0	0	161	0.2	s148.1	N29°40.920	W094°58.88	167	1166	0	0	343	2.4	
10	00:00:10	342	2.6	p9.3	N29°40.799	W094°58.83	19	171	0	0	162	1.6	s124.5	N29°40.921	W094°58.88	168	985	0	0	343	2.4	

10:04 SEP VHF channel 16 from OS



08:04:58 N29°41.017′ Display reference: Free Brg 264.1° Rng 0.127 n
0:04:58 W094°59.142′
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

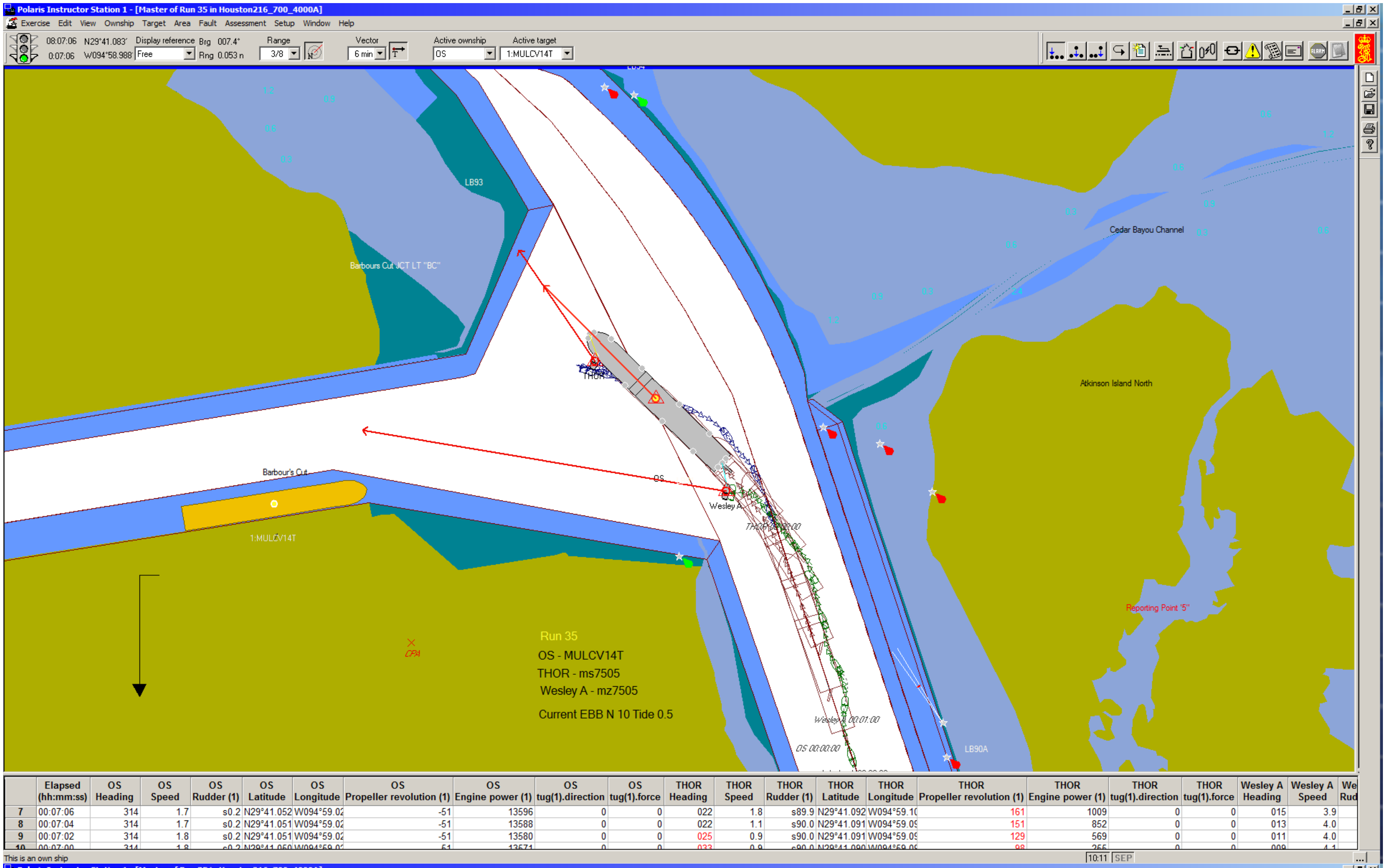
Wesley A 00:01:00
OS 00:00:00

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:04:56	316	2.5	s0.2	N29°40.992	W094°58.95	0	-0	0	0	109	2.3	s177.8	N29°41.078	W094°59.08	81	103	0	0	319	2.1	
8	00:04:54	316	2.5	s0.2	N29°40.991	W094°58.95	0	-0	0	0	110	2.4	s179.0	N29°41.077	W094°59.08	81	103	0	0	318	1.8	
9	00:04:52	316	2.5	s0.2	N29°40.990	W094°58.95	0	-0	0	0	110	2.4	s176.7	N29°41.077	W094°59.08	81	102	0	0	316	1.9	
10	00:04:50	317	2.5	s0.2	N29°40.989	W094°58.96	0	0	0	0	111	2.4	s179.5	N29°41.076	W094°59.08	81	102	0	0	313	2.1	

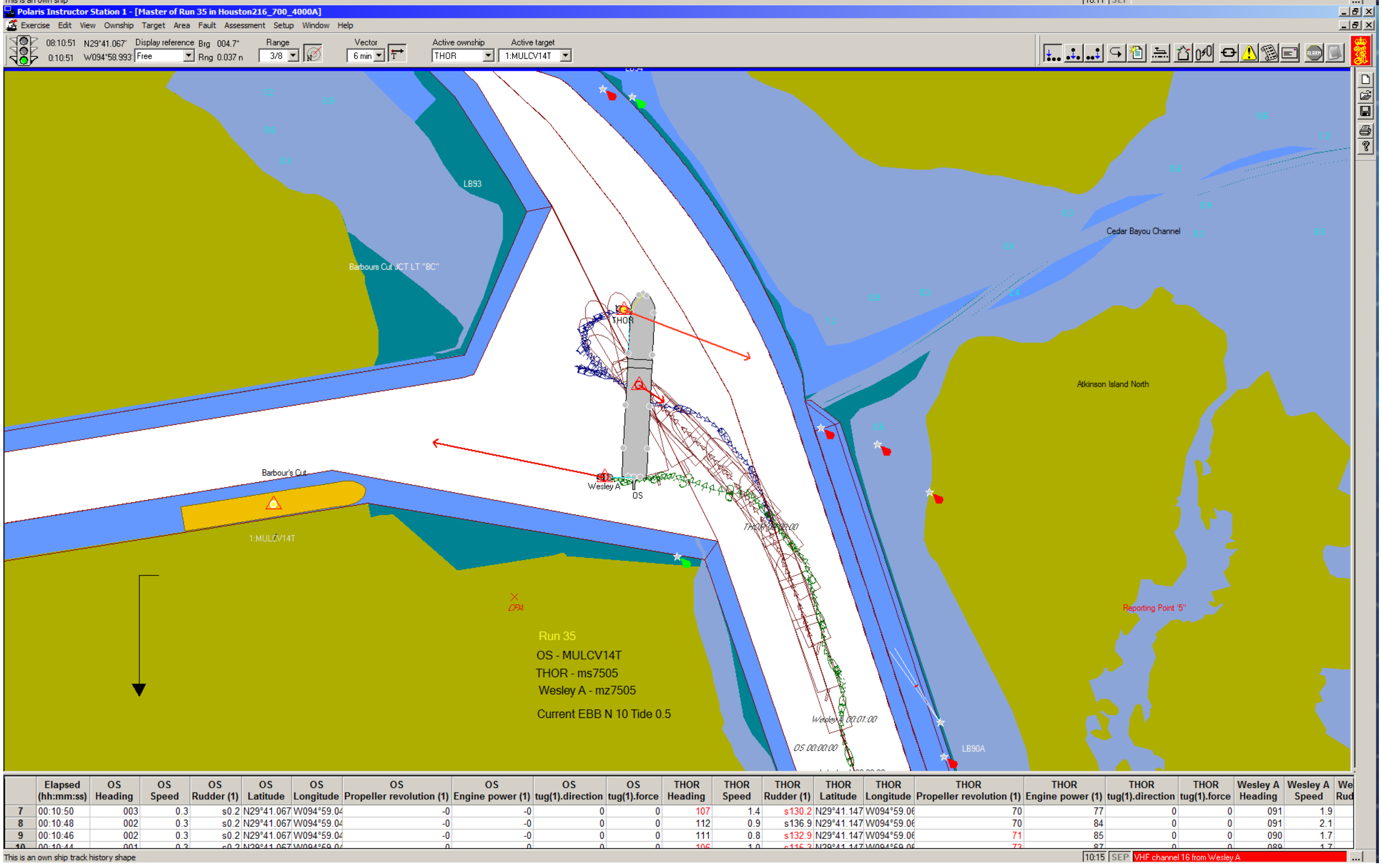
This is a lighthouse

10:09 SEP

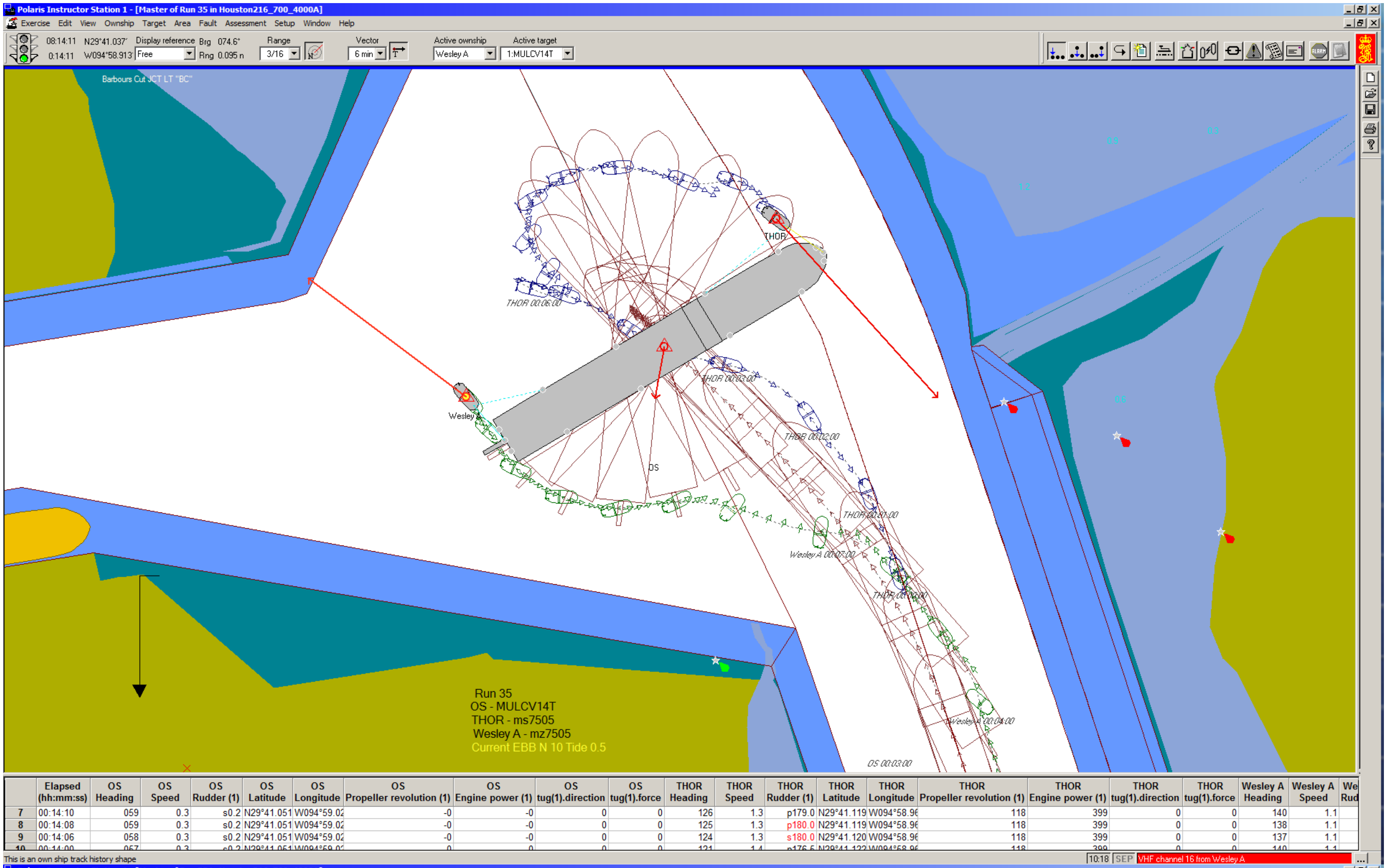
June 26, 2019



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:07:06	314	1.7	s0.2	N29°41.052	W094°59.02	-51	13596	0	0	022	1.8	s89.9	N29°41.092	W094°59.10	161	1009	0	0	015	3.9
8	00:07:04	314	1.7	s0.2	N29°41.051	W094°59.02	-51	13588	0	0	022	1.1	s90.0	N29°41.091	W094°59.09	151	852	0	0	013	4.0
9	00:07:02	314	1.8	s0.2	N29°41.051	W094°59.02	-51	13580	0	0	025	0.9	s90.0	N29°41.091	W094°59.09	129	569	0	0	011	4.0



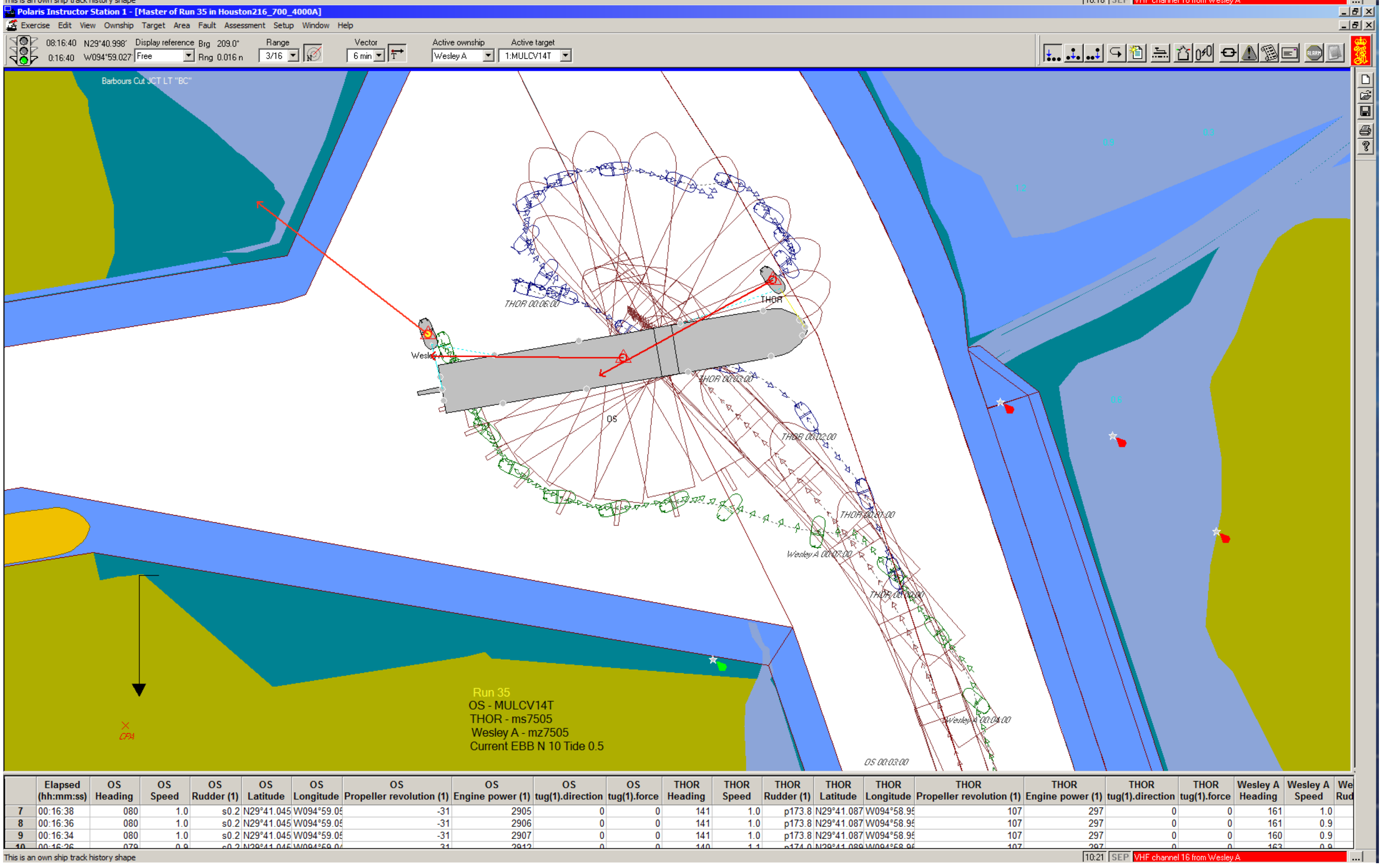
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:10:50	003	0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	107	1.4	s130.2	N29°41.147	W094°59.06	70	77	0	0	091	1.9
8	00:10:48	002	0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	112	0.9	s136.9	N29°41.147	W094°59.06	70	84	0	0	091	2.1
9	00:10:46	002	0.3	s0.2	N29°41.067	W094°59.04	-0	-0	0	0	111	0.8	s132.9	N29°41.147	W094°59.06	71	85	0	0	090	1.7



08:14:11 N29°41.037' Display reference: Free Brg 074.6°
0:14:11 W094°58.913' Rng 0.095 n
Range: 3/16
Vector: 6 min
Active ownship: Wesley A
Active target: 1:MULCV14T

Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

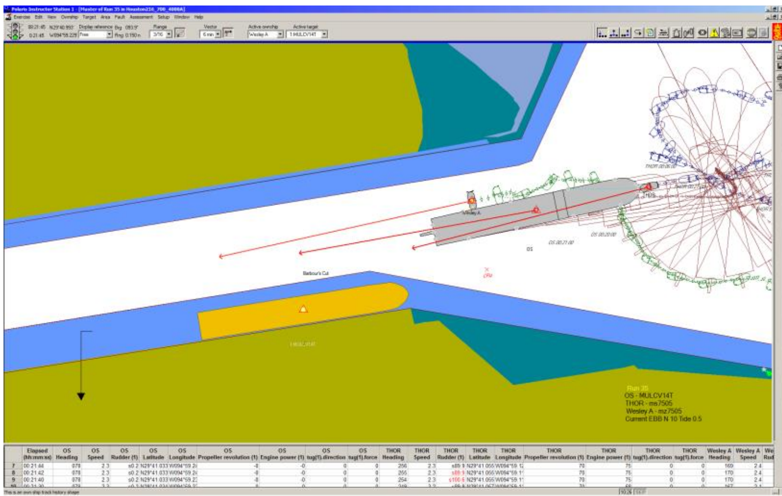
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:14:10	059	0.3	s0.2	N29°41.051	W094°59.02	-0	-0	0	0	126	1.3	p179.0	N29°41.119	W094°58.96	118	399	0	0	140	1.1
8	00:14:08	059	0.3	s0.2	N29°41.051	W094°59.02	-0	-0	0	0	125	1.3	p180.0	N29°41.119	W094°58.96	118	399	0	0	138	1.1
9	00:14:06	058	0.3	s0.2	N29°41.051	W094°59.02	-0	-0	0	0	124	1.3	s180.0	N29°41.120	W094°58.96	118	399	0	0	137	1.1

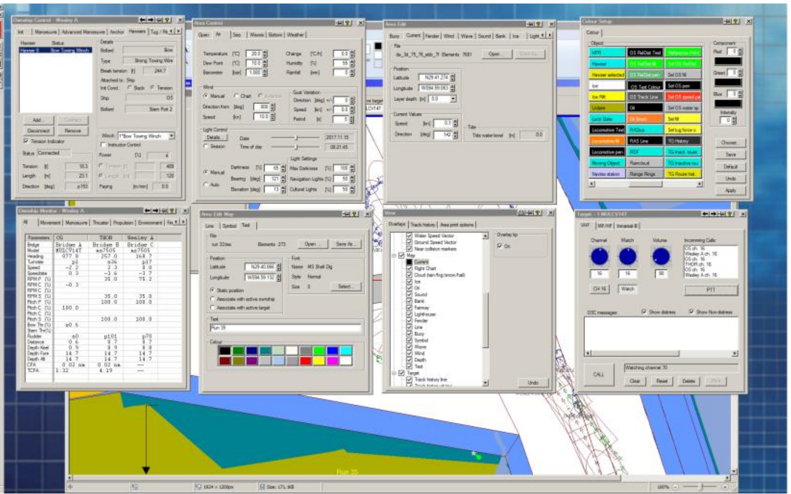


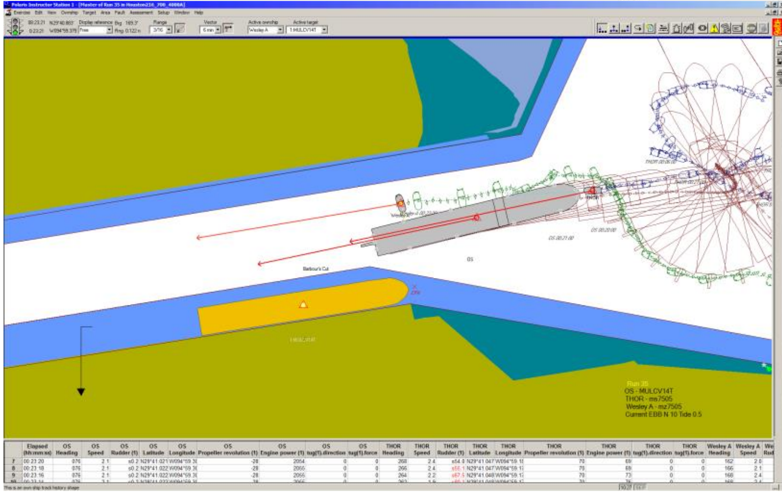
08:16:40 N29°40.998' Display reference: Free Brg 209.0°
0:16:40 W094°59.027' Rng 0.016 n
Range: 3/16
Vector: 6 min
Active ownship: Wesley A
Active target: 1:MULCV14T

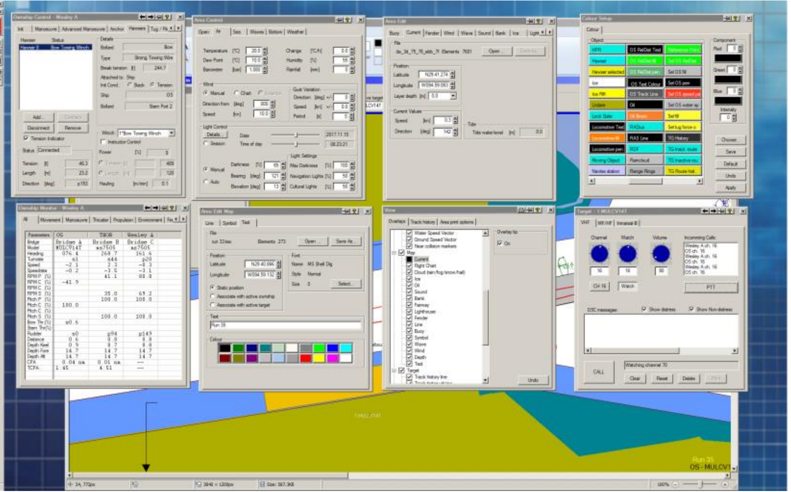
Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5

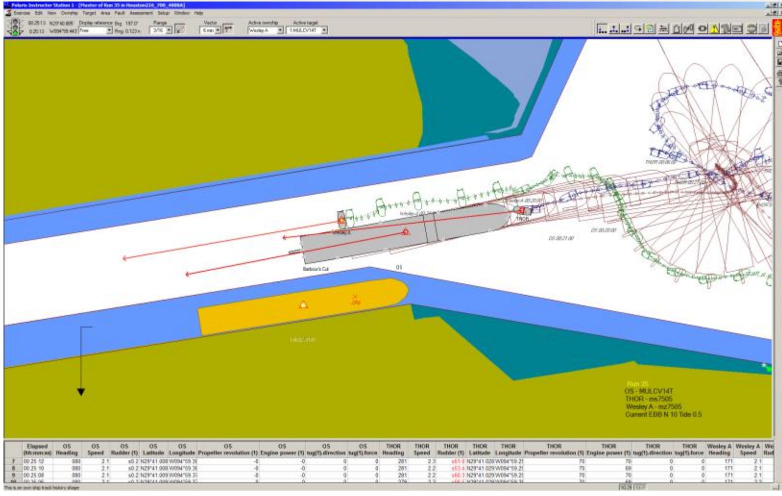
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:16:38	080	1.0	s0.2	N29°41.045	W094°59.05	-31	2905	0	0	141	1.0	p173.8	N29°41.087	W094°58.95	107	297	0	0	161	1.0
8	00:16:36	080	1.0	s0.2	N29°41.045	W094°59.05	-31	2906	0	0	141	1.0	p173.8	N29°41.087	W094°58.95	107	297	0	0	161	0.9
9	00:16:34	080	1.0	s0.2	N29°41.045	W094°59.05	-31	2907	0	0	141	1.0	p173.8	N29°41.087	W094°58.95	107	297	0	0	160	0.9

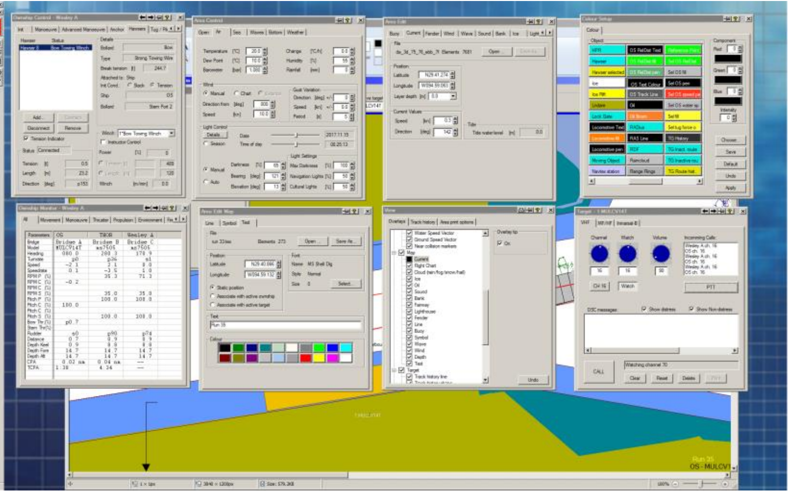

Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5




Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5


Run 35
OS - MULCV1


Run 35
OS - MULCV14T
THOR - ms7505
Wesley A - mz7505
Current EBB N 10 Tide 0.5


Run 35
OS - MULCV1

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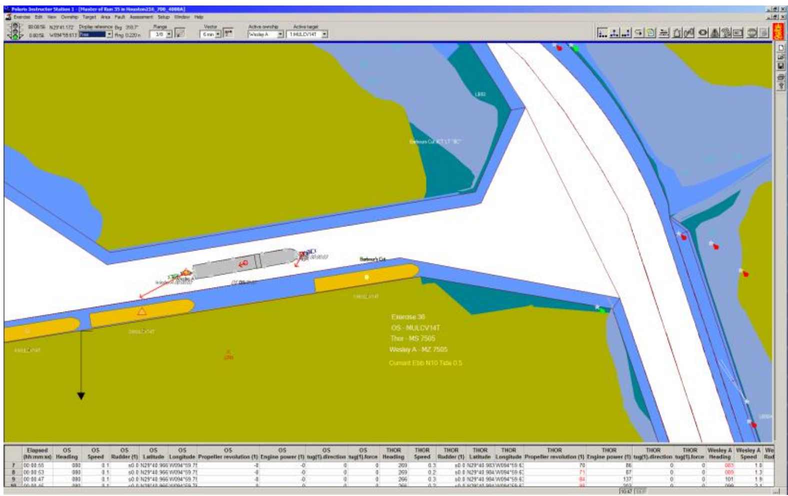
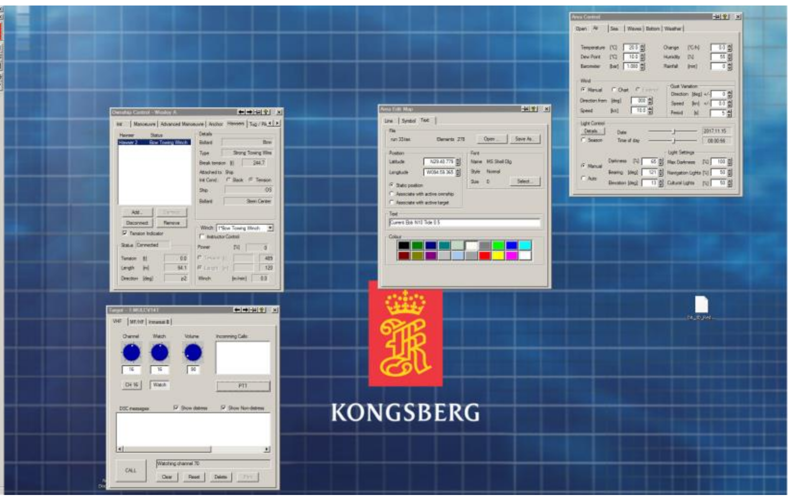
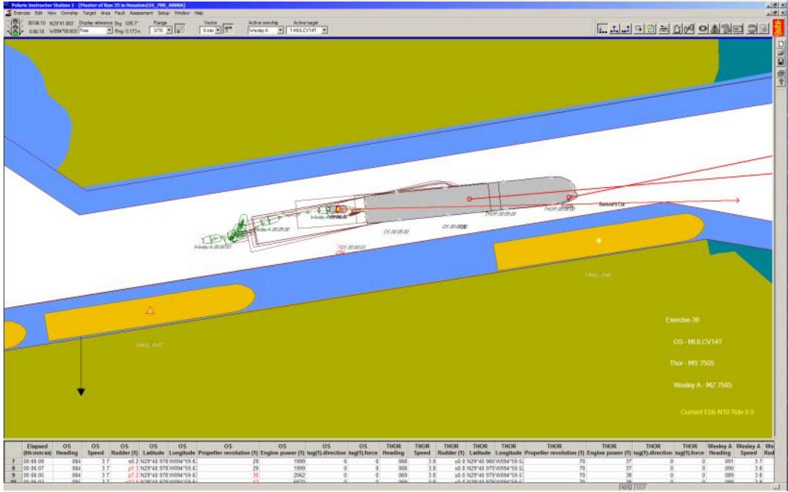
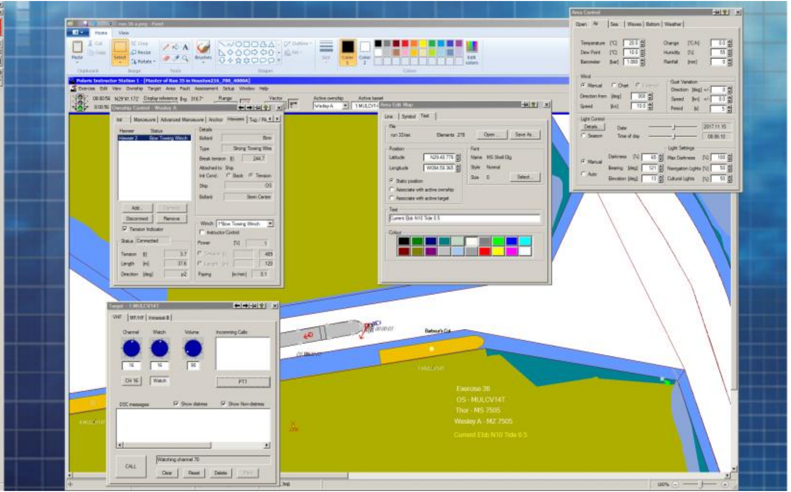
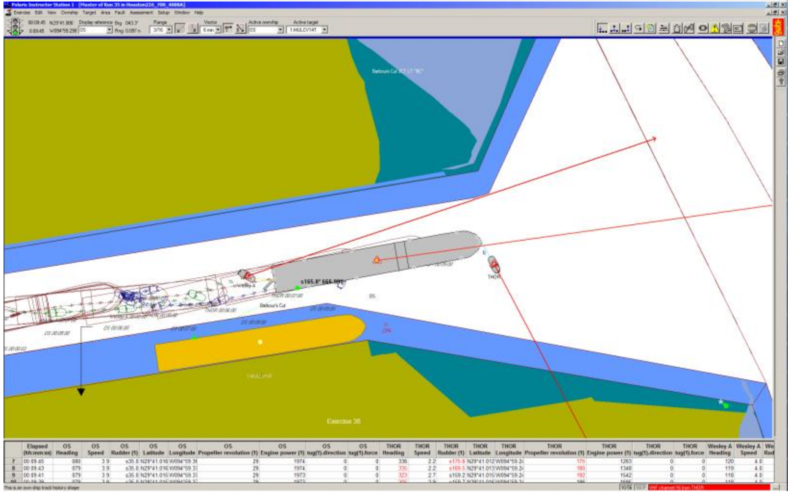
Run 36

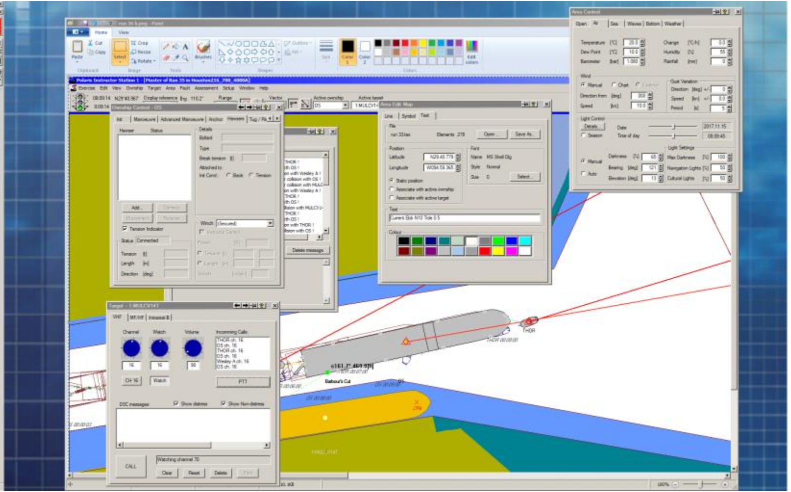


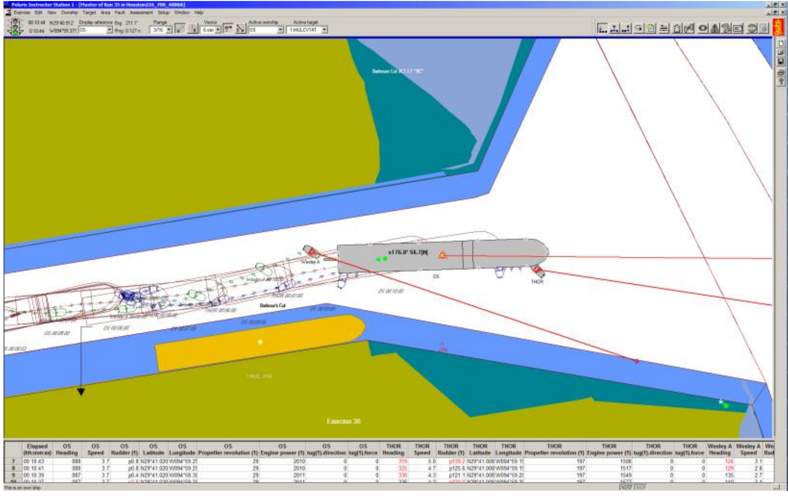


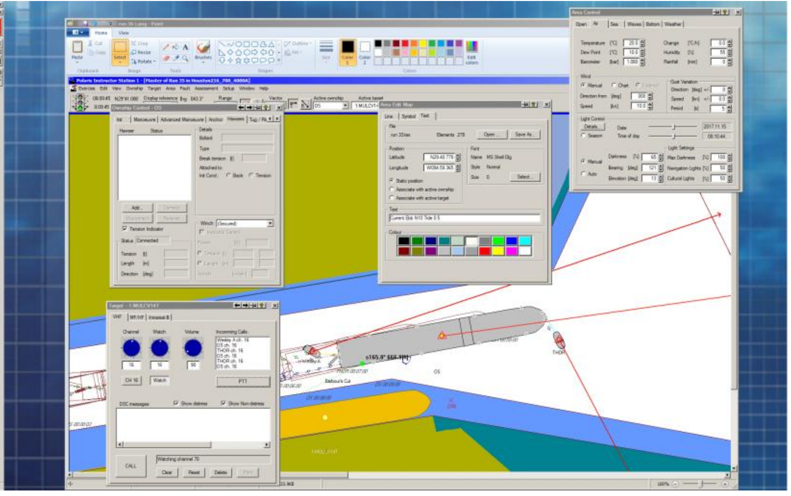


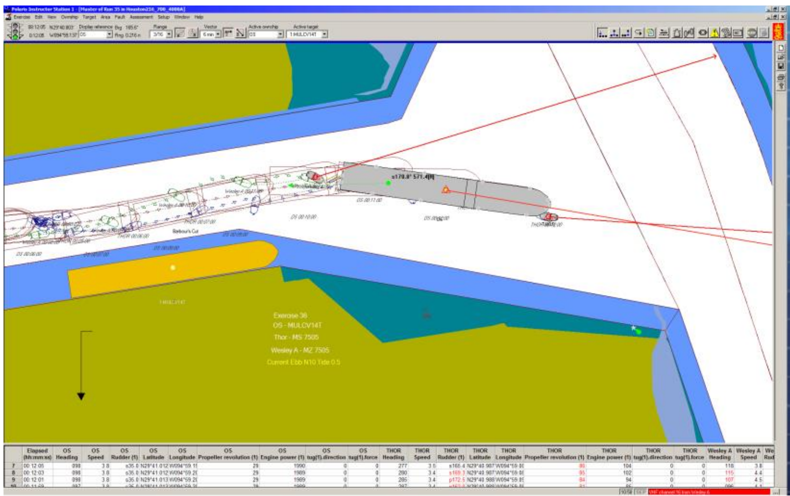


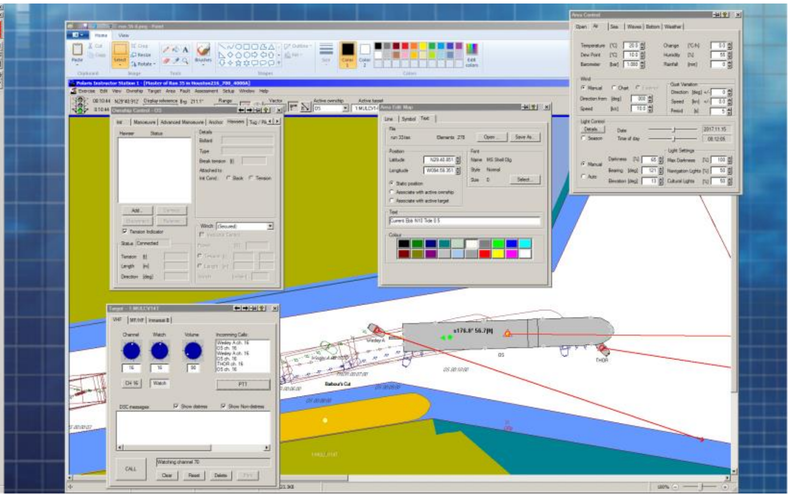


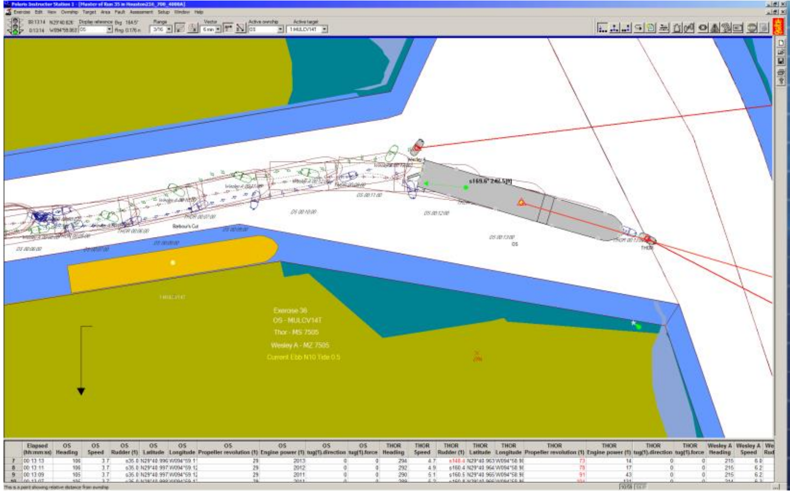


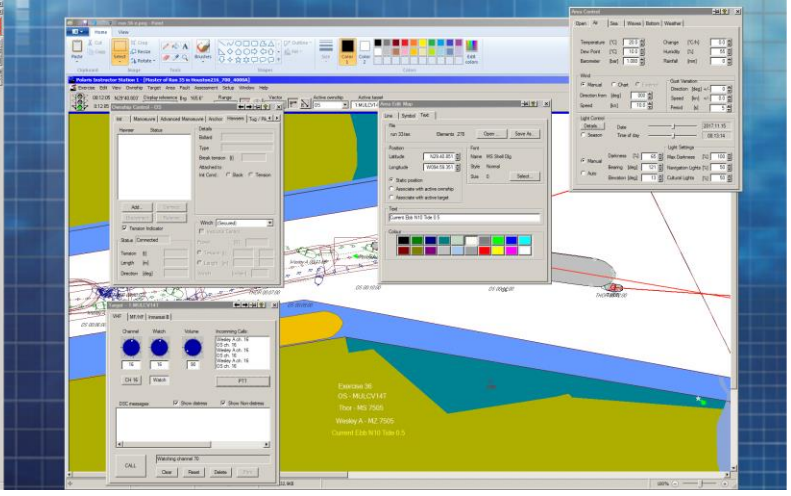





Exercise 36
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5
Balbour's Cut

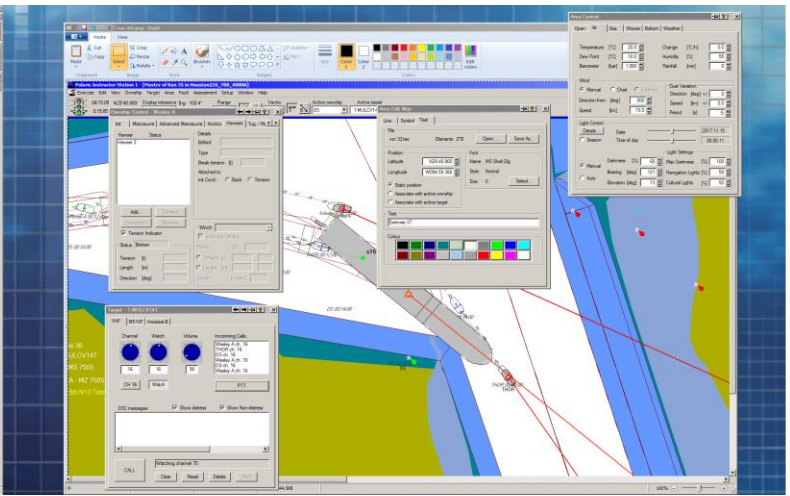
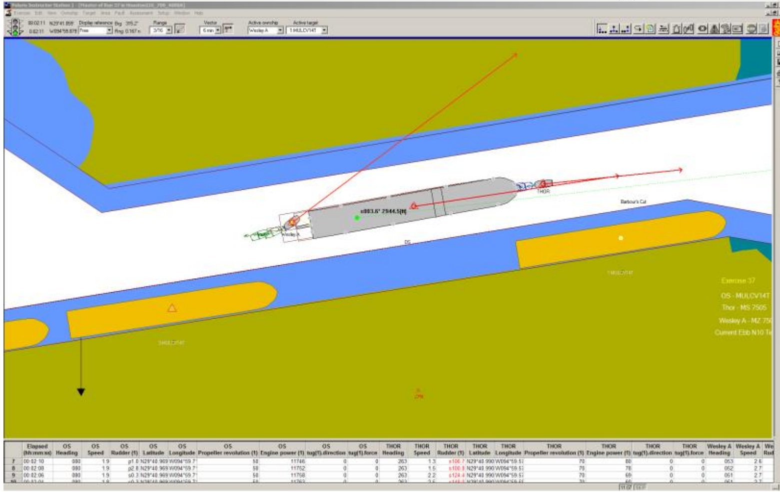
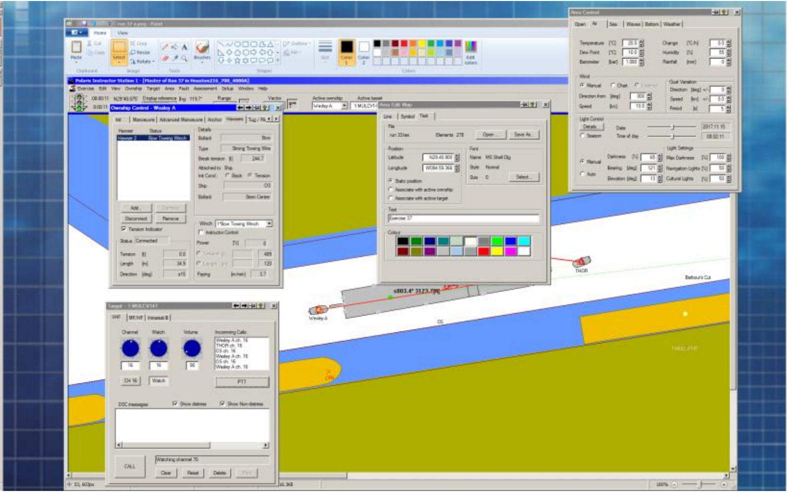
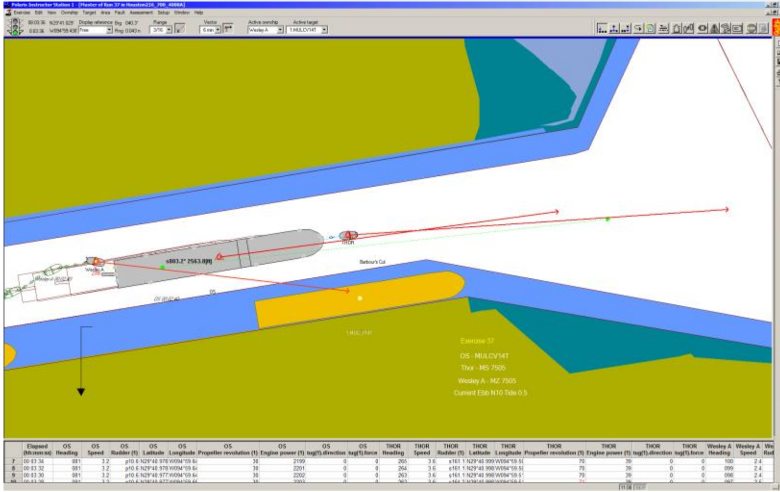
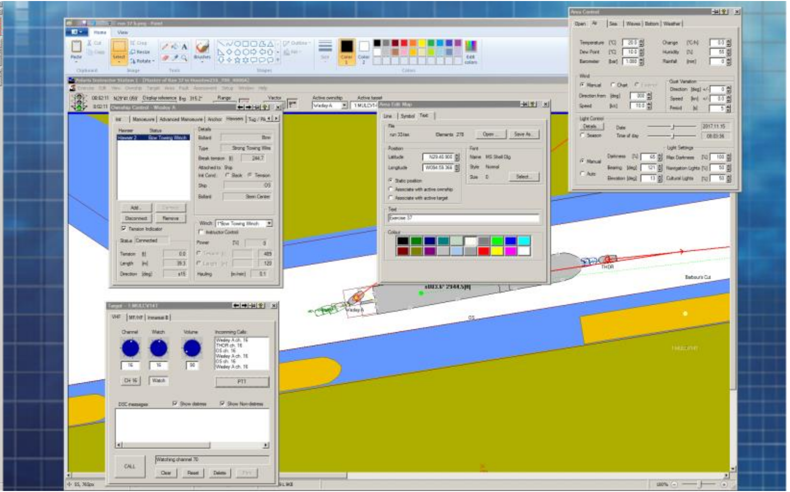
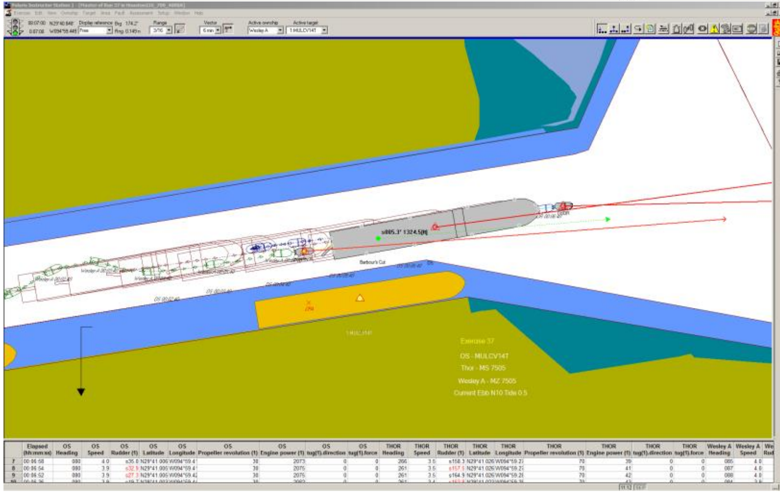
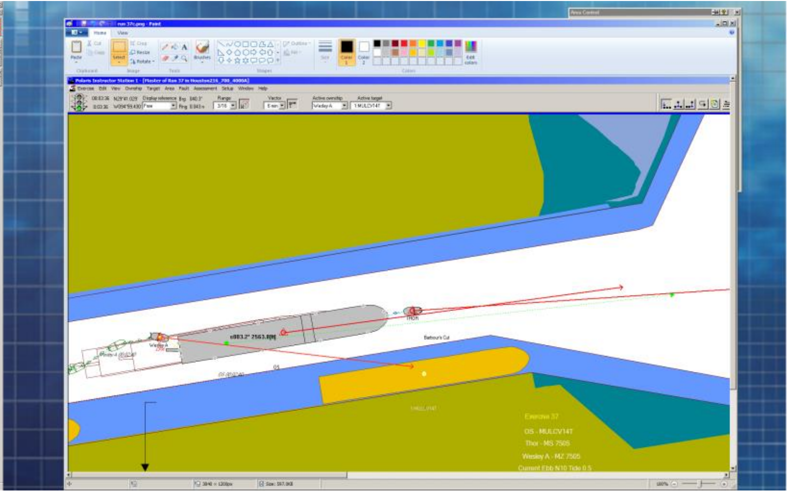

Balbour's Cut

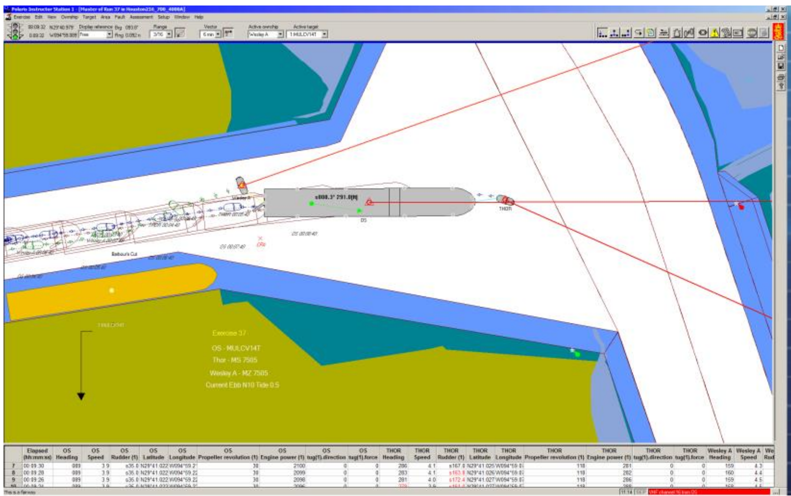

Exercise 36
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5
Balbour's Cut


Exercise 36
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5

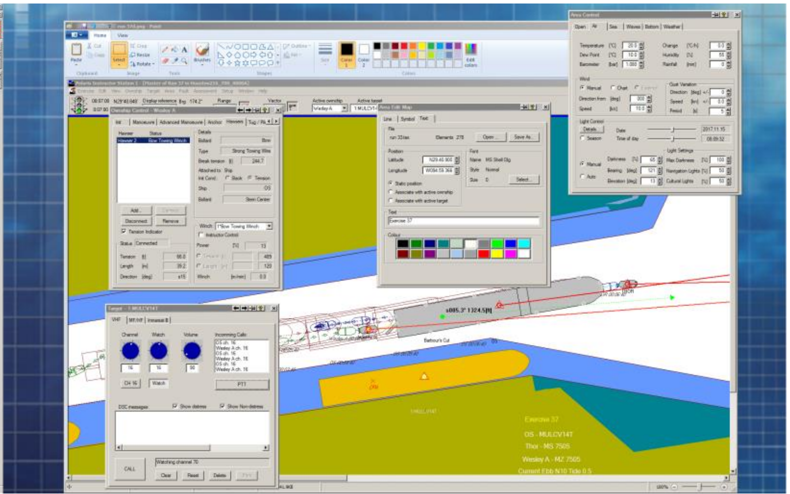
June 26, 2019

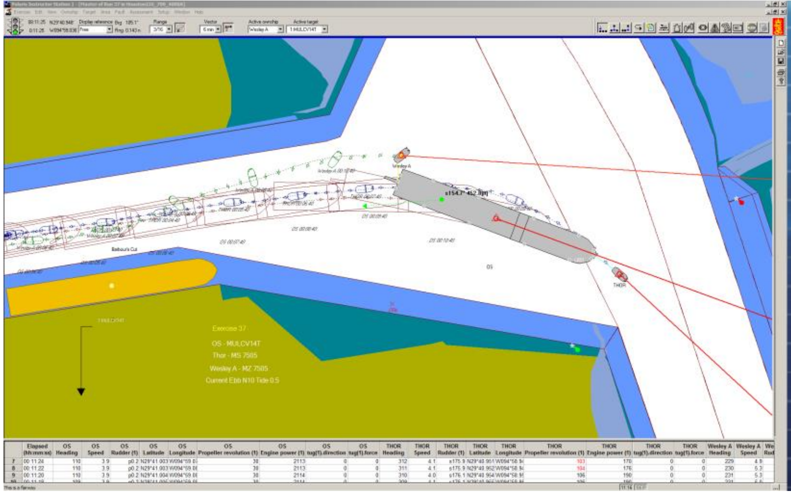
Run 37

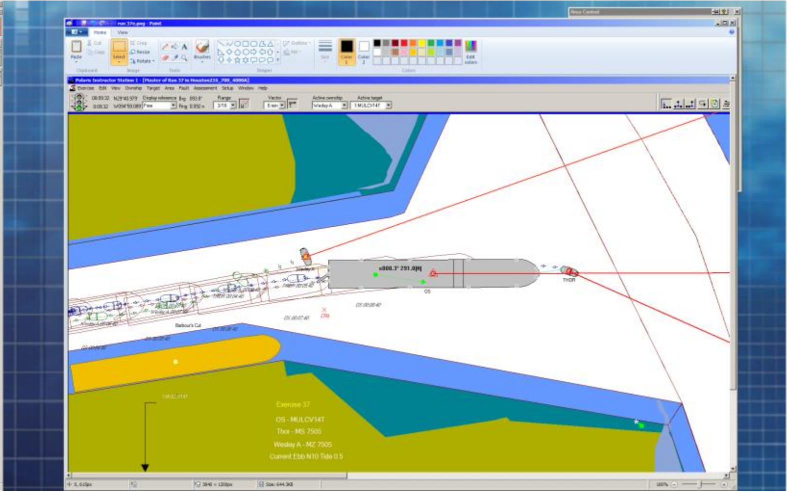


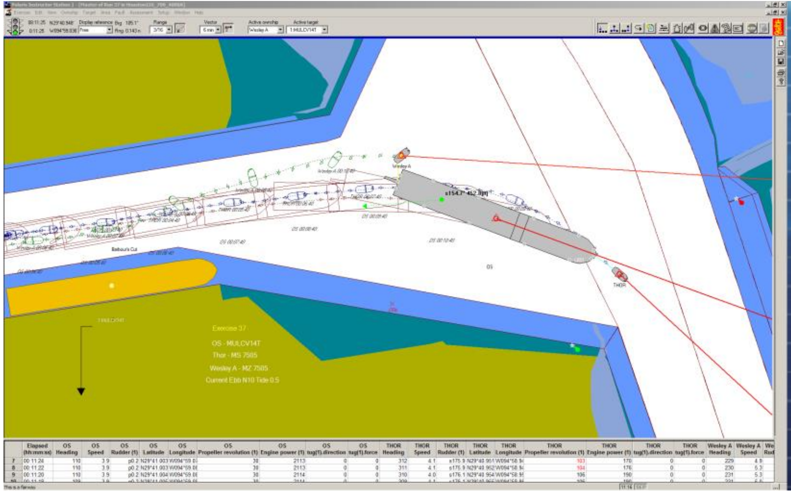
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:09:30	089	3.9	s35.0	N29°41.022	W094°59.2	38	2100	0	0	286	4.1	s167.0	N29°41.025	W094°59.0	118	281	0	0	159	4.3
8	00:09:28	089	3.9	s35.0	N29°41.022	W094°59.2	38	2099	0	0	283	4.1	s163.8	N29°41.026	W094°59.0	118	282	0	0	160	4.4
9	00:09:26	089	3.9	s35.0	N29°41.022	W094°59.2	38	2098	0	0	281	4.0	s172.4	N29°41.027	W094°59.0	118	286	0	0	159	4.5



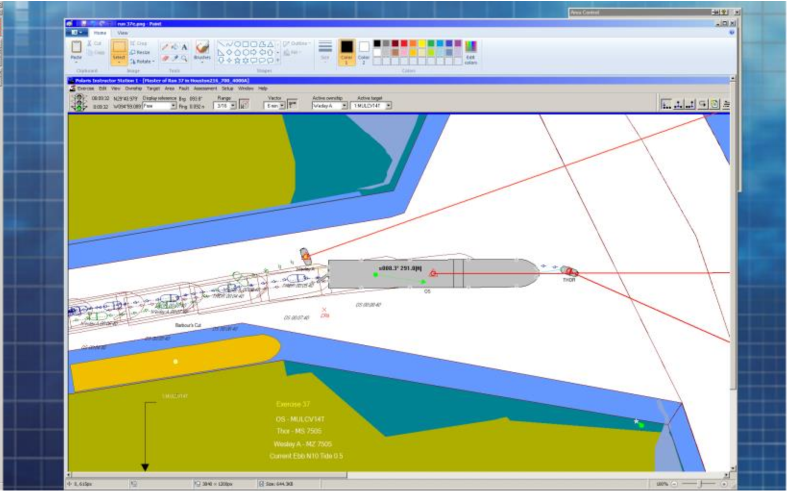


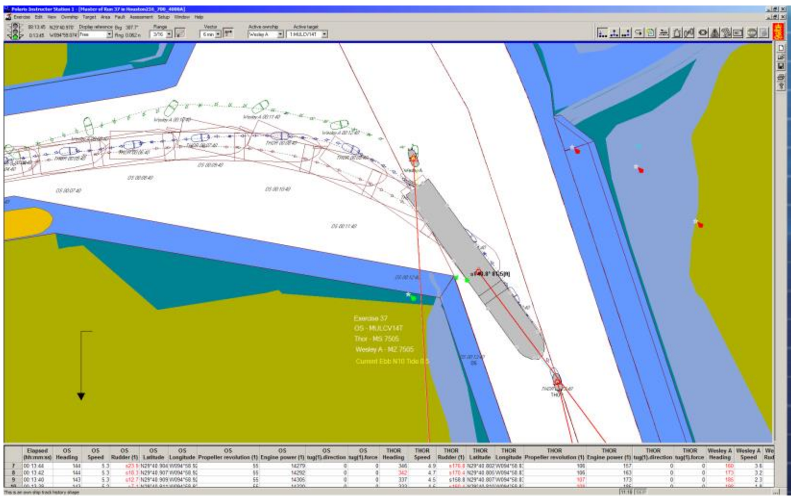
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:11:24	110	3.9	p0.2	N29°41.003	W094°59.0	38	2113	0	0	312	4.1	s175.9	N29°40.951	W094°58.9	103	170	0	0	229	4.9
8	00:11:22	110	3.9	p0.2	N29°41.003	W094°59.0	38	2113	0	0	311	4.1	s175.9	N29°40.952	W094°58.9	104	176	0	0	230	5.3
9	00:11:20	110	3.9	p0.2	N29°41.004	W094°59.0	38	2114	0	0	310	4.0	s176.1	N29°40.954	W094°58.9	106	190	0	0	231	5.3

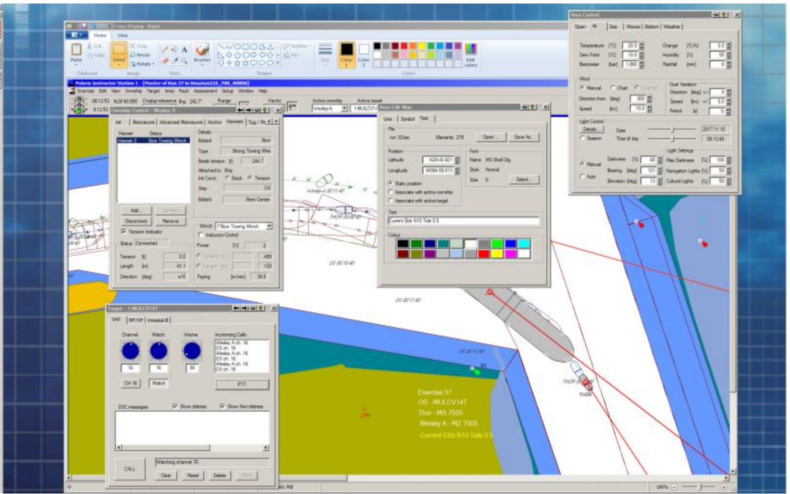


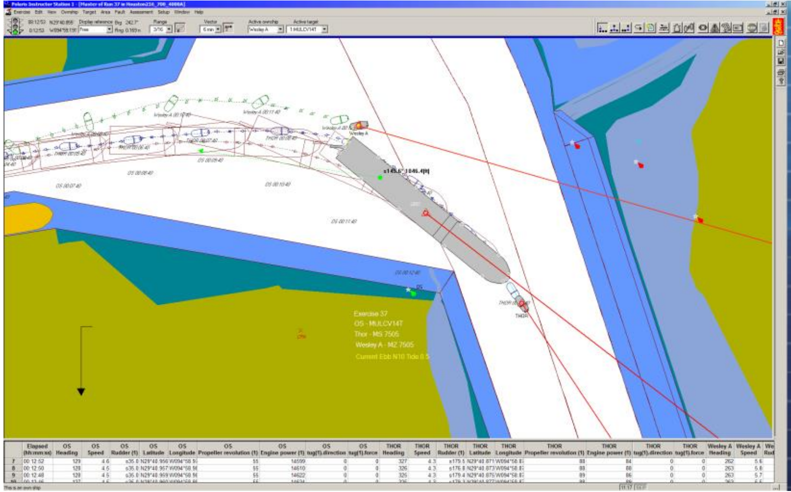


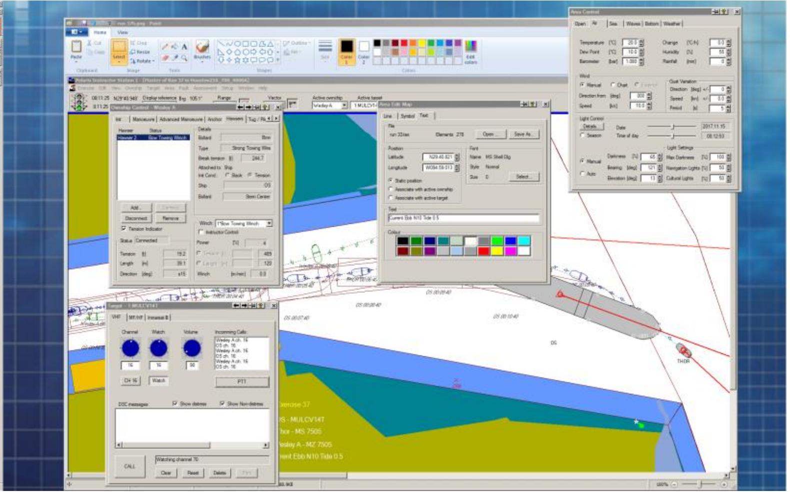
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:11:24	110	3.9	p0.2	N29°41.003	W094°59.0	38	2113	0	0	312	4.1	s175.9	N29°40.951	W094°58.9	103	170	0	0	229	4.9
8	00:11:22	110	3.9	p0.2	N29°41.003	W094°59.0	38	2113	0	0	311	4.1	s175.9	N29°40.952	W094°58.9	104	176	0	0	230	5.3
9	00:11:20	110	3.9	p0.2	N29°41.004	W094°59.0	38	2114	0	0	310	4.0	s176.1	N29°40.954	W094°58.9	106	190	0	0	231	5.3

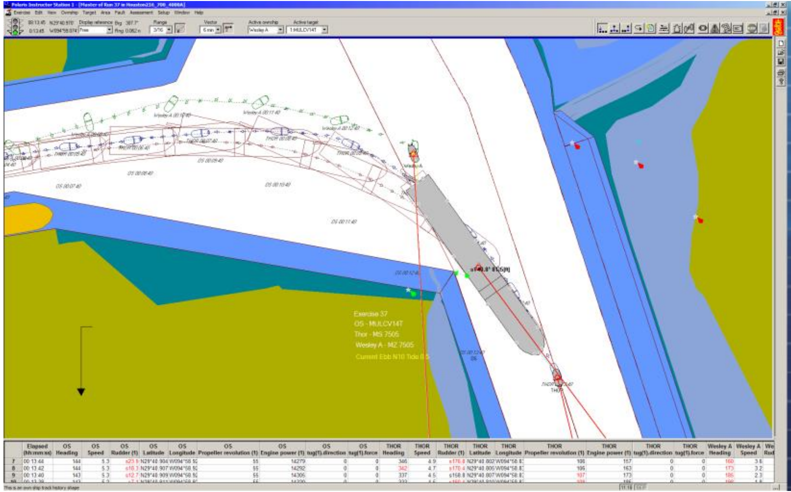


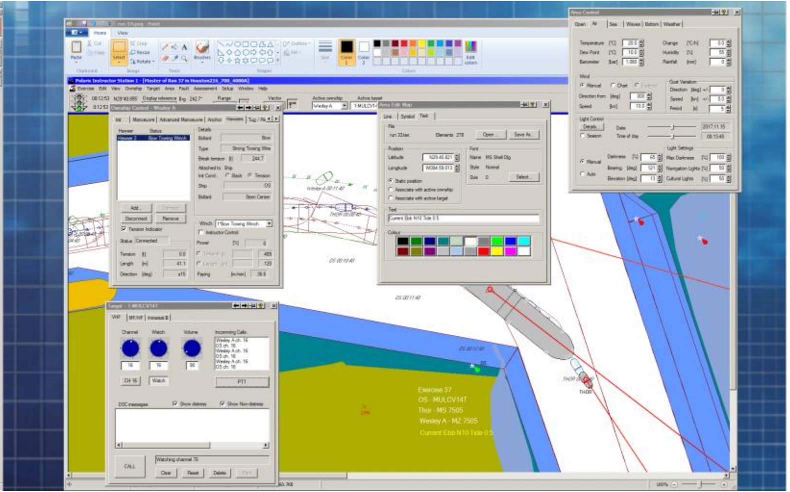

Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5

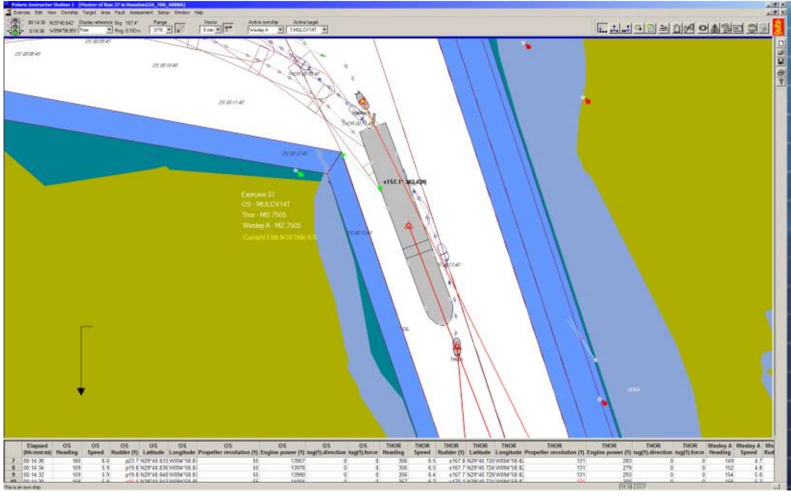

Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5

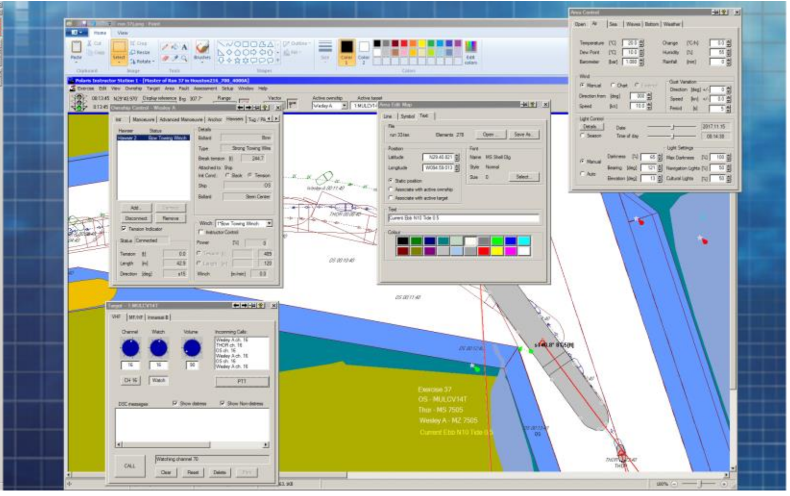

Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5


Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5

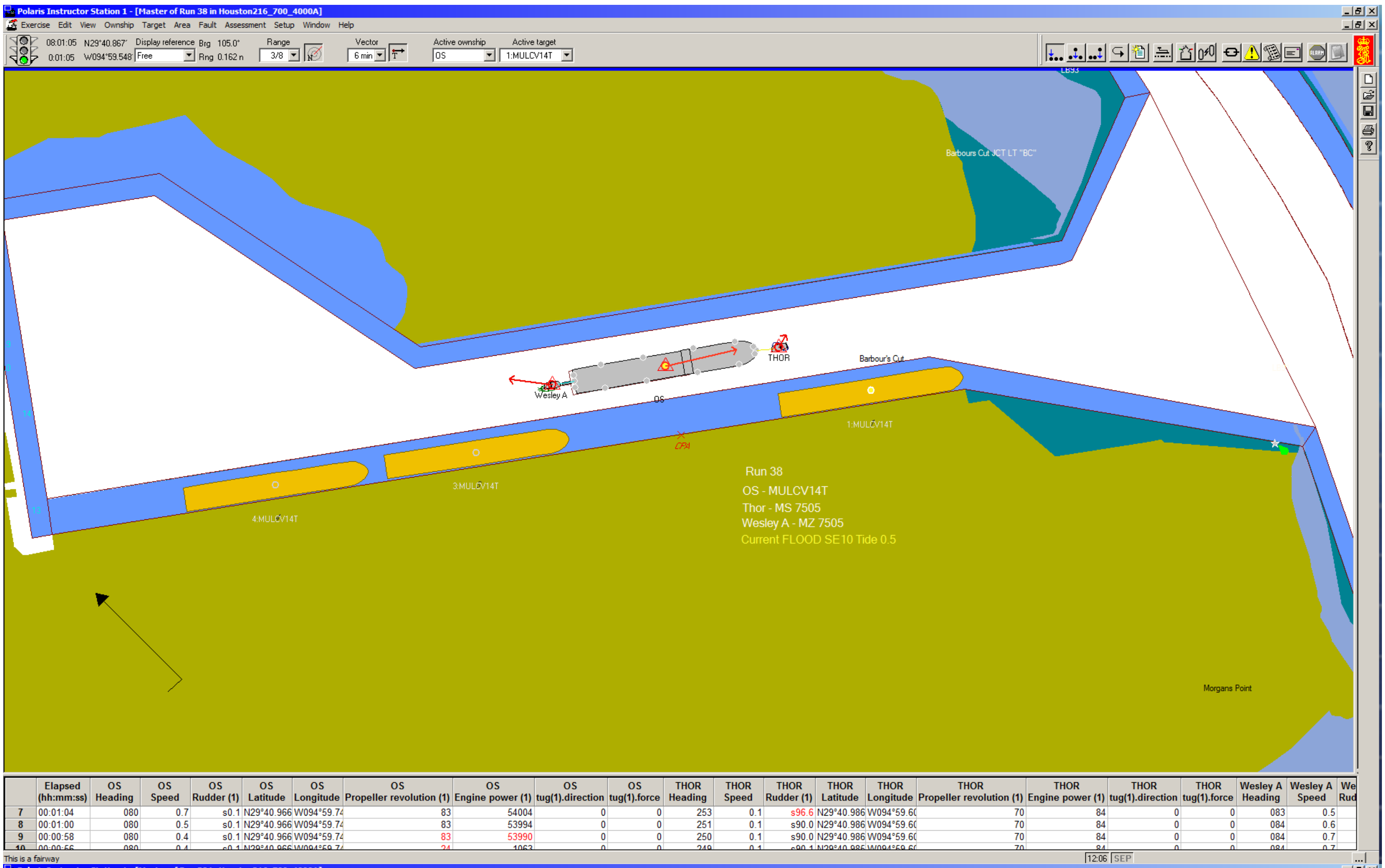

Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5


Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5


Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5


Exercise 37
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current Ebb N10 Tide 0.5

Run 38



Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

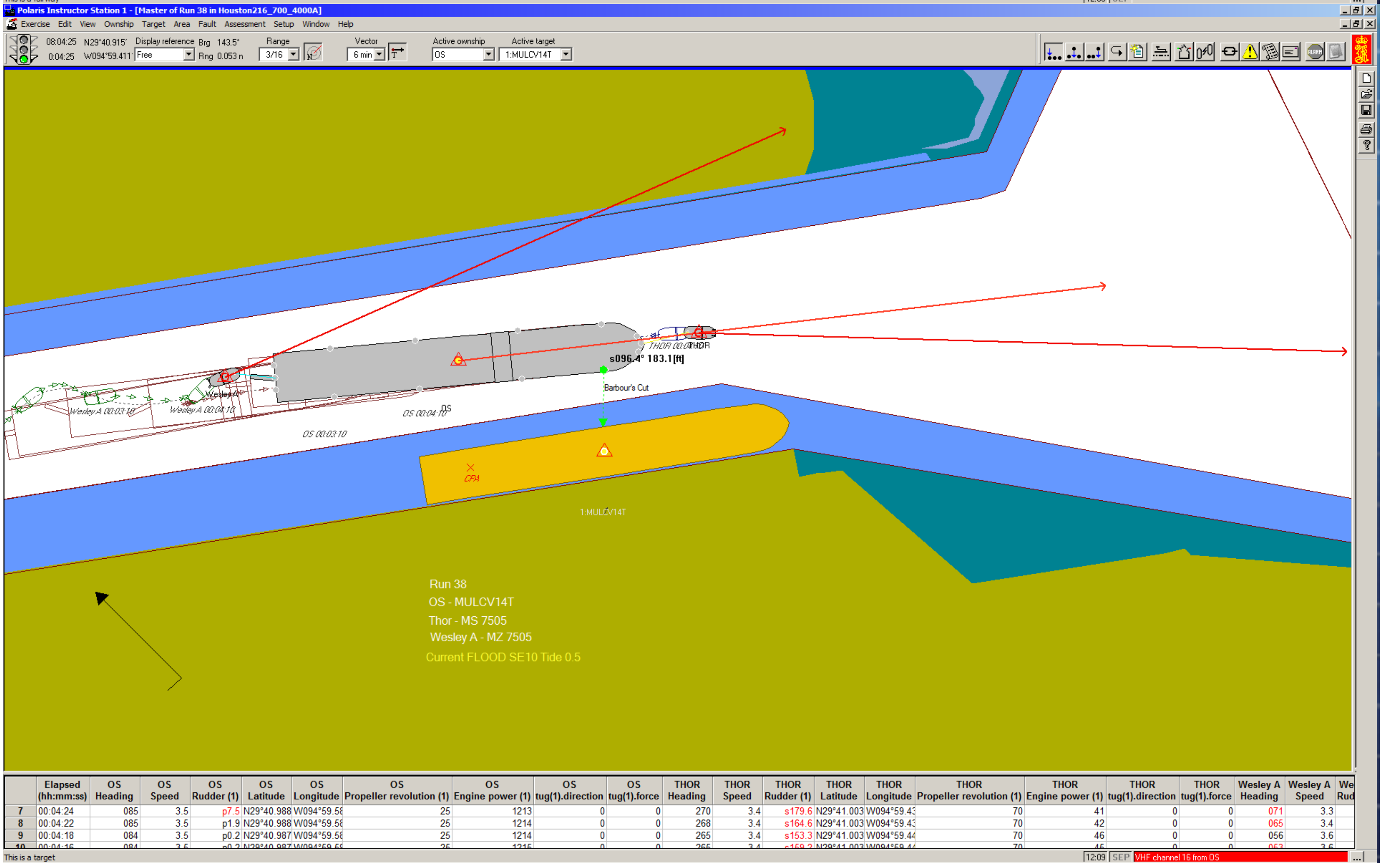
08:01:05 N29°40.867' Display reference: Free Brg 105.0° Rng 0.162 n Range: 3/8 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T

0:01:05 W094°59.548'

Run 38
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:01:04	080	0.7	s0.1	N29°40.966	W094°59.74	83	54004	0	0	253	0.1	s96.6	N29°40.986	W094°59.60	70	84	0	0	083	0.5	
8	00:01:00	080	0.5	s0.1	N29°40.966	W094°59.74	83	53994	0	0	251	0.1	s90.0	N29°40.986	W094°59.60	70	84	0	0	084	0.6	
9	00:00:58	080	0.4	s0.1	N29°40.966	W094°59.74	83	53990	0	0	250	0.1	s90.0	N29°40.986	W094°59.60	70	84	0	0	084	0.7	

This is a fairway 12:06 SEP



Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

Exercise Edit View Ownship Target Area Fault Assessment Setup Window Help

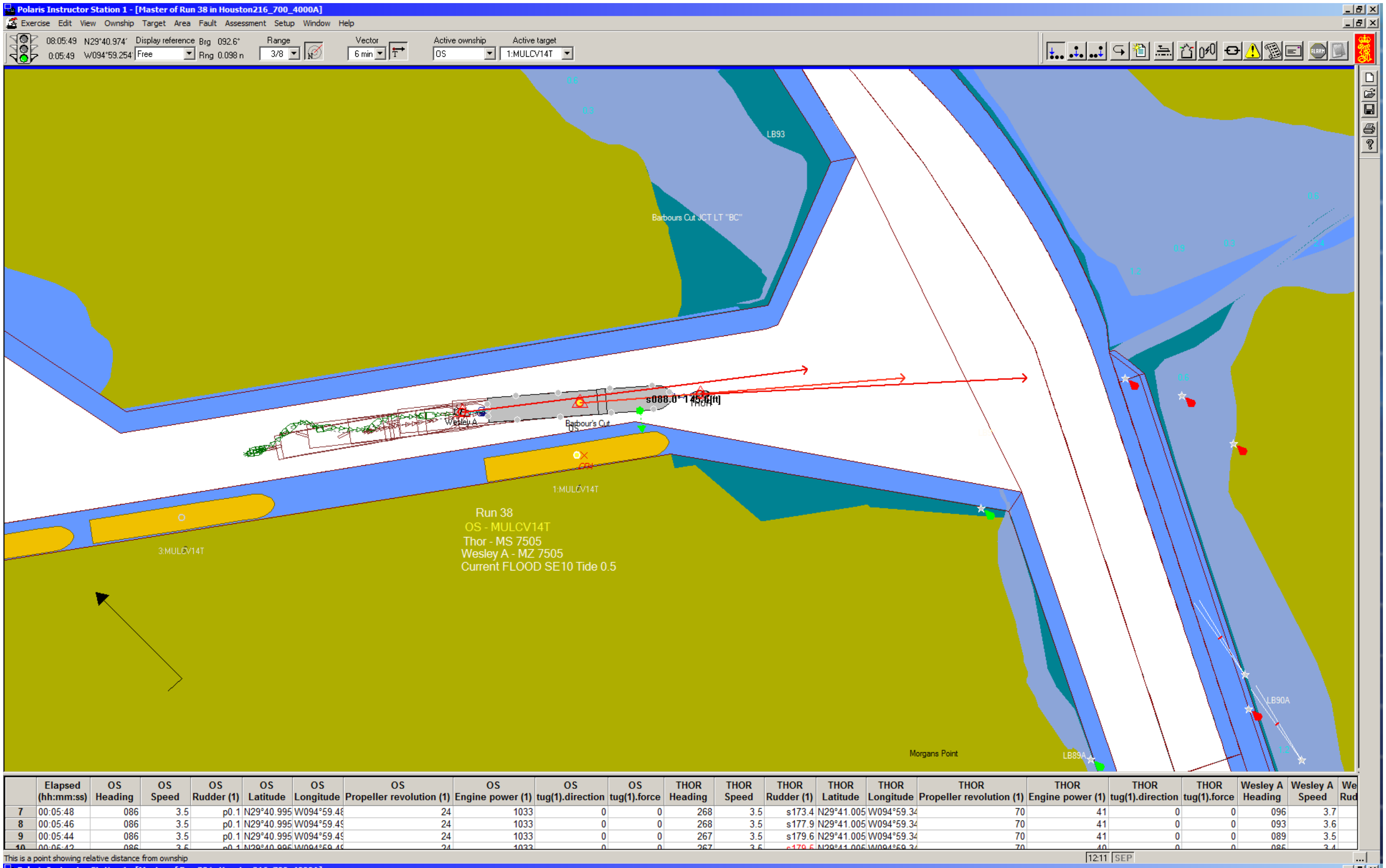
08:04:25 N29°40.915' Display reference: Free Brg 143.5° Rng 0.053 n Range: 3/16 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T

0:04:25 W094°59.411'

Run 38
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:04:24	085	3.5	p7.5	N29°40.988	W094°59.58	25	1213	0	0	270	3.4	s179.6	N29°41.003	W094°59.43	70	41	0	0	071	3.3	
8	00:04:22	085	3.5	p1.9	N29°40.988	W094°59.58	25	1214	0	0	268	3.4	s164.6	N29°41.003	W094°59.43	70	42	0	0	065	3.4	
9	00:04:18	084	3.5	p0.2	N29°40.987	W094°59.58	25	1214	0	0	265	3.4	s153.3	N29°41.003	W094°59.44	70	46	0	0	056	3.6	

This is a target 12:09 SEP VHF channel 16 from OS

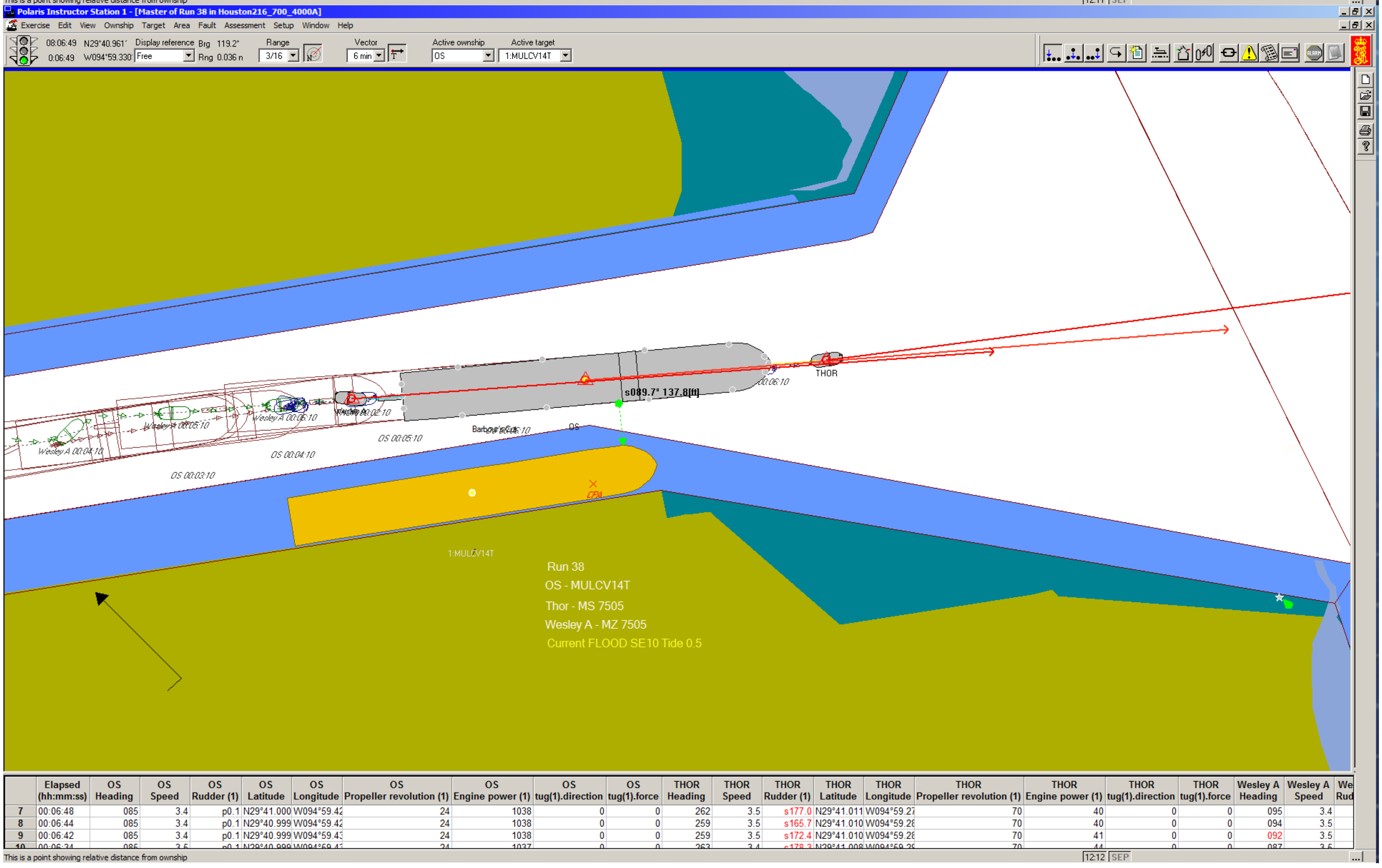


Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:05:49 N29°40.974'
0:05:49 W094°59.254'
Display reference: Free
Brg 092.6°
Rng 0.098 n
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:05:48	086	3.5	p0.1	N29°40.995	W094°59.48	24	1033	0	0	268	3.5	s173.4	N29°41.005	W094°59.34	70	41	0	0	096	3.7	
8	00:05:46	086	3.5	p0.1	N29°40.995	W094°59.49	24	1033	0	0	268	3.5	s177.9	N29°41.005	W094°59.34	70	41	0	0	093	3.6	
9	00:05:44	086	3.5	p0.1	N29°40.995	W094°59.49	24	1033	0	0	267	3.5	s179.6	N29°41.005	W094°59.34	70	41	0	0	089	3.5	
10	00:05:42	086	3.5	p0.1	N29°40.995	W094°59.49	24	1033	0	0	267	3.5	s179.5	N29°41.005	W094°59.34	70	40	0	0	085	3.4	

This is a point showing relative distance from ownship



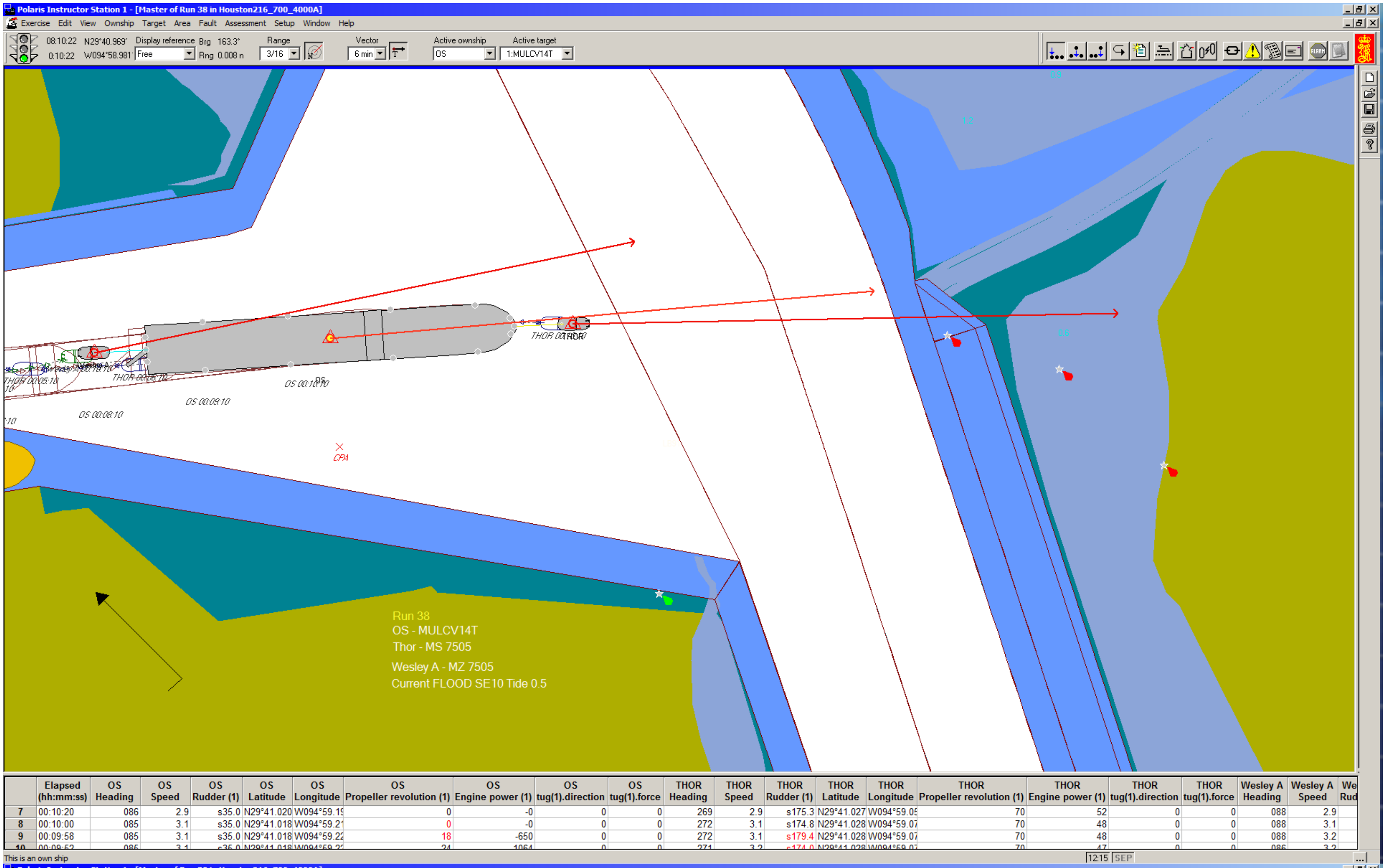
Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:06:49 N29°40.961'
0:06:49 W094°59.330'
Display reference: Free
Brg 119.2°
Rng 0.036 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:06:48	085	3.4	p0.1	N29°41.000	W094°59.42	24	1038	0	0	262	3.5	s177.0	N29°41.011	W094°59.27	70	40	0	0	095	3.4	
8	00:06:44	085	3.4	p0.1	N29°40.999	W094°59.42	24	1038	0	0	259	3.5	s165.7	N29°41.010	W094°59.28	70	40	0	0	094	3.5	
9	00:06:42	085	3.4	p0.1	N29°40.999	W094°59.43	24	1038	0	0	259	3.5	s172.4	N29°41.010	W094°59.28	70	41	0	0	092	3.5	
10	00:06:34	085	3.5	p0.1	N29°40.999	W094°59.43	24	1037	0	0	263	3.4	s178.3	N29°41.008	W094°59.29	70	44	0	0	087	3.5	

This is a point showing relative distance from ownship

June 26, 2019



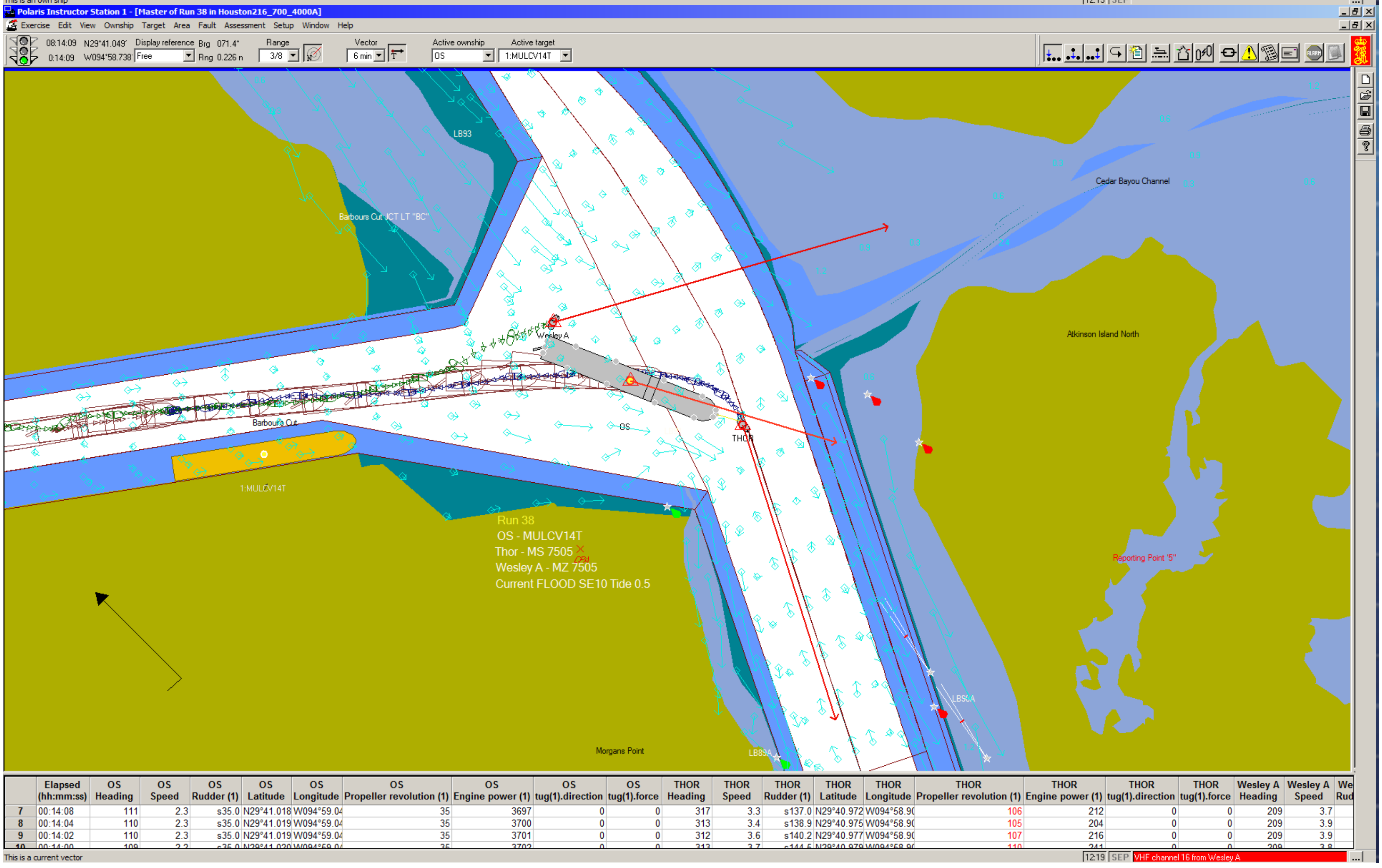
Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:10:22 N29°40.969' Display reference: Free Brg 163.3° Rng 0.008 n
0:10:22 W094°58.981'
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:10:20	086	2.9	s35.0	N29°41.020	W094°59.1	0	-0	0	0	269	2.9	s175.3	N29°41.027	W094°59.0	70	52	0	0	088	2.9	
8	00:10:00	085	3.1	s35.0	N29°41.018	W094°59.2	0	-0	0	0	272	3.1	s174.8	N29°41.028	W094°59.0	70	48	0	0	088	3.1	
9	00:09:58	085	3.1	s35.0	N29°41.018	W094°59.2	18	-650	0	0	272	3.1	s179.4	N29°41.028	W094°59.0	70	48	0	0	088	3.2	

This is an own ship

12:15 SEP



Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:14:09 N29°41.049' Display reference: Free Brg 071.4° Rng 0.226 n
0:14:09 W094°58.738'
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:08	111	2.3	s35.0	N29°41.018	W094°59.0	35	3697	0	0	317	3.3	s137.0	N29°40.972	W094°58.9	106	212	0	0	209	3.7	
8	00:14:04	110	2.3	s35.0	N29°41.019	W094°59.0	35	3700	0	0	313	3.4	s138.9	N29°40.975	W094°58.9	105	204	0	0	209	3.9	
9	00:14:02	110	2.3	s35.0	N29°41.019	W094°59.0	35	3701	0	0	312	3.6	s140.2	N29°40.977	W094°58.9	107	216	0	0	209	3.9	

This is a current vector

12:19 SEP VHF channel 16 from Wesley A

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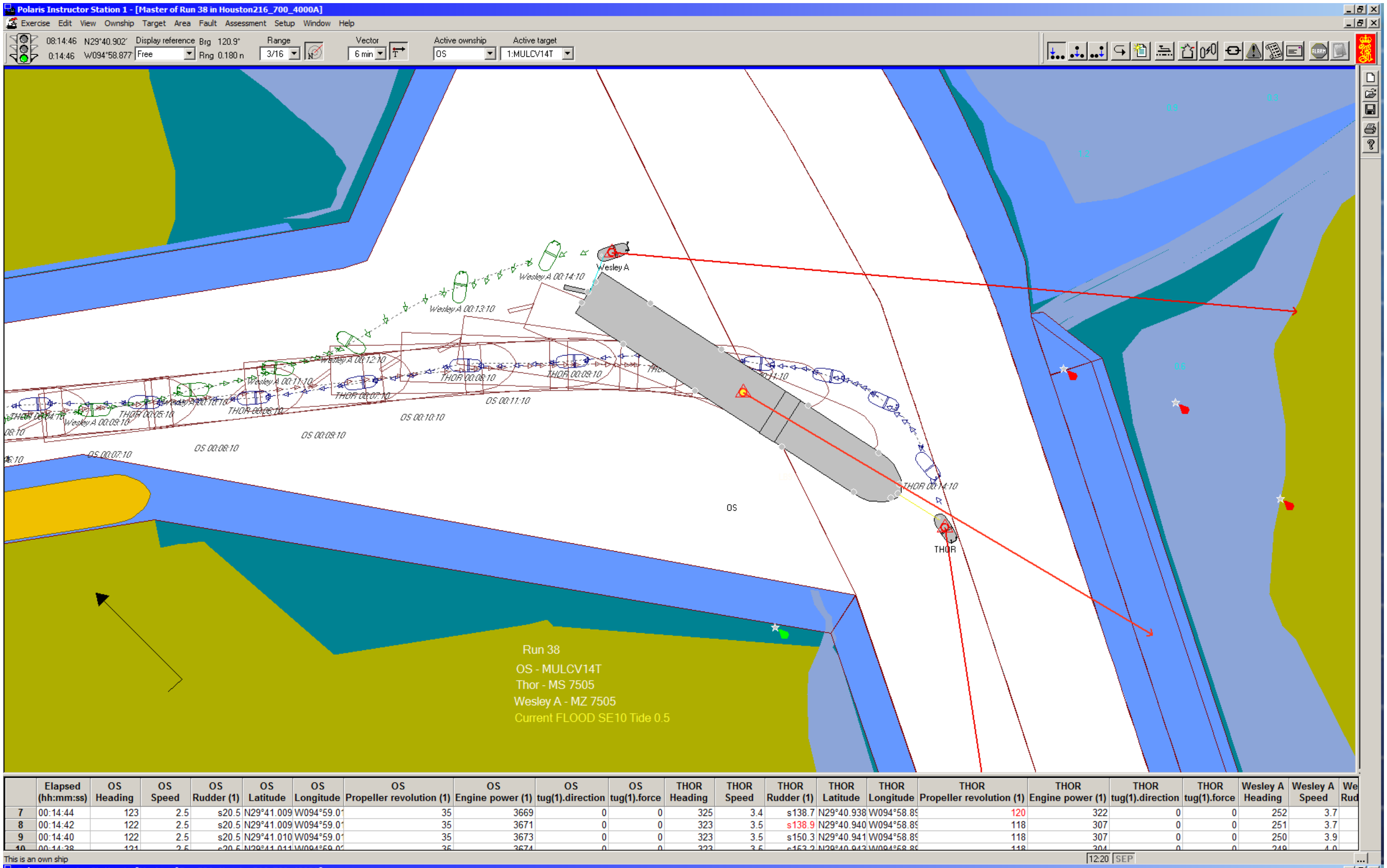


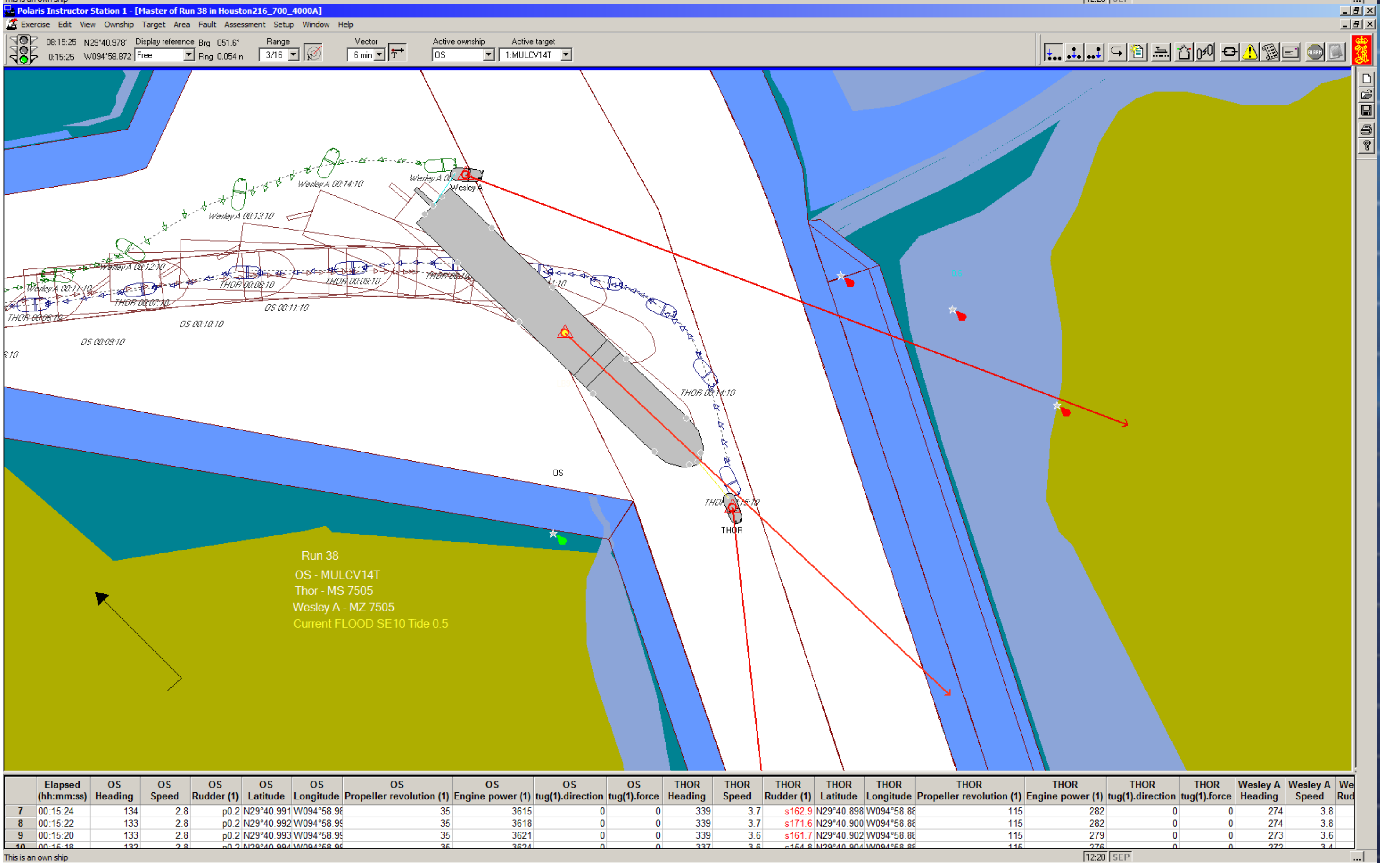
Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:14:46 N29°40.902' Display reference Free Brg 120.9° Rng 0.180 n
0:14:46 W094°58.877'
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 38
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:44	123	2.5	s20.5	N29°41.009	W094°59.01	35	3669	0	0	325	3.4	s138.7	N29°40.938	W094°58.89	120	322	0	0	252	3.7	
8	00:14:42	122	2.5	s20.5	N29°41.009	W094°59.01	35	3671	0	0	323	3.5	s138.9	N29°40.940	W094°58.89	118	307	0	0	251	3.7	
9	00:14:40	122	2.5	s20.5	N29°41.010	W094°59.01	35	3673	0	0	323	3.5	s150.3	N29°40.941	W094°58.89	118	307	0	0	250	3.9	
10	00:14:38	121	2.5	s20.5	N29°41.011	W094°59.0	35	3674	0	0	323	3.5	s153.2	N29°40.943	W094°58.8	118	304	0	0	249	4.0	

This is an own ship



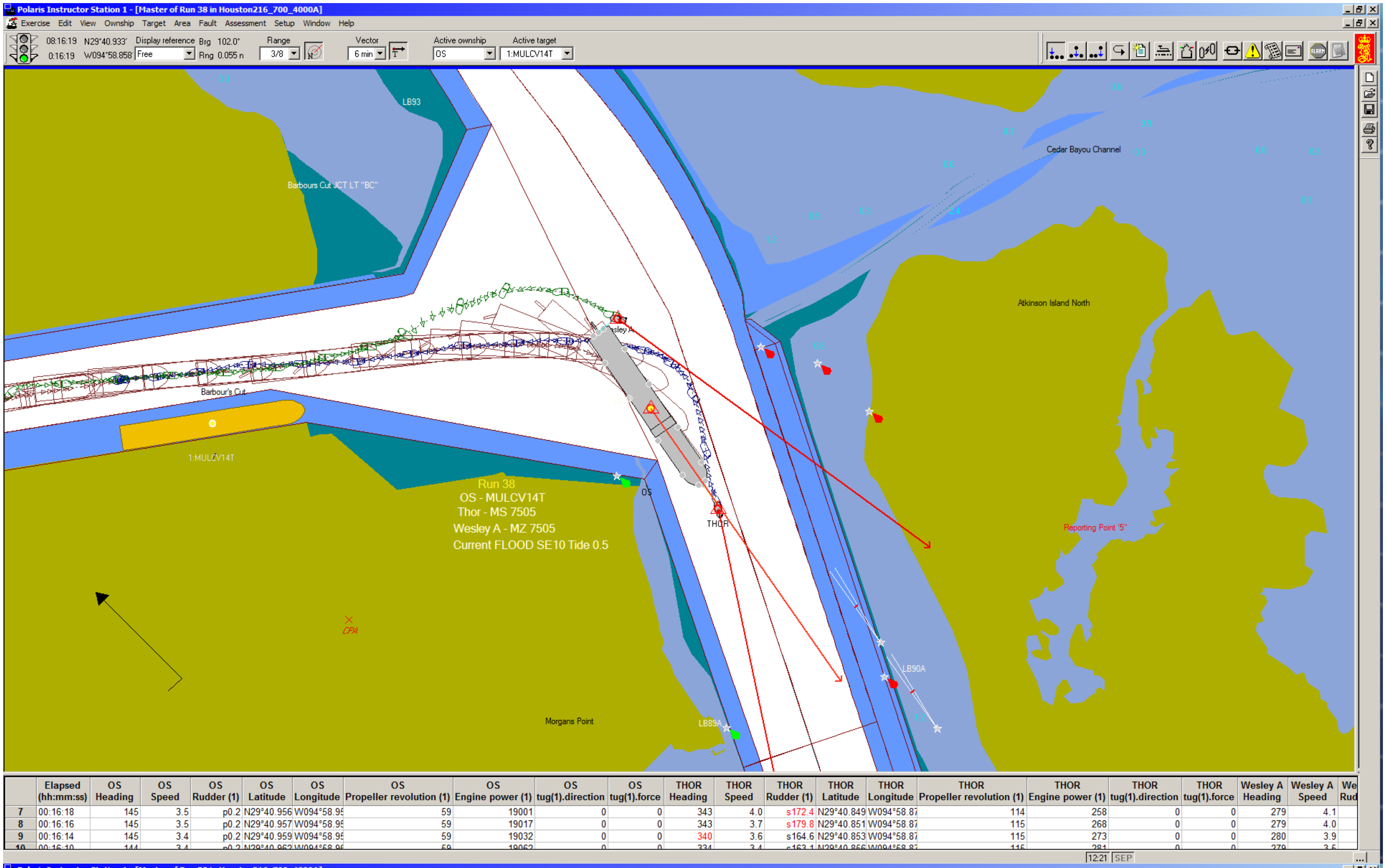
Polaris Instructor Station 1 - [Master of Run 38 in Houston216_700_4000A]

08:15:25 N29°40.978' Display reference Free Brg 051.6° Rng 0.054 n
0:15:25 W094°58.872'
Range 3/16
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

Run 38
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE10 Tide 0.5

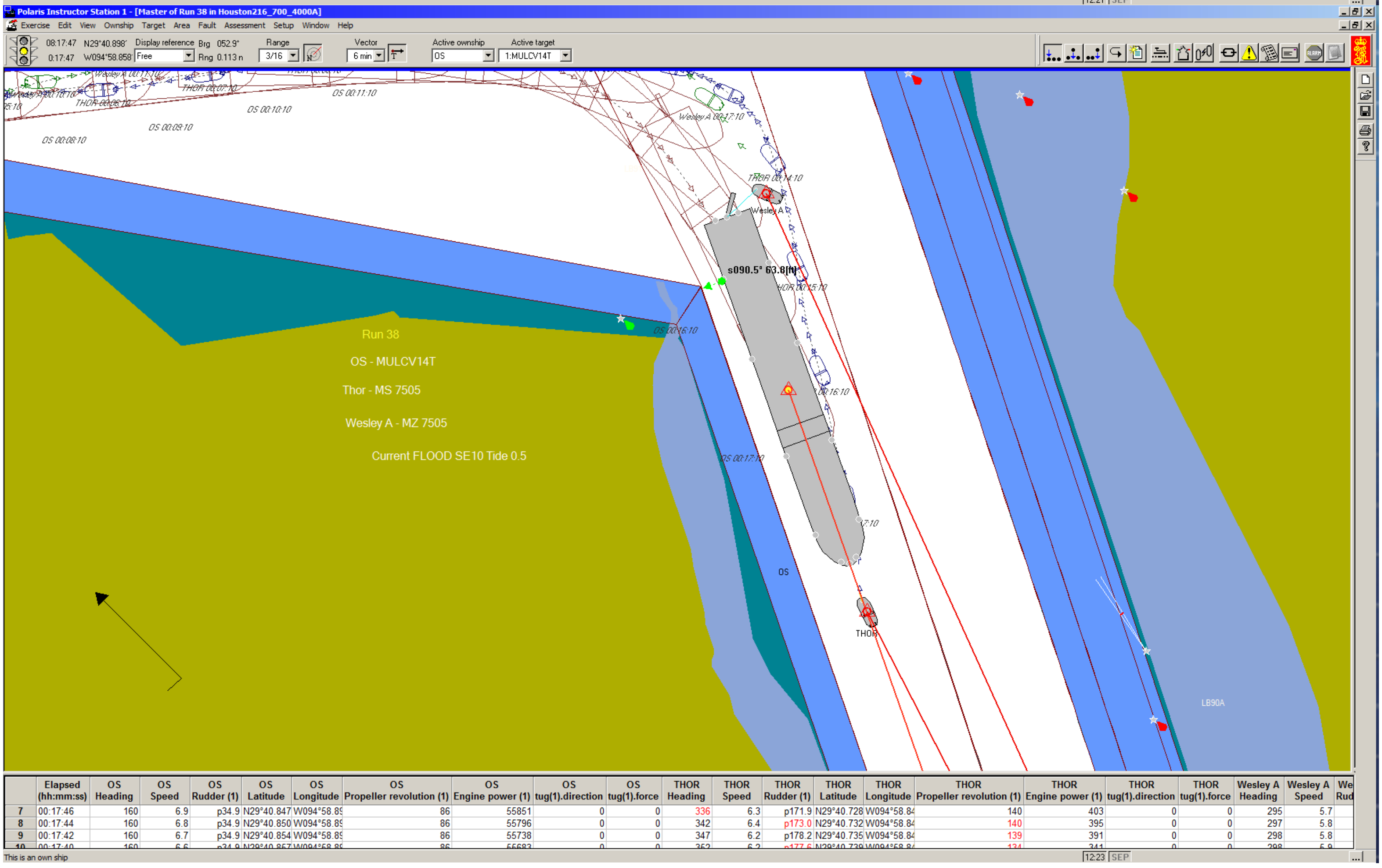
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:15:24	134	2.8	p0.2	N29°40.991	W094°58.98	35	3615	0	0	339	3.7	s162.9	N29°40.898	W094°58.88	115	282	0	0	274	3.8	
8	00:15:22	133	2.8	p0.2	N29°40.992	W094°58.99	35	3618	0	0	339	3.7	s171.6	N29°40.900	W094°58.88	115	282	0	0	274	3.8	
9	00:15:20	133	2.8	p0.2	N29°40.993	W094°58.99	35	3621	0	0	339	3.6	s161.7	N29°40.902	W094°58.88	115	279	0	0	273	3.6	
10	00:15:18	132	2.8	p0.2	N29°40.994	W094°58.9	35	3624	0	0	337	3.6	s154.8	N29°40.904	W094°58.8	115	276	0	0	272	3.4	

This is an own ship



Run 38
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:16:18	145	3.5	p0.2	N29°40.956	W094°58.95	59	19001	0	0	343	4.0	s172.4	N29°40.849	W094°58.87	114	258	0	0	279	4.1	
8	00:16:16	145	3.5	p0.2	N29°40.957	W094°58.95	59	19017	0	0	343	3.7	s179.8	N29°40.851	W094°58.87	115	268	0	0	279	4.0	
9	00:16:14	145	3.4	p0.2	N29°40.959	W094°58.95	59	19032	0	0	340	3.6	s164.6	N29°40.853	W094°58.87	115	273	0	0	280	3.9	



Run 38

OS - MULCV14T

Thor - MS 7505

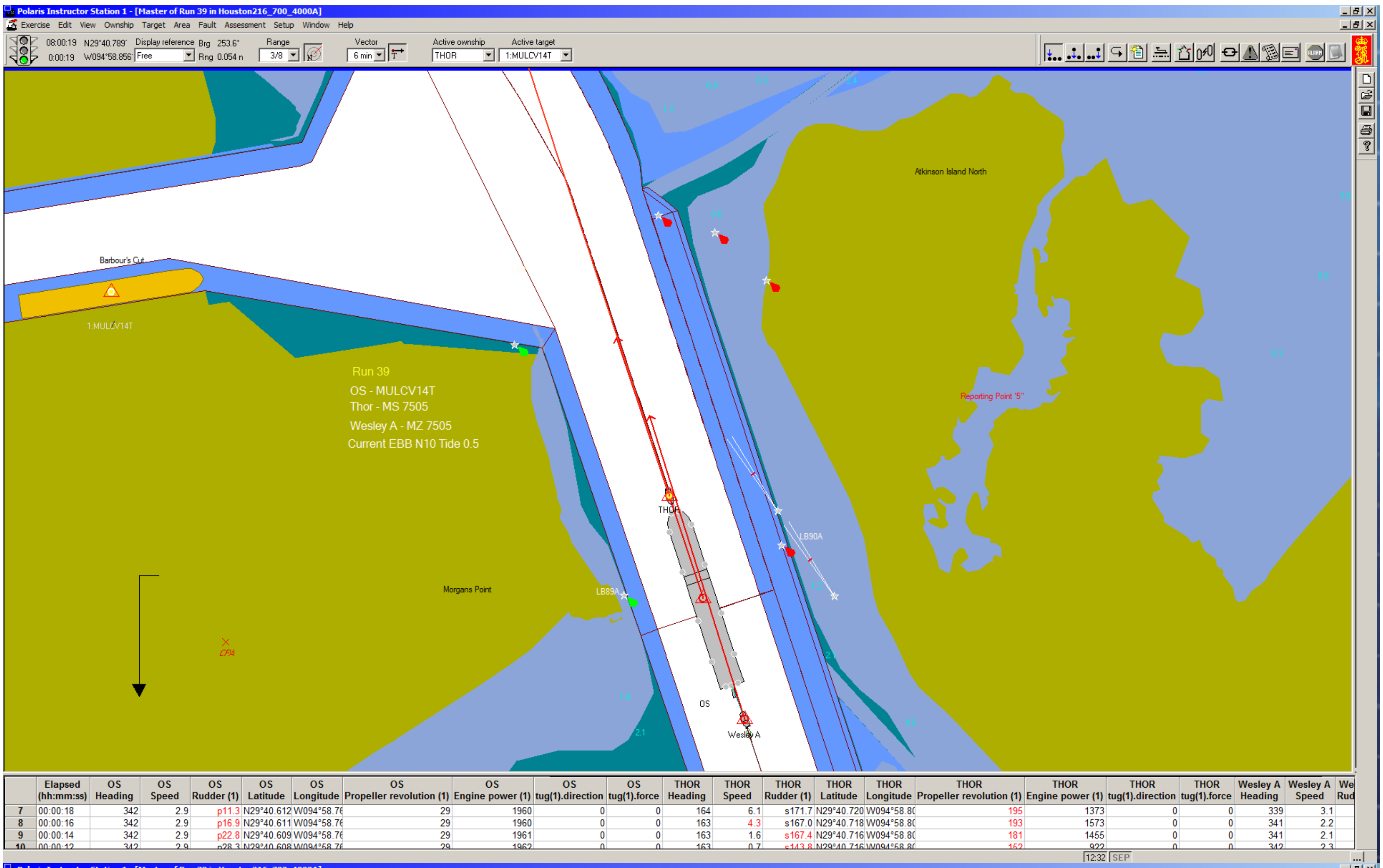
Wesley A - MZ 7505

Current FLOOD SE10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:17:46	160	6.9	p34.9	N29°40.847	W094°58.89	86	55851	0	0	336	6.3	p171.9	N29°40.728	W094°58.84	140	403	0	0	295	5.7	
8	00:17:44	160	6.8	p34.9	N29°40.850	W094°58.89	86	55796	0	0	342	6.4	p173.0	N29°40.732	W094°58.84	140	395	0	0	297	5.8	
9	00:17:42	160	6.7	p34.9	N29°40.854	W094°58.89	86	55738	0	0	347	6.2	p178.2	N29°40.735	W094°58.84	139	391	0	0	298	5.8	

This is an own ship

Run 39



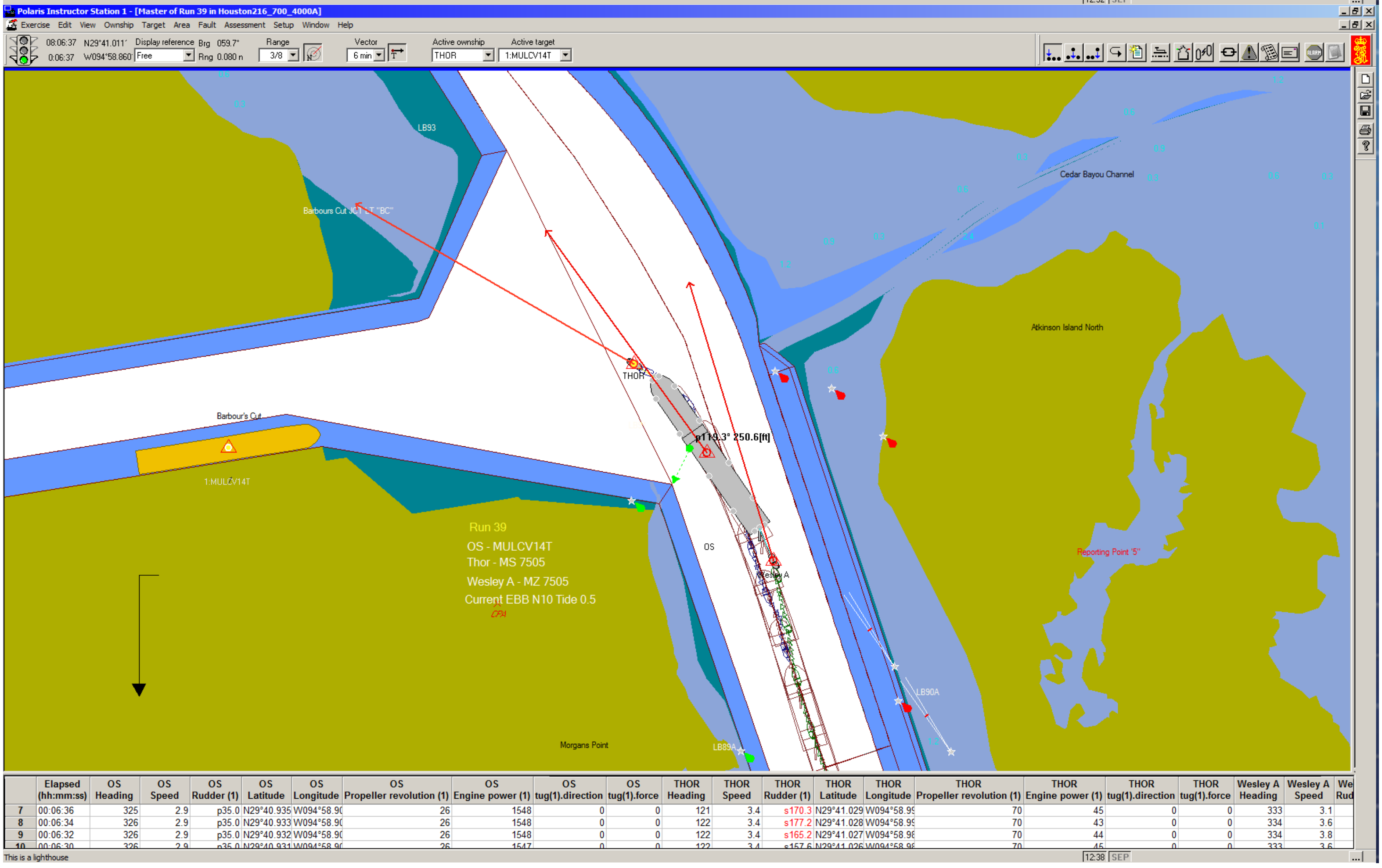
Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

08:00:19 N29°40.789′ Display reference Free Brg 253.6° Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T
0:00:19 W094°58.856′ Rng 0.054 n

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:00:18	342	2.9	p11.3	N29°40.612	W094°58.76	29	1960	0	0	164	6.1	s171.7	N29°40.720	W094°58.80	195	1373	0	0	339	3.1	
8	00:00:16	342	2.9	p16.9	N29°40.611	W094°58.76	29	1960	0	0	163	4.3	s167.0	N29°40.718	W094°58.80	193	1573	0	0	341	2.2	
9	00:00:14	342	2.9	p22.8	N29°40.609	W094°58.76	29	1961	0	0	163	1.6	s167.4	N29°40.716	W094°58.80	181	1455	0	0	341	2.1	
10	00:00:12	342	2.9	p28.3	N29°40.608	W094°58.76	29	1962	0	0	163	0.7	s143.8	N29°40.716	W094°58.80	152	922	0	0	342	2.3	

12:32 SEP



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

08:06:37 N29°41.011′ Display reference Free Brg 059.7° Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T
0:06:37 W094°58.860′ Rng 0.080 n

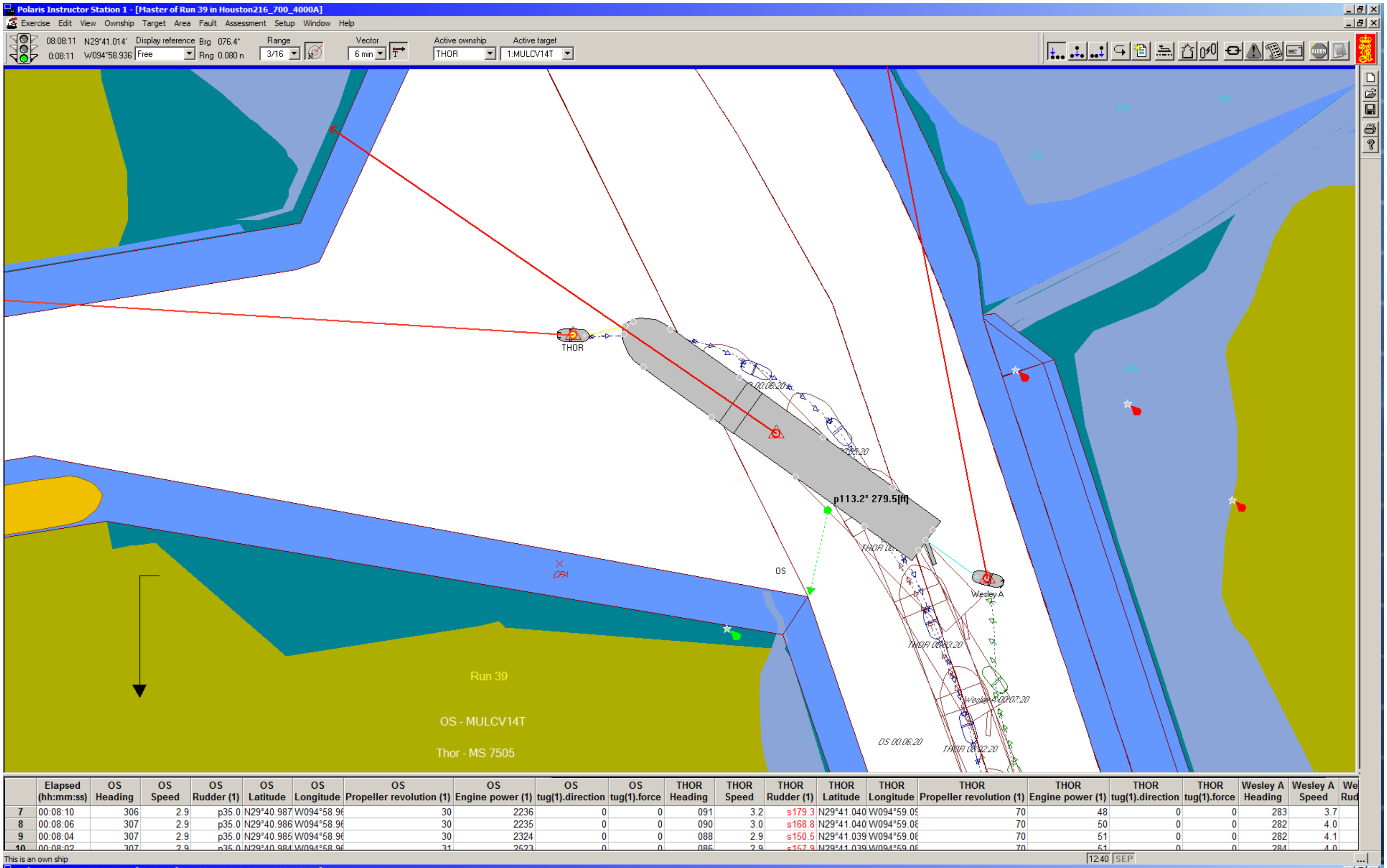
Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:06:36	325	2.9	p35.0	N29°40.935	W094°58.90	26	1548	0	0	121	3.4	s170.3	N29°41.029	W094°58.99	70	45	0	0	333	3.1	
8	00:06:34	326	2.9	p35.0	N29°40.933	W094°58.90	26	1548	0	0	122	3.4	s177.2	N29°41.028	W094°58.99	70	43	0	0	334	3.6	
9	00:06:32	326	2.9	p35.0	N29°40.932	W094°58.90	26	1548	0	0	122	3.4	s165.2	N29°41.027	W094°58.98	70	44	0	0	334	3.8	
10	00:06:30	326	2.9	p35.0	N29°40.931	W094°58.90	26	1547	0	0	122	3.4	s157.6	N29°41.026	W094°58.98	70	45	0	0	333	3.6	

This is a lighthouse

12:38 SEP

June 26, 2019



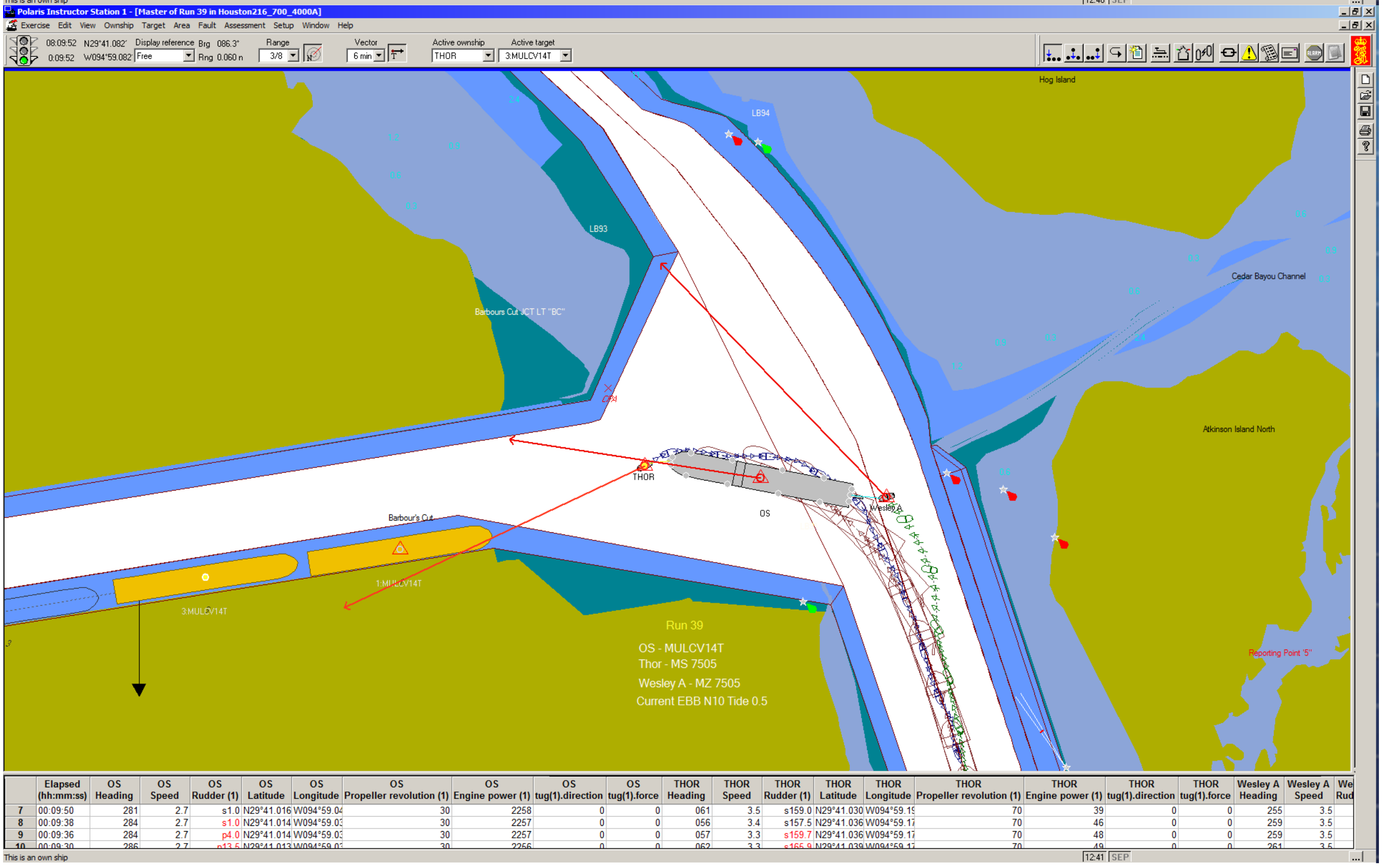
Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

08:08:11 N29°41.014′
0:08:11 W094°58.936′
Display reference: Free
Brg 076.4°
Rng 0.080 n
Range: 3/16
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:08:10	306	2.9	p35.0	N29°40.987	W094°58.96	30	2236	0	0	091	3.2	s179.3	N29°41.040	W094°59.09	70	48	0	0	283	3.7	
8	00:08:06	307	2.9	p35.0	N29°40.986	W094°58.96	30	2235	0	0	090	3.0	s168.8	N29°41.040	W094°59.08	70	50	0	0	282	4.0	
9	00:08:04	307	2.9	p35.0	N29°40.985	W094°58.96	30	2324	0	0	088	2.9	s150.5	N29°41.039	W094°59.08	70	51	0	0	282	4.1	
10	00:08:02	307	2.9	p35.0	N29°40.984	W094°58.96	31	2523	0	0	086	2.9	s157.9	N29°41.039	W094°59.08	70	51	0	0	284	4.0	

This is an own ship

12:40 SEP



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

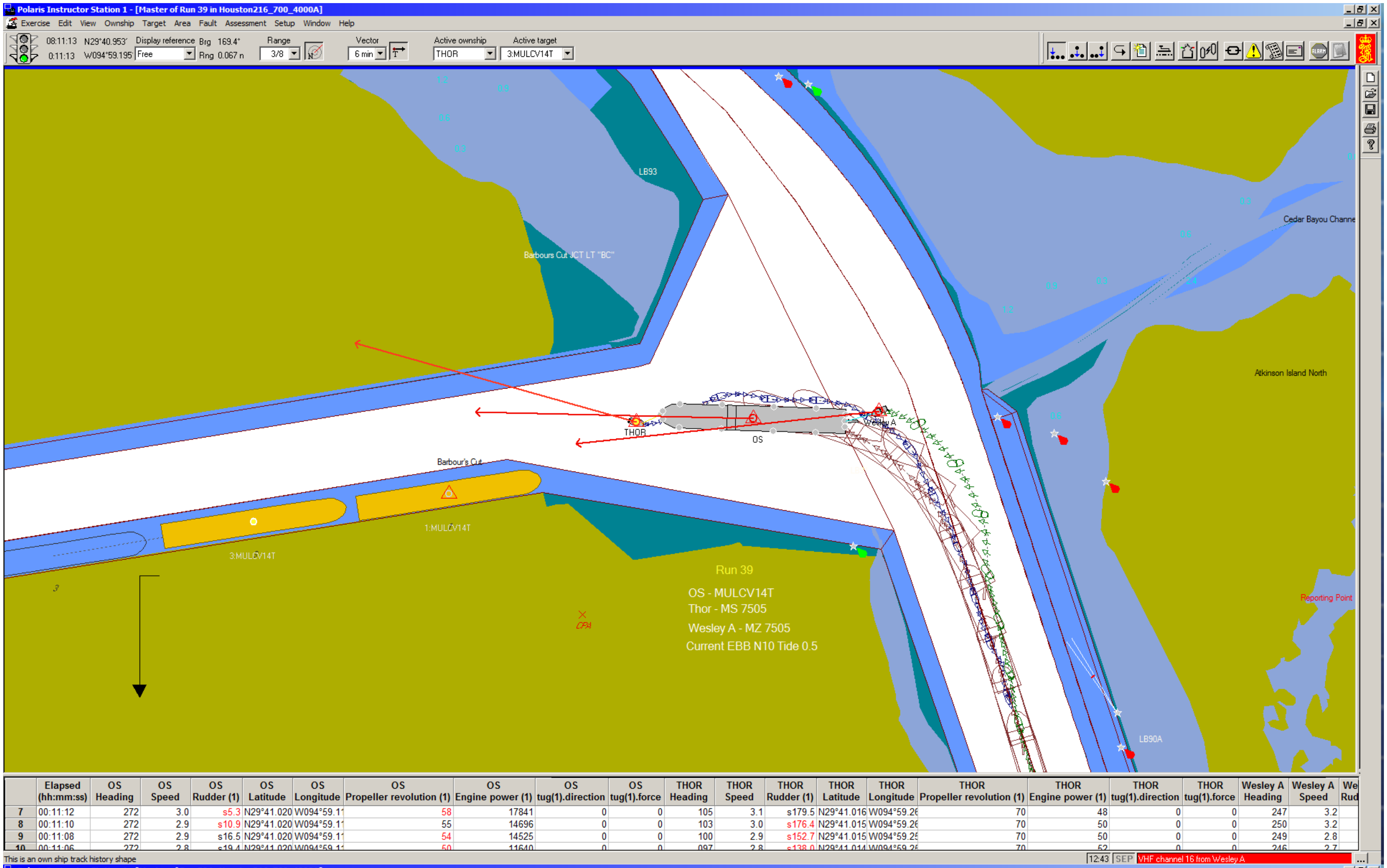
08:09:52 N29°41.082′
0:09:52 W094°59.082′
Display reference: Free
Brg 086.3°
Rng 0.060 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:09:50	281	2.7	s1.0	N29°41.016	W094°59.04	30	2258	0	0	061	3.5	s159.0	N29°41.030	W094°59.19	70	39	0	0	255	3.5	
8	00:09:38	284	2.7	s1.0	N29°41.014	W094°59.03	30	2257	0	0	056	3.4	s157.5	N29°41.036	W094°59.17	70	46	0	0	259	3.5	
9	00:09:36	284	2.7	p4.0	N29°41.014	W094°59.03	30	2257	0	0	057	3.3	s159.7	N29°41.036	W094°59.17	70	48	0	0	259	3.5	
10	00:09:30	286	2.7	p13.5	N29°41.013	W094°59.03	30	2256	0	0	062	3.3	s165.9	N29°41.039	W094°59.17	70	49	0	0	261	3.5	

This is an own ship

12:41 SEP

June 26, 2019



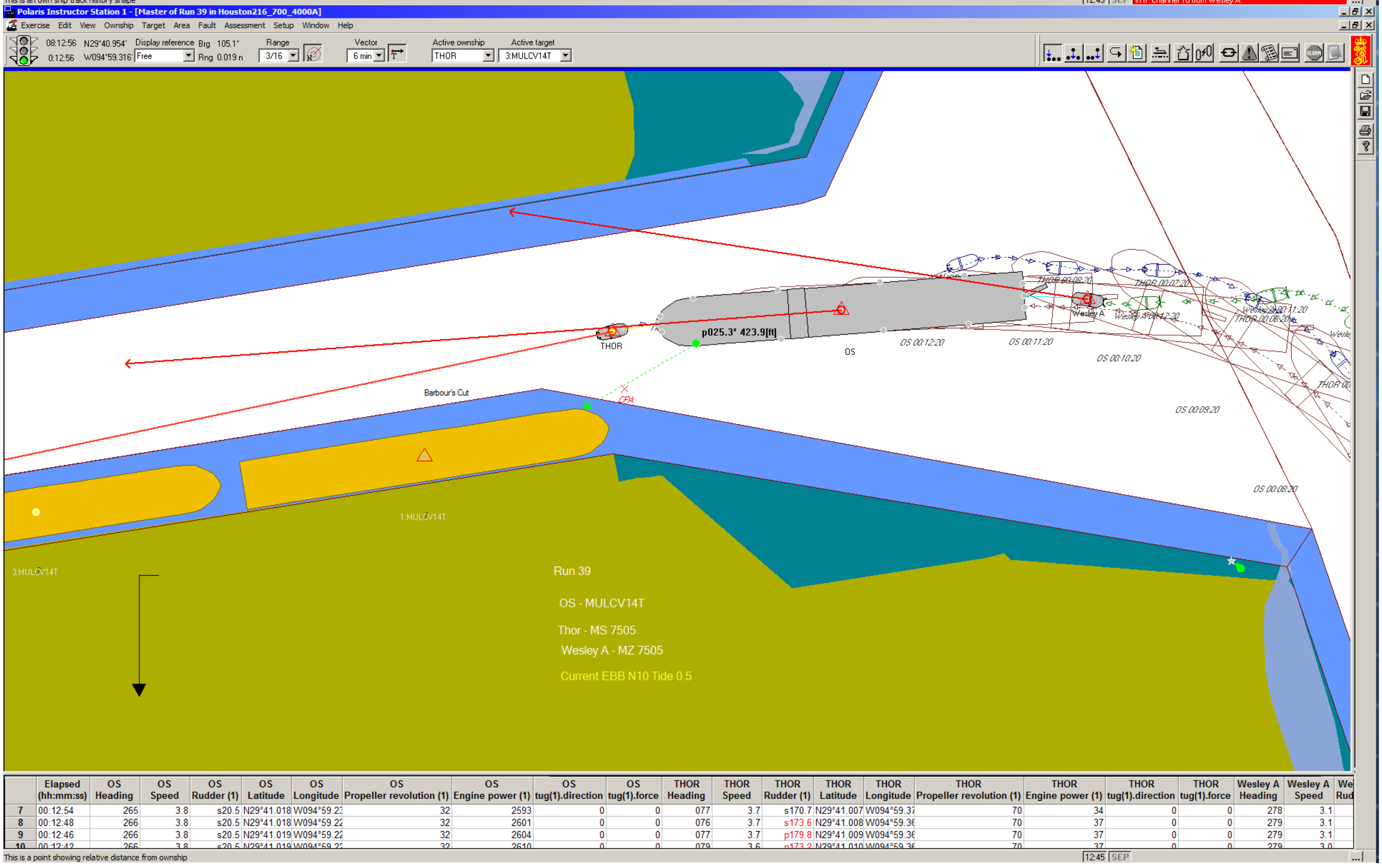
08:11:13 N29°40.953' Display reference: Free Brg 169.4° Rng 0.067 n Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:11:13 W094°59.195'

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:11:12	272	3.0	s5.3	N29°41.020	W094°59.11	58	17841	0	0	105	3.1	s179.5	N29°41.016	W094°59.26	70	48	0	0	247	3.2	
8	00:11:10	272	2.9	s10.9	N29°41.020	W094°59.11	55	14696	0	0	103	3.0	s176.4	N29°41.015	W094°59.26	70	50	0	0	250	3.2	
9	00:11:08	272	2.9	s16.5	N29°41.020	W094°59.11	54	14525	0	0	100	2.9	s152.7	N29°41.015	W094°59.25	70	50	0	0	249	2.8	
10	00:11:06	272	2.8	s19.4	N29°41.020	W094°59.11	50	11640	0	0	097	2.8	s138.0	N29°41.014	W094°59.25	70	52	0	0	246	2.7	

This is an own ship track history shape

12:43 SEP VHF channel 16 from Wesley A



08:12:56 N29°40.954' Display reference: Free Brg 105.1° Rng 0.019 n Range 3/16 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:12:56 W094°59.316'

Run 39

OS - MULCV14T

Thor - MS 7505

Wesley A - MZ 7505

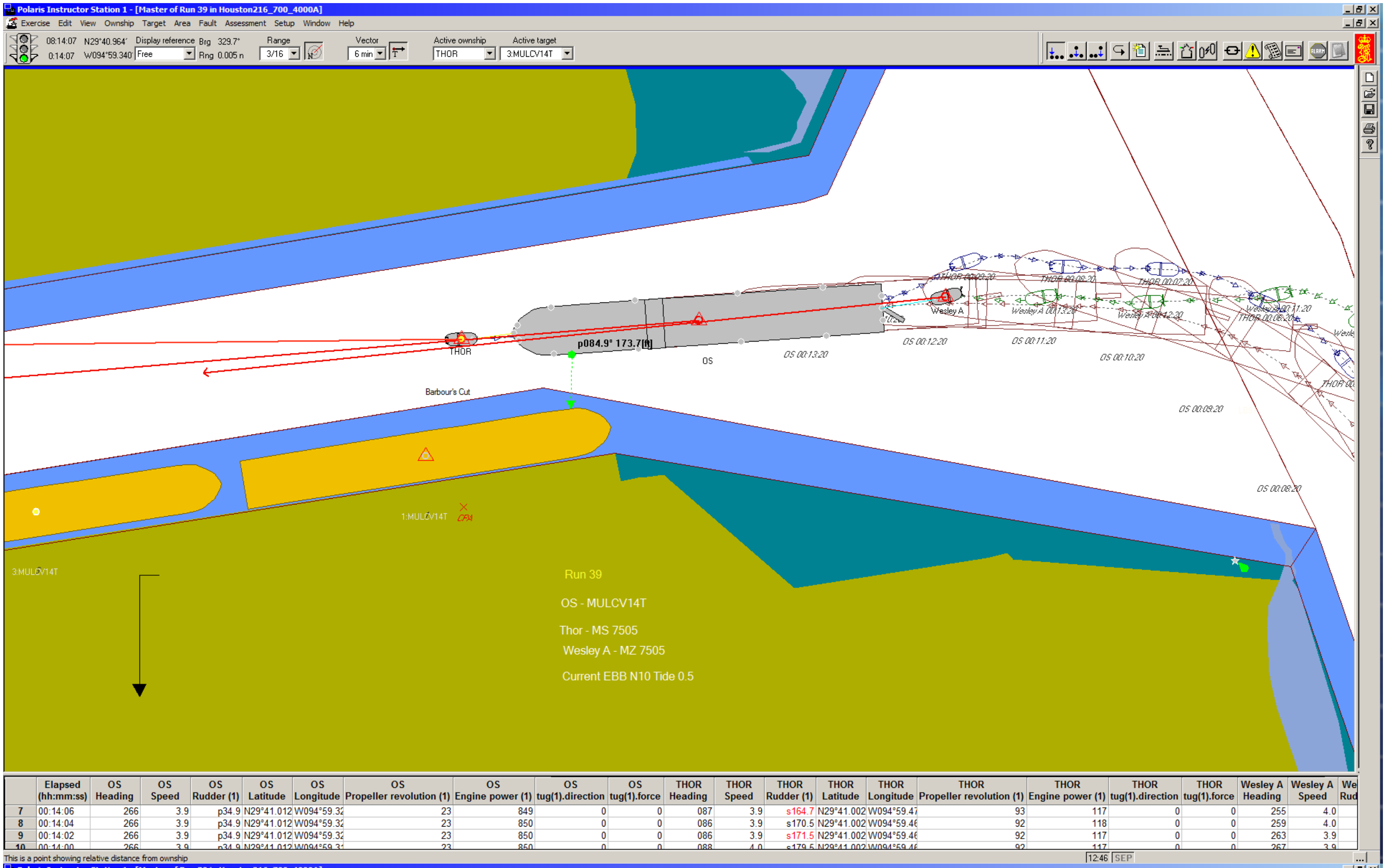
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:12:54	265	3.8	s20.5	N29°41.018	W094°59.23	32	2593	0	0	077	3.7	s170.7	N29°41.007	W094°59.37	70	34	0	0	278	3.1	
8	00:12:48	266	3.8	s20.5	N29°41.018	W094°59.22	32	2601	0	0	076	3.7	s173.6	N29°41.008	W094°59.36	70	37	0	0	279	3.1	
9	00:12:46	266	3.8	s20.5	N29°41.019	W094°59.22	32	2604	0	0	077	3.7	p179.8	N29°41.009	W094°59.36	70	37	0	0	279	3.1	
10	00:12:42	266	3.8	s20.5	N29°41.019	W094°59.22	32	2610	0	0	079	3.6	p173.2	N29°41.010	W094°59.36	70	37	0	0	279	3.0	

This is a point showing relative distance from ownship

12:45 SEP

June 26, 2019

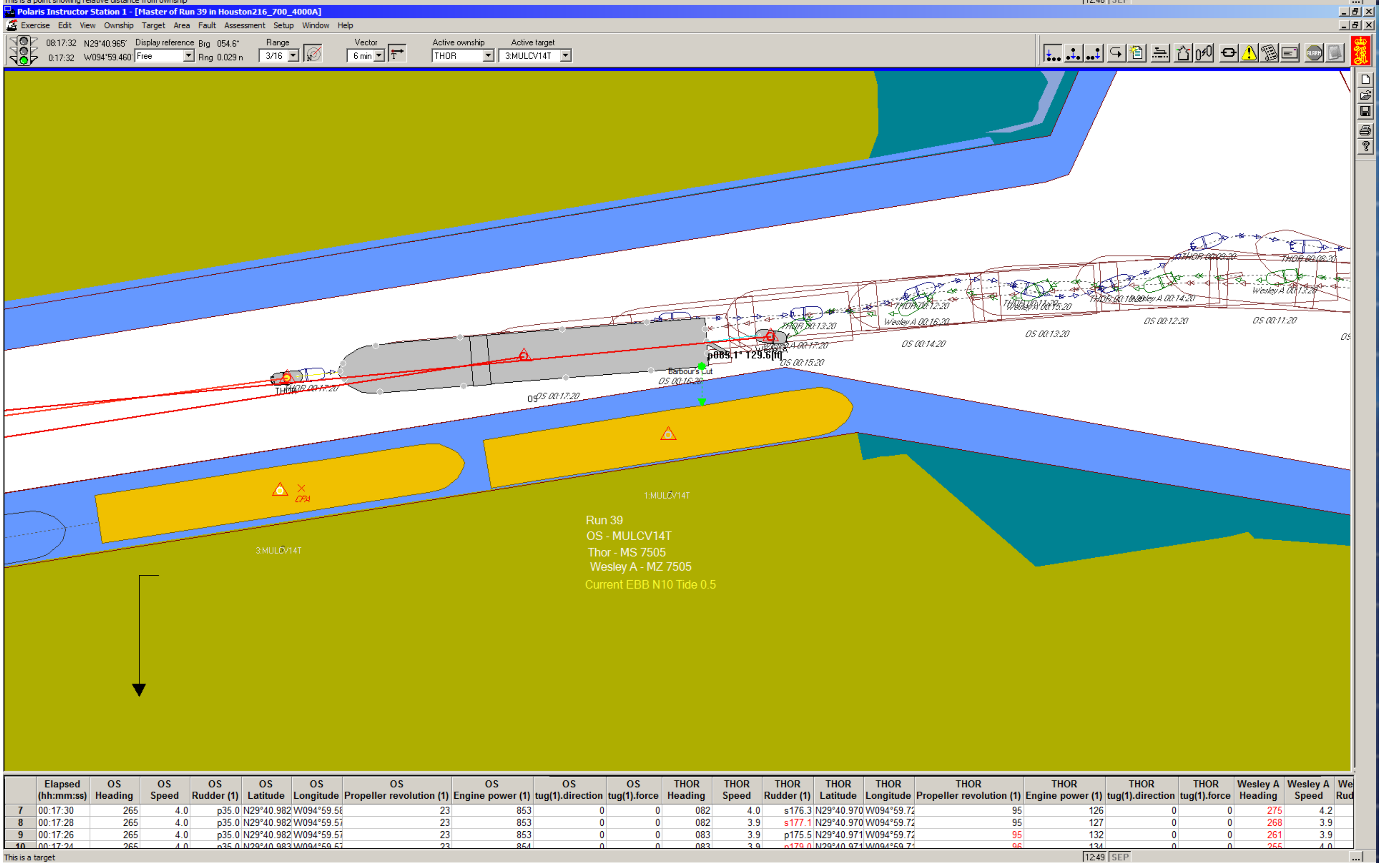


08:14:07 N29°40.964′ Display reference Free Brg 329.7° Range 3/16 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:14:07 W094°59.340′ Rng 0.005 n

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:06	266	3.9	p34.9	N29°41.012	W094°59.32	23	849	0	0	087	3.9	s164.7	N29°41.002	W094°59.47	93	117	0	0	255	4.0	
8	00:14:04	266	3.9	p34.9	N29°41.012	W094°59.32	23	850	0	0	086	3.9	s170.5	N29°41.002	W094°59.46	92	118	0	0	259	4.0	
9	00:14:02	266	3.9	p34.9	N29°41.012	W094°59.32	23	850	0	0	086	3.9	s171.5	N29°41.002	W094°59.46	92	117	0	0	263	3.9	
10	00:14:00	266	3.9	p34.9	N29°41.012	W094°59.31	23	850	0	0	088	4.0	s179.5	N29°41.002	W094°59.46	92	117	0	0	267	3.9	

This is a point showing relative distance from ownship



08:17:32 N29°40.965′ Display reference Free Brg 054.6° Range 3/16 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:17:32 W094°59.460′ Rng 0.029 n

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:17:30	265	4.0	p35.0	N29°40.982	W094°59.58	23	853	0	0	082	4.0	s176.3	N29°40.970	W094°59.72	95	126	0	0	275	4.2	
8	00:17:28	265	4.0	p35.0	N29°40.982	W094°59.57	23	853	0	0	082	3.9	s177.1	N29°40.970	W094°59.72	95	127	0	0	268	3.9	
9	00:17:26	265	4.0	p35.0	N29°40.982	W094°59.57	23	853	0	0	083	3.9	p175.5	N29°40.971	W094°59.72	95	132	0	0	261	3.9	
10	00:17:24	265	4.0	p35.0	N29°40.983	W094°59.57	23	854	0	0	083	3.9	p179.0	N29°40.971	W094°59.71	96	134	0	0	255	4.0	

This is a target

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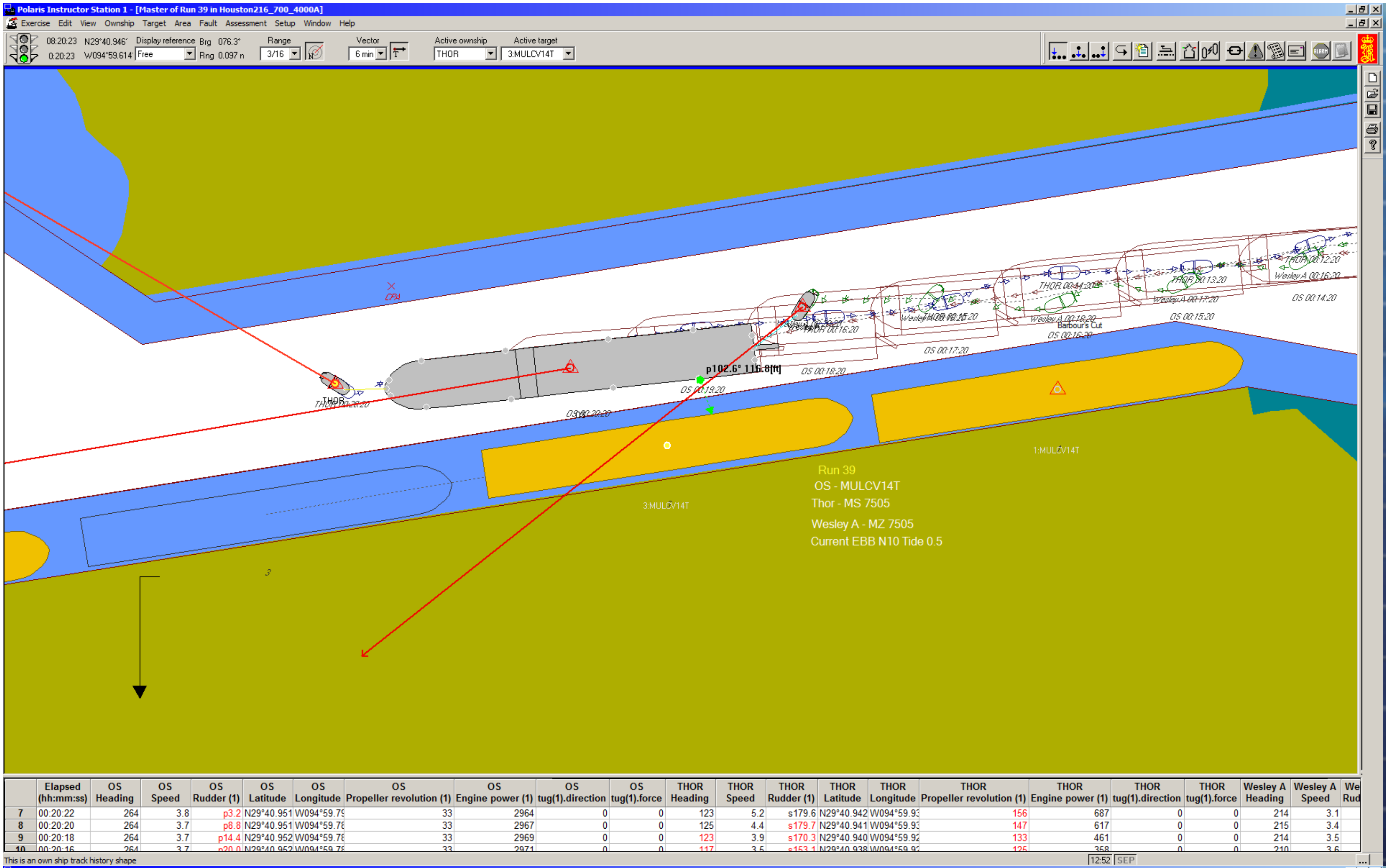


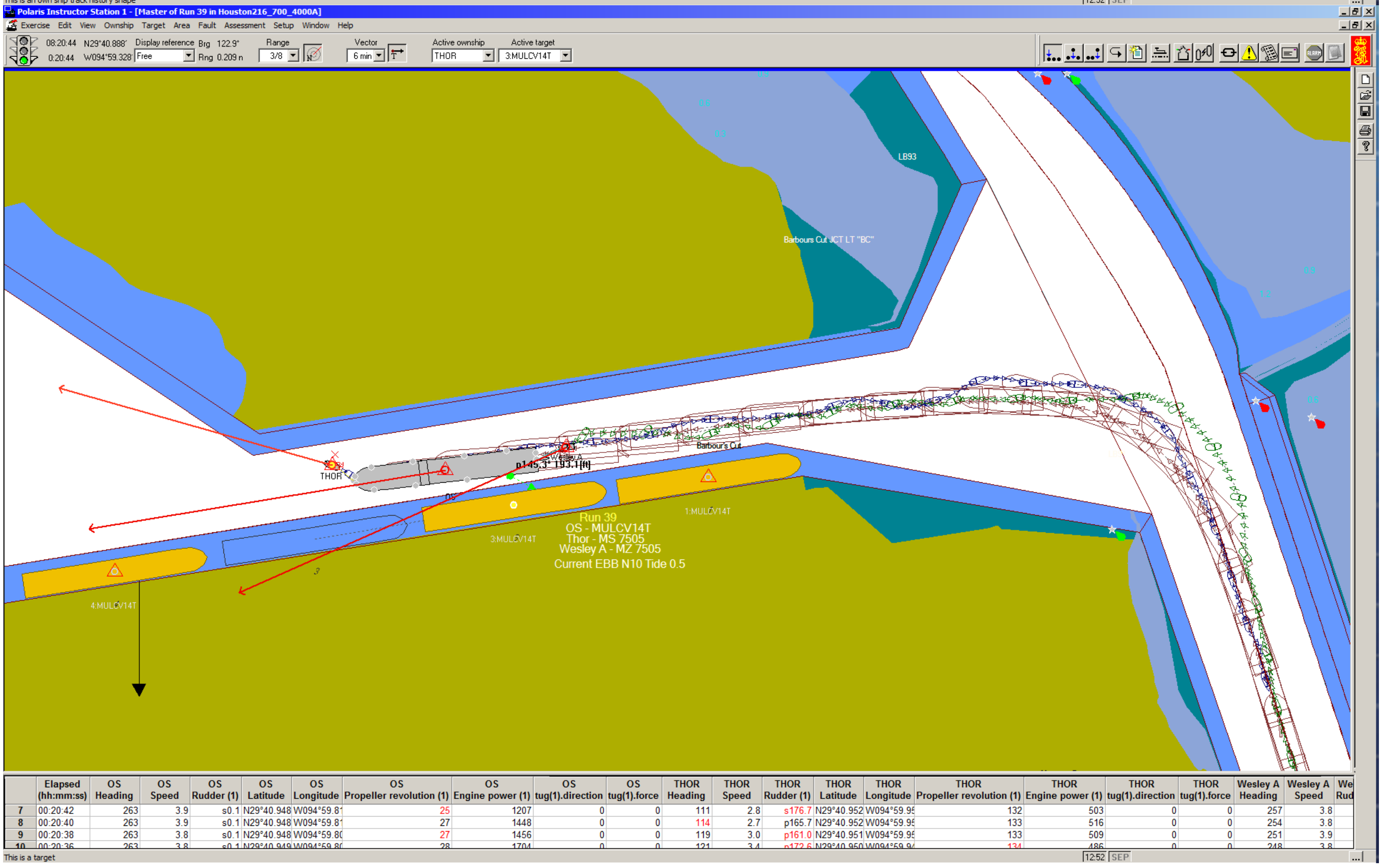
Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

08:20:23 N29°40.946' Display reference Free Brg 076.3° Rng 0.097 n
0:20:23 W094°59.614'
Range 3/16
Vector 6 min
Active ownship THOR
Active target 3:MULCV14T

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:20:22	264	3.8	p3.2	N29°40.951	W094°59.79	33	2964	0	0	123	5.2	s179.6	N29°40.942	W094°59.93	156	687	0	0	214	3.1	
8	00:20:20	264	3.7	p8.8	N29°40.951	W094°59.78	33	2967	0	0	125	4.4	s179.7	N29°40.941	W094°59.93	147	617	0	0	215	3.4	
9	00:20:18	264	3.7	p14.4	N29°40.952	W094°59.78	33	2969	0	0	123	3.9	s170.3	N29°40.940	W094°59.92	133	461	0	0	214	3.5	
10	00:20:16	264	3.7	p20.0	N29°40.952	W094°59.78	33	2971	0	0	117	3.5	s153.1	N29°40.938	W094°59.92	125	358	0	0	210	3.6	

This is an own ship track history shape



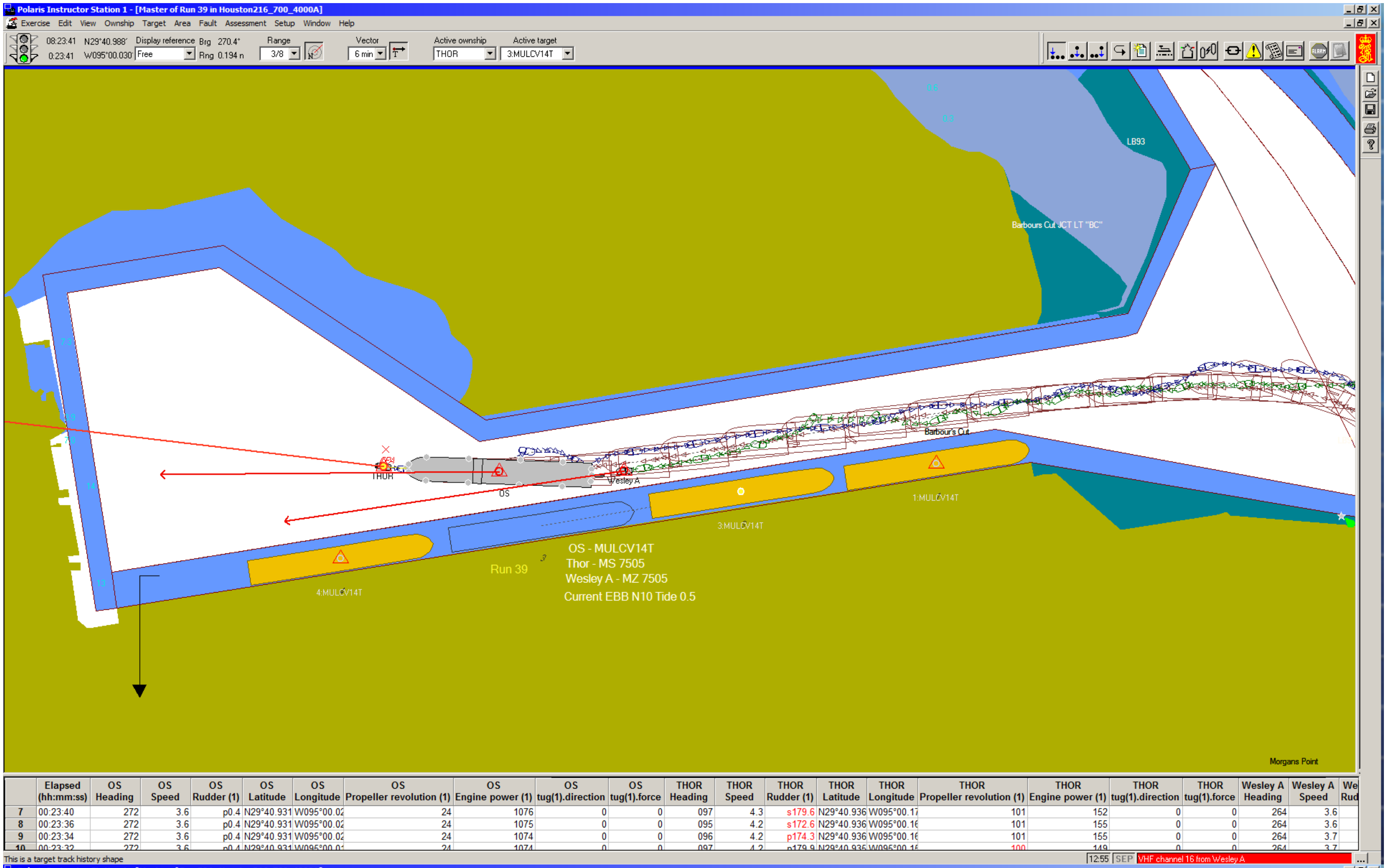
Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

08:20:44 N29°40.888' Display reference Free Brg 122.9° Rng 0.209 n
0:20:44 W094°59.328'
Range 3/8
Vector 6 min
Active ownship THOR
Active target 3:MULCV14T

Run 39
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:20:42	263	3.9	s0.1	N29°40.948	W094°59.81	25	1207	0	0	111	2.8	s176.7	N29°40.952	W094°59.95	132	503	0	0	257	3.8	
8	00:20:40	263	3.9	s0.1	N29°40.948	W094°59.81	27	1448	0	0	114	2.7	p165.7	N29°40.952	W094°59.95	133	516	0	0	254	3.8	
9	00:20:38	263	3.8	s0.1	N29°40.948	W094°59.80	27	1456	0	0	119	3.0	p161.0	N29°40.951	W094°59.95	133	509	0	0	251	3.9	
10	00:20:36	263	3.8	s0.1	N29°40.949	W094°59.80	28	1704	0	0	121	3.4	p172.6	N29°40.950	W094°59.94	134	486	0	0	248	3.8	

This is a target



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

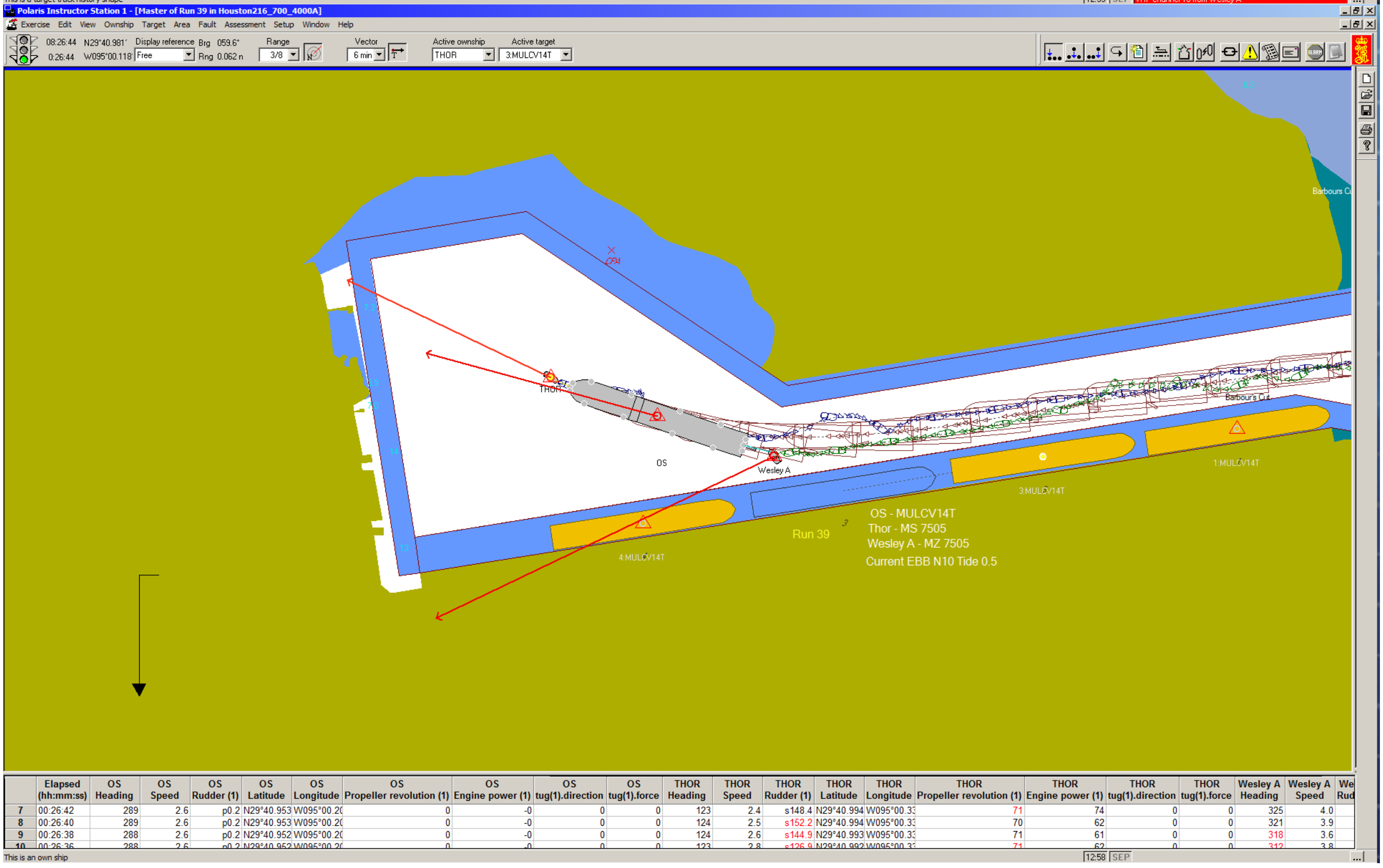
08:23:41 N29°40.988'
0:23:41 W095°00.030
Display reference: Free
Brg 270.4°
Rng 0.194 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:23:40	272	3.6	p0.4	N29°40.931	W095°00.02	24	1076	0	0	097	4.3	s179.6	N29°40.936	W095°00.17	101	152	0	0	264	3.6	
8	00:23:36	272	3.6	p0.4	N29°40.931	W095°00.02	24	1075	0	0	095	4.2	s172.6	N29°40.936	W095°00.16	101	155	0	0	264	3.6	
9	00:23:34	272	3.6	p0.4	N29°40.931	W095°00.02	24	1074	0	0	096	4.2	p174.3	N29°40.936	W095°00.16	101	155	0	0	264	3.7	
10	00:23:32	272	3.6	p0.4	N29°40.931	W095°00.01	24	1074	0	0	097	4.2	p179.9	N29°40.935	W095°00.16	100	149	0	0	264	3.7	

This is a target track history shape

12:55 SEP VHF channel 16 from Wesley A



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

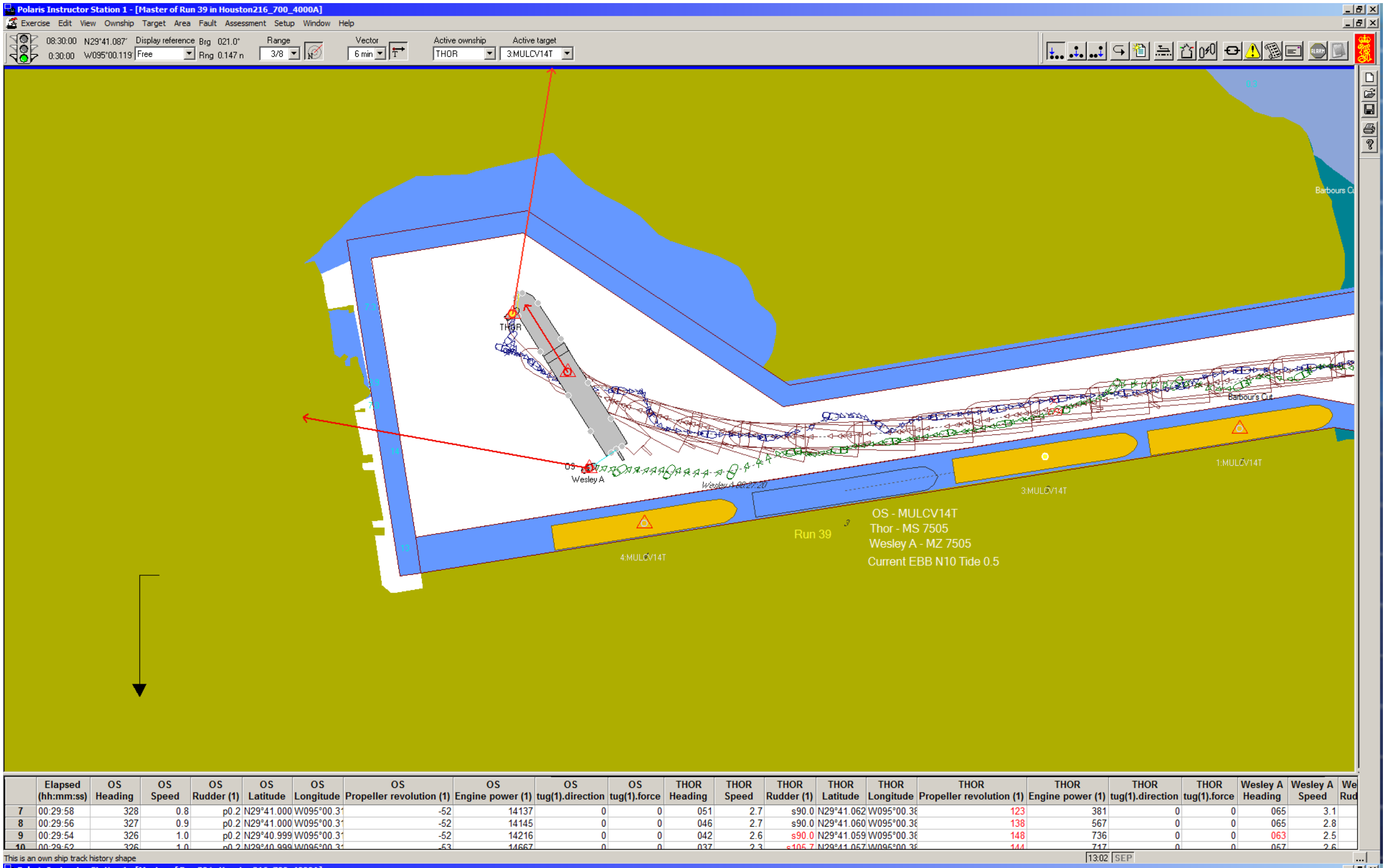
08:26:44 N29°40.981'
0:26:44 W095°00.118
Display reference: Free
Brg 059.6°
Rng 0.062 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:26:42	289	2.6	p0.2	N29°40.953	W095°00.20	0	-0	0	0	123	2.4	s148.4	N29°40.994	W095°00.33	71	74	0	0	325	4.0	
8	00:26:40	289	2.6	p0.2	N29°40.953	W095°00.20	0	-0	0	0	124	2.5	s152.2	N29°40.994	W095°00.33	70	62	0	0	321	3.9	
9	00:26:38	288	2.6	p0.2	N29°40.952	W095°00.20	0	-0	0	0	124	2.6	s144.9	N29°40.993	W095°00.33	71	61	0	0	318	3.6	
10	00:26:36	288	2.6	p0.2	N29°40.952	W095°00.20	0	-0	0	0	123	2.8	s126.9	N29°40.992	W095°00.33	71	62	0	0	312	3.8	

This is an own ship

12:58 SEP



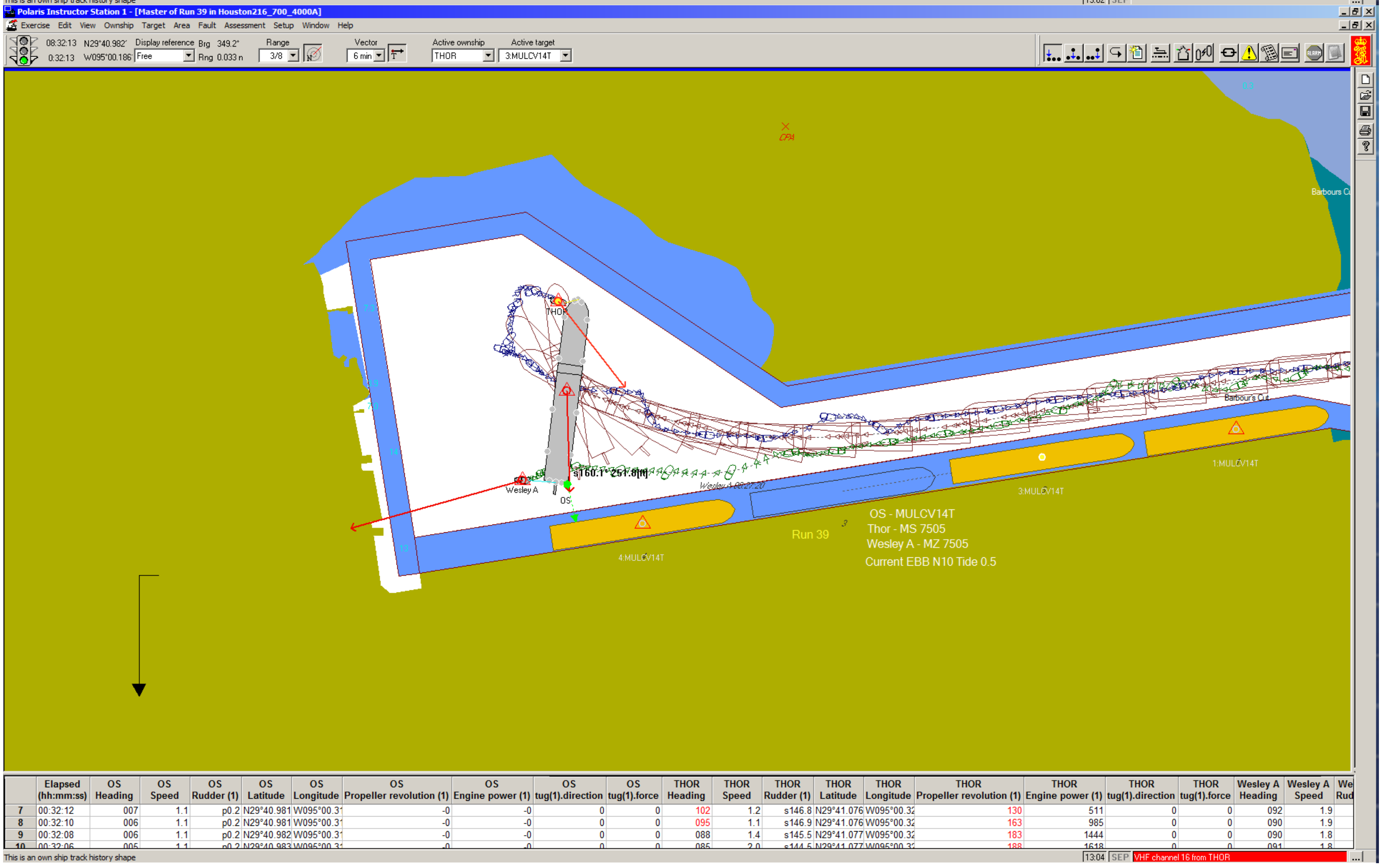
08:30:00 N29°41.087' Display reference Free Brg 021.0° Rng 0.147 n
0:30:00 W095°00.119'
Range 3/8
Vector 6 min
Active ownship THOR
Active target 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:29:58	328	0.8	p0.2	N29°41.000	W095°00.31	-52	14137	0	0	051	2.7	s90.0	N29°41.062	W095°00.38	123	381	0	0	065	3.1	
8	00:29:56	327	0.9	p0.2	N29°41.000	W095°00.31	-52	14145	0	0	046	2.7	s90.0	N29°41.060	W095°00.38	138	567	0	0	065	2.8	
9	00:29:54	326	1.0	p0.2	N29°40.999	W095°00.31	-52	14216	0	0	042	2.6	s90.0	N29°41.059	W095°00.38	148	736	0	0	063	2.5	
10	00:29:52	326	1.0	p0.2	N29°40.999	W095°00.31	-53	14667	0	0	037	2.3	s105.7	N29°41.057	W095°00.38	144	717	0	0	057	2.6	

This is an own ship track history shape

13:02 SEP



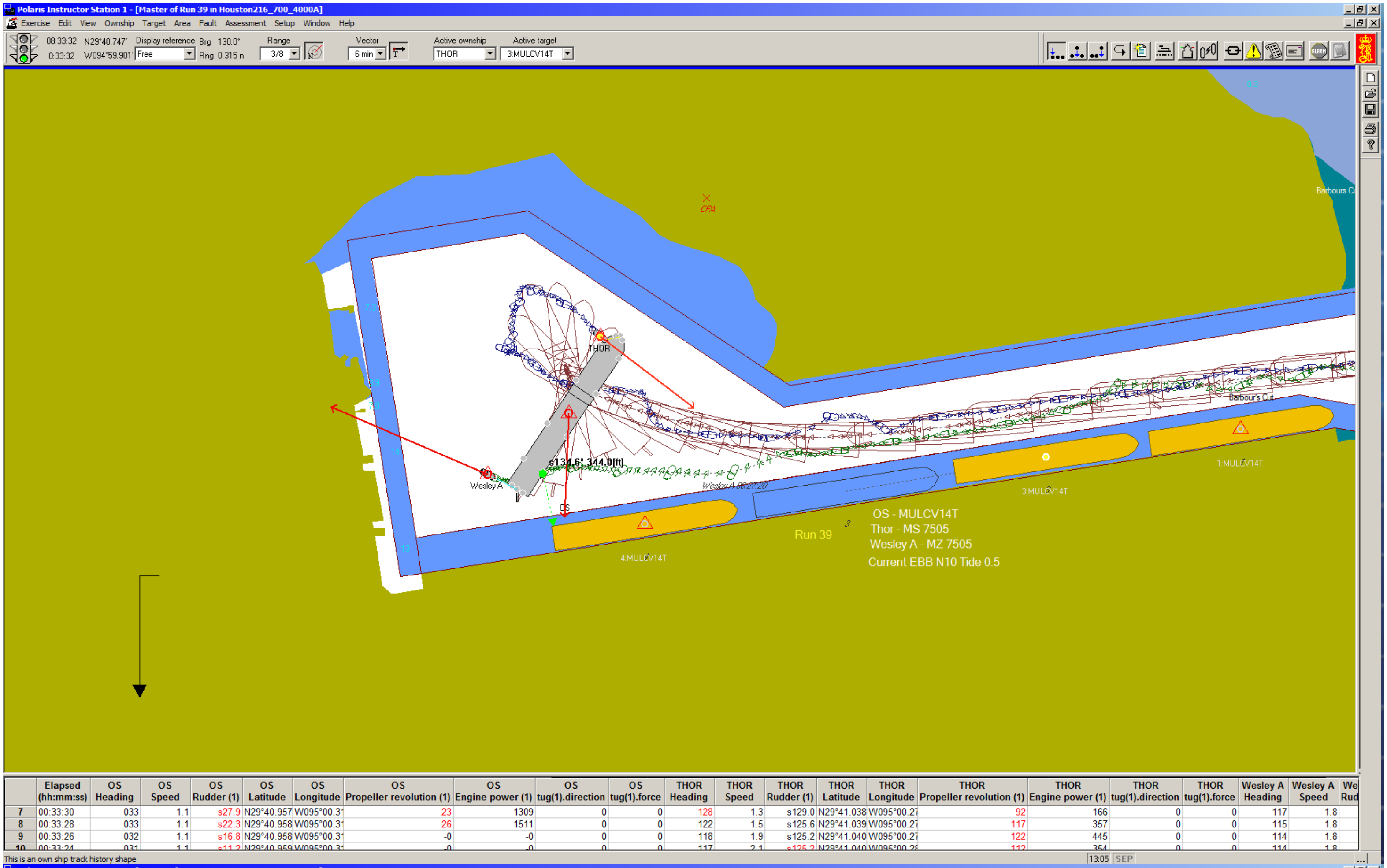
08:32:13 N29°40.982' Display reference Free Brg 349.2° Rng 0.033 n
0:32:13 W095°00.186'
Range 3/8
Vector 6 min
Active ownship THOR
Active target 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:32:12	007	1.1	p0.2	N29°40.981	W095°00.31	-0	-0	0	0	102	1.2	s146.8	N29°41.076	W095°00.32	130	511	0	0	092	1.9	
8	00:32:10	006	1.1	p0.2	N29°40.981	W095°00.31	-0	-0	0	0	095	1.1	s146.9	N29°41.076	W095°00.32	163	985	0	0	090	1.9	
9	00:32:08	006	1.1	p0.2	N29°40.982	W095°00.31	-0	-0	0	0	088	1.4	s145.5	N29°41.077	W095°00.32	183	1444	0	0	090	1.8	
10	00:32:06	005	1.1	p0.2	N29°40.983	W095°00.31	-0	-0	0	0	085	2.0	s144.5	N29°41.077	W095°00.32	188	1618	0	0	091	1.8	

This is an own ship track history shape

13:04 SEP VHF channel 16 from THOR



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

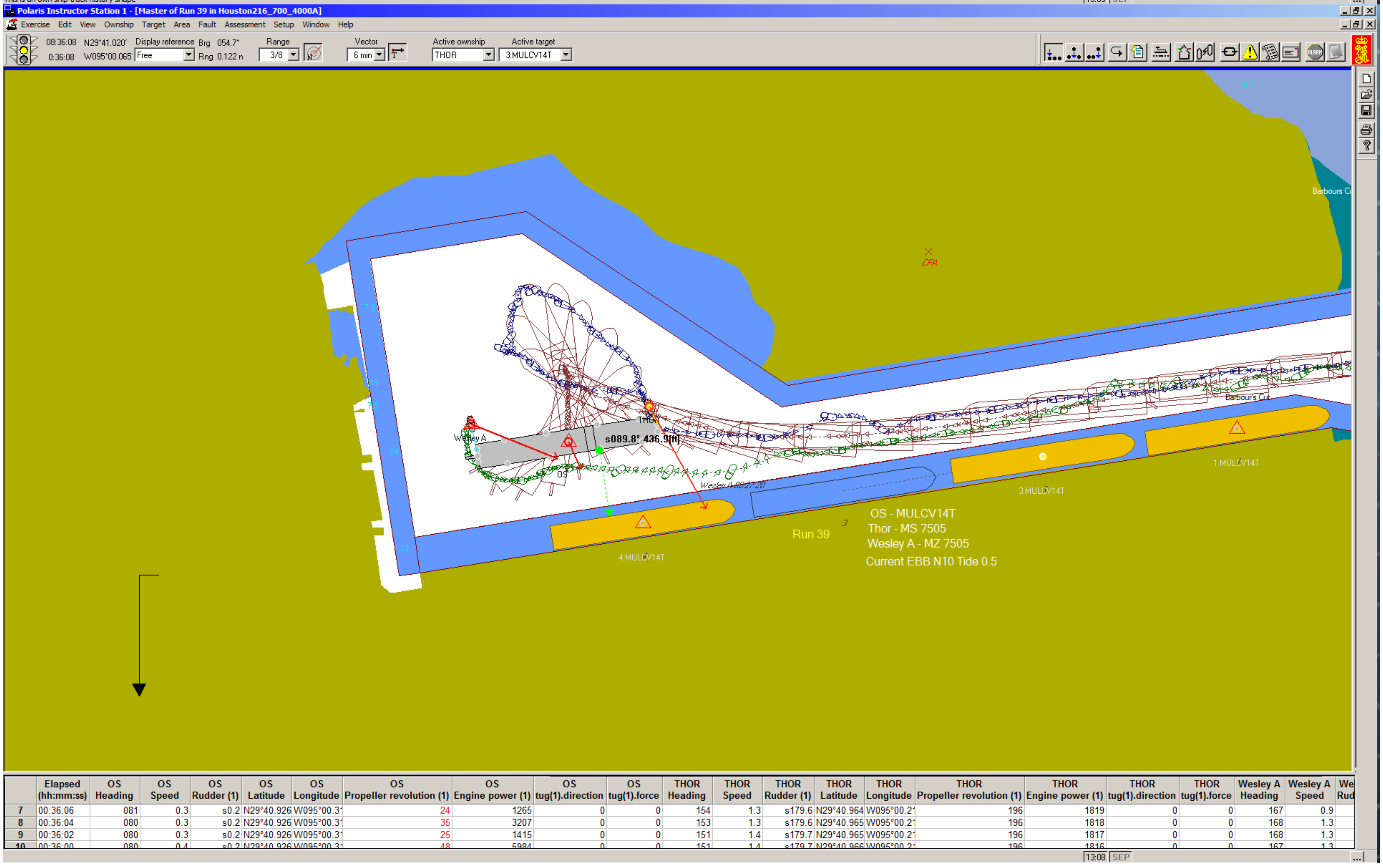
08:33:32 N29°40.747′ Display reference Free Brg 130.0° Rng 0.315 n
0:33:32 W094°59.901′

Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:33:30	033	1.1	s27.9	N29°40.957	W095°00.31	23	1309	0	0	128	1.3	s129.0	N29°41.038	W095°00.27	92	166	0	0	117	1.8	
8	00:33:28	033	1.1	s22.3	N29°40.958	W095°00.31	26	1511	0	0	122	1.5	s125.6	N29°41.039	W095°00.27	117	357	0	0	115	1.8	
9	00:33:26	032	1.1	s16.8	N29°40.958	W095°00.31	-0	-0	0	0	118	1.9	s125.2	N29°41.040	W095°00.27	122	445	0	0	114	1.8	
10	00:33:24	031	1.1	s11.2	N29°40.959	W095°00.31	-0	-0	0	0	117	2.1	s125.2	N29°41.040	W095°00.28	112	354	0	0	114	1.8	

This is an own ship track history shape

13:05 SEP



Polaris Instructor Station 1 - [Master of Run 39 in Houston216_700_4000A]

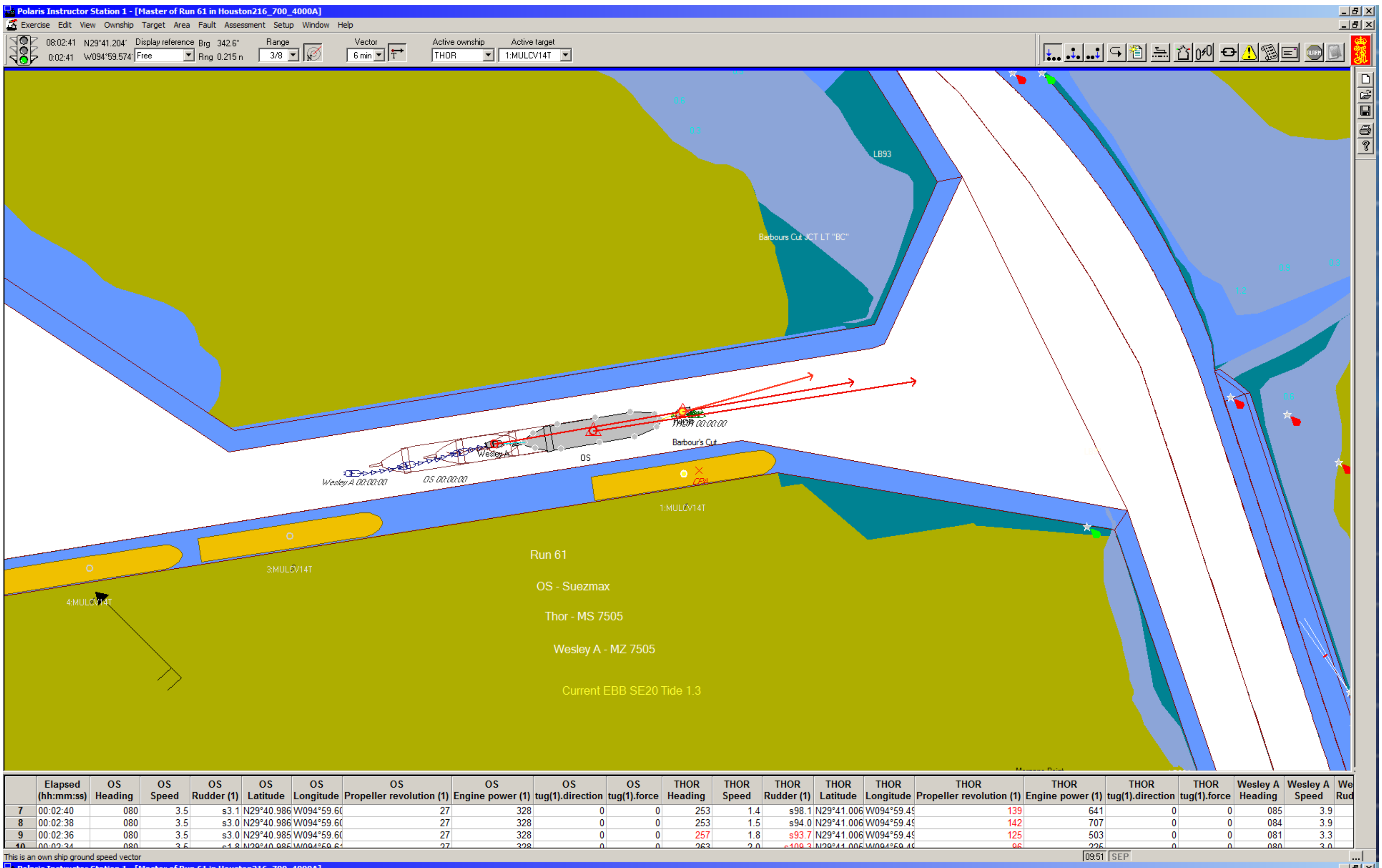
08:36:08 N29°41.020′ Display reference Free Brg 054.7° Rng 0.122 n
0:36:08 W095°00.065′

Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:36:06	081	0.3	s0.2	N29°40.926	W095°00.31	24	1265	0	0	154	1.3	s179.6	N29°40.964	W095°00.21	196	1819	0	0	167	0.9	
8	00:36:04	080	0.3	s0.2	N29°40.926	W095°00.31	35	3207	0	0	153	1.3	s179.6	N29°40.965	W095°00.21	196	1818	0	0	168	1.3	
9	00:36:02	080	0.3	s0.2	N29°40.926	W095°00.31	25	1415	0	0	151	1.4	s179.7	N29°40.965	W095°00.21	196	1817	0	0	168	1.3	
10	00:36:00	080	0.4	s0.2	N29°40.926	W095°00.31	48	5984	0	0	151	1.4	s179.7	N29°40.966	W095°00.21	196	1816	0	0	167	1.3	

13:08 SEP

Run 61


Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

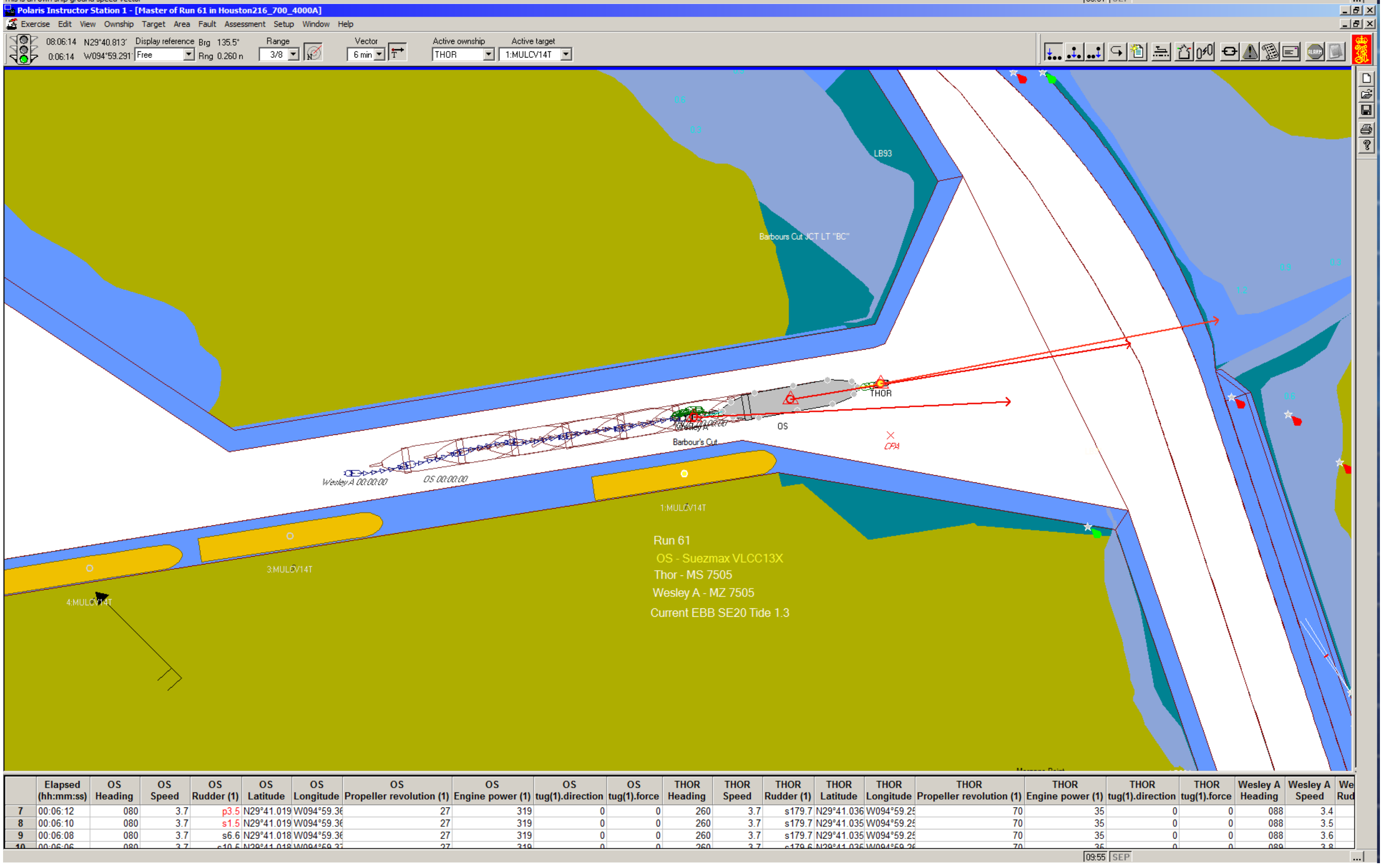
08:02:41 N29°41.204' Display reference: Free Brg 342.6° Rng 0.215 n
0:02:41 W094°59.574'
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 61
OS - Suezmax
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:02:40	080	3.5	s3.1	N29°40.986	W094°59.60	27	328	0	0	253	1.4	s98.1	N29°41.006	W094°59.49	139	641	0	0	085	3.9
8	00:02:38	080	3.5	s3.0	N29°40.986	W094°59.60	27	328	0	0	253	1.5	s94.0	N29°41.006	W094°59.49	142	707	0	0	084	3.9
9	00:02:36	080	3.5	s3.0	N29°40.985	W094°59.60	27	328	0	0	257	1.8	s93.7	N29°41.006	W094°59.49	125	503	0	0	081	3.3

This is an own ship ground speed vector

09:51 SEP


Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

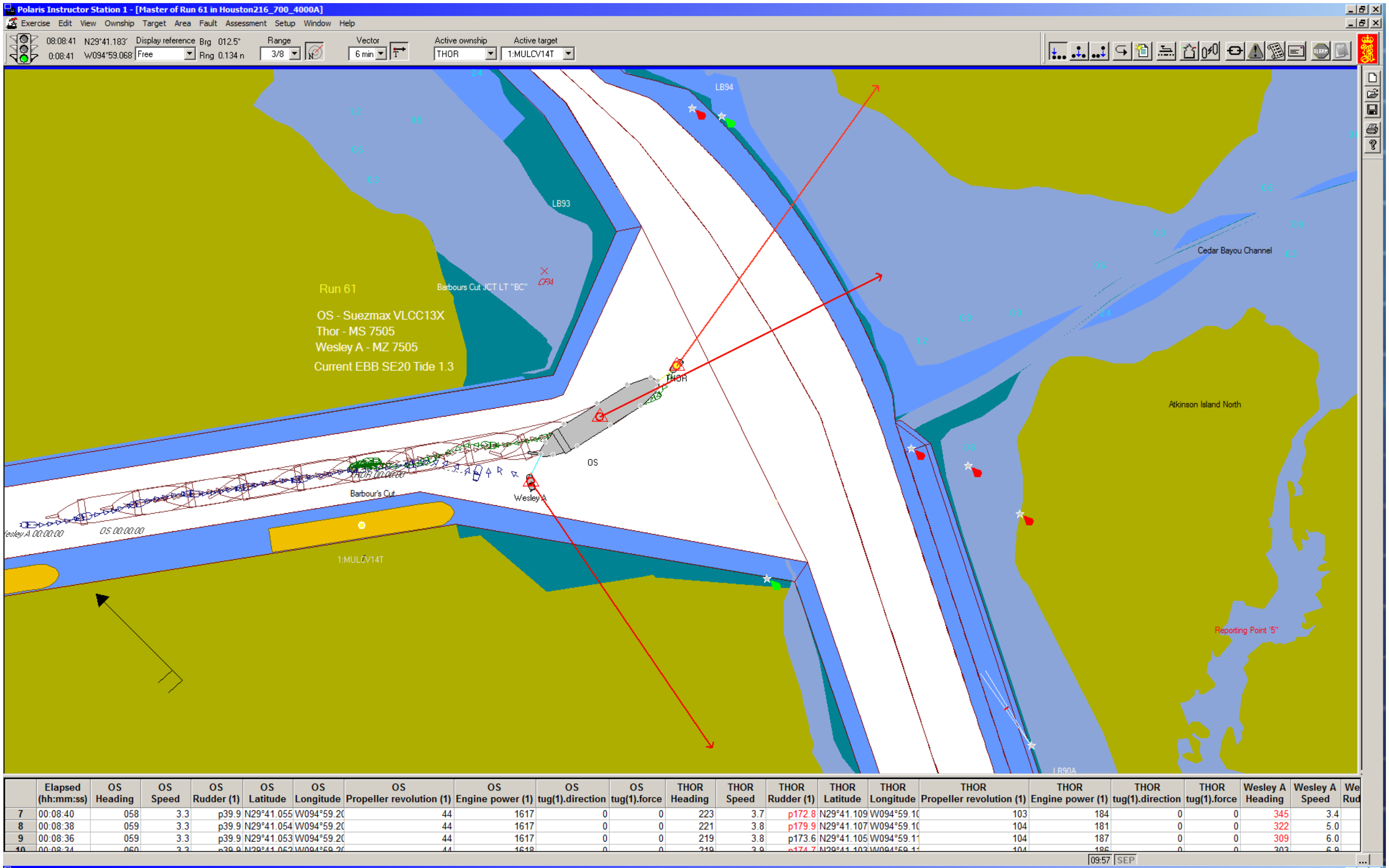
08:06:14 N29°40.813' Display reference: Free Brg 135.5° Rng 0.260 n
0:06:14 W094°59.291'
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 61
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:06:12	080	3.7	p3.5	N29°41.019	W094°59.36	27	319	0	0	260	3.7	s179.7	N29°41.036	W094°59.25	70	35	0	0	088	3.4
8	00:06:10	080	3.7	s1.5	N29°41.019	W094°59.36	27	319	0	0	260	3.7	s179.7	N29°41.035	W094°59.25	70	35	0	0	088	3.5
9	00:06:08	080	3.7	s6.6	N29°41.018	W094°59.36	27	319	0	0	260	3.7	s179.7	N29°41.035	W094°59.25	70	35	0	0	088	3.6

09:55 SEP

June 26, 2019



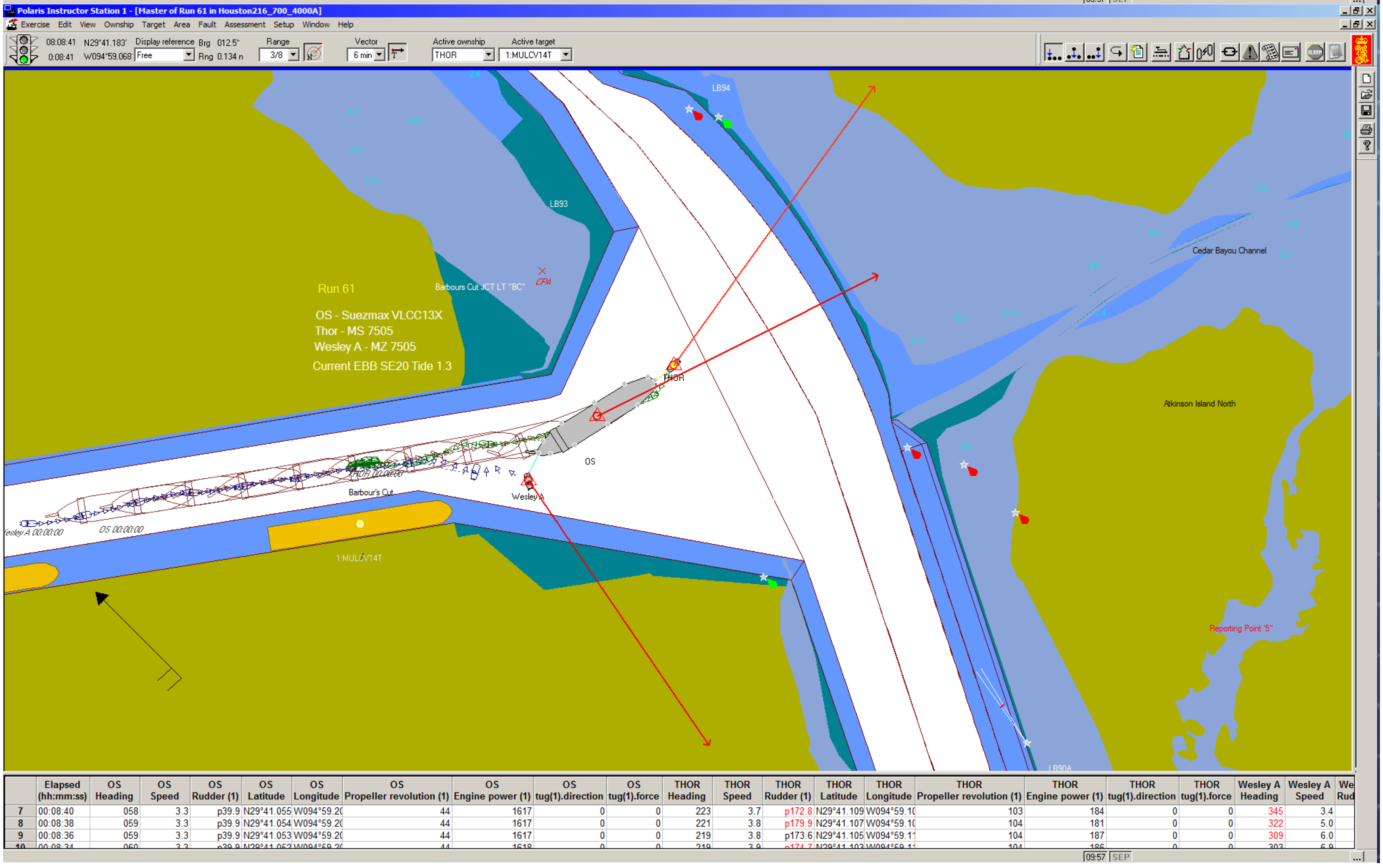
Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

08:08:41 N29°41.183′ Display reference Free Brg 012.5° Rng 0.134 n
0:08:41 W094°59.068′
Range 3/8
Vector 6 min
Active ownship THOR
Active target 1:MULCV14T

Run 61

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:08:40	058	3.3	p39.9	N29°41.055	W094°59.20	44	1617	0	0	223	3.7	p172.8	N29°41.109	W094°59.10	103	184	0	0	345	3.4	
8	00:08:38	059	3.3	p39.9	N29°41.054	W094°59.20	44	1617	0	0	221	3.8	p179.9	N29°41.107	W094°59.10	104	181	0	0	322	5.0	
9	00:08:36	059	3.3	p39.9	N29°41.053	W094°59.20	44	1617	0	0	219	3.8	p173.6	N29°41.105	W094°59.11	104	187	0	0	309	6.0	
10	00:08:34	060	3.3	p39.9	N29°41.052	W094°59.20	44	1618	0	0	219	3.9	p174.7	N29°41.103	W094°59.11	104	186	0	0	303	6.9	


Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

08:08:41 N29°41.183′ Display reference Free Brg 012.5° Rng 0.134 n
0:08:41 W094°59.068′
Range 3/8
Vector 6 min
Active ownship THOR
Active target 1:MULCV14T

Run 61

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:08:40	058	3.3	p39.9	N29°41.055	W094°59.20	44	1617	0	0	223	3.7	p172.8	N29°41.109	W094°59.10	103	184	0	0	345	3.4	
8	00:08:38	059	3.3	p39.9	N29°41.054	W094°59.20	44	1617	0	0	221	3.8	p179.9	N29°41.107	W094°59.10	104	181	0	0	322	5.0	
9	00:08:36	059	3.3	p39.9	N29°41.053	W094°59.20	44	1617	0	0	219	3.8	p173.6	N29°41.105	W094°59.11	104	187	0	0	309	6.0	
10	00:08:34	060	3.3	p39.9	N29°41.052	W094°59.20	44	1618	0	0	219	3.9	p174.7	N29°41.103	W094°59.11	104	186	0	0	303	6.9	

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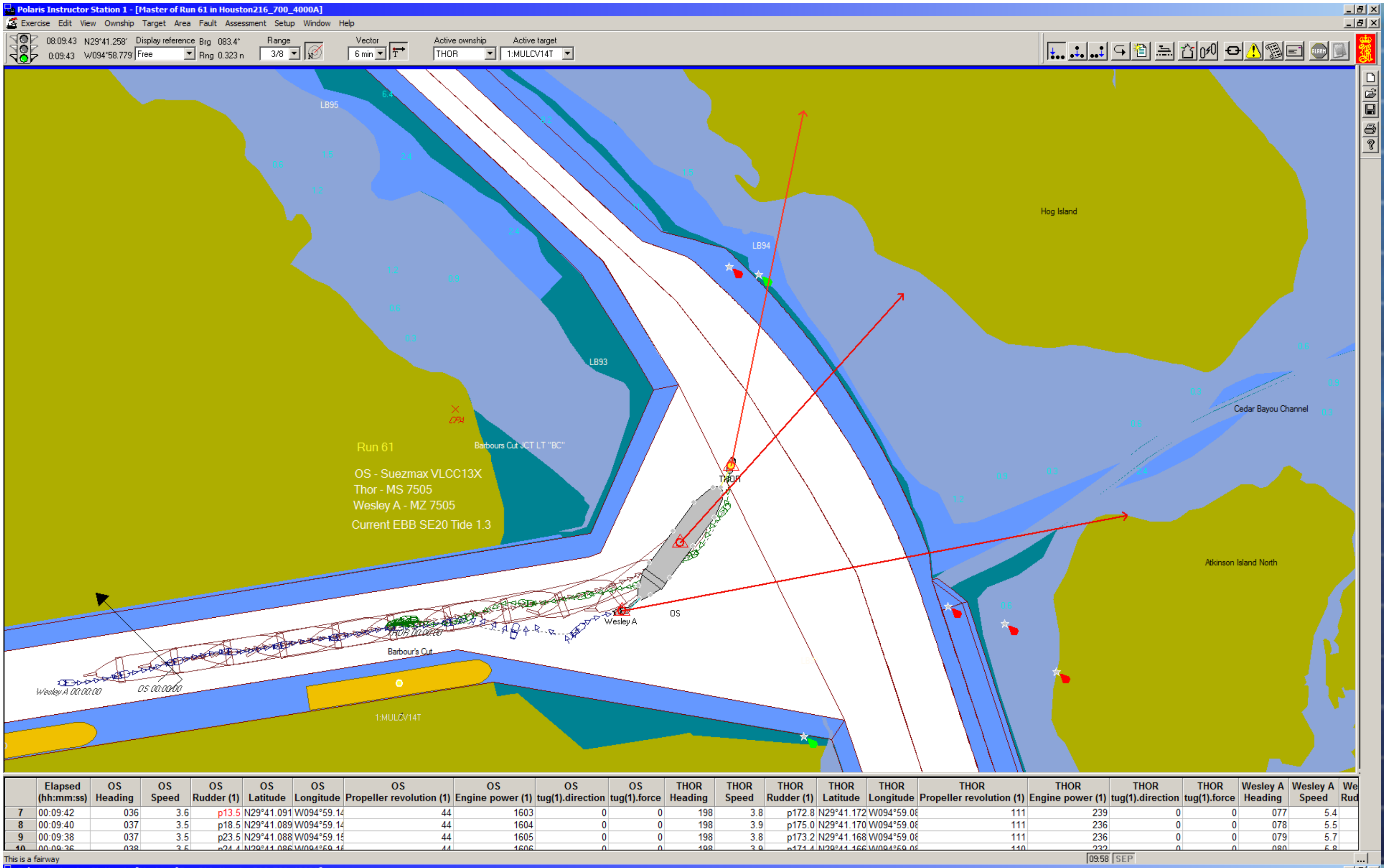


Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

08:09:43 N29°41.258′
0:09:43 W094°58.779′
Display reference: Free
Brg 083.4°
Rng 0.323 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

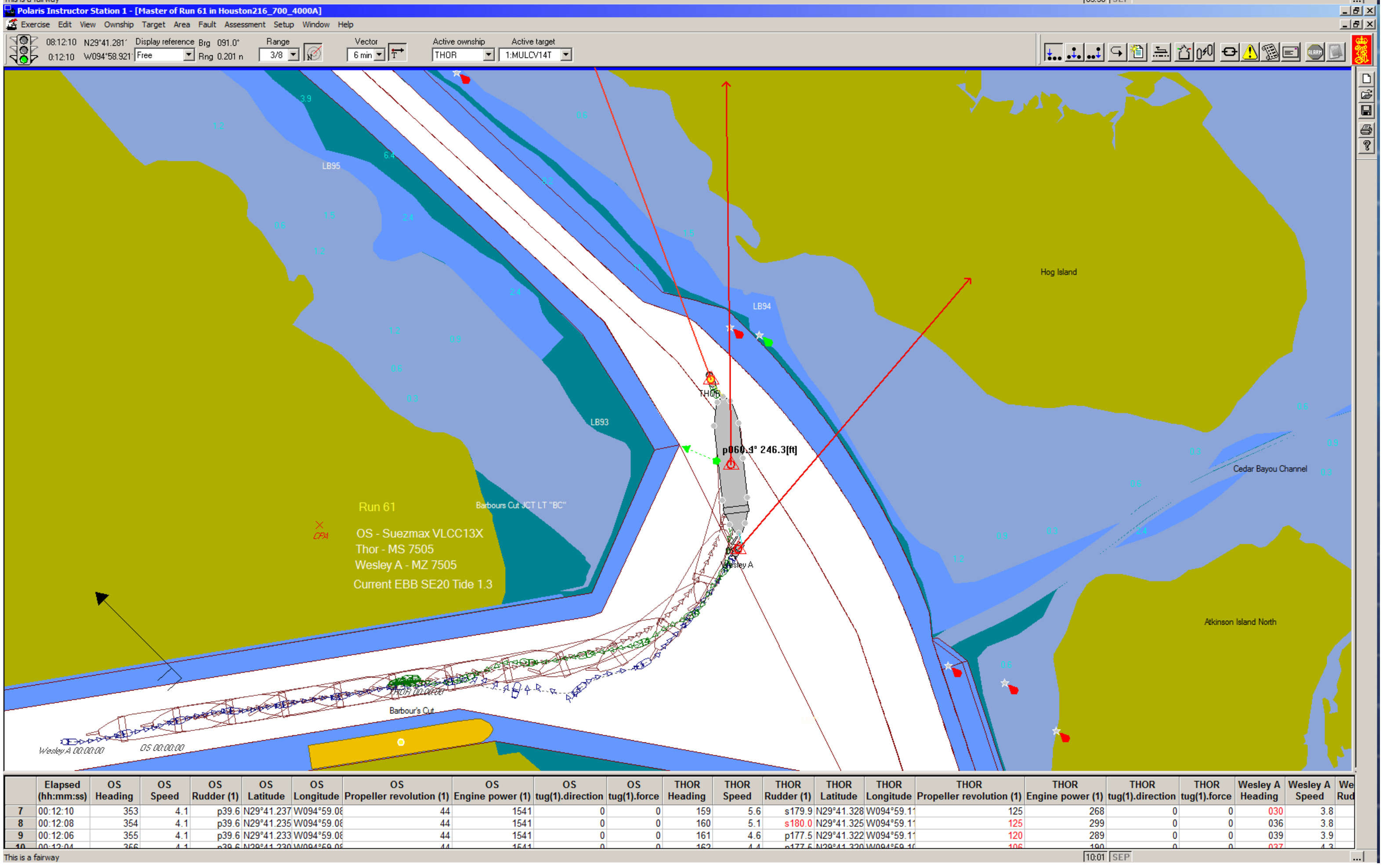
Run 61

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:09:42	036	3.6	p13.5	N29°41.091	W094°59.14	44	1603	0	0	198	3.8	p172.8	N29°41.172	W094°59.08	111	239	0	0	077	5.4	
8	00:09:40	037	3.5	p18.5	N29°41.089	W094°59.14	44	1604	0	0	198	3.9	p175.0	N29°41.170	W094°59.08	111	236	0	0	078	5.5	
9	00:09:38	037	3.5	p23.5	N29°41.088	W094°59.15	44	1605	0	0	198	3.8	p173.2	N29°41.168	W094°59.08	111	236	0	0	079	5.7	

This is a fairway

09:58 SEP



Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

08:12:10 N29°41.281′
0:12:10 W094°58.921′
Display reference: Free
Brg 091.0°
Rng 0.201 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 61

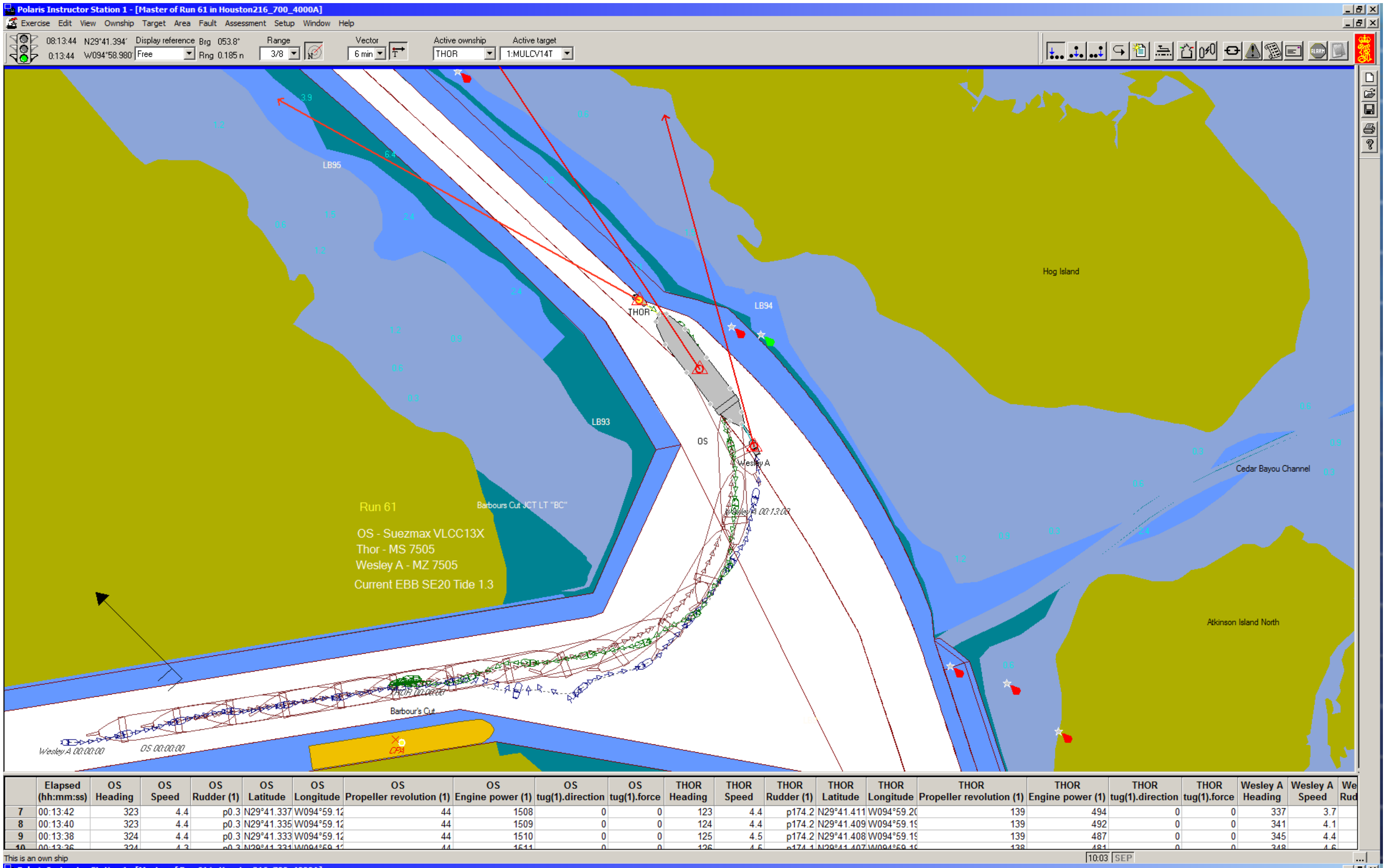
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:12:10	353	4.1	p39.6	N29°41.237	W094°59.08	44	1541	0	0	159	5.6	s179.9	N29°41.328	W094°59.11	125	268	0	0	030	3.8	
8	00:12:08	354	4.1	p39.6	N29°41.235	W094°59.08	44	1541	0	0	160	5.1	s180.0	N29°41.325	W094°59.11	125	299	0	0	036	3.8	
9	00:12:06	355	4.1	p39.6	N29°41.233	W094°59.08	44	1541	0	0	161	4.6	p177.5	N29°41.322	W094°59.11	120	289	0	0	039	3.9	

This is a fairway

10:01 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

08:13:44 N29°41.394′ Display reference Free Brg 053.8° Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T

0:13:44 W094°58.980′ Rng 0.185 n

Run 61

OS - Suezmax VLCC13X

Thor - MS 7505

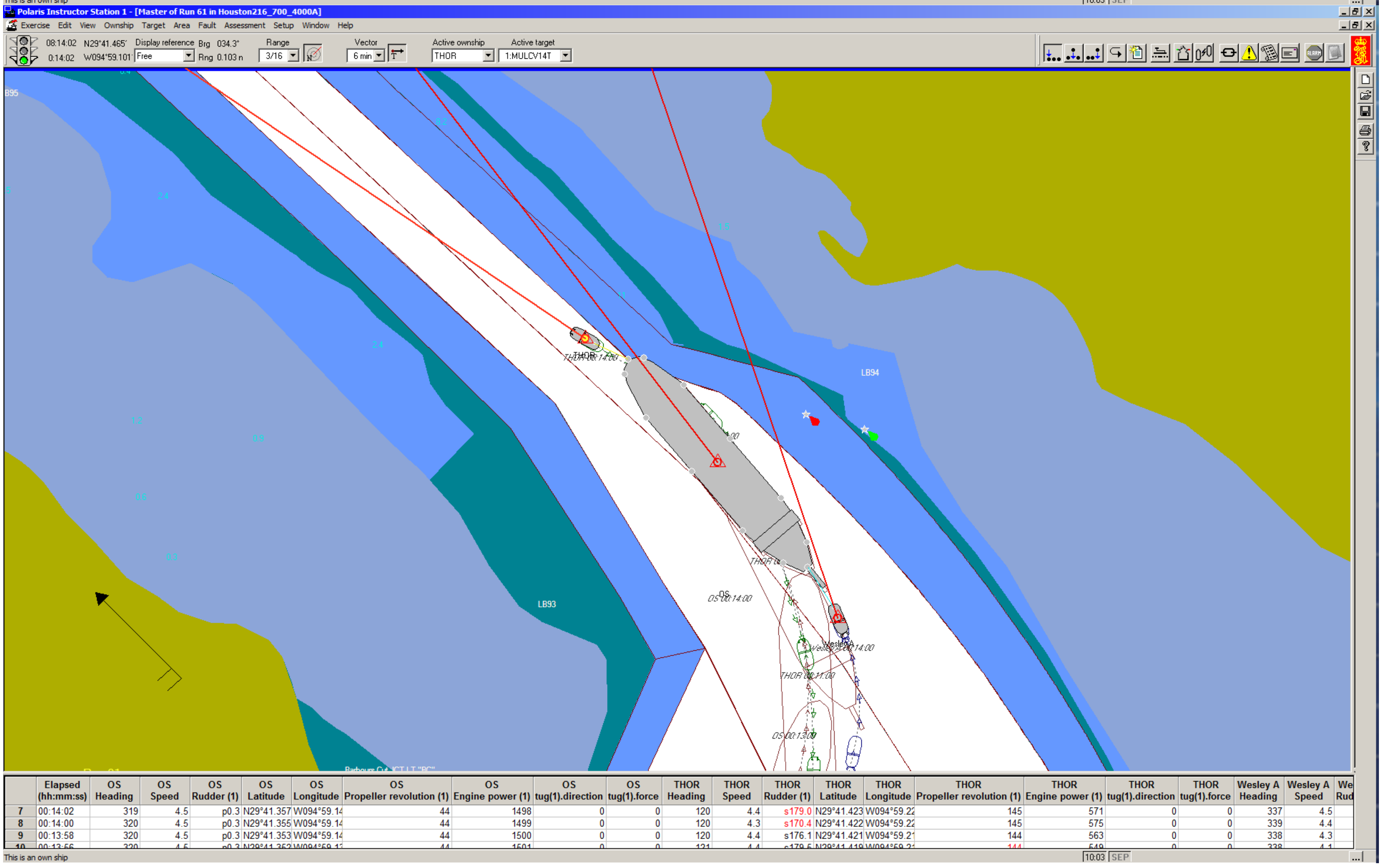
Wesley A - MZ 7505

Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:13:42	323	4.4	p0.3	N29°41.337	W094°59.12	44	1508	0	0	123	4.4	p174.2	N29°41.411	W094°59.20	139	494	0	0	337	3.7	
8	00:13:40	323	4.4	p0.3	N29°41.335	W094°59.12	44	1509	0	0	124	4.4	p174.2	N29°41.409	W094°59.19	139	492	0	0	341	4.1	
9	00:13:38	324	4.4	p0.3	N29°41.333	W094°59.12	44	1510	0	0	125	4.5	p174.2	N29°41.408	W094°59.19	139	487	0	0	345	4.4	
10	00:13:36	324	4.3	p0.3	N29°41.331	W094°59.12	44	1511	0	0	126	4.5	p174.1	N29°41.407	W094°59.19	138	481	0	0	348	4.6	

This is an own ship

10:03 SEP



Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

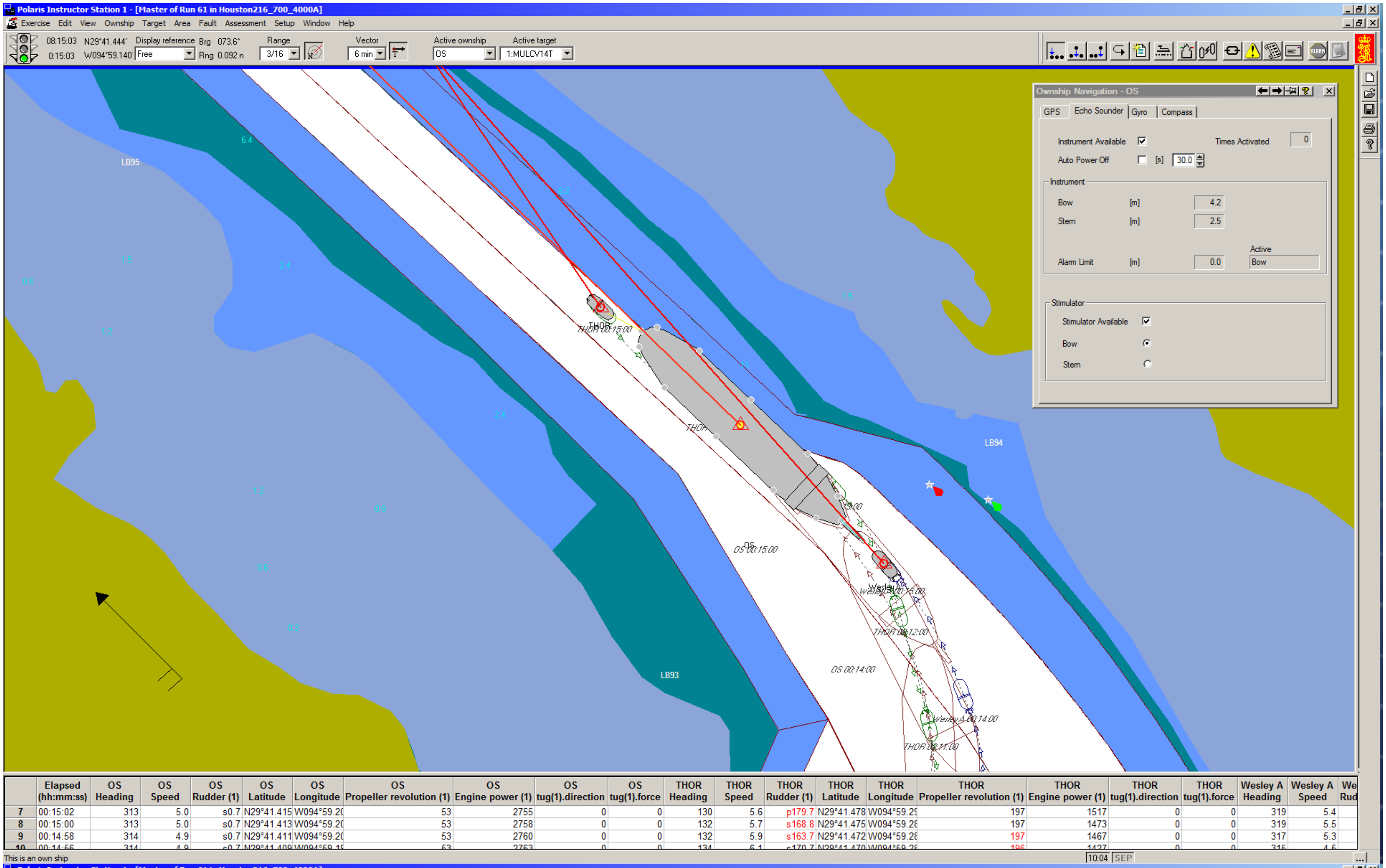
08:14:02 N29°41.465′ Display reference Free Brg 034.3° Range 3/16 Vector 6 min Active ownship THOR Active target 1:MULCV14T

0:14:02 W094°59.101′ Rng 0.103 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:02	319	4.5	p0.3	N29°41.357	W094°59.14	44	1498	0	0	120	4.4	s179.0	N29°41.423	W094°59.22	145	571	0	0	337	4.5	
8	00:14:00	320	4.5	p0.3	N29°41.355	W094°59.14	44	1499	0	0	120	4.3	s170.4	N29°41.422	W094°59.22	145	575	0	0	339	4.4	
9	00:13:58	320	4.5	p0.3	N29°41.353	W094°59.14	44	1500	0	0	120	4.4	s176.1	N29°41.421	W094°59.21	144	563	0	0	338	4.3	
10	00:13:56	320	4.5	p0.3	N29°41.352	W094°59.13	44	1501	0	0	121	4.4	s179.5	N29°41.419	W094°59.21	144	549	0	0	338	4.1	

This is an own ship

10:03 SEP



08:15:03 N29°41.444′ Display reference: Free Brg 073.6° Rng 0.092 n Range: 3/16 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:15:03 W094°59.140′

Ownship Navigation - OS

Instrument Available ☑ Times Activated 0
Auto Power Off ☐ [s] 30.0

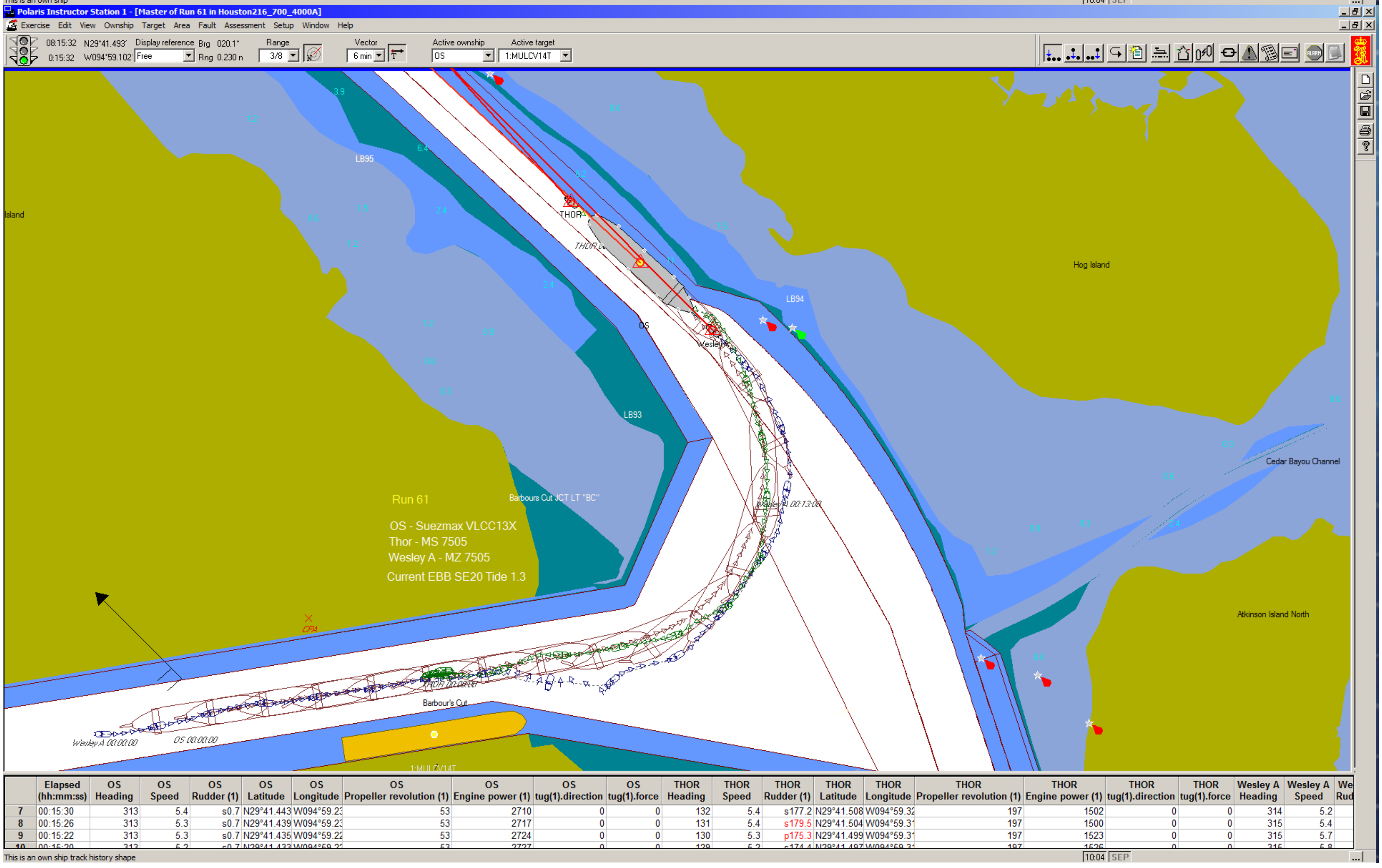
Instrument
Bow [m] 4.2
Stem [m] 2.5
Alarm Limit [m] 0.0 Active: Bow

Stimulator
Stimulator Available ☑
Bow ●
Stem ○

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:15:02	313	5.0	s0.7	N29°41.415	W094°59.20	53	2755	0	0	130	5.6	p179.7	N29°41.478	W094°59.29	197	1517	0	0	319	5.4	
8	00:15:00	313	5.0	s0.7	N29°41.413	W094°59.20	53	2758	0	0	132	5.7	s168.8	N29°41.475	W094°59.28	197	1473	0	0	319	5.5	
9	00:14:58	314	4.9	s0.7	N29°41.411	W094°59.20	53	2760	0	0	132	5.9	s163.7	N29°41.472	W094°59.28	197	1467	0	0	317	5.3	
10	00:14:56	314	4.9	s0.7	N29°41.409	W094°59.19	53	2763	0	0	134	6.1	s170.7	N29°41.470	W094°59.28	196	1427	0	0	315	4.5	

This is an own ship

10:04 SEP



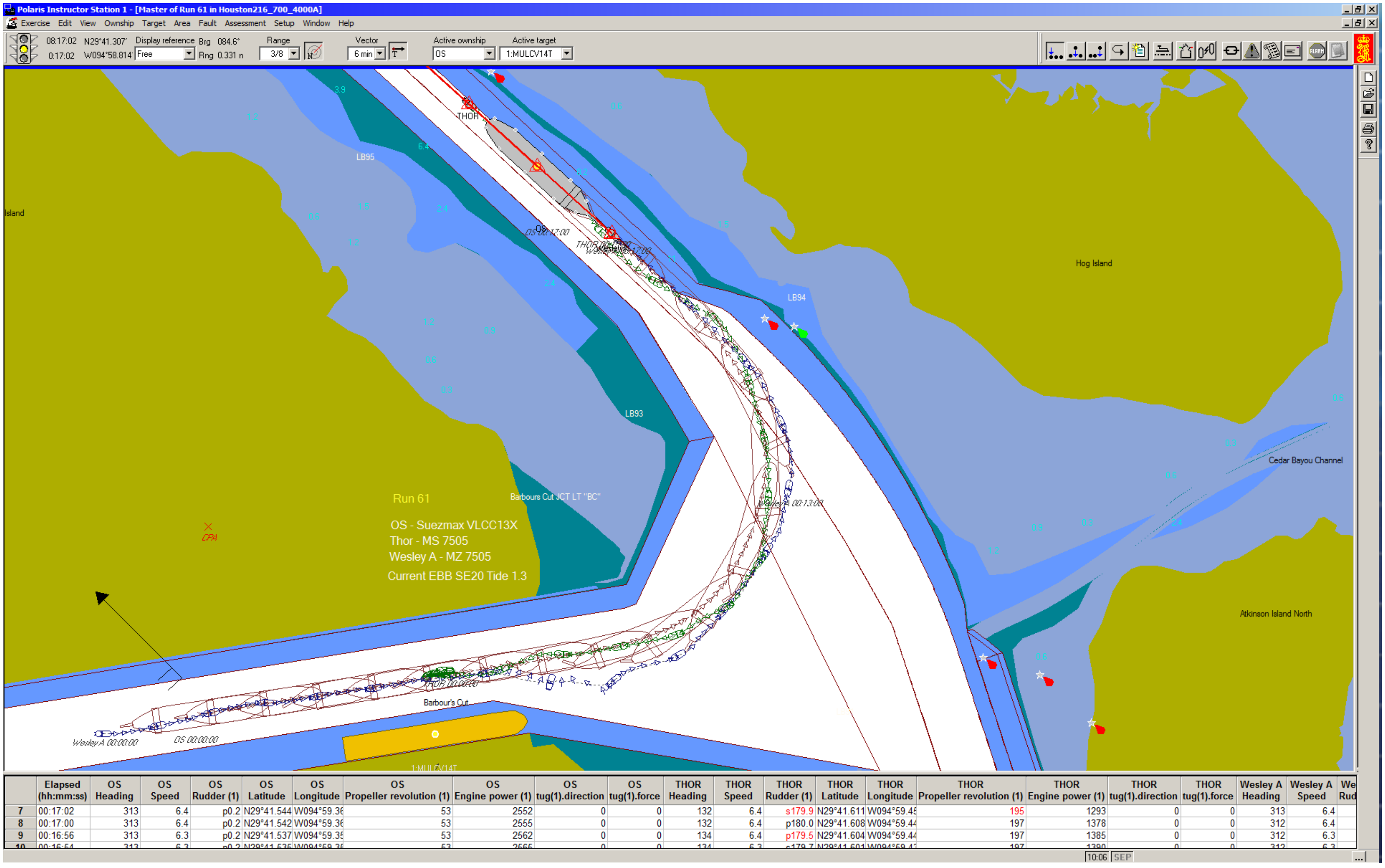
08:15:32 N29°41.493′ Display reference: Free Brg 020.1° Rng 0.230 n Range: 3/8 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:15:32 W094°59.102′

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:15:30	313	5.4	s0.7	N29°41.443	W094°59.23	53	2710	0	0	132	5.4	s177.2	N29°41.508	W094°59.32	197	1502	0	0	314	5.2	
8	00:15:26	313	5.3	s0.7	N29°41.439	W094°59.23	53	2717	0	0	131	5.4	s179.5	N29°41.504	W094°59.31	197	1500	0	0	315	5.4	
9	00:15:22	313	5.3	s0.7	N29°41.435	W094°59.22	53	2724	0	0	130	5.3	p175.3	N29°41.499	W094°59.31	197	1523	0	0	315	5.7	
10	00:15:20	313	5.2	s0.7	N29°41.433	W094°59.22	53	2727	0	0	129	5.2	s174.4	N29°41.497	W094°59.31	197	1526	0	0	315	5.8	

This is an own ship track history shape

10:04 SEP

June 26, 2019



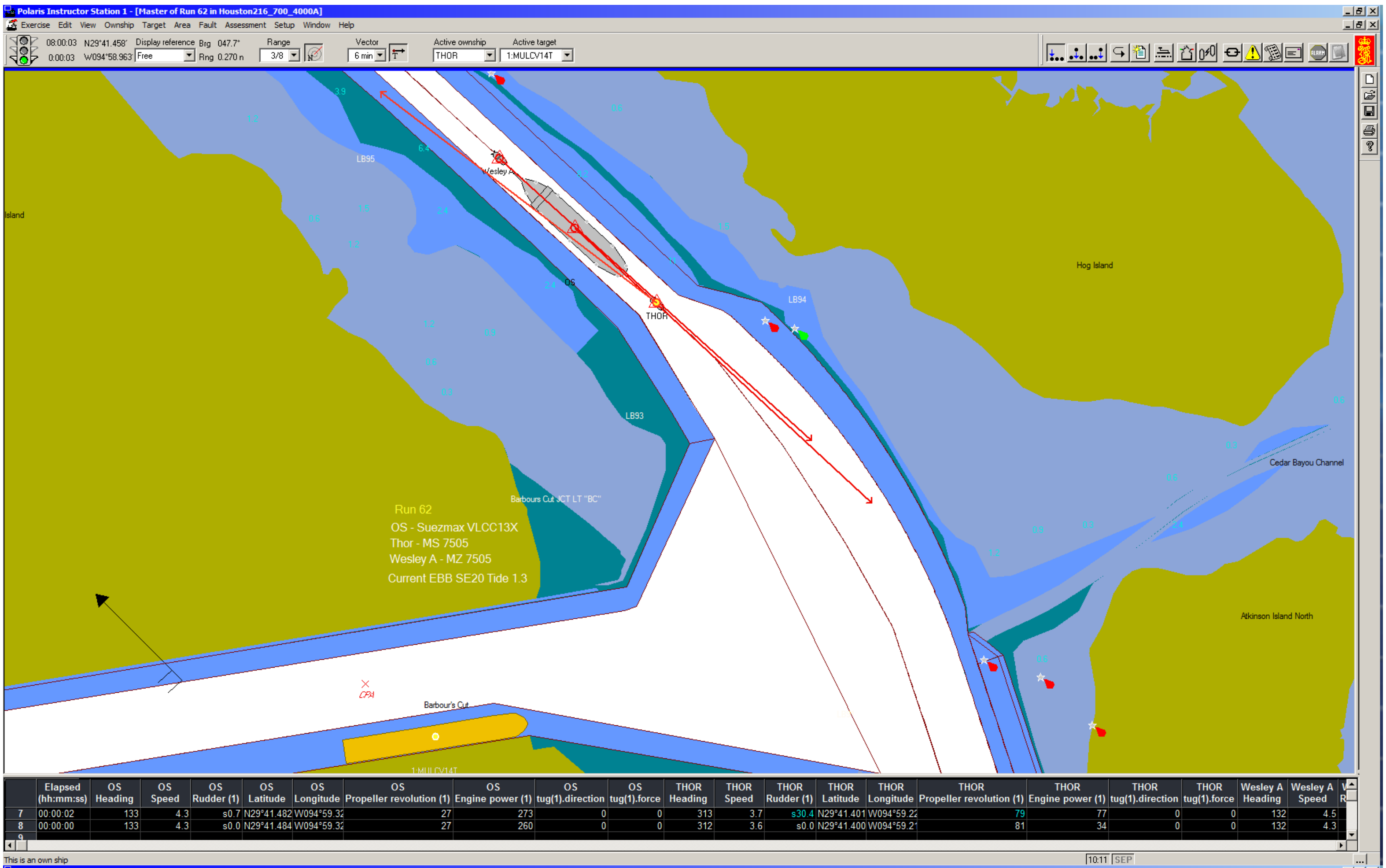
Polaris Instructor Station 1 - [Master of Run 61 in Houston216_700_4000A]

Run 61

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:17:02	313	6.4	p0.2	N29°41.544	W094°59.36	53	2552	0	0	132	6.4	s179.9	N29°41.611	W094°59.45	195	1293	0	0	313	6.4	
8	00:17:00	313	6.4	p0.2	N29°41.542	W094°59.36	53	2555	0	0	132	6.4	p180.0	N29°41.608	W094°59.44	197	1378	0	0	312	6.4	
9	00:16:56	313	6.3	p0.2	N29°41.537	W094°59.35	53	2562	0	0	134	6.4	p179.5	N29°41.604	W094°59.44	197	1385	0	0	312	6.3	
10	00:16:54	313	6.3	p0.2	N29°41.535	W094°59.35	53	2565	0	0	134	6.3	s179.7	N29°41.601	W094°59.43	197	1390	0	0	312	6.3	

Run 62



Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

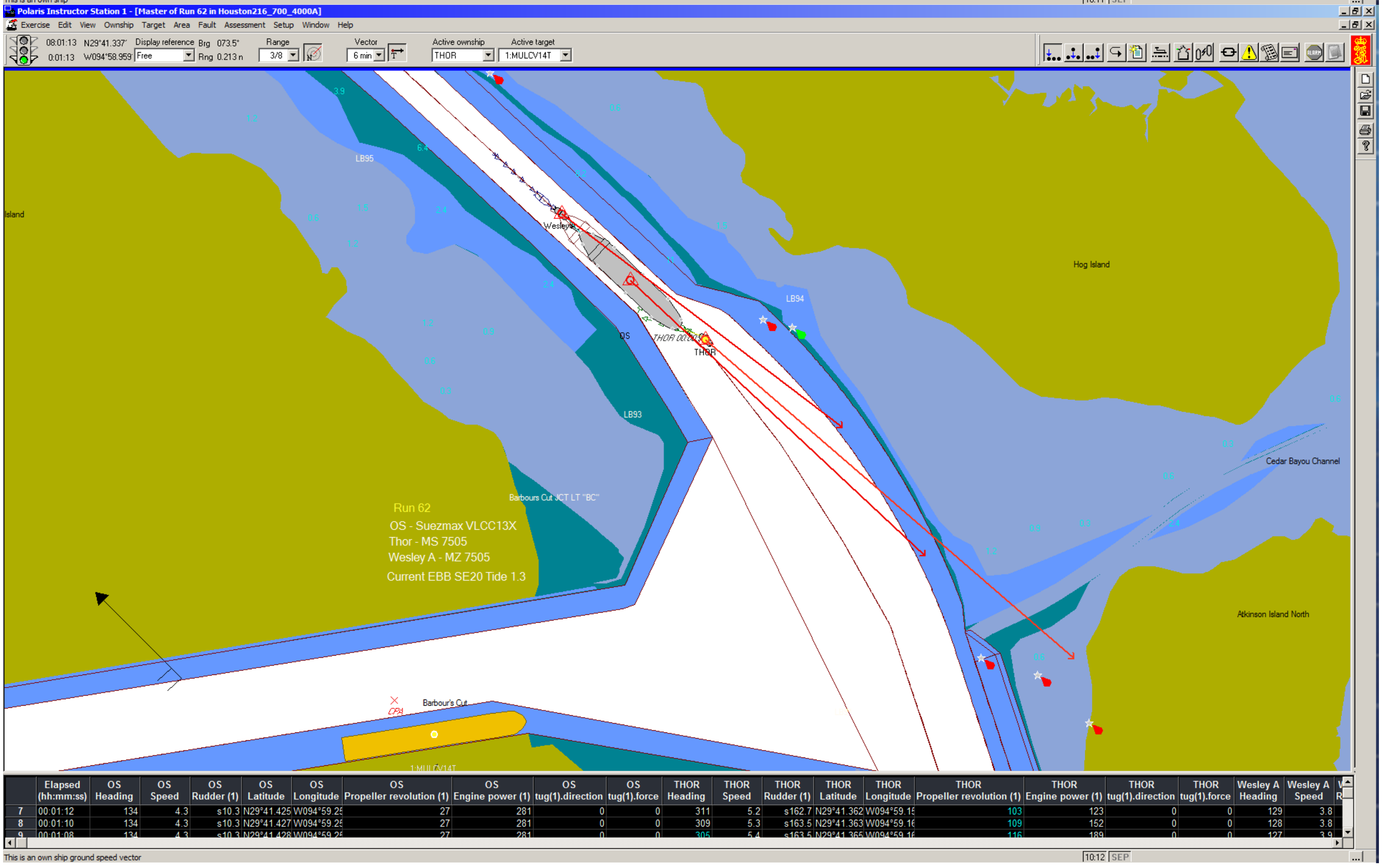
08:00:03 N29°41.458′
0:00:03 W094°58.963′
Display reference: Free
Brg 047.7°
Rng 0.270 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:00:02	133	4.3	s0.7	N29°41.482	W094°59.32	27	273	0	0	313	3.7	s30.4	N29°41.401	W094°59.22	79	77	0	0	132	4.5
8	00:00:00	133	4.3	s0.0	N29°41.484	W094°59.32	27	260	0	0	312	3.6	s0.0	N29°41.400	W094°59.21	81	34	0	0	132	4.3
9																					

This is an own ship

10:11 SEP



Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

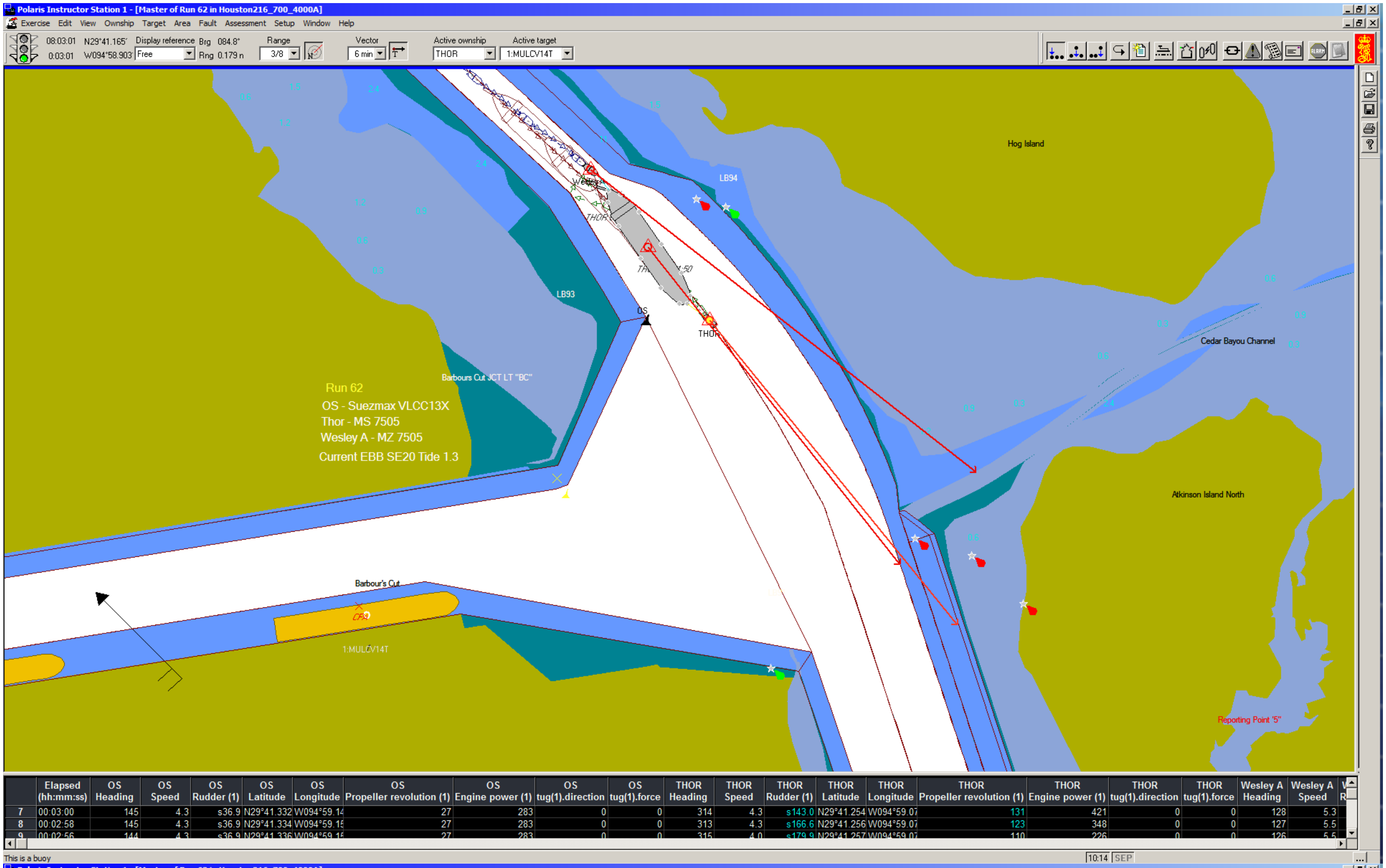
08:01:13 N29°41.337′
0:01:13 W094°58.959′
Display reference: Free
Brg 073.5°
Rng 0.213 n
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:01:12	134	4.3	s10.3	N29°41.425	W094°59.25	27	281	0	0	311	5.2	s162.7	N29°41.362	W094°59.15	103	123	0	0	129	3.8
8	00:01:10	134	4.3	s10.3	N29°41.427	W094°59.25	27	281	0	0	309	5.3	s163.5	N29°41.363	W094°59.16	109	152	0	0	128	3.8
9	00:01:08	134	4.3	s10.3	N29°41.428	W094°59.25	27	281	0	0	305	5.4	s163.5	N29°41.365	W094°59.16	116	189	0	0	127	3.9

This is an own ship ground speed vector

10:12 SEP



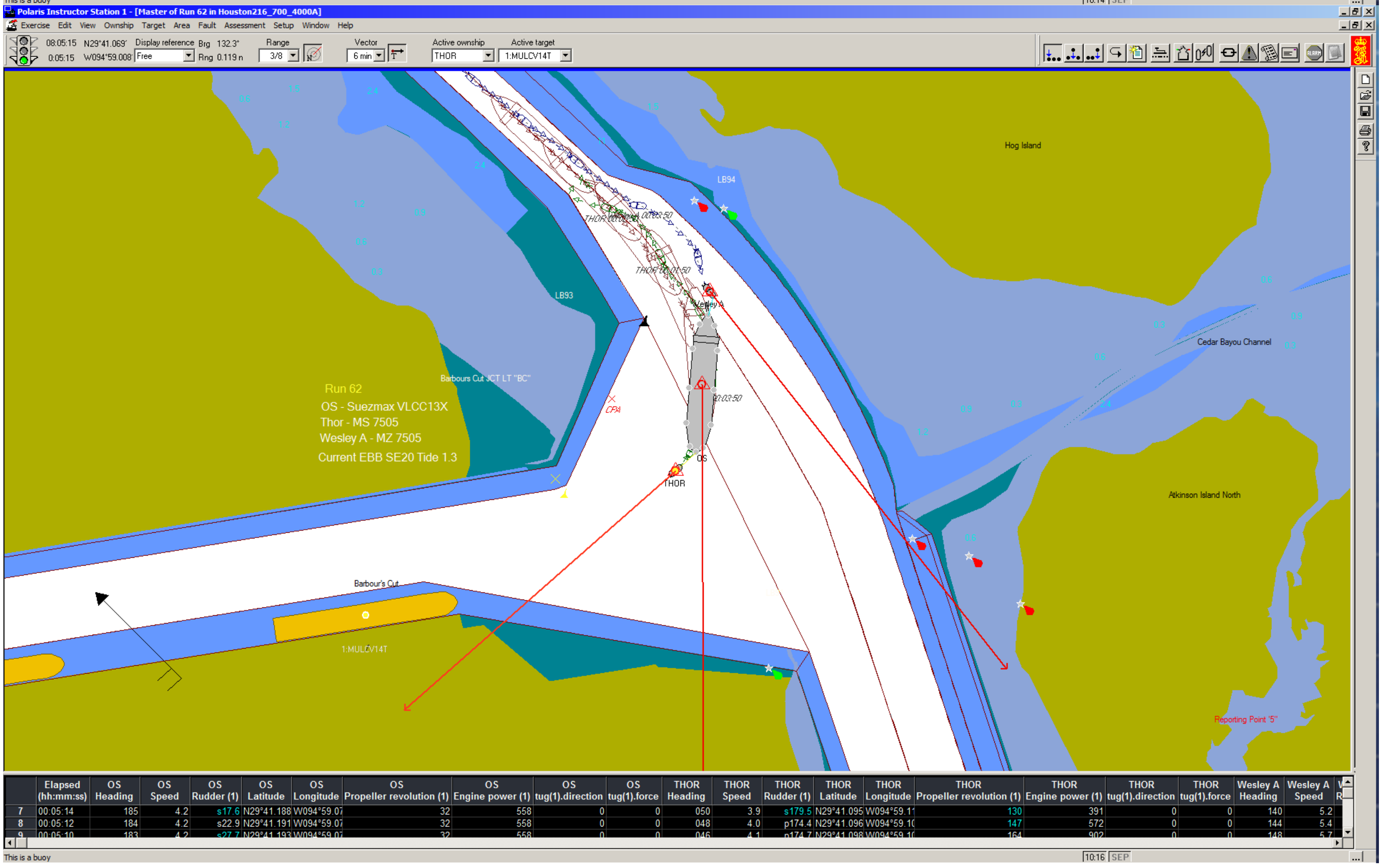
Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

08:03:01 N29°41.165′ Display reference Free Brg 084.8° Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T
0:03:01 W094°58.903′ Rng 0.179 n

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:03:00	145	4.3	s36.9	N29°41.332	W094°59.14	27	283	0	0	314	4.3	s143.0	N29°41.254	W094°59.07	131	421	0	0	128	5.3
8	00:02:58	145	4.3	s36.9	N29°41.334	W094°59.15	27	283	0	0	313	4.3	s166.6	N29°41.256	W094°59.07	123	348	0	0	127	5.5
9	00:02:56	144	4.3	s36.9	N29°41.336	W094°59.15	27	283	0	0	315	4.0	s179.9	N29°41.257	W094°59.07	110	226	0	0	126	5.5

This is a buoy 10:14 SEP



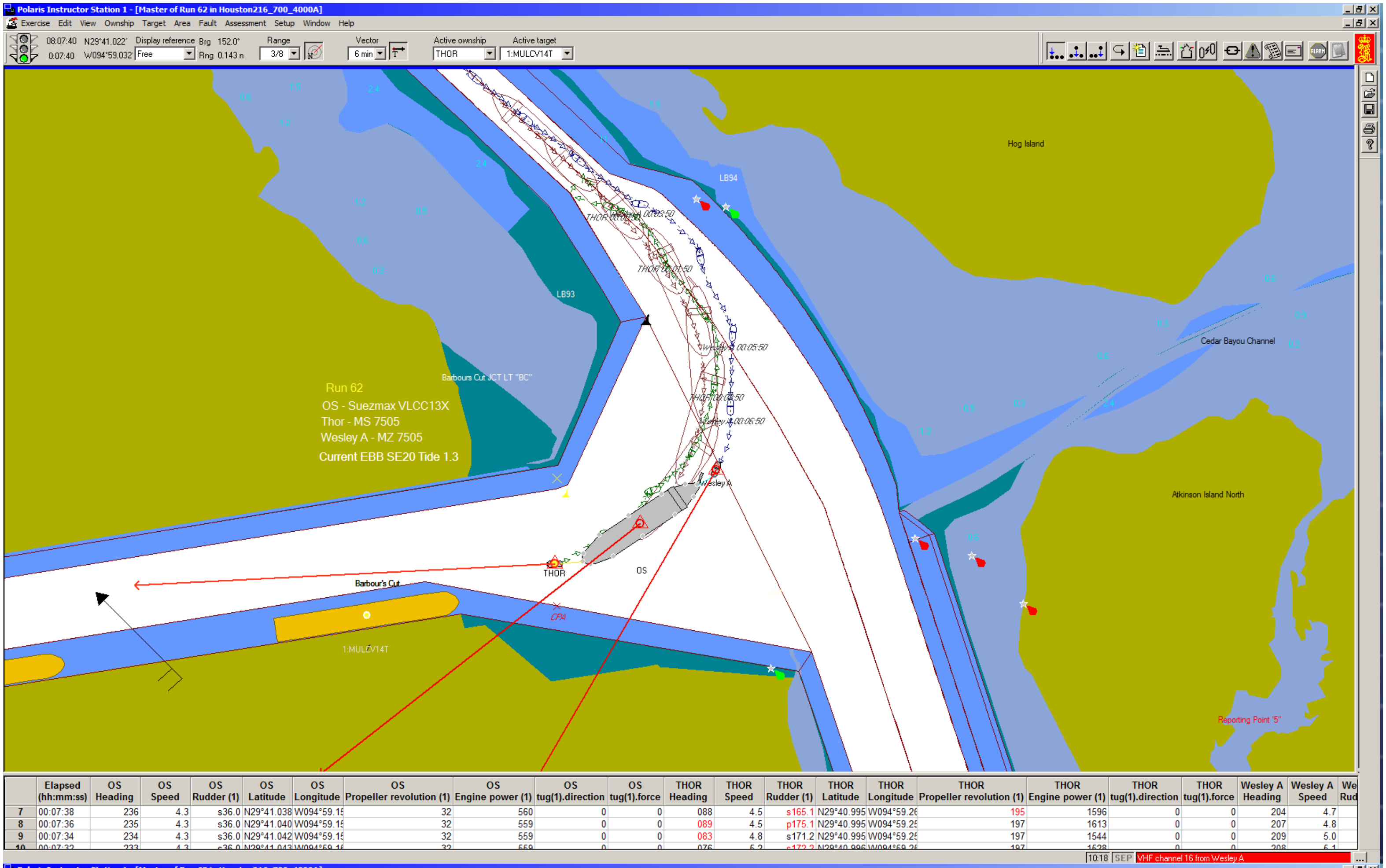
Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

08:05:15 N29°41.069′ Display reference Free Brg 132.3° Range 3/8 Vector 6 min Active ownship THOR Active target 1:MULCV14T
0:05:15 W094°59.008′ Rng 0.119 n

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:05:14	185	4.2	s17.6	N29°41.188	W094°59.07	32	558	0	0	050	3.9	s179.5	N29°41.095	W094°59.11	130	391	0	0	140	5.2
8	00:05:12	184	4.2	s22.9	N29°41.191	W094°59.07	32	558	0	0	048	4.0	p174.4	N29°41.096	W094°59.10	147	572	0	0	144	5.4
9	00:05:10	183	4.2	s27.7	N29°41.193	W094°59.07	32	558	0	0	046	4.1	p174.7	N29°41.098	W094°59.10	164	902	0	0	148	5.7

This is a buoy 10:16 SEP

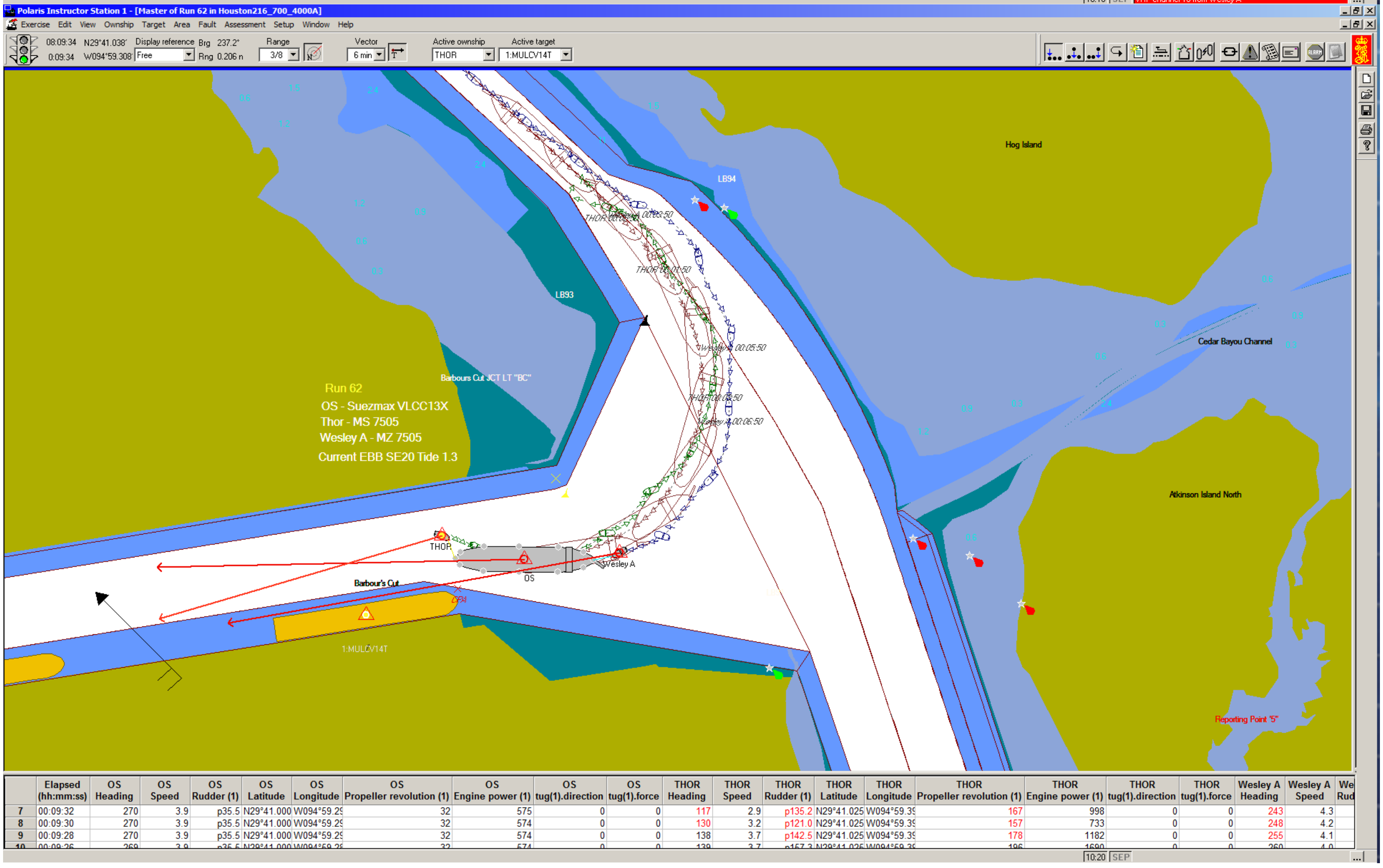


08:07:40 N29°41.022' Display reference: Free Brg 152.0° Rng 0.143 n
0:07:40 W094°59.032'
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:07:38	236	4.3	s36.0	N29°41.038	W094°59.15	32	560	0	0	088	4.5	s165.1	N29°40.995	W094°59.26	195	1596	0	0	204	4.7
8	00:07:36	235	4.3	s36.0	N29°41.040	W094°59.15	32	559	0	0	089	4.5	p175.1	N29°40.995	W094°59.25	197	1613	0	0	207	4.8
9	00:07:34	234	4.3	s36.0	N29°41.042	W094°59.15	32	559	0	0	083	4.8	s171.2	N29°40.995	W094°59.25	197	1544	0	0	209	5.0

10:18 SEP VHF channel 16 from Wesley A



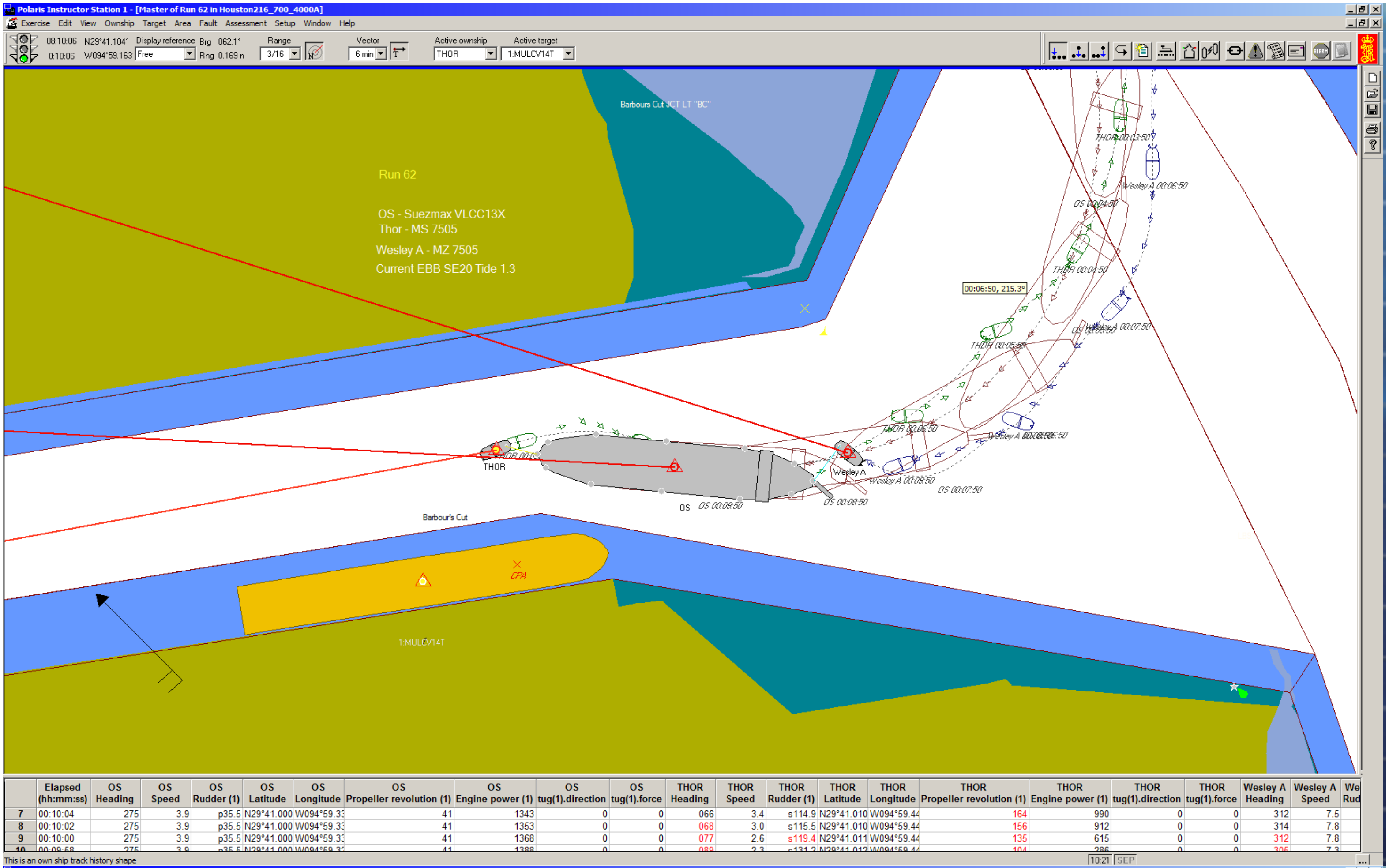
08:09:34 N29°41.038' Display reference: Free Brg 237.2° Rng 0.206 n
0:09:34 W094°59.308'
Range: 3/8
Vector: 6 min
Active ownship: THOR
Active target: 1:MULCV14T

Run 62
OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:09:32	270	3.9	p35.5	N29°41.000	W094°59.29	32	575	0	0	117	2.9	p135.2	N29°41.025	W094°59.39	167	998	0	0	243	4.3
8	00:09:30	270	3.9	p35.5	N29°41.000	W094°59.29	32	574	0	0	130	3.2	p121.0	N29°41.025	W094°59.39	157	733	0	0	248	4.2
9	00:09:28	270	3.9	p35.5	N29°41.000	W094°59.29	32	574	0	0	138	3.7	p142.5	N29°41.025	W094°59.39	178	1182	0	0	255	4.1

10:20 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

08:10:06 N29°41.104' Display reference Free Brg 062.1° Rng 0.169 n
0:10:06 W094°59.163'
Range 3/16
Vector 6 min
Active ownship THOR
Active target 1:MULCV14T

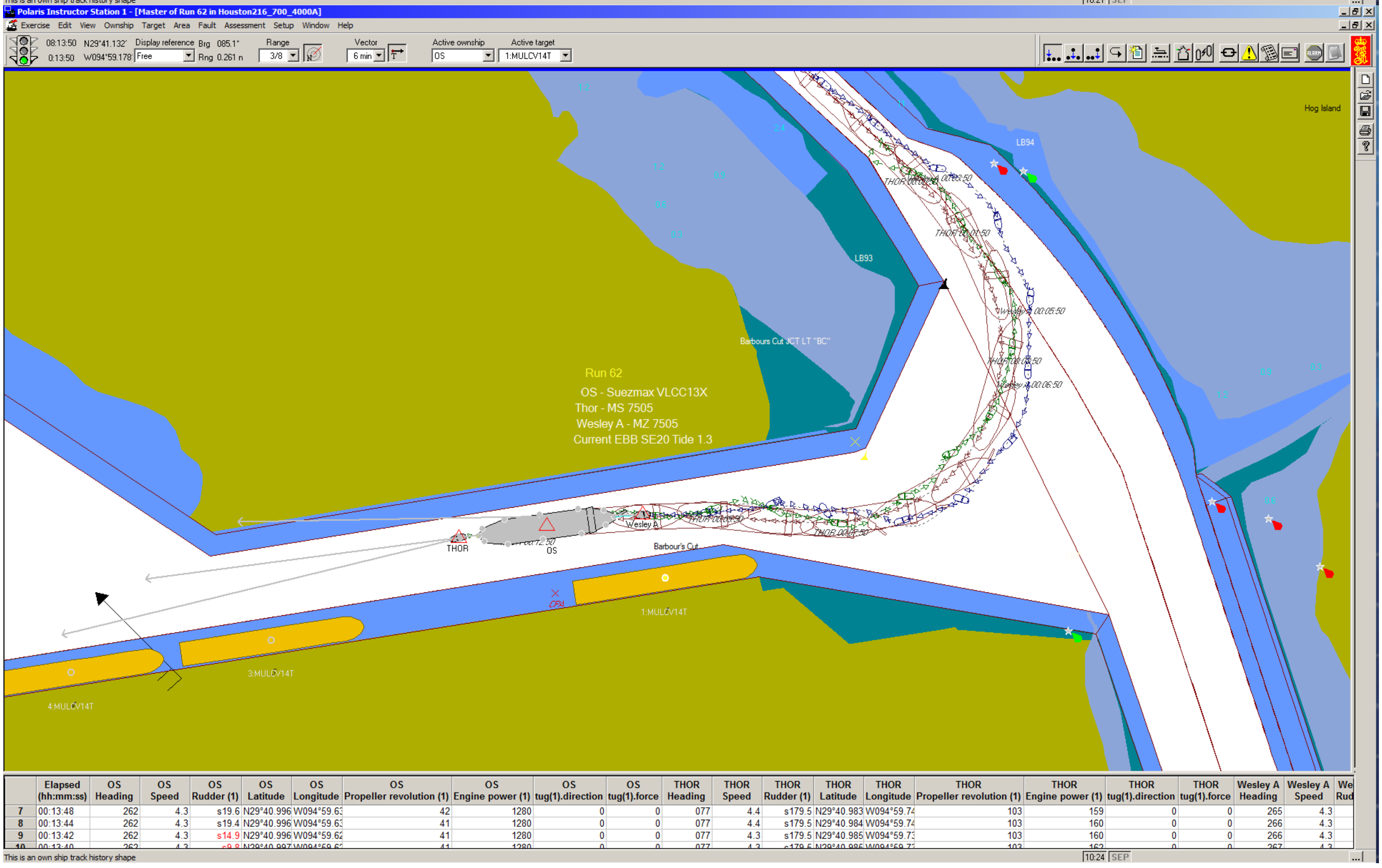
Run 62

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:10:04	275	3.9	p35.5	N29°41.000	W094°59.33	41	1343	0	0	066	3.4	s114.9	N29°41.010	W094°59.44	164	990	0	0	312	7.5	
8	00:10:02	275	3.9	p35.5	N29°41.000	W094°59.33	41	1353	0	0	068	3.0	s115.5	N29°41.010	W094°59.44	156	912	0	0	314	7.8	
9	00:10:00	275	3.9	p35.5	N29°41.000	W094°59.33	41	1368	0	0	077	2.6	s119.4	N29°41.011	W094°59.44	135	615	0	0	312	7.8	

This is an own ship track history shape

10:21 SEP



Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

08:13:50 N29°41.132' Display reference Free Brg 085.1° Rng 0.261 n
0:13:50 W094°59.178'
Range 3/8
Vector 6 min
Active ownship OS
Active target 1:MULCV14T

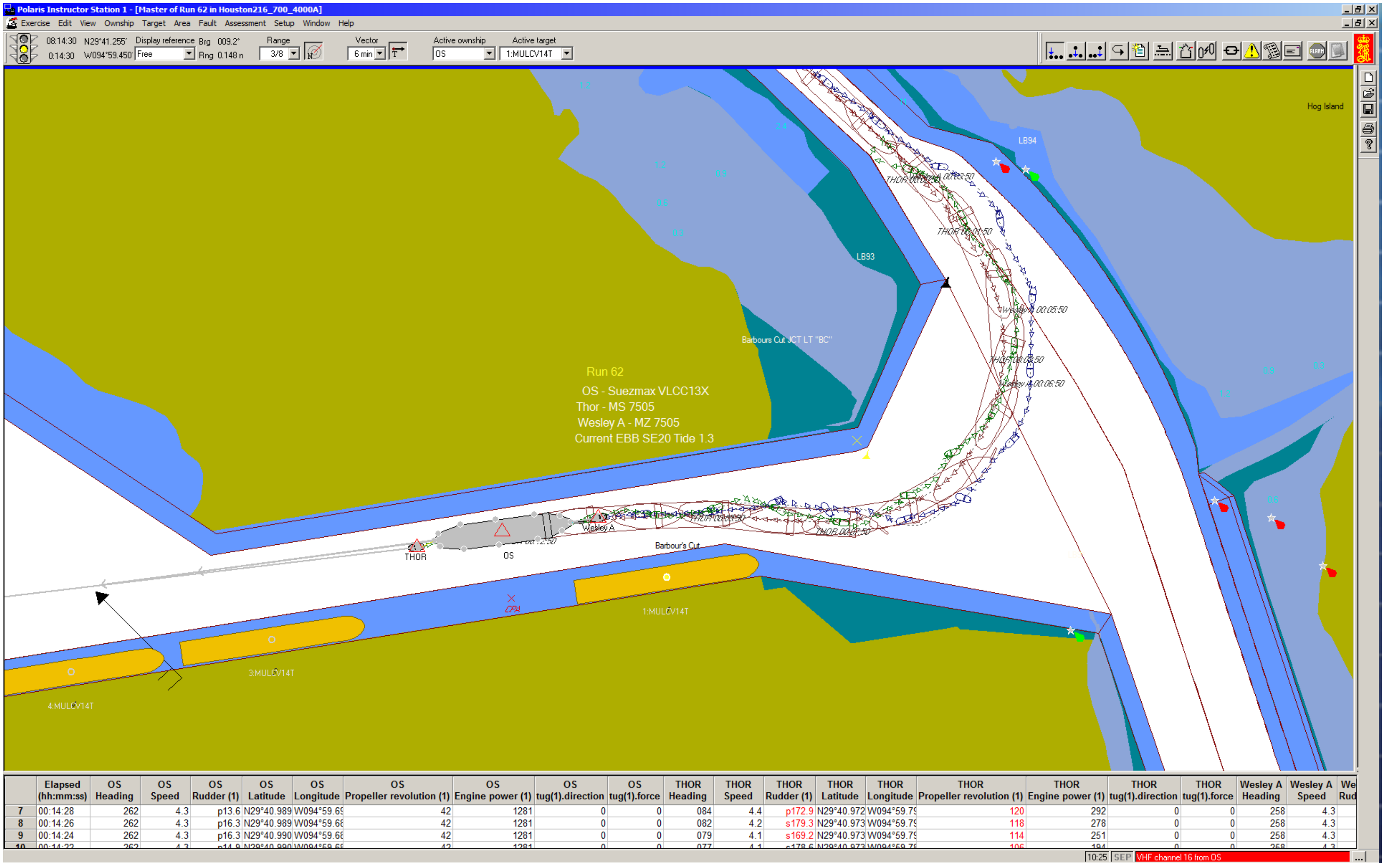
Run 62

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:13:48	262	4.3	s19.6	N29°40.996	W094°59.63	42	1280	0	0	077	4.4	s179.5	N29°40.983	W094°59.74	103	159	0	0	265	4.3	
8	00:13:44	262	4.3	s19.4	N29°40.996	W094°59.63	41	1280	0	0	077	4.4	s179.5	N29°40.984	W094°59.74	103	160	0	0	266	4.3	
9	00:13:42	262	4.3	s14.9	N29°40.996	W094°59.62	41	1280	0	0	077	4.3	s179.5	N29°40.985	W094°59.73	103	160	0	0	266	4.3	

This is an own ship track history shape

10:24 SEP



Polaris Instructor Station 1 - [Master of Run 62 in Houston216_700_4000A]

08:14:30 N29°41.255′ Display reference Free Brg 009.2° Range 3/8 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:14:30 W094°59.450′ Rng 0.148 n

Run 62

OS - Suezmax VLCC13X
Thor - MS 7505
Wesley A - MZ 7505
Current EBB SE20 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:28	262	4.3	p13.6	N29°40.989	W094°59.69	42	1281	0	0	084	4.4	p172.9	N29°40.972	W094°59.79	120	292	0	0	258	4.3	
8	00:14:26	262	4.3	p16.3	N29°40.989	W094°59.68	42	1281	0	0	082	4.2	s179.3	N29°40.973	W094°59.79	118	278	0	0	258	4.3	
9	00:14:24	262	4.3	p16.3	N29°40.990	W094°59.68	42	1281	0	0	079	4.1	s169.2	N29°40.973	W094°59.79	114	251	0	0	258	4.3	
10	00:14:22	262	4.3	p14.9	N29°40.990	W094°59.68	42	1281	0	0	077	4.1	s178.6	N29°40.973	W094°59.78	106	194	0	0	258	4.3	

10:25 SEP VHF channel 16 from OS

Appendix N: HSC – Bayport Ship Channel Simulations

Run 40

Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

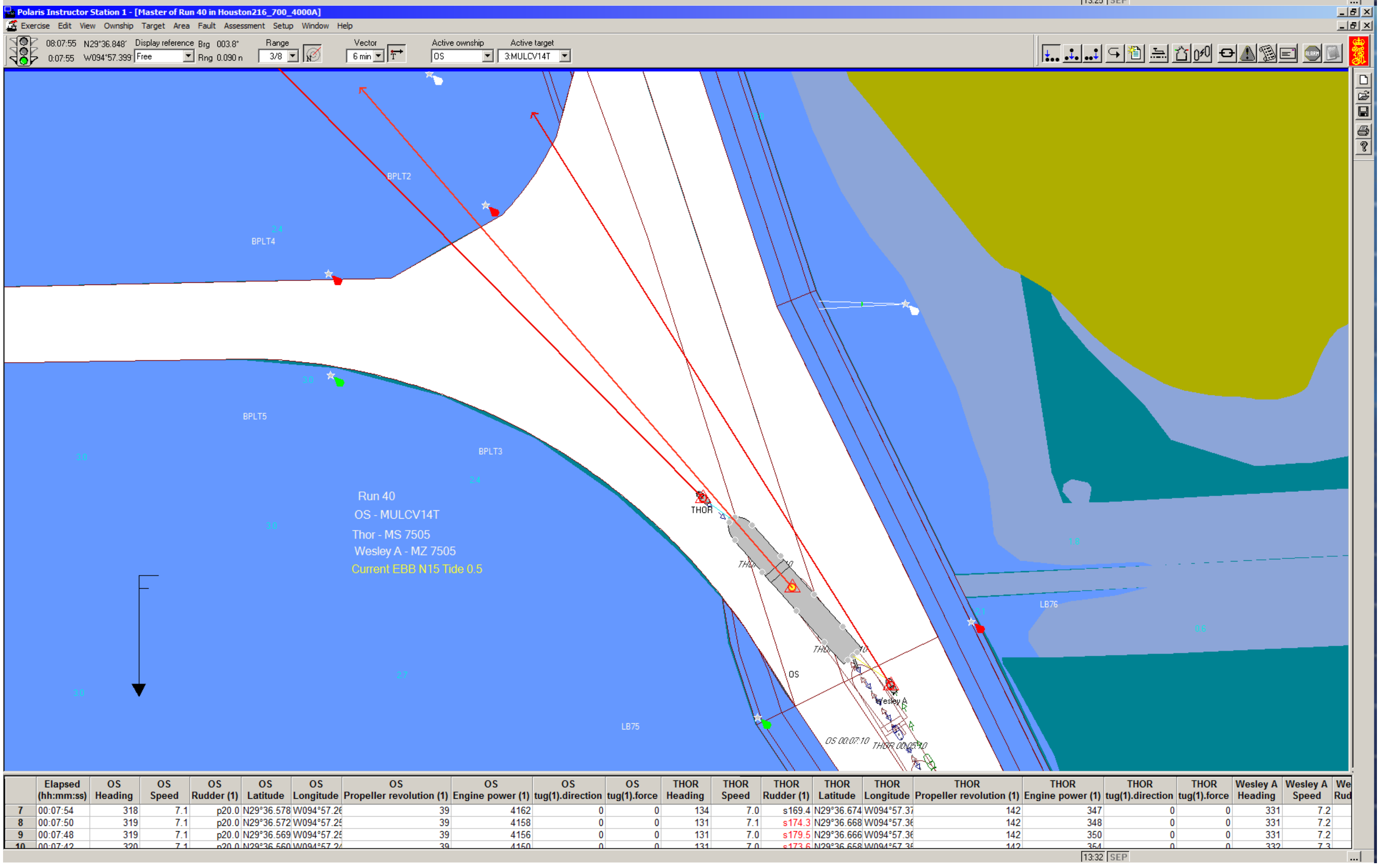
08:00:49 N29°36.338' Display reference Brg 086.7°
0:00:49 W094°56.619 Free Rng 0.355 n

Range 3/4 Vector 6 min Active ownship OS Active target 3:MULCV14T

Run 40
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N10 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:00:48	326	7.6	s9.9	N29°35.854	W094°56.72	39	4001	0	0	149	9.0	s178.0	N29°35.952	W094°56.79	188	874	0	0	303	6.5	
8	00:00:46	326	7.6	s9.9	N29°35.851	W094°56.71	39	3999	0	0	149	8.6	s177.9	N29°35.948	W094°56.79	172	598	0	0	308	6.3	
9	00:00:44	326	7.6	s9.9	N29°35.847	W094°56.71	39	3998	0	0	148	8.6	s173.3	N29°35.944	W094°56.79	160	384	0	0	318	7.2	
10	00:00:42	326	7.6	s9.9	N29°35.844	W094°56.71	39	3997	0	0	148	8.8	s173.7	N29°35.940	W094°56.79	159	352	0	0	330	8.5	

13:25 SEP



Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

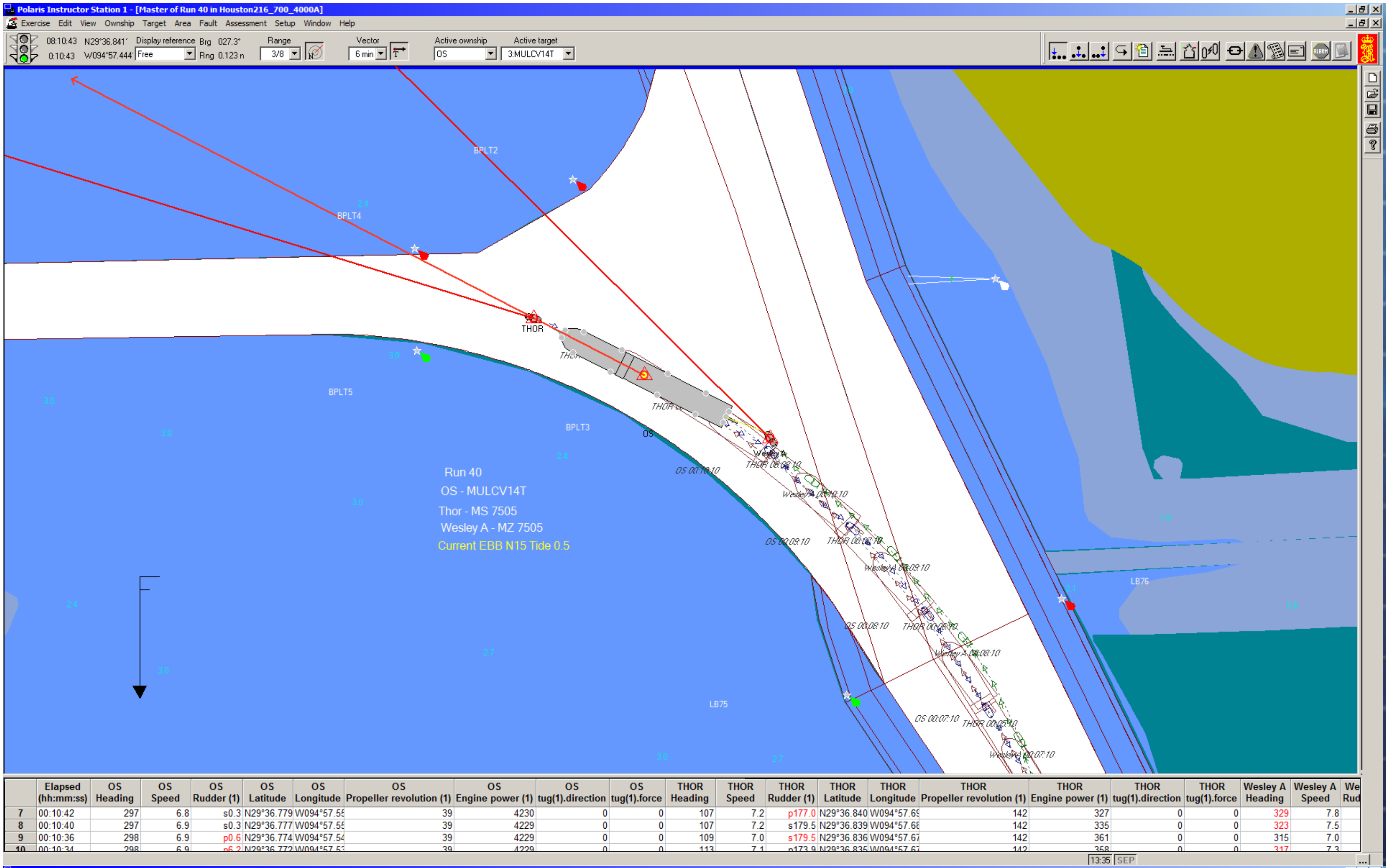
08:07:55 N29°36.848' Display reference Brg 003.8°
0:07:55 W094°57.399 Free Rng 0.090 n

Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T

Run 40
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:07:54	318	7.1	p20.0	N29°36.578	W094°57.26	39	4162	0	0	134	7.0	s169.4	N29°36.674	W094°57.37	142	347	0	0	331	7.2	
8	00:07:50	319	7.1	p20.0	N29°36.572	W094°57.25	39	4158	0	0	131	7.1	s174.3	N29°36.668	W094°57.36	142	348	0	0	331	7.2	
9	00:07:48	319	7.1	p20.0	N29°36.569	W094°57.25	39	4156	0	0	131	7.0	s179.5	N29°36.666	W094°57.36	142	350	0	0	331	7.2	
10	00:07:42	320	7.1	p20.0	N29°36.560	W094°57.24	39	4150	0	0	131	7.0	s173.6	N29°36.658	W094°57.35	142	354	0	0	332	7.3	

13:32 SEP

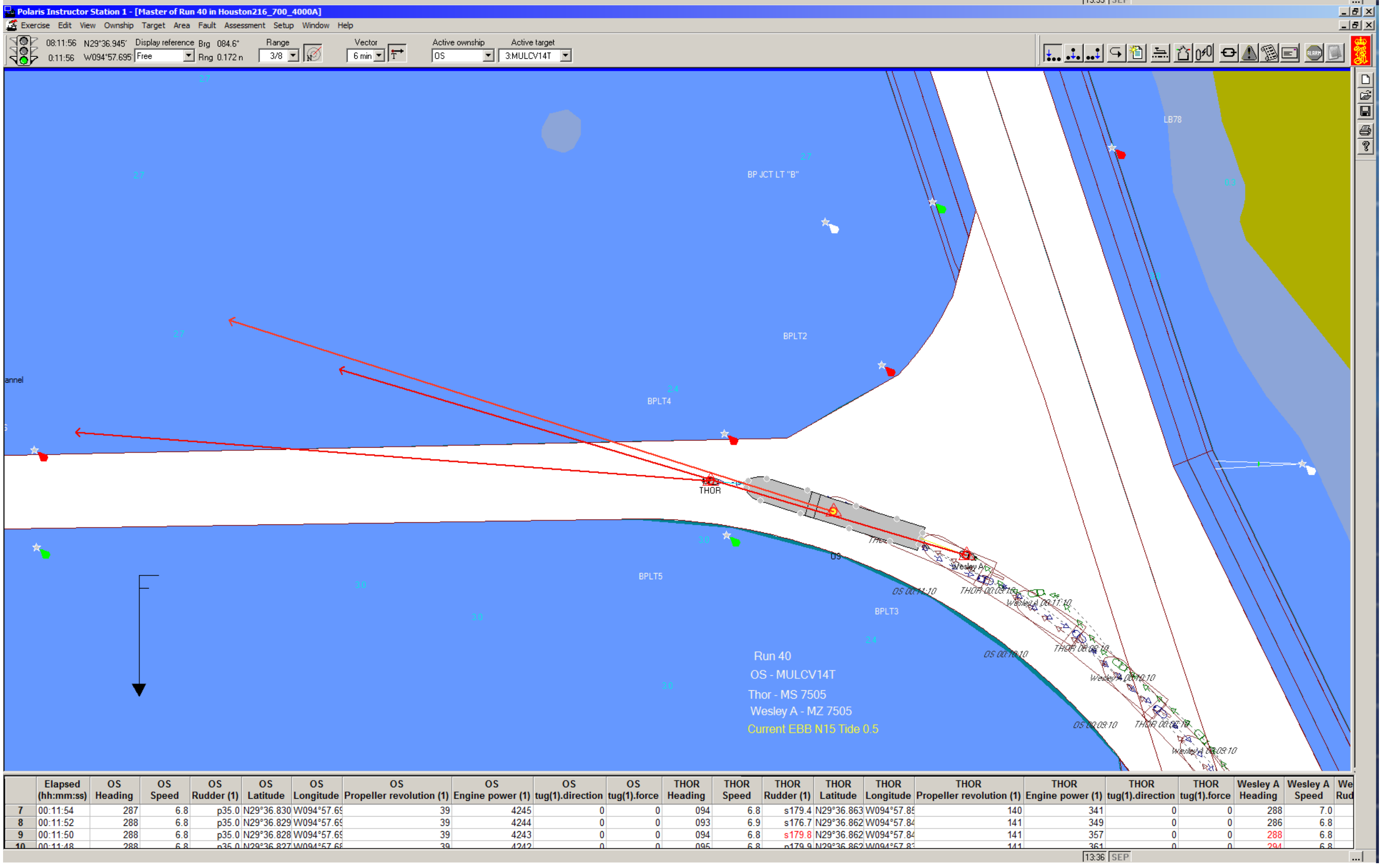


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:10:43 N29°36.841' Display reference Free Brg 027.3° Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:10:43 W094°57.444' Rng 0.123 n

Run 40
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:10:42	297	6.8	s0.3	N29°36.779	W094°57.55	39	4230	0	0	107	7.2	p177.0	N29°36.840	W094°57.69	142	327	0	0	329	7.8	
8	00:10:40	297	6.9	s0.3	N29°36.777	W094°57.55	39	4229	0	0	107	7.2	s179.5	N29°36.839	W094°57.68	142	335	0	0	323	7.5	
9	00:10:36	298	6.9	p0.6	N29°36.774	W094°57.54	39	4229	0	0	109	7.0	s179.5	N29°36.836	W094°57.67	142	361	0	0	315	7.0	
10	00:10:34	298	6.9	p6.2	N29°36.772	W094°57.53	39	4229	0	0	113	7.1	p173.9	N29°36.835	W094°57.67	142	358	0	0	317	7.3	

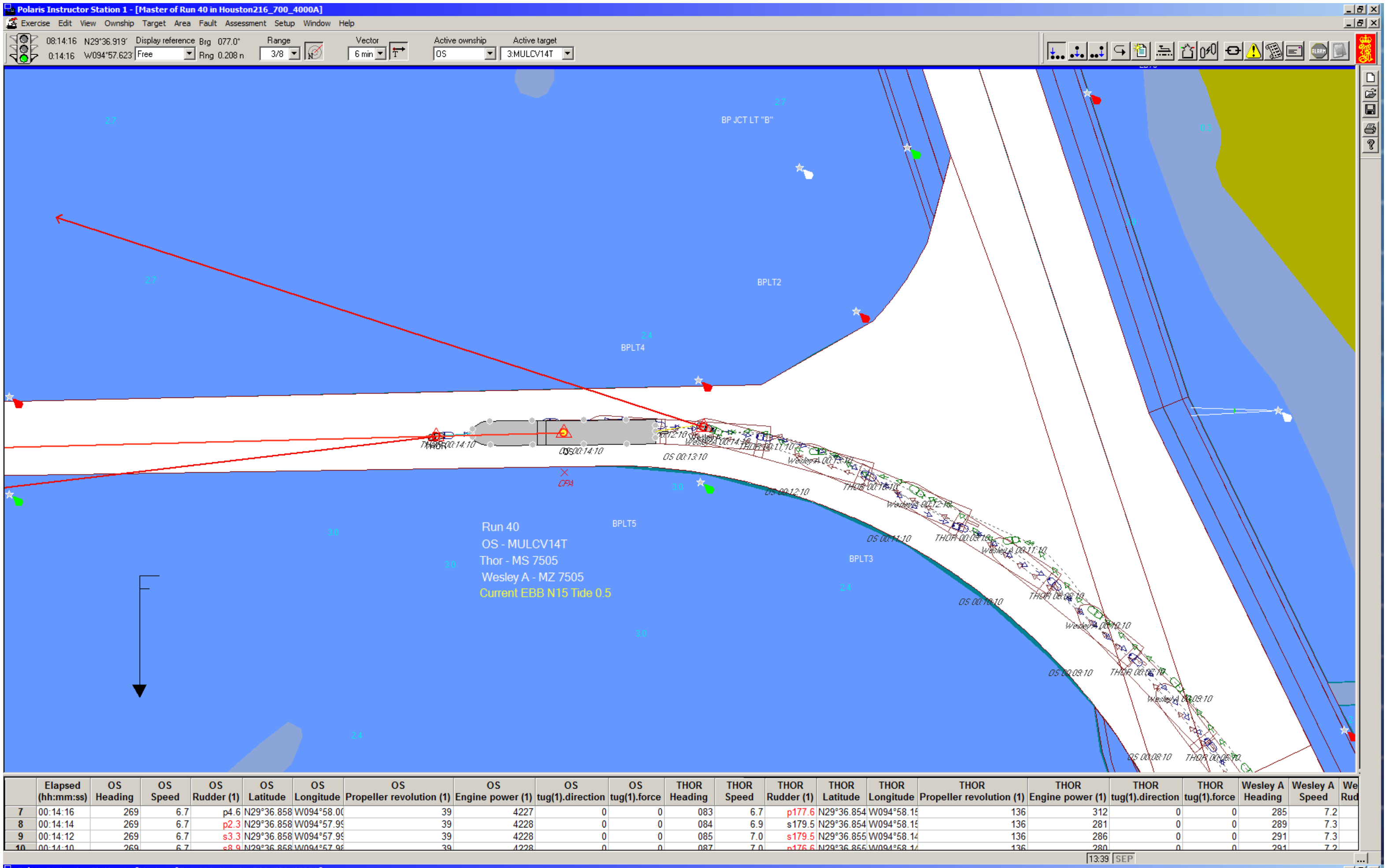


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

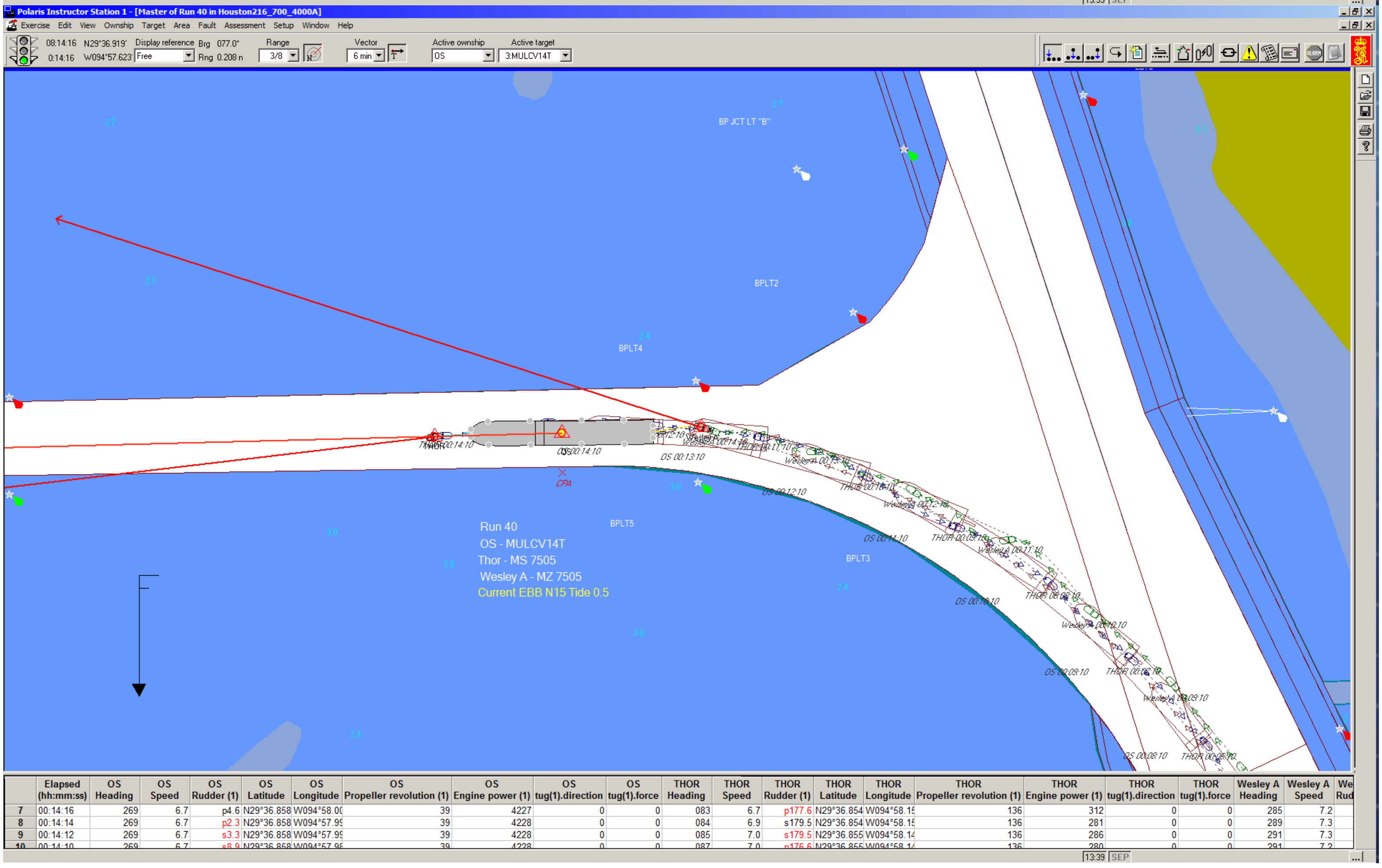
08:11:56 N29°36.945' Display reference Free Brg 084.6° Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:11:56 W094°57.695' Rng 0.172 n

