HOUSTON SHIP CHANNEL EXPANSION, TEXAS
Section 905(b) of the Water Resources Development Act (WRDA) of 1986
Analysis Report

1. STUDY AUTHORITY. Public Law 91-611; Title II - Flood Control Act of 1970, Section 216 dated December 31, 1970. The study is being performed in response to the standing authority of Section 216 of the Flood Control Act of 1970, as amended, which authorizes studies to review the operation of completed Federal projects and recommend project modifications "when found advisable due to significantly changed physical or economic conditions…and for improving the quality of the environment in the overall public interest".

The Section 216 of the Flood Control Act of 1970 (33 USC 426 et seq) as amended reads: *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operations of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

2. STUDY PURPOSE. The purpose of this reconnaissance study is to determine if there is a Federal interest in a cost shared feasibility study that will evaluate the need for channel improvements to the Houston Ship Channel (HSC) system. Possible improvements in the Federal interest include a more efficient depth for the HSC system since light loading is a concern throughout, as well as channel configuration or general navigation features (GNF) which impede efficient navigation in the Federal channel. Depending on the type of improvements identified for the HSC, there may be a need to make improvements to the Galveston Harbor and Channels and/or the Texas City Ship Channel. Even without an identified sponsor for the Galveston or Texas City Channels, this 905(b) analysis report acknowledges that improvements to those channels may be necessary.

3. RECOMMENDATION / FINDING OF FEDERAL INTEREST. This 905(b) analysis report demonstrates that channel modifications are necessary to improve the efficiency and safety of the HSC system, and supports initiation of a cost shared feasibility-level study effort.

4. STUDY AREA / EXISTING CONDITIONS. The HSC provides access to various private and public docks and berthing areas associated with the Port of Houston. It is the longest major navigation channel of a larger system of navigation channels of the Galveston Bay Area (herein referred to as the Galveston Bay Area Navigation Channel (GBANC) system) located in Harris, Chambers and Galveston Counties, Texas. Associated side channels of the HSC include Bayport Ship Channel, Barbours Cut Channel and Greens Bayou Channel. Other major channels included in the GBANC are the Galveston Harbor and Channels and the Texas City Ship Channel, which provide access to the Ports of Galveston and Texas City, respectively. Figure 1 identifies the channels discussed in this report and also includes channel mile markers for easier reference. While the focus for this reconnaissance report is the HSC, the 905(b) analysis acknowledges the

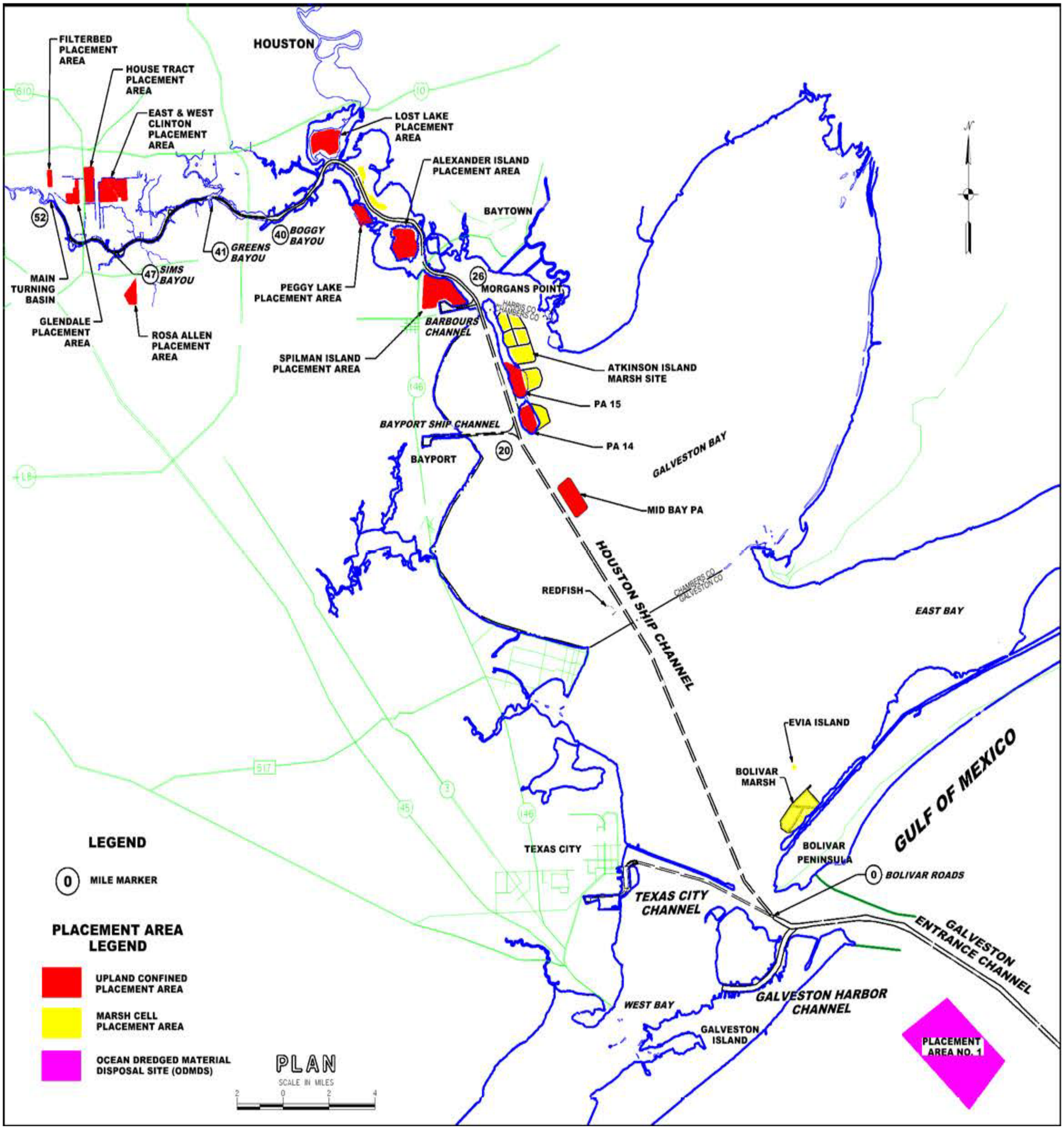


Figure 1. Channel Location and Placement Area Map

Galveston Harbor and Channels and the Texas City Ship Channel because they are integrally connected to the overall navigation system of the Galveston Bay area. Depending on what channel improvements are recommended (e.g. deepening), there may also be a need/opportunity for improvements to these latter two major channels in conjunction with any recommended changes in the HSC and associated side channels. Details and existing conditions of each of the channels is presented below; a summary table of channel dimensions can be found in Table 1. *Note: Depths in this report are in mean low tide (MLT) as the vertical datum control. The Galveston District is in the process of converting tidal datum to Mean Lower Low Water (MLLW), which will be the tidal datum used in the feasibility study report.*

Houston Ship Channel. The HSC is approximately 52 miles in length. It begins at Bolivar Roads at mile 0 and continues to the Main Turning Basin (terminal point for the HSC at mile 52). The authorized channel dimensions within the HSC vary. From Bolivar Roads (mile 0) to Boggy Bayou (mile 40) the channel depth is 45 feet and width is 530 feet. Between Boggy Bayou and Sims Bayou (mile 47) the channel depth is 40 feet and width is 300 feet. From Sims Bayou to the Main Turning Basin (mile 52), the channel depth is 36 feet and width is 300 feet. Additionally, barge lanes are immediately adjacent to and on either side of the HSC from Bolivar Roads to Morgan's Point (mile 26), a distance of approximately 26 miles. Each barge lane measures approximately 125 feet wide by 12 feet deep. Dredged material is typically deposited in a variety of upland confined placement area (PA) sites and beneficial use (BU) sites, but some material from the lower bay region has, at times, been placed offshore in the Ocean Dredged Material Disposal Site (ODMDS) referred to as PA 1. Refer back to Figure 1 for PA sites.

The HSC system also includes side channels known as Bayport Ship Channel, Barbours Cut Channel, and Greens Bayou Channel. The Bayport Ship Channel extends west from the main HSC approximately 4.1 miles to the Bayport Terminal. The authorized channel depth is 40 feet, with a width of 300 feet. The Port of Houston Authority (PHA) recently obtained Section 408 approval and a Section 404/10 permit to deepen the channel to 45 feet and widen the bay portion of the channel by 100 feet and widen the constricted portion of the channel within the land cut by 50 feet. The Bayport Ship Channel serves the Bayport Container and Cruise Terminals and two liquid bulk terminals at Odfjell and LBC. Barbours Cut Channel is approximately 1.5 miles in length extending to the west, north of Morgan's Point. The Barbours Cut Channel is approximately 300 feet wide with an authorized depth of 40 feet. The PHA recently obtained Section 408 approval and a Section 404/10 permit to deepen the channel to 45 feet and shift a portion of the channel to the north to provide sufficient berthing space for adjacent private facilities. The Barbours Cut Channel serves the Barbours Cut Container Terminal. Greens Bayou Channel intersects with the HSC above the northern end of the 45-foot deep channel project and extends to the north of the HSC (between Boggy and Sims Bayous). The Greens Bayou Channel is a 1.6 mile long combination deep (40 feet deep) and shallow draft (15 feet deep) tributary.

Galveston Harbor and Channels. This consists of the Galveston Entrance Channel and Galveston Harbor Channel. The total length of these channels is 18.7 miles. The Entrance Channel is 14.4 miles with a depth of 47 feet and width of 800 feet, but decreases to 45 feet in depth near Bolivar Roads (mile 0). The Galveston Harbor Channel is 4.3 miles with a depth of 45 feet and varying widths from 800 – 1,133 feet. The 45-foot depth ends around Pier 38; however, the last 2,571 feet of the west end of the channel remains at a depth of 40 feet. Dredged material placement for this reach is in the ODMDS in the Gulf of Mexico and Pelican Island and San Jacinto PA sites.

Texas City Ship Channel is a 6.5 mile channel that is 45 feet deep and 400 feet wide. The channel also includes an Industrial Canal that is 40 feet deep and varies between 300-400 feet in width; the Industrial Canal extends for a distance of 1.9 miles southwest of the south end of Texas City Turning Basin. Construction of the locally preferred plan to deepen the channel to 45 feet was completed in 2011. Dredged material from the channel is placed in both upland confined PA and BU sites.

A summary of channel dimensions can be found below in Table 1.

Table 1 – Channel Dimensions	Existing Depth (feet)	Existing Width (feet)	Distance Length (miles)
Houston Ship Channel System			
-Mile 0 to Boggy Bayou (mile 40)	45	530	40
-Boggy Bayou to Sims Bayou (mile 47)	40	300	7
-Sims Bayou to Main Turning Basin (mile 52)	36	300	5
-Bayport Ship Channel*	40	300	4.1
-Barbours Cut Channel*	40	300	1.1
Galveston Harbor and Channels	40/45/47	800-1133	18.7
Texas City Ship Channel	45	400	6.5

**PHA has approval to deepen channel to 45 feet*

4.1 Existing Economics. The Port of Houston is consistently ranked first among United States (U.S.) ports in foreign waterborne tonnage; first in U.S. imports; first in U.S. export tonnage; and second in U.S. total tonnage. The Waterborne Commerce Statistics Center (WCSC) reported that 238 million short tons moved across HSC docks in 2012, up from 148.1 million short tons in 1996. Exports grew steadily over the period of record and imports grew until 2006 meeting a record high of 107 million short tons (Table 2). Major export commodities include petroleum products (46.8 million short tons), chemicals (17.4 million short tons) and food/farm products (5.4 million short tons). Petroleum products exports almost match activity of crude petroleum (49.5 million short tons) imports. Imports also included petroleum products (10.1 million short tons), chemical products (17.4 million short tons) and primary manufacturing goods (10.4 million short tons) of which all showed healthy growth. The *Galveston Bay Area Navigation Study Feasibility Report* in 1987 forecasted HSC commerce to total 176,972,000 short tons by 2005. As shown in Table 2, the actual 2005 short tons reported were 211,665,685, a 20 percent increase over that forecasted in the 1987 report.

