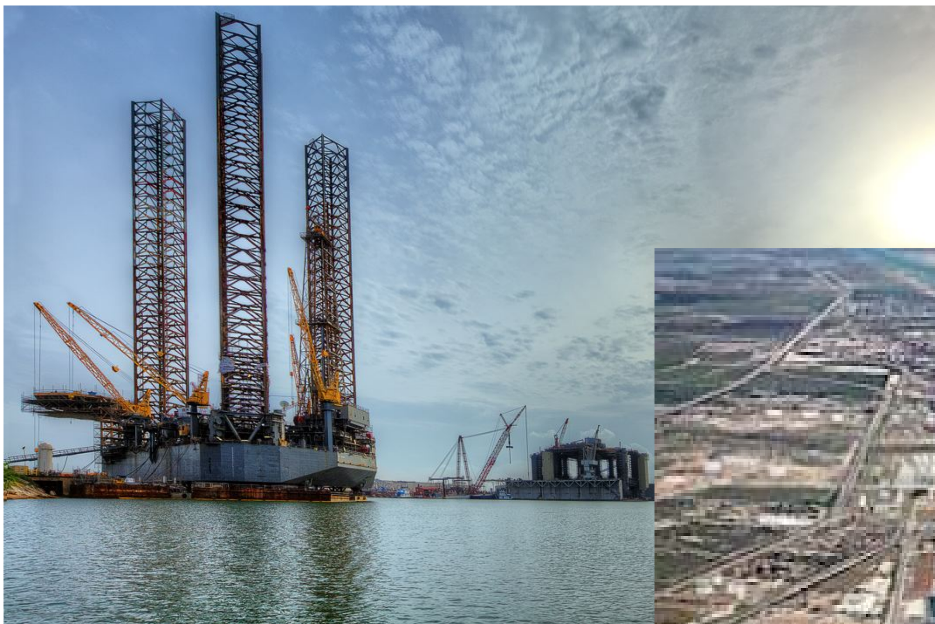
Brazos Island Harbor
Channel Improvement Project

Economic Appendix



U.S. Army Corps of Engineers
Southwestern Division
Galveston District

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EXECUTIVE SUMMARY

This appendix presents the economic analysis for the Brazos Island Harbor (BIH) Feasibility Study. BIH is the southernmost port in Texas, and receives commodities that include petroleum products, crude materials, and primary manufactured goods. These commodities move on barges, bulk carriers, tankers, and general cargo vessels. In addition, BIH has several shipbreakers that receive vessels to scrap. There is also a major oil drilling rig fabricator that builds, repairs, modifies, and inspects oil drilling rigs that are drilling in offshore deepwater in the Gulf of Mexico.

BIH is situated to serve southern Texas, as well as northern Mexico for trade. As experienced in the past, BIH is expected to continue receiving increases in tonnage. However, there are current channel constraints, leading to vessel inefficiency. Therefore, the project benefits were calculated based on reductions in transportation costs generated for more efficient vessel transportation and less restrictions on transit of larger oil drilling rigs. The proposed channel improvements are in response to the need for deeper access by allowing the existing fleet to load more fully and for the introduction of larger vessels, to include oil drilling rigs. The existing Federal project has an authorized depth of 42 feet and a width of 250 feet. Among the alternatives analyzed included 45-, 48-, 50-, and 52-foot depths in addition to 300- and 350-foot widths, as well as the without-project condition.

The benefits were calculated for a 2021 to 2071 period of analysis using the fiscal year (FY) 2014 Federal discount rate of 3.5 percent and the deep-draft vessel operating costs contained in the Economic Guidance Memorandum (EGM 11-05). The Recommended Plan is deepening of the channel to 52 feet without any channel widening. The average annual benefits for this project are $20,539,400 with average annual costs of $14,163,300, leading to a benefit-to-cost ratio of 1.5. The benefits were also calculated using Section 6009 of the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Tsunami Relief, 2005 (Public Law 109-13) – Offshore Oil and Gas Fabrication Ports, which led to a benefit-to-cost ratio of 6.4.

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ACRONYMS AND ABBREVIATIONS

AAE	Average Annual Equivalent
ABS	American Bureau of Shipping
AEO	Annual Energy Outlook
BCR	Benefit Cost Ratio
BEA	Bureau of Economic Analysis
BIH	Brazos Island Harbor
BLS	Bureau of Labor Statistics
BND	Brownsville Navigation District
BRG	Brownsville & Rio Grande International Railroad
BSC	Brownsville Ship Channel
DDNPCX	Deep-Draft Navigation Planning Center of Expertise
DWT	Deadweight Tonnage
EGM	Economic Guidance Memorandum
EIA	Energy Information Administration
ERDC	Engineering Research and Development Center
FTZ	Foreign Trade Zone
FWOP	Future Without Project
FY	Fiscal Year
GDP	Gross Domestic Product
GIWW	Gulf Intracoastal Waterway
GRT	Gross Register Tonnage
I&S	Iron & Steel
IDC	Interest During Construction
IWR	Institute of Water Resources
LOA	Length Overall
LPG	Liquefied Petroleum Gas
MSA	Metropolitan Statistical Area
NDC	Navigation Data Center
NED	National Economic Development
NRT	Net Register Tonnage
O&M	Operations and Maintenance
Pilots	Brazos Santiago Pilots Association
Port	Port of Brownsville
Sponsor	non-Federal Sponsor
TPI	Tons Per Inch

U.S.	United States
USACE	United States Army Corps of Engineers
VLCC	Very Large Crude Carrier
WCSC	Waterborne Commerce Statistics Center
WOP	Without Project
WP	With Project

1.0 FEDERAL NAVIGATION PROJECT DESCRIPTION

1.1 LOCATION

Brazos Island Harbor (BIH), Texas, serves the Port of Brownsville and Port Isabel. The Port of Brownsville (Port) is the southernmost navigation channel in the state of Texas (Figure 1-1) and meets the Gulf of Mexico at the Brazos Santiago Pass. The harbor contains one deep-draft vessel entrance-exit approximately 1 mile offshore and one shallow-draft vessel entrance-exit at the western terminus of the Gulf Intracoastal Waterway (GIWW) near Port Isabel. The GIWW is a shallow-draft navigation channel that traverses the entire length of the Laguna Madre (Figure 1-2). The harbor also includes two shallow-draft harbors for fishing fleets, one at Port Isabel adjacent to Laguna Madre, and another adjacent to the Brownsville Ship Channel (BSC) several miles inland.

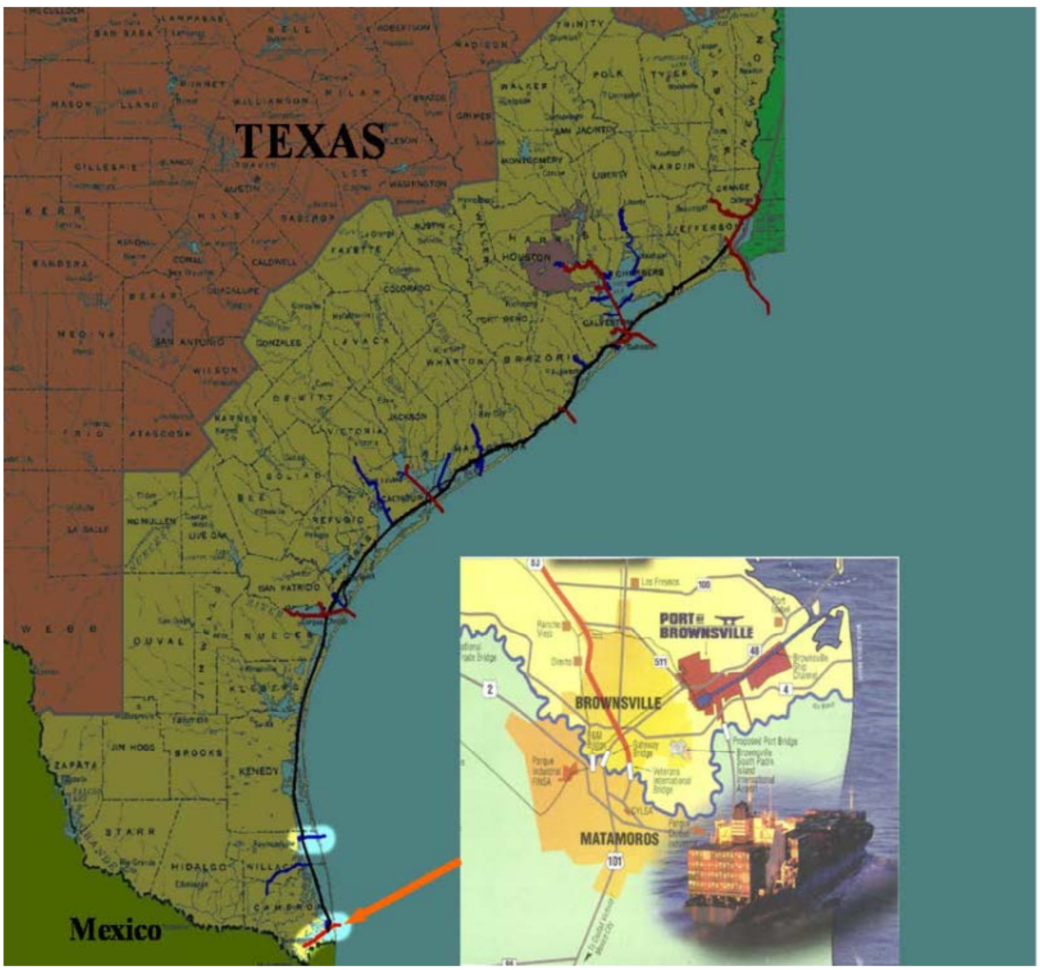


Figure 1-1: BIH Project Location Map

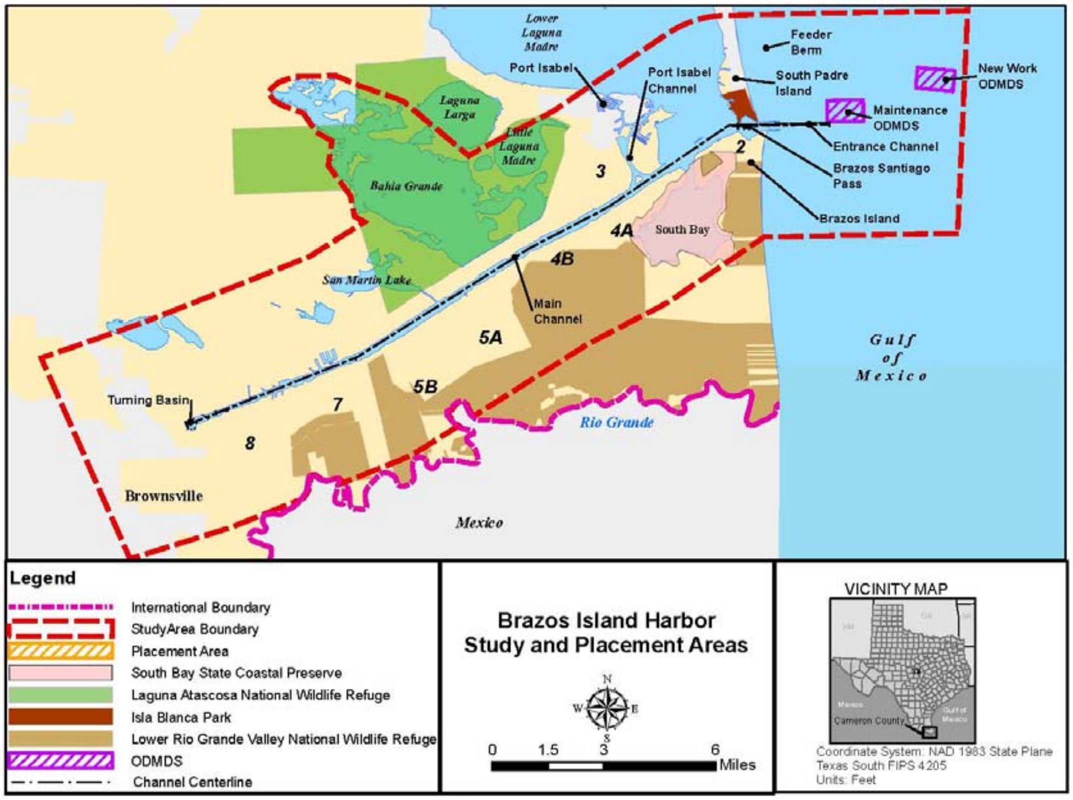


Figure 1-2: Brazos Island Harbor Study Area

1.2 FEDERAL PROJECT

The Port of Brownsville is located at the end of a 19.4-mile channel. The existing Entrance and Jetty Channel extends east to west for approximately 2.5 miles and is 44 feet deep and 300 feet wide. The Main Channel extends westward 14.8 miles and has an authorized depth of 42 feet and a width of 250 feet, although along some sections of the channel, the width is 300 feet. The Turning Basin Extension is 3,500 feet long, varies in width from 325 to 400 feet at a depth of 42 feet, and transitions into the Turning Basin, which is 1,200 feet wide with a depth of 36 feet for the remaining 1,780 feet. The GIWW channel to Port Isabel has an authorized depth of 12 feet and width of 125 feet.

1.3 PURPOSE, PROBLEMS, AND OPPORTUNITIES

The purpose of the BIH Feasibility Study is to evaluate problems and alternatives associated with navigation on the current channel, specifically inefficient vessel utilization of the channel and limited ability for oil drilling rig fabrication, maintenance, and repair at the Port due to current channel dimensions. The goal of the study is development and implementation of the National Economic Development (NED) plan. The BIH Feasibility Study has been developed in coordination with the Non-Federal Sponsor (Sponsor), the Brownsville Navigation District (BND).

Currently, one-way traffic along the channel is not efficient, i.e., vessels do not carry commodities at loaded drafts and there are draft restrictions, thereby causing more vessel trips than may be economically necessary. Due to the authorized channel depth, an absolute draft limit of 39 feet has been enforced by the Brazos Santiago Pilots Association (Pilots) for vessels to enter the channel. Vessels entering the channel with drafts between 34 and 39 feet require assistance from the Pilots, who provide restrictions in terms of tide and current for such vessels. However, the BSC has an average tidal range of about 1.3 feet, which is minimal compared to other United States (U.S.) ports. Until 2009, the harbor depth was lower than the authorized depth of 42 feet. In 2009, funding was appropriated to dredge the BSC to its authorized depth. Prior to maintenance dredging in 2009, hurricanes and delayed maintenance decreased channel depth in some sections of the channel, which impacted the size and loaded drafts of vessels calling on the Port and continues to have an impact.

In addition, as deepwater oil production in the Gulf of Mexico continues to increase, oil rigs become more technologically advanced for efficiency as well as to meet demand, but this also leads to larger sizes. The oil rigs require routine maintenance and inspections. Companies prefer to have such maintenance and inspections completed at ports closer to the drilling sites in order to minimize drilling downtime and sailing costs. The number of oil rigs that can visit the Port are limited by the channel dimensions, especially as rigs are built larger.

The Future Without-Project (FWOP) condition is maintaining the current authorized project depth of 42 feet and width of 250 feet. However, the volume of commodities is expected to grow in the future; thereby, there are efficiencies to be obtained for the vessel traffic as the annual number of vessel calls increase. The FWOP condition would continue restricting the draft of vessels and prevent larger vessels from utilizing the waterway. The alternatives examined included no widening, 50-foot widening, and 100-foot widening. For each action alternative, the following depths were examined: 45, 48, 50, and 52 feet. The deepening and widening alternatives evaluated in this study allow for the opportunity to have vessels carry commodities to their loaded drafts, as well as for commodities to be carried on larger vessels, which leads to transportation cost savings. Deepening of the channel will further prevent vessels from encountering possible delays due to waiting for appropriate conditions, as currently required by the Pilots. The increased channel dimensions would also allow the Port to serve larger offshore rigs presently operating in the U.S. Gulf Coast that need maintenance and inspection services.

1.4 GENERAL METHODOLOGY

The NED plan maximizes the net excess benefits, which will be assessed for the alternatives identified in the Purpose, Problems, and Opportunities section following the methodology for deep-draft commercial navigation analysis described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* and other relevant U.S. Army Corps of Engineers (USACE) analyses and policy guidance.

Benefits equal the difference between without- and with-project transportation costs. The costs and benefits in the analysis were calculated using FY 2014 (October 2013) price levels and then converted to Average Annual Equivalent (AAE) values using the FY 2014 Federal discount rate of 3.50 percent, assuming a 50-year period of analysis. The NED plan is the Federal recommended plan, and may or may not be equal to the locally preferred plan.

In addition to the traditional NED benefits, additional benefits were calculated for the oil drilling rigs that visit the Port. The Director of Civil Works issued Implementation Guidance for Section 6009 of the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Tsunami Relief, 2005 (Public Law 109-13) – Offshore Oil and Gas Fabrication Ports in September 2012 (Section 6009). Section 6009 provides that in determining the economic justification for a navigation project involving offshore oil and gas fabrication ports, the Secretary is directed to measure and include in the NED calculation the value of future energy exploration and production fabrication contracts and transportation cost savings that would result from larger navigation channels. Separate benefit-cost ratios (BCR) were calculated to include the Section 6009 benefits. These calculations include proprietary information, and therefore are included in a separate addendum for official use only.

Note that the numerical information provided in the tables throughout the report may not exactly match due to rounding of values. This, however, has no impact on the analysis.

2.0 SOCIOECONOMIC PROFILE OF THE BIH STUDY AREA

2.1 POPULATION

The Port serves the Brownsville-Harlingen Metropolitan Statistical Area (MSA), which is solely encompassed in Cameron County, Texas. The population represents less than 2 percent of the Texas state population, as presented in Table 2-1. The population is forecasted to increase by approximately 66 percent by 2050, or an average annual increase of 1.3 percent, as shown in the following table. The change in population is expected to be twice that for the State of Texas (0.6 percent).

