

Standard Permit Application

Mouth of Cedar Bayou Mobility Project SWG-2011-00070

PROPOSED PROJECT SUMMARY & PLANS

TABLE OF CONTENTS

Project Summary.....2
Summary of Special Aquatic Sites.....7
Proposed Project Plans.....8
Alternative Analysis.....20
Proposed Compensatory Mitigation Plan.....27

**Standard Permit Application
Mouth of Cedar Bayou Mobility Project
SWG-2011-00070
PROPOSED PROJECT SUMMARY**

LOCATION

(ENG 4345 Blocks 12 to 17)

The proposed project is located at the eastern terminus of the privately-owned Tri City Beach Road prior to its reaching Cedar Bayou, approximately 0.7-mile (mi) northwest of the intersection of Farm-to-Market (FM) Road 2354 and Atlantic Pipeline Road (Subject Property) in Baytown, Chambers County, Texas.

To access the Subject Property from the USACE - Galveston District:

PROJECT DESCRIPTION AND PURPOSE

(ENG 4345 Blocks 18 and 19)

The purpose of the proposed project is to construct a commercial dock for the loading and off-loading of commercial goods (including steel rolls, containers, and liquid products) safely and efficiently and to provide a safe area for fleeting barges. The Cedar Bayou Mobility Project meets the industry-driven demand for dockage and wharfage with the dramatic increase of industrial expansion along Cedar Bayou, while providing proximity to the Houston Ship Channel (HSC). The proposed project also would shorten trips required for ships hauling loads, reducing transportation costs, delays, traffic, and the potential for barge collisions, while providing a safe alternative for shipping and receiving commercial goods. The proposed project will be constructed in four separate phases as described in the attached figures and cross-sections that can be found in **the Plans** and in **Table 1** below:

Table 1: Proposed Construction Phases for the Mouth of Cedar Bayou Mobility Project

PHASE DESCRIPTION	ACRES	LINEAR FEET	CUBIC YARDS	CWA JURISDICTION
Oyster Mitigation				
Prior to the Phase I, the Applicant will mechanically remove the existing oyster reef identified within the Subject Property. The oyster cultch material will be loaded onto a shallow draft barge and transported to the adjacent oyster reef located to the south of the proposed project. Before the shell is placed, a geo-fabric filter will be installed to ensure the cultch will be supported. The oyster cultch will be placed to a height of 18 inches (in) to cover a minimum footprint of 0.08 ac. The footprint of the proposed oyster reef will be 42 feet (ft) by 104 ft, with the elongation situated perpendicular to the ebb and flow of the tides, to ensure the success of the oyster reef.	0.08	--	35	Section 10
Installing protective barriers around the oyster reef with signage so that barges or ship traffic will not impact the proposed oyster mitigation site.	--	1,000	--	Section 10
Phase I: Commercial Dock Access and Fleeting				
Mechanical dredging of new work material to a depth of -14 ft below Mean Low Lower Water (MLLW) to enable barge access and fleeting adjacent to the proposed commercial dock location. The fleeting area will be sufficient size to enable 38 regulation barges and spud barges. The dredged material will be loaded and transported in shallow-draft container barges and unloaded with trackhoes or other similar equipment into haul trucks. Dredged material will be placed via haul trucks in designated upland areas at the Waste Management Facility located just 0.2 miles away from the proposed project.	14.11	--	279,965	Section 10
Installing temporary channel markers indicating where fleeting boundaries exist.	--	--	--	Section 10

Mouth of Cedar Bayou Mobility Project

SWG-2011-00070

PROPOSED PROJECT SUMMARY

PHASE DESCRIPTION	ACRES	LINEAR FEET	CUBIC YARDS	CWA JURISDICTION
Phase II: Roll-on, Roll-off Dock Commercial Dock Construction				
Relocating Estuarine Emergent (E2EM) wetland vegetation (<i>Spartina alterniflora</i>) along Tri City Beach Road to an existing wetland habitat along Cedar Bayou. This existing wetland habitat is located within the same watershed.	0.24	--	--	Section 404, Section 10
Partial removal of the existing, privately owned Tri City Beach Road. The road will be mechanically excavated to a depth of -14 ft below MLLW. Dredged material will be placed via haul trucks in designated upland areas at the Waste Management Facility located just 0.2 miles away from the proposed project.	0.72	--	28,000	Section 404
Installing steel corrugated sheet pilings into bedrock to stabilize the sediment during the expansion of Tri City Beach Road from a width of 20 ft to 200 ft.	--	931	--	Section 404, Section 10
Filling Waters of the United States (WOUS), including wetlands with native clay material for the expansion of Tri City Beach Road from a width of 20 ft to 200 ft to allow safe thoroughfare for the loading and unloading of commercial trucks.	1.69	--	32,000	Section 404, Section 10
Phase III: Fleeting Area Dredging				
Mechanical dredging of new work material to a depth of -14 ft below MLLW to enable barge access and fleeting adjacent to the proposed commercial dock location. The area will be sufficient size to fleet 60 regulation barges and spud barges. The dredged material will be loaded and transported in shallow-draft container barges and unloaded with trackhoes or other similar equipment into haul trucks. Dredged material will be placed via haul trucks in designated upland areas at the Waste Management Facility located just 0.2 miles away from the proposed project.	16.46	--	341,000	Section 10
Installing channel markers on edges of fleeting areas to indicate where fleeting boundaries exist.	--	--	--	Section 10
Phase IV: Off-Stream Commercial Docking Area				
Installing steel corrugated sheet pilings into bedrock to stabilize the sediment for the loading and unloading of commercial goods.	--	407	--	Section 404
Mechanical dredging of new work material to a depth of -14 ft below MLLW to enable barge access adjacent to the proposed commercial dock location. The area will be large enough to enable barges to dock off-stream and unload or load commercial goods. The dredged material will be loaded into haul trucks. Dredged material will be placed via haul trucks in designated upland areas at the Waste Management Facility located just 0.2 miles away from the proposed.	1.65	--	35,000	Section 404, Section 10

REASON FOR DISCHARGE

(ENG 4345 Block 20)

In order to construct the commercial dock, the existing marina would need to be expanded to accommodate the loading and unloading of commercial goods. The current marina is not large enough to enable safe barge access to load and unload. Additionally, the existing Tri City Beach Road is only 25 ft wide. This width restriction inhibits large haul trucks from accessing the Subject Property, as there is not a safe turnaround area. To accommodate barges and trucks that would be utilized for shipping of commercial goods, the existing road and dock needs to be expanded. To stabilize the commercial dock, corrugated steel sheet pilings will be installed into the bedrock. The current depths within the Subject Property range from 2 in to 4 ft in depth, to enable safe access to the commercial dock and to fleet barges, the proposed project would need to be dredged to a depth of -14 ft below MLLW.

**Standard Permit Application
Mouth of Cedar Bayou Mobility Project
SWG-2011-00070
PROPOSED PROJECT SUMMARY**

IMPACTS

(ENG 4345 Block 21 to 22)

On October 16, 2018, CESI identified seven E2EM wetlands and two perennial waterbodies (Cedar Bayou and Fisher Marsh) on the Subject Property. A total of **34.16 ac** of potentially jurisdictional wetlands and waterbodies would be impacted by the proposed project. A request for a preliminary jurisdictional determination (PJD) was submitted to the USACE - Galveston District in November 2018 and is currently under review.

A total of 2.38 ac of live oyster reef were observed within a 500-ft buffer zone of the Subject Property in December 2018 to February 2019, with approximately **0.08 ac** of anticipated direct impacts to live oyster reef. No seagrasses were detected within or around the proposed project.

Although the proposed project will impact WOUS, including wetlands, the Applicant believes that the proposed project plan is the least environmentally damaging practicable alternative that meets the project’s stated purpose and need. **Table 2** summarizes the excavation and fill quantities required to construct the proposed project.

Table 2: Excavation and Fill Quantities of WOUS, Including Wetlands for the Proposed Project

AQUATIC FEATURE	TYPE	PROPOSED IMPACTS (ac)	AVOIDED IMPACTS (ac)	PROPOSED FILL (cy)	PROPOSED EXCAVATION (cy)
WET A	E2EM	0.26	--	Native Fill and Cement, 15.29	105.48
WET B	E2EM	0.07	--	Native Fill and Cement, 44.17	--
WET C	E2EM	0.09	--	--	32.61
WET D	E2EM	0.00	--	--	10.06
WET E	E2EM	0.11	--	Native Fill and Cement, 61.65	--
WET F	E2EM	--	0.10	--	--
WET G	E2EM	--	0.14	--	--
Fisher Marsh	Perennial Waterbody	31.90	30.19	Native Fill and Cement, 31,878.89	620,689.91
Cedar Bayou	Perennial Waterbody	1.65	34.17	--	35,000
Special Aquatic Sites	Oyster Reef	0.08	1.27	--	161.94
TOTAL WETLANDS		0.53	0.24	121.11	148.15
TOTAL WATERBODIES		33.55	64.36	31,878.89	655,689.91
TOTAL SPECIAL AQUATIC SITES		0.08	1.27	--	161.94
TOTAL		34.16	65.87	32,000.00	656,000.00

Standard Permit Application
Mouth of Cedar Bayou Mobility Project
SWG-2011-00070
PROPOSED PROJECT SUMMARY

THREATENED AND ENDANGERED SPECIES AND HABITAT ASSESSMENT

CESI conducted a Threatened and Endangered (T&E) Species Habitat Assessment on October 16, 2018, to determine the presence or likely presence of Federally or state-listed species. **Six** habitat types were identified on the Subject Property. Of the identified habitat types, four habitat types have low potential to support potentially **two Federally listed species** (black rail and piping plover) and **seven state-listed species** (bald eagle, peregrine falcon, reddish egret, swallow-tailed kite, white-face ibis, wood stork, and alligator snapping turtle). No impacts to these species are anticipated by the proposed project activities.

No Federally or state-listed T&E were observed on the Subject Property. No Federally or state-listed species are recorded on the Subject Property by the Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (NDD). The NDD Element of Occurrence data from TPWD stated that no listed species have been recorded within one mile of the Subject Property.

CULTURAL RESOURCES

Gray and Pape, LLC conducted a desktop review, pedestrian survey, including shovel testing, and marine side-scan sonar survey for potential cultural resources in January 2019.

One shell midden was encountered, however due to live oysters being present within the potential archaeological site, it is likely the site was misidentified. No artifacts or cultural features were encountered on the Subject Property. Additionally, there are no extant buildings of modern construction (less than 50 years old). A request for concurrence from the Texas Historical Commission (THC) has been submitted.

AVOIDANCE, MINIMIZATION AND COMPENSATION

(ENG 4345 Block 23)

The Applicant explored several alternatives when originally developing the project design, including off-site locations, site configuration, and a no action alternative. Best Management Practices (BMPs) including short-term measures to stabilize disturbed soils and installation of silt fencing to prevent sediment from flowing into protected wetland areas during storm events will be utilized throughout the project construction for the TCEQ Tier II Analysis and Checklist). Dredging will be accomplished using trackhoes, draglines, or similar excavation-type equipment. No hydraulic dredging is proposed. Dredge material will be placed via haul trucks in designated upland areas at the Waste Management Facility located just 0.2 miles away from the proposed project.

The proposed project avoids impacting the navigation and shipping channel, T&E species habitat, and cultural resources. The proposed project will relocate **0.24 ac** of E2EM wetland vegetation (*Spartina alterniflora*) to a nearby, existing wetland habitat along Cedar Bayou and **0.08 ac** of impacted oyster reef to a more productive and protected reef just south of the proposed project. With only **0.53 ac** of impacts to E2EM wetlands, the proposed project cannot be re-designed further to reduce impacts without compromising the practicability and overall purpose of the project.

The proposed project will result in the unavoidable loss of **0.53 ac** of estuarine emergent (E2EM) wetlands and **0.08 ac** of oyster reef habitat. The project is in the secondary service area of the USACE-approved Gulf Coastal Plains Mitigation Bank. The Applicant intends to purchase **1.78 credits** to mitigate impacts to E2EM wetlands, resulting in **no net loss of wetlands**. The Applicant also intends to relocate **0.24 ac** of E2EM vegetation to a nearby, existing wetland along Cedar Bayou, within the same watershed to avoid the permanent loss of wetland vegetation and function.

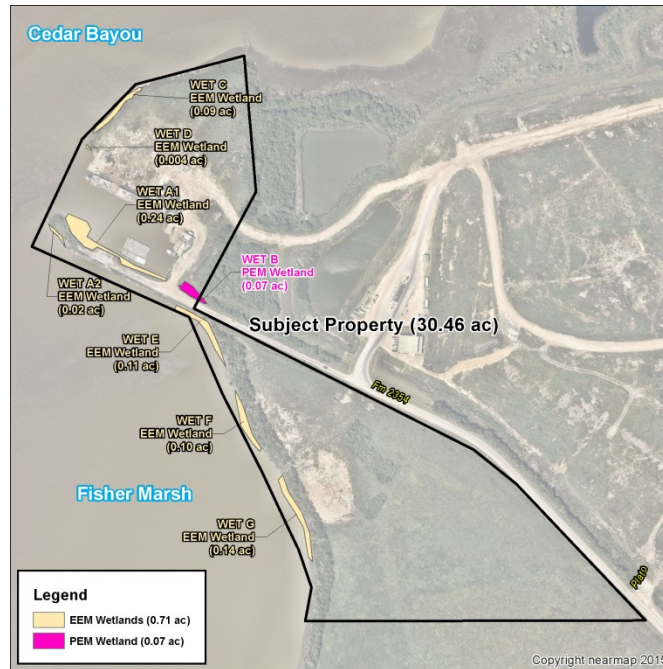
**Standard Permit Application
Mouth of Cedar Bayou Mobility Project
SWG-2011-00070**

PROPOSED PROJECT SUMMARY

There are currently no mitigation credits available within Mitigation Banks or in-lieu fee programs to compensate for the anticipated impacts to oyster reef habitat. The Applicant proposes to provide in-kind, Permittee Responsible Mitigation (PRM) that will protect **1.17 ac** of existing oyster habitat and create **0.08 ac** of artificial oyster reef habitat at a suitable location approximately 200 feet south of the Subject Property along Cedar Bayou, totaling to **1.25 ac** of oyster reef habitat. The creation and preservation of oyster habitat would protect and increase the existing oyster reef habitat within the Cedar Bayou watershed at a **15-to-1** compensatory mitigation-to-impact ratio, resulting in ***no net loss of aquatic resources***.

Special Aquatic Sites

Figure 1. Delineated Aquatic Features within the 30.46-acre Subject Property



All identified wetlands fall within the Federal Emergency Management Agency (FEMA) 100-year floodplain and provide surface water connectivity between potentially jurisdictional aquatic features.