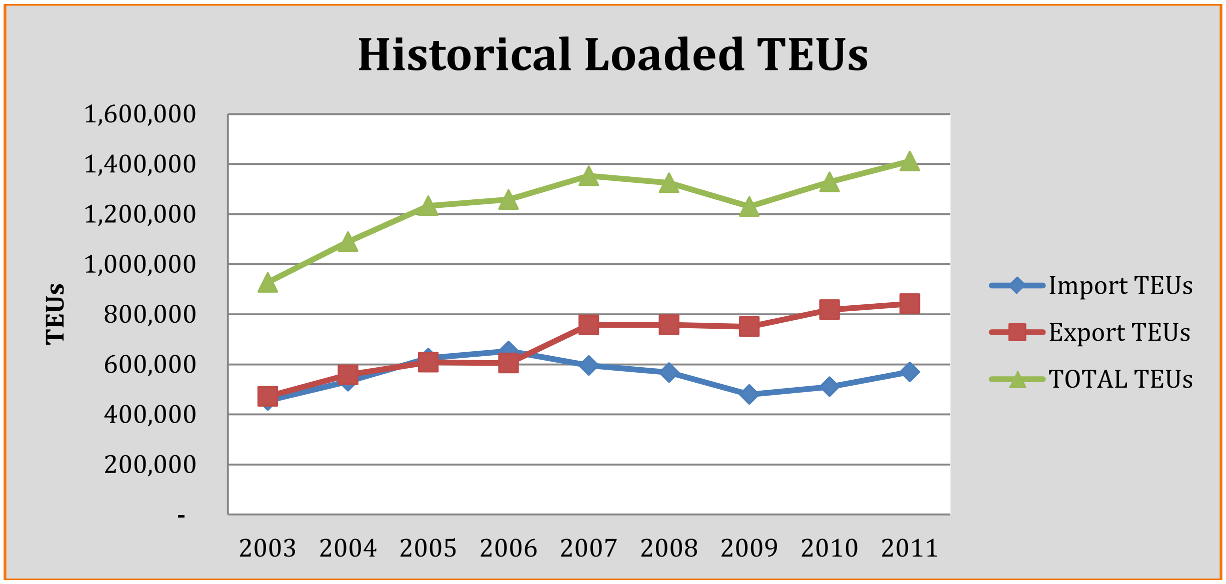
Table 2 – HSC Import/Export Tonnage Trend (short tons)

		FOREIGN			
	DOMESTIC	IMPORTS	EXPORTS	FOREIGN TOTAL	GRAND TOTAL
1996	61,124,588	58,041,465	29,016,823	87,058,288	148,182,876
1997	62,609,724	72,640,589	30,205,965	102,846,554	165,456,278
1998	60,520,562	75,118,513	33,431,259	108,549,772	169,070,334
1999	56,735,755	69,919,172	32,173,276	102,092,448	158,828,203
2000	62,616,967	87,031,704	36,918,575	123,950,279	186,567,246
2001	64,457,446	85,484,988	35,107,734	120,592,722	185,050,168
2002	62,372,636	80,026,918	35,161,131	115,188,049	177,560,685
2003	64,029,740	90,335,647	36,557,758	126,893,405	190,923,145
2004	64,510,816	97,713,314	39,823,197	137,536,511	202,047,327
2005	66,615,112	103,189,879	41,860,694	145,050,573	211,665,685
2006	69,269,334	106,905,495	45,971,921	152,877,416	222,146,750
2007	70,721,886	94,691,663	50,650,776	145,342,439	216,064,325
2008	65,808,295	92,018,956	54,380,670	146,399,626	212,207,921
2009	63,371,521	84,629,722	63,339,729	147,969,451	211,340,972
2010	67,572,638	88,507,605	71,052,988	159,560,593	227,133,231
2011	70,721,272	88,889,008	78,188,359	167,077,367	237,798,639
2012	75,742,260	83,816,269	78,627,053	162,443,322	238,185,582

Summarized from WCSC data sets

Based on container cargo processed through its facilities, the Port of Houston is the seventh largest container port in the U.S. and the leading container port on the Gulf of Mexico coast. According to U.S. Maritime Administration data, Houston typically handles over 65 percent of the container traffic in the Gulf of Mexico coast region and over 94 percent of the container traffic in Texas. Figure 2 shows an increase in loaded twenty-foot equivalent (TEU) at HSC. In anticipation of continued growth in containerized trade, the Port of Houston has been heavily investing in its terminals to accommodate the associated cargo and future fleet composition. The Port of Houston is currently dredging Bayport Ship Channel and Barbours Cut Channel. These two channels provide containerized cargo with access to the Bayport Terminal (BPT) and Barbours Cut Terminal (BCT). The Port of Houston is currently dredging both channels to 45 feet deep to match the 45-foot deep HSC. In addition, the Port of Houston has identified $325 million in capital improvements to handle post-Panamax (PPX) vessels; approximately $283 million of this total is to be spent on continuing development at Bayport Ship Channel and modernization at Barbours Cut Channel. Following historical trends at Houston, the containership fleet will include an increasing number of calls by PPX container ships, which make up a growing share of the world fleet.

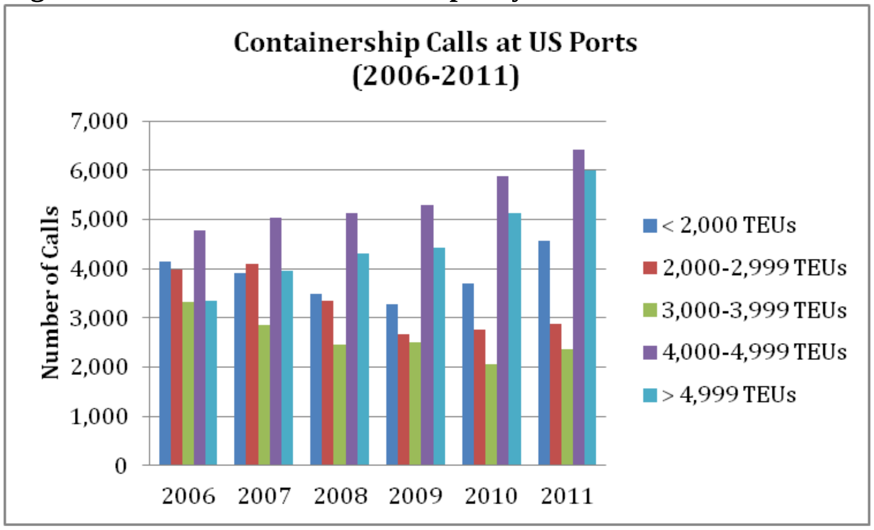
Figure 2 - HSC 2003-2011 Loaded TEU Trend



WCSC data for HSC

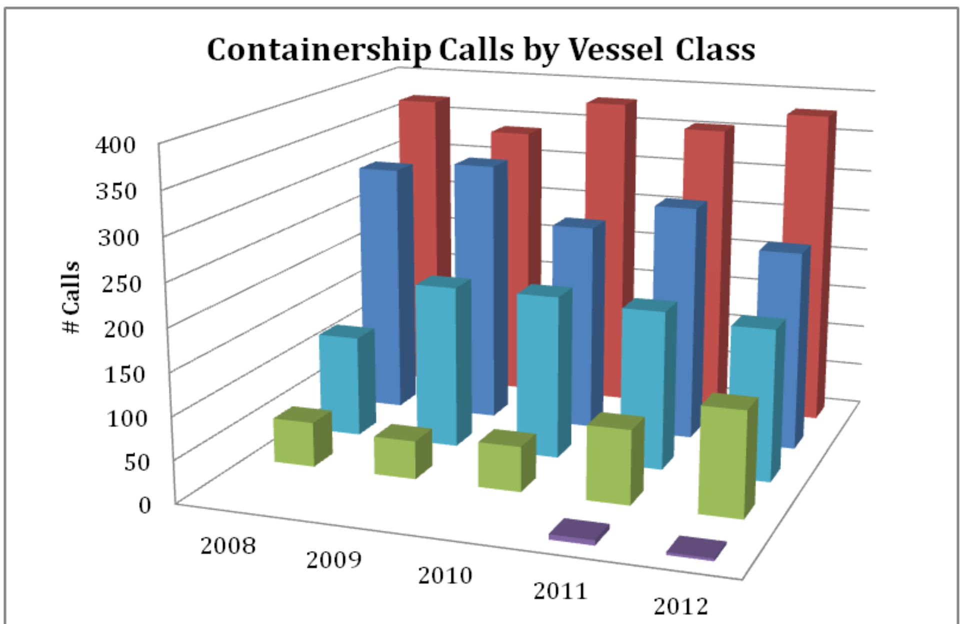
The Panama Canal and most major ports in the U.S., Europe, and Asia will be able to accommodate vessels with operating drafts in excess of 45 feet. Under future conditions it is assumed that the Bayport and Barbours Cut Channels will remain at a controlling depth of 45 feet. Vessels requiring operating drafts greater than 42 feet (Panamax (PX) and PPX) will continue to be constrained at the Port of Houston without channel deepening due to underkeel clearance (UKC) requirements. Over time, these inefficiencies are expected to increase significantly as the volume of cargo continues to grow and as larger vessels comprise a greater share of the vessel fleet calling at the Port of Houston. Figure 3 shows the trend of larger TEU capacity vessels calling at U.S. container ports from 2006-2011. Figure 4 provides the number of historical containership calls by vessel class for the HSC. As shown, the number of sub-Panamax (SPX) vessel calls is decreasing while the number of calls by larger vessel classes is increasing over time. Additionally, Figure 4 shows that in 2011 second generation post-Panamax (PPX2) vessels started to call and first generation post-Panamax (PPX1) vessel calls were on the rise. First generation Panamax (PX1) and second generation Panamax (PX2) vessels remained relatively constant while SPX vessel calls declined.

Figure 3- Container Vessel TEU Capacity Trends



Source: U.S. Department of Transportation, Maritime Administration – Vessel Calls Snapshot, 2011

Figure 4 - HSC Container Vessel Class Trends



	2008	2009	2010	2011	2012
PPX2				6	3
PPX1	53	45	53	87	123
PX2	121	194	194	188	179
SPX	303	316	249	282	238
PX1	370	336	380	354	379

Source: PHA

In 2011, the Port of Houston had the highest number of tanker calls among U.S. ports, accounting for 20 percent of total U.S. calls for that vessel class (4,652 calls out of a total 23,678).

Crude petroleum vessel calls are comprised of lightered, lightened and direct shipment. It is uncertain the quantity amount of each activity type. Lightering and lightening make up a significant portion of the total but not the entire portion. Both the Freeport Harbor Channel Improvement Final Feasibility Report in 2012 and the Houston-Galveston Navigation Channels, Texas, Limited Reevaluation Report (LRR) from 1995 document the importance of crude petroleum imports and the effects of lightering, lightening and direct shipments on the cost effectiveness for shippers.

Vessel lightering occurs in the international waters of the Gulf of Mexico and involves the transfer of tonnage from a larger vessel, called a Very Large Crude Carrier (VLCC), onto one or more shuttle vessels. With lightering, the VLCC does not enter the coastal receiving port. Lightering is more cost effective for long-haul freight relative to light loading as a larger quantity can be moved from origin/destination. Tankers larger than 175,000 dead weight ton (DWT) are normally totally lightered offshore onto shuttles. A frequent alternative to either direct shipment or lightering is lightening. Lightening is similar to lightering; however, these vessels are partially unloaded to meet the draft restriction of the before entering the channel. The tanker sizes associated with lightening on the Texas coast generally range from 120,000 to 175,000 DWT. This activity could potentially benefit from deepening and widening alternatives.

