Potential Economic Benefits from Improved USACE Processes

Issues and Potential Solutions to the U.S. Army Corps of Engineers' Roles Related to Waterway and Pipeline Infrastructure

August 30, 2018

Highlights

Waterborne and Pipeline Transportation are Critical for the U.S. Economy.

- 2.3 billion tons of goods valued at $1,957 billion dollars were moved through the U.S. waterborne transportation system in 2016. Over 40% of this tonnage was crude oil and petroleum products. Transportation services associated with these waterborne movements totaled $99 billion.
- In 2015, the U.S. pipeline system moved 17,380 million barrels of liquids, and 28,708 billion cubic feet of gases and provided transportation services valued at $48 billion.

The U.S. Army Corps of Engineers (USACE) plays a key role in identifying, defining, and implementing major port, waterway, and pipeline infrastructure investments and maintaining ports and waterway systems. However, widespread concerns exist regarding regulatory process, funding, and execution, including:

- Slow and inconsistent environmental review and permitting for infrastructure construction.
- Delays in construction and maintenance for navigation civil works projects.

The direct economic consequences of these inefficiencies are higher costs to develop oil and gas resources, higher pipeline and other infrastructure project costs, higher Civil Works project costs funded by the government, and higher waterborne and pipeline shipping costs.

- Direct costs of these inefficiencies are estimated to be $2.90 to $9.71 billion dollars per year depending on assumptions on the frequency and extent of constraints to the transportation and permitting systems.
- The potential increase in U.S. GDP that would come from improving the transportation and permitting systems are estimated to be $1.52 billion to $6.05 billion per year averaged over the years 2020 to 2040.

The USACE has shown a willingness to reduce inefficiencies and has several initiatives underway to achieve that end. Areas of improvement identified by various stakeholders and the USACE itself include:

1. Improving Regulatory Process Transparency and Efficiency by:
   - Increasing the ability to communicate with USACE both leading up to and following permit application submission.
   - Increasing the consistency in data requirements, processing times, and NWP eligibility from project to project and District to District.
2. Increasing Consistency of Regulatory Process Outcomes by:
   - Standardizing the permit application process.
   - Promoting consistent exercising of discretion in decision making.
   - Developing strong working relationships.
   - Facilitating the development and retention of regulatory staff.
3. Streamlining Process to Construct Civil Works Projects by:
   - Shortening the timeline for feasibility studies.
   - Aligning assumptions and calculations used in feasibility studies with stakeholders.
   - Improving the funding process.

Table of Contents

Table of Exhibits

Executive Summary

The American Petroleum Institute (API) asked ICF to conduct a study of the role played by the U.S. Army Corps of Engineers (USACE) in the nation's energy transportation infrastructure, especially as it applies to the waterborne and pipeline transportation of crude oil, petroleum products, petrochemicals and other goods. As part of their diverse missions, USACE builds and maintains waterways, locks, and ports through its Civil Works program, acts as a regulator of infrastructure under the Clean Water Act and Rivers and Harbors Act, and conducts environmental reviews under the National Environmental Policy Act. Other participants in the USACE's infrastructure-related activities include: Congress, which funds dredging and lock projects as well as the Corps budget and passes critical legislation that the USACE has to implement; the courts, which rule on the implementation of the regulations stemming from the legislation; and applicants who must navigate the sometimes complex permitting processes. This study identifies and documents problems and issues related to the processes surrounding USACE, estimates the economic implications of these problems and issues, and identifies potential improvements that could be implemented by the USACE and other participants in these processes.

Waterborne and pipeline transportation are critical for the U.S. economy. 2.3 billion tons of goods valued at $1.957 trillion dollars moved through the U.S. waterborne transportation system in 2016, with over 40 percent of the tonnage being crude and petroleum products. These shipments consist of coastwise movements between U.S. ports, along rivers and other inland waterways, across the Great Lakes, and deep-water imports and exports in global markets. Transportation services associated with these movements totaled $99 billion. Many commodity markets are critically dependent on waterborne commerce including farm and livestock products, coal, iron ore, and petroleum. Pipelines are the safest, most efficient and economical way to move crude oil, natural gas, petroleum products, natural gas liquids and carbon dioxide to fuel the nation's economic engine. In 2015, the U.S. pipeline system moved 17,380 million barrels of liquids and 28,708 billion cubic feet of gases and provided transportation services valued at $48 billion.

Looking towards the future, the existing waterborne and pipeline transportation systems will face increased pressures. International trade is expected to continue its historical trend of significantly increasing over the past couple of decades. A large contributor to this is America's globally competitive energy industry, which is exporting increasing quantities of refined products, crude oil, LNG, and NGLs. This puts a strain on the existing pipeline infrastructure out of the Permian Basin, and the ports along the Texas Gulf Coast where the petroleum products, crude oil, LNG and NGLs are being exported. Another challenge is ship sizes have grown larger over past years as global trade volume has expanded, shipping distances have lengthened, and container ships and other vessels have grown larger to maximize cost efficiency. The recently completed 2016 expansion of the Panama Canal adds further pressures as Gulf and Atlantic Coast ports seek channel dredging, channel widening, and port modifications to accommodate bigger ships and maintain their competitive positions among U.S. importers and exporters.

The existing infrastructure is aging and struggling to keep up with transportation trends as evidenced by the inland waterway lock system. The average age of locks in 2017 was 60 years. Because of high volume flows and more frequent congestion, severe weather events such as hurricanes and floods increasingly impact the effectiveness of ports and inland waterways. All of these challenges suggest that the effectiveness of the USACE will become increasingly critical to sustaining and growing commerce in the U.S.

Identified Issues

As part of the project, ICF conducted a survey of API Midstream Committee members and other USACE project stakeholders to obtain their recent experiences with USACE processes and general information and data on waterborne freight and pipeline industry trends. The survey questionnaire asked respondents to articulate the primary issues they had experienced with USACE, economic impacts, and possible improvements to the current process, as well as what is working well. The stakeholders who responded to the survey included pipeline operators, port and waterway operators, and refiners. ICF also conducted phone interviews with port and waterway representatives, the American Association of Port Authorities, a trade association that supports North American ports, the Waterways Council, Inc., an organization that advocates for inland waterway infrastructure, and the National Waterways Conference, an association that advocates for water resource infrastructure. Public testimony from the Congressional hearing "Examining the U.S. Army Corps of Engineers" in March 2018 provided insights and anecdotes about the issues related to the USACE. Testimonies came from several organizations including the Port of Corpus Christi Authority, the Upper Mississippi River Basin Association, and the Lake Carriers' Association. In addition, ICF reviewed reports, from USACE, the Government Accountability Office, the Congressional Research Service, and others. ICF also reviewed presentations and public statements from USACE.

The stakeholders described their experiences with USACE's Civil Works navigation project delays. Significant delays to port dredging or major rehabilitation projects on locks can stall economic benefits from improved waterborne transportation. With an aging waterborne transportation infrastructure and growing levels of cargo and congestion, there is concern that federal appropriations for USACE's navigation mission is insufficient to meet future demands. Many projects are backlogged for years after receiving Congressional authorization while waiting for funding. A lack of full funding and inconsistency in project funding year to year were also cited as the biggest impediment to inland river infrastructure projects and preventative maintenance. The stopping and starting of projects when they are funded or not funded creates extra costs and delays that quickly add up.

Furthermore, stakeholders have concerns how the limited funding is allocated to competing projects. Shippers are worried that not enough monetized benefits are counted towards the benefit to cost ratio (BCR) analysis relied on to prioritize projects. Another cause of delays is unnecessarily lengthy feasibility studies. Feasibility studies have historically been completed in around 10 years with some taking as much as 15-17 years. Reform in 2014 has limited most feasibility studies to three years, but it is still too early to know how much improvement has been made from this. A lack of mechanical commonality or standardization was identified as a contributing factor to delays when performing reactive maintenance activities on the inland waterways lock system.

The surveys and other research illustrated the point that permit applicants are generally frustrated with USACE's implementation of regulations, although there are exceptions. Delays in permitting and environmental review processes for new infrastructure construction (such as pipelines) add unnecessary costs for private and public entities. Inefficiencies are created by inconsistent interpretations of permitting requirements and inconsistent application of the nationwide permit program especially for companies that work with multiple Districts. Permit reviews tend to lack transparency, which frustrate the permit applicant who proactively has to check in for status reports. Coordination issues also arise when USACE is required to work with other agencies on joint permits. USACE generally makes decisions about the interpretation of regulations that have potentially significant impacts to permit applicants and other stakeholders, but USACE appears to not fully recognize - or seek feedback - on these impacts before they enact sometimes drastic changes. Additionally, late identification of the requirement for Section 408 permission created unnecessary burdens and delays for infrastructure projects. USACE has required project redesigns for permit approval, such as changes in pipeline routing or facility layout. The benefits of these changes are not always clear, but the decisions by the USACE can significantly delay the project and increase the overall costs.

Economic Consequences

The direct economic consequences of inefficiencies identified in our surveys and other research are higher costs to develop oil and gas resources, higher pipeline and other infrastructure project costs, higher Civil Works project costs funded by the government, and higher waterborne and pipeline shipping costs. The first three columns of Exhibit ES-1 show ICF's estimate of the direct annual costs. The range from $2.90 to $9.71 billion dollars per year indicates uncertainties in how often infrastructure permitting delays and other infrastructure development and maintenance problems occur or how much related costs developers and shippers must bear. The estimates of direct cost presented in Exhibit ES-1 are based on ICF's experience in supporting project permitting efforts on behalf of both developers and reviewing agencies, recent project experiences learned through the interview process, cost impact studies done by others, and our own calculations.

The net economic impact to U.S, Gross Domestic Product (GDP) of removing those annual direct costs is shown in the fifth to twelfth columns of Exhibit ES-1. The estimate of social welfare impacts (consumer surplus and producer surpluses) are shown in Exhibit ES-2.

The GDP and social welfare estimates are based on the assumption that efficiency-related cost savings would begin for upstream oil and gas development and for energy pipeline investments starting in the year 2019. The related impacts would build over time as in-place assets (oil wells, gas wells, pipelines) that benefited from the cost savings become a larger and larger portion of all in-place assets. The GDP and social welfare impact related to cost savings from waterborne shipping are not based on an explicit start date for efficiency improvements and schedules for new assets. Rather, we calculated the hypothetical GDP impacts estimated based on 2016 trade flows and prices and then adjusted those estimates for increased trade over time. We assume that the economic benefits related to waterborne shipping could be could be fully realized by 2025. The impacts on GDP and social welfare are based on the oil and gas price and production volume projections from the 2018 Annual Energy Outlook from EIA.

Exhibit ES-1: Summary of Direct Costs and GDP Impacts

Direct Cost Category	Range of Annual Direct Costs ($million)		Economic Impact Category	U.S. GDP Effects ($millions)							
				2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages	
Upstream Oil and Gas Development	$47	$95	More Oil & Gas Development Due to Lower Upstream Development Costs	$75	$150	$289	$579	$332	$665	$261	$522
Pipeline Construction	$176	$1,008	More Oil & Gas Development Due to Lower Pipeline Construction Costs & Rates	$62	$354	$418	$2,386	$478	$2,730	$347	$1,981
			Other Impacts from Lower Pipeline Rates	$44	$252	$297	$1,698	$340	$1,942	$247	$1,409
USACE Public Works Projects	$30	$90	Net Impacts from Reduced Waterborne Transportation Costs	$542	$1,742	$660	$2,123	$805	$2,588	$665	$2,139
Inland Shipping: Delays	$107	$301									
Domestic Shipping: Diversion to Other Transport Modes	$596	$2,385									
International Shipping: Vessel Size, Light Loading, Lightering, Anchorage Times	$1,945	$5,836									
Sum of Direct Costs	$2,902	$9,714	Sum of GDP Effects	$723	$2,499	$1,664	$6,786	$1,955	$7,925	$1,519	$6,051

Note: Economic impacts from lower upstream development costs and lower pipeline construction costs are assumed to accumulate over time starting in 2019 based on AEO 2018 Reference Case oil and gas prices and production rates. Economic impacts from lower waterborne transport cost are computed using actual 2016 transportation patterns and are assumed to grow at the rate of GDP growth (AEO rate of 2.0%/year).

The annual average all-sector U.S. GDP impacts from 2020 to 2040 range from $1.52 billion to $6.05 billion. Increased oil and gas production stemming from lower oil and gas development costs is assumed to build over time starting in 2019, when more wells are drilled compared a situation in which inefficiencies are not addressed. The impacts increase yearly, as there are more well vintages whose well counts have been boosted by lower costs. For 2020-2040, the contribution to GDP from lower permitting costs for oil and gas wells range from $0.26 to $0.52 billion per year.

The GDP impacts from reducing delays and costs of oil and gas pipelines is made up of higher oil and gas production and impacts of lower delivered fuel costs to consumers. It is assumed that lower permitting costs for new pipelines begin in 2019 and that as more new pipelines are constructed at these lower costs, the reduction in tariffs (as measured as a percent of base case pipeline revenues) increases each year for about 25 years into the future. The impact of lower pipeline tariffs on oil and gas production contributes $0.35 to $1.98 billion in annual GDP from 2020 to 2040.

The same buildup of impacts over time occurs with regard to how lower pipeline construction costs lead to lower delivered fuel prices and, thus, increases in industrial and commercial customer economic activity. The effects on GDP are $0.25 to $1.41 billion from 2020 to 2040.

As with the effects of pipeline tariffs on oil and gas drilling, the full effects on energy users will be felt after approximately 25 years.

Exhibit ES-2 shows the changes in producer and consumer surpluses, which when added together are called social welfare or social benefit. These estimates are useful in showing how benefits are distributed between consumers and producers. Producer surpluses are the revenue received by producers less the cost of production (that is, the rectangular area bounded a horizontal line drawn at the market price and a vertical line at the quantity produced minus the area under the supply curve). When the prices received by the producer go up, producer surplus increases. Consumer surpluses represent the consumers' willingness to pay for good less the actual market price of the good. Consumer surplus is represented as the area under the demand curve down to the horizontal line drawn at the market price. A decrease in consumer prices increases consumer surplus.

Exhibit ES-2: Summary of Consumer and Producer Surplus Impacts

Economic Impact Category	U.S. Consumer Surpluses ($millions)								U.S. Producer Surpluses ($millions)							
	2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages		2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages	
More Oil & Gas Development Due to Lower Upstream Development Costs	$51	$102	$197	$394	$226	$452	$177	$355	-$6	-$13	-$25	-$49	-$28	-$57	-$22	-$44
More Oil & Gas Development Due to Lower Pipeline Construction Costs & Rates	$42	$241	$284	$1,622	$325	$1,856	$236	$1,347	-$5	-$30	-$35	-$203	-$41	-$232	-$29	-$168
Other Impacts from Lower Pipeline Rates	$20	$114	$134	$764	$153	$874	$111	$634	$11	$63	$74	$425	$85	$485	$62	$352
Net Impacts from Reduced Waterborne Transportation Costs	$3,696	$11,885	$4,506	$14,487	$5,493	$17,660	$4,538	$14,592	-$156	-$501	-$190	-$611	-$232	-$745	-$191	-$615
Sum of Surpluses	$3,810	$12,341	$5,120	$17,267	$6,197	$20,842	$5,063	$16,928	-$157	-$481	-$176	-$438	-$216	-$548	-$181	-$476

Note: Economic impacts from lower upstream development costs and lower pipeline construction costs are assumed to accumulate over time starting in 2019 based on AEO 2018 Reference Case oil and gas prices and production rates. Economic impacts from lower waterborne transport cost are computed using actual 2016 transportation patterns and are assumed to grow at the rate of GDP growth (AEO rate of 2.0%/year).

The all-sector average annual impacts on consumer surpluses caused by lower prices for consumer goods range from $5.06 to $16.93 billion from 2020 to 2040. Estimated annual average impacts on producer surpluses have a range of -$0.18 to -$0.48 billion from 2020 to 2040. The producer surpluses increase in some sectors and decline in others, but on the whole, tend to go down due to lower prices for internationally trade goods and transportation services. Overall, social welfare (the sum of consumer and producer surpluses) is highly positive with a range of $4.88 to $16.45 billion on average annually from 2020 to 2040.

Potential Improvements

These benefits could be achieved through changes in how the USACE and other relevant parties operate. Ideas for potential improvements to Civil Works projects, regulatory processes, and consistency of regulatory outcomes follow. These ideas came from stakeholder surveys, interviews, Congressional testimony, and reports as well as presentations and public statements from USACE.

Streamlining the process to develop and construct Civil Works projects would help achieve the benefits described above. Annual congressional appropriation means project funding can be unpredictable year to year, leaving project stakeholders and contractors with considerable uncertainty. If projects were fully appropriated for multiple years up front, they could capture savings such as bulk purchasing and avoidance of remobilization costs similar to how private industry efficiently manages their capital investments with multiyear appropriations. Another option would be to give USACE multiyear contracting authority. Multiyear contracts would entitle USACE to purchase services or supplies from contractors for more than one year even if appropriations remained annual. Benefits would include increased competition for the initial award of the contract and reduced contract prices. Congress could enhance this by ensuring that the full annual collections of the IWTF and the HMTF are appropriated each year. The stakeholders indicated that these funds are intended for use on navigation construction and maintenance and should be utilized in that manner promptly every year.

Feasibility studies need to be completed in a timely manner and be aligned with the non-federal cost share partner and other relevant stakeholders. Increasing funding levels for feasibility studies or encouraging stakeholders to fund full studies would allow the critical studies to be completed quickly. In addition, USACE could utilize screening tools early in the planning process to pare down the number of alternatives analyzed in detail during the study. For the commodity forecasting that is done for feasibility studies, USACE should seek input from relevant commercial stakeholders impacted by the project being studied to capture planned future investments in the area. Starting from the beginning of the study, USACE should review the economic assumptions and models with project stakeholders to assure alignment on a continuous basis. Leveraging third-party consultants to prepare large portions or whole studies could allow studies to be completed quicker. This could be especially helpful when staff working on feasibility studies are diverted to emergency response tasks.

A potential way to address the USACE regulatory delays is improving overall process transparency and efficiency. Applicants want clarity on process requirements for permits. USACE could increase Headquarters-based outreach and guidance to the regulated community to improve quality, completeness, and consistency of applications received. Examples could include developing a help desk for applicants including a staffed helpline for answering questions from applicants and proactively maintaining a pre-application meeting calendar with biweekly meetings. To limit inconsistencies among Districts, existing or proposed regional conditions imposed on nationwide permits could be reviewed by the Chief Engineer's Office.

It would be helpful for the USACE to create and maintain an online permitting portal accessible by applicants and the public. The portal would have permit checklists with a list of the critical forms needed to obtain each specific permit. It would also show each application received, its progress through review, and its expected decision date. Mandated permit timelines for each stage of a Section 404 or Section 10 permit application give applicants predictability at the onset of the permitting process. Criteria could be developed to allow time-sensitive projects in the national interest to have an accelerated review. USACE should establish methods to enforce existing regulatory timelines and add additional time limits to the various phases of the permitting process (scoping, decision on whether there is a significant impact, etc.) and limit the scope of review to the actual infrastructure project (unless there are connected actions). Having established timelines for these permitting activities gives consistency and predictability to projects. It would also benefit the process if USACE made existing data easily available to the public and developed a plan to improve public access to archived public documents including regulatory decision documents. In addition, USACE should develop a user-friendly display of NWPs and all related documents including regional conditions and Section 401 water quality certifications at a central Corps online repository as well as create a publicly accessible database of the Corps' real estate interests.

USACE could improve the NEPA process by developing standards for cooperating with other agencies. They could develop standing MOUs with each cooperating federal agency laying out expected regional conditions, ESA Section 7 and NHPA Section 106 consultation, compensatory mitigation requirements, and agreed upon review times. USACE should coordinate with state, local, tribal governments, and federal agencies that have discretionary approval of one or more project elements. The process would also benefit from increased collaboration with FERC on gas pipelines especially during the pre-application stage.

If USACE increases their consistency of regulatory outcomes, permit applicants would have more predictability during the permit process for critical infrastructure. Notwithstanding certain Corps Districts with unique physiographical characteristics, USACE could develop nationwide standards for application contents, NWP applicability, and required supporting data that is enforced between applicants, Districts, and Divisions. The NWP program should be modified to include streamlined reviews by the cooperating agency through identification and diversion of projects with *de minimis* impacts that are currently subject to individual permits to a minimal review path.

USACE should also ensure consistent exercise of discretion by their staff. They can do this by mandating the implementation of an efficient quality assurance process for automatic and as-needed senior and legal review of key regulatory decision points. USACE could also train field office staff using nationwide standards rather than at the District level. They can also limit the discretion of individual regulatory staff by setting more specific criteria for permitting decisions, particularly in relation to Waters of the United States (WOTUS) determinations and NWP applicability.

The development of the USACE regulatory staff will allow for more organized and efficient permit reviews. USACE could improve staffing levels and budget to increase the ability of the Corps to engage in projects during the development stage to help influence alternatives development and avoid mid-project changes. A revised project management training could be geared to encourage collaboration and remove any existing tenor of conflict and mistrust from their relationship with the regulated community. USACE could increase experience standards for Corps staff working in regulatory positions by decreasing career incentives to leave positions frequently. Creating a career pipeline for regulatory project managers would encourage the retention of experienced staff members. Reassignment of staff when presently assigned to ongoing individual permit applications or complex NWP notification actions should be avoided. USACE should increase staffing to support regulatory project management's staff's access to cross-disciplinary training and topical experts to ensure responsible treatment of specialized resources. They could also develop document management capabilities among USACE staff to prepare concise, readable NEPA documents.

Summary: Potential Improvements – Benefit Mapping

The study identified a number of problems with the current funding, permitting and implementation of port and waterway projects and other kinds of infrastructure that come under USACE reviews and approvals. The potential impact on the U.S. economy from improvements in those processes can be substantial, with GDP impact ranging from $1.52 to $6.05 billion annually average from 2020 to 2040. While USACE is implementing some improvements, the magnitude of infrastructure investments needed in future years is substantial, and the entire system should be evaluated to insure the most critical projects are funded and built across all sectors of the economy.

The suggested improvements can be mapped to the Economic Benefits, as shown in Exhibit ES-3 below. The table identifies the economic sectors that the proposed improvements will affect. Improvement benefits cover a number of economic sectors. Bold check marks indicate areas of greater benefits.

Exhibit ES-3: Potential Improvements and Associated Areas of Economic Benefit

				Impact Area for Economic Benefits				
No.	Category	Improvement	Responsibility for Implementation	Upstream Oil & Gas Development	Pipeline Construction	USACE Public Works Projects	Domestic Shipping	International Shipping
1	Streamline Civil Works Projects	Initiate partnership agreements allowing capable ports to execute Corps construction projects	USACE			✓	✓	✓
2		Increase funding for feasibility studies, outsource studies when Corp is resource constrained	Congress, USACE			✓	✓	✓
3		Utilize screening tools early in feasibility studies	USACE			✓	✓	✓
4		Seek forecasting input from stakeholders in feasibility studies	USACE			✓	✓	✓
5		Review economic assumptions with stakeholders early	USACE			✓	✓	✓
6		Appropriate full funds up front	Congress			✔	✔	✔
7		Give USACE multiyear contracting authority	Congress			✔	✔	✔
8		Appropriate full annual collection of IWTF and HMTF	Congress			✔	✓	✔
9	Improve Regulatory Transparency and Efficiency	Increase USACE's HQ outreach and guidance	USACE	✔	✔		✓	✓
10		Develop and staff applicant assistant program	USACE	✔	✔		✓	✓
11		Maintain a pre-application consultation calendar	USACE, Permit Applicant	✔	✔		✓	✓
12		Clarify the WOTUS rule	USACE	✔	✔		✓	✓
13		Require HQ review for regional conditions imposed on NWP	USACE	✔	✔		✓	✓
14		Create an online permitting portal accessible by applicants	USACE, Permit Applicant	✔	✔		✓	✓
15		Mandate permit timelines for each stage	USACE	✔	✔		✓	✓
16		Facilitate parallel processing of applications of multiple USACE permits and other authorizations.	USACE	✔	✔		✓	✓
17		Develop plan to improve public access to digital archives	USACE	✔	✔		✓	✓
18		Develop standing MOU with each cooperating federal agency	USACE, Federal Agencies	✔	✔		✓	✓
19		Increase collaboration with FERC on gas pipelines	USACE, Federal Agencies	✔	✔		✓	✓
20	Increase Consistency of Regulatory Outcome	Develop nationwide standards for application contents	USACE	✔	✔		✓	✓
21		Modify the NWP program through identification of minimal impact projects	USACE	✔	✔		✓	✓
22		Implement a quality assurance process of key regulatory decision points	USACE	✔	✔		✓	✓
23		Train staff using nationwide standards	USACE	✔	✔		✓	✓
24		Improve staffing levels and budgets to increase engagement during planning	USACE, Congress	✔	✔		✓	✓
25		Revise project management training	USACE	✔	✔		✓	✓
26		Increase experience standards for regulatory positions	USACE	✔	✔		✓	✓
27		Create a career pipeline for regulatory project managers	USACE	✔	✔		✓	✓
28		Avoid reassignment of staff on ongoing complex permit applications	USACE	✔	✔		✓	✓
29		Increase staff's access to cross-disciplinary training and topical experts	USACE	✔	✔		✓	✓

1. Role of the Corps

The U.S. Army Corps of Engineers (Corps or USACE) is an Executive Branch agency located in the Department of Defense that has both military and civilian responsibilities. The Corps provides engineering, construction, and environmental management services for Department of Defense agencies. Under its civil works program at the direction of Congress, the Corps plans, constructs, operates, and maintains a wide range of infrastructure facilities. Under its regulatory program, the Corps administers and enforces Section 10 of the Rivers and Harbors Act of 1899 (RHA) and Section 404 of the Clean Water Act (CWA). Under RHA § 10, a permit is required to authorize activities or placement of structures in, over, or under the nation's navigable waters. CWA § 404 requires a permit be issued prior to the discharge of dredged or fill material into waters of the United States. Through the authority of these two regulatory programs, the Corps evaluates permit applications for essentially all construction activities that occur in the nation's waters, including jurisdictional wetlands.

1.1. Mission Overview

The Corps mission has expanded beyond the original responsibility of improving and maintaining navigable channels; it now includes flood control, disaster relief, environmental restoration, municipal water infrastructure, and other activities.

1.2. Organization

Eight divisions throughout the nation coordinate projects in 41 district offices in the United States and field offices worldwide.

Exhibit 1-1: USACE Division Map and District

Source: USACE (2018), available at: http://www.usace.army.mil/Locations.aspx

1.3. Role in Civil Works Projects

The Corps' oldest civil responsibilities are creating and maintaining navigable channels and flood control projects. Navigation projects include river and harbor deepening, channel widening, lock expansion, dam operations, and dredged material disposal. Flood control projects include dam and related hydropower construction, levee construction, river channelization, largescale pumping systems, and coastal protection. Many navigation and flood control projects are multi-purpose — that is, they provide water supply, recreation, and hydropower in addition to navigation or flood control[1]. USACE reviews those projects in Environmental Impact Statements or Environmental Assessments under the National Environmental Policy Act and also complies with the Endangered Species Act, National Historic Preservation Act, and other statutes and authorities as part of the review process.

In recent decades, Congress has given the Corps responsibilities in the areas of environmental restoration and infrastructure and other non-traditional activities, such as disaster relief and remediation of formerly used nuclear sites. Environmental restoration activities involve wetlands restoration and environmental mitigation activities for Corps facilities. Environmental infrastructure refers to municipal water and wastewater facilities.[2]

The Corps is also responsible for approving any alteration to a Civil Works project by any other party. This requirement was established in Section 14 of the RHA, which is codified at 33 USC 408 (Section 408). Common reasons for Civil Works alterations include improvements to the projects by parties other than the Corps; relocation of part of the project to accommodate development or restoration; or installing utilities, outfalls, or other non-project features. Under Section 408, the Corps may give such authorization following a determination that the proposed alternation will not be injurious to the public interest and will not impair the usefulness of the Civil Works project.

1.4. Role in Regulatory Permitting

The Corps' regulatory authority primarily involves two types of permits issued under CWA § 404 and RHA § 10: individual permits (including standard permits and letters of permission), and general permits (including nationwide and regional programmatic permits). CWA § 404 permits are required for discharges of dredged or fill material into jurisdictional waters of the United States, including wetlands. Such fills can result from construction of transportation facilities, residential, commercial development, including roadways and utility lines, and revetments, levees, and bank stabilization activities.[3]

RHA § 10 requires Corps' authorization prior to any work in, under, or over navigable waters of the United States, or which affects the course, location, condition or capacity of such waters. Navigable waters of the United States are defined as waters that have been used in the past,

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[1] Civil Works Program of the Army Corps of Engineers: A Primer http://www.mvp.usace.army.mil/Portals/57/docs/Civil%20Works/Civil%20Works%20Primer_RS20866_2005Feb03.pdf

[2] *Id.*

[3] 33 U.S.C. §1344

are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation. Typical activities requiring a permit are piers, dredging, bank stabilization, and aids to navigation.[4]

Because an activity that requires an RHA § 10 authorization will typically require issuance of a CWA § 404 permit as well, the Corps has developed a unified application that addresses both regulations. The type of permit issued by the Corps is controlled by the nature of the regulated activity and the severity of the impacts to waters of the U.S. Permits issued by the Corps fall into two categories, General Permits and Individual Permits.

1.4.1. General Permits

General permits are issued on a regional or nationwide basis for a specific category of activities when:

- Those activities are substantially similar in nature and cause only minimal individual and cumulative environmental impacts; or
- The general permit would result in avoiding unnecessary duplication of the regulatory control exercised by another Federal, state, or local agency provided it has been determined that the environmental consequences of the action are individually and cumulatively minor.

General Permits include Regional or Programmatic General Permits and Nationwide Permits (NWP). A NWP is a form of streamlined general permit that preauthorizes a category of activities throughout the nation that result in minimal individual and cumulative adverse effects on the aquatic environment. NWPs, which currently number 52 and cover a range of activities, can be issued for a period of no more than five years and cannot be extended. They automatically expire and become null and void if they are not modified or reissued within five years of their effective date. NWPs are available for use by any party provided the activity proposed meets all of the conditions and mitigation requirements applicable to the permit. NWPs include both notifying and non-notifying types; notifying NWPs require any party using that NWP provide a preconstruction notification to the Corps.

Regional permits are issued by the individual District Engineers. Regional General Permits (RGP) are issued on a regional basis, while Programmatic General Permits (PGP) are issued when an existing state, local, or other Federal program exists that meets the requirements of the Corps' regulatory obligations. A PGP is designed to avoid duplication of that program when the regulated activities are similar in nature and cause minimal direct and cumulative environmental effects.

1.4.2. Individual Permits

Individual permits authorize activities that do not qualify for use of an existing general permit. Often, these activities may have more than minimal individual or cumulative environmental impacts due to the proposed volume of fill, duration of impact, or the presence of protected

[4] 33 U.S.C. §403

wildlife species or cultural resources. Individual permits may be issued to the regulated public as either Letters of Permission (LOP) or Standard Permits.

An LOP is a type of individual permit issued through an abbreviated processing procedure which includes coordination with Federal and state fish and wildlife agencies, and a public interest evaluation, but without the publishing of an individual public notice. An LOP may be issued for work that will result in minimal effects to the aquatic ecosystem, and to which public objections are unlikely, but where no existing NWP authorizes the activity.

A Standard Permit application is processed through public interest review procedures, requiring both public notice and receipt and review of comments. The Standard Permit process is required for any activities ineligible for authorization under an RGP, PGP, NWP, or LOP. As such, the process is often considerably lengthier and more detailed, involving detailed compliance by applicants with several related environmental regulations, including the National Environmental Policy Act, the Endangered Species Act, and the National Historic Preservation Act, among others.

1.5. Corps Funding Process

The current funding process for USACE requires the authorization and appropriation of funds by Congress. After issuing a Chief's Report on a prospective project, USACE receives authorization from Congress to construct specific projects through the Water Resources Development Act (WRDA). WRDA legislation typically originates in the House Transportation and Infrastructure Committee and must pass through both chambers of Congress. Authorizations must be made for USACE to proceed on project studies and project construction. WRDA authorizations do not appropriate funds to projects, but instead make them eligible to receive future funding.

To begin the yearly budgeting process, each District submits their project portfolio to their respective Division. Then, the Divisions will consolidate this into a singular portfolio. All Division portfolios are rolled up and consolidated on the headquarters level for proposal to the Office of Management and Budget (OMB). OMB typically sets a minimum benefit-cost threshold of 2.5 for a project to be considered for inclusion in the President's annual budget request. Once projects are authorized, they must then be presented in the President's Budget request to receive appropriations. The President's Budget is reviewed by the Appropriations Committee's Subcommittee on Energy and Water Development, and their altered bill must be approved by both houses of Congress to become enacted. Historically, Congress has provided additional funding above what was requested in the President's budget. Congressional actions typically include either an alteration in the amount of funding requested by the President, or the provision of additional general funding for use on specific types of projects, since they are no longer allowed to "earmark" funds. Given limited budgets, projects that move through the authorization process may not receive funding for several years, receive funding one year but not the next, receive such little funding that work cannot efficiently proceed, or never receive funding.