Table 2-1. Population: Historic and Projected

Location	2000 (Actual)	2010 (Actual)	2012 (Projected)	2050 (Projected)
Cameron County, TX	335,227	406,220	417,504	674,611
State of Texas	20,851,820	25,145,561	25,613,722	32,052,451

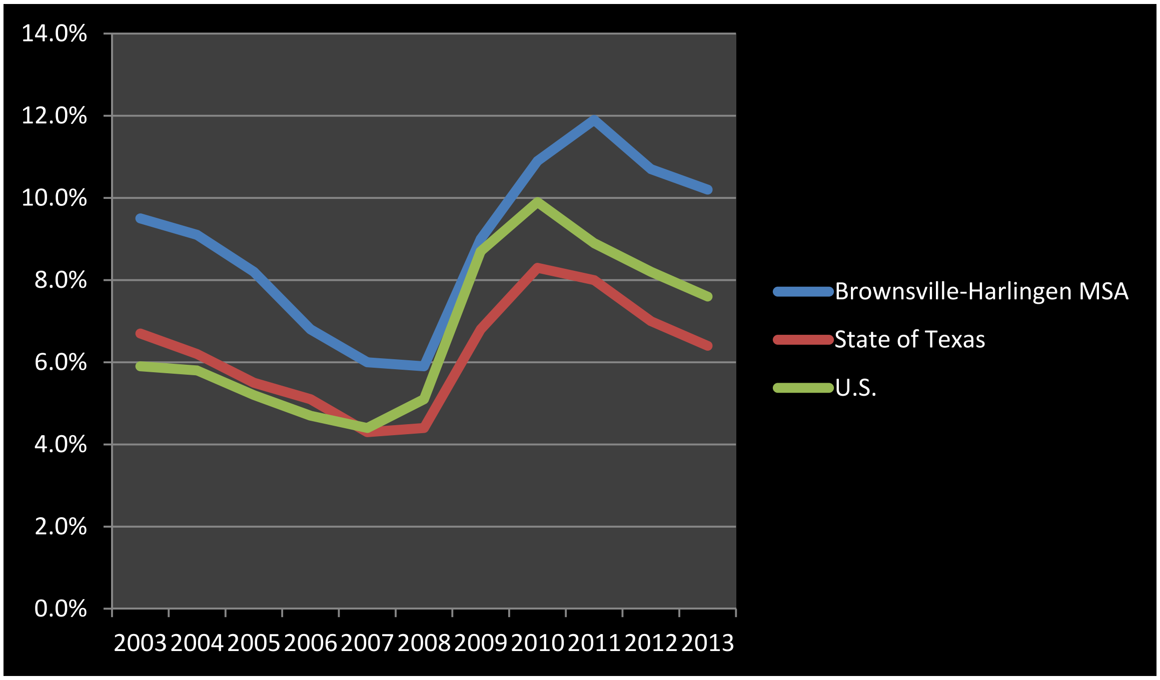
Source: Texas State Data Center, http://txsdc.utsa.edu/Data/TPEPP/Index.aspx

2.2 MEDIAN HOUSEHOLD INCOME

Based on U.S. Census data, over the period 2007–2011, the median household income for Cameron County was $32,156. This is approximately 40 percent lower than the median household income of $50,920 for the State of Texas, and $52,762 for the U.S. as a whole. The poverty rate in Cameron County for the period 2007–2011 was 34.9 percent, which is double the 17 percent poverty rate for the State of Texas.

2.3 UNEMPLOYMENT

Over the past 10 years, the unemployment rate in the Brownsville-Harlingen MSA has mirrored the ups and downs of the U.S. unemployment rate; however, the Brownsville-Harlingen MSA unemployment rate has been higher than both the State of Texas and U.S. unemployment rates. The unemployment rate peaked in 2011, but has been over 10 percent since 2009. The following Figure 2-1 shows the unemployment rate over the past decade, based on data from the Bureau of Labor Statistics (BLS).



Source: Bureau of Labor Statistics

Figure 2-1: BIH Study Area Unemployment Rate

2.4 EMPLOYMENT AND GDP

The Brownsville-Harlingen MSA has experienced steadily increasing employment numbers since 2001. The Brownsville-Harlingen MSA has also experienced a growing economy from $5 billion in 2001 to $8.1 billion in 2011, according to Bureau of Economic Analysis (BEA) figures. The following Table 2-2 provides details on employment and Gross Domestic Product (GDP) for the MSA over the past decade.

According to a Martin Associates report prepared for the Port in September 2012, of the 21,590 jobs that are in some way related to the cargo moving via the marine terminals and activity at the ship and rig repair yards within the BND, 4,373 direct jobs were generated in 2011 by the marine cargo and vessel activity and ship and rig repair operations. Overall, in 2011, marine cargo activity at the Port generated a total of $2 billion of economic activity in Texas, and $712 million of that was direct business revenue. Thus, BSC provides extensive business and employment opportunities for the people who live in the area.

Table 2-2. Brownsville-Harlingen MSA Economic Trends

Year	GDP (1,000 current $)	Employment (persons employed)	% Change in GDP	% Change in Employment
2001	5,074,000	119,524		
2002	5,378,000	123,314	5.99	3.17
2003	5,636,000	123,429	4.80	0.09
2004	5,893,000	125,001	4.56	1.27
2005	6,160,000	125,484	4.53	0.39
2006	6,565,000	130,697	6.57	4.15
2007	7,076,000	133,276	7.78	1.97
2008	7,444,000	135,047	5.20	1.33
2009	7,611,000	133,517	2.24	(1.13)
2010	7,927,000	135,026	4.15	1.13
2011	8,167,000	136,393	3.03	1.01

Source: Bureau of Economic Analysis

3.0 ECONOMIC STUDY AREA

3.1 THE BROWNSVILLE SHIP CHANNEL INFRASTRUCTURE AND TRANSPORTATION NETWORK

The Port is the closest deepwater port to industrialized Northern Mexico. As of September 2013, the Port was ranked as the number one U.S. Foreign Trade Zone (FTZ) for exports to other countries. According to the U.S. Department of Homeland Security, goods may be exported from an FTZ free of duty and excise taxes. In addition, an importer has the choice of paying duties at the rate of either the original foreign materials or the finished product, and the duties are not required until the merchandise enters U.S. Customs and Border Protection territory for domestic production. The FTZ program is designed to promote American competiveness by encouraging companies to maintain and expand operations in the U.S. Thus, the Port provides land transportation to Mexico that is linked with the GIWW inland waterway system, which provides a distribution advantage. The top commodities moved through the Port's FTZ include petroleum products, steel, metals, and offshore oil drilling platforms.

The variety of cargo that is transported along the channel includes chemicals; petroleum products, such as gasoline and distillate fuel oil; iron ore and iron and steel (I&S) products, such as aluminum and flat-rolled products; dry bulk and break bulk products, such as limestone and scrap; and food and farm products. As a bulk commodity port, the Port has developed a marine terminal operation covering both liquid and dry cargo handling. The Port has grain, dry bulk, and liquid bulk handling and storage facilities. The deep-draft vessels calling on the Port are primarily tankers and bulk carriers, while shallow-draft barge traffic enters the channel at the Port Isabel Wye. Table 3-1 provides a summary of the docks along BSC and the commodities and vessels that are expected to call at the docks. Table 3-2 provides detail on the dimensions of the channel and the reaches used in the analysis. The Port is the owner of the property along the channel and leases the land to the facility operators.

The Port estimates that the harbor dock capacity is 18.7 million tons. The Port owns approximately 40,000 acres of land in areas both North and South of the BSC. The available storage consists of 571,065 square feet of covered storage, 2.85 million square feet of open storage, and 3.4 million barrels of oil and liquid storage tanks.

The Port has a tenant public grain storage/elevator company that has the flexibility to load and unload both ships and barges with a capacity of over 3 million bushels. However, the grain elevator has not been functional in recent years. The Port owns and operates 10 transit warehouses, and the buildings are all located adjacent to vessel berths and are equipped with aprons and rail track on the landward side of all warehouses. Two open docks and three warehouses also have ship-side rail to facilitate efficient transfer to/from trucks or railroad cars.

Table 3-1. BIH Dock Information

Dock Name	Current Length (feet)	Current Limiting Depth (feet)	Vessel Type	Commodity Category
Amfels	2,700	40	Oil Rig	Drilling Rigs
BC Dock	800	39	Barge-Dry Open, Bulk Carrier	Chemicals, Dry Bulk & Break Bulk, Iron Ore/I&S Products
Docks 1, 2, and 4	1,250	32	Barge-Dry Open	Dry Bulk & Break Bulk, Iron Ore/I&S Products
Dock 3	450	32	General Cargo	Chemicals
Docks 7 and 8	1,000	29	Barge-Dry Open	Dry Bulk & Break Bulk, Iron Ore/I&S Products
Docks 10 and 11	1,250	32	Barge-Dry Open	Dry Bulk & Break Bulk, Iron Ore/I&S Products
Docks 12 and 13	1,120	32	Barge-Dry Open, Bulk Carrier	Dry Bulk & Break Bulk, Iron Ore/I&S Products
Docks 15 and 16[1]	1,450	42	Barge-Dry Open, Bulk Carrier, General Cargo	Chemicals, Dry Bulk & Break Bulk, Food & Farm Products, Iron Ore/I&S Products
Esco	2,060	35	Scrap	Iron Ore/I&S Products, Shipbreaking
International Shipbreaking	1,600	20	Scrap	Iron Ore/I&S Products, Shipbreaking
Liquid Dock	450	34	Barge-Liquid, Tank Ship	Petroleum Products
Oil Dock 1 and 2	675	32	Barge-Liquid, Tank Ship	Chemicals, Petroleum Products
Oil Dock 3 and 5	1,425	39	Barge-Liquid, Tank Ship	Chemicals, Petroleum Products
Transforma	1,000	20	Scrap	Iron Ore/I&S Products, Shipbreaking

Source: Port Series Book No. 26 (Revised 2003), Ports of Freeport, Port Lavaca/Point Comfort, Brownsville, and Ports Along the Gulf Intracoastal Waterway, TX

[1] Please note that as of May 2014, Dock 16 has not been built. However, the Port has plans to construct Dock 16 before the period of analysis begins, and thus, it has been included in the analysis.

Table 3-2. Current Dimensions of the Brownsville Ship Channel

Reach Name	Length (feet)	Width (feet)	Depth (feet)
Entrance Channel (Entry/Exit)	7,000	300	44
Jetty Channel (Topologic Node)	6,000	300	44
Laguna Madre (Topologic Node)	16,000	250	42
Brownsville Ship Channel	48,000	250	42
GIWW (Barge Entry/Exit)	100	150	12
Reach 5 (to Amfels Dock)	10,000	300	42
Reach 6 (to International Shipbreaking Dock)	1,000	300	42
Reach 7 (to Transforma Dock)	1,500	300	42
Reach 8 (to Esco Dock)	1,500	300	42
Reach 9 (to Liquid Dock)	1,610	300	42
Reach 10 (to Oil Docks 3 & 5)	1,690	400	42
Reach 11 (to Docks 15 & 16)	700	400	42
Reach 12 (to BC Dock)	2,000	400	42
Reach 13 (to Oil Docks 1 & 2)	1,100	325	42
Reach 14 (to Docks 12 & 13)	1,900	450	36
Reach 15 (to Docks 7 & 8)	500	690	36
Reach 16 (to Docks 10 & 11)	500	690	36
Reach 17 (to Docks 1, 2, & 4)	800	690	36
Reach 18 (to Dock 3)	200	690	36
Reach 19 (to Turning Basin)	500	861	36

Railroad car and truck loading racks at the various terminals provide for the transfer of petroleum products, chemicals, and edible oils moving in the U.S. and Mexican markets. The Port has over 33 miles of railroad tracks, with rail sidings serving warehouses, industries, and all docks in the Port area. The Union Pacific and the Burlington Northern Santa Fe provide rail service to and from the Port on the U.S. side. Grupo Transportacion Ferroviaria Mexicana, S.A. de C.V. provides rail service to and from the Port and Mexico directly. As a subsidiary of the BND, the Brownsville & Rio Grande International Railroad (BRG) has provided railroad service at the Port since 1984. Railroad operations maximize movement of a monthly average load of 4,000 plus cars. BRG has a direct interchange with the Union Pacific and the Burlington Northern Santa Fe rail lines.

3.2 MULTIPORT ANALYSIS

The purpose of the multiport analysis is to assess whether or not improvements at BIH would result in a diversion of cargo traffic from competing ports to Brownsville. Diverted traffic from competing U.S. ports is not an NED benefit as there is no increase in the net value of the national output of goods and services, except when the diversion results in a net reduction in transportation costs. If it is determined that there is an impact, the forecasted cargo traffic at BIH would be adjusted by an amount derived from the analysis of cargo movements and transportation costs at competing ports.

BIH is the southernmost major Gulf of Mexico port in Texas and borders Mexico. The BSC location compared to other Gulf of Mexico ports is as follows: 146 nautical miles to Corpus Christi Ship Channel, Texas, and 262 nautical miles to Galveston Ship Channel, Texas. These ports, as well as other Texas and Gulf of Mexico ports, could be a competing port for one or more of the commodities handled by BIH.

BIH handles dry bulk, break bulk, and liquid bulk. This analysis (1) identifies those commodities that would benefit from improvements to the Federal project; (2) for each benefiting cargo group, identifies their cargo volumes at competing ports; (3) assesses the extent of the overlap in the flow of these commodities and in the hinterlands served by each of the potential competing ports; and (4) identifies any advantageous/disadvantageous transportation costs and institutional and/or cargo capacity constraints resulting from port administration, terminal operators, and/or stevedore companies' policies, and/or future growth. Then, if appropriate, any diverted traffic due to improvements at BIH is quantified. Table 3-3 provides detail on the distribution of commodities in Texas by port.

3.3 BULK CARGOES

Dry and liquid bulk products are among the local/regional commodities of the BIH area to service the domestic economic hinterland. Liquid bulk is used primarily in support of transportation and electric power generation. Dry bulk commodities, such as crude materials, are used in support of local/regional construction aggregates.

The major liquid bulk cargo ports in Texas are Corpus Christi, Freeport, and Texas City. However, BIH handles a larger share of gasoline as a total of its petroleum and petroleum products imports and exports than the other ports. The primary petroleum products categories include gasoline and distillate fuel oil. As shown in Table 3-4, BIH has the second highest percentage of its petroleum products imports/exports from gasoline. BIH supplies southern Texas and Northern Mexico with transportation fuels.

Because of relatively high overland trucking costs, existing "institutional" arrangements such as the gasoline pipeline from BIH to Northern Mexico, and the use of a growth rate for future cargo volumes that is based on historical liquid bulk cargo levels at BIH that is consistent with other liquid bulk growth indicators, it is not anticipated that deepening improvements at BIH will significantly shift liquid bulk cargo movements to BIH from other ports, or vice versa.

Table 3-3. 2011 Texas Commodity Distribution (1,000s of short tons)

Commodity	BIH	Corpus Christi	Matagorda	Freeport	Galveston	Texas City
Coal	12	0	0	0	0	55
Petroleum and Petroleum Products	1,489	38,666	400	15,578	1,081	36,562
Chemicals and Related Products	2	3,085	2,071	2,303	867	2,202
Crude Materials, Inedible Except Fuels	608	6,653	4,619	96	718	0
Primary Manufactured Goods	1,257	82	0	55	62	23
Food and Farm Products	7	4,258	4	472	4,103	20
All Manufactured Equipment, Machinery and Products	11	118	0	62	348	25
Unknown or Not Elsewhere Classified	44	73	18	13	92	3
Total	3,430	52,935	7,112	18,579	7,271	38,890

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2011.

Table 3-4. 2011 Petroleum Product Distribution by Port (1,000s of short tons)

Port	Petroleum Products	Gasoline	% of Petroleum Products	Distillate Fuel Oil	% of Petroleum Products
BIH	1,489	902	61	475	32
Corpus Christi	38,666	7,619	20	6,355	16
Matagorda	400	297	74	44	11
Freeport	14,211	272	2	255	2
Galveston	1,081	60	6	746	69
Texas City	36,562	1,640	45	3,737	10

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2011.

Crude construction materials, which consist of dry bulk commodities, such as building stone, limestone, and sand and gravel, among others, are typically used to support regional private and public construction activity. As with liquid bulk cargo, BIH is positioned to service the southernmost part of Texas's construction aggregate demand. Improvements would not cause any significant shift of traffic from other ports to BIH. Moreover, given the high overland trucking costs, it is also doubtful if improvements at BIH would result in shifting aggregate traffic from Corpus Christi or other ports. Furthermore, the growth rate used for the future aggregate movements at BIH is consistent with historical traffic levels and does not depend on shifting traffic from other ports.

Primary manufactured goods, which consist of iron and steel primary forms and fabricated metal products, among others, are a primary commodity driver at BIH, but are relatively nonexistent at the other Texas ports. BIH is ideally situated to service Northern Mexico so these general cargo products are typically imported and then sent to Northern Mexico via rail; thus, improvements at BIH would not cause any significant shift of traffic from or to other ports. In addition, the growth rate used for the future aggregate movements at BIH is consistent with historical traffic levels and does not depend on shifting traffic from other ports.

3.4 MULTIPORT CONCLUSIONS

A multiport analysis was used to assess whether or not improvements at BIH would result in a diversion of cargo traffic that would either shift to or from competing ports to or from BIH. The analysis discussed previously did not find any reason to assume a shift in cargo to or from BIH. If it was determined that there is an impact, the forecasted cargo traffic at BIH would be adjusted by an amount derived from the cargo movements analysis and transportation costs at competing ports; however, in this case, there was no evidence that such a shift would occur.

Further, the multiport analysis was used to determine that the nonstructural measures developed to address at least one of the planning objectives are not reasonable. As explained above, utilizing another port would require additional transportation to the subject hinterland and the use of another port and alternative modes of commodity transport would add additional cost. Therefore, the additional cost compared to the transport to BIH leads to the nonstructural measures being removed from further consideration.

4.0 COMMODITY TYPES, FLOWS, AND FORECASTS

4.1 TYPES AND VOLUMES OF COMMODITY FLOW

The following section identifies the major past and present commodity volumes transiting BIH and forecasts future tonnages throughout the period of analysis. Cargo information is used for an initial determination of the economic study area and to provide the basis for commodity flow projections or forecasts. The existing and projected commodity flows developed in this section are integrated with the existing and projected fleet developed in Section 5 in order to provide a basis for NED benefits analysis. Ultimately, commodity projections drive vessel fleet projections in terms of the numbers and sizes of vessels for future without- and future with-project conditions.

4.1.1 DATA SOURCES

Data obtained from the Corps' Navigation Data Center (NDC) Waterborne Commerce Statistics Center (WCSC) U.S. publications and databases, as well as data from the Pilots and the Brownsville Port Authority was used for this analysis. Additional vessel data was obtained from terminal operators and from the Fairplay/Lloyds Vessel Register.

4.2 BIH COMMODITY CARGO COMPOSITION

The primary commodities at BIH include petroleum products, crude materials, and primary manufactured goods, all of which are the focus of the following sections. Table 4-1 presents BIH's major commodity groups through 2011. In addition to these commodities, there were 23 oil drilling rigs that called at the Port in 2011, which included 3 new-builds and 12 repairs.

The BIH tonnage experienced strong overall growth from the middle 1990s through 2011, with total tonnage increasing one and a half times from an average of 3.30 million short tons for 1999–2001 to 5.07 million short tons for 2009–2011. As shown on Figure 4-1, nearly half of BIH's tonnage is foreign imports. Table 4-2 displays the BIH 1980–2011 shallow-draft GIWW tonnage and the relative percentage of shallow-draft to total tonnage. The average shallow-draft tonnage of total tonnage has remained fairly steady, with an average of 43 percent in 1999–2001 compared to 40 percent in 2009–2011. There was a large decrease in shallow-draft tonnage in 2006 due to the use of the Valley Pipeline System for transporting gasoline from Corpus Christi to Harlingen and Brownsville. Gasoline barge movements on the GIWW have since increased, and again are at pre-2006 levels. In 2011, 62 percent of BIH's domestic exports were to other Texas ports, but the domestic exports to Texas and Louisiana ports combined is 75 percent. In 2011, 65 percent of BIH's domestic imports were from other Texas ports, but domestic imports from Texas and Louisiana ports combined is 76 percent.