The WCSC data for Galveston Channel reported 11.6 million short tons as of 2012. This is up from 7.5 million short tons in 2003 and down from its 2010 high of close to 14 million short tons. The Galveston Channel commerce showed increases in both exports and imports with the exception of exported food and farm products (grains) in 2012. The droughts in Oklahoma, Texas and New Mexico in 2011 and 2012 could be an explanation of this occurrence. There is no indication of long term changes to the food and farm products activity at the Galveston docks. Growth of vessel trips drafting more than 30 feet has a compounding annual growth rate of 14 percent from 1994 to 2012. Vessels drafting more than 39 feet reached as many calls as 38 and 36 in 2011 and 2010 respectively; this is up from 4 and 8 in 2006 and 2007 respectively.

The WCSC data for Texas City Ship Channel reported 56.7 million short tons as of 2012. This is up from 48.8 million in 2006 and down from its high in 2004 of 68.2 million short tons. Of the 56.7 million short ton moving at the Texas City Ship Channel docks, 26.5 million short tons consisted of imported crude petroleum. The Texas City Ship Channel also exported approximately 6.4 million short tons of petroleum products and 1.5 million short tons of chemical products.

5. SUMMARY OF APPLICABLE PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS. The study for improving deep-draft navigation channels within the Galveston Bay area was authorized by a resolution of the House Committee on Public Works adopted October 19, 1967. This resolution authorized a review of the reports on the Galveston Harbor and Channels, the HSC, and the Texas City Ship Channel. The reconnaissance report for this study was completed in 1980. Additional feasibility studies followed.

The feasibility study for the Texas City Ship Channel was completed in 1982, and the report recommended enlarging the project from its existing dimensions of 40 feet deep and 400 feet wide to 50 feet deep and 600 feet wide as well as deepening the Entrance Channel. These improvements were authorized for construction by Public Law 99-662, WRDA 1986.

Galveston Bay Area Navigation Study Feasibility Report and Environmental Impact Statement, USACE – Galveston District, July 1987. This report recommended improving the HSC to include a 50-foot deep by 600-foot wide channel from Bolivar Roads to Boggy Bayou, with intermittent widening upstream of Boggy Bayou. The Galveston Channel was recommended to be enlarged to a depth of 50 feet and width of 450 feet.

Houston-Galveston Navigation Channels, Texas, Limited Reevaluation Report and Final Supplemental Environmental Impact Statement, USACE – Galveston District, November 1995. This report supplemented the initial Galveston Bay Area Navigation Study Feasibility Report from July 1987 to address environmental concerns and update project economics. Based on the conclusions of this report and project authorization by WRDA 1996, the HSC (from the Entrance Channel at mile 0 to Boggy Bayou at mile 40) was deepened from 40 feet to 45 feet and widened from 400 feet to 530 feet. Construction was completed in 2005. The 1995 LRR also identified a Dredged Material Management Plan (DMMP) for a 50-year period of analysis. The plan included several different strategies for removal of new work and maintenance material over the 50-year period. These strategies included upland confined placement, BU of material through the construction of marsh and bird islands and offshore placement.

Houston-Galveston Navigation Channel, Texas, Final Limited Reevaluation Report, USACE Galveston District, May 2007. This report supplemented the information presented in the 1995 LRR by updating specific issues related to the Galveston Channel. The report confirmed that deepening a portion of the channel from 40 feet to 45 feet was justified. The Galveston Channel from the Entrance Channel to the vicinity of Pier 33, a distance of 11,400 feet (2.11 miles) was recommended to be deepened to 45 feet with a bottom width ranging from 650 – 1,112 feet. Construction was completed in January 2011.

Preliminary Assessment of the Dredged Material Management Plan for the Houston-Galveston Navigation Channels, Texas, dated June 2010, concluded that there is not sufficient capacity for 20-year placement of dredge material from the HSC under the current DMMP. A new DMMP is currently under development.

Navigation Study for Bayport Flare Improvement Data Report, USACE-Engineer Research and Development Center (ERDC) dated June 2011. The report was prepared with results from a ship simulation study and interviews with pilots. The report recommended increasing the radius of the Bayport flare to 4,000 feet, and adding a 250-foot widener on the east side of the HSC. This recommendation was based on the 40-foot channel depth.

Houston Ship Channel Expansion, Deep Draft Navigation, Initial Appraisal Report, USACE – Galveston District, September 2011. This report determined a potential Federal interest to undertake modifications to the existing channel of the HSC from Boggy Bayou to the Main Turning Basin (terminal point for the HSC).

Preliminary Analysis of the Costs to Deepen the Entrance Channel and the Houston Ship Channel – J. Simmons Group, Inc. Report prepared for the PHA, November 2011. This report provided a ball park estimate of the dredging quantities and their associated costs that are required to deepen the channel to 48 feet and 50 feet.

Bayport Ship Channel Improvements and Barbour's Cut Channel Improvement Projects, Section 204(f) Assumption of Maintenance Assessment Report for Harris and Chambers Counties, Texas, December 2013. The report presented the findings of a study prepared by the PHA. The study consisted of evaluating the Federal interest in assumption of maintenance of the two channels after sponsor modification of depths and widths. The study included an economic and environmental analysis. The report was approved in 2014.

Houston-Galveston Navigation Channel, Texas, Draft PACR and Section 902 Cost Limit Determination, USACE Galveston District, July 2014 – In Progress. The purpose of report is to document the project changes that have occurred to date; recommend a reduction in acres of marsh restoration created by BU of dredged material from 4,250 acres to 2,832 acres; determine and recommend Congressional approval to increase the spending amount; and recommend changes to the Project Partnership Agreement. The PACR is required because it is likely that the current cost of the project exceeds the maximum cost limit, as defined in Section 902 of WRDA 1986.

Houston Ship Channel, Texas, Dredged Material Management Plan, USACE – Galveston District, In Progress. The assessment was performed for the HSC to estimate future sedimentation rates and PA capacity over a 20-year period. Environmental concerns associated with the placement of dredged material and economic justification for continued maintenance of the Federal channel are being evaluated. A preliminary assessment in 2010 determined the existing PA sites and planned expansions were not sufficient to contain 20 years of dredged material, requiring a new DMMP to be developed.

6. SCOPING. The foundation of the scoping process during the 905(b) analysis was to first identify the existing problems with the HSC system. The problems were established by the PHA, readily available information from port users and pilots, and data presented in existing reports. By establishing the problems and going through the six-step planning process, a Federal interest in solving the problems in a feasibility study was demonstrated.

Scoping during development of the 905(b) analysis also meant reaching out early to the resource agencies, including Federal agencies such as the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS) and the Environmental Protection Agency (EPA). A formal letter was sent via email distribution to the resource agencies explaining the purpose of the reconnaissance study, and requested their initial concerns and feedback. On October 23 and 24, 2014, a vertical team scoping meeting was held at the Galveston District. The meeting allowed early feedback from the vertical team, PHA, and resource agencies to inform scoping the feasibility study.

7. PROBLEMS / OPPORTUNITIES.

The problems identified include:

•Inefficient vessel utilization of the HSC system due to current channel dimensions, including inefficiency of in-channel configurations;

•Safety concerns with vessel traffic; and

•Finding suitable placement areas for dredged material.

Currently, vessels calling at the Port of Houston experience inefficient vessel utilization due to channel depth and width constraints. The light loading of vessels prevents them from utilizing their optimal design draft. Light loading of vessels results in an increased number of vessel trips which results in increased congestion on the HSC. One-way traffic is required for vessels with large beams causing time delays in areas of the Boggy Bayou to Main Turning Basin. Channel configurations require slowing and tug assistance for larger vessel classes. Higher than average wait times are being experienced, as well as high rates of utilization at the anchorage, which result in extra expenses for shippers. Congestion has increased concerns for life and environmental safety.

More specific problem statements regarding inefficient vessel utilization are:

•The volume of petroleum product and chemical trade at HSC continues to increase and vessels are forced to operate at drafts constrained by channel depth limitations;

•Channel depth constraint of 40 feet in the Boggy Bayou to the Main Turning Basin results in inefficient vessel operations with associated impacts that ripple through the U.S. economy;

•VLCC require lightering at the Port of Houston in order to economically move products to Port of Houston refineries;

•Channel configurations cause slowing and tug assistance for larger vessel classes;

•Higher than average wait times are being experienced as well a high rate of utilization at the anchorage; and

•One way traffic is required for vessels with large beams causing time delays in areas of the Boggy Bayou to Turning Basin reach.

Opportunities in the study area are:

• Increase navigation efficiencies of vessels using the channel;

•Decrease safety concerns with vessel traffic; and

•Establish environmentally suitable placement areas for new dredged material.

PLANNING GOALS / OBJECTIVES.

The overall study goal is to provide an efficient and safe navigation channel while contributing to the national economic development consistent with protecting the nation's environment.

The planning objectives are:

•Improve deep-draft navigation efficiency for the HSC over the 50-year period of analysis to accommodate larger vessels (PPX class vessels) expected to increase in the Gulf of Mexico over the period of analysis timeframe,

•Reduce vessel traffic delays,

•Increase channel safety for vessels utilizing the HSC, and

•Establish environmentally suitable PAs including new upland confined PA sites and utilizing BU of dredged material.

9. PLANNING CONSTRAINTS.

The recognized planning constraints identified for this study are:

•Resources – minimizing significant impacts to endangered species, oyster habitat, and other fish and wildlife habitat;

•Physical constraints: Loop Interstate 610 Bridge will limit the height of vessels that can travel further west on the HSC;

•Compliance with Federal/State laws and policies; and

•Alternative plans that do not cause or amplify problems in other areas.

10. FISH AND WILDLIFE RESOURCES CONSIDERATIONS. Galveston Bay is one of a nearly continuous series of embayments throughout the flat low-land region of the Gulf Coastal Plain of Texas that are separated from the Gulf of Mexico by barrier islands or barrier peninsulas. At around 30 miles long and 17 miles wide, Galveston Bay covers about 600 square miles making it Texas' largest estuary. Elevations in the area range from approximately 35 feet in the surrounding mainland to sea level at Galveston Bay. The greatest natural depths in the bay are typically 6 to 12 feet.

The size and geography of Galveston Bay coupled with the mixing of fresh water from a variety of major tributary rivers and creeks in the upper bay with saline waters of the Gulf produces a wide range of salinities within the bay that can range from about 30 parts per thousand (ppt) near tidal inlets to about 3 ppt at major upstream points of freshwater inflow like the Trinity River. The location and dimensions of the HSC, which is the longest of the navigation channels in Galveston Bay, allow it to serve as a conduit for the higher salinity Gulf waters to enter into the upper bay. As result, salinities in the open-bay waters adjacent to the HSC may be around 2 ppt higher than that of the surrounding bay.

The broad range of salinities and flat topography allows Galveston Bay to support a wide spectrum of habitats, including tidal and freshwater coastal marshes; shallow bay waters which support seagrass meadows, tidal flats and reef complexes; coastal prairie with small wetland depressions; and forested riparian corridors. Wetland habitats provide important wintering and migration stopover habitat for migratory birds including Central Flyway waterfowl, shorebirds, wading birds and marsh and water birds. These habitats also support a variety of commercially, recreationally and ecologically important estuarine and marine fisheries species dependent on these areas as shelter as well as feeding and nursery habitat. Channel modifications, including deepening and widening and associated dredged material placement, can directly impact bay habitat and have the potential to further impact bay salinity and circulation which can also affect the health of these bay habitats as well as the distribution, abundance and diversity of organisms dependent on them for survival. The following sections provide a description of the habitats in Galveston Bay that could potentially be affected by channel modifications and associated construction and maintenance activities.