Federal law has dictated how some of USACE's work can be funded through cost share agreements or shared with trust funds. For example, the construction of a coastal port to a 50-foot depth is prescribed as a cost share of 65% federal funding and 35% by a nonfederal partner. Operations & Maintenance and Construction receive part of their funding through established trusts. The Harbor Maintenance Trust Fund (HMTF) was created by Congress to provide funding for maintenance dredging for federally maintained harbors and channels through a 0.125% ad valorem tax on imports and domestic trade. The Inland Waterways Trust Fund (IWTF) was established to help provide additional funding for construction and major rehabilitation of the nation's inland waterway system. Funds are generated through a $0.29 per gallon tax on the diesel fuel used on the inland waterway system. New construction and major rehabilitation projects are financed at 50% by the IWTF and 50% federal funds, although Congress has made exceptions in the past.

The President's Budget for FY 19 was issued in February 2018 and includes $4.785 billion in total funding for the USACE Civil Works program.[5] The House Appropriations Committee approved the FY 19 Energy and Water Development and Related Agencies Appropriation bill on May 16th, 2018, and the bill will head for a vote by the full House of Representatives. This bill, if passed by both houses, will fund the Corps at $7.28 billion.[6]

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[5] President's Fiscal 2019 Budget for U.S. Army Corps of Engineers Civil Works Program released, https://www.usace.army.mil/Media/News-Releases/News-Release-Article-View/Article/1438488/presidents-fiscal-2019-budget-for-us-army-corps-of-engineers-civil-works-progra/

[6] Appropriations Committee Releases Fiscal Year 2019 Energy and Water Appropriations Bill, https://appropriations.house.gov/news/documentsingle.aspx?DocumentID=395283

2. Identified Problems

API Midstream committee members and other non-petroleum stakeholders in the Civil Works and regulatory processes were surveyed to obtain real-world information and data to support and supplement the study to address the role played by USACE in the nation's energy transportation infrastructure. The survey questionnaire asked respondents to articulate the primary issues they had experienced, economic impacts, and possible improvements to the current process. Stakeholders were primarily, but not exclusively, from the different segments of the Midstream business (i.e. pipelines and marine). Surveys and/or phone interviews were also conducted with the American Association of Port Authorities, a trade association that supports North American ports, the Waterways Council, Inc., an organization that advocates for inland waterway infrastructure, and the National Waterways Conference, a proponent for water resource infrastructure. The Port of Houston also completed the survey and provided input for the study.

Additionally, public testimony from the congressional hearing "Examining the U.S. Army Corps of Engineers" in March 2018 provided insights and anecdotes about USACE operations. Several organizations including the Port of Corpus Christi Authority, the Upper Mississippi River Basin Association, and the Lake Carriers' Association gave testimonies. In addition, ICF reviewed reports from USACE, the Government Accountability Office, the Congressional Research Service, and others. The primary problems identified by this cross-section of stakeholders in transportation infrastructure are presented below.

It should be re-iterated that these issues are from a group of stakeholders – within and outside the petroleum industry – who have frequent interface with the USACE and who have contributed input. It is not a comprehensive aggregation of input from all parties who interface with the USACE. The examples shown are actual situations that have occurred, although in most cases the descriptions have been simplified to preserve anonymity.

2.1. Delays in Civil Works Projects

USACE builds and maintains waterways, locks, and ports through its Civil Works program. The infrastructure that the Corps maintains includes 25,000 miles of coastal and inland navigation channels, 241 locks, and 300 commercial harbors. Significant delays to port dredging or major rehabilitation projects on locks can stall economic benefits from enhanced waterborne transportation.

2.1.1. Lack of Funding for Construction and Maintenance Projects

With aging waterborne transportation infrastructure, there is significant competition for Civil Works project funding with limited federal appropriations. Many projects are backlogged after Congressional authorization while waiting for funding. The Harbor Maintenance Trust Fund (HMTF) and the Inland Users Trust Fund were created to collect money from the commercial users of the ports and locks and funnel it back into navigation projects to split the cost with federal funds. Congress still must appropriate these funds, and the trust funds are not always fully appropriated for USACE to use. The HMTF has historically been allocated at 50-75% of the annual collection, although this percentage is increasing with the reforms requested in WRRDA 2014. The balance in HMTF at the beginning of fiscal year 2018 was more than $9 billion.[7]

Testimony from the Port of Corpus Christi Authority for the Subcommittee on the Interior, Energy, and Environment "Examining the U.S. Army Corps of Engineers" about the Port of Corpus Christi illustrates how funding issues can severely delay critical infrastructure projects. The Port of Corpus Christi currently needs $327 million to complete the Channel Improvement Project to deepen and widen the Corpus Christi Ship Channel. The Port's cost share is $102 million, which they have in hand, and they have already transferred $32 million to the Corps. The remaining $225 million was requested at $60 million per year for three years, then $45 million in the fourth year. Although the project was included in the President's Budget for fiscal year 2019, the funding was only $13 million. The cost of the work was estimated as $188 million in 2007 and has ballooned to $327 million today. At a $13 million annual funding rate, the project would take more than a decade to construct, and it may be impossible to keep up with inflation.[8]

Lack of congressional funding and inconsistent project funding year to year were also cited as the biggest impediment to inland river infrastructure projects and preventative maintenance. An example from a shipper speaks to the impacts of unexpected lock outages. A recent outage at Lock and Dam 52 in the Paducah, KY area severely impeded the company's ability to deliver product into the Nashville, TN market. When full and efficient funding is provided for projects, the Corps can build and execute projects cost effectively. After 30 years as an unsuccessful and incomplete project, the Olmsted Project to replace Locks and Dam 52 and 53 on the Ohio River is coming in $330 million under the 2012 budget and 4 years ahead of schedule due to several consecutive years of full funding.[9]

2.1.2. Project Prioritization

The USACE calculates a benefit to cost ratio (BCR) for all prospective navigation Civil Works projects to make investment decisions. A project with a higher BCR generally is favored over one with a lower BCR and OMB has been requiring a ratio of 2.5 to 1 for a project to be considered for funding. Stakeholders, including some port authorities, are concerned that the methods used to determine benefits, costs and alternative costs should be re-evaluated. Although the economic analysis follows a standard methodology, it only includes national benefits, not regional or local benefits. Moreover, the BCR analyses have appeared inconsistent between geographic regions and some have questionable alternative economics, which is a key factor in BCR determinations (i.e. what is the alternative cost if this project is not constructed?). WRDA 2007 directed the USACE to reevaluate BCR methods, which resulted in a proposed shift towards incorporating more environmental considerations. However, Congress did not fund implementation of the newly proposed methodology. It is not clear if the current BCR process

[7] H. Rept. 115-230 – Energy and Water Development Appropriations, https://www.congress.gov/congressional-report/115th-congress/house-report/230/1.

[8] Statement of Sean Strawbridge, Chief Executive Officer of the Port of Corpus Christi Authority, https://oversight.house.gov/wp-content/uploads/2018/03/Strawbridge_PCCA-Testimony.pdf

[9] Inland Waterway User Board Meeting Minutes, https://www.iwr.usace.army.mil/Portals/70/docs/IWUB/board_meetings/meeting85/UB85_Minutes_Final_030118.pdf?ver=2018-03-15-093210-033

fully comprehends the critical nature of port and waterway infrastructure on the U.S. national and regional economic and energy security.

Ports in the Gulf Coast appear to be evaluated by the Corps differently than Ports of the Atlantic Coast in a manner that appears to discount the benefits of improvements. The port of Savannah has a major project ($973MM) to widen and deepen the Savannah River channel by 5 feet to 47 feet to allow larger container vessels to transit. The Port of Houston had a smaller project ($85MM) in 2016 to widen and deepen (by 5 feet to 46.5 feet) the Bayport and Barber's Cut side-channels, which handle substantial container traffic. Although the Port of Savannah has more container traffic than Bayport/Barbers Cut (about 55% more in 2017), Savannah was deemed by USACE to have $282 million in annual benefits compared to $39 million for the Houston project – about 700% higher.[10] [11] The dichotomy in the benefit determination for a similar expansion depth is difficult to rationalize with the data presented.

For a separate, new potential $1 billion-dollar project to deepen and widen the main Houston Ship Channel, the Corps does not believe the transportation cost savings exceed the cost to widen, so the Corps will not include the widening as part of the project. The Port of Houston Authority believes the Corps' transportation delay model does not properly reflect the impacts of ship traffic in Houston.

Testimony from the Lake Carriers' Association for the Subcommittee on the Interior, Energy, and Environment "Examining the U.S. Army Corps of Engineers" about the Soo Lock project details how flawed assumptions in the BCR calculation process can prevent important projects from being funded. The Lake Carriers' Association represents American companies who operate vessels on the Great Lakes. The Soo Locks support the crucial waterborne supply chain of iron ore to steel mills, and the Department of Homeland Security determined that a disruption to this shipping path would have severe impacts on the regional and national economy. This critical project has been in the works since 1986, but significant flawed assumptions in the BCR calculations has prevented the project from receiving funding. USACE assumed that railroad transportation could be used as alternative transportation during a lock outage, but the rail infrastructure connecting the steel mills with raw material does not exist.

Congressional intervention convinced USACE to update the new lock's BCR, but the Principles and Guidelines provides no guidance on how to calculate BCR without existing alternative transportation. In this unique case, they needed to include the cost to build the rail system in the "without project case" which was estimated at $6.5 billion by a USACE hired contractor. Instead, USACE modeled frequency and duration of a lock outage where they averaged all scenarios that included cases where no rail was used due to sufficient iron ore stockpiles at the steel plants. The Monte Carlo simulation model output yielded $2 billion as an alternative cost, and this was used as the cost of the rail system in the BCR calculation. However, this is less

[10] Savannah Harbor Expansion Project FAQ, http://www.sas.usace.army.mil/Portals/61/SHEP%20FAQs%20-%2007%20April%202017.pdf
[11] Port of Houston-Bayport and Barbours Cut Channels Non-Federal Improvements with Federal Assumption of Maintenance, Section 204(f) report, (Corps) Economics Appendix, pg 68

than the amount needed to complete even minimal rail infrastructure. These errors produce a low BCR that does not meet the hurdle rate to receive funding.[12]

2.1.3. Timing to Complete Feasibility Studies

Feasibility studies are completed by the USACE to provide a recommendation to Congress to authorize the execution of a Civil Works project. They establish the Federal interest, engineering feasibility, economic justification, and environmental acceptability. Feasibility studies have historically been completed in around ten years with some studies taking as much as 15-17 years. A lack of funding typically is the cause of this delay. Since 2014, feasibility studies with an integrated EIS must be completed in three years. With the addition of at least four years to get funding and construct the project, this still takes around seven years to complete a project from inception. The Corpus Christi Channel Improvement Project took 13 years to complete the feasibility study and Chief's Report. This significant delay can increase construction costs through inflation and delay national economic benefits that the project would provide.

2.1.4. Lack of Mechanical Commonality

The USACE does not design projects with commonality, as each project is unique. Design standardization on future projects can save engineering hours, drive lower operational costs, lower maintenance expenses, and reduce spare inventory costs. For the locks and dams on the inland waterway system, there seems to be less than adequate spare parts inventory. An example was when Lock 26 on the Upper Mississippi River had a cable fail. For this particular cable, there was no spare in inventory, and it was not an off-the-shelf part. The USACE process is to put out a request for companies to bid, and then the part is manufactured by the winning bidder. Lock 26 was out for around six months to get the new cable manufactured and installed. Since most of the locks were originally constructed 50 years ago or more, the manufacturers of the original parts are no longer in business. The USACE has identified this as an issue and recently has made strides to start studying standardization and implementing changes. The Inland Navigation Design Center has been tasked with the responsibility to standardize design of components for navigation locks and dams.[13]

2.2. Delays in Regulatory Review and Permitting

USACE acts as a regulator of private and public infrastructure projects under both the Clean Water Act (CWA) and Rivers and Harbors Act (RHA). As such, USACE has a key role in the permitting of oil and gas pipelines, railroads, and other modes of transportation that cross federally jurisdictional waters, including navigable waters, wetlands, and other Waters of the United States. Lack of efficiencies in permitting and environmental review processes for new infrastructure construction can add unnecessary costs due to inflation, remobilization, inefficient

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[12] Statement of James Weakley, President, Lake Carriers' Association, https://oversight.house.gov/wp-content/uploads/2018/03/Weakley_LCA-Testimony.pdf

[13] Inland Marine Transportation System Progress Report, https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll11/id/2085

procurement, and reengineering. The regulatory function has received stagnant funding over several years which constrains personnel levels, leading to inefficiencies.

2.2.1. Inconsistent Interpretation of Requirements across Districts

Many companies own and operate infrastructure that crosses the borders of multiple USACE Districts, especially major interstate pipeline infrastructure. Companies that work with multiple Districts have found that there are often different requirements from office to office to acquire the same permit, creating inefficiencies that can hamper the application process. For example, one District may require applicants to provide additional or different supporting material when compared with another District. An example encountered is a District approving remote sensing in lieu of a land survey in cases where landowners deny the survey request, whereas this is not an acceptable process to meet permit requirements in other Districts. Furthermore, applicants have difficulty anticipating and planning for the likely length of the permit process, as permit forms, needed supporting data, and the Corps' internal review processes vary across the autonomous Districts.

2.2.2. Inconsistent Application of Nationwide Permit Program

As described in Chapter 1 above, the nationwide permit program (NWP) streamlines the authorization of minor activities regulated under the CWA and RHA. By preauthorizing over 50 classes of project types, the NWP program is intended to reduce permit application processing time and associated documentation burden for applicants. Projects with more than minimal environmental impacts are regulated using individual permits, which require more time, effort, and expense. While the NWP program is developed by Corps Headquarters, it is implemented at the District level. Much of the regulated community perceives District authorization to utilize a NWP to be granted inconsistently between Districts, making project scheduling and planning unpredictable.

For example, a stakeholder described a project to enhance the depth of cover for an existing pipeline. They had previous experience with a similar project that was authorized under the NWP program. However, in the present case, they instead had to complete a lengthy and costly environmental assessment when USACE determined the project did not fall within any existing NWP. A similar case was reported where minor construction activities at an energy facility resulted in impacts below the threshold of the relevant NWP but which were instead treated as a modification to the terminal's original individual permit. Among stakeholders, there is a general concern that some Districts interpret and apply the NWP program more restrictively, reducing the program's utility and increasing project cost and processing times. In addition, some companies disagreed with the selection of the nationwide permit that their project fit under especially when a less restrictive NWP was available and thought to be applicable.

2.2.3. Insufficient Communication with Permit Applicants

Clear and timely communication between USACE and a permit applicant is critical to achieve an expeditious permit review. To illustrate a negative example of this, a permit applicant indicated that USACE has "stopped the clock" on their CWA § 404 permit reviews without informing them or their consultants. Since USACE has no defined timeframe under which they will review the submission of permits, it can be time-consuming and frustrating for both parties to have to check-in for status reports. If there was a better-defined flow of information and the levels of approval required, the applicant would be less in the dark of the permit status.

Permit applicants indicate that they need clearer direction on what the USACE expects to be submitted. When guidance is unclear regarding why the permit application is deemed incomplete, it can result in significant revisions for the applicant. Challenges have also been encountered in getting the USACE to cite regulations or interpretations that would help applicants understand what requirements the Corps are relying on to make decisions.

2.2.4. Coordination Challenges with Other Agencies

Similarly, companies indicated that USACE has a lack of coordination with other agencies on joint permits and NEPA reviews. A permit applicant attributed most of its 3-year permitting delay to the breakdown of communication between USACE and the Bureau of Land Management (BLM). Due to a disagreement over technical issues and its own lack of funding, USACE chose not to comment during the BLM permitting process and, as a result, BLM moved forward with the permitting process without USACE involvement. Later, the company was required to begin a new process to review and approve the project separately with the USACE. In a similar illustration, another applicant indicated that USACE would not accept its permit after FERC, as lead federal agency, selected an alternative that USACE did not consider the Least Environmentally Damaging Practicable Alternative. Multiple parties also report that the USACE performs redundant work processes to other agencies, which can extend the overall permitting duration.

2.2.5. Unanticipated Modifications to Project Design

Occasionally, USACE has required project redesigns such as changing pipeline routing or facility layout for permit acceptance, and these changes can significantly delay the project and increase the overall costs. In some instances, these changes are justified and illustrate the USACE doing its job to minimize adverse effects to jurisdictional waters and wetlands. However, pipeline rerouting to longer, less optimal designs adds substantial cost to the company building the pipeline. While the permit is under review, companies may proceed with detailing their proposed design. The longer USACE takes to respond that their design must be altered for approval, the more expensive the re-engineering costs will be. A situation was described where the USACE would not approve a permit for a routing that was already approved and selected by the lead federal agency. The applicant had to ultimately make the change to accommodate USACE's preferred routing, at significant expense and delay to their project.

Alternative construction methods have also been required by USACE for permit approvals. In some cases, permits impose prescriptive methods that do not allow companies the freedom to use a technology that is the best fit for the job. Although a common practice, the Corps requires horizontal directional drilling (HDD) in certain situations for replacing and removing a portion of a line instead of other engineered solutions such as open cut or jack and bore. For one project, the permit holder preferred not to use HDD since it added cost to the project without commensurate benefit, but there was no flexibility to debate the advantages and disadvantages of other methods with USACE.

2.2.6. Late Requirement of Section 408 Permit

In September 2015, the Corps issued engineering circular (EC) 1165-2-216, which altered the framework for conducting Section 408 reviews. This change added additional obligations for non-federal interests that propose an alteration of a civil works project, often elongating the project approval process. As a part of this policy change, USACE determined that a change in pipeline service from natural gas to crude oil and natural gas liquids, even though it did not require construction or alteration of the existing pipeline, implicated the Section 408 review process. The unexpected, lengthy review made the in-service date of the pipeline very difficult to predict and delayed realization of the transportation benefits the pipeline would provide.

Over five years into the NEPA process for a pipeline project for which USACE is a cooperating agency, USACE determined a Section 408 permission was required where the project crossed a river downstream of a USACE-owned dam. After a year of effort, this company has still not received the requested permission. This determination led to a consequential delay in the receipt of the requested Grant of Right of Way and Temporary Use Permit from the Bureau of Land Management.

2.2.7. Detached Decision Making

USACE sometimes may interpret regulations in ways that result in significant impacts to stakeholders without fully recognizing the impacts prior to enacting policy changes. In 2014, USACE modified the CWA § 401(c) process: the application process to perform maintenance dredging in privately owned marine terminals using federal dredged material placement areas. The new procedure required additional sediment testing, drawings from underwater surveys, additional paperwork, and approvals that had to go through the division and headquarters levels. Maintenance dredging applications were initiated at the District level for marine terminals, but the District did not staff up for the additional work and had a lack of clarity on the new process. Applications that had taken 3 months in the past were now taking 15 months. In certain areas with high siltation, this can lead to significant draft restrictions, which can cost companies several million dollars per year. A study of the Houston Ship Channel by the Texas Transportation Institute concluded that 1 foot of draft would translate to $282 million per year based on 2008 vessel traffic.[14] With higher volumes in 2018, the impact could be even greater now.

A congressional letter to the Assistant Secretary of the Army describes the consequences that this CWA § 401(c) change had in the Houston Ship Channel which includes increased shipping costs, increased dredging costs, and decreased scheduling predictability. The Congressmen from Texas indicate that USACE was viewing the maintenance of the federal channel as a higher priority than private terminals, but it needs to be recognized as a symbiotic relationship to realize the true economic benefits of the harbor. A new 217(b) process under the Water Resources Development Act was defined in 2017, which allowed the port authority to become the Corps point of contact for maintenance dredging. The 217(b) process effectively became a means to avoid some of the lengthy and complicated procedure that CWA § 401(c) had

[14] Direct Economic Effects of Lack of Maintenance Dredging of the Houston Ship Channel, https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2010-17.pdf

become. With reduced approval delays under 217(b), private terminals were able to return to their normal dredging cycles to avoid draft reductions.

2.3. General Issues Causing Delays

2.3.1. Staffing Levels and Development

USACE may lack the staffing necessary to be successful as their workload grows in the coming years should funding for infrastructure grow. Staffing levels and experience level were cited as widespread issues. Personnel turnover also contributes to delays when key staff on a complex permitting review are reassigned. It takes time for the new staff member to get up to speed on the work. For a certain project, staffing issues contributed to most of the delay on a Section 408 review. The assigned project coordinator had a lack of experience in the regulatory process, yet the coordinator appeared to be an autonomous decision maker with no direction given to him from management.

2.3.2. Mission Scope Issues

USACE is responsible for a heavy workload, which includes many diverse missions: navigation, flood risk, recreation, emergency assistance, regulatory administration, and others. Staff become diverted for emergency relief, which is a large scope of work. For FY 2018, four major hurricanes in the United States led to an additional appropriation of $17.4 billion for emergency response. The Corps pull key staffing resources from base project activities to work the emergency effort. Personnel tend to be pulled off permitting activities when waters, such as the Mississippi River, are in flood stage, which can extend for months at a time. This creates extended delays and a large backlog of work for USACE personnel once water levels recede.

2.3.3. Other Issues

Other issues include running out of funding for permit review in the middle of reviewing a Section 408 permit. The applicant ultimately used a new process to provide private funding for USACE to complete the review. The project was delayed for several months due to a budget shortfall of less than $10,000, and the delay could have been significantly longer without the company's intervention and support. Another issue was that USACE did not enforce its public comment period deadline. This caused additional delay to the project, since the company had to work to evaluate, review, and respond to the late comments.

2.4. Economic Impacts Identified in Surveys

2.4.1. Economic Impact of Civil Works Projects Delays

Inadequate maintenance at locks can result in higher costs for transporting commodities such as fuel, grain, and coal. Higher transportation costs occur due to congestion and delays through locks. Delays can also be caused when there is a mismatch between lock size and the quantity of barges per tow. If a tow has more connected barges than can fit through the lock, it must disconnect and go through the lock in multiple passes.

When locks are out of service for either scheduled or unscheduled maintenance, shippers must use costlier alternative transportation. The alternative transportation can be less reliable and could require sourcing of product from non-optimal areas to meet demand. During lengthy outages, supply issues could cause refined product terminals to run out of product. This also translates to lost revenue for marine based terminal owners. If terminal outages are happening consistently, there can be a negative impact on the company brand, and retailers may choose to source product from other suppliers with more reliable supply. Also, the USACE has scheduled maintenance activities in poorly timed windows which intensifies the economic effects of the downtime. An example was provided of USACE scheduling maintenance during harvest season when there are increased grain movements required on the waterways.

Delays in projects at major ports to deepen channels or widen the waterways have resulted in higher costs due to using non-optimal transportation. Port projects provide the option to use larger, deeper draft vessels or large “U” shaped container vessels. The larger vessels capture economies of scale to provide transportation at lower costs to shippers either importing or exporting commodities. Sean Strawbridge from the Port of Corpus Christi indicated that larger tankers could save fifty to seventy-five cents per barrel for their shippers.[15] Corpus Christi had almost a million barrels a day of petroleum exports in 2017 and about 2 million barrels per day of new crude pipeline capacity being built to export Permian crude. This magnitude of volume translates to significant savings at even fifty cents per barrel.

Delays in port projects can stall the completion and startup of major manufacturing and transportation projects -- either at the port or at locations supplied through the port. Delays can often last for years. Pipeline projects to ports such as Corpus Christi, Houston, and Sabine Pass are necessary to ship crude, petroleum products and NGL’s for export and further sustain the U.S.’s role in global oil markets. The potential exists for projects to be delayed due to the uncertainty of funding to get the port investments needed in multiple areas. The delays affect petroleum, grain, and container business, and impedes development of jobs supporting those business investments.

2.4.2. Economic Impacts of Permitting Delays

For the infrastructure developer applying for a USACE permit, delays substantially increase construction costs. They will most likely pay retainage to hold their construction contractor beyond the expected timeline, or risk losing the contractor or inspection staff. There are costs associated with having purchased materials that sit until construction, or material purchases are delayed until permits are final, and the costs are higher due to inflation. Delays also mean lost revenue for the investor from shipper tariffs. Delays in getting permits granted have affected the scheduling of work beyond the optimal timing. For example, permit delays have previously pushed pipeline maintenance work into hurricane season or wintertime, which increase costs, jeopardize supply, and can have safety impacts.

Shippers (parties who transport their commodities on pipelines) also are subject to negative impacts from project delays. Volumes planned to be shipped on new pipelines or existing

[15] Statement of Sean Strawbridge, Chief Executive Officer of the Port of Corpus Christi Authority, https://oversight.house.gov/wp-content/uploads/2018/03/Strawbridge_PCCA-Testimony.pdf

pipelines requiring maintenance work must find alternative, more costly transportation modes to destination markets. Not only does this cost more, alternative shipping routes may not be as reliable as pipeline delivery, which could impact market supply. Shippers may need to source product from other, non-optimal terminals until the pipeline is permitted and built or until the maintenance work is completed. This means increased truck use and traffic congestion as trucks typically have to drive further from the alternative terminal to deliver to retail stations.

Pipelines typically can move product from origin to destination at costs well below rail, marine or truck.[16] Delays in building pipelines will delay the ability of consumers to benefit from the more efficient transportation cost into their area. Pipelines are also less vulnerable to delays due to severe weather, which can affect rail, marine and truck movements. Hence, the delays in pipeline completion can aggravate supply issues in the destination markets.

2.5. Recent Corps Reforms

As part of recent testimony from Mr. James Dalton, Director of Civil Works at USACE, he said, “The Corps continues to work on policy and administrative changes that can improve infrastructure delivery. More specifically, we are looking internally at our organization, authorities, policies, regulations and procedures in order to identify opportunities for increased efficiency and effectiveness. This will include efforts to reduce redundancy and delegate authority for decision making to the most practical and appropriate level.”[17] The Corps have identified some of their issues and have plans in place to make improvements.

2.5.1. 3-3-3

In February 2012, the Deputy Commanding General for Civil and Emergency Operations issued a memorandum stating that all feasibility studies that have not reached the Feasibility Scoping Meeting milestone will follow a new “3x3x3 rule”. This new rule states that Corps’ feasibility reports will be produced in a target goal of 18 months but no more than three years, with a cost not greater than $3 million, and involve all three levels of Corps review (district, division, and headquarters) through the entire study process. Furthermore, the target length of the main report for an integrated feasibility study and EIS should be no more than 100 pages. The full report and appendices should not exceed a single 3-inch binder. The 3 years is defined from execution of a Feasibility Cost Sharing Agreement to the signed Chief’s Report. WRRDA 2014 reinforces the “3x3x3 rule”.[18]

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[16] A key example is the Colonial pipeline moving products from Houston to Linden, N.J and points in between. Colonial’s tariff to Linden is under 5 cents per gallon; marine options can be significantly higher. Rail movements are also expensive with limited loading and receipt capability, and trucking is impractical over 1,500 miles. It should also be noted that in many cases options do not exist for all four modes between locations (for example, crude rail movements from North Dakota to the Pacific Northwest have no pipeline or marine options).

[17] Complete Statement of Mr. James Dalton Director of Civil Works, https://oversight.house.gov/wp-content/uploads/2018/03/Dalton_USACE-Testimony.pdf

[18] Feasibility Study Implementation, Frequently Asked Questions, http://www.sas.usace.army.mil/Portals/61/docs/CWTransformation/FAQ_feasibilitystudyimplementation.pdf

Although this reform seems to be a significant improvement over past lengthy studies, studies deemed as "complex" can apply for an exception if they are thought to require more time or funds. Factors that determine if a study is complex include type, size, location, scope, project cost, whether an innovative design or construction technique is proposed, and whether there is significant public dispute as to the economic or environmental benefits of the project.[19] The ongoing Houston Ship Channel Expansion feasibility study has been granted an exception and is projected to take 4 years and $10 million to complete.[20]

2.5.2. One Federal Decision

USACE has committed to the "One Federal Decision" process for major infrastructure projects. The Memorandum of Understanding (MOU) signed in April 2018 establishes a coordinated and timely process for environmental reviews. A lead federal agency is first established to navigate the project through the entire process. All agencies involved are then committed to meeting the lead federal agency's permitting timetable and to conduct the necessary review processes concurrently and in one EIS and one Record of Decision (ROD) for purposes of complying with NEPA. Environmental reviews and authorization decisions should be completed within two years on average. Relevant federal agencies are required to issue the necessary permits for the project within 90 days of the signing of the ROD. The MOU requires automatic escalation of interagency disputes so that these disagreements do not lead to lengthy delays for projects. Once implemented, this has the possibility of improving the Corps' ability to work with other federal agencies and remove roadblocks that delay the implementation of projects.

2.5.3. Principles & Guidelines Changes

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) was written in 1983 to provide direction to USACE when evaluating and selecting water resource projects. WRDA 2007 called for the development of new P&G to encourage national development and protect the environment. This document was developed in 2013, and the proposed revised P&G gave significant weight to environmental considerations. This method was perceived by infrastructure stakeholders and some in Congress as reducing the priority for critical navigation infrastructure. After congressional evaluation of the new P&G, Congress refused to fund the implementation of the new P&G. As a result, the original 1983 P&G are still in use today, 35 years later.

In the Senate's version of "America's Water Infrastructure Act of 2018", Congress calls for a GAO study on the benefit-cost calculation. They are called to examine the benefits and costs that are and are not included, in particular local and regional economic benefits. The

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[19] Understanding 3x3x3 Rules and Exemptions, https://planning.erdc.dren.mil/toolbox/library/PCoP/A3_Understanding%203x3x3%20Rule_ColemanHanneken.pdf

[20] Winter 2018 Stakeholder Meeting Presentation, http://www.swg.usace.army.mil/Portals/26/docs/Stakeholder%20Partnering%20Forum/6%20-%20HSC%20ECIP%20Winter%20Stakeholder%202018%20Presentation_V1.pdf?ver=2018-03-02-213237-927

subsequent report submitted to Congress will include recommendations for legislative or regulatory changes to improve benefit-cost analysis procedures.

2.5.4. Section 408 Reform

The Corps FY 2017 budget only included $3 million nationwide to process Section 408 reviews. Only a limited number of reviews were able to proceed, so in June 2017, the Corps issued interim guidance to simplify nonfederal funding of Section 408 reviews to address the issue.[21] USACE recognized that changes needed to be made to the Section 408 process, and a draft Engineering Circular (EC) was issued and went out for public comment in February 2018. The finalized guidance should be issued in late summer of 2018. Included in the new document, USACE will establish a multi-phase review option for large-scale projects with complex engineering and design or multiple construction phases. The EC creates timelines for a completeness determination and for the review and decision phases of the Section 408 process. This predictability will allow stakeholders an efficient planning process, as well as keep project costs in check. Section 408 decisions will no longer need approval from Corps Headquarters. Delegating decision making to the Division level will allow for a more efficient process.[22]

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[21] USACE Issues Guidance on Contributed Funds for Section 408 Review, https://www.theleveewasdry.com/2017/06/usace-issues-guidance-contributed-funds-section-408-review/
[22] Policy and Procedural Guidance for Processing Requests to Alter U.S. Army Corps of Engineers Civil Works Projects, http://cdm16021.contentdm.oclc.org/utils/getfile/collection/p16021coll9/id/505

3. Economic Costs

This chapter presents the economic costs associated with inefficiencies in the operations overseen by the USACE and the potential economic benefits that would occur if those inefficiencies were reduced or eliminated. ICF estimates that the inefficiencies lead to direct annual costs of between $2.90 to $9.71 billion borne by infrastructure developers, oil and producers, the USACE itself, and by shippers using waterborne and pipeline transportation services. These costs reverberate through the U.S. economy in complex ways leading to net reductions in GDP. Between 2020 and 2040, we estimate that average annual U.S. GDP could be $1.52 to $6.05 billion larger if those inefficiencies were eliminated. This chapter begins with an explanation of the roles played by waterborne and pipeline transportation services in the U.S. economy. Then the chapter explains how we estimated the direct costs and their economic impacts in terms of GDP and social welfare.

3.1. Base Year Statistics for Freight Transportation

Freight transportation costs associated with trucking, pipelines, parcel, railways, and waterways along with associated freight costs accounted for $1,466 billion or 7.9% of the Gross Domestic Product in the U.S. in 2016[23]. This study estimated the freight costs in the U.S. utilizing information from the Council of Supply Chain Management Professionals (CSCMP)[24], the U.S. Census Economic Census[25], and IBIS World[26] with adjustments to pipeline and waterborne freight cost estimates. As the U.S. Census Economic Survey and IBIS World represent the transportation cost associated with U.S. companies, the difference in Freight on Board (FOB) and Cost, Insurance and Freight (CIF) from the U.S. Census Harmonized Tariff Schedule data was used to estimate deep-sea shipments.