Run 40
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:11:54	287	6.8	p35.0	N29°36.830	W094°57.69	39	4245	0	0	094	6.8	s179.4	N29°36.863	W094°57.85	140	341	0	0	288	7.0	
8	00:11:52	288	6.8	p35.0	N29°36.829	W094°57.69	39	4244	0	0	093	6.9	s176.7	N29°36.862	W094°57.84	141	349	0	0	286	6.8	
9	00:11:50	288	6.8	p35.0	N29°36.828	W094°57.69	39	4243	0	0	094	6.8	s179.8	N29°36.862	W094°57.84	141	357	0	0	288	6.8	
10	00:11:48	288	6.8	p35.0	N29°36.827	W094°57.68	39	4242	0	0	095	6.8	p179.9	N29°36.862	W094°57.83	141	361	0	0	294	6.8	



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:16	269	6.7	p4.6	N29°36.858	W094°58.0	39	4227	0	0	083	6.7	p177.6	N29°36.854	W094°58.1	136	312	0	0	285	7.2	
8	00:14:14	269	6.7	p2.3	N29°36.858	W094°57.9	39	4228	0	0	084	6.9	s179.5	N29°36.854	W094°58.1	136	281	0	0	289	7.3	
9	00:14:12	269	6.7	s3.3	N29°36.858	W094°57.9	39	4228	0	0	085	7.0	s179.5	N29°36.855	W094°58.1	136	286	0	0	291	7.3	
10	00:14:10	269	6.7	s8.9	N29°36.858	W094°57.9	39	4228	0	0	087	7.0	p176.6	N29°36.855	W094°58.1	136	280	0	0	291	7.2	



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:16	269	6.7	p4.6	N29°36.858	W094°58.0	39	4227	0	0	083	6.7	p177.6	N29°36.854	W094°58.1	136	312	0	0	285	7.2	
8	00:14:14	269	6.7	p2.3	N29°36.858	W094°57.9	39	4228	0	0	084	6.9	s179.5	N29°36.854	W094°58.1	136	281	0	0	289	7.3	
9	00:14:12	269	6.7	s3.3	N29°36.858	W094°57.9	39	4228	0	0	085	7.0	s179.5	N29°36.855	W094°58.1	136	286	0	0	291	7.3	
10	00:14:10	269	6.7	s8.9	N29°36.858	W094°57.9	39	4228	0	0	087	7.0	p176.6	N29°36.855	W094°58.1	136	280	0	0	291	7.2	

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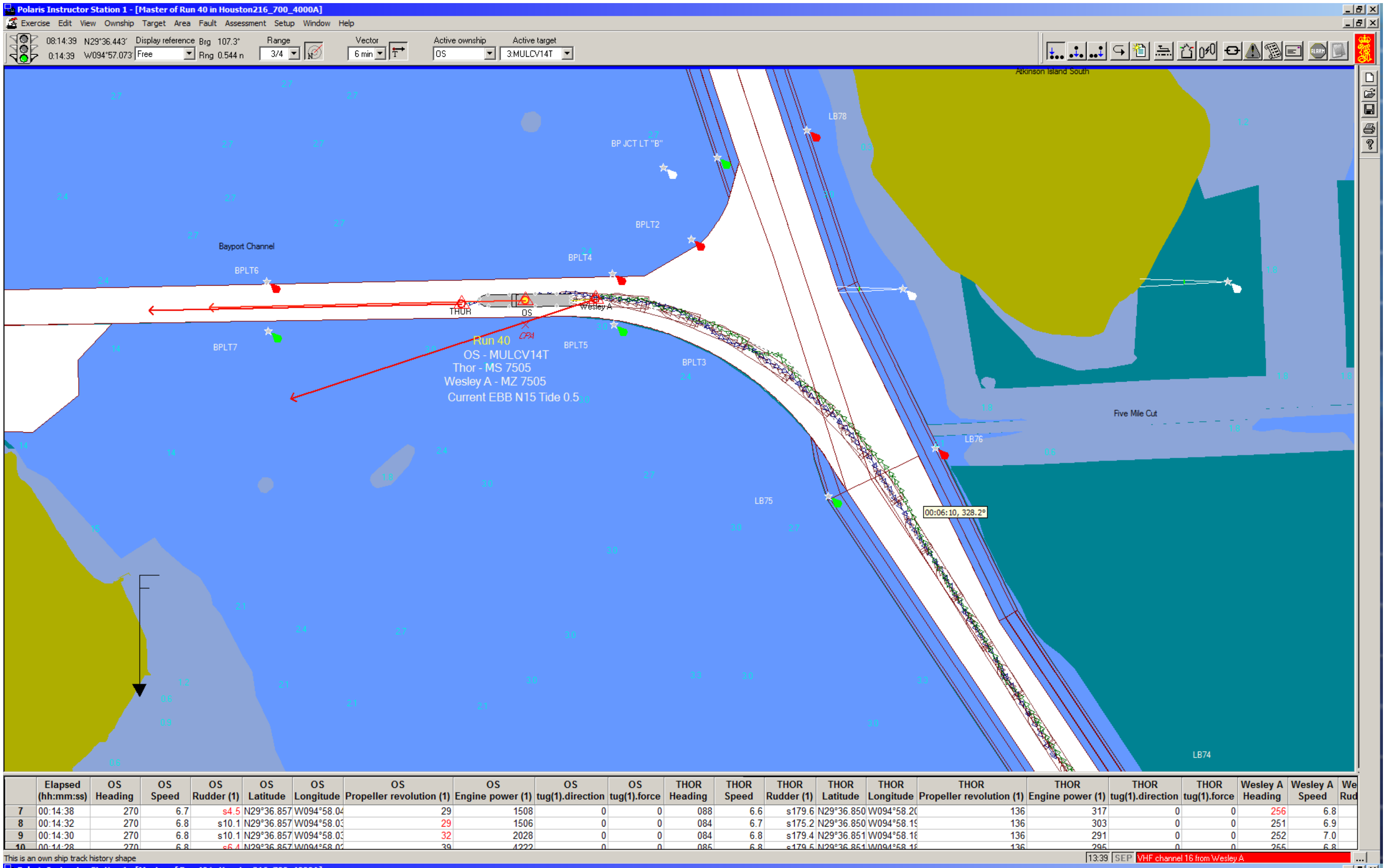


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

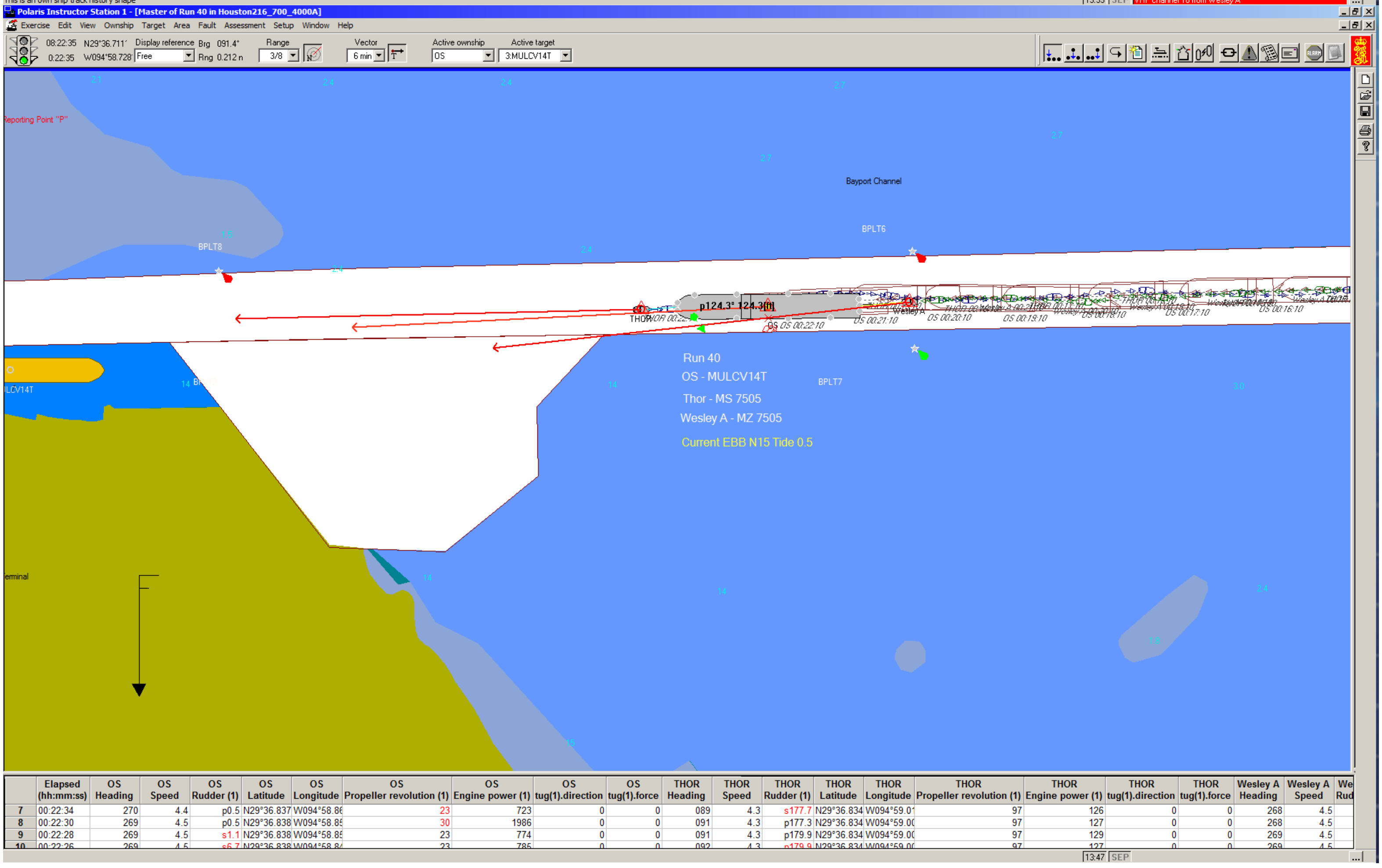
08:14:39 N29°36.443' Display reference Free Brg 107.3° Rng 0.544 n Range 3/4 Vector 6 min Active ownship OS Active target 3:MULCV14T

0:14:39 W094°57.073'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:14:38	270	6.7	s4.5	N29°36.857	W094°58.04	29	1508	0	0	088	6.6	s179.6	N29°36.850	W094°58.20	136	317	0	0	256	6.8	
8	00:14:32	270	6.8	s10.1	N29°36.857	W094°58.03	29	1506	0	0	084	6.7	s175.2	N29°36.850	W094°58.19	136	303	0	0	251	6.9	
9	00:14:30	270	6.8	s10.1	N29°36.857	W094°58.03	32	2028	0	0	084	6.8	s179.4	N29°36.851	W094°58.18	136	291	0	0	252	7.0	
10	00:14:28	270	6.8	s6.4	N29°36.857	W094°58.02	39	4222	0	0	085	6.8	s179.5	N29°36.851	W094°58.18	136	295	0	0	255	6.8	

This is an own ship track history shape

13:39 SEP VHF channel 16 from Wesley A



Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

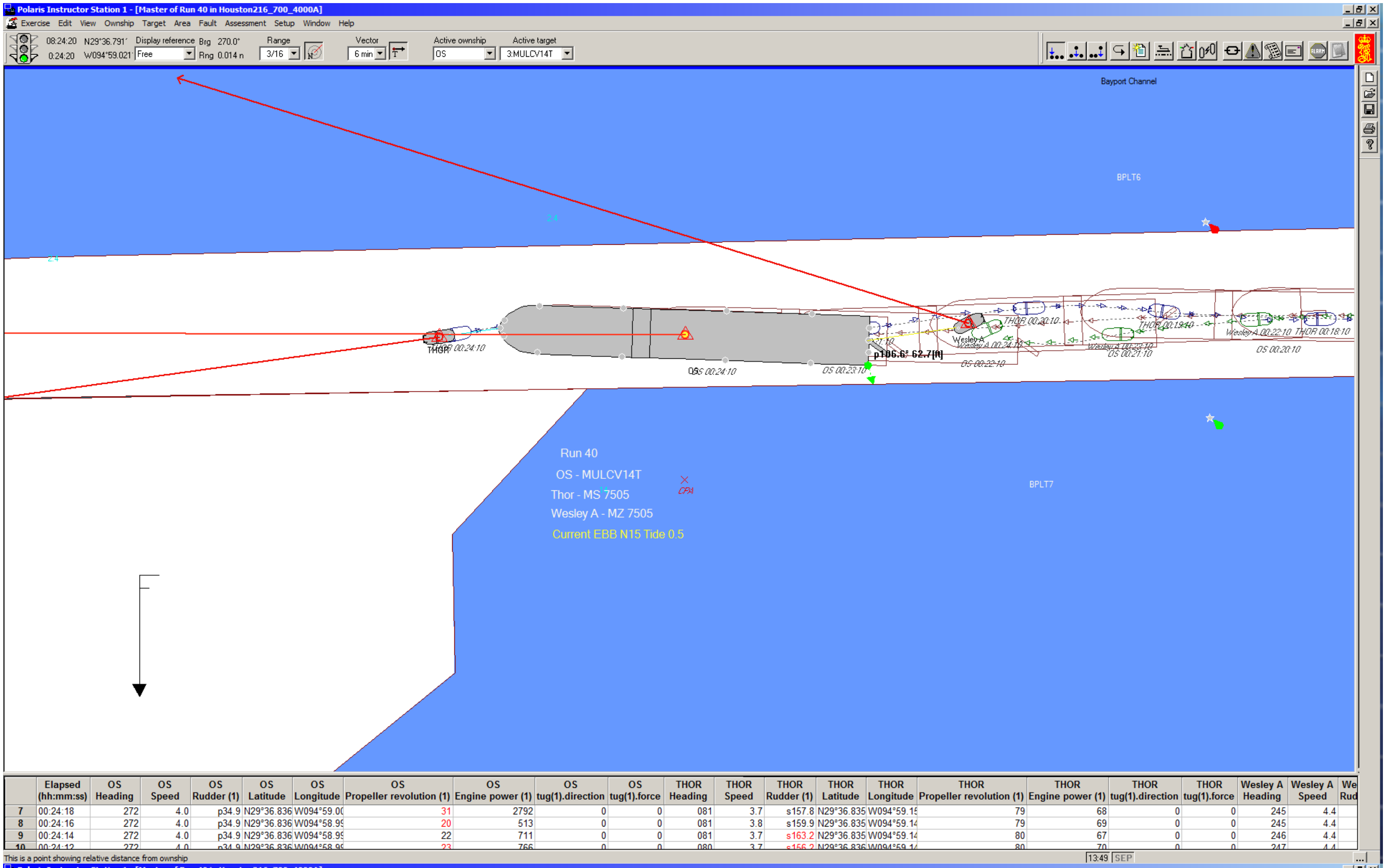
08:22:35 N29°36.711' Display reference Free Brg 091.4° Rng 0.212 n Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T

0:22:35 W094°58.728'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:22:34	270	4.4	p0.5	N29°36.837	W094°58.86	23	723	0	0	089	4.3	s177.7	N29°36.834	W094°59.01	97	126	0	0	268	4.5	
8	00:22:30	269	4.5	p0.5	N29°36.838	W094°58.85	30	1986	0	0	091	4.3	p177.3	N29°36.834	W094°59.00	97	127	0	0	268	4.5	
9	00:22:28	269	4.5	s1.1	N29°36.838	W094°58.85	23	774	0	0	091	4.3	p179.9	N29°36.834	W094°59.00	97	129	0	0	269	4.5	
10	00:22:26	269	4.5	s6.7	N29°36.838	W094°58.84	23	785	0	0	092	4.3	p179.9	N29°36.834	W094°59.00	97	127	0	0	269	4.5	

13:47 SEP

June 26, 2019

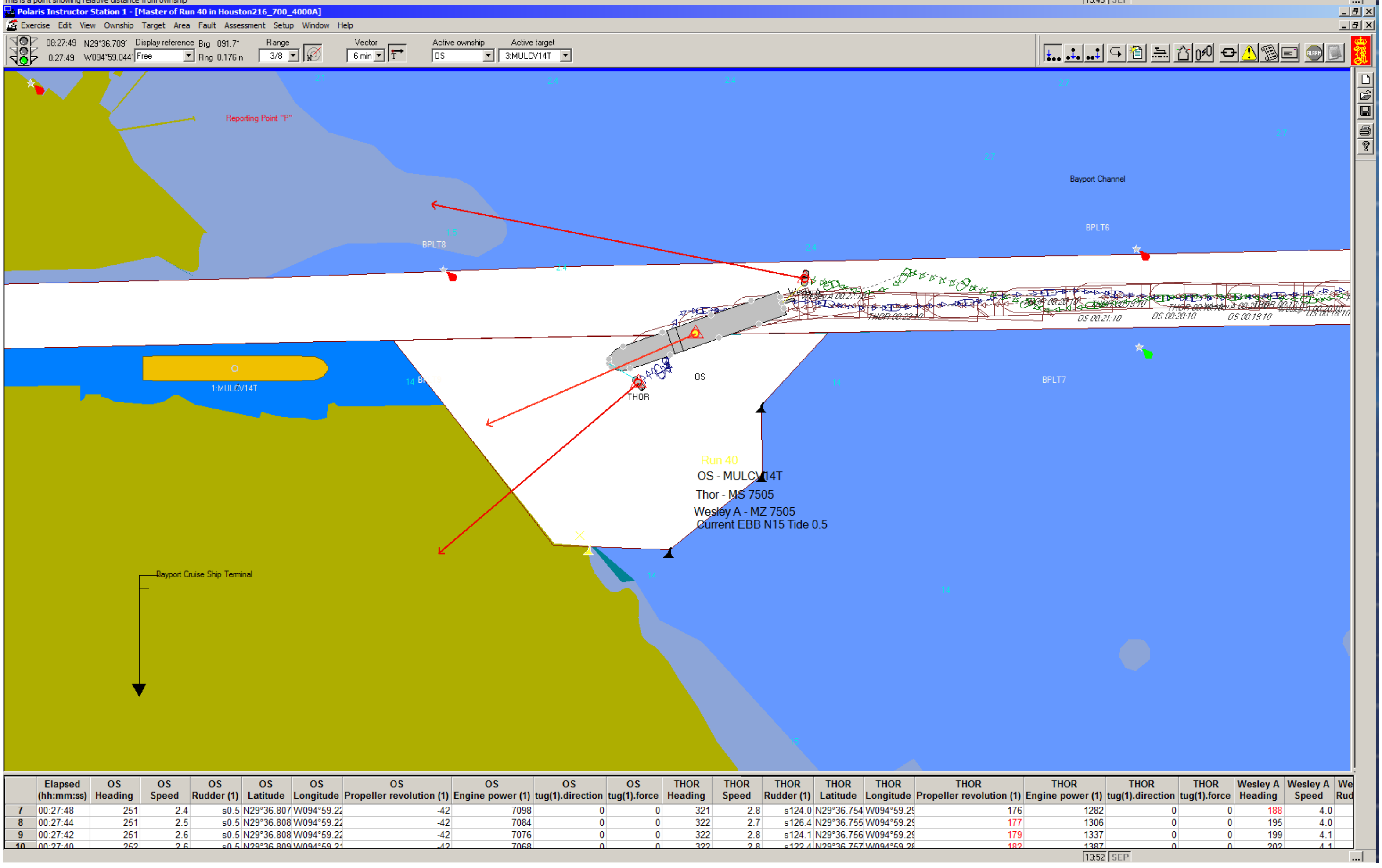


08:24:20 N29°36.791′ Display reference: Free Brg 270.0° Range: 3/16 Vector: 6 min Active ownship: OS Active target: 3:MULCV14T
0:24:20 W094°59.021′ Rng 0.014 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:24:18	272	4.0	p34.9	N29°36.836	W094°59.00	31	2792	0	0	081	3.7	s157.8	N29°36.835	W094°59.15	79	68	0	0	245	4.4	
8	00:24:16	272	4.0	p34.9	N29°36.836	W094°58.99	20	513	0	0	081	3.8	s159.9	N29°36.835	W094°59.14	79	69	0	0	245	4.4	
9	00:24:14	272	4.0	p34.9	N29°36.836	W094°58.99	22	711	0	0	081	3.7	s163.2	N29°36.835	W094°59.14	80	67	0	0	246	4.4	
10	00:24:12	272	4.0	p34.9	N29°36.836	W094°58.99	23	766	0	0	080	3.7	s156.2	N29°36.836	W094°59.14	80	70	0	0	247	4.4	

This is a point showing relative distance from ownship

13:49 SEP



08:27:49 N29°36.709′ Display reference: Free Brg 091.7° Range: 3/8 Vector: 6 min Active ownship: OS Active target: 3:MULCV14T
0:27:49 W094°59.044′ Rng 0.176 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:27:48	251	2.4	s0.5	N29°36.807	W094°59.22	-42	7098	0	0	321	2.8	s124.0	N29°36.754	W094°59.29	176	1282	0	0	188	4.0	
8	00:27:44	251	2.5	s0.5	N29°36.808	W094°59.22	-42	7084	0	0	322	2.7	s126.4	N29°36.755	W094°59.29	177	1306	0	0	195	4.0	
9	00:27:42	251	2.6	s0.5	N29°36.808	W094°59.22	-42	7076	0	0	322	2.8	s124.1	N29°36.756	W094°59.29	179	1337	0	0	199	4.1	
10	00:27:40	252	2.6	s0.5	N29°36.809	W094°59.21	-42	7068	0	0	322	2.8	s122.4	N29°36.757	W094°59.28	182	1387	0	0	202	4.1	

13:52 SEP

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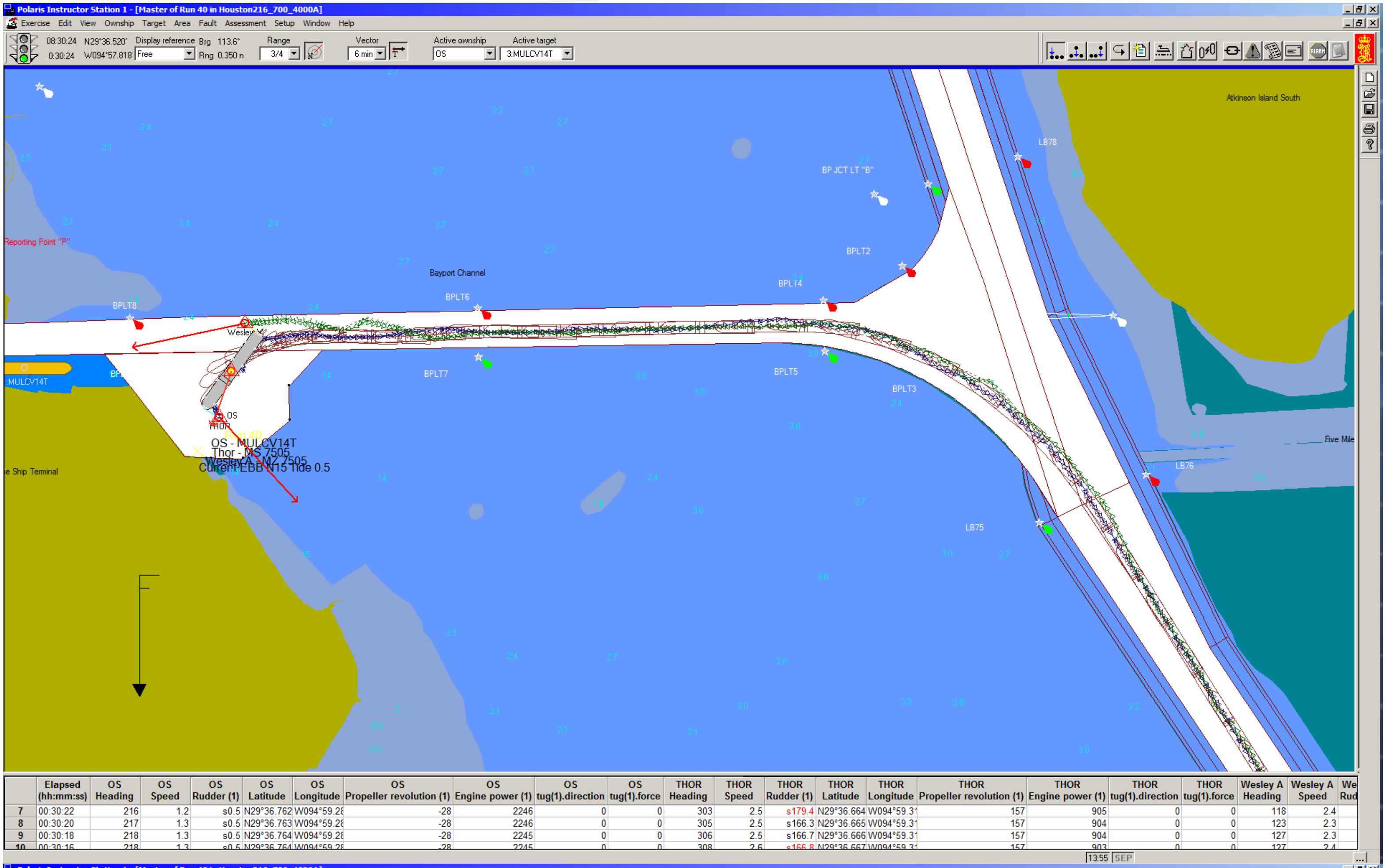
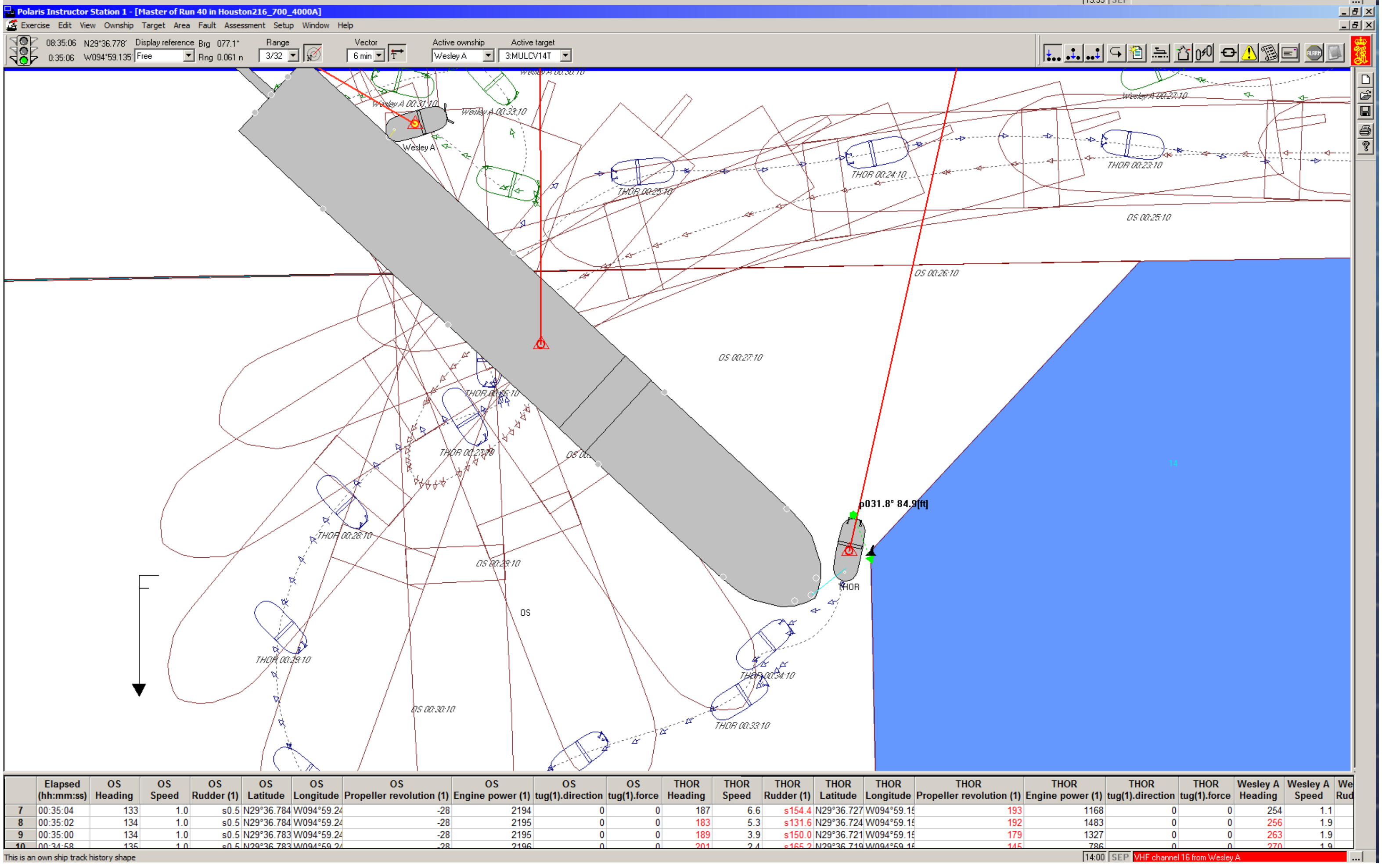


08:30:24 N29°36.520' Display reference: Free Brg 113.6°
0:30:24 W094°57.818 Rng 0.350 n
Range: 3/4
Vector: 6 min
Active ownship: OS
Active target: 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current EBB N15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:30:22	216	1.2	s0.5	N29°36.762	W094°59.28	-28	2246	0	0	303	2.5	s179.4	N29°36.664	W094°59.31	157	905	0	0	118	2.4
8	00:30:20	217	1.3	s0.5	N29°36.763	W094°59.28	-28	2246	0	0	305	2.5	s166.3	N29°36.665	W094°59.31	157	904	0	0	123	2.3
9	00:30:18	218	1.3	s0.5	N29°36.764	W094°59.28	-28	2245	0	0	306	2.5	s166.7	N29°36.666	W094°59.31	157	904	0	0	127	2.3
10	00:30:16	218	1.3	s0.5	N29°36.764	W094°59.28	-28	2245	0	0	308	2.6	s166.8	N29°36.667	W094°59.31	157	903	0	0	127	2.4

13:55 SEP

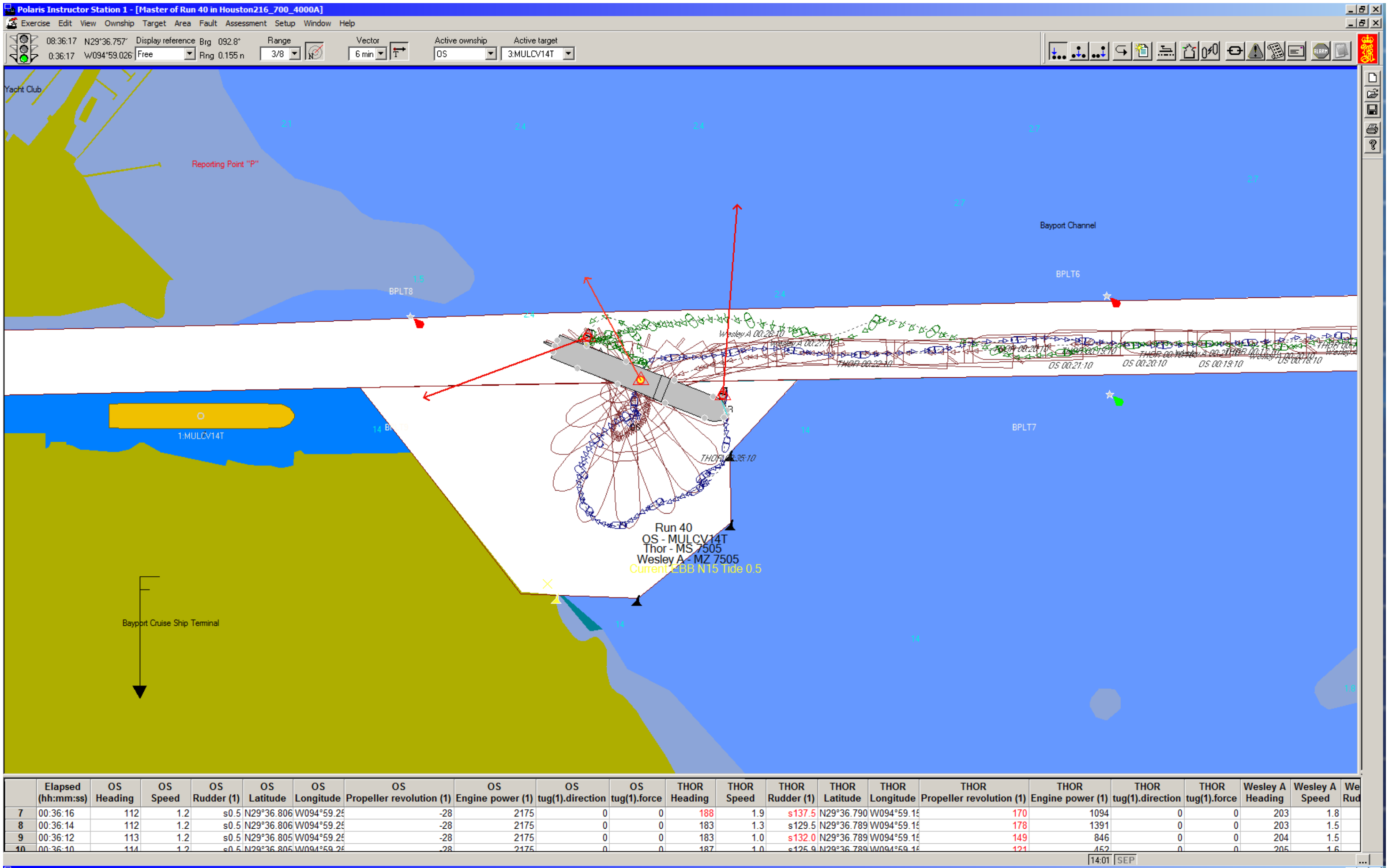


08:35:06 N29°36.778' Display reference: Free Brg 077.1°
0:35:06 W094°59.135 Rng 0.061 n
Range: 3/32
Vector: 6 min
Active ownship: Wesley A
Active target: 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed
7	00:35:04	133	1.0	s0.5	N29°36.784	W094°59.24	-28	2194	0	0	187	6.6	s154.4	N29°36.727	W094°59.15	193	1168	0	0	254	1.1
8	00:35:02	134	1.0	s0.5	N29°36.784	W094°59.24	-28	2195	0	0	183	5.3	s131.6	N29°36.724	W094°59.15	192	1483	0	0	256	1.9
9	00:35:00	134	1.0	s0.5	N29°36.783	W094°59.24	-28	2195	0	0	189	3.9	s150.0	N29°36.721	W094°59.15	179	1327	0	0	263	1.9
10	00:34:58	135	1.0	s0.5	N29°36.783	W094°59.24	-28	2196	0	0	201	2.4	s165.2	N29°36.719	W094°59.15	145	786	0	0	270	1.9

This is an own ship track history shape

14:00 SEP VHF channel 16 from Wesley A

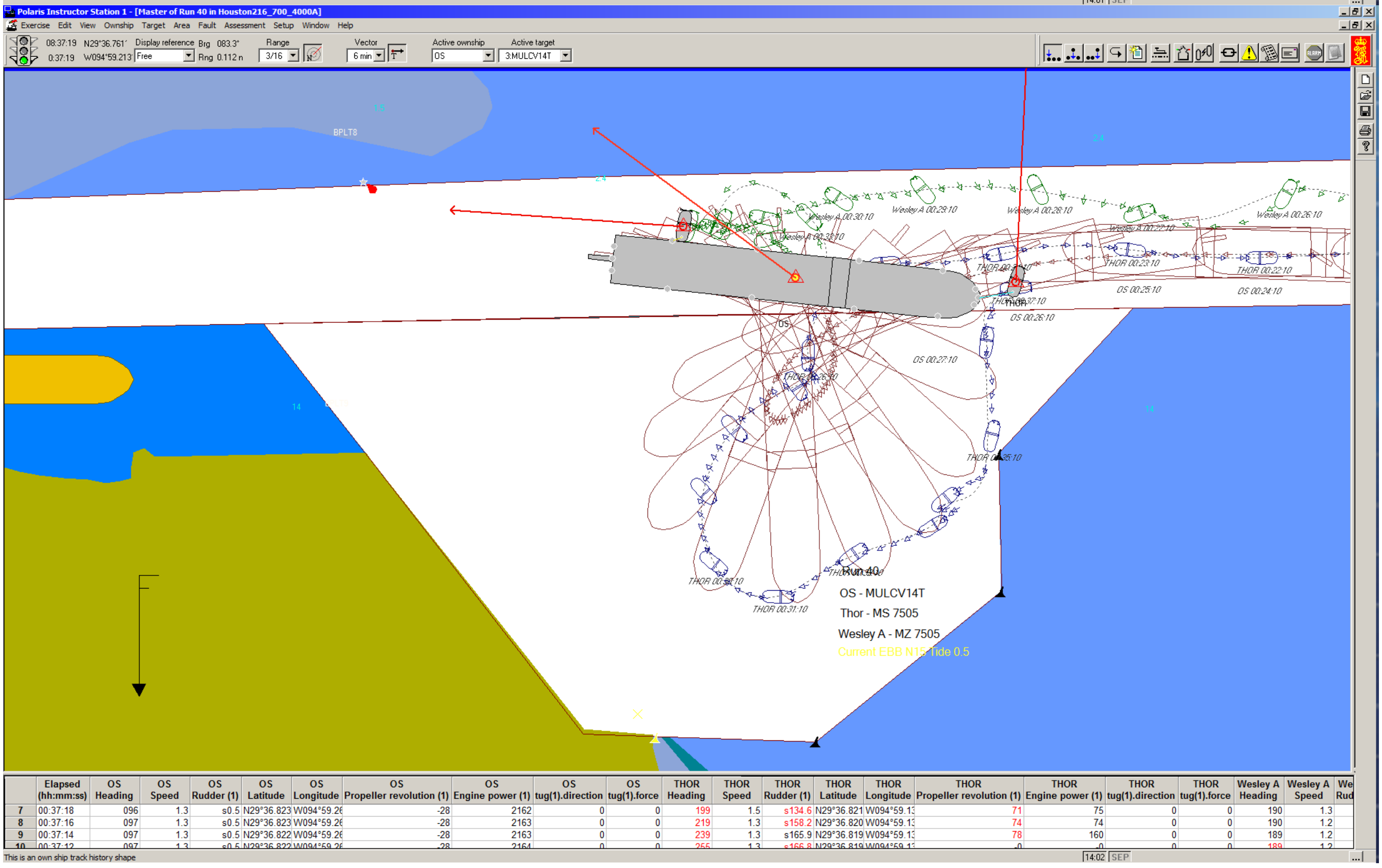


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:36:17 N29°36.757′ Display reference Free Brg 092.8° Rng 0.155 n Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T

0:36:17 W094°59.026′

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:36:16	112	1.2	s0.5	N29°36.806	W094°59.25	-28	2175	0	0	188	1.9	s137.5	N29°36.790	W094°59.15	170	1094	0	0	203	1.8	
8	00:36:14	112	1.2	s0.5	N29°36.806	W094°59.25	-28	2175	0	0	183	1.3	s129.5	N29°36.789	W094°59.15	178	1391	0	0	203	1.5	
9	00:36:12	113	1.2	s0.5	N29°36.805	W094°59.25	-28	2175	0	0	183	1.0	s132.0	N29°36.789	W094°59.15	149	846	0	0	204	1.5	
10	00:36:10	114	1.2	s0.5	N29°36.805	W094°59.25	-28	2175	0	0	187	1.0	s125.9	N29°36.789	W094°59.15	121	452	0	0	205	1.6	



Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

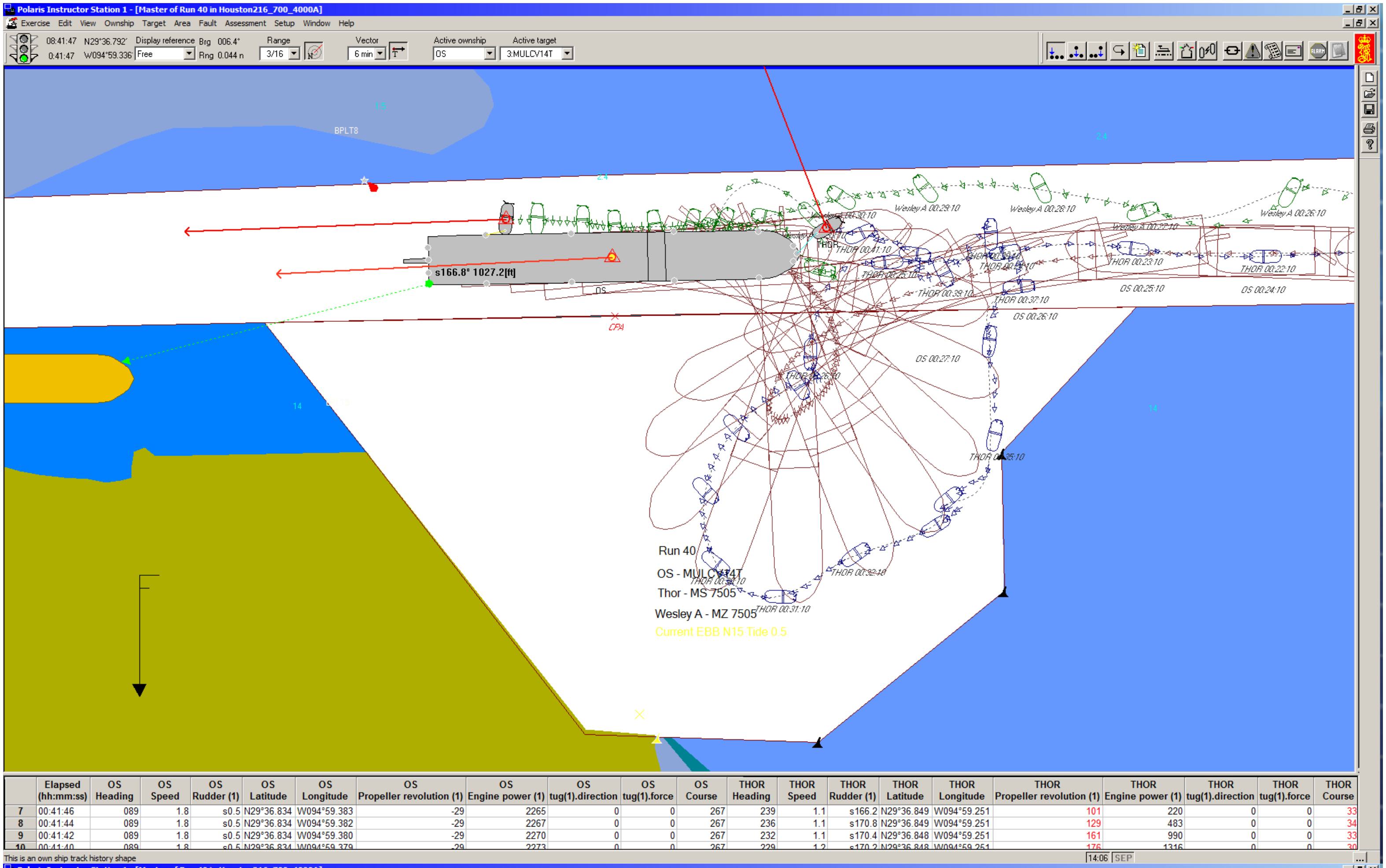
08:37:19 N29°36.761′ Display reference Free Brg 083.3° Rng 0.112 n Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T

0:37:19 W094°59.213′

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	Wesley A Heading	Wesley A Speed	We Rud
7	00:37:18	096	1.3	s0.5	N29°36.823	W094°59.26	-28	2162	0	0	199	1.5	s134.6	N29°36.821	W094°59.13	71	75	0	0	190	1.3	
8	00:37:16	097	1.3	s0.5	N29°36.823	W094°59.26	-28	2163	0	0	219	1.3	s158.2	N29°36.820	W094°59.13	74	74	0	0	190	1.2	
9	00:37:14	097	1.3	s0.5	N29°36.822	W094°59.26	-28	2163	0	0	239	1.3	s165.9	N29°36.819	W094°59.13	78	160	0	0	189	1.2	
10	00:37:12	097	1.3	s0.5	N29°36.822	W094°59.26	-28	2164	0	0	255	1.3	s166.8	N29°36.819	W094°59.13	-0	-0	0	0	189	1.2	

This is an own ship track history shape

June 26, 2019

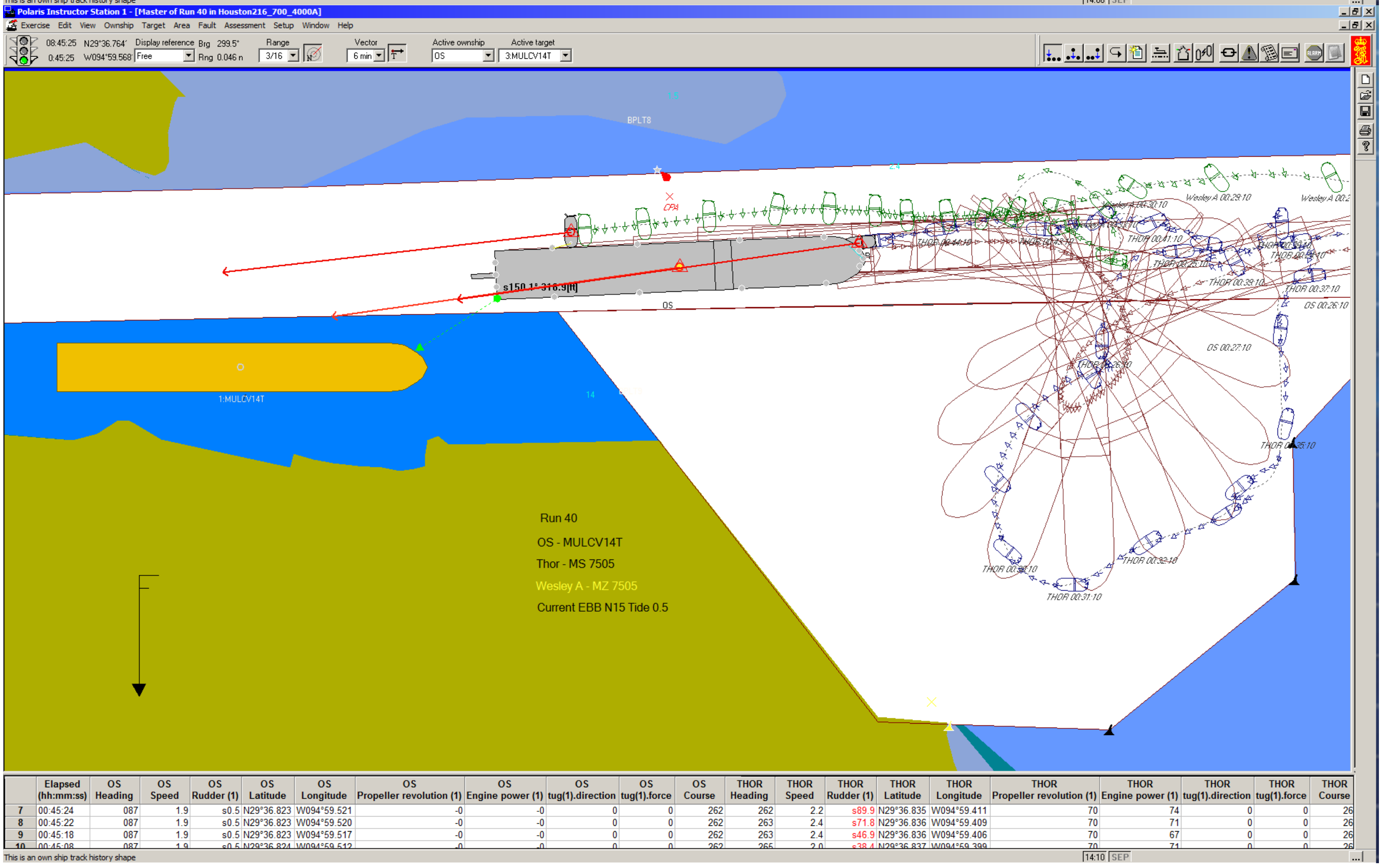


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:41:47 N29°36.792′ Display reference Free Brg 006.4° Rng 0.044 n
0:41:47 W094°59.336′
Range 3/16
Vector 6 min
Active ownship OS
Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:41:46	089	1.8	s0.5	N29°36.834	W094°59.383	-29	2265	0	0	267	239	1.1	s166.2	N29°36.849	W094°59.251	101	220	0	0	33
8	00:41:44	089	1.8	s0.5	N29°36.834	W094°59.382	-29	2267	0	0	267	236	1.1	s170.8	N29°36.849	W094°59.251	129	483	0	0	34
9	00:41:42	089	1.8	s0.5	N29°36.834	W094°59.380	-29	2270	0	0	267	232	1.1	s170.4	N29°36.848	W094°59.251	161	990	0	0	33
10	00:41:40	089	1.8	s0.5	N29°36.834	W094°59.379	-29	2273	0	0	267	229	1.2	s170.2	N29°36.848	W094°59.251	176	1316	0	0	30

This is an own ship track history shape

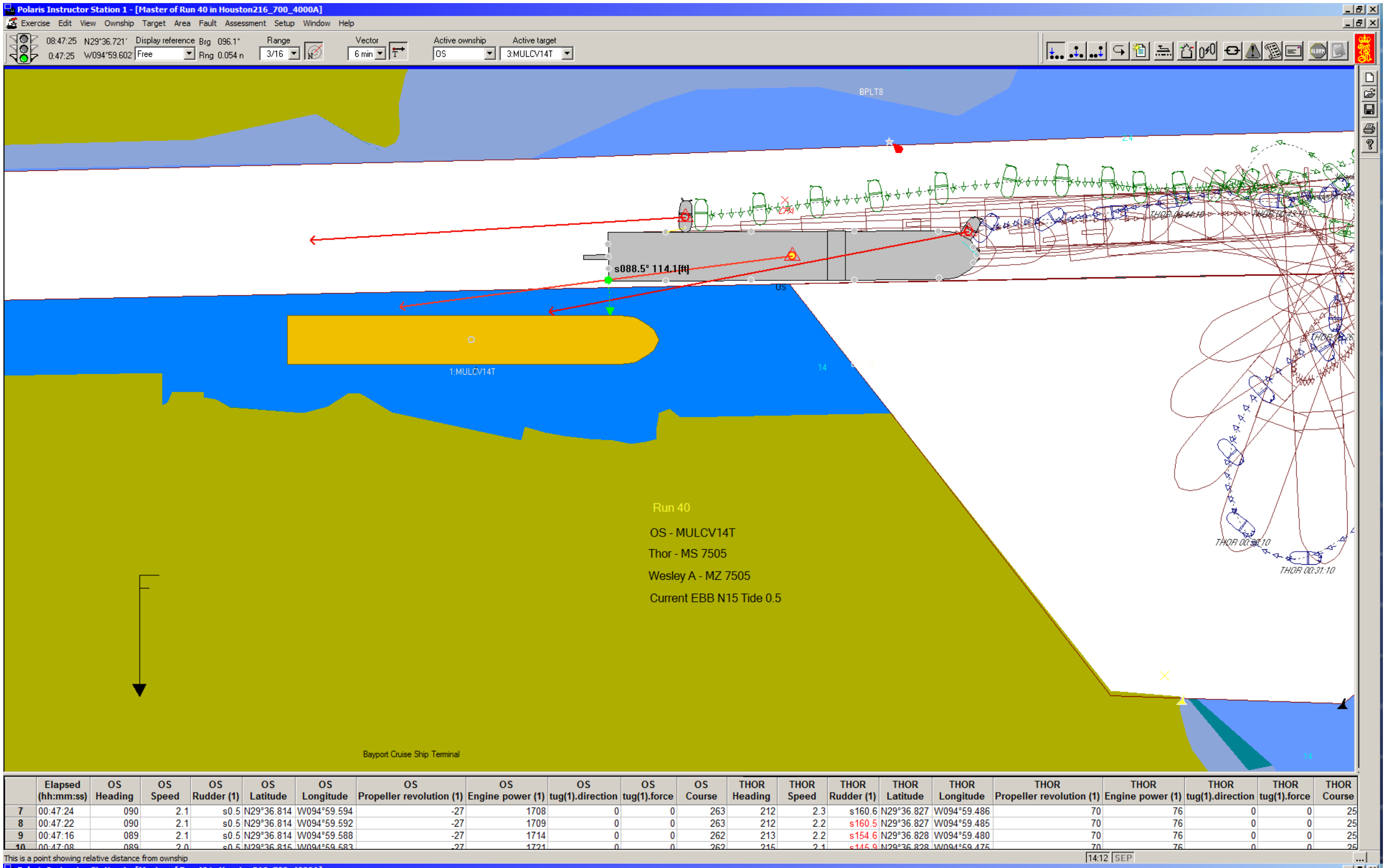


Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:45:25 N29°36.764′ Display reference Free Brg 299.5° Rng 0.046 n
0:45:25 W094°59.568′
Range 3/16
Vector 6 min
Active ownship OS
Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:45:24	087	1.9	s0.5	N29°36.823	W094°59.521	-0	-0	0	0	262	262	2.2	s89.9	N29°36.835	W094°59.411	70	74	0	0	26
8	00:45:22	087	1.9	s0.5	N29°36.823	W094°59.520	-0	-0	0	0	262	263	2.4	s71.8	N29°36.836	W094°59.409	70	71	0	0	26
9	00:45:18	087	1.9	s0.5	N29°36.823	W094°59.517	-0	-0	0	0	262	263	2.4	s46.9	N29°36.836	W094°59.406	70	67	0	0	26
10	00:45:08	087	1.9	s0.5	N29°36.824	W094°59.512	-0	-0	0	0	262	265	2.0	s38.4	N29°36.837	W094°59.399	70	71	0	0	26

This is an own ship track history shape



08:47:25 N29°36.721' Display reference: Free Brg 096.1° Rng 0.054 n Range: 3/16 Vector: 6 min Active ownship: OS Active target: 3:MULCV14T
0:47:25 W094°59.602'

Run 40

OS - MULCV14T

Thor - MS 7505

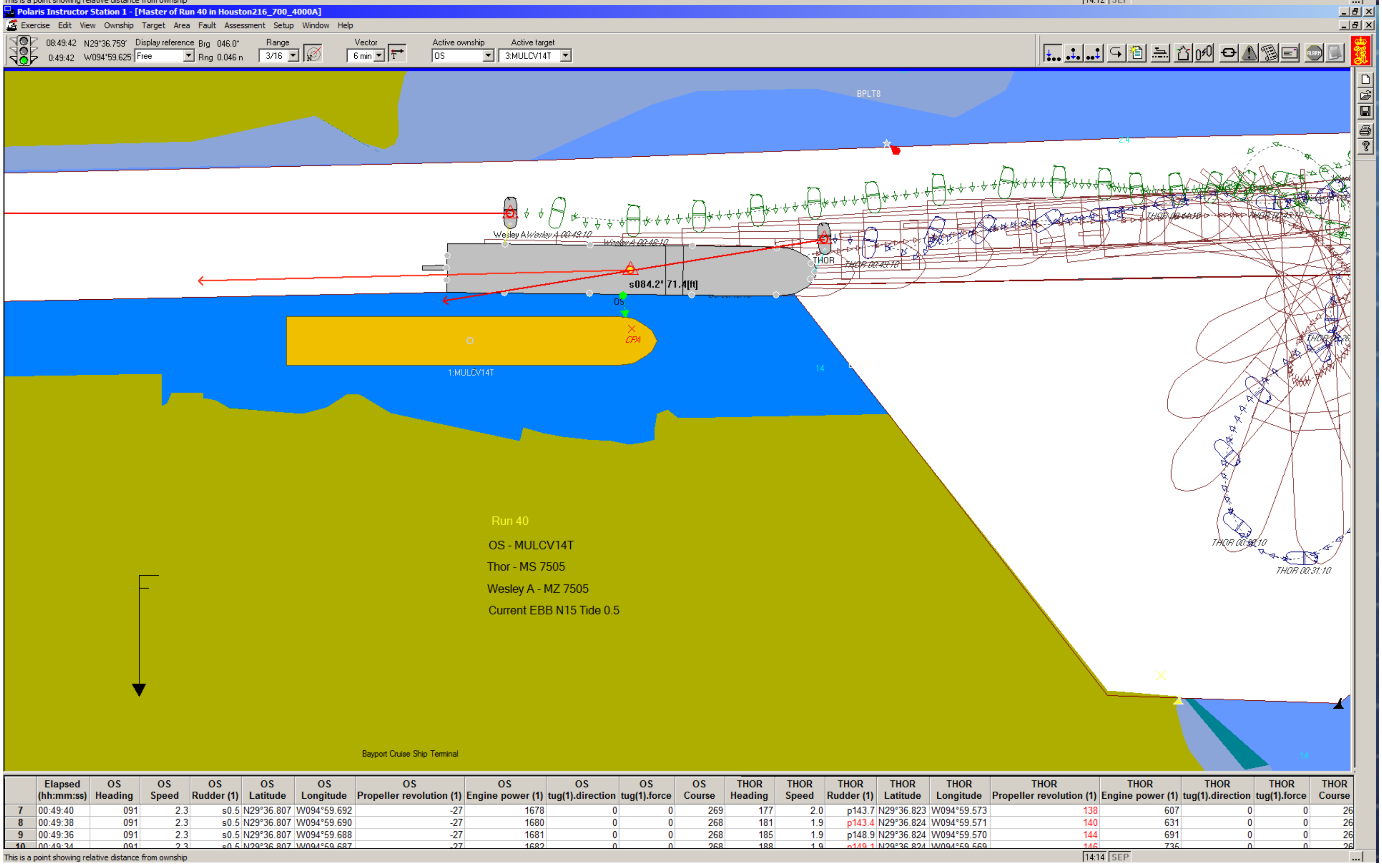
Wesley A - MZ 7505

Current EBB N15 Tide 0.5

Bayport Cruise Ship Terminal

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:47:24	090	2.1	s0.5	N29°36.814	W094°59.594	-27	1708	0	0	263	212	2.3	s160.6	N29°36.827	W094°59.486	70	76	0	0	25
8	00:47:22	090	2.1	s0.5	N29°36.814	W094°59.592	-27	1709	0	0	263	212	2.2	s160.5	N29°36.827	W094°59.485	70	76	0	0	25
9	00:47:16	089	2.1	s0.5	N29°36.814	W094°59.588	-27	1714	0	0	262	213	2.2	s154.6	N29°36.828	W094°59.480	70	76	0	0	25
10	00:47:08	089	2.0	s0.5	N29°36.815	W094°59.583	-27	1721	0	0	262	215	2.1	s145.9	N29°36.828	W094°59.475	70	76	0	0	25

This is a point showing relative distance from ownship



08:49:42 N29°36.759' Display reference: Free Brg 046.0° Rng 0.046 n Range: 3/16 Vector: 6 min Active ownship: OS Active target: 3:MULCV14T
0:49:42 W094°59.625'

Run 40

OS - MULCV14T

Thor - MS 7505

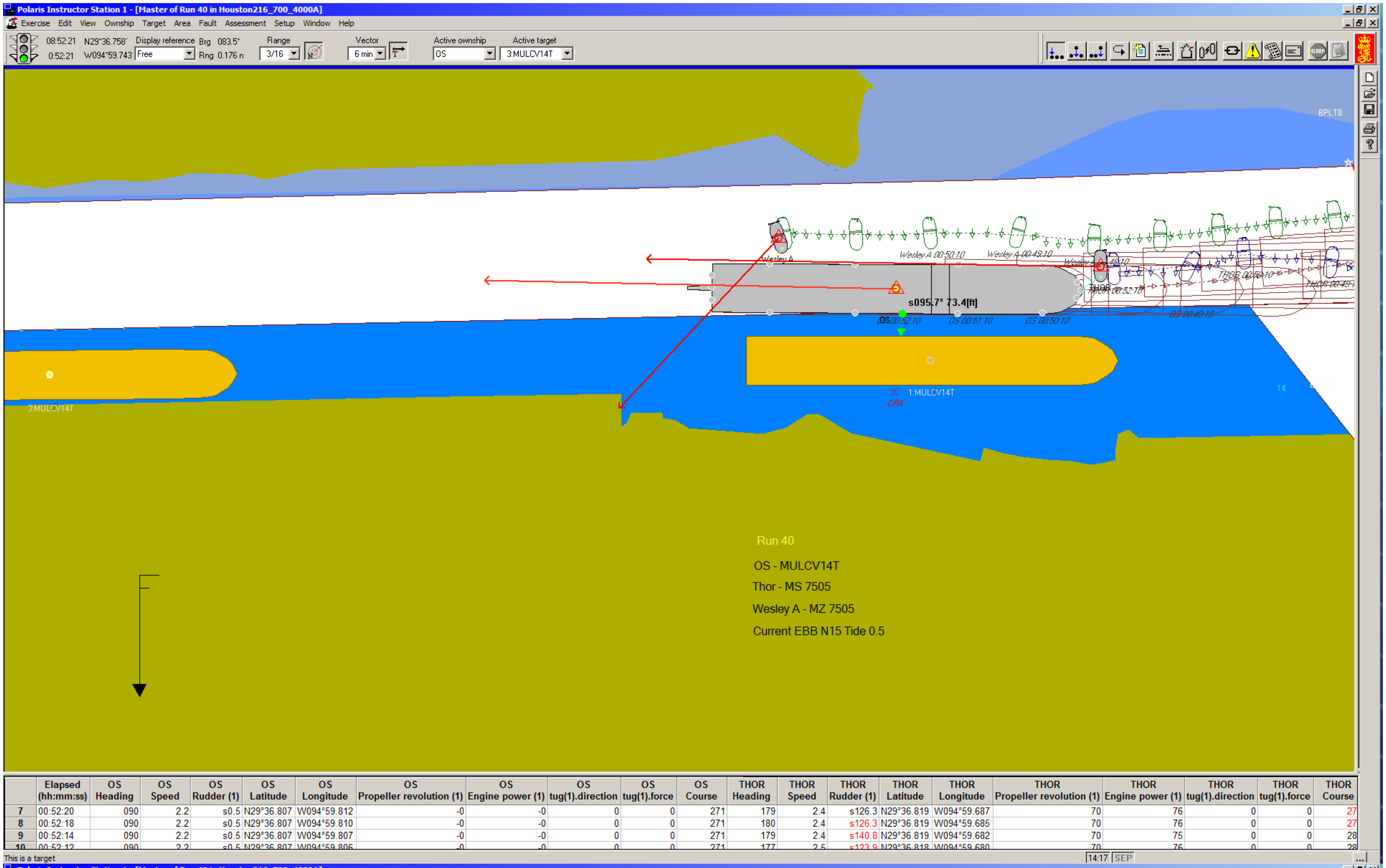
Wesley A - MZ 7505

Current EBB N15 Tide 0.5

Bayport Cruise Ship Terminal

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:49:40	091	2.3	s0.5	N29°36.807	W094°59.692	-27	1678	0	0	269	177	2.0	p143.7	N29°36.823	W094°59.573	138	607	0	0	26
8	00:49:38	091	2.3	s0.5	N29°36.807	W094°59.690	-27	1680	0	0	268	181	1.9	p143.4	N29°36.824	W094°59.571	140	631	0	0	26
9	00:49:36	091	2.3	s0.5	N29°36.807	W094°59.688	-27	1681	0	0	268	185	1.9	p148.9	N29°36.824	W094°59.570	144	691	0	0	26
10	00:49:34	091	2.3	s0.5	N29°36.807	W094°59.687	-27	1682	0	0	268	188	1.9	p149.1	N29°36.824	W094°59.569	146	735	0	0	26

This is a point showing relative distance from ownship



Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:52:21 N29°36.758′ Display reference: Free Brg 083.5° Rng 0.176 n Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:52:21 W094°59.743′

Run 40

OS - MULCV14T

Thor - MS 7505

Wesley A - MZ 7505

Current EBB N15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:52:20	090	2.2	s0.5	N29°36.807	W094°59.812	-0	-0	0	0	271	179	2.4	s126.3	N29°36.819	W094°59.687	70	76	0	0	27
8	00:52:18	090	2.2	s0.5	N29°36.807	W094°59.810	-0	-0	0	0	271	180	2.4	s126.3	N29°36.819	W094°59.685	70	76	0	0	27
9	00:52:14	090	2.2	s0.5	N29°36.807	W094°59.807	-0	-0	0	0	271	179	2.4	s140.8	N29°36.819	W094°59.682	70	75	0	0	28
10	00:52:12	090	2.2	s0.5	N29°36.807	W094°59.806	-0	-0	0	0	271	177	2.5	s123.9	N29°36.818	W094°59.680	70	76	0	0	28

This is a target

14:17 SEP

Polaris Instructor Station 1 - [Master of Run 40 in Houston216_700_4000A]

08:53:20 N29°36.740′ Display reference: Free Brg 089.3° Rng 0.200 n Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:53:20 W094°59.715′

Run 40

OS - MULCV14T

Thor - MS 7505

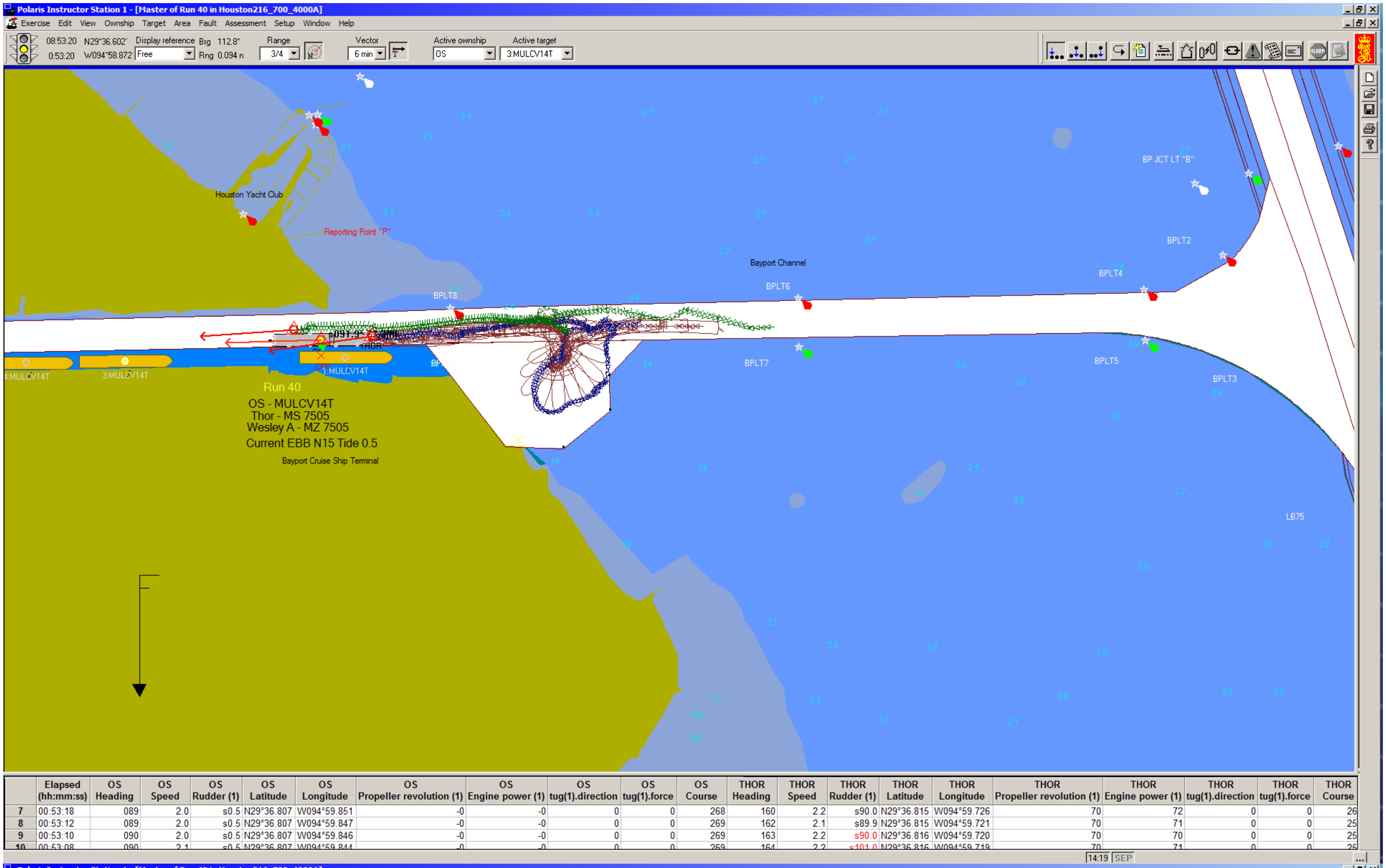
Wesley A - MZ 7505

Current EBB N15 Tide 0.5

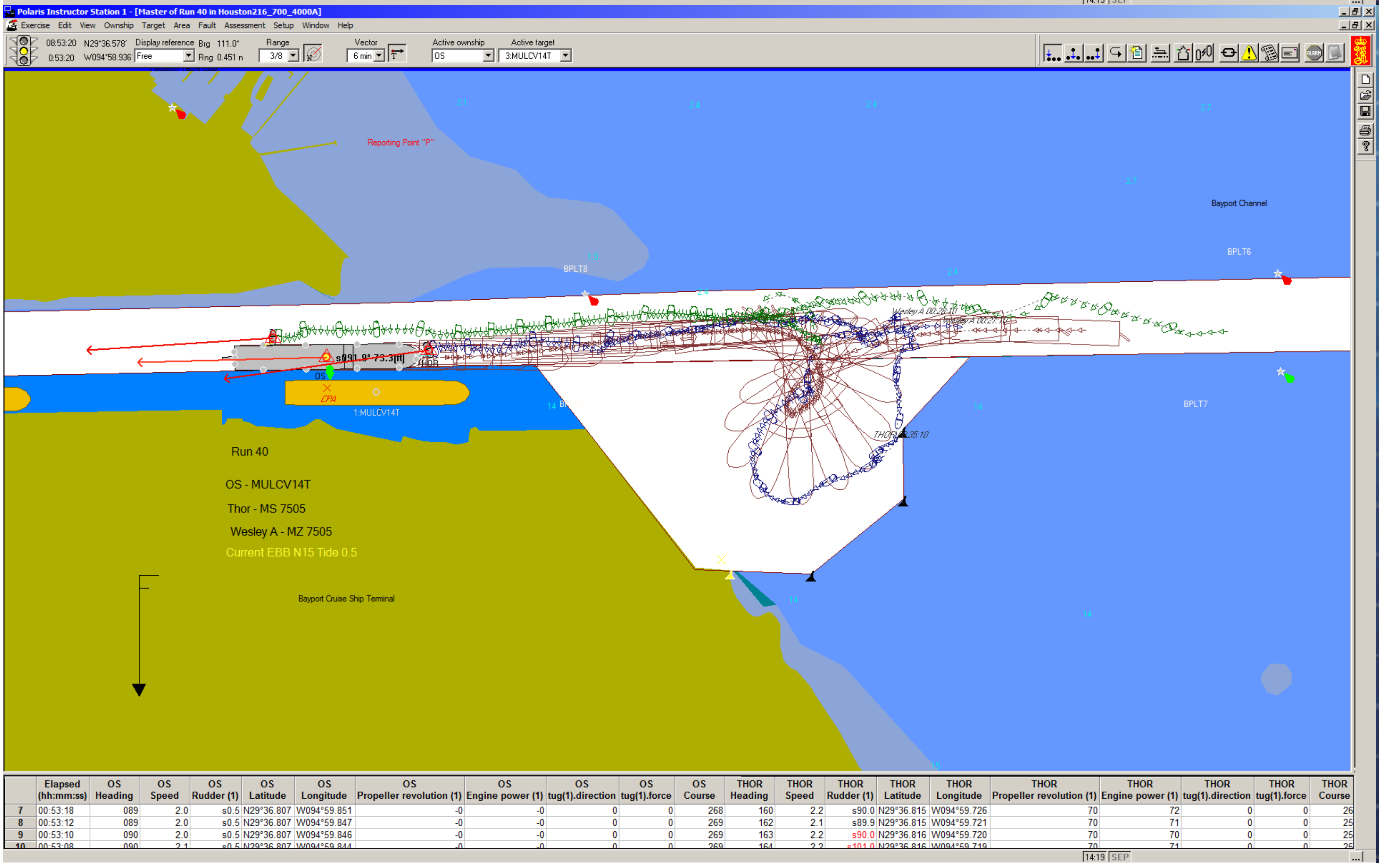
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:53:18	089	2.0	s0.5	N29°36.807	W094°59.851	-0	-0	0	0	268	160	2.2	s90.0	N29°36.815	W094°59.726	70	72	0	0	26
8	00:53:12	089	2.0	s0.5	N29°36.807	W094°59.847	-0	-0	0	0	269	162	2.1	s89.9	N29°36.815	W094°59.721	70	71	0	0	25
9	00:53:10	090	2.0	s0.5	N29°36.807	W094°59.846	-0	-0	0	0	269	163	2.2	s90.0	N29°36.816	W094°59.720	70	70	0	0	25
10	00:53:08	090	2.1	s0.5	N29°36.807	W094°59.844	-0	-0	0	0	269	164	2.2	s101.0	N29°36.816	W094°59.719	70	71	0	0	25

This is a point showing relative distance from ownship

14:18 SEP

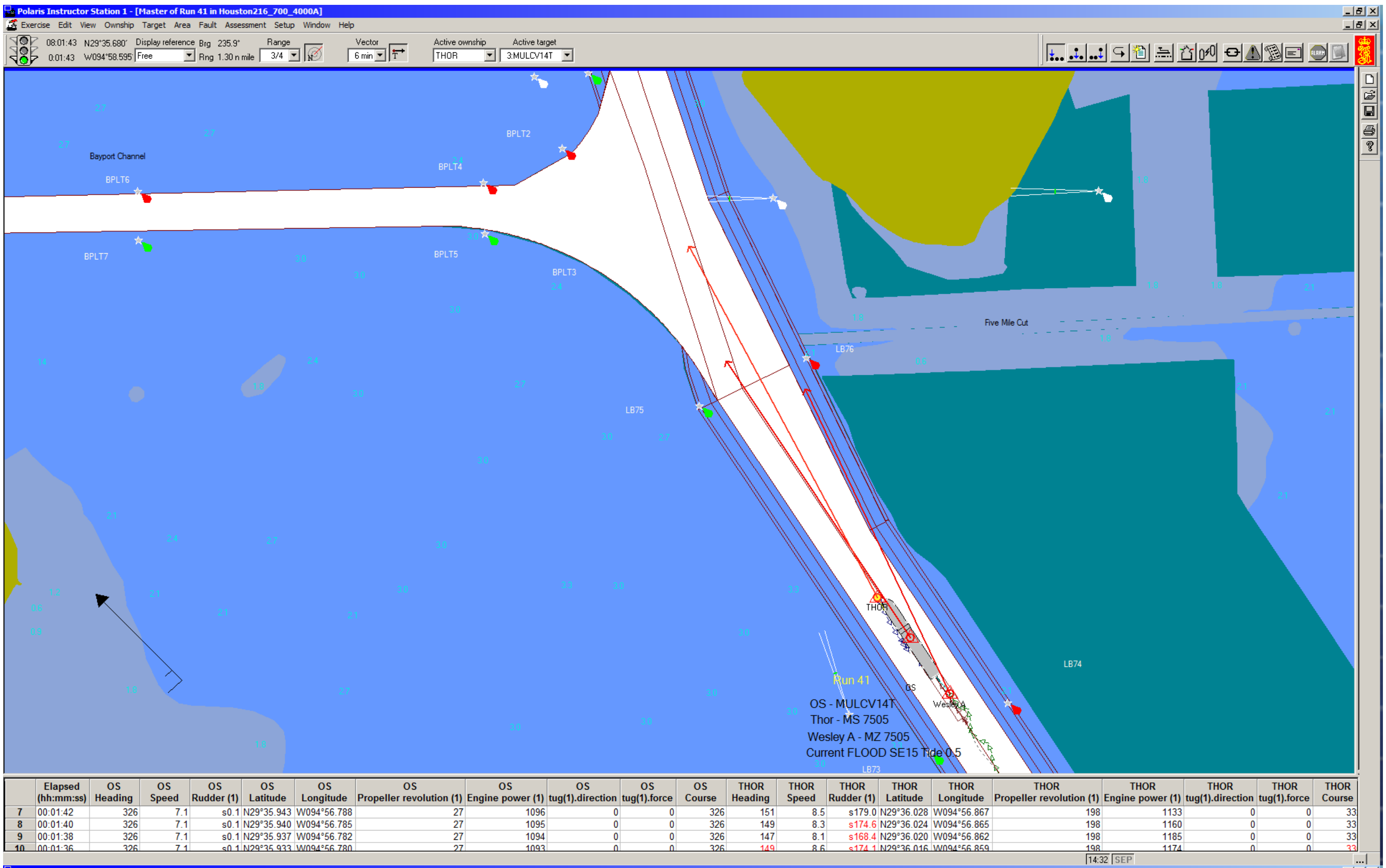


	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:53:18	089	2.0	s0.5	N29°36.807	W094°59.851	-0	-0	0	0	268	160	2.2	s90.0	N29°36.815	W094°59.726	70	72	0	0	26
8	00:53:12	089	2.0	s0.5	N29°36.807	W094°59.847	-0	-0	0	0	269	162	2.1	s89.9	N29°36.815	W094°59.721	70	71	0	0	25
9	00:53:10	090	2.0	s0.5	N29°36.807	W094°59.846	-0	-0	0	0	269	163	2.2	s90.0	N29°36.816	W094°59.720	70	70	0	0	25
10	00:53:08	090	2.1	s0.5	N29°36.807	W094°59.844	-0	-0	0	0	269	164	2.2	s101.0	N29°36.816	W094°59.719	70	71	0	0	25



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:53:18	089	2.0	s0.5	N29°36.807	W094°59.851	-0	-0	0	0	268	160	2.2	s90.0	N29°36.815	W094°59.726	70	72	0	0	26
8	00:53:12	089	2.0	s0.5	N29°36.807	W094°59.847	-0	-0	0	0	269	162	2.1	s89.9	N29°36.815	W094°59.721	70	71	0	0	25
9	00:53:10	090	2.0	s0.5	N29°36.807	W094°59.846	-0	-0	0	0	269	163	2.2	s90.0	N29°36.816	W094°59.720	70	70	0	0	25
10	00:53:08	090	2.1	s0.5	N29°36.807	W094°59.844	-0	-0	0	0	269	164	2.2	s101.0	N29°36.816	W094°59.719	70	71	0	0	25

Run 41



Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:01:43 N29°35.680' Display reference Free Brg 235.9° Rng 1.30 n mile Range 3/4 Vector 6 min Active ownship THOR Active target 3:MULCV14T

0:01:43 W094°58.595'

Run 41

OS - MULCV14T

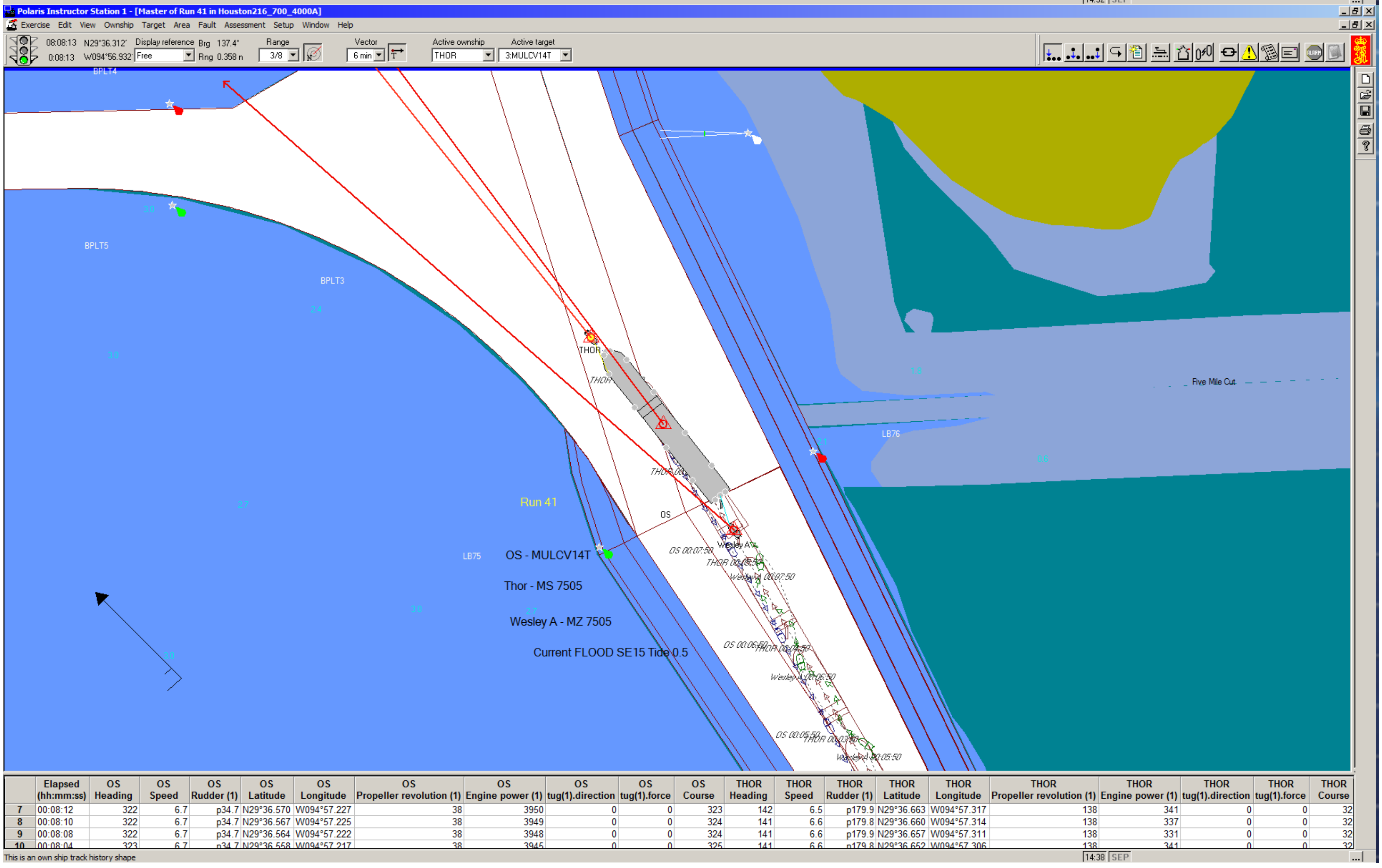
Thor - MS 7505

Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:01:42	326	7.1	s0.1	N29°35.943	W094°56.788	27	1096	0	0	326	151	8.5	s179.0	N29°36.028	W094°56.867	198	1133	0	0	33
8	00:01:40	326	7.1	s0.1	N29°35.940	W094°56.785	27	1095	0	0	326	149	8.3	s174.6	N29°36.024	W094°56.865	198	1160	0	0	33
9	00:01:38	326	7.1	s0.1	N29°35.937	W094°56.782	27	1094	0	0	326	147	8.1	s168.4	N29°36.020	W094°56.862	198	1185	0	0	33
10	00:01:36	326	7.1	s0.1	N29°35.933	W094°56.780	27	1093	0	0	326	149	8.6	s174.1	N29°36.016	W094°56.859	198	1174	0	0	33

14:32 SEP



Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:08:13 N29°36.312' Display reference Free Brg 137.4° Rng 0.358 n Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T

0:08:13 W094°56.932'

Run 41

OS - MULCV14T

Thor - MS 7505

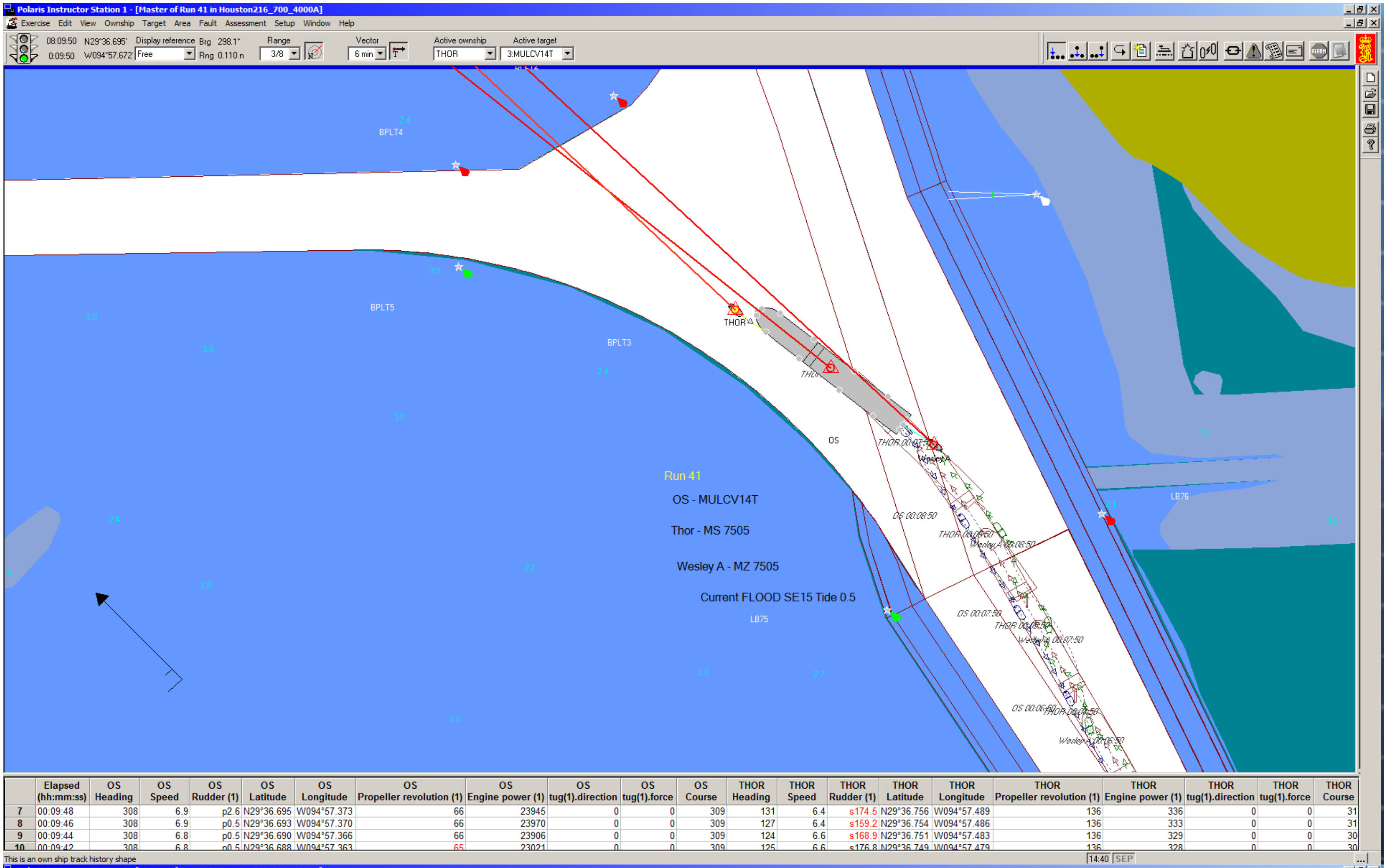
Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:08:12	322	6.7	p34.7	N29°36.570	W094°57.227	38	3950	0	0	323	142	6.5	p179.9	N29°36.663	W094°57.317	138	341	0	0	32
8	00:08:10	322	6.7	p34.7	N29°36.567	W094°57.225	38	3949	0	0	324	141	6.6	p179.8	N29°36.660	W094°57.314	138	337	0	0	32
9	00:08:08	322	6.7	p34.7	N29°36.564	W094°57.222	38	3948	0	0	324	141	6.6	p179.9	N29°36.657	W094°57.311	138	331	0	0	32
10	00:08:04	323	6.7	p34.7	N29°36.558	W094°57.217	38	3945	0	0	325	141	6.6	p179.8	N29°36.652	W094°57.306	138	341	0	0	32

This is an own ship track history shape

14:38 SEP



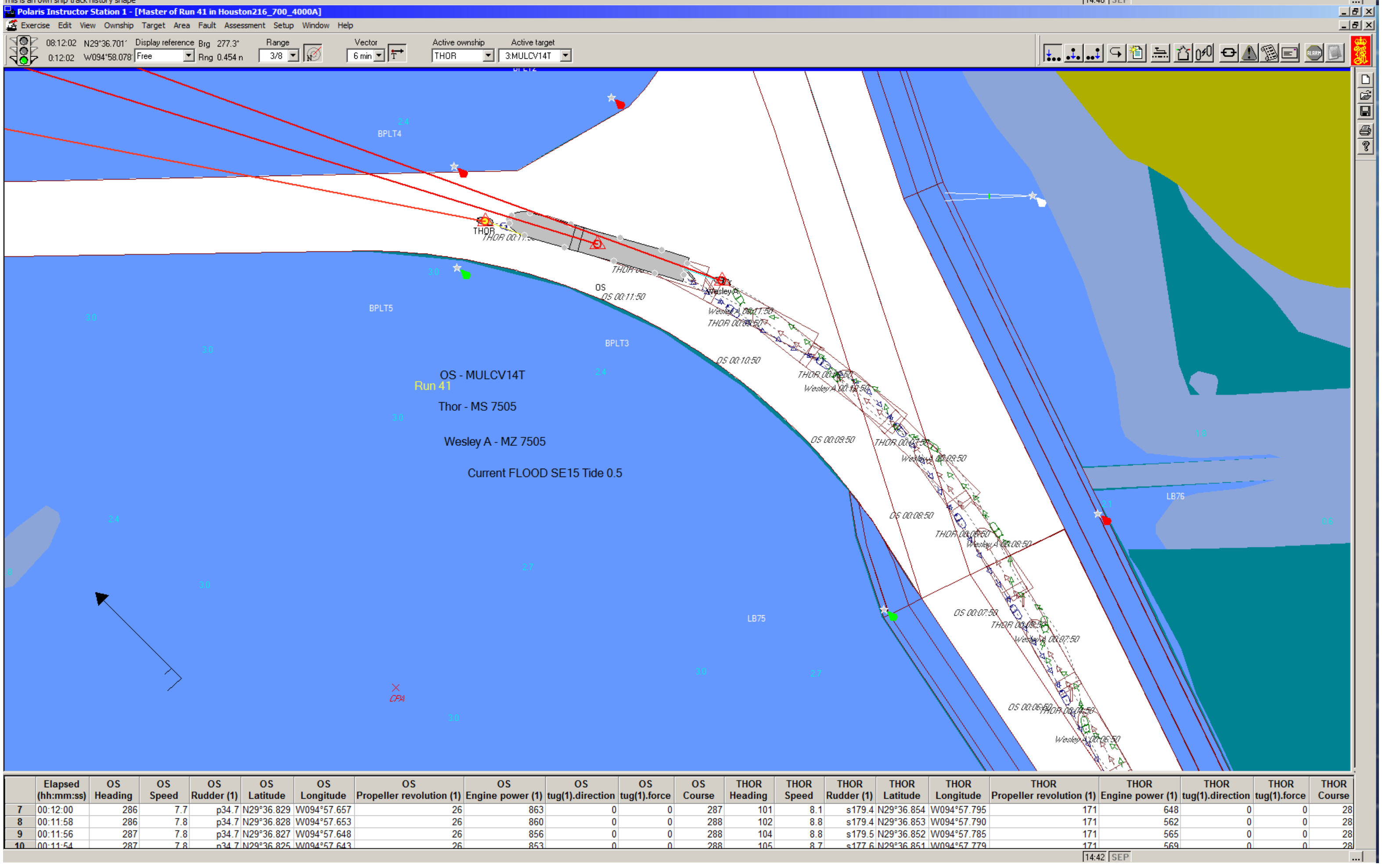
Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:09:50 N29°36.695' Display reference Free Brg 298.1° Rng 0.110 n Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:09:48	308	6.9	p2.6	N29°36.695	W094°57.373	66	23945	0	0	309	131	6.4	s174.5	N29°36.756	W094°57.489	136	336	0	0	31
8	00:09:46	308	6.9	p0.5	N29°36.693	W094°57.370	66	23970	0	0	309	127	6.4	s159.2	N29°36.754	W094°57.486	136	333	0	0	31
9	00:09:44	308	6.8	p0.5	N29°36.690	W094°57.366	66	23906	0	0	309	124	6.6	s168.9	N29°36.751	W094°57.483	136	329	0	0	30
10	00:09:42	308	6.8	p0.5	N29°36.688	W094°57.363	65	23021	0	0	309	125	6.6	s176.8	N29°36.749	W094°57.479	136	328	0	0	30

This is an own ship track history shape

14:40 SEP

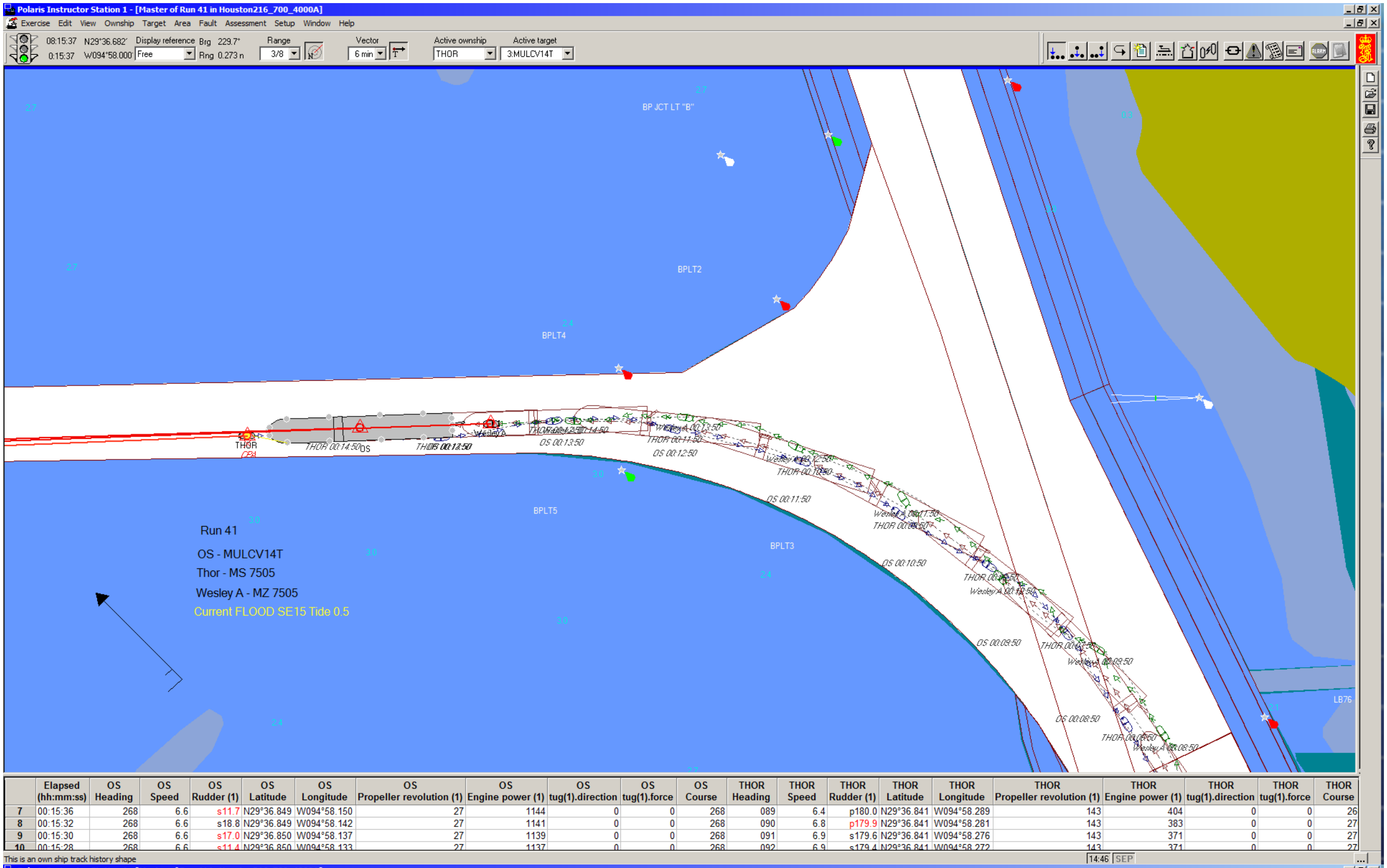


Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:12:02 N29°36.701' 0:12:02 W094°58.078' Display reference Free Brg 277.3° Rng 0.454 n Range 3/8 Vector 6 min Active ownship THOR Active target 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:12:00	286	7.7	p34.7	N29°36.829	W094°57.657	26	863	0	0	287	101	8.1	s179.4	N29°36.854	W094°57.795	171	648	0	0	28
8	00:11:58	286	7.8	p34.7	N29°36.828	W094°57.653	26	860	0	0	288	102	8.8	s179.4	N29°36.853	W094°57.790	171	562	0	0	28
9	00:11:56	287	7.8	p34.7	N29°36.827	W094°57.648	26	856	0	0	288	104	8.8	s179.5	N29°36.852	W094°57.785	171	565	0	0	28
10	00:11:54	287	7.8	p34.7	N29°36.825	W094°57.643	26	853	0	0	288	105	8.7	s177.6	N29°36.851	W094°57.779	171	569	0	0	28

14:42 SEP



08:15:37 N29°36.682' Display reference Brg 229.7° Range Vector Active ownship Active target

0:15:37 W094°58.000 Free Rng 0.273 n 3/8 6 min THOR 3:MULCV14T

Run 41

OS - MULCV14T

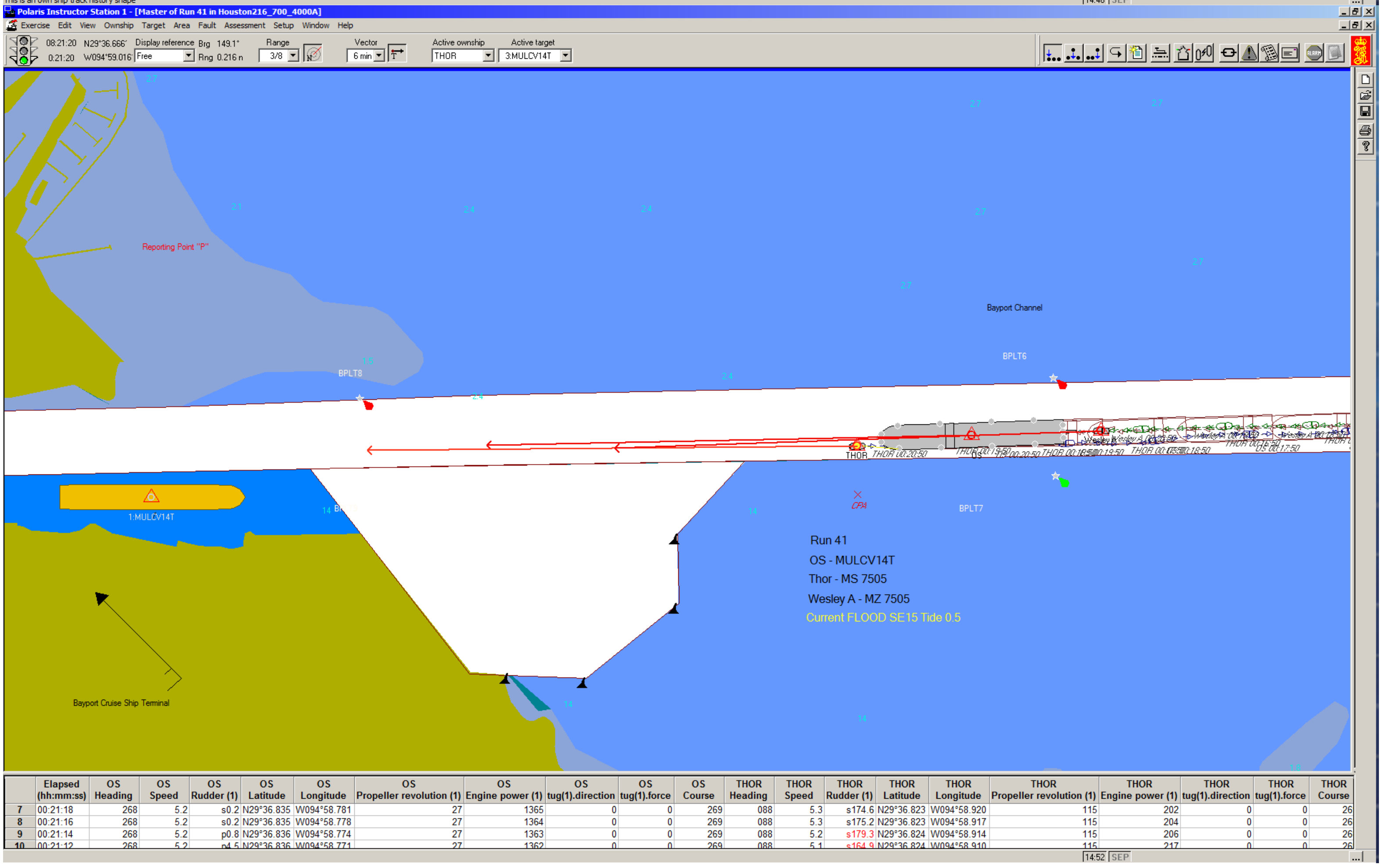
Thor - MS 7505

Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:15:36	268	6.6	s11.7	N29°36.849	W094°58.150	27	1144	0	0	268	089	6.4	p180.0	N29°36.841	W094°58.289	143	404	0	0	26
8	00:15:32	268	6.6	s18.8	N29°36.849	W094°58.142	27	1141	0	0	268	090	6.8	p179.9	N29°36.841	W094°58.281	143	383	0	0	27
9	00:15:30	268	6.6	s17.0	N29°36.850	W094°58.137	27	1139	0	0	268	091	6.9	s179.6	N29°36.841	W094°58.276	143	371	0	0	27
10	00:15:28	268	6.6	s11.4	N29°36.850	W094°58.133	27	1137	0	0	268	092	6.9	s179.4	N29°36.841	W094°58.272	143	371	0	0	27

This is an own ship track history shape



08:21:20 N29°36.666' Display reference Brg 149.1° Range Vector Active ownship Active target

0:21:20 W094°59.016 Free Rng 0.216 n 3/8 6 min THOR 3:MULCV14T

Run 41

OS - MULCV14T

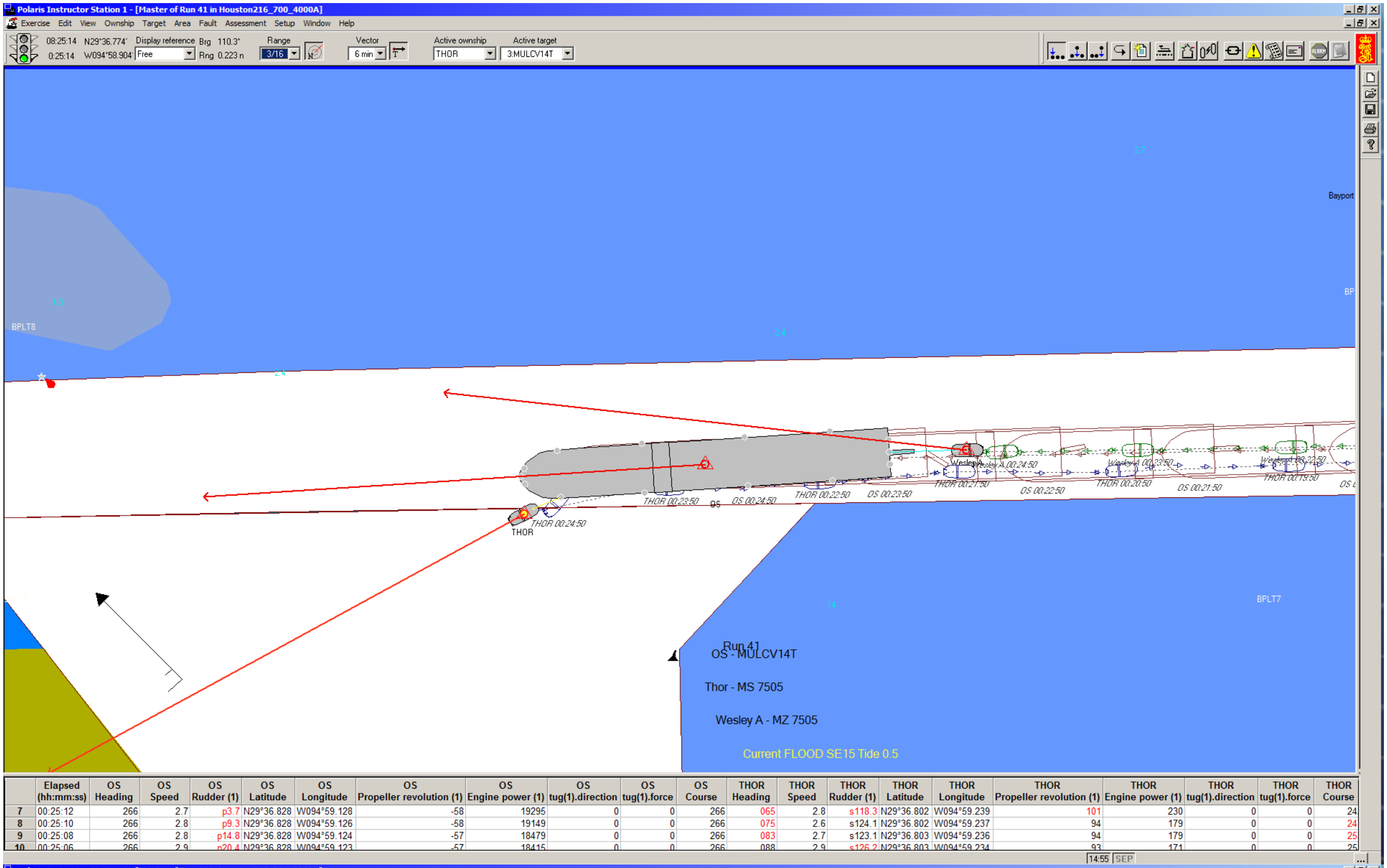
Thor - MS 7505

Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:21:18	268	5.2	s0.2	N29°36.835	W094°58.781	27	1365	0	0	269	088	5.3	s174.6	N29°36.823	W094°58.920	115	202	0	0	26
8	00:21:16	268	5.2	s0.2	N29°36.835	W094°58.778	27	1364	0	0	269	088	5.3	s175.2	N29°36.823	W094°58.917	115	204	0	0	26
9	00:21:14	268	5.2	p0.8	N29°36.836	W094°58.774	27	1363	0	0	269	088	5.2	s179.3	N29°36.824	W094°58.914	115	206	0	0	26
10	00:21:12	268	5.2	p4.5	N29°36.836	W094°58.771	27	1362	0	0	269	088	5.1	s164.9	N29°36.824	W094°58.910	115	217	0	0	26

June 26, 2019



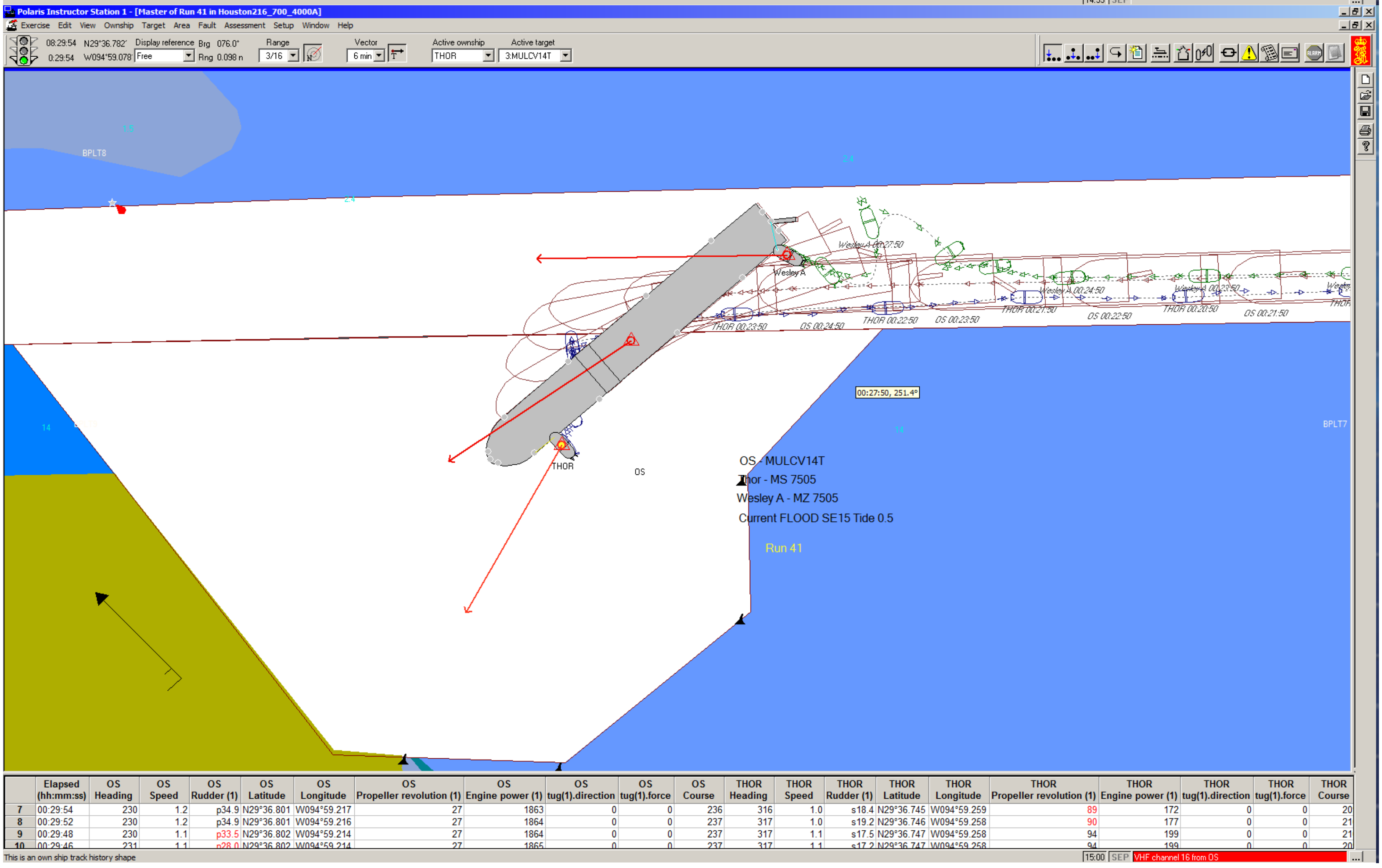
Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:25:14 N29°36.774' Display reference Free Brg 110.3° Rng 0.223 n Range 3/16 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:25:14 W094°58.904'

Run 41
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:25:12	266	2.7	p3.7	N29°36.828	W094°59.128	-58	19295	0	0	266	065	2.8	s118.3	N29°36.802	W094°59.239	101	230	0	0	24
8	00:25:10	266	2.8	p9.3	N29°36.828	W094°59.126	-58	19149	0	0	266	075	2.6	s124.1	N29°36.802	W094°59.237	94	179	0	0	24
9	00:25:08	266	2.8	p14.8	N29°36.828	W094°59.124	-57	18479	0	0	266	083	2.7	s123.1	N29°36.803	W094°59.236	94	179	0	0	25
10	00:25:06	266	2.9	p20.4	N29°36.828	W094°59.123	-57	18415	0	0	266	088	2.9	s126.2	N29°36.803	W094°59.234	93	171	0	0	25

14:55 SEP



Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

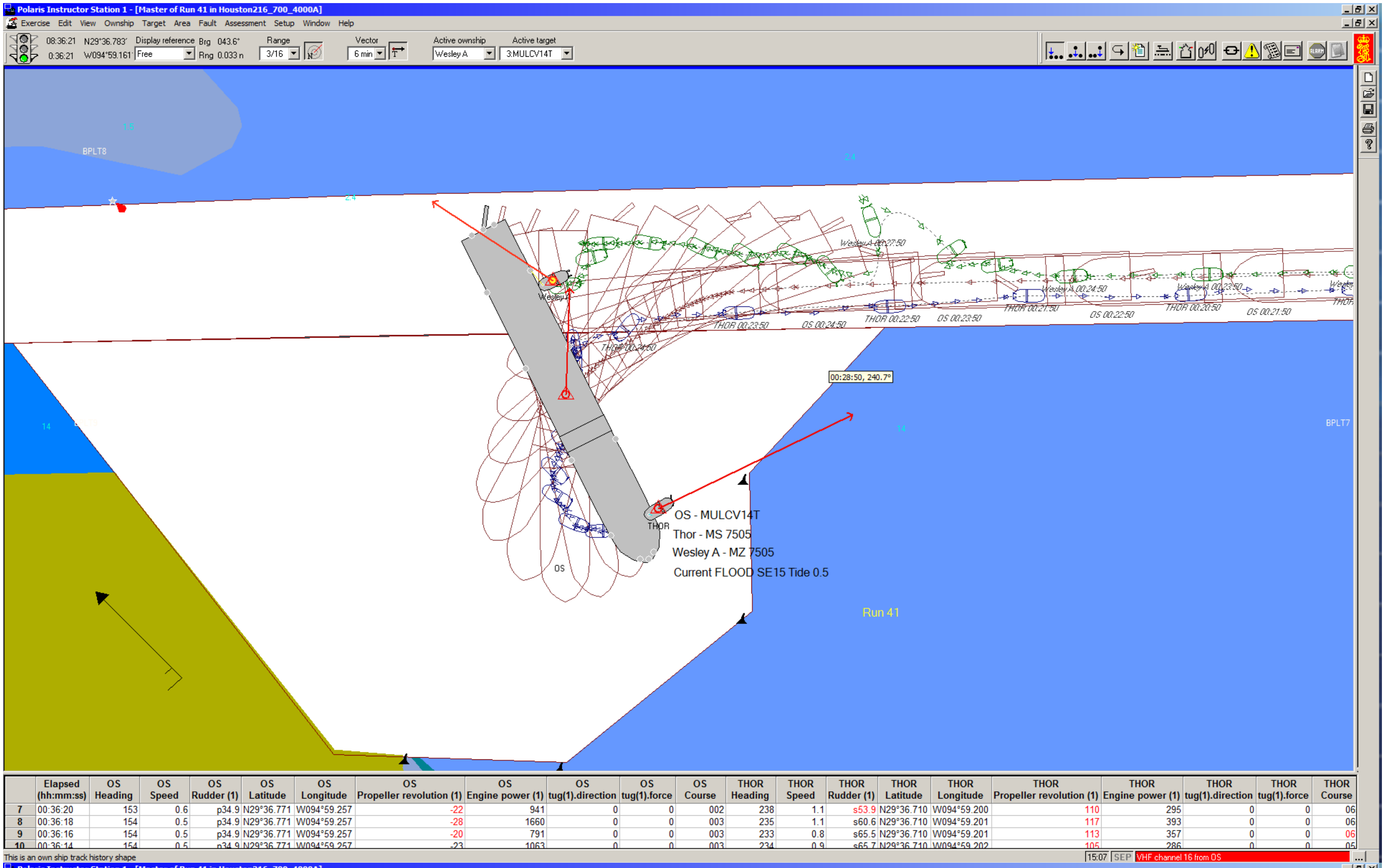
08:29:54 N29°36.782' Display reference Free Brg 076.0° Rng 0.098 n Range 3/16 Vector 6 min Active ownship THOR Active target 3:MULCV14T
0:29:54 W094°59.078'

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5
Run 41

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:29:54	230	1.2	p34.9	N29°36.801	W094°59.217	27	1863	0	0	236	316	1.0	s18.4	N29°36.745	W094°59.259	89	172	0	0	20
8	00:29:52	230	1.2	p34.9	N29°36.801	W094°59.216	27	1864	0	0	237	317	1.0	s19.2	N29°36.746	W094°59.258	90	177	0	0	21
9	00:29:48	230	1.1	p33.5	N29°36.802	W094°59.214	27	1864	0	0	237	317	1.1	s17.5	N29°36.747	W094°59.258	94	199	0	0	21
10	00:29:46	231	1.1	p28.0	N29°36.802	W094°59.214	27	1865	0	0	237	317	1.1	s17.2	N29°36.747	W094°59.258	94	199	0	0	20

This is an own ship track history shape

15:00 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

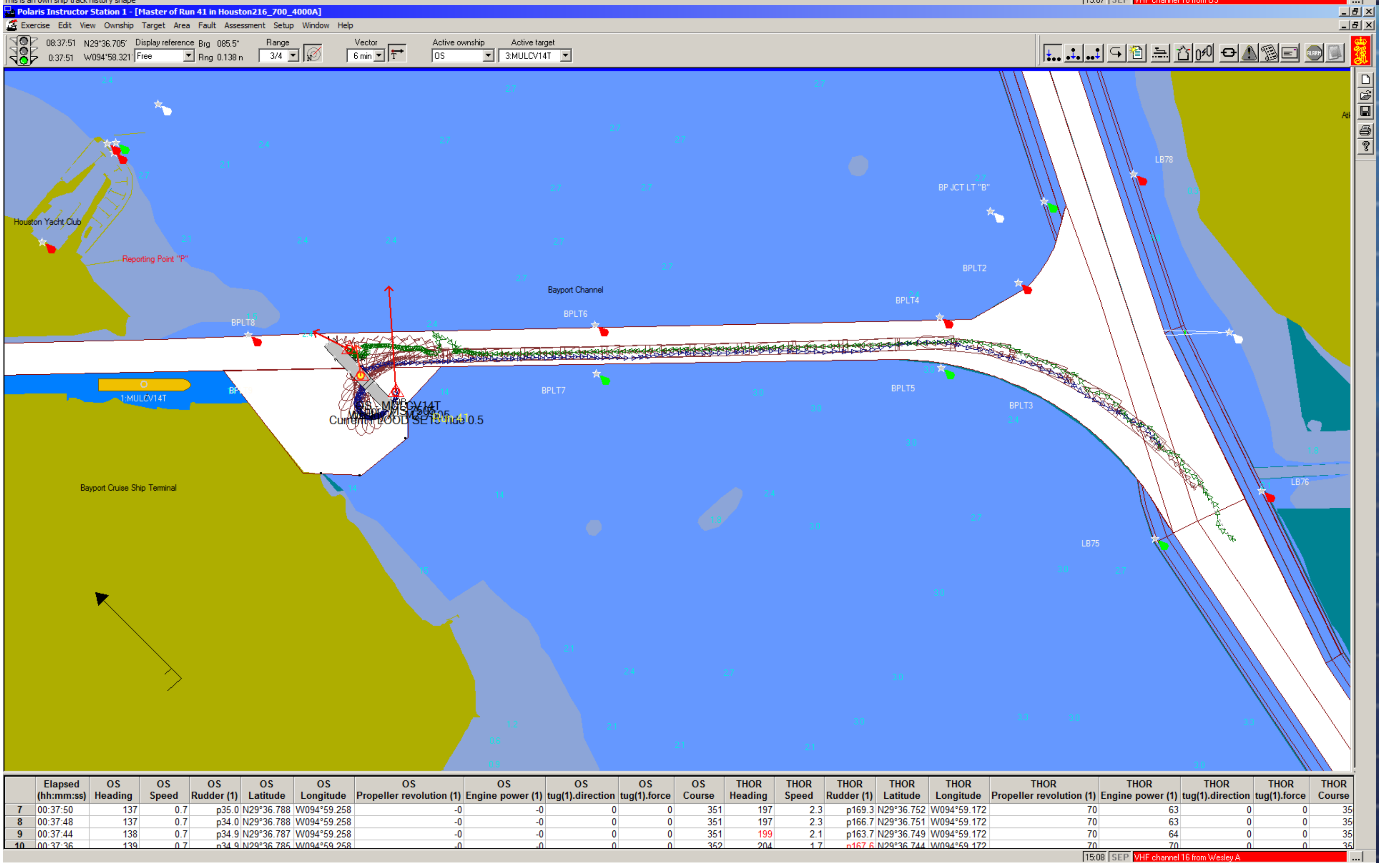
08:36:21 N29°36.783′
0:36:21 W094°59.161′
Display reference: Free
Brg 043.6°
Rng 0.033 n
Range: 3/16
Vector: 6 min
Active ownship: Wesley A
Active target: 3:MULCV14T

OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:36:20	153	0.6	p34.9	N29°36.771	W094°59.257	-22	941	0	0	002	238	1.1	s53.9	N29°36.710	W094°59.200	110	295	0	0	06
8	00:36:18	154	0.5	p34.9	N29°36.771	W094°59.257	-28	1660	0	0	003	235	1.1	s60.6	N29°36.710	W094°59.201	117	393	0	0	06
9	00:36:16	154	0.5	p34.9	N29°36.771	W094°59.257	-20	791	0	0	003	233	0.8	s65.5	N29°36.710	W094°59.201	113	357	0	0	06
10	00:36:14	154	0.5	p34.9	N29°36.771	W094°59.257	-23	1063	0	0	003	234	0.9	s65.7	N29°36.710	W094°59.202	105	286	0	0	05

This is an own ship track history shape

15:07 SEP VHF channel 16 from OS



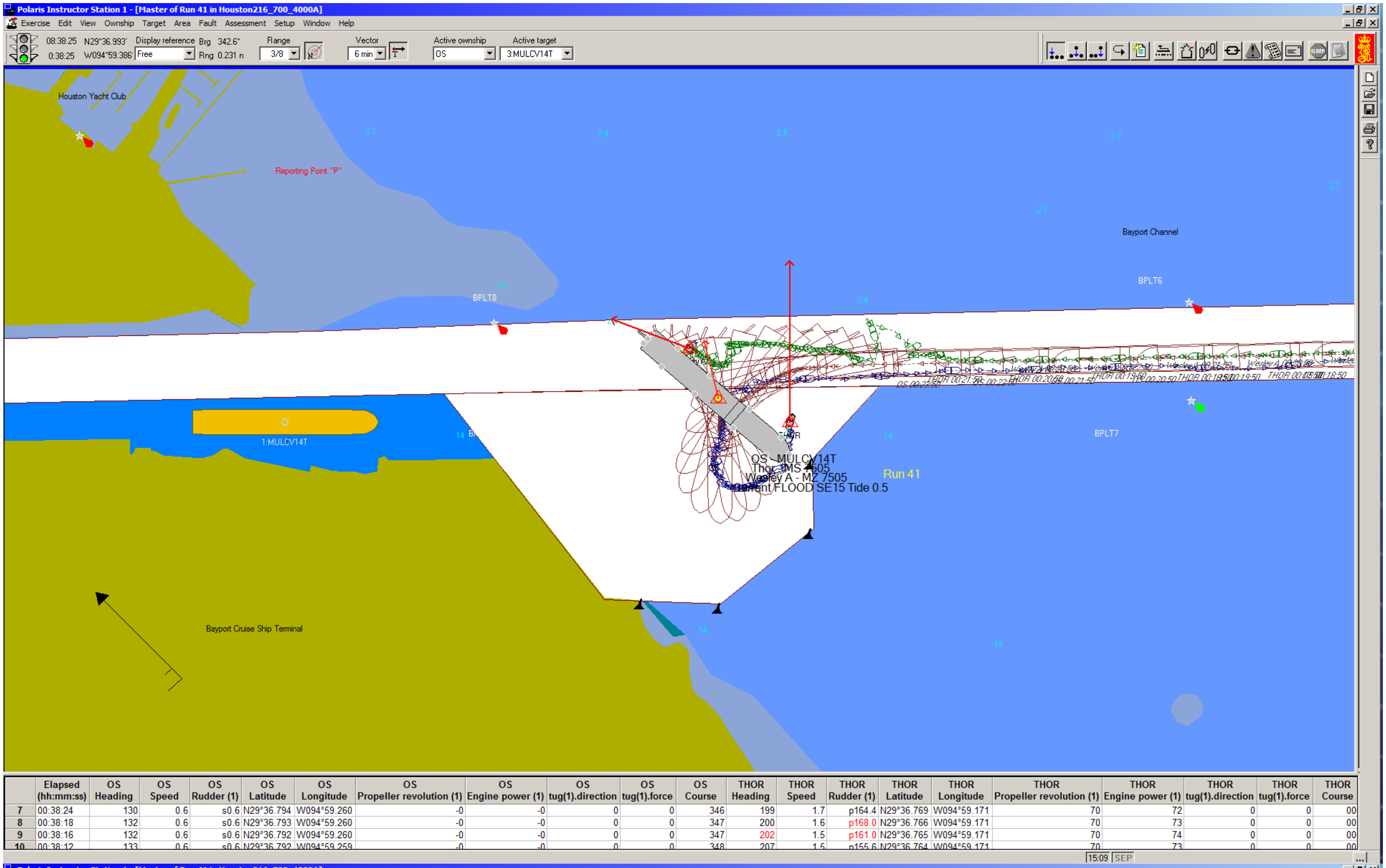
Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:37:51 N29°36.705′
0:37:51 W094°58.321′
Display reference: Free
Brg 085.5°
Rng 0.138 n
Range: 3/4
Vector: 6 min
Active ownship: OS
Active target: 3:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:37:50	137	0.7	p35.0	N29°36.788	W094°59.258	-0	-0	0	0	351	197	2.3	p169.3	N29°36.752	W094°59.172	70	63	0	0	35
8	00:37:48	137	0.7	p34.0	N29°36.788	W094°59.258	-0	-0	0	0	351	197	2.3	p166.7	N29°36.751	W094°59.172	70	63	0	0	35
9	00:37:44	138	0.7	p34.9	N29°36.787	W094°59.258	-0	-0	0	0	351	199	2.1	p163.7	N29°36.749	W094°59.172	70	64	0	0	35
10	00:37:36	139	0.7	p34.9	N29°36.785	W094°59.258	-0	-0	0	0	352	204	1.7	p167.6	N29°36.744	W094°59.172	70	70	0	0	35

15:08 SEP VHF channel 16 from Wesley A

June 26, 2019

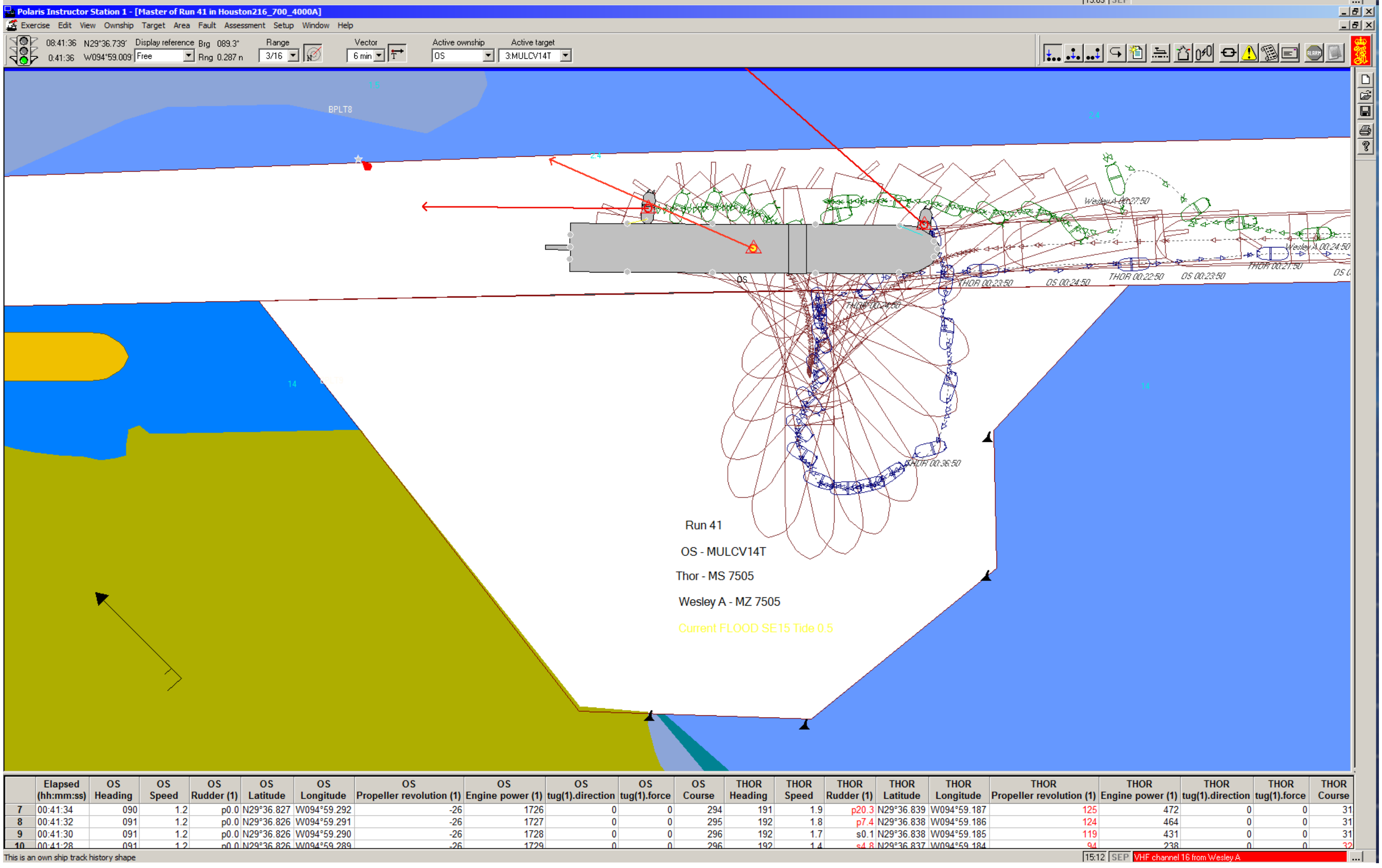


Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:38:25 N29°36.993' Display reference: Free Brg 342.6° Range 3/8 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:38:25 W094°59.386' Rng 0.231 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:38:24	130	0.6	s0.6	N29°36.794	W094°59.260	-0	-0	0	0	346	199	1.7	p164.4	N29°36.769	W094°59.171	70	72	0	0	00
8	00:38:18	132	0.6	s0.6	N29°36.793	W094°59.260	-0	-0	0	0	347	200	1.6	p168.0	N29°36.766	W094°59.171	70	73	0	0	00
9	00:38:16	132	0.6	s0.6	N29°36.792	W094°59.260	-0	-0	0	0	347	202	1.5	p161.0	N29°36.765	W094°59.171	70	74	0	0	00
10	00:38:12	133	0.6	s0.6	N29°36.792	W094°59.259	-0	-0	0	0	348	207	1.5	p155.6	N29°36.764	W094°59.171	70	73	0	0	00

15:09 SEP



Polaris Instructor Station 1 - [Master of Run 41 in Houston216_700_4000A]

08:41:36 N29°36.739' Display reference: Free Brg 089.3° Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:41:36 W094°59.009' Rng 0.287 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:41:34	090	1.2	p0.0	N29°36.827	W094°59.292	-26	1726	0	0	294	191	1.9	p20.3	N29°36.839	W094°59.187	125	472	0	0	31
8	00:41:32	091	1.2	p0.0	N29°36.826	W094°59.291	-26	1727	0	0	295	192	1.8	p7.4	N29°36.838	W094°59.186	124	464	0	0	31
9	00:41:30	091	1.2	p0.0	N29°36.826	W094°59.290	-26	1728	0	0	296	192	1.7	s0.1	N29°36.838	W094°59.185	119	431	0	0	31
10	00:41:28	091	1.2	p0.0	N29°36.826	W094°59.289	-26	1729	0	0	296	192	1.4	s4.8	N29°36.837	W094°59.184	94	238	0	0	32

This is an own ship track history shape

15:12 SEP VHF channel 16 from Wesley A

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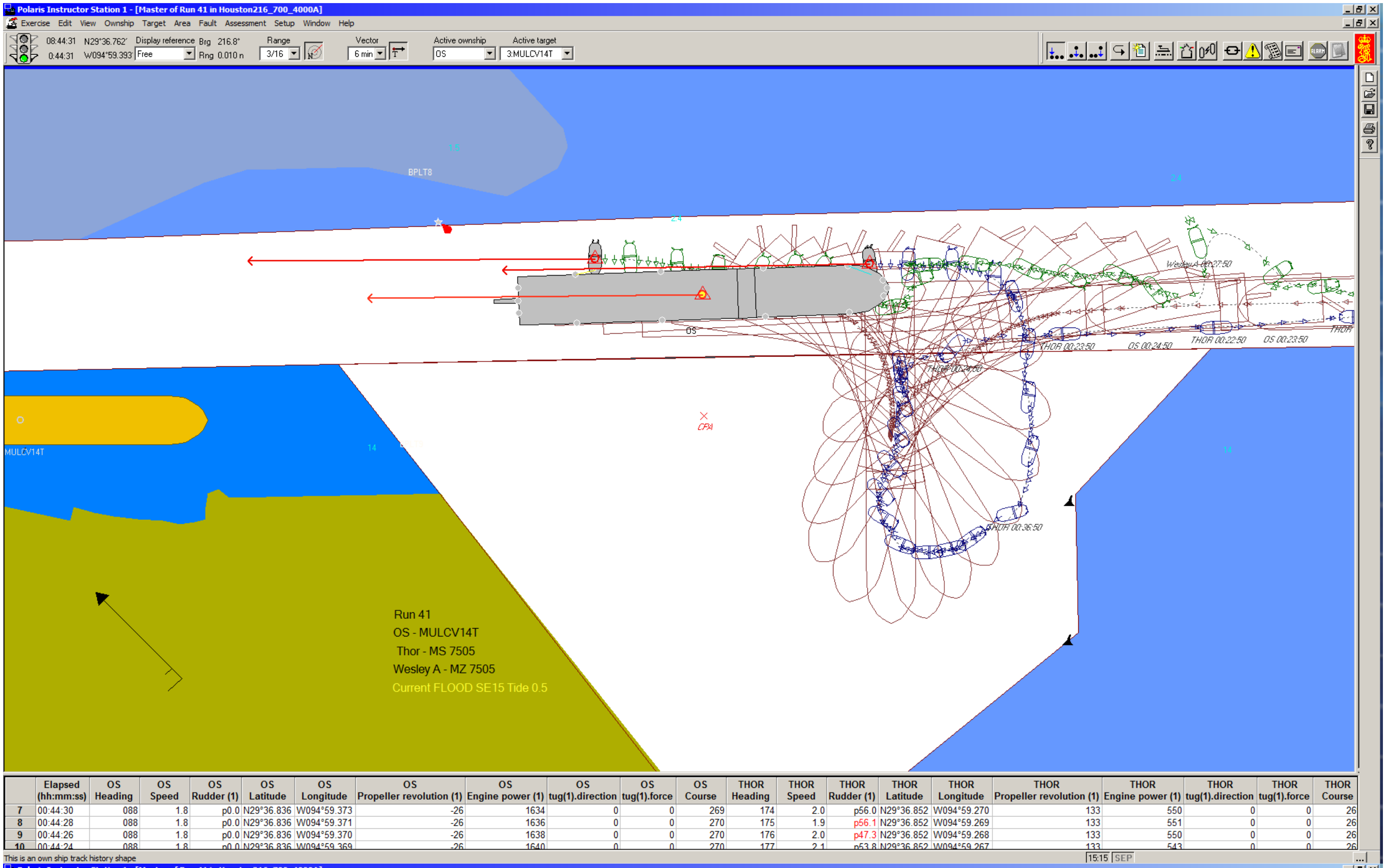


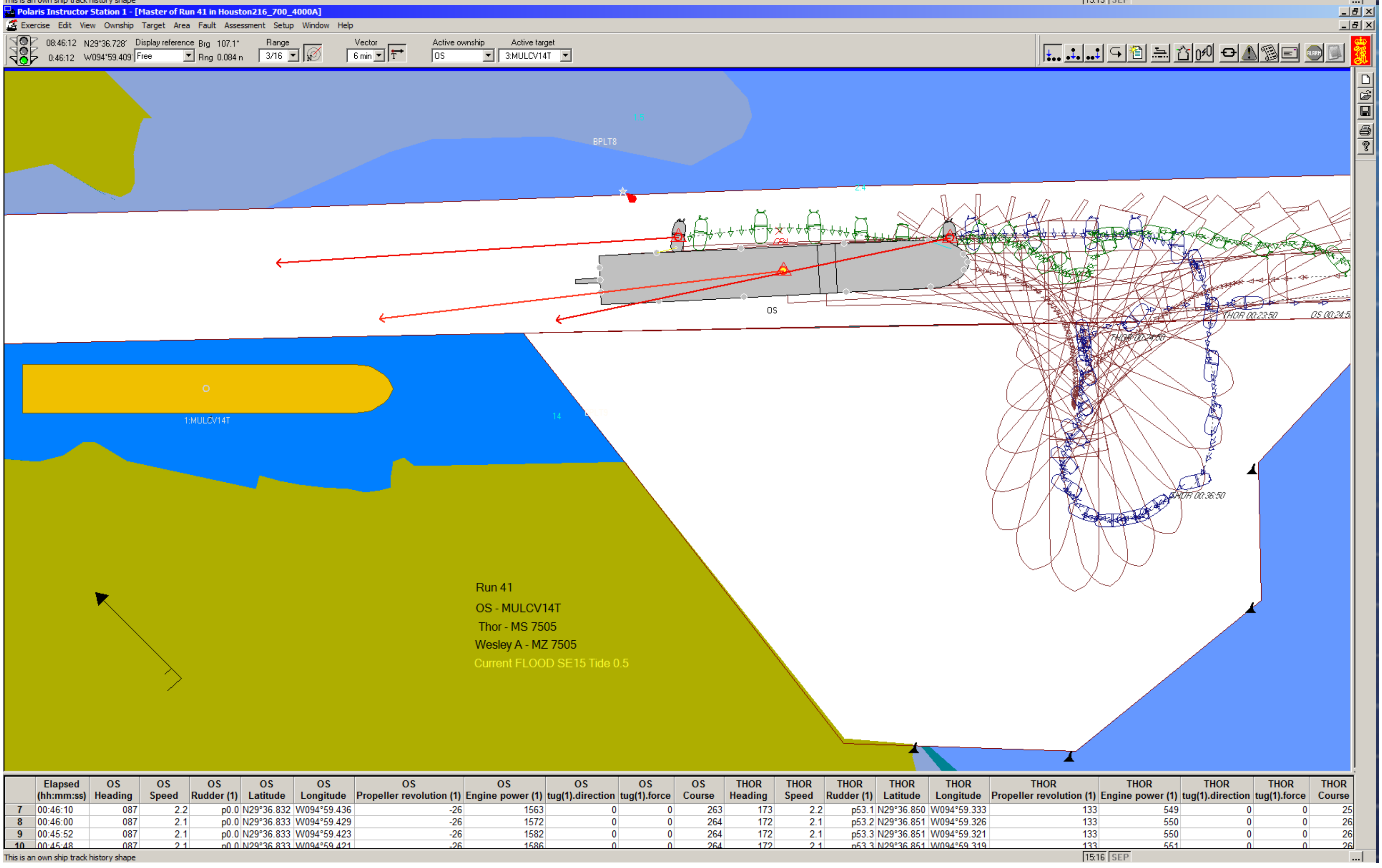
08:44:31 N29°36.762′ Display reference Free Brg 216.8° Rng 0.010 n Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:44:31 W094°59.393′

Run 41
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:44:30	088	1.8	p0.0	N29°36.836	W094°59.373	-26	1634	0	0	269	174	2.0	p56.0	N29°36.852	W094°59.270	133	550	0	0	26
8	00:44:28	088	1.8	p0.0	N29°36.836	W094°59.371	-26	1636	0	0	270	175	1.9	p56.1	N29°36.852	W094°59.269	133	551	0	0	26
9	00:44:26	088	1.8	p0.0	N29°36.836	W094°59.370	-26	1638	0	0	270	176	2.0	p47.3	N29°36.852	W094°59.268	133	550	0	0	26
10	00:44:24	088	1.8	p0.0	N29°36.836	W094°59.369	-26	1640	0	0	270	177	2.1	p53.8	N29°36.852	W094°59.267	133	543	0	0	26

This is an own ship track history shape

15:15 SEP



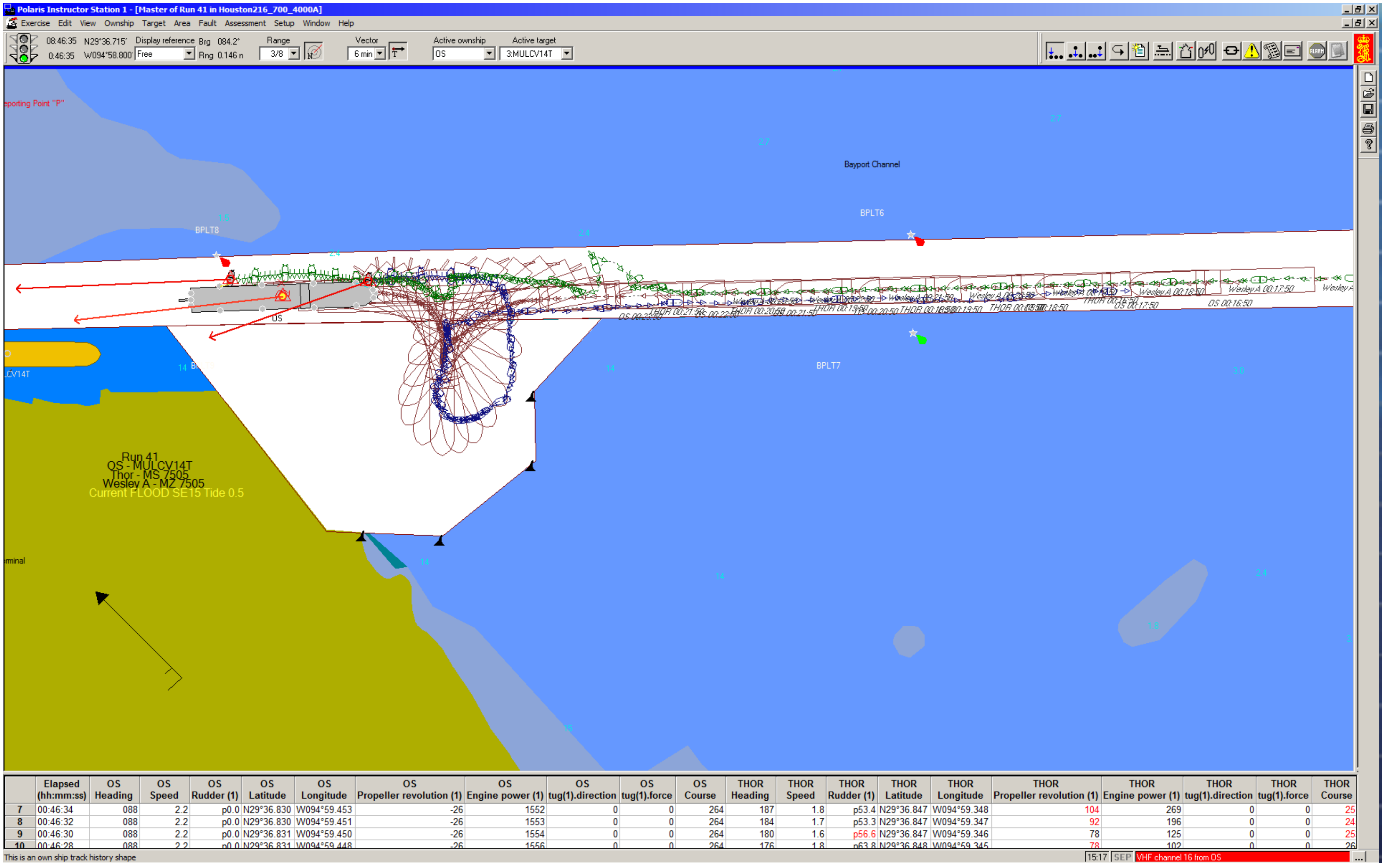
08:46:12 N29°36.728′ Display reference Free Brg 107.1° Rng 0.084 n Range 3/16 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:46:12 W094°59.409′

Run 41
OS - MULCV14T
Thor - MS 7505
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:46:10	087	2.2	p0.0	N29°36.832	W094°59.436	-26	1563	0	0	263	173	2.2	p53.1	N29°36.850	W094°59.333	133	549	0	0	25
8	00:46:00	087	2.1	p0.0	N29°36.833	W094°59.429	-26	1572	0	0	264	172	2.1	p53.2	N29°36.851	W094°59.326	133	550	0	0	26
9	00:45:52	087	2.1	p0.0	N29°36.833	W094°59.423	-26	1582	0	0	264	172	2.1	p53.3	N29°36.851	W094°59.321	133	550	0	0	26
10	00:45:48	087	2.1	p0.0	N29°36.833	W094°59.421	-26	1586	0	0	264	172	2.1	p53.3	N29°36.851	W094°59.319	133	551	0	0	26

This is an own ship track history shape

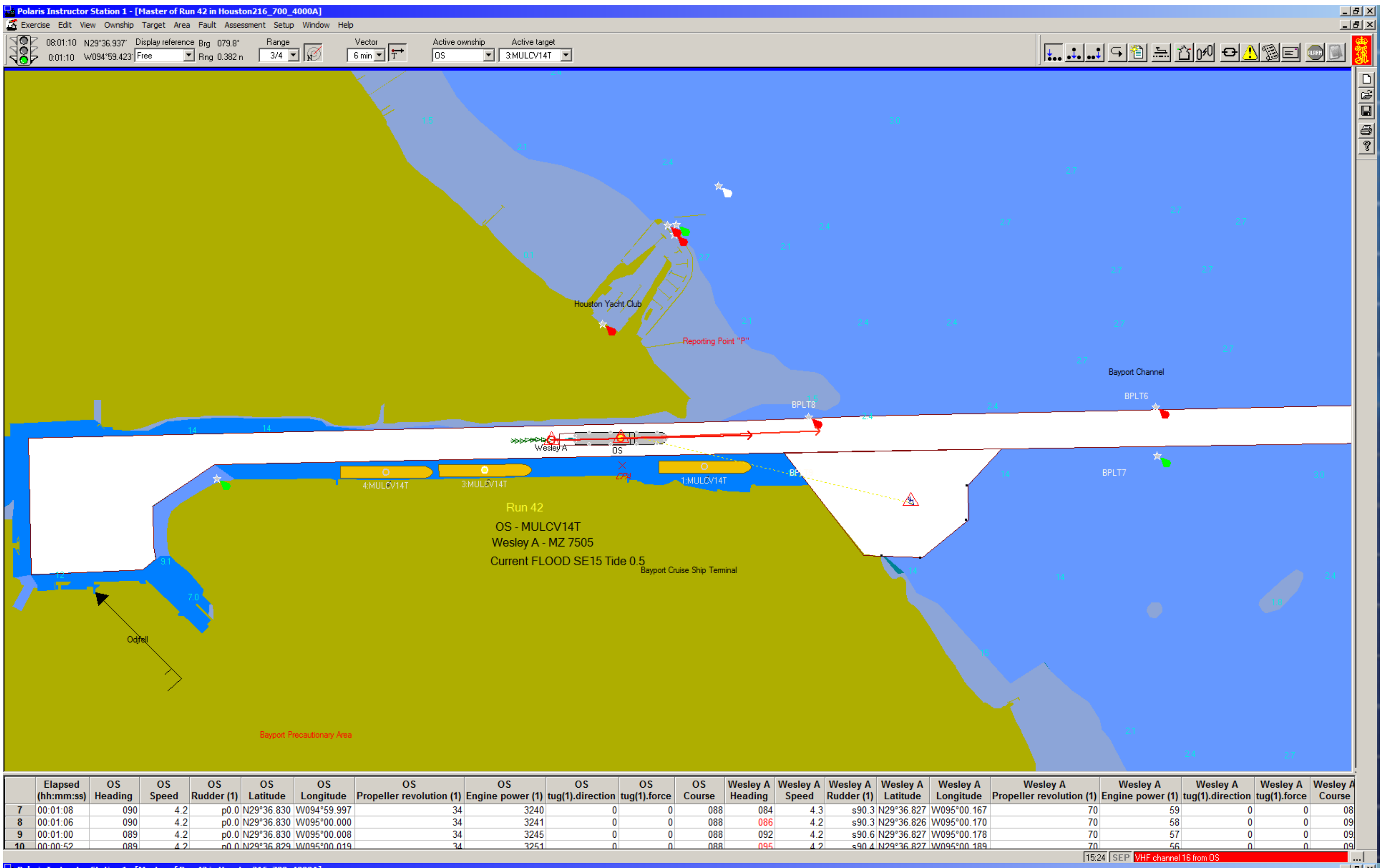
15:16 SEP



	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	THOR Heading	THOR Speed	THOR Rudder (1)	THOR Latitude	THOR Longitude	THOR Propeller revolution (1)	THOR Engine power (1)	THOR tug(1).direction	THOR tug(1).force	THOR Course
7	00:46:34	088	2.2	p0.0	N29°36.830	W094°59.453	-26	1552	0	0	264	187	1.8	p53.4	N29°36.847	W094°59.348	104	269	0	0	25
8	00:46:32	088	2.2	p0.0	N29°36.830	W094°59.451	-26	1553	0	0	264	184	1.7	p53.3	N29°36.847	W094°59.347	92	196	0	0	24
9	00:46:30	088	2.2	p0.0	N29°36.831	W094°59.450	-26	1554	0	0	264	180	1.6	p56.6	N29°36.847	W094°59.346	78	125	0	0	25
10	00:46:28	088	2.2	p0.0	N29°36.831	W094°59.448	-26	1556	0	0	264	176	1.8	p63.8	N29°36.848	W094°59.345	78	102	0	0	26

June 26, 2019

Run 42



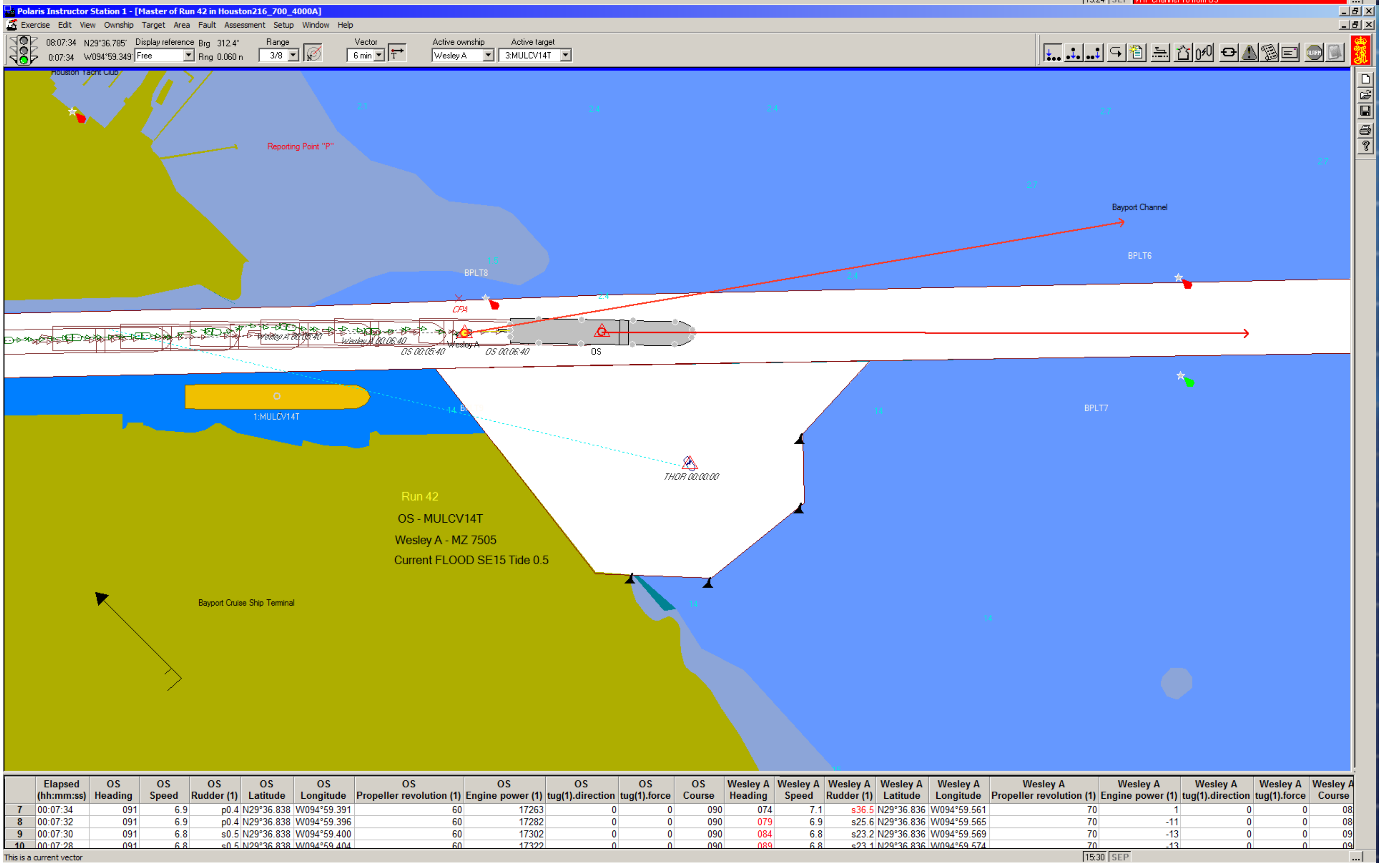
Polaris Instructor Station 1 - [Master of Run 42 in Houston216_700_4000A]

08:01:10 N29°36.937′ Display reference Free Brg 079.8° Range 3/4 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:01:10 W094°59.423′ Rng 0.382 n

Run 42
OS - MULCV14T
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:01:08	090	4.2	p0.0	N29°36.830	W094°59.997	34	3240	0	0	088	084	4.3	s90.3	N29°36.827	W095°00.167	70	59	0	0	08
8	00:01:06	090	4.2	p0.0	N29°36.830	W095°00.000	34	3241	0	0	088	086	4.2	s90.3	N29°36.826	W095°00.170	70	58	0	0	09
9	00:01:00	089	4.2	p0.0	N29°36.830	W095°00.008	34	3245	0	0	088	092	4.2	s90.6	N29°36.827	W095°00.178	70	57	0	0	09
10	00:00:52	089	4.2	p0.0	N29°36.829	W095°00.019	34	3251	0	0	088	095	4.2	s90.4	N29°36.827	W095°00.189	70	56	0	0	09

15:24 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 42 in Houston216_700_4000A]

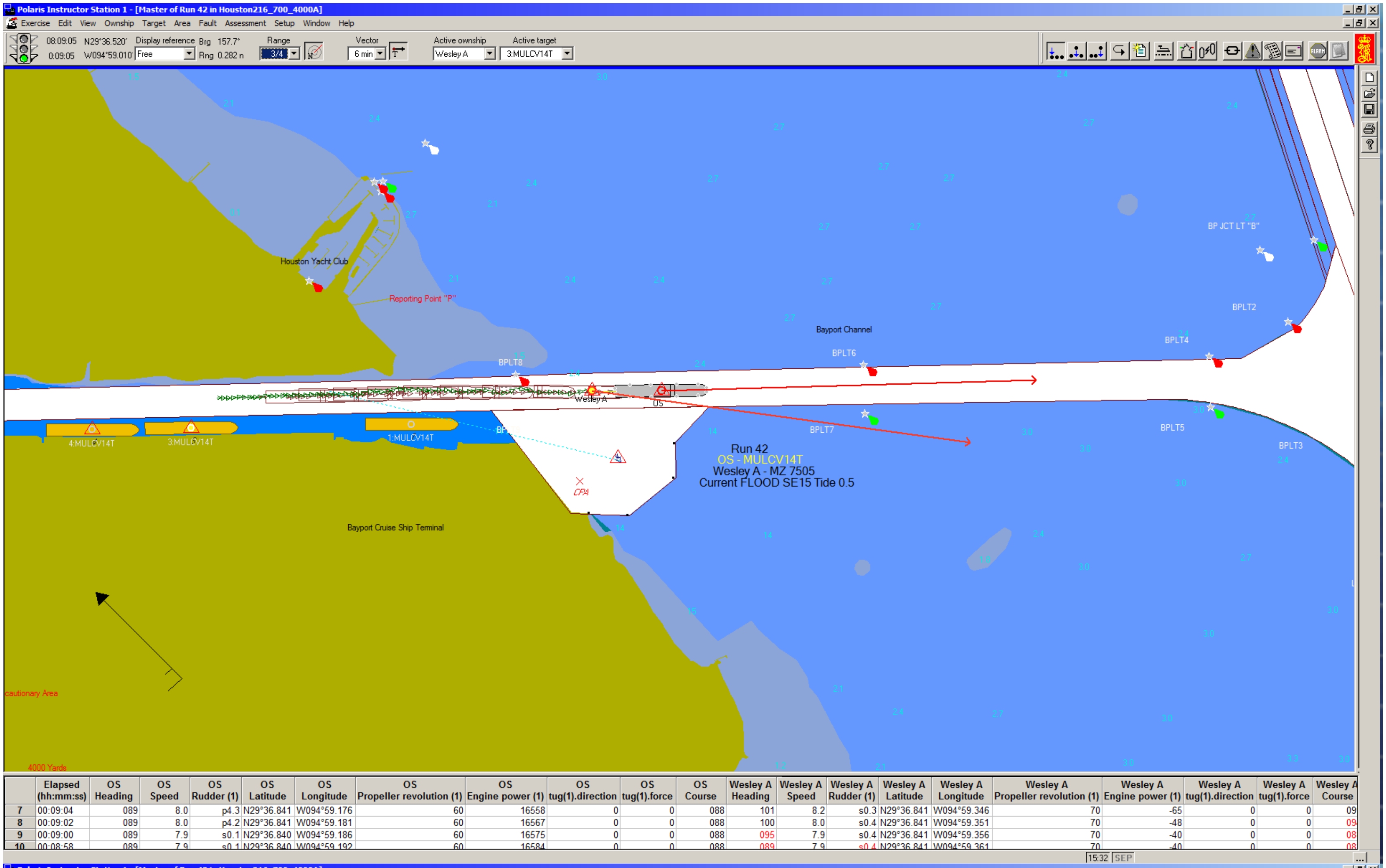
08:07:34 N29°36.785′ Display reference Free Brg 312.4° Range 3/8 Vector 6 min Active ownship Wesley A Active target 3:MULCV14T
0:07:34 W094°59.349′ Rng 0.060 n

Run 42
OS - MULCV14T
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:07:34	091	6.9	p0.4	N29°36.838	W094°59.391	60	17263	0	0	090	074	7.1	s36.5	N29°36.836	W094°59.561	70	1	0	0	08
8	00:07:32	091	6.9	p0.4	N29°36.838	W094°59.396	60	17282	0	0	090	079	6.9	s25.6	N29°36.836	W094°59.565	70	-11	0	0	08
9	00:07:30	091	6.8	s0.5	N29°36.838	W094°59.400	60	17302	0	0	090	084	6.8	s23.2	N29°36.836	W094°59.569	70	-13	0	0	09
10	00:07:28	091	6.8	s0.5	N29°36.838	W094°59.404	60	17322	0	0	090	089	6.8	s23.1	N29°36.836	W094°59.574	70	-13	0	0	09

This is a current vector

15:30 SEP

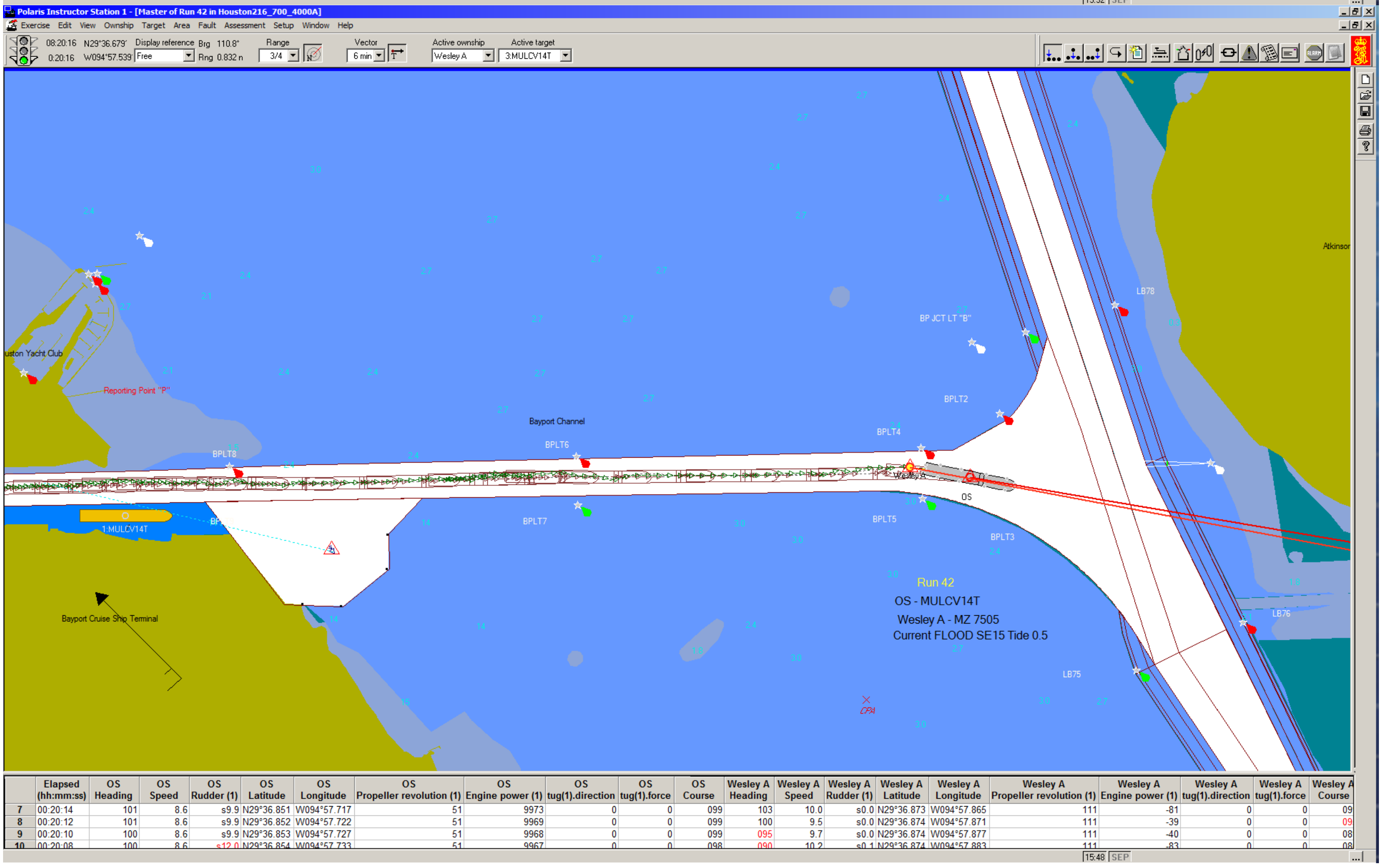


08:09:05 N29°36.520' Display reference Free Brg 157.7°
0:09:05 W094°59.010 Rng 0.282 n
Range 3/4 Vector 6 min Active ownship Wesley A Active target 3:MULCV14T

Run 42
OS - MULCV14T
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:09:04	089	8.0	p4.3	N29°36.841	W094°59.176	60	16558	0	0	088	101	8.2	s0.3	N29°36.841	W094°59.346	70	-65	0	0	09
8	00:09:02	089	8.0	p4.2	N29°36.841	W094°59.181	60	16567	0	0	088	100	8.0	s0.4	N29°36.841	W094°59.351	70	-48	0	0	09
9	00:09:00	089	7.9	s0.1	N29°36.840	W094°59.186	60	16575	0	0	088	095	7.9	s0.4	N29°36.841	W094°59.356	70	-40	0	0	08
10	00:08:58	089	7.9	s0.1	N29°36.840	W094°59.192	60	16584	0	0	088	089	7.9	s0.4	N29°36.841	W094°59.361	70	-40	0	0	08

15:32 SEP

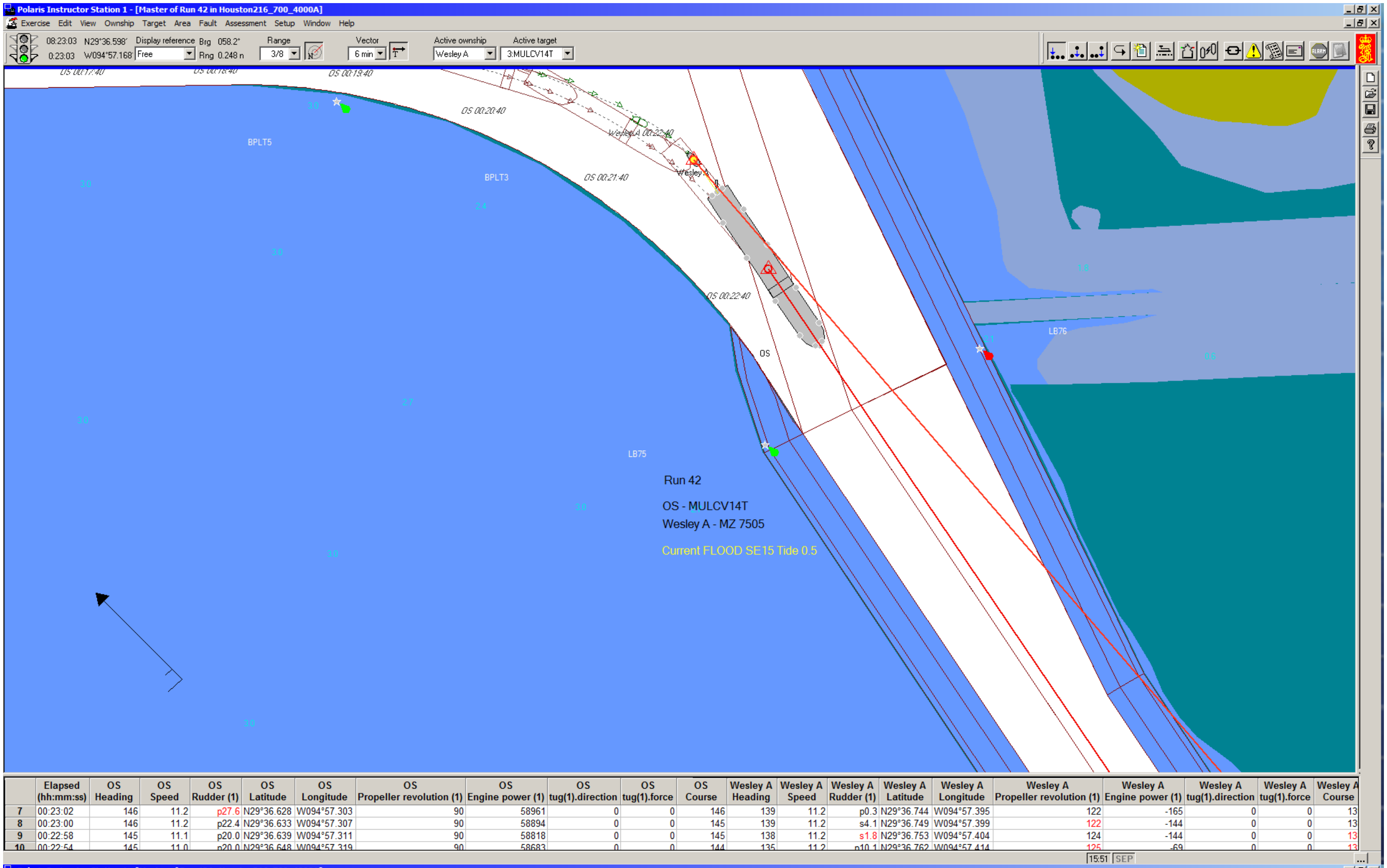


08:20:16 N29°36.679' Display reference Free Brg 110.8°
0:20:16 W094°57.539' Rng 0.832 n
Range 3/4 Vector 6 min Active ownship Wesley A Active target 3:MULCV14T

Run 42
OS - MULCV14T
Wesley A - MZ 7505
Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:20:14	101	8.6	s9.9	N29°36.851	W094°57.717	51	9973	0	0	099	103	10.0	s0.0	N29°36.873	W094°57.865	111	-81	0	0	09
8	00:20:12	101	8.6	s9.9	N29°36.852	W094°57.722	51	9969	0	0	099	100	9.5	s0.0	N29°36.874	W094°57.871	111	-39	0	0	09
9	00:20:10	100	8.6	s9.9	N29°36.853	W094°57.727	51	9968	0	0	099	095	9.7	s0.0	N29°36.874	W094°57.877	111	-40	0	0	08
10	00:20:08	100	8.6	s12.0	N29°36.854	W094°57.733	51	9967	0	0	098	090	10.2	s0.1	N29°36.874	W094°57.883	111	-83	0	0	08

15:48 SEP



08:23:03 N29°36.598' Display reference Free Brg 058.2° Rng 0.248 n Range 3/8 Vector 6 min Active ownship Wesley A Active target 3:MULCV14T

0:23:03 W094°57.168'

Run 42

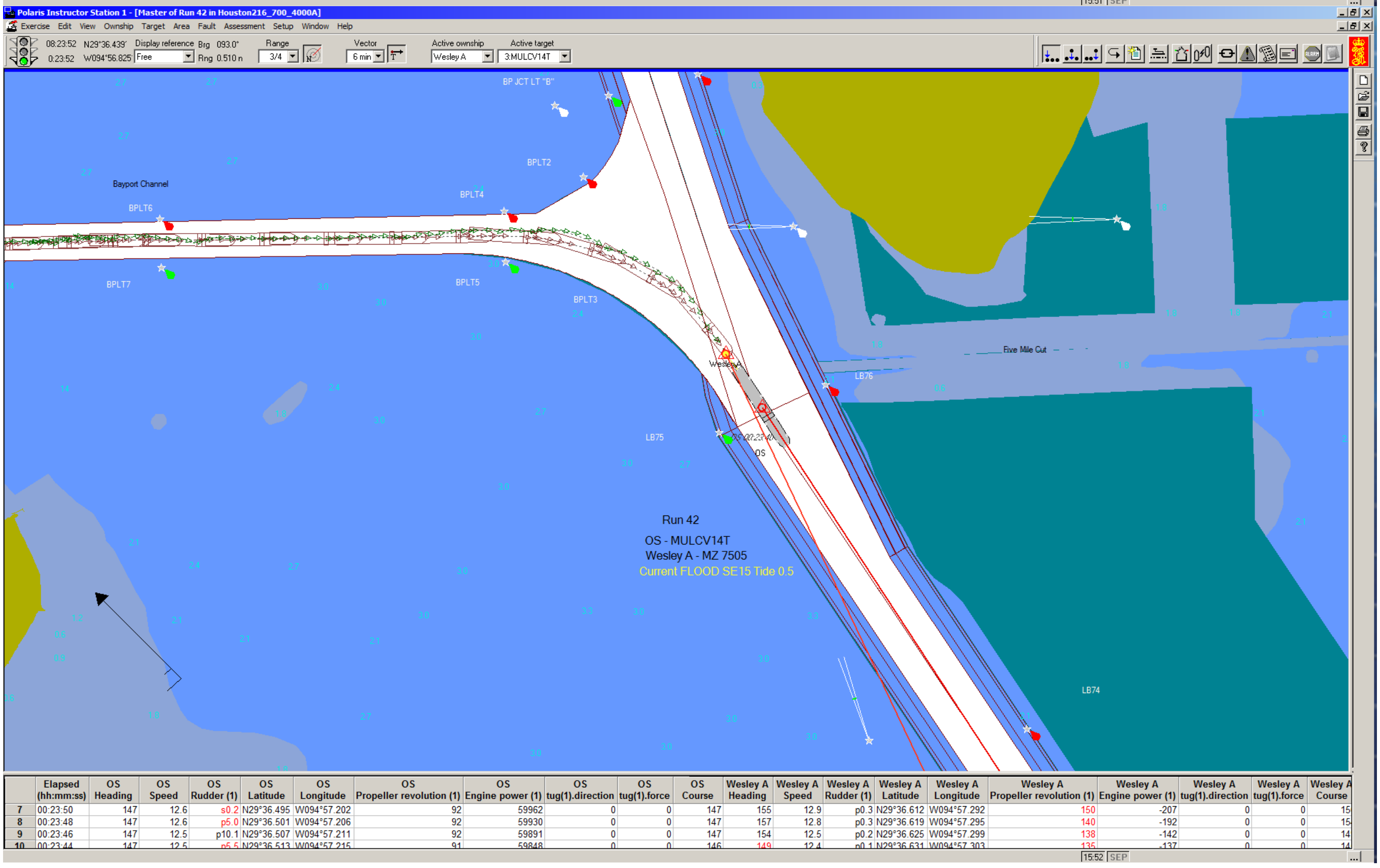
OS - MULCV14T

Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:23:02	146	11.2	p27.6	N29°36.628	W094°57.303	90	58961	0	0	146	139	11.2	p0.3	N29°36.744	W094°57.395	122	-165	0	0	13
8	00:23:00	146	11.2	p22.4	N29°36.633	W094°57.307	90	58894	0	0	145	139	11.2	s4.1	N29°36.749	W094°57.399	122	-144	0	0	13
9	00:22:58	145	11.1	p20.0	N29°36.639	W094°57.311	90	58818	0	0	145	138	11.2	s1.8	N29°36.753	W094°57.404	124	-144	0	0	13
10	00:22:54	145	11.0	p20.0	N29°36.648	W094°57.319	90	58683	0	0	144	135	11.2	p10.1	N29°36.762	W094°57.414	125	-69	0	0	13

15:51 SEP



08:23:52 N29°36.439' Display reference Free Brg 093.0° Rng 0.510 n Range 3/4 Vector 6 min Active ownship Wesley A Active target 3:MULCV14T

0:23:52 W094°56.825'

Run 42

OS - MULCV14T

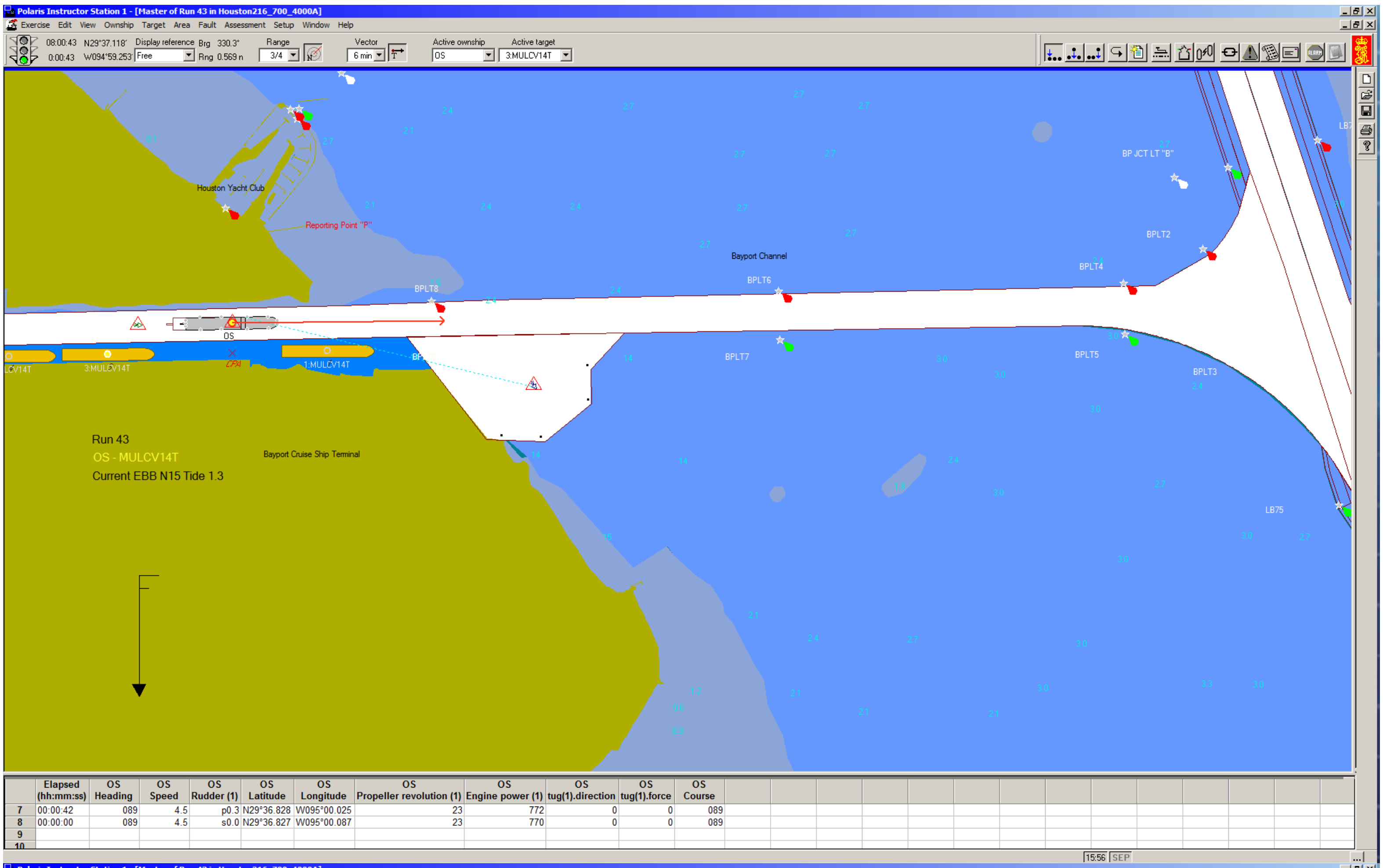
Wesley A - MZ 7505

Current FLOOD SE15 Tide 0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Wesley A Heading	Wesley A Speed	Wesley A Rudder (1)	Wesley A Latitude	Wesley A Longitude	Wesley A Propeller revolution (1)	Wesley A Engine power (1)	Wesley A tug(1).direction	Wesley A tug(1).force	Wesley A Course
7	00:23:50	147	12.6	s0.2	N29°36.495	W094°57.202	92	59962	0	0	147	155	12.9	p0.3	N29°36.612	W094°57.292	150	-207	0	0	15
8	00:23:48	147	12.6	p5.0	N29°36.501	W094°57.206	92	59930	0	0	147	157	12.8	p0.3	N29°36.619	W094°57.295	140	-192	0	0	15
9	00:23:46	147	12.5	p10.1	N29°36.507	W094°57.211	92	59891	0	0	147	154	12.5	p0.2	N29°36.625	W094°57.299	138	-142	0	0	14
10	00:23:44	147	12.5	p5.5	N29°36.513	W094°57.215	91	59848	0	0	146	149	12.4	p0.1	N29°36.631	W094°57.303	135	-137	0	0	14

15:52 SEP

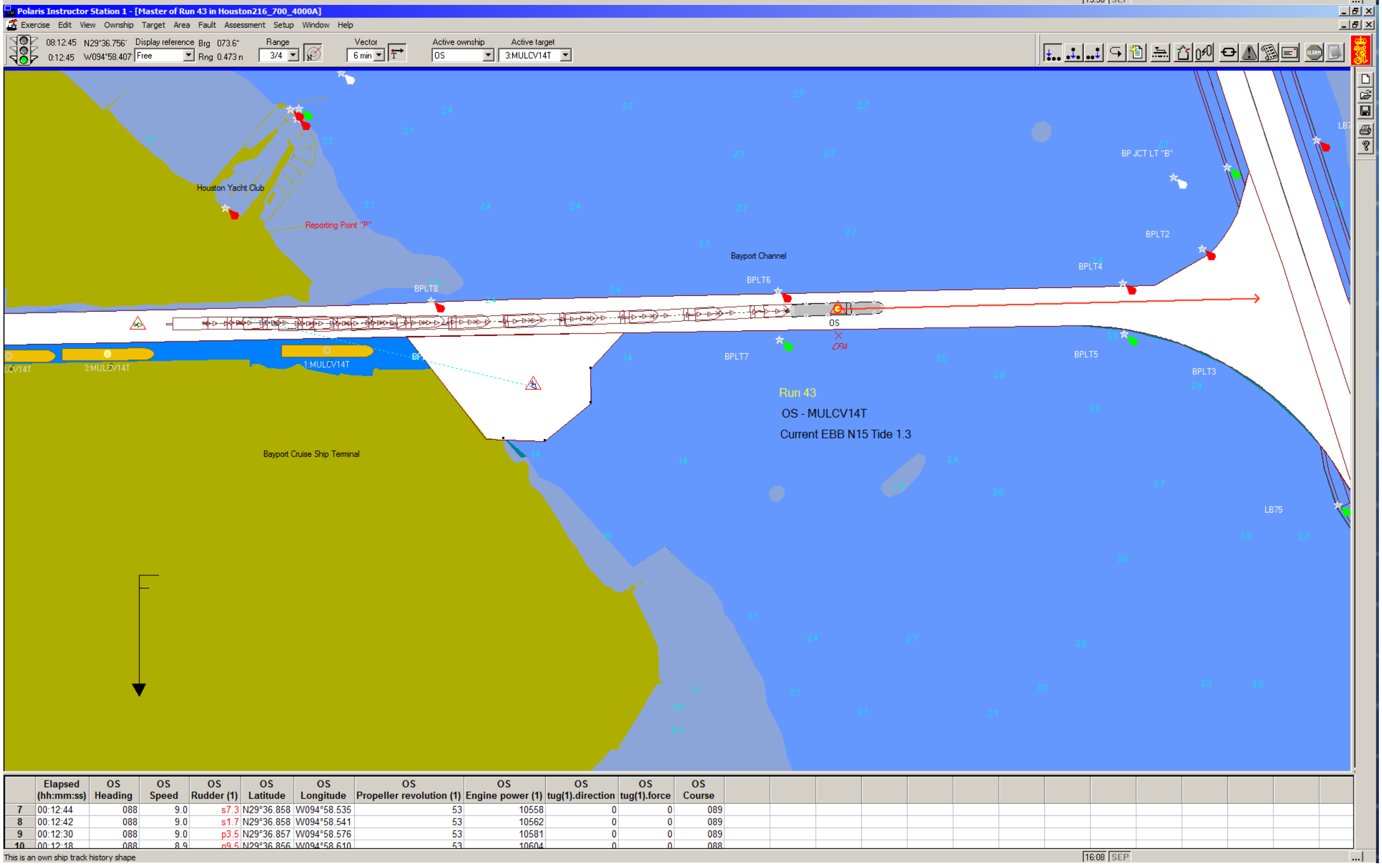
Run 43



Polaris Instructor Station 1 - [Master of Run 43 in Houston216_700_4000A]

08:00:43 N29°37.118' Display reference Brg 330.3° Range 3/4 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:00:43 W094°59.253 Free Rng 0.569 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:00:42	089	4.5	p0.3	N29°36.828	W095°00.025	23	772	0	0	089
8	00:00:00	089	4.5	s0.0	N29°36.827	W095°00.087	23	770	0	0	089
9											
10											

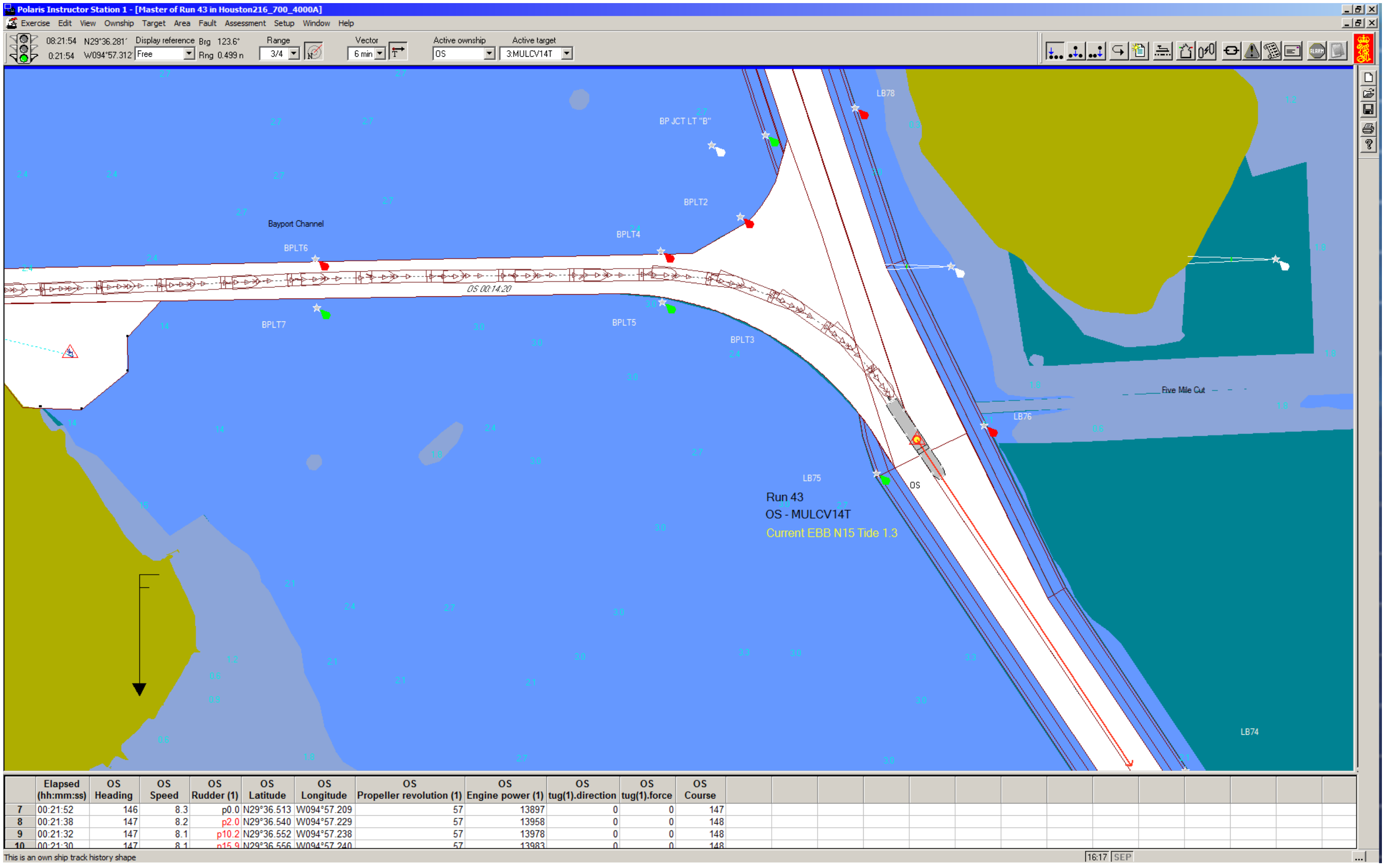


Polaris Instructor Station 1 - [Master of Run 43 in Houston216_700_4000A]

08:12:45 N29°36.756' Display reference Brg 073.6° Range 3/4 Vector 6 min Active ownship OS Active target 3:MULCV14T
0:12:45 W094°58.407' Free Rng 0.473 n

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:12:44	088	9.0	s7.3	N29°36.858	W094°58.535	53	10558	0	0	089
8	00:12:42	088	9.0	s1.7	N29°36.858	W094°58.541	53	10562	0	0	089
9	00:12:30	088	9.0	p3.5	N29°36.857	W094°58.576	53	10581	0	0	089
10	00:12:18	088	8.9	p9.5	N29°36.856	W094°58.610	53	10604	0	0	088

This is an own ship track history shape



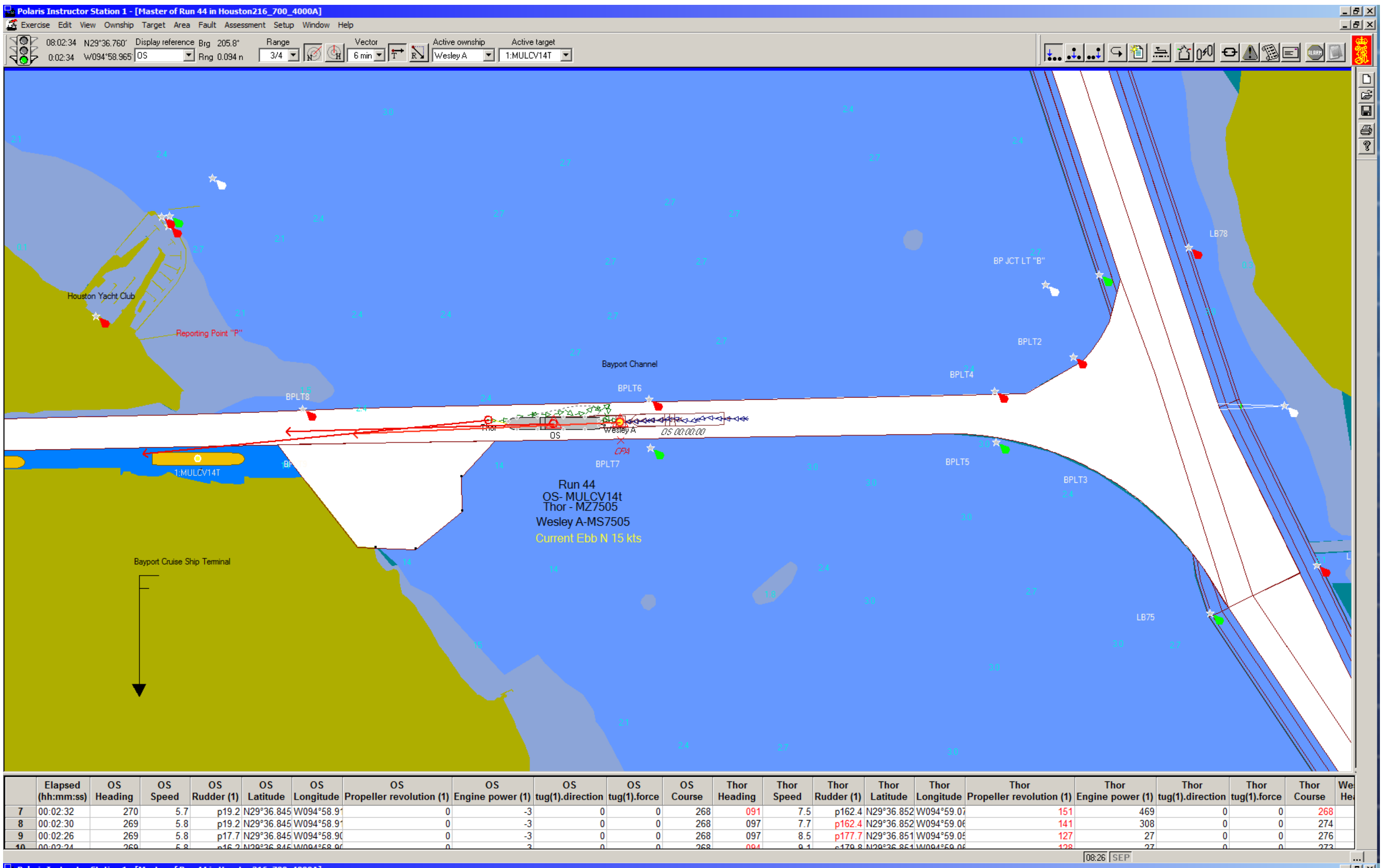
08:21:54 N29°36.281′ Display reference: Free Brg 123.6°
0:21:54 W094°57.312′ Rng 0.499 n
Range: 3/4
Vector: 6 min
Active ownship: OS
Active target: 3:MULCV14T

Run 43
OS - MULCV14T
Current EBB N15 Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:21:52	146	8.3	p0.0	N29°36.513	W094°57.209	57	13897	0	0	147
8	00:21:38	147	8.2	p2.0	N29°36.540	W094°57.229	57	13958	0	0	148
9	00:21:32	147	8.1	p10.2	N29°36.552	W094°57.238	57	13978	0	0	148
10	00:21:30	147	8.1	p15.9	N29°36.556	W094°57.240	57	13983	0	0	148

This is an own ship track history shape

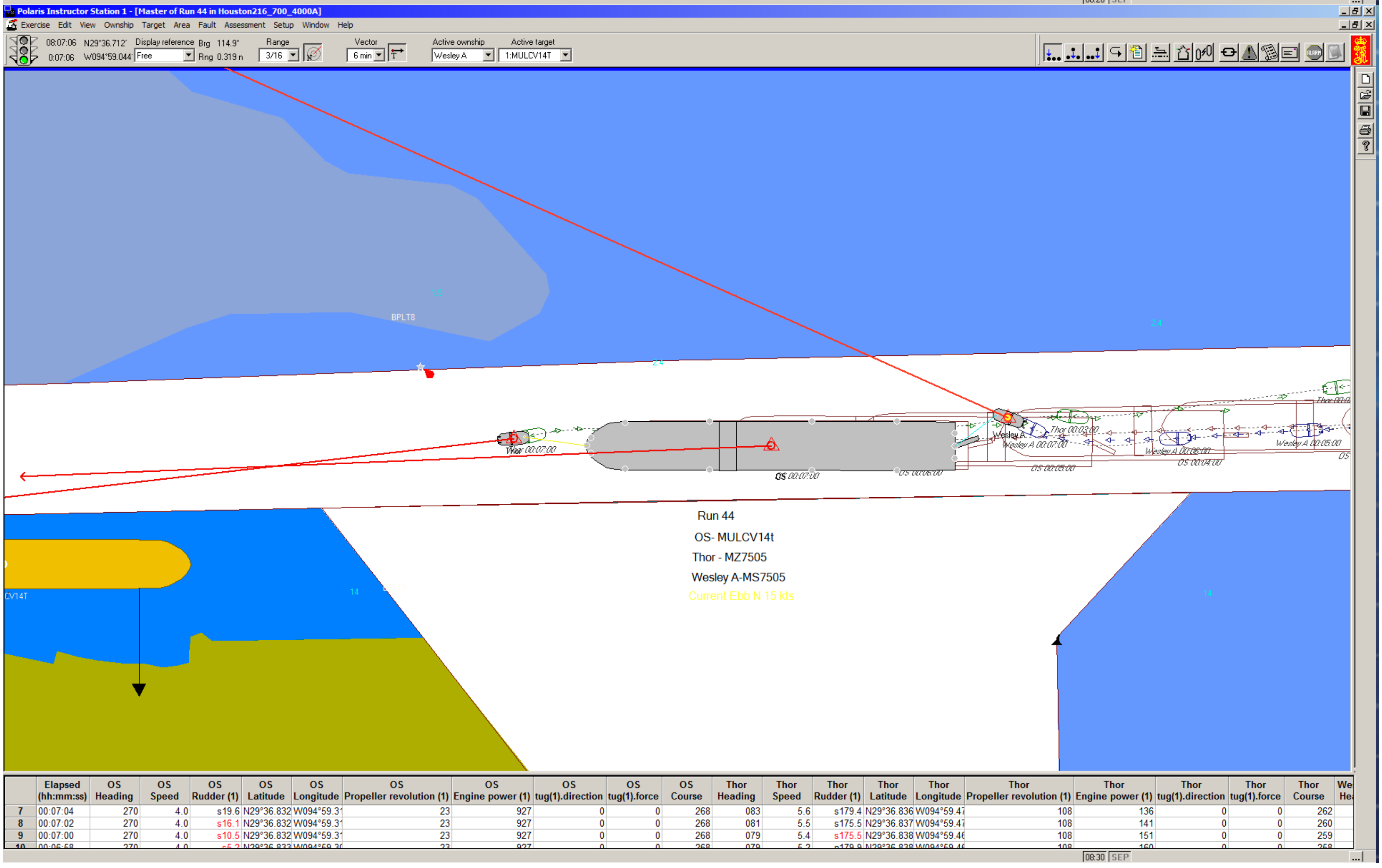
Run 44



Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:02:34 N29°36.760' W094°58.965' Display reference: OS Brg 205.8° Rng 0.094 n Range 3/4 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:02:32	270	5.7	p19.2	N29°36.845	W094°58.91	0	-3	0	0	268	091	7.5	p162.4	N29°36.852	W094°59.07	151	469	0	0	268
8	00:02:30	269	5.8	p19.2	N29°36.845	W094°58.91	0	-3	0	0	268	097	7.7	p162.4	N29°36.852	W094°59.06	141	308	0	0	274
9	00:02:26	269	5.8	p17.7	N29°36.845	W094°58.90	0	-3	0	0	268	097	8.5	p177.7	N29°36.851	W094°59.05	127	27	0	0	276

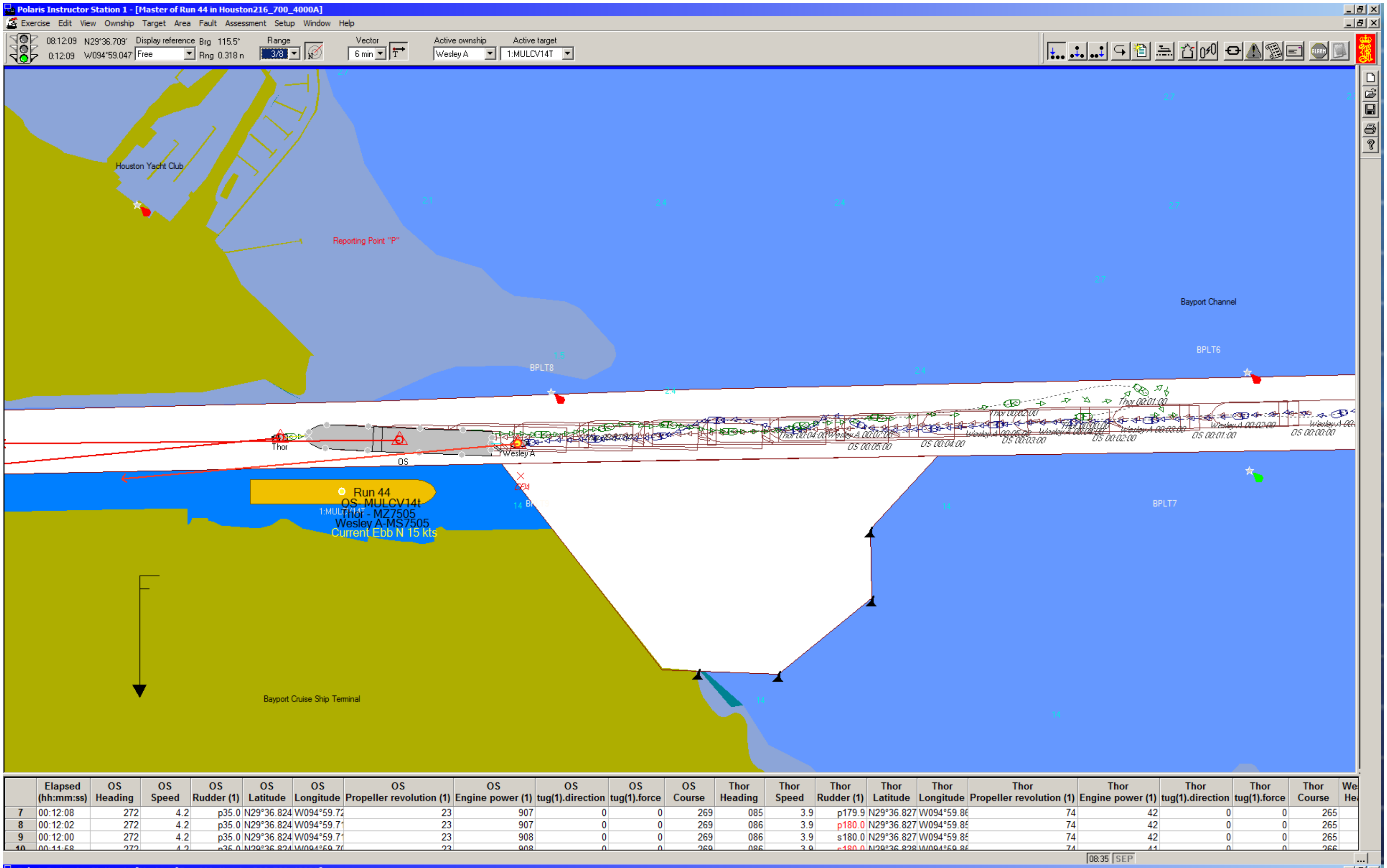


Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:07:06 N29°36.712' W094°59.044' Display reference: Free Brg 114.9° Rng 0.319 n Range 3/16 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:07:04	270	4.0	s19.6	N29°36.832	W094°59.31	23	927	0	0	268	083	5.6	s179.4	N29°36.836	W094°59.47	108	136	0	0	262
8	00:07:02	270	4.0	s16.1	N29°36.832	W094°59.31	23	927	0	0	268	081	5.5	s175.5	N29°36.837	W094°59.47	108	141	0	0	260
9	00:07:00	270	4.0	s10.5	N29°36.832	W094°59.31	23	927	0	0	268	079	5.4	s175.5	N29°36.838	W094°59.46	108	151	0	0	259

June 26, 2019

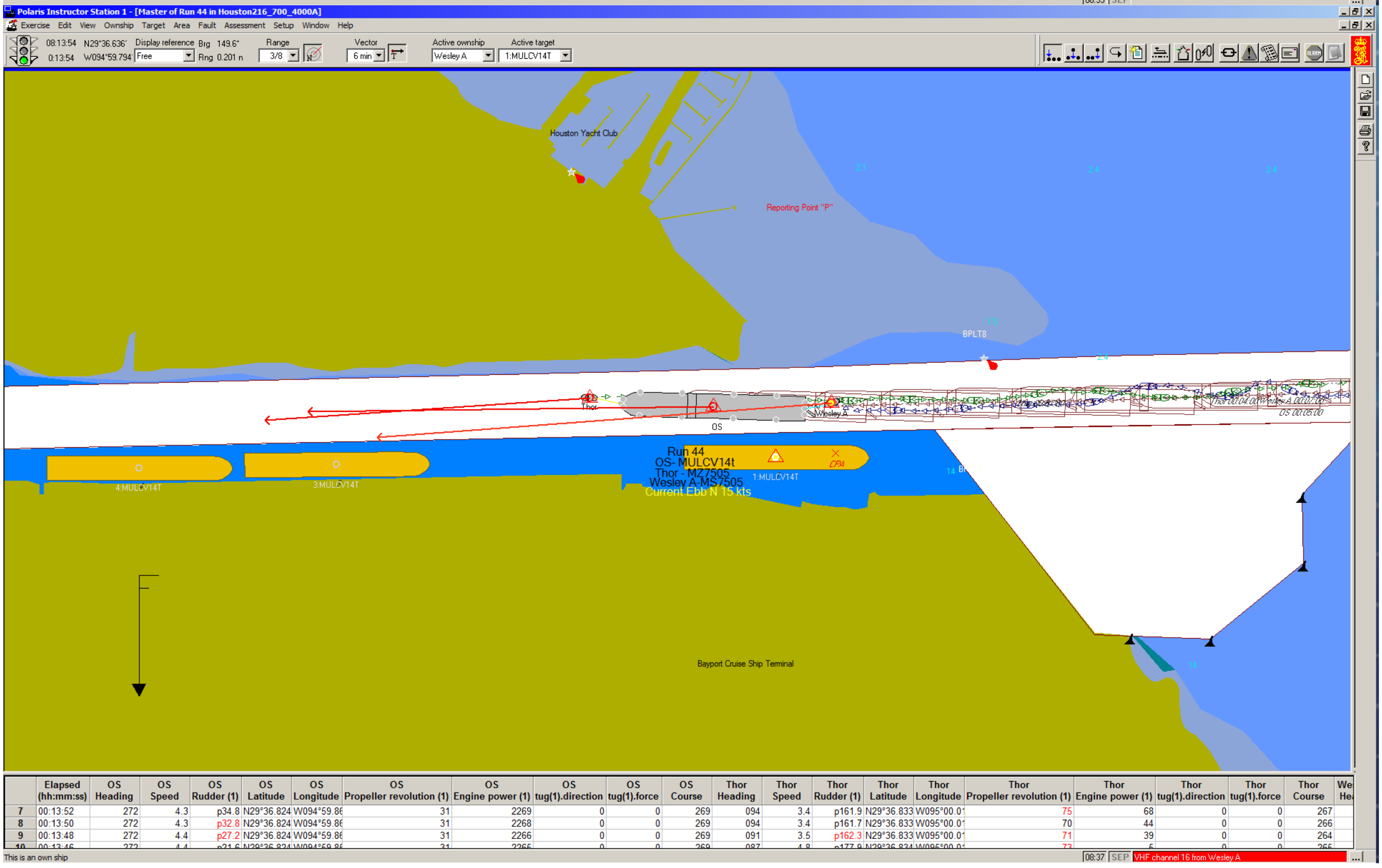


Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:12:09 N29°36.709'
0:12:09 W094°59.047'
Display reference: Free
Brg 115.5°
Rng 0.318 n
Range: 3/8
Vector: 6 min
Active ownship: Wesley A
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:12:08	272	4.2	p35.0	N29°36.824	W094°59.72	23	907	0	0	269	085	3.9	p179.9	N29°36.827	W094°59.86	74	42	0	0	265	
8	00:12:02	272	4.2	p35.0	N29°36.824	W094°59.71	23	907	0	0	269	086	3.9	p180.0	N29°36.827	W094°59.85	74	42	0	0	265	
9	00:12:00	272	4.2	p35.0	N29°36.824	W094°59.71	23	908	0	0	269	086	3.9	s180.0	N29°36.827	W094°59.85	74	42	0	0	265	

08:35 SEP



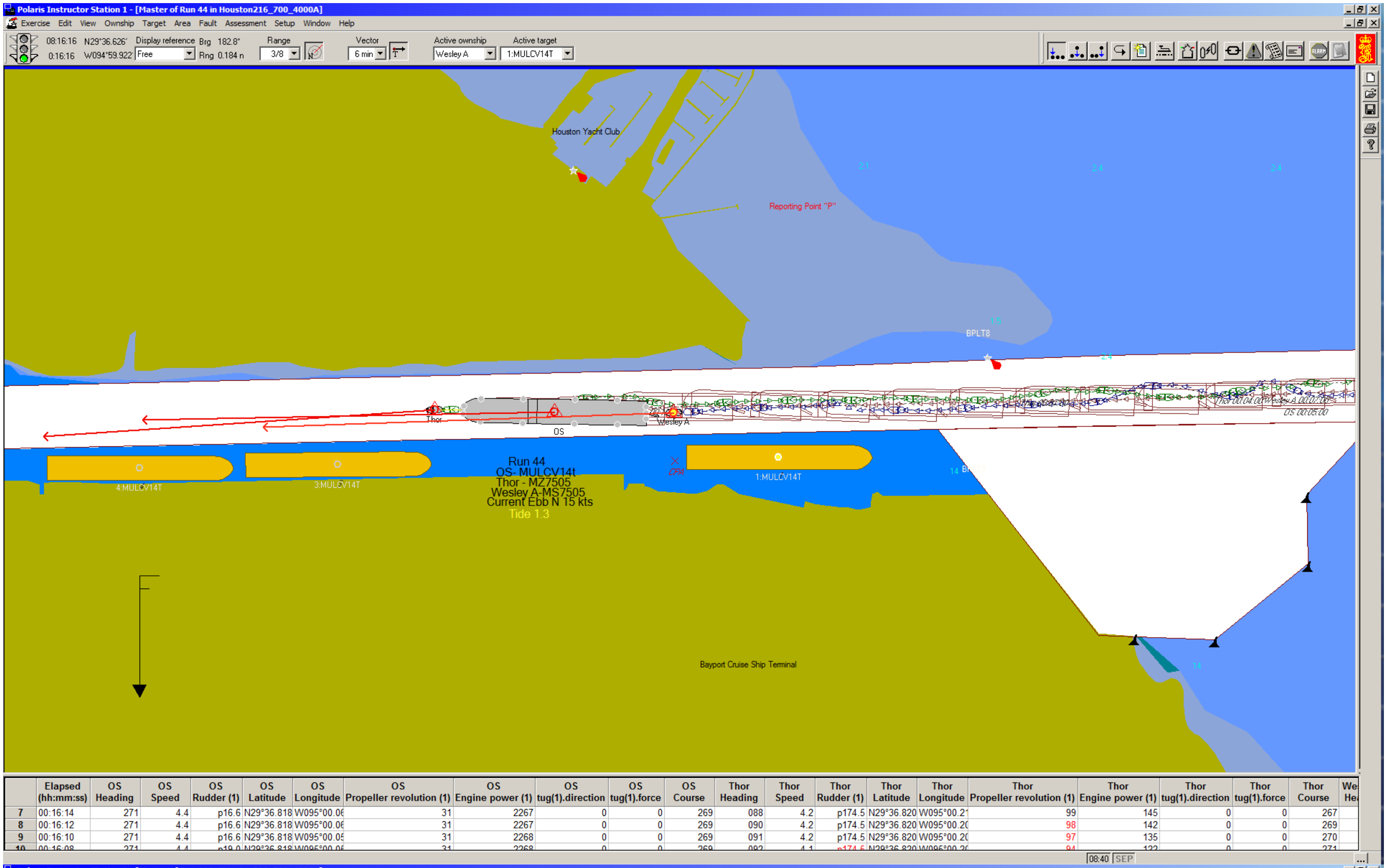
Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:13:54 N29°36.636'
0:13:54 W094°59.794'
Display reference: Free
Brg 149.6°
Rng 0.201 n
Range: 3/8
Vector: 6 min
Active ownship: Wesley A
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:13:52	272	4.3	p34.8	N29°36.824	W094°59.86	31	2269	0	0	269	094	3.4	p161.9	N29°36.833	W095°00.01	75	68	0	0	267	
8	00:13:50	272	4.3	p32.8	N29°36.824	W094°59.86	31	2268	0	0	269	094	3.4	p161.7	N29°36.833	W095°00.01	70	44	0	0	266	
9	00:13:48	272	4.4	p27.2	N29°36.824	W094°59.86	31	2266	0	0	269	091	3.5	p162.3	N29°36.833	W095°00.01	71	39	0	0	264	

This is an own ship

08:37 SEP VHF channel 16 from Wesley A

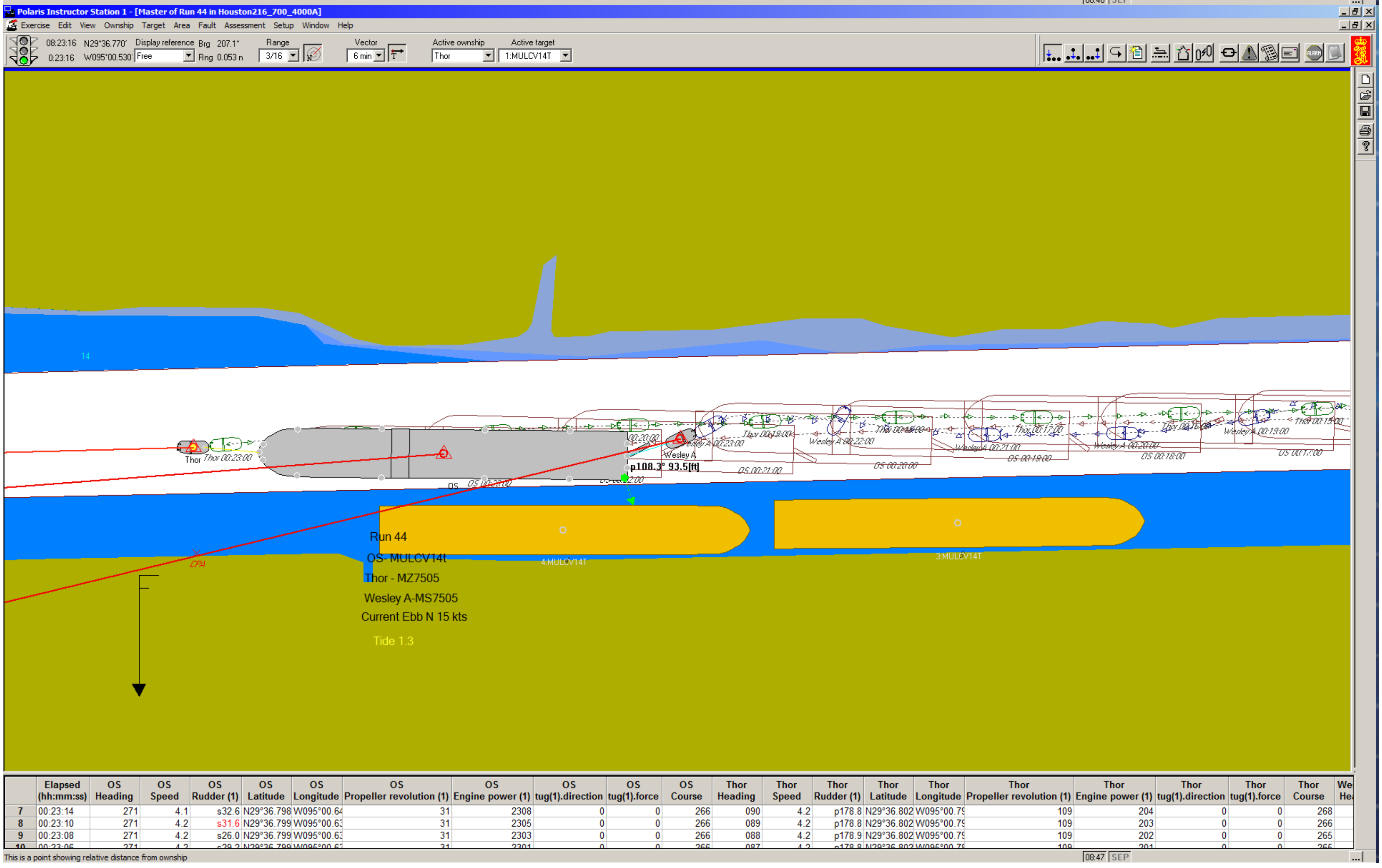


Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:16:16 N29°36.626' Display reference Free Brg 182.8° Rng 0.184 n Range 3/8 Vector 6 min Active ownship Wesley A Active target 1:MULCV14T

0:16:16 W094°59.922'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:16:14	271	4.4	p16.6	N29°36.818	W095°00.06	31	2267	0	0	269	088	4.2	p174.5	N29°36.820	W095°00.21	99	145	0	0	267	
8	00:16:12	271	4.4	p16.6	N29°36.818	W095°00.06	31	2267	0	0	269	090	4.2	p174.5	N29°36.820	W095°00.20	98	142	0	0	269	
9	00:16:10	271	4.4	p16.6	N29°36.818	W095°00.05	31	2268	0	0	269	091	4.2	p174.5	N29°36.820	W095°00.20	97	135	0	0	270	
10	00:16:08	271	4.4	p19.0	N29°36.818	W095°00.06	31	2268	0	0	269	092	4.1	p174.5	N29°36.820	W095°00.20	94	122	0	0	271	



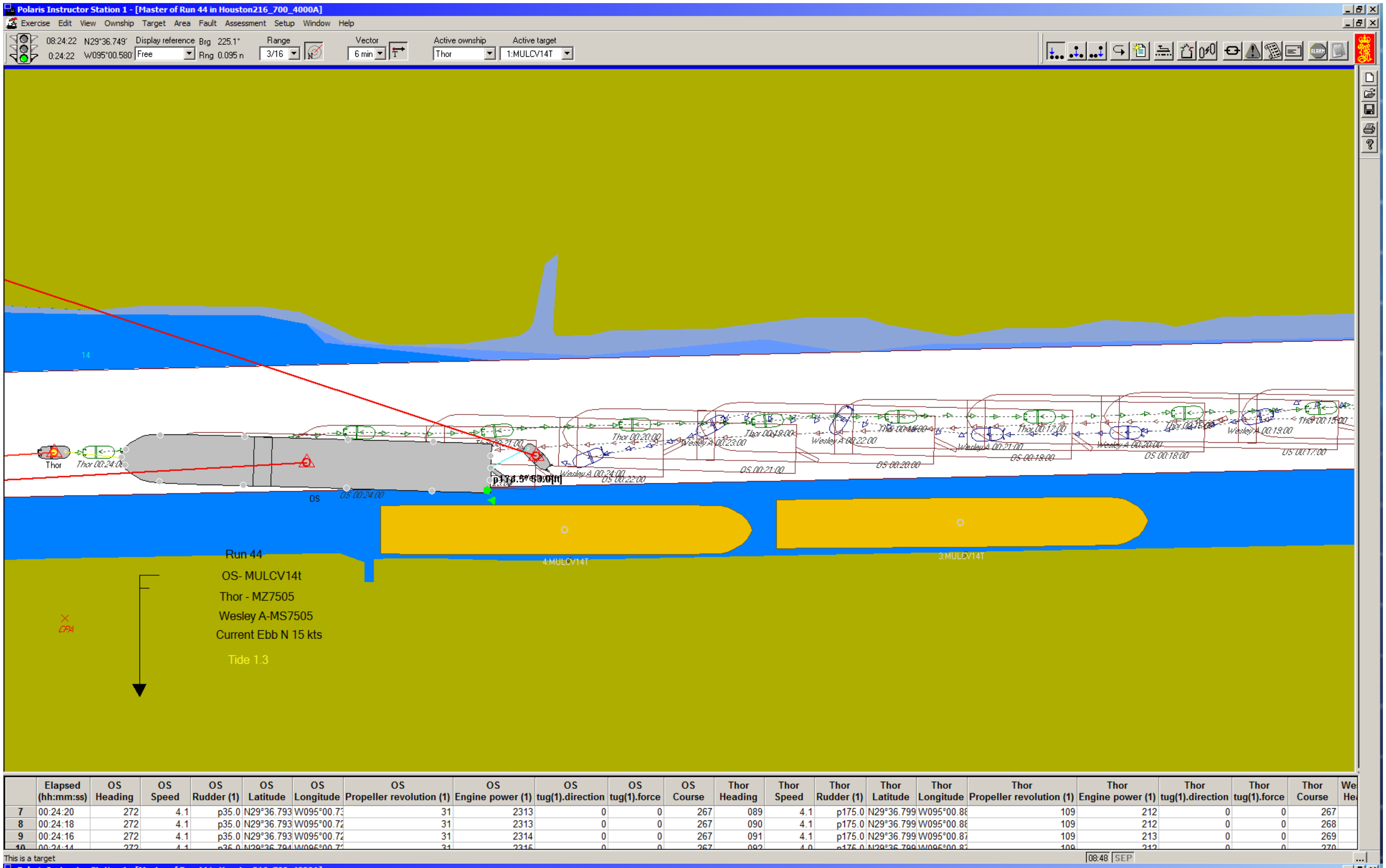
Polaris Instructor Station 1 - [Master of Run 44 in Houston216_700_4000A]

08:23:16 N29°36.770' Display reference Free Brg 207.1° Rng 0.053 n Range 3/16 Vector 6 min Active ownship Thor Active target 1:MULCV14T

0:23:16 W095°00.530'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:23:14	271	4.1	s32.6	N29°36.798	W095°00.64	31	2308	0	0	266	090	4.2	p178.8	N29°36.802	W095°00.79	109	204	0	0	268	
8	00:23:10	271	4.2	s31.6	N29°36.799	W095°00.63	31	2305	0	0	266	089	4.2	p178.8	N29°36.802	W095°00.79	109	203	0	0	266	
9	00:23:08	271	4.2	s26.0	N29°36.799	W095°00.63	31	2303	0	0	266	088	4.2	p178.9	N29°36.802	W095°00.79	109	202	0	0	265	
10	00:23:06	271	4.2	s29.2	N29°36.799	W095°00.63	31	2301	0	0	266	087	4.2	p178.8	N29°36.802	W095°00.78	109	201	0	0	265	

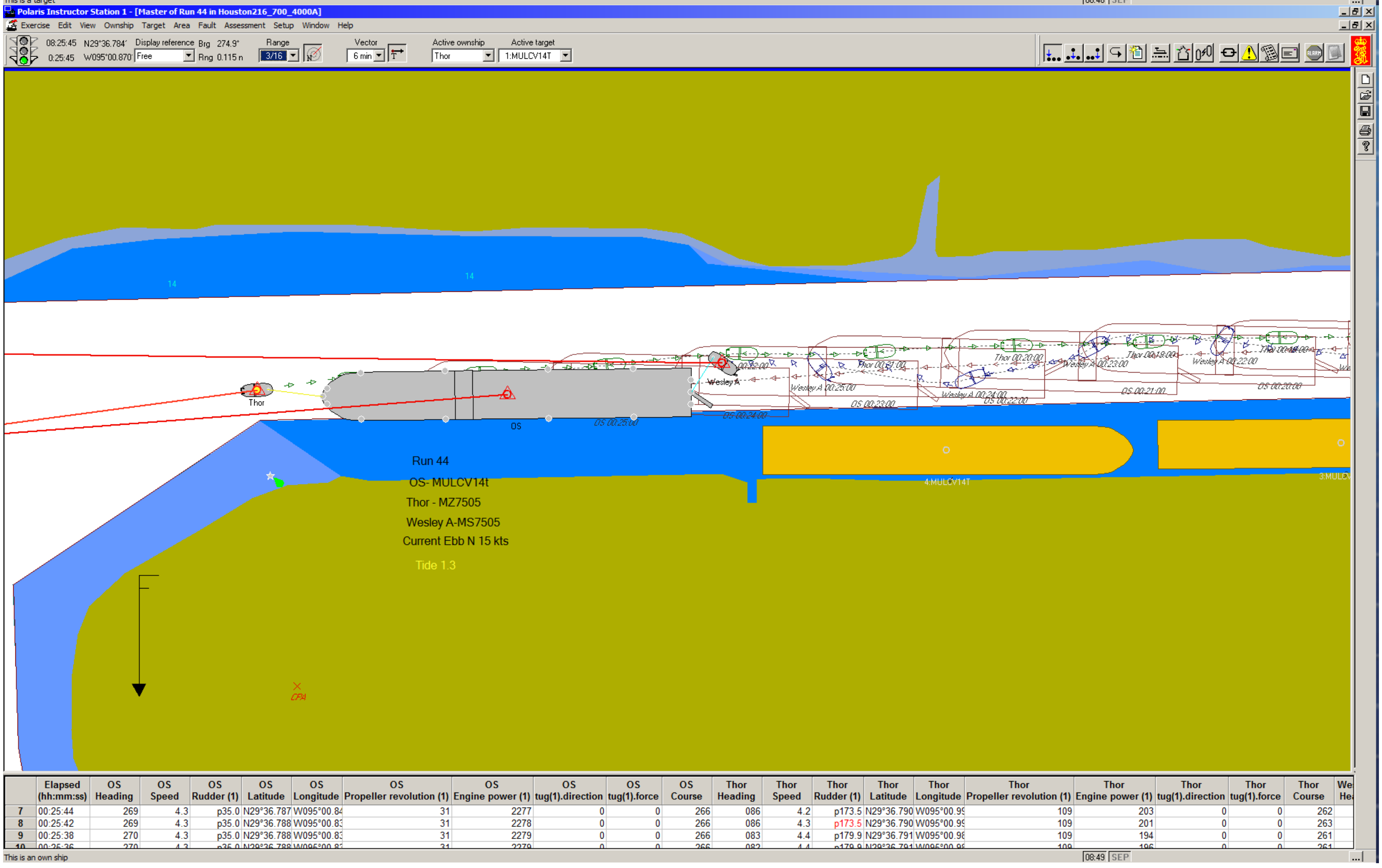
This is a point showing relative distance from ownship



08:24:22 N29°36.749' Display reference Free Brg 225.1° Rng 0.095 n Range 3/16 Vector 6 min Active ownship Thor Active target 1:MULCV14T
0:24:22 W095°00.580'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:24:20	272	4.1	p35.0	N29°36.793	W095°00.73	31	2313	0	0	267	089	4.1	p175.0	N29°36.799	W095°00.88	109	212	0	0	267
8	00:24:18	272	4.1	p35.0	N29°36.793	W095°00.72	31	2313	0	0	267	090	4.1	p175.0	N29°36.799	W095°00.88	109	212	0	0	268
9	00:24:16	272	4.1	p35.0	N29°36.793	W095°00.72	31	2314	0	0	267	091	4.1	p175.0	N29°36.799	W095°00.87	109	213	0	0	269
10	00:24:14	272	4.1	p35.0	N29°36.794	W095°00.72	31	2315	0	0	267	092	4.0	p175.0	N29°36.799	W095°00.87	109	212	0	0	270

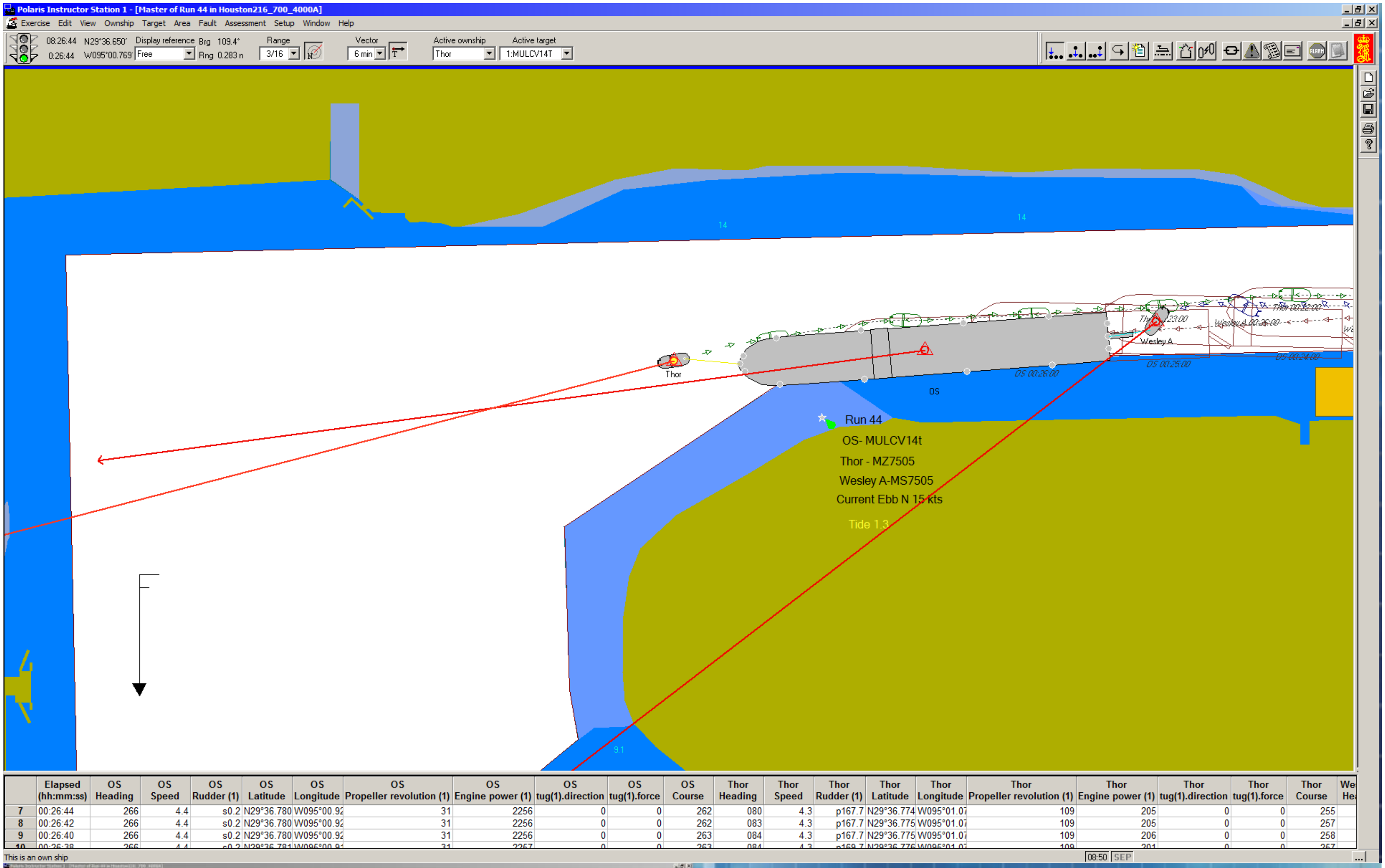
This is a target



08:25:45 N29°36.784' Display reference Free Brg 274.9° Rng 0.115 n Range 3/16 Vector 6 min Active ownship Thor Active target 1:MULCV14T
0:25:45 W095°00.870'

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:25:44	269	4.3	p35.0	N29°36.787	W095°00.84	31	2277	0	0	266	086	4.2	p173.5	N29°36.790	W095°00.99	109	203	0	0	262
8	00:25:42	269	4.3	p35.0	N29°36.788	W095°00.83	31	2278	0	0	266	086	4.3	p173.5	N29°36.790	W095°00.99	109	201	0	0	263
9	00:25:38	270	4.3	p35.0	N29°36.788	W095°00.83	31	2279	0	0	266	083	4.4	p179.9	N29°36.791	W095°00.98	109	194	0	0	261
10	00:25:36	270	4.3	p35.0	N29°36.788	W095°00.83	31	2279	0	0	266	082	4.4	p179.9	N29°36.791	W095°00.98	109	196	0	0	261

This is an own ship



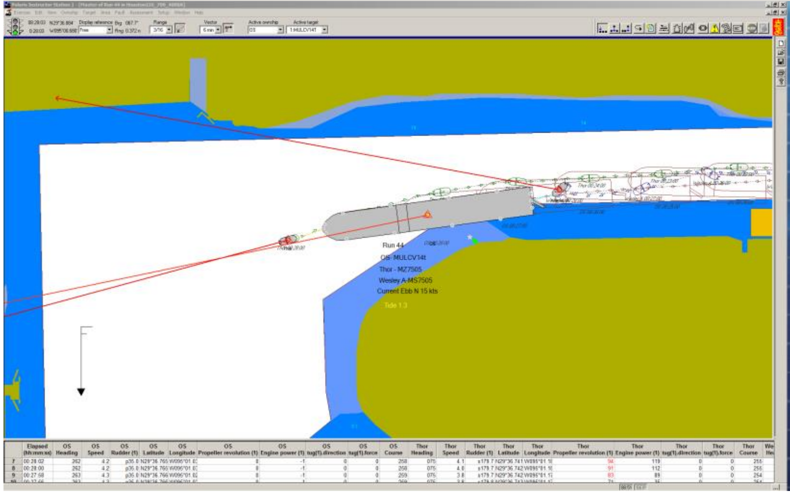
08:26:44 N29°36.650′ Brg 109.4°
0:26:44 W095°00.769′ Rng 0.283 n
Display reference: Free
Range: 3/16
Vector: 6 min
Active ownship: Thor
Active target: 1:MULCV14T

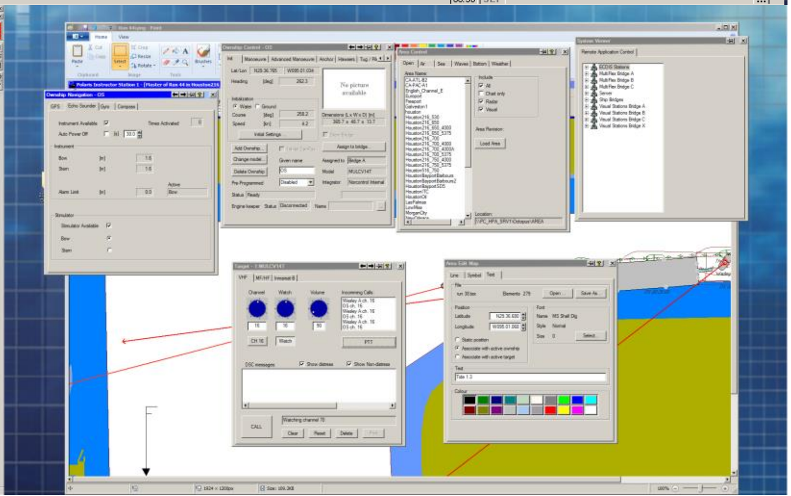
Run 44
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

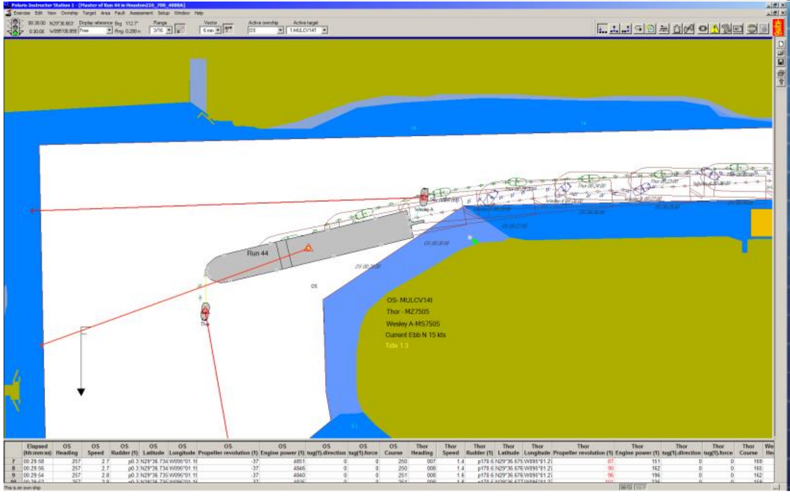
	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:26:44	266	4.4	s0.2	N29°36.780	W095°00.92	31	2256	0	0	262	080	4.3	p167.7	N29°36.774	W095°01.07	109	205	0	0	255	
8	00:26:42	266	4.4	s0.2	N29°36.780	W095°00.92	31	2256	0	0	262	083	4.3	p167.7	N29°36.775	W095°01.07	109	205	0	0	257	
9	00:26:40	266	4.4	s0.2	N29°36.780	W095°00.92	31	2256	0	0	263	084	4.3	p167.7	N29°36.775	W095°01.07	109	206	0	0	258	

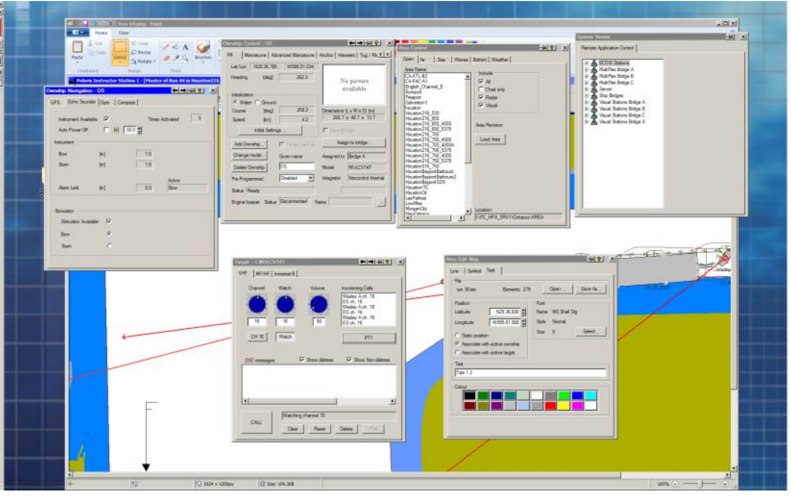
This is an own ship

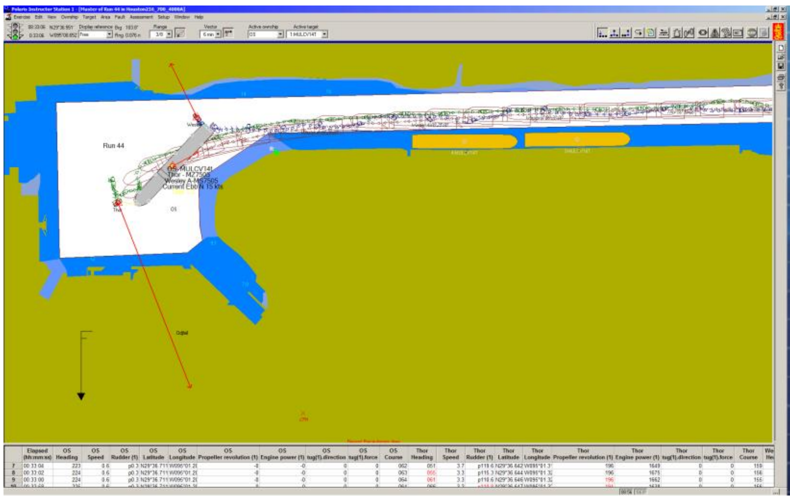
08:50 SEP

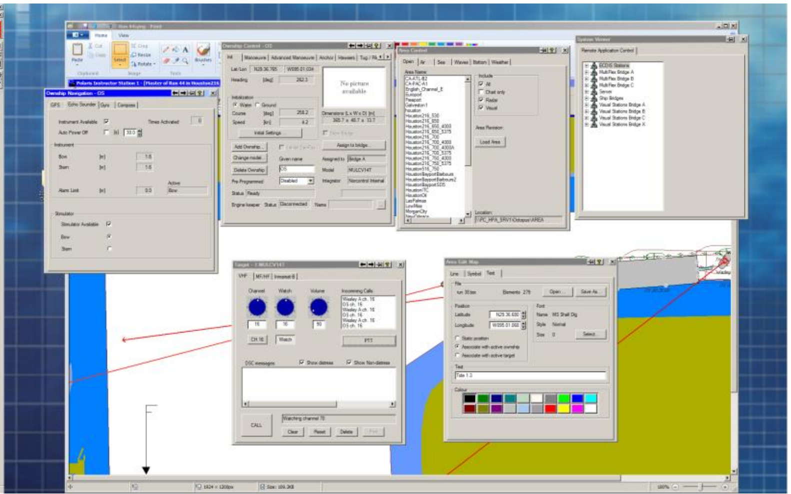


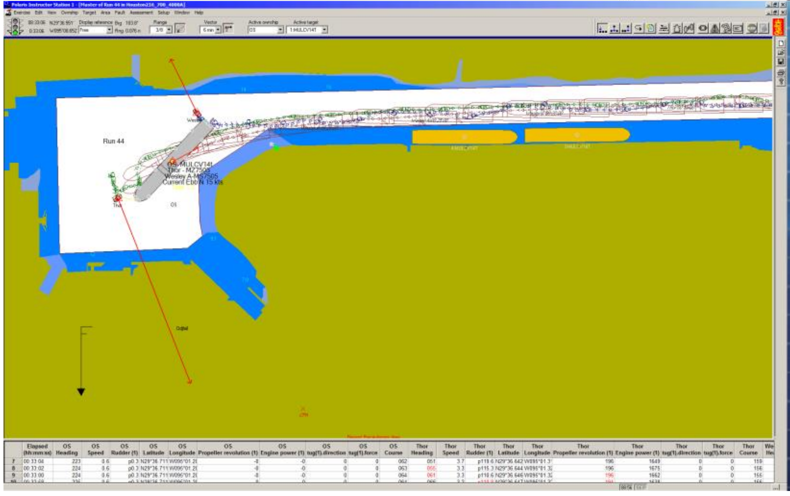


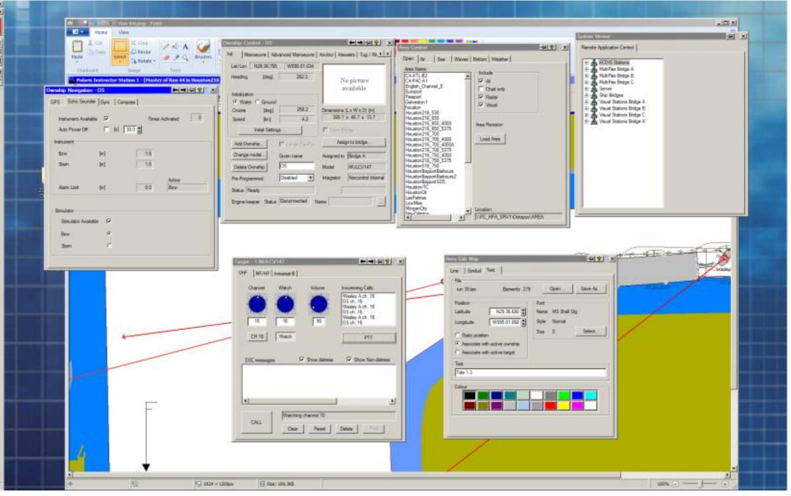





Run 44
OS-MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 1.5 kts




Run 44
OS-MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 1.5 kts



June 26, 2019

Run 45

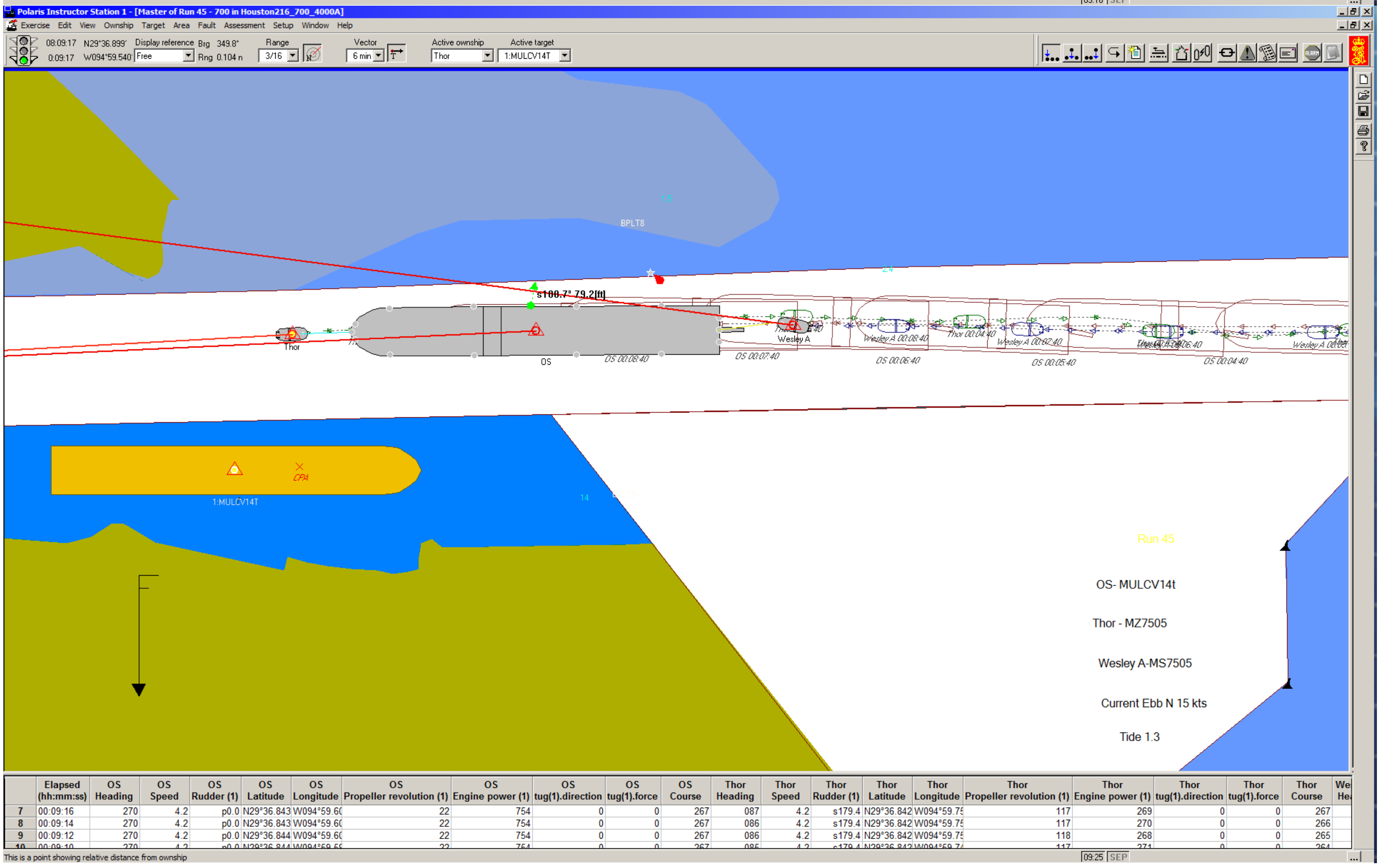
Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:00:29 N29°37.107' Display reference Free Brg 321.5° Rng 0.199 n Range 3/4 Vector 6 min Active ownship Thor Active target 1:MULCV14T
0:00:29 W094°59.336'

OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:00:28	269	6.8	s7.4	N29°36.852	W094°58.67	36	3226	0	0	269	082	7.7	s179.6	N29°36.841	W094°58.80	198	1216	0	0	263
8	00:00:26	269	6.8	s3.8	N29°36.852	W094°58.67	36	3226	0	0	269	081	6.1	s176.2	N29°36.841	W094°58.79	197	1404	0	0	263
9	00:00:24	269	6.8	s0.2	N29°36.852	W094°58.66	36	3226	0	0	269	082	4.0	s179.8	N29°36.842	W094°58.79	194	1617	0	0	263

09:16 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:09:17 N29°36.899' Display reference Free Brg 349.8° Rng 0.104 n Range 3/16 Vector 6 min Active ownship Thor Active target 1:MULCV14T
0:09:17 W094°59.540'

OS- MULCV14t

Thor - MZ7505

Wesley A-MS7505

Current Ebb N 15 kts

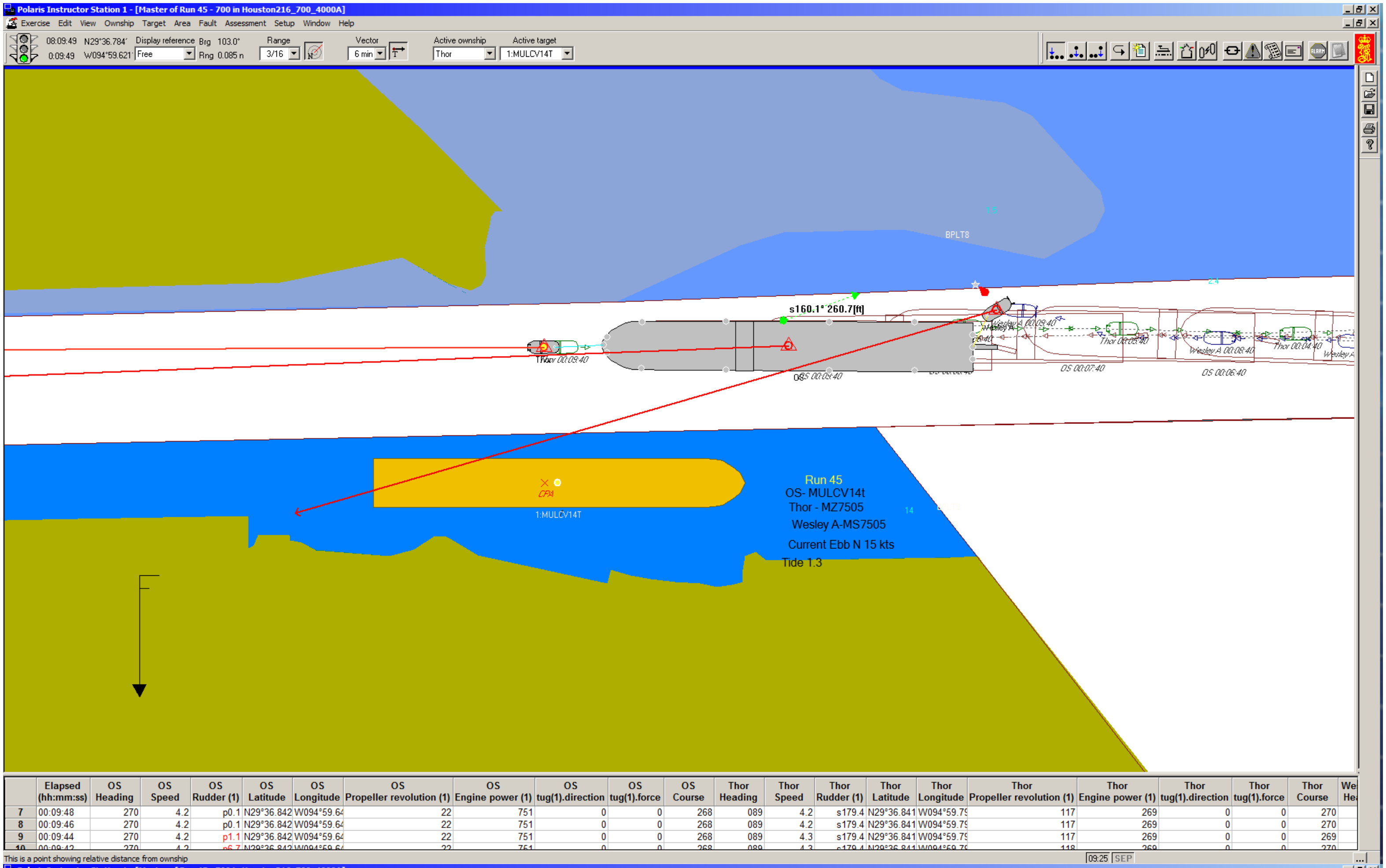
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:09:16	270	4.2	p0.0	N29°36.843	W094°59.60	22	754	0	0	267	087	4.2	s179.4	N29°36.842	W094°59.75	117	269	0	0	267
8	00:09:14	270	4.2	p0.0	N29°36.843	W094°59.60	22	754	0	0	267	086	4.2	s179.4	N29°36.842	W094°59.75	117	270	0	0	266
9	00:09:12	270	4.2	p0.0	N29°36.844	W094°59.60	22	754	0	0	267	086	4.2	s179.4	N29°36.842	W094°59.75	118	268	0	0	265

This is a point showing relative distance from ownship

09:25 SEP

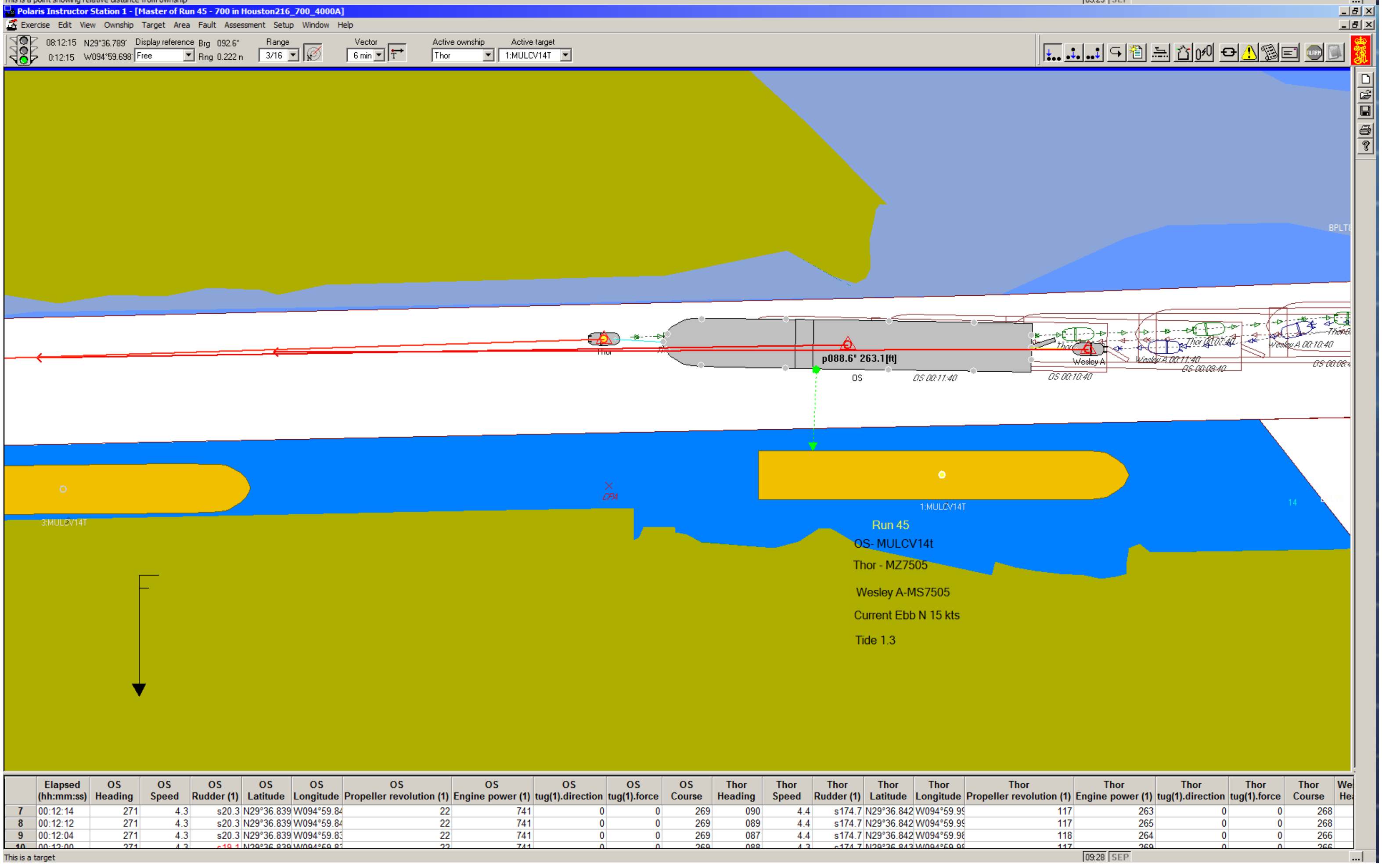
- Page 440



Run 45
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:09:48	270	4.2	p0.1	N29°36.842	W094°59.64	22	751	0	0	268	089	4.2	s179.4	N29°36.841	W094°59.79	117	269	0	0	270
8	00:09:46	270	4.2	p0.1	N29°36.842	W094°59.64	22	751	0	0	268	089	4.2	s179.4	N29°36.841	W094°59.79	117	269	0	0	270
9	00:09:44	270	4.2	p1.1	N29°36.842	W094°59.64	22	751	0	0	268	089	4.3	s179.4	N29°36.841	W094°59.79	117	269	0	0	269

This is a point showing relative distance from ownship



Run 45
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:12:14	271	4.3	s20.3	N29°36.839	W094°59.84	22	741	0	0	269	090	4.4	s174.7	N29°36.842	W094°59.99	117	263	0	0	268
8	00:12:12	271	4.3	s20.3	N29°36.839	W094°59.84	22	741	0	0	269	089	4.4	s174.7	N29°36.842	W094°59.99	117	265	0	0	268
9	00:12:04	271	4.3	s20.3	N29°36.839	W094°59.83	22	741	0	0	269	087	4.4	s174.7	N29°36.842	W094°59.98	118	264	0	0	266

This is a target

08:15:08 N29°36.786′ Display reference Free Brg 091.6° Rng 0.120 n

0:15:08 W095°00.054′ Range 3/16 Vector 6 min Active ownship Thor Active target 1:MULCV14T

Run 45

OS- MULCV14t

Thor - MZ7505

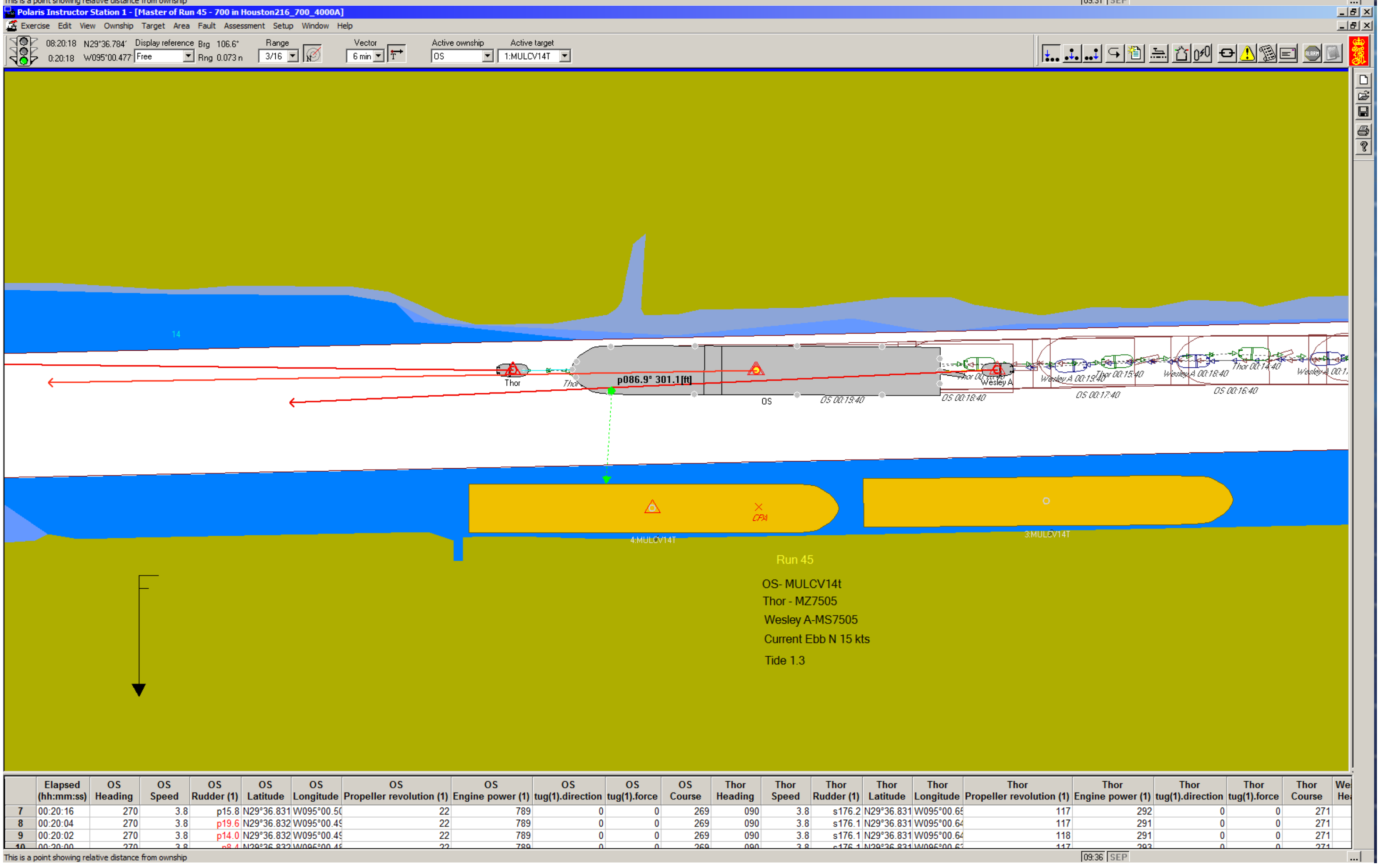
Wesley A-MS7505

Current Ebb N 15 kts

Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:15:06	270	4.4	s0.5	N29°36.837	W095°00.08	22	734	0	0	270	087	4.5	s174.7	N29°36.839	W095°00.23	117	262	0	0	266
8	00:15:00	270	4.4	s0.5	N29°36.837	W095°00.08	22	734	0	0	270	088	4.4	s174.7	N29°36.840	W095°00.23	117	264	0	0	266
9	00:14:48	271	4.4	s0.5	N29°36.837	W095°00.06	22	734	0	0	270	091	4.4	s174.7	N29°36.840	W095°00.21	117	266	0	0	270

This is a point showing relative distance from ownship



08:20:18 N29°36.784′ Display reference Free Brg 106.6° Rng 0.073 n

0:20:18 W095°00.477′ Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T

Run 45

OS- MULCV14t

Thor - MZ7505

Wesley A-MS7505

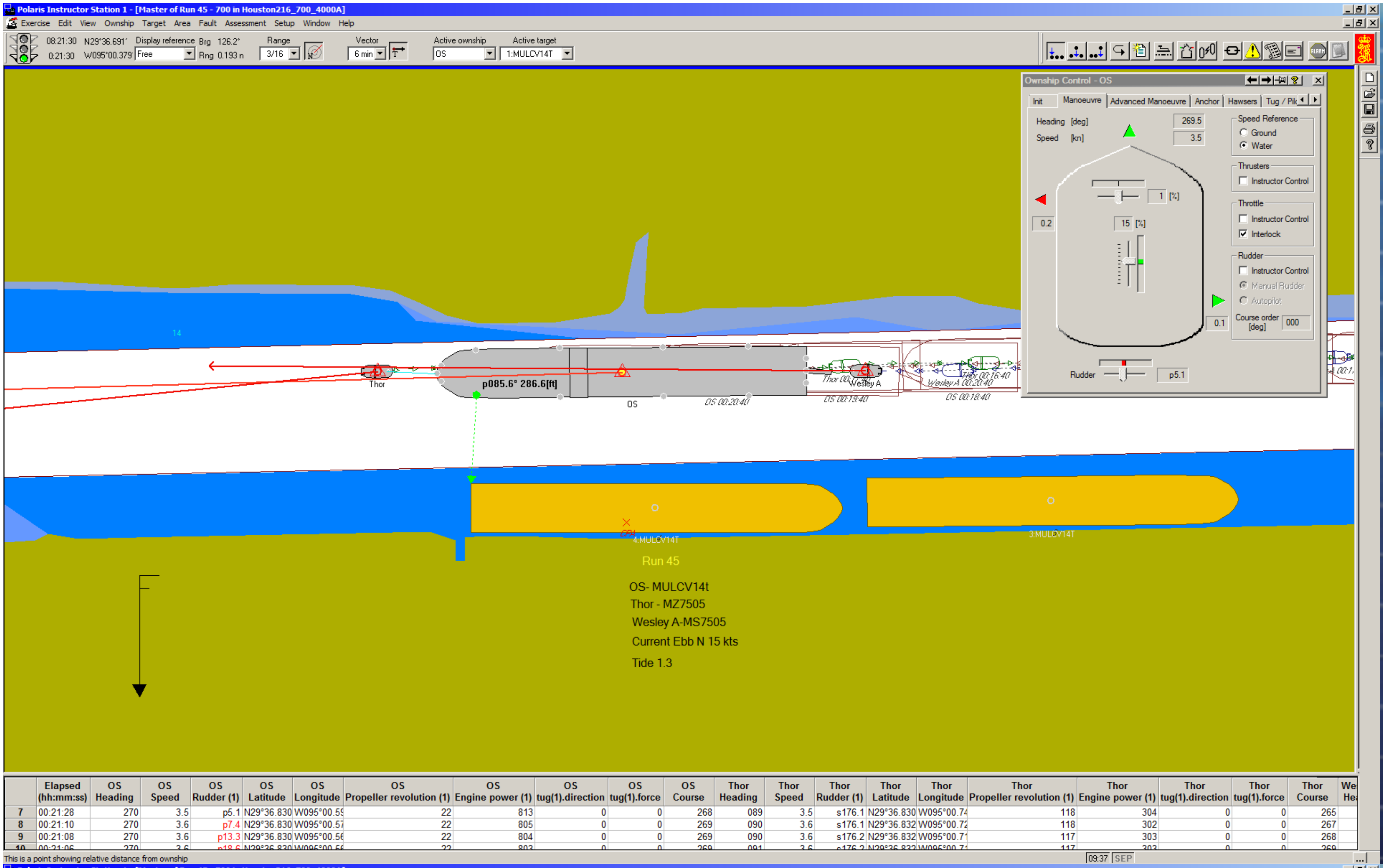
Current Ebb N 15 kts

Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:20:16	270	3.8	p15.8	N29°36.831	W095°00.50	22	789	0	0	269	090	3.8	s176.2	N29°36.831	W095°00.65	117	292	0	0	271
8	00:20:04	270	3.8	p19.6	N29°36.832	W095°00.49	22	789	0	0	269	090	3.8	s176.1	N29°36.831	W095°00.64	117	291	0	0	271
9	00:20:02	270	3.8	p14.0	N29°36.832	W095°00.49	22	789	0	0	269	090	3.8	s176.1	N29°36.831	W095°00.64	118	291	0	0	271

This is a point showing relative distance from ownship

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:21:30 N29°36.691' Display reference Free Brg 126.2° Rng 0.193 n Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T

Ownship Control - OS: Heading [deg] 269.5; Speed [kn] 3.5; Speed Reference: ○ Ground ● Water; Thrusters: ☐ Instructor Control; Throttle: ☐ Instructor Control ☑ Interlock; Rudder: ☐ Instructor Control; Course order [deg] 000; Rudder p5.1

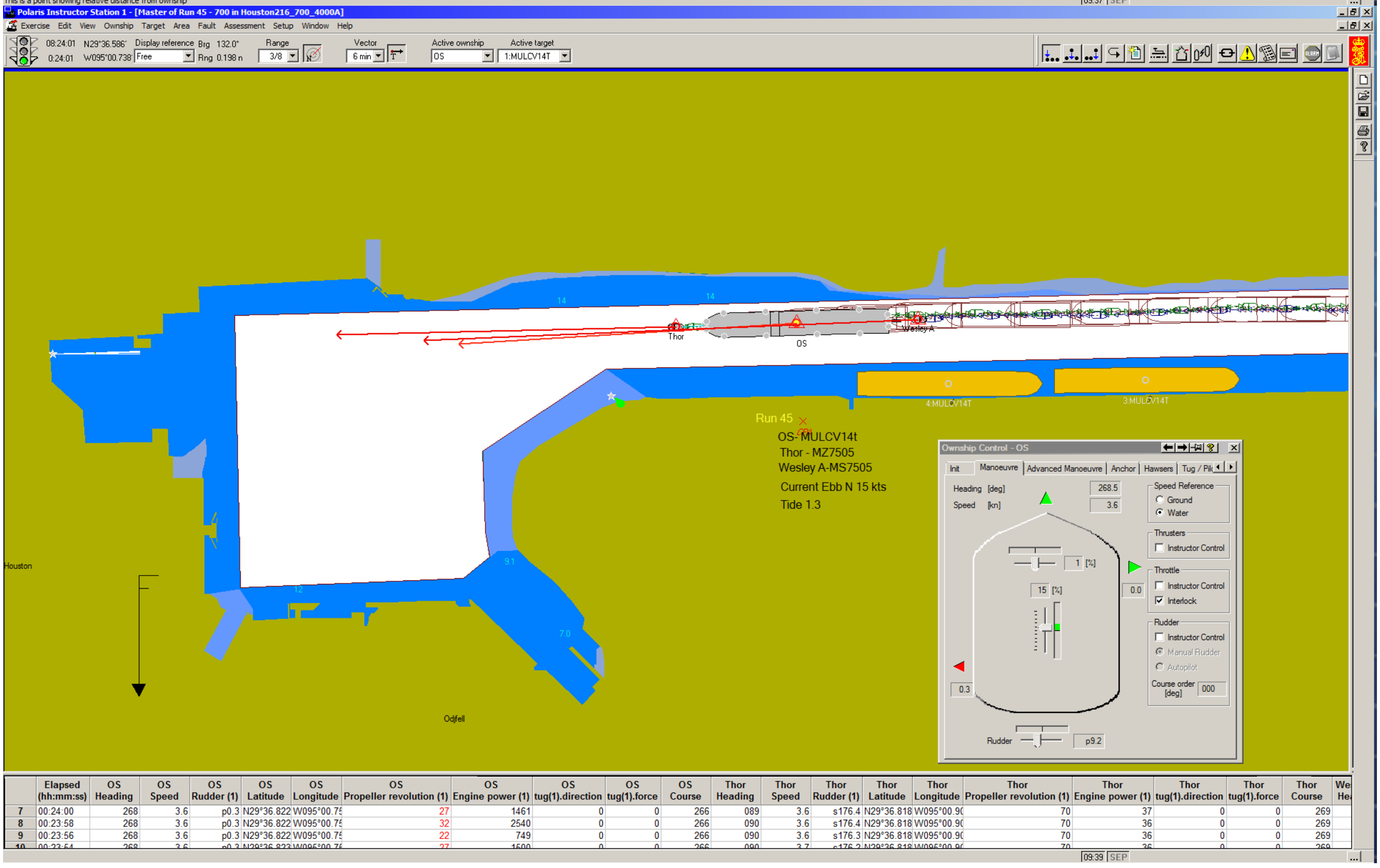
Run 45

OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:21:28	270	3.5	p5.1	N29°36.830	W095°00.59	22	813	0	0	268	089	3.5	s176.1	N29°36.830	W095°00.74	118	304	0	0	265
8	00:21:10	270	3.6	p7.4	N29°36.830	W095°00.57	22	805	0	0	269	090	3.6	s176.1	N29°36.832	W095°00.72	118	302	0	0	267
9	00:21:08	270	3.6	p13.3	N29°36.830	W095°00.56	22	804	0	0	269	090	3.6	s176.2	N29°36.832	W095°00.71	117	303	0	0	268

This is a point showing relative distance from ownship

09:37 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:24:01 N29°36.586' Display reference Free Brg 132.0° Rng 0.198 n Range 3/8 Vector 6 min Active ownship OS Active target 1:MULCV14T

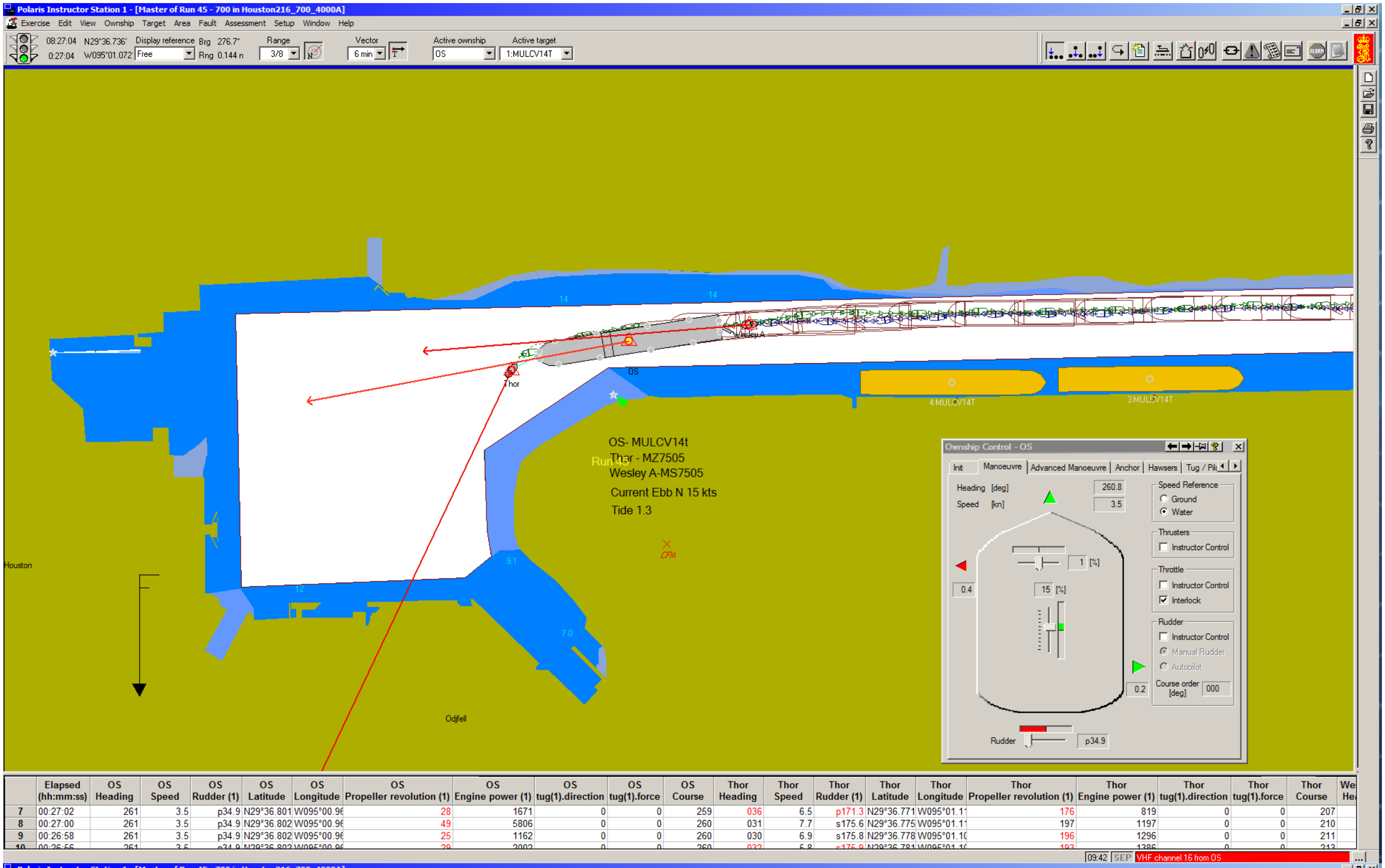
Ownship Control - OS: Heading [deg] 268.5; Speed [kn] 3.6; Speed Reference: ○ Ground ● Water; Thrusters: ☐ Instructor Control; Throttle: ☐ Instructor Control ☑ Interlock; Rudder: ☐ Instructor Control; Course order [deg] 000; Rudder p9.2

Run 45

OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:24:00	268	3.6	p0.3	N29°36.822	W095°00.75	27	1461	0	0	266	089	3.6	s176.4	N29°36.818	W095°00.90	70	37	0	0	269
8	00:23:58	268	3.6	p0.3	N29°36.822	W095°00.75	32	2540	0	0	266	090	3.6	s176.4	N29°36.818	W095°00.90	70	36	0	0	269
9	00:23:56	268	3.6	p0.3	N29°36.822	W095°00.75	22	749	0	0	266	090	3.6	s176.3	N29°36.818	W095°00.90	70	36	0	0	269

09:39 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

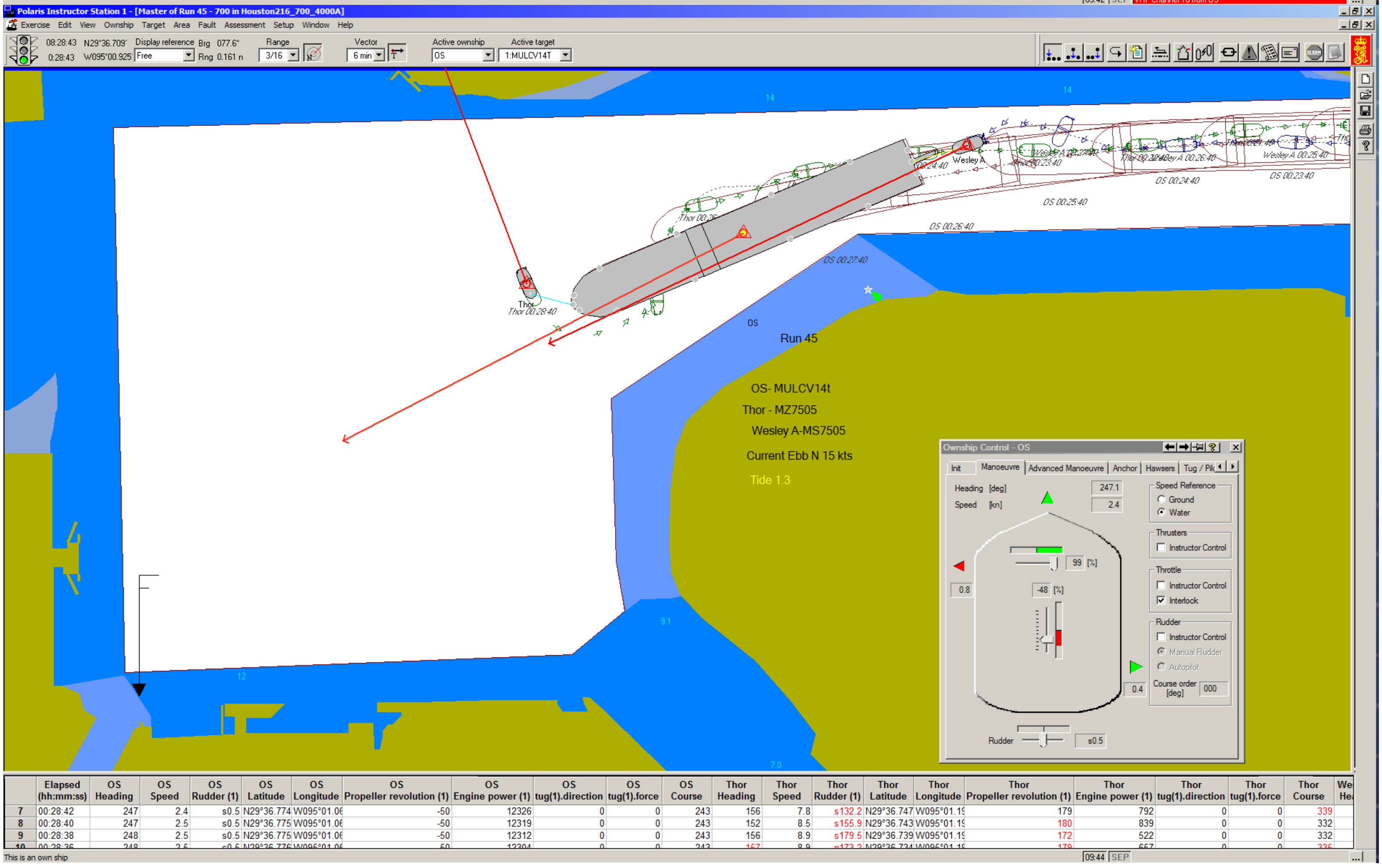
08:27:04 N29°36.736′
0:27:04 W095°01.072′
Display reference: Free
Brg 276.7°
Rng 0.144 n
Range: 3/8
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 45
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

Ownship Control - OS
Heading [deg] 260.8
Speed [kn] 3.5
1 [%]
15 [%]
0.4
0.2
Rudder p34.9
Speed Reference: ○ Ground ● Water
Thrusters: ☐ Instructor Control
Throttle: ☐ Instructor Control ☑ Interlock
Rudder: ☐ Instructor Control ● Manual Rudder ○ Autopilot
Course order [deg] 000

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:27:02	261	3.5	p34.9	N29°36.801	W095°00.96	28	1671	0	0	259	036	6.5	p171.3	N29°36.771	W095°01.11	176	819	0	0	207
8	00:27:00	261	3.5	p34.9	N29°36.802	W095°00.96	49	5806	0	0	260	031	7.7	s175.6	N29°36.775	W095°01.11	197	1197	0	0	210
9	00:26:58	261	3.5	p34.9	N29°36.802	W095°00.96	25	1162	0	0	260	030	6.9	s175.8	N29°36.778	W095°01.10	196	1296	0	0	211

09:42 SEP VHF channel 16 from OS



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:28:43 N29°36.709′
0:28:43 W095°00.925′
Display reference: Free
Brg 077.6°
Rng 0.161 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 45
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

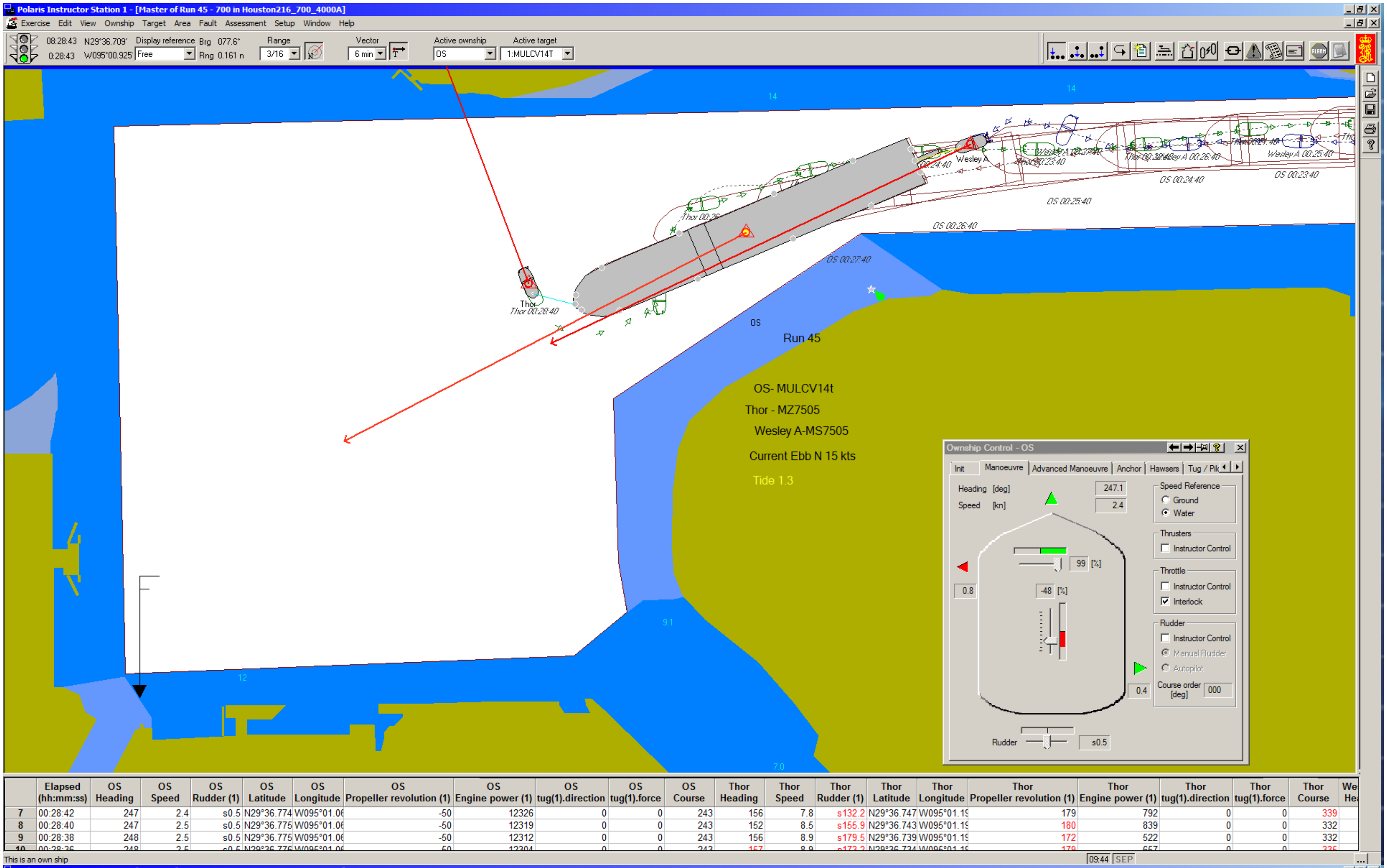
Ownship Control - OS
Heading [deg] 247.1
Speed [kn] 2.4
99 [%]
-48 [%]
0.8
0.4
Rudder s0.5
Speed Reference: ○ Ground ● Water
Thrusters: ☐ Instructor Control
Throttle: ☐ Instructor Control ☑ Interlock
Rudder: ☐ Instructor Control ● Manual Rudder ○ Autopilot
Course order [deg] 000

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:28:42	247	2.4	s0.5	N29°36.774	W095°01.06	-50	12326	0	0	243	156	7.8	s132.2	N29°36.747	W095°01.19	179	792	0	0	339
8	00:28:40	247	2.5	s0.5	N29°36.775	W095°01.06	-50	12319	0	0	243	152	8.5	s155.9	N29°36.743	W095°01.19	180	839	0	0	332
9	00:28:38	248	2.5	s0.5	N29°36.775	W095°01.06	-50	12312	0	0	243	156	8.9	s179.5	N29°36.739	W095°01.19	172	522	0	0	332

This is an own ship

09:44 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

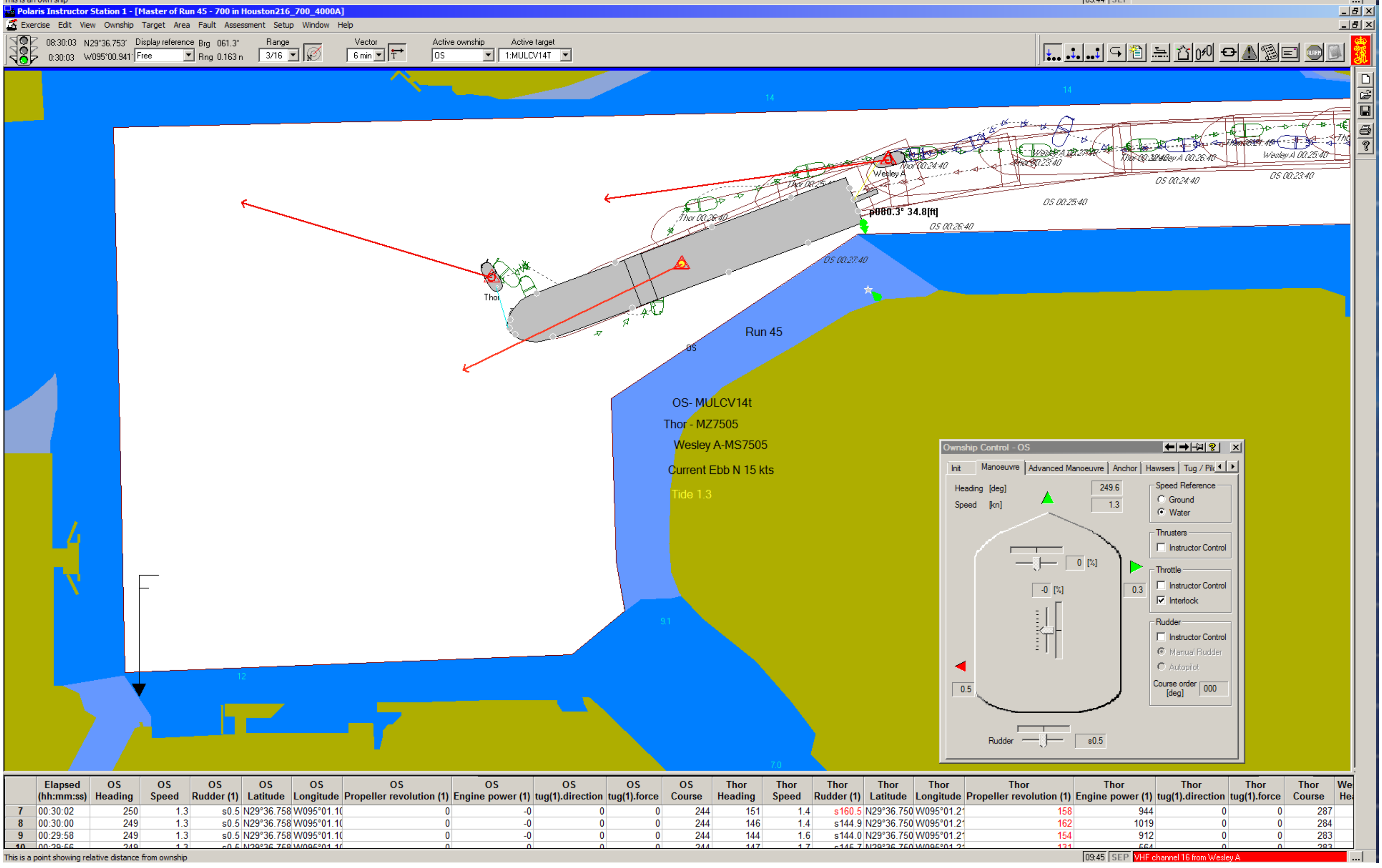
08:28:43 N29°36.709' Display reference Free Brg 077.6° Rng 0.161 n
0:28:43 W095°00.925
Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T

Heading [deg] 247.1
Speed [kn] 2.4
99 [%]
-48 [%]
0.8
0.4
Speed Reference: ○ Ground ● Water
Thrusters: ☐ Instructor Control
Throttle: ☐ Instructor Control ☑ Interlock
Rudder: ☐ Instructor Control ● Manual Rudder ○ Autopilot
Course order [deg] 000
Rudder s0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:28:42	247	2.4	s0.5	N29°36.774	W095°01.06	-50	12326	0	0	243	156	7.8	s132.2	N29°36.747	W095°01.19	179	792	0	0	339
8	00:28:40	247	2.5	s0.5	N29°36.775	W095°01.06	-50	12319	0	0	243	152	8.5	s155.9	N29°36.743	W095°01.19	180	839	0	0	332
9	00:28:38	248	2.5	s0.5	N29°36.775	W095°01.06	-50	12312	0	0	243	156	8.9	s179.5	N29°36.739	W095°01.19	172	522	0	0	332

This is an own ship

09:44 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:30:03 N29°36.753' Display reference Free Brg 061.3° Rng 0.163 n
0:30:03 W095°00.941
Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T

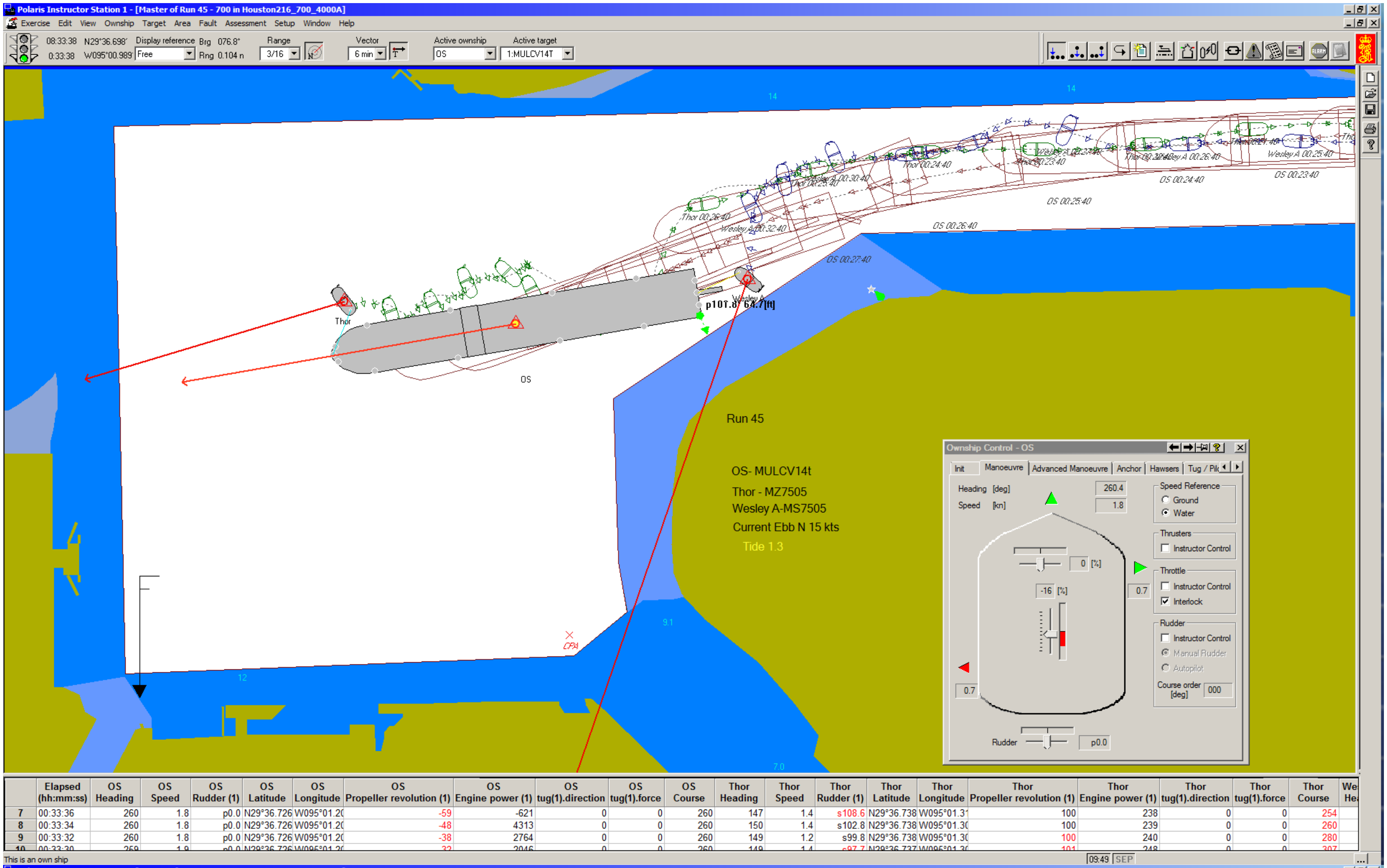
Heading [deg] 249.6
Speed [kn] 1.3
0 [%]
-0 [%]
0.3
0.5
Speed Reference: ○ Ground ● Water
Thrusters: ☐ Instructor Control
Throttle: ☐ Instructor Control ☑ Interlock
Rudder: ☐ Instructor Control ● Manual Rudder ○ Autopilot
Course order [deg] 000
Rudder s0.5

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:30:02	250	1.3	s0.5	N29°36.758	W095°01.10	0	-0	0	0	244	151	1.4	s160.5	N29°36.750	W095°01.21	158	944	0	0	287
8	00:30:00	249	1.3	s0.5	N29°36.758	W095°01.10	0	-0	0	0	244	146	1.4	s144.9	N29°36.750	W095°01.21	162	1019	0	0	284
9	00:29:58	249	1.3	s0.5	N29°36.758	W095°01.10	0	-0	0	0	244	144	1.6	s144.0	N29°36.750	W095°01.21	154	912	0	0	283

This is a point showing relative distance from ownship

09:45 SEP VHF channel 16 from Wesley A

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:33:38 N29°36.698' Display reference: Free Brg 076.8° Rng 0.104 n Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:33:38 W095°00.989'

Run 45

OS- MULCV14t

Thor - MZ7505

Wesley A-MS7505

Current Ebb N 15 kts

Tide 1.3

Ownship Control - OS

Heading [deg] 260.4

Speed [kn] 1.8

Speed Reference ○ Ground ● Water

Thrusters ☐ Instructor Control

Throttle ☐ Instructor Control ☑ Interlock

Rudder ☐ Instructor Control ● Manual Rudder ○ Autopilot

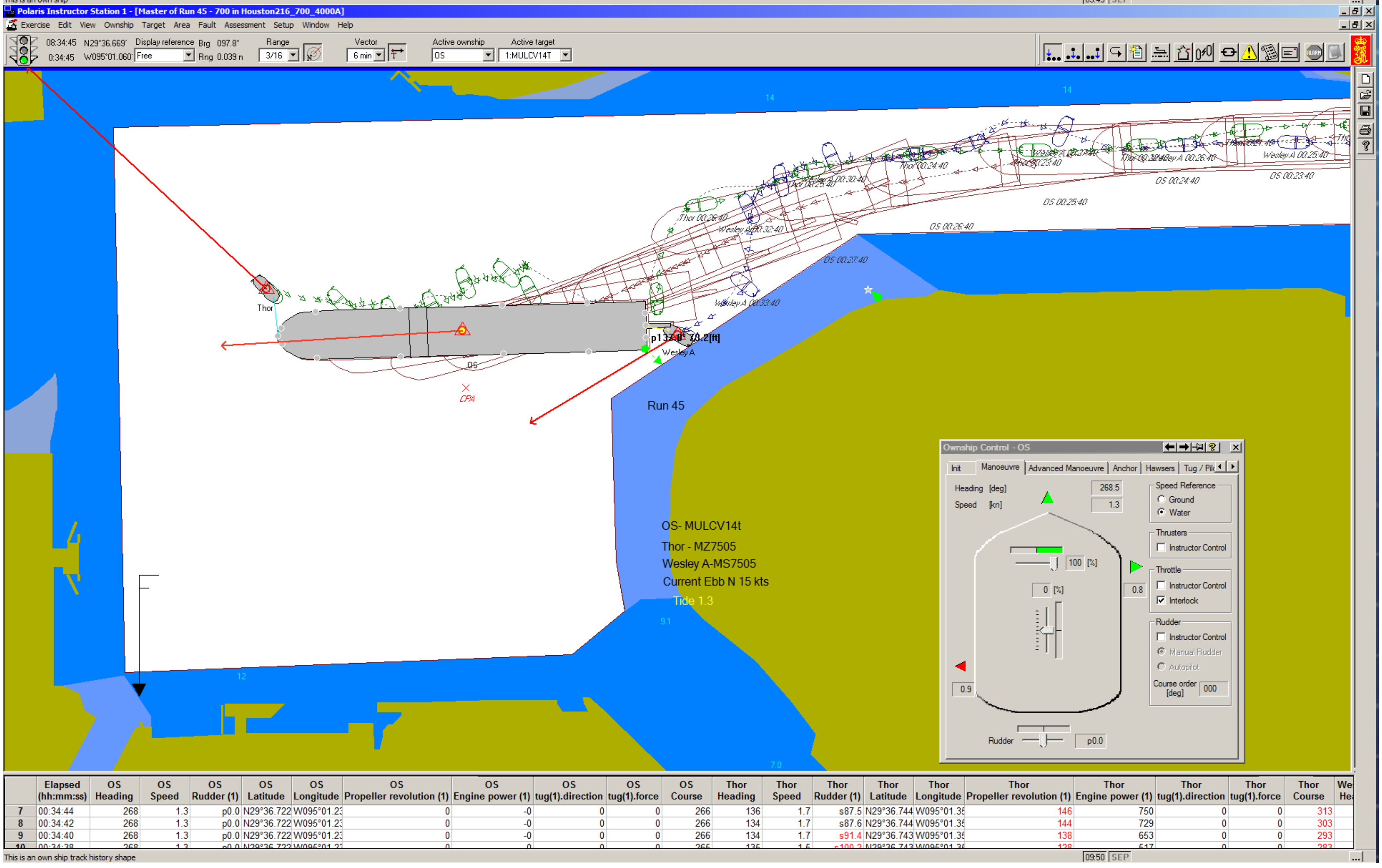
Course order [deg] 000

Rudder p0.0

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:33:36	260	1.8	p0.0	N29°36.726	W095°01.2	-59	-621	0	0	260	147	1.4	s108.6	N29°36.738	W095°01.3	100	238	0	0	254
8	00:33:34	260	1.8	p0.0	N29°36.726	W095°01.2	-48	4313	0	0	260	150	1.4	s102.8	N29°36.738	W095°01.3	100	239	0	0	260
9	00:33:32	260	1.8	p0.0	N29°36.726	W095°01.2	-38	2764	0	0	260	149	1.2	s99.8	N29°36.738	W095°01.3	100	240	0	0	280

This is an own ship

09:49 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:34:45 N29°36.669' Display reference: Free Brg 097.8° Rng 0.039 n Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:34:45 W095°01.060'

Run 45

OS- MULCV14t

Thor - MZ7505

Wesley A-MS7505

Current Ebb N 15 kts

Tide 1.3

Ownship Control - OS

Heading [deg] 268.5

Speed [kn] 1.3

Speed Reference ○ Ground ● Water

Thrusters ☐ Instructor Control

Throttle ☐ Instructor Control ☑ Interlock

Rudder ☐ Instructor Control ● Manual Rudder ○ Autopilot

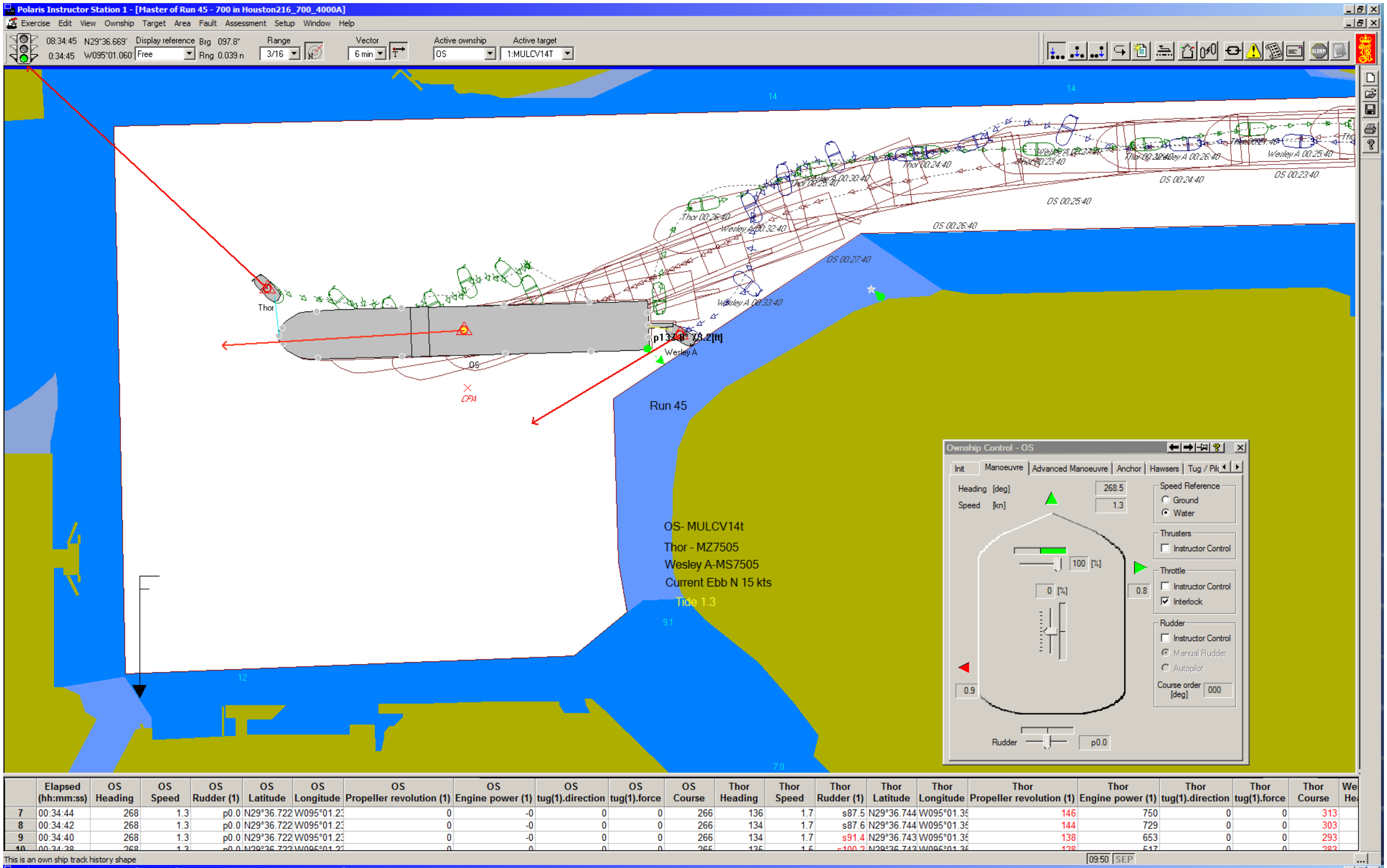
Course order [deg] 000

Rudder p0.0

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course
7	00:34:44	268	1.3	p0.0	N29°36.722	W095°01.2	0	-0	0	0	266	136	1.7	s87.5	N29°36.744	W095°01.3	146	750	0	0	313
8	00:34:42	268	1.3	p0.0	N29°36.722	W095°01.2	0	-0	0	0	266	134	1.7	s87.6	N29°36.744	W095°01.3	144	729	0	0	303
9	00:34:40	268	1.3	p0.0	N29°36.722	W095°01.2	0	-0	0	0	266	134	1.7	s91.4	N29°36.743	W095°01.3	138	653	0	0	293

This is an own ship track history shape

09:50 SEP



08:34:45 N29°36.669' Display reference: Free Brg 097.8° Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:34:45 W095°01.060' Rng 0.039 n

Ownship Control - OS

Init | Manoeuvre | Advanced Manoeuvre | Anchor | Hawsers | Tug / Pil

Heading [deg] 268.5
Speed [kn] 1.3

Speed Reference
○ Ground
● Water

Thrusters
☐ Instructor Control

100 [%]
0 [%]
0.8
0.9

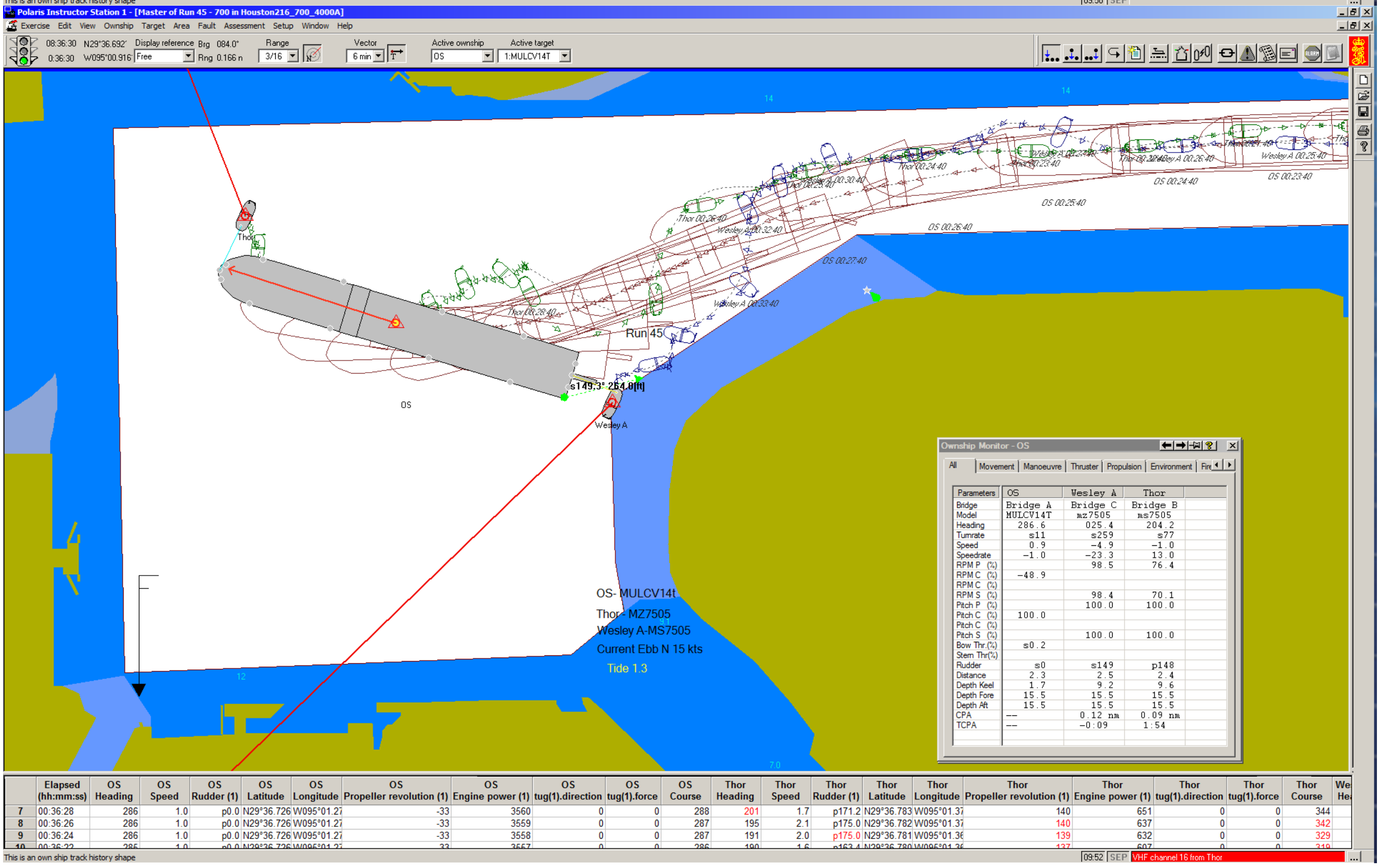
Throttle
☐ Instructor Control
☑ Interlock