<u>Vegetation Communities</u>

Forested Wetlands

Forested habitats occur along the riparian areas of the San Jacinto and Trinity Rivers upstream of where these rivers discharge into Galveston Bay. Forested areas along the Trinity River are dominated by dense bottomland hardwood forests and cypress-tupelo swamps. These wetland forests cover an intricate network of sloughs and sandy ridges formed within the rivers' relict meander belts. Bald cypress (*Taxodium distichum*) – tupelo-gum (*Nyssa aquatica*) swamps grow in the inundated areas between the ridges, and floodplain hardwood forest of oaks (*Quercus nigra, Q. phellos, Q. alba, Q. lyrata*), sweetgum (*Liquidambar styraciflua*), hickories (*Carya* spp.), American elm (*Ulmus americanus*), maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American holly (*Ilex opaca*), and loblolly pine (*Pinus taeda*) grow atop the sandier ridges and on the Pleistocene terrace uplands which border the floodplains. In general, these are healthy, stable habitats. The hardwoods, and especially the cypress trees, have been logged repeatedly since the turn of the century and as recently, perhaps, as the 1950s. Though much of the forest is secondary growth, the swamp and bottomland hardwood habitats have medium to high value for food and cover to resident and migratory fish and wildlife. Forested wetlands in the San Jacinto River system are dominated by bottomland hardwood communities similar to those found along the Trinity River. Oak woodlot habitats (also known as oak mottes) can be also be found on higher ridges and mounds scattered across coastal marshlands. They are vital for resident and migrant species of wildlife, especially neotropical migrant passerine species.

Coastal Prairies

Remnant tracts of tall grass and salty prairies are present at higher elevations in the study area and are often interspersed within coastal marshes at lower elevations. Wooly rosemallow, bushy bluestem and gulf cordgrass thrive in coastal prairie habitats and provide important nesting habitat for mottled ducks, dickcissels and other species. Black rails, short-eared owls and LeConte's sparrow find shelter and feed within these prairie habitats. Almost all of the region's historic native coastal tall grass prairie and its associated prairie wetlands have been lost through conversion to agricultural uses and urban development.

Coastal Marshes

Salt marsh is located along the Gulf shoreline and higher salinity areas of the estuarine systems. Subjected to regular tidal inundation, low saline marsh is dominated by smooth cordgrass/oystergrass (*Spartina alterniflora*) and often accompanied by seashore saltgrass (*Distichlis spicata*), blackrush (*Juncus romerianus*), saline marsh aster (*Aster tenuifolius*), and marshhay cordgrass/wiregrass (*S. patens*). The dominant species in high salt marsh, which is subject to less-frequent tidal inundation, is glasswort (*Salicornia spp.).* Brackish marshes grade inland from salt marsh. The dominant species in low brackish marsh is saltmarsh bulrush (*Scirpus robustus*); seashore saltgrass and marshhay cordgrass are co-dominant species in high brackish marsh. Intermediate marshes are subjected to periodic pulses of salt water and maintain a year-round salinity in the range of 3 to 4 parts per thousand (ppt). They grade inland from brackish marshes and dominate interior marshes of Galveston Bay. The diversity and density of plant species are relatively high with marshhay cordgrass the most dominant species in high marsh. Co-dominant species in low marsh are seashore paspalum (*Paspalum vaginatum*), Olney bulrush (*S. americanus*), California bulrush/giant bulrush (*S. californicus*), and common reedgrass/roseau cane (*Phragmites australis*); bulltongue (*Sagittarius lancifolia*) and sand spikerush (*E. montevidensis*) are also frequent. Freshwater marshes dominate in upstream reaches of the Trinity and San Jacinto Rivers. They are heterogeneous, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity. Co-dominant species in low marsh are maidencane (*P. hemitomen*), giant cutgrass (*Zizaniopsis milacea*), and bulltongue. Co-dominant species in high marsh are squarestem spikerush (*E. quadrangulata*) and marshhay cordgrass. Other characteristic species include American lotus (*Nelumbo lutea*), watershield (*Brasenia screben*), duckweed (*Lemna spp.),* and fanwort (*Cabomba caroliniana*). Salinity is quite low, rarely increasing above 2 ppt, with a year-round average of approximately 0.5 to 1 ppt. Tidal fresh marshes support extremely high densities of wildlife, such as migratory waterfowl. Marsh serves as nursery areas for many important commercial and recreational fish and shellfish species including white and brown shrimp, blue crab, red drum, flounder and speckled sea trout. Coastal marsh habitats provide important functions of improving water quality in the estuarine ecosystem, providing flood control benefits, and buffering inland habitats from tropical storm-generated tidal surges. In addition, marshes are extremely biologically productive and diverse and provide detrital input, which is the basis for the estuarine food chain.

Seagrass

In Galveston Bay, seagrasses can establish dense meadows on areas of the bay bottom where water is shallow and turbidity is low. The animal community associated with seagrass meadows is quite diverse. Juvenile shrimp, crab and fish use this habitat as a nursery area and migrate to other habitats when they mature. Historically all four species of seagrasses found in Texas (shoal grass (*Halodule wrightii),* clover grass *(Halophila englemanni)*, turtlegrass (*Thalassia testudinum*), and widgeongrass [*Ruppia maritime]),* were present along the shallow shoreline areas of Upper and West Galveston Bay. During the 1970s and 80s seagrasses nearly disappeared entirely from the area due to human disturbances, hurricane activity, and their limited tolerances to turbidity, deep water, and wave energy. At one time, only around 400 acres of natural seagrass beds remained in Galveston Bay located within a small shallow sub embayment known as Christmas Bay, over 20 miles west of the HSC. In the 1990s, in recognition of the value being lost with declining seagrass resources, state agencies approved a Seagrass Conservation Plan for Texas, providing recommendations and management actions to help reverse the decline in this resource. In recent years, seagrass restoration efforts conducted in West Galveston Bay have resulted in a slow return of the resource in this area of the bay.

<u>Estuarine and Marine Aquatic Resources</u>

Oysters

Extensive oyster reef habitat occurs throughout Galveston Bay, and is concentrated along a 17-mile stretch of the HSC between just south of Redfish Reef and Morgan's Point, where currents provide the oysters with an abundance of food. Oyster reef habitat dominated by the Easter oyster (*Crassostrea vircinica*) is perhaps one of the most important habitats in Galveston Bay, playing an essential role in maintaining the health and productivity of this estuarine ecosystem. One average-sized oyster can filter up to 50 gallons of water a day while feeding, reducing phytoplankton biomass resulting from nutrient loading as well as suspended solids from the huge amounts of municipal wastewater and storm water runoff introduced into the bay. After feeding, oysters concentrate and eliminate undigested material (pseudofeces) which is quickly colonized by bacteria and provides an important food source to other benthic species. The combination of filtering water and biodeposition of material can lower turbidity and improve water quality, resulting in higher benthic algae productivity over a large area of the bay. The reefs that oysters build also provide a complex three-dimensional structure above the soft bay bottom sediments, creating habitat that may be colonized by other mollusks, barnacles, polychaete worms, and other invertebrates. Juvenile fish and mobile crustaceans (e.g. crab and shrimp) may find shelter and foraging habitat on the reef, attracting larger transient and resident fish for feeding. Oyster reef, depending on location, may also provide important corridors for organisms transiting between shelter and foraging areas. In Galveston Bay, oyster reef has been identified as an essential habitat for finfish, and can support a higher abundance, biomass and species richness of most fish species than either marsh or shallow non-vegetated bay bottom.

In addition to habitat and water quality, other important ecosystem services that oyster may provide including both wave attenuation and carbon sequestration may exist. Reef may attenuate wave energy and reduce erosion, providing protection for other nearby habitats such as submerged aquatic vegetation (SAV) or salt marsh. Oysters may also influence greenhouse gas concentrations, serving as a carbon sink by sequestering CO_2 dissolved in the water column to build their calcium carbonate shells.

Between 2003 and 2007, Texas had the second largest annual oyster harvest in the U.S, weighing in at over 5 million pounds annually. According to the Texas Parks and Wildlife Department (TPWD), each year, harvesting of oysters from both privately leased and public reefs within Galveston Bay yields an average annual economic value of over $11.8 million.

TPWD estimates that in 2008, around 60 percent of the oyster reef habitat in Galveston Bay was destroyed when Hurricane Ike deposited a layer of sediments and debris atop the bay bottom, smothering live oysters. High salinities during recent droughts and increased harvesting pressures on Galveston Bay oysters following direct impacts to oyster reef in other Gulf Coast states from the Deepwater Horizon oil spill in 2011 have resulted in additional stress to oyster reef in Galveston Bay and hampered their recovery. In recent years, TPWD has initiated several large-scale restoration projects to restore hundreds of acres of impacted oyster reef in Galveston Bay.

Essential Fish Habitat

Essential fish habitat (EFH) consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils, as described in a series of Fishery Management Plans, pursuant to the Magnuson-Stevens Fishery Conservation and Management Act. The categories of EFH that occur within the study area include estuarine water column, estuarine mud, sand and shell bottoms (unvegetated estuarine benthic habitats), estuarine emergent wetlands, marine water column, and marine nonvegetated bottoms.   These areas provide important spawning, nursery and or feeding habitat for adult and juvenile brown, white, and pink shrimp (*Penaeus aztecus*, *Penaeus setiferus*, and *Penaeus duorarum*), red drum (*Sciaenops ocellatus*), gag grouper (*Mycteroperca microlepis*), scamp (*Mycteroperca phenax*), red snapper (*Lutjanus campechanus*), gray snapper (*Lutjanus griseus*), lane snapper (*Lutjanus synagris*), greater amberjack (*Seriola dumerili*), king mackerel (Scomberomorus cavalla), Spanish mackerel (*Scomberomorus maculatus*), cobia (*Rachycentron canadum*), Atlantic bluefin tuna (*Thunnus thynnus*), bonnethead shark (*Sphyrna tiburo*), blacktip shark (*Carcharhinus leucas*), bull shark (*C. leucas*), and Atlantic sharpnose shark (*Rhizoprionodon terraenovae*).

<u>Threatened and Endangered Species</u>

Based on previous consultations with USFWS and NMFS, there are Federally-listed species potentially occurring within the vicinity of the study area (Chambers, Galveston, and Harris Counties) include wintering populations of the piping plover (*Charadrius melodus*), Atwater's prairie chicken (*Tympanuchus cupido attwateri*), Eskimo curlew (*Numenius borealis*), whooping crane (*Grus americana*), several species of whales (blue [*Balaenoptera musculus*], finback

[*Balaenoptera physalus*], humpback [*Megaptera novaeangliae*], sei [*Balaenoptera borealis*], and sperm [*Physeter macrocephalus*]), all five species of sea turtles (green [*Chelonia mydas*], hawksbill [*Eretmochelys imbricate*], Kemp's ridley [*Lepidochelys kempii*], leatherback [*Dermochelys coriacea*] and loggerhead [*Caretta caretta*]), and Texas prairie dawn-flower (*Hymenoxys texana*). National Marine Fisheries Service has also identified the scalloped hammerhead shark (*Sphyrna lewini*) and seven species of corals (*Montastraea annularis, Montastraea franksi, Dichocoenia stokesii, Agaricia lamarcki, Montastraea faveolata, Dendrogyra cylindrus,* and *Mycetophyllia ferox*) as Candidate Species for this area. Critical habitat for wintering populations of the piping plover is present in the Galveston Bay area. Designated Critical Habitat Units include shoreline areas around Rollover Pass (TX-37), Bolivar Flats (TX-36) near Fort Travis at the Galveston North Jetty, Galveston East Beach at the Galveston South Jetty (TX-35), and for 3.5 miles north of San Luis Pass (TX-34).

11. HISTORICAL AND CULTURAL RESOURCES CONSIDERATIONS. The HSC system has an estimated total of 473 cultural resources that include five National Historic Landmarks, 68 National Register of Historic Places listed properties, 200 archeological sites, 30 cemeteries, and 170 shipwrecks and submerged resources (Table 3). The primary considerations concerning cultural resources are threats to submerged resources from dredging, wake-induced erosion of shoreline sites, and from construction of new PA sites. A large portion of the study area, especially along the margins of the ship channels, has been altered for industrial and commercial use. As such, in upland areas, the probability for intact prehistoric archeological sites to occur is low. However, there is a moderate to high potential for encountering historic age archeological sites, as well as historic age structures and buildings. For the marine portions of the study area, the potential for encountering submerged cultural resources, such as shipwrecks, is moderate. Although much of the area has been dredged in years past, the very dynamic nature of the study area means that submerged resources may occur anywhere. Based on the proposed alternatives, the submerged cultural resources are the most likely to be affected by project activities. Investigations of these submerged resources are, in general, more costly to conduct than investigations in upland settings, especially with regard to mitigation.