Waterborne freight transportation includes all marine activity by ships, barges, tankers or boats used to transport goods from one location to another. The marine freight costs include transportation cost and port activities to load vessels, unloading, insurance of the goods and costs associated with storing product. The transportation costs were separated into three categories including deep-sea freight, coastal and Great Lakes freight and inland water freight as defined below:

- ***Deep Sea Freight Transportation Costs***[27] includes costs of shipping/transporting freight to or from foreign ports to U.S. ports. This source includes transportation of bulk liquids, dry bulk, boxed, palletized and other packed goods, automobiles, light trucks,

[23] The nominal GDP in 2016 was 18,624.5 billion dollars. Retrieved from: https://www.bea.gov/national/xls/gdplev.xlsx
[24] *Council of Supply Chain Management Professionals.* 28th Annual State of Logistics Report. 2016. Available at: http://cscmp.org/store/SearchResults.aspx?Category=SOL
[25] U.S. Economic Census. 2012 Transportation and Warehousing (NAICS Sector 48-49). 2012. Available at: https://www.census.gov/data/tables/2012/econ/census/transportation-warehousing.html
[26] IBISWorld Industry Reports
[27] NAICs Code 483111 Deep Sea Freight Transportation: Available at: https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart_code=48&search=2017%20NAICS%20Search

and truck trailer for deep-sea voyages. Additionally, the cost of chartering a crew associated with these voyages is also included.

Exhibit 3-1: Transportation Costs in 2016[28]

Transportation Logistics	2016 Costs (Billions of $)
Full truckload	*$269.40*
Less-than-truckload	*$58.00*
Private or dedicated	*$268.10*
Trucking/Motor Carriers	***$595.50***
Parcel	***$86.30***
Carload	*$52.60*
Intermodal	*$19.30*
Rail	***$71.90***
Air freight (includes domestic, imports, export, cargo, and express)	***$66.90***
Water - Deep-sea	*$83.22*
Water - Coastal and Great Lakes freight transportation	*$7.49*
Water - Inland water freight transportation	*$8.31*
Water - Inland	*$15.80*
Waterborne	***$99.02***
Pipeline	***$48.40***
Transportation Costs - Total	**$968.02**
Storage	***$143.50***
Financial cost (WACC x total business inventory)	***$143.40***
Other (obsolescence, shrinkage, insurance, handling, others)	***$122.90***
Carrier's support activities	***$44.70***
Shipper's administrative costs	***$43.30***
Inventory Carrying Costs and Other Costs- Total	**$497.80**
Total Costs	**$1,465.82**

** Note the deep water costs includes insurance and, therefore, there is some double counting of insurance for waterborne transportation*
*** Substituted values from the Council of Supply Chain Management Professional's with derived values for pipelines and waterborne transportation*

[28] Categories other than Water and Pipeline based on *Council of Supply Chain Management Professionals.* 28th Annual State of Logistics Report. 2016. Available at: http://cscmp.org/store/SearchResults.aspx?Category=SOL

- ***Coastal and Great Lakes Freight Transportation Costs***[29] includes the cost of chartering a crew and shipping barges/freight and towing services to and from domestic ports. These domestic ports include coastal ports as well as ports along the Great Lakes including the St. Lawrence Seaway. Additionally, this category includes deep-sea freight transportation from domestic ports including Puerto Rico.
- ***Inland Water Freight Transportation Costs***[30] includes the cost of barge transportation, freight transportation and towing services on canals and inland waterways except the Great Lakes system. Additionally, any lightering costs and chartering crew costs are also included in this category.

Utilizing the U.S. Army Corps of Engineers Navigation Data Center[31] for tons transported coupled with the Freight Analysis Framework[32] for distances traveled by commodity, and the waterborne transportation cost identified above, ICF generated waterborne transportation statistics.

Exhibit 3-2: Waterborne Transportation Statistics

Description	Domestic					Foreign				Total
						Import		Export		
	Coastwise	Lakewise	Internal	Intraport	Intraterritory	Coastwise	Lakewise	Coastwise	Lakewise	
Million Metric Tons Shipped by Water	153	71	497	73	1	673	13	582	17	2,079
Average Distance (Nautical Miles)	556					4,711		4,888		3,173
Million Metric Ton – Nautical Miles	441,951					3,170,283		2,984,791		6,597,025
Million Dollars Transport Cost*	$15,800					$40,972		$42,245		$99,017
$/MT Transport Cost*	$19.9					$59.8		$70.6		$47.6
Cents/MT-Nautical Mile*	3.6¢					1.3¢		1.4¢		1.5¢

* Includes some insurance for international shipping.

3.1.1. Domestic Waterborne Movements

The USACE provides domestic movements by commodity and ship traffic type. Exhibit 3-3 below shows 14 high-level groupings of commodities by domestic traffic type in 2016. Coastwise represents any cargo transported along coasts or over deep-sea routes, while lakewise and internal movements represent inland cargo transported through lake or waterway systems. Intraport represents cargo which was transported locally (i.e., moved within the same port), and intra-territory represents cargo transported to and from U.S. territories such as Puerto Rico or the U.S. Virgin Islands.

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29 NAICs Code 483113 Coastal and Great Lakes Freight Transportation. Available at: https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart_code=48&search=2017%20NAICS%20Search

30 NAICs Code 483211 Inland Water Freight Transportation. Available at: https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart_code=48&search=2017%20NAICS%20Search

31 U.S. Army Corps of Engineers Navigation Data Center http://www.navigationdatacenter.us/index.htm

32 Bureau of Transportation Statistics. Freight Analysis Framework Data Tabulation Tool. Available at: https://faf.ornl.gov/fafweb/Extraction0.aspx

Inland, coastal and Great Lakes waterborne freight transportation costs are estimated to be $15.8 billion in 2016 by the Council of Supply Chain Management Professionals (CSCMP).[33] This overall cost was then split into two sub-categories of coastal and Great Lakes freight transportation and inland water freight transportation by utilizing six-digit NAICS code revenue data from the U.S. Census Economic Census[34], and IBIS World[35]. This split was calculated by using NAICS code level data for waterborne traffic from the Census and apportioning it into freight, passenger/recreation, and intermediate costs using product and service code level information. This percentage of freight costs by NAICS code was applied to the appropriate NAICS code for both the Economic Census and the IBIS data and then scaled to match the total $15.8 billion dollars. This methodology generated two unique estimates for the costs of inland and coastal and Great Lakes (Utilizing Economic Census and IBIS). These two estimates were averaged to yield $7.5 billion for coastal and Great Lakes freight transportation costs and $8.3 billion for inland water freight transportation costs.

Exhibit 3-3: Summary of 2016 Domestic Commodity Waterborne Movements (metric tons)

Commodity Description	Coastwise	Lakewise	Internal	Intraport	Intraterritory
Coal, Lignite, and Coal Coke	2,528,909	11,187,801	99,512,333	7,491,751	0
Crude Petroleum	43,763,723	0	32,520,589	4,849,789	0
Petroleum Products	71,972,390	1,827,320	110,353,738	39,934,855	728,625
Chemical Fertilizers	1,746,669	0	15,866,466	111,479	0
Chemicals excluding Fertilizers	8,097,948	118,740	31,539,869	9,948,820	0
Lumber, Logs, Wood Chips, and Pulp	734,199	0	3,733,446	504,828	0
Sand, Gravel, Shells, Clay, Salt, and Slag	4,581,042	19,351,824	73,247,690	4,992,990	0
Iron Ore, Iron, and Steel Waste and Scrap	315,434	35,141,462	6,609,441	3,643,460	0
Non-Ferrous Ores and Scrap	121,460	5,438	4,011,710	10,876	0
Primary Non-Metal Products	1,057,791	2,896,882	9,479,092	318,123	0
Primary Metal Products	348,065	94,266	14,828,642	22,658	0
Food and Food Products	4,955,393	235,666	88,061,830	223,864	5,444
Manufactured Goods	12,237,563	22,660	6,169,839	271,900	167,865
Unknown and Not Elsewhere Classified Products	473,151	16,315	852,919	239,272	440,079
Total	**153,067,789**	**70,960,520**	**497,223,054**	**72,628,269**	**1,343,190**

3.1.2. Waterborne Imports

While the USACE provides information regarding import and export tonnages by commodity, they do not provide origin or destination country information. Additionally, the USACE does not provide any value estimates of foreign cargo shipments. To determine both the origin/ destination country of foreign cargo as well as commodity values and associated shipping rates, U.S. Census Trade data[36] was utilized. This database provides both vessel tonnages and values for imports and exports at the commodity level, as well as the foreign country destination or origin. For imports, the FOB and CIF value of each shipment was used to determine a cost of freight and insurance for a given commodity and region of origin. Ton-miles were determined by

33 Council of Supply Chain Management Professionals. 28th Annual State of Logistics Report. 2016. Available at: http://cscmp.org/store/SearchResults.aspx?Category=SOL

34 U.S. Economic Census. 2012 Transportation and Warehousing (NAICS Sector 48-49). 2012. Available at: https://www.census.gov/data/tables/2012/econ/census/transportation-warehousing.html

35 IBISWorld Industry Reports

36 USA Trade Statistics; https://usatrade.census.gov/index.php?do=login

utilizing a matrix of nautical mileage between regions of origin to particular U.S. regions established using latitude and longitude calculations from publicly available sources[37].

Exhibit 3-4 below gives a summary of 2016 import movements by commodity type. Additional tables showing intermediate calculations can be found in Appendix B.

Exhibit 3-4: Summary of 2016 Waterborne Import Tonnages and Shipping Costs

Commodity Code	Commodity Name	Tonnes	Ton-Miles	F&I ($)	F&I ($) / Tonne	cents/ton-mile
1000	Coal, Lignite, and Coal Coke	8,533,255	32,398,633,038	65,053,916	7.62	0.20
2100	Crude Petroleum	252,006,521	1,228,300,272,096	3,668,192,159	14.56	0.30
2229	Petroleum Products	107,922,938	435,457,998,238	2,211,969,166	20.50	0.51
3100	Chemical Fertilizers	12,762,647	72,627,186,988	258,612,184	20.26	0.36
3200	Chemicals excluding Fertilizers	40,066,359	213,782,460,996	4,627,176,698	115.49	2.16
4142	Lumber, Logs, Wood Chips, and Pulp	7,779,186	36,543,341,287	715,964,720	92.04	1.96
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	55,294,968	147,459,276,985	370,911,642	6.71	0.25
4400	Iron Ore, Iron, and Steel Waste and Scrap	3,111,247	9,126,971,489	30,236,672	9.72	0.33
4600	Non-Ferrous Ores and Scrap	11,029,048	44,649,921,612	95,785,339	8.68	0.21
5155	Primary Non-Metal Products	9,977,087	53,138,169,451	1,422,516,280	142.58	2.68
5354	Primary Metal Products	33,466,086	158,452,718,656	1,729,878,171	51.69	1.09
6168	Food and Food Products	44,307,007	200,487,954,876	4,577,887,233	103.32	2.28
7000	Manufactured Goods	84,746,539	528,302,880,024	21,024,870,256	248.09	3.98
8099	Unknown and Not Elsewhere Classified Products	1,198,218	5,708,470,945	58,047,039	48.44	1.02
	All USACE categories	672,201,105	3,166,478,526,851	40,857,101,474	60.78	1.29

3.1.3. Waterborne Exports

Data for exported commodities were summed into destination regions using a similar method to imports[36]. However, unlike imports, only FOB values and not shipping costs are provided at the commodity level for exports. To determine relevant export freight and insurance costs, the calculated cents-per-ton-mile shipping costs for imports were applied to exports on a basis of commodity and trade route. Because some low-volume import commodity movements produced extremely high per-unit shipping costs, a commodity average cents-per-ton-mile shipping cost was used for some low-volume trade routes.

Exhibit 3-5 below shows a summary of 2016 exports movements by commodity type. Additional tables showing intermediate calculations can be found in Appendix B.

[37] Nautical Distances Calculator; https://sea-distances.org/

Exhibit 3-5: Summary of 2016 Export Tonnages and Shipping Costs

Commodity Code	Commodity Name	Tonnes	Ton-Miles	F&I ($)	F&I ($) / Tonne	cents/ton-mile
1000	Coal, Lignite, and Coal Coke	51,844,005	207,465,889,528	664,234,683	12.81	0.32
2100	Crude Petroleum	16,027,309	61,385,355,590	228,512,841	14.26	0.37
2229	Petroleum Products	194,496,469	828,916,200,476	3,754,200,184	19.30	0.45
3100	Chemical Fertilizers	8,565,188	35,778,953,349	203,719,568	23.78	0.57
3200	Chemicals excluding Fertilizers	55,870,819	270,955,174,222	5,610,091,173	100.41	2.07
4142	Lumber, Logs, Wood Chips, and Pulp	31,177,390	191,739,191,072	4,607,684,676	147.79	2.40
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	6,534,149	30,282,784,833	78,718,564	12.05	0.26
4400	Iron Ore, Iron, and Steel Waste and Scrap	7,083,147	15,562,344,851	151,313,918	21.36	0.97
4600	Non-Ferrous Ores and Scrap	1,909,150	10,566,917,183	30,049,277	15.74	0.28
5155	Primary Non-Metal Products	24,095,066	141,216,809,504	3,882,837,653	161.15	2.75
5354	Primary Metal Products	15,790,050	89,898,001,263	1,102,448,390	69.82	1.23
6168	Food and Food Products	184,691,967	1,034,404,145,192	19,252,394,969	104.24	1.86
7000	Manufactured Goods	12,397,203	66,147,628,350	2,674,041,915	215.70	4.04
8099	Unknown and Not Elsewhere Classified Products	109,476	471,114,560	4,749,288	43.38	1.01
	All USACE categories	610,591,386	2,984,790,509,971	42,244,997,102	69.19	1.42

3.2. Base Year Statistics for Energy Pipelines

The USACE can affect energy pipelines when they are seeking construction permits and when approvals are needed for a significant change in operations, such as conversion from natural gas to crude oil service. A pipeline will require a Section 404 permit under the Clean Water Act when its construction involves the discharge of dredged or fill material into waters of the United States, including wetlands. The more complex and time-consuming Section 404 Individual Permits would be required for potentially significant impacts (generally more than an acre of wetland), while Section 404 General Permit (Nationwide Permit 12) are used for pipeline project elements with less significant impacts including most pipeline water crossings. A pipeline might need a Section 10 when any of its structures and construction work occur in or affect the course, condition, or capacity of navigable waters. In addition, a pipeline may require a Section 408 permit when it involves the permanent or temporary alteration or use of any USACE Civil Works project such as crossing a USACE levee.

Energy-related pipelines include those transporting natural gas, crude oil, natural gas liquids, petroleum products, and carbon dioxide. The U.S. has 298,005 miles of natural gas pipelines that transport gas to local gas distribution companies and to some large industrial gas consumers and gas-fired power plants. U.S. natural gas transmission pipelines have over 1,400 compressor stations, collect gas from over 5,000 receiving points, and deliver gas to over 11,000 delivery points. The U.S. also has 73,260 miles of crude oil pipelines that transport lease condensate and crude oil to refineries and terminals. There are also about 67,467 miles of “highly volatile liquid” or HVL pipelines in the U.S. These mostly transport a mixture of raw NGLs from a production region to a market center or transport fractionated “purity” ethane, propane and butane from a market center to a consuming region. Some of these HVL pipelines also transport chemicals, including ethylene. The U.S. has 62,543 miles of petroleum product pipelines that move gasoline, diesel fuel, jet fuel and other light products from refineries to terminals in consuming regions. The final category of energy-related pipelines are carbon dioxide pipelines: There are 5,205 miles of such pipelines that move carbon dioxide from carbon dioxide fields, natural gas processing plants, and industrial plants to oil fields for enhanced oil recovery.

The estimated volumes of product moved through each type of pipeline and the associated revenues are shown in Exhibit 3-6. These figures include both interstate and intrastate flows and revenues. Total capital investment in energy pipelines is estimated to have been $21.3 billion in 2015. The annual level of capital investment can fluctuate considerably depending on which large projects are under construction at any given time.

Exhibit 3-6: Transport Volumes and Revenues for Energy-related Pipelines

NAICS	Sector	Product/ Service	Volume Transported 2015	Volume Units	Revenue ($million)
486110	Pipeline Transportation of Crude Oil	crude oil and condensate transport	9,289	million barrels	$12,739
486210	Pipeline Transportation of Natural Gas	natural gas transport	27,388	Bcf (delivered)	$25,545
486910	Pipeline Transportation of Refined Petroleum Products	petroleum products	6,478	million barrels	$4,746
486910	Pipeline Transportation of NGLs (Highly Volatile Liquids)	NGLs (Y grade and purity)	1,613	million barrels	$4,470
486910	Pipeline Transportation of CO2	CO2	1,320	Bcf	$726
486	Pipelines	Total			$48,226

Source: ICF estimates derived from FERC Form 2 for interstate gas pipelines and FERC Form 6 for interstate oil pipelines adjusted to account for non-reporting intrastate pipelines. Revenues for CO2 pipelines represent imputed transportation-only services and do not reflect the cost of the CO2 itself (which is often sold on a delivered basis as a bundled service).

3.3. Base Year Statistics for Oil and Gas Production

There were 555,364 natural gas wells and 215,867 natural gas producing oil wells operating in 2015. Total upstream industry revenues in 2015 are shown in Exhibit 3-7 along with production volumes. Total 2015 revenues (including royalties and severance taxes) were $213.24 billion dollars, the largest components of which was crude oil, which had gross revenues of $132.86 billion. The components that make up the natural gas value chain (dry gas, lease condensate and gas plant liquids) had a wellhead value of $80.38 billion, or 37.7% of all wellhead revenues.

Exhibit 3-7: U.S. Upstream Production and Revenues 2015

Product/ Service	Production Volume	Volume Units	Valuation Concept	Gross Wellhead Revenue ($billions)
Crude Oil	3,118	Million barrels	wellhead value	$132.86
Lease Condensate	323	Million barrels	wellhead value	$13.76
Dry Natural Gas	27,059	Bcf	wellhead value	$52.01
Natural Gas Liquids (other plant products appear only under gas processing)	1,202	Million barrels	value of shrinkage for NGLs + processing gains kept by producers	$14.60
Total	9,012	Million BOE of hydrocarbons	wellhead value	$213.24

ICF estimates based on EIA volume data, EIA pricing data for crude oil and private survey price data for natural gas and NGLs.

Total capital expenditures in the U.S. by oil and gas producers (excluding land acquisition cost and the cost of buying either producing properties or other companies) for the last several years are shown in Exhibit 3-8. The recent peak in expenditures was $186.6 billion in 2014, which was followed by a decline in expenditures in 2015 and 2016 after the drop in oil prices in the fall of 2014.

Exhibit 3-8: U.S. Upstream Capital Expenditures on Wells and Equipment 2010 to 2016 ($billions)

Type of Expenditure	2010	2011	2012	2013	2014	2015	2016
Onshore Oil and Gas Drilling & Completion	72.4	118.6	140.0	136.4	153.8	113.7	56.9
Offshore Oil and Gas Drilling & Completion	6.3	6.2	8.8	11.3	15.0	9.1	2.9
Onshore Lease Equipment	4.8	6.2	7.1	7.1	7.3	4.4	2.2
Offshore Platforms, etc.	10.2	10.5	10.9	15.0	15.8	12.6	12.3
Total Upstream	93.7	141.5	166.8	169.8	191.9	139.8	74.3

ICF estimates based on company financial reports, API Quarterly Well Completion Report and API Joint Association Survey of Drilling Costs and Department of Census capital expenditure surveys.

In 2015, upstream capital expenditures on drilling and equipping wells were estimated to be $139.8 billion. The largest portion of expenditures is related to onshore oil and gas wells, for which $113.7 billion was spent on drilling and completing and another $4.4 billion was spent on onshore lease equipment (flow lines, separators, meters, dehydrators, tanks, etc.). An approximate breakout of costs for drilling and completing onshore wells is shown in Exhibit 3-9. The largest cost category, representing about 40% of expenditures, is for oil and gas support services; this category includes cementing, well completion, hydraulic fracturing, wireline and other geological and geophysical surveys. The second largest category is drilling services, which is computed here to represent 12% of costs. This category includes rig day rates, tool rentals and rig fuel. Frac sand (7.1%) and oil country tubular goods (6.4%) are the next largest categories. The construction of roads, drilling pads and site remediation are about 4.6% of costs and the trucking of equipment and materials to and from the drill site is about 4.0%.

Exhibit 3-9: Breakout of Drilling and Completion Costs for Onshore Wells 2015

Cost Category	$ billion in 2015	Percent
Support Services (wireline, other geological & geophysical, cementing, hydraulic fracturing, etc.)	46.0	40.4%
Drilling Services (rig day rates, tool rentals, rig fuel)	13.7	12.0%
Frac Sand and Other Proppants	8.1	7.1%
Oil Country Tubular Goods	7.3	6.4%
Road and Pad Construction, Site Remediation	5.3	4.6%
Trucking Services (rig mobilization, materials, water, etc.)	4.5	4.0%
Completion & Frac Chemicals and Gases	2.9	2.5%
Water and Water Treatment, Recycling, Disposal (excluding trucking which is listed separately)	2.5	2.2%
Cement	2.0	1.8%
Other Costs (solid waste disposal, legal assistance, environmental surveys and consultants, permits, insurance, lodging, food, etc.)	6.6	5.8%
Engineering, Supervision, Overhead	14.8	13.0%
Total	113.7	100.0%

Source: ICF estimates

Capital costs for new gathering lines in 2015 were approximately $4.2 billion. The capital expenditure for gas processing plants in 2015 was $5.6 billion.

3.4. Direct Impact of USACE Processes on Shipping Costs

This section of the report presents estimates for the costs of providing waterborne transportation services and how those costs are affected by inadequacies in infrastructure. The first part of this section deals with cargo vessels and the second part deals with barges.

3.4.1. Cost Impacts Related to Channel Depths and Widths

One of the important responsibilities of the USACE is to establish and maintain adequate channel depths and widths at marine ports. The USACE is responsible for seaward portions of the navigation channel that fall under federal responsibility. Port authorities and terminal owners establish and maintain the remaining portions of the navigation channels near the docks. USACE projects to deepen and widen navigation channels require benefit cost analyses and specific project funding, while the USACE's annual maintenance budget is typically used to maintain (that is, dredge to counter the effects of shoaling) a channel's previously authorized dimensions. Maintaining adequate navigation channel dimensions allows larger and more economical ships to be used for freight transport and it reduces the chances of traffic congestion that can create delays and add to shipping cost.

There are several economic impacts that can occur when channel depths are inadequate:

- Smaller ships are used
- Ships are light loaded
- Lightering and reverse lightering is used
- Port entrances and clearances are delayed awaiting high tides
- Traffic is re-routed to other, less economically desirable ports.

When channel widths are inadequate, there is an increased probability that one-way traffic will be required instead of two-way traffic in the channel. This forces ships to stop and wait at anchorage areas outside of the channels or in sidetrack lanes along the channels.

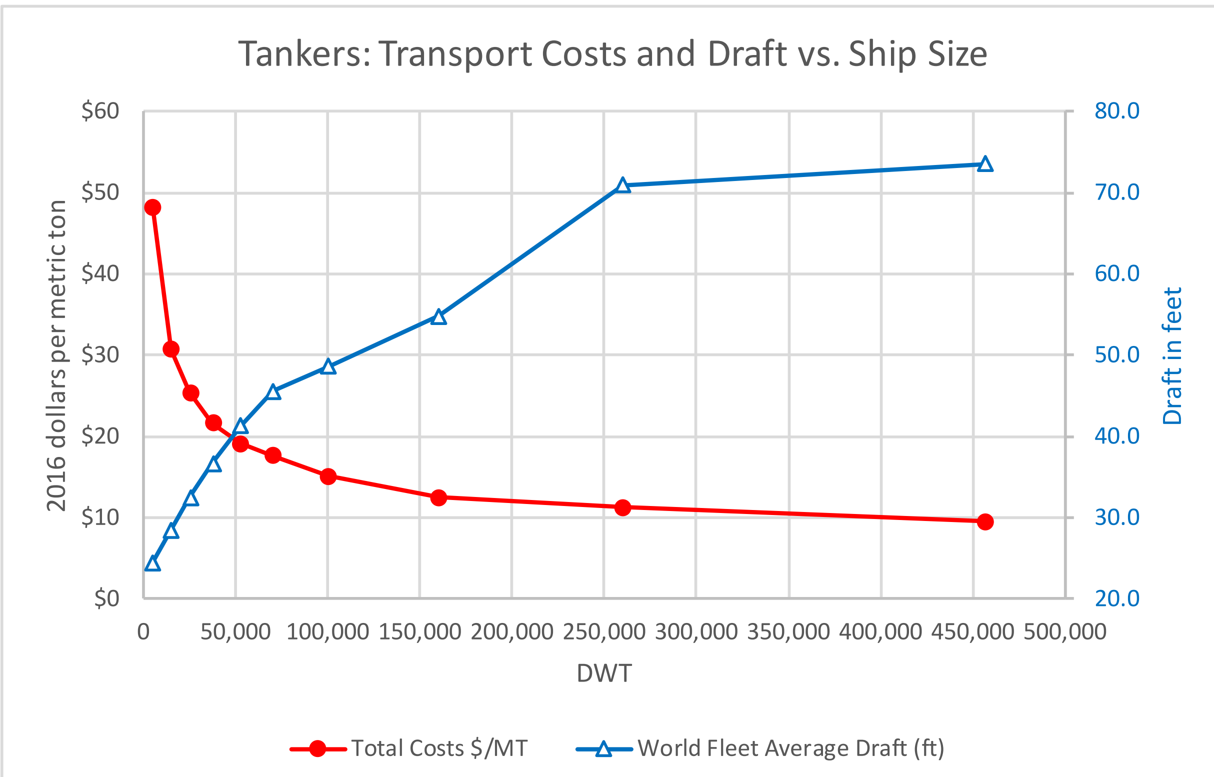
3.4.2. Economic Cost of Using Smaller Ships to Compensate for Insufficient Channel Depth

To estimate the economic costs of using smaller ships, ICF developed pro forma estimates of the costs of purchasing and operating several types and sizes of ships. We then calculated the shipping costs (measured as a daily charter rate, a dollar per cargo unit rate, a dollar per metric ton rate and a cents per ton mile rate) for example shipping distances. The methodology and data for these pro forma calculations are summarized in this chapter and presented in more detail in Appendix C. Examples are provided for three types of ships (tankers, containerships and dry bulk carriers) and for eight to twelve sizes classes for each ship type.

Appendix C also compares the pro forma results to the actual market prices for waterborne transportation services as measured by daily charter rates, dollars per ton shipped, or cents per ton-mile. Market prices for waterborne transportation services can vary widely based on the demand for freight transportation, surpluses/deficits in available ship capacity and the cost of bunker fuels. The pro forma cases developed for this report are presented in real 2016 dollars and are based on average shipbuilding cost over the last few years, current operating cost, and bunker fuel prices reflecting a Brent oil price of $75.00 per barrel. The pro forma cases represent the long-run average prices needed to cover the costs of the ship owner and generally fall between the highest and lowest market prices experienced in the last several years.

The pro forma $/MT results for various size classes of tankers are shown in Exhibit 3-10 along with the average draft of each size of ship. The largest sizes of tankers have drafts that exceed 70 feet and have shipping costs for around $10/MT for the modelled 4,700 nautical mile one-way distance. Smaller ships have less draft and can navigate through shallower channels. However, shipping has significant economies of scale, and so, the $/MT shipping cost increase as ship size declines. Exhibit 3-10 shows that as ship size increases, costs per metric ton decrease but the need for a deeper channel goes up. Charts similar to Exhibit 3-10 can be found in Appendix C for containerships and dry bulk carriers. As is explained more fully in Appendix C, these economies of scale exist for all types of cargo ships and stem from several influencing factors including capital costs, fuel use, and crew size that all rise with larger ships at less than a proportionate rate to ship size.

Exhibit 3-10: Tanker Costs and Draft vs. Ship Size

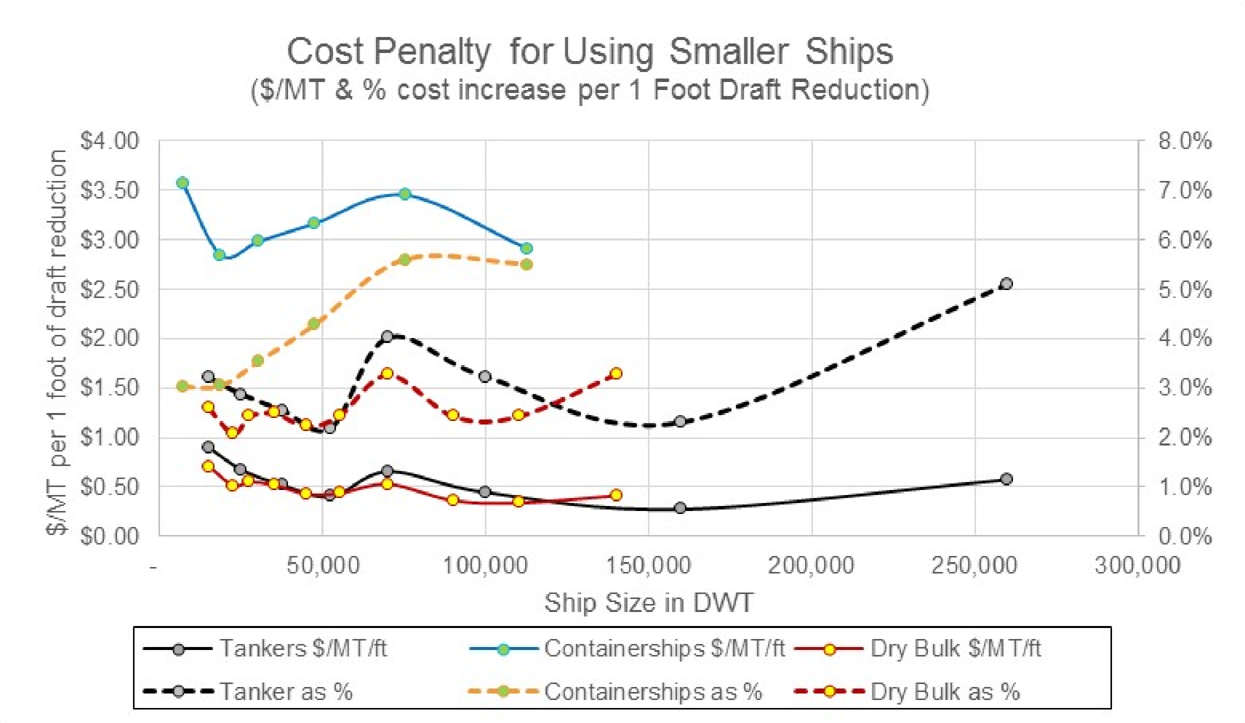


Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Another way of looking at the economic value of having sufficient channel depth to accommodate larger ships is shown in Exhibit 3-11. It shows the cost increase that occurs from using the next smallest size of ship (per the ship size classes used in pro forma cost examples) divided by the feet of draft reduction gained from using that smaller ship. For tankers and dry bulk carrier, the cost penalty for having to use smaller ships is roughly $0.50/MT per one foot of draft reduction gained by using a smaller ship. For containerships, the cost penalty is around

$3.00/MT per one foot of reduced draft. Expressed as percent of shipping costs, using smaller containerships to work around restricted channel depths adds from 2 to 5 percent to shipping costs for each foot of reduced draft. One reason to express the cost penalty as dollars per ton (or as a percent of costs) per one foot of draft reduction is to more easily compare the economics of different method for compensating for insufficient channel depth. Such presentation of the cost penalty also makes it easier to create scenarios for the economic value of maintaining or increasing channel depths by X or Y feet.

Exhibit 3-11: Cost Penalty for Using Smaller Ships Due to Insufficient Channel Depths



3.4.3. Economic Cost of Light Loading to Compensate for Insufficient Channel Depth

Another method of compensating for insufficient channel depth is to light load ships. This means loading the ship to less than its full capacity so that it will float higher in the water and have a reduced draft. The ratio by which changes in cargo tonnage affects draft is called the immersion factor and can be measured as metric tons of cargo per centimeter of draft, metric tons of cargo per foot of draft, barrels of oil per foot of draft, etc. Exhibit 3-13 shows calculations for how much the pro forma costs of moving crude oil in tankers are changed for each foot of reduced draft achieved by light loading the tankers. For example, an Aframax tanker can achieve a one-foot reduction in draft by reducing its cargo by 20,000 barrels or 3% of its cargo capacity. Since the cost of operating the tanker is not significantly changed by light loading, this leads to an approximate 3% increase in the shipping cost per cargo unit or $0.46 per metric ton per one foot of reduced draft.