Table 4-1. BIH Total Tonnage and Major Commodity Tonnage (1,000s of Short Tons)

Year	Total Tonnage	Total Deep-Draft Tonnage[2]	Principal Deep-Draft Commodities					
			Crude Materials		Petroleum Products		Primary Manufactured Goods	
			Imports	Exports	Imports	Exports	Imports	Exports
1980	2,875	1,196	132	45	250	37	100	0.21
1985	1,722	540	56	0	105	0	6	0
1990	1,641	472	122	13	10	35	4	9
1995	2,786	1,703	184	2	7	196	222	849
1996	2,515	1,250	172	1	9	21	207	471
1997	2,372	913	287	27	7	22	244	126
1998	2,829	1,470	500	7	144	17	481	5
1999	2,493	1,160	275	0	46	0	605	33
2000	3,273	1,933	441	0	46	9	1,187	46
2001	4,120	2,654	939	0	109	287	867	14
2002	4,741	3,330	621	4	354	396	1,694	0
2003	3,732	2,373	654	62	122	154	994	196
2004	4,173	2,292	408	1	193	154	1,285	52
2005	5,105	3,379	488	0	611	196	1,739	220
2006	5,310	4,444	440	0	674	368	2,686	21
2007	4,509	3,168	336	0	623	289	1,431	176
2008	5,669	4,202	857	0	927	213	1,655	72
2009	4,693	3,149	642	0	1,104	150	1,111	61
2010	4,617	2,481	287	0	858	209	1,065	0
2011	5,907	3,429	589	18	994	494	1,247	10

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1980–2011.

[2] Includes commodities in addition to what is shown.

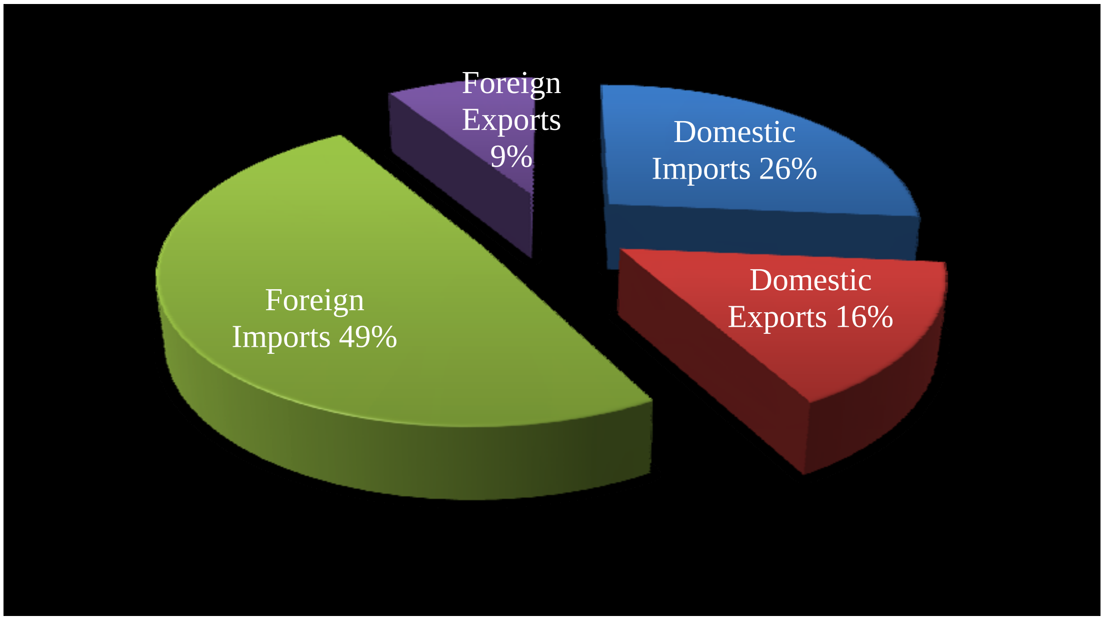


Figure 4-1: 2011 BIH Cargo Traffic Distribution

Table 4-2. Shallow-Draft Port and Deep-Draft Tonnage Comparison
(1,000s of Short Tons)

Year	Shallow-Draft Port Tonnage and GIWW Through Tonnage	Deep-Draft Tonnage	BIH Total	Shallow-Draft % of Total Tonnage
1980	1,679	1,196	2,875	58
1985	1,182	540	1,722	69
1990	1,169	472	1,641	71
1995	1,083	1,703	2,786	39
1996	1,265	1,250	2,515	50
1997	1,459	913	2,372	62
1998	1,359	1,470	2,829	48
1999	1,333	1,160	2,493	53
2000	1,340	1,933	3,273	41
2001	1,466	2,654	4,120	36
2002	1,411	3,330	4,741	30
2003	1,359	2,373	3,732	36
2004	1,881	2,292	4,173	45
2005	1,726	3,379	5,105	34
2006	866	4,444	5,310	16
2007	1,341	3,168	4,509	30
2008	1,467	4,202	5,669	26
2009	1,544	3,149	4,693	33
2010	2,134	2,481	4,617	46
2011	2,478	3,429	5,907	42

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1980–2011

Crude materials and primary manufactured goods imports comprise approximately 18 percent and 37 percent of BIH's 2011 total oceangoing tonnage, respectively, as shown in Table 4-3. Whereas, petroleum products imports and exports comprise 43 percent of BIH's 2011 total oceangoing tonnage. While crude materials imports have fluctuated during the most recent 10-year period, BIH has experienced significant growth for petroleum products imports and exports and primary manufactured goods imports since 1998.

Table 4-3. 2011 BIH Commodity Distribution
(1,000s of short tons)

Commodity	BIH	% of BIH Total
Coal	12	0.4
Petroleum and Petroleum Products	1,489	43.4
Chemicals and Related Products	2	0.1
Crude Materials, Inedible Except Fuels	608	17.7
Primary Manufactured Goods	1,257	36.6
Food and Farm Products	7	0.2
All Manufactured Equipment, Machinery and Products	11	0.3
Unknown or Not Elsewhere Classified	44	1.3
Total	3,430	100

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2011

4.3 COMMODITY ANALYSIS AND FORECASTS

The objective of this section is to identify the major commodities transiting BIH and assess the following topics: 1) cargo composition by commodity; 2) commodity usage; 3) sources and destinations; 4) past and present commodity volume; 5) projection of waterborne commerce; and 6) cargo categorization.

4.3.1 PETROLEUM PRODUCTS

BIH's primary petroleum products imports and exports consist of gasoline and distillate fuel oil. Petroleum products typical usage includes motor vehicle, aviation, and waterborne transportation, as well as electric power generation. Distillate fuel oil is also used for power generation.

As shown in Table 4-4, BIH handled 1,489 thousand short tons of petroleum products in 2011. Petroleum products increased between 2007 and 2011 by over 60 percent. There were no measurable gasoline imports into BIH before 2003 so petroleum products have increased dramatically in less than a decade. Gasoline and distillate fuel oil increased 11 and 183 percent, respectively, between 2010 and 2011.

Table 4-4. Petroleum Products Distribution 2007–2011 (1,000s of Short Tons)

Petroleum Products	2007	2008	2009	2010	2011	% Change 2007–2011	% Change 2010–2011
Gasoline	672	996	1,109	810	902	34	11
Distillate Fuel Oil	129	53	90	168	475	268	183
Residual Fuel Oil	25	0	0	21	26	4	24
Lube Oil and Greases	1	29	4	0	3	200	N/A
Petro Jelly and Waxes	28	34	46	57	50	79	–12
Naptha and Solvents	45	19	0	0	1	–98	N/A
Petroleum Coke	11	7	6	12	32	191	167
Total	911	1,140	1,254	1,067	1,489	63	40

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

The imports of gasoline can likely be attributed to the installation of a pipeline by Valero L.P., which has a terminal at the Port and installed a pipeline in 2006 that directly links the Port to the Burgos Basin near Reynosa, Mexico. In addition, Transmontaigne Partners L.P. has a Liquefied Petroleum Gas (LPG) terminal in Brownsville with a pipeline from the Port facilities to a terminal in Matamoros, Mexico. BIH's primary foreign petroleum product sources include the Netherlands and Italy, whereas 92 percent of the petroleum product exports are to Mexico and Central America. Over 98 percent of BIH's domestic petroleum product imports are from Texas and Louisiana, thus from U.S. Gulf of Mexico refineries. Table 4-5 provides information about the petroleum products regions.

Table 4-5. Petroleum Products Tonnage 2009–2011 Tonnage by Region (1,000s of Short Tons)

Region	2009	2009 % of Total	2010	2010 % of Total	2011	2011 % of Total	2009-2011 Average %
Asia[3]	35,031	2.7	58,121	5.5	52,576	3.5	3.9
Canada	0	0	31,397	3.0	0	0	1
Central America[4]	104,350	8.3	52,056	4.9	458,141	30.6	14.6
East Europe[5]	171,166	13.5	280,535	26.4	546,054	36.4	25.4
Mexico	39,665	3.1	116,201	10.9	41,905	2.8	5.6
North Africa[6]	120,891	9.6	170,615	16.1	217,971	14.6	13.4
North Europe[7]	744,490	58.9	324,899	30.6	141,070	9.4	33
Orient[8]	44,021	3.5	27,318	2.6	38,625	2.6	2.9
South America	4,748	0.4	0	0	1,608	0.1	0.2
Total	1,264,362	100	1,061,142	100	1,497,950	100	100

Source: USACE, NDC detailed unpublished data, 2009–2011

[3] Asia encompasses China, Taiwan, Malaysia, and Singapore.
[4] Central America encompasses Bahamas, Panama, Colombia, and Venezuela.
[5] East Europe encompasses Italy, Sweden, Lithuania, Latvia, Finland, and Russia.
[6] North Africa encompasses Portugal, Morocco, and Spain.
[7] North Europe encompasses Netherlands, Belgium, Norway, and United Kingdom.
[8] Orient encompasses Australia, Russia, Japan, and South Korea.

The number of vessels that are transporting petroleum products with deeper design drafts has been increasing, as presented in Table 4-6. For the period of 2009-2011, a comparison of vessel's design drafts versus sailing drafts is presented for a representative dock at BIH. Vessels with design drafts at or close to the channel depth but not utilizing the entire design draft are those of the historical fleet mix set to benefit from navigation deepening improvements. The 70 vessels importing from 2009 to 2011 account for the majority of the petroleum products being transferred across docks at BIH. Table 4-6 also presents the port-pair data for the vessel trips with the drafts at the foreign ports.

Table 4-6. 2009-2011 Trip Comparison of Vessel Design Draft and Sailing Draft for Petroleum Products

Design Draft (Feet)	39	40	41		42		43	44	46	Grand Total
Sailing Draft (Feet)	33-37	33-38	34-35	37	33-35	38-39	33-37	34	39	
Amsterdam, Netherlands (50ft)	2	8	1	0	0	1	7	0	0	20
Barcelona, Spain (80ft)	0	1	0	0	0	0	0	0	0	1
Donges, France (62ft)	0	0	0	0	0	1	0	0	0	1
Freeport, Grand Bahama I (52.5ft)	0	1	0	0	0	0	1	0	0	2
High Seas,Gulf of Mexico	0	0	0	0	0	0	1	0	0	1
Kao Hsiung, Taiwan (50ft)	1	0	0	0	0	0	0	0	0	1
Klaipeda, Japan (48ft)	1	1	0	1	0	0	2	0	0	5
Le Havre, France (56ft)	0	0	0	0	0	0	1	0	0	1
New Amsterdam, Netherland (78ft)	0	1	0	0	0	0	0	0	0	1
Rotterdam, Netherland (77ft)	1	2	0	0	0	0	1	0	0	4
Sarroch Oil Terminal, Italy (68ft)	3	9	1	0	2	0	9	1	0	25
Sines, Portugal (76ft)	2	5	0	0	0	0	0	0	1	8
Grand Total	10	28	2	1	3	2	22	1	1	70

4.3.2 PETROLEUM PRODUCT PROJECTIONS

As shown on Figure 4-2, nearly all of the petroleum product tonnage consists of gasoline and distillate fuel oil, and these are anticipated to remain the major petroleum products commodities. As stated above, there are several terminals at the Port with direct pipeline access to Mexico and there are multiple-year contracts in place to supply LPG so the need for petroleum products is expected to continue. In addition, the Port's FTZ lends itself to continued trade with Mexico.

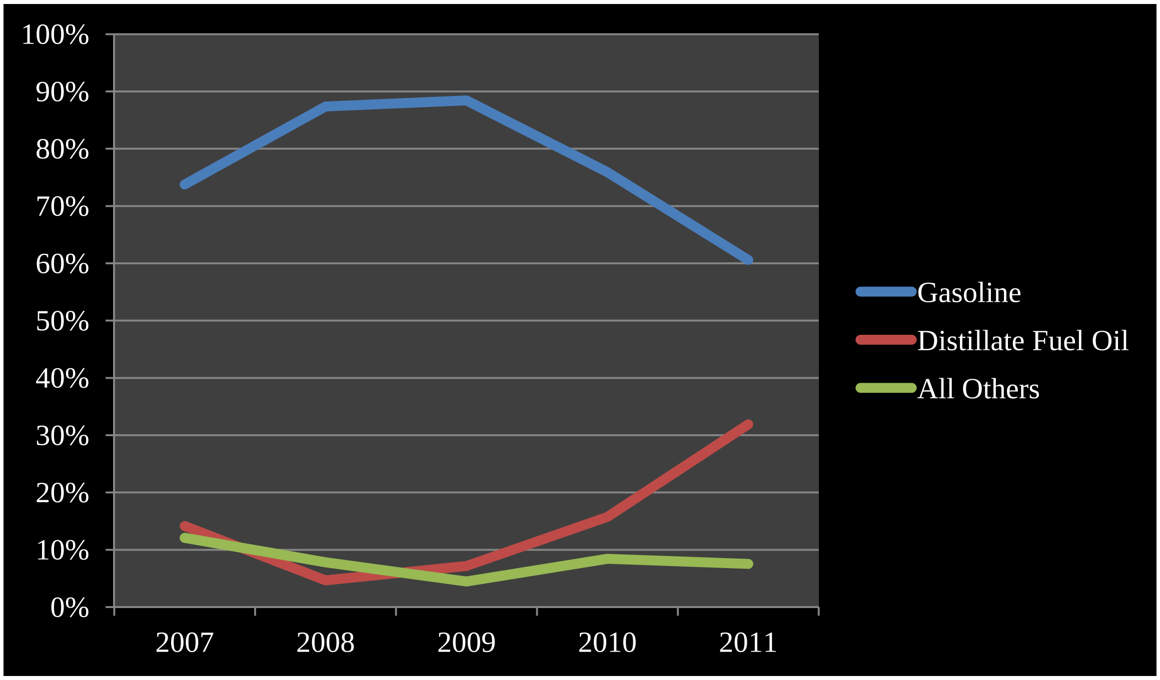


Figure 4-2: Percent of Total Petroleum Product Tonnage

Table 4-7 provides the average annual growth rate of petroleum products at BIH since 2007. Petroleum product volume grew at more than an average annual rate of 13 percent, which is greater than most Texas ports during the recession that began in 2007. The forecast of BIH's petroleum product tonnage is based on analysis of regional data and national trends. According to the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2013, growth of petroleum products is expected to grow through 2040, as shown in Table 4-8. The AEO's projected gross refined product imports, as well as the liquefied petroleum gases consumption for both the U.S. and Mexico, were examined through 2040. Mexico's liquids consumption was also reviewed due to the large number of exports that are exported to Mexico via BIH. Based on the compiled information, a 2.5 percent growth rate is applied to the 2011 tonnage through 2017, then a 1.5 percent growth rate is projected for the first 10 years of the period of analysis, followed by a 0.5 percent growth rate for the next 10 years, and then no growth is projected for the remainder of the period of analysis. Thus, growth is only projected for the first 20 years of the period of analysis. An average annual growth rate of 0.4 percent is projected for petroleum products for the period of analysis.

Table 4-7. 2007–2011 Petroleum Product Growth Rates

Petroleum Products	BIH Petroleum Product Distribution 2007–11 (1,000s of short tons)					Average Annual Growth Rate 2007–2011	Average Annual Growth Rate 2009–2011
	2007	2008	2009	2010	2011		
Gasoline	672	996	1,109	810	902	7.6%	–9.8%
Distillate Fuel Oil	129	53	90	168	475	38.5%	129.7%
Total	911	1,140	1,254	1,067	1,489	13.1%	9.0%

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

4.3.3 CRUDE MATERIALS

BIH's primary crude material commodities include limestone, nonmetal minerals, building stone, and sand and gravel. Limestone is often used to create cement, and all the aforementioned crude materials are typically used as building materials, such as for roads, for private, commercial, and/or public infrastructure uses. Vulcan Materials Company is an example of a terminal operator that moves limestone along BIH.

Table 4-9 provides the crude materials tonnage for the period 2007-2011. In 2011, BIH saw 606 thousand short tons of crude materials, which was a 111 percent increase over 2010. For the period of 2007-2011, limestone has on average consisted of nearly 82 percent of the crude materials volume at BIH. Limestone had an average annual growth rate of 12 percent between 2007 and 2011. Table 4-10 presents the information about the crude materials regions.

Crude materials transport can be impacted by a variety of events, such as economic downturns, which leads to less building activity, sensitivity to energy costs, and high transportation costs. Due to their weight, crude materials are costly to transport via truck and to a lesser extent rail, so benefits accrue to coastal waterway producers, such as BIH. Construction is often tied to population growth; therefore, the forecast for crude materials is primarily based on population growth projections. Through 2021, the growth rate for crude materials is 3 percent, which is considered reasonable considering the significant growth rates over the past five years in these commodities at BIH. The first 10 years of the period of analysis will be half that growth rate at 1.5 percent, followed by 1 percent for the next 10 years, which is reasonable considering the projected 1.3 percent annual growth rate for population. No growth is projected for the remainder of the period of analysis; thus, growth is only projected for the first 20 years of the period of analysis. The average annual growth rate for crude materials at BIH is 0.5 percent.

Table 4-8. EIA's AEO 2013 Reference Case (million barrels per day)

Supply and Disposition	2010	2011	2021	2026	2031	2036	2040	Average Annual Growth Rate 2011–2021	Average Annual Growth Rate 2021–2031	Average Annual Growth Rate 2031–2040	Average Annual Growth Rate 2011–2040
Gross Refined Product Imports	1.23	1.15	2.62	1.50	1.54	1.49	1.42	2.62%	0.33%	–0.90%	0.73%
Liquefied Petroleum Gases Consumption	2.27	2.30	2.35	2.97	2.90	2.83	2.75	2.35%	0.0%	–0.59%	0.62%
Liquids Consumption in Mexico and Chile	2.40	2.41	1.10	2.83	3.05	3.26	3.47	1.10%	1.38%	1.44%	1.26%

Source: Energy Information Administration, 2013.