Table 3 - Cultural Resource Locations

CULTURAL RESOURCES	HSC SYSTEM TOTAL	HSC - BOGGY BAYOU TO MAIN TURNING BASIN	BAYPORT CHANNEL
Archeological Sites	200	23	5
National Register Properties	66	2	0
National Register Districts	7	0	0
Cemeteries	30	10	1
Shipwrecks	170	1	8
TOTALS	**473**	**36**	**14**

12. FORMULATING ALTERNATIVE PLANS. The reconnaissance level alternative formulation analysis does not constitute a complete analysis of the full array of alternatives nor does it define a preferred alternative or National Economic Development (NED) plan. Detailed analysis is expected to be conducted in the proposed feasibility phase and would likely involve evaluation of all alternatives to address the problems and opportunities. The array of alternatives that may be examined in the feasibility study would likely be built from a combination of the following management measures identified below.

12.1. Management Measures

Structural

- channel deepening
- channel widening (including passing lanes)
- other channel configurations (bend easing/flares)
- anchorage/turning basins
- disposal area (upland/offshore/in-bay/BU)
- mooring areas
- breakwaters/jetties
- offshore crude terminal (LOOP)

Non- Structural - Operational Practices

- traffic controls
- change in operating procedures (tides, lightering, etc.)
- changes to Shipper Association Operating Procedures

Non-Structural – Modification of Local Service Facility

- storage (e.g. grain shipment)
- structural measures by non-Federal interest, i.e. berthing areas

12.2. Screening of Measures.

The following are preliminary criteria that will be used to screen alternatives. These criteria will be finalized in the feasibility study. The navigation project must be economically justified with expected benefits exceeding cost over the 50-year period of analysis.

•Environmental Considerations – a measure that increases (or causes) adverse impact on sensitive habitats or species that cannot be mitigated in a cost effective way will be eliminated from further study.

•Cultural Resource Concerns - a measure that increases (or causes) adverse impact on cultural resource sites that cannot be mitigated in a cost effective way will be eliminated from further study.

•Construction Costs or Cost to Perform – measures that are very expensive due to construction cost, environmental impacts, and resultant mitigation costs will be eliminated from further study.

12.3. Engineering with Nature (EWN) Opportunities

During development of alternatives in feasibility, the PDT will take into consideration opportunities that promote sustainability of the ecological resources within the Galveston Bay system. One opportunity to achieve this is to incorporate the principles and practices of the USACE Engineering with Nature (EWN) Program. The EWN Program is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits. The HSC study will identify the practical actions that can be considered in support of the EWN vision to better align and integrate engineering and natural systems to produce a socially acceptable, economically viable and environmentally sustainable project.

The HSC feasibility study could incorporate the EWN principles and practices to seek a broader range of dredged material management opportunities on which to apply EWN principles and practices. The use of EWN and Natural Nature-Based Features (NNBF) is a method to develop solutions that are different from traditional dredged material management, including confined disposal facilities and BU, and could be designed to enhance and promote resiliency and sustainability of the ecological resources within the Galveston Bay system and improve the operational efficiency of the HSC.

13. POTENTIAL ALTERNATIVE PLANS. Alternative plans will be formulated through combinations of screened management measures. The following is a list of the preliminary structural and nonstructural alternative plans formulated for the reconnaissance study. Likely benefits, costs, and environmental impacts and outputs for each alternative analyzed based on available information and professional judgment are discussed below.

13.1. No Action Alternative

The No Action alternative would involve no action on the part of the U.S. Army Corps of Engineers (USACE). The existing navigation project would remain at its current authorized depth, dimension and location. This alternative will be considered further in the feasibility phase and will also be used as a basis of comparison to all action alternatives considered.

13.2. Channel Improvements – Deepening Boggy Bayou to the Main Turning Basin

This alternative would analyze deepening the 12-mile portion of the HSC from Boggy Bayou to the Main Turning Basin to potentially match the existing 45-foot depth of the HSC (mile 0 to mile 40). The portion of the channel between Boggy Bayou and the Main Turning Basin is within a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other Port of Houston infrastructure associated with petrochemical, manufacturing and bulk commodities. There may be limits to deepening the entire 12-miles to 45 feet due to constraints such as the Interstate 610 Bridge that currently has a 135-foot air draft.

A preliminary engineering analysis was performed on this portion of the HSC from Boggy Bayou to the Main Turning Basin. The analysis identified the material to be removed during the deepening, facilities along the channel that would be impacted by the project, and infrastructure that might be affected by the new channel dimensions. The analysis determined that about 14.4 million cubic yards (MCY) of new work material would have to be removed from the channel with the proposed 45-foot deepening. Dredged material quantities were also calculated for the deepening at the numerous wharves and dock facilities this portion of the channel up to the Main Turning Basin to allow deeper draft access to these facilities. Table 4 shows the channel sections and the quantity of material removal.

Table 4 – Estimated New Work Volume

HSC Expansion – New Work Volume 45 ft. Depth	**VOLUME (CY)**
HSC from Boggy Bayou to the Main Turning Basin	7,095,056
Main Turning Basin	4,756,298
HSC Wharfs	1,655,106
Main Turning Basin & Channel Wharfs	859,608
TOTAL	**14,366,068**

Source: HSC Expansion – USACE Initial Appraisal Report, September 2011.

An assortment of grain, petrochemical and bulk facilities utilize this upper portion (Boggy Bayou to the Main Turning Basin) of the HSC. The Port of Houston's main break bulk docks are populated around the Interstate 610 Bridge on the north side of the channel. Overall trips to this segment of the channel grew from 1,750 (exports) and 1,739 (imports) in 2009 to 1,847 (exports) and 1,882 (imports) in 2012. A trip is defined by one leg of a vessel call at the Port of Houston, either the import trip or the export trip. Tonnage in this segment grew from 30.1 million short tons in 2009 to 32.3 million short tons in 2012. The growth was largely attributed to export of petroleum products. A review of the 2012 detailed vessel call records from the WCSC shows the current vessel fleet would benefit by loading deeper even without the assumption of transitioning vessel fleet mix. Table 5 is a comparison of actual sailing drafts and design drafts of those vessels calling at HSC in the reach above Boggy Bayou. The vessels in this snapshot are expected to draft deeper if the channel depth constraint would be alleviated to some degree. For example, vessels drafting at the 38, 39 and 40-feet row falling in any column to the right of 40 feet would be constrained by the channel depth and could potentially benefit. The HSC vessel traffic shows a growing trend toward deeper drafting vessels utilizing the channel (2009-2012). Section 13.3 discusses historical sailing draft trends for the entire HSC which also applies to the Boggy Bayou to Main Turning Basin reach. With the commodity growth in this area and the trend towards larger vessels it is likely that channel improvements including widening, deepening, turning basins and bend easing would warrant further investigation. Channel deepening, to be investigated in 2-foot increments, will benefit cargo transferred at docks below the Interstate 610 Bridge. The Interstate 610 Bridge provides a height constraint on vessels which correlates with an overall vessel dimension constraint. An accompanying turning basin near the East side of the Interstate 610 Bridge would facilitate vessel utilization of the additional channel depth.

Table 5 - Boggy Bayou to the Turning Basin Sailing Drafts by Call

		Design Maximum Draft (Feet)												
		39	40	41	42	43	44	45	46	47	48	49	50	51
Sailing Draft (Feet)	36	2	27	15	10	19	3	0	1	3	3	0	0	0
	37	5	13	5	10	10	7	0	0	1	0	0	0	0
	38	6	19	15	8	7	3	0	0	0	3	0	0	0
	39	1	12	11	4	7	3	2	0	1	0	1	0	1
	40	-	2	0	1	4	0	1	2	2	1	1	0	0
	41	-	-	0	0	0	0	0	0	1	1	0	0	0
	42	-	-	-	0	0	0	0	0	0	3	0	1	0
	43	-	-	-	-	1	0	0	0	0	0	0	0	0

Summarized from WCSC detailed data

Channel width constraints have resulted in HSC Pilots Association implementing the following rules for safety purposes. Vessels with a beam width greater than 105 feet cannot meet any vessel above Boggy Bayou and are restricted to a maximum beam of 120 feet. Car carriers cannot meet any traffic above Greens Bayou. Vessels approaching the upper turning basin are constrained by the 256 feet rule. The 256 feet maximum restriction on vessel beams rule for vessel meeting in a portion of the Upper Boggy Bayou. Pilots not choosing to wait in lay berth or schedule around open channel transits (if any), turn into the channel prior to the constraint at the Port of Houston Berth #27 (Brays Bayou turning point) then transit backwards to their desired dock. Modifications such as channel widening near Port of Houston public wharves #1 and #2, as well as improvements to Brays Bayou turning point could alleviate some of these channel operating inefficiencies.

The Houston-Galveston Navigation Channel LRR in 1995 found a $.75 savings per ton in the channel deepening increment from 40 to 45 feet in the HSC segment below Boggy Bayou. It also found that domestic shipments of petroleum products saved approximately $2.33 per short ton for the deepening increment from 40 to 45 feet; savings for foreign petroleum products was similar to domestic savings of $2.33 per short ton all the way up to $4.62 per short ton for shipments to the Middle East and Indian Subcontinent.

<u>Environmental Effects</u>

Most of the environmental effects of deepening this portion of the HSC would be similar to what is experienced during routine maintenance dredging of the existing 40-foot project and adjacent docks/berths (e.g. benthic habitat, noise, water quality, turbidity, etc.). The project channel segment is located within a highly developed industrialized urban area of Houston, though a few tracts of vacant undeveloped land remain. Such vacant land in the vicinity of the project is dominated by forested areas and grasslands. Freshwater wetland habitats can be expected on these sites. Any new PA site that may be required by the proposed action would likely impact forested/herbaceous wetland habitats that remain on these undeveloped tracts of land and affect associated fish and wildlife species. Efforts to avoid and minimize impacts to fish and wildlife habitat would be made where feasible. The most likely suite of in-kind mitigation alternatives that would be considered to offset unavoidable impacts to habitat would include the use of an appropriate mitigation bank within the service area of the project, or other suitable compensation measures (e.g. wetland creation or preservation).

Because this alternative is located within a narrow, highly industrialized area of Buffalo Bayou that is closely bordered on both sides by berths, docking facilities and other port infrastructure associated with petrochemical, manufacturing and bulk commodities, sediment and water quality testing would be necessary to identify whether contaminants, if any, are present in the maintenance and new work dredged material. Should any contaminated sediment be identified, proper handling and placement of contaminated material would be evaluated.

New PA development would also require investigations to identify previously unknown cultural resources that may occur on the sites. Potential cultural resources impacts exist concerning any proposed channel deepening scenarios on the Washburn Tunnel, which was added to the National Register of Historic Places in 2008. The current maximum water depth is 45 feet within the HSC at the Tunnel. Proposed channel deepening scenarios would likely require removal of the Tunnel, which may require mitigation under the National Historic Preservation Act.

13.3. Deepen Existing HSC and Entrance Channel

This alternative would increase the depth of the entire main stem of the HSC (52 miles) from its juncture at the Texas City Channel up to the Main Turning Basin. Deepening the HSC would also require investigating the deepening the Entrance Channel. Based on a preliminary analysis completed for the PHA in 2011, it was found that the existing Entrance Channel would need to be extended an additional 22-23 miles into the Gulf of Mexico (depending on the extent of the deepening). Some adjustment may be required to the orientation of the channel extension or to the existing shipping lanes with this alternative.

With any deepening of the HSC and Entrance Channel, new PA sites for the dredged material produced from the deepening would be required. For the Entrance Channel, it can be assumed that the dredged material would be placed in ODMDS. As for the main stem of the HSC, it can be assumed that placement of the dredged material will be made in similar locations as was used during the previous deepening/widening project. However, there are many uncertainties involved with the placement of the dredged material from new work. It is assumed that new PA sites would be explored in the bay, utilizing BU when possible. However, establishing new PA sites within the bay complex would have significant bay bottom resource impacts that would require mitigation. Oyster reefs exist in the bay and along the HSC. This resource would be directly and indirectly impacted by deepening and establishing new dredged material PA sites in the bay.