Rudder
☐ Instructor Control
● Manual Rudder
○ Autopilot
Course order [deg] 000

Rudder p0.0

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:34:44	268	1.3	p0.0	N29°36.722	W095°01.23	0	-0	0	0	266	136	1.7	s87.5	N29°36.744	W095°01.35	146	750	0	0	313	
8	00:34:42	268	1.3	p0.0	N29°36.722	W095°01.23	0	-0	0	0	266	134	1.7	s87.6	N29°36.744	W095°01.35	144	729	0	0	303	
9	00:34:40	268	1.3	p0.0	N29°36.722	W095°01.23	0	-0	0	0	266	134	1.7	s91.4	N29°36.743	W095°01.35	138	653	0	0	293	

This is an own ship track history shape 09:50 SEP



08:36:30 N29°36.692' Display reference: Free Brg 084.0° Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:36:30 W095°00.916' Rng 0.166 n

Ownship Monitor - OS

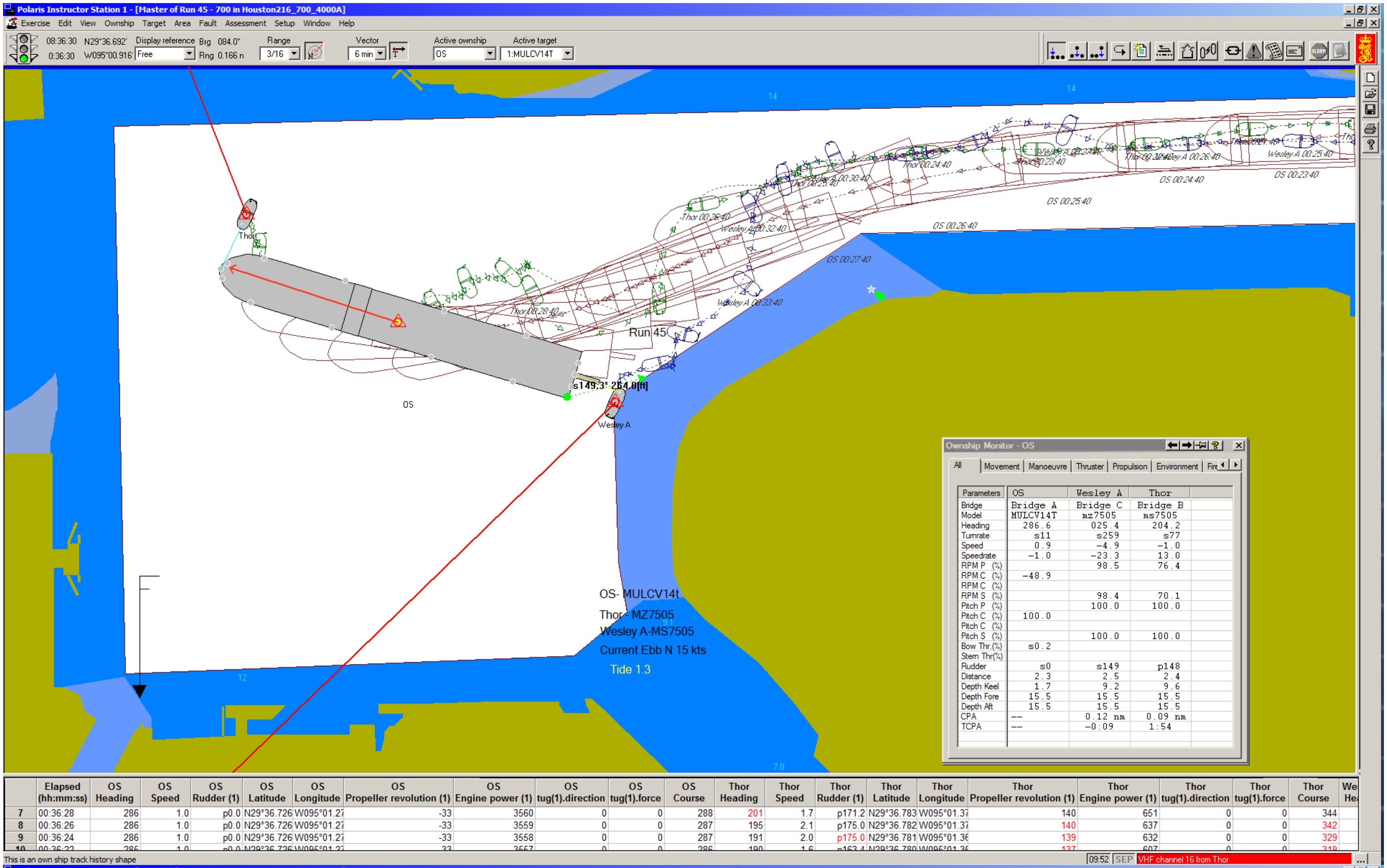
All | Movement | Manoeuvre | Thruster | Propulsion | Environment | Fire

Parameters	OS	Wesley A	Thor
Bridge	Bridge A	Bridge C	Bridge B
Model	MULCV14T	mz7505	ms7505
Heading	286.6	025.4	204.2
Turnrate	s11	s259	s77
Speed	0.9	-4.9	-1.0
Speedrate	-1.0	-23.3	13.0
RPM P (%)		98.5	76.4
RPM C (%)	-48.9		
RPM C (%)			
RPM S (%)		98.4	70.1
Pitch P (%)		100.0	100.0
Pitch C (%)	100.0		
Pitch C (%)			
Pitch S (%)		100.0	100.0
Bow Thr.(%)	s0.2		
Stern Thr(%)			
Rudder	s0	s149	p148
Distance	2.3	2.5	2.4
Depth Keel	1.7	9.2	9.6
Depth Fore	15.5	15.5	15.5
Depth Aft	15.5	15.5	15.5
CPA	--	0.12 nm	0.09 nm
TCPA	--	-0:09	1:54

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:36:28	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3560	0	0	288	201	1.7	p171.2	N29°36.783	W095°01.37	140	651	0	0	344	
8	00:36:26	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3559	0	0	287	195	2.1	p175.0	N29°36.782	W095°01.37	140	637	0	0	342	
9	00:36:24	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3558	0	0	287	191	2.0	p175.0	N29°36.781	W095°01.36	139	632	0	0	329	

This is an own ship track history shape 09:52 SEP VHF channel 16 from Thor

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:36:30 N29°36.692′ Display reference Free Brg 084.0° Rng 0.166 n Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:36:30 W095°00.916′

OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts
Tide 1.3

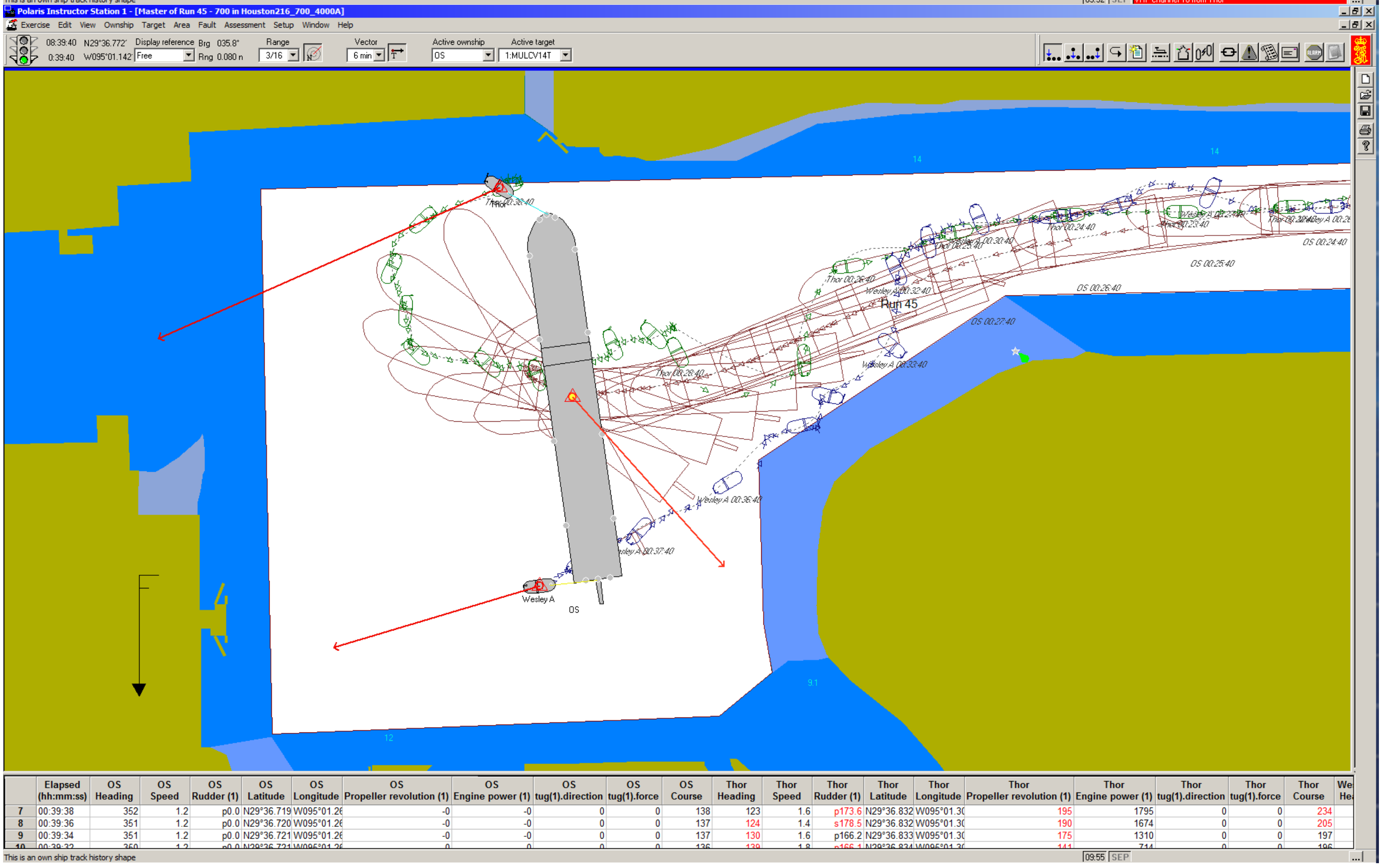
Ownship Monitor - OS

Parameters	OS	Wesley A	Thor
Bridge	Bridge A	Bridge C	Bridge B
Model	MULCV14T	mz7505	ms7505
Heading	286.6	025.4	204.2
Turnrate	s11	s259	s77
Speed	0.9	−4.9	−1.0
Speedrate	−1.0	−23.3	13.0
RPM P (%)		98.5	76.4
RPM C (%)	−48.9		
RPM C (%)			
RPM S (%)		98.4	70.1
Pitch P (%)		100.0	100.0
Pitch C (%)	100.0		
Pitch C (%)			
Pitch S (%)		100.0	100.0
Bow Thr.(%)	s0.2		
Stern Thr(%)			
Rudder	s0	s149	p148
Distance	2.3	2.5	2.4
Depth Keel	1.7	9.2	9.6
Depth Fore	15.5	15.5	15.5
Depth Aft	15.5	15.5	15.5
CPA	--	0.12 nm	0.09 nm
TCPA	--	−0:09	1:54

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We Hea
7	00:36:28	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3560	0	0	288	201	1.7	p171.2	N29°36.783	W095°01.37	140	651	0	0	344	
8	00:36:26	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3559	0	0	287	195	2.1	p175.0	N29°36.782	W095°01.37	140	637	0	0	342	
9	00:36:24	286	1.0	p0.0	N29°36.726	W095°01.27	-33	3558	0	0	287	191	2.0	p175.0	N29°36.781	W095°01.36	139	632	0	0	329	
10	00:36:22	285	1.0	p0.0	N29°36.726	W095°01.27	-33	3557	0	0	286	190	1.6	p163.4	N29°36.780	W095°01.36	137	607	0	0	319	

This is an own ship track history shape

09:52 SEP VHF channel 16 from Thor



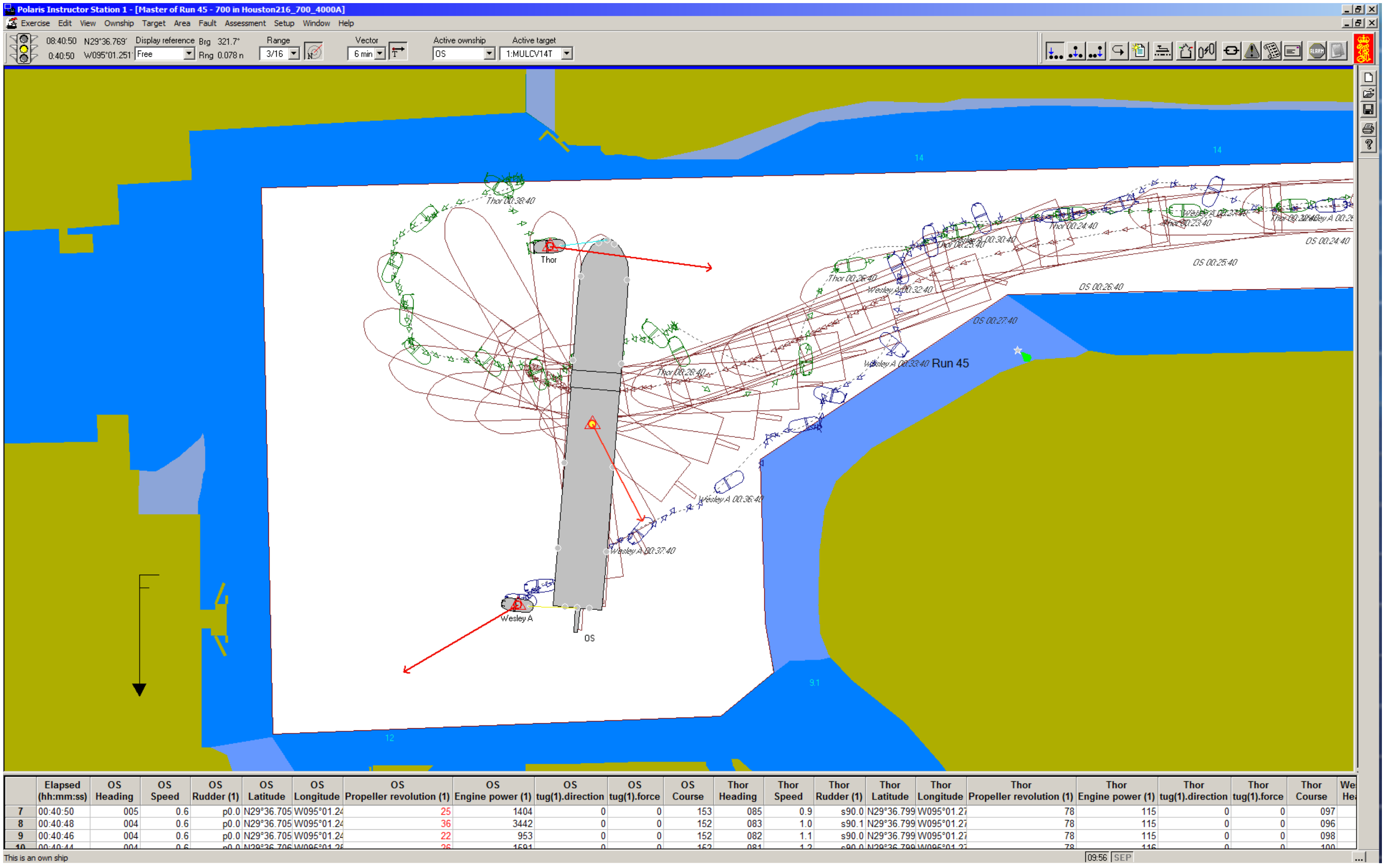
Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:39:40 N29°36.772′ Display reference Free Brg 035.8° Rng 0.080 n Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:39:40 W095°01.142′

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We Hea
7	00:39:38	352	1.2	p0.0	N29°36.719	W095°01.26	-0	-0	0	0	138	123	1.6	p173.6	N29°36.832	W095°01.30	195	1795	0	0	234	
8	00:39:36	351	1.2	p0.0	N29°36.720	W095°01.26	-0	-0	0	0	137	124	1.4	s178.5	N29°36.832	W095°01.30	190	1674	0	0	205	
9	00:39:34	351	1.2	p0.0	N29°36.721	W095°01.26	-0	-0	0	0	137	130	1.6	p166.2	N29°36.833	W095°01.30	175	1310	0	0	197	
10	00:39:32	350	1.2	p0.0	N29°36.721	W095°01.26	-0	-0	0	0	136	139	1.8	p166.1	N29°36.834	W095°01.30	141	714	0	0	196	

This is an own ship track history shape

09:55 SEP



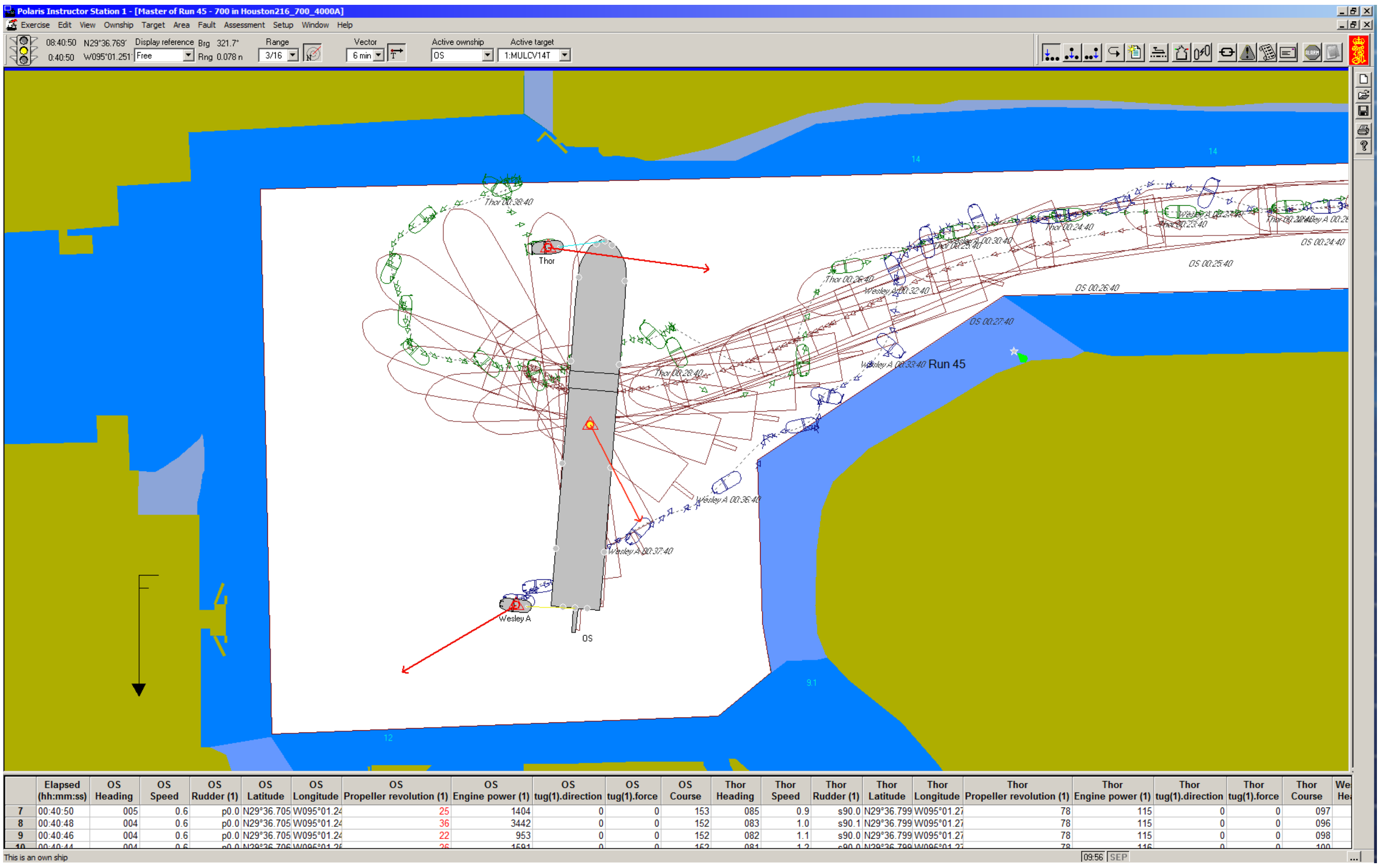
Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:40:50 N29°36.769' Display reference: Free Brg 321.7°
0:40:50 W095°01.251' Rng 0.078 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:40:50	005	0.6	p0.0	N29°36.705	W095°01.24	25	1404	0	0	153	085	0.9	s90.0	N29°36.799	W095°01.27	78	115	0	0	097	
8	00:40:48	004	0.6	p0.0	N29°36.705	W095°01.24	36	3442	0	0	152	083	1.0	s90.1	N29°36.799	W095°01.27	78	115	0	0	096	
9	00:40:46	004	0.6	p0.0	N29°36.705	W095°01.24	22	953	0	0	152	082	1.1	s90.0	N29°36.799	W095°01.27	78	115	0	0	098	

This is an own ship

09:56 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

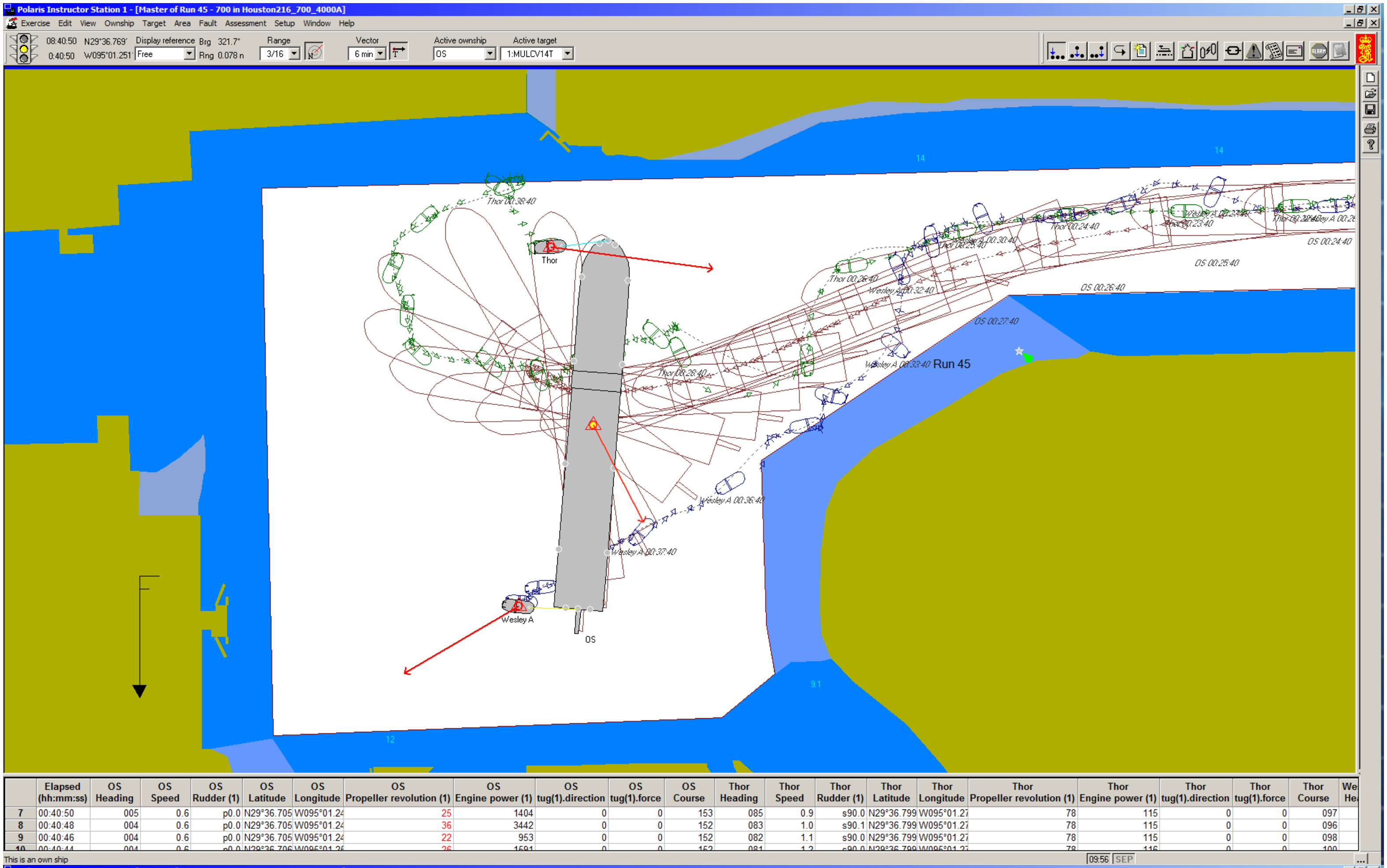
08:40:50 N29°36.769' Display reference: Free Brg 321.7°
0:40:50 W095°01.251' Rng 0.078 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:40:50	005	0.6	p0.0	N29°36.705	W095°01.24	25	1404	0	0	153	085	0.9	s90.0	N29°36.799	W095°01.27	78	115	0	0	097	
8	00:40:48	004	0.6	p0.0	N29°36.705	W095°01.24	36	3442	0	0	152	083	1.0	s90.1	N29°36.799	W095°01.27	78	115	0	0	096	
9	00:40:46	004	0.6	p0.0	N29°36.705	W095°01.24	22	953	0	0	152	082	1.1	s90.0	N29°36.799	W095°01.27	78	115	0	0	098	

This is an own ship

09:56 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

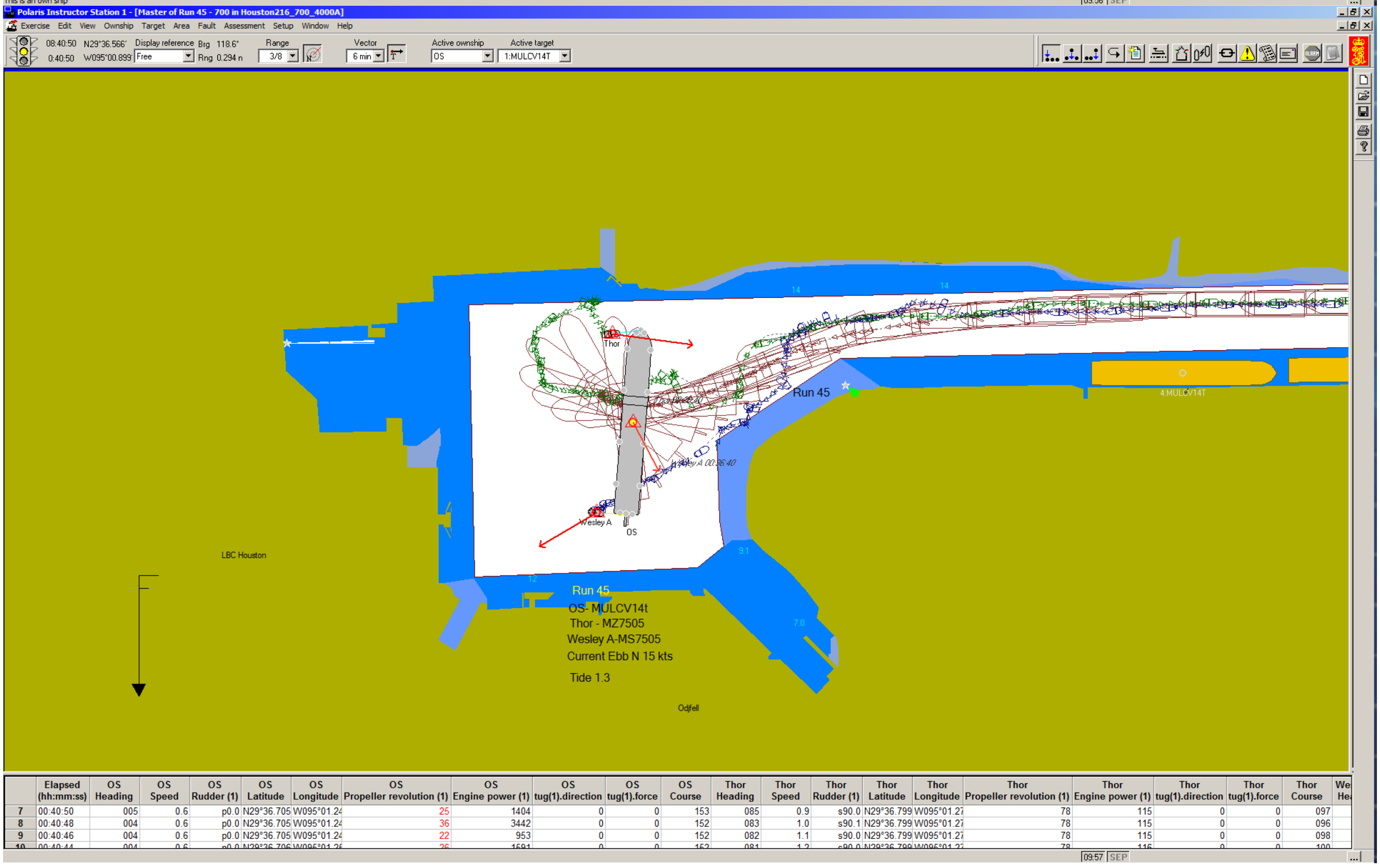
08:40:50 N29°36.769' Display reference: Free Brg 321.7° Rng 0.078 n Range: 3/16 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:40:50 W095°01.251'

Run 45

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:40:50	005	0.6	p0.0	N29°36.705	W095°01.24	25	1404	0	0	153	085	0.9	s90.0	N29°36.799	W095°01.27	78	115	0	0	097	
8	00:40:48	004	0.6	p0.0	N29°36.705	W095°01.24	36	3442	0	0	152	083	1.0	s90.1	N29°36.799	W095°01.27	78	115	0	0	096	
9	00:40:46	004	0.6	p0.0	N29°36.705	W095°01.24	22	953	0	0	152	082	1.1	s90.0	N29°36.799	W095°01.27	78	115	0	0	098	

This is an own ship

09:56 SEP



Polaris Instructor Station 1 - [Master of Run 45 - 700 in Houston216_700_4000A]

08:40:50 N29°36.566' Display reference: Free Brg 118.6° Rng 0.294 n Range: 3/8 Vector: 6 min Active ownship: OS Active target: 1:MULCV14T
0:40:50 W095°00.899'

Run 45

Run 45
OS- MULCV14t
Thor - MZ7505
Wesley A-MS7505
Current Ebb N 15 kts

Tide 1.3

	Elapsed (hh:mm:ss)	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course	Thor Heading	Thor Speed	Thor Rudder (1)	Thor Latitude	Thor Longitude	Thor Propeller revolution (1)	Thor Engine power (1)	Thor tug(1).direction	Thor tug(1).force	Thor Course	We He
7	00:40:50	005	0.6	p0.0	N29°36.705	W095°01.24	25	1404	0	0	153	085	0.9	s90.0	N29°36.799	W095°01.27	78	115	0	0	097	
8	00:40:48	004	0.6	p0.0	N29°36.705	W095°01.24	36	3442	0	0	152	083	1.0	s90.1	N29°36.799	W095°01.27	78	115	0	0	096	
9	00:40:46	004	0.6	p0.0	N29°36.705	W095°01.24	22	953	0	0	152	082	1.1	s90.0	N29°36.799	W095°01.27	78	115	0	0	098	

09:57 SEP

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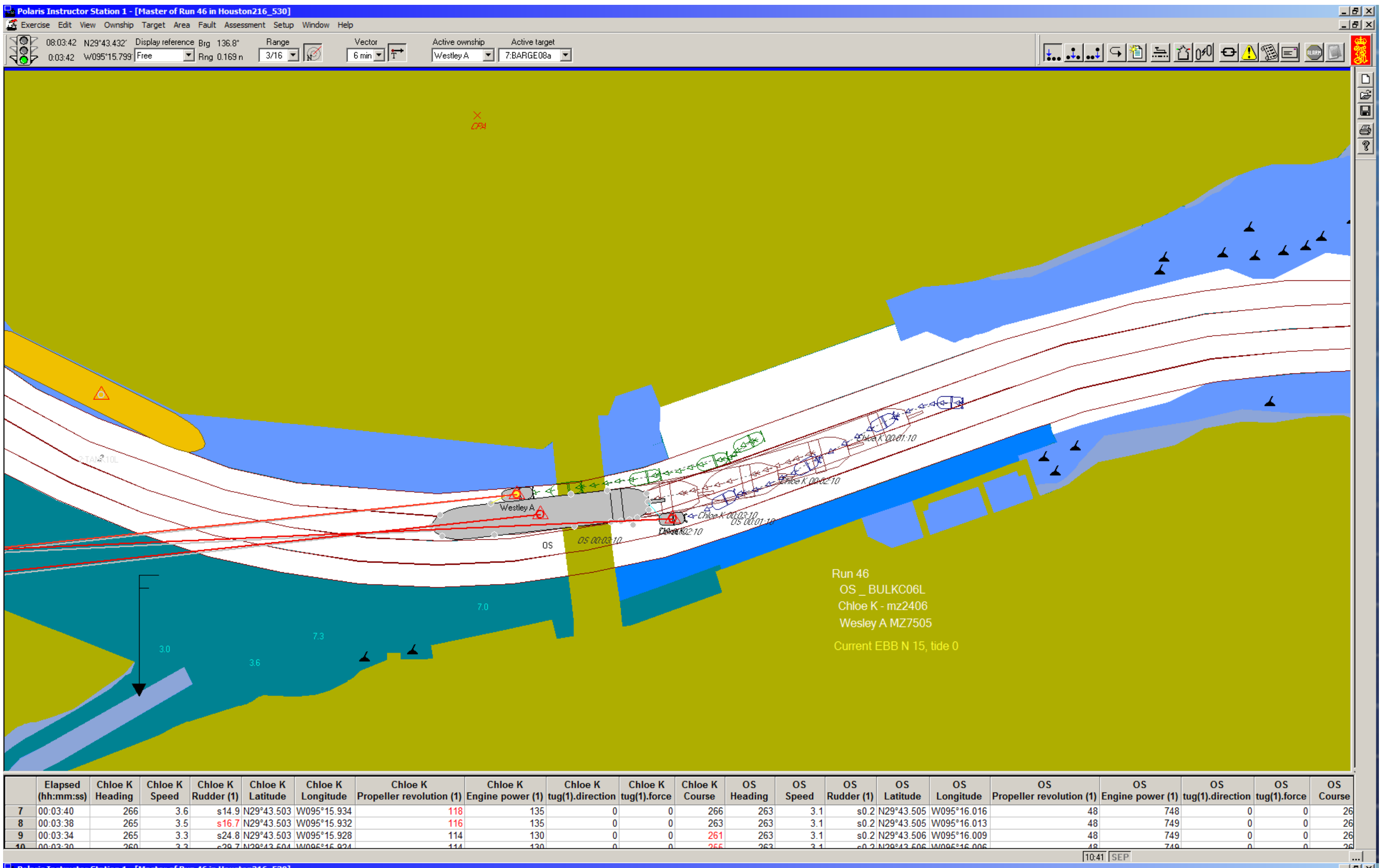
Appendix O: Brady Island Turning Basin Simulations

Run 46



Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

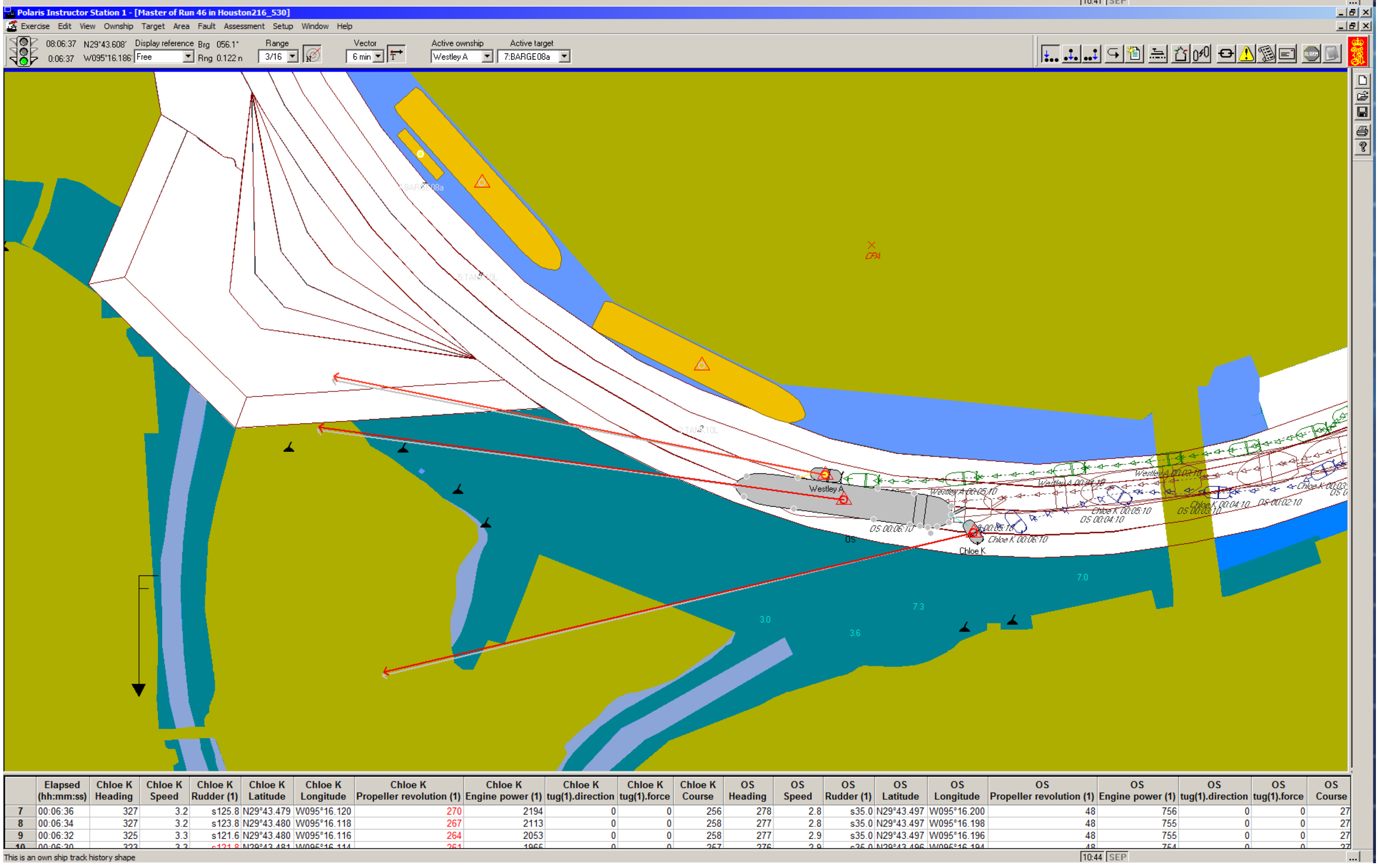
08:03:42 N29°43.432′ Display reference Free Brg 136.8° Rng 0.169 n Range 3/16 Vector 6 min Active ownship Westley A Active target 7:BARGE08a
0:03:42 W095°15.799′

Run 46
OS _ BULKC06L
Chloe K - mz2406
Wesley A MZ7505

Current EBB N 15, tide 0

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:03:40	266	3.6	s14.9	N29°43.503	W095°15.934	118	135	0	0	266	263	3.1	s0.2	N29°43.505	W095°16.016	48	748	0	0	26
8	00:03:38	265	3.5	s16.7	N29°43.503	W095°15.932	116	135	0	0	263	263	3.1	s0.2	N29°43.505	W095°16.013	48	749	0	0	26
9	00:03:34	265	3.3	s24.8	N29°43.503	W095°15.928	114	130	0	0	261	263	3.1	s0.2	N29°43.506	W095°16.009	48	749	0	0	26
10	00:03:30	260	3.3	s29.7	N29°43.504	W095°15.924	114	130	0	0	255	263	3.1	s0.2	N29°43.506	W095°16.006	48	749	0	0	26

10:41 SEP



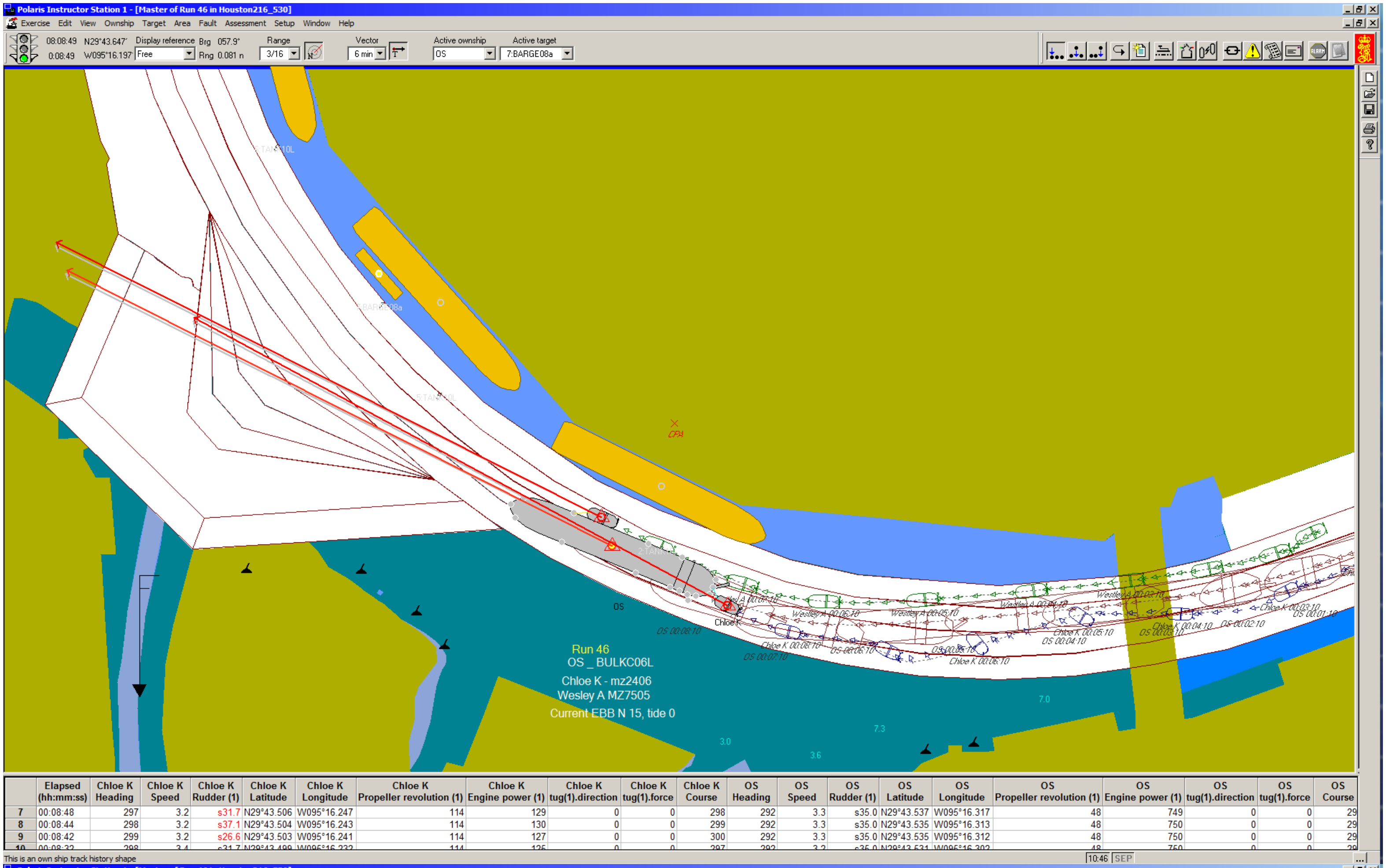
Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

08:06:37 N29°43.608′ Display reference Free Brg 056.1° Rng 0.122 n Range 3/16 Vector 6 min Active ownship Westley A Active target 7:BARGE08a
0:06:37 W095°16.186′

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:06:36	327	3.2	s125.8	N29°43.479	W095°16.120	270	2194	0	0	256	278	2.8	s35.0	N29°43.497	W095°16.200	48	756	0	0	27
8	00:06:34	327	3.2	s123.8	N29°43.480	W095°16.118	267	2113	0	0	258	277	2.8	s35.0	N29°43.497	W095°16.198	48	755	0	0	27
9	00:06:32	325	3.3	s121.6	N29°43.480	W095°16.116	264	2053	0	0	258	277	2.9	s35.0	N29°43.497	W095°16.196	48	755	0	0	27
10	00:06:30	323	3.3	s121.8	N29°43.481	W095°16.114	261	1965	0	0	257	276	2.9	s35.0	N29°43.496	W095°16.194	48	754	0	0	27

This is an own ship track history shape

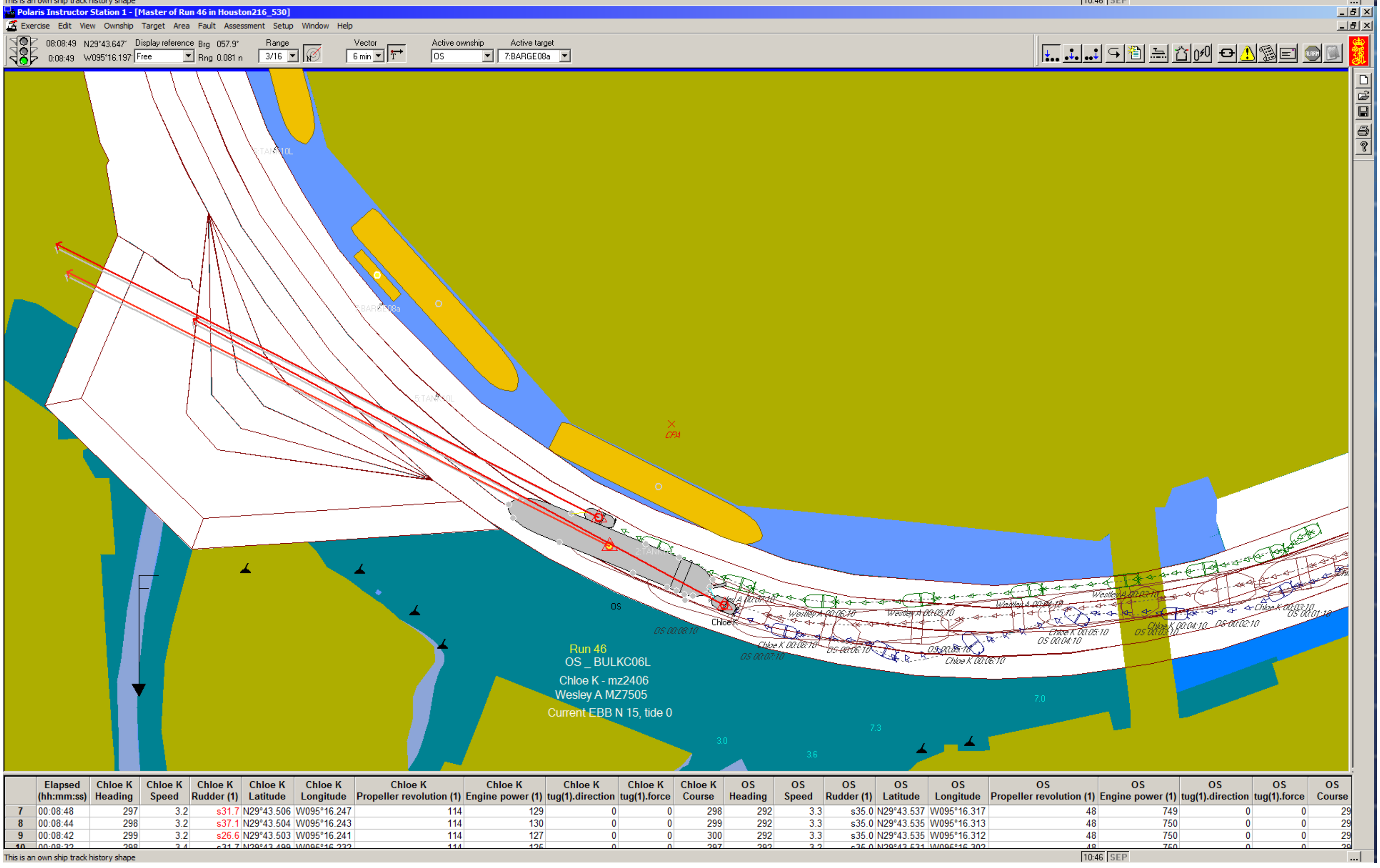
10:44 SEP



Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:08:48	297	3.2	s31.7	N29°43.506	W095°16.247	114	129	0	0	298	292	3.3	s35.0	N29°43.537	W095°16.317	48	749	0	0	29
8	00:08:44	298	3.2	s37.1	N29°43.504	W095°16.243	114	130	0	0	299	292	3.3	s35.0	N29°43.535	W095°16.313	48	750	0	0	29
9	00:08:42	299	3.2	s26.6	N29°43.503	W095°16.241	114	127	0	0	300	292	3.3	s35.0	N29°43.535	W095°16.312	48	750	0	0	29
10	00:08:32	298	3.4	s31.7	N29°43.499	W095°16.232	114	125	0	0	297	292	3.2	s35.0	N29°43.531	W095°16.302	48	750	0	0	29

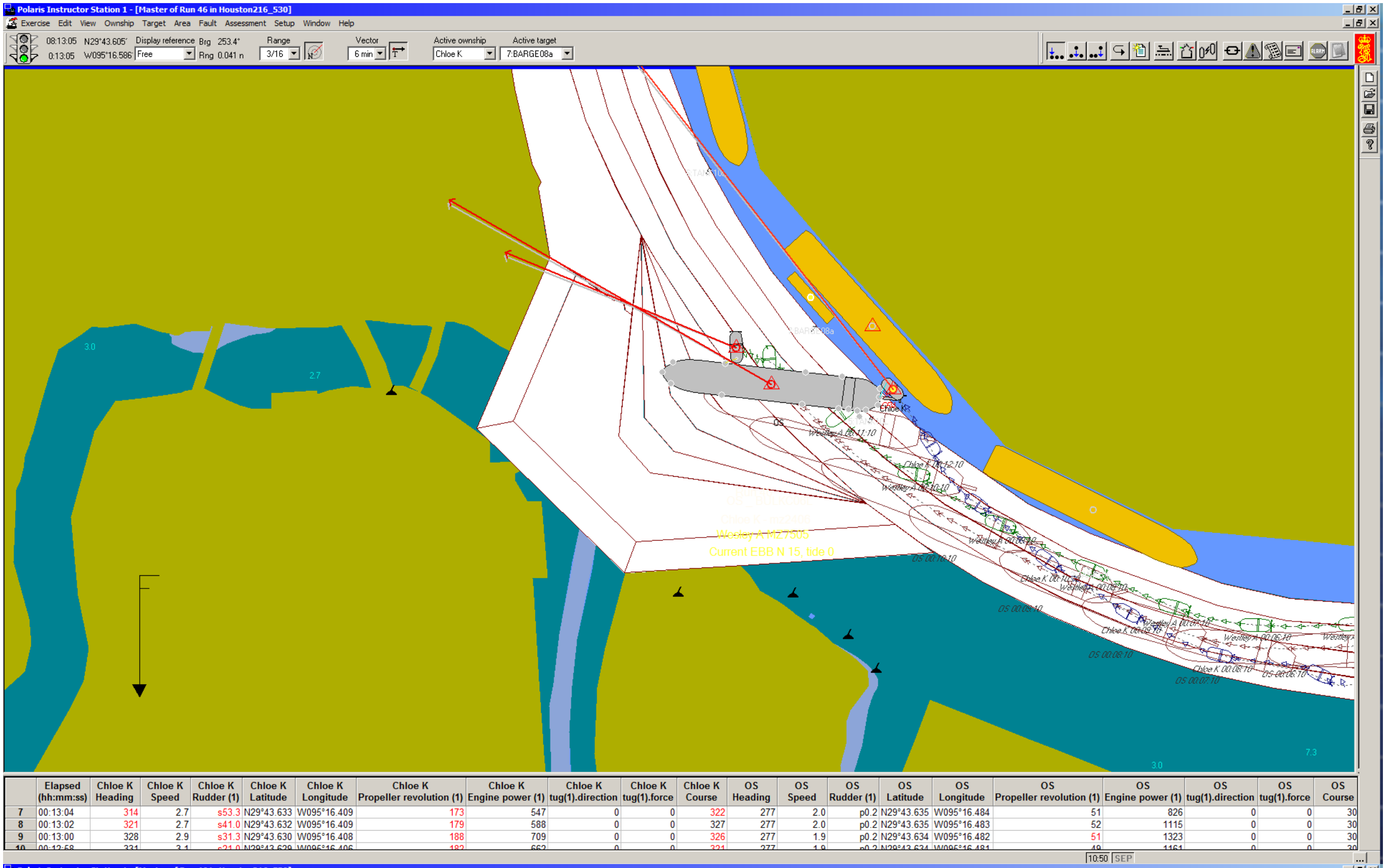
This is an own ship track history shape



Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

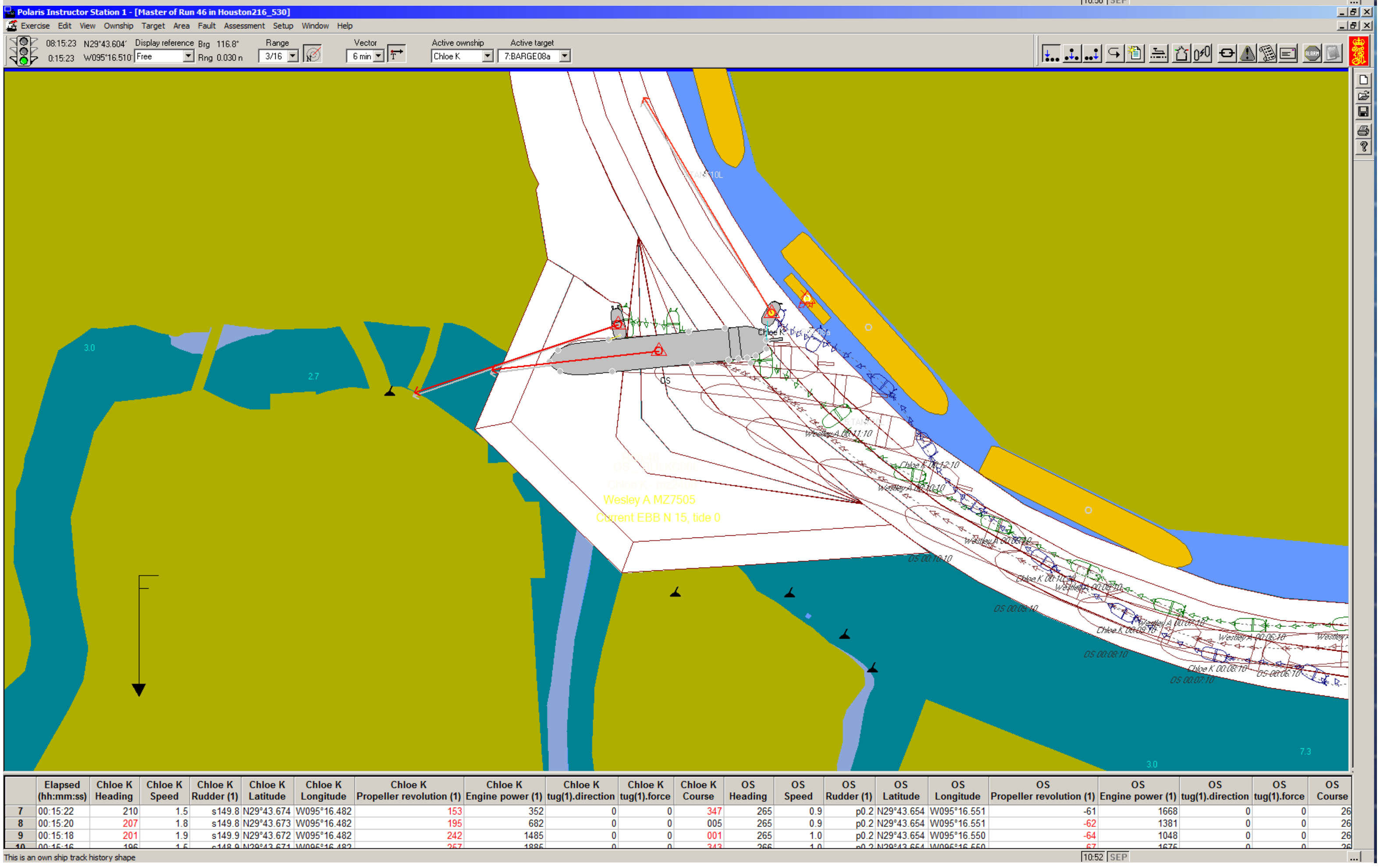
	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:08:48	297	3.2	s31.7	N29°43.506	W095°16.247	114	129	0	0	298	292	3.3	s35.0	N29°43.537	W095°16.317	48	749	0	0	29
8	00:08:44	298	3.2	s37.1	N29°43.504	W095°16.243	114	130	0	0	299	292	3.3	s35.0	N29°43.535	W095°16.313	48	750	0	0	29
9	00:08:42	299	3.2	s26.6	N29°43.503	W095°16.241	114	127	0	0	300	292	3.3	s35.0	N29°43.535	W095°16.312	48	750	0	0	29
10	00:08:32	298	3.4	s31.7	N29°43.499	W095°16.232	114	125	0	0	297	292	3.2	s35.0	N29°43.531	W095°16.302	48	750	0	0	29

This is an own ship track history shape



08:13:05 N29°43.605' Display reference: Free Brg 253.4° Rng 0.041 n
0:13:05 W095°16.586'
Range: 3/16
Vector: 6 min
Active ownship: Chloe K
Active target: 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:13:04	314	2.7	s53.3	N29°43.633	W095°16.409	173	547	0	0	322	277	2.0	p0.2	N29°43.635	W095°16.484	51	826	0	0	30
8	00:13:02	321	2.7	s41.0	N29°43.632	W095°16.409	179	588	0	0	327	277	2.0	p0.2	N29°43.635	W095°16.483	52	1115	0	0	30
9	00:13:00	328	2.9	s31.3	N29°43.630	W095°16.408	188	709	0	0	326	277	1.9	p0.2	N29°43.634	W095°16.482	51	1323	0	0	30

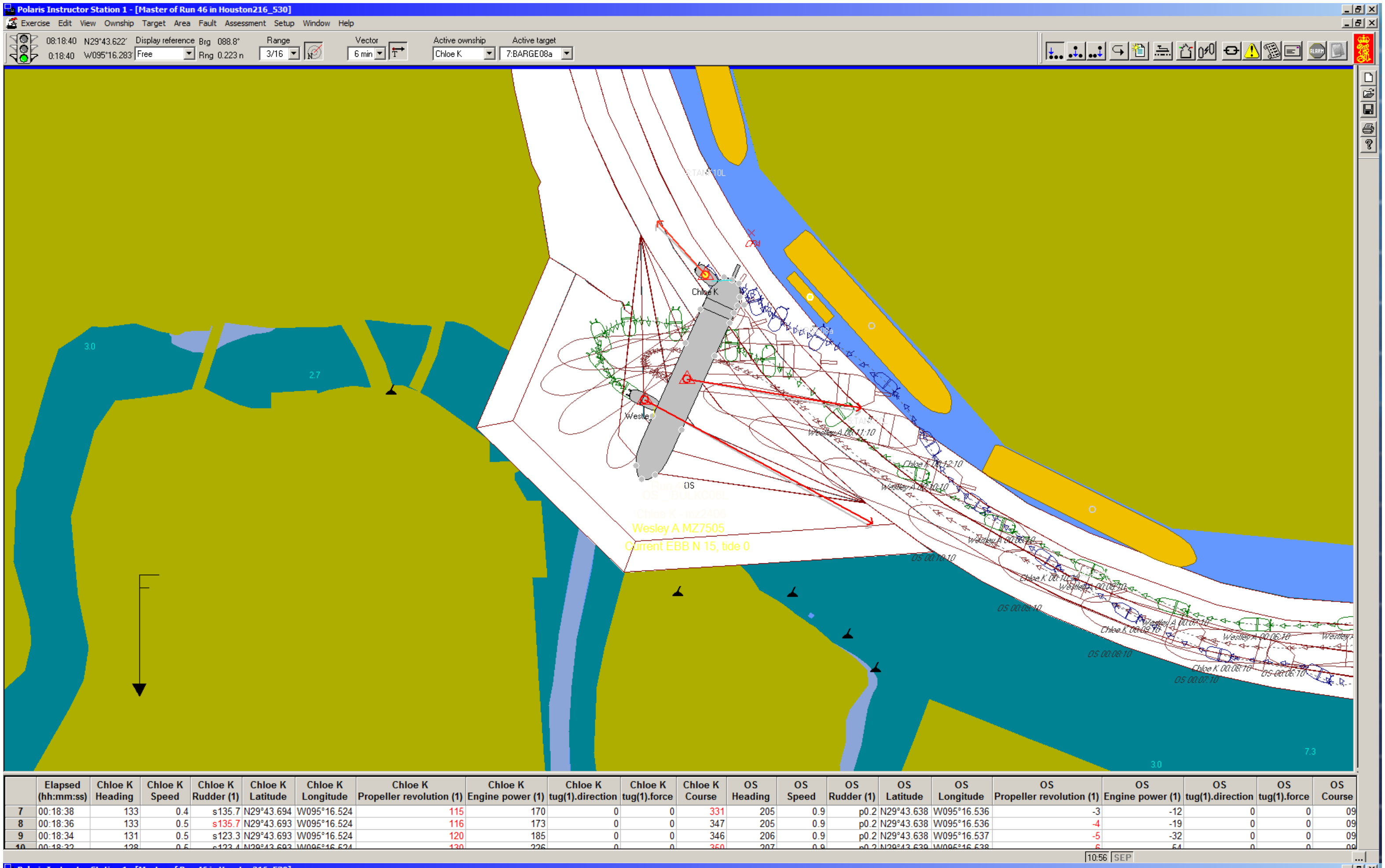


08:15:23 N29°43.604' Display reference: Free Brg 116.8° Rng 0.030 n
0:15:23 W095°16.510'
Range: 3/16
Vector: 6 min
Active ownship: Chloe K
Active target: 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:15:22	210	1.5	s149.8	N29°43.674	W095°16.482	153	352	0	0	347	265	0.9	p0.2	N29°43.654	W095°16.551	-61	1668	0	0	26
8	00:15:20	207	1.8	s149.8	N29°43.673	W095°16.482	195	682	0	0	005	265	0.9	p0.2	N29°43.654	W095°16.551	-62	1381	0	0	26
9	00:15:18	201	1.9	s149.9	N29°43.672	W095°16.482	242	1485	0	0	001	265	1.0	p0.2	N29°43.654	W095°16.550	-64	1048	0	0	26

This is an own ship track history shape

June 26, 2019

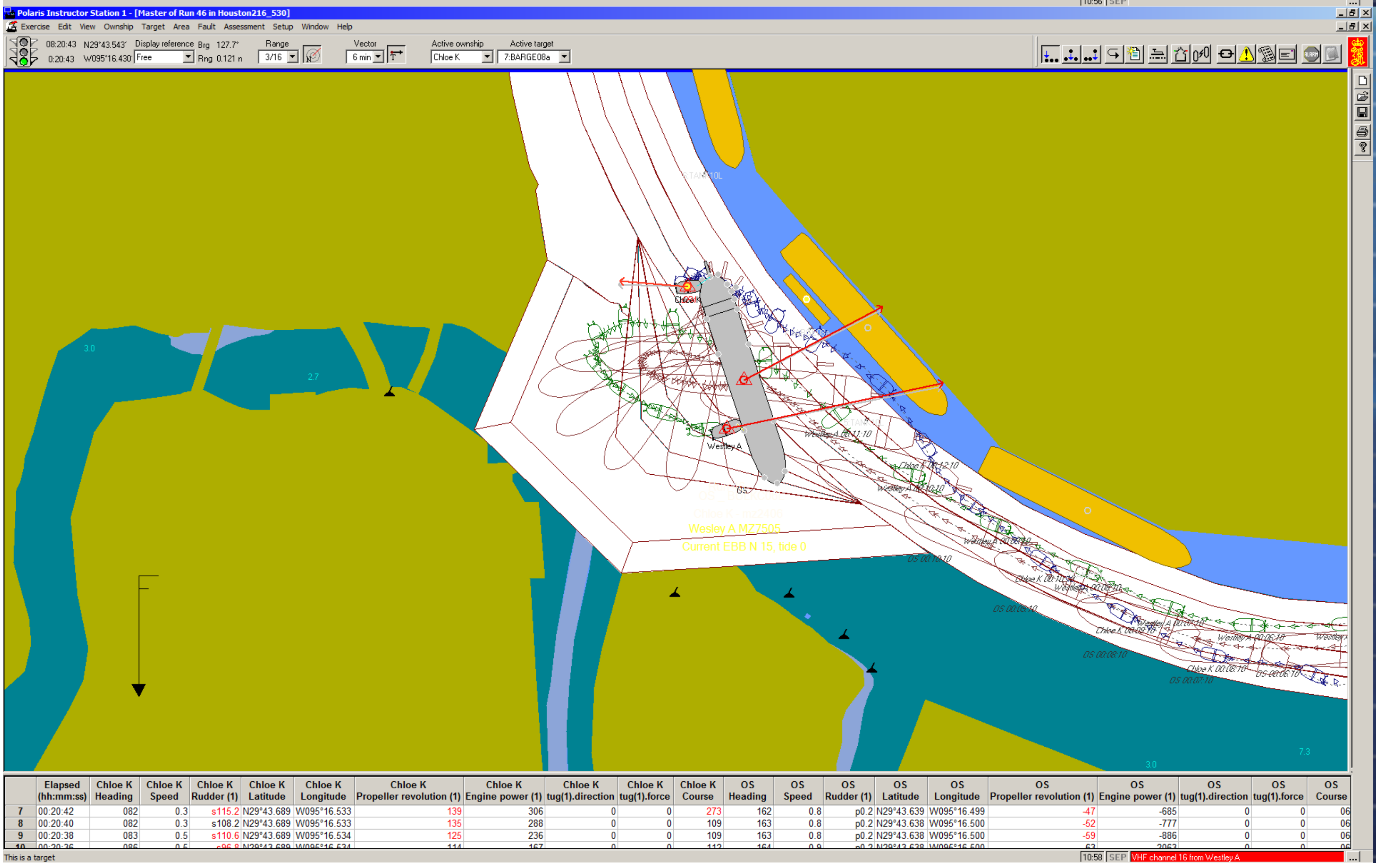


Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

08:18:40 N29°43.622′ Display reference Free Brg 088.8° Rng 0.223 n Range 3/16 Vector 6 min Active ownship Chloe K Active target 7:BARGE08a
0:18:40 W095°16.283′

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:18:38	133	0.4	s135.7	N29°43.694	W095°16.524	115	170	0	0	331	205	0.9	p0.2	N29°43.638	W095°16.536	-3	-12	0	0	09
8	00:18:36	133	0.5	s135.7	N29°43.693	W095°16.524	116	173	0	0	347	205	0.9	p0.2	N29°43.638	W095°16.536	-4	-19	0	0	09
9	00:18:34	131	0.5	s123.3	N29°43.693	W095°16.524	120	185	0	0	346	206	0.9	p0.2	N29°43.638	W095°16.537	-5	-32	0	0	09
10	00:18:32	128	0.5	s123.4	N29°43.693	W095°16.524	130	226	0	0	350	207	0.9	p0.2	N29°43.639	W095°16.538	-6	-54	0	0	09

10:56 SEP



Polaris Instructor Station 1 - [Master of Run 46 in Houston216_530]

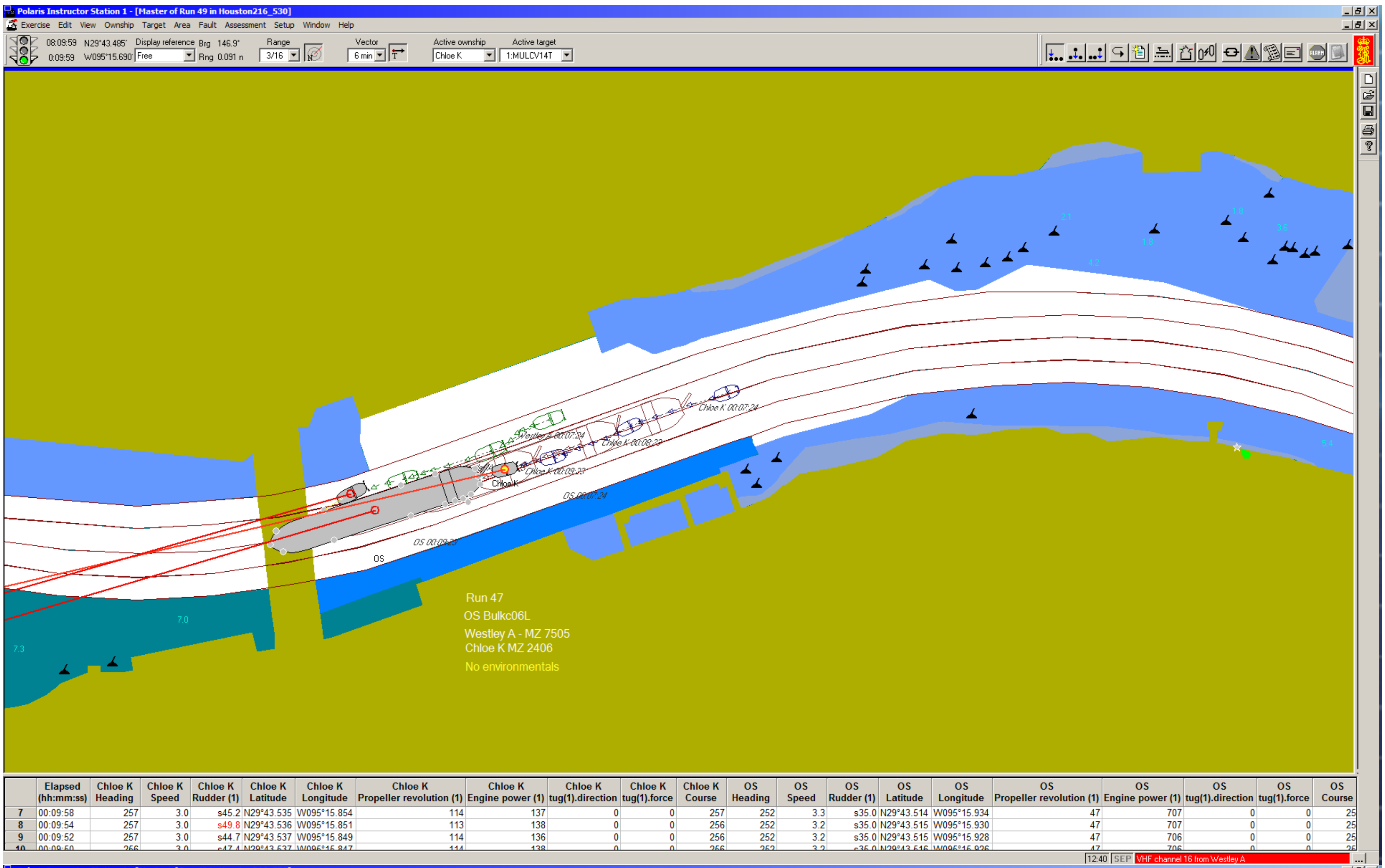
08:20:43 N29°43.543′ Display reference Free Brg 127.7° Rng 0.121 n Range 3/16 Vector 6 min Active ownship Chloe K Active target 7:BARGE08a
0:20:43 W095°16.430′

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:20:42	082	0.3	s115.2	N29°43.689	W095°16.533	139	306	0	0	273	162	0.8	p0.2	N29°43.639	W095°16.499	-47	-685	0	0	06
8	00:20:40	082	0.3	s108.2	N29°43.689	W095°16.533	135	288	0	0	109	163	0.8	p0.2	N29°43.638	W095°16.500	-52	-777	0	0	06
9	00:20:38	083	0.5	s110.6	N29°43.689	W095°16.534	125	236	0	0	109	163	0.8	p0.2	N29°43.638	W095°16.500	-59	-886	0	0	06
10	00:20:36	086	0.5	s96.8	N29°43.689	W095°16.534	114	167	0	0	112	164	0.9	p0.2	N29°43.638	W095°16.500	-63	-2063	0	0	06

This is a target

10:58 SEP VHF channel 16 from Westley A

Run47



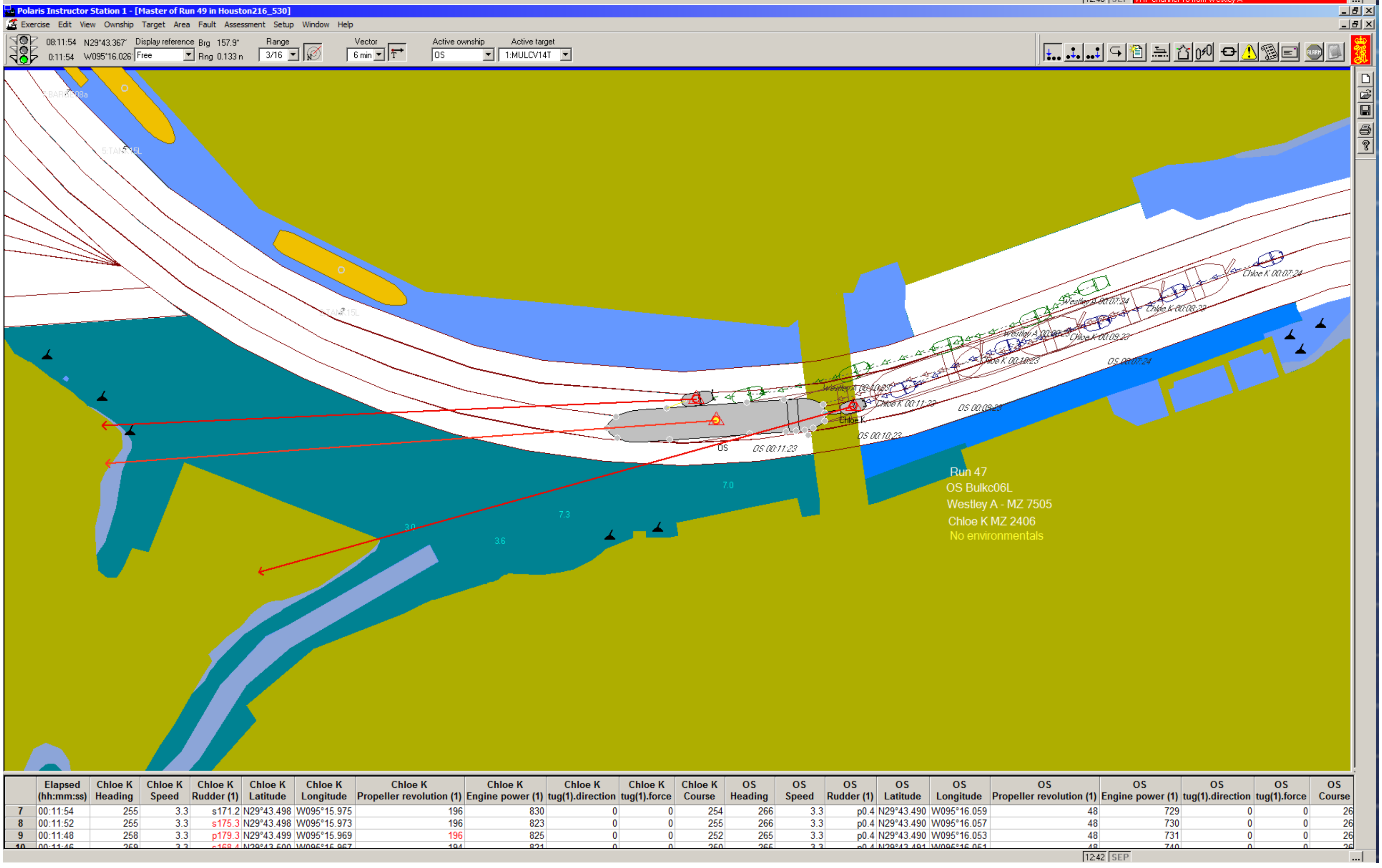
Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:09:59 N29°43.485'
0:09:59 W095°15.690'
Display reference: Free
Brg 146.9°
Rng 0.091 n
Range: 3/16
Vector: 6 min
Active ownship: Chloe K
Active target: 1:MULCV14T

Run 47
OS Bulkc06L
Westley A - MZ 7505
Chloe K MZ 2406
No environmentals

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:09:58	257	3.0	s45.2	N29°43.535	W095°15.854	114	137	0	0	257	252	3.3	s35.0	N29°43.514	W095°15.934	47	707	0	0	25
8	00:09:54	257	3.0	s49.8	N29°43.536	W095°15.851	113	138	0	0	256	252	3.2	s35.0	N29°43.515	W095°15.930	47	707	0	0	25
9	00:09:52	257	3.0	s44.7	N29°43.537	W095°15.849	114	136	0	0	256	252	3.2	s35.0	N29°43.515	W095°15.928	47	706	0	0	25

12:40 SEP VHF channel 16 from Westley A



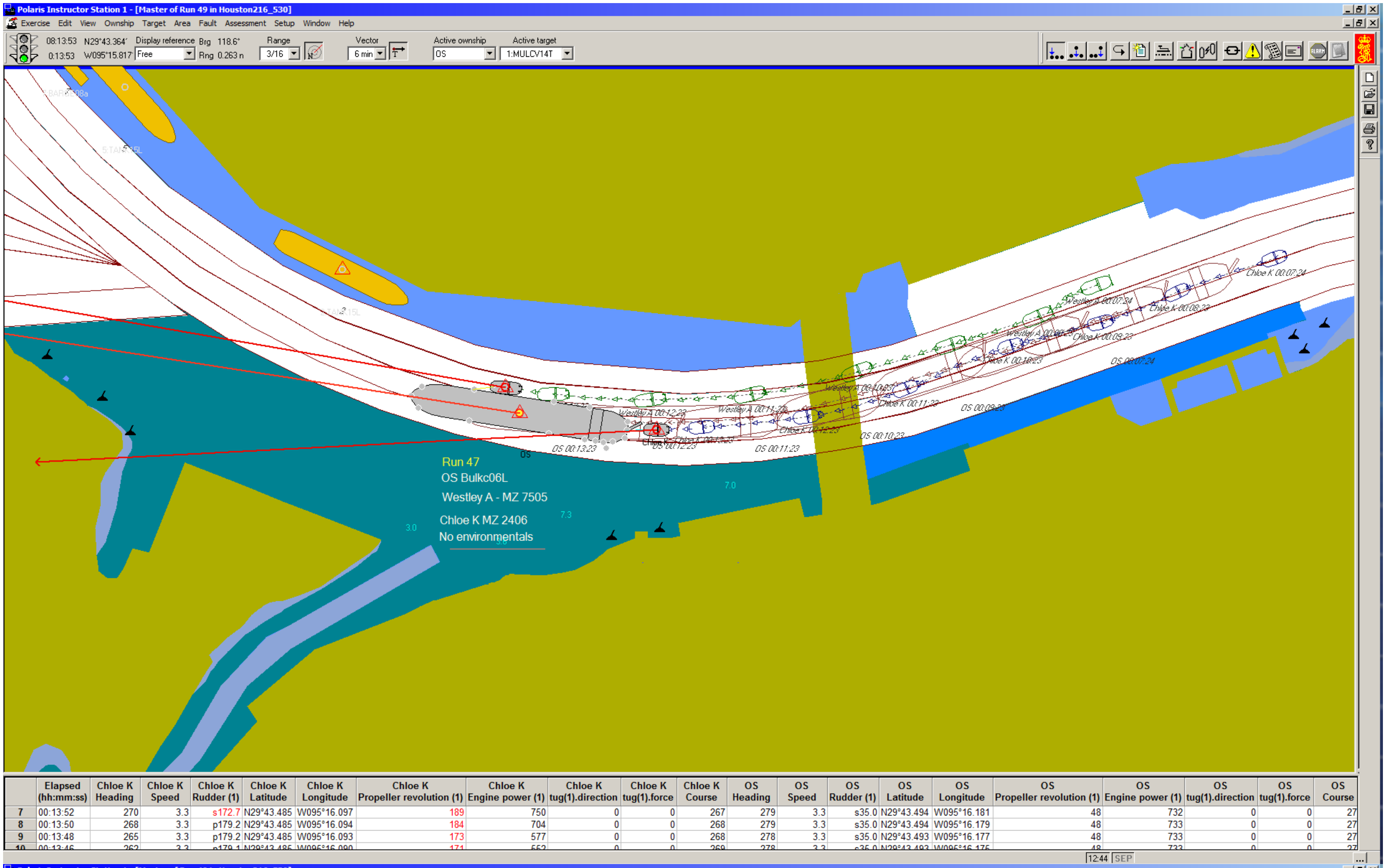
Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:11:54 N29°43.367'
0:11:54 W095°16.026'
Display reference: Free
Brg 157.9°
Rng 0.133 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 1:MULCV14T

Run 47
OS Bulkc06L
Westley A - MZ 7505
Chloe K MZ 2406
No environmentals

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:11:54	255	3.3	s171.2	N29°43.498	W095°15.975	196	830	0	0	254	266	3.3	p0.4	N29°43.490	W095°16.059	48	729	0	0	26
8	00:11:52	255	3.3	s175.3	N29°43.498	W095°15.973	196	823	0	0	255	266	3.3	p0.4	N29°43.490	W095°16.057	48	730	0	0	26
9	00:11:48	258	3.3	p179.3	N29°43.499	W095°15.969	196	825	0	0	252	265	3.3	p0.4	N29°43.490	W095°16.053	48	731	0	0	26

12:42 SEP



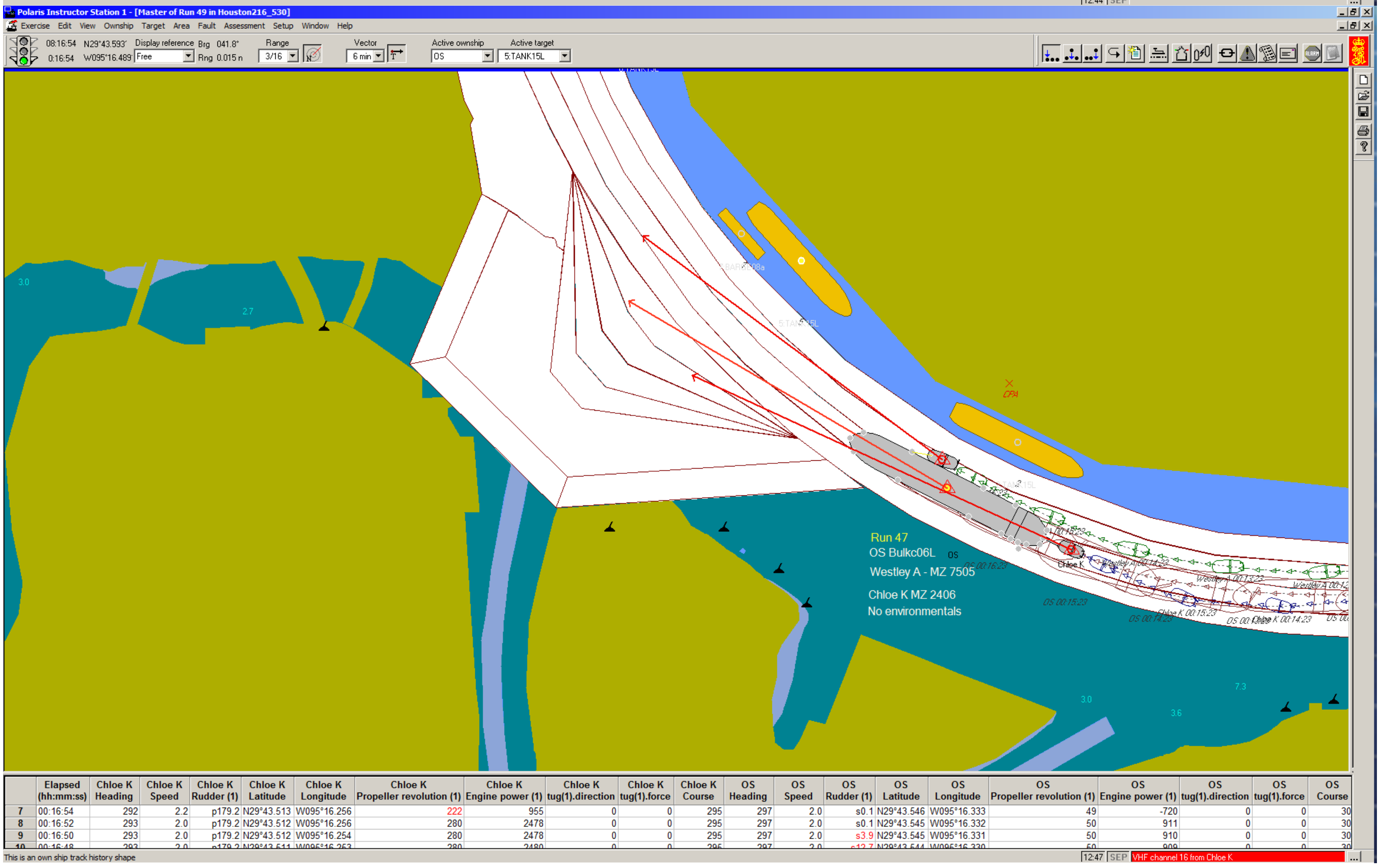
Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:13:53 N29°43.364' Display reference Free Brg 118.6° Range 3/16 Vector 6 min Active ownship OS Active target 1:MULCV14T
0:13:53 W095°15.817' Rng 0.263 n

Run 47
OS Bulkc06L
Westley A - MZ 7505
Chloe K MZ 2406
No environmentals

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:13:52	270	3.3	s172.7	N29°43.485	W095°16.097	189	750	0	0	267	279	3.3	s35.0	N29°43.494	W095°16.181	48	732	0	0	27
8	00:13:50	268	3.3	p179.2	N29°43.485	W095°16.094	184	704	0	0	268	279	3.3	s35.0	N29°43.494	W095°16.179	48	733	0	0	27
9	00:13:48	265	3.3	p179.2	N29°43.485	W095°16.093	173	577	0	0	268	278	3.3	s35.0	N29°43.493	W095°16.177	48	733	0	0	27

12:44 SEP



Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

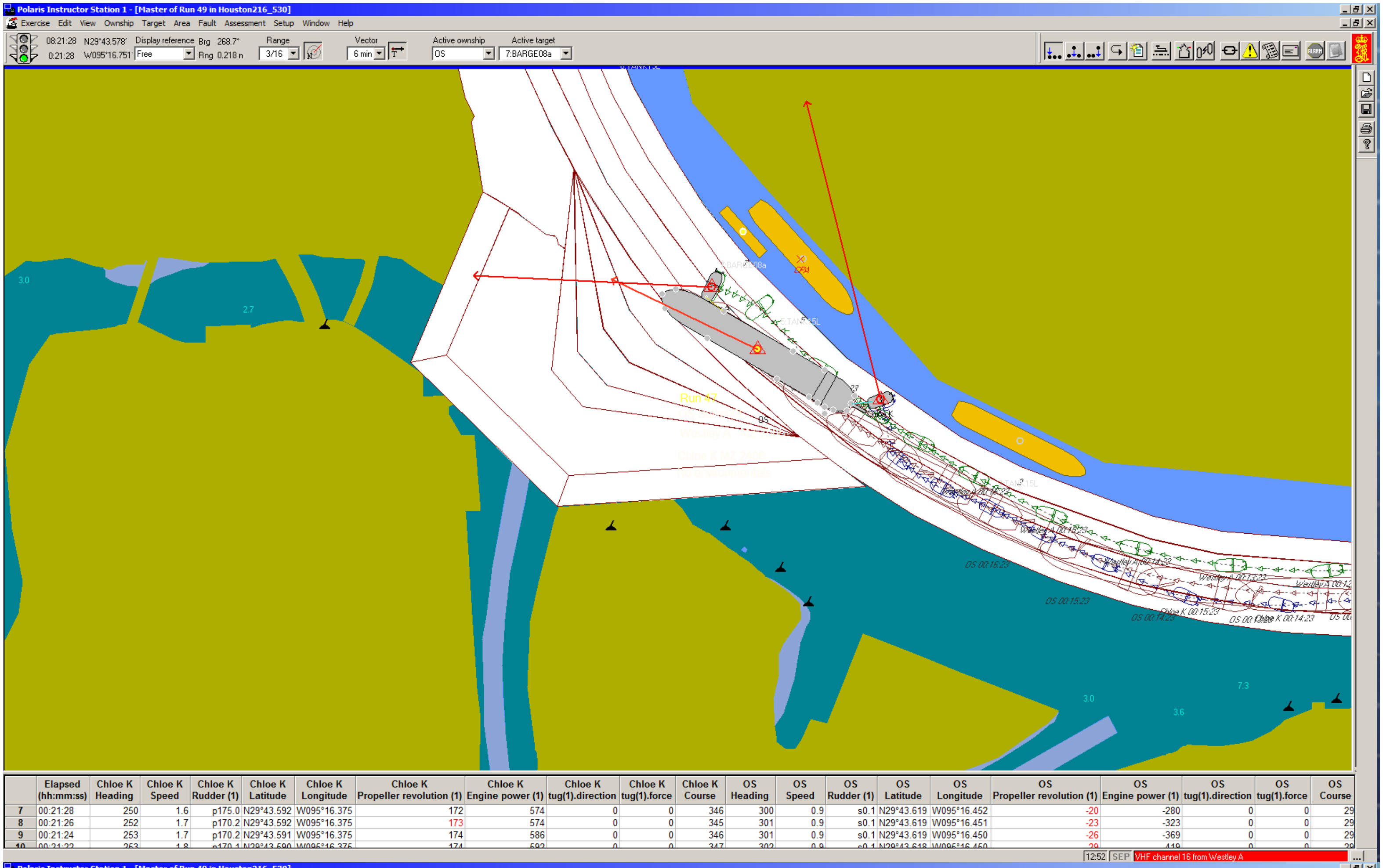
08:16:54 N29°43.593' Display reference Free Brg 041.8° Range 3/16 Vector 6 min Active ownship OS Active target 5:TANK15L
0:16:54 W095°16.489' Rng 0.015 n

Run 47
OS Bulkc06L
Westley A - MZ 7505
Chloe K MZ 2406
No environmentals

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:16:54	292	2.2	p179.2	N29°43.513	W095°16.256	222	955	0	0	295	297	2.0	s0.1	N29°43.546	W095°16.333	49	-720	0	0	30
8	00:16:52	293	2.0	p179.2	N29°43.512	W095°16.256	280	2478	0	0	295	297	2.0	s0.1	N29°43.545	W095°16.332	50	911	0	0	30
9	00:16:50	293	2.0	p179.2	N29°43.512	W095°16.254	280	2478	0	0	295	297	2.0	s3.9	N29°43.545	W095°16.331	50	910	0	0	30

This is an own ship track history shape

12:47 SEP VHF channel 16 from Chloe K

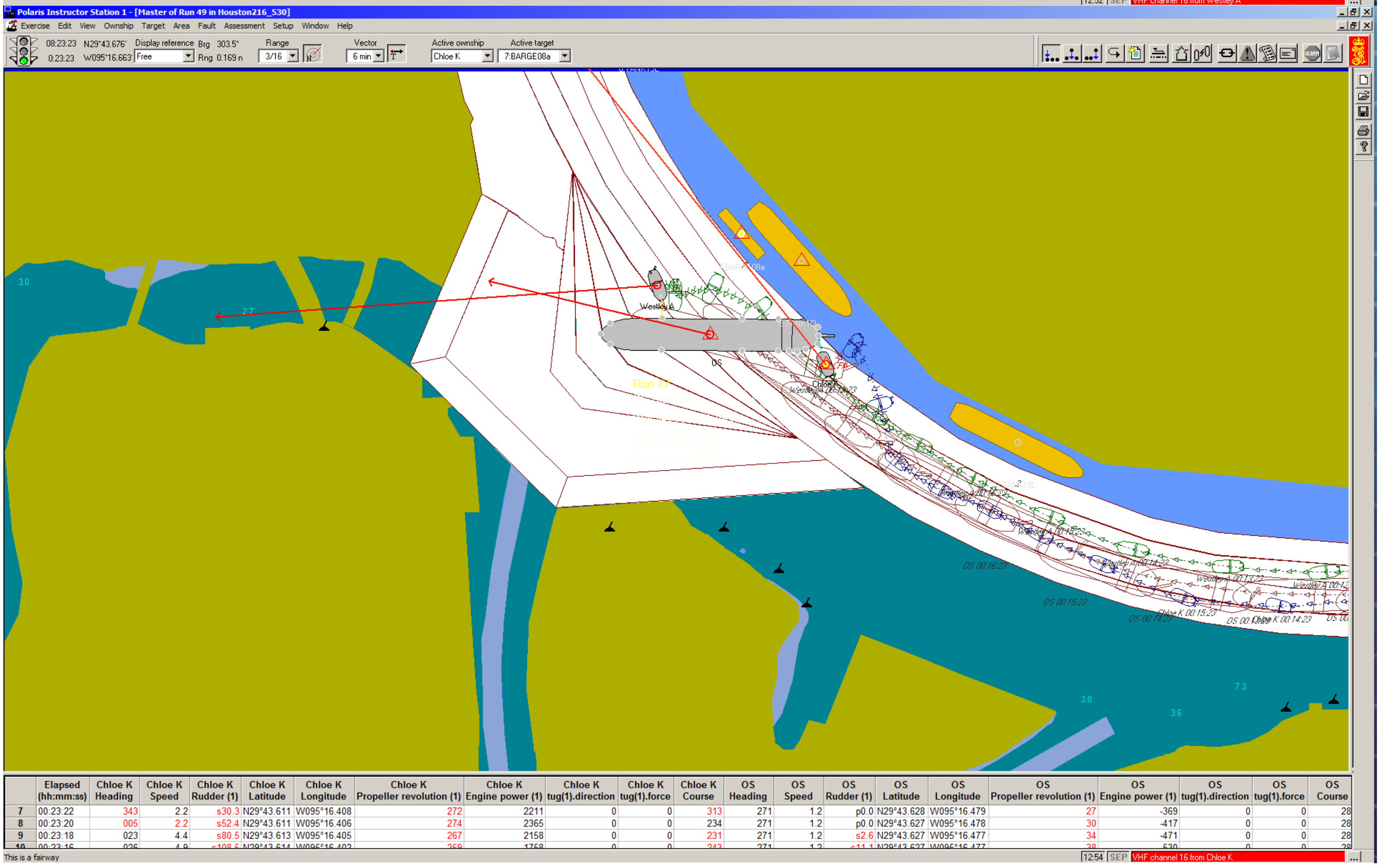


Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:21:28 N29°43.578′
0:21:28 W095°16.751′
Display reference: Free
Brg 268.7°
Rng 0.218 n
Range: 3/16
Vector: 6 min
Active ownship: OS
Active target: 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:21:28	250	1.6	p175.0	N29°43.592	W095°16.375	172	574	0	0	346	300	0.9	s0.1	N29°43.619	W095°16.452	-20	-280	0	0	29
8	00:21:26	252	1.7	p170.2	N29°43.592	W095°16.375	173	574	0	0	345	301	0.9	s0.1	N29°43.619	W095°16.451	-23	-323	0	0	29
9	00:21:24	253	1.7	p170.2	N29°43.591	W095°16.375	174	586	0	0	346	301	0.9	s0.1	N29°43.619	W095°16.450	-26	-369	0	0	29
10	00:21:22	253	1.8	p170.1	N29°43.590	W095°16.375	174	592	0	0	347	302	0.9	s0.1	N29°43.618	W095°16.450	-29	-419	0	0	29

12:52 SEP VHF channel 16 from Westley A



Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

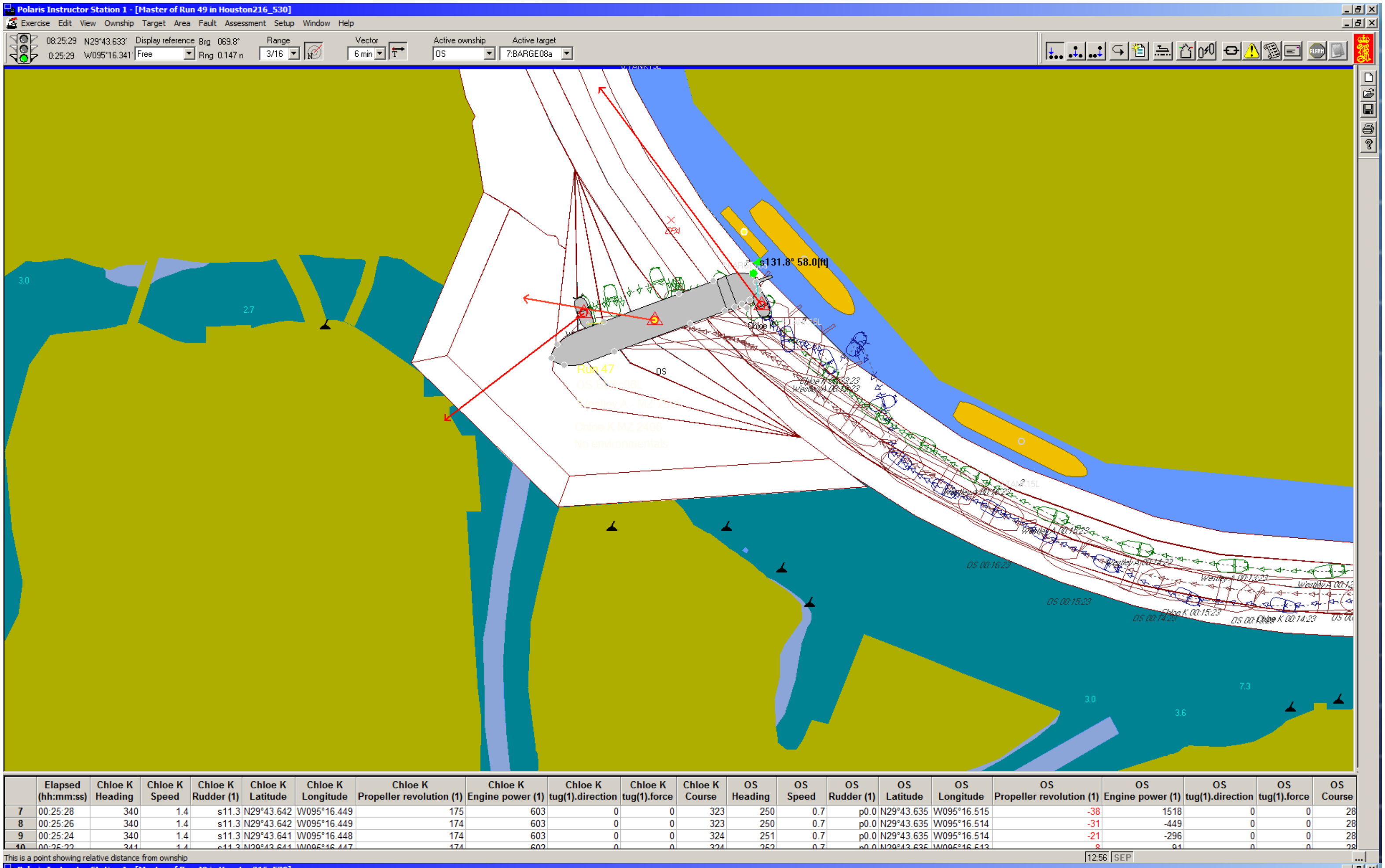
08:23:23 N29°43.676′
0:23:23 W095°16.663′
Display reference: Free
Brg 303.5°
Rng 0.169 n
Range: 3/16
Vector: 6 min
Active ownship: Chloe K
Active target: 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:23:22	343	2.2	s30.3	N29°43.611	W095°16.408	272	2211	0	0	313	271	1.2	p0.0	N29°43.628	W095°16.479	27	-369	0	0	28
8	00:23:20	005	2.2	s52.4	N29°43.611	W095°16.406	274	2365	0	0	234	271	1.2	p0.0	N29°43.627	W095°16.478	30	-417	0	0	28
9	00:23:18	023	4.4	s80.5	N29°43.613	W095°16.405	267	2158	0	0	231	271	1.2	s2.6	N29°43.627	W095°16.477	34	-471	0	0	28
10	00:23:16	026	4.9	s108.5	N29°43.614	W095°16.402	259	1758	0	0	243	271	1.2	s11.1	N29°43.627	W095°16.477	38	-530	0	0	28

This is a fairway

12:54 SEP VHF channel 16 from Chloe K

June 26, 2019

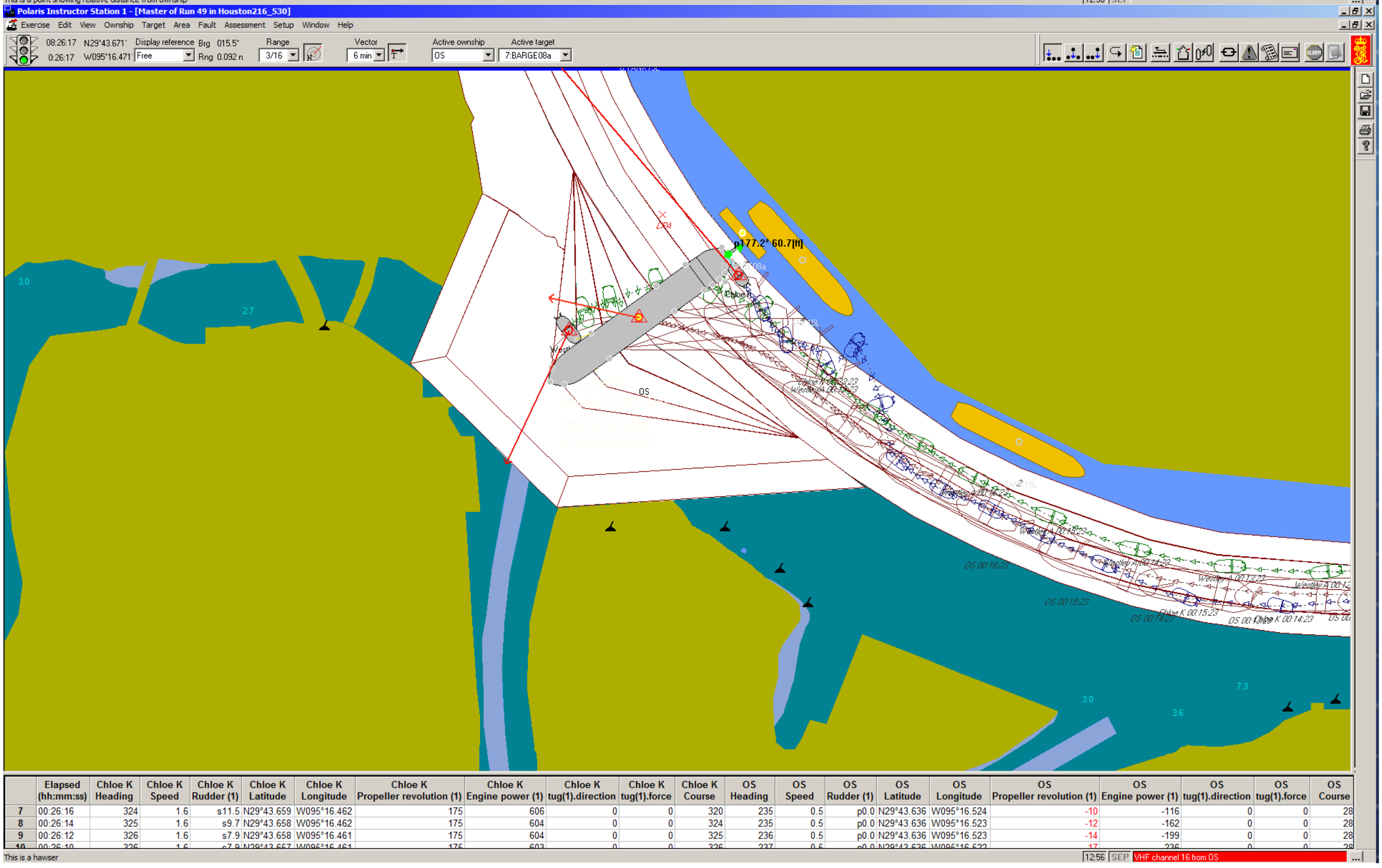


08:25:29 N29°43.633′ Display reference Brg 069.8°
0:25:29 W095°16.341′ Free Rng 0.147 n
Range 3/16
Vector 6 min
Active ownship OS
Active target 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:25:28	340	1.4	s11.3	N29°43.642	W095°16.449	175	603	0	0	323	250	0.7	p0.0	N29°43.635	W095°16.515	-38	1518	0	0	28
8	00:25:26	340	1.4	s11.3	N29°43.642	W095°16.449	174	603	0	0	323	250	0.7	p0.0	N29°43.635	W095°16.514	-31	-449	0	0	28
9	00:25:24	340	1.4	s11.3	N29°43.641	W095°16.448	174	603	0	0	324	251	0.7	p0.0	N29°43.635	W095°16.514	-21	-296	0	0	28
10	00:25:22	341	1.4	s11.3	N29°43.641	W095°16.447	174	602	0	0	324	252	0.7	p0.0	N29°43.635	W095°16.513	8	91	0	0	28

This is a point showing relative distance from ownship

12:56 SEP



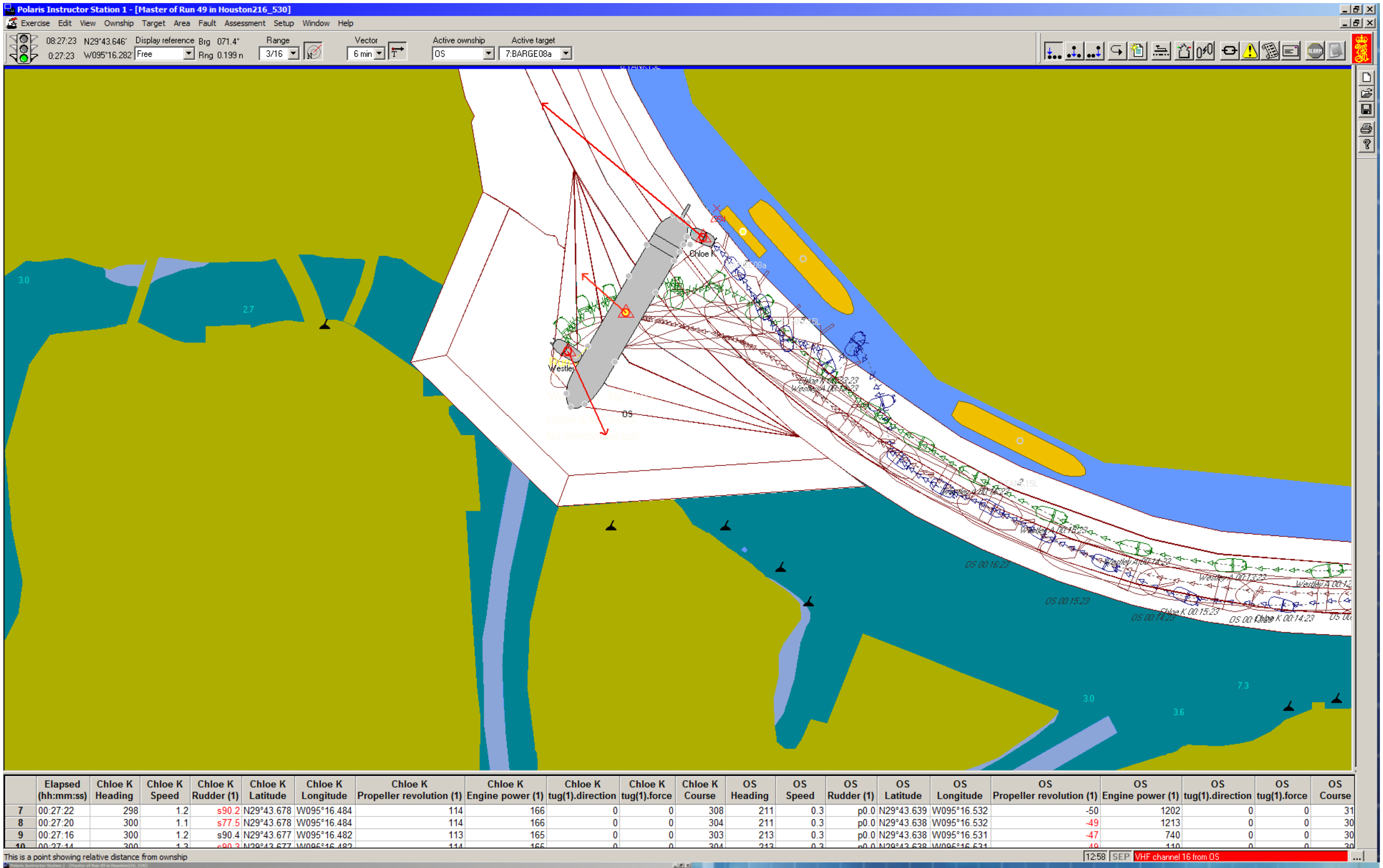
08:26:17 N29°43.671′ Display reference Brg 015.5°
0:26:17 W095°16.471′ Free Rng 0.092 n
Range 3/16
Vector 6 min
Active ownship OS
Active target 7:BARGE08a

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:26:16	324	1.6	s11.5	N29°43.659	W095°16.462	175	606	0	0	320	235	0.5	p0.0	N29°43.636	W095°16.524	-10	-116	0	0	28
8	00:26:14	325	1.6	s9.7	N29°43.658	W095°16.462	175	604	0	0	324	235	0.5	p0.0	N29°43.636	W095°16.523	-12	-162	0	0	28
9	00:26:12	326	1.6	s7.9	N29°43.658	W095°16.461	175	604	0	0	325	236	0.5	p0.0	N29°43.636	W095°16.523	-14	-199	0	0	28
10	00:26:10	326	1.6	s7.9	N29°43.657	W095°16.461	175	603	0	0	326	237	0.5	p0.0	N29°43.636	W095°16.522	-17	-236	0	0	28

This is a hawser

12:56 SEP VHF channel 16 from OS

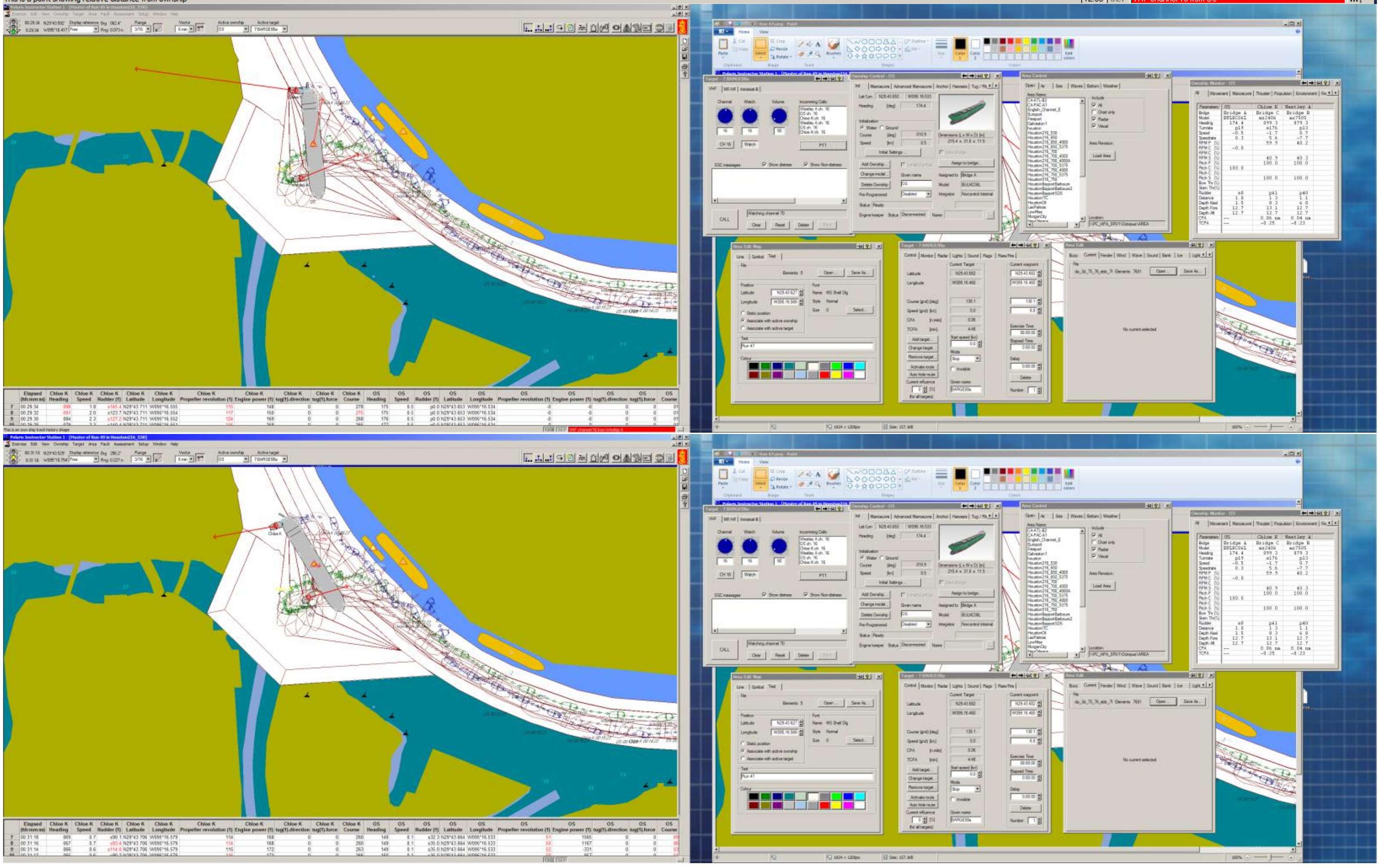
June 26, 2019



	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Course
7	00:27:22	298	1.2	s90.2	N29°43.678	W095°16.484	114	166	0	0	308	211	0.3	p0.0	N29°43.639	W095°16.532	-50	1202	0	0	31
8	00:27:20	300	1.1	s77.5	N29°43.678	W095°16.484	114	166	0	0	304	211	0.3	p0.0	N29°43.638	W095°16.532	-49	1213	0	0	30
9	00:27:16	300	1.2	s90.4	N29°43.677	W095°16.482	113	165	0	0	303	213	0.3	p0.0	N29°43.638	W095°16.531	-47	740	0	0	30
10	00:27:14	300	1.3	s90.3	N29°43.677	W095°16.482	114	165	0	0	304	213	0.3	p0.0	N29°43.638	W095°16.531	-49	110	0	0	30

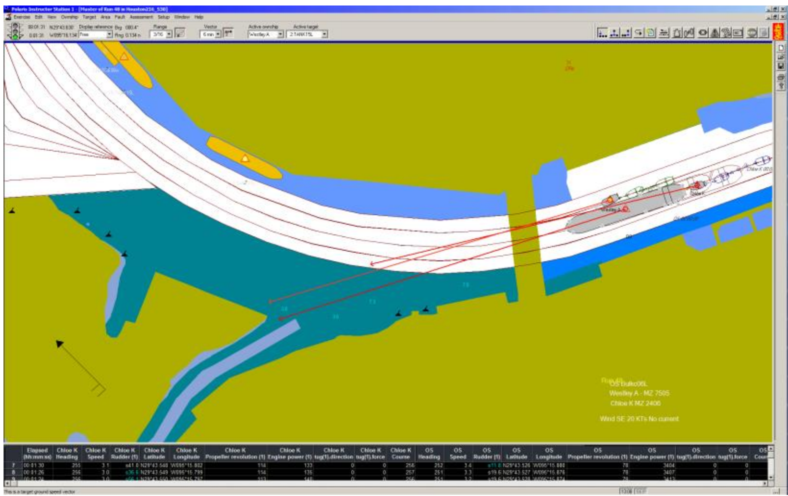
This is a point showing relative distance from ownship

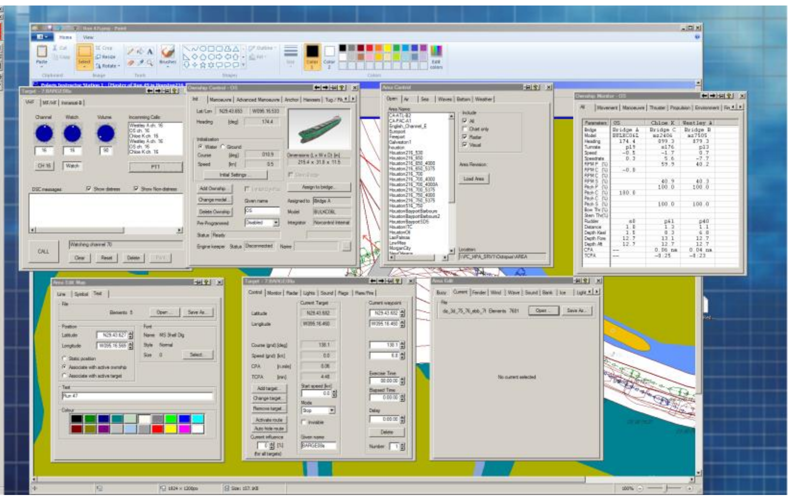
12:58 SEP VHF channel 16 from OS

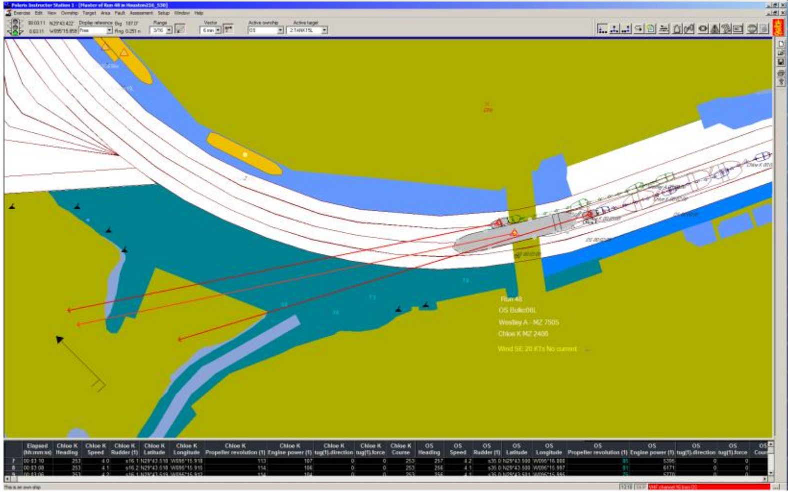


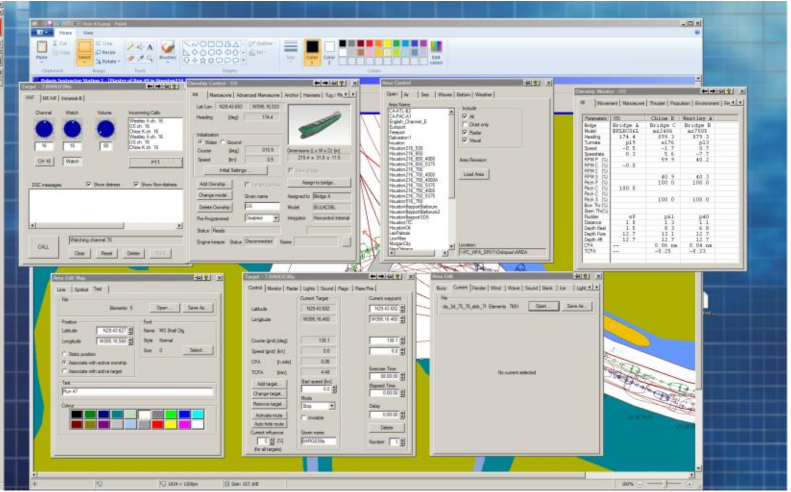
June 26, 2019

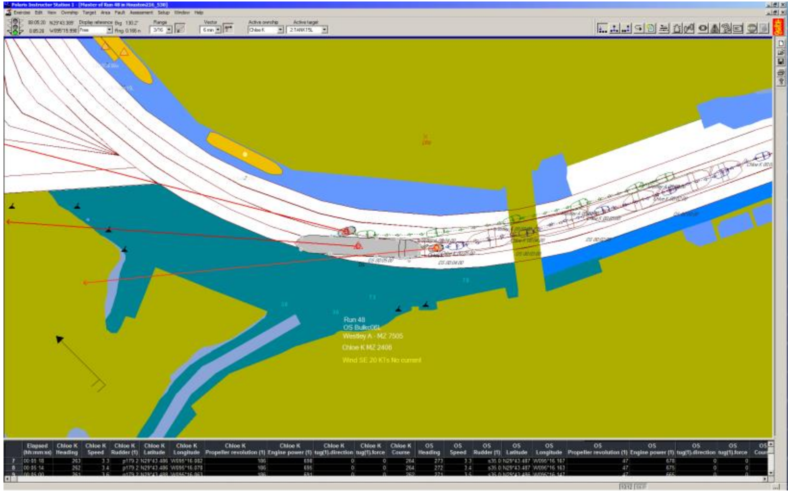
Run 48

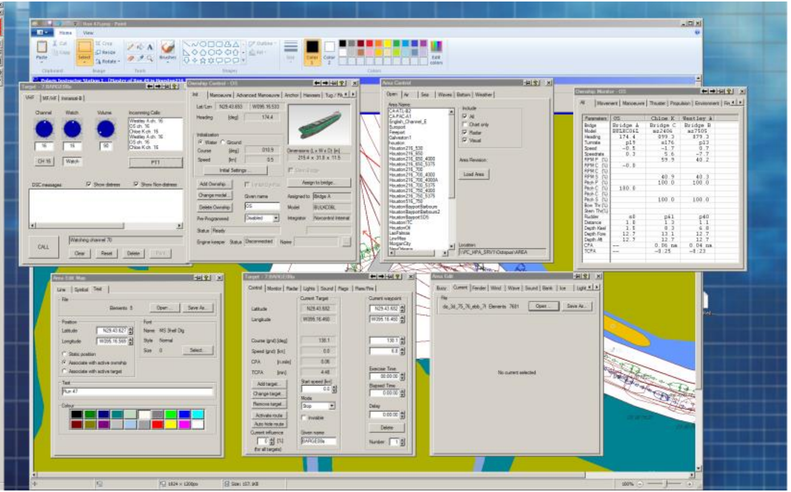


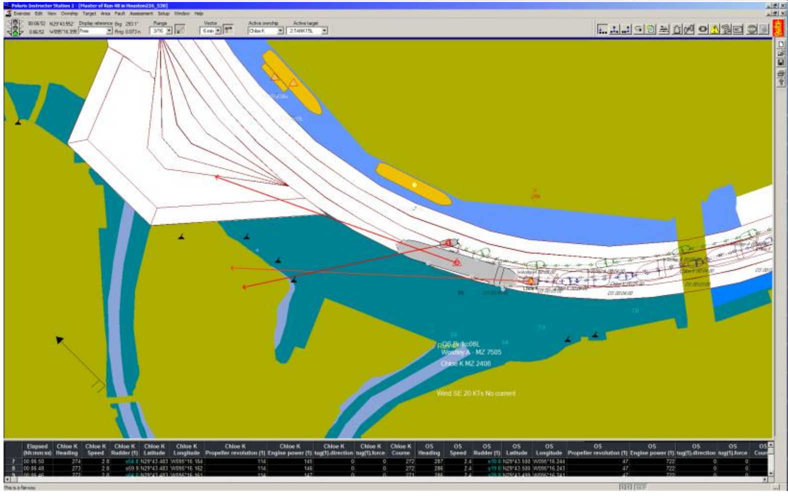


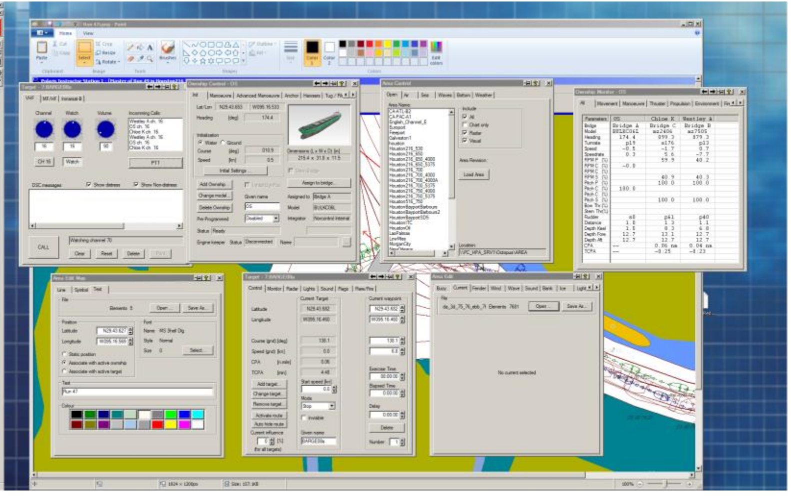




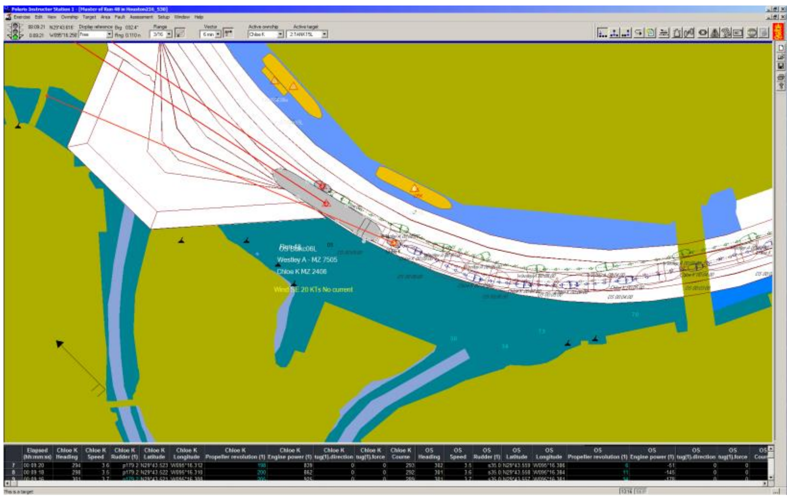


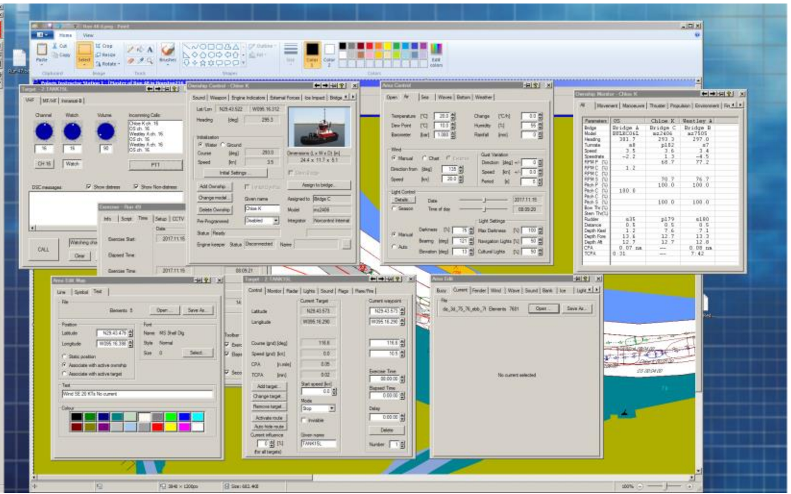


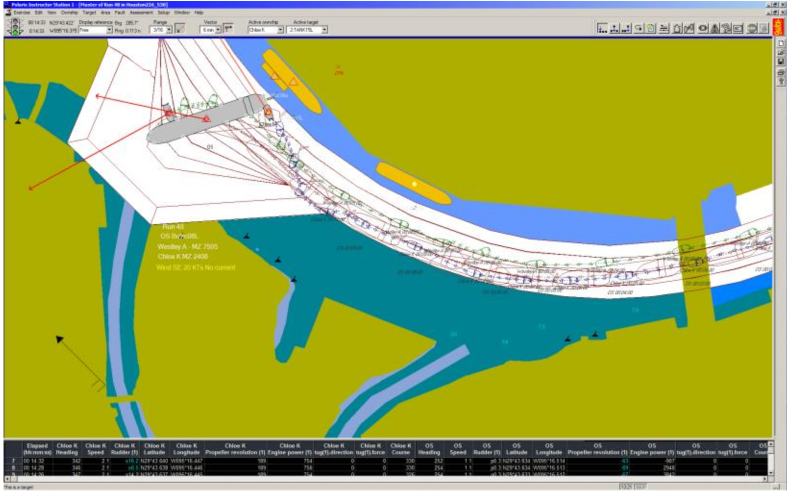


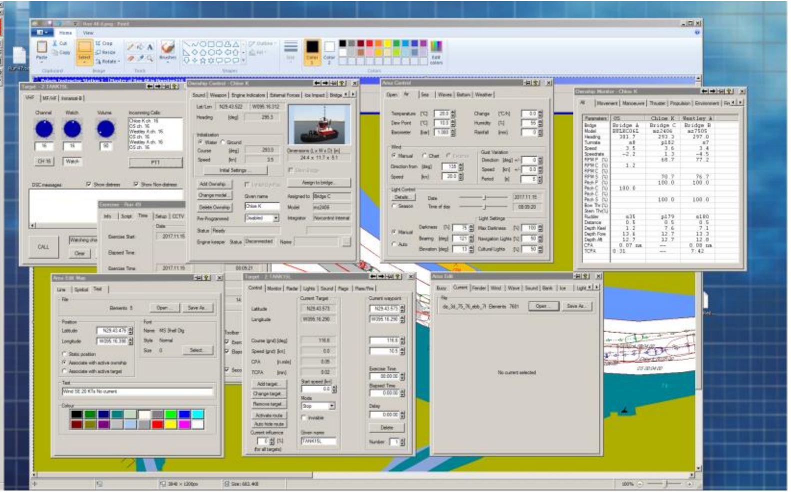


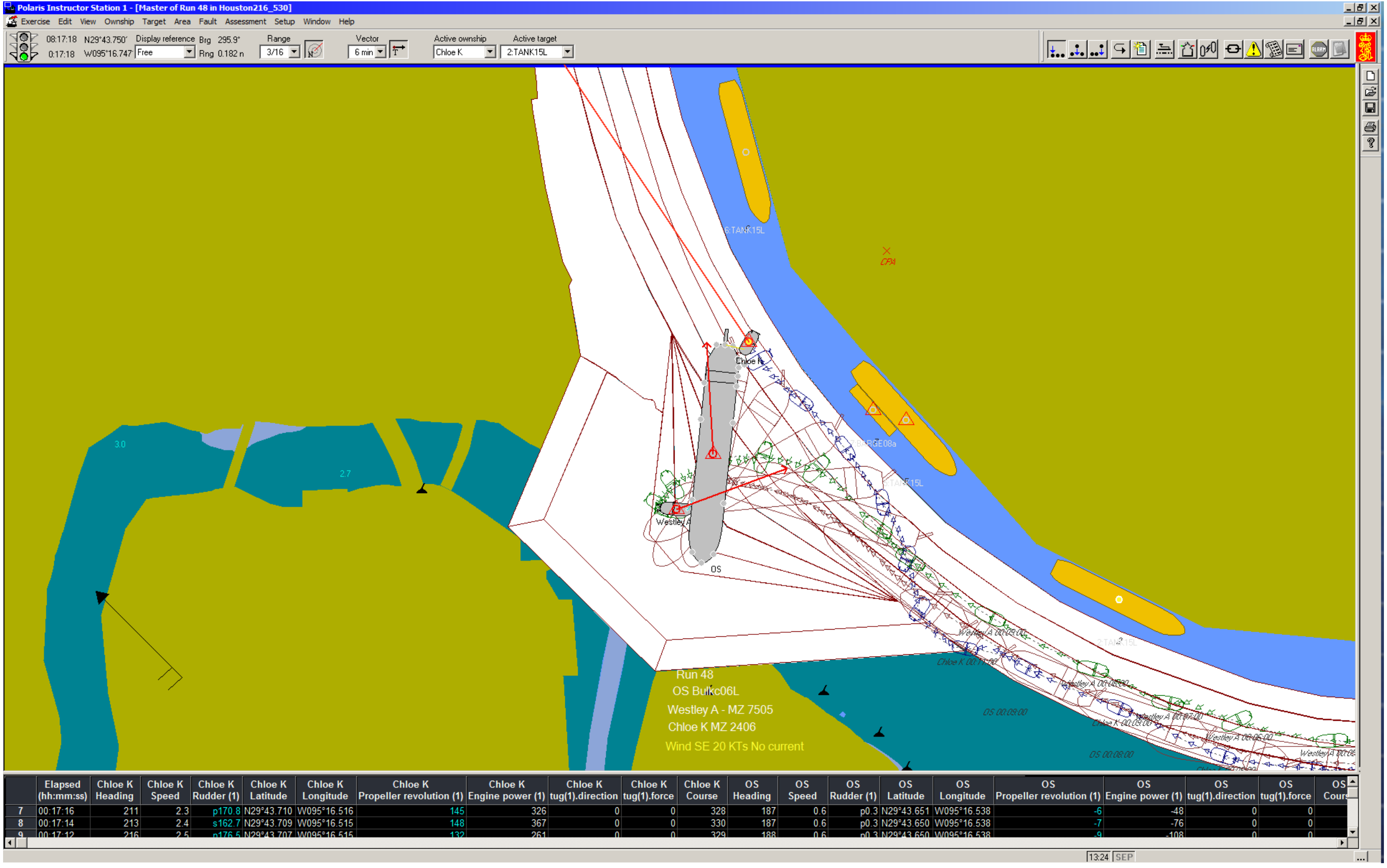
June 26, 2019











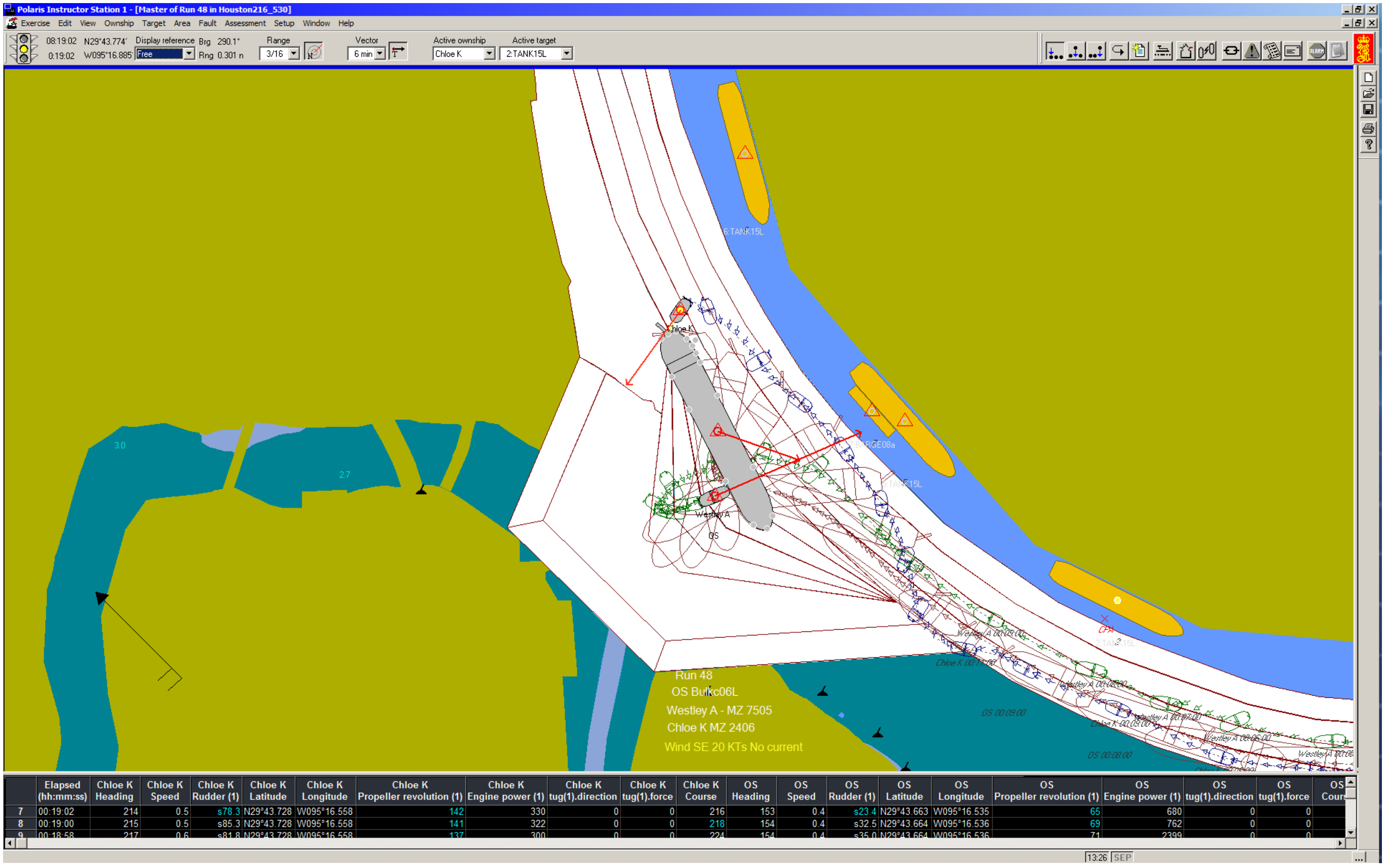
Polaris Instructor Station 1 - [Master of Run 48 in Houston216_530]

08:17:18 N29°43.750' Display reference Free Brg 295.9° Range 3/16 Vector 6 min Active ownship Chloe K Active target 2:TANK15L

0:17:18 W095°16.747' Rng 0.182 n

Run 48
OS Bulkc06L
Westley A - MZ 7505
Chloe K MZ 2406
Wind SE 20 KTs No current

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force
7	00:17:16	211	2.3	p170.8	N29°43.710	W095°16.516	145	326	0	0	328	187	0.6	p0.3	N29°43.651	W095°16.538	-6	-48	0	0
8	00:17:14	213	2.4	s162.7	N29°43.709	W095°16.515	148	367	0	0	330	187	0.6	p0.3	N29°43.650	W095°16.538	-7	-76	0	0
9	00:17:12	216	2.5	p176.5	N29°43.707	W095°16.515	132	261	0	0	329	188	0.6	p0.3	N29°43.650	W095°16.538	-9	-108	0	0



08:19:02 N29°43.774′ Display reference Free Brg 290.1° Range 3/16 Vector 6 min Active ownship Chloe K Active target 2:TANK15L

0:19:02 W095°16.885′ Rng 0.301 n

Run 48

OS Bulkc06L

Westley A - MZ 7505

Chloe K MZ 2406

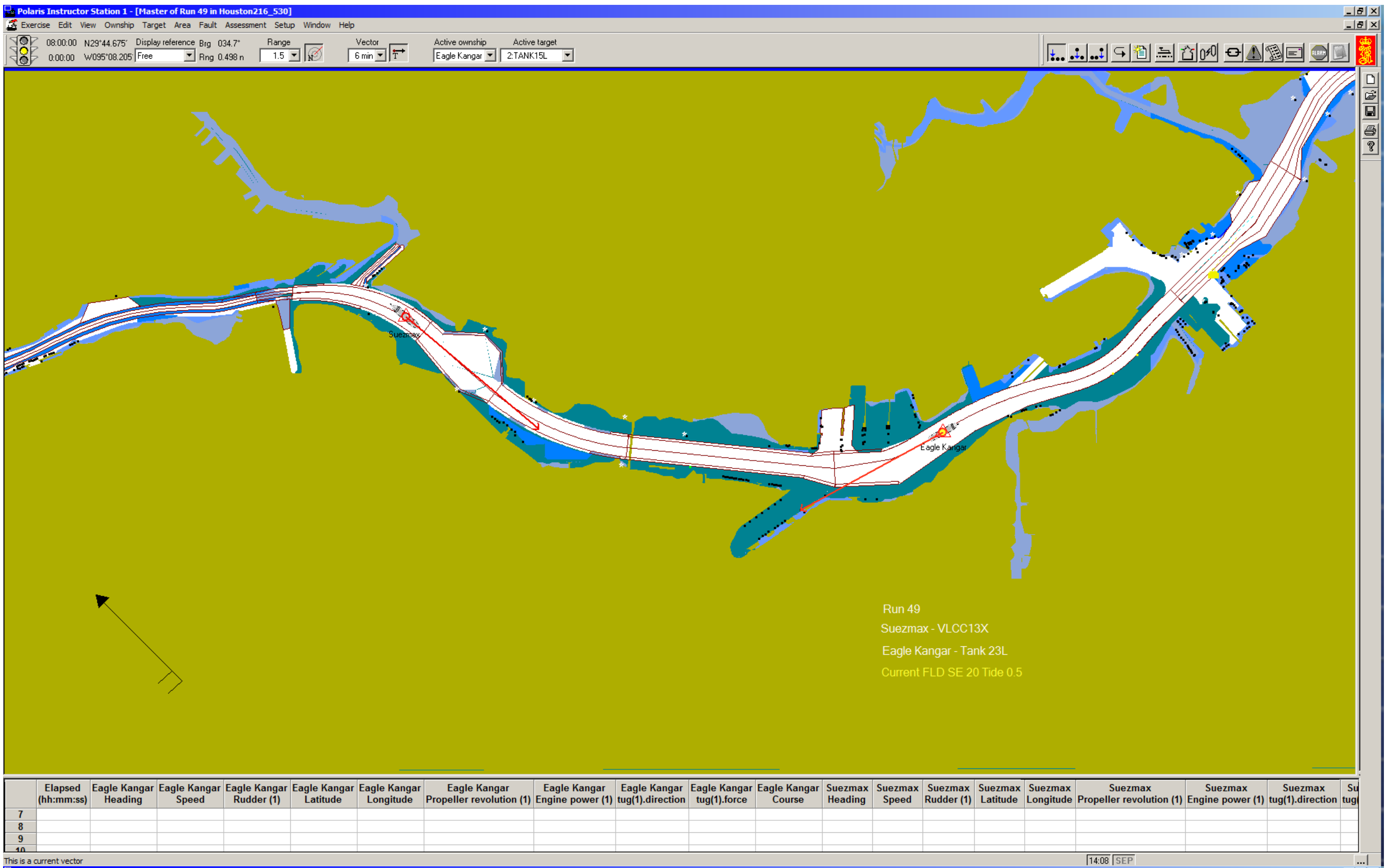
Wind SE 20 KTs No current

	Elapsed (hh:mm:ss)	Chloe K Heading	Chloe K Speed	Chloe K Rudder (1)	Chloe K Latitude	Chloe K Longitude	Chloe K Propeller revolution (1)	Chloe K Engine power (1)	Chloe K tug(1).direction	Chloe K tug(1).force	Chloe K Course	OS Heading	OS Speed	OS Rudder (1)	OS Latitude	OS Longitude	OS Propeller revolution (1)	OS Engine power (1)	OS tug(1).direction	OS tug(1).force	OS Cours
7	00:19:02	214	0.5	s78.3	N29°43.728	W095°16.558	142	330	0	0	216	153	0.4	s23.4	N29°43.663	W095°16.535	65	680	0	0	
8	00:19:00	215	0.5	s85.3	N29°43.728	W095°16.558	141	322	0	0	218	154	0.4	s32.5	N29°43.664	W095°16.536	69	762	0	0	
9	00:18:58	217	0.6	s81.8	N29°43.728	W095°16.558	137	300	0	0	224	154	0.4	s35.0	N29°43.664	W095°16.536	71	2399	0	0	

Appendix P: Boggy Bayou to Greens Bayou Simulations

June 26, 2019

Run 49


Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:00:00 N29°44.675′ Display reference Free Brg 034.7° Rng 0.498 n Range 1.5 Vector 6 min Active ownship Eagle Kangar Active target 2:TANK15L

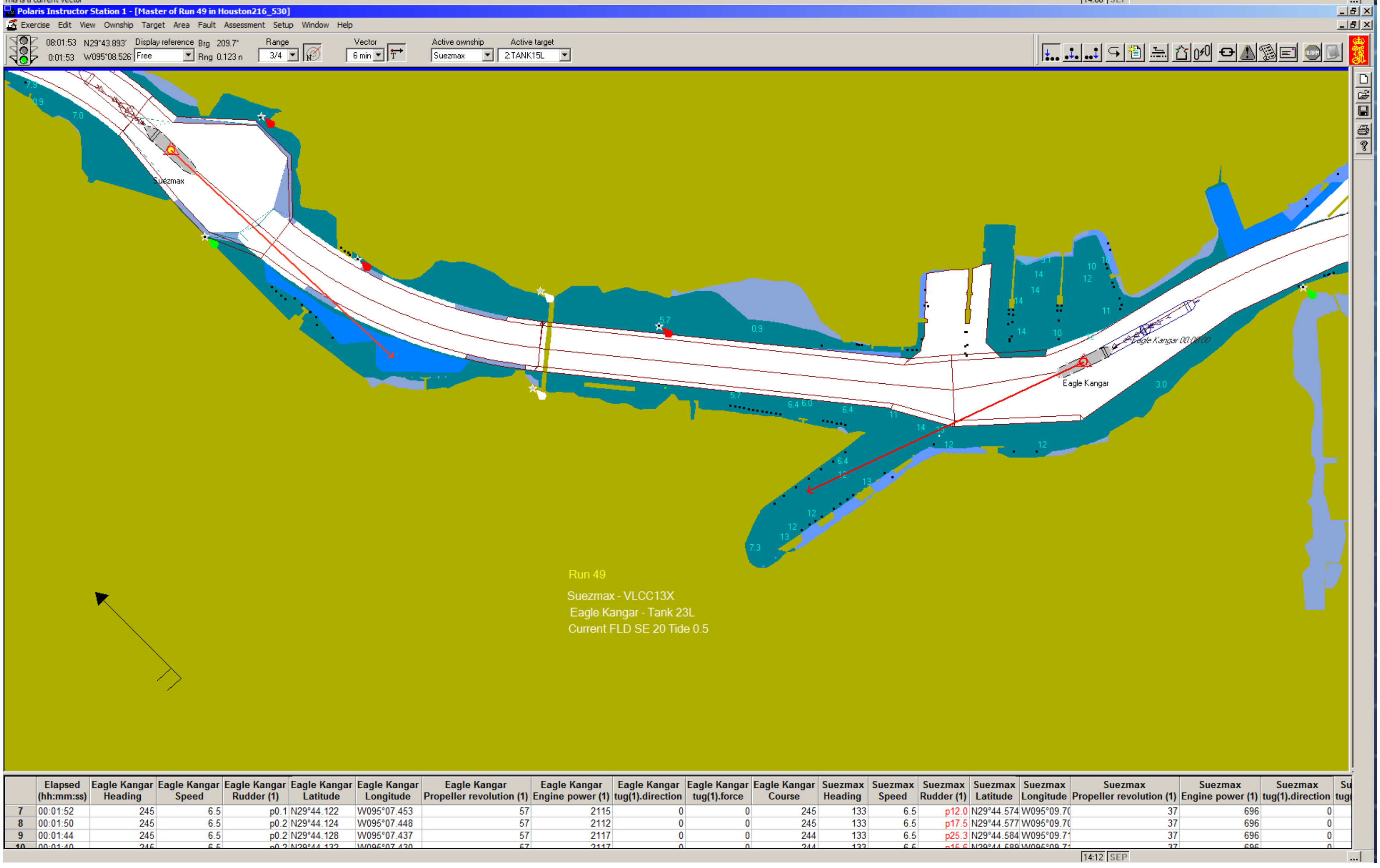
0:00:00 W095°08.205′

Run 49
Suezmax - VLCC13X
Eagle Kangar - Tank 23L
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar tug(1).direction	Eagle Kangar tug(1).force	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax tug(1).direction
7																			
8																			
9																			

This is a current vector

14:08 SEP


Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:01:53 N29°43.893′ Display reference Free Brg 209.7° Rng 0.123 n Range 3/4 Vector 6 min Active ownship Suezmax Active target 2:TANK15L

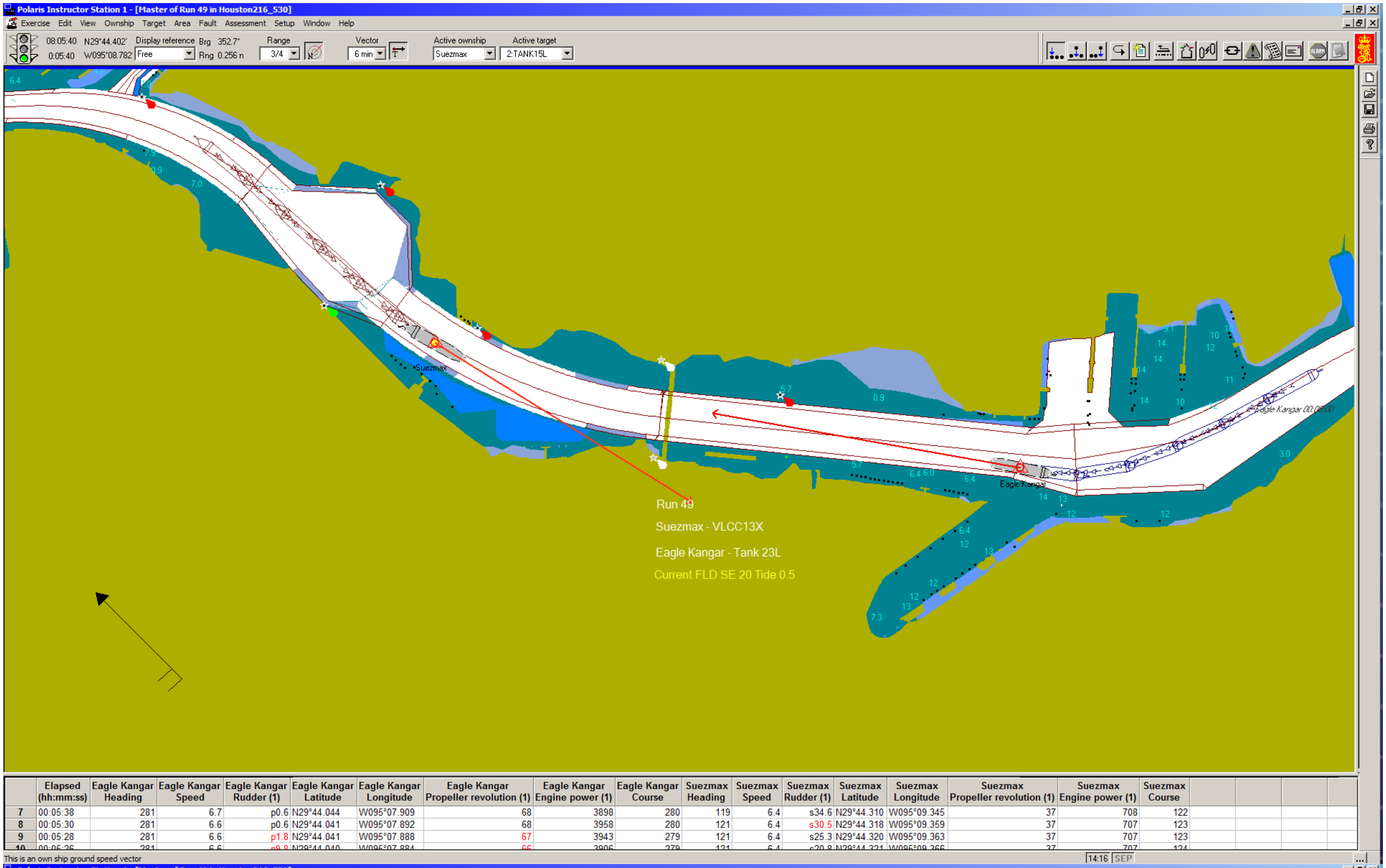
0:01:53 W095°08.526′

Run 49
Suezmax - VLCC13X
Eagle Kangar - Tank 23L
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar tug(1).direction	Eagle Kangar tug(1).force	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax tug(1).direction
7	00:01:52	245	6.5	p0.1	N29°44.122	W095°07.453	57	2115	0	0	245	133	6.5	p12.0	N29°44.574	W095°09.70	37	696	0
8	00:01:50	245	6.5	p0.2	N29°44.124	W095°07.448	57	2112	0	0	245	133	6.5	p17.5	N29°44.577	W095°09.70	37	696	0
9	00:01:44	245	6.5	p0.2	N29°44.128	W095°07.437	57	2117	0	0	244	133	6.5	p25.3	N29°44.584	W095°09.7	37	696	0

14:12 SEP

June 26, 2019



08:05:40 N29°44.402' Display reference: Free Brg 352.7° Rng 0.256 n Range 3/4 Vector 6 min Active ownship Suezmax Active target 2:TANK15L
0:05:40 W095°08.782'

Run 49

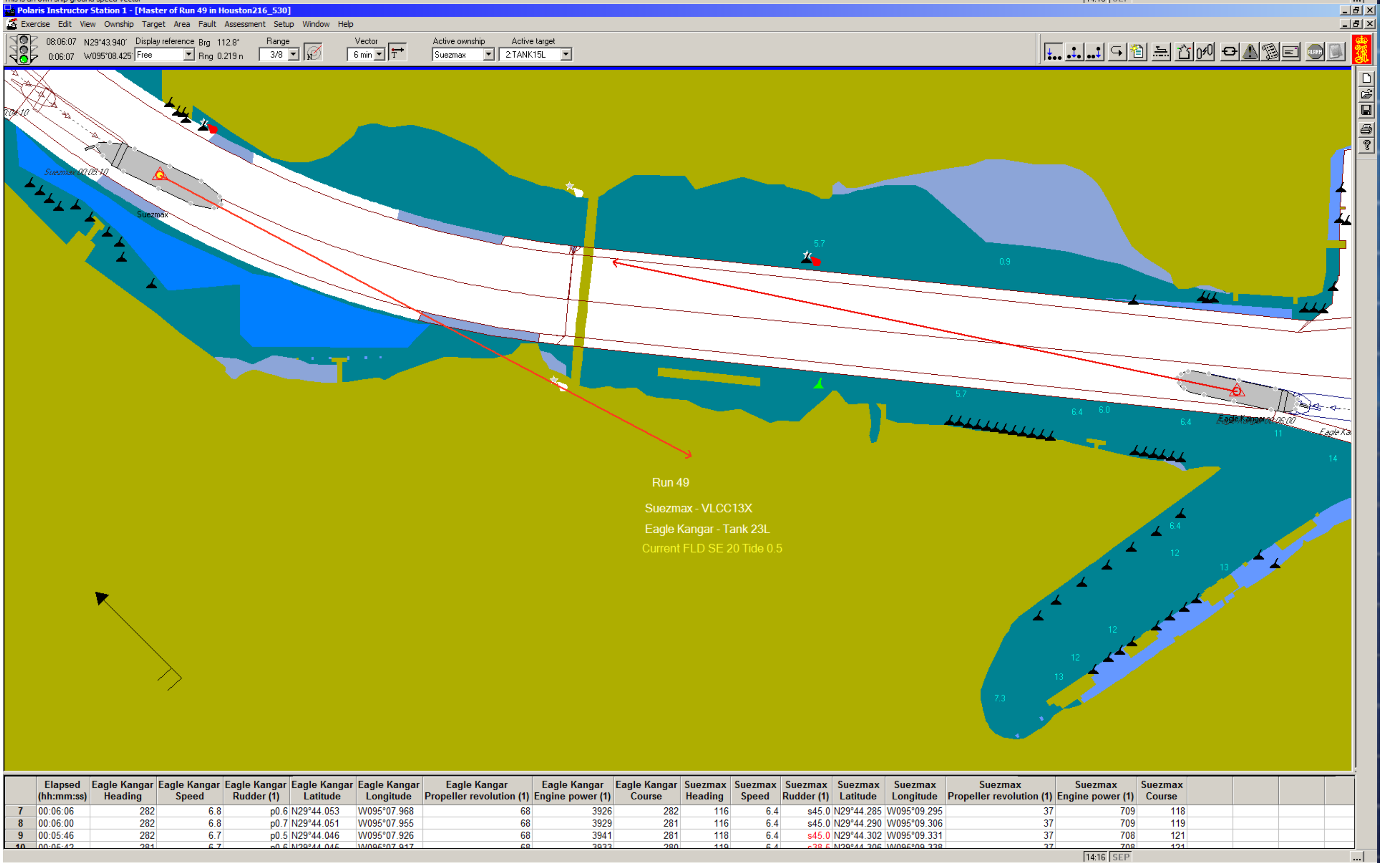
Suezmax - VLCC13X

Eagle Kangar - Tank 23L

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:38	281	6.7	p0.6	N29°44.044	W095°07.909	68	3898	280	119	6.4	s34.6	N29°44.310	W095°09.345	37	708	122
8	00:05:30	281	6.6	p0.6	N29°44.041	W095°07.892	68	3958	280	121	6.4	s30.5	N29°44.318	W095°09.359	37	707	123
9	00:05:28	281	6.6	p1.8	N29°44.041	W095°07.888	67	3943	279	121	6.4	s25.3	N29°44.320	W095°09.363	37	707	123
10	00:05:26	281	6.6	p0.8	N29°44.040	W095°07.884	66	3906	279	121	6.4	s20.8	N29°44.321	W095°09.366	37	707	124

This is an own ship ground speed vector



08:06:07 N29°43.940' Display reference: Free Brg 112.8° Rng 0.219 n Range 3/8 Vector 6 min Active ownship Suezmax Active target 2:TANK15L
0:06:07 W095°08.425'

Run 49

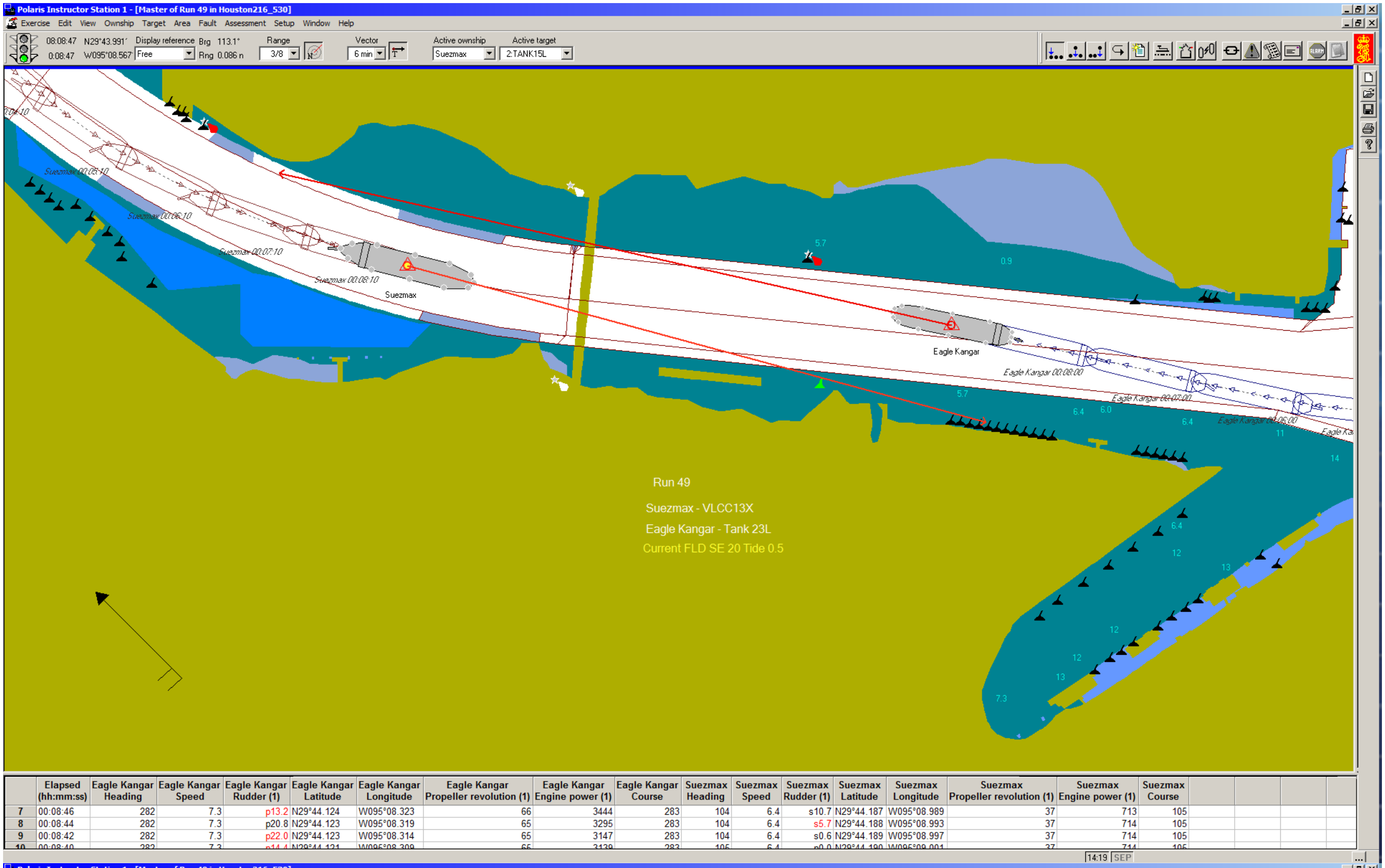
Suezmax - VLCC13X

Eagle Kangar - Tank 23L

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:06	282	6.8	p0.6	N29°44.053	W095°07.968	68	3926	282	116	6.4	s45.0	N29°44.285	W095°09.295	37	709	118
8	00:06:00	282	6.8	p0.7	N29°44.051	W095°07.955	68	3929	281	116	6.4	s45.0	N29°44.290	W095°09.306	37	709	119
9	00:05:46	282	6.7	p0.5	N29°44.046	W095°07.926	68	3941	281	118	6.4	s45.0	N29°44.302	W095°09.331	37	708	121
10	00:05:42	281	6.7	p0.6	N29°44.045	W095°07.917	68	3933	280	119	6.4	s38.5	N29°44.306	W095°09.338	37	708	121

June 26, 2019



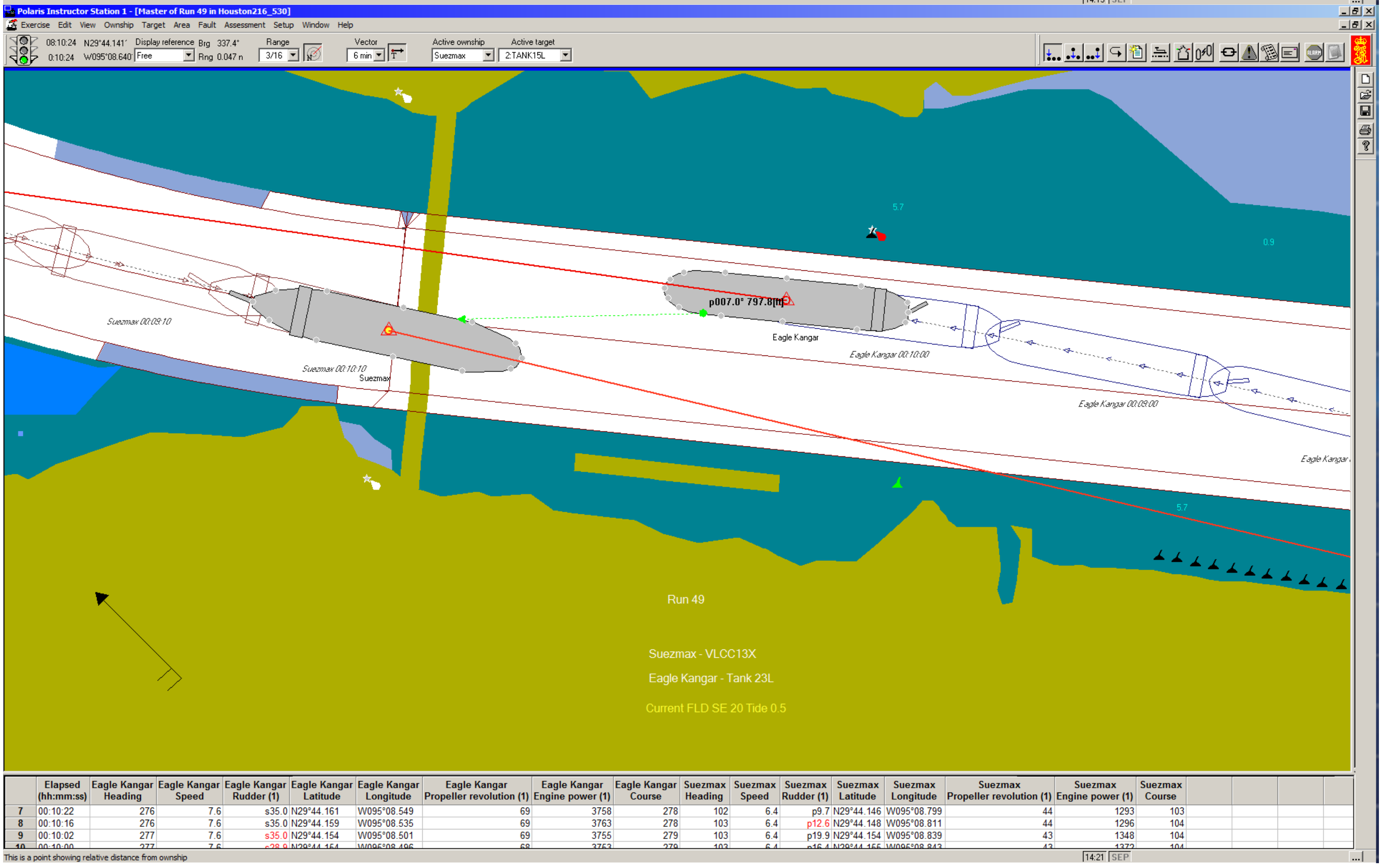
Run 49

Suezmax - VLCC13X

Eagle Kangar - Tank 23L

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:08:46	282	7.3	p13.2	N29°44.124	W095°08.323	66	3444	283	104	6.4	s10.7	N29°44.187	W095°08.989	37	713	105
8	00:08:44	282	7.3	p20.8	N29°44.123	W095°08.319	65	3295	283	104	6.4	s5.7	N29°44.188	W095°08.993	37	714	105
9	00:08:42	282	7.3	p22.0	N29°44.123	W095°08.314	65	3147	283	104	6.4	s0.6	N29°44.189	W095°08.997	37	714	105
10	00:08:40	282	7.3	p14.4	N29°44.121	W095°08.309	65	3139	283	105	6.4	p0.0	N29°44.190	W095°09.001	37	714	105



Run 49

Suezmax - VLCC13X

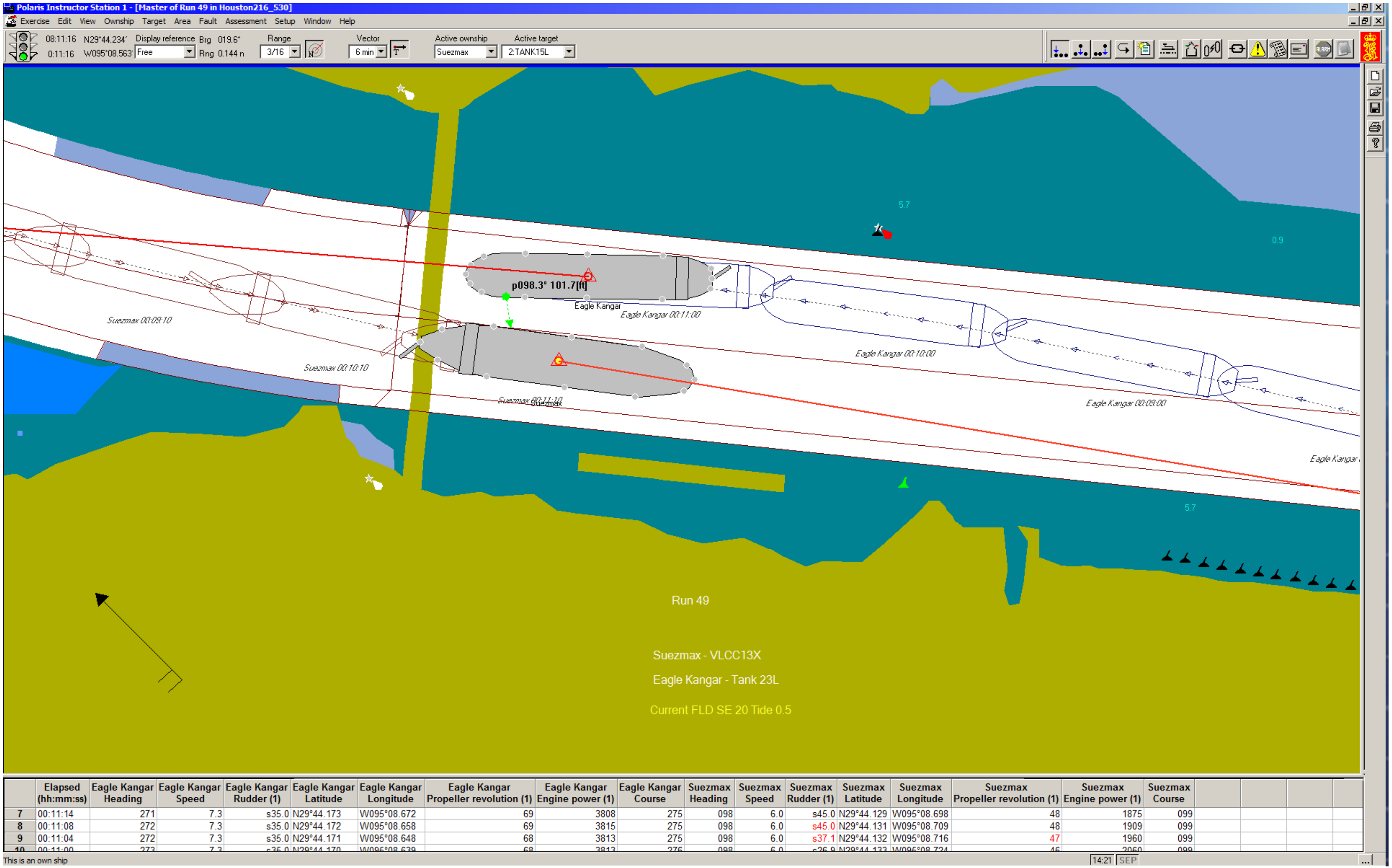
Eagle Kangar - Tank 23L

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:10:22	276	7.6	s35.0	N29°44.161	W095°08.549	69	3758	278	102	6.4	p9.7	N29°44.146	W095°08.799	44	1293	103
8	00:10:16	276	7.6	s35.0	N29°44.159	W095°08.535	69	3763	278	103	6.4	p12.6	N29°44.148	W095°08.811	44	1296	104
9	00:10:02	277	7.6	s35.0	N29°44.154	W095°08.501	69	3755	279	103	6.4	p19.9	N29°44.154	W095°08.839	43	1348	104
10	00:10:00	277	7.6	s28.9	N29°44.154	W095°08.496	68	3753	279	103	6.4	p16.4	N29°44.155	W095°08.843	43	1372	104

This is a point showing relative distance from ownship

June 26, 2019

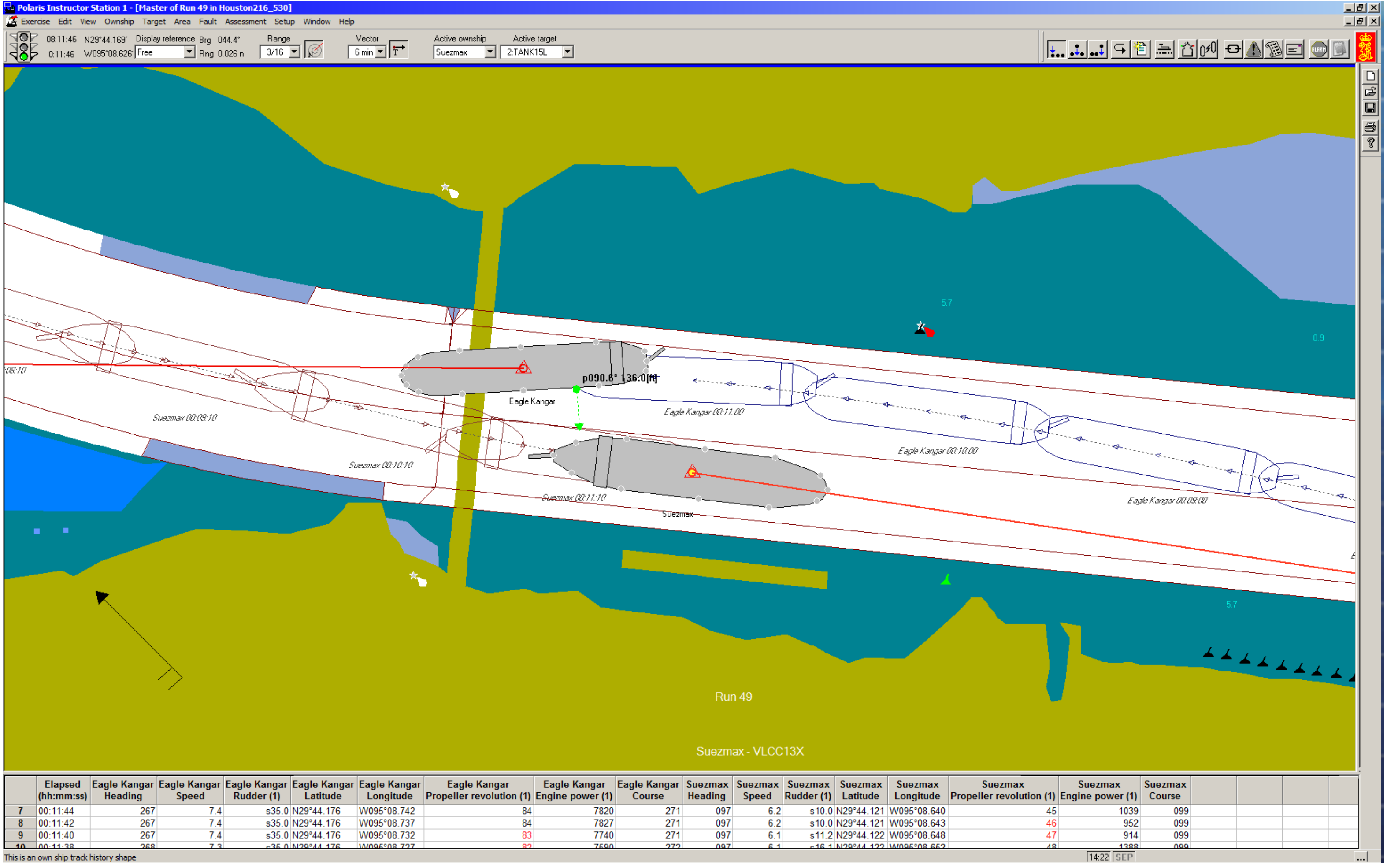


08:11:16 N29°44.234′ Display reference Free Brg 019.6° Rng 0.144 n
0:11:16 W095°08.563′
Range 3/16
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:11:14	271	7.3	s35.0	N29°44.173	W095°08.672	69	3808	275	098	6.0	s45.0	N29°44.129	W095°08.698	48	1875	099
8	00:11:08	272	7.3	s35.0	N29°44.172	W095°08.658	69	3815	275	098	6.0	s45.0	N29°44.131	W095°08.709	48	1909	099
9	00:11:04	272	7.3	s35.0	N29°44.171	W095°08.648	68	3813	275	098	6.0	s37.1	N29°44.132	W095°08.716	47	1960	099
10	00:11:00	273	7.3	s35.0	N29°44.170	W095°08.639	68	3813	276	098	6.0	s26.9	N29°44.133	W095°08.724	46	2060	099

This is an own ship

14:21 SEP



08:11:46 N29°44.169′ Display reference Free Brg 044.4° Rng 0.026 n
0:11:46 W095°08.626′
Range 3/16
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:11:44	267	7.4	s35.0	N29°44.176	W095°08.742	84	7820	271	097	6.2	s10.0	N29°44.121	W095°08.640	45	1039	099
8	00:11:42	267	7.4	s35.0	N29°44.176	W095°08.737	84	7827	271	097	6.2	s10.0	N29°44.121	W095°08.643	46	952	099
9	00:11:40	267	7.4	s35.0	N29°44.176	W095°08.732	83	7740	271	097	6.1	s11.2	N29°44.122	W095°08.648	47	914	099
10	00:11:38	268	7.3	s35.0	N29°44.176	W095°08.727	82	7590	272	097	6.1	s16.1	N29°44.122	W095°08.652	48	1388	099

This is an own ship track history shape

14:22 SEP

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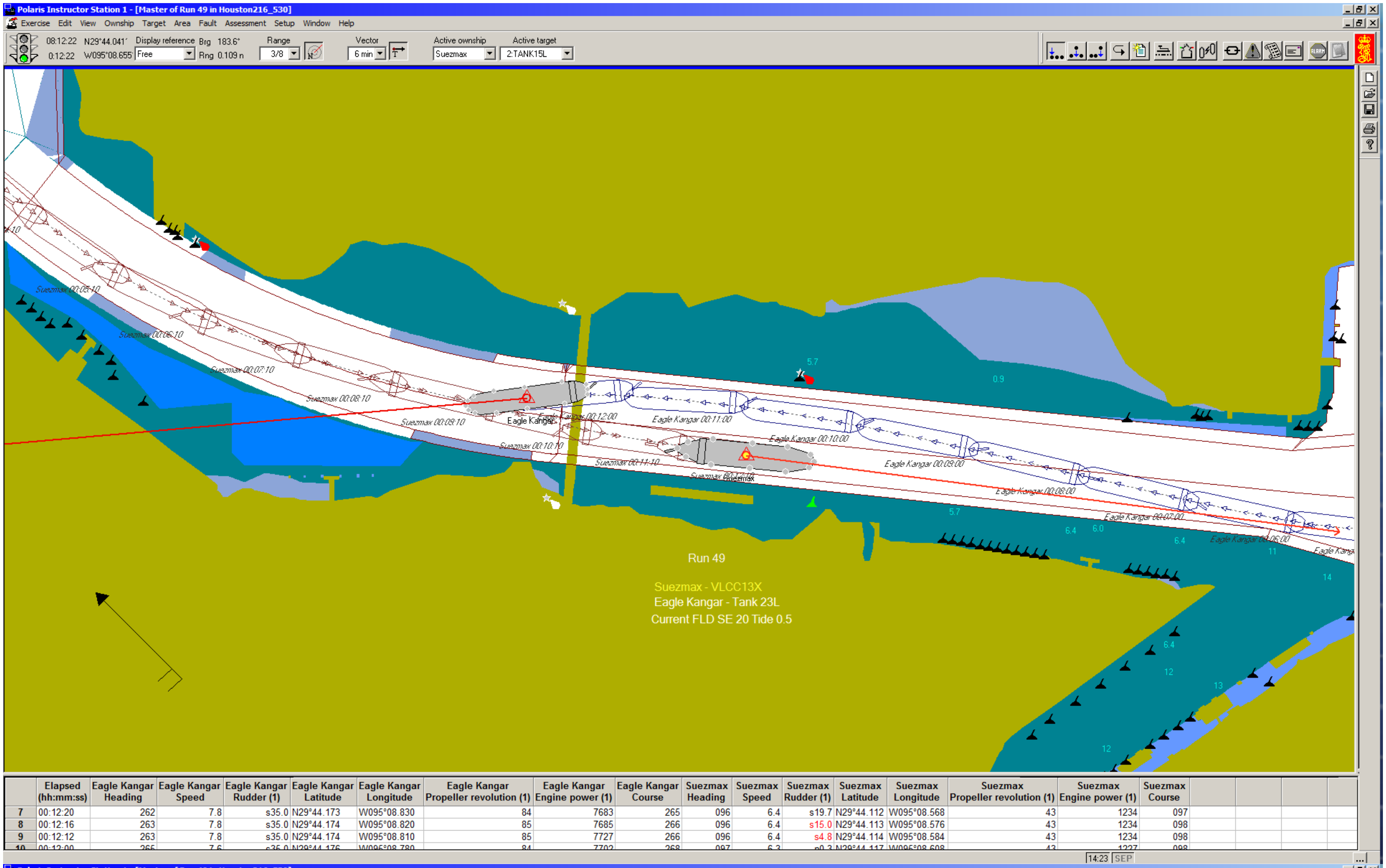
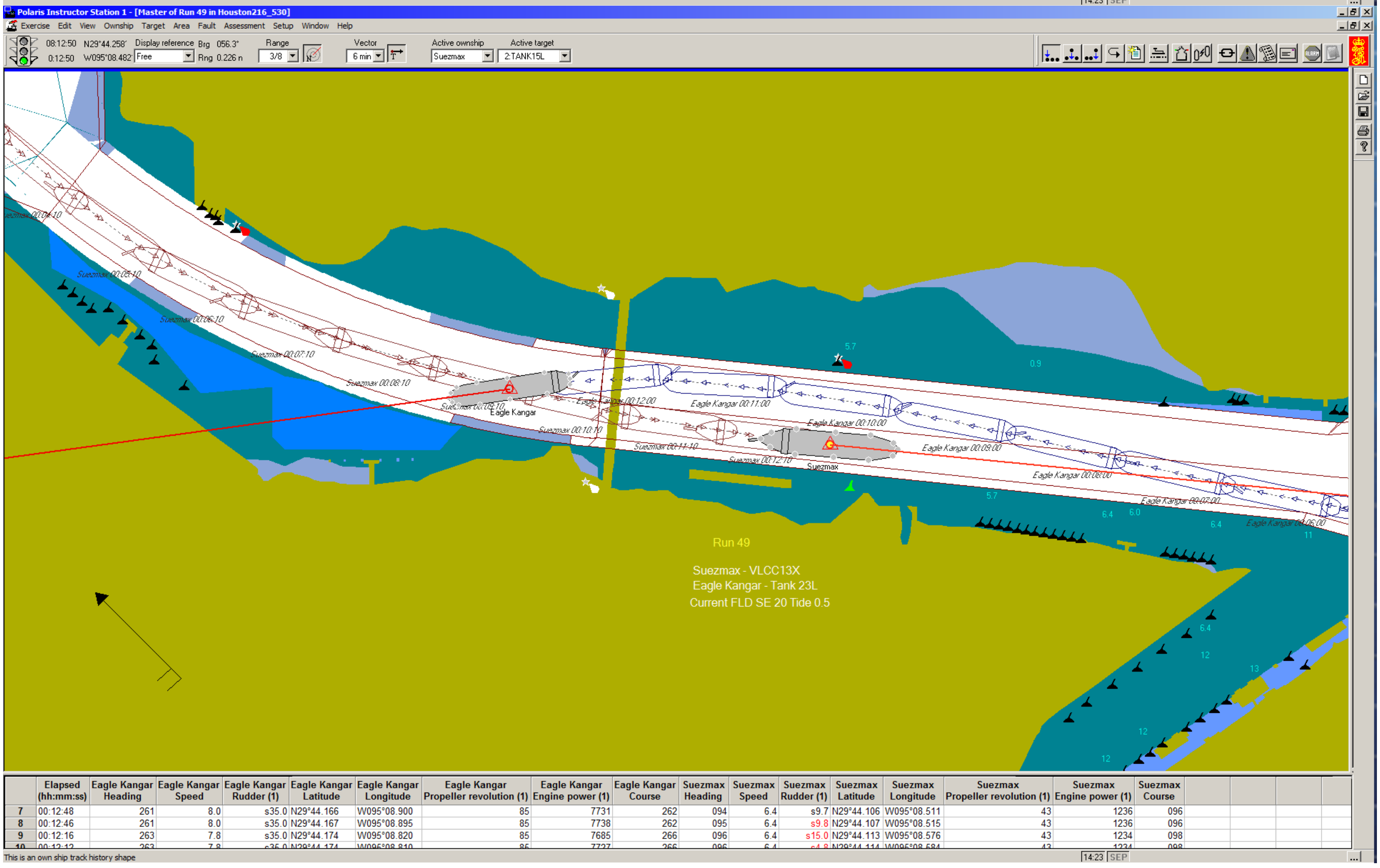


Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:12:22 N29°44.041' Display reference: Free Brg 183.6° Rng 0.109 n Range 3/8 Vector 6 min Active ownship Suezmax Active target 2:TANK15L
0:12:22 W095°08.655'

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:12:20	262	7.8	s35.0	N29°44.173	W095°08.830	84	7683	265	096	6.4	s19.7	N29°44.112	W095°08.568	43	1234	097
8	00:12:16	263	7.8	s35.0	N29°44.174	W095°08.820	85	7685	266	096	6.4	s15.0	N29°44.113	W095°08.576	43	1234	098
9	00:12:12	263	7.8	s35.0	N29°44.174	W095°08.810	85	7727	266	096	6.4	s4.8	N29°44.114	W095°08.584	43	1234	098
10	00:12:00	265	7.6	s35.0	N29°44.176	W095°08.780	84	7702	268	097	6.3	p0.3	N29°44.117	W095°08.608	43	1227	098

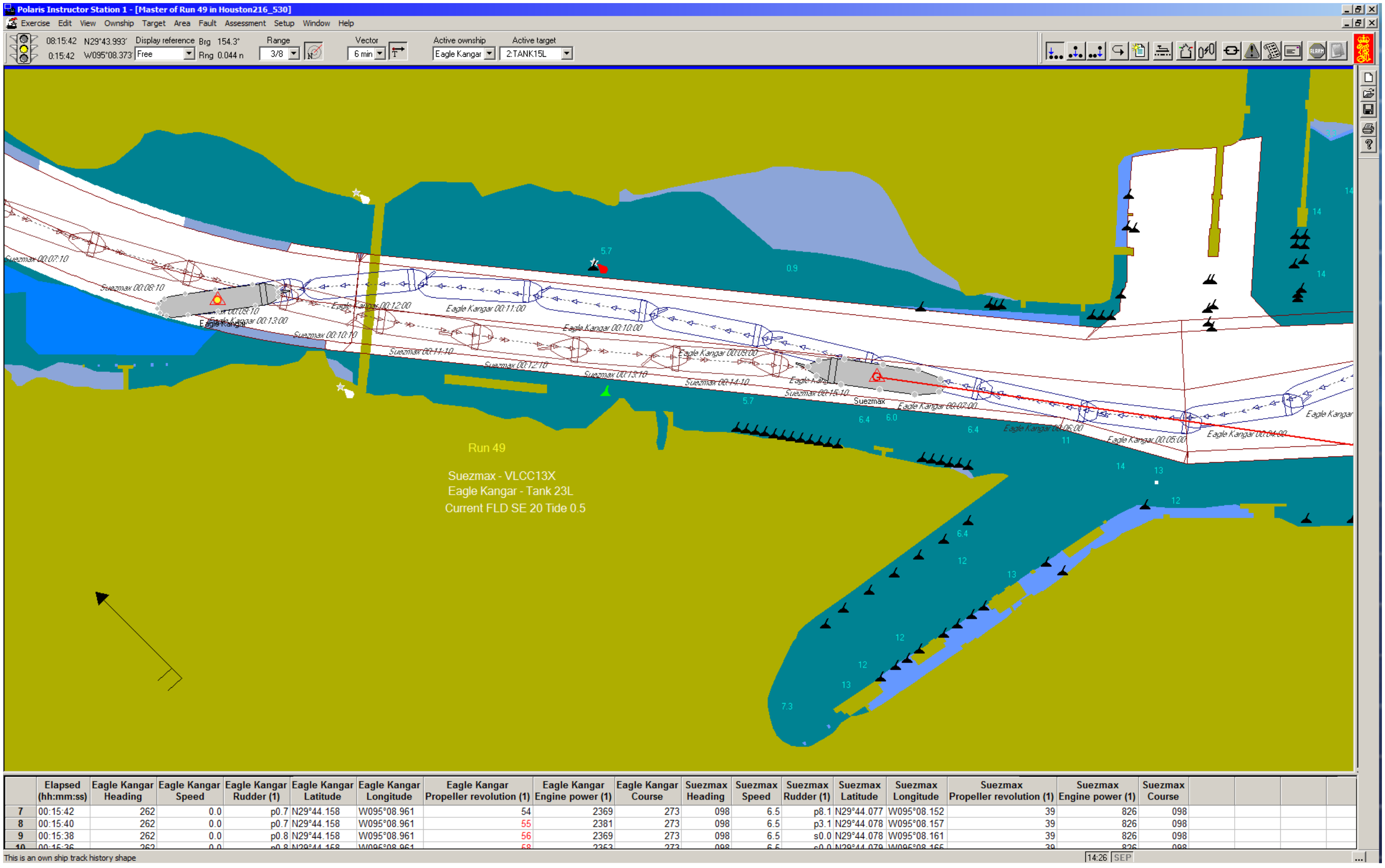


Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:12:50 N29°44.258' Display reference: Free Brg 056.3° Rng 0.226 n Range 3/8 Vector 6 min Active ownship Suezmax Active target 2:TANK15L
0:12:50 W095°08.482'

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:12:48	261	8.0	s35.0	N29°44.166	W095°08.900	85	7731	262	094	6.4	s9.7	N29°44.106	W095°08.511	43	1236	096
8	00:12:46	261	8.0	s35.0	N29°44.167	W095°08.895	85	7738	262	095	6.4	s9.8	N29°44.107	W095°08.515	43	1236	096
9	00:12:16	263	7.8	s35.0	N29°44.174	W095°08.820	85	7685	266	096	6.4	s15.0	N29°44.113	W095°08.576	43	1234	098
10	00:12:12	263	7.8	s35.0	N29°44.174	W095°08.810	85	7727	266	096	6.4	s4.8	N29°44.114	W095°08.584	43	1234	098

This is an own ship track history shape



Polaris Instructor Station 1 - [Master of Run 49 in Houston216_530]

08:15:42 N29°43.993'
0:15:42 W095°08.373'
Display reference: Free
Brg 154.3°
Rng 0.044 n
Range: 3/8
Vector: 6 min
Active ownship: Eagle Kangar
Active target: 2:TANK15L

Run 49

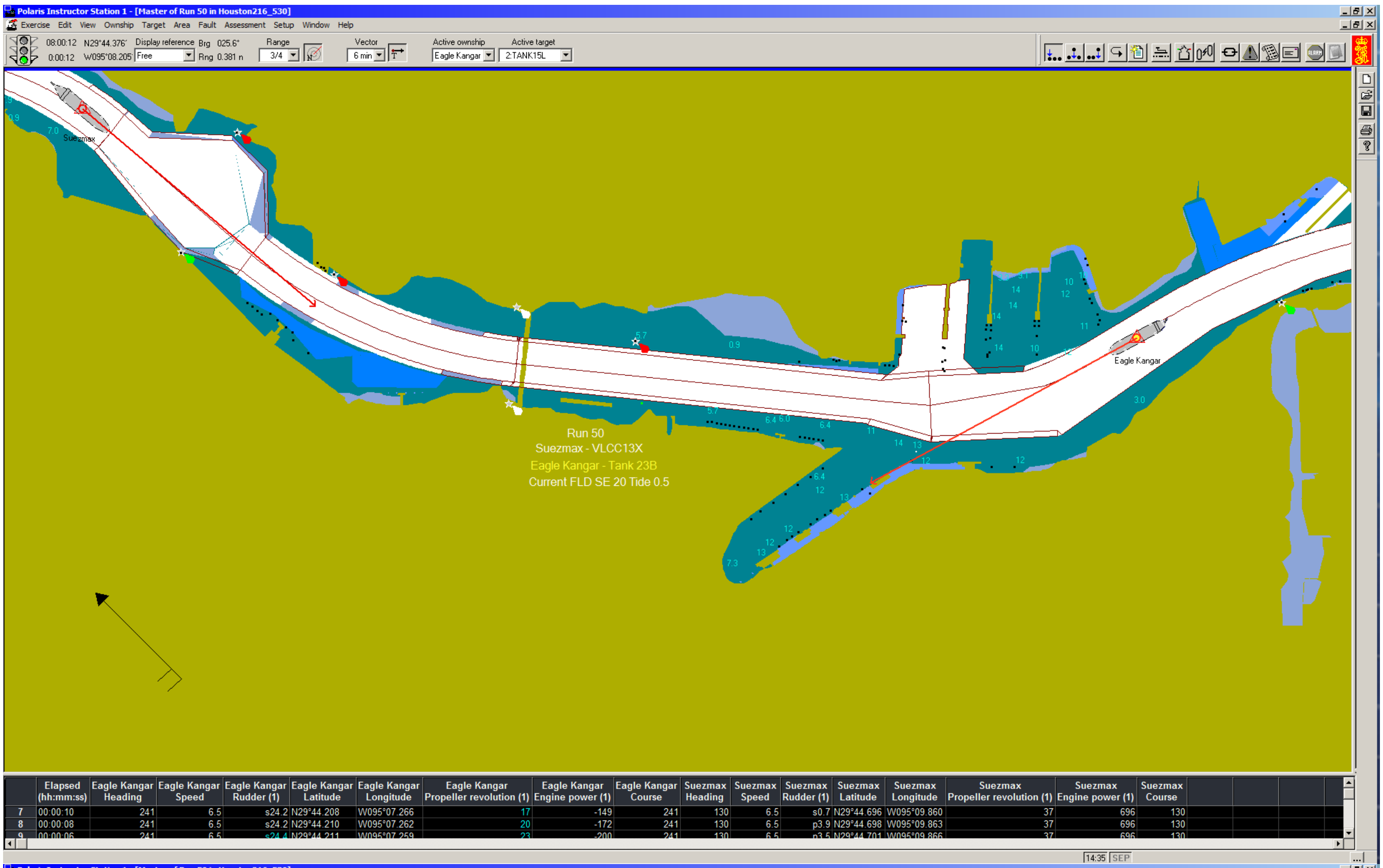
Suezmax - VLCC13X
Eagle Kangar - Tank 23L
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:15:42	262	0.0	p0.7	N29°44.158	W095°08.961	54	2369	273	098	6.5	p8.1	N29°44.077	W095°08.152	39	826	098
8	00:15:40	262	0.0	p0.7	N29°44.158	W095°08.961	55	2381	273	098	6.5	p3.1	N29°44.078	W095°08.157	39	826	098
9	00:15:38	262	0.0	p0.8	N29°44.158	W095°08.961	56	2369	273	098	6.5	s0.0	N29°44.078	W095°08.161	39	826	098
10	00:15:36	262	0.0	p0.8	N29°44.158	W095°08.961	58	2353	273	098	6.5	s0.0	N29°44.079	W095°08.165	39	826	098

This is an own ship track history shape

June 26, 2019

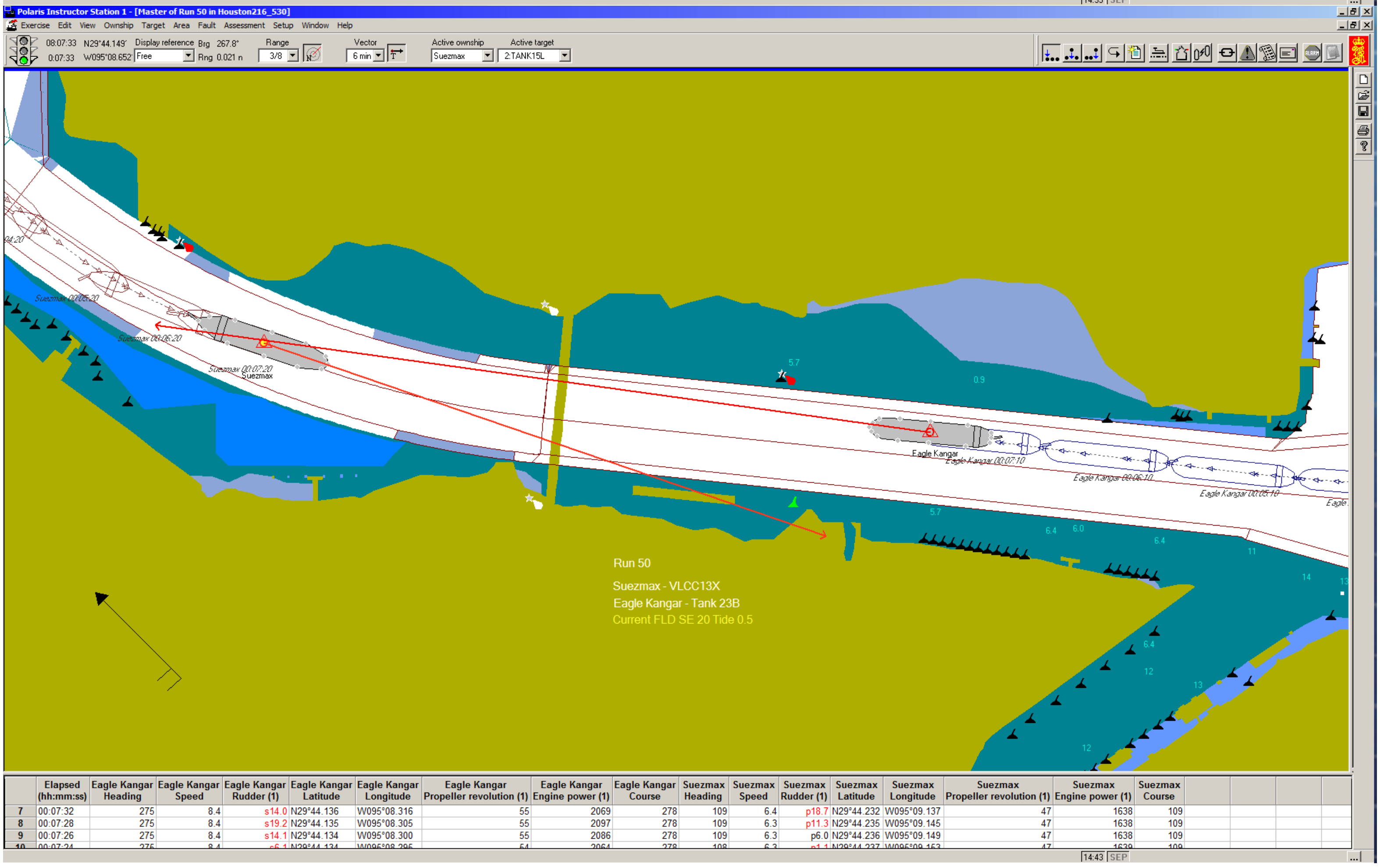
Run 50



Polaris Instructor Station 1 - [Master of Run 50 in Houston216_530]

08:00:12 N29°44.376' 0:00:12 W095°08.205 Display reference: Free Brg 025.6° Rng 0.381 n Range: 3/4 Vector: 6 min Active ownship: Eagle Kangar Active target: 2:TANK15L

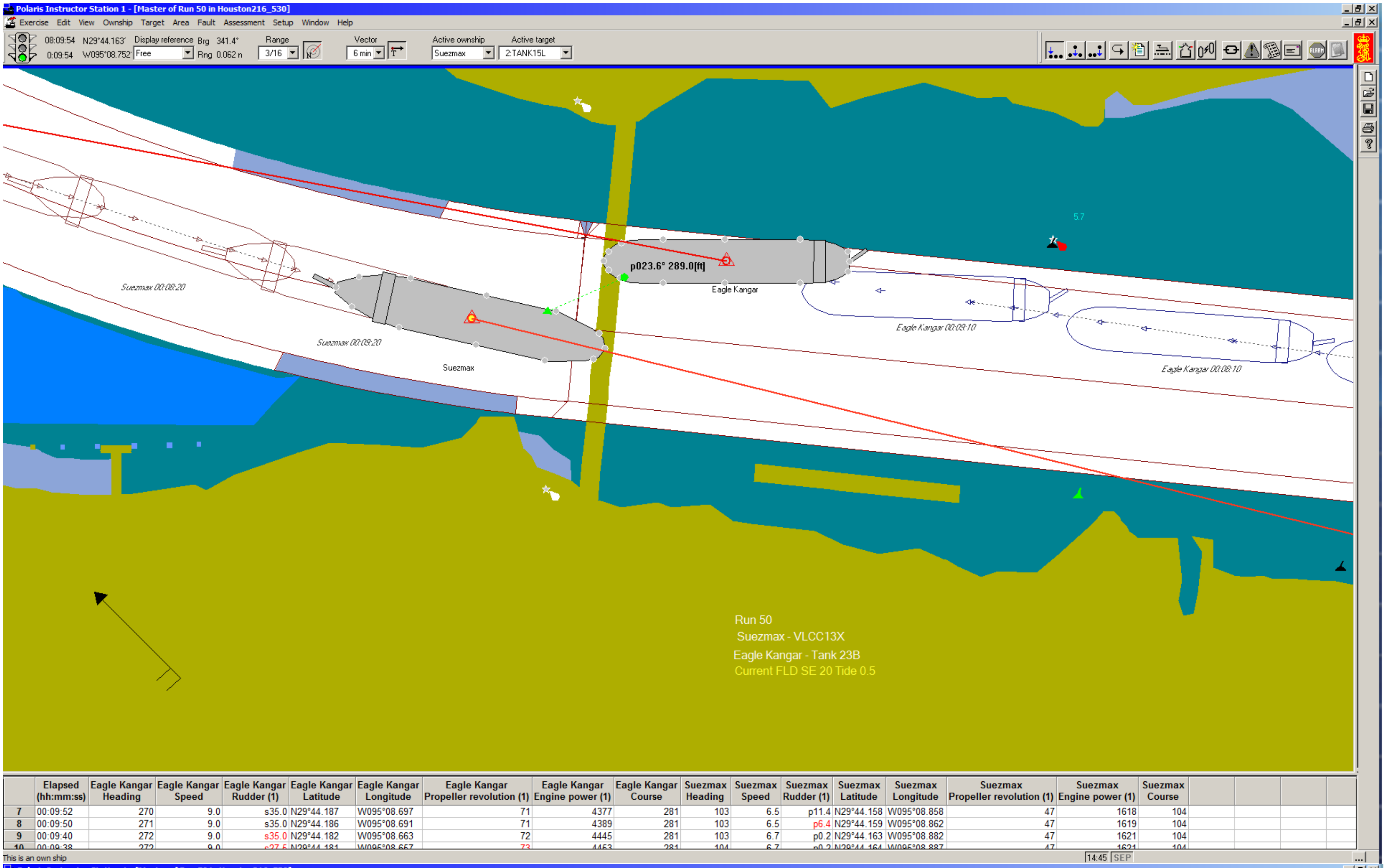
	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:00:10	241	6.5	s24.2	N29°44.208	W095°07.266	17	-149	241	130	6.5	s0.7	N29°44.696	W095°09.860	37	696	130
8	00:00:08	241	6.5	s24.2	N29°44.210	W095°07.262	20	-172	241	130	6.5	p3.9	N29°44.698	W095°09.863	37	696	130
9	00:00:06	241	6.5	s24.4	N29°44.211	W095°07.259	23	-200	241	130	6.5	p3.5	N29°44.701	W095°09.866	37	696	130



Polaris Instructor Station 1 - [Master of Run 50 in Houston216_530]

08:07:33 N29°44.149' 0:07:33 W095°08.652' Display reference: Free Brg 267.8° Rng 0.021 n Range: 3/8 Vector: 6 min Active ownship: Suezmax Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:32	275	8.4	s14.0	N29°44.136	W095°08.316	55	2069	278	109	6.4	p18.7	N29°44.232	W095°09.137	47	1638	109
8	00:07:28	275	8.4	s19.2	N29°44.135	W095°08.305	55	2097	278	109	6.3	p11.3	N29°44.235	W095°09.145	47	1638	109
9	00:07:26	275	8.4	s14.1	N29°44.134	W095°08.300	55	2086	278	109	6.3	p6.0	N29°44.236	W095°09.149	47	1638	109
10	00:07:24	275	8.4	s6.1	N29°44.134	W095°08.295	54	2064	278	108	6.3	p1.1	N29°44.237	W095°09.153	47	1639	109



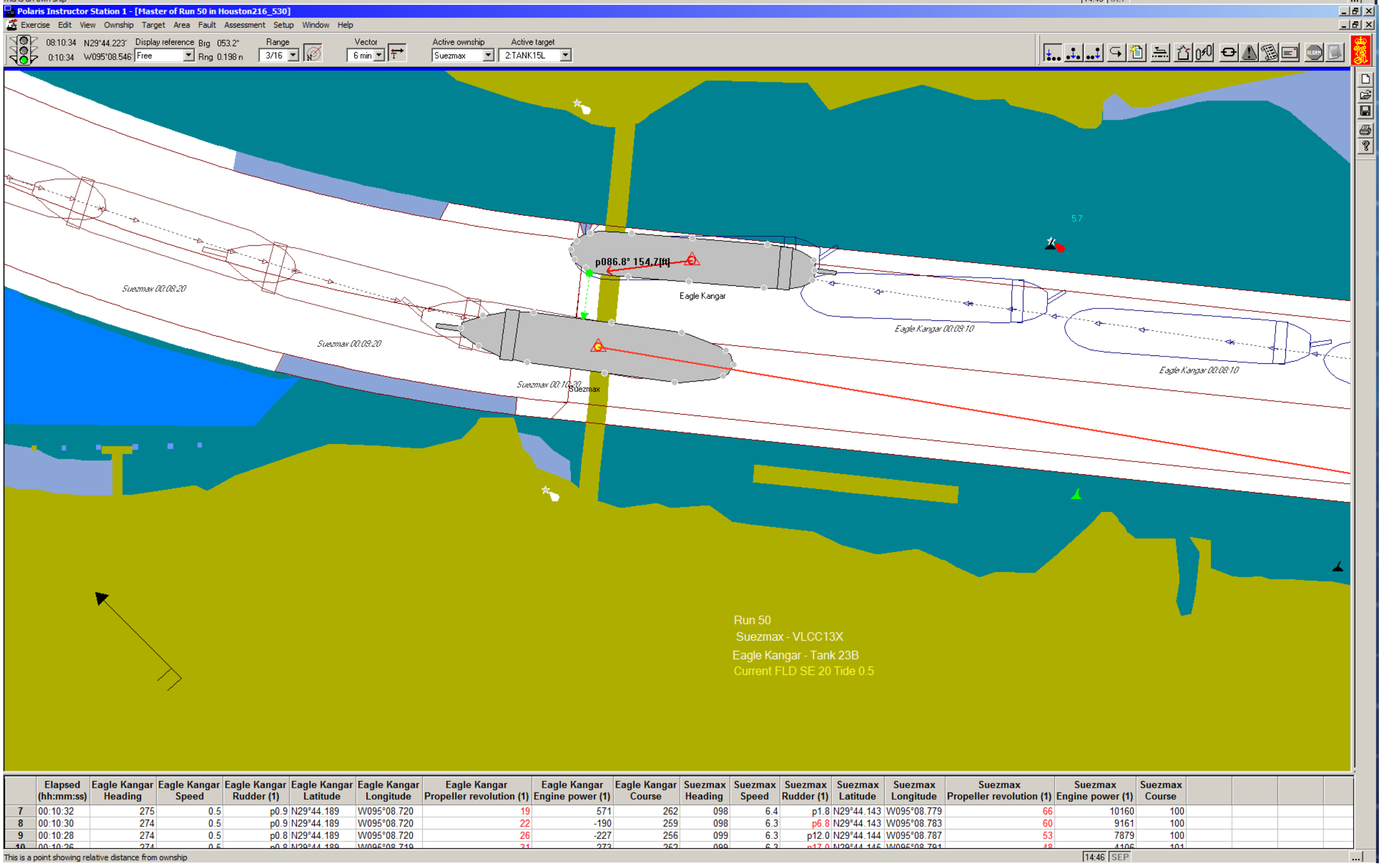
Polaris Instructor Station 1 - [Master of Run 50 in Houston216_530]

08:09:54 N29°44.163' Display reference Free Brg 341.4° Rng 0.062 n
0:09:54 W095°08.752'
Range 3/16
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:09:52	270	9.0	s35.0	N29°44.187	W095°08.697	71	4377	281	103	6.5	p11.4	N29°44.158	W095°08.858	47	1618	104
8	00:09:50	271	9.0	s35.0	N29°44.186	W095°08.691	71	4389	281	103	6.5	p6.4	N29°44.159	W095°08.862	47	1619	104
9	00:09:40	272	9.0	s35.0	N29°44.182	W095°08.663	72	4445	281	103	6.7	p0.2	N29°44.163	W095°08.882	47	1621	104

This is an own ship

14:45 SEP



Polaris Instructor Station 1 - [Master of Run 50 in Houston216_530]

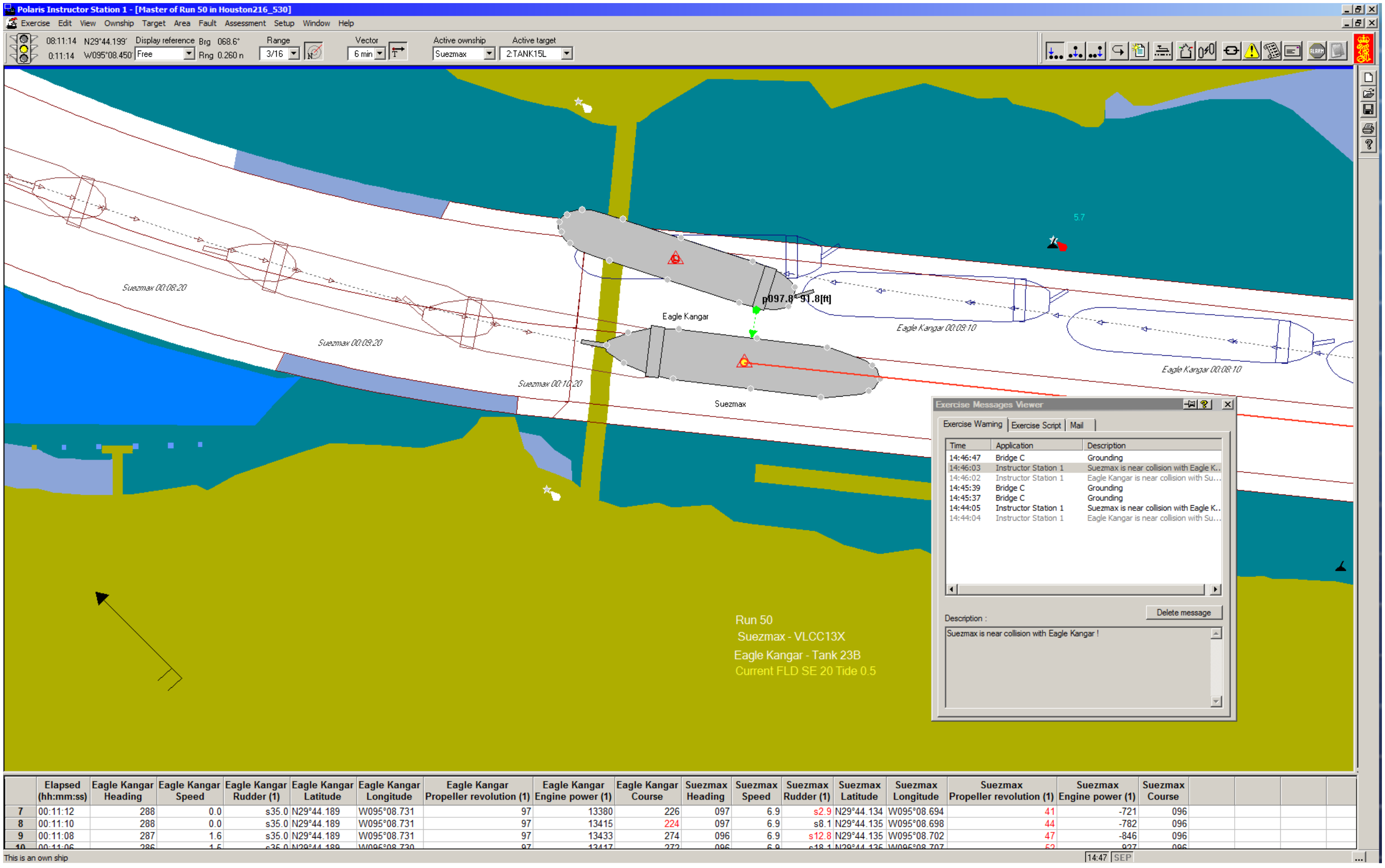
08:10:34 N29°44.223' Display reference Free Brg 053.2° Rng 0.198 n
0:10:34 W095°08.546'
Range 3/16
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:10:32	275	0.5	p0.9	N29°44.189	W095°08.720	19	571	262	098	6.4	p1.8	N29°44.143	W095°08.779	66	10160	100
8	00:10:30	274	0.5	p0.9	N29°44.189	W095°08.720	22	-190	259	098	6.3	p6.8	N29°44.143	W095°08.783	60	9161	100
9	00:10:28	274	0.5	p0.8	N29°44.189	W095°08.720	26	-227	256	099	6.3	p12.0	N29°44.144	W095°08.787	53	7879	100

This is a point showing relative distance from ownship

14:46 SEP

June 26, 2019



08:11:14 N29°44.199' Display reference: Free Brg 068.6°
0:11:14 W095°08.450' Rng 0.260 n
Range: 3/16
Vector: 6 min
Active ownship: Suezmax
Active target: 2:TANK15L

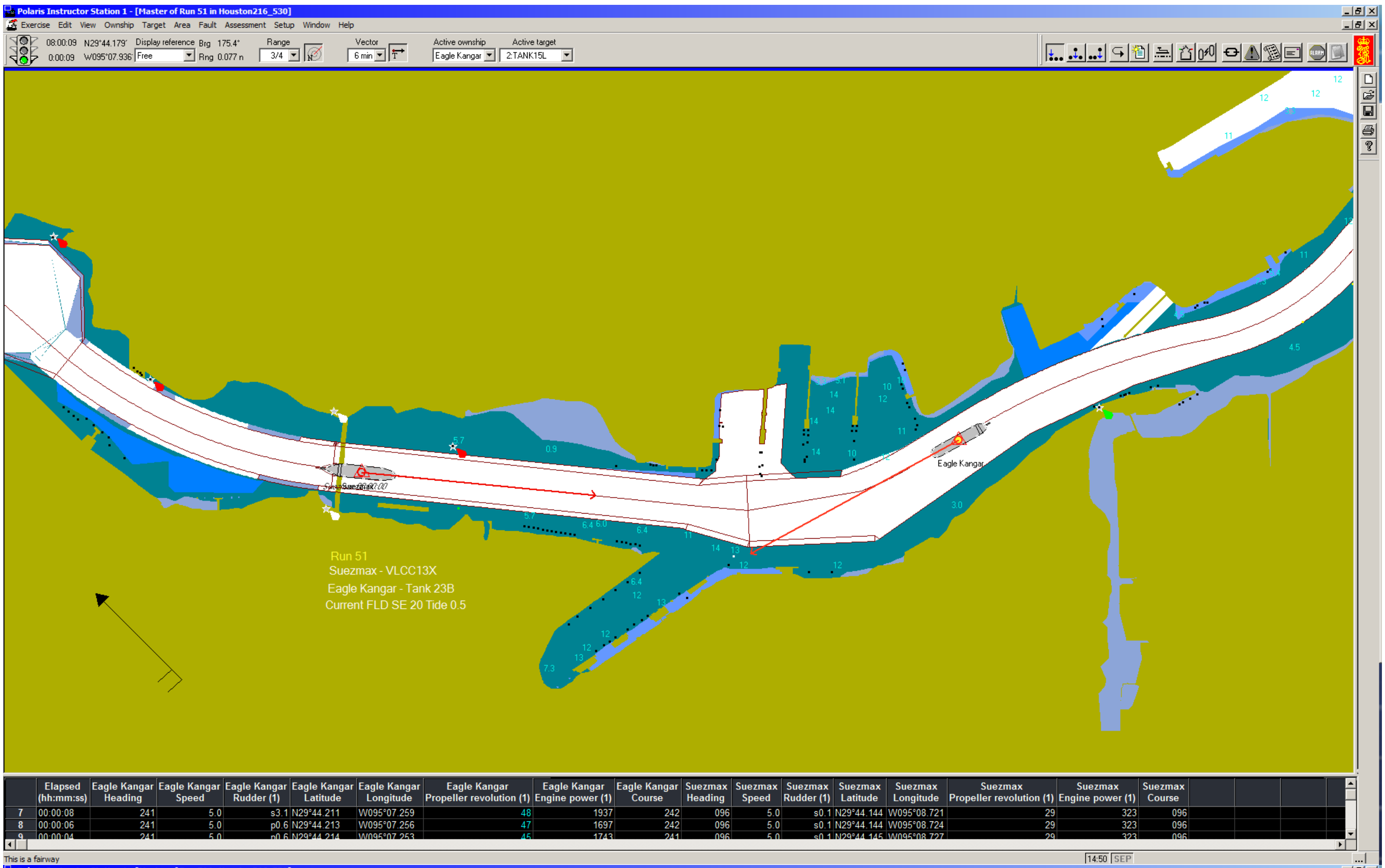
Time	Application	Description
14:46:47	Bridge C	Grounding
14:46:03	Instructor Station 1	Suezmax is near collision with Eagle K..
14:46:02	Instructor Station 1	Eagle Kangar is near collision with Su...
14:45:39	Bridge C	Grounding
14:45:37	Bridge C	Grounding
14:44:05	Instructor Station 1	Suezmax is near collision with Eagle K..
14:44:04	Instructor Station 1	Eagle Kangar is near collision with Su...

Description : Suezmax is near collision with Eagle Kangar !

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:11:12	288	0.0	s35.0	N29°44.189	W095°08.731	97	13380	226	097	6.9	s2.9	N29°44.134	W095°08.694	41	-721	096
8	00:11:10	288	0.0	s35.0	N29°44.189	W095°08.731	97	13415	224	097	6.9	s8.1	N29°44.135	W095°08.698	44	-782	096
9	00:11:08	287	1.6	s35.0	N29°44.189	W095°08.731	97	13433	274	096	6.9	s12.8	N29°44.135	W095°08.702	47	-846	096

This is an own ship 14:47

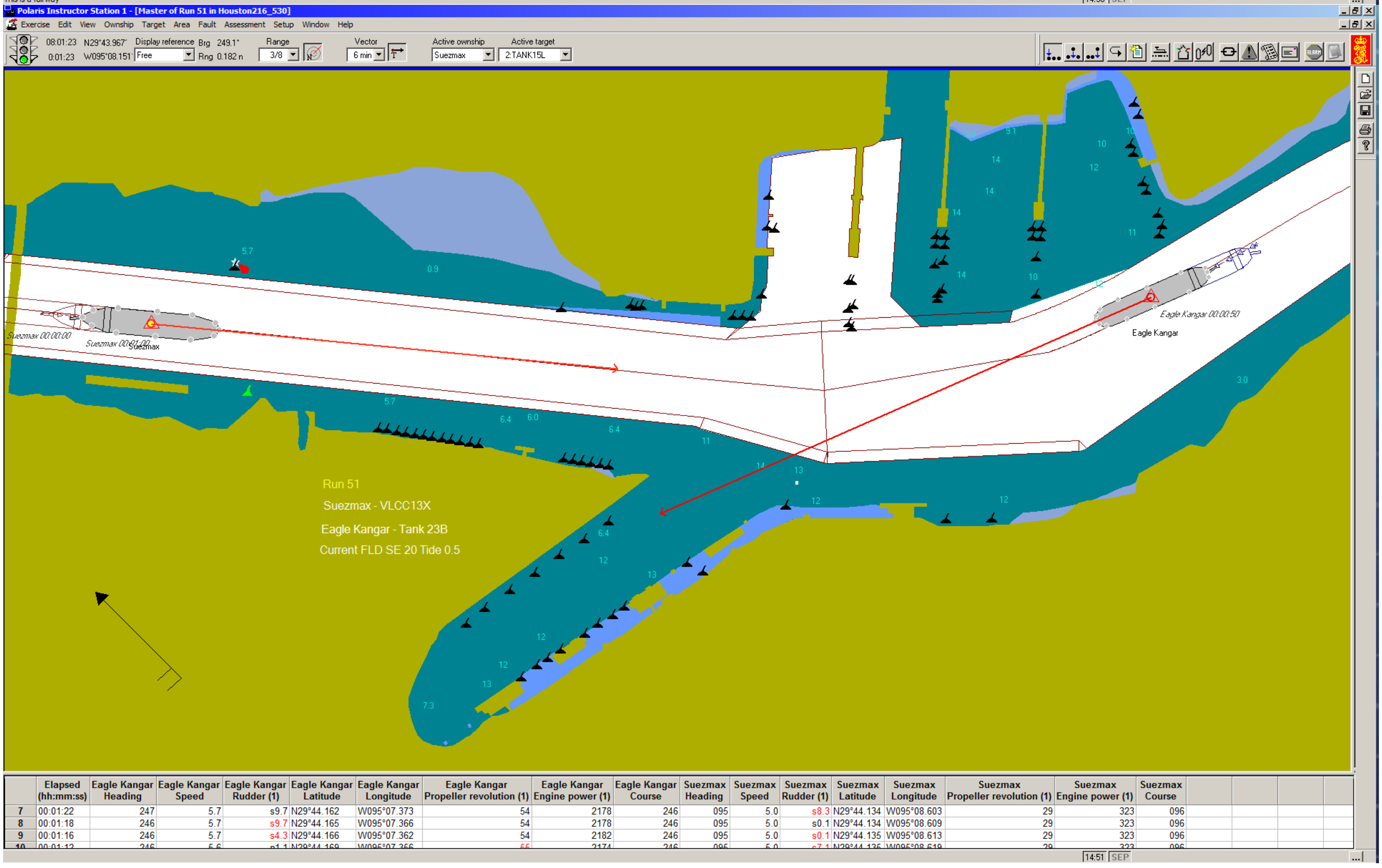
Run 51



08:00:09 N29°44.179′ Display reference: Free Brg 175.4°
0:00:09 W095°07.936′ Rng 0.077 n
Range: 3/4
Vector: 6 min
Active ownship: Eagle Kangar
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:00:08	241	5.0	s3.1	N29°44.211	W095°07.259	48	1937	242	096	5.0	s0.1	N29°44.144	W095°08.721	29	323	096
8	00:00:06	241	5.0	p0.6	N29°44.213	W095°07.256	47	1697	242	096	5.0	s0.1	N29°44.144	W095°08.724	29	323	096
9	00:00:04	241	5.0	p0.6	N29°44.214	W095°07.253	45	1743	241	096	5.0	s0.1	N29°44.145	W095°08.727	29	323	096

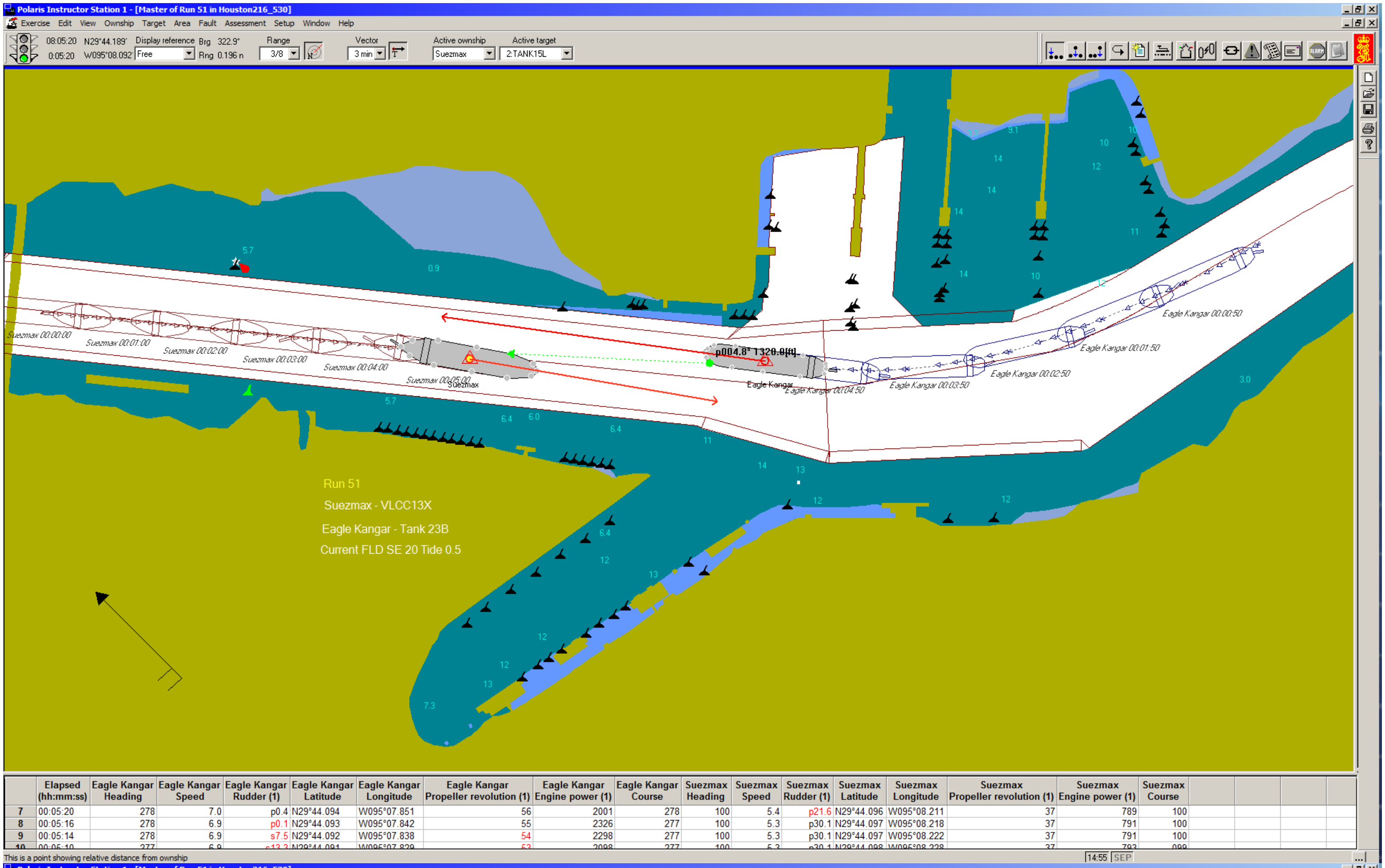
This is a fairway 14:50 SEP



08:01:23 N29°43.967′ Display reference: Free Brg 249.1°
0:01:23 W095°08.151′ Rng 0.182 n
Range: 3/8
Vector: 6 min
Active ownship: Suezmax
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:01:22	247	5.7	s9.7	N29°44.162	W095°07.373	54	2178	246	095	5.0	s8.3	N29°44.134	W095°08.603	29	323	096
8	00:01:18	246	5.7	s9.7	N29°44.165	W095°07.366	54	2178	246	095	5.0	s0.1	N29°44.134	W095°08.609	29	323	096
9	00:01:16	246	5.7	s4.3	N29°44.166	W095°07.362	54	2182	246	095	5.0	s0.1	N29°44.135	W095°08.613	29	323	096
10	00:01:12	246	5.6	p1.1	N29°44.169	W095°07.356	55	2174	246	095	5.0	s7.1	N29°44.136	W095°08.619	29	323	096

14:51 SEP



Polaris Instructor Station 1 - [Master of Run 51 in Houston216_530]

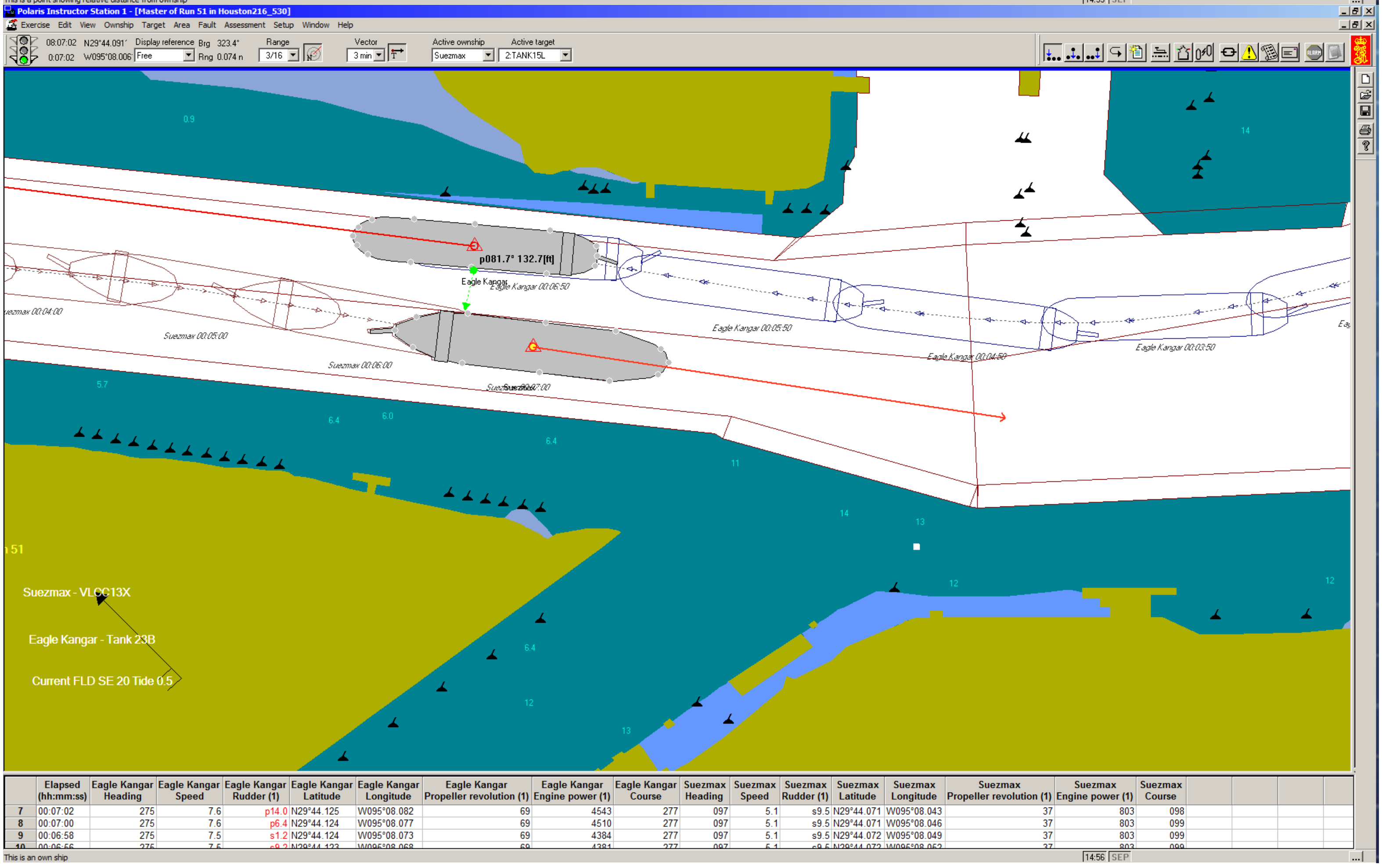
08:05:20 N29°44.189' Display reference Free Brg 322.9° Rng 0.196 n Range 3/8 Vector 3 min Active ownship Suezmax Active target 2:TANK15L

0:05:20 W095°08.092'

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:20	278	7.0	p0.4	N29°44.094	W095°07.851	56	2001	278	100	5.4	p21.6	N29°44.096	W095°08.211	37	789	100
8	00:05:16	278	6.9	p0.1	N29°44.093	W095°07.842	55	2326	277	100	5.3	p30.1	N29°44.097	W095°08.218	37	791	100
9	00:05:14	278	6.9	s7.5	N29°44.092	W095°07.838	54	2298	277	100	5.3	p30.1	N29°44.097	W095°08.222	37	791	100
10	00:05:10	277	6.9	s13.3	N29°44.091	W095°07.829	53	2098	277	100	5.3	p30.1	N29°44.098	W095°08.228	37	793	099

This is a point showing relative distance from ownship

14:55 SEP



Polaris Instructor Station 1 - [Master of Run 51 in Houston216_530]

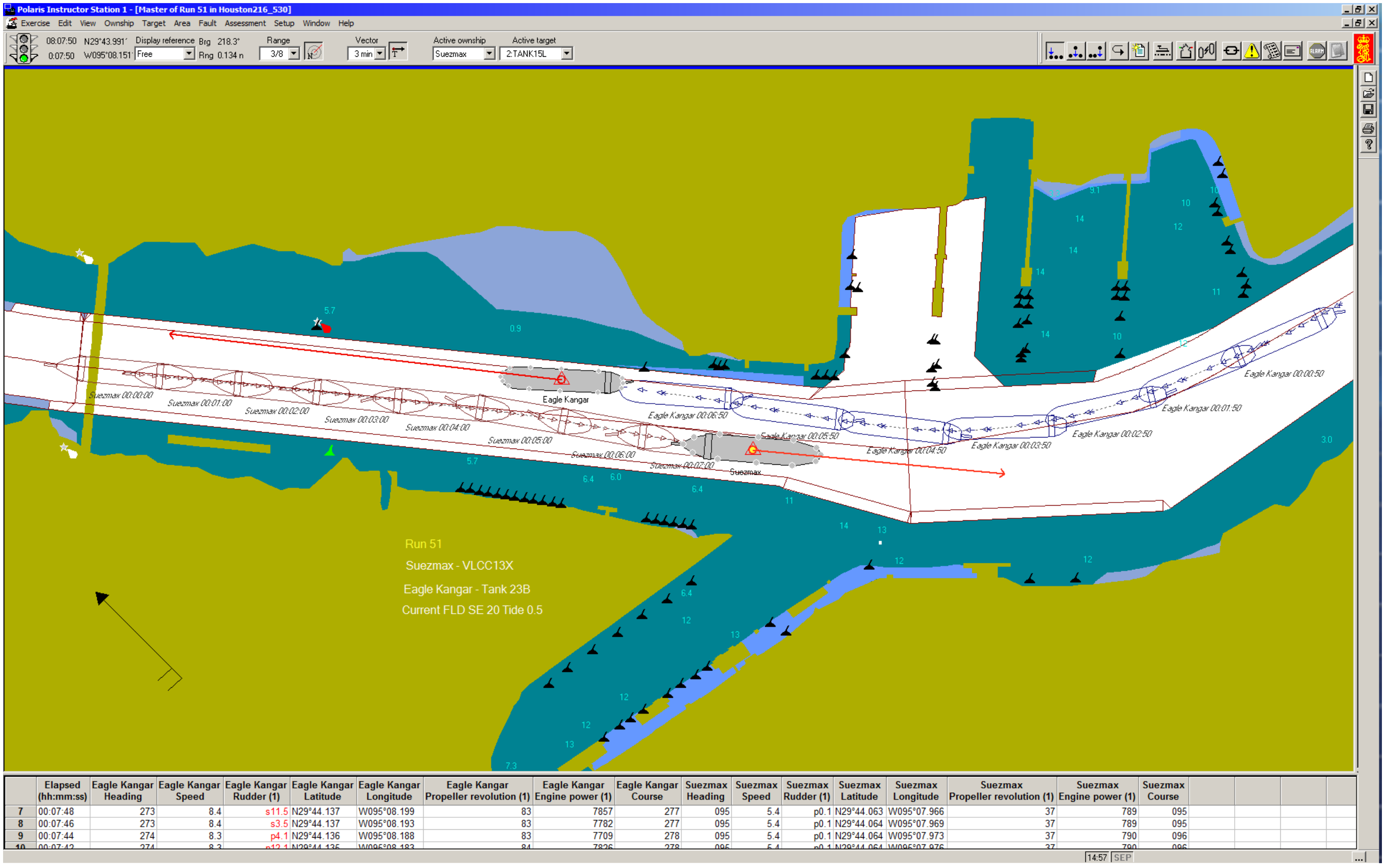
08:07:02 N29°44.091' Display reference Free Brg 323.4° Rng 0.074 n Range 3/16 Vector 3 min Active ownship Suezmax Active target 2:TANK15L

0:07:02 W095°08.006'

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:02	275	7.6	p14.0	N29°44.125	W095°08.082	69	4543	277	097	5.1	s9.5	N29°44.071	W095°08.043	37	803	098
8	00:07:00	275	7.6	p6.4	N29°44.124	W095°08.077	69	4510	277	097	5.1	s9.5	N29°44.071	W095°08.046	37	803	099
9	00:06:58	275	7.5	s1.2	N29°44.124	W095°08.073	69	4384	277	097	5.1	s9.5	N29°44.072	W095°08.049	37	803	099
10	00:06:56	275	7.5	s9.2	N29°44.123	W095°08.068	69	4381	277	097	5.1	s9.5	N29°44.072	W095°08.052	37	803	099

This is an own ship

14:56 SEP



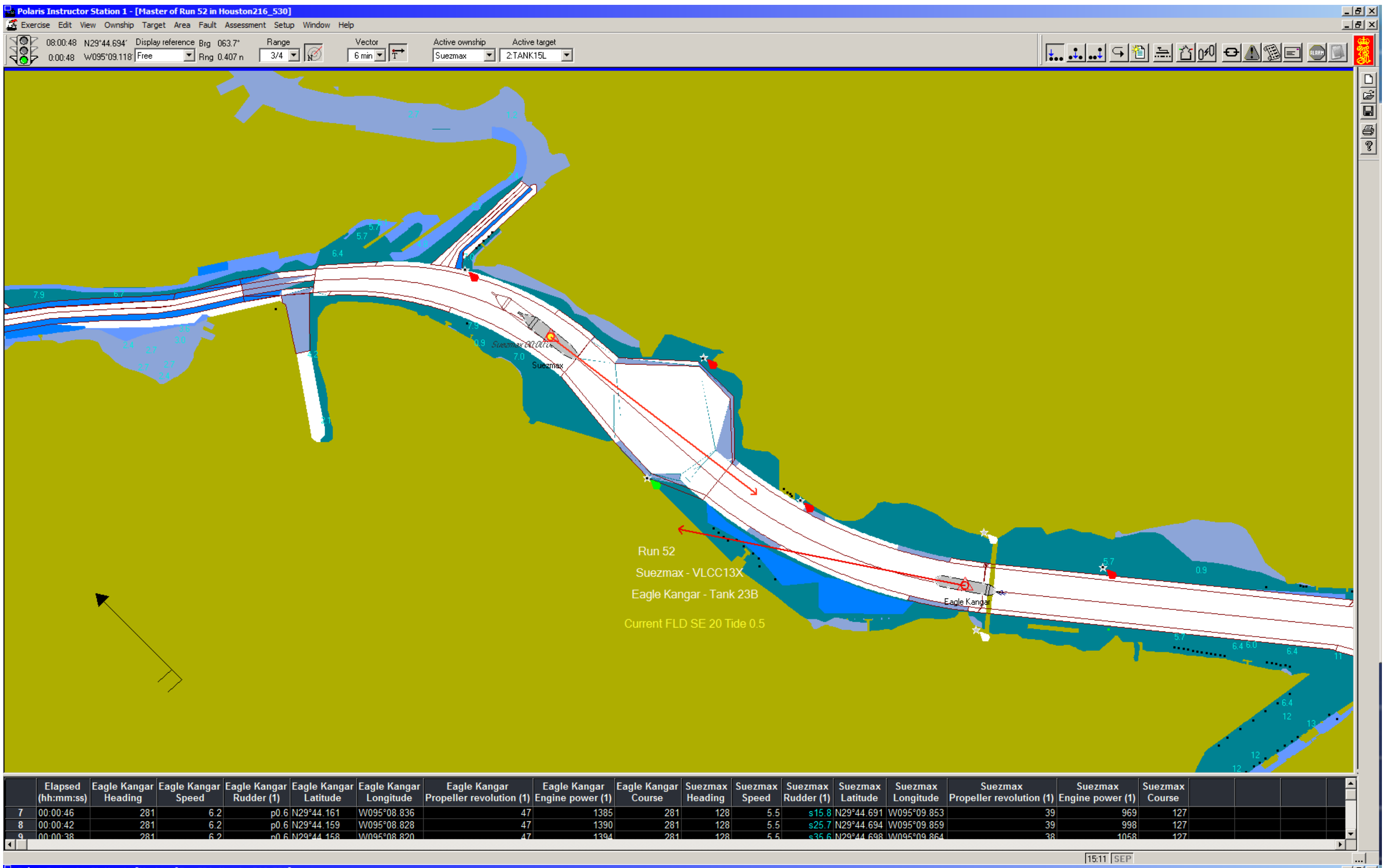
Polaris Instructor Station 1 - [Master of Run 51 in Houston216_530]

08:07:50 N29°43.991´
0:07:50 W095°08.151´
Display reference: Free
Brg 218.3°
Rng 0.134 n
Range: 3/8
Vector: 3 min
Active ownship: Suezmax
Active target: 2:TANK15L

Run 51
Suezmax - VLCC13X
Eagle Kangar - Tank 23B
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:48	273	8.4	s11.5	N29°44.137	W095°08.199	83	7857	277	095	5.4	p0.1	N29°44.063	W095°07.966	37	789	095
8	00:07:46	273	8.4	s3.5	N29°44.137	W095°08.193	83	7782	277	095	5.4	p0.1	N29°44.064	W095°07.969	37	789	095
9	00:07:44	274	8.3	p4.1	N29°44.136	W095°08.188	83	7709	278	095	5.4	p0.1	N29°44.064	W095°07.973	37	790	096
10	00:07:42	274	8.3	p12.1	N29°44.135	W095°08.183	84	7826	278	095	5.4	p0.1	N29°44.064	W095°07.976	37	790	096

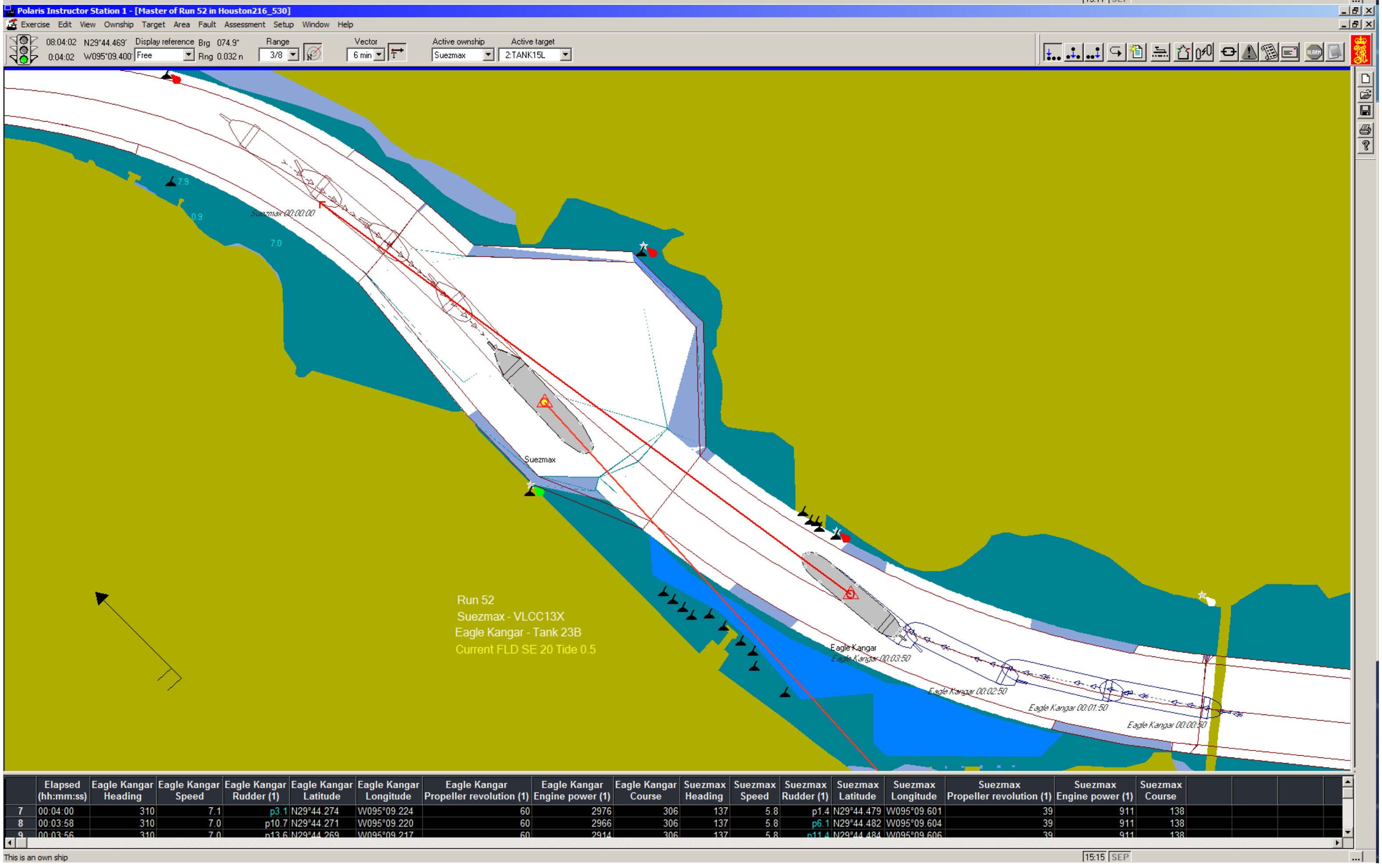
Run 52



08:00:48 N29°44.694′ Display reference Free Brg 063.7° Rng 0.407 n
0:00:48 W095°09.118′
Range 3/4
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

Run 52
Suezmax - VLCC13X
Eagle Kangar - Tank 23B
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:00:46	281	6.2	p0.6	N29°44.161	W095°08.836	47	1385	281	128	5.5	s15.8	N29°44.691	W095°09.853	39	969	127
8	00:00:42	281	6.2	p0.6	N29°44.159	W095°08.828	47	1390	281	128	5.5	s25.7	N29°44.694	W095°09.859	39	998	127
9	00:00:38	281	6.2	p0.6	N29°44.158	W095°08.820	47	1394	281	128	5.5	s35.6	N29°44.698	W095°09.864	38	1058	127

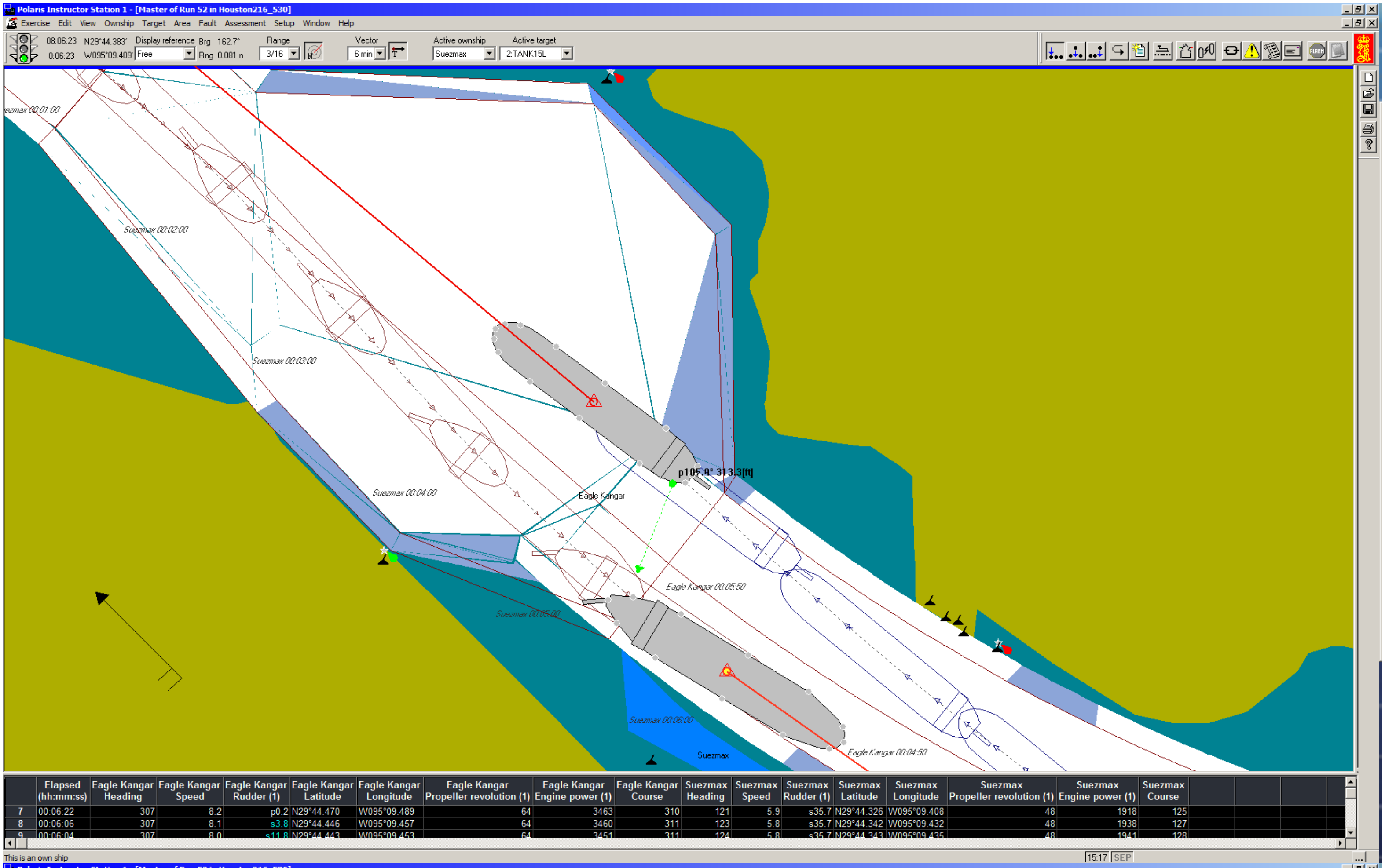


08:04:02 N29°44.469′ Display reference Free Brg 074.9° Rng 0.032 n
0:04:02 W095°09.400′
Range 3/8
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

Run 52
Suezmax - VLCC13X
Eagle Kangar - Tank 23B
Current FLD SE 20 Tide 0.5

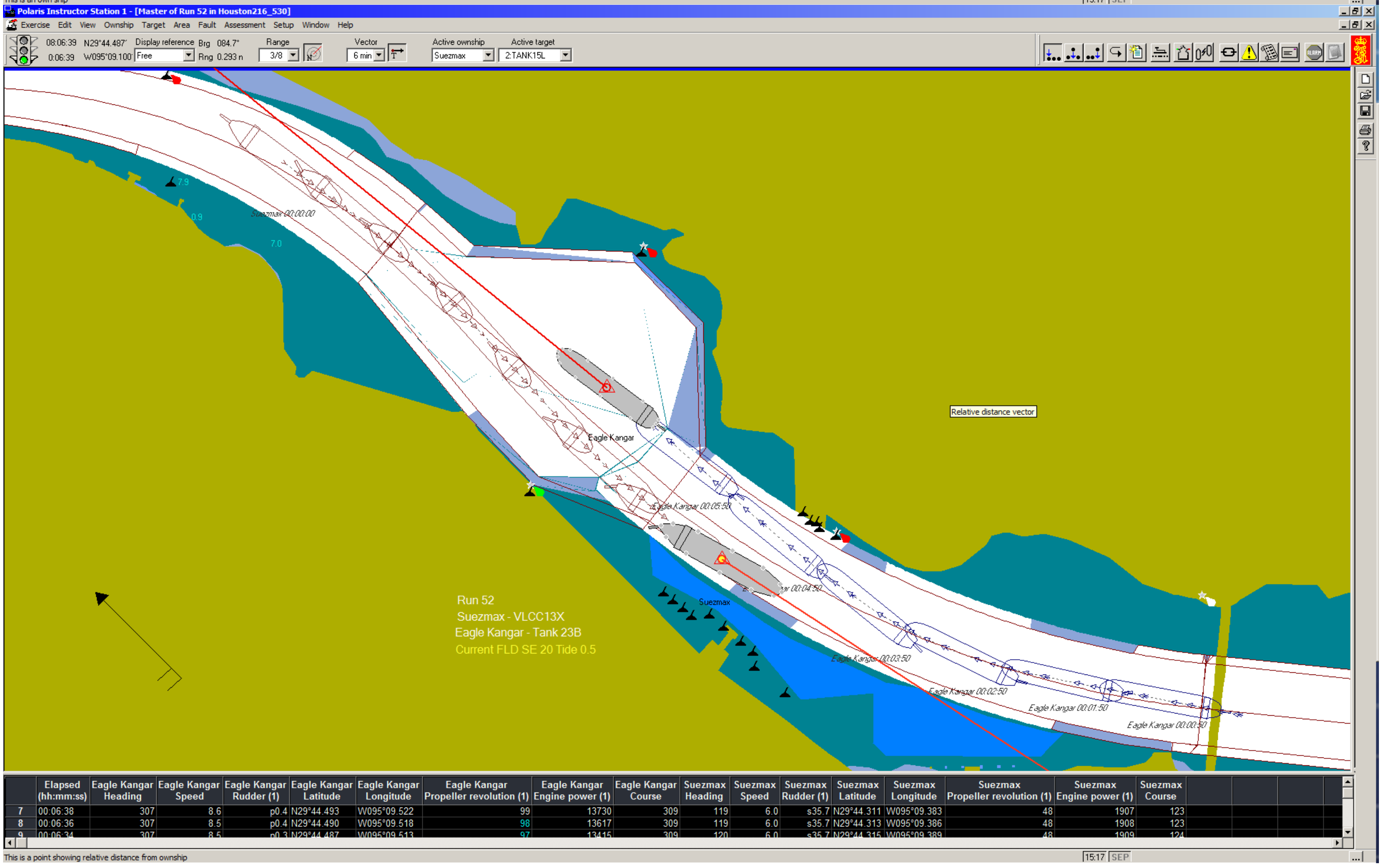
	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:04:00	310	7.1	p3.1	N29°44.274	W095°09.224	60	2976	306	137	5.8	p1.4	N29°44.479	W095°09.601	39	911	138
8	00:03:58	310	7.0	p10.7	N29°44.271	W095°09.220	60	2966	306	137	5.8	p6.1	N29°44.482	W095°09.604	39	911	138
9	00:03:56	310	7.0	p13.6	N29°44.269	W095°09.217	60	2914	306	137	5.8	p11.4	N29°44.484	W095°09.606	39	911	138

This is an own ship



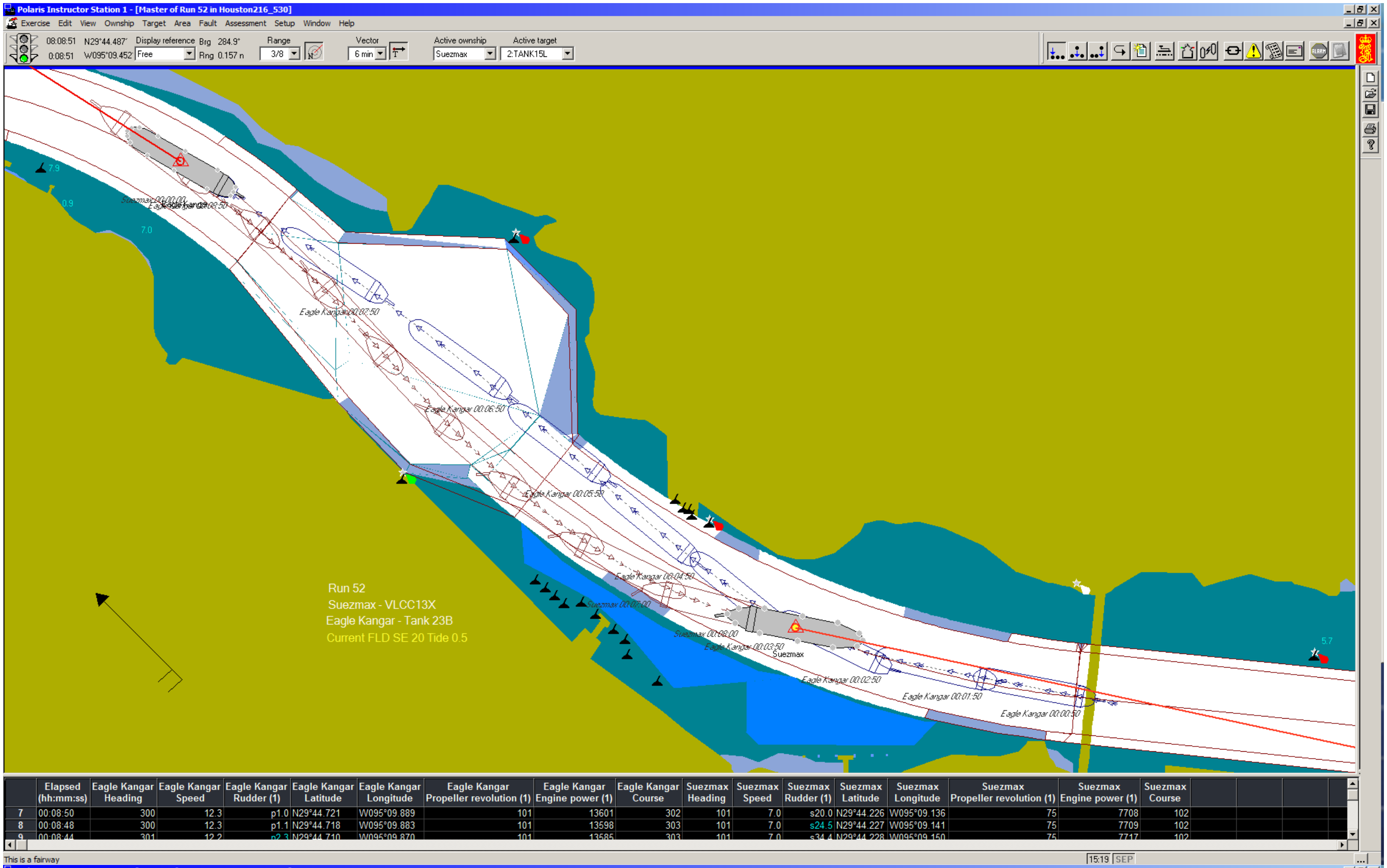
This is an own ship

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:22	307	8.2	p0.2	N29°44.470	W095°09.489	64	3463	310	121	5.9	s35.7	N29°44.326	W095°09.408	48	1918	125
8	00:06:06	307	8.1	s3.8	N29°44.446	W095°09.457	64	3460	311	123	5.8	s35.7	N29°44.342	W095°09.432	48	1938	127
9	00:06:04	307	8.0	s11.8	N29°44.443	W095°09.453	64	3451	311	124	5.8	s35.7	N29°44.343	W095°09.435	48	1941	128



	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:38	307	8.6	p0.4	N29°44.493	W095°09.522	99	13730	309	119	6.0	s35.7	N29°44.311	W095°09.383	48	1907	123
8	00:06:36	307	8.5	p0.4	N29°44.490	W095°09.518	98	13617	309	119	6.0	s35.7	N29°44.313	W095°09.386	48	1908	123
9	00:06:34	307	8.5	p0.3	N29°44.487	W095°09.513	97	13415	309	120	6.0	s35.7	N29°44.315	W095°09.389	48	1909	124

This is a point showing relative distance from ownship



08:08:51 N29°44.487' Display reference Free Brg 284.9° Rng 0.157 n

0:08:51 W095°09.452'

Range 3/8

Vector 6 min

Active ownship Suezmax

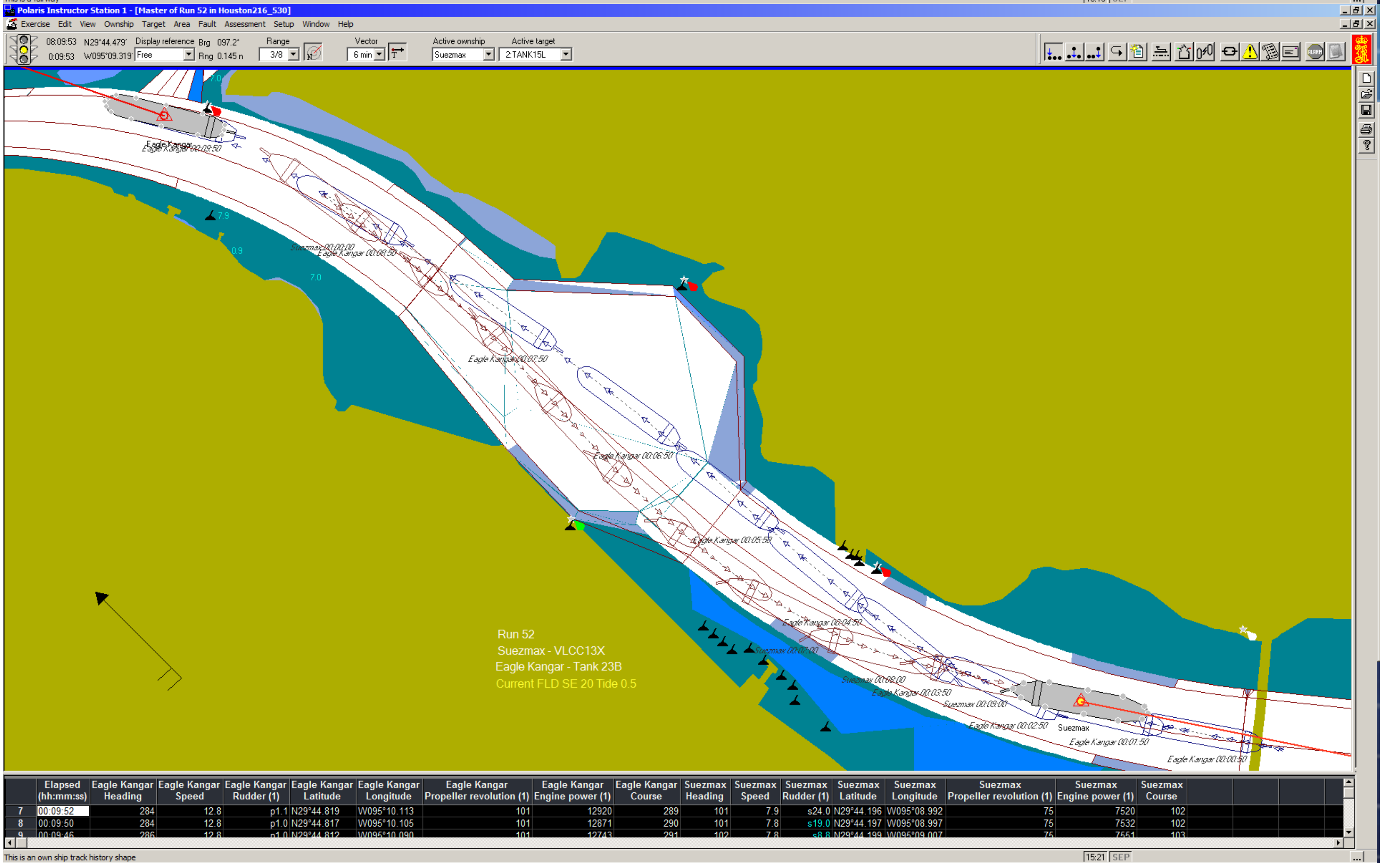
Active target 2:TANK15L

Run 52
Suezmax - VLCC13X
Eagle Kangar - Tank 23B
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:08:50	300	12.3	p1.0	N29°44.721	W095°09.889	101	13601	302	101	7.0	s20.0	N29°44.226	W095°09.136	75	7708	102
8	00:08:48	300	12.3	p1.1	N29°44.718	W095°09.883	101	13598	303	101	7.0	s24.5	N29°44.227	W095°09.141	75	7709	102
9	00:08:44	301	12.2	p2.3	N29°44.710	W095°09.870	101	13585	303	101	7.0	s34.4	N29°44.228	W095°09.150	75	7717	102

This is a fairway

15:19 SEP



08:09:53 N29°44.479' Display reference Free Brg 097.2° Rng 0.145 n

0:09:53 W095°09.319'

Range 3/8

Vector 6 min

Active ownship Suezmax

Active target 2:TANK15L

Run 52
Suezmax - VLCC13X
Eagle Kangar - Tank 23B
Current FLD SE 20 Tide 0.5

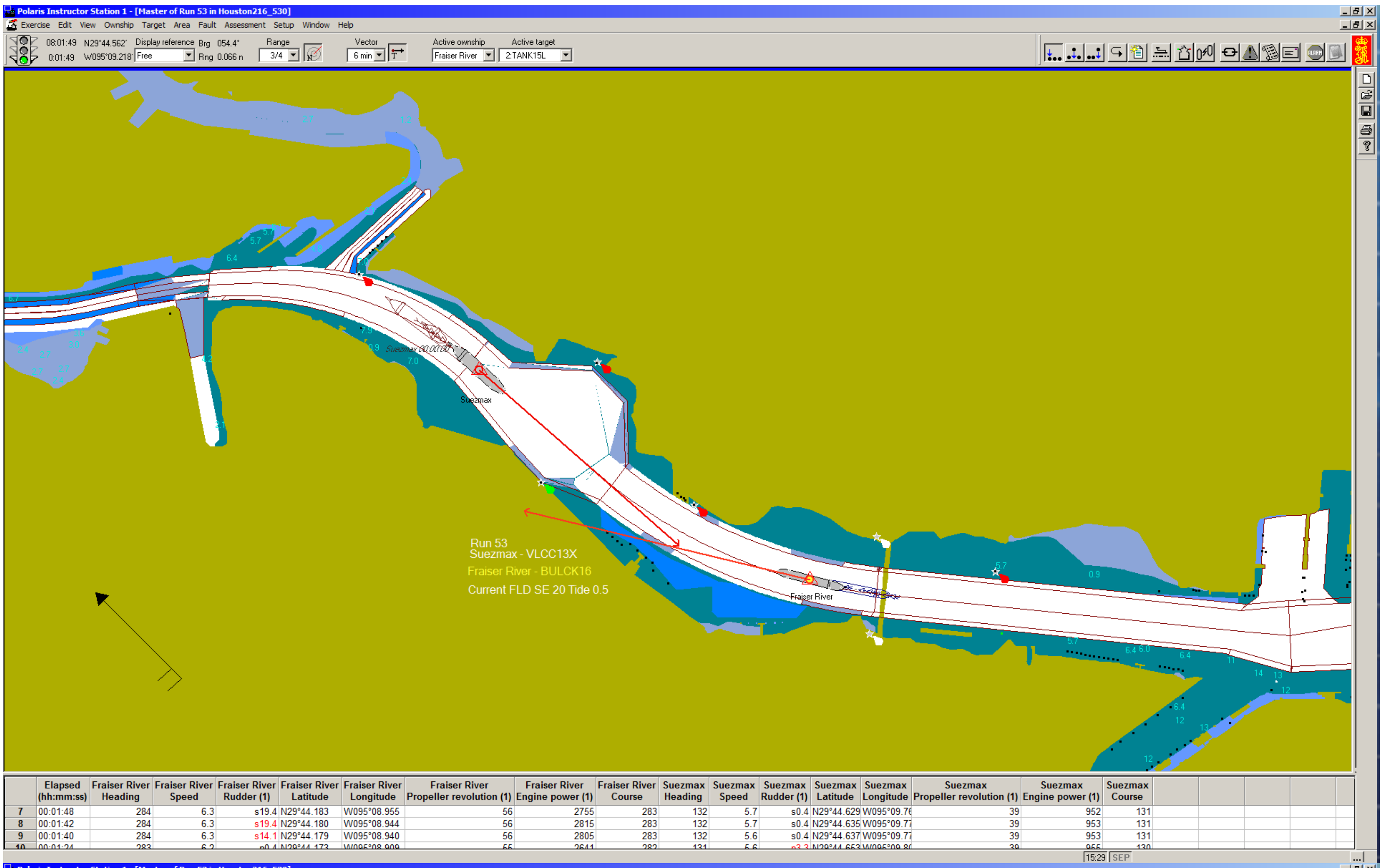
	Elapsed (hh:mm:ss)	Eagle Kangar Heading	Eagle Kangar Speed	Eagle Kangar Rudder (1)	Eagle Kangar Latitude	Eagle Kangar Longitude	Eagle Kangar Propeller revolution (1)	Eagle Kangar Engine power (1)	Eagle Kangar Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:09:52	284	12.8	p1.1	N29°44.819	W095°10.113	101	12920	289	101	7.9	s24.0	N29°44.196	W095°08.992	75	7520	102
8	00:09:50	284	12.8	p1.0	N29°44.817	W095°10.105	101	12871	290	101	7.8	s19.0	N29°44.197	W095°08.997	75	7532	102
9	00:09:46	286	12.8	p1.0	N29°44.812	W095°10.090	101	12743	291	102	7.8	s8.8	N29°44.199	W095°09.007	75	7551	103

This is an own ship track history shape

15:21 SEP

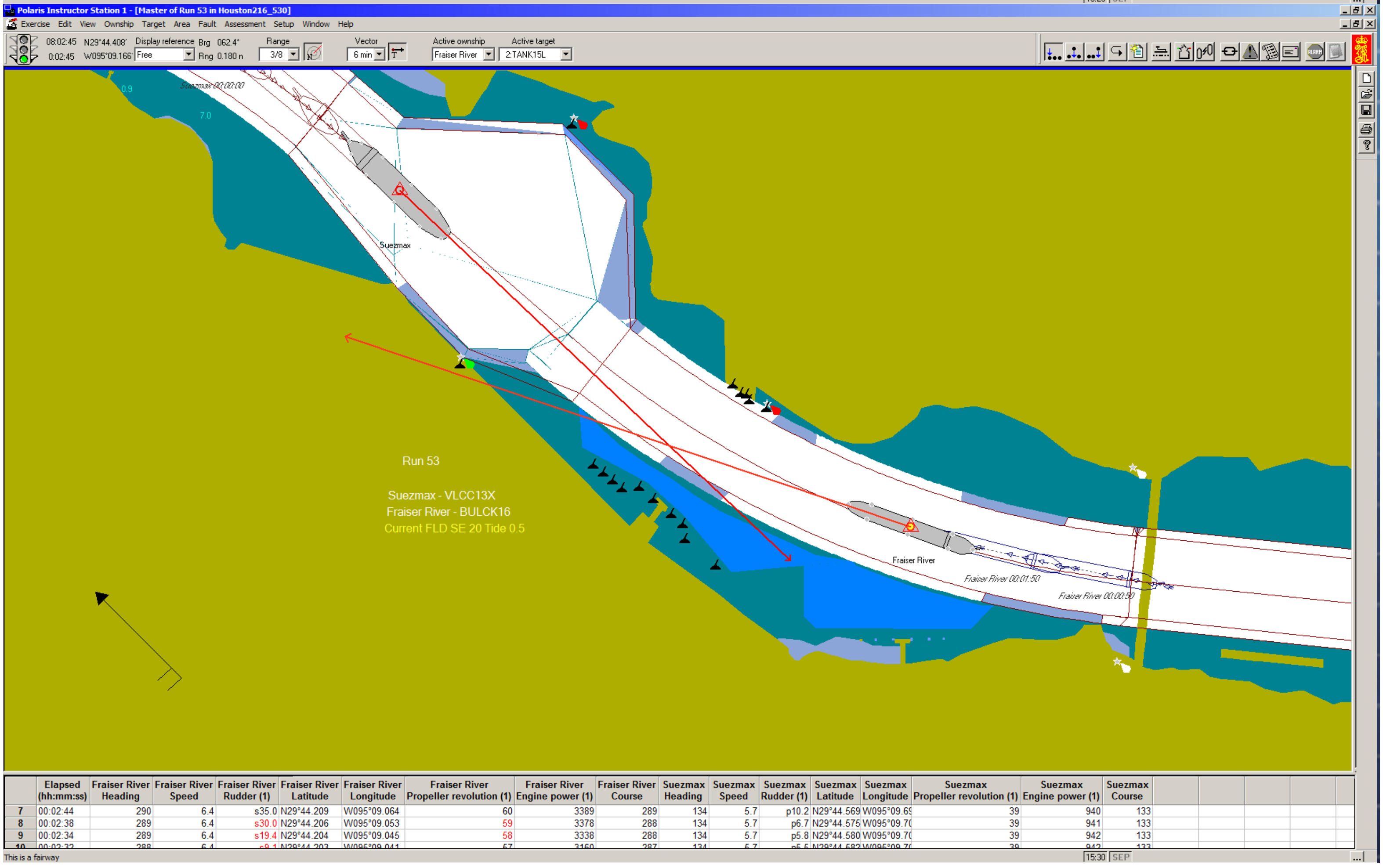
June 26, 2019

Run 53



Run 53
Suezmax - VLCC13X
Fraiser River - BULCK16
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:01:48	284	6.3	s19.4	N29°44.183	W095°08.955	56	2755	283	132	5.7	s0.4	N29°44.629	W095°09.76	39	952	131
8	00:01:42	284	6.3	s19.4	N29°44.180	W095°08.944	56	2815	283	132	5.7	s0.4	N29°44.635	W095°09.77	39	953	131
9	00:01:40	284	6.3	s14.1	N29°44.179	W095°08.940	56	2805	283	132	5.6	s0.4	N29°44.637	W095°09.77	39	953	131



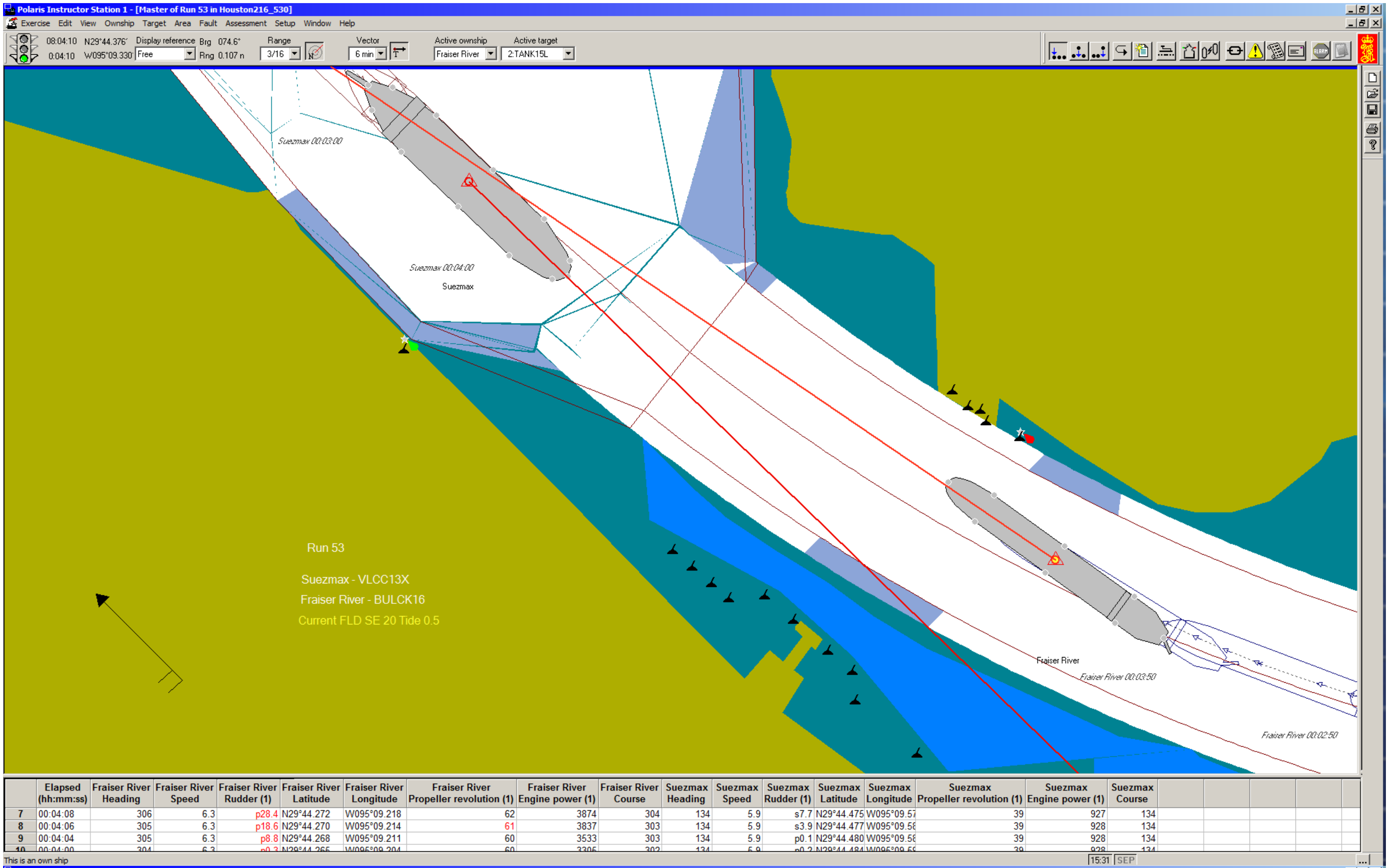
Run 53

Suezmax - VLCC13X
Fraiser River - BULCK16
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:02:44	290	6.4	s35.0	N29°44.209	W095°09.064	60	3389	289	134	5.7	p10.2	N29°44.569	W095°09.69	39	940	133
8	00:02:38	289	6.4	s30.0	N29°44.206	W095°09.053	59	3378	288	134	5.7	p6.7	N29°44.575	W095°09.70	39	941	133
9	00:02:34	289	6.4	s19.4	N29°44.204	W095°09.045	58	3338	288	134	5.7	p5.8	N29°44.580	W095°09.70	39	942	133

This is a fairway

- Page 480



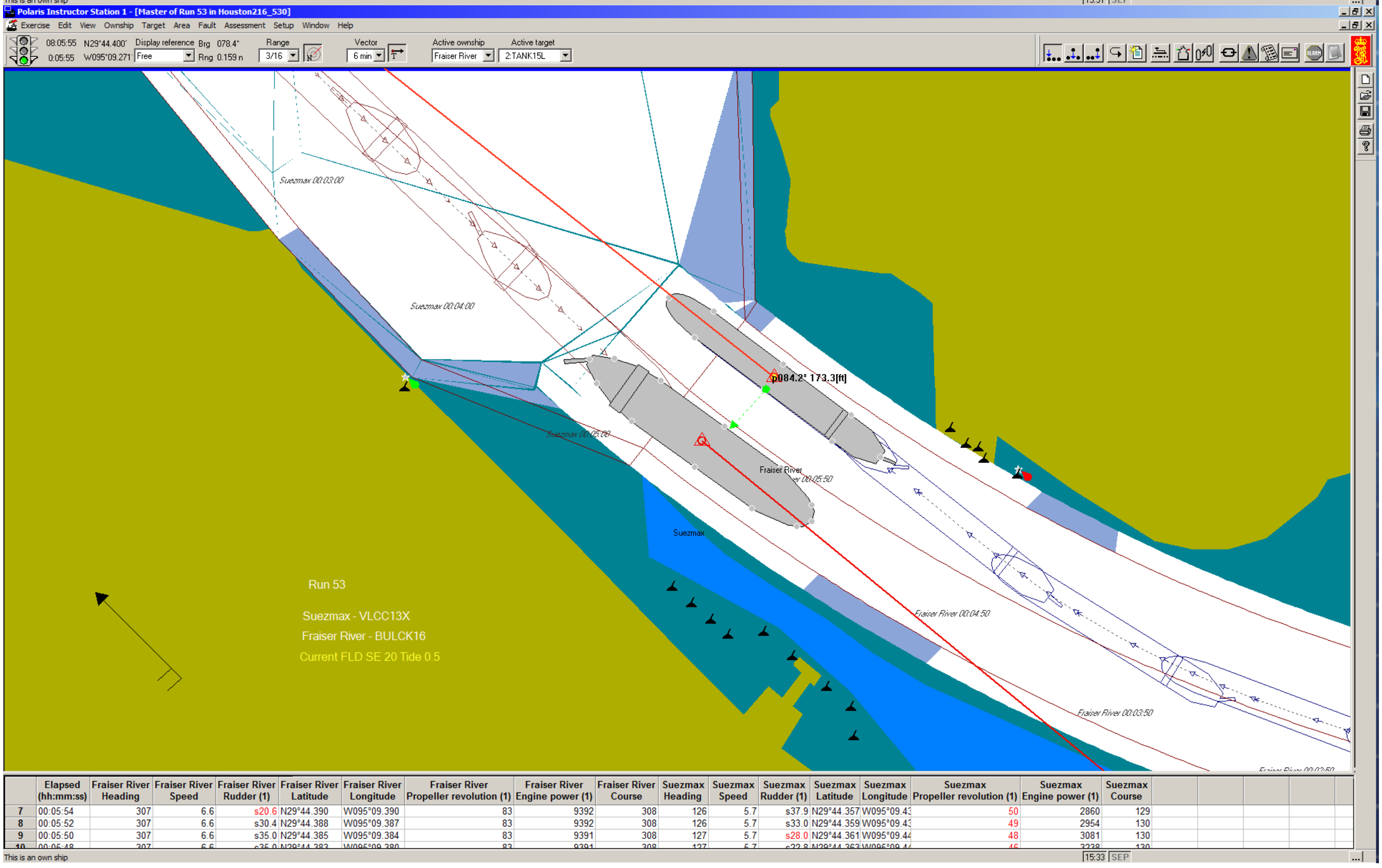
Polaris Instructor Station 1 - [Master of Run 53 in Houston216_530]

08:04:10 N29°44.376' Display reference: Free Brg 074.6° Range 3/16 Vector 6 min Active ownship: Fraiser River Active target: 2:TANK15L
0:04:10 W095°09.330' Rng 0.107 n

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:04:08	306	6.3	p28.4	N29°44.272	W095°09.218	62	3874	304	134	5.9	s7.7	N29°44.475	W095°09.57	39	927	134
8	00:04:06	305	6.3	p18.6	N29°44.270	W095°09.214	61	3837	303	134	5.9	s3.9	N29°44.477	W095°09.58	39	928	134
9	00:04:04	305	6.3	p8.8	N29°44.268	W095°09.211	60	3533	303	134	5.9	p0.1	N29°44.480	W095°09.58	39	928	134

This is an own ship

15:31 SEP



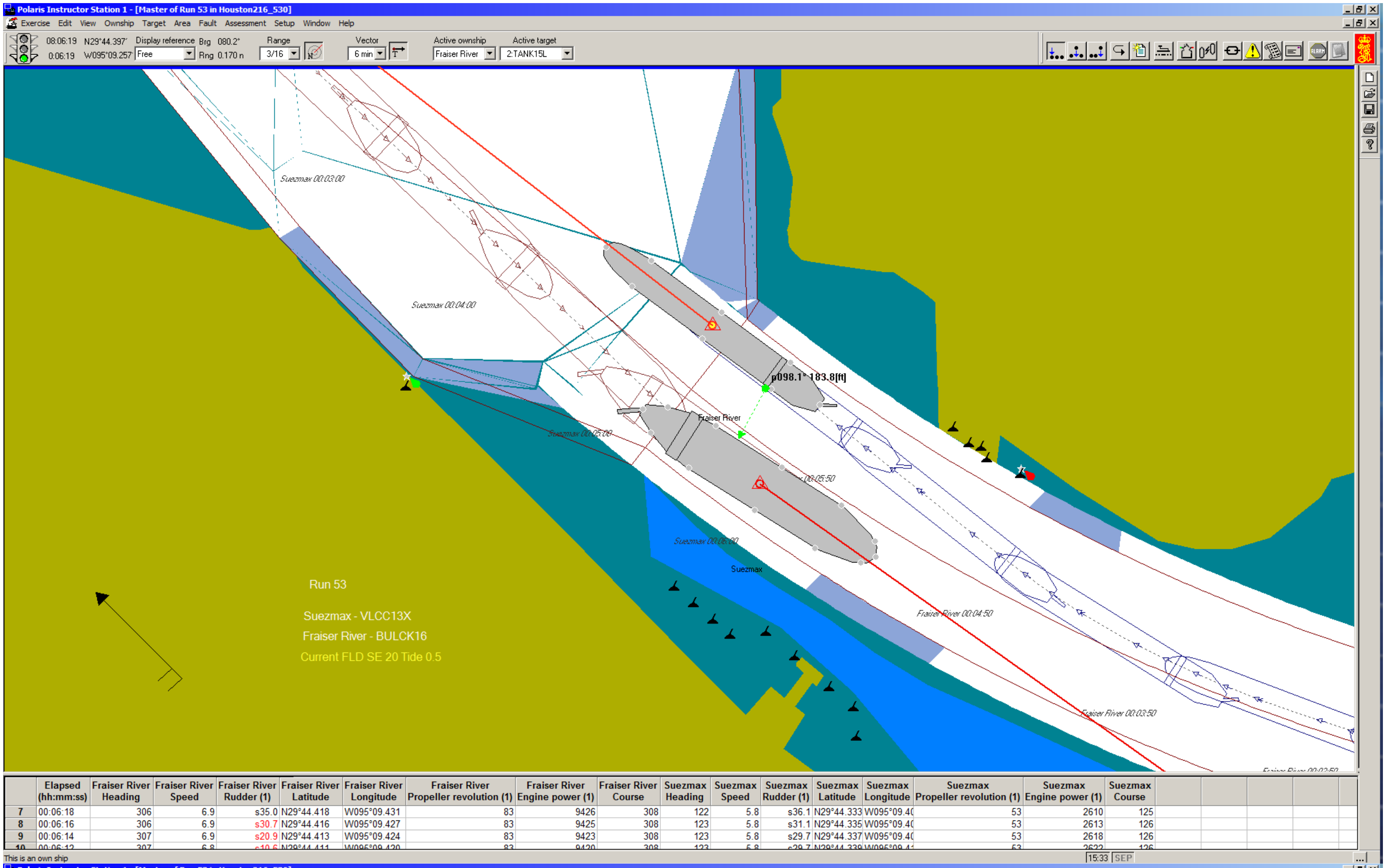
Polaris Instructor Station 1 - [Master of Run 53 in Houston216_530]

08:05:55 N29°44.400' Display reference: Free Brg 078.4° Range 3/16 Vector 6 min Active ownship: Fraiser River Active target: 2:TANK15L
0:05:55 W095°09.271' Rng 0.159 n

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:54	307	6.6	s20.6	N29°44.390	W095°09.390	83	9392	308	126	5.7	s37.9	N29°44.357	W095°09.43	50	2860	129
8	00:05:52	307	6.6	s30.4	N29°44.388	W095°09.387	83	9392	308	126	5.7	s33.0	N29°44.359	W095°09.43	49	2954	130
9	00:05:50	307	6.6	s35.0	N29°44.385	W095°09.384	83	9391	308	127	5.7	s28.0	N29°44.361	W095°09.44	48	3081	130

This is an own ship

15:33 SEP



08:06:19 N29°44.397' Display reference Free Brg 080.2° Rng 0.170 n
0:06:19 W095°09.257'
Range 3/16
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

Run 53

Suezmax - VLCC13X

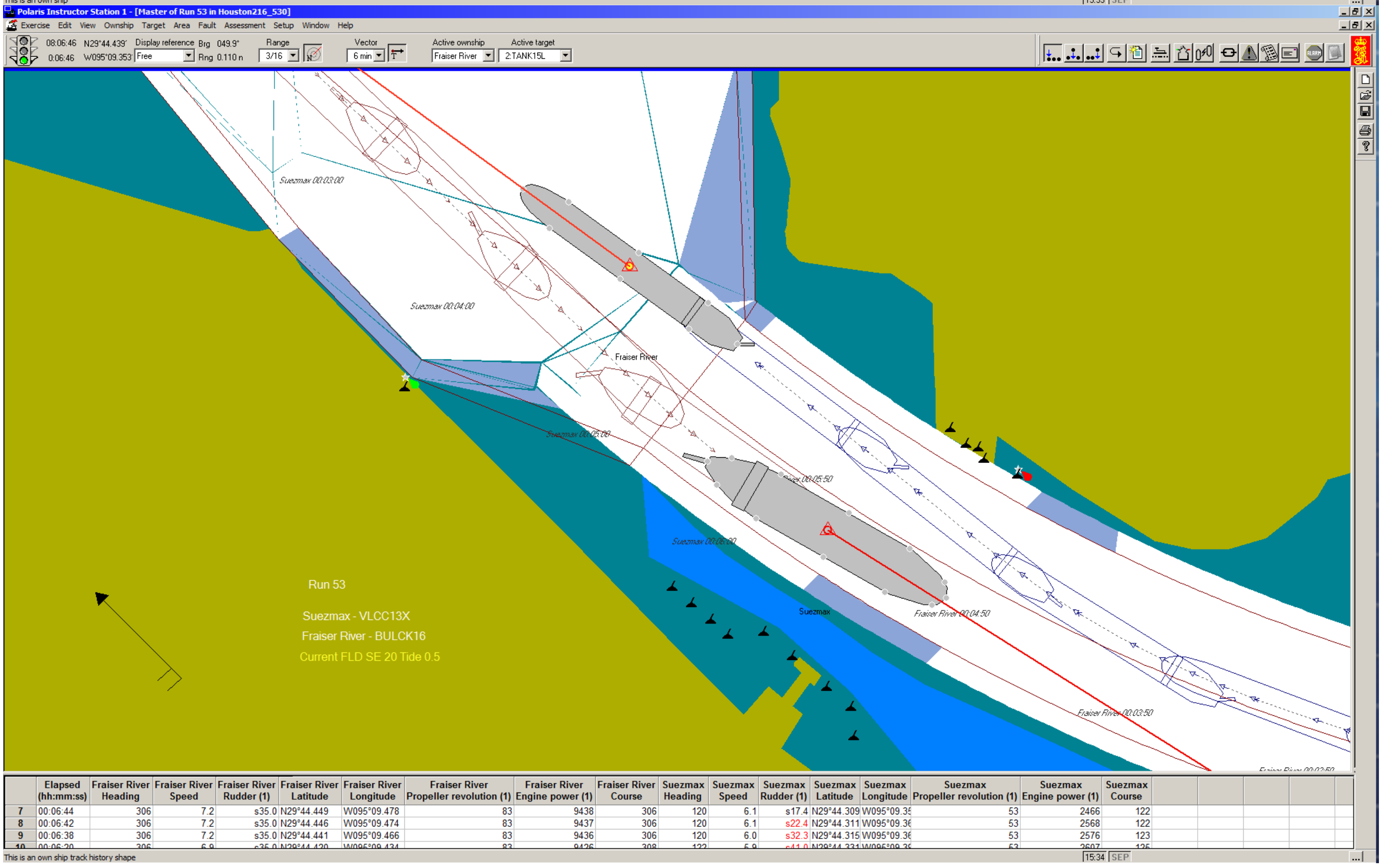
Fraiser River - BULCK16

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:18	306	6.9	s35.0	N29°44.418	W095°09.431	83	9426	308	122	5.8	s36.1	N29°44.333	W095°09.40	53	2610	125
8	00:06:16	306	6.9	s30.7	N29°44.416	W095°09.427	83	9425	308	123	5.8	s31.1	N29°44.335	W095°09.40	53	2613	126
9	00:06:14	307	6.9	s20.9	N29°44.413	W095°09.424	83	9423	308	123	5.8	s29.7	N29°44.337	W095°09.40	53	2618	126

This is an own ship

15:33 SEP



08:06:46 N29°44.439' Display reference Free Brg 049.9° Rng 0.110 n
0:06:46 W095°09.353'
Range 3/16
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

Run 53

Suezmax - VLCC13X

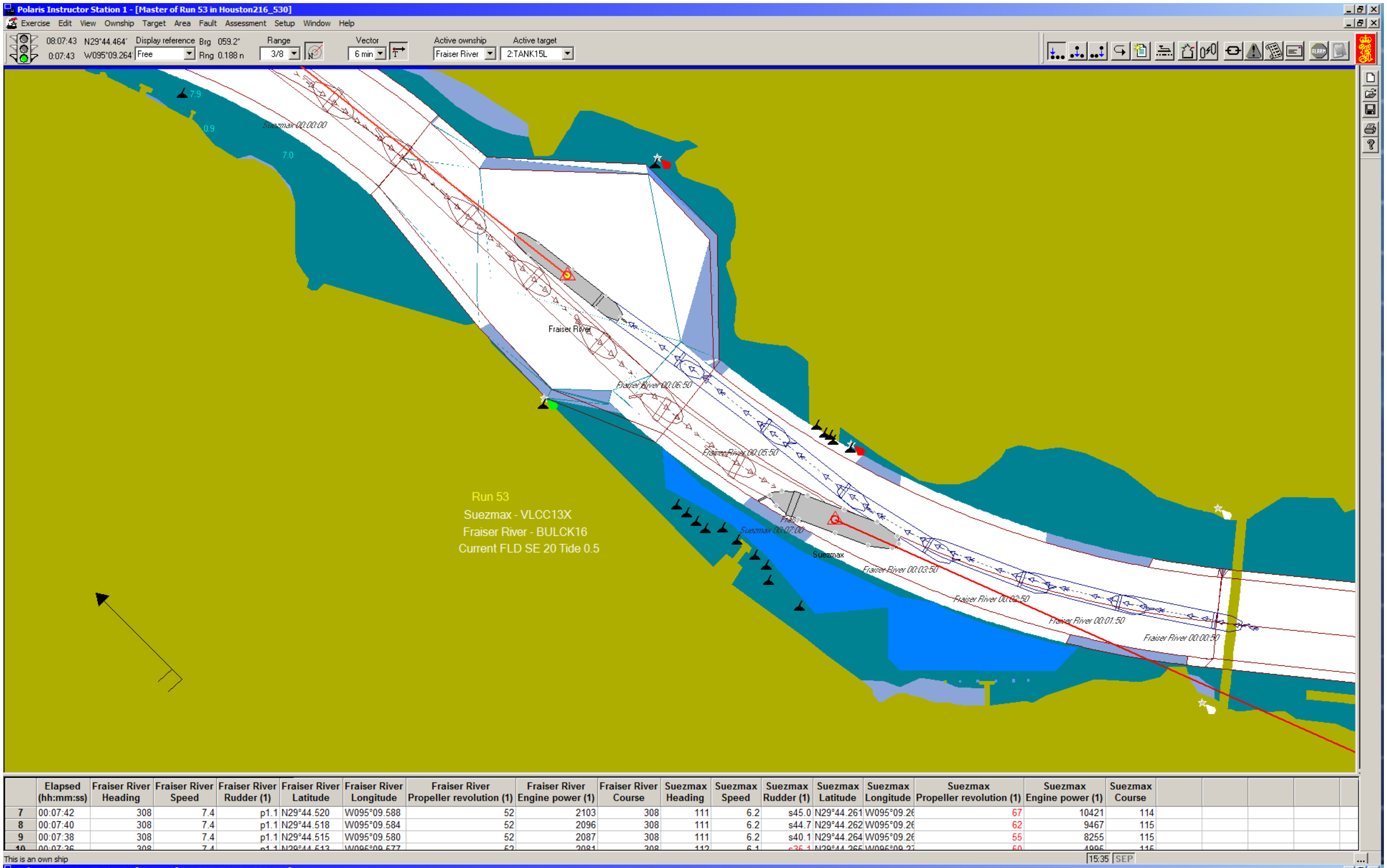
Fraiser River - BULCK16

Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:44	306	7.2	s35.0	N29°44.449	W095°09.478	83	9438	306	120	6.1	s17.4	N29°44.309	W095°09.35	53	2466	122
8	00:06:42	306	7.2	s35.0	N29°44.446	W095°09.474	83	9437	306	120	6.1	s22.4	N29°44.311	W095°09.36	53	2568	122
9	00:06:38	306	7.2	s35.0	N29°44.441	W095°09.466	83	9436	306	120	6.0	s32.3	N29°44.315	W095°09.36	53	2576	123

This is an own ship track history shape

15:34 SEP



Polaris Instructor Station 1 - [Master of Run 53 in Houston216_530]

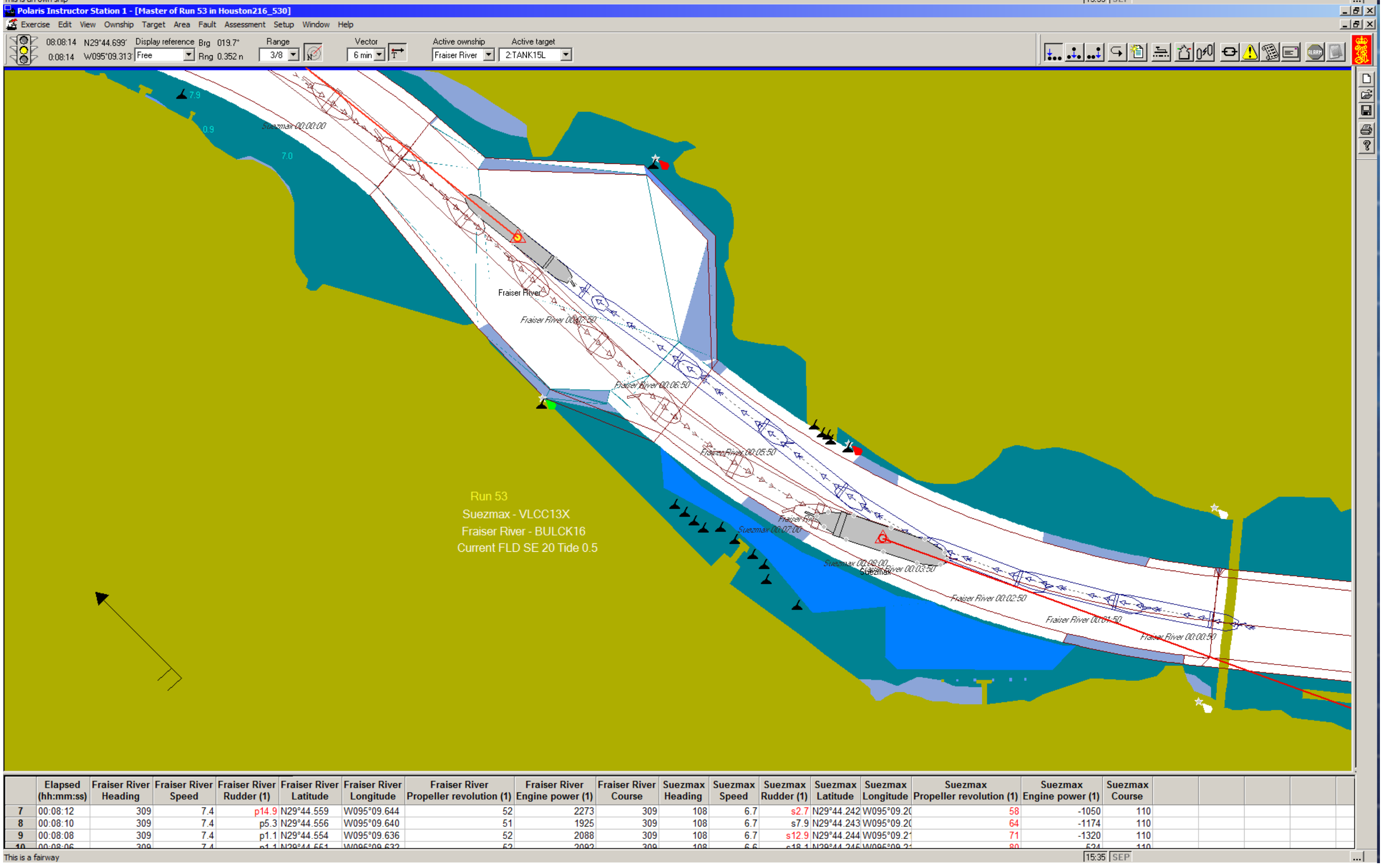
08:07:43 N29°44.464' Display reference Brg 059.2°
0:07:43 W095°09.264' Free Rng 0.188 n
Range 3/8
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

Run 53
Suezmax - VLCC13X
Fraiser River - BULCK16
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:42	308	7.4	p1.1	N29°44.520	W095°09.588	52	2103	308	111	6.2	s45.0	N29°44.261	W095°09.26	67	10421	114
8	00:07:40	308	7.4	p1.1	N29°44.518	W095°09.584	52	2096	308	111	6.2	s44.7	N29°44.262	W095°09.26	62	9467	115
9	00:07:38	308	7.4	p1.1	N29°44.515	W095°09.580	52	2087	308	111	6.2	s40.1	N29°44.264	W095°09.26	55	8255	115

This is an own ship

15:35 SEP



Polaris Instructor Station 1 - [Master of Run 53 in Houston216_530]

08:08:14 N29°44.699' Display reference Brg 019.7°
0:08:14 W095°09.313' Free Rng 0.352 n
Range 3/8
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

Run 53
Suezmax - VLCC13X
Fraiser River - BULCK16
Current FLD SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:08:12	309	7.4	p14.9	N29°44.559	W095°09.644	52	2273	309	108	6.7	s2.7	N29°44.242	W095°09.20	58	-1050	110
8	00:08:10	309	7.4	p5.3	N29°44.556	W095°09.640	51	1925	309	108	6.7	s7.9	N29°44.243	W095°09.20	64	-1174	110
9	00:08:08	309	7.4	p1.1	N29°44.554	W095°09.636	52	2088	309	108	6.7	s12.9	N29°44.244	W095°09.21	71	-1320	110

This is a fairway

15:35 SEP

June 26, 2019

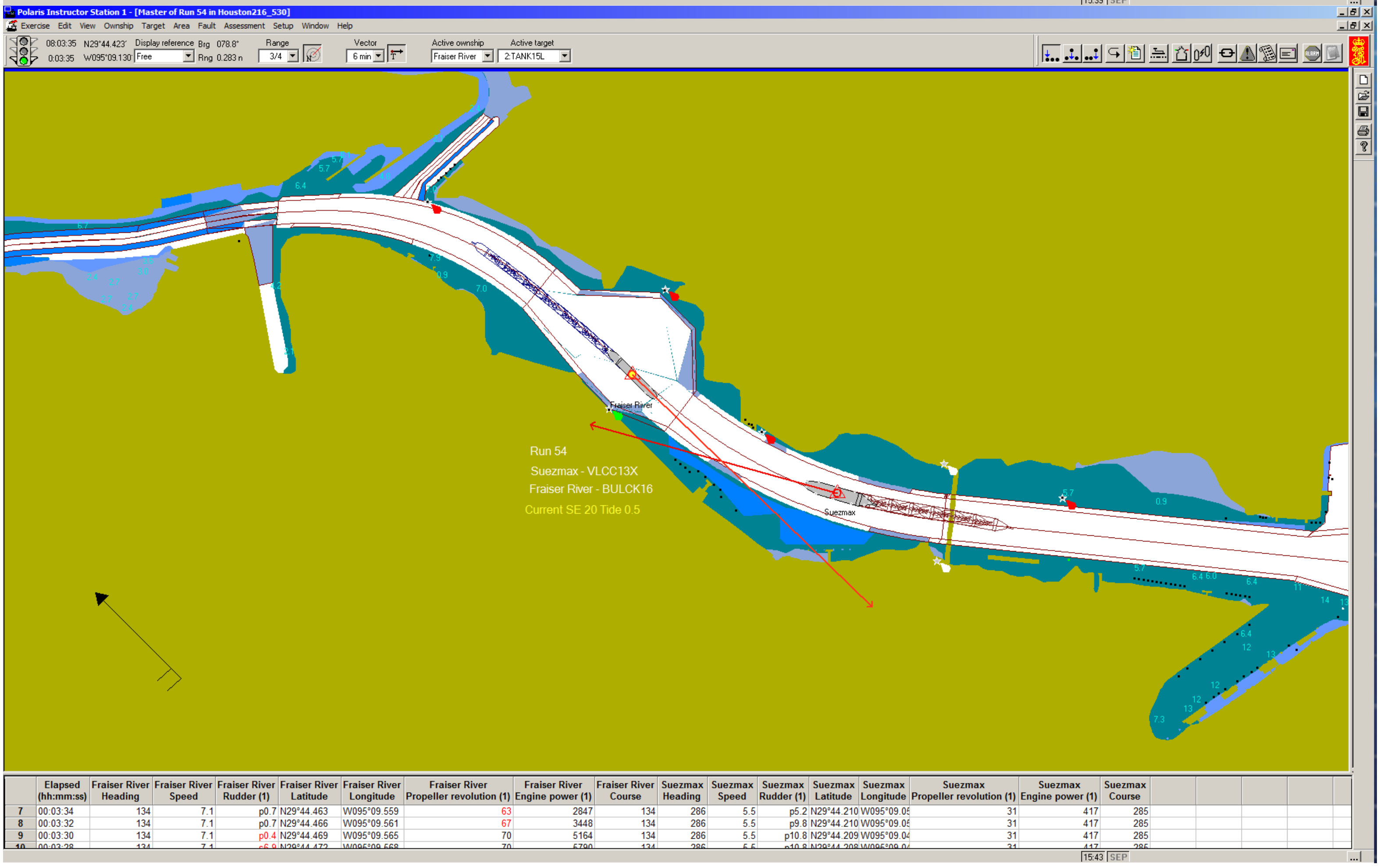
Run 54


Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:00:00 N29°44.440′ Display reference Free Brg 076.1° Rng 0.299 n Range 3/4 Vector 6 min Active ownship Fraiser River Active target 2:TANK15L