Table 3. Summary of Aquatic Features Delineated Within the Subject Property








Feature Name	Feature Type*	Potential Jurisdictional Status	Ordinary High Water Mark (OHWM) (ft)	Size (ac)	Length (ft)
WET A1	EEM Wetlands	JURISDICTIONAL	N/A	0.24	N/A
WET A2	EEM Wetlands	JURISDICTIONAL	N/A	0.02	N/A
WET B	PEM Wetlands	JURISDICTIONAL	N/A	0.07	N/A
WET C	EEM Wetlands	JURISDICTIONAL	N/A	0.09	N/A
WET D	EEM Wetlands	JURISDICTIONAL	N/A	0.004	N/A
WET E	EEM Wetlands	JURISDICTIONAL	N/A	0.11	N/A
WET F	EEM Wetlands	JURISDICTIONAL	N/A	0.1	N/A
WET G	EEM Wetlands	JURISDICTIONAL	N/A	0.14	N/A
Cedar Bayou	Waterbody	JURISDICTIONAL		1.44	N/A
Fisher Marsh	Waterbody	JURISDICTIONAL		10.46	N/A
Total Potentially Jurisdictional WOUS				12.67	N/A

*EEM – Estuarine Emergent, PEM – Palustrine Emergent

Cedar Bayou

Upland Waste Management
Disposal Area

Legend

-  Proposed Bulkhead (1,338 linear feet)
-  Proposed Fill Area (1.69 ac / 32,000 cu yd)
-  Proposed Dredging Activities (32.94 ac, 684,000 cu yd)
-  Previously Permitted Area
-  Upland Waste Management Disposal Area
-  Navigable Channel
-  Subject Property (43.60 ac)

Mouth of Cedar
Bayou Mobility Project

2018 AERIAL PHOTOGRAPH WITH
PROPOSED PROJECT

Chambers County, Texas



0 200 400
Feet

CROUCH  ENVIRONMENTAL
SERVICES, INC.

APR 08 2019

Cedar Bayou

Subject Property (43.60 ac)

Upland Waste Management Disposal Area

SWG-2011-00070
Fisher Industrial Gateway Terminals, LLC
Page 9 of 61

Legend

- Phase I
- Phase IV
- Subject Property (43.60 ac)
- Phase II
- Potential Oyster Mitigation Site
- Phase III
- Upland Waste Management Disposal Area

Mouth of Cedar Bayou Mobility Project

2018 AERIAL PHOTOGRAPH WITH PROJECT PHASES

Chambers County, Texas

Created: 4/3/2019

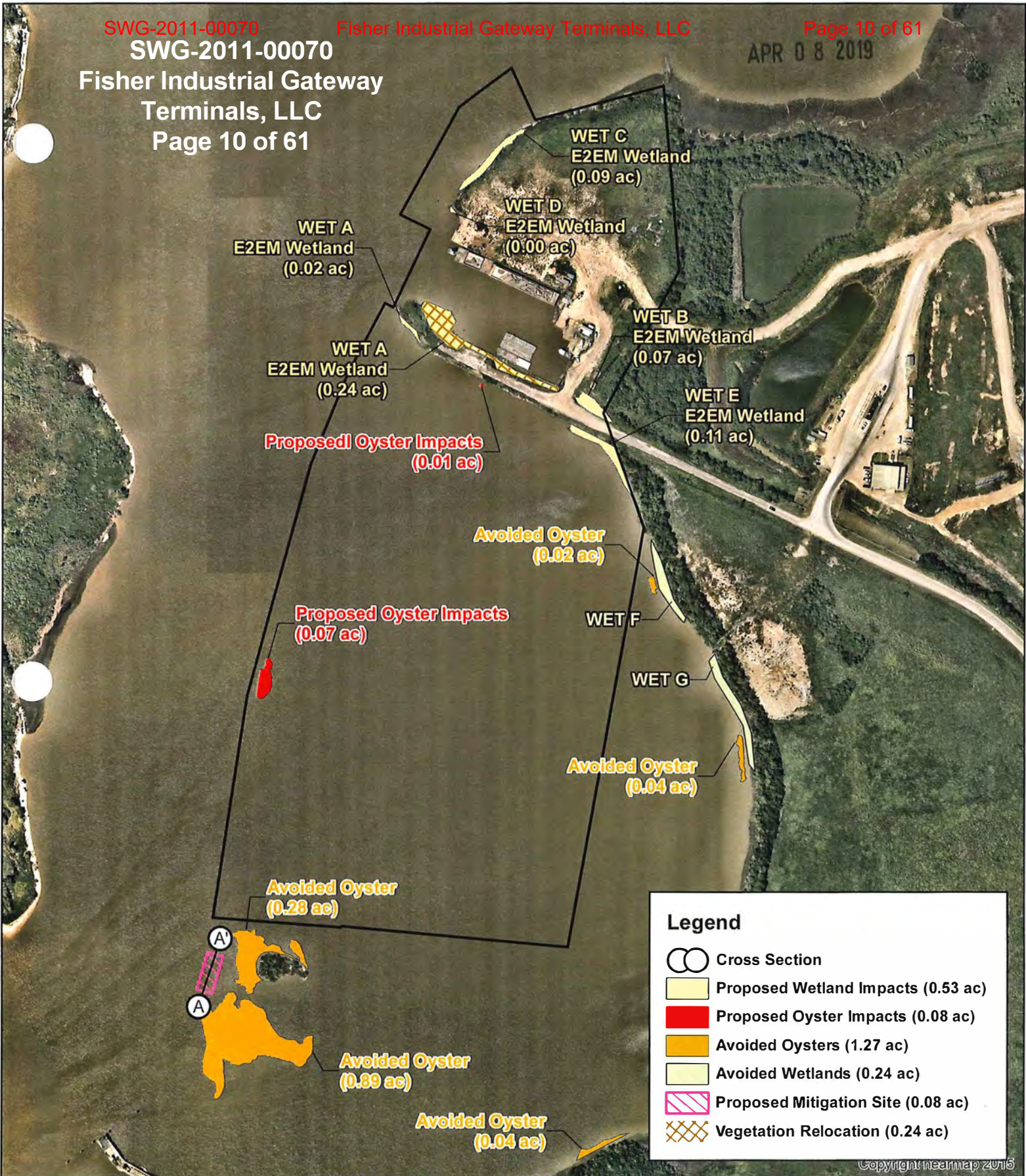


N

0 270 540 Feet

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Page 10 of 61

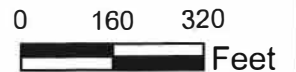


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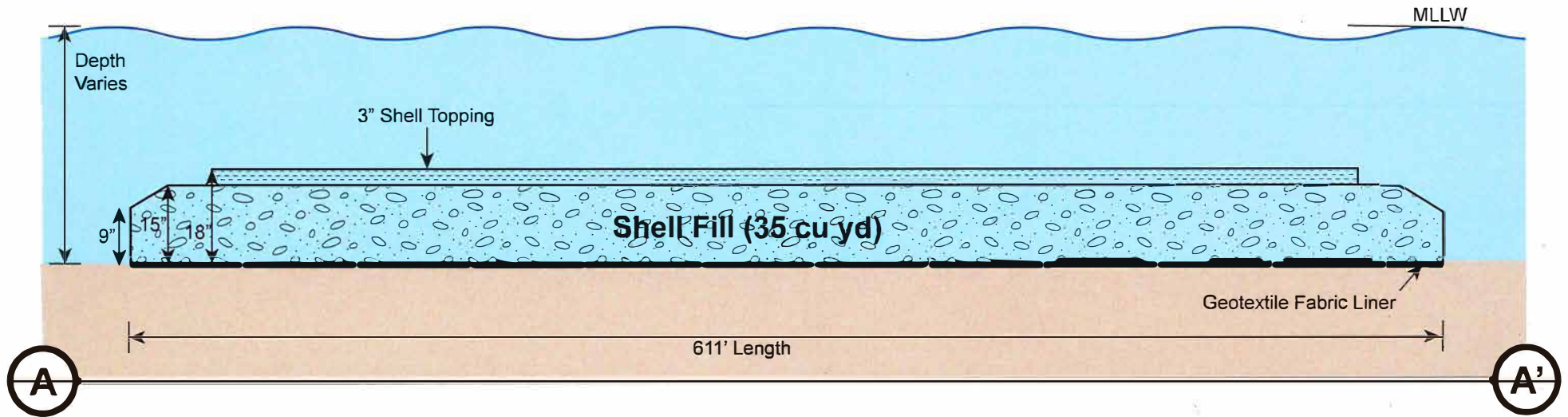
Mouth of Cedar Bayou Mobility Project

2017 AERIAL PHOTOGRAPH WITH PROPOSED IMPACTS, AVOIDANCE, AND MINIMIZATION MAP
Chambers County, Texas

Created: 4/4/2019



Cross Section A-A'



SWG-2011-00070
Fisher Industrial Gateway
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Page 11 of 61

Note: Not to Scale



Mouth of Cedar Bayou Mobility Project
Mitigation Oyster Mound

Cross Section A-A'

Chambers County, Texas

Cedar Bayou

Proposed Oyster Impacts

Proposed Oyster Impacts

SWG-2011-00070
Fisher Industrial Gateway
Terminals, LLC
Page 12 of 61

Legend

- CrossSection
- Navigable Channel
- Spud Barge
- 30,000 Barrel Barge
- Regulation Barges
- Dredging Area (14.11 ac / 279,965 cu yd)
- Proposed Oyster Impacts (0.08 ac / 35 cu yd)

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Mouth of Cedar Bayou Mobility Project

2018 AERIAL PHOTOGRAPH WITH PHASE I PROPOSED SITE PLAN

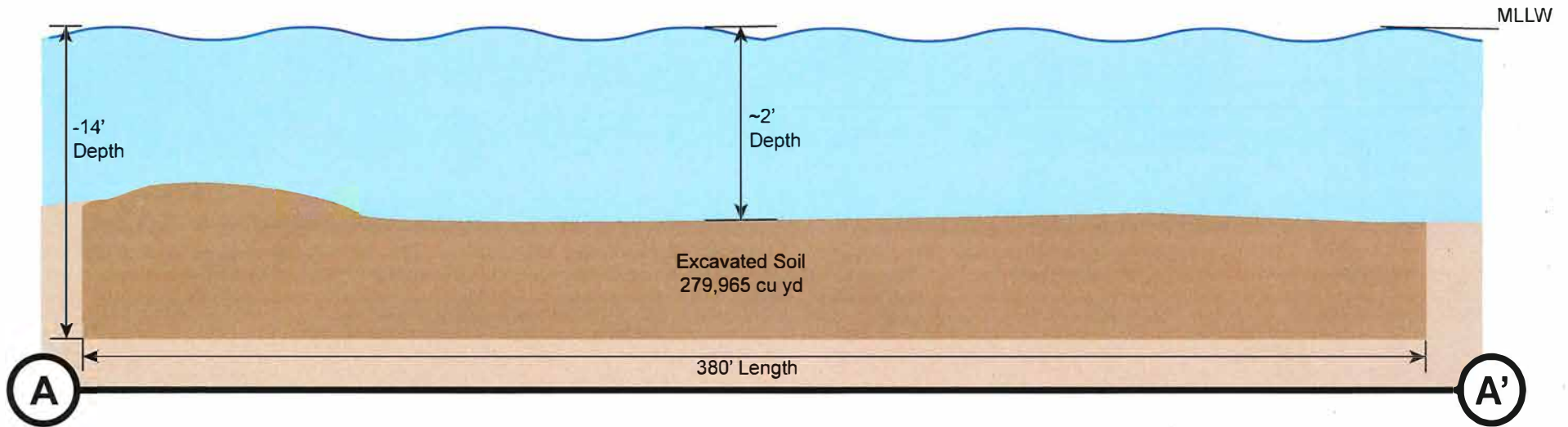
Chambers County, Texas Created: 4/4/2019



0 90 180
Feet

CROUCH ENVIRONMENTAL SERVICES, INC.

Cross Section A-A'



SWG-2011-00070
Fisher Industrial Gateway
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Page 13 of 61

Note: Not to Scale



Mouth of Cedar Bayou Mobility Project
Phase I

Cross Section A-A'

Chambers County, Texas

WET A

SWG-2011-00070
Fisher Industrial Gateway
Terminals, LLC
Page 14 of 61

455'

476'






B'

WET B

WET E

B

Legend

-  Proposed Bulkhead (931 linear feet) E2EM
-  Relocation (0.24 ac)
-  Mechanical Removal (0.72 ac / 28,000 cu yd)
-  Proposed E2EM Wetland Impacts (0.20 ac)
-  Proposed Fill Area (1.69 ac / 32,000 cu yd)

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**Mouth of Cedar
Bayou Mobility Project**

2018 AERIAL PHOTOGRAPH WITH
PHASE II PROPOSED SITE PLAN

Chambers County, Texas

Created: 4/4/2019



North arrow pointing up.

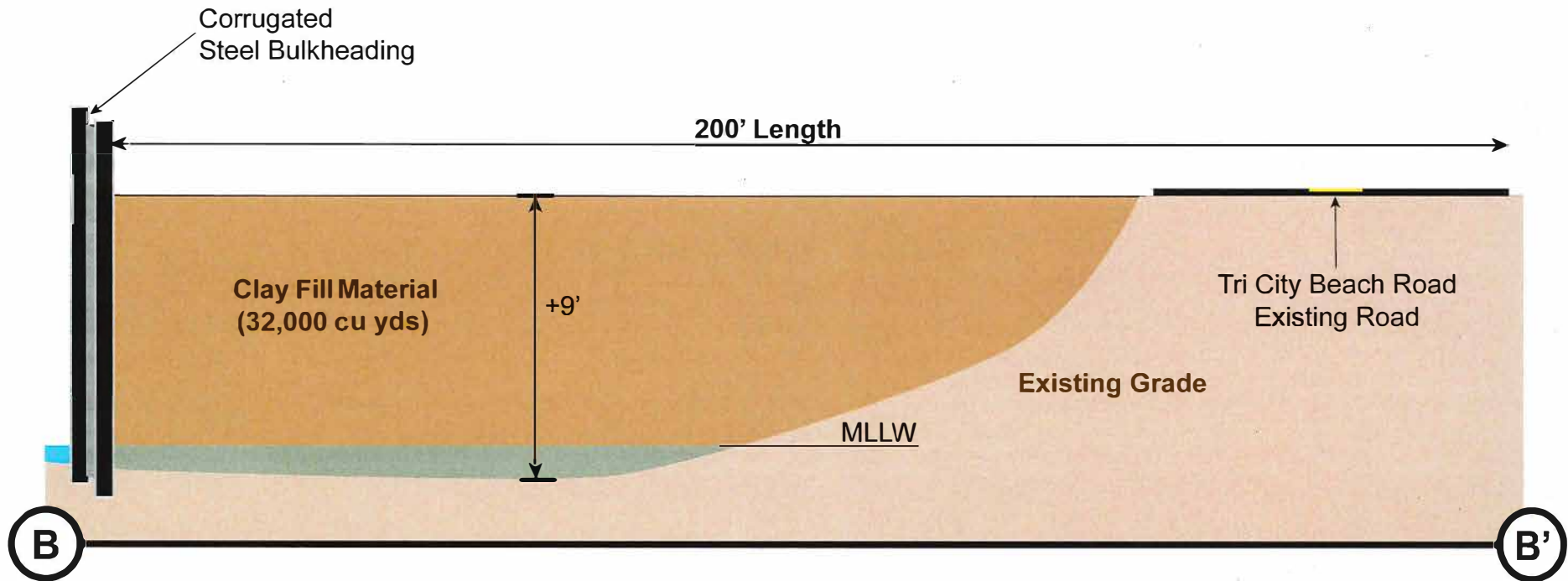
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CROUCH ENVIRONMENTAL SERVICES, INC.