Table 4-9. BIH Crude Materials Distribution 2007–11
(1,000s of Short Tons)

Crude Materials, Inedible Except Fuels	2007	2008	2009	2010	2011	% Change 2007–2011	% Change 2010–2011
Building Stone	24	42	37	0	43	79	N/A
Limestone	247	726	541	287	388	57	35
Sand and Gravel	0	0	0	0	47	N/A	N/A
Iron Ore and Scrap	0	0	11	0	23	N/A	N/A
non-Ferrous Ores	11	31	0	0	6	–45	N/A
non-Metal Minerals	42	57	53	0	99	136	N/A
Total	324	856	642	287	606	87	111

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

Table 4-10. Crude Materials 2009–2011 Tonnage by Region
(1,000s of Short Tons)

Region	2009	2009 % of Total	2010	2010 % of Total	2011	2011 % of Total	2009–2011 Average %
Asia[9]	53,317	8.5	2,159	0.7	0	0	3.1
Canada	0	0	0	0	6,474	1.0	0.3
Central America[10]	0	0	0	0	6,157	1.0	0.3
Mexico	540,285	85.7	288,596	88.1	433,750	69.2	81
North Africa[11]	0	0	0	0	43,561	6.9	2.3
Orient[12]	0	0	0	0	94,392	15.0	5
South America	36,718	5.8	36,718	11.2	43,028	6.9	8
Total	630,320	100	327,473	100	627,362	100	100

Source: USACE, NDC detailed unpublished data, 2009–2011

4.3.4 PRIMARY MANUFACTURED GOODS

Primary manufactured goods at BIH generally consist of iron and steel products, to include plates and sheets and other primary forms. The primary use of iron and steel products includes construction, such as buildings and highways, but can also include domestic products, such as appliances. Mexico has implemented maquiladoras for trade, in which foreign companies are allowed to operate in Mexico and in return are given special customs treatment. There is a major maquila program that operates in Matamoros, Mexico, directly across the border from Brownsville. Manufacturing in Mexico has increased in recent years, which is evidenced by several manufacturing plants that have been built in the past 10 years. Primary manufactured

[9] Asia encompasses China, Taiwan, Malaysia, and Singapore.
[10] Central America encompasses Bahamas, Panama, Colombia, and Venezuela.
[11] North Africa encompasses Portugal, Morocco, and Spain.
[12] Orient encompasses Australia, Russia, Japan, and South Korea.

goods can be sent to Mexico via rail for a variety of items to be produced, such as appliances and nails.

Table 4-11 provides the primary manufactured goods tonnage over the past five years. While there has been a decline in total tonnage during the period 2007–2011, the change from 2010–2011 included an 18 percent increase. Primary Iron and Steel Products fell annually from 2007 to 2010, but Primary Non-Ferrous Metal Products has grown substantially. Table 4-12 presents the primary manufactured goods by region.

Table 4-11. BIH Primary Manufactured Goods Distribution 2007–2011 (1,000s of Short Tons)

Primary Manufactured Goods	2007	2008	2009	2010	2011	% Change 2007–2011	% Change 2010–2011
Primary Iron and Steel Products[13]	1,538	1,221	1,062	729	749	–51	3
Primary Non-Ferrous Metal Products[14]	69	461	98	334	508	636	52
Total	1,607	1,682	1,160	1,063	1,257	–22	18

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

Table 4-12. Primary Manufactured Goods 2009–2011 Tonnage by Region (1,000's of Short Tons)

Region	2009	2009 % of Total	2010	2010 % of Total	2011	2011 % of Total	2009–2011 Average %
Asia[15]	24,415	2.1	0	0	0	0	0.7
Canada	11,773	1.0	0	0	8,377	0.7	0.6
Central America[16]	87,991	7.6	0	0	0	0	2.5
East Europe[17]	30,991	2.7	16,768	1.6	0	0	1.4
Mexico	5,594	0.5	0	0	26,488	2.0	0.8
North Europe[18]	190,217	16.4	8,649	0.8	5,258	0.4	5.7
Orient[19]	349,316	30.2	567,331	55	933,082	72.8	52.7
South Africa	12,418	1.0	33,203	3.2	0	0	1.4
South America	445,547	38.5	406,343	39.4	308,255	24.1	34
Total	1,158,262	100%	1,032,294	100	1,281,460	100	100

Source: USACE, NDC detailed unpublished data, 2009–2011

[13] Primary Iron and Steel (I&S) Products consist of pig iron, ferro alloys, iron and steel primary forms, I%S plates and sheets, I&S bars and shapes, I&S pipe and tube, primary I&S nec.

[14] Primary Non-Ferrous Metal Products consist of copper, aluminum, smelted prod. Nec, and fabricated metal products.

[15] Asia encompasses China, Taiwan, Malaysia, and Singapore.

[16] Central America encompasses Bahamas, Panama, Colombia, and Venezuela.

[17] East Europe encompasses Italy, Sweden, Lithuania, Latvia, Finland, and Russia.

[18] North Europe encompasses Netherlands, Belgium, Norway, and United Kingdom.

[19] Orient encompasses Australia, Russia, Japan, and South Korea.

The number of vessels that are transporting primary manufactured goods with deeper design drafts has been increasing, as presented in Table 4-13. For the period of 2009-2011, a comparison of vessel's design drafts versus sailing drafts is presented for a representative dock at BIH. Vessels with design drafts at or close to the channel depth but not utilizing the entire design draft are those of the historical fleet mix set to benefit from navigation deepening improvements. The 28 vessels importing from 2009 to 2011 account for the majority of the primary manufactured goods being transferred across docks at BIH. Table 4-13 also presents the port-pair data for the vessel trips with the drafts at the foreign ports.

Table 4-13. 2009-2011 Trip Comparison of Vessel Design Draft and Sailing Draft for Primary Manufactured Goods

Vessel Design Draft (Feet)	36		37	38				39		41	42	Grand Total
Sailing Draft (Feet)	31	36	35-37	33	35	36	37	33	35	34-38	39	
All Other Argentina Ports	0	0	0	0	0	0	0	1	0	0	0	1
All Other Ukraine Ports	0	0	0	0	1	0	0	0	1	2	1	5
Mariupol, Ukraine (43ft)	0	0	0	0	0	0	1	0	1	0	0	2
North Tees, UK (46ft)	0	0	1	0	2	0	0	0	0	0	0	3
Odessa, Ukraine (44.5ft)	0	0	1	0	0	0	0	0	0	1	0	2
Provideniya, Russia (75ft)	0	0	0	0	0	0	1	0	1	0	0	2
Rio de Janeiro, Brazil (45ft)	0	0	0	0	0	0	0	1	0	0	0	1
San Nicolas, Argentina (59 ft)	0	0	0	0	0	0	0	1	0	1	0	3
Sao Paulo, Brazil (50ft)	1	1	0	1	0	0	0	1	0	0	0	4
Tuapse, Russia (47.5 ft)	0	0	0	0	0	1	0	0	0	0	0	1
Vostochnyy, Russia (54ft)	0	1	1	0	1	0	0	0	0	1	0	4
Grand Total	1	2	3	1	4	1	2	4	3	5	1	28

Similar to crude materials, the stability of primary manufactured goods imports and exports are often dependent on the health of the economy and the amount of construction occurring. Construction is often tied to population growth; therefore, the forecast for primary manufactured goods is primarily based on population growth projections. Through 2021, the growth rate for primary manufactured goods is 3 percent, which is reasonable considering the fluctuations in this commodity during 2007–2011 at BIH. The first 10 years of the period of analysis will be half that growth rate at 1.5 percent, followed by 1 percent for the next 10 years, which is reasonable considering the projected 1.3 percent annual growth rate for population. No growth is projected for the remainder of the period of analysis; thus, growth is only projected for the first 20 years of the period of analysis. The average annual growth rate for primary manufactured goods at BIH is 0.5 percent.

4.4 FORECASTED TONNAGE

The following Table 4-14 provides the forecasted tonnages for the major commodities at BIH throughout the period of analysis using the aforementioned growth rates.

For clarification through the remainder of the report, Crude Materials may be referred to as Dry Bulk & Break-Bulk, while Primary Manufactured Goods may be referred to as Iron Ore/I&S Products, as these were the groups used for the economic model.

Table 4-14. BIH Forecasted Tonnage in Short Tons

Commodity Name	2021	2031	2041	2051	2061	2071	Average Annual Growth Rate
Crude Materials	843,533	978,955	1,081,375	1,081,375	1,081,375	1,081,375	0.5%
Primary Manufactured Goods	1,387,315	1,610,036	1,778,482	1,778,482	1,778,482	1,778,482	0.5%
Petroleum Products[20]	3,036,645	3,524,151	3,704,376	3,704,376	3,704,376	3,704,376	0.4%
Total	5,267,494	6,113,142	6,564,233	6,564,233	6,564,233	6,564,233	0.44%

[20] Petroleum Products tonnage includes deep-draft domestic barges.

5.0 FLEET COMPOSITION AND FORECAST

Development of the existing, and future without-project fleet and associated transportation costs was based on analysis of BIH's existing fleet composition. The purpose of this section is to analyze the present and likely future operations, composition, and characteristics of the vessels that constitute the fleet currently calling at BIH. Also, an examination of the commodities and their associated tonnages per vessel type will be explored. The data sources used in the analysis of the fleet include the WCSC, Lloyds Registry of Ships, the Pilots, and the Port. The composition of the BIH fleet was determined by compiling all vessels that called on BIH during 2009–2011 and using an average of the vessel calls.

5.1 COMPOSITION AND CHARACTERISTICS

The BIH fleet consists primarily of liquid barges, dry open barges, tank ships, bulk carriers, general cargo, oil drilling rigs, and shipbreaking scrap vessels. Domestic cargo is generally carried on non-self-propelled vessels that require towboat assistance to move freight. The most common type of liquid barge that traverses the GIWW to BIH is assumed to be a double-hull tank barge that is 297.5 feet x 54 feet x 12 feet in dimensions. These liquid barges carry petroleum products and chemicals. Domestic deep-draft liquid barges also traverse the channel with design drafts up to 32 feet. The most common dry open barge that traverses the GIWW to BIH is assumed to be an open-hopper barge that is 195 feet x 35 feet x 12 feet in dimensions. Dry open barges can carry a variety of cargo, such as dry bulk and iron and steel products commodities. As explained in previous sections, the domestic cargo that travels on barges is primarily coming from or to other Texas ports or Louisiana ports.

Self-propelled vessels that carry BIH's foreign cargo are primarily found on bulk carriers and tankers, although general cargo ships are also used. Bulk carriers primarily carry dry bulk and iron and steel products commodities, while the tankers carry petroleum products. Table 5-1 provides a percentage breakdown of BIH's self-propelled and non-self-propelled vessel trips between 2007 and 2011. Less than 20 percent of the vessel fleet is representative of bulk carriers and tankers; rather, the majority of the fleet is composed of shallow-draft vessels.

Table 5-1. 2007–2011 BIH Vessel Trip Percentages

Vessel Type	2007	2008	2009	2010	2011	Average
Non-Self-Propelled Dry Cargo	19	24	12	22	23	20
Non-Self-Propelled Tanker	20	21	30	25	21	23
Towboat	34	38	40	40	43	39
Self Propelled Dry Cargo	23	12	10	7	8	12
Self Propelled Tanker	4	5	8	6	5	6

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

5.2 EXISTING OPERATING CONSTRAINTS

BIH's existing deep-draft traffic is subject to vessel size limitations due to the current channel dimensions. The maximum ship dimensions permitted by the Pilots are presented in Table 5-2. The Pilots only allow daylight movement for oil drilling rigs and vessels being brought into the shipbreakers to be scrapped.

Table 5-2. BIH Pilots' Vessel Operating Constraints

Vessel Dimensions	Feet	Meters
Maximum Length	850	259.0
Maximum Beam	135	41.1
Maximum Draft	39	11.88

Source: Brazos Santiago Pilots Association Navigation Guidelines

The size range of the existing self-propelled vessels includes barges to the largest Panamax-size ships. Panamax ships refer to vessels that can transit the Panama Canal, whose lock dimensions are 1,000 feet long and 110 feet wide. For safety purposes, the Panama Canal Authority restricts the size of the ships to a beam of 106 feet and an overall length of 950 feet. The largest bulk carriers that have transited BIH have had a beam up to 106 feet and a length of 797 feet. On three occasions since 2006, BIH has received tankers with beams of 140 feet and a length of 793 feet, but those vessels were not drafting near their design draft, as they were light-loaded, and received special permission by the Pilots. The current typical maximum-sized tanker that transits BIH has a beam of 106 feet and a length of 600 feet.

5.3 VESSEL UTILIZATION

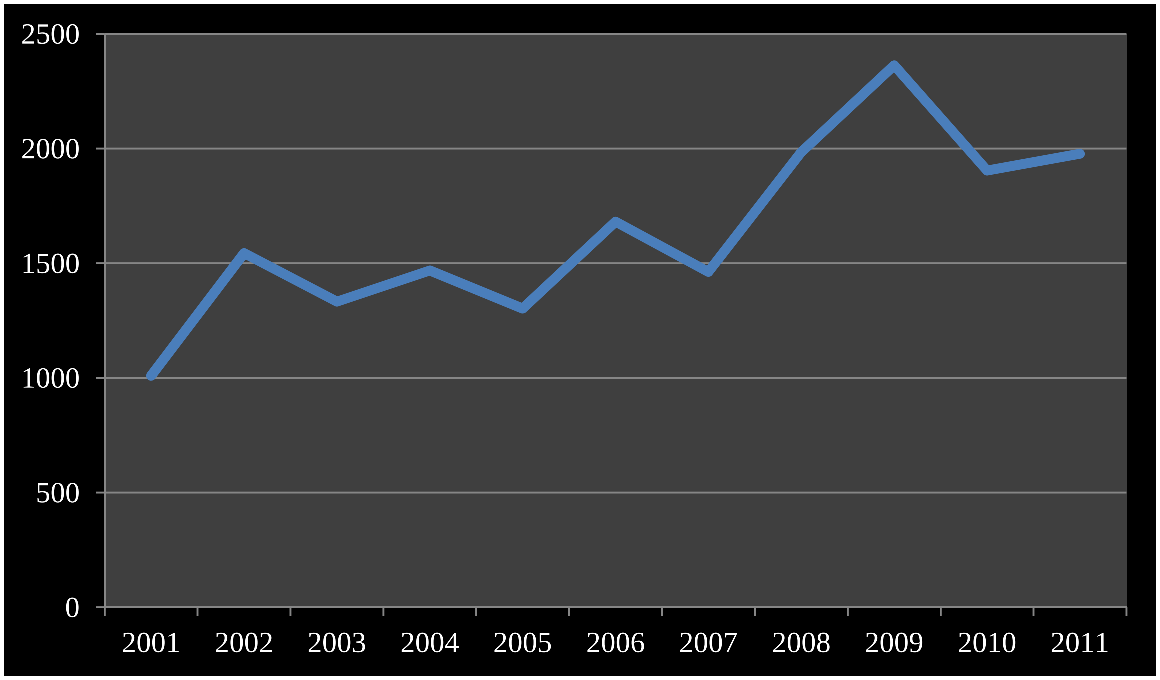
Table 5-3 presents the 2007–2011 sailing draft distribution by vessel trips. Between 98 and 99 percent of all trips drafted less than 35 feet of water. There was an overall decrease of 0.8 percent annually of total trips between 2007 and 2011. However, total trips for drafts of 35 feet or greater grew at an average annual rate of 17.9 percent.

Table 5-3. BIH Total Trips by Sailing Draft
(number of trips)

Draft (feet)	2007	2008	2009	2010	2011	Average
39	0	0	4	0	2	1.2
38	6	5	6	2	3	4.4
37	6	14	10	11	8	9.8
36	6	34	24	18	18	20
35	12	15	9	15	27	15.6
0–34	3,053	2,788	1,934	2,379	2,930	2,616.8
Total	3,083	2,856	1,987	2,425	2,988	2,667.8

Source: USACE, Waterborne Commerce of the U.S., Part 2, 2007–2011

As shown on Figure 5-1, the average tonnage per trip has increased over the past decade, which is consistent with fewer trips and greater volumes of tonnage. While the increases in the volume of tonnage per trip are primarily associated with petroleum products and dry bulk, larger vessels are also being used for Iron Ore/I&S products. It is anticipated that over the period of analysis, which in part will be due to the Panama Canal Expansion, there will be an increase in deeper-drafting vessels. If a deeper channel is available at BIH, vessels could be loaded to deeper drafts to maintain the patterns of the world vessel fleet. Also, the ability to deploy larger vessels or load existing fleet more fully will reduce per ton transportation costs for vessels using BIH, as the percentage increase tonnage per ship will be greater than the percentage increase in cost.



Source: USACE, Waterborne Commerce of the U.S., Part 2, 2001–2011

Figure 5-1: BIH Short Tons per Vessel Movement 2001–2011

5.4 UNDERKEEL CLEARANCE

Underkeel clearance is defined as the minimum clearance available between the deepest point on the vessel and the channel bottom, in still water. The Pilots require a 3-foot underkeel clearance for all deep-draft vessels; hence, the 39-foot draft restriction on all vessels at BIH. However, as larger bulk carriers and tankers enter the channel, the largest vessels may require a 4-foot underkeel clearance, which is consistent with the 10 percent standard often used for deep-draft navigation. In addition, there is a 1-foot underkeel clearance for all shallow-draft vessels. There is a 4-foot underkeel clearance for oil drilling rigs to transit the channel.

5.5 BULK CARRIERS

BIH's fleet of bulk carriers consists of foreign flag vessels with a variety of sizes. The following Table 5-4 provides the characteristics in which bulk carriers were classified for the analysis.

Table 5-4. BIH Bulk Carrier Fleet Classification Characteristics

Bulker Size	Capacity Range (DWT)	Design Draft Range (feet)	Beam Range (feet)	LOA Range (feet)
Very Small	3,000–20,000	25–30	60–75	400–480
Small	20,001–30,000	31–35	76–90	481–550
Medium Small	30,001–40,000	36––37	91–95	551–590
Medium Large	40,001––50,000	38–40	96–103	591–620
Large	50,001–60,000	41–43	104–106	621–700
Very Large	60,001–105,000	44–50	107–140	701–800

On average, 90 percent of the cargo tonnage transported by bulk carriers along BIH was on Medium Large or larger bulk carriers. Table 5-5 presents the average percentage of tonnage for dry bulk/break bulk products on bulkers by vessel Deadweight Tonnage (DWT). The average for 2007–2011 is more than 45 percent of dry bulk volume carried on very large bulkers. As shown in Figure 5-2, over the past decade, dry bulk tonnage has shifted from being carried solely on Very Small bulkers to predominantly Medium Large, Large, and Very Large bulkers.