J. Simmons Group, Inc. prepared a report in November 2011 for the PHA that showed the preliminary analysis to deepen the Entrance Channel and HSC to 48 feet and 50 feet. The report estimates the quantity of material for the 48-foot plan to be approximately 140,250,000 CY. The report estimates the quantity of material for the 50-foot plan to be approximately 199,000,000 CY. The report estimates the costs of dredging the channel to 48 feet at $1,310,400,000 and dredging the channel to 50 feet is estimated at $1,785,300,000. The cost includes dredging, PAs and mitigation. Relocations and other impacts due to deepening/widening were not included in this estimate.

If the HSC is deepened to any depth beyond the existing 45 feet, then Texas City Ship Channel and Galveston Channels would also need to be investigated for opportunities as well as the terminal channels. The PHA recently completed a Section 204(f) study report for the Assumption of Maintenance (AOM) for the Bayport and Barbours Cut terminal channels. The report was approved in 2014. The study completed an economic analysis that revealed economic justification for deepening both channels to 45 feet to match the depth of the main HSC.

Exxon-Mobil Chemical Company is expected to spend about $190 billion in capital spending worldwide over the next five years. One of those projects is a multi-billion dollar ethane catalytic cracking unit (cat cracker) at its Baytown, Texas, complex. The new steam cracker will have the capacity to process 1.5 million short tons per year of natural gas. The plant will produce high-valued polyethylene products. Production of these high-quality petrochemical products used in a wide range of consumer and industrial applications is expected to start in 2017.

The largest benefit category is typically economies of scale calculated through transportation cost savings as a result of a deepening project. The benefits arise by providing a lower cost per ton for shipping cargo from its origin to its destination. These benefits are assumed to be passed onto the end consumer of goods and services and the Nation. In the 204(f) AOM economic analysis of Bayport and Barbours Cut, the Deep Draft Navigation Center of Expertise (DDNPCX) found benefits to be increasing at a decreasing rate for each increment of deepening (Table 6 and Figure 5). The analysis was constrained to a maximum depth of 45 feet due to PHA funding constraints and because the HSC is currently 45 feet deep. However transportation cost showed that the plan that maximizes the net benefits might be at a depth of greater than 45 feet as benefits were still increasing at a depth of 45 feet. The expected inefficiencies and resultant benefits would assist in justification of a greater depth in the HSC and Entrance Channel.

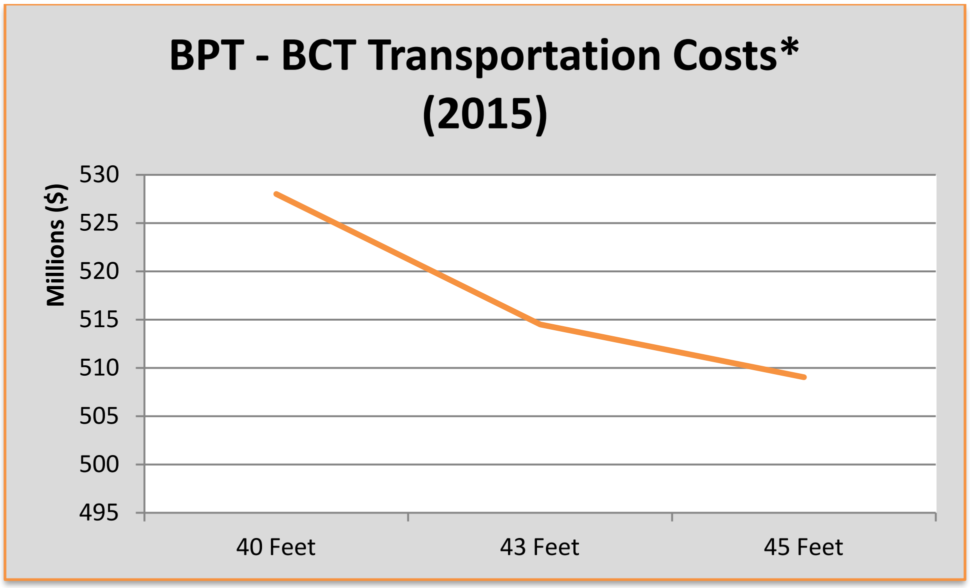
Table 6 - BPT and BCT Incremental Transportation Costs and Benefits

Year	Transportation Costs*			Benefits**	
	40 Feet	43 Feet	45 Feet	43 Feet	45 Feet
Total - 2015	527,999,507	514,502,434	509,030,825	13,497,073	18,968,685
Total - 2020	849,341,471	823,189,403	813,214,597	26,152,068	36,126,874
Total - 2035	1,085,665,337	1,051,676,711	1,039,300,173	33,988,626	46,365,164

estimated shippers costs

***Average annual benefits of the year increments*

Figure 5 – BPT and BCT Transportation Costs Trend



*Estimated transportation costs by depth for BPT BCT 204(f) AOM

The Houston-Galveston Navigation Channel 1995 LRR found that for direct crude petroleum shipments the 50 feet channel would provide $8.08 savings/short ton (i.e. versus the cost/short ton for the existing 40 feet channel). It also concluded that approximately $2.90 savings/short ton would occur in the lightering activity and $3.54 savings/short ton would occur in the lightening activity for a 50 feet channel depth. With these estimates, savings totaled $59.4 million (average annual) for crude petroleum imports. The Houston-Galveston Navigation Channel 1995 LRR also estimated average annual savings of $36 million for petroleum products and $6.3 million for grain export traversing the HSC below Boggy Bayou under a 50 feet channel alternative. These benefits as well other benefit categories such as domestic crude, delay reductions and casualty reductions equated to an average annual saving of over $107 million for a 50-foot project.

The assumption of benefits relies on vessels utilizing the new depth; either with the current fleet loading deeper and/or assuming that the vessel fleet mix will continue to shift to larger vessels as exemplified through empirical data. Over the period of 2004-2012, WCSC shows that an increasing number of vessels were traversing the HSC at deeper sailing drafts (Table 7). Starting in 2009, WCSC reported an increasing number of vessels drafting 45 feet. Even as far back as 2004 to 2005 the trend appears to be more vessels falling in the 41 feet and deeper ranges.

Table 7 – HSC Vessel Sailing Draft Trends*

	CY2004	CY2005	CY2006	CY2007	CY2008	CY2009	CY2010	CY2011	CY2012
18-20 ft.	1,275	1,194	1,172	1,271	1,267	1,180	1,053	896	1,063
21-23 ft.	1,250	1,369	1,573	1,611	1,430	1,458	1,283	1,542	1,658
24-26 ft.	1,751	1,679	1,819	1,659	1,665	1,458	1,596	1,695	1,905
27-29 ft.	2,290	2,340	2,549	2,544	2,433	2,359	2,682	2,763	2,858
30-32 ft.	1,539	1,449	1,595	1,700	1,552	1,520	1,585	1,662	1,705
33-35 ft.	1,045	1,279	1,413	1,513	1,409	1,337	1,392	1,460	1,287
36-38 ft.	1,077	1,031	1,088	1,247	1,179	1,123	1,263	1,209	1,194
39-40 ft.	616	709	719	516	611	690	796	714	766
41 ft.	0	37	75	35	108	126	37	71	80
42 ft.	3	27	65	83	43	36	57	90	57
43 ft.	0	21	87	136	98	35	29	107	70
44 ft.	0	0	0	0	0	46	24	51	23
45 ft.	0	0	0	0	0	9	23	21	10

***WCSC grey books data reported in trips to HSC**

A review of the detailed 2012 vessel call records from the WCSC shows the current vessel fleet would benefit by loading deeper even without the assumption of transitioning vessel fleet mix. Table 8 is a comparison of actual drafts and design drafts of those vessels calling at HSC. The vessels in this snapshot are expected to draft deeper if the channel depth constraint would be alleviated to some degree. For example, vessels drafting at the 42-foot row falling in any column to the right of 42 feet would be constrained by the channel depth and could benefit.

Table 8 - Sailing Draft Comparison to Design Draft by Calls

Sailing Draft (Feet)	Design Maximum Draft (Feet)																	
	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
39	35	26	39	17	9	16	13	17	51	48	3	3	1	1	1	0	7	1
40	8	3	8	12	4	7	13	8	29	38	1	5	0	0	1	1	3	1
41	-	0	0	1	1	5	3	2	26	32	2	0	0	0	1	0	1	0
42	-	-	1	1	2	2	2	6	9	23	0	3	5	1	0	0	1	0
43	-	-	-	1	0	3	1	2	15	16	4	1	9	0	0	1	3	0
44	-	-	-	-	0	0	0	0	5	4	0	0	0	0	0	0	0	0
45	-	-	-	-	-	0	0	2	1	2	0	0	1	0	0	0	0	0

A review of the detailed WCSC data for HSC over 2009-2012 shows a larger percentage of total cargo traversing on DWT vessels leading to the assumption that vessels will continue the trend of transitioning to a larger fleet (Table 9). The tons and percent of tons grew on the vessel classes above 120,000 DWT. Total tons grew on the 80,000-100,000 DWT vessel class, however not relative to other classes, thus the percent of tonnage dropped. The smaller DWT vessels classes all also grew in level of tonnage, with the 40,000-60,000 DWT growing the most. The vessels in the 40,000-60,000 DWT class are the typically the shuttle vessels engaged in lightering and lightening of VLCC and Suezmax tankers.

Table 9 – HSC Fleet Mix Trends

Vessel Category	2009	2010	2011	2012
20-40KDWT	10.2%	11.1%	11.0%	9.5%
40-60KDWT	24.5%	26.5%	28.0%	29.3%
60-80KDWT	10.5%	11.0%	11.5%	10.8%
80-100KDWT	9.1%	6.2%	4.0%	2.3%
100-120KDWT	35.5%	33.4%	34.2%	32.7%
120-160KDWT	3.3%	4.1%	5.2%	6.1%
>160KDWT	0.6%	1.0%	1.0%	1.0%

*cargo increased on every vessel classification, some grew more than others resulting in a change in distribution across vessel classes

**Percentages do not equal 100% due to data gaps of the readily available data sets

The data showed an increase in small SPX class of vessels in the activity of lightering or lightening VLCC and Suezmax vessels. Two million barrel capacity VLCCs are lightered at the HSC. The VLCC never intends to traverse most U.S. Gulf coast channels with typical dimensions of 1,542-feet length overall (LOA), 197-feet beam and design draft of 66 feet. The VLCC entirely unloads offshore into smaller crude carriers. The number of smaller unloading vessels is contingent on channel depth. Suezmax vessels capable of carrying one million barrels of crude oil have a typical beam of 164 feet, 950 feet LOA and a draft of 53 feet. These Suezmax vessels are currently lightened at the HSC. The activity describes crude vessels being loaded deeper at their origin than can traverse the HSC. Smaller crude carriers then unload enough of the vessels cargo offshore to allow it to make a safe transit into HSC. The number of smaller vessels trips required is contingent on channel depth as is the entire activity of lightening. Suezmax vessels which likely required lightening before entering HSC shipped 13.5 million tons in 2012. Smaller shuttle vessels involved in the lightering activity shipped an additional amount of crude petroleum Potential benefits would arise from the shuttle vessels ability to load deeper thus making fewer required trips of the smaller DWT shuttle vessels. Traditionally the lightering, lightening and light loading issues impact crude oil imports; however, growth trends throughout the gulf show an increased quantity of exported crude petroleum. The exported crude petroleum will likely undertake the same lightering and lightening activity which will also potentially benefit from improvements to the HSC.