Cross Section B-B'

SWG-2011-00070
Fisher Industrial Gateway
Terminals, LLC
Page 15 of 61



Note: Not to Scale

Mouth of Cedar Bayou Mobility Project
Phase II

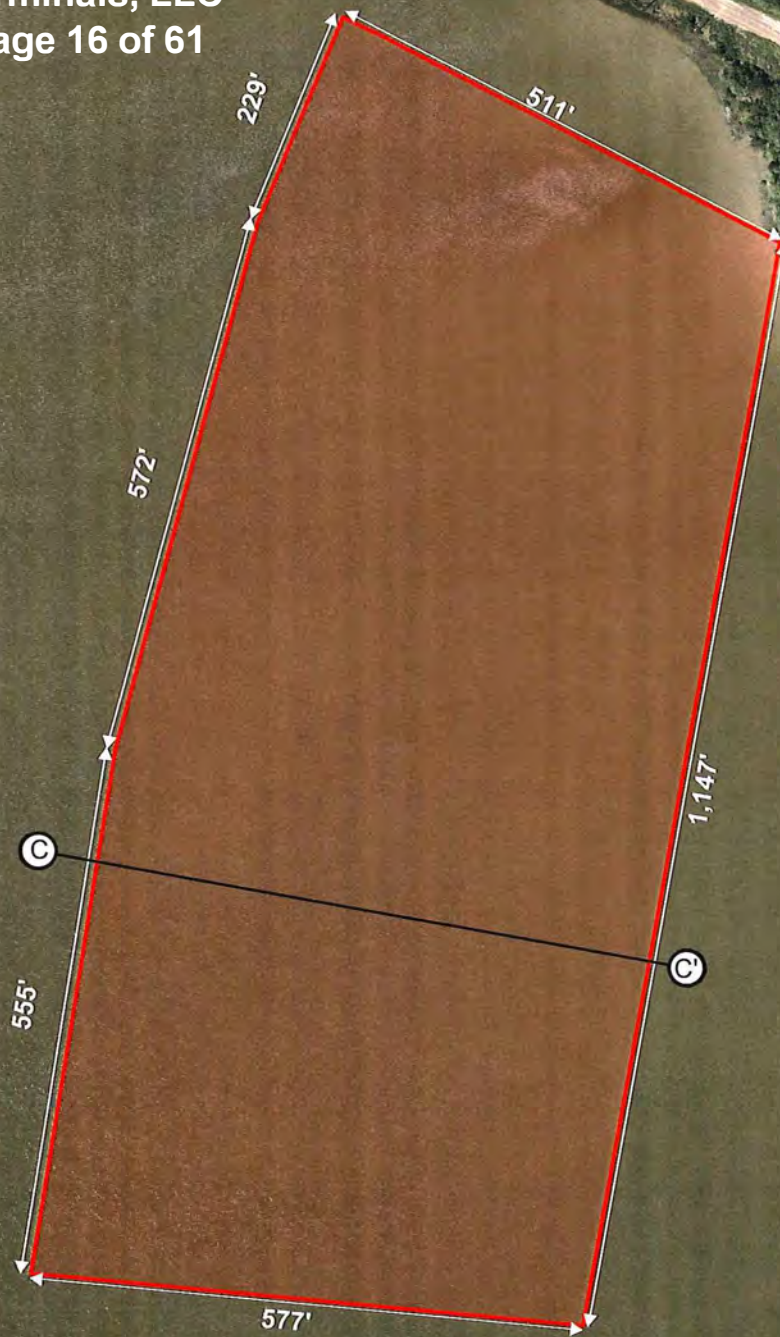
Cross Section B-B'

Chambers County, Texas



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SWG-2011-00070
Fisher Industrial Gateway
Terminals, LLC
Page 16 of 61



Legend

- CrossSection
- Proposed Dredge Area
(16.46 ac / 341,000 cu yd)
- Avoided E2EM Wetlands
(0.24 ac)

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**Mouth of Cedar
Bayou Mobility Project**

2018 AERIAL PHOTOGRAPH WITH
PHASE III PROPOSED SITE PLAN

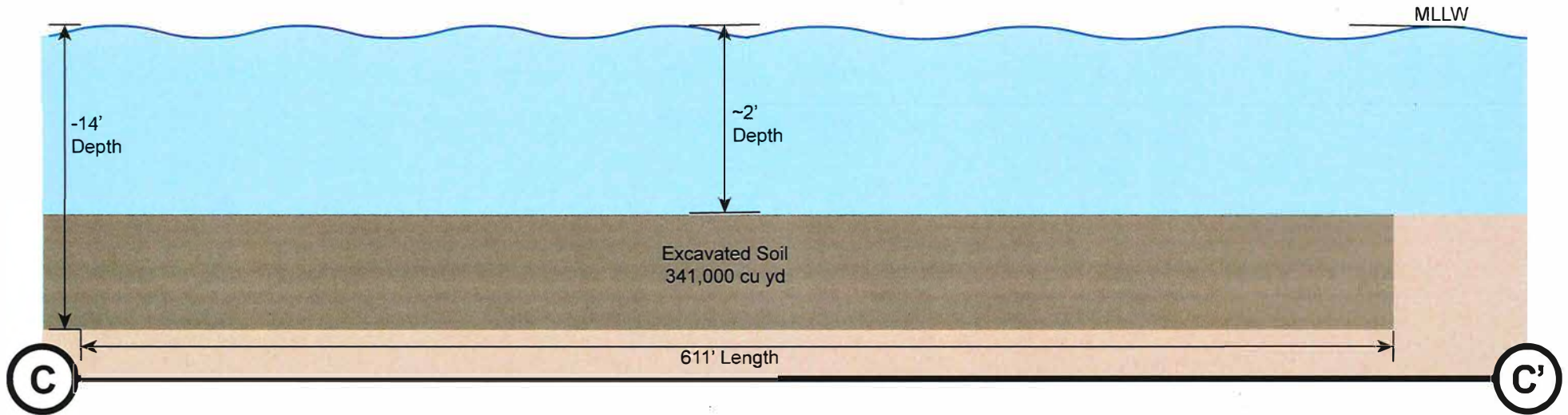
Chambers County, Texas

Created: 4/4/2019



Cross Section C-C'

SWG-2011-00070
Fisher Industrial Gateway
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Page 17 of 61



Note: Not to Scale



Mouth of Cedar Bayou Mobility Project
Phase III

Cross Section C-C'

Chambers County, Texas






Cedar Bayou



WET C

WET D

Legend

-  Proposed Bulkhead (407 linear feet)
-  CrossSection
-  Navigable Channel
-  Proposed Dredging Area (1.65 ac / 35,000 cu yd)
-  Proposed E2EM Wetland Impacts (0.09 ac)

SWG-2011-00070
 Fisher Industrial Gateway
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 Page 18 of 61

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**Mouth of Cedar
 Bayou Mobility Project**

2018 AERIAL PHOTOGRAPH WITH
 PHASE IV PROPOSED SITE PLAN

Chambers County, Texas

Created: 4/4/2019



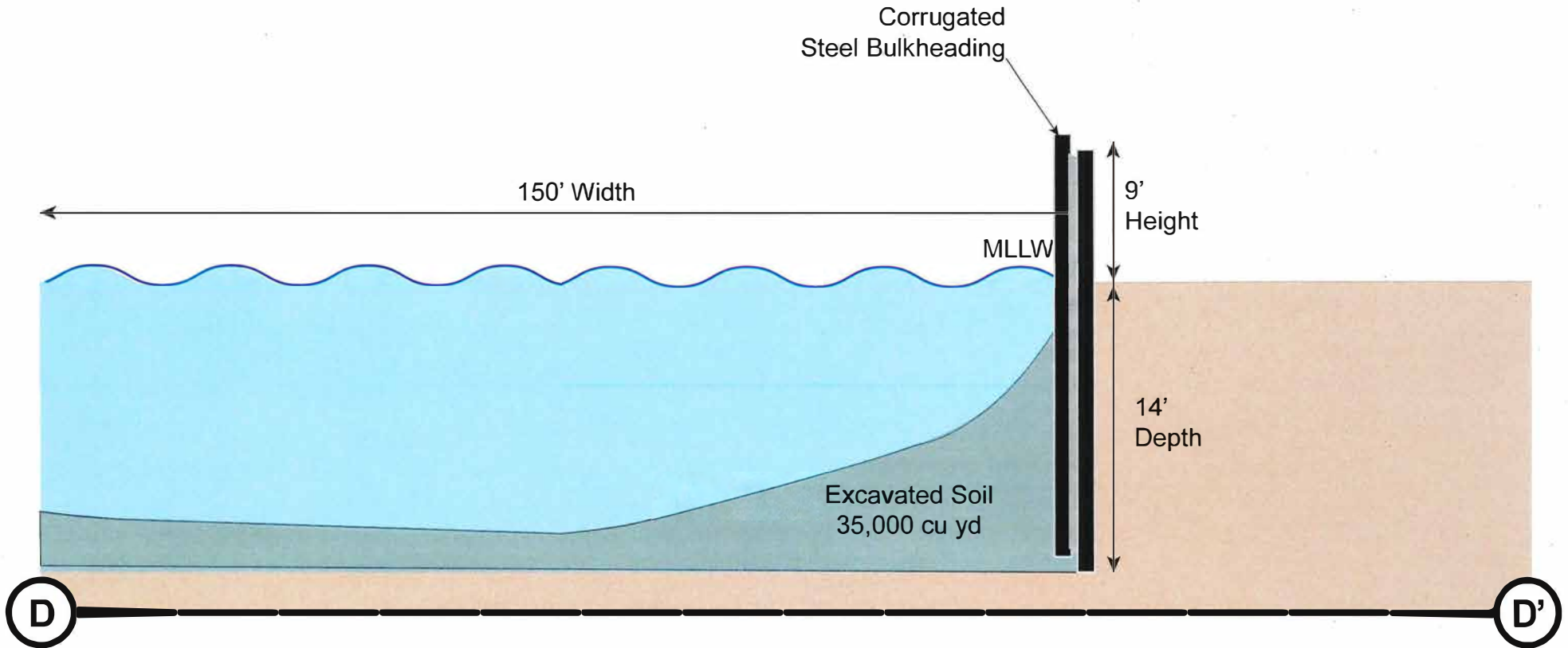
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Cross Section D-D'



SWG-2011-00070
Fisher Industrial Gateway
Terminals, LLC
Page 19 of 61

Note: Not to Scale



Mouth of Cedar Bayou Mobility Project
Phase IV

Cross Section D-D'

Chambers County, Texas

Alternatives Analysis

INTRODUCTION

A key provision of the Clean Water Act (CWA) Section 404 (b) (1) guidelines (40 Code of Federal Regulations [CFR] 230) is the “practicable alternative test”. This provision requires that “no discharge of fill material shall be permitted if there is a practicable alternative to the proposed fill which would have less adverse impact on the aquatic ecosystem.” As a result, Fisher Industrial Gateway Terminals, LLC (the Applicant) has investigated available alternatives, including the No-Action Alternative, in order to determine if there are fewer damaging alternatives available and that all on-site impacts to waters of the U.S. (WOUS) have been avoided to the maximum practicable extent possible.

PROJECT NEED

The Cedar Bayou Navigation District is the local sponsor of the U.S. Army Corps of Engineers (USACE) Cedar Bayou Channel Improvement Project. This deepening and widening project will increase channel dimensions to 100 feet wide and 10-foot deep for 8 miles upstream to accommodate increasing barge traffic on Cedar Bayou. Historically, Cedar Bayou has been plagued by width restrictions and sharp, winding turns that cause delayed barge traffic, collisions, and groundings. With the expansion of Cedar Bayou as well as with the existing barge traffic, the Applicant has found that the existing dock and dockside depth at Fisher Industrial Gateway Terminals, LLC are inadequate to accommodate the increasing demand along the Bayou for safe and efficient water transportation.

PROJECT PURPOSE

The purpose of the proposed project is to construct a commercial dock for the loading and off-loading of commercial goods (including steel rolls, containers, and liquid products) safely and efficiently along Cedar Bayou in Baytown, Chambers County, Texas. The proposed project would shorten water-based trips required for hauling loads to the Chambers County region by approximately 10 miles. The proposed project is located only a half-mile upstream on Cedar Bayou from the intersection of the Houston Ship Channel. The project location will reduce transportation costs, delays, traffic, and the potential for barge collisions while providing a secure and safe alternative for shipping and receiving commercial goods.

ALTERNATIVES

The design process evaluated four possible options to determine the least environmentally damaging practicable alternative (LEDPA) that meets the purpose and need of the project. Alternatives considered include:

1. No Action Alternative
2. Onsite Alternative 1
3. Onsite Alternative 2 (Preferred Alternative)
4. Offsite Alternative

To meet the project purpose, alternatives need to meet the following site criteria:

- Located along Cedar Bayou
- Sufficient size to accommodate barge traffic
- Safe access to a permitted upland disposal site for dredged material
- Minimal impacts to submerged aquatic resources and WOUS, including wetlands
- Reasonable cost
- Availability

Alternatives Analysis

The proposed project is water dependent and cannot avoid impacts to WOUS, however, efforts have been made to minimize impacts to WOUS, including wetlands and oyster reef habitats to the extent practicable. Because water transportation can be an economically competitive form of transit for the commodities handled by the Applicant, the alternative analyses focused on water-based options available to the Applicant for a LEDPA. Because of the scarcity of available vacant land along Cedar Bayou and the requirements of the Applicant for water-based transit and heavy haul routes, the alternatives analysis was confined to the parcels owned by the Applicant along Cedar Bayou.

Table 1 on the below provides a summary of the alternative comparison matrix.