Table 5-5. BIH Dry Bulk/Break Bulk Percentage of Tonnage by Vessel DWT

DWT Range	2007	2008	2009	2010	2011	Average
0–19,999	0	0	0	0.6	0	0.1
20,000–29,999	0	0.4	0	0	4.5	1.0
30,000–39,999	10.5	0	5.8	0	0	3.3
40,000–49,999	25.9	26.8	21.5	0	53	25.4
50,000–59,999	13.9	48.3	33.1	13.4	15.8	24.9
60,000+	49.7	24.5	39.6	86	26.7	45.3
Total	100	100	100	100	100	100

Source: USACE, NDC detailed unpublished data, 2007–2011

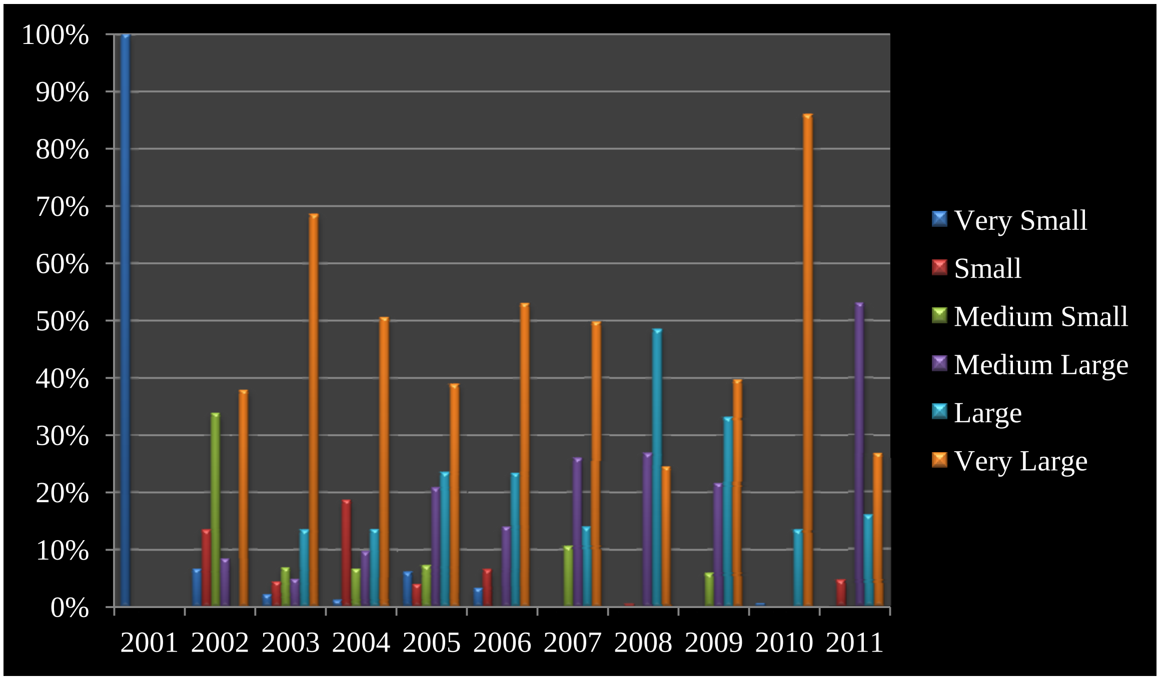


Figure 5-2: Percentage of Dry Bulk Tonnage on Bulkers

Table 5-6 presents the dry bulk tonnage carried on bulkers with design drafts of 39 feet or greater. Approximately 76 percent of the dry bulk tonnage for 2009–2011 was carried on bulkers with design drafts of 39 feet or greater.

Table 5-6. 2009–2011 Dry Bulk/Break Bulk Percentage of Tonnage on Bulkers with Design Drafts of 39 Feet or More

39	40	41	43	44	46
18.3%	2.8%	9.9%	13.5%	23.6%	7.5%

Source: USACE, NDC detailed unpublished data, 2009–2011

Table 5-7 presents the average percentage of tonnage for Iron Ore/I&S products on bulkers by vessel DWT. Nearly half of the iron ore volume is carried on Medium Large bulkers and another third is carried on Large bulkers. As shown on Figure 5-3, over the past decade, iron ore tonnage has shifted from being carried solely on Very Small bulkers to predominantly Medium Large and Large bulkers.

Table 5-8 presents the iron ore tonnage carried on bulkers with design drafts of 39 feet or greater. Approximately 50 percent of the dry bulk tonnage for 2009–2011 was carried on bulkers with design drafts of 39 feet or greater.

Table 5-7. BIH Iron Ore/I&S Products Percentage of Tonnage by Vessel DWT

DWT Range	2007	2008	2009	2010	2011	Average
0–19,999	4.2	4.8	4.3	2.7	1.6	3.5
20,000–29,999	9.6	10.8	3.8	0.8	0.3	5.1
30,000–39,999	23.5	8.0	0.8	1.3	3.5	7.4
40,000–49,999	46.1	47.3	64.6	46.0	37.2	48.2
50,000–59,999	16.6	25.8	26.5	49.2	57.4	35.1
60,000+	0	3.3	0	0	0	0.7
Total	100	100	100	100	100	100

Source: USACE, NDC detailed unpublished data, 2007–2011

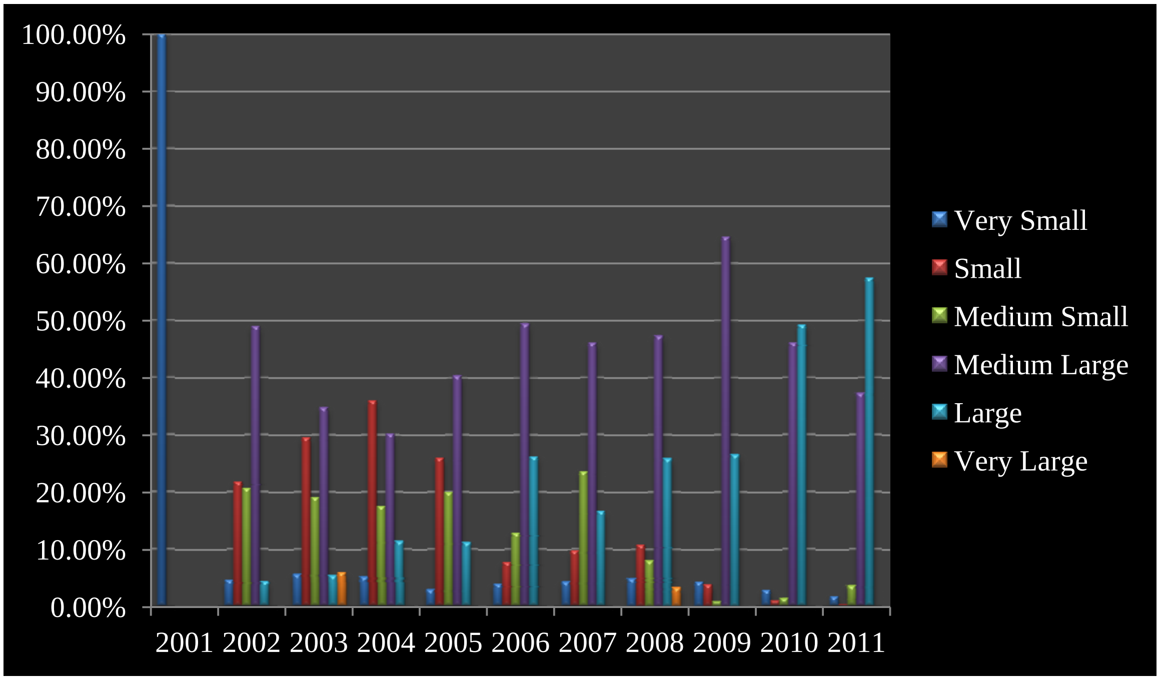


Figure 5-3: Percentage of Iron Ore/I&S Products Tonnage on Bulkers

Table 5-8. 2009–2011 Iron Ore/I&S Products Percentage of Tonnage on Bulkers with Design Drafts of 39 Feet or More

39	40	41	42
19.8	3.6	17.6	8.5

For both crude materials and primary manufactured goods, the fleet composition for 2007–2011 has shown a trend towards vessels with larger DWT ranges. Medium Large and larger bulk carriers have a deeper design draft and a greater average shipment size.

Table 5-9 presents the average world bulker fleet as of 2010. As shown, the Large and Very Large bulkers have been built most recently and with greater design drafts. It is assumed that the world fleet will continue this trend, especially as vessels are replaced.

Table 5-9. Bulker World Fleet Characteristics

Size	Number of Vessels	Average Design Draft (Feet)	Average Year Built
Very Small	2,142	22	1985
Small	1,920	32	1986
Medium Small	2,043	32	1996
Medium Large	963	37	1991
Large	1,954	36	2005
Very Large	2,729	41	2000

Source: Lloyd's Register – Fairplay, Register of Ships, 2010

5.6 TANKERS

BIH's fleet of tankers consists of foreign flag vessels with a variety of sizes. The following Table 5-10 provides the characteristics in which tankers were classified for the analysis.

Table 5-10. BIH Tanker Fleet Classification Characteristics

Size	Capacity Range (DWT)	Draft Range (feet)	Beam Range (feet)	LOA Range (feet)
Very Small	3,000–20,000	19–32	40–85	275–475
Small	20,001–30,000	32–35	86–90	476–615
Medium Small	30,001–40,000	36–37	91–105	616–660
Medium Large	40,001–50,000	38–41	106–110	661–670
Large	50,001–60,000	42–43	111–115	671–730
Very Large	60,001–110,000	44–50	116–140	731–800

Table 5-11 presents the average percentage of tonnage for petroleum products on tankers by vessel DWT. More than 90 percent of the petroleum volume is carried on Medium Large tankers or larger. As shown in Figure 5-4, over the past decade, petroleum products tonnage has shifted to primarily Medium Large and Large tankers.

Table 5-12 presents the petroleum products tonnage carried on tankers with design drafts of 39 feet or greater. Nearly 90 percent of the petroleum products tonnage for 2009–2011 was carried on tankers with design drafts of 39 feet or greater.

Table 5-11. BIH Petroleum Products Percentage of Tonnage by Vessel DWT

DWT Range	2007	2008	2009	2010	2011	Average
0–19,999	3.0	7.1	4.0	5.2	2.8	4.4
20,000–29,999	3.2	1.6	0.6	2.2	0.6	1.6
30,000–39,999	0	7.4	1.2	1.6	3.2	2.7
40,000–49,999	80.0	74.4	59.2	59.8	49.8	64.6
50,000–59,999	4.5	9.5	31.8	29.5	43.6	23.8
60,000+	9.3	0	3.2	1.7	0	2.8
Total	100	100	100	100	100	100

Source: USACE, NDC detailed unpublished data, 2007–2011

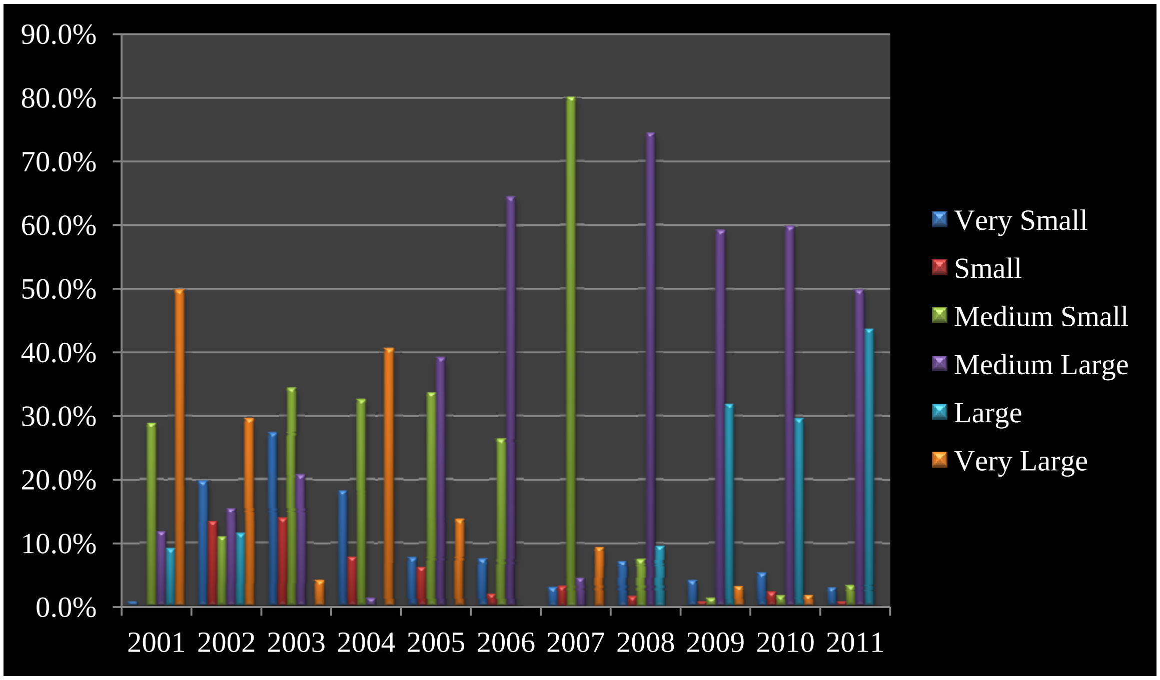


Figure 5-4: Percentage of Petroleum Products Tonnage on Tankers

Table 5-12. 2009–2011 Petroleum Products Percentage of Tonnage on Tankers with Design Drafts of 39 Feet or More

39	40	41	42	43	44	46	48
11.4	34.8	4.2	7.0	28.1	1.4	0.5	1.2

Source: USACE, NDC detailed unpublished data, 2009–2011

The fleet composition for 2007–2011 for petroleum products has shown a trend towards vessels with larger DWT ranges. Medium Large and larger tankers have a deeper design draft and a greater average shipment size.

Petroleum products that are carried on tankers have different densities, which affect the sailing drafts of vessels. While the vessel may be filled to capacity, the sailing draft will not be as deep. This is because certain petroleum products, such as gasoline, are not as dense, and therefore, not as heavy as other petroleum products, such as crude oil or distillate fuel oil. Gasoline is on average 90 percent of the petroleum products tonnage at BIH, while distillate fuel oil is approximately 10 percent of the volume. A representative Very Large tanker that visits BIH with a design draft of 48 feet would have a sailing draft of 43 feet if it was solely carrying gasoline, and 47 feet if it was solely carrying distillate fuel oil. A combination of gasoline and distillate fuel oil based on the historical tonnage composite at BIH would lead to a sailing draft of 44 feet.

The following Table 5-13 presents the average world tanker fleet as of 2010. As shown, the Medium Large and Large tankers have been built most recently and with greater design drafts. It is assumed that the world fleet will continue this trend, especially as vessels are replaced.

Table 5-13. Tanker World Fleet Characteristics

Size	Number of Vessels	Average Design Draft (feet)	Average Year Built
Very Small	10,760	22	1995
Small	737	32	1989
Medium Small	1,011	36	1994
Medium Large	1,344	37	2002
Large	592	41	2003
Very Large	1,401	42	1994

Source: Lloyd's Register – Fairplay, Register of Ships, 2010

5.7 OIL DRILLING RIGS

The following Table 5-14 provides the characteristics in which rigs were classified for the analysis.

Table 5-14. BIH Oil Drilling Rigs Classification Characteristics

Size	Capacity Range (DWT)	Draft Range (feet)	Beam Range (feet)	LOA Range (feet)
Jack Up	10,000–13,000	0–25	100–250	140–160
Semi-Submersible-Small	13,001–19,000	26–40	150–250	161–250
Semi-Submersible-Large	19,001–27,000	41–65	251–500	251–500

Keppel AmFELS (Amfels) is a large offshore rig facility at the Port that assembles and repairs oil drilling rigs and offshore platforms and also performs American Bureau of Shipping (ABS) inspections. The oil drilling rig fleet at BIH currently consists of jack-up and semi-submersible platform rigs.

Jack-up rigs are self-elevating with several movable legs that can be extended above or below the hull, and the legs are jacked downward through the water and into the sea floor. Jack-up rigs are typically for shallower water and are not self-propelled, but have been the most popular and numerous mobile platforms. These types of rigs generally are the smallest mobile platforms in terms of beam and length. Figure 5-5 is an example of a jack-up rig.

Semi-submersible rigs can float on top of the water, to allow transportation to various locations, and then are partially submerged during drilling operations, which can take place in deep ocean water. Semi-submersible rigs have become popular because the combination of the submerged portion of the rig and anchors ensure stability for use in turbulent offshore waters. The vast majorities of new drilling rigs are built or are being built to meet so called ultra deepwater specifications, generally described as the ability to drill in at least 12,000 feet of water and to a total vertical drilling depth of at least 30,000 feet. These types of rigs are grouped into generations based upon their era of construction, with a trend for increasing depth and capacities, such as dynamic positioning, over time. The newest semi-submersible rigs are classified as sixth and seventh generation and were either constructed or upgraded after 2004 and 2012, respectively. Dynamic positioning is used to keep a rig in place while drilling by using different motors or propulsion units on the vessel to counteract against the motions of the water. One such dynamic positioning unit is an azimuth thruster, which is retractable and removable. Tugs or heavy-lift vessels are used to transport a semi-submersible rig to its drilling location. Figure 5-6 is an example of a semi-submersible rig.

Figure 5-5: Jack-Up Rig Example

Figure 5-6: Semi-Submersible Rig Example

Since 1990, Amfels has built, inspected, modified, or upgraded 81 jack-up rigs and 26 semi-submersible rigs. The following Table 5-15 presents the average age of offshore structures in the Gulf of Mexico and the rest of the world. Rigs generally have a life span of 30-35 years, but this can be extended with upgrades to the rig for an additional 25–30 years.

The number of rigs operating in the Gulf of Mexico is very dependent on the oil industry and regulations for the industry. For example, when the moratorium was placed on deepwater offshore drilling on the Outer Continental Shelf in 2010, several rigs relocated to the African coast. Since the moratorium was lifted, those rigs have returned to the Gulf of Mexico and the Bureau of Ocean Energy Management continues to offer leases for deepwater offshore exploration and drilling. The ABS regulations require a rig to be inspected every five years, which can be completed in the water, but every 10 years, a full inspection is required on a dry dock. Also, rig owners often choose to return a rig to dry dock within a year or two of construction for inspection to review for the warranty. In the mid-1990s, Amfels purchased a former U.S. Navy dry dock that was operated in Europe to service nuclear submarines and was decommissioned after the Cold War. Amfels purchased the dry dock for $1 million, which represents considerable savings compared to a new dry dock that would have cost $50 million. The dry dock is one of the largest in the industry, which offers a competitive advantage to

Table 5-15. Offshore Drilling Structures Age

	Drill Ship		Jack-Up		Semi-Submersible		Submersible		Total	
	Rest of the World	Gulf of Mexico	Rest of the World	Gulf of Mexico	Rest of the World	Gulf of Mexico	Rest of the World	Gulf of Mexico	Rest of the World	Gulf of Mexico
Average Age	25.7	6.2	21.8	28.9	23.5	19.7		28.3	23	25.4
Decade Offshore Structure was Built										
<1970	56	N/A	45	2	12	1	N/A	N/A	113	3
1970–1979	36	N/A	112	42	106	11	N/A	N/A	254	53
1980–1989	46	N/A	239	54	105	7	N/A	6	390	67
1990–1999	29	3	31	1	15	1	N/A	N/A	75	5
2000–2009	15	5	111	4	42	10	N/A	N/A	168	19
>2009	55	3	96	6	48	5	N/A	N/A	199	14
Unknown	35	N/A	85	N/A	9	N/A	N/A	N/A	129	
Total	272	11	719	109	337	35	N/A	6	1,328	161

Amfels. Pascagoula, Mississippi, is the only other U.S. port that has a dry dock where jack-ups and semi-submersible rigs can be constructed, modified, or inspected. However, Pascagoula has a shallower depth than BIH. If a rig needs to be placed on a dry dock that cannot fit into the Brownsville or Pascagoula channels, the rig would have to travel to another country, such as Brazil, Norway, or Singapore.

As drilling rigs are built larger, the ability for semi-submersibles to transit the BSC becomes limited due to the current dimensions of the channel. A semi-submersible's breadth is mostly above water, not near the seabed and the depth is only significant due to the rig's thrusters, as the thrusters can add an additional 15 to 20 feet in depth to the hull of a semi-submersible rig. Therefore, the limitations of a rig traveling to BIH are mostly due to the thrusters, which can be used to move the rig into and through the channel. Thrusters can be removed from the rig before entering the channel to remove the depth restrictions, but this has yet to be done at BIH for a variety of reasons.