<u>Environmental Effects</u>

Impacts to fish and wildlife resources, including wetlands, from deepening and widening the HSC would include all of those previously described in Section 13.2 for deepening the HSC from Boggy Bayou to the Main Turning Basin (e.g. impacts to terrestrial wetlands from creating new upland confined placement facilities). In addition to these impacts, the following impacts would also need to be evaluated to accommodate a deeper/wider channel that extends into the Gulf of Mexico:

(1) Overall salinity increases and their effects on recreationally and commercially important species, such as oysters, shrimp, blue crabs and various finfish;

(2) Effects of any increases in up channel salinity gradient (wedge) on sediment distribution within the existing HSC and the resultant impacts on dredged material management;

(3) Physical destruction and disruption of hundreds of acres of important benthic habitat, such as oyster reef and shell habitats located on and along the sides of the ship channels and barge lanes;

(4) Effects and proper disposal of contaminated sediments (if any are identified through sediment and water quality testing);

(5) Impacts to fish and wildlife species including hundreds of acres of oyster reef/shell habitat, other benthic habitat, and EFH by either unconfined open bay disposal, the creation of new confined disposal facilities in the open bay, and the designation of new ODMDS sites;

(6) Effects on bay shorelines and associated wetlands from larger displacement waves caused by existing and larger vessels traveling at faster speeds in a deeper, wider, safer channel; and

(7) Impacts to sea turtles from potentially increased hopper dredging volumes (additional area and time) of new work and maintenance material.

The degree and magnitude of effects on fish and wildlife resources would depend on the specific depths and widths that would be considered and associated placement needs.

Opportunities for beneficially using new work and maintenance dredged material in the Bay and Offshore should be considered rather than placement in unconfined open bay disposal areas or creating new confined disposal facilities in the open bay. Incorporating BU, where feasible as a least cost plan would help to avoid, and perhaps offset, impacts to fish and wildlife species including oyster reef/shell habitat, other benthic habitat, and EFH. Efforts to align any channel widening and PAs to avoid and minimize direct impacts to oyster and other benthic habitats and wetlands would be considered where feasible. The most likely suite of in-kind mitigation alternatives that would be considered to offset unavoidable impacts to wetland habitats would include the use of an appropriate mitigation bank within the service area of the project, or other suitable compensation measures (e.g. wetland creation or preservation). Based on experience with past projects in Galveston Bay, impacts to oyster reef habitat may include creation of oyster reef habitat in suitable areas of the bay identified through coordination with the resource agencies.

13.4. Other Channel Modifications

Bend Easings/Flares. Any deepening and widening activities in the HSC system may also require channel modification such as bend easing or flares. Currently, the Bayport Ship Channel configuration contributes to navigational inefficiencies for vessels turning into this channel from the main HSC. The Bayport Ship Channel has an existing 3,000-foot flare radius. Vessels entering the Bayport Ship Channel typically do so with tug assistance due to the reduction in speed and the sharp turn necessary to safely enter the channel. Modification to the flare could be investigated separately, or in conjunction with alternatives 13.2 or 13.3. Modification to the flare could allow larger vessels to call on Bayport, and reduce the number of tugs required to make the turn. In a report prepared by USACE Engineering, Research and Design Center (ERDC) in 2011 (Navigation Study for Bayport Flare Improvement Data Report) it was recommended to increase the flare radius to 4,000 feet with a 250-foot channel widener/straightener on the eastern side of the HSC. The study results were based on a 40-foot channel depth. A ballpark construction cost estimate prepared in 2013 for increasing the flare radius to 4,000 feet with a channel widener was approximately $34 million.

Under existing conditions at Bayport, all vessels are limited to one-way traffic and no passing is allowed. For SPX and PX vessel classes, tug assist begins prior to the land cut and remains with the vessel until it is turned and docked. A tug returns for undocking and assistance with departure for heavily loaded vessels. PPX vessels have tug assist further down on the HSC to aid in slowing. The tug remains with the vessel until after docking is complete. Similar to smaller container vessel classes, tug assist for undocking is also provided for heavily loaded vessels. For PPX vessels in excess of 1,000 feet, tug assist is obtained for undocking, departing, and transition to the HSC through the flare. Additionally, container vessels in excess of 1,000 feet in length are daylight restricted (i.e., nighttime transits are not allowed). These vessels are also restricted from transiting the channel when wind speeds are equal to or great than 20 knots. The Houston Pilots Association noted that under such conditions, vessel control is impacted resulting in difficulties keeping vessels of this size within the existing channel alignment. Because of the angle of the flare, fully loaded large container ships (PX and PPX) and chemical tankers have trouble navigating the turn, and must use tugboats to assist them in transit through the turn into Bayport. The Houston Pilots Association believes that a widened Bayport Flare would reduce the need for tugboat assistance and also slightly reduce the amount of time that deep-draft vessels need to navigate the flare. Figures 4 and 5 indicate an upward trend in larger TEU capacity vessel calls and more PPX1 and PPX2 vessel class calls. With the current costly tug assisted inefficiency on PPX vessels and the likelihood of that vessel class calls to grow in the near future, it is thought that adjustments to the current configuration at the Bayport Flare would contribute benefits to shippers in excess of the costs of the improvements.

Anchorage. Multiple shifts out to the offshore anchorage or to Bolivar Roads are a common occurrence for chemical tankers at the Port of Houston. Chemical tankers often have multiple stops within the Port of Houston. After the vessel has unloaded its parcel at the first dock, prior to the second dock being available, the pilot will shift out to the anchorage for safety reasons. There are even instances where a chemical tanker may shift to anchorage up to twice on its call to the HSC. While this activity is partly due to congestion at the HSC dock, it also contributes to congestion in the channel. The chemical tanker incurs additional costs transiting out to the anchorage and sitting idle at the anchorage. Additional closer anchorage would alleviate some of the inefficiencies and capacity issues with the current anchorage configuration.

Environmental Effects

Unavoidable impacts to fish and wildlife resources from modifying the Bayport Flare would include physical destruction and disruption of important known benthic resources in the vicinity, including over 40 acres of oyster reef and shell habitats located on and along the flare, HSC and barge lanes. Additional capacity for the placement of new work and maintenance dredged material would require the construction of a new PA within the bay waters in the vicinity of the flare. This would potentially result in additional impacts to fish and wildlife species, including known oyster reef/shell habitat, other benthic habitat, and EFH in the area. The effects and proper disposal of contaminated sediments (if any are identified through sediment and water quality testing) would also need to be evaluated.

Based on experience with past projects in Galveston Bay, impacts to oyster reef habitat could be through coordination with the resource agencies.

14. REAL ESTATE.

Real Estate issues are possible because of the magnitude of this project, which will be further addressed during the feasibility study. The lack of environmentally suitable PAs for new work dredged material is considered a planning constraint for this report. The project area is located within a highly developed industrialized urban area of Houston where few tracts of vacant undeveloped land remain. Any new PAs that may be required by the proposed action will result in potential impacts including residential, business, pipeline, roadway and rail-road relocations. Estimates of the requirements associated within the above noted relocations will be applied in accordance with Public Law 91-646 (PL 91-646). The necessity to obtain new PAs will potentially result in Condemnation actions as well as substantial facility/utility relocations. During the feasibility phase, mitigation impacts associated with this project will also be estimated and included in the overall cost estimate for the project.

All alternative plans will be reviewed to identify real estate requirements and assess the appropriate estate required for project execution, to include any non-standard estates that may be required. An evaluation of each alternative will be made to assess the ownership issues involved, and to determine and compare the number and kind of utility/facility relocations affected by each alternative. Each alternative will be valued by an appraiser in order to obtain a gross estimate for real estate requirements. Any mitigation measures requiring additional real estate will be included in the analysis.

15. KEY FEASIBILITY STUDY ASSUMPTIONS AND UNCERTAINTIES.

In order to scope the feasibility study, the Project Delivery Team (PDT) made the following assumptions and uncertainties. The assumptions are for items such as roles and responsibilities, and the uncertainties concern activities or conditions that may significantly impact the feasibility study. The assumptions and uncertainties will be refined further during development of the

Project Management Plan (PMP) as the PDT further assesses what data it has and what data it truly needs. The PDT has taken an initial look at those needs by developing a planning risk register. The risk register assisted the PDT with identifying the key uncertainties that may significantly impact the feasibility scope of work. Risks identified in this early phase of the study will continue to be evaluated through the PMP development and align with the future Decision Management Plan.

<u>Key Assumptions</u>

•There will be streamlined Federal funding to complete the study in 3-years;

•Full array of reasonable alternatives would be analyzed, including the No Action alternative, to optimize potential feasibility alternatives in terms of location and alignment while minimizing environmental effects;

•A detailed economic analysis will be performed in two foot increments of depth (e.g. 43, 45). An economic analysis utilizing HarborSym will address the benefits from an array of alternatives (with-project) compared to the without project condition in three economic reaches (Boggy Bayou to approximately the Washburn Tunnel, the Washburn Tunnel to the Interstate 610 Bridge, and the Interstate 610 Bridge to the Main Turning Basin). The economic analysis will consist of a socioeconomic assessment, commodity forecast, fleet forecast, regional economic development and load factor analysis. HarborSym is the USACE certified model and it will be used along with its accompanying assistance programs;

•The study will use already certified and approved planning and engineering models;

•Public support and involvement will be ensured or achieved through public meetings and/or workshops and interagency work group meetings;

•An integrated Environmental Assessment will be included in the Feasibility Report to fully document the decision making process and any recommendation in compliance with NEPA and other environmental statutes;

•Utilize existing modeling/surveys/data during the feasibility phase if available;

•Modeling/surveys/studies conducted during feasibility may include, but not limited to, hydrodynamic, saltwater intrusion, shoreline erosion, ship simulation, contaminants, sea level rise, oyster impacts, stability, utilities/pipeline relocations, advance maintenance, sediment and water quality, value engineering, and economic models;

•Tidal datum in the feasibility report will be in MLLW;

•Key resource agencies such as USFWS, NMFS and EPA will be included early and often during the planning process to minimize delays in completing consultations;

•Appropriate cultural resources investigations will be conducted within the study area to ensure historic areas are not adversely affected by proposed project plans; and

•Willing sponsor and buy-in with study approach.

Key Uncertainties

•The ability to scope any of the preliminary alternatives identified for $3 million/3-years due to the large study area and associated modeling/surveys/data that may be necessary to reduce risks;

•The ability to find environmentally suitable PA sites for new work and maintenance dredged material;

•Because of degree and magnitude of potential impacts to fish and wildlife resources, consultation with resource agencies will be greater than for similar feasibility studies;

•Significant impacts are determined requiring an Environmental Impact Statement instead of an Environmental Assessment; and

•No planning or engineering models will be developed.

16. IMPLEMENTATION.

The information below presents the results of the initial iterations of alternative plans that could be implemented or further investigated in the feasibility phase. The preliminary plans are comprised of one or more of the management measures previously identified. For implementation purposes, the 52 mile HSC has been separated into reaches that could potentially be analyzed separately or considered separable elements for implementation purposes. The three reaches are provided to better frame the different management measures that could be implemented in each reach. The preliminary plans were developed with emphasis on the problems and opportunities pertinent to each reach. The same consideration has been applied to associated side channels of the HSC, as well as other major channels in the GBANC system because they are integrally connected. A systems approach must be applied. The results of the 905(b) analysis demonstrate that these major channels such as the Galveston Harbor and Channels and Texas City Ship Channel should be considered. There is also an opportunity to incorporate the results to date from the USACE Galveston Harbor Channel Extension study that began in 2011. The purpose of the study was to determine the feasibility of deepening the remaining 2,571-foot segment of the Galveston Harbor Channel from the authorized depth of 40 feet to a depth of 45 feet.

Due to the large geographic study area and complexities of scoping a navigation study of this size within the 3x3x3 constraints, a vertical team scoping meeting was held October 23 and 24 which presented an opportunity to obtain early feedback from the vertical team, sponsor and resources agencies. The PDT utilized the feedback to inform the 905(b) analysis and PMP development. This section also takes into consideration the meeting discussions, decisions, and

PHA perspectives and lays out an implementation road map with more specificity for the preliminary alternative plans identified in Section 13. Providing more specifics is necessary for the PDT to properly scope the feasibility study, and to identify those risks associated with scoping a plan within the 3x3x3 constraints. It should be noted that even though the reconnaissance study determined the preliminary plans/alternatives identified in this report are to be studied further in feasibility, the analysis was based on existing information and professional judgment. A more detailed analysis will be completed in feasibility which may alter some of the plans or alternatives identified during the reconnaissance study.