Table 1: Alternative Comparison Matrix for Practicability

Category	Practicability Factor	1	2	3	4
		No Action Alternative	Onsite Alternative 1	Onsite Alternative 2 (Preferred)	Offsite Alternative
Availability	Available for acquisition	YES Applicant owns the parcel	YES Applicant owns the parcel	YES Applicant owns the parcel	YES Applicant owns the parcel
	Reasonable acquisition costs?	YES Applicant owns the parcel	YES Applicant owns the parcel	YES Applicant owns the parcel	YES Applicant owns the parcel
Cost	Cost feasible for mitigating impacts to WOUS, including wetlands?	YES No costs would be incurred with this alternative	YES 1.78 mitigation credits would need to be purchased	YES 1.78 mitigation credits would need to be purchased	YES A minimum of 4 mitigation credits would need to be purchased
	Cost feasible for mitigating impacts to historic and cultural resources?	YES No historical or cultural resources found on the project	YES No historical or cultural resources found on the project	YES No historical or cultural resources found on the project	YES No historical or cultural resources found on the project
Logistics and Safety	Sufficient parcel size?	NO With the current configuration of Cedar Bayou and existing depths of Fisher Marsh, barges would not be able to fleet or unload commercial goods near or at the mouth of Cedar Bayou	YES	YES	NO Although the parcel is currently being used as a commercial dock, it is not large enough to support fleeting and the growing demand for shipments along Cedar Bayou
	Availability for access?	NO With the current restrictions of Cedar Bayou and Fisher Marsh, barges would not be able to fleet or unload commercial goods near or at the mouth of Cedar Bayou	YES	YES	NO Although this alternative is located adjacent to Cedar Bayou, there is not enough space to accommodate fleeting barges

Alternatives Analysis

Category	Practicability Factor	1	2	3	4
		No Action Alternative	Onsite Alternative 1	Onsite Alternative 2 (Preferred)	Offsite Alternative
Logistics and Safety	Proximity to approved upland disposal area?	N/A	YES EPA authorized Waste Management property is 0.2 miles from the project	YES EPA authorized Waste Management property is 0.2 miles from the project	NO The Applicant would need to construct an upland placement area
	Wetland impacts	N/A	YES 5.56 ac of impacts	YES 0.53 acres of impacts	YES 2 acres of impacts
Environmental	Special aquatic site impacts?	YES	YES Impacts to oyster reefs total to 0.08 ac	YES Impacts to oyster reefs total to 0.08 ac	NO
	Threatened and endangered species impacts?	NO No critical habitat is located within the project	NO No critical habitat is located within the project	NO No critical habitat is located within the project	NO No critical habitat is located within the project
	Cultural impacts?	NO No historical or cultural resource found on the project	NO No historical or cultural resource found on the project	NO No historical or cultural resource found on the project	NO No historical or cultural resource found on the project
Existing Technology	Topography and other site conditions feasible for construction project?	NO The current depths of the project would not enable safe thoroughfare or barges to fleet adjacent to the existing marina	YES With extensive use of mechanical dredging and corrugated steel bulkheading	YES With use of mechanical dredging and corrugated steel bulkheading	YES With use of additional mechanical dredging

1. NO ACTION ALTERNATIVE

The Applicant has considered not dredging or bulkheading the areas within the adjacent bay and utilizing the area for fleeting purposes, however, the depths are too shallow (-2 inches to -3 feet below Mean Low-Lower Water [MLLW]) to support barge fleeting within the area. The demand for berthing and safe transport of commodities is increasing and will further increase with the dredging of the Cedar Bayou Improvement Project. Without sufficient dockage and depth to accommodate fully-loaded barges, the Applicant will not be able to take advantage of the Federal investment in Cedar Bayou. Cedar Bayou has had an 10% increase in annual growth of barges utilizing the bayou within the last year.

By not dredging the shallow bay, barges will continue to impact existing wetlands and oyster reefs along the Cedar Bayou Navigation Channel. The No Action Alternative would result in increased barge traffic within the area with no fleeting opportunities along the lower Cedar Bayou Navigation Channel. Additionally, the oyster reefs that are currently located within the area will remain vulnerable to damage by barges colliding with them. Currently tug captains will beach barge tows along the channel shoreline to avoid collisions and adverse wave and wind conditions. A No Action Alternative would not provide any operational options to those barge handling operations with potentially more damage to estuarine emergent wetlands, fish, and wildlife habitats.

Alternatives Analysis

The No Action Alternative would result in increased traffic congestion along the Houston Ship Channel, Cedar Bayou, and adjacent waters. The nearest commercial dock open to general cargo handling, is located approximately 5 miles upstream from the mouth of Cedar Bayou which has many tight and winding turns. There are no fleeting areas for barges along the lower Cedar Bayou Navigation Channel. The closest fleeting areas for Houston Ship Channel cargo, is located approximately 12 miles upstream, near Channelview, Texas. The Houston Ship Channel near Channelview is becoming increasingly congested with barge traffic with barges often blocking access or causing delays. There is increased traffic congestion at the Bayport Terminals, a commercial dock off the Houston Ship Channel in closed proximity to Cedar Bayou. There are traffic jams surrounding the Bayport Terminals along State Highway (SH) 146 and SH 225.

The No Action Alternative does not fulfill the Applicant's purpose or need for safe and efficient water-borne transport of commodities that supports the local economy and that fills a niche in the manufacturing supply and processing chain.

2. ONSITE ALTERNATIVE 1

Onsite Alternative 1 is the Applicant's original proposed plan for action. Onsite Alternative 1 has accounted for the additional space that would be required for the loading and off-loading of commercial goods. Onsite Alternative 1 incorporated expanding, the privately-owned portion of Tri City Beach Road along the roadway until it terminated at Cedar Bayou. This involved extending the road 200 ft to the south into the adjacent bay and impacting adjacent waterbodies and wetlands, totaling to 3.19 ac. Large barges could be placed on either side of the privately owned, expanded Tri City Beach Road enabling more efficient loading and off-loading of commercial goods. Onsite Alternative 1 also had an on-stream loading and off-loading dock that would have enabled barges to easily pull off Cedar Bayou. By creating this quick access, barges would be able to briefly stop, load and off-load and continue on their way, satisfying supply and demand, and enabling barge operators to increase their shipments upbound and down bound on Cedar Bayou efficiently. To stabilize the commercial dock and road expansion, approximately 2,420 linear feet of bulkheading would need to be installed into the bedrock for Onsite Alternative 1. Once the dock and road were stabilized the Applicant intended to raise the dock and expand the road to +9 ft above MLLW.

Onsite Alternative 1 meets the need for opportunities in a developing area and associated economic benefit to the community. Additionally, it would offer an area large enough to support and accommodate expanding truck to barge and barge to truck traffic driven by the significant industrial expansion in west Chambers County and east Harris County regions. This project will help fulfill the anticipated economic return on investment that the Federal government is making in the USACE Cedar Bayou Improvement Project.

Anticipated impacts are 37.79 ac to WOUS, including wetlands, 0.53 ac to wetlands, and 0.08 ac of impacts to oyster reefs. To compensate for the unavoidable loss of wetlands, the Applicant would need to purchase 1.78 credits at an USACE approved wetland mitigation bank. No critical habitat for threatened and endangered species occurs within the On-Site Alternative 1. Additionally, there are no historical or cultural resources identified within the area of Onsite Alternative 1.

This alternative would also require permitting for Section 408, as dredging would have impacts to the Cedar Bayou Navigation Channel. Additionally, this Onsite Alternative 1 is anticipated to have resistance from state agencies, as additional waters of the U.S. and State would need to be permanently filled.

The site is owned by the Applicant and has waterfrontage through a commercial state land use lease with the Texas General Land Office (GLO). Onsite Alternative 1 is located on a permitted heavy haul route from Mount Belvieu to

Alternatives Analysis

Bayport and Barbour's Cut Terminal along the HSC. This access to a heavy haul route enables efficient and approved access to and from the site for haul trucks importing and exporting commodities.

Beneficial Uses (BU) of dredged material was also considered during the development of Onsite Alternative 1. The Applicant coordinated with the USACE and the GLO to determine the level of effort that would be involved for the construction of a BU site within Fisher Marsh. The required monitoring for BU sites or Habitat Creation sites would be over 3 years, including a perpetual surface lease. The BU site would be constructed within the Half Moon Bay area of the adjacent bay. This area is mostly protected from high velocity waves, which would enable smooth cordgrass to develop. Additionally, since there have been live oysters observed on the shoreline along the bay, it is likely that oysters would also develop well within the area.

To construct the BU site, the Applicant considered using some of the new, clay dredged material and creating a berm to protect the proposed BU Site. Once the berm was in place the 0.08 ac of oyster shell of anticipated impacts would be relocated on the exterior of the berm for further protection of the BU site. Dredged fill material would be mechanically placed within the interior at a slope of 10:1 within BU site bringing the elevation of -1 ft to -2 ft MLLW. Smooth cordgrass (*Spartina alterniflora*) along the privately-owned Tri City Beach Road would then be relocated to the newly developed BU site and planted within the interior along 2-ft centerline spacing.

Onsite Alternative 1 meets the Applicants purpose and need, however due to increased impacts to WOUS, including wetlands, this alternative is not the LEDPA.

3. ONSITE ALTERNATIVE 2 (PREFERRED ALTERNATIVE)

The proposed project described as Onsite Alternative 1 underwent significant redesign and modification to reduce the adverse impacts to surface water. The Applicant worked closely with the United States Army Corps of Engineers (USACE) and various State and Federal resource agencies in the development of Onsite Alternative 2 (Preferred Alternative). As with Onsite Alternative 1, Onsite Alternative 2 is located on property currently owned by the Applicant with water access through a commercial State land use lease with the GLO along Cedar Bayou. The Onsite Alternative 2 (Preferred Alternative) was also selected due to its waterfront location adjacent to an existing marina, Cedar Bayou, and the HSC.,. Onsite Alternative 2 is located on a permitted heavy haul route from Mount Belvieu to Bayport and Barbour's Cut Terminal along the HSC. This access to a heavy haul route enables efficient and approved access to and from the site for haul trucks importing and exporting commodities.

In order to complete the Onsite Alternative 2 (Preferred Alternative), the Applicant is proposing to install 1,338 feet (ft) of steel corrugated bulkheading to stabilize the banks of the commercial dock, expand the existing, privately owned Tri City Beach Road to a width of 200 ft to allow safe thoroughfare. Expanding the road would fill 1.69 ac of WOUS, including wetlands. Onsite Alternative 2 (Preferred Alternative) would also raise the loading and unloading dock to an elevation of +9 ft above Mean Low Lower Water (MLLW). To facilitate barge access within the adjacent bay for fleeting, the applicant proposes to mechanically dredge approximately 32.94 acres (ac) and 684,000 cubic yards to a depth of -14 ft below MLLW. Dredged material would be loaded onto haul trucks and transported 0.2 mi on private roads to a previously approved upland placement area. It is anticipated that only 0.08 ac of oyster reef, 0.53 ac of estuarine wetlands, and 33.55 ac of waterbodies will be directly impacted by the proposed project.

Alternatives Analysis

Onsite Alternative 2 (Preferred Alternative) avoids impacting the Cedar Bayou Navigation Channel by approximately 98 ft to 165 ft. Since the Cedar Bayou Navigation Channel is not being impacted, a Section 408 permit from the USACE would not be required.

To compensate for the unavoidable loss of wetlands, the Applicant would need to purchase 1.78 credits at an USACE approved wetland mitigation bank. The Onsite Alternative 2 would still enable the Applicant to relocate 0.24 ac of E2EM vegetation to a nearby wetland restoration project along Cedar Bayou, within the same watershed to avoid the permanent loss of wetland vegetation and function. Onsite Alternative 2 would also involve the construction, enhancement, and protection of an oyster reef at a 15-to-1 compensatory ratio resulting in no net loss of aquatic resource functions and values. No critical habitat for threatened and endangered species occurs within the area of On-Site Alternative 2. Additionally, there are no historical or cultural resources identified within the area of Onsite Alternative 2.

The Onsite Alternative 2 (Preferred Alternative) provides the only LEDPA for the Applicant that is consistent with the project purpose and need.

4. OFFSITE ALTERNATIVE

There exists a paucity of available waterfrontage along the mouth of Cedar Bayou for land use compatible with the needs of the Applicant. Additionally, there are no private roads for the use the Applicant requires.

The Applicant owns an additional waterfront parcel along Cedar Bayou that is currently operating as a commercial dock. This Offsite Alternative offers convenient and efficient access for barge and shipping traffic that is well utilized. The Offsite Alternative is also constructed along a heavy haul route adjacent to the new constructed and expanded Grand Parkway (State Highway 99).

The Offsite Alternative is limited in its space for potential expansion. There is also limited compatible space for potential barge fleeting near the active commercial docks upstream. In order to create additional docks or fleeting areas adjacent waterbodies and wetlands would need to be extensively excavated. Land would also need to be acquired that is not currently available for reasonable purchase around the existing commercial docks.

During the permitting period of the Applicant's upstream dock location, the public expressed concerns with a commercial dock being constructed across the bayou from a local park, Roseland Park. Due to the proximity to this park and previous experience with public concerns, community support for expanding this commercial dock would cause additional challenges and is not practicable. However, the Applicant has an approved contractual enforceable development agreement with the City of Baytown for this proposed location for the specific purposes contemplated in this permit request.

CONCLUSION

After taking into consideration the project site criteria for the purpose of the proposed project, the Applicant has concluded that the Onsite Alternative 2 is the Preferred Alternative and is the LEDPA. The Preferred Alternative provides convenient access to Cedar Bayou from the HSC; provides enough capacity to meet the proposed project's need and purpose; and, is available for use. The Preferred Alternative also results in lower impacts of WOUS, including wetlands, special aquatic sites, threatened and endangered species, or cultural resources. Additionally, there are private roads available for use; adjacent previously approved upland disposal sites; and, access to the previously permitted heavy haul routes.

Alternatives Analysis

After review of other properties and the project area, the Applicant concluded that there are no feasible alternatives that would have avoided affecting WOUS or have fewer impacts than the Preferred Alternative, while meeting the project purpose and need.

The Preferred Alternative continues to meet the need for opportunities in a developing area and associated economic benefit to the community while minimizing impacts to WOUS, including wetlands making it the LEDPA. Additionally, it would offer an area large enough to support and accommodate the additional trucks and barges. The preferred alternative represents the least environmentally damaging practicable alternative while remaining both economically and logistically practical.

The No Action Alternative is inadequate and impractical as it does not fulfill the Applicant's purpose and need or serve the surrounding community. If the project is not developed, the community would suffer a loss of job opportunities in a developing area with the associated economic benefits. The surrounding community would also not realize the environmental benefits associated with the proposed project. These benefits include providing a safe location for barges to load and off-load their cargo, avoiding shoreline and oyster reef impacts, and protecting a thriving oyster reef habitat from barge impacts with the proposed mitigation plan.

Additionally, the Preferred Alternative would aid in relieving traffic congestion near the Bayport Terminals and shorten trips to only a half-mile upstream of Cedar Bayou from the intersection of the Houston Ship Channel, saving transportation costs, delays, traffic congestion, and providing a safer alternative for the shipment and receiving of goods.

The costs associated with the construction of the BU site described in Onsite Alternative 1 reached over a quarter of a million dollars without factoring in costs for any adaptive management, associated permits, or agency coordination. The BU site would also be a loss of property with inhibited future development within the area. Due to estimated exorbitant costs this alternative had the potential for adverse environmental impacts and unintended consequences.

The Applicant is able to fulfill the oyster mitigation requirements by coordinating with TPWD and the GLO. The Applicant would still mitigate the impacts to the oyster reef habitat by relocating the existing oyster reef to 200 feet south of the Onsite Alternative 2 (Preferred Alternative), to a more productive reef. The Applicant would also protect this reef from getting impacted by barges by protecting the oyster reef until the mitigation project is complete.