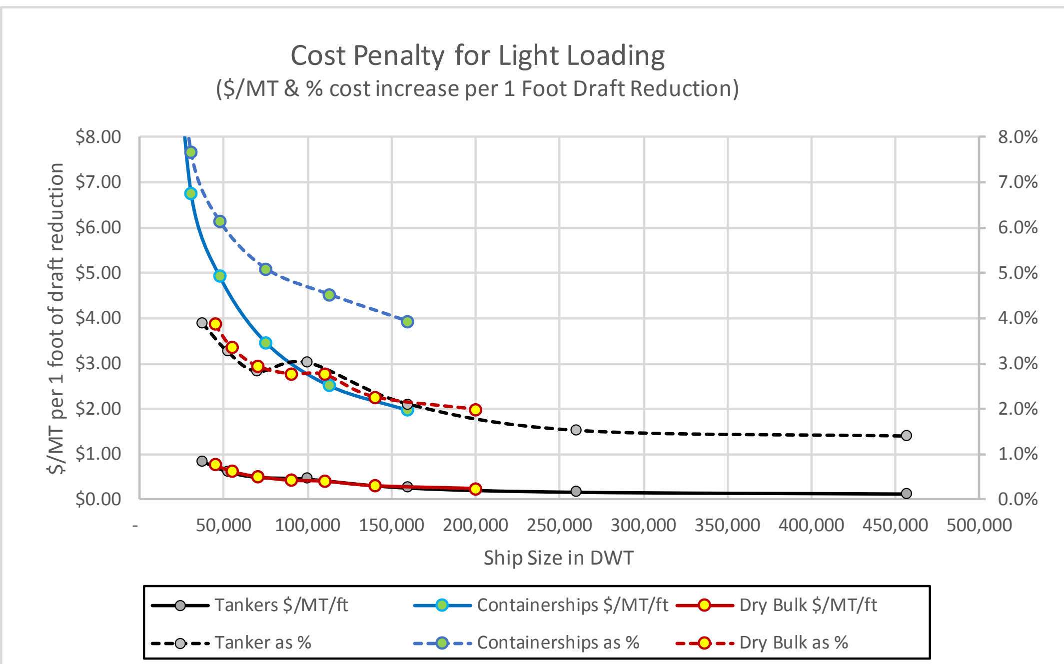
Exhibit 3-12 shows the cost of light loading tankers, containerships and dry bulk carriers of various sizes. The largest tankers and bulk carriers have a cost penalty that is about 1.5% to

2% per foot of draft reduction, while the middle-to-smaller sizes examined have cost penalties of 2% to 4% per foot of draft reduction. Containerships tend to have larger penalties of 4% or more due to the fact they are typically not fully loaded with filled containers (many containers are returned empty and some container bays are unused) and a smaller fraction of ship displacement (even at full load) is made up of cargo compared to other cargo vessel types. These factors mean that a larger fraction of a typical containership's cargo load needs to be eliminated to reduce draft by one foot.

Exhibit 3-12: Cost Penalty for Light Loading Tankers of Different Sizes

Sensitivty of Light-loading Results to Ship Size							
Label	Class #	Vessel Class	Full-load Draft (ft)	Cargo Units	Cargo Loss per ft.	Cost Penalty in $/MT/ft	Cost Penalty /ft. as % of full-load cost
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	36.7	bbl	8,978	$0.84	3.9%
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	41.3	bbl	11,020	$0.62	3.3%
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	45.6	bbl	13,155	$0.50	2.8%
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	48.6	bbl	20,000	$0.46	3.0%
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	54.8	bbl	24,207	$0.26	2.1%
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	70.9	bbl	29,819	$0.17	1.5%
Crude Oil Tanker	10	ULCC (320k dwt & over)	73.5	bbl	49,392	$0.13	1.4%

Exhibit 3-13: Cost Penalty for Light Loading Due to Insufficient Channel Depths



3.4.4. Economic Cost of Lightering and Reverse Lightering to Compensate for Insufficient Channel Depth

Lightering is the use of smaller vessel to offload -- in a deepwater anchorage zone -- larger vessels whose draft is too large to provide safe under keel clearance for a given channel depth.[38] The smaller lightering vessels shuttle back and forth to the docks to deliver the cargo. Reverse-lightering is a similar process but it consists of using smaller vessels to load larger vessels. Lightering and reverse lightering can occur such that the larger ship remains in a deepwater anchorage zone for the entire loading or unloading process and all of the cargo is lightered or reverse lightered. Alternatively, it is also possible to partly load a ship at a dock (consistent with the navigation channel's depth and the ship's minimum required under keel clearance) and then move the partly loaded ship to a deepwater anchorage zone to be "topped off" by lightering vessels. The same process can be performed by partially reverse lightering an incoming cargo ship to reduce its draft and then docking the ship to complete its unloading.

Lightering and reverse lightering occurs in less developed countries with poor port infrastructure where all types of cargo is lightered and reverse lightered using barges or small ships. In the U.S., lightering is almost exclusively performed in the petroleum trade, particularly for crude oil. According to MARAD statistics covering large ports and lightering areas, 28% of 2015 tanker calls constituting 31% of aggregated tanker capacity[39] was at the four main Gulf Coast Lightering Zones (Gulfmex No. 2, Offshore Pascagoula No. 2, South Sabine Point and Southtex).[40] There were no lightering calls at these Lightering Zones for non-tanker ship types in 2015.

Exhibit 3-14 shows examples of the cost of part-load lightering of crude oil tankers and Exhibit 3-15 shows parallel examples for full-load lightering of crude oil tankers. Lightering cost components include added charter time for the large ship under anchor in the lightering zone, the chartering and fuel costs for the lightering vessels and the time value of money (carrying costs) of the cargo's extended voyage time. The examples all assume that the port has a channel depth and other conditions whereby the ship drafts at full load are from 10.2 feet (Panamax) to 20.3 feet (Suezmax) too large to provide adequate under keel clearance. Before the ships can be docked, between 133,657 barrels (Panamax) and 490,922 barrels must be lightered. This lightering adds $0.74 to $0.81 per metric ton of crude delivered or from 4.6% to 5.9% of the base case pro forma costs with no channel depth restrictions. Looked at in terms of degree of channel depth restriction, these part-load lightering examples are 0.3% to 0.5% per foot of restriction versus the base case pro forma shipping costs.

[38] Any specific ship loaded to a given weight will have a draft that depends on water salinity and temperature. A ship's minimum required under keel clearance will depend on several factors including wind speeds, wave action, tides, the ship's speed, and whether the ship in being guided by a harbor tugboat. As an approximation, required under keel clearance for mild sea and weather conditions can be thought of as being the greater of 2 feet or 10% on the ship's static draft.
[39] Aggregated capacity is found by summing in each ship's DWT capacity once for each U.S. port call it makes in a year.
[40] https://www.marad.dot.gov/wp-content/uploads/pdf/DS_VesselCall_Notes.pdf

Exhibit 3-14: Examples of the Cost of Part-Load Lightering or Reverse-Lightering of Various Sizes of Tankers

Examples of Cost of Lightering or Reverse Lightering (part load lightered)

Long-haul Tanker	Panamax (60k-79.9 dwt)	Aframax (80k-119.9 dwt)	Suezmax (120k-199.9k dwt)
Draft at Full-load	45.6	48.6	54.8
Long-haul Tanker Capacity (bbl)	459,900	657,000	1,051,200
Long-haul Tanker Daily Charter Rate	$20,184	$23,361	$28,330
Draft Feet Shortfall	10.2	13.5	20.3
Implied Barrels Shortfall Caused by Insufficient Channel Depth	133,657	269,200	490,922
Lightering Tanker	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)
Lightering Tanker Capacity (bbl)	98,550	98,550	98,550
Lightering Tanker Daily Charter + Fuel Rate $/day	$14,037	$14,037	$14,037
Number of Lightering Tankers Required	2.0	3.0	5.0
Added Cost for Lightering Services	$48,258	$65,472	$98,515
Added Cost for Lightering Services $/bbl	$0.10	$0.10	$0.09
Time Value of Money for 1 Day Delay $/bbl	$0.01	$0.01	$0.01
Total Added Cost $/MT	$0.81	$0.78	$0.74
Cost without Lightering $/MT	$17.64	$15.11	$12.51
Cost with Lightering $/MT	$18.46	$15.89	$13.25
Total Added by Lightering as % of Cost w/o Lightering	4.6%	5.2%	5.9%
Total Added by Lightering as % of Cost w/o Lightering PER FOOT OF DRAFT SHORTFALL	0.5%	0.4%	0.3%

Note: Examples are based on 4,700 nautical mile one-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price). Time value of money computed at 6% per annum. Assumed channel depth is 40 feet and required under keel clearance is 10% of static draft.

The cost examples in Exhibit 3-15 are similar to those in the prior exhibit except that they assume that each ship's entire load is lightered. This assumption adds further costs and brings the cost of lightering up to 0.5% to 0.8% per foot of restriction versus the base case pro forma shipping costs.

Exhibit 3-15: Examples of the Cost of Full-Load Lightering or Reverse-Lightering of Various Sizes of Tankers

Examples of Cost of Lightering or Reverse Lightering (full load lightered)

Long-haul Tanker	Panamax (60k-79.9 dwt)	Aframax (80k-119.9 dwt)	Suezmax (120k-199.9k dwt)
Draft at Full-load	45.6	48.6	54.8
Long-haul Tanker Capacity (bbl)	459,900	657,000	1,051,200
Long-haul Tanker Daily Charter Rate	$20,184	$23,361	$28,330
Draft Feet Shortfall	*full load lightered*	*full load lightered*	*full load lightered*
Implied Barrels Shortfall Caused by Insufficient Channel Depth	459,900	657,000	1,051,200
Lightering Tanker	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)
Lightering Tanker Capacity (bbl)	98,550	98,550	98,550
Lightering Tanker Daily Charter + Fuel Rate $/day	$14,037	$14,037	$14,037
Number of Lightering Tankers Required	5.0	7.0	11.0
Added Cost for Lightering Services	$90,369	$121,620	$182,738
Added Cost for Lightering Services $/bbl	$0.20	$0.19	$0.17
Time Value of Money for 1 Day Delay $/bbl	$0.01	$0.01	$0.01
Total Added Cost $/MT	$1.45	$1.37	$1.29
Cost without Lightering $/MT	$17.64	$15.11	$12.51
Cost with Lightering $/MT	$19.09	$16.48	$13.81
Total Added by Lightering as % of Cost w/o Lightering	8.2%	9.1%	10.3%
Total Added by Lightering as % of Cost w/o Lightering PER FOOT OF DRAFT SHORTFALL	0.8%	0.7%	0.5%

Note: Examples are based on 4,700 nautical mile one-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price). Time value of money computed at 6% per annum. Assumed channel depth is 40 feet and under keel clearance is 10% of static draft.

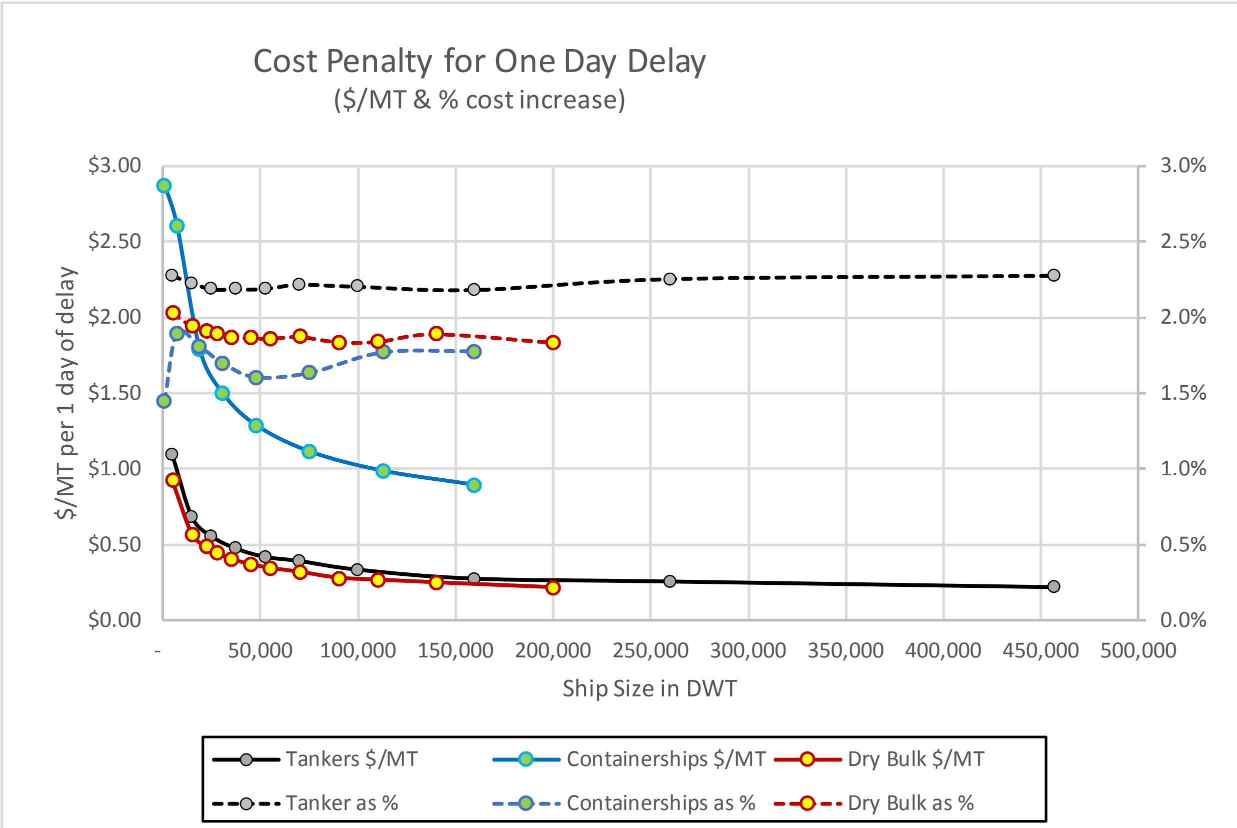
Where shippers can employ lightering of tankers to compensate for insufficient channel depth, it is usually less expensive (0.3% to 0.5%/foot for part-load lightering and 0.5% to 0.8%/foot for full-load lightering) compared to either using smaller ships (approximately 1.0%/foot) or light loading of ships (1.5% to 3.0%/foot). Since it is difficult and expensive to load or unload non-tanker cargo ships in a deepwater lightering zone, this practice is seldom practical for containerized, break bulk, and dry bulk cargo and so the use of smaller ships or light loading is a much more common way of compensating for insufficient channel depth for non-petroleum shipments.

3.4.5. Economic Cost of Shipping Delays Related to Insufficient Channel Depth or Width

One method that can be available to compensate for inadequate channel depth when a ship's draft exceeds allowable clearances by only a small amount is to delay port entrances or clearances until high tides occur. Shipping delays can also occur when channel widths are inadequate and there is an increased probability that one-way traffic will be required instead of two-way traffic in the navigation channel. Inadequate channel width may force ships to stop and wait at anchorage areas outside of the channels or in sidetrack lanes spaced along the channels.

The cost of shipping delays include the cost of longer ship charter times and the time value of money as the cargo carrying cost are increased as voyage times expand. Exhibit 3-16 shows some examples of the costs that are added for each one day of delay. These cost increases range from 1.5% to 2.3% of the pro forma base case shipping cost for one day of delay.

Exhibit 3-16: Cost Penalty for a Delay of One Day for Various Ship Types and Sizes



3.4.6. Cost Impacts Related to Barge Movements

Barge traffic made up 84% of all domestic waterborne freight movements in 2016, while the remaining 16% of movements was by self-propelled vessels. As shown in Exhibit 3-17, the greatest market share for the use of barges was for internal movements along river systems, where 98% of movements were by barge. The next greatest market share for barges (97%) was for intra-port movements where barges shuttle cargo among ships and storage warehouses within the same port area. Barges are also used for domestic coastwise movements along intra-coastal waterways and deepwater shipping lanes between U.S. ports. Ocean going barges and their tugboats are larger and of a different design than those in use for internal (river) freight movements.

Exhibit 3-17: Domestic Waterborne Movements by Barge

Domestic Waterborne Movements by Barge (million metric tons)

Traffic Type	Barge Million Tons	Self-Propelled Million Tons	Total Million Tons	Market Share by Barge
Coastwise	87.9	65.2	153.1	57%
Lakewise	16.7	54.4	71.1	23%
Internal	488.9	8.4	497.4	98%
Intraport	70.3	2.3	72.6	97%
Inter-territory	0.7	0.6	1.4	53%
All Traffic	664.6	130.9	795.5	84%

source: USACE, Waterborne Commerce of the United States: Calendar Year 2016, Part 5 National Summaries

The inventory of the 32,354 barges operated in the U.S. in 2016 is shown in Exhibit 3-18. The largest number of barges are covered dry cargo barges commonly used for the transportation of grains, seeds and other farm products. The other popular kinds of barges include open dry cargo barges (for coal, ores, etc.), deck barges (for pallets, containers, etc.) and various kinds of tank barges (for crude oil, petroleum products, chemicals, NGLs, liquid food products, etc.).

Note that barges typically have much shallower drafts than the cargo ships used for international or coastal domestic trade. Unloaded barges have an average light draft of around two feet and a fully loaded draft near eleven feet. A “tow” is made up of a single pushboat (or a single towboat) plus one or more attached barges. The configuration for the number of barges in a tow varies by river system, location and fraction of loaded versus empty barges. As shown in Exhibit 3-19, there can be from three to 45 barges per boat. The single towboat and pushboat that propels the barges in a tow is sized to provide roughly 250 horsepower per barge. The actual horsepower needs depend on whether the barges are loaded or empty and whether the direction to travel is upriver or downriver.

Travel along U.S. river systems (including on the Mississippi north of St. Louis) involves passing through locks. Lock dimensions vary from lock to lock, but the most typical size of lock chambers built in the years 1920 to 1940 is 110 feet wide by 600 feet long. The average length of a single U.S barge is approximately 200 feet. This means that large tows must be broken up to pass through a lock. Another important factor determining a lock’s utility is its dependable minimum depth of water, which for a majority of U.S. locks is nine feet under typical condition and less under drought conditions. Given that the average loaded draft of barges is about eleven feet, this means that barges going through locks will typically be loaded less fully than those operating in open river.

Exhibit 3-18: U.S. 2016 Barge Inventory

Inventory of U.S. Barges 2016

ICST Code	Vessel Type	Count	Average Capacity (tons)	Average Liq. Capacity (bbl.)	Average Length (ft.)	Average Breadth (ft.)	Average Load Draft (ft.)	Average Light Draft (ft.)
141	Liquid Tank Barge (Single Hull)	97	2,211	16,185	180.8	41.1	10.2	2.4
142	Liquid Tank Barge (Double Hull)	4,141	3,547	25,943	250.3	46.7	10.9	2.2
143	Liquid Tank Barge (Double Sided Only)	59	2,528	35,216	252.1	51.7	9.2	2.2
144	Liquid Tank Barge (Double Bottom Only)	2	2,498	22,323	249.3	45.1	11.2	1.8
149	Liquid Tank Barge (Other)	746	3,249	23,885	248.8	47.4	11.1	2.1
341	Dry Cargo Deck Barge	7,774	1,805		179.0	37.9	10.1	2.1
344	Open Dry Cargo Barge	8,283	1,695		195.6	35.1	9.7	1.7
345	Dry Cargo Covered Barge	11,086	1,913		201.0	35.5	10.4	1.7
349	Dry Cargo Other Barge	166	3,411		219.4	53.8	9.4	3.6
	All Barges	32,354	2,081		201.9	37.8	10.2	1.9

Source: USACE Waterborne Transportation Lines of the United States vessel database 2016.

Exhibit 3-19: Typical Number of Barges in a Tow

Typical Number of Barges per Tow

River	Waterway Type	Barges per Tow	Towboat or Pushboat Size (HP)
Upper Mississippi	canalized	15 (3 wide by five long)	3,200 to 6,000
Middle Mississippi	open river	downward: 25 (5 wide by 5 long), upward: 30 (5 wide by 6 long)	5,600 to 6,000
Lower Mississippi	open river	downward: 30-35, upward: 30-45	5,600 to 10,500
Arkansas River	canalized	standard is 8, maximum is 17. Limit of 1,200 feet	
Missouri River (above Kansas City)	open river	3 to 4	
Missouri River (below Kansas City)	open river	6 to 9	

source: M.S. Peterson, Inland Navigation and Canalization, University of Arizona. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1110-2-14.pdf?ver=2013-08-22-104452-560

Examples for the historical cost of moving farm commodities by barge to New Orleans are shown in Exhibit 3-20 in units of dollars per metric ton. The U.S. Inland Waterway System utilizes a "percent of base tariff" system to establish barge freight rates. The base tariffs were originally from the Bulk Grain and Grain Products Freight Tariff No. 7, which were issued by the Waterways Freight Bureau (WFB) of the Interstate Commerce Commission (ICC). Today, the WFB no longer exists and the ICC has become the Surface Transportation Board of the United States Department of Transportation. However, the barge industry continues to use the tariffs as benchmarks for rate units represented as a percent of the base rates. The U.S. Department of Agriculture compiles those indices and they have been translated into units of dollars per metric ton for movements to New Orleans for Exhibit 3-20. Consistent with the other historical data for transportation services shown in this report, there are substantial fluctuations in the market rates for barge transportation services. These fluctuations stem from swings in the demand for those services, the relative surplus/deficit of barge capacity, fuel prices, and river conditions. For example, the large increase in barge freight costs between 2017 and early 2018 are due to heavy rains and flooding which reduced average speeds to approximately 2.7 miles per hour and has substantially increased voyage times.

Exhibit 3-20: Barge Transportation Rates for Grain Movements to New Orleans ($/metric ton)

Indexed Benchmark in $/metric ton	2010	2011	2012	2013	2014	2015	2016	2017	2018
Twin Cities (TWC)	$31.68	$35.22	$32.11	$28.94	$39.23	$31.92	$29.39	$26.08	$42.25
Mid-Mississippi (MM)	$24.41	$27.19	$24.26	$22.54	$31.25	$25.42	$22.34	$19.67	$34.39
St. Louis	$14.77	$15.63	$16.22	$14.12	$18.84	$14.89	$11.68	$11.19	$21.33
Illinois	$20.80	$23.18	$20.44	$18.74	$26.66	$20.25	$18.39	$17.25	$29.72
Cincinnati	$20.51	$22.62	$19.58	$17.40	$23.92	$18.98	$14.81	$15.67	$27.35
Lower Ohio	$19.50	$21.52	$18.62	$16.54	$22.73	$18.04	$14.04	$14.90	$26.32
Cairo-Mem	$10.95	$11.57	$12.33	$10.10	$13.79	$10.68	$8.51	$8.32	$14.79

Based on indexes from April to October in each year. Year 2018 reflects one month (April) only. Heavy rain in March/April 2018 caused flooding along the lower and middle Mississippi and Ohio Rivers bringing delays and disruption to barge movements, driving up barge rates and USGC grain prices. Source: USDA Grain Transportation Report, www.ams.usda.gov/GTR.

Exhibit 3-21 shows the same barge rates for agricultural products as the previous exhibit, but in units of cents per metric ton mile. These were computed by dividing the $/MT rates by the river miles between each area of origination and New Orleans. The annual average barge rates since 2010 have been in the range of approximately 0.9 cent to 2.4 cents per metric ton mile. These rates are for the basic waterborne transportation services and do not include any additional charges for packing, loading, unloading, storage, demurrage, or insurance.

Exhibit 3-21: Barge Transportation Rates for Grain Movements to New Orleans (cents per metric ton – statute mile)

Indexed Benchmark in cents/ metric ton - mile	2010	2011	2012	2013	2014	2015	2016	2017	2018
Twin Cities (TWC)	1.77	1.96	1.79	1.61	2.19	1.78	1.64	1.45	2.36
Mid-Mississippi (MM)	1.70	1.90	1.69	1.57	2.18	1.77	1.56	1.37	2.40
St. Louis	1.30	1.38	1.43	1.25	1.66	1.31	1.03	0.99	1.88
Illinois	1.65	1.84	1.62	1.49	2.11	1.61	1.46	1.37	2.36
Cincinnati	1.40	1.55	1.34	1.19	1.63	1.30	1.01	1.07	1.87
Lower Ohio	1.46	1.62	1.40	1.24	1.71	1.35	1.05	1.12	1.98
Cairo-Mem	1.15	1.21	1.29	1.06	1.45	1.12	0.89	0.87	1.55

Based on indexes from April to October in each year. Year 2018 reflects one month (April) only. Source: USDA Grain Transportation Report, www.ams.usda.gov/GTR.

3.4.7. Impact of Delays and Other Factors on Costs of Moving Freight by Barge

USACE operations can affect the cost of barge service primarily through the operation of locks. Delays in passing through the locks can increase transportation costs. If the lock are inoperable for an extended period, cargo might have to re-routed using other, more expensive, means of transportation.

To help analyze the impact of lock delays and other factors, ICF create pro forma cost analyses for barge transport operations and computed $/MT and cents-per-ton-mile rates for various conditions. Details for these calculations can be found in Appendix C. A summary of the calculations is shown in Exhibit 3-22. The base case uses barge speeds of 4.2 mile per hour (MPH) and fully loaded barges and produces rates of 1.01 to 1.48 cents per metric ton mile. Reducing speeds to 2.7 MPH increases the rates an average of 38% compared to the base case. If the barges were partly loaded to 78% of capacity to pass through locks with a typical dependable minimum depth of water of nine feet, rates would be 23% higher than the base case. A further reduction of barge loadings to 50% of capacity (as might occur under drought conditions) would increase the cents-per-ton-mile rates by 79% compared to the base case.[41] If barges were employed in a manner that required them to return empty, then the calculation would increase the cents-per-ton-mile rates by 95% compared to the base case.

The USACE reports that in 2015 48% of lockages experienced delays that averaged 2.4 hours. Based on the pro forma analyses made for this report, a one-hour delay would add about 0.9% to the cost of an average 477-mile barge trip. Therefore, the average delay of 2.4 hour would

[41] The calculated cents/ton-mile rates are not inversely proportionate to capacity utilization because fuel use does not decline proportionately to cargo tons. This is because the pushboats and the empty barge weights are constant and because the fuel use is a function of the total displacement of the tow (weight of pushboat plus weight of empty barge plus weight of cargo) raised to the 2/3 power.

add 2.1% to costs. This is computed as 2.4 hours of delay divided by the 114 hours required for the trip (477 mile divided by 4.2 MPH). These costs per average incidence of delay would be compounded if delays occurred at several locks on a trip.

Exhibit 3-22: Barge Operator Pro Forma Costs

$/Day	Dry Covered Barge	Tank Barge	Deck Barge	Dry Open Barge
Barge Cost	$7,117	$5,255	$5,474	$6,569
Pushboat Capital Recovery	$2,956	$1,861	$2,956	$2,956
Pushboat O&M	$8,430	$7,025	$8,430	$8,430
Fuel	$9,493	$4,603	$9,493	$9,493
Overhead @15%	$4,199	$2,812	$3,953	$4,117
Total Cost	$32,195	$21,556	$30,307	$31,566
Cents/Metric-Ton-Mile				
Barge	0.24	0.36	0.18	0.22
Pushboat Capital	0.10	0.13	0.10	0.10
Pushboat O&M	0.28	0.48	0.28	0.28
Fuel	0.32	0.32	0.32	0.32
Overhead @%15%	0.14	0.19	0.13	0.14
Total Boat & Barge	1.08	1.48	1.01	1.05
Alternative Cases (cents/MT-mile)				
Base Case	1.08	1.48	1.01	1.05
Reduced Speed to 2.7 MPH	1.47	2.11	1.37	1.44
78% Loading (9 ft. lock depth)	1.31	1.84	1.23	1.29
50% Loading (e.g. due to draught)	1.91	2.73	1.78	1.87
Equipment Used for One Direction Hauls	1.90	2.97	2.02	2.11

Note: Actual 2016 rates were roughly 1.5 c/MT-mile from Northern locations (more locks, slower speeds, fewer barges per push boat and 1.0 c/MT-mile from Southern locations)

3.4.8. Cost Impact of Modal Shifts from Barge to Rail and Truck

In situations where a lock was inoperable for an extended period, cargo might have to be re-routed using other, more expensive, means of transportation. Exhibit 3-23 shows a hypothetical example where all barge movements in 2016 had to be moved to rail, truck or a combination of 75% rail and 25% truck. Additional details on these calculations are in Appendix C. Because rivers meander, the distance cargo must travel by barge is greater than the distance that same cargo would travel by rail or truck. Roughly speaking, a one-mile travel distance for a long-haul truck is equal to 1.15 miles on rail and 1.50 miles by barge. Taking those adjustments into account, the cost increase from shifting from barge to rail would be 88% (almost a doubling of the cost of transport), to truck 283% and to a 75/25 combination of the two modes 138%.

Exhibit 3-23: Cost Penalties from Diverting Barge Traffic to Rail and Trucks

		Inland Barging			Rail Only			Trucking Only			75% Rail/25% Trucking		
Commodity	Total 2016 tonnage (thousands metric tons)	Average Mileage	Ton-Miles	Transportation Cost ($M)	Equivalent Mileage	Differential Cost to Barge (cents per ton-mile)	Differential Transportation Cost to Barge ($M)	Equivalent Mileage	Rail Cents per metric ton-mile	Differential Transportation Cost to Barge ($M)	Equivalent Mileage	Differential Cost to Barge (cents per ton-mile)	Differential Transportation Cost to Barge ($M)
Coal, Lignite, and Coal Coke	99,599	296	29,511,603	$590	227	2.75	$484	198	9.5	$1,672	220	4.31	$791
Crude Petroleum	32,549	213	6,920,907	$138	163	3.06	$130	142	9.5	$392	158	4.55	$198
Petroleum Products	110,450	293	32,337,481	$647	224	3.06	$608	195	9.5	$1,832	217	4.55	$923
Chemical Fertilizers	15,880	975	15,489,260	$310	748	2.83	$264	650	9.5	$878	723	4.37	$422
Chemicals excluding Fertilizers	31,568	528	16,654,084	$333	404	3.06	$313	352	9.5	$944	391	4.55	$475
Lumber, Logs, Wood Chips, and Pulp	3,738	307	1,145,773	$23	235	2.77	$19	204	9.5	$65	227	4.33	$31
Sand, Gravel, Clay, Salt	71,963	332	23,894,319	$478	255	2.75	$392	221	9.5	$1,354	246	4.31	$641
Iron Ore, Iron, and Steel Waste and Scrap	6,615	631	4,171,232	$83	483	2.76	$69	420	9.5	$236	468	4.32	$112
Non-Ferrous Ores and Scrap	5,363	486	2,605,432	$52	372	2.76	$43	324	9.5	$148	360	4.32	$70
Primary Non-Metal Products	9,487	504	4,786,303	$96	387	3.56	$108	336	9.5	$271	374	4.92	$150
Primary Metal Products	14,842	723	10,736,523	$215	555	3.56	$243	482	9.5	$608	537	4.92	$336
Food and Food Products	88,140	993	87,491,547	$1,750	761	2.81	$1,477	662	9.5	$4,958	736	4.36	$2,376
Manufactured Goods	6,174	61	379,203	$8	47	3.56	$9	41	9.5	$21	46	4.92	$12
Unknown, Not Classified	854	304	259,455	$5	233	3.04	$5	203	9.5	$15	225	4.53	$7
Total	*497,222*			*$4,728*			*$4,163*			*$13,395*			*$6,544*

3.5. Direct Impact of USACE Processes on Project Costs (Civil and Non-Federal)

Project costs can substantially increase due to delays. Expenses subject to increases include construction, materials, and engineering costs. USACE Civil Works projects are often delayed by inadequate funding processes, while non-federal projects (e.g. pipelines) can be delayed by lengthy permit reviews.

3.5.1. Project Cost Inflation

Project expenses cost more in the future caused by inflation, a sustained increase in the prices of goods and services as time goes on. When projects have significant delays where spending must be postponed, construction costs will be more expensive due to inflation.

3.5.2. Mobilization Costs

When funding is not provided up front, the total work might need to be divided into smaller packages with multiple contracts. If project funding is not appropriated at its predicted timing, the contractor might have to demobilize his crew. Once the funding arrives, the same contractor might not be available, so there are costs associated with getting a new contractor up to speed. There are also associated costs to remobilize major construction equipment, trailers, and crews. Similarly, when a non-federal entity is constructing an infrastructure project, they may have to demobilize construction if a permit becomes unpredictably delayed.

3.5.3. Inefficient Bulk Purchase Costs and Carrying Costs

Contractors can typically procure construction materials and equipment with reduced costs if purchased far enough ahead of time. Bundling of purchases can also provide discounts on the price of materials. When USACE is not funded in advance, they are unable to take advantage of these savings.

Stop-and-go funding or permit delays can also increase costs because of carrying costs (also called time value of money or interest costs) for purchases made before the delay occurs. The time value of money means that money available in the present is worth more than the same sum in the future due to its potential to earn interest. When money is spent towards a project that subsequently becomes delayed, there will be added carrying costs on those expended dollars.