0:00:00 W095°09.116′

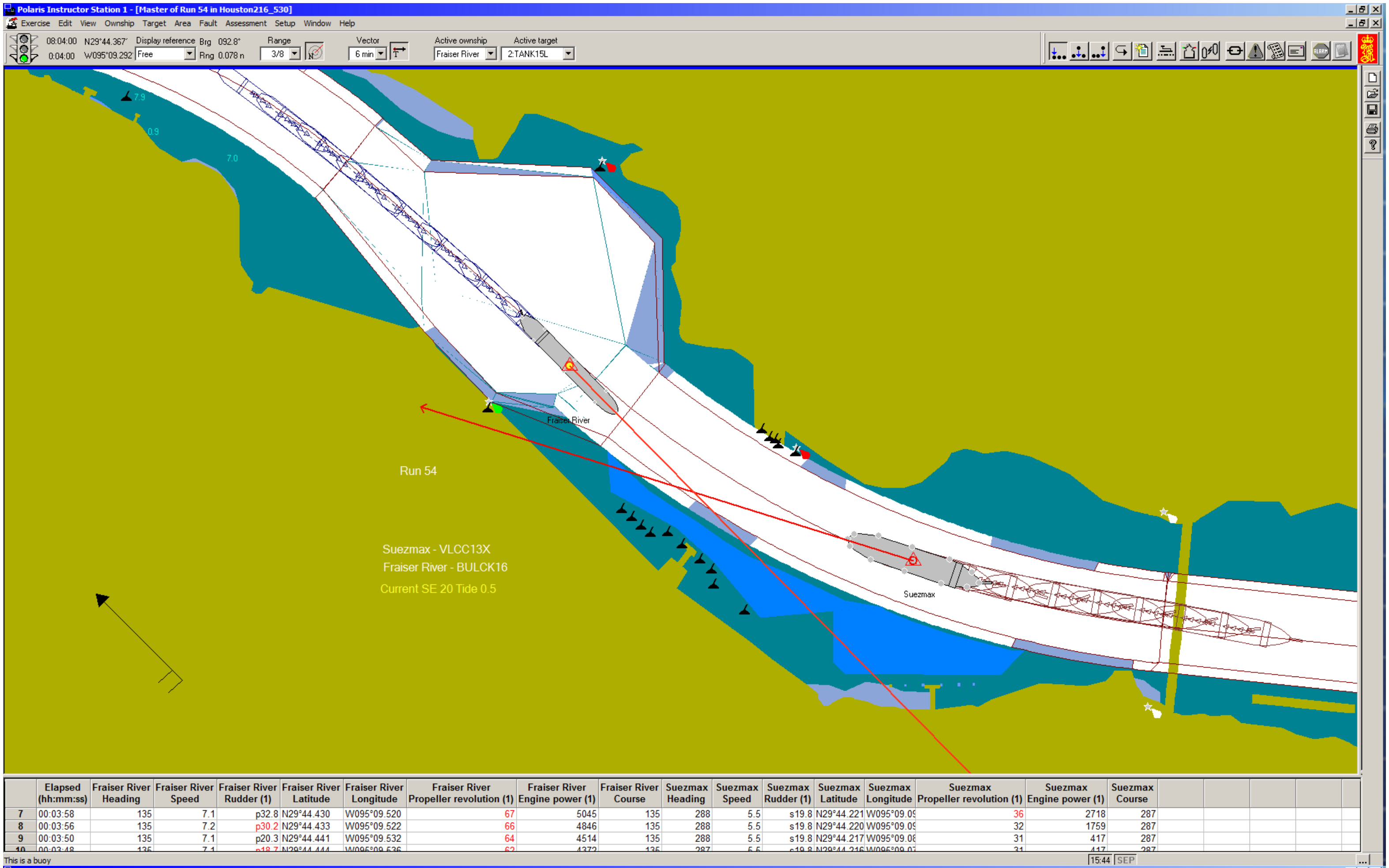
	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7																	
8																	
9																	


Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:03:35 N29°44.423′ Display reference Free Brg 078.8° Rng 0.283 n Range 3/4 Vector 6 min Active ownship Fraiser River Active target 2:TANK15L

0:03:35 W095°09.130′

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:03:34	134	7.1	p0.7	N29°44.463	W095°09.559	63	2847	134	286	5.5	p5.2	N29°44.210	W095°09.05	31	417	285
8	00:03:32	134	7.1	p0.7	N29°44.466	W095°09.561	67	3448	134	286	5.5	p9.8	N29°44.210	W095°09.05	31	417	285
9	00:03:30	134	7.1	p0.4	N29°44.469	W095°09.565	70	5164	134	286	5.5	p10.8	N29°44.209	W095°09.04	31	417	285

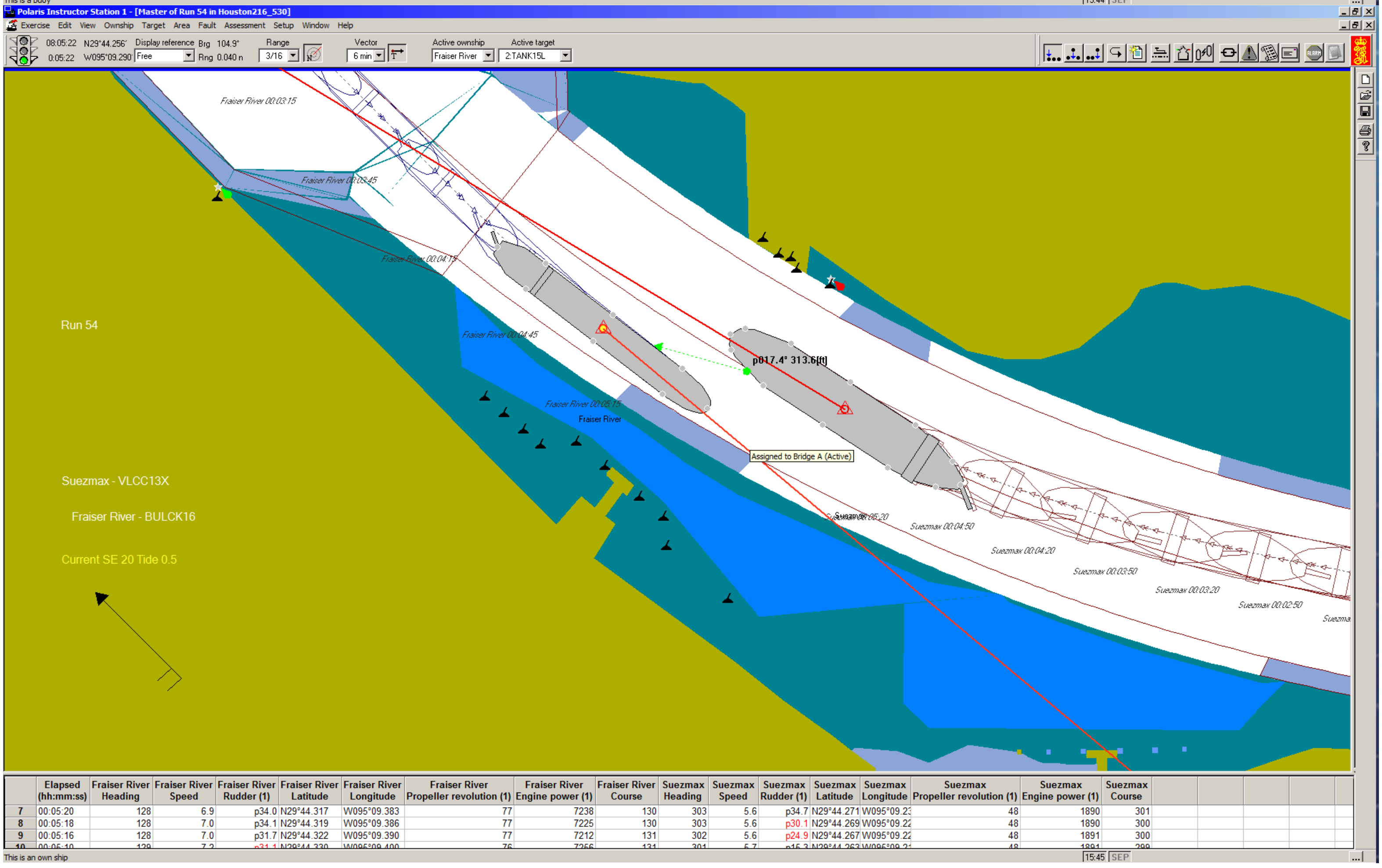


Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:04:00 N29°44.367′
0:04:00 W095°09.292′
Display reference: Free
Brg 092.8°
Rng 0.078 n
Range: 3/8
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:03:58	135	7.1	p32.8	N29°44.430	W095°09.520	67	5045	135	288	5.5	s19.8	N29°44.221	W095°09.0	36	2718	287
8	00:03:56	135	7.2	p30.2	N29°44.433	W095°09.522	66	4846	135	288	5.5	s19.8	N29°44.220	W095°09.0	32	1759	287
9	00:03:50	135	7.1	p20.3	N29°44.441	W095°09.532	64	4514	135	288	5.5	s19.8	N29°44.217	W095°09.0	31	417	287

This is a buoy



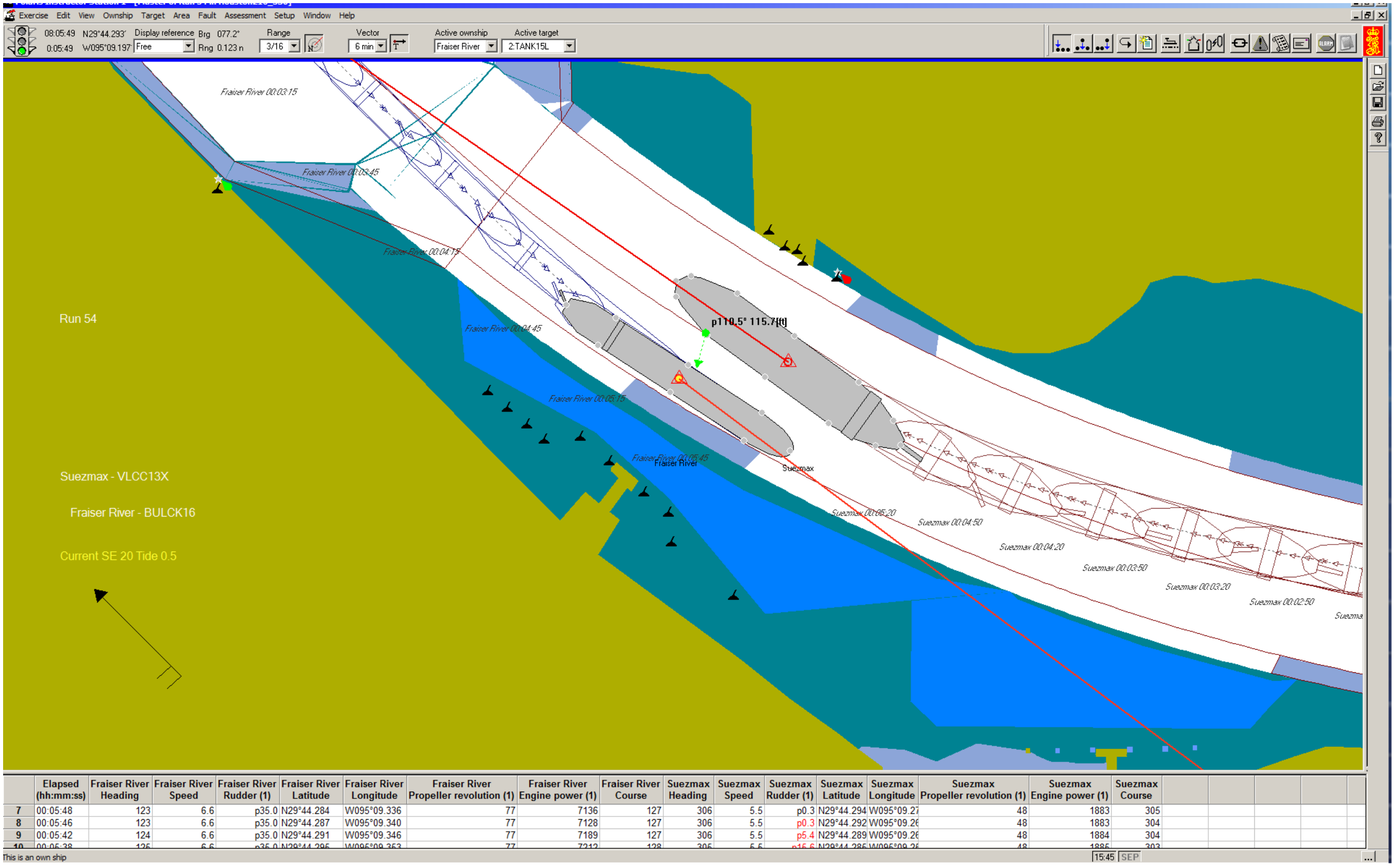
Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:05:22 N29°44.256′
0:05:22 W095°09.290′
Display reference: Free
Brg 104.9°
Rng 0.040 n
Range: 3/16
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:20	128	6.9	p34.0	N29°44.317	W095°09.383	77	7238	130	303	5.6	p34.7	N29°44.271	W095°09.2	48	1890	301
8	00:05:18	128	7.0	p34.1	N29°44.319	W095°09.386	77	7225	130	303	5.6	p30.1	N29°44.269	W095°09.2	48	1890	300
9	00:05:16	128	7.0	p31.7	N29°44.322	W095°09.390	77	7212	131	302	5.6	p24.9	N29°44.267	W095°09.2	48	1891	300

This is an own ship

June 26, 2019

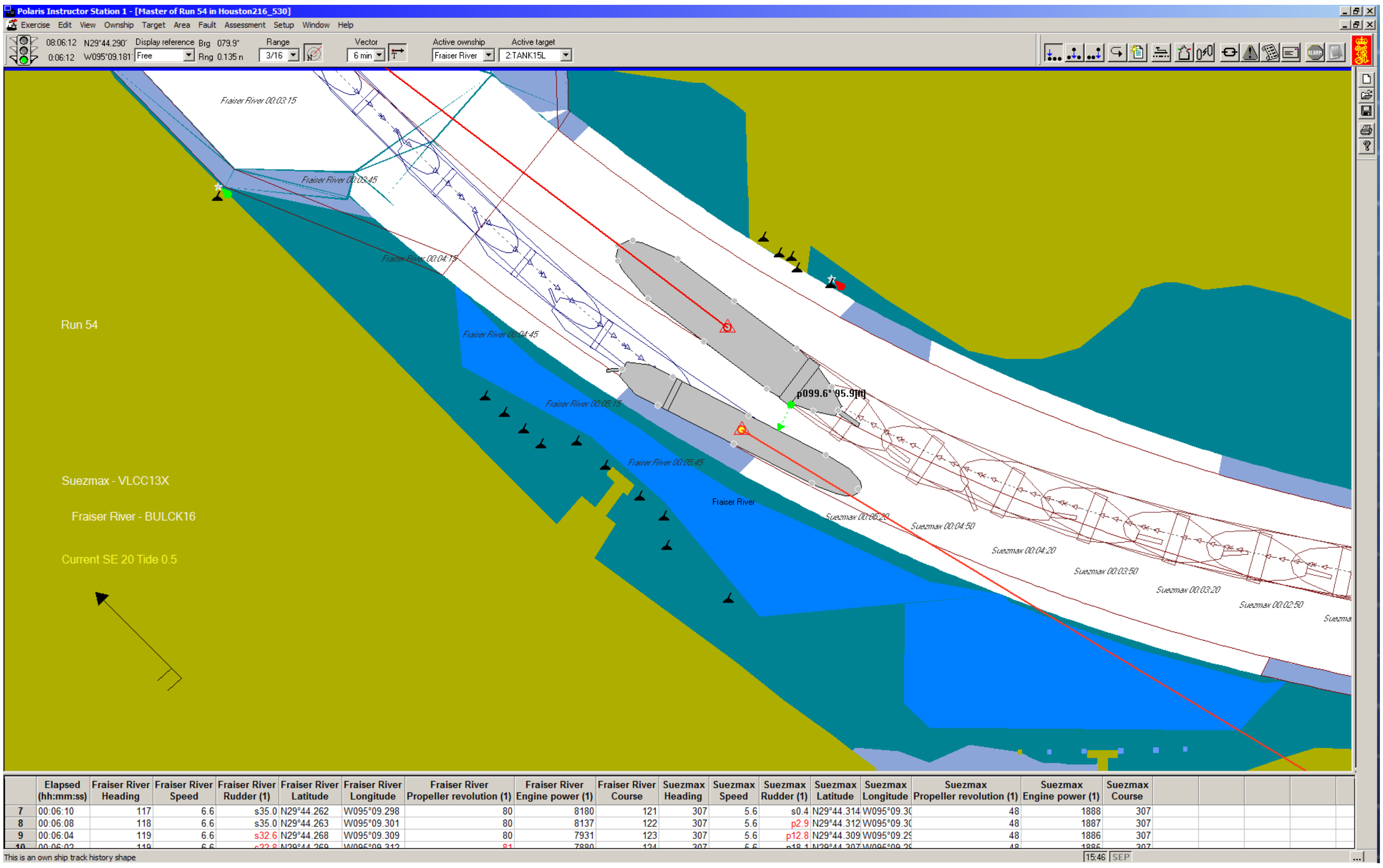


08:05:49 N29°44.293' Display reference: Free Brg 077.2°
0:05:49 W095°09.197' Rng 0.123 n
Range: 3/16
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:48	123	6.6	p35.0	N29°44.284	W095°09.336	77	7136	127	306	5.5	p0.3	N29°44.294	W095°09.27	48	1883	305
8	00:05:46	123	6.6	p35.0	N29°44.287	W095°09.340	77	7128	127	306	5.5	p0.3	N29°44.292	W095°09.26	48	1883	304
9	00:05:42	124	6.6	p35.0	N29°44.291	W095°09.346	77	7189	127	306	5.5	p5.4	N29°44.289	W095°09.26	48	1884	304
10	00:05:38	126	6.6	p35.0	N29°44.296	W095°09.353	77	7212	128	305	5.5	p15.6	N29°44.285	W095°09.26	48	1885	303

This is an own ship

15:45 SEP



Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:06:12 N29°44.290' Display reference: Free Brg 079.9°
0:06:12 W095°09.181' Rng 0.135 n
Range: 3/16
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:10	117	6.6	s35.0	N29°44.262	W095°09.298	80	8180	121	307	5.6	s0.4	N29°44.314	W095°09.30	48	1888	307
8	00:06:08	118	6.6	s35.0	N29°44.263	W095°09.301	80	8137	122	307	5.6	p2.9	N29°44.312	W095°09.30	48	1887	307
9	00:06:04	119	6.6	s32.6	N29°44.268	W095°09.309	80	7931	123	307	5.6	p12.8	N29°44.309	W095°09.29	48	1886	307
10	00:06:02	119	6.6	s22.8	N29°44.269	W095°09.312	81	7880	124	307	5.6	p18.1	N29°44.307	W095°09.29	48	1885	307

This is an own ship track history shape

15:46 SEP

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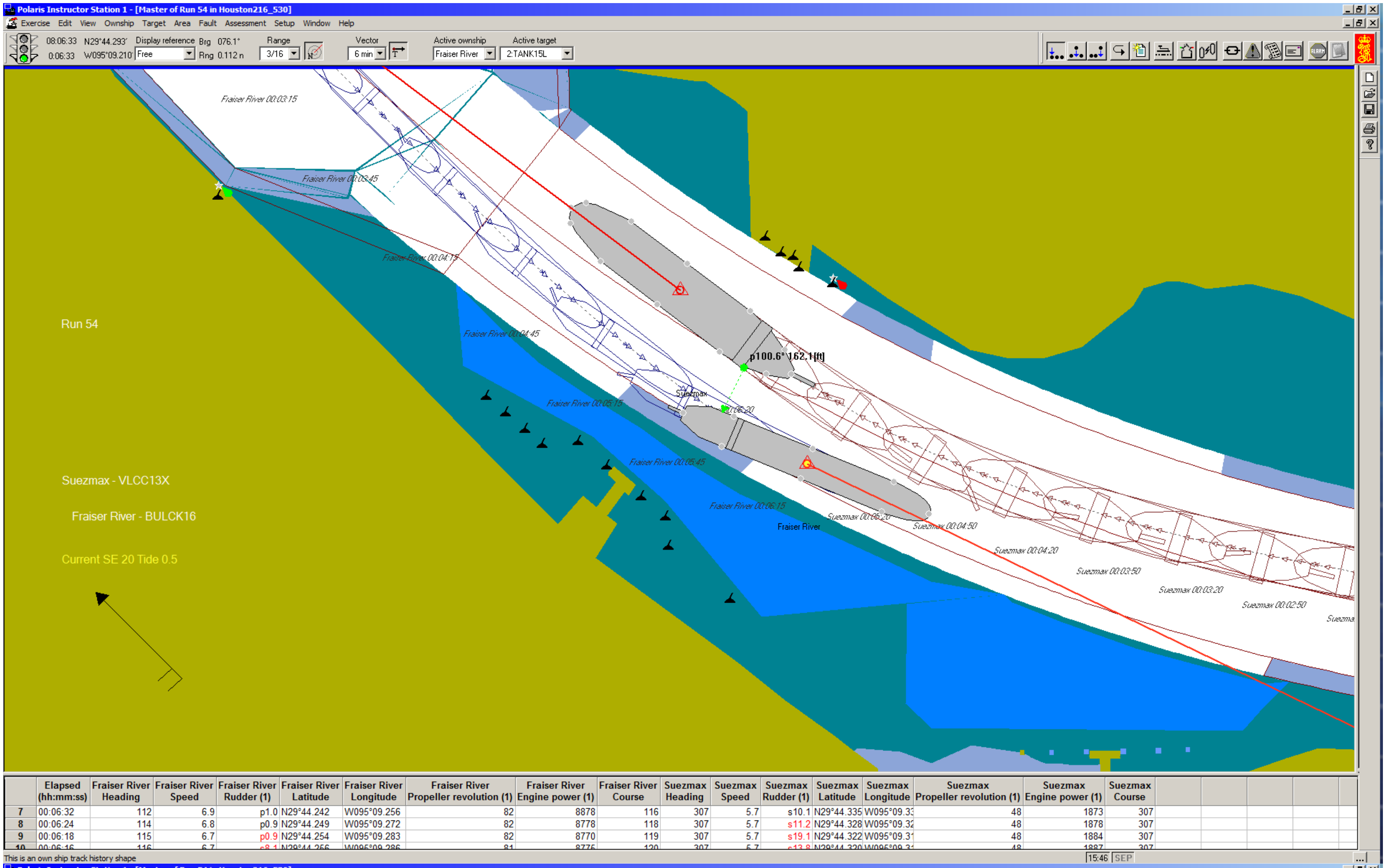
June 26, 2019



Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:06:33 N29°44.293'
0:06:33 W095°09.210'
Display reference: Free
Brg 076.1°
Rng 0.112 n
Range: 3/16
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

p100.6° 162.1[ft]

Run 54

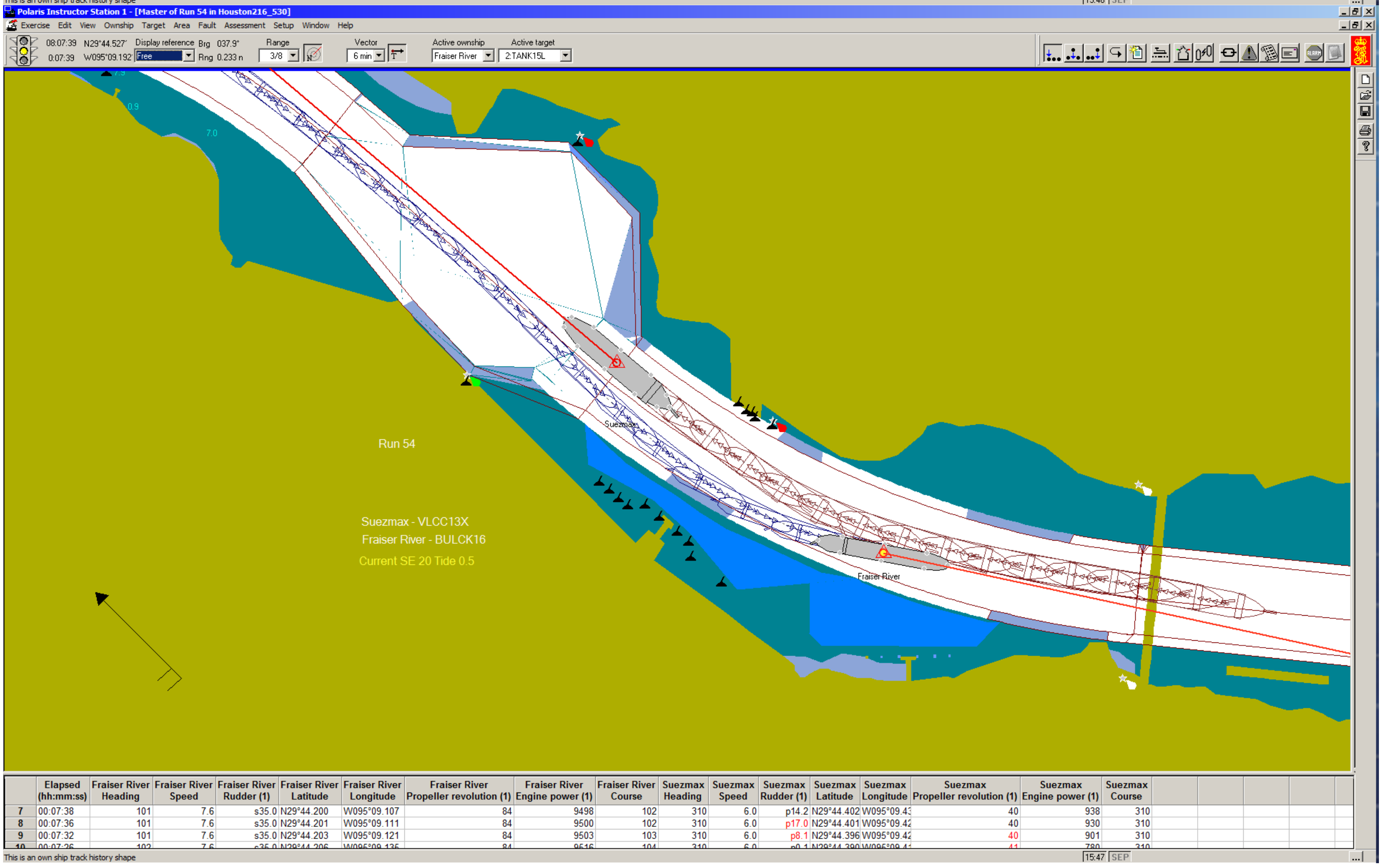
Suezmax - VLCC13X

Fraiser River - BULCK16

Current SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:32	112	6.9	p1.0	N29°44.242	W095°09.256	82	8878	116	307	5.7	s10.1	N29°44.335	W095°09.33	48	1873	307
8	00:06:24	114	6.8	p0.9	N29°44.249	W095°09.272	82	8778	118	307	5.7	s11.2	N29°44.328	W095°09.32	48	1878	307
9	00:06:18	115	6.7	p0.9	N29°44.254	W095°09.283	82	8770	119	307	5.7	s19.1	N29°44.322	W095°09.31	48	1884	307

This is an own ship track history shape



Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

08:07:39 N29°44.527'
0:07:39 W095°09.192'
Display reference: Free
Brg 037.9°
Rng 0.233 n
Range: 3/8
Vector: 6 min
Active ownship: Fraiser River
Active target: 2:TANK15L

Run 54

Suezmax - VLCC13X

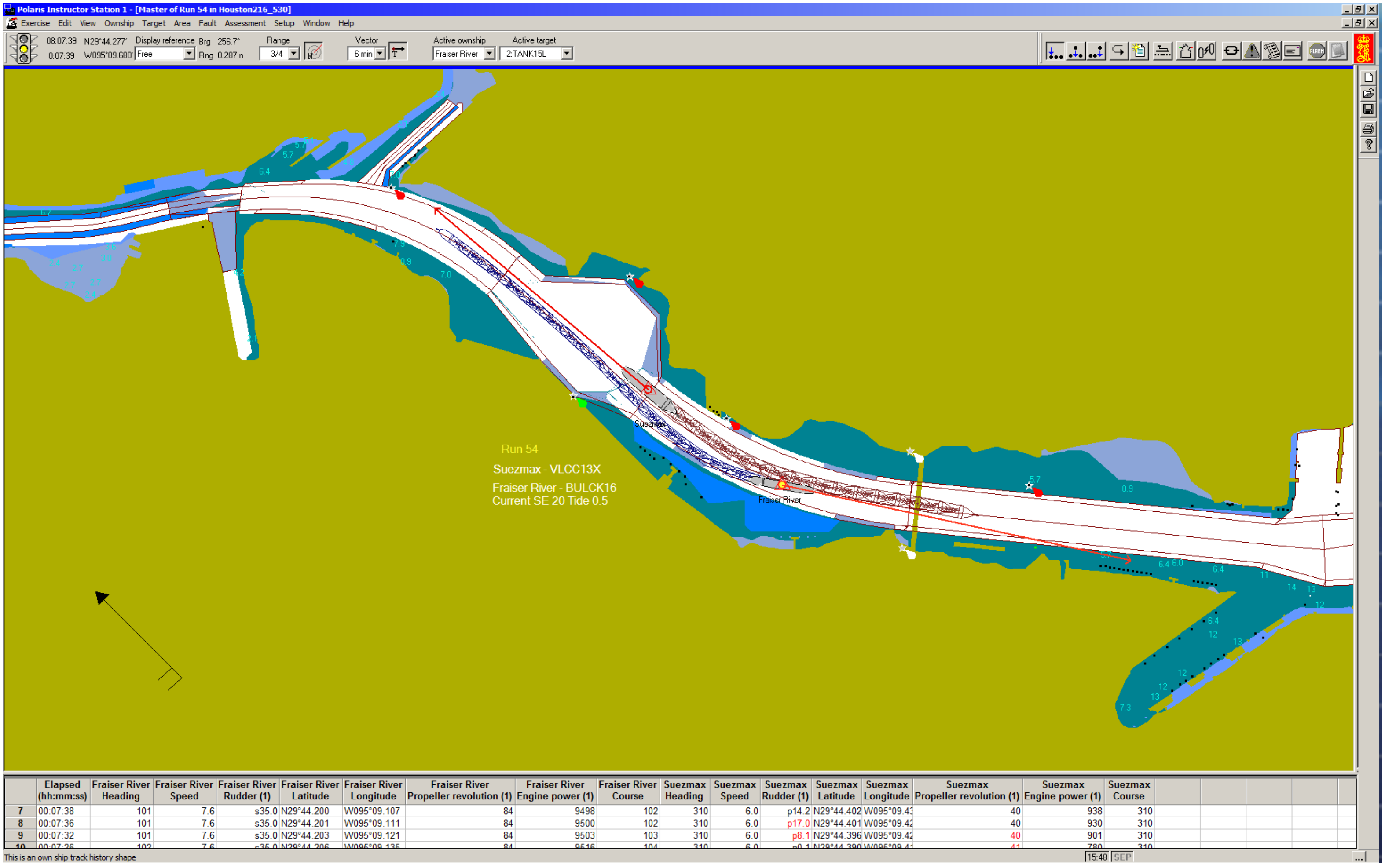
Fraiser River - BULCK16

Current SE 20 Tide 0.5

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:38	101	7.6	s35.0	N29°44.200	W095°09.107	84	9498	102	310	6.0	p14.2	N29°44.402	W095°09.43	40	938	310
8	00:07:36	101	7.6	s35.0	N29°44.201	W095°09.111	84	9500	102	310	6.0	p17.0	N29°44.401	W095°09.42	40	930	310
9	00:07:32	101	7.6	s35.0	N29°44.203	W095°09.121	84	9503	103	310	6.0	p8.1	N29°44.396	W095°09.42	40	901	310

This is an own ship track history shape

- Page 487



Polaris Instructor Station 1 - [Master of Run 54 in Houston216_530]

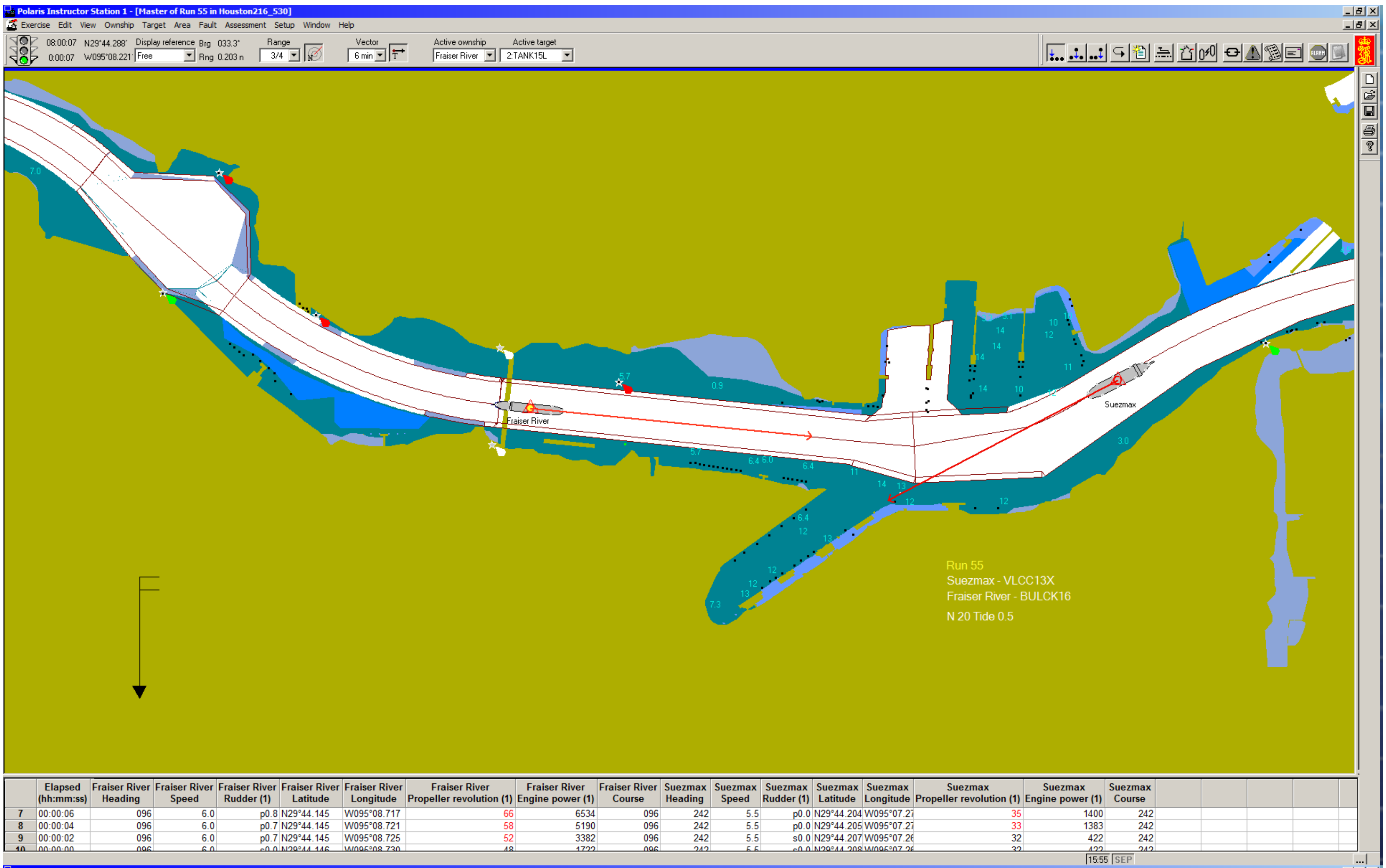
08:07:39 N29°44.277' Display reference Free Brg 256.7° Rng 0.287 n Range 3/4 Vector 6 min Active ownship Fraiser River Active target 2:TANK15L
0:07:39 W095°09.680'

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:38	101	7.6	s35.0	N29°44.200	W095°09.107	84	9498	102	310	6.0	p14.2	N29°44.402	W095°09.43	40	938	310
8	00:07:36	101	7.6	s35.0	N29°44.201	W095°09.111	84	9500	102	310	6.0	p17.0	N29°44.401	W095°09.42	40	930	310
9	00:07:32	101	7.6	s35.0	N29°44.203	W095°09.121	84	9503	103	310	6.0	p8.1	N29°44.396	W095°09.42	40	901	310
10	00:07:26	102	7.6	s35.0	N29°44.206	W095°09.135	84	9516	104	310	6.0	p0.1	N29°44.390	W095°09.41	41	780	310

This is an own ship track history shape

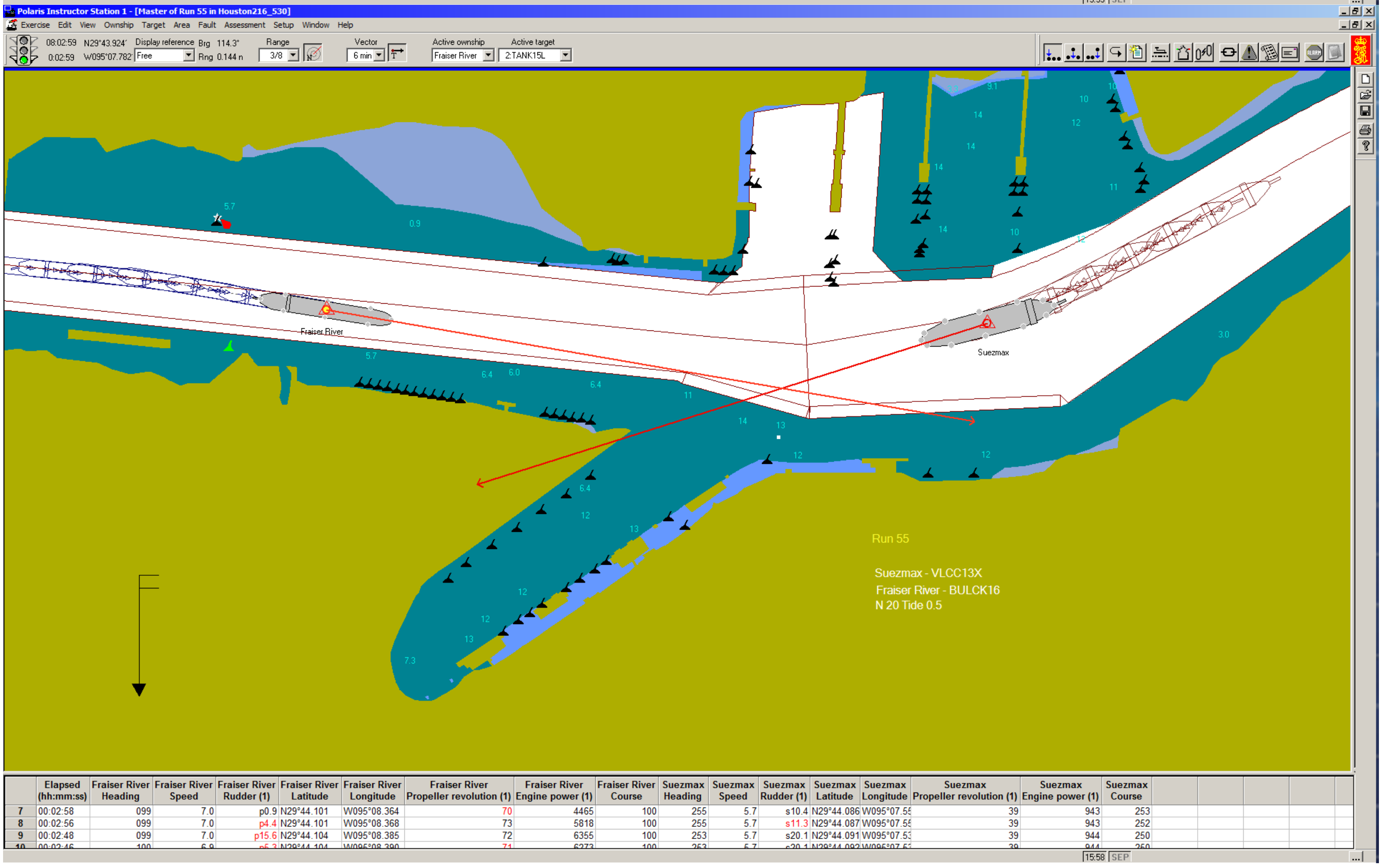
15:48 SEP

Run 55



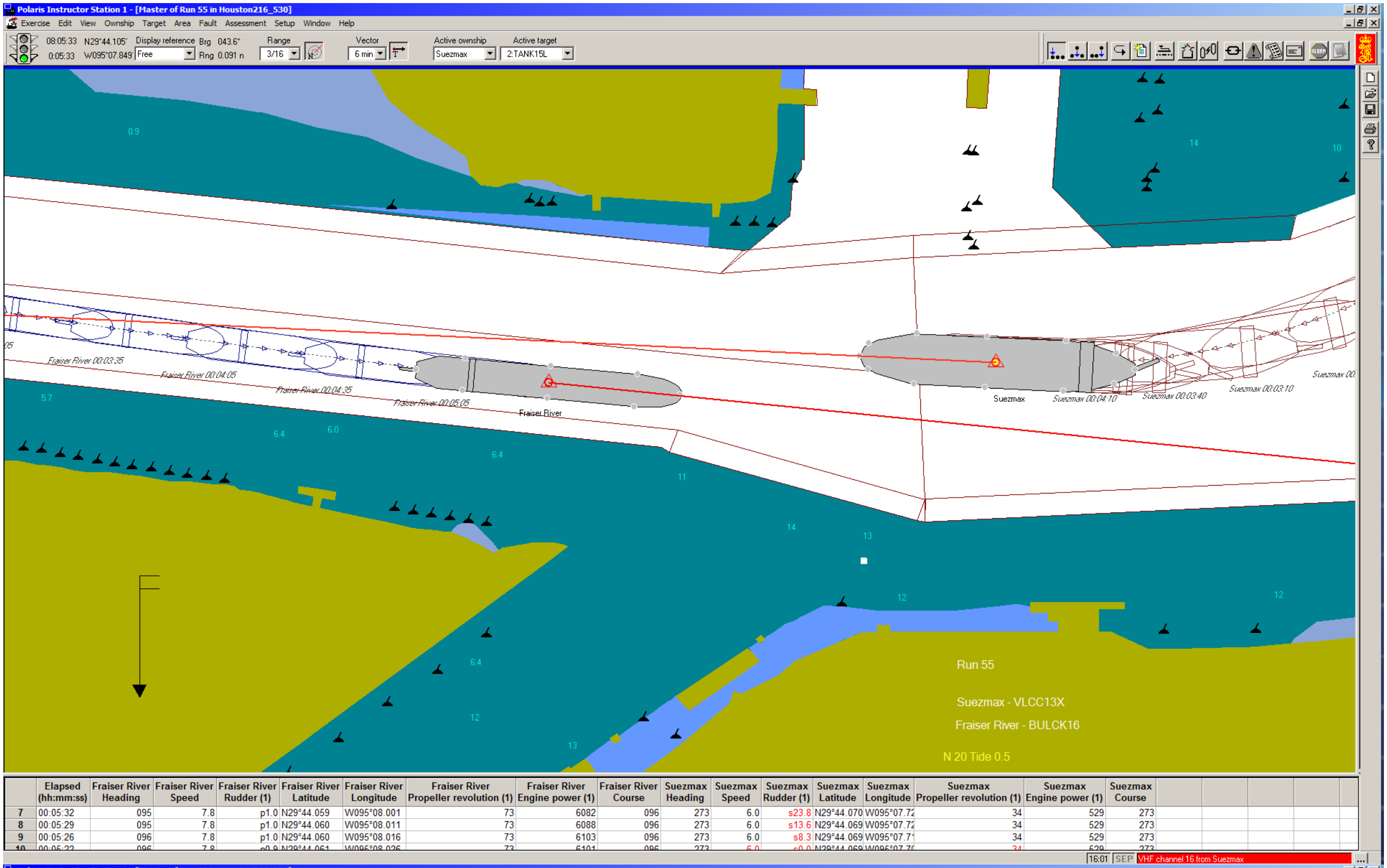
08:00:07 N29°44.288' Display reference Free Brg 033.3°
0:00:07 W095°08.221' Rng 0.203 n
Range 3/4
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:00:06	096	6.0	p0.8	N29°44.145	W095°08.717	66	6534	096	242	5.5	p0.0	N29°44.204	W095°07.27	35	1400	242
8	00:00:04	096	6.0	p0.7	N29°44.145	W095°08.721	58	5190	096	242	5.5	p0.0	N29°44.205	W095°07.27	33	1383	242
9	00:00:02	096	6.0	p0.7	N29°44.145	W095°08.725	52	3382	096	242	5.5	s0.0	N29°44.207	W095°07.26	32	422	242



08:02:59 N29°43.924' Display reference Free Brg 114.3°
0:02:59 W095°07.782' Rng 0.144 n
Range 3/8
Vector 6 min
Active ownship Fraiser River
Active target 2:TANK15L

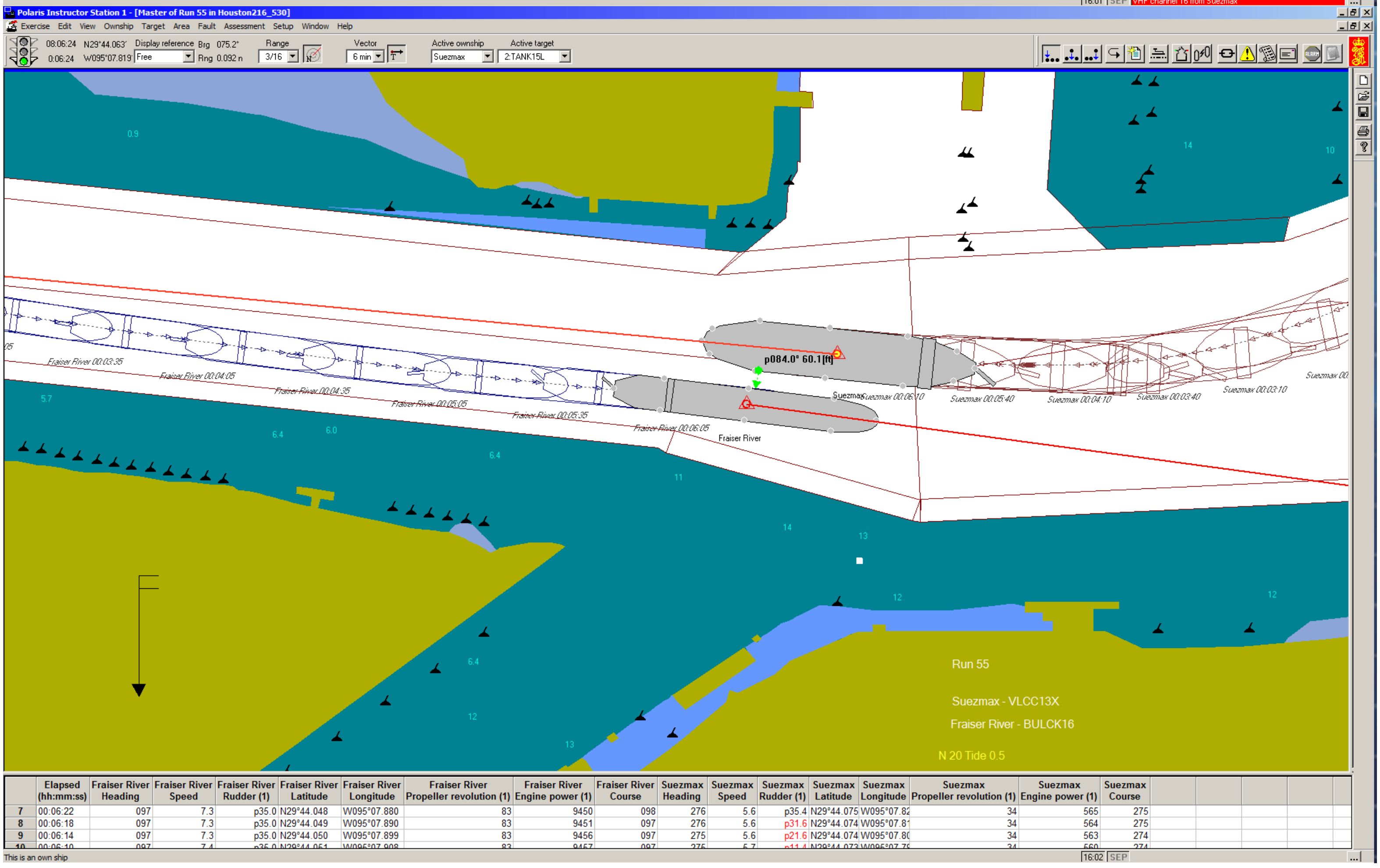
	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:02:58	099	7.0	p0.9	N29°44.101	W095°08.364	70	4465	100	255	5.7	s10.4	N29°44.086	W095°07.55	39	943	253
8	00:02:56	099	7.0	p4.4	N29°44.101	W095°08.368	73	5818	100	255	5.7	s11.3	N29°44.087	W095°07.55	39	943	252
9	00:02:48	099	7.0	p15.6	N29°44.104	W095°08.385	72	6355	100	253	5.7	s20.1	N29°44.091	W095°07.53	39	944	250



08:05:33 N29°44.105' Display reference: Free Brg 043.6° Rng 0.091 n
0:05:33 W095°07.849' Range: 3/16 Vector: 6 min Active ownship: Suezmax Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:32	095	7.8	p1.0	N29°44.059	W095°08.001	73	6082	096	273	6.0	s23.8	N29°44.070	W095°07.72	34	529	273
8	00:05:29	095	7.8	p1.0	N29°44.060	W095°08.011	73	6088	096	273	6.0	s13.6	N29°44.069	W095°07.72	34	529	273
9	00:05:26	096	7.8	p1.0	N29°44.060	W095°08.016	73	6103	096	273	6.0	s8.3	N29°44.069	W095°07.71	34	529	273

16:01 SEP VHF channel 16 from Suezmax

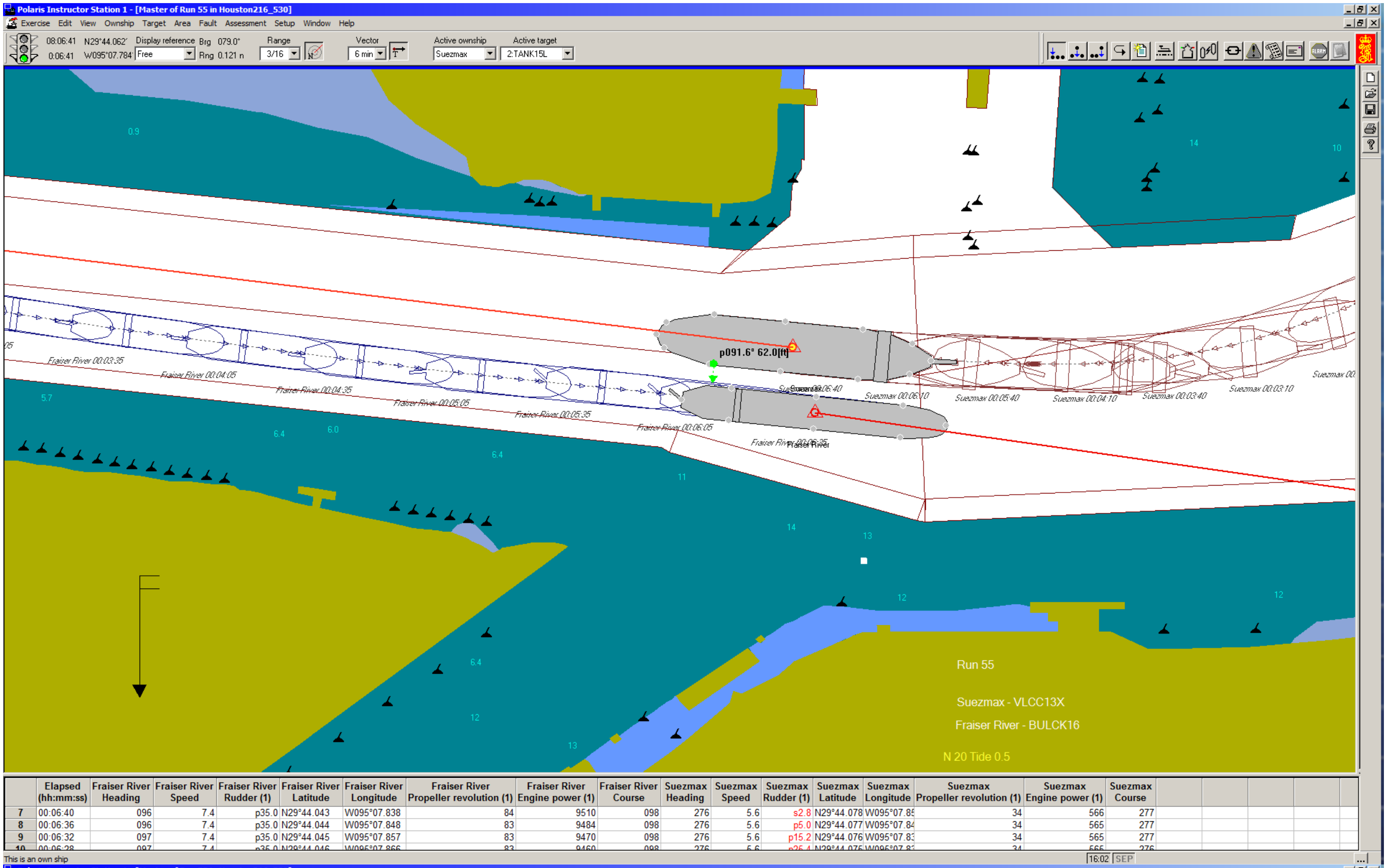


08:06:24 N29°44.063' Display reference: Free Brg 075.2° Rng 0.092 n
0:06:24 W095°07.819' Range: 3/16 Vector: 6 min Active ownship: Suezmax Active target: 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:22	097	7.3	p35.0	N29°44.048	W095°07.880	83	9450	098	276	5.6	p35.4	N29°44.075	W095°07.82	34	565	275
8	00:06:18	097	7.3	p35.0	N29°44.049	W095°07.890	83	9451	097	276	5.6	p31.6	N29°44.074	W095°07.81	34	564	275
9	00:06:14	097	7.3	p35.0	N29°44.050	W095°07.899	83	9456	097	275	5.6	p21.6	N29°44.074	W095°07.80	34	563	274

This is an own ship

16:02 SEP

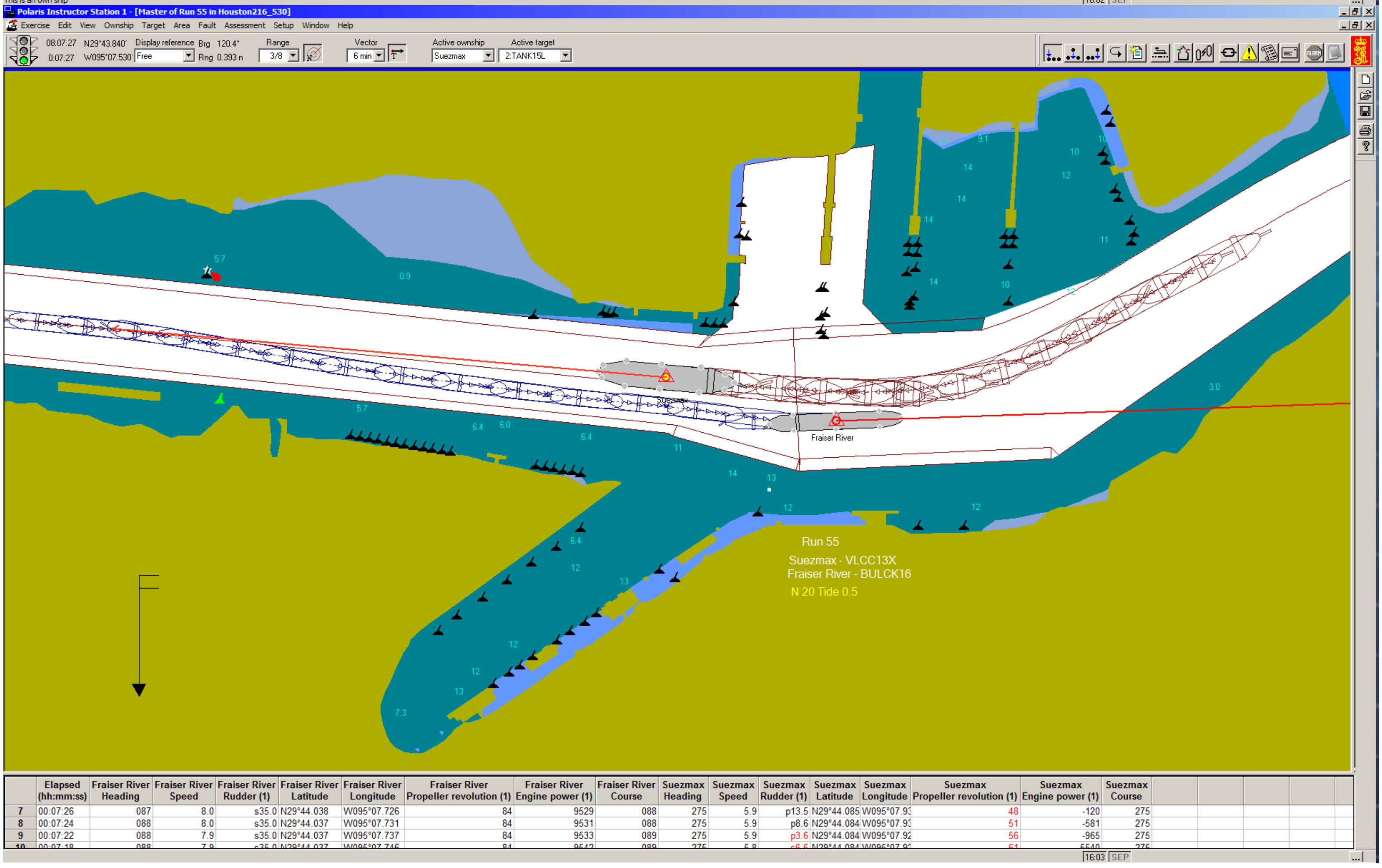


08:06:41 N29°44.062' Display reference Free Brg 079.0° Rng 0.121 n
0:06:41 W095°07.784'
Range 3/16
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:40	096	7.4	p35.0	N29°44.043	W095°07.838	84	9510	098	276	5.6	s2.8	N29°44.078	W095°07.85	34	566	277
8	00:06:36	096	7.4	p35.0	N29°44.044	W095°07.848	83	9484	098	276	5.6	p5.0	N29°44.077	W095°07.84	34	565	277
9	00:06:32	097	7.4	p35.0	N29°44.045	W095°07.857	83	9470	098	276	5.6	p15.2	N29°44.076	W095°07.83	34	565	277

This is an own ship

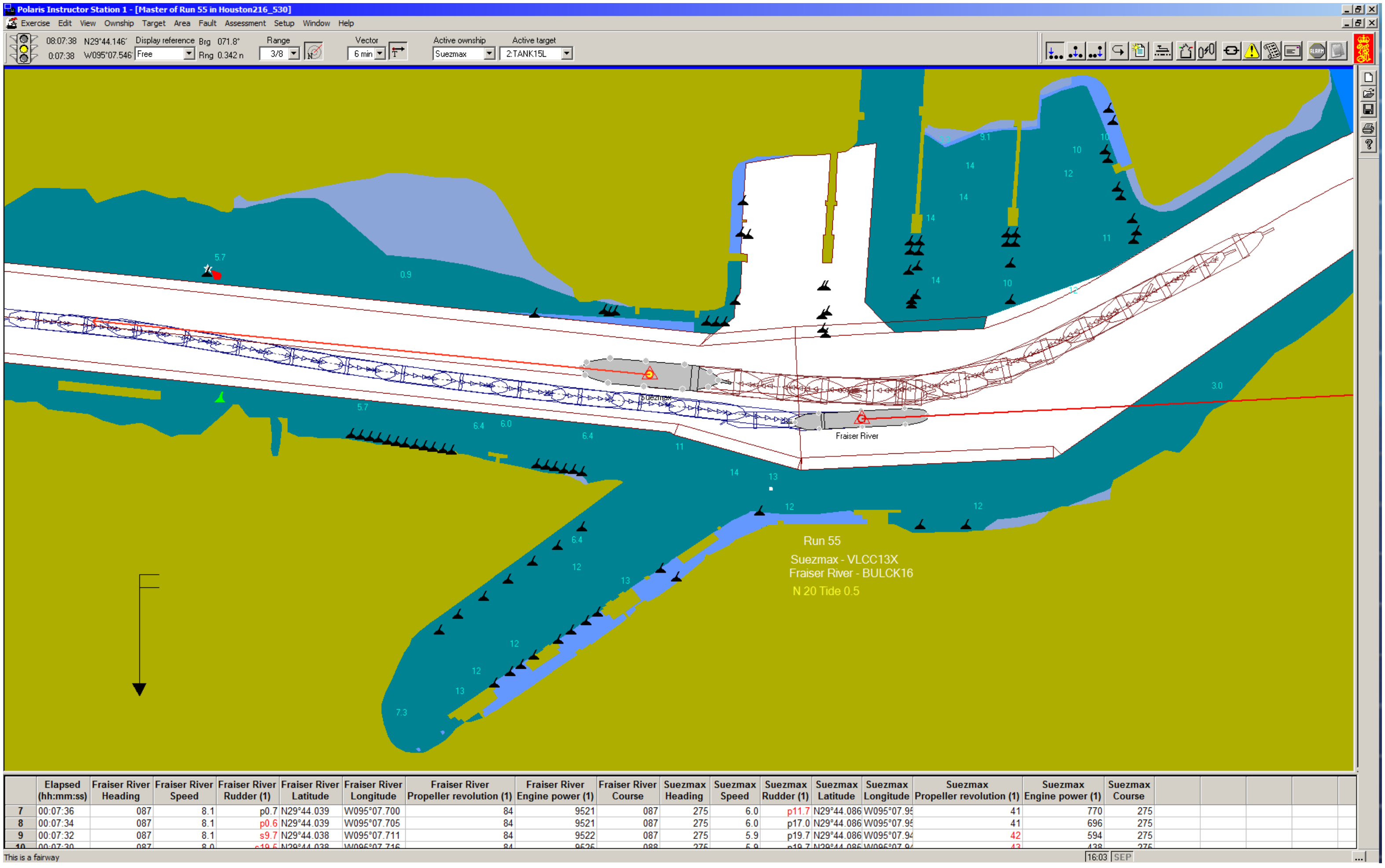
16:02 SEP



08:07:27 N29°43.840' Display reference Free Brg 120.4° Rng 0.393 n
0:07:27 W095°07.530'
Range 3/8
Vector 6 min
Active ownship Suezmax
Active target 2:TANK15L

	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:26	087	8.0	s35.0	N29°44.038	W095°07.726	84	9529	088	275	5.9	p13.5	N29°44.085	W095°07.93	48	-120	275
8	00:07:24	088	8.0	s35.0	N29°44.037	W095°07.731	84	9531	088	275	5.9	p8.6	N29°44.084	W095°07.93	51	-581	275
9	00:07:22	088	7.9	s35.0	N29°44.037	W095°07.737	84	9533	089	275	5.9	p3.6	N29°44.084	W095°07.92	56	-965	275

16:03 SEP

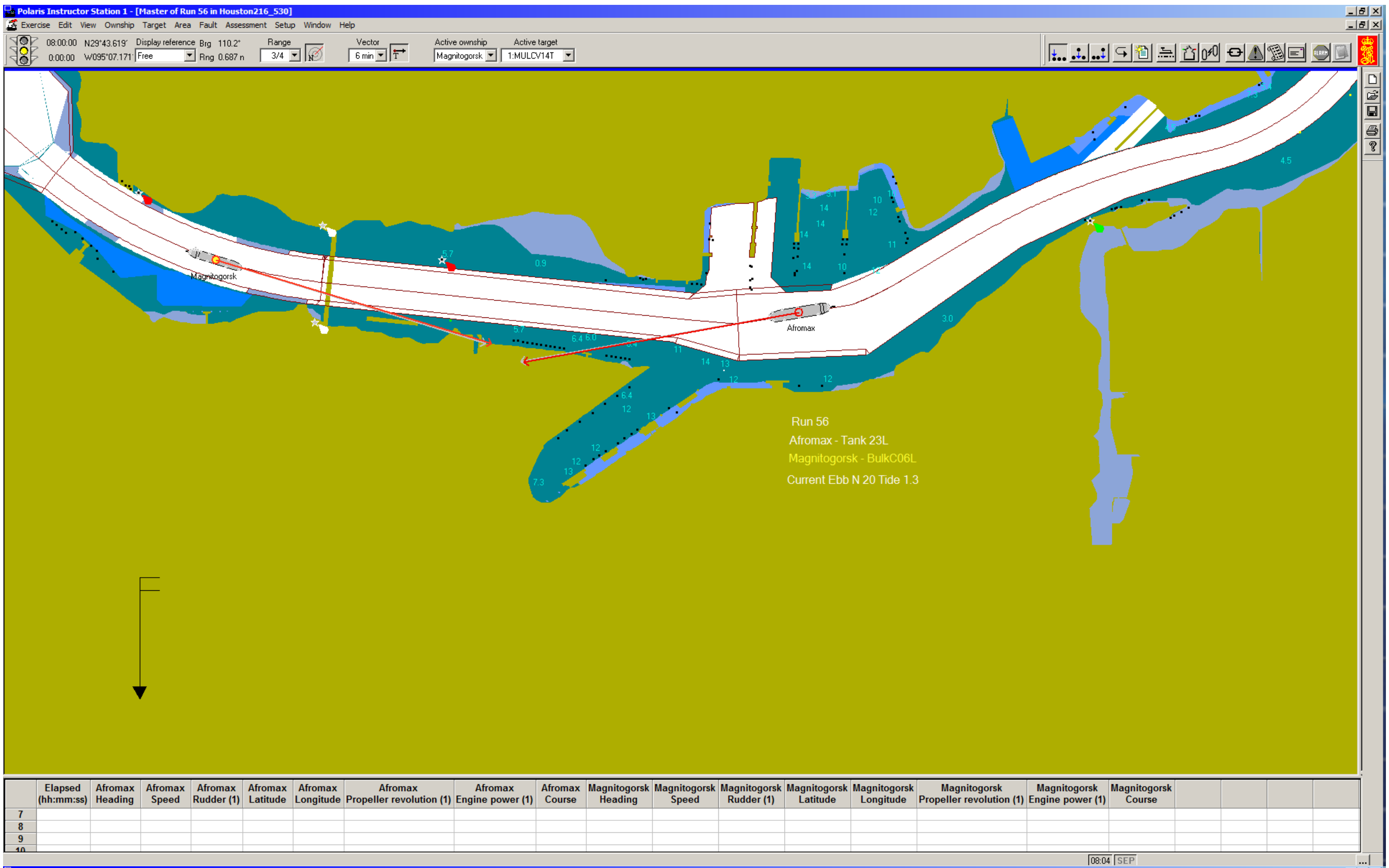


	Elapsed (hh:mm:ss)	Fraiser River Heading	Fraiser River Speed	Fraiser River Rudder (1)	Fraiser River Latitude	Fraiser River Longitude	Fraiser River Propeller revolution (1)	Fraiser River Engine power (1)	Fraiser River Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:36	087	8.1	p0.7	N29°44.039	W095°07.700	84	9521	087	275	6.0	p11.7	N29°44.086	W095°07.95	41	770	275
8	00:07:34	087	8.1	p0.6	N29°44.039	W095°07.705	84	9521	087	275	6.0	p17.0	N29°44.086	W095°07.95	41	696	275
9	00:07:32	087	8.1	s9.7	N29°44.038	W095°07.711	84	9522	087	275	5.9	p19.7	N29°44.086	W095°07.94	42	594	275
10	00:07:30	087	8.0	s19.6	N29°44.038	W095°07.716	84	9525	088	275	5.9	p19.7	N29°44.085	W095°07.94	43	438	275

This is a fairway

June 26, 2019

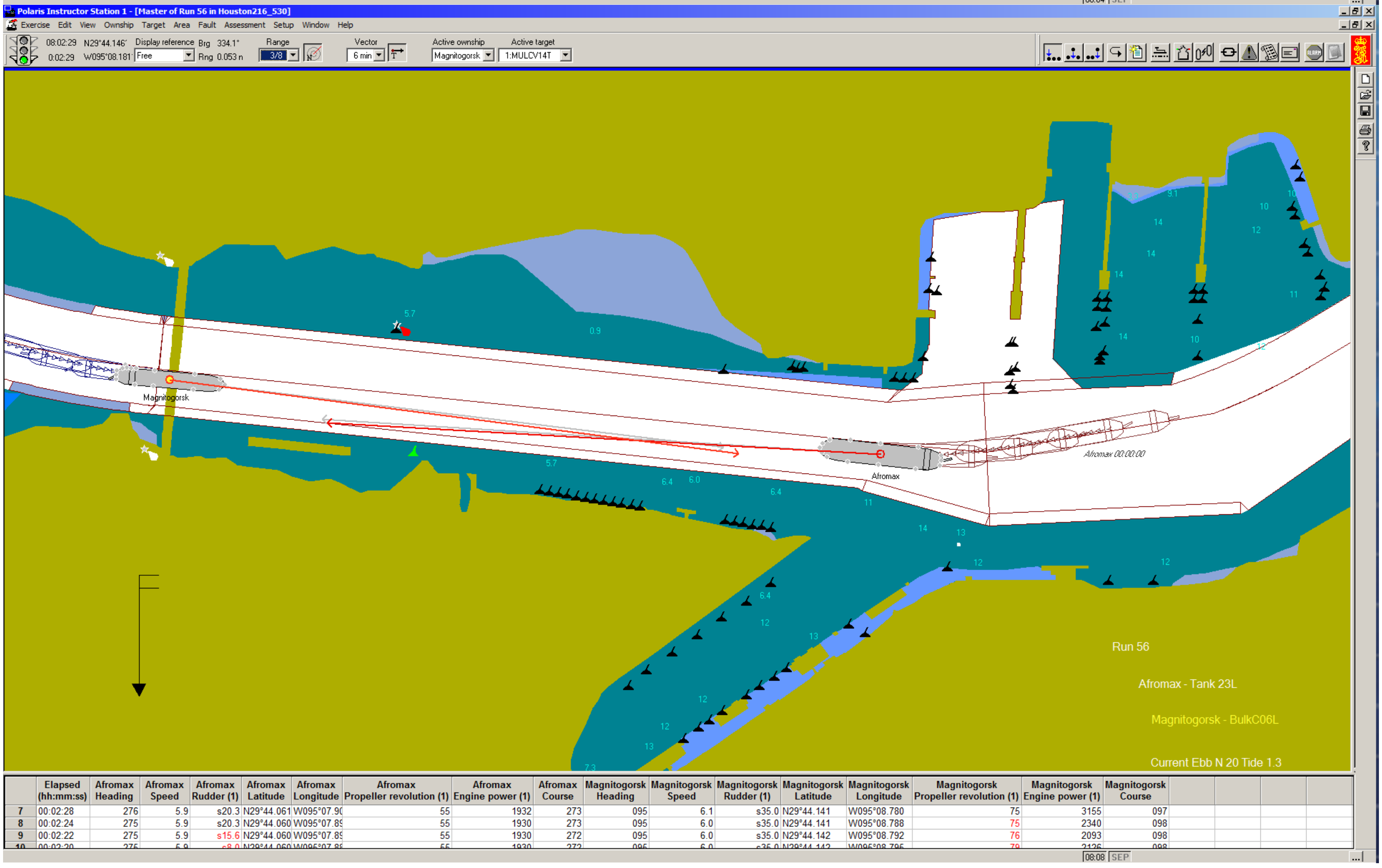
Run 56



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

08:00:00 N29°43.619' W095°07.171' 0:00:00
Display reference: Free
Brg 110.2°
Rng 0.687 n
Range: 3/4
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

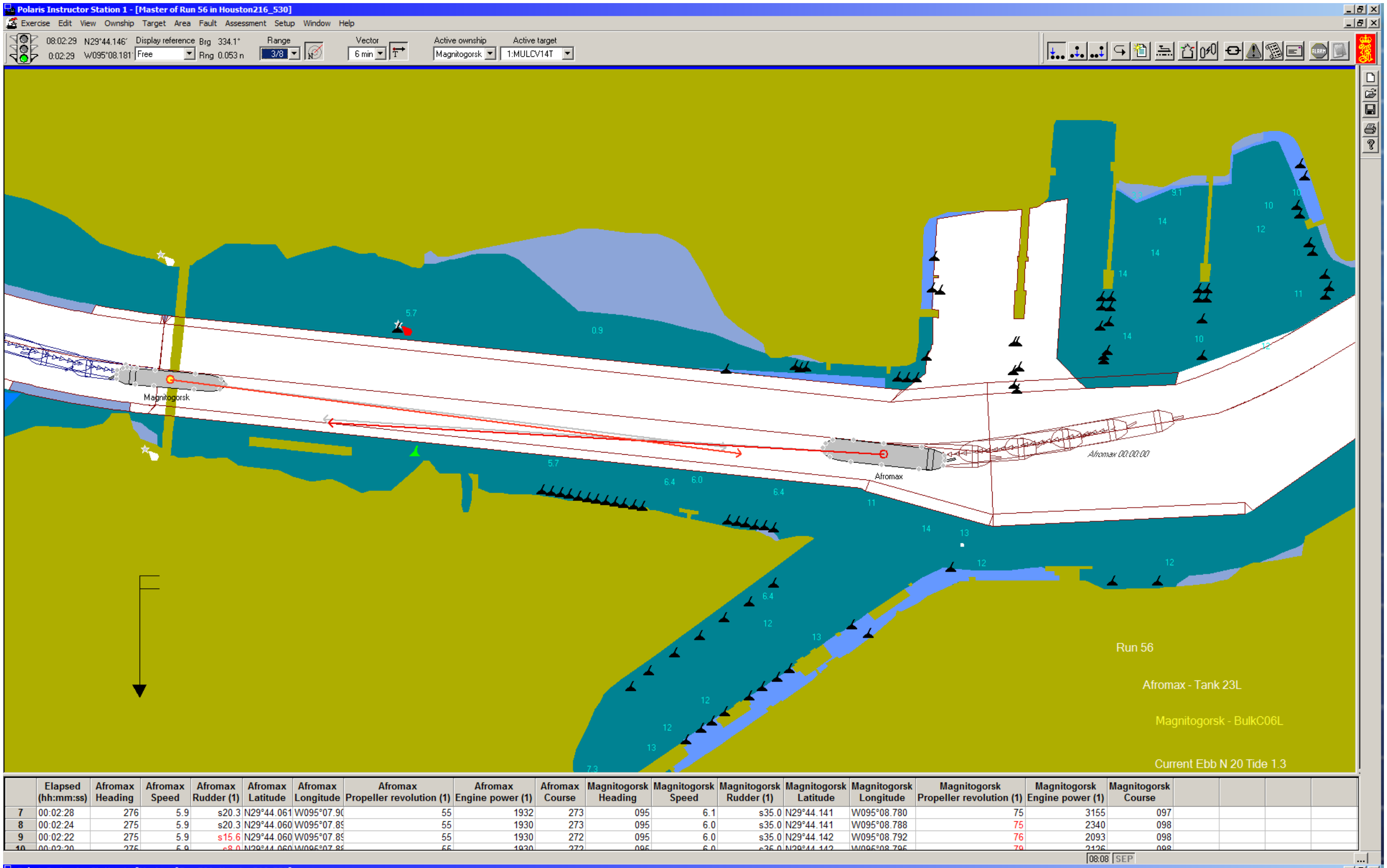
	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7																	
8																	
9																	



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

08:02:29 N29°44.146' W095°08.181' 0:02:29
Display reference: Free
Brg 334.1°
Rng 0.053 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:02:28	276	5.9	s20.3	N29°44.061	W095°07.90	55	1932	273	095	6.1	s35.0	N29°44.141	W095°08.780	75	3155	097
8	00:02:24	275	5.9	s20.3	N29°44.060	W095°07.89	55	1930	273	095	6.0	s35.0	N29°44.141	W095°08.788	75	2340	098
9	00:02:22	275	5.9	s15.6	N29°44.060	W095°07.89	55	1930	272	095	6.0	s35.0	N29°44.142	W095°08.792	76	2093	098
10	00:02:20	275	5.9	s8.0	N29°44.060	W095°07.88	55	1930	272	095	6.0	s35.0	N29°44.142	W095°08.795	79	2126	098



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

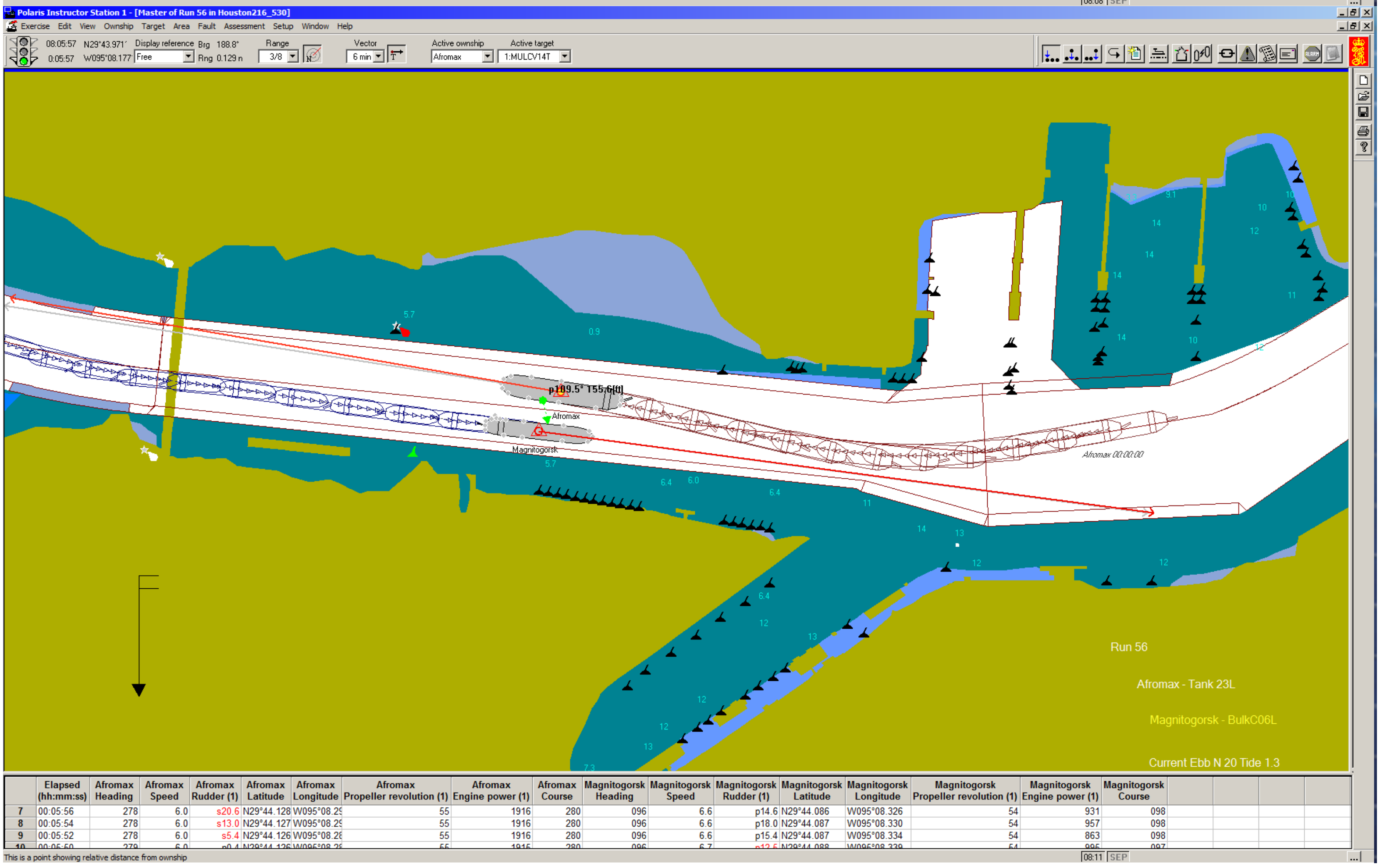
08:02:29 N29°44.146′ Display reference: Free Brg 334.1° Rng 0.053 n

0:02:29 W095°08.181′

Range: 3/8 Vector: 6 min Active ownship: Magnitogorsk Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:02:28	276	5.9	s20.3	N29°44.061	W095°07.9	55	1932	273	095	6.1	s35.0	N29°44.141	W095°08.780	75	3155	097
8	00:02:24	275	5.9	s20.3	N29°44.060	W095°07.8	55	1930	273	095	6.0	s35.0	N29°44.141	W095°08.788	75	2340	098
9	00:02:22	275	5.9	s15.6	N29°44.060	W095°07.8	55	1930	272	095	6.0	s35.0	N29°44.142	W095°08.792	76	2093	098

08:08 SEP



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

08:05:57 N29°43.971′ Display reference: Free Brg 188.8° Rng 0.129 n

0:05:57 W095°08.177′

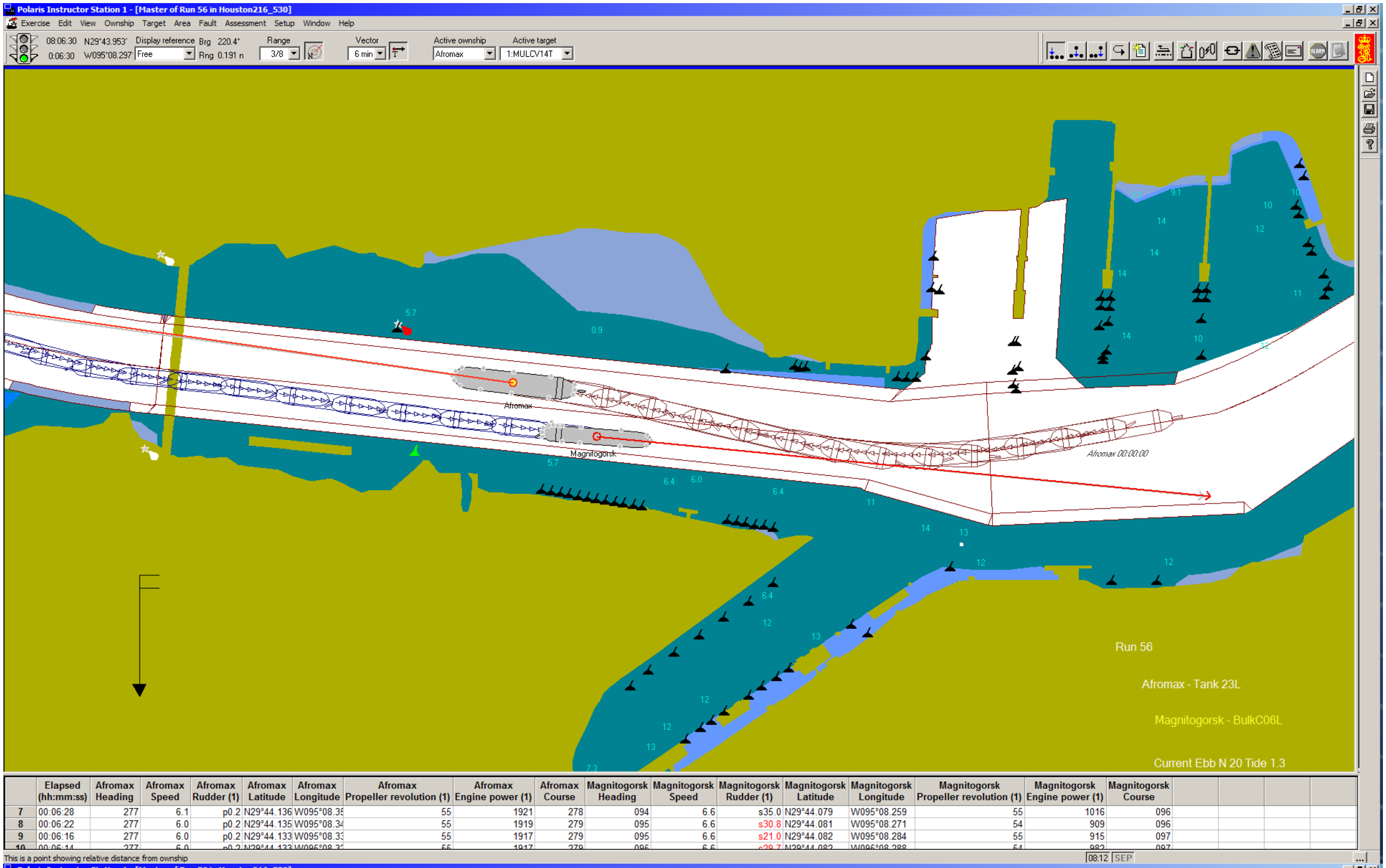
Range: 3/8 Vector: 6 min Active ownship: Afromax Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:05:56	278	6.0	s20.6	N29°44.128	W095°08.2	55	1916	280	096	6.6	p14.6	N29°44.086	W095°08.326	54	931	098
8	00:05:54	278	6.0	s13.0	N29°44.127	W095°08.2	55	1916	280	096	6.6	p18.0	N29°44.087	W095°08.330	54	957	098
9	00:05:52	278	6.0	s5.4	N29°44.126	W095°08.2	55	1916	280	096	6.6	p15.4	N29°44.087	W095°08.334	54	863	098

This is a point showing relative distance from ownship

08:11 SEP

June 26, 2019



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

08:06:30 N29°43.953′
0:06:30 W095°08.297′
Display reference: Free
Brg 220.4°
Rng 0.191 n
Range: 3/8
Vector: 6 min
Active ownship: Afromax
Active target: 1:MULCV14T

Run 56

Afromax - Tank 23L

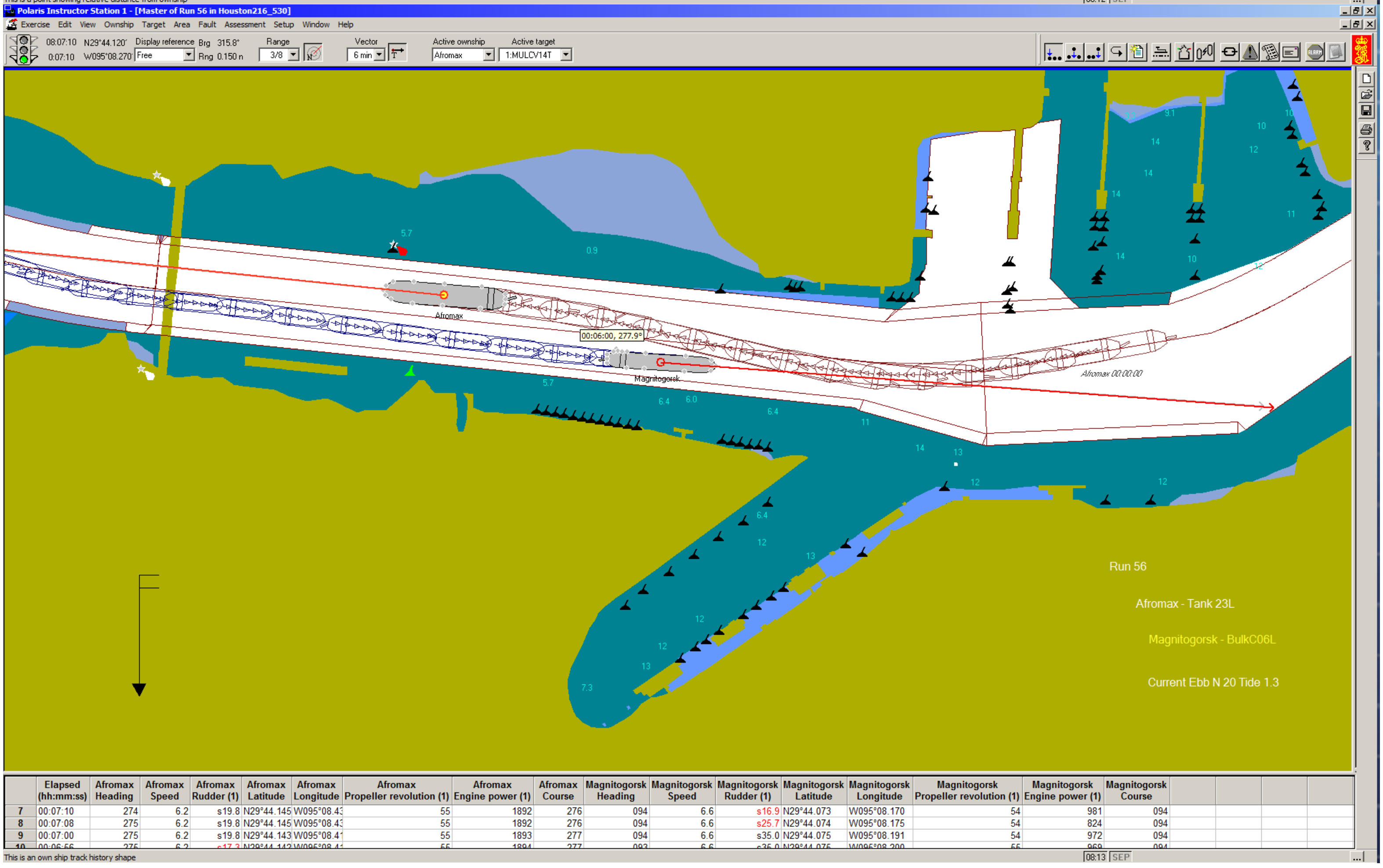
Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:06:28	277	6.1	p0.2	N29°44.136	W095°08.35	55	1921	278	094	6.6	s35.0	N29°44.079	W095°08.259	55	1016	096
8	00:06:22	277	6.0	p0.2	N29°44.135	W095°08.34	55	1919	279	095	6.6	s30.8	N29°44.081	W095°08.271	54	909	096
9	00:06:16	277	6.0	p0.2	N29°44.133	W095°08.33	55	1917	279	095	6.6	s21.0	N29°44.082	W095°08.284	55	915	097

This is a point showing relative distance from ownship

08:12 SEP



Polaris Instructor Station 1 - [Master of Run 56 in Houston216_530]

08:07:10 N29°44.120′
0:07:10 W095°08.270′
Display reference: Free
Brg 315.8°
Rng 0.150 n
Range: 3/8
Vector: 6 min
Active ownship: Afromax
Active target: 1:MULCV14T

Run 56

Afromax - Tank 23L

Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:10	274	6.2	s19.8	N29°44.145	W095°08.43	55	1892	276	094	6.6	s16.9	N29°44.073	W095°08.170	54	981	094
8	00:07:08	275	6.2	s19.8	N29°44.145	W095°08.43	55	1892	276	094	6.6	s25.7	N29°44.074	W095°08.175	54	824	094
9	00:07:00	275	6.2	s19.8	N29°44.143	W095°08.41	55	1893	277	094	6.6	s35.0	N29°44.075	W095°08.191	54	972	094

This is an own ship track history shape

08:13 SEP

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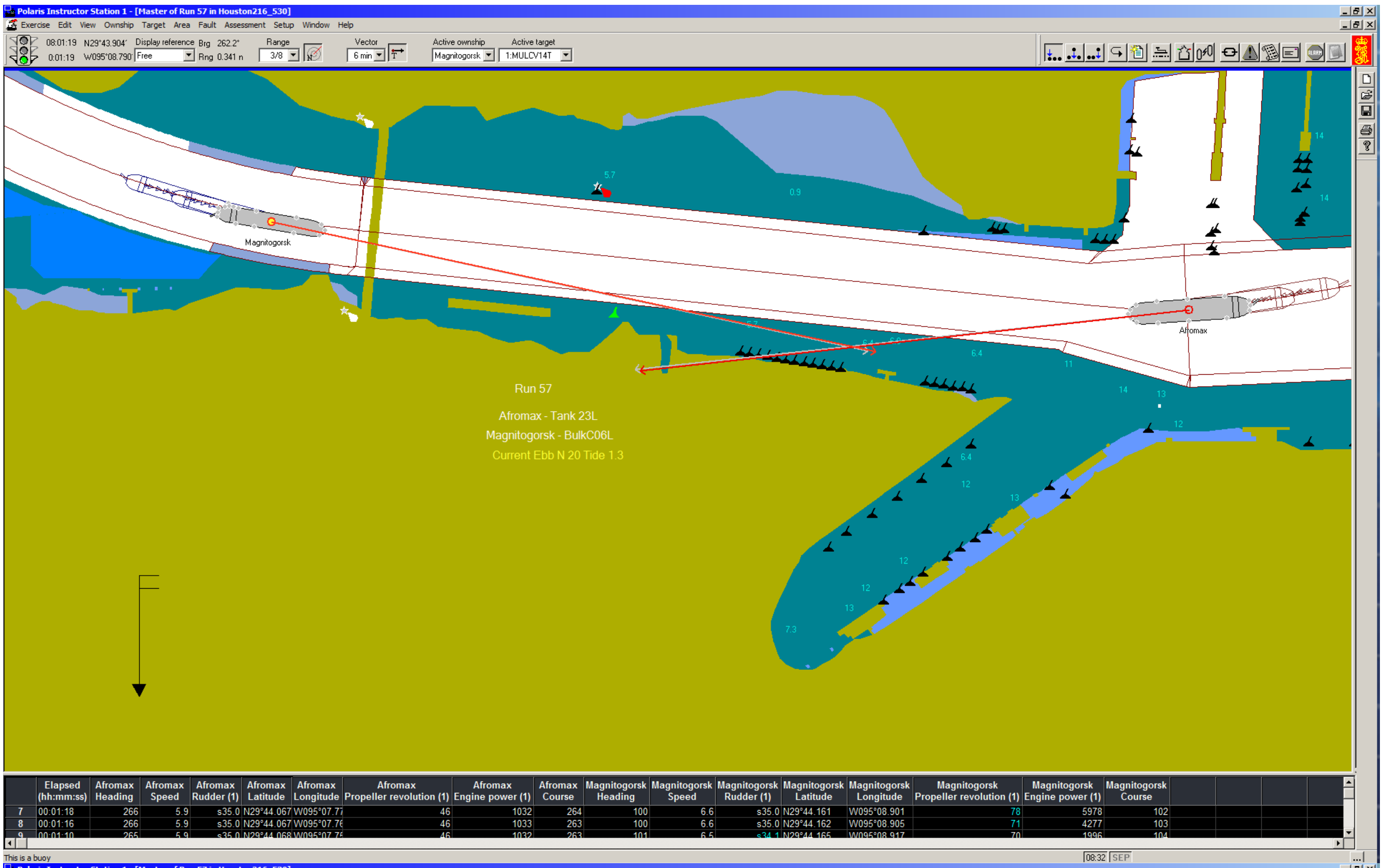
Run 57



Polaris Instructor Station 1 - [Master of Run 57 in Houston216_530]

08:01:19 N29°43.904' Display reference Free Brg 262.2° Rng 0.341 n
0:01:19 W095°08.790'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 57

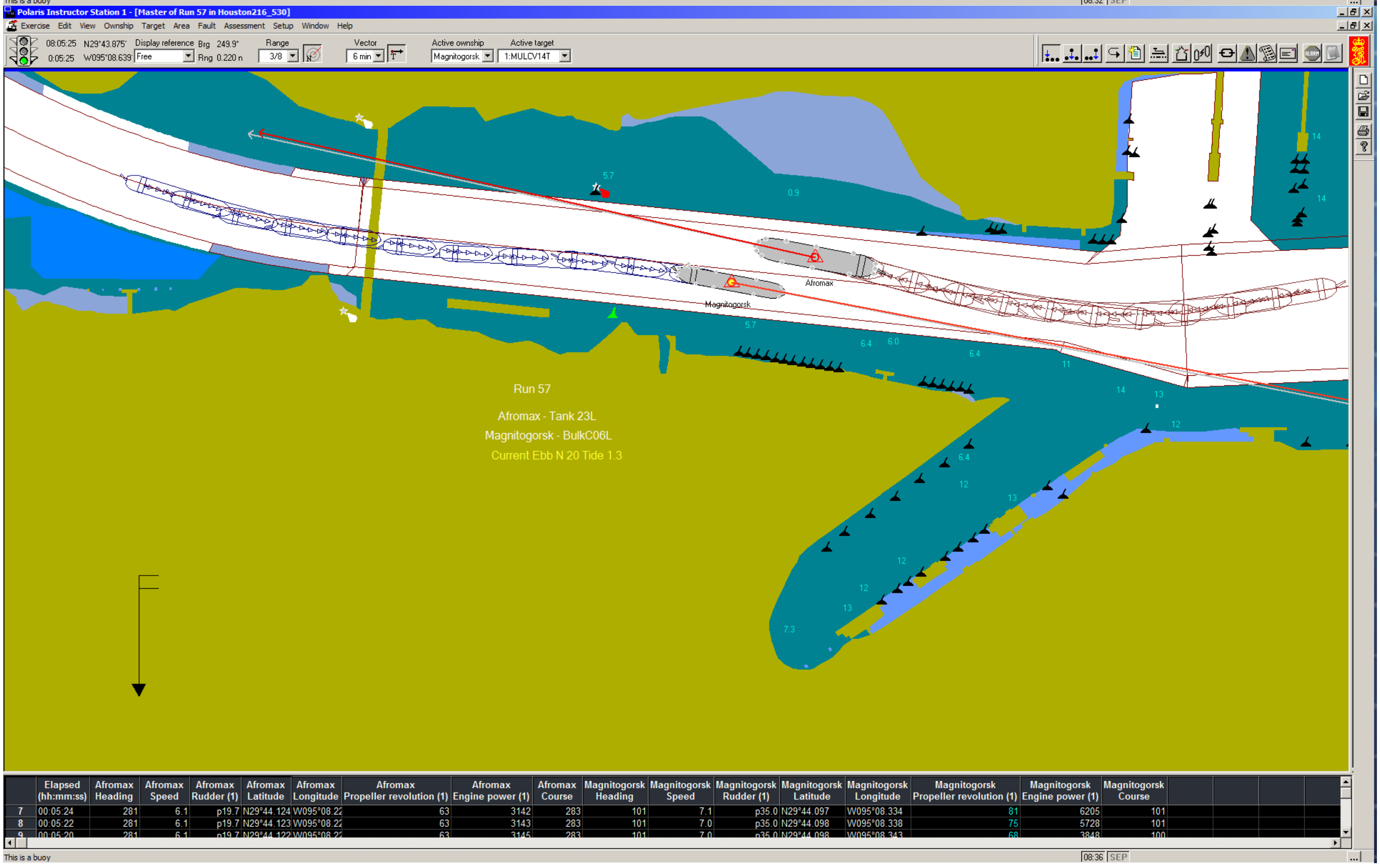
Afromax - Tank 23L

Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:01:18	266	5.9	s35.0	N29°44.067	W095°07.77	46	1032	264	100	6.6	s35.0	N29°44.161	W095°08.901	78	5978	102
8	00:01:16	266	5.9	s35.0	N29°44.067	W095°07.76	46	1033	263	100	6.6	s35.0	N29°44.162	W095°08.905	71	4277	103
9	00:01:10	265	5.9	s35.0	N29°44.068	W095°07.75	46	1032	263	101	6.5	s34.1	N29°44.165	W095°08.917	70	1996	104

This is a buoy 08:32 SEP



Polaris Instructor Station 1 - [Master of Run 57 in Houston216_530]

08:05:25 N29°43.875' Display reference Free Brg 249.9° Rng 0.220 n
0:05:25 W095°08.639'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 57

Afromax - Tank 23L

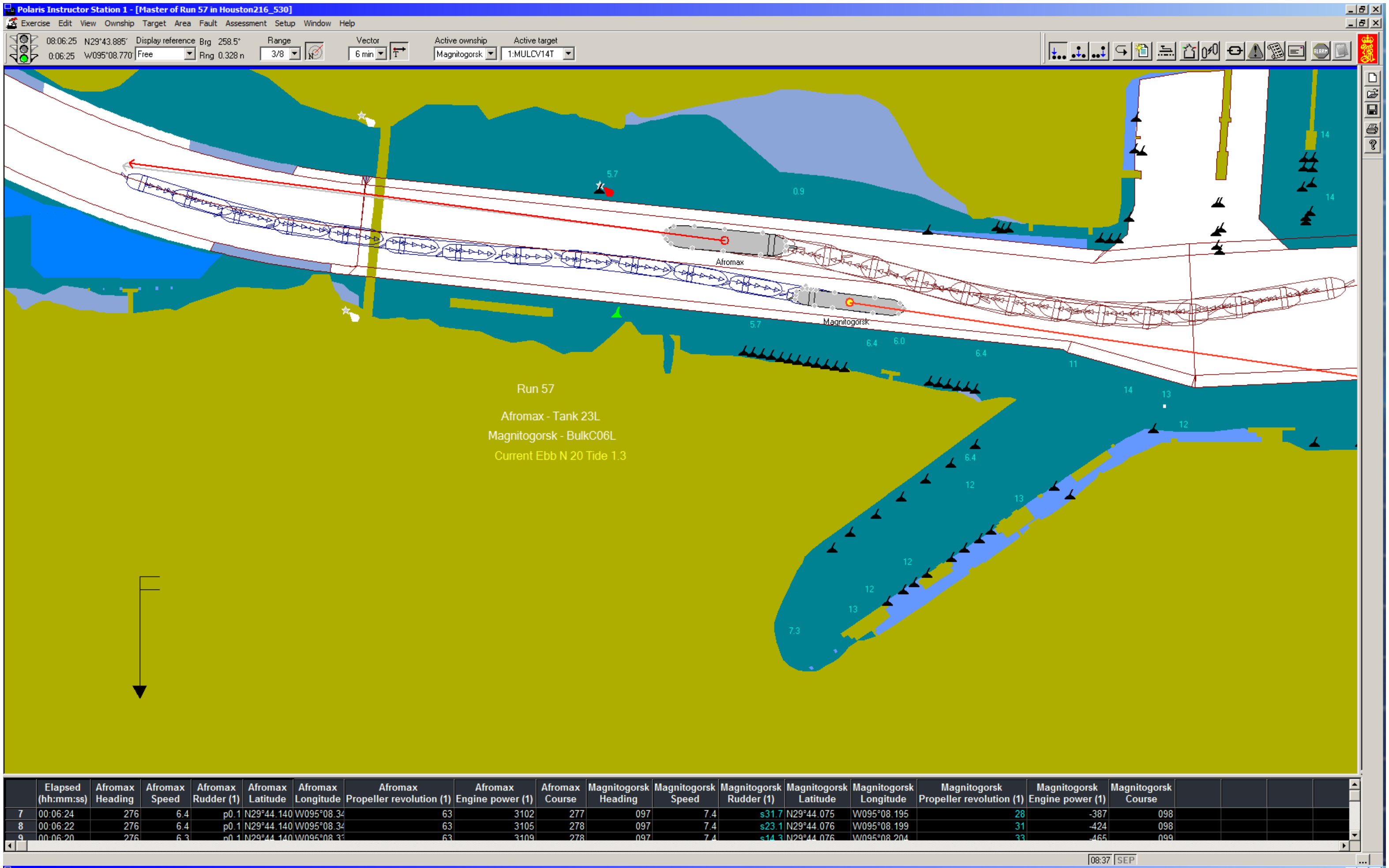
Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:05:24	281	6.1	p19.7	N29°44.124	W095°08.22	63	3142	283	101	7.1	p35.0	N29°44.097	W095°08.334	81	6205	101
8	00:05:22	281	6.1	p19.7	N29°44.123	W095°08.22	63	3143	283	101	7.0	p35.0	N29°44.098	W095°08.338	75	5728	101
9	00:05:20	281	6.1	p19.7	N29°44.122	W095°08.22	63	3145	283	101	7.0	p35.0	N29°44.098	W095°08.343	68	3848	100

This is a buoy 08:36 SEP

June 26, 2019



08:06:25 N29°43.885′ Display reference Free Brg 258.5° Rng 0.328 n
0:06:25 W095°08.770′
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

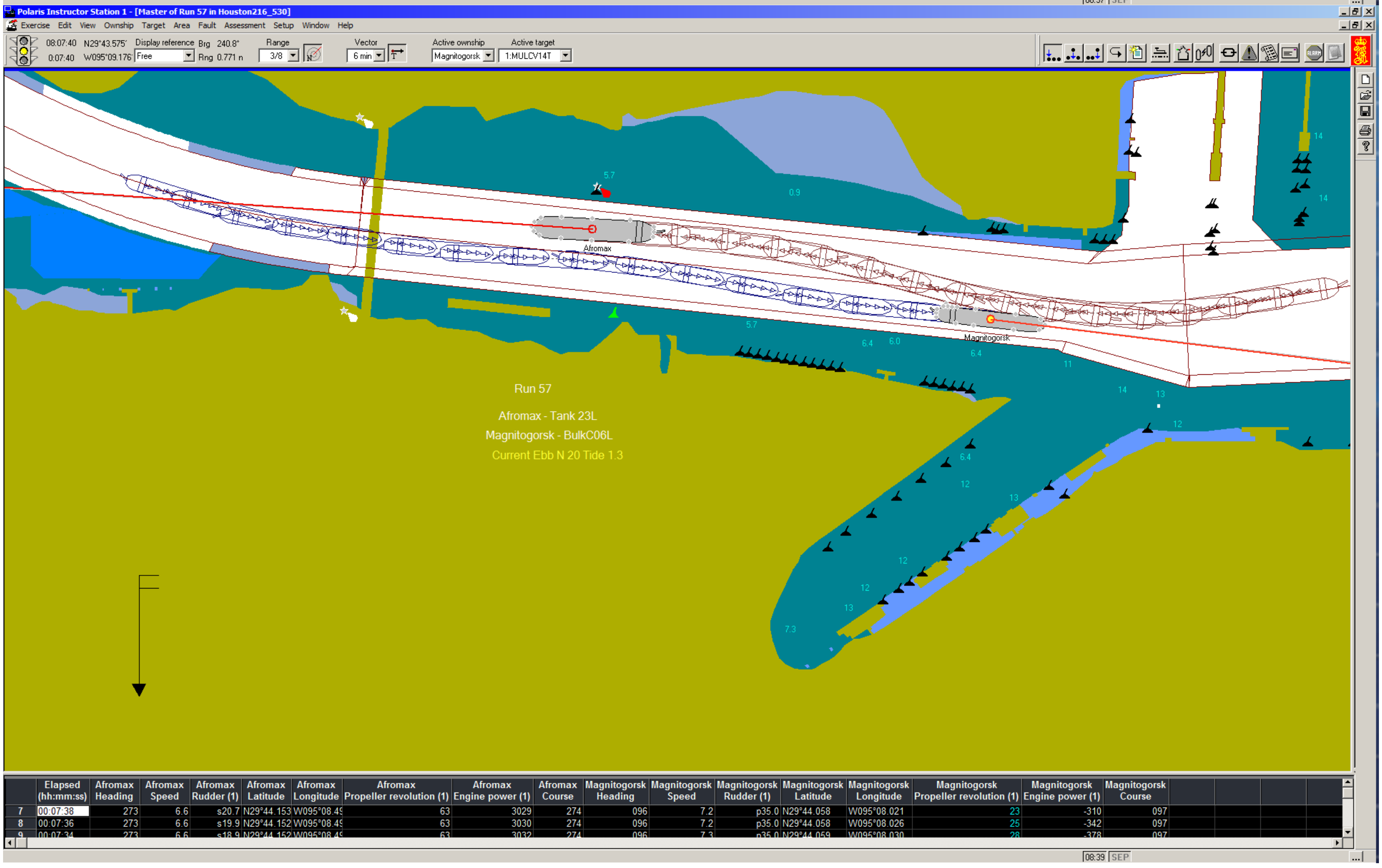
Run 57

Afromax - Tank 23L

Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:06:24	276	6.4	p0.1	N29°44.140	W095°08.34	63	3102	277	097	7.4	s31.7	N29°44.075	W095°08.195	28	-387	098
8	00:06:22	276	6.4	p0.1	N29°44.140	W095°08.34	63	3105	278	097	7.4	s23.1	N29°44.076	W095°08.199	31	-424	098
9	00:06:20	276	6.3	p0.1	N29°44.140	W095°08.33	63	3109	278	097	7.4	s14.3	N29°44.076	W095°08.204	33	-465	099



08:07:40 N29°43.575′ Display reference Free Brg 240.8° Rng 0.771 n
0:07:40 W095°09.176′
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 57

Afromax - Tank 23L

Magnitogorsk - BulkC06L

Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:38	273	6.6	s20.7	N29°44.153	W095°08.49	63	3029	274	096	7.2	p35.0	N29°44.058	W095°08.021	23	-310	097
8	00:07:36	273	6.6	s19.9	N29°44.152	W095°08.49	63	3030	274	096	7.2	p35.0	N29°44.058	W095°08.026	25	-342	097
9	00:07:34	273	6.6	s18.9	N29°44.152	W095°08.49	63	3032	274	096	7.3	p35.0	N29°44.059	W095°08.030	28	-378	097

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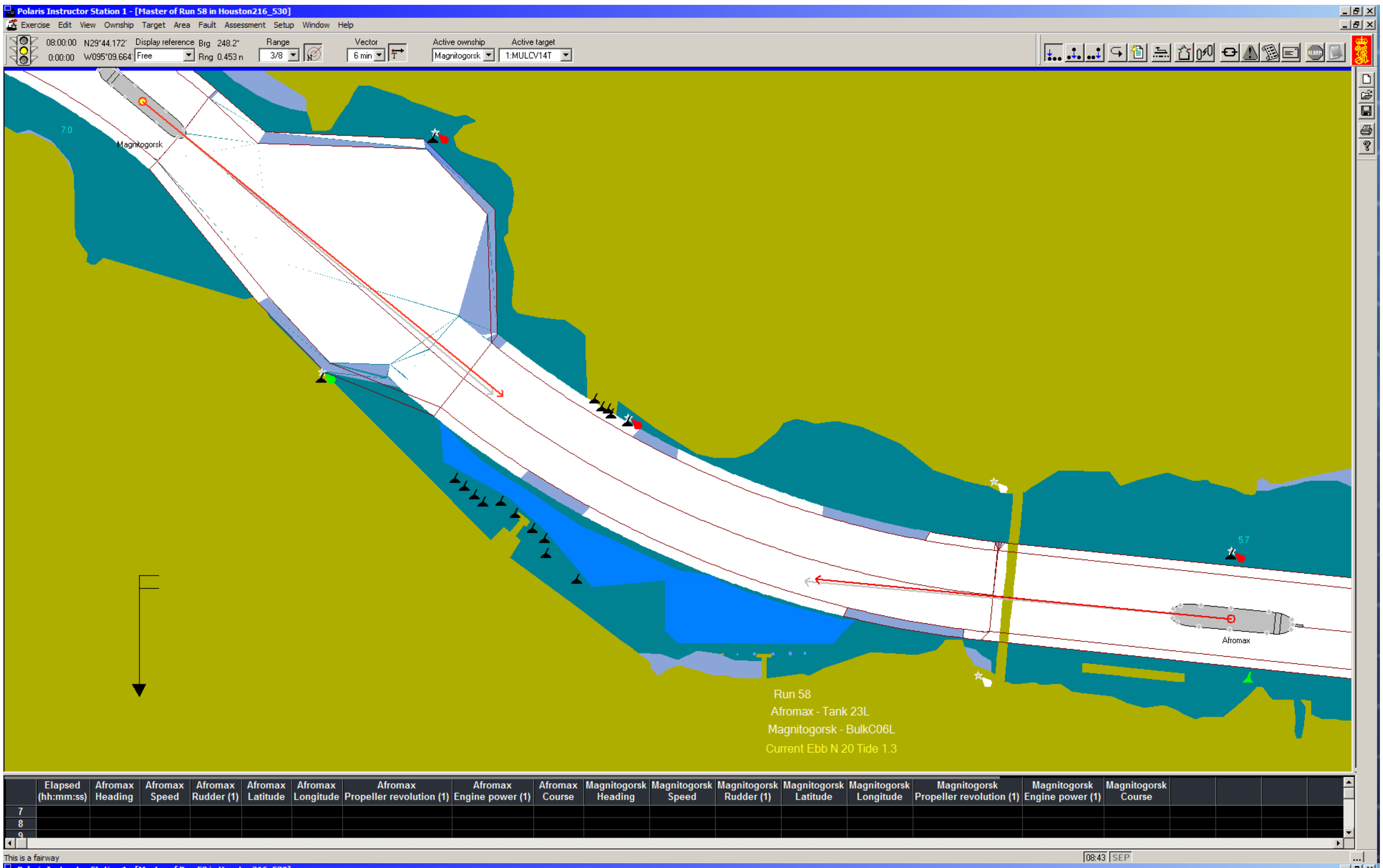
June 26, 2019

Run 58



Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

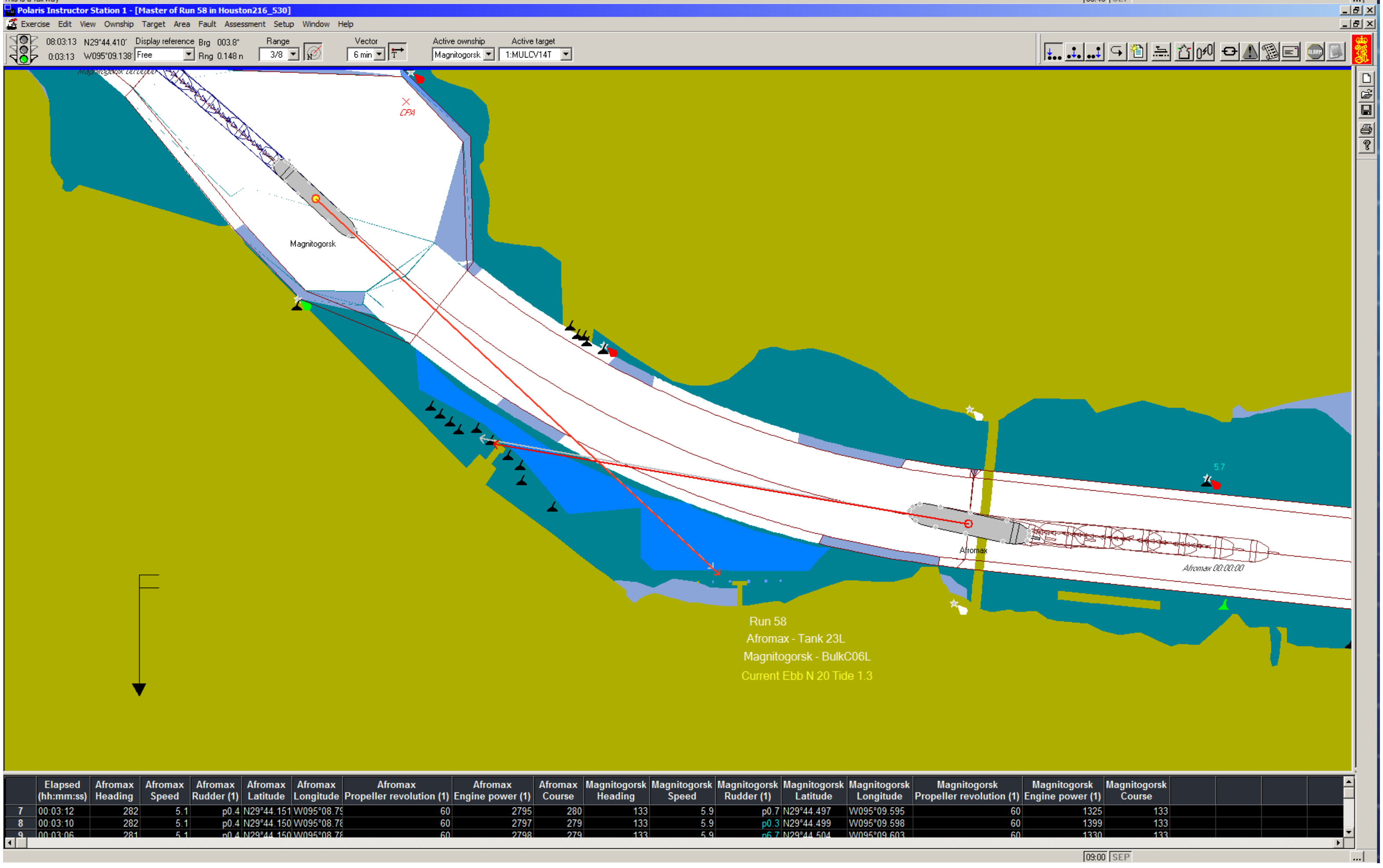
08:00:00 N29°44.172'
0:00:00 W095°09.664'
Display reference: Free
Brg 248.2°
Rng 0.453 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 58
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7																	
8																	
9																	

This is a fairway

08:43 SEP



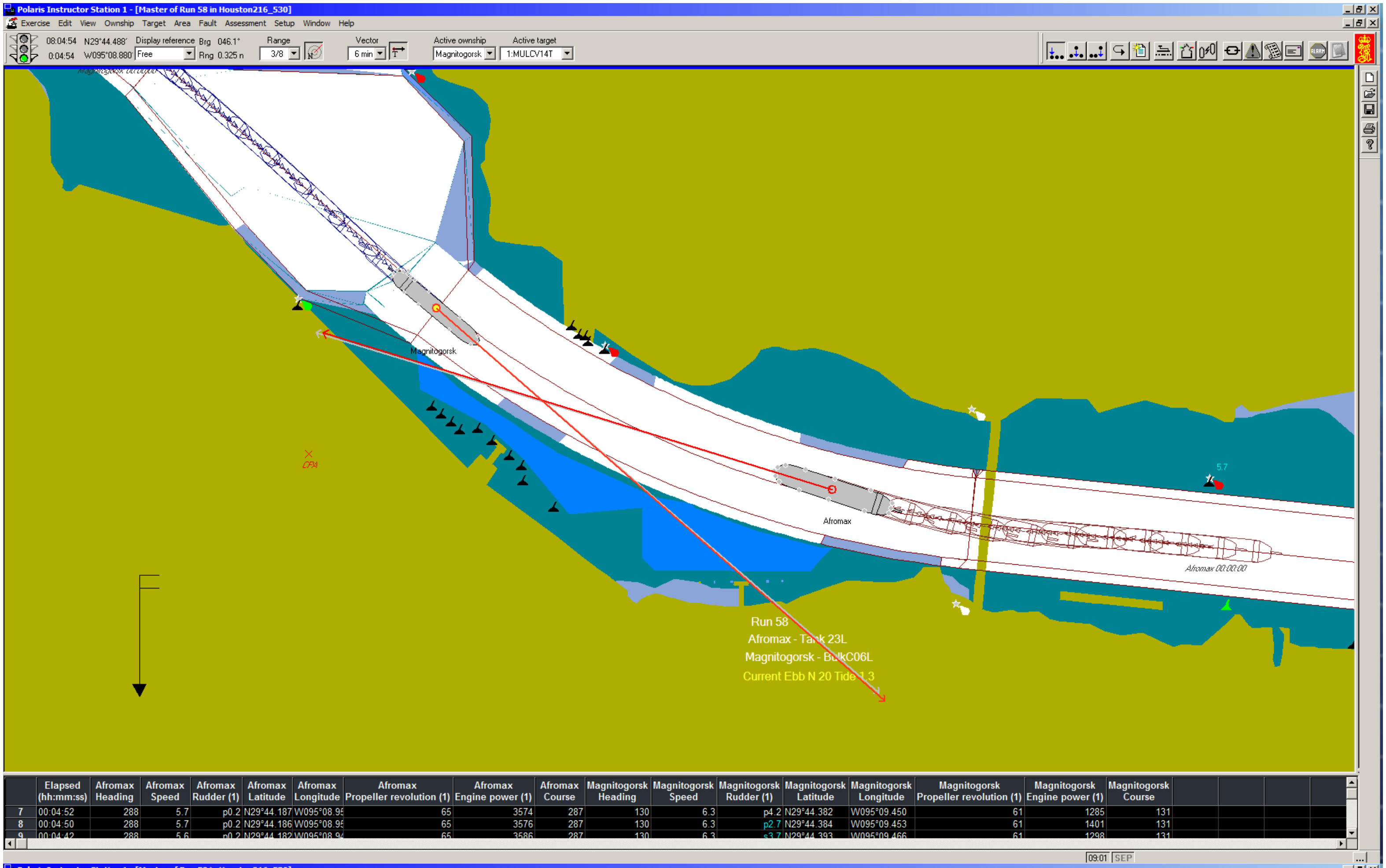
Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

08:03:13 N29°44.410'
0:03:13 W095°09.138'
Display reference: Free
Brg 003.8°
Rng 0.148 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 58
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:03:12	282	5.1	p0.4	N29°44.151	W095°08.79	60	2795	280	133	5.9	p0.7	N29°44.497	W095°09.595	60	1325	133
8	00:03:10	282	5.1	p0.4	N29°44.150	W095°08.78	60	2797	279	133	5.9	p0.3	N29°44.499	W095°09.598	60	1399	133
9	00:03:06	281	5.1	p0.4	N29°44.150	W095°08.78	60	2798	279	133	5.9	p6.7	N29°44.504	W095°09.603	60	1330	133

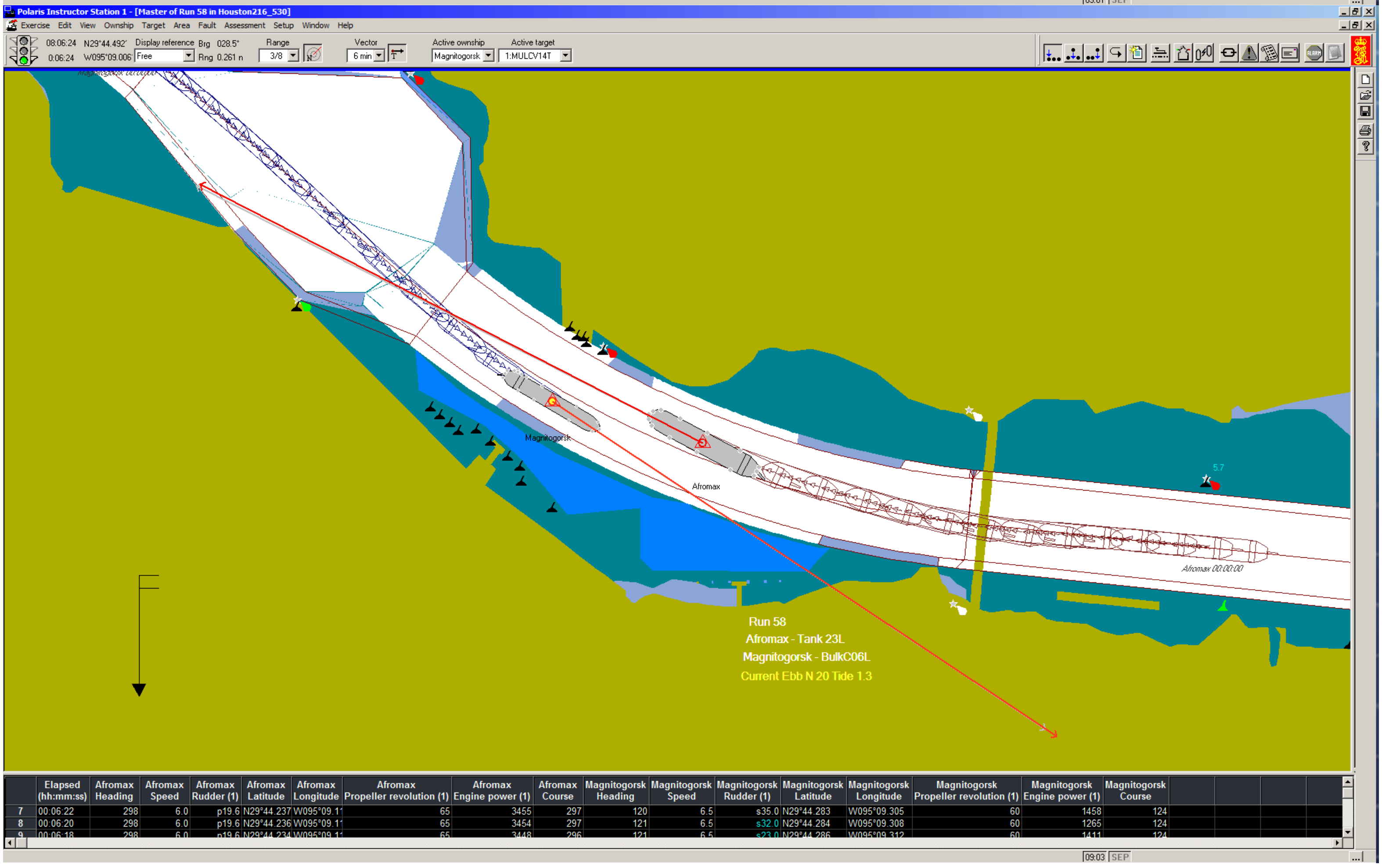
09:00 SEP



Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

08:04:54 N29°44.488'
0:04:54 W095°08.880'
Display reference: Free
Brg 046.1°
Rng 0.325 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

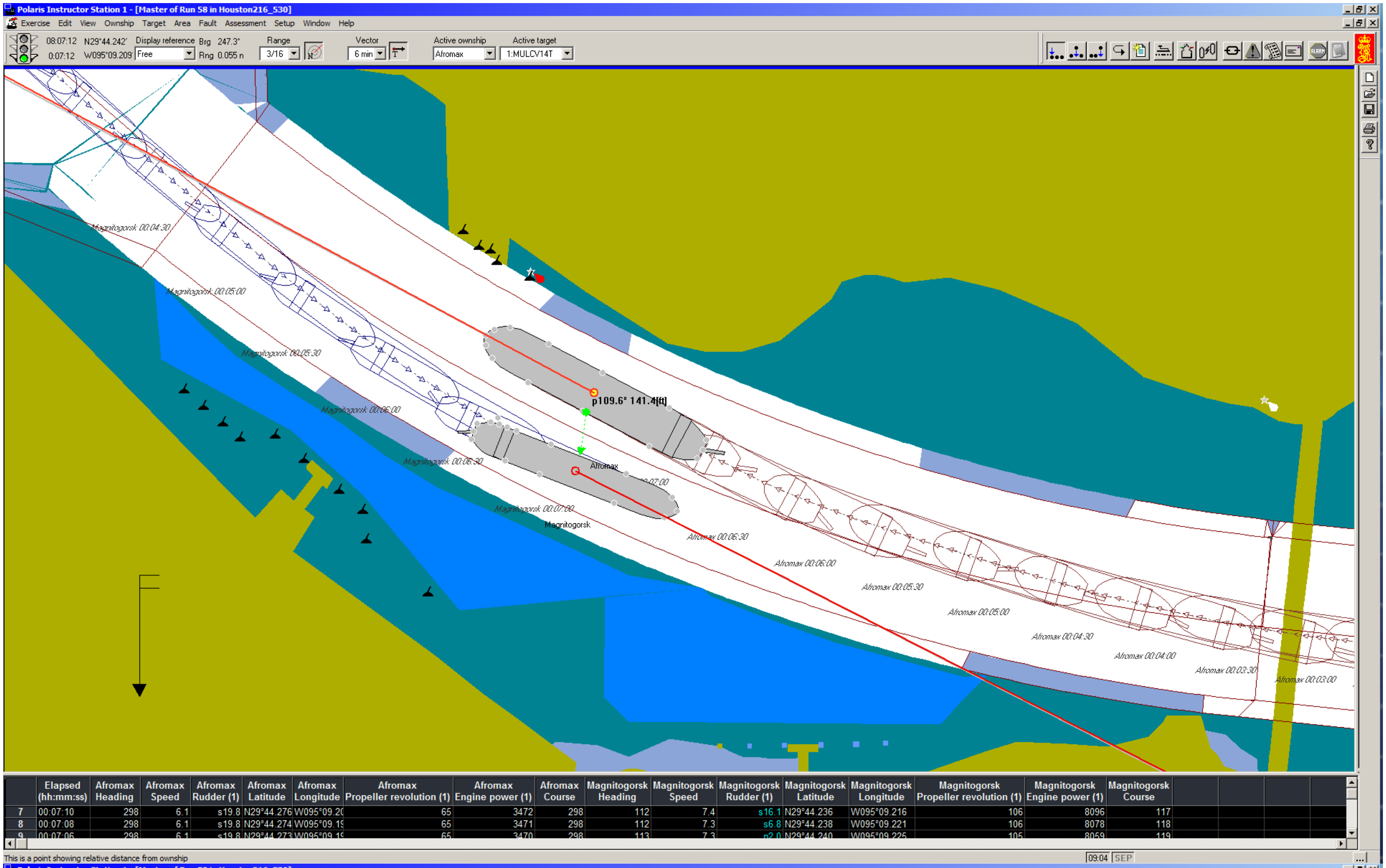
	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:04:52	288	5.7	p0.2	N29°44.187	W095°08.95	65	3574	287	130	6.3	p4.2	N29°44.382	W095°09.450	61	1285	131
8	00:04:50	288	5.7	p0.2	N29°44.186	W095°08.95	65	3576	287	130	6.3	p2.7	N29°44.384	W095°09.453	61	1401	131
9	00:04:42	288	5.6	p0.2	N29°44.182	W095°08.94	65	3586	287	130	6.3	s3.7	N29°44.393	W095°09.466	61	1298	131



Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

08:06:24 N29°44.492'
0:06:24 W095°09.006'
Display reference: Free
Brg 028.5°
Rng 0.261 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:06:22	298	6.0	p19.6	N29°44.237	W095°09.11	65	3455	297	120	6.5	s35.0	N29°44.283	W095°09.305	60	1458	124
8	00:06:20	298	6.0	p19.6	N29°44.236	W095°09.11	65	3454	297	121	6.5	s32.0	N29°44.284	W095°09.308	60	1265	124
9	00:06:18	298	6.0	p19.6	N29°44.234	W095°09.11	65	3448	296	121	6.5	s23.0	N29°44.286	W095°09.312	60	1411	124



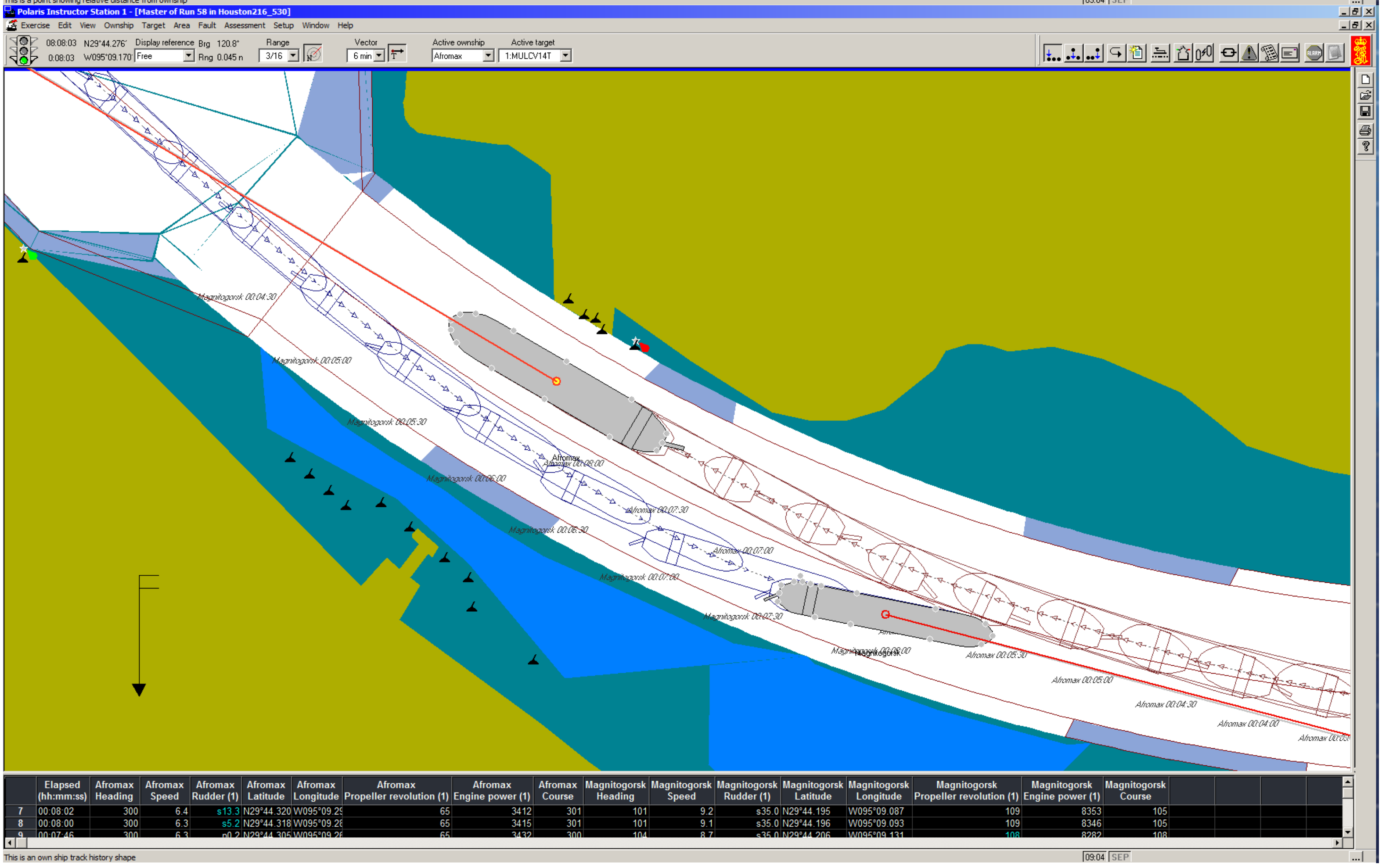
Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

08:07:12 N29°44.242′ Display reference Brg 247.3°
0:07:12 W095°09.209′ Free Rng 0.055 n
Range 3/16
Vector 6 min
Active ownship Afromax
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:10	298	6.1	s19.8	N29°44.276	W095°09.20	65	3472	298	112	7.4	s16.1	N29°44.236	W095°09.216	106	8096	117
8	00:07:08	298	6.1	s19.8	N29°44.274	W095°09.19	65	3471	298	112	7.3	s6.8	N29°44.238	W095°09.221	106	8078	118
9	00:07:06	298	6.1	s19.8	N29°44.273	W095°09.19	65	3470	298	113	7.3	p2.0	N29°44.240	W095°09.225	105	8059	119

This is a point showing relative distance from ownship

09:04 SEP



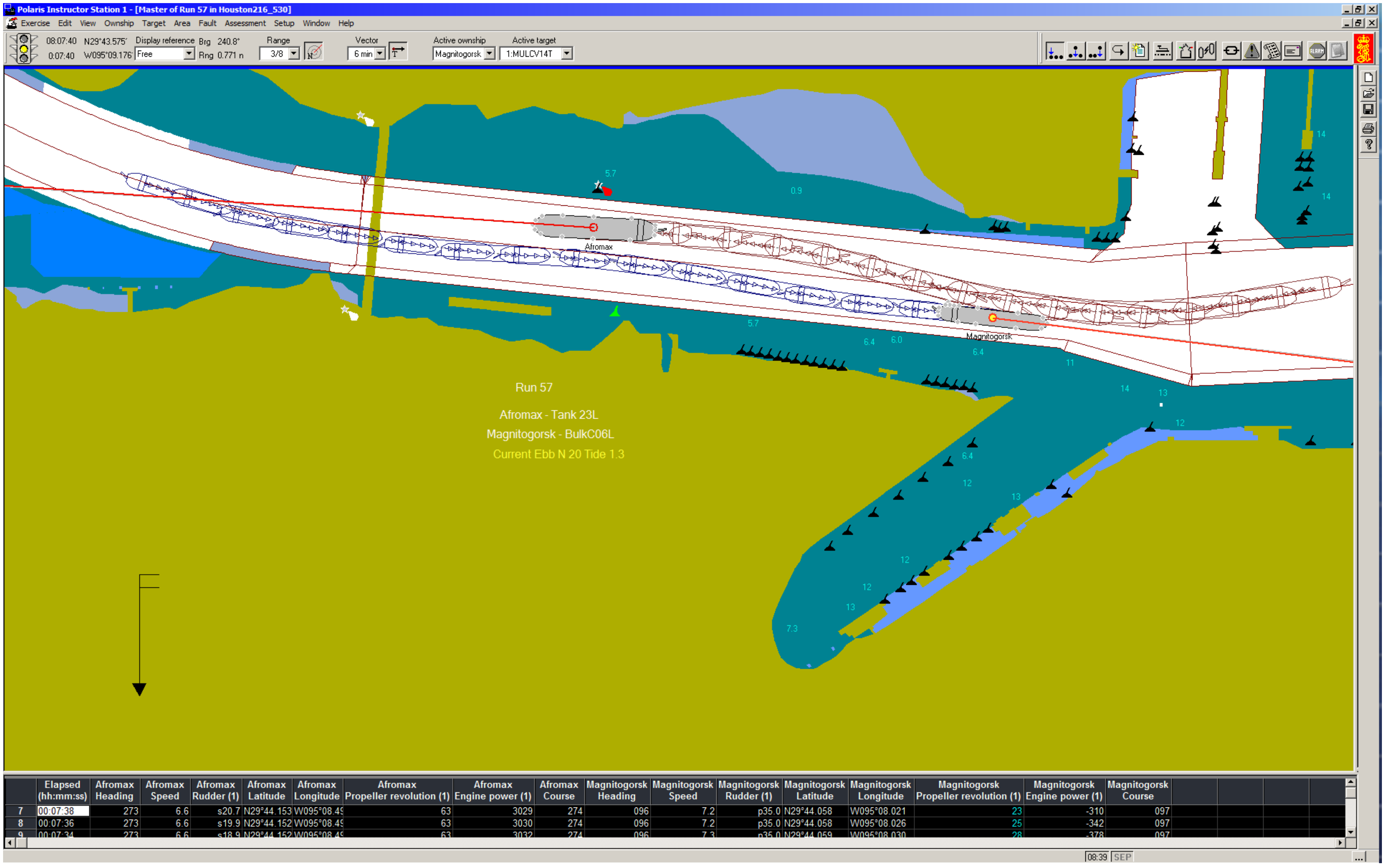
Polaris Instructor Station 1 - [Master of Run 58 in Houston216_530]

08:08:03 N29°44.276′ Display reference Brg 120.8°
0:08:03 W095°09.170′ Free Rng 0.045 n
Range 3/16
Vector 6 min
Active ownship Afromax
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:08:02	300	6.4	s13.3	N29°44.320	W095°09.29	65	3412	301	101	9.2	s35.0	N29°44.195	W095°09.087	109	8353	105
8	00:08:00	300	6.3	s5.2	N29°44.318	W095°09.28	65	3415	301	101	9.1	s35.0	N29°44.196	W095°09.093	109	8346	105
9	00:07:46	300	6.3	p0.2	N29°44.305	W095°09.26	65	3432	300	104	8.7	s35.0	N29°44.206	W095°09.131	108	8282	108

This is an own ship track history shape

09:04 SEP



Polaris Instructor Station 1 - [Master of Run 57 in Houston216_530]

08:07:40 N29°43.575' Display reference Free Brg 240.8° Rng 0.771 n
0:07:40 W095°09.176'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 57

Afromax - Tank 23L

Magnitogorsk - BulkC06L

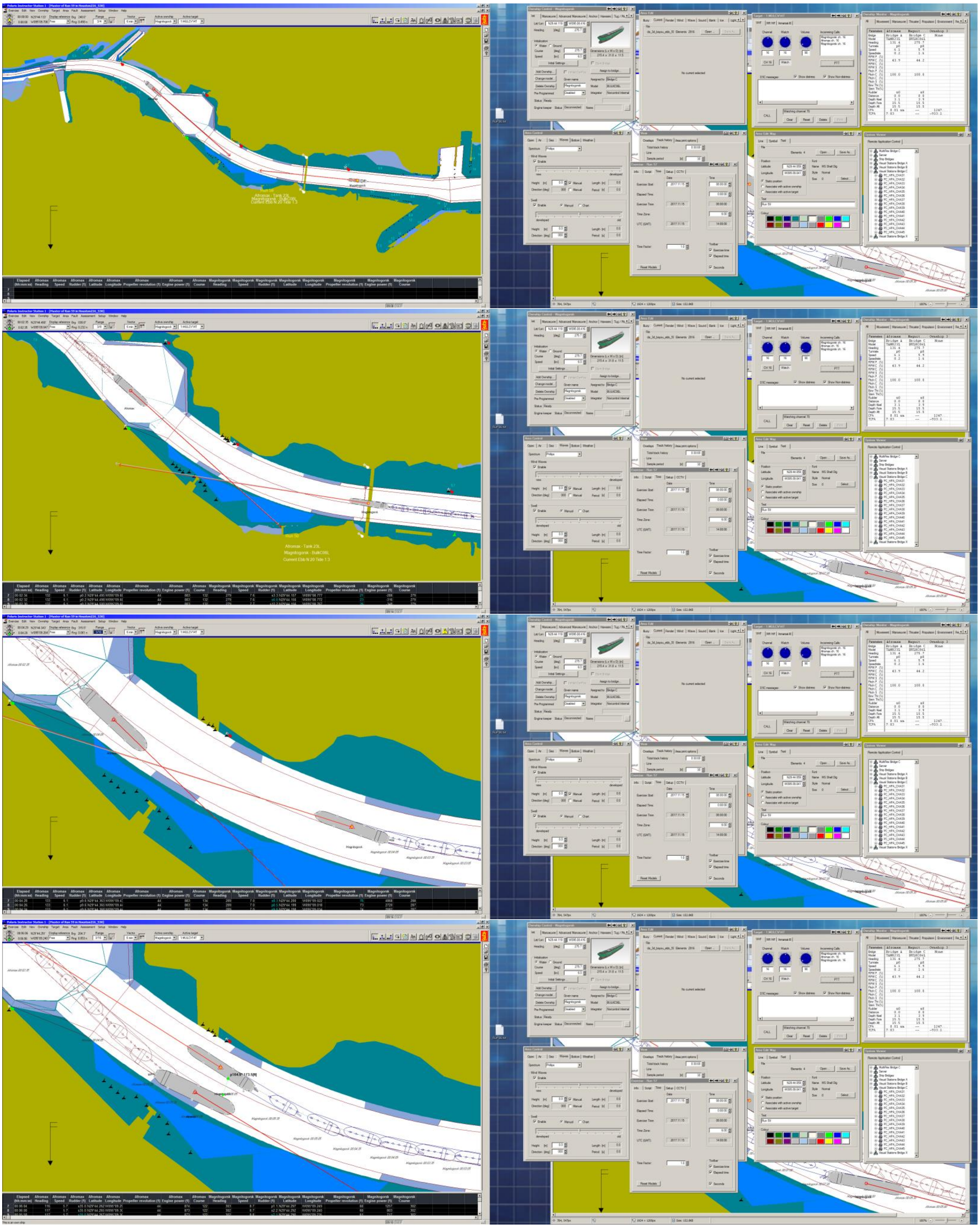
Current Ebb N 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:38	273	6.6	s20.7	N29°44.153	W095°08.4	63	3029	274	096	7.2	p35.0	N29°44.058	W095°08.021	23	-310	097
8	00:07:36	273	6.6	s19.9	N29°44.152	W095°08.4	63	3030	274	096	7.2	p35.0	N29°44.058	W095°08.026	25	-342	097
9	00:07:34	273	6.6	s18.9	N29°44.152	W095°08.4	63	3032	274	096	7.3	p35.0	N29°44.059	W095°08.030	28	-378	097

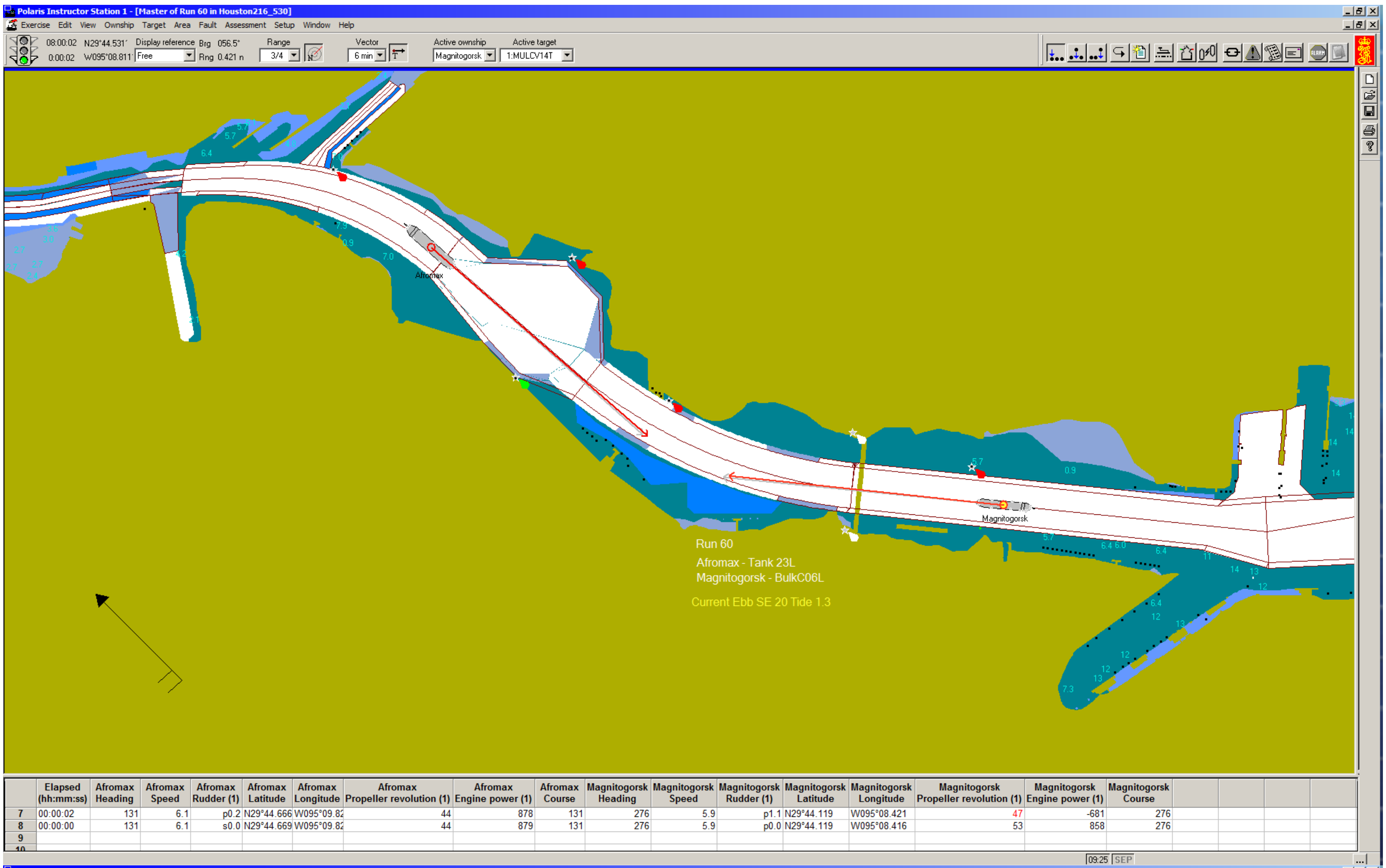
08:39 SEP

June 26, 2019

Run 59



Run 60

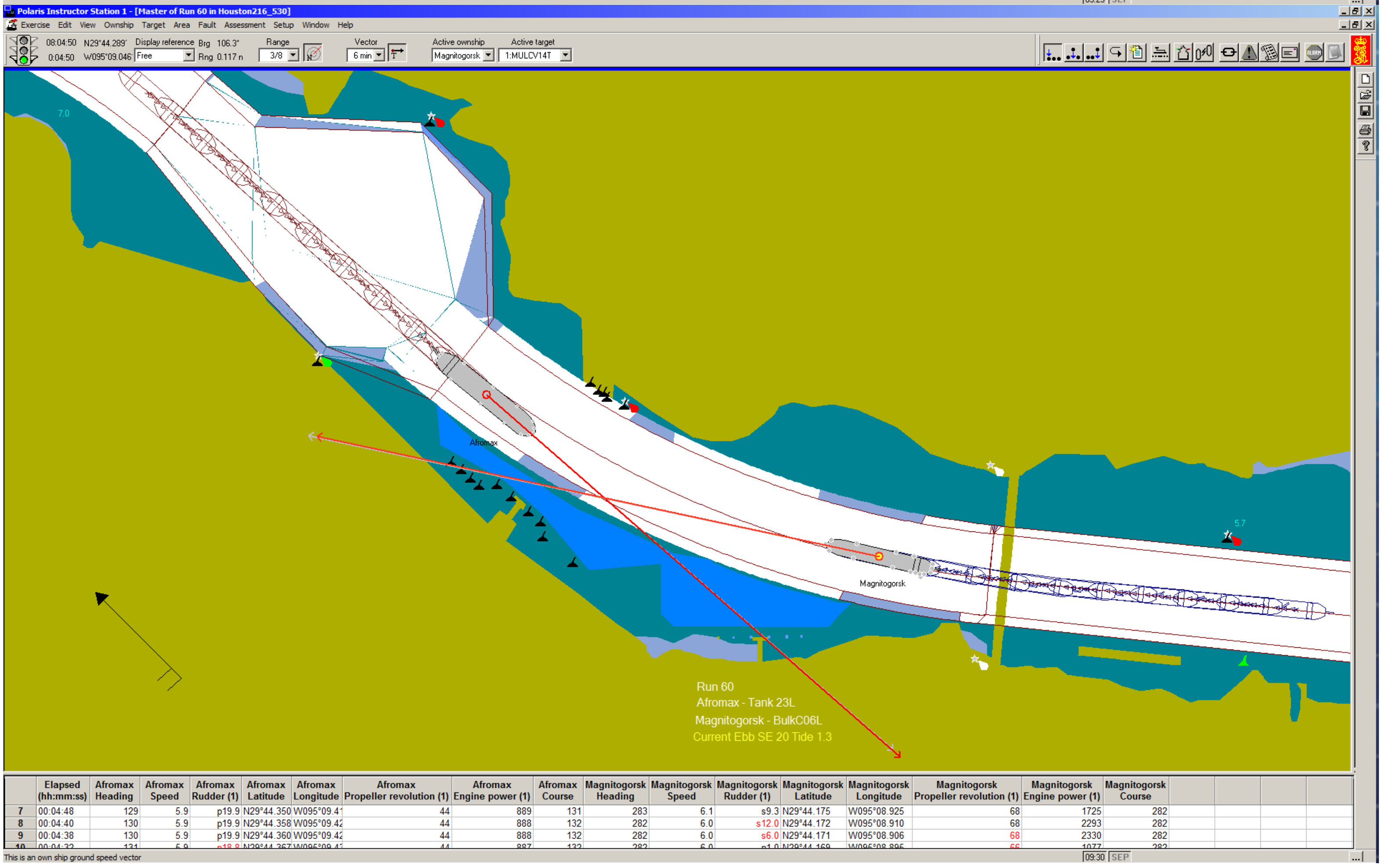


Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:00:02 N29°44.531′ Display reference: Free Brg 056.5° Rng 0.421 n Range: 3/4 Vector: 6 min Active ownship: Magnitogorsk Active target: 1:MULCV14T
0:00:02 W095°08.811′

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:00:02	131	6.1	p0.2	N29°44.666	W095°09.82	44	878	131	276	5.9	p1.1	N29°44.119	W095°08.421	47	-681	276
8	00:00:00	131	6.1	s0.0	N29°44.669	W095°09.82	44	879	131	276	5.9	p0.0	N29°44.119	W095°08.416	53	858	276
9																	

09:25 SEP



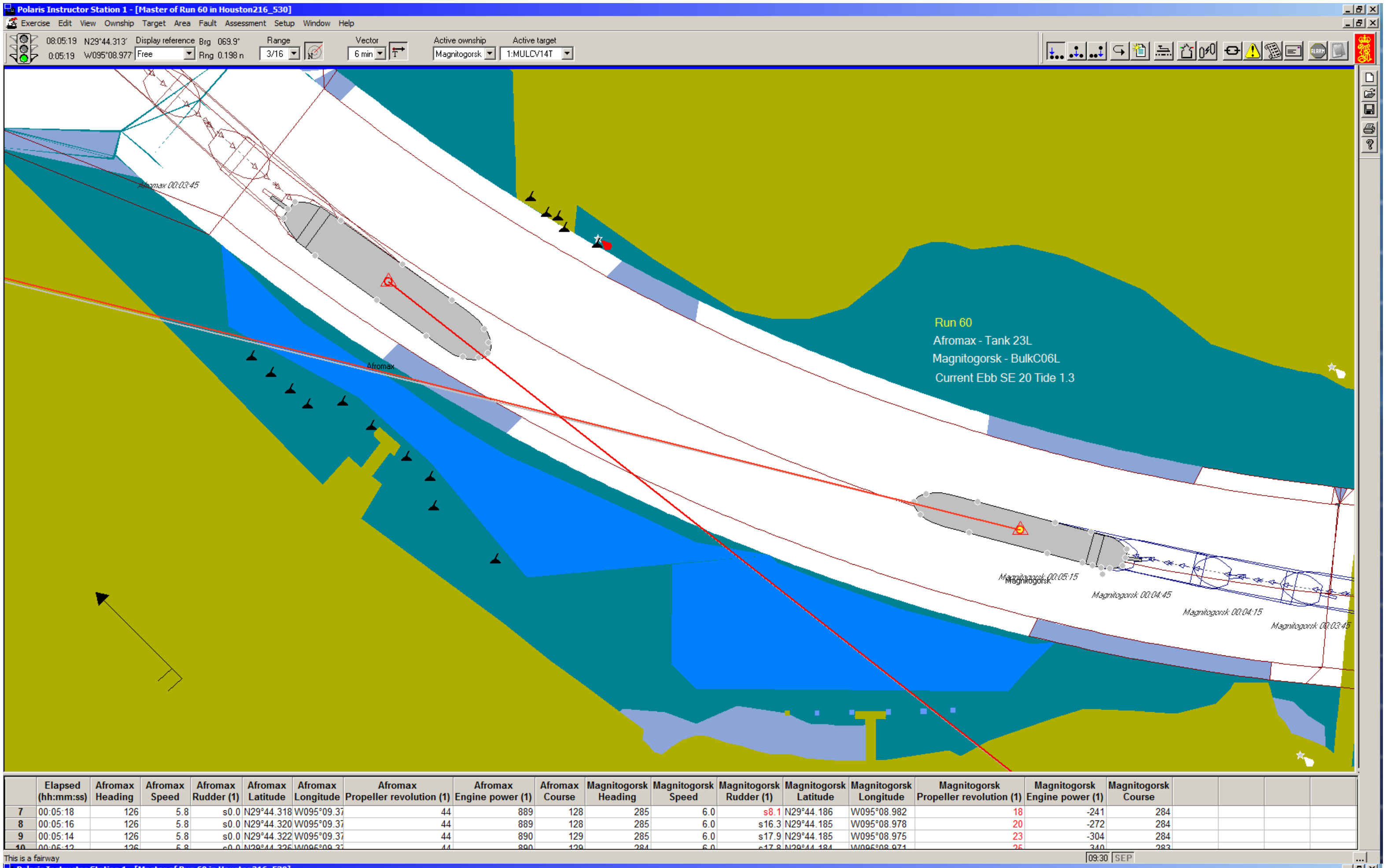
Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:04:50 N29°44.289′ Display reference: Free Brg 106.3° Rng 0.117 n Range: 3/8 Vector: 6 min Active ownship: Magnitogorsk Active target: 1:MULCV14T
0:04:50 W095°09.046′

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:04:48	129	5.9	p19.9	N29°44.350	W095°09.41	44	889	131	283	6.1	s9.3	N29°44.175	W095°08.925	68	1725	282
8	00:04:40	130	5.9	p19.9	N29°44.358	W095°09.42	44	888	132	282	6.0	s12.0	N29°44.172	W095°08.910	68	2293	282
9	00:04:38	130	5.9	p19.9	N29°44.360	W095°09.42	44	888	132	282	6.0	s6.0	N29°44.171	W095°08.906	68	2330	282
10	00:04:32	131	5.9	p18.8	N29°44.367	W095°09.4	44	887	132	282	6.0	p1.0	N29°44.169	W095°08.895	66	1077	282

This is an own ship ground speed vector

09:30 SEP

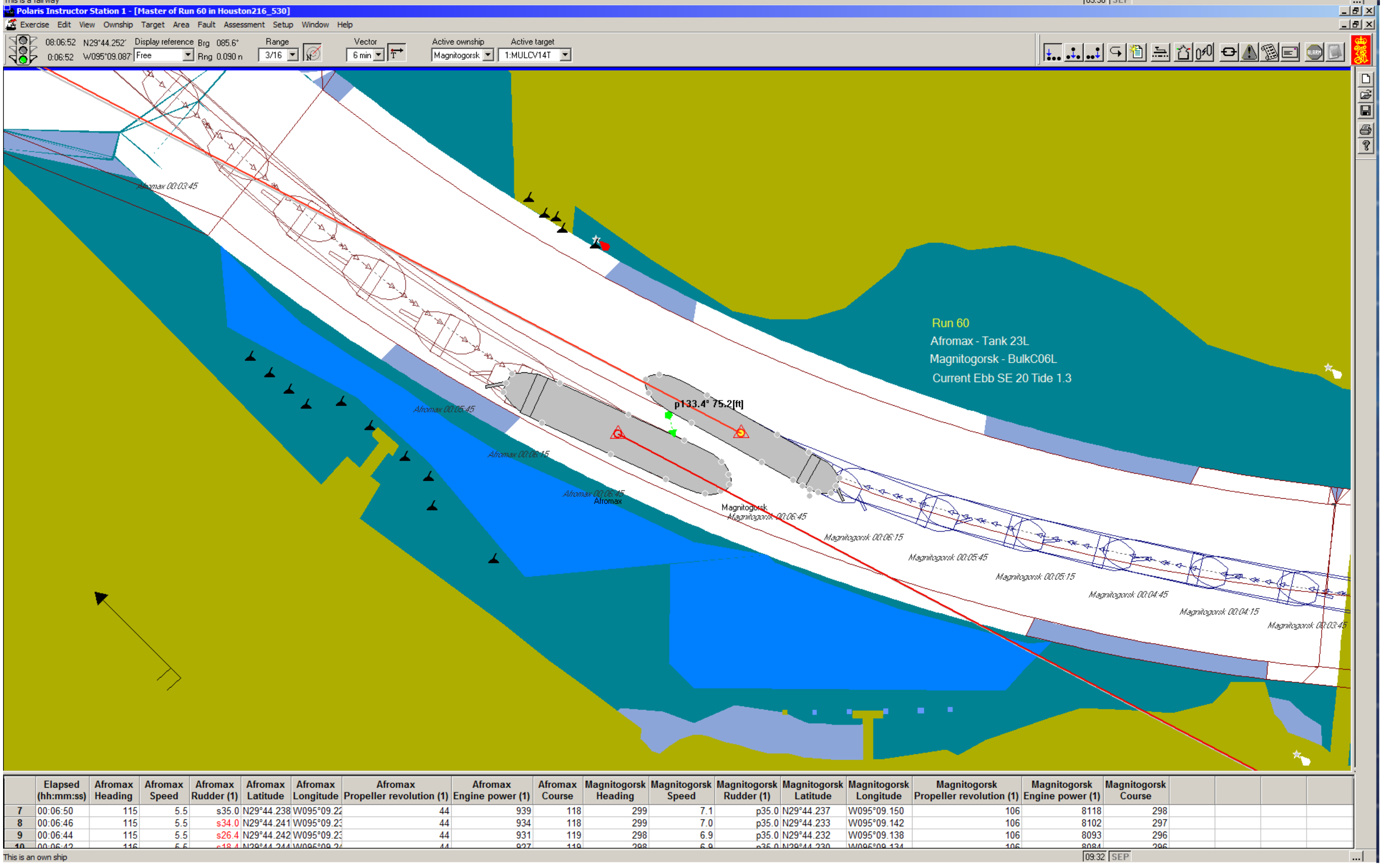


Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:05:19 N29°44.313' Display reference Brg 069.9°
0:05:19 W095°08.977' Free Rng 0.198 n
Range 3/16
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:05:18	126	5.8	s0.0	N29°44.318	W095°09.37	44	889	128	285	6.0	s8.1	N29°44.186	W095°08.982	18	-241	284
8	00:05:16	126	5.8	s0.0	N29°44.320	W095°09.37	44	889	128	285	6.0	s16.3	N29°44.185	W095°08.978	20	-272	284
9	00:05:14	126	5.8	s0.0	N29°44.322	W095°09.37	44	890	129	285	6.0	s17.9	N29°44.185	W095°08.975	23	-304	284

This is a fairway 09:30 SEP

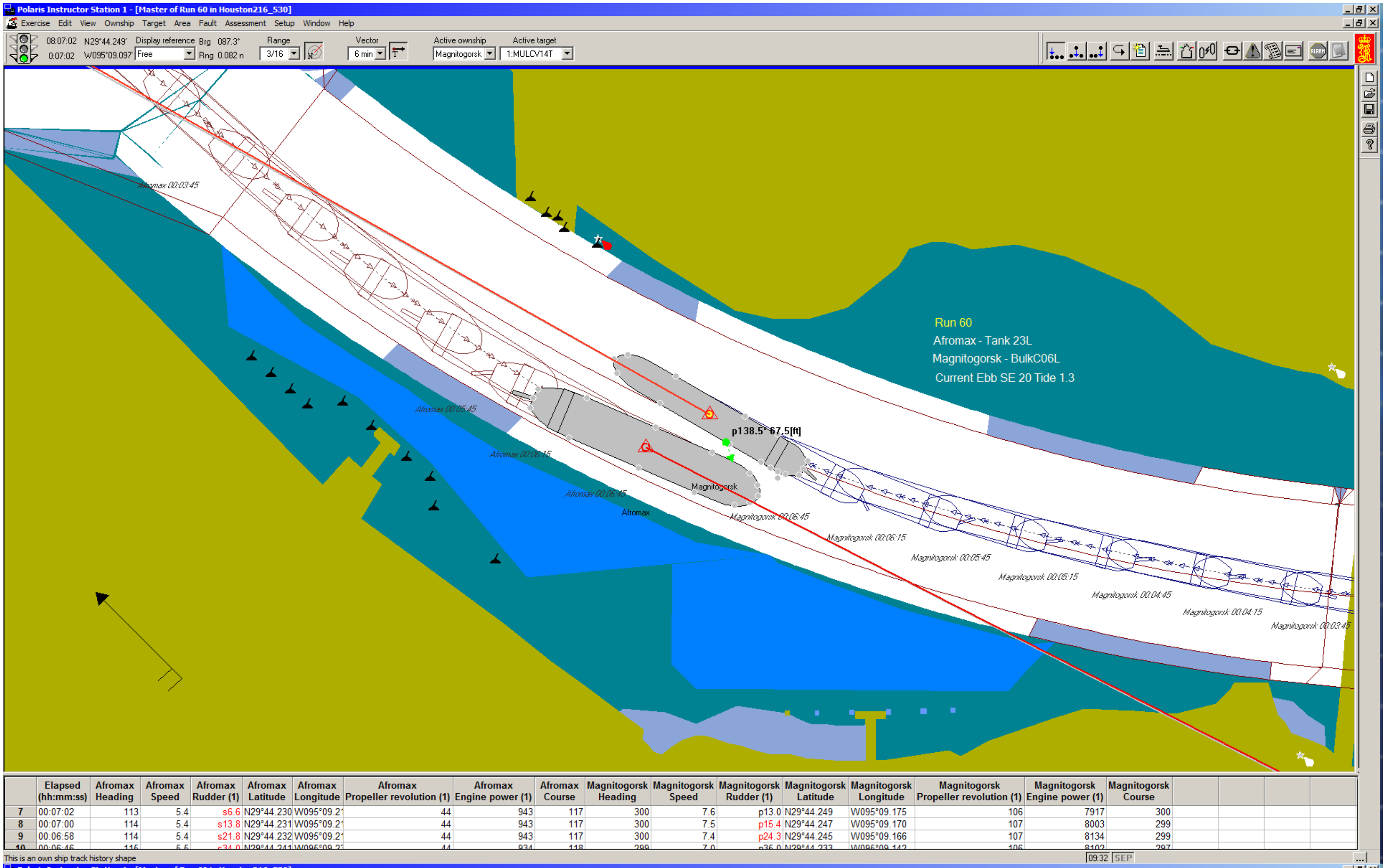


Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:06:52 N29°44.252' Display reference Brg 085.6°
0:06:52 W095°09.087' Free Rng 0.090 n
Range 3/16
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:06:50	115	5.5	s35.0	N29°44.238	W095°09.22	44	939	118	299	7.1	p35.0	N29°44.237	W095°09.150	106	8118	298
8	00:06:46	115	5.5	s34.0	N29°44.241	W095°09.23	44	934	118	299	7.0	p35.0	N29°44.233	W095°09.142	106	8102	297
9	00:06:44	115	5.5	s26.4	N29°44.242	W095°09.23	44	931	119	298	6.9	p35.0	N29°44.232	W095°09.138	106	8093	296

This is an own ship 09:32 SEP

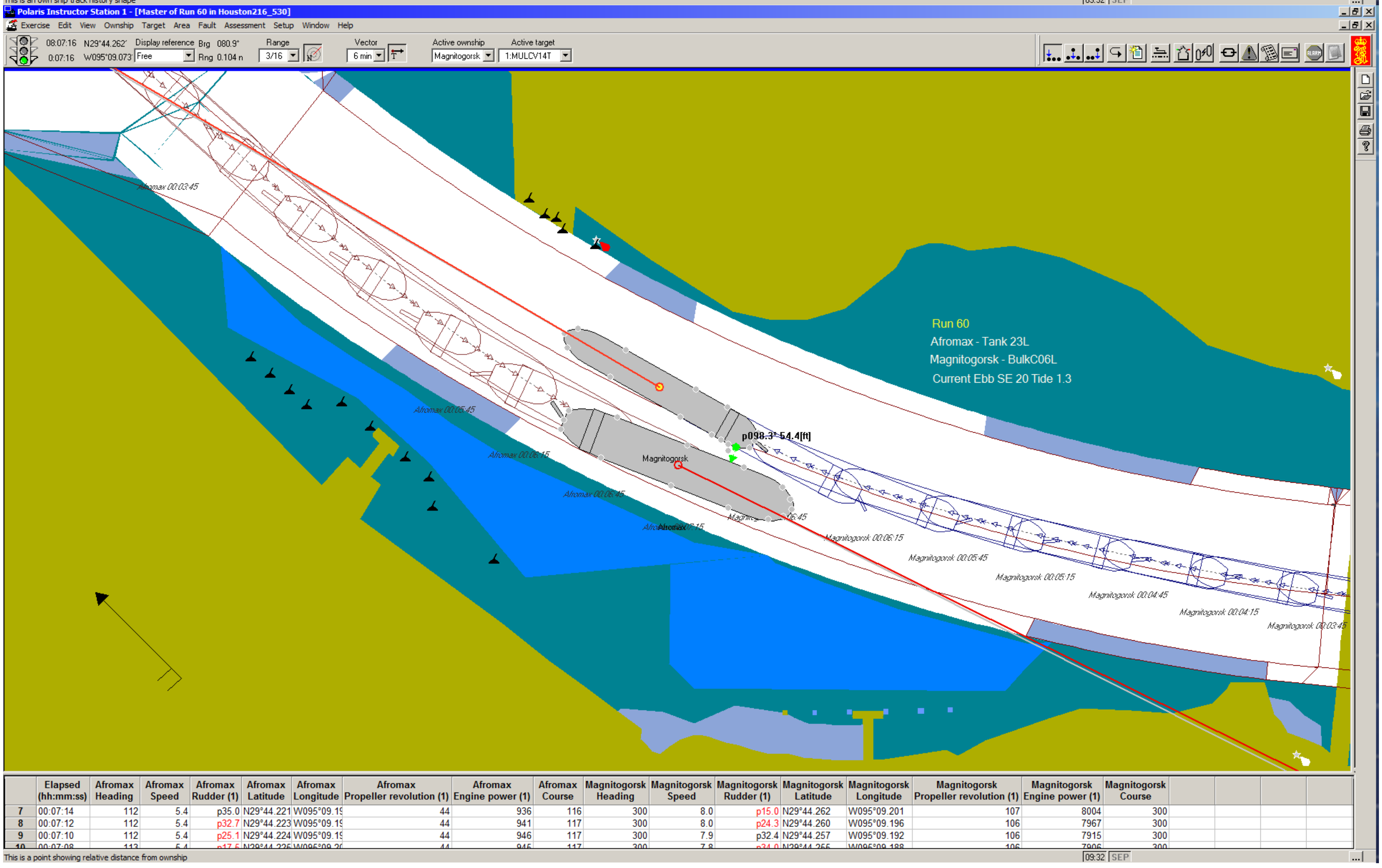


08:07:02 N29°44.249' Display reference Free Brg 087.3° Rng 0.082 n
0:07:02 W095°09.097'
Range 3/16
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 60
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:02	113	5.4	s6.6	N29°44.230	W095°09.21	44	943	117	300	7.6	p13.0	N29°44.249	W095°09.175	106	7917	300
8	00:07:00	114	5.4	s13.8	N29°44.231	W095°09.21	44	943	117	300	7.5	p15.4	N29°44.247	W095°09.170	107	8003	299
9	00:06:58	114	5.4	s21.8	N29°44.232	W095°09.21	44	943	117	300	7.4	p24.3	N29°44.245	W095°09.166	107	8134	299
10	00:06:46	115	5.5	s34.0	N29°44.241	W095°09.2	44	934	118	299	7.0	p35.0	N29°44.233	W095°09.142	106	8102	297

This is an own ship track history shape



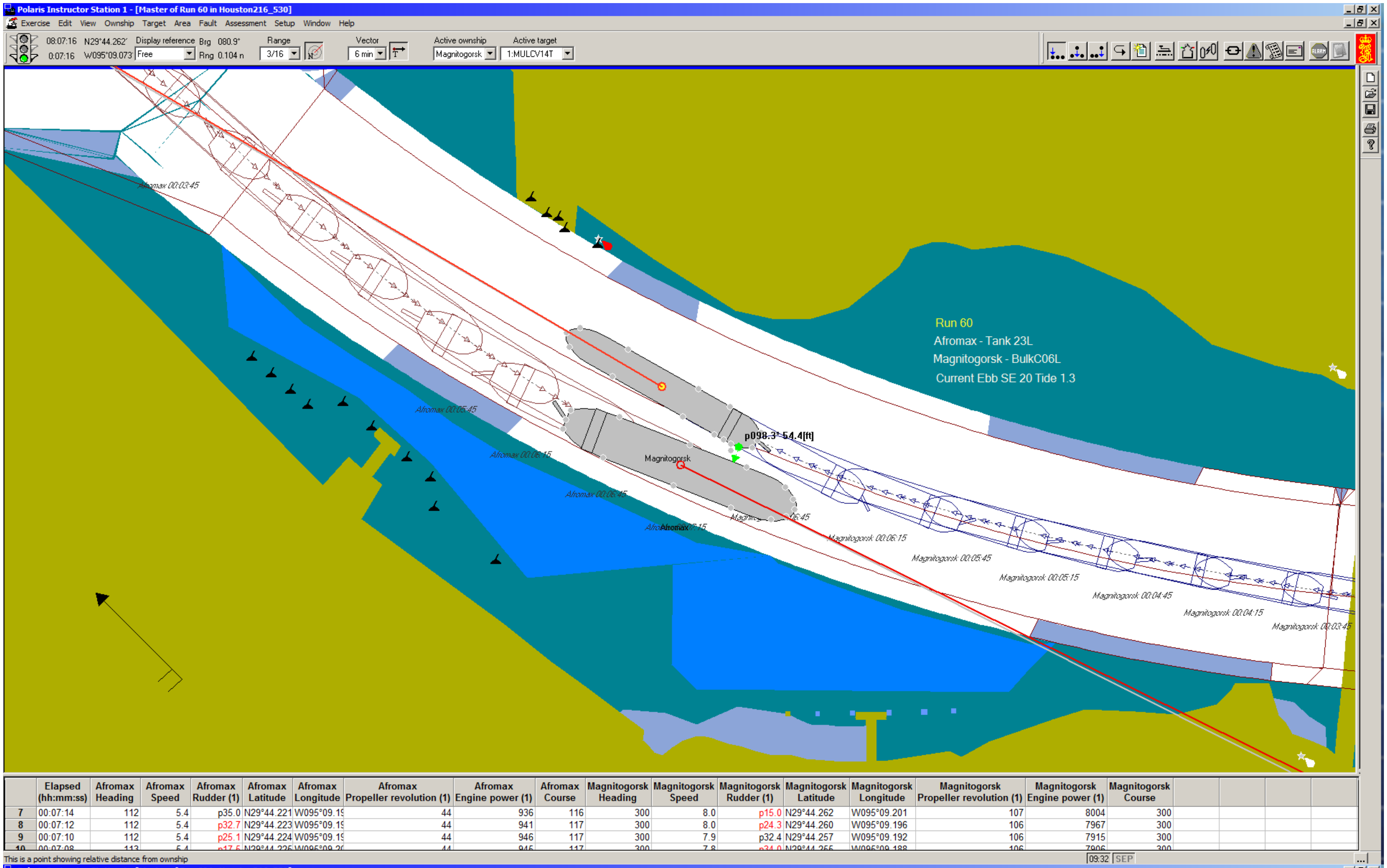
08:07:16 N29°44.262' Display reference Free Brg 080.9° Rng 0.104 n
0:07:16 W095°09.073'
Range 3/16
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 60
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:14	112	5.4	p35.0	N29°44.221	W095°09.19	44	936	116	300	8.0	p15.0	N29°44.262	W095°09.201	107	8004	300
8	00:07:12	112	5.4	p32.7	N29°44.223	W095°09.19	44	941	117	300	8.0	p24.3	N29°44.260	W095°09.196	106	7967	300
9	00:07:10	112	5.4	p25.1	N29°44.224	W095°09.19	44	946	117	300	7.9	p32.4	N29°44.257	W095°09.192	106	7915	300
10	00:07:08	113	5.4	p17.5	N29°44.225	W095°09.20	44	945	117	300	7.8	p34.0	N29°44.255	W095°09.188	106	7906	300

This is a point showing relative distance from ownship

June 26, 2019



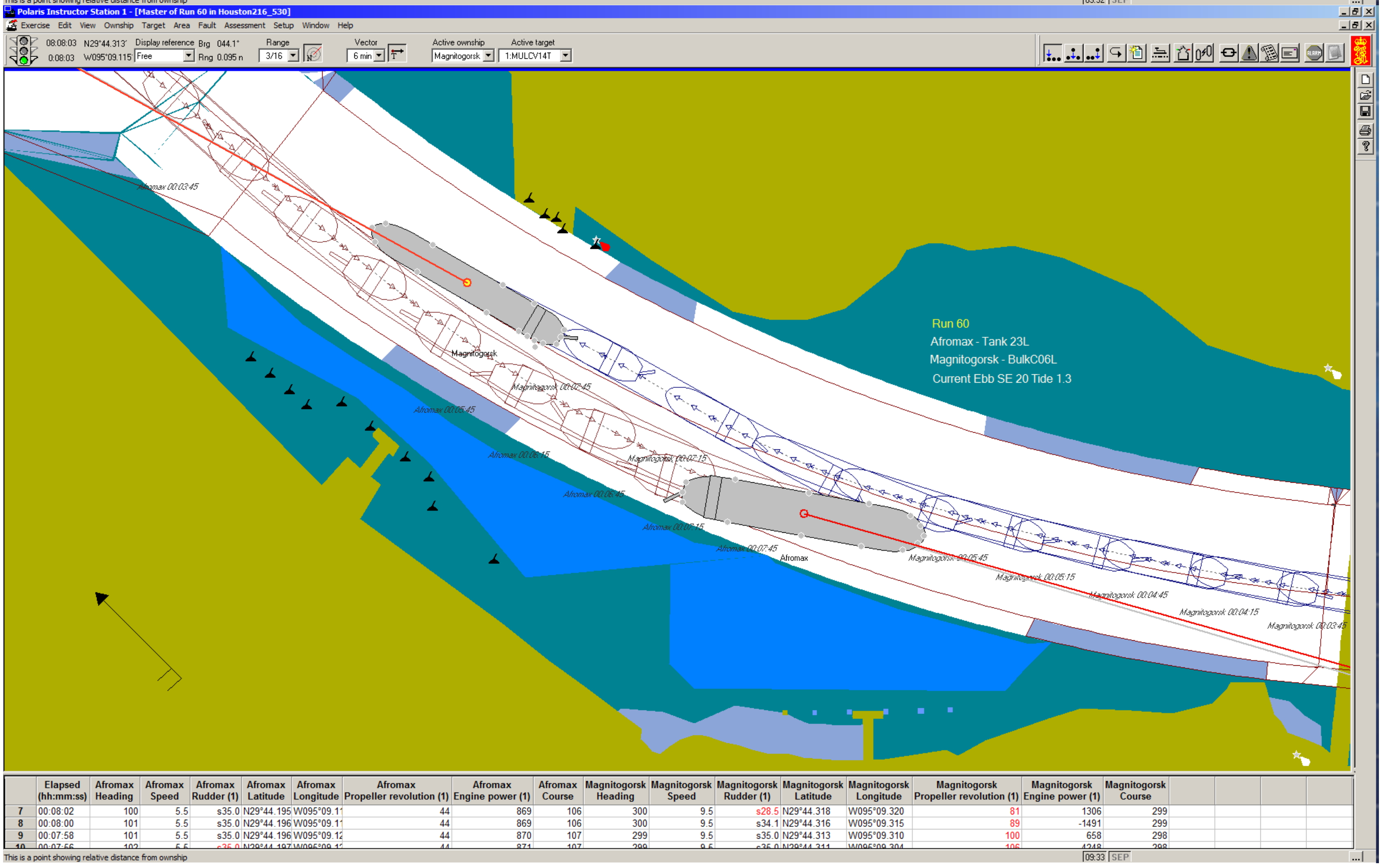
Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:07:16 N29°44.262′ Display reference: Free Brg 080.9°
0:07:16 W095°09.073′ Rng 0.104 n
Range: 3/16
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:07:14	112	5.4	p35.0	N29°44.221	W095°09.1	44	936	116	300	8.0	p15.0	N29°44.262	W095°09.201	107	8004	300
8	00:07:12	112	5.4	p32.7	N29°44.223	W095°09.1	44	941	117	300	8.0	p24.3	N29°44.260	W095°09.196	106	7967	300
9	00:07:10	112	5.4	p25.1	N29°44.224	W095°09.1	44	946	117	300	7.9	p32.4	N29°44.257	W095°09.192	106	7915	300

This is a point showing relative distance from ownship

09:32 SEP



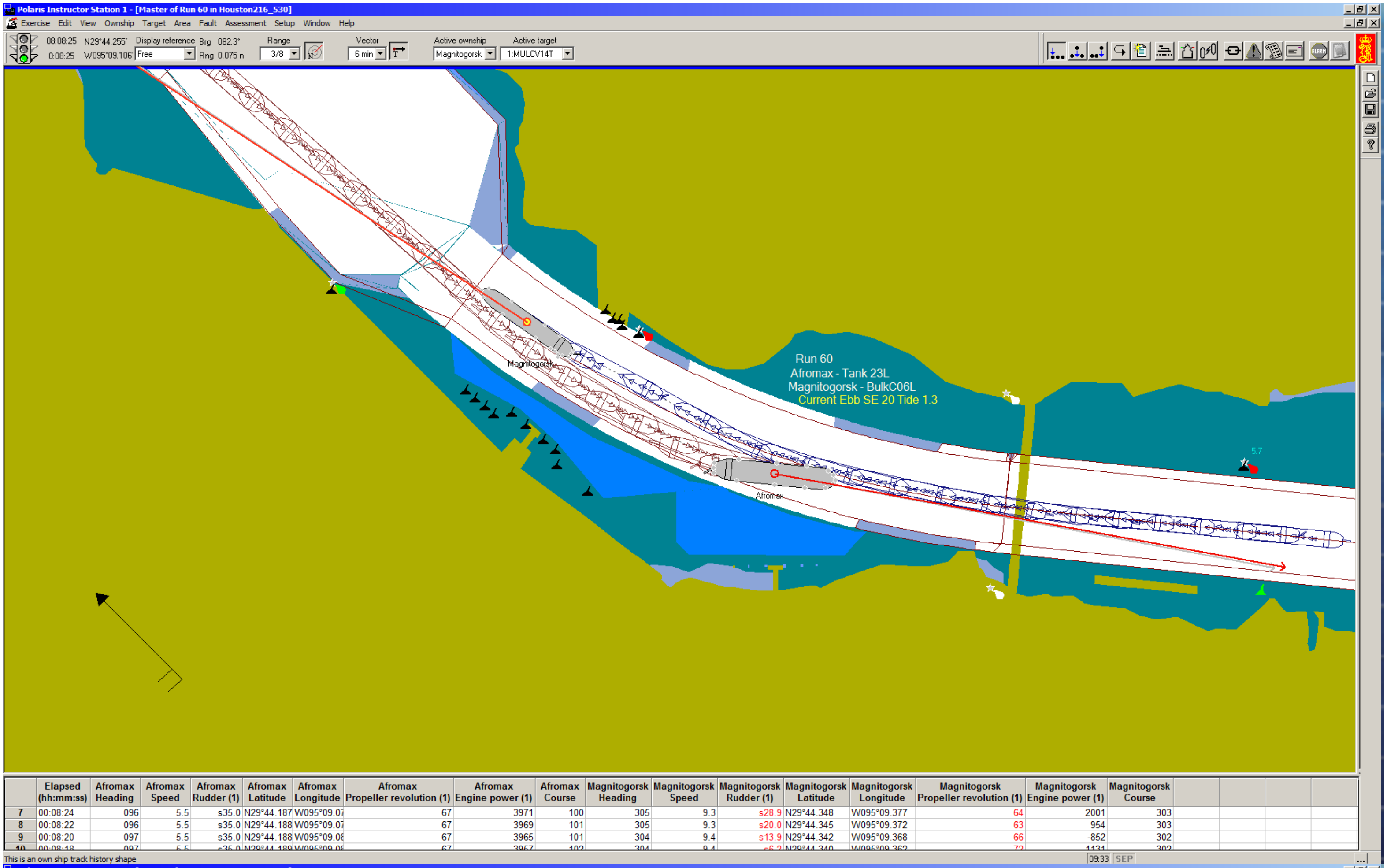
Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:08:03 N29°44.313′ Display reference: Free Brg 044.1°
0:08:03 W095°09.115′ Rng 0.095 n
Range: 3/16
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:08:02	100	5.5	s35.0	N29°44.195	W095°09.1	44	869	106	300	9.5	s28.5	N29°44.318	W095°09.320	81	1306	299
8	00:08:00	101	5.5	s35.0	N29°44.196	W095°09.1	44	869	106	300	9.5	s34.1	N29°44.316	W095°09.315	89	-1491	299
9	00:07:58	101	5.5	s35.0	N29°44.196	W095°09.12	44	870	107	299	9.5	s35.0	N29°44.313	W095°09.310	100	658	298

This is a point showing relative distance from ownship

09:33 SEP



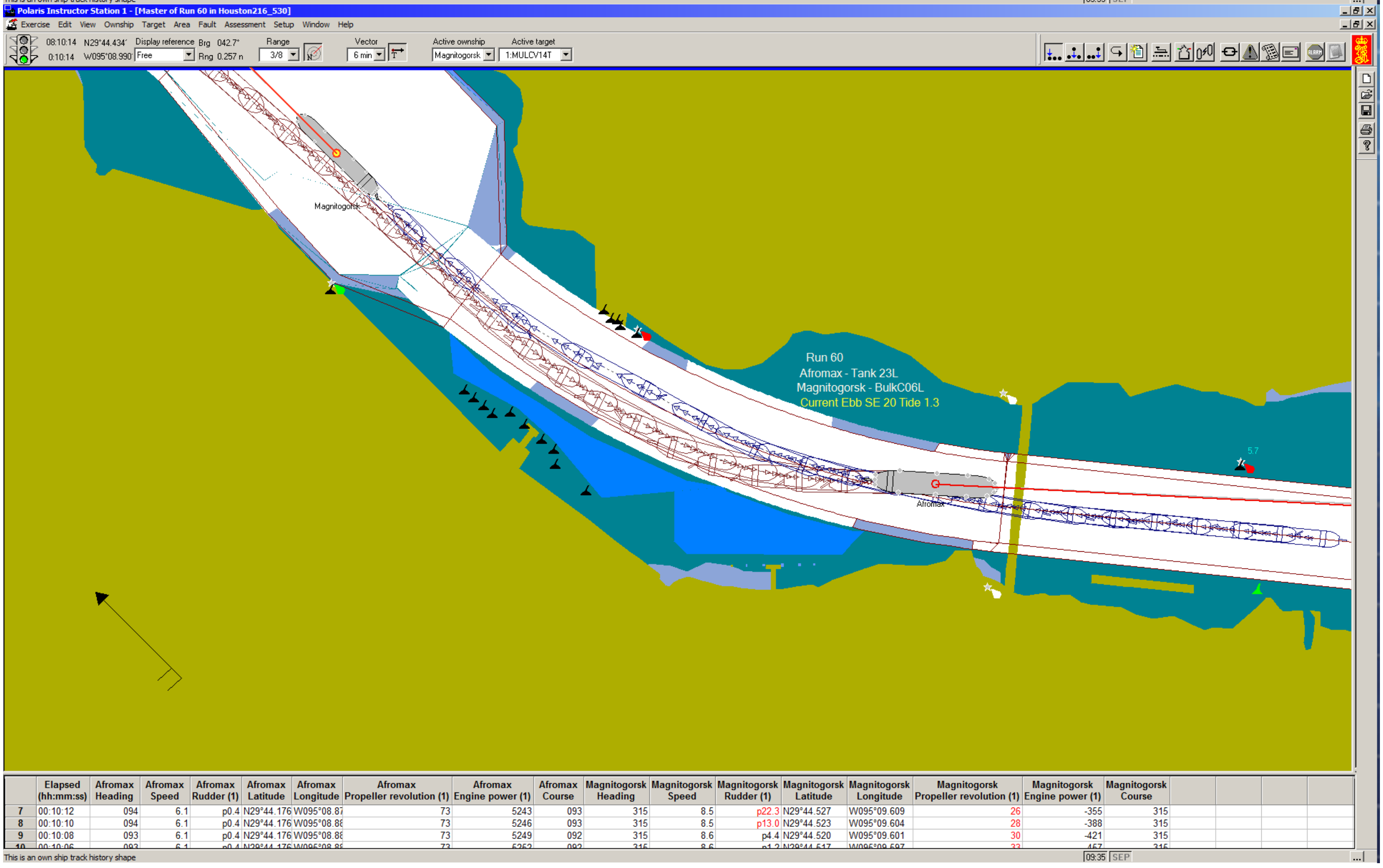
08:08:25 N29°44.255′ Display reference: Free Brg 082.3°
0:08:25 W095°09.106′ Rng 0.075 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 60
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:08:24	096	5.5	s35.0	N29°44.187	W095°09.07	67	3971	100	305	9.3	s28.9	N29°44.348	W095°09.377	64	2001	303
8	00:08:22	096	5.5	s35.0	N29°44.188	W095°09.07	67	3969	101	305	9.3	s20.0	N29°44.345	W095°09.372	63	954	303
9	00:08:20	097	5.5	s35.0	N29°44.188	W095°09.08	67	3965	101	304	9.4	s13.9	N29°44.342	W095°09.368	66	-852	302

This is an own ship track history shape

09:33 SEP



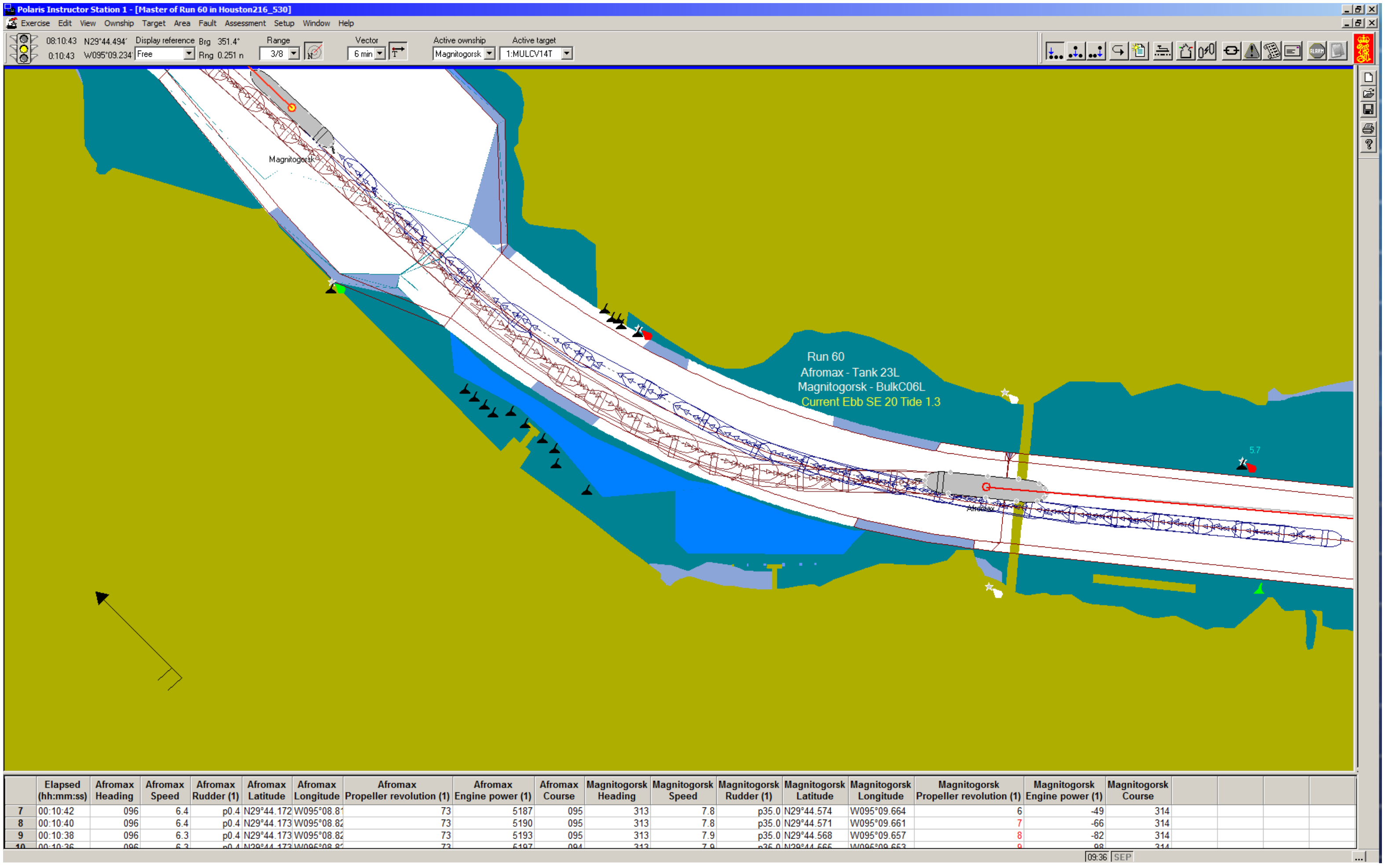
08:10:14 N29°44.434′ Display reference: Free Brg 042.7°
0:10:14 W095°08.990′ Rng 0.257 n
Range: 3/8
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 60
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:10:12	094	6.1	p0.4	N29°44.176	W095°08.87	73	5243	093	315	8.5	p22.3	N29°44.527	W095°09.609	26	-355	315
8	00:10:10	094	6.1	p0.4	N29°44.176	W095°08.88	73	5246	093	315	8.5	p13.0	N29°44.523	W095°09.604	28	-388	315
9	00:10:08	093	6.1	p0.4	N29°44.176	W095°08.88	73	5249	092	315	8.6	p4.4	N29°44.520	W095°09.601	30	-421	315

This is an own ship track history shape

09:35 SEP



Polaris Instructor Station 1 - [Master of Run 60 in Houston216_530]

08:10:43 N29°44.494′ Display reference Free Brg 351.4° Range 3/8 Vector 6 min Active ownship Magnitogorsk Active target 1:MULCV14T

0:10:43 W095°09.234′ Rng 0.251 n

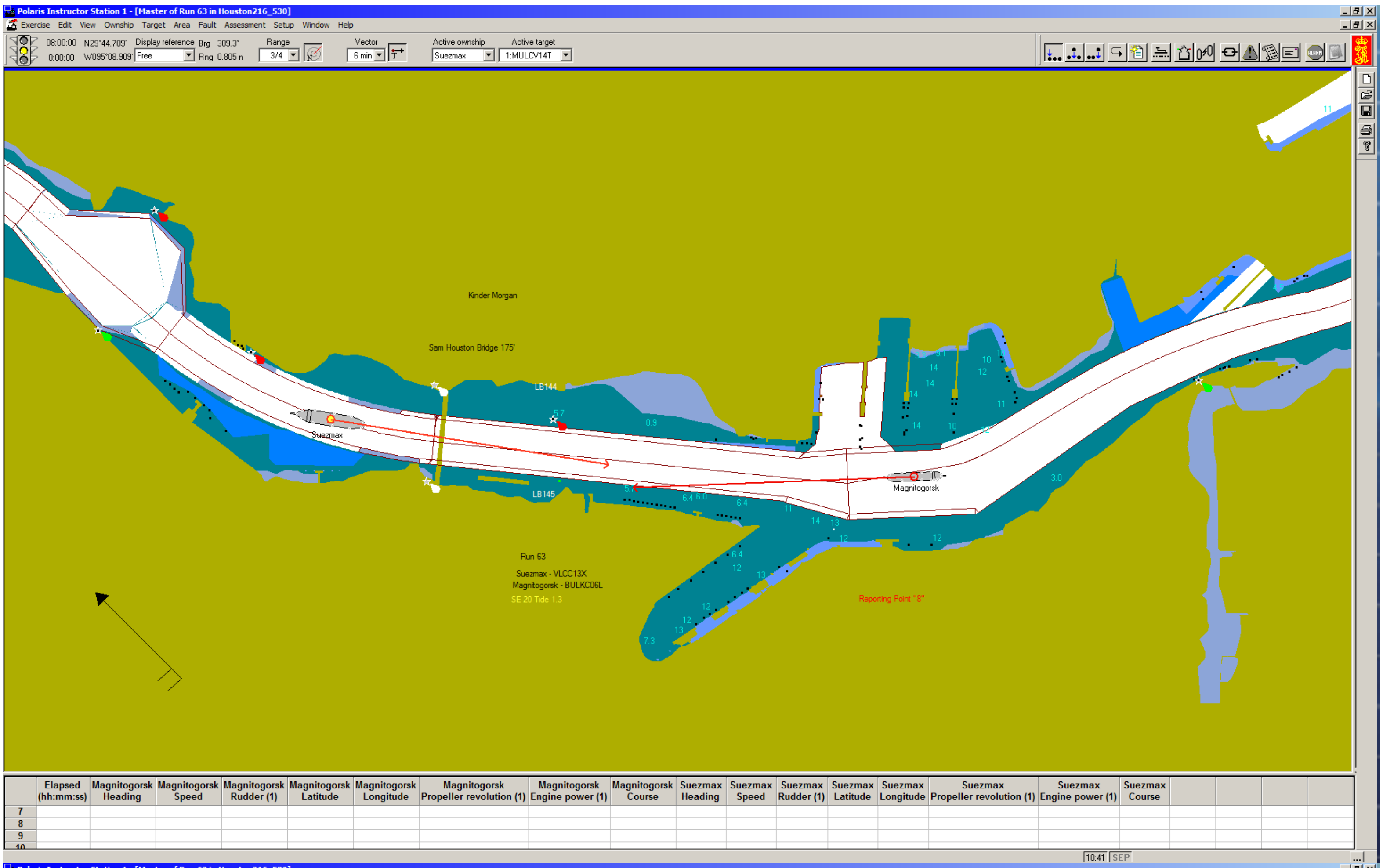
Run 60
Afromax - Tank 23L
Magnitogorsk - BulkC06L
Current Ebb SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Afromax Heading	Afromax Speed	Afromax Rudder (1)	Afromax Latitude	Afromax Longitude	Afromax Propeller revolution (1)	Afromax Engine power (1)	Afromax Course	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course
7	00:10:42	096	6.4	p0.4	N29°44.172	W095°08.81	73	5187	095	313	7.8	p35.0	N29°44.574	W095°09.664	6	-49	314
8	00:10:40	096	6.4	p0.4	N29°44.173	W095°08.82	73	5190	095	313	7.8	p35.0	N29°44.571	W095°09.661	7	-66	314
9	00:10:38	096	6.3	p0.4	N29°44.173	W095°08.82	73	5193	095	313	7.9	p35.0	N29°44.568	W095°09.657	8	-82	314
10	00:10:36	096	6.3	p0.4	N29°44.173	W095°08.82	73	5197	094	313	7.9	p35.0	N29°44.565	W095°09.653	9	98	314

09:36 SEP

June 26, 2019

Run 63

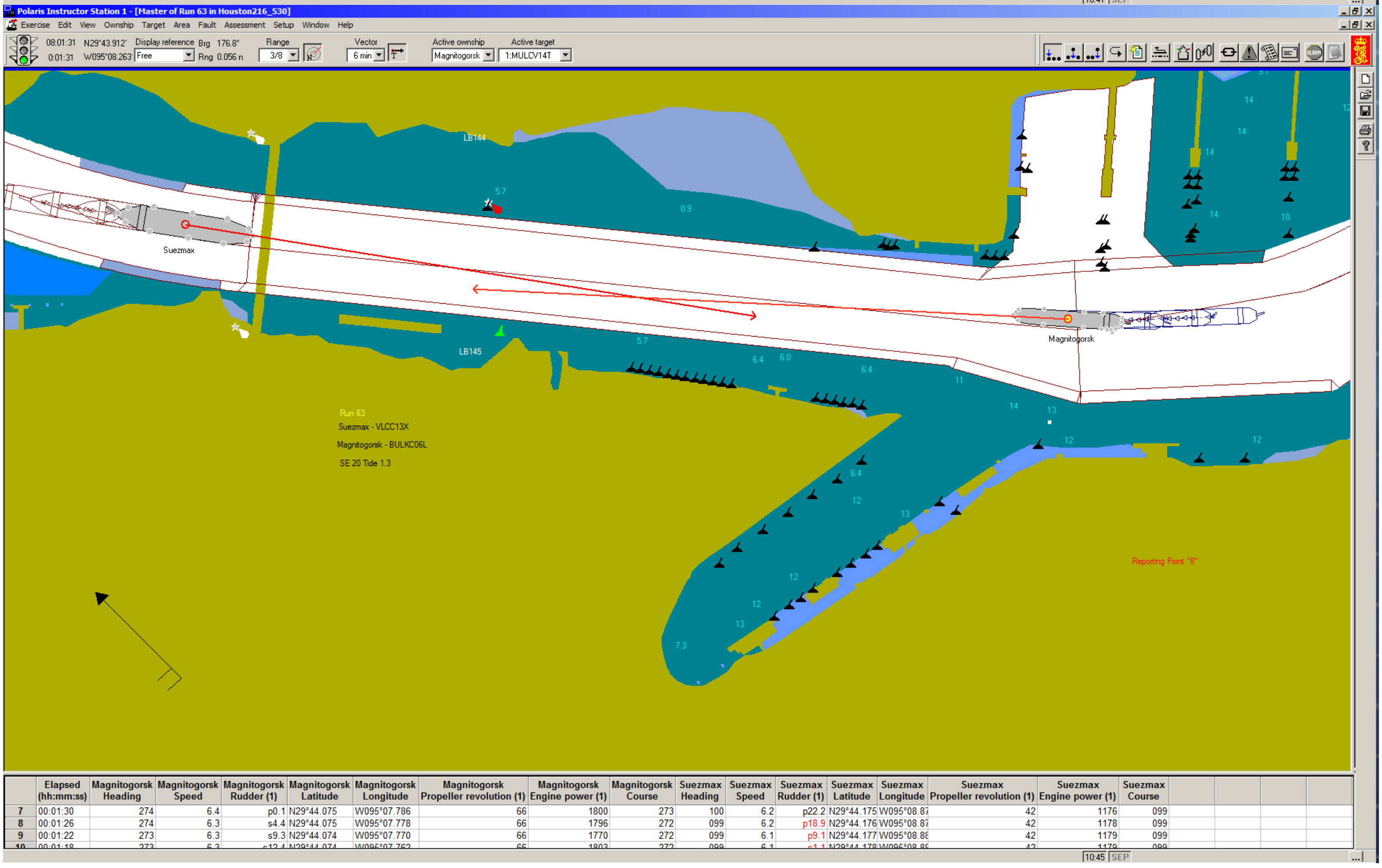


08:00:00 N29°44.709' Display reference Free Brg 309.3° Rng 0.805 n
0:00:00 W095°08.909'
Range 3/4
Vector 6 min
Active ownship Suezmax
Active target 1:MULCV14T

Run 63
Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7																	
8																	
9																	

10:41 SEP



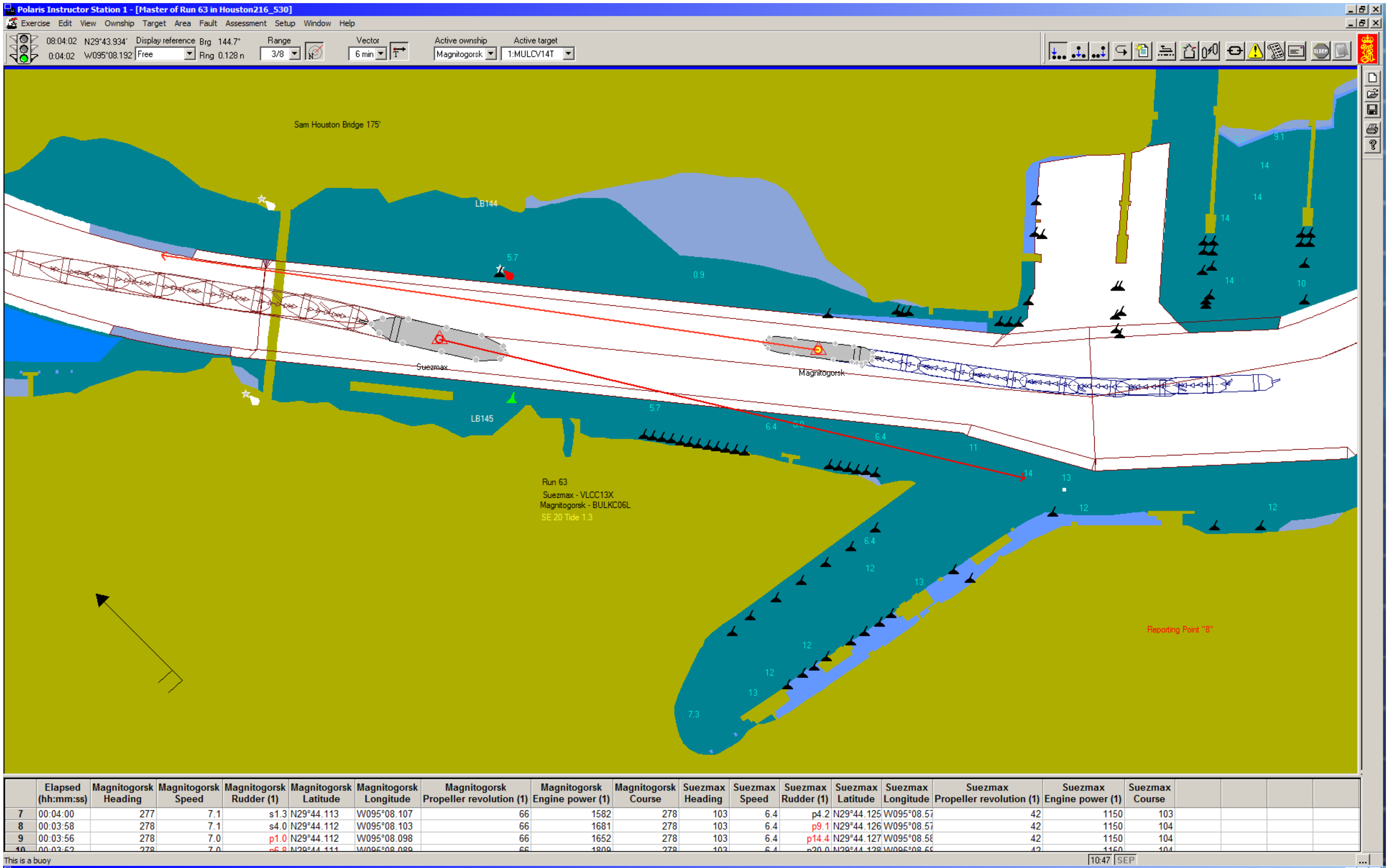
08:01:31 N29°43.912' Display reference Free Brg 176.8° Rng 0.056 n
0:01:31 W095°08.263'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

Run 63
Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:01:30	274	6.4	p0.1	N29°44.075	W095°07.786	66	1800	273	100	6.2	p22.2	N29°44.175	W095°08.87	42	1176	099
8	00:01:26	274	6.3	s4.4	N29°44.075	W095°07.778	66	1796	272	099	6.2	p18.9	N29°44.176	W095°08.87	42	1178	099
9	00:01:22	273	6.3	s9.3	N29°44.074	W095°07.770	66	1770	272	099	6.1	p9.1	N29°44.177	W095°08.88	42	1179	099
10	00:01:18	273	6.3	s12.4	N29°44.074	W095°07.762	66	1803	272	099	6.1	s1.1	N29°44.178	W095°08.89	42	1179	099

10:45 SEP

June 26, 2019

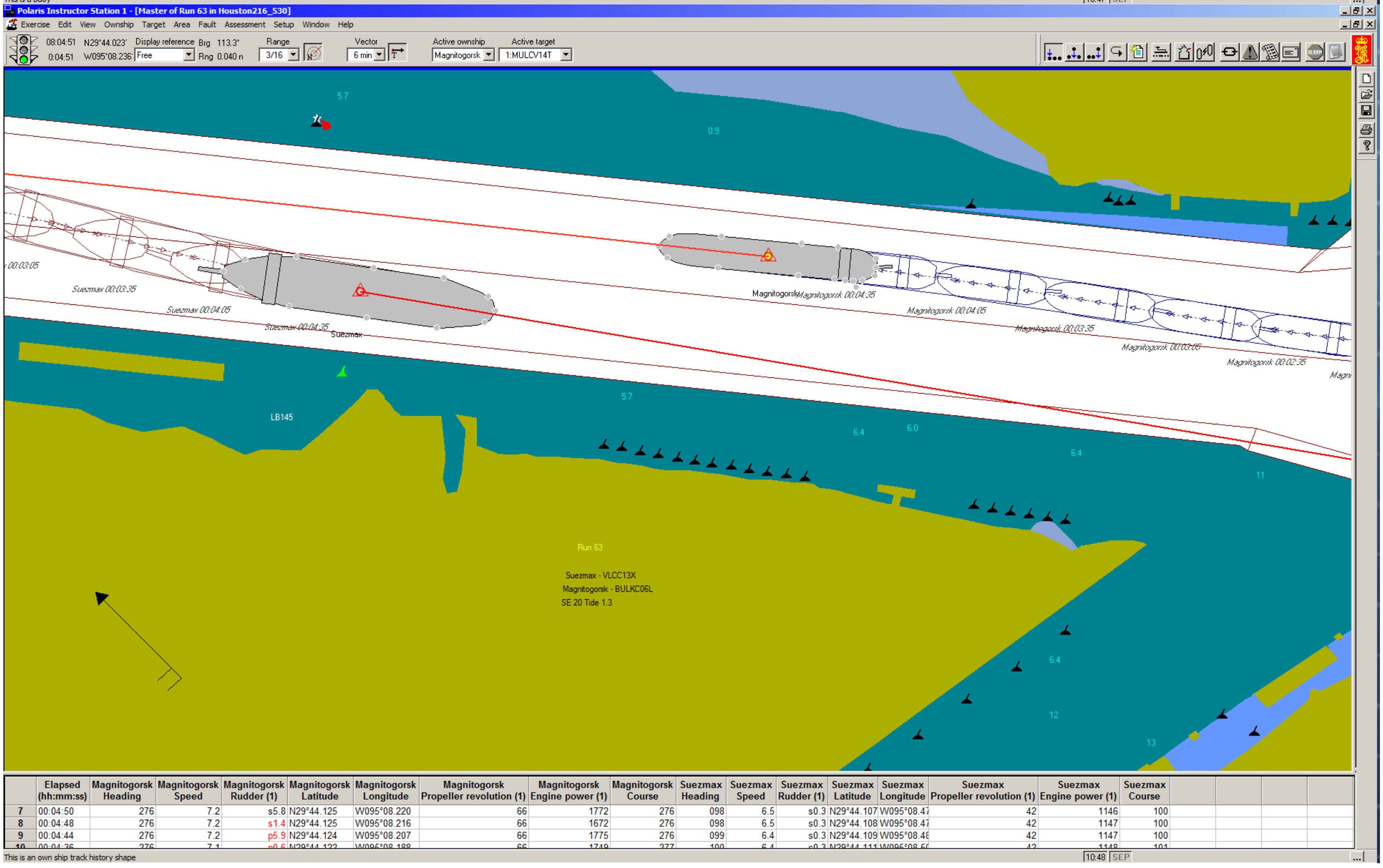


08:04:02 N29°43.934' Display reference Free Brg 144.7° Rng 0.128 n Range 3/8 Vector 6 min Active ownship Magnitogorsk Active target 1:MULCV14T
0:04:02 W095°08.192'

Run 63
Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:04:00	277	7.1	s1.3	N29°44.113	W095°08.107	66	1582	278	103	6.4	p4.2	N29°44.125	W095°08.57	42	1150	103
8	00:03:58	278	7.1	s4.0	N29°44.112	W095°08.103	66	1681	278	103	6.4	p9.1	N29°44.126	W095°08.57	42	1150	104
9	00:03:56	278	7.0	p1.0	N29°44.112	W095°08.098	66	1652	278	103	6.4	p14.4	N29°44.127	W095°08.58	42	1150	104
10	00:03:52	278	7.0	p6.8	N29°44.111	W095°08.089	66	1809	278	103	6.4	p20.0	N29°44.128	W095°08.59	42	1150	104

This is a buoy 10:47 SEP



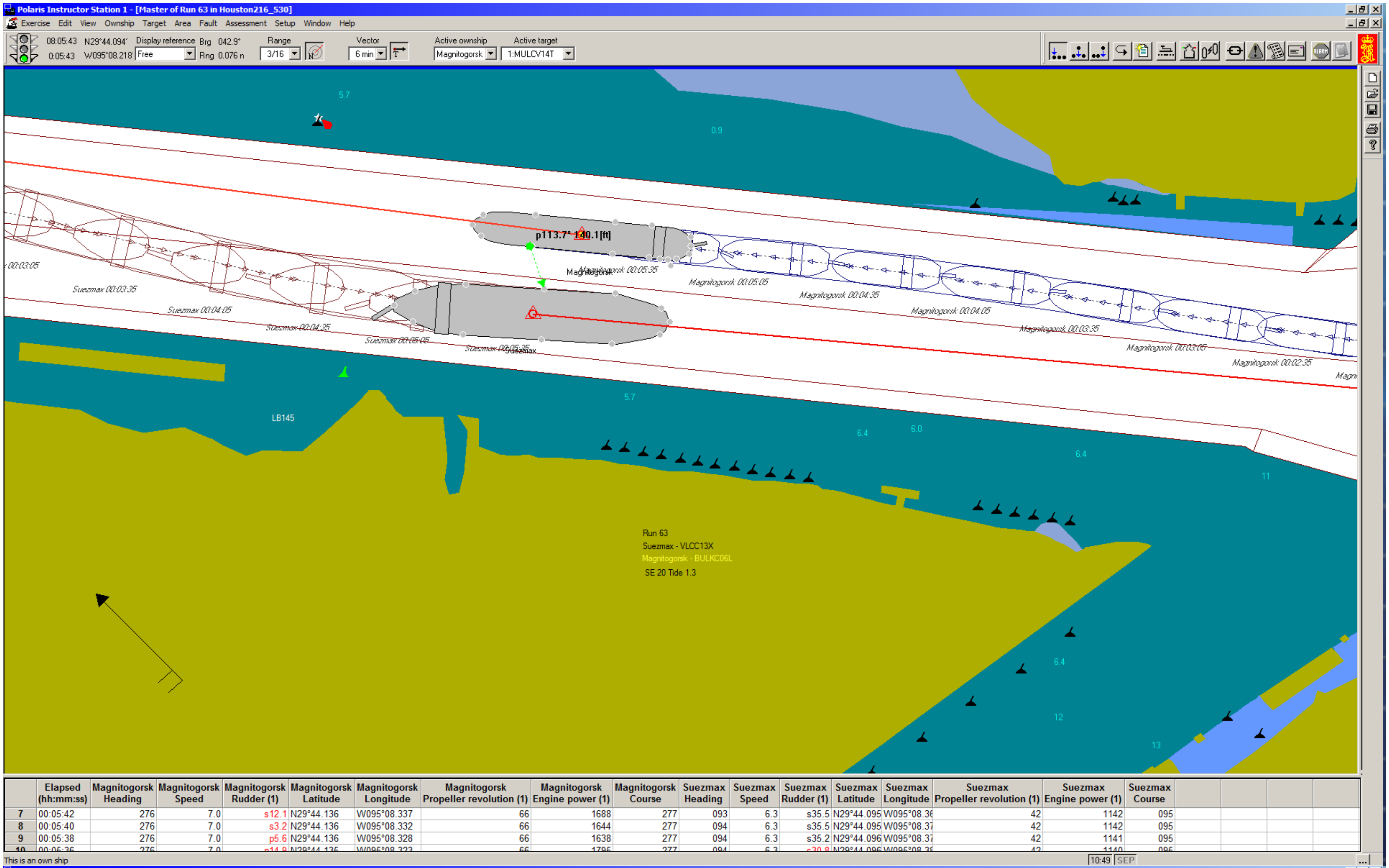
08:04:51 N29°44.023' Display reference Free Brg 113.3° Rng 0.040 n Range 3/16 Vector 6 min Active ownship Magnitogorsk Active target 1:MULCV14T
0:04:51 W095°08.236'

Run 63

Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:04:50	276	7.2	s5.8	N29°44.125	W095°08.220	66	1772	276	098	6.5	s0.3	N29°44.107	W095°08.47	42	1146	100
8	00:04:48	276	7.2	s1.4	N29°44.125	W095°08.216	66	1672	276	098	6.5	s0.3	N29°44.108	W095°08.47	42	1147	100
9	00:04:44	276	7.2	p5.9	N29°44.124	W095°08.207	66	1775	276	099	6.4	s0.3	N29°44.109	W095°08.48	42	1147	100
10	00:04:36	276	7.1	p0.6	N29°44.122	W095°08.188	66	1749	277	100	6.4	s0.3	N29°44.111	W095°08.50	42	1148	101

This is an own ship track history shape 10:48 SEP



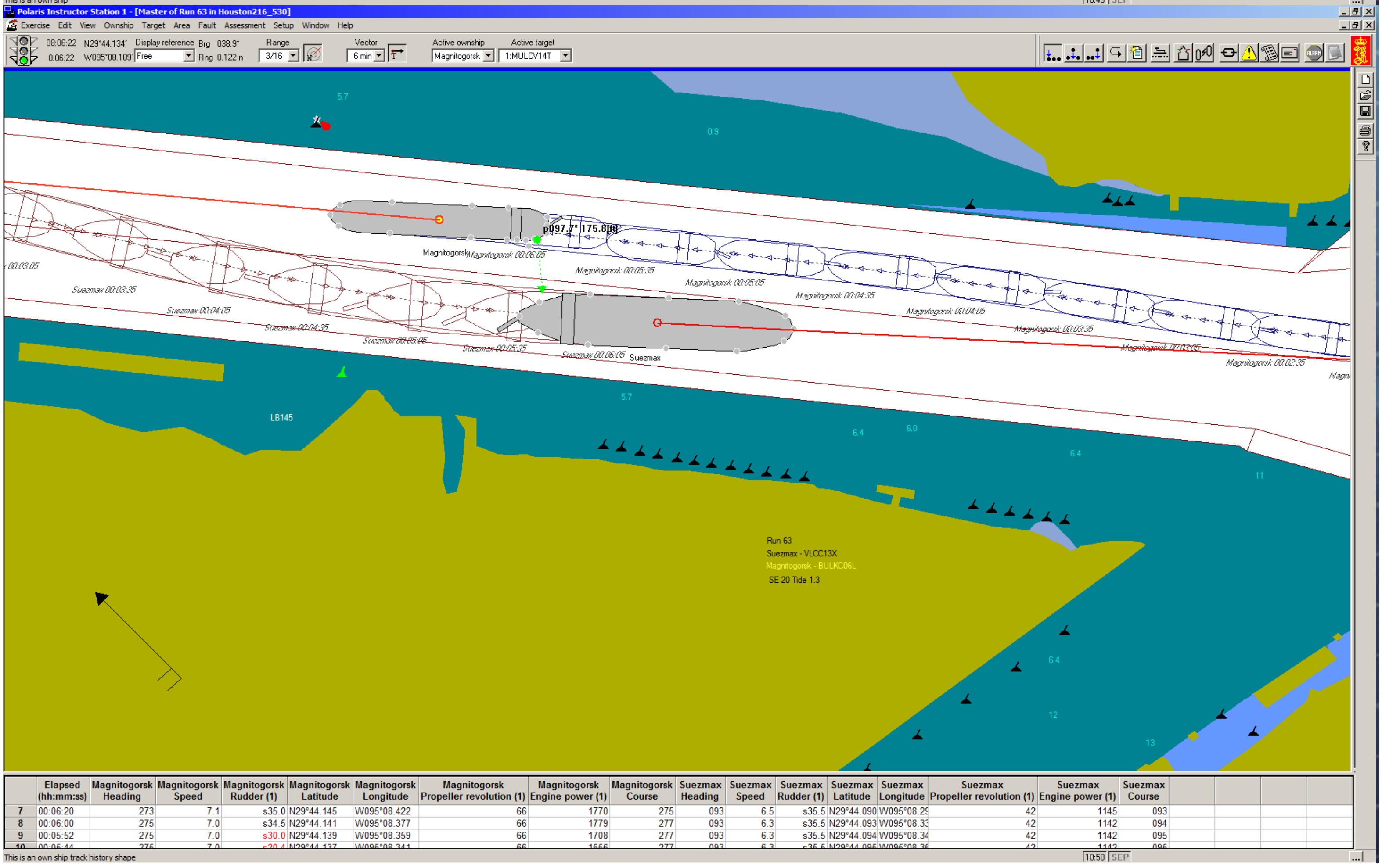
08:05:43 N29°44.094' Display reference: Free Brg 042.9°
0:05:43 W095°08.218' Rng 0.076 n
Range: 3/16
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 63
Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:05:42	276	7.0	s12.1	N29°44.136	W095°08.337	66	1688	277	093	6.3	s35.5	N29°44.095	W095°08.36	42	1142	095
8	00:05:40	276	7.0	s3.2	N29°44.136	W095°08.332	66	1644	277	094	6.3	s35.5	N29°44.095	W095°08.37	42	1142	095
9	00:05:38	276	7.0	p5.6	N29°44.136	W095°08.328	66	1638	277	094	6.3	s35.2	N29°44.096	W095°08.37	42	1141	095
10	00:05:36	276	7.0	p14.9	N29°44.135	W095°08.323	66	1795	277	094	6.3	s30.8	N29°44.096	W095°08.3	42	1140	095

This is an own ship

10:49 SEP



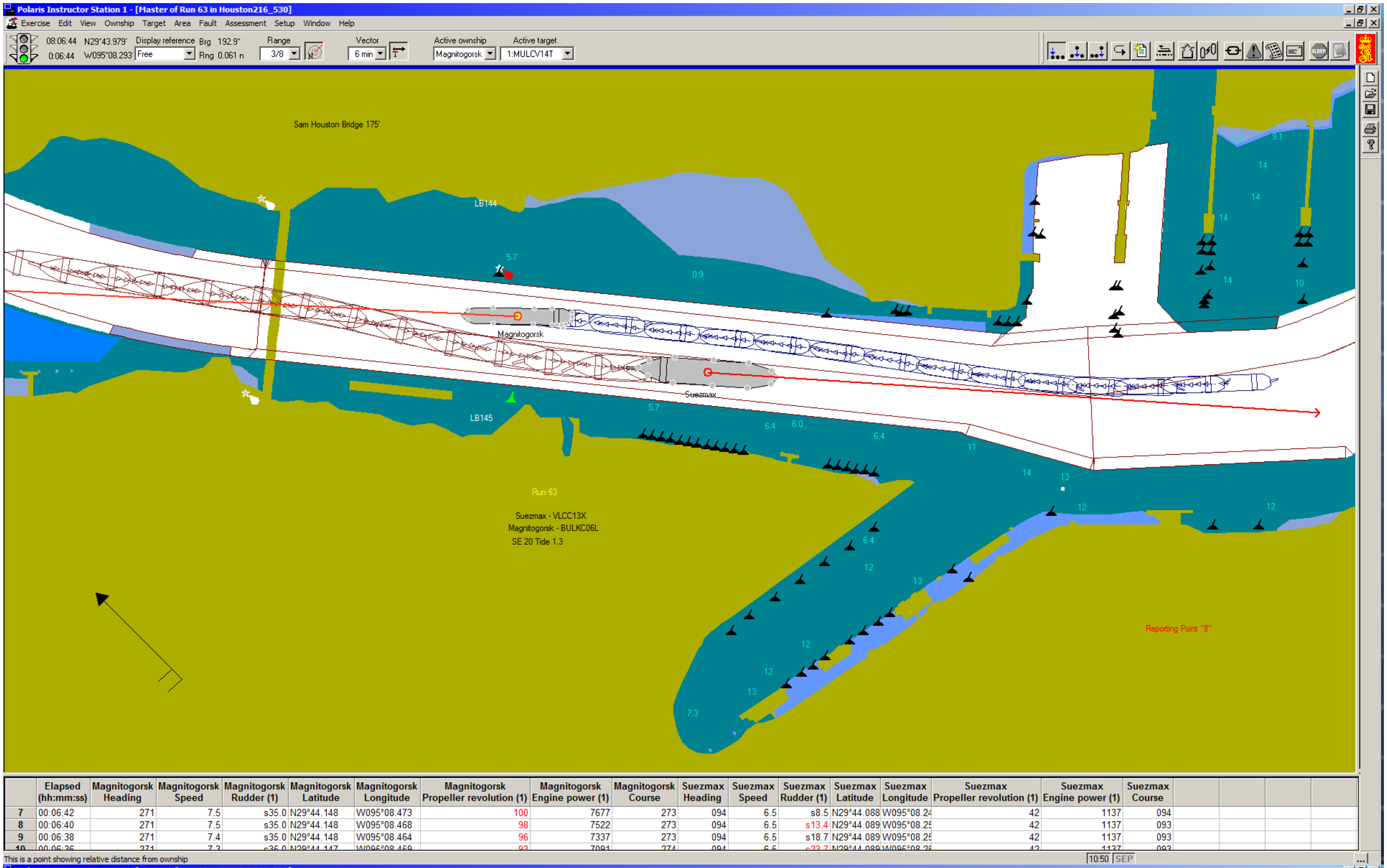
08:06:22 N29°44.134' Display reference: Free Brg 038.9°
0:06:22 W095°08.189' Rng 0.122 n
Range: 3/16
Vector: 6 min
Active ownship: Magnitogorsk
Active target: 1:MULCV14T

Run 63
Suezmax - VLCC13X
Magnitogorsk - BULKC06L
SE 20 Tide 1.3

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:20	273	7.1	s35.0	N29°44.145	W095°08.422	66	1770	275	093	6.5	s35.5	N29°44.090	W095°08.29	42	1145	093
8	00:06:00	275	7.0	s34.5	N29°44.141	W095°08.377	66	1779	277	093	6.3	s35.5	N29°44.093	W095°08.33	42	1142	094
9	00:05:52	275	7.0	s30.0	N29°44.139	W095°08.359	66	1708	277	093	6.3	s35.5	N29°44.094	W095°08.34	42	1142	095
10	00:05:44	275	7.0	s20.4	N29°44.137	W095°08.341	66	1656	277	093	6.3	s35.5	N29°44.095	W095°08.36	42	1142	095

This is an own ship track history shape

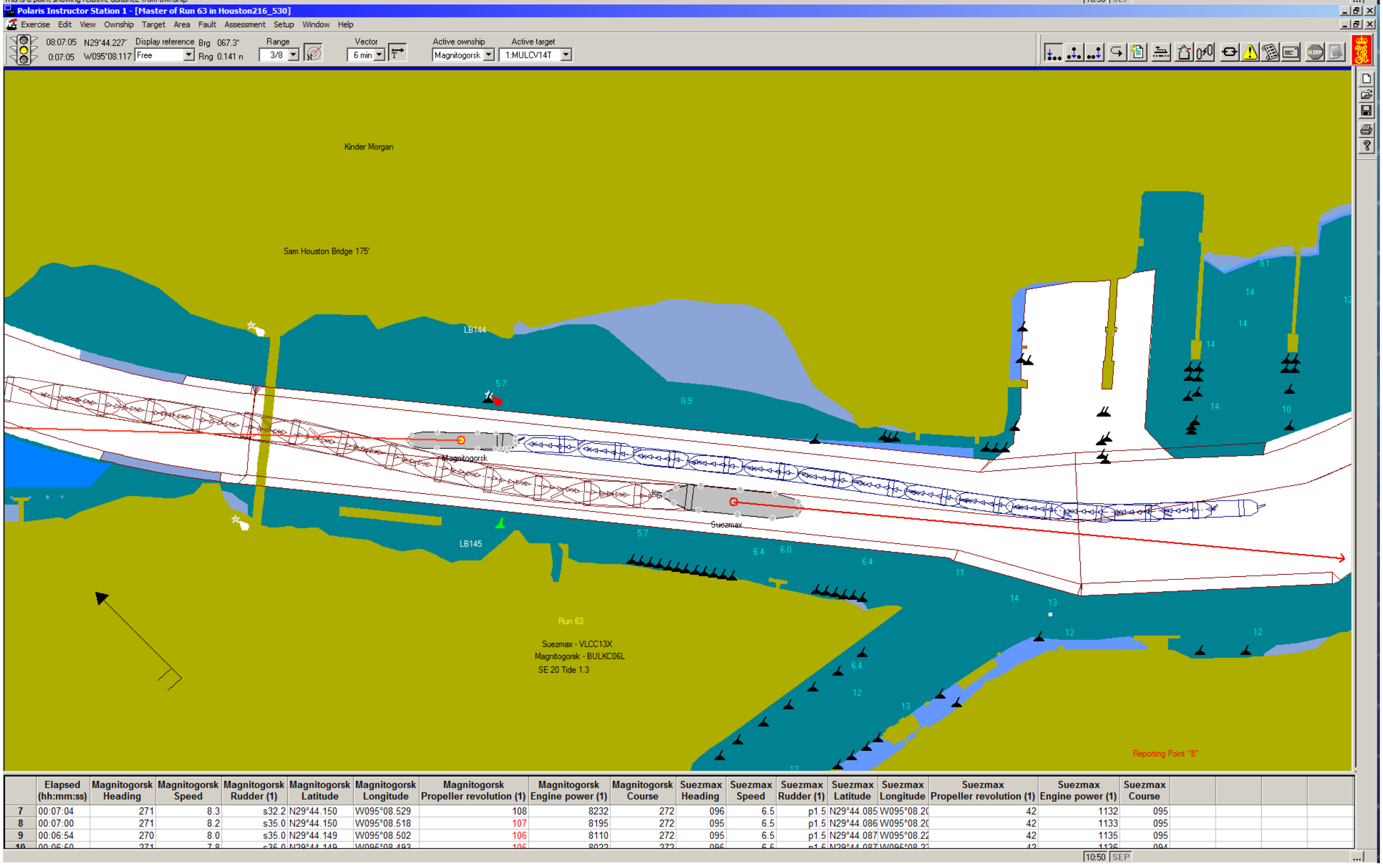
10:50 SEP



08:06:44 N29°43.979' Display reference Free Brg 192.9° Rng 0.061 n
0:06:44 W095°08.293'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:06:42	271	7.5	s35.0	N29°44.148	W095°08.473	100	7677	273	094	6.5	s8.5	N29°44.088	W095°08.24	42	1137	094
8	00:06:40	271	7.5	s35.0	N29°44.148	W095°08.468	98	7522	273	094	6.5	s13.4	N29°44.089	W095°08.25	42	1137	093
9	00:06:38	271	7.4	s35.0	N29°44.148	W095°08.464	96	7337	273	094	6.5	s18.7	N29°44.089	W095°08.25	42	1137	093

This is a point showing relative distance from ownship



08:07:05 N29°44.227' Display reference Free Brg 067.3° Rng 0.141 n
0:07:05 W095°08.117'
Range 3/8
Vector 6 min
Active ownship Magnitogorsk
Active target 1:MULCV14T

	Elapsed (hh:mm:ss)	Magnitogorsk Heading	Magnitogorsk Speed	Magnitogorsk Rudder (1)	Magnitogorsk Latitude	Magnitogorsk Longitude	Magnitogorsk Propeller revolution (1)	Magnitogorsk Engine power (1)	Magnitogorsk Course	Suezmax Heading	Suezmax Speed	Suezmax Rudder (1)	Suezmax Latitude	Suezmax Longitude	Suezmax Propeller revolution (1)	Suezmax Engine power (1)	Suezmax Course
7	00:07:04	271	8.3	s32.2	N29°44.150	W095°08.529	108	8232	272	096	6.5	p1.5	N29°44.085	W095°08.20	42	1132	095
8	00:07:00	271	8.2	s35.0	N29°44.150	W095°08.518	107	8195	272	095	6.5	p1.5	N29°44.086	W095°08.20	42	1133	095
9	00:06:54	270	8.0	s35.0	N29°44.149	W095°08.502	106	8110	272	095	6.5	p1.5	N29°44.087	W095°08.22	42	1135	095

ATTACHMENT 6

SLOPE STABILITY ANALYSIS FOR BSC AND BCC

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GEOTECHNICAL STUDY
HSC-ECIP Preliminary Slope Evaluation
Barbours Cut and Bayport Channels
Galveston Bay, Texas

SUBMITTED TO

Turner, Collie, and Braden/GBA Joint Venture

c/o Gahagan & Bryant Associates, Inc.

9330 Kirby Drive, Suite 100

Houston, Texas 77054

BY

HVJ ASSOCIATES, INC.

HOUSTON, TEXAS

AUGUST 14, 2018

REPORT NO. HG1710448

HVJ ASSOCIATES

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August 14, 2018

Ms. Dana Cheney
Turner, Collie, and Braden/GBA Joint Venture
c/o Gahagan & Bryant Associates, Inc.
9330 Kirby Drive, Suite 100
Houston, TX 77054

Re: Geotechnical Study
HSC-ECIP Preliminary Slope Evaluation
Barbours Cut and Bayport Channels
Owner: Port of Houston Authority
HVJ Report No. HG1710448

Dear Ms. Cheney:

Submitted herein is the report of our geotechnical study for the above referenced project. This report presents the stability analysis of the proposed channel slopes for the widening of Barbours Cut and Bayport channels. The study was conducted in general accordance with our proposal number HG1710448 dated November 16, 2017 and is subject to the limitations presented in this report. We appreciate the opportunity of working with you on this project. Please read the entire report and notify us if there are questions concerning this report or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.
Firm License No. F-646

MICHAEL HASEN
57498

Michael Hasen, PE
Executive Vice President

Anil K. Raavi, PE
Project Manager

MH/AR:ar

Copies submitted: 1 (electronic)

The seal appearing on this document was authorized by Michael Hasen, PE 57498 on August 14, 2018. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

The following lists the pages which complete this report:

- Main Text – 14 pages
- Plates – 10 pages
- Appendix A – 123 pages
- Appendix B – 224 pages
- Appendix C – 135 pages

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LIST OF TABLES

ILLUSTRATIONS

APPENDICES

1 EXECUTIVE SUMMARY

HVJ Associates, Inc. was retained by Turner, Collie, and Braden/GBA Joint Venture (TCB/GBA) to perform slope stability analysis for the widening of Barbours Cut Channel (BCC) and Bayport Ship Channel (BSC). Both channels will be widened to a final base width of about 455 feet by extending the base width by 55 to 155 feet to the north of the current channel centerline. The overall channel bottom elevation will remain at El. -50.5 feet MLLW. The purpose of this study is to assess the stability of the proposed channel slopes based on the existing soil data from our previous studies.

Geotechnical exploration was performed previously along the north shoreline of BSC for the deepening and widening of the ship channel to a total base width of 350 to 400 feet. A similar study was performed along the north shoreline of BCC to support the deepening and widening of BCC to a base width of 300 feet. We submitted reports previously that present our assessment of the soil shear strength characteristics and our recommendations for the proposed improvements at that time. The soil properties used in the current analysis are based on our previous exploration reports. For a detailed discussion of the geotechnical data please see reports HVJ Report No. HG1010561 dated October 17, 2013 for BCC and HVJ Report No. HG1019742 dated May 2, 2013 for BSC.

Slope stability analyses were performed for the long term (LT), rapid drawdown (RDD) and short term (ST) conditions. The following assumptions and design considerations were used in the analyses.

a. **Barbours Cut Channel** – The proposed widening will shift the channel toe about 155 feet north towards the Spilman Island Placement Area. Based on the cross sections provided to us and the soils information obtained from subsurface investigation conducted for the previous studies, we have analyzed the slope stability at sections 34+00, 44+00, 56+00, and 64+00. These cross sections were chosen to be representative of the slope configuration and soil conditions along the proposed project.

   The new shoreline will be immediately adjacent to the Spilman Island dike and increase in the dike height in future will impact the stability of the channel slope. In order to account for the future storage capacity increase at Spilman Island Placement Area, we assumed future dike raising to a crest elevation of +45.14 feet MLLW with 2 feet freeboard and 2 feet ponding depth in the interior for long term and rapid drawdown conditions. We assumed that the future dike will have 15 feet crown width with 3H:1V side slopes.

b. **Bayport Ship Channel** – The proposed widening will be about 55 to 105 feet towards the north (away from container terminal). Based on the cross sections provided to us and the soils information obtained from subsurface investigation conducted for the previous studies, we have analyzed the slope stability at sections 40+00, 66+00, 76+00, 92+00, 98+00, 110+00, 166+00, and 186+00. In the area north of the turning basin, the 3H:1V bank slope from the proposed channel toe will result in the cut extending to the adjacent San Jacinto College building as shown in the cross sections. In order to provide proposed channel base width and to retain the existing building, a bulkhead is required at this location.

We analyzed several cross sections based on the historic soil data and proposed channel templates provided to us as shown on Plates 3 and 4. The global stability analysis results are summarized below:

Slope Stability Analyses Results – Proposed Template

Location	**Station**	**Factor of Safety**			
		Short Term		**Long Term (circular)**	**Rapid Drawdown (circular)**
		Circular	**Block**		
Barbours Cut Channel	34+00	1.47	1.56	**1.28***	1.32
	44+00	**1.24***	1.37	**1.26***	**1.24***
	56+00	**1.06***	**1.02***	1.50	1.49
	64+00	1.34	1.36	**1.43***	1.43
Bayport Ship Channel	40+00	1.56	1.53	1.56	1.42
	66+00	1.50	1.40	1.74	1.54
	76+00	2.47	2.37	1.89	1.62
	92+00	2.42	2.38	1.72	1.50
	98+00	2.51	2.45	1.77	1.49
	110+00	2.33	2.31	1.56	1.41
	166+00	3.85	3.83	2.09	2.09
	186+00	5.60	4.05	2.17	2.16

* Does not meet the minimum required.

According to US Army Corps of Engineers EM 1110-2-1902 Slope Stability, Chapter 3, Table 3-1, the recommended minimum factors of safety are 1.3, 1.5, and 1.3 for short term (end-of-construction), long term, and rapid drawdown conditions, respectively.

Barbours Cut Channel: The calculated factors of safety for the proposed 3H:1V slope does not meet the minimum required. We understand that a flatter channel slope from the proposed channel toe is not an option considering the reduction in the placement area capacity. In order to provide proposed channel base width while maintaining the Spilman Island placement area, a bulkhead is required along the entire length adjacent to Spilman Island. Based on our global stability analysis, the 3H:1V channel slope requires a bulkhead installed between Sta. 30+00 and Sta. 67+00 at an offset of about 530 feet from the existing centerline and embedded to El. -52 feet MLLW to achieve the required factors of safety. The results of our analyses including the proposed bulkhead are presented in Appendix C. The global stability analysis results are summarized in the following table.

Slope Stability Analyses Results with Bulkhead

Location	Station	Factor of Safety			
		Short Term		Long Term (circular)	Rapid Drawdown (circular)
		Circular	Block		
Barbours Cut Channel	34+00	1.85	2.04	1.53	1.64
	44+00	1.89	1.89	1.61	1.64
	56+00	1.64	1.89	1.51	1.49
	64+00	1.72	1.89	1.56	1.55

Note that the soil conditions of the Spilman Island dike are important to the analysis. We suggest additional borings be performed for final design.

Bayport Ship Channel: The calculated factor of safety exceeds the required minimum factor of safety at all sections we analyzed. However, installation of a bulkhead is required for the area north of the turning basin adjacent to the San Jacinto College building. Our analysis indicates that the bulkhead must be installed between about Sta. 35+00 and Sta. 43+50 at about 400 feet from the existing centerline embedded to an elevation of -40 feet MLLW to achieve the required factor of safety for global stability.

Bulkheads: For analyses purposes, we modeled the bulkheads as a high strength material. The bottom elevation of the bulkhead was adjusted to achieve the required factor of safety for global stability. The SLOPE/W program assumes the strength of bulkhead to be infinity, therefore, the slip surfaces passing through the bulkhead are considered very stable. A detailed analysis must be performed to assess the bulkhead against rotational and flexural failures. Rotational failures are caused due to inadequate penetration length and flexural failures are resulted by overstressing the retaining structure. An analysis of the bulkhead was beyond the scope of this study.

Please note that this executive summary does not fully relate our findings and opinions. Those findings and opinions are only presented through our full report.

2 INTRODUCTION

2.1 Project Description

HVJ Associates, Inc. was retained by TCB/GBA Joint Venture to perform slope stability analysis for the widening of two tributary channels of the Houston Ship Channel (HSC), Barbours Cut Channel (BCC) and Bayport Ship Channel (BSC). The BCC extends to the west from the main HSC approximately 1.5 miles to the Barbours Cut Turning Basin and the BSC extends west from the main HSC approximately 4 miles to the Bayport Turning Basin. Both channels will be widened to a final base width of about 455 feet by extending the base width by 55 to 155 feet to the north of the current channel centerline. The channel bottom elevation will remain at about El. -46.5 feet MLLW with an allowance of 2 feet for advance maintenance and an additional 2 feet of overdredge resulting in an overall bottom elevation of -50.5 feet MLLW. The purpose of this study is to assess the stability of the proposed channel slopes based on the existing soil data from our previous studies.

2.2 Geotechnical Study Program

Geotechnical exploration was performed previously along the north shoreline of BSC that consisted of drilling twelve 60-foot deep borings for the deepening and widening of the ship channel to a total base width of 350 to 400 feet. A similar study was performed along the north shoreline of BCC and twelve borings were performed to depths varying between 80 and 100 feet below the existing grade. The study was performed to support the widening and deepening of BCC for a base width of 300 feet. The borings were drilled at the approximate locations indicated on the Plan of Borings included in Plates 1 and 2 at BCC and BSC, respectively. The geotechnical data from these borings in conjunction with the historic soil borings were used to determine the subsurface conditions. We submitted reports previously that present our assessment of the soil shear strength characteristics and our recommendations for the proposed improvements at that time.

The soil properties used in the current analysis are based on our previous exploration reports. For a detailed discussion of the geotechnical data please see reports HVJ Report No. HG1010561 dated October 17, 2013 for BCC and HVJ Report No. HG1019742 dated May 2, 2013 for BSC.

3 PRELIMINARY SLOPE STABILITY ANALYSIS AND RECOMMENDATIONS

3.1 General

The proposed channel cross sections are shown on Plates 3 and 4. Slope stability analyses were performed for the long term (LT), rapid drawdown (RDD) and short term (ST) conditions. The following assumptions and design considerations were used in the analyses.

c. **Barbours Cut Channel** – The proposed widening will shift the channel toe about 155 feet north towards the Spilman Island Placement Area. Based on the cross sections provided to us and the soils information obtained from subsurface investigation conducted for the previous studies, we have analyzed the slope stability at sections 34+00, 44+00, 56+00, and 64+00. These cross sections were chosen to be representative of the slope configuration and soil conditions along the proposed project.

   The new shore line will be immediately adjacent to the Spilman Island dike and increase in the dike height in future will impact the stability of the channel slope. In order to account for the future storage capacity increase at Spilman Island Placement Area, we assumed future dike raising to a crest elevation of +45.14 feet MLLW with 2 feet freeboard and 2 feet ponding depth in the interior for long term and rapid drawdown conditions. We assumed that the future dike will have 15 feet crown width with 3H:1V side slopes.

d. **Bayport Ship Channel** – The proposed widening will be about 55 to 105 feet towards the north (away from container terminal). Based on the cross sections provided to us and the soils information obtained from subsurface investigation conducted for the previous studies, we have analyzed the slope stability at sections 40+00, 66+00, 76+00, 92+00, 98+00, 110+00, 166+00, and 186+00. In the area north of the turning basin, the 3H:1V bank slope from the proposed channel toe will result in the cut extending to the adjacent San Jacinto College building as shown in the cross sections. In order to provide proposed channel base width and to retain the existing building, a bulkhead is required at this location.

3.2 Method of Analysis and Required Factor of Safety

Slope stability analyses were conducted using the 2012 version of slope stability program SLOPE/W by the Morgenstern-Price method for circular rotational failure and block failure. Block failure evaluates non-circular failure surfaces and is particularly helpful in evaluating the potential for translational failures. During block failure analysis we avoided analyses configured with slip surfaces that are inadmissible for the software (i.e. comprising too short of a horizontal section to avoid convergence errors). The program calculates the factor of safety against slope failure using a two-dimensional limiting equilibrium method.

According to US Army Corps of Engineers EM 1110-2-1902 Slope Stability, Chapter 3, Table 3-1, the recommended minimum factors of safety are 1.3, 1.5, and 1.3 for short term (end-of-construction), long term, and rapid drawdown conditions, respectively. The factor of safety represents the calculated resisting forces and moments divided by the calculated driving forces and moments of the various potential failure surfaces analyzed. These forces and moments are based on the estimated unit weights and shear strengths of the various soils in the slope profile. Accordingly, a factor of safety of 1.0 indicates impending failure. The larger the factor of safety is above 1.0, the lower the risk is that the slope will fail. As a practical matter, and in consideration of the variables and unknowns involved, the risk cannot be reduced to zero. The goal is to reduce the risk of slope failure to a reasonable and acceptable level, with due consideration of the consequences of failure.

3.3 Soil Parameters and Water Level

Based on the cross-sections provided to us and the soils information obtained from subsurface investigation conducted for the previous studies, we have analyzed the slope stability at the BCC centerline stations 34+00, 44+00, 56+00, 64+00 and at the BSC centerline stations 40+00, 66+00, 76+00, 92+00, 98+00, 110+00, 166+00, 186+00.

The soil parameters were determined based on the stratigraphy and material properties determined from borings located in the vicinity of the cross section. For detailed discussion and our interpretation of shear strengths see our previous geotechnical reports HVJ Report No. HG1019742 dated May 2, 2013 for BSC and HVJ Report No. HG1010561 dated October 17, 2013 for BCC.

Short Term: The short term case models the initial undrained condition of the soil. For this analysis, unconfined compression and unconsolidated undrained soil parameters were used.

Long Term. The long-term design case represents steady state piezometric and stress conditions. When a slope is constructed, altered stress conditions create changes within the slope and the undrained strength of the soils is mobilized. With time, the soil pore pressures adjust to the imposed stress and piezometric conditions, and the bank soils rely on their available strength for long-term stability. Drained or effective shear strength parameters (from Consolidated Undrained Tests and engineering judgment) were used in this analysis.

Rapid Drawdown. The rapid drawdown design case represents the rapid lowering of water level and associated stress conditions. When the water level is lowered in a short duration of time, it destabilizes the slope due to the development of excess pore pressures in the embankment consisting of low permeability materials (e.g. clay) and removal of stabilizing force on the upstream face of the slope due to water. In this analysis, a drawdown of the water level was taken from El. +12.54 to El. -3.64 feet MLLW at BCC and from El. +12.49 to El. -3.69 feet MLLW at BSC to reflect the impact of hurricane surge on the slope. The program SLOPE/W utilizes the Duncan et al.'s (1992) staged rapid drawdown method to evaluate slope stability after rapid drawdown. This is a 3-stage process:

The first stage involves the stability analysis of the embankment before drawdown when the water level is high and the pore water pressure in the soils is at steady state condition. Both the effective normal stress and the shear stress along the slip surface are used to determine the undrained shear strength of the soils that do not drain freely.

The second stage involves the stability analysis of the embankment after drawdown when the water level is low and the pore water pressure in the soils is in steady state condition. The effective normal stress obtained from stage two, together with the effective strength parameters are used to compute the drained strength along the slip surface. Both the drained and undrained strength at the slice base along the slip surface are compared and the smaller strength is chosen as the computed shear strength to be used.

The third stage involves stability analysis using the computed shear strength and final drawdown water level. The computed factor of safety from the first and second stages are ignored, and only the factor of safety computed from the third stage analysis is used to represent the stability after rapid drawdown.

The Long-Term and Rapid Drawdown strength parameters in clay were determined from Consolidated Undrained Triaxial Compression tests with pore pressure measurements. Long-term strength parameters were based on effective stress parameters and rapid drawdown strengths were based on total stress parameters. The soil parameters used for the analyses are presented in Table 3-1.

Table 3-1 – Soil Parameters for Slope Stability Analysis

Station & Boring Numbers	Soil Description	Unit Weight γ (pcf)	Short Term		Long Term		Rapid Drawdown	
			c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	c_{cu} (psf)	ϕ_{cu} (deg)
Barbours Cut Channel								
Sta. 34+00 S-04, L-08, L-04	Fat Clay 1	125	1000	0	300	22	500	15
	Fat Clay 2	125	2200	0	300	22	500	15
	Soft Fat Clay	115	300	0	100	15	150	10
	Loose Clayey Sand	110	0	28	0	28	0	28
	Clayey Sand	120	0	30	0	30	0	30
	Dredge Fill	90	50	0	16	15	50	0
	Fill	110	10 psf/ft (50 psf – 150 psf)				100	20
	Levee	125	NA		100	25	150	22
	Sediment	90	50	0	16	15	50	0
Sta. 44+00 S-03, L-07, L-03	Fat Clay 1	125	1000	0	300	22	500	15
	Fat Clay 2	125	2200	0	300	22	500	15
	Clayey Sand	120	0	30	0	30	0	30
	Dredge Fill	90	50	0	16	15	50	0
	Fill	110	300	0	100	20	150	15
	Levee	125	NA		100	25	150	22
	Sediment	90	50	0	16	15	50	0
Sta. 56+00 S-02, L-06, L-02	Lean Clay	125	500	0	100	25	150	20
	Fat Clay 1	125	1000	0	300	22	500	15
	Fat Clay 2	125	2200	0	300	22	500	15
	Clayey Sand	120	0	30	0	30	0	30
	Dredge Fill	90	50	0	16	15	50	0
	Levee	125	NA		100	25	150	22
	Sediment	90	50	0	16	15	50	0
Sta. 64+00 S-01, L-05, L-01	Lean Clay	125	500	0	100	25	150	20
	Fat Clay 1	125	1000	0	400	18	500	14
	Fat Clay 2	125	2200	0	300	22	500	15
	Clayey Sand	120	0	30	0	30	0	30
	Dredge Fill	90	50	0	16	15	50	0
	Levee	125	NA		100	25	150	22
	Sediment	90	50	0	16	15	50	0
Bayport Ship Channel								
Sta. 40+00 12-59, B-1, B-2, B-18	Lean Clay	123	532	0	200	23	300	19
	Fat Clay	115	1200	0	200	18	300	14
	Clayey Sand	120	0	28	0	28	0.1	27.9
	Silty Sand	120	0	31	0	31	0.1	30.9

Station & Boring Numbers	Soil Description	Unit Weight γ (pcf)	Short Term		Long Term		Rapid Drawdown	
			c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	c_{cu} (psf)	ϕ_{cu} (deg)
Bayport Ship Channel								
Sta. 66+00 12-60, B-4, B-5, B-15	Lean Clay	125	1000	0	200	23	300	19
	Silt	110	0	30	0	30	0.1	29.9
	Silty Clay	115	500	0	100	30	200	25
	Fat Clay	115	1200	0	300	17	310	14
	Silty Sand	120	0	34	0	34	0.1	33.9
Sta. 76+00 12-61, B-6	Silt	110	0	31	0	31	0.1	30.9
	Lean Clay	125	1000	0	200	23	300	19
	Fat Clay	115	1200	0	300	16	310	14
	Silty Sand	120	0	33	0	33	0.1	32.9
Sta. 92+00 12-63, B-8	Lean Clay	125	1000	0	200	23	300	19
	Clayey Sand	115	0	32	0	32	0.1	31.9
	Fat Clay	115	1200	0	200	18	300	14
Sta. 98+00 12-64, B-9	Silty Sand	120	0	32	0	32	0.1	31.9
	Clayey Sand	115	0	33	0	33	0.1	32.9
	Lean Clay	125	1200	0	200	23	300	19
	Silt	110	0	32	0	32	0.1	31.9
	Fat Clay	115	1200	0	200	18	300	14
Sta. 110+00 12-65, B-10, B-11	Silt	110	0	33	0	33	0.1	32.9
	Fat Clay	115	1200	0	200	18	300	14
	Lean Clay	125	1000	0	200	23	300	19
	Silty sand	120	0	31	0	31	0.1	30.9
Sta. 166+00 12-68	Silty Clay	115	1400	0	100	30	200	25
	Fat Clay 1	115	900	0	200	17	300	14
	Fat Clay 2	115	1500	0	200	17	300	14
	Lean Clay	120	2000	0	200	23	300	19
	Silty Sand	120	0	34	0	34	0.1	33.9
	Clayey Sand	115	0	32	0	32	0.1	31.9
Sta. 186+00 12-69	Lean Clay	120	1200	0	200	23	300	19
	Fat Clay	115	1200	0	200	17	300	14
	Clayey Sand	115	0	32	0	32	0.1	31.9

Where:

γ: Moist Unit Weight of Soil
c: Unconsolidated Undrained Cohesion
ϕ: Unconsolidated Undrained Friction Angle

c': Consolidated Drained Cohesion
ϕ': Consolidated Drained Friction Angle
c_{cu}: Consolidated Undrained Cohesion
ϕ_{cu}: Consolidated Undrained Friction Angle

3.4 Results of Slope Stability Analysis

Based on the soil parameters and water level discussed earlier, slope stability analyses were performed for the short-term, long-term, and rapid drawdown loading conditions. The results of our analyses are presented in Appendix A. The global stability analysis results are summarized below:

Table 3-2 – Slope Stability Analyses Results – Proposed Template

Location	**Station**	**Factor of Safety**			
		Short Term		**Long Term (circular)**	**Rapid Drawdown (circular)**
		Circular	**Block**		
Barbours Cut Channel	34+00	1.47	1.56	**1.28***	1.32
	44+00	**1.24***	1.37	**1.26***	**1.24***
	56+00	**1.06***	**1.02***	1.50	1.49
	64+00	1.34	1.36	**1.43***	1.43
Bayport Ship Channel	40+00	1.56	1.53	1.56	1.42
	66+00	1.50	1.40	1.74	1.54
	76+00	2.47	2.37	1.89	1.62
	92+00	2.42	2.38	1.72	1.50
	98+00	2.51	2.45	1.77	1.49
	110+00	2.33	2.31	1.56	1.41
	166+00	3.85	3.83	2.09	2.09
	186+00	5.60	4.05	2.17	2.16

* Does not meet the minimum required.

Barbours Cut Channel: The calculated factors of safety for the proposed 3H:1V slope does not meet the minimum required. We understand that a flatter channel slope from the proposed channel toe is not an option considering the reduction in the placement area capacity. In order to provide proposed channel base width while maintaining the Spilman Island placement area, a bulkhead is required along the entire length adjacent to Spilman Island. Based on our global stability analysis, the 3H:1V channel slope requires a bulkhead installed between Sta. 30+00 and Sta. 67+00 at an offset of about 530 feet from the existing centerline and embedded to El. -52 feet MLLW to achieve the required factors of safety. The results of our analyses including the proposed bulkhead are presented in Appendix C. The global stability analysis results are summarized in Table 3-3.

Table 3-3 – Slope Stability Analyses Results with Bulkhead

Location	Station	Factor of Safety			
		Short Term		Long Term (circular)	Rapid Drawdown (circular)
		Circular	Block		
Barbours Cut Channel	34+00	1.85	2.04	1.53	1.64
	44+00	1.89	1.89	1.61	1.64
	56+00	1.64	1.89	1.51	1.49
	64+00	1.72	1.89	1.56	1.55

Note that the soil conditions of the Spilman Island dike are important to the analysis. We suggest additional borings be performed for final design.

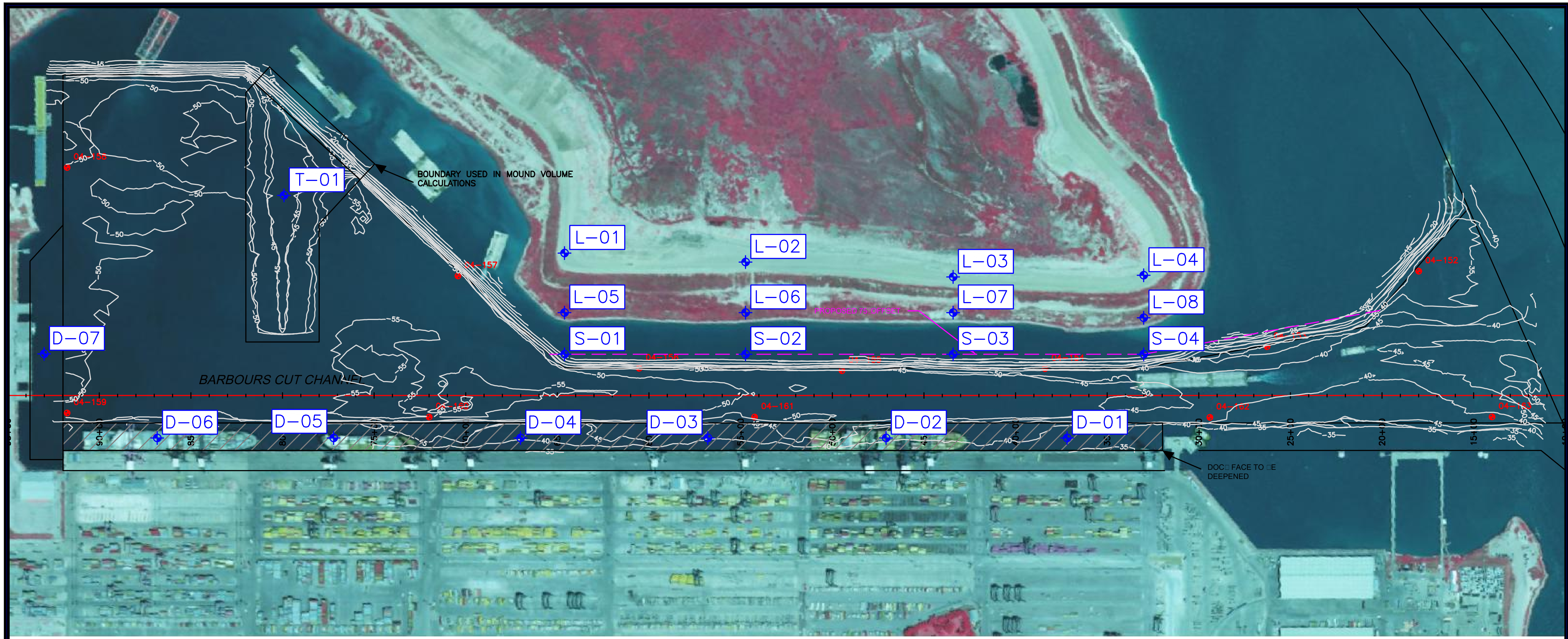
Bayport Ship Channel: The calculated factor of safety exceeds the required minimum factor of safety at all sections we analyzed. However, installation of a bulkhead is required for the area north of the turning basin adjacent to the San Jacinto College building. Our analysis indicates that the bulkhead must be installed between about Sta. 35+00 and Sta. 43+50 at about 400 feet from the existing centerline embedded to an elevation of -40 feet MLLW to achieve the required factor of safety for global stability.

Bulkheads: For analyses purposes, we modeled the bulkheads as a high strength material. The bottom elevation of the bulkhead was adjusted to achieve the required factor of safety for global stability. The SLOPE/W program assumes the strength of bulkhead to be infinity, therefore, any slip surfaces passing through the bulkhead are considered very stable. A detailed analysis must be performed to assess the bulkhead stability against rotational and flexural failures. Rotational failures are caused due to inadequate penetration length and flexural failures are resulted by overstressing the retaining structure. An analysis of the bulkhead was beyond the scope of this study.

4 LIMITATIONS

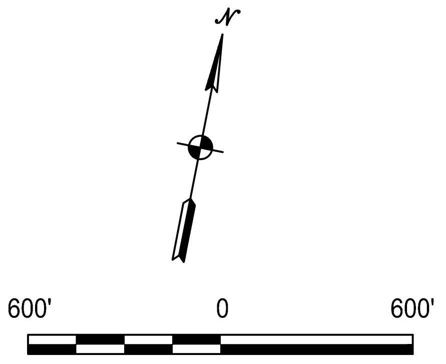
This investigation was performed for the exclusive use of Tuner, Collie, and Braden/GBA Joint Venture for specific application to HSC-ECIP Preliminary Slope Evaluation Project. HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates, Inc. makes no warranty, express or implied. The analyses and recommendations contained in this report are based on data obtained from subsurface exploration, laboratory testing, the project information provided to us and our experience with similar soils and site conditions. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any subsurface conditions other than those described in our boring logs be encountered, HVJ Associates should be immediately notified so that further investigation and supplemental recommendations can be provided.

ILLUSTRATIONS



NOTES:

1. THE INFORMATION DEPICTED ON THIS MAP REPRESENTS THE RESULTS OF SURVEYS MADE ON THE DATES SHOWN AND CAN ONLY BE CONSIDERED AS INDICATING THE GENERAL CONDITION EXISTING AT THAT TIME.
2. AERIAL IMAGERY OBTAINED FROM TEXAS NATURAL RESOURCES INFORMATION SYSTEM AND IS DATED 2010.
3. CONTOURS BASED ON SURVEY CONDUCTED BY THE USACE ON JANUARY 26, 2010.



SCALE:
1" = 600'

SURVEY DATA	
Survey Date:	26 JANUARY 2010
Horizontal Projection:	U.S. State Plane, NAD 83
Zone:	Texas South Central – 4204
Vertical Reference:	MLT
Survey Units:	U.S. Survey Feet

PRELIMINARY DRAFT

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW AND IS NOT INTENDED TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

ENGINEER:	C. HEDDERMAN
LICENSE NO.:	100209
DATE:	08 MARCH 2012

Turner Collie&Braden Inc.
GAHAGAN & BRYANT ASSOCIATES

GBA
ENGINEERS ★ SURVEYORS

GAHAGAN & BRYANT ASSOCIATES, INC.
9330 KIRBY DRIVE, SUITE 100
HOUSTON, TEXAS 77054
TEL: 832.377.4800
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TX REGISTERED ENGINEERING FIRM F–408

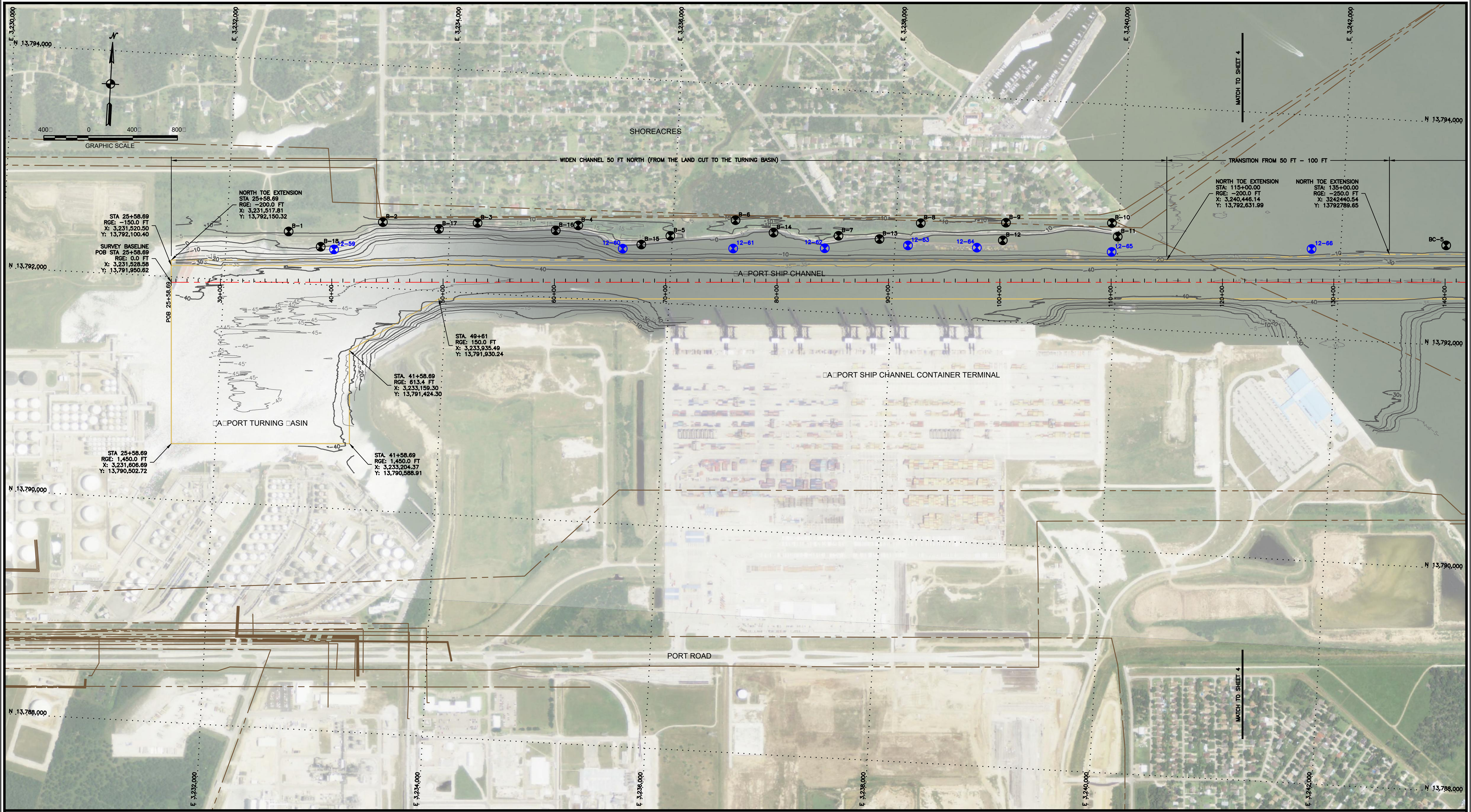
Drawing Date:	DD MONTH YYYY	Drawing Name:	XXXX.DWG
Drawn By:	F. LAST	Drawing Scale:	AS SHOWN
Checked By:	F. LAST	Sheet: 1 OF X	Rev. No. 0

REV	REVISIONS	DATE	APP

BARBOURS CUT
CHANNEL WIDENING INVESTIGATION

PROPOSED BORING LOCATIONS

PLATE 1



REV	REVISIONS	DATE	APP

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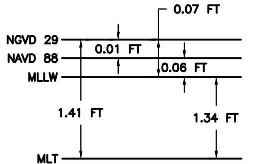
2. 2012 BORINGS WERE CONDUCTED BY TRIANGLE RESOURCES AND HVJ ASSOCIATES FROM NOVEMBER 29 TO DECEMBER 17, 2012.
3. 2012 BORING POSITIONS WERE OBTAINED USING A MAGELLAN TRITON 200 HANDHELD GPS UNIT WITH WIDE AREA AUGMENTATION SYSTEM (WAAS) WITH DIFFERENTIAL CORRECTIONS CAPABILITIES.
4. COORDINATES ARE IN SURVEY FEET AND ARE REFERENCED TO U.S. STATE PLANE TEXAS SOUTH CENTRAL ZONE 4204, NAD83.
5. CONTOURS AND 2012 BORING ELEVATIONS ARE IN SURVEY FEET AND ARE REFERENCED TO MLT USING THE RELATIONSHIPS SHOWN.
6. CONTOURS AND BORING ELEVATIONS ARE BASED ON SURVEYS CONDUCTED BY THE JOINT VENTURE FROM FEBRUARY 16–23, 2011.
7. AERIAL IMAGERY WAS OBTAINED FROM THE USDA/FSA – AERIAL PHOTOGRAPHY FIELD OFFICE AND WAS DATED 2012.

LEGEND

— - —	PIPELINES	⊗	2012 BORINGS
— - —	CHANNEL ALIGNMENTS	⊗	PREVIOUS BORINGS
———	CHANNEL TOES		
– – –	CHANNEL EXTENSION		
–5–	5–FT CONTOURS		
–10–	10–FT CONTOURS		

RELATIONSHIP BETWEEN VERTICAL DATUMS AT NOAA MORGAN'S POINT TIDE GAUGE BASED ON THE 1983–2001 EPOCH



(NOT TO SCALE)

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ENGINEER:	C. HEDDERMAN
LICENSE NO.:	100209
DATE:	24 JAN. 2013

Turner Collie & Braden Inc.
JOINT VENTURE - PORT DEVELOPMENT AND ENVIRONMENTAL SERVICES
GAHAGAN & BRYANT ASSOCIATES
TEXAS ENGINEERING FIRM F-10788
5757 WOODWAY DRIVE
HOUSTON, TEXAS 77057-15□□
TEL. 713.780.4100

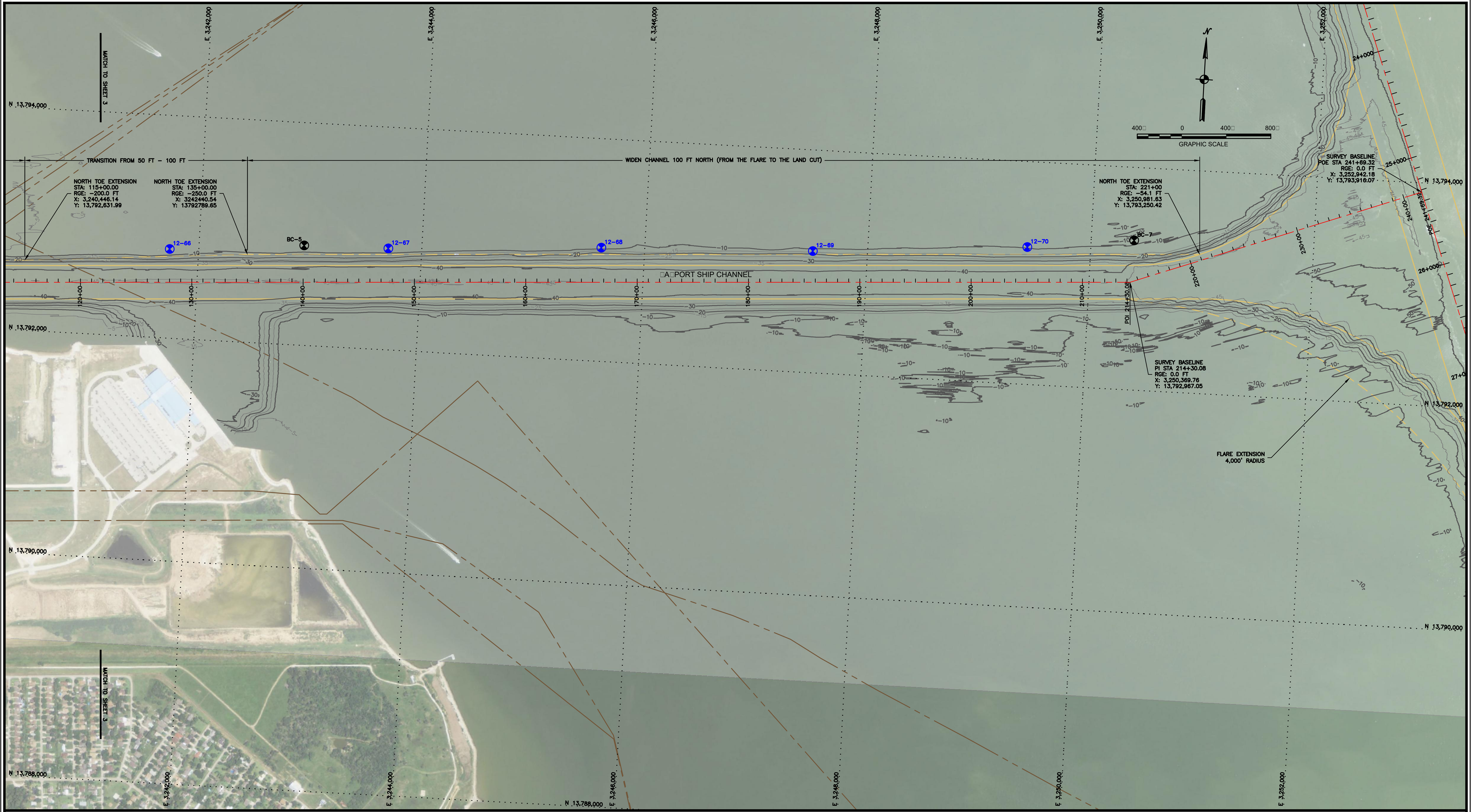
PORT OF HOUSTON AUTHORITY

BAYPORT CHANNEL
DEEPENING AND WIDENING PROJECT

BAYPORT BORINGS

DWG DATE:	24 JANUARY 2013	DWG:	Bayport2012_Borings.dwg		
DRAWN:	J. MCCLURE	CHECKED:	S. HALPIN	ENGR:	C. HEDDERMAN
SCALE:	AS SHOWN	SHEET:	3 OF 39	REV:	0

PLATE 2A



REV	REVISIONS	DATE	APP

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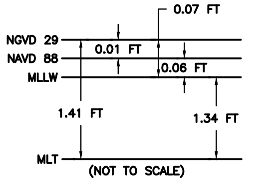
7. AERIAL IMAGERY WAS OBTAINED FROM THE USDA/FSA – AERIAL PHOTOGRAPHY FIELD OFFICE AND WAS DATED 2012.

LEGEND

━ ‒ ━	PIPELINES	⊗	2012 BORINGS
─ · ─	CHANNEL/LEVEE ALIGNMENTS	⊗	PREVIOUS BORINGS
──	CHANNEL TOES		
‒ ‒ ‒	CHANNEL EXTENSION		
∼ –5 ∼	5–FT CONTOURS		
∼ –10 ∼	10–FT CONTOURS		

RELATIONSHIP BETWEEN VERTICAL DATUMS AT NOAA MORGAN'S POINT TIDE GAUGE BASED ON THE 1983–2001 EPOCH



(NOT TO SCALE)

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TEXAS ENGINEERING FIRM F-10788
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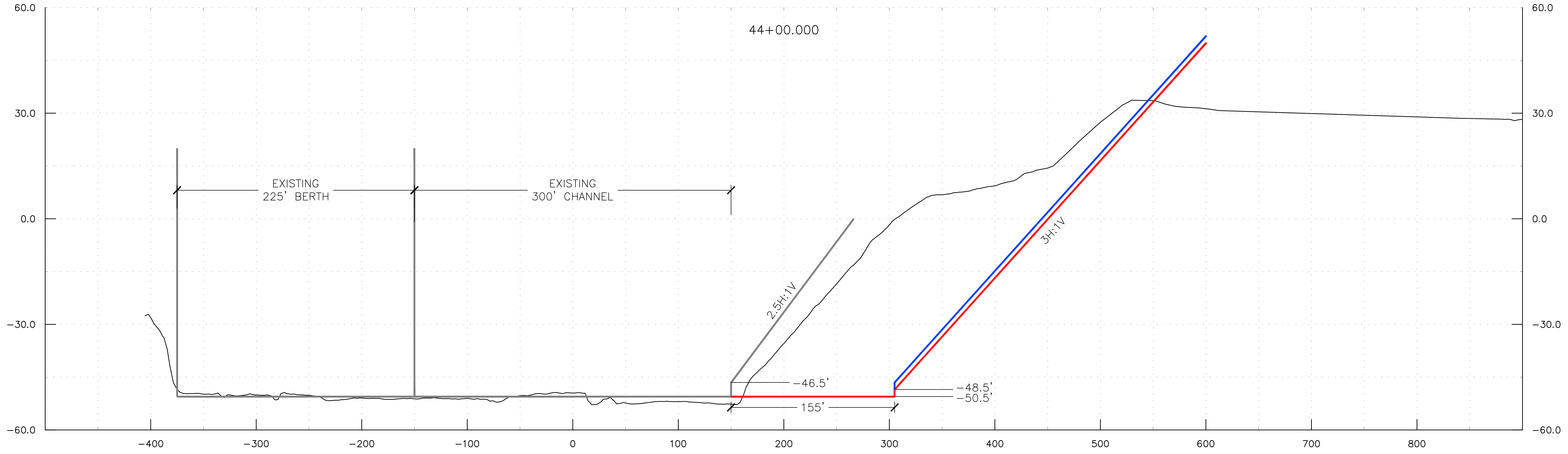
HOUSTON, TEXAS 77057-15□□
TEL. 713.780.4100

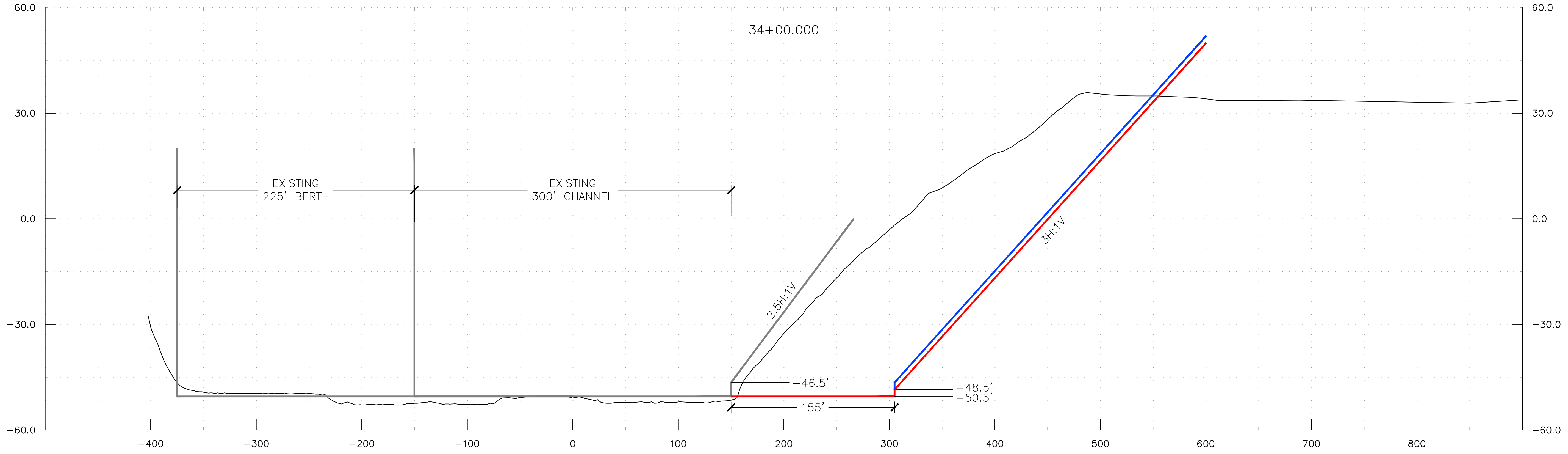
PORT OF HOUSTON AUTHORITY

BAYPORT CHANNEL
DEEPENING AND WIDENING PROJECT

BAYPORT BORINGS

DWG DATE:	24 JANUARY 2013	DWG:	Bayport2012_Borings.dwg		
DRAWN:	J. MCCLURE	CHECKED:	S. HALPIN	ENGR:	C. HEDDERMAN
SCALE:	AS SHOWN	SHEET:	4 OF 39	REV:	0





REV	REVISIONS	DATE	APP

NOTES:

1. SURVEY LAYER REPRESENTS A COMBINED DATASET COMPILATION OF SURVEYS PERFORMED BY THE JV ON THE DATES OF 09/14–17/15 AND 06/12/14, AS WELL AS TOPOGRAPHIC SURVEY DATA PROVIDED BY THE JV (AUG 2013), HTI (MAY 2013), AND ORION MARINE GROUP (2015) PERFORMED AND/OR PREPARED IN CONJUNCTION WITH THE BCC IMPROVEMENTS PROJECT (2014–2015).
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3. HORIZONTAL SCALE IS 1" = 100'. VERTICAL SCALE IS 1" = 30'. (VERTICAL EXAGGERATION = 3.33X)
4. CENTERLINE SHOWN REPRESENTS EXISTING (POST–BCC IMPROVEMENTS PROJECT) CHANNEL CENTERLINE.

LEGEND:

━	455' WIDTH WIDENED CHANNEL
━	EXISTING CHANNEL
─	COMPOSITE SURVEY SURFACE
━	455' WIDTH WIDENED CHANNEL SLOPE FROM −46.5'

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DATE:	01/23/18

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HOUSTON, TEXAS 77056
TEL. 713.780.4100

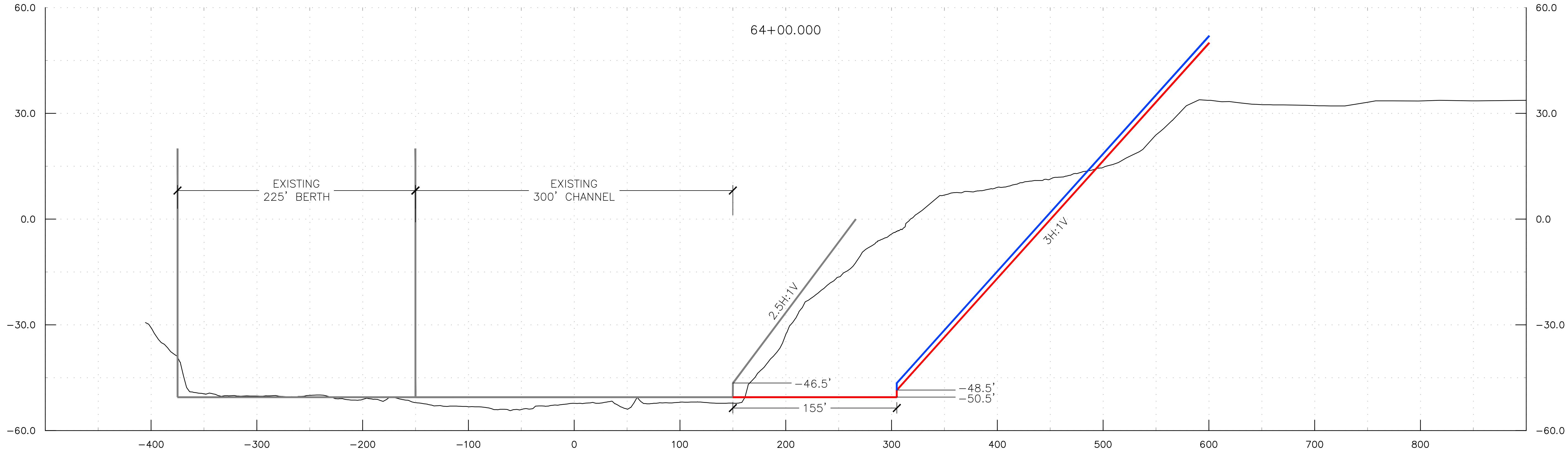
PORT OF HOUSTON AUTHORITY

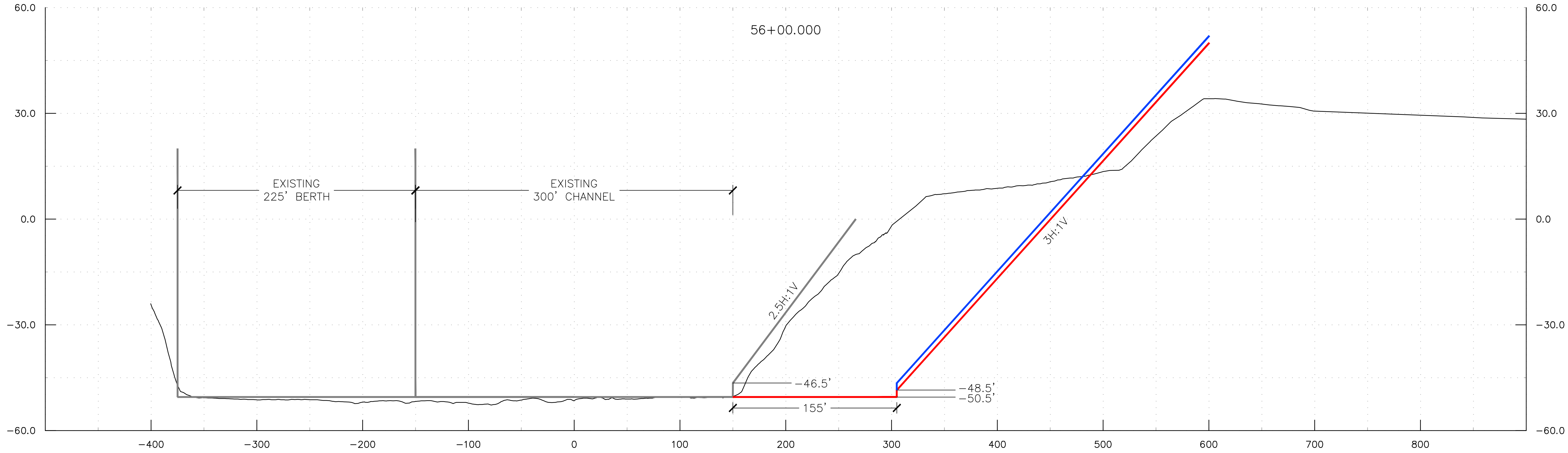
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT

CHANNEL WIDENING MEASURE: CW3_BCC_455

DWG DATE:	23 JANUARY 2018	DWG:	HSC–ECIP BCC SECTIONS.dwg		
DRAWN:	C.HEDDERMAN	CHECKED:	...	ENGR:	C.HEDDERMAN
SCALE:	SEE NOTES	SHEET:	01 OF 02	REV:	00

PLATE 3A





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4. CENTERLINE SHOWN REPRESENTS EXISTING (POST–BCC IMPROVEMENTS PROJECT) CHANNEL CENTERLINE.

LEGEND:

- 455' WIDTH WIDENED CHANNEL
- EXISTING CHANNEL
- COMPOSITE SURVEY SURFACE
- 455' WIDTH WIDENED CHANNEL SLOPE FROM −46.5'

PRELIMINARY DRAFT

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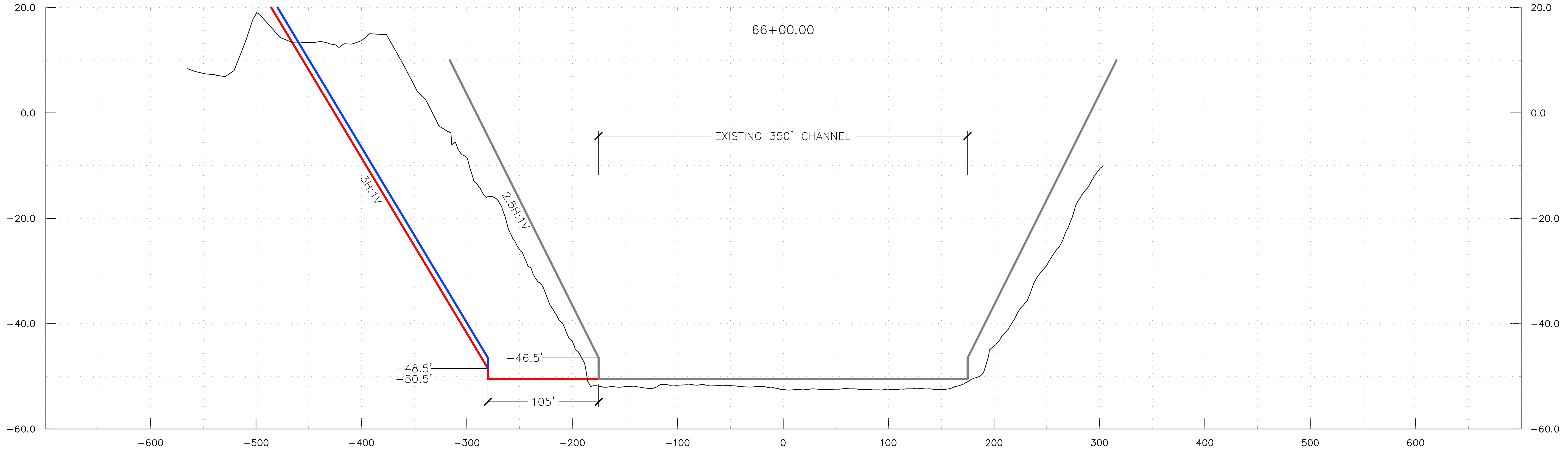
PORT OF HOUSTON AUTHORITY

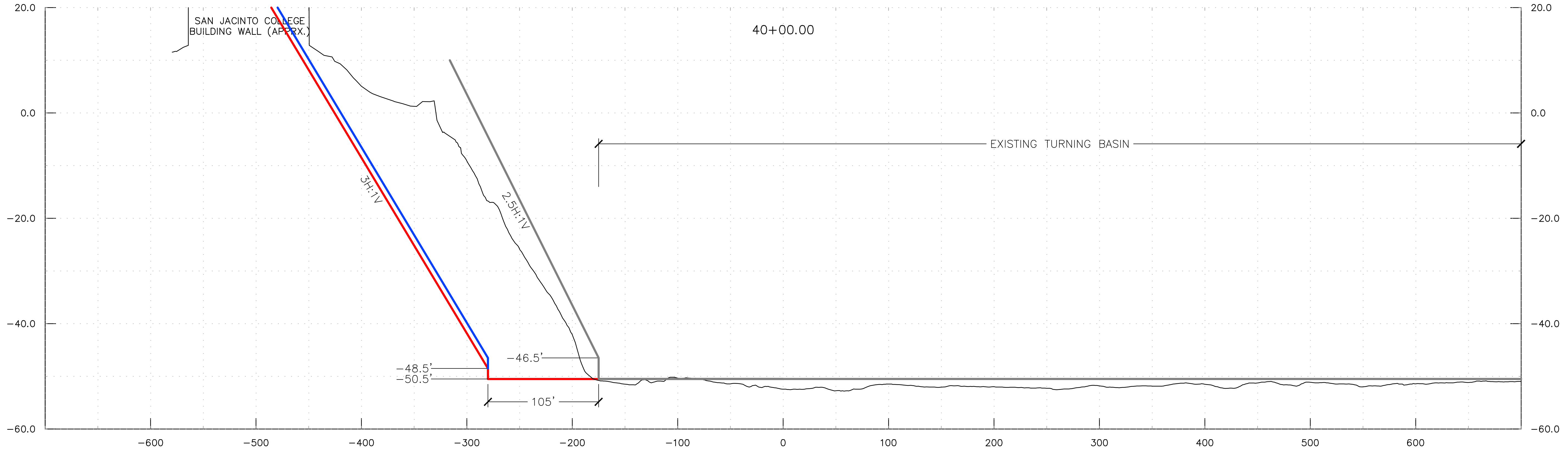
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT

CHANNEL WIDENING MEASURE: CW3_BCC_455

DWG DATE:	23 JANUARY 2018	DWG:	HSC–ECIP BCC SECTIONS.dwg		
DRAWN:	C.HEDDERMAN	CHECKED:	...	ENGR:	C.HEDDERMAN
SCALE:	SEE NOTES	SHEET:	02 OF 02	REV:	00

PLATE 3B





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LEGEND:

🟥	455' WIDTH WIDENED CHANNEL
▬	EXISTING CHANNEL
—	COMPOSITE SURVEY SURFACE
🟦	455' WIDTH WIDENED CHANNEL SLOPE FROM −46.5'

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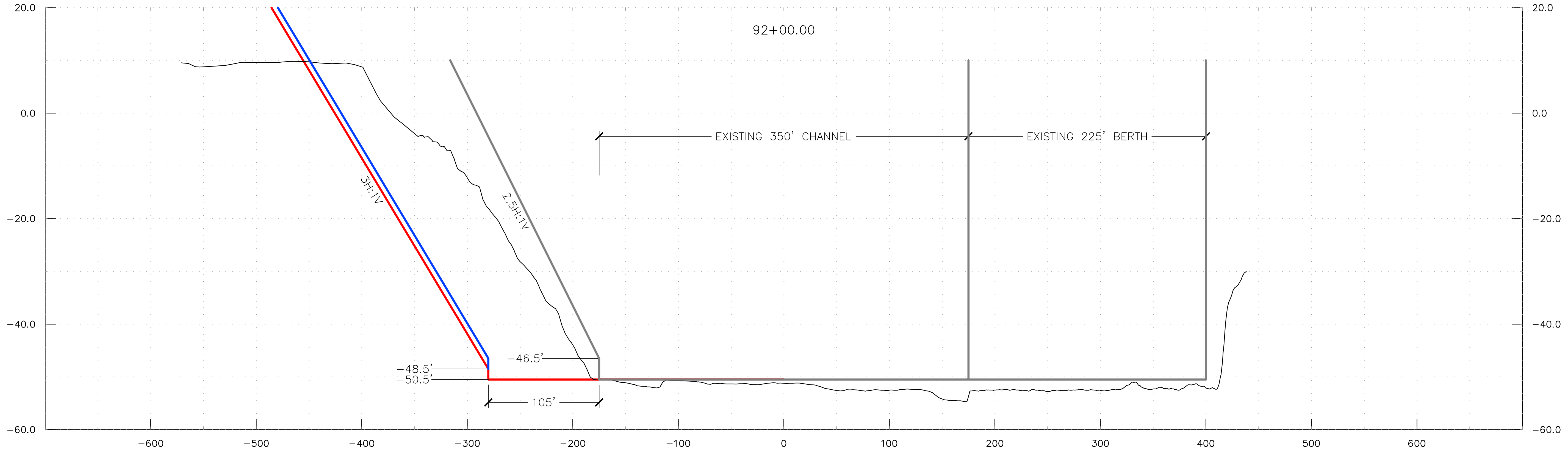
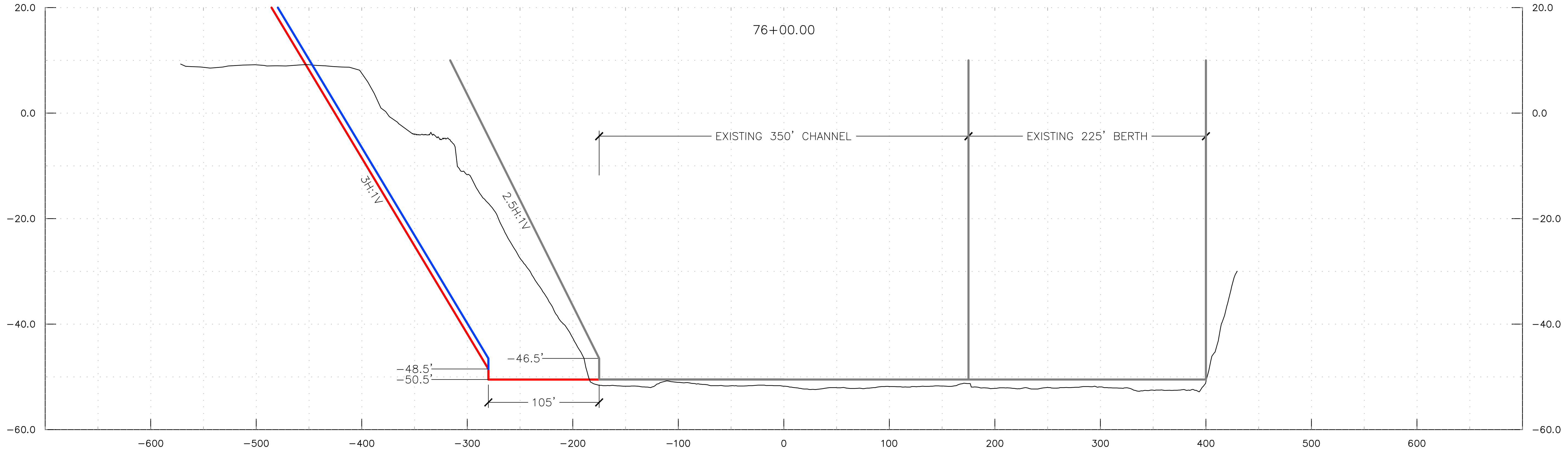
PORT OF HOUSTON AUTHORITY
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT
CHANNEL WIDENING MEASURE: CW2_BSC_455

DWG DATE:	23 JANUARY 2018	DWG:	HSC–ECIP BSC SECTIONS.dwg		
DRAWN:	C.HEDDERMAN	CHECKED:	...	ENGR:	C.HEDDERMAN
SCALE:	SEE NOTES	SHEET:	01 OF 04	REV:	00





REV	REVISIONS	DATE	APP

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4. CENTERLINE SHOWN REPRESENTS EXISTING (POST–BSC IMPROVEMENTS PROJECT) CHANNEL CENTERLINE.

LEGEND:

🟥	455' WIDTH WIDENED CHANNEL
▬	EXISTING CHANNEL
—	COMPOSITE SURVEY SURFACE
🟦	455' WIDTH WIDENED CHANNEL SLOPE FROM –46.5'

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ENGINEER:	C.HEDDERMAN
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DATE:	01/23/18

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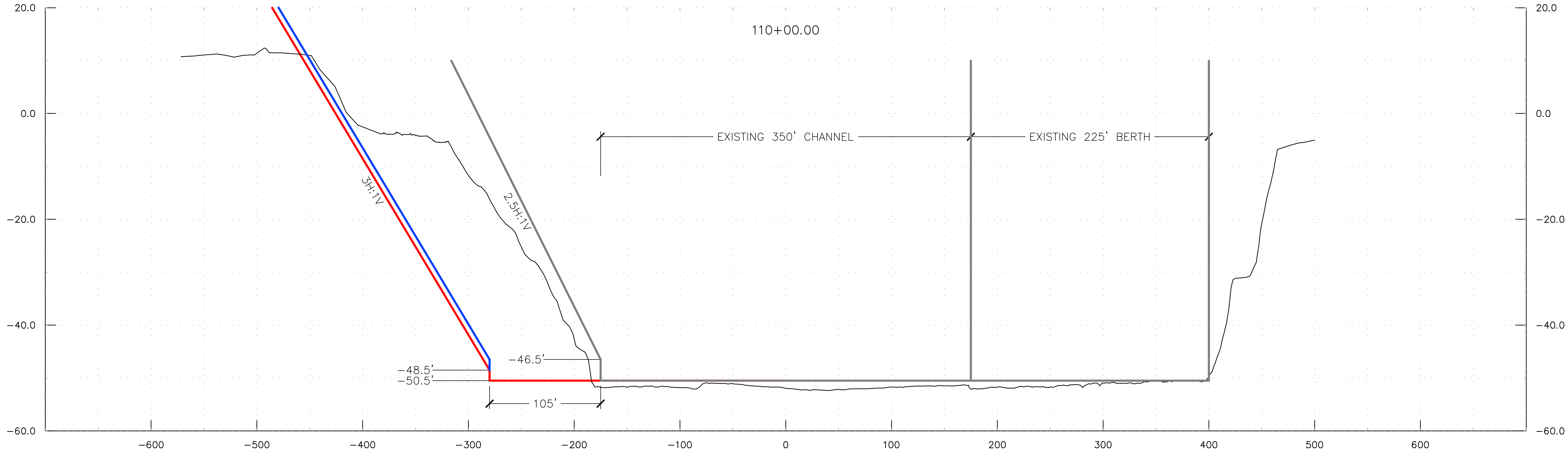
PORT OF HOUSTON AUTHORITY

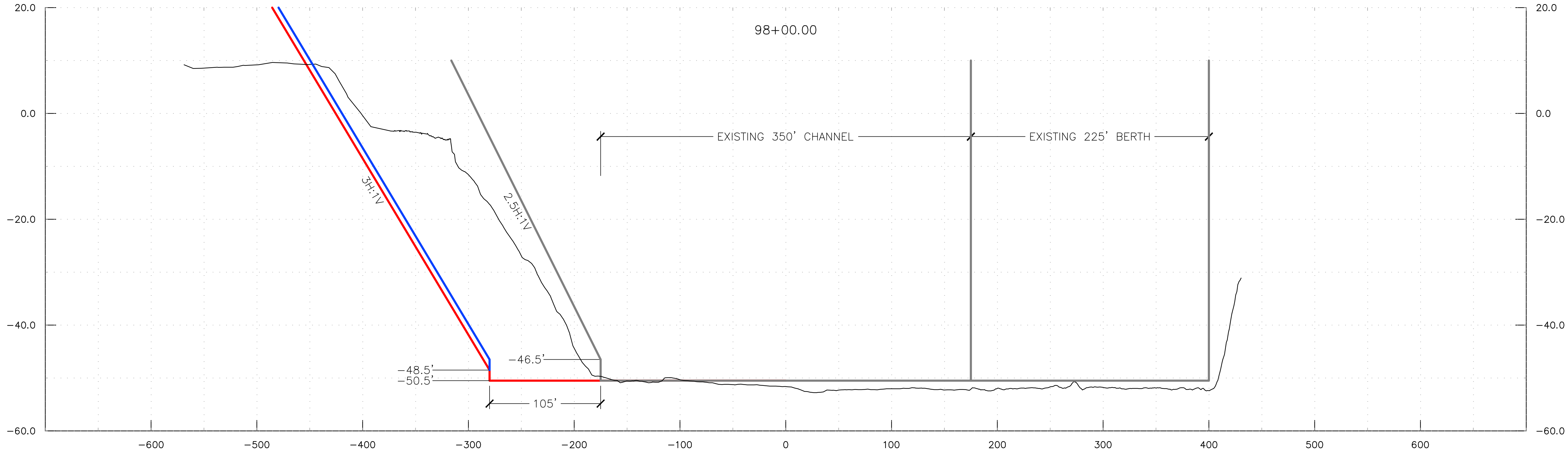
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT

CHANNEL WIDENING MEASURE: CW2_BSC_455

DWG DATE: 23 JANUARY 2018		DWG: HSC–ECIP BSC SECTIONS.dwg	
DRAWN: C.HEDDERMAN	CHECKED: ...	ENGR: C.HEDDERMAN	
SCALE: SEE NOTES	SHEET: 02 OF 04	REV: 00	

PLATE 4B





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2. SURVEY DATA PROVIDED RELATIVE TO MEAN LOWER LOW WATER (MLLW). ORIGINAL DATA COLLECTED IN MEAN LOW TIDE (MLT) AND CONVERTED TO MLLW AS FOLLOWS: ELEV. MLLW = ELEV. MLT – 1.31'.
3. HORIZONTAL SCALE IS 1" = 100'. VERTICAL SCALE IS 1" = 20'. (VERTICAL EXAGGERATION = 5X)
4. CENTERLINE SHOWN REPRESENTS EXISTING (POST–BSC IMPROVEMENTS PROJECT) CHANNEL CENTERLINE.

LEGEND:

455' WIDTH WIDENED CHANNEL
EXISTING CHANNEL
COMPOSITE SURVEY SURFACE
455' WIDTH WIDENED CHANNEL SLOPE FROM −46.5'

PRELIMINARY DRAFT

THIS DOCUMENT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING, RECORDATION, CONVEYANCE, SALES, OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT.

ENGINEER:	C.HEDDERMAN
LICENSE NO.:	100209
DATE:	01/23/18

Turner Collie & Braden Inc.
JOINT VENTURE - PORT DEVELOPMENT AND ENVIRONMENTAL SERVICES
GAHAGAN & BRYANT ASSOCIATES
TEXAS ENGINEERING FIRM F-10788
5444 WESTHEIMER, SUITE 200
HOUSTON, TEXAS 77056
TEL. 713.780.4100

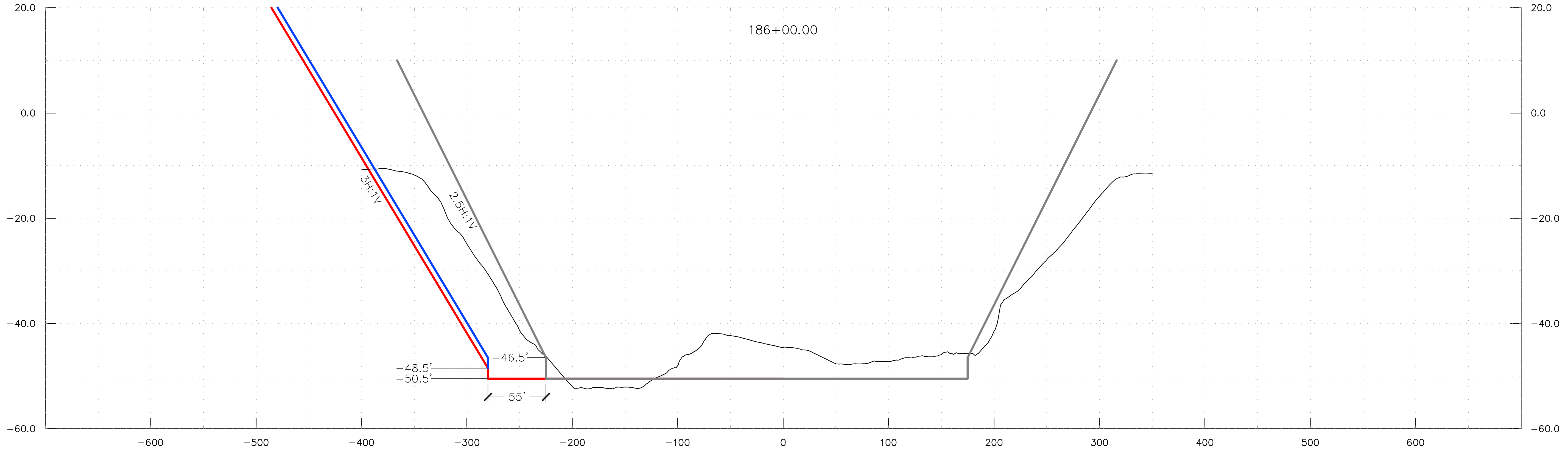
PORT OF HOUSTON AUTHORITY

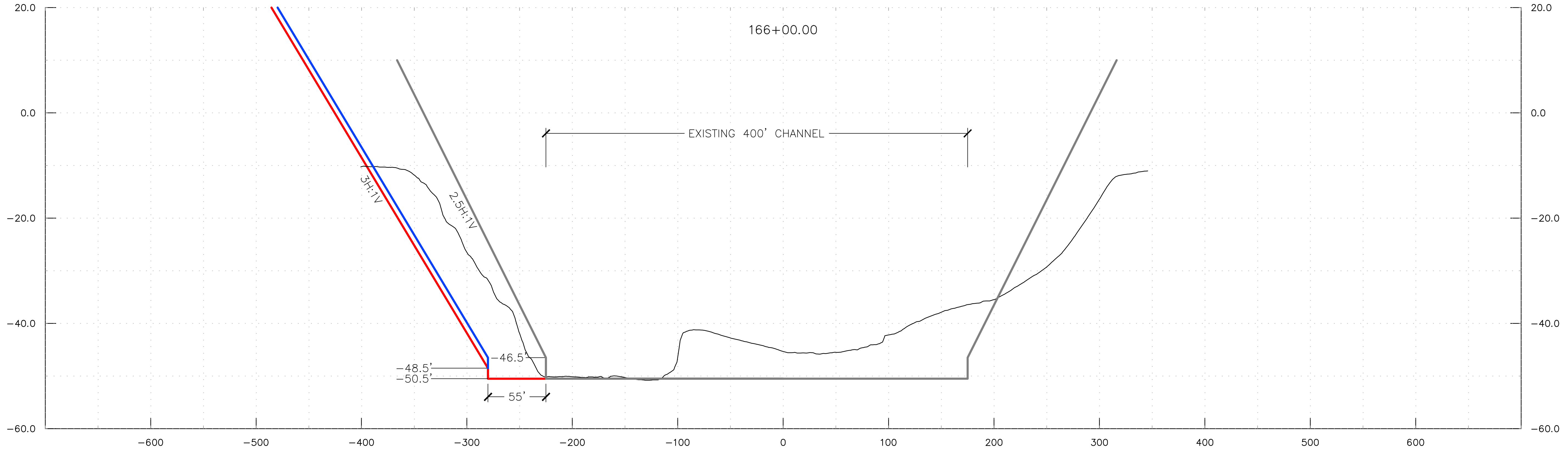
HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT

CHANNEL WIDENING MEASURE: CW2_BSC_455

DWG DATE:	23 JANUARY 2018	DWG:	HSC–ECIP BSC SECTIONS.dwg		
DRAWN:	C.HEDDERMAN	CHECKED:	...	ENGR:	C.HEDDERMAN
SCALE:	SEE NOTES	SHEET:	03 OF 04	REV:	00

PLATE 4C





REV	REVISIONS	DATE	APP

NOTES:

1. UPDATED SURVEY LAYER REPRESENTS A COMBINED DATASET COMPILATION OF SURVEYS PERFORMED BY THE JV ON THE DATES OF 02/07/17, 01/19/17, 01/03/17, 03/21/16, 11/01/15, AND 10/05/15, AS WELL AS ACCEPTANCE SURVEY DATASETS PREPARED ON THE DATES OF 01/04/17, 10/18/16, 07/18/16, 01/15/16, AND 01/06/16, PERFORMED AND/OR PREPARED IN CONJUNCTION WITH THE BSC IMPROVEMENTS PROJECT (2015–2016).