Removing thrusters before entering the channel can be cost prohibitive because of the additional expense this adds to the vessel transportation to the channel. Among the elements included in the thruster removal costs are tractor tugs (to be transported from Corpus Christi Ship Channel), divers to remove the thrusters, a crane barge, crew, and miscellaneous support. On average it takes one day to remove or reattach one thruster and a semi-submersible rig typically has four to eight thrusters that need to be removed to enter the channel and then reattached after the work on the rig in the channel has been completed. The total cost to remove and then reattach the thrusters offshore can be upwards of $15 million. In addition, as shown in Table 5-15, over 100 semi-submersible rigs have been built since 2000, and so not all have required their decadal ABS dry dock inspection. Also, the rigs have not yet required significant retrofitting due to their age.

However, while thrusters have not, to date, been removed offshore for a rig to enter the BSC, it is reasonable to assume that in the future, the without project condition will experience rigs entering the channel with their thrusters removed for a variety of reasons. No matter where in the world a rig travels to, including BIH for modifications or inspections, if it will be dry docked, the thrusters will need to be removed. Thrusters protrude significantly and because of their height, scaffolding would likely have to be 20 feet high for work to be completed, which increases the difficulty and adds additional risk. Thus, thrusters will always be removed; it is just a matter of whether or not it will be done at the dock or in the case of BIH, outside the channel in the without-project condition. The with-project condition assumes thrusters will also be removed at BIH, but that would be done dockside in that condition.

As mentioned above, the newest semi-submersible rigs have not reached the age in which they have required their decadal ABS inspection or modifications. As the fleet ages, though, drilling rig owners would rather have a rig operating in the Gulf of Mexico visit a local port for repair or inspection in order to reduce the transit time and cost. BIH will be competitive because Rolls-Royce, a major thruster manufacturer, is located in Houston so the thrusters can be removed for service within 300 miles of where the rig is being serviced. Even with the cost to remove and reattach the thrusters at sea before entering BIH, it is more time effective than moving the rig to a foreign country. With the assumption that it will take a week to remove the thrusters and another week to reattach the thrusters for a rig to visit BIH, this is only two weeks of downtime, but the downtime would be longer if a rig has to move to a foreign country for service. A semi-submersible rig can only move five knots an hour under its own power, and if a rig were to move from the Gulf of Mexico to Brazil, it would take the rig over 40 days to relocate. Typically, a rig would be moved under tow, which would still take over 20 days to reach Brazil. A rig owner could also choose to move the rig via heavy-lift vessel, which would take 20 days to reach West Africa or 40 days to reach Singapore. Either way, a rig will experience at least an additional week of downtime to travel overseas. In addition, an offshore oil drilling rig can produce 200,000 barrels of oil daily, which may lead the rig owner to earn $500,000 a day. Therefore, the cost to remove the thrusters to visit BIH will in the future be as cost effective as moving the rig overseas because it will reduce downtime and avoid additional risk of damage from moving the rig over large distances, which significantly increases the insurance rates on the rig.

Taking into consideration the competition to keep rigs near the Gulf of Mexico, the time and cost savings to remove the thrusters at BIH, and the upcoming need for inspections and modifications, it is reasonable to assume that thrusters will be removed at BIH in the near future, even without the channel modifications. Amfels has taken measures to be ready for such activities by securing a regulatory permit from USACE for a square mile of land six miles from the channel jetties where the thrusters will be able to be removed. Amfels has incurred the cost for this permit as commitment to remove thrusters in the without project condition in attempt to remain competitive in the oil drilling rig fabrication market while oil production occurs in the Gulf of Mexico because if the channel dimensions are increased, it will eliminate the need to remove thrusters from a rig before entering the channel.

The number of rigs that can be docked at the Amfels facilities at one time is dependent on a variety of factors, to include yard capacity, Gulf of Mexico drilling demand, and the type of work that is required. For example, an inspection will generally only take 60 days, while repairs can take 6 months or longer. As the rigs do not fall within the traditional transportation cost savings category because they are in Port for months on end, the only costs allocated to the rigs in the analysis are related to the thruster removal, which only applies in the without-project condition since they do not need to be removed offshore with the recommended plan. To account for all of these conditions, the analysis assumed a conservative number of rigs in the with- and without-project conditions during the period of analysis, with just a different mix of the types of rigs that would visit the Port.

5.8 DESIGN VESSELS

A design vessel for a particular vessel type represents among the largest vessels that are expected to call over the study period of analysis on a recurring basis. The identification of the design vessel(s) is important so that decision makers can be reasonably confident that the project costs will result in a channel design that will accommodate cost-effective vessel traffic for the future at BIH.

In May and September of 2010, the Engineering Research and Development Center (ERDC) performed ship simulations for BIH for depths of 42, 45, and 48 feet and various widths, with an assumed three feet of underkeel clearance. This simulation included a 2-foot allowance so it could also be applied to the 50-foot depth. ERDC modeled two vessels, a tanker with dimensions of 846 feet x 157 feet x 47 feet and a Very Large Crude Carrier (VLCC) with dimensions of 1,087 feet x 195 feet x 24 feet. The tanker was selected because it was one of the vessels ERDC had in their database that was larger than any vessels currently coming into the channel. The VLCC was selected because it was a part of ERDC’s database and represented the largest vessel that would come in to be scrapped. Originally, a bulker vessel was to be modeled for future conditions, but the one selected could already safely travel in the existing channel dimensions. However, since the ship simulation was completed, it was determined that the tanker modeled will not be part of the vessel fleet that will visit BIH in the future.

In addition, the BIH shipbreaker industry recently conducted a separate ship simulation study with ERDC to model transits of aircraft carriers, which is now the largest vessel the shipbreaker facilities expect to service. This simulation study indicated these aircraft carriers can come in under the current channel dimensions. Based on these results, the modeled VLCC should also be able to use the existing channel with no restrictions. The updated fleet forecast and shipbreaker modeling outcome have negated the results of the 2010 ship simulation so that the ship simulation's recommendations should no longer be used as the basis to increase the size of the channel.

In May 2010, a geometric analysis was performed by DOF Subsea to show a real time oil rig movement simulation for two rigs. The design rig for the modeling was based on the widest beam and deepest draft expected to be accommodated in future transit of the Port of Brownsville navigation channel. The analysis was performed with the rig's thrusters in place. These thrusters require additional channel depth beneath the oil rig. Significant savings could occur if these thrusters did not have to be removed offshore because the offshore removal process requires additional time and specialized diver expertise. The geometric analysis included channel widths of 300 and 350 feet. The geometric analysis results supported the need for the 50-foot channel depth and 350-foot width.

For the rigs, 43 percent of the original list of rigs used in the rig geometric analysis needed a maximum width of 300 feet; 11 percent more, or 54 percent of total, require 325 feet; and 74 percent of all the rigs could get in with a width of 350 feet. However, the recent report developed for the Section 6009 benefits forecasts more drillships working in the Gulf of Mexico rather than semi-submersibles in the future. These drillships need more depth to traverse the channel and would not need additional widening. This has negated the need to widen the channel to the 350-foot width as was shown in the geometric rig movement analysis.

The design vessel for the proposed deepening is the oil rig with a draft of 48 feet and 4 feet of underkeel clearance. This is a large semi-submersible rig that will enter the channel with its thrusters still attached. An additional design vessel is a tanker that has a design draft of 47.5 feet and a beam of 106 feet. This vessel assumes a 4 feet underkeel clearance.

5.9 FUTURE FLEET COMPOSITION

Projections of BIH's future fleet composition are based on the integration of an average of 2009–2011 vessel and commodity movements with commodity growth projections as presented in Section 6. Vessel and commodity movements were initially developed using commodity movement data acquired from WCSC, and compared to the Pilots logs. Each movement consists of an individual vessel calling the Port to transport a certain type and tonnage of commodity to or from a terminal within the harbor. The commodity movements for 2010 became the basis for future fleet growth to the base year of 2021, and throughout the period of analysis. The fleet grew based on the following methodology:

1. Each 2010 commodity movement was broken down to its essential components as follows: date of call, vessel type, calling port, dock visited, commodity type, and tonnage transported.

2. The commodity movement’s proportion of the annual tonnage for the commodity type being transported on the individual vessel fleet size categories was calculated. Based on this proportion, future forecasted tonnages were disaggregated to individual commodity movements. Thus, forecasted tonnages for 2021 were developed based on 2010 commodity movement proportions. Commodity forecast tonnages for each additional 10 years were disaggregated based on 2021 commodity movement proportions, thereby increasing the tonnage transported per vessel.
3. Generally, each future individual commodity movement transports more cargo than the preceding forecasted year throughout the period of analysis (or less in some cases where negative growth rates occur). An additional vessel call is added in the event of the following:
    a. When cargo tonnage carried by the vessel exceeds the vessel’s capacity.
    b. Tonnage added to the vessel would result in a sailing draft in excess of the channel and/or berthing depth.

Therefore, the number of vessel calls is primarily dependent on the proportion of tonnage for the individual vessel categories and sizes. The difference between the number of vessel calls in the without-project and with-project conditions is that the larger vessels are able to carry more volume and have deeper sailing drafts, thereby leading to fewer vessel calls in the with-project condition. Also, for the period of analysis for both the with- and without-project condition, it is assumed that all vessels are transiting as efficiently as possible, which leads to fewer overall vessel calls than in the current condition.

The following Tables 5-16 through 5-19 present the fleet composition for the primary benefiting commodities for the period of analysis. The future fleet is based on the information presented above in this section, such as the world fleet. Due to the lag before the period of analysis is scheduled to begin and the fact that there are a relatively small number of annual vessel trips, it was assumed that shippers would be fully aware of the new channel dimensions at BIH and could prepare by transitioning the vessel fleet to larger capacity limit vessels by 2021. Based on the bulker world fleet, in which there are newer and a greater number of Very Large bulkers, it was reasonable to transition to a larger percentage of tonnage on such vessels. The Very Large bulkers were also introduced for the Iron Ore/I&S Products for the same reason. The tonnage for petroleum products experienced a shift from Medium Large tankers to Very Large tankers because the world fleet also has a new and greater number of Very Large tankers. For each commodity, the vessel fleet transition from 2010 to 2021 remained the same for the first 20 years of the period of analysis, and then there was an additional shift in 2041, which remained the same for the remainder of the period of analysis. These assumptions for the vessel fleet will lead to transportation cost savings as tonnage is transported on larger vessels with a reduced number of total vessel trips.

Table 5-16. Dry Bulk/Break Bulk Bulker Forecasted Vessel Trips

Bulker Size	2010 % of Total Tonnage	2021 % of Total Tonnage	2021 Without Project Trips	2021 With Project Trips	2031 % of Total Tonnage	2031 Without Project Trips	2031 With Project Trips	2041–2071 % of Total Tonnage	2041–2071 Without Project Trips	2041–2071 With Project Trips
Very Small	5	5	3	2	5	3	4	5	4	2
Medium Large	13	5	1	1	5	1	1	0	0	0
Large	15	10	2	1	10	2	2	5	1	1
Very Large	66	80	11	8	80	13	11	90	16	14
Total	100	100	17	12	100	19	18	100	21	17

Table 5-17. Iron Ore/I&S Products Bulker Forecasted Vessel Trips

Bulker Size	2010 % of Total Tonnage	2021 % of Total Tonnage	2021 Without Project Trips	2021 WP Trips	2031 % of Total Tonnage	2031 Without Project Trips	2031 With Project Trips	2041–2071 % of Total Tonnage	2041–2071 Without Project Trips	2041–2071 With Project Trips
Small	1	0	0	0	0	0	0	0	0	0
Medium Small	1	4	1	0	4	2	0	4	3	3
Medium Large	46	31	10	8	31	12	12	25	11	11
Large	49	40	12	9	40	13	13	36	13	13
Very Large	0	25	6	5	25	7	7	35	10	8
Total	100	100	29	22	100	34	32	100	37	35

Table 5-18. Petroleum Products Tanker and Deep-Draft Barge Forecasted Vessel Trips

Vessel Size	2010 % of Total Tonnage	2021 % of Total Tonnage	2021 Without Project Trips	2021 With Project Trips	2031 % of Total Tonnage	2031 Without Project Trips	2031 With Project Trips	2041–2071 % of Total Tonnage	2041–2071 Without Project Trips	2041–2071 With Project Trips
Liquid Barge-Ocean	100	100	39	39	100	45	45	100	47	47
Very Small	4	4	6	4	4	7	5	2	3	3
Small	2	0	0	0	0	0	0	0	0	0
Medium Small	6	4	3	2	4	3	3	2	2	1
Medium Large	51	21	10	9	21	12	12	11	6	6
Large	26	30	12	10	30	14	14	25	12	12
Very Large	11	40	13	10	40	15	13	60	24	21
Total	100	100	83	74	100	96	92	100	94	90

Table 5-19. Oil Drilling Rigs Forecasted Vessel Trips

Rig Size	2021–2051 Yearly Without Project Trips	2021–2051 Yearly With Project Trips	2061–2071 Yearly Without Project Trips	2061–2071 Yearly With Project Trips
Rig-Jack-Up	4	2	3	2
Rig-Semi-Submersible Small	3	5	3	4
Rig-Semi-Submersible Large	1	1	1	1
Total	8	8	7	7

6.0 ALTERNATIVE EVALUATION

6.1 METHODOLOGY

A HarborSym analysis was conducted to determine the Recommended Plan. The analysis used the most current data available at the time, which was 2010. Based on the various alternatives studied, the analysis determined the Recommended Plan width and depth selection.

HarborSym is a discrete-event Monte Carlo simulation model of vessel movements in harbors that measures delays and allocates costs to a navigation system. The HarborSym model is the primary, approved evaluation tool used by USACE to evaluate economic benefits for channel deepening and/or widening alternatives. The model measures the economic effects of modifications to deep draft harbors as overall reductions in transit times and associated changes in total vessel operating costs. The model is oriented primarily towards improvements that reduce congestion in the waterway or increase vessel operating efficiencies, as opposed to landside materials handling improvements, although changes to loading/unloading times can be represented. The simulation results can be used in a comparative analysis of alternative harbor improvements and to support a general benefit-cost analysis of proposed navigation improvements.

6.2 BIH HARBORSYM MODEL

This section describes the BIH HarborSym Model Version 1.5.5 and its inputs. HarborSym is a data-driven Monte Carlo simulation model and was developed by the USACE Institute of Water Resources (IWR) to assist in economic analyses of proposed deep-draft channel improvements. It is a planning-level model that creates an event-driven simulation based on data stored in a database. Transit rules that are BIH specific are included in the system, and the model processes each vessel call in order to compute transit delays within the system. HarborSym used the alternatives to determine the potential transportation cost savings from reduced delays and improved efficiencies, which equate to benefits. HarborSym served as the primary evaluation tool for estimating navigation benefits for the proposed channel improvement alternatives. The model determines transportation cost savings by computing quantities, such as transit times, unloading times, and transportation costs. All calculations and assumptions are based on BIH-specific data and information, such as commodity and fleet forecasts and traffic rules, all of which have been reviewed by the Deep-Draft Navigation Planning Center of Expertise (DDNPCX).

HarborSym is a tree-structured network of reaches and nodes built by the user. The reaches represent channels in the harbor, whereas the nodes represent docks, anchorages, and turning areas. When a vessel visits the Port, it is called a vessel call. All vessel calls may adhere to transit restrictions that are based on the channel dimensions and/or vessel characteristics that result in delays until the restriction is alleviated. The vessel classifications, commodity categories, and basic vessel call information are defined by the user. The HarborSym model then uses these inputs to simulate vessel traffic in user-defined scenarios. Transportation cost savings are computed for each project alternative, which allows for a comparison of the plans.

HarborSym's Monte Carlo simulations mimic movements of vessels through a harbor. The systems created in HarborSym have randomized behavior in terms of generation of trips, loading and unloading times at docks, and docking and undocking time. The user inputs statistical parameters with minimum, maximum, and most likely values. The key features of the model are:

- User defined network describing the port;
- Historical vessel calls, with multiple commodities and docks;
- User definition of vessel classes commodity types, and route groups;
- Tidal influence and internal calculation of tide height and current by reach;
- Transit analysis based on user-parameterized rules; and
- Intra-harbor vessel movements.

6.2.1 Specific Physical and Descriptive Characteristics of BIH

This includes the specific network of BIH, such as the node locations and types, reaches, and tide and current stations, as appropriate. The following Table 6-1 provides the list of reaches and nodes used in HarborSym to simulate the channel. HarborSym does not allow vessels to wait within the turning basin and other traffic must wait while turning maneuvers are completed. A triangular distribution of minimum, maximum, and most likely time required to utilize the turning basin is required for each vessel type, and in the case of BIH those times range from 10 minutes to 90 minutes. These times are based on historical information gathered from the end-users and pilots and there are no changes to these times in the without-project versus the with-project condition since the turning basin dimensions are not expected to change. While the oil rigs and scrap vessels have the highest vessel turning basin times, these types of vessels are not expected to use the turning basin. In addition, the bulkers and tankers are required to use the turning basin at their lightest condition, meaning they may offload their cargo before using the turning basin and loading to exit the channel.

Further physical characteristic inputs of the channel used in HarborSym are presented in Table 6-2, BIH Dock Information and Table 6-3, Current Dimensions of the Brownsville Ship Channel. The dock depths used for the Recommended Plan alternative are presented in Table 6-2.

Table 6-1. BIH Reach Names

Entrance Channel (Entry/Exit)
Jetty Channel (Topologic Node)
Laguna Madre (Topologic Node)
Brownsville Ship Channel
GIWW (Barge Entry/Exit)
Reach 5 (to Amfels Dock)
Reach 6 (to International Shipbreaking Dock)
Reach 7 (to Transforma Dock)
Reach 8 (to Esco Dock)
Reach 9 (to Liquid Dock)
Reach 10 (to Oil Docks 3 & 5)
Reach 11 (to Docks 15 & 16)
Reach 12 (to BC Dock)
Reach 13 (to Oil Docks 1 & 2)
Reach 14 (to Docks 12 & 13)
Reach 15 (to Docks 7 & 8)
Reach 16 (to Docks 10 & 11)
Reach 17 (to Docks 1, 2, & 4)
Reach 18 (to Dock 3)
Reach 19 (to Turning Basin)

Table 6-2.BIH HarborSym Dock Information for Recommended Plan

Dock Name	Length (feet)	Limiting Depth (feet)
Amfels	2,700	51
BC Dock	800	49
Docks 1, 2, and 4	1,250	32
Dock 3	450	32
Docks 7 and 8	1,000	29
Docks 10 and 11	1,250	32
Docks 12 and 13	1,120	32
Docks 15 and 16[21]	1,450	49
Esco	2,060	35
International Shipbreaking	1,600	20
Liquid Dock	450	49
Oil Dock 1 and 2	675	42
Oil Dock 3 and 5	1,425	49
Transforma	1,000	20

6.2.2 Vessel Speeds

Vessel speeds for the BSC by vessel class for both loaded and light-loaded conditions were determined with assistance of the Pilots and end-users. For the reaches past the BSC reach, 5 knots was used for all vessels, except for oil drilling rigs, which used a speed of 2.5 knots. The speeds are fixed numbers, not defined by a distribution and were determined not to be different in the without and with-project condition because of the docks.