3.5.4. Reengineering/Re-Surveying Costs

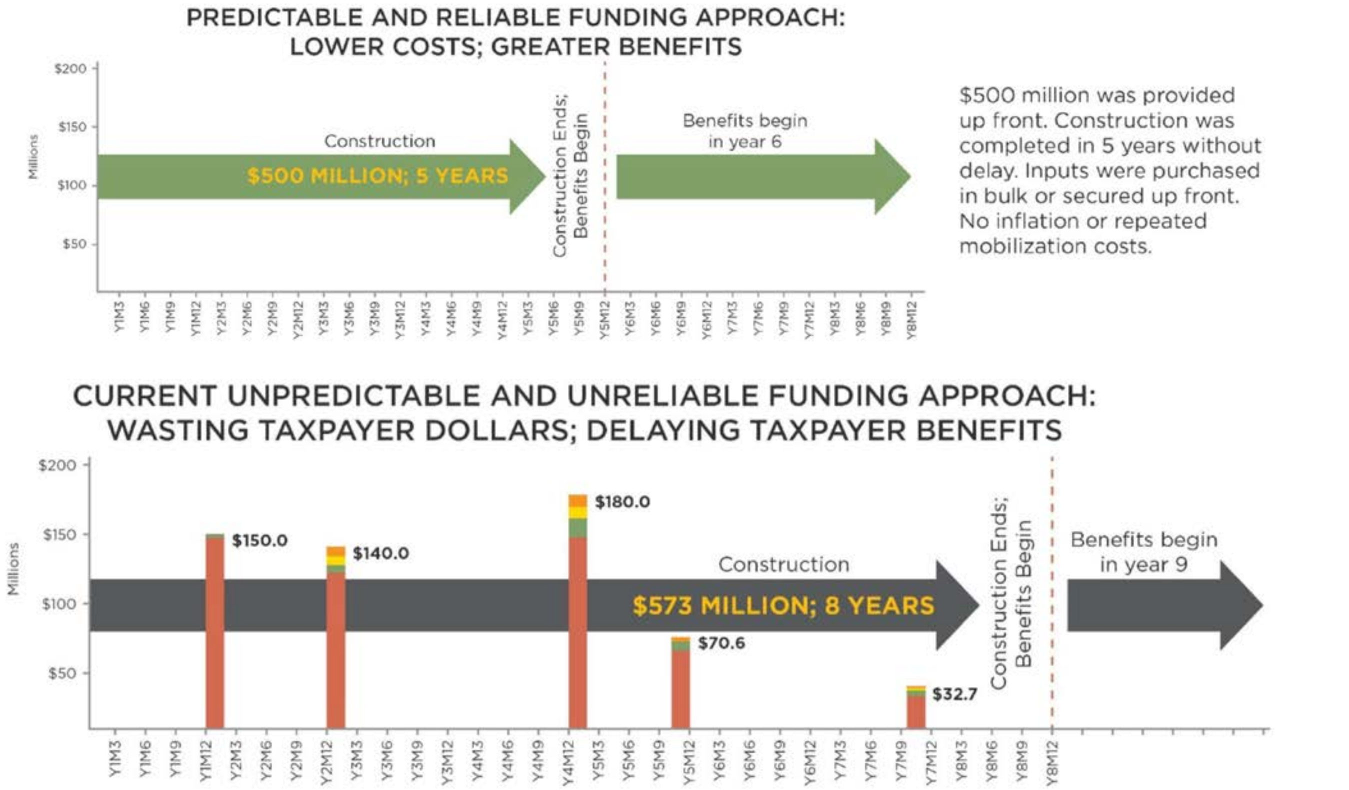
Engineering costs to design infrastructure projects can be substantial. When permit outcomes require changes to the design, engineering may need to be reworked. The reengineering costs would be on top of what was spent on the original unusable design.

3.5.5. Examples of Increased Project Costs

A report prepared by Texas A&M Transportation Institute analyzes the cost escalations resulting from unpredictable funding for lock and dam infrastructure projects. They conduct a comparison of hypothetical projects under an ideal funding scenario vs. an inconsistent funding scenario. In Exhibit 3-24, they highlight that the unreliable funding scenario experiences significant schedule delays and cost overruns due to inflation, mobilization, and disadvantaged purchasing.[42]

[42] "Predictable Funding for Locks and Dams", http://www.soytransportation.org/newsroom/PredictableFundingForLocksAndDams_FinalReport-4-16-18.pdf

Exhibit 3-24: Comparison of Funding Approaches from "Predictable Funding for Locks and Dams"



Time	Allocation	Inflation	Mobilization Costs	Piecemeal vs. Bulk Purchasing	Available for Construction
Year 2 Month 1	$150.0	$3.0			$147.0
Year 3 Month 1	$140.0	$5.6	$7.0	$7.0	$120.4
Year 5 Month 1	$180.0	$14.4	$9.0	$9.0	$147.6
Year 5 Month 12	$70.6	$7.1		$3.5	$60.0
Year 7 Month 11	$32.7	$4.4	$1.6	$1.6	$25.0
Total	$573.3	$34.5	$17.6	$21.2	$500.0

Inflation (2%)
Mobilization (5%)
Piecemeal vs. Bulk Purchasing (5%)
Available for Construction

Funded by the soybean checkoff.

A hypothetical pipeline project was also evaluated to show the types of costs involved and which of these would be subject to higher costs due to delays. In Exhibit 3-25, a crude oil and a natural gas pipeline project costs are broken down. It is then identified if expenditures would be subject to remobilization increases, time value of money costs, re-routing costs, or general inflation. Exhibit 3-26 shows the total cost impact from a 1-year delay across all the factors. In this example, there is 7-8% of additional cost from a 1-year delay compared with a project completed on schedule.

Exhibit 3-25: Example Pipeline Construction Costs (million dollars)

Example Pipeline Construction Costs (280 miles, 36 inch diameter) and Potential Impact of Delays

			Subject to Higher Costs Due to Delays			
	Crude Oil Pipeline	Natural Gas Pipeline	Upfront Expenditure (time value of money costs)	Liquidated Damages and/or Higher Mobilization Costs	Higher Expenses Due to Re-Design, Re-routing	General Inflation
Land	$12.6	$12.6	Yes		Yes	
Rights of Way	$116.6	$116.6	Yes		Yes	
Line pipe (FOB mill or port of import)	$243.7	$243.7	Yes			
Line pipe broker and other services mark-up (procurement, inspection, logistics)	$24.4	$24.4	Yes			
Packing for shipping	$4.7	$4.7	Yes			
Rail shipping to coating plant	$3.9	$3.9	Yes			
Factory coating	$69.7	$69.7	Yes			
Repacking for shipping	$2.4	$2.4	Yes			
Rail shipping to staging	$3.2	$3.2	Yes			
Truck shipping to site	$1.9	$1.9				Yes
Field Joint Coatings	$10.5	$10.5				Yes
Welding electrodes	$0.2	$0.2				Yes
Trench bedding and fill materials	$45.1	$45.1				Yes
Mainline valves	$6.5	$6.5	Yes			
Steel sleeve pipes for HDD crossings	$10.3	$10.3				Yes
Engineering, surveying, permitting, construction monitoring, AFUDC, overhead & misc.	$111.9	$111.9	Yes		Yes	
Line Pipe Fittings & Non-mainline Valves	$44.9	$44.9				Yes
Pipeline Construction	$1,081.9	$1,081.9		Yes		Yes
Building	$46.3	$47.8				Yes
Pumps or Compressors, Tool, Other Station Equip.	$340.9	$412.7	Yes			
Oil Tanks	$136.1	$0.0				Yes
Delivery Facilities	$27.2	$0.0				Yes
Communication Systems	$17.9	$17.9				Yes
Office Furn. & Equip.	$13.6	$14.1				Yes
Vehicles	$13.6	$14.1				Yes
Other Property	$35.4	$36.6				
Total Pipeline Cost	$2,425	$2,337				

Exhibit 3-26: Pipeline Project Higher Costs from Delays (million dollars)

Costs Subject to Increases from Delays	Crude Oil Pipeline	Natural Gas Pipeline
Upfront Expenditure (subject to time value of money during delays)	$940	$1,012
Subject to Liquidated Damages or Remobilization Costs	$1,082	$1,082
Subject to Higher Expenses Due to Re-Design, Re-Routing	$241	$241
Subject to General Inflation	$1,450	$1,289

Illustrative Higher Cost Caused by 1-year delay due to permitting delays, redesign, re-routing		
Upfront Expenditure @6% p.a. interest cost	$56	$61
Liquidated Damages & Higher Mobilization Costs @5%	$54	$54
Re-Design, Re-Routing @15%	$36	$36
General Inflation @2% p.a.	$29	$26
Total Cost Impact	$176	$177
Total Cost Impact as %	7.2%	7.6%

3.6. Direct Impact of USACE Processes on Upstream Oil and Gas Development Costs

Oil and gas exploration, development and production activities can be directly impacted by the USACE through the permit approvals that might be needed for the construction of onshore infrastructure. The type of upstream onshore infrastructure that could come under USACE review include:

- Drilling pads,
- Roads to drilling pads,
- Gathering lines and pipeline transporting oil and gas,
- Water diversion mounds, ditches and impoundments, and
- Other types of field facilities such as separators, treatment plants, and storage tanks.

Such infrastructure may require a Section 404 permit under the Clean Water Act when its construction involves the discharge of dredged or fill material into waters of the United States, including wetlands. Such 404 permits could be the more complex and time-consuming Section 404 Individual Permits where significant impacts (generally more than an acre of wetland) are expected to occur. Otherwise, Section 404 General Permits or Nationwide Permits are used for project elements with less significant impacts including most water crossings by gathering lines and pipeline (which fall under Linear Infrastructure Nationwide Permit #12). An upstream infrastructure project might need a Section 10 permit when any of its structures and construction work occur in or affect the course, condition, or capacity of navigable waters. In addition, upstream projects may require a Section 408 permit when it involves the permanent or temporary alteration or use of any USACE Civil Works project such as crossing a USACE levee.

The authors of this report are not aware of any nation-wide information of the frequency with which upstream infrastructure projects come under USACE review. However, some regional data have been published. In 2014, the American Petroleum Institute provided comments to the U.S. EPA and USACE related to a proposed change to the definition of "Waters of the United States" under the Clean Water Act. In those comments, API and its contractor (Arcadis) provided information on a sample of 100 sites in the Appalachian Basin where 6% would need 404 General permits and 2% would require 404 Individual permits under the existing definitions. Similar data for a sample of 147 sites in East Texas concluded that 19% of the sites would need 404 General permits and 2% would require 404 Individual permits.[43] This suggests that under the WOTUS rules (prior to the proposed changes in 2014), 8% to 21% of onshore upstream projects would come under USACE review for Section 404 alone and that 2% would need the more costly Individual Section 404 permits. The pre-2014 rules are still in effect due to various lawsuits. USACE and EPA are currently conducting a proposed rulemaking to define the scope of federal Clean Water Act (CWA) jurisdiction.[44] Had the 2014 WOTUS rule changes gone into effect, the API survey of Appalachian and Permian Basin sites suggest that the number of sites

[43] Arcadis, "An Assessment of EPA/USACE's Economic Analysis of the Proposed Definition of 'Waters of the United States,' and Cost Implications for the Oil and Gas Industry," report to API, November 2014.

[44] Department of the Army, Corps of Engineers, Environmental Protection Agency, Definition of ''Waters of the United States—Recodification of Preexisting Rule" Federal Register /Vol. 83, No. 134 /Thursday, July 12, 2018 / Proposed Rules 32227

that require general permits would have gone up 84% and that those requiring individual permits would have doubled.

The cost impacts of having to obtain an individual Section 404 permit include the cost of obtaining the permit itself; the cost of any required mitigation; the time value of money for “upfront” expenditures incurred before the permits are obtained; and potential loss of all sunk costs if the permit process is prolonged to the point where a lease expires.[45]

Exhibit 3-27 shows an estimate for the cost for gaining an Individual Section 404 permit for an upstream project that affects one acre of wetlands for which mitigation will be needed. This cost of $422,000 comes from the API comments and Arcadis study cited above.

Exhibit 3-27: Section 404 Permitting & Mitigation Cost for an Upstream Project

One-Acre Site Section 404 Permit Compliance Costs

	Cost
Wetland Delineation & Technical Report	$36,000
Wetland Mitigation Plan	$16,000
Section 7 - Endangered Species Act Compliance	$52,000
Historic Resources Assessment	$26,000
Individual 404 Permit Application	$120,000
Water Quality Certification	$16,000
Wetland Mitigation per Acre (with 5 years of maintenance, monitoring and reporting)	$156,000
Total with One Acre of Restoration	$422,000

source: Arcadis 2014. Costs adjusted to 2016 dollars.

Typical well spacing for the horizontal gas shale and tight oil wells that are now dominating onshore U.S. drilling are 80 to 160 acres per well. One square mile is 640 acres. Four to eight wells are usually being drilled from a single well pad and there might be one or two well pads per square mile. Therefore, a Section 404 Individual permit might be needed for multiple locations in a square mile, could involve one to several acres of mitigation, and would cover four (160 acre spacing) to eight (80 acre spacing) wells. For the purpose of the cost estimates provided here, we assume that the $422,000 cost shown above for permitting and mitigation would apply to one well on average.

The other costs associated with an Individual Section 404 permit include the time value of money for upfront costs that must be borne before the permit is granted. ICF estimates that these upfront costs per well are about $863,000 and include lease bonuses, geological and geophysical surveys, geophysical test holes and exploration wells, and the cost of the permit itself. The average time needed to obtain an Individual Section 404 permit cited in the Arcadia study is 788 days versus 313 days for a General or Nationwide permit. The extra 475 days at 6% annual interest rate comes to a carrying cost of $70,000 for the $863,000 upfront costs.

The final component of cost is the lost sunk cost that would occur if the lease expired before the permit could be obtained. The probability of this happening so that the upfront cost of $863,000

[45] Onshore oil and gas leases typically have primary terms of three years and expire if oil and gas production has not been established on that lease within that primary term. Once production has been established, the lease is “held by production” and continues indefinitely until oil and gas production is no longer profitable.

is lost is assumed to be 6.3%, which comes to an expected value cost of $54,000 per well. This probability of 6.3% is calculated assuming that:

- The primary lease term is three years,
- The Section 404 permit is applied for six months after the lease is signed,
- The average time needed to obtain a permit is 788 days,
- Permitting time are normally distributed with a standard deviation of 240 days, and
- 20% of the wells are drilled on new leases (that is, leases that are in their primary terms and are not held by production).

Given these assumptions, 6.3% of the wells would have their leases expire before the individual permits could be granted.

The total cost of an Individual Section 404 permit, therefore, comes to $546,000 or about 9% of a typical new horizontal well cost. The Arcadia study suggest that Individual permits have cost that are 10 times those of a General permit. Therefore, the Section 404 General permitting cost would be roughly $42,000 for a typical well located in an area where such a permit is required.

3.7. Summary of Direct Costs

Exhibit 3-28 summaries “direct costs” that could be avoided through improvements in processes for which USACE plays an important role. These include potential cost savings in developing oil and gas resources, permitting and constructing pipeline and other infrastructure project costs, building Civil Works projects funded by the government, and shipping goods using waterborne transportation and pipelines. We estimate these direct costs to be $2.90 to $9.71 billion per year. These are the cost savings that would go to infrastructure project developers and foreign and domestic entities shipping goods to, from, and within the U.S.

There is a wide range of direct costs because of the uncertainties in estimating how often infrastructure permitting delays and other infrastructure development and maintenance problems occur or how much related extra costs developers and shippers must bear. The ICF estimates are explained in the narrative presented below for each cost area. The cost estimates reflect ICF’s experience in supporting project permitting efforts on behalf of both developers and reviewing agencies, recent project experiences learned through the interview process, cost impact studies done by others, and our own calculations.

Exhibit 3-28: Potential Annual Direct Economic Impacts

Upstream Oil and Gas Development

	Range of Annual Impacts ($million)	
Annual capital expenditures for new onshore oil and gas wells ($million)	$86,400	
Fraction of projects that require USACE review and approvals	10%	20%
Cost impact of problems/delays as portion of capital costs	1.9%	1.9%
Reduction in problems and delays from potential improvements	-29%	-29%
Annual direct cost impact ($million)	$47	$95

Pipeline Construction

Annual capital expenditures for new and refurbished oil and gas pipelines ($million)	$21,000	
Fraction of projects that require USACE review and approvals	70%	80%
Fraction of USACE-related projects that experience substantial problems and delays	10%	25%
Cost impact as portion of capital costs per year of delay	6.0%	8.0%
Potential average reduction in years of delay (average of six going to goal of 3 or with exceptions 4)	-2.0	-3.0
Annual direct cost impact ($million)	$176	$1,008

USACE Public Works Projects

Annual expenditures for new and refurbished infrastructure ($million)	$2,000	
Fraction of projects that encounter stop-go funding	10%	30%
Cost impact as portion of capital costs	15.0%	15.0%
Annual direct cost impact ($million)	$30	$90

Inland Shipping: Delays

Total number of lockages	600,000	
Percentage of lockages that are commercial	77.9%	77.9%
Percentage of lockages that are delayed	48.0%	48.0%
Number of delayed commercial lockages	224,352	224,352
Average number of lockages per pushboat/barge tow at a single lock	3	2
Number of delayed pushboat/barge tows (at all locks)	74,784	112,176
Average delay in hours	2.4	2.4
Cost per hour of delay for a pushboat/barge set ($/hour)	$1,200	$1,500
Portion of delays that could be eliminated with improvements	-50%	-75%
Annual direct cost impact ($million)	$107	$301

Domestic Shipping: Diversion to Other Transport Modes

Annual inland tons shipped (million tons)	795	
Volume diverted to other modes as percent of inland movements	5.0%	10.0%
Cost penalty for diversion to other modes ($/ton)	$15.00	$30.00
Annual direct cost impact ($million)	$596	$2,385

International Shipping: Use of Smaller Vessels, Light Loading, Lightering, Increased Anchorage Time

Annual tons shipped (million tons)	1,255	
Percent of volume affected	25.0%	50.0%
Cost penalty ($/ton)	$6.20	$9.30
Annual direct cost impact ($million)	$1,945	$5,836

Sum of Annual Direct Costs	$2,902	$9,714

Upstream Oil & Gas: We have created the following scenario for illustrative purposes. As shown in Exhibit 3-29, for the upstream sector we have assumed that approximately 35% of the costs identified above for Individual Section 404 permits under the current regulations (i.e., a total cost of $546,000 or about 9% of a typical new horizontal well cost) could be eliminated by improved permitting processes and procedures. Our calculations assume that the cost of the permit including mitigation measures could be reduced by approximately 18% and that the time needed to review and approve permits could be cut in half. This would bring down the cost for wells that require individual permits from $546,000 to $356,000, or a reduction of 35%. For wells requiring General Permits, we assume a cost reduction of 18% related to the permit itself and (because the General Permits are assumed to be obtainable within the general planning/permitting period otherwise needed for the wells) no cost reduction related to time value of money or risk of lost sunk cost. Given the assumption that about 86% of the Section 404 wells would get general permits and the remainder would get individual permits[46], the weighted average cost under current regulations, processes and practices is $112,000 while the estimated cost with efficiency assumptions is $79,000 or a 29% average cost reduction.

Exhibit 3-29: Components of Assumed Upstream Efficiency Gains
(applies only to wells requiring Section 404 permits)

	Before Efficiency Gains ($1,000 per well)	After Efficiency Gains ($1,000 per well)
Individual 404 permit	$422	$344
Time value of money for upfront well costs	$70	$11
Risk of lost sunk costs	$54	$1
Total per well (Individual Permit)	$546	$356
General 404 permit	$42	$34
Total per well (General Permit)	$42	$34
Weighted average per well (Ind. or Gen. Permit)	$112	$79

Note: Efficiency gains reflect reduction in effort needed to obtain permits of roughly 18% and reduction in time (from 788 to 390 days) required for permit review and approval. Weight for individual permits in average is 14% and for general permits weight is 86% of wells.

The potential efficiency gains would apply to all sectors - not just upstream oil and gas activity. The first area of potential efficiency gains is in the planning process wherein clearer definitions would help oil and gas producers determine more easily whether a project is in a WOTUS area and whether general *versus* individual permits would be needed. These efficiency gains would come about through the clearer definitions themselves and through more effective pre-filing communications between applicants and the USACE. The second area of potential efficiency gains would come from making public USACE's maps of the WOTUS jurisdictional areas and other information as an aid to project developers in determining which planned facilities might impact those areas. The USACE has been reluctant to make its internal WOTUS area maps available to the public out of concerns that the maps may be old and that hydrological, biological or land use conditions may have changed and that the latest (newly acquired) information needs to be incorporated into the regulatory processes. Even so, the publication of dated maps would be useful to developers in better understanding an area and in understanding how the regulations have been applied in the past. In addition, it is possible that clearer definitions could

[46] The API comments cited above showed that the surveyed sites in the Appalachian and Permian Basins that fall under Section 404 have to obtain individual permits on average 14% of the time.

reduce mitigation costs and encourage mitigation banking. Having clearer definitions for WOTUS, and more accessible maps and data on past WOTUS determinations could help clarify the value of mitigation projects, reduce risks to mitigation bankers, encourage more banking, and, thus, reduce the cost of mitigation.

Under our assumptions, the potential cost impact for U.S. onshore well/upstream facility sites comes to $47 to $95 million per year. Our calculation of the direct cost impacts is based on:

- Annual expenditure of onshore wells in 2016 of approximately $86.4 billion,
- The assumption that between 10% to 20% of onshore wells require some kind of Section 404 permit (based on rounding the API survey results showing 8% to 21% for the two surveyed regions),
- The assumption that the fraction of USACE-related projects that require individual permits (or otherwise experience substantial delays and costs) is approximately 14% and those requiring general permits are 86% (averages from the API results of two surveyed regions), and
- The weighted average potential reduction in costs from efficiency improvements could be 29% for wells that require Section 404 permits (ICF assumptions derived from on Arcadis cost estimates).

Energy Pipelines: The estimated annual potential efficiency gains for energy pipelines comes to $176 to $1,008 million. The primary driver of this result is the assumption that the time needed for Environmental Impact Statements associated with Individual Section 404 Permits and other types of permits for large projects declines from the historical six years to the USACE goal of three years (or to 4 years allowing for exceptions). Other assumptions are that 70% to 80% of energy pipeline (measured as expenditures – not project counts) will require USACE reviews and approvals of one type or another. This is much higher than the corresponding value for upstream oil and gas production projects because the "linear" nature of pipelines makes intersection with wetlands, navigable water, USACE facilities, etc. much more likely. The cost reduction range of 6% to 8% per annum of reduced project delays comes from rounding down and up the cost penalty for pipeline project delays presented above.

USACE Public Works Projects: The estimated direct savings from fully funding USACE projects so that the costly stop-and-go nature of the project is eliminated comes to $30 to $90 million per year. These are based on $2 billion of capital spending each year and the assumption that 10% to 30% (measured as dollars – not project counts) is subject to stop-and-go funding that prolongs project execution time and adds to total cost. Based on the study cited above, we assume that such delays can add 15% to total capital costs. We assume that the entire amount could be saved with more stable and faster funding.

Inland Shipping Delays: The direct savings to providers of barging services and their customers by significantly reducing or eliminating delays at locks would be $107 to $301 million per year. This is calculated by starting from statistics for 2015 delays published by USACE. In that year, there were 600,000 lockages (i.e., one cycle/pass through a lock of one or more vessel or barges). Of those lockages, some 77.9% were commercial and 48% were delayed. The average delay was 2.4 hours. In 2020 the expected number hours of delay (probability times average wait) was 68% lower than the 2015 value. Our calculations assume that the best case would be to bring the delays down past the 2000 levels (that is, a 75% reduction versus

2015). In contrast, the low-end estimate assumes a 50% reduction versus 2015. The cost saving are computed with an assumption that the average barge tow on a canalized river requires two or three lockages to get through each lock and that the hourly cost of the tow is $1,200 to $1,500.

Domestic Shipping: Diversion to Other Transport Modes: This cost category is intended to capture the fact that there are periodic upsets to the domestic waterborne transportation system that can lead to diversion of cargos to other transportation modes including rail and truck. These diversions can be on a periodic or emergency basis or on a continuous basis where the shippers have abandoned the domestic waterborne option in favor of more predictable and reliable service by other modes. Assuming that an amount equal to 5% to 10% of the 2016 domestic waterborne tonnage were diverted in this manner and that the average cost penalty was $15 to $30 per ton (the upper end matches the 75%/25% diversion mix to rail and truck shown above), the total annual cost would be $596 to $2,385 million. These costs are high relative to other categories because of the large cost savings often afforded by barge and other waterborne transport. The 2017 study by the Center for Transportation Research at the University of Tennessee summarized in Appendix A concluded that the loss of a single lock can lead to $1 billion or more in additional transportation costs per year for the four locks they studied in detail.

International Shipping: Use of Smaller Vessel, Light Loading, Lightering, Increase Anchorage Time. The estimated potential cost savings for international shipping ranges from $1,945 to $5,836 million annually. The key assumptions that go into this calculation are shown below in Exhibit 3-30. The starting point for this table are the cost penalties shown above as a percent of the pro forma costs for each foot of draft reduction or per one day of added anchorage. For example, the cost penalty for compensating for one foot of inadequate channel depth by using smaller ships is roughly 3% of unconstrained base case costs for tankers and dry bulk carriers and 4.5% for container ships. The scenario examined in Exhibit 3-30 is that channels depths could be increased by five feet where economically justified. Where problems exist that lead to increased anchorage times, improvements could lead to one-day reduction in anchorage time for the affected ships.

Exhibit 3-30: Assumptions for High-End Case for International Shipping Annual Direct Cost Impacts

		Cost Penalty per Unit					
Compensation	Cost Penalty Units	Tanker	Dry Bulk	Container	Scenario for Units in Feet or Days	Simple Average of Cost Impact	Fraction of Tonnage Subject to This Compensation
Smaller ships	%/foot of draft	3.0%	3.0%	4.5%	5.0	17.5%	22.00%
Light loading	%/foot of draft	2.0%	2.0%	4.5%	5.0	14.2%	20.0%
Lightering	%/foot of draft	0.5%			5.0	2.5%	8.0%
1 day delay	%/day	2.3%	1.8%	1.8%	1.0	2.0%	15.0%
Fraction of Tonnage Impacted							50.0%
Weighted Average Cost for Cargo Impacted as %						14.4%	
Weighted Average Cost for Cargo Impacted as $/MT						$9.31	

When assumptions are added for what percent of tonnage is affected by each kind of problem and what method of compensation is used, then an average cost penalty (14.4% or $9.31/MT) can be computed. Under the high-end case assumption, one-half of the cargo is affected in one way or another.[47] In the low-end assumption the estimate for effected cargo is 25% instead of 50% and the $/MT average cost penalty is reduced by one-third. These parameters and results can be thought of as today's inadequacies in channel depths or width or as potential future inadequacies if improvements are not made.

3.8. GDP Impact from Improved USACE Processes Related to 2016 Waterborne Shipping

The "direct costs" that were presented above are the costs that could be avoided in developing oil and gas resources, permitting and constructing pipeline and other infrastructure project costs, building Civil Works projects funded by the government, and shipping goods using waterborne transportation and pipelines. These are the cost savings going to infrastructure project developers, foreign and domestic providers of transportation services, and foreign and domestic entities shipping goods to, from, and within the U.S.

In contrast, the "GDP impacts" are the changes to U.S. and foreign GDP that would result as these cost savings make their way through the economy as the quantities of transportation services and the production of goods shifts as prices change due these cost savings. In the U.S. exporting industries would tend to see their output increase while industries facing foreign competition might see decreases. However, overall the U.S. economy would be larger due to efficiency gains (i.e., fewer resource would go into transporting goods and those resource would be redeployed into providing more goods and services).

This section of the report presents the hypothetical GDP impact in the year 2016 if the direct waterborne costs had been avoided. To estimate the GDP impacts of waterborne shipping costs we compiled or estimated the domestic prices and production volumes for 141 categories of goods tracked by the USACE and computed how their domestic and international shipping costs would be affected by applying the high-end estimates for the direct cost impacts of potential improvements. Prices and volumes for energy goods came from EIA[48], those for farm products came from the USDA[49], those for mineral product came from the USGS Mineral Yearbook[50], those for chemicals came from ACC Yearbook[51] and Bloomberg Terminal[52], and those of other products came from the DOT Freight Analysis System[53]. Transportation cost for other modes

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[47] In comparison, a "two-foot shoaling scenario" produced by USACE estimated that 19.4% of import and export tonnage would be impacted if channel depths were allowed to be degraded by shoaling to be two feet below authorized depths. K.N. Mitchell and Capt. D. MacFarland, "Quantifying the Impacts of Shoaling in Navigation Channels via Historical Waterborne Commerce Data," June 26, 2012 before CMTS-TRB R&D Conference.

[48] EIA Petroleum Marketing Monthly https://www.eia.gov/petroleum/marketing/monthly/?src=email, EIA Petroleum Supply Annual https://www.eia.gov/petroleum/supply/annual/volume1/

[49] U.S. Department of Agriculture, "Agricultural Statistics 2017," https://www.nass.usda.gov/Publications/Ag_Statistics/2017/Complete%20Ag%20Stats%202017.pdf

[50] USGS Mineral Yearbook https://minerals.usgs.gov/minerals/pubs/myb.html

[51] American Chemistry Council Annual Statistics "Elements of the Business of Chemistry", https://www.americanchemistry.com/2017-Elements-of-the-Business-of-Chemistry.pdf

[52] Bloomberg Terminal https://www.bloomberg.com/professional/solution/bloomberg-terminal/

[53] Department of Transportation Freight Analysis System https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

was assumed to be unchanged between the base case and the case with the high-end direct cost savings. We made similar price and volume calculations for foreign markets, whereby all foreign countries were grouped together into a single foreign market. Using simple price elasticity models for each region and product for both production and consumption volumes in the U.S. and in the one foreign region, we computed the new equilibrium for prices and volumes.

The direct cost impacts presented above related to waterborne transportation represent 2.7% to 8.6% of the base year 2016 costs ($99 billion) incurred by shippers for imports into the US, exports from the U.S., and domestic waterborne freight traffic. The net economic impact of removing those extra costs is shown in Exhibit 3-31, which depicts changes to Gross Domestic Product (GDP) in the U.S. and the Rest of the World that could come from reducing waterborne freight costs by 10% (rounded up from the 8.6% upper estimate to account for unquantifiable cost impacts). The net impact to the U.S. would be an annual GDP gain of $1.61 billion while the rest of the world would annually gain $8.42 billion in GDP. These impacts are the results of several offsetting impacts including:

- Better efficiencies in waterborne freight transportation would reduce the GDP contribution from the waterborne transportation sector itself – both in the U.S. and by foreign shipping companies that provide transport services to the U.S. In other words, more efficiencies mean that less money needs to be spent to ship the same volume of goods over water. These GDP reductions are partly offset by higher sales volume for goods transported over water (which will sell at lower prices in the U.S.).
- U.S. industries that <u>export</u> goods would take advantage of lower transportation costs by increasing production (i.e., increasing their contribution to GDP) and gaining world market share. There would be reductions in GDP contributions from those same industries in other countries.
- U.S. industries that <u>compete with imported goods</u> would lose market share to foreign producers who would now have lower shipping costs to the US. This would reduce GDP from those industries in the U.S. and increase GDP contributions in foreign counties.
- For products (such as manufactured goods and crude oil) with substantial imports into the US, prices would come down and U.S. consumers and businesses would increase their purchases of those products and use remaining costs savings to purchase other goods. The opposite occurs among consumers in foreign markets, wherein prices will increase as more production goes to the US.
- For products (such as agricultural goods, chemicals, and petroleum products) with substantial exports from the U.S., prices would go up as demand from foreign consumer increases due to lower shipping costs. These higher prices would cause U.S. consumers and businesses to decrease their purchases of those products.
- For goods that are transported only domestically, the reduction in waterborne freight cost will be split up (based on relative supply and demand price elasticities) as an increase in producer's prices and a decrease in consumer prices. This will increase GDP contribution from the affected U.S. industry.
- Overall the reduction in waterborne freight transportation costs due to better efficiencies will free resources (capital, labor, energy) allowing U.S. and the world GDP to be higher.

Exhibit 3-31: GDP Impacts for 2016 from 10% Reduction in Waterborne Transportation Costs To, From and Within US ($billions)

	US	Rest of World	World Total
Waterborne and Other Transportation Services	-2.86	-6.82	-9.68
Production of Goods Transported by Water	-4.37	12.44	8.07
Production of Other Goods & Services	8.84	2.80	11.63
Total GDP	1.61	8.42	10.03

source: ICF estimates based on 2016 trade flows and prices

The hypothetical GDP impacts for 2016 are shown by the USACE's aggregated commodity groups in Exhibit 3-32. The biggest positive impact for U.S. GDP occurs among petroleum products, chemical & fertilizers, and farm & processed food products. The largest negative impacts occur among crude petroleum production, primary metal products and manufactured goods.

Because the farm & processed food products have one of the largest positive GDP impacts, we have provided details for their individual product groups in Exhibit 3-33. As might be expected from current export patterns and a high dependence on waterborne transportation, wheat, corn, and soybean are among the farm products whose GPD contribution increases substantially when waterborne transportation costs are reduced.

Exhibit 3-32: U.S. GDP Impact by Major Commodity Group for 2016 from 10% Reduction in Waterborne Transportation Costs, To, From and Within U.S.