2. ADDITIONAL DATA IN UPDATED SURVEY LAYER INCLUDES AECOM 2011 TOPOGRAPHIC SURVEY DATA ALONG NORTH SHORELINE, AS WELL AS 2016 ORION MARINE GROUP AS–BUILT TOPOGRAPHIC SURVEY DATA AT LOCATIONS OF SHORE PROTECTION REMOVAL PERFORMED DURING THE BSC IMPROVEMENTS PROJECT.

2. SURVEY DATA PROVIDED RELATIVE TO MEAN LOWER LOW WATER (MLLW). ORIGINAL DATA COLLECTED IN MEAN LOW TIDE (MLT) AND CONVERTED TO MLLW AS FOLLOWS: ELEV. MLLW = ELEV. MLT – 1.31'.

3. HORIZONTAL SCALE IS 1" = 100'. VERTICAL SCALE IS 1" = 20'. (VERTICAL EXAGGERATION = 5X)

4. CENTERLINE SHOWN REPRESENTS EXISTING (POST–BSC IMPROVEMENTS PROJECT) CHANNEL CENTERLINE.

LEGEND:

🟥	455' WIDTH WIDENED CHANNEL
▬	EXISTING CHANNEL
—	COMPOSITE SURVEY SURFACE
🟦	455' WIDTH WIDENED CHANNEL SLOPE FROM –46.5'

PRELIMINARY DRAFT

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ENGINEER:	C.HEDDERMAN
LICENSE NO.:	100209
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PORT OF HOUSTON AUTHORITY

HOUSTON SHIP CHANNEL
EXPANSION CHANNEL IMPROVEMENTS PROJECT

CHANNEL WIDENING MEASURE: CW2_BSC_455

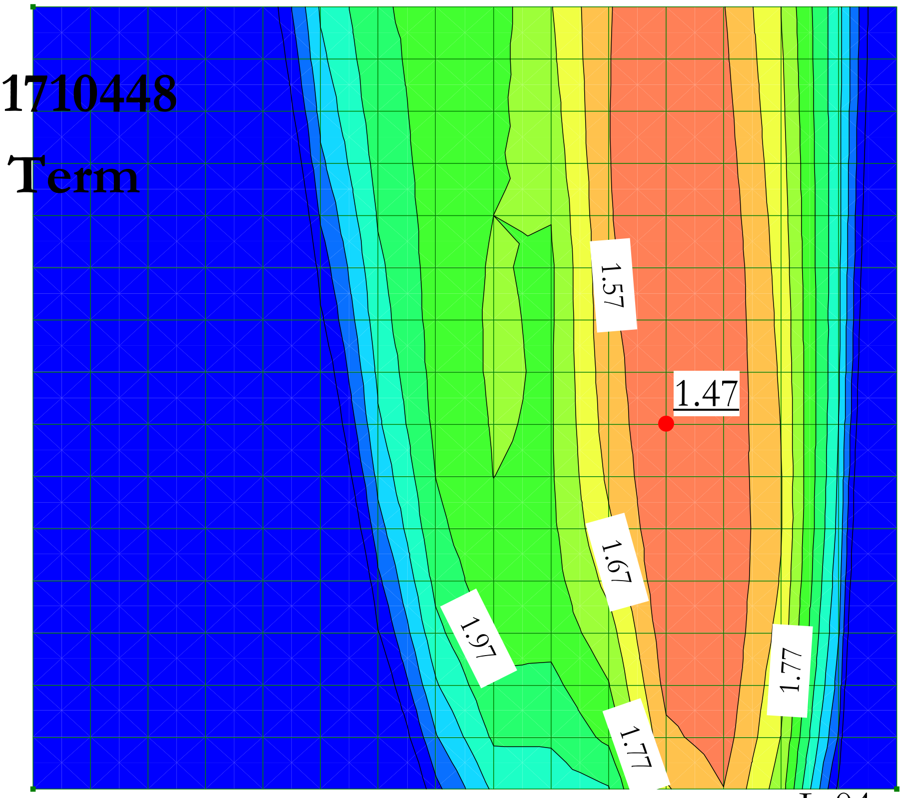
DWG DATE:	23 JANUARY 2018	DWG:	HSC–ECIP BSC SECTIONS.dwg		
DRAWN:	C.HEDDERMAN	CHECKED:	...	ENGR:	C.HEDDERMAN
SCALE:	SEE NOTES	SHEET:	04 OF 04	REV:	00

APPENDIX A

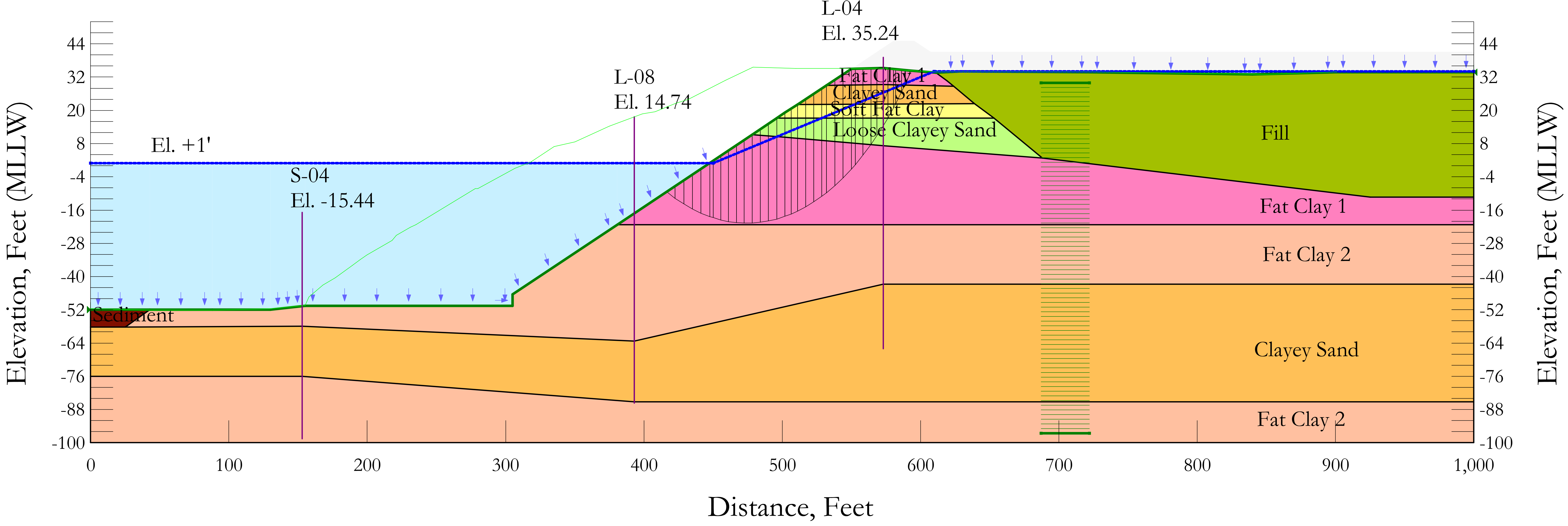
SLOPE STABILITY ANALYSIS: PROPOSED AT BARBOURS CUT CHANNEL

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448

Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
🟧	Clayey Sand	120	0	30				
🟪	Fat Clay 1(U)	125			1,000			
🟩	Fill	110				50	10	150
🟫	Sediment (U)	90			50			
🟧	Fat Clay 2 (U)	125			2,200			
🟨	Soft Fat Clay (U)	115			300			
🟩	Loose Clayey Sand	110	0	28				



Short Term 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 212
Date: 4/25/2018
Time: 1:19:25 PM
Tool Version: 8.16.1.13452
File Name: 34+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\
Last Solved Date: 4/25/2018
Last Solved Time: 1:19:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 34+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fill

Model: S=f(depth)
Unit Weight: 110 pcf
C-Top of Layer: 50 psf
C-Rate of Change: 10 (lbs/ft^2)/ft
C-Maximum: 150 psf
Pore Water Pressure
Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf

Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 300 psf
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (217.8737, 219.00031) ft
Lower Left: (217.8737, 60.51432) ft
Lower Right: (568.0477, 60.51432) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (687.0189, 29.85921) ft
Upper Right Coordinate: (722.1145, 29.85921) ft
Lower Left Coordinate: (687.0189, -96.57772) ft
Lower Right Coordinate: (722.1145, -96.57772) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 33.75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	610	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74
Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5

Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	717.6	36.74
Point 56	722	33.7
Point 57	1,000	41.14
Point 58	900	33.75
Point 59	502	10.23641
Point 60	502	17.19722
Point 61	502	19.1605

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay 1(U)	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2 (U)	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,58,22,56,30	13,510
Region 4	Loose Clayey Sand	14,31,32,13,60,47,46,59	1,852
Region 5	Soft Fat Clay (U)	47,60,13,32,33,12,48,61	716.27
Region 6	Clayey Sand	33,18,11,49,48,12	748.17
Region 7	Clayey Sand	25,38,1,6,15,24,27,9,3,26	31,487
Region 8	Fat Clay 2 (U)	39,38,1,6,15,24,34,35,36,45,44,37,43,42	19,681
Region 9	Fat Clay 1(U)	36,46,59,14,31,23,41,34,35	12,273
Region 10	Sediment (U)	39,40,25,38	212.84
Region 11		51,50,10,21,20,30,53,52	502.37
Region 12		53,54,55,56,30	699.64
Region 13		54,55,56,22,58,17,57	2,180.1

Current Slip Surface

Slip Surface: 9,379
F of S: 1.47
Volume: 4,679.2221 ft^3
Weight: 568,802.71 lbs
Resisting Moment: 27,796,495 lbs-ft
Activating Moment: 18,961,422 lbs-ft
Resisting Force: 165,415.55 lbs
Activating Force: 112,845.39 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (416.40698, -9.3643396) ft
Entry: (593.18805, 34.289977) ft
Radius: 155.19001 ft
Center: (474.66797, 134.47445) ft

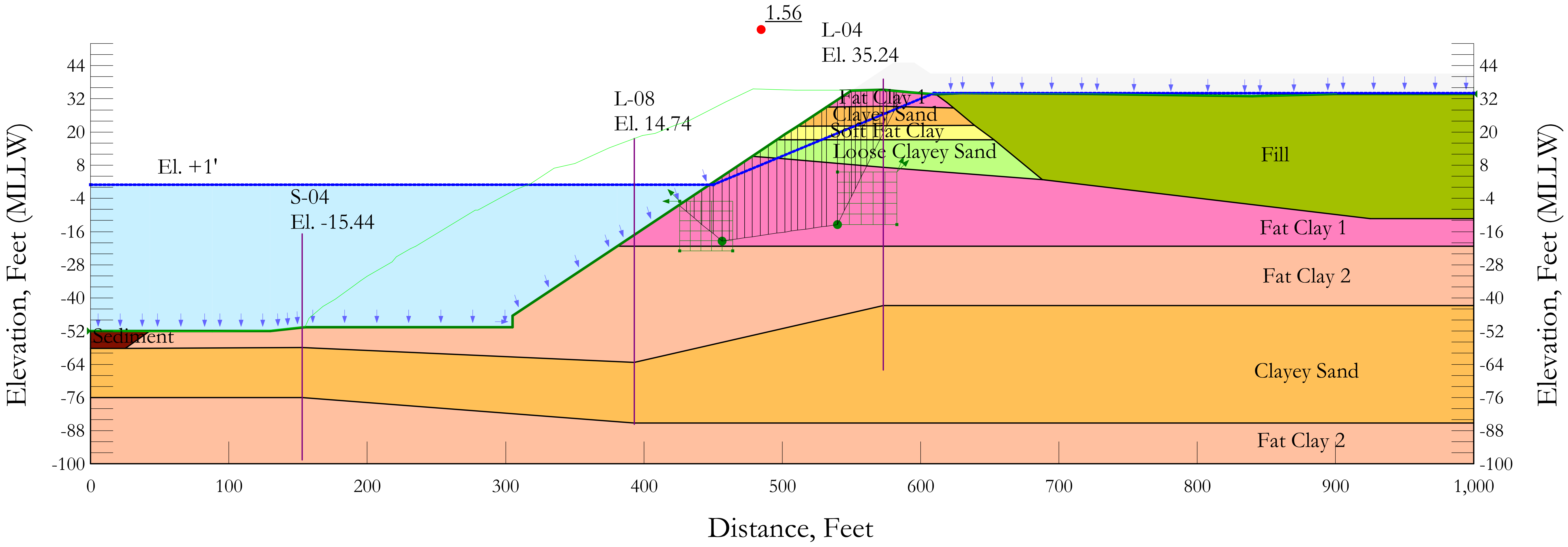
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	419.51628	-10.546809	720.52089	1,146.9584	0	1,000
Slice 2	425.73489	-12.762631	858.78816	1,578.4753	0	1,000
Slice 3	431.95349	-14.686379	978.83002	1,972.5523	0	1,000
Slice 4	438.17209	-16.329254	1,081.3454	2,325.464	0	1,000
Slice 5	444.3907	-17.700372	1,166.9032	2,634.2447	0	1,000
Slice 6	448.75	-18.530751	1,218.7189	2,854.5903	0	1,000
Slice 7	452.822	-19.143807	1,240.522	3,097.2336	0	1,000
Slice 8	458.466	-19.84141	1,351.9507	3,405.0528	0	1,000
Slice 9	464.11	-20.330164	1,450.8789	3,674.3907	0	1,000
Slice 10	469.754	-20.612045	1,537.425	3,905.2406	0	1,000
Slice 11	475.398	-20.688184	1,611.6566	4,098.2378	0	1,000
Slice 12	481.18333	-20.550364	1,674.8267	4,241.5888	0	1,000
Slice 13	487.11	-20.187431	1,726.2676	4,335.38	0	1,000
Slice 14	493.03667	-19.595743	1,764.0167	4,393.3257	0	1,000
Slice 15	499	-18.766096	1,787.9756	4,420.3068	0	1,000
Slice 16	504.25	-17.852795	1,798.1215	4,421.8792	0	1,000
Slice 17	508.75	-16.909287	1,797.2008	4,403.611	0	1,000
Slice 18	513.93495	-15.634978	1,784.9359	4,367.1756	0	1,000
Slice 19	519.80486	-13.974837	1,758.0332	4,308.421	0	1,000
Slice 20	525.67476	-12.060833	1,715.9358	4,225.2586	0	1,000
Slice 21	530.30486	-10.388171	1,672.9784	4,145.3812	0	1,000
Slice 22	535	-8.4709323	1,616.1852	4,048.2619	0	1,000
Slice 23	541	-5.7859801	1,529.5496	3,907.8915	0	1,000
Slice 24	547	-2.7863145	1,424.0771	3,740.7243	0	1,000
Slice 25	551.38877	-0.4155239	1,336.3549	3,552.1372	0	1,000
Slice 26	555.59851	2.0990197	1,237.8184	3,240.0466	0	1,000
Slice 27	561.24044	5.7204559	1,090.7102	2,794.8576	0	1,000

Slice 28	566.29605	9.252383	941.72156	2,465.3433	810.12405	0
Slice 29	570.76535	12.650267	793.51789	2,149.9689	721.2378	0
Slice 30	574.67452	15.824409	651.79142	1,849.717	636.94836	0
Slice 31	578.38452	19.065064	503.62507	1,664.4893	0	300
Slice 32	581.14058	21.57387	387.48647	1,381.9669	0	300
Slice 33	584.07534	24.455285	251.25177	966.97386	413.22234	0
Slice 34	587.43808	27.872167	88.250722	616.78431	305.14901	0
Slice 35	588.86846	29.393468	14.852906	-75.619857	0	1,000
Slice 36	590.57514	31.300452	-78.218778	-356.7201	0	1,000
Slice 37	592.59403	33.595567	-190.66746	-701.30903	0	1,000

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
🟧	Clayey Sand	120	0	30				
🟪	Fat Clay 1(U)	125			1,000			
🟩	Fill	110				50	10	150
🟥	Sediment (U)	90			50			
🟧	Fat Clay 2 (U)	125			2,200			
🟨	Soft Fat Clay (U)	115			300			
🟩	Loose Clayey Sand	110	0	28				



Short Term - Block 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 212
Date: 4/25/2018
Time: 1:19:25 PM
Tool Version: 8.16.1.13452
File Name: 34+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\
Last Solved Date: 4/25/2018
Last Solved Time: 1:20:48 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block 34+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fill

Model: S=f(depth)
Unit Weight: 110 pcf
C-Top of Layer: 50 psf
C-Rate of Change: 10 (lbs/ft^2)/ft
C-Maximum: 150 psf
Pore Water Pressure
    Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf

Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 300 psf
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 33.75) ft

Slip Surface Block

Left Grid
Upper Left: (426.0139, -4.99326) ft
Lower Left: (426.0139, -23.02716) ft
Lower Right: (464.0721, -23.02716) ft
X Increments: 5
Y Increments: 5
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 2
Right Grid
Upper Left: (539.8834, 5.56181) ft
Lower Left: (539.8834, -13.44051) ft
Lower Right: (582.9256, -13.44051) ft
X Increments: 5
Y Increments: 5
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	610	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
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Point 9	393	-85.26
Point 10	573	35.24
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Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74
Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5

Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	717.6	36.74
Point 56	722	33.7
Point 57	1,000	41.14
Point 58	900	33.75
Point 59	502	10.23641
Point 60	502	17.19722
Point 61	502	19.1605

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay 1(U)	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2 (U)	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,58,22,56,30	13,510
Region 4	Loose Clayey Sand	14,31,32,13,60,47,46,59	1,852
Region 5	Soft Fat Clay (U)	47,60,13,32,33,12,48,61	716.27
Region 6	Clayey Sand	33,18,11,49,48,12	748.17
Region 7	Clayey Sand	25,38,1,6,15,24,27,9,3,26	31,487
Region 8	Fat Clay 2 (U)	39,38,1,6,15,24,34,35,36,45,44,37,43,42	19,681
Region 9	Fat Clay 1(U)	36,46,59,14,31,23,41,34,35	12,273
Region 10	Sediment (U)	39,40,25,38	212.84
Region 11		51,50,10,21,20,30,53,52	502.37
Region 12		53,54,55,56,30	699.64
Region 13		54,55,56,22,58,17,57	2,180.1

Current Slip Surface

Slip Surface: 3,349

F of S: 1.56

Volume: 4,384.4382 ft³

Weight: 533,141.12 lbs

Resisting Moment: 11,399,001 lbs-ft

Activating Moment: 7,331,185.5 lbs-ft

Resisting Force: 152,350.91 lbs

Activating Force: 97,980.669 lbs

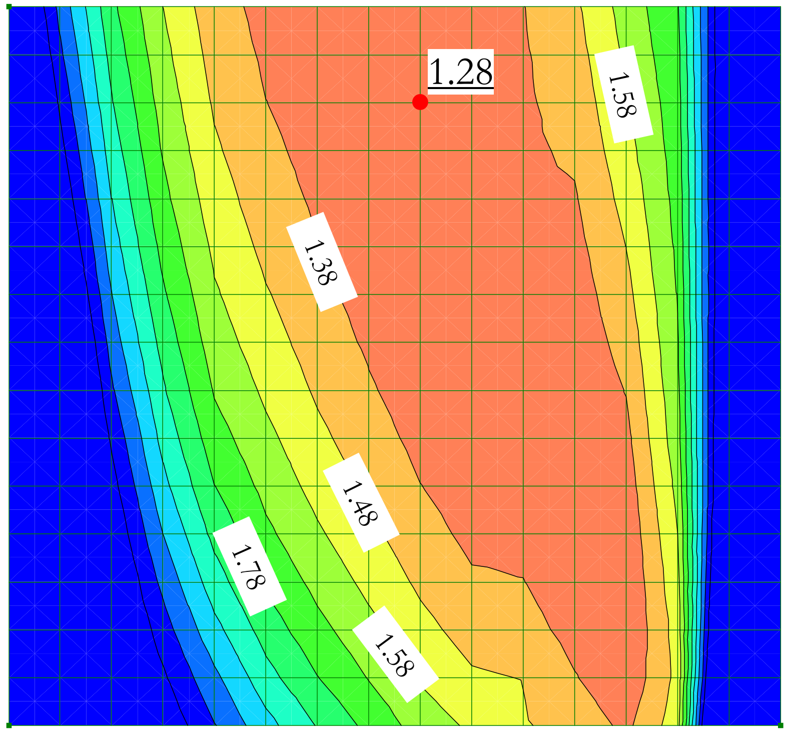
F of S Rank (Analysis): 1 of 11,664 slip surfaces
F of S Rank (Query): 1 of 11,664 slip surfaces
Exit: (425.14844, -6.4505185) ft
Entry: (587.86001, 34.536105) ft
Radius: 80.160415 ft
Center: (498.76091, 44.78276) ft

Slip Slices

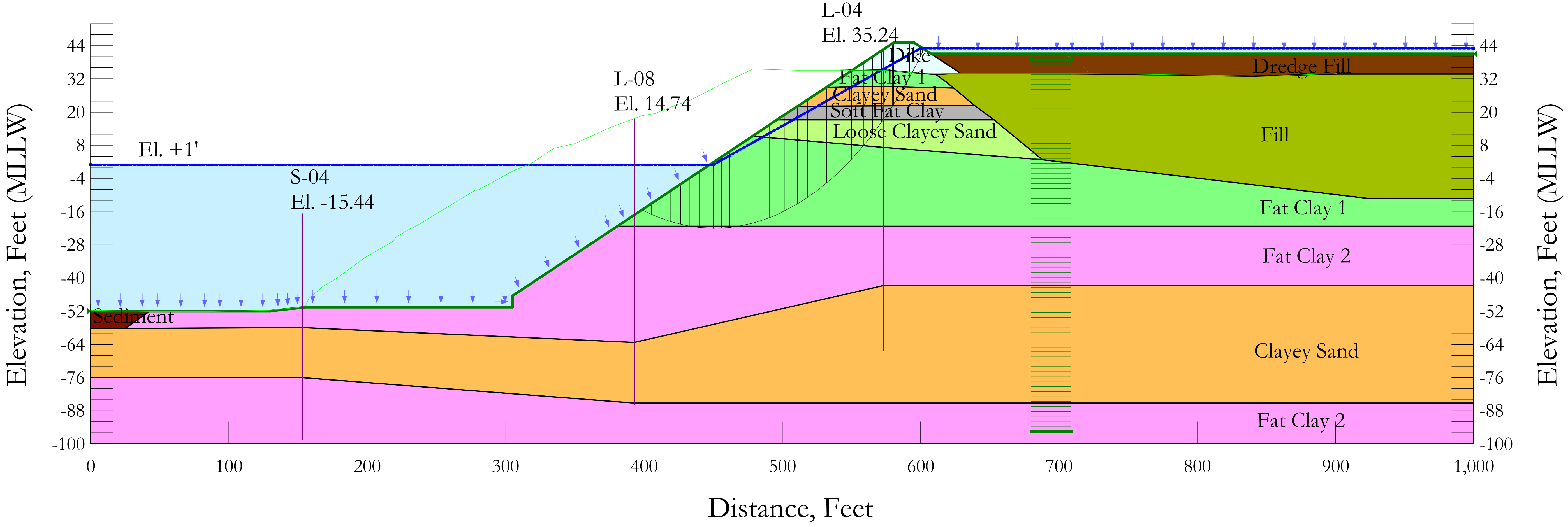
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	427.94239	-7.6078082	537.12723	959.93795	0	1,000
Slice 2	433.53028	-9.9223875	681.55698	1,423.4743	0	1,000
Slice 3	439.11817	-12.236967	825.98673	1,895.1647	0	1,000
Slice 4	444.70606	-14.551546	970.41649	2,373.3783	0	1,000
Slice 5	448.75	-16.226603	1,074.94	2,750.186	0	1,000
Slice 6	453.23023	-18.082375	1,182.0308	3,240.8575	0	1,000
Slice 7	459.1804	-19.225411	1,323.9	3,175.4753	0	1,000
Slice 8	464.62029	-18.835472	1,367.7153	3,351.2601	0	1,000
Slice 9	470.06017	-18.445534	1,411.5306	3,523.0101	0	1,000
Slice 10	475.50006	-18.055596	1,455.3459	3,690.7817	0	1,000
Slice 11	481.18333	-17.648211	1,501.1215	3,845.9281	0	1,000
Slice 12	487.11	-17.223379	1,548.8576	3,988.2351	0	1,000
Slice 13	493.03667	-16.798548	1,596.5937	4,126.5525	0	1,000
Slice 14	499	-16.371088	1,644.6251	4,264.5979	0	1,000
Slice 15	504.25	-15.994761	1,686.911	4,385.7416	0	1,000
Slice 16	508.75	-15.672195	1,723.156	4,487.7787	0	1,000
Slice 17	513.93495	-15.30053	1,764.918	4,609.5226	0	1,000
Slice 18	519.80486	-14.879767	1,812.1968	4,750.8204	0	1,000
Slice 19	525.67476	-14.459005	1,859.4757	4,890.9388	0	1,000
Slice 20	530.30486	-14.127113	1,896.7686	5,001.0491	0	1,000
Slice 21	535.9417	-13.723056	1,942.1703	5,140.816	0	1,000
Slice 22	542.41255	-10.91136	1,853.7611	3,888.6042	0	1,000
Slice 23	547.47085	-5.85306	1,613.4463	3,573.9822	0	1,000
Slice 24	551.38877	-1.9351372	1,427.3097	3,281.4526	0	1,000
Slice 25	554.85003	1.5261235	1,262.8686	2,940.1924	0	1,000
Slice 26	558.99501	5.6710991	1,065.9449	2,523.2701	0	1,000
Slice 27	563.44123	10.117323	854.70919	2,239.9648	736.55349	0

Slice 28	568.18871	14.864795	629.16148	1,857.3787	653.05466	0
Slice 29	571.78122	18.457311	458.48462	1,719.9198	0	300
Slice 30	574.2839	20.95999	339.58478	1,466.8819	0	300
Slice 31	577.9939	24.66999	163.32635	958.21386	458.92852	0
Slice 32	580.92585	27.601939	24.032377	666.73712	371.06576	0
Slice 33	581.95138	28.627467	-24.689456	569.6949	328.91351	0
Slice 34	585.16554	31.841626	-177.39095	-270.80933	0	1,000

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
🟩	Fat Clay 1	125	300	22			
🟧	Clayey Sand	120	0	30			
🟫	Dredge Fill	90	16	15			
⬜	Dike	125	100	25			
🟩	Fill	110			50	10	150
🟪	Fat Clay 2	125	300	22			
🟩	Loose Clayey Sand	110	0	28			
⬜	Soft Fat Clay	115	100	15			
🟥	Sediment	90	16	15			



Long Term 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 212
Date: 4/25/2018
Time: 1:19:25 PM
Tool Version: 8.16.1.13452
File Name: 34+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\
Last Solved Date: 4/25/2018
Last Solved Time: 1:19:52 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 34+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

        - Tension Crack Option: (none)
- F of S Distribution
    - F of S Calculation Option: Constant
- Advanced
    - Number of Slices: 30
    - F of S Tolerance: 0.001
    - Minimum Slip Surface Depth: 0.1 ft
    - Search Method: Linear Search
    - Must Obtain Factor of Safety at Lambda: 0.2
    - Lambda
        - Lambda 1: -1
        - Lambda 2: -0.8
        - Lambda 3: -0.6
        - Lambda 4: -0.4
        - Lambda 5: -0.2
        - Lambda 6: 0
        - Lambda 7: 0.2
        - Lambda 8: 0.4
        - Lambda 9: 0.6
        - Lambda 10: 0.8
        - Lambda 11: 1

Materials

Fat Clay 1

- Model: Mohr-Coulomb
- Unit Weight: 125 pcf
- Cohesion': 300 psf
- Phi': 22 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

Clayey Sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 30 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

Dredge Fill

- Model: Mohr-Coulomb
- Unit Weight: 90 pcf
- Cohesion': 16 psf
- Phi': 15 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

Dike

- Model: Mohr-Coulomb

Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill

Model: S=f(depth)
Unit Weight: 110 pcf
C-Top of Layer: 50 psf
C-Rate of Change: 10 (lbs/ft²)/ft
C-Maximum: 150 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (284.0829, 207.5) ft
Lower Left: (284.0829, 62) ft
Lower Right: (596.7434, 62) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (680, 38.97749) ft
Upper Right Coordinate: (709, 38.97749) ft
Lower Left Coordinate: (680, -95.49959) ft
Lower Right Coordinate: (709, -95.49959) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24

Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74
Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	717.6	36.74
Point 56	722	33.7
Point 57	1,000	41.14
Point 58	900	33.75
Point 59	502	10.23641
Point 60	502	17.19722
Point 61	502	19.1605

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay 1	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,58,22,56,30	13,510
Region 4	Loose Clayey Sand	14,31,32,13,60,47,46,59	1,852
Region 5	Soft Fat Clay	47,60,13,32,33,12,48,61	716.27
Region 6	Clayey Sand	33,18,11,49,48,12	748.17
Region 7	Clayey Sand	25,38,1,6,15,24,27,9,3,26	31,487
Region 8	Fat Clay 2	39,38,1,6,15,24,34,35,36,45,44,37,43,42	19,681
Region 9	Fat Clay 1	36,46,59,14,31,23,41,34,35	12,273
Region 10	Sediment	39,40,25,38	212.84
Region 11	Dike	51,50,10,21,20,30,53,52	502.37
Region 12	Dredge Fill	53,54,55,56,30	699.64
Region 13	Dredge Fill	54,55,56,22,58,17,57	2,180.1

Current Slip Surface

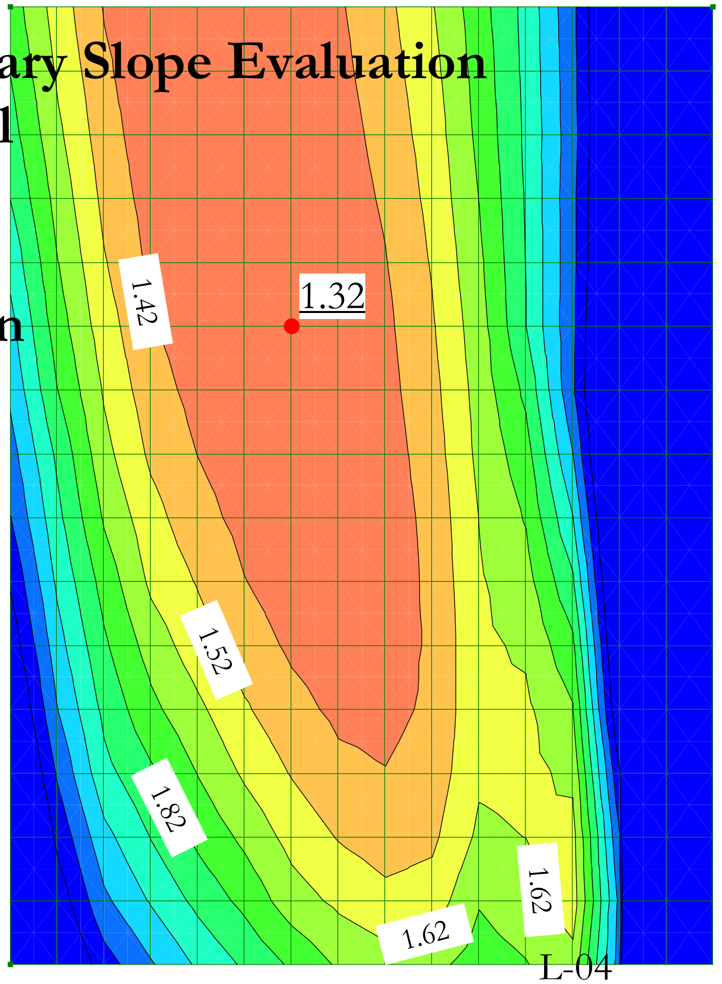
Slip Surface: 16,451
F of S: 1.28
Volume: 5,032.1728 ft³
Weight: 613,740.48 lbs
Resisting Moment: 41,185,895 lbs-ft
Activating Moment: 32,160,169 lbs-ft
Resisting Force: 183,827.35 lbs
Activating Force: 143,640.72 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (398.45088, -15.349708) ft
Entry: (602.53941, 42.766864) ft
Radius: 210.08545 ft
Center: (450.83517, 188.1) ft

Slip Slices

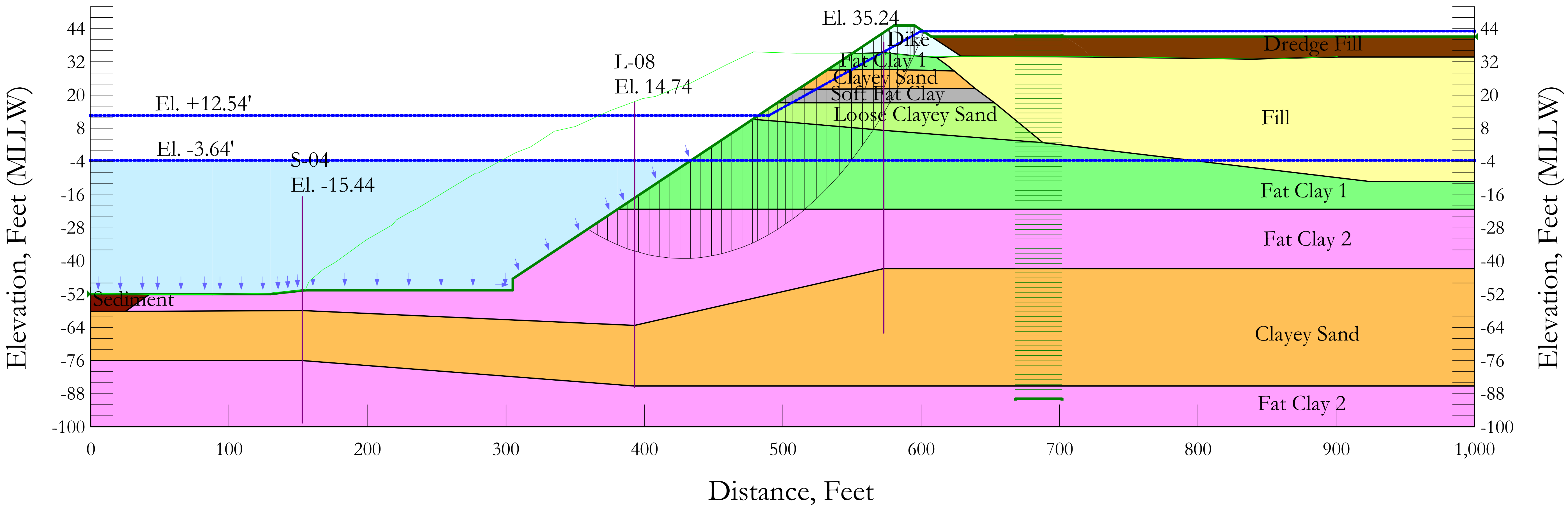
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	401.94492	-16.185912	1,072.4009	1,300.3522	92.098288	300
Slice 2	408.93301	-17.733409	1,168.9647	1,712.7653	219.70969	300
Slice 3	415.9211	-19.033652	1,250.0999	2,088.6933	338.81373	300
Slice 4	422.90918	-20.09128	1,316.0959	2,422.8434	447.15502	300
Slice 5	429.89727	-20.909979	1,367.1827	2,710.708	542.81944	300
Slice 6	436.91849	-21.494198	1,403.6379	2,949.8552	624.71235	300
Slice 7	443.97283	-21.843687	1,425.4461	3,137.7606	691.81995	300
Slice 8	448.75	-21.971385	1,433.4144	3,268.8132	741.54927	300
Slice 9	453.0465	-21.951721	1,376.9218	3,439.9431	833.51471	300
Slice 10	459.13951	-21.799118	1,467.0945	3,640.7545	878.21564	300
Slice 11	465.23251	-21.469294	1,547.0175	3,803.373	911.62681	300
Slice 12	473.24951	-20.726494	1,634.3166	3,956.0858	938.05563	300
Slice						

13	481.79753	-19.659829	1,711.513	4,043.9671	942.37261	300
Slice 14	488.0313	-18.648788	1,754.3246	4,049.4648	927.29683	300
Slice 15	493.34377	-17.622045	1,781.259	4,030.2897	908.6674	300
Slice 16	499	-16.366493	1,800.5455	3,991.4548	885.18482	300
Slice 17	504.83359	-14.906084	1,810.8658	3,934.7338	858.09838	300
Slice 18	509.33359	-13.669228	1,812.4472	3,879.8399	835.28088	300
Slice 19	514.56276	-12.051722	1,803.861	3,805.3313	808.64649	300
Slice 20	521.68827	-9.640772	1,780.1972	3,691.9019	772.37884	300
Slice 21	528.62551	-7.0188426	1,741.2725	3,561.1408	735.2745	300
Slice 22	535	-4.3615734	1,691.1602	3,427.9443	701.70634	300
Slice 23	541	-1.6239249	1,630.3146	3,290.7214	670.8479	300
Slice 24	547	1.3465904	1,556.0009	3,138.2257	639.26031	300
Slice 25	554.36877	5.3666485	1,443.2262	2,926.3025	599.20171	300
Slice 26	562.01221	9.8847756	1,306.1082	2,744.4569	764.78355	0
Slice 27	568.56155	14.143796	1,166.199	2,568.6799	745.71232	0
Slice 28	572.41811	16.772898	1,076.8048	2,457.245	733.99308	0
Slice 29	576.39582	19.718064	971.09927	2,419.4896	388.09501	100
Slice 30	580.10582	22.49554	870.74246	2,158.5749	743.53037	0
Slice 31	584.27928	25.916186	740.71788	1,847.956	639.26422	0
Slice 32	590.06928	30.800568	552.30294	1,311.7585	306.83995	300
Slice 33	592.95268	33.384663	449.69996	1,044.0783	240.14442	300
Slice 34	594.66268	34.971089	385.73225	966.68547	270.90294	100
Slice 35	597.71	37.922036	264.57546	598.65915	155.78578	100
Slice 36	600.71	40.884494	140.74359	206.58324	30.701533	100
Slice 37	601.9797	42.187092	59.461489	35.699552	-11.080373	100

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟩	Fat Clay 1	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟫	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟨	Fill (RDD)	110	50	25	100	20	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟩	Loose Clayey Sand	110	0	28	0	28	2
⬜	Soft Fat Clay	115	100	15	150	10	2
🟥	Sediment	90	16	15	50	0	2



RDD 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 212
Date: 4/25/2018
Time: 1:19:25 PM
Tool Version: 8.16.1.13452
File Name: 34+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\
Last Solved Date: 4/25/2018
Last Solved Time: 1:20:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 34+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °

Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Fill (RDD)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 50 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 100 psf
Phi R: 20 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 28 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Soft Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 10 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (598.9835, 251.50812) ft
Lower Left: (314.0476, 251.50812) ft
Lower Right: (314.0476, 57.52096) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (668, 41.5) ft
Upper Right Coordinate: (702, 41.5) ft
Lower Left Coordinate: (668, -90) ft
Lower Right Coordinate: (702, -90) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	490	12.54
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64
Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74

Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	717.6	36.74
Point 56	722	33.7
Point 57	1,000	41.14
Point 58	900	33.75
Point 59	502	10.23641
Point 60	502	17.19722
Point 61	502	19.1605

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay 1	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2	26,3,9,27,28,29	17,271
Region 3	Fill (RDD)	20,19,18,33,32,31,23,41,17,58,22,56,30	13,510
Region 4	Loose Clayey Sand	14,31,32,13,60,47,46,59	1,852
Region 5	Soft Fat Clay	47,60,13,32,33,12,48,61	716.27
Region 6	Clayey Sand	33,18,11,49,48,12	748.17
Region 7	Clayey Sand	25,38,1,6,15,24,27,9,3,26	31,487
Region 8	Fat Clay 2	39,38,1,6,15,24,34,35,36,45,44,37,43,42	19,681
Region 9	Fat Clay 1	36,46,59,14,31,23,41,34,35	12,273
Region 10	Sediment	39,40,25,38	212.84
Region 11	Dike	51,50,10,21,20,30,53,52	502.37
Region 12	Dredge Fill	53,54,55,56,30	699.64
Region 13	Dredge Fill	54,55,56,22,58,17,57	2,180.1

Current Slip Surface

Slip Surface: 7,723

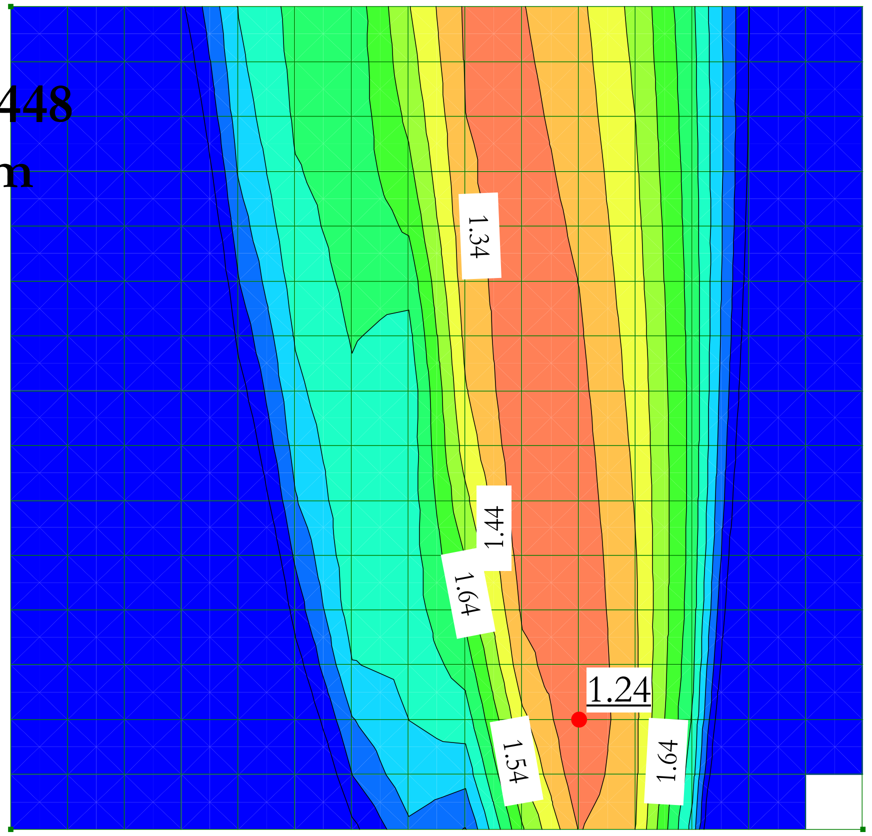
F of S: 1.32
Volume: 7,746.3833 ft³
Weight: 951,927.47 lbs
Resisting Moment: 67,394,522 lbs-ft
Activating Moment: 50,996,206 lbs-ft
Resisting Force: 274,208.54 lbs
Activating Force: 207,704.33 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (359.2212, -28.426266) ft
Entry: (602.22578, 42.871406) ft
Radius: 225.99907 ft
Center: (428.02196, 186.84573) ft

Slip Slices

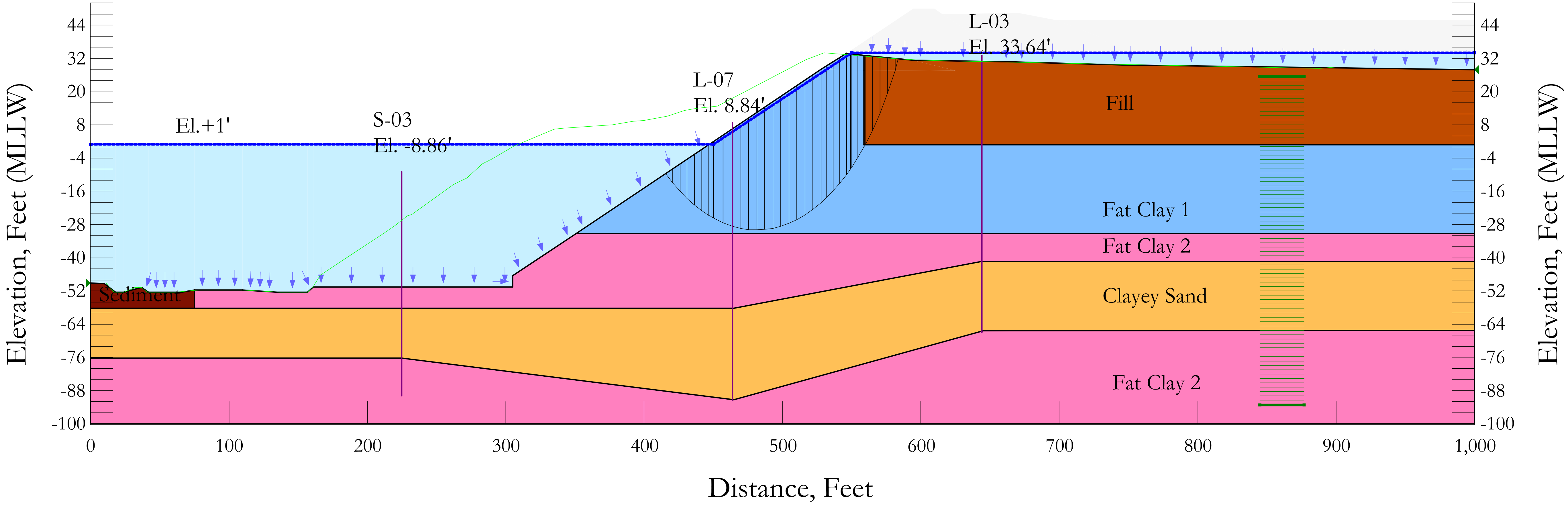
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	362.80433	-29.506373	1,614.0617	1,882.7638	108.56271	300
Slice 2	369.9706	-31.538954	1,740.8947	2,377.0461	257.02187	300
Slice 3	377.13687	-33.31957	1,852.0052	2,834.7415	397.05125	300
Slice 4	384.49571	-34.88888	1,949.9301	3,261.6047	529.95093	300
Slice 5	392.04714	-36.238923	2,034.1728	3,650.7895	653.15554	300
Slice 6	399.59857	-37.326531	2,102.0395	3,986.4353	761.34531	300
Slice 7	407.15	-38.155513	2,153.768	4,266.0549	853.41932	300
Slice 8	414.70143	-38.728724	2,189.5364	4,488.4487	928.82088	300
Slice 9	422.25286	-39.048114	2,209.4663	4,653.7416	987.55131	300
Slice 10	429.80429	-39.11476	2,213.625	4,763.3183	1,030.143	300
Slice 11	437.3	-38.93211	2,202.2276	4,907.0222	1,092.8079	300
Slice 12	444.74	-38.503264	2,175.4677	5,086.3962	1,176.0915	300
Slice 13	452.18	-37.827293	2,133.2871	5,204.2738	0	1,425.4463
Slice 14	459.62	-36.901954	2,075.5459	5,284.9218	0	1,418.1188
Slice 15	467.06	-35.724133	2,002.0499	5,325.8877	0	1,402.992
Slice 16	474.5	-34.289791	1,912.547	5,330.8529	0	1,381.59
Slice 17	480.16118	-33.047651	1,835.0374	5,305.531	0	1,358.719
Slice 18	486.05118	-31.53809	1,740.8408	5,234.8919	0	1,354.6535
Slice 19	493	-29.588139	1,619.1639	5,132.5187	0	1,415.9487
Slice 20	499	-27.694964	1,501.0298	5,027.5025	0	1,384.786
Slice 21	504.37597	-25.849521	1,385.8741	4,923.4629	0	1,356.318
Slice 22	508.87597	-24.182781	1,281.8695	4,826.8826	0	1,331.5183
Slice 23	513.57792	-22.314487	1,165.288	4,721.0505	0	1,306.4118
Slice						

24	520.33097	-19.391268	982.87914	4,556.821	0	1,270.7796
Slice 25	528.25305	-15.66804	750.54969	4,345.537	0	1,228.1001
Slice 26	536.40981	-11.402578	484.38484	4,102.8958	0	1,183.7828
Slice 27	545.22943	-6.3158058	166.97028	3,812.2123	0	1,135.2413
Slice 28	549.6568	-3.6287898	-0.69951682	3,658.3376	0	1,110.7177
Slice 29	549.83718	-3.5133848	-7.9007856	3,651.5353	0	1,109.6475
Slice 30	553.90149	-0.79181787	-177.72656	3,488.5634	0	1,084.5446
Slice 31	561.70446	4.6888026	-519.71728	3,156.3251	0	1,034.7943
Slice 32	568.57637	9.9117232	-845.62753	2,656.0974	1,412.2721	0
Slice 33	572.2734	12.873868	-1,030.4654	2,513.4291	1,336.414	0
Slice 34	575.18965	15.355434	-1,185.3151	2,391.8436	1,271.7658	0
Slice 35	578.89965	18.597911	-1,387.6456	2,622.9223	0	511.36403
Slice 36	581.65719	21.108144	-1,544.2842	2,440.08	0	490.53955
Slice 37	586.36545	25.664964	-1,828.6297	1,639.4861	946.55773	0
Slice 38	590.91826	30.199836	-2,111.6058	1,208.2295	488.15642	300
Slice 39	593.35191	32.775446	-2,272.3238	961.82461	388.60237	300
Slice 40	595.06191	34.619091	-2,387.3673	873.60105	407.36686	100
Slice 41	597.71	37.615969	-2,574.3725	535.81034	249.85247	100
Slice 42	600.71	41.060935	-2,789.3383	175.17518	0	126.78127
Slice 43	601.82289	42.386682	-2,872.065	-0.40095205	0	85.635321

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	120	0	30	
🟦	Fat Clay 1 (U)	125			1,000
🟪	Fat Clay 2 (U)	125			2,200
🟧	Fill (U)	110			300
🟫	Sediment (U)	90			50



Short Term 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 154
Date: 2/16/2018
Time: 9:19:35 AM
Tool Version: 8.16.1.13452
File Name: 44+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\
Last Solved Date: 2/16/2018
Last Solved Time: 9:20:02 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 44+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 2,200 psf

Pore Water Pressure

Piezometric Line: 1

Fill (U)

Model: Undrained (Phi=0)

Unit Weight: 110 pcf

Cohesion: 300 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (245.9759, 233.47631) ft
Lower Left: (245.9759, 63.16979) ft
Lower Right: (598.7619, 63.16979) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (845.056, 25.44217) ft
Upper Right Coordinate: (877.0413, 25.44217) ft
Lower Left Coordinate: (845.056, -93.25256) ft
Lower Right Coordinate: (877.0413, -93.25256) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 27.94) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	550	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26

Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	705.5	44.34
Point 11	730.5	39.54
Point 12	742.5	33.2
Point 13	1,000	46
Point 14	999.9742	-11.27583
Point 15	1,000	-66.26
Point 16	0	-76.26
Point 17	0	-100
Point 18	1,000	-100
Point 19	1,000	-41.26
Point 20	644	-41.26
Point 21	0	-58.26
Point 22	1,000	-31.26
Point 23	644	-31.26
Point 24	464	-31.26
Point 25	135	-52.4
Point 26	1,000	0.74
Point 27	644	0.74
Point 28	464	0.74
Point 29	559	27.72993
Point 30	559	0.74
Point 31	559	33.14
Point 32	110	-51.6
Point 33	75	-51.6
Point 34	75	-58.26
Point 35	0	-49.2
Point 36	305	-50.5
Point 37	305	-46.5
Point 38	350.72	-31.26
Point 39	446.72	0.74
Point 40	546.2	33.9
Point 41	161	-50.5
Point 42	157	-52.4
Point 43	42	-52.4
Point 44	66	-52.4
Point 45	37	-50.8
Point 46	24	-52.4
Point 47	18	-52.5
Point 48	10	-49.29
Point 49	527.69	28
Point 50	594.5	50
Point 51	609.5	50
Point 52	745.7421	29.59999
Point 53	667.28	30.74
Point 54	615.5	48

Point 55	670.5	48.4
Point 56	696.5	46

Regions

	Points	Area (ft²)	Material
Region 1	56,10,11,12,52,6,13	4,652.7	
Region 2	15,5,4,2,16,17,18	25,013	Fat Clay 2 (U)
Region 3	15,19,20,3,1,34,21,16,2,4,5	24,300	Clayey Sand
Region 4	19,22,23,24,38,37,36,41,42,25,32,33,34,1,3,20	12,506	Fat Clay 2 (U)
Region 5	38,24,23,22,26,27,30,28,39	19,241	Fat Clay 1 (U)
Region 6	29,49,39,28,30	1,952.9	Fat Clay 1 (U)
Region 7	29,7,8,9,31	219.6	Fill (U)
Region 8	29,49,40,31	129.49	Fat Clay 1 (U)
Region 9	34,33,44,43,45,46,47,48,35,21	500.79	Sediment (U)
Region 10	9,8,7,29,30,27,26,6,52,53	12,543	Fill (U)
Region 11	50,40,31,9,53,54,51	1,273	
Region 12	54,55,56,10,11,12,52,53	1,465.7	

Current Slip Surface

Slip Surface: 3,228
F of S: 1.24
Volume: 5,608.764 ft³
Weight: 694,309.43 lbs
Resisting Moment: 19,428,322 lbs-ft
Activating Moment: 15,724,834 lbs-ft
Resisting Force: 151,256.97 lbs
Activating Force: 122,408.52 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (415.62871, -9.6237642) ft
Entry: (583.65515, 31.91661) ft
Radius: 115.82603 ft
Center: (481.16657, 85.877326) ft

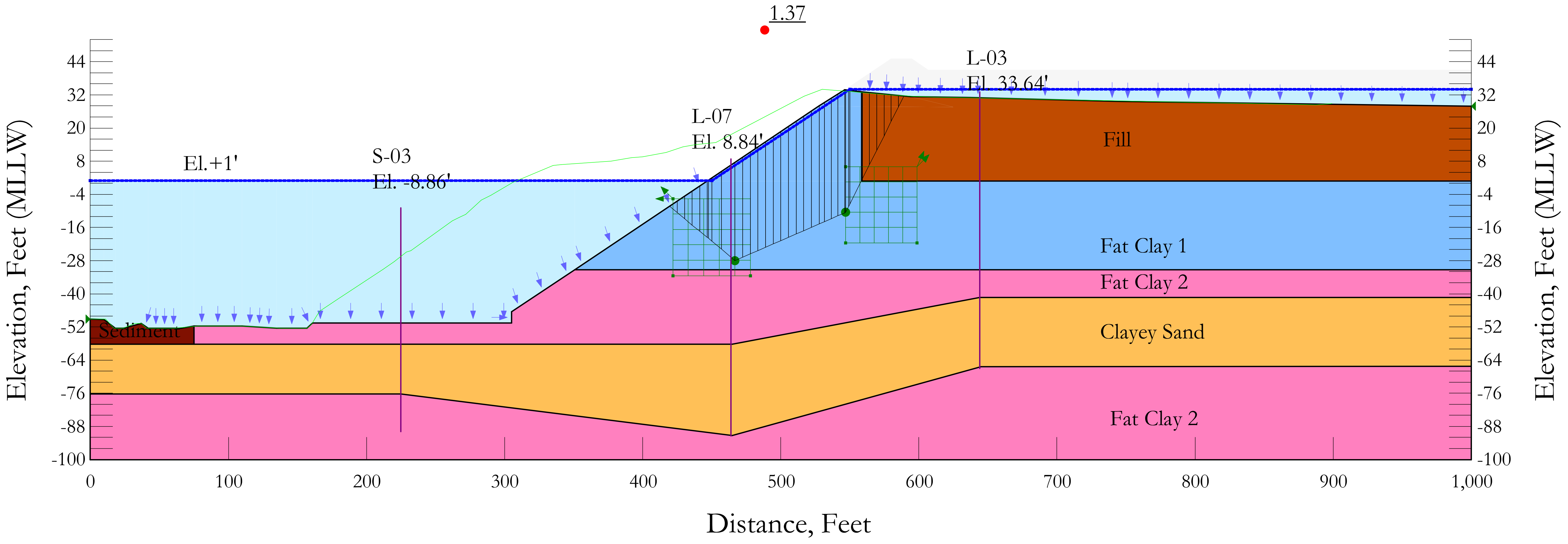
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	418.21965	-11.30202	767.64602	1,488.8225	0	1,000
Slice 2	423.40153	-14.471727	965.43576	2,015.7695	0	1,000
Slice 3	428.58341	-17.28383	1,140.911	2,505.329	0	1,000
Slice 4	433.76529	-19.767003	1,295.861	2,953.2314	0	1,000
Slice 5	438.94718	-21.944055	1,431.709	3,355.8723	0	1,000
Slice 6	444.12906	-23.833267	1,549.5959	3,710.4835	0	1,000
Slice 7	447.10614	-24.826753	1,611.5894	3,896.5425	0	1,000
Slice 8	448.74614	-25.311159	1,641.8163	4,016.937	0	1,000
Slice 9	453.5	-26.538146	1,614.6202	4,358.9126	0	1,000
Slice 10	460.5	-28.034522	1,828.8125	4,797.1332	0	1,000
Slice	466.895	-29.029076	2,003.5316	5,120.8754	0	1,000

11						
Slice 12	472.685	-29.601269	2,143.2489	5,348.3649	0	1,000
Slice 13	478.475	-29.881212	2,266.5207	5,518.714	0	1,000
Slice 14	484.265	-29.87103	2,373.4666	5,635.6709	0	1,000
Slice 15	490.055	-29.570646	2,464.0823	5,703.4937	0	1,000
Slice 16	495.845	-28.977778	2,538.2393	5,726.631	0	1,000
Slice 17	501.635	-28.087849	2,595.6801	5,709.4216	0	1,000
Slice 18	507.425	-26.893807	2,636.0079	5,655.8222	0	1,000
Slice 19	513.215	-25.385834	2,658.6701	5,569.161	0	1,000
Slice 20	519.005	-23.550911	2,662.9343	5,451.9124	0	1,000
Slice 21	524.795	-21.372201	2,647.8528	5,305.4734	0	1,000
Slice 22	529.70151	-19.266004	2,620.4457	5,157.1072	0	1,000
Slice 23	534.12752	-17.095654	2,580.5057	4,995.8587	0	1,000
Slice 24	538.95651	-14.463233	2,522.0473	4,799.4159	0	1,000
Slice 25	543.7855	-11.520304	2,446.116	4,577.4806	0	1,000
Slice 26	547.68186	-8.9283062	2,372.6136	4,315.4583	0	1,000
Slice 27	549.58186	-7.5825481	2,586.1407	4,138.0288	0	1,000
Slice 28	552.25	-5.5266699	2,466.4642	3,874.3425	0	1,000
Slice 29	556.75	-1.8380796	2,236.2962	3,391.1434	0	1,000
Slice 30	559.34938	0.42036075	2,095.3695	2,645.9016	0	1,000
Slice 31	562.39915	3.3996246	1,909.4634	2,778.35	0	300
Slice 32	567.79993	9.1065539	1,553.351	2,205.2272	0	300
Slice 33	573.20071	15.695039	1,142.2295	1,523.0967	0	300
Slice 34	578.60149	23.450986	658.25849	674.01705	0	300
Slice 35	582.47852	29.791181	262.63034	-68.89532	0	300

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	120	0	30	
🟦	Fat Clay 1 (U)	125			1,000
🟪	Fat Clay 2 (U)	125			2,200
🟧	Fill (U)	110			300
🟫	Sediment (U)	90			50



Short Term - Block 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 181
Date: 4/25/2018
Time: 4:08:34 PM
Tool Version: 8.16.1.13452
File Name: 44+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\
Last Solved Date: 4/25/2018
Last Solved Time: 4:09:52 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block 44+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 1 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
    Piezometric Line: 1

Fill (U)

Model: Undrained (Phi=0)
Unit Weight: 110 pcf
Cohesion: 300 psf
Pore Water Pressure

  - Piezometric Line: 1

Sediment (U)

- Model: Undrained (Phi=0)
- Unit Weight: 90 pcf
- Cohesion: 50 psf
- Pore Water Pressure
  - Piezometric Line: 1

Slip Surface Limits

- Left Coordinate: (0, -49.2) ft
- Right Coordinate: (1,000, 27.94) ft

Slip Surface Block

- Left Grid
  - Upper Left: (422.0035, -5.60585) ft
  - Lower Left: (422.0035, -33.52792) ft
  - Lower Right: (478.0903, -33.52792) ft
  - X Increments: 5
  - Y Increments: 5
  - Starting Angle: 135 °
  - Ending Angle: 180 °
  - Angle Increments: 2
- Right Grid
  - Upper Left: (546.98, 6.04062) ft
  - Lower Left: (546.98, -21.58966) ft
  - Lower Right: (598.6636, -21.58966) ft
  - X Increments: 5
  - Y Increments: 5
  - Starting Angle: 45 °
  - Ending Angle: 65 °
  - Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	550	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26

Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	464	0.74
Point 26	559	27.72993
Point 27	559	0.74
Point 28	559	33.14
Point 29	110	-51.6
Point 30	75	-51.6
Point 31	75	-58.26
Point 32	0	-49.2
Point 33	305	-50.5
Point 34	305	-46.5
Point 35	350.72	-31.26
Point 36	446.72	0.74
Point 37	546.2	33.9
Point 38	161	-50.5
Point 39	157	-52.4
Point 40	42	-52.4
Point 41	66	-52.4
Point 42	37	-50.8
Point 43	24	-52.4
Point 44	18	-52.5
Point 45	10	-49.29
Point 46	527.69	28
Point 47	579.92	45.14
Point 48	594.92	45.14
Point 49	745.7421	29.59999
Point 50	637.13	31.07
Point 51	606.92	41.14
Point 52	696.5	41.14

Regions

	Points	Area (ft²)	Material
Region 1	52,49,6,10	3,429.3	
Region 2	12,5,4,2,13,14,15	25,013	Fat Clay 2 (U)
Region 3	12,16,17,3,1,31,18,13,2,4,5	24,300	Clayey Sand
Region 4	16,19,20,21,35,34,33,38,39,22,29,30,31,1,3,17	12,506	Fat Clay 2 (U)
Region 5	35,21,20,19,23,24,27,25,36	19,241	Fat Clay 1 (U)
Region 6	26,46,36,25,27	1,952.9	Fat Clay 1 (U)
Region 7	26,7,8,9,28	219.6	Fill (U)
Region 8	26,46,37,28	129.49	Fat Clay 1 (U)
Region 9	31,30,41,40,42,43,44,45,32,18	500.79	Sediment (U)
Region 10	9,8,7,26,27,24,23,6,49,50	12,541	Fill (U)
Region 11	47,37,28,9,50,51,48	712.18	
Region 12	51,52,49,50	1,041.5	

Current Slip Surface

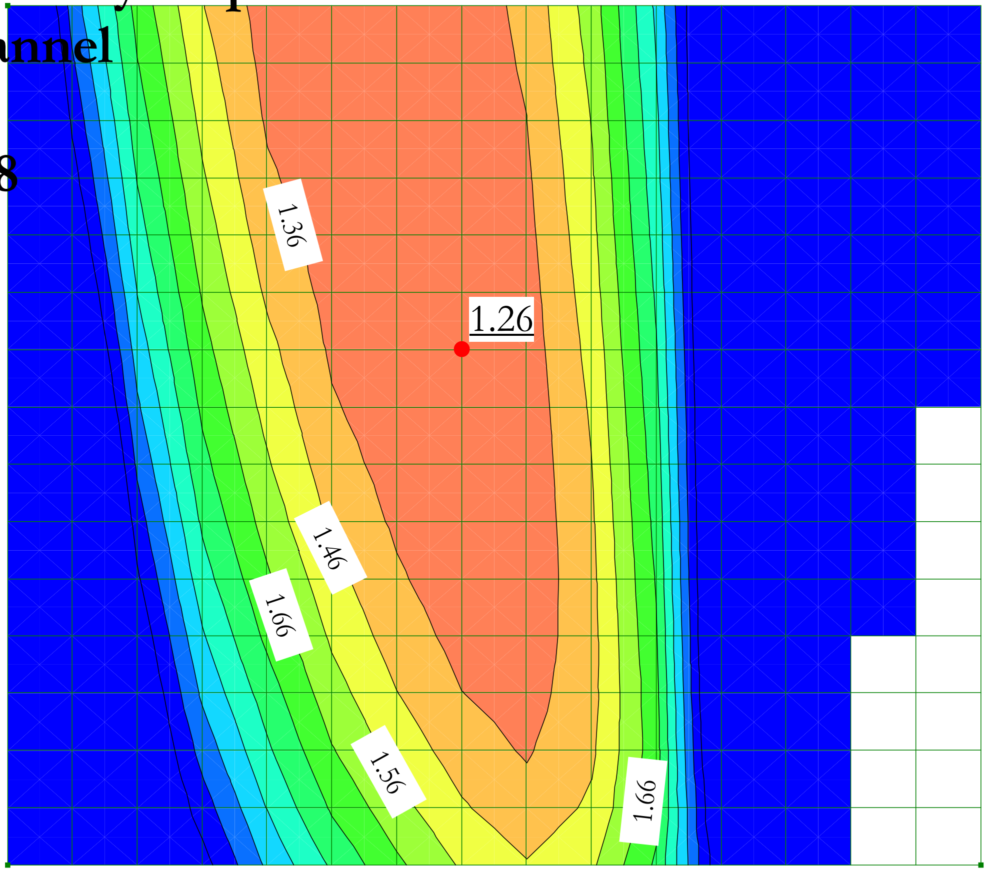
Slip Surface: 3,385
F of S: 1.37
Volume: 4,994.2464 ft³
Weight: 617,119.63 lbs
Resisting Moment: 11,082,461 lbs-ft
Activating Moment: 8,120,684.7 lbs-ft
Resisting Force: 148,531.78 lbs
Activating Force: 108,852.02 lbs
F of S Rank (Analysis): 1 of 11,664 slip surfaces
F of S Rank (Query): 1 of 11,664 slip surfaces
Exit: (419.51651, -8.3278302) ft
Entry: (589.16096, 31.643411) ft
Radius: 82.232873 ft
Center: (497.27528, 41.636222) ft

Slip Slices

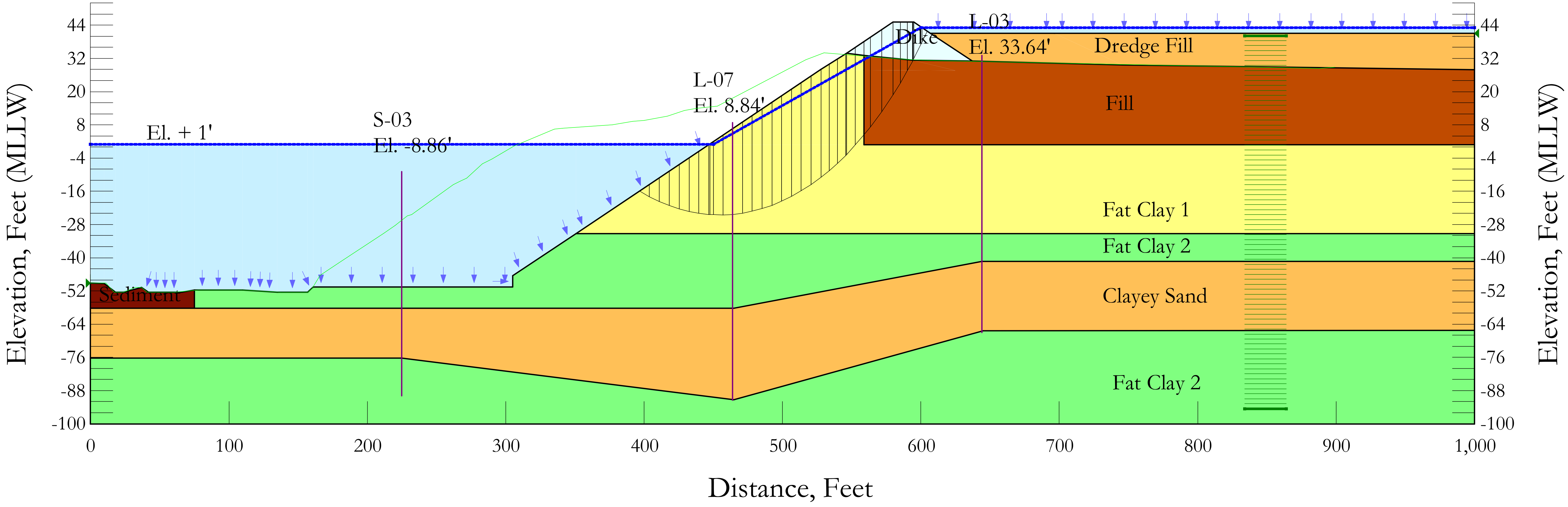
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	422.23686	-9.4546357	652.36927	1,111.9652	0	1,000
Slice 2	427.67756	-11.708247	792.99459	1,570.6873	0	1,000
Slice 3	433.11825	-13.961858	933.61991	2,037.1992	0	1,000
Slice 4	438.55895	-16.215469	1,074.2452	2,509.9923	0	1,000
Slice 5	443.99965	-18.469079	1,214.8706	2,987.1951	0	1,000
Slice 6	447.10614	-19.755828	1,295.1637	3,260.8542	0	1,000
Slice 7	448.74614	-20.435138	1,337.5526	3,434.466	0	1,000
Slice 8	453.5	-22.404253	1,381.9978	3,965.3663	0	1,000
Slice 9	460.5	-25.303748	1,675.1464	4,748.9005	0	1,000
Slice 10	465.43647	-27.348501	1,881.8777	5,299.6067	0	1,000
Slice 11	469.63735	-27.342844	1,959.5688	4,497.7674	0	1,000
Slice 12	475.16618	-26.141521	1,994.6369	4,541.301	0	1,000
Slice 13	480.695	-24.940198	2,029.7049	4,584.0107	0	1,000

Slice 14	486.22382	-23.738875	2,064.773	4,626.4408	0	1,000
Slice 15	491.75265	-22.537551	2,099.841	4,669.1274	0	1,000
Slice 16	497.28147	-21.336228	2,134.9091	4,712.5946	0	1,000
Slice 17	502.81029	-20.134905	2,169.9771	4,757.3504	0	1,000
Slice 18	508.33912	-18.933582	2,205.0452	4,803.8829	0	1,000
Slice 19	513.86794	-17.732259	2,240.1132	4,852.6565	0	1,000
Slice 20	519.39676	-16.530935	2,275.1813	4,904.1084	0	1,000
Slice 21	524.92559	-15.329612	2,310.2494	4,958.6444	0	1,000
Slice 22	529.70151	-14.291881	2,340.5419	5,004.115	0	1,000
Slice 23	534.12752	-13.330182	2,368.6151	5,043.2911	0	1,000
Slice 24	538.95651	-12.280921	2,399.2443	5,088.8378	0	1,000
Slice 25	543.7855	-11.23166	2,429.8735	5,137.5001	0	1,000
Slice 26	546.59	-10.622289	2,447.6617	5,149.2472	0	1,000
Slice 27	548.07186	-9.445686	2,408.9698	4,007.0887	0	1,000
Slice 28	549.58186	-7.935686	2,608.1765	3,860.7744	0	1,000
Slice 29	554.12877	-3.388774	2,333.0595	3,409.7943	0	1,000
Slice 30	558.62877	1.111226	2,052.2595	2,949.0396	0	1,000
Slice 31	561.615	4.097452	1,865.919	2,664.636	0	300
Slice 32	566.845	9.327452	1,539.567	2,196.4871	0	300
Slice 33	572.075	14.557452	1,213.215	1,708.8081	0	300
Slice 34	577.305	19.787452	886.863	1,197.0366	0	300
Slice 35	582.54608	25.028533	559.81955	655.68773	0	300
Slice 36	587.16656	29.649012	271.50162	152.30497	0	300

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Fat Clay 1	125	300	22
🟩	Fat Clay 2	125	300	22
🟧	Clayey Sand	120	0	30
🟧	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟫	Fill	110	100	20
🟫	Sediment	90	16	15



Long Term 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 183
Date: 4/25/2018
Time: 5:03:01 PM
Tool Version: 8.16.1.13452
File Name: 44+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:03:18 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 44+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 300 psf

Phi': 22 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 300 psf

Phi': 22 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 20 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Slip Surface Grid

Upper Left: (267.004, 248.0868) ft
Lower Left: (267.004, 69.98645) ft
Lower Right: (670.0211, 69.98645) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (834.0689, 40.15019) ft
Upper Right Coordinate: (864.0265, 40.15019) ft
Lower Left Coordinate: (834.0689, -94.59981) ft
Lower Right Coordinate: (864.0265, -94.59981) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	464	0.74
Point 26	559	27.72993
Point 27	559	0.74
Point 28	559	33.14
Point 29	110	-51.6

Point 30	75	-51.6
Point 31	75	-58.26
Point 32	0	-49.2
Point 33	305	-50.5
Point 34	305	-46.5
Point 35	350.72	-31.26
Point 36	446.72	0.74
Point 37	546.2	33.9
Point 38	161	-50.5
Point 39	157	-52.4
Point 40	42	-52.4
Point 41	66	-52.4
Point 42	37	-50.8
Point 43	24	-52.4
Point 44	18	-52.5
Point 45	10	-49.29
Point 46	527.69	28
Point 47	579.92	45.14
Point 48	594.92	45.14
Point 49	745.7421	29.59999
Point 50	637.13	31.07
Point 51	606.92	41.14
Point 52	696.5	41.14

Regions

	Material	Points	Area (ft²)
Region 1	Dredge Fill	52,49,6,10	3,429.3
Region 2	Fat Clay 2	12,5,4,2,13,14,15	25,013
Region 3	Clayey Sand	12,16,17,3,1,31,18,13,2,4,5	24,300
Region 4	Fat Clay 2	16,19,20,21,35,34,33,38,39,22,29,30,31,1,3,17	12,506
Region 5	Fat Clay 1	35,21,20,19,23,24,27,25,36	19,241
Region 6	Fat Clay 1	26,46,36,25,27	1,952.9
Region 7	Fill	26,7,8,9,28	219.6
Region 8	Fat Clay 1	26,46,37,28	129.49
Region 9	Sediment	31,30,41,40,42,43,44,45,32,18	500.79
Region 10	Fill	9,8,7,26,27,24,23,6,49,50	12,541
Region 11	Dike	47,37,28,9,50,51,48	712.18
Region 12	Dredge Fill	51,52,49,50	1,041.5

Current Slip Surface

Slip Surface: 11,513
F of S: 1.26
Volume: 5,657.0009 ft³
Weight: 698,965.33 lbs
Resisting Moment: 43,021,295 lbs-ft
Activating Moment: 34,218,470 lbs-ft
Resisting Force: 200,886.28 lbs
Activating Force: 159,993.98 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces

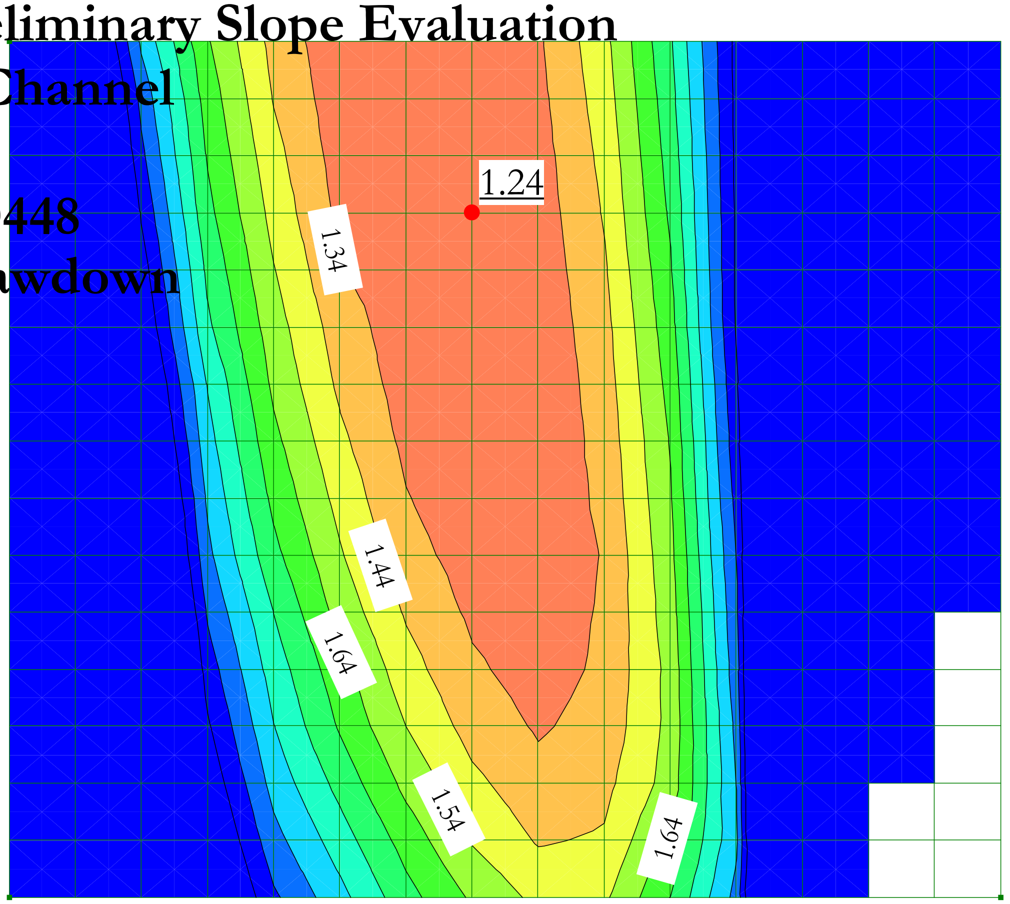
Exit: (396.78039, -15.906538) ft
Entry: (604.57132, 41.922893) ft
Radius: 201.37647 ft
Center: (455.07865, 176.84666) ft

Slip Slices

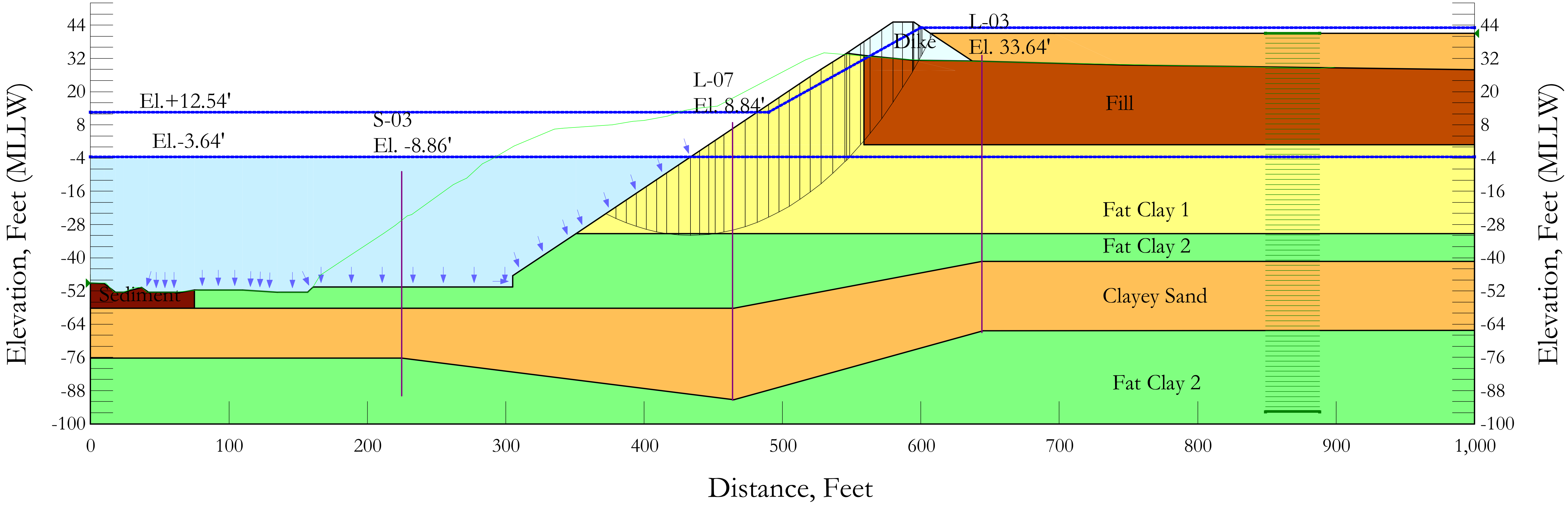
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	400.3475	-16.914133	1,117.8419	1,378.7836	105.4273	300
Slice 2	407.48173	-18.789581	1,234.8699	1,848.7647	248.02959	300
Slice 3	414.61596	-20.389224	1,334.6876	2,278.8558	381.46873	300
Slice 4	421.75019	-21.719737	1,417.7116	2,662.7861	503.04273	300
Slice 5	428.88442	-22.786508	1,484.2781	2,995.156	610.4343	300
Slice 6	436.01865	-23.593755	1,534.6503	3,271.8939	701.89196	300
Slice 7	443.15288	-24.144608	1,569.0235	3,490.5728	776.35633	300
Slice 8	447.10614	-24.371561	1,583.1854	3,591.4362	811.386	300
Slice 9	448.74614	-24.42631	1,586.6017	3,656.4642	836.27873	300
Slice 10	453.5	-24.493201	1,531.2778	3,857.6348	939.90923	300
Slice 11	460.5	-24.42637	1,641.1478	4,096.9755	992.21881	300
Slice 12	467.53833	-24.112716	1,737.3656	4,282.9637	1,028.4884	300
Slice 13	474.615	-23.548387	1,819.7084	4,417.5726	1,049.6053	300
Slice 14	481.69167	-22.731614	1,887.4509	4,503.3015	1,056.8722	300
Slice 15	488.76833	-21.659278	1,940.4129	4,544.6169	1,052.1667	300
Slice 16	495.845	-20.327203	1,978.3527	4,546.303	1,037.5193	300
Slice 17	502.92167	-18.730075	2,000.9631	4,513.1046	1,014.9711	300
Slice 18	509.99833	-16.861328	2,007.8643	4,449.42	986.45255	300
Slice 19	517.075	-14.713001	1,998.5958	4,359.0527	953.6865	300
Slice 20	524.15167	-12.275551	1,972.6059	4,245.0222	918.11579	300
Slice 21	530.66826	-9.77694	1,933.9786	4,116.2664	881.70149	300
Slice 22	536.62478	-7.2514151	1,884.6946	3,976.3141	845.06912	300
Slice 23	542.58129	-4.4951015	1,822.0629	3,822.2704	808.13627	300
Slice 24	545.87978	-2.896237	1,783.1854	3,733.75	788.07927	300
Slice 25	549.47304	-0.99723414	1,731.7387	3,629.9516	766.92779	300
Slice 26	555.87304	2.5482794	1,630.669	3,437.8569	730.15129	300
Slice 27	561.29655	5.7825449	1,531.7346	3,007.6787	537.1997	100
Slice 28	567.67483	9.9624553	1,393.6213	2,840.6015	526.65773	100

Slice 29	575.83828	15.776585	1,189.9975	2,594.5424	511.21253	100
Slice 30	582.51961	20.962055	998.65116	2,275.2149	464.63117	100
Slice 31	587.71882	25.363563	828.56437	1,891.5094	386.88035	100
Slice 32	592.07656	29.271936	673.32614	1,548.9069	318.68532	100
Slice 33	594.07038	31.128873	598.32483	1,384.9289	286.30046	100
Slice 34	594.3341	31.380509	588.0561	1,362.4736	281.86491	100
Slice 35	594.64106	31.675501	575.98265	1,292.0102	333.88913	100
Slice 36	597.46	34.483996	459.35398	936.5105	222.50174	100
Slice 37	600.46	37.504266	351.66982	551.87435	93.356903	100
Slice 38	602.74566	39.953547	198.83465	250.74598	24.206653	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Fat Clay 1	125	300	22	500	15	2
🟩	Fat Clay 2	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟧	Dredge Fill	90	16	15	50	0	2
🟦	Dike	125	100	25	150	22	2
🟫	Fill	110	100	20	150	15	2
🟫	Sediment	90	16	15	50	0	2



RDD 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 183
Date: 4/25/2018
Time: 5:03:01 PM
Tool Version: 8.16.1.13452
File Name: 44+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:03:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 44+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: Yes

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

- Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Linear Search
  - Must Obtain Factor of Safety at Lambda: 0.2
  - Lambda
    - Lambda 1: -1
    - Lambda 2: -0.8
    - Lambda 3: -0.6
    - Lambda 4: -0.4
    - Lambda 5: -0.2
    - Lambda 6: 0
    - Lambda 7: 0.2
    - Lambda 8: 0.4
    - Lambda 9: 0.6
    - Lambda 10: 0.8
    - Lambda 11: 1

Materials

Fat Clay 1

- Model: Mohr-Coulomb
- Unit Weight: 125 pcf
- Cohesion': 300 psf
- Phi': 22 °
- Phi-B: 0 °
- Cohesion R: 500 psf
- Phi R: 15 °
- Pore Water Pressure
  - Piezometric Line: 1
  - Piezometric Line After Drawdown: 2

Fat Clay 2

- Model: Mohr-Coulomb
- Unit Weight: 125 pcf
- Cohesion': 300 psf
- Phi': 22 °
- Phi-B: 0 °
- Cohesion R: 500 psf
- Phi R: 15 °
- Pore Water Pressure
  - Piezometric Line: 1
  - Piezometric Line After Drawdown: 2

Clayey Sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 20 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (242.2658, 249.51717) ft
Lower Left: (242.2658, 72.20246) ft
Lower Right: (653.0031, 72.20246) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (848.9456, 41.02998) ft
Upper Right Coordinate: (888.1061, 41.02998) ft
Lower Left Coordinate: (848.9456, -95.69264) ft
Lower Right Coordinate: (888.1061, -95.69264) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	490	12.54
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64
Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26

Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	464	0.74
Point 26	559	27.72993
Point 27	559	0.74
Point 28	559	33.14
Point 29	110	-51.6
Point 30	75	-51.6
Point 31	75	-58.26
Point 32	0	-49.2
Point 33	305	-50.5
Point 34	305	-46.5
Point 35	350.72	-31.26
Point 36	446.72	0.74
Point 37	546.2	33.9
Point 38	161	-50.5
Point 39	157	-52.4
Point 40	42	-52.4
Point 41	66	-52.4
Point 42	37	-50.8
Point 43	24	-52.4
Point 44	18	-52.5
Point 45	10	-49.29
Point 46	527.69	28
Point 47	579.92	45.14
Point 48	594.92	45.14
Point 49	745.7421	29.59999
Point 50	637.13	31.07
Point 51	606.92	41.14
Point 52	696.5	41.14

Regions

	Material	Points	Area (ft²)
Region 1	Dredge Fill	52,49,6,10	3,429.3
Region 2	Fat Clay 2	12,5,4,2,13,14,15	25,013
Region 3	Clayey Sand	12,16,17,3,1,31,18,13,2,4,5	24,300
Region 4	Fat Clay 2	16,19,20,21,35,34,33,38,39,22,29,30,31,1,3,17	12,506
Region 5	Fat Clay 1	35,21,20,19,23,24,27,25,36	19,241
Region 6	Fat Clay 1	26,46,36,25,27	1,952.9
Region 7	Fill	26,7,8,9,28	219.6
Region 8	Fat Clay 1	26,46,37,28	129.49
Region 9	Sediment	31,30,41,40,42,43,44,45,32,18	500.79
Region 10	Fill	9,8,7,26,27,24,23,6,49,50	12,541
Region 11	Dike	47,37,28,9,50,51,48	712.18
Region 12	Dredge Fill	51,52,49,50	1,041.5

Current Slip Surface

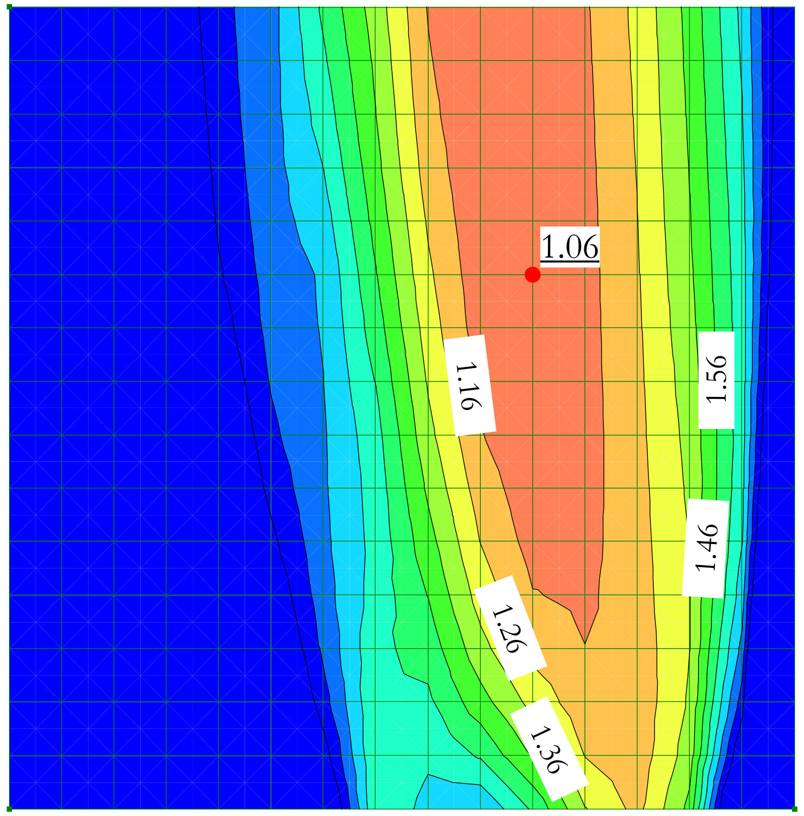
Slip Surface: 15,165
F of S: 1.24
Volume: 6,884.4109 ft³
Weight: 850,832.03 lbs
Resisting Moment: 62,809,883 lbs-ft
Activating Moment: 50,793,186 lbs-ft
Resisting Force: 240,467.31 lbs
Activating Force: 194,593.44 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (372.34786, -24.050712) ft
Entry: (608.83923, 41.14) ft
Radius: 245.94298 ft
Center: (433.94321, 214.05423) ft

Slip Slices

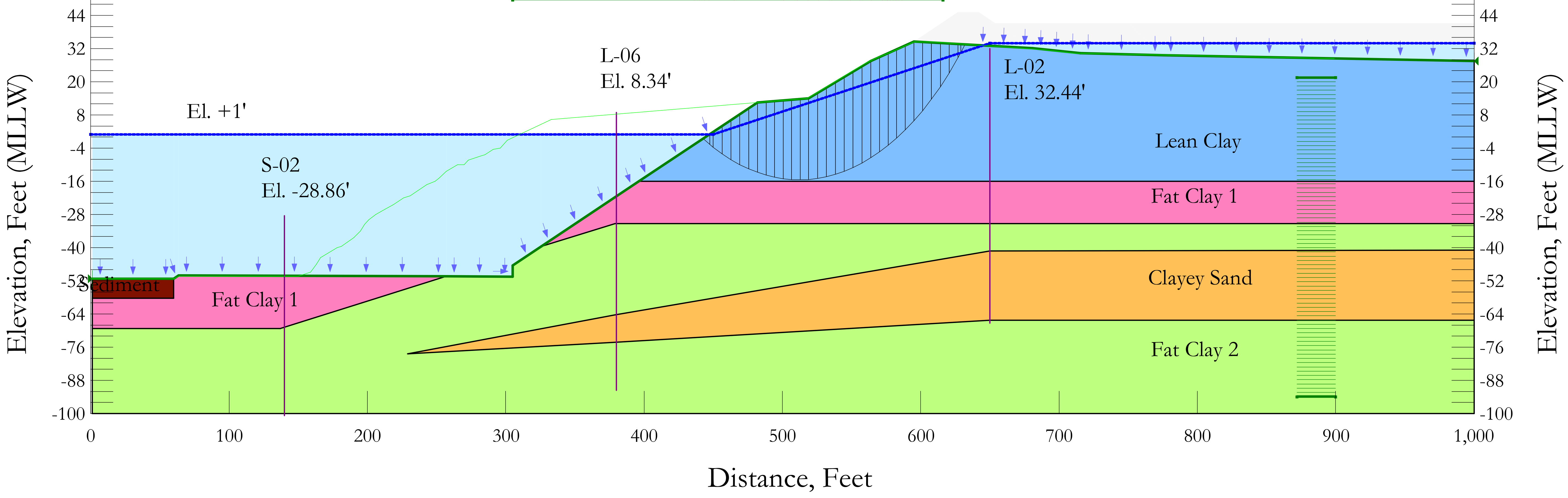
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	376.01623	-24.939845	1,329.1103	1,569.6789	97.196022	300
Slice 2	383.35297	-26.60014	1,432.7127	2,008.9433	232.81227	300
Slice 3	390.6897	-28.026743	1,521.7328	2,414.3349	360.63465	300
Slice 4	398.02644	-29.22377	1,596.4272	2,781.3348	478.73373	300
Slice 5	405.36317	-30.194598	1,657.0069	3,105.9349	585.40489	300
Slice 6	412.69991	-30.941921	1,703.6398	3,384.9046	679.27505	300
Slice 7	420.6712	-31.492577	1,738.0008	3,632.1123	765.27074	300
Slice 8	429.27707	-31.806818	1,757.6095	3,835.7153	839.60925	300
Slice 9	436.865	-31.849451	1,760.2697	4,040.5563	921.29558	300
Slice 10	443.435	-31.683533	1,749.9165	4,263.1547	1,015.4141	300
Slice 11	449.11907	-31.408324	1,732.7434	4,427.4908	1,088.7486	300
Slice 12	454.63861	-30.996466	1,707.0435	4,538.6526	0	1,304.7827
Slice 13	460.87954	-30.389073	1,669.1422	4,651.4718	0	1,311.0474

Slice 14	468.44234	-29.415745	1,608.4065	4,746.1081	0	1,309.7321
Slice 15	477.32703	-27.990032	1,519.442	4,810.318	0	1,299.0686
Slice 16	485.88469	-26.304472	1,414.263	4,828.5156	0	1,314.0692
Slice 17	493.769	-24.469826	1,299.7811	4,809.7947	0	1,392.8188
Slice 18	501.307	-22.450973	1,173.8047	4,757.2761	0	1,377.1455
Slice 19	508.845	-20.172184	1,031.6083	4,678.8012	0	1,357.4794
Slice 20	516.383	-17.625778	872.71255	4,576.7543	0	1,334.6965
Slice 21	523.921	-14.802811	696.55941	4,452.8793	0	1,309.4946
Slice 22	532.02682	-11.434546	486.37969	4,286.881	0	1,276.9301
Slice 23	540.70045	-7.4579896	238.24255	4,076.7508	0	1,237.4343
Slice 24	545.61864	-5.0715843	89.330861	3,950.6205	0	1,215.0287
Slice 25	547.29304	-4.2076486	35.421273	3,905.2099	0	1,207.5387
Slice 26	552.37124	-1.45	-136.656	3,759.4109	0	1,184.6348
Slice 27	557.6782	1.5095	-321.3288	3,604.0552	0	1,161.1034
Slice 28	561.14376	3.57455	-450.18792	3,230.7557	0	710.29848
Slice 29	567.44563	7.5583835	-698.77913	3,079.7511	0	702.23238
Slice 30	575.76188	13.182366	-1,049.7156	2,854.5675	0	689.376
Slice 31	583.39868	18.780518	-1,399.0403	2,498.2271	0	632.47632
Slice 32	590.35603	24.310573	-1,744.1157	2,010.9622	0	531.08644
Slice 33	594.09693	27.403176	-1,937.0942	1,737.6996	0	475.12458
Slice 34	594.63958	27.870211	-1,966.2372	1,695.8604	0	466.62324
Slice 35	596.49759	29.50179	-2,068.0477	1,497.6136	0	418.60854
Slice 36	598.3436	31.132576	-2,169.8087	1,290.4549	0	367.70719
Slice 37	599.30601	32.004197	-2,224.1979	1,116.4013	0	419.75272
Slice 38	600.46	33.057776	-2,289.9412	987.18573	0	356.51305
Slice 39	603.92	36.35053	-2,495.4091	514.14244	0	260.0248
Slice 40	607.64126	39.939621	-2,719.3684	62.324032	0	98.415584
Slice 41	608.60088	40.899579	-2,779.2697	9.488487	0	14.891707

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay 1(U)	125			1,000
🟩	Fat Clay 2(U)	125			2,200
🟫	Sediment (U)	90			50



Short Term 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 140
Date: 4/25/2018
Time: 4:56:47 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\
Last Solved Date: 4/25/2018
Last Solved Time: 4:57:22 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 56+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 500 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2(U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 2,200 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (305, 208.5) ft
Lower Left: (305, 49.5) ft
Lower Right: (616, 49.5) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (872, 21.5) ft
Upper Right Coordinate: (900, 21.5) ft
Lower Left Coordinate: (872, -94) ft
Lower Right Coordinate: (900, -94) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 27.54) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	650	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96

Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.04	32.1
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	519	13.94
Point 19	1,000	-16.06
Point 20	1,000	-31.26
Point 21	379	-31.26
Point 22	137	-69.26
Point 23	1	-69.26
Point 24	1	-100
Point 25	1,000	-100
Point 26	1,000	-66.26
Point 27	229	-78.46
Point 28	379	-64.26
Point 29	1,000	-40.86
Point 30	60	-51.26
Point 31	63.6	-50.06
Point 32	60	-58.26
Point 33	1	-58.26
Point 34	1	-51.26
Point 35	325.7	-39.6
Point 36	305	-50.5
Point 37	305	-46.5
Point 38	256.9893	-50.4
Point 39	196	-60
Point 40	396.32	-16.06
Point 41	482	12.5
Point 42	715.3	30.4

Regions

	Points	Area (ft²)	Material
Region 1	10,11,12,42,14	982.22	
Region 2	11,13,9,12	2,972.5	
Region 3	15,16,17,10,14	593.84	
Region 4	8,18,41,40,19,9,12,42,14,15	24,082	Lean Clay (U)
Region 5	19,20,21,35,40	9,640.4	Fat Clay 1(U)
Region 6	20,21,35,37,36,38,39,22,23,24,25,26,7,5,27,28,6,29	44,368	Fat Clay 2(U)
Region 7	27,5,7,26,29,6,28	14,319	Clayey Sand
Region 8	30,34,33,32	413	Sediment (U)

Region 9	38,31,30,32,33,23,22,39	3,265.5	Fat Clay 1(U)

Current Slip Surface

Slip Surface: 12,945
F of S: 1.06
Volume: 4,637.457 ft^3
Weight: 579,682.12 lbs
Resisting Moment: 17,468,633 lbs-ft
Activating Moment: 16,428,747 lbs-ft
Resisting Force: 94,704.475 lbs
Activating Force: 89,138.983 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (442.65353, -0.61549053) ft
Entry: (632.06248, 33.466179) ft
Radius: 170.96 ft
Center: (512.33333, 155.5) ft

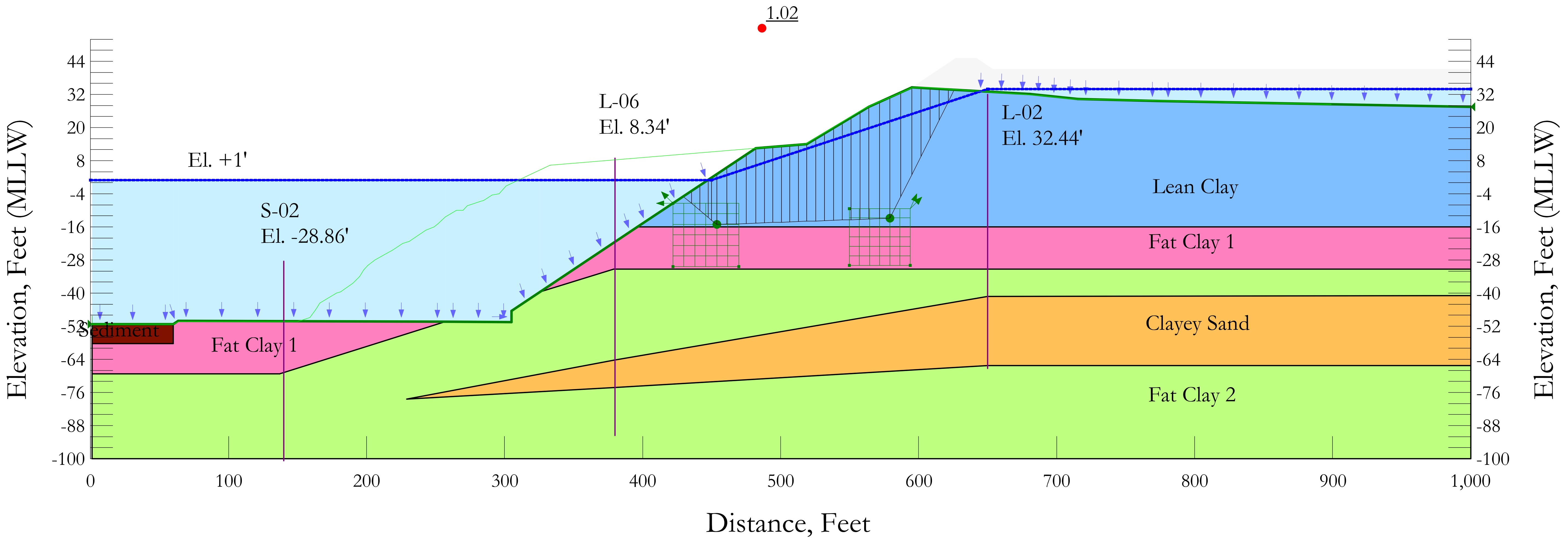
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	445.07676	-1.6525626	165.5199	489.5236	0	500
Slice 2	448.75	-3.1904785	261.48586	783.94013	0	500
Slice 3	453.2	-4.8712513	388.73011	1,182.752	0	500
Slice 4	459.6	-7.0890524	587.60103	1,734.9069	0	500
Slice 5	466	-9.028088	769.53802	2,253.3921	0	500
Slice 6	472.4	-10.698133	935.13483	2,736.0269	0	500
Slice 7	478.8	-12.107241	1,084.8808	3,181.0033	0	500
Slice 8	485.08333	-13.245383	1,216.9971	3,465.1107	0	500
Slice 9	491.25	-14.126533	1,332.3329	3,589.6769	0	500
Slice 10	497.41667	-14.779872	1,433.83	3,678.318	0	500
Slice 11	503.58333	-15.208017	1,521.6474	3,731.8675	0	500
Slice 12	509.75	-15.412664	1,595.8882	3,751.4005	0	500
Slice 13	515.91667	-15.394617	1,656.6011	3,738.1598	0	500
Slice 14	522.21429	-15.143846	1,704.4895	3,796.9004	0	500
Slice 15	528.64286	-14.649624	1,738.9018	3,926.0864	0	500
Slice 16	535.07143	-13.910103	1,758.413	4,021.9173	0	500
Slice 17	541.5	-12.922046	1,762.8267	4,085.8366	0	500
Slice 18	547.92857	-11.681041	1,751.8748	4,119.1834	0	500
Slice 19	554.35714	-10.181395	1,725.2113	4,123.0861	0	500
Slice 20	560.78571	-8.4159968	1,682.4045	4,098.3599	0	500
Slice						

21	567.1	-6.4173381	1,624.2824	4,017.853	0	500
Slice 22	573.3	-4.1852415	1,550.8344	3,882.4783	0	500
Slice 23	579.5	-1.6769563	1,460.609	3,719.9608	0	500
Slice 24	585.7	1.1210073	1,352.7867	3,528.6954	0	500
Slice 25	591.9	4.2247589	1,226.389	3,306.2586	0	500
Slice 26	598.192	7.7096643	1,077.7598	2,947.7022	0	500
Slice 27	604.576	11.610334	904.79655	2,445.3035	0	500
Slice 28	610.96	15.911939	707.4781	1,890.54	0	500
Slice 29	617.344	20.652999	483.46438	1,272.9021	0	500
Slice 30	623.728	25.881962	229.81239	578.72935	0	500
Slice 31	627.95989	29.580077	47.582792	77.395114	0	500
Slice 32	630.53113	32.000572	-73.68118	-256.78897	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay 1(U)	125			1,000
🟩	Fat Clay 2(U)	125			2,200
🟫	Sediment (U)	90			50



Short Term - Block 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 140
Date: 4/25/2018
Time: 4:56:47 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\
Last Solved Date: 4/25/2018
Last Solved Time: 4:58:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block 56+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 500 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 2(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure

  - Piezometric Line: 1

Sediment (U)

- Model: Undrained (Phi=0)
- Unit Weight: 90 pcf
- Cohesion: 50 psf
- Pore Water Pressure
  - Piezometric Line: 1

Slip Surface Limits

- Left Coordinate: (1, -51.26) ft
- Right Coordinate: (1,000, 27.54) ft

Slip Surface Block

- Left Grid
  - Upper Left: (421.9916, -7.48074) ft
  - Lower Left: (421.9916, -30.44074) ft
  - Lower Right: (469.7676, -30.44074) ft
  - X Increments: 6
  - Y Increments: 6
  - Starting Angle: 135 °
  - Ending Angle: 180 °
  - Angle Increments: 2
- Right Grid
  - Upper Left: (549.76, -9.45259) ft
  - Lower Left: (549.76, -29.98398) ft
  - Lower Right: (594.001, -29.98398) ft
  - X Increments: 6
  - Y Increments: 6
  - Starting Angle: 45 °
  - Ending Angle: 65 °
  - Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	650	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96

Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.04	32.1
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	519	13.94
Point 19	1,000	-16.06
Point 20	1,000	-31.26
Point 21	379	-31.26
Point 22	137	-69.26
Point 23	1	-69.26
Point 24	1	-100
Point 25	1,000	-100
Point 26	1,000	-66.26
Point 27	229	-78.46
Point 28	379	-64.26
Point 29	1,000	-40.86
Point 30	60	-51.26
Point 31	63.6	-50.06
Point 32	60	-58.26
Point 33	1	-58.26
Point 34	1	-51.26
Point 35	325.7	-39.6
Point 36	305	-50.5
Point 37	305	-46.5
Point 38	256.9893	-50.4
Point 39	196	-60
Point 40	396.32	-16.06
Point 41	482	12.5
Point 42	715.3	30.4

Regions

	Points	Area (ft²)	Material
Region 1	10,11,12,42,14	982.22	
Region 2	11,13,9,12	2,972.5	
Region 3	15,16,17,10,14	593.84	
Region 4	8,18,41,40,19,9,12,42,14,15	24,082	Lean Clay (U)
Region 5	19,20,21,35,40	9,640.4	Fat Clay 1(U)
Region 6	20,21,35,37,36,38,39,22,23,24,25,26,7,5,27,28,6,29	44,368	Fat Clay 2(U)
Region 7	27,5,7,26,29,6,28	14,319	Clayey Sand

Region 8	30,34,33,32	413	Sediment (U)
Region 9	38,31,30,32,33,23,22,39	3,265.5	Fat Clay 1(U)

Current Slip Surface

Slip Surface: 14,377

F of S: 1.02

Volume: 5,148.2759 ft³

Weight: 643,534.49 lbs

Resisting Moment: 7,285,963.9 lbs-ft

Activating Moment: 7,142,300.3 lbs-ft

Resisting Force: 98,169.322 lbs

Activating Force: 95,802.445 lbs

F of S Rank (Analysis): 1 of 21,609 slip surfaces

F of S Rank (Query): 1 of 21,609 slip surfaces

Exit: (429.43154, -5.0228197) ft

Entry: (625.77018, 33.641696) ft

Radius: 88.685023 ft

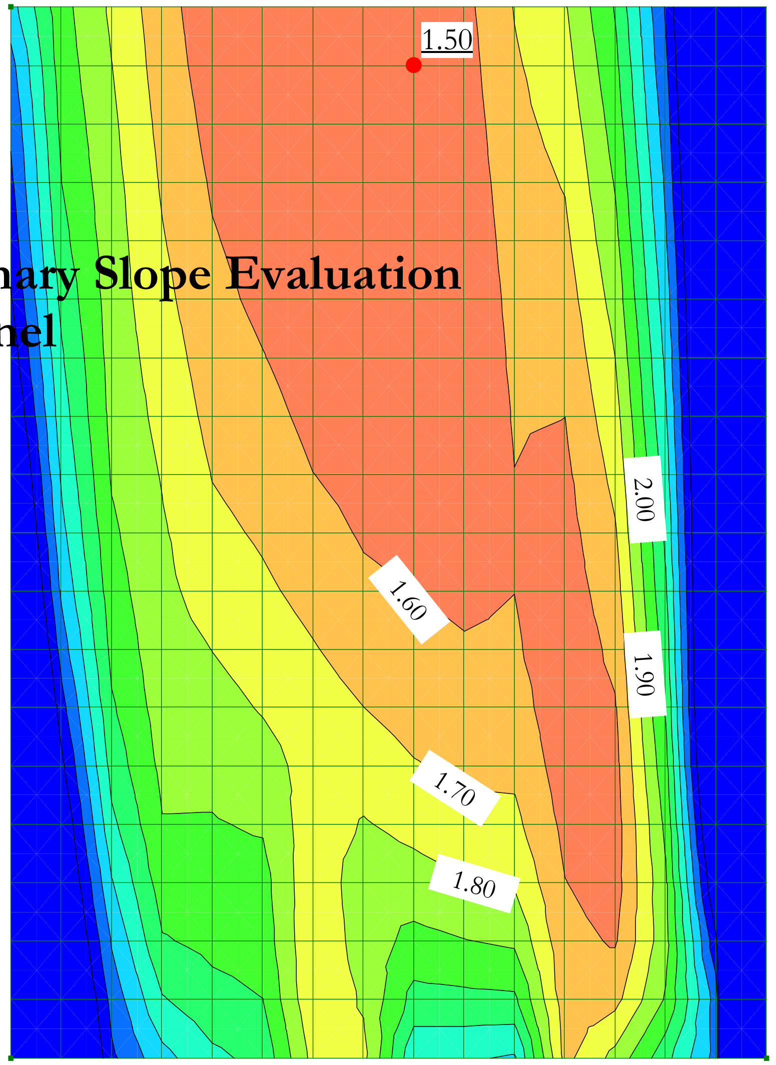
Center: (521.89028, 43.307825) ft

Slip Slices

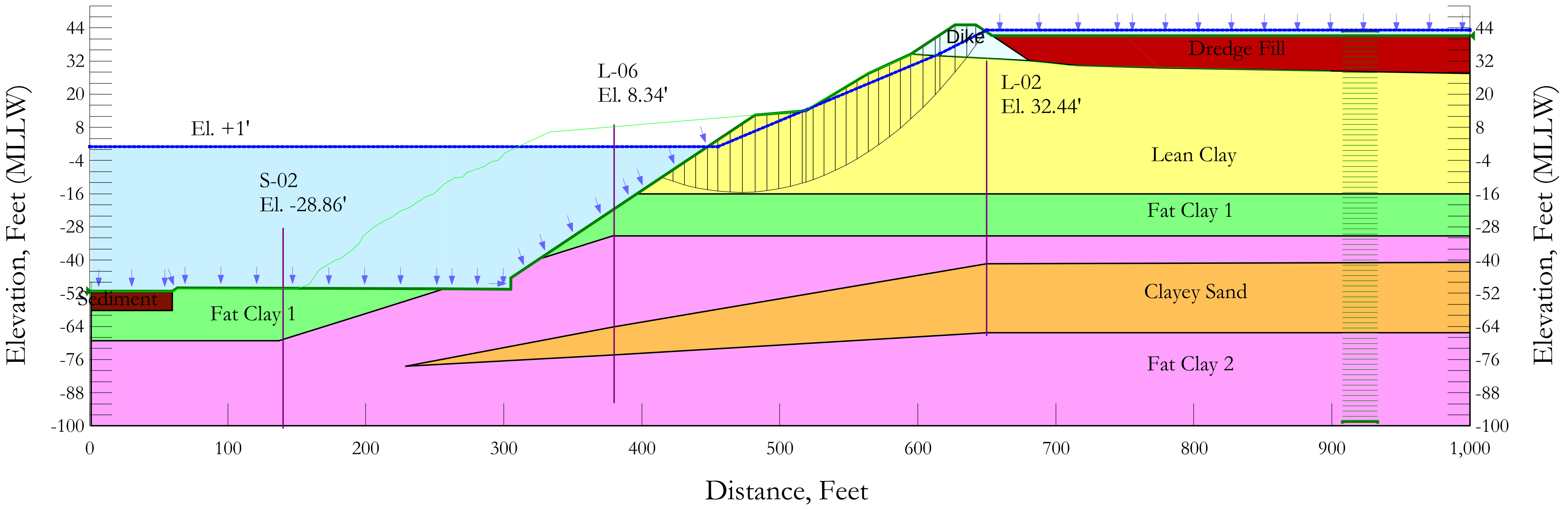
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	432.44295	-6.2701865	453.65964	811.39211	0	500
Slice 2	438.46577	-8.7649201	609.33101	1,280.8405	0	500
Slice 3	444.48859	-11.259654	765.00239	1,756.2658	0	500
Slice 4	448.75	-13.024787	875.14673	2,122.6941	0	500
Slice 5	451.92113	-14.338314	950.9998	2,446.2033	0	500
Slice 6	457.36198	-15.070657	1,050.0212	2,508.1646	0	500
Slice 7	464.40142	-14.943826	1,112.8737	2,794.3905	0	500
Slice 8	471.44085	-14.816994	1,175.7263	3,078.1388	0	500
Slice 9	478.48028	-14.690162	1,238.5788	3,359.2047	0	500
Slice 10	485.08333	-14.571193	1,297.535	3,507.0844	0	500
Slice 11	491.25	-14.460086	1,352.595	3,522.2097	0	500
Slice 12	497.41667	-14.348979	1,407.6549	3,535.1365	0	500
Slice 13	503.58333	-14.237872	1,462.7148	3,545.8349	0	500
Slice 14	509.75	-14.126765	1,517.7747	3,554.3069	0	500
Slice 15	515.91667	-14.015658	1,572.8346	3,560.587	0	500
Slice 16	522.21429	-13.902192	1,629.0638	3,670.2989	0	500
Slice 17	528.64286	-13.786366	1,686.4622	3,883.4315	0	500
Slice 18	535.07143	-13.67054	1,743.8605	4,094.5476	0	500
Slice 19	541.5	-13.554715	1,801.2589	4,303.8695	0	500
Slice 20	547.92857	-13.438889	1,858.6573	4,511.6517	0	500

Slice 21	554.35714	-13.323063	1,916.0557	4,718.1771	0	500
Slice 22	560.78571	-13.207238	1,973.4541	4,923.754	0	500
Slice 23	567.8135	-13.080616	2,036.2026	5,110.829	0	500
Slice 24	575.4405	-12.943197	2,104.3013	5,279.7088	0	500
Slice 25	583.1905	-8.9379883	1,938.6793	4,125.3611	0	500
Slice 26	591.0635	-1.0649883	1,539.3366	3,512.9391	0	500
Slice 27	598.30142	6.1729321	1,172.2071	2,837.6177	0	500
Slice 28	604.90426	12.775773	837.2908	2,091.1494	0	500
Slice 29	611.5071	19.378614	502.37448	1,313.9703	0	500
Slice 30	618.10994	25.981455	167.45816	501.14333	0	500
Slice 31	623.59077	31.462286	-110.54639	-202.58862	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Lean Clay	125	100	25
🟩	Fat Clay 1	125	300	22
🟧	Clayey Sand	120	0	30
🟥	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟪	Fat Clay 2	125	300	22
🟫	Sediment	90	16	15



Long Term 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 144
Date: 4/25/2018
Time: 5:01:20 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:01:36 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 56+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 300 psf

Phi': 22 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (289.8782, 296.40863) ft
Lower Left: (289.8782, 59.18752) ft
Lower Right: (630.7282, 59.18752) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 18
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (907.9586, 42.95493) ft
Upper Right Coordinate: (933.1186, 42.95493) ft
Lower Left Coordinate: (907.9586, -98.52178) ft
Lower Right Coordinate: (933.1186, -98.52178) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	455	1
Coordinate 3	616	34.74
Coordinate 4	650	43.14
Coordinate 5	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.04	32.1
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	519	13.94
Point 19	1,000	-16.06
Point 20	1,000	-31.26
Point 21	379	-31.26
Point 22	137	-69.26
Point 23	1	-69.26
Point 24	1	-100
Point 25	1,000	-100
Point 26	1,000	-66.26
Point 27	229	-78.46
Point 28	379	-64.26

Point 29	1,000	-40.86
Point 30	60	-51.26
Point 31	63.6	-50.06
Point 32	60	-58.26
Point 33	1	-58.26
Point 34	1	-51.26
Point 35	325.7	-39.6
Point 36	305	-50.5
Point 37	305	-46.5
Point 38	256.9893	-50.4
Point 39	196	-60
Point 40	396.32	-16.06
Point 41	482	12.5
Point 42	715.3	30.4

Regions

	Material	Points	Area (ft²)
Region 1	Dredge Fill	10,11,12,42,14	982.22
Region 2	Dredge Fill	11,13,9,12	2,972.5
Region 3	Dike	15,16,17,10,14	593.84
Region 4	Lean Clay	8,18,41,40,19,9,12,42,14,15	24,082
Region 5	Fat Clay 1	19,20,21,35,40	9,640.4
Region 6	Fat Clay 2	20,21,35,37,36,38,39,22,23,24,25,26,7,5,27,28,6,29	44,368
Region 7	Clayey Sand	27,5,7,26,29,6,28	14,319
Region 8	Sediment	30,34,33,32	413
Region 9	Fat Clay 1	38,31,30,32,33,23,22,39	3,265.5

Current Slip Surface

Slip Surface: 21,312
F of S: 1.50
Volume: 4,956.9764 ft³
Weight: 619,622.05 lbs
Resisting Moment: 56,595,303 lbs-ft
Activating Moment: 37,836,868 lbs-ft
Resisting Force: 181,247.34 lbs
Activating Force: 121,208.62 lbs
F of S Rank (Analysis): 1 of 23,104 slip surfaces
F of S Rank (Query): 1 of 23,104 slip surfaces
Exit: (414.49624, -10.001253) ft
Entry: (648.97832, 42.787228) ft
Radius: 298.75179 ft
Center: (471.66487, 283.22968) ft

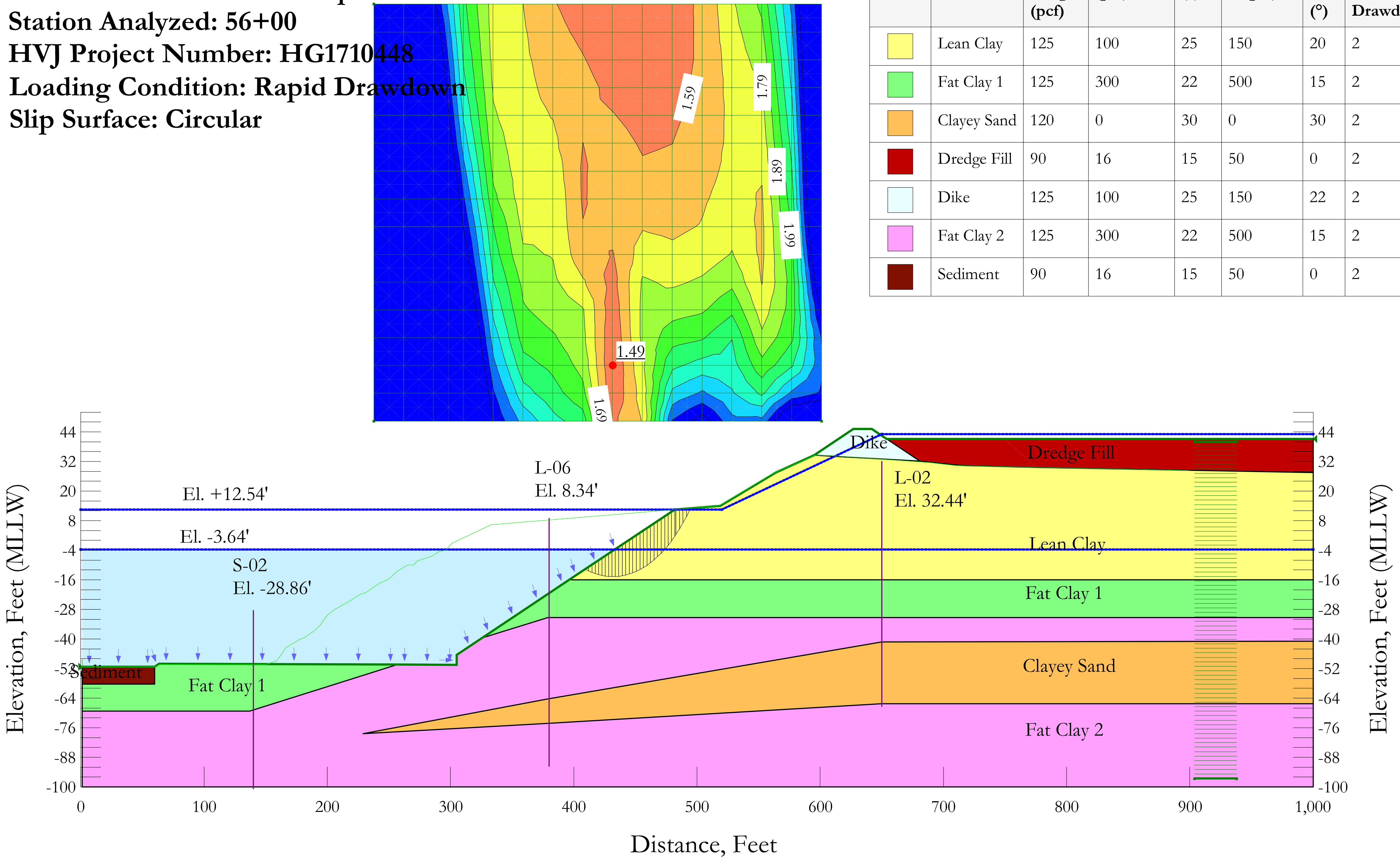
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	418.62171	-10.745629	732.92722	900.01464	77.914144	100
Slice 2	426.87265	-12.115675	818.41809	1,283.3373	216.79541	100
Slice 3	435.12359	-13.249812	889.18827	1,633.0687	346.87712	100
Slice 4	443.37453	-14.150742	945.4063	1,946.0321	466.59947	100

Slice 5	451.25	-14.800078	985.92489	2,296.003	610.89944	100
Slice 6	459.5	-15.24036	1,027.1351	2,722.1617	790.40387	100
Slice 7	468.5	-15.471447	1,153.6888	3,136.6164	924.65431	100
Slice 8	477.5	-15.431207	1,264.024	3,499.8947	1,042.6036	100
Slice 9	486.27913	-15.13369	1,356.2137	3,640.0879	1,064.988	100
Slice 10	494.83738	-14.591147	1,430.9902	3,565.4195	995.30073	100
Slice 11	503.39564	-13.801076	1,490.9708	3,452.6386	914.74071	100
Slice 12	511.9539	-12.761495	1,536.037	3,305.3897	825.06272	100
Slice 13	517.61651	-11.963677	1,627.7614	3,207.3634	736.58051	100
Slice 14	521.54797	-11.316802	1,638.8075	3,202.8061	729.3045	100
Slice 15	528.08634	-10.117788	1,580.0965	3,237.5815	772.89796	100
Slice 16	536.06715	-8.4692711	1,581.5301	3,273.2174	788.84674	100
Slice 17	544.04797	-6.5916483	1,569.269	3,281.66	798.50104	100
Slice 18	552.02878	-4.4804308	1,543.0448	3,264.6866	802.81476	100
Slice 19	560.00959	-2.130429	1,502.5473	3,223.7596	802.61447	100
Slice 20	567.875	0.42322873	1,448.4306	3,127.3577	782.89656	100
Slice 21	575.625	3.1799738	1,380.7288	2,977.9843	744.81246	100
Slice 22	583.375	6.1809094	1,298.4305	2,809.1977	704.4823	100
Slice 23	591.125	9.4340728	1,201.0553	2,620.2118	661.76354	100
Slice 24	599.38061	13.19665	1,079.5637	2,445.0124	636.71917	100
Slice 25	608.14184	17.518532	930.97344	2,276.7713	627.55587	100
Slice 26	614.26123	20.713025	816.67898	2,142.6481	618.30952	100
Slice 27	621.46	24.822597	662.57745	1,948.007	599.40564	100
Slice 28	631.18214	30.679766	459.37425	1,508.8681	489.387	100
Slice 29	638.68214	35.555273	281.61617	985.90925	328.41726	100
Slice 30	645.3627	40.199255	105.56804	365.845	121.36914	100
Slice 31	648.89186	42.72352	8.9047675	-26.398425	-16.462149	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Lean Clay	125	100	25	150	20	2
🟩	Fat Clay 1	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟥	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟫	Sediment	90	16	15	50	0	2



RDD 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 140
Date: 4/25/2018
Time: 4:56:47 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\
Last Solved Date: 4/25/2018
Last Solved Time: 4:57:50 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 56+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Cohesion R: 150 psf

Phi R: 20 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 300 psf

Phi': 22 °

Phi-B: 0 °

Cohesion R: 500 psf

Phi R: 15 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (237.892, 217.61929) ft
Lower Left: (237.892, 48.37518) ft
Lower Right: (601.1356, 48.37518) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (903.9399, 39.9822) ft
Upper Right Coordinate: (937.9492, 39.9822) ft
Lower Left Coordinate: (903.9399, -96.76581) ft
Lower Right Coordinate: (937.9492, -96.76581) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	520	12.54
Coordinate 3	650	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64
Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34

Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.04	32.1
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	519	13.94
Point 19	1,000	-16.06
Point 20	1,000	-31.26
Point 21	379	-31.26
Point 22	137	-69.26
Point 23	1	-69.26
Point 24	1	-100
Point 25	1,000	-100
Point 26	1,000	-66.26
Point 27	229	-78.46
Point 28	379	-64.26
Point 29	1,000	-40.86
Point 30	60	-51.26
Point 31	63.6	-50.06
Point 32	60	-58.26
Point 33	1	-58.26
Point 34	1	-51.26
Point 35	325.7	-39.6
Point 36	305	-50.5
Point 37	305	-46.5
Point 38	256.9893	-50.4
Point 39	196	-60
Point 40	396.32	-16.06
Point 41	482	12.5
Point 42	715.3	30.4

Regions

	Material	Points	Area (ft²)
Region 1	Dredge Fill	10,11,12,42,14	982.22
Region 2	Dredge Fill	11,13,9,12	2,972.5
Region 3	Dike	15,16,17,10,14	593.84
Region 4	Lean Clay	8,18,41,40,19,9,12,42,14,15	24,082
Region 5	Fat Clay 1	19,20,21,35,40	9,640.4
Region 6	Fat Clay 2	20,21,35,37,36,38,39,22,23,24,25,26,7,5,27,28,6,29	44,368
Region 7	Clayey Sand	27,5,7,26,29,6,28	14,319
Region 8	Sediment	30,34,33,32	413

Region 9	Fat Clay 1	38,31,30,32,33,23,22,39	3,265.5

Current Slip Surface

Slip Surface: 3,071

F of S: 1.49

Volume: 885.10023 ft³

Weight: 110,637.53 lbs

Resisting Moment: 3,426,643.3 lbs-ft

Activating Moment: 2,301,362.1 lbs-ft

Resisting Force: 37,096.953 lbs

Activating Force: 24,932.599 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (409.26012, -11.746628) ft

Entry: (494.70517, 12.994472) ft

Radius: 85.658065 ft

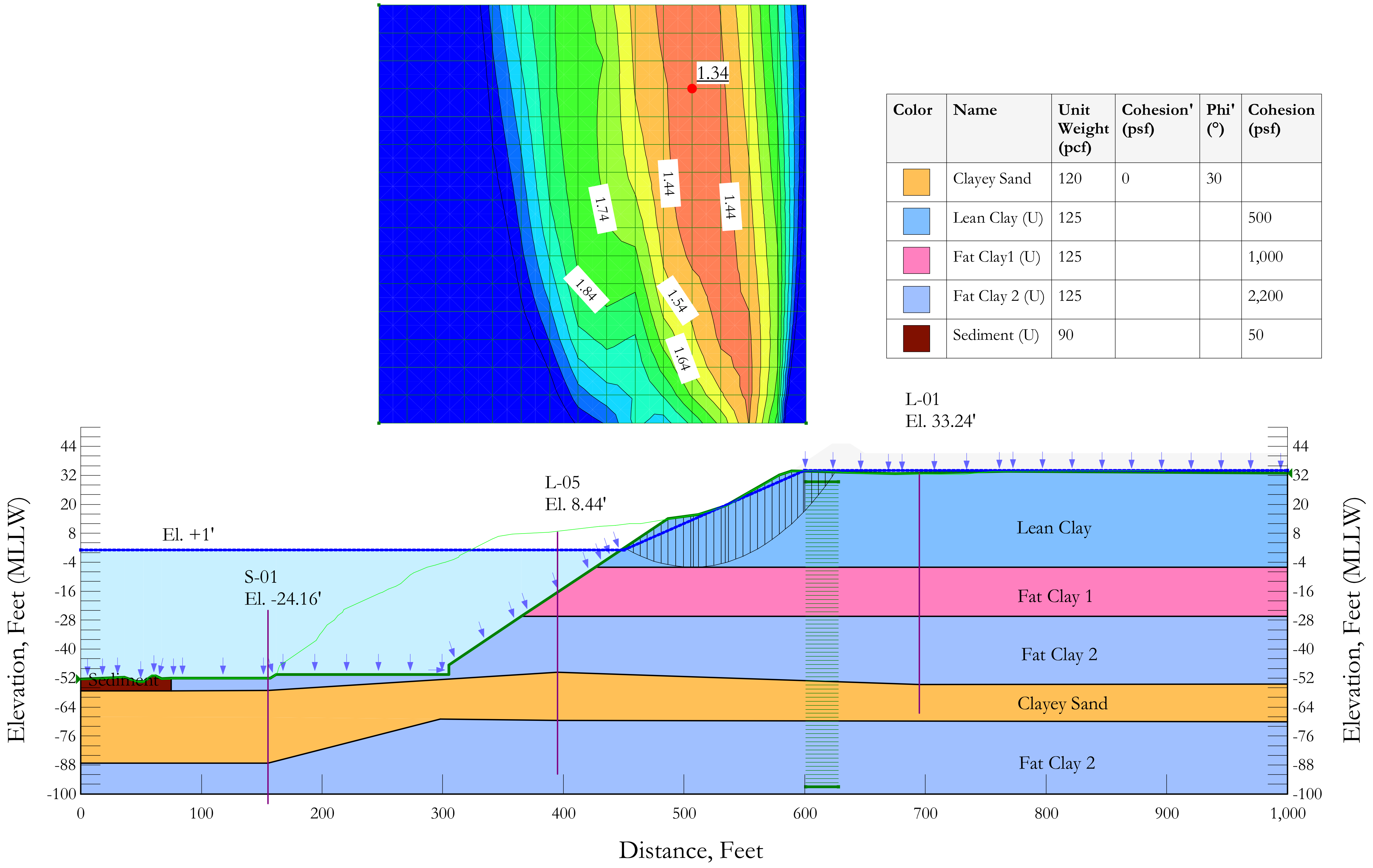
Center: (431.62192, 70.941061) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	410.61122	-12.088526	527.18801	611.06897	39.114334	100
Slice 2	413.31343	-12.72608	566.97137	775.41161	97.19728	100
Slice 3	416.01564	-13.272121	601.04432	926.17034	151.60875	100
Slice 4	418.71785	-13.728421	629.51747	1,061.7665	201.56102	100
Slice 5	421.42006	-14.096427	652.48104	1,180.8374	246.37661	100
Slice 6	424.12227	-14.377282	670.00642	1,282.3299	285.53111	100
Slice 7	426.82448	-14.571847	682.14724	1,365.5681	318.6844	100
Slice 8	429.52669	-14.680709	688.94025	1,430.2908	345.69746	100
Slice 9	432.2289	-14.704196	690.40585	1,476.6545	366.63376	100
Slice 10	435.01473	-14.637741	686.25902	1,539.2838	397.77196	100
Slice 11	437.88418	-14.475675	676.14611	1,617.0601	438.75538	100
Slice 12	440.75363	-14.216639	659.9823	1,675.6086	473.59432	100
Slice 13	443.62308	-13.859745	637.71208	1,712.7625	0	561.42361
Slice 14	446.49253	-13.403748	609.25785	1,735.3491	0	566.37471
Slice 15	449.36198	-12.847027	574.51851	1,742.9702	0	568.11469
Slice 16	452.23143	-12.187558	533.36763	1,736.9862	0	566.92191
Slice 17	455.10088	-11.422869	485.651	1,718.6939	0	563.05289
Slice 18	457.97033	-10.549993	431.18354	1,689.2559	0	556.7304
Slice 19	460.83978	-9.5654061	369.74534	1,649.6415	0	548.13245
Slice 20	463.70923	-8.464947	301.07669	1,600.5769	0	537.38225
Slice						

21	466.57868	-7.2437144	224.87178	1,542.5025	0	524.53905
Slice 22	469.44813	-5.8959392	140.7706	1,475.5353	0	509.5898
Slice 23	472.31758	-4.414818	48.348643	1,399.4294	0	492.44154
Slice 24	475.12692	-2.8293408	-50.585134	1,315.5944	0	473.3866
Slice 25	477.87615	-1.1365521	-156.21515	1,223.327	0	452.25411
Slice 26	480.62538	0.70463722	-271.10536	1,119.6347	0	428.37263
Slice 27	482.51389	2.0432857	-354.63703	1,026.6814	0	406.90241
Slice 28	484.43489	3.5251925	-447.10801	876.06163	0	373.82287
Slice 29	487.24911	5.8296605	-590.90682	640.58224	0	323.92606
Slice 30	490.06334	8.3455399	-747.89769	375.59495	175.1428	100
Slice 31	492.87756	11.099635	-919.75321	133.35926	0	136.15554
Slice 32	494.49492	12.767236	-1,023.8115	-33.478673	-15.611361	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay1 (U)	125			1,000
🟦	Fat Clay 2 (U)	125			2,200
🟥	Sediment (U)	90			50

Short Term 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/25/2018
Time: 5:15:34 PM
Tool Version: 8.16.1.13452
File Name: 64+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:16:06 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 500 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay1 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 2,200 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (246.9755, 226.94565) ft
Lower Left: (246.9755, 53.57301) ft
Lower Right: (601.0543, 53.57301) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (600.8933, 29.30808) ft
Upper Right Coordinate: (627.8293, 29.30808) ft
Lower Left Coordinate: (600.8933, -97.01541) ft
Lower Right Coordinate: (627.8293, -97.01541) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 33) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16

Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	674.92	32.7
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5

Point 55	36	-51.6

Regions

	Material	Points	Area (ft²)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,6,1	15,337
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2 (U)	22,24,25,21,7,23,3	26,362
Region 4		17,26,27,29,28	595.28
Region 5		29,30,31,28	676.69
Region 6		30,32,16,31	1,992.6
Region 7	Lean Clay (U)	33,16,31,28,17,47,34,46,45,44	19,642
Region 8	Fat Clay1 (U)	43,35,33,44	12,327
Region 9	Fat Clay 2 (U)	36,49,38,37,39,1,6,13,18,35,43,42,41	18,953
Region 10	Sediment (U)	37,50,51,52,53,54,55,40,19,39	383

Current Slip Surface

Slip Surface: 15,450

F of S: 1.34

Volume: 3,178.481 ft³

Weight: 397,310.12 lbs

Resisting Moment: 18,258,394 lbs-ft

Activating Moment: 13,588,826 lbs-ft

Resisting Force: 87,403.059 lbs

Activating Force: 65,057.881 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (450.57456, 2.024852) ft

Entry: (625.38067, 33.414953) ft

Radius: 198.33362 ft

Center: (506.63329, 192.27112) ft

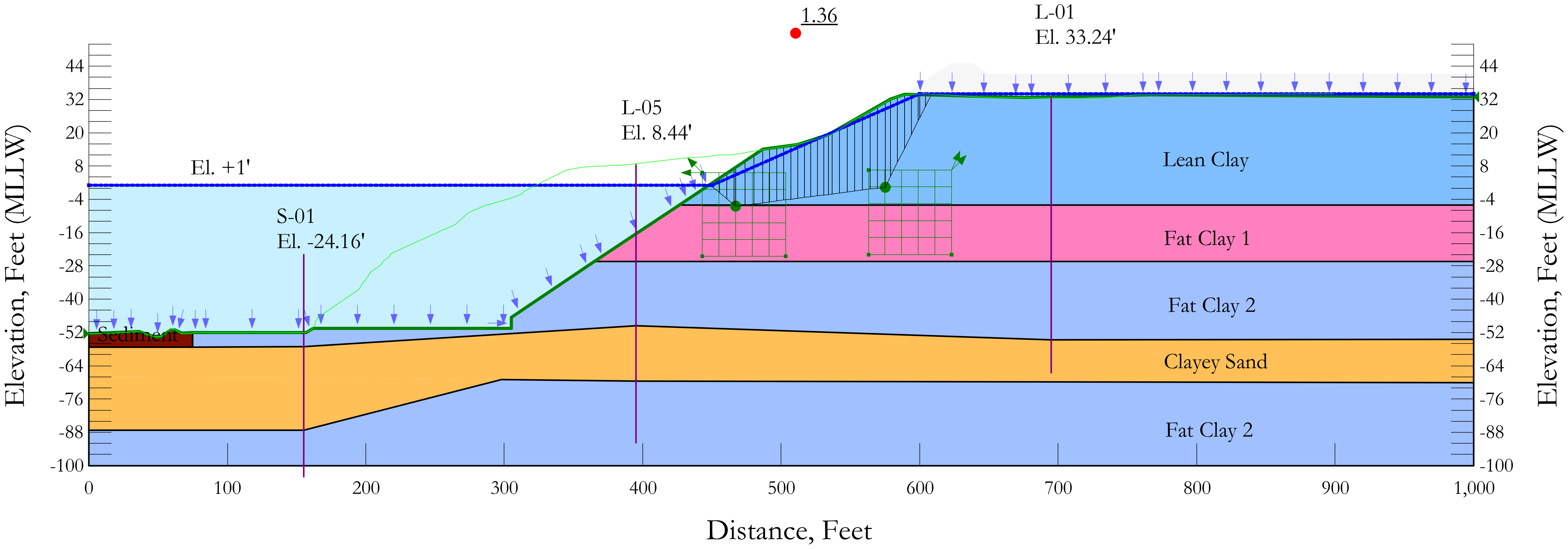
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	451.45601	1.7695465	-26.737534	178.3438	0	500
Slice 2	455.18434	0.74947682	82.795912	462.86256	0	500
Slice 3	460.87809	-0.69034171	243.04827	885.47344	0	500
Slice 4	466.57185	-1.9526056	392.7327	1,287.7718	0	500
Slice 5	472.26561	-3.0407607	532.0543	1,668.1182	0	500
Slice 6	477.95936	-3.957706	661.18563	2,025.0344	0	500
Slice 7	483.65312	-4.7058348	780.26912	2,357.2785	0	500
Slice 8	489.68967	-5.3114925	895.36143	2,573.4009	0	500
Slice 9	496.06901	-5.7551834	1,005.3022	2,669.8636	0	500
Slice 10	502.44835	-5.9926727	1,102.97	2,734.4815	0	500
Slice 11	506.63329	-6.06	1,161.7758	2,762.9701	0	500
Slice 12	509.81428	-6.0249375	1,201.3415	2,772.2037	0	500
Slice						

13	515.12913	-5.855695	1,260.8624	2,809.6178	0	500
Slice 14	521.3874	-5.4880616	1,320.9283	2,860.6238	0	500
Slice 15	527.64566	-4.9211745	1,369.1349	2,884.029	0	500
Slice 16	532.3874	-4.3765455	1,466.5106	2,892.0295	0	500
Slice 17	535.35	-3.9677971	1,481.6753	2,905.1373	0	500
Slice 18	539.72143	-3.2589496	1,428.3234	2,941.0913	0	500
Slice 19	545.76429	-2.1395015	1,440.8213	2,981.7604	0	500
Slice 20	551.80714	-0.82449824	1,441.6798	2,999.8243	0	500
Slice 21	557.85	0.69009135	1,430.6592	2,996.0154	0	500
Slice 22	563.89286	2.409049	1,407.4747	2,970.821	0	500
Slice 23	569.93571	4.3379893	1,371.7922	2,924.4169	0	500
Slice 24	575.97857	6.4834606	1,323.2219	2,856.6017	0	500
Slice 25	581.5	8.6304104	1,267.736	2,742.5537	0	500
Slice 26	586.5	10.749573	1,207.0761	2,584.4625	0	500
Slice 27	591.51672	13.041458	1,136.355	2,351.1594	0	500
Slice 28	596.55016	15.513641	1,055.1215	2,040.1841	0	500
Slice 29	599.53344	17.041254	1,051.8209	1,854.751	0	500
Slice 30	602.825	18.855602	945.01045	1,635.2782	0	500
Slice 31	608.475	22.1134	741.72387	1,227.3145	0	500
Slice 32	614.125	25.626425	522.51106	781.02969	0	500
Slice 33	619.775	29.411229	286.33933	290.36793	0	500
Slice 34	623.99034	32.39438	100.19068	-104.62006	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay1 (U)	125			1,000
🟦	Fat Clay 2 (U)	125			2,200
🟫	Sediment (U)	90			50



Short Term - Block 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/25/2018
Time: 5:15:34 PM
Tool Version: 8.16.1.13452
File Name: 64+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:17:02 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 500 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay1 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure

  - Piezometric Line: 1

Sediment (U)

- Model: Undrained (Phi=0)
- Unit Weight: 90 pcf
- Cohesion: 50 psf
- Pore Water Pressure
  - Piezometric Line: 1

Slip Surface Limits

- Left Coordinate: (0, -52.4) ft
- Right Coordinate: (1,000, 33) ft

Slip Surface Block

- Left Grid
  - Upper Left: (443.0048, 5.52893) ft
  - Lower Left: (443.0048, -24.49958) ft
  - Lower Right: (503.0619, -24.49958) ft
  - X Increments: 5
  - Y Increments: 5
  - Starting Angle: 135 °
  - Ending Angle: 180 °
  - Angle Increments: 2
- Right Grid
  - Upper Left: (563.0034, 6.45178) ft
  - Lower Left: (563.0034, -23.99346) ft
  - Lower Right: (623.0497, -23.99346) ft
  - X Increments: 5
  - Y Increments: 5
  - Starting Angle: 45 °
  - Ending Angle: 65 °
  - Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16

Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	674.92	32.7
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5

Point 55	36	-51.6

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,6,1	15,337
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2 (U)	22,24,25,21,7,23,3	26,362
Region 4		17,26,27,29,28	595.28
Region 5		29,30,31,28	676.69
Region 6		30,32,16,31	1,992.6
Region 7	Lean Clay (U)	33,16,31,28,17,47,34,46,45,44	19,642
Region 8	Fat Clay1 (U)	43,35,33,44	12,327
Region 9	Fat Clay 2 (U)	36,49,38,37,39,1,6,13,18,35,43,42,41	18,953
Region 10	Sediment (U)	37,50,51,52,53,54,55,40,19,39	383

Current Slip Surface

Slip Surface: 6,664

F of S: 1.36

Volume: 3,009.8699 ft^3

Weight: 376,233.73 lbs

Resisting Moment: 4,815,729.2 lbs-ft

Activating Moment: 3,554,545.9 lbs-ft

Resisting Force: 83,842.488 lbs

Activating Force: 61,693.652 lbs

F of S Rank (Analysis): 1 of 11,664 slip surfaces

F of S Rank (Query): 1 of 11,664 slip surfaces

Exit: (448.31084, 1.2702793) ft

Entry: (608.31123, 33.6613) ft

Radius: 71.745141 ft

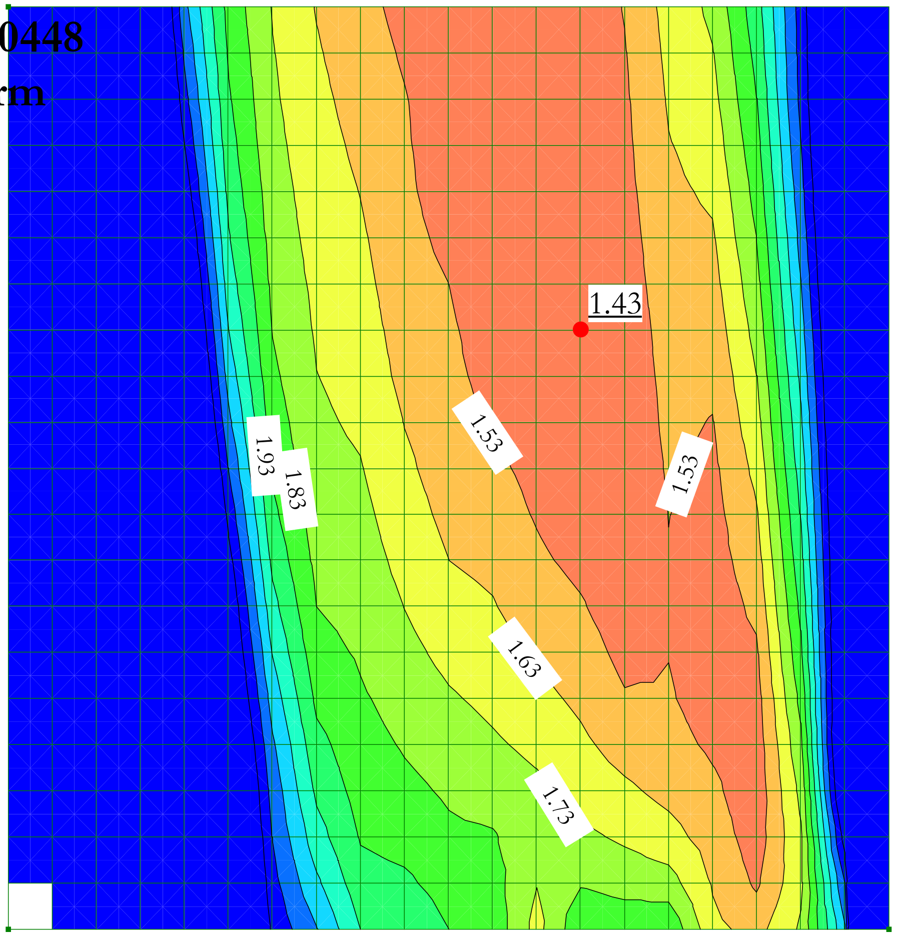
Center: (523.39302, 41.759055) ft

Slip Slices

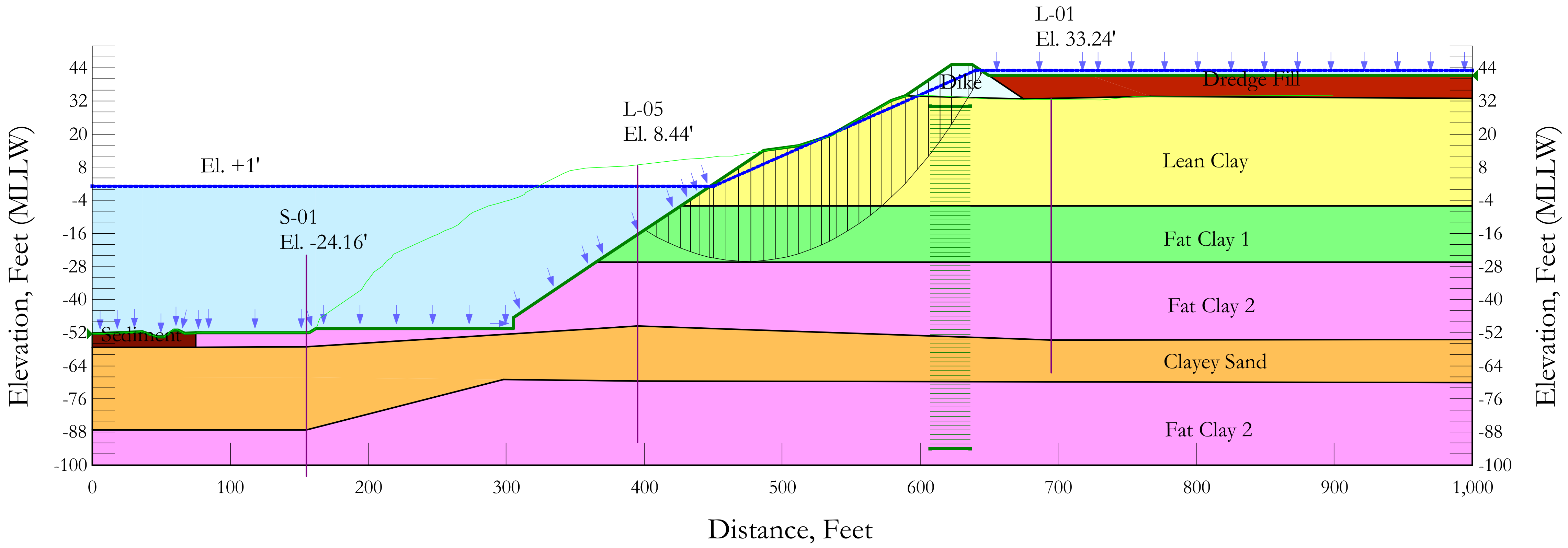
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	448.63709	1.1351396	-8.4327138	184.31568	0	500
Slice 2	449.48167	0.78530271	13.397111	266.00913	0	500
Slice 3	452.66795	-0.53449548	126.26682	577.26398	0	500
Slice 4	458.00385	-2.7446973	327.68595	1,106.8916	0	500
Slice 5	463.33975	-4.9548991	529.10508	1,647.457	0	500
Slice 6	466.51767	-6.271237	649.065	2,154.4807	0	1,000
Slice 7	470.35996	-6.271237	699.37691	1,914.949	0	1,000
Slice 8	476.89421	-5.8570287	760.28458	2,139.7922	0	500
Slice 9	483.29807	-5.451086	819.97681	2,357.1462	0	500
Slice 10	489.05	-5.0864693	873.59222	2,465.6258	0	500
Slice 11	494.15	-4.7631787	921.13082	2,466.1591	0	500
Slice 12	499.25	-4.439888	968.66941	2,465.3136	0	500
Slice						

13	504.35	-4.1165973	1,016.208	2,463.0757	0	500
Slice 14	509.45	-3.7933066	1,063.7466	2,459.4507	0	500
Slice 15	514.34685	-3.4828937	1,109.3916	2,483.1374	0	500
Slice 16	519.04055	-3.1853585	1,153.1429	2,534.2892	0	500
Slice 17	523.73425	-2.8878234	1,196.8943	2,584.361	0	500
Slice 18	528.42795	-2.5902882	1,240.6456	2,633.4446	0	500
Slice 19	532.3874	-2.3392973	1,339.3864	2,679.8895	0	500
Slice 20	535.35	-2.1514971	1,368.3382	2,730.5462	0	500
Slice 21	539.43662	-1.892445	1,343.2607	2,827.6517	0	500
Slice 22	544.90986	-1.5454947	1,394.2783	2,964.9528	0	500
Slice 23	550.38309	-1.1985444	1,445.2959	3,101.8222	0	500
Slice 24	555.85633	-0.85159407	1,496.3136	3,238.5492	0	500
Slice 25	561.32957	-0.50464376	1,547.3312	3,375.4267	0	500
Slice 26	566.8028	-0.15769346	1,598.3489	3,512.7469	0	500
Slice 27	572.27604	0.18925685	1,649.3665	3,650.796	0	500
Slice 28	577.00633	2.356402	1,582.3192	2,934.9881	0	500
Slice 29	581.5	6.850072	1,373.7004	2,589.029	0	500
Slice 30	586.5	11.850072	1,141.5753	2,165.1598	0	500
Slice 31	591.51672	16.866793	908.67385	1,668.3412	0	500
Slice 32	596.55016	21.900235	674.99617	1,091.2719	0	500
Slice 33	599.53344	24.883514	562.46382	744.20154	0	500
Slice 34	602.07781	27.427879	410.10035	441.16353	0	500
Slice 35	606.23342	31.583493	150.79005	-79.87284	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Lean Clay	125	100	25
🟩	Fat Clay 1	125	400	18
🟧	Clayey Sand	120	0	30
🟥	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟪	Fat Clay 2	125	300	22
🟫	Sediment	90	16	15



Long Term 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/25/2018
Time: 5:15:34 PM
Tool Version: 8.16.1.13452
File Name: 64+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:15:58 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Linear Search
  - Must Obtain Factor of Safety at Lambda: 0.2
  - Lambda
    - Lambda 1: -1
    - Lambda 2: -0.8
    - Lambda 3: -0.6
    - Lambda 4: -0.4
    - Lambda 5: -0.2
    - Lambda 6: 0
    - Lambda 7: 0.2
    - Lambda 8: 0.4
    - Lambda 9: 0.6
    - Lambda 10: 0.8
    - Lambda 11: 1

Materials

Lean Clay

- Model: Mohr-Coulomb
- Unit Weight: 125 pcf
- Cohesion': 100 psf
- Phi': 25 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Fat Clay 1

- Model: Mohr-Coulomb
- Unit Weight: 125 pcf
- Cohesion': 400 psf
- Phi': 18 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Clayey Sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 30 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Dredge Fill

- Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Grid

Upper Left: (189.9206, 299.45421) ft
Lower Left: (189.9206, 70.01303) ft
Lower Right: (627.8489, 70.01303) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (607, 30) ft
Upper Right Coordinate: (636, 30) ft
Lower Left Coordinate: (607, -94) ft
Lower Right Coordinate: (636, -94) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	674.92	32.7
Point 29	649.6	41.14

Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6

Regions

	Material	Points	Area (ft²)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,6,1	15,337
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2	22,24,25,21,7,23,3	26,362
Region 4	Dike	17,26,27,29,28	595.28
Region 5	Dredge Fill	29,30,31,28	676.69
Region 6	Dredge Fill	30,32,16,31	1,992.6
Region 7	Lean Clay	33,16,31,28,17,47,34,46,45,44	19,642
Region 8	Fat Clay 1	43,35,33,44	12,327
Region 9	Fat Clay 2	36,49,38,37,39,1,6,13,18,35,43,42,41	18,953
Region 10	Sediment	37,50,51,52,53,54,55,40,19,39	383

Current Slip Surface

Slip Surface: 21,771

F of S: 1.43

Volume: 7,014.9405 ft³

Weight: 876,867.57 lbs

Resisting Moment: 61,178,049 lbs-ft

Activating Moment: 42,656,933 lbs-ft

Resisting Force: 236,242.44 lbs

Activating Force: 164,880.69 lbs

F of S Rank (Analysis): 1 of 33,516 slip surfaces

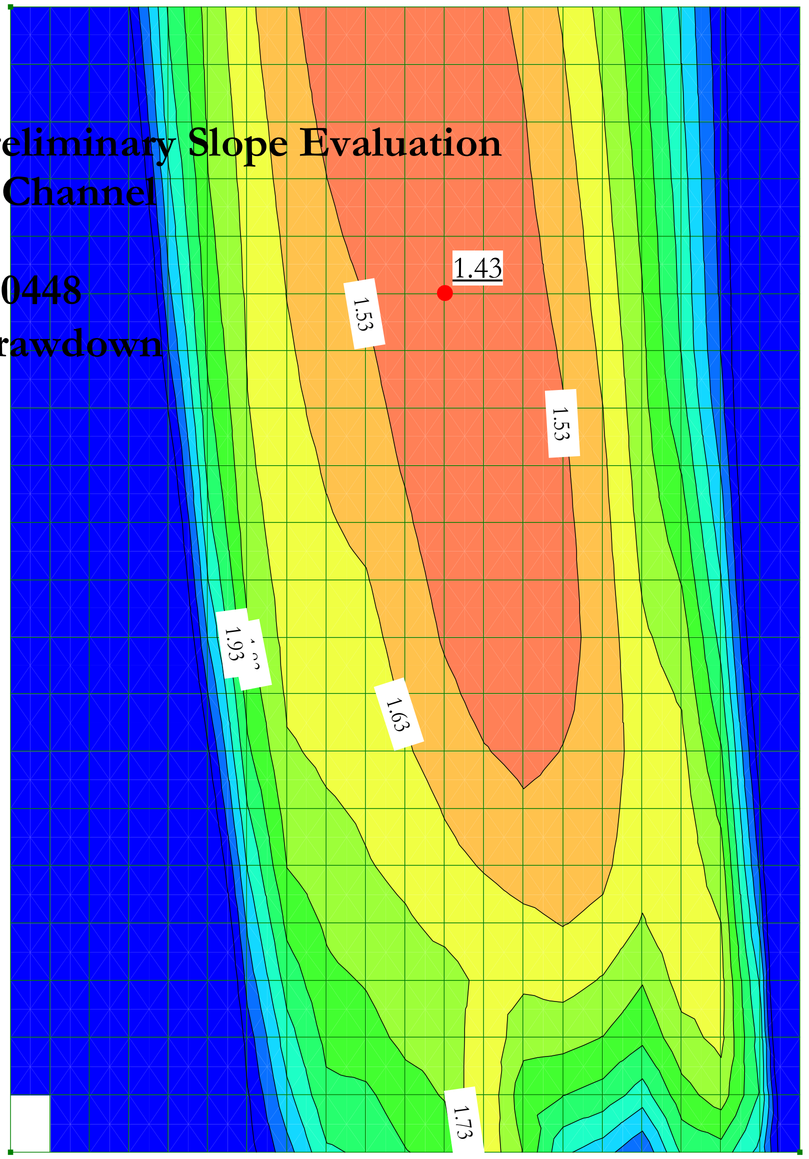
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (400.34888, -14.717041) ft
Entry: (645.03075, 42.663083) ft
Radius: 245.36313 ft
Center: (474.57399, 219.1498) ft

Slip Slices

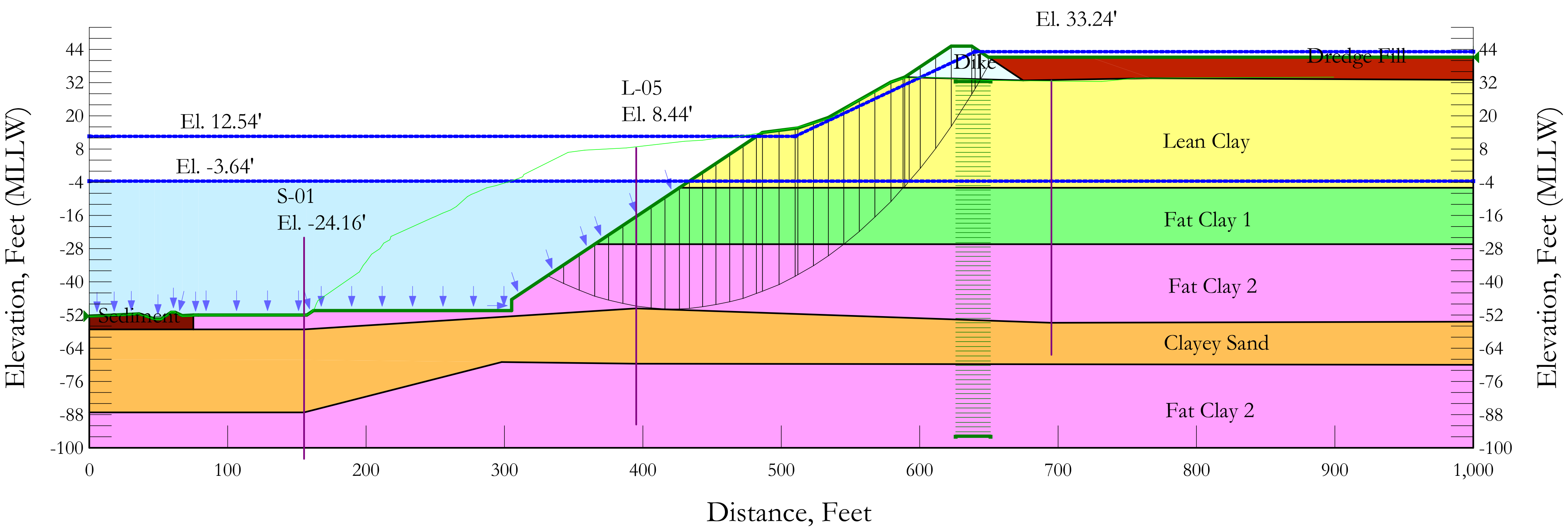
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	404.6774	-16.003642	1,061.0273	1,362.6291	97.996362	400
Slice 2	413.33444	-18.406094	1,210.9403	1,914.0244	228.44586	400
Slice 3	421.99148	-20.471793	1,339.8399	2,418.0343	350.32661	400
Slice 4	429.85	-22.076115	1,439.9496	2,831.7564	452.22544	400
Slice 5	436.91	-23.279012	1,515.0104	3,161.8015	535.07488	400
Slice 6	443.97	-24.271244	1,576.9256	3,451.9926	609.2462	400
Slice 7	448.75	-24.847348	1,612.8745	3,657.7837	664.43126	400
Slice 8	454.5625	-25.353066	1,627.5163	3,974.9105	762.71462	400
Slice 9	463.6875	-25.929155	1,782.1449	4,417.166	856.17025	400
Slice 10	472.8125	-26.164584	1,916.513	4,790.0818	933.67911	400
Slice 11	481.9375	-26.060336	2,030.679	5,094.2368	995.41028	400
Slice 12	490.75	-25.642485	2,122.0714	5,180.7659	993.8301	400
Slice 13	499.25	-24.931979	2,191.9363	5,064.1066	933.22471	400
Slice 14	507.75	-23.922249	2,244.005	4,905.6567	864.82306	400
Slice 15	516.06634	-22.644391	2,277.7043	4,763.6462	807.73149	400
Slice 16	524.19901	-21.106698	2,293.5273	4,641.2293	762.81463	400
Slice 17	531.13267	-19.587504	2,407.5091	4,525.457	688.16298	400
Slice 18	536.5457	-18.243655	2,398.5674	4,449.2749	666.31527	400
Slice 19	543.19971	-16.382083	2,263.168	4,373.6265	685.72952	400
Slice 20	551.41632	-13.83005	2,219.771	4,271.1381	666.52957	400
Slice 21	559.63292	-10.956395	2,157.2457	4,141.3015	644.65879	400
Slice 22	567.84953	-7.7488787	2,074.8641	3,984.6461	620.5258	400
Slice 23	575.47892	-4.471176	1,980.5624	3,822.6982	859.00205	100
Slice 24	584	-0.3901863	1,850.2477	3,545.5287	790.5225	100
Slice 25	593.46882	4.5781674	1,679.6591	3,235.5131	725.50665	100
Slice 26	602.04803	9.5542577	1,496.8757	2,989.9955	696.25319	100
Slice 27	610.26882	14.783371	1,294.316	2,713.0228	661.55384	100
Slice						

28	618.48961	20.490289	1,063.3391	2,389.7834	618.53112	100
Slice 29	628.67352	28.373886	728.80065	1,704.8977	455.16155	100
Slice 30	636.17352	34.528382	461.69657	1,066.3934	281.97478	100
Slice 31	638.8	36.858063	357.7856	783.83472	198.66997	100
Slice 32	641.8	39.615739	219.91389	394.1685	81.256261	100
Slice 33	644.31538	41.977711	72.52683	65.699997	-3.1834044	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Lean Clay	125	100	25	150	20	2
🟩	Fat Clay 1	125	400	18	500	14	2
🟧	Clayey Sand	120	0	30	0	30	2
🟥	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟫	Sediment	90	16	15	50	0	2



RDD 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/25/2018
Time: 5:15:34 PM
Tool Version: 8.16.1.13452
File Name: 64+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\
Last Solved Date: 4/25/2018
Last Solved Time: 5:16:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Cohesion R: 150 psf

Phi R: 20 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 400 psf

Phi': 18 °

Phi-B: 0 °

Cohesion R: 500 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (191.7483, 366.48988) ft
Lower Left: (191.7483, 63.70715) ft
Lower Right: (608.9357, 63.70715) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (625.9097, 32.48158) ft
Upper Right Coordinate: (651.0697, 32.48158) ft
Lower Left Coordinate: (625.9097, -96.0427) ft
Lower Right Coordinate: (651.0697, -96.0427) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	510	12.54
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64
Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16

Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	674.92	32.7
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6

Regions

	Material	Points	Area (ft²)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,6,1	15,337
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2	22,24,25,21,7,23,3	26,362
Region 4	Dike	17,26,27,29,28	595.28
Region 5	Dredge Fill	29,30,31,28	676.69
Region 6	Dredge Fill	30,32,16,31	1,992.6
Region 7	Lean Clay	33,16,31,28,17,47,34,46,45,44	19,642
Region 8	Fat Clay 1	43,35,33,44	12,327
Region 9	Fat Clay 2	36,49,38,37,39,1,6,13,18,35,43,42,41	18,953
Region 10	Sediment	37,50,51,52,53,54,55,40,19,39	383

Current Slip Surface

Slip Surface: 24,825

F of S: 1.43

Volume: 12,105.902 ft³

Weight: 1,513,192.6 lbs

Resisting Moment: 1.4352383e+008 lbs-ft

Activating Moment: 1.002606e+008 lbs-ft

Resisting Force: 398,835.9 lbs

Activating Force: 278,747.91 lbs

F of S Rank (Analysis): 1 of 33,516 slip surfaces

F of S Rank (Query): 1 of 33,516 slip surfaces

Exit: (331.36502, -37.711661) ft

Entry: (652.84647, 41.14) ft

Radius: 340.56816 ft

Center: (421.20137, 290.7942) ft

Slip Slices

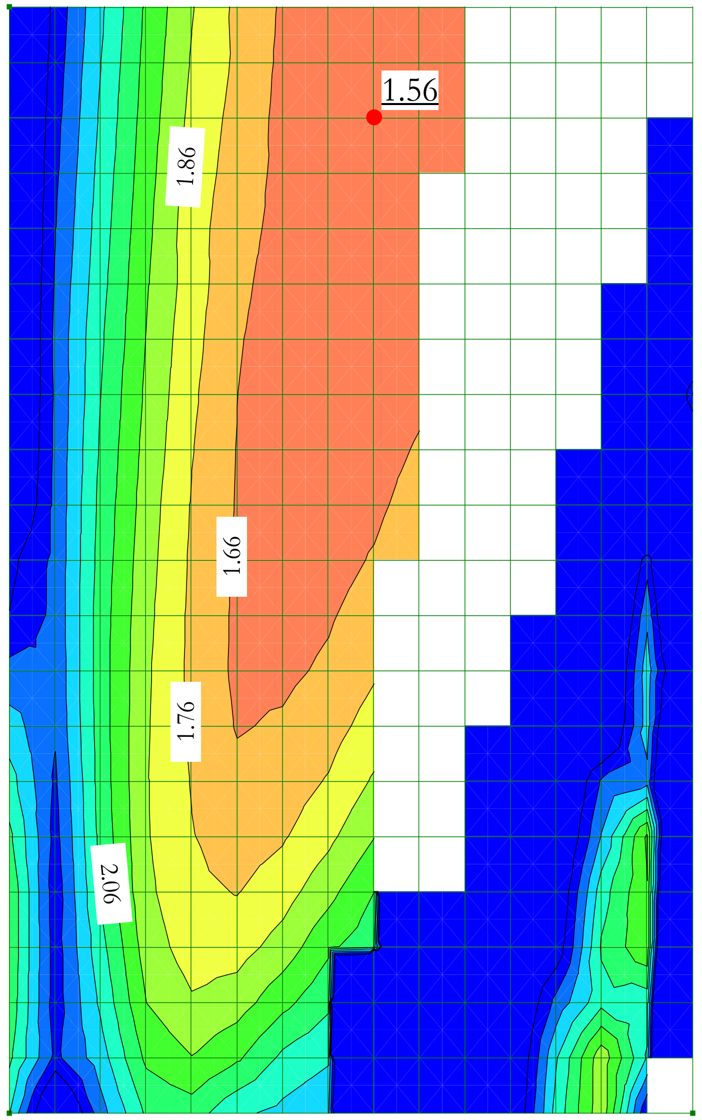
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	336.99085	-39.147533	2,215.6701	2,539.6255	130.88647	300
Slice 2	348.24251	-41.81744	2,382.2722	3,213.3728	335.78644	300
Slice 3	359.49417	-44.088119	2,523.9626	3,826.517	526.26614	300
Slice 4	370.22	-45.897001	2,636.8368	4,350.1398	692.21936	300
Slice 5	380.42	-47.284434	2,723.4127	4,786.6618	833.60674	300
Slice 6	390.62	-48.359496	2,790.4965	5,161.523	957.95689	300
Slice 7	400.82	-49.125154	2,838.2736	5,473.0792	1,064.5306	300
Slice 8	411.02	-49.583498	2,866.8743	5,720.9134	1,153.1067	300
Slice 9	421.22	-49.73577	2,876.3761	5,905.8249	1,223.9768	300
Slice 10	429.95	-49.642207	2,870.5377	6,018.2775	1,271.7694	300
Slice 11	438.434	-49.302971	2,849.3694	6,192.7186	1,350.8007	300
Slice 12	448.142	-48.671798	2,809.9842	6,430.3411	0	1,655.0854
Slice 13	457.85	-47.76113	2,753.1585	6,621.3692	0	1,671.7941
Slice 14	467.558	-46.568702	2,678.751	6,766.4323	0	1,679.2753
Slice						

15	477.266	-45.091511	2,586.5743	6,868.6423	0	1,678.7929
Slice 16	484.31	-43.868324	2,510.2474	6,921.7724	0	1,691.7703
Slice 17	492.375	-42.199633	2,406.1211	6,760.8733	0	1,675.2334
Slice 18	504.125	-39.468803	2,235.7173	6,395.5662	0	1,610.2568
Slice 19	511	-37.720339	2,126.6132	6,167.6812	0	1,624.6788
Slice 20	517.5	-35.825403	2,008.3692	5,993.8418	0	1,572.6198
Slice 21	528.5	-32.377721	1,793.2338	5,702.2762	0	1,490.3244
Slice 22	539.52088	-28.505813	1,551.6267	5,454.3696	0	1,432.4712
Slice 23	550.70147	-24.13269	1,278.7439	5,254.8185	0	1,325.7649
Slice 24	562.02088	-19.234661	973.10687	5,007.0693	0	1,292.7891
Slice 25	573.34029	-13.837376	636.31624	4,719.5709	0	1,255.9667
Slice 26	583.56363	-8.5354043	305.47323	4,370.1546	0	1,201.8788
Slice 27	588.56363	-5.8137782	135.64376	4,166.2364	0	1,127.7973
Slice 28	590.67985	-4.6037782	60.139757	4,100.0921	0	1,116.5787
Slice 29	596.2932	-1.2819726	-147.14091	3,933.3959	0	1,094.0431
Slice 30	605.82002	4.6852829	-519.49765	3,620.565	0	1,050.2986
Slice 31	617.00667	12.226055	-990.04183	3,202.4498	0	989.07676
Slice 32	630.1	21.986068	-1,599.0666	2,371.1739	0	778.04909
Slice 33	638.8	28.811236	-2,024.9571	1,626.3664	0	554.25567
Slice 34	641.8	31.33836	-2,182.6497	1,269.2662	0	427.76001
Slice 35	643.76133	33.008069	-2,286.8395	1,023.9684	0	362.31812
Slice 36	646.76133	35.656945	-2,452.1294	612.42392	0	298.50304
Slice 37	650.79312	39.25556	-2,676.6829	146.12631	0	117.75411
Slice 38	652.41636	40.742292	-2,769.455	25.148754	0	16.436286

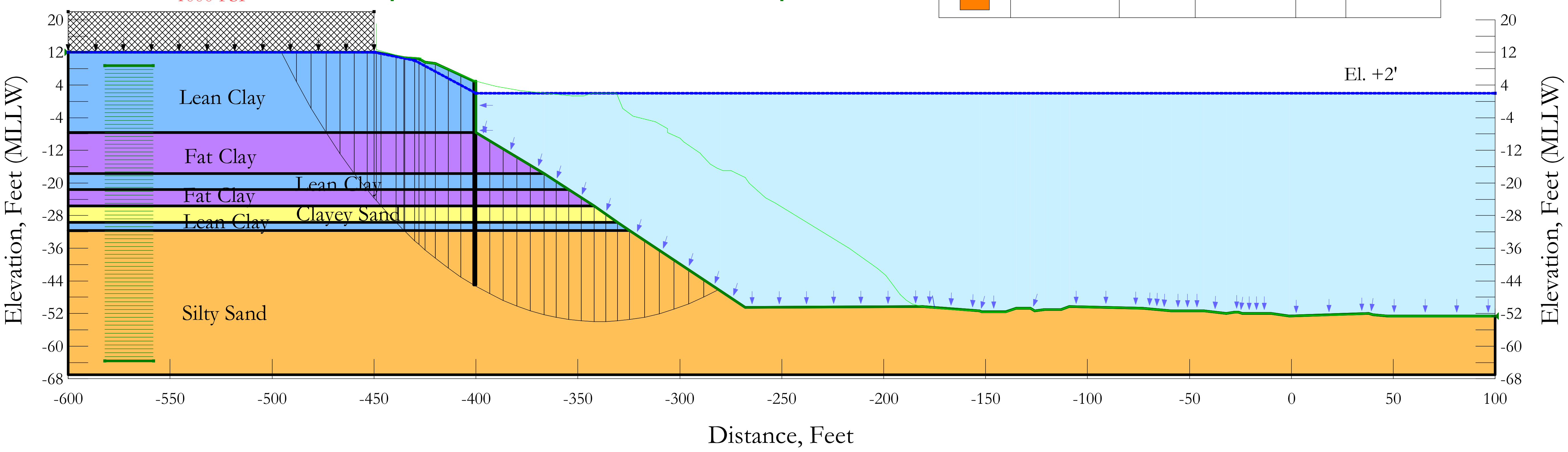
APPENDIX B

SLOPE STABILITY ANALYSIS: PROPOSED AT BAYPORT SHIP CHANNEL

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 40+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	120	0	28	
🟧	Silty sand	120	0	31	
🟦	Lean Clay (Undrained)	123			532
🟪	Fat Clay (Undrained)	115			1,200
🟧	Bulkhead	150			



Short Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 174
Date: 4/26/2018
Time: 8:58:21 PM
Tool Version: 8.16.1.13452
File Name: 040+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\040+00\
Last Solved Date: 4/26/2018
Last Solved Time: 8:58:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 4 ft

Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 123 pcf
Cohesion: 532 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-441, 179.58357) ft
Lower Left: (-441, 25.00513) ft

Lower Right: (-250, 25.00513) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-581.95887, 8.73276) ft
Upper Right Coordinate: (-558.24914, 8.73276) ft
Lower Left Coordinate: (-581.95887, -63.64172) ft
Lower Right Coordinate: (-558.0587, -63.64172) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 12) ft
Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12
Coordinate 2	-450	12
Coordinate 3	-430	10
Coordinate 4	-400	2
Coordinate 5	100	2

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 100 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-600	22
	-450	22

Points

	X (ft)	Y (ft)
Point 1	-600	-7.64333
Point 2	-600	-17.64333
Point 3	-600	-21.64333
Point 4	-600	-25.64333
Point 5	-600	-29.64333
Point 6	-600	-31.64333

Point 7	-175	-48.31
Point 8	-181	-50.31
Point 9	-268	-50.5
Point 10	-280	-46.5
Point 11	-400	-31.64333
Point 12	-400	-29.64333
Point 13	-400	-25.64333
Point 14	-400	-21.64333
Point 15	-400	-17.64333
Point 16	-400	-7.64333
Point 17	-350	8.85667
Point 18	-400	-6.64
Point 19	-400	5
Point 20	-401	5
Point 21	-401	-6.66667
Point 22	-401	-7.64333
Point 23	-401	-17.64333
Point 24	-401	-21.64333
Point 25	-401	-25.64333
Point 26	-401	-29.64333
Point 27	-401	-31.64333
Point 28	-400	-45
Point 29	-401	-45
Point 30	-449	12
Point 31	-435	10.66667
Point 32	-428	10.5
Point 33	-425	9.66667
Point 34	-420	9.33333
Point 35	-324.58	-31.64
Point 36	-330.58	-29.64
Point 37	-342	-25.64
Point 38	-354.58	-21.64
Point 39	-366.58	-17.64
Point 40	-600	12
Point 41	-153	-51.31
Point 42	-152	-51.6
Point 43	-140	-51.53857
Point 44	-135	-50.66667
Point 45	-128	-50.66667
Point 46	-126	-51.33333
Point 47	-121	-51
Point 48	-113	-51
Point 49	-109	-50.33333
Point 50	-73	-50.66667
Point 51	-59	-51.33333
Point 52	-43	-51.33333
Point 53	-32	-52
Point 54	-28	-51.66667
Point 55	-26	-51.66667
Point 56	-24	-52
Point 57	-10	-52
Point 58	-1	-52.66667
Point 59	38	-52
Point 60	40	-52.33333
Point 61	47	-52.66667
Point 62	100	-52.66667
Point 63	100	-67
Point 64	-600	-67

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay (Undrained)	40,1,22,21,20,34,33,32,31,30	3,779.7
Region 2	Fat Clay (Undrained)	23,2,1,22	1,990
Region 3	Lean Clay (Undrained)	24,3,2,23	796
Region 4	Fat Clay (Undrained)	25,4,3,24	796
Region 5	Clayey Sand	26,5,4,25	796
Region 6	Lean Clay (Undrained)	27,6,5,26	398
Region 7	Bulkhead	19,20,21,22,23,24,25,26,27,29,28,11,12,13,14,15,16,18	50
Region 8	Fat Clay (Undrained)	39,15,16	167.1
Region 9	Lean Clay (Undrained)	15,39,38,14	157.7
Region 10	Fat Clay (Undrained)	14,38,37,13	206.86
Region 11	Clayey Sand	12,36,37,13	254.86
Region 12	Lean Clay (Undrained)	12,11,35,36	144.85
Region 13	Silty sand	6,27,29,28,11,35,10,9,8,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64	16,952

Current Slip Surface

Slip Surface: 22,562
F of S: 1.56
Volume: 6,081.2287 ft^3
Weight: 731,458.23 lbs
Resisting Moment: 49,721,689 lbs-ft
Activating Moment: 31,850,021 lbs-ft
Resisting Force: 212,151.55 lbs
Activating Force: 136,069.06 lbs
F of S Rank (Analysis): 1 of 25,536 slip surfaces
F of S Rank (Query): 1 of 25,536 slip surfaces
Exit: (-281.10581, -46.131396) ft
Entry: (-495.44397, 12) ft
Radius: 218.11752 ft
Center: (-339.13333, 164.12573) ft

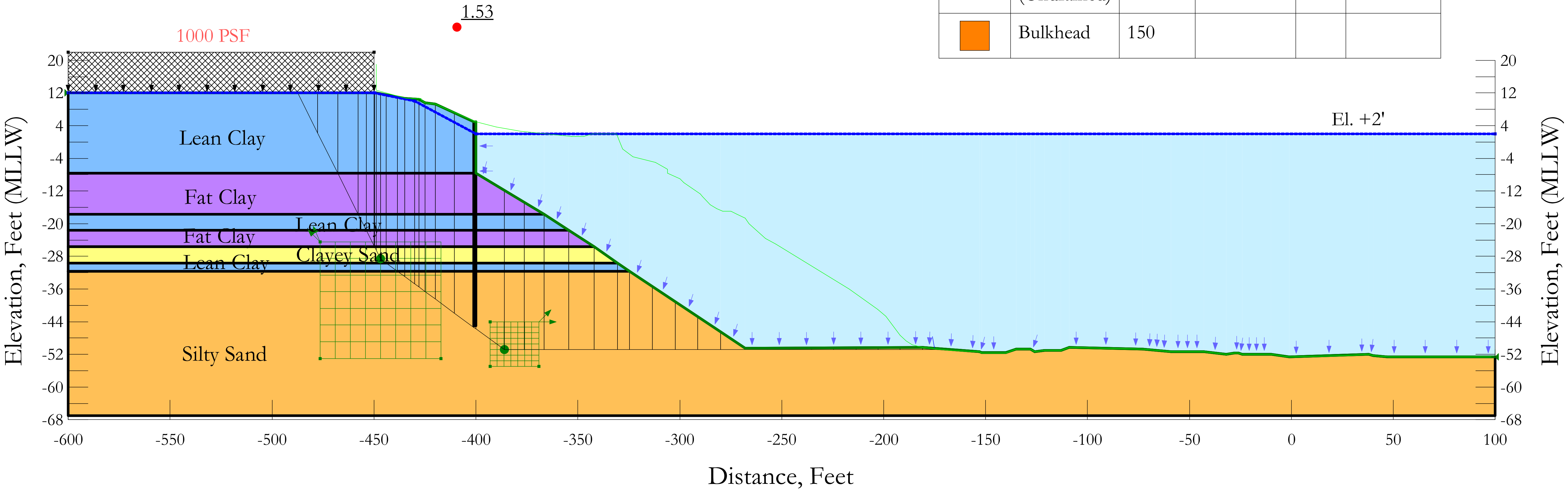
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-491.79671	8.4239166	223.1476	1,092.0389	0	532
Slice 2	-484.50219	1.5858783	649.8412	1,911.3492	0	532
Slice 3	-477.20768	-4.6597034	1,039.5655	2,631.3934	0	532
Slice 4	-470.09422	-10.246594	1,388.1875	2,964.108	0	1,200
Slice 5	-463.16181	-15.246594	1,700.1875	3,522.9293	0	1,200
Slice 6	-456.56582	-19.64333	1,974.5438	4,243.376	0	532
Slice 7	-451.71802	-22.678758	2,163.9545	4,375.4143	0	1,200
Slice 8	-449.5	-24.007507	2,221.5331	3,586.3595	0	1,200
Slice 9	-447.83226	-24.972079	2,270.8228	3,685.0651	0	1,200
Slice 10	-442.97088	-27.64333	2,405.8239	4,035.0878	866.29497	0
Slice 11	-437.29304	-30.64333	2,556.0915	4,406.4169	0	532

Slice 12	-435.15442	-31.71904	2,609.3383	4,396.6766	1,073.9412	0
Slice 13	-432.5	-32.978976	2,670.7803	4,536.6107	1,121.104	0
Slice 14	-429	-34.615383	2,583.6347	4,706.8232	1,275.7403	0
Slice 15	-426.5	-35.723307	2,609.3412	4,795.0497	1,313.3062	0
Slice 16	-422.5	-37.413178	2,645.6474	4,944.1853	1,381.1009	0
Slice 17	-416.83333	-39.654731	2,688.201	5,140.8601	1,473.7063	0
Slice 18	-410.5	-41.958769	2,724.0378	5,300.5685	1,548.1358	0
Slice 19	-404.16667	-44.04466	2,747.1661	5,445.3382	1,621.2253	0
Slice 20	-400.5	-45.180536	2,756.3764	7,378.0815	2,777.0006	0
Slice 21	-396.658	-46.240999	3,010.2384	4,823.1897	1,089.331	0
Slice 22	-389.974	-47.956018	3,117.2555	5,005.2603	1,134.4277	0
Slice 23	-383.29	-49.448132	3,210.3634	5,165.8101	1,174.9509	0
Slice 24	-376.606	-50.72199	3,289.8522	5,302.5785	1,209.368	0
Slice 25	-369.922	-51.781459	3,355.963	5,412.9873	1,235.9849	0
Slice 26	-363.58	-52.596438	3,406.8177	5,485.5642	1,249.0369	0
Slice 27	-357.58	-53.189497	3,443.8246	5,506.2558	1,239.2337	0
Slice 28	-351.435	-53.621827	3,470.802	5,504.897	1,222.2076	0
Slice 29	-345.145	-53.886227	3,487.3006	5,485.5407	1,200.6638	0
Slice 30	-339.145	-53.973103	3,492.7216	5,432.7398	1,165.6805	0
Slice 31	-333.435	-53.898637	3,488.075	5,332.016	1,107.9516	0
Slice 32	-327.58	-53.664874	3,473.4882	5,191.3941	1,032.222	0
Slice 33	-320.95715	-53.202735	3,444.6507	4,999.3309	934.1461	0
Slice 34	-313.71145	-52.474534	3,399.2109	4,744.8405	808.53581	0
Slice 35	-306.46576	-51.500463	3,338.4289	4,439.4004	661.53042	0
Slice 36	-299.22006	-50.277168	3,262.0953	4,084.6372	494.23306	0
Slice 37	-291.97436	-48.800348	3,169.9417	3,682.9922	308.27184	0
Slice 38	-284.72866	-47.064677	3,061.6358	3,237.5283	105.68687	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 40+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	**Name**	**Unit Weight (pcf)**	**Cohesion' (psf)**	**Phi' (°)**	**Cohesion (psf)**
🟨	Clayey Sand	120	0	28	
🟧	Silty sand	120	0	31	
🟦	Lean Clay (Undrained)	123			532
🟪	Fat Clay (Undrained)	115			1,200
🟧	Bulkhead	150			



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 174
Date: 4/26/2018
Time: 8:58:21 PM
Tool Version: 8.16.1.13452
File Name: 040+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\040+00\
Last Solved Date: 4/26/2018
Last Solved Time: 8:59:22 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001

Minimum Slip Surface Depth: 4 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 123 pcf
Cohesion: 532 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 12) ft

Right Coordinate: (100, -52.66667) ft

Slip Surface Block

Left Grid
- Upper Left: (-476.5184, -24.49092) ft
- Lower Left: (-476.5184, -53.01372) ft
- Lower Right: (-417.23972, -53.01372) ft
- X Increments: 8
- Y Increments: 7
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 2

Right Grid
- Upper Left: (-392.98134, -43.99251) ft
- Lower Left: (-392.98134, -54.97868) ft
- Lower Right: (-369.06866, -54.97868) ft
- X Increments: 7
- Y Increments: 8
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12
Coordinate 2	-450	12
Coordinate 3	-430	10
Coordinate 4	-400	2
Coordinate 5	100	2

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 100 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-600	22
	-450	22

Points

	X (ft)	Y (ft)
Point 1	-600	-7.64333
Point 2	-600	-17.64333
Point 3	-600	-21.64333
Point 4	-600	-25.64333
Point 5	-600	-29.64333
Point 6	-600	-31.64333

Point 7	-175	-48.31
Point 8	-181	-50.31
Point 9	-268	-50.5
Point 10	-280	-46.5
Point 11	-400	-31.64333
Point 12	-400	-29.64333
Point 13	-400	-25.64333
Point 14	-400	-21.64333
Point 15	-400	-17.64333
Point 16	-400	-7.64333
Point 17	-350	8.85667
Point 18	-400	-6.64
Point 19	-400	5
Point 20	-401	5
Point 21	-401	-6.66667
Point 22	-401	-7.64333
Point 23	-401	-17.64333
Point 24	-401	-21.64333
Point 25	-401	-25.64333
Point 26	-401	-29.64333
Point 27	-401	-31.64333
Point 28	-400	-45
Point 29	-401	-45
Point 30	-449	12
Point 31	-435	10.66667
Point 32	-428	10.5
Point 33	-425	9.66667
Point 34	-420	9.33333
Point 35	-324.58	-31.64
Point 36	-330.58	-29.64
Point 37	-342	-25.64
Point 38	-354.58	-21.64
Point 39	-366.58	-17.64
Point 40	-600	12
Point 41	-153	-51.31
Point 42	-152	-51.6
Point 43	-140	-51.53857
Point 44	-135	-50.66667
Point 45	-128	-50.66667
Point 46	-126	-51.33333
Point 47	-121	-51
Point 48	-113	-51
Point 49	-109	-50.33333
Point 50	-73	-50.66667
Point 51	-59	-51.33333
Point 52	-43	-51.33333
Point 53	-32	-52
Point 54	-28	-51.66667
Point 55	-26	-51.66667
Point 56	-24	-52
Point 57	-10	-52
Point 58	-1	-52.66667
Point 59	38	-52
Point 60	40	-52.33333
Point 61	47	-52.66667
Point 62	100	-52.66667
Point 63	100	-67
Point 64	-600	-67

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay (Undrained)	40,1,22,21,20,34,33,32,31,30	3,779.7
Region 2	Fat Clay (Undrained)	23,2,1,22	1,990
Region 3	Lean Clay (Undrained)	24,3,2,23	796
Region 4	Fat Clay (Undrained)	25,4,3,24	796
Region 5	Clayey Sand	26,5,4,25	796
Region 6	Lean Clay (Undrained)	27,6,5,26	398
Region 7	Bulkhead	19,20,21,22,23,24,25,26,27,29,28,11,12,13,14,15,16,18	50
Region 8	Fat Clay (Undrained)	39,15,16	167.1
Region 9	Lean Clay (Undrained)	15,39,38,14	157.7
Region 10	Fat Clay (Undrained)	14,38,37,13	206.86
Region 11	Clayey Sand	12,36,37,13	254.86
Region 12	Lean Clay (Undrained)	12,11,35,36	144.85
Region 13	Silty sand	6,27,29,28,11,35,10,9,8,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64	16,952

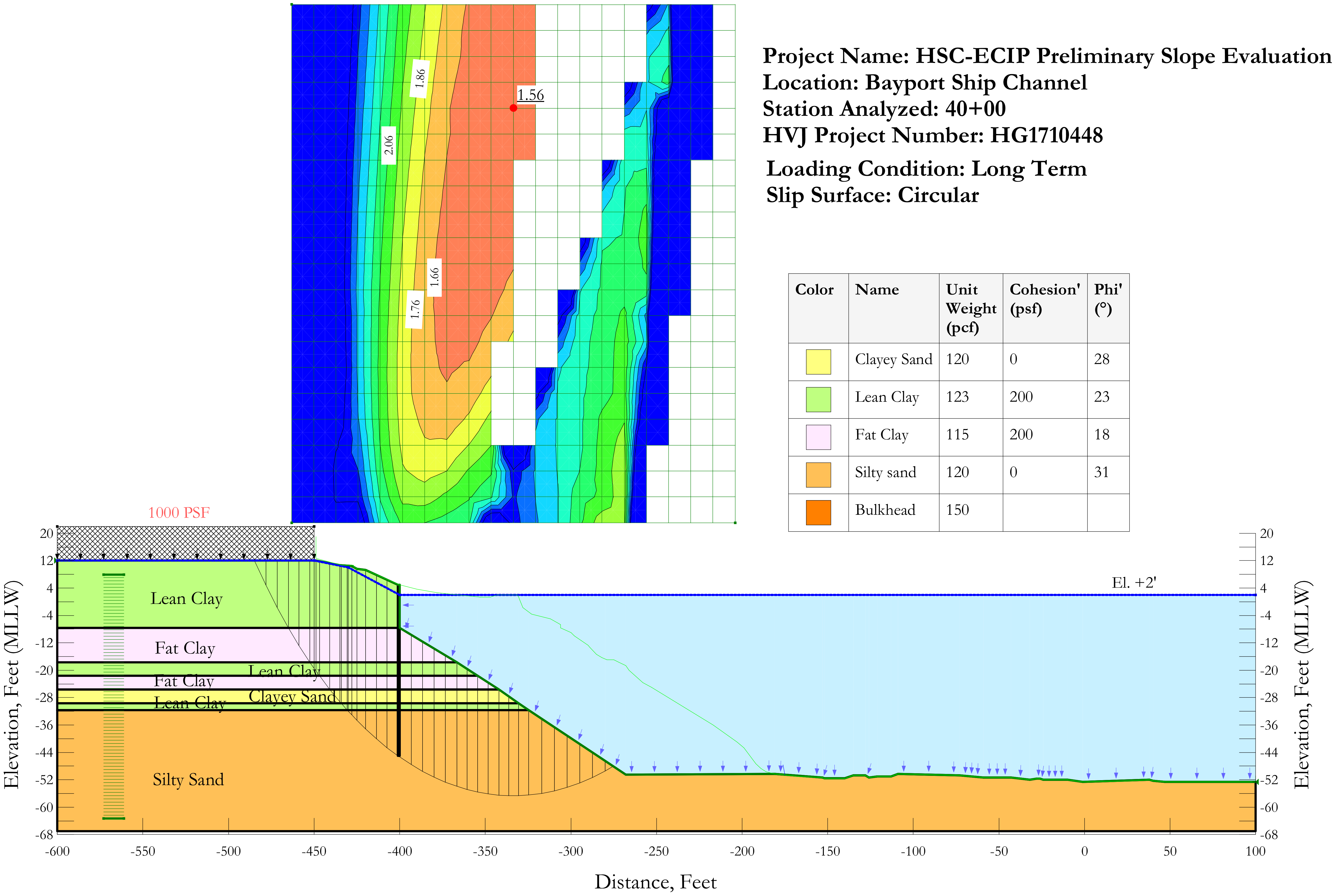
Current Slip Surface

Slip Surface: 38,095
F of S: 1.53
Volume: 5,934.5707 ft^3
Weight: 713,606.56 lbs
Resisting Moment: 21,293,595 lbs-ft
Activating Moment: 13,944,097 lbs-ft
Resisting Force: 203,736.15 lbs
Activating Force: 133,262.11 lbs
F of S Rank (Analysis): 1 of 46,656 slip surfaces
F of S Rank (Query): 1 of 46,656 slip surfaces
Exit: (-165.63175, -50.858866) ft
Entry: (-487.44467, 12) ft
Radius: 140.26332 ft
Center: (-317.32966, 27.714717) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-482.53383	7.0891675	306.43595	1,239.5722	0	532
Slice 2	-472.71217	-2.7324975	919.30784	2,374.3323	0	532
Slice 3	-462.80134	-12.64333	1,537.7438	3,032.0512	0	1,200
Slice 4	-455.80134	-19.64333	1,974.5438	4,140.7939	0	532
Slice 5	-451.90067	-23.543998	2,217.9455	4,146.9395	0	1,200
Slice 6	-449.90067	-25.543998	2,318.9363	3,405.1584	0	1,200
Slice 7	-449.40067	-26.043998	2,346.7383	3,723.223	731.88991	0
Slice 8	-447.93953	-27.505136	2,427.9833	3,847.5786	754.81219	0
Slice 9	-445.41113	-29.104468	2,511.1725	4,420.3108	1,015.1068	0
Slice 10	-441.21905	-30.64333	2,580.3472	4,630.0066	0	532
Slice 11	-436.74746	-32.284802	2,654.1344	4,642.0111	1,194.4368	0

Slice 12	-432.5	-33.843995	2,724.2231	4,780.3195	1,235.4274	0
Slice 13	-429	-35.128805	2,613.5453	4,890.2753	1,367.9974	0
Slice 14	-426.5	-36.046527	2,628.1711	4,936.8707	1,387.2067	0
Slice 15	-422.5	-37.514881	2,651.5723	5,024.9271	1,426.0554	0
Slice 16	-415.25	-40.176274	2,693.9871	5,165.1909	1,484.849	0
Slice 17	-405.75	-43.663616	2,749.565	5,294.7557	1,529.3049	0
Slice 18	-400.5	-45.590831	2,780.2791	7,071.895	2,578.663	0
Slice 19	-393.07457	-48.316621	3,139.7571	4,792.8386	993.2716	0
Slice 20	-381.25686	-50.858866	3,298.3933	5,497.1656	1,321.1557	0
Slice 21	-371.47229	-50.858866	3,298.3933	5,385.4928	1,254.0559	0
Slice 22	-360.58	-50.858866	3,298.3933	5,236.5943	1,164.5887	0
Slice 23	-348.29	-50.858866	3,298.3933	5,044.8581	1,049.3819	0
Slice 24	-336.29	-50.858866	3,298.3933	4,865.6546	941.70558	0
Slice 25	-327.58	-50.858866	3,298.3933	4,698.2405	841.11303	0
Slice 26	-319.0075	-50.858866	3,298.3933	4,539.3215	745.62487	0
Slice 27	-307.8625	-50.858866	3,298.3933	4,329.3202	619.44335	0
Slice 28	-296.7175	-50.858866	3,298.3933	4,110.4665	487.94278	0
Slice 29	-285.5725	-50.858866	3,298.3933	3,883.1452	351.35437	0
Slice 30	-274	-50.858866	3,298.3933	3,638.7588	204.51223	0
Slice 31	-262.5625	-50.858866	3,298.3933	3,322.6099	14.550821	0
Slice 32	-251.6875	-50.858866	3,298.3933	3,324.3625	15.603877	0
Slice 33	-240.8125	-50.858866	3,298.3933	3,326.0373	16.61018	0
Slice 34	-229.9375	-50.858866	3,298.3933	3,327.6284	17.566206	0
Slice 35	-219.0625	-50.858866	3,298.3933	3,329.1324	18.469932	0
Slice 36	-208.1875	-50.858866	3,298.3933	3,330.5485	19.320801	0
Slice 37	-197.3125	-50.858866	3,298.3933	3,331.878	20.11964	0
Slice 38	-186.4375	-50.858866	3,298.3933	3,333.1244	20.86854	0
Slice 39	-173.31587	-50.858866	3,298.3933	3,317.7485	11.629766	0



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 40+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Clayey Sand	120	0	28
🟩	Lean Clay	123	200	23
🟪	Fat Clay	115	200	18
🟧	Silty sand	120	0	31
🟧	Bulkhead	150		

Long Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 174
Date: 4/26/2018
Time: 8:58:21 PM
Tool Version: 8.16.1.13452
File Name: 040+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\040+00\
Last Solved Date: 4/26/2018
Last Solved Time: 8:58:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001

Minimum Slip Surface Depth: 4 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
  Lambda 1: -1
  Lambda 2: -0.8
  Lambda 3: -0.6
  Lambda 4: -0.4
  Lambda 5: -0.2
  Lambda 6: 0
  Lambda 7: 0.2
  Lambda 8: 0.4
  Lambda 9: 0.6
  Lambda 10: 0.8
  Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 123 pcf
Cohesion': 200 psf
Phi': 23 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 18 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Silty sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-463.14431, 174.53862) ft
Lower Left: (-463.14431, 23.01022) ft
Lower Right: (-203.97755, 23.01022) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-573, 7.95197) ft
Upper Right Coordinate: (-561, 7.95197) ft
Lower Left Coordinate: (-573, -63.31921) ft
Lower Right Coordinate: (-561, -63.31921) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 12) ft
Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12
Coordinate 2	-450	12
Coordinate 3	-430	10
Coordinate 4	-400	2
Coordinate 5	100	2

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 100 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-600	22
	-450	22

Points

	X (ft)	Y (ft)
Point 1	-600	-7.64333
Point 2	-600	-17.64333
Point 3	-600	-21.64333
Point 4	-600	-25.64333
Point 5	-600	-29.64333
Point 6	-600	-31.64333
Point 7	-175	-48.31
Point 8	-181	-50.31
Point 9	-268	-50.5
Point 10	-280	-46.5
Point 11	-400	-31.64333
Point 12	-400	-29.64333
Point 13	-400	-25.64333
Point 14	-400	-21.64333
Point 15	-400	-17.64333
Point 16	-400	-7.64333
Point 17	-350	8.85667
Point 18	-400	-6.64
Point 19	-400	5
Point 20	-401	5
Point 21	-401	-6.66667
Point 22	-401	-7.64333
Point 23	-401	-17.64333
Point 24	-401	-21.64333
Point 25	-401	-25.64333
Point 26	-401	-29.64333
Point 27	-401	-31.64333
Point 28	-400	-45
Point 29	-401	-45
Point 30	-449	12
Point 31	-435	10.66667
Point 32	-428	10.5
Point 33	-425	9.66667
Point 34	-420	9.33333
Point 35	-324.58	-31.64
Point 36	-330.58	-29.64
Point 37	-342	-25.64
Point 38	-354.58	-21.64
Point 39	-366.58	-17.64
Point 40	-600	12
Point 41	-153	-51.31
Point 42	-152	-51.6
Point 43	-140	-51.53857
Point 44	-135	-50.66667
Point 45	-128	-50.66667
Point 46	-126	-51.33333
Point 47	-121	-51
Point 48	-113	-51
Point 49	-109	-50.33333
Point 50	-73	-50.66667
Point 51	-59	-51.33333
Point 52	-43	-51.33333
Point 53	-32	-52
Point 54	-28	-51.66667
Point 55	-26	-51.66667
Point 56	-24	-52

Point 57	-10	-52
Point 58	-1	-52.66667
Point 59	38	-52
Point 60	40	-52.33333
Point 61	47	-52.66667
Point 62	100	-52.66667
Point 63	100	-67
Point 64	-600	-67

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	40,1,22,21,20,34,33,32,31,30	3,779.7
Region 2	Fat Clay	23,2,1,22	1,990
Region 3	Lean Clay	24,3,2,23	796
Region 4	Fat Clay	25,4,3,24	796
Region 5	Clayey Sand	26,5,4,25	796
Region 6	Lean Clay	27,6,5,26	398
Region 7	Bulkhead	19,20,21,22,23,24,25,26,27,29,28,11,12,13,14,15,16,18	50
Region 8	Fat Clay	39,15,16	167.1
Region 9	Lean Clay	15,39,38,14	157.7
Region 10	Fat Clay	14,38,37,13	206.86
Region 11	Clayey Sand	12,36,37,13	254.86
Region 12	Lean Clay	12,11,35,36	144.85
Region 13	Silty sand	6,27,29,28,11,35,10,9,8,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64	16,952

Current Slip Surface

Slip Surface: 26,365
F of S: 1.56
Volume: 5,979.2908 ft³
Weight: 719,065.54 lbs
Resisting Moment: 44,735,835 lbs-ft
Activating Moment: 28,608,962 lbs-ft
Resisting Force: 205,402.19 lbs
Activating Force: 131,526.63 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-275.35148, -48.049507) ft
Entry: (-484.80685, 12) ft
Radius: 200.90017 ft
Center: (-333.56093, 144.23294) ft

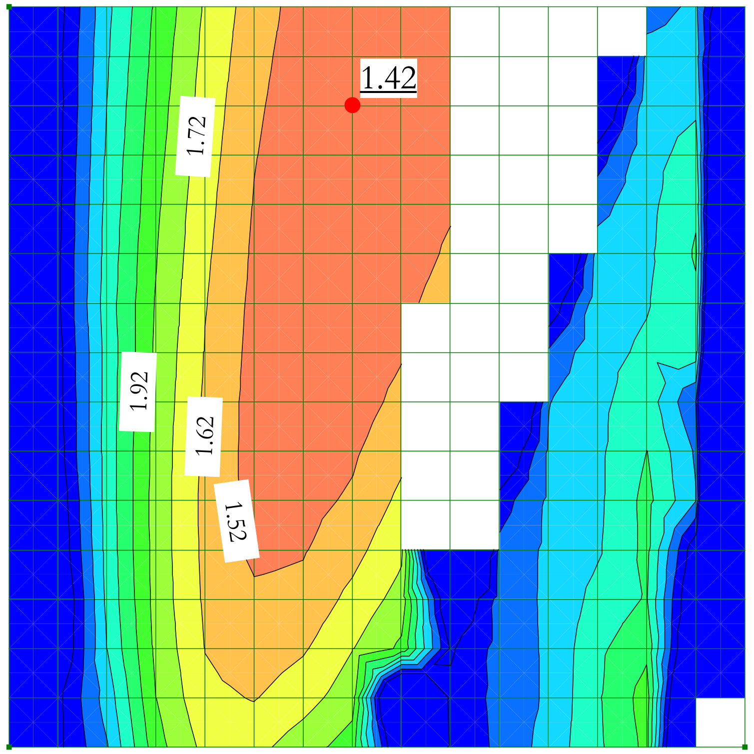
Slip Slices

				Base Normal Stress	Frictional Strength	

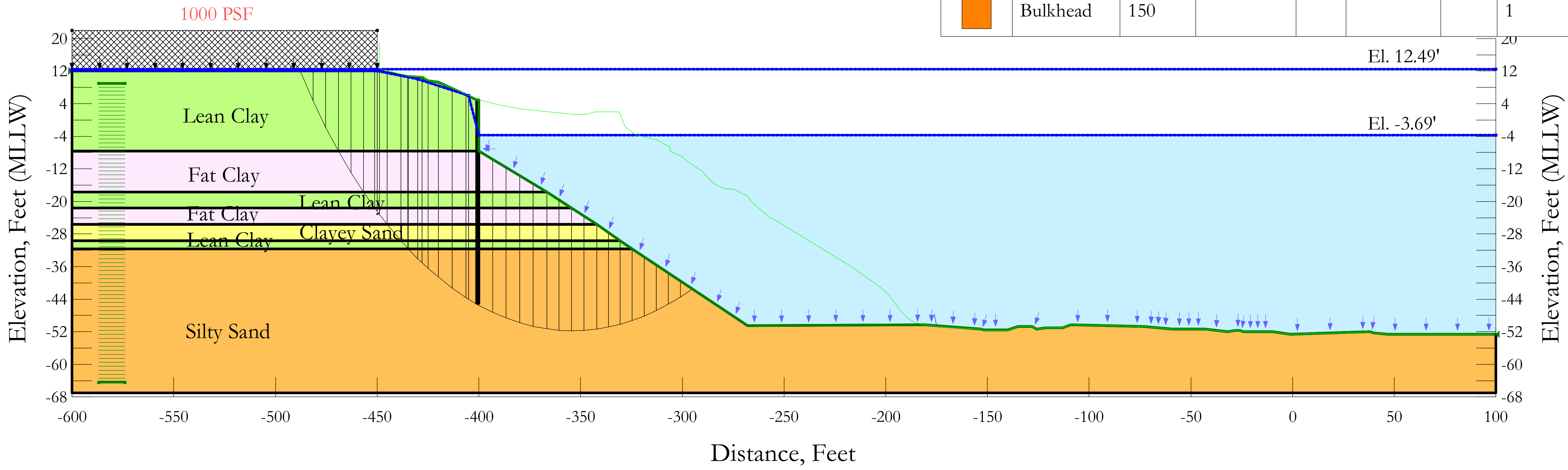
	X (ft)	Y (ft)	PWP (psf)	(psf)	(psf)	Cohesive Strength (psf)
Slice 1	-481.51728	8.4163902	223.61725	1,044.8265	348.58262	200
Slice 2	-474.93813	1.5727886	650.65799	1,788.9094	483.15907	200
Slice 3	-468.35898	-4.6652666	1,039.9126	2,459.1687	602.43846	200
Slice 4	-461.93803	-10.245608	1,388.1259	3,105.4996	558.00853	200
Slice 5	-455.67529	-15.245608	1,700.1259	3,608.246	619.98581	200
Slice 6	-451.27196	-18.563033	1,907.1333	3,883.3477	838.85325	200
Slice 7	-449.5	-19.83606	1,963.812	3,207.0373	527.71782	200
Slice 8	-447.95044	-20.916357	2,020.9816	3,312.6428	548.27767	200
Slice 9	-443.85676	-23.64333	2,164.1683	3,595.4969	465.06686	200
Slice 10	-437.90633	-27.410147	2,360.1274	3,901.5268	819.57659	0
Slice 11	-434.59925	-29.410147	2,463.2599	4,088.6098	864.21387	0
Slice 12	-432.42974	-30.64333	2,526.0449	4,216.984	717.76107	200
Slice 13	-430.33048	-31.824979	2,586.0801	4,323.562	1,043.9844	0
Slice 14	-429	-32.546505	2,463.1076	4,381.6376	1,152.7691	0
Slice 15	-426.5	-33.869127	2,501.3217	4,486.3528	1,192.727	0
Slice 16	-422.5	-35.886319	2,556.6968	4,660.5203	1,264.1047	0
Slice 17	-416.83333	-38.563334	2,624.6191	4,891.7859	1,362.2513	0
Slice 18	-410.5	-41.318959	2,686.7642	5,090.9866	1,444.6026	0
Slice 19	-404.16667	-43.820957	2,734.1338	5,274.9654	1,526.6856	0
Slice 20	-400.5	-45.186592	2,756.7293	7,170.2203	2,651.8929	0
Slice 21	-396.658	-46.469047	3,024.4685	4,727.9194	1,023.5366	0
Slice 22	-389.974	-48.552744	3,154.4912	4,951.86	1,079.9681	0
Slice 23	-383.29	-50.384636	3,268.8013	5,155.4321	1,133.6022	0
Slice 24	-376.606	-51.971787	3,367.8395	5,336.6376	1,182.9732	0
Slice 25	-369.922	-53.320103	3,451.9744	5,492.9454	1,226.3391	0
Slice 26	-363.58	-54.388633	3,518.6507	5,610.8655	1,257.1295	0
Slice 27	-357.58	-55.203349	3,569.489	5,675.303	1,265.3007	0
Slice 28	-351.435	-55.845613	3,609.5662	5,718.5274	1,267.1917	0
Slice 29	-345.145	-56.30824	3,638.4342	5,744.4933	1,265.4479	0
Slice 30	-339.145	-56.569302	3,654.7244	5,734.9308	1,249.9141	0
Slice 31	-333.435	-56.646906	3,659.567	5,673.2464	1,209.9406	0
Slice 32	-327.58	-56.555755	3,653.8791	5,569.6485	1,151.1104	0
Slice 33	-320.865	-56.231113	3,633.6214	5,413.3799	1,069.3868	0
Slice 34	-313.435	-55.621721	3,595.5954	5,188.3498	957.02342	0

Slice 35	-306.005	-54.733098	3,540.1453	4,902.4099	818.53113	0
Slice 36	-298.575	-53.561477	3,467.0361	4,556.4913	654.61073	0
Slice 37	-291.145	-52.101782	3,375.9512	4,152.781	466.76642	0
Slice 38	-283.715	-50.347521	3,266.4853	3,694.5273	257.19356	0
Slice 39	-277.67574	-48.722676	3,165.095	3,287.4544	73.520953	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 40+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Clayey Sand	120	0	28	0.1	27.9	1
🟩	Lean Clay	123	200	23	300	19	1
🟪	Fat Clay	115	200	18	300	14	1
🟧	Silty sand	120	0	31	0.1	30.9	1
🟧	Bulkhead	150					1



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 174
Date: 4/26/2018
Time: 8:58:21 PM
Tool Version: 8.16.1.13452
File Name: 040+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\040+00\
Last Solved Date: 4/26/2018
Last Solved Time: 8:58:52 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001

    Minimum Slip Surface Depth: 4 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 28 °
- Phi-B: 0 °
- Cohesion R: 0.1 psf
- Phi R: 27.9 °
- Pore Water Pressure
    - Piezometric Line: 2
    - Piezometric Line After Drawdown: 1

Lean Clay

- Model: Mohr-Coulomb
- Unit Weight: 123 pcf
- Cohesion': 200 psf
- Phi': 23 °
- Phi-B: 0 °
- Cohesion R: 300 psf
- Phi R: 19 °
- Pore Water Pressure
    - Piezometric Line: 2
    - Piezometric Line After Drawdown: 1

Fat Clay

- Model: Mohr-Coulomb
- Unit Weight: 115 pcf
- Cohesion': 200 psf
- Phi': 18 °
- Phi-B: 0 °
- Cohesion R: 300 psf
- Phi R: 14 °
- Pore Water Pressure
    - Piezometric Line: 2
    - Piezometric Line After Drawdown: 1

Silty sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf

Phi': 31 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 30.9 °
Pore Water Pressure
    Piezometric Line: 2
    Piezometric Line After Drawdown: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
    Piezometric Line: 2
    Piezometric Line After Drawdown: 1

Slip Surface Grid

Upper Left: (-450, 134.5) ft
Lower Left: (-450, 31) ft
Lower Right: (-244, 31) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-587, 9) ft
Upper Right Coordinate: (-574, 9) ft
Lower Left Coordinate: (-587, -64.5) ft
Lower Right Coordinate: (-574, -64.5) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 12) ft
Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12
Coordinate 2	-450	12
Coordinate 3	-430	10
Coordinate 4	-405	6
Coordinate 5	-400	-3.69
Coordinate 6	100	-3.69

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 100 pcf
Direction: Vertical

Coordinates

	X (ft)	Y (ft)
	-600	22
	-450	22

Points

	X (ft)	Y (ft)
Point 1	-600	-7.64333
Point 2	-600	-17.64333
Point 3	-600	-21.64333
Point 4	-600	-25.64333
Point 5	-600	-29.64333
Point 6	-600	-31.64333
Point 7	-175	-48.31
Point 8	-181	-50.31
Point 9	-268	-50.5
Point 10	-280	-46.5
Point 11	-400	-31.64333
Point 12	-400	-29.64333
Point 13	-400	-25.64333
Point 14	-400	-21.64333
Point 15	-400	-17.64333
Point 16	-400	-7.64333
Point 17	-350	8.85667
Point 18	-400	-6.64
Point 19	-400	5
Point 20	-401	5
Point 21	-401	-6.66667
Point 22	-401	-7.64333
Point 23	-401	-17.64333
Point 24	-401	-21.64333
Point 25	-401	-25.64333
Point 26	-401	-29.64333
Point 27	-401	-31.64333
Point 28	-400	-45
Point 29	-401	-45
Point 30	-449	12
Point 31	-435	10.66667
Point 32	-428	10.5
Point 33	-425	9.66667
Point 34	-420	9.33333
Point 35	-324.58	-31.64

Point 36	-330.58	-29.64
Point 37	-342	-25.64
Point 38	-354.58	-21.64
Point 39	-366.58	-17.64
Point 40	-600	12
Point 41	-153	-51.31
Point 42	-152	-51.6
Point 43	-140	-51.53857
Point 44	-135	-50.66667
Point 45	-128	-50.66667
Point 46	-126	-51.33333
Point 47	-121	-51
Point 48	-113	-51
Point 49	-109	-50.33333
Point 50	-73	-50.66667
Point 51	-59	-51.33333
Point 52	-43	-51.33333
Point 53	-32	-52
Point 54	-28	-51.66667
Point 55	-26	-51.66667
Point 56	-24	-52
Point 57	-10	-52
Point 58	-1	-52.66667
Point 59	38	-52
Point 60	40	-52.33333
Point 61	47	-52.66667
Point 62	100	-52.66667
Point 63	100	-67
Point 64	-600	-67

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	40,1,22,21,20,34,33,32,31,30	3,779.7
Region 2	Fat Clay	23,2,1,22	1,990
Region 3	Lean Clay	24,3,2,23	796
Region 4	Fat Clay	25,4,3,24	796
Region 5	Clayey Sand	26,5,4,25	796
Region 6	Lean Clay	27,6,5,26	398
Region 7	Bulkhead	19,20,21,22,23,24,25,26,27,29,28,11,12,13,14,15,16,18	50
Region 8	Fat Clay	39,15,16	167.1
Region 9	Lean Clay	15,39,38,14	157.7
Region 10	Fat Clay	14,38,37,13	206.86
Region 11	Clayey Sand	12,36,37,13	254.86
Region 12	Lean Clay	12,11,35,36	144.85

Region 13	Silty sand	6,27,29,28,11,35,10,9,8,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64	16,952

Current Slip Surface

Slip Surface: 16,403
F of S: 1.42
Volume: 5,556.4256 ft³
Weight: 668,309.17 lbs
Resisting Moment: 36,138,982 lbs-ft
Activating Moment: 25,401,374 lbs-ft
Resisting Force: 193,287.62 lbs
Activating Force: 136,013.74 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (-295.14032, -41.453225) ft
Entry: (-487.75752, 12) ft
Radius: 172.46 ft
Center: (-353.86667, 120.7) ft

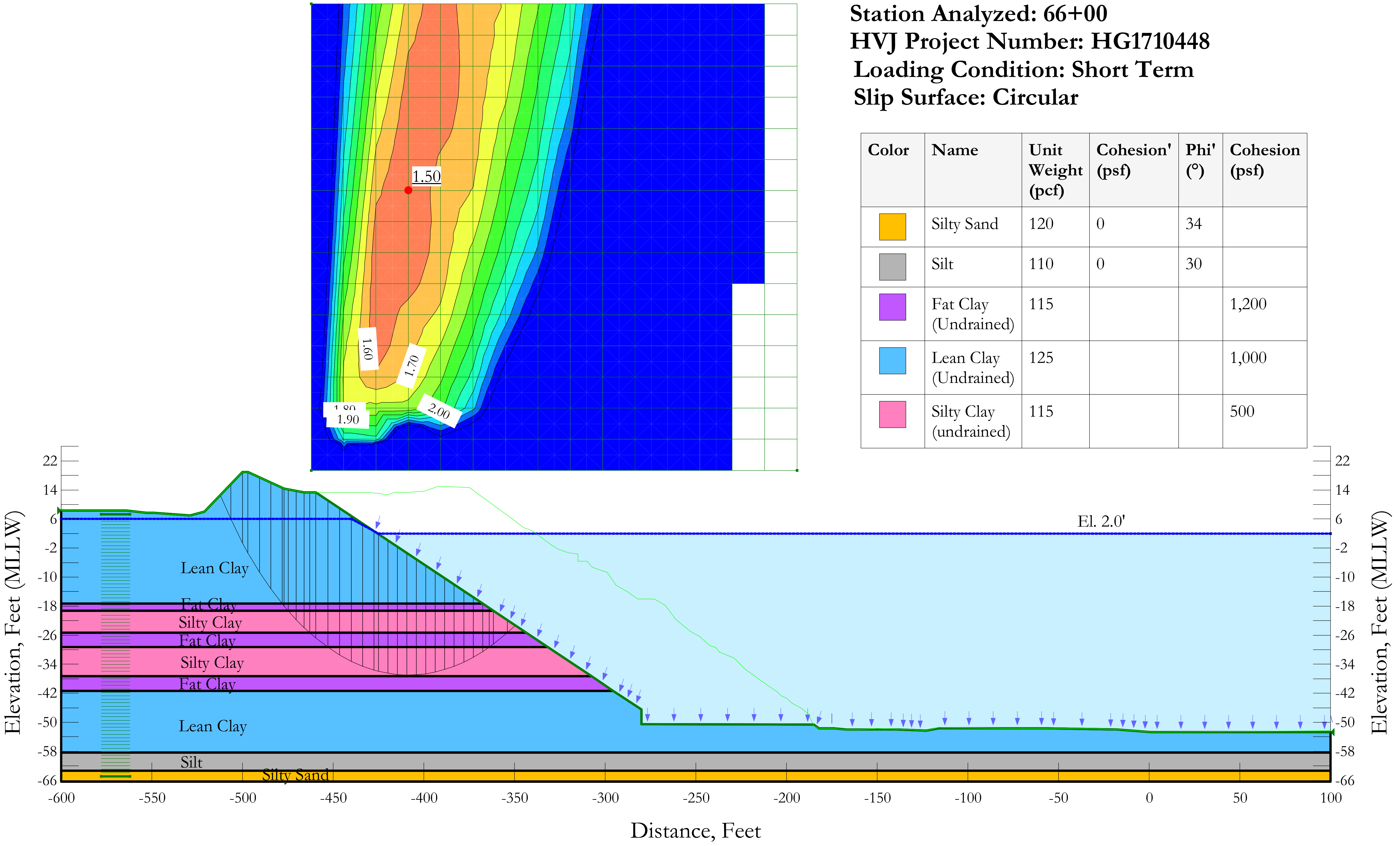
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-484.64195	8.3727387	226.3411	997.46107	327.32101	200
Slice 2	-478.4108	1.4904799	655.79405	1,733.9996	457.67106	200
Slice 3	-472.17964	-4.7039238	1,042.3248	2,387.3785	570.94142	200
Slice 4	-466.00813	-10.260134	1,389.0324	3,022.2102	530.65163	200
Slice 5	-459.89626	-15.260134	1,701.0324	3,515.6425	589.60257	200
Slice 6	-454.03827	-19.64333	1,974.5438	3,901.2794	817.85075	200
Slice 7	-450.61811	-22.062226	2,125.4829	4,227.9072	683.11907	200
Slice 8	-449.5	-22.814306	2,147.8146	3,474.8375	431.17587	200
Slice 9	-447.05702	-24.39541	2,230.4053	3,616.8372	450.47902	200
Slice 10	-441.73764	-27.64333	2,398.2046	3,883.756	789.88171	0
Slice 11	-436.68063	-30.563442	2,547.3721	4,155.1745	682.47163	200
Slice 12	-434.84979	-31.563442	2,597.843	4,256.7594	704.16822	200
Slice 13	-432.34979	-32.844411	2,661.5386	4,382.4509	1,034.0284	0
Slice 14	-429	-34.529506	2,699.5487	4,573.1772	1,125.7896	0
Slice 15	-426.5	-35.710087	2,747.0412	4,675.6802	1,158.8432	0
Slice 16	-422.5	-37.49131	2,816.476	4,846.8424	1,219.9672	0
Slice 17	-416.57217	-39.914229	2,906.1861	5,082.1593	1,307.4566	0
Slice 18	-409.71651	-42.426086	2,992.2751	5,290.7822	1,381.0824	0
Slice 19	-405.64434	-43.802487	3,114.1082	5,415.0296	1,382.5331	0
Slice 20	-403	-44.599769	613.04854	5,452.9574	0	1,917.8575
Slice 21	-400.5	-45.334677	559.12126	6,978.6901	3,857.2661	0
Slice 22	-396.658	-46.331289	2,660.8164	4,488.1937	1,097.999	0
Slice 23	-389.974	-47.903176	2,758.9022	4,691.7219	1,161.3552	0

Slice 24	-383.29	-49.197661	2,839.678	4,868.0865	1,218.7908	0
Slice 25	-376.606	-50.221057	2,903.5379	5,012.6938	1,267.3087	0
Slice 26	-369.922	-50.97822	2,950.7849	5,120.3427	1,303.6018	0
Slice 27	-363.58	-51.460025	2,980.8495	5,176.8651	1,319.4993	0
Slice 28	-357.58	-51.693905	2,995.4437	5,169.0381	1,306.0273	0
Slice 29	-351.435	-51.714169	2,996.7081	5,123.9829	1,278.1956	0
Slice 30	-345.145	-51.510533	2,984.0013	5,043.0572	1,237.2056	0
Slice 31	-339.145	-51.106616	2,958.7968	4,913.2608	1,174.3604	0
Slice 32	-333.435	-50.521294	2,922.2727	4,723.1311	1,082.0649	0
Slice 33	-327.58	-49.717865	2,872.1388	4,475.9024	963.6384	0
Slice 34	-321.63603	-48.694974	2,808.3104	4,183.5158	826.30679	0
Slice 35	-315.7481	-47.467518	2,731.7171	3,849.9378	671.8948	0
Slice 36	-309.86016	-46.023149	2,641.5885	3,471.7904	498.83565	0
Slice 37	-303.97223	-44.356165	2,537.5687	3,052.2063	309.22545	0
Slice 38	-298.08429	-42.459733	2,419.2313	2,594.785	105.48331	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 66+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Silty Sand	120	0	34	
⬜	Silt	110	0	30	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (Undrained)	125			1,000
🟥	Silty Clay (undrained)	115			500



Short Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 81
Date: 4/26/2018
Time: 9:25:51 PM
Tool Version: 8.16.1.13452
File Name: 066+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\066+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:26:36 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 34 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)

Unit Weight: 115 pcf

Cohesion: 1,200 psf

Pore Water Pressure

Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Silty Clay (undrained)

Model: Undrained (Phi=0)

Unit Weight: 115 pcf

Cohesion: 500 psf

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-462, 147.96504) ft

Lower Left: (-462, 19.36474) ft

Lower Right: (-194.20183, 19.36474) ft

Grid Horizontal Increment: 15

Grid Vertical Increment: 15

Left Projection Angle: 0 °

Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-578.00828, 7.2798) ft

Upper Right Coordinate: (-562.03796, 7.2798) ft

Lower Left Coordinate: (-578.00828, -64.86904) ft

Lower Right Coordinate: (-562.03796, -64.86904) ft

Number of Increments: 75

Left Projection: No

Left Projection Angle: 135 °

Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 8.33333) ft

Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	6
Coordinate 2	-440	6
Coordinate 3	-425	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)

Point 1	-600	-17.31
Point 2	-600	-19.31
Point 3	-600	-25.31
Point 4	-600	-29.31
Point 5	-600	-37.31
Point 6	-600	-41.31
Point 7	-600	-58.31
Point 8	100	-58.31
Point 9	-600	-63.31
Point 10	100	-63.31
Point 11	-600	-66.31
Point 12	100	-66.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-295.57	-41.31
Point 16	-307.57	-37.31
Point 17	-331.57	-29.31
Point 18	-343.57	-25.31
Point 19	-361.57	-19.31
Point 20	-367.57	-17.31
Point 21	-459.5	13.33333
Point 22	-600	8.33333
Point 23	-564	8.33333
Point 24	-553	7.66667
Point 25	-549	7.66667
Point 26	-529	7
Point 27	-521	8
Point 28	-500	19
Point 29	-497	19
Point 30	-477	14.33333
Point 31	-466	13.33333
Point 32	-185	-50.66667
Point 33	-182	-51.66667
Point 34	-174	-51.66667
Point 35	-167	-52
Point 36	-139	-52
Point 37	-123	-52.33333
Point 38	-116	-51.66667
Point 39	-56	-51.66667
Point 40	-18	-52
Point 41	1	-52.66667
Point 42	100	-52.66667

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay (Undrained)	19,2,1,20	470.86
Region 2	Silty Clay (undrained)	18,3,2,19	1,484.6
Region 3	Fat Clay (Undrained)	17,4,3,18	1,049.7
Region 4	Silty Clay (undrained)	16,5,4,17	2,243.4
Region 5	Fat Clay (Undrained)	15,6,5,16	1,193.7

Region 6	Silt	7,9,10,8	3,500
Region 7	Silty Sand	9,11,12,10	2,100
Region 8	Lean Clay (Undrained)	22,23,24,25,26,27,28,29,30,31,21,20,1	5,378.6
Region 9	Lean Clay (Undrained)	6,15,14,13,32,33,34,35,36,37,38,39,40,41,42,8,7	7,889.6

Current Slip Surface

Slip Surface: 11,219
F of S: 1.50
Volume: 4,458.1467 ft³
Weight: 539,602.93 lbs
Resisting Moment: 17,417,264 lbs-ft
Activating Moment: 11,579,854 lbs-ft
Resisting Force: 114,713.07 lbs
Activating Force: 76,502.029 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (-349.59448, -23.301841) ft
Entry: (-512.24547, 12.585706) ft
Radius: 133.49641 ft
Center: (-408.44037, 96.52492) ft

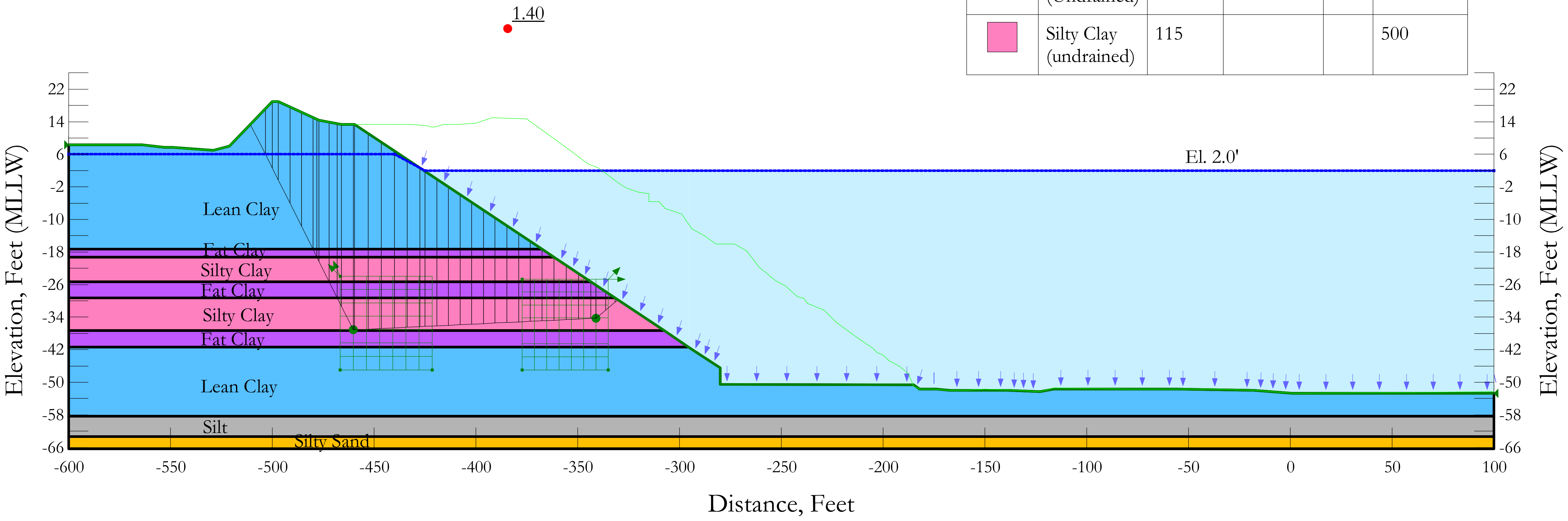
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-509.40036	9.2928532	-205.47404	-164.86342	0	1,000
Slice 2	-503.27762	2.6874548	206.70282	1,150.9177	0	1,000
Slice 3	-498.5	-1.996262	498.96675	1,995.1214	0	1,000
Slice 4	-493.86248	-5.9820236	747.67827	2,435.7414	0	1,000
Slice 5	-487.58744	-10.90806	1,055.0629	2,907.8578	0	1,000
Slice 6	-481.3124	-15.264753	1,326.9206	3,305.1451	0	1,000
Slice 7	-477.58744	-17.665718	1,476.7408	3,441.6693	0	1,200
Slice 8	-475.89985	-18.665718	1,539.1408	3,539.7127	0	1,200
Slice 9	-472.59978	-20.515955	1,654.5956	3,964.2525	0	500
Slice 10	-468.19993	-22.823448	1,798.5831	4,187.754	0	500
Slice 11	-464.50362	-24.617493	1,910.5315	4,378.0851	0	500
Slice 12	-461.25362	-26.065477	2,000.8858	4,386.4057	0	1,200
Slice 13	-456.25731	-28.065477	2,125.6858	4,527.8009	0	1,200
Slice 14	-449.76096	-30.369487	2,269.456	4,705.3907	0	500
Slice 15	-443.25365	-32.308177	2,390.4302	4,699.5055	0	500
Slice 16	-436.87501	-33.868839	2,274.1018	4,658.6769	0	500
Slice 17	-430.62502	-35.07709	2,247.396	4,583.9053	0	500
Slice 18	-426.25002	-35.772157	2,377.7829	4,519.7882	0	500
Slice 19	-422.38955	-36.214757	2,384.6008	4,499.0686	0	500

Slice 20	-417.16864	-36.660157	2,412.3938	4,481.099	0	500
Slice 21	-411.94773	-36.899854	2,427.3509	4,437.504	0	500
Slice 22	-406.72682	-36.934959	2,429.5414	4,367.3825	0	500
Slice 23	-401.50591	-36.765633	2,418.9755	4,269.8398	0	500
Slice 24	-396.285	-36.391094	2,395.6042	4,144.0325	0	500
Slice 25	-391.06409	-35.809596	2,359.3188	3,989.2084	0	500
Slice 26	-385.84318	-35.018391	2,309.9476	3,804.739	0	500
Slice 27	-380.62227	-34.01366	2,247.2524	3,590.1445	0	500
Slice 28	-375.40136	-32.790416	2,170.922	3,345.1069	0	500
Slice 29	-370.18045	-31.342377	2,080.5643	3,069.472	0	500
Slice 30	-365.71806	-29.935644	1,992.7842	2,817.609	0	500
Slice 31	-362.71806	-28.89146	1,927.6271	2,819.9288	0	1,200
Slice 32	-357.72175	-26.89146	1,802.8271	2,509.6531	0	1,200
Slice 33	-351.73399	-24.30592	1,641.4894	1,898.0266	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 66+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Silty Sand	120	0	34	
⬜	Silt	110	0	30	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (Undrained)	125			1,000
🟥	Silty Clay (undrained)	115			500



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 81
Date: 4/26/2018
Time: 9:25:51 PM
Tool Version: 8.16.1.13452
File Name: 066+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\066+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:27:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
    Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf

Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Silty Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 500 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 8.33333) ft
Right Coordinate: (100, -52.66667) ft

Slip Surface Block

Left Grid
Upper Left: (-466.71366, -24.00079) ft
Lower Left: (-466.71366, -46.97058) ft
Lower Right: (-421.38292, -46.97058) ft
X Increments: 7
Y Increments: 7
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 2
Right Grid
Upper Left: (-377.21577, -24.70938) ft
Lower Left: (-377.21577, -46.98267) ft
Lower Right: (-335.01768, -46.98267) ft
X Increments: 7
Y Increments: 7
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	6
Coordinate 2	-440	6
Coordinate 3	-425	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)

Point 1	-600	-17.31
Point 2	-600	-19.31
Point 3	-600	-25.31
Point 4	-600	-29.31
Point 5	-600	-37.31
Point 6	-600	-41.31
Point 7	-600	-58.31
Point 8	100	-58.31
Point 9	-600	-63.31
Point 10	100	-63.31
Point 11	-600	-66.31
Point 12	100	-66.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-295.57	-41.31
Point 16	-307.57	-37.31
Point 17	-331.57	-29.31
Point 18	-343.57	-25.31
Point 19	-361.57	-19.31
Point 20	-367.57	-17.31
Point 21	-459.5	13.33333
Point 22	-600	8.33333
Point 23	-564	8.33333
Point 24	-553	7.66667
Point 25	-549	7.66667
Point 26	-529	7
Point 27	-521	8
Point 28	-500	19
Point 29	-497	19
Point 30	-477	14.33333
Point 31	-466	13.33333
Point 32	-185	-50.66667
Point 33	-182	-51.66667
Point 34	-174	-51.66667
Point 35	-167	-52
Point 36	-139	-52
Point 37	-123	-52.33333
Point 38	-116	-51.66667
Point 39	-56	-51.66667
Point 40	-18	-52
Point 41	1	-52.66667
Point 42	100	-52.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay (Undrained)	19,2,1,20	470.86
Region 2	Silty Clay (undrained)	18,3,2,19	1,484.6
Region 3	Fat Clay (Undrained)	17,4,3,18	1,049.7
Region 4	Silty Clay (undrained)	16,5,4,17	2,243.4
Region 5	Fat Clay (Undrained)	15,6,5,16	1,193.7

Region 6	Silt	7,9,10,8	3,500
Region 7	Silty Sand	9,11,12,10	2,100
Region 8	Lean Clay (Undrained)	22,23,24,25,26,27,28,29,30,31,21,20,1	5,378.6
Region 9	Lean Clay (Undrained)	6,15,14,13,32,33,34,35,36,37,38,39,40,41,42,8,7	7,889.6

Current Slip Surface

Slip Surface: 14,900
F of S: 1.40
Volume: 4,941.5412 ft³
Weight: 594,554.17 lbs
Resisting Moment: 8,934,513.6 lbs-ft
Activating Moment: 6,425,613.1 lbs-ft
Resisting Force: 109,809.14 lbs
Activating Force: 78,843.971 lbs
F of S Rank (Analysis): 1 of 36,864 slip surfaces
F of S Rank (Query): 1 of 36,864 slip surfaces
Exit: (-330.20554, -29.76482) ft
Entry: (-510.73902, 13.374798) ft
Radius: 86.000356 ft
Center: (-412.74092, 24.159702) ft

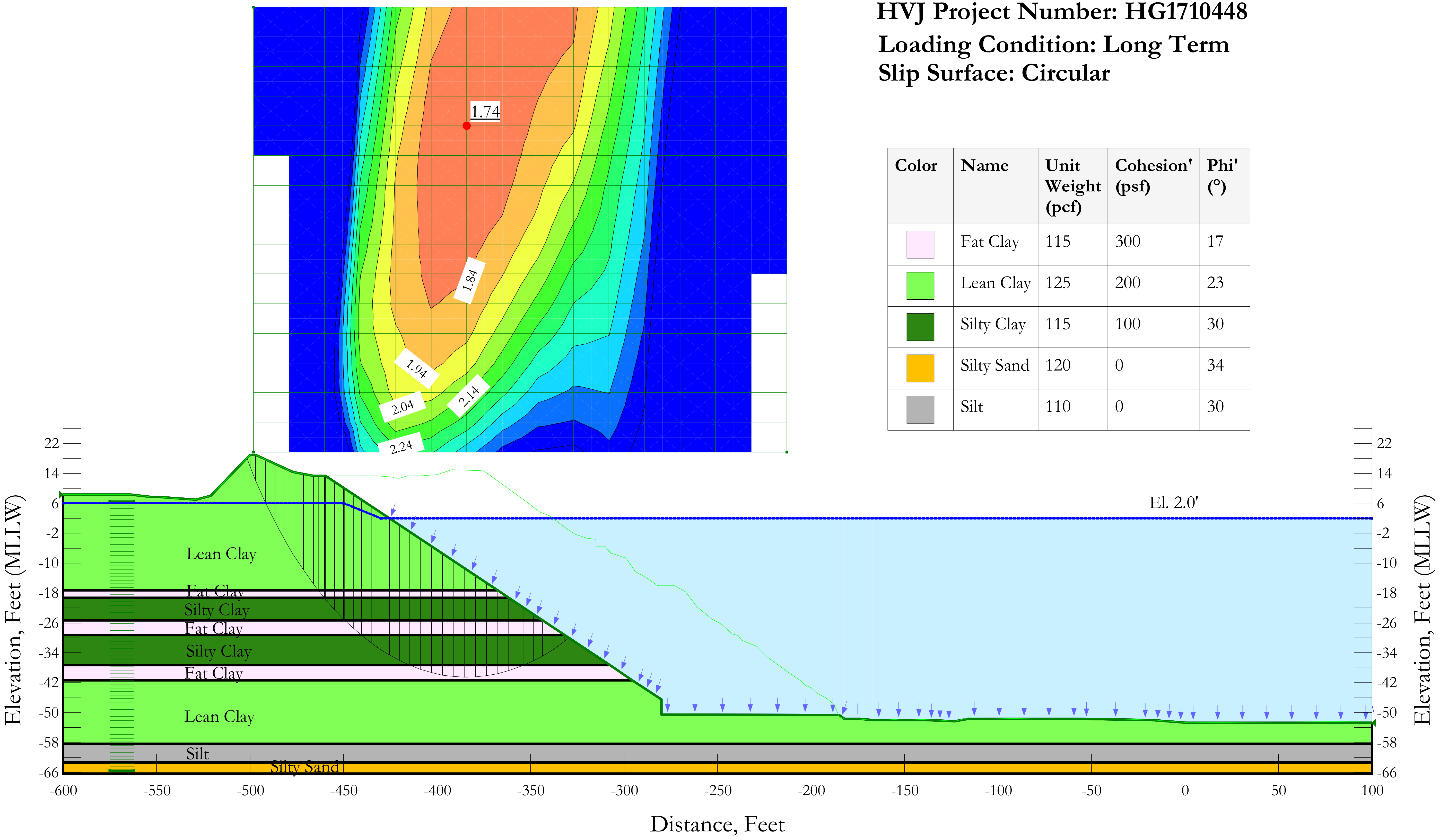
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-507.05162	9.687399	-230.09369	-9.0103256	0	1,000
Slice 2	-501.68211	4.3178879	104.9638	1,009.253	0	1,000
Slice 3	-498.5	1.1357757	303.5276	1,504.9256	0	1,000
Slice 4	-494.1757	-3.1885202	573.36366	1,941.905	0	1,000
Slice 5	-488.52711	-8.8371121	925.8358	2,447.5494	0	1,000
Slice 6	-482.87852	-14.485704	1,278.3079	2,944.0147	0	1,000
Slice 7	-479.05422	-18.31	1,516.944	3,134.7322	0	1,200
Slice 8	-477.52711	-19.837112	1,612.2358	3,712.5762	0	500
Slice 9	-474.52711	-22.837112	1,799.4358	3,978.8408	0	500
Slice 10	-470.05422	-27.31	2,078.544	3,936.6546	0	1,200
Slice 11	-467.02711	-30.337112	2,267.4358	4,666.5901	0	500
Slice 12	-463.11892	-34.245304	2,511.307	5,052.3823	0	500
Slice 13	-459.86892	-37.117497	2,690.5318	6,057.811	0	500
Slice 14	-456.25	-37.030318	2,685.0918	5,922.4057	0	500
Slice 15	-449.75	-36.873734	2,675.321	5,651.2787	0	500
Slice 16	-443.25	-36.717151	2,665.5502	5,379.5644	0	500
Slice 17	-436.87501	-36.563578	2,431.0899	5,112.2772	0	500
Slice 18	-430.62502	-36.413017	2,325.2235	4,849.2605	0	500
Slice 19	-426.25002	-36.307624	2,411.196	4,669.8807	0	500

Slice 20	-422.1285	-36.208338	2,384.2003	4,562.0506	0	500
Slice 21	-416.3855	-36.06999	2,375.5674	4,440.6596	0	500
Slice 22	-410.6425	-35.931642	2,366.9345	4,317.8347	0	500
Slice 23	-404.8995	-35.793295	2,358.3016	4,193.3089	0	500
Slice 24	-399.1565	-35.654947	2,349.6687	4,066.8451	0	500
Slice 25	-393.4135	-35.516599	2,341.0358	3,938.2411	0	500
Slice 26	-387.6705	-35.378251	2,332.4029	3,807.3336	0	500
Slice 27	-381.9275	-35.239904	2,323.77	3,674.0021	0	500
Slice 28	-376.1845	-35.101556	2,315.1371	3,538.1719	0	500
Slice 29	-370.4415	-34.963208	2,306.5042	3,399.8158	0	500
Slice 30	-364.57	-34.821765	2,297.6781	3,265.777	0	500
Slice 31	-358.57	-34.677226	2,288.6589	3,135.9761	0	500
Slice 32	-352.57	-34.532687	2,279.6397	3,003.6528	0	500
Slice 33	-346.57	-34.388148	2,270.6205	2,869.0046	0	500
Slice 34	-342.30799	-34.285477	2,264.2138	2,772.1473	0	500
Slice 35	-338.67698	-33.273806	2,201.0855	2,731.9712	0	500
Slice 36	-333.93899	-31.311267	2,078.623	2,395.1973	0	500
Slice 37	-330.88777	-30.047408	1,999.7583	2,179.1971	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 66+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟪	Fat Clay	115	300	17
🟩	Lean Clay	125	200	23
🟩	Silty Clay	115	100	30
🟧	Silty Sand	120	0	34
⬜	Silt	110	0	30



Long Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 81
Date: 4/26/2018
Time: 9:25:51 PM
Tool Version: 8.16.1.13452
File Name: 066+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\066+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:26:06 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 300 psf
Phi': 17 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-498.20961, 138.72892) ft
Lower Left: (-498.20961, 19.6738) ft
Lower Right: (-212.85988, 19.6738) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-575, 6.50221) ft
Upper Right Coordinate: (-562, 6.50221) ft
Lower Left Coordinate: (-575, -65.47066) ft
Lower Right Coordinate: (-562, -65.47066) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 8.33333) ft
Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	6
Coordinate 2	-450	6

Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-17.31
Point 2	-600	-19.31
Point 3	-600	-25.31
Point 4	-600	-29.31
Point 5	-600	-37.31
Point 6	-600	-41.31
Point 7	-600	-58.31
Point 8	100	-58.31
Point 9	-600	-63.31
Point 10	100	-63.31
Point 11	-600	-66.31
Point 12	100	-66.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-295.57	-41.31
Point 16	-307.57	-37.31
Point 17	-331.57	-29.31
Point 18	-343.57	-25.31
Point 19	-361.57	-19.31
Point 20	-367.57	-17.31
Point 21	-459.5	13.33333
Point 22	-600	8.33333
Point 23	-564	8.33333
Point 24	-553	7.66667
Point 25	-549	7.66667
Point 26	-529	7
Point 27	-521	8
Point 28	-500	19
Point 29	-497	19
Point 30	-477	14.33333
Point 31	-466	13.33333
Point 32	-185	-50.66667
Point 33	-182	-51.66667
Point 34	-174	-51.66667
Point 35	-167	-52
Point 36	-139	-52
Point 37	-123	-52.33333
Point 38	-116	-51.66667
Point 39	-56	-51.66667
Point 40	-18	-52
Point 41	1	-52.66667
Point 42	100	-52.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay	19,2,1,20	470.86
Region 2	Silty Clay	18,3,2,19	1,484.6
Region 3	Fat Clay	17,4,3,18	1,049.7
Region 4	Silty Clay	16,5,4,17	2,243.4
Region 5	Fat Clay	15,6,5,16	1,193.7
Region 6	Silt	7,9,10,8	3,500
Region 7	Silty Sand	9,11,12,10	2,100
Region 8	Lean Clay	22,23,24,25,26,27,28,29,30,31,21,20,1	5,378.6
Region 9	Lean Clay	6,15,14,13,32,33,34,35,36,37,38,39,40,41,42,8,7	7,889.6

Current Slip Surface

Slip Surface: 13,882

F of S: 1.74

Volume: 4,288.958 ft^3

Weight: 515,274.46 lbs

Resisting Moment: 22,802,402 lbs-ft

Activating Moment: 13,126,592 lbs-ft

Resisting Force: 140,423.85 lbs

Activating Force: 81,016.532 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (-329.42564, -30.024788) ft

Entry: (-501.76555, 18.07519) ft

Radius: 147.50095 ft

Center: (-384.06972, 106.98089) ft

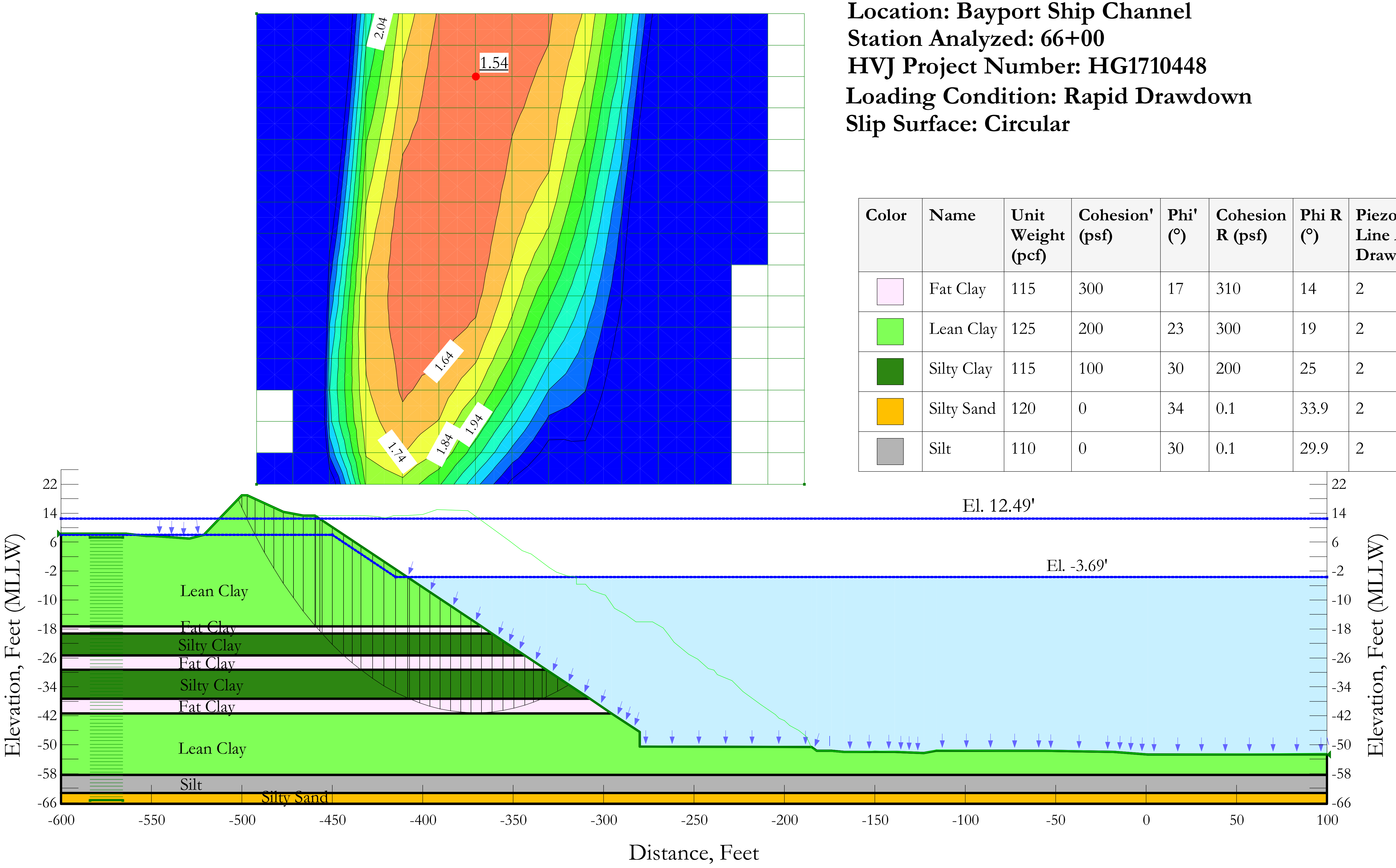
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-500.88277	16.930065	-682.03607	39.491479	16.763138	200
Slice 2	-498.5	13.9401	-495.46222	375.16142	159.24657	200
Slice 3	-494.29216	9.0476296	-190.17209	797.64189	338.57889	200
Slice 4	-489.15361	3.5308878	154.0726	1,264.2028	471.2223	200
Slice 5	-484.29216	-1.1903285	448.6765	1,682.4316	523.69799	200
Slice 6	-479.43072	-5.5031344	717.79559	2,052.8413	566.69326	200
Slice 7	-474.25	-9.6894474	979.02152	2,441.7285	620.88227	200
Slice 8	-468.75	-13.743996	1,232.0254	2,852.4699	687.83786	200
Slice 9	-464.74728	-16.491467	1,403.4675	3,144.5765	739.05692	200
Slice 10	-461.88445	-18.31	1,516.944	3,380.2523	569.67052	300
Slice 11	-459.88716	-19.542004	1,593.8211	3,442.4676	1,067.3165	100
Slice 12	-457.125	-21.12837	1,692.8103	3,540.3837	1,066.697	100
Slice 13	-452.375	-23.723888	1,854.7706	3,674.9776	1,050.897	100
Slice 14	-449.65254	-25.137522	1,938.6451	3,745.4654	1,043.1682	100
Slice 15	-447.09705	-26.353737	1,982.6443	3,849.7495	570.83136	300
Slice						

16	-442.68098	-28.353737	2,052.3319	3,927.7475	573.37208	300
Slice 17	-437.85472	-30.335529	2,115.7638	3,957.909	1,063.563	100
Slice 18	-432.61824	-32.273857	2,171.3643	4,022.8269	1,068.9424	100
Slice 19	-427.75	-33.884348	2,239.1833	4,067.6086	1,055.6418	100
Slice 20	-422.7937	-35.318506	2,328.6748	4,148.8718	1,050.8912	100
Slice 21	-417.3811	-36.682487	2,413.7872	4,268.2284	1,070.6621	100
Slice 22	-411.73075	-37.872193	2,488.0249	4,375.6267	577.09779	300
Slice 23	-405.84265	-38.873869	2,550.5294	4,448.1249	580.15315	300
Slice 24	-399.95455	-39.632325	2,597.8571	4,490.9022	578.76196	300
Slice 25	-394.06645	-40.151328	2,630.2429	4,501.1979	572.00835	300
Slice 26	-388.17835	-40.433413	2,647.845	4,476.1888	558.98079	300
Slice 27	-382.29025	-40.479941	2,650.7483	4,413.1556	538.82197	300
Slice 28	-376.40215	-40.291135	2,638.9668	4,309.6537	510.78025	300
Slice 29	-370.51405	-39.866086	2,612.4438	4,163.6761	474.25932	300
Slice 30	-364.57	-39.194117	2,570.5129	3,982.1492	431.58053	300
Slice 31	-357.51732	-38.051959	2,499.2422	3,716.8324	372.25469	300
Slice 32	-350.99098	-36.740666	2,417.4176	3,435.9747	588.06423	100
Slice 33	-346.04366	-35.511201	2,340.6989	3,163.934	475.29503	100
Slice 34	-340.57	-33.924924	2,241.7153	2,824.2231	336.31103	100
Slice 35	-334.57	-31.929753	2,117.2166	2,410.0173	169.04856	100
Slice 36	-330.49782	-30.442758	2,024.4281	2,107.9693	48.232559	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 66+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟪	Fat Clay	115	300	17	310	14	2
🟩	Lean Clay	125	200	23	300	19	2
🟩	Silty Clay	115	100	30	200	25	2
🟧	Silty Sand	120	0	34	0.1	33.9	2
⬜	Silt	110	0	30	0.1	29.9	2



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 81
Date: 4/26/2018
Time: 9:25:51 PM
Tool Version: 8.16.1.13452
File Name: 066+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\066+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:26:30 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: Yes

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 300 psf

Phi': 17 °

Phi-B: 0 °

Cohesion R: 310 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 19 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Silty Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 100 psf

Phi': 30 °

Phi-B: 0 °
Cohesion R: 200 psf
Phi R: 25 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 33.9 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 29.9 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-491.87152, 152.04784) ft
Lower Left: (-491.87152, 21.99368) ft
Lower Right: (-188.86831, 21.99368) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-584.02884, 7.24626) ft
Upper Right Coordinate: (-565.91485, 7.24626) ft
Lower Left Coordinate: (-584.02884, -65.39904) ft
Lower Right Coordinate: (-565.91485, -65.39904) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 8.33333) ft
Right Coordinate: (100, -52.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-415	-3.69
Coordinate 4	100	-3.69

Points

	X (ft)	Y (ft)
Point 1	-600	-17.31
Point 2	-600	-19.31
Point 3	-600	-25.31
Point 4	-600	-29.31
Point 5	-600	-37.31
Point 6	-600	-41.31
Point 7	-600	-58.31
Point 8	100	-58.31
Point 9	-600	-63.31
Point 10	100	-63.31
Point 11	-600	-66.31
Point 12	100	-66.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-295.57	-41.31
Point 16	-307.57	-37.31
Point 17	-331.57	-29.31
Point 18	-343.57	-25.31
Point 19	-361.57	-19.31
Point 20	-367.57	-17.31
Point 21	-459.5	13.33333
Point 22	-600	8.33333
Point 23	-564	8.33333
Point 24	-553	7.66667

Point 25	-549	7.66667
Point 26	-529	7
Point 27	-521	8
Point 28	-500	19
Point 29	-497	19
Point 30	-477	14.33333
Point 31	-466	13.33333
Point 32	-185	-50.66667
Point 33	-182	-51.66667
Point 34	-174	-51.66667
Point 35	-167	-52
Point 36	-139	-52
Point 37	-123	-52.33333
Point 38	-116	-51.66667
Point 39	-56	-51.66667
Point 40	-18	-52
Point 41	1	-52.66667
Point 42	100	-52.66667

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay	19,2,1,20	470.86
Region 2	Silty Clay	18,3,2,19	1,484.6
Region 3	Fat Clay	17,4,3,18	1,049.7
Region 4	Silty Clay	16,5,4,17	2,243.4
Region 5	Fat Clay	15,6,5,16	1,193.7
Region 6	Silt	7,9,10,8	3,500
Region 7	Silty Sand	9,11,12,10	2,100
Region 8	Lean Clay	22,23,24,25,26,27,28,29,30,31,21,20,1	5,378.6
Region 9	Lean Clay	6,15,14,13,32,33,34,35,36,37,38,39,40,41,42,8,7	7,889.6

Current Slip Surface

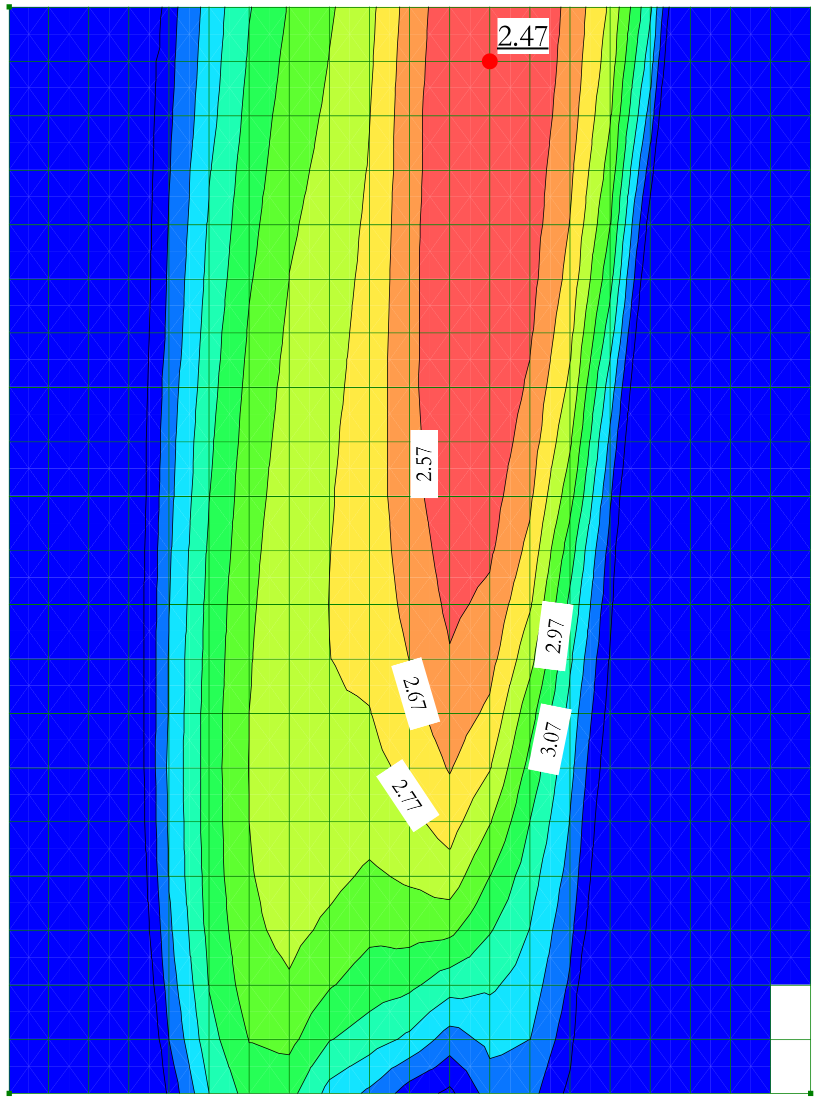
Slip Surface: 16,315
F of S: 1.54
Volume: 4,273.9922 ft³
Weight: 512,908.53 lbs
Resisting Moment: 27,204,821 lbs-ft
Activating Moment: 17,638,480 lbs-ft
Resisting Force: 142,484.73 lbs
Activating Force: 92,407.347 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (-319.11972, -33.460094) ft
Entry: (-502.1519, 17.872812) ft
Radius: 175.89123 ft
Center: (-370.67024, 134.70729) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

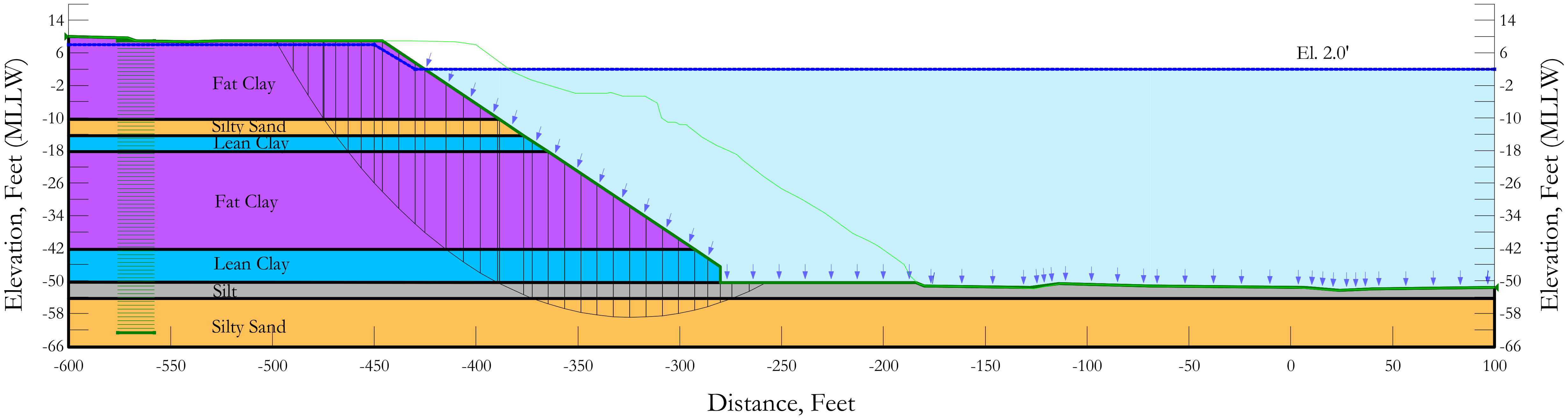
Slice 1	-501.07595	16.683977	-541.88015	58.60791	24.877582	200
Slice 2	-498.58197	13.992571	-373.93641	376.68174	159.89191	200
Slice 3	-497.08197	12.405273	-274.88905	533.2144	226.33608	200
Slice 4	-494.83304	10.160273	-134.80105	706.1258	299.73262	200
Slice 5	-490.05507	5.5858731	150.64152	1,082.0151	395.34463	200
Slice 6	-484.83304	0.94333784	440.33572	1,477.9168	440.42704	200
Slice 7	-479.61101	-3.3454847	707.95825	1,830.9861	476.697	200
Slice 8	-474.25	-7.4101871	961.59567	2,194.2856	523.24582	200
Slice 9	-468.75	-11.262253	1,201.9646	2,572.633	581.8142	200
Slice 10	-462.75	-15.107559	1,441.9117	2,982.0132	653.73432	200
Slice 11	-459.32443	-17.207543	1,572.9507	3,217.7299	698.16734	200
Slice 12	-458.05944	-17.933714	1,618.2637	3,276.2344	506.89251	300
Slice 13	-456.29482	-18.933714	1,680.6637	3,321.9084	501.77885	300
Slice 14	-452.80981	-20.79421	1,796.7587	3,354.5194	899.37357	100
Slice 15	-446.84605	-23.79421	1,725.7118	3,462.9599	1,003.0007	100
Slice 16	-441.31911	-26.350918	1,765.6094	3,607.601	0	863.20091
Slice 17	-436.57316	-28.350918	1,788.898	3,673.9187	0	871.5062
Slice 18	-431.00015	-30.478728	1,803.8545	3,699.7121	1,094.5739	100
Slice 19	-424.60009	-32.67847	1,807.3419	3,758.5226	1,126.5147	100
Slice 20	-418.20003	-34.60779	1,795.6485	3,793.8794	1,153.6792	100
Slice 21	-411.715	-36.294578	2,034.5257	3,808.3686	1,024.1287	100
Slice 22	-407.90616	-37.19653	2,090.8075	3,814.4951	995.17149	100
Slice 23	-404.53858	-37.86809	2,132.7128	3,868.0995	530.56095	300
Slice 24	-398.8511	-38.887824	2,196.3442	3,938.3761	532.59259	300
Slice 25	-393.16363	-39.716191	2,248.0343	3,985.266	531.12504	300
Slice 26	-387.47616	-40.355911	2,287.9529	4,006.6025	525.44393	300
Slice 27	-381.78868	-40.80905	2,316.2287	4,000.1883	514.83813	300
Slice 28	-376.10121	-41.077052	2,332.952	3,963.9103	498.634	300
Slice 29	-370.41374	-41.160763	2,338.1756	3,895.8568	476.23093	300
Slice 30	-364.57	-41.052492	2,331.4195	3,801.1853	449.35249	300
Slice 31	-358.57	-40.741467	2,312.0115	3,676.6561	417.21373	300
Slice 32	-352.57	-40.224153	2,279.7312	3,513.0431	377.0613	300

Slice 33	-346.57	-39.498712	2,234.4636	3,310.1706	328.87663	300
Slice 34	-341.16704	-38.674787	2,183.0507	3,095.5967	278.99331	300
Slice 35	-336.36112	-37.787946	2,127.7118	2,877.9458	229.36956	300
Slice 36	-332.76408	-37.046466	2,081.4435	2,695.4884	354.51901	100
Slice 37	-328.45743	-36.01331	2,016.9746	2,453.8369	252.22258	100
Slice 38	-322.23229	-34.351891	1,913.302	2,077.7008	94.915697	100



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 76+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Silty Sand	120	0	33	
⬜	Silt	110	0	31	
🟦	Lean Clay (undrained)	125			1,000
🟪	Fat Clay (undrained)	115			1,200



Short Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 78
Date: 4/26/2018
Time: 9:38:41 PM
Tool Version: 8.16.1.13452
File Name: 076+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\076+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:39:34 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 33 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 31 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)

Unit Weight: 115 pcf

Cohesion: 1,200 psf

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-473.80158, 208.9749) ft

Lower Left: (-473.80158, 39.05527) ft

Lower Right: (-223.00018, 39.05527) ft

Grid Horizontal Increment: 20

Grid Vertical Increment: 20

Left Projection Angle: 0 °

Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-576.03475, 8.94191) ft

Upper Right Coordinate: (-557.86914, 8.94191) ft

Lower Left Coordinate: (-576.03475, -62.80284) ft

Lower Right Coordinate: (-557.86914, -62.80284) ft

Number of Increments: 75

Left Projection: No

Left Projection Angle: 135 °

Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 10) ft

Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-14.31
Point 2	-600	-18.31
Point 3	-600	-42.31
Point 4	-600	-50.31
Point 5	-600	-54.31
Point 6	100	-54.31

Point 7	-600	-66.31
Point 8	100	-66.31
Point 9	-600	-10.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-292.57	-42.31
Point 13	-364.57	-18.31
Point 14	-376.57	-14.31
Point 15	-388.57	-10.31
Point 16	-600	10
Point 17	-571	9.66667
Point 18	-567	9
Point 19	-541	8.66667
Point 20	-525	9
Point 21	-475	9
Point 22	-446	9
Point 23	-184	-50.5
Point 24	-180	-51.33333
Point 25	-128	-51.66667
Point 26	-114	-50.66667
Point 27	-69	-51.33333
Point 28	7	-51.66667
Point 29	24	-52.33333
Point 30	40	-52
Point 31	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay (undrained)	1,14,13,2	917.72
Region 2	Fat Clay (undrained)	2,13,12,3	6,514.3
Region 3	Silty Sand	5,7,8,6	8,400
Region 4	Lean Clay (undrained)	10,4,3,12,11	2,564.1
Region 5	Silty Sand	9,1,14,15	869.72
Region 6	Fat Clay (undrained)	16,17,18,19,20,21,22,15,9	3,546.7
Region 7	Silt	4,10,23,24,25,26,27,28,29,30,31,6,5	2,403.7

Current Slip Surface

Slip Surface: 31,308
F of S: 2.47
Volume: 6,497.551 ft^3
Weight: 761,859.52 lbs
Resisting Moment: 66,227,000 lbs-ft
Activating Moment: 26,769,619 lbs-ft
Resisting Force: 235,780.76 lbs
Activating Force: 95,655.777 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-257.54329, -50.5) ft
Entry: (-498.40048, 9) ft
Radius: 259.45537 ft

Center: (-323.32074, 200.47892) ft

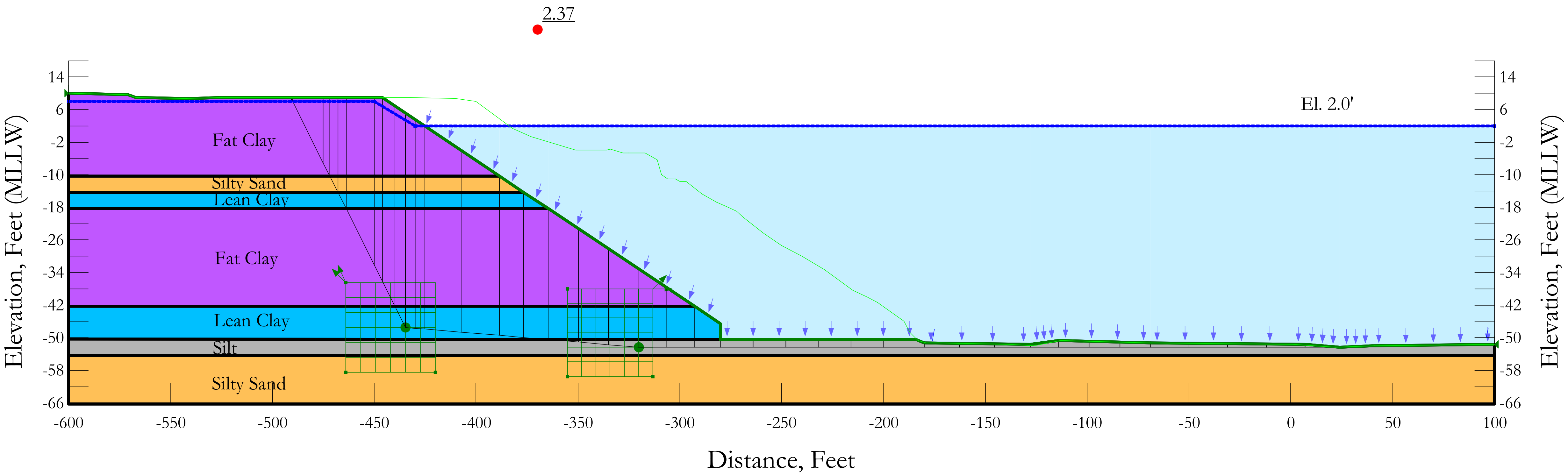
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-497.85049	8.5	-31.2	-382.78396	0	1,200
Slice 2	-493.58375	4.7665561	201.7669	68.23255	0	1,200
Slice 3	-486.15025	-1.4637606	590.53866	813.25943	0	1,200
Slice 4	-478.71675	-7.2411449	951.04744	1,496.2078	0	1,200
Slice 5	-474.79952	-10.165828	1,133.5477	1,839.6032	0	1,200
Slice 6	-471.73146	-12.31	1,267.344	2,251.2591	638.96194	0
Slice 7	-465.82126	-16.31	1,516.944	2,644.8292	0	1,000
Slice 8	-459.58396	-20.28188	1,764.7893	3,075.1729	0	1,200
Slice 9	-453.19465	-24.101218	2,003.116	3,518.3012	0	1,200
Slice 10	-448	-27.044643	1,971.8768	3,860.0492	0	1,200
Slice 11	-442	-30.198536	2,049.3841	4,075.7767	0	1,200
Slice 12	-434	-34.143397	2,137.8238	4,234.8962	0	1,200
Slice 13	-427.59063	-37.087824	2,439.0802	4,339.9372	0	1,200
Slice 14	-419.99657	-40.227659	2,635.0059	4,536.0846	0	1,200
Slice 15	-410.56748	-43.825776	2,859.5284	4,851.2053	0	1,000
Slice 16	-402.07865	-46.693971	3,038.5038	5,086.4872	0	1,000
Slice 17	-393.58983	-49.240733	3,197.4217	5,285.6392	0	1,000
Slice 18	-388.95771	-50.536456	3,278.2748	5,361.743	1,251.874	0
Slice 19	-382.57	-52.045602	3,372.4456	5,436.3422	1,240.1142	0
Slice 20	-374.43872	-53.881684	3,487.0171	5,518.5087	1,220.6433	0
Slice 21	-368.43872	-54.99324	3,556.3782	5,547.6545	1,293.15	0
Slice 22	-360.57	-56.256832	3,635.2263	5,587.2591	1,267.6649	0
Slice 23	-352.57	-57.291066	3,699.7625	5,608.5328	1,239.5699	0
Slice 24	-344.57	-58.073689	3,748.5982	5,596.7815	1,200.2243	0
Slice 25	-336.57	-58.606985	3,781.8758	5,551.0366	1,148.9064	0
Slice 26	-328.57	-58.892492	3,799.6915	5,470.3408	1,084.9323	0
Slice 27	-320.57	-58.93103	3,802.0963	5,353.7886	1,007.6808	0
Slice 28	-312.57	-58.72271	3,789.0971	5,200.5614	916.6156	0
Slice 29	-304.57	-58.266933	3,760.6566	5,009.9548	811.30376	0
Slice						

30	-296.57	-57.562388	3,716.693	4,781.398	691.42752	0
Slice 31	-289.4275	-56.733623	3,664.9781	4,535.5182	565.33537	0
Slice 32	-283.1425	-55.826916	3,608.3996	4,314.1997	458.35196	0
Slice 33	-277.16702	-54.822151	3,545.7022	3,790.163	158.75471	0
Slice 34	-270.13635	-53.430745	3,458.8785	3,621.5713	97.755702	0
Slice 35	-261.74098	-51.525745	3,340.0065	3,397.4406	34.509877	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 76+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Silty Sand	120	0	33	
◼	Silt	110	0	31	
🟦	Lean Clay (undrained)	125			1,000
🟪	Fat Clay (undrained)	115			1,200



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 78
Date: 4/26/2018
Time: 9:38:41 PM
Tool Version: 8.16.1.13452
File Name: 076+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\076+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:39:48 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf

Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 10) ft
Right Coordinate: (100, -51.66667) ft

Slip Surface Block

Left Grid
Upper Left: (-463.96232, -36.51769) ft
Lower Left: (-463.96232, -58.46847) ft
Lower Right: (-419.93474, -58.46847) ft
X Increments: 6
Y Increments: 6
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 2
Right Grid
Upper Left: (-355.00804, -37.96792) ft
Lower Left: (-355.00804, -59.50465) ft
Lower Right: (-313.23852, -59.50465) ft
X Increments: 6
Y Increments: 6
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-14.31
Point 2	-600	-18.31
Point 3	-600	-42.31
Point 4	-600	-50.31
Point 5	-600	-54.31
Point 6	100	-54.31
Point 7	-600	-66.31

Point 8	100	-66.31
Point 9	-600	-10.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-292.57	-42.31
Point 13	-364.57	-18.31
Point 14	-376.57	-14.31
Point 15	-388.57	-10.31
Point 16	-600	10
Point 17	-571	9.66667
Point 18	-567	9
Point 19	-541	8.66667
Point 20	-525	9
Point 21	-475	9
Point 22	-446	9
Point 23	-184	-50.5
Point 24	-180	-51.33333
Point 25	-128	-51.66667
Point 26	-114	-50.66667
Point 27	-69	-51.33333
Point 28	7	-51.66667
Point 29	24	-52.33333
Point 30	40	-52
Point 31	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay (undrained)	1,14,13,2	917.72
Region 2	Fat Clay (undrained)	2,13,12,3	6,514.3
Region 3	Silty Sand	5,7,8,6	8,400
Region 4	Lean Clay (undrained)	10,4,3,12,11	2,564.1
Region 5	Silty Sand	9,1,14,15	869.72
Region 6	Fat Clay (undrained)	16,17,18,19,20,21,22,15,9	3,546.7
Region 7	Silt	4,10,23,24,25,26,27,28,29,30,31,6,5	2,403.7

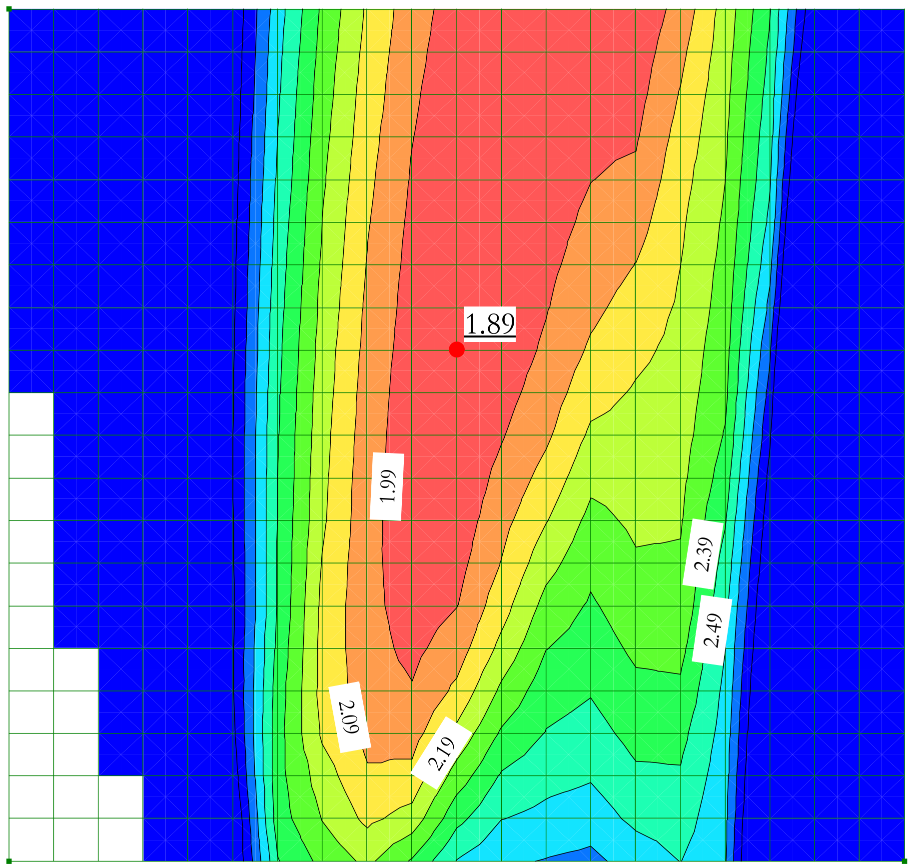
Current Slip Surface

Slip Surface: 11,377
F of S: 2.37
Volume: 6,553.3681 ft^3
Weight: 768,218.25 lbs
Resisting Moment: 28,778,550 lbs-ft
Activating Moment: 12,273,957 lbs-ft
Resisting Force: 202,846.04 lbs
Activating Force: 85,702.351 lbs
F of S Rank (Analysis): 1 of 21,609 slip surfaces
F of S Rank (Query): 1 of 21,609 slip surfaces
Exit: (23.806453, -52.32574) ft
Entry: (-491.10368, 9) ft
Radius: 201.20394 ft
Center: (-228.1707, 24.331435) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-490.60368	8.5	-31.2	-453.93525	0	1,200
Slice 2	-482.55184	0.44816	471.23482	472.27673	0	1,200
Slice 3	-473.39684	-8.70684	1,042.5068	1,514.8817	0	1,200
Slice 4	-469.79368	-12.31	1,267.344	2,182.639	594.39955	0
Slice 5	-465.79368	-16.31	1,516.944	2,489.6537	0	1,000
Slice 6	-456.89684	-25.20684	2,072.1068	3,410.8606	0	1,200
Slice 7	-448	-34.10368	2,375.9905	4,385.2913	0	1,200
Slice 8	-442.89684	-39.20684	2,580.4914	4,821.0919	0	1,200
Slice 9	-437.20214	-44.90154	2,808.6974	5,326.0457	0	1,000
Slice 10	-432.3053	-47.590455	2,878.5318	6,016.8421	0	1,000
Slice 11	-427.59063	-47.789601	3,106.8711	5,861.111	0	1,000
Slice 12	-416.02844	-48.277984	3,137.3462	5,673.9865	0	1,000
Slice 13	-397.72281	-49.051207	3,185.5953	5,461.3618	0	1,000
Slice 14	-382.57	-49.691257	3,225.5344	5,278.5858	0	1,000
Slice 15	-370.57	-50.198133	3,257.1635	5,114.3292	0	1,000
Slice 16	-357.17502	-50.763932	3,292.4694	4,940.8026	990.41849	0
Slice 17	-342.38505	-51.388655	3,331.4521	4,766.6113	862.33065	0
Slice 18	-327.59509	-52.013378	3,370.4348	4,592.2164	734.12043	0
Slice 19	-313.29258	-52.32574	3,389.9262	4,416.6556	616.92128	0
Slice 20	-299.47753	-52.32574	3,389.9262	4,186.062	478.36666	0
Slice 21	-286.285	-52.32574	3,389.9262	4,027.4009	383.03347	0
Slice 22	-272	-52.32574	3,389.9262	3,477.3981	52.558415	0
Slice 23	-256	-52.32574	3,389.9262	3,478.0008	52.920587	0
Slice 24	-240	-52.32574	3,389.9262	3,478.5558	53.254063	0
Slice 25	-224	-52.32574	3,389.9262	3,479.0567	53.555034	0
Slice 26	-208	-52.32574	3,389.9262	3,479.4982	53.820279	0
Slice 27	-192	-52.32574	3,389.9262	3,479.8759	54.047212	0
Slice 28	-182	-52.32574	3,389.9262	3,516.8277	76.250122	0
Slice 29	-171.33333	-52.32574	3,389.9262	3,438.2434	29.031916	0
Slice 30	-154	-52.32574	3,389.9262	3,432.8591	25.796688	0
Slice						

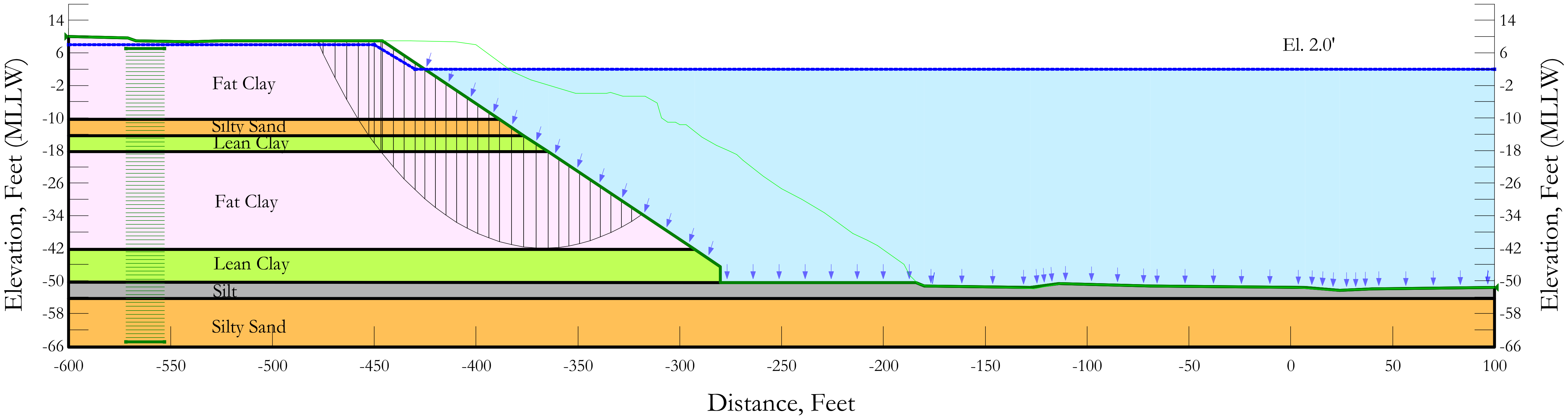
31	-136.66667	-52.32574	3,389.9262	3,427.395	22.513499	0
Slice 32	-121	-52.32574	3,389.9262	3,431.984	25.270866	0
Slice 33	-106.5	-52.32574	3,389.9262	3,470.2831	48.283309	0
Slice 34	-91.5	-52.32574	3,389.9262	3,458.973	41.487528	0
Slice 35	-76.5	-52.32574	3,389.9262	3,447.5985	34.653004	0
Slice 36	-59.5	-52.32574	3,389.9262	3,438.1034	28.947796	0
Slice 37	-40.5	-52.32574	3,389.9262	3,433.7245	26.316683	0
Slice 38	-21.5	-52.32574	3,389.9262	3,429.319	23.66959	0
Slice 39	-2.5	-52.32574	3,389.9262	3,424.9015	21.015268	0
Slice 40	15.403227	-52.32574	3,389.9262	3,406.8087	10.144047	0



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 76+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Lean Clay	125	200	23
🟪	Fat Clay	115	300	16
🟧	Silty Sand	120	0	33
▒	Silt	110	0	31



Long Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 78
Date: 4/26/2018
Time: 9:38:41 PM
Tool Version: 8.16.1.13452
File Name: 076+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\076+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:39:00 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 300 psf
Phi': 16 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-507.01079, 157.58996) ft
Lower Left: (-507.01079, 24.36187) ft
Lower Right: (-226.90128, 24.36187) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-572, 7.00687) ft
Upper Right Coordinate: (-553, 7.00687) ft
Lower Left Coordinate: (-572, -64.98816) ft
Lower Right Coordinate: (-553, -64.98816) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 10) ft
Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-14.31
Point 2	-600	-18.31
Point 3	-600	-42.31

Point 4	-600	-50.31
Point 5	-600	-54.31
Point 6	100	-54.31
Point 7	-600	-66.31
Point 8	100	-66.31
Point 9	-600	-10.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-292.57	-42.31
Point 13	-364.57	-18.31
Point 14	-376.57	-14.31
Point 15	-388.57	-10.31
Point 16	-600	10
Point 17	-571	9.66667
Point 18	-567	9
Point 19	-541	8.66667
Point 20	-525	9
Point 21	-475	9
Point 22	-446	9
Point 23	-184	-50.5
Point 24	-180	-51.33333
Point 25	-128	-51.66667
Point 26	-114	-50.66667
Point 27	-69	-51.33333
Point 28	7	-51.66667
Point 29	24	-52.33333
Point 30	40	-52
Point 31	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay	1,14,13,2	917.72
Region 2	Fat Clay	2,13,12,3	6,514.3
Region 3	Silty Sand	5,7,8,6	8,400
Region 4	Lean Clay	10,4,3,12,11	2,564.1
Region 5	Silty Sand	9,1,14,15	869.72
Region 6	Fat Clay	16,17,18,19,20,21,22,15,9	3,546.7
Region 7	Silt	4,10,23,24,25,26,27,28,29,30,31,6,5	2,403.7

Current Slip Surface

Slip Surface: 19,964
F of S: 1.89
Volume: 3,530.2649 ft^3
Weight: 410,594.87 lbs
Resisting Moment: 15,990,776 lbs-ft
Activating Moment: 8,479,373.6 lbs-ft
Resisting Force: 100,878.5 lbs
Activating Force: 53,754.98 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces

Exit: (-318.46729, -33.67757) ft
Entry: (-477.89191, 9) ft
Radius: 146.24847 ft
Center: (-366.95603, 104.29872) ft

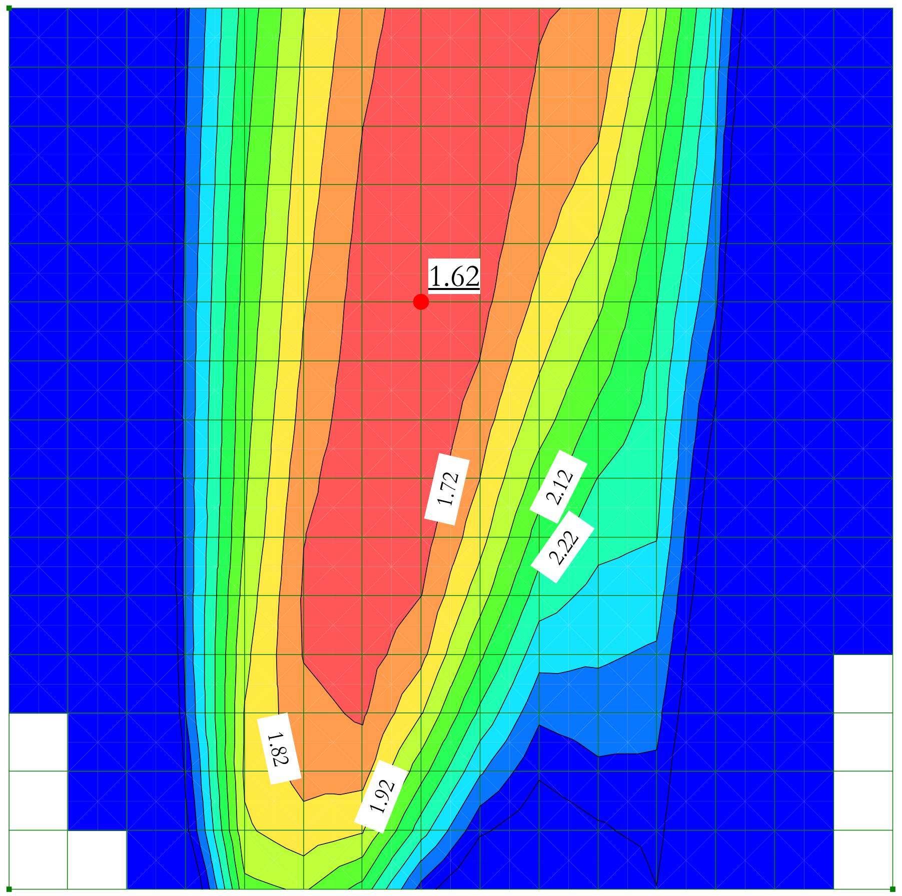
Slip Slices

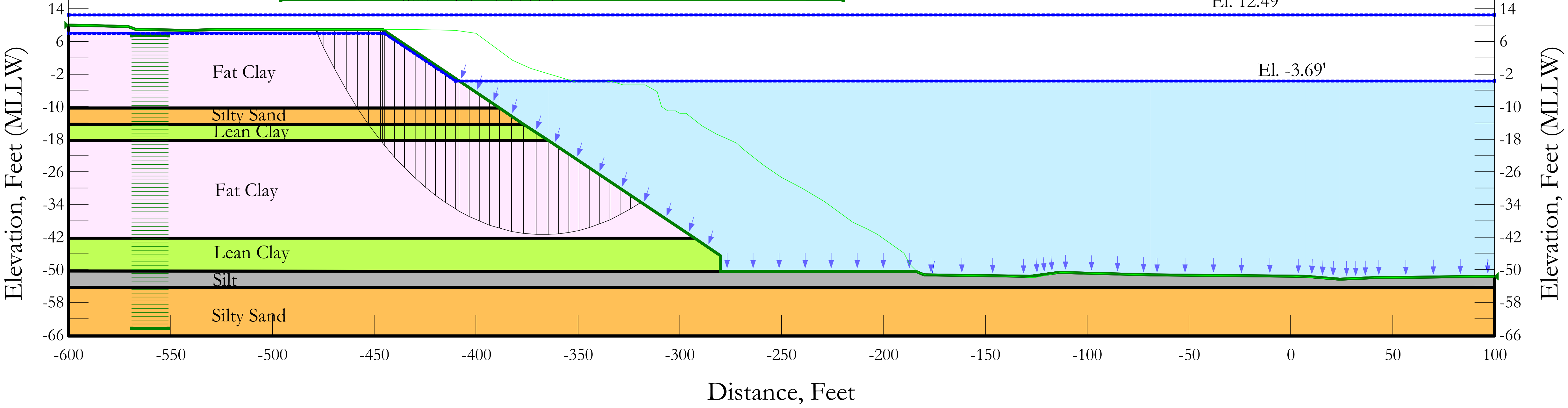
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-477.45845	8.5	-31.2	-106.77165	-30.616277	300
Slice 2	-476.01249	6.8667132	70.717096	68.614507	-0.60290764	300
Slice 3	-472.1341	2.7646659	326.68485	517.098	54.600093	300
Slice 4	-466.40229	-2.8636427	677.8913	1,126.801	128.72278	300
Slice 5	-460.67048	-7.9165954	993.19556	1,669.832	194.02238	300
Slice 6	-455.16052	-12.31	1,267.344	2,144.0171	569.31819	0
Slice 7	-451.25823	-15.197656	1,447.5337	2,465.2612	431.9997	200
Slice 8	-448.33939	-17.197656	1,413.9882	2,677.5697	536.35854	200
Slice 9	-446.33939	-18.529349	1,455.876	2,851.1289	400.08233	300
Slice 10	-443.33333	-20.382249	1,510.3232	2,959.3651	415.50609	300
Slice 11	-438	-23.498234	1,597.1099	3,116.2801	435.61504	300
Slice 12	-432.66667	-26.322172	1,667.1775	3,247.3351	453.10291	300
Slice 13	-427.59063	-28.761608	1,919.5244	3,360.5856	413.21766	300
Slice 14	-422.56616	-30.934906	2,055.1381	3,496.267	413.23706	300
Slice 15	-417.33598	-32.970053	2,182.1313	3,667.7031	425.98086	300
Slice 16	-412.10581	-34.778791	2,294.9965	3,819.4694	437.13557	300
Slice 17	-406.87563	-36.369869	2,394.2798	3,951.5848	446.55003	300
Slice 18	-401.64545	-37.750614	2,480.4383	4,063.6797	453.98717	300
Slice 19	-396.41527	-38.927118	2,553.8522	4,155.0544	459.13735	300
Slice 20	-391.18509	-39.904388	2,614.8338	4,224.7396	461.63306	300
Slice 21	-385.57	-40.728819	2,666.2783	4,268.457	459.41736	300
Slice 22	-379.57	-41.373637	2,706.5149	4,281.0641	451.49471	300
Slice 23	-373.57	-41.769251	2,731.2013	4,254.4594	436.78724	300
Slice 24	-367.57	-41.917688	2,740.4637	4,186.4777	414.63784	300
Slice 25	-362.00874	-41.84358	2,735.8394	4,099.1296	390.91717	300
Slice 26	-356.88621	-41.580074	2,719.3966	3,997.1197	366.38121	300
Slice 27	-351.76369	-41.135719	2,691.6689	3,865.6286	336.62753	300
Slice 28	-346.64117	-40.508849	2,652.5522	3,704.1319	301.53563	300

Slice 29	-341.51864	-39.697077	2,601.8976	3,512.382	261.07719	300
Slice 30	-336.39612	-38.697249	2,539.5083	3,290.4167	215.31952	300
Slice 31	-331.2736	-37.505382	2,465.1358	3,038.5501	164.4239	300
Slice 32	-326.15107	-36.116579	2,378.4745	2,757.3434	108.63891	300
Slice 33	-321.02855	-34.524921	2,279.1551	2,447.557	48.288455	300

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 76+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟩	Lean Clay	125	200	23	300	19	2
⬜	Fat Clay	115	300	16	310	14	2
🟧	Silty Sand	120	0	33	0.1	32.9	2
⬜	Silt	110	0	31	0.1	30.9	2





Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 78
Date: 4/26/2018
Time: 9:38:41 PM
Tool Version: 8.16.1.13452
File Name: 076+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\076+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:39:26 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 19 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 300 psf

Phi': 16 °

Phi-B: 0 °

Cohesion R: 310 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 33 °

Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 32.9 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 30.9 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-495.93678, 153.76171) ft
Lower Left: (-495.93678, 16.00861) ft
Lower Right: (-219.84049, 16.00861) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-569.06304, 7.45119) ft
Upper Right Coordinate: (-551.00644, 7.45119) ft
Lower Left Coordinate: (-569.06304, -64.38558) ft
Lower Right Coordinate: (-551.00644, -64.38558) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 10) ft
Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-445	8
Coordinate 3	-410	-3.69
Coordinate 4	100	-3.69

Points

	X (ft)	Y (ft)
Point 1	-600	-14.31
Point 2	-600	-18.31
Point 3	-600	-42.31
Point 4	-600	-50.31
Point 5	-600	-54.31
Point 6	100	-54.31
Point 7	-600	-66.31
Point 8	100	-66.31
Point 9	-600	-10.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-292.57	-42.31
Point 13	-364.57	-18.31
Point 14	-376.57	-14.31
Point 15	-388.57	-10.31
Point 16	-600	10
Point 17	-571	9.66667
Point 18	-567	9
Point 19	-541	8.66667
Point 20	-525	9
Point 21	-475	9
Point 22	-446	9
Point 23	-184	-50.5
Point 24	-180	-51.33333
Point 25	-128	-51.66667
Point 26	-114	-50.66667
Point 27	-69	-51.33333
Point 28	7	-51.66667
Point 29	24	-52.33333
Point 30	40	-52
Point 31	100	-51.66667

Regions

	Material	Points	Area (ft^2)

Region 1	Lean Clay	1,14,13,2	917.72
Region 2	Fat Clay	2,13,12,3	6,514.3
Region 3	Silty Sand	5,7,8,6	8,400
Region 4	Lean Clay	10,4,3,12,11	2,564.1
Region 5	Silty Sand	9,1,14,15	869.72
Region 6	Fat Clay	16,17,18,19,20,21,22,15,9	3,546.7
Region 7	Silt	4,10,23,24,25,26,27,28,29,30,31,6,5	2,403.7

Current Slip Surface

Slip Surface: 12,744

F of S: 1.62

Volume: 3,495.0611 ft³

Weight: 406,562.09 lbs

Resisting Moment: 16,214,315 lbs-ft

Activating Moment: 9,992,128.6 lbs-ft

Resisting Force: 100,663.29 lbs

Activating Force: 62,198.57 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (-319.0937, -33.468765) ft

Entry: (-478.90859, 9) ft

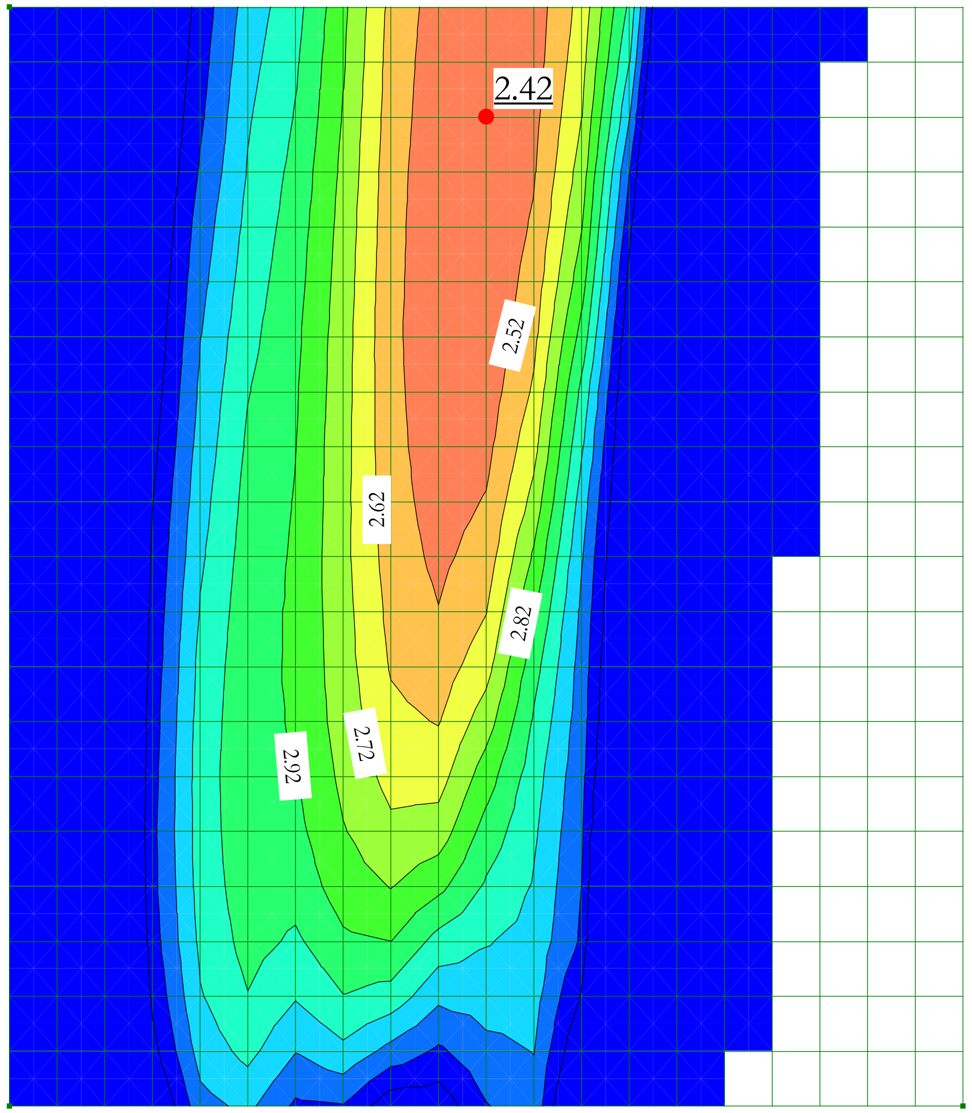
Radius: 149.24182 ft

Center: (-367.09184, 107.84401) ft

Slip Slices

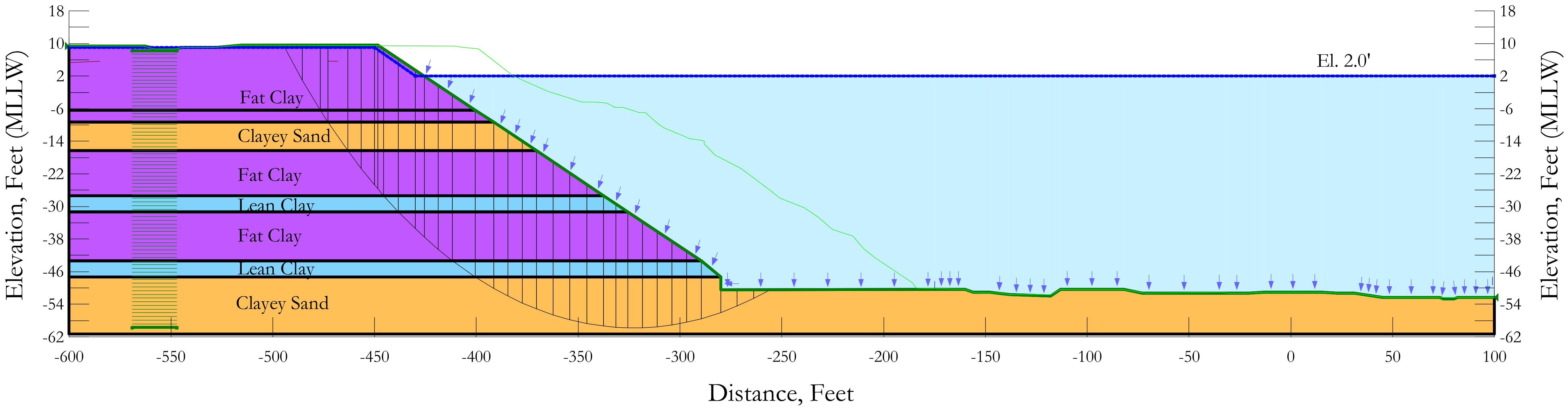
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-478.46258	8.5	-31.2	-124.32799	-35.650478	300
Slice 2	-476.50829	6.3736007	101.48731	105.12107	0	298.72332
Slice 3	-472.21102	1.977902	375.77892	580.11016	58.591041	300
Slice 4	-466.63307	-3.2894586	704.46221	1,142.5438	125.61786	300
Slice 5	-461.05512	-8.0487598	1,001.4426	1,644.9219	184.51473	300
Slice 6	-455.54949	-12.31	1,267.344	2,100.896	541.31497	0
Slice 7	-449.83178	-16.31	1,516.944	2,537.9219	433.37941	200
Slice 8	-446.41536	-18.570632	1,658.0074	2,809.7664	330.26157	300
Slice 9	-445.5	-19.139996	1,693.5357	2,854.2132	332.81891	300
Slice 10	-442.5	-20.912886	1,576.223	2,928.1603	387.66177	300
Slice 11	-437.5	-23.715001	1,639.7771	3,061.9667	407.8063	300
Slice 12	-432.5	-26.272203	1,689.5824	3,176.3541	426.32491	300
Slice 13	-427.5	-28.598291	1,726.4136	3,272.6331	443.37131	300
Slice 14	-422.5	-30.70493	1,750.9254	3,351.6091	458.98866	300
Slice 15	-417.5	-32.60201	1,763.6731	3,413.6455	473.12197	300
Slice 16	-412.5	-34.297938	1,765.1287	3,458.7201	485.62953	300
Slice 17	-409.12929	-35.352189	1,975.7206	3,486.9565	433.33992	300
Slice						

18	-405.79751	-36.268791	2,032.9165	3,548.854	434.68809	300
Slice 19	-400.87537	-37.501824	2,109.8578	3,656.0121	443.35261	300
Slice 20	-395.95322	-38.559032	2,175.8276	3,745.7874	450.17873	300
Slice 21	-391.03107	-39.444205	2,231.0624	3,816.9935	454.75843	300
Slice 22	-385.57	-40.21861	2,279.3853	3,866.7057	455.15681	300
Slice 23	-379.57	-40.844773	2,318.4578	3,887.8332	450.01116	300
Slice 24	-373.57	-41.226907	2,342.303	3,868.8275	437.72387	300
Slice 25	-367.57	-41.366892	2,351.038	3,806.8633	417.45119	300
Slice 26	-362.04354	-41.290983	2,346.3014	3,724.0037	395.04977	300
Slice 27	-356.99062	-41.034043	2,330.2683	3,625.5942	371.42872	300
Slice 28	-351.9377	-40.604716	2,303.4783	3,496.7508	342.16539	300
Slice 29	-346.88477	-40.001497	2,265.8374	3,336.9946	307.14938	300
Slice 30	-341.83185	-39.222245	2,217.2121	3,146.2479	266.39674	300
Slice 31	-336.77893	-38.26414	2,157.4263	2,924.8449	220.05374	300
Slice 32	-331.72601	-37.12363	2,086.2585	2,673.5168	168.3936	300
Slice 33	-326.67309	-35.796366	2,003.4372	2,393.3503	111.80578	300
Slice 34	-321.62017	-34.277107	1,908.6355	2,085.7207	50.778352	300