16.1. Houston Ship Channel – Includes the 52 mile channel from the Entrance Channel to the Main Turning Basin at Houston. This 52 mile channel has been separated into three reaches. Associated side channels of the HSC that will be considered for further evaluation in the feasibility phase are Bayport Ship Channel (including the existing flare), and Barbours Cut Channel. The PHA will be the non-Federal sponsor.

16.1.1. HSC Reach 1 – Entrance Channel to Boggy Bayou

•Deepen channel beyond 45 feet (2-foot increments)
•Widen existing channel
•Anchorage/layberth
•Passing lanes
-Offshore Crude Terminal (LOOP)
•Regional Sediment Management (RSM) Shoaling Reduction
  -back passing
  -jetty modification
  -PA modification/relocation
  -sediment trap
  -planting/fencing to reduce wind-blown sand

This analysis would evaluate deepening and widening of the 40 mile portion of the HSC from the Entrance Channel to Boggy Bayou (mile 0 to mile 40) to a depth beyond the existing 45 feet (in 2 foot increments) and a width of greater than 530 feet evaluated in 50-foot increments. Terminals such as Exxon and Shell reside in this reach which imports large amounts of crude petroleum transports by Suezmax and Very Large Crude Carriers which utilize shuttle vessels to lightering and lightening. This analysis would also evaluate other general navigation features that would lead to an increase in shipping transit efficiencies such as bend easing, flare adjustments in the vicinity of Bayport Ship Channel, anchorages/mooring areas and breakwater jetties. The RSM shoaling reduction measures would also apply to this reach.

16.1.2. HSC Reach 2 – Boggy Bayou to I-610 Bridge

•Deepen channel beyond 36 feet from Sims Bayou to I-610 Bridge (2-foot increments)
•Deepen channel beyond 40 feet from Boggy Bayou, i.e. mile 40
•Deepen channel beyond 40 feet from Boggy Bayou to Sims Bayou (2-foot increments)
•Widen existing channel
•Passing lanes to improve two-way traffic in hot spots

•New turning basin

This analysis would evaluate deepening and widening the 8-mile portion of the HSC from Boggy Bayou to the Interstate 610 Bridge (mile 40 to mile 48) to a depth beyond the existing 40 feet (Boggy Bayou to Sims Bayou) and beyond existing 36 feet (Sims Bayou to I-610 Bridge) in 2-foot increments and a width greater than the existing 300 feet (in 50-foot increments). The portion of the channel between Boggy Bayou and the Interstate 610 Bridge is a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other Port of Houston infrastructure associated with this reach are petrochemical, manufacturing and bulk commodities. This analysis could also evaluate passing lanes to improve two-way traffic in hot spots, turning basins and mooring all of which may provide reductions to the overall shipper transportation cost of moving goods through the HSC.

16.1.3. HSC Reach 3 – I-610 Bridge to Main Turning Basin

•Deepen channel beyond 36 feet (2-foot increments)
•Optimize depth with new turning basin (Brays Bayou)

This analysis would evaluate the deepening and widening of the 4-mile portion of the HSC from the Interstate I-610 Bridge to the Main Turning Basin (48 to mile 52) to a depth beyond the existing 36 feet (in 2-foot increments) and a width greater than 300 feet (25-foot increments). In addition, this alternative would evaluate the channel configurations that lead to shipping transit inefficiencies. Current channel configuration in this reach causes delays, bottlenecks and overall channel transit constraints. The analysis could also include an evaluation on a new turning basin near Brays Bayou, and revisit dimensions of existing turning basins and mooring areas.

16.1.4. Bayport Ship Channel

•Evaluate PHA's channel deepening conducted under Sections 408/204(f)
•Deepen channel beyond 45 feet (2-foot increments)
•Widen existing channel
•Open water turning basin
•Flare improvements
•Jetty/Structures (general for shoaling)

The 4.1 mile long Bayport Ship Channel is currently authorized to a depth of 40 feet. The PHA has the authority under Sections 408 and 204(f) to deepen the channel to 45 feet. The feasibility study analysis would evaluate whether to include the PHA's channel deepening for Federal authorization, and would evaluate deepening beyond 45 feet (in 2-foot increments). The analysis would also evaluate widening to a width greater than 300 feet (25-foot increments). Other opportunities in this area are to evaluate the need for open water turning basin, and adding jetty/structures for minimizing shoaling. There is also an opportunity to evaluate flare improvements. Currently, the Bayport Ship Channel configuration contributes to navigational inefficiencies for vessels turning into this channel from the main HSC. The Bayport Ship Channel has an existing 3,000-foot flare radius. Vessels entering the Bayport Ship Channel typically do so with tug assistance due to the reduction in speed and the sharp turn necessary to safely enter the channel. Modification to the flare could be investigated separately, or in conjunction with the deepening and widening of the channel.

16.1.5. Barbours Cut Channel

•Evaluate PHA's channel deepening conducted under Sections 408/204(f)
•Deepen channel beyond 45 feet (2-foot increments)
•Widen existing channel
•Open water turning basin
•flare/bend easing

The 1.1 mile long Barbours Cut Channel is currently authorized to a depth of 40 feet. The PHA has the authority under Sections 408 and 204(f) to deepen the channel to 45 feet. The feasibility study analysis would evaluate whether to include the PHA's channel deepening for Federal authorization, and would evaluate deepening beyond 45 feet (in 2-foot increments). The analysis would also evaluate widening to a width greater than 300 feet (25-foot increments).
Other opportunities in this area are to evaluate the need for open water turning basin and flare improvements.

16.2. Galveston Harbor Channel

•Extend 45-foot depth of Galveston Harbor Channel by ½ mile
•Deepen beyond 45 feet (2-foot increments)
•Widen existing channel

This analysis would examine the deepening and widening of the 4.3 mile Galveston Harbor Channel to a depth beyond 45 feet, and beyond the existing varying widths of 800 – 1,133 feet. The 45-foot depth currently ends around Pier 38. This analysis would also evaluate deepening the last 2,571 feet of the west end of the channel which still remains at a depth of 40 feet, taking into consideration the results to date from the USACE Galveston Harbor Channel Extension study. The Port of Galveston is the non-Federal sponsor for the nearly completed Galveston Harbor Channel Extension study that began in 2011. Improvements to the Galveston Harbor Channel, including extension of the 45-foot depth for the last 2,571 feet, could be investigated separately, or in conjunction with the HSC.

16.3. Texas City Ship Channel

•Deepen channel beyond 45 feet (2-foot increments) Note: currently authorized to 50 feet
•Widen existing channel

This analysis would examine deepening and widening the 6.5 mile channel beyond 45 feet deep and 400 feet wide. The analysis could also evaluate the depth and width of the Industrial Canal that is currently 40 feet deep and varies between 300-400 feet in width; the Industrial Canal extends for a distance of 1.9 miles southwest of the south end of Texas City Turning Basin. Texas City Ship Channel is not part of the HSC; therefore, identification of a non-Federal sponsor would be necessary before proceeding to the feasibility phase planning. Modification to the channel could be investigated separately, or in conjunction with the HSC.

16.4. Galveston Entrance Channel

•Deepen channel beyond existing depths of 45 and 47 feet
•Widen existing channel

While analyzing the deepening of the HSC, Galveston Harbor Channel or the Texas City Ship Channel, the feasibility study also must consider analyzing widening and deepening of the Galveston Entrance Channel. This analysis would evaluate the deepening and widening of the 14.4 mile Galveston Entrance Channel to a depth beyond the existing 47 feet and width of 800, and deepening beyond 45 feet near Bolivar Roads (mile 0) with widening. The Galveston Entrance Channel benefits all Ports within the GBANC system.

16.5. Dredged Material Disposal

During feasibility, the study will investigate ways to utilize construction and future maintenance dredged sediments in a beneficial way. A DMMP must be identified for all reaches. Multiple DMMPs may be considered. Or it may be more practical to consider a regional DMMP that ties together all of the various Federal channels in the GBANC system.

In alignment with the USACE EWN program, a systematic approach sediment management in the Galveston Bay area should be developed. This approach would tie all of the existing and future projects for the HSC and Coastal Texas Storm Risk Management (Coastal Texas) feasibility studies together in order to share the dredged material resources for project implementation. The Coastal Texas and HSC studies could be formulated as such to design Coastal Texas projects which utilize new work dredged material from the HSC project as well as material from future channel maintenance. This connection between the studies has the potential to lessen the placement needs for the HSC while providing a nearby material source for the various Coastal Texas ecosystem restoration (ER) and coastal storm risk management (CSRM) project features such as marsh restoration, beach and dune renourishment, barrier island creation, levee construction, etc. within the entire GBANC system. This systematic cross-project formulation could greatly improve operational efficiencies with the costs for the blended features being segregated so as to be allocated to the appropriate authorities.

17. FEASIBILITY PHASE COST ESTIMATE AND SCHEDULE. A detailed feasibility phase cost estimate will be developed and included in the PMP. The information below in Table 10 is a snap shot overview of the study cost estimate. A cost range has been provided based on the assumptions and uncertainties identified in the 905(b) analysis and study risk register. The cost estimate will be refined further during development of the PMP.

Table 11 displays a preliminary schedule based on the availability of full funding, a similar feasibility study, and standard review durations. The schedule is based on receiving the needed resources to complete the study in 3-years, and will be consistent with the SMART Planning process and milestones.

Table 10 - Feasibility Phase Cost Estimate

Major Work Items	**Study Cost Range**
Public Involvement	$85,000-125,000
Economic Studies	$325,000-750,000
Environmental Studies (except USFW CAR)	$250,000-500,000
Cultural Resources Studies	$75,000-125,000
USFWS Coordination Act Report	$35,000-40,000
Plan Formulation and Evaluation	$225,000-400,000
Programs & Project Management	$200,000-275,000
Surveys & Mapping	$85,000-200,000
Hydrology and Hydraulics Studies/Reports	$200,000-400,000
Ship Simulation Study	$200,000-400,000
Geotech Studies/Report	$150,000-350,000
Engineering & Design Analysis Report	$175,000-300,000
HTRW Studies/Report	$75,000-125,000
Cost Support	$75,000-100,000
Cost Risk Analysis	$60,000-85,000
Value Engineering Study	$60,000-75,000
Real Estate Studies	$75,000-150,000
Agency Technical Reviews	$100,000-125,000
Independent External Peer Review (100% Federal)	$200,000-300,00
Dredged Material and ocean disposal investigations	$200,000-300,000
Supervision/Administration	$150,000-200,000
Total Study Cost	**$3,000,000 – 5,350,000**
Federal	$1,700,000-2,975,000
Non-Federal	$1,300,000-2,375,000

Table 11 - Feasibility Phase Scheduled Milestones

Feasibility Milestones	End Date
Execute Feasibility Cost Sharing Agreement and Initiate Study	Feb 2015
Public Workshop/NEPA Scoping	Mar 2015
Alternatives Milestone Meeting	June 2015
Tentatively Selected Plan (TSP) Milestone	June 2016
Release Draft Feasibility Report/EIS for Concurrent Reviews	July 2016
Agency Decision Milestone (ADM) Meeting	Oct 2016
ATR of Final Report	June 2017
Division Engineers Transmittal of Report to HQUSACE	Sep 2017
Civil Works Review Board (CWRB)	Nov 2017
State and Agency Review of Final Report	Dec 2017
Chief of Engineer's Report signed	Feb 2018

18. LETTER OF INTENT. A letter of intent dated August 27, 2014 was received from PHA stating its willingness to pursue the feasibility study described in the Section 905(b) analysis and to share in its cost of project construction.

12/12/14
Date

Richard P. Pannell
Colonel, Corps of Engineers
District Commander