6.2.3 Transit Rules for each Reach

Rules for each reach reflect restrictions on passing, overtaking, and meeting, and are used to determine delays in the system. There are several types of rules (such as no passing or no meeting) that are applicable to a certain condition (day, night, always), and that are restricted by vessel specifications (beam, draft, length). The rules are BIH specific and were derived from the Pilots' rules. Rules are specific to a particular vessel type and reach. The rules for transiting the reaches of BIH under the without-project condition are as follows.

Entrance Channel

Draft limit of 38 feet plus tide to a maximum draft of 39 feet.
Draft limit of 34 feet to transit inbound or outbound if the current is 1 knot or greater.

[21] Please note that as of May 2014, Dock 16 has not been built. However, the Port has plans to construct Dock 16 before the period of analysis begins, and thus, it has been included in the analysis.

No vessel may meet (as this is not a two-way traffic channel).

Scrap vessels are not allowed to travel at night.

Jetty Channel Reach

No vessel may meet (as this is not a two-way traffic channel).

Laguna Madre Reach

No vessel may meet (as this is not a two-way traffic channel).

Brownsville Ship Channel Reach

No vessel may meet (as this is not a two-way traffic channel).

Reach 19

Draft limit of 35 feet plus tide to a maximum draft of 36 feet.

Draft limit of 34 feet in the absence of tide.

Entire BIH Channel

Oil rigs are not allowed to travel at night.

No channel entrance if the draft plus tide or underkeel is greater than the moving vessel's draft.

Vessels must always stay within the safety zone limits as set throughout the projects.

6.2.4 General Information

General information includes BIH specific vessel and commodity classes (classified by WCSC data and Pilots' logs), commodity transfer rates at dock (provided by end-users at BIH), and specifications of vessel docking time at each dock, estimated to be 0.25–2 hours (depending on the vessel type). The following Table 6-3 provides more detail on examples of the commodity transfer rates used in the model. When a vessel arrives at a dock, the HarborSym model will pick from the triangular distribution of commodity transfer rates to determine how long it will take to load or unload the cargo.

6.2.1 Vessel Calls

Vessel call lists are made up of vessel calls that are specific to a given year. Each call is given a movement number based on its date and time of entry. The vessel call list is imported into HarborSym using an Excel spreadsheet. Vessel call lists were developed using WCSC data from 2010, in comparison to the 2010 Pilots' logs. Future growth rates were developed and applied to out-year vessel call lists using a variety of methods based on the individual commodity group, as explained above in Section 5. Call lists were developed for 2017, 2037, and 2067.

Table 6-3. BIH HarborSym Commodity Transfer Rates (Short Tons per Hour)

Vessel Type	Commodity Category	Loading Rate (hourly) Units			Unloading Rate (hourly) Units		
		Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Barge-Liquid	Petroleum Products	300	1,125	1,500	300	1,125	1,500
Barge-Dry Open	Iron Ore/I&S Products	200	350	500	150	250	350
Barge-Dry Open	Dry Bulk/Break-Bulk Products	200	350	500	150	250	350
Bulk Carrier	Iron Ore/I&S Products	150	275	400	100	175	250
Bulk Carrier	Dry Bulk/Break-Bulk Products	200	350	500	150	250	350
Tanker	Petroleum Products	750	1,500	2,250	750	1,500	2,250
Shipbreaking	Scrap	900	1,100	1,300	0.001	0.001	0.001
Oil Rig	Drilling Rigs	10	10	10	0.005	0.01	0.015

6.2.2 Vessel Call Lists

The Vessel Call List is the primary parameter of the Monte Carlo simulation. For all ports, there is a fleet of specific vessel types that transit. BIH has the following vessel types currently transiting: Bulk Carriers, Tankers, General Cargo, Barges, Tugboats, Shipbreaking vessels, and Oil Rigs. The fleet of vessels at the port is described in Tables 5-4, BIH Bulk Carrier Fleet Classification Characteristics, 5-10, BIH Tanker Fleet Classification Characteristics, and 5-14, BIH Oil Drilling Rigs Classification Characteristics.

Each vessel call list contains the following information: Arrival Date, Arrival Time, Vessel Name, Entry Point, Exit Point, Arrival Draft, Import/Export, Dock, Dock Number, Dock Order, Commodity, Commodity Number, Tons, Origin/Destination, Vessel Type, Vessel Type Number, Unique Vessel Identifier (IMO), Net Register Tonnage (NRT), Gross Register Tonnage (GRT), DWT, Capacity, LOA, Beam, Draft, Flag, and Tons per Inch (TPI) Factor. The call list was compiled using data provided by the WCSC, the Pilots, Lloyds Register, and the IWR NED Procedures Manual. Table 6-4 presents the cargo capacity factors published in the deep-draft manual for bulkers and tankers that was used for the load factors.

Table 6-4. Adjustments for Estimating Actual Vessel Capacity Shorts Tons of Cargo as a Percentage of Vessel DWT

Vessel DWT	% of Cargo to DWT
<20,000	90
20,000-70,000	92
70,000-120,000	95

Source: USACE[22]

The route groups and the mileage assumed are presented in Table 6-5.

Table 6-5. BIH HarborSym Route Groups

Route Group Name	Assumed Countries Included	Mileage Distance Distribution (Nautical Miles)
Asia	China, Taiwan, Malaysia, Singapore	10,110–11,742
Canada	Canada	2,500–3,500
Central America/Northern South America	Bahamas, Panama, Colombia, Venezuela	1,074–1,759
East Europe	Italy, Sweden, Lithuania, Latvia, Finland, Russia	5,531–6,055
Mexico	Mexico	500–600
North Africa/West Europe	Portugal, Morocco, Spain	4,610–4,819
North Europe	Netherlands, Belgium, Norway, United Kingdom	5,099–5,127
Orient	Australia, Russia, Japan, South Korea	9,167–9,613
South Africa	South Africa	7,000–8,000
South America	South America	4,253–5,326

Source: Distances received from http://sea-distances.com/index.htm

[22] USACE, IWR Report 91-R-13, National Economic Development Procedures Manual, Deep-Draft Navigation, November 1991, p. 77 and May 2008 draft.

6.3 INITIAL MODEL RUNS/SCREENING

The HarborSym analysis was performed to assess the vessel transit time reductions and increased vessel operating efficiencies for proposed channel improvements. The benefits of channel improvements were estimated in terms of reductions in harbor transit times and consequent vessel delays, as well as the reduction in total harbor costs as a result of efficiencies gained through the improvements. Transit times and transportation costs were estimated by analyzing the most likely condition in the absence of an improved channel at BIH, which is the without-project condition, and the proposed channel improvement alternatives for the 50-year period of analysis. The without-project scenario was analyzed next to 12 channel improvement alternative scenarios, each for three distinct years during the period of analysis, i.e., 2017: the beginning of the period of analysis, 2037: the middle of the period of analysis, and 2067: the end of the period of analysis. Please note that the period of analysis has since changed, as described later (see Section 7). Table 6-6 provides the list of alternatives evaluated in the HarborSym analysis.

Table 6-6. HarborSym Model Alternative Runs

CurrentCondition2010 (used as validation)	*45x250WP2017	48x250WP2017	50x250WP2017	52x250WP2017
*WOP2017	45x250WP2037	48x250WP2037	50x250WP2037	52x250WP2037
WOP2037	45x250WP2067	48x250WP2067	50x250WP2067	52x250WP2067
WOP2067	45x300WP2017	48x300WP2017	50x300WP2017	52x300WP2017
	45x300WP2037	48x300WP2037	50x300WP2037	52x300WP2037
	45x300WP2067	48x300WP2067	50x300WP2067	52x300WP2067
	45x350WP2017	48x350WP2017	50x350WP2017	52x350WP2017
	45x350WP2037	48x350WP2037	50x350WP2037	52x350WP2037
	45x350WP2067	48x350WP2067	50x350WP2067	52x350WP2067

*WP = with project; WOP = without project

6.3.1 Parameters of the Simulation Run

This includes start date, duration, number of iterations, wait time before rechecking rules, and the level of detail of the results output.

The model for BIH was run for the Base Year and Years 20 and 50 for all alternatives. Using the HarborSym output files, it was determined that the model results for the vessel operating times in the system became consistent after approximately 50 iterations; thus, this was the number of iterations run for this analysis. The duration for each model run was 8,760 hours, or 1 year. The wait time is the amount of time a vessel is delayed before attempting to move once it has been delayed, and for this analysis, 10 minutes was used for the wait time.

There are several elements of variability that are incorporated into the model when more than one iteration is run, which includes, vessel arrival time, vessel operating costs, turning time, vessel docking time, commodity transfer rates, speed at sea, and at sea distances. HarborSym perturbs the arrival date and time of each call between iterations, but the other factors stated above are all drawn from the triangular distribution, based on the information provided in the model.

6.3.2 Legs and Wait Times

Each vessel call is composed of a system of legs. A leg is a system of reaches between a stopping point, such as a dock or anchorage. A vessel cannot stop unless it is at a dock, anchorage, or a turning basin. If a rule restricts a vessel, that vessel must wait at a dock, anchorage, turning basin, or at the entry node until the rule restriction is no longer valid, at which point in time the vessel may continue to transit the system. A vessel will wait for a time period, specified for BIH, and then attempt to enter the leg again. This process is repeated in the system until the vessel may enter. The accumulated waiting times at each location are stored in HarborSym, along with the statistics associated with each rule. On arrival at a dock, the quantity of commodity transferred is used, in conjunction with the vessel TPI, to calculate the departure draft based on the arrival draft. Draft on departure from the dock is important in the process of checking the leg to determine if the vessel can proceed.

6.3.3 Priority Vessels

As a Monte Carlo event-driven model, each vessel call is modeled separately and its particular interactions with other vessels are applied. Each iteration places vessel calls in a priority queue based on arrival time. All of BIH’s deep-draft vessels are priority vessels, as they have priority over the barges. Priority vessels are not typically subjected to delays, but would still benefit from improvements to the channel, such as deeper drafts, higher unloading rates, etc.

6.3.4 Outputs

A number of parameters are collected and stored in HarborSym after the model runs occur. Among those parameters are the number of vessels entering and exiting BIH, the average time a vessel spends in the BIH system (to include time at a dock and transiting), total cost of the fleet and the average cost per vessel class, vessel times spent waiting, vessel times in anchorage areas, vessel times docking and undocking, vessel times loading and unloading, commodity quantities transferred, and total commodity statistics at the port. These outputs are then used to compute benefits. All outputs have been reviewed by the DDNPCX.

6.3.5 Economic Analysis

The economic analysis compares the without-project condition to each alternative with-project condition over a 50-year period of analysis. The without-project condition shows the existing channel conditions, as well as any anticipated channel changes that will be implemented in absence of the project. The traffic and commodity forecasts for the without-project condition are based on conditions of the channel without the project. The model simulates the without-project condition based upon the parameters that are currently maintained. The existing rules and their parameters were programmed into HarborSym to allow for an accurate picture of the current reality. The future parameters of the system were used to represent channel conditions both under the with- and without-project conditions. The with-project conditions illustrate the channel system if the particular alternative is implemented. Benefits for BIH were computed based on a decrease in delay times/transit costs for a channel alternative.

Commodity tonnage volumes, vessel loadings, and distributions of vessel classes were extrapolated from Pilots' logs and WCSC data using the commodity traffic forecasts discussed in previous sections. For each alternative and decade, transit times and delays were estimated by individual vessel movements. HarborSym measures the cost of delays in the system associated with transit rules and restrictions. The vessel operating costs are by vessel type and are for both in port and at sea. However, each vessel type will only have an operating cost related to domestic or foreign cost depending on the country flag of the vessel, for example, the barges are domestic vessels and thus are only associated with domestic operating costs. The deep-draft vessel operating costs were supplied by IWR per EGM 11-05, while the Shallow-Draft/Inland Vessel Operating Costs were provided by Informa Economics. The following Tables 6-7 and 6-8 present the vessel operating costs used in HarborSym.

6.3.1 Analysis Results

HarborSym provides detailed output from simulations. The Total Time in the System is the time vessels spend between arrival at the harbor and exit from the harbor and is based upon the number of vessels exiting the system. The hourly costs for each vessel class (at sea/in port) are then used to derive the Total Operating Costs for the system. Ultimately, the goal when using Harborsym is to measure the benefits of potential harbor improvements. Once the model has estimated the amount of time vessels spend in the harbor under current harbor conditions, and therefore has quantified the total operating cost for the system, the benefits of any harbor improvements will be reduced time that vessels spend in the harbor, in return reducing cost.

Table 6-7. BIH HarborSym Barge, Tank, and Bulker Operating Costs in Dollars[23]

Vessel Type	Hourly Domestic Operating Cost						Hourly Foreign Operating Cost					
	At Sea			In Port			At Sea			In Port		
	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
Barge-Liquid	261	300	435	271	291	312	1	1	1	1	1	1
Barge Ocean-Liquid	1,131	1,230	1,422	956	1,062	1,168	1	1	1	1	1	1
Barge-Dry Open	261	300	435	256	274	296	1	1	1	1	1	1
Tank Ship-Very Small	1	1	1	1	1	1	738	825	920	400	453	678
Tank Ship-Small	1	1	1	1	1	1	806	903	1,008	450	500	751
Tank Ship-Medium Small	1	1	1	1	1	1	915	1,020	1,135	500	578	858
Tank Ship-Medium Large	1	1	1	1	1	1	1,004	1,116	1,240	570	633	929
Tank Ship-Large	1	1	1	1	1	1	1,140	1,263	1,399	658	731	1,056
Tank Ship-Very Large	1	1	1	1	1	1	1,269	1,403	1,552	741	823	1,181
Bulk Carrier-Very Small	1	1	1	1	1	1	598	690	790	340	377	648
Bulk Carrier-Small	1	1	1	1	1	1	695	793	901	397	441	731
Bulk Carrier-Medium Small	1	1	1	1	1	1	783	889	1,004	448	497	804
Bulk Carrier-Medium Large	1	1	1	1	1	1	881	995	1,122	513	569	900
Bulk Carrier-Large	1	1	1	1	1	1	954	1,075	1,210	551	612	957
Bulk Carrier-Very Large	1	1	1	1	1	1	1,003	1,131	1,273	569	632	988

[23] Each vessel type has a placeholder of $1 for either the domestic or foreign operating cost for use in HarborSym.

Table 6-8. BIH HarborSym Rig and Scrap Operating Costs in Dollars

Vessel Type	Hourly Domestic Operating Cost						Hourly Foreign Operating Cost					
	At Sea			In Port			At Sea			In Port		
	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
Oil Rig-JackUp	1	1	1	1	1	1	1	1	1	1	1	1
Oil Rig-Semi-Submersible Small	1	1	1	1	1	1	1	1	1	1	1	1
Oil Rig-Semi-Submersible Large[24]	1	1	1	1	1	1	1	1	1	2,000	3,000	4,000
Scrap-Small	261	300	435	256	274	296	1	1	1	1	1	1
Scrap-Medium	287	330	435	281	301	325	1	1	1	1	1	1
Scrap-Large	315	363	525	309	331	357	1	1	1	1	1	1

[24] The operating costs for the Oil Rig-Semi-Submersible Large is only included in the without-project conditions because this cost is related to the removal of thrusters, which is not required in the with-project conditions. These costs were calculated based on interviews with Amfels and in coordination with IWR. The hourly operating costs are based on the distribution of the total thruster removal costs.

6.4 BENEFIT COST RATIO

The resulting benefits as calculated by HarborSym were then discounted back to the present value. The same was done for the project costs for each alternative. The following Tables 6-9 through 6-11 display the Alternative Net Excess Benefits and BCRs at the FY13 Federal Discount rate of 3.75 percent. Based on this, the alternative to deepen the channel to 52 feet with no widening was selected as the Recommended Plan.

Table 6-9. BCR Results for 250-Foot Width Alternatives

	Depth Alternatives (feet)									
	43	44	45	46	47	48	49	50	51	52
Project Cost	$67,773.3	$78,486.7	$89,200.0	$99,913.3	$110,626.7	$121,340.0	$141,755.0	$162,170.0	$178,060.0	$193,950.0
Interest during construction (IDC)	$1,350.5	$1,765.6	$2,236.4	$2,763.4	$3,346.6	$3,986.5	$5,352.4	$6,923.4	$8,308.7	$9,824.0
AAE Costs (w/operations & maintenance [O&M])	$3,366.6	$4,148.0	$4,932.0	$5,509.0	$6,088.5	$6,670.5	$7,761.4	$8,861.4	$9,721.0	$10,586.4
AAE Benefits	$3,239.1	$5,795.9	$9,717.2	$11,213.0	$12,503.7	$14,204.6	$15,792.7	$17,380.8	$18,627.3	$19,873.8
Net Excess Benefits	($127.5)	$1,647.8	$4,785.2	$5,704.0	$6,415.2	$7,534.1	$8,031.4	$8,519.5	$8,906.3	$9,287.4
BCR (at 3.75%)	1.0	1.4	2.0	2.0	2.1	2.1	2.0	2.0	2.0	1.9

Table 6-10. BCR Results for 300-Foot Width Alternatives

	Depth Alternatives (feet)									
	43	44	45	46	47	48	49	50	51	52
Project Cost	$83,863.3	$104,976.7	$126,090.0	$147,203.3	$168,316.7	$189,430.0	$210,080.0	$230,730.0	$252,475.0	$274,220.0
IDC	$1,886.5	$3,107.5	$4,636.9	$6,478.9	$8,637.9	$11,118.2	$13,608.3	$16,360.4	$19,461.7	$22,844.5
AAE Costs (w/O&M)	$4,569.0	$6,311.2	$8,067.3	$9,218.4	$10,383.6	$11,563.2	$12,709.3	$13,867.0	$15,098.4	$16,342.2
AAE Benefits	$3,614.4	$6,542.9	$10,843.1	$11,815.6	$12,609.6	$13,760.4	$15,849.8	$17,939.3	$19,189.8	$20,440.4
Net Excess Benefits	($954.6)	$231.6	$2,775.9	$2,597.2	$2,226.0	$2,197.3	$3,140.6	$4,072.2	$4,091.5	$4,098.1
BCR (at 3.75%)	0.8	1.0	1.3	1.3	1.2	1.2	1.3	1.3	1.3	1.3

Table 6-11. BCR Results for 350-Foot Width Alternatives

	Depth Alternatives (feet)									
	43	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**
Project Cost	$160,890.0	$182,930.0	$204,970.0	$227,010.0	$249,050.0	$271,090.0	$290,985.0	$310,880.0	$338,370.0	$365,860.0
IDC	$7,935.1	$10,244.8	$12,860.6	$15,786.4	$19,026.2	$22,583.8	$24,847.9	$27,196.6	$32,448.7	$38,194.8
AAE Costs (w/O&M)	$8,976.7	$11,513.5	$14,063.9	$15,355.1	$16,660.2	$17,979.5	$19,159.1	$20,342.4	$21,968.5	$23,616.5
AAE Benefits	$2,986.1	$5,382.2	$8,958.2	$10,685.6	$12,255.7	$14,140.2	$15,413.6	$16,687.0	$18,291.6	$19,896.1
Net Excess Benefits	($5,990.6)	($6,131.3)	($5,105.7)	($4,669.5)	($4,404.5)	($3,839.3)	($3,745.5)	($3,655.4)	($3,676.9)	($3,720.4)
BCR (at 3.75%)	0.3	0.5	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.8

7.0 RECOMMENDED PLAN OPTIMIZATION

7.1 HARBORSYM ANALYSIS

The alternative to deepen the channel to 52 feet with no widening was selected as the Recommended Plan. It is not known if the Recommended Plan is the NED plan, which maximizes net excess benefits, because the net excess benefits were still increasing with deeper channel dimensions and a deeper alternative was not included in the Final Array of alternatives. However, the Recommended Plan was the most cost effective of the Final Array of alternatives considered and the deepest channel dimension that the non-Federal sponsor would support at this time. Once the Recommended Plan was selected, additional efforts were required to optimize the plan. For example, the future vessel fleet composition was updated (as presented in Section 7) and certain model inputs were updated based on new information, as explained below.