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 92+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	115	0	32	
🟦	Lean Clay (undrained)	125			1,000
🟪	Fat Clay (undrained)	115			1,200



Short Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 90
Date: 4/26/2018
Time: 9:49:04 PM
Tool Version: 8.16.1.13452
File Name: 092+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\092+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:50:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: Yes
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Grid and Radius
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: No
    Tension Crack

            Tension Crack Option: (none)
    F of S Distribution
        F of S Calculation Option: Constant
    Advanced
        Number of Slices: 30
        F of S Tolerance: 0.001
        Minimum Slip Surface Depth: 2 ft
        Search Method: Linear Search
        Must Obtain Factor of Safety at Lambda: 0.2
        Lambda
            Lambda 1: -1
            Lambda 2: -0.8
            Lambda 3: -0.6
            Lambda 4: -0.4
            Lambda 5: -0.2
            Lambda 6: 0
            Lambda 7: 0.2
            Lambda 8: 0.4
            Lambda 9: 0.6
            Lambda 10: 0.8
            Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Grid

Upper Left: (-470, 204.62228) ft
Lower Left: (-470, 35.16828) ft
Lower Right: (-176, 35.16828) ft
Grid Horizontal Increment: 20

Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-569.09642, 8.23153) ft
Upper Right Coordinate: (-547.0701, 8.23153) ft
Lower Left Coordinate: (-569.09642, -59.79444) ft
Lower Right Coordinate: (-547.0701, -59.79444) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9.33333) ft
Right Coordinate: (100, -52.33333) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	9
Coordinate 2	-450	9
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-6.31
Point 2	-600	-9.31
Point 3	-600	-16.31
Point 4	-600	-27.31
Point 5	-600	-31.31
Point 6	-600	-43.31
Point 7	-600	-47.31
Point 8	-175	-48.64333
Point 9	-600	9.33333
Point 10	-563	9.33333
Point 11	-557	8.66667
Point 12	-548	8.66667
Point 13	-544	9
Point 14	-528	9
Point 15	-515	9.66667

Point 16	-448.5	9.66667
Point 17	-400.57	-6.31
Point 18	-280	-47.31
Point 19	-280	-50.5
Point 20	-175	-50.33333
Point 21	-160	-50.33333
Point 22	-156	-51
Point 23	-148	-51
Point 24	-138	-51.66667
Point 25	-118	-52
Point 26	-113	-50.33333
Point 27	-82	-50.33333
Point 28	-73	-51.33333
Point 29	-32	-51.33333
Point 30	-21	-51.33333
Point 31	-13	-51
Point 32	15	-51
Point 33	23	-51.33333
Point 34	31	-51.33333
Point 35	45	-52.33333
Point 36	73	-52.33333
Point 37	75	-52.66667
Point 38	80	-52.66667
Point 39	82	-52.33333
Point 40	100	-52.33333
Point 41	100	-61.33333
Point 42	-600	-61.33333
Point 43	-280	-46.5
Point 44	-289.57	-43.31
Point 45	-325.57	-31.31
Point 46	-337.57	-27.31
Point 47	-370.57	-16.31
Point 48	-391.57	-9.31

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay (undrained)	48,2,1,17	611.79
Region 2	Clayey Sand	47,3,2,48	1,532.5
Region 3	Fat Clay (undrained)	46,4,3,47	2,705.2
Region 4	Lean Clay (undrained)	45,5,4,46	1,073.7
Region 5	Fat Clay (undrained)	44,6,5,45	3,509.2
Region 6	Lean Clay (undrained)	18,7,6,44	1,260.9
Region 7	Fat Clay (undrained)	9,10,11,12,13,14,15,16,17,1	2,759.7
Region		7,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42	8,378

8	Clayey Sand		

Current Slip Surface

Slip Surface: 29,564
F of S: 2.42
Volume: 6,478.1988 ft^3
Weight: 754,263.69 lbs
Resisting Moment: 62,296,168 lbs-ft
Activating Moment: 25,691,002 lbs-ft
Resisting Force: 231,389.58 lbs
Activating Force: 95,811.67 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-255.67826, -50.461393) ft
Entry: (-494.91399, 9.66667) ft
Radius: 247.47132 ft
Center: (-323, 187.67688) ft

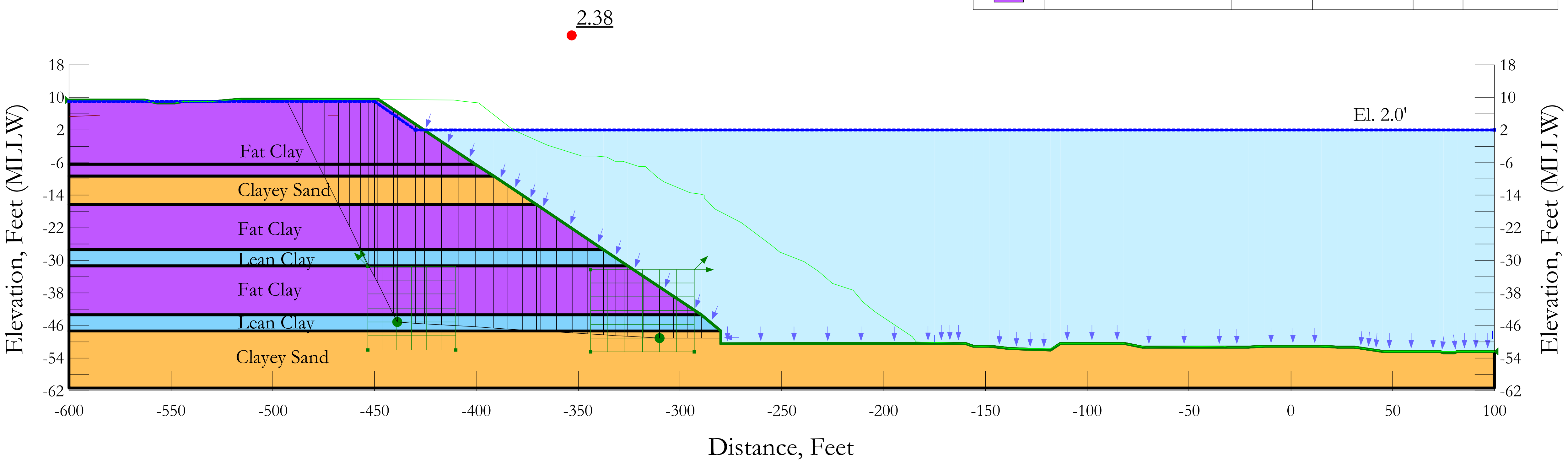
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-494.56749	9.333335	-20.800104	-437.21766	0	1,200
Slice 2	-489.83054	4.9906056	250.18621	89.51442	0	1,200
Slice 3	-481.04963	-2.6643944	727.85821	1,005.6634	0	1,200
Slice 4	-474.72656	-7.81	1,048.944	1,613.5345	0	1,200
Slice 5	-467.95303	-12.81	1,360.944	2,361.2671	625.07122	0
Slice 6	-459.83409	-18.485692	1,715.1072	2,856.4772	0	1,200
Slice 7	-453.27803	-22.691422	1,977.5447	3,344.0767	0	1,200
Slice 8	-449.25	-25.166328	1,884.7206	3,630.8606	0	1,200
Slice 9	-447.03355	-26.460599	1,913.5449	3,725.9145	0	1,200
Slice 10	-441.91775	-29.31	1,972.4076	3,925.7211	0	1,000
Slice 11	-434.13419	-33.388347	2,047.6825	4,089.0199	0	1,200
Slice 12	-427.75	-36.517956	2,403.5205	4,218.4401	0	1,200
Slice 13	-422.07735	-39.064781	2,562.4423	4,379.7091	0	1,200
Slice 14	-415.23207	-41.935171	2,741.5547	4,610.0482	0	1,200
Slice 15	-406.18972	-45.316506	2,952.55	4,916.2112	0	1,000
Slice 16	-396.07	-48.713992	3,164.5531	5,161.5636	1,247.8707	0
Slice 17	-388.07	-51.058935	3,310.8775	5,327.6814	1,260.2389	0
Slice 18	-381.07	-52.857869	3,423.131	5,446.8801	1,264.5788	0
Slice 19	-374.07	-54.441096	3,521.9244	5,542.9944	1,262.9047	0
Slice 20	-366.445	-55.915052	3,613.8992	5,619.7582	1,253.3998	0
Slice						

21	-358.195	-57.243514	3,696.7952	5,671.7733	1,234.1033	0
Slice 22	-349.945	-58.288161	3,761.9812	5,689.1874	1,204.2521	0
Slice 23	-341.695	-59.052603	3,809.6824	5,670.8309	1,162.9746	0
Slice 24	-334.57	-59.505582	3,837.9483	5,617.2287	1,111.8178	0
Slice 25	-328.57	-59.71355	3,850.9255	5,536.7346	1,053.4105	0
Slice 26	-321.97	-59.76611	3,854.2052	5,435.3462	988.00653	0
Slice 27	-314.77	-59.631322	3,845.7945	5,307.8285	913.58023	0
Slice 28	-307.57	-59.286597	3,824.2836	5,149.5059	828.09078	0
Slice 29	-300.37	-58.73105	3,789.6175	4,959.8612	731.24941	0
Slice 30	-293.17	-57.963251	3,741.7069	4,738.4862	622.85682	0
Slice 31	-284.785	-56.778049	3,667.7502	4,420.9787	470.6694	0
Slice 32	-275.94638	-55.244841	3,572.0781	3,863.5757	182.14789	0
Slice 33	-267.83913	-53.532658	3,465.2379	3,654.1727	118.05957	0
Slice 34	-259.73188	-51.533525	3,340.492	3,407.0292	41.577085	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 92+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	115	0	32	
🟦	Lean Clay (undrained)	125			1,000
🟪	Fat Clay (undrained)	115			1,200



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 90
Date: 4/26/2018
Time: 9:49:04 PM
Tool Version: 8.16.1.13452
File Name: 092+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\092+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:50:20 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 2 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 9.33333) ft
Right Coordinate: (100, -52.33333) ft

Slip Surface Block

Left Grid

- Upper Left: (-453.30442, -31.40467) ft
- Lower Left: (-453.30442, -51.98319) ft
- Lower Right: (-410.10442, -51.98319) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 2

Right Grid

- Upper Left: (-343.94775, -32.31147) ft
- Lower Left: (-343.94775, -52.48459) ft
- Lower Right: (-293.096, -52.48459) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	9
Coordinate 2	-450	9
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-6.31
Point 2	-600	-9.31
Point 3	-600	-16.31
Point 4	-600	-27.31
Point 5	-600	-31.31
Point 6	-600	-43.31
Point 7	-600	-47.31
Point 8	-175	-48.64333
Point 9	-600	9.33333
Point 10	-563	9.33333
Point 11	-557	8.66667
Point 12	-548	8.66667
Point 13	-544	9
Point 14	-528	9
Point 15	-515	9.66667
Point 16	-448.5	9.66667

Point 17	-400.57	-6.31
Point 18	-280	-47.31
Point 19	-280	-50.5
Point 20	-175	-50.33333
Point 21	-160	-50.33333
Point 22	-156	-51
Point 23	-148	-51
Point 24	-138	-51.66667
Point 25	-118	-52
Point 26	-113	-50.33333
Point 27	-82	-50.33333
Point 28	-73	-51.33333
Point 29	-32	-51.33333
Point 30	-21	-51.33333
Point 31	-13	-51
Point 32	15	-51
Point 33	23	-51.33333
Point 34	31	-51.33333
Point 35	45	-52.33333
Point 36	73	-52.33333
Point 37	75	-52.66667
Point 38	80	-52.66667
Point 39	82	-52.33333
Point 40	100	-52.33333
Point 41	100	-61.33333
Point 42	-600	-61.33333
Point 43	-280	-46.5
Point 44	-289.57	-43.31
Point 45	-325.57	-31.31
Point 46	-337.57	-27.31
Point 47	-370.57	-16.31
Point 48	-391.57	-9.31

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay (undrained)	48,2,1,17	611.79
Region 2	Clayey Sand	47,3,2,48	1,532.5
Region 3	Fat Clay (undrained)	46,4,3,47	2,705.2
Region 4	Lean Clay (undrained)	45,5,4,46	1,073.7
Region 5	Fat Clay (undrained)	44,6,5,45	3,509.2
Region 6	Lean Clay (undrained)	18,7,6,44	1,260.9
Region 7	Fat Clay (undrained)	9,10,11,12,13,14,15,16,17,1	2,759.7
Region 8	Clayey Sand	7,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42	8,378

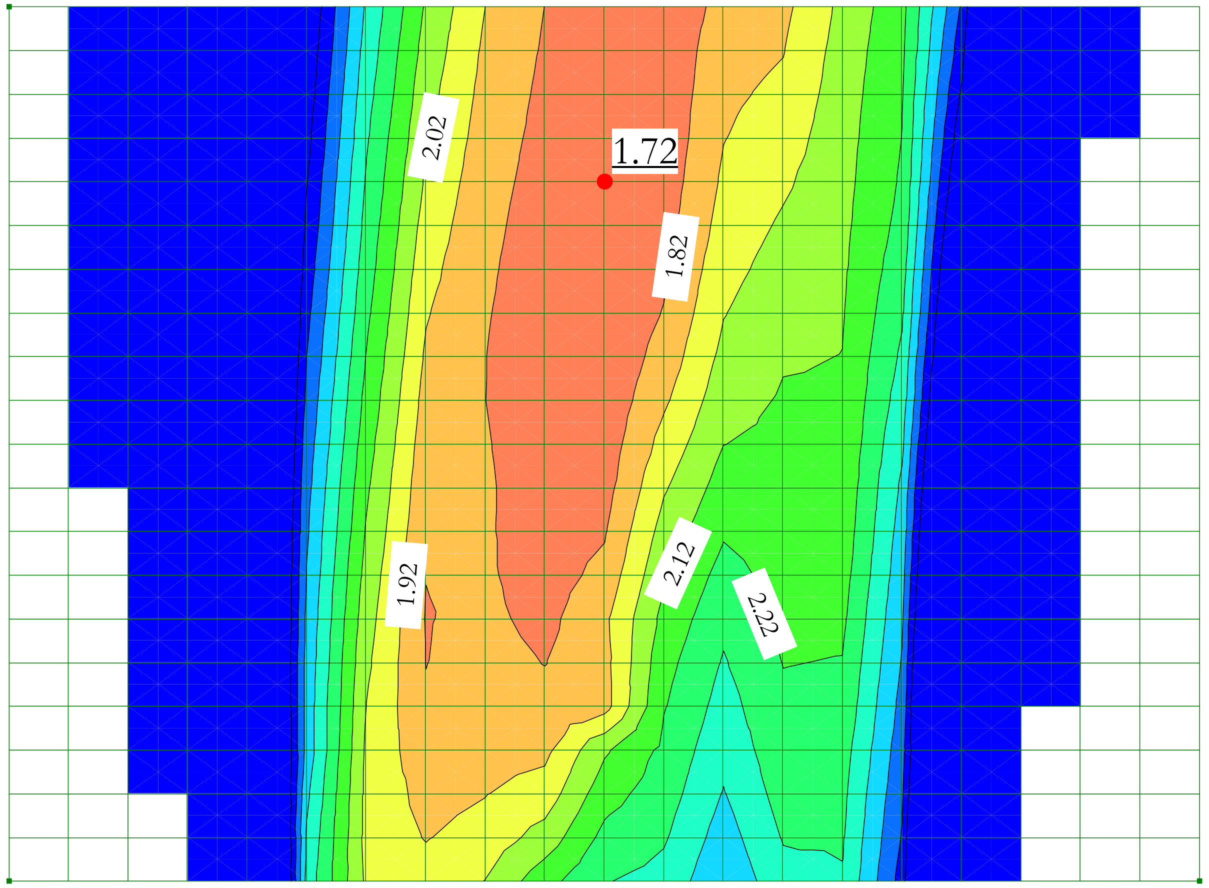
Current Slip Surface

Slip Surface: 7,384
F of S: 2.38
Volume: 5,849.2838 ft³
Weight: 683,004.62 lbs
Resisting Moment: 17,015,925 lbs-ft
Activating Moment: 7,205,425.5 lbs-ft
Resisting Force: 185,396.93 lbs
Activating Force: 78,365.672 lbs
F of S Rank (Analysis): 1 of 21,609 slip surfaces
F of S Rank (Query): 1 of 21,609 slip surfaces
Exit: (-280, -49.122403) ft
Entry: (-493.69477, 9.66667) ft
Radius: 103.96458 ft
Center: (-374.71739, 24.363938) ft

Slip Slices

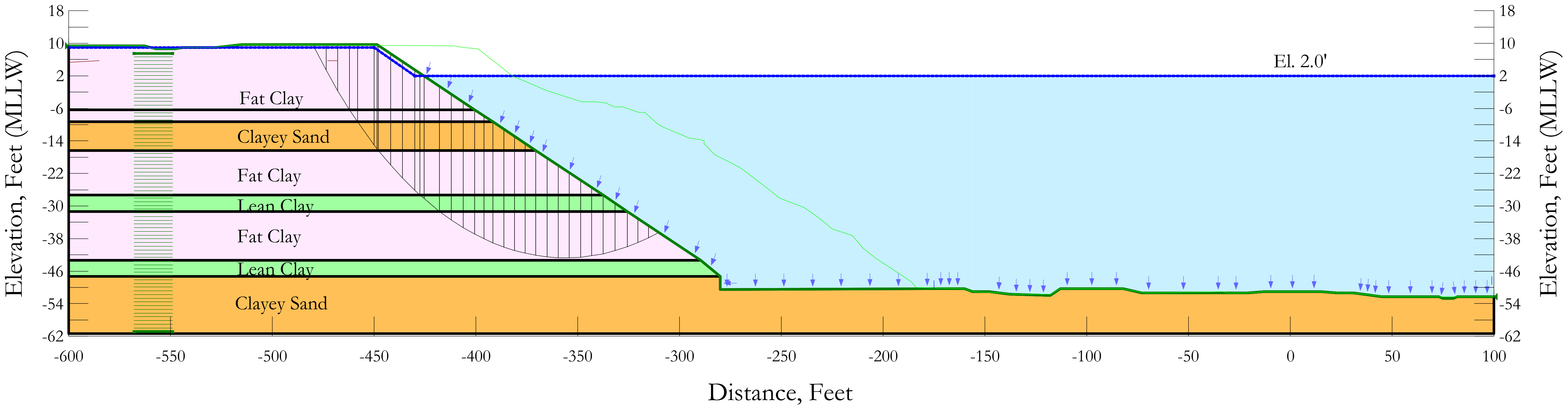
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-493.36144	9.333335	-20.800104	-469.09899	0	1,200
Slice 2	-489.2006	5.1725	238.836	13.43565	0	1,200
Slice 3	-481.5456	-2.4825	716.508	887.42529	0	1,200
Slice 4	-476.2181	-7.81	1,048.944	1,485.0921	0	1,200
Slice 5	-471.2181	-12.81	1,360.944	2,287.2908	578.84572	0
Slice 6	-464.9681	-19.06	1,750.944	2,715.1434	0	1,200
Slice 7	-459.4681	-24.56	2,094.144	3,306.6607	0	1,200
Slice 8	-454.7181	-29.31	2,390.544	3,910.334	0	1,000
Slice 9	-451.35905	-32.669052	2,600.1488	4,205.8477	0	1,200
Slice 10	-449.25	-34.778103	2,419.0411	4,428.0034	0	1,200
Slice 11	-444.60905	-39.419052	2,586.7354	4,772.2678	0	1,200
Slice 12	-439.81126	-44.216842	2,760.097	5,184.8751	0	1,000
Slice 13	-434.45221	-45.261844	2,713.9201	5,764.7777	0	1,000
Slice 14	-427.75	-45.469828	2,962.1172	5,544.9221	0	1,000
Slice 15	-421.345	-45.668588	2,974.5199	5,423.1125	0	1,000
Slice 16	-413.035	-45.926464	2,990.6114	5,327.3802	0	1,000
Slice 17	-404.725	-46.18434	3,006.7028	5,231.8458	0	1,000
Slice 18	-396.07	-46.452922	3,023.4623	5,131.9218	0	1,000
Slice 19	-388.07	-46.701178	3,038.9535	5,038.6568	0	1,000
Slice 20	-381.07	-46.918403	3,052.5083	4,955.8937	0	1,000
Slice 21	-374.07	-47.135627	3,066.0631	4,871.7382	0	1,000
Slice 22	-369.51043	-47.277119	3,074.8923	4,816.1053	0	1,000

Slice 23	-364.59076	-47.429787	3,084.4187	4,754.4076	1,043.5249	0
Slice 24	-356.87054	-47.669361	3,099.3681	4,653.2975	971.00284	0
Slice 25	-349.15032	-47.908935	3,114.3175	4,549.7707	896.97068	0
Slice 26	-341.43011	-48.148509	3,129.267	4,443.7667	821.39059	0
Slice 27	-334.57	-48.361392	3,142.5509	4,337.5068	746.6913	0
Slice 28	-328.57	-48.547584	3,154.1693	4,231.7178	673.32701	0
Slice 29	-321.68915	-48.761111	3,167.4933	4,121.6424	596.2185	0
Slice 30	-313.92744	-49.001973	3,182.5231	4,006.7393	515.02744	0
Slice 31	-306.63382	-49.122403	3,190.038	3,893.2439	439.41181	0
Slice 32	-299.80829	-49.122403	3,190.038	3,762.0377	357.42506	0
Slice 33	-292.98276	-49.122403	3,190.038	3,629.7176	274.74232	0
Slice 34	-284.785	-49.122403	3,190.038	3,428.3673	148.92467	0



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 92+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular

Color	**Name**	**Unit Weight (pcf)**	**Cohesion' (psf)**	**Phi' (°)**
🟩	Lean Clay	125	200	23
🟪	Fat Clay	115	200	18
🟧	Clayey Sand	115	0	32



Long Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 90
Date: 4/26/2018
Time: 9:49:04 PM
Tool Version: 8.16.1.13452
File Name: 092+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\092+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:49:24 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 18 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-520.01625, 153.9474) ft
Lower Left: (-520.01625, 33.6521) ft
Lower Right: (-192.19958, 33.6521) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-568, 7.45533) ft
Upper Right Coordinate: (-549, 7.45533) ft
Lower Left Coordinate: (-568, -60.97977) ft
Lower Right Coordinate: (-549, -60.97977) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9.33333) ft
Right Coordinate: (100, -52.33333) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	9
Coordinate 2	-450	9
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-6.31
Point 2	-600	-9.31
Point 3	-600	-16.31
Point 4	-600	-27.31
Point 5	-600	-31.31
Point 6	-600	-43.31
Point 7	-600	-47.31
Point 8	-175	-48.64333
Point 9	-600	9.33333
Point 10	-563	9.33333
Point 11	-557	8.66667

Point 12	-548	8.66667
Point 13	-544	9
Point 14	-528	9
Point 15	-515	9.66667
Point 16	-448.5	9.66667
Point 17	-400.57	-6.31
Point 18	-280	-47.31
Point 19	-280	-50.5
Point 20	-175	-50.33333
Point 21	-160	-50.33333
Point 22	-156	-51
Point 23	-148	-51
Point 24	-138	-51.66667
Point 25	-118	-52
Point 26	-113	-50.33333
Point 27	-82	-50.33333
Point 28	-73	-51.33333
Point 29	-32	-51.33333
Point 30	-21	-51.33333
Point 31	-13	-51
Point 32	15	-51
Point 33	23	-51.33333
Point 34	31	-51.33333
Point 35	45	-52.33333
Point 36	73	-52.33333
Point 37	75	-52.66667
Point 38	80	-52.66667
Point 39	82	-52.33333
Point 40	100	-52.33333
Point 41	100	-61.33333
Point 42	-600	-61.33333
Point 43	-280	-46.5
Point 44	-289.57	-43.31
Point 45	-325.57	-31.31
Point 46	-337.57	-27.31
Point 47	-370.57	-16.31
Point 48	-391.57	-9.31

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay	48,2,1,17	611.79
Region 2	Clayey Sand	47,3,2,48	1,532.5
Region 3	Fat Clay	46,4,3,47	2,705.2
Region 4	Lean Clay	45,5,4,46	1,073.7
Region 5	Fat Clay	44,6,5,45	3,509.2
Region	Lean Clay	18,7,6,44	1,260.9

6			
Region 7	Fat Clay	9,10,11,12,13,14,15,16,17,1	2,759.7
Region 8	Clayey Sand	7,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42	8,378

Current Slip Surface

Slip Surface: 26,352
F of S: 1.72
Volume: 3,597.7186 ft³
Weight: 417,382.97 lbs
Resisting Moment: 17,787,737 lbs-ft
Activating Moment: 10,369,497 lbs-ft
Resisting Force: 96,046.248 lbs
Activating Force: 56,186.935 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-310.06789, -36.477369) ft
Entry: (-479.97875, 9.66667) ft
Radius: 172.61875 ft
Center: (-356.10791, 129.88834) ft

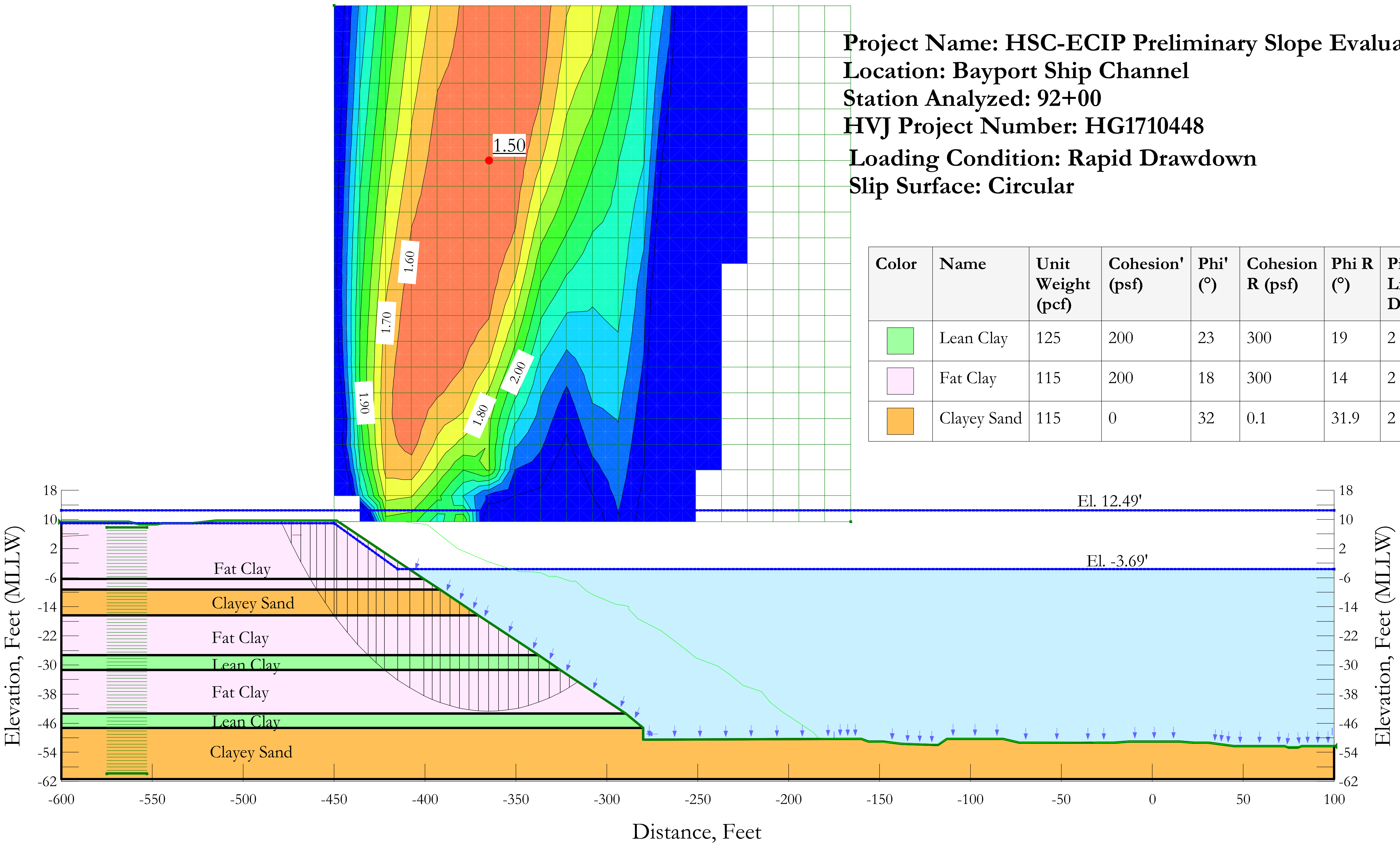
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-479.65348	9.333335	-20.800104	-67.738516	-22.009578	200
Slice 2	-476.467	6.2154542	173.75566	265.22035	29.718678	200
Slice 3	-470.74458	0.88827582	506.17159	835.47706	106.99783	200
Slice 4	-465.02216	-3.9821783	810.08793	1,352.1699	176.1331	200
Slice 5	-460.17621	-7.81	1,048.944	1,756.6907	229.96085	200
Slice 6	-454.09574	-12.135807	1,318.8744	2,193.8599	546.7516	0
Slice 7	-449.25	-15.442288	1,344.1592	2,504.9734	725.35723	0
Slice 8	-448.19317	-16.11648	1,361.0754	2,562.2757	750.59326	0
Slice 9	-444.90528	-18.098737	1,407.2984	2,705.8227	421.91613	200
Slice 10	-438.94317	-21.518421	1,481.3971	2,867.7369	450.4491	200
Slice 11	-432.98106	-24.632425	1,538.503	3,003.3037	475.94261	200
Slice 12	-428.71176	-26.712741	1,791.6751	3,102.0714	425.77358	200
Slice 13	-426.46175	-27.739262	1,855.7299	3,123.3937	538.09137	200
Slice 14	-421.67598	-29.739262	1,980.5299	3,287.6542	554.84136	200
Slice 15	-414.97164	-32.355016	2,143.753	3,537.9557	453.00391	200
Slice 16	-409.21098	-34.331431	2,267.0813	3,698.5249	465.10421	200
Slice 17	-403.45033	-36.084421	2,376.4679	3,839.2385	475.28296	200
Slice 18	-398.32	-37.473508	2,463.1469	3,948.559	482.63964	200
Slice						

19	-393.82	-38.544778	2,529.9941	4,029.7188	487.2901	200
Slice 20	-388.945	-39.557254	2,593.1726	4,101.8941	490.21333	200
Slice 21	-383.695	-40.490985	2,651.4375	4,161.8588	490.76563	200
Slice 22	-378.445	-41.258613	2,699.3374	4,201.6499	488.13091	200
Slice 23	-373.195	-41.862368	2,737.0117	4,220.1278	481.89365	200
Slice 24	-367.82	-42.310564	2,764.9792	4,215.5138	471.30727	200
Slice 25	-362.32	-42.596646	2,782.8307	4,185.4034	455.7235	200
Slice 26	-356.82	-42.707034	2,789.7189	4,128.1914	434.89609	200
Slice 27	-351.32	-42.642064	2,785.6648	4,042.8646	408.48897	200
Slice 28	-345.82	-42.401538	2,770.656	3,928.6326	376.24941	200
Slice 29	-340.32	-41.984719	2,744.6464	3,784.9718	338.02221	200
Slice 30	-334.57	-41.354787	2,705.3387	3,592.1351	288.13763	200
Slice 31	-328.57	-40.492589	2,651.5376	3,347.0102	225.97273	200
Slice 32	-322.98632	-39.502515	2,589.757	3,097.6223	165.01543	200
Slice 33	-317.81895	-38.409511	2,521.5535	2,849.656	106.60696	200
Slice 34	-312.65158	-37.149537	2,442.9311	2,577.4281	43.70073	200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 92+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	**Name**	**Unit Weight (pcf)**	**Cohesion' (psf)**	**Phi' (°)**	**Cohesion R (psf)**	**Phi R (°)**	**Piezometric Line After Drawdown**
🟩	Lean Clay	125	200	23	300	19	2
🟪	Fat Clay	115	200	18	300	14	2
🟧	Clayey Sand	115	0	32	0.1	31.9	2



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 90
Date: 4/26/2018
Time: 9:49:04 PM
Tool Version: 8.16.1.13452
File Name: 092+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\092+00\
Last Solved Date: 4/26/2018
Last Solved Time: 9:49:54 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 23 °
Phi-B: 0 °
Cohesion R: 300 psf
Phi R: 19 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 18 °
Phi-B: 0 °
Cohesion R: 300 psf
Phi R: 14 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 31.9 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-449.94274, 151.23333) ft
Lower Left: (-449.94274, 9.32857) ft
Lower Right: (-165.92983, 9.32857) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-574.99231, 7.86324) ft
Upper Right Coordinate: (-552.98645, 7.86324) ft
Lower Left Coordinate: (-574.99231, -59.87761) ft
Lower Right Coordinate: (-552.98645, -59.87761) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9.33333) ft
Right Coordinate: (100, -52.33333) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	9
Coordinate 2	-450	9
Coordinate 3	-415	-3.69

Coordinate 4	100	-3.69

Points

	X (ft)	Y (ft)
Point 1	-600	-6.31
Point 2	-600	-9.31
Point 3	-600	-16.31
Point 4	-600	-27.31
Point 5	-600	-31.31
Point 6	-600	-43.31
Point 7	-600	-47.31
Point 8	-175	-48.64333
Point 9	-600	9.33333
Point 10	-563	9.33333
Point 11	-557	8.66667
Point 12	-548	8.66667
Point 13	-544	9
Point 14	-528	9
Point 15	-515	9.66667
Point 16	-448.5	9.66667
Point 17	-400.57	-6.31
Point 18	-280	-47.31
Point 19	-280	-50.5
Point 20	-175	-50.33333
Point 21	-160	-50.33333
Point 22	-156	-51
Point 23	-148	-51
Point 24	-138	-51.66667
Point 25	-118	-52
Point 26	-113	-50.33333
Point 27	-82	-50.33333
Point 28	-73	-51.33333
Point 29	-32	-51.33333
Point 30	-21	-51.33333
Point 31	-13	-51
Point 32	15	-51
Point 33	23	-51.33333
Point 34	31	-51.33333
Point 35	45	-52.33333
Point 36	73	-52.33333
Point 37	75	-52.66667
Point 38	80	-52.66667
Point 39	82	-52.33333
Point 40	100	-52.33333
Point 41	100	-61.33333
Point 42	-600	-61.33333
Point 43	-280	-46.5
Point 44	-289.57	-43.31
Point 45	-325.57	-31.31
Point 46	-337.57	-27.31
Point 47	-370.57	-16.31

Point 48	-391.57	-9.31

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay	48,2,1,17	611.79
Region 2	Clayey Sand	47,3,2,48	1,532.5
Region 3	Fat Clay	46,4,3,47	2,705.2
Region 4	Lean Clay	45,5,4,46	1,073.7
Region 5	Fat Clay	44,6,5,45	3,509.2
Region 6	Lean Clay	18,7,6,44	1,260.9
Region 7	Fat Clay	9,10,11,12,13,14,15,16,17,1	2,759.7
Region 8	Clayey Sand	7,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42	8,378

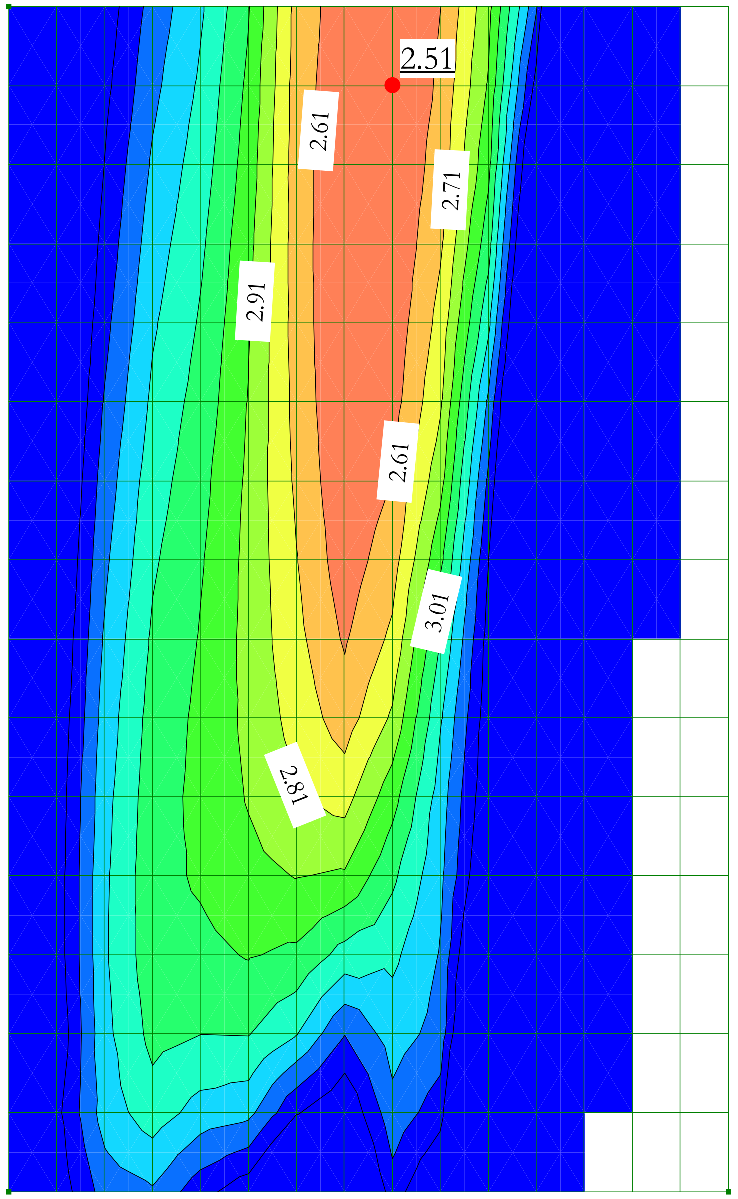
Current Slip Surface

Slip Surface: 22,857
F of S: 1.50
Volume: 3,655.9036 ft³
Weight: 424,243.18 lbs
Resisting Moment: 15,836,636 lbs-ft
Activating Moment: 10,527,021 lbs-ft
Resisting Force: 97,065.01 lbs
Activating Force: 64,685.404 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-315.76891, -34.577032) ft
Entry: (-479.26132, 9.66667) ft
Radius: 151.3785 ft
Center: (-364.73887, 108.6619) ft

Slip Slices

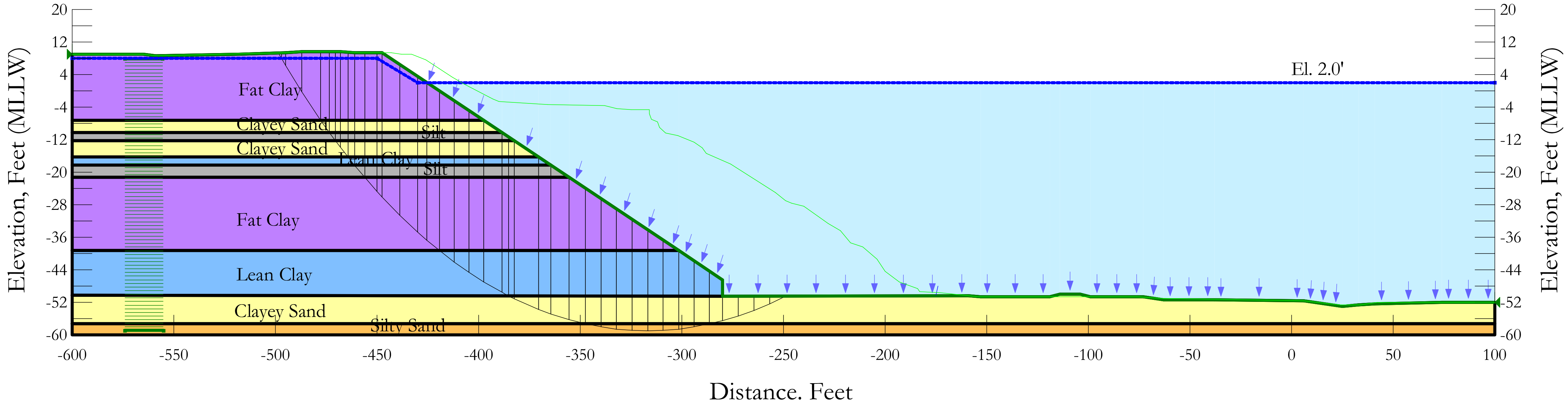
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-478.97148	9.333335	-20.800104	-91.431504	-29.707897	200
Slice 2	-476.10332	6.1977293	174.86169	238.1154	20.552376	200
Slice 3	-470.9467	0.85538068	508.22425	799.993	94.801415	200
Slice 4	-465.79007	-3.9973486	811.03455	1,303.2147	159.91902	200
Slice 5	-461.40442	-7.81	1,048.944	1,695.7702	210.16658	200
Slice 6	-457.23883	-11.130953	1,256.1714	2,024.9303	480.37387	0
Slice 7	-452.4403	-14.686965	1,478.0666	2,379.0594	563.00277	0
Slice 8	-449.25	-16.926714	1,414.8634	2,615.2626	390.03336	200
Slice 9	-445.62921	-19.24691	1,470.4217	2,758.8217	418.62654	200
Slice 10	-439.88763	-22.704663	1,546.3093	2,931.746	450.15569	200

Slice 11	-434.14605	-25.828455	1,603.7789	3,079.0347	479.33968	200
Slice 12	-429.05321	-28.353021	1,641.1733	3,170.587	649.19759	200
Slice 13	-424.60912	-30.353021	1,662.6101	3,274.2008	684.07965	200
Slice 14	-418.69354	-32.719546	1,674.8371	3,398.2569	559.97303	200
Slice 15	-411.715	-35.20175	1,966.3332	3,487.6261	494.29803	200
Slice 16	-404.5	-37.344643	2,100.0498	3,613.4709	491.74034	200
Slice 17	-398.32	-38.926824	2,198.7778	3,756.4778	506.12742	200
Slice 18	-393.82	-39.879272	2,258.2106	3,840.8977	514.2462	200
Slice 19	-388.945	-40.745062	2,312.2359	3,914.3889	520.57108	200
Slice 20	-383.695	-41.501722	2,359.4514	3,972.6382	524.15617	200
Slice 21	-378.445	-42.071782	2,395.0232	4,006.5058	523.60244	200
Slice 22	-373.195	-42.457358	2,419.0832	4,013.9682	518.20955	200
Slice 23	-367.82	-42.660239	2,431.7429	3,991.8854	506.92102	200
Slice 24	-362.32	-42.672278	2,432.4941	3,936.7079	488.7487	200
Slice 25	-356.82	-42.484244	2,420.7608	3,846.4699	463.24098	200
Slice 26	-351.32	-42.095389	2,396.4963	3,719.7633	429.95551	200
Slice 27	-345.82	-41.50415	2,359.603	3,555.6966	388.63436	200
Slice 28	-340.32	-40.70812	2,309.9307	3,353.964	339.22698	200
Slice 29	-334.57	-39.648301	2,243.798	3,091.8016	275.53307	200
Slice 30	-328.57	-38.299716	2,159.6463	2,766.3128	197.1179	200
Slice 31	-323.11973	-36.86061	2,069.8461	2,444.9567	121.88081	200
Slice 32	-318.21918	-35.368434	1,976.7343	2,136.9897	52.070144	200



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 98+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
▨	Silt	110	0	32	
🟨	Clayey Sand	115	0	33	
🟧	Silty Sand	120	0	32	
🟦	Lean Clay (undrained)	125			1,200
🟪	Fat Clay (undrained)	115			1,200



Short Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 79
Date: 4/27/2018
Time: 11:08:27 AM
Tool Version: 8.16.1.13452
File Name: 098+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\098+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:10:06 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 3 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 33 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-443.82911, 229.6386) ft
Lower Left: (-443.82911, 33.88454) ft
Lower Right: (-206.00367, 33.88454) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-573.94258, 7.85919) ft
Upper Right Coordinate: (-555.4229, 7.85919) ft
Lower Left Coordinate: (-573.94258, -58.99534) ft
Lower Right Coordinate: (-555.04494, -58.99534) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9) ft
Right Coordinate: (100, -52) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-7.31
Point 2	-600	-10.31
Point 3	-600	-12.31
Point 4	-600	-16.31
Point 5	-600	-18.31
Point 6	-600	-21.31
Point 7	-600	-39.31
Point 8	-600	-50.31
Point 9	-600	-57.31
Point 10	100	-57.31
Point 11	-600	-60
Point 12	100	-60
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-301.57	-39.31
Point 16	-355.57	-21.31
Point 17	-364.57	-18.31
Point 18	-370.57	-16.31
Point 19	-382.57	-12.31
Point 20	-388.57	-10.31
Point 21	-397.57	-7.31
Point 22	-447.5	9.33333
Point 23	-600	9
Point 24	-565	9
Point 25	-559	8.66667
Point 26	-518	9
Point 27	-495	9.33333
Point 28	-487	9.66667
Point 29	-468	9.66667
Point 30	-461	9.33333
Point 31	-159	-50.33333
Point 32	-153	-50.66667
Point 33	-119	-50.66667
Point 34	-114	-50
Point 35	-104	-50
Point 36	-99	-50.66667
Point 37	-73	-50.66667
Point 38	-63	-51.33333
Point 39	-38	-51.33333
Point 40	6	-51.66667
Point 41	25	-53
Point 42	33	-52.66667
Point 43	41	-52.33333
Point 44	74	-52
Point 45	100	-52

Regions

	Material	Points	Area (ft^2)

Region 1	Clayey Sand	20,2,1,21	620.79
Region 2	Silt	19,3,2,20	428.86
Region 3	Clayey Sand	18,4,3,19	893.72
Region 4	Lean Clay (undrained)	17,5,4,18	464.86
Region 5	Silt	16,6,5,17	719.79
Region 6	Fat Clay (undrained)	15,7,6,16	4,885.7
Region 7	Silty Sand	9,11,12,10	1,883
Region 8	Lean Clay (undrained)	7,15,14,13,8	3,472.9
Region 9	Fat Clay (undrained)	23,24,25,26,27,28,29,30,22,21,1	2,923.4
Region 10	Clayey Sand	8,13,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,10,9	4,570.8

Current Slip Surface

Slip Surface: 17,708
F of S: 2.51
Volume: 6,430.6525 ft^3
Weight: 752,412.25 lbs
Resisting Moment: 70,689,159 lbs-ft
Activating Moment: 28,111,272 lbs-ft
Resisting Force: 238,157.98 lbs
Activating Force: 95,027.475 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (-248.92238, -50.457192) ft
Entry: (-498.56613, 9.2816475) ft
Radius: 275.58367 ft
Center: (-316.98888, 216.58833) ft

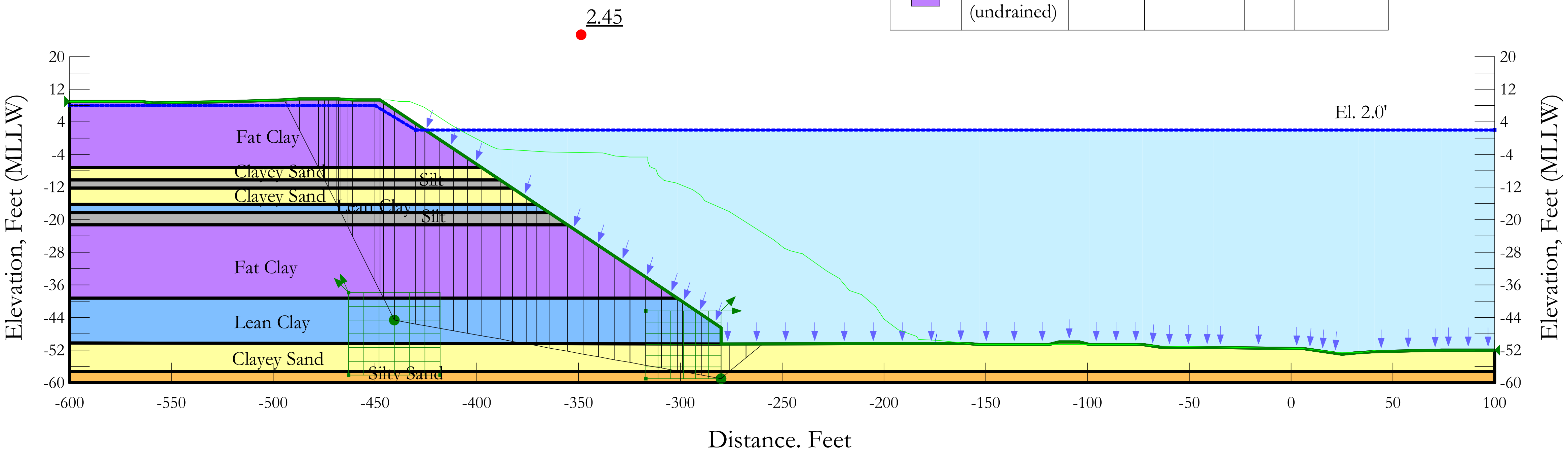
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-497.82925	8.6408238	-39.987402	-339.17445	0	1,200
Slice 2	-496.04618	7.1057643	55.800309	-150.87069	0	1,200
Slice 3	-491	2.9534257	314.90624	367.67498	0	1,200
Slice 4	-482.33107	-3.8073386	736.77793	1,187.8239	0	1,200
Slice 5	-475.52958	-8.81	1,048.944	1,940.873	579.2255	0
Slice 6	-471.92611	-11.31	1,204.944	2,207.4774	626.45238	0
Slice 7	-469.2276	-13.123578	1,318.1112	2,390.6601	696.52139	0
Slice 8	-466.15706	-15.123578	1,442.9112	2,595.2006	748.30551	0
Slice 9	-462.65706	-17.34185	1,581.3314	2,733.5063	0	1,200
Slice 10	-458.54791	-19.84185	1,737.3314	3,093.5435	847.4554	0
Slice 11	-453.04791	-23.040576	1,936.932	3,377.2199	0	1,200
Slice 12	-448.75	-25.451625	1,893.5609	3,655.8	0	1,200
Slice 13	-443.125	-28.384775	1,964.8715	3,831.2979	0	1,200
Slice 14	-434.375	-32.697594	2,061.4953	4,005.2267	0	1,200
Slice 15	-427.75	-35.745365	2,355.3108	4,114.4203	0	1,200
Slice						

16	-422.38739	-38.021498	2,497.3414	4,247.2927	0	1,200
Slice 17	-415.65731	-40.697288	2,664.3108	4,467.8149	0	1,200
Slice 18	-408.42238	-43.356987	2,830.276	4,694.4945	0	1,200
Slice 19	-401.18746	-45.790258	2,982.1121	4,896.0257	0	1,200
Slice 20	-393.07	-48.243882	3,135.2182	5,091.0295	0	1,200
Slice 21	-386.85114	-49.987111	3,243.9957	5,228.0558	0	1,200
Slice 22	-383.85114	-50.757986	3,292.0983	5,279.7161	1,290.7741	0
Slice 23	-376.57	-52.407363	3,395.0194	5,377.7208	1,287.5813	0
Slice 24	-367.57	-54.296508	3,512.9021	5,470.5244	1,271.2948	0
Slice 25	-360.07	-55.569011	3,592.3063	5,518.9446	1,251.1735	0
Slice 26	-351.49509	-56.795669	3,668.8498	5,556.8404	1,226.0754	0
Slice 27	-343.59933	-57.680711	3,724.0764	5,557.0993	1,145.3998	0
Slice 28	-335.95763	-58.315066	3,763.6601	5,528.8136	1,102.9903	0
Slice 29	-328.31594	-58.735903	3,789.9203	5,470.8089	1,050.3358	0
Slice 30	-320.67424	-58.944201	3,802.9182	5,382.3177	986.91835	0
Slice 31	-313.03254	-58.940443	3,802.6836	5,262.6345	912.27856	0
Slice 32	-305.39085	-58.724619	3,789.2163	5,111.1413	826.0304	0
Slice 33	-297.81689	-58.301903	3,762.8387	4,916.3478	720.79246	0
Slice 34	-290.31068	-57.675073	3,723.7245	4,678.2705	596.46654	0
Slice 35	-283.27879	-56.905866	3,675.7261	4,477.6383	520.76784	0
Slice 36	-276.1153	-55.919063	3,614.1495	3,941.5259	212.60074	0
Slice 37	-268.34589	-54.639698	3,534.3171	3,787.4405	164.38026	0
Slice 38	-260.57649	-53.130506	3,440.1436	3,603.2163	105.90062	0
Slice 39	-252.80708	-51.387601	3,331.3863	3,388.5665	37.13325	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 98+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
▨	Silt	110	0	32	
🟨	Clayey Sand	115	0	33	
🟧	Silty Sand	120	0	32	
🟦	Lean Clay (undrained)	125			1,200
🟪	Fat Clay (undrained)	115			1,200



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 79
Date: 4/27/2018
Time: 11:08:27 AM
Tool Version: 8.16.1.13452
File Name: 098+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\098+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:10:26 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 9) ft
Right Coordinate: (100, -52) ft

Slip Surface Block

Left Grid
- Upper Left: (-462.96184, -37.90826) ft
- Lower Left: (-462.96184, -58.16958) ft
- Lower Right: (-418.02584, -58.16958) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 2

Right Grid
- Upper Left: (-316.97852, -42.41549) ft
- Lower Left: (-316.97852, -59.00036) ft
- Lower Right: (-280.0596, -59.00036) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-7.31
Point 2	-600	-10.31
Point 3	-600	-12.31
Point 4	-600	-16.31
Point 5	-600	-18.31
Point 6	-600	-21.31
Point 7	-600	-39.31
Point 8	-600	-50.31
Point 9	-600	-57.31
Point 10	100	-57.31
Point 11	-600	-60
Point 12	100	-60
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-301.57	-39.31
Point 16	-355.57	-21.31
Point 17	-364.57	-18.31
Point 18	-370.57	-16.31
Point 19	-382.57	-12.31
Point 20	-388.57	-10.31
Point 21	-397.57	-7.31
Point 22	-447.5	9.33333
Point 23	-600	9
Point 24	-565	9
Point 25	-559	8.66667
Point 26	-518	9
Point 27	-495	9.33333
Point 28	-487	9.66667
Point 29	-468	9.66667
Point 30	-461	9.33333
Point 31	-159	-50.33333
Point 32	-153	-50.66667
Point 33	-119	-50.66667
Point 34	-114	-50
Point 35	-104	-50
Point 36	-99	-50.66667
Point 37	-73	-50.66667
Point 38	-63	-51.33333
Point 39	-38	-51.33333
Point 40	6	-51.66667
Point 41	25	-53
Point 42	33	-52.66667
Point 43	41	-52.33333
Point 44	74	-52
Point 45	100	-52

Regions

	Material	Points	Area (ft²)

Region 1	Clayey Sand	20,2,1,21	620.79
Region 2	Silt	19,3,2,20	428.86
Region 3	Clayey Sand	18,4,3,19	893.72
Region 4	Lean Clay (undrained)	17,5,4,18	464.86
Region 5	Silt	16,6,5,17	719.79
Region 6	Fat Clay (undrained)	15,7,6,16	4,885.7
Region 7	Silty Sand	9,11,12,10	1,883
Region 8	Lean Clay (undrained)	7,15,14,13,8	3,472.9
Region 9	Fat Clay (undrained)	23,24,25,26,27,28,29,30,22,21,1	2,923.4
Region 10	Clayey Sand	8,13,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,10,9	4,570.8

Current Slip Surface

Slip Surface: 13,985
F of S: 2.45
Volume: 6,694.3554 ft³
Weight: 784,884.18 lbs
Resisting Moment: 21,352,816 lbs-ft
Activating Moment: 8,810,965.4 lbs-ft
Resisting Force: 227,631.44 lbs
Activating Force: 93,149.365 lbs
F of S Rank (Analysis): 1 of 21,609 slip surfaces
F of S Rank (Query): 1 of 21,609 slip surfaces
Exit: (-259.46964, -50.471721) ft
Entry: (-494.50964, 9.3537623) ft
Radius: 111.70889 ft
Center: (-365.56896, 24.310133) ft

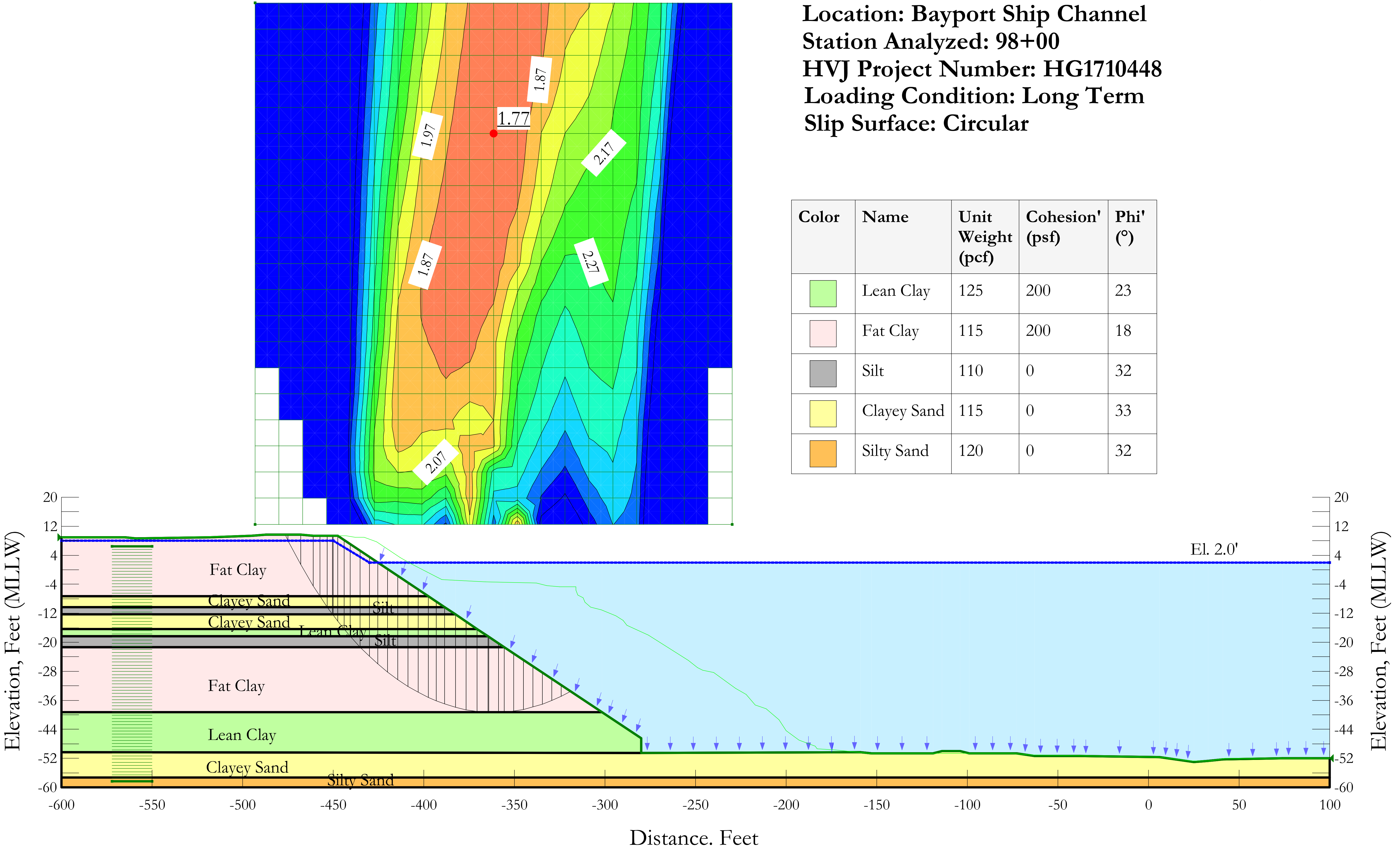
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-493.83275	8.6768811	-42.237382	-412.73892	0	1,200
Slice 2	-490.07794	4.9220633	192.06325	40.62143	0	1,200
Slice 3	-482.42294	-2.7329367	669.73525	927.23975	0	1,200
Slice 4	-476.34587	-8.81	1,048.944	1,870.3796	533.44655	0
Slice 5	-473.84587	-11.31	1,204.944	2,122.5483	573.38281	0
Slice 6	-470.84587	-14.31	1,392.144	2,408.6166	660.10502	0
Slice 7	-468.42294	-16.732937	1,543.3352	2,462.9573	0	1,200
Slice 8	-467.42294	-17.732937	1,605.7352	2,577.6357	0	1,200
Slice 9	-465.34587	-19.81	1,735.344	2,957.4171	763.63601	0
Slice 10	-462.42294	-22.732937	1,917.7352	3,077.2895	0	1,200
Slice 11	-455.5	-29.655873	2,349.7265	3,801.4686	0	1,200
Slice 12	-448.75	-36.405873	2,520.6665	4,507.4168	0	1,200
Slice 13	-446.67294	-38.482937	2,603.9015	4,692.6042	0	1,200
Slice 14	-443.16986	-41.986017	2,744.2818	4,952.4981	0	1,200
Slice 15	-435.24692	-45.130961	2,788.2517	5,716.05	0	1,200
Slice						

16	-427.75	-45.800975	2,982.7809	5,522.36	0	1,200
Slice 17	-422.00875	-46.314082	3,014.7987	5,448.6224	0	1,200
Slice 18	-415.02625	-46.938122	3,053.7388	5,417.7264	0	1,200
Slice 19	-408.04375	-47.562162	3,092.6789	5,387.7485	0	1,200
Slice 20	-401.06125	-48.186202	3,131.619	5,358.3995	0	1,200
Slice 21	-393.07	-48.900396	3,176.1847	5,325.1929	0	1,200
Slice 22	-385.57	-49.570686	3,218.0108	5,298.9739	0	1,200
Slice 23	-379.18912	-50.140958	3,253.5958	5,277.0877	0	1,200
Slice 24	-373.18912	-50.67719	3,287.0566	5,248.7516	1,273.9396	0
Slice 25	-367.57	-51.179382	3,318.3934	5,209.3342	1,227.9913	0
Slice 26	-360.07	-51.849672	3,360.2195	5,166.2947	1,172.8789	0
Slice 27	-351.71286	-52.596566	3,406.8257	5,126.8073	1,116.9691	0
Slice 28	-343.99857	-53.286007	3,449.8468	5,081.5752	1,059.6568	0
Slice 29	-336.28429	-53.975448	3,492.868	5,034.3247	1,001.0337	0
Slice 30	-328.57	-54.664889	3,535.8891	4,984.9144	941.00805	0
Slice 31	-320.85571	-55.35433	3,578.9102	4,933.249	879.51788	0
Slice 32	-313.14143	-56.043771	3,621.9313	4,879.2802	816.53195	0
Slice 33	-305.42714	-56.733212	3,664.9524	4,823.009	752.05072	0
Slice 34	-300.27168	-57.193966	3,693.7035	4,779.9672	705.42787	0
Slice 35	-294.24492	-57.73259	3,727.3136	4,716.0981	617.86112	0
Slice 36	-284.75824	-58.565426	3,779.2826	4,640.6761	538.25841	0
Slice 37	-277.98935	-58.142836	3,752.913	4,284.4801	332.16	0
Slice 38	-271.85144	-55.60043	3,594.2668	3,944.9287	227.72249	0
Slice 39	-263.59691	-52.181291	3,380.9125	3,496.2929	74.928925	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 98+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Lean Clay	125	200	23
🟥	Fat Clay	115	200	18
⬛	Silt	110	0	32
🟨	Clayey Sand	115	0	33
🟧	Silty Sand	120	0	32



Long Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 79
Date: 4/27/2018
Time: 11:08:27 AM
Tool Version: 8.16.1.13452
File Name: 098+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\098+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:09:00 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 18 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-493.03183, 156.31112) ft
Lower Left: (-493.03183, 12.4996) ft
Lower Right: (-229.87401, 12.4996) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-572, 6.44308) ft
Upper Right Coordinate: (-550, 6.44308) ft
Lower Left Coordinate: (-572, -58.3341) ft
Lower Right Coordinate: (-550, -58.3341) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9) ft
Right Coordinate: (100, -52) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8

Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-7.31
Point 2	-600	-10.31
Point 3	-600	-12.31
Point 4	-600	-16.31
Point 5	-600	-18.31
Point 6	-600	-21.31
Point 7	-600	-39.31
Point 8	-600	-50.31
Point 9	-600	-57.31
Point 10	100	-57.31
Point 11	-600	-60
Point 12	100	-60
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-301.57	-39.31
Point 16	-355.57	-21.31
Point 17	-364.57	-18.31
Point 18	-370.57	-16.31
Point 19	-382.57	-12.31
Point 20	-388.57	-10.31
Point 21	-397.57	-7.31
Point 22	-447.5	9.33333
Point 23	-600	9
Point 24	-565	9
Point 25	-559	8.66667
Point 26	-518	9
Point 27	-495	9.33333
Point 28	-487	9.66667
Point 29	-468	9.66667
Point 30	-461	9.33333
Point 31	-159	-50.33333
Point 32	-153	-50.66667
Point 33	-119	-50.66667
Point 34	-114	-50
Point 35	-104	-50
Point 36	-99	-50.66667
Point 37	-73	-50.66667
Point 38	-63	-51.33333
Point 39	-38	-51.33333
Point 40	6	-51.66667
Point 41	25	-53
Point 42	33	-52.66667
Point 43	41	-52.33333
Point 44	74	-52
Point 45	100	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Sand	20,2,1,21	620.79
Region 2	Silt	19,3,2,20	428.86
Region 3	Clayey Sand	18,4,3,19	893.72
Region 4	Lean Clay	17,5,4,18	464.86
Region 5	Silt	16,6,5,17	719.79
Region 6	Fat Clay	15,7,6,16	4,885.7
Region 7	Silty Sand	9,11,12,10	1,883
Region 8	Lean Clay	7,15,14,13,8	3,472.9
Region 9	Fat Clay	23,24,25,26,27,28,29,30,22,21,1	2,923.4
Region 10	Clayey Sand	8,13,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,10,9	4,570.8

Current Slip Surface

Slip Surface: 24,754

F of S: 1.77

Volume: 3,088.7144 ft^3

Weight: 354,868.11 lbs

Resisting Moment: 14,611,261 lbs-ft

Activating Moment: 8,257,179.9 lbs-ft

Resisting Force: 84,910.868 lbs

Activating Force: 48,147.036 lbs

F of S Rank (Analysis): 1 of 33,516 slip surfaces

F of S Rank (Query): 1 of 33,516 slip surfaces

Exit: (-318.85814, -33.547286) ft

Entry: (-476.55549, 9.66667) ft

Radius: 159.69103 ft

Center: (-361.45292, 120.35824) ft

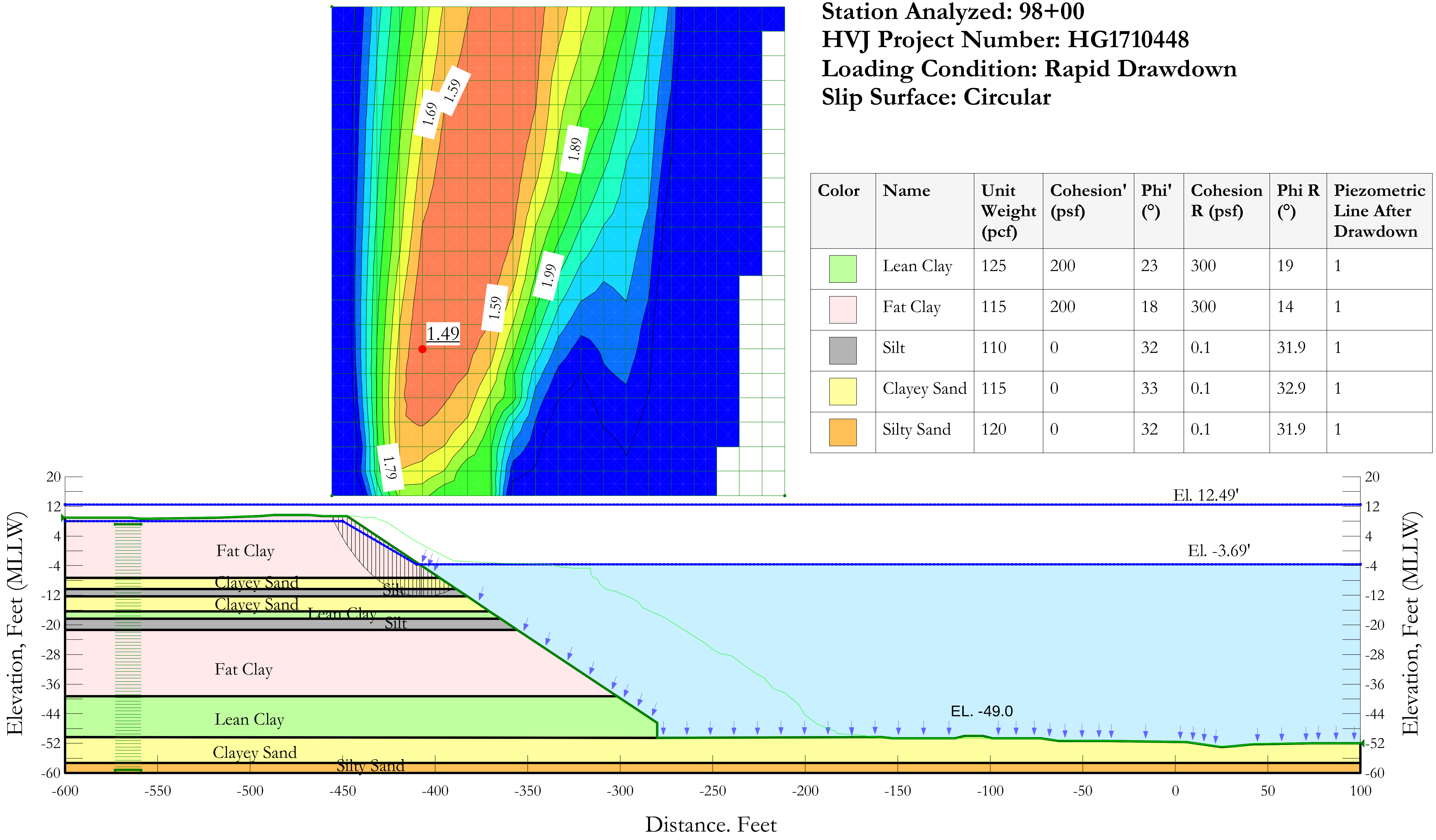
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-475.74232	8.833335	-52.000104	-16.411325	-5.3323627	200
Slice 2	-471.46457	4.7044488	205.64239	421.36055	70.091078	200
Slice 3	-464.5	-1.5496058	595.8954	1,074.1438	155.39232	200
Slice 4	-459.19011	-5.9090546	867.92501	1,520.7681	212.12157	200
Slice 5	-455.31602	-8.81	1,048.944	1,812.3539	495.76418	0
Slice 6	-451.79437	-11.31	1,204.944	2,070.9452	541.13761	0
Slice 7	-450.16846	-12.422552	1,274.3672	2,175.8682	585.44159	0
Slice 8	-448.75	-13.351212	1,200.84	2,249.4657	680.98546	0
Slice 9	-445.77724	-15.23866	1,257.837	2,385.1656	732.09577	0
Slice 10	-442.35277	-17.31	1,317.6036	2,513.2805	507.53473	200
Slice 11	-437.90079	-19.81	1,384.2631	2,623.7212	774.49941	0
Slice 12	-432.57526	-22.591281	1,452.0227	2,780.0727	431.50961	200
Slice 13	-427.75	-24.899483	1,678.5277	2,883.1083	391.39196	200
Slice 14	-422.707	-27.08672	1,815.0113	3,018.1698	390.92991	200
Slice						

15	-417.121	-29.286039	1,952.2489	3,197.4492	404.59012	200
Slice 16	-411.535	-31.247694	2,074.6561	3,356.4273	416.47271	200
Slice 17	-405.949	-32.98082	2,182.8032	3,495.1135	426.39545	200
Slice 18	-400.363	-34.493103	2,277.1696	3,613.0615	434.05759	200
Slice 19	-395.32	-35.683249	2,351.4347	3,702.0713	438.84843	200
Slice 20	-390.82	-36.592584	2,408.1772	3,765.0711	440.88156	200
Slice 21	-385.57	-37.471994	2,463.0524	3,822.4955	441.70985	200
Slice 22	-379.57	-38.273032	2,513.0372	3,862.0267	438.31327	200
Slice 23	-373.57	-38.843992	2,548.6651	3,865.8014	427.96352	200
Slice 24	-367.57	-39.187347	2,570.0905	3,826.7199	408.30363	200
Slice 25	-364.36048	-39.306185	2,577.5059	3,790.8762	394.24792	200
Slice 26	-361.45292	-39.31	2,577.744	3,757.2745	383.2527	200
Slice 27	-357.16244	-39.267198	2,575.0731	3,698.4195	364.99738	200
Slice 28	-352.94772	-39.084515	2,563.6737	3,614.1805	341.33035	200
Slice 29	-347.70317	-38.717978	2,540.8018	3,482.324	305.91912	200
Slice 30	-342.45862	-38.177144	2,507.0538	3,321.5638	264.65034	200
Slice 31	-337.21407	-37.460219	2,462.3177	3,131.9332	217.57126	200
Slice 32	-331.96952	-36.564787	2,406.4427	2,913.7747	164.84215	200
Slice 33	-326.72497	-35.487767	2,339.2367	2,667.7164	106.72952	200
Slice 34	-321.48042	-34.225359	2,260.4624	2,394.6274	43.592862	200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 98+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟩	Lean Clay	125	200	23	300	19	1
🟥	Fat Clay	115	200	18	300	14	1
⬛	Silt	110	0	32	0.1	31.9	1
🟨	Clayey Sand	115	0	33	0.1	32.9	1
🟧	Silty Sand	120	0	32	0.1	31.9	1



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 79
Date: 4/27/2018
Time: 11:08:27 AM
Tool Version: 8.16.1.13452
File Name: 098+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\098+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:09:56 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 19 °

Pore Water Pressure

Piezometric Line: 2

Piezometric Line After Drawdown: 1

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 18 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 2

Piezometric Line After Drawdown: 1

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 31.9 °
Pore Water Pressure
    Piezometric Line: 2
    Piezometric Line After Drawdown: 1

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 32.9 °
Pore Water Pressure
    Piezometric Line: 2
    Piezometric Line After Drawdown: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 31.9 °
Pore Water Pressure
    Piezometric Line: 2
    Piezometric Line After Drawdown: 1

Slip Surface Grid

Upper Left: (-455.74787, 146.99344) ft
Lower Left: (-455.74787, 14.8442) ft
Lower Right: (-211.08753, 14.8442) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-573.00809, 7.1797) ft
Upper Right Coordinate: (-559.02196, 7.1797) ft
Lower Left Coordinate: (-573.00809, -59.27302) ft
Lower Right Coordinate: (-559.02196, -59.27302) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 9) ft

Right Coordinate: (100, -52) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	8
Coordinate 2	-450	8
Coordinate 3	-410	-3.69
Coordinate 4	100	-3.69

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Points

	X (ft)	Y (ft)
Point 1	-600	-7.31
Point 2	-600	-10.31
Point 3	-600	-12.31
Point 4	-600	-16.31
Point 5	-600	-18.31
Point 6	-600	-21.31
Point 7	-600	-39.31
Point 8	-600	-50.31
Point 9	-600	-57.31
Point 10	100	-57.31
Point 11	-600	-60
Point 12	100	-60
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-301.57	-39.31
Point 16	-355.57	-21.31
Point 17	-364.57	-18.31
Point 18	-370.57	-16.31
Point 19	-382.57	-12.31
Point 20	-388.57	-10.31
Point 21	-397.57	-7.31
Point 22	-447.5	9.33333
Point 23	-600	9
Point 24	-565	9

Point 25	-559	8.66667
Point 26	-518	9
Point 27	-495	9.33333
Point 28	-487	9.66667
Point 29	-468	9.66667
Point 30	-461	9.33333
Point 31	-159	-50.33333
Point 32	-153	-50.66667
Point 33	-119	-50.66667
Point 34	-114	-50
Point 35	-104	-50
Point 36	-99	-50.66667
Point 37	-73	-50.66667
Point 38	-63	-51.33333
Point 39	-38	-51.33333
Point 40	6	-51.66667
Point 41	25	-53
Point 42	33	-52.66667
Point 43	41	-52.33333
Point 44	74	-52
Point 45	100	-52

Regions

	Material	Points	Area (ft²)
Region 1	Clayey Sand	20,2,1,21	620.79
Region 2	Silt	19,3,2,20	428.86
Region 3	Clayey Sand	18,4,3,19	893.72
Region 4	Lean Clay	17,5,4,18	464.86
Region 5	Silt	16,6,5,17	719.79
Region 6	Fat Clay	15,7,6,16	4,885.7
Region 7	Silty Sand	9,11,12,10	1,883
Region 8	Lean Clay	7,15,14,13,8	3,472.9
Region 9	Fat Clay	23,24,25,26,27,28,29,30,22,21,1	2,923.4
Region 10	Clayey Sand	8,13,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,10,9	4,570.8

Current Slip Surface

Slip Surface: 9,903
F of S: 1.49
Volume: 537.70945 ft³
Weight: 61,620.056 lbs
Resisting Moment: 1,494,359.3 lbs-ft
Activating Moment: 1,001,249.6 lbs-ft
Resisting Force: 20,527.747 lbs
Activating Force: 13,765.093 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-389.45041, -10.01653) ft
Entry: (-456.0447, 9.33333) ft
Radius: 66.80207 ft
Center: (-406.8158, 54.488972) ft

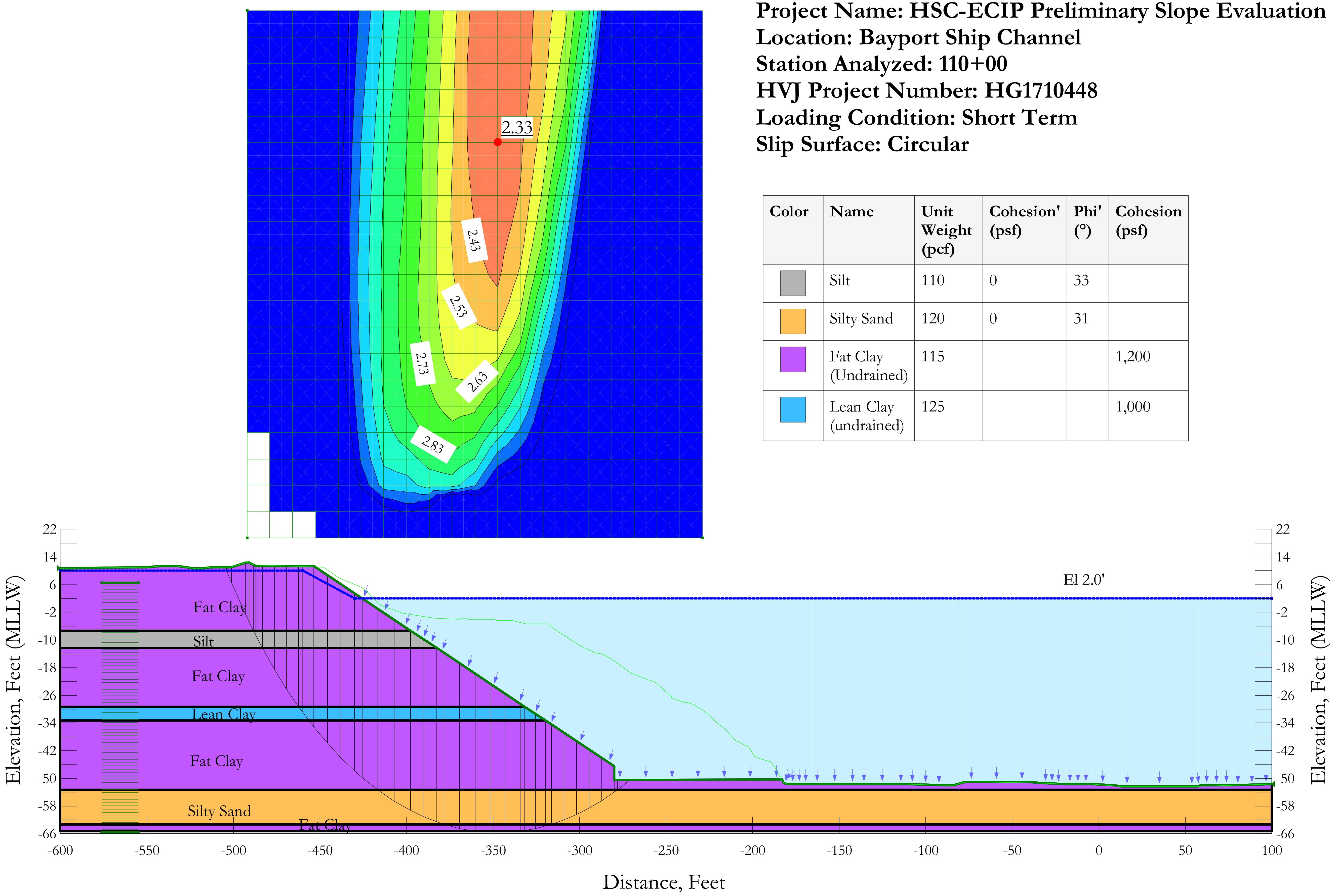
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-455.41614	8.666665	-41.599896	-51.043013	-16.58488	200
Slice 2	-453.59069	6.8254192	73.293842	148.79086	0	216.26201
Slice 3	-451.1969	4.5863734	213.0103	386.34594	0	251.87652
Slice 4	-448.75	2.5134009	294.42171	594.53541	97.512852	200
Slice 5	-446.4058	0.69954262	359.31423	742.66903	124.55952	200
Slice 6	-444.2174	-0.84539959	411.36448	829.85494	135.97579	200
Slice 7	-442.029	-2.263904	456.14585	905.9787	146.15955	200
Slice 8	-439.8406	-3.5652649	494.19266	972.66228	155.4642	200
Slice 9	-437.6522	-4.7572206	525.94979	1,031.1017	164.13382	200
Slice 10	-435.4638	-5.8462697	551.79083	1,082.1313	172.31807	200
Slice 11	-433.2754	-6.8379054	572.03161	1,126.2705	180.08313	200
Slice 12	-431.04004	-7.754128	587.14778	1,165.5543	375.6216	0
Slice 13	-428.7577	-8.5951762	597.15307	1,196.554	389.2555	0
Slice 14	-426.47537	-9.3435607	601.83114	1,220.4959	401.76558	0
Slice 15	-424.19303	-10.002512	601.36775	1,236.7731	412.63703	0
Slice 16	-421.96421	-10.563277	596.15867	1,243.2865	404.37034	0
Slice 17	-419.7889	-11.031909	586.55199	1,239.5623	408.04612	0
Slice 18	-417.61359	-11.425439	572.62768	1,226.698	408.70851	0
Slice 19	-415.43828	-11.745207	554.46279	1,203.7676	405.73065	0
Slice 20	-413.26297	-11.992277	532.11857	1,169.8767	398.5155	0
Slice 21	-411.08766	-12.16746	505.64156	1,124.229	386.53634	0
Slice 22	-409.215	-12.265379	535.10364	1,071.7587	335.33928	0
Slice 23	-407.94457	-12.301796	537.37608	1,043.217	316.0845	0
Slice 24	-406.8158	-12.31	537.888	1,030.2164	307.64096	0
Slice 25	-405.09716	-12.282322	536.16092	1,003.1838	291.82828	0
Slice 26	-402.94654	-12.192249	530.54032	958.52263	267.43303	0
Slice 27	-400.79593	-12.032542	520.57464	900.68925	237.52197	0
Slice 28	-398.64531	-11.8027	506.23245	829.84739	202.21706	0
Slice 29	-396.40496	-11.486324	486.49063	742.51982	159.98479	0
Slice 30	-394.07487	-11.076084	460.89165	638.3177	110.8681	0
Slice						

31	-391.74478	-10.579843	429.92623	521.4406	57.184522	0
Slice 32	-390.01507	-10.163265	403.93172	427.44898	15.272289	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 110+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
▨	Silt	110	0	33	
🟧	Silty Sand	120	0	31	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (undrained)	125			1,000



Short Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 76
Date: 4/27/2018
Time: 11:14:57 AM
Tool Version: 8.16.1.13452
File Name: 110+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\110+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:16:20 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
  F of S Calculation Option: Constant
Advanced
  Number of Slices: 30
  F of S Tolerance: 0.001
  Minimum Slip Surface Depth: 1 ft
  Search Method: Linear Search
  Must Obtain Factor of Safety at Lambda: 0.2
  Lambda
    Lambda 1: -1
    Lambda 2: -0.8
    Lambda 3: -0.6
    Lambda 4: -0.4
    Lambda 5: -0.2
    Lambda 6: 0
    Lambda 7: 0.2
    Lambda 8: 0.4
    Lambda 9: 0.6
    Lambda 10: 0.8
    Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
  Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf

Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-492, 171.98336) ft
Lower Left: (-492, 19.453) ft
Lower Right: (-229, 19.453) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-576.03354, 6.56951) ft
Upper Right Coordinate: (-555.05901, 6.56951) ft
Lower Left Coordinate: (-576.03354, -65.73101) ft
Lower Right Coordinate: (-555.05901, -65.73101) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 10.66667) ft
Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	10
Coordinate 2	-460	10
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-12.31
Point 2	-600	-29.31
Point 3	-600	-33.31
Point 4	-600	-53.31
Point 5	100	-53.31
Point 6	-600	-63.31

Point 7	100	-63.31
Point 8	-600	-65.31
Point 9	100	-65.31
Point 10	-175	-48.31
Point 11	-600	-7.31
Point 12	-280	-50.5
Point 13	-280	-46.5
Point 14	-319.57	-33.31
Point 15	-331.57	-29.31
Point 16	-382.57	-12.31
Point 17	-397.57	-7.31
Point 18	-453.5	11.33333
Point 19	-600	10.66667
Point 20	-550	11
Point 21	-542	11.33333
Point 22	-532	11.33333
Point 23	-523	10.66667
Point 24	-518	10.66667
Point 25	-512	11
Point 26	-501	11
Point 27	-493	12.33333
Point 28	-491	12.33333
Point 29	-487	11.33333
Point 30	-183	-50.33333
Point 31	-182	-51.33333
Point 32	-180	-51.66667
Point 33	-166	-51.66667
Point 34	-139	-51.66667
Point 35	-111	-51.66667
Point 36	-89	-52
Point 37	-84	-52
Point 38	-77	-51
Point 39	-41	-51
Point 40	-34	-51.33333
Point 41	-20	-51.66667
Point 42	-4	-51.66667
Point 43	9	-52
Point 44	13	-52.33333
Point 45	57	-52.33333
Point 46	59	-52
Point 47	77	-52
Point 48	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay (Undrained)	1,2,15,16	4,129.8
Region 2	Lean Clay (undrained)	2,3,14,15	1,097.7
Region			

3	Silty Sand	4,6,7,5	7,000
Region 4	Fat Clay (Undrained)	6,8,9,7	1,400
Region 5	Silt	11,1,16,17	1,049.7
Region 6	Fat Clay (Undrained)	19,20,21,22,23,24,25,26,27,28,29,18,17,11	3,219.9
Region 7	Fat Clay (Undrained)	3,14,13,12,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,5,4	6,867.3

Current Slip Surface

Slip Surface: 24,852
F of S: 2.33
Volume: 8,391.3637 ft³
Weight: 973,228.29 lbs
Resisting Moment: 59,558,010 lbs-ft
Activating Moment: 25,563,732 lbs-ft
Resisting Force: 269,394.31 lbs
Activating Force: 116,391.74 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-270.84195, -50.484264) ft
Entry: (-504.64137, 11) ft
Radius: 199.58178 ft
Center: (-347.35, 133.85077) ft

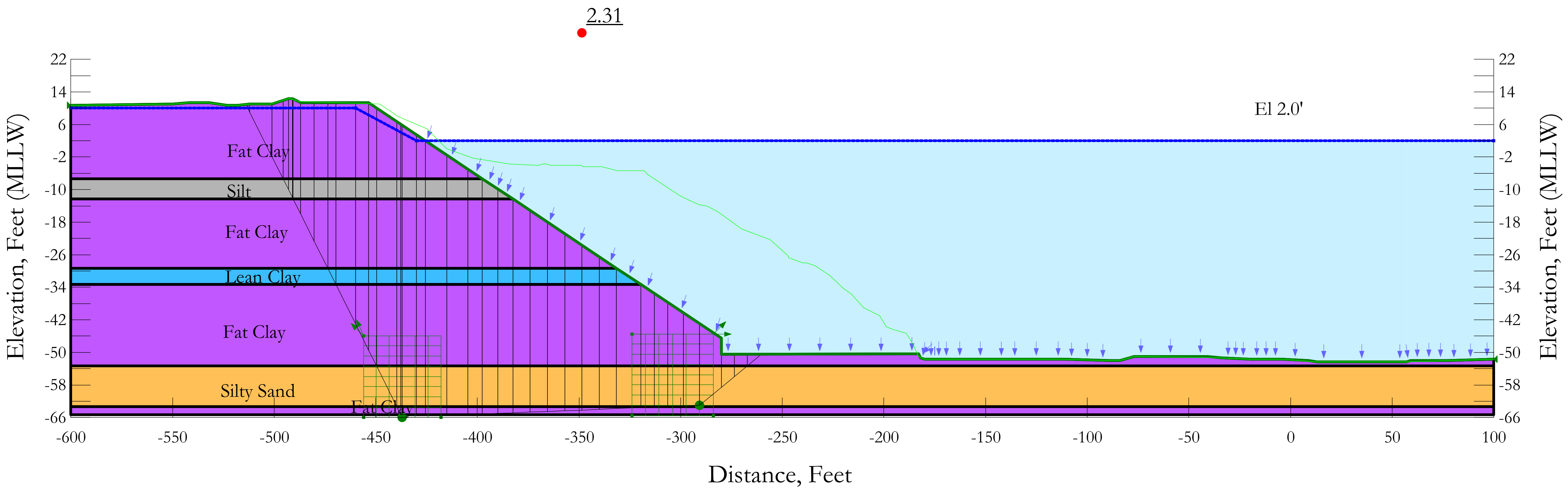
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-504.24828	10.5	-31.2	-596.62301	0	1,200
Slice 2	-502.42759	8.2375439	109.97726	-313.81235	0	1,200
Slice 3	-497	1.9372658	503.11461	537.18232	0	1,200
Slice 4	-492	-3.6525309	851.91793	1,287.9918	0	1,200
Slice 5	-489.72024	-6.0072528	998.85258	1,532.3728	0	1,200
Slice 6	-487.72024	-8.0226098	1,124.6108	1,976.3672	553.13705	0
Slice 7	-485.12703	-10.52261	1,280.6108	2,207.5138	601.93782	0
Slice 8	-479.76024	-15.409415	1,585.5475	2,534.6291	0	1,200
Slice 9	-472.77257	-21.332621	1,955.1556	3,222.239	0	1,200
Slice 10	-465.7849	-26.733206	2,292.1521	3,845.6675	0	1,200
Slice 11	-461.14554	-30.105073	2,502.5566	4,296.4889	0	1,000
Slice 12	-458.19601	-32.105073	2,424.9008	4,544.1338	0	1,000
Slice 13	-454.94601	-34.235627	2,498.5315	4,750.1707	0	1,200
Slice 14	-449.58333	-37.498089	2,605.2828	4,984.2278	0	1,200
Slice 15	-441.75	-41.938202	2,742.2588	5,215.3908	0	1,200
Slice 16	-433.91667	-45.927432	2,852.9674	5,402.0262	0	1,200

Slice 17	-427.75	-48.803776	3,170.1556	5,523.5177	0	1,200
Slice 18	-421.07949	-51.552085	3,341.6501	5,710.2505	0	1,200
Slice 19	-411.88673	-54.941344	3,553.1399	5,973.5545	1,454.3318	0
Slice 20	-402.34224	-57.941027	3,740.3201	6,234.7896	1,498.8285	0
Slice 21	-393.82	-60.207358	3,881.7392	6,432.4154	1,532.6009	0
Slice 22	-386.32	-61.852081	3,984.3699	6,575.4288	1,556.8653	0
Slice 23	-380.45611	-62.954406	4,053.155	6,663.3026	1,568.3349	0
Slice 24	-373.83333	-63.913801	4,113.0212	6,728.0244	0	1,200
Slice 25	-364.81554	-64.913801	4,175.4212	6,756.6446	0	1,200
Slice 26	-355.98776	-65.31	4,200.144	6,754.4843	0	1,200
Slice 27	-347.35	-65.31	4,200.144	6,616.5098	0	1,200
Slice 28	-338.71224	-65.31	4,200.144	6,473.7843	0	1,200
Slice 29	-332.98168	-65.208103	4,193.7856	6,427.5227	0	1,200
Slice 30	-328.57	-64.822626	4,169.7318	6,311.8624	0	1,200
Slice 31	-322.57	-64.163617	4,128.6097	6,127.8262	0	1,200
Slice 32	-317.96389	-63.549095	4,090.2635	5,975.6139	0	1,200
Slice 33	-312.722	-62.669355	4,035.3677	5,770.7346	1,042.7136	0
Slice 34	-305.45045	-61.247886	3,946.6681	5,458.1657	908.1994	0
Slice 35	-298.17889	-59.542651	3,840.2614	5,098.517	756.03621	0
Slice 36	-290.90733	-57.546053	3,715.6737	4,691.1947	586.15215	0
Slice 37	-283.63578	-55.248847	3,572.3281	4,253.4159	409.23882	0
Slice 38	-279.02052	-53.666914	3,473.6154	3,689.4097	129.6623	0
Slice 39	-274.44149	-51.897132	3,363.181	3,653.5422	0	1,200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 110+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	**Name**	**Unit Weight (pcf)**	**Cohesion' (psf)**	**Phi' (°)**	**Cohesion (psf)**
▩	Silt	110	0	33	
🟧	Silty Sand	120	0	31	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (undrained)	125			1,000



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 76
Date: 4/27/2018
Time: 11:14:57 AM
Tool Version: 8.16.1.13452
File Name: 110+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\110+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:16:48 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf

Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-600, 10.66667) ft
Right Coordinate: (100, -51.66667) ft

Slip Surface Block

Left Grid
Upper Left: (-456, -45.97041) ft
Lower Left: (-456, -65.96841) ft
Lower Right: (-418, -65.96841) ft
X Increments: 6
Y Increments: 8
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 2
Right Grid
Upper Left: (-324, -45.47946) ft
Lower Left: (-324, -65.48944) ft
Lower Right: (-284, -65.48944) ft
X Increments: 6
Y Increments: 8
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	10
Coordinate 2	-460	10
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-12.31
Point 2	-600	-29.31
Point 3	-600	-33.31
Point 4	-600	-53.31
Point 5	100	-53.31
Point 6	-600	-63.31
Point 7	100	-63.31

Point 8	-600	-65.31
Point 9	100	-65.31
Point 10	-175	-48.31
Point 11	-600	-7.31
Point 12	-280	-50.5
Point 13	-280	-46.5
Point 14	-319.57	-33.31
Point 15	-331.57	-29.31
Point 16	-382.57	-12.31
Point 17	-397.57	-7.31
Point 18	-453.5	11.33333
Point 19	-600	10.66667
Point 20	-550	11
Point 21	-542	11.33333
Point 22	-532	11.33333
Point 23	-523	10.66667
Point 24	-518	10.66667
Point 25	-512	11
Point 26	-501	11
Point 27	-493	12.33333
Point 28	-491	12.33333
Point 29	-487	11.33333
Point 30	-183	-50.33333
Point 31	-182	-51.33333
Point 32	-180	-51.66667
Point 33	-166	-51.66667
Point 34	-139	-51.66667
Point 35	-111	-51.66667
Point 36	-89	-52
Point 37	-84	-52
Point 38	-77	-51
Point 39	-41	-51
Point 40	-34	-51.33333
Point 41	-20	-51.66667
Point 42	-4	-51.66667
Point 43	9	-52
Point 44	13	-52.33333
Point 45	57	-52.33333
Point 46	59	-52
Point 47	77	-52
Point 48	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay (Undrained)	1,2,15,16	4,129.8
Region 2	Lean Clay (undrained)	2,3,14,15	1,097.7
Region 3	Silty Sand	4,6,7,5	7,000

Region 4	Fat Clay (Undrained)	6,8,9,7	1,400
Region 5	Silt	11,1,16,17	1,049.7
Region 6	Fat Clay (Undrained)	19,20,21,22,23,24,25,26,27,28,29,18,17,11	3,219.9
Region 7	Fat Clay (Undrained)	3,14,13,12,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,5,4	6,867.3

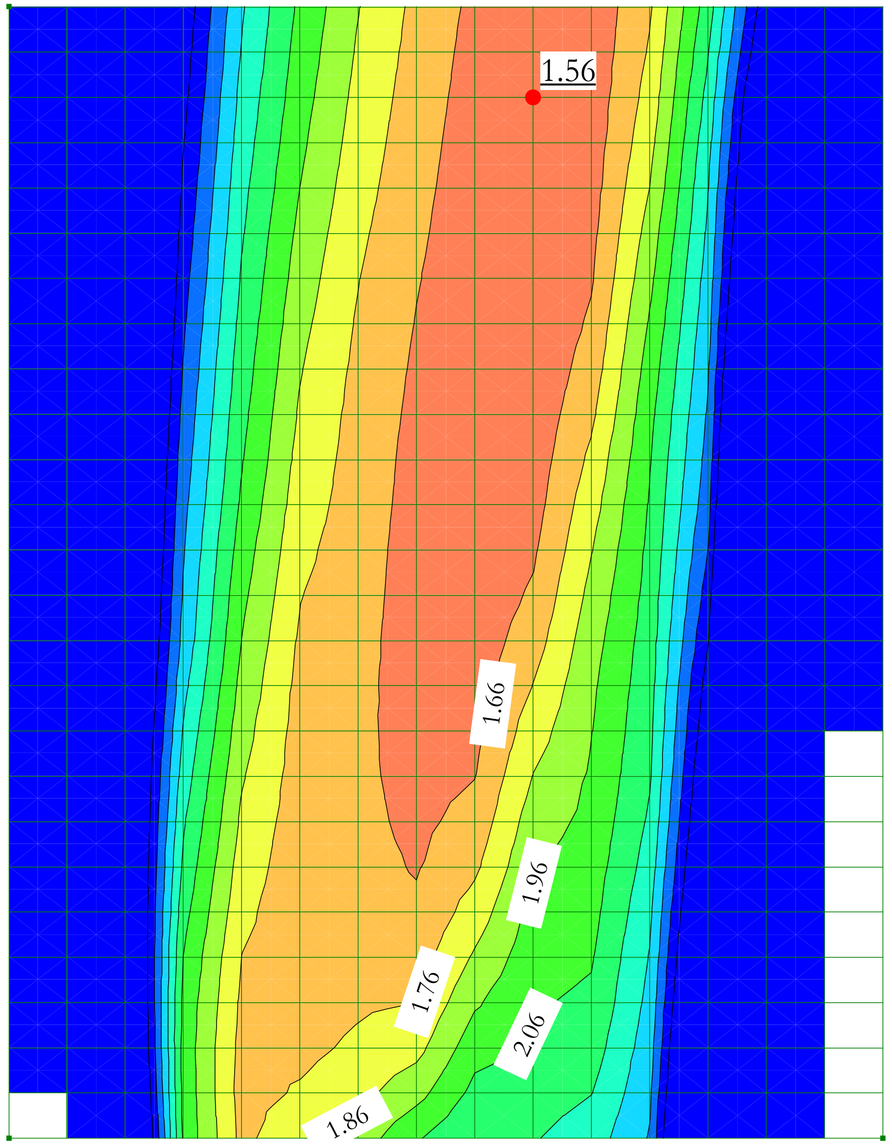
Current Slip Surface

Slip Surface: 2,117
F of S: 2.31
Volume: 9,903.9711 ft³
Weight: 1,150,475.2 lbs
Resisting Moment: 32,040,958 lbs-ft
Activating Moment: 13,975,190 lbs-ft
Resisting Force: 281,784.78 lbs
Activating Force: 123,309.97 lbs
F of S Rank (Analysis): 1 of 35,721 slip surfaces
F of S Rank (Query): 1 of 35,721 slip surfaces
Exit: (-260.43635, -50.466385) ft
Entry: (-513.86481, 10.8964) ft
Radius: 123.09521 ft
Center: (-376.00722, 26.237097) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-513.41661	10.4482	-27.967694	-468.09127	0	1,200
Slice 2	-512.4842	9.515795	30.214392	-353.33322	0	1,200
Slice 3	-506.5	3.53159	403.62878	339.48133	0	1,200
Slice 4	-498.32921	-4.639205	913.48639	1,316.2544	0	1,200
Slice 5	-494.32921	-8.639205	1,163.0864	2,082.8017	597.2701	0
Slice 6	-492	-10.96841	1,308.4288	2,324.6726	659.95643	0
Slice 7	-490.82921	-12.139205	1,381.4864	2,432.2568	682.37828	0
Slice 8	-488.82921	-14.139205	1,506.2864	2,377.568	0	1,200
Slice 9	-483.6646	-19.303808	1,828.5576	2,886.1536	0	1,200
Slice 10	-476.99381	-25.974603	2,244.8152	3,600.3179	0	1,200
Slice 11	-471.65841	-31.31	2,577.744	4,264.5053	0	1,000
Slice 12	-464.82921	-38.139205	3,003.8864	4,916.7884	0	1,200
Slice 13	-456.75	-46.21841	3,224.641	5,754.1129	0	1,200
Slice 14	-451.57921	-51.389205	3,445.5476	6,216.9512	0	1,200
Slice 15	-444.65841	-58.31	3,741.2178	6,520.7807	1,670.1299	0
Slice 16	-438.65841	-64.31	3,997.5497	7,129.2593	0	1,200
Slice 17	-437.32921	-65.31	4,035.1574	8,159.3515	0	1,200

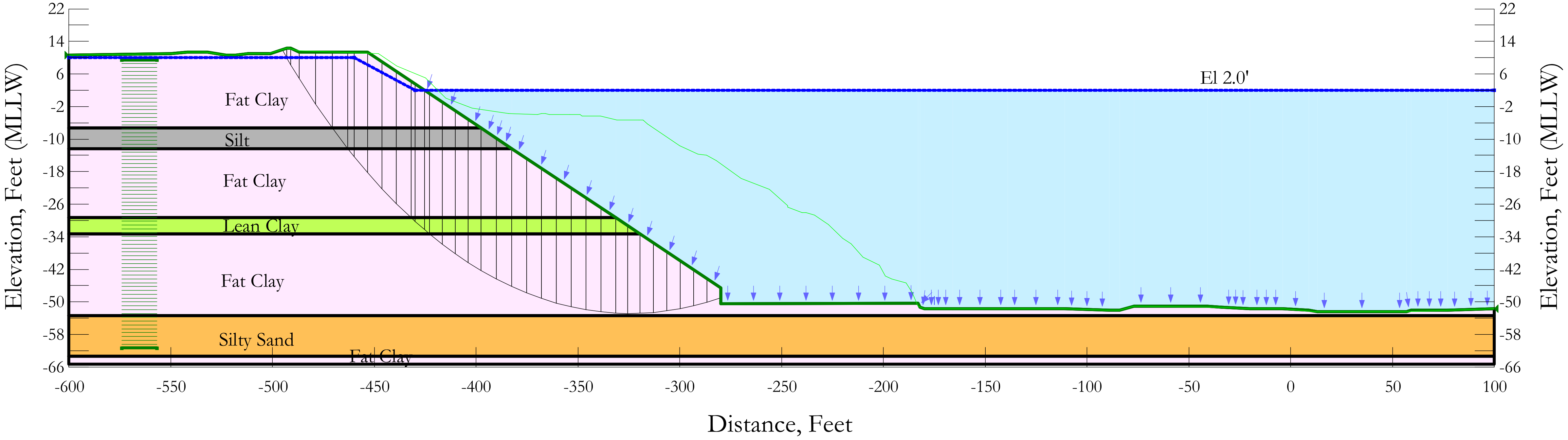
Slice 18	-433.5	-65.31	3,975.6697	8,023.6445	0	1,200
Slice 19	-427.75	-65.31	4,200.144	7,819.9262	0	1,200
Slice 20	-420.29276	-65.31	4,200.144	7,666.6431	0	1,200
Slice 21	-409.87828	-65.31	4,200.144	7,519.5293	0	1,200
Slice 22	-401.12052	-65.23769	4,195.6319	7,409.234	0	1,200
Slice 23	-393.82	-65.089008	4,186.3541	7,293.9305	0	1,200
Slice 24	-386.32	-64.936264	4,176.8228	7,180.033	0	1,200
Slice 25	-378.32	-64.773336	4,166.6562	7,049.2957	0	1,200
Slice 26	-369.82	-64.600225	4,155.8541	6,900.9114	0	1,200
Slice 27	-361.32	-64.427115	4,145.052	6,749.1666	0	1,200
Slice 28	-352.82	-64.254004	4,134.2499	6,593.6917	0	1,200
Slice 29	-344.32	-64.080894	4,123.4478	6,434.1903	0	1,200
Slice 30	-335.82	-63.907783	4,112.6457	6,270.4463	0	1,200
Slice 31	-325.57	-63.699032	4,099.6196	6,046.9643	0	1,200
Slice 32	-316.29448	-63.510127	4,087.8319	5,837.7277	0	1,200
Slice 33	-309.74344	-63.376709	4,079.5066	5,700.7931	0	1,200
Slice 34	-302.5176	-63.229548	4,070.3238	5,538.6812	882.27811	0
Slice 35	-294.61698	-63.068644	4,060.2834	5,366.101	784.61435	0
Slice 36	-285.33333	-60.779054	3,917.4129	5,089.138	704.04345	0
Slice 37	-276.82536	-57.254936	3,697.508	4,183.0237	291.72728	0
Slice 38	-270.47608	-54.624979	3,533.3987	3,823.5023	174.31183	0
Slice 39	-263.8689	-51.888192	3,362.6232	3,667.2934	0	1,200



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 110+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
■	Silt	110	0	33
🟪	Fat Clay	115	200	18
🟩	Lean Clay	125	200	23
🟧	Silty Sand	120	0	31



Long Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 76
Date: 4/27/2018
Time: 11:14:57 AM
Tool Version: 8.16.1.13452
File Name: 110+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\110+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:15:16 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 18 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 31 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-493.09257, 219.03047) ft
Lower Left: (-493.09257, 37.21206) ft
Lower Right: (-212.2191, 37.21206) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 25
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-574.0045, 9.47012) ft
Upper Right Coordinate: (-556.92375, 9.47012) ft
Lower Left Coordinate: (-574.0045, -61.33591) ft
Lower Right Coordinate: (-556.92375, -61.33591) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-600, 10.66667) ft
Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	10
Coordinate 2	-460	10
Coordinate 3	-430	2
Coordinate 4	100	2

Points

	X (ft)	Y (ft)
Point 1	-600	-12.31
Point 2	-600	-29.31
Point 3	-600	-33.31

Point 4	-600	-53.31
Point 5	100	-53.31
Point 6	-600	-63.31
Point 7	100	-63.31
Point 8	-600	-65.31
Point 9	100	-65.31
Point 10	-175	-48.31
Point 11	-600	-7.31
Point 12	-280	-50.5
Point 13	-280	-46.5
Point 14	-319.57	-33.31
Point 15	-331.57	-29.31
Point 16	-382.57	-12.31
Point 17	-397.57	-7.31
Point 18	-453.5	11.33333
Point 19	-600	10.66667
Point 20	-550	11
Point 21	-542	11.33333
Point 22	-532	11.33333
Point 23	-523	10.66667
Point 24	-518	10.66667
Point 25	-512	11
Point 26	-501	11
Point 27	-493	12.33333
Point 28	-491	12.33333
Point 29	-487	11.33333
Point 30	-183	-50.33333
Point 31	-182	-51.33333
Point 32	-180	-51.66667
Point 33	-166	-51.66667
Point 34	-139	-51.66667
Point 35	-111	-51.66667
Point 36	-89	-52
Point 37	-84	-52
Point 38	-77	-51
Point 39	-41	-51
Point 40	-34	-51.33333
Point 41	-20	-51.66667
Point 42	-4	-51.66667
Point 43	9	-52
Point 44	13	-52.33333
Point 45	57	-52.33333
Point 46	59	-52
Point 47	77	-52
Point 48	100	-51.66667

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay	1,2,15,16	4,129.8
Region 2	Lean Clay	2,3,14,15	1,097.7

Region 3	Silty Sand	4,6,7,5	7,000
Region 4	Fat Clay	6,8,9,7	1,400
Region 5	Silt	11,1,16,17	1,049.7
Region 6	Fat Clay	19,20,21,22,23,24,25,26,27,28,29,18,17,11	3,219.9
Region 7	Fat Clay	3,14,13,12,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,5,4	6,867.3

Current Slip Surface

Slip Surface: 28,719

F of S: 1.56

Volume: 5,264.1912 ft³

Weight: 607,539.23 lbs

Resisting Moment: 35,788,839 lbs-ft

Activating Moment: 22,919,789 lbs-ft

Resisting Force: 130,695.61 lbs

Activating Force: 83,885.787 lbs

F of S Rank (Analysis): 1 of 31,616 slip surfaces

F of S Rank (Query): 1 of 31,616 slip surfaces

Exit: (-280, -48.950173) ft

Entry: (-495.29201, 11.951329) ft

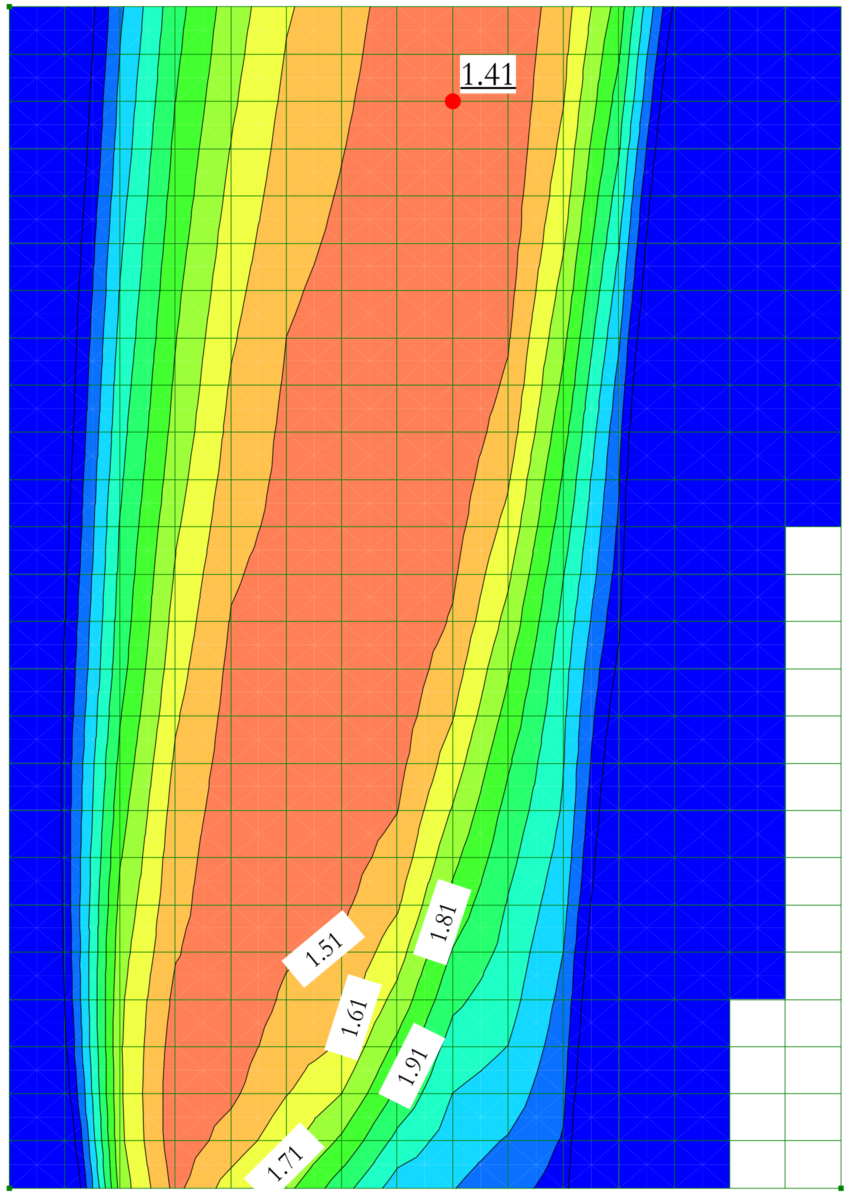
Radius: 257.32418 ft

Center: (-324.56849, 204.485) ft

Slip Slices

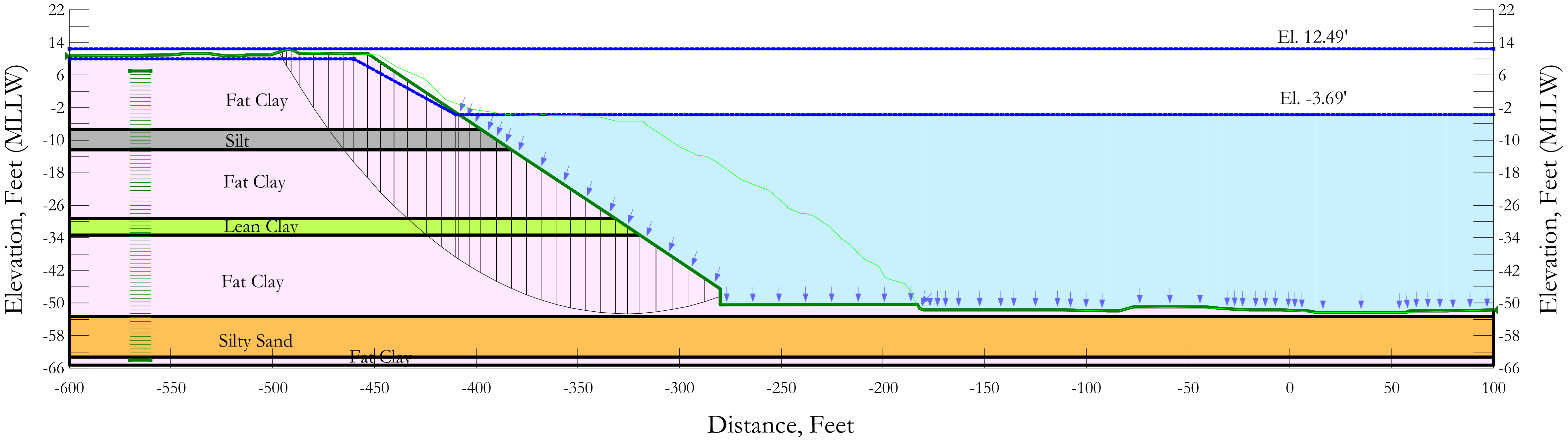
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-494.17887	10.975664	-60.881458	18.379357	5.971815	200
Slice 2	-493.03287	9.9715353	1.7761993	136.39485	43.740251	200
Slice 3	-492	9.0861998	57.021133	232.60228	57.049776	200
Slice 4	-489	6.5677106	214.17486	455.18751	78.309757	200
Slice 5	-482.92859	1.7262098	516.28451	924.29707	132.57132	200
Slice 6	-474.78577	-4.3818362	897.42658	1,573.4483	219.65278	200
Slice 7	-466.95171	-9.81	1,236.144	2,109.0047	566.84239	0
Slice 8	-461.59453	-13.313188	1,454.7429	2,498.0929	339.00498	200
Slice 9	-456.75	-16.262446	1,584.6966	2,806.0435	396.83967	200
Slice 10	-449.9276	-20.201657	1,716.9788	3,097.8685	448.67825	200
Slice 11	-442.78281	-24.042751	1,837.7737	3,263.5376	463.25877	200
Slice 12	-435.63802	-27.600352	1,940.8786	3,403.7623	475.31973	200
Slice 13	-431.03281	-29.779375	2,000.219	3,458.3255	618.92949	200
Slice 14	-427.75	-31.233644	2,073.7794	3,524.1111	615.62928	200
Slice 15	-424.20048	-32.76427	2,169.2904	3,617.3847	614.67956	200
Slice 16	-419.73459	-34.570507	2,281.9996	3,791.0823	490.33068	200
Slice 17	-413.40185	-36.995823	2,433.3394	3,980.9916	502.86269	200
Slice 18	-407.06911	-39.232479	2,572.9067	4,154.8334	513.99913	200
Slice						

19	-400.73637	-41.285628	2,701.0232	4,312.5904	523.62991	200
Slice 20	-393.82	-43.314928	2,827.6515	4,471.1338	533.99976	200
Slice 21	-386.32	-45.29003	2,950.8979	4,626.8936	544.56401	200
Slice 22	-378.92714	-47.004529	3,057.8826	4,750.8446	550.07669	200
Slice 23	-371.64143	-48.469828	3,149.3173	4,842.2163	550.05624	200
Slice 24	-364.35571	-49.717907	3,227.1974	4,907.5766	545.98831	200
Slice 25	-357.07	-50.751955	3,291.722	4,945.4157	537.31766	200
Slice 26	-349.78429	-51.574566	3,343.0529	4,954.2143	523.49806	200
Slice 27	-342.49857	-52.187776	3,381.3172	4,932.5264	504.01842	200
Slice 28	-335.21286	-52.593084	3,406.6084	4,879.0594	478.42833	200
Slice 29	-328.57	-52.790577	3,418.932	4,792.6746	446.35604	200
Slice 30	-322.57	-52.813936	3,420.3896	4,678.5093	408.78787	200
Slice 31	-316.2725	-52.684261	3,412.2979	4,544.4842	367.86962	200
Slice 32	-309.6775	-52.386729	3,393.7319	4,387.9595	323.04412	200
Slice 33	-303.0825	-51.91925	3,364.5612	4,203.6079	272.62281	200
Slice 34	-296.4875	-51.28089	3,324.7275	3,991.7882	216.74115	200
Slice 35	-289.8925	-50.470365	3,274.1508	3,753.0951	155.61845	200
Slice 36	-283.2975	-49.486025	3,212.728	3,488.3322	89.54925	200



Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 110+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
◼	Silt	110	0	33	0.1	32.9	2
⬜	Fat Clay	115	200	18	300	14	2
🟩	Lean Clay	125	200	23	300	19	2
🟧	Silty Sand	120	0	31	0.1	30.9	2



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 76
Date: 4/27/2018
Time: 11:14:57 AM
Tool Version: 8.16.1.13452
File Name: 110+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\110+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:16:04 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: Yes

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Silt

Model: Mohr-Coulomb

Unit Weight: 110 pcf

Cohesion': 0 psf

Phi': 33 °

Phi-B: 0 °

Cohesion R: 0.1 psf

Phi R: 32.9 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 18 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 200 psf

Phi': 23 °

- Phi-B: 0 °
- Cohesion R: 300 psf
- Phi R: 19 °
- Pore Water Pressure
  - Piezometric Line: 1
  - Piezometric Line After Drawdown: 2

Silty Sand

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 31 °
- Phi-B: 0 °
- Cohesion R: 0.1 psf
- Phi R: 30.9 °
- Pore Water Pressure
  - Piezometric Line: 1
  - Piezometric Line After Drawdown: 2

Slip Surface Grid

- Upper Left: (-470.9994, 220.97486) ft
- Lower Left: (-470.9994, 28.49448) ft
- Lower Right: (-199.88481, 28.49448) ft
- Grid Horizontal Increment: 15
- Grid Vertical Increment: 25
- Left Projection Angle: 0 °
- Right Projection Angle: 0 °

Slip Surface Radius

- Upper Left Coordinate: (-570, 6.99985) ft
- Upper Right Coordinate: (-560, 6.99985) ft
- Lower Left Coordinate: (-570, -63.98968) ft
- Lower Right Coordinate: (-560, -63.98968) ft
- Number of Increments: 75
- Left Projection: No
- Left Projection Angle: 135 °
- Right Projection: No
- Right Projection Angle: 45 °

Slip Surface Limits

- Left Coordinate: (-600, 10.66667) ft
- Right Coordinate: (100, -51.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	12.49
Coordinate 2	100	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-600	10
Coordinate 2	-460	10
Coordinate 3	-410	-3.69
Coordinate 4	100	-3.69

Points

	X (ft)	Y (ft)
Point 1	-600	-12.31
Point 2	-600	-29.31
Point 3	-600	-33.31
Point 4	-600	-53.31
Point 5	100	-53.31
Point 6	-600	-63.31
Point 7	100	-63.31
Point 8	-600	-65.31
Point 9	100	-65.31
Point 10	-175	-48.31
Point 11	-600	-7.31
Point 12	-280	-50.5
Point 13	-280	-46.5
Point 14	-319.57	-33.31
Point 15	-331.57	-29.31
Point 16	-382.57	-12.31
Point 17	-397.57	-7.31
Point 18	-453.5	11.33333
Point 19	-600	10.66667
Point 20	-550	11
Point 21	-542	11.33333
Point 22	-532	11.33333
Point 23	-523	10.66667
Point 24	-518	10.66667
Point 25	-512	11
Point 26	-501	11
Point 27	-493	12.33333
Point 28	-491	12.33333
Point 29	-487	11.33333
Point 30	-183	-50.33333
Point 31	-182	-51.33333
Point 32	-180	-51.66667
Point 33	-166	-51.66667
Point 34	-139	-51.66667
Point 35	-111	-51.66667

Point 36	-89	-52
Point 37	-84	-52
Point 38	-77	-51
Point 39	-41	-51
Point 40	-34	-51.33333
Point 41	-20	-51.66667
Point 42	-4	-51.66667
Point 43	9	-52
Point 44	13	-52.33333
Point 45	57	-52.33333
Point 46	59	-52
Point 47	77	-52
Point 48	100	-51.66667

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay	1,2,15,16	4,129.8
Region 2	Lean Clay	2,3,14,15	1,097.7
Region 3	Silty Sand	4,6,7,5	7,000
Region 4	Fat Clay	6,8,9,7	1,400
Region 5	Silt	11,1,16,17	1,049.7
Region 6	Fat Clay	19,20,21,22,23,24,25,26,27,28,29,18,17,11	3,219.9
Region 7	Fat Clay	3,14,13,12,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,5,4	6,867.3

Current Slip Surface

Slip Surface: 28,640
F of S: 1.41
Volume: 5,344.3381 ft³
Weight: 616,770.3 lbs
Resisting Moment: 36,826,127 lbs-ft
Activating Moment: 26,038,413 lbs-ft
Resisting Force: 134,215.87 lbs
Activating Force: 95,039.544 lbs
F of S Rank (Analysis): 1 of 31,616 slip surfaces
F of S Rank (Query): 1 of 31,616 slip surfaces
Exit: (-280, -48.427194) ft
Entry: (-496.92013, 11.679977) ft
Radius: 258.20778 ft
Center: (-326.40495, 205.57643) ft

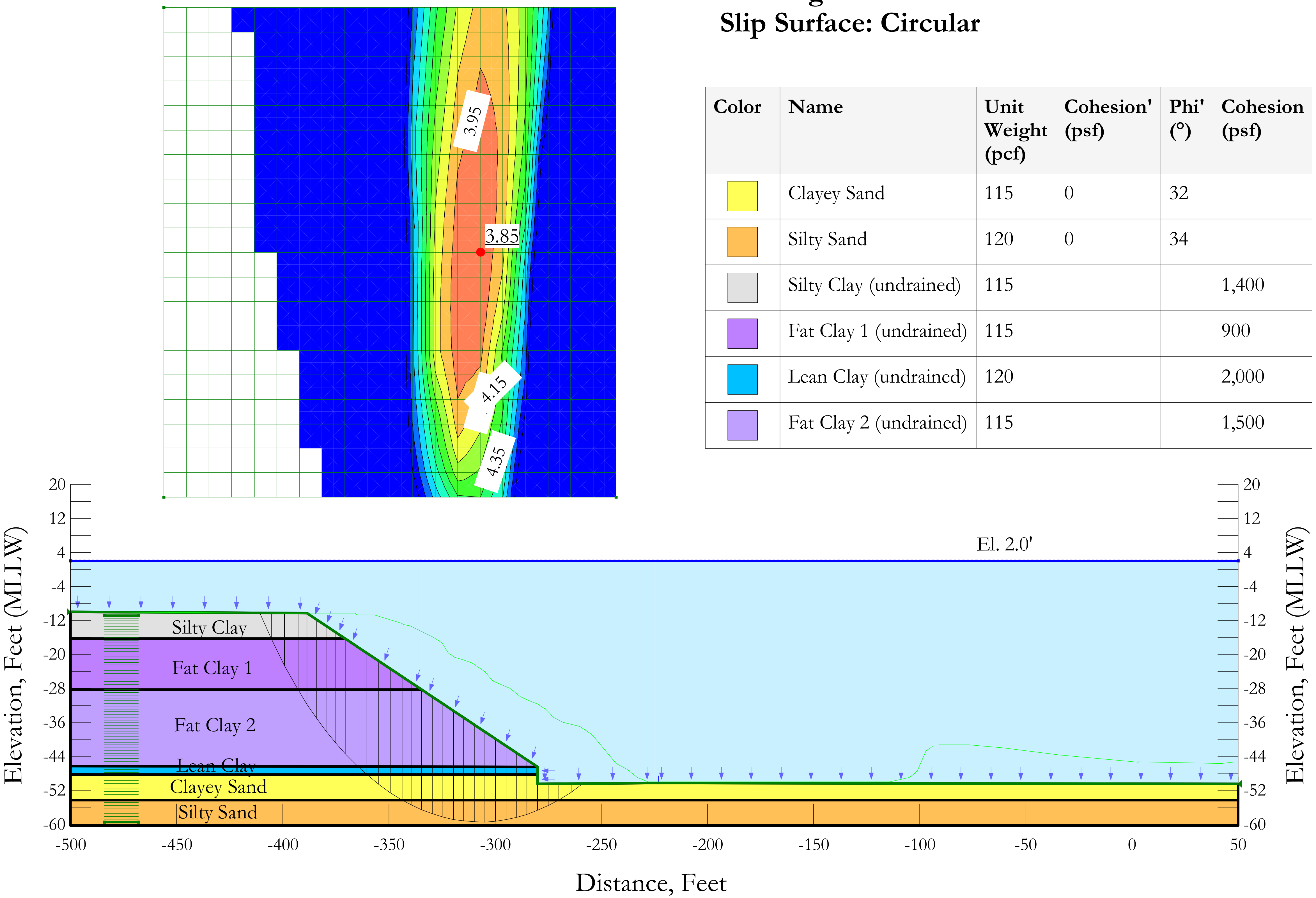
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-495.95536	10.839988	-52.415274	-0.62951182	0	188.92659
Slice 2	-493.9953	9.1508105	52.989425	214.94095	0	219.37385
Slice 3	-492	7.4657496	158.13722	412.01036	0	247.32738
Slice 4	-489	5.0085315	311.46763	608.8149	96.613985	200
Slice 5	-483.38087	0.61536221	585.6014	1,025.2774	142.85939	200
Slice 6	-476.14262	-4.7332302	919.35357	1,586.2914	216.70122	200

Slice 7	-468.74042	-9.81	1,236.144	2,078.8274	547.24503	0
Slice 8	-462.47867	-13.847127	1,488.0607	2,516.2134	334.06706	200
Slice 9	-456.75	-17.285081	1,532.1989	2,859.2729	431.19246	200
Slice 10	-450.19021	-20.99419	1,643.2476	3,132.4471	483.87026	200
Slice 11	-443.57063	-24.488058	1,740.8516	3,278.4285	499.58901	200
Slice 12	-436.95105	-27.741823	1,824.518	3,404.402	513.33542	200
Slice 13	-429.02447	-31.31	1,905.6626	3,514.6236	682.96344	200
Slice 14	-420.80576	-34.72499	1,973.2718	3,670.4117	551.43417	200
Slice 15	-413.60192	-37.432428	2,015.939	3,739.0261	559.86493	200
Slice 16	-409.215	-38.990676	2,202.7622	3,780.5278	512.64712	200
Slice 17	-405.715	-40.132823	2,274.0322	3,854.6555	513.57563	200
Slice 18	-400.285	-41.819953	2,379.309	3,987.2437	522.44965	200
Slice 19	-393.82	-43.645118	2,493.1994	4,134.6346	533.33462	200
Slice 20	-386.32	-45.554182	2,612.325	4,291.448	545.58015	200
Slice 21	-378.92714	-47.205762	2,715.3835	4,417.1208	552.92798	200
Slice 22	-371.64143	-48.610963	2,803.0681	4,510.426	554.75422	200
Slice 23	-364.35571	-49.800618	2,877.3025	4,577.527	552.43643	200
Slice 24	-357.07	-50.777729	2,938.2743	4,616.4869	545.28432	200
Slice 25	-349.78429	-51.544722	2,986.1347	4,625.3755	532.62161	200
Slice 26	-342.49857	-52.103475	3,021.0009	4,602.3772	513.8203	200
Slice 27	-335.21286	-52.455342	3,042.9573	4,545.8961	488.33442	200
Slice 28	-328.57	-52.604848	3,052.2865	4,455.04	455.78225	200
Slice 29	-322.57	-52.585441	3,051.0755	4,335.2877	417.26583	200
Slice 30	-315.613	-52.375327	3,037.9644	4,177.5726	370.28116	200
Slice 31	-307.699	-51.922322	3,009.6969	3,971.8936	312.63666	200
Slice 32	-299.785	-51.224684	2,966.1643	3,724.3524	246.35023	200
Slice 33	-291.871	-50.280412	2,907.2417	3,436.2009	171.86925	200
Slice 34	-283.957	-49.086757	2,832.7576	3,109.2849	89.849177	200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 166+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	115	0	32	
🟧	Silty Sand	120	0	34	
⬜	Silty Clay (undrained)	115			1,400
🟪	Fat Clay 1 (undrained)	115			900
🟦	Lean Clay (undrained)	120			2,000
🟪	Fat Clay 2 (undrained)	115			1,500



Short Term

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 70
Date: 4/27/2018
Time: 11:19:33 AM
Tool Version: 8.16.1.13452
File Name: 166+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\166+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:20:26 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,400 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 1 (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 900 psf

Pore Water Pressure

Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)

Unit Weight: 120 pcf

Cohesion: 2,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2 (undrained)

Model: Undrained (Phi=0)

Unit Weight: 115 pcf

Cohesion: 1,500 psf

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-456, 132.3189) ft

Lower Left: (-456, 17.00129) ft

Lower Right: (-243, 17.00129) ft

Grid Horizontal Increment: 20

Grid Vertical Increment: 20

Left Projection Angle: 0 °

Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-484.00975, -10.94478) ft

Upper Right Coordinate: (-468.00472, -10.94478) ft

Lower Left Coordinate: (-484.00975, -59.46821) ft

Lower Right Coordinate: (-468.00472, -59.46821) ft

Number of Increments: 75

Left Projection: No

Left Projection Angle: 135 °

Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10) ft

Right Coordinate: (50, -50.5) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2

Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-16.31
Point 2	-500	-46.31
Point 3	-500	-48.31
Point 4	-280	-48.31
Point 5	-500	-54.31
Point 6	50	-54.31
Point 7	-500	-60.31
Point 8	50	-60.31
Point 9	-500	-28.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-334.57	-28.31
Point 13	-370.57	-16.31
Point 14	-388.5	-10.33333
Point 15	-225	-50.33333
Point 16	50	-50.5
Point 17	-500	-10

Regions

	Material	Points	Area (ft^2)
Region 1	Lean Clay (undrained)	2,3,4,11	419.1
Region 2	Silty Sand	5,7,8,6	3,300
Region 3	Fat Clay 1 (undrained)	1,13,12,9	1,769.2
Region 4	Fat Clay 2 (undrained)	9,2,11,12	3,484.6
Region 5	Clayey Sand	3,4,10,15,16,6,5	2,604.8
Region 6	Silty Clay (undrained)	17,14,13,1	738.56

Current Slip Surface

Slip Surface: 17,100
F of S: 3.85
Volume: 2,953.2338 ft^3
Weight: 341,649.47 lbs
Resisting Moment: 21,073,557 lbs-ft
Activating Moment: 5,480,182.9 lbs-ft
Resisting Force: 138,452.71 lbs
Activating Force: 36,147.8 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-258.5094, -50.434876) ft
Entry: (-410.71621, -10.266914) ft
Radius: 134.12831 ft
Center: (-306.9, 74.660095) ft

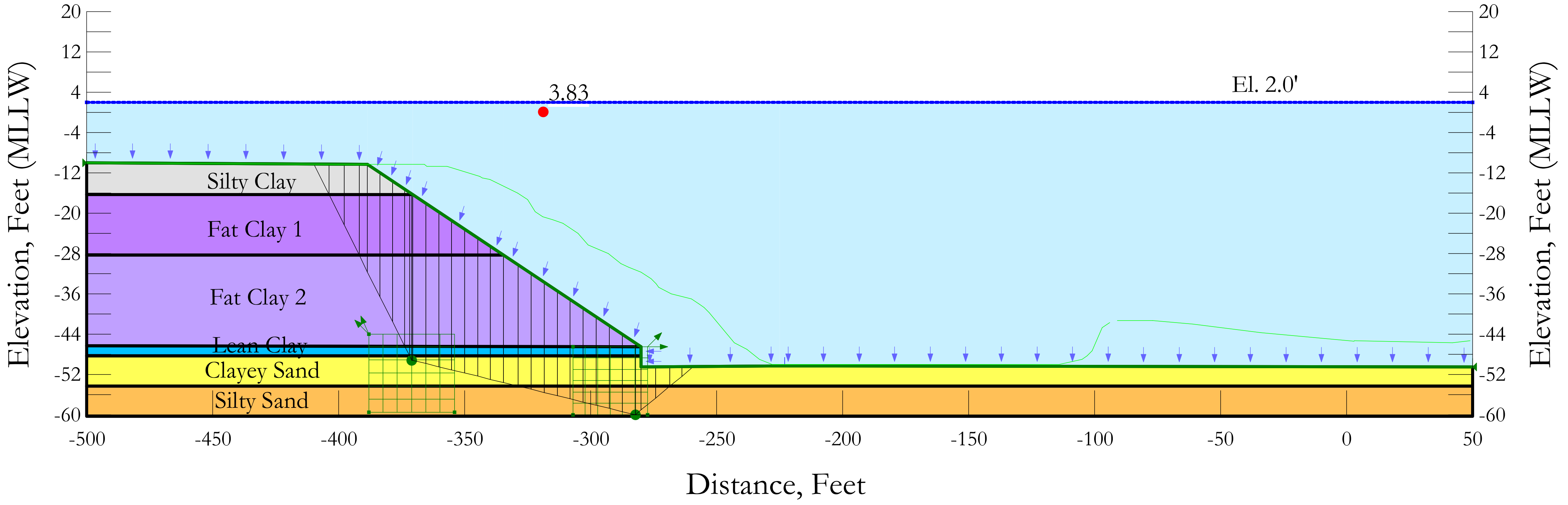
Slip Slices

				Base Normal Stress	Frictional Strength	Cohesive Strength

	X (ft)	Y (ft)	PWP (psf)	(psf)	(psf)	(psf)
Slice 1	-408.09006	-13.288457	953.99973	693.22101	0	1,400
Slice 2	-402.31066	-19.504956	1,341.9093	1,586.0366	0	900
Slice 3	-396.00417	-25.504956	1,716.3093	2,299.502	0	900
Slice 4	-390.67546	-30.050515	1,999.9522	2,714.4325	0	1,500
Slice 5	-386.25875	-33.436438	2,211.2337	3,088.3195	0	1,500
Slice 6	-381.77625	-36.590302	2,408.0348	3,394.387	0	1,500
Slice 7	-377.29375	-39.480995	2,588.4141	3,668.8489	0	1,500
Slice 8	-372.81125	-42.128116	2,753.5944	3,914.3541	0	1,500
Slice 9	-367.58085	-44.909972	2,927.1822	4,164.701	0	1,500
Slice 10	-362.52624	-47.368472	3,080.5926	4,326.3152	0	2,000
Slice 11	-357.67383	-49.45015	3,210.4894	4,626.9823	885.12301	0
Slice 12	-352.09993	-51.588098	3,343.8973	4,787.6669	902.16739	0
Slice 13	-346.52602	-53.447947	3,459.9519	4,917.6689	910.88267	0
Slice 14	-341.4468	-54.921126	3,551.8783	5,009.6849	983.30297	0
Slice 15	-336.86227	-56.057671	3,622.7986	5,078.6101	981.95723	0
Slice 16	-332.08955	-57.057449	3,685.1848	5,128.5642	973.5717	0
Slice 17	-327.12864	-57.910296	3,738.4025	5,158.0248	957.54735	0
Slice 18	-322.16773	-58.573029	3,779.757	5,164.2504	933.85261	0
Slice 19	-317.20682	-59.048478	3,809.425	5,147.2548	902.3776	0
Slice 20	-312.24591	-59.33864	3,827.5311	5,106.958	862.98435	0
Slice 21	-307.285	-59.444719	3,834.1505	5,043.1933	815.50965	0
Slice 22	-302.32409	-59.367154	3,829.3104	4,955.7113	759.76697	0
Slice 23	-297.36318	-59.105623	3,812.9909	4,844.1821	695.54724	0
Slice 24	-292.40227	-58.659044	3,785.1243	4,708.1941	622.61841	0
Slice 25	-287.44136	-58.025544	3,745.5939	4,547.2492	540.72336	0
Slice 26	-282.48045	-57.202426	3,694.2314	4,370.9469	456.45038	0
Slice 27	-277.51523	-56.185051	3,630.7472	3,959.3768	221.66344	0
Slice 28	-272.5457	-54.968515	3,554.8354	3,811.9083	173.39784	0
Slice 29	-267.17305	-53.414217	3,457.8471	3,625.3545	104.67024	0
Slice 30	-261.39728	-51.476654	3,336.9432	3,396.0612	36.941046	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 166+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	115	0	32	
🟧	Silty Sand	120	0	34	
⬜	Silty Clay (undrained)	115			1,400
🟪	Fat Clay 1 (undrained)	115			900
🟦	Lean Clay (undrained)	120			2,000
🟪	Fat Clay 2 (undrained)	115			1,500



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 70
Date: 4/27/2018
Time: 11:19:33 AM
Tool Version: 8.16.1.13452
File Name: 166+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\166+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:20:58 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No

Tension Crack
        Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Silty Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,400 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 1 (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf

Cohesion: 900 psf
Pore Water Pressure
Piezometric Line: 1

Lean Clay (undrained)

Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,500 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-500, -10) ft
Right Coordinate: (50, -50.5) ft

Slip Surface Block

Left Grid
- Upper Left: (-388, -43.97595) ft
- Lower Left: (-388, -59.50986) ft
- Lower Right: (-354, -59.50986) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 115 °
- Ending Angle: 135 °
- Angle Increments: 2

Right Grid
- Upper Left: (-307.00784, -46.48459) ft
- Lower Left: (-307.00784, -59.99428) ft
- Lower Right: (-277.3425, -59.99428) ft
- X Increments: 6
- Y Increments: 6
- Starting Angle: 0 °
- Ending Angle: 45 °
- Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2
Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-16.31
Point 2	-500	-46.31
Point 3	-500	-48.31
Point 4	-280	-48.31
Point 5	-500	-54.31
Point 6	50	-54.31
Point 7	-500	-60.31
Point 8	50	-60.31
Point 9	-500	-28.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-334.57	-28.31
Point 13	-370.57	-16.31
Point 14	-388.5	-10.33333
Point 15	-225	-50.33333
Point 16	50	-50.5
Point 17	-500	-10

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay (undrained)	2,3,4,11	419.1
Region 2	Silty Sand	5,7,8,6	3,300
Region 3	Fat Clay 1 (undrained)	1,13,12,9	1,769.2
Region 4	Fat Clay 2 (undrained)	9,2,11,12	3,484.6
Region 5	Clayey Sand	3,4,10,15,16,6,5	2,604.8
Region 6	Silty Clay (undrained)	17,14,13,1	738.56

Current Slip Surface

Slip Surface: 13,982

F of S: 3.83

Volume: 2,918.2125 ft³

Weight: 337,308.83 lbs

Resisting Moment: 9,002,171.2 lbs-ft

Activating Moment: 2,360,999.7 lbs-ft

Resisting Force: 126,854.69 lbs

Activating Force: 33,302.045 lbs

F of S Rank (Analysis): 1 of 21,609 slip surfaces

F of S Rank (Query): 1 of 21,609 slip surfaces

Exit: (-259.21343, -50.437009) ft

Entry: (-409.88452, -10.269401) ft

Radius: 73.973394 ft

Center: (-326.51772, -0.22749876) ft

Slip Slices

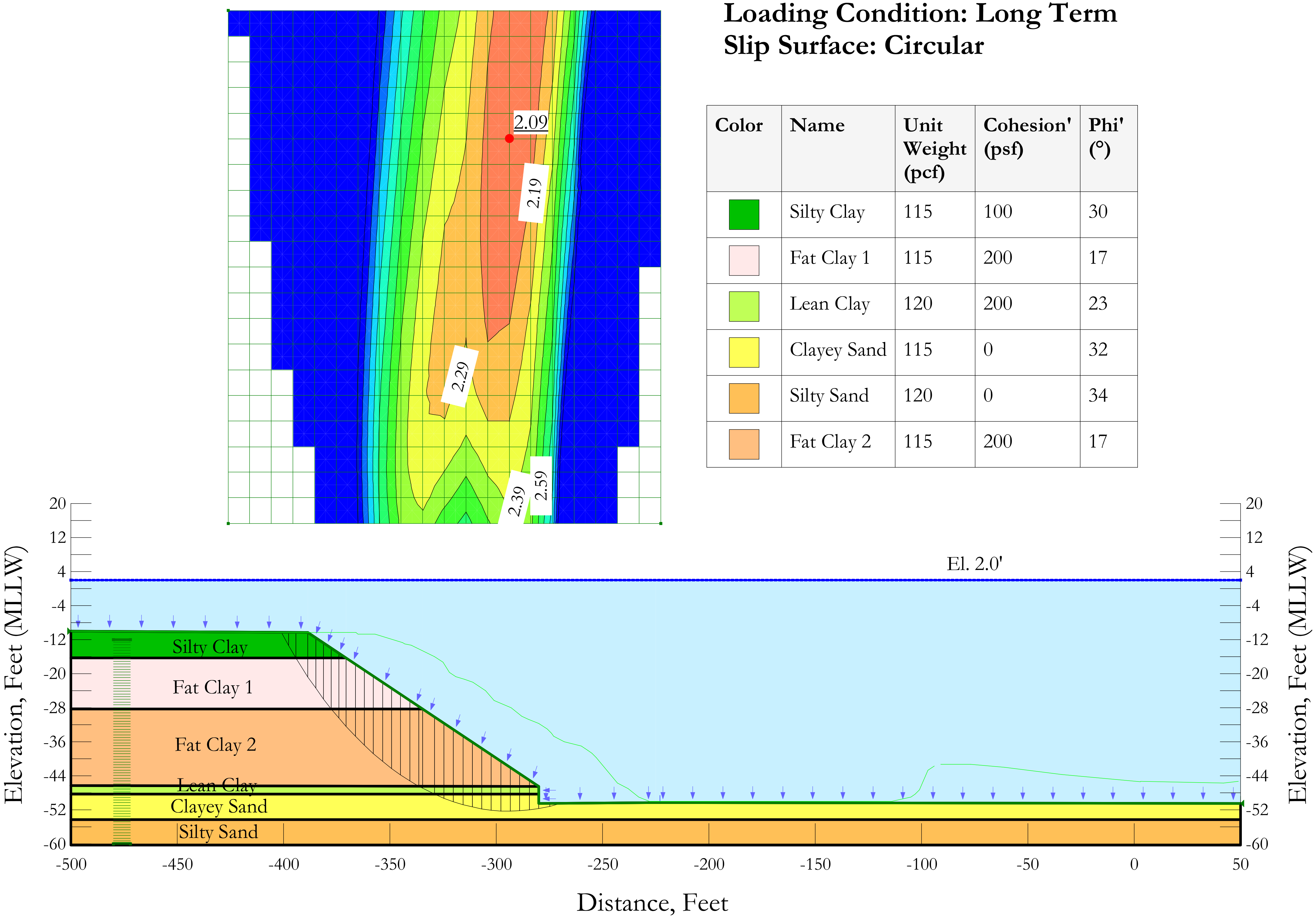
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-406.86422	-13.2897	954.07731	744.78777	0	1,400

Slice 2	-400.84392	-19.31	1,329.744	1,563.3067	0	900
Slice 3	-394.84392	-25.31	1,704.144	2,245.5232	0	900
Slice 4	-390.17196	-29.98196	1,995.6743	2,619.3439	0	1,500
Slice 5	-386.03915	-34.114775	2,253.5619	3,046.3565	0	1,500
Slice 6	-381.11744	-39.036484	2,560.6766	3,518.3592	0	1,500
Slice 7	-376.19573	-43.958193	2,867.7912	3,989.737	0	1,500
Slice 8	-372.7894	-47.364524	3,080.3463	4,191.6022	0	2,000
Slice 9	-371.42196	-48.73196	3,165.6743	4,610.031	902.53426	0
Slice 10	-370.785	-49.180192	3,193.644	4,888.4069	1,059.0054	0
Slice 11	-367.99857	-49.520681	3,214.8905	4,880.3804	1,040.7136	0
Slice 12	-362.85571	-50.149115	3,254.1048	4,865.6945	1,007.033	0
Slice 13	-357.71286	-50.777549	3,293.319	4,851.1608	973.44758	0
Slice 14	-352.57	-51.405982	3,332.5333	4,836.7349	939.9295	0
Slice 15	-347.42714	-52.034416	3,371.7476	4,822.37	906.44951	0
Slice 16	-342.28429	-52.66285	3,410.9618	4,808.0179	872.97754	0
Slice 17	-337.14143	-53.291284	3,450.1761	4,793.6302	839.48331	0
Slice 18	-331.68733	-53.95775	3,491.7636	4,778.2781	803.90348	0
Slice 19	-326.22032	-54.625793	3,533.4495	4,762.5596	829.04525	0
Slice 20	-321.05166	-55.25738	3,572.8605	4,750.8443	794.56014	0
Slice 21	-315.88301	-55.888967	3,612.2715	4,738.9029	759.92251	0
Slice 22	-310.71435	-56.520553	3,651.6825	4,726.7002	725.10862	0
Slice 23	-305.54569	-57.15214	3,691.0935	4,714.2063	690.09831	0
Slice 24	-300.37703	-57.783727	3,730.5045	4,701.3972	654.8754	0
Slice 25	-295.20837	-58.415313	3,769.9156	4,688.2555	619.4281	0
Slice 26	-290.03971	-59.0469	3,809.3266	4,674.7705	583.74928	0
Slice 27	-284.87105	-59.678487	3,848.7376	4,660.9388	547.83666	0
Slice 28	-281.14336	-59.520684	3,838.8907	4,697.7521	579.30933	0
Slice 29	-277.14091	-57.862816	3,735.4397	4,188.7865	305.78627	0
Slice 30	-271.42274	-55.494272	3,587.6426	3,889.2652	203.44703	0
Slice 31	-266.2261	-53.341752	3,453.3253	3,621.6242	105.16483	0
Slice 32	-261.55099	-51.405257	3,332.488	3,388.5023	35.001619	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 166+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Silty Clay	115	100	30
⬜	Fat Clay 1	115	200	17
🟩	Lean Clay	120	200	23
🟨	Clayey Sand	115	0	32
🟧	Silty Sand	120	0	34
🟧	Fat Clay 2	115	200	17



Long Term

File Information

- File Version: 8.16
- Title: Bayport Channel
- Created By: Nishant Dayal
- Last Edited By: Anil Raavi
- Revision Number: 70
- Date: 4/27/2018
- Time: 11:19:33 AM
- Tool Version: 8.16.1.13452
- File Name: 166+00.gsz
- Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\166+00\
- Last Solved Date: 4/27/2018
- Last Solved Time: 11:19:52 AM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Long Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
    - Side Function
        - Interslice force function option: Half-Sine
    - PWP Conditions Source: Piezometric Line
    - Apply Phreatic Correction: Yes
    - Use Staged Rapid Drawdown: No
- Slip Surface
    - Direction of movement: Left to Right
    - Use Passive Mode: No
    - Slip Surface Option: Grid and Radius
    - Critical slip surfaces saved: 1
    - Resisting Side Maximum Convex Angle: 1 °
    - Driving Side Maximum Convex Angle: 5 °
    - Optimize Critical Slip Surface Location: No
    - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Silty Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 100 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 17 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 17 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-425.96668, 135.91451) ft
Lower Left: (-425.96668, 15.34286) ft
Lower Right: (-222.60373, 15.34286) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-480, -11.99991) ft
Upper Right Coordinate: (-472, -11.99991) ft
Lower Left Coordinate: (-480, -59.97942) ft
Lower Right Coordinate: (-472, -59.97942) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10) ft
Right Coordinate: (50, -50.5) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2
Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-16.31
Point 2	-500	-46.31
Point 3	-500	-48.31
Point 4	-280	-48.31
Point 5	-500	-54.31
Point 6	50	-54.31
Point 7	-500	-60.31
Point 8	50	-60.31
Point 9	-500	-28.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-334.57	-28.31
Point 13	-370.57	-16.31
Point 14	-388.5	-10.33333
Point 15	-225	-50.33333
Point 16	50	-50.5
Point 17	-500	-10

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	2,3,4,11	419.1
Region 2	Silty Sand	5,7,8,6	3,300
Region 3	Fat Clay 1	1,13,12,9	1,769.2
Region 4	Fat Clay 2	9,2,11,12	3,484.6
Region 5	Clayey Sand	3,4,10,15,16,6,5	2,604.8
Region 6	Silty Clay	17,14,13,1	738.56

Current Slip Surface

Slip Surface: 24,992

F of S: 2.09

Volume: 1,710.2003 ft³

Weight: 197,156.93 lbs

Resisting Moment: 8,676,907.6 lbs-ft

Activating Moment: 4,152,687.7 lbs-ft

Resisting Force: 51,225.628 lbs

Activating Force: 24,681.732 lbs

F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-269.77335, -50.46901) ft
Entry: (-401.09278, -10.295684) ft
Radius: 158.0743 ft
Center: (-293.78076, 105.7716) ft

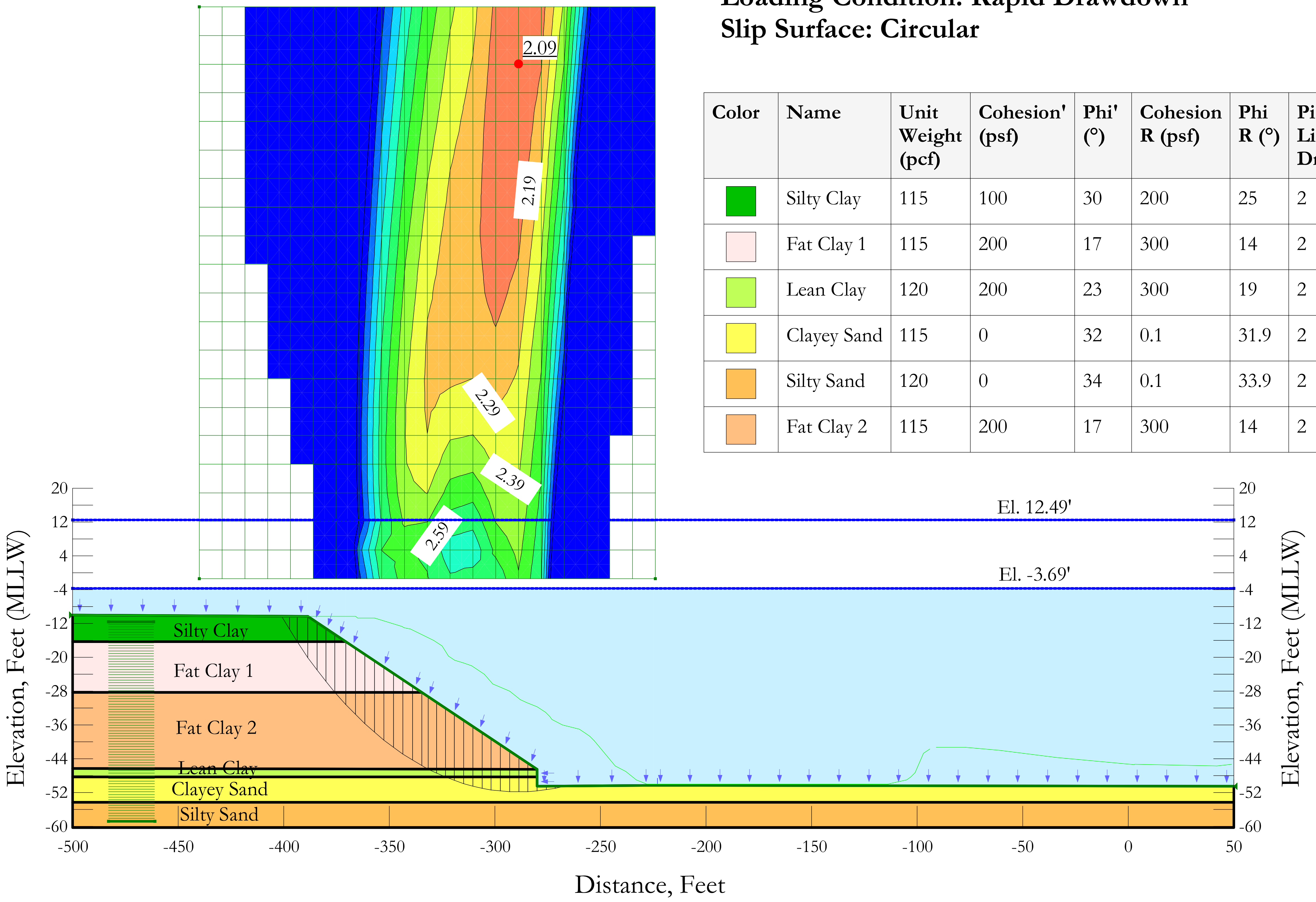
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-399.36902	-11.843186	863.81484	892.66872	16.658793	100
Slice 2	-395.92149	-14.850345	1,051.4615	1,206.0031	89.224621	100
Slice 3	-391.34886	-18.545874	1,282.0625	1,587.919	93.509728	200
Slice 4	-386.66736	-22.112852	1,504.642	1,952.1729	136.82393	200
Slice 5	-383.00208	-24.69721	1,665.9059	2,179.5022	157.02214	200
Slice 6	-379.3368	-27.130232	1,817.7265	2,390.9933	175.26525	200
Slice 7	-375.77062	-29.361796	1,956.9761	2,582.7597	191.32124	200
Slice 8	-372.30354	-31.405902	2,084.5283	2,756.3707	205.40283	200
Slice 9	-368.43384	-33.542893	2,217.8765	2,935.4717	219.39087	200
Slice 10	-364.16153	-35.749918	2,355.5949	3,117.9761	233.08333	200
Slice 11	-359.88921	-37.795896	2,483.2639	3,284.3638	244.92082	200
Slice 12	-355.6169	-39.687633	2,601.3083	3,435.3013	254.97726	200
Slice 13	-351.34458	-41.431082	2,710.0995	3,571.2914	263.29279	200
Slice 14	-347.07227	-43.031461	2,809.9632	3,692.6909	269.87694	200
Slice 15	-342.79995	-44.493347	2,901.1848	3,799.7268	274.71185	200
Slice 16	-338.52764	-45.820749	2,984.0148	3,892.5131	277.75581	200
Slice 17	-335.48074	-46.700379	3,038.9036	3,940.9954	382.91524	200
Slice 18	-331.82718	-47.62973	3,096.8951	4,003.2987	384.74551	200
Slice 19	-326.85326	-48.787412	3,169.1345	4,074.5865	565.78922	0
Slice 20	-322.39104	-49.675462	3,224.5489	4,116.5361	557.37544	0
Slice 21	-317.92883	-50.431018	3,271.6955	4,142.3592	544.05105	0
Slice 22	-313.46661	-51.055996	3,310.6941	4,151.7232	525.53332	0
Slice 23	-309.0044	-51.551953	3,341.6419	4,144.2856	501.54743	0
Slice 24	-304.54218	-51.920108	3,364.6147	4,119.7097	471.83573	0
Slice 25	-300.07997	-52.161354	3,379.6685	4,077.6803	436.1662	0
Slice 26	-295.61775	-52.276275	3,386.8396	4,017.9147	394.33951	0
Slice 27	-291.15554	-52.265145	3,386.1451	3,940.1722	346.19456	0

Slice 28	-286.69332	-52.127938	3,377.5833	3,844.2599	291.61193	0
Slice 29	-282.23111	-51.864325	3,361.1339	3,754.9687	246.09532	0
Slice 30	-277.44334	-51.43516	3,334.354	3,390.7192	35.220889	0
Slice 31	-272.33001	-50.819236	3,295.9203	3,316.741	13.010195	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 166+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	**Name**	**Unit Weight (pcf)**	**Cohesion' (psf)**	**Phi' (°)**	**Cohesion R (psf)**	**Phi R (°)**	**Piezometric Line After Drawdown**
🟩	Silty Clay	115	100	30	200	25	2
⬜	Fat Clay 1	115	200	17	300	14	2
🟩	Lean Clay	120	200	23	300	19	2
🟨	Clayey Sand	115	0	32	0.1	31.9	2
🟧	Silty Sand	120	0	34	0.1	33.9	2
🟧	Fat Clay 2	115	200	17	300	14	2



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 70
Date: 4/27/2018
Time: 11:19:33 AM
Tool Version: 8.16.1.13452
File Name: 166+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\166+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:20:56 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: Yes

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Silty Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 200 psf
Phi R: 25 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 17 °
Phi-B: 0 °
Cohesion R: 300 psf
Phi R: 14 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 23 °

Phi-B: 0 °
Cohesion R: 300 psf
Phi R: 19 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 31.9 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Silty Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 33.9 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 17 °
Phi-B: 0 °
Cohesion R: 300 psf
Phi R: 14 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-440, 133.92534) ft
Lower Left: (-440, -1.35231) ft
Lower Right: (-224, -1.35231) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-483.03894, -11.6018) ft
Upper Right Coordinate: (-461.6528, -11.6018) ft
Lower Left Coordinate: (-483.03894, -58.75541) ft
Lower Right Coordinate: (-460.98448, -58.75541) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10) ft
Right Coordinate: (50, -50.5) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	12.49
Coordinate 2	50	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	-3.69
Coordinate 2	50	-3.69

Points

	X (ft)	Y (ft)
Point 1	-500	-16.31
Point 2	-500	-46.31
Point 3	-500	-48.31
Point 4	-280	-48.31
Point 5	-500	-54.31
Point 6	50	-54.31
Point 7	-500	-60.31
Point 8	50	-60.31
Point 9	-500	-28.31
Point 10	-280	-50.5
Point 11	-280	-46.5
Point 12	-334.57	-28.31
Point 13	-370.57	-16.31
Point 14	-388.5	-10.33333

Point 15	-225	-50.33333
Point 16	50	-50.5
Point 17	-500	-10

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	2,3,4,11	419.1
Region 2	Silty Sand	5,7,8,6	3,300
Region 3	Fat Clay 1	1,13,12,9	1,769.2
Region 4	Fat Clay 2	9,2,11,12	3,484.6
Region 5	Clayey Sand	3,4,10,15,16,6,5	2,604.8
Region 6	Silty Clay	17,14,13,1	738.56

Current Slip Surface

Slip Surface: 29,857
F of S: 2.09
Volume: 1,595.8925 ft³
Weight: 183,963.45 lbs
Resisting Moment: 8,901,738.8 lbs-ft
Activating Moment: 4,265,422.3 lbs-ft
Resisting Force: 48,328.25 lbs
Activating Force: 23,257.761 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-267.05014, -50.460757) ft
Entry: (-400.98205, -10.296015) ft
Radius: 172.23712 ft
Center: (-288.8, 120.39757) ft

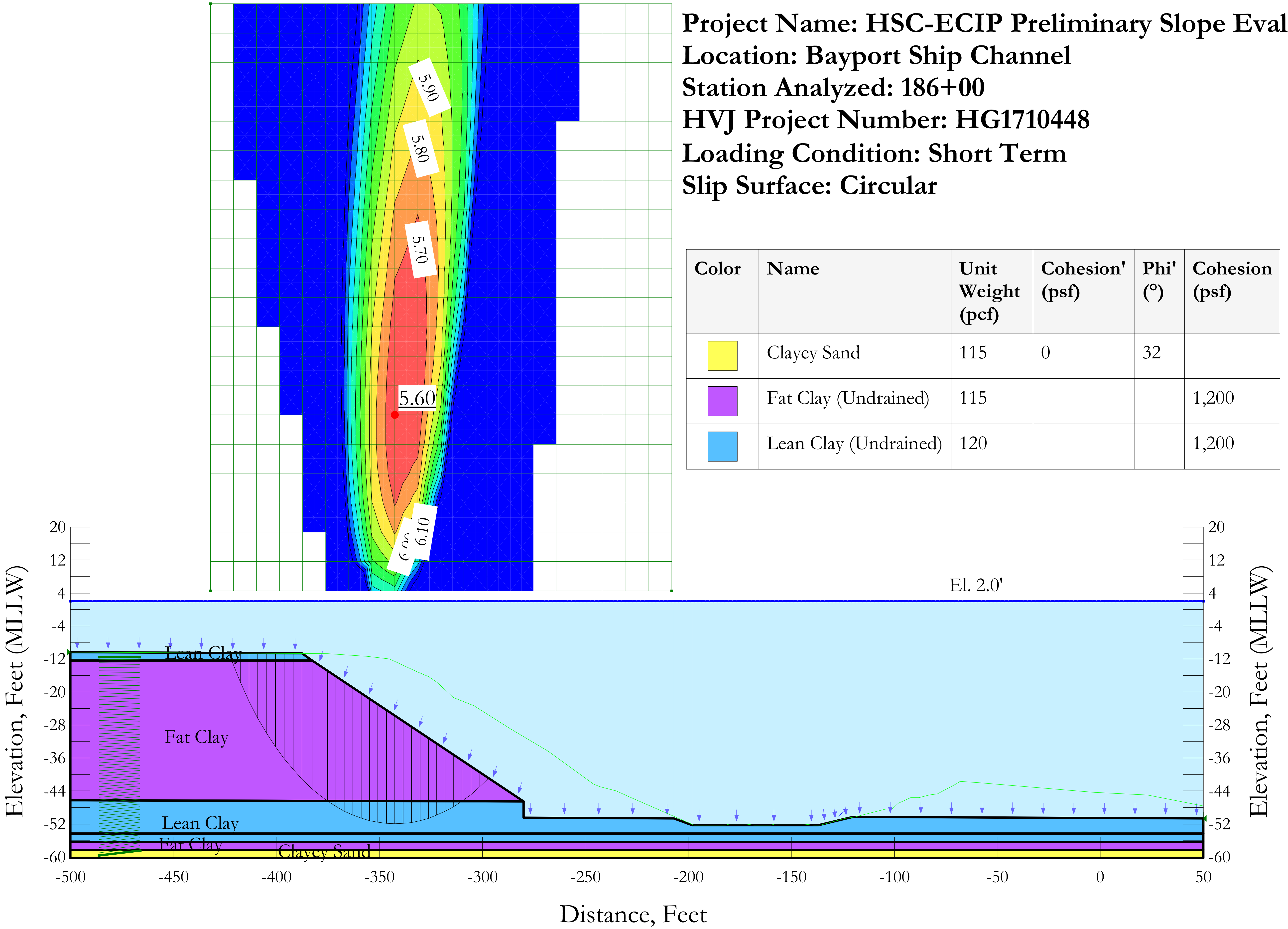
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-399.12893	-11.842089	508.69037	541.23161	0	117.98704
Slice 2	-395.4227	-14.849082	696.32671	856.89385	92.703481	100
Slice 3	-391.03479	-18.180027	904.17766	1,202.695	91.265899	200
Slice 4	-386.36674	-21.516682	1,112.3849	1,536.9966	129.81683	200
Slice 5	-382.10021	-24.358273	1,289.7002	1,783.2399	150.89022	200
Slice 6	-377.83369	-27.021618	1,455.893	2,010.6369	169.60224	200
Slice 7	-373.13521	-29.750825	1,626.1955	2,239.8248	187.60529	200
Slice 8	-368.32	-32.362896	1,789.1887	2,455.8722	203.8256	200
Slice 9	-363.82	-34.622997	1,930.219	2,639.4063	216.82032	200
Slice 10	-359.32	-36.721722	2,061.1795	2,806.7113	227.93196	200
Slice 11	-354.82	-38.665467	2,182.4691	2,958.4476	237.24043	200
Slice 12	-350.32	-40.459855	2,294.439	3,095.1105	244.78985	200
Slice 13	-345.82	-42.109841	2,397.398	3,217.0459	250.5915	200
Slice 14	-341.32	-43.619785	2,491.6186	3,324.4667	254.62722	200

Slice 15	-336.82	-44.993527	2,577.3401	3,417.4685	256.85302	200
Slice 16	-333.04898	-46.051148	2,643.3356	3,485.2915	257.41176	200
Slice 17	-329.51841	-46.94447	2,699.0789	3,531.0564	353.15349	200
Slice 18	-325.49932	-47.871721	2,756.9394	3,586.384	352.07832	200
Slice 19	-321.31529	-48.728057	2,810.3747	3,631.2557	512.94341	0
Slice 20	-316.96631	-49.506595	2,858.9555	3,659.4471	500.20268	0
Slice 21	-312.61733	-50.170712	2,900.3964	3,673.3823	483.0152	0
Slice 22	-308.26835	-50.72174	2,934.7806	3,672.7821	461.1545	0
Slice 23	-303.91938	-51.16077	2,962.176	3,657.3729	434.40722	0
Slice 24	-299.5704	-51.48866	2,982.6364	3,626.8991	402.57998	0
Slice 25	-295.22142	-51.706047	2,996.2013	3,581.1323	365.50548	0
Slice 26	-290.87244	-51.813348	3,002.8969	3,519.8807	323.04734	0
Slice 27	-286.52347	-51.810771	3,002.7361	3,442.9941	275.1037	0
Slice 28	-282.17449	-51.698309	2,995.7185	3,381.0776	240.79908	0
Slice 29	-277.84169	-51.476985	2,981.9079	3,039.4404	35.9503	0
Slice 30	-273.52507	-51.147193	2,961.3289	3,000.9042	24.729422	0
Slice 31	-269.20845	-50.707884	2,933.9159	2,948.3901	9.0444628	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 186+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	115	0	32	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (Undrained)	120			1,200



Short Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 97
Date: 4/27/2018
Time: 11:25:35 AM
Tool Version: 8.16.1.13452
File Name: 186+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\186+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:26:38 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)

Unit Weight: 115 pcf

Cohesion: 1,200 psf

Pore Water Pressure

Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)

Unit Weight: 120 pcf

Cohesion: 1,200 psf

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-432, 147) ft

Lower Left: (-432, 4.5) ft

Lower Right: (-208, 4.5) ft

Grid Horizontal Increment: 20

Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-485.98367, -11.54301) ft
Upper Right Coordinate: (-466.3438, -11.54301) ft
Lower Left Coordinate: (-485.98367, -59.63908) ft
Lower Right Coordinate: (-466.05067, -58.59349) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10.31) ft
Right Coordinate: (50, -50.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2
Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-12.31
Point 2	-500	-10.31
Point 3	-500	-46.31
Point 4	-500	-54.31
Point 5	50	-54.31
Point 6	-500	-56.31
Point 7	50	-56.31
Point 8	-500	-58.31
Point 9	50	-58.31
Point 10	-500	-60.31
Point 11	50	-60.31
Point 12	-125	-48.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-382.57	-12.31
Point 16	-387.57	-10.59428
Point 17	-207	-50.66667

Point 18	-198	-52.33333
Point 19	-137	-52.33333
Point 20	-120	-50.33333
Point 21	50	-50.66667

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay (Undrained)	1,15,16,2	213.17
Region 2	Fat Clay (Undrained)	14,3,1,15	5,747.5
Region 3	Lean Clay (Undrained)	4,6,7,5	1,100
Region 4	Fat Clay (Undrained)	6,8,9,7	1,100
Region 5	Clayey Sand	8,10,11,9	1,100
Region 6	Lean Clay (Undrained)	3,14,13,17,18,19,20,21,5,4	2,855.3

Current Slip Surface

Slip Surface: 10,260
F of S: 5.60
Volume: 2,680.1856 ft³
Weight: 309,753.92 lbs
Resisting Moment: 16,847,613 lbs-ft
Activating Moment: 3,009,452.8 lbs-ft
Resisting Force: 151,495.76 lbs
Activating Force: 27,469.279 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-296.83325, -40.888918) ft
Entry: (-423.07971, -10.504493) ft
Radius: 99.220954 ft
Center: (-342.4, 47.25) ft

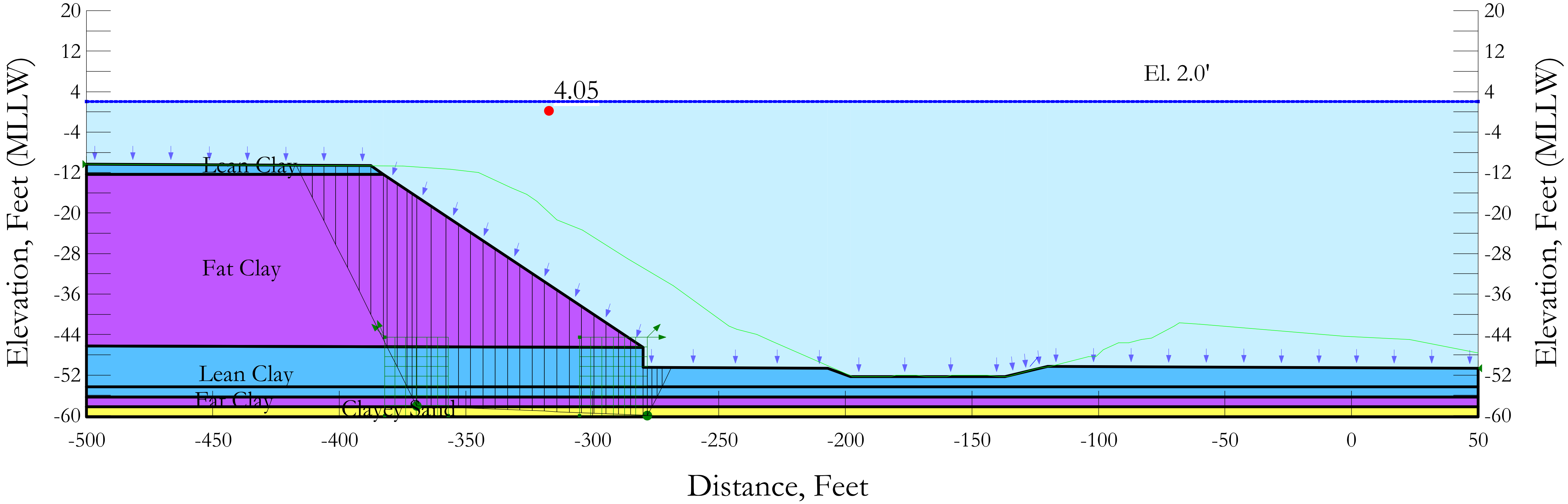
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-422.41795	-11.407247	836.6122	595.7491	0	1,200
Slice 2	-419.61955	-14.96206	1,058.4325	1,032.3344	0	1,200
Slice 3	-415.34628	-19.934012	1,368.6824	1,630.6185	0	1,200
Slice 4	-411.073	-24.304499	1,641.4007	2,152.087	0	1,200
Slice 5	-406.79973	-28.179303	1,883.1885	2,612.0742	0	1,200
Slice 6	-402.52646	-31.632124	2,098.6445	3,021.0663	0	1,200
Slice 7	-398.25318	-34.716669	2,291.1201	3,386.5828	0	1,200
Slice 8	-393.97991	-37.473394	2,463.1398	3,714.1942	0	1,200
Slice 9	-389.70664	-39.933545	2,616.6532	4,008.117	0	1,200
Slice 10	-385.07	-42.284347	2,763.3433	4,247.0477	0	1,200
Slice 11	-380.70954	-44.254693	2,886.2928	4,406.9423	0	1,200
Slice 12	-376.98862	-45.72572	2,978.0849	4,524.8702	0	1,200
Slice 13	-373.08771	-47.081638	3,062.6942	4,631.121	0	1,200
Slice						

14	-369.00681	-48.313536	3,139.5647	4,724.1521	0	1,200
Slice 15	-364.9259	-49.35741	3,204.7024	4,795.1234	0	1,200
Slice 16	-360.845	-50.219315	3,258.4853	4,844.5231	0	1,200
Slice 17	-356.76409	-50.904053	3,301.2129	4,872.6632	0	1,200
Slice 18	-352.68318	-51.415319	3,333.1159	4,879.71	0	1,200
Slice 19	-348.60228	-51.755807	3,354.3623	4,865.709	0	1,200
Slice 20	-344.52137	-51.927277	3,365.0621	4,830.606	0	1,200
Slice 21	-340.44047	-51.930608	3,365.2699	4,774.2633	0	1,200
Slice 22	-336.35956	-51.765817	3,354.987	4,696.475	0	1,200
Slice 23	-332.27865	-51.43206	3,334.1605	4,596.9758	0	1,200
Slice 24	-328.19775	-50.927611	3,302.6829	4,475.4491	0	1,200
Slice 25	-324.11684	-50.249816	3,260.3885	4,331.5294	0	1,200
Slice 26	-320.03594	-49.395021	3,207.0493	4,164.8009	0	1,200
Slice 27	-315.95503	-48.35847	3,142.3685	3,974.7921	0	1,200
Slice 28	-311.87413	-47.134161	3,065.9716	3,760.9637	0	1,200
Slice 29	-307.66694	-45.664268	2,974.2503	3,518.5902	0	1,200
Slice 30	-303.33346	-43.92591	2,865.7768	3,245.8325	0	1,200
Slice 31	-298.99998	-41.943218	2,742.0568	2,944.7682	0	1,200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 186+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟨	Clayey Sand	115	0	32	
🟪	Fat Clay (Undrained)	115			1,200
🟦	Lean Clay (Undrained)	120			1,200



Short Term - Block

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 97
Date: 4/27/2018
Time: 11:25:35 AM
Tool Version: 8.16.1.13452
File Name: 186+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\186+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:26:58 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
    Tension Crack Option: (none)
F of S Distribution
    F of S Calculation Option: Constant
Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
        Lambda 1: -1
        Lambda 2: -0.8
        Lambda 3: -0.6
        Lambda 4: -0.4
        Lambda 5: -0.2
        Lambda 6: 0
        Lambda 7: 0.2
        Lambda 8: 0.4
        Lambda 9: 0.6
        Lambda 10: 0.8
        Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 1,200 psf
Pore Water Pressure
    Piezometric Line: 1

Lean Clay (Undrained)

Model: Undrained (Phi=0)
Unit Weight: 120 pcf
Cohesion: 1,200 psf
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (-500, -10.31) ft
Right Coordinate: (50, -50.66667) ft

Slip Surface Block

Left Grid

Upper Left: (-382, -44.48617) ft
Lower Left: (-382, -60.00077) ft
Lower Right: (-357, -60.00077) ft
X Increments: 6
Y Increments: 8
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 2

Right Grid

Upper Left: (-304.99555, -44.50305) ft
Lower Left: (-304.99555, -60.00736) ft
Lower Right: (-278.2181, -60.00736) ft
X Increments: 6
Y Increments: 8
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2
Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-12.31
Point 2	-500	-10.31
Point 3	-500	-46.31
Point 4	-500	-54.31
Point 5	50	-54.31
Point 6	-500	-56.31
Point 7	50	-56.31
Point 8	-500	-58.31
Point 9	50	-58.31
Point 10	-500	-60.31
Point 11	50	-60.31
Point 12	-125	-48.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-382.57	-12.31
Point 16	-387.57	-10.59428
Point 17	-207	-50.66667
Point 18	-198	-52.33333

Point 19	-137	-52.33333
Point 20	-120	-50.33333
Point 21	50	-50.66667

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay (Undrained)	1,15,16,2	213.17
Region 2	Fat Clay (Undrained)	14,3,1,15	5,747.5
Region 3	Lean Clay (Undrained)	4,6,7,5	1,100
Region 4	Fat Clay (Undrained)	6,8,9,7	1,100
Region 5	Clayey Sand	8,10,11,9	1,100
Region 6	Lean Clay (Undrained)	3,14,13,17,18,19,20,21,5,4	2,855.3

Current Slip Surface

Slip Surface: 6,069
F of S: 4.05
Volume: 3,589.6046 ft³
Weight: 418,057.66 lbs
Resisting Moment: 11,296,526 lbs-ft
Activating Moment: 2,801,926.1 lbs-ft
Resisting Force: 150,669.02 lbs
Activating Force: 38,046.553 lbs
F of S Rank (Analysis): 1 of 35,721 slip surfaces
F of S Rank (Query): 1 of 35,721 slip surfaces
Exit: (-268.73646, -50.525716) ft
Entry: (-417.04168, -10.519761) ft
Radius: 74.792021 ft
Center: (-334.79524, -0.51827172) ft

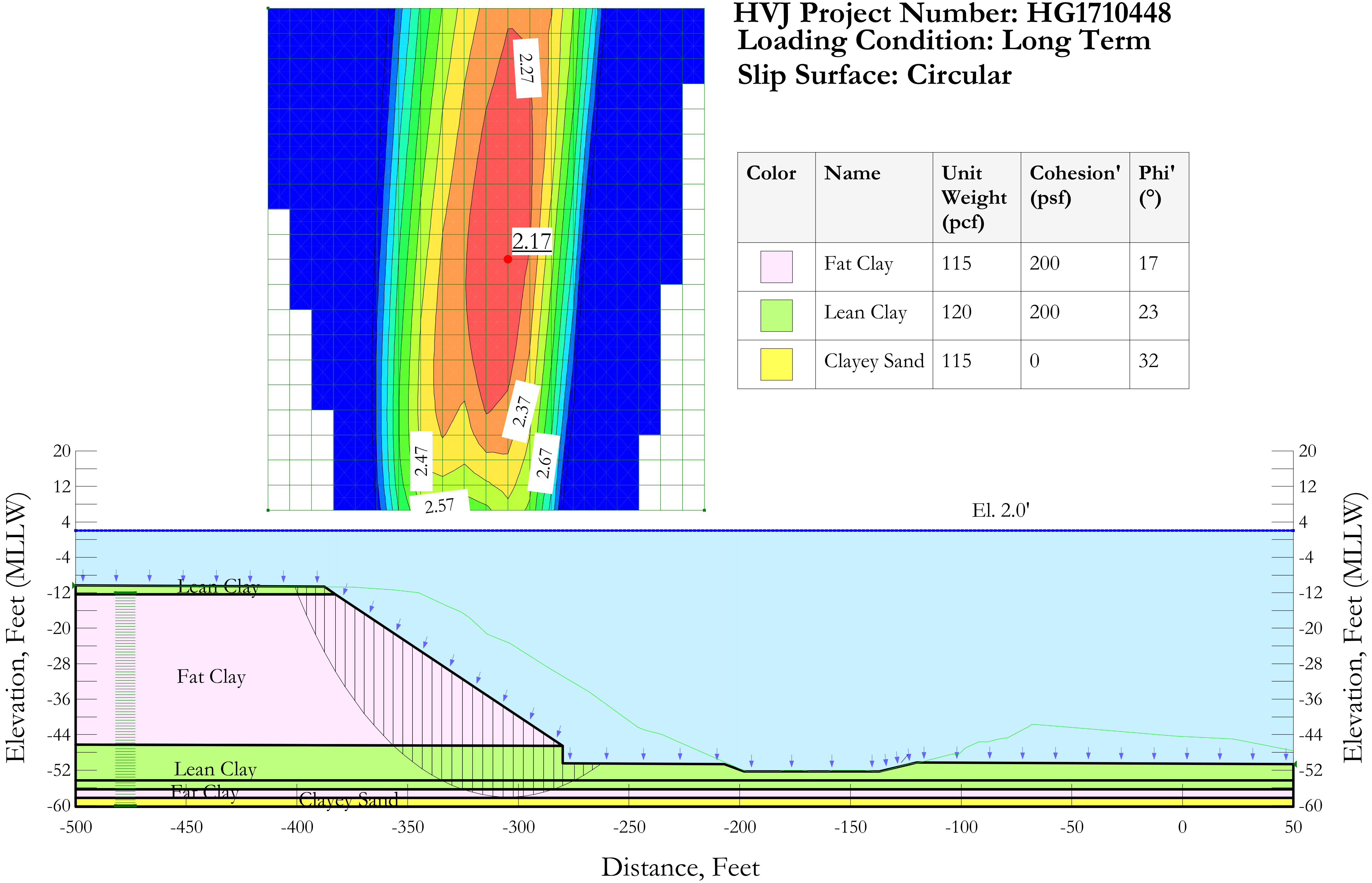
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-416.14656	-11.41488	837.08853	590.67064	0	1,200
Slice 2	-412.94466	-14.616787	1,036.8875	961.10157	0	1,200
Slice 3	-408.33108	-19.230361	1,324.7745	1,485.9587	0	1,200
Slice 4	-403.71751	-23.843935	1,612.6616	2,007.9062	0	1,200
Slice 5	-399.10394	-28.45751	1,900.5486	2,527.2104	0	1,200
Slice 6	-394.49036	-33.071084	2,188.4356	3,044.2234	0	1,200
Slice 7	-389.87679	-37.684658	2,476.3227	3,559.3741	0	1,200
Slice 8	-385.07	-42.491445	2,776.2662	4,050.1068	0	1,200
Slice 9	-381.8594	-45.702045	2,976.6076	4,347.4567	0	1,200
Slice 10	-379.17446	-48.386983	3,144.1477	4,610.4844	0	1,200
Slice 11	-375.22578	-52.335661	3,390.5452	5,002.5896	0	1,200
Slice 12	-372.25144	-55.31	3,576.144	5,298.1975	0	1,200
Slice 13	-370.37572	-57.185722	3,693.1891	5,480.518	0	1,200
Slice 14	-366.5851	-58.123584	3,751.7116	5,908.5663	0	1,200

Slice 15	-360.75531	-58.247861	3,759.4665	5,828.694	0	1,200
Slice 16	-355.4079	-58.361855	3,766.5798	5,755.3159	1,242.7002	0
Slice 17	-350.54287	-58.465566	3,773.0513	5,688.3567	1,196.8156	0
Slice 18	-345.67785	-58.569277	3,779.5229	5,621.058	1,150.7189	0
Slice 19	-340.81282	-58.672988	3,785.9945	5,553.329	1,104.3532	0
Slice 20	-335.94779	-58.776699	3,792.466	5,485.0865	1,057.6667	0
Slice 21	-331.08277	-58.88041	3,798.9376	5,416.2568	1,010.6132	0
Slice 22	-326.21774	-58.984121	3,805.4091	5,346.7762	963.15306	0
Slice 23	-321.35272	-59.087832	3,811.8807	5,276.5931	915.25388	0
Slice 24	-316.48769	-59.191542	3,818.3523	5,205.6679	866.89099	0
Slice 25	-311.62267	-59.295253	3,824.8238	5,133.9742	818.04797	0
Slice 26	-306.75764	-59.398964	3,831.2954	5,061.4996	768.71687	0
Slice 27	-301.89262	-59.502675	3,837.7669	4,988.2449	718.89846	0
Slice 28	-297.02759	-59.606386	3,844.2385	4,914.2256	668.60214	0
Slice 29	-292.16256	-59.710097	3,850.71	4,839.4701	617.84591	0
Slice 30	-287.29754	-59.813808	3,857.1816	4,764.0208	566.65603	0
Slice 31	-282.43251	-59.917519	3,863.6532	4,700.413	522.86555	0
Slice 32	-279.10905	-59.988367	3,868.0741	4,411.9246	339.8355	0
Slice 33	-277.36942	-59.15868	3,816.3016	4,428.2724	382.40178	0
Slice 34	-275.52074	-57.31	3,700.944	4,411.6288	0	1,200
Slice 35	-273.52074	-55.31	3,576.144	4,167.8996	0	1,200
Slice 36	-270.6286	-52.417858	3,395.6744	3,809.2906	0	1,200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 186+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟪	Fat Clay	115	200	17
🟩	Lean Clay	120	200	23
🟨	Clayey Sand	115	0	32



Long Term

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 97
Date: 4/27/2018
Time: 11:25:35 AM
Tool Version: 8.16.1.13452
File Name: 186+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\186+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:25:56 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
  Side Function
    Interslice force function option: Half-Sine
  PWP Conditions Source: Piezometric Line
  Apply Phreatic Correction: Yes
  Use Staged Rapid Drawdown: No
Slip Surface
  Direction of movement: Left to Right
  Use Passive Mode: No
  Slip Surface Option: Grid and Radius
  Critical slip surfaces saved: 1
  Resisting Side Maximum Convex Angle: 1 °
  Driving Side Maximum Convex Angle: 5 °
  Optimize Critical Slip Surface Location: No
  Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 17 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Grid

Upper Left: (-412.98645, 119.90044) ft
Lower Left: (-412.98645, 6.65529) ft
Lower Right: (-215.99872, 6.65529) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-482, -12) ft
Upper Right Coordinate: (-473, -12) ft
Lower Left Coordinate: (-482, -60) ft
Lower Right Coordinate: (-473, -60) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10.31) ft
Right Coordinate: (50, -50.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	2
Coordinate 2	50	2

Points

	X (ft)	Y (ft)
Point 1	-500	-12.31
Point 2	-500	-10.31
Point 3	-500	-46.31
Point 4	-500	-54.31
Point 5	50	-54.31
Point 6	-500	-56.31
Point 7	50	-56.31
Point 8	-500	-58.31
Point 9	50	-58.31
Point 10	-500	-60.31
Point 11	50	-60.31
Point 12	-125	-48.31
Point 13	-280	-50.5

Point 14	-280	-46.5
Point 15	-382.57	-12.31
Point 16	-387.57	-10.59428
Point 17	-207	-50.66667
Point 18	-198	-52.33333
Point 19	-137	-52.33333
Point 20	-120	-50.33333
Point 21	50	-50.66667

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	1,15,16,2	213.17
Region 2	Fat Clay	14,3,1,15	5,747.5
Region 3	Lean Clay	4,6,7,5	1,100
Region 4	Fat Clay	6,8,9,7	1,100
Region 5	Clayey Sand	8,10,11,9	1,100
Region 6	Lean Clay	3,14,13,17,18,19,20,21,5,4	2,855.3

Current Slip Surface

Slip Surface: 16,869
F of S: 2.17
Volume: 2,453.2345 ft³
Weight: 285,599.39 lbs
Resisting Moment: 9,369,437.1 lbs-ft
Activating Moment: 4,318,706.4 lbs-ft
Resisting Force: 70,855.949 lbs
Activating Force: 33,144.04 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-262.53319, -50.539879) ft
Entry: (-400.9533, -10.56044) ft
Radius: 121.35787 ft
Center: (-304.6432, 63.277865) ft

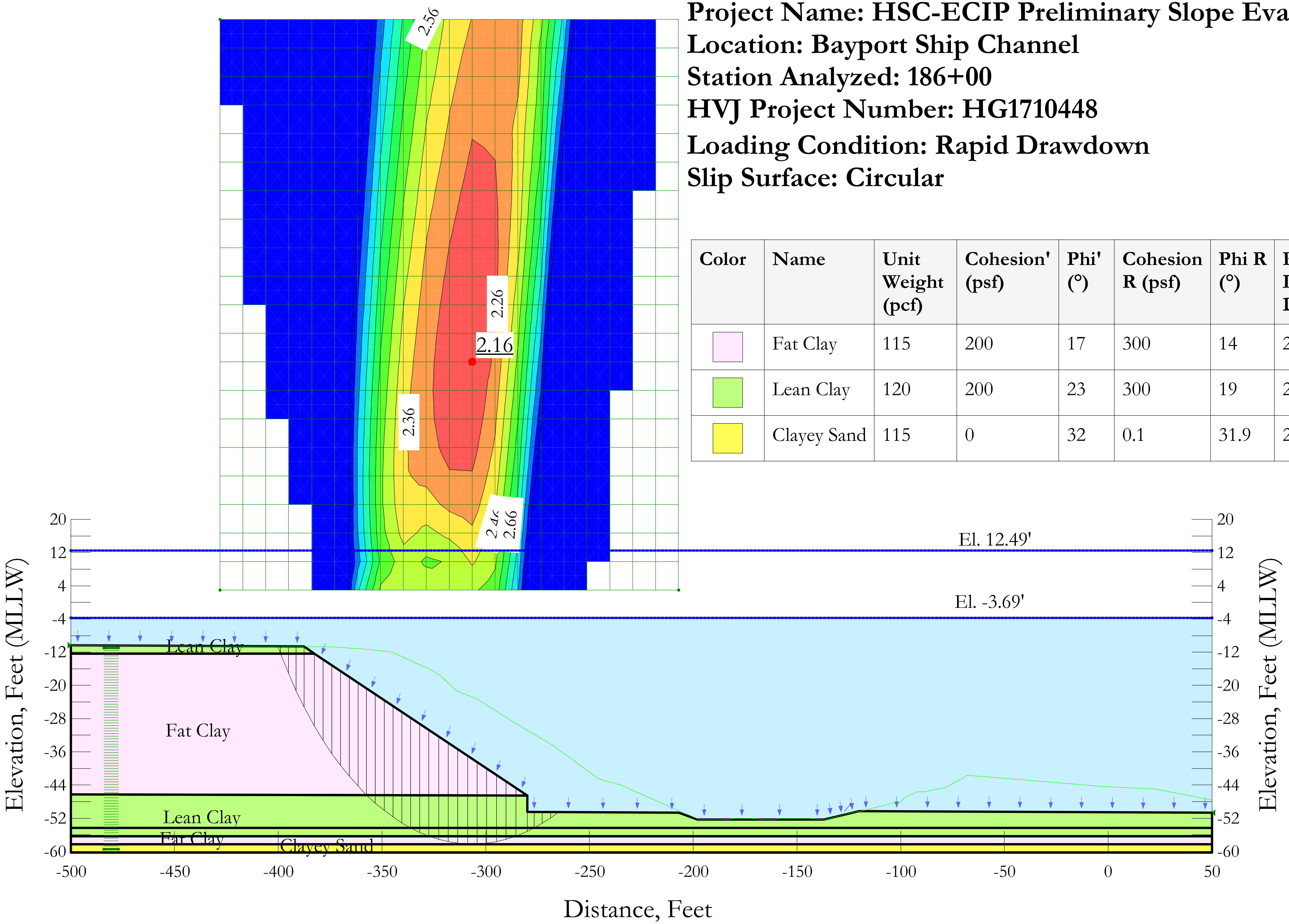
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-400.26984	-11.43522	838.35774	783.29147	-23.374243	200
Slice 2	-397.58364	-14.697105	1,041.8994	1,134.8635	28.42198	200
Slice 3	-393.57819	-19.242616	1,325.5393	1,625.2358	91.626406	200
Slice 4	-389.57273	-23.364166	1,582.7239	2,070.9935	149.279	200
Slice 5	-385.07	-27.541238	1,843.3733	2,485.6258	196.3563	200
Slice 6	-380.39905	-31.490578	2,089.8121	2,842.3243	230.06608	200
Slice 7	-376.05715	-34.806628	2,296.7336	3,142.0423	258.43679	200
Slice 8	-371.71525	-37.827449	2,485.2328	3,411.9904	283.33823	200
Slice 9	-367.37335	-40.5789	2,656.9233	3,655.1542	305.1898	200
Slice 10	-363.03144	-43.081952	2,813.1138	3,873.8741	324.30698	200
Slice 11	-358.68954	-45.353826	2,954.8788	4,069.969	340.91729	200
Slice						

12	-354.33243	-47.415267	3,083.5126	4,225.9872	484.95169	200
Slice 13	-349.9601	-49.276814	3,199.6732	4,392.1279	506.16698	200
Slice 14	-345.58777	-50.940696	3,303.4995	4,537.8946	523.96964	200
Slice 15	-341.21544	-52.415459	3,395.5247	4,663.7219	538.31776	200
Slice 16	-336.84312	-53.708268	3,476.1959	4,769.8148	549.10863	200
Slice 17	-332.31633	-54.858287	3,547.9571	4,858.5057	556.29488	200
Slice 18	-327.63507	-55.858287	3,610.3571	4,928.1826	559.38372	200
Slice 19	-322.99986	-56.661186	3,660.458	4,980.6573	403.62542	200
Slice 20	-318.4107	-57.274421	3,698.7239	4,997.9158	397.20283	200
Slice 21	-313.82153	-57.71054	3,725.9377	4,992.843	387.33181	200
Slice 22	-309.23236	-57.971458	3,742.219	4,964.8809	373.80525	200
Slice 23	-304.6432	-58.058306	3,747.6383	4,913.4471	356.42353	200
Slice 24	-300.05403	-57.971458	3,742.219	4,837.9608	335.00189	200
Slice 25	-295.46487	-57.71054	3,725.9377	4,737.8643	309.37701	200
Slice 26	-290.8757	-57.274421	3,698.7239	4,612.6402	279.41226	200
Slice 27	-286.28654	-56.661186	3,660.458	4,461.822	245.00155	200
Slice 28	-281.99598	-55.930805	3,614.8822	4,356.7215	314.89211	200
Slice 29	-277.31472	-54.930805	3,552.4822	3,873.3934	136.21873	200
Slice 30	-272.6134	-53.758261	3,479.3155	3,727.0402	105.15289	200
Slice 31	-268.58132	-52.579004	3,405.7298	3,577.4207	72.878455	200
Slice 32	-264.54924	-51.245683	3,322.5306	3,406.4102	35.604764	200

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Bayport Ship Channel
Station Analyzed: 186+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟪	Fat Clay	115	200	17	300	14	2
🟩	Lean Clay	120	200	23	300	19	2
🟨	Clayey Sand	115	0	32	0.1	31.9	2



Rapid Drawdown

File Information

File Version: 8.16
Title: Bayport Channel Widening
Created By: Nishant Dayal
Last Edited By: Anil Raavi
Revision Number: 97
Date: 4/27/2018
Time: 11:25:35 AM
Tool Version: 8.16.1.13452
File Name: 186+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BSC\186+00\
Last Solved Date: 4/27/2018
Last Solved Time: 11:26:30 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Rapid Drawdown

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: Yes

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Fat Clay

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 200 psf

Phi': 17 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 200 psf

Phi': 23 °

Phi-B: 0 °

Cohesion R: 300 psf

Phi R: 19 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 32 °

Phi-B: 0 °
Cohesion R: 0.1 psf
Phi R: 31.9 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (-428, 140.5) ft
Lower Left: (-428, 3) ft
Lower Right: (-207, 3) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (-484, -11) ft
Upper Right Coordinate: (-477, -11) ft
Lower Left Coordinate: (-484, -59.5) ft
Lower Right Coordinate: (-477, -59.5) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-500, -10.31) ft
Right Coordinate: (50, -50.66667) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	12.49
Coordinate 2	50	12.49

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-500	-3.69
Coordinate 2	50	-3.69

Points

	X (ft)	Y (ft)
Point 1	-500	-12.31
Point 2	-500	-10.31
Point 3	-500	-46.31
Point 4	-500	-54.31
Point 5	50	-54.31
Point 6	-500	-56.31
Point 7	50	-56.31
Point 8	-500	-58.31
Point 9	50	-58.31
Point 10	-500	-60.31
Point 11	50	-60.31
Point 12	-125	-48.31
Point 13	-280	-50.5
Point 14	-280	-46.5
Point 15	-382.57	-12.31
Point 16	-387.57	-10.59428
Point 17	-207	-50.66667
Point 18	-198	-52.33333
Point 19	-137	-52.33333
Point 20	-120	-50.33333
Point 21	50	-50.66667

Regions

	Material	Points	Area (ft²)
Region 1	Lean Clay	1,15,16,2	213.17
Region 2	Fat Clay	14,3,1,15	5,747.5
Region 3	Lean Clay	4,6,7,5	1,100
Region 4	Fat Clay	6,8,9,7	1,100
Region 5	Clayey Sand	8,10,11,9	1,100
Region 6	Lean Clay	3,14,13,17,18,19,20,21,5,4	2,855.3

Current Slip Surface

Slip Surface: 13,678
F of S: 2.16
Volume: 2,460.0105 ft³
Weight: 286,379.6 lbs
Resisting Moment: 8,925,167 lbs-ft
Activating Moment: 4,128,673.2 lbs-ft
Resisting Force: 70,267.638 lbs
Activating Force: 32,955.184 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (-264.92567, -50.534417) ft
Entry: (-400.27548, -10.562154) ft
Radius: 116.20667 ft
Center: (-306.45, 58) ft

Slip Slices

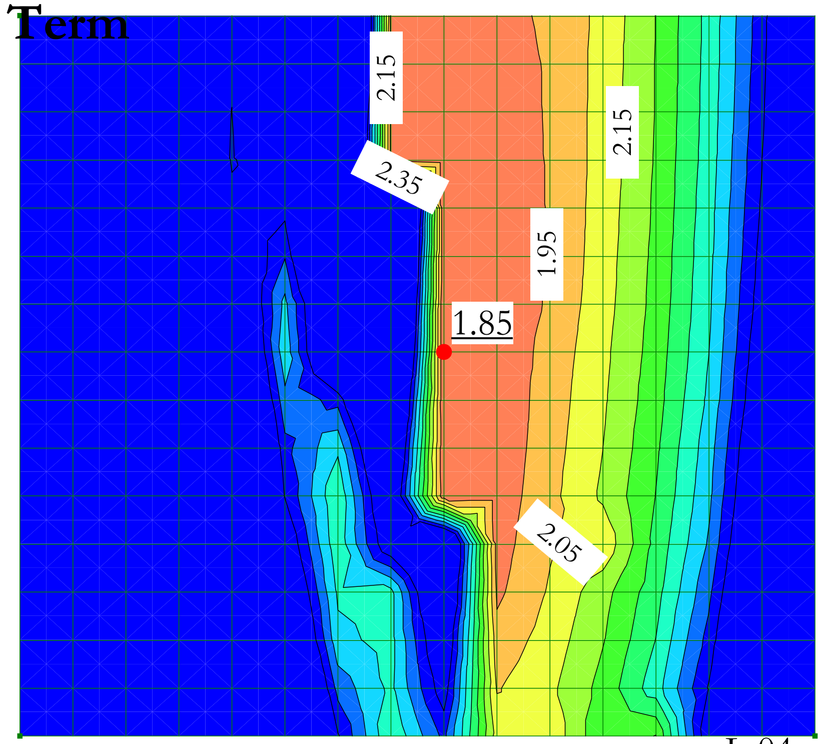
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-399.62421	-11.436077	483.35521	424.31206	-25.062329	200
Slice 2	-397.07244	-14.679672	685.75551	774.62514	0	225.99975
Slice 3	-393.27147	-19.18705	967.01589	1,260.5211	89.733544	200
Slice 4	-389.47049	-23.266269	1,221.5592	1,701.2649	146.66074	200
Slice 5	-385.07	-27.506439	1,486.1458	2,120.5726	193.96374	200
Slice 6	-380.47398	-31.537948	1,737.712	2,485.9597	228.76227	200
Slice 7	-376.28193	-34.847253	1,944.2126	2,785.8092	257.30189	200
Slice 8	-372.08988	-37.858967	2,132.1436	3,055.7171	282.36476	200
Slice 9	-367.89784	-40.600471	2,303.2134	3,298.934	304.42235	200
Slice 10	-363.70579	-43.093823	2,458.7986	3,517.9975	323.82961	200
Slice 11	-359.51375	-45.357036	2,600.023	3,714.873	340.84384	200
Slice 12	-355.305	-47.412315	2,728.2725	3,871.7935	485.39587	200
Slice 13	-351.07955	-49.270484	2,844.2222	4,040.026	507.58861	200
Slice 14	-346.85409	-50.933103	2,947.9696	4,188.5496	526.59496	200
Slice 15	-342.62864	-52.409023	3,040.067	4,317.8351	542.38039	200
Slice 16	-338.40319	-53.705659	3,120.9771	4,428.1046	554.84268	200
Slice 17	-334.05776	-54.856182	3,192.7697	4,521.3935	563.96735	200
Slice 18	-329.59235	-55.856182	3,255.1697	4,596.4154	569.32501	200
Slice 19	-325.03635	-56.686518	3,306.9827	4,656.6241	412.62679	200
Slice 20	-320.38976	-57.343816	3,347.9981	4,681.7945	407.78249	200
Slice 21	-315.74318	-57.811026	3,377.152	4,683.0812	399.26261	200
Slice 22	-311.09659	-58.090449	3,394.588	4,659.7633	386.80289	200
Slice 23	-306.45	-58.18344	3,400.3906	4,611.0903	370.14805	200
Slice 24	-301.80341	-58.090449	3,394.588	4,536.3198	349.06245	200
Slice 25	-297.15682	-57.811026	3,377.152	4,434.7485	323.3397	200
Slice 26	-292.51024	-57.343816	3,347.9981	4,305.7381	292.81052	200
Slice 27	-287.86365	-56.686518	3,306.9827	4,148.7318	257.34853	200
Slice 28	-282.77018	-55.733235	3,247.4979	3,984.0852	312.66277	200
Slice 29	-278.30477	-54.733235	3,185.0979	3,499.2977	133.36992	200
Slice 30	-274.66223	-53.756109	3,124.1252	3,376.2076	107.00264	200
Slice						

31	-270.7676	-52.573818	3,050.3502	3,225.1865	74.213588	200
Slice 32	-266.87298	-51.239917	2,967.1148	3,053.0235	36.466071	200

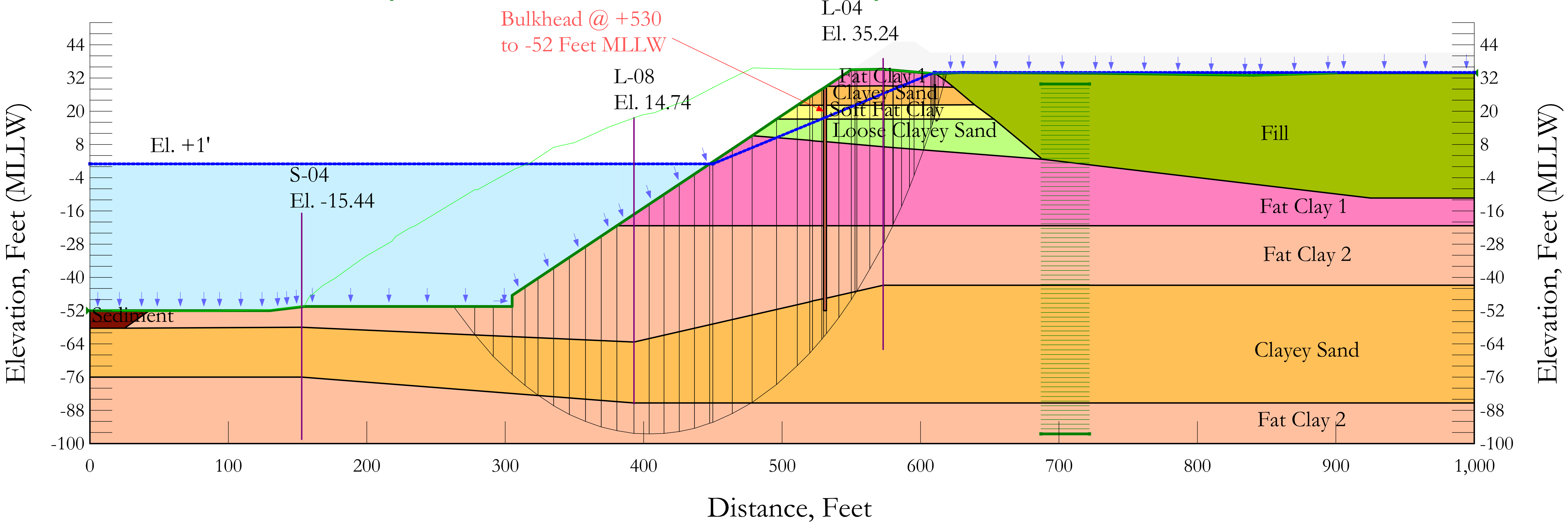
APPENDIX C

SLOPE STABILITY ANALYSIS: RECOMMENDED AT BARBOURS CUT CHANNEL

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
■	Clayey Sand	120	0	30				
■	Fat Clay 1(U)	125			1,000			
■	Fill	110				50	10	150
■	Sediment (U)	90			50			
■	Fat Clay 2 (U)	125			2,200			
■	Soft Fat Clay (U)	115			300			
■	Loose Clayey Sand	110	0	28				
■	Bulkhead	150						



Short Term 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 222
Date: 4/26/2018
Time: 4:51:35 PM
Tool Version: 8.16.1.13452
File Name: 34+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 4:51:46 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 34+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fill

Model: S=f(depth)

Unit Weight: 110 pcf

C-Top of Layer: 50 psf

C-Rate of Change: 10 (lbs/ft^2)/ft

C-Maximum: 150 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)

Unit Weight: 90 pcf

Cohesion: 50 psf

Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 300 psf
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (217.8737, 219.00031) ft
Lower Left: (217.8737, 60.51432) ft
Lower Right: (568.0477, 60.51432) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (687.0189, 29.85921) ft
Upper Right Coordinate: (722.1145, 29.85921) ft
Lower Left Coordinate: (687.0189, -96.57772) ft
Lower Right Coordinate: (722.1145, -96.57772) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft

Right Coordinate: (1,000, 33.75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	610	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74

Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	732	33.7
Point 56	1,000	41.14
Point 57	900	33.75
Point 58	530	28.40251
Point 59	530	22.15041
Point 60	530	17.21409
Point 61	530	9.05473
Point 62	530	-21.26
Point 63	530	-46
Point 64	532	-46
Point 65	532	-21.26
Point 66	532	8.97032
Point 67	532	17.2153
Point 68	532	22.15458
Point 69	532	-47.42944
Point 70	530	-47.65722
Point 71	530	-52
Point 72	532	-52
Point 73	520	25.0911
Point 74	522	25.75338
Point 75	520	22.12958
Point 76	522	22.13375
Point 77	520	17.19
Point 78	522	17.19482
Point 79	520	9.47676
Point 80	522	9.39235
Point 81	520	-21.26
Point 82	522	-21.26
Point 83	520	-48.79611

Point 84	522	-48.56833
Point 85	520	-50

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay 1(U)	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2 (U)	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,57,22,55,30	13,515
Region 4	Loose Clayey Sand	14,31,32,13,67,66	1,523.3
Region 5	Soft Fat Clay (U)	67,13,32,33,12,68	576.06
Region 6	Clayey Sand	33,18,11,49,68,12	675.61
Region 7	Clayey Sand	25,38,1,6,83,84,70,71,72,69,15,24,27,9,3,26	31,479
Region 8	Fat Clay 2 (U)	39,38,1,6,83,84,70,63,62,82,81,36,45,44,37,43,42	9,470.6
Region 9	Fat Clay 1(U)	66,14,31,23,41,34,35,65	9,001.7
Region 10	Sediment (U)	39,40,25,38	212.84
Region 11		51,50,10,21,20,30,53,52	502.37
Region 12		53,54,55,30	724.35
Region 13		54,55,22,57,17,56	2,150.4
Region 14	Clayey Sand	58,74,73,48,75,76,59	59.395
Region 15	Soft Fat Clay (U)	59,76,75,48,47,77,78,60	130.64
Region 16	Loose Clayey Sand	60,78,77,47,46,79,80,61	311.97
Region 17	Fat Clay 1(U)	61,80,79,46,36,81,82,62	3,210.6
Region 18	Bulkhead	49,58,59,60,61,62,63,70,71,72,69,64,65,66,67,68	161.47
Region 19	Fat Clay 2 (U)	65,35,34,24,15,69,64	10,158

Current Slip Surface

Slip Surface: 10,412
F of S: 1.85
Volume: 23,160.602 ft³
Weight: 2,846,552.4 lbs
Resisting Moment: 1.9716479e+008 lbs-ft
Activating Moment: 1.0671048e+008 lbs-ft
Resisting Force: 730,114.69 lbs
Activating Force: 397,334.76 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (262.70626, -50.5) ft
Entry: (619.09392, 33.7487) ft
Radius: 241.6179 ft
Center: (404.63317, 145.04018) ft

Slip Slices

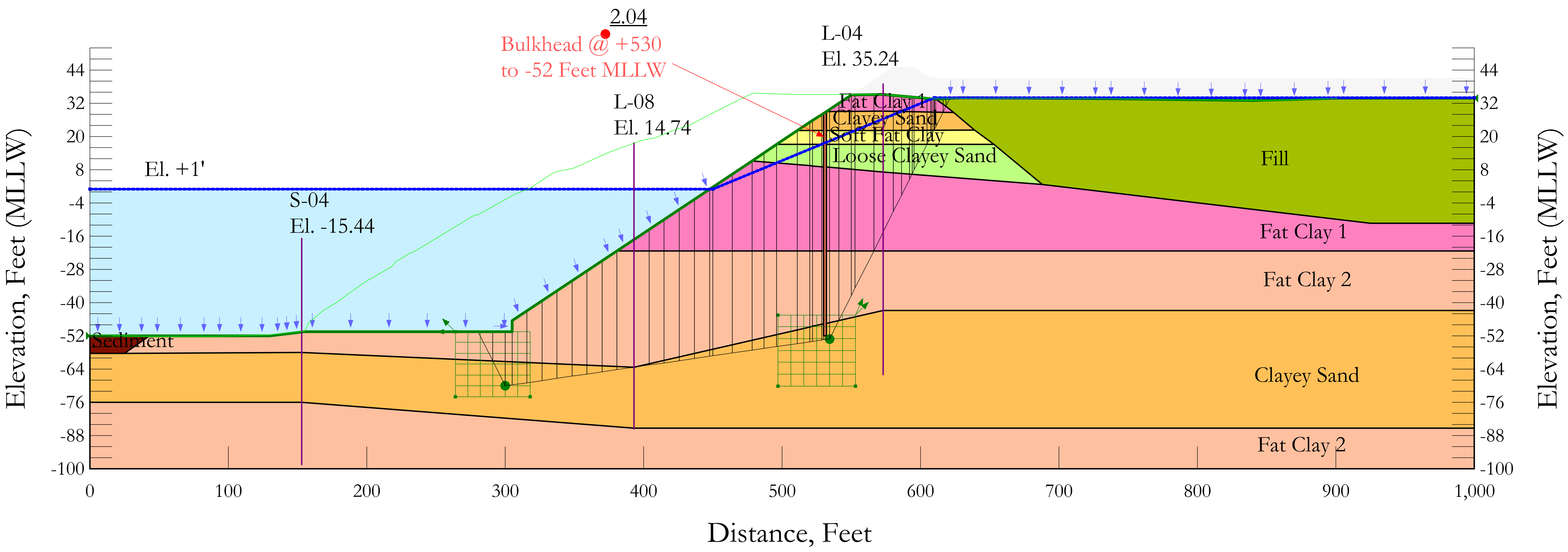
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	270.3412	-55.609945	3,532.4606	4,736.9221	0	2,200
Slice 2	284.7321	-64.584171	4,092.4523	5,408.8371	760.01511	0
Slice 3	298.24403	-71.763713	4,540.4557	6,462.0739	1,109.4468	0
Slice 4	309.63944	-77.063265	4,871.1478	7,828.9939	1,707.7132	0
Slice 5	318.91833	-80.808335	5,104.8401	8,510.0385	1,965.9922	0
Slice 6	329.274	-84.446218	5,331.844	9,251.0481	0	2,200

Slice 7	340.70644	-87.892101	5,546.8671	9,911.2659	0	2,200
Slice 8	352.13889	-90.733579	5,724.1753	10,459.32	0	2,200
Slice 9	363.57133	-92.992355	5,865.123	10,897.241	0	2,200
Slice 10	375.00378	-94.684943	5,970.7404	11,228.554	0	2,200
Slice 11	386.86	-95.84448	6,043.0955	11,463.169	0	2,200
Slice 12	398.45	-96.437057	6,080.0724	11,593.91	0	2,200
Slice 13	409.35	-96.470166	6,082.1384	11,627.87	0	2,200
Slice 14	420.25	-96.010638	6,053.4638	11,586.298	0	2,200
Slice 15	431.15	-95.055639	5,993.8719	11,474.829	0	2,200
Slice 16	442.05	-93.599208	5,902.9906	11,298.744	0	2,200
Slice 17	448.75	-92.512547	5,835.183	11,194.421	0	2,200
Slice 18	456.92889	-90.74361	5,576.7465	11,156.854	0	2,200
Slice 19	471.03889	-87.153065	5,536.0245	11,036.039	0	2,200
Slice 20	487.11	-81.867969	5,418.0866	10,649.641	3,020.4394	0
Slice 21	503.5	-75.27092	5,225.56	10,209.06	2,877.2248	0
Slice 22	515.5	-69.580652	5,033.1137	9,835.4252	2,772.6158	0
Slice 23	521	-66.706527	4,928.9829	9,650.3348	2,725.8738	0
Slice 24	525.29869	-64.255166	4,835.3263	9,488.1277	2,686.2961	0
Slice 25	529.29869	-61.930943	4,745.592	9,335.4553	2,649.9588	0
Slice 26	531	-60.894899	4,704.5831	11,103.203	3,694.2449	0
Slice 27	536.5	-57.3493	4,560.262	9,032.9561	2,582.3111	0
Slice 28	545.5	-51.18688	4,302.5211	8,624.8035	2,495.4709	0
Slice 29	551.38877	-46.894564	4,118.3054	8,294.4894	2,411.121	0
Slice 30	553.35434	-45.382211	4,052.0499	8,130.6921	2,354.8051	0
Slice 31	558.69835	-40.983512	3,854.7418	7,643.9517	0	2,200
Slice 32	568.23278	-32.646012	3,473.4114	6,614.7086	0	2,200
Slice 33	573.5	-27.768135	3,246.4746	6,007.4619	0	2,200
Slice 34	576.95713	-24.269769	3,079.7617	5,548.046	0	2,200
Slice 35	580.16713	-20.992657	2,923.2408	5,736.909	0	1,000

Slice 36	583.35475	-17.498364	2,753.4446	5,308.8879	0	1,000
Slice 37	589.14475	-10.892874	2,429.5572	4,494.3948	0	1,000
Slice 38	593.71	-5.3646595	2,155.0295	3,806.315	0	1,000
Slice 39	598.86104	1.4392056	1,811.3807	2,947.7199	0	1,000
Slice 40	604.86104	9.8843894	1,379.973	2,309.2452	494.10279	0
Slice 41	607.86868	14.373239	1,148.4268	1,893.291	396.05129	0
Slice 42	608.98698	16.132637	1,101.8858	1,751.2119	345.25282	0
Slice 43	609.8283	17.470354	1,029.2402	1,653.2044	0	300
Slice 44	610.5	18.560361	963.43345	1,531.3836	0	300
Slice 45	611.8768	20.837213	821.35788	1,269.682	0	300
Slice 46	614.60687	25.557076	526.83843	823.74738	171.42046	0
Slice 47	617.10084	29.997192	249.77521	-547.27684	0	1,000
Slice 48	618.41773	32.464582	95.810086	91.453579	0	62.666823

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
🟧	Clayey Sand	120	0	30				
🟪	Fat Clay 1(U)	125			1,000			
🟩	Fill	110				50	10	150
🟫	Sediment (U)	90			50			
🟧	Fat Clay 2 (U)	125			2,200			
🟨	Soft Fat Clay (U)	115			300			
🟩	Loose Clayey Sand	110	0	28				
🟥	Bulkhead	150						



Short Term - 34+00 Block

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 222
Date: 4/26/2018
Time: 4:51:35 PM
Tool Version: 8.16.1.13452
File Name: 34+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 4:52:34 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term - 34+00 Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fill

Model: S=f(depth)
Unit Weight: 110 pcf
C-Top of Layer: 50 psf
C-Rate of Change: 10 (lbs/ft²)/ft
C-Maximum: 150 psf
Pore Water Pressure
Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf

Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 115 pcf
Cohesion: 300 psf
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 33.75) ft

Slip Surface Block

Left Grid
Upper Left: (263.9875, -50.50385) ft
Lower Left: (263.9875, -73.9829) ft
Lower Right: (318.0132, -73.9829) ft
X Increments: 6
Y Increments: 6
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 2
Right Grid
Upper Left: (497.0051, -44.5153) ft
Lower Left: (497.0051, -70.2344) ft
Lower Right: (553.0725, -70.2344) ft
X Increments: 6

Y Increments: 6
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	610	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74

Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	732	33.7
Point 56	1,000	41.14
Point 57	900	33.75
Point 58	530	28.40251
Point 59	530	22.15041
Point 60	530	17.21409
Point 61	530	9.05473
Point 62	530	-21.26
Point 63	530	-46
Point 64	532	-46
Point 65	532	-21.26
Point 66	532	8.97032
Point 67	532	17.2153
Point 68	532	22.15458
Point 69	532	-47.42944
Point 70	530	-47.65722
Point 71	530	-52
Point 72	532	-52
Point 73	520	25.0911
Point 74	522	25.75338
Point 75	520	22.12958
Point 76	522	22.13375
Point 77	520	17.19
Point 78	522	17.19482
Point 79	520	9.47676
Point 80	522	9.39235
Point 81	520	-21.26
Point 82	522	-21.26
Point 83	520	-48.79611

Point 84	522	-48.56833
Point 85	520	-50

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay 1(U)	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2 (U)	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,57,22,55,30	13,515
Region 4	Loose Clayey Sand	14,31,32,13,67,66	1,523.3
Region 5	Soft Fat Clay (U)	67,13,32,33,12,68	576.06
Region 6	Clayey Sand	33,18,11,49,68,12	675.61
Region 7	Clayey Sand	25,38,1,6,83,84,70,71,72,69,15,24,27,9,3,26	31,479
Region 8	Fat Clay 2 (U)	39,38,1,6,83,84,70,63,62,82,81,36,45,44,37,43,42	9,470.6
Region 9	Fat Clay 1(U)	66,14,31,23,41,34,35,65	9,001.7
Region 10	Sediment (U)	39,40,25,38	212.84
Region 11		51,50,10,21,20,30,53,52	502.37
Region 12		53,54,55,30	724.35
Region 13		54,55,22,57,17,56	2,150.4
Region 14	Clayey Sand	58,74,73,48,75,76,59	59.395
Region 15	Soft Fat Clay (U)	59,76,75,48,47,77,78,60	130.64
Region 16	Loose Clayey Sand	60,78,77,47,46,79,80,61	311.97
Region 17	Fat Clay 1(U)	61,80,79,46,36,81,82,62	3,210.6
Region 18	Bulkhead	49,58,59,60,61,62,63,70,71,72,69,64,65,66,67,68	161.47
Region 19	Fat Clay 2 (U)	65,35,34,24,15,69,64	10,158

Current Slip Surface

Slip Surface: 4,948
F of S: 2.04
Volume: 16,277.121 ft³
Weight: 2,011,437.3 lbs
Resisting Moment: 85,852,988 lbs-ft
Activating Moment: 42,165,818 lbs-ft
Resisting Force: 618,971.02 lbs
Activating Force: 303,803.14 lbs
F of S Rank (Analysis): 1 of 21,609 slip surfaces
F of S Rank (Query): 1 of 21,609 slip surfaces
Exit: (280.43491, -50.5) ft
Entry: (621.27668, 33.804982) ft
Radius: 163.19631 ft
Center: (435.21658, 54.881227) ft

Slip Slices

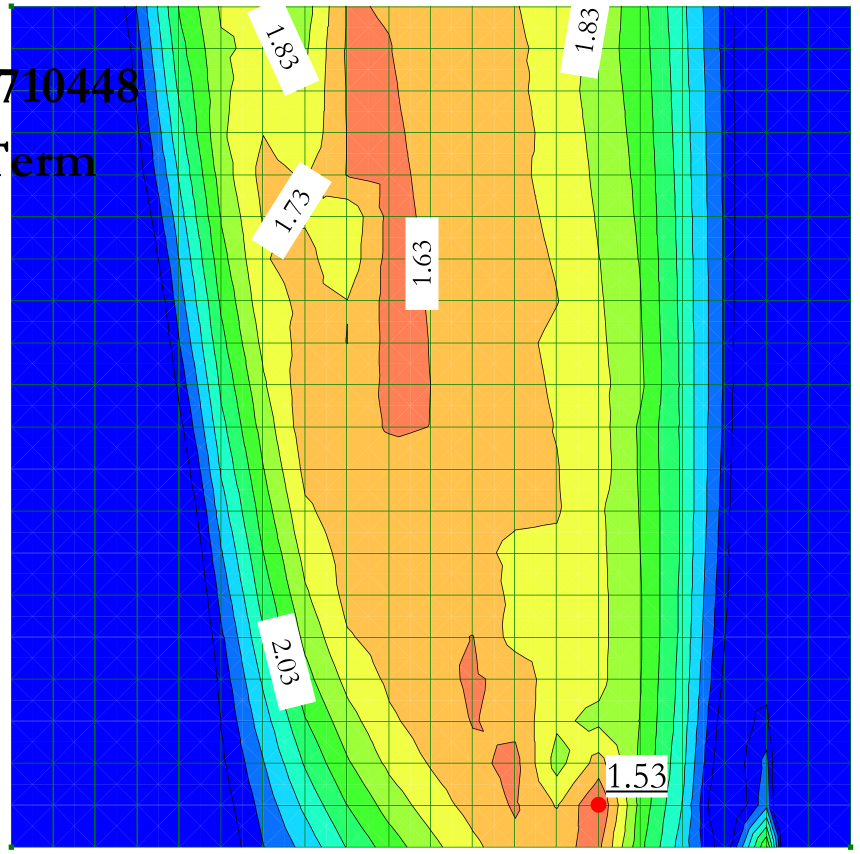
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	285.68801	-55.7531	3,541.3934	5,063.0146	0	2,200
Slice 2	295.47287	-65.537962	4,151.9688	5,892.9709	1,005.168	0
Slice 3	302.50232	-69.888761	4,423.4587	5,773.8371	779.64135	0
Slice 4	310.40857	-69.315931	4,387.7141	6,188.0412	1,039.4193	0
Slice 5	321.22571	-68.532199	4,338.8092	6,294.2091	1,128.9507	0
Slice 6	332.04286	-67.748467	4,289.9043	6,442.3939	1,242.7405	0

Slice 7	342.86	-66.964734	4,240.9994	6,584.1489	1,352.818	0
Slice 8	353.67714	-66.181002	4,192.0945	6,719.1031	1,458.9691	0
Slice 9	364.49429	-65.39727	4,143.1897	6,847.0161	1,561.0549	0
Slice 10	375.31143	-64.613538	4,094.2848	6,967.7868	1,659.0171	0
Slice 11	386.86	-63.776812	4,042.0731	7,088.8107	1,759.0347	0
Slice 12	398.45	-62.937084	3,989.6741	7,198.7765	1,852.7761	0
Slice 13	409.35	-62.147349	3,940.3946	7,291.2843	1,934.6371	0
Slice 14	420.25	-61.357613	3,891.1151	7,377.6738	2,012.9656	0
Slice 15	431.15	-60.567878	3,841.8356	7,458.609	2,088.1451	0
Slice 16	442.05	-59.778143	3,792.5561	7,534.875	2,160.6288	0
Slice 17	448.75	-59.292709	3,762.265	7,608.1296	2,220.411	0
Slice 18	457.055	-58.690989	3,659.8298	7,851.2586	2,419.9226	0
Slice 19	471.165	-57.66868	3,772.8267	8,250.4281	2,585.1444	0
Slice 20	482.665	-56.835473	3,864.9219	8,546.9607	2,703.1764	0
Slice 21	491.555	-56.191368	3,936.1155	8,743.3946	2,775.4839	0
Slice 22	503.5	-55.325919	4,031.7745	9,011.0208	2,874.7692	0
Slice 23	515.5	-54.456486	4,127.8738	9,290.5965	2,980.6994	0
Slice 24	521	-54.057995	4,171.9194	9,424.9939	3,032.864	0
Slice 25	525.29869	-53.746543	4,206.3445	9,529.6445	3,073.4087	0
Slice 26	529.29869	-53.456732	4,238.3777	9,626.8669	3,111.0457	0
Slice 27	531	-53.333468	4,252.0022	11,933.885	4,435.1368	0
Slice 28	533.19168	-53.174674	4,269.5538	9,721.9382	3,147.9356	0
Slice 29	537.72964	-49.742065	4,120.1192	7,629.6988	2,026.2567	0
Slice 30	545.53795	-41.933748	3,749.1538	7,084.6718	0	2,200
Slice 31	551.38877	-36.082929	3,471.1872	6,664.3858	0	2,200
Slice 32	559.49462	-27.977079	3,086.0863	5,848.6075	0	2,200
Slice 33	569.60585	-17.86585	2,605.7118	5,309.7655	0	1,000
Slice 34	576.71	-10.7617	2,268.2007	4,555.3418	0	1,000
Slice 35	583.35475	-4.1169467	1,952.515	3,810.9393	0	1,000
Slice						

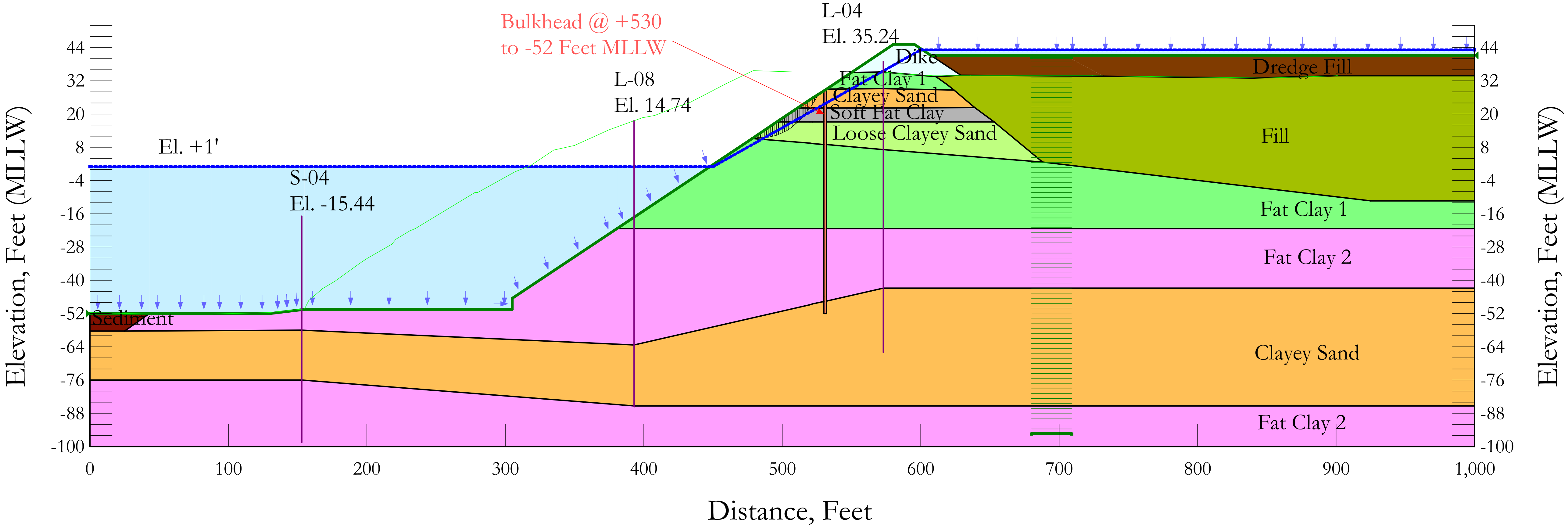
36	589.14475	1.6730533	1,677.4378	3,145.3878	0	1,000
Slice 37	592.94705	5.4753523	1,496.7944	2,700.3291	0	1,000
Slice 38	594.65705	7.1853523	1,415.5539	2,661.2675	662.35767	0
Slice 39	600.04605	12.574355	1,159.5278	2,159.6008	531.74826	0
Slice 40	606.04605	18.574355	874.47369	1,624.2652	0	300
Slice 41	607.86868	20.396976	787.88279	1,419.0485	0	300
Slice 42	609.04238	21.57068	763.26502	1,296.7778	0	300
Slice 43	609.8837	22.412004	721.59422	1,219.0999	287.23505	0
Slice 44	610.5	23.0283	684.63408	1,155.8124	272.03493	0
Slice 45	613.64366	26.171957	488.46987	820.10823	191.47149	0
Slice 46	617.35169	29.879994	257.08835	-26.472	0	1,000
Slice 47	619.84638	32.374678	101.4201	135.82933	0	63.934238

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	C-Top of Layer (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)
🟩	Fat Clay 1	125	300	22			
🟧	Clayey Sand	120	0	30			
🟫	Dredge Fill	90	16	15			
⬜	Dike	125	100	25			
🟩	Fill	110			50	10	150
🟪	Fat Clay 2	125	300	22			
🟩	Loose Clayey Sand	110	0	28			
⬜	Soft Fat Clay	115	100	15			
🟥	Sediment	90	16	15			
🟧	Bulkhead	150					



Long Term 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 222
Date: 4/26/2018
Time: 4:51:35 PM
Tool Version: 8.16.1.13452
File Name: 34+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 4:51:56 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 34+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dike

Model: Mohr-Coulomb

Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill

Model: S=f(depth)
Unit Weight: 110 pcf
C-Top of Layer: 50 psf
C-Rate of Change: 10 (lbs/ft²)/ft
C-Maximum: 150 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Soft Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength

Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (227.0672, 247.0971) ft
Lower Left: (227.0672, 62.00415) ft
Lower Right: (596.7231, 62.00415) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (680, 40.48201) ft
Upper Right Coordinate: (709, 40.48201) ft
Lower Left Coordinate: (680, -95.49981) ft
Lower Right Coordinate: (709, -95.49981) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74

Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76
Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74
Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	732	33.7
Point 56	1,000	41.14
Point 57	900	33.75

Point 58	530	28.40251
Point 59	530	22.15041
Point 60	530	17.21409
Point 61	530	9.05473
Point 62	530	-21.26
Point 63	530	-46
Point 64	532	-46
Point 65	532	-21.26
Point 66	532	8.97032
Point 67	532	17.2153
Point 68	532	22.15458
Point 69	532	-47.42944
Point 70	530	-47.65722
Point 71	530	-52
Point 72	532	-52
Point 73	520	25.0911
Point 74	522	25.75338
Point 75	520	22.12958
Point 76	522	22.13375
Point 77	520	17.19
Point 78	522	17.19482
Point 79	520	9.47676
Point 80	522	9.39235
Point 81	520	-21.26
Point 82	522	-21.26
Point 83	520	-48.79611
Point 84	522	-48.56833
Point 85	520	-50

Regions

	Material	Points	Area (ft^2)
Region 1	Fat Clay 1	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2	26,3,9,27,28,29	17,271
Region 3	Fill	20,19,18,33,32,31,23,41,17,57,22,55,30	13,515
Region 4	Loose Clayey Sand	14,31,32,13,67,66	1,523.3
Region 5	Soft Fat Clay	67,13,32,33,12,68	576.06
Region 6	Clayey Sand	33,18,11,49,68,12	675.61
Region 7	Clayey Sand	25,38,1,6,83,84,70,71,72,69,15,24,27,9,3,26	31,479
Region 8	Fat Clay 2	39,38,1,6,83,84,70,63,62,82,81,36,45,44,37,43,42	9,470.6
Region 9	Fat Clay 1	66,14,31,23,41,34,35,65	9,001.7
Region 10	Sediment	39,40,25,38	212.84
Region 11	Dike	51,50,10,21,20,30,53,52	502.37
Region 12	Dredge Fill	53,54,55,30	724.35
Region 13	Dredge Fill	54,55,22,57,17,56	2,150.4
Region 14	Clayey Sand	58,74,73,48,75,76,59	59.395
Region 15	Soft Fat Clay	59,76,75,48,47,77,78,60	130.64
Region 16	Loose Clayey Sand	60,78,77,47,46,79,80,61	311.97
Region 17	Fat Clay 1	61,80,79,46,36,81,82,62	3,210.6
Region 18	Bulkhead	49,58,59,60,61,62,63,70,71,72,69,64,65,66,67,68	161.47
Region 19	Fat Clay 2	65,35,34,24,15,69,64	10,158

Current Slip Surface

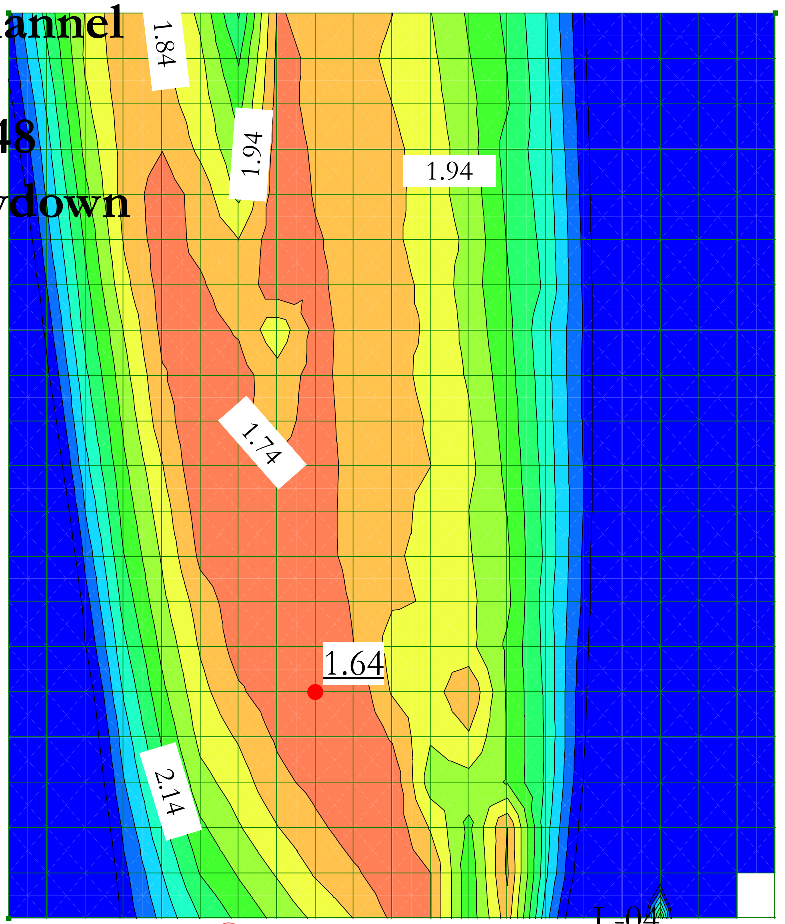
Slip Surface: 2,677
F of S: 1.53
Volume: 171.91782 ft^3
Weight: 19,444.326 lbs
Resisting Moment: 536,476.72 lbs-ft
Activating Moment: 351,010.55 lbs-ft
Resisting Force: 8,385.9081 lbs
Activating Force: 5,487.1604 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (479.81833, 11.775197) ft
Entry: (526.16624, 27.132993) ft
Radius: 59.786242 ft
Center: (485.82633, 71.258798) ft

Slip Slices

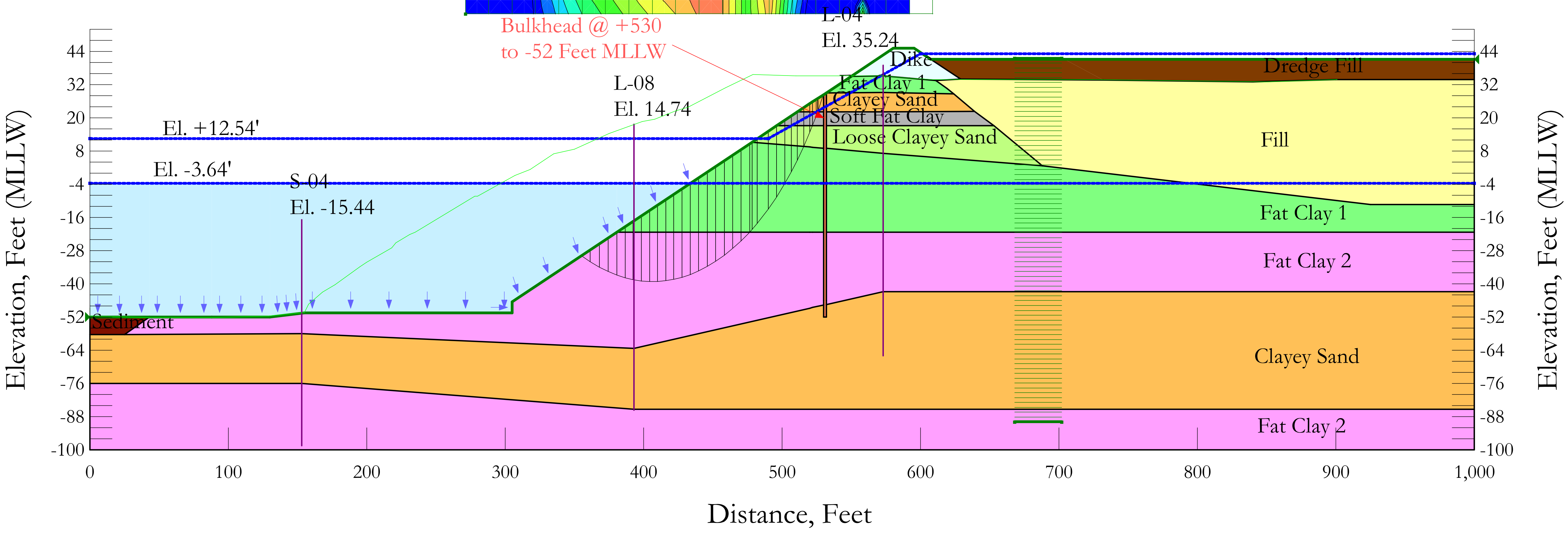
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	480.57115	11.708762	-122.62893	36.764221	19.547883	0
Slice 2	482.07679	11.595017	-91.586894	109.32624	58.129793	0
Slice 3	483.58243	11.519429	-62.751744	178.94486	95.146669	0
Slice 4	485.08807	11.481854	-36.115099	244.81061	130.16811	0
Slice 5	486.59371	11.482221	-11.672811	306.09936	162.75592	0
Slice 6	488.06765	11.518941	10.15198	360.31975	186.18751	0
Slice 7	489.5099	11.590514	29.445974	407.01307	200.75599	0
Slice 8	490.95214	11.69709	46.715505	447.66654	213.18944	0
Slice 9	492.39439	11.83886	61.949673	482.09446	223.39495	0
Slice 10	493.83663	12.016074	75.133857	510.26216	231.36182	0
Slice 11	495.27888	12.229053	86.249583	532.27664	237.15679	0
Slice 12	496.72725	12.479399	95.303668	549.03838	241.25502	0
Slice 13	498.18174	12.767891	102.25105	560.79375	243.81148	0
Slice 14	499.63623	13.094181	107.01241	567.21651	244.69486	0
Slice 15	501.09073	13.458909	109.5507	568.73799	244.15421	0
Slice 16	502.54522	13.862808	109.82351	565.79365	242.44363	0
Slice 17	503.99972	14.306712	107.78259	558.79424	239.80715	0
Slice 18	505.45421	14.791565	103.37335	548.10129	236.46604	0
Slice 19	506.9087	15.318434	96.53415	534.0073	232.6086	0
Slice 20	508.47696	15.936851	86.248631	515.06732	228.00694	0
Slice 21	510.15899	16.65597	71.987471	490.95518	222.76908	0
Slice 22	511.1715	17.111026	62.120337	475.42506	219.75802	0

Slice 23	512.06136	17.542142	51.644812	460.04459	109.43039	100
Slice 24	513.49806	18.268105	33.001842	431.35523	106.73847	100
Slice 25	514.93476	19.043687	11.48908	398.78725	103.77623	100
Slice 26	516.36014	19.864196	-12.806007	362.90989	97.241412	100
Slice 27	517.77419	20.73129	-39.979301	323.70994	86.737816	100
Slice 28	519.18825	21.653848	-70.36039	279.86298	74.98906	100
Slice 29	519.94764	22.165754	-87.6282	260.54288	150.4245	0
Slice 30	521	22.929945	-114.72685	222.28311	128.33521	0
Slice 31	522.69437	24.201768	-160.75327	158.28338	91.384954	0
Slice 32	524.08312	25.324102	-203.09974	99.342249	57.355274	0
Slice 33	525.47187	26.517702	-249.56794	34.19737	19.743861	0

Project Name: HSC - ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 34+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟩	Fat Clay 1	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟫	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟨	Fill (RDD)	110	50	25	100	20	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟩	Loose Clayey Sand	110	0	28	0	28	2
⬜	Soft Fat Clay	115	100	15	150	10	2
🟫	Sediment	90	16	15	50	0	2
🟥	Bulkhead	150					2



RDD 34+00

File Information

File Version: 8.16
Title: Barbours Cut Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 222
Date: 4/26/2018
Time: 4:51:35 PM
Tool Version: 8.16.1.13452
File Name: 34+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\34+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 4:52:28 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 34+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °

Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fill (RDD)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 50 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 100 psf
Phi R: 20 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Loose Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 28 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Soft Fat Clay

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 10 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (609.064, 256.88125) ft
Lower Left: (271.3642, 256.88125) ft
Lower Right: (271.3642, 57.51914) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (668, 41.5) ft
Upper Right Coordinate: (702, 41.5) ft
Lower Left Coordinate: (668, -90) ft
Lower Right Coordinate: (702, -90) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	490	12.54
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64
Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	153	-57.96
Point 2	228	-64.7
Point 3	153	-75.96
Point 4	228	-96.7
Point 5	393	14.74
Point 6	393	-63.26
Point 7	468	-67
Point 8	468	-82
Point 9	393	-85.26
Point 10	573	35.24
Point 11	573	29.24
Point 12	573	22.24
Point 13	573	17.24
Point 14	573	7.24
Point 15	573	-42.76
Point 16	648	-63.5
Point 17	1,000	33.75
Point 18	624	28.74
Point 19	619	30.74
Point 20	611	33.54
Point 21	592	34.34
Point 22	840	33
Point 23	925	-11.26
Point 24	1,000	-42.76

Point 25	0	-58.26
Point 26	0	-76.06
Point 27	1,000	-85.26
Point 28	1,000	-100
Point 29	0	-100
Point 30	628.84	34
Point 31	688	2.74
Point 32	653	17.14
Point 33	639	22.34
Point 34	1,000	-21.26
Point 35	574	-21.26
Point 36	380.72	-21.26
Point 37	155	-50.5
Point 38	25	-58.26
Point 39	43	-52
Point 40	0	-52
Point 41	1,000	-11.26
Point 42	88	-52
Point 43	130	-52
Point 44	305	-50.5
Point 45	305	-46.5
Point 46	478.22	11.24
Point 47	496	17.19361
Point 48	511	22.11083
Point 49	532	29.06479
Point 50	550	35
Point 51	580.42	45.14
Point 52	595.42	45.14
Point 53	607.42	41.14
Point 54	704	41.14
Point 55	732	33.7
Point 56	1,000	41.14
Point 57	900	33.75
Point 58	530	28.40251
Point 59	530	22.15041
Point 60	530	17.21409
Point 61	530	9.05473
Point 62	530	-21.26
Point 63	530	-46
Point 64	532	-46
Point 65	532	-21.26
Point 66	532	8.97032
Point 67	532	17.2153
Point 68	532	22.15458
Point 69	532	-47.42944
Point 70	530	-47.65722
Point 71	530	-52
Point 72	532	-52
Point 73	520	25.0911
Point 74	522	25.75338
Point 75	520	22.12958
Point 76	522	22.13375

Point 77	520	17.19
Point 78	522	17.19482
Point 79	520	9.47676
Point 80	522	9.39235
Point 81	520	-21.26
Point 82	522	-21.26
Point 83	520	-48.79611
Point 84	522	-48.56833
Point 85	520	-50

Regions

	Material	Points	Area (ft²)
Region 1	Fat Clay 1	18,19,20,21,10,50,49,11	422.29
Region 2	Fat Clay 2	26,3,9,27,28,29	17,271
Region 3	Fill (RDD)	20,19,18,33,32,31,23,41,17,57,22,55,30	13,515
Region 4	Loose Clayey Sand	14,31,32,13,67,66	1,523.3
Region 5	Soft Fat Clay	67,13,32,33,12,68	576.06
Region 6	Clayey Sand	33,18,11,49,68,12	675.61
Region 7	Clayey Sand	25,38,1,6,83,84,70,71,72,69,15,24,27,9,3,26	31,479
Region 8	Fat Clay 2	39,38,1,6,83,84,70,63,62,82,81,36,45,44,37,43,42	9,470.6
Region 9	Fat Clay 1	66,14,31,23,41,34,35,65	9,001.7
Region 10	Sediment	39,40,25,38	212.84
Region 11	Dike	51,50,10,21,20,30,53,52	502.37
Region 12	Dredge Fill	53,54,55,30	724.35
Region 13	Dredge Fill	54,55,22,57,17,56	2,150.4
Region 14	Clayey Sand	58,74,73,48,75,76,59	59.395
Region 15	Soft Fat Clay	59,76,75,48,47,77,78,60	130.64
Region 16	Loose Clayey Sand	60,78,77,47,46,79,80,61	311.97
Region 17	Fat Clay 1	61,80,79,46,36,81,82,62	3,210.6
Region 18	Bulkhead	49,58,59,60,61,62,63,70,71,72,69,64,65,66,67,68	161.47
Region 19	Fat Clay 2	65,35,34,24,15,69,64	10,158

Current Slip Surface

Slip Surface: 13,955
F of S: 1.64
Volume: 4,102.6339 ft³
Weight: 508,252.1 lbs
Resisting Moment: 25,791,857 lbs-ft
Activating Moment: 15,764,925 lbs-ft
Resisting Force: 159,603.68 lbs
Activating Force: 97,696.375 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (355.01213, -29.82929) ft
Entry: (529.82413, 28.344272) ft
Radius: 146.513 ft
Center: (406.44412, 107.35967) ft

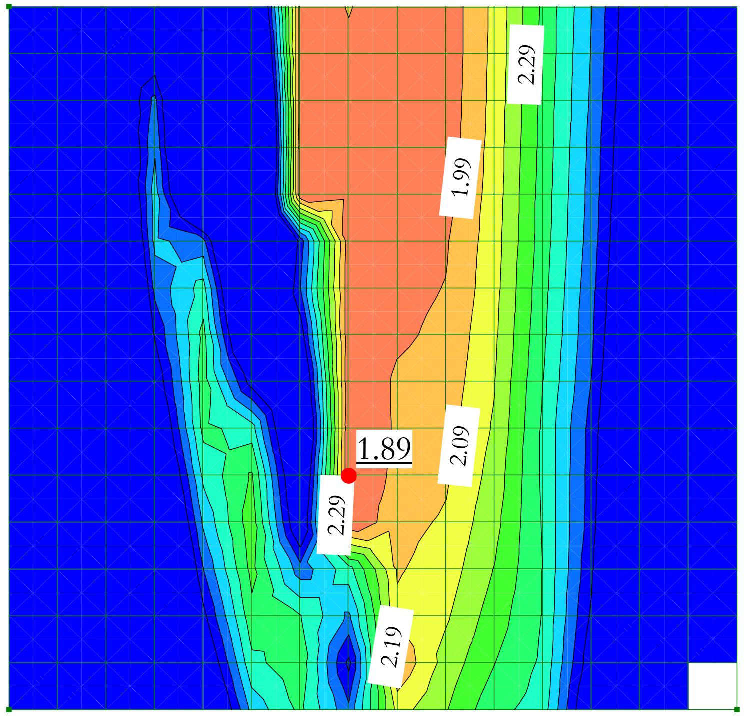
Slip Slices

				Base Normal Stress	Frictional Strength	Cohesive Strength

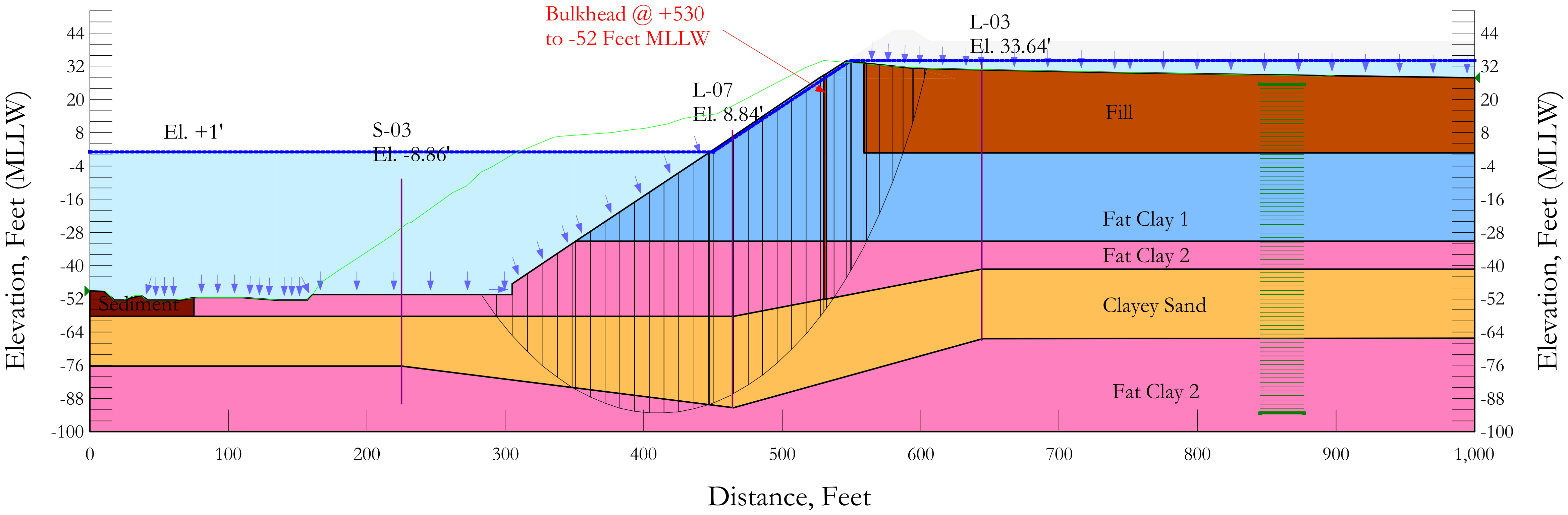
	X (ft)	Y (ft)	PWP (psf)	(psf)	(psf)	(psf)
Slice 1	358.22561	-30.9496	1,704.1191	1,966.89	106.16634	300
Slice 2	364.65258	-33.026533	1,833.7196	2,456.2319	251.51131	300
Slice 3	371.07955	-34.782659	1,943.3019	2,894.1155	384.15365	300
Slice 4	377.50652	-36.229777	2,033.6021	3,274.8362	501.49114	300
Slice 5	383.65667	-37.339861	2,102.8713	3,582.5158	597.81519	300
Slice 6	389.53	-38.143705	2,153.0312	3,820.7345	673.79588	300
Slice 7	395.40333	-38.707054	2,188.1842	4,004.7847	733.95424	300
Slice 8	401.27667	-39.032689	2,208.5038	4,135.3623	778.50136	300
Slice 9	407.15	-39.122198	2,214.0892	4,214.3959	808.17639	300
Slice 10	413.02333	-38.976015	2,204.9673	4,244.8417	824.16276	300
Slice 11	418.89667	-38.59343	2,181.094	4,230.4154	827.97959	300
Slice 12	424.77	-37.972574	2,142.3526	4,175.2914	821.36059	300
Slice 13	430.64333	-37.110369	2,088.551	4,083.7986	806.13234	300
Slice 14	436.65346	-35.970682	2,017.4346	4,022.5394	810.11494	300
Slice 15	442.80039	-34.535415	1,927.8739	3,990.1084	833.19683	300
Slice 16	448.94732	-32.816017	1,820.5835	3,924.6683	0	1,147.5716
Slice 17	455.09425	-30.801857	1,694.8998	3,831.2478	0	1,121.7644
Slice 18	461.24118	-28.47979	1,550.0029	3,711.3287	0	1,093.2166
Slice 19	467.38811	-25.833672	1,384.8852	3,565.9253	0	1,062.4052
Slice 20	473.53504	-22.843688	1,198.3102	3,394.9407	0	1,029.5251
Slice 21	477.41425	-20.813854	1,071.6485	3,277.9283	0	1,008.3809
Slice 22	480.16118	-19.237368	973.27575	3,174.5571	0	988.88832
Slice 23	486.05118	-15.549411	743.14724	2,914.2761	0	966.9569
Slice 24	493	-10.794085	446.41488	2,564.7772	0	969.09866
Slice 25	499.03715	-6.1181875	154.6389	2,228.3632	0	913.82216
Slice 26	504.39859	-1.5495115	-130.44648	1,891.5272	0	860.65604
Slice 27	508.86143	2.6323737	-391.39612	1,518.3815	613.46593	300
Slice 28	513.31392	7.1925243	-675.94952	1,193.0501	482.02353	300
Slice 29	517.81392	12.220297	-989.68253	954.68525	507.61515	0
Slice 30	521	16.033678	-1,227.6375	745.42814	396.35117	0
Slice 31	523.25305	18.943476	-1,409.2089	611.10787	163.74586	100

Slice 32	525.06514	21.370104	-1,560.6305	444.81384	119.18751	100
Slice 33	525.76138	22.333812	-1,620.7659	367.70868	212.2967	0
Slice 34	527.86135	25.4353	-1,814.2987	175.85632	101.53069	0

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Fat Clay 1 (U)	125			1,000
🟪	Fat Clay 2 (U)	125			2,200
🟫	Fill (U)	110			300
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			



Short Term 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Nitharsan Kanapathippillai
Revision Number: 193
Date: 4/27/2018
Time: 8:23:07 AM
Tool Version: 8.16.1.13452
File Name: 44+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\Rec\
Last Solved Date: 4/27/2018
Last Solved Time: 8:23:30 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 44+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

            Tension Crack Option: (none)
    F of S Distribution
        F of S Calculation Option: Constant
    Advanced
        Number of Slices: 30
        F of S Tolerance: 0.001
        Minimum Slip Surface Depth: 0.1 ft
        Search Method: Linear Search
        Must Obtain Factor of Safety at Lambda: 0.2
        Lambda
            Lambda 1: -1
            Lambda 2: -0.8
            Lambda 3: -0.6
            Lambda 4: -0.4
            Lambda 5: -0.2
            Lambda 6: 0
            Lambda 7: 0.2
            Lambda 8: 0.4
            Lambda 9: 0.6
            Lambda 10: 0.8
            Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 1 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
    Piezometric Line: 1

Fill (U)

Model: Undrained (Phi=0)
Unit Weight: 110 pcf
Cohesion: 300 psf
Pore Water Pressure
    Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (245.9759, 233.47631) ft
Lower Left: (245.9759, 63.16979) ft
Lower Right: (598.7619, 63.16979) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (845.056, 25.44217) ft
Upper Right Coordinate: (877.0413, 25.44217) ft
Lower Left Coordinate: (845.056, -93.25256) ft
Lower Right Coordinate: (877.0413, -93.25256) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 27.94) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	550	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	559	27.72993
Point 26	559	0.74
Point 27	559	33.14
Point 28	110	-51.6
Point 29	75	-51.6
Point 30	75	-58.26
Point 31	0	-49.2
Point 32	305	-50.5
Point 33	305	-46.5
Point 34	350.72	-31.26
Point 35	446.72	0.74
Point 36	546.2	33.9
Point 37	161	-50.5
Point 38	157	-52.4
Point 39	42	-52.4
Point 40	66	-52.4
Point 41	37	-50.8
Point 42	24	-52.4
Point 43	18	-52.5
Point 44	10	-49.29
Point 45	527.69	28
Point 46	579.92	45.14
Point 47	594.92	45.14
Point 48	745.7421	29.59999
Point 49	638.12	30.74

Point 50	606.92	41.14
Point 51	696.5	41.14
Point 52	530	28.7363
Point 53	530	27.98007
Point 54	532	29.37379
Point 55	532	27.96282
Point 56	530	0.74
Point 57	532	0.74
Point 58	530	-31.26
Point 59	532	-31.26
Point 60	530	-52
Point 61	532	-52

Regions

	Points	Area (ft^2)	Material
Region 1	51,48,6,10	3,429.3	
Region 2	12,5,4,2,13,14,15	25,013	Fat Clay 2 (U)
Region 3	12,16,17,61,60,3,1,30,18,13,2,4,5	24,297	Clayey Sand
Region 4	58,21,34,33,32,37,38,22,28,29,30,1,3,60	7,186.4	Fat Clay 2 (U)
Region 5	59,20,19,23,24,26,57	14,976	Fat Clay 1 (U)
Region 6	25,55,57,26	731.87	Fat Clay 1 (U)
Region 7	25,7,8,9,27	219.6	Fill (U)
Region 8	25,55,54,36,27	126.45	Fat Clay 1 (U)
Region 9	30,29,40,39,41,42,43,44,31,18	500.79	Sediment (U)
Region 10	9,8,7,25,26,24,23,6,48,49	12,517	Fill (U)
Region 11	46,36,27,9,49,50,47	719.15	
Region 12	50,51,48,49	1,058.7	
Region 13	54,52,53,56,58,60,61,59,57,55	162.11	Bulkhead
Region 14	52,45,53	0.87345	Fat Clay 1 (U)
Region 15	45,35,56,53	1,166.6	Fat Clay 1 (U)
Region 16	56,35,34,21,58	4,201	Fat Clay 1 (U)
Region 17	19,20,59,61,17,16	5,281.4	Fat Clay 2 (U)

Current Slip Surface

Slip Surface: 6,688
F of S: 1.89
Volume: 20,714.609 ft^3
Weight: 2,548,799.3 lbs
Resisting Moment: 1.5970862e+008 lbs-ft
Activating Moment: 84,689,386 lbs-ft
Resisting Force: 672,578.33 lbs
Activating Force: 358,543.5 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (282.54237, -50.5) ft
Entry: (604.47745, 31.250124) ft
Radius: 213.19119 ft
Center: (410.60937, 119.93863) ft

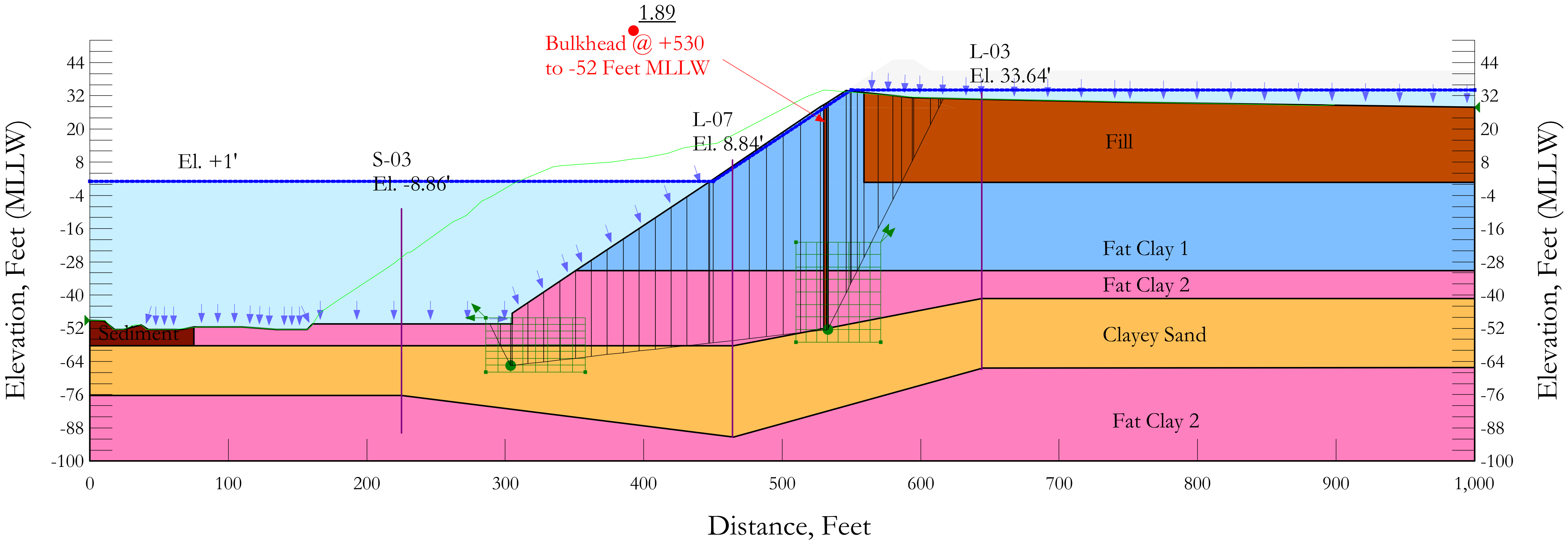
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	288.06148	-54.38	3,455.712	4,596.6033	0	2,200
Slice 2	299.2903	-61.758127	3,916.1071	5,006.5538	629.56968	0
Slice 3	310.42408	-68.145456	4,314.6765	6,565.4308	1,299.4736	0
Slice 4	321.27224	-73.539191	4,651.2455	7,624.1261	1,716.3934	0
Slice 5	332.12039	-78.192455	4,941.6092	8,583.8722	2,102.8615	0
Slice 6	342.96855	-82.156613	5,188.9726	9,395.0779	2,428.396	0
Slice 7	349.55631	-84.319866	5,323.9596	9,741.0255	0	2,200
Slice 8	356.05333	-86.080019	5,433.7932	10,075.377	0	2,200
Slice 9	366.72	-88.614727	5,591.959	10,547.226	0	2,200
Slice 10	377.38667	-90.578787	5,714.5163	10,904.467	0	2,200
Slice 11	388.05333	-91.988108	5,802.4579	11,152.051	0	2,200
Slice 12	398.72	-92.853741	5,856.4734	11,296.34	0	2,200
Slice 13	409.38667	-93.182329	5,876.9773	11,344.68	0	2,200
Slice 14	420.05333	-92.976364	5,864.1251	11,304.937	0	2,200
Slice 15	430.72	-92.234285	5,817.8194	11,185.048	0	2,200
Slice 16	441.38667	-90.950419	5,737.7062	10,992.582	0	2,200
Slice 17	446.83614	-90.152043	5,687.8875	10,876.941	0	2,200
Slice 18	447.22227	-90.084948	5,683.7008	10,864.098	2,990.904	0
Slice 19	448.74614	-89.809901	5,666.5378	10,851.551	2,993.5686	0
Slice 20	457	-88.020391	5,139.342	10,772.941	3,252.5599	0
Slice 21	464.5	-86.328226	5,183.3938	10,700.88	3,185.5221	0
Slice 22	470.22417	-84.67552	5,196.6891	10,607.498	3,123.9318	0
Slice 23	480.6725	-81.33492	5,202.7298	10,413.638	3,008.5193	0
Slice 24	491.12083	-77.38484	5,174.474	10,174.056	2,886.5099	0
Slice 25	501.56917	-72.787671	5,109.8052	9,889.6532	2,759.6465	0
Slice 26	512.0175	-67.495607	5,006.0332	9,559.1989	2,628.7714	0
Slice 27	522.46583	-61.447543	4,859.7196	9,178.9843	2,493.7286	0
Slice 28	528.845	-57.456105	4,753.5731	8,928.0427	2,410.1311	0
Slice 29	531	-56.002015	4,711.7664	10,453.825	3,315.1792	0
Slice 30	534.67626	-53.402239	4,633.7391	8,660.7335	2,324.9863	0
Slice 31	541.77626	-48.032277	4,463.406	8,292.5762	0	2,200

Slice 32	547.68186	-43.333753	4,308.6762	7,861.6915	0	2,200
Slice 33	549.58186	-41.730245	4,716.957	7,659.7028	0	2,200
Slice 34	554.5	-37.251544	4,446.0963	7,097.7834	0	2,200
Slice 35	559.95363	-32.19614	4,130.6391	6,000.3344	0	2,200
Slice 36	565.66045	-26.217542	3,757.5746	5,844.8152	0	1,000
Slice 37	575.16682	-15.395524	3,082.2807	4,569.8427	0	1,000
Slice 38	583.64196	-4.4379822	2,398.5301	3,245.5693	0	1,000
Slice 39	590.59931	5.8439925	1,756.9349	2,594.7148	0	300
Slice 40	594.37735	11.870754	1,380.865	1,963.0394	0	300
Slice 41	598.84381	20.198751	861.19794	1,063.0677	0	300
Slice 42	603.373	28.885592	319.13904	95.92716	0	300
Slice 43	604.22791	30.708665	205.37932	-113.51644	0	300

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Fat Clay 1 (U)	125			1,000
🟪	Fat Clay 2 (U)	125			2,200
🟫	Fill (U)	110			300
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			



Short Term 44+00 Block

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 199
Date: 4/27/2018
Time: 3:09:52 PM
Tool Version: 8.16.1.13452
File Name: 44+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\Rec\
Last Solved Date: 4/27/2018
Last Solved Time: 3:10:08 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 44+00 Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Restrict Block Crossing: No
- Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 1 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure
Piezometric Line: 1

Fill (U)

Model: Undrained (Phi=0)
Unit Weight: 110 pcf
Cohesion: 300 psf
Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 27.94) ft

Slip Surface Block

Left Grid
Upper Left: (285.8115, -48.22191) ft
Lower Left: (285.8115, -67.92193) ft
Lower Right: (357.9455, -67.92193) ft
X Increments: 8
Y Increments: 8
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 2
Right Grid
Upper Left: (509.9823, -20.98882) ft
Lower Left: (509.9823, -57.01488) ft
Lower Right: (571.0258, -57.01488) ft
X Increments: 8
Y Increments: 8
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	550	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	559	27.72993
Point 26	559	0.74
Point 27	559	33.14
Point 28	110	-51.6
Point 29	75	-51.6
Point 30	75	-58.26
Point 31	0	-49.2
Point 32	305	-50.5
Point 33	305	-46.5
Point 34	350.72	-31.26
Point 35	446.72	0.74
Point 36	546.2	33.9
Point 37	161	-50.5
Point 38	157	-52.4
Point 39	42	-52.4
Point 40	66	-52.4
Point 41	37	-50.8
Point 42	24	-52.4
Point 43	18	-52.5
Point 44	10	-49.29
Point 45	527.69	28
Point 46	579.92	45.14
Point 47	594.92	45.14
Point 48	745.7421	29.59999
Point 49	638.12	30.74

Point 50	606.92	41.14
Point 51	696.5	41.14
Point 52	530	28.7363
Point 53	530	27.98007
Point 54	532	29.37379
Point 55	532	27.96282
Point 56	530	0.74
Point 57	532	0.74
Point 58	530	-31.26
Point 59	532	-31.26
Point 60	530	-52
Point 61	532	-52

Regions

	Points	Area (ft²)	Material
Region 1	51,48,6,10	3,429.3	
Region 2	12,5,4,2,13,14,15	25,013	Fat Clay 2 (U)
Region 3	12,16,17,61,60,3,1,30,18,13,2,4,5	24,297	Clayey Sand
Region 4	58,21,34,33,32,37,38,22,28,29,30,1,3,60	7,186.4	Fat Clay 2 (U)
Region 5	59,20,19,23,24,26,57	14,976	Fat Clay 1 (U)
Region 6	25,55,57,26	731.87	Fat Clay 1 (U)
Region 7	25,7,8,9,27	219.6	Fill (U)
Region 8	25,55,54,36,27	126.45	Fat Clay 1 (U)
Region 9	30,29,40,39,41,42,43,44,31,18	500.79	Sediment (U)
Region 10	9,8,7,25,26,24,23,6,48,49	12,517	Fill (U)
Region 11	46,36,27,9,49,50,47	719.15	
Region 12	50,51,48,49	1,058.7	
Region 13	54,52,53,56,58,60,61,59,57,55	162.11	Bulkhead
Region 14	52,45,53	0.87345	Fat Clay 1 (U)
Region 15	45,35,56,53	1,166.6	Fat Clay 1 (U)
Region 16	56,35,34,21,58	4,201	Fat Clay 1 (U)
Region 17	19,20,59,61,17,16	5,281.4	Fat Clay 2 (U)

Current Slip Surface

Slip Surface: 8,056
F of S: 1.89
Volume: 15,212.908 ft³
Weight: 1,883,278.7 lbs
Resisting Moment: 69,868,848 lbs-ft
Activating Moment: 36,982,326 lbs-ft
Resisting Force: 537,418.04 lbs
Activating Force: 284,288.43 lbs
F of S Rank (Analysis): 1 of 59,049 slip surfaces
F of S Rank (Query): 1 of 59,049 slip surfaces
Exit: (288.88557, -50.5) ft
Entry: (616.45376, 31.068526) ft
Radius: 156.64053 ft
Center: (437.43599, 51.460658) ft

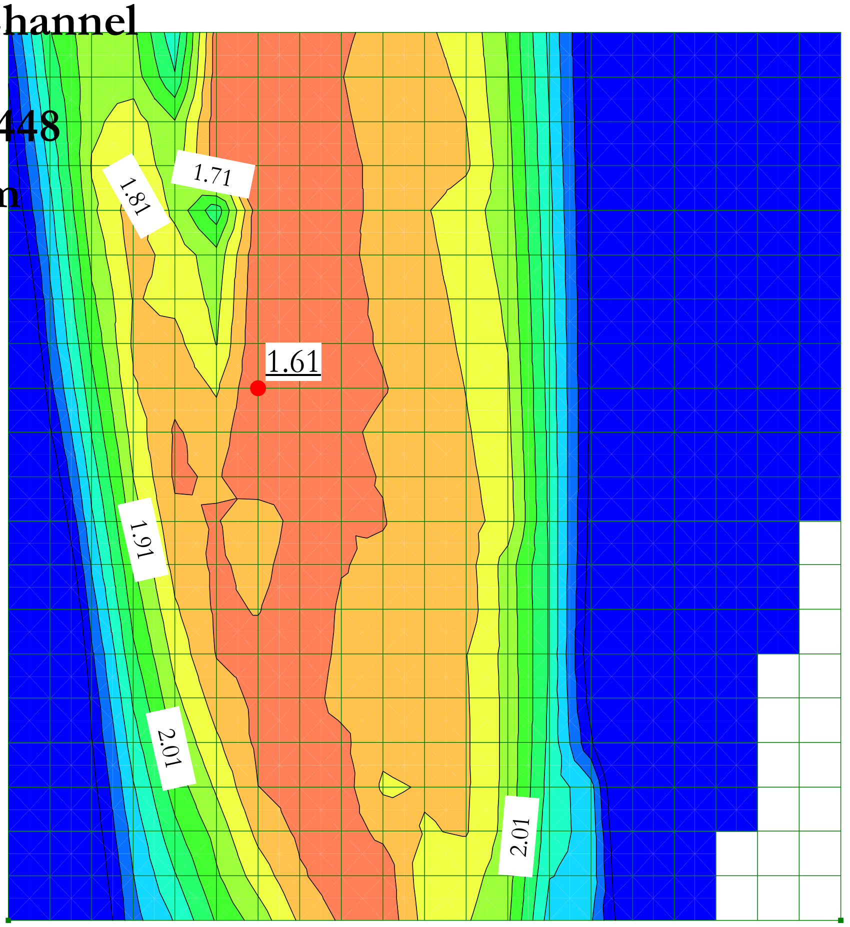
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	292.76557	-54.38	3,455.712	4,949.2429	0	2,200
Slice 2	300.24529	-61.859714	3,922.4461	5,265.7393	775.55069	0
Slice 3	304.4225	-65.426779	4,145.031	5,185.2029	600.54353	0
Slice 4	310.715	-65.071042	4,122.833	5,609.2849	858.20343	0
Slice 5	322.145	-64.424863	4,082.5115	5,770.9548	974.82319	0
Slice 6	333.575	-63.778684	4,042.1899	5,957.9998	1,106.0933	0
Slice 7	345.005	-63.132506	4,001.8684	6,138.2859	1,233.4612	0
Slice 8	356.46806	-62.484458	3,961.4302	6,311.5498	1,356.8422	0
Slice 9	367.96418	-61.834541	3,920.8754	6,477.1395	1,475.8598	0
Slice 10	379.4603	-61.184625	3,880.3206	6,634.1299	1,589.9125	0
Slice 11	390.95642	-60.534708	3,839.7658	6,782.3161	1,698.8822	0
Slice 12	402.45253	-59.884792	3,799.211	6,921.7126	1,802.7771	0
Slice 13	413.94865	-59.234875	3,758.6562	7,052.5592	1,901.7358	0
Slice 14	425.44477	-58.584958	3,718.1014	7,175.3205	1,996.0264	0
Slice 15	438.95642	-57.821097	3,670.4364	7,314.6872	0	2,200
Slice 16	447.10614	-57.360364	3,641.6867	7,385.7627	0	2,200
Slice 17	448.74614	-57.267649	3,635.9013	7,427.5928	0	2,200
Slice 18	457	-56.801029	3,382.5667	7,679.2556	0	2,200
Slice 19	470.13154	-56.058656	3,584.6414	8,075.3286	0	2,200
Slice 20	482.39463	-55.36538	3,773.3519	8,440.8161	0	2,200
Slice 21	494.65772	-54.672104	3,962.0624	8,803.3768	0	2,200
Slice 22	506.9208	-53.978827	4,150.7728	9,164.31	0	2,200
Slice 23	520.37117	-53.21843	4,357.7538	9,595.7665	3,024.168	0
Slice 24	528.845	-52.739374	4,488.1533	9,835.1943	3,087.1156	0
Slice 25	531	-52.617545	4,521.3155	11,953.342	4,290.8828	0
Slice 26	532.43681	-52.536317	4,543.4258	9,928.792	3,109.2426	0
Slice 27	533.20289	-52.18235	4,537.7333	7,899.3724	1,940.8433	0
Slice 28	539.86608	-45.519156	4,286.516	7,373.9889	0	2,200
Slice 29	547.68186	-37.703373	3,991.8436	6,815.4885	0	2,200
Slice 30	549.58186	-35.803373	4,347.1202	6,622.6707	0	2,200
Slice 31	552.06262	-33.322618	4,200.9313	6,373.5238	0	2,200

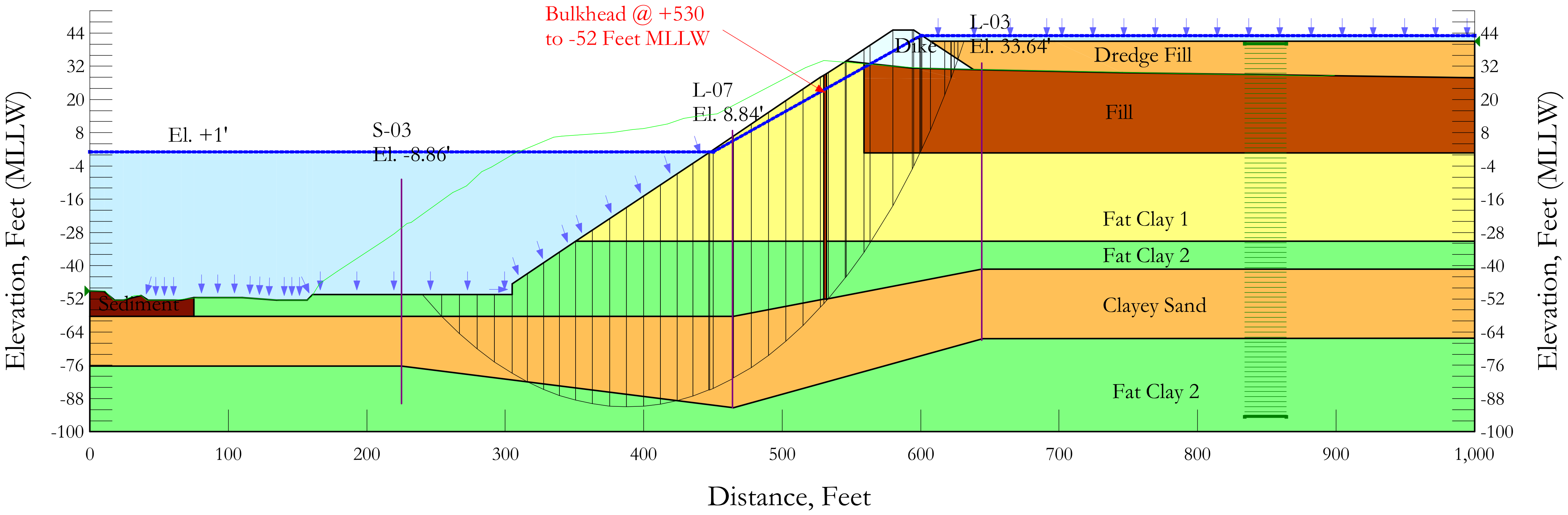
Slice 32	556.56262	-28.822618	3,920.1313	6,424.3315	0	1,000
Slice 33	564.23	-21.155235	3,441.6867	5,192.5661	0	1,000
Slice 34	574.69	-10.695235	2,788.9827	4,084.276	0	1,000
Slice 35	583.02262	-2.3626175	2,269.0273	3,170.0582	0	1,000
Slice 36	589.97997	4.5947325	1,834.8887	2,776.0122	0	300
Slice 37	594.37735	8.992115	1,560.492	2,340.2052	0	300
Slice 38	600.92	15.534765	1,152.2307	1,678.1749	0	300
Slice 39	609.93994	24.554707	589.38631	734.93877	0	300
Slice 40	613.62385	28.238614	359.51051	336.36834	0	300
Slice 41	615.37079	29.985553	250.50151	144.09181	0	300

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448

Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Fat Clay 1	125	300	22
🟩	Fat Clay 2	125	300	22
🟧	Clayey Sand	120	0	30
🟧	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟫	Fill	110	100	20
🟫	Sediment	90	16	15
🟥	Bulkhead	150		



Long Term 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Nitharsan Kanapathippillai
Revision Number: 193
Date: 4/27/2018
Time: 8:23:07 AM
Tool Version: 8.16.1.13452
File Name: 44+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\Rec\
Last Solved Date: 4/27/2018
Last Solved Time: 8:23:25 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 44+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

        Tension Crack Option: (none)
    F of S Distribution
        F of S Calculation Option: Constant
    Advanced
        Number of Slices: 30
        F of S Tolerance: 0.001
        Minimum Slip Surface Depth: 0.1 ft
        Search Method: Linear Search
        Must Obtain Factor of Safety at Lambda: 0.2
        Lambda
            Lambda 1: -1
            Lambda 2: -0.8
            Lambda 3: -0.6
            Lambda 4: -0.4
            Lambda 5: -0.2
            Lambda 6: 0
            Lambda 7: 0.2
            Lambda 8: 0.4
            Lambda 9: 0.6
            Lambda 10: 0.8
            Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 20 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (267.004, 285.00146) ft
Lower Left: (267.004, 69.97217) ft
Lower Right: (670.0211, 69.97217) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (834.0689, 40.15019) ft
Upper Right Coordinate: (864.0265, 40.15019) ft

Lower Left Coordinate: (834.0689, -94.59981) ft
Lower Right Coordinate: (864.0265, -94.59981) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74

Point 24	644	0.74
Point 25	559	27.72993
Point 26	559	0.74
Point 27	559	33.14
Point 28	110	-51.6
Point 29	75	-51.6
Point 30	75	-58.26
Point 31	0	-49.2
Point 32	305	-50.5
Point 33	305	-46.5
Point 34	350.72	-31.26
Point 35	446.72	0.74
Point 36	546.2	33.9
Point 37	161	-50.5
Point 38	157	-52.4
Point 39	42	-52.4
Point 40	66	-52.4
Point 41	37	-50.8
Point 42	24	-52.4
Point 43	18	-52.5
Point 44	10	-49.29
Point 45	527.69	28
Point 46	579.92	45.14
Point 47	594.92	45.14
Point 48	745.7421	29.59999
Point 49	638.12	30.74
Point 50	606.92	41.14
Point 51	696.5	41.14
Point 52	530	28.7363
Point 53	530	27.98007
Point 54	532	29.37379
Point 55	532	27.96282
Point 56	530	0.74
Point 57	532	0.74
Point 58	530	-31.26
Point 59	532	-31.26
Point 60	530	-52
Point 61	532	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Dredge Fill	51,48,6,10	3,429.3
Region 2	Fat Clay 2	12,5,4,2,13,14,15	25,013
Region 3	Clayey Sand	12,16,17,61,60,3,1,30,18,13,2,4,5	24,297
Region 4	Fat Clay 2	58,21,34,33,32,37,38,22,28,29,30,1,3,60	7,186.4
Region 5	Fat Clay 1	59,20,19,23,24,26,57	14,976
Region 6	Fat Clay 1	25,55,57,26	731.87
Region 7	Fill	25,7,8,9,27	219.6
Region 8	Fat Clay 1	25,55,54,36,27	126.45
Region 9	Sediment	30,29,40,39,41,42,43,44,31,18	500.79
Region 10	Fill	9,8,7,25,26,24,23,6,48,49	12,517

Region 11	Dike	46,36,27,9,49,50,47	719.15
Region 12	Dredge Fill	50,51,48,49	1,058.7
Region 13	Bulkhead	54,52,53,56,58,60,61,59,57,55	162.11
Region 14	Fat Clay 1	52,45,53	0.87345
Region 15	Fat Clay 1	45,35,56,53	1,166.6
Region 16	Fat Clay 1	56,35,34,21,58	4,201
Region 17	Fat Clay 2	19,20,59,61,17,16	5,281.4

Current Slip Surface

Slip Surface: 19,682
F of S: 1.61
Volume: 22,874.038 ft³
Weight: 2,806,884.2 lbs
Resisting Moment: 2.2761775e+008 lbs-ft
Activating Moment: 1.4145326e+008 lbs-ft
Resisting Force: 725,764.49 lbs
Activating Force: 451,225.1 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (240.08262, -50.5) ft
Entry: (631.18113, 41.14) ft
Radius: 289.99622 ft
Center: (387.90913, 198.98974) ft

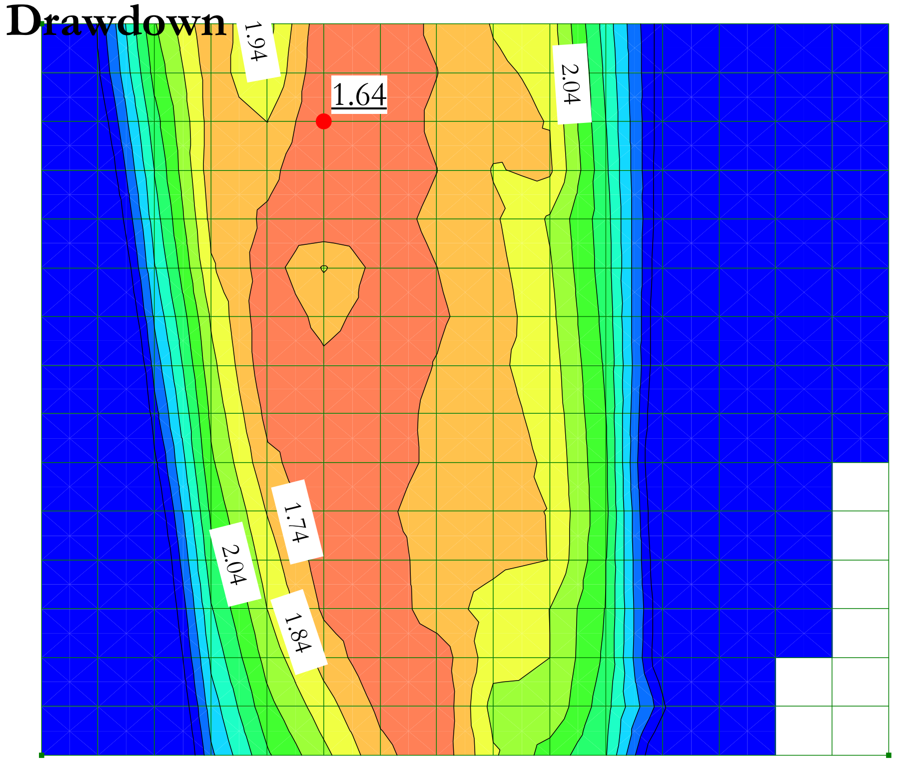
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	247.06237	-54.38	3,455.712	3,921.6582	188.2545	300
Slice 2	260.41185	-61.379128	3,892.4576	4,904.7256	584.4332	0
Slice 3	273.15132	-67.243879	4,258.418	5,790.3943	884.48691	0
Slice 4	285.89079	-72.384093	4,579.1674	6,557.8776	1,142.4089	0
Slice 5	298.63026	-76.840399	4,857.2409	7,204.5162	1,355.2	0
Slice 6	310.49471	-80.424476	5,080.8873	8,420.6007	1,928.1844	0
Slice 7	321.77785	-83.302865	5,260.4988	8,875.3474	1,460.4937	300
Slice 8	333.35471	-85.767851	5,414.3139	9,444.4251	1,628.2706	300
Slice 9	344.93157	-87.744416	5,537.6516	9,904.4104	1,764.2851	300
Slice 10	356.85073	-89.27257	5,633.0083	10,266.284	1,871.9649	300
Slice 11	369.11218	-90.331424	5,699.0809	10,527.993	1,951.007	300
Slice 12	381.37363	-90.867963	5,732.5609	10,683.458	2,000.2921	300
Slice 13	393.63509	-90.885093	5,733.6298	10,740.862	2,023.053	300
Slice 14	405.89654	-90.382905	5,702.2933	10,708.977	2,022.8314	300
Slice 15	418.15799	-89.358682	5,638.3818	10,596.688	2,003.2858	300
Slice 16	429.89654	-87.894804	5,547.0358	10,445.531	2,828.1476	0
Slice 17	441.11218	-86.027273	5,430.5018	10,221.336	2,765.9891	0
Slice						

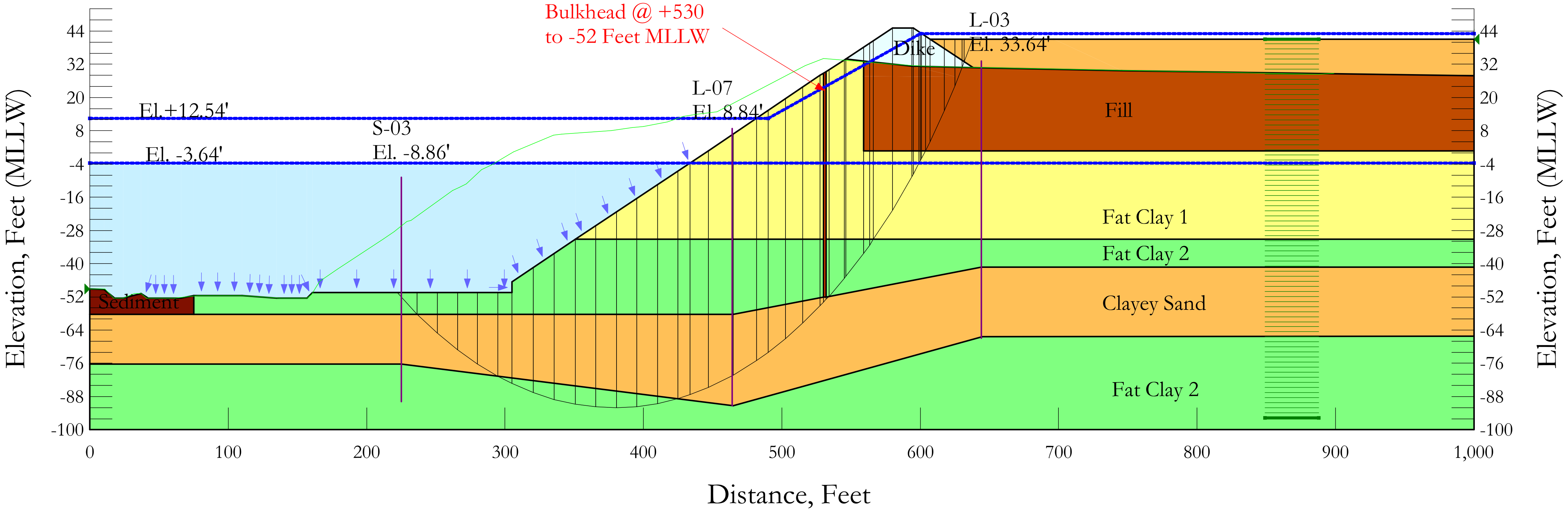
18	447.10614	-84.899965	5,360.1578	10,088.546	2,729.9362	0
Slice 19	448.74614	-84.550415	5,338.3459	10,074.884	2,734.6416	0
Slice 20	457	-82.563642	4,946.6739	10,016.843	2,927.2633	0
Slice 21	464.5	-80.708983	4,961.2682	9,963.9728	2,888.3129	0
Slice 22	471.269	-78.690104	4,954.4875	9,879.1851	2,843.2755	0
Slice 23	483.807	-74.610837	4,922.2775	9,696.765	2,756.5516	0
Slice 24	496.345	-69.885278	4,852.689	9,464.6059	2,662.6915	0
Slice 25	508.883	-64.478555	4,743.705	9,183.8044	2,563.4926	0
Slice 26	521.421	-58.347602	4,592.8348	8,853.4274	2,459.8543	0
Slice 27	528.845	-54.452837	4,488.2039	8,640.7285	2,397.4612	0
Slice 28	531	-53.243262	4,453.2618	10,213.802	3,325.8493	0
Slice 29	532.70357	-52.270515	4,424.6821	8,513.5383	2,360.7022	0
Slice 30	539.48335	-48.138271	4,295.849	8,349.4089	1,637.7445	300
Slice 31	545.87977	-44.203468	4,172.2065	8,108.4333	1,590.3388	300
Slice 32	552.6	-39.577323	4,013.841	7,820.5647	1,538.0162	300
Slice 33	561.29655	-33.446055	3,800.5373	7,052.1698	1,313.7448	300
Slice 34	571.75655	-25.033489	3,483.946	6,512.6876	1,223.691	300
Slice 35	586.87735	-11.765823	2,962.2861	5,409.758	988.84282	300
Slice 36	594.37735	-4.6473964	2,672.4481	4,685.9556	813.50983	300
Slice 37	597.23853	-1.6786011	2,547.2347	4,308.4388	711.57263	300
Slice 38	599.77853	0.9769672	2,434.9185	4,089.2323	602.12099	100
Slice 39	600.46	1.7095411	2,585.2606	4,034.3651	527.4309	100
Slice 40	603.92	5.5552884	2,345.286	3,611.926	461.01926	100
Slice 41	612.11405	15.243133	1,740.7645	2,608.8771	315.96713	100
Slice 42	619.55513	24.565019	1,159.0788	1,661.1673	182.74527	100
Slice 43	621.93698	27.733439	961.36942	1,337.6468	136.95377	100
Slice 44	623.16461	29.433937	855.25833	1,163.4537	112.17395	100
Slice 45	625.50869	32.738442	649.0572	794.12729	67.647295	100

Slice 46	628.97054	37.833343	331.1354	389.16553	15.549127	16

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 44+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Fat Clay 1	125	300	22	500	15	2
🟩	Fat Clay 2	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟧	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟫	Fill	110	100	20	150	15	2
🟫	Sediment	90	16	15	50	0	2
🟥	Bulkhead	150					2



RDD 44+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Nitharsan Kanapathippillai
Revision Number: 193
Date: 4/27/2018
Time: 8:23:07 AM
Tool Version: 8.16.1.13452
File Name: 44+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\44+00\Rec\
Last Solved Date: 4/27/2018
Last Solved Time: 8:23:48 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 44+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

      Tension Crack Option: (none)
  F of S Distribution
    F of S Calculation Option: Constant
  Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Linear Search
    Must Obtain Factor of Safety at Lambda: 0.2
    Lambda
      Lambda 1: -1
      Lambda 2: -0.8
      Lambda 3: -0.6
      Lambda 4: -0.4
      Lambda 5: -0.2
      Lambda 6: 0
      Lambda 7: 0.2
      Lambda 8: 0.4
      Lambda 9: 0.6
      Lambda 10: 0.8
      Lambda 11: 1

Materials

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
  Piezometric Line: 1
  Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 20 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (242.2658, 249.51717) ft
Lower Left: (242.2658, 72.20246) ft
Lower Right: (653.0031, 72.20246) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (848.9456, 41.02998) ft
Upper Right Coordinate: (888.1061, 41.02998) ft
Lower Left Coordinate: (848.9456, -95.69264) ft
Lower Right Coordinate: (888.1061, -95.69264) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -49.2) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	490	12.54
Coordinate 3	600	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64

Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	225	-58.26
Point 2	225	-76.26
Point 3	465	-58.26
Point 4	465	-91.26
Point 5	645	-66.36
Point 6	1,000	27.94
Point 7	625	27.54
Point 8	617.3081	28.53209
Point 9	593.8347	31.4115
Point 10	1,000	41.14
Point 11	999.9742	-11.27583
Point 12	1,000	-66.26
Point 13	0	-76.26
Point 14	0	-100
Point 15	1,000	-100
Point 16	1,000	-41.26
Point 17	644	-41.26
Point 18	0	-58.26
Point 19	1,000	-31.26
Point 20	644	-31.26
Point 21	464	-31.26
Point 22	135	-52.4
Point 23	1,000	0.74
Point 24	644	0.74
Point 25	559	27.72993
Point 26	559	0.74
Point 27	559	33.14
Point 28	110	-51.6
Point 29	75	-51.6
Point 30	75	-58.26
Point 31	0	-49.2
Point 32	305	-50.5
Point 33	305	-46.5
Point 34	350.72	-31.26
Point 35	446.72	0.74
Point 36	546.2	33.9
Point 37	161	-50.5
Point 38	157	-52.4
Point 39	42	-52.4
Point 40	66	-52.4
Point 41	37	-50.8
Point 42	24	-52.4
Point 43	18	-52.5
Point 44	10	-49.29
Point 45	527.69	28
Point 46	579.92	45.14
Point 47	594.92	45.14

Point 48	745.7421	29.59999
Point 49	638.12	30.74
Point 50	606.92	41.14
Point 51	696.5	41.14
Point 52	530	28.7363
Point 53	530	27.98007
Point 54	532	29.37379
Point 55	532	27.96282
Point 56	530	0.74
Point 57	532	0.74
Point 58	530	-31.26
Point 59	532	-31.26
Point 60	530	-52
Point 61	532	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Dredge Fill	51,48,6,10	3,429.3
Region 2	Fat Clay 2	12,5,4,2,13,14,15	25,013
Region 3	Clayey Sand	12,16,17,61,60,3,1,30,18,13,2,4,5	24,297
Region 4	Fat Clay 2	58,21,34,33,32,37,38,22,28,29,30,1,3,60	7,186.4
Region 5	Fat Clay 1	59,20,19,23,24,26,57	14,976
Region 6	Fat Clay 1	25,55,57,26	731.87
Region 7	Fill	25,7,8,9,27	219.6
Region 8	Fat Clay 1	25,55,54,36,27	126.45
Region 9	Sediment	30,29,40,39,41,42,43,44,31,18	500.79
Region 10	Fill	9,8,7,25,26,24,23,6,48,49	12,517
Region 11	Dike	46,36,27,9,49,50,47	719.15
Region 12	Dredge Fill	50,51,48,49	1,058.7
Region 13	Bulkhead	54,52,53,56,58,60,61,59,57,55	162.11
Region 14	Fat Clay 1	52,45,53	0.87345
Region 15	Fat Clay 1	45,35,56,53	1,166.6
Region 16	Fat Clay 1	56,35,34,21,58	4,201
Region 17	Fat Clay 2	19,20,59,61,17,16	5,281.4

Current Slip Surface

Slip Surface: 16,262
F of S: 1.64
Volume: 23,934.395 ft^3
Weight: 2,933,606.9 lbs
Resisting Moment: 2.7045249e+008 lbs-ft
Activating Moment: 1.6468314e+008 lbs-ft
Resisting Force: 788,253.13 lbs
Activating Force: 480,285.69 lbs
F of S Rank (Analysis): 1 of 19,456 slip surfaces
F of S Rank (Query): 1 of 19,456 slip surfaces
Exit: (222.04426, -50.5) ft
Entry: (637.91989, 41.14) ft
Radius: 317.92191 ft
Center: (379.17823, 225.87521) ft

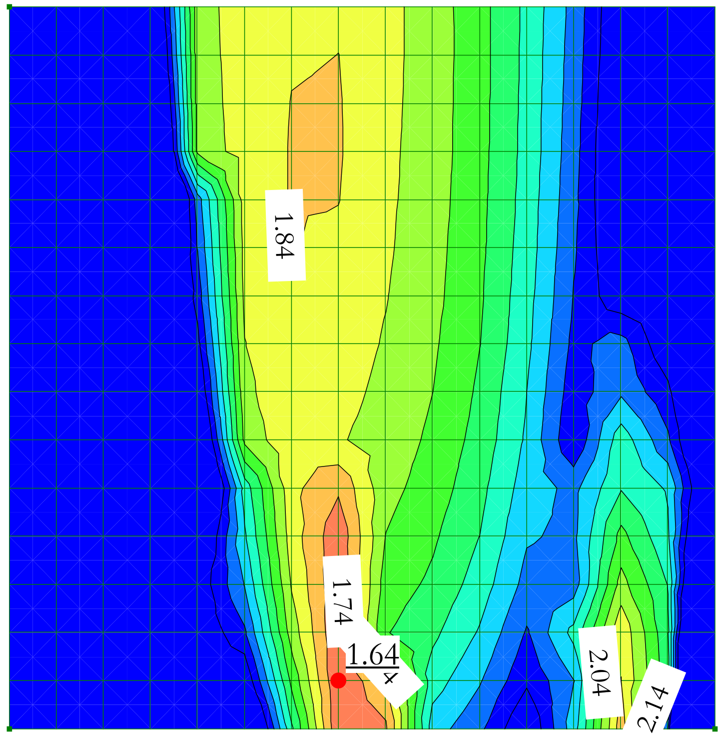
Slip Slices

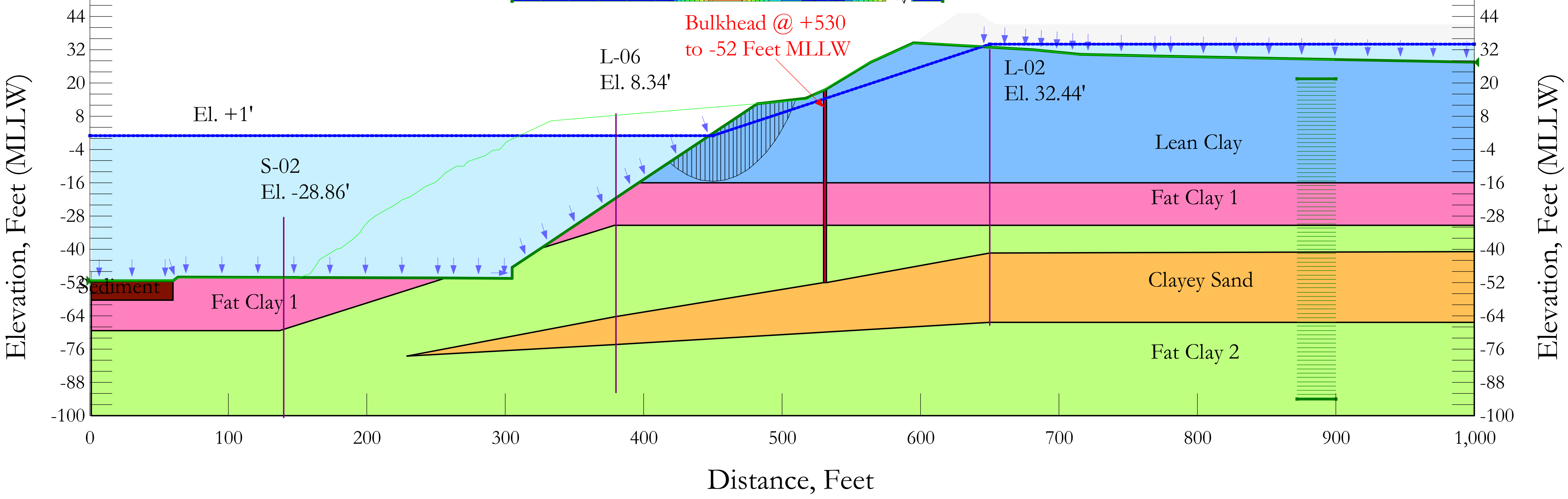
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	229.29939	-54.38	3,166.176	3,612.3262	180.25637	300
Slice 2	243.82198	-61.680886	3,621.7513	4,622.4704	577.76546	0
Slice 3	258.3569	-68.088751	4,021.6021	5,570.4609	894.23403	0
Slice 4	272.89183	-73.654549	4,368.9078	6,385.1339	1,164.0687	0
Slice 5	287.42675	-78.424627	4,666.5607	7,063.0898	1,383.6367	0
Slice 6	299.84711	-81.943892	4,886.1628	7,504.2487	1,057.7754	300
Slice 7	312.62	-84.903838	5,070.8635	8,573.6542	1,415.2193	300
Slice 8	327.86	-87.782507	5,250.4924	9,166.212	1,582.0534	300
Slice 9	343.1	-89.899839	5,382.614	9,688.8622	1,739.8372	300
Slice 10	358.13225	-91.262341	5,467.6341	10,052.539	1,852.422	300
Slice 11	372.95674	-91.899354	5,507.3837	10,271.289	1,924.7426	300
Slice 12	387.78124	-91.843769	5,503.9152	10,362.867	1,963.1438	300
Slice 13	402.60573	-91.09522	5,457.2058	10,339.263	1,972.4793	300
Slice 14	417.43023	-89.648765	5,366.947	10,210.896	0	2,217.076
Slice 15	429.21124	-88.053875	5,267.4258	10,068.685	2,772.0085	0
Slice 16	440.15	-86.07346	5,143.8479	10,002.75	2,805.2882	0
Slice 17	455.36	-82.655956	4,930.5957	9,964.5768	2,906.3703	0
Slice 18	464.5	-80.383292	4,788.7814	9,917.6995	2,961.1823	0
Slice 19	473.38469	-77.641529	4,617.6954	9,811.3562	2,998.5615	0
Slice 20	485.88469	-73.572597	4,363.7941	9,643.0006	3,047.9513	0
Slice 21	496.28167	-69.616706	4,116.9464	9,448.0511	3,077.9147	0
Slice 22	508.845	-64.320474	3,786.4616	9,167.1668	3,106.5516	0
Slice 23	521.40833	-58.370463	3,415.1809	8,829.3236	3,125.8568	0
Slice 24	528.845	-54.610954	3,180.5875	8,608.0026	3,133.5196	0
Slice 25	531	-53.45112	3,108.2139	10,198.719	4,093.7053	0
Slice 26	532.99313	-52.358561	3,040.0382	8,465.2896	3,132.2704	0
Slice 27	539.51177	-48.581618	2,804.357	8,491.0867	0	2,028.5112
Slice 28	545.61863	-44.996477	2,580.6442	8,279.6582	0	1,991.683
Slice 29	552.6	-40.472136	2,298.3253	8,008.9819	0	1,947.3791
Slice 30	561.14376	-34.808615	1,944.9216	7,271.1897	0	1,747.7763
Slice						

31	564.71526	-32.286103	1,787.5168	7,120.2222	0	1,724.6017
Slice 32	573.0315	-25.957441	1,392.6083	6,725.169	0	1,663.967
Slice 33	586.87735	-14.646972	686.83506	5,762.8161	0	1,468.5474
Slice 34	594.37735	-8.1400449	280.8028	5,083.441	0	1,314.0326
Slice 35	597.04583	-5.6405135	124.83204	4,750.0412	0	1,230.3692
Slice 36	599.58583	-3.2415772	-24.861584	4,414.1281	0	1,144.9352
Slice 37	600.46	-2.3972415	-77.548129	4,327.244	0	1,057.3522
Slice 38	602.28601	-0.60566435	-189.34254	4,068.7432	0	1,014.6942
Slice 39	605.28601	2.3931892	-376.47101	3,829.1165	0	645.79561
Slice 40	612.11405	9.6416253	-828.77342	3,034.2664	0	535.14994
Slice 41	621.15405	19.751773	-1,459.6466	1,984.7282	0	387.23235
Slice 42	627.63102	27.562912	-1,947.0617	1,166.7038	0	274.68812
Slice 43	631.02831	31.853811	-2,214.8138	577.87606	269.46803	100
Slice 44	634.85724	36.994236	-2,535.5763	333.398	0	43.60213

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay 1(U)	125			1,000
🟩	Fat Clay 2(U)	125			2,200
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			





Short Term 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/26/2018
Time: 5:15:44 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:16:02 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 56+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: Yes
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 500 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2(U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 2,200 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (305, 208.5) ft
Lower Left: (305, 49.5) ft
Lower Right: (616, 49.5) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (872, 21.5) ft
Upper Right Coordinate: (900, 21.5) ft
Lower Left Coordinate: (872, -94) ft
Lower Right Coordinate: (900, -94) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 27.54) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	650	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.28	32
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	1,000	-16.06
Point 19	1,000	-31.26
Point 20	379	-31.26
Point 21	137	-69.26
Point 22	1	-69.26
Point 23	1	-100
Point 24	1,000	-100
Point 25	1,000	-66.26
Point 26	229	-78.46
Point 27	379	-64.26
Point 28	1,000	-40.86
Point 29	60	-51.26
Point 30	63.6	-50.06
Point 31	60	-58.26
Point 32	1	-58.26
Point 33	1	-51.26
Point 34	325.7	-39.6
Point 35	305	-50.5
Point 36	305	-46.5
Point 37	256.9893	-50.4
Point 38	196	-60
Point 39	396.32	-16.06
Point 40	482	12.5
Point 41	715.3	30.4
Point 42	530	17.26444
Point 43	532	17.86888
Point 44	530	-16.06
Point 45	532	-16.06
Point 46	530	-31.26
Point 47	532	-31.26
Point 48	530	-52
Point 49	532	-52