		Waterborne Volumes in 2016 (million metric tons)			Percent Change in Waterborne Volumes (with 10% cost reduction vs. actual 2016)			Net GDP Effect (billion US dollars)		
Code	Commodity Group	Imported	Exported	Domestic	Imported	Exported	Domestic	US	Rest of World	World Total
1000	Coal, Lignite, and Coal Coke	8.3	50.2	120.9	0.8%	3.2%	1.4%	0.30	(0.06)	0.25
2100	Crude Petroleum	254.3	16.0	81.2	1.6%	0.6%	0.5%	(0.34)	0.83	0.49
2229	Petroleum Products	105.6	183.4	225.1	1.2%	0.7%	0.3%	1.12	0.34	1.46
3100	Chemical Fertilizers	12.4	8.0	17.7	1.8%	0.5%	0.6%	0.03	0.07	0.10
3200	Chemicals excluding Fertilizers	30.7	50.3	49.8	2.4%	1.3%	0.4%	0.73	0.11	0.84
4142	Lumber, Logs, Wood Chips, and Pulp	7.1	38.4	5.0	1.1%	2.4%	1.8%	0.88	(0.26)	0.62
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	50.9	6.5	102.3	3.2%	3.1%	2.0%	(0.03)	0.22	0.20
4400	Iron Ore, Iron, and Steel Waste and Scrap	6.1	17.8	45.8	1.1%	0.5%	0.5%	0.15	0.01	0.16
4600	Non-Ferrous Ores and Scrap	9.1	4.0	4.2	1.5%	2.2%	1.1%	0.01	0.02	0.02
5155	Primary Non-Metal Products	26.1	7.6	13.8	2.5%	1.1%	0.6%	0.22	0.11	0.32
5354	Primary Metal Products	45.3	5.1	15.3	1.6%	0.2%	0.3%	(1.43)	2.00	0.57
6168	Food and Food Products	42.1	179.0	93.6	1.4%	1.6%	0.6%	2.91	(0.34)	2.57
7000	Manufactured Goods	79.1	22.9	18.9	1.4%	0.3%	0.2%	(3.01)	5.35	2.34
8099	Unknown and Not Elsewhere Classified Products	8.5	9.6	2.0	0.3%	0.4%	0.6%	0.07	0.01	0.08
	All Goods	685.7	598.8	795.4	1.7%	1.3%	0.8%	1.61	8.42	10.03

source: ICF estimates based on 2016 trade flows and prices. Quantities by Commodity Group are from USACE statistics and differ from Census import/export volumes shown earlier due to differing data sources and commodity classification schemes. Changes to GDP include volume and price changes related to all commodities produced and consumed - not just waterborne volumes.

Exhibit 3-33: U.S. GDP Impact for Food Groups for 2016 from 10% Reduction in Waterborne Transportation Costs To, From and Within U.S.

		Waterborne Volumes in 2016 (million metric tons)			Percent Change in Waterborne Volumes (with 10% cost reduction vs. actual 2016)			Net GDP Effect (billion US dollars)		
Code	Commodity	Imported	Exported	Domestic	Imported	Exported	Domestic	US	Rest of World	World Total
6241	Wheat	0.8	21.7	8.0	0.9%	1.9%	1.0%	0.35	(0.09)	0.26
6344	Corn	0.8	47.3	32.5	0.8%	2.8%	0.8%	0.95	(0.34)	0.61
6442	Rice	0.7	3.0	2.0	0.7%	2.9%	0.9%	0.06	(0.02)	0.04
6443	Barley & Rye	0.1	0.0	0.1	NM	NM	0.7%	0.00	0.00	0.00
6445	Oats	0.1	0.0	0.0	2.4%	NM	NM	(0.00)	0.00	0.00
6447	Sorghum Grains	0.0	6.0	0.2	NM	1.7%	10.1%	0.09	(0.03)	0.06
6521	Peanuts	0.0	0.3	-	NM	0.3%	NM	0.01	(0.00)	0.00
6522	Soybeans	0.5	53.9	33.7	0.6%	1.1%	0.3%	1.13	(0.45)	0.68
6534	Flaxseed	0.0	0.0	-	NM	NM	NM	0.00	(0.00)	0.00
6590	Oilseeds nec	0.3	6.4	3.9	0.6%	1.0%	0.3%	0.13	(0.05)	0.08
6653	Vegetable oils	3.0	1.4	1.0	0.2%	0.7%	0.2%	0.03	0.00	0.03
6654	Vegetables & prod.	2.8	3.4	0.3	0.4%	0.8%	2.2%	0.06	(0.00)	0.06
6781	Hay & fodder	0.0	4.0	0.0	NM	0.9%	NM	0.06	(0.02)	0.04
6782	Animal feed, prep.	0.4	11.7	5.7	0.6%	1.1%	0.5%	0.22	(0.07)	0.14
6811	Meat, fresh, frozen	1.0	4.4	0.2	0.3%	0.3%	1.4%	0.09	(0.03)	0.06
6856	Bananas & plantains	5.4	0.0	0.0	2.5%	NM	NM	(0.16)	0.21	0.05
6857	Fruit & nuts nec	4.3	2.6	0.0	0.8%	0.4%	NM	0.01	0.05	0.06
6858	Fruit juices	3.1	0.4	0.0	2.3%	0.7%	NM	(0.04)	0.07	0.03
6861	Sugar	2.5	0.0	1.2	1.8%	NM	0.4%	(0.02)	0.03	0.01
6889	Food products nec	3.2	3.5	1.4	0.9%	0.6%	0.3%	0.05	0.02	0.07
6893	Cotton	0.3	1.9	-	0.5%	0.3%	NM	0.03	(0.01)	0.03
6899	Farm products nec	0.2	0.9	0.0	1.1%	1.5%	NM	0.02	(0.01)	0.01
Subtotal of Selected Food Products		29.5	172.8	90.2	1.3%	1.6%	0.6%	3.06	(0.72)	2.34
Subtotal of Other Food Products		12.6	6.2	3.4	1.7%	0.5%	0.6%	(0.15)	0.38	0.24
6168	Food and Food Products	42.10	179.01	93.59	1.4%	1.6%	0.6%	2.91	(0.34)	2.57

source: ICF estimates based on 2016 trade flows and prices. Quantities by Commodity are from USACE statistics and differ from Census import/export volumes shown earlier due to differing data sources and commodity classification schemes. Changes to GDP include volume and price changes related to all commodities produced and consumed - not just waterborne volumes. "NM" indicates "not meaningful" volume change results for commodities with zero or low trade volumes.

3.9. Social Welfare Impacts from Improved USACE Processes Related to 2016 Waterborne Shipping

Another way of estimating economic impacts is to measure changes in producer and consumer surpluses, which when added together are called social welfare or social benefit. Producer surpluses are the revenue received by producers less the cost of production (that is, the rectangular area bounded a horizontal line drawn at the market price and a vertical line at quantity produced minus the area under the supply curve). When the prices received by the producer go up, producer surplus increases. Consumer surpluses represent the consumer’s willingness to pay for goods less the actual market price of the good. Consumer surplus is represented as the area under the demand curves down to the horizontal line drawn at the market price. A decrease in consumer prices increases consumer surplus. These estimates are useful in showing how benefits are distributed between consumers and producers

Exhibit 3-34: Social Welfare Impact for 2016 from 10% Reduction in Waterborne Transportation Costs To, From and Within U.S.

Consumer and Producer Surplus Effects (billion US dollars)

	US	Rest of World	World Total
Supplier Surplus	-0.46	6.05	5.59
Consumer Surplus	10.98	-4.77	6.21
Total Social Welfare/Benefit	10.52	1.29	11.80

source: ICF estimates based on 2016 trade flows and prices

A reduction in waterborne transportation costs by 10% in 2016 would have increased U.S. social welfare by $10.52 billion annually and would come about mostly in the form of increased consumer surpluses arising from the decrease in prices for imported goods.

3.10. All-Sector GDP and Social Welfare Impacts for 2020, 2030 and 2040

This section of the report presents estimates of GDP and social welfare impacts for the years 2020, 2030, and 2040 that would come about from costs that could be avoided through improvements in the processes for which USACE plays an important role. The estimates are based on the assumption that efficiency-related cost savings would begin for upstream oil and gas development and for energy pipeline investments starting in the year 2019. The related impacts would build over time as in-place assets (e.g., oil wells, gas wells, pipelines) that benefited from the cost savings become a larger and larger portion of all in-place assets. The GDP and social welfare impact related to cost savings from waterborne shipping are not based on an explicit start date for efficiency improvements and schedules for new assets. Rather, we assume that the hypothetical GDP and social welfare impacts estimated above based on 2016 trade flows and prices (adjusted for increased trade over time) could be fully realized by 2025.[54]

GDP and social welfare impacts from greater efficiencies in the operations overseen by the USACE will come through oil and gas producers, providers and users of pipeline transportation services, and providers and users of waterborne transportation services. The overall impacts on GDP and social welfare from all of these effects are shown in

Exhibit 3-36 for the years 2020, 2030 and 2040 under the oil and gas price and production volume projections from the 2018 Annual Energy Outlook from EIA. (See Exhibit 3-35 for selected data from the AEO Reference Case). The all-sector GDP impacts for 2020 range from $0.72 billion to $2.50 billion. For the year 2030, the all-sector impacts range from $1.66 to $6.79 billion and for 2040, the all-sector impacts range from $1.96 to $7.93 billion. Averaged over the 2020 to 2040 period, the annual GDP impacts range from $1.52 to $6.05 billion.

[54] To the extent that more time is needed to achieve full cost savings related to waterborne transportation, then the realized GDP and social welfare impacts for 2020 would more likely be in the low-to-middle part of the estimated ranges.

Exhibit 3-35: Selected Values from 2018 AEO Reference Case

Item	Units	2016	2020	2030	2040
Domestic Crude & Cond. Production	MMbbl/day	8.90	10.70	11.70	11.90
Dry NG Production	Tcf/Year	26.94	32.66	37.83	40.15
Natural Gas Plant Liquids Production	MMbbl/day	3.48	4.77	5.34	5.46
L48 Avr. Crude Wellhead Price	2017$/bbl	$39.25	$66.89	$88.59	$100.85
Henry Hub Spot NG Price	2017$/MMBtu	$2.57	$3.69	$4.26	$4.50
Total Lower 48 Wells	count	14,382	26,447	31,605	34,037
Approx. Value of Oil, Gas, NGL Production	2017$Billion	225	440	626	719
Approx. Pipeline Revenues (Oil, Gas, NGL, Products)	2017$Billion	48	58	65	68

Increased oil and gas production stemming from lower oil and gas development costs is assumed to build over time starting in 2019, when more wells are drilled compared a situation in which inefficiencies are not addressed. The impacts increase each year as there are more well vintages whose well counts have been boosted by lower costs. From 2020 to 2040, the average contribution to GDP from lower permitting costs for oil and gas wells is $0.26 to $0.52 billion annually.

Exhibit 3-36: All Sector 2020, 2030 and 2040 GDP Effects

Direct Cost Category	Range of Annual Direct Costs ($million)		Economic Impact Category	U.S. GDP Effects ($millions)							
				2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages	
Upstream Oil and Gas Development	$47	$95	More Oil & Gas Development Due to Lower Upstream Development Costs	$75	$150	$289	$579	$332	$665	$261	$522
Pipeline Construction	$176	$1,008	More Oil & Gas Development Due to Lower Pipeline Construction Costs & Rates	$62	$354	$418	$2,386	$478	$2,730	$347	$1,981
			Other Impacts from Lower Pipeline Rates	$44	$252	$297	$1,698	$340	$1,942	$247	$1,409
USACE Public Works Projects	$30	$90	Net Impacts from Reduced Waterborne Transportation Costs	$542	$1,742	$660	$2,123	$805	$2,588	$665	$2,139
Inland Shipping: Delays	$107	$301									
Domestic Shipping: Diversion to Other	$596	$2,385									
International Shipping: Vessel Size, Light	$1,945	$5,836									
Sum of Direct Costs	$2,902	$9,714	Sum of GDP Effects	$723	$2,499	$1,664	$6,786	$1,955	$7,925	$1,519	$6,051

Note: Economic impacts from lower upstream development costs and lower pipeline construction costs are assumed to accumulate over time starting in 2019 based on AEO 2018 Reference Case oil and gas prices and production rates. Economic impacts from lower waterborne transport cost are computed using actual 2016 transportation patterns and are assumed to grow at the rate of GDP growth (AEO rate of 2.0%/year).

The GDP impacts from reducing delays and costs of oil and gas pipelines are made up of higher oil and gas production and impacts of lower delivered fuel costs to consumers. It is assumed that lower permitting costs for new pipelines begin in 2019 and that as more new pipelines are constructed at these lower costs, the reduction in tariffs (as measured as a percent of base case pipeline revenues) increases each year for about 25 years into the future. (Pipeline depreciation periods typically range from 20 to 30 years.) The impact of lower pipeline tariffs on oil and gas production contributes $0.35 to $1.98 billion annually average over the 2020 to 2040 period.

The same buildup of impacts over time occurs with regard to how lower pipeline construction costs lead to lower delivered fuel prices and thus increases in industrial and commercial customer economic activity. The effects on GDP are $0.25 to $1.41 billion annually averaged over the 2020 to 2040 period. As with the effects of pipeline tariffs on oil and gas drilling, the full effects on energy users will be felt after approximately 25 years.

The effects of lower waterborne transportation cost on GDP are $0.67 to $2.14 billion annually averaged over the 2020 to 2040 period. These are computed by taking the waterborne-transportation-related GDP impact values for 2016 presented above and assuming that waterborne transportation grows at 2% per year, a rate of growth equal to the average U.S. GDP growth assumption in the 2018 AEO Reference Case.

Exhibit 3-37 shows the all-sector impacts on U.S. consumer surpluses and producer surpluses. The all-sector annual impacts on consumer surpluses caused by lower prices for consumer goods range from $5.06 to $16.93 billion averaged from 2020 to 2040. Estimated annual impacts on producer surpluses have a range of -$0.18 to -$0.48 billion averaged from 2020 to 2040. The producer surpluses increase in some sectors and decline in others, but on the whole, tend to go down due to lower prices for internationally trade goods and transportation services. Overall, social welfare (the sum of consumer and producer surpluses) is highly positive with a range of $4.88 to $16.45 billion annually averaged over the 2020 to 2040 period.

Exhibit 3-37: All Sector 2020, 2030 and 2040 Social Welfare Effects

Economic Impact Category	U.S. Consumer Surpluses ($millions)								U.S. Producer Surpluses ($millions)							
	2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages		2020 Low & High Estimates		2030 Low & High Estimates		2040 Low & High Estimates		2020-2040 Low & High Annual Averages	
More Oil & Gas Development Due to Lower Upstream Development Costs	$51	$102	$197	$394	$226	$452	$177	$355	-$6	-$13	-$25	-$49	-$28	-$57	-$22	-$44
More Oil & Gas Development Due to Lower Pipeline Construction Costs & Rates	$42	$241	$284	$1,622	$325	$1,856	$236	$1,347	-$5	-$30	-$35	-$203	-$41	-$232	-$29	-$168
Other Impacts from Lower Pipeline Rates	$20	$114	$134	$764	$153	$874	$111	$634	$11	$63	$74	$425	$85	$485	$62	$352
Net Impacts from Reduced Waterborne Transportation Costs	$3,696	$11,885	$4,506	$14,487	$5,493	$17,660	$4,538	$14,592	-$156	-$501	-$190	-$611	-$232	-$745	-$191	-$615
Sum of Surpluses	$3,810	$12,341	$5,120	$17,267	$6,197	$20,842	$5,063	$16,928	-$157	-$481	-$176	-$438	-$216	-$548	-$181	-$476

Note: Economic impacts from lower upstream development costs and lower pipeline construction costs are assumed to accumulate over time starting in 2019 based on AEO 2018 Reference Case oil and gas prices and production rates. Economic impacts from lower waterborne transport cost are computed using actual 2016 transportation patterns and are assumed to grow at the rate of GDP growth (AEO rate of 2.0%/year).

4. Potential Ways to Address Issues

These benefits could be achieved through changes in how the USACE and other relevant parties operate. Ideas for potential improvements to Civil Works projects, regulatory processes, and consistency of regulatory outcomes follow. These ideas came from stakeholder surveys, interviews, Congressional testimony, and reports as well as presentations and public statements from USACE.

4.1. Streamline Process to Construct Civil Works Projects

To realize the true economic benefits, the process to develop and construct Civil Works Projects would have to be streamlined.

4.1.1. Shorten Timeline for Feasibility Studies

USACE has historically taken many years to complete feasibility studies that determine if prospective projects are nationally worthwhile. The study and the decision to construct have to be completed promptly to take full advantage of projected economic benefits. Outsourcing large portions or whole studies to third party consultants could allow studies to be finalized quicker. This could be especially helpful when staff are diverted to emergency response tasks and would possibly need to put feasibility study work as a lower priority. Increasing funding levels for feasibility studies or encouraging stakeholders to fund full studies would allow the critical studies to be completed quickly. Another measure to reduce the total time, USACE could utilize screening tools early in the planning process to pare down the number of alternatives looked at in detail during the study. The 3-3-3 program discussed earlier in this report is a way that USACE is addressing this issue, but at this point, there is not available data to show if feasibility timeline's have shortened from this program.

4.1.2. Align Feasibility Studies with Stakeholders

Some of the commentary gathered for this study has come from nonfederal cost share partners who described their disagreement with assumptions or calculations in the feasibility study. USACE should gain alignment with all impacted stakeholders and cost share partners. When feasibility studies address commodity forecasting, USACE should seek input from relevant commercial stakeholders impacted by the project being studied to capture planned future investments in the area. For example, if a feasibility study were evaluating a ship channel on the Gulf of Mexico, it would be critical for USACE to know about planned refinery and pipeline expansions over the next couple of years and incorporate the information in their forecasts. Currently, USACE has a public meeting to present the tentatively selected plan and collect public comments, but these do not give much detail into methods. Starting from the beginning of the study, USACE should review the economic assumptions and models with project stakeholders to assure alignment on a continuous basis.

4.1.3. Improve Funding Process

Currently, USACE projects are appropriated yearly by Congress. This means project funding can be unpredictable year to year leaving project stakeholders and contractors with considerable uncertainty. If projects were fully appropriated for multiple years up front, they could capture savings such as bulk purchasing, purchasing during ideal market timings, and avoiding remobilization costs. This is how private industry efficiently manages their capital investments. They also capture the economic benefits of the project as soon as reasonably possible since the project is funded at a rate that will optimize the construction schedule. When projects are funded unreliably, not only does that project become delayed and cost more, other projects already authorized by Congress are pushed out. These projects will cost more due to inflation and could hurt their benefit-cost ratio.[55] An alternative would be to give USACE multiyear contracting authority. Multiyear contracts would entitle USACE to purchase services or supplies from contractors for more than one year even if appropriations stayed on an annual basis. Benefits would include increased competition for the initial award of the contract and reduced contract prices.

Congress should ensure that the full annual collections of the Inland Waterway Trust Fund (IWTF) and the Harbor Maintenance Trust Fund (HMTF) are appropriated each year. Historically, the budget has included only 50%-75% of the annual HMTF collection. This large of a gap translates to around $300 million that could be used to fund USACE maintenance projects. At the end of FY 2017, the IWTF had a surplus of $63 million that could be spent to fund ongoing projects to improve schedules and reduce overall costs.[56] These funds are intended for use on navigation construction and maintenance and should be utilized in that manner promptly every year.

Steps should be taken to improve project prioritization. In the Senate's version of "America's Water Infrastructure Act of 2018," Congress calls for a GAO study on the benefit-cost calculation. GAO is asked to examine the benefits and costs that are and are not included, in particular local and regional economic benefits. The subsequent report submitted to Congress will include recommendations for legislative or regulatory changes to improve benefit-cost analysis procedures. The USACE BC guidelines drive the perceived value of many projects competing for limited funding and GAO should fairly evaluate those guidelines.

4.1.4. Partnership Agreements

In their testimony, the Port of Corpus Christi Authority suggested that the Corps should grant more authority for ports to execute on Corps construction projects. When Corps resources are running short to execute on projects, they could take advantage of certain ports that are already responsible for dredging from the federally authorized ship channel to the docks. Although this could only be implemented with larger ports that can demonstrate that they have the personnel and expertise to manage projects of this magnitude, this could lead to cheaper and faster project execution even under the same cost share structure. The delegation of authority to states and port authorities to manage certain projects could be modeled from the Federal Highway Administration. Under this method, the nonfederal project sponsor could serve as construction manager. They would administer the contracts and USACE would continue to have

[55] Predictable Funding for Locks and Dams, Texas A&M Transportation Institute, April 2018
[56] Inland Waterways Users Board Meeting No. 85, Financial Report and Project Summaries, http://www.iwr.usace.army.mil/Portals/70/docs/IWUB/board_meetings/meeting85/UB85_04_Status_of_Inland_Waterways_Trust_Fund_McKee.pdf?ver=2018-01-08-151237-250

regulatory oversight. This potential improvement could reduce USACE's workload and facilitate construction work to be completed sooner.

4.2. Improve Regulatory Process Transparency and Efficiency

ICF's survey results and other research showed many members of the regulated community had experienced frustrations with a reported lack of transparency and efficiency in the CWA and RHA regulatory processes. Specifically, the efficiency of project development and implementation could benefit from an increase in communication with USACE, both leading up to and following permit application submission. Additionally, respondents identified a need for increased consistency in data requirements, processing times, and NWP eligibility from project to project and District to District. The following recommendations address these improvements.

4.2.1. Clarity of Process Requirements

Applicant Outreach

Increase USACE's headquarters-based outreach and guidance to the regulated community to improve quality, completeness, and consistency of applications received. At the district level, develop and staff an applicant assistant program, including a staffed helpline and online form for answering questions from applicants; proactively maintain a pre-application consultation calendar, with meetings held at least bi-weekly. At the headquarters level, identify a division level or headquarters level permitting coordinator that coordinates the processing and permits for projects that cross multiple districts or divisions, as well as implements a single form of application managed by a central permit coordinator.

USACE should create and maintain an online permitting portal accessible by applicants and the public. Such a portal would have permit checklists with a list of the critical forms needed to obtain each specific permit. It would also show each application received, its progress through review, and its expected decision date.

NWP Regional Conditions Oversight

Require review of regional conditions by the Chief Engineer's Office for scientific accuracy on adverse effects on the environment and factual evidence of concerns relating to public interest.

4.2.2. Consistency of Processing Times

Quality and Efficiency of Environmental Reviews

Increase standards for environmental review to encourage creation of environmental documents that are concise, clear, and supported succinctly by scientific evidence. Limit scope of review to the actual infrastructure project.

Additionally, USACE could take steps to facilitate parallel processing of applications for Corps permits, permissions, easements, and other authorizations.

NEPA Review Time Targets

Under the One Federal Decision MOU, USACE shall complete EISs for proposed major infrastructure projects within 2 years from issuance of a Notice of Intent to the issuance of the Record of Decision. By doing so, it should issue all necessary authorizations within 90 days after issuance of the ROD. The time limits may only be exceeded subject to limited exceptions.

Establish method to enforce existing regulatory timelines and add additional time limits to the various phases of the permitting process (scoping, decision on whether there is a significant impact, etc.).

WOTUS Rule

USACE and EPA are conducting a proposed rulemaking to define the scope of federal Clean Water Act (CWA) jurisdiction. The stated purpose of the proposed regulations is to develop a clear and predictable regulatory framework. If finalized, the regulations could reduce uncertainty for developers of infrastructure.

4.2.3. Standardized Coordination with Other Agencies

Standards for Cooperating Agency Consultation

Development standing Memoranda of Understanding (MOUs) with each cooperating federal agency laying out expected regional conditions, ESA Section 7 and NHPA Section 106 consultations, compensatory mitigation requirements, and agreed upon review timelines. Include delegation of cooperating agency regulatory review to USACE where appropriate, i.e., where impacts are below certain thresholds of concern.

NHPA Regulatory Consistency

Reconcile inconsistencies between the Corps' interim guidance (in 33 C.F.R. part 325) on compliance with National Historic Preservation Act (NHPA) and the NHPA implementing regulations. The Advisory Council on Historic Preservation, which oversees NHPA, stated that when "the Corps developed Appendix C in 1990 as its own regulations for complying with Section 106, it did not develop Appendix C as an alternative to the Section 106 implementing regulations pursuant to 36 C.F.R § 800.14. Further, the ACHP membership was unable to approve Appendix C as a counterpart regulation for implementing Section 106, as required by Section 306102(b)(5)(A) of the NHPA, because of the differences in many of its essential core elements …" Reconciling these regulations would avoid delays encountered during consultation with State Historic Preservation Offices under the NHPA process. It would also reduce inconsistencies between federal agencies during NEPA reviews.

In addition, USACE in 2005 and 2007 issued regulatory guidance to guide implementation of the Appendix C Regulations. USACE should update current regulations at 33 CFR Part 325, Appendix C to incorporate guidance previously issued by the Corps in 2005 and 2007.

Coordination with State/Local Agencies/Tribal Governments

Increase USACE coordination with state and local as well as federal agencies and tribal governments that have discretionary approval of one or more project elements, develop guidelines for same. For example, allow the permittee to attend the Corps/tribal government consultations, to allow the permittee to better understand tribal concerns and perhaps address them during agency consultations, which would help to eliminate much delay and inefficiency in the process that results from the long back and forth correspondence between the Corps, tribal governments, and the permittee.

Adhere to statutory requirements for state review time of Section 401 water quality certifications and provide clear direction in its regulations to states and applicable authorities as to conditions that trigger the review time (i.e. receipt of a written application).

Collaboration when USACE is a Cooperating Agency

Increase collaboration with Federal Energy Regulatory Commission (FERC) on gas pipelines. For example, engaging with FERC and the applicant at the pre-filing stage. Issue CWA § 404 permits contingent upon FERC's successful compliance with the NHPA when FERC is the federal lead agency.

4.2.4. Easy Access to Existing Data

Access to Public Documents

Develop a plan to improve public access to archived public documents including regulatory decision documents such as maps and related data for WOTUS jurisdictional determinations.

Develop a user-friendly display of NWPs and all related documents including regional conditions and Section 401 water quality certifications at a central Corps online repository. Create a publicly accessible database of Corps' real estate interests.

4.3. Increase Consistency of Regulatory Process Outcome

ICF's survey results also indicated that members of the regulated community would benefit from increased predictability and consistency in the CWA and RHA regulatory processes. Specifically, respondents identified a need for a reduction in project staffing turnover/reassignment, increased standardization in application outcomes between regulatory staff members and various districts, and a focus on Corps/regulated community relations. The following recommendations address these recommended improvements.

4.3.1. Standardization of Permit Application Process

National Application Instructions

Notwithstanding certain Corps Districts with unique physiographical characteristics, develop nationwide standards for required application contents (including use of desktop materials), NWP applicability, and required supporting data enforced between applicants, districts, and divisions.

Modification of NWP Program

Modify NWP program to include streamlined reviews by cooperating federal agencies and, when appropriate, consider other opportunities for streamlining.

4.3.2. Consistent Exercise of Discretion by USACE Staff

Regulatory Process Quality Assurance

Implement an efficient quality assurance process for automatic and as-needed senior and/or legal review of key regulatory decision points, including alternatives screening, LEDPA determinations, project area, and extent of jurisdictional waters, among others.

Nationwide Training Standards

Train new field office staff and retrain existing field office staff using both national permit processing standards plus District-specific information and instructions.

Cross District Decision-making

Review and modify the discretion of individual regulatory staff by setting more specific criteria for permitting decisions, particularly in relation to Waters of the United States determinations and NWP applicability. Examples include: District Engineer cannot, on a discretionary basis, lower the thresholds at which a PCN is required; limit the use of NWP that are appropriate to the type project, or modify other PCN triggers, without allowing for public comment.

Specific Criteria for Permitting Decisions

Review and modify discretion of individual regulatory staff by setting more specific criteria for permitting decisions, particularly in relation to WOTUS determinations and NWP applicability.

4.3.3. Development of Working Relationships

Collaborative Training

Revise regulatory project management training curriculum to encourage collaborative efforts and remove any existing tenor of conflict and mistrust from relationship with regulated community where needed.

Increased Staff Engagement

Improve regulatory staffing and budget generally to increase ability of Corps staff to engage in projects during development stage to help influence alternatives development and avoid mid-project changes.

4.3.4. Development and Retention of Regulatory Staff

Staff Experience and Longevity

Increase experience standards for Corps staff working in Regulatory positions by decreasing career incentives to leave positions frequently. Create a career pipeline for regulatory PMs that encourages retention of experienced staff members. Facilitate regulatory PM access to Corps staff across Districts to balance workload and provide specialized expertise where needed. Increase the time District Engineers (DEs)/District Commanders spend deployed in specific commands and promoting Deputy Commanders to DEs would provide greater continuity in leadership and in turn, more consistent guidance to staff in properly applying Corps regulations and guidance.

Commitment of Resources

Avoid reassignment of staff to new temporary or permanent positions when presently assigned to ongoing individual permit applications or complex NWP notification actions.

Expansion of Staff Expertise

Increase staffing to support regulatory project management staff's access to cross-disciplinary training and topical experts such as biologists and archaeologists to ensure responsible treatment of sensitive resources. Develop document management capabilities among USACE staff to prepare concise, readable NEPA documents. Increase staff training in areas including consistent use of categorical exclusions for uses in flowage easements. Allow the use of contract resources, funded by applicants, to work on permitting issues, as is done at other regulatory agencies.

5. Conclusion

The importance of transportation infrastructure to American commerce and consumers is difficult to overstate. The ability of private industry and government entities to maintain, enhance, and grow the transportation infrastructure in an efficient and cost-effective manner has never been more critical. Much of our existing roadways, bridges, waterways, ports, railways, and pipelines need to be upgraded or expanded. At the same time, global economic competition for goods and services has never been stronger and the U.S. needs to be prepared to compete in global markets.

Getting U.S. goods to compete in global markets is heavily dependent upon the efficiency of the supply chains from U.S. production sources to export destinations. This is critical not only for commodities such as wheat, corn, soybean, lumber products, and manufactured goods but also for the U.S.'s growing production of crude oil, NGL's, petroleum products, LNG, and petrochemicals. Efficient permitting and construction of pipelines is needed to move these products from the heart of the country to the coasts. Similarly, U.S. ports must be prepared to receive and load the most economically sized petroleum and petrochemical vessels to insure U.S. exports can effectively compete in global markets.

5.1.1. Importance of USACE Performance

This report commissioned by API has focused on the ports and waterways as well as pipeline infrastructure, and the critical role the USACE plays in the maintenance and development of that infrastructure to meet the current and future needs of the United States. That role for USACE is also critical to the stakeholders who rely on efficient, reliable, and cost-effective transportation of goods to market. Total waterborne transportation costs related to the U.S. economy are estimated in this report to be $99 billion annually and pipeline transportation costs are estimated to be $48 billion annually. These significant costs must be managed efficiently to maximize U.S. competitiveness in a global market and minimize consumer costs.

The ability to optimize the transportation infrastructure is heavily impacted by the performance of the USACE. It is also highly dependent on the funding levels approved by Congress, determination of benefits for the infrastructure projects, expeditious Court rulings for issues requiring legal decisions, and the performance of the stakeholders in understanding and submitting accurate and timely documents for the USACE to review.

Implementing a major project such as a port channel widening and deepening, a major pipeline construction, or a river lock refurbishment can be billion-dollar investments that touch on sensitive environmental issues, property issues, inflation impacts, and security of energy supply as well as jobs in the farm belt and across the country. Consequently, it is critical that these projects receive timely and effective permitting review and approval and secure reliable Federal funding where appropriate.

5.1.2. Primary Conclusions

Based on ICF survey results and other research, Chapter 4 delineates a number of possible improvements to the USACE process for project feasibility studies, benefit/cost determinations, and project approval and funding. It also identifies a number of possible enhancements to the permitting and regulatory processes. While the report suggests consideration for all of these enhancements, the primary conclusions that may provide the greatest impact are as follows:

5.1.3. Key Takeaways: Civil Works Projects

- Continue to refine and improve recent initiatives such as the "3x3x3 Rule," "One Federal Decision," and "Section 408 Reform" so that they become ingrained in the project development process.

- Update Principals and Guidelines: In the Senate's version of "America's Water Infrastructure Act of 2018", Congress calls for a GAO study on the benefit-cost calculation. GAO is asked to examine the benefits and costs that are and are not included, in particular local and regional economic benefits. The subsequent report submitted to Congress will include recommendations for legislative or regulatory changes to improve benefit-cost analysis procedures. These USACE BC guidelines drive the perceived value of many projects competing for limited funding and GAO must fairly evaluate them.

- Ensure that the Harbor Maintenance Trust Fund and the Inland Waterway Trust Fund are fully utilized and deployed for their intended purpose – to aid required navigation work on locks, waterways and port infrastructure. This will help insure that needed projects and maintenance work can be completed within projected timeframes.