Additionally, the Preferred Alternative enables the wetland vegetation to be relocated to a nearby restoration project located approximately 2 miles upstream of Cedar Bayou. This smooth cordgrass would be removed, stored, and replanted in a reasonable time frame. The plants will be monitored as part of the restoration project to ensure the continued success of the wetland vegetation.

Conceptual Compensatory Mitigation Plan

for the

Proposed Mouth of Cedar Bayou Mobility Project

SWG-2011-00070

April 2019

Prepared For



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Contents

Contents **ii**

Acronyms **iii**

Exhibits and Appendices **iv**

Introduction..... **1**

Baseline Information **2**

Site Description 2

Wetland Impacts..... 3

SAR Impacts 4

Compensatory Mitigation Strategy..... **5**

Proposed Wetland Mitigation..... 5

Proposed On-Site Oyster Mitigation 5

Work Plan..... 5

Maintenance..... 6

Monitoring and Adaptive Management **7**

Monitoring..... 7

Adaptive Management..... 7

Conclusion..... **8**

References **9**

Acronyms

ac – acre(s)
Applicant – Fisher Industrial Gateway Terminals, LLC
BMP – Best Management Practices
CESI – Crouch Environmental Services, Inc.
CFR – Code of Federal Regulations
CWA – Clean Water Act
cy – cubic yards
E2EM – Estuarine Emergent Wetlands
EPA – Environmental Protection Agency
FCI – Fuctional Capacity Index
FCU – Functional Condition Unit
FEMA – Federal Emergency Management Agency
ft – feet
GBF – Galveston Bay Foundation
GPS – Global Positioning System
HGAC – Houston-Galveston Area Council
HUC – Hydrologic Unit Code
iHGM – Inteim Hydrogeomorphic Model
in – inches
MLLW – Mean Low Lower Water
NRCS – Natural Resources Conservation Services
OHWM – Ordinary High Water Mark
PCB – Polychlorinated Biphenyl
PJD – Preliminary Jurisdictional Determination
PRM – Permittee Responsible Mitigation
Project – Mouth of Cedar Bayou Mobility Project
RGL – Regulatory Guidance Letter
SAR – Submerged Aquatic Resources
SAV – Submerged Aquatic Vegetation
SP – Standard Permit
Subject Property – Area within Project Boundaries
TCEQ – Texas Commission on Environmental Quality
TPWD – Texas Park and Wildlife Department
USACE – U.S. Army Corps of Engineers
USCG – U.S. Coast Guard
WOUS – Waters of the United States

Exhibits and Appendices

- Exhibits:**
1. 2018 Aerial Photograph with Proposed Project
 2. 2018 Aerial Photograph with Proposed Conceptual Mitigation Planning Map
 3. 2018 Aerial Photograph with 2017 NRCS Soil Survey
 4. 2018 Aerial Photograph with FEMA Floodplain Data
 5. 2018 Aerial Photograph with Mitigation Site
 6. Mitigation Oyster Mound Creation Cross-Section

Appendix A: iHGM Datasets

Appendix B: Subject Property Photograph Log

Introduction

This Conceptual Compensatory Mitigation Plan has been developed by Crouch Environmental Services, Inc. (CESI) on behalf of Fisher Industrial Gateway Terminals, LLC (Applicant) to be included in the U.S. Army Corps of Engineers (USACE) Standard Permit (SP) application package (SWG-2011-00070) for the proposed Mouth of Cedar Bayou Mobility Project (project), located adjacent to Cedar Bayou, Baytown, Chambers County, Texas (Subject Property). The proposed project includes construction of a commercial dock for the loading and unloading of commercial goods (including steel rolls, containers, and liquid products) safely and efficiently. The proposed project would shorten trips needed for hauling loads to only a half-mile up-stream of Cedar Bayou, reducing transportation costs, delays, traffic, and decreasing barge collisions, while providing a safer alternative for the shipping and receiving of commercial goods. The proposed project, depicted in **Exhibit 1**, involves the following activities described below:

- Mechanically dredging approximately 32.94 acres (ac) and 684,000 cubic yards (cy) of material to a depth of -14 feet (ft) below mean low-lower water (MLLW) to facilitate barge access
- Installation of 1,338 ft of steel corrugated bulkheading to stabilize the banks of the commercial dock
- Expanding the existing, privately owned Tri City Beach Road by 1.69 ac to a width of 200 ft to allow safe thoroughfare with approximately 28,000 cy of native clay fill material
- Raising the loading and unloading dock to an elevation of +9 ft above MLLW

Preliminary application meetings were held with the USACE-Galveston District from August 2018 to March 2019, including a Joint Evaluation Meeting (JEM), to review the proposed project and alternatives, discuss the permitting requirements, and consider potential mitigation for unavoidable impacts to Waters of the United States (WOUS) and Submerged Aquatic Resources (SAR). Additionally, CESI has coordinated with the Texas Parks and Wildlife Department (TPWD), and it was indicated that a ratio of one acre of oyster reef impact to one acre of sustainable cultch material would be acceptable.

CESI biologists conducted four field surveys on the Subject Property from October 2018 to February 2019. These surveys consist of a wetland delineation and Submerged Aquatic Resources (SAR) assessment to determine the amount and quality of natural resources present, including wetlands, seagrasses, and oyster reefs. These assessments provide the data necessary to avoid and minimize impacts to natural resources in the planning and development of the proposed project. The Applicant reviewed potential alternatives and designed the project to avoid natural resources to the greatest extent practicable and to minimize impacts where they were otherwise unavoidable.

The proposed project will result in the unavoidable loss of **0.53** ac of estuarine emergent (E2EM) wetlands and **0.08** ac of oyster reef habitat. The project is in the secondary service area of the USACE approved Gulf Coastal Plains Mitigation Bank, the Applicant intends to purchase credits to mitigate impacts to 0.53 ac of E2EM. The Applicant also intends to relocate 0.24 ac of E2EM wetlands to a nearby wetland along Cedar Bayou, within the same watershed to avoid the permanent loss of wetland vegetation and function.

There are currently no credits available within Mitigation Banks or in-lieu fee programs to compensate for the anticipated impacts to oyster reef habitat. The Applicant proposes to provide in-kind Permittee Responsible Mitigation (PRM) that will protect **1.17 ac** of existing oyster habitat and create **0.08 ac** of artificial oyster reef habitat at a suitable nearby location along Cedar Bayou totaling to 1.25 ac of oyster reef habitat (see **Exhibit 2**). The creation and preservation would protect and increase the existing oyster reef habitat within the Cedar Bayou watershed at a **15 to 1** compensatory mitigation to impact ratio, resulting in **no net loss of aquatic resources**. Compensatory mitigation strategies presented in this plan follows 33 Code of Federal Regulations (CFR) 230 to 332 and Regulatory Guidance Letter (RGL) 08_03.

Baseline Information

Site Description

The Subject Property is located within the North Galveston Bay watershed (Hydrologic Unit Code [HUC] 12040203) and is included in the Cedar Bayou Watershed Protection Plan that was developed and approved by the Environmental Protection Agency (EPA) in June 2016. This watershed plan was developed in response to the existing water quality issues along Cedar Bayou with elevated levels of fecal bacteria and fish advisories for polychlorinated biphenyls (PCBs) and dioxins in edible fish tissue, low dissolved oxygen, and other stressors on aquatic communities (Houston-Galveston Area Council 2016). The Subject Property also occurs within the Texas Commission of Environmental Quality water quality segment identified as 'Cedar Bayou Tidal (Segment 0901),' an impaired waterbody.

According to the ecoregions of Texas described by Griffith et al, the Subject Property is in the **Northern Humid Gulf Coastal Prairies**, a sub-ecoregion of the **Western Gulf Coastal Plains**. This ecoregion is described by quaternary-age deltaic sands, silts, and clays which underlie this gently sloping coastal plain. The historical vegetation included mostly grasslands with a few clusters of oaks, known as oak mottes or maritime woodlands.

Almost all the coastal prairies have been converted to cropland, rangeland, pasture, or urban land uses. The invasive Chinese tallow (*Triadica sebifera*) tree and Chinese privet (*Ligustrum sinense*) have invaded large areas in this region. Soils are mostly fine-textured: clay, clay loam, or sandy clay loam (see **Exhibit 3**). Annual precipitation varies from 37 inches in the southwest portion to 58 inches in the northeast, with a summer maximum (Griffith et al 2010).

The Applicant has owned the Subject Property for over 80 years and previously used the surrounding land adjacent to Cedar Bayou and Fisher Marsh to support agricultural activities, including rice field farming and livestock use. Portions of the Subject Property are currently being used as a marina, currently permitted under SWG-2011-00070. The Subject Property consists of E2EM, herbaceous uplands, and forested uplands. Most of the Subject Property consists of shallow water ranging in depths from 2 inches (in) to 4 ft. The benthic habitat consists of sand, mud, silt, clay particles, and shell. No seagrasses occur within the Subject Property. The oyster reef comprises 0.08 acre along the Cedar Bayou and Fisher Marsh, a perennial waterbody. The entire Subject Property is located within the Federal Emergency Management Agency (FEMA) 100-year flood zone (see **Exhibit 4**).



Facing west, this is a view of the Subject Property, south of the man-made peninsula with oysters and E2EM wetlands.



Facing south, this is a view of herbaceous uplands within the Subject Property, adjacent to the marina.

Baseline Information

Wetland Impacts

On October 16, 2018, CESI identified five E2EM wetlands and two perennial waterbodies (Cedar Bayou and Fisher Marsh) on the Subject Property (CESI Wetland Delineation Report 2018). A total of **33.53 acres** of potentially jurisdictional wetlands and waterbodies would be impacted by the proposed project. A request for a preliminary jurisdictional determination (PJD) was submitted to the USACE - Galveston District on November 2018 and is currently under review. Preliminary jurisdictional boundaries of areas identified as WOUS, along the unavoidable proposed project impacts are detailed in **Table 1** below.

Table 1: Summary of Aquatic Features Delineated Within the Subject Property

Feature Name	Feature Type	Potential Jurisdictional Status	Ordinary High Water Mark (OHWM) (ft)	Anticipated Impacts (ac)
WET A1	E2EM Wetlands	JURISDICTIONAL	N/A	0.24
WET A2	E2EM Wetlands	JURISDICTIONAL	N/A	0.02
WET B	E2EM Wetlands	JURISDICTIONAL	N/A	0.07
WET C	E2EM Wetlands	JURISDICTIONAL	N/A	0.09
WET E	E2EM Wetlands	JURISDICTIONAL	N/A	0.11
Cedar Bayou	Perennial Waterbody	JURISDICTIONAL	450	1.65
Fisher Marsh	Perennial Waterbody	JURISDICTIONAL	1,500	31.98
Total Potentially Jurisdictional E2EM WOUS				0.53
Total Potentially Jurisdictional Waterbodies				33.63
Total Potentially Jurisdictional WOUS				34.16

(CESI Wetland Delineation Report 2018)

CESI utilized the USACE interim Hydrogeomorphic Model (iHGMs) approach, which is the preferred ecological modeling methodology by the Galveston District for determining the number of mitigation credits required to adequately compensate for impacts to WOUS. The Tidal Fringe iHGM was utilized for the tidal wetlands located within the Subject Property.

For each impacted wetland, Functional Capacity Indices (FCI) were assigned based on the data collected, and then multiplied by the acreage of impacts to calculate the Functional Capacity Units (FCU) for that wetland. Within the iHGM model, Functional Capacity can be defined as the ability of the wetlands in question to perform a function compared with the level of performance in reference wetland standards. The Galveston District iHGM Tidal Fringe model for E2EM wetlands uses four FCI categories: biota, botanical, physical, and chemical. **Table 2**, included on the next page, shows calculated iHGM tidal fringe values for the Subject Property proposed impacted E2EM wetlands. The FCIs for each wetland are multiplied by the acreage of wetland impact, which produces an FCU. FCUs are added together for each wetland to determine the compensatory mitigation credits required for proposed impacts to the wetland. The iHGM datasheets with detailed calculations are included in **Appendix A**.

The results of the ecological modeling for the impacted wetlands within the project area conclude that **1.78 E2EM wetland mitigation bank credits** will be required for impacts to 0.53 acres of E2EM wetlands.

Additionally, the Applicant intends to relocate approximately **0.24 ac** of E2EM wetlands to a nearby wetland along Cedar Bayou, within the same watershed to avoid the permanent loss of wetland vegetation and function.

Baseline Information

Table 2: Tidal Fringe iHGM Results for Impacted Estuarine Emergent Wetlands

Wetland Designation	Size (ac)	Biota		Botanical		Physical		Chemical		Total FCUs
		FCI	FCU	FCI	FCU	FCI	FCU	FCI	FCU	
WET A1	0.24	0.66	0.16	0.50	0.12	0.52	0.12	0.71	0.17	0.57
WET A2	0.02	0.76	0.02	0.70	0.01	0.72	0.01	0.84	0.02	0.06
WET B	0.07	0.66	0.16	0.50	0.12	0.52	0.12	0.71	0.17	0.57
WET C	0.09	0.76	0.07	0.70	0.06	0.52	0.05	0.84	0.08	0.25
WET E	0.11	0.77	0.08	0.70	0.08	0.70	0.08	0.84	0.09	0.33
TOTAL	0.53	Total Mitigation Credits Required								1.78

SAR Impacts

A total of 2.38 acres of live oyster reef were observed within a 500-ft buffer zone of the intended work space in December 2018 to February 2019, with approximately **0.08 acres** of anticipated direct impacts to the oyster reef (CESI Submerged Aquatic Resources Report 2019). No seagrasses were detected within or around the proposed project.

Substrate types were identified and recorded as the vessel traveled along the predetermined transects. Along each transect, points were analyzed at distances of approximately 50 feet. Poling data was gathered in real-time using a sub-metered Trimble GeoExplorer global positioning system (GPS) unit. During poling, a metered 10-foot-long PVC pipe was used to determine depths and classify substrate type into one of six categories:

- Type I: soft or unconsolidated mud
- Type II: moderately firm to firm mud or sand, or buried shell which could support small pieces of cultch material (i.e. broken shell bottom hash)
- Type III: exposed shell, or hard substrate without oyster clusters which could support cultch material
- Type IV: consolidated reef and/or habitat with numerous, closely spaced, large oyster clusters
- Type V: submerged aquatic vegetation (SAV) or sea grasses
- Unclassified: area is too deep to pole using conventional methods

Table 3: Oyster and Submerged Aquatic Vegetation Results

Substrate Type	Direct Impact		500-foot Buffer Zone		Total	
	Acres	% of Total Area	Acres	% of Total Area	Acres	%
Type I	21.86	67.0	35.01	52.2	56.87	57.0
Type II	9.64	29.5	4.36	6.5	14.00	14.0
Type III	0.51	1.6	1.63	2.4	2.14	2.1
Type IV	0.08	0.25	2.38	2.9	2.04	2.0
Type V	0	0	0	0	0	0
Unclassified	0.22	0.7	14.78	22.7	15.42	15.4
Shoreline	0.33	1.0	8.89	13.3	9.22	9.2
Total (acres)	32.64 ac		67.05 ac		99.69 a	

(CESI Submerged Aquatic Resources Report 2019)

Compensatory Mitigation Strategy

Compensatory mitigation strategies were developed after reviewing publicly available data, watershed needs of the area, and on-site surveys of the Subject Property and surrounding areas. The goal of the mitigation strategy is to result in no net loss of ecological functions and aquatic resources. Based on the 2008 Final Compensatory Mitigation Rule, the following options were considered in order of hierarchical importance:

1. Purchasing credits from a USACE approved mitigation bank
2. Purchasing credits from an USACE approved in-lieu fee program
3. Permittee-responsible mitigation under a watershed approach
4. Permittee-responsible mitigation through on-site, in-kind mitigation
5. Permittee-responsible mitigation through off-site and/or out-of-kind mitigation

The following strategies enable compensation for direct impacts to WOUS and SAR from the proposed project while remaining consistent with the USACE guidelines.