Point 50	517	14.5

Regions

	Points	Area (ft^2)	Material
Region 1	10,11,12,41,14	984	
Region 2	11,13,9,12	2,972.5	
Region 3	15,16,17,10,14	597.58	
Region 4	8,43,45,18,9,12,41,14,15	21,354	Lean Clay (U)
Region 5	18,19,47,45	7,113.6	Fat Clay 1(U)
Region 6	48,46,20,34,36,35,37,38,21,22,23,24,25,7,5,26,27	39,169	Fat Clay 2(U)
Region 7	26,5,7,25,28,6,49,48,27	14,233	Clayey Sand
Region 8	29,33,32,31	413	Sediment (U)
Region 9	37,30,29,31,32,22,21,38	3,265.5	Fat Clay 1(U)
Region 10	42,50,40,39,44	2,673.4	Lean Clay (U)
Region 11	44,39,34,20,46	2,496.4	Fat Clay 1(U)
Region 12	43,42,44,46,48,49,47,45	139.13	Bulkhead
Region 13	19,47,49,6,28	5,243.7	Fat Clay 2(U)

Current Slip Surface

Slip Surface: 1,773

F of S: 1.64

Volume: 1,302.7902 ft^3

Weight: 162,848.77 lbs

Resisting Moment: 3,839,842.3 lbs-ft

Activating Moment: 2,334,982.6 lbs-ft

Resisting Force: 45,697.792 lbs

Activating Force: 27,825.793 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (418.68556, -8.6048126) ft

Entry: (510.08115, 14.104637) ft

Radius: 75.56 ft

Center: (450.13333, 60.1) ft

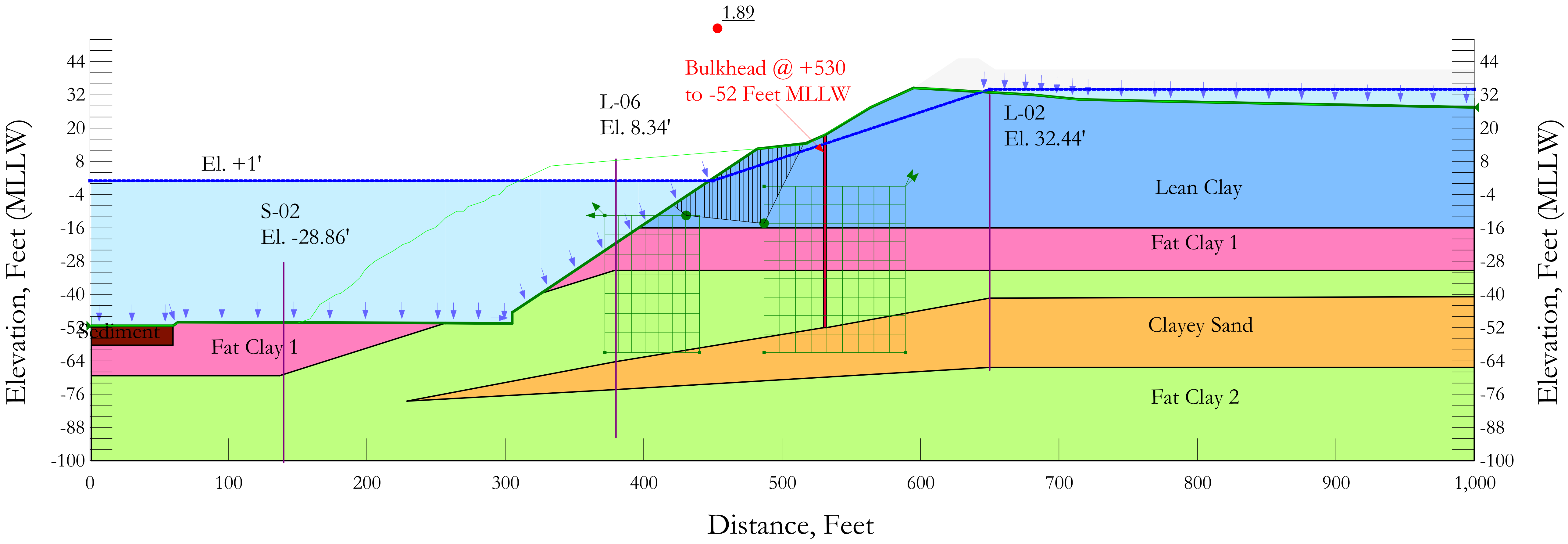
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	420.28636	-9.2933383	642.30431	861.51106	0	500
Slice 2	423.48797	-10.585299	722.92263	1,097.7954	0	500
Slice 3	426.68957	-11.711336	793.18738	1,312.969	0	500
Slice 4	429.89118	-12.679172	853.58034	1,505.9752	0	500
Slice 5	433.09278	-13.495062	904.4919	1,675.9929	0	500
Slice 6	436.29439	-14.164026	946.23522	1,822.4936	0	500
Slice 7	439.49599	-14.690013	979.05684	1,945.2731	0	500
Slice 8	442.69759	-15.076032	1,003.1444	2,044.4555	0	500
Slice 9	445.8992	-15.324234	1,018.6322	2,120.4737	0	500
Slice 10	448.75	-15.436991	1,025.6682	2,197.1419	0	500
Slice 11	451.45455	-15.43444	1,012.9086	2,285.297	0	500
Slice						

12	454.36364	-15.327421	1,035.5658	2,363.7395	0	500
Slice 13	457.27273	-15.107765	1,051.3807	2,425.282	0	500
Slice 14	460.18182	-14.77448	1,060.2931	2,470.6261	0	500
Slice 15	463.09091	-14.326037	1,062.21	2,500.4888	0	500
Slice 16	466	-13.760335	1,057.004	2,515.5564	0	500
Slice 17	468.90909	-13.074651	1,044.5094	2,516.4372	0	500
Slice 18	471.81818	-12.265567	1,024.5188	2,503.616	0	500
Slice 19	474.72727	-11.328882	996.777	2,477.4064	0	500
Slice 20	477.63636	-10.259491	960.97372	2,437.9026	0	500
Slice 21	480.54545	-9.0512225	916.73419	2,384.9277	0	500
Slice 22	483.56629	-7.6384697	861.19303	2,263.1116	0	500
Slice 23	486.69886	-5.998953	792.99683	2,070.1952	0	500
Slice 24	489.83144	-4.1649562	712.9867	1,857.2502	0	500
Slice 25	492.96402	-2.1192133	620.11381	1,620.8475	0	500
Slice 26	496.09659	0.16005719	513.05501	1,356.3143	0	500
Slice 27	499.22917	2.7008304	390.11091	1,057.2917	0	500
Slice 28	502.36174	5.5398902	249.04704	715.00928	0	500
Slice 29	505.49432	8.7271203	86.833159	317.01662	0	500
Slice 30	508.57088	12.259818	-96.928068	-145.29913	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay 1(U)	125			1,000
🟩	Fat Clay 2(U)	125			2,200
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			



Short Term 56+00 Block

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/26/2018
Time: 5:15:44 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:16:30 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 56+00 Block

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
  Side Function
    Interslice force function option: Half-Sine
  PWP Conditions Source: Piezometric Line
  Apply Phreatic Correction: Yes
  Use Staged Rapid Drawdown: No
Slip Surface
  Direction of movement: Right to Left
  Use Passive Mode: No
  Slip Surface Option: Block
  Critical slip surfaces saved: 1
  Resisting Side Maximum Convex Angle: 1 °
  Driving Side Maximum Convex Angle: 5 °
  Restrict Block Crossing: No
  Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 500 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 1(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2(U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 27.54) ft

Slip Surface Block

Left Grid
Upper Left: (372.0438, -11.5123) ft
Lower Left: (372.0438, -61.07368) ft
Lower Right: (440.2923, -61.07368) ft
X Increments: 7
Y Increments: 7
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 2
Right Grid
Upper Left: (486.9862, -0.99251) ft
Lower Left: (486.9862, -61.04894) ft
Lower Right: (589.0441, -61.04894) ft
X Increments: 9
Y Increments: 9
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	650	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.28	32
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	1,000	-16.06
Point 19	1,000	-31.26
Point 20	379	-31.26
Point 21	137	-69.26
Point 22	1	-69.26
Point 23	1	-100
Point 24	1,000	-100
Point 25	1,000	-66.26
Point 26	229	-78.46
Point 27	379	-64.26
Point 28	1,000	-40.86
Point 29	60	-51.26
Point 30	63.6	-50.06
Point 31	60	-58.26
Point 32	1	-58.26
Point 33	1	-51.26
Point 34	325.7	-39.6
Point 35	305	-50.5
Point 36	305	-46.5
Point 37	256.9893	-50.4
Point 38	196	-60
Point 39	396.32	-16.06
Point 40	482	12.5
Point 41	715.3	30.4
Point 42	530	17.26444
Point 43	532	17.86888
Point 44	530	-16.06
Point 45	532	-16.06
Point 46	530	-31.26
Point 47	532	-31.26
Point 48	530	-52
Point 49	532	-52

Point 50	517	14.5

Regions

	Points	Area (ft²)	Material
Region 1	10,11,12,41,14	984	
Region 2	11,13,9,12	2,972.5	
Region 3	15,16,17,10,14	597.58	
Region 4	8,43,45,18,9,12,41,14,15	21,354	Lean Clay (U)
Region 5	18,19,47,45	7,113.6	Fat Clay 1(U)
Region 6	48,46,20,34,36,35,37,38,21,22,23,24,25,7,5,26,27	39,169	Fat Clay 2(U)
Region 7	26,5,7,25,28,6,49,48,27	14,233	Clayey Sand
Region 8	29,33,32,31	413	Sediment (U)
Region 9	37,30,29,31,32,22,21,38	3,265.5	Fat Clay 1(U)
Region 10	42,50,40,39,44	2,673.4	Lean Clay (U)
Region 11	44,39,34,20,46	2,496.4	Fat Clay 1(U)
Region 12	43,42,44,46,48,49,47,45	139.13	Bulkhead
Region 13	19,47,49,6,28	5,243.7	Fat Clay 2(U)

Current Slip Surface

Slip Surface: 56,311

F of S: 1.89

Volume: 1,416.1025 ft³

Weight: 177,012.82 lbs

Resisting Moment: 1,960,247.2 lbs-ft

Activating Moment: 1,036,636.3 lbs-ft

Resisting Force: 47,193.626 lbs

Activating Force: 24,979.701 lbs

F of S Rank (Analysis): 1 of 57,600 slip surfaces

F of S Rank (Query): 1 of 57,600 slip surfaces

Exit: (421.36609, -7.7113021) ft

Entry: (515.75335, 14.428763) ft

Radius: 45.460396 ft

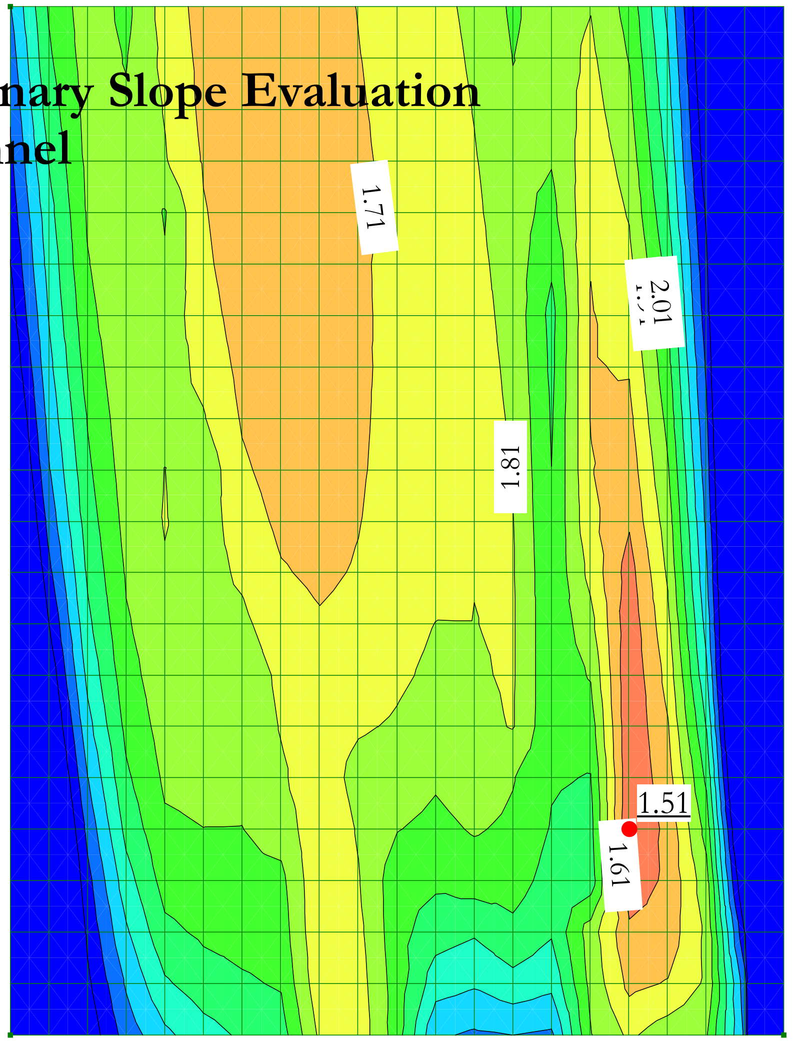
Center: (464.66474, 19.963779) ft

Slip Slices

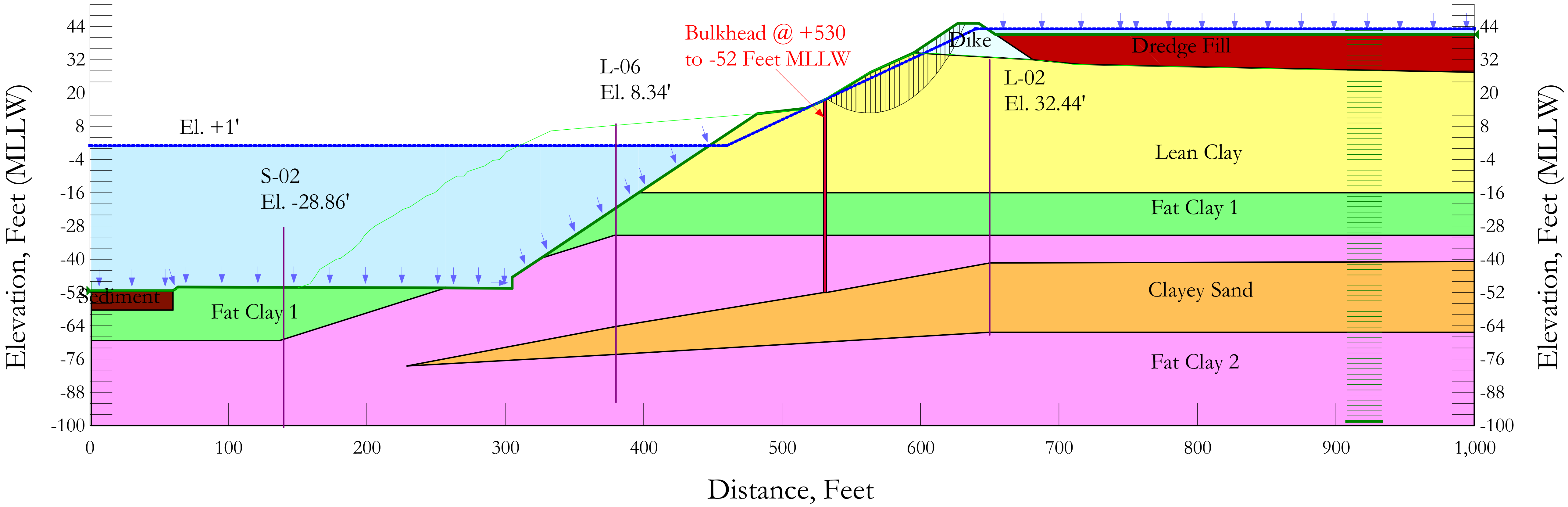
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	422.8955	-8.3448018	583.11563	774.65696	0	500
Slice 2	425.9543	-9.6118011	662.17639	1,019.7655	0	500
Slice 3	429.01311	-10.8788	741.23714	1,267.5007	0	500
Slice 4	432.23826	-11.597205	786.06557	1,326.0842	0	500
Slice 5	435.62976	-11.767014	796.66166	1,427.146	0	500
Slice 6	439.02126	-11.936823	807.25775	1,525.9477	0	500
Slice 7	442.41275	-12.106632	817.85384	1,622.3396	0	500
Slice 8	445.80425	-12.276441	828.44993	1,716.2343	0	500
Slice 9	448.75	-12.423932	837.65336	1,822.9009	0	500
Slice 10	451.6	-12.566629	840.15794	1,960.1299	0	500
Slice 11	454.8	-12.72685	881.96475	2,112.6431	0	500
Slice						

12	458	-12.887071	923.77155	2,263.3675	0	500
Slice 13	461.2	-13.047292	965.57835	2,412.229	0	500
Slice 14	464.4	-13.207513	1,007.3852	2,559.1853	0	500
Slice 15	467.6	-13.367734	1,049.192	2,704.2279	0	500
Slice 16	470.8	-13.527955	1,090.9988	2,847.3842	0	500
Slice 17	474	-13.688176	1,132.8056	2,988.7182	0	500
Slice 18	477.2	-13.848397	1,174.6124	3,128.3306	0	500
Slice 19	480.4	-14.008618	1,216.4192	3,266.359	0	500
Slice 20	483.24655	-14.151143	1,253.6083	3,344.6796	0	500
Slice 21	485.73965	-14.27597	1,286.1797	3,363.838	0	500
Slice 22	488.59107	-12.73351	1,221.0613	2,612.3032	0	500
Slice 23	491.80082	-9.5237636	1,058.2531	2,299.5167	0	500
Slice 24	495.01057	-6.3140172	895.44497	1,984.8576	0	500
Slice 25	498.22031	-3.1042707	732.6368	1,665.6035	0	500
Slice 26	501.43006	0.10547572	569.82862	1,339.1319	0	500
Slice 27	504.63981	3.3152222	407.02044	1,002.9678	0	500
Slice 28	507.84955	6.5249686	244.21227	654.84443	0	500
Slice 29	511.0593	9.7347151	81.404088	292.77487	0	500
Slice 30	514.20876	12.884175	-78.346194	-77.568077	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Lean Clay	125	100	25
🟩	Fat Clay 1	125	300	22
🟧	Clayey Sand	120	0	30
🟥	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟪	Fat Clay 2	125	300	22
🟫	Sediment	90	16	15
🟥	Bulkhead	150		



Long Term 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/26/2018
Time: 5:15:44 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:15:58 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 56+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 300 psf

Phi': 22 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (289.8782, 285.48819) ft
Lower Left: (289.8782, 59.18752) ft
Lower Right: (630.7282, 59.18752) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (907.9586, 42.95493) ft
Upper Right Coordinate: (933.1186, 42.95493) ft

Lower Left Coordinate: (907.9586, -98.52178) ft
Lower Right Coordinate: (933.1186, -98.52178) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	460	1
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.28	32
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	1,000	-16.06
Point 19	1,000	-31.26
Point 20	379	-31.26
Point 21	137	-69.26
Point 22	1	-69.26
Point 23	1	-100

Point 24	1,000	-100
Point 25	1,000	-66.26
Point 26	229	-78.46
Point 27	379	-64.26
Point 28	1,000	-40.86
Point 29	60	-51.26
Point 30	63.6	-50.06
Point 31	60	-58.26
Point 32	1	-58.26
Point 33	1	-51.26
Point 34	325.7	-39.6
Point 35	305	-50.5
Point 36	305	-46.5
Point 37	256.9893	-50.4
Point 38	196	-60
Point 39	396.32	-16.06
Point 40	482	12.5
Point 41	715.3	30.4
Point 42	530	17.26444
Point 43	532	17.86888
Point 44	530	-16.06
Point 45	532	-16.06
Point 46	530	-31.26
Point 47	532	-31.26
Point 48	530	-52
Point 49	532	-52
Point 50	517	14.5

Regions

	Material	Points	Area (ft²)
Region 1	Dredge Fill	10,11,12,41,14	984
Region 2	Dredge Fill	11,13,9,12	2,972.5
Region 3	Dike	15,16,17,10,14	597.58
Region 4	Lean Clay	8,43,45,18,9,12,41,14,15	21,354
Region 5	Fat Clay 1	18,19,47,45	7,113.6
Region 6	Fat Clay 2	48,46,20,34,36,35,37,38,21,22,23,24,25,7,5,26,27	39,169
Region 7	Clayey Sand	26,5,7,25,28,6,49,48,27	14,233
Region 8	Sediment	29,33,32,31	413
Region 9	Fat Clay 1	37,30,29,31,32,22,21,38	3,265.5
Region 10	Lean Clay	42,50,40,39,44	2,673.4
Region 11	Fat Clay 1	44,39,34,20,46	2,496.4
Region 12	Bulkhead	43,42,44,46,48,49,47,45	139.13
Region 13	Fat Clay 2	19,47,49,6,28	5,243.7

Current Slip Surface

Slip Surface: 7,617

F of S: 1.51

Volume: 1,180.5726 ft³

Weight: 147,571.57 lbs

Resisting Moment: 4,820,813.2 lbs-ft
Activating Moment: 3,190,855.2 lbs-ft
Resisting Force: 48,909.248 lbs
Activating Force: 32,356.786 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (532.22515, 17.936926) ft
Entry: (632.46386, 45.14) ft
Radius: 91.674422 ft
Center: (562.5582, 104.44765) ft

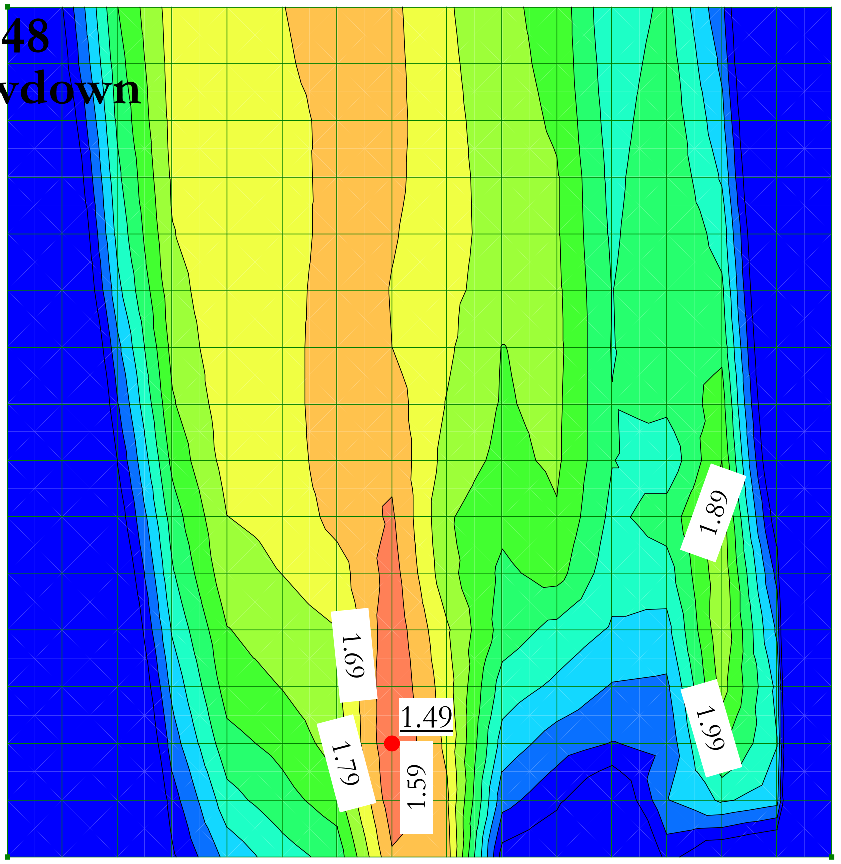
Slip Slices

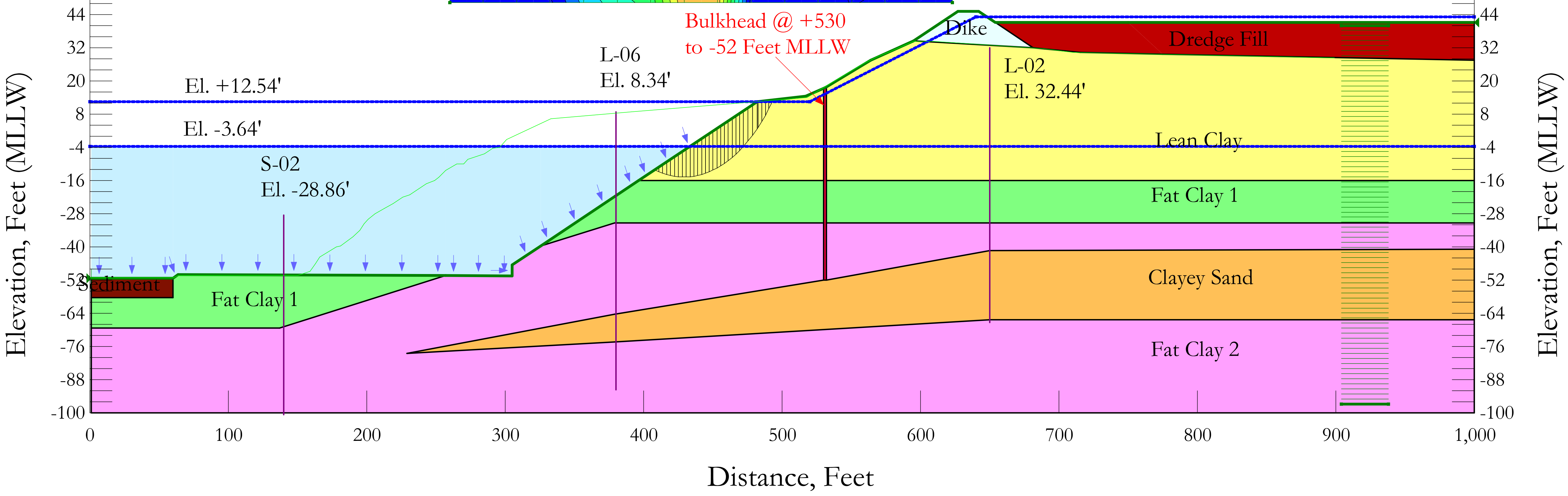
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	532.24929	17.92847	-0.83458265	28.247795	13.172163	100
Slice 2	534.03602	17.34286	58.553957	182.87414	57.97145	100
Slice 3	537.56119	16.266063	171.07659	481.77189	144.8796	100
Slice 4	541.08637	15.341689	274.58221	764.43145	228.42045	100
Slice 5	544.61154	14.565027	369.34952	1,027.1747	306.74891	100
Slice 6	548.13672	13.932269	455.60383	1,266.6331	378.18917	100
Slice 7	551.66189	13.440408	533.523	1,479.9915	441.34553	100
Slice 8	555.18706	13.087164	603.24187	1,665.1746	495.18734	100
Slice 9	558.71224	12.870932	664.85548	1,820.9622	539.10143	100
Slice 10	562.23741	12.790739	718.42128	1,947.0289	572.90915	100
Slice 11	565.72222	12.844057	763.52992	2,025.332	588.38797	100
Slice 12	569.16667	13.028037	800.34977	2,058.7849	586.81792	100
Slice 13	572.61111	13.342569	829.44654	2,068.7051	577.8758	100
Slice 14	576.05556	13.789013	850.73972	2,057.3655	562.65886	100
Slice 15	579.5	14.369332	864.1131	2,027.14	542.32835	100
Slice 16	582.94444	15.086139	869.41216	1,980.3274	518.02826	100
Slice 17	586.38889	15.942757	866.4404	1,918.9943	490.81397	100
Slice 18	589.83333	16.943297	854.95451	1,844.847	461.59446	100
Slice 19	593.27778	18.092771	834.658	1,759.1339	431.0902	100
Slice 20	596.80074	19.430717	804.29934	1,681.4077	409.00236	100
Slice 21	600.40221	20.972382	762.97659	1,610.084	395.01268	100
Slice 22	603.76257	22.573656	714.78797	1,531.7241	380.94359	100
Slice 23	606.88179	24.2202	660.58183	1,447.023	366.72355	100
Slice 24	610.00101	26.025358	596.99251	1,350.2485	351.24905	100
Slice 25	613.12024	28.000393	523.35358	1,239.8389	334.10257	100

Slice 26	616.23946	30.158897	438.8611	1,113.6534	314.66082	100
Slice 27	619.35868	32.517441	342.53466	968.8434	292.05256	100
Slice 28	622.41872	35.043104	235.50222	805.32811	265.71417	100
Slice 29	625.41957	37.751356	116.84853	619.39665	234.34204	100
Slice 30	627.5124	39.760356	26.985282	456.93245	200.48766	100
Slice 31	630.28433	42.747601	-111.34344	167.06194	77.902262	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 56+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Lean Clay	125	100	25	150	20	2
🟩	Fat Clay 1	125	300	22	500	15	2
🟧	Clayey Sand	120	0	30	0	30	2
🟥	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟫	Sediment	90	16	15	50	0	2
🟥	Bulkhead	150					2





RDD 56+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 153
Date: 4/26/2018
Time: 5:15:44 PM
Tool Version: 8.16.1.13452
File Name: 56+00.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\56+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:16:20 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 56+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: Yes
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 20 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Fat Clay 1

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Bulkhead

Model: High Strength

Unit Weight: 150 pcf

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (259.892, 235.51225) ft

Lower Left: (259.892, 48.36902) ft

Lower Right: (623.1356, 48.36902) ft

Grid Horizontal Increment: 15

Grid Vertical Increment: 15

Left Projection Angle: 0 °

Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (903.9399, 39.9822) ft

Upper Right Coordinate: (937.9492, 39.9822) ft

Lower Left Coordinate: (903.9399, -96.76581) ft

Lower Right Coordinate: (937.9492, -96.76581) ft

Number of Increments: 75

Left Projection: No

Left Projection Angle: 135 °

Right Projection: No

Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (1, -51.26) ft

Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	520	12.54
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64

Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	140	-37.96
Point 2	140	-41.96
Point 3	380	4.34
Point 4	380	-4.66
Point 5	380	-74.26
Point 6	650	-41.26
Point 7	650	-66.26
Point 8	564	27.54
Point 9	1,000	27.54
Point 10	653.92	41.14
Point 11	750	41.14
Point 12	775	29.6
Point 13	1,000	41.14
Point 14	681.28	32
Point 15	595	34.5
Point 16	626.92	45.14
Point 17	641.92	45.14
Point 18	1,000	-16.06
Point 19	1,000	-31.26
Point 20	379	-31.26
Point 21	137	-69.26
Point 22	1	-69.26
Point 23	1	-100
Point 24	1,000	-100
Point 25	1,000	-66.26
Point 26	229	-78.46
Point 27	379	-64.26
Point 28	1,000	-40.86
Point 29	60	-51.26
Point 30	63.6	-50.06
Point 31	60	-58.26
Point 32	1	-58.26
Point 33	1	-51.26
Point 34	325.7	-39.6
Point 35	305	-50.5
Point 36	305	-46.5
Point 37	256.9893	-50.4
Point 38	196	-60
Point 39	396.32	-16.06
Point 40	482	12.5
Point 41	715.3	30.4
Point 42	530	17.26444
Point 43	532	17.86888
Point 44	530	-16.06
Point 45	532	-16.06
Point 46	530	-31.26
Point 47	532	-31.26

Point 48	530	-52
Point 49	532	-52
Point 50	517	14.5

Regions

	Material	Points	Area (ft^2)
Region 1	Dredge Fill	10,11,12,41,14	984
Region 2	Dredge Fill	11,13,9,12	2,972.5
Region 3	Dike	15,16,17,10,14	597.58
Region 4	Lean Clay	8,43,45,18,9,12,41,14,15	21,354
Region 5	Fat Clay 1	18,19,47,45	7,113.6
Region 6	Fat Clay 2	48,46,20,34,36,35,37,38,21,22,23,24,25,7,5,26,27	39,169
Region 7	Clayey Sand	26,5,7,25,28,6,49,48,27	14,233
Region 8	Sediment	29,33,32,31	413
Region 9	Fat Clay 1	37,30,29,31,32,22,21,38	3,265.5
Region 10	Lean Clay	42,50,40,39,44	2,673.4
Region 11	Fat Clay 1	44,39,34,20,46	2,496.4
Region 12	Bulkhead	43,42,44,46,48,49,47,45	139.13
Region 13	Fat Clay 2	19,47,49,6,28	5,243.7

Current Slip Surface

Slip Surface: 2,995

F of S: 1.49

Volume: 850.17355 ft^3

Weight: 106,271.69 lbs

Resisting Moment: 3,412,790 lbs-ft

Activating Moment: 2,296,239.1 lbs-ft

Resisting Force: 35,944.601 lbs

Activating Force: 24,201.048 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (408.1571, -12.1143) ft

Entry: (493.68883, 13.167933) ft

Radius: 88.038455 ft

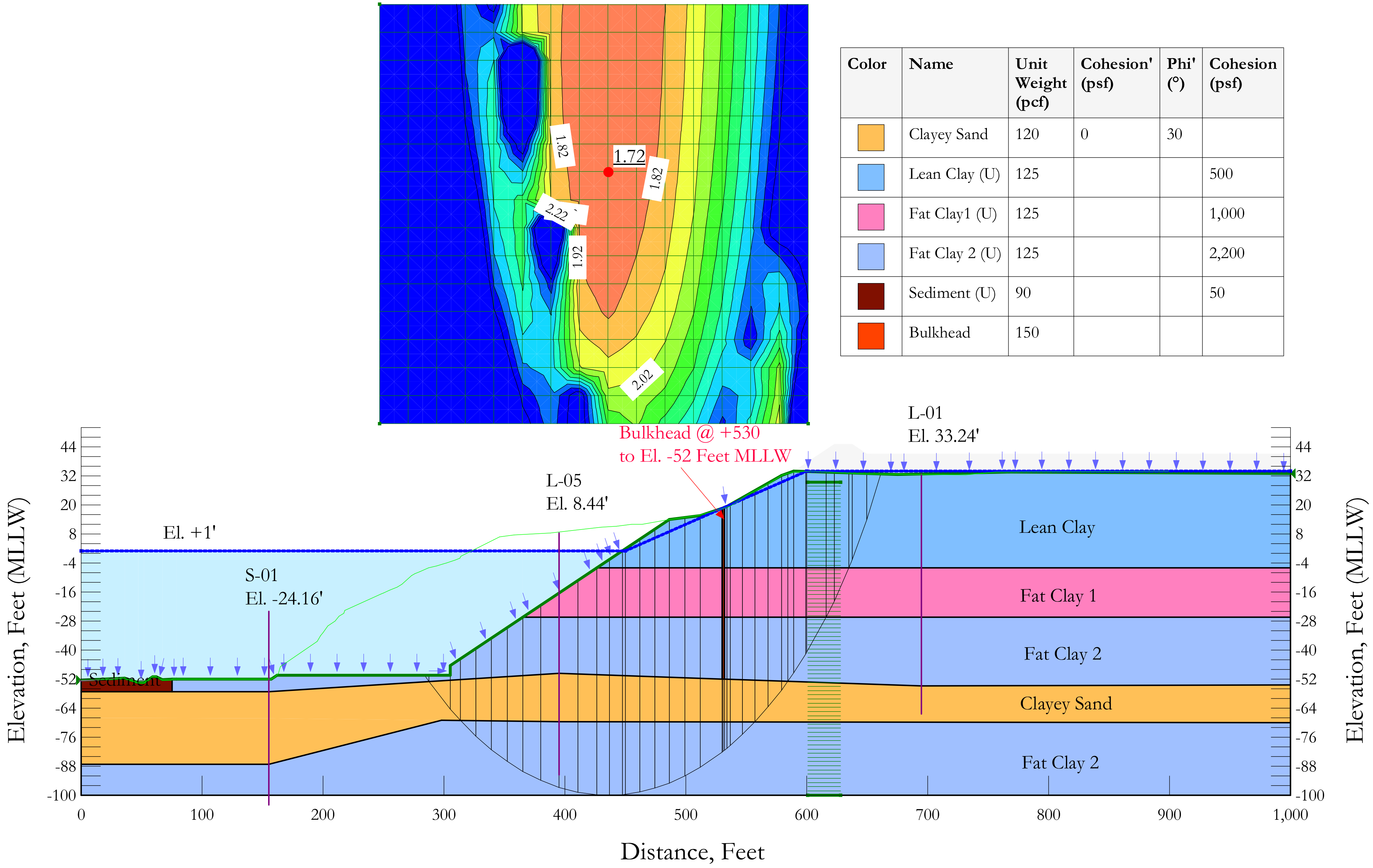
Center: (429.40568, 73.321451) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	409.56948	-12.440973	549.18072	631.85524	38.551764	100
Slice 2	412.39425	-13.045838	586.9243	794.74909	96.910292	100
Slice 3	415.21902	-13.554669	618.67532	943.03083	151.24946	100
Slice 4	418.04378	-13.969146	644.53869	1,075.0069	200.73064	100
Slice 5	420.86855	-14.29061	664.59806	1,189.2515	244.64993	100
Slice 6	423.69332	-14.520084	678.91722	1,284.7108	282.48618	100
Slice 7	426.51808	-14.658287	687.54113	1,360.7748	313.93403	100
Slice 8	429.34285	-14.705652	690.49666	1,417.3101	338.91866	100
Slice 9	432.16762	-14.662323	687.79295	1,454.6507	357.59163	100
Slice 10	434.95776	-14.530915	679.59307	1,505.5591	385.15426	100

Slice 11	437.71329	-14.313234	666.00978	1,570.7569	421.89049	100
Slice 12	440.46881	-14.008086	646.96855	1,619.2236	453.36999	100
Slice 13	443.22434	-13.614549	622.41187	1,649.5655	0	546.46544
Slice 14	445.97986	-13.131415	592.26433	1,666.7363	0	550.14844
Slice 15	448.73538	-12.557171	556.43146	1,670.8407	0	551.01858
Slice 16	451.49091	-11.889971	514.79821	1,663.0115	0	549.30985
Slice 17	454.24643	-11.127611	467.22692	1,644.3188	0	545.23645
Slice 18	457.00196	-10.267483	413.55494	1,615.7158	0	538.98349
Slice 19	459.75748	-9.3065304	353.59149	1,577.9935	0	530.69853
Slice 20	462.51301	-8.2411844	287.11391	1,531.7421	0	520.48376
Slice 21	465.26853	-7.0672886	213.86281	1,477.319	0	508.38898
Slice 22	468.02406	-5.7800026	133.53616	1,414.8177	0	494.4053
Slice 23	470.77958	-4.3736804	45.781658	1,344.0382	0	478.45947
Slice 24	473.79779	-2.6818479	-59.788689	1,255.6653	0	458.4033
Slice 25	477.07867	-0.66670475	-185.53362	1,146.8777	0	433.56137
Slice 26	480.35956	1.5549939	-324.16762	1,021.7218	0	404.86991
Slice 27	482.35	2.9831498	-413.28454	929.22794	0	383.66782
Slice 28	483.99943	4.2740182	-493.83473	800.95046	0	356.49321
Slice 29	486.59829	6.4121621	-627.25491	586.41127	0	312.85686
Slice 30	489.19715	8.7256701	-771.61782	350.44864	163.41688	100
Slice 31	491.796	11.234227	-928.15177	133.04665	0	139.69643
Slice 32	493.39213	12.853967	-1,029.2235	-25.186583	-11.744696	100

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay1 (U)	125			1,000
🟦	Fat Clay 2 (U)	125			2,200
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			

Short Term 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 161
Date: 4/26/2018
Time: 5:28:50 PM
Tool Version: 8.16.1.13452
File Name: 64+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:29:08 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 500 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay1 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 1,000 psf

Pore Water Pressure

Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)

Unit Weight: 125 pcf

Cohesion: 2,200 psf

Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (246.9755, 226.94565) ft
Lower Left: (246.9755, 53.57301) ft
Lower Right: (601.0543, 53.57301) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (600.8933, 29.3081) ft
Upper Right Coordinate: (627.8293, 29.3081) ft
Lower Left Coordinate: (600.8933, -99.99257) ft
Lower Right Coordinate: (627.8293, -99.99257) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 33) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	675	32.67
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52

Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6
Point 56	530	18.64324
Point 57	532	18.97162
Point 58	530	-6.06
Point 59	532	-6.06
Point 60	530	-26.46
Point 61	532	-26.46
Point 62	530	-52
Point 63	532	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,63,62,6,1	15,325
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2 (U)	22,24,25,21,7,23,3	26,362
Region 4		17,26,27,29,28	596.48
Region 5		29,30,31,28	678.15
Region 6		30,32,16,31	1,992.6
Region 7	Lean Clay (U)	33,16,31,28,17,47,34,57,59	18,035
Region 8	Fat Clay1 (U)	61,35,33,59	9,547.2
Region 9	Fat Clay 2 (U)	36,49,38,37,39,1,6,62,60,43,42,41	5,940.7
Region 10	Sediment (U)	37,50,51,52,53,54,55,40,19,39	383
Region 11	Fat Clay1 (U)	58,44,43,60	2,739.3
Region 12	Lean Clay (U)	56,46,45,44,58	1,554.7
Region 13	Bulkhead	57,56,58,60,62,63,61,59	141.61
Region 14	Fat Clay 2 (U)	61,63,13,18,35	12,974

Current Slip Surface

Slip Surface: 11,628

F of S: 1.72

Volume: 27,283.039 ft^3

Weight: 3,388,956.9 lbs

Resisting Moment: 2.0876853e+008 lbs-ft

Activating Moment: 1.213929e+008 lbs-ft

Resisting Force: 731,404.33 lbs

Activating Force: 428,218.63 lbs

F of S Rank (Analysis): 1 of 19,456 slip surfaces

F of S Rank (Query): 1 of 19,456 slip surfaces

Exit: (284.0019, -50.5) ft

Entry: (661.19811, 32.873819) ft

Radius: 257.58916 ft

Center: (435.81753, 157.59659) ft

Slip Slices

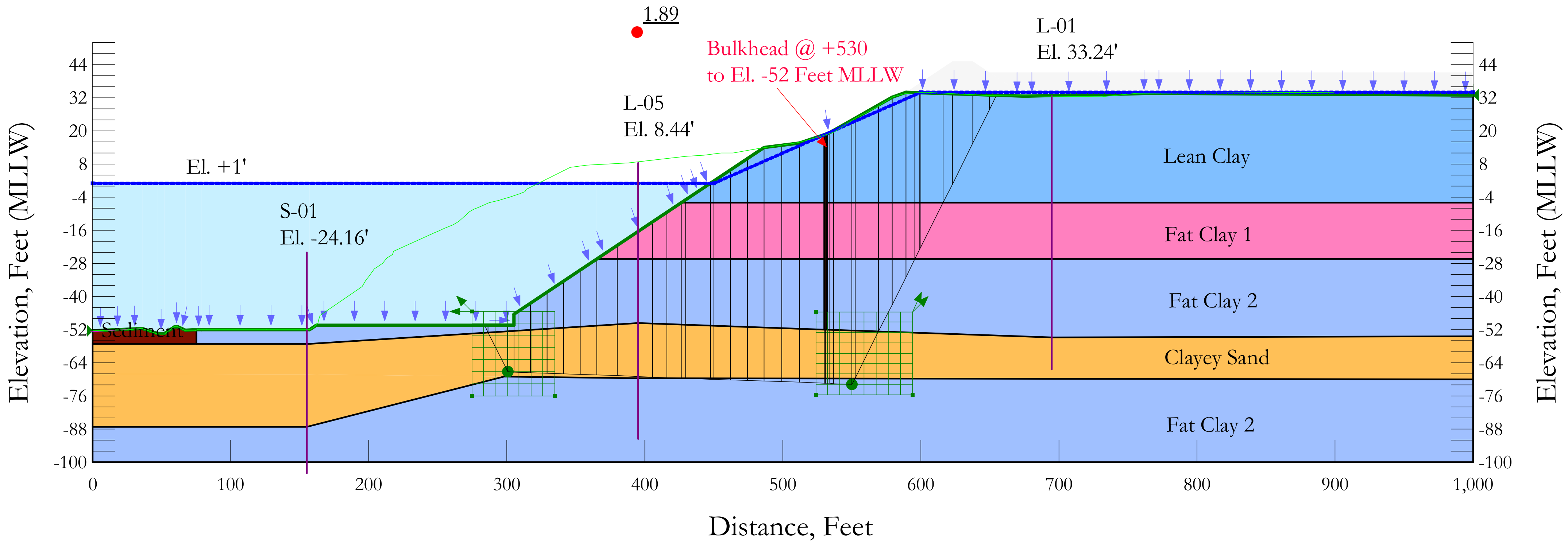
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress	Frictional Strength	Cohesive Strength

				(psf)	(psf)	(psf)
Slice 1	285.72151	-51.733016	3,290.5402	4,302.6216	0	2,200
Slice 2	296.22056	-58.633977	3,721.1602	4,453.4033	422.76074	0
Slice 3	309.2371	-66.69318	4,224.0544	6,179.9548	1,129.2396	0
Slice 4	319.92993	-72.338135	4,576.2996	7,494.5056	0	2,200
Slice 5	332.84138	-78.408659	4,955.1003	8,586.182	0	2,200
Slice 6	345.75283	-83.635745	5,281.2705	9,547.7616	0	2,200
Slice 7	358.66428	-88.073442	5,558.1828	10,376.726	0	2,200
Slice 8	372.59	-91.99322	5,802.7769	11,117.322	0	2,200
Slice 9	387.53	-95.311803	6,009.8565	11,747.013	0	2,200
Slice 10	402.83	-97.74958	6,161.9738	12,216.678	0	2,200
Slice 11	418.49	-99.289269	6,258.0504	12,526.91	0	2,200
Slice 12	431.615	-99.903836	6,296.3994	12,669.123	0	2,200
Slice 13	442.205	-99.858884	6,293.5944	12,698.456	0	2,200
Slice 14	448.75	-99.664678	6,281.4759	12,717.601	0	2,200
Slice 15	456.08333	-99.121611	6,038.8216	12,821.939	0	2,200
Slice 16	468.25	-97.869076	6,123.5849	12,945.313	0	2,200
Slice 17	480.41667	-96.02703	6,173.2609	12,992.751	0	2,200
Slice 18	492.875	-93.508729	6,186.5058	12,760.451	0	2,200
Slice 19	505.625	-90.264718	6,160.3762	12,253.038	0	2,200
Slice 20	521	-85.313189	6,066.9888	11,647.506	0	2,200
Slice 21	530.38739	-82.004211	5,992.9615	12,987.554	0	2,200
Slice 22	531.38739	-81.60655	6,271.9348	12,951.938	0	2,200
Slice 23	533	-80.954403	6,253.3788	11,202.088	0	2,200
Slice 24	535.35	-79.981439	6,224.9266	11,119.382	0	2,200
Slice 25	541.7812	-77.121952	5,851.5664	10,913.892	0	2,200
Slice 26	551.94361	-72.260974	5,695.3135	10,568.975	0	2,200
Slice 27	562.51861	-66.589022	5,496.1947	10,057.201	2,633.298	0
Slice 28	573.5062	-60.007956	5,248.3686	9,606.4377	2,516.1324	0
Slice 29	581.65393	-54.708737	5,039.6513	9,211.932	2,408.8674	0
Slice 30	586.65393	-51.190809	4,895.738	8,944.6507	0	2,200
Slice 31	594.02625	-45.582136	4,658.4487	8,277.3989	0	2,200
Slice	599.52625	-41.278378	4,690.8672	7,734.2741	0	2,200

32						
Slice 33	608.01335	-33.6742	4,222.8701	6,779.3387	0	2,200
Slice 34	619.31335	-23.12286	3,564.4664	6,085.6863	0	1,000
Slice 35	628.66817	-12.92286	2,927.9864	4,869.0966	0	1,000
Slice 36	636.16817	-4.2879502	2,389.1681	4,164.4967	0	500
Slice 37	643.6	5.6911445	1,766.4726	2,970.0985	0	500
Slice 38	655.39905	23.386004	662.31335	772.80516	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Short Term
Slip Surface: Block

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟧	Clayey Sand	120	0	30	
🟦	Lean Clay (U)	125			500
🟪	Fat Clay1 (U)	125			1,000
🟦	Fat Clay 2 (U)	125			2,200
🟫	Sediment (U)	90			50
🟥	Bulkhead	150			



Short Term 64+00 Block

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 161
Date: 4/26/2018
Time: 5:28:50 PM
Tool Version: 8.16.1.13452
File Name: 64+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:30:00 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Short Term 64+00 Block

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Block
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Restrict Block Crossing: No
  - Optimize Critical Slip Surface Location: No

Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Linear Search
Must Obtain Factor of Safety at Lambda: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Clayey Sand

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lean Clay (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 500 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay1 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2 (U)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 2,200 psf
Pore Water Pressure

Piezometric Line: 1

Sediment (U)

Model: Undrained (Phi=0)
Unit Weight: 90 pcf
Cohesion: 50 psf
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 33) ft

Slip Surface Block

Left Grid
Upper Left: (274.9243, -45.46814) ft
Lower Left: (274.9243, -75.96312) ft
Lower Right: (334.9245, -75.96312) ft
X Increments: 7
Y Increments: 7
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 2
Right Grid
Upper Left: (523.9153, -45.59091) ft
Lower Left: (523.9153, -75.50747) ft
Lower Right: (593.8581, -75.50747) ft
X Increments: 8
Y Increments: 8
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 2

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	450	1
Coordinate 3	600	34
Coordinate 4	1,000	34

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	675	32.67
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52

Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6
Point 56	530	18.64324
Point 57	532	18.97162
Point 58	530	-6.06
Point 59	532	-6.06
Point 60	530	-26.46
Point 61	532	-26.46
Point 62	530	-52
Point 63	532	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,63,62,6,1	15,325
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2 (U)	22,24,25,21,7,23,3	26,362
Region 4		17,26,27,29,28	596.48
Region 5		29,30,31,28	678.15
Region 6		30,32,16,31	1,992.6
Region 7	Lean Clay (U)	33,16,31,28,17,47,34,57,59	18,035
Region 8	Fat Clay1 (U)	61,35,33,59	9,547.2
Region 9	Fat Clay 2 (U)	36,49,38,37,39,1,6,62,60,43,42,41	5,940.7
Region 10	Sediment (U)	37,50,51,52,53,54,55,40,19,39	383
Region 11	Fat Clay1 (U)	58,44,43,60	2,739.3
Region 12	Lean Clay (U)	56,46,45,44,58	1,554.7
Region 13	Bulkhead	57,56,58,60,62,63,61,59	141.61
Region 14	Fat Clay 2 (U)	61,63,13,18,35	12,974

Current Slip Surface

Slip Surface: 13,888

F of S: 1.89

Volume: 20,802.16 ft^3

Weight: 2,579,893.1 lbs

Resisting Moment: 93,548,999 lbs-ft

Activating Moment: 49,730,421 lbs-ft

Resisting Force: 632,043.17 lbs

Activating Force: 335,821.83 lbs

F of S Rank (Analysis): 1 of 46,656 slip surfaces

F of S Rank (Query): 1 of 46,656 slip surfaces

Exit: (283.8884, -50.5) ft

Entry: (654.87889, 32.967137) ft

Radius: 175.42348 ft

Center: (455.29953, 53.833922) ft

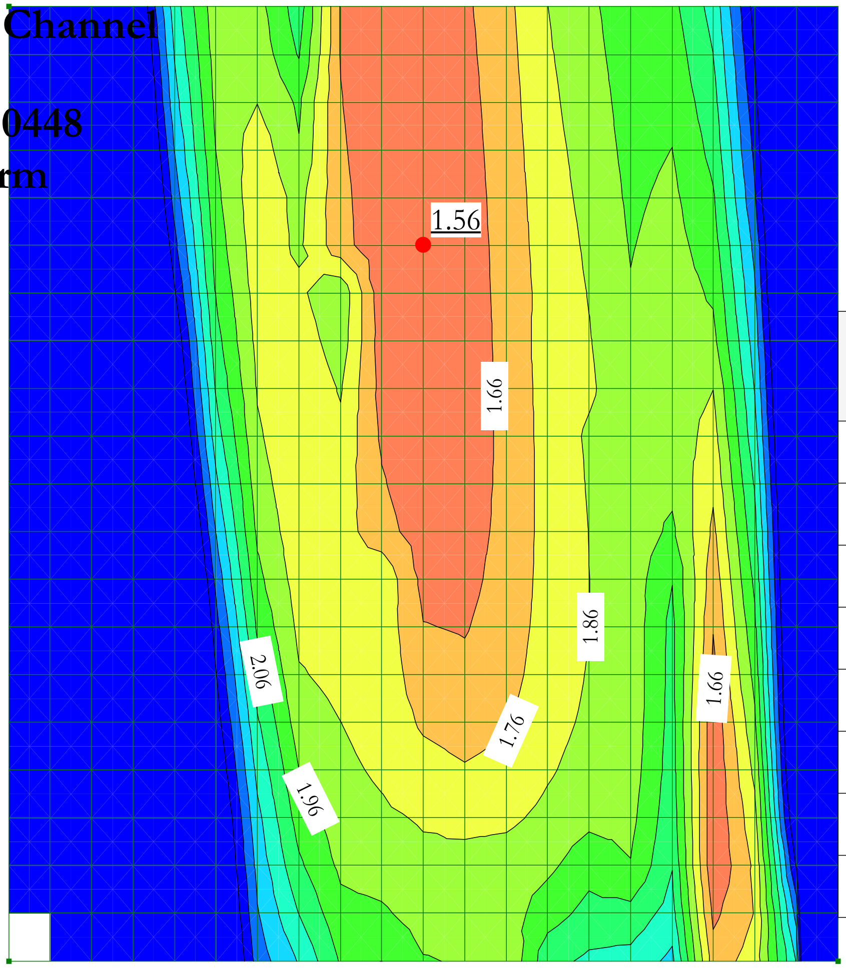
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress	Frictional Strength	Cohesive Strength

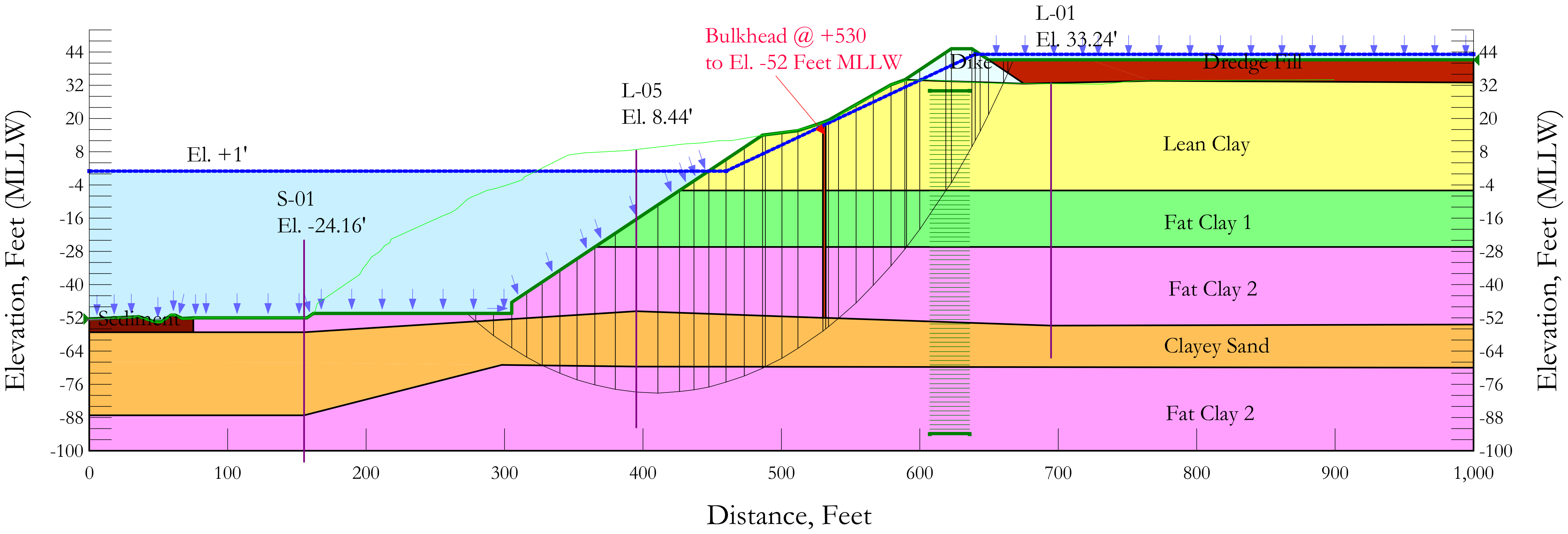
				(psf)	(psf)	(psf)
Slice 1	285.1381	-51.749693	3,291.5809	4,560.2299	0	2,200
Slice 2	293.51323	-60.124828	3,814.1892	4,842.5768	593.73987	0
Slice 3	302.81934	-67.289752	4,261.2806	5,385.1031	648.83922	0
Slice 4	311.012	-67.438092	4,270.5369	5,891.0789	935.62036	0
Slice 5	323.036	-67.655803	4,284.1221	6,184.0455	1,096.9213	0
Slice 6	335.06	-67.873514	4,297.7073	6,505.3127	1,274.5616	0
Slice 7	347.084	-68.091225	4,311.2924	6,821.6026	1,449.3283	0
Slice 8	359.108	-68.308935	4,324.8776	7,131.7859	1,620.5692	0
Slice 9	372.59	-68.553045	4,340.11	7,470.8238	1,807.5184	0
Slice 10	387.53	-68.823555	4,356.9898	7,834.5722	2,007.7831	0
Slice 11	400.22	-69.053324	4,371.3274	8,134.1178	2,172.4481	0
Slice 12	410.66	-69.242355	4,383.1229	8,373.7249	2,303.9751	0
Slice 13	421.1	-69.431385	4,394.9184	8,605.6414	2,431.0621	0
Slice 14	428.05565	-69.557327	4,402.7772	8,756.0966	2,513.3901	0
Slice 15	438.64565	-69.749073	4,414.7422	8,934.3331	0	2,200
Slice 16	448.75	-69.932026	4,426.1584	9,155.4507	0	2,200
Slice 17	456.08333	-70.064806	4,309.3818	9,452.9657	0	2,200
Slice 18	468.25	-70.2851	4,481.8068	9,940.8195	0	2,200
Slice 19	480.41667	-70.505394	4,654.2318	10,421.184	0	2,200
Slice 20	492.875	-70.730969	4,830.7902	10,692.305	0	2,200
Slice 21	505.625	-70.961826	5,011.4822	10,754.546	0	2,200
Slice 22	521	-71.240211	5,229.3754	10,932.362	0	2,200
Slice 23	530.38739	-71.410182	5,362.4126	12,858.311	0	2,200
Slice 24	531.38739	-71.428289	5,636.8112	12,880.667	0	2,200
Slice 25	533	-71.457487	5,660.7712	11,135.822	0	2,200
Slice 26	535.35	-71.500037	5,695.6871	11,192.31	0	2,200
Slice 27	543.42192	-71.64619	5,547.137	11,439.512	0	2,200
Slice 28	551.18283	-70.728918	5,594.1648	9,125.0803	0	2,200
Slice 29	560.75116	-61.160594	5,149.9551	8,591.9351	1,987.2281	0
Slice 30	574.14025	-47.771501	4,528.3661	7,619.2256	0	2,200
Slice 31	584	-37.91175	4,070.6269	6,868.6667	0	2,200
Slice	592.22587	-29.685875	3,688.7404	6,110.7945	0	2,200

32						
Slice 33	597.25213	-24.659624	3,455.3965	6,118.517	0	1,000
Slice 34	599.52625	-22.385499	3,511.9515	5,886.0185	0	1,000
Slice 35	607.92588	-13.985875	2,994.3186	4,999.597	0	1,000
Slice 36	619.22587	-2.685875	2,289.1986	4,010.4346	0	500
Slice 37	630.1	8.18825	1,610.6532	2,786.1738	0	500
Slice 38	643.6	21.68825	768.2532	1,196.4692	0	500
Slice 39	652.23944	30.327694	229.15191	132.06112	0	500

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Long Term
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Lean Clay	125	100	25
🟩	Fat Clay 1	125	400	18
🟧	Clayey Sand	120	0	30
🟥	Dredge Fill	90	16	15
⬜	Dike	125	100	25
🟪	Fat Clay 2	125	300	22
🟫	Sediment	90	16	15
🟥	Bulkhead	150		



Long Term 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 161
Date: 4/26/2018
Time: 5:28:50 PM
Tool Version: 8.16.1.13452
File Name: 64+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:29:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Long Term 64+00

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: Yes
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Grid and Radius
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: No
    Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 400 psf

Phi': 18 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Dredge Fill

Model: Mohr-Coulomb

Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (189.9206, 322.48791) ft
Lower Left: (189.9206, 70.01732) ft
Lower Right: (627.8489, 70.01732) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (607, 30) ft
Upper Right Coordinate: (636, 30) ft

Lower Left Coordinate: (607, -94) ft
Lower Right Coordinate: (636, -94) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	1
Coordinate 2	460	1
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417

Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	675	32.67
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2
Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6
Point 56	530	18.64324
Point 57	532	18.97162
Point 58	530	-6.06
Point 59	532	-6.06
Point 60	530	-26.46
Point 61	532	-26.46
Point 62	530	-52
Point 63	532	-52

Regions

	Material	Points	Area (ft^2)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,63,62,6,1	15,325
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2	22,24,25,21,7,23,3	26,362
Region 4	Dike	17,26,27,29,28	596.48
Region 5	Dredge Fill	29,30,31,28	678.15
Region 6	Dredge Fill	30,32,16,31	1,992.6
Region 7	Lean Clay	33,16,31,28,17,47,34,57,59	18,035
Region 8	Fat Clay 1	61,35,33,59	9,547.2

Region 9	Fat Clay 2	36,49,38,37,39,1,6,62,60,43,42,41	5,940.7
Region 10	Sediment	37,50,51,52,53,54,55,40,19,39	383
Region 11	Fat Clay 1	58,44,43,60	2,739.3
Region 12	Lean Clay	56,46,45,44,58	1,554.7
Region 13	Bulkhead	57,56,58,60,62,63,61,59	141.61
Region 14	Fat Clay 2	61,63,13,18,35	12,974

Current Slip Surface

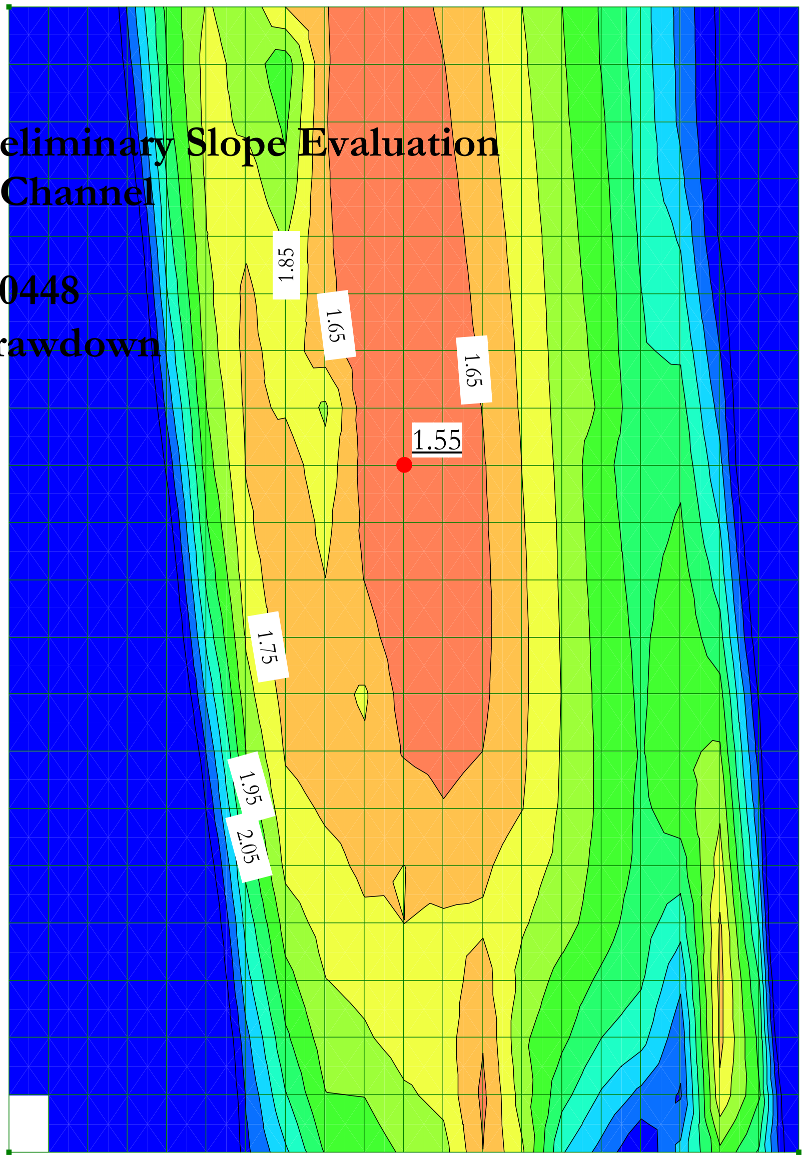
Slip Surface: 24,767
F of S: 1.56
Volume: 21,385.487 ft³
Weight: 2,655,065 lbs
Resisting Moment: 2.3774872e+008 lbs-ft
Activating Moment: 1.5277225e+008 lbs-ft
Resisting Force: 659,527.2 lbs
Activating Force: 424,234.86 lbs
F of S Rank (Analysis): 1 of 33,516 slip surfaces
F of S Rank (Query): 1 of 33,516 slip surfaces
Exit: (272.66405, -50.5) ft
Entry: (667.63407, 41.14) ft
Radius: 338.49026 ft
Center: (408.88475, 259.37026) ft

Slip Slices

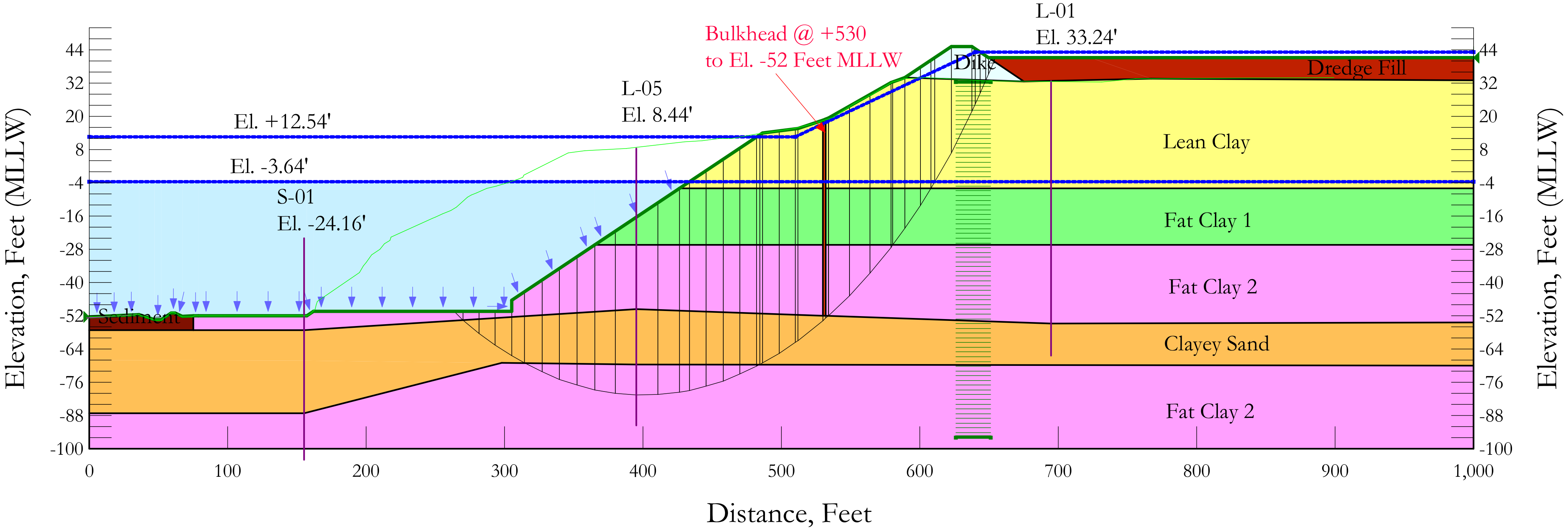
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	275.85957	-51.865794	3,298.8256	3,507.1496	84.168354	300
Slice 2	285.54132	-55.770245	3,542.4633	3,993.2159	260.24211	0
Slice 3	298.51377	-60.546643	3,840.5105	4,684.872	487.49233	0
Slice 4	310.59994	-64.483882	4,086.1943	5,850.537	1,018.6437	0
Slice 5	321.79983	-67.674524	4,285.2903	6,546.8759	1,305.727	0
Slice 6	333.68648	-70.598377	4,467.7387	7,230.2379	1,116.1221	300
Slice 7	346.25989	-73.214856	4,631.007	7,888.8083	1,316.2372	300
Slice 8	358.8333	-75.338721	4,763.5362	8,444.3841	1,487.1591	300
Slice 9	372.59	-77.084636	4,872.4813	8,930.27	1,639.453	300
Slice 10	387.53	-78.362781	4,952.2375	9,324.7176	1,766.5966	300
Slice 11	402.83	-78.975226	4,990.4541	9,587.9656	1,857.5152	300
Slice 12	418.49	-78.893006	4,985.3236	9,722.2445	1,913.8403	300
Slice 13	431.615	-78.314249	4,949.2092	9,742.5741	1,936.6451	300
Slice 14	442.205	-77.433994	4,894.2812	9,693.4147	1,938.9758	300
Slice 15	453.75	-76.074228	4,809.4318	9,719.1693	1,983.6627	300
Slice 16	466.625	-74.091152	4,533.9714	9,810.5735	2,131.8856	300
Slice 17	479.875	-71.522668	4,565.5314	9,831.7073	2,127.6732	300
Slice 18	487.47217	-69.869279	4,572.9376	9,792.0863	2,108.673	300

Slice 19	494.33326	-68.100605	4,563.3293	9,522.5526	2,863.2089	0
Slice 20	506.11109	-64.797747	4,531.0566	9,076.7455	2,624.4547	0
Slice 21	521	-59.870772	4,445.7917	8,563.3853	2,377.2937	0
Slice 22	531	-56.323218	4,374.4214	9,799.3404	3,132.0784	0
Slice 23	533	-55.542276	4,355.9216	8,187.5496	2,212.1914	0
Slice 24	537.63607	-53.652576	4,308.3384	8,073.9418	2,174.0721	0
Slice 25	547.56012	-49.332316	4,190.2047	7,881.8018	1,491.502	300
Slice 26	560.13607	-43.366071	4,011.4257	7,533.5102	1,423.0145	300
Slice 27	572.71202	-36.745663	3,793.948	7,135.5182	1,350.082	300
Slice 28	584	-30.243561	3,565.6312	6,676.5447	1,256.8906	300
Slice 29	589.60207	-26.840154	3,441.8791	6,409.5457	1,199.0151	300
Slice 30	595.10609	-23.229821	3,304.528	6,242.6785	954.66297	400
Slice 31	609.4731	-13.029821	2,900.0952	5,636.2143	889.01898	400
Slice 32	620.76908	-4.590297	2,557.2758	5,101.0498	1,186.1813	100
Slice 33	630.1	3.3600634	2,216.1792	4,338.6508	989.72474	100
Slice 34	638.8	10.951338	1,887.5874	3,523.7241	762.94305	100
Slice 35	641.8	13.76898	1,832.7517	3,154.1315	616.16953	100
Slice 36	646.6	18.435922	1,541.5345	2,553.7189	471.98932	100
Slice 37	655.02005	27.140426	998.37343	1,530.1899	247.9901	100
Slice 38	662.02912	34.67523	528.20168	661.23466	62.034298	100
Slice 39	665.62611	38.802723	270.64607	312.61827	11.246416	16

Project Name: HSC-ECIP Preliminary Slope Evaluation
Location: Barbours Cut Ship Channel
Station Analyzed: 64+00
HVJ Project Number: HG1710448
Loading Condition: Rapid Drawdown
Slip Surface: Circular



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line After Drawdown
🟨	Lean Clay	125	100	25	150	20	2
🟩	Fat Clay 1	125	400	18	500	14	2
🟧	Clayey Sand	120	0	30	0	30	2
🟥	Dredge Fill	90	16	15	50	0	2
⬜	Dike	125	100	25	150	22	2
🟪	Fat Clay 2	125	300	22	500	15	2
🟫	Sediment	90	16	15	50	0	2
🟥	Bulkhead	150					2



RDD 64+00

File Information

File Version: 8.16
Title: Barbours Cut Ship Channel Widening
Created By: Anil Raavi
Last Edited By: Anil Raavi
Revision Number: 161
Date: 4/26/2018
Time: 5:28:50 PM
Tool Version: 8.16.1.13452
File Name: 64+00 with Bulkhead.gsz
Directory: G:\HOUSTON\HOU PS\GEO\PROJECTS\2017\HG1710448 HSC-ECIP Preliminary Slope Evaluation – Barbours Cut and Bayport Channels, TCB&GBA\Slope Stability\BCC\64+00\Rec\
Last Solved Date: 4/26/2018
Last Solved Time: 5:29:36 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

RDD 64+00

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
    - Side Function
        - Interslice force function option: Half-Sine
    - PWP Conditions Source: Piezometric Line
    - Apply Phreatic Correction: Yes
    - Use Staged Rapid Drawdown: Yes
- Slip Surface
    - Direction of movement: Right to Left
    - Use Passive Mode: No
    - Slip Surface Option: Grid and Radius
    - Critical slip surfaces saved: 1
    - Resisting Side Maximum Convex Angle: 1 °
    - Driving Side Maximum Convex Angle: 5 °
    - Optimize Critical Slip Surface Location: No
    - Tension Crack

Tension Crack Option: (none)

F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Linear Search

Must Obtain Factor of Safety at Lambda: 0.2

Lambda

Lambda 1: -1

Lambda 2: -0.8

Lambda 3: -0.6

Lambda 4: -0.4

Lambda 5: -0.2

Lambda 6: 0

Lambda 7: 0.2

Lambda 8: 0.4

Lambda 9: 0.6

Lambda 10: 0.8

Lambda 11: 1

Materials

Lean Clay

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 100 psf

Phi': 25 °

Phi-B: 0 °

Cohesion R: 150 psf

Phi R: 20 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Fat Clay 1

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 400 psf

Phi': 18 °

Phi-B: 0 °

Cohesion R: 500 psf

Phi R: 14 °

Pore Water Pressure

Piezometric Line: 1

Piezometric Line After Drawdown: 2

Clayey Sand

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Cohesion': 0 psf

Phi': 30 °

Phi-B: 0 °
Cohesion R: 0 psf
Phi R: 30 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dredge Fill

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Dike

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 25 °
Phi-B: 0 °
Cohesion R: 150 psf
Phi R: 22 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Fat Clay 2

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 22 °
Phi-B: 0 °
Cohesion R: 500 psf
Phi R: 15 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Sediment

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 16 psf
Phi': 15 °
Phi-B: 0 °
Cohesion R: 50 psf
Phi R: 0 °
Pore Water Pressure
    Piezometric Line: 1
    Piezometric Line After Drawdown: 2

Bulkhead

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1
Piezometric Line After Drawdown: 2

Slip Surface Grid

Upper Left: (191.7483, 366.48988) ft
Lower Left: (191.7483, 63.70715) ft
Lower Right: (608.9357, 63.70715) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (625.9097, 32.48158) ft
Upper Right Coordinate: (651.0697, 32.48158) ft
Lower Left Coordinate: (625.9097, -96.0427) ft
Lower Right Coordinate: (651.0697, -96.0427) ft
Number of Increments: 75
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, -52.4) ft
Right Coordinate: (1,000, 41.14) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	12.54
Coordinate 2	510	12.54
Coordinate 3	640	43.14
Coordinate 4	1,000	43.14

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-3.64

Coordinate 2	1,000	-3.64

Points

	X (ft)	Y (ft)
Point 1	155	-57.16
Point 2	155	-68.16
Point 3	155	-87.16
Point 4	155	-104.16
Point 5	395	-14.56
Point 6	395	-49.56
Point 7	395	-69.56
Point 8	395	-91.56
Point 9	695	29.24
Point 10	695	25.24
Point 11	695	5.24
Point 12	695	-4.76
Point 13	695	-54.76
Point 14	695	-64.76
Point 15	695	-66.76
Point 16	1,000	33
Point 17	589	33.94
Point 18	1,000	-54.46
Point 19	0	-57.26
Point 20	0	-68.06
Point 21	1,000	-70.06
Point 22	0	-87.26
Point 23	298	-68.99417
Point 24	0	-100
Point 25	1,000	-100
Point 26	622.6	45.14
Point 27	637.6	45.14
Point 28	675	32.67
Point 29	649.6	41.14
Point 30	723	41.14
Point 31	767	33.6
Point 32	1,000	41.14
Point 33	1,000	-6.06
Point 34	534	19.3
Point 35	1,000	-26.46
Point 36	162	-50.5
Point 37	75	-52.1
Point 38	78.6	-52
Point 39	75	-57.26
Point 40	0	-52.4
Point 41	305	-50.5
Point 42	305	-46.5
Point 43	365.12	-26.46
Point 44	426.32	-6.06
Point 45	486.5	14
Point 46	512	15.68783
Point 47	579	32.2

Point 48	395	8.7
Point 49	157	-52
Point 50	67	-52.2
Point 51	62	-51
Point 52	59	-51
Point 53	52	-53.5
Point 54	47	-53.5
Point 55	36	-51.6
Point 56	530	18.64324
Point 57	532	18.97162
Point 58	530	-6.06
Point 59	532	-6.06
Point 60	530	-26.46
Point 61	532	-26.46
Point 62	530	-52
Point 63	532	-52

Regions

	Material	Points	Area (ft²)
Region 1	Clayey Sand	39,19,20,2,23,7,21,18,13,63,62,6,1	15,325
Region 2	Clayey Sand	20,22,3,23,2	4,319
Region 3	Fat Clay 2	22,24,25,21,7,23,3	26,362
Region 4	Dike	17,26,27,29,28	596.48
Region 5	Dredge Fill	29,30,31,28	678.15
Region 6	Dredge Fill	30,32,16,31	1,992.6
Region 7	Lean Clay	33,16,31,28,17,47,34,57,59	18,035
Region 8	Fat Clay 1	61,35,33,59	9,547.2
Region 9	Fat Clay 2	36,49,38,37,39,1,6,62,60,43,42,41	5,940.7
Region 10	Sediment	37,50,51,52,53,54,55,40,19,39	383
Region 11	Fat Clay 1	58,44,43,60	2,739.3
Region 12	Lean Clay	56,46,45,44,58	1,554.7
Region 13	Bulkhead	57,56,58,60,62,63,61,59	141.61
Region 14	Fat Clay 2	61,63,13,18,35	12,974

Current Slip Surface

Slip Surface: 19,979

F of S: 1.55

Volume: 20,683.923 ft³

Weight: 2,568,434.2 lbs

Resisting Moment: 2.3143757e+008 lbs-ft

Activating Moment: 1.4895596e+008 lbs-ft

Resisting Force: 660,892.95 lbs

Activating Force: 425,516.19 lbs

F of S Rank (Analysis): 1 of 33,516 slip surfaces

F of S Rank (Query): 1 of 33,516 slip surfaces

Exit: (263.48188, -50.5) ft

Entry: (654.43077, 41.14) ft

Radius: 325.99657 ft

Center: (400.342, 245.37679) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	266.83679	-52.006131	3,018.0466	3,244.2796	91.40406	300
Slice 2	275.99308	-55.906672	3,261.4403	3,728.9044	269.89055	0
Slice 3	287.59585	-60.439891	3,544.3132	4,389.8274	488.15785	0
Slice 4	299.19862	-64.472434	3,795.9439	4,977.8806	682.39149	0
Slice 5	309.70451	-67.728028	3,999.0929	6,062.4146	1,191.2594	0
Slice 6	320.7479	-70.686206	4,183.6832	6,659.179	1,000.1652	300
Slice 7	333.42564	-73.612268	4,366.2695	7,378.5135	1,217.0256	300
Slice 8	346.10339	-76.011783	4,515.9993	7,988.2885	1,402.8959	300
Slice 9	358.78113	-77.896494	4,633.6052	8,487.4651	1,557.0605	300
Slice 10	372.59	-79.349842	4,724.2942	8,903.184	1,688.3811	300
Slice 11	387.53	-80.282132	4,782.469	9,216.1562	1,791.3259	300
Slice 12	402.83	-80.516237	4,797.0772	9,395.1491	1,857.7416	300
Slice 13	418.49	-80.019765	4,766.0974	9,445.0466	1,890.4182	300
Slice 14	429.95	-79.251994	4,718.1884	9,412.226	1,896.5143	300
Slice 15	439.6475	-78.18385	4,651.5362	9,453.4274	0	2,154.7956
Slice 16	451.7825	-76.47704	4,545.0313	9,554.317	0	2,143.3286
Slice 17	463.9175	-74.30063	4,409.2233	9,594.7564	0	2,121.7478
Slice 18	476.0525	-71.644934	4,243.5079	9,579.985	0	2,091.9748
Slice 19	483.18966	-69.914837	4,135.5498	9,553.9167	0	2,080.4291
Slice 20	485.37966	-69.331039	4,099.1208	9,497.0539	3,116.4981	0
Slice 21	492.375	-67.299063	3,972.3255	9,245.5026	3,044.4702	0
Slice 22	504.125	-63.596424	3,741.2808	8,748.1073	2,890.6926	0
Slice 23	511	-61.262158	3,595.6227	8,448.1502	2,801.608	0
Slice 24	521	-57.313719	3,349.2401	8,062.2632	2,721.0651	0
Slice 25	531	-53.288681	3,098.0777	9,198.7315	3,522.2141	0
Slice 26	532.92102	-52.441199	3,045.1948	7,613.046	2,637.2501	0
Slice 27	533.92102	-51.995713	3,017.3965	7,711.0964	0	1,802.614
Slice 28	541.5	-48.35599	2,790.2778	7,488.0559	0	1,763.8869
Slice 29	556.5	-40.657179	2,309.8719	7,017.6561	0	1,685.8993
Slice 30	571.5	-31.933557	1,765.518	6,467.2661	0	1,598.764
Slice						

31	579.64117	-26.882251	1,450.3164	6,138.8101	0	1,546.752
Slice 32	584.64117	-23.471969	1,237.5149	5,880.7103	0	1,415.0303
Slice 33	594.60582	-16.322644	791.39699	5,375.6657	0	1,344.5293
Slice 34	604.02328	-9.1106751	341.37013	4,924.079	0	1,294.2979
Slice 35	609.28399	-4.85	75.504	4,646.8079	0	1,266.674
Slice 36	616.66654	1.6258387	-328.58834	4,217.1193	0	1,192.4957
Slice 37	630.1	14.350504	-1,122.6075	3,102.517	0	922.96658
Slice 38	638.8	23.096669	-1,668.3681	2,175.4212	0	663.54743
Slice 39	641.8	26.368518	-1,872.5315	1,755.3675	0	519.03764
Slice 40	645.66492	30.71287	-2,143.6191	1,162.4605	0	384.91401
Slice 41	648.66492	34.172124	-2,359.4766	612.0183	285.38882	100
Slice 42	651.50275	37.571269	-2,571.5832	252.95602	117.95533	100
Slice 43	653.91814	40.5055	-2,754.6792	43.239655	0	17.315825

ATTACHMENT 7

SLOPE STABILITY ANALYSIS OF EXISTING PLACEMENT AREAS

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Houston Ship Channel DMMP
Mid Bay Placement Area, Sta 15+00, EL +35
Exterior Slope - Short Term Condition
MidBay.EL35.80Step.4H1V.WL33.Geo.EOC1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Firm Elastic SILT w/SA (Dike)
Unit Weight: 120 pcf
Cohesion': 500 psf
Phi': 0 °

Name: Hyd Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hyd Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hyd Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hyd Fill 4
Unit Weight: 100 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Soft SA Lean CLAY
Unit Weight: 120 pcf
Cohesion': 300 psf
Phi': 0 °

Name: Soft SA Lean CLAY (2)
Unit Weight: 120 pcf
Cohesion': 350 psf
Phi': 0 °

Name: Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

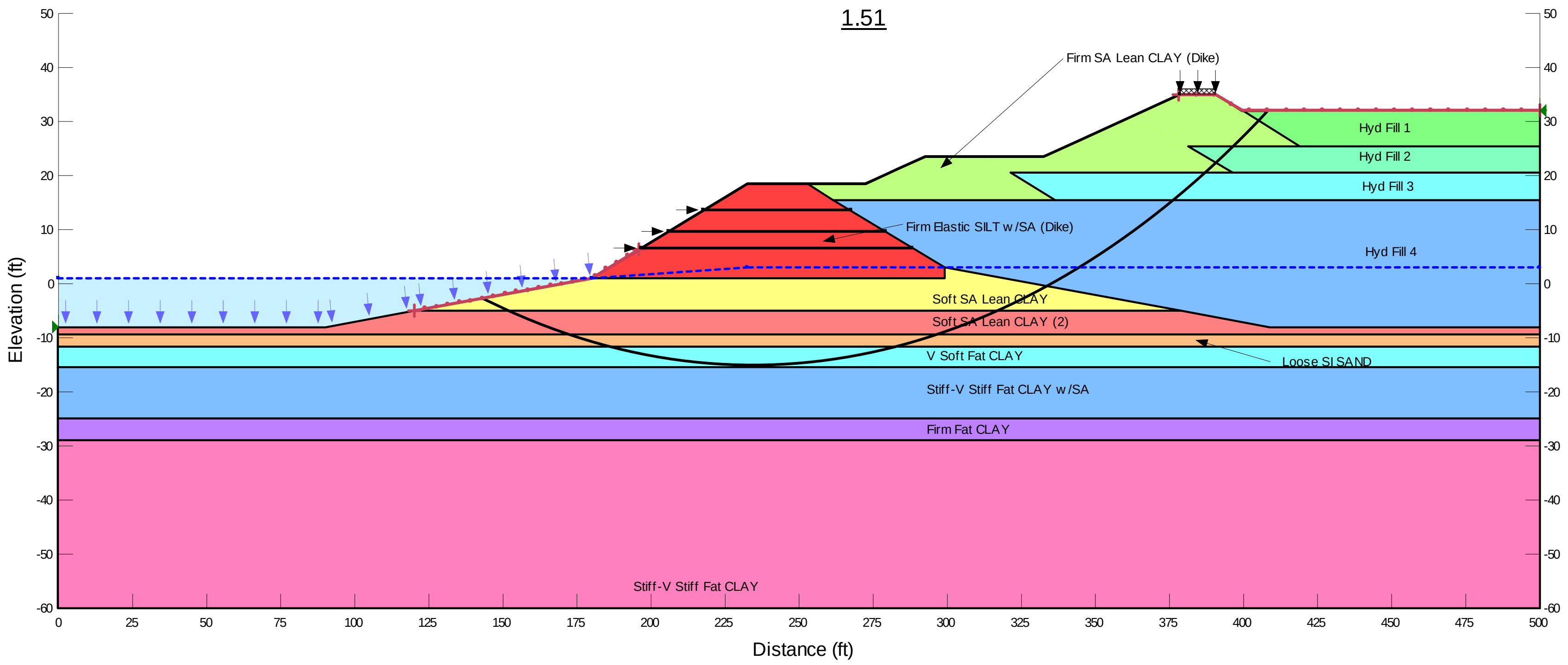
Name: V Soft Fat CLAY
Unit Weight: 120 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Stiff-V Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Firm Fat CLAY
Unit Weight: 125 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff-V Stiff Fat CLAY
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °

Geotextile Dike Reinforcement
Tensile Capacity: 2,400 lbs
Interface Adhesion: 240 psf
Interface Shear Angle: 11 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 MAY 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
MID BAY PA CONTAINMENT DIKE STA. 15+00, EL +35

FILE NO:

PLATE NO: STAB-01

Houston Ship Channel DMMP
Mid Bay Placement Area, Sta 15+00, EL +35
Exterior Slope - Long Term Condition
MidBay.EL35.80Step.4H1V.WL33.Geo.LT1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Firm Elastic SILT w/SA (Dike)
Unit Weight: 120 pcf
Cohesion': 80 psf
Phi': 14 °

Name: Hyd Fill 1
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hyd Fill 2
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hyd Fill 3
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Hyd Fill 4
Unit Weight: 100 pcf
Cohesion': 130 psf
Phi': 18 °

Name: Soft SA Lean CLAY
Unit Weight: 120 pcf
Cohesion': 60 psf
Phi': 16 °

Name: Soft SA Lean CLAY (2)
Unit Weight: 120 pcf
Cohesion': 80 psf
Phi': 18 °

Name: Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

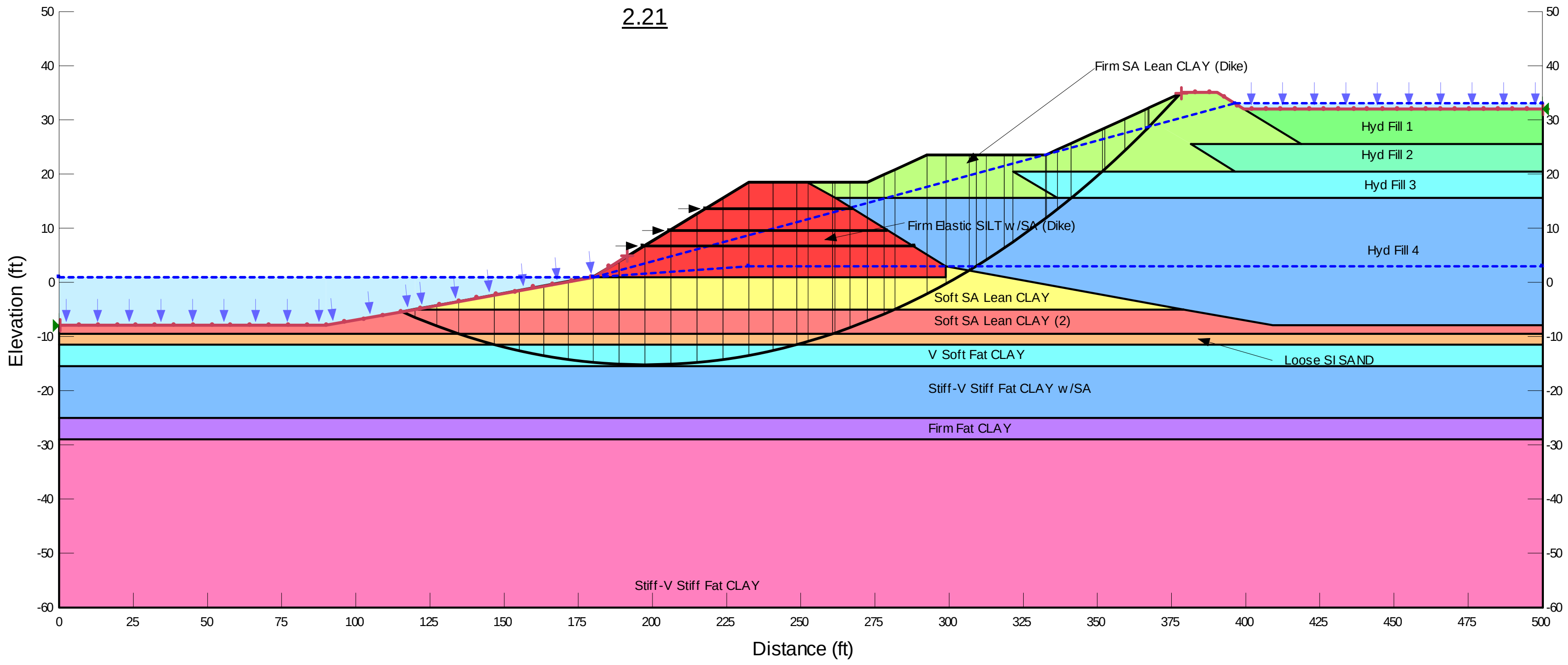
Name: V Soft Fat CLAY
Unit Weight: 120 pcf
Cohesion': 60 psf
Phi': 18 °

Name: Stiff-V Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 22 °

Name: Firm Fat CLAY
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 18 °

Name: Stiff-V Stiff Fat CLAY
Unit Weight: 130 pcf
Cohesion': 200 psf
Phi': 22 °

Geotextile Dike Reinforcement
Tensile Capacity: 2,400 lbs
Interface Adhesion: 240 psf
Interface Shear Angle: 11 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 MAY 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
MID BAY PA CONTAINMENT DIKE STA. 15+00, EL +35

FILE NO:

PLATE NO:
STAB-02

Houston Ship Channel DPR
PA14, Sta 46+50, EL +50
Exterior Slope - Short Term Condition
PA14.Step80.EL50.WL3.MP.EOC1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Berm
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hyd Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hyd Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hyd Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hyd Fill 4
Unit Weight: 100 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Me Dense Si SAND (Dike)
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff-V Stiff Fat CLAY w/SA (Dike)
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Soft Fat CLAY w/SA (Dike)
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Firm Fat CLAY w/SA (Dike)
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Me Dense SILT w/SA
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

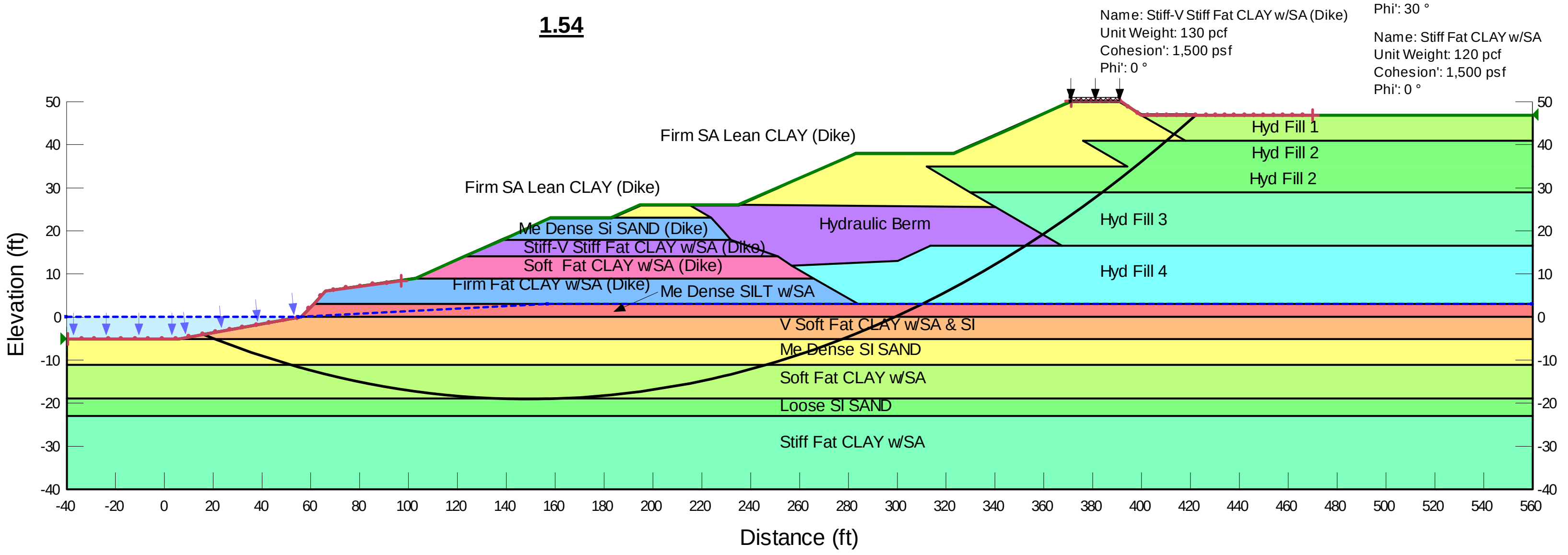
Name: V Soft Fat CLAY w/SA & SI
Unit Weight: 120 pcf
Cohesion': 300 psf
Phi': 0 °

Name: Me Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Stiff Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 MAY 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
PA 14 CONTAINMENT DIKE STA. 46+50, EL +50

FILE NO:

PLATE NO:
STAB-03

Houston Ship Channel DPR
PA14, Sta 46+50, EL +50
Exterior Slope - Long Term Condition
PA14.Step60.EL50.WL47.MP.LT1
5/19/2016

Name: Firm SA Lean CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Berm LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 17 °

Name: Hyd Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hyd Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hyd Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Hyd Fill 4 LT
Unit Weight: 100 pcf
Cohesion': 130 psf
Phi': 18 °

Name: Me Dense Si SAND (Dike) LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff-V Stiff Fat CLAY w/SA (Dike) LT
Unit Weight: 130 pcf
Cohesion': 140 psf
Phi': 20 °

Name: Soft Fat CLAY w/SA (Dike) LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 16 °

Name: Firm Fat CLAY w/SA (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 18 °

Name: Me Dense SILT w/SA LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

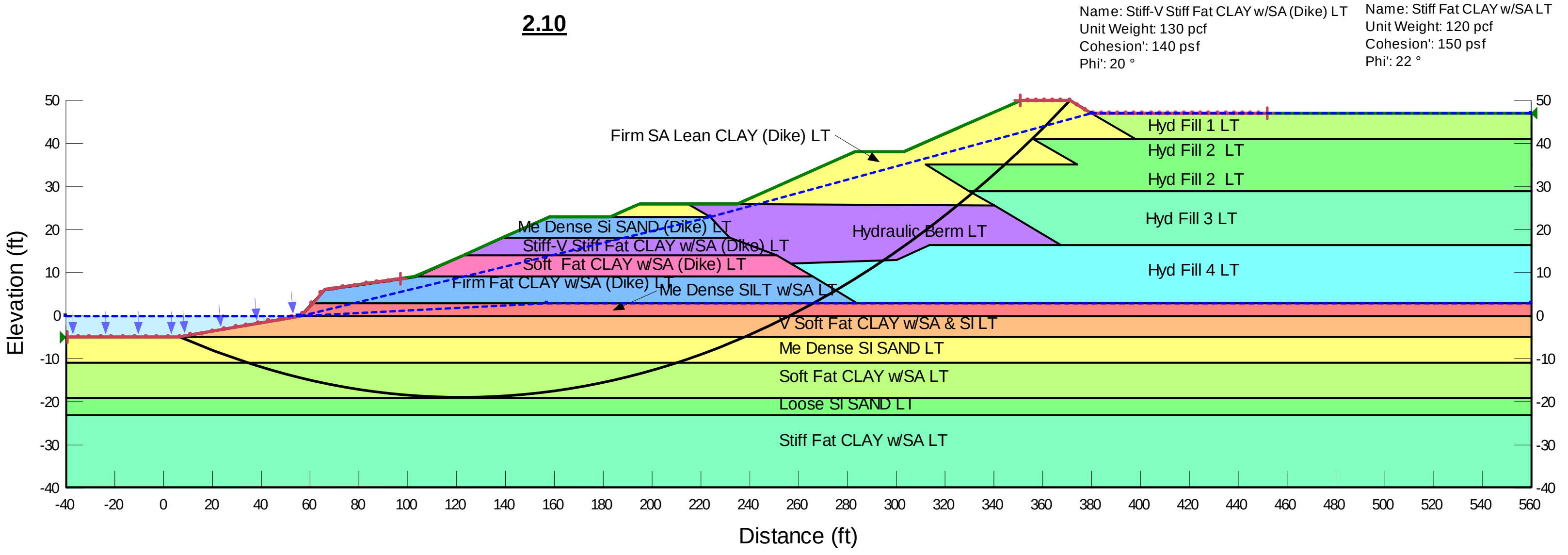
Name: V Soft Fat CLAY w/SA & SI LT
Unit Weight: 120 pcf
Cohesion': 80 psf
Phi': 15 °

Name: Me Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 80 psf
Phi': 16 °

Name: Loose SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Stiff Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 150 psf
Phi': 22 °



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CORPS OF ENGINEERS
GALVESTON, TEXAS

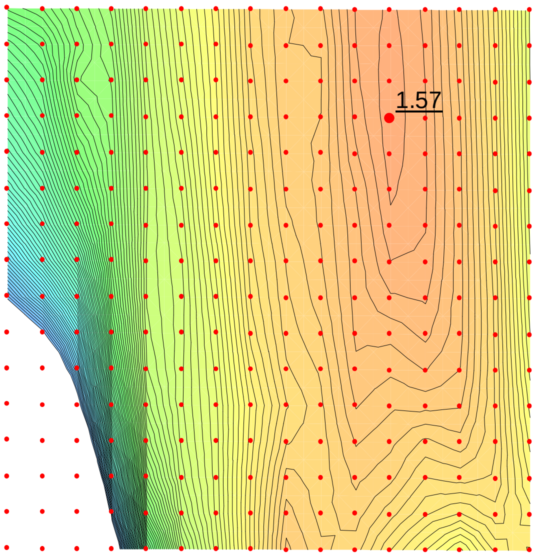
DATE: 19 MAY 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
PA 14 CONTAINMENT DIKE STA. 46+50, EL +50

FILE NO:

PLATE NO:
STAB-04

Houston Ship Channel DMMP
PA 15, Sta 150+00, EL +50
Exterior Slope - Short Term Condition
PA15.EL50Step.150+00.WL+3.EOC
1/19/2016



Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Firm to Stiff SA LN CLAY
Unit Weight: 125 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Me. Dense CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Stiff Ln CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 1,000 psf
Phi': 0 °

Name: Soft LN CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Stiff SA Ln CLAY
Unit Weight: 125 pcf
Cohesion': 1,000 psf
Phi': 0 °

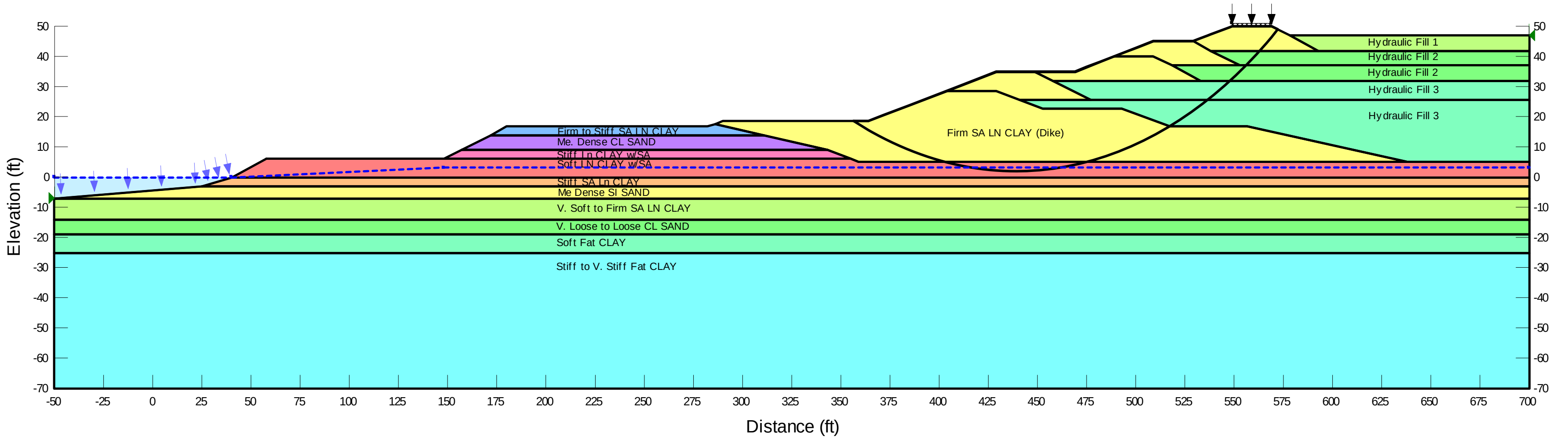
Name: Me Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V. Soft to Firm SA LN CLAY
Unit Weight: 120 pcf
Cohesion Spatial Fn: 350-500
Phi': 0 °

Name: V. Loose to Loose CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Soft Fat CLAY
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Stiff to V. Stiff Fat CLAY
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °



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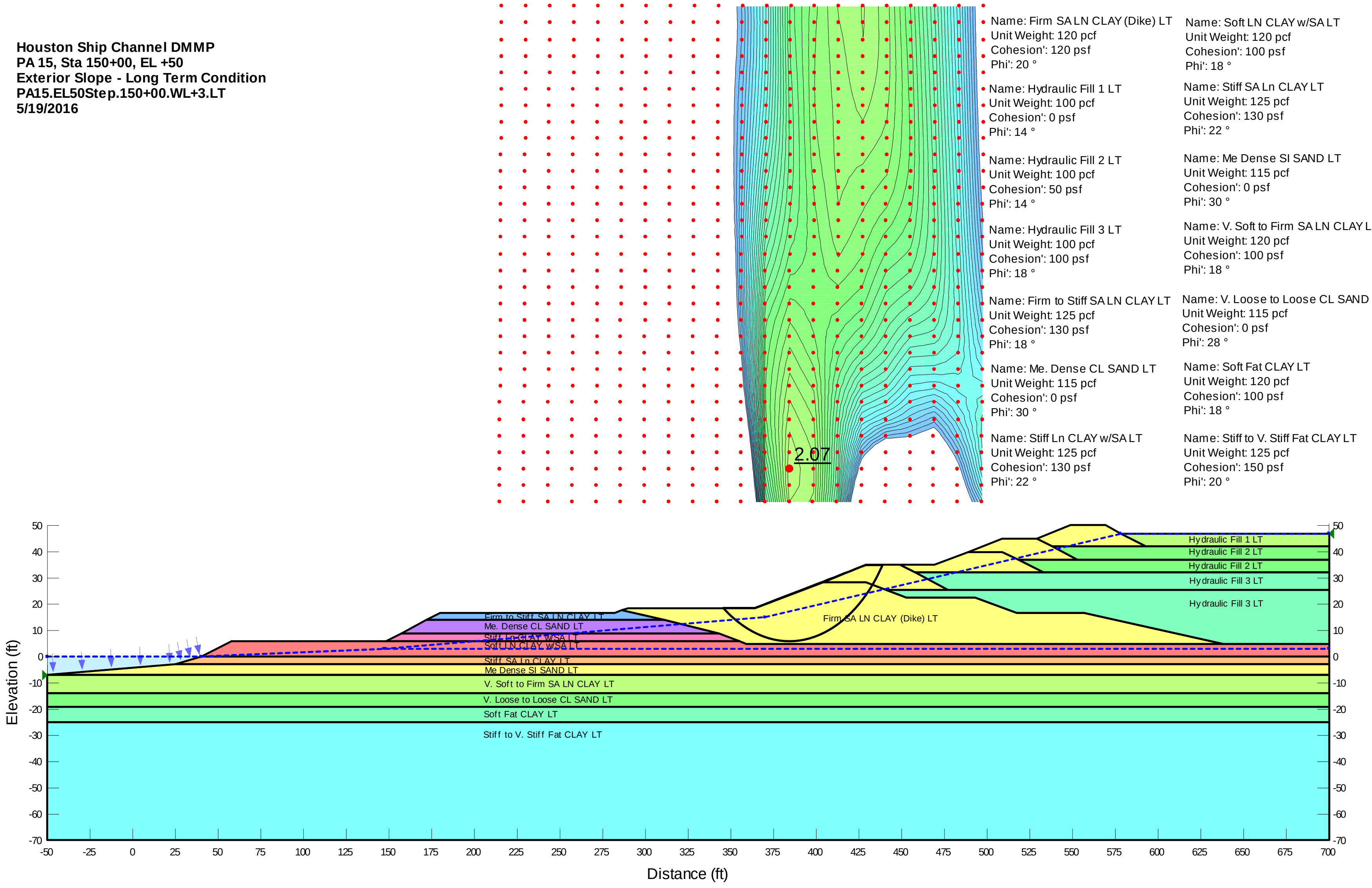
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
PA 15 CONTAINMENT DIKE STA. 150+00, EL +50

FILE NO:	PLATE NO: STAB-05

Houston Ship Channel DMMP
PA 15, Sta 150+00, EL +50
Exterior Slope - Long Term Condition
PA15.EL50Step.150+00.WL+3.LT
5/19/2016



Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Soft LN CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Stiff SA Ln CLAY LT
Unit Weight: 125 pcf
Cohesion': 130 psf
Phi': 22 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Me Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: V. Soft to Firm SA LN CLAY LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Firm to Stiff SA LN CLAY LT
Unit Weight: 125 pcf
Cohesion': 130 psf
Phi': 18 °

Name: V. Loose to Loose CL SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Me. Dense CL SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Soft Fat CLAY LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff Ln CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 130 psf
Phi': 22 °

Name: Stiff to V. Stiff Fat CLAY LT
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 20 °

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
PA 15 CONTAINMENT DIKE STA. 150+00, EL +50

FILE NO:	PLATE NO:
	STAB-06

Houston Ship Channel DMMP
Spilman Is PA, Sta 133+00, EL +45
Exterior Slope - Short Term Condition
SpilmanIs.133+00.EL45.Channel.EOC1.1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Firm Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Soft Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 450 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

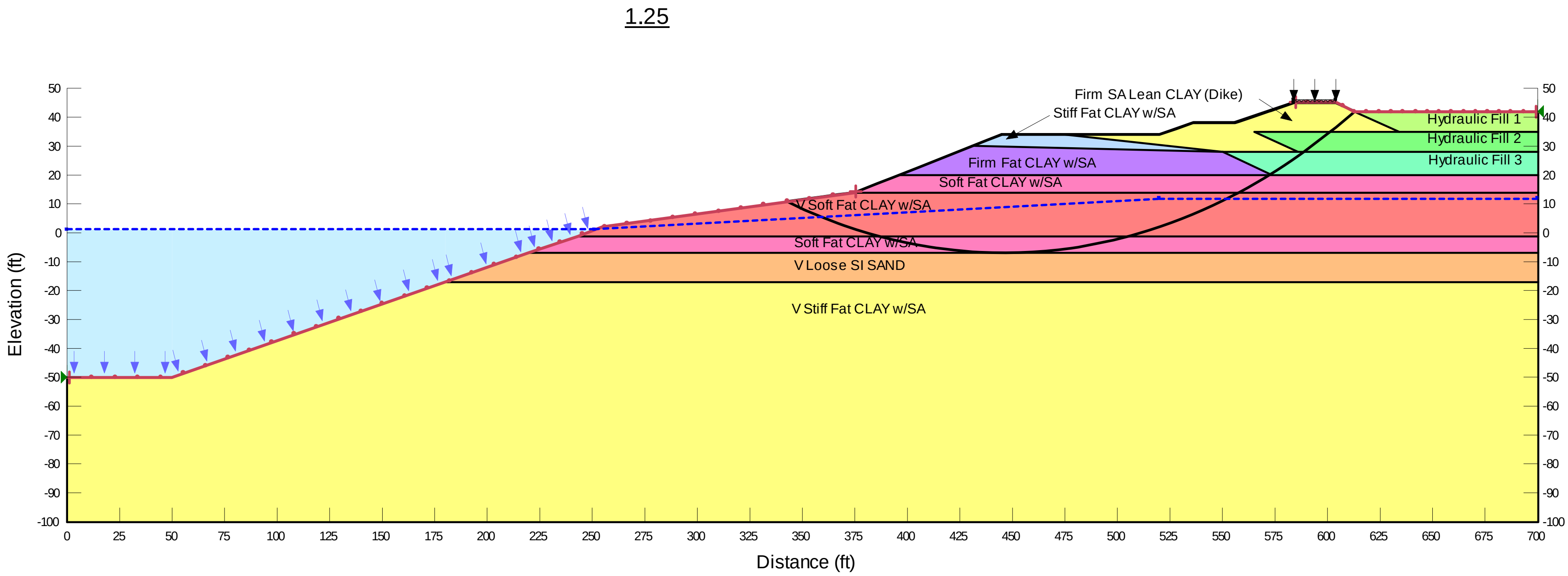
Name: V Soft Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 350 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: V Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 1,200 psf
Phi': 0 °

Name: V Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 19, 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
SPILMAN IS. PA CONTAINMENT DIKE STA. 133+00, EL +45

FILE NO:	PLATE NO: STAB-07

Houston Ship Channel DMMP
Spilman Is PA, Sta 133+00, EL +45
Exterior Slope - Long Term Condition
SpilmanIs.133+00.EL45.Channel.LT1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 140 psf
Phi': 20 °

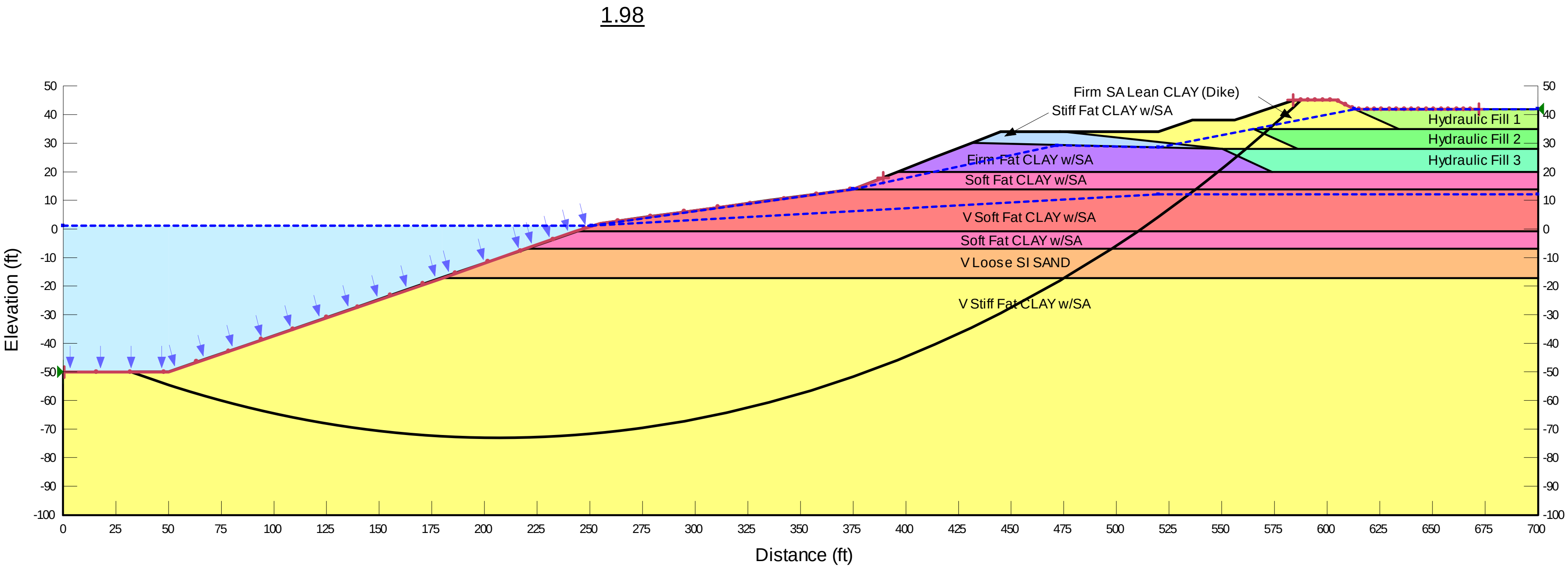
Name: Firm Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Soft Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 18 °

Name: V Soft Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 80 psf
Phi': 18 °

Name: V Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

Name: V Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 20 °



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CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
SPILMAN IS. PA CONTAINMENT DIKE STA. 133+00, EL +45

FILE NO:	PLATE NO: STAB-08

Houston Ship Channel DMMP
Alexander Island PA, Sta 35+50, EL +45
Exterior Slope - Short Term Condition
Name: AlexanderIs.EL45.Step90.35+50new.EOC1
Date: 5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 4
Unit Weight: 100 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Loose-Me Dense SI SAND (Dike)
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Soft to Firm Lean CLAY w/SA (Dike)
Unit Weight: 130 pcf
Cohesion': 450 psf
Phi': 0 °

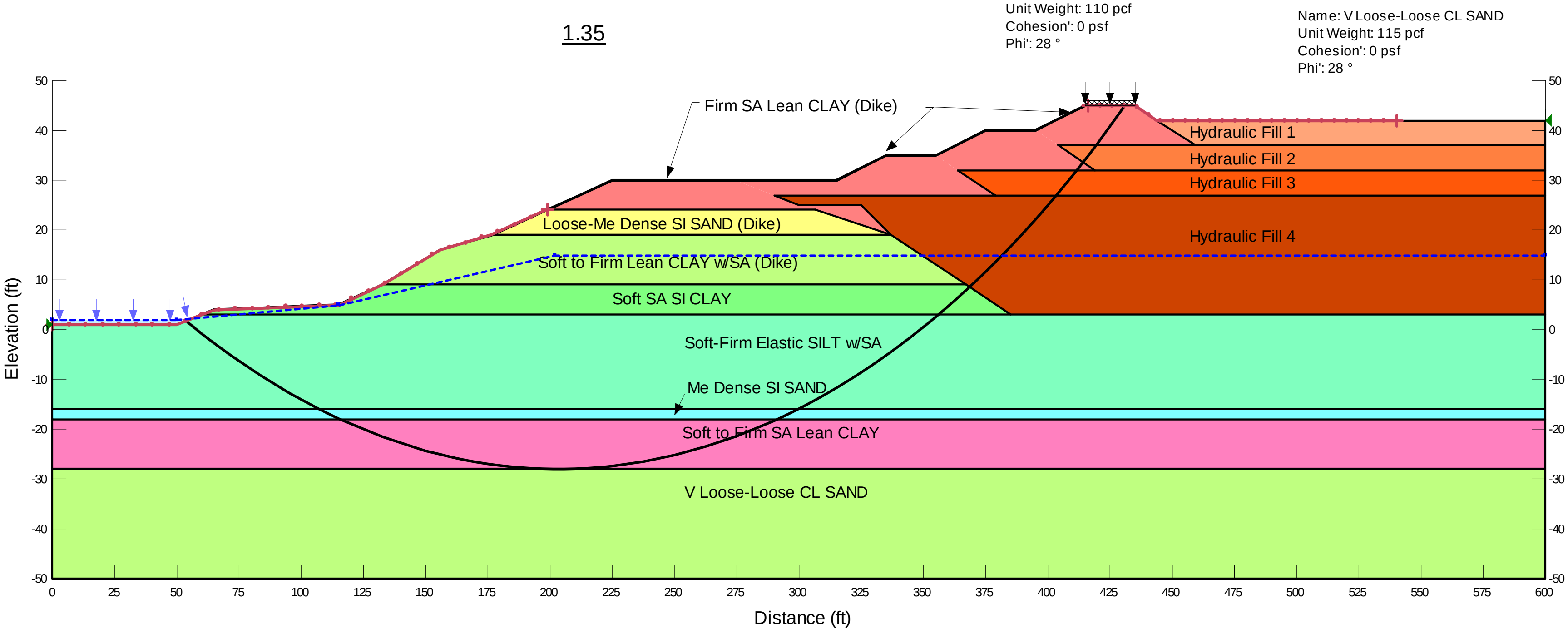
Name: Soft SA SI CLAY
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Soft-Firm Elastic SILT w/SA
Unit Weight: 110 pcf
Cohesion Spatial Fn: 350 - 500 psf
Phi': 0 °

Name: Me Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft to Firm SA Lean CLAY
Unit Weight: 130 pcf
Cohesion': 500 psf
Phi': 0 °

Name: V Loose-Loose CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
ALEXANDER IS. PA CONTAINMENT DIKE STA. 35+50, EL +45

FILE NO:

PLATE NO:
STAB-09

Houston Ship Channel DMMP
Alexander Island PA, Sta 35+50, EL +45
Exterior Slope - Long Term Condition
Name: AlexanderIs.EL45.Step90.35+50new.LT1
Date: 5/19/2016

Name: Firm SA Lean CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Hydraulic Fill 4 LT
Unit Weight: 100 pcf
Cohesion': 130 psf
Phi': 18 °

Name: Loose-Me Dense SI SAND (Dike) LT
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Soft to Firm Lean CLAY w/SA (Dike) l
Unit Weight: 130 pcf
Cohesion': 120 psf
Phi': 18 °

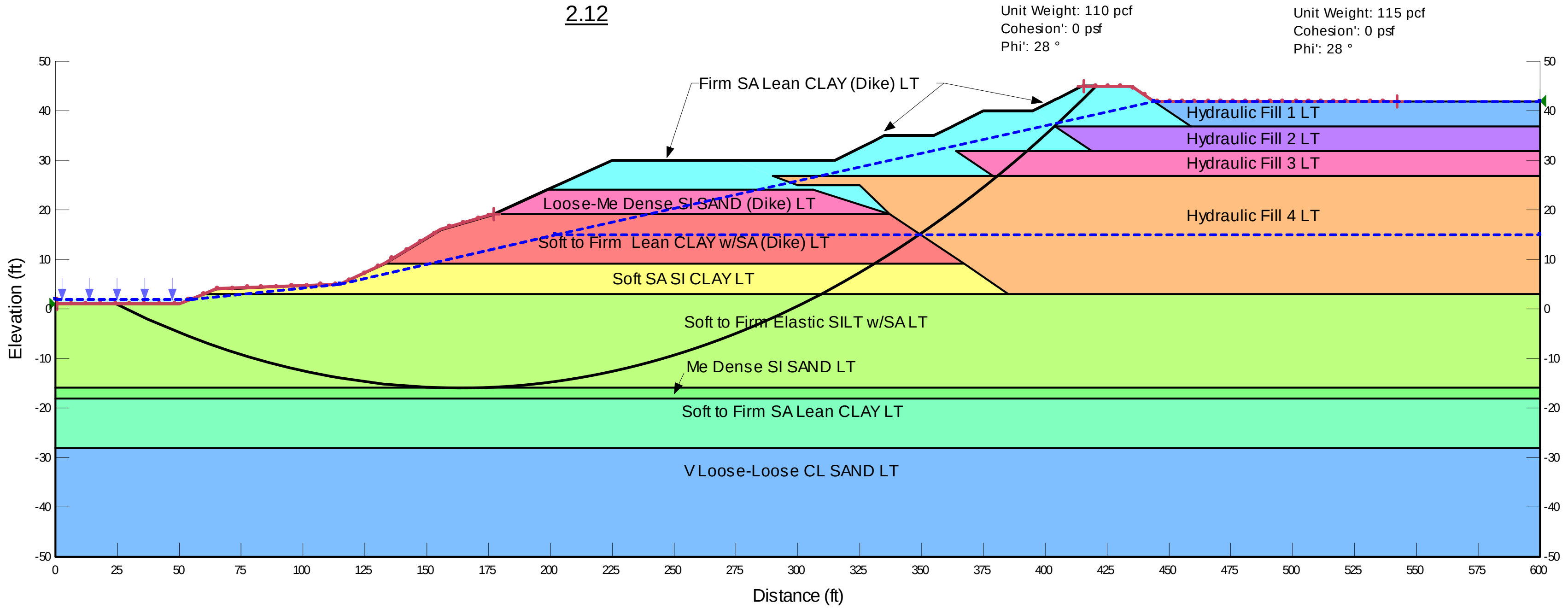
Name: Soft SA SI CLAY LT
Unit Weight: 110 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Soft to Firm Elastic SILT w/SA LT
Unit Weight: 110 pcf
Cohesion': 80 psf
Phi': 18 °

Name: Me Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft to Firm SA Lean CLAY LT
Unit Weight: 130 pcf
Cohesion': 120 psf
Phi': 22 °

Name: V Loose-Loose CL SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE:	APPROVED BY:	PREPARED BY:
19 May 2016		DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
ALEXANDER IS. PA CONTAINMENT DIKE STA. 35+50, EL +45

FILE NO:

PLATE NO:
STAB-10

Houston Ship Channel DMMP
Peggy Lake PA, Sta 130+00, EL +35
Exterior Slope - Short Term Condition
PeggyLake.EL35.130+00New.Step.EOC
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff - V. Stiff Fat CLAY w/SA
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Soft SA Lean CLAY (Berm)
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Me. Dense to V. Dense SI SAND w/CL
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff Ln CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °

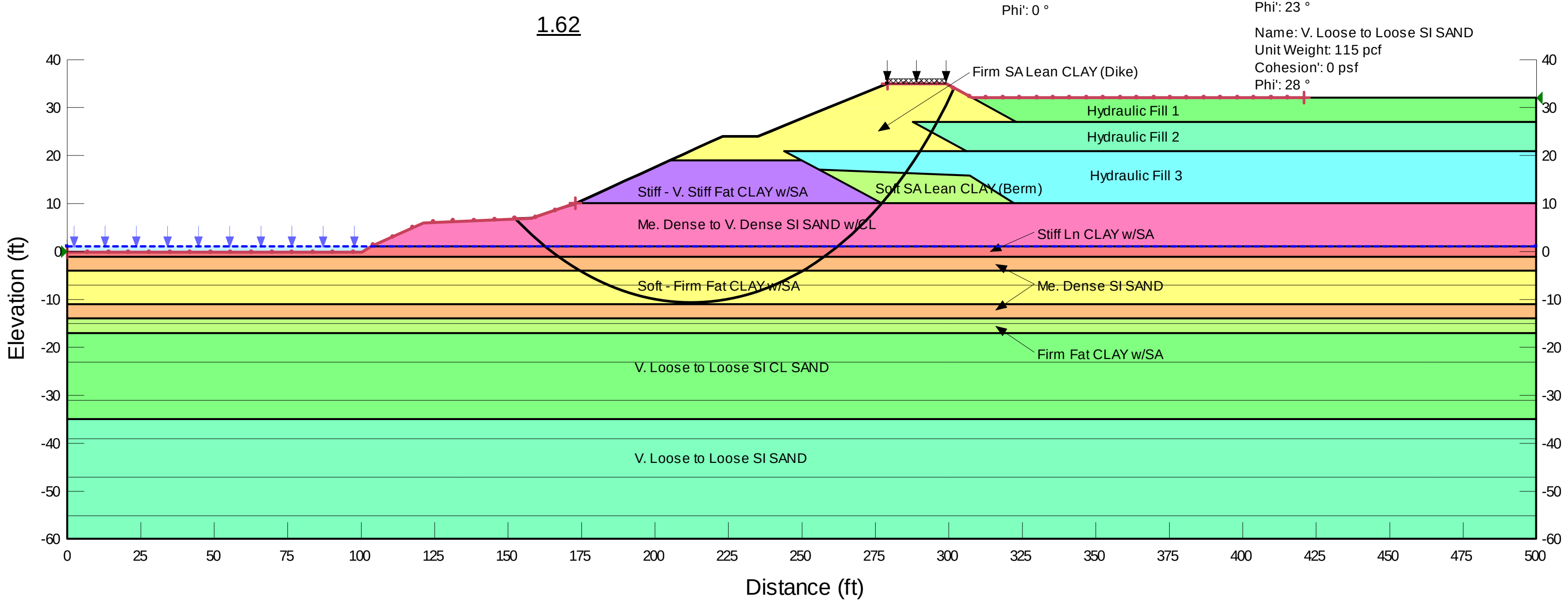
Name: Me. Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft - Firm Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion Spatial Fn: 350-500 psf
Phi': 0 °

Name: Firm Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: V. Loose to Loose SI CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 23 °

Name: V. Loose to Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
PEGGY LAKE PA CONTAINMENT DIKE STA. 130+00, EL +35

FILE NO:	PLATE NO: STAB-11

Houston Ship Channel DMMP
Peggy Lake PA, Sta 130+00, EL +35
Exterior Slope - Long Term Condition
PeggyLake.EL35.130+00New.Step.LT
5/19/2016

Name: Firm SA Lean CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff - V. Stiff Fat CLAY w/SA LT
Unit Weight: 130 pcf
Cohesion': 140 psf
Phi': 18 °

Name: Soft SA Lean CLAY (Berm) LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 20 °

Name: Me. Dense to V. Dense SI SAND w/CL LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff Ln CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 130 psf
Phi': 18 °

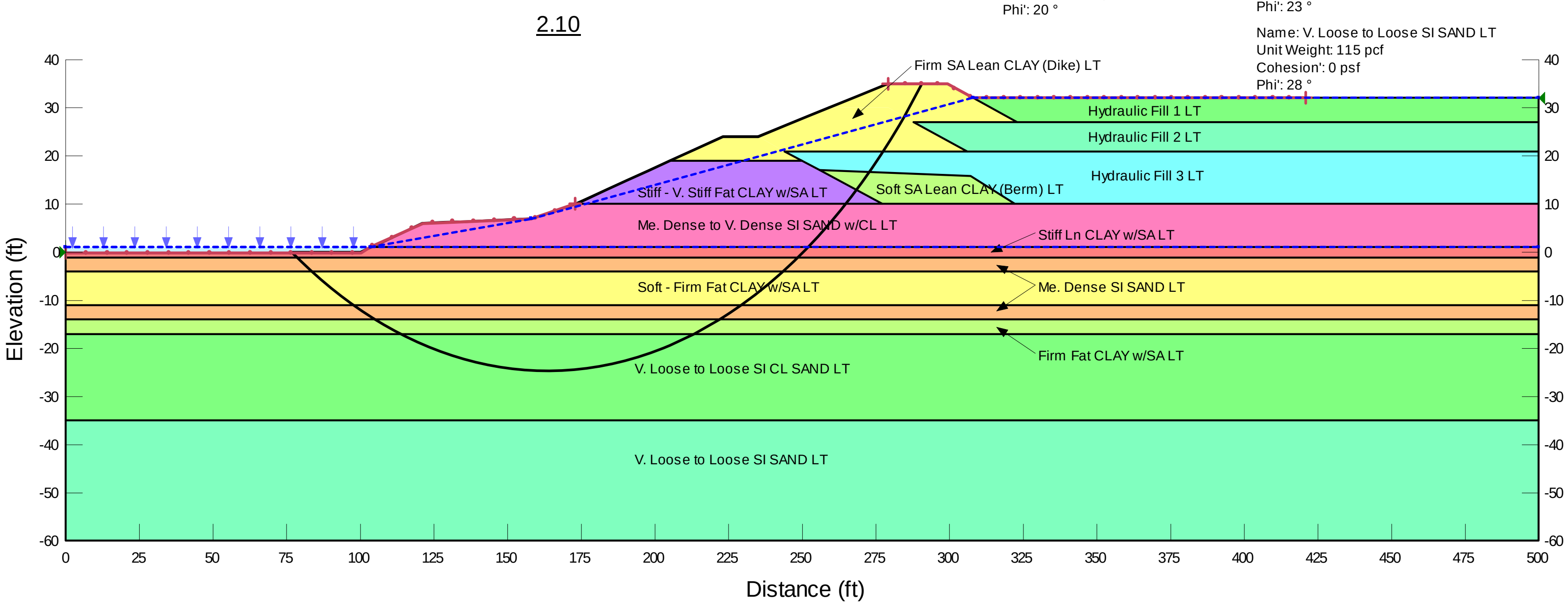
Name: Me. Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Soft - Firm Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Firm Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 18 °

Name: V. Loose to Loose SI CL SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 23 °

Name: V. Loose to Loose SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °



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CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE:	APPROVED BY:	PREPARED BY:
19 MAY 2016		DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
PEGGY LAKE PA CONTAINMENT DIKE STA. 130+00, EL +35

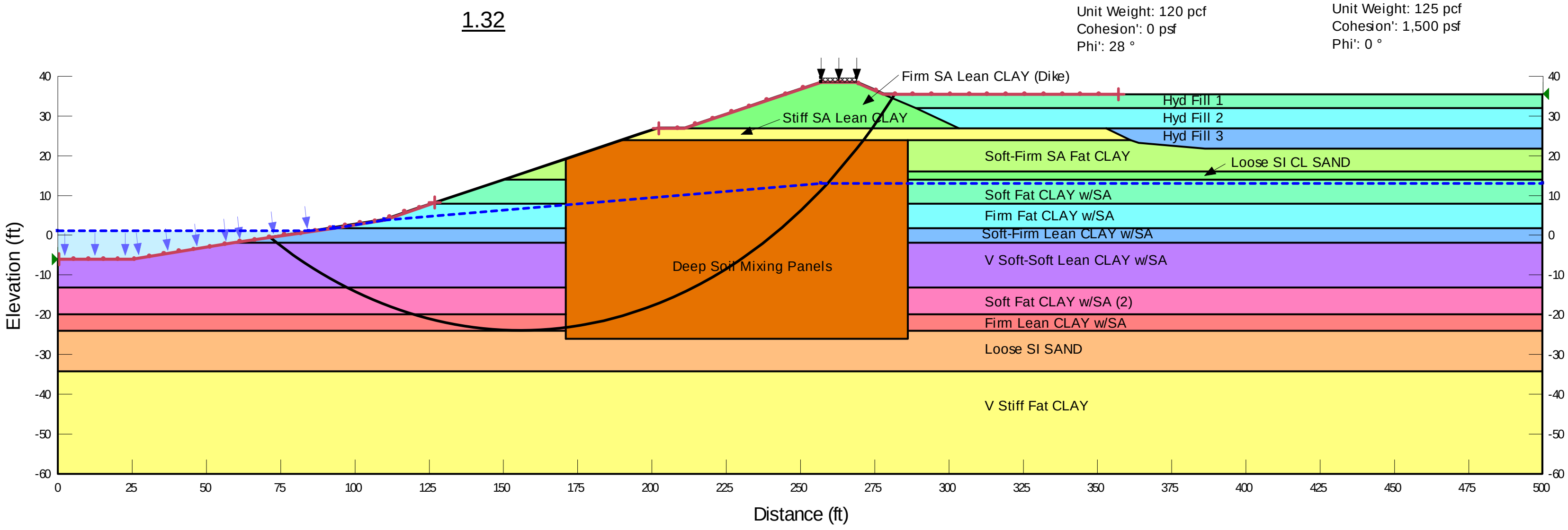
FILE NO:

PLATE NO:
STAB-12

Houston Ship Channel DMMP
Lost Lake PA, Sta 167+00, EL +38.6
Exterior Slope - Short Term Condition
LostLake.EL38.5.4H1V.Stable2.1.EOC1
5/19/2016

Name: Firm SA Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Hyd Fill 1
Unit Weight: 110 pcf
Cohesion': 150 psf
Phi': 0 °
Name: Hyd Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °
Name: Hyd Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Stiff SA Lean CLAY
Unit Weight: 125 pcf
Cohesion': 1,000 psf
Phi': 0 °
Name: Deep Soil Mixing Panels
Unit Weight: 115 pcf
Cohesion': 900 psf
Phi': 0 °
Name: Soft-Firm SA Fat CLAY
Unit Weight: 125 pcf
Cohesion Spatial Fn: 350-500
Phi': 0 °
Name: Loose SI CL SAND
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Soft Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 400 psf
Phi': 0 °
Name: Firm Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 800 psf
Phi': 0 °
Name: Soft-Firm Lean CLAY w/SA
Unit Weight: 125 pcf
Cohesion Spatial Fn: 350-500
Phi': 0 °
Name: V Soft-Soft Lean CLAY w/SA
Unit Weight: 125 pcf
Cohesion Spatial Fn: 300-400
Phi': 0 °
Name: Soft Fat CLAY w/SA (2)
Unit Weight: 125 pcf
Cohesion': 450 psf
Phi': 0 °
Name: Firm Lean CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Loose SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Name: V Stiff Fat CLAY
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

DATE: 19 May 2016	APPROVED BY:	PREPARED BY: DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
LOST LAKE PA CONTAINMENT DIKE STA. 167+00, EL +38.5

FILE NO:

PLATE NO:
STAB-13

Houston Ship Channel DMMP
Lost Lake PA, Sta 167+00, EL +38.6
Exterior Slope - Long Term Condition
LostLake.EL38.5.4H1V.Stable2.1.LT1.1
5/19/2016

Name: Firm SA Lean CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hyd Fill 1 LT
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hyd Fill 2 LT
Unit Weight: 115 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hyd Fill 3 LT
Unit Weight: 115 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff SA Lean CLAY LT
Unit Weight: 125 pcf
Cohesion': 130 psf
Phi': 20 °

Name: Deep Soil Mixing Panels LT
Unit Weight: 115 pcf
Cohesion': 150 psf
Phi': 22 °

Name: Soft-Firm SA Fat CLAY LT
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Loose SI CL SAND LT
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Soft Fat CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Firm Fat CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Soft-Firm Lean CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 18 °

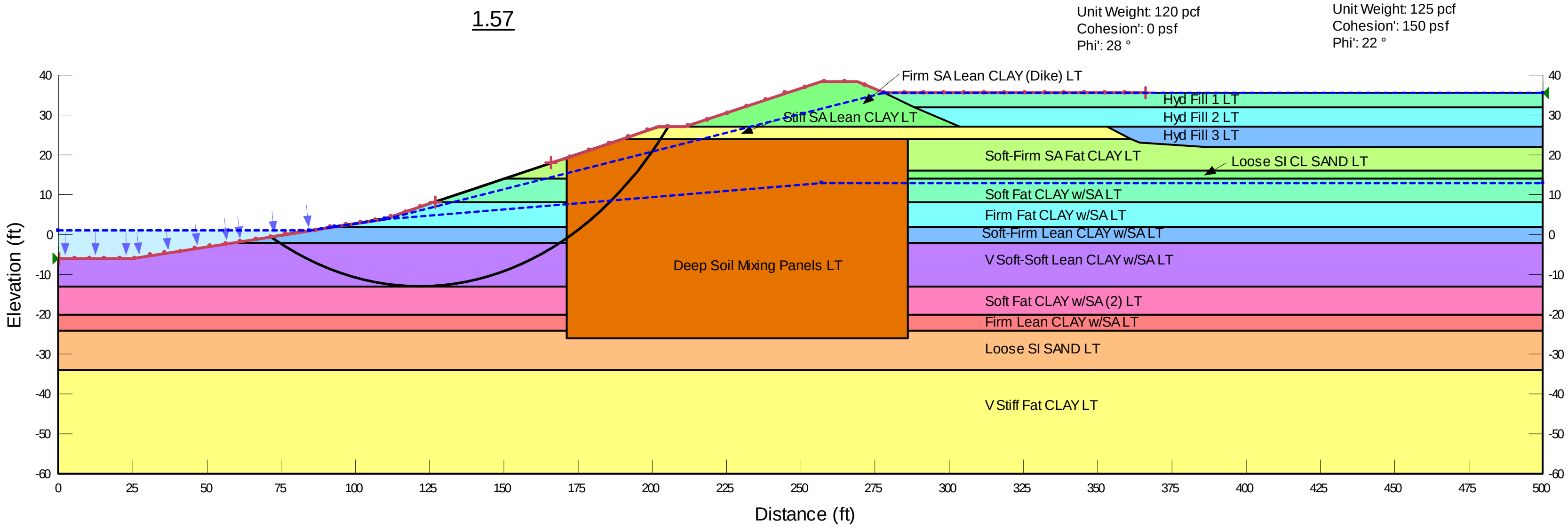
Name: V Soft-Soft Lean CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 80 psf
Phi': 18 °

Name: Soft Fat CLAY w/SA (2) LT
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Firm Lean CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Loose SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff Fat CLAY LT
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 22 °



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GALVESTON, TEXAS

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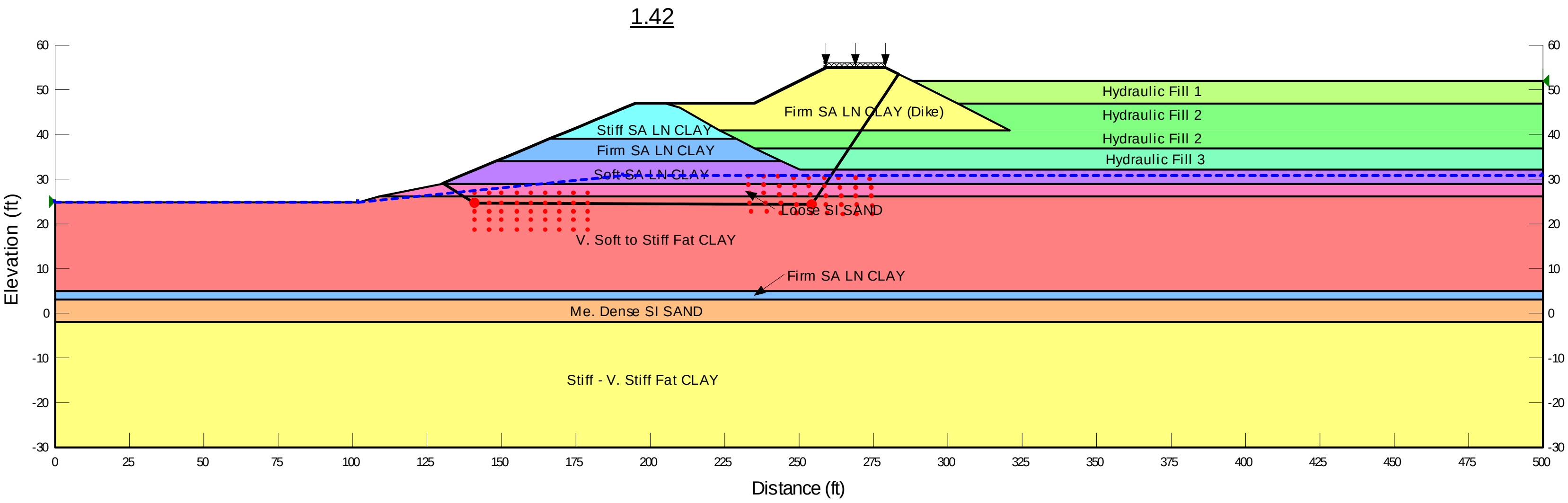
HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
LOST LAKE PA CONTAINMENT DIKE STA. 167+00, EL +38.5

FILE NO:	PLATE NO:
	STAB-14

Houston Ship Channel DMMP
Rosa Allen PA, Sta 19+00, EL +55
Exterior Slope - Short Term Conditions
RosaAllen.EL55.Sta19+00Step40.WL31.EOC
5/19/2016

Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °
Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °
Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Stiff SA LN CLAY
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °
Name: Firm SA LN CLAY
Unit Weight: 125 pcf
Cohesion': 600 psf
Phi': 0 °
Name: Soft SA LN CLAY
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Loose SI SAND
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Name: V. Soft to Stiff Fat CLA
Unit Weight: 125 pcf
Cohesion Spatial Fn: 250-120
Phi': 0 °
Name: Me. Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Name: Stiff - V. Stiff Fat CLAY
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
ROSA ALLEN PA CONTAINMENT DIKE STA. 19+00, EL +55

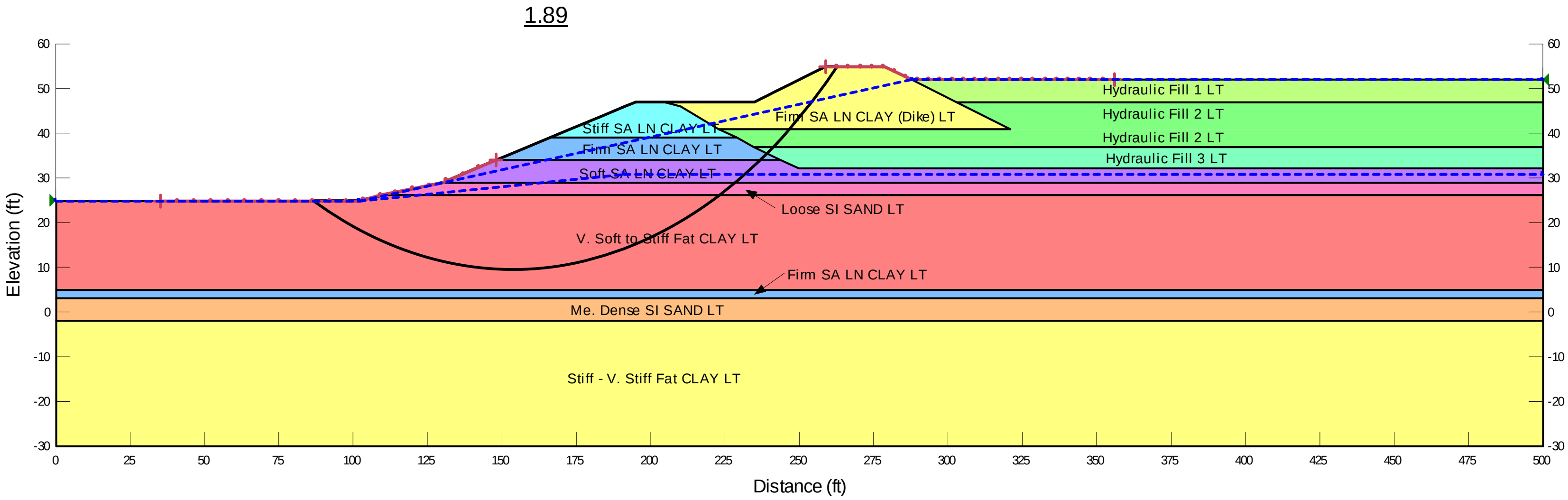
FILE NO:

PLATE NO: STAB-15

Houston Ship Channel DMMP
Rosa Allen PA, Sta 19+00, EL +55
Exterior Slope - Long Term Conditions
RosaAllen.EL55.Sta19+00Step40.WL31.LT
5/19/2016

Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °
Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °
Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °
Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °
Name: Stiff SA LN CLAY LT
Unit Weight: 120 pcf
Cohesion': 130 psf
Phi': 20 °
Name: Firm SA LN CLAY LT
Unit Weight: 125 pcf
Cohesion': 120 psf
Phi': 20 °
Name: Soft SA LN CLAY LT
Unit Weight: 120 pcf
Cohesion': 110 psf
Phi': 18 °

Name: Loose SI SAND LT
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °
Name: V. Soft to Stiff Fat CLAY L
Unit Weight: 125 pcf
Cohesion Spatial Fn: 80-200
Phi': 18 °
Name: Me. Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Name: Stiff - V. Stiff Fat CLAY LT
Unit Weight: 130 pcf
Cohesion': 220 psf
Phi': 18 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
ROSA ALLEN PA CONTAINMENT DIKE STA. 19+00, EL +55

FILE NO:

PLATE NO:
STAB-16

Houston Ship Channel DMMP
Clinton PA, East Cell, Sta 38+00, EL +60
Exterior Slope - Short Term Condition
ClintonEast.EL60Step40.38+00.WL32.EOC
5/19/2016

Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff SA LN CLAY
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °

Name: V. Stiff SA LN CLAY
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °

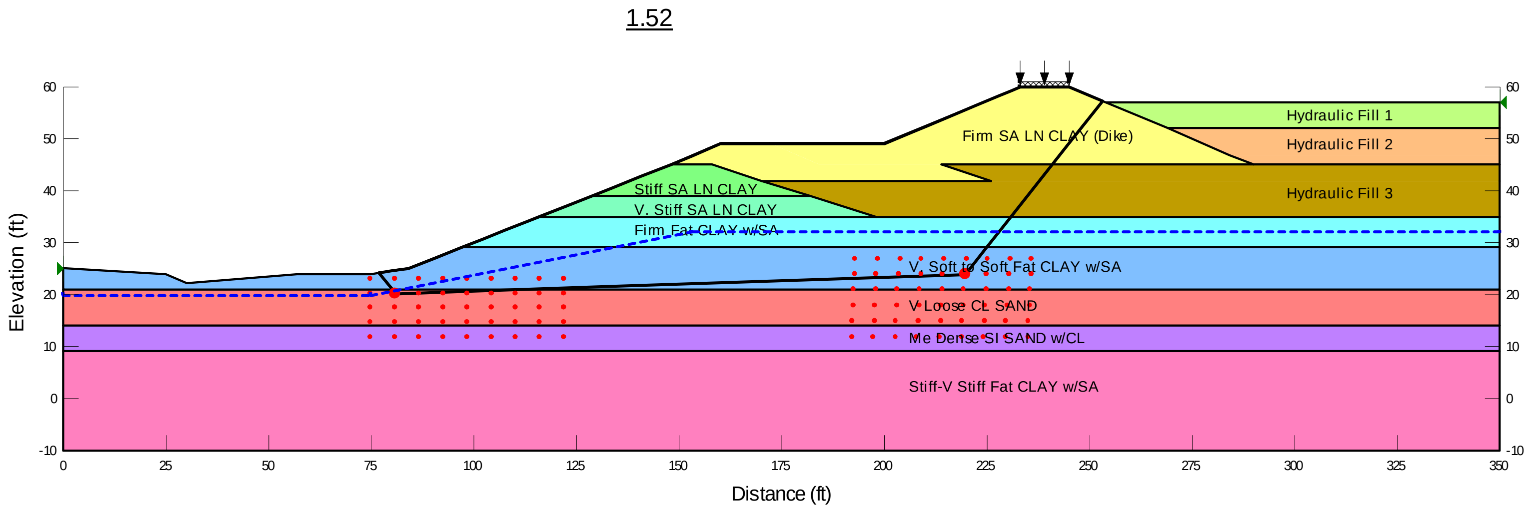
Name: Firm Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

Name: V. Soft to Soft Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 500 psf
Phi': 0 °

Name: V Loose CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Me Dense SI SAND w/CL
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Stiff-V Stiff Fat CLAY w/SA
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
CLINTON PA EAST CELL CONTAINMENT DIKE STA. 38+00, EL +60

FILE NO:

PLATE NO:
STAB-17

Houston Ship Channel DMMP
Clinton PA, East Cell, Sta 38+00, EL +60
Exterior Slope - Long Term Condition
ClintonEast.EL60Step40.38+00.WL57.LT
5/19/2016

Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff SA LN CLAY LT
Unit Weight: 120 pcf
Cohesion': 130 psf
Phi': 20 °

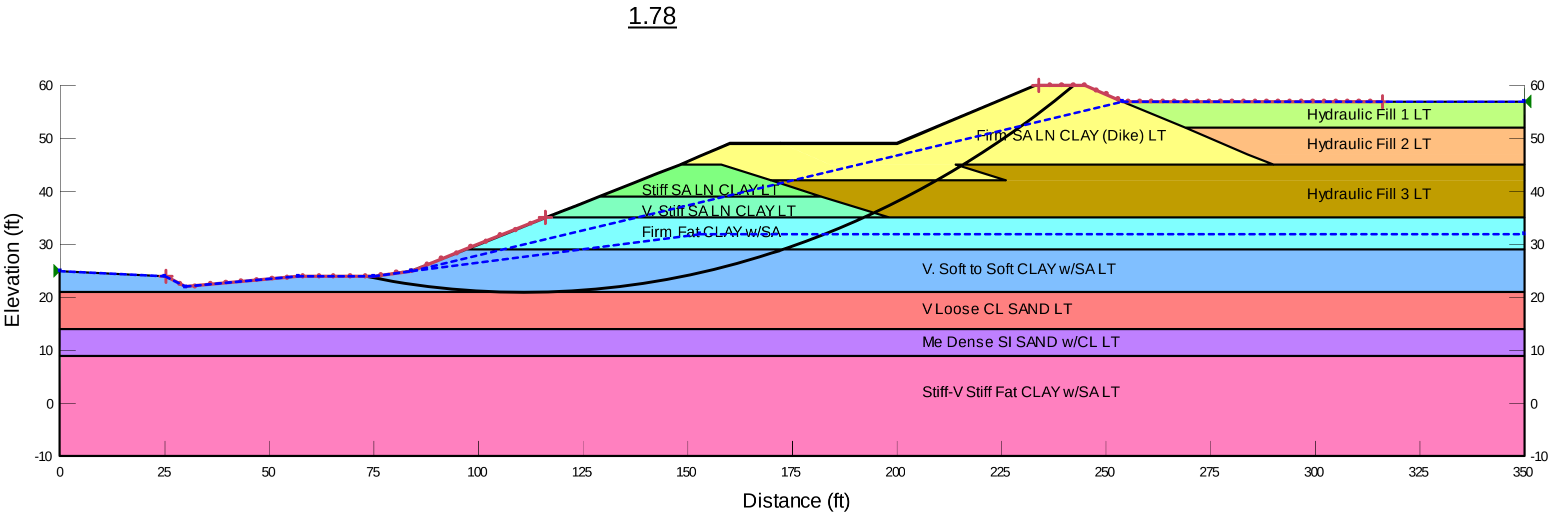
Name: V. Stiff SA LN CLAY LT
Unit Weight: 130 pcf
Cohesion': 200 psf
Phi': 20 °

Name: Firm Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 18 °

Name: V. Soft to Soft CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Me Dense SI SAND w/CL LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Stiff-V Stiff Fat CLAY w/SA LT
Unit Weight: 130 pcf
Cohesion': 200 psf
Phi': 20 °



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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
CLINTON PA EAST CELL CONTAINMENT DIKE STA. 38+00, EL +60

FILE NO:	PLATE NO:
	STAB-18

Houston Ship Channel DMMP
Clinton PA, West Cell, Sta 102+00, EL +60
Exterior Slope - Short Term Condition
ClintonWest.EL60Step40.102+00.EOC1.2
5/19/2016

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Loose-Me Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Firm-Stiff Fat CLAY w/Sa
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

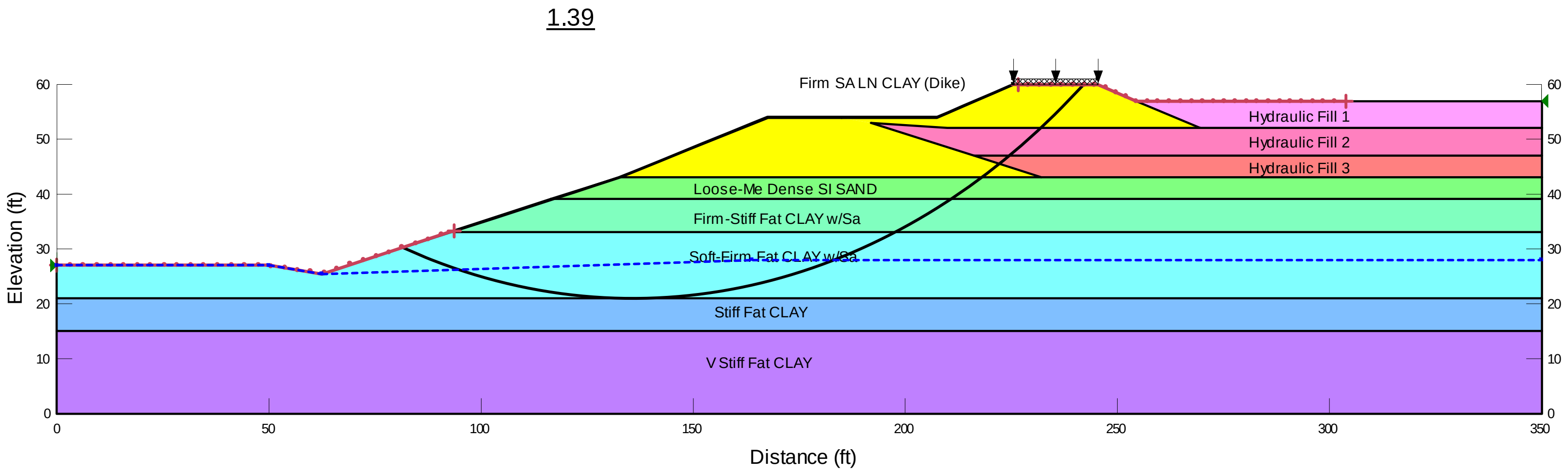
Name: Soft-Firm Fat CLAY w/Sa
Unit Weight: 120 pcf
Cohesion': 400 psf
Phi': 0 °

Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Stiff Fat CLAY
Unit Weight: 130 pcf
Cohesion': 1,200 psf
Phi': 0 °

Name: V Stiff Fat CLAY
Unit Weight: 130 pcf
Cohesion': 1,500 psf
Phi': 0 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
CLINTON PA WEST CELL CONTAINMENT DIKE STA. 102+00, EL +60

FILE NO:	PLATE NO:
	STAB-19

Houston Ship Channel DMMP
Clinton PA, West Cell, Sta 102+00, EL +60
Exterior Slope - Long Term Condition
ClintonWest.EL60Step40.102+00.LT1.1
5/19/2016

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Loose-Me Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: Firm-Stiff Fat CLAY w/Sa LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

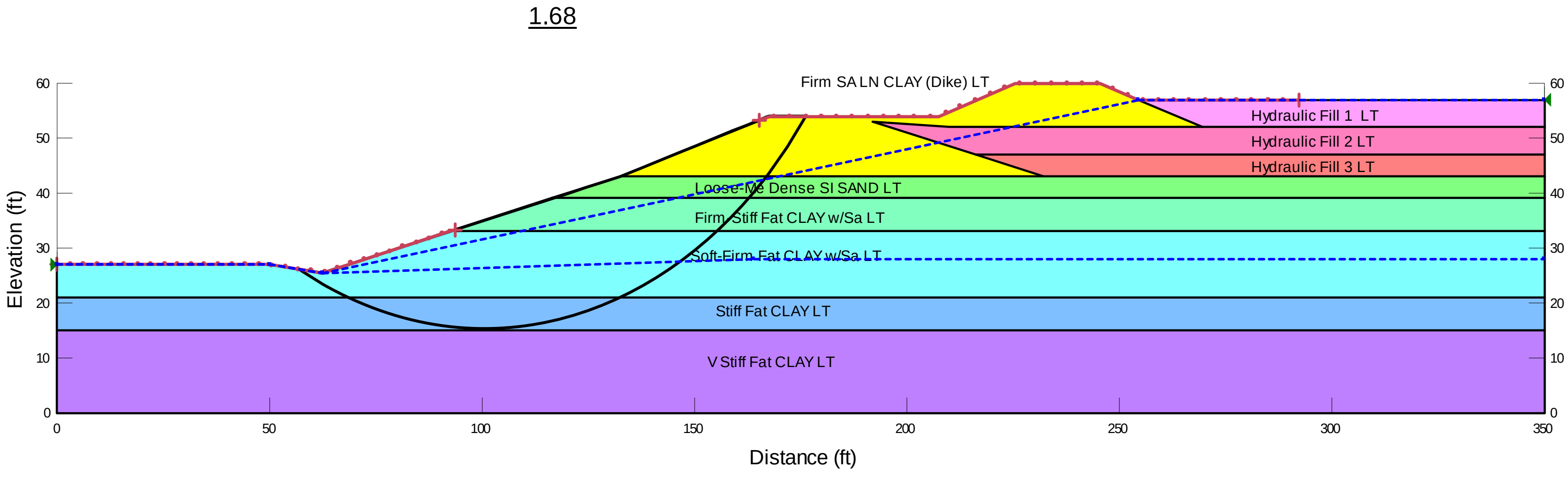
Name: Soft-Firm Fat CLAY w/Sa LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 20 °

Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Stiff Fat CLAY LT
Unit Weight: 130 pcf
Cohesion': 150 psf
Phi': 18 °

Name: V Stiff Fat CLAY LT
Unit Weight: 130 pcf
Cohesion': 220 psf
Phi': 18 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
CLINTON PA WEST CELL CONTAINMENT DIKE STA. 102+00, EL +60

FILE NO:

PLATE NO:
STAB-20

Houston Ship Channel DMMP
House Tract PA, Sta 163+00, EL +66
Exterior Slope - Short Term Condition
Housetract.Sta163+00.EL66 Step 40.WL22.EOC
5/19/2016

Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 3
Unit Weight: 100 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff-V Stiff Fat CLAY w/S
Unit Weight: 125 pcf
Cohesion': 1,200 psf
Phi': 0 °

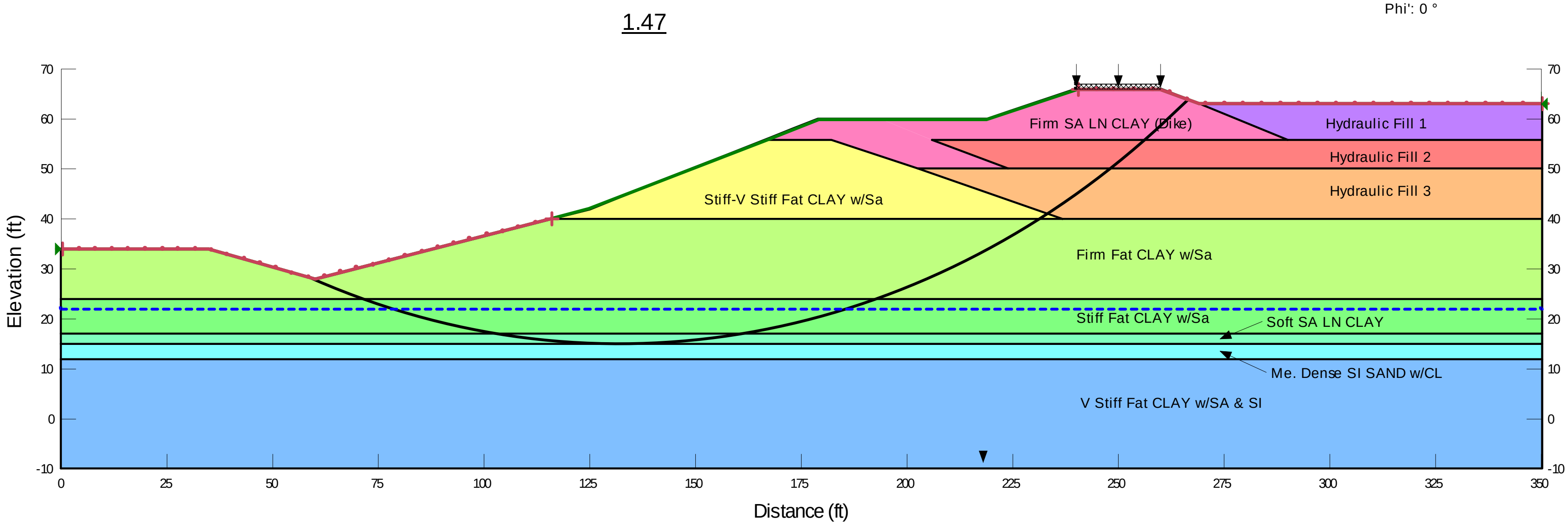
Name: Firm Fat CLAY w/Sa
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff Fat CLAY w/Sa
Unit Weight: 125 pcf
Cohesion': 1,200 psf
Phi': 0 °

Name: Soft SA LN CLAY
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 0 °

Name: Me. Dense SI SAND w/CL
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff Fat CLAY w/SA & S
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
HOUSE TRACT PA CONTAINMENT DIKE STA. 163+00, EL +66

FILE NO:

PLATE NO:
STAB-21

Houston Ship Channel DMMP
House Tract PA, Sta 163+00, EL +66
Exterior Slope - Long Term Condition
Housetract.Sta163+00.EL66 Step 40.WL63.LT
5/19/2016

Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 3 LT
Unit Weight: 100 pcf
Cohesion': 100 psf
Phi': 18 °

Name: Stiff-V Stiff Fat CLAY w/Sa L
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 20 °

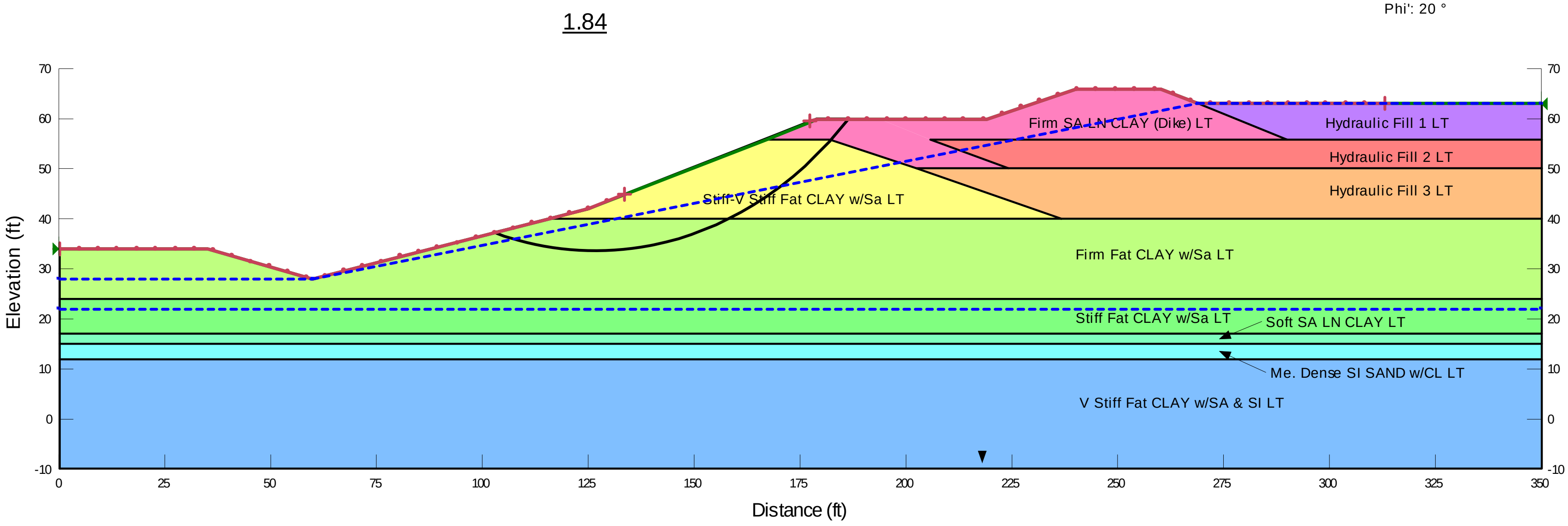
Name: Firm Fat CLAY w/Sa LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Stiff Fat CLAY w/Sa LT
Unit Weight: 125 pcf
Cohesion': 150 psf
Phi': 20 °

Name: Soft SA LN CLAY LT
Unit Weight: 125 pcf
Cohesion': 80 psf
Phi': 20 °

Name: Me. Dense SI SAND w/CL LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff Fat CLAY w/SA & SI L
Unit Weight: 125 pcf
Cohesion': 200 psf
Phi': 20 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
HOUSE TRACT PA CONTAINMENT DIKE STA. 163+00, EL +66

FILE NO:

PLATE NO: STAB-22

Houston Ship Channel DMMP
Glendale PA, Sta 120+00, EL +60
Exterior Slope - Short Term Condition
HSC DMMP Glendale 3.5:1 Slope EL60 Step 20' WL24 EOC
5/19/2016

Name: Firm Sa Lean CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 2
Unit Weight: 100 pcf
Cohesion': 250 psf
Phi': 0 °

Name: Hydraulic Fill 4
Unit Weight: 100 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Firm SA Lean CLAY
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Stiff-V Stiff SA Lean CLAY
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °

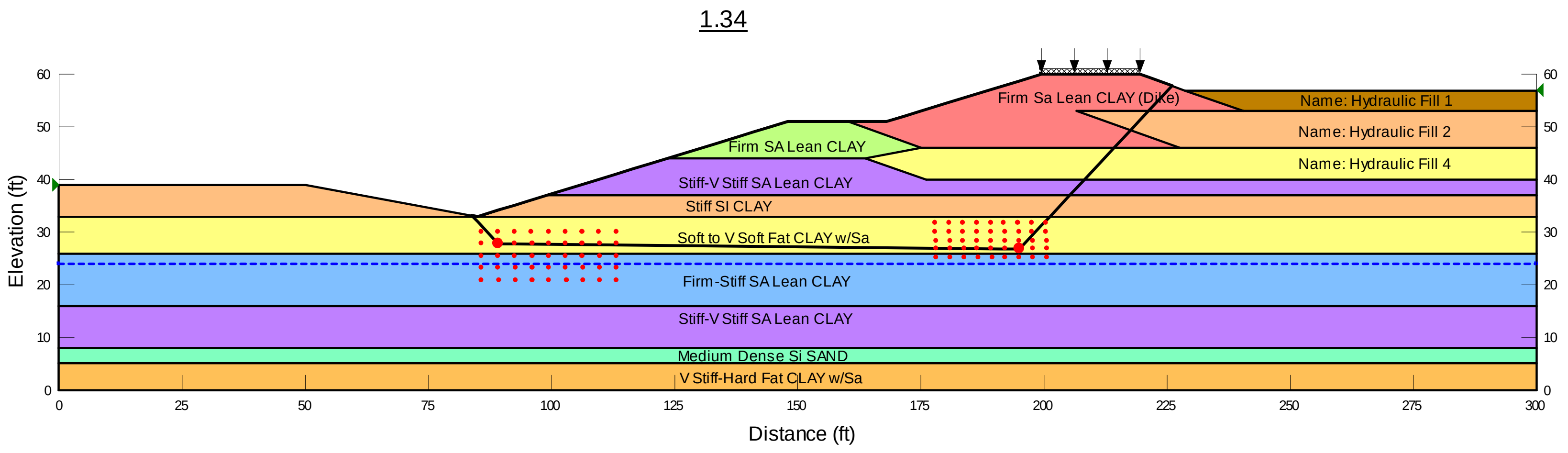
Name: Stiff SI CLAY
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °

Name: Soft to V Soft Fat CLAY w/Sa
Unit Weight: 125 pcf
Cohesion': 300 psf
Phi': 0 °

Name: Firm-Stiff SA Lean CLAY
Unit Weight: 125 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Medium Dense Si SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff-Hard Fat CLAY w/Sa
Unit Weight: 130 pcf
Cohesion': 2,000 psf
Phi': 0 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
GLENDALE PA CONTAINMENT DIKE STA. 120+00, EL +60

FILE NO:	PLATE NO:
	STAB-23

Houston Ship Channel DMMP
Glendale PA, Sta 120+00, EL +60
Exterior Slope - Long Term Condition
HSC DMMP Glendale 3.5:1 Slope EL60 Step 20' WL57 LT
5/19/2016

Name: Firm Sa Lean CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 2 LT
Unit Weight: 100 pcf
Cohesion': 50 psf
Phi': 14 °

Name: Hydraulic Fill 4 LT
Unit Weight: 100 pcf
Cohesion': 130 psf
Phi': 18 °

Name: Firm SA Lean CLAY LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Stiff-V Stiff SA Lean CLAY LT
Unit Weight: 125 pcf
Cohesion': 220 psf
Phi': 20 °

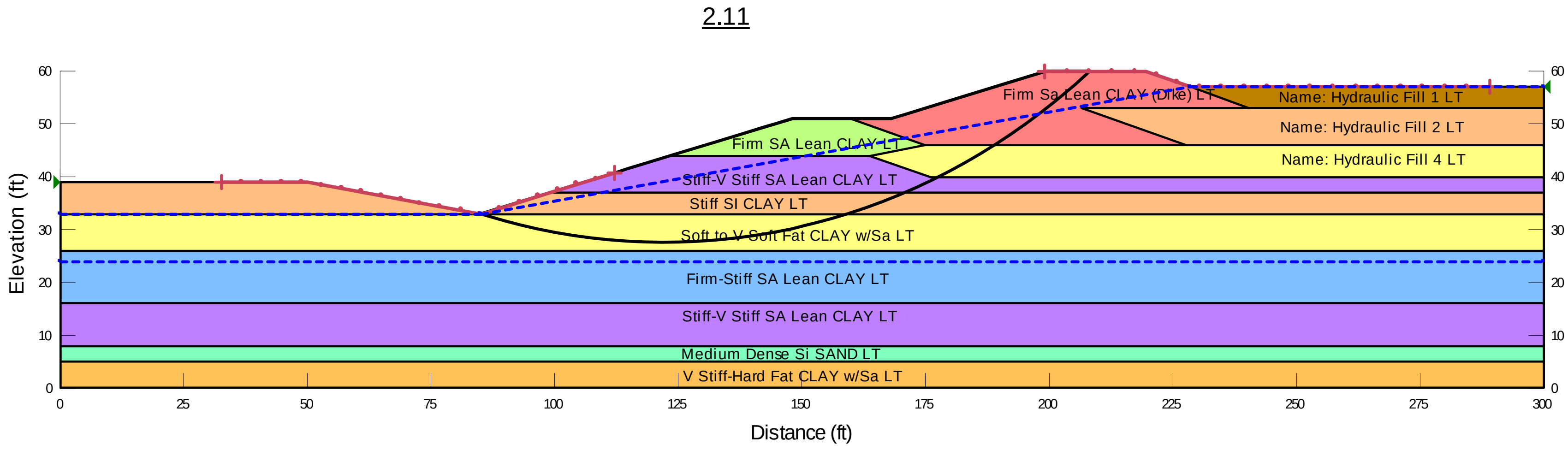
Name: Stiff Sl CLAY LT
Unit Weight: 120 pcf
Cohesion': 150 psf
Phi': 18 °

Name: Soft to V Soft Fat CLAY w/Sa L
Unit Weight: 125 pcf
Cohesion': 80 psf
Phi': 18 °

Name: Firm-Stiff SA Lean CLAY LT
Unit Weight: 125 pcf
Cohesion': 140 psf
Phi': 20 °

Name: Medium Dense Si SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff-Hard Fat CLAY w/Sa LT
Unit Weight: 130 pcf
Cohesion': 250 psf
Phi': 20 °



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GALVESTON, TEXAS

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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
GLENDALE PA CONTAINMENT DIKE STA. 120+00, EL +60

FILE NO:

PLATE NO: STAB-24

Houston Ship Channel DMMP
Filterbed PA, Sta 62+50, EL +60
Exterior Slope - Short Term Condition
Filterbed.62+50.EL60 Step20 WL24 EOC
5/19/2016

Name: Firm SA LN CLAY (Dike)
Unit Weight: 120 pcf
Cohesion': 600 psf
Phi': 0 °

Name: Hydraulic Fill 1
Unit Weight: 100 pcf
Cohesion': 150 psf
Phi': 0 °

Name: Hydraulic Fill 4
Unit Weight: 100 pcf
Cohesion': 800 psf
Phi': 0 °

Name: V. Stiff-Hard Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Loose SI CL SAND
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Firm-Stiff Fat CLAY
Unit Weight: 120 pcf
Cohesion': 800 psf
Phi': 0 °

Name: Soft-Firm Fat CLAY w/SA
Unit Weight: 120 pcf
Cohesion': 500 psf
Phi': 0 °

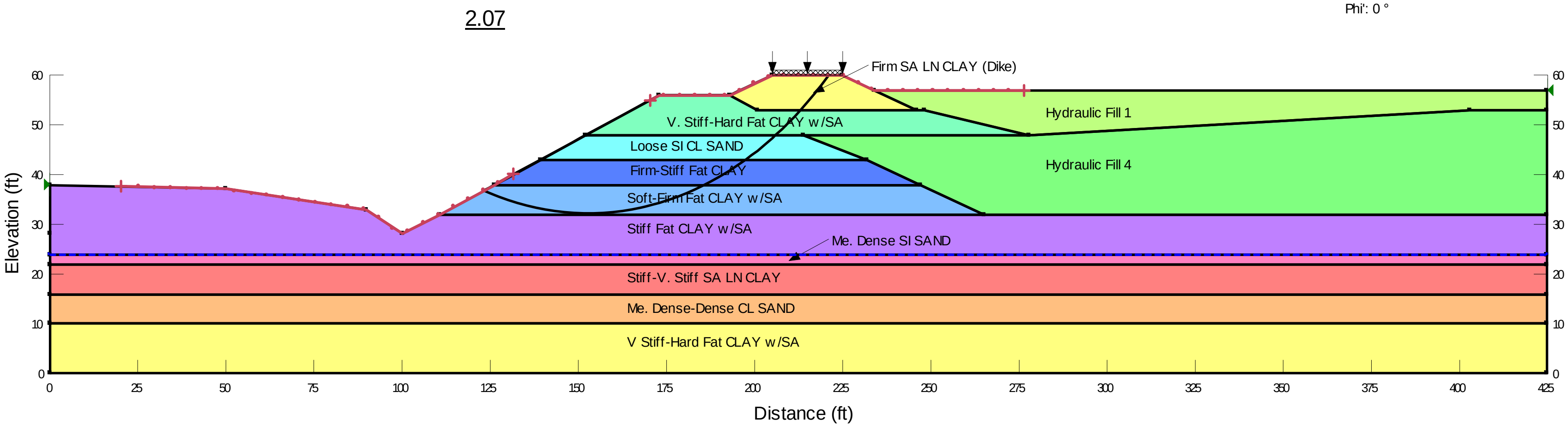
Name: Stiff Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 1,200 psf
Phi': 0 °

Name: Me. Dense SI SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff-V. Stiff SA LN CLAY
Unit Weight: 125 pcf
Cohesion': 1,500 psf
Phi': 0 °

Name: Me. Dense-Dense CL SAND
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff-Hard Fat CLAY w/SA
Unit Weight: 125 pcf
Cohesion': 2,000 psf
Phi': 0 °



U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

DATE:	APPROVED BY:	PREPARED BY:
19 May 2016		DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – SHORT TERM
FILTERBED PA CONTAINMENT DIKE STA. 62+50, EL +60

FILE NO:

PLATE NO:
STAB-25

Houston Ship Channel DMMP
Filterbed PA, Sta 62+50, EL +60
Exterior Slope - Long Term Condition
Filterbed.62+50.EL60 Step20 WL24 LT
5/19/2016

Name: Firm SA LN CLAY (Dike) LT
Unit Weight: 120 pcf
Cohesion': 120 psf
Phi': 20 °

Name: Hydraulic Fill 1 LT
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 14 °

Name: Hydraulic Fill 4 LT
Unit Weight: 100 pcf
Cohesion': 130 psf
Phi': 18 °

Name: V. Stiff-Hard Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 220 psf
Phi': 18 °

Name: Loose SI CL SAND LT
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 28 °

Name: Firm-Stiff Fat CLAY LT
Unit Weight: 120 pcf
Cohesion': 140 psf
Phi': 18 °

Name: Soft-Firm Fat CLAY w/SA LT
Unit Weight: 120 pcf
Cohesion': 100 psf
Phi': 18 °

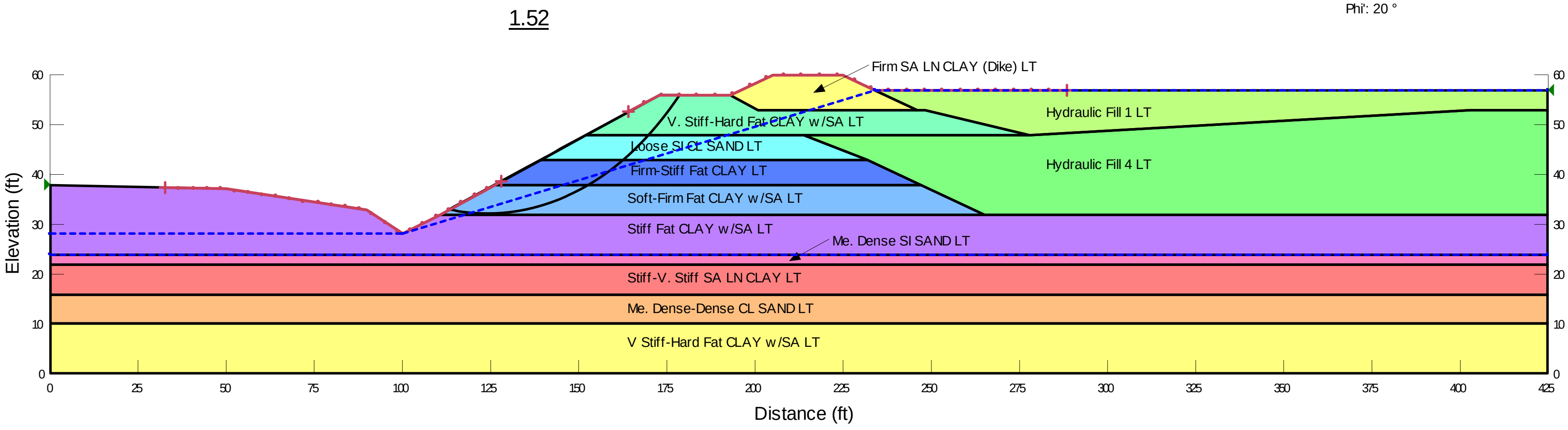
Name: Stiff Fat CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 180 psf
Phi': 20 °

Name: Me. Dense SI SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °

Name: Stiff-V. Stiff SA LN CLAY LT
Unit Weight: 125 pcf
Cohesion': 220 psf
Phi': 20 °

Name: Me. Dense-Dense CL SAND LT
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °

Name: V Stiff-Hard Fat CLAY w/SA LT
Unit Weight: 125 pcf
Cohesion': 250 psf
Phi': 20 °



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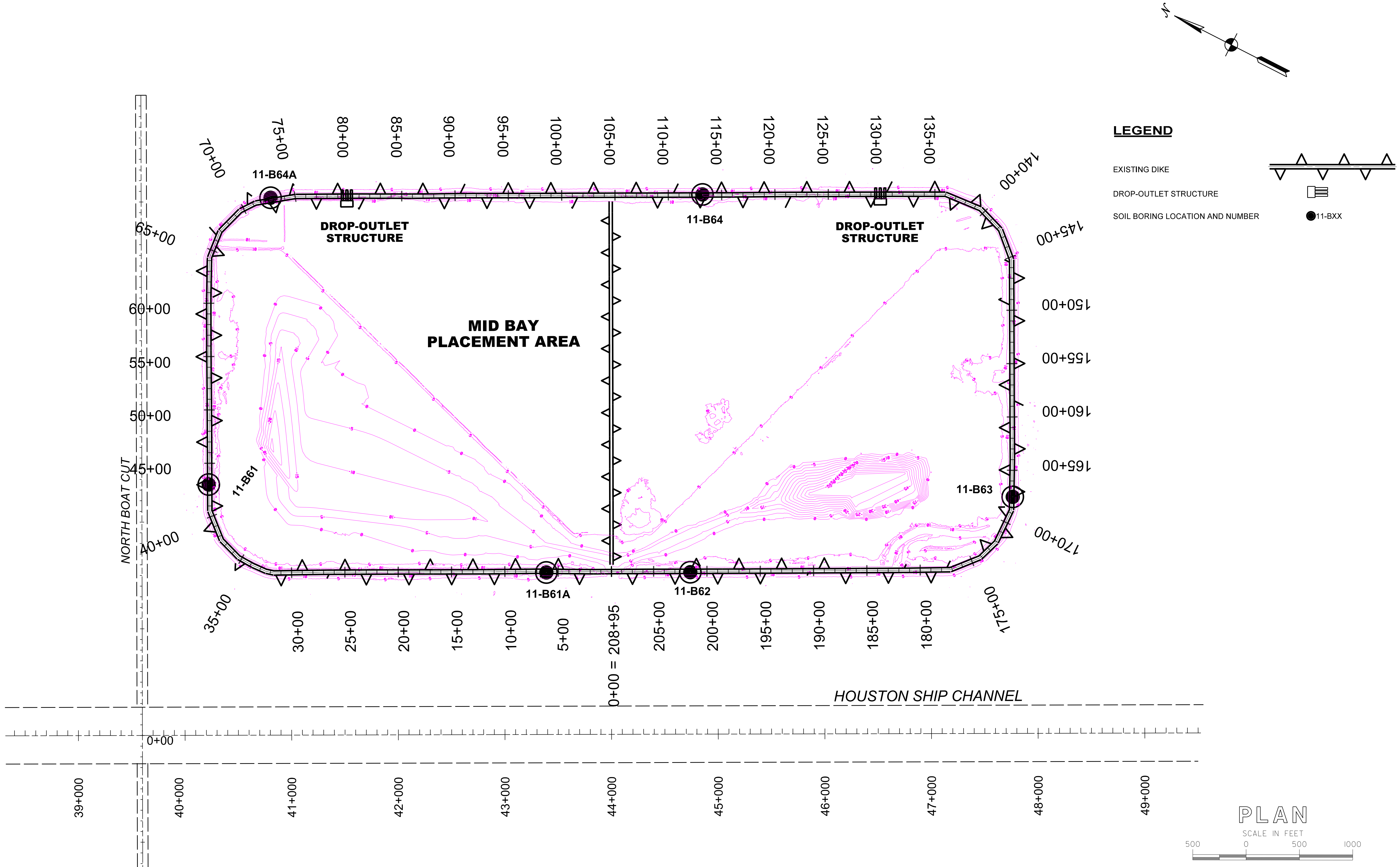
19 May 2016		DBB

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN
SLOPE STABILITY ANALYSIS – LONG TERM
FILTERBED PA CONTAINMENT DIKE STA. 62+50, EL +60

FILE NO:

PLATE NO: STAB-26



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Galveston District

Drawn by: DBB	Date:
Designed by: DBB	July 2016
Checked by: DBB	Scale: AS SHOWN
Submitted by:	Approval Recommended:
LORI K. HODGES, P.E. Chief, Geotech/Structure Section	JOSEPH L. KING, R.A. Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division	

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
MID BAY PLACEMENT AREA

Drawing No.:
B-01
Sheet 1 of 30

Rev.	Description	Date	By

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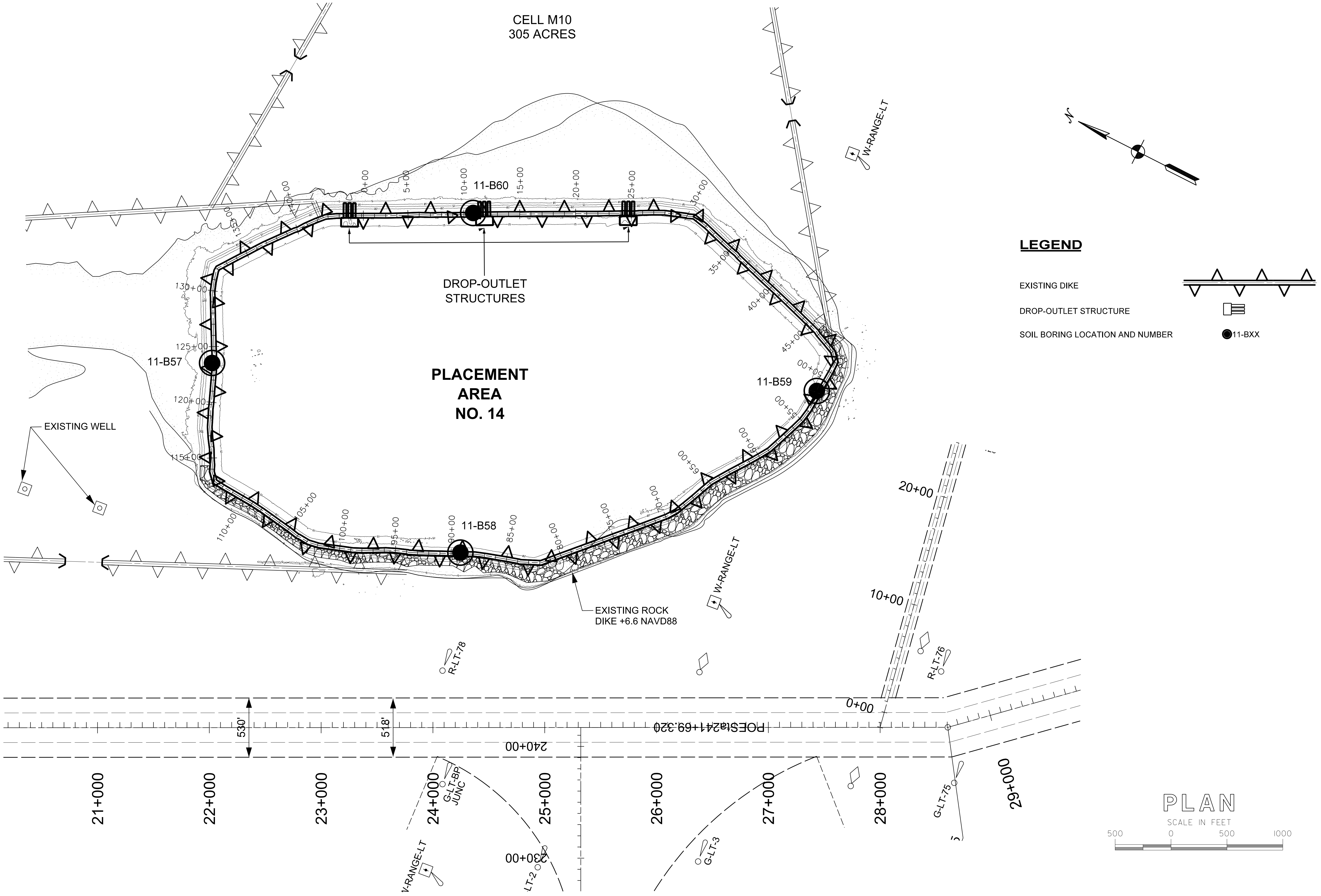

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Checked by: DBB
Date: July 2016
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Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section

Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch

Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
PLACEMENT AREA NO. 14

Drawing No.:
B-02
Sheet 2 of 30

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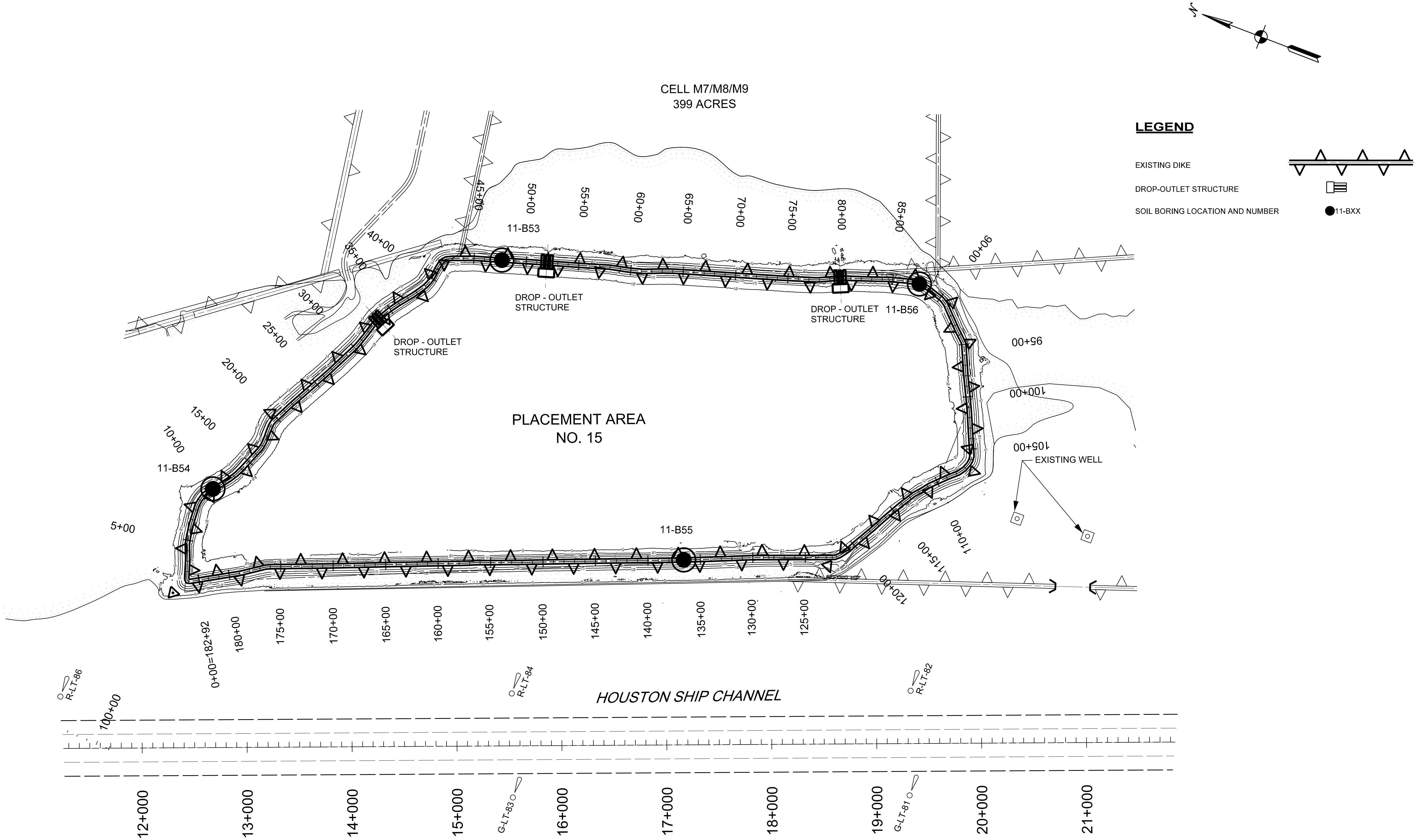

PLAN

SCALE IN FEET

500 0 500 1000

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Submitted by: LORI K. HODGES, P.E. Chief, Geotech/Structure Section		Approval Recommended: JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division			

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
PLACEMENT AREA NO. 15

Drawing No.:
B-03

Sheet 3 of 30

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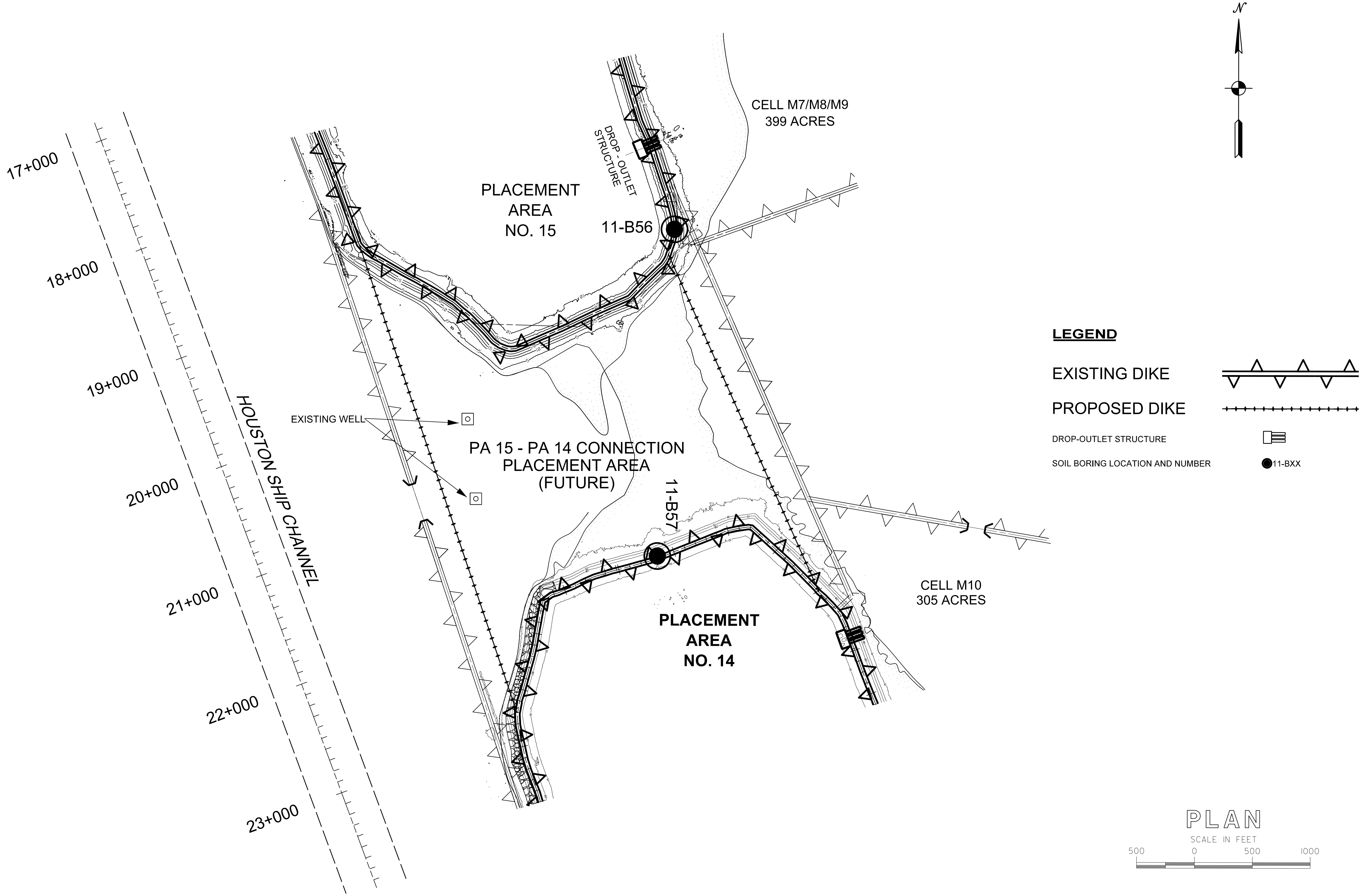

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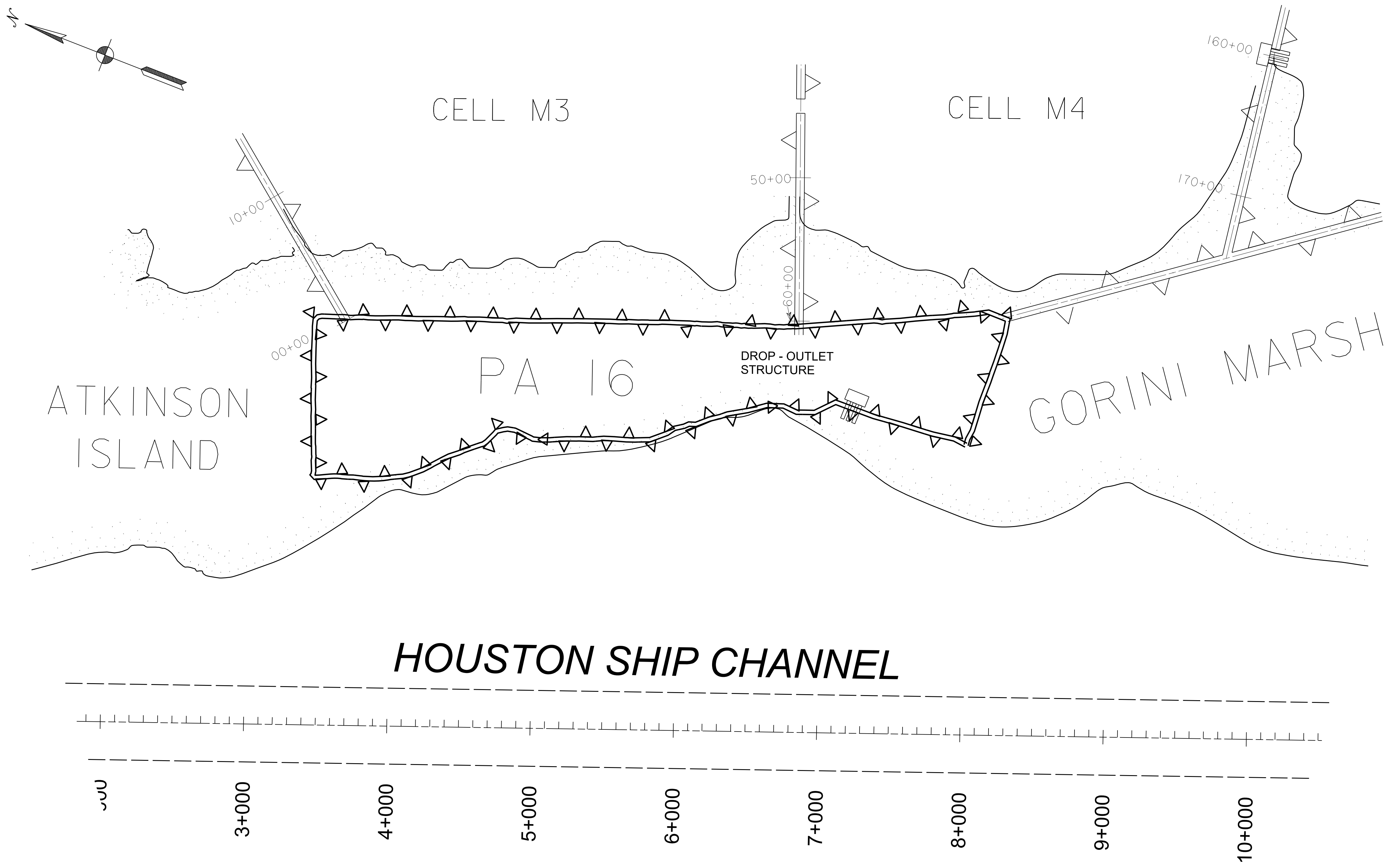
Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
PA 14/15 CONNECTION
PLACEMENT AREA

Drawing No.:
B-04
Sheet 4 of 30



PLAN

SCALE IN FEET

LEGEND

EXISTING DIKE	
DROP-OUTLET STRUCTURE	
SOIL BORING LOCATION AND NUMBER	● 11-BXX

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Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
PLACEMENT AREA NO. 16

Drawing No.:
B-05
Sheet 5 of 30

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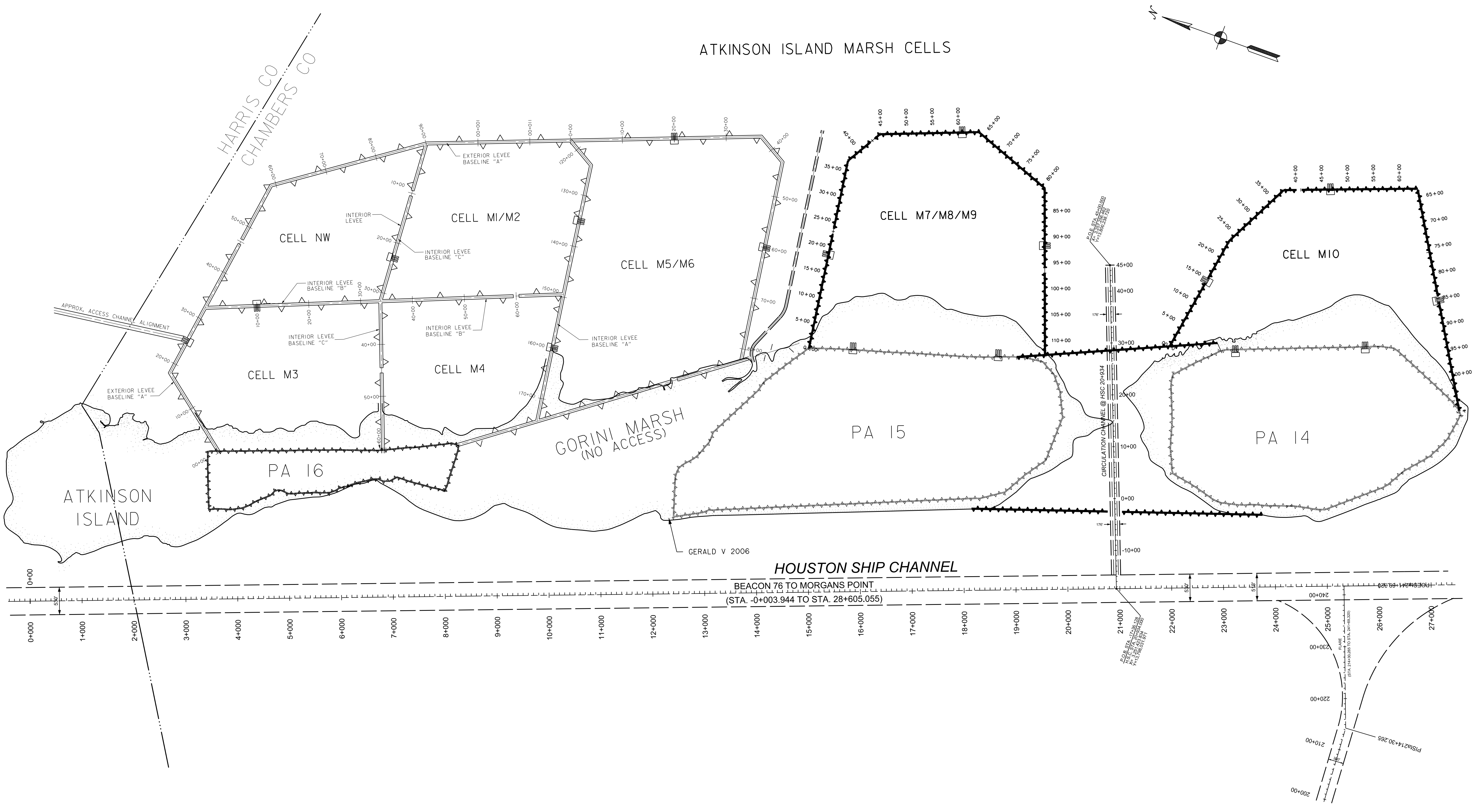

PLAN

SCALE IN FEET

1000 0 1000 2000

LEGEND

EXISTING DIKE ▽▽▽

DROP-OUTLET STRUCTURE ▤

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Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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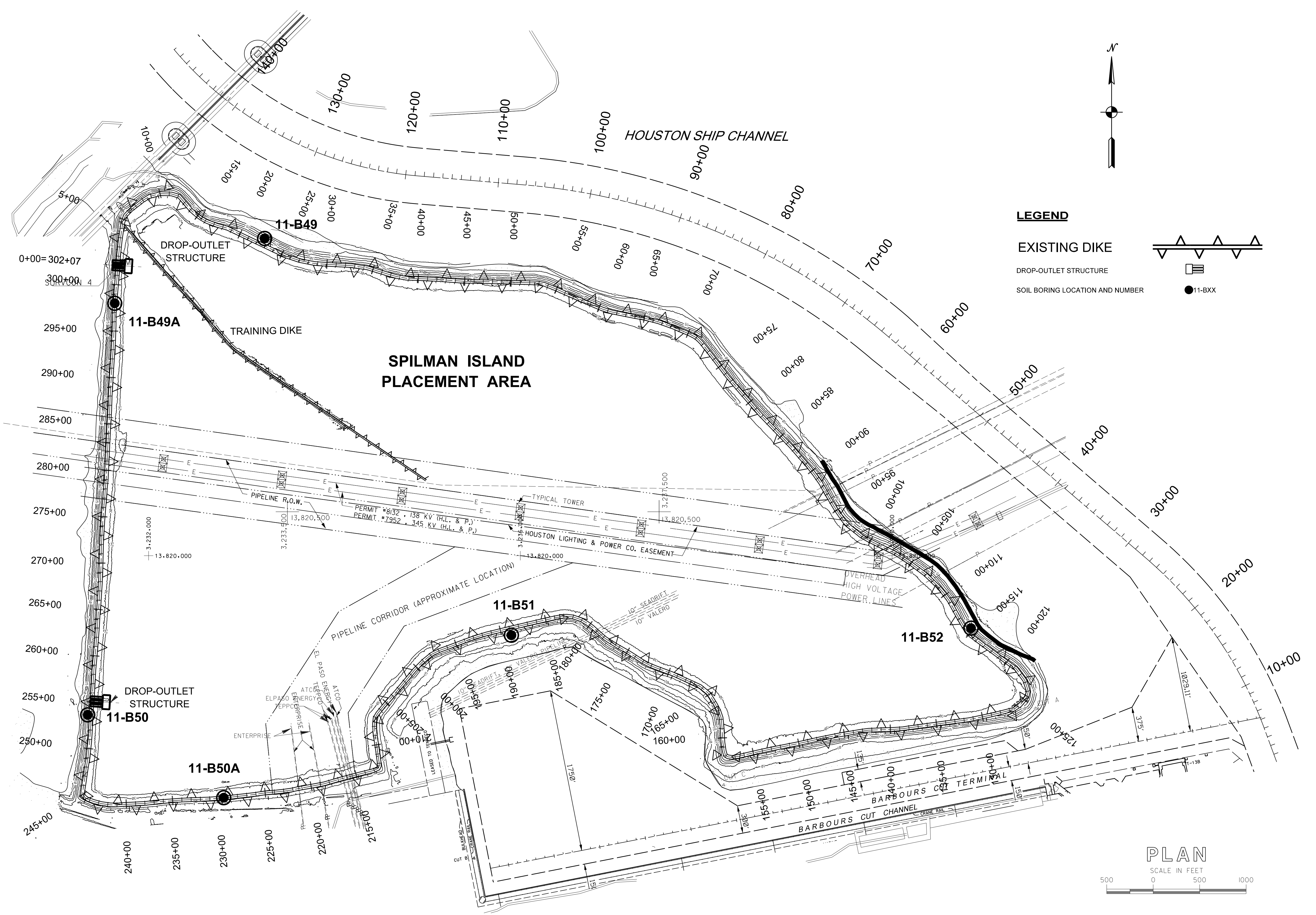
HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
ATKINSON ISLAND MARSH

Drawing No.:
B-06
Sheet 6 of 30



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Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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PREPARED UNDER THE DIRECTION OF
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Date: July 2016
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Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
SPILMAN ISLAND PLACEMENT AREA

Drawing No.:
B-07
Sheet 7 of 30

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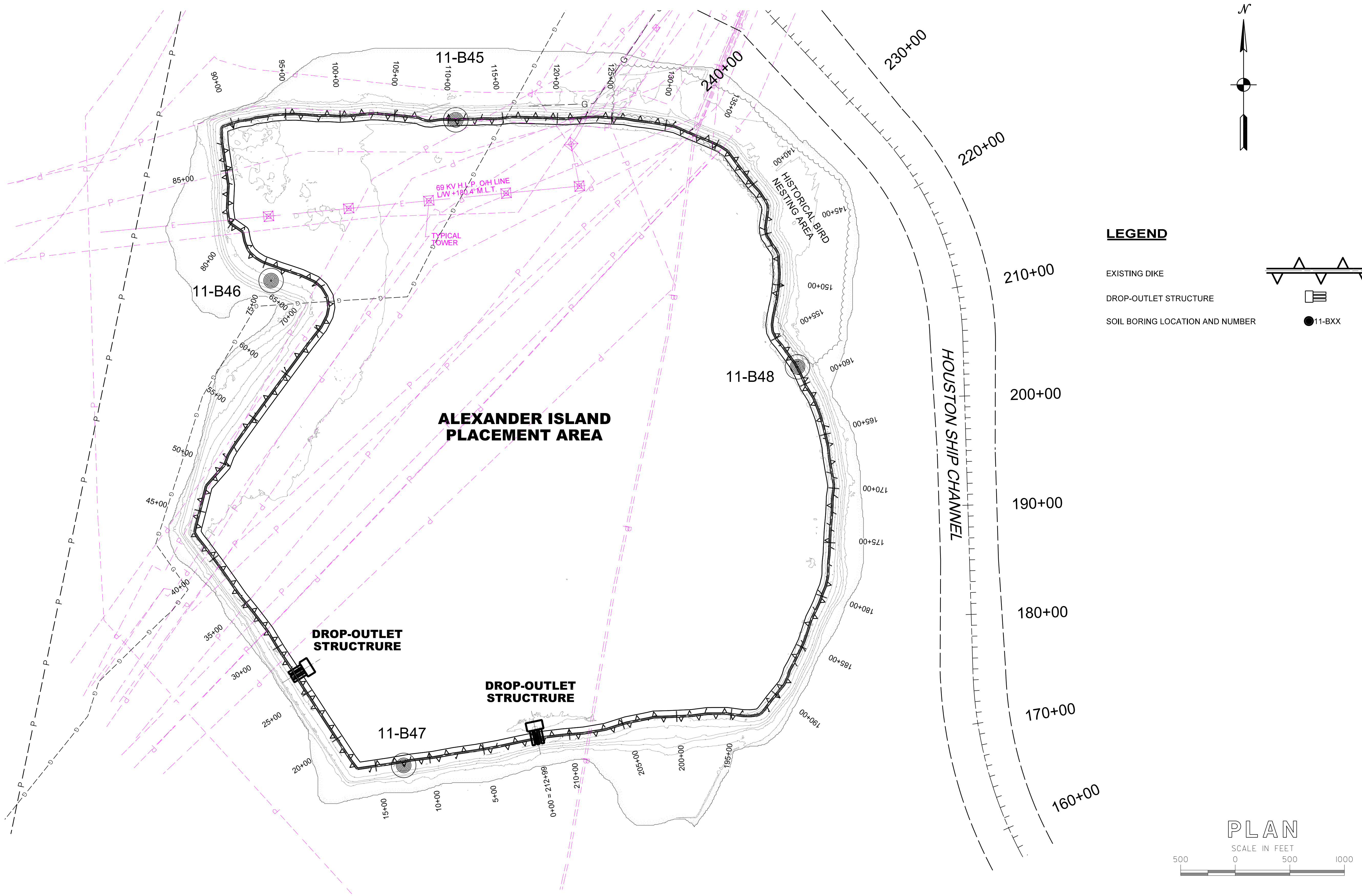
U.S. Army Corps of Engineers
Galveston District



LEGEND

EXISTING DIKE	
DROP-OUTLET STRUCTURE	
SOIL BORING LOCATION AND NUMBER	● 11-BXX

Rev.	Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
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Date: July 2016
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Scale: AS SHOWN
Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
ALEXANDER ISLAND
PLACEMENT AREA

Drawing No.:
B-08
Sheet 8 of 30

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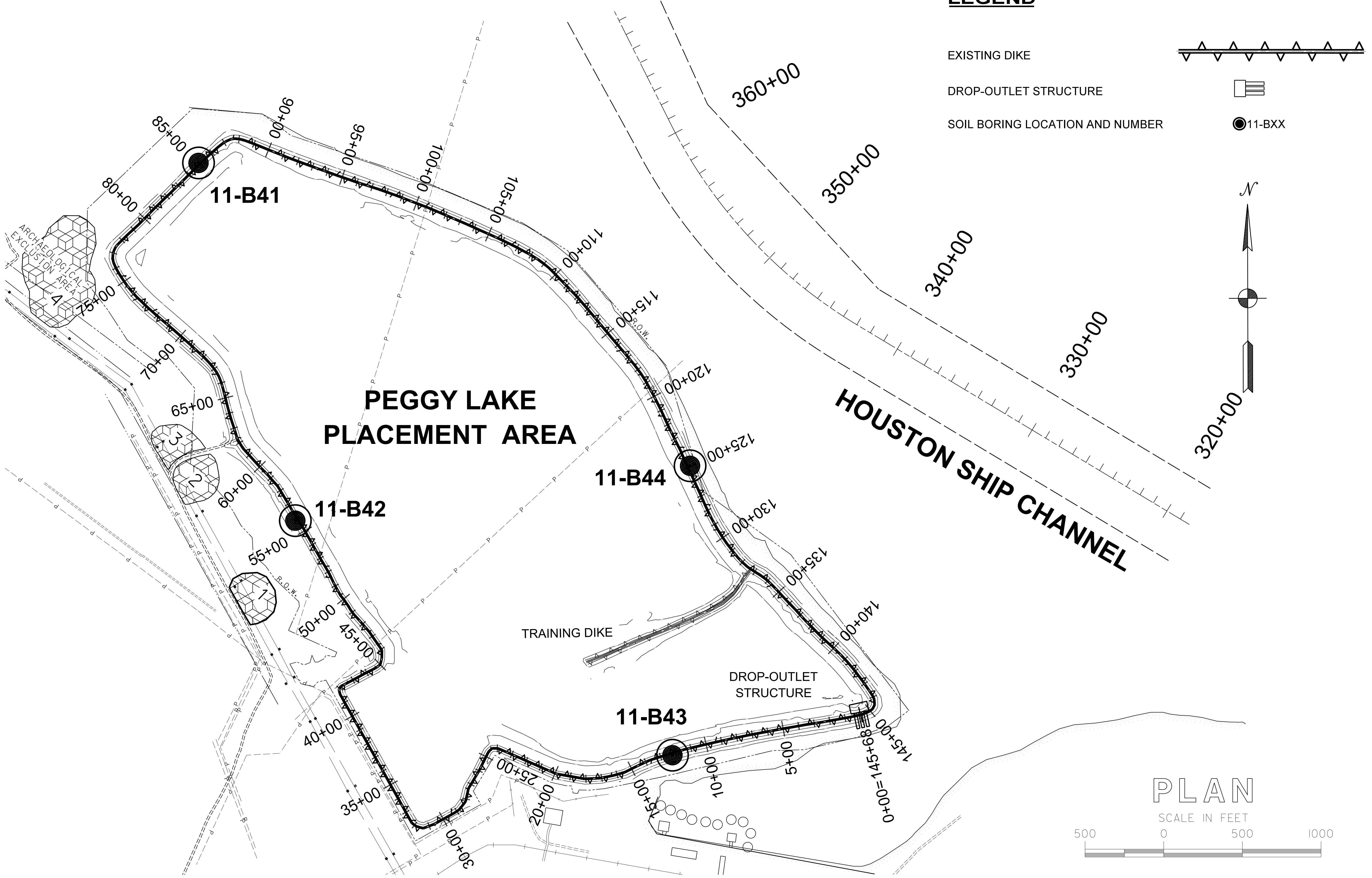
Time: 1:05:44 PM

LEGEND

EXISTING DIKE	△▽△▽
DROP-OUTLET STRUCTURE	▭
SOIL BORING LOCATION AND NUMBER	◉11-BXX



PLAN

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500 0 500 1000

U.S. Army Corps of Engineers
Galveston District

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LORI K. HODGES, P.E. Chief, Geotech/Structure Section		JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division			

U.S. ARMY ENGINEER DISTRICT, GALVESTON
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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
PEGGY LAKE PLACEMENT AREA

Drawing No.:
B-09

Sheet 9 of 30

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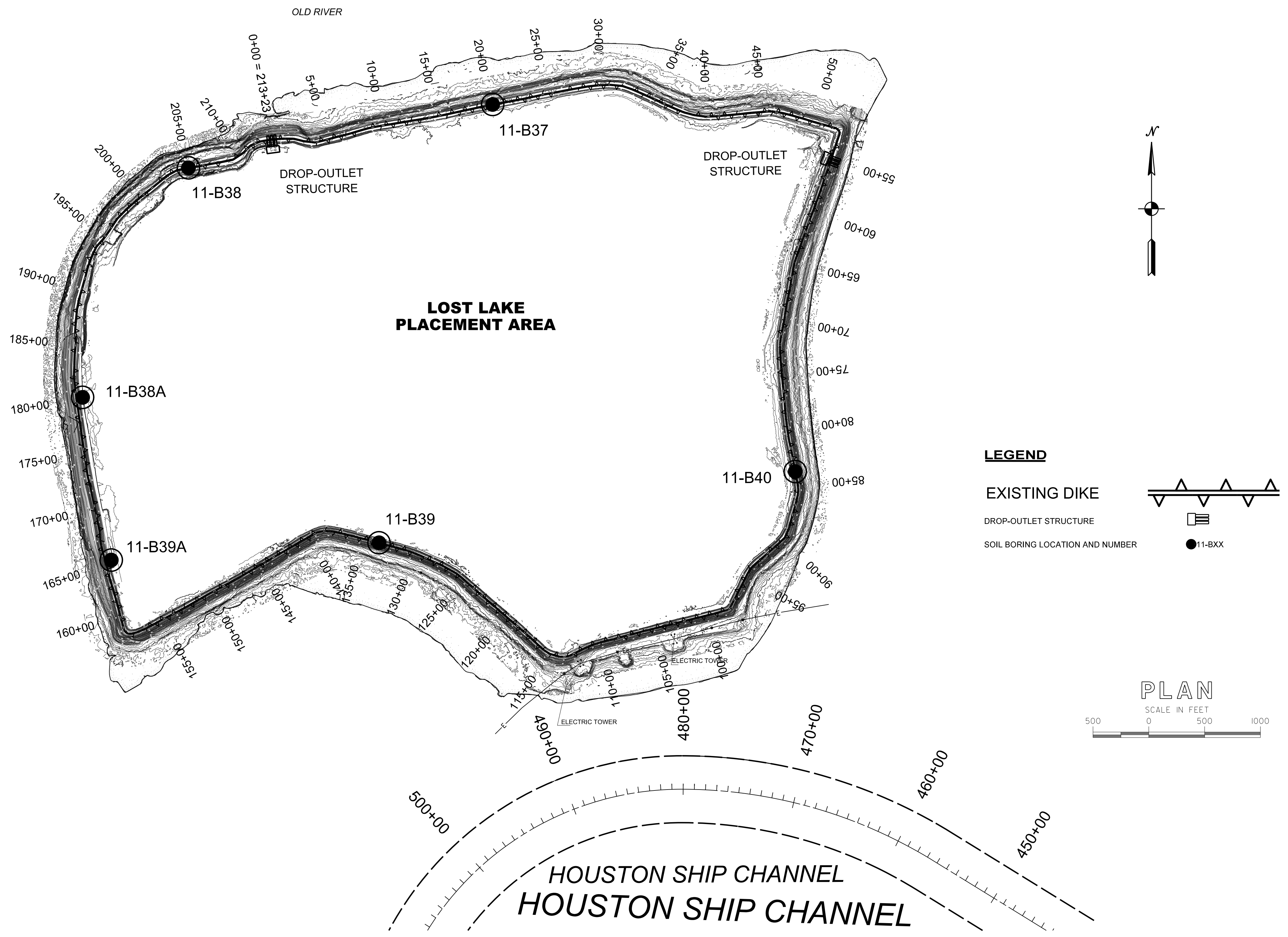

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GALVESTON, TEXAS

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Date: July 2016
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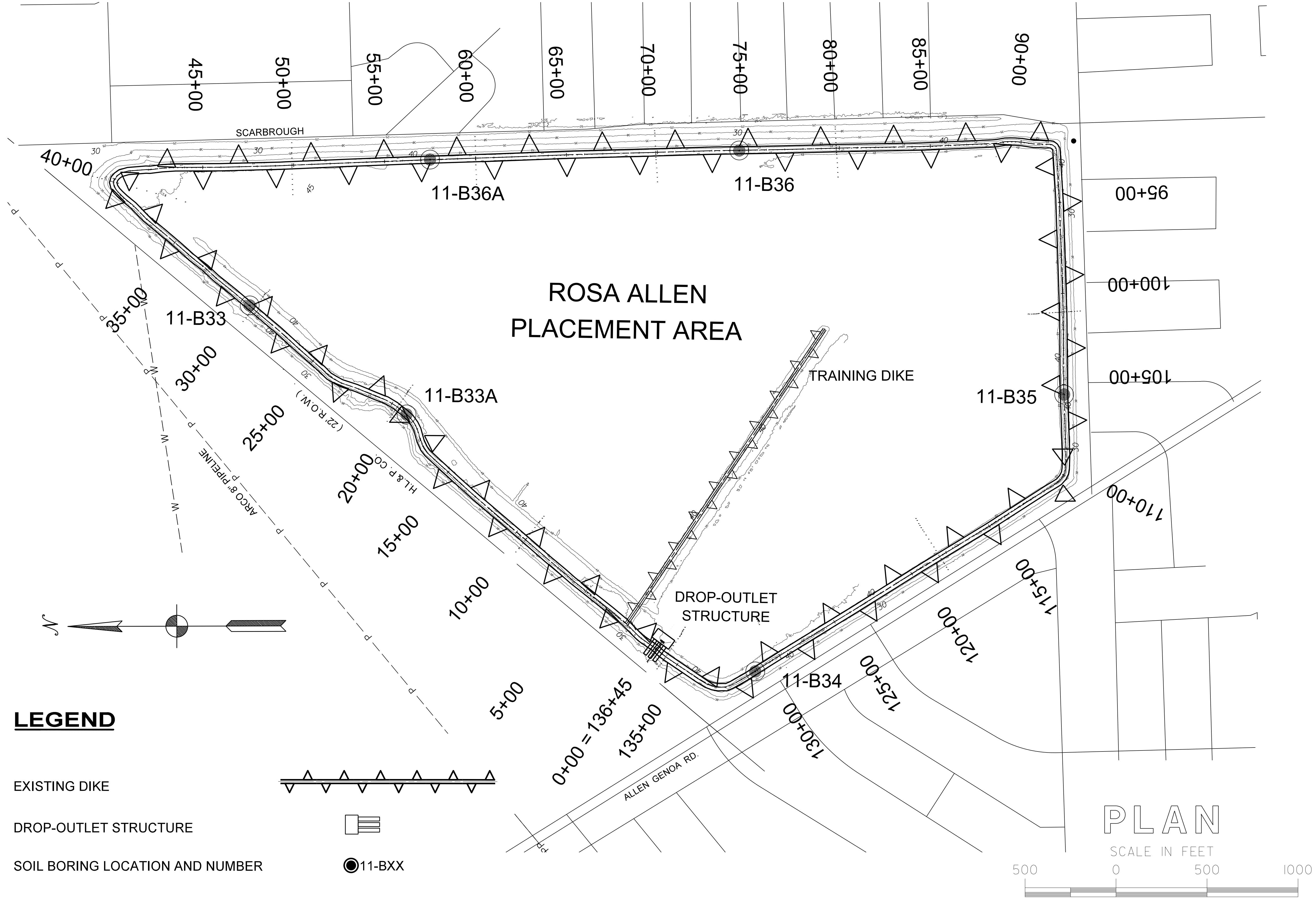
Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
LOST LAKE PLACEMENT AREA

Drawing No.:
B-10
Sheet 10 of 30



LEGEND

EXISTING DIKE	
DROP-OUTLET STRUCTURE	
SOIL BORING LOCATION AND NUMBER	●11-BXX

U.S. Army Corps of Engineers
Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

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Rev.
Scale: AS SHOWN
Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
ROSA ALLEN PLACEMENT AREA

Drawing No.:
B-11
Sheet 11 of 30

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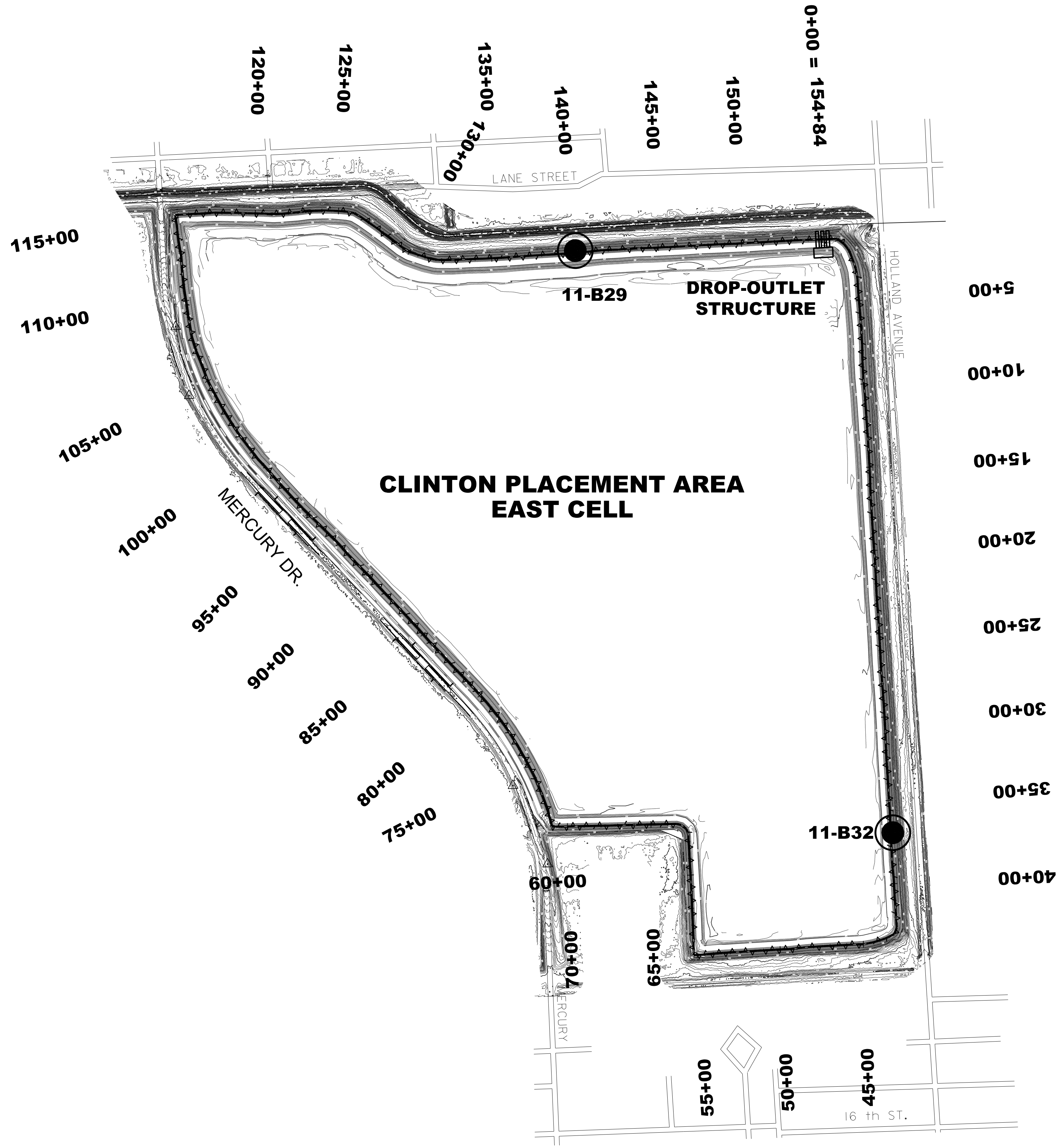

N

LEGEND

EXISTING DIKE	▽△▽△▽△▽
DROP-OUTLET STRUCTURE	▤
SOIL BORING LOCATION AND NUMBER	● 11-BXX

PLAN

SCALE IN FEET

500 0 500 1000

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Galveston District

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Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
CLINTON PLACEMENT AREA
EAST CELL

Drawing No.:
B-12
Sheet 12 of 30

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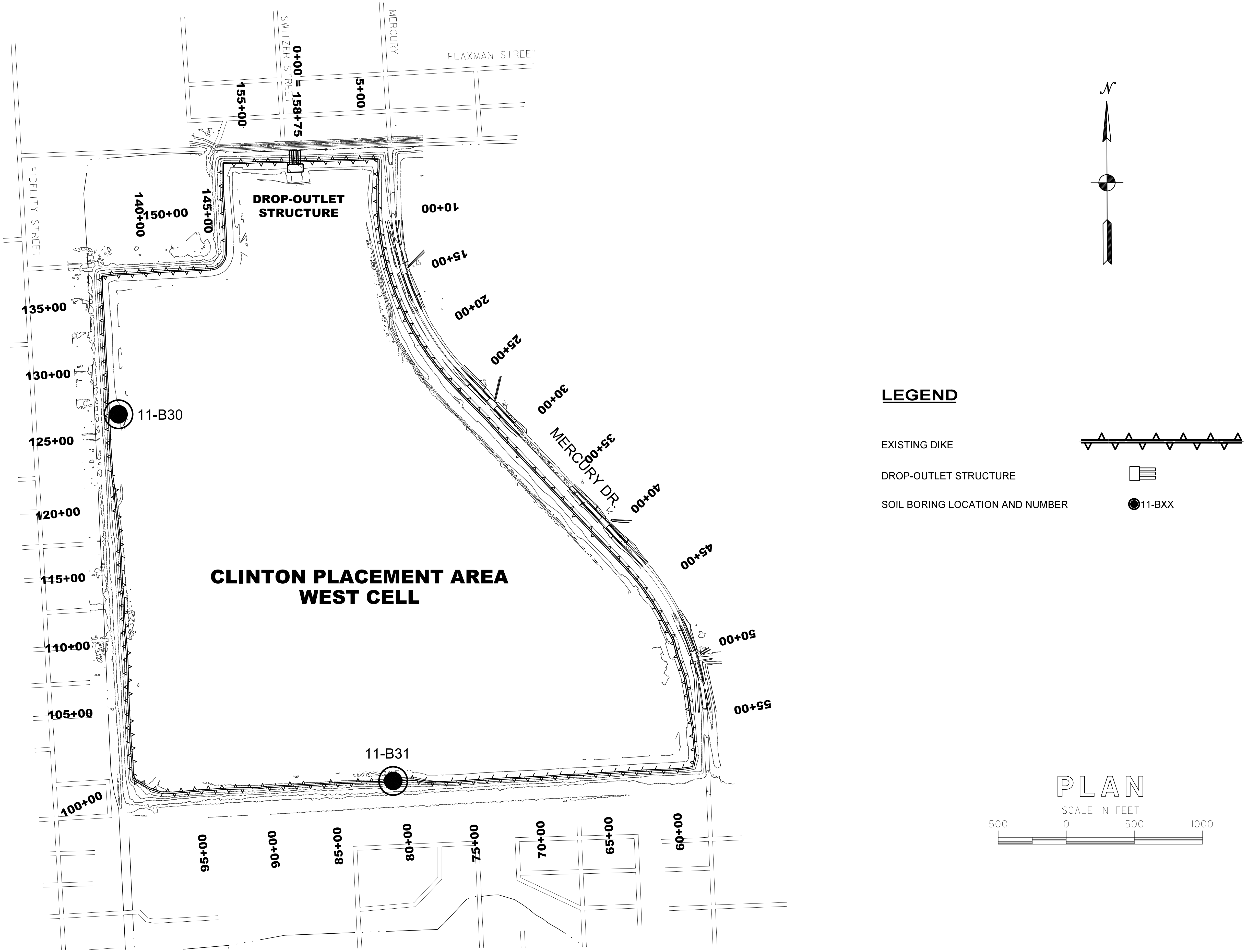

U.S. Army Corps
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Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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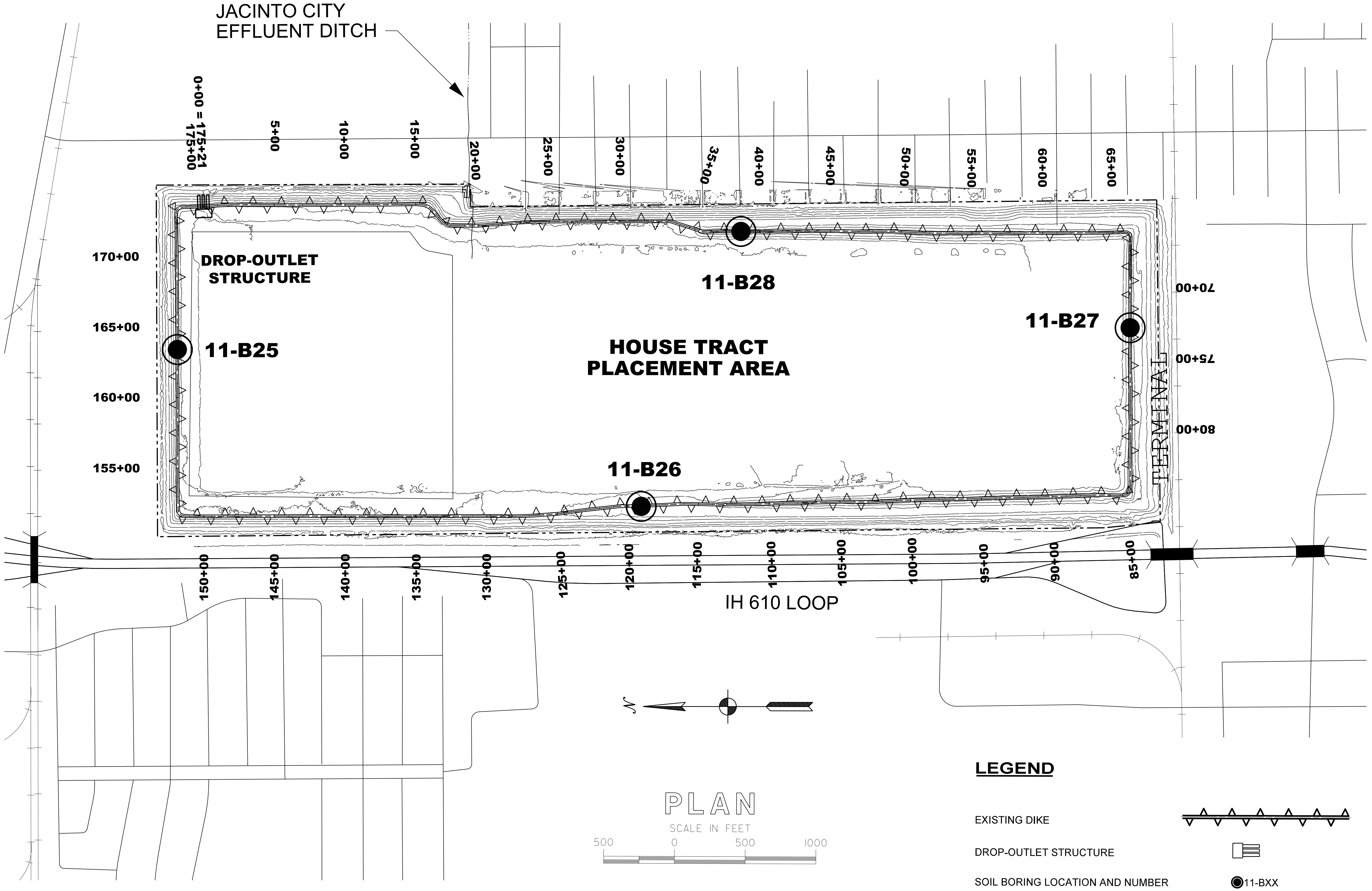
HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
CLINTON PLACEMENT AREA
WEST CELL

Drawing No.:
B-13
Sheet 13 of 30



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Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
HOUSE TRACT PLACEMENT AREA

Drawing No.:
B-14
Sheet 14 of 30

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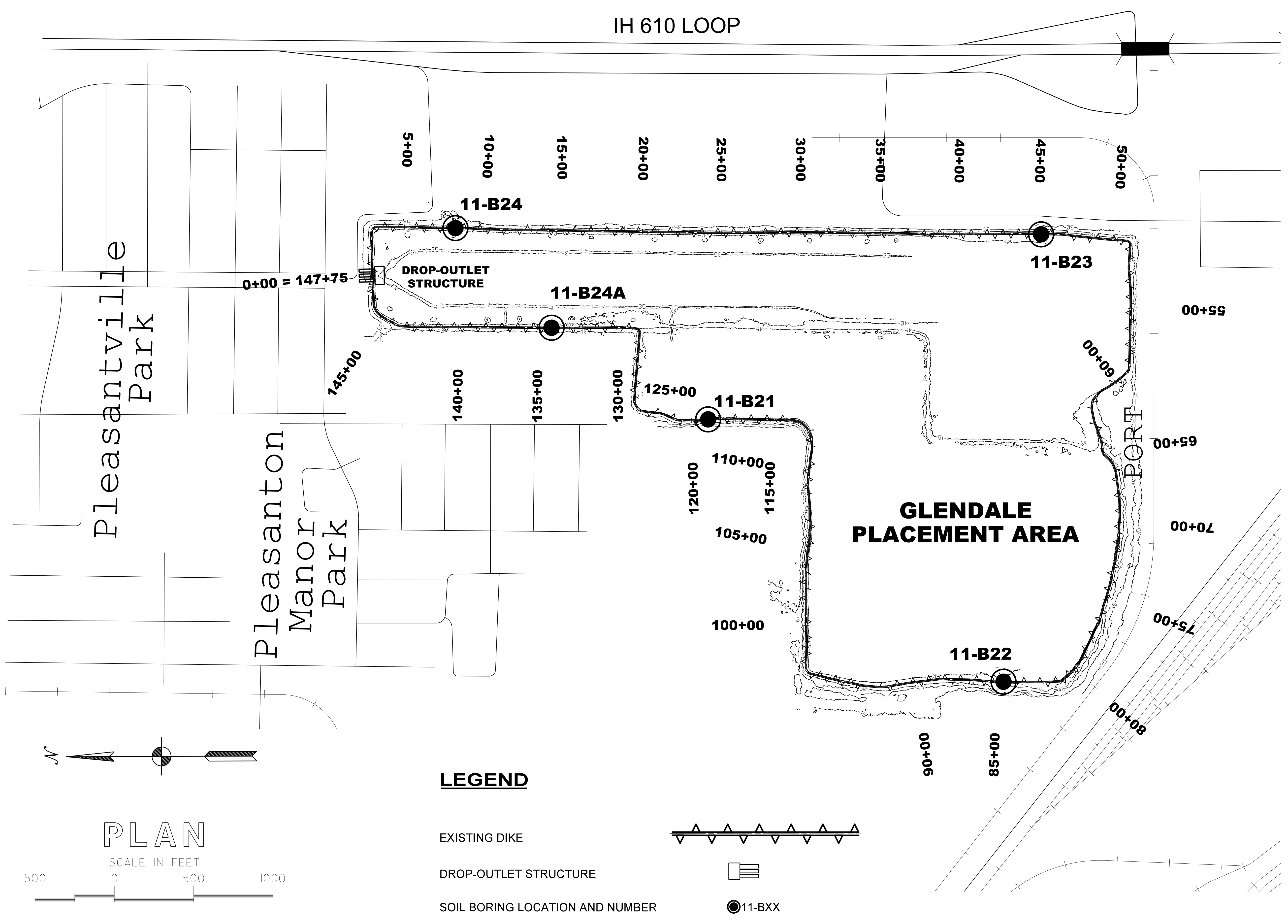

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

Drawn by: DBB
Designed by: DBB
Checked by: DBB
Date: July 2016
Rev.
Scale: AS SHOWN
Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
GLENDALE PLACEMENT AREA

Drawing No.:
B-15
Sheet 15 of 30

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By: M3ECEDBB Date: 5/16/2016 Time: 3:07:51 PM

LEGEND

EXISTING DIKE

DROP-OUTLET STRUCTURE

SOIL BORING LOCATION AND NUMBER ●11-BXX

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Galveston District

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Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

PLAN VIEW
FILTERBED PLACEMENT AREA

Drawing No.:
B-16
Sheet 16 of 30

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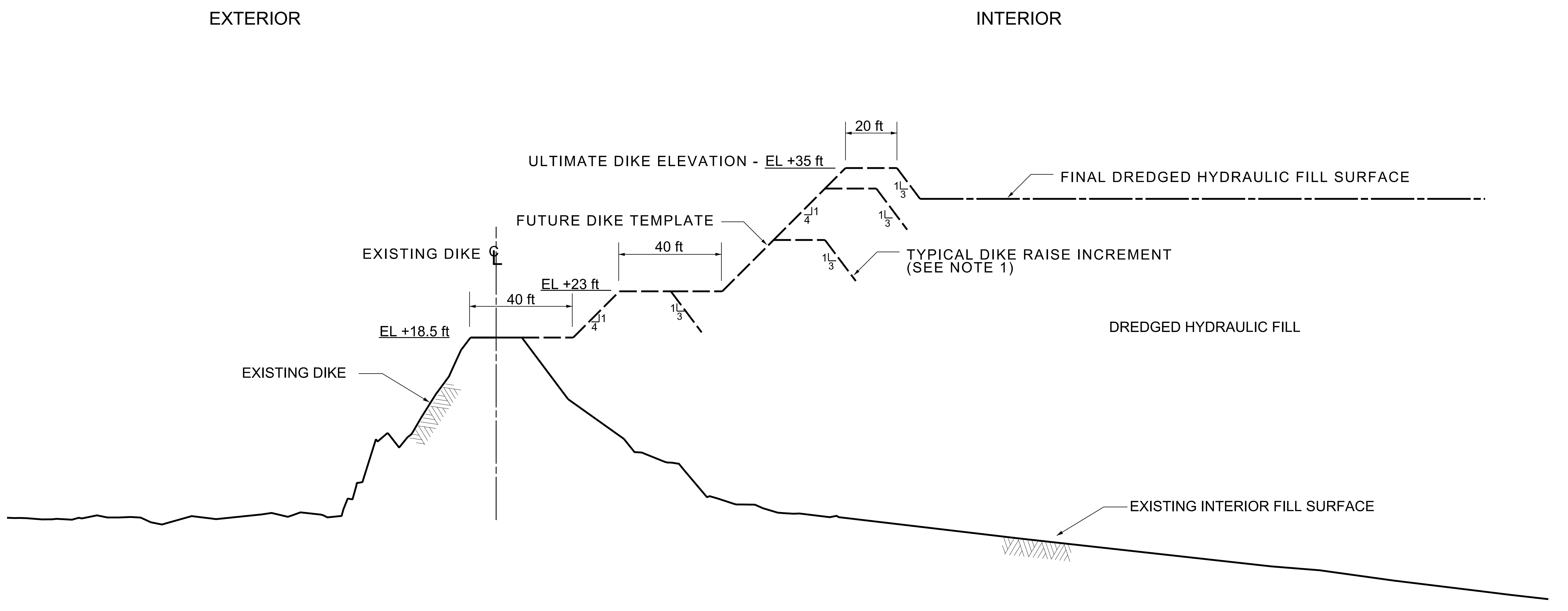

NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — —
FINAL HYDRAULIC FILL SURFACE	——-——-——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
MID BAY PLACEMENT AREA
N.T.S.

U.S. Army Corps
of Engineers
Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

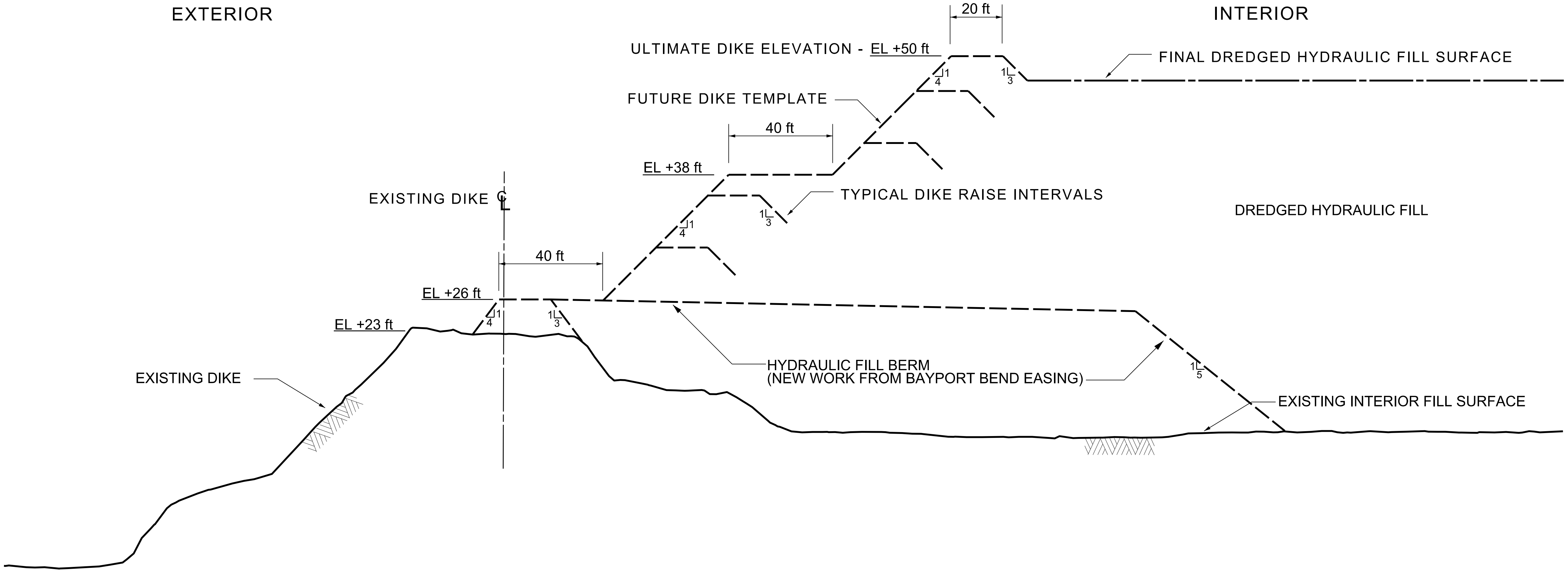
PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

Drawn by:	DBB	Date: July 2016	Rev.
Designed by:	DBB		
Checked by:	DBB	Scale: AS SHOWN	
Submitted by: LORI K. HODGES, P.E. Chief, Geotech/Structure Section		Approval Recommended: JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division			

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
MID BAY PLACEMENT AREA

Drawing No.:
B-17
Sheet 17 of 30



NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.
4. CONFIGURATION SHOWN ASSUMES NEW WORK FROM THE BAYPORT BEND EASING PROJECT IS PLACED AND USED IN PA 14.

LEGEND

EXISTING DIKE TEMPLATE	————————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——-——-——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
PLACEMENT AREA 14

N.T.S.

U.S. Army Corps
of Engineers
Galveston District

Rev.	Description	Date	By

Drawn by: DBB
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Checked by: DBB
Date: July 2016
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Scale: AS SHOWN
Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
PLACEMENT AREA 14

Drawing No.:
B-18
Sheet 18 of 30

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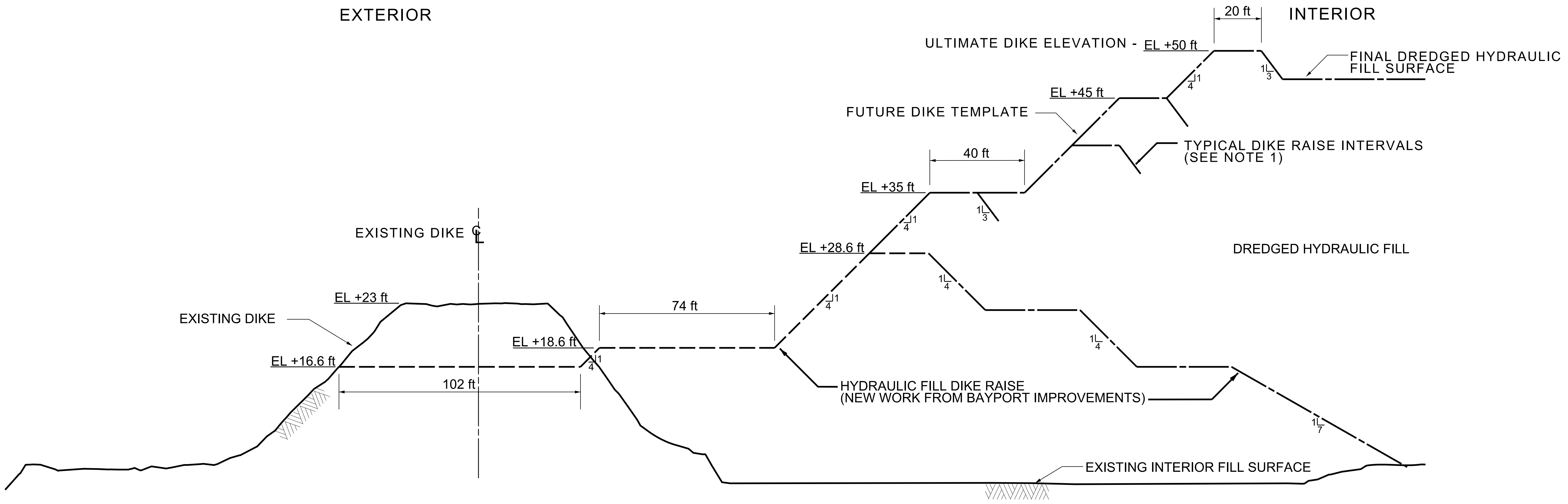

NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.
4. CONFIGURATION SHOWN INCLUDES NEW WORK FROM THE BAYPORT IMPROVEMENT PROJECT USED TO CONSTRUCT HYDRAULIC DIKE RAISE IN PA 15.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — —
FINAL HYDRAULIC FILL SURFACE	———-———-———

TYPICAL SECTION (FUTURE) CONTAINMENT DIKE PLACEMENT AREA 15

N.T.S.

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Galveston District

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Checked by:	DBB	Scale: AS SHOWN	
Submitted by: LORI K. HODGES, P.E. Chief, Geotech/Structure Section		Approval Recommended: JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division			

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
PLACEMENT AREA 15

Drawing No.:
B-19

Sheet 19 of 30

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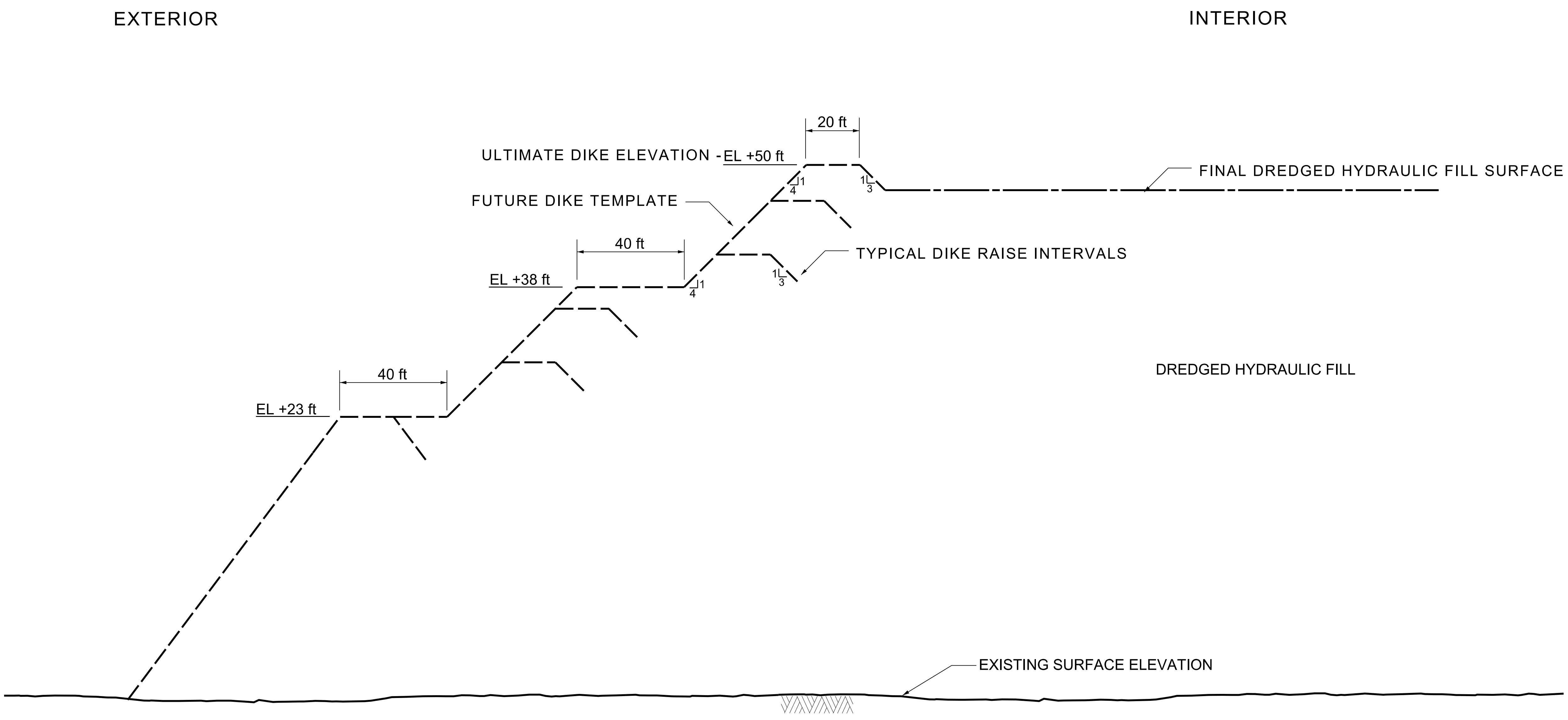

NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
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3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING SURFACE ELEVATION	————————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——·——·——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
PA 14/15 CONNECTION PLACEMENT AREA

N.T.S.

U.S. Army Corps of Engineers
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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
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Designed by: DBB
Checked by: DBB
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Approval Recommended:
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Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
PA 14/15 CONNECTION
PLACEMENT AREA

Drawing No.:
B-20
Sheet 20 of 30

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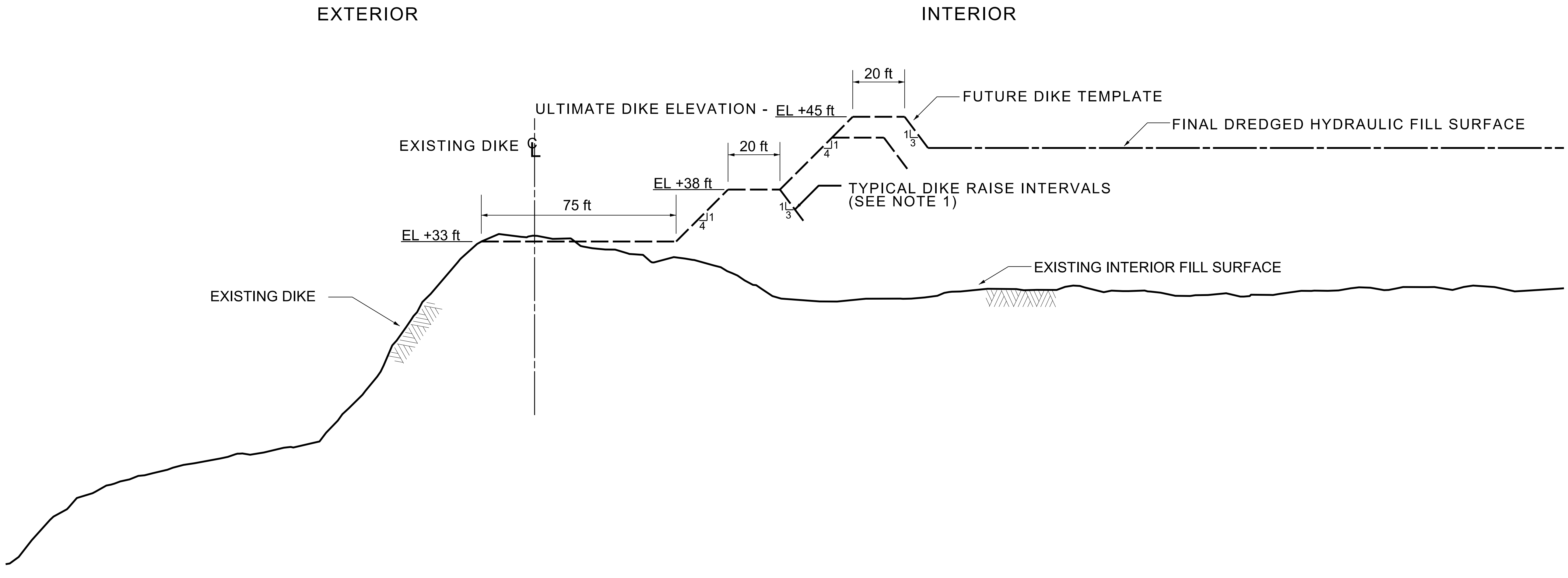

NOTES:
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3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——·——·——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
SPILMAN ISLAND PLACEMENT AREA

N.T.S.

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

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Chief, Geotech/Structure Section
Approval Recommended:
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Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
SPILMAN ISLAND PLACEMENT AREA

Drawing No.:
B-21
Sheet 21 of 30

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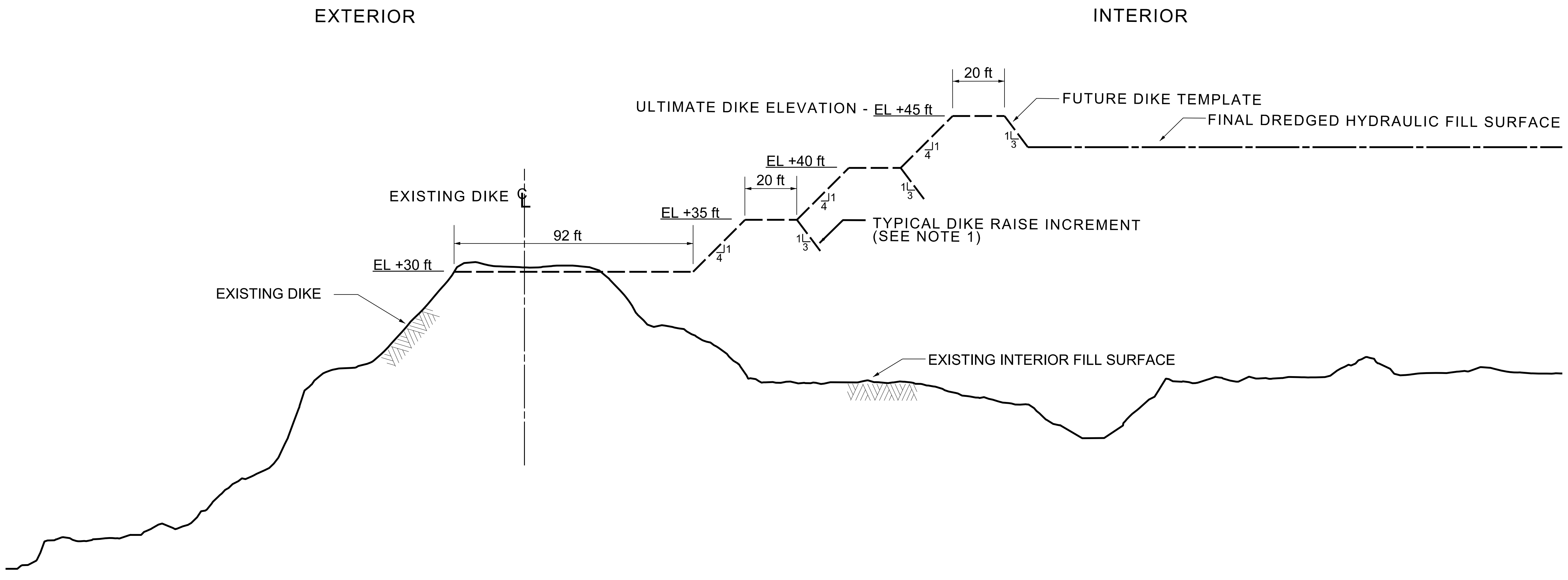

NOTES:
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2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——— - ——— - ———

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
ALEXANDER ISLAND PLACEMENT AREA
N.T.S.

U.S. Army Corps
of Engineers
Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

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Date: July 2016
Rev.
Scale: AS SHOWN
Submitted by: LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
ALEXANDER ISLAND PLACEMENT AREA

Drawing No.:
B-22
Sheet 22 of 30

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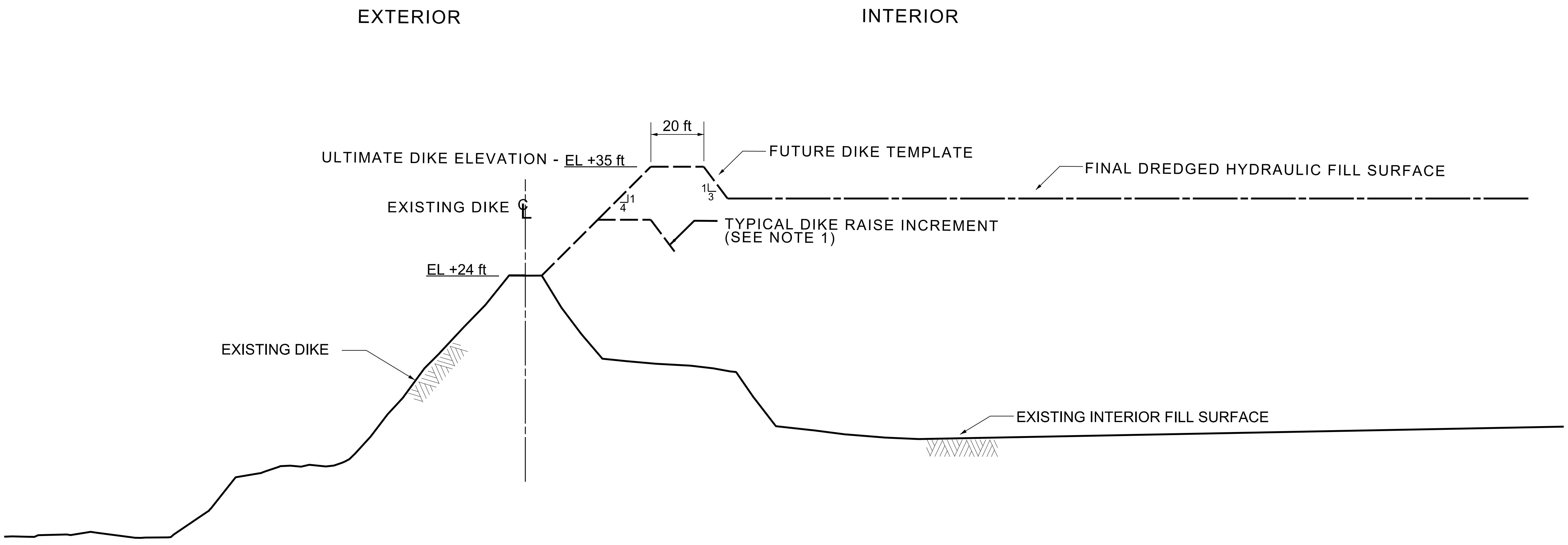

NOTES:
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2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——– · ——– · ——–

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
PEGGY LAKE PLACEMENT AREA
N.T.S.

U.S. Army Corps
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Galveston District

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Checked by: DBB	Scale: AS SHOWN
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Approved by: TERRY F. BAUTISTA, P.E. Chief, Engineering and Construction Division	

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GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
PEGGY LAKE PLACEMENT AREA

Drawing No.:
B-23

Sheet 23 of 30

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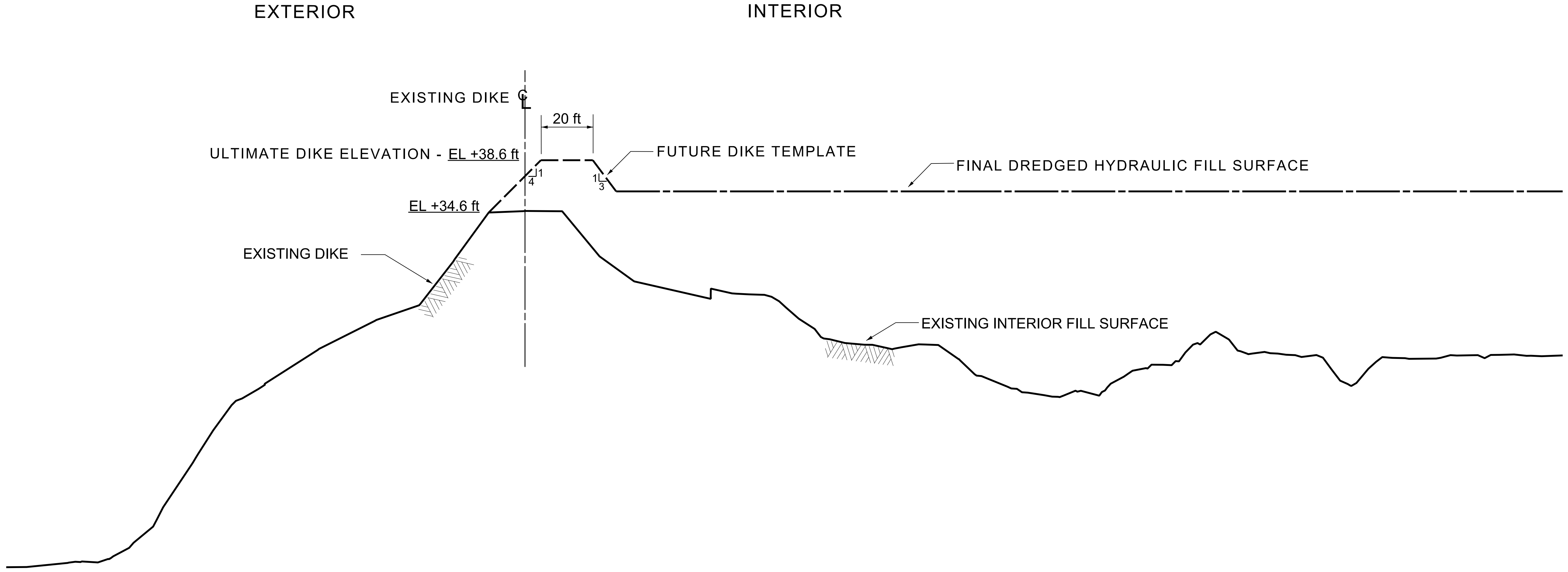

NOTES:
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3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——-——-——

TYPICAL SECTION (FUTURE) CONTAINMENT DIKE LOST LAKE PLACEMENT AREA

N.T.S.

U.S. Army Corps of Engineers
Galveston District

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Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
LOST LAKE PLACEMENT AREA

Drawing No.:
B-24
Sheet 24 of 30

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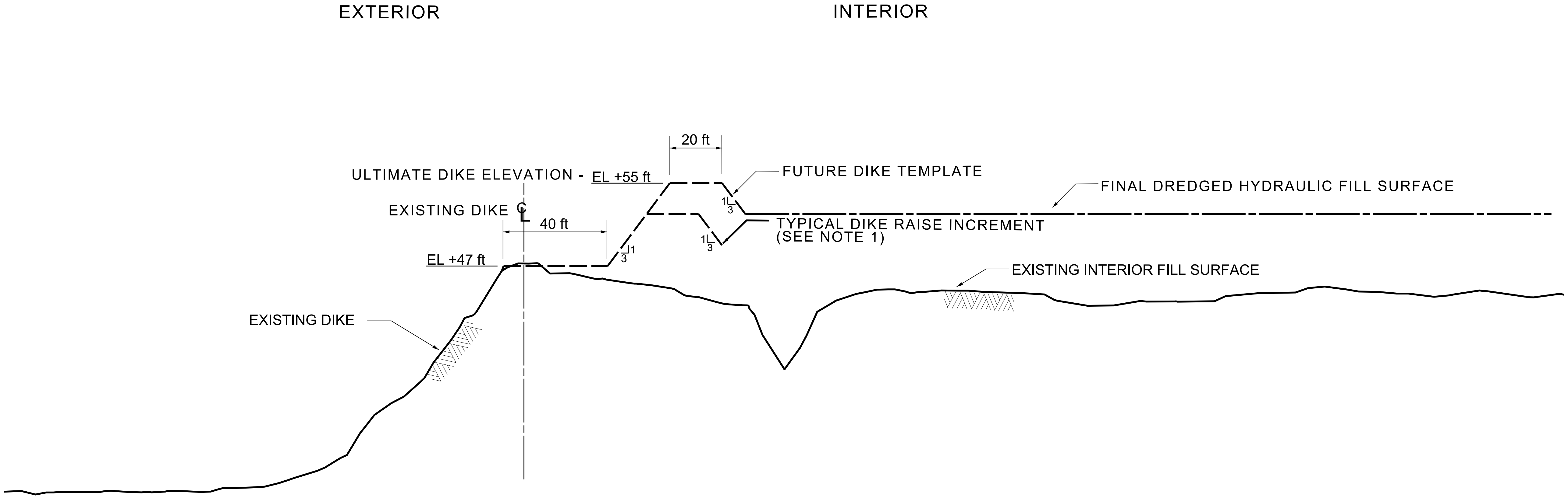

NOTES:
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3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — —
FINAL HYDRAULIC FILL SURFACE	——-——-——

TYPICAL SECTION (FUTURE) CONTAINMENT DIKE ROSA ALLEN PLACEMENT AREA

N.T.S.

U.S. Army Corps of Engineers
Galveston District

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

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RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

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Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by: TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
ROSA ALLEN PLACEMENT AREA

Drawing No.:
B-25
Sheet 25 of 30

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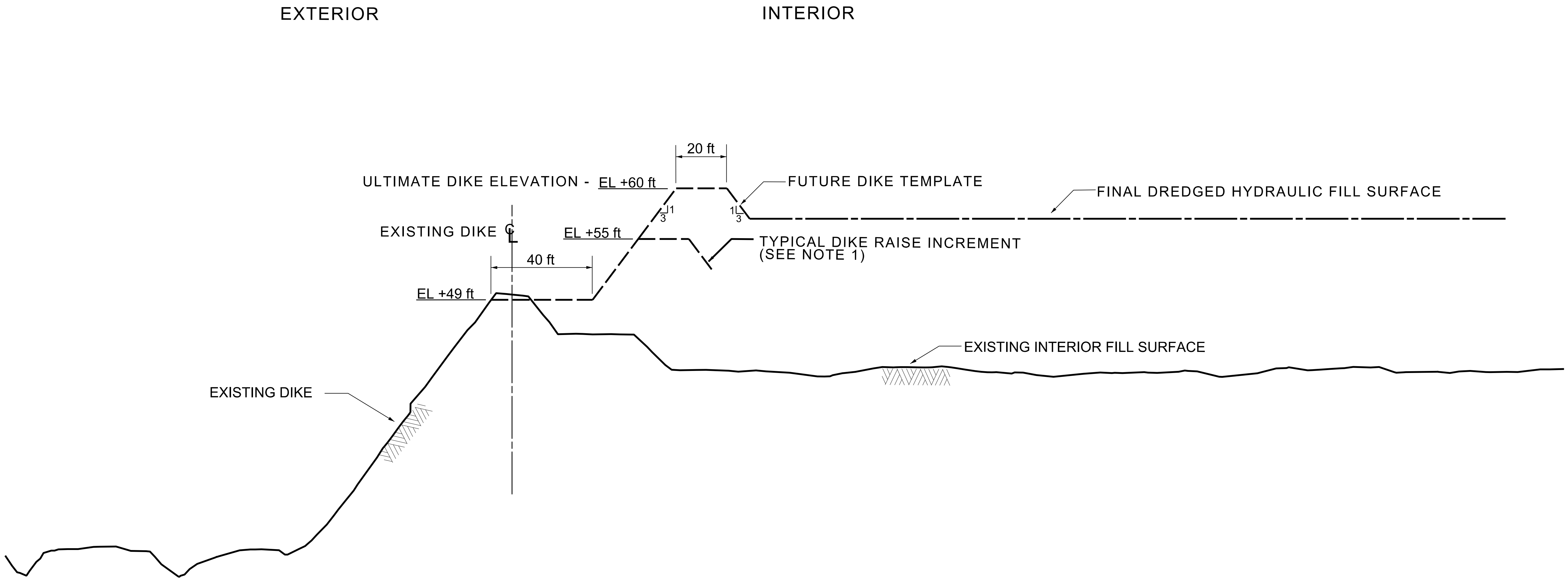

NOTES:
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3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — —
FINAL HYDRAULIC FILL SURFACE	——-——-——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
CLINTON PLACEMENT AREA EAST CELL

N.T.S.

U.S. Army Corps
of Engineers
Galveston District

Rev.	Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

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Approval Recommended: JOSEPH L. KING, R.A.
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Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
CLINTON PA EAST CELL

Drawing No.:
B-26
Sheet 26 of 30

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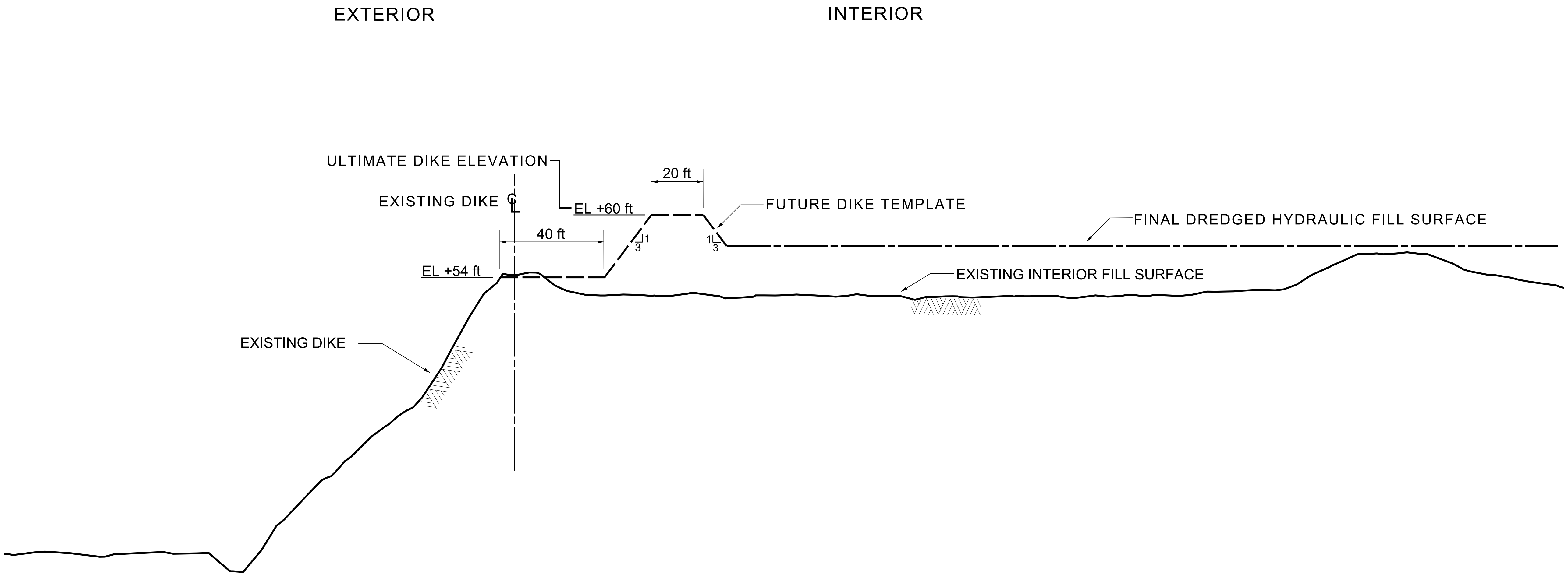
Galveston District



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2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	————————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——·——·——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
CLINTON PLACEMENT AREA WEST CELL

N.T.S.

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U.S. ARMY ENGINEER DISTRICT, GALVESTON
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GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
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HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
CLINTON PA WEST CELL

Drawing No.:
B-27
Sheet 27 of 30

File: C:\Users\M3ECEDBB\Documents\Projects\Houston Ship Channel\HSC DMMP\DMMP Engr Appendix\Geotechnical Plates\B-27-xSEC Clinton West PA.dgn
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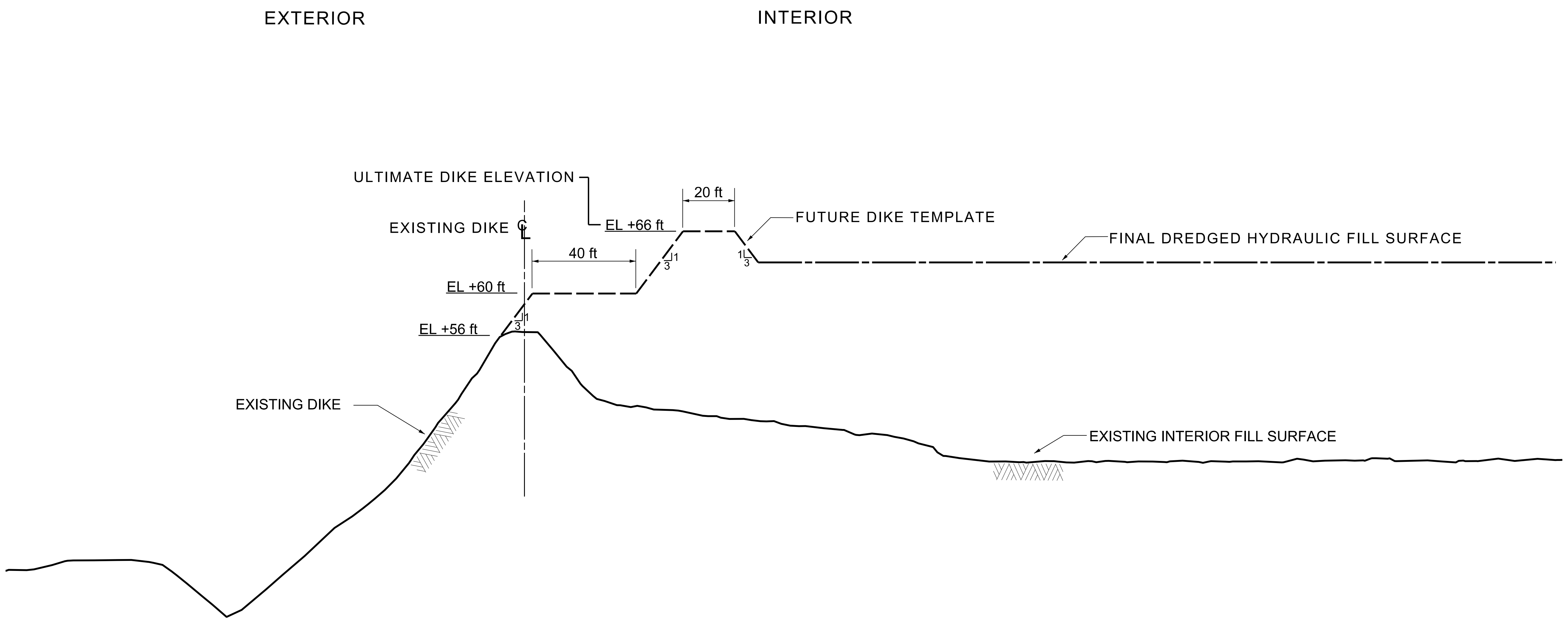

NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	———————
FUTURE DIKE TEMPLATE	— — — — — — —
FINAL HYDRAULIC FILL SURFACE	——·——·——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
HOUSE TRACT PLACEMENT AREA
N.T.S.

U.S. Army Corps of Engineers
Galveston District

Rev.							Description	Date	By

Drawn by: DBB
Designed by: DBB
Checked by: DBB
Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division
Date: July 2016
Rev.
Scale: AS SHOWN
Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
HOUSE TRACT PLACEMENT AREA

Drawing No.:
B-28
Sheet 28 of 30

File: C:\Users\M3ECEDBB\Documents\Projects\Houston Ship Channel\HSC DMMP\DMMP Engr Appendix\Geotechnical Plates\B-28-xSEC House Tract PA.dgn
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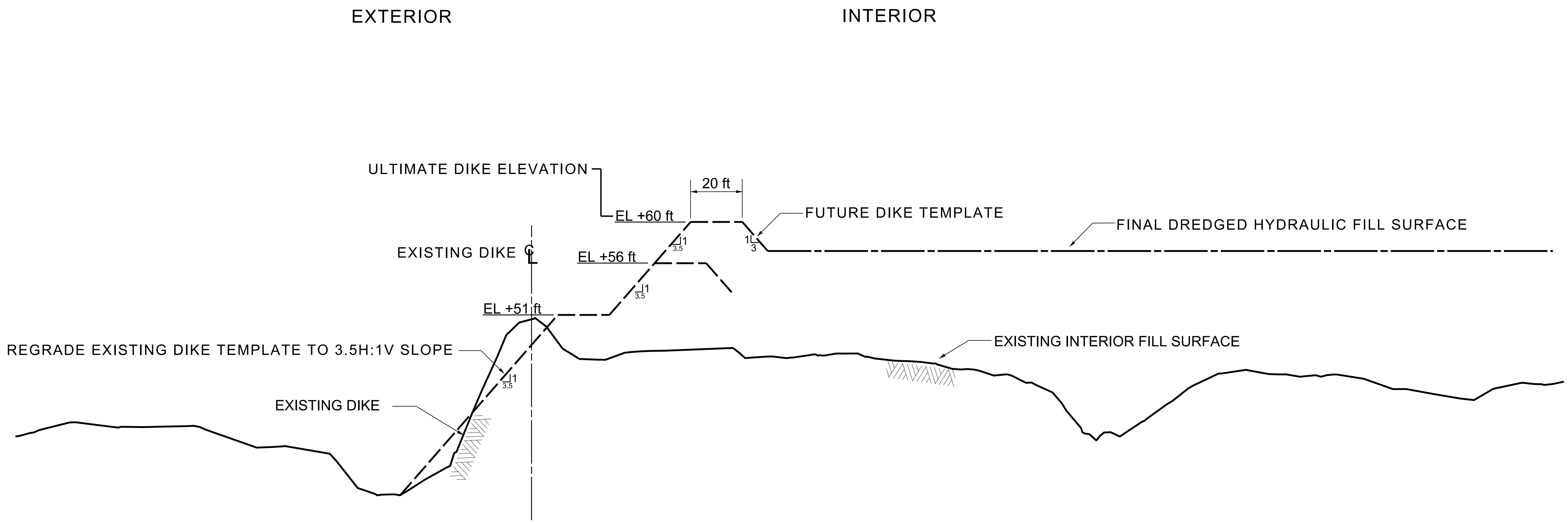


NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	————
FUTURE DIKE TEMPLATE	— — — — —
FINAL HYDRAULIC FILL SURFACE	——·——·——

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
GLENDALE PLACEMENT AREA

N.T.S.

File: C:\Users\M3ECEDBB\Documents\Projects\Houston Ship Channel\HSC DMMP\DMMP Engr Appendix\Geotechnical Plates\B-29-xSEC Glendale PA.dgn
Model Name: Default
By: M3ECEDBB Date: 5/16/2016 Time: 4:09:29 PM

U.S. Army Corps
of Engineers
Galveston District

Rev.	Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

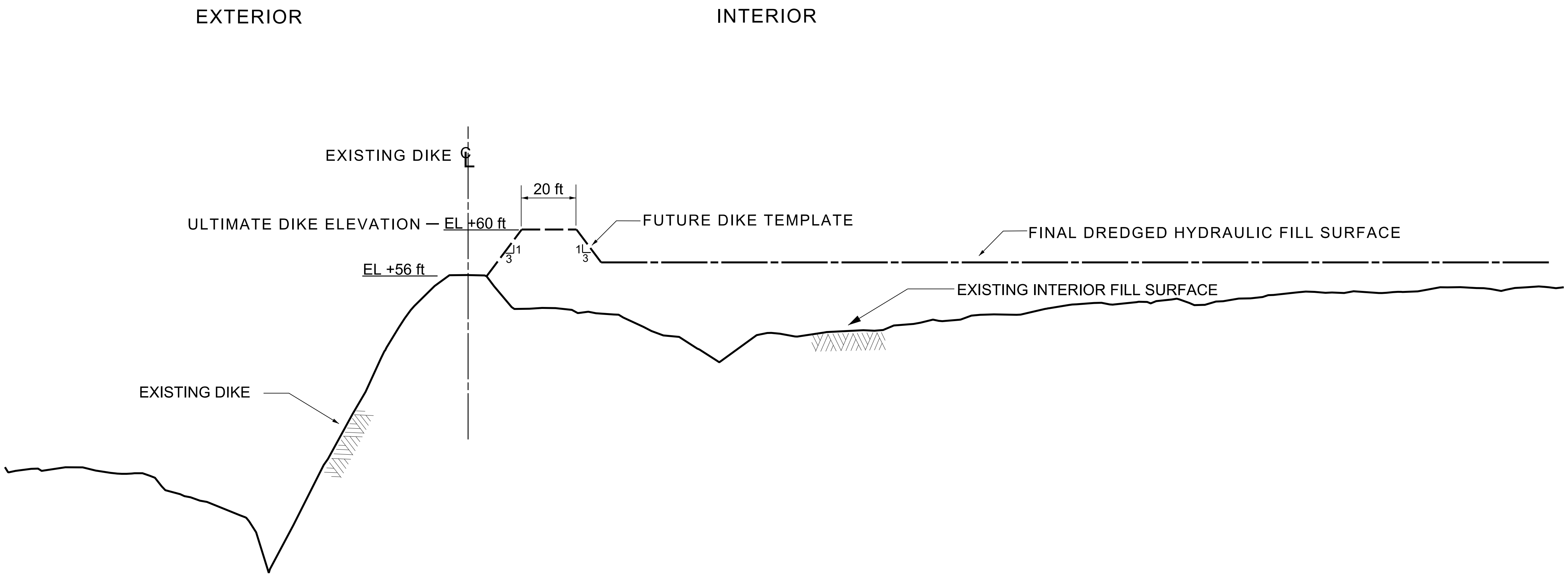
PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

Drawn by: DBB
Designed by: DBB
Checked by: DBB
Date: July 2016
Rev.
Scale: AS SHOWN
Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section
Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch
Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
GLENDALE PLACEMENT AREA

Drawing No.:
B-29
Sheet 29 of 30



NOTES:
1. TYPICAL DIKE RAISE INCREMENT IS ASSUMED TO BE 5 FT.
2. FUTURE DIKE CONSTRUCTION TO BE PERFORMED USING SEMI-COMPACTED SELECT DIKE FILL.
3. ELEVATIONS REFERENCED TO NAVD88 DATUM.

LEGEND

EXISTING DIKE TEMPLATE	————————
FUTURE DIKE TEMPLATE	— — — — — — — -
FINAL HYDRAULIC FILL SURFACE	——- ——— - ———

TYPICAL SECTION (FUTURE)
CONTAINMENT DIKE
FILTERBED PLACEMENT AREA

N.T.S.