- Determine a mechanism to appropriate fully significant navigation projects for multiple years up front. This will allow capture of savings such as bulk purchasing, purchasing during ideal market timings, and avoid remobilization costs. This is how private industry efficiently manages their capital investments. They also capture the economic benefits of the project as soon as reasonably possible since the project is funded at a rate that will optimize the construction schedule.

- Align Feasibility Studies in Collaboration with Stakeholders - Some of the commentary gathered for this study has come from nonfederal cost share partners who described their disagreement with assumptions or calculations in the feasibility study. USACE could benefit from gaining alignment with all impacted stakeholders and cost share partners. When feasibility studies address commodity forecasting, USACE should seek input from relevant commercial stakeholders impacted by the project being studied to capture planned future investments in the area.

5.1.4. Key Takeaways: Regulatory and Permitting

- Increase USACE's headquarters-based outreach and guidance to the regulated community to improve quality, completeness, and consistency of applications received.
- At the district level, develop and staff an applicant assistant program, including a staffed helpline and online form for answering questions from applicants; proactively maintain a pre-application consultation calendar, with meetings held at least bi-weekly.
- Create and maintain an online permitting portal accessible by applicants and the public. This portal would have permit checklists with a list of the critical forms needed to obtain each specific permit. It would also show each application received, its progress through review, and its expected decision date

- At the headquarters level, identify a division level or headquarters permitting coordinator that could coordinate processing and permits for projects that cross multiple districts or divisions, as well as implement a single form of application managed by a central permit coordinator.
- Develop a user-friendly display of NWPs and all related documents including regional conditions and Section 401 water quality certifications at a central Corps online repository. Create a publicly accessible database of Corps' real estate interests.
- Require review of regional conditions by the Chief Engineer's Office for scientific accuracy on adverse effects on the environment and factual evidence of concerns relating to public interest.
- Increase standards for environmental review to encourage creation of environmental documents that are concise, clear, and supported succinctly by scientific evidence.
- Establish method to enforce existing regulatory timelines and add additional time limits to the various phases of the permitting process (scoping, decision on whether there is a significant impact, etc.).
- Follow time targets for NEPA reviews. Under the One Federal Decision MOU, USACE shall complete EISs for proposed major infrastructure projects within 2 years from issuance of a Notice of Intent to completion of the ROD. By doing so, it should issue all necessary authorizations within 90 days after issuance of the ROD. The time limits may only be exceeded subject to limited exceptions under the MOU.
- Draft and implement a clarified and updated WOTUS rule to define likely jurisdictional determination and reduce uncertainty for developers of infrastructure.
- Develop standing Memoranda of Understanding (MOUs) with each cooperating federal agency laying out expected regional conditions, ESA Section 7 and NHPA Section 106 consultations, compensatory mitigation requirements, and agreed upon review timelines. Include delegation of cooperating agency regulatory review to USACE where appropriate, i.e., where impacts are below certain thresholds of concern.
- Reconcile inconsistencies between the Corps' interim guidance (in 33 C.F.R. part 325) on compliance with National Historic Preservation Act (NHPA) and the NHPA implementing regulations. In addition, update current regulations at 33 CFR Part 325, Appendix C to incorporate guidance previously issued by the Corps in 2005 and 2007.
- Increase USACE coordination with state and local as well as federal agencies and tribal governments that have discretionary approval of one or more project elements, develop guidelines for same.
- Increase collaboration with Federal Energy Regulatory Commission (FERC) on gas pipelines. For example, engaging with FERC and the applicant at the pre-filing stage. Issue CWA § 404 permits contingent upon FERC's successful compliance with the NHPA when FERC is the federal lead agency.
- Notwithstanding certain Corps Districts with unique physiographical characteristics, develop nationwide standards for required application contents, NWP applicability, and required supporting data enforced between applicants, districts, and divisions. Clarify requirements on what constitutes a complete application for a Section 404 permit.
- Modify NWP program to include streamlined reviews by cooperating federal agencies through identification and diversion of projects with *de minimis* impacts to a minimal review path.
- Implement an efficient quality assurance process for automatic and as-needed senior and/or legal review of key regulatory decision points, including alternatives screening, LEDPA determinations, project area, and extent of jurisdictional waters, among others.

- Train new staff and retrain existing staff using national permit processing standards in addition to instruction at the District level.
- Review and modify the discretion of individual regulatory staff for permitting decisions. In particular, set more specific criteria relate to WOTUS determinations and NWP applicability.
- Revise regulatory project management training curriculum to encourage collaborative efforts and remove any existing tenor of conflict and mistrust from the relationship with the regulated community where needed.
- Improve regulatory staffing and budget generally to increase the ability of Corps staff to engage in projects during development stage to help influence alternatives development and avoid mid-project changes.
- Increase experience standards for Corps staff working in regulatory positions by decreasing career incentives to leave positions frequently. Create a career pipeline for regulatory Project Managers (PMs) that encourages retention of experienced staff members. Facilitate regulatory PM access to Corps staff across Districts to balance workload and provide specialized expertise where needed. Increase the time District Engineers (DEs)/District Commanders spend deployed in specific commands and promoting Deputy Commanders to DEs would provide greater continuity in leadership and in turn, more consistent guidance to staff in properly applying Corps regulations and guidance.
- Avoid reassignment of staff to new temporary or permanent positions when presently assigned to ongoing individual permit applications or complex NWP notification actions.
- Increase staffing to support regulatory project management staff's access to cross-disciplinary training and topical experts such as archaeologists to ensure responsible treatment of specialized resources. Increase staff training in areas including consistent use of categorical exclusions for uses in flowage easements.
- Allow the use of contract resources, funded by applicants, to work on permitting issues, as is done at other regulatory agencies. Develop document management capabilities among USACE staff to prepare concise, readable NEPA documents.

5.1.5. Strategic Benefits

This study estimates that the "direct costs" that could be avoided through implementing more efficient processes in developing oil and gas resources, permitting and constructing pipeline and other infrastructure project costs, building Civil Works projects funded by the government, and shipping goods using waterborne transportation and pipelines would be $2.90 to $9.71 billion per year. These are the cost savings going to infrastructure project developers and foreign and domestic entities shipping goods to, from, and within the U.S. Reductions in direct costs would work their way through the U.S. and foreign economies as some U.S. industries would see their output increase while other would see decreases. However, overall the U.S. economy would be larger due to efficiency gains. Also, the "social welfare" of the U.S. would improve, particularly among consumers who benefit from lower prices for goods that are transported over water or through pipelines.

Implementing more efficient processes would help U.S. port and waterway infrastructure handle larger vessels in and out of port and move commodities on inland waterways more efficiently. This would better position the U.S. as a strategic global provider of energy products (crude, LPG, NGL's, LNG, petroleum products), petrochemicals, food and food products, and many other commodities that move through key Gulf Coast ports in Texas and Louisiana. Likewise, more timely delivery of infrastructure projects that increase the capability of east coast and west coast ports to receive imported commodities and export U.S. goods is also important to the nation's economic growth.

5.1.6. USACE Supportive of Initiatives

As noted in Chapter 2, the USACE has recognized the need for improvements. It has initiated and supported the 3-3-3 plan for feasibility studies, as well as the "One Federal Decision" initiative, and has improved Section 408 funding methods. Those who regularly interact with USACE are supportive of these efforts. From our research and interviews, it was clear that the working relationships with USACE personnel are strong, and that the Corps can execute project work effectively and on schedule, when provided the funding and clarity of mission. This study indicates that improvements within the USACE processes could further enhance the USACE performance in their missions, but also notes that there are areas such as funding, environmental interventions, Court issues, and more which can precipitate delays and costs that are outside the direct control of the USACE.

Appendix A: Related Studies

Summary of Economic Studies Involving Waterborne Transportation

Study	Scope		Direct Impacts			Secondary Impacts	
	Project Specific	National	Shipping Costs	Civil Works Project Costs	Non-Federal Project Costs	Industry Impacts	Indirect Impacts
Feasibility Studies Using U.S. Army Corps Principles and Guidelines (1983)	✔		✔				
The Economic Impact of Reduced Dredging of the Mississippi River (2012)	✔		✔			✔	✔
The Impacts of Unscheduled Lock Outages (2017)	✔		✔			✔	✔
Estimated Value of Barge Freight Rates for Commodities Shipped on the Missouri River and Implied Freight Savings (2004)	✔		✔				
The Economic Impacts of the Great Lakes-St. Lawrence Seaway System	✔					✔	✔
Failure to Act: The Economic Impact of Current Investment Trends in Airports, Inland Waterways, and Marine Ports Infrastructure (ASCE, 2012)		✔				✔	✔
Predictable Funding for Locks and Dams (2018)				✔			
Direct Economic Effects of a Lack of Maintenance Dredging on Corpus Christi Ship Channel (2012)	✔		✔			✔	

Estimated Value of Barge Freight Rates for Commodities Shipped on the Missouri River and Implied Freight Savings

In April 2004, the Food and Agricultural Policy Research Institute at the University of Missouri-Columbia released a report where they surveyed 39 terminals and businesses along the Missouri River to determine the economic value of the barge traffic on this waterway. Commodities analyzed include grains and oilseeds, fertilizer, asphalt, cement, and sand and gravel. Terminals surveyed were asked to provide their differential freight rate for transportation delivered by either truck or train or both. The survey reports the estimated change in transportation cost per ton as a weighted average to take into consideration terminal operation size. Savings were reported to be between $4.85 and $13.16 per ton depending on commodity type compared to alternative transportation. Current transport rates are the basis, but the added conversion cost to move all barge transport to rail and truck transport is not addressed in this study.

- *https://fapri.missouri.edu/wp-content/uploads/2015/03/FAPRI-MU-Report-05-04.pdf*

Direct Economic Effects of Lack of Maintenance Dredging on Port Corpus Christi Customers Utilizing the Corpus Christi Ship Channel

In March 2012, the Texas Transportation Institute released a report that analyzed the economic effect of losing 1-2 feet of draft in the Corpus Christi Ship Channel if maintenance dredging was not performed in a timely manner. The economic impacts included were transportation cost increases due to light loading of vessels, a direct loss of business from the need to leave cargo behind, and additional mitigation costs needed for deep draft rig movements. They assumed that the leftover tonnage due to light loading was unable to be loaded on additional vessels and therefore was lost business. A loss of 1 foot of depth would cost $71.2 million per year and 2 feet of depth reduction would cost $120.4 million per year. Around 85% of the additional costs came from the calculated lost business. Vessel calls and tonnage are based on 2010 data with no forecasting.

- *https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2012-4.pdf*

The Impacts of Unscheduled Lock Outages

In October 2017, the Center for Transportation Research at the University of Tennessee and the Vanderbilt Engineering Center for Transportation and Operational Resiliency published a report that analyzed the economic impacts of an unplanned year-long lock closure based on four selected locks (Markland, LaGrange, Calcasieu, and Lock and Dam 25). Supply chain savings were calculated for barges versus alternative transportation (rail, split barge-rail, truck) for a base year tonnage. This study derived economic impact multipliers to estimate indirect regional costs attributable to each lock. The multiplier included a regional sales multiplier, income multiplier, and an employment multiplier. Each of these four locks helps shippers to avoid more than $1 billion in additional transportation costs per year. Significant regional commercial value was determined for these locks in the states of Louisiana, Texas, and Illinois.

Exhibit A-1: Freight Transportation Savings for Waterways over Alternative Modes (Cents per Ton-Mile)

	Savings in Cents per Ton-Mile				
Commodity	Markland	Calcasieu	LeGrange	Lock & Dam 25	Weighted Average
Coal	1.52	2.13	4.86	5.46	1.66
Petroleum Products	5.12	4.00	2.71	3.11	4.02
Chemicals	5.02	3.01	4.18	4.17	3.84
Crude Materials	2.24	3.71	4.82	4.55	3.11
Primary Manufactured Goods	2.53	3.93	2.93	2.71	2.96
Farm Products and Food	0.70	2.64	6.64	6.29	5.53
Equipment	2.69	5.15	5.99	6.47	3.55

- *http://www.nationalwaterwaysfoundation.org/documents/low%20res%20Lock%20Outage%20NWF_FINAL_REPORT%202017.pdf*

USACE Final Feasibility Report for Upper Ohio Navigation Study

This 2014 report by USACE (revised in 2016) analyzes the economic benefits of the improved reliability and increased size of the Emsworth, Dashields, and Montgomery Locks and Dams on the Ohio River to reduce shipping delays during unscheduled outages. Transportation costs are evaluated based on cost differentials between transporting through the lock or transporting on rail using estimated outage frequencies and durations for each alternative capital modifications. The recommended plan was to construct a new lock at each facility with the same size as the main chamber in the footprint of the existing auxiliary lock with reactive maintenance of the main lock. The differential cost of land transportation usage during unscheduled outages between the “without project plan” and the recommended plan is $175 million on an average annual basis. The recommended plan was determined to have a BCR of 4.2.

- *http://www.lrp.usace.army.mil/Portals/72/Tab%202%20UONS%20Final%20Report%20Revised%20Aug%202016_signed.pdf?ver=2016-12-12-123417-567*

USACE Final Feasibility Report for Sabine-Neches Waterway Channel Improvement Project

This 2011 report by USACE analyzed the benefits and costs of deepening and widening the Sabine-Neches Waterway (SNWW) to allow larger, less costly ships to enter the harbor safely and reduce traffic delays. Transportation costs included cost differential for light loading of vessels and from reduced delay frequency and duration. Traffic and fleet size forecasted for 50 years into the future. Channel widening, turning basins, and anchorage alternatives were evaluated. The selected alternative from the study was to deepen the SNWW to Beaumont to a 48’ depth. This had an average annual deepening benefit of $112.9 million and a BCR of 1.3. Around 80% of these benefits come from crude oil and petroleum products. Turning and anchorage basins were included in the selected alternative along the Neches River Channel.

Modeling of widening the channel indicated an average time reduction of 1.5 hours per round trip voyage which was about $3.5 million benefit per year. The BCR was 3.2 for anchorage basins, but widening was cost prohibitive.

- *https://www.navigationdistrict.org/wp-content/uploads/2014/06/SNWW-Vol-I-FFR-March-2011.pdf*

USACE Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies

This 1983 guidance document is intended to ensure consistent planning by Federal agencies in the formulation and evaluation of water and related land resources implementation studies. The planning process evaluates a do-nothing case against multiple alternative plans. An alternative plan consists of a system of structural and/or non-structural measures to alleviate specific problems. The main way that USACE evaluates benefits is through the National Economic Development (NED) account, which are increases in the net value of the national output of goods and services. Three other accounts are established to facilitate evaluation of alternative plans which include Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms. The RED account registers changes in the distribution of regional economic activity including transfers of income to the region from outside of the region. The OSE account shows effects on urban and community impacts and effects on life, health, and safety.

The basic economic benefit of a navigation project is the reduction in the value of resources required to transport commodities. Inland navigation typical NED benefits are categorized as cost reduction benefits, shift of mode benefits, and shift of origin-destination benefits, and new movement benefits. Cost reduction benefits include reductions in costs incurred from trip delays, from larger or longer tows able to use the waterway, or from more fully loaded barges. The shift in mode benefit is the difference in cost between using the alternative mode without the project and the cost of using the waterway with the project. Benefits are also counted if a shift in origin or destination results in a cost reduction. A new movement benefit can be applied to a project if an increase in production and consumption results from the lower transportation costs. Deep-draft navigation projects have similar categories of NED benefits. These include savings from the use of larger vessels, more efficient use of existing vessels, reduction in transit time, lower cargo handling and tug assistance costs, reduced interest and storage costs, and the use of water transportation rather than an alternative land mode.

- *https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1256524&ext=pdf*

The Economic Impacts of the Great Lakes-St. Lawrence Seaway System

Martin Associates released a report in 2011 that assesses the contributions made by the Great Lakes-Seaway system to the state, provincial, regional, and national economies of the United States and Canada. They calculated that 226,833 jobs could be attributed to the Great Lakes. These jobs include direct, indirect, induced, and related user. 322 million tons of cargo in 2010 were handled on the Great Lakes-Seaway system and this generated $13.1 billion in total personal wage and salary income and $33.6 billion in business revenue. Taxes ($6.4 billion) and local purchases ($4.6 billion) were also impacts analyzed.

- *http://www.greatlakes-seaway.com/en/pdf/eco_impact_full.pdf*

Failure to Act: The Economic Impact of Current Investment Trends in Airports, Inland Waterways, and Marine Ports Infrastructure

The American Society of Civil Engineers developed a report in 2012 that analyzes the economic impacts if critical needs in air and waterborne transportation systems continues to be unmet. Delays in inland waterway transportation was estimated to cost $33 billion in 2010 across the system. Using undersized ships at marine ports was estimated to cost $7 billion in 2010. They analyze the lost trade value and total impact on GDP due to losses driven by less competitive exports and higher prices for imports. Multipliers were estimated to determine the associated lost jobs, business sales, and disposable personal income. For ports and waterways, the lost trade value projected for 2020 was $63.3 billion with total GDP loss at $94 billion.

- *http://www.asce.org/uploadedFiles/Issues_and_Advocacy/Our_Initiatives/Infrastructure/Content_Pieces/failure-to-act-ports-aviation-report.pdf*

The Economic Impact of Reduced Dredging of the Mississippi River

Written by Timothy P. Ryan, Ph.D. in January 2012, this report analyzes the economic impacts of a USACE dredging program that would limit drafts on the Lower Mississippi River to 38’ compared to the historic allowance of 47’. The study analyzes impacts to U.S. producers in two different ways: first by a reduction in production due to loss of competitiveness compared to foreign goods and then by absorption of higher transportation costs because of more ships required to move the same volume. Impacts are also evaluated from losses to the Louisiana economy and from higher gasoline prices. With the assumption that higher transportation costs are absorbed, the direct loss was calculated at $445 million and $860 million when indirect losses are also included. If the assumption is that production is lost due to the higher transportation costs, it was determined that $5.5 billion was directly lost. Comparing these losses to the $45 million that Congress could have appropriated for the dredging, a compelling case is made in favor of regular maintenance dredging.

- *https://www.americaswetland.com/photos/OFFICIAL_Dr_Ryan_Final_Report_1_10_12.pdf*

Appendix B : Detailed Tables on International Waterborne Trade

The following tables display more detailed information regarding the international movements of waterborne trade. Vessel tonnages were derived directly from U.S. Census Trade data[36] by commodity and region of origin or destination. For imports, freight and insurance costs were determined by using applicable FOB and CIF values. Shipping rates per route were determined by using a ratio of freight and insurance costs to tonnage transported, and cent per ton-mile determined using relevant nautical mileages. Exports did not provide CIF values. As such, export freight and insurance costs were determined by utilizing similar imported shipping rates with respective to each commodity and origin/destination pair. In certain instances, import shipping rates were very high based on tonnages for certain routes. For exports, these cases were adjusted to consider an overall average shipping rate.

The USACE also provides an entrances and clearances database[57]. This data provides vessel entrances and clearances by port. However, the data represents foreign cargo traffic (i.e., cargo that has at some point originated from a foreign country). As such, ship traffic can be determined for particular ports or along routes, but any movements that are strictly domestic will not be captured. The data was processed to consider each vessel and track the port at which the vessel originally enters a U.S. port from a foreign country for a particular trip. The vessel information was also processed with respect to ship type and class, with class being determined based on applicable vessel type and size ranges. The table below shows the number of calls and DWT of each ship type at the point of first entry into the U.S. as well as the number of additional domestic calls each ship type received in 2016.

[57] Vessel Entrances and Clearances; http://www.navigationdatacenter.us/data/dataclen.htm

Exhibit B-1: 2016 Import Vessel Tonnages by Region of Origin

Vessel SWT by Region (tonnes)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	24,175	1	482	565,467	112,199	169,104	426,263	0	7,235,564	8,533,255
2100	Crude Petroleum	26,214,605	89,261,779	0	2,466,565	218,836	5,952,879	8,311,330	31,232,265	88,348,262	252,006,521
2229	Petroleum Products	9,630,758	1,684,897	4,895,356	8,175,152	10,062	48,674,913	16,797,521	3,404,347	14,649,933	107,922,938
3100	Chemical Fertilizers	1,786,824	4,161,710	7,908	1,359,738	9,628	4,046,366	96,335	27,020	1,267,118	12,762,647
3200	Chemicals excluding Fertilizers	837,839	1,347,673	1,050,523	18,163,949	500,680	7,941,527	410,184	546,684	9,423,728	40,222,787
4142	Lumber, Logs, Wood Chips, and Pulp	19,339	49,344	49,407	2,178,254	187,949	2,555,963	207,517	6,188	2,525,226	7,779,186
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	1,378,329	176,532	535,137	4,461,345	370,622	8,616,667	16,245,749	13,290,907	10,219,681	55,294,968
4400	Iron Ore, Iron, and Steel Waste and Scrap	82,395	0	0	0	84	359,687	563,143	0	2,105,938	3,111,247
4600	Non-Ferrous Ores and Scrap	1,367,907	12,559	19,629	1,103,454	548,377	1,511,572	689,720	62,502	5,713,452	11,029,174
5155	Primary Non-Metal Products	61,643	70,142	412,879	4,862,876	198,201	1,621,394	439,378	12,631	2,307,207	9,986,349
5354	Primary Metal Products	913,423	1,074,193	366,599	7,761,858	483,790	13,477,814	1,385,913	755,260	7,247,236	33,466,086
6168	Food and Food Products	1,121,030	166,819	1,367,375	9,866,646	1,973,787	10,654,558	1,073,227	1,534,988	16,930,377	44,688,808
7000	Manufactured Goods	420,553	579,318	3,847,693	62,410,617	92,539	13,240,492	22,631	981,194	3,411,624	85,006,662
8099	Unknown and Not Elsewhere Classified Products	69,001	27,365	5,308	205,228	73,541	512,033	42,219	29,751	233,772	1,198,218
	All USACE categories	43,927,823	98,612,331	12,558,297	123,581,150	4,780,294	119,334,967	46,711,131	51,883,735	171,619,118	673,008,846

Exhibit B-2: 2016 Import Vessel FOB Values by Region of Origin

Vessel FOB Values by Region ($)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	$2,147,555	$4,256	$229,647	$34,567,175	$6,174,097	$29,235,060	$43,956,854	$0	$536,470,886	$652,785,530
2100	Crude Petroleum	$8,448,237,333	$25,274,224,984	$0	$779,141,176	$68,679,812	$1,854,924,445	$2,601,764,891	$7,582,564,869	$21,586,877,266	$68,196,414,776
2229	Petroleum Products	$3,159,762,347	$807,215,174	$2,384,035,385	$4,130,497,807	$3,186,697	$17,968,435,808	$6,086,276,015	$815,893,173	$4,140,258,097	$39,495,560,503
3100	Chemical Fertilizers	$527,730,480	$949,741,079	$8,264,506	$324,002,571	$8,206,016	$833,692,217	$27,537,826	$16,897,398	$262,677,721	$2,958,749,814
3200	Chemicals excluding Fertilizers	$776,125,988	$4,300,699,376	$3,459,861,084	$51,764,728,877	$683,806,355	$28,909,779,403	$278,781,274	$533,713,055	$6,454,386,656	$97,161,882,067
4142	Lumber, Logs, Wood Chips, and Pulp	$57,622,632	$51,550,884	$85,595,489	$4,311,891,782	$103,974,631	$2,978,081,772	$102,001,431	$5,532,247	$1,367,222,491	$9,063,473,359
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	$104,115,008	$34,347,637	$80,851,244	$467,679,562	$38,107,746	$555,962,621	$325,529,277	$186,051,886	$360,010,354	$2,152,655,335
4400	Iron Ore, Iron, and Steel Waste and Scrap	$6,068,058	$0	$0	$0	$12,420	$29,742,503	$38,723,487	$0	$171,349,661	$245,896,129
4600	Non-Ferrous Ores and Scrap	$572,451,391	$51,366,197	$8,615,328	$568,426,292	$376,615,969	$869,206,270	$100,307,757	$4,424,369	$472,020,996	$3,023,434,569
5155	Primary Non-Metal Products	$91,876,554	$199,408,284	$1,187,021,745	$16,143,352,296	$210,232,423	$2,839,671,676	$50,818,372	$33,588,672	$2,339,199,915	$23,095,169,938
5354	Primary Metal Products	$939,847,034	$1,982,911,291	$617,073,872	$10,156,265,162	$525,267,541	$11,194,039,546	$1,129,324,817	$382,309,614	$5,800,696,287	$32,727,735,164
6168	Food and Food Products	$2,713,682,764	$390,885,914	$3,652,354,159	$20,992,302,795	$5,520,740,061	$24,400,207,259	$419,480,813	$1,217,544,581	$19,123,239,130	$78,430,437,477
7000	Manufactured Goods	$4,174,294,914	$2,923,074,262	$21,674,263,299	$442,310,365,111	$1,370,099,916	$115,632,976,884	$99,418,698	$7,045,056,192	$17,704,463,181	$612,934,012,458
8099	Unknown and Not Elsewhere Classified Products	$137,616,290	$260,535,600	$47,435,263	$1,473,352,004	$266,910,257	$2,188,608,547	$37,786,485	$186,453,755	$1,009,923,268	$5,608,621,469
	All USACE categories	$21,711,578,349	$37,225,964,938	$33,205,601,021	$553,456,572,611	$9,182,013,941	$210,284,564,011	$11,341,707,997	$18,010,029,811	$81,328,795,909	$975,746,828,587

Exhibit B-3: 2016 Import Freight and Insurance Costs by Region of Origin

F&I Values by Region ($)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	$776,195	$708	$27,552	$4,289,930	$745,544	$5,360,893	$3,173,315	$0	$50,679,778	$65,053,916
2100	Crude Petroleum	$420,828,220	$1,579,708,387	$0	$53,637,430	$4,228,975	$88,648,603	$197,787,317	$197,240,891	$1,126,112,337	$3,668,192,159
2229	Petroleum Products	$199,171,015	$38,894,157	$109,392,993	$197,563,587	$1,825,036	$1,041,717,872	$394,752,281	$35,300,428	$193,351,796	$2,211,969,166
3100	Chemical Fertilizers	$15,844,354	$59,191,319	$770,043	$34,541,908	$264,171	$108,182,428	$850,046	$895,891	$38,072,023	$258,612,184
3200	Chemicals excluding Fertilizers	$59,000,103	$109,102,307	$153,603,819	$3,130,601,909	$27,049,614	$805,601,739	$3,894,773	$12,296,166	$344,080,632	$4,645,231,062
4142	Lumber, Logs, Wood Chips, and Pulp	$4,719,162	$3,563,274	$8,333,880	$380,784,178	$21,104,151	$200,358,053	$3,283,190	$76,953	$93,741,877	$715,964,720
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	$13,322,010	$2,432,770	$11,205,881	$88,895,780	$3,237,574	$116,171,760	$23,735,111	$23,799,739	$88,111,015	$370,911,642
4400	Iron Ore, Iron, and Steel Waste and Scrap	$220,756	$0	$0	$0	$8,000	$4,318,032	$3,920,012	$0	$21,769,872	$30,236,672
4600	Non-Ferrous Ores and Scrap	$19,431,505	$1,247,820	$512,134	$21,760,601	$16,007,734	$15,132,129	$3,944,369	$280,438	$17,469,328	$95,786,057
5155	Primary Non-Metal Products	$7,975,872	$12,023,172	$70,798,633	$956,658,541	$20,915,155	$182,852,551	$1,141,268	$659,196	$170,522,881	$1,423,547,270
5354	Primary Metal Products	$30,272,478	$120,371,643	$36,232,060	$681,537,345	$26,141,387	$595,216,489	$16,049,270	$14,764,408	$209,293,093	$1,729,878,174
6168	Food and Food Products	$107,989,546	$27,428,670	$196,548,017	$1,063,522,672	$265,407,293	$1,263,877,606	$6,330,397	$28,535,103	$1,657,313,388	$4,616,952,691
7000	Manufactured Goods	$115,331,807	$108,680,435	$1,022,852,144	$16,448,790,302	$26,115,898	$2,768,384,993	$1,436,345	$44,033,774	$545,636,623	$21,081,262,319
8099	Unknown and Not Elsewhere Classified Products	$2,272,699	$2,131,845	$816,465	$20,734,430	$3,656,641	$17,523,294	$430,346	$1,435,545	$9,045,803	$58,047,066
	All USACE categories	$997,155,722	$2,064,776,507	$1,611,093,620	$23,083,318,613	$416,707,174	$7,213,346,443	$660,728,042	$359,318,533	$4,565,200,445	$40,971,645,098

Exhibit B-4: 2016 Import Freight and Insurance Costs per Ton by Region of Origin

F&I Values per Ton by Region ($/tonne)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	32.11	706.59	57.20	7.59	6.64	31.70	7.44		7.00	7.62
2100	Crude Petroleum	16.05	17.70		21.75	19.32	14.89	23.80	6.32	12.75	14.56
2229	Petroleum Products	20.68	23.08	22.35	24.17	181.38	21.40	23.50	10.37	13.20	20.50
3100	Chemical Fertilizers	8.87	14.22	97.37	25.40	27.44	26.74	8.82	33.16	30.05	20.26
3200	Chemicals excluding Fertilizers	70.42	80.96	146.22	172.35	54.03	101.44	9.50	22.49	36.51	115.49
4142	Lumber, Logs, Wood Chips, and Pulp	244.02	72.21	168.68	174.81	112.29	78.39	15.82	12.44	37.12	92.04
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	9.67	13.78	20.94	19.93	8.74	13.48	1.46	1.79	8.62	6.71
4400	Iron Ore, Iron, and Steel Waste and Scrap	2.68				95.24	12.00	6.96		10.34	9.72
4600	Non-Ferrous Ores and Scrap	14.21	99.35	26.09	19.72	29.19	10.01	5.72	4.49	3.06	8.68
5155	Primary Non-Metal Products	129.39	171.41	171.48	196.73	105.53	112.77	2.60	52.19	73.91	142.55
5354	Primary Metal Products	33.14	112.06	98.83	87.81	54.03	44.16	11.58	19.55	28.88	51.69
6168	Food and Food Products	96.33	164.42	143.74	107.79	134.47	118.62	5.90	18.59	97.89	103.31
7000	Manufactured Goods	274.24	187.60	265.84	263.56	282.21	209.08	63.47	44.88	159.93	248.00
8099	Unknown and Not Elsewhere Classified Products	32.94	77.90	153.83	101.03	49.72	34.22	10.19	48.25	38.69	48.44
	All USACE categories	22.70	20.94	128.29	186.79	87.17	60.45	14.14	6.93	26.60	60.88

Exhibit B-5: 2016 Import Freight and Insurance Costs per Ton-Mile

F&I (cents/tonne-mile)

Commodity Code	Commodity Name	All Region
1000	Coal, Lignite, and Coal Coke	0.20
2100	Crude Petroleum	0.30
2229	Petroleum Products	0.51
3100	Chemical Fertilizers	0.36
3200	Chemicals excluding Fertilizers	2.16
4142	Lumber, Logs, Wood Chips, and Pulp	1.96
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	0.25
4400	Iron Ore, Iron, and Steel Waste and Scrap	0.33
4600	Non-Ferrous Ores and Scrap	0.21
5155	Primary Non-Metal Products	2.68
5354	Primary Metal Products	1.09
6168	Food and Food Products	2.28
7000	Manufactured Goods	3.98
8099	Unknown and Not Elsewhere Classified Products	1.02
	All USACE categories	1.29

Exhibit B-6: 2016 Export Vessel Tonnages by Destination Region

Vessel SWT by Region (tonnes)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	1,108,734	2,791	5,016,148	8,305,645	975	24,689,024	4,812,527	977,486	6,930,676	51,844,005
2100	Crude Petroleum	132,393	100,420	0	2,517,736	63,276	5,112,962	5,130,942	41,233	2,928,347	16,027,309
2229	Petroleum Products	6,441,773	3,311,540	10,170,458	28,537,396	831,438	36,800,840	9,290,600	32,269,911	66,842,512	194,496,469
3100	Chemical Fertilizers	45,118	24,645	555,251	1,367,947	604,436	684,487	371,421	396,145	4,515,737	8,565,188
3200	Chemicals excluding Fertilizers	1,673,268	1,596,540	1,900,987	18,774,130	1,568,610	10,849,060	479,387	5,083,525	13,945,311	55,870,819
4142	Lumber, Logs, Wood Chips, and Pulp	587,388	547,472	2,120,462	20,914,292	148,845	3,778,655	2,381	387,261	2,690,634	31,177,390
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	482,593	173,447	122,803	2,030,067	266,892	952,819	717,515	442,966	1,345,048	6,534,149
4400	Iron Ore, Iron, and Steel Waste and Scrap	0	0	0	1,271,191	0	90,369	5,688,181	33,000	405	7,083,147
4600	Non-Ferrous Ores and Scrap	667	1,334	8,441	1,036,010	92,495	562,802	198,439	346	8,617	1,909,150
5155	Primary Non-Metal Products	124,269	131,583	572,444	14,260,429	163,081	7,064,600	67,710	28,865	1,682,085	24,095,066
5354	Primary Metal Products	143,266	584,001	2,118,102	6,795,539	20,518	4,040,283	34,549	1,319,734	734,058	15,790,050
6168	Food and Food Products	9,628,880	6,873,716	2,973,627	108,878,574	972,897	13,033,924	169,221	9,774,287	32,386,842	184,691,967
7000	Manufactured Goods	796,734	1,527,266	441,901	2,841,610	636,502	3,108,564	18,954	104,888	2,920,784	12,397,203
8099	Unknown and Not Elsewhere Classified Products	22,208	4,207	2,073	5,023	410	17,710	26	15	57,804	109,476
	All USACE categories	21,187,289	14,878,963	26,002,698	217,535,590	5,370,373	110,786,099	26,981,853	50,859,662	136,988,859	610,591,386