Proposed Wetland Mitigation

The proposed project falls within the secondary service area of an USACE approved mitigation bank. The proposed mitigation for the unavoidable loss of wetlands is to purchase **1.78 credits** from the Gulf Coastal Plains Mitigation Bank. CESI has already coordinated with the proposed mitigation bank to ensure credits are available for purchase.

Proposed On-Site Oyster Mitigation

When considering site selection, the Applicant reviewed publicly available data, watershed needs, and on-site and off-site alternatives. The mitigation areas were selected based on their likelihood of success, similar environments and habitats, quality contribution to the watershed and wildlife, and practicability of accomplishing ecologically self-sustaining aquatic resource creation, enhancement, and preservation as required by Section 332.3(d) of the Clean Water Act (CWA). Based on a review of publicly available data and feedback received during coordination with the USACE and TPWD, the proposed 0.10-acre mitigation site was selected (see **Exhibit 2**) to adequately compensate for 0.08 acres of unavoidable impacts.

Work Plan

In addition to preserving the site from future development, the Applicant proposes creation, enhancement, and preservation activities to further increase the function and value of the site to the surrounding watershed and wildlife. The following actions, depicted in **Exhibit 2**, are proposed:

1. Enhancement: Trash and debris will be removed from the proposed mitigation site prior to adding cultch at each monitoring event to protect wildlife and fisheries
2. Creation: Relocating approximately 0.1 acres of oyster cultch within a suitable depth and thickness to encourage oyster adhesion prior to spawning (typically late spring to early fall)
3. Preservation: Installing signage and barriers around the oyster reef at strategic points to inhibit barges from impacting the SARs

Compensatory Mitigation Strategy

1. Oyster Habitat Enhancement

Initial surveys identified the presence of trash and debris, such as plastics, beer cans, and bottles (see **Appendix B**). These items will be removed and disposed of properly to restore site integrity and protect wildlife.

Trash and debris removal will be the initial step in the construction sequence to ensure that debris will not be spread during construction activities within the proposed Mitigation Site. Initial trash and debris removal are expected to be complete within approximately one day. Trash and debris removal will reoccur during each monitoring event.

2. Oyster Habitat Creation

The proposed on-site oyster mitigation would include relocating existing oyster reef that is anticipated to be directly impacted by the proposed project to the flourishing oyster reef south of the proposed project, closer to the mouth of Cedar Bayou (see **Exhibit 2**). The oyster shell will be mechanically removed and relocated via a shallow draft barge. Prior to the oyster cultch being placed, a filter fabric will be installed to ensure the cultch will be supported. The oyster cultch will be placed to a height of 18 in to cover a minimum footprint of 0.08 ac. The shape of the proposed oyster reef will be 42 ft by 104 ft, with the elongation situated perpendicular to the ebb and flow of the tides (see **Exhibit 5** and **Exhibit 6**). This perpendicular location will allow for more edge exposure to currents and assist with oyster pseudofecal waste removal.

Before any construction occurs, contractors will be made aware of the oyster habitat, and this area will also be marked off with signage and fencing prior to construction. Additionally, a qualified CESI bio-monitor will be present throughout construction activities to ensure Best Management Practices (BMPs) are adhered to and that prop wash does not occur. Construction will be conducted outside of spawning season, which occurs within the Gulf of Mexico in all months except the coldest months (Coke, 1983).

3. Oyster Habitat Preservation



Example signage to be installed

After the cultch is placed, the Applicant proposes to protect the natural and artificial reefs along Cedar Bayou by installing a barrier around the reefs to prevent barges and ships from pushing up onto the oyster reefs. The barriers will be in accordance with U.S. Coast Guard (USCG) regulations and installed with reflectors to ensure boating safety within the area.

Once the barriers are placed, signage will be installed in front of the oyster reefs to inform boats, barges, and ships of their presence. Safety indicators will also be identified on the sign indicating health risks associated with consuming fish tissues and oysters within the area, as the Cedar Bayou watershed has elevated pollutants and toxins within edible fish tissues, to inform the public that these oysters should not be harvested for public consumption.

Maintenance

Once the cultch has been placed on the bottom of Fisher's Marsh near Cedar Bayou, no further maintenance of the project would be required. The cultch should stay exposed for colonization by oyster larvae and other aquatic organisms. The substrate will develop on its own into mature reef with market size oysters expected in two to three years. No specific long-term maintenance in response to natural disasters are planned.

Monitoring and Adaptive Management

Monitoring

The objective of this plan is to replace oyster habitat utilizing a ratio of **1 to 1**. Each successive year of monitoring (up to 3 years) will require a minimum of 0.08 ac of viable oyster habitat within the mitigation site. Restored reef acreage would be quantified by subtracting pre-restoration reef acreage from post-restoration reef acreage to determine the amount of habitat created.

The Applicant will submit a Post-construction Report to the USACE, following the proposed construction activities within 90-days after construction completion. Every year following, for up to three years, a monitoring event will occur. Success criteria will be determined based on structural and functional success. Structural success would be measured by the number of reef acres created and protected, whereas functional success would be determined by oyster density, shell length, and number of live oysters per square meter. Functionality will be assessed twice a year, pre- and post-oyster spawning season.

The Applicant will provide a report bi-annually to the USACE after each monitoring event. The report will include photographs, figures, the results of the monitoring event, and any adaptive management measures needed. Documentation of adaptive management measures implemented or recommended will be provided after each event.

Adaptive Management

If the success criteria are met, then no adaptive management activities would be required. If the success criteria are not met, the Applicant would notify the TPWD and USACE District Engineer as soon as possible, so that the mitigation can be evaluated and measures pursued to address deficiencies of the mitigation. Discussions on meeting the success criteria would be included in monitoring event reporting. Potential adaptations to the mitigation plan could include the addition of cultch material in the event the reef height is not met. Performance standard criteria should meet or better oyster recruitment and survival of reference reefs.

Conclusion

The Applicant believes that the proposed Conceptual Compensatory Mitigation Plan satisfies the CWA mandate to preserve the function and value of the WOUS through adequate compensatory mitigation. The iHGM modeling calculated that the proposed mitigation plan should achieve a minimum of **2 to 1** ratio for wetland impacts through purchase of mitigation bank credits.

Through discussions and coordination with TPWD, a minimum of a **1 to 1** ratio for submerged aquatic resources was determined to be sufficient. This proposed conceptual compensatory mitigation plan includes the relocation and construction of **0.1 ac** of oyster reef habitat mitigation for **0.08 ac** of proposed oyster reef impacts and preservation of **1.26 ac** of oyster reef. The Applicant anticipates this would achieve approximately **15 to 1** compensatory mitigation to impact ratio. This conceptual compensatory mitigation plan meets and exceeds the compensatory mitigation requirements under 33 CFR 332.4(c) and 40 CFR 230.92.4(c).



Facing south, this is a view of the proposed reference reef.

References

- Cake, Edwin W. 1983. Habitat Suitability Index Models: Gulf of Mexico American Oyster. Natural Coastal Ecosystems Team, Division of Biological Services – Research and Development, U.S. Fish and Wildlife Service. U.S. Department of the Interior, Washington, DC, 20240. FWS/OBS-82/10.57. September 1983.
- Crouch Environmental Services, Inc. (CESI). 2018. Wetland Delineation Report for the Mouth of Cedar Bayou Mobility Project. November 2018.
- _____. 2019. Submerged Aquatic Resources Report of the Mouth of Cedar Bayou Mobility Project. March 2019.
- Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D. 2004. *Ecoregions of Texas (color poster with map, descriptive text, and photographs)*: Reston, Virginia, U.S. Geological Survey (map scale 1: 2,500,000).
- Houston-Galveston Area Council (HGAC). 2016. Cedar Bayou Watershed Protection Plan. Retrieved from: <http://www.cedarbayouwatershed.com/Documents/Cedar-Bayou-Watershed-Protection-Plan.pdf>. Accessed March 2019.
- Texas Commission on Environmental Quality (TCEQ). 2018. Texas Watershed-Based Plans, updated November 2018. Retrieved from: https://www.tceq.texas.gov/assets/public/waterquality/nps/watersheds/WBP_ListForWeb.pdf. Accessed March 2019.
- U.S. Army Corps of Engineers (USACE). 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Exhibits








- 1. 2018 AERIAL PHOTOGRAPH WITH PROPOSED PROJECT**
- 2. 2018 AERIAL PHOTOGRAPH WITH CONCEPTUAL MITIGATION PLANNING**
- 3. 2018 AERIAL PHOTOGRAPH WITH 2017 NRCS SOIL SURVEY**
- 4. 2018 AERIAL PHOTOGRAPH WITH 2010 FEMA FLOODPLAIN DATA**
- 5. 2018 AERIAL PHOTOGRAPH WITH MITIGATION SITE**
- 6. MITIGATION OYSTER MOUND CREATION CROSS-SECTION**

Cedar Bayou

Upland Waste Management Disposal Area

Tri-City Beach Road

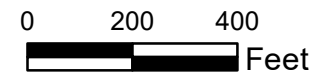
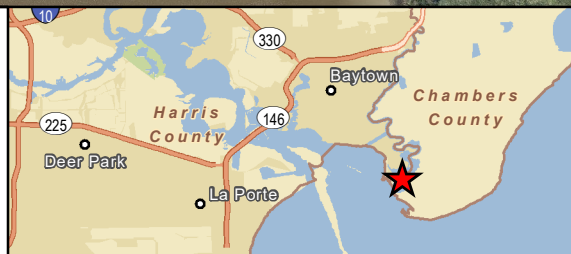
Legend

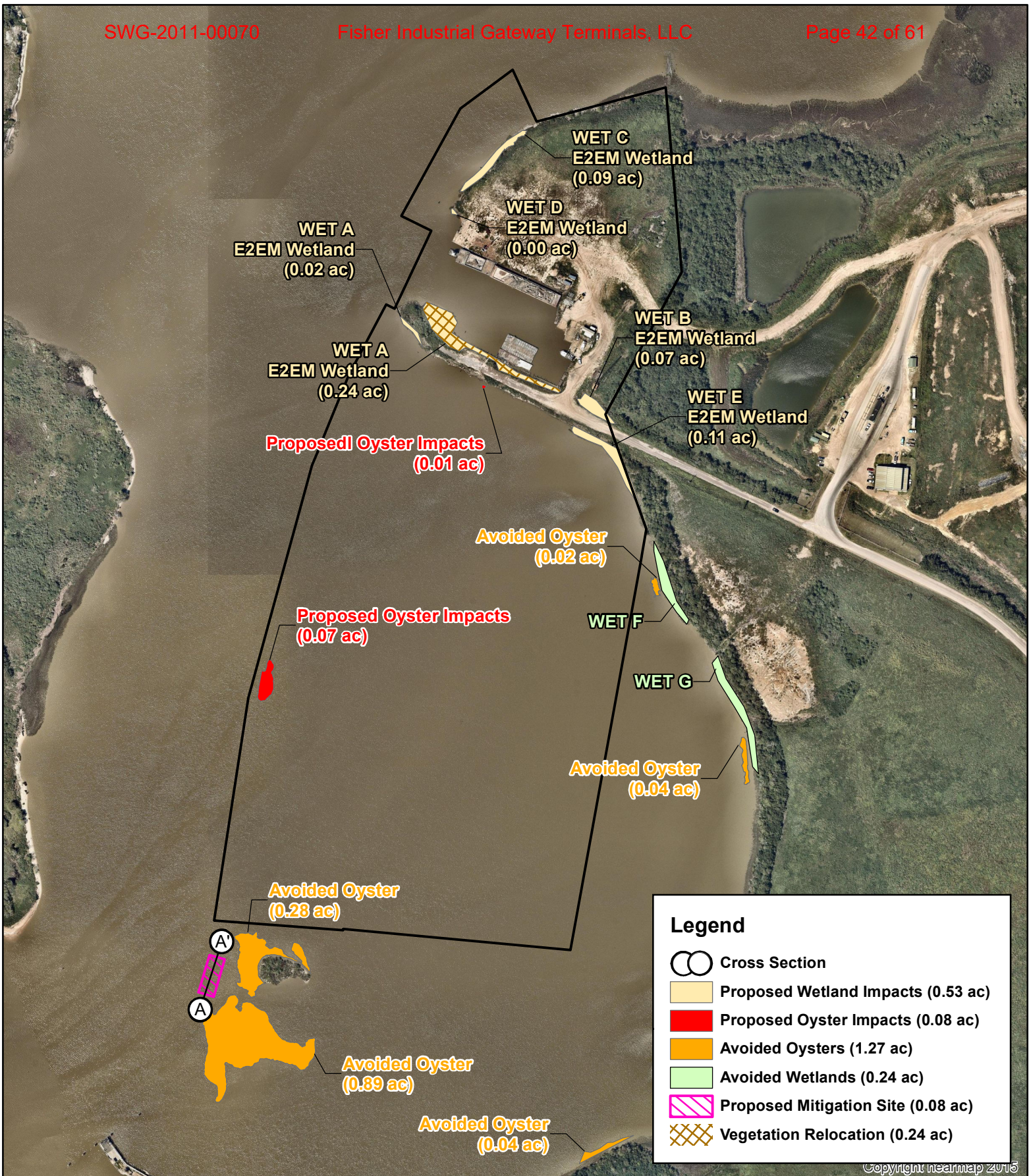
-  Proposed Bulkhead (1,338 linear feet)
-  Proposed Fill Area (1.69 ac / 32,000 cu yd)
-  Proposed Dredging Activities (32.94 ac, 684,000 cu yd)
-  Previously Permitted Area
-  Upland Waste Management Disposal Area
-  Navigable Channel
-  Subject Property (43.60 ac)