U.S. Army Corps
of Engineers
Galveston District

Rev.							Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
RICHARD P. PANNELL, COL., C.E.,
DISTRICT COMMANDER

Drawn by:	DBB	Date: July 2016	Rev.
Designed by:	DBB		
Checked by:	DBB	Scale: AS SHOWN	

Submitted by:
LORI K. HODGES, P.E.
Chief, Geotech/Structure Section

Approval Recommended:
JOSEPH L. KING, R.A.
Chief, Engineering Branch

Approved by:
TERRY F. BAUTISTA, P.E.
Chief, Engineering and Construction Division

HOUSTON SHIP CHANNEL, TEXAS
DREDGED MATERIAL MANAGEMENT PLAN

FUTURE CROSS SECTION
CONTAINMENT DIKE
FILTERBED PLACEMENT AREA

Drawing No.:
B-30
Sheet 30 of 30

File: C:\Users\M3ECEDBB\Documents\Projects\Houston Ship Channel\HSC DMMP\DMMP Engr Appendix\Geotechnical Plates\B-30-xSEC Filterbed PA.dgn
Model Name: Default
By: M3ECEDBB Date: 5/16/2016 Time: 4:10:27 PM

Hole No. 11-B17

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 1 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Filterbed, N=13844407.59 E=3145592.29

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
▽ TOD: 23.3 ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
54.26 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
▽ TOD: 30.96 ft ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 9/9/11 COMPLETED: 9/9/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very stiff, dark brown with ferrous nodules	■	1			4.5		16.0				
		▨		■	2			4.5	105	17.0	89	27	62	
5		▨		■	3			4.5		21.0				
		▨		■	4			4.5		23.0				
		▨		■	5			2.25	90	29.0	85	31	54	
10		▨	-soft to sfiff, dark gray below 10'	■	6			1.25		36.0				
		▨	-traces of organics and strong hydrocarbons odour below 13' to 22'	■	7			0.75	79	36.0				
15		▨		■	8			1.5		22.0				
		▨		■	9			0.25	75	46.0				
	34.3	▨		■	10			0.5		48.0				
20	32.3	▨	**SANDY LEAN CLAY(CL)**, soft, dark brown	■	11			0.5		17.0	43	14	29	
▽		▨	**FAT CLAY(CH)**, stiff, light gray with sand pockets	■	12			0.75		21.0				
25		▨		■	13			1.75		18.0				
		▨		■	14			1.75	105	21.0				
	23.8	▨		■	15			1.75		21.0				
30	22.3	⁘	**SILTY SAND(SM)**, medium dense, brown	☒	16		18			24.0				48
		▨	**SANDY LEAN CLAY(CL)**, very stiff, brown and light gray with sand seams	■	17			4.0	111	16.0	47	20	27	

Hole No. 11-B17

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 54.26 ft	
2. LOCATION (Coordinates or Station) Filterbed, N=13844407.59 E=3145592.29		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 30.96 ft ⯯ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/9/11 COMPLETED: 9/9/11	
5. DEPTH OF WATER ⊻ TOD: 23.3 ft ⯯ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			2.75		28.0				
	16.3	▨		■	19			3.75		15.0				
40		⁚	**SILTY SAND(SM)**, loose to very dense, brown, light gray with clay pockets	☒	20		38			7.0				
		⁚		☒	21		10			27.0				
		⁚		☒	22		24			24.0				
45		⁚		☒	23		40			23.0				
		⁚		☒	24		40			25.0				
50	3.3	⁚		☒	25		41			29.0				
	2.3	▨	**FAT CLAY(CH)**, very stiff, reddish brown	■	26			4.0	100	15.0				
		⁚	**SILTY SAND(SM)**, medium dense to very dense, reddish brown with clay pockets	■	27					22.0				
55		⁚		☒	28		27			30.0				
		⁚		☒	29		28			24.0				
60	-5.7	⁚		☒	30		27			19.0				
65														

Hole No. 11-B18

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +55.86 ft	
2. LOCATION (Coordinates or Station) Filterbed, N=13842631.67 E=3145054.27		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 23.36 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/9/11 COMPLETED: 9/9/11	
5. DEPTH OF WATER ▽ TOD: 32.5 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, very stiff, brown	■	1			4.5		14.0				
	51.9	▨		■	2			4.5	103	17.0	45	18	27	
5		▨	**FAT CLAY(CH)**, very stiff, brown with sand seams	■	3			4.5		22.0				
	47.9	▨		■	4			4.0		31.0				
		░	**SILTY SAND(SM)**, loose,brown, with clay pockets with hyrdocarbon odours	■	5				98	25.0				
10		░		☒	6		9			32.0				
	42.9	░		■	7			1.25		20.0				
15		▨	**FAT CLAY(CH)**, soft to stiff, dark gray with hydrocarbon odours	☒	8		14			23.0				
		▨		☒	9		8			27.0				
		▨	-sand pockets below 19'	■	10			0.5	79	42.0				
20		▨	-calcareous nodules below 21'	■	11			1.25		24.0				
		▨		■	12			1.0		24.0				
25		▨	-light gray and reddish brown below 25'	■	13			2.0		16.0	69	24	45	
		▨		■	14			2.25		27.0				
		▨		■	15			2.75		24.0				
30	23.9	▨		■	16			3.0		25.0				
▽	21.9	░	**SILTY SAND(SM)**, medium dense, brown	☒	17		20			15.0				53
		▨	**SANDY LEAN CLAY(CL)**, stiff to very stiff,	■										

Hole No. 11-B18

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +55.86 ft	
2. LOCATION (Coordinates or Station) Filterbed, N=13842631.67 E=3145054.27		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 23.36 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/9/11 COMPLETED: 9/9/11	
5. DEPTH OF WATER ⊻ TOD: 32.5 ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	reddish brown and light gray with gravel and sand seams	■	18			1.75	118	16.0	34	12	22	
		▨		■	19			2.5		15.0				
	15.9	▨		■	20			4.5		14.0				
40		▒	**CLAYEY SAND(SM)**, medium dense to very dense, reddish brown light gray with clay pockets	☒	21		30			20.0				
		▒		☒	22		65			23.0				
45	9.9	▒		☒	23		63			20.0				
		▨	**FAT CLAY(CH)**, very stiff, reddish brown and light gray with sand seams	■	24			3.0	117	16.0				
		▨		■	25			4.5						
50		▨		■	26			4.0		15.0				
		▨		■	27			4.5		12.0				
55		▨		■	28			4.5	97	19.0				
		▨		■	29			3.75		20.0				
	-4.1	▨		■	30			4.5		19.0				
60														
65														

Hole No. 11-B19

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +55.90 ft	
2. LOCATION (Coordinates or Station) Filterbed, N=13840966.04 E=3145878.72		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ∇ TOD: 39.8 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/8/11 COMPLETED: 9/8/11	
5. DEPTH OF WATER ∇ TOD: 16.1 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	55.4	6" Top soil											
		SILTY SAND(SM), loose to medium dense, brown and light gray, with gravel	☒	1		20			4.0				
			☒	2		26			4.0				27
5			☒	3		18			3.0				
			☒	4		9		95	7.0				
			■	5					8.0				
10		-with clay pockets below 10'	☒	6		10			15.0				
	41.9		■	7			1.25	95	30.0	71	25	46	
15		**CLAYEY SAND(SC)**, loose to medium dense, light gray with hyrdo carbons odours -too soft from 14' to 16'	■	8					23.0				
∇			■	9		7		79	21.0				
			☒	10		13			22.0				
20	32.9		○	11					20.0				
		FAT CLAY(CH), very stiff, dark gray with ferrous stains and calcareous nodules	■	12			0.25		20.0	56	22	34	
25			■	13			2.25		20.0				
			■	14			2.25		21.0				
30		-light gray with gravel seams from 31' to 32'	■	15			2.25		29.0				
			■	16			3.75	104	22.0				
			■	17			3.75		21.0				

SWG 1836 BOR FILTERBED.GPJ TOLUNAY-WONG ENGINEERS.GDT 1/4/12

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +55.90 ft
2. LOCATION (Coordinates or Station) Filterbed, N=13840966.04 E=3145878.72	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 39.8 ft 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/8/11 COMPLETED: 9/8/11
5. DEPTH OF WATER TOD: 16.1 ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			4.5	113	19.0				
		▨	-with sand seams from 37' to 44'	■	19			4.5		21.0				
40		▨		☒	20		24			19.0				
		▨		■	21			3.75	106	24.0	73	23	50	
	11.9	▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff to very stiff, light gray and reddish brown with silt seams	■	22			1.25		16.0				
45		▨		■	23			2.25		15.0				
		▨		■	24			3.0	111	17.0				
50	5.9	▨	**<u>FAT CLAY</u>(CH)**, very stiff, reddish brown and light gray	■	25			3.0		20.0				
		▨		☒	26		25			28.0				
		▨		■	27			4.5	97	19.0				
55		▨		■	28			3.5		15.0				
		▨		■	29			3.75		14.0				
60	-4.1	▨		■	30			3.75		16.0				
65														

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +55.45 ft	
2. LOCATION (Coordinates or Station) Filterbed, N=138426658.35 E=3146212.68		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 32.15 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/8/11 COMPLETED: 9/8/11	
5. DEPTH OF WATER ⊻ TOD: 23.3 ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	55.0		6" top soil											
		▨	**FAT CLAY(CH)**, very stiff, dark brown with sand seams	■	1			4.5		17.0				
		▨		■	2			4.5	100	22.0				
5		▨		■	3			4.5		20.0				
		▨		■	4			2.25		23.0				
		▨		■	5			2.0		18.0				
10	43.5	▨		■	6			2.0	110	18.0	59	18	41	
			SILTY SAND(SM), loose, brown sand with clay pockets	■	7					11.0				
15	39.5			☒	8		6			27.0				
	36.5		-no recovery	○	9									
20		▨	**FAT CLAY(CH)**, soft to very stiff, dark gray with organics and hydrocarbon odours	☒	10		2			27.0				
	32.5 ⊻	▨		■	11			2.25	61	59.0	97	31	66	
		▨	**FAT CLAY(CH)**, stiff to very stiff, light gray with sand seams	■	12			2.0		18.0				
25		▨		■	13			1.5	108	20.0				82
		▨		■	14			2.5		22.0				
30	24.5	▨		■	15			2.25		18.0				
		▨	**SANDY LEAN CLAY(CI)**, very stiff, reddish brown, light gray with sand seams and calcareous deposits	■	16			4.5	118	15.0				
		▨		■	17			4.5		23.0				

BORING LOG	DISTRICT Galveston	INSTALLATION Filterbed	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +55.45 ft
2. LOCATION (Coordinates or Station) Filterbed, N=138426658.35 E=3146212.68	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 32.15 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/8/11 COMPLETED: 9/8/11
5. DEPTH OF WATER ▽ TOD: 23.3 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	18.5			■	18			4.5		16.0				
	16.5		**FAT CLAY(CH)**, very stiff, reddish brown, light gray with calcareous nodules	■	19			3.25		30.0				
40			**SANDY LEAN CLAY(CI)**, very stiff, reddish brown, light gray with lots of silt pockets	■	20			3.0	110	19.0	32	19	13	
				■	21			4.5		25.0				
	11.5													
			FAT CLAY(CH), very stiff, reddish brown, light gray with calcareous nodules	☒	22		21			24.0				
45				■	23			3.75		22.0				
				■	24			3.5		16.0	53	16	37	
50				■	25			4.0	115	16.0				
				■	26			4.0		14.0				
				■	27			4.25		18.0				
55				☒	28			4.5		15.0				
				☒	29			4.5		15.0				
	-4.6			☒	30			4.5						
60														
65														

SWG 1836 BOR FILTERBED.GPJ TOLUNAY-WONG ENGINEERS.GDT 1/4/12

Hole No. 11-B24A

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 1 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Glendale N=13841395.75 E=3151548.93

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
⊻ TOD: 26.0 ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+44.03 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
⊻ TOD: 18.03 ft ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 12/15/11 COMPLETED: 12/15/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, very stiff, reddish brown and light gray with lot of sand seams	■	1			3.75			17.0				
	40.5	▨	- dark gray	■	2			3.25		102	17.0				
		▥	**SILT(ML)**, light gray with clay pockets												
5	38.0	▥		☒	3		11				22.0				92
	36.0	▧	**FAT CLAY(CH)**, very stiff, reddish brown and dark gray with sand pockets and seams	■	4			2.5		93	28.0	80	30	50	99
		▧	**FAT CLAY WITH SAND(CH)**, stiff to very stiff, light gray, light brown and dark gray with calcareous nodules and ferrous stains	■	5			2.75			18.0				
10		▧		■	6			1.0		107	20.0	61	20	41	81
		▧		■	7			1.0			27.0				
15		▧	- gray	■	8			1.0		93	29.0				
		▧		■	9			1.75			22.0				
	24.0	▧		■	10			1.25			14.0				
20		▧	**FAT CLAY(CH)**, very stiff, light gray, light brown and reddish brown with calcareous nodules and ferrous stains	■	11			2.25				50	21	29	86
	20.0	▧	- with sand pockets	■	12			2.75			19.0				
25		▨	**SANDY LEAN CLAY(CL)**, stiff to very stiff, light brown and light gray with silty sand at bottom	■	13			1.75			25.0				
⊻		▨	- ferrous stains	■	14			3.75			16.0				
		▨		■	15			1.5			12.0				
30		▨		■	16			1.5			18.0				
		▨	- reddish brown with calcareous nodules	■	17			2.0			20.0				

SWG 1836 BOR GLENDALE.GPJ TOLUNAY-WONG ENGINEERS.GDT 3/6/12

Hole No. 11-B24A

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Glendale N=13841395.75 E=3151548.93

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
⊻ TOD: 26.0 ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+44.03 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
⊻ TOD: 18.03 ft ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 12/15/11 COMPLETED: 12/15/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	8.0	▨		■	18			3.5			15.0				
		▧	**FAT CLAY WITH SAND(CH)**, very stiff, reddish brown and light gray	■	19			3.5			22.0				
		▧	- calcareous nodules	■	20			3.0			23.0				
40		▧	- with sand seams, calcareous nodules and ferrous stains	■	21			3.75			13.0				
	1.0	▨	**SANDY LEAN CLAY(CL)**, very stiff, light gray with calcareous nodules and ferrous stains	■	22			3.75			29.0				
45		▨	- light brown	■	23			4.0			17.0				
		▨		■	24			4.0			19.0				
		▨		■	25			4.5			15.0				
50		▨		■	26			3.5			16.0				
	-9.0	░	**SILTY SAND(SM)**, very dense, light gray with clay pockets	☒	27		70								
55	-12.0	░		☒	28		50				16.0				
		▨	**SANDY LEAN CLAY(CL)**, light gray and reddish brown	☒	29		36								
	-16.0	▨	- light brown	○	30										
60															
65															

ENG FORM: SWG 1836 BOR

Hole No. 11-B21

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +50.97 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13840375.80 E=3151031.44		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/12/11 COMPLETED: 9/12/11	
5. DEPTH OF WATER ⊻ TOD: 30'2" ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, firm to stiff, brown with clay pockets	☒	1		7			8.0				
		▨		☒	2		7			9.0				
5		▨		☒	3		9			8.0				
	43.0	▨		☒	4		8			5.0				
		▩	**FAT CLAY(CH)**, very stiff to hard, dark brown with sand seams	■	5			3.0		24.0				
10		▩		■	6			4.5	116	20.0	60	22	38	
	37.0	▩		■	7			4.5		21.0				
15		▥	**SILTY CLAY(CL-ML)**, stiff, brown with clay pockets	☒	8		10			24.0				87
	33.0	▥	- light gray	■	9					14.0				
		▩	**FAT CLAY(CH)**, soft, dark gray with sand pockets, trace of organics and apparent hydro carbon	■	10			0.25	66	54.0	105	34	71	99
20		▩		■	11			0.5		23.0				
	28.0	▩		■	12			0.5	107	18.0				
25		▨	**SANDY LEAN CLAY(CL)**, stiff to hard, dark gray - light gray and yellowish brown with calcareous nodules	■	13			2.75		19.0				
		▨		■	14			1.0	102	21.0	46	19	27	81
		▨	- reddish brown and light gray with calcareous granules	■	15			2.25		11.0				
30		▨	- reddish brown and light gray with clay pockets	■	16			1.0	114	16.0				
		▨	- calcareous granules	■	17			1.0		13.0	47	27	20	57

Hole No. 11-B21

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +50.97 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13840375.80 E=3151031.44		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/12/11 COMPLETED: 9/12/11	
5. DEPTH OF WATER TOD: 30'2" ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			0.5		14.0				
				■	19			3.5		14.0				
40				■	20			2.0	113	17.0				
	10.0		**FAT CLAY(CH)**, very stiff, reddish brown and light gray with calcareous nodules	■	21			4.25		18.0				
				■	22			4.0		24.0				
	7.5		**SILTY SAND(SM)**, medium dense, light gray											
45				☒	23		21			24.0				
	5.0		**FAT CLAY(CH)**, very stiff to hard, light gray with sand seams	■	24			4.0		34.0				
				■	25			4.5		23.0				
50				■	26			3.25	115	16.0				
	-1.0		**SANDY LEAN CLAY(CL)**, very stiff to hard, yellowish brown	■	27			2.75		15.0				
55				■	28			3.25		16.0				
			- ferrous nodules	■	29			4.5		14.0				
60	-9.0			■	30			4.5		15.0				
65														

Hole No. 11-B22

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +55.33 ft
2. LOCATION (Coordinates or Station) Glendale, N=13838418.18 E=3149492.17	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/12/11 COMPLETED: 9/12/11
5. DEPTH OF WATER TOD: 21'6" ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, very stiff, brown with clay pockets	■	1					2.0	23	21	2	
		▨		☒	2		20			5.0				
5		▨		☒	3		21		105	3.0				
	47.3	▨		☒	4		18			4.0				
		▨	**FAT CLAY(CH)**, hard, dark brown with gray sand seams	■	5			4.5		16.0				
10	43.3	▨		■	6			4.5	108	12.0				
		░	**SILTY SAND(SM)**, loose to medium dense, brown with reddish brown clay pockets	■	7					6.0				
15		░		☒	8		16			5.0				85
		░		☒	9		13			9.0				
		░	- light gray	☒	10		11							
20		░		☒	11		5			22.0				10
	31.3	░	- trace of organics and apparent hydro carbon odour	☒	12		4			36.0				
25		▨	**SANDY LEAN CLAY(CL)**, firm to hard, brown and light gray with sand pockets	■	13			3.75		17.0				
		▨	- light gray	■	14			3.0	116	15.0	45	27	18	83
		▨	- firm to hard, reddish brown and light gray with calcareous deposits and gravel	■	15			2.75		18.0				
30		▨		■	16			2.0	110	16.0				
		▨		■	17			4.0	121	11.0				
		▨	- silt seams	■										

Hole No. 11-B22

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Glendale, N=13838418.18 E=3149492.17

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
▽ TOD: 21'6" ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+55.33 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
▽ TOD: ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 9/12/11 COMPLETED: 9/12/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	19.3	▨		■	18			3.5		17.0				
		⁘	**SILTY SAND(SM)**, medium dense, light gray with reddish brown clay pockets	☒	19		20		122	13.0				
	16.3	▨	**SANDY LEAN CLAY(CL)**, very stiff to hard, yellowish brown with clay pockets and ferrous nodules	■	20			3.25		14.0				
40		▨		■	21			4.5		10.0	38	23	15	62
		▨		■	22			4.5		22.0				
45		▨		■	23			4.5		17.0				
		▨		■	24			3.75		19.0				
		▨	- reddish brown	■	25			4.5		15.0				
50		▨	- yellowish brown	■	26			4.0		15.0				
		▨		■	27			4.5		16.0				
55		▨	- sand seams from 54 - 55 feet	■	28			4.5		20.0				
		▨		■	29			4.5		18.0				
	-4.7	▨		■	30			4.5		18.0				
60														
65														

Hole No. 11-B23

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +43.33 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13838350.12 E=3152321.04		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/13/11 COMPLETED: 9/13/11	
5. DEPTH OF WATER ▽ TOD: 23'5" ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, soft to hard, dark brown with gravel and calcareous deposits	■	1			4.5	113	12.0	42	18	24	75
		▨		☒	2		12			11.0				
5		▨	- light gray and yellowish brown with sand pockets	☒	3		11			14.0				
		▨	- brown and gray with sand pockets, gravel and calcareous granules	■	4			4.5	115	15.0				
		▨		■	5			1.5	112	17.0				
10		▨		■	6			1.25		22.0				
		▨	- dark gray with sand pockets and trace of organics	■	7			0.25	104	21.0				
15		▨	- dark gray	■	8			1.25		24.0				
		▨	- light gray	■	9			0.75		21.0				
		▨	- reddish brown and light gray with sand and calcareous deposits	■	10			1.25	103	20.0	41	24	17	0.5
20	23.3	▥	**SILTY CLAY(CL-ML)**, stiff, reddish brown with clay pockets	☐	11					16.0				
		▥		☐	12					16.0				90
25		▥		☒	13		24			20.0				
		▥		☒	14		29			18.0				
	15.3	▨	**SANDY LEAN CLAY(CL)**, stiff to hard, reddish brown and light gray with calcareous granules	■	15			2.25	109	17.0				
30		▨	- yellowish brown with ferrous nodules	■	16			3,25		25.0				
		▨		■	17			1.5	113	18.0	26	11	15	74
		▨		■										

Hole No. 11-B23

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +43.33 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13838350.12 E=3152321.04		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/13/11 COMPLETED: 9/13/11	
5. DEPTH OF WATER ▽ TOD: 23'5" ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			4.0		15.0				
		▨	- increase of calcareous granules	■	19			3.75		16.0				
		▨		■	20			4.0		13.0				
40		▨	- light gray and yellowish brown with calcareous nodules and ferrous nodules	■	21			3.25		18.0				
		▨		■	22			3.75		22.0				
45		▨		■	23			3.5	102	24.0				
		▨		■	24			4.5		16.0				
		▨	- gravel	■	25			4.5		17.0				
50		▨	- reddish brown with sand sand pockets and gravel	■	26			4.5		18.0				
		▨		■	27			4.5						
55		▨		■	28			4.5		17.0				
	-14.7	▨	- silty sand seams	■	29			4.5						
60	-16.7	░	**SILTY SAND(SM)**, very dense, reddish brown and light gray	☒	30		51			21.0				
65														

Hole No. 11-B24

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +42.93 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13842038.30 E=3152139.53		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/13/11 COMPLETED: 9/13/11	
5. DEPTH OF WATER ⊻ TOD: 22'8" ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, firm to very stiff, dark brown and gray with gravel and sand pockets	☒	1		22			10.0				
				■	2			4.5	124	11.0				
5				■	3			4.5	122	13.0	49	37	12	77
			- calcareous granules											
			- dark gray and yellowish brown with sand pockets	■	4			3.5		18.0				
				■	5			1.75	106	23.0				
10														
				■	6			1.25		19.0				
	29.9													
		▨	**<u>FAT CLAY</u>(CH)**, stiff, dark gray to light gray and yellowish brown clay with sand pockets	■	7			1.5		23.0				
15				■	8			1.5	108	16.0	66	43	23	
				■	9			1.5	106	23.0				
	23.9													
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff to very stiff, yellowish brown, bottom sand	■	10			1.0		20.0				
20														
	21.9													
		▥	**<u>SILTY CLAY</u>(CL-ML)**, very stiff, with clay pockets	■	11			1.0	98	21.0	34	17	17	3
				☒	12		21			24.0				78
	18.9													
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, firm to hard, yellowish brown											
25				■	13			1.0		16.0				
				■	14			1.5		16.0				
			- gravel and calcareous granules											
	13.9													
		▨	**<u>FAT CLAY</u>(CH)**, stiff to hard, reddish brown and light gray with gravel and calcareous granules	■	15			1.5		20.0				
30														
				■	16			4.5	101	24.0				
				■	17			4.5		16.0				
	7.9													

BORING LOG	DISTRICT Galveston	INSTALLATION Glendale	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +42.93 ft	
2. LOCATION (Coordinates or Station) Glendale, N=13842038.30 E=3152139.53		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/13/11 COMPLETED: 9/13/11	
5. DEPTH OF WATER TOD: 22'8" ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	6.9	░	**SILTY SAND(SM)**, medium dense, with clay pockets	■	18			4.0		14.0				
		▨	**FAT CLAY(CH)**, very stiff to hard, reddish brown and light gray with gravel and calcareous granules, sand seams from 36 to 40 feet	☒	19		22			21.0				
		▨		■	20			4.5		18.0				
40		▨		■	21			4.5		14.0	52	38	14	
	-1.1	▨		■	22			4.5		15.0				
45		▧	**SANDY LEAN CLAY(CL)**, very stiff to hard, yellowish brown	■	23			4.5		11.0				
	-5.1	▧		■	24			4.5	121	13.0				
		░	**SILTY SAND(SM)**, dense, brown and light gray with gravel	■	25					15.0				
50		░												
		░		☒	26		34			25.0				
		░		☒	27		35			23.0				
55		░		☒	28		31			24.0				11
		░		☒	29		31			24.0				
60	-17.1	░		☒	30		32			24.0				
65														

Hole No. 11-B25

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +56.30 ft
2. LOCATION (Coordinates or Station) Housetract, N=13844852.79 E=3154649.81	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: 16.3 ft ⊻ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/14/11 COMPLETED: 9/14/11
5. DEPTH OF WATER ⊻ TOD: 40.0 ft ⊻ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, stiff to hard, dark gray and reddish brown clay with brown sand seams and slicken sided	■	1			4.5		14.0				
		▨		■	2			4.5	117	12.0				
5		▨		■	3			4.5		10.0				
		▨		■	4			4.0		15.0				
		▨		■	5			3.0	108	19.0	64	14	50	78
10		▨	- light gray	■	6			3.0		26.0				
		▨	- gravel and sand pockets	■	7			2.25	104	22.0				
15		▨		■	8			3.5		22.0				
		▨	- gravel, calcareous nodules and sand pockets	■	9			1.25	103	23.0	65	50	15	89
		▨		■	10			1.5		23.0				
20		▨		■	11			3.5		22.0				
		▨		■	12			1.5		32.0				
25		▨		■	13			1.25	88	32.0				
	29.3	▨	**FAT CLAY(CH)**, stiff, light gray with sand pockets	■	14			1.25		30.0				
		▨		■	15			1.25		28.0				
30		▨	- yellowish brown - calcareous nodules	■	16			1.5	94	28.0				
		▨	- reddish brown and light gray with sand pockets	■	17			1.5		25.0				

Hole No. 11-B25

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +56.30 ft
2. LOCATION (Coordinates or Station) Housetract, N=13844852.79 E=3154649.81	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 16.3 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/14/11 COMPLETED: 9/14/11
5. DEPTH OF WATER ▽ TOD: 40.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			1.5		22.0				
				■	19			3.25		23.0				
40 ▽	17.3		**<u>SANDY LEAN CLAY</u>(CL)**, soft, reddish brown and light gray	■	20			0.5		19.0				
	15.3		**<u>SILTY SAND</u>(SM)**, light gray and yellowish brown with clay seams	■	21			3.5	115	17.0	24	15	9	86
				■	22					19.0				
	12.3		**<u>SILTY CLAY</u>(CL-ML)**, very stiff, light gray and yellowish brown											
45	11.3		**<u>FAT CLAY</u>(CH)**, very stiff to hard, yellowish brown and light gray with gravel and sand pockets	☒	23		28			14.0				
			- silty sand seam	■	24			4.5		15.0				
			- calcareous nodules	■	25			3.75		25.0				
50			- Gravel seams at 51'-52'	■	26			4.0		21.0				
	4.3		**<u>SANDY SILTY CLAY</u>(CL-ML)**, very stiff, reddish brown clay seams	■	27			3.0		18.0				
55				■	28			3.0	108	15.0	26	20	6	76
	-0.2		**<u>FAT CLAY</u>(CH)**, hard, light gray and reddish brown with silt seams	■	29			4.5		19.0				
				■	30			4.5						
60	-3.7													
65														

SWG 1836 BOR HOUSE TRACT.GPJ TOLUNAY-WONG ENGINEERS.GDT 1/13/12

Hole No. 11-B26

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +58.58 ft
2. LOCATION (Coordinates or Station) Housetract, N=13841527.12 E=3153693.11	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ∇ TOD: 48.08 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/15/11 COMPLETED: 9/15/11
5. DEPTH OF WATER ∇ TOD: 10.5 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░	**SILTY SAND(SM)**, loose to medium dense, brown, with gravel and clay pockets	■	1					1.0				
		░		☒	2		21			9.0				
5		░		☒	3		10			8.0				39
		░	- light gray	☒	4		10			17.0				
		░		☒	5		4			22.0				
10 ∇		░	- strong chemical odour											
	46.6	░		☒	6		15			19.0				
		▨	**FAT CLAY(CH)**, stiff, reddish brown and light gray with sand pockets	☒	7		5			38.0				
15		▨		■	8			1.25	85	37.0	81	54	27	95
		▨	- ferrous nodules	■	9			1.5		38.0				
		▨	- brown sand with clay pockets - soft, dark gray with hydro carbon odour	■	10			0.75		30.0				
20		▨		■	11			0.75	85	35.0				
		▨		■	12			0.25	75	45.0	82	54	28	100
25		▨		■	13			0.25	0.75	31.0				
	30.6	▨		■	14			0.75	97	29.0				
		▨	**FAT CLAY(CH)**, soft to hard, dark gray with silt pockets	■	15			0.25	105	20.0	51	23	28	85
30		▨		■	16			1.5		24.0				
		▨		■	17			1.0		17.0				
		▨	- yellowish brown clay with gravel, calcareous	■										

Hole No. 11-B26

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +58.58 ft	
2. LOCATION (Coordinates or Station) Housetract, N=13841527.12 E=3153693.11		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 48.08 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/15/11 COMPLETED: 9/15/11	
5. DEPTH OF WATER TOD: 10.5 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			nodules and ferrous nodules		18			2.0	111	20.0				
					19			2.0		23.0				
40					20			4.5	113	17.0				
	17.6		**LEAN CLAY(CL)**, very stiff, yellowish brown and light gray with calcareous granules and sand pockets		21			4.5		17.0				
					22			2.75		15.0				
45			- ferrous nodules		23			3.75		20.0				
	12.6		**FAT CLAY(CH)**, very stiff to hard, reddish brown and light gray with sand pockets - yellowish brown		24			3.5		18.0				
					25			4.5	115	16.0	58	21	37	92
50					26			4.5		23.0				
			- reddish brown		27			4.0		24.0				
55	2.6				28			4.5		20.0				
			SANDY LEAN CLAY(CL), hard, reddish brown with calcareous and ferrous nodules		29			4.25		15.0				
60	-1.4				30			4.5		16.0				
65														

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Hole No. 11-B27

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +70.34 ft	
2. LOCATION (Coordinates or Station) Housetract, N=13838133.15 E=3155112.37		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ∇ TOD: 48.74 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/15/11 COMPLETED: 9/15/11	
5. DEPTH OF WATER ∇ TOD: 21.6 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very stiff, reddish brown with gravel, sand seams and calcareous nodules	■	1					8.0				
	66.8	▨		■	2			4.5	107	11.0	74	30	44	
5	64.8	░	**SILTY SAND(SM)**, medium dense, brown with clay pockets	☒	3		21			18.0				
	62.8	▧	**SANDY LEAN CLAY(CL)**, very stiff, orange brown	■	4			3.75	110	9.0				
		░	**SILTY SAND(SM)**, medium dense to dense, dark gray with clay pockets	☒	5		34			13.0				
10		░		■	6					25.0				
		░	- light gray with apparent hydro carbon odour	☒	7		27			17.0				
15		░		☒	8		19			15.0	Non Plastic	Non Plastic	NP	48
		░		☒	9		15			18.0				
20		░	- loose to medium dark gray with apparent hydro carbon odour	☒	10		6			18.0				
∇		░		☒	11		5			21.0				
		░		☒	12		18			27.0				
25	44.3	░		☒	13		3			59.0				
		▨	**FAT CLAY(CH)**, soft, brown with hydro carbon odour	■	14			0.75		37.0				
		▨		■	15			0.25	77	43.0	53	22	31	98
30		▨		■	16			0.5	81	36.0				
		▨	- sand pockets at 33.5'	☒	17		4			35.0				
		▨		☒										

Hole No. 11-B27

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +70.34 ft	
2. LOCATION (Coordinates or Station) Housetract, N=13838133.15 E=3155112.37		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 48.74 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/15/11 COMPLETED: 9/15/11	
5. DEPTH OF WATER TOD: 21.6 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		☒	18		3			26.0				
		▨	- trace of organics	■	19			0.25	81	36.0				
	30.3	▨		■	20			0.25		26.0				
40		⋯	**<u>SILTY SAND</u>(SM)**, loose to dense, light gray	☒	21		9			26.0				
	27.3													
		▨	**<u>FAT CLAY</u>(CH)**, soft to hard, reddish brown and dark gray	☒	22		34							
45		▨	- ferrous nodules	■	23			0.75	84	38.0				
		▨		■	24			1.5		28.0				
		▨		■	25			1.5	100	24.0	72	18	54	92
50		▨		■	26			1.75		27.0				
		▨	- calcareous nodules	■	27			2.0		25.0				
55		▨		■	28			4.5	117	19.0				
	13.3	▨	- calcareous nodules and gravel seams											
	12.3	⋯	**<u>SILTY SAND</u>(SM)**, reddish brown and light gray	■	29			4.5		20.0				
		▨	**<u>FAT CLAY</u>(CH)**, very stiff, reddish brown and light gray with calcareous nodules and silt	■	30			3.0		14.0				
60	10.3													
65														

Hole No. 11-B28

BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +70.01 ft
2. LOCATION (Coordinates or Station) Housetract, N=13840912.36 E=3155665.97	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 37.51 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/14/11 COMPLETED: 9/15/11
5. DEPTH OF WATER ▽ TOD: 32.5 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff, brown with clay pockets	■	1			4.5		2.0				
		▨		☒	2		9			8.0				
5		▨		☒	3		12			13.0	35	21	14	87
		▨		☒	4		7			14.0				
		▨		☒	5		16			12.0				
10		▨	- dark gray with apparent hydro carbon odour	☒	6		16			17.0				
		▨		■	7					18.0				
15		▨		■	8					16.0				
		▨	- ferrous nodules	☒	9		11			15.0				
		▨		■	10			1.25	105	17.0				
20		▨		■	11					17.0				
		▨		☒	12		8			30.0				
25		▨		■	13			1.25	103	22.0	45	24	21	88
		▨		■	14			1.0		39.0				
	41.0	▨		■	15			0.25	85	35.0				
	40.0	▨	**<u>FAT CLAY</u>(CH)**, soft, dark gray with hydro carbon odour											
30		▨	**<u>SANDY LEAN CLAY to CLAYEY SAND</u>**, soft, gray with hydro carbon odour	■	16			0.25		17.0				
▽		▨		☒	17		3			33.0				
	36.0	▨	**<u>FAT CLAY</u>(CH)**, soft, dark gray with hydro	■										

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BORING LOG	DISTRICT Galveston	INSTALLATION Housetract	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +70.01 ft	
2. LOCATION (Coordinates or Station) Housetract, N=13840912.36 E=3155665.97		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 37.51 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/14/11 COMPLETED: 9/15/11	
5. DEPTH OF WATER ⊻ TOD: 32.5 ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	carbon odour	■	18			0.25		63.0				
		▨		■	19			0.25	85	36.0	76	28	48	96
		▨		■	20			0.25		47.0				
40														
		▨		■	21			0.25	76	43.0				
	26.5	▨		■	22			0.25		23.0				
45		▨	**FAT CLAY(CH)**, stiff to very stiff, light gray and yellowish brown with ferrous nodules	■	23			1.5		26.0				
		▨		■	24			1.25	99	26.0	88	25	63	91
		▨		■	25			2.25		24.0				
50														
		▨		■	26			3.75	108	21.0				
	16.0	▨	- calcareous, ferrous nodules and gravel seams	■	27			3.5		22.0				
55		▨	**SANDY LEAN CLAY(CL)**, stiff to very stiff, yellowish brown and light gray with ferrous nodules	■	28			3.25		19.0				
		▨		■	29			1.25		15.0				
	10.0	▨		■	30			4.5						
60														
65														

Hole No. 11-B29

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 44.68 ft
2. LOCATION (Coordinates or Station) Clinton N=13842586.26 E=3161470.84	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ☐ TOD: ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/23/11 COMPLETED: 9/23/11
5. DEPTH OF WATER ☐ TOD: 38'3" ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**LEAN CLAY WITH SAND(CL)**, very stiff to hard, brown and reddish brown with sand, gravel and rock pieces	■	1			4.5		11.0				
				■	2			4.5		7.0				
5			- yellowish brown and light gray with sand pockets and calcareous nodules	■	3			4.5	109	12.0				
				■	4			3.75	119	13.0	47	16	31	82
			- calcareous and ferrous nodules - reddish brown and gray	■	5			3.5		15.0				
10	34.7	▨	**FAT CLAY(CH)**, soft to firm to stiff, yellowish brown and gray with sand pockets and calcareous nodules	■	6			0.5	104	20.0	55	24	31	80
			- trace of gravel	■	7			0.75	94	30.0				
15			- ferrous nodules	■	8			0.5		36.0				
			- reddish brown	■	9			1		41.0				
				■	10			0.75	77	42.0	85	33	52	100
20			- dark gray with sand pockets	■	11			3.25		18.0				
				■	12			0.75	77	65.0				
25			- light gray with ferrous and calcareous nodules	■	13			0.25		26.0				
			- yellowish brown and light gray with sand pockets and calcareous deposits	■	14			2.5		24.0				
			- slickensided	■	15			2.25		26.0				
30				■	16			3	105	23.0				
			- stiff to very stiff, yellowish brown, reddish brown and light gray with sand seams, gravel	■	17			1.5		18.0				

Hole No. 11-B29

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 44.68 ft	
2. LOCATION (Coordinates or Station) Clinton N=13842586.26 E=3161470.84		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/23/11 COMPLETED: 9/23/11	
5. DEPTH OF WATER ⊻ TOD: 38'3" ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	deposits and calcium deposits	■	18			1.25	111	18.0				
		▨	- slickensided	■	19			2.75	107	18.0	56	24	32	72
		▨		■	20			4.5		22.0				
40		▨		■	21			3.75		20.0				
		▨	- gravel seams 42'-43'	■	22			3.5		16.0				
45		▨	- ferrous nodules	■	23			2.75	106	15.0				
		▨	- calcareous nodules	■	24			2.75		15.0				
	-5.3	▨		■	25			4.5		15.0				
50	-7.3	▧	**<u>CLAYEY SAND</u>(SC)**, light gray and yellowish brown	■	26			4.5		15.0				
		░	**<u>SILTY SAND</u>(SM)**, very dense, yellowish brown with clay pockets	☒	27		66			22.0				
55	-11.3	░		☒	28		70			23.0				
		▨	**<u>FAT CLAY</u>(CH)**, very stiff, reddish brown and light gray with slickensided	☒	29		27			23.0				
60	-15.3	▨		■	30			2.5		25.0				
65														

Hole No. 11-B30

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 1 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Clinton N=13840915.23 E=3156989.87

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
⊻ TOD: 22'2" ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
48.68 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
⊻ TOD: ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 9/21/11 COMPLETED: 9/21/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, stiff, brown with roots - trace of gravel	☒	1		9			13.0				
		▨		☒	2		11			7.0				
5	43.7	░	**SILTY SAND(SM)**, loose to medium dense, brown with clay pockets	☒	3		15			8.0				
		░		☒	4		5			10.0				36
		░	- light gray	☒	5		11			12.0				
10	38.7	▩	**FAT CLAY(CH)**, soft to very stiff, dark gray with sand seams and apparent hydrocarbon odour	☒	6		1			27.0				
		▩		☒	7		6			42.0				
15		▩	- ferrous nodules	■	8			0.25	87	31.0	89	33	56	98
		▩	- light gray and brown sand seams	■	9			0.25		31.0				
20		▩	- light reddish brown with ferrous nodules	■	10			0.5		34.0				
		▩		■	11			1	95	28.0				
		▩	- gray with sand pockets and ferrous stains	■	12			1.25		28.0				
25		▩		■	13			1		34.0				
		▩	- yellowish brown and light gray	■	14			1	93	28.0	72	25	47	91
30		▩	- gravel pockets	■	15			2.5		24.0				
		▩	- reddish brown and light gray with ferrous nodules, gravel, sand pockets and calcareous deposits	■	16			3.75		23.0				
	15.2	▩		■	17			2.25	117	15.0				
		▨	**SANDY LEAN CLAY(CL)**, stiff, yellowish brown and light gray with roots	■										

SWG 1836 BOR CLINTON.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/3/12

Hole No. 11-B30

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 48.68 ft	
2. LOCATION (Coordinates or Station) Clinton N=13840915.23 E=3156989.87		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/21/11 COMPLETED: 9/21/11	
5. DEPTH OF WATER TOD: 22'2" ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			4	120	13.0				
	10.7	▨		■	19			4		12.0				
		▨	**FAT CLAY(CH)**, stiff to very stiff, reddish brown and light gray with gravel seams and calcium deposits	■	20			3.75	111	18.0				
40		▨		■	21			4.5		21.0				
		▨	- calcareous nodules and slickensided from 43 ft to 60 feet	■	22			4.5		26.0				
45		▨		■	23			4		26.0				
		▨		■	24			3.25	99	28.0	72	27	45	
		▨		■	25			3		28.0				
50		▨	- sand seams below 50'	■	26			1.5		24.0				
		▨		■	27			4.25		29.0				
55		▨		■	28			4	100	25.0				
		▨		■	29			3.25		32.0				
	-11.3	▨		■	30			3.25		31.0				
60														
65														

Hole No. 11-B31

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 53.28 ft
2. LOCATION (Coordinates or Station) Clinton N=13838221.69 E=3159007.06	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/21/11 COMPLETED: 9/21/11
5. DEPTH OF WATER ▽ TOD: 24'8" ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░	**<u>SILTY SAND</u>(SM)**, loose, brown with clay pockets	☒	1					8.0				
		░		☒	2		8			8.0				69
5		░		☒	3		8			6.0				
		░		☒	4		6			7.0				
		░		☒	5		7			6.0				
10	42.3	░												
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff, brown and dark gray with light gray sand seams and ferrous stains	☒	6		10			19.0				
	39.3	▨		☒	7		7			9.0	43	22	21	66
15		▩	**<u>FAT CLAY</u>(CH)**, stiff to very stiff, dark gray with light gray sand seams - hydrcarbon odour	■	8			0.25		25.0				
		▩		☒	9		6			45.0				
		▩		■	10			0.5		20.0				
20		▩												
		▩		■	11			0.5		26.0				
	29.3	▩		■	12			1	96	24.0	53	21	32	60
25	27.3	░	**<u>SILTY SAND</u>(SM)**, loose, reddish brown and light gray with clay pockets - 1" gravel seams	■	13					31.0				79
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff, gray with sand seams, pockets and ferrous stains	■	14			1.75	102	23.0				
		▨		■	15			2.75	112	18.0				
30		▨												
		▨		■	16			3.5		16.0				
		▨	- light gray and yellowish brown with sand pockets and ferrous stains	■	17			2	114	17.0	40	19	21	74

Hole No. 11-B31

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Clinton N=13838221.69 E=3159007.06

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
TOD: 24'8" ft 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
53.28 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
TOD: 24-HR:

10. DRILLING DATE and TIME
STARTED: 9/21/11 COMPLETED: 9/21/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	17.3	▨		■	18			3.25	111	19.0				
	15.8	▨	**CLAYEY SAND(SC)**, soft, light gray and yellowish brown	■	19			0.75		20.0				
		⁘	**SILTY SAND(SM)**, medium dense, yellowish brown with clay pockets	☒	20		13			25.0				
40		⁘		☒	21	239	20			22.0				
		⁘		☒	22		19			24.0				
45		⁘		☒	23		18			31.0				
		⁘	- brown with clay pockets	☒	24		19			26.0				
		⁘		☒	25		23			27.0				
50		⁘		☒	26		20			24.0				
		⁘		☒	27		19			24.0				
55		⁘	- dense below 55'	☒	28		40			25.0				
		⁘		☒	29		45			21.0				
		⁘	- brown and light gray	☒	30		77			23.0				
60	-6.7													
65														

Hole No. 11-B32

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 44.97 ft	
2. LOCATION (Coordinates or Station) Clinton N=13839099.37 E=3163374.11		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/26/11 COMPLETED: 9/26/11	
5. DEPTH OF WATER ⊻ TOD: 12'8" ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, firm to very stiff, dark brown and gray with gravel and sand pockets	☒	1		13			7.0				
		▨		☒	2		10			6.0	42	20	22	35
5		▨	- calcareous granules	☒	3		15			13.0				
		▨	- dark gray and yellowish brown with sand pockets and gravel	■	4			4.5		7.0				
		▨		■	5			4.5		18.0				
10	35.0													
		▩	**FAT CLAY(CH)**, very soft to stiff, dark gray to light gray and yellowish brown clay with sand pockets	■	6			1.25	97	27.0				
		▩		■	7			1	83	44.0				
15		▩		■	8			1.25		26.0				
		▩		■	9			0.25		14.0				
	26.0													
		▨	**SANDY LEAN CLAY(CL)**, very soft, yellowish brown, bottom sand	■	10			0.25	86	26.0	112	38	74	91
20		▨		■	11			0.25		25.0				
	23.0													
		▤	**CLAYEY SAND(SC-SM)**, very loose to loose, brown and dark gray, with clay pcokets and hydrocarbon odour	■	12					13.0				66
25		▤		☒	13		2			31.0				
		▤		☒	14		2			21.0				
30		▤		☒	15		4			25.0				
	14.0													
		░	**SILTY SAND(SM)**, medium dense, light gray and yellowish brown, with clay pockets	☒	16		15			21.0				
		░		☒	17		19			26.0				
		░		■										

SWG 1836 BOR CLINTON.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/3/12

BORING LOG	DISTRICT Galveston	INSTALLATION Clinton	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 44.97 ft	
2. LOCATION (Coordinates or Station) Clinton N=13839099.37 E=3163374.11		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/26/11 COMPLETED: 9/26/11	
5. DEPTH OF WATER ⊻ TOD: 12'8" ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	9.5			■	18					10.0				
		▨	**FAT CLAY(CH)**, very stiff, reddish brown to light gray, with gravel, calcareous nodules and sand pockets, slicken sided	■	19			2.75	113	19.0				
	6.0	▨	**LEAN CLAY WITH SAND(CL)**, stiff, light gray to yellowish brown, with sand pockets, ferrous nodules	■	20			2.5		19.0				
40		▨		■	21				114	19.0	24	15	9	81
		▨		■	22			1.5		18.0				
45		▨		■	23			2.5		19.0				
		▨		■	24			4		16.0				
		▨		■	25			4.25	118	15.0				
50		▨		■	26			4.5		15.0				
		▨		■	27			4.5		15.0				
55	-11.0	▨	- calcareous nodules	■	28			3.75		16.0				
		▨	**SANDY LEAN CLAY(CL)**, very stiff, light gray to reddish brown	■	29			3						
60	-15.0	▨		■	30			3.75		18.0				
65														

Hole No. 11-B33

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 47.24 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13822489.37 E=3164743.85		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/26/11 COMPLETED: 9/26/11	
5. DEPTH OF WATER ▽ TOD: 16'5" ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, firm to stiff, brown with gravel	☒	1		11			22.0				
			- reddish brown											
			- brown with trace of gravel - reddish brown clay seams	☒	2		12			14.0				
5				☒	3		15			20.0				
			- reddish brown with sand seams - brown silty sand	■	4					26.0				
			- brown silty sand seams	☒	5		4			22.0				
10			- reddish brown and ligth gray with brown sand seams	■	6			1.25	101	22.0				
			- firm to stiff, reddish brown with brown sand seams	■	7			1.0	108	19.0				
15				■	8			0.5	92	30.0	41	20	21	99
	29.2			■	9					27.0				
20		⁘	**SILTY SAND(SM)**, very loose to loose, brown and dark gray with sand seams and apparent hydrocarbon odour	☒	10		5			22.0				32
	26.2	▩	**FAT CLAY(CH)**, soft to firm to stiff, dark gray and gray with sand seams and apparent hydrcarbon odour	☒	11		2			28.0				
				☒	12		1			33.0				
25				☒	13		2			34.0				
			- gray with sand pockets and ferrous nodules	■	14			0.75	80	42.0				
				■	15			1.0	82	38.0	93	38	55	98
30				■	16			2.0		31.0				
			- yellowsh brown with sand pockets, trace of gravel and ferrous nodules - reddish brown and light gray with sand pockets from 32' to 42'	■	17			2.0	98	28.0				

Hole No. 11-B33

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 47.24 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13822489.37 E=3164743.85		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/26/11 COMPLETED: 9/26/11	
5. DEPTH OF WATER ⊻ TOD: 16'5" ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			1.5		34.0				
		▨		■	19			2.5		25.0				
		▨		■	20			1.75		30.0				
40	5.2	▨	- ferrous nodules - calcareous nodules	■	21			2.0		29.0				
	3.2	▨	**SANDY LEAN CLAY(CL)**, firm, reddish brown with gravel deposits	■	22			0.75	106	22.0	43	20	23	93
45		░	**SILTY SAND(SM)**, medium dense, reddish brown and reddish brown clay seams	■	23			2.5		25.0				
	-1.8	░		☒	24		19			26.0				
50		▨	**FAT CLAY(CH)**, very stiff to hard, reddish brown with trace of calcareous nodules - reddish brown and light gray with ferrous nodules and slickensided from 49.5' to 60 '	■	25			2.25		29.0				
		▨		■	26			4.25		29.0				
		▨		■	27			4.25		31.0				
55		▨		■	28			3.5		33.0				
		▨		■	29			4.25		31.0				
60	-12.8	▨		■	30			2.75		35.0				
65														

SWG 1836 BOR ROSA ALLEN.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/3/12

ENG FORM: SWG 1836 BOR

Hole No. 11-B34

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 45.14 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13819680.87 E=3162775.75		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/27/11 COMPLETED: 9/27/11	
5. DEPTH OF WATER ⊻ TOD: 37'4" ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, firm to stiff to very stiff to hard, reddish brown with sand and slickensided	■	1			4.5		20.0				
		▨		■	2			4.5	101	20.0	89	25	64	100
5		▨		■	3			4.5		12.0				
		▨	- with sand pockets and calcareous nodules	■	4			4.5		17.0				
		▨		■	5			3.25	103	23.0	68	22	46	84
10		▨		■										
		▨	- light gray with sand and gravel	■	6			0.75		29.0				
	31.1	▨	- brown sand seams	■	7			1.5	97	30.0				
15	29.1	▧	**SANDY LEAN CLAY(CL)**, brown with silt and sand pockets	■	8					23.0				91
		▨	**FAT CLAY(CH)**, very soft to stiff to very stiff, dark gray with sand and apparent hydrocarbon odour	■	9			0.25						
		▨	- gray with sand and ferrous nodules	■	10			0.25	78	37.0	88	28	60	97
20		▨		■										
		▨		■	11			0.25		33.0				
		▨	- light gray with ferrous nodules	■	12			0.25		37.0				
25		▨		■	13			1.0	97	28.0				
		▨	- yellowish brown and light gray with sand and ferrous nodules	■	14			1.5		31.0				
		▨	- yellowish brown and light gray with sand pockets, calcareous nodules and ferrous nodules	■	15			3.0		22.0				
30		▨		■										
		▨	- reddish brown and light gray with sand pockets and calcareous nodules	■	16			4.5	110	20.0				
		▨		■	17			3.0		16.0				

SWG 1836 BOR ROSA ALLEN.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/3/12

Hole No. 11-B34

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 45.14 ft
2. LOCATION (Coordinates or Station) Rosa Allen N=13819680.87 E=3162775.75	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/27/11 COMPLETED: 9/27/11
5. DEPTH OF WATER TOD: 37'4" ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
					18			2.5		24.0				
			- ferrous nodules		19			2.0		21.0				
					20			2.5		29.0				
40					21			2.5	108	20.0				
					22			2.25		30.0				
45			- reddish brown and light gray with sand and trace of gravel		23			2.5		22.0				
	-2.9				24			3.0		22.0				
			SILTY CLAY(CL-ML), very stiff, reddish brown with reddish brown clay seams		25				103	23.0				
50	-6.4				26			2.5		22.0				
			FAT CLAY(CH), very stiff, reddish brown with sand - silty sand seams - with sand and trace of calcareous nodules		27			3.5		19.0				
55			- with ferrous nodules and slickensided		28			3.5		26.0				
					29			3.0		27.0				
	-14.9		- brown sand seams		30			3.0		26.0				
60			- 3 " sand seam											
65														

SWG 1836 BOR ROSA ALLEN.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/3/12

Hole No. 11-B35

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 46.00 ft
2. LOCATION (Coordinates or Station) Rosa Allen N=13818006.87 E=3164322.72	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: ⯆ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/27/11 COMPLETED: 9/27/11
5. DEPTH OF WATER ⊻ TOD: 38'4" ft ⯆ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very soft to soft to firm to stiff to very stiff to hard, reddish brown and dark gray with sand seams and slickensided	■	1			4.5		17.0				
					2			4.5		22.0				
5					3			4.5	108	22.0	94	28	66	
					4			3.25		19.0				
					5			1.0		20.0				
10														
			- sand pockets		6			1.0	88	33.0				85
			- yellowish brown and gray with brown sand seams		7			0.75		36.0				
15			- dark gray with light gray sand seams and apparent hydrocarbon odour		8			0.25		30.0				
			- reddish brown		9			0.75		25.0				
			- brown sand		10			0.25	74	42.0	93	27	66	99
20			- dark gray with apparent hydrocarbon odour											
			- gray with sand and ferrous nodules		11			0.25		23.0				
					12			0.5		35.0				
25					13			1.25	92	32.0				
			- light gray and yellowish brown with ferrous nodules		14			1.0		21.0				
			- reddish brown and light gray with calcareous nodules and trace of gravel		15			1.75		31.0				
30														
					16			1.75		34.0				
					17			1.75	93	29.0	98	29	69	96

Hole No. 11-B35

BORING LOG

DISTRICT
Galveston

INSTALLATION
Rosa Allen

SHEET 2
OF 2 SHEETS

1. PROJECT
HSCDMMP

7. ELEVATION OF HOLE
46.00 ft

2. LOCATION (Coordinates or Station)
Rosa Allen N=13818006.87 E=3164322.72

8. DATUM FOR ELEVATION

3. DRILLING AGENCY
Kenall Inc.

9. ELEVATION OF GROUNDWATER
∇ TOD: ▼ 24-HR:

4. LABORATORY TESTING AGENCY
Kenall Inc.

10. DRILLING DATE and TIME
STARTED: 9/27/11 COMPLETED: 9/27/11

5. DEPTH OF WATER
∇ TOD: 38'4" ft ▼ 24-HR:

11. CLASSIFICATION REFERENCE

6. DEPTH OF HOLE
60 ft

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			1.75		29.0				
				■	19			1.5	101	26.0				
	7.0		- yellowish brown and light gray	■										
	6.0		**SILTY SAND(SM)**, reddish brown and light gray with clay pockets	■	20			2.0		23.0				
40	4.5		**SANDY LEAN CLAY(CL)**, very stiff, ligth gray and yellowish brown	■	21			3.0		13.0				
	2.0		**FAT CLAY(CH)**, very stiff, reddish brown and light gray with sand and slickensided and calcareous nodules - gravel seam	■	22			3.0		20.0				
45	0.0		**SANDY SILT(ML)**, brown and light gray with clay seams	■	23					22.0				90
			FAT CLAY(CH), stiff to very stiff, reddish brown and light gray with trace of gravel	☒	24		18			22.0				
				■	25			3.5	110	22.0				
50	-5.5			■	26			2.5		17.0				
	-6.5		**SILTY SAND(SM)**, medium dense, reddish brown	■										
	-7.5		**FAT CLAY(CH)**, very stiff, reddish brown	■	27			2.5		21.0				
55	-9.5		**SILTY SAND(SM)**, medium dense, reddish brown	■	28			4.0		12.0				
			FAT CLAY(CH), very stiff, reddish brown with slickensided	☒	29		26			30.0				
				■	30			3.25		20.0				
60	-14.0		- reddish brown and light gray											
65														

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 48.17 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13819812.41 E=3165636.16		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/28/11 COMPLETED: 9/28/11	
5. DEPTH OF WATER ⊻ TOD: 30' ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			ELASTIC SILT WITH SAND(MH), stiff to very stiff to hard, reddish brown and dark gray with gravel with brown sand seams	■	1			4.5		10.0				
				☒	2		12			13.0				
5				■	3			4.5	101	15.0	55	33	22	79
				☒	4		11			17.0				
				■	5			3.25		18.0				
10	36.2		- light gray	☒	6		8			21.0				
			FAT CLAY(CH), soft to stiff, reddish brown and dark gray with apparent hydrocarbon odour and sand seams	■	7			1.0		41.0				
15				■	8			0.25	89	29.0	60	40	20	100
	30.2			■	9			0.25		28.0				
			ELASTIC SILT(MH), very soft, dark gray with apparent hydrocarbon odour - gray with sand pockets	■	10			0.25		31.0				
20				■	11			0.25		29.0				
				■	12			0.25	81	33.0	83	54	29	99
25				■	13			0.25	85	33.0				98
				■	14			0.25		39.0				
				■	15			0.25		29.0				
30				■	16			0.25	86	32.0				
				■	17			0.25		29.0				

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 48.17 ft
2. LOCATION (Coordinates or Station) Rosa Allen N=13819812.41 E=3165636.16	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/28/11 COMPLETED: 9/28/11
5. DEPTH OF WATER ⊻ TOD: 30' ft ⊻ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	12.7	▨	**<u>FAT CLAY</u>(CH)**, firm to very stiff, gray with sand pockets and ferrous nodules	■	18			0.25		23.0				
		▨	- light gray and yellowish brown with sand and ferrous nodules	■	19			0.75	93	30.0				
		▨	- trace of calcareous deposits - trace of gravel	■	20			2.25		23.0				
40	8.7	⁘	**<u>SILTY SAND</u>(SM)**, medium dense, light gray and yellowish brown with clay pockets	⊠	21		16			24.0				
	7.2	▧	**<u>SANDY LEAN CLAY</u>(CL)**, very stiff, light gray and yellowish brown with sand, ferrous nodules and trace of gravel											
	5.2	▨	**<u>FAT CLAY</u>(CH)**, very stiff, reddish brown and ligth gray with sand, ferrous nodules and trace of gravel	■	22			2.0		20.0				
45		▨		■	23			2.25		17.0				
		▨		■	24			2.25		22.0				
		▨		■	25			2.25	100	25.0				
50		▨	- reddish brown with sand and trace of gravel	■	26			2.25		27.0				
		▨		■	27			2.0		22.0				
55		▨		■	28			2.75		23.0				
		▨		■	29			3.25		22.0				
		▨		■	30			2.0						
60	-11.8													
65														

Hole No. 11-B33A

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Rosa Allen N=13821618.48 E=3164158.23

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
TOD: NA ft 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
47.17 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
TOD: 24-HR:

10. DRILLING DATE and TIME
STARTED: 12/10/11 COMPLETED: 12/10/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	45.2	▨	**SANDY LEAN CLAY(CL)**, hard, light brown with roots and light gray silty sand at 1.5 feet	■	1			4.5+			7.0				
	42.7	⁙	**SILTY SAND(SM)**, medium dense, light brown and light gray	☒	2		18				6.0				47
5		▨	**FAT CLAY(CH)**, soft to firm to stiff to very stiff, reddish brown with sand pockets and sand seams	☒	3		21				15.0				
		▨		■	4			3.5		117	13.0	63	32	31	99
		▨	- light gray and light brown with ferrous stains	■	5			2.75		97	19.0				
10		▨		■	6			1.5			22.0				
		▨	- with silt and calcareous nodules	■	7			0.75		106	21.0	50	24	26	87
15	30.9	▨	- with sand	■	8			0.25	0.187		27.0				
		▥	**SILT(ML)**, soft to firm, gray, black and reddish brown with sand pockets	■	9			0.25	0.125		26.0				
		▥		■	10			0.75				38	26	12	93
20	25.2	▥		■	11			1.0			12.0				
		▨	**FAT CLAY(CH)**, stiff to very stiff to hard, black and gray with sand - reddish brown and light gray with calcareous nodules and ferrous stains	■	12			2.0		91	30.0				
25		▨		■	13			1.0			32.0				
		▨		■	14			1.0		89	35.0				
		▨	- gray and light brown	■	15			1.5			32.0				
30		▨		■	16			1.5			28.0				
		▨		■	17			2.75			22.0				

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 47.17 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13821618.48 E=3164158.23		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/10/11 COMPLETED: 12/10/11	
5. DEPTH OF WATER ⊻ TOD: NA ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			2.5			23.0				
		▨		■	19			3.25			17.0				
		▨		■	20			3.25			21.0				
40		▨		■	21			3.75			22.0				
		▨		■	22			4.25			24.0				
45	2.2	░	**<u>SILTY SAND</u>(SM)**, dense, light brown and light gray	■	23			1.75			16.0				
	0.2	▧	**<u>SANDY LEAN CLAY</u>(CL)**, stiff to hard, reddish brown and light gray with gravel	☒	24		35				26.0				
		▧		■	25			1.75			23.0				
50		▧	- ferrous stains	■	26			4.5			26.0				
	-4.8	░	**<u>SILTY SAND</u>(SM)**, dense, reddish brown	☒	27		41				21.0				
55	-6.8	▨	**<u>FAT CLAY</u>(CH)**, hard, reddish brown with large sand pockets and calcareous nodules	■	28			4.0			17.0				
	-8.8	▧	**<u>SANDY LEAN CLAY</u>(CL)**, hard, light brown	■	29			4.5+			17.0				
	-10.8	░	**<u>SILTY SAND</u>(SM)**, dense, light brown - reddish brown clay	☒	30		31								
60	-12.8														
65															

Hole No. 11-B36A

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 1 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Rosa Allen N=13821510.70 E=3165560.10

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
TOD: NA ft 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
48.49 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
TOD: 24-HR:

10. DRILLING DATE and TIME
STARTED: 12/12/11 COMPLETED: 12/12/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	46.5	▨	**SANDY LEAN CLAY(CL)**, hard, reddish brown with silt pockets	■	1			4.5+		100	18.0				
		▩	**FAT CLAY(CH)**, hard, reddish brown and dark gray with sand pockets and sand seams	■	2			4.5+		108	18.0				72
5	42.5	▩		■	3			4.5+		103	20.0				
		░	**SILTY SAND(SM)**, loose, light brown and light gray with clay pcokets	■	4						16.0				
10		░		☒	5		11				9.0				40
		░		☒	6		5				18.0				
	34.5	░		☒	7		4				21.0				
15		▨	**LEAN CLAY WITH SAND(CL)**, black with hydrocarbon odour	☒	8		4				25.0	26	18	8	83
	30.5	▨		☒	9		4				30.0				
20		▨	**SANDY LEAN CLAY(CL)**, black with hydrocarbon odour	☒	10		3				35.0				
		▨		☒	11		2				31.0				
	24.5	▨		■	12		3				37.0				
25		▩	**FAT CLAY(CH)**, stiff to very stiff, light brown and gray with ferrous stains	■	13			0.75		79	42.0	89	41	48	100
		▩		■	14			1.0			20.0				
30		▩		■	15			1.25			17.0				
		▩	- reddish brown	■	16			1.25		89	35.0	99	38	61	
		▩	- reddish brown and light gray	■	17			1.25			31.0				

Hole No. 11-B36A

BORING LOG	DISTRICT Galveston	INSTALLATION Rosa Allen	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 48.49 ft	
2. LOCATION (Coordinates or Station) Rosa Allen N=13821510.70 E=3165560.10		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/12/11 COMPLETED: 12/12/11	
5. DEPTH OF WATER ⊻ TOD: NA ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			1.75			32.0				
		▨		■	19			2.25			30.0				
		▨		■	20			3.0			29.0				
40		▨		■	21			2.75			28.0				
		▨		■	22			3.0			24.0				
45		▨		■	23			2.5			22.0				
	1.5	▨	**SANDY LEAN CLAY(CL)**, very stiff, reddish brown and light gray	■	24			2.5			34.0				
	-0.5	░	**SILTY SAND(SM)**, dense to very dense, reddish brown and light gray with sandy clay	■	25			3.0			19.0				
50		░		☒	26		39				19.0				
		░		☒	27		40				18.0				
55		░		☒	28		62				21.0				
		░		☒	29		59				21.0				
60	-11.5	░		☒	30		61				25.0				
65															

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 33.84 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13852198.66 E=3209358.32		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ∇ TOD: 13.84 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/19/12 COMPLETED: 1/19/12	
5. DEPTH OF WATER ∇ TOD: 20.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>FAT CLAY</u>(CH)**, stiff to very stiff, tan and yellowish brown with sand	■	1			1.5		21.0				
		▨		■	2			2.5	111	18.0	53	16	37	
5		▨	- light gray	■	3			3.5		18.0				
	25.8	▨		■	4			2.5	106	21.0				
		▧	**<u>CLAYEY SAND</u>(SC)**, tan and reddish brown with clay pockets	■	5			1.0	118	14.0	25	11	14	32
10		▧		■	6			1.5		14.0				
	19.8	▧		■	7			1.5	118	8.0				
15		⁙	**<u>SILTY SAND</u>(SM)**, very loose to medium dense, gray and dark gray	☒	8		2			19.0				25
	15.8	⁙		☒	9		19			15.0				
		▧	**<u>CLAYEY SAND</u>(SC)**, dark gray with clay pockets	■	10			0.0		17.0				23
20	∇13.8	⁙	**<u>SILTY SAND</u>(SM)**, medium dense, gray and dark gray with clay pockets	☒	11		14			21.0				
	9.8	⁙		☒	12		12			28.0				
25		▧	**<u>SANDY LEAN CLAY</u>(CL)**, very soft to soft, tan and reddish brown with ferrous nodules	■	13			1.0		22.0	46	15	31	50
		▧		■	14			0.5		19.0				
		▧		■	15			0.0	92	28.0				
30		▧	- tan and black	■	16			0.5		58.0				
		▧	- brown and black	■	17			0.0		58.0				

Hole No. 11-B37

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 33.84 ft
2. LOCATION (Coordinates or Station) Lost Lake N=13852198.66 E=3209358.32	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 13.84 ft 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/19/12 COMPLETED: 1/19/12
5. DEPTH OF WATER TOD: 20.0 ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	- brown with roots and hydrocarbon odour	■	18			0.0	61	59.0				
		▨		■	19			0.0		55.0				
		▨	- dark gray	■	20			0.0		38.0				
40	-8.2	▨		☒	21		20			41.0				
		░	**SILTY SAND(SM)**, medium dense to dense, dark gray and light gray with clay pockets	☒	22		31			24.0				
45		░		☒	23		37			24.0				
		░		☒	24		25			32.0				
	-16.2	░		☒	25		24			23.0				
50	-18.2	▨	**SANDY LEAN CLAY(CL)**, brown and reddish brown with sand and hydrocarbon odour	☒	26		23			32.0				
		░	**SILTY SAND(SM)**, medium dense, dark gray and light gray with clay pockets	☒	27		22			27.0				
55	-22.2	░		☒	28		23			20.0				
	-24.2	▧	**CLAYEY SAND(SC)**, medium dense, black with organics and hydrocarbon odour	☒	29		17			41.0				
	-26.2	▨	**SANDY LEAN CLAY(CL)**, brown hydrocarbon odour	☒	30		19			33.0				
60														
65														

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 34.29 ft
2. LOCATION (Coordinates or Station) Lost Lake N=13851630.30 E=3206632.14	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 15.29 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/18/12 COMPLETED: 1/18/12
5. DEPTH OF WATER ▽ TOD: 19.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY WITH SAND(CH)**, stiff to very stiff to hard, tan and yellowish brown with sand seams and pockets	■	1			4.0		20.0				
		▨	- calcareous nodules	■	2			3.0	107	20.0				
5		▨	- tan and brown	■	3			4.5		27.0				
		▨	- ferrous nodules	■	4			3.0	100	25.0				
		▨		■	5			3.0		17.0				
10	22.3	▨	- reddish brown with sand seams and ferrous nodules	■	6			1.5	106	20.0	50	17	33	74
		░	**SILTY SAND(SM)**, medium dense, brown with clay pockets	☒	7		25			7.0				
15		░		☒	8		30			9.0				
	16.3	░	- gray	☒	9		11			13.0				
▽	14.3	▧	**CLAYEY SAND(SC)**, medium dense, gray with clay pockets	☒	10		16			14.0				
20		░	**SILTY SAND(SM)**, loose to medium dense to dense, dark gray and gray with clay pockets	☒	11		8			23.0				33
		░		☒	12		35			21.0				
25		░		☒	13		29			23.0				21
	6.3	░	- hydrocarbon odour	☒	14		7			20.0				
	4.3	▧	**CLAYEY SAND(SC)**, loose, dark gray with clay pockets	☒	15		5			21.0				
30		▨	**FAT CLAY(CH)**, very soft to soft to firm, dark gray with silt and sand pockets	■	16			0.5			67	33	34	97
		▨	- with sand seams and hydrocarbon odour	■	17			0.5	63	65.0				

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 34.29 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13851630.30 E=3206632.14		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 15.29 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/18/12 COMPLETED: 1/18/12	
5. DEPTH OF WATER TOD: 19.0 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.5		56.0				
		▨		■	19			0.5		71.0				
	-5.7	▨		■	20			0.5		36.0				
40		░	**SILTY SAND(SM)**, medium dense, dark gray with clay pockets	■	21			1.0		21.0				
	-9.7	░		☒	22		26			22.0				
45	-11.7	▨	**CLAYEY SAND(SC)**, medium dense, brown and dark gray with organics	☒	23		29			39.0				
		░	**SILTY SAND(SM)**, dense, gray and dark gray with clay pockets	☒	24		34			22.0				
	-15.7	░		☒	25		31			31.0				
50	-17.7	▨	**CLAYEY SAND(SC)**, medium dense, dark gray	☒	26		21			29.0				
		░	**SILTY SAND(SM)**, medium dense, gray and dark gray with clay pockets - gravel	☒	27		20			20.0				
55		░		☒	28		22			18.0				
	-23.7	░		☒	29		22			19.0				
60	-25.7	▨	**SANDY LEAN CLAY(CL)**, gray with sand pockets	☒	30		37			23.0				
65														

Hole No. 11-B38A

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 30.94 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13849572.85 E=3205682.90		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 13.94 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/17/12 COMPLETED: 1/17/12	
5. DEPTH OF WATER ▽ TOD: 17.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			LEAN CLAY WITH SAND(CL), soft to stiff to very hard, tan and brown with gravel	■	1			1.5		31.0				
			- brown and reddish brown with gravel and calcareous nodules	■	2			0.5	101	24.0				
5			- with sand seams and ferrous nodules	■	3			1.0	97	26.0	44	14	30	78
			- yellowish brown with roots, sand seams and ferrous nodules	■	4			4.0		21.0				
			- calcareous nodules	■	5			3.5	107	21.0				
10			- reddish brown	■	6			4.5		18.0				
			- sand seams, gravel, calcareous and ferrous nodules	■	7			4.5	119	11.0				
15			- brown with sand pockets	■	8			1.5	112	17.0				
	▽13.9		- brown and dark gray with sand seams	■	9			0.5		19.0				
			CLAYEY SAND(SC), reddish brown with lot of clay pockets, wood, burnt wood (debris) and with hydrocarbon odour	■	10			0.0		21.0	47	16	31	44
20			- with clay pockets	■	11			0.5		14.0	22	13	9	34
	8.9		**SANDY LEAN CLAY(CL)**, very soft, gray, reddish brown and dark gray with lots of sand pockets and shell	☒	12		5			20.0				
25				■	13			0.5		9.0				
				■	14			0.5	107	16.0	24	16	8	16
			- brown with gravel and shell	☒	15		4			28.0				
30	0.9		**FAT CLAY(CH)**, brown and dark gray with organics	☒	16		3			66.0				
				☒	17		2			64.0				
				☒										

Hole No. 11-B38A

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS

1. PROJECT: HSCDMMP
2. LOCATION (Coordinates or Station): Lost Lake N=13849572.85 E=3205682.90
3. DRILLING AGENCY: Kenall Inc.
4. LABORATORY TESTING AGENCY: Kenall Inc.
5. DEPTH OF WATER: ⊻ TOD: 17.0 ft ⊻ 24-HR:
6. DEPTH OF HOLE: 60 ft
7. ELEVATION OF HOLE: 30.94 ft
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ⊻ TOD: 13.94 ft ⊻ 24-HR:
10. DRILLING DATE and TIME: STARTED: 1/17/12 COMPLETED: 1/17/12
11. CLASSIFICATION REFERENCE:
12. ENGINEER: Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		☒	18		3			67.0				
				☒	19		2			56.0				
40				☒	20		2			57.0				
				☒	21		4			68.0				
				☒	22		2			74.0				
45			- black and brown	■	23			0.0		87.0				
				■	24			0.0		43.0				
50				☒	25		3			61.0				
				☒	26		3			68.0				
	-23.1		- with lots of sand pockets and seams	■	27			0.5		22.0				
55		▨	**SANDY LEAN CLAY(CL)**, soft, tan and reddish brown with sand pockets and calcareous nodules	■	28			3.5		22.0				
				■	29			4.0		27.0				
60	-29.1			■	30			4.0		29.0				
65														

Hole No. 11-B39

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 34.14 ft
2. LOCATION (Coordinates or Station) Lost Lake N=13848269.02 E=3208339.81	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 12.14 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/18/12 COMPLETED: 1/18/12
5. DEPTH OF WATER ▽ TOD: 22.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY WITH SAND(CH)**, firm to very stiff to hard, reddish brown and dark gray with sand pockets	■	1			4.5	113	16.0				
		▨	- calcareous nodules - brown and gray with calcareous nodules	■	2			3.0		7.0				
5		▨		■	3			3.0		12.0				
		▨	- dark gray with many sand pockets	■	4			0.5	69	53.0	97	31	66	76
		▨		■	5			0.5		15.0				
10		▨	- brown, dark gray with sand seams and pockets	■	6			2.5	97	27.0				
		▨	- reddish brown	■	7			1.0	98	28.0				
15		▨	- dark gray	■	8			2.5		16.0				
	16.1	▨	- with shell	■	9			2.0	111	17.0				
		▧	**SANDY LEAN CLAY(CL)**, very soft to soft to firm, tan and gray with sand pockets	■	10			1.0		21.0				59
20		▧	- dark gray with many sand pockets	■	11			0.5	92	18.0	39	16	23	62
	▽	▧		☒	12		2			34.0				
25		▧	- brown, dark gray	☒	13		3			25.0				
	6.1	▧		■	14			0.5		16.0				
	4.1	░	**CLAYEY SAND(SM)**, gray with clay pockets	■	15			0.0		30.0				29
30		▨	**FAT CLAY WITH SAND(CH)**, soft to firm to very stiff, dark gray with sand pockets	■	16			0.5	79	35.0				
		▨	- gray with sand pockets and shell	■	17			1.0		43.0				
		▨	- dark gray, reddish brown and tan with sand	■										

Hole No. 11-B39

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 34.14 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13848269.02 E=3208339.81		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 12.14 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/18/12 COMPLETED: 1/18/12	
5. DEPTH OF WATER ▽ TOD: 22.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	seams and gravel	■	18			0.5		21.0				
		▨	- shell	☒	19		2			37.0				
		▨	- black and dark gray with silt pockets	■	20			1.0		17.0				
40		▨	- dark gray with shell	■	21			2.5		25.0				
		▨	- gray sand											
	-9.9	▨	- dark gray and brown with shell	☒	22		26			41.0				
45		░	**SILTY SAND(SM)**, medium dense to dense, gray with silt and clay pockets	☒	23		22			24.0				64
		░		☒	24		24			26.0				
		░		☒	25		26			24.0				
50		░	- dark gray	☒	26		38			20.0				
		░		☒	27		35			37.0				
55	-21.9	░		☒	28		13			20.0				
	-23.9	▨	**SANDY LEAN CLAY(CL)**, brown and dark gray with shell and gravel	☒	29		7			25.0				
60	-25.9	░	**SILTY SAND(SM)**, medium dense, dark gray with clay pockets	☒	30		30			19.0				
65														

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BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 34.59 ft
2. LOCATION (Coordinates or Station) Lost Lake N=13848114.07 E=3205940.23	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 11.59 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/17/12 COMPLETED: 1/17/12
5. DEPTH OF WATER ▽ TOD: 23.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, stiff to hard, reddish brown and yellowish brown with gravel and shell	■	1			1.0		20.0				
		▨	- with sand seams	■	2			1.0	99	24.0	40	15	25	54
5		▨	- with sand pockets	■	3			1.5		15.0				
		▨	- calcareous nodules	■	4			2.0	107	23.0				
	24.6	▨	- brown with sand pockets	■	5			4.5		16.0				
10		▨	**<u>SANDY FAT CLAY</u>(CH)**, soft, reddish brown and brown with many sand pockets and gravel	■	6			1.0	106	19.0	65	18	47	66
		▨	- brown and gray sand with clay and gravel	■	7			0.5		14.0				
15	18.6	▨		■	8			0.5		28.0				
	16.6	▨	**<u>FAT CLAY WITH SAND</u>(CH)**, soft, reddish brown with sand seams and calcareous nodules	■	9			0.5		30.0	54	20	34	79
	14.6	▨	**<u>SILTY, CLAYEY SAND</u>(SC-SM)**, brown with silt and clay pockets	■	10			0.5		20.0	22	16	6	23
20		▨	**<u>FAT CLAY</u>(CH)**, soft to stiff, reddish brown and gray with sand pockets	■	11			0.5	88	35.0				
▽		▨	- brown with ferrous nodules	■	12			0.5	93	38.0				
25		▨		■	13			0.5		35.0				
		▨	- sand seams, shell and gravel	■	14			1.5	90	35.0				
		▨	- yellowish brown	■	15			1.5		34.0				
30	2.6	▨		■	16			1.5		26.0				
		▨	**<u>LEAN CLAY WITH SAND</u>(CL)**, very soft to soft to stiff, gray and black with sand and organics	■	17			0.0	95	29.0	36	17	19	75
		▨		■										

Hole No. 11-B39A

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 34.59 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13848114.07 E=3205940.23		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 11.59 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/17/12 COMPLETED: 1/17/12	
5. DEPTH OF WATER TOD: 23.0 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.0		26.0				
		▨	- dark gray and brown with sand pockets	■	19			0.5		31.0				
		▨		■	20			1.0	98	29.0				
40		▨	- hydrocarbon odour	■	21			0.5	77	40.0				
		▨		☒	22		3			40.0				
45		▨	- brown and gray with sand	☒	23		3			26.0				
		▨		☒	24		2			48.0				
		▨		☒	25		3			60.0				
50		▨	- dark gray with shell	■	26			0.5		72.0				
		▨	- gray with sand	☒	27		7			76.0				
55		▨		☒	28		5			63.0				
	-23.4	▨	- dark gray with many sand pockets	■	29			1.0		56.0				
60	-25.4	⁘	**SILTY SAND(SM)**, dark gray with many clay pockets	■	30			1.0		43.0				
65														

Hole No. 11-B40

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 34.33 ft	
2. LOCATION (Coordinates or Station) Lost Lake N=13848907.66 E=3212070.13		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 15.33 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/19/12 COMPLETED: 1/19/12	
5. DEPTH OF WATER ▽ TOD: 19.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, hard, brown and gray with sand pockets	■	1			4.5		17.0				
		▨	- reddish brown	■	2			4.5	117	15.0	37	13	24	
5	28.3	▨		■	3			4.0		17.0				
		░	**SILTY SAND(SM)**, loose to medium dense, gray with clay pockets	☒	4		9			15.0				50
10	24.3	░		☒	5		12			23.0				
		▨	**SANDY LEAN CLAY(CL)**, firm to stiff to very stiff, brown, yellowish brown and gray with sand pockets, shell and gravel	■	6			1.0	116	15.0	31	14	17	50
		▨		■	7			1.0		13.0				
15		▨		■	8			1.5	107	22.0				
		▨	- tan and yellowish brown	■	9			3.0		17.0				
▽		▨	- gray	■	10			3.0		19.0				
20		▨		■	11			0.5	83	18.0	41	13	28	50
		▨	- dark gray	■	12			1.0		21.0				
25		▨	- with shell	■	13			1.0	100	21.0				
	6.3	▨	- gray with sand	☒	14		3			28.0				
30		░	**SILTY SAND(SM)**, very loose to loose, gray with clay pockets and shell	☒	15		2			24.0				
	2.3	░		☒	16		7			31.0				
		▩	**FAT CLAY(CH)**, very soft to soft to firm, black and gray with sand pockets	☒	17		2			34.0				
		▩	- dark gray with gravel	■										

BORING LOG	DISTRICT Galveston	INSTALLATION Lost Lake	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 34.33 ft
2. LOCATION (Coordinates or Station) Lost Lake N=13848907.66 E=3212070.13	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: 15.33 ft ⊻ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/19/12 COMPLETED: 1/19/12
5. DEPTH OF WATER ⊻ TOD: 19.0 ft ⊻ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			0.5	61	65.0				
				■	19			1.0		60.0				
				■	20			1.0		59.0				
40	-7.7			■	21			0.0	65	38.0				
			SILTY SAND(SM), dense to very dense, gray with organics	☒	22		53			22.0				
45				☒	23		44			23.0				
				○	24									
50				☒	25		42			28.0				
	-17.7		- gray and black with clay pockets and shell	☒	26		23			28.0				
			SANDY LEAN CLAY(CL), very stiff, gray and black with gravel	☒	27		23			35.0				
55				☒	28		19			35.0				
			- light gray and reddish brown with sand pockets	■	29			4.0		20.0				
60	-25.7		- yellowish brown and gray with some sand	■	30			4.0		17.0				
65														

SWG 1836 BOR LOST LAKE.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/17/12

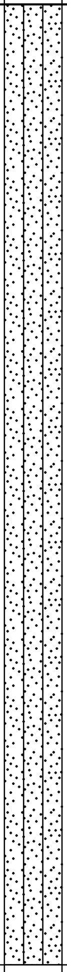
BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +19.10 ft	
2. LOCATION (Coordinates or Station) Peggy Lake N=13837588.30 E=3215723.56		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 8.02 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 10/5/11 COMPLETED: 10/5/11	
5. DEPTH OF WATER ▽ TOD: 11.08 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY WITH SAND(CH)**, firm to stiff to very stiff, dark gray and light gray with sand and gravel	■	1			1.75		18.0				
		▨	- yellowish brown and gray	■	2			2.5	95	29.0				
5		▨		■	3			2.75	95	28.0				
		▨	- reddish brown and light gray	■	4			3.25		22.0				
		▨	- gray and light gray	■	5			0.75	91	28.0	74	19	55	73
10	9.1	▨	- sand seam											
▽		░	**SILTY SAND(SM)**, loose to medium dense, gray with shell	■	6					16.0				
		░		☒	7		11			16.0				
15	4.1	▨	**FAT CLAY(CH)**, very soft to soft to firm to stiff to very stiff, reddish brown and light gray with sand seams	☒	8		8			20.0				66
		▨	- light gray and yellowish brown with sand and gravel	■	9			0.75	77	41.0	111	12	99	88
		▨	- dark gray with sand seams	■	10			1.0		28.0				
20		▨	- yellowish brown and light gray with sand	■	11			0.5	105	20.0				
		▨		■	12			0.625		43.0				
		▨	- gray with sand seams and a trace of organics											
25		▨	- dark gray with debris and trace of organics	■	13			0.687		35.0				
		▨	- gray and brown with sand seams	■	14			0.437			53	14	39	44
		▨	- gray sand with shell	■	15			1.75		14.0				
30		▨	- gray with sand seams	☒	16		5			34.0				
	-12.9	░	**SILTY SAND(SM)**, very loose to loose, gray with clay seams	☒	17		8			23.0				
		░		☒										

Hole No. 11-B41

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +19.10 ft
2. LOCATION (Coordinates or Station) Peggy Lake N=13837588.30 E=3215723.56	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 8.02 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 10/5/11 COMPLETED: 10/5/11
5. DEPTH OF WATER ▽ TOD: 11.08 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala



DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				☒	18		7			25.0				
				☒	19		6			25.0				
				☒	20		3			23.0				
40														
				☒	21		3			22.0				
				☒	22		5			24.0				
45														
				☒	23		3							
				☒	24		3			28.0				
				☒	25		1			23.0				
50														
				☒	26		0			26.0				
				☒	27		2			23.0				
55														
				☒	28		4			23.0				
				☒	29		0							
				☒	30		0			23.0				
60	-40.9													
65														

Hole No. 11-B42

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +18.23 ft	
2. LOCATION (Coordinates or Station) Peggy Lake N=13835312.73 E=3216338.98		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 2.73 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 10/4/11 COMPLETED: 10/5/11	
5. DEPTH OF WATER ⊻ TOD: 15.5 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very stiff to hard, dark gray with sand and gravel	■	1			4.5		10.0				
		▨	- reddish brown and dark gray with sand and gravel and plastic	■	2			4.5	111	10.0				
5		▨	- dark gray and light gray with sand and gravel	■	3			4	90	52.0				
		▨	- dark gray and yellowish brown	■	4			3.75		15.0				
		▨	- dark gray and light gray											
		▨	- dark gray and yellowish brown	■	5			2		23.0				
10	8.2													
		⁘	**SILTY SAND(SM)**, very loose to medium dense to dense, yellowish brown and light gray with shell	■	6					9.0				
		⁘		☒	7		16			6.0				
15 ⊻		⁘	- gray with clay pockets	☒	8		35			12.0				
		⁘		☒	9		16			16.0				69
20		⁘		☒	10		22			17.0				
	-3.8	⁘		☒	11		2			24.0				
		▨	**FAT CLAY(CH)**, very soft to stiff, dark gray with apparent hydrocarbon odour	☒	12		3			85.0				
25		▨		■	13			0.125			116	35	81	99
		▨		■	14			0.125	50	87.0				
		▨	- gray	■	15			0.125		71.0				
30		▨	- light gray and yellowish brown with sand and a trace of gravel	■	16			1.75	93	27.0	86	24	62	94
		▨		■	17			1.75		31.0				

Hole No. 11-B42

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +18.23 ft
2. LOCATION (Coordinates or Station) Peggy Lake N=13835312.73 E=3216338.98	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: 2.73 ft ⧗ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 10/4/11 COMPLETED: 10/5/11
5. DEPTH OF WATER ⊻ TOD: 15.5 ft ⧗ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			1.5		34.0				
		▨		■	19			1.25	96	25.0				
		▨		■	20			1.0		30.0				
40	-22.8	▨	**LEAN CLAY(CL)**, firm to stiff, light gray with sand	■	21			1.0		16.0				
		▨	- light gray and yellowish brown with sand and ferrous nodules	■	22			0.5		19.0				
45		▨		■	23			1.75	113	15.0	26	16	10	92
	-29.8	▨		■	24			2.0		17.0				
		▨	**FAT CLAY(CH)**, very stiff to hard, light gray and yellowish brown with sand	■	25			4.0		32.0				
50		▨		■	26			3.0						
		▨		■	27			4.25		15.0				
55		▨	- with sand, gravel and calcareous deposits	■	28			4.5		18.0				
		▨	- gravel and calcareous nodules	■	29			2.75		19.0				
	-41.8	▨		■	30			3.5		22.0				
60														
65														

SWG 1836 BOR PEGGY LAKE.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/13/12

Hole No. 11-B43

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +19.19 ft	
2. LOCATION (Coordinates or Station) Peggy Lake N=13833820.72 E=3218736.79		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ∇ TOD: 6.19 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 10/7/11 COMPLETED: 10/7/11	
5. DEPTH OF WATER ∇ TOD: 13.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), loose, light gray and brown with shell and clay pockets - yellowish and light gray clay with sand upto 1'	■	1			0.75		8.0				
				■	2					8.0				
5				☒	3		7			18.0				79
	11.2		- light gray with dark gray clay pockets and trace of tree roots	☒	4		6			18.0				
10	9.2		**CLAYEY SAND(SC)**, reddish brown and gray with brown and dark gray sand seams and shell	■	5			1.0	116	8.0	59	11	48	45
			SILTY SAND(SM), loose, light gray and brown with sand pockets	■	6					13.0				
∇			- gray - brown	☒	7		9			19.0				
15	4.2		- gray and dark gray	☒	8		7			35.0				
			FAT CLAY(CH), firm to stiff, yellowish brown, reddish brown and gray with sand and gravel	■	9			1.5	94	29.0				
20				■	10			1.25		21.0				
				■	11			0.75			68	20	48	88
				■	12			0.75		29.0				
25				■	13			1.0	96	30.0				
	-8.8		- dark gray with sand and ferrous nodules - dark gray and yellowish brown with sand	■	14			1.75		24.0				
30			**SILTY SAND(SM)**, very loose, light gray with shell and reddish brown clay pockets - gray	■	15					19.0				
	-12.3			☒	16		2			51.0				
	-14.3		**FAT CLAY(CH)**, very soft, dark gray - gray with trace of organics	■	17			0.187		19.0				
	-15.8		**CLAYEY SAND(SC)**, light gray	■										

Hole No. 11-B43

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Peggy Lake N=13833820.72 E=3218736.79

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
⊻ TOD: 13.0 ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+19.19 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
⊻ TOD: 6.19 ft ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 10/7/11 COMPLETED: 10/7/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, stiff to very stiff to hard, light gray and reddish brown with sand and slickensided	■	18			2.25		28.0				
		▨	- light gray and yellowish brown with sand seams	■	19			2.25	93	29.0	63	23	40	95
		▨	- with sand and gravel	■	20			1.25		24.0				
40		▨	- yellowish brown and light gray with vertical sand seams	■										
		▨		■	21			2.25		14.0				
		▨		■	22			2.25	116	15.0				
45		▨	- with ferrous nodules and sand seams	■	23			4.0		17.0				
		▨		■	24			2.5		13.0				
		▨	- sand pockets	■	25			4.5		19.0				
50		▨		■										
		▨		■	26			3.25						
	-34.3	▨		■	27			2.75		22.0				
		▥	**SILTY CLAY(CL-ML)**, very stiff, reddish brown and light gray with clay pockets	□										
55	-36.3	▥		☒	28		32			22.0				
		▨	**FAT CLAY(CH)**, very stiff to hard, reddish brown and light gray with gravel and slickensided - with sand and slickensided	■	29			4.5	102	22.0				
	-40.8	▨	- with rock and slickensided	■	30			3.75		24.0				
60														
65														

SWG 1836 BOR PEGGY LAKE.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/13/12

ENG FORM: SWG 1836 BOR

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +19.08 ft	
2. LOCATION (Coordinates or Station) Peggy Lake N=13835661.76 E=3218848.69		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 1.08 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 10/11/11 COMPLETED: 10/11/11	
5. DEPTH OF WATER ▽ TOD: 18.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY(CH), firm to stiff to very stiff to hard, dark gray with sand and gravel	■	1			4.5	120	13.0				
			- yellowish brown, gray	■	2			2.75		32.0				
5				■	3			1.5	102	23.0				
				■	4			1.5	107	20.0	72	22	50	96
	10.1		- gray with vertical sand seams	■	5			0.75		20.0				
10			**SILTY SAND(SM)**, medium dense to very dense, light gray											
			- with sand pockets	☒	6		24			9.0				
			- with reddish brown clay seams	☒	7		80			18.0				
15				■	8					14.0				
	▽ 1.1		- light gray and dark gray	☒	9		16			19.0				
	-0.4		**LEAN CLAY WITH SAND(CL)**, stiff, dark brown with trace of roots	■	10			1.0	108	12.0	42	17	25	83
20			**SILTY SAND(SM)**, loose to medium dense, light gray with shell											
	-3.9			☒	11		14			24.0				
			FAT CLAY(CH), very soft, dark gray with yellowish brown clay pockets	☒	12		4			65.0				97
25	-6.4			■	13			0.25	66	55.0				
	-7.9		**CLAYEY SAND(SC)**, very loose, dark gray											
	-9.9		**FAT CLAY(CH)**, dark gray	☒	14		3			25.0				
	-10.9		**CLAYEY SAND(SC)**, dark gray	☒	15					45.0				
30	-13.9		**SILTY SAND(SM)**, loose to medium dense, light gray	☒	16		18			23.0				
			FAT CLAY(CH), very soft, dark gray with sand seams	☒	17		7			27.0				
				■										

Hole No. 11-B44

BORING LOG	DISTRICT Galveston	INSTALLATION Peggy Lake	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Peggy Lake N=13835661.76 E=3218848.69

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
TOD: 18.0 ft
24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+19.08 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
TOD: 1.08 ft
24-HR:

10. DRILLING DATE and TIME
STARTED: 10/11/11 COMPLETED: 10/11/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-16.9	▨		■	18			0.25	79	37.0				
		▨	**SANDY SILTY CLAY(CL-ML)**, very soft, gray	☒	19					33.0	32	18	14	49
40		▨		☒	20		0			26.0				
		▨		☒	21		0			32.0				
		▨		☒	22		0			30.0				
45		▨		☒	23		4			36.0				
		▨		■	24			0.125		26.0				
50		▨		☒	25					47.0				
		▨		☒	26		4			21.0				
	-34.9	▨		☒	27		2			24.0				
55		░	**SILTY SAND(SM)**, very loose to loose, gray	☒	28		5			24.0				
		░		☒	29		3			26.0				
		░		☒	30		6			26.0				
60	-40.9													
65														

Hole No. 11-B45

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +28.73 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13832862.32 E=3226633.57		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 14.07 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/9/11 COMPLETED: 11/9/11	
5. DEPTH OF WATER ▽ TOD: 14.66 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), loose to medium dense, gray and tan	☒	1		16			13.0				
	24.7			☒	2		5			18.0				
5			**LEAN CLAY WITH SAND(CL)**, soft, light gray and yellowish brown with sand seams and organics	■	3					22.0				84
				■	4			0.5		14.0				
			- sand pockets	■	5			0.375	110	17.0	31	17	14	73
10				■	6			0.312	104	19.0				
				■	7			0.312		17.0				
15	▽13.7		**FAT CLAY(CH)**, soft, reddish brown and light gray with light gray sand seams and shells	■	8			0.375		19.0				
				■	9			0.375	100	29.0	56	22	34	
	8.7			■	10			0.375		27.0				
20	6.7		**SILTY SAND(SM)**, medium dense, gray and dark gray with clay pockets, organics and hydrocarbon odour	☒	11		26			19.0				
			FAT CLAY(CH), very soft to soft, dark gray with sand seams, trace of organics and apparent hydrocarbon odour	☒	12		4			34.0				
25				■	13			0.375	61	69.0				
				■	14			0.375		54.0	126	41	85	69
				■	15			0.375		63.0				
30				■	16			0.5	77	44.0				
	-4.8			■	17			0.315	81	40.0				
			SILTY SAND(SM), medium dense to very dense, light gray with dark gray clay seams	☒										

SWG 1836 BOR ALEXANDER.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/9/12

Hole No. 11-B45

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +28.73 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13832862.32 E=3226633.57		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 14.07 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/9/11 COMPLETED: 11/9/11	
5. DEPTH OF WATER ▽ TOD: 14.66 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				☒	18		14			37.0				
			- light gray with clay pockets	☒	19		77			17.0				22
				☒	20		18			21.0				
40	-12.3													
			FAT CLAY(CH), very soft, dark gray with organics and sand seams	☒	21		10			50.0				
				■	22			0.187		36.0				
45	-17.3			■	23			0.315		38.0				
			CLAYEY SAND(SC), very loose to loose, gray with clay pockets	☒	24					26.0				
50				☒	25		4			19.0				
				☒	26		2			22.0				
				☒	27		4			21.0				
55				☒	28		4			27.0				
				☒	29		9			24.0				
60	-31.3			☒	30		4			24.0				
65														

SWG 1836 BOR ALEXANDER.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/9/12

Hole No. 11-B46

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +24.24 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13831380.02 E=3224944.38		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 12.84 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/8/11 COMPLETED: 11/8/11	
5. DEPTH OF WATER ▽ TOD: 11.4 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		⁙	**SILTY SAND(SM)**, loose to medium dense, light gray with shell and gravel	☒	1		23			15.0				
		⁙		☒	2		20			9.0				18
5	19.2	▨	**LEAN CLAY(CL)**, very soft to stiff, light gray and yellowish brown with sand seams and trace of organics	☒	3		6			22.0				
		▨	- redddish brown and light gray with gravel	■	4			0.315		22.0				
		▨		■	5			1.5	111	17.0	46	16	30	73
10	▽	▨	- yellowish brown and gray with sand pockets and ferrous nodules	■	6			0.375		18.0				
		▨		■	7			0.315	111	17.0				
15	9.2	⁙	**SILTY SAND(SM)**, loose, light gray with shell and clay pockets	■	8			0.55		17.0				
		⁙		■	9					20.0				65
		⁙		☒	10		4			21.0				
20	3.2	▥	**ELASTIC SILT(MH)**, very soft, dark gray with sand pockets and ferrous nodules	☒	11		4			49.0				
		▥		■	12			0.315	76	46.0	79	44	35	
25		▥		■	13			0.315		51.0				
		▥	- dark gray with shell	■	14			0.25		51.0				
		▥	- dark gray with apparent hydrocarbon odour	■	15			0.125			95	42	53	98
30		▥		■	16			0.125		43.0				
		▥		■	17			0.125	71	48.0				

Hole No. 11-B46

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +24.24 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13831380.02 E=3224944.38		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 12.84 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/8/11 COMPLETED: 11/8/11	
5. DEPTH OF WATER TOD: 11.4 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▥		■	18			0.187		61.0				
		▥		☒	19			0.25		54.0				
40	-15.8	▥	- gray with sand seams	■	20			0.437		67.0				
	-17.8	░	**SILTY SAND(SM)**, medium dense, light gray	☒	21		18			28.0				
		▨	**SANDY LEAN CLAY(CL)**, very soft, gray with sand seams and apparent hydrocarbon odour	☒	22		6		97	35.0				
45		▨		■	23					32.0				
		▨		☒	24		5			42.0				
50		▨		■	25			0.375		46.0				
	-27.8	▨		■	26			0.375		34.0				
		▧	**FAT CLAY(CH)**, firm, gray with light gray sand seams	■	27			1		36.0				
55		▧		☒	28		6			32.0				
		▧		☒	29		2							
60	-35.8	▧	- with shell	☒	30		2			34.0				
65														

Hole No. 11-B47

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +24.5 ft
2. LOCATION (Coordinates or Station) Alexander Island N=13826950.56 E=3226155.67	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 14.34 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 11/7/11 COMPLETED: 11/7/11
5. DEPTH OF WATER ▽ TOD: 10.16 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), light gray with shell - brown sandy clay		1			4.5		6.0				
	20.5				2					5.0				
5			**LEAN CLAY(CL)**, very soft to stiff to very stiff, light gray and yellowish brown with sand and ferrous nodules		3			2.5	112	20.0	49	24	25	
			- brown sand seams		4			0.56		23.0				
			- reddish brown with gravel		5			1.5	99	32.0				
10 ▽					6			1.5	99	28.0				
					7			0.5	111	18.0	46	21	25	78
15	8.5		- reddish brown and light gray with brown sand seams and shells		8			0.187		22.0				
			SILTY CLAY(CL-ML), very soft, gray with apparaent hydrocarbon odour		9					28.0				84
	5.0		- sand		10			0.25		58.0				
20			**ELASTIC SILT(MH)**, very soft, dark gray		11			0.25	66	48.0				
					12			0.25		23.0				
25					13			0.25			107	54	53	100
	-3.5		- light gray sand seams		14			0.25		31.0				
			FAT CLAY(CH), stiff to very stiff, reddish brown and light gray with brown and light gray sand seams		15			2.5		14.0				
30					16			1.75	107	18.0				
	-9.5				17			1.25		21.0				
			SILTY SAND(SM), gray with clay pockets											

ENG FORM: SWG 1836 BOR

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +24.5 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13826950.56 E=3226155.67		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 14.34 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/7/11 COMPLETED: 11/7/11	
5. DEPTH OF WATER ⊻ TOD: 10.16 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░	and shell	■	18					22.0				32
	-13.5	░		☒	19		9			16.0				
40		▨	**CLAYEY SAND(SC)**, very loose to loose, gray with clay pockets and shell	☒	20		5			22.0				
		▨		☒	21		3			18.0				
		▨		☒	22		5			18.0				
45		▨		☒	23		5			17.0				
		▨		☒	24					19.0				
50		▨		☒	25		6			20.0				
		▨		☒	26		3			16.0				
		▨		☒	27		1			20.0				
55		▨		☒	28		2							
		▨		☒	29		4			26.0				
60	-35.5	▨		☒	30		2			23.0				
65														

Hole No. 11-B48

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +29.92 ft	
2. LOCATION (Coordinates or Station) Alexander Island N=13830591.44 E=3229758.91		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 16.76 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/9/11 COMPLETED: 11/9/11	
5. DEPTH OF WATER ⊻ TOD: 13.16 ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			<u>SILTY SAND</u>(SM), loose to medium dense, tan and light gray	☒	1		27			13.0				
				☒	2		15			12.0				33
5	24.9		**<u>FAT CLAY</u>(CH)**, firm, yellowish brown and light gray with sand	☒	3		7			38.0				
	21.9		- gray sand seams below 7.5'	■	4			0.75		20.0				
			<u>SILTY SAND</u>(SM), gray	■	5					12.0				
10	19.9		**<u>SANDY LEAN CLAY</u>(CL)**, very soft, yellowish brown, bottom sand	■	6			0.437	109	18.0	39	16	23	73
⊻				■	7			0.375		18.0				
15				■	8					22.0				
	13.4		**<u>SILTY SAND</u>(SM)**, loose to medium dense, light gray with shell, clay pockets and hydrocarbon odour	☒	9		10			38.0				
				☒	10		14			27.0				71
20	8.4		**<u>FAT CLAY</u>(CH)**, very soft to soft to firm, light gray with light gray sand seams	☒	11		4			23.0				
				■	12			0.5	97	18.0				
25				■	13			0.375		24.0				
				■	14			0.5		25.0				
				■	15			0.375	84	28.0				
30			- dark gray with light gray sand seams	☒	16		3			45.0				
				■	17			1	78	37.0	112	42	70	99

SWG 1836 BOR ALEXANDER.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/9/12

Hole No. 11-B48

BORING LOG	DISTRICT Galveston	INSTALLATION Alexander	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Alexander Island N=13830591.44 E=3229758.91

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
⊻ TOD: 13.16 ft ⊻ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
+29.92 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
⊻ TOD: 16.76 ft ⊻ 24-HR:

10. DRILLING DATE and TIME
STARTED: 11/9/11 COMPLETED: 11/9/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.5		51.0				
		▨	- light gray sand	■	19			0.25		55.0				
		▨		☒	20		2			57.0				
40		▨	- dark gray with organics and sand seams	■	21			0.25	91	29.0				
	-14.1	▨		■	22			0.25		33.0				
45		▒	**<u>SILTY SAND</u>(SM)**, medium dense, light gray with sand pockets and apparent hydrocarbon odour	☒	23		24			35.0				
	-18.1	▒		☒	24		19			25.0				
50		▨	**<u>CLAYEY SAND</u>(SC)**, very loose to loose to medium dense, light gray with clay pockets and apparent hydrocarbon odour	☒	25		2			20.0				
		▨		☒	26		10			22.0				
		▨		☒	27		14			24.0				
55		▨		☒	28		3			21.0				
		▨		☒	29		4			25.0				
		▨		☒	30		4							
60	-30.1													
65														

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +33.7 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13823353.81 E=3233248.72		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 3.54 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/29/11 COMPLETED: 9/30/11	
5. DEPTH OF WATER ▽ TOD: 30.16 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY WITH SAND(CH)**, very soft to firm to very stiff, reddish brown and light gray with brown sand deposits	■	1			0.75		18.0				
		▨		■	2			3.75	110	13.0				
5		▨		■	3			0.25	104	23.0	60	28	32	77
		▨		■	4			0.25		20.0				
	24.7	▨	- with shell	■	5			0.25		16.0				
10		░	**SILTY SAND(SM)**, loose, light gray with shell											
	22.7	▨	**FAT CLAY(CH)**, very soft to soft to firm to stiff to very stiff, yellowish brown and light gray with sand seams	☒	6		8			19.0				
		▨		■	7			2.5	111	17.0				
15		▨	- with trace of gravel	■	8			0.75		24.0				
		▨		■	9			0.25	75	45.0	85	37	48	
		▨		■	10			0.75		21.0				
20		▨		■	11			0.75		24.0	50	20	30	94
		▨		■	12			0.5		22.0				
25		▨	- dark gray	■	13			1.75	71	39.0				
	5.7	▨	- gray with sand seams	■	14			0.25		13.0				
		░	**SILTY SAND(SM)**, loose to medium dense, gray with shell	■	15					15.0				
30 ▽		░		☒	16		9			33.0				23
		░		☒	17		20			35.0				
		░		☒										

Hole No. 11-B49

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +33.7 ft
2. LOCATION (Coordinates or Station) Spillman Island N=13823353.81 E=3233248.72	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 3.54 ft 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 9/29/11 COMPLETED: 9/30/11
5. DEPTH OF WATER TOD: 30.16 ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			- light and yellowish brown clay at 35'-35.5'	☒	18		13			22.0				
				☒	19		15			49.0				
	-5.8			☒	20		12			58.0				
40			**FAT CLAY(CH)**, very soft, gray and dark gray with sand pockets	■	21			0.25		47.0				
	-7.8		**SILTY SAND(SM)**, very loose to loose to medium dense, gray with shell	☒	22		4			25.0				
45				☒	23		8			23.0				24
				☒	24		3			25.0				
50				☒	25		15			22.0				
				☒	26		4							
				☒	27		5			21.0				
55				☒	28		3							
				☒	29		14			20.0				
60	-26.3			☒	30		18			21.0				
65														

Hole No. 11-B50

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +33.6 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13819835.66 E=3231476.32		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 17.6 ft ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 9/29/11 COMPLETED: 9/29/11	
5. DEPTH OF WATER ⊻ TOD: 16.0 ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, firm to stiff to very stiff, reddish brown and light gray with sand and gravel	■	1			2.25	105	23.0				
		▨	- yellowish brown with brown sand seams	■	2			1		15.0				
5	28.6	▨	- reddish brown and dark gray with brown sand seams - with sand and shell	■	3			0.75		7.0				
		⁘	**SILTY SAND(SM)**, medium dense, light gray with shell	☒	4		23			5.0				
		⁘		☒	5		22			4.0				52
10		⁘												
	21.6	⁘		☒	6		14			8.0				
		▨	**FAT CLAY(CH)**, very soft to soft, light gray and yellowish brown with sand - sand seams	■	7			0.5	104	22.0	52	22	30	82
15		▨		■	8			0.5		26.0				
⊻		▨	- light gray sand with shell at 15'-16'											
		▨		■	9			0.25		24.0				
		▨	- brown sand seams	■	10			0.25	99	27.0				
20		▨												
		▨		■	11			0.25		23.0				
		▨	- with trace of gravel and organics											
		▨		■	12			0.5	101	23.0				
		▨	- with shell											
25		▨	- yellowish brown and dark gray with shell	■	13			0.5		31.0				
		▨	- with trace of gravel and ferrous nodules											
		▨		■	14			0.5	107	20.0				
		▨		■	15			0.5		21.0				
30		▨	- sand seam											
		▨		■	16			0.25		19.0				
		▨	- dark gray with apparent hydrocarbon odour	■	17			0.25			109	35	74	99
		▨		■										

Hole No. 11-B50

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP
2. LOCATION (Coordinates or Station) Spillman Island N=13819835.66 E=3231476.32
3. DRILLING AGENCY Kenall Inc.
4. LABORATORY TESTING AGENCY Kenall Inc.
5. DEPTH OF WATER ⊻ TOD: 16.0 ft ⊻ 24-HR:
6. DEPTH OF HOLE 60 ft
7. ELEVATION OF HOLE +33.6 ft
8. DATUM FOR ELEVATION
9. ELEVATION OF GROUNDWATER ⊻ TOD: 17.6 ft ⊻ 24-HR:
10. DRILLING DATE and TIME STARTED: 9/29/11 COMPLETED: 9/29/11
11. CLASSIFICATION REFERENCE
12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			0.25		41.0				
	-3.4		**SILTY SAND(SM)**, very loose to medium dense, light gray	■	19			0.25		55.0				
40				☒	20		21			19.0				
	-8.4		- dark gray clayey sand with apparent hydrocarbon odour	☒	21		2			54.0				
			SANDY LEAN CLAY(CL), dark gray	☒	22		2			64.0				
45			(Marsh material)	☒	23		0		57	80.0	38	18	20	86
				☒	24		0			36.0				
50			- gray	☒	25		2			28.0				
	-17.4		**FAT CLAY(CH)**, very stiff, light gray and yellowish brown with sand and slickensided	☒	26		7			32.0				
			- reddish brown and light gray with ferrous nodules and a trace of gravel	■	27			2.0		28.0				
55			- slickensided	■	28			2.75		32.0				
				■	29			3.0						
	-26.4		- 1/4 inch sand seam	■	30			2.25		32.0				
60														
65														

Hole No. 11-B51

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +33.91 ft
2. LOCATION (Coordinates or Station) Spillman Island N=13819226.09 E=3235903.79	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: 12.66 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 10/3/11 COMPLETED: 10/3/11
5. DEPTH OF WATER ⊻ TOD: 21.25 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very soft to soft to firm to very stiff, yellowish brown and light gray with sand and trace of gravel	■	1			4	111	14.0				
		▨		■	2			3.75		17.0				
5		▨	- dark gray with sand seams	■	3			0.25	83	29.0	72	30	42	97
		▨	- yellowish brown and light gray with sand and trace of gravel	■	4			0.75	97	27.0				
		▨		■	5			0.5		28.0				
10		▨												
		▨		■	6			0.5	99	24.0				
		▨	- light gray sand seams	■	7			1.25		24.0				
15		▨	- yellowish brown and light gray with sand and ferrous nodules	■	8			0.5	99	24.0				
		▨		■	9			0.5		28.0				
		▨		■	10			0.5	99	25.0	67	26	41	90
20		▨												
⊻		▨		■	11			0.25		25.0				
		▨	- dark gray	■	12			0.25			68	22	46	88
25		▨		☒	13		0			56.0				
		▨	- dark gray with brown sand seams	■	14			0.25	88	31.0				
		▨	- dark gray with sand	☒	15		0			43.0				
30		▨												
		▨		☒	16		3			53.0				
		▨		☒	17		2			59.0				
		▨		☒										

Hole No. 11-B51

BORING LOG

DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS	
1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +33.91 ft		
2. LOCATION (Coordinates or Station) Spillman Island N=13819226.09 E=3235903.79	8. DATUM FOR ELEVATION		
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: 12.66 ft ⊻ 24-HR:		
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 10/3/11 COMPLETED: 10/3/11		
5. DEPTH OF WATER ⊻ TOD: 21.25 ft ⊻ 24-HR:	11. CLASSIFICATION REFERENCE		
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala		

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		☒	18		3			54.0				
		▨		☒	19		3			56.0				
40	-7.1	▨		☒	20		5			64.0	110	37	73	100
		░	**<u>SILTY SAND</u>(SM)**, very loose to loose to medium dense, gray	☒	21		16			36.0				
		░		☒	22		4			30.0				
45		░	- with shell	☒	23		2			29.0				
		░		☒	24		2			25.0				
50	-17.1	░		☒	25		0			25.0				
		▨	**<u>FAT CLAY</u>(CH)**, very stiff, yellowish brown and light gray with sand and gravel	☒	26		10			28.0				84
		▨	- reddish brown and light gray with sand seams and calcareous nodules	■	27			3.75		16.0				
55		▨		■	28			3.5		13.0				
		▨		■	29			2.75	102	24.0				
60	-26.1	▨	- light gray with sand pockets	■	30			3.25		21.0				
65														

Hole No. 11-B52

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +34.25 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13819143.97 E=3240849.66		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ∇ TOD: 12.25 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/9/11 COMPLETED: 11/9/11	
5. DEPTH OF WATER ∇ TOD: 22.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY FAT CLAY(CH)**, stiff to hard, reddish brown and light gray with brown sand seams and shell	■	1			1.75		5.0				
		▨		■	2			4.5	116	10.0	50	14	36	61
5	29.3	░	**SILTY SAND(SM)**, loose to medium dense, light gray with shell and clay seams	■	3			4.5		13.0				
		░		■	4					8.0				52
		░		☒	5		24			9.0				
10		░	- gray with shell											
		░	- dark gray with shell	☒	6		8			30.0				
	21.3	▨	**FAT CLAY(CH)**, firm to stiff, yellowish brown and light gray with shell	☒	7		7			27.0				
15		▨		■	8			1.5	108	20.0	62	18	44	81
		▨	- with sand and gravel	■	9			0.5		20.0				
		▨		■	10			0.5	94	30.0				
20		▨		■	11			0.5		18.0				
	∇12.3	░	**SILTY SAND(SM)**, gray	■	12					21.0				
25	10.3	▨	**FAT CLAY(CH)**, soft, yellowish brown and light gray with sand	■	13			0.25	96	28.0				
		▨		■	14			0.5	96	27.0	50	16	34	85
		▨		☒	15		0			38.0				
30	4.3	░	**SILTY SAND(SM)**, loose to medium dense, gray	☒	16		8			25.0				
		░		☒	17		15			25.0				
	0.8	▨	**FAT CLAY(CH)**, dark gray											
	-0.8			☒										

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +34.25 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13819143.97 E=3240849.66		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 12.25 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/9/11 COMPLETED: 11/9/11	
5. DEPTH OF WATER TOD: 22.0 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░	**SILTY SAND(SM)**, very loose to loose to medium dense, gray	☒	18		9			37.0				
		░	- dark gray clay at 37'-38'	☒	19		9			42.0				
		░		☒	20		10			26.0				
40		░												
		░		☒	21		20			28.0				
		░		☒	22		3			31.0				
45		░		☒	23		7			30.0				
		░		☒	24		3			25.0				
		░		☒	25		0			30.0				
50	-16.8	░												
		▨	**FAT CLAY(CH)**, stiff to very stiff, light gray and yellowish brown with sand, gravel and ferrous nodules	☒	26		8			30.0				
		▨		■	27			1	90	33.0				
55		▨		■	28			1.75		33.0				
		▨	- sand pockets	■	29			2.75		28.0				
		▨		■	30			2.25		24.0				
60	-25.8													
65														

SWG 1836 BOR SPILLMAN.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/10/12

Hole No. 11-B49A

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +33.14 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13822714.72 E=3231635.39		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 17.14 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/14/11 COMPLETED: 12/14/11	
5. DEPTH OF WATER ▽ TOD: 16.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, soft to stiff, reddish brown with calcareous nodules	■	1			2.0		112	18.0				
	29.1	▨	- with large sand pockets	■	2			0.5			23.0				
5	28.1	▥	**SILTY CLAY(CL-ML)**, stiff, reddish brown with calcareous nodules	■	3			1.75			28.0				
		▧	**FAT CLAY(CH)**, soft to firm to stiff, light brown, light gray and reddish brown with calcareous nodules	■	4			0.75		102	23.0	59	20	39	92
		▧	- ferrous stains	■	5			1.25			24.0				
10		▧		■	6			0.75		100	24.0				
		▧		■	7			1.25			23.0				
15		▧		■	8			0.5			22.0				
▽		▧		■	9			0.25	0.125		24.0				
		▧	- with sand seams	■	10			0.5			24.0				
20		▧		■	11			0.25	0.187		31.0	66	27	39	86
		▧		■	12			0.5			33.0				
25		▧		■	13			0.75		98	29.0	52	22	30	84
		▧		■	14			0.5			28.0				
		▧		■	15			0.5		97	28.0				
30		▧		■	16			0.75			26.0				
		▧		■	17			0.75			22.0				

SWG 1836 BOR SPILLMAN.GPJ TOLUNAY-WONG ENGINEERS.GDT 3/6/12

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +33.14 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13822714.72 E=3231635.39		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 17.14 ft ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/14/11 COMPLETED: 12/14/11	
5. DEPTH OF WATER ⊻ TOD: 16.0 ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-2.9			■	18			0.75		97	25.0				
			SANDY LEAN CLAY(CL), soft, black, light gray and light brown with sand seams and with hydrocarbon odour	■	19			0.5			49.0				
	-6.9		- 4 inch silty sand with shell	■	20			0.25	0.25		29.0				
40			**FAT CLAY(CH)**, dark gray with hydrocarbon odour	☒	21		8				50.0				
	-9.9			■	22			0.5			24.0				
45			**SILTY SAND(SM)**, loose, dark gray with shell and hydrocarbon odour	☒	23		5				25.0				
	-15.4		- with clay seams	☒	24		5				20.0				
50			**SANDY LEAN CLAY(CL)**, soft, dark gray with sand seams	☒	25		7				29.0				
				■	26			0.5			20.0				
			- with sand pockets and shell	☒	27		6				32.0				
55				☒	28		8				31.0				
				☒	29		6				29.0				
60	-26.9			☒	30		14				34.0				
65															

Hole No. 11-B50A

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +33.54 ft	
2. LOCATION (Coordinates or Station) Spillman Island N=13817396.43 E=3232808.41		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 8.54 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/14/11 COMPLETED: 12/14/11	
5. DEPTH OF WATER ⊻ TOD: 25.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	31.5	▨	**SANDY LEAN CLAY(CL)**, stiff, light brown and light gray with sand seams	■	1			2.0		98	24.0				
		▨	**FAT CLAY(CH)**, soft to firm to stiff to very stiff, light brown and light gray with sand and ferrous nodules and large rocks	■	2			1.75		94	29.0	60	23	37	92
5		▨	- reddish brown with calcareous nodules	■	3			2.25			26.0				
		▨	- with sand pockets	■	4			1.75		100	25.0	58	27	31	91
		▨		■	5			0.5		104	18.0				
10		▨	- light gray silty sand												
		▨	- dark gray	☒	6		7				31.0				
		▨		■	7			1.25			35.0				
15		▨	- with ferrous stains and sand pockets	■	8			1.75		104	21.0				
		▨		■	9			0.5			26.0				
		▨		■	10			1.5			30.0	68	27	41	96
20		▨		■	11			0.75			29.0				
		▨		■	12			1.25			27.0				
25 ⊻		▨	- reddish brown and dark gray with sand and shell seam	■	13			1.5			17.0				
		▨	- with calcareous nodules	■	14			1.25			26.0				
		▨		■	15			0.75			25.0				
30		▨	- reddish brown with sand pockets and calcareous nodules	■	16			0.5			23.0				
		▨		■	17			0.75			24.0				

Hole No. 11-B50A

BORING LOG	DISTRICT Galveston	INSTALLATION Spillman Island	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +33.54 ft
2. LOCATION (Coordinates or Station) Spillman Island N=13817396.43 E=3232808.41	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 8.54 ft 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 12/14/11 COMPLETED: 12/14/11
5. DEPTH OF WATER TOD: 25.0 ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			0.75			27.0				
				■	19			0.5			27.0				
			- black with calcareous nodules and ferrous stains	■	20			0.25	0.125		40.0				
40	-8.5		- black with sand seams	■	21			0.5			40.0				
			SANDY LEAN CLAY(CL), stiff to very stiff to hard, light brown and light gray with calcareous nodules and ferrous stains	■	22			2.0			17.0				
45				■	23			4.25			13.0				
			- reddish brown	■	24			2.0			17.0				
				■	25			1.75			14.0				
50			- silty sand	☒	26		49				22.0				
	-20.5			■	27			4.5+			25.0				
55			**FAT CLAY(CH)**, very stiff to hard, reddish brown and light gray with calcareous nodules and ferrous stains	☒	28		37				18.0				
				■	29			3.5			21.0				
60	-26.5			■	30			4.25			13.0				
65															

Hole No. 11-B53

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.78 ft	
2. LOCATION (Coordinates or Station) PA 15 N=13804775.31 E=3253870.95		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 4.95 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/21/11 COMPLETED: 11/21/11	
5. DEPTH OF WATER ▽ TOD: 17.83 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), medium dense, brown with brown and light gray clay seams	■	1			1.5		19.0				
				■	2					6.0				
5				☒	3		18			11.0				35
	15.8		**LEAN CLAY WITH SAND(CL)**, soft to firm to very stiff, gray with sand	☒	4		26			22.0				
				☒	5		15			25.0				
10				■	6			2.5	107	20.0	38	15	23	
			- with sand pockets and shell	■	7			0.75	97	27.0	41	24	17	73
15			- brown	■	8			0.5		22.0				
▽			- gray and brown with sand and shell - yellowish brown with sand pockets	■	9			<0.25	115	16.0				
	3.8		- brown and gray with sand pockets **SILTY SAND(SM)**, medium dense to dense, gray with shell	■	10			<0.25		41.0				
20														
				☒	11		37			20.0				22
	-1.2			☒	12		23			21.0				
25			**FAT CLAY(CH)**, soft, gray with sand and trace of organic roots	☒	13		2			69.0				
	-5.2		- brown silty clay	■	14			<0.25	65	58.0				
			SILTY SAND(SM), very loose, brown	○	15					25.0				33
30														
	-9.2			☒	16		3			58.0				
	-10.2		**SILTY CLAY(CL-ML)**, brown											
			FAT CLAY(CH), very soft, reddish brown	☒	17		7			52.0				
				■										

Hole No. 11-B53

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 2 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +22.78 ft
2. LOCATION (Coordinates or Station) PA 15 N=13804775.31 E=3253870.95	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER TOD: 4.95 ft 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 11/21/11 COMPLETED: 11/21/11
5. DEPTH OF WATER TOD: 17.83 ft 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-12.7	▨	- gray with sand	■	18			<0.25	86	31.0				
		▨	**CLAYEY SAND(SC)**, very loose to loose, gray with shell	☒	19		4			25.0				
				☒	20		7			24.0				
40				☒	21		5			26.0				
				☒	22		7			26.0				
45				○	23		1							
				☒	24		9			27.0				
				☒	25		7			28.0				
50	-29.2			☒	26		7			40.0				
		▨	**SANDY LEAN CLAY(CL)**, soft, gray with sand	■	27			<0.25	103	25.0	39	16	23	63
55				■	28			<0.25		25.0				
				■	29			<0.25	102	24.0				
	-37.2			■	30			<0.25						
60														
65														

Hole No. 11-B54

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +22.85 ft
2. LOCATION (Coordinates or Station) PA 15 N=13806621.52 E=3250883.25	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 7.85 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 11/23/11 COMPLETED: 11/23/11
5. DEPTH OF WATER ▽ TOD: 15.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), medium dense, brown with clay pockets	☒	1		15			10.0				
				☒	2		11			18.0				
5	17.9		**CLAYEY SAND(SC)**, medium dense, gray	☒	3		29			12.0				
	15.4			☒	4		20				N/P	N/P	NP	38
			SILTY SAND(SM), medium dense to dense, gray with clay pockets	■	5					12.0				
10				☒	6		41			13.0				
				☒	7		35			13.0				
15 ▽	6.9		- brown	☒	8		15			20.0				
			SANDY LEAN CLAY(CL), very soft to soft, yellowish brown and light gray with sand pockets, roots and shell	■	9			<0.25	106	24.0	43	15	28	66
				■	10			<0.25		28.0				
20	1.9													
			SANDY SILT(ML), loose to medium dense, gray with clay seams	☒	11		16			29.0				
				☒	12		5			26.0				62
25	-3.2		- with clay pockets - gray clayey sand to sandy clay	☒	13		4			33.0				
			FAT CLAY(CH), stiff, dark gray with sand	■	14			1.0	90	35.0				
			- reddish brown with sand pockets and shell	■	15			2.0			65	24	41	86
30	-8.7													
			SILTY SAND(SM), loose to medium dense, gray with shell	☒	16		11			24.0				
	-11.2			☒	17		6			47.0				
			SILTY CLAY(CL-ML), gray with sand	☒										

Hole No. 11-B54

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 2 OF 2 SHEETS

1. PROJECT: HSCDMMP
2. LOCATION (Coordinates or Station): PA 15 N=13806621.52 E=3250883.25
3. DRILLING AGENCY: Kenall Inc.
4. LABORATORY TESTING AGENCY: Kenall Inc.
5. DEPTH OF WATER: ⊻ TOD: 15.0 ft ⊻ 24-HR:
6. DEPTH OF HOLE: 60 ft
7. ELEVATION OF HOLE: +22.85 ft
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ⊻ TOD: 7.85 ft ⊻ 24-HR:
10. DRILLING DATE and TIME: STARTED: 11/23/11 COMPLETED: 11/23/11
11. CLASSIFICATION REFERENCE:
12. ENGINEER: Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-13.2			☒	18		7			41.0				
	-15.2		**CLAYEY SAND(SC)**, gray with shell	■	19					23.0				18
40			**SILTY SAND(SM)**, very loose to loose, gray with shell	☒	20		3			30.0				
				☒	21		2			27.0				
				☒	22		2			24.0				
45				☒	23		2			25.0				
	-25.2			☒	24		5			24.0				
50			**CLAYEY SAND(SC)**, loose, gray with shell	☒	25		5							
			- very soft, gray clayey sand to sandy clay with shell	■	26			<0.25		19.0				
				☒	27		4			22.0				
55				☒	28		5							
				☒	29		5			24.0				
60	-37.2			☒	30		4							
65														

SWG 1836 BOR PA 15.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/16/12

Hole No. 11-B55

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +23.35 ft	
2. LOCATION (Coordinates or Station) PA 15 N=13802172.29 E=3251775.14		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 1.35 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/23/11 COMPLETED: 11/23/11	
5. DEPTH OF WATER ▽ TOD: 22.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**SANDY LEAN CLAY(CL)**, soft to stiff to very stiff, brown with sand seams	☒	1		21			27.0				
		▨	- with organics and sand pockets	■	2			2.5	119	14.0				58
5		▨		☒	3		7			13.0				
		▨	- shale - brown and gray with sand pockets and a trace of gravel	■	4			1.5		12.0				
	13.4	▨		■	5			<0.25	106	28.0				
10		▨	**CLAYEY SAND(SC)**, medium dense, tan and brown with clay pockets and trace of organics	■	6			<0.25	110	20.0	34	13	21	32
	9.4	▨		☒	7		18			17.0				
15		▨	**LEAN CLAY(CL)**, soft to stiff to very stiff, light gray and brown with sand pockets and gravel	■	8			2.75		20.0				
		▨	- light gray and reddish brown with sand seams and gravel	■	9			1.0	107	24.0				
	3.4	▨		■	10			<0.25		27.0				
20	▽ 1.4	▨	**CLAYEY SAND(SC)**, light gray and brown with clay pockets	■	11				112	20.0				
		▨	**SANDY LEAN CLAY(CL)**, gray with sand - light gray sand seam	☒	12		8			23.0				
25	-2.7	▨		☒	13		20			29.0				
		⁘	**SILTY SAND(SM)**, medium dense, gray with clay pockets and shell - gravel seam	☒	14		16			21.0				
	-6.7	⁘		☒	15		10			14.0				21
30		▨	**SANDY LEAN CLAY(CL)**, very soft, gray with sand seams and shell	☒	16		6			38.0				
		▨		■	17			<0.25		25.0	32	17	15	50
		▨		☒										

SWG 1836 BOR PA 15.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/16/12

Hole No. 11-B55

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +23.35 ft	
2. LOCATION (Coordinates or Station) PA 15 N=13802172.29 E=3251775.14		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 1.35 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/23/11 COMPLETED: 11/23/11	
5. DEPTH OF WATER TOD: 22.0 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				☒	18		4			33.0				
	-13.7		**CLAYEY SAND(SC)**, very loose to loose, gray with shell	■	19			<0.25	107	21.0				
40				☒	20		5			28.0				
	-18.7			☒	21		3			27.0				
			FAT CLAY(CH), soft to stiff to very stiff, gray and reddish brown with sand and sand pockets	☒	22		8			37.0				
45				■	23			<0.25	79	44.0				
				■	24			<0.25		40.0				
			- light gray with ferrous nodules	■	25			1.75		27.0				
50			- light gray with calcareous nodules and shell	■	26			1.75	95	30.0	81	23	58	
				■	27			3.25		21.0				
55				■	28			2.5		28.0				
				■	29			3.0		22.0				
	-36.7			■	30			3.75		19.0				
60														
65														

Hole No. 11-B56

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.96 ft	
2. LOCATION (Coordinates or Station) PA 15 N=13800957.00 E=3255012.54		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: -0.04 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/18/11 COMPLETED: 11/18/11	
5. DEPTH OF WATER ⊻ TOD: 23 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND(SM), medium dense to dense, gray and brown with clay pockets	☒	1		30			13.0				
				■	2					10.0				
5				☒	3		43			13.0				30
	15.0			☒	4		14			16.0				
			CLAYEY SAND(SC), loose, gray and brown with clay pockets	☒	5		9			15.0				
10	11.0			☒	6		10			18.0				
			SANDY FAT CLAY(CH), soft to stiff, gray with sand pockets	☒	7		4			47.0				
15				■	8			<0.25	89	33.0				
			- yellowish brown and light gray with sand pockets and shell	■	9			1.75	105	26.0				
			- sand seams	■	10			0.5			50	19	31	63
20	1.0		- brown sand seam	■	11			<0.25		20.0				
⊻			**FAT CLAY(CH)**, soft, gray with sand	☒	12		2			52.0				
25	-3.0		- gray with sand seams and pockets	■	13			<0.25	77	41.0				91
	-5.0		**CLAYEY SAND(SC)**, gray with clay pockets and shell	■	14					28.0				
30	-7.0		**SANDY SILT(ML)**, brown with clay pockets	☒	15		15			29.0				
			SILTY CLAY(CL-ML), very soft, brown with clay pockets	☒	16		2			24.0				
			- gray clay with sand	☒	17		4			35.0				
			- gray and brown with sand pockets and	■										

Hole No. 11-B56

BORING LOG	DISTRICT Galveston	INSTALLATION PA 15	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.96 ft	
2. LOCATION (Coordinates or Station) PA 15 N=13800957.00 E=3255012.54		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: -0.04 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/18/11 COMPLETED: 11/18/11	
5. DEPTH OF WATER ⊻ TOD: 23 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-13.0	▥	seams	■	18			<0.25	69	62.0	29	22	7	
		▨	**CLAYEY SAND(SC)**, very loose, gray with clay pockets and shell	☒	19		2			27.0				
		▨		☒	20		2			28.0				
40		▨		☒	21		3			28.0				
		▨		■	22			<0.25	101	27.0				
45	-22.0	▧	**FAT CLAY(CH)**, firm to stiff to very stiff, light gray and yellowish brown with sand pockets and gravel	■	23			<0.25		35.0				
		▧		■	24					35.0				
		▧	- ferrous nodules	■	25			1.25	104	23.0	51	17	34	
50		▧		■	26			0.75		25.0				
		▧	- sand seams - reddish brown	■	27			2.75		25.0				
55		▧	- with slickensided	■	28			3.75		31.0				
		▧	- yellowish brown and light gray with sand pockets	■	29			3.0		27.0				
		▧		■	30			3.25		19.0				
60	-37.0													
65														

Hole No. 11-B57

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.88 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13798136.94 E=3254863.99		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: N/A ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/16/11 COMPLETED: 11/16/11	
5. DEPTH OF WATER ⊻ TOD: N/A ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>SANDY LEAN CLAY</u>(CL)**, very stiff, reddish brown with brown sand seams	■	1			2.75		11.0				50
	19.4	▨		☒	2		10			14.0				
5		▨	**<u>FAT CLAY</u>(CH)**, very soft to soft, reddish brown with sand and shell - gray	■	3			0.25	105	20.0	52	19	33	
		▨	- gray sand seam - gray with sand seams and shell	■	4			0.1875		19.0				
10	12.4	▨	- sand pockets	■	5			0.1875		24.0				
		▨	**<u>LEAN CLAY WITH SAND</u>(CL)**, very soft to soft, yellowish brown and light gray with sand pockets	■	6			0.1875		27.0	45	18	27	84
		▨		■	7			0.25		41.0				
15		▨	- shell	■	8			0.25	94	25.0				
		▨	- silty sand seams and roots	■	9			0.25		15.0				
20	2.9	▨	- gray with shell and silty sand seams	☒	10		3			32.0				
		▨	**<u>FAT CLAY</u>(CH)**, very soft, reddish brown with sand seams	■	11			0.25	91	29.0	66	25	41	80
		▨		■	12			0.25		40.0				
25		▨	- sand pockets, seams and shell	■	13			0.25	90	34.0				
		▨		■	14			0.25		38.0				
30		▨		■	15			0.25	88	36.0				
		▨		■	16			0.75		35.0				
		▨	- roots	■	17			0.25		27.0				

SWG 1836 BOR PA 14.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/15/12

Hole No. 11-B57

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.88 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13798136.94 E=3254863.99		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: N/A ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/16/11 COMPLETED: 11/16/11	
5. DEPTH OF WATER TOD: N/A ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-13.1	▨	- gray with sand seams	■	18			0.25		54.0				
		▧	**<u>CLAYEY SAND</u>(SC)**, very loose, gray with shell and clay seams	☒	19		2			29.0				71
40	-17.1	▧		☒	20		3			38.0				
		▨	**<u>FAT CLAY</u>(CH)**, firm to stiff to very stiff, light gray and reddish brown with sand pockets and ferrous nodules	■	21			2.25	94	29.0				
		▨	- with sand	■	22			2.75		27.0				
45		▨		■	23			1.75		27.0				
		▨	- trace of shell	■	24			3.0		27.0				
50	-27.1	▨	- with sand and silt pockets and shell	■	25			0.5		20.0				
	-29.1	▥	**<u>SILTY CLAY</u>(CL-ML)**, soft, yellowish brown and light gray	■	26			0.5		16.0				
		░	**<u>SILTY SAND</u>(SM)**, dense to very dense, yellowish brown and light gray with clay pockets	■	27					21.0				
55		░		☒	28		46							
		░		☒	29		69			22.0				
60	-37.1	░		☒	30		71							
65														

Hole No. 11-B58

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +23.28 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13795466.53 E=3254039.05		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 2.28 ft ⯆ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/16/11 COMPLETED: 11/16/11	
5. DEPTH OF WATER ⊻ TOD: 21.0 ft ⯆ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, soft to stiff to hard, reddish brown clay with trace of sand and gravel	■	1			4.25	103	27.0				
		▨		■	2			1.25	96	27.0	67	22	45	89
5		▨		■	3			1.0		31.0				
		▨	- with sand and shell	■	4			0.25	85	38.0				
		▨		■	5			0.3125		40.0				
10		▨	- with trace of organics	■	6			0.25		34.0				
		▨	- gray with sand and shell	■	7			0.25	74	48.0	92	30	62	88
15		▨		■	8			0.25		30.0				
		▨		■	9			0.25	95	27.0				
		▨		■	10			1.25	79	41.0	102	32	70	94
20	⊻ 2.3	░	**SILTY SAND(SM)**, loose, gray with clay pockets	■	11			0.25		27.0				
		░		■	12					38.0				45
25	-2.2	░		☒	13		8			32.0				
	-2.7	▨	**FAT CLAY(CH)**, reddish brown											
		░	**SILTY SAND(SM)**, loose, gray with clay pockets	■	14					17.0				
		░		☒	15		5			29.0				
30		░		☒	16		6			24.0				
		░		☒	17		6			30.0				
	-10.7	▨	**FAT CLAY(CH)**, soft, gray with sand seams	■										

SWG 1836 BOR PA 14.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/15/12

Hole No. 11-B58

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 2 OF 2 SHEETS

1. PROJECT: HSCDMMP
2. LOCATION (Coordinates or Station): PA 14 N=13795466.53 E=3254039.05
3. DRILLING AGENCY: Kenall Inc.
4. LABORATORY TESTING AGENCY: Kenall Inc.
5. DEPTH OF WATER: ⊻ TOD: 21.0 ft ⊻ 24-HR:
6. DEPTH OF HOLE: 60 ft
7. ELEVATION OF HOLE: +23.28 ft
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ⊻ TOD: 2.28 ft ⊻ 24-HR:
10. DRILLING DATE and TIME: STARTED: 11/16/11 COMPLETED: 11/16/11
11. CLASSIFICATION REFERENCE:
12. ENGINEER: Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-12.7	▨		■	18			0.25		34.0				
		▧	**CLAYEY SAND(CH)**, very loose to loose, gray with clay seams	■	19					29.0				50
		▧		■	20					26.0				
40		▧		☒	21		3			26.0				
		▧		☒	22		5			25.0				
45		▧	- with silt seams - gray with silt	■	23			0.25		24.0				
		▧	- clay pockets	■	24					26.0				
	-25.7	▧	- yellowish brown and gray sand with clay pockets	☒	25		12			33.0				
50		▨	**FAT CLAY(CH)**, stiff to very stiff, reddish brown and gray with sand and silt seams	■	26			1.0		44.0				
		▨		■	27			1.75		30.0				
55		▨		■	28			3.25		33.0				
		▨		■	29			2.5		34.0				
		▨		■	30			2.75		34.0				
60	-36.7													
65														

Hole No. 11-B59

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.19 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13792975.00 E=3256498.92		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: N/A ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/10/11 COMPLETED: 11/14/11	
5. DEPTH OF WATER TOD: N/A ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░	**<u>SILTY SAND</u>(SM)**, medium dense, tan and brown with shell	☒	1		16			9.0				
		░		☒	2		13			17.0				29
5	16.7	░		■	3			1.25		18.0				
		▨	**<u>FAT CLAY</u>(CH)**, very soft to firm to stiff, gray with sand and trace of gravel and sand seams	■	4			1.75	110	18.0				53
		▨	- with organics	■	5			0.125		13.0				
10		▨	- with sand pockets, gravel and shell	■	6			0.75	103	24.0				
		▨	- organics	■	7			0.25		18.0				
15		▨		■	8			0.25	108	34.0				
		▨		■	9			0.25	93	20.0	50	23	27	
	3.2	▨		■	10			0.125		24.0				
20		▥	**<u>SILT WITH SAND</u>(ML)**, loose to medium dense, reddish brown with clay pockets											
		▥		☒	11		25			22.0				71
	-0.8	▥	**<u>SILTY CLAY</u>(CL-ML)**, very soft, gray with sand pockets	☒	12		6			33.0				
25	-3.3	▨		■	13			0.1875		26.0				
		▨	**<u>FAT CLAY</u>(CH)**, very soft, dark gray with sand and shell	■	14			0.125		25.0				
	-5.3	░	**<u>SILTY SAND</u>(SM)**, medium dense, brown and gray											
		░		☒	15		13			29.0				
30		░		☒	16		16			41.0				
	-11.3	░		☒	17		17			47.0				
		▨	**<u>FAT CLAY</u>(CH)**, very soft, gray with sand and sand pockets	■										

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +22.19 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13792975.00 E=3256498.92		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: N/A ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/10/11 COMPLETED: 11/14/11	
5. DEPTH OF WATER TOD: N/A ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
				■	18			0.25		48.0	86	30	56	98
	-14.8		**SANDY LEAN CLAY(CL)**, very soft, gray with sand pockets	■	19			0.1875		39.0				
				■	20			0.1875	96	24.0				
40	-18.8		**SILTY SAND(SM)**, loose to medium dense, gray with shell	■	21			0.125		18.0				
				☒	22		5			26.0				
45	-22.8		**FAT CLAY(CH)**, firm to stiff to very stiff, reddish brown with sand and silt pockets	☒	23		14			31.0				
				■	24			2.5	95	29.0	62	26	36	100
				■	25			2.5		12.0				
50			- sand seams	■	26			2.5		32.0				
			- calcareous nodules - sand seams	■	27			0.5		29.0				
55			- with sand	■	28			2.0		29.0				
			- with sand, slickensided and calcareous nodules	■	29			1.75		29.0				
60	-37.8			■	30			2.75		19.0				
65														

BORING LOG

DISTRICT Galveston	INSTALLATION PA 14	SHEET 1 OF 2 SHEETS	
1. PROJECT HSCDMMP	7. ELEVATION OF HOLE +23.41 ft		
2. LOCATION (Coordinates or Station) PA 14 N=13796409.93 E=3256931.27	8. DATUM FOR ELEVATION		
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 4.41 ft ▼ 24-HR:		
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 11/14/11 COMPLETED: 11/14/11		
5. DEPTH OF WATER ▽ TOD: 19.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE		
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala		

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY(CH), firm to stiff to very stiff to hard, dark brown and reddish brown with ferrous nodules and gravel	■	1			4.5		14.0				
			- with sand and gravel	■	2			2.75	106	21.0				
5			- sand pockets - gray and reddish brown	■	3			4.5		15.0				
			- gray, light gray and brown with sand and shell - sand seam	■	4			0.75	103	23.0	62	22	40	66
			- reddish brown	■	5			1.75	109	16.0				
10	13.4		**SILT WITH SAND(ML)**, loose to medium dense, tan and reddish brown	■	6					10.0				
				☒	7		18			20.0				73
15	8.4		**SANDY LEAN CLAY(CL)**, very soft to soft to firm, light gray and reddish brown with sand pockets and shell	☒	8		9			26.0				
				■	9			1.0	94	30.0	47	21	26	61
▽				■	10			1.0		24.0				
20				■	11			0.25	86	36.0				
	0.4		- with sand seams **SILTY SAND(SM)**, loose, gray and brown with shell and clay pockets	■	12			0.5		39.0				
25	-1.6		**FAT CLAY(CH)**, very soft, dark gray with sand pockets and seams	☒	13		4			26.0				
	-3.6		- Marsh material	■	14			0.25		41.0				
	-4.6		**SILTY SAND(SM)**, brown											
			FAT CLAY(CH), soft to firm, reddish brown with silty sand seams and sand pockets	■	15			0.5		38.0	67	29	38	87
30				■	16			0.75	88	37.0				
			- slickensided	■	17			1.0		37.0				
	-10.6		**CLAYEY SAND(CL)**, loose, gray	■										

SWG 1836 BOR PA 14.GPJ TOLUNAY-WONG ENGINEERS.GDT 2/15/12

Hole No. 11-B60

BORING LOG	DISTRICT Galveston	INSTALLATION PA 14	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE +23.41 ft	
2. LOCATION (Coordinates or Station) PA 14 N=13796409.93 E=3256931.27		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 4.41 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 11/14/11 COMPLETED: 11/14/11	
5. DEPTH OF WATER ⊻ TOD: 19.0 ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		░		■	18					21.0				
		░		■	19					27.0				
		░		■	20					28.0				
40		░												
		░		☒	21		6			29.0				
	-19.6	░												
		▨	**FAT CLAY(CH)**, stiff to very stiff, yellowish brown and light gray with slickensided and sand pockets	☒	22		7			33.0				
45		▨		■	23			2.25	94	27.0				
		▨	- with sand seams and gravel pockets	■	24			2.25		23.0				
		▨	- reddish brown with sand pockets and silt seams	■	25			1.5		22.0				
50		▨												
		▨		■	26			1.0		29.0				
		▨		■	27			1.0		31.0				
55		▨	- with sand	■	28			3.0		31.0				
		▨		■	29			3.0		31.0				
		▨		■	30			2.5		32.0				
60	-36.6													
65														

Hole No. 11-B61

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 18.38 ft
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13782790.23 E=3262798.84	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ▽ TOD: 6.38 ft ▼ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 1/24/12 COMPLETED: 1/24/12
5. DEPTH OF WATER ▽ TOD: 12.0 ft ▼ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	16.4		**SILTY SAND(SM)**, gray with brown clay pockets and clay seams	■	1			0.0	0.0625		13.0				
			FAT CLAY WITH SAND(CH), very soft to stiff, gray and brown with sand seams and pockets	■	2			1.5		91	28.0	55	24	31	78
5	12.4		- ferrous nodules	■	3			1.5		80	41.0				
			SILTY SAND(SM), light gray, brown and gray, medium dense to dense	☒	4		19				6.0				
10			- with clay pockets	☒	5		29				19.0				34
▽				☒	6		24				18.0				20
				☒	7		44				23.0				
15	2.4			☒	8		35				23.0				23
	0.4		**SILTY CLAY(CL-ML)**, gray,	☒	9		2				28.0				97
20	-1.6		**SANDY LEAN CLAY(CL)**, gray	☒	10		3				30.0				
			FAT CLAY(CH), very soft to stiff to very stiff, reddish brown and dark gray with sand pockets - hydrocarbon odour	■	11			1.0		86	37.0	54	26	28	94
				■	12			0.5			39.0	50	26	24	
25			- tan and gray	☒	13		2				37.0				
			- reddish brown with sand pockets and shell	■	14			0.5		85	32.0				
				■	15			1.0		88	37.0	67	33	34	
30				■	16			0.5			43.0				
			- brown and tan with shell	■	17			0.0	0.125	89	35.0				
			- reddish brown and dark gray with sand	■											

Hole No. 11-B61

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 18.38 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13782790.23 E=3262798.84		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: 6.38 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 1/24/12 COMPLETED: 1/24/12	
5. DEPTH OF WATER ▽ TOD: 12.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	pockets and shell	■	18			1.0			32.0				
		▨		■	19			2.5		97	27.0				
		▨		■	20			2.5			29.0				
40		▨													
		▨		■	21			2.0		110	29.0				
		▨		■	22			1.5			24.0				
45		▨	- tan and reddish brown with lots of sand pockets	■	23			1.5		104	24.0				
		▨		■	24			1.0			27.0				
		▨	- ferrous stains and sand pockets												
		▨		☒	25		22				30.0				
50		▨													
		▨		■	26			1.5			25.0				
		▨		☒	27		25				34.0				
55		▨		☒	28		20				32.0				
		▨		■	29			3.0			34.0				
		▨		■	30			3.0			32.0				
60	-41.6														
65															

Hole No. 11-B61A

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 18.48 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13779778.67 E=3263975.60		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ⊻ TOD: 18.48 ft ⊻ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 2/8/12 COMPLETED: 2/8/12	
5. DEPTH OF WATER ⊻ TOD: N/A ft ⊻ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▥	**ELASTIC SILT(MH)**, very soft to soft to firm, reddish brown with sand and calcareous nodules	■	1			1.0			32.0				
		▥		■	2			0.75		92	31.0				
5		▥		■	3			0.25	0.125	88	35.0	64	33	31	89
		▥		■	4			0.25	0.1875	86	36.0				
		▥		■	5			0.0	0.125		34.0	66	34	32	94
10		▥													
		▥		■	6			0.75		86	36.0				
	4.5	▥		■	7			1.0			34.0	60	31	29	88
15	2.5	░	**SILTY SAND(SM)**, dense, light gray	☒	8		44				21.0				49
		▨	**SANDY LEAN CLAY(CL)**, stiff, light gray and light brown	■	9			1.0		100	26.0				
	-1.5	▨		■	10			1.25			24.0				
20		▧	**FAT CLAY(CH)**, soft to firm to stiff, reddish brown and light gray with large sand pockets and shell	■	11			0.5		90	35.0	50	28	22	
		▧		■	12			0.5			36.0				
25		▧		■	13			1.0		92	31.0				
	-8.5	▧		■	14			0.25	0.125		36.0				99
	-9.5	▨	**SANDY LEAN CLAY(CL)**, very soft, gray and brown												
	-11.5	░	**SILTY SAND(SM)**, dark gray with shell	☒	15						21.0				26
30		▧	**FAT CLAY(CH)**, dark gray												
		▧		☒	16		2				33.0				
	-15.5	▧		☒	17		2				39.0				
		▨	**SANDY LEAN CLAY(CL)**, very stiff, light	■											

Hole No. 11-B61A

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 18.48 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13779778.67 E=3263975.60		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 18.48 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 2/8/12 COMPLETED: 2/8/12	
5. DEPTH OF WATER TOD: N/A ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
	-17.5	▨	brown and gray	■	18			3.0		96	27.0				
		▨	**FAT CLAY(CH)**, stiff to very stiff to hard, light brown and light gray with ferrous stains	■	19			4.0		100	25.0				
		▨		■	20			4.0			22.0				
40		▨		■	21			3.0			23.0				
		▨	- calcareous nodules	■	22			3.75			21.0				
45		▨		■	23			1.25			22.0				
		▨		■	24			1.0			20.0				
		▨	- reddish brown with ferrous stains	■	25			4.25			23.0				
50		▨	- with calcareous nodules	■	26			3.75			24.0				
	-34.5	▨	**SANDY LEAN CLAY(CL)**, very stiff, reddish brown	■	27			2.75			26.0				
55	-36.5	▨	**FAT CLAY(CH)**, very stiff, reddish brown	■	28			3.5			30.0				
		▨		■	29			3.0			33.0				
	-40.5	⁙	**SILTY SAND(SM)**, reddish brown	■	30			2.75			33.0				
60	-41.5														
65															

Hole No. 11-B62

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 18.72 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13778656.34 E=3264786.27		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: -1.28 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/3/11 COMPLETED: 2/7/12	
5. DEPTH OF WATER ▽ TOD: 20.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, very soft tostiff, reddish brown with silt pockets and trace of gravel	■	1			1.25		102	23.0	64	21	43	94
		▨	- with sand	■	2			0.25	0.125		25.0				
5		▨	- gray	■	3			<0.25	0.1875	100	26.0				
		▨	- reddish brown with sand and gray silt seams	■	4			<0.25	0.0625	82	41.0	73	26	47	
		▨		■	5			<0.25	0.25		38.0				
10		▨		■	6			<0.25	0.125			72	33	39	93
		▨	- with sand pockets and seams	■	7			<0.25	0.125		37.0				
15	3.2	▨		■	8			<0.25	0.25	89	33.0				
	0.7	▥	**SILTY CLAY WITH SAND(CL-ML)**, gray and brown with reddish brown clay seam	☒	9		9				33.0				77
20 ▽		░	**SILTY SAND(SM)**, loose, gray with clay pockets	☒	10		7				35.0				
	-3.3	░		☒	11		6				29.0				
		▨	**FAT CLAY WITH SAND(CH)**, reddish brown with gray sand seams	☒	12		5			87	33.0				84
25	-6.3	░	**SILTY SAND(SM)**, very loose to loose, gray with clay pockets and shell	■	13			1.5			31.0				
		░		☒	14		6				34.0				17
30		░		☒	15		5				23.0				
	-12.8	░		☒	16		3				53.0				
		▨	**FAT CLAY(CH)**, very loose to stiff to very stiff to hard, gray with sand and shell	☒	17		4				37.0				
		▨		■											

Hole No. 11-B62

BORING LOG	DISTRICT Galveston
INSTALLATION Mid Bay Marsh	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP	7. ELEVATION OF HOLE 18.72 ft
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13778656.34 E=3264786.27	8. DATUM FOR ELEVATION
3. DRILLING AGENCY Kenall Inc.	9. ELEVATION OF GROUNDWATER ⊻ TOD: -1.28 ft ⊻ 24-HR:
4. LABORATORY TESTING AGENCY Kenall Inc.	10. DRILLING DATE and TIME STARTED: 12/3/11 COMPLETED: 2/7/12
5. DEPTH OF WATER ⊻ TOD: 20.0 ft ⊻ 24-HR:	11. CLASSIFICATION REFERENCE
6. DEPTH OF HOLE 60 ft	12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			<0.25	0.125	92	32.0				
		▨	- light brown and light gray with with ferrous stains	■	19			4.25			47.0				
		▨		■	20			2.5		108	21.0				
40		▨	- with calcareous nodules and ferrous stains	■	21			3.75			30.0				
		▨		■	22			4.0		110	19.0				
45		▨		■	23			2.0			23.0				
		▨		■	24			1.5			21.0				
		▨	- reddish brown with ferrous stains and calcareous nodules	■	25			4.5+			24.0				
50		▨		■	26			3.0			31.0				
	-34.3	▥	**SILTY CLAY(CL-ML)**, soft, reddish brown	■	27			0.25			24.0				
55	-37.3	▥		☒	28		16				26.0				
		▨	**FAT CLAY(CH)**, reddish brown with gray sand seams	■	29			2.0			30.0				
	-41.3	▨		■	30			2.75			38.0				
60															
65															

ENG FORM: SWG 1836 BOR

Hole No. 11-B63

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 1 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 17.92 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13776620.24 E=3267114.15		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER ▽ TOD: -0.08 ft ▼ 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 12/2/11 COMPLETED: 12/2/11	
5. DEPTH OF WATER ▽ TOD: 18.0 ft ▼ 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>FAT CLAY</u>(CH)**, very soft to soft to stiff, reddish brown with calcareous nodules	■	1			2.0		109	19.0	54	25	29	
		▨	- with silty sand seams	■	2			<0.25	0.125	98	25.0				
5		▨		■	3			0.5		95	28.0	52	21	31	83
		▨	- with silty sand pockets	■	4			<0.25	0.125		30.0				
		▨	- with silt	■	5			<0.25	0.0625	83	37.0				96
10		▨		■	6			<0.25	0.125		36.0				
		▨		■	7			<0.25	0.125		34.0				
	3.9	▨	- with silty sand seams												
15		▥	**<u>SANDY SILT</u>(ML)**, reddish brown with clay pockets	■	8						22.0				
		▥		☒	9						23.0				75
▽	-1.1	▥													
20		▨	**<u>FAT CLAY WITH SAND</u>(CH)**, very soft to soft to firm to stiff, gray with sand seams	☒	10						32.0				
		▨		■	11			0.75		89	33.0	81	26	55	79
		▨		■	12			0.5			25.0				
25		▨		■	13			1.0		88	34.0				
		▨		■	14			1.0		90	35.0				
		▨	- reddish brown and gray with sand seams	■	15			1.25		92	33.0				
30		▨		■	16			<0.25	0.25		31.0				
		▨		■	17			0.5			31.0				
		▨	- gray with sand seams and shell	■											

Hole No. 11-B63

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 2 OF 2 SHEETS

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Mid Bay Marsh N=13776620.24 E=3267114.15

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
TOD: 18.0 ft 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
17.92 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
TOD: -0.08 ft 24-HR:

10. DRILLING DATE and TIME
STARTED: 12/2/11 COMPLETED: 12/2/11

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.5		94	30.0				
		▨		■	19			<0.25	0.1875		17.0				
		▨		■	20			<0.25	0.125		15.0				
40		▨		■											
		▨		■	21			1.5		109	16.0				
	-25.1	▨													
		░	**SILTY SAND(SM)**, dense, gray with brown seams	■	22			<0.25	0.25		10.0				
45		░		☒	23		34				24.0				
		░		☒	24		36				28.0				
		░		☒	25		36				36.0				
50		░													
		░		☒	26		37				27.0				
		░		☒	27		38				24.0				
55		░		☒	28		35				21.0				
		░		☒	29		30				35.0				
		░		☒	30		36				32.0				
60	-42.1														
65															

SWG 1836 BOR MID BAY MARSH.GPJ TOLUNAY-WONG ENGINEERS.GDT 3/5/12

BORING LOG

DISTRICT Galveston

INSTALLATION Mid Bay Marsh

SHEET 1 OF 2 SHEETS

1. PROJECT HSCDMMP
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13780633.60 E=3267708.41
3. DRILLING AGENCY Kenall Inc.
4. LABORATORY TESTING AGENCY Kenall Inc.
5. DEPTH OF WATER ∇ TOD: 12.0 ft ▼ 24-HR:
6. DEPTH OF HOLE 60 ft
7. ELEVATION OF HOLE 19.07 ft
8. DATUM FOR ELEVATION
9. ELEVATION OF GROUNDWATER ∇ TOD: 7.07 ft ▼ 24-HR:
10. DRILLING DATE and TIME STARTED: 11/30/11 COMPLETED: 12/2/11
11. CLASSIFICATION REFERENCE
12. ENGINEER Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**<u>FAT CLAY</u>(CH)**, very soft to soft to stiff to very stiff to hard, reddish brown and dark gray with sand	■	1			4.25			21.0				85
			- gray silty sand - light gray with sand pockets	■	2			2.0		102	21.0	61	20	41	83
5				■	3			0.5			39.0				
				■	4			0.5		81	45.0	70	29	41	94
			- gray	■	5			<0.25	0.0625	80	42.0				
10			- with sand and gravel												
				■	6			<0.25	0.0625	82	40.0				
∇															
			- brown sand with clay pockets	■	7			<0.25	0.125		36.0				
15			- reddish brown with brown sand seams	☒	8		7				33.0				
				☒	9		5				40.0				
			- gray with sand pockets	■	10			<0.25	0.0625			53	27	26	90
20			- shell seams												
				■	11			0.5		84	39.0				
			- gray and reddish brown with with sand pockets, seams and shell	☒	12		4				39.0				
25				■	13			<0.25	0.125		33.0				
				■	14			<0.25	0.25	98	26.0				
			- light gray	■	15			<0.25	0.1875		34.0				
30			- reddish brown and light gray with sand pockets, seams and shell												
				■	16			0.5		93	34.0				
				■	17			0.25	0.125		34.0				

SWG 1836 BOR MID BAY MARSH.GPJ TOLUNAY-WONG ENGINEERS.GDT 3/5/12

Hole No. 11-B64

BORING LOG

DISTRICT: Galveston

INSTALLATION: Mid Bay Marsh

SHEET 2 OF 2 SHEETS

1. PROJECT: HSCDMMP
2. LOCATION (Coordinates or Station): Mid Bay Marsh N=13780633.60 E=3267708.41
3. DRILLING AGENCY: Kenall Inc.
4. LABORATORY TESTING AGENCY: Kenall Inc.
5. DEPTH OF WATER: TOD: 12.0 ft 24-HR:
6. DEPTH OF HOLE: 60 ft
7. ELEVATION OF HOLE: 19.07 ft
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: TOD: 7.07 ft 24-HR:
10. DRILLING DATE and TIME: STARTED: 11/30/11 COMPLETED: 12/2/11
11. CLASSIFICATION REFERENCE:
12. ENGINEER: Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.25	0.1875		30.0				
		▨	- light gray and yellowish brown wih sand pockets and trace of calcareous noduels	■	19			1.5			31.0				
		▨		■	20			2.0			23.0				
40		▨		■	21			2.25		115	17.0				
		▨	- light gray with sand seams	■	22			2.0			14.0				
45		▨		■	23			1.5			20.0				
	-27.9	▨	- with calcareous nodules	■	24			2.0			22.0				
		▥	**SILTY CLAY(CL-ML)**, reddish brown with sand												
50		▥		☒	25		23				24.0				
	-32.9	▥		☒	26		22				23.0				
		▨	**FAT CLAY WITH SAND(CH)**, stiff to very stiff, reddish brown with calcareous nodules and slicken sided	■	27			2.75			33.0				
55		▨		■	28			1.5			30.0				
		▨		■	29			2.5			19.0				
60	-40.9	▨		■	30			2.75			29.0				
65															

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh
SHEET 1 OF 2 SHEETS		

1. PROJECT
HSCDMMP

2. LOCATION (Coordinates or Station)
Mid Bay Marsh N=13783980.66 E=3265204.98

3. DRILLING AGENCY
Kenall Inc.

4. LABORATORY TESTING AGENCY
Kenall Inc.

5. DEPTH OF WATER
▽ TOD: 12.08 ft ▼ 24-HR:

6. DEPTH OF HOLE
60 ft

7. ELEVATION OF HOLE
18.67 ft

8. DATUM FOR ELEVATION

9. ELEVATION OF GROUNDWATER
▽ TOD: 6.59 ft ▼ 24-HR:

10. DRILLING DATE and TIME
STARTED: 2/9/12 COMPLETED: 2/9/12

11. CLASSIFICATION REFERENCE

12. ENGINEER
Vivek Chikyala

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨	**FAT CLAY(CH)**, stiff, dark brown with sand pockets	■	1			1.5		94	28.0	62	27	35	
		▨	- reddish brown and gray with sand pockets and seams	■	2			1.75		90	31.0				88
5		▨		■	3			1.5			37.0				
	10.7	▨		■	4			1.0		87	37.0				
		▨	**FAT CLAY WITH SAND(CH)**, firm, reddish brown and gray with sand pockets	■	5			0.75			28.0	74	33	41	71
10	7.7	▨		■	6			0.5		102	23.0				
▽		░	**SILTY SAND(SM)**, medium dense, light gray	☒	7		26				21.0				
15		░		☒	8		30				18.0				23
		░		☒	9		14				24.0				
20	-1.3	░		■	10		17				18.0				
		▨	**FAT CLAY(CH)**, soft to stiff to very stiff, reddish brown and dark brown with large sand pockets	■	11			1.0		81	40.0				
		▨		■	12			0.5		93	33.0	60	27	33	
25		▨	- light gray	■	13			1.5			36.0				85
		▨	- gray	■	14			1.0		90	33.0	71	30	41	97
		▨		■	15			1.75		93	33.0				
30		▨		■	16			0.75			36.0				
		▨		■	17			0.5		95	29.0				96
		▨	- with sand pockets and shell	■											

Hole No. 11-B64A

BORING LOG	DISTRICT Galveston	INSTALLATION Mid Bay Marsh	SHEET 2 OF 2 SHEETS
1. PROJECT HSCDMMP		7. ELEVATION OF HOLE 18.67 ft	
2. LOCATION (Coordinates or Station) Mid Bay Marsh N=13783980.66 E=3265204.98		8. DATUM FOR ELEVATION	
3. DRILLING AGENCY Kenall Inc.		9. ELEVATION OF GROUNDWATER TOD: 6.59 ft 24-HR:	
4. LABORATORY TESTING AGENCY Kenall Inc.		10. DRILLING DATE and TIME STARTED: 2/9/12 COMPLETED: 2/9/12	
5. DEPTH OF WATER TOD: 12.08 ft 24-HR:		11. CLASSIFICATION REFERENCE	
6. DEPTH OF HOLE 60 ft		12. ENGINEER Vivek Chikyala	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	TORVANE (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
		▨		■	18			0.25	0.25		36.0	73	27	46	89
		▨	- dark gray and light brown	■	19			2.25		86	37.0				
		▨	- light brown and light gray	■	20			2.25			28.0				
40		▨		■	21			2.75			31.0				
		▨	- reddish brown	■	22			2.25		88	35.0				
45		▨	- with ferrous stains	■	23			2.75			30.0				
		▨	- with calcareous nodules	■	24			3.5			29.0				
		▨		■	25			3.25			30.0				
50		▨		■	26			3.75			26.0				
		▨		■	27			1.75			29.0				
55	-36.3	░	**SILTY SAND(SM)**, medium dense, reddish brown	☒	28		15				28.0				
	-38.3	▨	**FAT CLAY(CH)**, very stiff, reddish brown	■	29			2.5			29.0				
		▨		■	30			3.5			31.0				
60	-41.3														
65															

ATTACHMENT 8

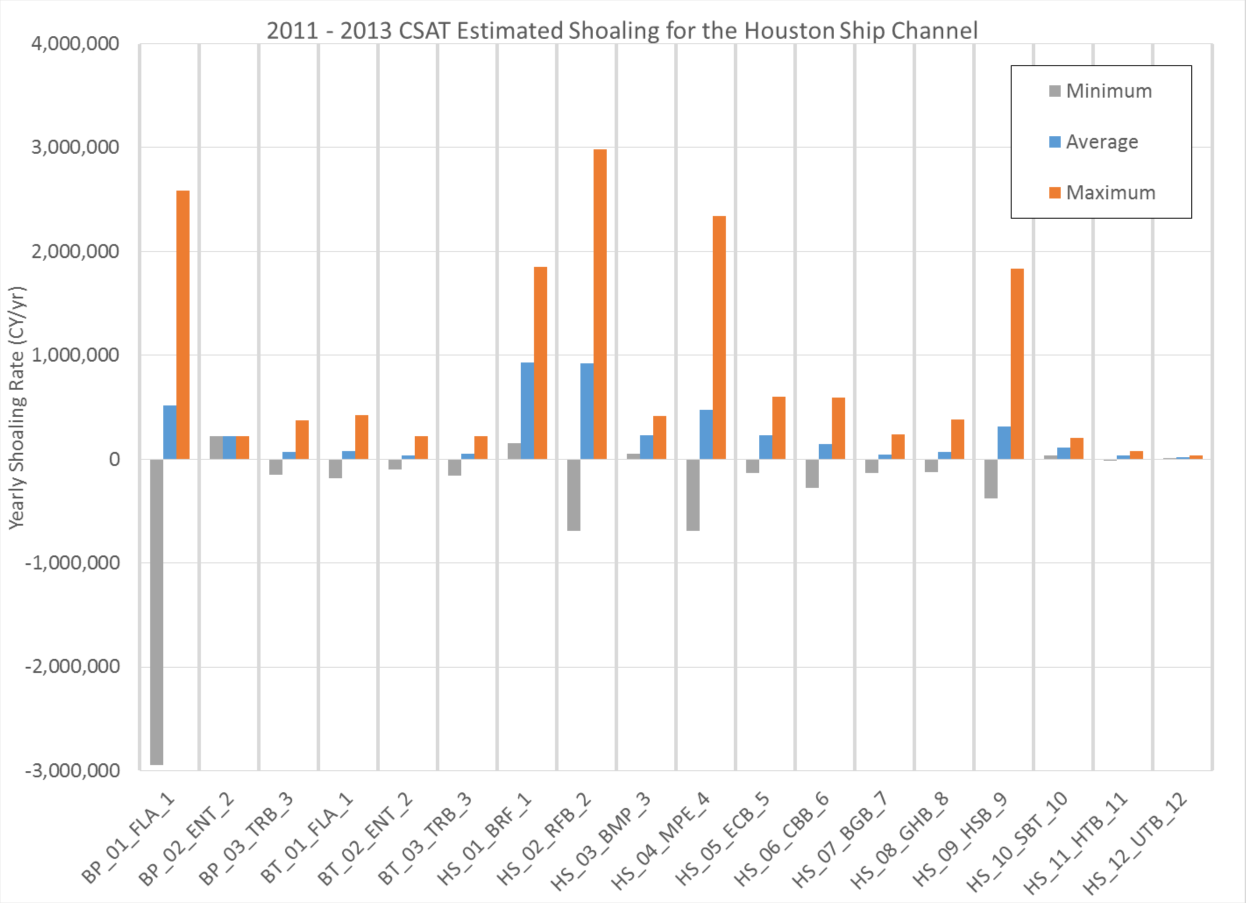
CORPS SHOALING ANALYSIS TOOL (CSTAT) REPORT

AdH Sediment Model Calibration to Corps Shoaling Analysis Tool (CSAT) Estimates

Approach:

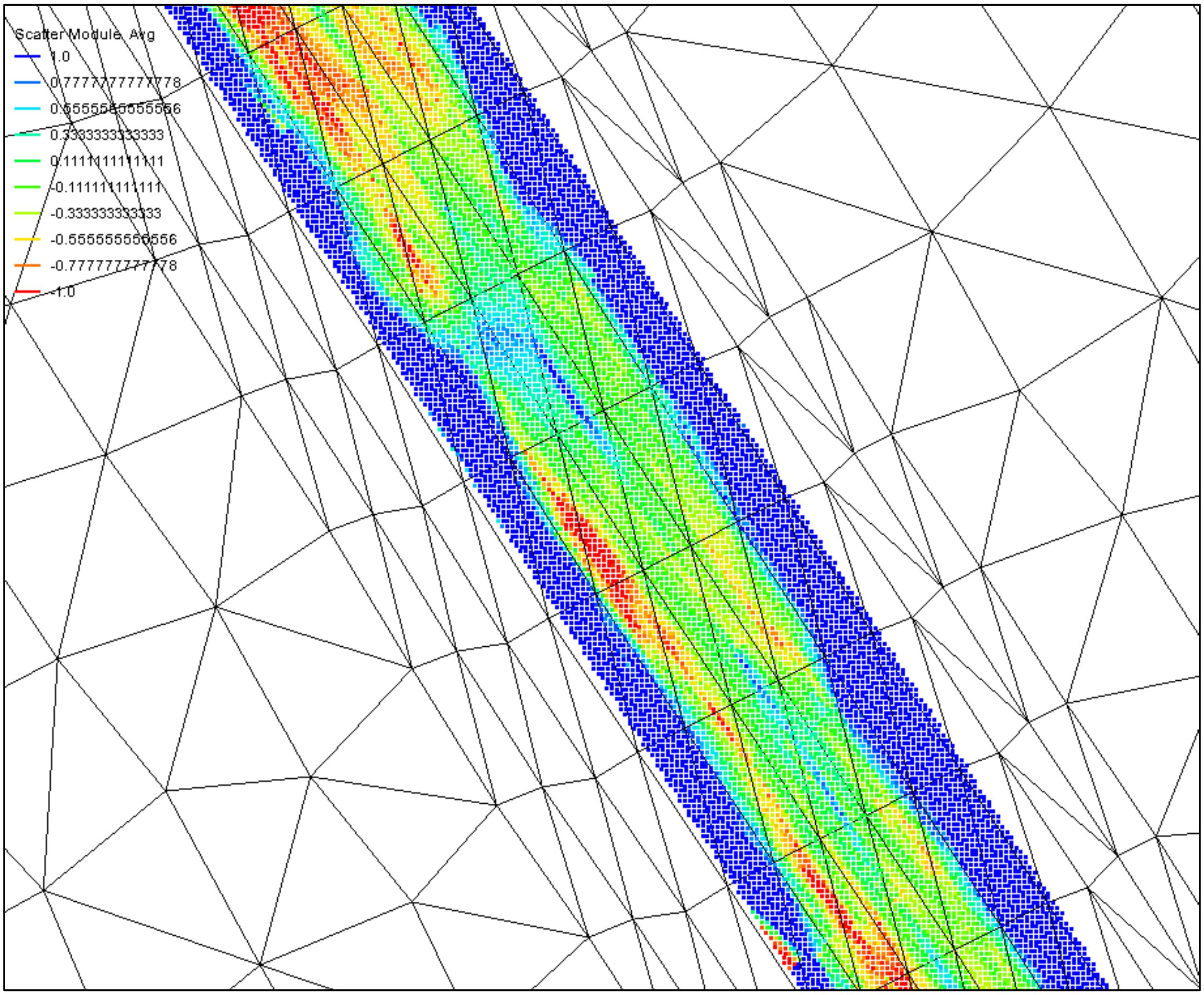
The CSAT compiles channel surveys over time to provide estimates of shoaling rates. These rates are based on the change in the bed elevation over time and in coordination with dredging events. For each reach of data provided to CSAT over the three analysis years (2011, 2012, 2013), a minimum, average, and maximum shoaling volume is determined for that reach (see figure 1). The range from maximum to minimum is extremely large (nearly 4 million CY) for many reaches and shows the large variability in the data provided to and/or being computed by CSAT. These maximum and minimum values, however, are based on a single cell maximum and applying it over the entire reach area – indicating an extreme possibility.

Figure 1. CSAT minimum, average, and maximum shoaling volumes by reach.



CSAT produces a scatter data set of yearly average shoal heights (see figure 2). These data are very fine, much finer than the AdH numerical model resolution. The AdH numerical model computes a yearly shoal height at each mesh node. However, within a single mesh element are hundreds of CSAT points that vary greatly with the element. Applying the CSAT data to the mesh nodes and determining a ratio or scale factor is impractical given this large disparity in resolution between the two tools.

Figure 2. CSAT shoal height points and AdH mesh elements/nodes.



A better approach is to average out the variations over several mesh elements/nodes. This option allows for the use of reach analysis which is more practical given the data available. This is also a better option given the AdH model simulation periods do not match the CSAT analysis periods, which also requires an averaging or "ball-park" analysis.

CSAT Comparison to Annual Reports:

All previous sediment modeling with this AdH model has applied a historical scale factor based on seven years of dredge volumes (post 40x530 ft construction) provided in the USACE Annual Reports. These reports are best viewed over several years since some reaches are not dredged every year. The CSAT analysis was performed on data from 2011-2013. The USACE Annual Reports are not available beyond 2012. However, the total shoaling estimates for the entire Houston Ship Channel for 2011 and 2012 are comparable to the CSAT shoaling estimate for 2011-2013: although there are large differences in some of the reach shoaling volumes (see table 1). (CSAT reaches were combined to match the Annual Report reaches shown in figure 3). Presently there is no explanation as to why there are such large differences between the Annual Report reach volumes and the CSAT reach volumes.

Figure 3. Annual report dredge reaches.

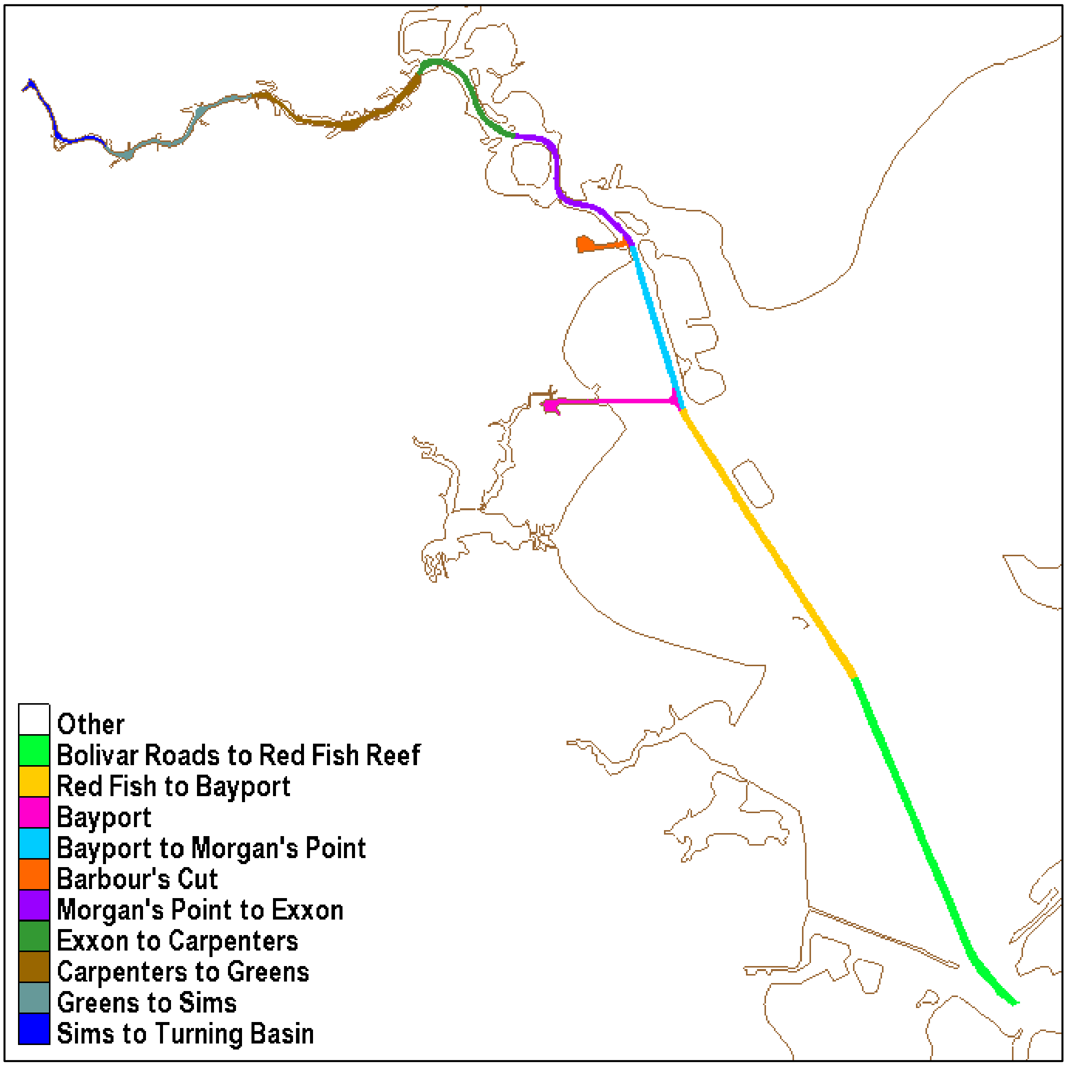


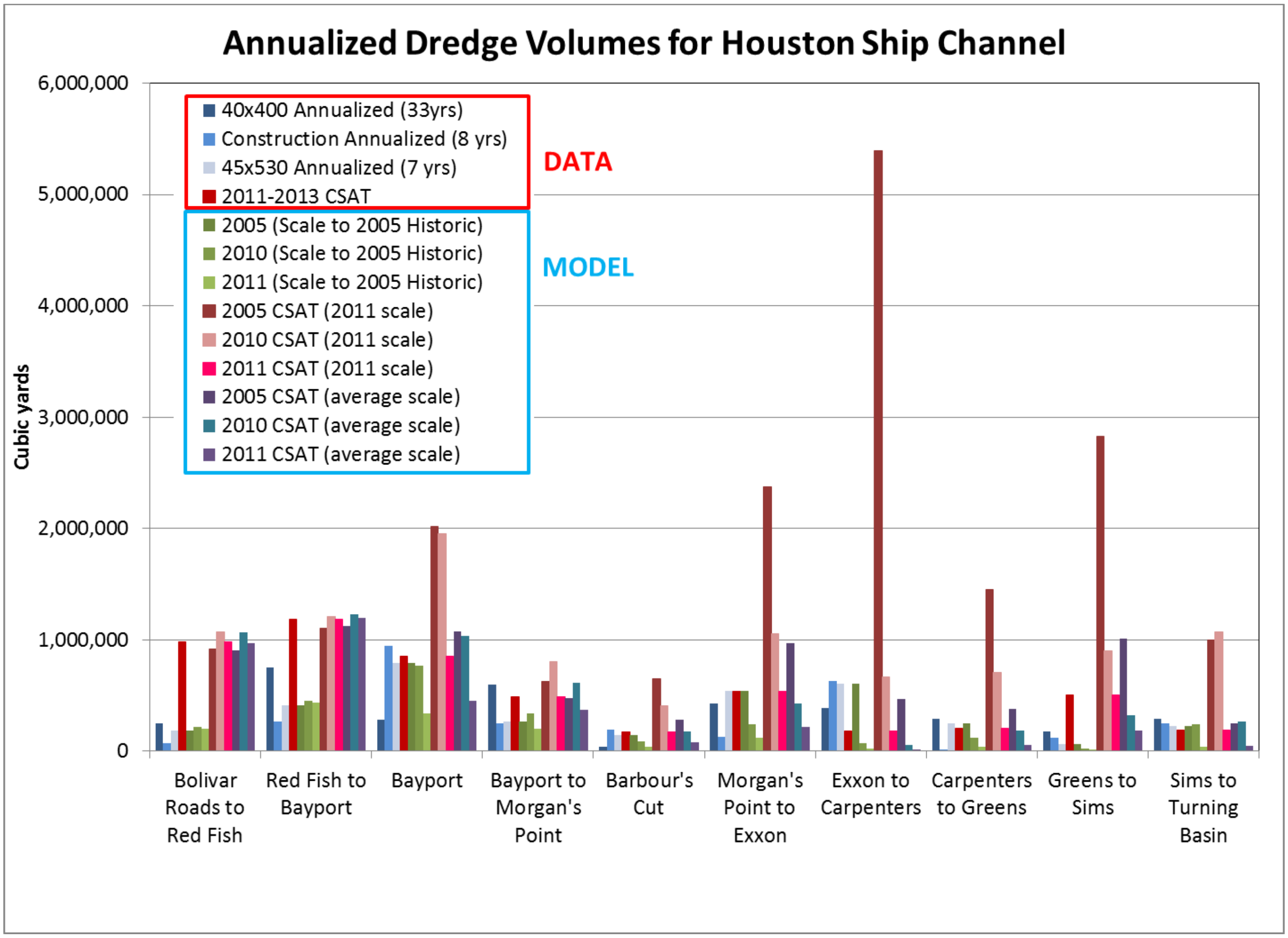
Table 1. Comparisons by reach for Annual Report data and CSAT estimates of shoaling volume for the HSC.

	Bolivar Roads to Red Fish	Red Fish to Bayport	Bayport	Bayport to Morgan's Point	Barbours Cut	Morgan's Point to Exxon	Exxon to Carpenters	Carpenters to Greens	Greens to Sims	Sims to Turning Basin	SUM
2011 (CY)			741,492	914,986	7,362	2,024,913	64,535			130,347	3,883,635
2012 (CY)		1,946,206	176,916				3,543,921		431,216		6,098,259
Avg/year	**0**	**973,103**	**459,204**	**457,493**	**3,681**	**1,012,457**	**1,804,228**	**0**	**215,608**	**65,174**	**4,990,947**
CSAT 2011-2013 Volume (CY)	**935,032**	**926,405**	**802,561**	**231,949**	**169,650**	**472,026**	**228,338**	**192,423**	**377,957**	**167,909**	**4,504,250**

CSAT scaling of AdH model results:

The CSAT results were analyzed over the Annual Report reaches and a scale factor determined such that the AdH model results could be adjusted to better match the CSAT values. Initially this scale factor was determined using the 2011 AdH model results. However, 2011 is a drought year and therefore a year of less shoaling. Using 2011 AdH results to compare back to CSAT 2011-2013 results artificially increases the scale factor since we know this is not an average condition. Instead, the average of the AdH shoaling results for 2005, 2010, and 2011 (the model validation years) for each reach were used to compare back to the CSAT results and a better scale factor determined. Figure 4 shows the results of the various scaling options. The Annual Report volumes and the CSAT volume analysis results are considered “data”. The AdH model computed results scaled in various ways are listed as “model”. The green data sets are model shoaling volumes scaled by the 2005 historic Annual Report data as documented in the AdH model validation report. The pink data sets are the model shoaling volumes scaled by the CSAT to 2011 AdH model shoaling results (the 2011 pink bar matches the red CSAT bar). The dark blue model data sets are model shoaling volumes scaled by the CSAT to 2005, 2010, and 2011 average AdH model shoaling results. The 2011 scaling option produces extremely large shoaling volumes at reaches in the upper Houston Ship Channel which are likely incorrect since they are so much larger than the Annual Report values and CSAT values. However, the CSAT maximum values do reach some extremely large shoaling volumes. Scaled results that fall in the general range of the reported data and the CSAT data are considered more reliable at this time.

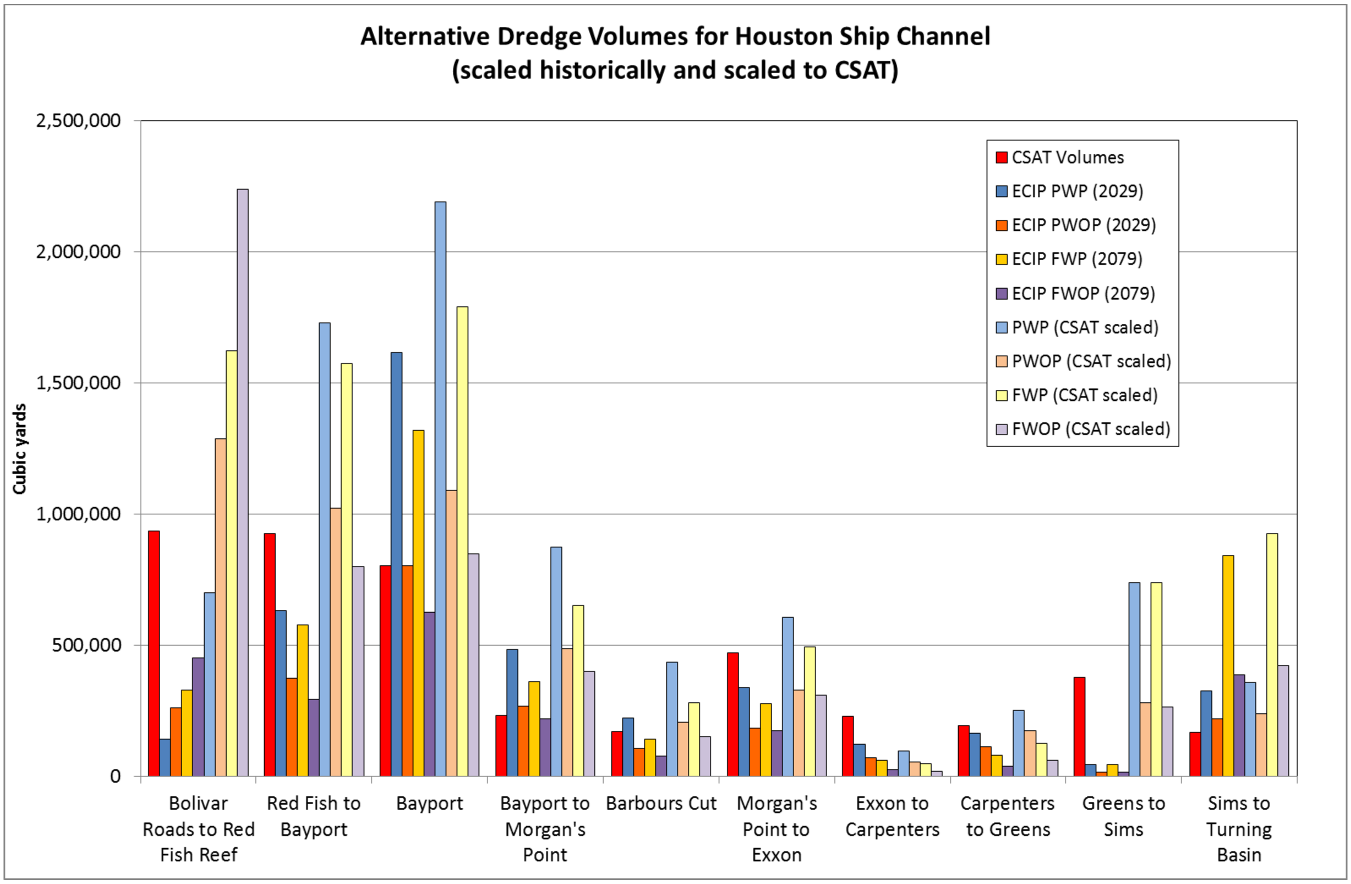
Figure 4. AdH model scaled shoaling results.



CSAT scaled ECIP alternative results:

The CSAT scaling of the AdH model results using the average shoaling of the three validation years is applied to the four ECIP alternatives – present with project (PWP), present without project (PWOP), future with project (FWP), and future without project (FWOP) – over the Annual Report reaches. The results for both the historic Annual Report scaling (as presented in the ECIP modeling report) and the CSAT scaling are shown in in Figure 5 along with the CSAT computed volume for each reach (red). The CSAT scaling generates higher shoaling volumes than the Annual Report scaling although most reaches do not show extreme differences (more than double) except Bolivar Roads to Red Fish Reef and Greens to Sims.

Figure 5. ECIP alternative scaled AdH model shoaling volume results for Annual Report reachs.



CSAT scaled ECIP alternative results over CSAT reaches:

The CSAT scaling of the AdH model results using the average shoaling of the three validation years is applied to the four ECIP alternatives – present with project (PWP), present without project (PWOP), future with project (FWP), and future without project (FWOP) – over the CSAT reaches (see Figure 6). Only reaches along the Houston Ship Channel, Bayport Channel, and Barbours Cut channel are included in this analysis. The Galveston Channel is also not included since the AdH model does not include sand transport which is dominant in this area. Figure 7 shows the CSAT scaled AdH estimated shoaling volumes for the alternatives. The CSAT estimated shoaling volumes for each reach are shown in red. The AdH model shoaling results scaled using the average shoaling of the three validation years are shown in the additional four data sets. Most reaches show alternative shoaling volume estimates on the order of the CSAT volumes except at the lower Houston Ship Channel reach of Bolivar Roads to Red Fish Reef (HS_01_BRF).

Figure 6. CSAT reaches.

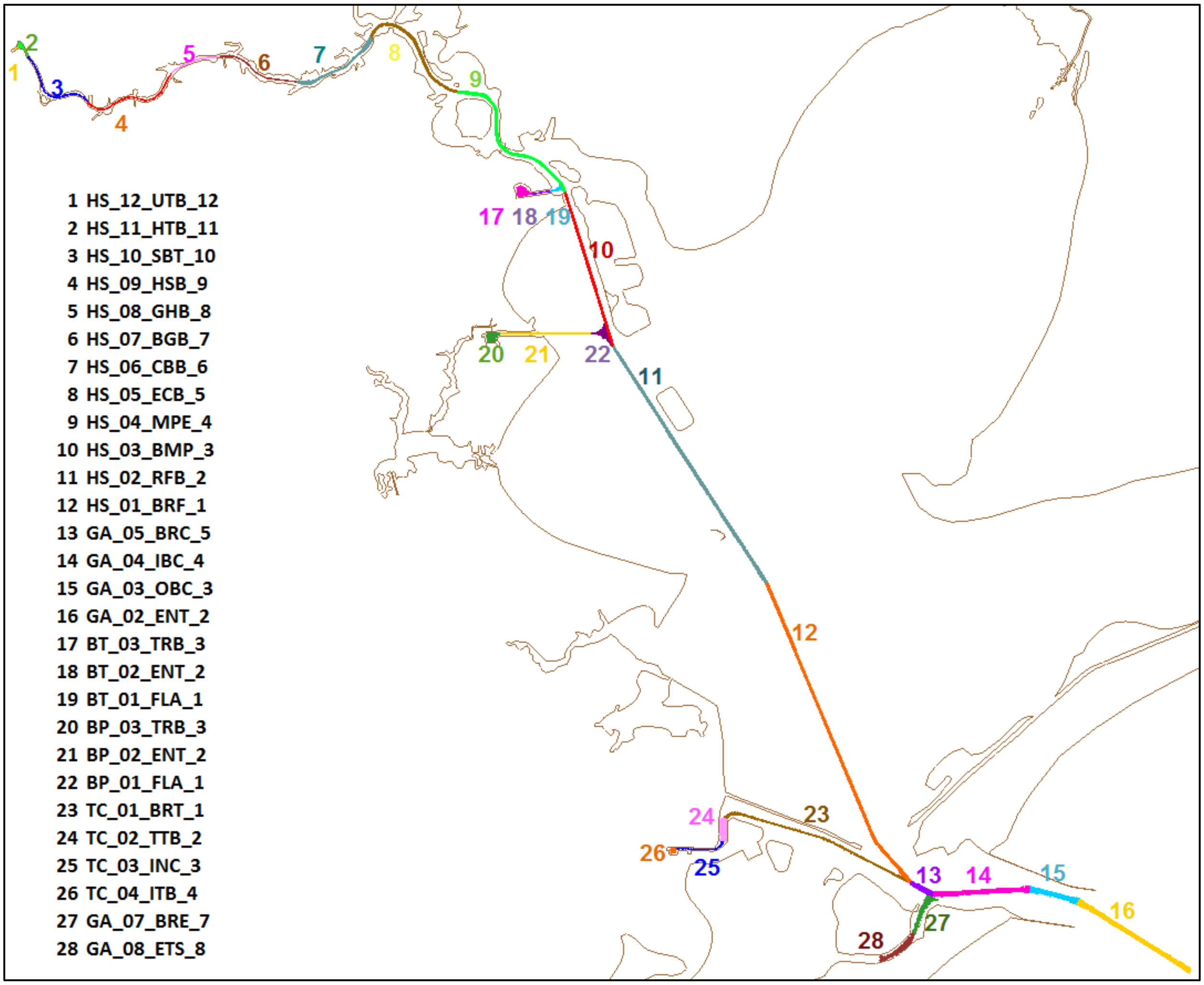
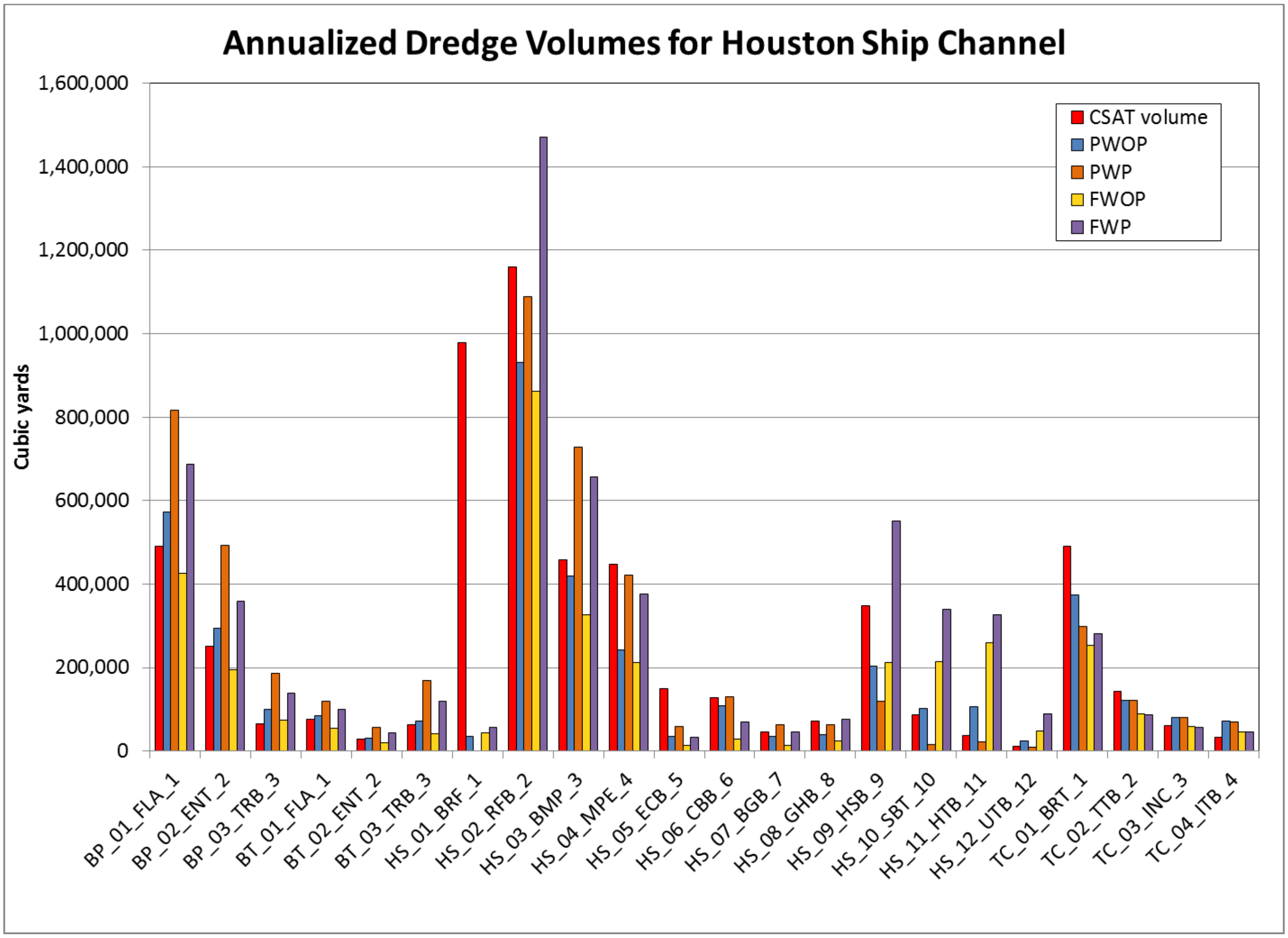
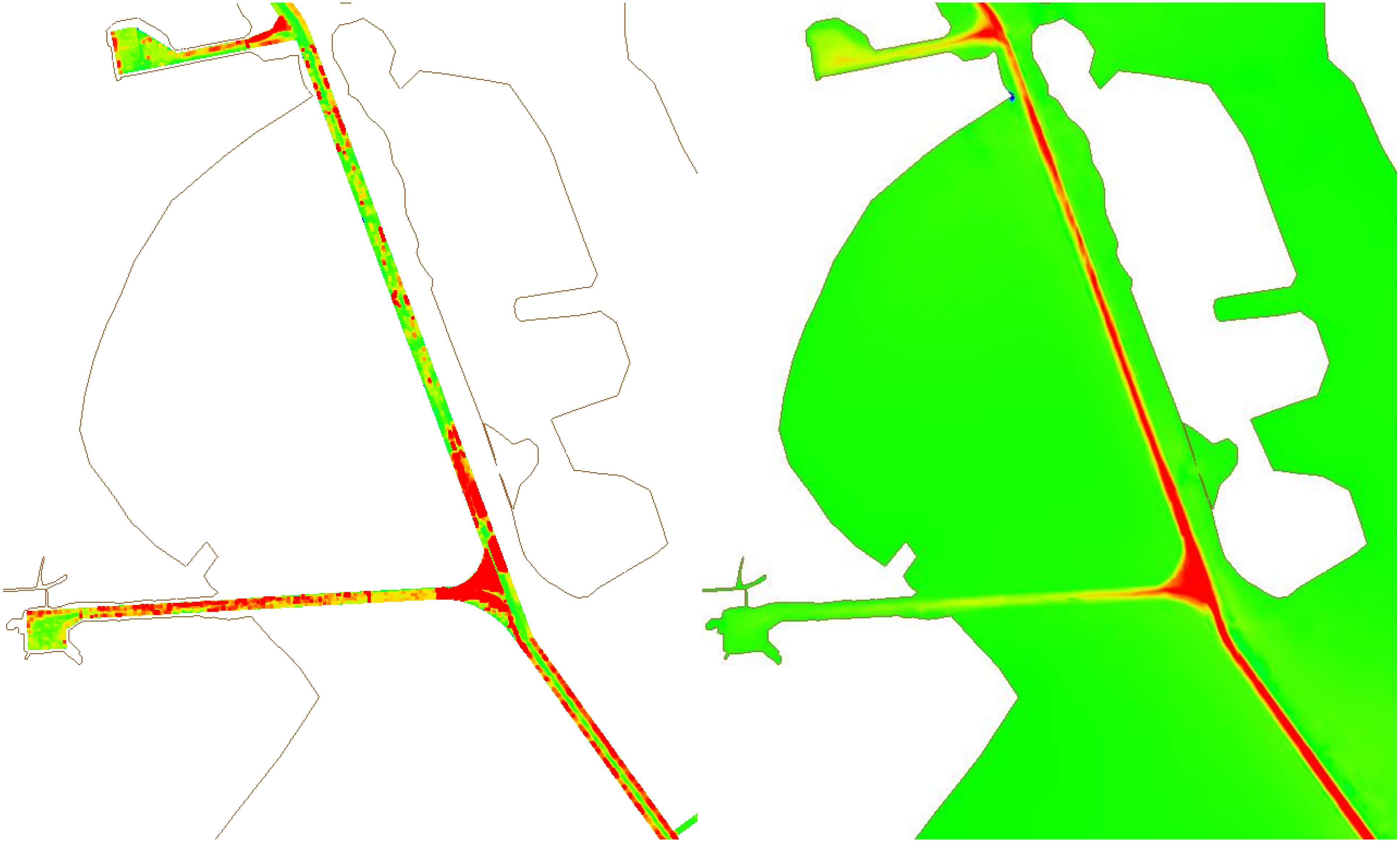


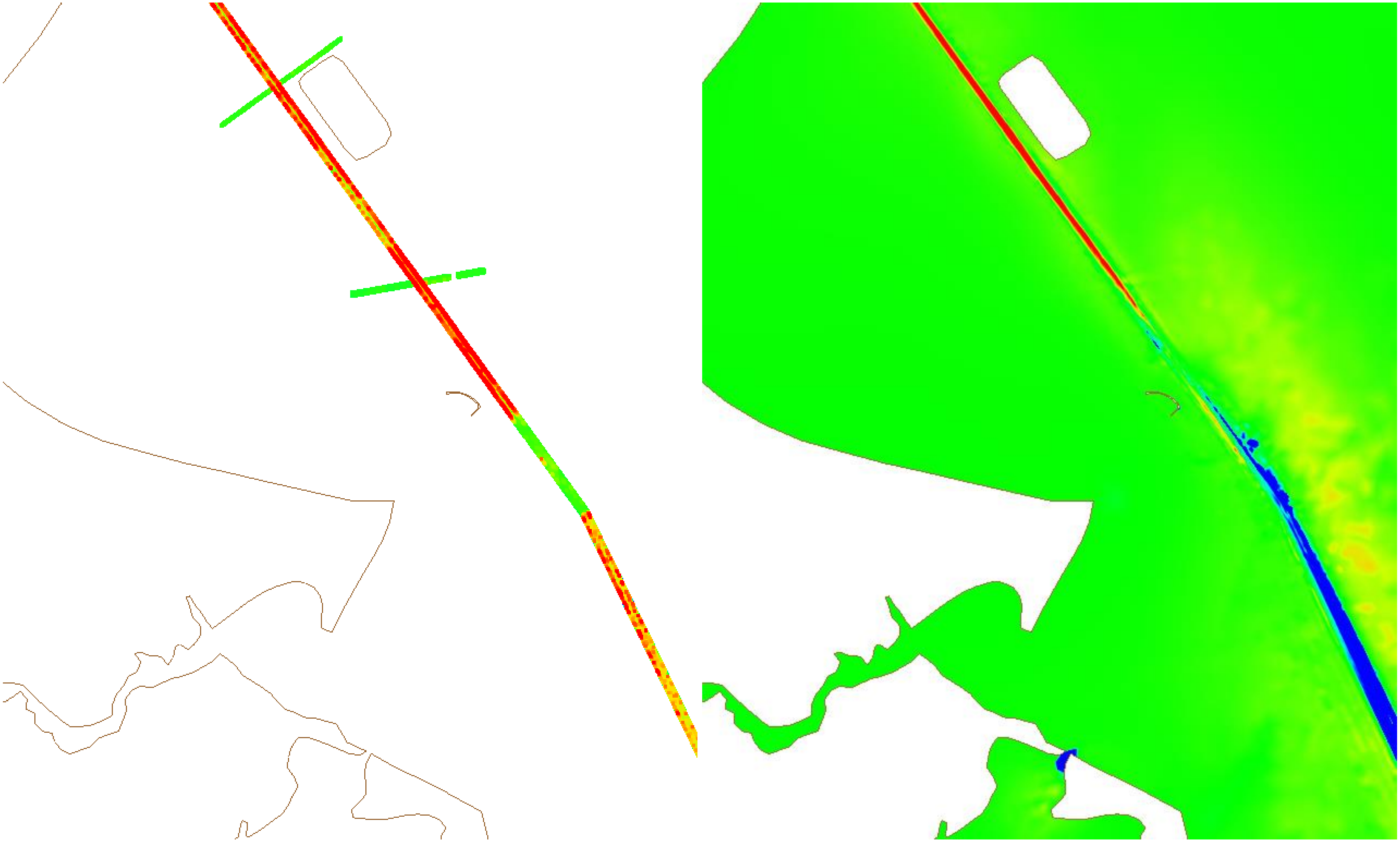
Figure 7. ECIP alternative scaled AdH model shoaling volume results for CSAT reaches.

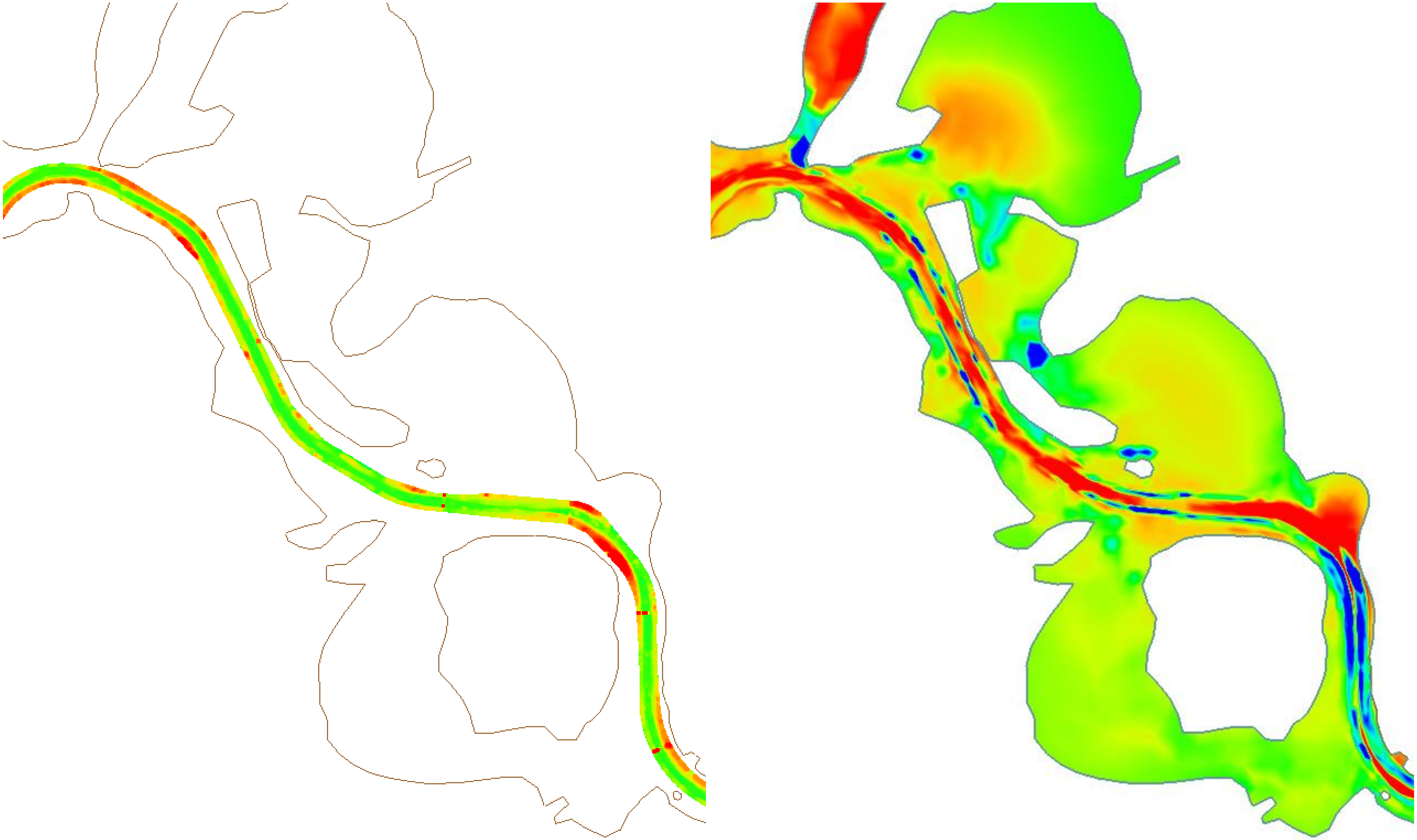


CSAT shoal heights compared to AdH bed displacement:

The CSAT yearly average shoal heights (feet) are shown spatially for several segments of the Houston Ship Channel alongside the AdH computed bed displacement for year 2011. The scales are not the same, so patterns of change are most important. Looking at the CSAT data, it is obvious that reach shoaling values vary within the reach but also between reaches – as indicated by the definitive change in the contours. The CSAT data indicates shoaling along the channel sideslopes which is generated by the deep draft vessels preventing material to settle in the channel center. The AdH model does not enforce this pattern since vessel traffic is not included. However, the pattern of shoaling along the channel and in the flares is generally represented by the model and the historic dredge records (as noted in the model validation report).







ATTACHMENT 9

SEDIMENT TRAINING OPTIONS FFOR BAYPORT FLARE

Sediment Training Options for the Bayport Flare in the Houston Ship Channel

Design options for sediment and current training structures are investigated for the potential to reduce the amount of sediment that settles in the Houston ship channel (HSC) and Bayport flare. The location of the Bayport flare is shown in Figure 1. This reach of the HSC is exceptionally busy, and has required substantial maintenance dredging due to ongoing shoaling.

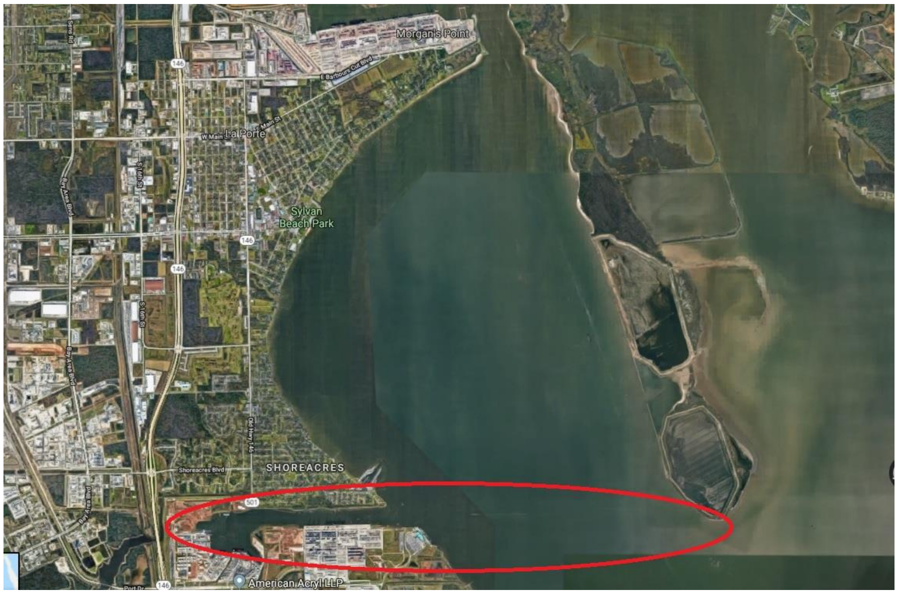


Figure 1: Bayport flare adjoining the HSC

Previous sediment modeling of vessel movements near the flare found that vessel induced fluid pressures and sheer loads on the soil bed are eroding the soft surface material on the shallow bed surrounding the HSC (1)(2). Eroded materials become suspended in the water column and carried by existing currents. Previous circulation modeling has also shown that the residual bottom currents progress in a generally counter-clockwise circulation pattern, with residual bottom current flowing South to North in the Channel (Figure 2). Suspended sediments generally settle in locations with lower currents, such as the Bayport Flare (circled in Figure 1). Modeling has also shown that vessel induced erosion generates the majority of the of the shoaling material rather than other sources such as river sediments or shoreline erosion. The vessel induced shear stresses that cause erosion and subsequent transport are larger and impact more area in the reach along Atkinson Island. Historical dredging records indicate the Bayport Flare (circled in Figure 1) is a major sink; it is a large, deep area where the velocity drops sufficiently for material to settle. Movement of sinks within the flare are probably caused by turbidity maxima or salt wedge tip migration throughout the year. These locations tend to be further downstream in the HSC in spring during high freshwater flows, and are likely to be pushed further upstream along Atkinson Island during periods of high tides and lower flows.

Figure 2 shows the bottom flow residual velocities in the area of interest (circled in red) without any current or sediment training structures. There is a residual circulation in the shallow flats north of the Bayport flare and west of the HSC. Ship wakes generated in the HSC dislodge material in these shallow flats, most of which gets mobilized by the circulation. The reach is sufficiently busy that entrained sediments do not have adequate low-energy time to settle in the shallow flats West of the channel. Entrained sediments continue with the counter-clockwise circulation and are ultimately deposited in the deeper and lower energy Bayport flare. Additionally, sediment coming down the river also gets entrained in this circulation and goes into the flare instead of being flushed through the ship channel. Only a small percentage of suspended sediment becomes entrained in the channel and flows Southward.

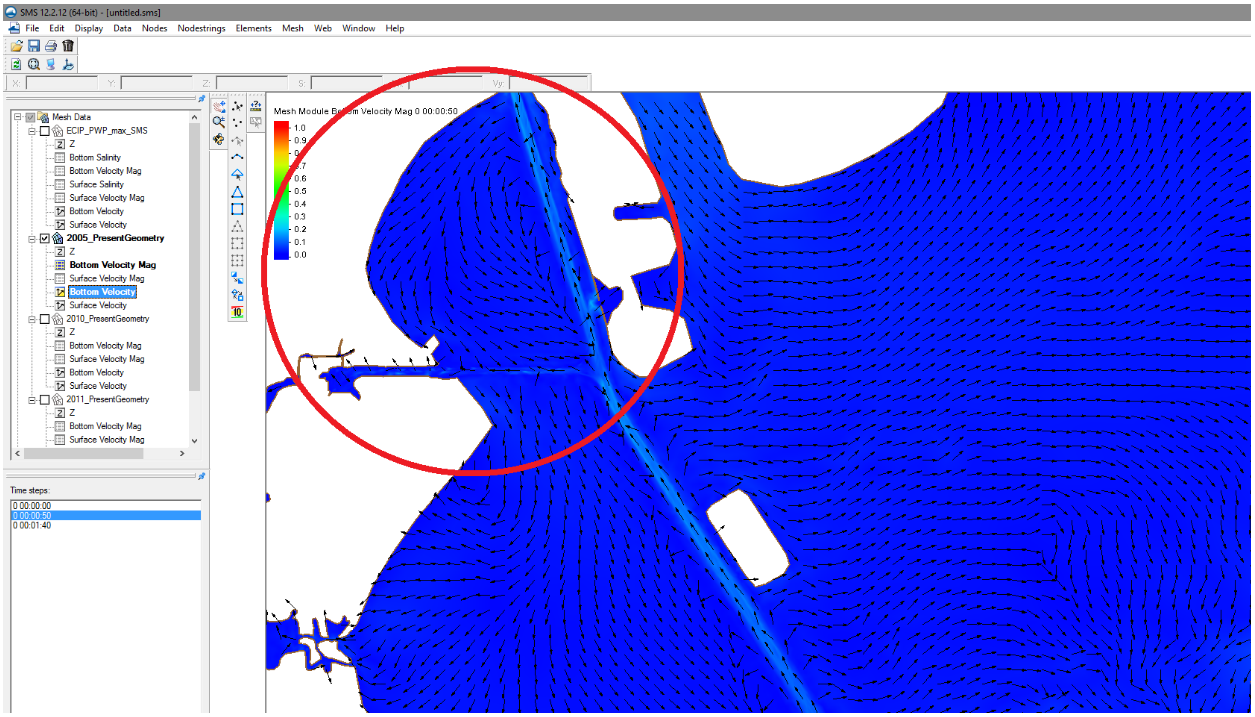


Figure 2: Bottom residual velocities w/o Training structures

The fundamental problem leading to the shoaling is believed to be the broad circulation pattern combined with the large amount of traffic in the reach. Sediments are continuously suspended by passing ships, and then carried with the circulating currents until they settle in the relatively quiescent deep sections the depth of which are subsequently maintained by dredging. Prior modeling included assessment of two proposed sediment-training structures (Figures 3 and 4). These chevron-shaped structures are intended to prevent sediment entering the HSC as well as the Bayport flare, but are not believed to be effective because detailed circulation modeling has shown these structures to have little or no impact on the broad circulation through and North of the Flare. The proposed chevron structures may encourage greater shoaling because of reduced bottom velocities in the dredged areas, but have no effect on the problematic circulation of extremely sediment-rich water.

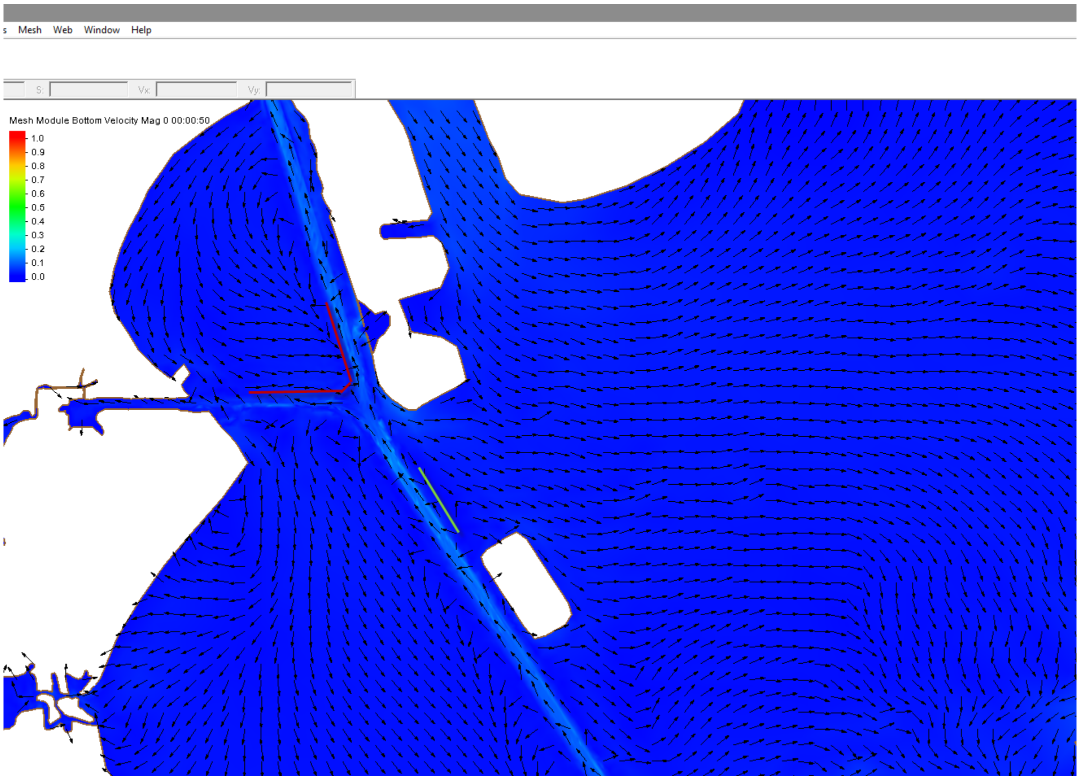


Figure 3: Bottom residual velocities with single chevron sediment training structure.

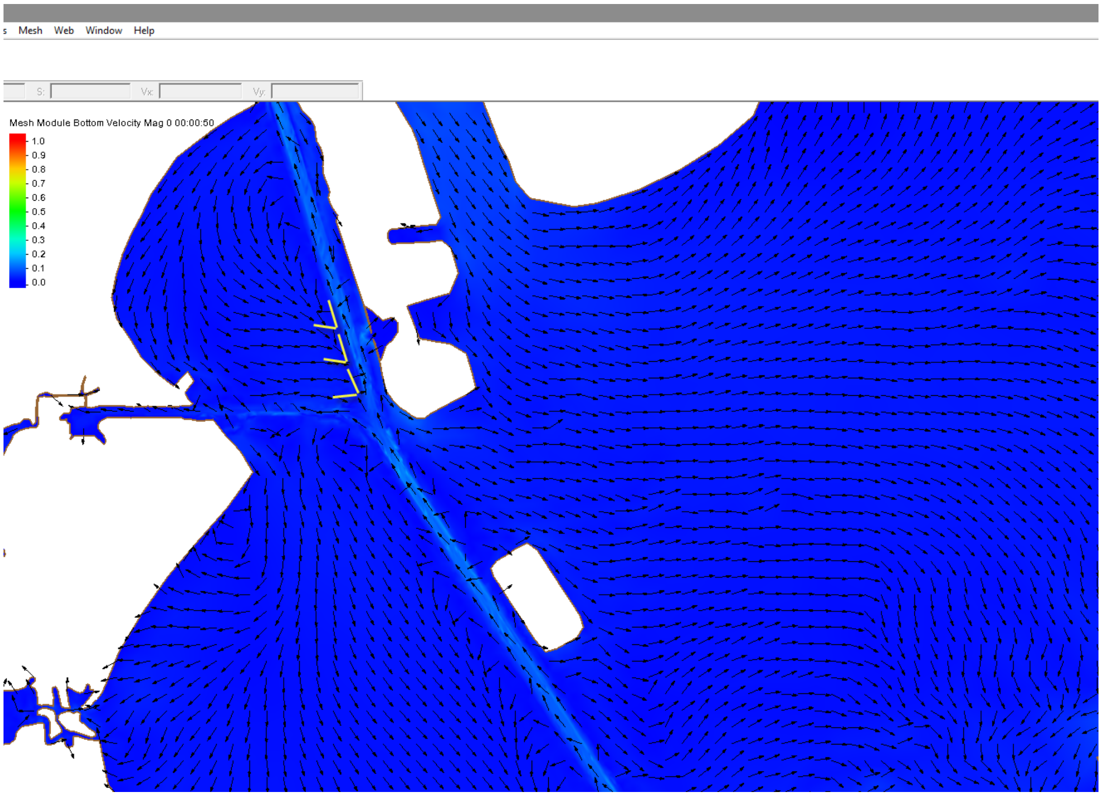


Figure 4: Bottom residual velocities with multiple chevron sediment training structures.

Two new solutions are proposed for detailed evaluation in Engineering Design, each of which is intended to reduce the counterclockwise circulation. Figure 5 shows the less costly proposed solution, which is a segmented breakwater that runs north-south from the northernmost part of the flats adjoining the HSC to about 1/4th the way to the flare, Appendix A for cost details. This structure is intended to train the downstream currents in a way that interrupts the large-scale counter-clockwise circulation such that suspended sediments are carried Southward though the ship channel, rather than entering the large circulation pattern. In addition to training the currents, the breakwaters are only slightly emergent, such that wave energy can overtop the breakwaters, but neither the energy nor entrained sediments can return to the ship channel. The breakwater segments are about 1,200 ft long, interrupted by a series of gaps of approximately 100ft to allow small-boat navigation and environmental circulation. The low energy and low current area behind the breakwater will also allow sediments generated in the upper part of the reach to settle in the wedge-shaped area rather than into the ship channel or further downstream. This option is the less costly of the two because it is relatively short, but it offers no settlement area for suspended sediments South of the end of the breakwater. Detailed analysis should be performed to determine where these suspended sediments are likely to be deposited after they are carried South in the new current circulation pattern.

The second solution proposed is shown in Figure 6. A new breakwater is proposed from the Northernmost part of the flats all the way down to the flare. The advantage of this more expensive solution is that the entire flats region is sheltered from ship wakes and currents such that it becomes a sediment deposition areas outside the ship channel. This solution is costlier as compared to the shorter breakwater, but is expected to provide better sediment detainment at a known fixed location outside the ship channel.

Figure 5: 1/4th Breakwater Concept

Figure 6: Extended Breakwater Concept

The preliminary design specifications for these breakwaters based on calculations in CEDAS are given in Table 1. These calculations assume a structure slope of 1:3.

Table 1: Breakwater Design Specifications (CEDAS)

Wave period	4.3 secs
Armor unit weight	165 lb/ft^3
Wave height	4.6 ft
Stability Coefficient	1.2 (Trunk) & 1.1(Top)
Layer Coefficient	1.02
Porosity	38%
COT of structure slope	3
Number of units comprising the layer thickness	2
Single Armor Unit Weight	11,100 lb
Minimum crest width	6.0 ft
Average layer thickness	4.0 ft
Average number of single armor units per unit surface area	340/1,000 ft^2
Single Armor Unit Weight (Top)	1,235 lb

The proposed cross-section is the same for either the longer or shorter breakwater. The breakwater is to be only marginally emergent (2ft above MSL). Emergence above the water surface is necessary to prevent a serious navigation hazard for small craft, but it is to be only marginally emergent such that wave energy and entrained sediments can pass over the breakwater out of the channel area.

The breakwater is to be fully armored on top and on the East side facing the ship channel, but the subaqueous areas on the West side would be backed by a long gentle slope of dredge tailings, stabilized using living shoreline techniques. Use of the tailings is less costly to construct because less rock armoring is required, provides additional space for placement of dredge tailings, and provides additional shallow water habitat for marine life. The low height was included in calculating the size of the rock armoring: the Van der Meer reduction factor (3) has been calculated to be 0.87, and the size of the armor units shown in Table 1 has been reduced to 87% of the value calculated using CEDAS.

REFERENCES:

1. Tate, J. N., and R. C. Berger. 2006. Houston-Galveston Navigation Channels, Texas Project: Navigation Channel Sedimentation Study, Phase 1. ERDC/CHL TR-06-8. Vicksburg, MS: U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory.

2. Tate, J. N., R. C. Berger, and C. G. Ross. 2008. Houston-Galveston Navigation Channels, Texas Project, Navigation Channel Sedimentation Study, Phase 2. ERDC/CHL TR-08-8. Vicksburg, MS: U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory.

3. Van der Meer, J.W. (1990), Verification of Breakwater for berm breakwaters and low-crested structures, Delft Hydraulics Report H986/Q638, Delft, The Netherlands.

APPENDIX A

18 October 2018

Thomas White, PhD, PE, D.CE

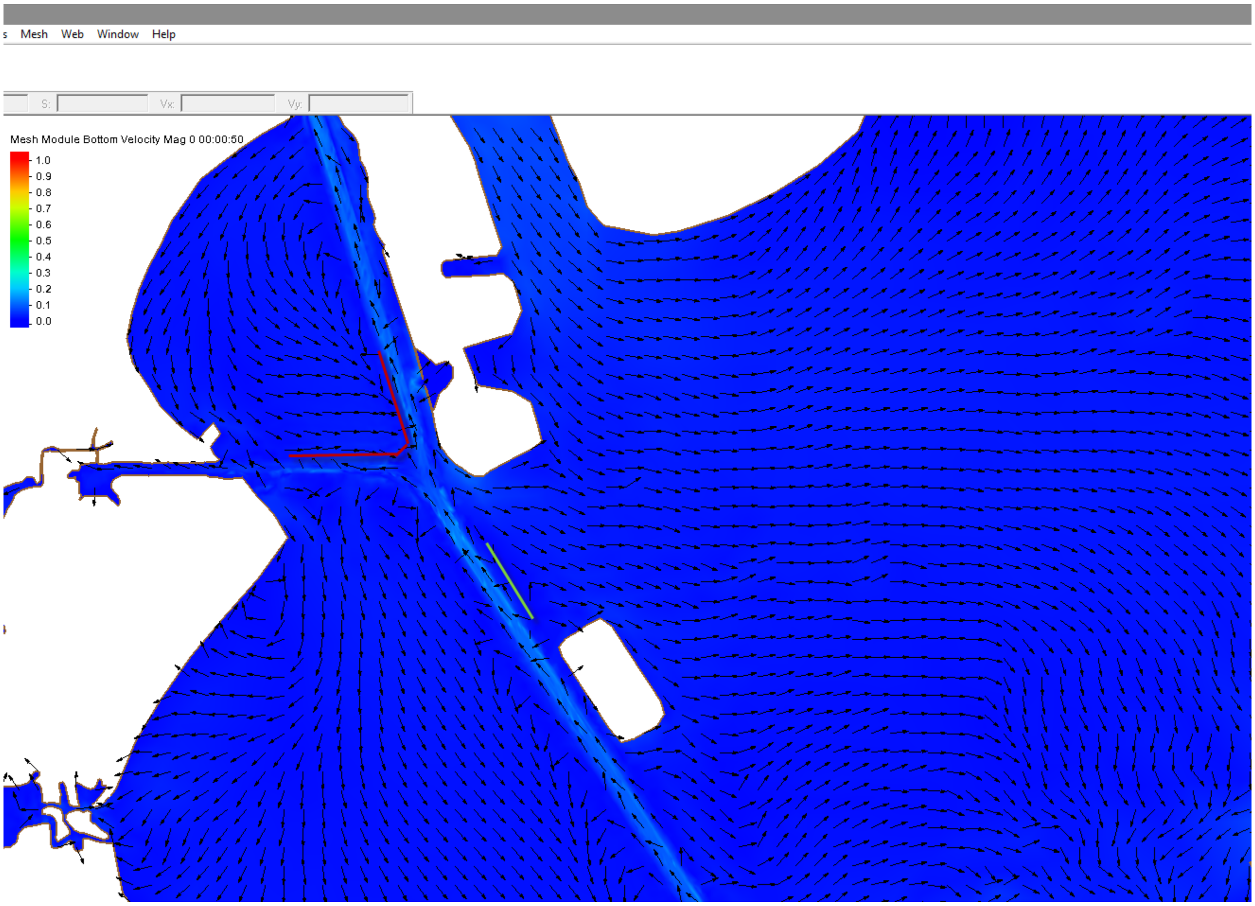
HSC Sediment Attenuation Feature

Options and Costs

Per the team’s 11 September 2018 decision to compare costs between continuing additional dredging near the Bayport Flare vs. a sediment attenuation feature, four options were examined to determine construction costs.

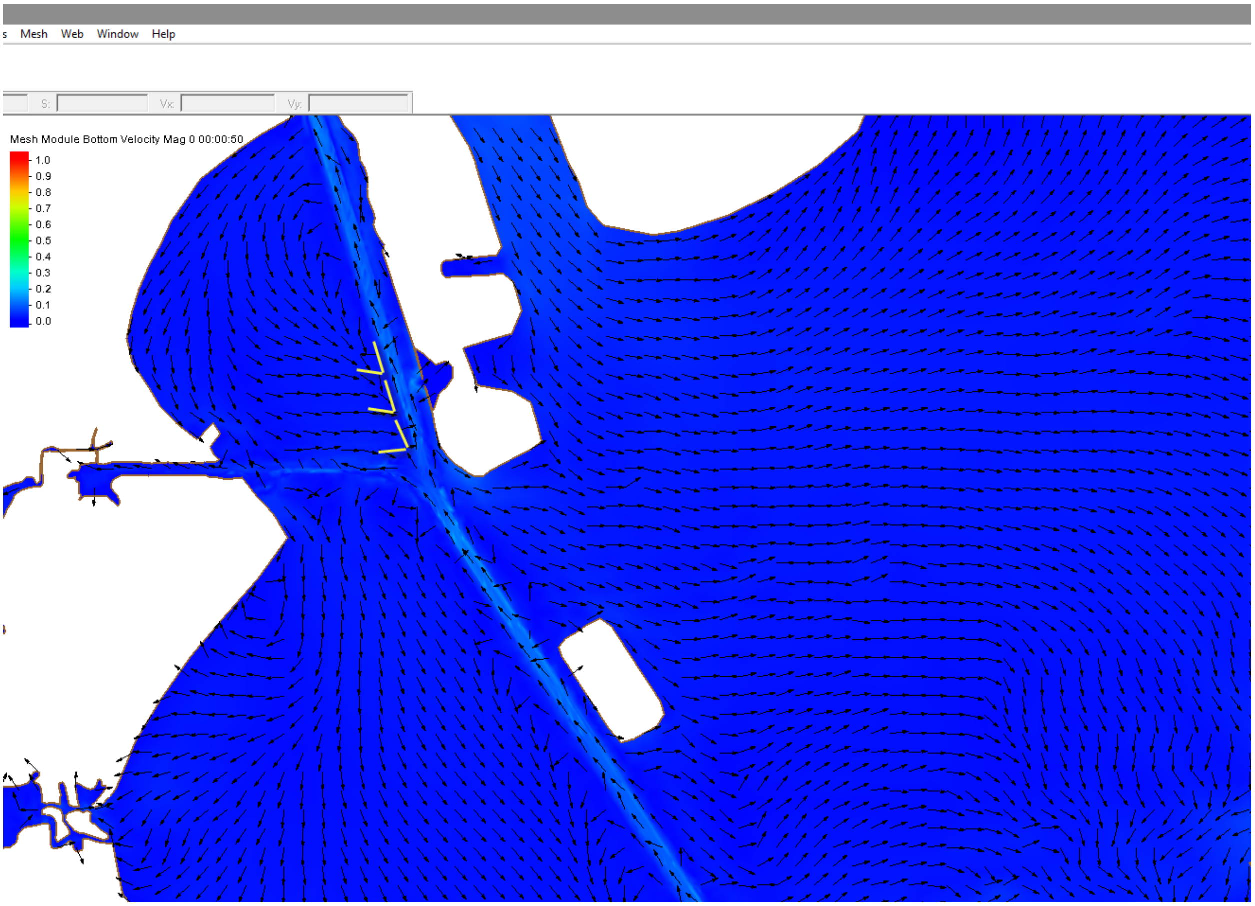
Option #1 was proposed by ERDC and consists of the triangular section shown in red and a straight section in green.

Lengths are 4858 yards for the triangle and 1817 yards for the straight section for a total length of 6675 yards.



Option #2 was proposed by ERDC and consists of 3 triangular sections shown in white.

Lengths are 2 x 3 x 877 = 5262 yards for a total length.



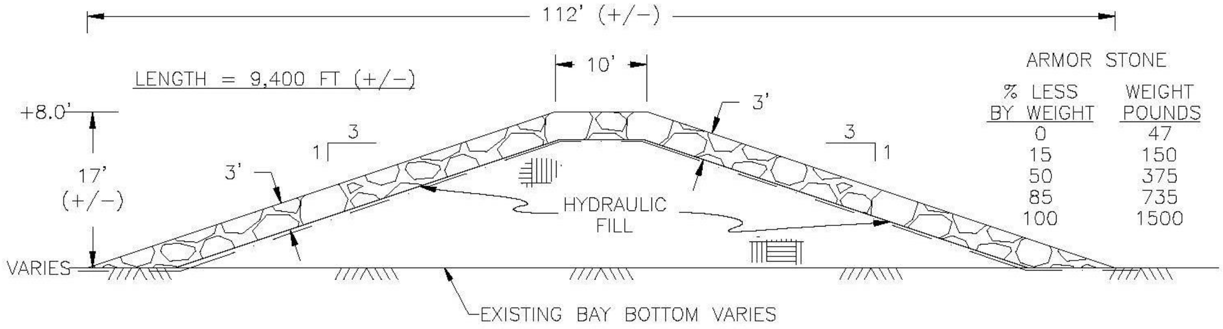
HSC Bayport Shoaling Prevention
Concept Sketch 1:
Typical Continuous Breakwater Length= 1200 ft;
Typical Gap between two breakwaters = 100ft.

Short Option #3 has a total length of 2433 yards, with length of each segment = 1200ft and typical gap of 100ft.

Long Option #4 has a total length of 7140 yards, with length of each segment = 1200ft and typical gap of 100ft.

Cross Section

The following cross-section was taken from this Feasibility Study's Engineering Appendix. In order to be able to consistently compare the four options, the same cross-section was used for all four. Most likely, this cross-section will produce an overestimate of cost, since the rock quantities are rather high, which may be considered a contingency factor.



BSC FLARE SEDIMENTATION ATTENUATION FEATURE
[CONCEPTUAL]
N.T.S.

Cross-sectional areas of the rock and sediment portions were provided by one of the team members working for the HPA, Chester Hedderman, P.E.

Rock = 322.6 ft^2, and sediment = 1400 ft^2, which includes 5ft of sediment used to vertically compress the Bay floor.

Cost Estimates

The Port's price for rock, listed in the Draft Engineering Appendix is $ 91.55/ton. In order to convert this price into a price per cubic yard, a conversion factor was computed as 166 lb/ft^3 x 27 ft^3/yd^3 / 2000 lb/ton = 2.24 ton/yd^3.

The price of the rock portion of the cross-section is then 322.6 ft^2 x $91.55/ton x 2.24 ton/yd^3 / $9ft^2/yd^2$ = 7351 $/yd.

For the sediment, the unit price is then 1400 ft^2 x $\$20/yd^3$ / $9ft^2/yd^2$ = 3112 $/yd.

Option #1 (large triangle plus straight section) is 6675yd x (7351 + 3112)$/yd = $69.8 million

Option #2 (three triangles) is 5262yd x (7351 + 3112)$/yd = $55.1 million

Option #3 (short segmented breakwater) is 2433yd x (7351 + 3112)$/yd = $25.5 million

Option #4 (long segmented breakwater) is 7140yd x (7351 + 3112)$/yd = $74.7 million

Caveats (reasons why these are likely to be overestimates of cost):

\$20/yd^3 is probably an overestimate of dredged sediment unit cost.

Gaps in the two TAMU options (#3 and #4) were ignored. (The breakwaters were assumed to be continuous.)

The cross-section is probably overdesigned in terms of how much rock is used.

Final Step

It is out of the purview of H&H to estimate excess dredging quantities near the Bayport Flare. Other disciplines should provide such estimates. The final step is to compare the attenuation feature's **annualized** cost to the excess dredging's annual cost. If the ratio is low, then such a feature is worth pursuing with modeling.

ATTACHMENT 10

CHANNEL MEASURE VOLUME REPORTS

CW1_BR-RF_700 (RECOMMENDED PLAN - LPP)							
Phase	RQD	ADV	OD	Phase	RQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
78+844.00	11,271	957	994	78+844.00			
79+000.00	11,472	953	976	79+000.00	65,701	5,516	5,693
79+500.00	9,826	839	882	79+500.00	197,202	16,586	17,208
80+000.00	8,333	726	777	80+000.00	168,136	14,483	15,360
80+500.00	6,667	649	703	80+500.00	138,883	12,728	13,705
81+000.00	4,489	552	614	81+000.00	103,298	11,117	12,197
81+500.00	3,199	504	532	81+500.00	71,188	9,771	10,614
82+000.00	1,982	407	447	82+000.00	47,966	8,436	9,067
82+500.00	1,195	337	359	82+500.00	29,411	6,890	7,458
82+605.10	1,086	327	340	82+605.10	4,440	1,291	1,360
83+000.00	1,082	316	340	83+000.00	15,860	4,704	4,973
83+500.00	1,139	334	340	83+500.00	20,567	6,023	6,297
84+000.00	993	316	340	84+000.00	19,739	6,017	6,297
84+500.00	929	314	340	84+500.00	17,795	5,833	6,297
85+000.00	946	329	340	85+000.00	17,360	5,955	6,297
85+500.00	934	306	340	85+500.00	17,405	5,875	6,297
86+000.00	842	307	340	86+000.00	16,442	5,673	6,297
86+500.00	940	333	340	86+500.00	16,499	5,922	6,297
87+000.00	892	297	340	87+000.00	16,962	5,827	6,297
87+500.00	839	315	340	87+500.00	16,029	5,659	6,297
88+000.00	824	286	340	88+000.00	15,402	5,562	6,297
88+500.00	840	314	340	88+500.00	15,413	5,559	6,297
89+000.00	786	335	340	89+000.00	15,057	6,007	6,297
89+500.00	764	308	340	89+500.00	14,346	5,947	6,295
90+000.00	758	300	340	90+000.00	14,088	5,628	6,295
90+500.00	755	310	340	90+500.00	14,012	5,646	6,297
91+000.00	785	300	340	91+000.00	14,259	5,642	6,297
91+500.00	683	296	340	91+500.00	13,587	5,514	6,292
92+000.00	643	271	329	92+000.00	12,277	5,247	6,195
92+500.00	598	253	334	92+500.00	11,498	4,853	6,145
93+000.00	611	280	340	93+000.00	11,197	4,937	6,241
93+500.00	622	261	335	93+500.00	11,411	5,008	6,249
94+000.00	642	318	340	94+000.00	11,700	5,357	6,251
94+500.00	585	284	338	94+500.00	11,365	5,575	6,279
95+000.00	494	245	339	95+000.00	9,998	4,902	6,273
95+500.00	571	280	339	95+500.00	9,866	4,861	6,285
96+000.00	799	304	340	96+000.00	12,682	5,407	6,291
96+500.00	726	284	340	96+500.00	14,113	5,446	6,297
97+000.00	876	321	340	97+000.00	14,828	5,600	6,297
97+500.00	689	308	340	97+500.00	14,493	5,825	6,297
98+000.00	664	284	340	98+000.00	12,530	5,480	6,297
98+500.00	693	288	340	98+500.00	12,559	5,290	6,297
99+000.00	797	266	337	99+000.00	13,792	5,128	6,265

99+500.00	977	277	335	99+500.00	16,426	5,028	6,218
100+000.00	1,250	301	340	100+000.00	20,617	5,352	6,250
100+500.00	1,375	289	340	100+500.00	24,305	5,465	6,297
101+000.00	1,858	324	340	101+000.00	29,938	5,682	6,297
101+500.00	1,758	322	340	101+500.00	33,482	5,985	6,297
102+000.00	1,384	315	340	102+000.00	29,092	5,903	6,297
102+500.00	1,674	330	340	102+500.00	28,316	5,973	6,297
103+000.00	1,651	313	340	103+000.00	30,788	5,948	6,297
103+500.00	1,832	314	340	103+500.00	32,247	5,803	6,294
104+000.00	1,839	310	340	104+000.00	33,990	5,775	6,293
104+500.00	1,936	318	340	104+500.00	34,954	5,815	6,296
105+000.00	1,773	302	339	105+000.00	34,339	5,743	6,288
105+500.00	1,531	301	340	105+500.00	30,585	5,587	6,288
106+000.00	1,264	289	340	106+000.00	25,874	5,466	6,297
106+500.00	1,250	274	340	106+500.00	23,276	5,210	6,295
107+000.00	1,232	264	335	107+000.00	22,985	4,979	6,245
107+500.00	1,058	263	326	107+500.00	21,210	4,880	6,120
108+000.00	1,063	242	324	108+000.00	19,645	4,680	6,021
108+500.00	1,069	219	309	108+500.00	19,747	4,274	5,856
109+000.00	1,165	221	301	109+000.00	20,686	4,074	5,644
109+500.00	1,088	211	283	109+500.00	20,863	4,000	5,407
110+000.00	1,049	239	316	110+000.00	19,788	4,171	5,549
110+500.00	1,014	221	300	110+500.00	19,104	4,262	5,701
111+000.00	1,029	220	314	111+000.00	18,917	4,083	5,682
111+500.00	1,024	226	309	111+500.00	19,008	4,131	5,771
112+000.00	459	158	273	112+000.00	13,734	3,560	5,392
112+500.00	1,022	230	315	112+500.00	13,710	3,595	5,451
113+000.00	892	247	315	113+000.00	17,719	4,421	5,835
113+500.00	777	234	308	113+500.00	15,452	4,460	5,767
114+000.00	711	223	294	114+000.00	13,776	4,237	5,578
114+500.00	625	226	294	114+500.00	12,371	4,159	5,450
115+000.00	632	199	277	115+000.00	11,641	3,937	5,293
115+500.00	503	176	241	115+500.00	10,506	3,477	4,801
116+000.00	417	166	228	116+000.00	8,511	3,170	4,346
116+500.00	357	153	224	116+500.00	7,166	2,961	4,184
117+000.00	330	140	205	117+000.00	6,362	2,720	3,965
117+500.00	403	144	214	117+500.00	6,788	2,634	3,873
118+000.00	352	139	191	118+000.00	6,994	2,619	3,745
118+500.00	407	138	185	118+500.00	7,031	2,564	3,481
119+000.00	331	119	165	119+000.00	6,840	2,378	3,240
119+500.00	317	123	174	119+500.00	6,001	2,233	3,141
120+000.00	273	118	172	120+000.00	5,459	2,232	3,207
120+500.00	242	120	174	120+500.00	4,771	2,211	3,201
121+000.00	159	130	191	121+000.00	3,719	2,316	3,376
121+500.00	253	108	162	121+500.00	3,814	2,199	3,271
122+000.00	210	119	180	122+000.00	4,285	2,095	3,173
122+500.00	341	148	196	122+500.00	5,105	2,470	3,485

123+000.00	309	162	217	123+000.00	6,021	2,871	3,827
123+500.00	267	143	197	123+500.00	5,334	2,828	3,838
124+000.00	247	139	225	124+000.00	4,761	2,614	3,910
124+500.00	273	150	216	124+500.00	4,818	2,671	4,083
125+000.00	299	184	257	125+000.00	5,299	3,088	4,384
125+500.00	504	221	292	125+500.00	7,437	3,752	5,091
126+000.00	850	265	318	126+000.00	12,535	4,500	5,648
126+500.00	865	216	260	126+500.00	15,882	4,457	5,349
126+568.83	861	214	255	126+568.83	2,200	549	656
127+000.00	2,211	282	346	127+000.00	24,526	3,963	4,796
127+500.00	3,113	381	452	127+500.00	49,290	6,137	7,391
128+000.00	4,620	567	639	128+000.00	71,596	8,774	10,108
128+500.00	5,444	696	784	128+500.00	93,183	11,699	13,176
128+731.09	5,002	768	906	128+731.09	44,705	6,265	7,229
129+000.00	4,042	641	816	129+000.00	45,038	7,014	8,573
129+500.00	2,693	492	555	129+500.00	62,359	10,489	12,691
130+000.00	1,202	335	388	130+000.00	36,067	7,656	8,727
130+500.00	322	181	220	130+500.00	14,118	4,780	5,630
130+893.36	25	62	97	130+893.36	2,531	1,773	2,314
131+000.00	26	62	93	131+000.00	100	245	376
131+500.00	16	56	96	131+500.00	388	1,097	1,756
132+000.00	41	63	104	132+000.00	527	1,104	1,856
132+500.00	5	46	76	132+500.00	428	1,004	1,667
133+000.00	-	10	51	133+000.00	50	512	1,179
133+500.00	-	18	82	133+500.00	-	256	1,233
134+000.00	-	-	5	134+000.00	-	166	802
134+500.00	-	12	119	134+500.00	-	108	1,148
135+000.00	-	14	142	135+000.00	-	238	2,421
135+500.00	-	-	98	135+500.00	-	130	2,224
136+000.00	-	-	38	136+000.00	-	-	1,260
136+229.94	-	-	30	136+229.94	-	-	290
136+500.00	-	-	29	136+500.00	-	-	296
136+968.89	-	-	41	136+968.89	-	-	609
137+000.00	-	-	41	137+000.00	-	-	47
137+500.00	-	-	94	137+500.00	-	-	1,251
137+957.12	-	56	371	137+957.12	-	476	3,933
138+000.00	8	115	423	138+000.00	6	136	630
138+369.01	52	187	557	138+369.01	411	2,060	6,698
00+282.63	-	98	487	00+282.63	274	1,490	5,466
00+500.00	-	109	470	00+500.00	-	834	3,853
01+000.00	5	232	343	01+000.00	49	3,159	7,530
01+200.00	29	205	265	01+200.00	125	1,618	2,252
01+500.00	5	73	94	01+500.00	189	1,543	1,995
01+664.57	-	-	0	01+664.57	17	222	286
02+000.00	-	-	-	02+000.00	-	-	0
02+007.37	-	-	-	02+007.37	-	-	-
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Total	2,633,553	575,918	712,659

Total NW	3,922,000

CW1_BR-RF_700 (NED)							
Phase	RQD	ADV	OD	Phase	RQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
74+119.99				74+119.99			
74+500.00	150	81	81	74+500.00	1,053	568	568
75+000.00	1,017	187	187	75+000.00	10,804	2,477	2,477
75+500.00	2,333	293	293	75+500.00	31,018	4,443	4,443
76+000.00	3,582	372	399	76+000.00	54,764	6,161	6,409
76+500.00	5,421	476	505	76+500.00	83,356	7,859	8,375
77+000.00	6,735	610	611	77+000.00	112,548	10,055	10,340
77+500.00	8,410	713	718	77+500.00	140,223	12,243	12,306
78+000.00	9,686	822	824	78+000.00	167,548	14,210	14,272
78+500.00	11,039	930	930	78+500.00	191,895	16,221	16,238
78+844.00	11,271	957	994	78+844.00	142,124	12,016	12,258
79+000.00	11,472	953	976	79+000.00	65,701	5,516	5,693
79+500.00	9,826	839	882	79+500.00	197,202	16,586	17,208
80+000.00	8,333	726	777	80+000.00	168,136	14,483	15,360
80+500.00	6,667	649	703	80+500.00	138,883	12,728	13,705
81+000.00	4,489	552	614	81+000.00	103,298	11,117	12,197
81+500.00	3,199	504	532	81+500.00	71,188	9,771	10,614
82+000.00	1,982	407	447	82+000.00	47,966	8,436	9,067
82+500.00	1,195	337	359	82+500.00	29,411	6,890	7,458
82+605.10	1,086	327	340	82+605.10	4,440	1,291	1,360
83+000.00	1,082	316	340	83+000.00	15,860	4,704	4,973
83+500.00	1,139	334	340	83+500.00	20,567	6,023	6,297
84+000.00	993	316	340	84+000.00	19,739	6,017	6,297
84+500.00	929	314	340	84+500.00	17,795	5,833	6,297
85+000.00	946	329	340	85+000.00	17,360	5,955	6,297
85+500.00	934	306	340	85+500.00	17,405	5,875	6,297
86+000.00	842	307	340	86+000.00	16,442	5,673	6,297
86+500.00	940	333	340	86+500.00	16,499	5,922	6,297
87+000.00	892	297	340	87+000.00	16,962	5,827	6,297
87+500.00	839	315	340	87+500.00	16,029	5,659	6,297
88+000.00	824	286	340	88+000.00	15,402	5,562	6,297
88+500.00	840	314	340	88+500.00	15,413	5,559	6,297
89+000.00	786	335	340	89+000.00	15,057	6,007	6,297
89+500.00	764	308	340	89+500.00	14,346	5,947	6,295
90+000.00	758	300	340	90+000.00	14,088	5,628	6,295
90+500.00	755	310	340	90+500.00	14,012	5,646	6,297
91+000.00	785	300	340	91+000.00	14,259	5,642	6,297
91+500.00	683	296	340	91+500.00	13,587	5,514	6,292
92+000.00	643	271	329	92+000.00	12,277	5,247	6,195
92+500.00	598	253	334	92+500.00	11,498	4,853	6,145
93+000.00	611	280	340	93+000.00	11,197	4,937	6,241
93+500.00	622	261	335	93+500.00	11,411	5,008	6,249
94+000.00	642	318	340	94+000.00	11,700	5,357	6,251

94+500.00	585	284	338	94+500.00	11,365	5,575	6,279
95+000.00	494	245	339	95+000.00	9,998	4,902	6,273
95+500.00	571	280	339	95+500.00	9,866	4,861	6,285
96+000.00	799	304	340	96+000.00	12,682	5,407	6,291
96+500.00	726	284	340	96+500.00	14,113	5,446	6,297
97+000.00	876	321	340	97+000.00	14,828	5,600	6,297
97+500.00	689	308	340	97+500.00	14,493	5,825	6,297
98+000.00	664	284	340	98+000.00	12,530	5,480	6,297
98+500.00	693	288	340	98+500.00	12,559	5,290	6,297
99+000.00	797	266	337	99+000.00	13,792	5,128	6,265
99+500.00	977	277	335	99+500.00	16,426	5,028	6,218
100+000.00	1,250	301	340	100+000.00	20,617	5,352	6,250
100+500.00	1,375	289	340	100+500.00	24,305	5,465	6,297
101+000.00	1,858	324	340	101+000.00	29,938	5,682	6,297
101+500.00	1,758	322	340	101+500.00	33,482	5,985	6,297
102+000.00	1,384	315	340	102+000.00	29,092	5,903	6,297
102+500.00	1,674	330	340	102+500.00	28,316	5,973	6,297
103+000.00	1,651	313	340	103+000.00	30,788	5,948	6,297
103+500.00	1,832	314	340	103+500.00	32,247	5,803	6,294
104+000.00	1,839	310	340	104+000.00	33,990	5,775	6,293
104+500.00	1,936	318	340	104+500.00	34,954	5,815	6,296
105+000.00	1,773	302	339	105+000.00	34,339	5,743	6,288
105+500.00	1,531	301	340	105+500.00	30,585	5,587	6,288
106+000.00	1,264	289	340	106+000.00	25,874	5,466	6,297
106+500.00	1,250	274	340	106+500.00	23,276	5,210	6,295
107+000.00	1,232	264	335	107+000.00	22,985	4,979	6,245
107+500.00	1,058	263	326	107+500.00	21,210	4,880	6,120
108+000.00	1,063	242	324	108+000.00	19,645	4,680	6,021
108+500.00	1,069	219	309	108+500.00	19,747	4,274	5,856
109+000.00	1,165	221	301	109+000.00	20,686	4,074	5,644
109+500.00	1,088	211	283	109+500.00	20,863	4,000	5,407
110+000.00	1,049	239	316	110+000.00	19,788	4,171	5,549
110+500.00	1,014	221	300	110+500.00	19,104	4,262	5,701
111+000.00	1,029	220	314	111+000.00	18,917	4,083	5,682
111+500.00	1,024	226	309	111+500.00	19,008	4,131	5,771
112+000.00	459	158	273	112+000.00	13,734	3,560	5,392
112+500.00	1,022	230	315	112+500.00	13,710	3,595	5,451
113+000.00	892	247	315	113+000.00	17,719	4,421	5,835
113+500.00	777	234	308	113+500.00	15,452	4,460	5,767
114+000.00	711	223	294	114+000.00	13,776	4,237	5,578
114+500.00	625	226	294	114+500.00	12,371	4,159	5,450
115+000.00	632	199	277	115+000.00	11,641	3,937	5,293
115+500.00	503	176	241	115+500.00	10,506	3,477	4,801
116+000.00	417	166	228	116+000.00	8,511	3,170	4,346
116+500.00	357	153	224	116+500.00	7,166	2,961	4,184
117+000.00	330	140	205	117+000.00	6,362	2,720	3,965
117+500.00	403	144	214	117+500.00	6,788	2,634	3,873

118+000.00	352	139	191	118+000.00	6,994	2,619	3,745
118+500.00	407	138	185	118+500.00	7,031	2,564	3,481
119+000.00	331	119	165	119+000.00	6,840	2,378	3,240
119+500.00	317	123	174	119+500.00	6,001	2,233	3,141
120+000.00	273	118	172	120+000.00	5,459	2,232	3,207
120+500.00	242	120	174	120+500.00	4,771	2,211	3,201
121+000.00	159	130	191	121+000.00	3,719	2,316	3,376
121+500.00	253	108	162	121+500.00	3,814	2,199	3,271
122+000.00	210	119	180	122+000.00	4,285	2,095	3,173
122+500.00	341	148	196	122+500.00	5,105	2,470	3,485
123+000.00	309	162	217	123+000.00	6,021	2,871	3,827
123+500.00	267	143	197	123+500.00	5,334	2,828	3,838
124+000.00	247	139	225	124+000.00	4,761	2,614	3,910
124+500.00	273	150	216	124+500.00	4,818	2,671	4,083
125+000.00	299	184	257	125+000.00	5,299	3,088	4,384
125+500.00	504	221	292	125+500.00	7,437	3,752	5,091
126+000.00	850	265	318	126+000.00	12,535	4,500	5,648
126+500.00	865	216	260	126+500.00	15,882	4,457	5,349
126+568.83	861	214	255	126+568.83	2,200	549	656
127+000.00	2,211	282	346	127+000.00	24,526	3,963	4,796
127+500.00	3,113	381	452	127+500.00	49,290	6,137	7,391
128+000.00	4,620	567	639	128+000.00	71,596	8,774	10,108
128+500.00	5,444	696	784	128+500.00	93,183	11,699	13,176
128+731.09	5,002	768	906	128+731.09	44,705	6,265	7,229
129+000.00	4,042	641	816	129+000.00	45,038	7,014	8,573
129+500.00	2,693	492	555	129+500.00	62,359	10,489	12,691
130+000.00	1,202	335	388	130+000.00	36,067	7,656	8,727
130+500.00	322	181	220	130+500.00	14,118	4,780	5,630
130+893.36	25	62	97	130+893.36	2,531	1,773	2,314
131+000.00	26	62	93	131+000.00	100	245	376
131+500.00	16	56	96	131+500.00	388	1,097	1,756
132+000.00	41	63	104	132+000.00	527	1,104	1,856
132+500.00	5	46	76	132+500.00	428	1,004	1,667
133+000.00	-	10	51	133+000.00	50	512	1,179
133+500.00	-	18	82	133+500.00	-	256	1,233
134+000.00	-	-	5	134+000.00	-	166	802
134+500.00	-	12	119	134+500.00	-	108	1,148
135+000.00	-	14	142	135+000.00	-	238	2,421
135+500.00	-	-	98	135+500.00	-	130	2,224
136+000.00	-	-	38	136+000.00	-	-	1,260
136+229.94	-	-	30	136+229.94	-	-	290
136+500.00	-	-	29	136+500.00	-	-	296
136+968.89	-	-	41	136+968.89	-	-	609
137+000.00	-	-	41	137+000.00	-	-	47
137+500.00	-	-	94	137+500.00	-	-	1,251
137+957.12	-	56	371	137+957.12	-	476	3,933
138+000.00	8	115	423	138+000.00	6	136	630

138+369.01	52	187	557	138+369.01	411	2,060	6,698
00+282.63	-	98	487	00+282.63	274	1,490	5,466
00+500.00	-	109	470	00+500.00	-	834	3,853
01+000.00	5	232	343	01+000.00	49	3,159	7,530
01+200.00	29	205	265	01+200.00	125	1,618	2,252
01+500.00	5	73	94	01+500.00	189	1,543	1,995
01+664.57	-	-	0	01+664.57	17	222	286
02+000.00	-	-	-	02+000.00	-	-	0
02+007.37	-	-	-	02+007.37	-	-	-
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				Total	3,568,886	662,171	800,344

Total NW	5,031,000

CW1_BSC-BCC_700													
Phase	RQD	RQD	ADV	ADV	OD	OD	Phase	RQD	RQD	ADV	ADV	OD	OD
Material	MAINT	NW	MAINT	NW	MAINT	NW	Material	MAINT	NW	MAINT	NW	MAINT	NW
Station	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3	yd3	yd3	yd3
-0+003.94		3,713	71	337	183	340	-0+003.94		-	-	-	-	-
0+500.00	52	3,275	109	324	249	340	0+500.00	485	65,212	1,678	6,164	4,029	6,346
1+000.00	125	3,974	193	340	391	340	1+000.00	1,643	67,120	2,799	6,146	5,921	6,297
1+500.00	249	4,480	238	340	423	340	1+500.00	3,467	78,285	3,992	6,297	7,532	6,297
2+000.00	430	4,777	216	340	407	340	2+000.00	6,289	85,719	4,205	6,297	7,683	6,297
2+500.00	241	4,832	232	340	402	340	2+500.00	6,212	88,972	4,148	6,297	7,495	6,297
3+000.00	155	3,657	263	340	449	340	3+000.00	3,664	78,600	4,579	6,297	7,886	6,297
3+500.00	175	3,729	270	340	421	340	3+500.00	3,058	68,392	4,931	6,297	8,053	6,297
3+899.98	147	4,405	270	340	426	340	3+899.98	2,389	60,248	3,997	5,037	6,273	5,037
3+900.00	147	4,404	270	340	426	340	3+900.00	0	3	0	0	0	0
3+900.01	147	4,404	270	340	426	340	3+900.01	0	2	0	0	0	0
4+000.00	133	4,542	260	340	443	340	4+000.00	519	16,567	981	1,259	1,609	1,259
4+099.98	117	4,612	249	340	441	340	4+099.98	464	16,949	942	1,259	1,637	1,259
4+100.00	117	4,611	249	340	441	340	4+100.00	0	3	0	0	0	0
4+100.01	117	4,611	249	340	441	340	4+100.01	-	2	0	0	0	0
4+500.00	272	4,382	241	340	445	340	4+500.00	2,885	66,617	3,629	5,037	6,566	5,037
5+000.00	224	3,935	265	340	471	340	5+000.00	4,601	77,015	4,684	6,297	8,489	6,297
5+500.00	116	4,035	253	340	479	340	5+500.00	3,153	73,802	4,797	6,297	8,799	6,297
6+000.00	181	4,597	275	340	506	340	6+000.00	2,752	79,923	4,894	6,297	9,119	6,297
6+500.00	267	4,296	259	340	491	340	6+500.00	4,153	82,336	4,944	6,297	9,232	6,297
7+000.00	322	4,752	287	340	460	340	7+000.00	5,453	83,779	5,055	6,297	8,808	6,297
7+500.00	270	4,605	274	340	486	340	7+500.00	5,479	86,642	5,194	6,297	8,760	6,297
8+000.00	144	4,234	257	340	482	340	8+000.00	3,839	81,846	4,917	6,297	8,961	6,297
8+500.00	191	4,615	260	340	472	340	8+500.00	3,107	81,942	4,789	6,297	8,830	6,297
9+000.00	273	4,519	301	340	504	340	9+000.00	4,296	84,573	5,196	6,297	9,038	6,297
9+500.00	189	4,619	295	340	445	340	9+500.00	4,274	84,612	5,524	6,297	8,794	6,297
10+000.00	117	4,255	273	340	471	340	10+000.00	2,836	82,168	5,264	6,297	8,485	6,297
10+500.00	144	4,285	251	340	438	340	10+500.00	2,419	79,069	4,857	6,297	8,421	6,297
11+000.00	149	4,533	236	340	420	340	11+000.00	2,710	81,650	4,509	6,297	7,951	6,297
11+500.00	137	4,431	242	340	438	340	11+500.00	2,645	83,002	4,426	6,297	7,948	6,297
12+000.00	175	4,516	291	340	453	340	12+000.00	2,887	82,841	4,940	6,297	8,255	6,297
12+500.00	161	4,379	295	340	452	340	12+500.00	3,112	82,365	5,428	6,297	8,388	6,297
13+000.00	146	4,056	313	340	479	340	13+000.00	2,846	78,106	5,630	6,297	8,622	6,297
13+500.00	92	4,088	277	340	446	340	13+500.00	2,206	75,405	5,460	6,297	8,561	6,297
14+000.00	141	3,489	282	340	414	340	14+000.00	2,160	70,153	5,172	6,297	7,958	6,297
14+500.00	176	4,216	251	340	386	340	14+500.00	2,943	71,339	4,933	6,297	7,404	6,297
15+000.00	251	4,330	233	340	388	340	15+000.00	3,958	79,130	4,484	6,297	7,165	6,297
15+500.00	102	3,963	216	340	393	340	15+500.00	3,268	76,792	4,165	6,297	7,225	6,297
16+000.00	52	3,843	201	340	380	340	16+000.00	1,426	72,276	3,861	6,297	7,155	6,297
16+500.00	48	3,925	201	340	359	340	16+500.00	929	71,918	3,720	6,297	6,845	6,297
17+000.00	28	3,925	185	340	368	340	17+000.00	701	72,685	3,576	6,297	6,737	6,297
17+500.00	8	4,124	184	340	367	340	17+500.00	331	74,528	3,416	6,297	6,806	6,297
18+000.00	35	3,313	203	340	378	340	18+000.00	396	68,857	3,587	6,297	6,894	6,297
18+500.00	35	4,128	186	340	369	340	18+500.00	641	68,894	3,603	6,297	6,919	6,297
19+000.00	75	4,330	256	340	448	340	19+000.00	1,011	78,315	4,089	6,297	7,571	6,297
19+500.00	130	4,012	310	340	462	340	19+500.00	1,897	77,239	5,243	6,297	8,431	6,297
20+000.00	196	4,354	336	340	471	340	20+000.00	3,020	77,454	5,982	6,297	8,637	6,297
20+500.00	111	3,827	261	340	439	340	20+500.00	2,846	75,747	5,529	6,297	8,418	6,297
21+000.00	32	3,913	213	340	400	340	21+000.00	1,330	71,669	4,395	6,297	7,764	6,297
21+500.00	26	3,883	185	340	413	340	21+500.00	535	72,185	3,688	6,293	7,524	6,297
22+000.00	28	4,074	187	340	407	340	22+000.00	499	73,671	3,444	6,290	7,590	6,297
22+500.00	41	3,522	169	340	371	340	22+500.00	639	70,326	3,293	6,294	7,208	6,297
23+000.00	81	3,528	239	340	406	340	23+000.00	1,125	65,271	3,772	6,297	7,198	6,297
23+500.00	100	3,464	244	340	394	340	23+500.00	1,671	64,737	4,467	6,297	7,406	6,297
24+000.00	209	3,114	156	283	317	331	24+000.00	2,857	60,907	3,706	5,771	6,585	6,215
24+052.37	281	2,911	174	267	311	279	24+052.37	475	5,843	321	534	610	591
24+052.38	281	2,910	174	267	311	279	24+052.38	0	1	0	0	0	0
24+052.40	281	2,910	174	267	311	279	24+052.40	0	2	0	0	0	0
24+500.00	493	1,542	273	340	440	340	24+500.00	6,415	36,903	3,706	5,033	6,226	5,128
25+000.00	609	1,708	376	340	525	340	25+000.00	10,199	30,094	6,013	6,296	8,940	6,297
25+500.00	641	1,846	393	340	541	340	25+500.00	11,570	32,911	7,123	6,297	9,878	6,297

26+000.00	528	1,858	341	340	497	340	26+000.00	10,825	34,299	6,799	6,297	9,616	6,297
26+153.63	509	1,796	243	288	437	340	26+153.63	2,950	10,395	1,664	1,787	2,659	1,935
26+156.06	508	1,806	243	286	436	340	26+156.06	46	162	22	26	39	31
26+500.00	355	3,209	169	265	243	380	26+500.00	5,495	31,944	2,620	3,509	4,325	4,589
27+000.00	150	5,560	128	570	276	572	27+000.00	4,680	81,195	2,749	7,734	4,810	8,821
27+416.64	81	8,579	142	687	301	687	27+416.64	1,788	109,087	2,082	9,697	4,453	9,715
27+416.67	81	8,579	142	687	301	687	27+416.67	0	10	0	1	0	1
27+500.00	80	9,282	141	709	307	710	27+500.00	249	27,563	436	2,153	938	2,155
28+000.00	182	11,845	244	847	393	847	28+000.00	2,426	195,618	3,566	14,407	6,478	14,418
28+500.00	424	14,576	246	985	397	985	28+500.00	5,609	244,637	4,536	16,965	7,312	16,966
28+604.06	498	15,066	263	994	334	1037	28+604.06	1,776	57,119	981	3,813	1,409	3,896
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							Total	192,530	4,565,636	257,128	385,958	443,273	389,354

Total NW 5,341,000

CW1_RF-BSC_700							
Phase	RQD	ADV	OD	Phase	RQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
28+604.06	15,066	994	1,037	28+604.06			
28+605.04	14,559	988	860	28+605.04	543	36	35
28+605.06	14,657	998	866	28+605.06	6	0	0
28+605.06	14,959	993	892	28+605.06	0	-	-
28+605.06	14,711	993	1,140	28+605.06	0	-	-
28+605.07	14,280	988	1,149	28+605.07	5	0	0
29+000.00	13,673	905	905	29+000.00	204,439	13,849	15,023
29+500.00	11,736	768	768	29+500.00	235,274	15,488	15,489
30+000.00	9,326	630	630	30+000.00	195,024	12,941	12,941
30+500.00	6,772	492	492	30+500.00	149,059	10,393	10,394
31+000.00	4,269	355	355	31+000.00	102,235	7,846	7,846
31+054.05	3,950	340	340	31+054.05	8,227	696	696
31+056.48	3,941	340	340	31+056.48	356	31	31
31+500.00	3,678	340	340	31+500.00	62,577	5,585	5,586
32+000.00	3,925	340	340	32+000.00	70,390	6,297	6,297
32+500.00	3,909	340	340	32+500.00	72,530	6,297	6,297
33+000.00	3,828	340	340	33+000.00	71,632	6,294	6,297
33+500.00	3,794	340	340	33+500.00	70,569	6,294	6,297
34+000.00	3,907	340	340	34+000.00	71,306	6,297	6,297
34+500.00	3,999	340	340	34+500.00	73,205	6,297	6,297
35+000.00	3,879	340	340	35+000.00	72,941	6,297	6,297
35+500.00	4,281	340	340	35+500.00	75,551	6,297	6,297
36+000.00	3,889	340	340	36+000.00	75,644	6,297	6,297
36+500.00	3,826	340	340	36+500.00	71,435	6,297	6,297
37+000.00	3,565	340	340	37+000.00	68,436	6,297	6,297
37+500.00	3,909	340	340	37+500.00	69,207	6,297	6,297
38+000.00	3,733	335	340	38+000.00	70,759	6,252	6,297
38+500.00	3,760	340	340	38+500.00	69,377	6,252	6,297
39+000.00	3,325	340	340	39+000.00	65,608	6,297	6,297
39+500.00	3,340	340	340	39+500.00	61,714	6,297	6,297
40+000.00	3,534	340	340	40+000.00	63,649	6,297	6,297
40+500.00	3,960	340	340	40+500.00	69,391	6,297	6,297
41+000.00	3,820	340	340	41+000.00	72,038	6,297	6,297
41+500.00	3,806	340	340	41+500.00	70,613	6,293	6,297
42+000.00	4,113	340	340	42+000.00	73,324	6,293	6,297
42+500.00	3,677	340	340	42+500.00	72,135	6,297	6,297
43+000.00	4,053	340	340	43+000.00	71,581	6,297	6,297
43+500.00	3,903	340	340	43+500.00	73,667	6,293	6,297
44+000.00	3,726	340	340	44+000.00	70,631	6,293	6,297
44+500.00	3,725	340	340	44+500.00	68,988	6,297	6,297
45+000.00	3,374	340	340	45+000.00	65,732	6,297	6,297
45+500.00	3,870	340	340	45+500.00	67,075	6,297	6,297
46+000.00	3,412	340	340	46+000.00	67,426	6,297	6,297

46+500.00	2,963	340	340	46+500.00	59,025	6,297	6,297
47+000.00	2,945	340	340	47+000.00	54,704	6,297	6,297
47+500.00	2,888	340	340	47+500.00	54,008	6,297	6,297
48+000.00	3,228	340	340	48+000.00	56,626	6,297	6,297
48+500.00	3,589	340	340	48+500.00	63,116	6,297	6,297
49+000.00	3,559	340	340	49+000.00	66,180	6,297	6,297
49+500.00	3,571	340	340	49+500.00	66,018	6,297	6,297
50+000.00	3,610	340	340	50+000.00	66,495	6,297	6,297
50+500.00	3,787	340	340	50+500.00	68,490	6,297	6,297
51+000.00	3,857	340	340	51+000.00	70,777	6,297	6,297
51+500.00	4,024	340	340	51+500.00	72,979	6,297	6,297
52+000.00	3,827	340	340	52+000.00	72,699	6,297	6,297
52+500.00	3,812	340	340	52+500.00	70,731	6,297	6,297
53+000.00	3,780	340	340	53+000.00	70,295	6,297	6,297
53+500.00	3,834	340	340	53+500.00	70,505	6,297	6,297
54+000.00	3,603	340	340	54+000.00	68,861	6,297	6,297
54+500.00	3,670	340	340	54+500.00	67,337	6,297	6,297
55+000.00	3,574	340	340	55+000.00	67,068	6,297	6,297
55+500.00	3,518	340	340	55+500.00	65,661	6,297	6,297
56+000.00	3,471	340	340	56+000.00	64,707	6,297	6,297
56+500.00	3,320	340	340	56+500.00	62,877	6,297	6,297
57+000.00	3,228	340	340	57+000.00	60,631	6,297	6,297
57+500.00	2,994	340	340	57+500.00	57,612	6,297	6,297
58+000.00	2,863	340	340	58+000.00	54,231	6,297	6,297
58+500.00	3,610	340	340	58+500.00	59,935	6,297	6,297
59+000.00	3,015	340	340	59+000.00	61,346	6,297	6,297
59+500.00	3,243	340	340	59+500.00	57,945	6,297	6,297
60+000.00	3,146	340	340	60+000.00	59,153	6,297	6,297
60+500.00	3,076	340	340	60+500.00	57,608	6,297	6,297
61+000.00	3,192	340	340	61+000.00	58,037	6,297	6,297
61+500.00	3,446	340	340	61+500.00	61,463	6,297	6,297
62+000.00	3,529	340	340	62+000.00	64,588	6,297	6,297
62+500.00	3,508	338	340	62+500.00	65,162	6,280	6,297
63+000.00	3,796	332	340	63+000.00	67,626	6,208	6,297
63+500.00	3,672	340	340	63+500.00	69,148	6,224	6,297
64+000.00	3,172	340	340	64+000.00	63,375	6,296	6,297
64+500.00	3,532	340	340	64+500.00	62,077	6,297	6,297
65+000.00	3,304	340	340	65+000.00	63,297	6,297	6,297
65+500.00	3,170	340	340	65+500.00	59,939	6,297	6,297
66+000.00	3,080	340	340	66+000.00	57,862	6,296	6,297
66+500.00	2,791	340	340	66+500.00	54,356	6,296	6,297
67+000.00	2,634	340	340	67+000.00	50,232	6,297	6,297
67+500.00	2,542	340	340	67+500.00	47,924	6,296	6,297
68+000.00	2,865	340	340	68+000.00	50,057	6,296	6,297
68+500.00	2,695	340	340	68+500.00	51,481	6,297	6,297
69+000.00	2,788	340	340	69+000.00	50,768	6,297	6,297
69+500.00	2,583	337	340	69+500.00	49,726	6,269	6,297

70+000.00	2,426	331	340	70+000.00	46,376	6,186	6,297
70+500.00	2,578	340	340	70+500.00	46,332	6,213	6,297
71+000.00	2,464	337	340	71+000.00	46,687	6,265	6,297
71+500.00	2,116	340	340	71+500.00	42,404	6,265	6,297
72+000.00	2,306	330	340	72+000.00	40,937	6,206	6,297
72+500.00	2,611	340	340	72+500.00	45,524	6,206	6,297
73+000.00	2,433	340	340	73+000.00	46,701	6,297	6,297
73+500.00	2,574	340	340	73+500.00	46,362	6,297	6,297
74+000.00	2,354	340	340	74+000.00	45,630	6,297	6,297
74+500.00	2,404	340	340	74+500.00	44,053	6,297	6,297
75+000.00	2,177	340	340	75+000.00	42,422	6,297	6,297
75+085.11	2,166	340	340	75+085.11	6,846	1,072	1,072
75+086.67	2,167	340	340	75+086.67	125	20	20
75+500.00	3,441	413	413	75+500.00	42,927	5,764	5,764
76+000.00	4,779	475	501	76+000.00	76,108	8,218	8,466
76+500.00	5,962	561	590	76+500.00	99,456	9,585	10,100
77+000.00	6,881	676	678	77+000.00	118,918	11,450	11,735
77+500.00	8,516	761	766	77+500.00	142,561	13,306	13,370
78+000.00	9,811	853	854	78+000.00	169,694	14,943	15,004
78+500.00	11,187	942	943	78+500.00	194,432	16,622	16,639
78+844.00	11,260	956	994	78+844.00	142,998	12,093	12,335
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				Total	7,376,524	706,980	710,373

Total NW	8,794,000

CW2_BSC_455							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
25+58.69	4,515	209	210	25+58.69	-	-	
26+00.00	4,536	168	177	26+00.00	6,924	288	296
27+00.00	4,422	176	185	27+00.00	16,588	637	672
28+00.00	4,494	177	184	28+00.00	16,510	654	684
29+00.00	4,227	176	183	29+00.00	16,151	653	680
30+00.00	4,395	176	183	30+00.00	15,967	651	678
31+00.00	4,314	174	182	31+00.00	16,127	647	676
32+00.00	4,611	175	183	32+00.00	16,526	646	675
33+00.00	5,181	188	199	33+00.00	18,133	673	707
34+00.00	4,783	195	208	34+00.00	18,452	709	754
35+00.00	4,072	177	188	35+00.00	16,398	689	733
36+00.00	4,418	181	187	36+00.00	15,722	664	695
37+00.00	4,476	182	187	37+00.00	16,470	673	693
38+00.00	4,486	172	180	38+00.00	16,596	656	680
39+00.00	4,461	177	185	39+00.00	16,569	645	676
40+00.00	4,381	176	189	40+00.00	16,375	654	692
41+00.00	4,285	180	191	41+00.00	16,049	660	703
42+00.00	3,913	182	190	42+00.00	15,181	671	705
43+00.00	2,954	186	193	43+00.00	12,716	681	708
43+50.00	1,981	187	195	43+50.00	4,569	345	359
44+00.00	1,717	180	191	44+00.00	3,424	340	357
45+00.00	1,632	177	189	45+00.00	6,202	661	704
46+00.00	1,659	169	180	46+00.00	6,095	640	682
47+00.00	1,661	169	180	47+00.00	6,148	625	666
48+00.00	1,657	169	179	48+00.00	6,144	626	664
49+00.00	1,717	178	186	49+00.00	6,248	642	676
50+00.00	1,602	172	183	50+00.00	6,148	649	684
51+00.00	1,670	177	185	51+00.00	6,061	648	682
52+00.00	1,633	177	187	52+00.00	6,118	655	689
53+00.00	1,696	176	188	53+00.00	6,165	653	694
54+00.00	1,750	182	190	54+00.00	6,381	663	700
55+00.00	1,751	181	192	55+00.00	6,483	673	708
56+00.00	1,894	178	184	56+00.00	6,750	666	697
57+00.00	2,070	179	186	57+00.00	7,340	662	685
58+00.00	2,072	177	184	58+00.00	7,671	660	684
59+00.00	2,074	171	181	59+00.00	7,678	645	676
60+00.00	2,189	172	182	60+00.00	7,893	635	673
61+00.00	2,300	174	182	61+00.00	8,312	641	674
62+00.00	2,384	172	184	62+00.00	8,674	641	676
63+00.00	2,618	166	184	63+00.00	9,264	625	681
64+00.00	4,005	172	185	64+00.00	12,266	627	683
65+00.00	4,850	177	186	65+00.00	16,398	646	687
66+00.00	5,422	182	187	66+00.00	19,022	663	690

67+00.00	5,265	173	179	67+00.00	19,791	656	678
68+00.00	5,300	178	186	68+00.00	19,564	650	676
69+00.00	5,166	178	185	69+00.00	19,381	660	687
70+00.00	4,759	176	182	70+00.00	18,381	656	679
71+00.00	3,936	178	184	71+00.00	16,103	655	677
72+00.00	4,587	180	192	72+00.00	15,783	662	697
73+00.00	4,489	185	199	73+00.00	16,806	675	724
74+00.00	4,366	181	194	74+00.00	16,398	676	728
75+00.00	4,271	175	180	75+00.00	15,996	659	692
76+00.00	4,299	183	188	76+00.00	15,870	662	682
77+00.00	3,896	181	188	77+00.00	15,175	674	697
78+00.00	3,616	174	182	78+00.00	13,911	657	686
79+00.00	3,551	173	181	79+00.00	13,273	642	674
80+00.00	3,608	173	181	80+00.00	13,258	641	671
81+00.00	3,873	172	180	81+00.00	13,854	640	670
82+00.00	4,325	171	181	82+00.00	15,181	635	669
83+00.00	4,784	178	185	83+00.00	16,868	646	676
84+00.00	4,920	175	185	84+00.00	17,970	654	684
85+00.00	4,725	173	184	85+00.00	17,860	645	683
86+00.00	4,464	180	188	86+00.00	17,015	655	689
87+00.00	4,588	183	188	87+00.00	16,762	674	696
88+00.00	4,461	180	185	88+00.00	16,757	673	691
89+00.00	4,328	176	183	89+00.00	16,276	661	683
90+00.00	4,180	163	174	90+00.00	15,756	629	662
91+00.00	4,231	176	184	91+00.00	15,576	628	663
92+00.00	4,268	180	192	92+00.00	15,739	658	695
93+00.00	4,055	169	177	93+00.00	15,414	647	684
94+00.00	4,017	183	191	94+00.00	14,948	653	682
95+00.00	4,091	181	189	95+00.00	15,014	676	704
96+00.00	4,031	179	186	96+00.00	15,041	668	695
97+00.00	4,006	178	193	97+00.00	14,883	662	702
98+00.00	4,002	179	199	98+00.00	14,829	660	726
99+00.00	3,968	183	192	99+00.00	14,758	669	724
100+00.00	4,056	188	196	100+00.00	14,859	686	718
101+00.00	3,972	184	190	101+00.00	14,867	688	714
102+00.00	3,985	174	182	102+00.00	14,736	663	689
103+00.00	3,968	185	194	103+00.00	14,728	666	697
104+00.00	3,929	179	190	104+00.00	14,623	676	711
105+00.00	3,795	177	185	105+00.00	14,304	660	694
106+00.00	3,790	184	190	106+00.00	14,047	667	694
107+00.00	3,829	185	192	107+00.00	14,110	682	708
108+00.00	3,858	187	192	108+00.00	14,235	688	712
109+00.00	3,844	182	189	109+00.00	14,263	684	707
110+00.00	3,997	187	191	110+00.00	14,520	685	705
111+00.00	4,040	187	192	111+00.00	14,883	693	709
112+00.00	3,798	181	187	112+00.00	14,515	681	702
113+00.00	3,512	182	190	113+00.00	13,538	672	698

114+00.00	3,669	182	190	114+00.00	13,298	674	703
115+00.00	3,619	180	189	115+00.00	13,496	671	702
116+00.00	3,347	172	183	116+00.00	12,900	653	688
117+00.00	3,281	171	177	117+00.00	12,273	635	666
118+00.00	3,190	164	175	118+00.00	11,982	620	651
119+00.00	3,198	163	168	119+00.00	11,830	605	635
120+00.00	3,099	161	170	120+00.00	11,662	599	625
121+00.00	3,018	154	161	121+00.00	11,328	583	612
122+00.00	2,900	153	163	122+00.00	10,959	568	601
123+00.00	2,741	148	154	123+00.00	10,445	557	588
124+00.00	2,572	143	149	124+00.00	9,838	539	561
125+00.00	2,528	138	147	125+00.00	9,444	520	547
126+00.00	2,404	125	133	126+00.00	9,133	487	518
127+00.00	2,179	117	127	127+00.00	8,486	449	483
128+00.00	2,284	111	116	128+00.00	8,263	423	451
129+00.00	1,835	94	101	129+00.00	7,628	380	403
130+00.00	2,015	106	113	130+00.00	7,130	370	397
131+00.00	1,839	95	99	131+00.00	7,136	372	394
132+00.00	1,857	89	94	132+00.00	6,844	340	358
133+00.00	1,634	88	93	133+00.00	6,464	327	347
134+00.00	1,639	86	95	134+00.00	6,061	323	349
135+00.00	1,393	81	91	135+00.00	5,615	310	344
136+00.00	1,539	81	89	136+00.00	5,430	300	333
137+00.00	1,302	86	94	137+00.00	5,262	309	339
138+00.00	1,529	81	88	138+00.00	5,243	310	338
139+00.00	1,493	81	88	139+00.00	5,596	301	326
140+00.00	1,528	81	87	140+00.00	5,595	300	324
141+00.00	1,518	82	91	141+00.00	5,641	303	330
142+00.00	1,544	82	89	142+00.00	5,669	305	333
143+00.00	1,549	83	90	143+00.00	5,726	305	331
144+00.00	1,459	75	83	144+00.00	5,570	292	320
145+00.00	1,392	80	94	145+00.00	5,280	287	328
146+00.00	1,416	88	100	146+00.00	5,200	311	360
147+00.00	1,588	91	97	147+00.00	5,562	332	365
148+00.00	1,543	78	96	148+00.00	5,798	312	357
149+00.00	1,530	85	90	149+00.00	5,691	301	343
150+00.00	1,520	81	100	150+00.00	5,648	307	351
151+00.00	1,613	85	105	151+00.00	5,803	307	379
152+00.00	1,489	83	103	152+00.00	5,746	310	384
153+00.00	1,468	88	99	153+00.00	5,476	316	374
154+00.00	1,505	84	101	154+00.00	5,506	319	371
155+00.00	1,399	73	98	155+00.00	5,379	292	369
156+00.00	1,360	69	96	156+00.00	5,109	263	359
157+00.00	1,361	73	90	157+00.00	5,039	262	345
158+00.00	1,440	74	95	158+00.00	5,187	272	344
159+00.00	1,522	65	91	159+00.00	5,485	258	345
160+00.00	1,599	83	100	160+00.00	5,779	275	353

161+00.00	1,543	86	102	161+00.00	5,817	313	374
162+00.00	1,600	89	105	162+00.00	5,821	325	383
163+00.00	1,526	88	101	163+00.00	5,789	329	381
164+00.00	1,562	87	101	164+00.00	5,719	325	373
165+00.00	1,526	87	104	165+00.00	5,719	323	379
166+00.00	1,502	86	99	166+00.00	5,608	321	377
167+00.00	1,571	86	98	167+00.00	5,692	318	366
168+00.00	1,518	85	96	168+00.00	5,721	316	360
169+00.00	1,534	79	93	169+00.00	5,652	304	350
170+00.00	1,491	77	99	170+00.00	5,603	289	355
171+00.00	1,546	84	100	171+00.00	5,625	298	369
172+00.00	1,610	88	109	172+00.00	5,845	319	387
173+00.00	1,620	80	99	173+00.00	5,982	311	385
174+00.00	1,618	83	104	174+00.00	5,996	301	375
175+00.00	1,677	82	91	175+00.00	6,101	305	362
176+00.00	1,673	87	94	176+00.00	6,204	313	343
177+00.00	1,547	91	97	177+00.00	5,964	331	353
178+00.00	1,601	91	97	178+00.00	5,830	339	360
179+00.00	1,381	87	93	179+00.00	5,521	330	352
180+00.00	1,487	109	110	180+00.00	5,311	364	376
181+00.00	1,559	109	110	181+00.00	5,641	405	408
182+00.00	1,561	109	110	182+00.00	5,778	405	408
183+00.00	1,497	109	110	183+00.00	5,664	405	408
184+00.00	1,576	109	110	184+00.00	5,691	405	408
185+00.00	1,610	109	110	185+00.00	5,899	405	408
186+00.00	1,604	109	110	186+00.00	5,951	405	408
187+00.00	1,579	109	110	187+00.00	5,895	405	408
188+00.00	1,590	99	110	188+00.00	5,869	386	408
189+00.00	1,516	103	110	189+00.00	5,751	373	408
190+00.00	1,565	94	110	190+00.00	5,705	364	408
191+00.00	1,493	98	110	191+00.00	5,664	356	408
192+00.00	1,537	102	110	192+00.00	5,611	370	408
193+00.00	1,585	101	110	193+00.00	5,781	375	408
194+00.00	1,522	103	110	194+00.00	5,754	379	408
195+00.00	1,512	103	110	195+00.00	5,618	383	408
196+00.00	1,561	95	110	196+00.00	5,691	367	408
197+00.00	1,543	108	110	197+00.00	5,748	376	407
198+00.00	1,522	109	110	198+00.00	5,675	403	408
199+00.00	1,519	95	110	199+00.00	5,632	377	408
200+00.00	1,538	109	110	200+00.00	5,663	377	408
201+00.00	1,467	104	110	201+00.00	5,566	394	407
202+00.00	1,451	109	110	202+00.00	5,405	396	408
203+00.00	1,597	109	110	203+00.00	5,644	405	408
203+66.28	1,579	109	110	203+66.28	3,897	269	270
204+00.00	1,572	109	110	204+00.00	1,968	137	137
205+00.00	1,568	109	110	205+00.00	5,816	405	407
206+00.00	1,463	109	110	206+00.00	5,614	405	408

207+00.00	1,530	109	110	207+00.00	5,543	405	407
208+00.00	1,446	109	110	208+00.00	5,512	405	408
209+00.00	1,409	109	110	209+00.00	5,288	405	408
210+00.00	1,451	109	110	210+00.00	5,296	405	407
211+00.00	1,422	109	110	211+00.00	5,320	405	407
212+00.00	1,453	109	110	212+00.00	5,324	405	407
213+00.00	1,479	109	110	213+00.00	5,429	405	408
214+00.00	1,534	109	110	214+00.00	5,579	405	408
215+00.00	1,510	109	110	215+00.00	5,638	405	407
216+00.00	1,464	109	110	216+00.00	5,508	405	408
217+00.00	1,499	109	110	217+00.00	5,487	405	407
218+00.00	1,559	109	110	218+00.00	5,662	405	408
219+00.00	1,494	109	110	219+00.00	5,652	405	407
220+00.00	1,368	111	111	220+00.00	5,299	408	410
221+00.00	1,469	115	115	221+00.00	5,253	417	419
222+00.00	777	58	59	222+00.00	4,158	320	322
222+75.87	27	-	0	222+75.87	1,129	82	83
223+00.00	-	-	-	223+00.00	12	-	-
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				TOTALS	1,904,153	99,083	105,261

NW TOTAL	2,108,000

CW3_BCC_455							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQFT	SQ FT	SQ FT	Station	yd3	yd3	yd3
24+68.65	-			24+68.65	-		
24+68.65	-			24+68.65	-		
25+00.00	-		3	25+00.00	-		2
26+00.00	227	22	28	26+00.00	421	41	57
27+00.00	1,017	62	75	27+00.00	2,304	155	192
28+00.00	1,918	94	102	28+00.00	5,435	287	328
29+00.00	2,573	132	138	29+00.00	8,316	418	444
30+00.00	3,497	166	172	30+00.00	11,240	552	573
30+83.64	4,651	203	206	30+83.64	12,620	571	585
31+00.00	5,018	206	210	31+00.00	2,930	124	126
32+00.00	7,199	237	242	32+00.00	22,624	820	838
33+00.00	9,336	286	291	33+00.00	30,620	967	986
33+05.09	9,443	287	292	33+05.09	1,768	54	55
34+00.00	10,171	291	296	34+00.00	34,475	1,016	1,033
35+00.00	9,980	287	292	35+00.00	37,317	1,070	1,088
36+00.00	9,941	289	294	36+00.00	36,891	1,067	1,086
37+00.00	9,903	286	291	37+00.00	36,749	1,065	1,085
38+00.00	9,661	284	289	38+00.00	36,230	1,056	1,074
39+00.00	9,267	284	289	39+00.00	35,052	1,053	1,069
40+00.00	8,990	283	291	40+00.00	33,809	1,050	1,074
41+00.00	9,063	286	291	41+00.00	33,431	1,053	1,079
42+00.00	9,106	297	310	42+00.00	33,646	1,080	1,114
43+00.00	8,613	295	310	43+00.00	32,813	1,095	1,148
44+00.00	8,402	280	285	44+00.00	31,509	1,064	1,102
45+00.00	8,308	279	285	45+00.00	30,943	1,035	1,055
46+00.00	8,096	283	288	46+00.00	30,377	1,041	1,061
47+00.00	7,847	286	305	47+00.00	29,524	1,054	1,099
48+00.00	7,710	286	305	48+00.00	28,809	1,060	1,130
49+00.00	7,647	280	305	49+00.00	28,439	1,048	1,129
50+00.00	7,552	280	299	50+00.00	28,145	1,036	1,119
51+00.00	7,542	278	299	51+00.00	27,951	1,033	1,108
52+00.00	7,549	285	301	52+00.00	27,946	1,043	1,112
53+00.00	7,938	288	301	53+00.00	28,679	1,062	1,114
54+00.00	7,988	290	301	54+00.00	29,492	1,071	1,114
55+00.00	8,114	290	298	55+00.00	29,820	1,075	1,110
56+00.00	8,060	289	299	56+00.00	29,953	1,073	1,107
57+00.00	8,047	289	298	57+00.00	29,829	1,071	1,106
58+00.00	8,187	284	298	58+00.00	30,063	1,062	1,105
59+00.00	7,993	289	297	59+00.00	29,962	1,061	1,102
60+00.00	7,612	287	302	60+00.00	28,898	1,067	1,108
61+00.00	7,793	283	292	61+00.00	28,527	1,056	1,100
62+00.00	7,694	284	293	62+00.00	28,680	1,049	1,083
63+00.00	7,787	276	286	63+00.00	28,669	1,037	1,072
64+00.00	7,839	282	285	64+00.00	28,937	1,033	1,058
65+00.00	7,631	277	285	65+00.00	28,648	1,035	1,056
65+42.54	6,498	277	285	65+42.54	11,130	437	449
66+00.00	4,265	174	189	66+00.00	11,455	481	504
67+00.00	-	-	2	67+00.00	7,899	323	353
67+10.85	-	-	-	67+10.85	-	-	0
68+00.00	-	-	0	68+00.00	-	-	-
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				TOTALS	1,122,969	39,001	40,488

TOTAL NW 1,202,000

CW4_BB-GB_530							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
676+53.13				676+53.13			
676+53.13	14	0	0	676+53.13	-	-	-
678+91.52	930	91	46	678+91.52	4,168	404	202
680+00.00	1,521	171	85	680+00.00	4,922	527	263
681+24.00	2,269	262	131	681+24.00	8,701	993	496
681+27.98	2,291	264	132	681+27.98	336	39	19
684+03.19	4,329	461	231	684+03.19	33,741	3,699	1,850
684+03.20	4,317	460	230	684+03.20	2	0	0
685+00.00	4,715	460	230	685+00.00	16,191	1,649	825
690+00.00	5,460	460	230	690+00.00	94,211	8,519	4,259
695+00.00	4,701	460	230	695+00.00	94,076	8,519	4,259
700+00.00	4,537	460	230	700+00.00	85,531	8,519	4,259
705+00.00	5,454	460	230	705+00.00	92,507	8,519	4,259
710+00.00	2,681	460	230	710+00.00	75,320	8,519	4,259
715+00.00	2,246	444	230	715+00.00	45,620	8,373	4,259
720+00.00	3,606	459	230	720+00.00	54,186	8,361	4,259
725+00.00	7,445	460	230	725+00.00	102,320	8,507	4,259
727+96.01	6,191	461	231	727+96.01	74,745	5,049	2,525
730+00.00	6,029	461	230	730+00.00	44,486	3,431	1,715
735+00.00	6,406	452	230	735+00.00	109,766	8,283	4,180
740+00.00	6,807	357	182	740+00.00	115,820	7,248	3,696
745+00.00	7,344	357	180	745+00.00	123,922	6,325	3,212
750+00.00	7,194	343	171	750+00.00	127,328	6,201	3,117
753+98.40	5,245	325	185	753+98.40	86,954	4,718	2,536
755+00.00	5,390	374	228	755+00.00	19,112	1,275	762
760+00.00	5,083	461	230	760+00.00	93,068	7,608	4,198
765+00.00	2,450	461	231	765+00.00	67,405	8,500	4,250
770+00.00	2,790	467	233	770+00.00	47,403	8,649	4,325
775+00.00	4,832	463	232	775+00.00	69,564	8,473	4,236
780+00.00	1,496	453	230	780+00.00	55,840	8,131	4,099
785+00.00	1,343	452	232	785+00.00	25,808	8,045	4,113
790+00.00	3,862	463	232	790+00.00	49,578	8,286	4,200
795+00.00	5,357	434	217	795+00.00	88,655	8,296	4,148
800+00.00	5,500	381	191	800+00.00	105,006	7,668	3,834
805+00.00	1,373	307	153	805+00.00	66,579	6,552	3,277
810+00.00	221	215	114	810+00.00	15,404	4,996	2,559
815+00.00	27	61	53	815+00.00	2,390	2,645	1,600
820+00.00	-	17	10	820+00.00	263	752	606
823+35.36	0	0	0	823+35.36	0	112	65
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				TOTALS	2,100,925	206,384	104,979

TOTAL NW 2,412,000

CD4_WHOLE							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
676+53.13	-	-	-	676+53.13	-	-	-
678+91.52	-	-	-	678+91.52	-	-	-
680+00.00	-	-	-	680+00.00	-	-	-
681+24.00	-	-	-	681+24.00	-	-	-
681+27.98	-	-	-	681+27.98	-	-	-
684+03.19	-	-	-	684+03.19	-	-	-
684+03.20	51	322	241	684+03.20	-	-	-
685+00.00	104	391	262	685+00.00	279	1,277	900
690+00.00	189	506	300	690+00.00	2,715	8,305	5,200
695+00.00	149	441	299	695+00.00	3,130	8,773	5,549
700+00.00	131	319	275	700+00.00	2,587	7,039	5,315
705+00.00	136	262	217	705+00.00	2,470	5,379	4,552
710+00.00	133	230	242	710+00.00	2,493	4,555	4,252
715+00.00	20	212	203	715+00.00	1,415	4,093	4,118
720+00.00	77	280	215	720+00.00	897	4,562	3,864
725+00.00	142	325	212	725+00.00	2,029	5,607	3,949
727+96.01	222	372	232	727+96.01	1,995	3,822	2,434
730+00.00	219	386	253	730+00.00	1,646	2,859	1,832
735+00.00	307	335	183	735+00.00	4,789	6,630	4,018
740+00.00	368	427	262	740+00.00	6,151	6,982	4,097
745+00.00	724	524	295	745+00.00	9,925	8,756	5,151
750+00.00	566	480	271	750+00.00	11,670	9,261	5,232
753+98.40	674	412	262	753+98.40	8,903	6,540	3,917
755+00.00	460	418	294	755+00.00	2,084	1,550	1,044
760+00.00	255	496	299	760+00.00	6,523	8,427	5,488
765+00.00	263	476	299	765+00.00	4,805	8,998	5,539
770+00.00	282	487	300	770+00.00	5,081	8,928	5,550
775+00.00	196	351	292	775+00.00	4,445	7,764	5,477
780+00.00	227	249	214	780+00.00	3,999	5,594	4,684
785+00.00	275	241	221	785+00.00	4,746	4,598	4,038
790+00.00	403	317	255	790+00.00	6,428	5,216	4,418
795+00.00	323	247	189	795+00.00	6,896	5,258	4,119
800+00.00	43	187	134	800+00.00	3,473	4,025	2,997
805+00.00	74	181	134	805+00.00	1,071	3,375	2,476
810+00.00	191	224	174	810+00.00	2,397	3,696	2,833
815+00.00	222	241	160	815+00.00	3,743	4,243	3,062
820+00.00	215	254	233	820+00.00	3,960	4,519	3,616
823+35.36	219	279	210	823+35.36	2,640	3,276	2,741
825+00.00	246	273	217	825+00.00	1,390	1,671	1,296
830+00.00	259	435	248	830+00.00	4,077	6,985	4,427
833+05.17	237	446	256	833+05.17	2,806	4,979	2,848
835+00.00	256	457	267	835+00.00	1,776	3,257	1,884
839+54.93	252	403	300	839+54.93	4,278	7,248	4,773

840+00.00	310	388	299	840+00.00	477	661	500
845+00.00	251	427	253	845+00.00	5,254	7,551	5,113
847+11.88	264	368	235	847+11.88	2,024	3,121	1,917
850+00.00	220	432	260	850+00.00	2,585	4,269	2,642
851+21.65	240	427	249	851+21.65	1,037	1,935	1,147
855+00.00	271	445	256	855+00.00	3,611	6,122	3,542
860+00.00	211	422	261	860+00.00	4,467	8,037	4,791
865+00.00	238	333	232	865+00.00	4,110	6,975	4,559
870+00.00	228	323	244	870+00.00	4,258	6,038	4,403
875+00.00	222	361	265	875+00.00	4,108	6,296	4,711
880+00.00	146	344	255	880+00.00	3,361	6,503	4,811
885+00.00	243	414	261	885+00.00	3,577	7,012	4,773
886+19.11	215	404	263	886+19.11	1,005	1,806	1,156
889+66.20	213	379	256	889+66.20	2,752	5,038	3,340
890+00.00	297	390	246	890+00.00	322	482	314
893+34.90	212	354	259	893+34.90	3,185	4,617	3,131
893+35.10	111	314	239	893+35.10	1	3	2
895+00.00	182	314	237	895+00.00	899	1,913	1,452
896+61.27	125	321	232	896+61.27	916	1,893	1,399
897+33.33	148	340	229	897+33.33	364	882	615
899+34.90	98	336	237	899+34.90	929	2,529	1,743
899+35.10	130	377	257	899+35.10	1	3	2
900+00.00	240	376	259	900+00.00	445	905	620
905+00.00	210	291	222	905+00.00	4,119	6,153	4,454
910+00.00	314	302	175	910+00.00	4,744	5,429	3,654
911+50.00	353	341	178	911+50.00	1,818	1,765	970
915+00.00	383	719	613	915+00.00	4,695	6,973	5,238
918+02.68	1,214	1,699	975	918+02.68	9,397	14,320	9,349
920+00.00	1,139	1,710	946	920+00.00	9,178	13,269	7,445
920+36.76	1,159	1,699	941	920+36.76	1,664	2,462	1,359
925+00.00	667	642	329	925+00.00	16,234	20,969	11,368
925+25.00	599	576	300	925+25.00	579	564	292
930+00.00	469	508	300	930+00.00	9,253	9,524	5,277
930+12.50	0	-	-	930+12.50	107	117	69
				--------	-	-	-
				TOTALS	251,186	364,182	243,846

TOTAL NW 860,000

CD5_WHOLE							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
1110+77.54	140	312		1110+77.54		-	
1110+77.55	140	312	216	1110+77.55	0	0	0
1111+70.15	224	381	242	1111+70.15	625	1,189	787
1115+00.00	375	428	253	1115+00.00	3,659	4,953	3,031
1120+00.00	385	382	261	1120+00.00	6,961	7,509	4,768
1125+00.00	428	317	220	1125+00.00	7,268	6,436	4,449
1130+00.00	325	328	194	1130+00.00	6,672	5,890	3,802
1135+00.00	346	342	213	1135+00.00	5,930	6,095	3,727
1140+00.00	545	387	241	1140+00.00	7,884	6,660	4,182
1145+00.00	471	396	246	1145+00.00	9,135	7,199	4,500
1145+37.97	487	397	246	1145+37.97	665	555	345
1150+00.00	437	406	286	1150+00.00	7,873	6,851	4,551
1152+19.02	259	423	274	1152+19.02	2,824	3,354	2,274
1155+00.00	98	355	238	1155+00.00	1,858	4,048	2,669
1160+00.00	120	353	251	1160+00.00	2,021	6,552	4,530
1160+62.20	158	387	269	1160+62.20	320	852	599
				--------	--------	--------	--------
				TOTALS	63,694	68,143	44,211

TOTAL NW	176,000

CD6_WHOLE							
Phase	REQD	ADV	OD	Phase	REQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
1160+62.20	158	387	269	1160+62.20			
1161+94.48	218	454	299	1161+94.48	922	2,059	1,391
1165+00.00	355	409	294	1165+00.00	3,261	4,892	3,356
1170+00.00	351	343	239	1170+00.00	6,659	6,959	4,929
1175+00.00	310	528	300	1175+00.00	6,288	8,045	4,982
1180+00.00	272	543	300	1180+00.00	5,439	9,910	5,556
1185+00.00	187	390	298	1185+00.00	4,227	8,606	5,541
1190+00.00	48	161	151	1190+00.00	2,142	5,027	4,145
1195+00.00	730	666	398	1195+00.00	8,451	8,441	5,512
1196+58.44	298	541	425	1196+58.44	3,586	4,049	2,714
1200+00.00	56	124	119	1200+00.00	2,632	4,766	3,804
1201+00.00	12	151	181	1201+00.00	134	512	558
1205+00.00	264	530	300	1205+00.00	2,075	5,023	3,549
1210+00.00	255	596	300	1210+00.00	4,870	10,427	5,556
1212+07.70	225	588	300	1212+07.70	1,870	4,556	2,308
1215+00.00	309	600	300	1215+00.00	2,877	6,430	3,248
1220+00.00	338	600	300	1220+00.00	5,958	11,111	5,556
1220+80.47	354	600	300	1220+80.47	1,023	1,788	894
1225+00.00	329	600	300	1225+00.00	5,307	9,323	4,661
1230+00.00	325	600	300	1230+00.00	6,058	11,111	5,556
1235+00.00	361	600	300	1235+00.00	6,354	11,111	5,556
1235+83.53	367	600	300	1235+83.53	1,126	1,856	928
1240+00.00	442	600	300	1240+00.00	6,203	9,255	4,627
1245+00.00	368	600	300	1245+00.00	7,470	11,111	5,556
1249+37.33	339	600	300	1249+37.33	5,729	9,719	4,859
1250+00.00	348	600	300	1250+00.00	798	1,393	696
1255+00.00	381	600	300	1255+00.00	6,744	11,111	5,556
1260+00.00	322	576	288	1260+00.00	6,510	10,893	5,447
1265+00.00	377	518	259	1265+00.00	6,478	10,129	5,065
1266+48.72	326	502	251	1266+48.72	1,936	2,807	1,403
1266+48.72	309	504	252	1266+48.72	-	-	-
00+00.01	309	504	252	00+00.01	0	0	0
02+00.00	301	500	250	02+00.00	2,260	3,720	1,860
04+00.00	275	500	250	04+00.00	2,136	3,704	1,852
06+00.00	288	500	250	06+00.00	2,087	3,704	1,852
08+00.00	306	500	250	08+00.00	2,201	3,704	1,852
10+00.00	299	500	250	10+00.00	2,242	3,704	1,852
12+00.00	283	500	250	12+00.00	2,155	3,704	1,852
14+00.00	274	500	250	14+00.00	2,060	3,704	1,852
14+32.07	265	500	250	14+32.07	320	594	297
16+00.00	467	852	426	16+00.00	2,275	4,204	2,102
18+00.00	692	1,271	635	18+00.00	4,293	7,862	3,931
20+00.00	940	1,690	845	20+00.00	6,044	10,966	5,483

20+26.65	896	1,746	873	20+26.65	906	1,696	848
22+00.00	1,041	2,109	1,054	22+00.00	6,216	12,374	6,187
22+96.50	1,088	2,311	1,156	22+96.50	3,804	7,898	3,949
22+96.60	1,168	2,311	1,156	22+96.60	4	9	4
24+00.00	903	2,133	1,066	24+00.00	3,966	8,510	4,255
24+88.60	741	1,978	990	24+88.60	2,697	6,745	3,374
24+88.81	741	1,977	990	24+88.81	9,397	25,084	12,558
26+00.00	593	1,609	826	26+00.00	2,747	7,384	3,738
28+00.00	305	1,048	530	28+00.00	3,327	9,842	5,020
29+68.41	173	556	281	29+68.41	1,491	5,002	2,529
30+00.00	252	422	211	30+00.00	249	572	288
30+95.04	11	0	0	30+95.04	463	743	371
30+95.06	-	-	-	30+95.06	-	-	-
	-	-	-	--------	-	-	-
	-	-	-	TOTALS	186,467	337,845	181,411

TOTAL NW	706,000

BETB3_BCCFLARE_1800NW

Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW	Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW
Material	NW	NW	NW	NW	NW	NW	NW	NW	NW	Material	NW	NW	NW	NW	NW	NW	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3
08+77.69	170	225	305	341	398	455	523	612	1,437	08+77.69	-	-	-	-	-	-	-	-	-
09+00.00	478	319	375	417	458	516	578	647	1,447	09+00.00	268	225	281	313	354	401	455	520	1,192
10+00.00	8,321	588	600	609	611	621	660	776	1,700	10+00.00	16,295	1,678	1,807	1,899	1,980	2,105	2,292	2,636	5,827
11+00.00	16,992	565	567	570	575	603	762	821	1,841	11+00.00	46,876	2,135	2,162	2,183	2,196	2,265	2,632	2,957	6,557
12+00.00	19,663	533	536	538	540	609	781	844	1,936	12+00.00	67,880	2,035	2,042	2,052	2,064	2,244	2,857	3,083	6,995
13+00.00	18,584	498	500	502	504	576	902	1,100	2,324	13+00.00	70,828	1,910	1,917	1,925	1,933	2,195	3,116	3,600	7,888
14+00.00	19,515	516	517	519	552	688	1,057	1,335	2,790	14+00.00	70,554	1,878	1,883	1,890	1,956	2,342	3,628	4,508	9,470
15+00.00	17,919	488	489	492	534	695	1,197	1,529	3,213	15+00.00	69,323	1,860	1,864	1,872	2,012	2,561	4,175	5,304	11,118
16+00.00	16,454	455	457	458	539	871	1,321	1,545	3,221	16+00.00	63,653	1,748	1,752	1,759	1,987	2,900	4,663	5,692	11,915
16+68.05	17,012	431	431	442	522	891	1,355	1,484	3,023	16+68.05	42,174	1,117	1,119	1,134	1,337	2,221	3,372	3,817	7,868
17+00.00	26,426	964	966	971	1,057	1,370	1,829	2,017	4,101	17+00.00	25,700	825	827	836	935	1,338	1,884	2,072	4,215
18+00.00	31,921	901	906	910	950	1,280	1,796	1,860	3,755	18+00.00	108,049	3,453	3,467	3,483	3,717	4,907	6,713	7,181	14,549
19+00.00	30,421	808	812	818	851	1,212	1,510	1,674	3,397	19+00.00	115,448	3,164	3,182	3,200	3,335	4,615	6,122	6,545	13,245
20+00.00	28,806	724	735	747	785	858	1,164	1,462	3,030	20+00.00	109,680	2,835	2,865	2,898	3,030	3,834	4,952	5,807	11,902
21+00.00	23,997	573	580	587	603	777	1,021	1,306	2,681	21+00.00	97,783	2,401	2,434	2,470	2,570	3,029	4,045	5,126	10,576
22+00.00	18,385	431	438	445	458	640	843	1,117	2,323	22+00.00	78,485	1,860	1,884	1,912	1,965	2,624	3,452	4,486	9,267
23+00.00	12,239	253	258	267	279	424	645	919	1,965	23+00.00	56,712	1,267	1,289	1,319	1,365	1,969	2,756	3,770	7,942
23+87.58	5,467	117	118	120	124	201	386	761	1,652	23+87.58	28,716	600	611	627	653	1,013	1,673	2,725	5,866
24+00.00	5,293	112	113	114	118	190	394	744	1,638	24+00.00	2,475	53	53	54	56	90	180	346	757
24+68.65	4,388	88	89	91	105	210	403	671	1,565	24+68.65	12,308	254	257	260	283	508	1,014	1,798	4,072
25+00.00	4,024	78	79	80	86	146	326	680	1,531	25+00.00	4,884	96	97	99	111	207	423	784	1,797
26+00.00	3,104	49	52	56	57	145	393	629	1,423	26+00.00	13,202	235	242	252	265	539	1,331	2,424	5,471
27+00.00	1,177	9	10	11	16	148	413	656	1,316	27+00.00	7,929	108	116	124	136	544	1,492	2,379	5,073
28+00.00	-	-	-	-	46	194	421	603	1,208	28+00.00	2,180	17	19	20	115	633	1,545	2,331	4,674
29+00.00	-	-	-	-	35	122	371	535	1,101	29+00.00	-	-	-	-	150	584	1,466	2,108	4,276
30+00.00	-	-	-	-	0	126	381	490	993	30+00.00	-	-	-	-	64	458	1,392	1,897	3,878
30+83.64	101	22	23	27	49	178	402	452	903	30+83.64	156	34	35	41	76	471	1,212	1,458	2,937
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										TOTALS	1,111,554	31,787	32,205	32,620	34,644	46,595	68,841	85,353	179,326

TOTAL NW	1,623,000

BE2_BSCFlare																			
Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW	Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW
Material	NW	NW	NW	NW	NW	NW	NW	NW	NW	Material	NW	NW	NW	NW	NW	NW	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3
203+66.28	-	-	-	-	-	0	0	0	0	203+66.28	-	-	-	-	-	-	-	-	-
204+00.00	1	-	-	0	0	0	0	0	0	204+00.00	0	-	-	-	0	0	0	0	0
205+00.00	1	-	1	2	2	2	2	2	3	205+00.00	2	-	2	3	3	3	3	3	7
206+00.00	25	5	5	5	5	5	5	5	10	206+00.00	47	9	12	13	13	13	12	13	25
207+00.00	81	9	10	10	10	10	10	10	21	207+00.00	195	27	28	29	29	29	28	29	57
208+00.00	250	13	17	18	18	18	17	18	35	208+00.00	612	41	51	52	52	52	51	52	103
209+00.00	400	17	25	27	27	27	26	27	53	209+00.00	1,203	55	79	82	83	82	81	82	164
210+00.00	610	28	34	37	38	38	37	38	75	210+00.00	1,871	84	110	119	120	119	118	119	237
211+00.00	1,138	50	50	50	51	50	50	50	101	211+00.00	3,238	145	155	163	164	163	161	163	325
212+00.00	1,646	64	64	65	66	65	64	65	130	212+00.00	5,155	213	212	214	216	214	212	214	427
213+00.00	2,004	45	46	48	51	53	58	74	163	213+00.00	6,759	203	204	210	216	219	226	258	544
214+00.00	2,015	59	60	63	66	72	83	100	201	214+00.00	7,443	193	197	206	215	232	261	323	674
215+00.00	2,764	73	74	76	81	86	106	121	242	215+00.00	8,850	246	248	258	272	292	351	410	820
216+00.00	3,311	83	83	88	93	96	132	144	287	216+00.00	11,249	289	289	305	323	337	440	490	980
217+00.00	3,737	92	92	95	99	108	130	168	336	217+00.00	13,051	324	323	340	355	378	485	577	1,154
218+00.00	4,122	112	111	113	116	117	118	149	389	218+00.00	14,552	377	376	385	399	417	460	587	1,343
219+00.00	4,464	103	104	107	110	110	112	122	428	219+00.00	15,899	398	398	407	419	420	427	502	1,514
220+00.00	5,325	139	142	146	150	150	152	196	558	220+00.00	18,128	449	455	470	481	481	488	589	1,826
221+00.00	6,610	168	168	184	197	201	215	273	721	221+00.00	22,102	569	574	611	642	650	679	868	2,369
222+00.00	7,150	181	182	187	192	193	215	380	811	222+00.00	25,482	646	649	686	719	730	797	1,208	2,837
223+00.00	7,757	201	200	203	207	207	240	432	898	223+00.00	27,607	708	708	722	738	740	844	1,504	3,164
224+00.00	8,088	203	203	207	216	219	247	407	984	224+00.00	29,343	749	745	760	782	788	903	1,554	3,485
225+00.00	8,665	223	222	226	230	237	317	509	1,072	225+00.00	31,025	790	787	803	825	845	1,045	1,696	3,808
226+00.00	9,001	242	242	248	252	259	427	579	1,159	226+00.00	32,714	861	860	877	893	919	1,378	2,016	4,132
227+00.00	9,356	253	251	256	263	266	521	624	1,247	227+00.00	33,994	916	914	933	953	972	1,756	2,228	4,457
228+00.00	9,833	254	253	257	261	358	635	668	1,336	228+00.00	35,535	940	935	950	970	1,156	2,142	2,392	4,784
229+00.00	10,262	262	263	276	294	520	705	713	1,425	229+00.00	37,213	956	956	986	1,029	1,627	2,482	2,557	5,113
230+00.00	10,431	268	268	272	293	627	749	758	1,516	230+00.00	38,320	983	983	1,015	1,088	2,124	2,691	2,723	5,447
231+00.00	10,344	301	300	304	314	675	796	804	1,608	231+00.00	38,472	1,054	1,052	1,067	1,125	2,410	2,860	2,892	5,785
232+00.00	10,292	280	279	286	300	528	788	851	1,702	232+00.00	38,216	1,076	1,072	1,092	1,136	2,228	2,934	3,064	6,128
233+00.00	11,216	321	320	337	359	486	821	899	1,797	233+00.00	39,830	1,113	1,110	1,154	1,220	1,879	2,980	3,240	6,479
234+00.00	10,510	341	541	619	660	676	858	948	1,896	234+00.00	40,233	1,226	1,596	1,770	1,887	2,151	3,110	3,419	6,839
235+00.00	10,486	305	707	798	843	892	980	999	1,997	235+00.00	38,880	1,196	2,312	2,623	2,783	2,904	3,404	3,604	7,209
236+00.00	9,543	334	397	807	1,029	1,051	1,041	1,051	2,102	236+00.00	37,090	1,182	2,046	2,972	3,467	3,599	3,741	3,796	7,591
237+00.00	6,710	322	573	705	1,035	1,106	1,095	1,106	2,212	237+00.00	30,098	1,214	1,797	2,799	3,823	3,995	3,955	3,995	7,990
238+00.00	3,197	126	145	634	931	1,045	1,140	1,164	2,327	238+00.00	18,346	830	1,329	2,479	3,642	3,984	4,139	4,203	8,406
239+00.00	184	104	172	316	474	931	1,209	1,224	2,447	239+00.00	6,261	427	587	1,759	2,602	3,659	4,351	4,421	8,842
239+22.31	180	63	67	71	128	530	1,178	1,237	2,475	239+22.31	150	69	99	160	249	603	986	1,017	2,033
239+76.76	5,168	243	244	251	282	566	1,214	1,280	2,559	239+76.76	5,393	309	314	324	414	1,105	2,412	2,538	5,077
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										TOTALS	714,559	20,863	24,561	29,795	34,342	42,514	53,390	59,343	122,173

EXISTING FLARE																			
Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW	Phase	46.5 MLLW	47.5 MLLW	48.5 MLLW	49.5 MLLW	50.5 MLLW	51.5 MLLW	52.5 MLLW	53.5 MLLW	55.5 MLLW
Material	NW	NW	NW	NW	NW	NW	NW	NW	NW	Material	NW	NW	NW	NW	NW	NW	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3	yd3
203+66.28	-	3	27	98	273	400	396	400	800	203+66.28									
204+00.00	-	4	28	97	274	400	396	400	800	204+00.00	-	5	34	122	342	500	495	500	999
205+00.00	-	3	33	136	324	400	396	400	800	205+00.00	-	12	112	432	1,107	1,482	1,467	1,482	2,963
206+00.00	-	10	61	175	348	400	396	400	800	206+00.00	-	23	173	577	1,243	1,482	1,467	1,482	2,963
207+00.00	-	5	51	155	357	400	396	400	800	207+00.00	-	28	207	611	1,306	1,482	1,467	1,482	2,963
208+00.00	-	2	39	133	360	400	396	400	800	208+00.00	-	14	168	532	1,328	1,482	1,467	1,481	2,963
209+00.00	-	-	20	126	334	400	396	400	800	209+00.00	-	4	110	479	1,285	1,482	1,467	1,482	2,963
210+00.00	-	-	15	115	309	400	396	400	800	210+00.00	-	-	65	446	1,192	1,482	1,467	1,482	2,963
211+00.00	33	117	194	280	408	400	396	400	800	211+00.00	62	216	388	732	1,328	1,482	1,467	1,481	2,963
212+00.00	25	138	227	298	404	400	396	400	800	212+00.00	108	471	780	1,070	1,503	1,481	1,467	1,482	2,963
213+00.00	21	68	180	262	375	377	387	400	800	213+00.00	86	381	752	1,037	1,442	1,440	1,450	1,481	2,963
214+00.00	31	61	147	253	380	384	394	400	800	214+00.00	98	238	605	954	1,398	1,410	1,447	1,482	2,963
215+00.00	72	92	163	256	371	382	394	400	800	215+00.00	190	283	573	943	1,391	1,419	1,460	1,482	2,963
216+00.00	67	94	177	262	371	388	396	400	800	216+00.00	256	345	630	959	1,375	1,427	1,463	1,481	2,963

217+00.00	13	59	149	256	364	381	390	400	800	217+00.00	147	283	604	959	1,363	1,424	1,456	1,482	2,963
218+00.00	6	49	101	195	337	377	383	400	800	218+00.00	34	200	462	835	1,298	1,403	1,432	1,482	2,963
219+00.00	1	52	120	189	318	360	377	397	800	219+00.00	12	187	409	710	1,212	1,363	1,406	1,475	2,963
220+00.00	2	58	127	175	314	376	397	405	809	220+00.00	4	203	457	673	1,170	1,362	1,432	1,484	2,980
221+00.00	-	4	55	133	262	368	407	420	840	221+00.00	3	114	338	569	1,067	1,378	1,488	1,527	3,054
222+00.00	-	-	10	150	296	408	445	453	907	222+00.00	-	7	121	524	1,033	1,437	1,577	1,617	3,234
223+00.00	-	-	19	141	333	439	494	502	1,004	223+00.00	-	-	53	539	1,165	1,568	1,738	1,769	3,538
224+00.00	2	29	65	170	349	509	552	560	1,119	224+00.00	3	53	155	575	1,263	1,755	1,936	1,966	3,932
225+00.00	-	41	189	271	392	554	614	627	1,255	225+00.00	3	130	470	817	1,373	1,967	2,159	2,198	4,396
226+00.00	10	121	247	309	424	654	698	705	1,410	226+00.00	18	302	807	1,074	1,512	2,237	2,430	2,467	4,934
227+00.00	26	144	287	368	579	770	785	793	1,586	227+00.00	66	492	989	1,253	1,858	2,637	2,747	2,774	5,549
228+00.00	55	206	344	498	637	880	884	893	1,785	228+00.00	150	648	1,169	1,603	2,252	3,056	3,091	3,122	6,244
229+00.00	111	187	347	529	711	980	994	1,004	2,008	229+00.00	308	728	1,280	1,901	2,497	3,446	3,477	3,512	7,024
230+00.00	207	309	493	748	946	1,118	1,117	1,128	2,257	230+00.00	588	918	1,556	2,364	3,069	3,885	3,909	3,949	7,897
231+00.00	274	440	748	905	1,023	1,252	1,254	1,267	2,533	231+00.00	890	1,386	2,298	3,062	3,646	4,388	4,391	4,435	8,870
232+00.00	545	661	856	981	1,113	1,350	1,406	1,421	2,841	232+00.00	1,516	2,040	2,970	3,494	3,955	4,818	4,926	4,977	9,953
233+00.00	651	814	978	1,107	1,271	1,514	1,576	1,592	3,184	233+00.00	2,215	2,733	3,396	3,867	4,414	5,304	5,523	5,579	11,159
234+00.00	745	876	1,034	1,185	1,431	1,643	1,764	1,784	3,568	234+00.00	2,586	3,131	3,726	4,244	5,003	5,846	6,185	6,252	12,505
235+00.00	807	938	1,216	1,334	1,530	1,728	1,947	1,999	3,999	235+00.00	3,391	3,360	4,167	4,665	5,483	6,242	6,872	7,005	14,013
236+00.00	560	849	1,156	1,464	1,781	1,980	2,193	2,244	4,487	236+00.00	3,048	3,310	4,393	5,182	6,131	6,868	7,667	7,856	15,715
237+00.00	223	724	1,144	1,507	1,896	2,178	2,397	2,523	5,049	237+00.00	1,450	2,914	4,259	5,503	6,809	7,702	8,499	8,828	17,660
238+00.00	24	503	1,167	1,526	1,874	2,272	2,640	2,837	5,710	238+00.00	458	2,273	4,279	5,617	6,983	8,242	9,328	9,928	19,923
239+00.00	-	96	829	1,310	1,932	2,330	2,804	3,130	6,514	239+00.00	691	1,108	3,695	5,252	7,048	8,522	10,083	11,051	22,636
239+22.31	-	64	778	1,330	1,808	2,223	2,679	3,107	6,687	239+22.31	144	66	664	1,091	1,545	1,881	2,266	2,577	5,454
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										TOTALS	18,522	28,603	47,313	65,269	89,385	106,774	114,063	117,587	236,112

TOTAL NW 1,925,000

BE1_028+605_530							
Phase	RQD	ADV	OD	Phase	RQD	ADV	OD
Material	NW	NW	NW	Material	NW	NW	NW
Station	SQ FT	SQ FT	SQ FT	Station	yd3	yd3	yd3
26+028.00		0	0	26+028.00			
26+156.06	24	0	0	26+156.06	58	-	0
26+161.88	28	-	0	26+161.88	6	-	-
26+500.00	519	44	89	26+500.00	3,421	273	558
27+000.00	1,051	84	179	27+000.00	14,533	1,181	2,484
27+416.64	1,633	82	174	27+416.64	20,705	1,282	2,723
27+416.67	1,633	82	174	27+416.67	2	0	0
27+500.00	1,816	91	184	27+500.00	5,322	268	552
28+000.00	2,346	121	272	28+000.00	38,540	1,964	4,223
28+500.00	2,768	144	279	28+500.00	47,355	2,455	5,103
28+604.06	2,763	151	328	28+604.06	10,659	568	1,169
28+605.04	2,597	144	345	28+605.04	98	5	12
28+605.06	2,621	146	347	28+605.06	1	0	0
28+605.06	2,630	145	181	28+605.06	-	-	-
28+605.06	2,575	139	220	28+605.06	-	-	-
28+605.07	2,541	135	385	28+605.07	1	-	0
29+000.00	3,062	145	190	29+000.00	40,980	2,047	4,203
29+500.00	3,252	171	180	29+500.00	58,469	2,921	3,428
30+000.00	3,636	198	206	30+000.00	63,786	3,410	3,578
30+500.00	1,806	151	151	30+500.00	50,392	3,225	3,308
31+000.00	41	13	13	31+000.00	17,099	1,520	1,520
31+048.23	8	0	0	31+048.23	44	12	12
31+054.05	5	-	0	31+054.05	1	-	-
31+171.11	-	-	0	31+171.11	11	-	0
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				Total	371,482	21,131	32,874

Total NW	425,000