To begin with, due to the timing of the project, the base year of the project was deferred to 2021 to represent a more realistic start date. Therefore, the Recommended Plan optimization examined the following projects in HarborSym, as shown in Table 7-1.

Table 7-1. Recommended Plan HarborSym Model Runs

WOP2021	52x250WP2021
WOP2031	52x250WP2031
WOP2041	52x250WP2041
WOP2051	52x250WP2051
WOP2061	52x250WP2061
WOP2071	52x250WP2071

Based on interviews with the Pilots and end-users, several model inputs were updated. The speed in the reaches was increased to 5.5 knots, per the Pilots. Also, the loading and unloading rates were updated for the following vessel types, as shown in Table 7-2.

In addition, the vessel operating costs for the oil drilling rigs in the without-project condition were also updated, as presented in Table 7-3. These updated costs are more consistent with the cost to remove a semi-submersible rig's thrusters before entering the channel.

The model was run with the above changes for 50 iterations. The following Figure 7-1 presents the total time all vessels spent in the system throughout the period of analysis, which on average is less for the with-project condition. Figure 7-2 presents the average wait time for all vessels, which is reduced in the with-project condition.

Table 7-2. BIH HarborSym Vessel Commodity Rates (Short Tons per Hour)

Vessel Type	Commodity Category	Loading Rate (hourly) Units			Unloading Rate (hourly) Units		
		Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Bulk Carrier	Dry Bulk/ Break-Bulk	4,000	4,400	5,800	4,000	4,400	5,800
Oil Rig	Drilling Rigs	10	10	10	0.0033	0.01	0.02

Table 7-3. BIH HarborSym Oil Rig Operating Costs in dollars

Vessel Type	Hourly Domestic Operating Cost						Hourly Foreign Operating Cost					
	At Sea			In Port			At Sea			In Port		
	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
Oil Rig-Semi-submersible Large	1	1	1	1	1	1	1	1	1	3,000	5,000	7,000

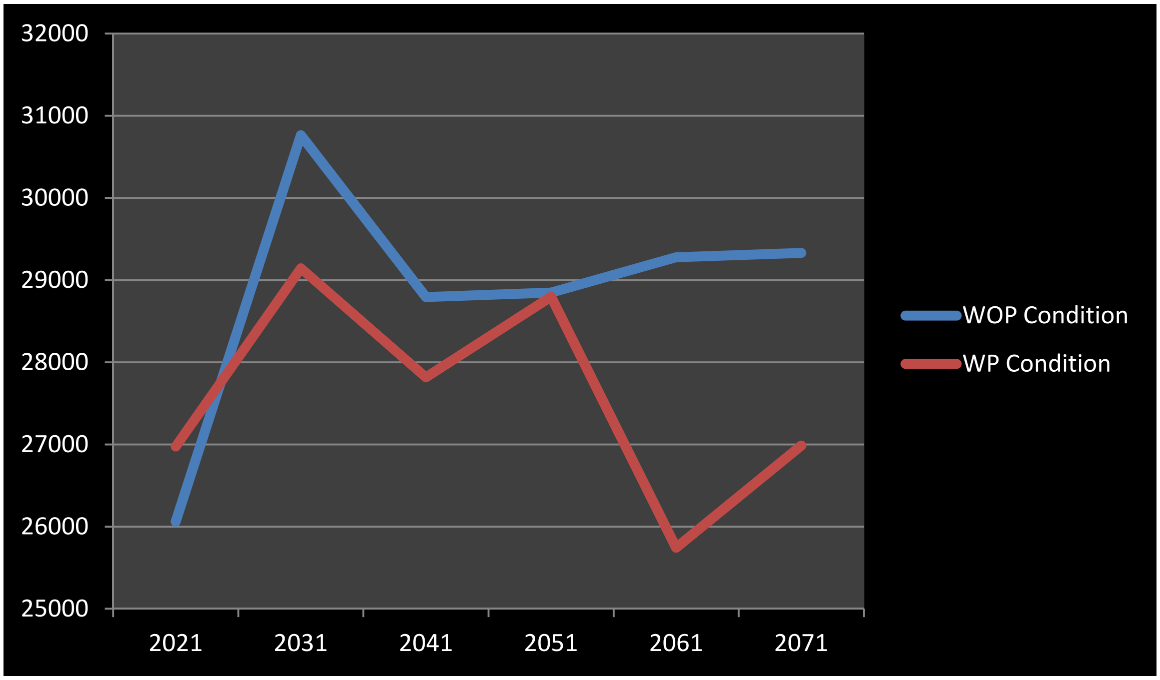


Figure 7-1: Average Total Vessel Time in BIH Channel (Hours)

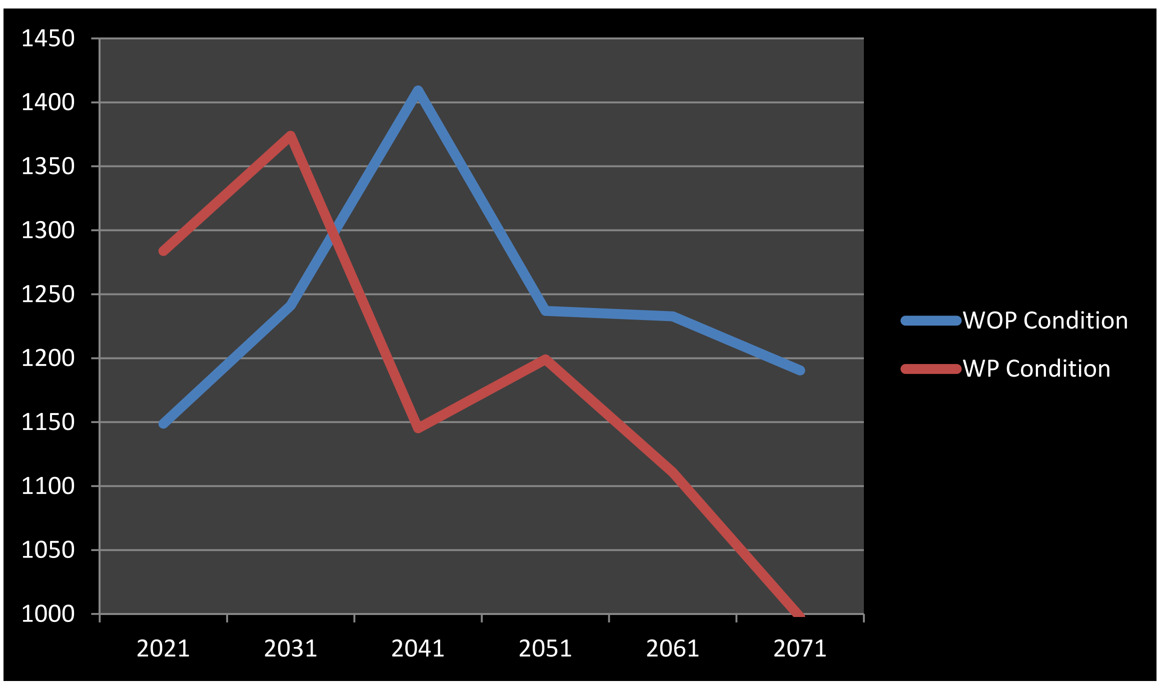


Figure 7-2: Average Total Vessel Wait Time in BIH Channel (Hours)

Figure 7-3 presents the annual costs for the without-project and with-project conditions. This is also presented in the following Table 7-4.

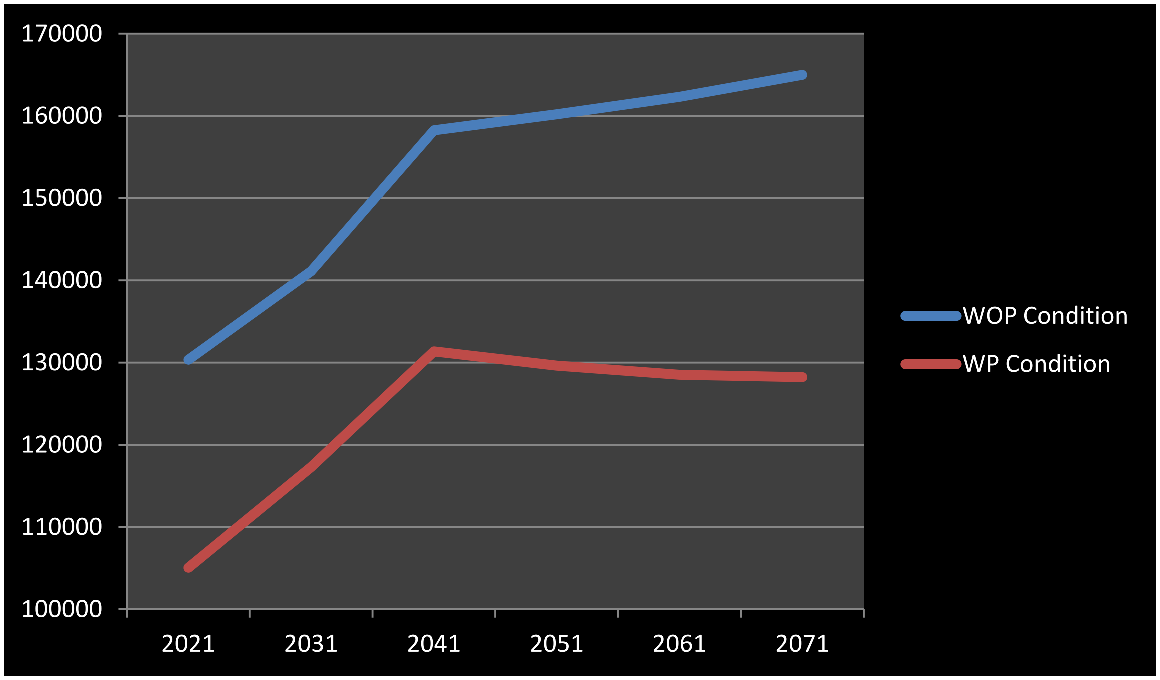


Figure 7-3: Total Annual Costs of Vessels in BIH Channel (1,000s of $)

Table 7-4. Total Annual Vessel Costs and Benefits (1,000s of $)

Year	WOP Condition	WP Condition	Benefits
2021	122,757	105,049	17,708
2031	133,746	117,293	16,453
2041	153,175	131,367	21,809
2051	153,707	129,651	24,056
2061	155,615	128,545	27,070
2071	157,038	128,206	28,832
Total	**876,038**	**740,111**	**135,927**

7.2 AVERAGE ANNUAL BENEFITS

The following Table 7-5 presents the annualized benefits for the with-project condition at the current interest rate of 3.5 percent.

Table 7-5. Benefits at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	17,109
2031	11,269
2041	10,590
2051	8,281
2061	6,606
2071	4,988
Average Annual Benefits	**20,539**

7.3 INCREMENTAL ANALYSIS

To complete the required incremental analysis, the channel was also analyzed using two distinct reaches. The first reach begins at the entrance channel and extends to and includes the Amfels dock, which is assumed to be 14.5 miles in length. The second reach begins after Amfels and extends to the turning basin, which is assumed to be 2.5 miles in length. The following Table 7-6 presents the annualized benefits for Reach 1. Table 7-7 presents the annualized benefits for Reach 2.

Table 7-6. Reach 1 Benefits at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	7,930
2031	5,468
2041	2,688
2051	2,443
2061	1,764
2071	1,486
Average Annual Benefits	**7,330**

Table 7-7. Reach 2 Benefits at 3.5% Interest Rate
(1,000s of $)

Year	Benefits
2021	9,179
2031	5,801
2041	7,902
2051	5,838
2061	4,842
2071	3,501
Average Annual Benefits	**13,209**

In addition, the benefits are being presented for the individual vessel classes. Three vessel classes, very large tankers, very large bulkers, and large semi-submersible rigs comprise 90 percent of the benefits, and are presented in Tables 7-8 to 7-10.

Table 7-8. Very Large Tanker Benefits at 3.5% Interest Rate
(1,000s of $)

Year	Benefits
2021	3,596
2031	3,559
2041	3,161
2051	2,158
2061	1,639
2071	1,103
Average Annual Benefits	**5,532**

Table 7-9. Very Large Bulker Benefits at 3.5% Interest Rate
(1,000s of $)

Year	Benefits
2021	3,526
2031	805
2041	3,897
2051	2,848
2061	2,089
2071	1,595
Average Annual Benefits	**5,246**

Table 7-10. Large Semi-Submersible Rig Benefits at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	7,923
2031	5,460
2041	2,648
2051	2,440
2061	1,762
2071	1,485
Average Annual Benefits	**7,321**

7.4 SENSITIVITY ANALYSIS

In order to examine areas of risk and uncertainty, sensitivity analyses were conducted to use as a comparison of the degree of reliability of the estimated benefits of the alternatives. The first sensitivity assumes no growth in the commodities during the period of analysis. A scenario with 1 percent growth rate is used to grow the tonnage from 2011 to 2021, which is a reasonable assumption that there will be minimal continued growth over the next decade. However, the tonnage remains constant throughout the period of analysis. Table 7-11 presents the annualized benefits for the no-growth sensitivity at the 3.5 interest rate.

Table 7-11. Benefits for No Growth Sensitivity at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	16,183
2031	13,372
2041	7,662
2051	5,321
2061	4,759
2071	2,942
Average Annual Benefits	**17,472**

In another sensitivity that was developed, the current vessel fleet mix and the resultant tonnage percentage associated with the fleet sizes was carried throughout the period of analysis, while incorporating the tonnage growth, as presented in Section 6. The resultant benefits are presented in Table 7-12.

Table 7-12. Benefits for No Fleet Transition Sensitivity at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	11,728
2031	4,603
2041	7,184
2051	4,230
2061	2,728
2071	2,294
Average Annual Benefits	**11,060**

Finally, sensitivities were developed that only involve changes to the assumptions used for the oil drilling rigs visiting the channel. In the without project condition, it was assumed that one large semi-submersible rig would visit yearly that would require thruster removal outside the channel. In the sensitivity shown in Table 7-13, the large semi-submersible rig was completely removed leaving the resultant benefits. In Table 7-14, benefits are shown for a sensitivity in which the semi-submersible rig only occurs every other year. Finally, in Table 7-15, benefits are shown for a sensitivity in which the costs related to thruster removal is increased to a range of $7,000-$12,000 hourly compared to the original $3,000-$7,000 hourly.

Table 7-13. Benefits for No Semi-Submersible Rigs at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	9,186
2031	5,809
2041	7,906
2051	5,841
2061	4,844
2071	3,503
Average Annual Benefits	**13,218**

Table 7-14. Benefits for Fewer Semi-Submersible Rigs at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	17,109
2031	5,809
2041	10,590
2051	5,841
2061	6,606
2071	3,503
Average Annual Benefits	**15,484**

Table 7-15. Benefits for Higher Semi-Submersible Rig Operating Costs at 3.5% Interest Rate (1,000s of $)

Year	Benefits
2021	24,438
2031	16,316
2041	13,049
2051	10,512
2061	8,243
2071	6,363
Average Annual Benefits	**27,291**

8.0 ECONOMIC SUMMARY

This section presents summaries of the costs and benefits, with the resultant BCRs for the most likely scenario as well as sensitivity items. Table 8-1 presents the economic summary for the Recommended Plan project at 3.5 percent. This scenario represents the most likely commodity and fleet forecast as well as the most likely rig behavior. Table 8-2 shows the channel incrementally segmented into two reaches. Table 8-2 presents the economic summary for Reach 1 at 3.5 percent. Table 8-3 presents the economic summary for Reach 2 at 3.5 percent.

Table 8-1. Economic Summary of Recommended Plan at 3.5%
(1,000s of $)

First Cost of Construction	251,952.0
Interest During Construction	10,563.3
Total Investment	262,515.3
Average Annual Cost	11,192.0
Average Annual O&M	2,971.3
Total Annual Cost	14,163.3
Average Annual Benefits	20,539.4
Net Excess Benefits	6,376.1
B/C Ratio	**1.5**

Table 8-2. Economic Summary of Reach 1 at 3.5%
(1,000s of $)

First Cost of Construction	214,900.2
Interest During Construction	7,605.6
Total Investment	222,505.8
Average Annual Cost	9,486.2
Average Annual O&M	2,534.3
Total Annual Cost	12,020.6
Average Annual Benefits	7,330.1
Net Excess Benefits	(4,690.5)
B/C Ratio	**0.6**

Table 8-3. Economic Summary of Reach 2 at 3.5%
(1,000s of $)

First Cost of Construction	37,051.8
Interest During Construction	176.8
Total Investment	37,228.6
Average Annual Cost	1,587.2
Average Annual O&M	437.0
Total Annual Cost	2,024.1
Average Annual Benefits	13,209.3
Net Excess Benefits	11,185.2
B/C Ratio	**6.5**

While the details of the benefits that include Section 6009 are provided in the addendum, the BCR is 6.4. Per Section 6009 Implementation Guidance, Keppel-AmFELS provided a statement of their certification to the data related to such benefits.

Benefits were also developed for the sensitivity analyses, to include the different commodity and fleet forecasts. Table 8-4 presents the economic summary for the Recommended Plan project with the no commodity growth sensitivity. Table 8-5 presents the economic summary for the Recommended Plan project with the sensitivity in which there is no change in the fleet composition.

Table 8-4. Economic Summary of No Growth Sensitivity
(1,000s of $)

	@ 3.5%
Average Annual Benefits	17,471.7
Total Annual Cost	14,163.3
Net Excess Benefits	3,308.4
B/C Ratio	**1.2**

Table 8-5. Economic Summary of No Fleet Transition Sensitivity
(1,000s of $)

	@ 3.5%
Average Annual Benefits	11,060.0
Total Annual Cost	14,163.3
Net Excess Benefits	(3,103.2)
B/C Ratio	**0.8**

Table 8-6 presents the economic summary for the Recommended Plan project with the sensitivities in which the assumptions regarding the large semi-submersible rigs are changed. The most likely rig behavior was shown in Table 8-1 at the beginning of this section.

Table 8-6. Economic Summary of Large Semi-Submersible Rig Sensitivity at 3.5% (1,000s of $)

	No Large Semi-Submersible Rigs	**Fewer Large Semi-Submersible Rigs**	**Higher Large Semi-Submersible Rig Operating Costs**
Average Annual Benefits	13,218.4	15,484.5	27,291.5
Total Annual Cost	14,163.3	14,163.3	14,163.3
Net Excess Benefits	(944.9)	1,321.2	13,128.2
B/C Ratio	**0.9**	**1.1**	**1.9**