Mouth of Cedar Bayou Mobility Project

2018 AERIAL PHOTOGRAPH WITH PROPOSED PROJECT

Chambers County, Texas





Legend

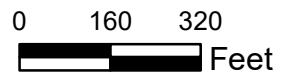
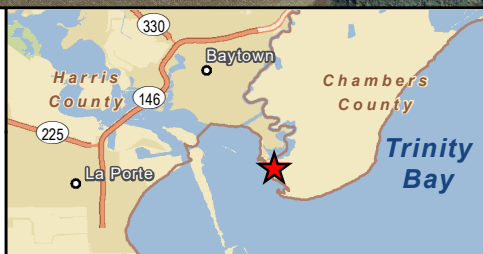
- Cross Section
- Proposed Wetland Impacts (0.53 ac)
- Proposed Oyster Impacts (0.08 ac)
- Avoided Oysters (1.27 ac)
- Avoided Wetlands (0.24 ac)
- Proposed Mitigation Site (0.08 ac)
- Vegetation Relocation (0.24 ac)

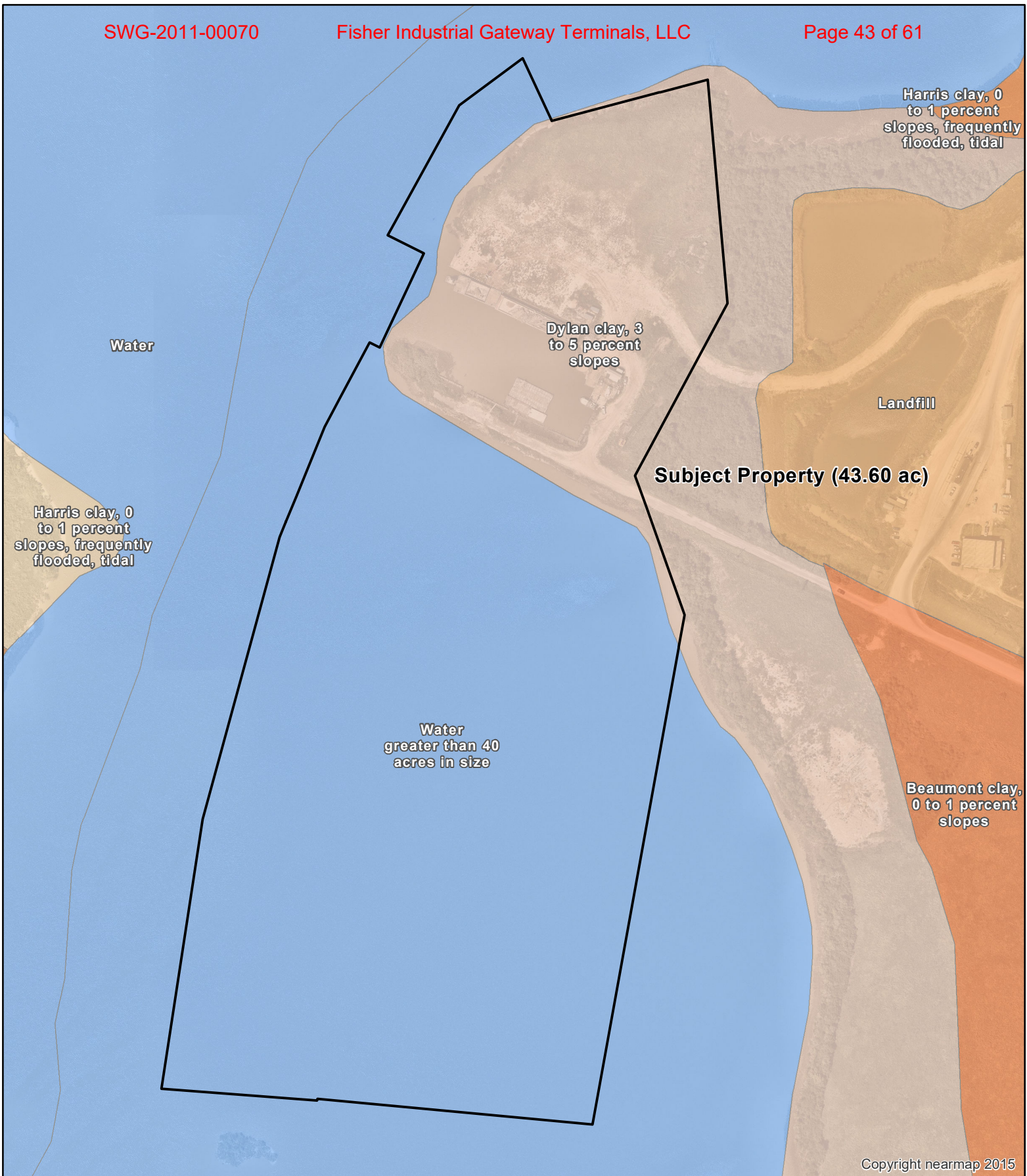
Copyright nearmap 2015

Mouth of Cedar Bayou Mobility Project

2017 AERIAL PHOTOGRAPH WITH CONCEPTUAL MITIGATION PLANNING
Chambers County, Texas

Created: 4/4/2019





Harris clay, 0 to 1 percent slopes, frequently flooded, tidal

Dylan clay, 3 to 5 percent slopes

Landfill

Subject Property (43.60 ac)

Harris clay, 0 to 1 percent slopes, frequently flooded, tidal

Water greater than 40 acres in size

Beaumont clay, 0 to 1 percent slopes

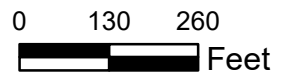
Copyright nearmap 2015

Mouth of Cedar Bayou Mobility Project

2018 AERIAL PHOTOGRAPH WITH 2017 NRCS SOIL SURVEY DATA

Chambers County, Texas

Created: 3/5/2019



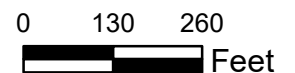


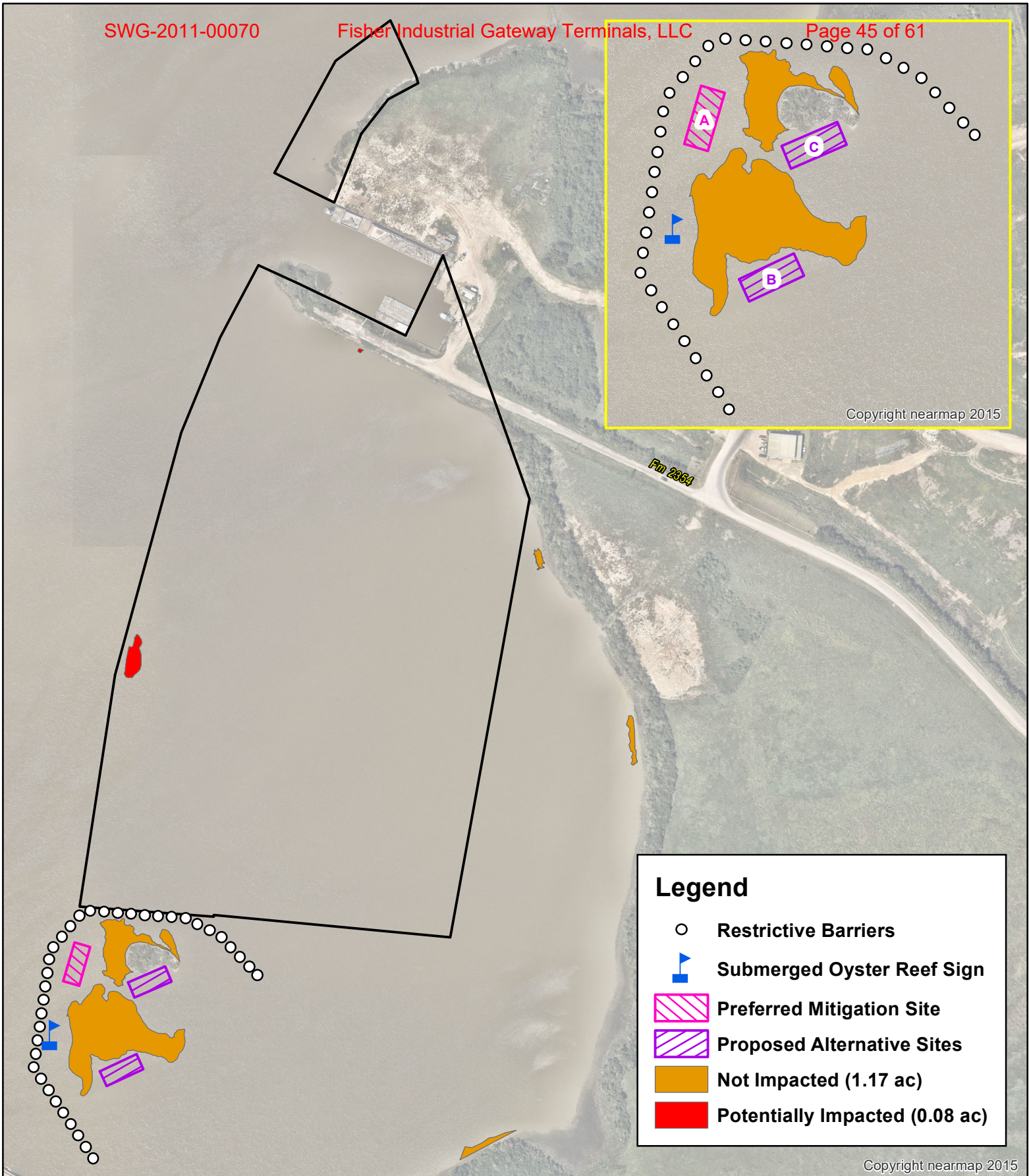
Copyright nearmap 2015

**Mouth of Cedar
Bayou Mobility Project**

EXHIBIT 4
2018 AERIAL PHOTOGRAPH WITH
2010 FEMA FLOODPLAIN DATA
Chambers County, Texas







Created: 3/6/2019





Copyright nearmap 2015

Legend

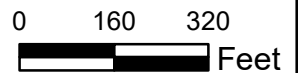
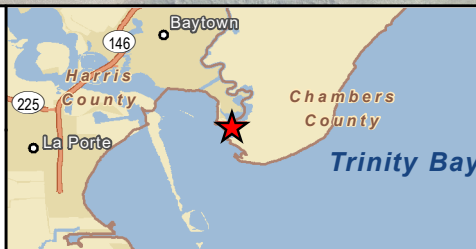
-  Restrictive Barriers
-  Submerged Oyster Reef Sign
-  Preferred Mitigation Site
-  Proposed Alternative Sites
-  Not Impacted (1.17 ac)
-  Potentially Impacted (0.08 ac)

Copyright nearmap 2015

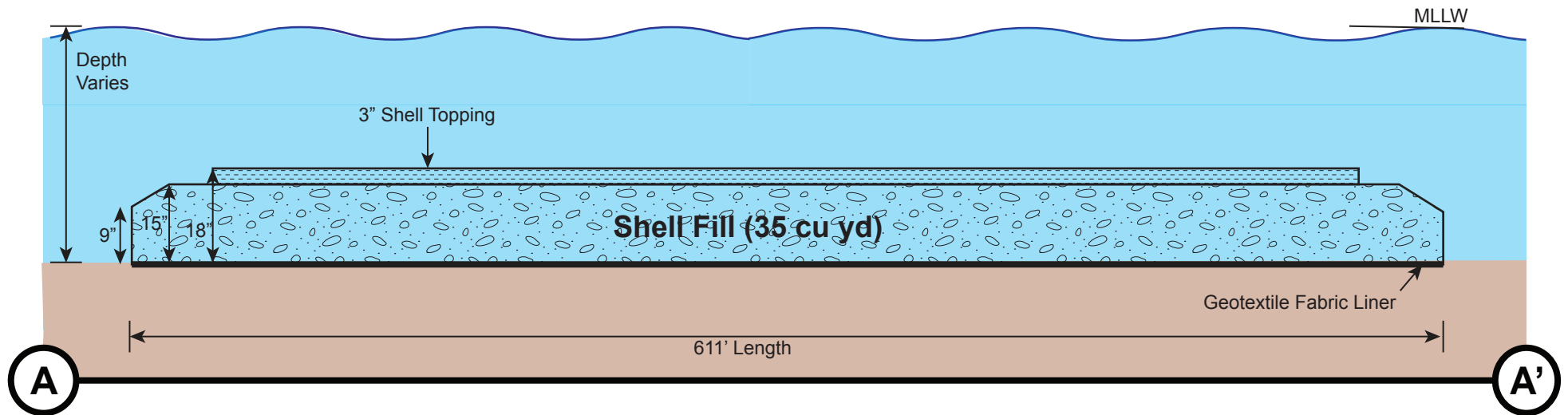
Mouth of Cedar Bayou Mobility Project

EXHIBIT 5
2018 AERIAL PHOTOGRAPH WITH
MITIGATION SITE

Chambers County, Texas Created: 2/25/2019



Cross Section A-A'



Note: Not to Scale



Mouth of Cedar Bayou Mobility Project
Mitigation Oyster Mound

EXHIBIT 6
Cross Section A-A'

Chambers County, Texas

Appendix A

iHGM DATASETS

SWG-2011-00070

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	
Simple tidal drainage network...isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266 - 465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	x
2	0.3	
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclss

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge

(*Sapium sabiferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp*, *Cyperus entrianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	x
60%	0.6	
70%	0.7	
80%	0.9	
90%	1.0	
100%	1.0	

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.20
V _{typical}	0.50
V _{slope}	0.10
V _{width}	0.10
V _{rough}	0.40
V _{soil}	1.00

Biota:

$$FCL = \frac{[V_{edge} + 2 V_{hydro} + 0.5 V_{nhc} / 3.5] + V_{typical}}{2}$$

FCI = 0.66

Botanical

$$FCL = V_{typical}$$

FCI = 0.50

Physical

$$FCL = \frac{[V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro}]}{5}$$

FCI = 0.52

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$

FCI = 0.71

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.10	x
151 - 450 ft	0.50	
Greater than 450 ft	1.00	

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0 - 30 ft	0.1	x
31 - 75 ft	0.25	
76 - 150 ft	0.5	
151 - 225 ft	0.6	
226 - 300 ft	0.8	
301 - 375 ft	0.85	
376 - 450 ft	0.9	
451 - 525 ft	0.95	
526 - 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$P_{base} + P_{topo} + P_{veg} = \text{manning's end}$

(Pbase) = 0.025

Sediment surface		Base value for bare marsh soil	
0.025		Base value for bare marsh soil	x
0.030		More than 25% of the sediment surface covered with gravel or broken shell	

(Ptopo) = 0.005

Topographic relief		WAA is flat no microtopographic or macrotopographic relief	
0.001		WAA is flat no microtopographic or macrotopographic relief	
0.005		WAA has 5-25% topographic relief	x
0.010		WAA has 26-50% topographic relief	
0.20		WAA has greater than 50% topographic relief	

(Pveg) = 0.030

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
0.025	0.030	0.035		Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	x
0.035	0.040	0.05		Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
0.050	0.060	0.07		Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	
0.070	0.100	0.16		Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
	x				

Roughness (rounded down) = 0.06

FCI variable sub index =

Roughness	Variable Sub Index	"x" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	x
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	

Lookup
3
0.4

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	x

SWG-2011-00070

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350- 800 m/ha (465-1,062 ft/acre)	1.0	
Simple tidal drainage network.. isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266-465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	x
2	0.3	
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclass

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge

(*Sapium sabiniferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp.*, *Cyperus erianianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	
70%	0.7	x
80%	0.9	
90%	1.0	
100%	1.0	

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.20
V _{typical}	0.70
V _{slope}	0.50
V _{width}	0.10
V _{rough}	1.00
V _{soil}	1.00

Biota:

$$FCL = [(V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5) + V_{typical}]/2$$

FCI = 0.76

Botanical

$$FCL = V_{typical}$$

FCI = 0.70

Physical

$$FCL = [(V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro})/5]$$

FCI = 0.72

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$

FCI = 0.84

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.10	
151-450 ft	0.50	X
Greater than 450 ft	1.00	

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0 - 30 ft	0.1	X
31 - 75 ft	0.25	
76 - 150 ft	0.5	
151 - 225 ft	0.6	
226 - 300 ft	0.8	
301 - 375 ft	0.85	
376 - 450 ft	0.9	
451 - 525 ft	0.95	
526 - 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$\text{Nbase} + \text{Ntopo} + \text{Nveg} = \text{manning's end}$

(Nbase) = 0.025

Sediment surface		Base value for bare marsh soil	
0.025		Base value for bare marsh soil	X
0.030		More than 25% of the sediment surface covered with gravel or broken shell	

(Ntopo) = 0.005

Topographic relief		WAA is flat no microtopographic or macrotopographic relief	
0.001		WAA is flat no microtopographic or macrotopographic relief	
0.005		WAA has 5-25% topographic relief	X
0.010		WAA has 26-50% topographic relief	
0.20		WAA has greater than 50% topographic relief	

(Nveg) = 0.060

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
0.025	0.030	0.035		Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	
0.035	0.040	0.05		Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
0.050	0.060	0.07		Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	X
0.070	0.100	0.16		Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
	X				

Roughness (rounded down) = 0.09

FCI variable sub index =

Roughness	Variable Sub Index	"X" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	
0.07	0.6	
0.08	0.8	
0.09	1.0	X
0.10	1.0	

Lookup
6
1

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	X

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	x
Simple tidal drainage network...isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266 - 465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	x
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	x
2	0.3	
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclss

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge
(*Sapium sabiferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp.*, *Cyperus erianianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	
70%	0.7	
80%	0.9	
90%	1.0	
100%	1.0	x

Variable	Subindex
V _{edge}	1.00
V _{hydro}	0.30
V _{nhc}	0.20
V _{typical}	1.00
V _{slope}	1.00
V _{width}	0.10
V _{rough}	0.40
V _{soil}	1.00

Biota:

$$FCL = [(V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5) + V_{typical}]/2$$
FCI = 0.74

Botanical

$$FCL = V_{typical}$$
FCI = 1.00

Physical

$$FCL = [(V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro})/5]$$
FCI = 0.70

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$
FCI = 1.00

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.10	
151 - 450 ft	0.50	
Greater than 450 ft	1.00	X

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0 - 30 ft	0.1	X
31 - 75 ft	0.25	
76 - 150 ft	0.5	
151 - 225 ft	0.6	
226 - 300 ft	0.8	
301 - 375 ft	0.85	
376 - 450 ft	0.9	
451 - 525 ft	0.95	
526 - 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$n_{base} + n_{topo} + n_{veg} = \text{manning's end}$

(fbase) = 0.025

Sediment surface	0.025	Base value for bare marsh soil	X
	0.030	More than 25% of the sediment surface covered with gravel or broken shell	

(ftopo) = 0.005

Topographic relief	0.001	WAA is flat no microtopographic or macrotopographic relief	
	0.005	WAA has 5-25% topographic relief	X
	0.010	WAA has 26-50% topographic relief	
	0.20	WAA has greater than 50% topographic relief	

(fveg) = 0.035

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
	0.025	0.030	0.035	Predominantly short flexible stem grass (i.e. <i>Spartina alterniflora</i> , <i>S. patens</i> , <i>Distichlis spicata</i>)	X
	0.035	0.040	0.05	Predominantly short stiff trailing stems (i.e. <i>Batis</i> & <i>Salicornia</i>)	
	0.050	0.060	0.07	Predominantly tall flexible grass (i.e. tall <i>Spartina alterniflora</i> , <i>S. cynosuroides</i> , <i>Scirpus</i> sp.)	
	0.070	0.100	0.16	Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. <i>Juncus roemerianus</i> , Mangroves, etc.)	
			X		

Roughness (rounded down) = 0.06

FCI variable sub index =

Roughness	Variable Sub Index	"X" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	X
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	

Lookup
3
0.4

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	X

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	
Simple tidal drainage network... isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (+465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	x
2	0.3	
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclass

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge

(*Sapium sabiniferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp.*, *Cyperus erianianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	
70%	0.7	x
80%	0.9	
90%	1.0	
100%	1.0	

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.20
V _{typical}	0.70
V _{slope}	0.10
V _{width}	0.10
V _{rough}	0.40
V _{soil}	1.00

Biota:

$$FCI = \{[V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5] + V_{typical}\}/2$$

FCI = 0.76

Botanical

$$FCI = V_{typical}$$

FCI = 0.70

Physical

$$FCI = \{[V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro}]/5$$

FCI = 0.52

Chemical

$$FCI = [V_{typical} \times V_{hydro}]^{1/2}$$

FCI = 0.84

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.10	X
151-450 ft	0.50	
Greater than 450 ft	1.00	

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0- 30 ft	0.1	X
31- 75 ft	0.25	
76- 150 ft	0.5	
151- 225 ft	0.6	
226- 300 ft	0.8	
301- 375 ft	0.85	
376- 450 ft	0.9	
451- 525 ft	0.95	
526- 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$n_{base} + n_{topo} + n_{veg} = \text{manning's end}$

(fbase) = 0.025

Sediment surface	0.025	Base value for bare marsh soil	X
	0.030	More than 25% of the sediment surface covered with gravel or broken shell	

(ftopo) = 0.005

Topographic relief	0.001	WAA is flat no microtopographic or macrotopographic relief	
	0.005	WAA has 5-25% topographic relief	X
	0.010	WAA has 26-50% topographic relief	
	0.20	WAA has greater than 50% topographic relief	

(fveg) = 0.030

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
	0.025	0.030	0.035	Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	X
	0.035	0.040	0.05	Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
	0.050	0.060	0.07	Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	
	0.070	0.100	0.16	Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
		X			

Roughness (rounded down) = 0.06

FCI variable sub index =

Roughness	Variable Sub Index	"X" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	X
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	

Lookup
3
0.4

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	X

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	
Simple tidal drainage network... isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266 - 465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth... Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	
2	0.3	x
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclass

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge

(*Sapium sabinum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp.*, *Cyperus erianianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	
70%	0.7	x
80%	0.9	
90%	1.0	
100%	1.0	

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.30
V _{typical}	0.70
V _{slope}	1.00
V _{width}	0.10
V _{rough}	0.40
V _{soil}	1.00

Biota:

$$FCL = \{[V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5] + V_{typical}\}/2$$

FCI = 0.77

Botanical

$$FCI = V_{typical}$$

FCI = 0.70

Physical

$$FCL = \{[V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro}]/5$$

FCI = 0.70

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$

FCI = 0.84

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.30	
151-450 ft	0.50	
Greater than 450 ft	1.00	x

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0 - 30 ft	0.1	x
31 - 75 ft	0.25	
76 - 150 ft	0.5	
151 - 225 ft	0.6	
226 - 300 ft	0.8	
301 - 375 ft	0.85	
376 - 450 ft	0.9	
451 - 525 ft	0.95	
526 - 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$\Pi_{base} + \Pi_{topo} + \Pi_{veg} = \text{manning's end}$

(Π_{base}) = 0.025

Sediment surface	Base value for bare marsh soil	
0.025	Base value for bare marsh soil	x
0.030	More than 25% of the sediment surface covered with gravel or broken shell	

(Π_{topo}) = 0.005

Topographic relief		
0.001	WAA is flat no microtopographic or macrotopographic relief	
0.005	WAA has 5-25% topographic relief	x
0.010	WAA has 26-50% topographic relief	
0.20	WAA has greater than 50% topographic relief	

(Π_{veg}) = 0.035

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
0.025	0.030	0.035		Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	x
0.035	0.040	0.05		Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
0.050	0.060	0.07		Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	
0.070	0.100	0.16		Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
		x			

Roughness (rounded down) = 0.06

Lookup	3
	0.4

FCI variable sub index =

Roughness	Variable Sub Index	"x" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	x
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	x

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	
Simple tidal drainage network...isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266 - 465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	
2	0.3	x
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclss

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge
(*Sapium sabiniferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp*, *Cyperus entrarianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	x
70%	0.7	
80%	0.9	
90%	1.0	
100%	1.0	

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub index	
Less than 150 ft	0.10	
151-450 ft	0.50	
Greater than 450 ft	1.00	x

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.30
V _{typical}	0.60
V _{slope}	1.00
V _{width}	0.10
V _{rough}	0.40
V _{soil}	1.00

Biota:

$$FCL = [(V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5) + V_{typical}]/2$$
FCL = 0.72

Botanical

$$FCL = V_{typical}$$
FCL = 0.60

Physical

$$FCL = [(V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro})/5]$$
FCL = 0.70

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$
FCL = 0.77

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0 - 30 ft	0.1	x
31 - 75 ft	0.25	
76 - 150 ft	0.5	
151 - 225 ft	0.6	
226 - 300 ft	0.8	
301 - 375 ft	0.85	
376 - 450 ft	0.9	
451 - 525 ft	0.95	
526 - 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$\Pi_{base} + \Pi_{topo} + \Pi_{veg}$ = manning's end

(Π_{base}) = 0.025					
Sediment surface	0.025	Base value for bare marsh soil		x	
	0.030	More than 25% of the sediment surface covered with gravel or broken shell			
(Π_{topo}) = 0.005					
Topographic relief	0.001	WAA is flat no microtopographic or macrotopographic relief			
	0.005	WAA has 5-25% topographic relief		x	
	0.010	WAA has 26-50% topographic relief			
	0.20	WAA has greater than 50% topographic relief			
(Π_{veg}) = 0.030					
Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
	0.025	0.030	0.035	Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	x
	0.035	0.040	0.05	Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
	0.050	0.060	0.07	Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	
	0.070	0.100	0.16	Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
	x				

Roughness (rounded down) = 0.06

FCI variable sub index =

Roughness	Variable Sub Index	"x" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	x
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	

Lookup
3
0.4

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	x

Vedge: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub index	
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m/ha (>1,062 ft/acre)	0.8	x
Well developed tidal drainage network present OR Simple tidal network with isolated ponds & depression in the marsh interior OR Large amount of shallow shoreline in relation to the entire area	High	350 - 800 m/ha (465 - 1,062 ft/acre)	1.0	
Simple tidal drainage network... isolated ponds and depressions are few & lacking	Moderate	200-350 m/ha (266 - 465 ft/acre)	0.7	
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth...Marsh area is large relative to shoreline length. OR the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m/ha (<266 ft/acre)	0.4	

Vhydro: Site hydroperiod or degree of hydrological modifications

Site Description	Sub index	
Site is open, no hydrologic restrictions	1.0	x
Moderate hydrologic restriction (i.e. low-level berms overtopped frequently by waves, or has multi-breaches or large numerous culverts)	0.6	
Severe hydrologic restriction (high elevation berm with infrequent over-top, small culverts, single opening or breach)	0.3	
Site receives water only during extreme storm events	0.1	
Site is cut off from tidal exchange	0.0	

Vnhc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA

Low Marsh	High Marsh	Subtidal creeks	Intertidal creeks
ponds or depressions	SAVs	Oyster Reef	Unvegetative flats
Algal flats	Mangroves	Coarse woody debris	

Number of habitat types	Variable Subindex	
1	0.2	
2	0.3	x
3	0.5	
4	0.7	
5	0.8	
6	1.0	

Vtypical: Proportion of the site that is covered by vegetation typical of the regional subclass

Invasive species: tallow, alligator weeds, spiny aster, common reed, rattlebox, cattail, flat sedge
(*Sapium sabiniferum*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp.*, *Cyperus erianianus*)

Total % Cover by typical species	Variable Sub index	
10%	0.1	
20%	0.1	
30%	0.2	
40%	0.4	
50%	0.5	
60%	0.6	
70%	0.7	
80%	0.9	
90%	1.0	x
100%	1.0	

Variable	Subindex
V _{edge}	0.80
V _{hydro}	1.00
V _{nhc}	0.30
V _{typical}	1.00
V _{slope}	1.00
V _{width}	0.10
V _{rough}	1.00
V _{soil}	1.00

Biota:

$$FCL = [(V_{edge} + 2 V_{hydro} + 0.5V_{nhc}/3.5) + V_{typical}]/2$$
FCL = 0.92

Botanical

$$FCL = V_{typical}$$
FCL = 1.00

Physical

$$FCL = [(V_{slope} + V_{width} + V_{rough} + V_{soil} + V_{hydro})/5]$$
FCL = 0.82

Chemical

$$FCL = [V_{typical} \times V_{hydro}]^{1/2}$$
FCL = 1.00

Vslope: Distance to water greater than or equal to 6 feet deep

Distance to Navigation Channel or water greater than or equal to 6 ft deep	Variable Sub Index	
Less than 150 ft	0.10	
151-450 ft	0.50	
Greater than 450 ft	1.00	X

Vwidth: Average marsh width

Mean Width WAA Distance (ft)	Variable Sub Index	
0- 30 ft	0.1	X
31- 75 ft	0.25	
76- 150 ft	0.5	
151- 225 ft	0.6	
226- 300 ft	0.8	
301- 375 ft	0.85	
376- 450 ft	0.9	
451- 525 ft	0.95	
526- 600 ft	1.0	
Greater than 600 ft	1.0	

Vrough: Manning's roughness coefficient

$n_{base} + n_{topo} + n_{veg} = \text{manning's end}$

(fbase) = 0.025

Sediment surface	0.025	Base value for bare marsh soil	X
	0.030	More than 25% of the sediment surface covered with gravel or broken shell	

(ftopo) = 0.005

Topographic relief	0.001	WAA is flat no microtopographic or macrotopographic relief	
	0.005	WAA has 5-25% topographic relief	X
	0.010	WAA has 26-50% topographic relief	
	0.20	WAA has greater than 50% topographic relief	

(fveg) = 0.070

Vegetation	Less 50% cover	50-75% cover	76-100% cover	Description of Conditions	
	0.025	0.030	0.035	Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)	
	0.035	0.040	0.05	Predominantly short stiff trailing stems (i.e. Batis & Salicornia)	
	0.050	0.060	0.07	Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)	X
	0.070	0.100	0.16	Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)	
			X		

Roughness (rounded down) = 0.10

FCI variable sub index =

Roughness	Variable Sub Index	"X" Automatically picked
0.04	0.1	
0.05	0.2	
0.06	0.4	
0.07	0.6	
0.08	0.8	
0.09	1.0	
0.10	1.0	X

Lookup
7
1

Vsoil

Soil Texture	Variable Sub Index	
Sandy	0.2	
Sandy loam	0.40	
Loam	0.6	
Clay loam	0.8	
Clay	1.0	X