Exhibit B-: 2016 Export Vessel FOB Values by Destination Region

Vessel FOB Value by Region ($)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	65,192,666	2,206,056	324,562,776	818,924,900	453,365	1,967,180,214	435,247,351	81,845,736	608,528,682	4,304,141,746
2100	Crude Petroleum	40,134,987	28,782,530	0	865,418,516	19,752,022	1,769,392,093	1,453,396,468	15,042,885	1,036,070,634	5,227,990,135
2229	Petroleum Products	1,626,312,641	1,036,601,242	867,479,731	7,375,095,340	312,187,675	11,502,448,258	3,020,105,442	12,907,038,598	27,345,437,693	65,992,706,620
3100	Chemical Fertilizers	13,120,374	9,137,045	190,148,688	397,830,850	195,127,582	148,016,294	127,501,670	128,466,315	1,275,142,702	2,484,491,520
3200	Chemicals excluding Fertilizers	2,017,863,804	3,130,204,223	2,643,505,821	32,852,802,612	2,644,659,458	29,835,428,368	305,465,833	3,231,550,560	16,858,176,869	93,519,657,548
4142	Lumber, Logs, Wood Chips, and Pulp	365,015,740	350,073,815	667,882,079	6,904,722,415	181,065,952	2,790,862,137	1,743,219	169,629,647	1,932,317,013	13,363,312,017
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	77,222,865	40,493,389	45,891,403	572,712,370	43,143,512	382,559,033	56,157,755	41,909,605	272,200,492	1,532,290,424
4400	Iron Ore, Iron, and Steel Waste and Scrap	0	0	0	59,912,937	0	5,176,330	369,267,124	1,473,470	93,888	435,923,749
4600	Non-Ferrous Ores and Scrap	4,392,408	28,439,084	23,917,732	1,795,802,120	88,836,389	1,270,205,556	322,671,839	550,508	51,283,461	3,586,099,097
5155	Primary Non-Metal Products	211,329,658	200,035,959	773,438,498	8,871,196,619	191,814,812	3,208,793,774	4,419,431	58,562,828	2,959,502,404	16,479,093,983
5354	Primary Metal Products	96,174,425	472,856,873	996,394,911	8,185,552,111	97,642,510	2,927,900,918	9,112,801	796,881,324	894,886,398	14,477,402,271
6168	Food and Food Products	3,282,254,269	4,127,444,983	2,063,354,913	53,788,965,213	1,776,751,637	13,138,332,862	187,377,484	2,365,204,575	14,049,402,463	94,779,088,399
7000	Manufactured Goods	6,948,741,992	19,235,678,621	3,308,336,307	44,407,047,924	8,582,480,861	43,818,632,949	256,329,224	1,416,199,637	26,865,168,351	154,838,615,866
8099	Unknown and Not Elsewhere Classified Products	96,054,377	142,672,923	5,801,337	140,168,938	82,821,571	105,464,501	41,691	12,195	1,190,492,747	1,763,530,280
	All USACE categories	14,843,810,206	28,804,626,743	11,910,714,196	167,036,152,865	14,216,737,346	112,870,393,287	6,548,837,332	21,214,367,883	95,338,703,797	472,784,343,655

Exhibit B-7: 2016 Export Freight and Insurance Costs by Destination Region

F&I Values by Region ($)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	$16,775,401	$63,052	$115,169,788	$54,190,346	$7,362	$396,430,822	$14,693,366	$18,774,143	$48,130,402	$664,234,683
2100	Crude Petroleum	$2,616,499	$1,302,625	$0	$49,603,871	$983,647	$80,829,462	$57,369,427	$130,526	$35,676,785	$228,512,841
2229	Petroleum Products	$175,002,227	$68,071,997	$250,240,546	$785,571,982	$64,026,860	$880,858,880	$176,690,176	$173,754,647	$1,179,982,984	$3,754,200,300
3100	Chemical Fertilizers	$477,305	$350,526	$31,442,670	$34,750,447	$16,584,662	$18,300,230	$3,059,340	$2,456,832	$96,297,555	$203,719,568
3200	Chemicals excluding Fertilizers	$117,830,562	$129,249,643	$277,955,627	$3,235,768,215	$119,226,489	$1,100,546,758	$6,000,401	$114,340,124	$509,173,359	$5,610,091,178
4142	Lumber, Logs, Wood Chips, and Pulp	$136,763,033	$39,534,573	$357,671,969	$3,656,062,606	$16,713,233	$296,203,087	$37,672	$4,816,300	$99,882,203	$4,607,684,676
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	$4,664,419	$2,390,257	$2,571,523	$40,450,679	$2,357,481	$12,846,105	$1,048,292	$793,210	$11,596,599	$78,718,564
4400	Iron Ore, Iron, and Steel Waste and Scrap	$0	$0	$0	$110,258,298	$0	$1,084,879	$39,595,154	$371,404	$4,183	$151,313,918
4600	Non-Ferrous Ores and Scrap	$9,473	$41,157	$220,234	$20,430,577	$2,700,019	$5,634,126	$984,724	$1,292	$27,676	$30,049,277
5155	Primary Non-Metal Products	$16,079,024	$22,554,954	$98,160,186	$2,805,410,122	$17,209,136	$796,709,795	$1,048,009	$1,345,562	$124,320,864	$3,882,837,653
5354	Primary Metal Products	$4,748,087	$65,441,848	$209,338,093	$596,688,777	$1,108,688	$178,429,768	$400,083	$25,094,203	$21,198,876	$1,102,448,423
6168	Food and Food Products	$927,555,904	$1,130,190,553	$427,432,389	$11,735,987,195	$130,821,627	$1,546,125,634	$2,234,317	$181,701,885	$3,170,345,518	$19,252,395,023
7000	Manufactured Goods	$218,494,746	$286,516,406	$117,472,793	$748,927,846	$179,629,644	$649,953,402	$1,201,269	$4,707,158	$467,134,255	$2,674,037,521
8099	Unknown and Not Elsewhere Classified Products	$731,475	$327,766	$318,863	$507,456	$20,393	$606,078	$268	$263	$2,236,725	$4,749,288
	All USACE categories	$1,621,748,155	$1,746,035,358	$1,887,994,682	$23,874,608,419	$551,389,241	$5,964,559,026	$304,362,500	$528,287,550	$5,766,007,983	$42,244,992,913

Exhibit B-8: 2016 Export Freight and Insurance Costs per Ton by Destination Region

F&I Values per Ton by Region ($/tonne)

Commodity Code	Commodity Name	Africa	Asia Near East	Asia - South	Asia - Other	Australia and Oceania	Europe	Canada	Mexico	South/Central America	All Region
1000	Coal, Lignite, and Coal Coke	15.13	22.59	22.96	6.52	7.55	16.06	3.05	19.21	6.94	12.81
2100	Crude Petroleum	19.76	12.97		19.70	15.55	15.81	11.18	3.17	12.18	14.26
2229	Petroleum Products	27.17	20.56	24.60	27.53	77.01	23.94	19.02	5.38	17.65	19.30
3100	Chemical Fertilizers	10.58	14.22	56.63	25.40	27.44	26.74	8.24	6.20	21.32	23.78
3200	Chemicals excluding Fertilizers	70.42	80.96	146.22	172.35	76.01	101.44	12.52	22.49	36.51	100.41
4142	Lumber, Logs, Wood Chips, and Pulp	232.83	72.21	168.68	174.81	112.29	78.39	15.82	12.44	37.12	147.79
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	9.67	13.78	20.94	19.93	8.83	13.48	1.46	1.79	8.62	12.05
4400	Iron Ore, Iron, and Steel Waste and Scrap	9.84			86.74	46.54	12.00	6.96	11.25	10.34	21.36
4600	Non-Ferrous Ores and Scrap	14.21	30.86	26.09	19.72	29.19	10.01	4.96	3.74	3.21	15.74
5155	Primary Non-Metal Products	129.39	171.41	171.48	196.73	105.53	112.77	15.48	46.62	73.91	161.15
5354	Primary Metal Products	33.14	112.06	98.83	87.81	54.03	44.16	11.58	19.01	28.88	69.82
6168	Food and Food Products	96.33	164.42	143.74	107.79	134.47	118.62	13.20	18.59	97.89	104.24
7000	Manufactured Goods	274.24	187.60	265.84	263.56	282.21	209.08	63.38	44.88	159.93	215.70
8099	Unknown and Not Elsewhere Classified Products	32.94	77.90	153.83	101.03	49.72	34.22	10.14	17.71	38.69	43.38
	All USACE categories	24.62	17.19	126.11	187.25	87.90	61.03	20.96	6.69	32.17	69.19

Exhibit B-9: 2016 Export Freight and Insurance Costs per Ton-Mile

F&I (cents/tonne-mile)

Commodity Code	Commodity Name	All Region
1000	Coal, Lignite, and Coal Coke	0.32
2100	Crude Petroleum	0.37
2229	Petroleum Products	0.45
3100	Chemical Fertilizers	0.57
3200	Chemicals excluding Fertilizers	2.07
4142	Lumber, Logs, Wood Chips, and Pulp	2.40
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	0.26
4400	Iron Ore, Iron, and Steel Waste and Scrap	0.97
4600	Non-Ferrous Ores and Scrap	0.28
5155	Primary Non-Metal Products	2.75
5354	Primary Metal Products	1.23
6168	Food and Food Products	1.86
7000	Manufactured Goods	4.04
8099	Unknown and Not Elsewhere Classified Products	1.01
	All USACE categories	1.42

Exhibit B-10: 2016 Ship Calls and Tonnages from Foreign and Domestic Ports

Ship Type	Calls from Foreign Ports	DWT at First Entry	Calls from Domestic Ports
Bulk Carrier	6,828	324,642,356	2,497
Chemical Tanker	6,618	239,296,320	3,691
Containership	8,691	459,743,378	10,355
Crude Oil Tanker	2,768	331,487,321	587
Crude/ Products Tanker	830	63,535,723	274
Dry Cargo Barge	3,499	8,811,330	275
General Cargo	8,444	101,962,361	6,145
LPG & Other Gas Carrier	810	11,546,765	110
Oil Products Tanker	876	50,063,857	333
Vehicle & Other Carrier	591	3,683,866	137
Total	39,955	1,594,773,277	24,404

Appendix C: Details of Shipping Cost Calculations

This appendix contains various tables and charts displaying information related to the cost of waterborne shipping and how those costs are affected by various factors. The information includes:

- Charts of capital cost for new ships over time.
- Charts of capital costs for new ships *versus* ship size.
- Tables of pro forma economics for ships operation and implied cargo shipping rates in dollars per metric ton ($/MT).
- Chart of implied cargo shipping rates in $/MT and ship draft versus size of ship (demonstrates economies of scale and cost increases caused by limitation of channel depth that may require use of smaller ships).
- Chart of the cost penalty in $/MT caused by light loading an example ship to achieved one to seven feet of draft reduction.
- A table showing the cost penalty of light loading various ship size to achieve one foot of draft reduction.
- Various tables on barge operating costs and shipping rates.
- Various tables on cost of shipping by rail or truck.

Pro Forma Cost of Marine Freight Transportation

Among the tables in this appendix are pro forma estimates of the cost of purchasing and operating tankers, container ships and dry bulk carriers and the rates that would need to be charged shippers for typical international transportation services. These rates are computed in terms of:

(1) Daily charter rates,[58]
(2) Dollar per standard unit of cargo (e.g. $/barrel),
(3) Dollar per metric ton, and
(4) Cents per metric ton-nautical mile.

These costs and rates are computed from the “bottom up” so that changes can be made in various assumptions for parameters such the capital cost of the vessels, shipping distances, bunker fuel costs, and what fraction of the ship capacity is loaded. Specifically for this study, these pro forma examples are used to compute:

(1) The cost savings (penalties) related to using larger (smaller) ships,
(2) The cost penalty that must be borne when the ships have to be light loaded due to draft restrictions, and
(3) The cost penalty that must be borne when ships have to be lightered or reverse lightered due to draft restrictions.

[58] Daily charter rates as defined and computed here include the cost of ship and crew but exclude bunker fuel costs, canal fees and port fees.

As is shown in these examples, there are considerable economies of scale that come from using larger ships and from loading ships to their full operable cargo capacities. These economies of scale occur due to the following engineering and economic factors:

- There are economies of scale in vessel capital costs whereby the "power factor"[59] is approximately 0.6. This means a doubling of ship size (i.e., a 100% increase in size) will cause the capital cost to go up by only 60%.
- Fuel use also has economies of scale with a "power factor" of 2/3 relative to ship size. This means a doubling of ship displacement[60] (i.e., a 100% increase) will cause the fuel use to go up by only 67%.
- Larger ships tend to be more "weight efficient" in that the ratio of displacement to deadweight tons decreases as the ship size increases. For example, smaller tankers might have a displacement to deadweight ratio of 130% while larger tankers have a ratio of 115%.
- The number of crewmembers for a ship is not proportionate to ship size, as crew count grows modestly for larger ships. Most tankers, container ships and dry bulk carriers used for international trade will have crews ranging from 20 to 30 in number.

The basic pro forma examples are shown in this appendix in three sets of tables for tankers, containerships and dry bulk carriers respectively. These tables have columns with the following information:

- **Label**: The type of ship such as tankers, containerships or dry bulk carrier.
- **Class # and Vessel Class**: The size of the ship measured in deadweight tons or other units. These classifications come from tables describing the world cargo fleet compiled by the American Association of Port Authorities.[61]
- **Minimum DWT**: The lower end of the size class in DWT.
- **Maximum DWT**: The upper end of the size class in DWT.
- **Modeled DWT**: The DWT size of the ship assumed for the cost estimation for each class.
- **Cargo Units**: The unit of measure of ship cargo capacity such as barrels for tankers or twenty-foot equivalent units (TEUs) for containerships.
- **Modeled Cargo Unit Capacity**: The size of the ship assumed for the cost estimation for each class measured in cargo units.
- **World Ship Count** (1/2016): The number of ships in this type and class in the world fleet as reported by the American Association of Port Authorities. Noted that counts of small cargo ships under 10,000 DWT are usually not reported.
- **Total DWT** (1,000s): The sum of DWT for the ships in this type and class in the world fleet as reported by the American Association of Port Authorities.

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59 The "power factor" is often employed in cost estimation rules of thumb. It is the exponent by which size is raised to estimate capital costs

60 Displacement is the weight of the water (measured in long tons or metric tons) displaced by a ship and is equivalent to the total weight of the ship. A ship's displacement is made up of its deadweight tons (the weight of cargo, fuel, and stores) plus the lightship or lightweight tonnage (the weight of the hull, machinery, and outfitting).

61 http://www.aapa-ports.org/unifying/content.aspx?ItemNumber=21048&navItemNumber=20803

- **World Fleet Average DWT**: The average size of the world fleet for this ship type and class in DWT.
- **World Fleet Average Length** (ft.): The average length of the world fleet for this ship type and class measured in feet.
- **World Fleet Average Beam** (ft.): The average width of the world fleet for this ship type and class in feet.
- **World Fleet Average Draft** (ft.): The average width of the world fleet for this ship type and class measured in feet.
- **World Fleet Average Speed** (knots): The speed of the world fleet for this ship type and class measured in nautical miles per hour.
- **Capital Costs** $mm: The capital cost assumed for this ship type and size measured in real 2016 million U.S. dollars. This reflects an average for the period 2011 to 2018.
- **Capital Costs $/dwt**: The capital cost assumed for this ship type and size measured in real 2016 U.S. dollars per DWT. This reflects an average for the period 2011 to 2018.
- **Displacement** (MT): The assumed displacement for this ship type and class measured in metric tons. This use to estimate fuel use and emersion factors.
- **Ratio Displacement/DWT**: The ratio of displacement to DWT.
- **Annual Capital Recovery**: The annual revenue required to cover debt payments, depreciation and return on equity. This assumed to be 10% to 11% of the capital cost.
- **Annual Non-Fuel Operating**: The annual operating and maintenance cost of the ship in 2016 U.S. dollars. This includes, crew, stores, lubricant, dry dock costs and insurance.
- **Drydock Days per Year**: The number of days per year a ship is not available for work due to maintenance and repairs.
- **1-Way Distance** (nautical miles): The one-way voyage distance assumed for the purposes of calculating costs and required rates.
- **Round Trip Steaming Days**: The number of days per two-way voyage the ship will be under power.
- **Round Trip Port Days**: The number of days per two-way voyage the ship will be in port.
- **Round Trips per Year**: The number of two-way voyages a ship will undertake in one year.
- **Annual Port Fees**: The cost in 2016 U.S. dollars expected to be paid as port fees.
- **Annual Broker Fees**: The annual cost paid to brokers to arrange use of the ships.
- **Load as Fraction of Capacity**: The fraction of the ship cargo capacity carried in the laden plus ballast voyages. For tankers and dry bulk carriers this is assumed to be 100% indicating fully loaded ships in the laden voyage and empty ships in the ballast voyage. For containerships, the assumed value is 84% counting filled containers and not counting returning empty containers. Containerships typically will carry both filled and empty containers in both directions.
- **Loaded Cargo Units**: The amount of cargo in a two-way voyage measured in cargo units such as barrels, TEUs or metric tons.
- **Displacement as Loaded** (MT): The ship displacement when loaded measured in metric tons.
- **HP Required**: The shaft horsepower required to reach the assumed speed (that is, the World Fleet Average Speed in knots). The required horsepower is a function of displacement raised to the 2/3 power and ship speed raised to the power of 3.

- **HP per 1,000 DWT**: The required horsepower divided by deadweight tons.
- **Fuel Use in MT/Day**: The amount of bunker fuel measured in tons required per day.
- **Bunker Fuel Cost $/MT**: The cost for bunker fuel in 2016 U.S. dollars per ton.
- **Annual Fuel Costs:** The annual cost of fuel.
- **Total Annual Costs**: The sum of all annual costs including annual capital recovery costs, O&M, fuel, broker fees, and port fees. Note that these cost do not include cargo insurance, loading/unloading, or any port storage costs.
- **Total Costs $/Unit**: The total costs divided by the annual volume transported as measured in cargo units of barrels, TEUs or metric tons.
- **Total Costs $/MT**: The total costs divided by the annual volume transported as measured in metric tons.
- **Implied Daily Charter Rate**: The daily charter rate that would be needed to cover annual capital recovery costs plus O&M. This daily charter rate does not cover fuel, broker fees or port fees, which are usually paid the shipper in addition to the daily charter rate.
- **Maximum Market Charter Rate** 2007-18: This is the maximum long-term charter rate reported over the last several years.
- **Minimum Market Charter Rate** 2007-18: This is the minimum long-term charter rate reported over the last several years.
- **Average Market Charter Rate** 2007-18: This is the average long-term charter rate reported over the last several years.
- **Implied Daily Fuel, Port, Broker Charges**: The cost components of fuel, broker fees and port fees expressed as dollars work per day.
- **Implied Daily Charter Rate + Other Costs**: The total daily cost to charter the ship and pay fuel, broker fees and port fees.
- **All Costs** $/hr.: The total daily costs divided by 24 hours per day.
- **Cents per Ton Mile**: Total costs in $/MT divided by 1-way distance multiplied by 100.

Sensitivity of Light-loading Results to Ship Size

For each type of ship there is a table provided in this appendix that shows the cost increase measured in $/MT of having to reduce cargo loads to compensate for insufficient draft clearance. The tables are created assuming that the ships must be light loaded to reduce draft by one foot. These tables are labeled “Sensitivity of Light-loading Results to Ship Size” and contain the following information:

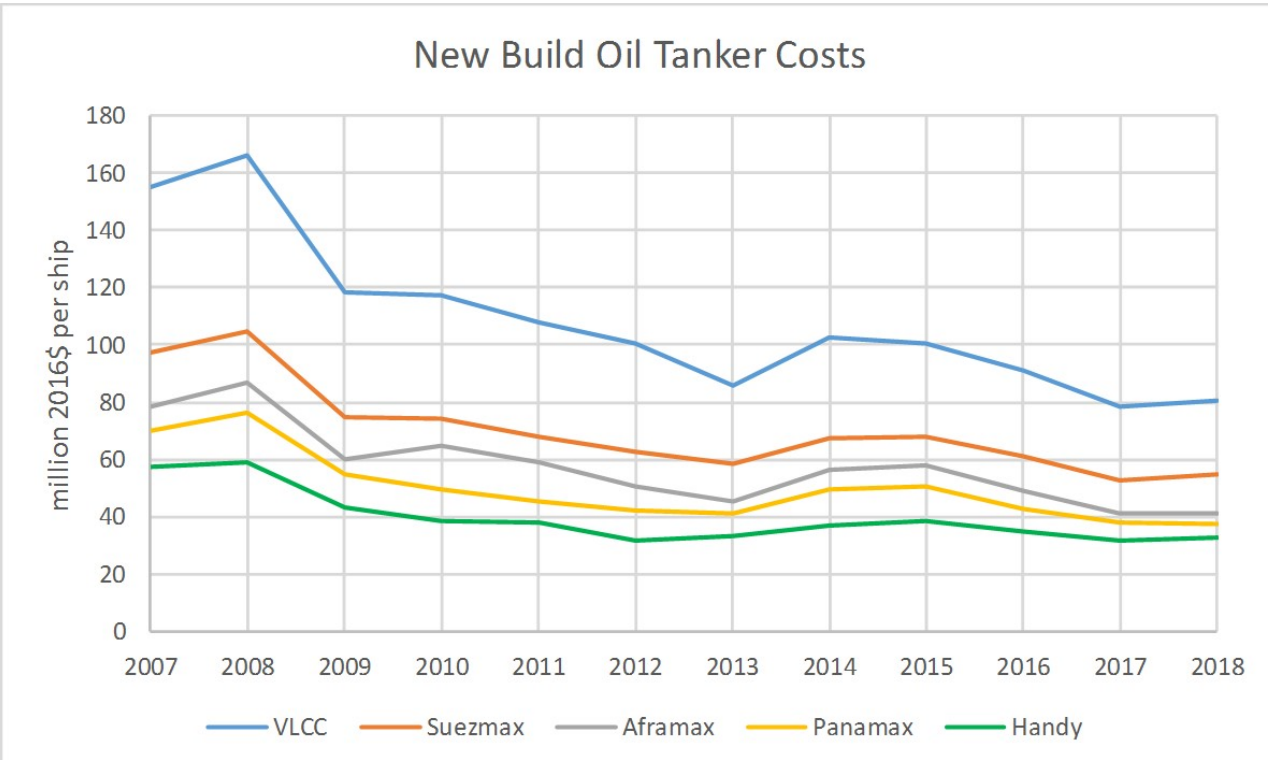
- **Label**: The type of ship such as tankers, containerships or dry bulk carrier.
- **Class # and Vessel Class**: The size of the ship measured in deadweight tons or other units. These classifications come from tables describing the world cargo fleet compiled by the American Association of Port Authorities.[62]
- **Full-load Draft (ft)**: Ship draft at full load (that is the load assumed in the pro forma analysis).
- **Cargo Units**: The unit of measure of ship cargo capacity such as barrels for tankers or twenty-foot equivalent units (TEUs) for containerships.

[62] http://www.aapa-ports.org/unifying/content.aspx?ItemNumber=21048&navItemNumber=20803

- **Cargo Loss per foot**: The amount cargo that must be removed to reduce draft by one foot.
- **Cost Penalty in $/MT per foot**: The increase in total shipping costs measured in $/MT from light loading to reduce draft by one foot.
- **Cost Penalty per foot as % of full-load cost**: The increase in total shipping costs measured in percent of the base case pro forma cost caused by light loading to reduce draft by one foot.

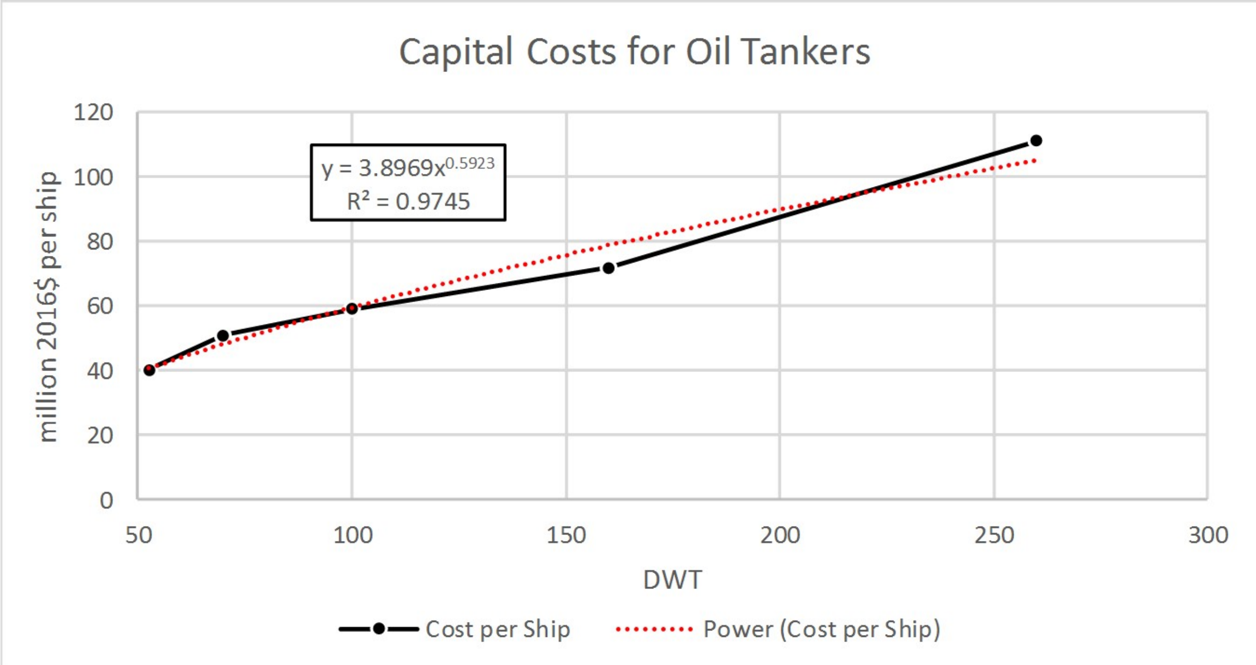
Most of the costs of operating a ship are not impacted by light loading, so those fixed cost when expressed as dollars per unit of cargo shipped go up at the same percentage rate as the cargo load is reduced. The one exception is that fuel use is reduced slightly as the ship displacement is reduced. This is why the tables show a percent increase in shipping costs that is slightly lower than the percent reduction in cargo shipped.

Exhibit C-1: Cost of New Oil Tankers 2007-2018



Sources: Bloomberg, UNCTAD, Athenian Shipbrokers

Exhibit C-2: Cost of New Oil Tanker vs Size



Sources: Bloomberg, UNCTAD, Athenian Shipbrokers

Exhibit C-3: Characterization of Tanker Costs and Rates (1 of 4)

Label	Class #	Vessel Class	Modeled DWT	Cargo Units	Modeled Cargo Unit Capacity	World Ship Count (1/2016)	Total DWT (1,000s)	World Fleet Average DWT	World Fleet Average Lenght (ft)	World Fleet Average Beam (ft)	World Fleet Average Draft (ft)	World Fleet Average Speed (knots)
Crude Oil Tanker	1	Small Ship (<10k dwt)	5,000	bbl	32,850			5,000			24.5	13.5
Crude Oil Tanker	2	Handy Size (10k-19.9k dwt)	15,000	bbl	98,550	1,286	19,366	15,050	452	70.9	28.5	13.8
Crude Oil Tanker	3	Handy Size (20k-29.9k dwt)	25,000	bbl	164,250	223	5,616	25,182	537	85.3	32.5	14.7
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	37,500	bbl	246,375	804	30,472	37,900	592	95.8	36.7	14.7
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	52,500	bbl	344,925	1,296	62,871	48,512	602	105.6	41.3	14.7
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	70,000	bbl	459,900	408	29,606	72,565	745	107.6	45.6	14.9
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	100,000	bbl	657,000	918	98,973	107,814	804	139.8	48.6	14.9
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	160,000	bbl	1,051,200	499	77,387	155,083	899	157.2	54.8	15.2
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	260,000	bbl	1,708,200	598	183,054	306,111	1,091	165.7	70.9	15.7
Crude Oil Tanker	10	ULCC (320k dwt & over)	456,621	bbl	3,000,000	53	17,248	325,434	1,097	197.8	73.5	16.3

Source: ICF pro forma model of tanker operator costs. World fleet inventory is from the American Association of Port Authorities.

Exhibit C-4: Characterization of Tanker Costs and Rates (2 of 4)

Label	Class #	Vessel Class	Capital Costs $mm	Capital Costs $dwt	Displacement (MT)	Ratio Disp./DWT	Annual Capital Recovery	Annual Non-Fuel Operating	Drydock Days per Year
Crude Oil Tanker	1	Small Ship (<10k dwt)	$9.99	$1,999	6,852	137%	$999,262	$648,496	20
Crude Oil Tanker	2	Handy Size (10k-19.9k dwt)	$19.15	$1,277	19,671	131%	$1,914,863	$1,006,370	20
Crude Oil Tanker	3	Handy Size (20k-29.9k dwt)	$25.91	$1,036	32,122	128%	$2,591,029	$1,234,517	20
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	$32.94	$878	47,408	126%	$3,293,959	$1,451,890	20
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	$40.20	$766	65,484	125%	$4,020,000	$1,661,058	20
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	$51.00	$729	86,314	123%	$5,100,000	$1,863,633	20
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	$59.10	$591	121,558	122%	$5,910,000	$2,149,420	20
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	$71.80	$449	190,871	119%	$7,180,000	$2,593,995	20
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	$111.30	$428	304,200	117%	$11,130,000	$3,150,000	20
Crude Oil Tanker	10	ULCC (320k dwt & over)	$155.34	$340	522,346	114%	$15,534,169	$3,945,877	20

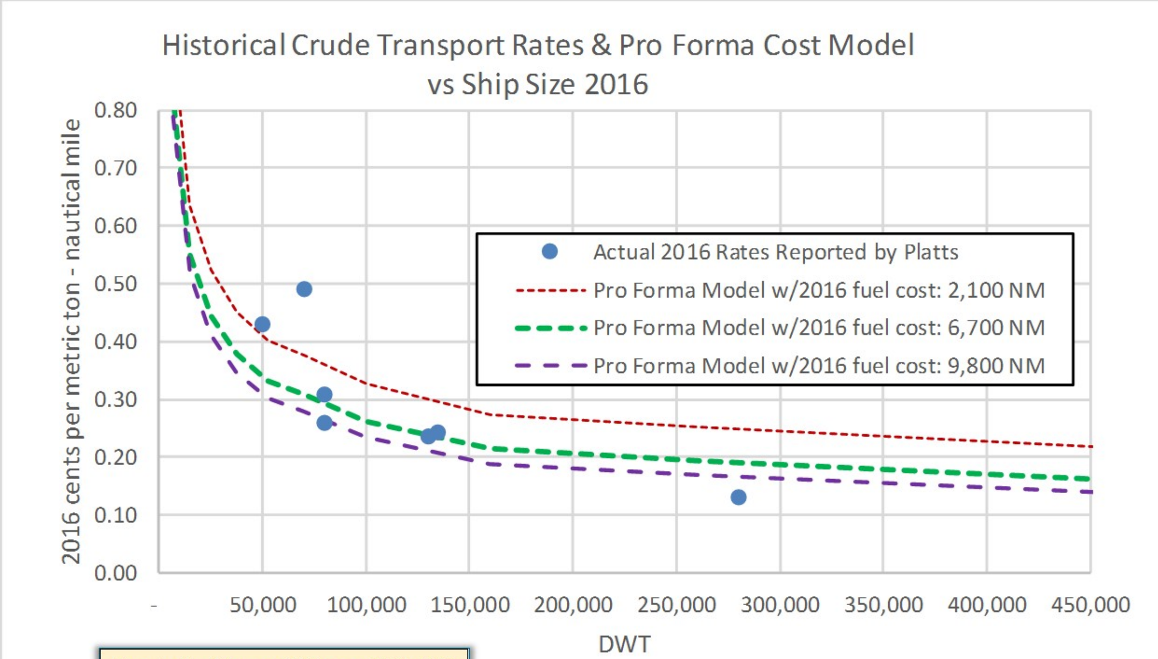
Exhibit C-5: Characterization of Tanker Costs and Rates (3 of 4)

Label	Class #	Vessel Class	1-Way Distance (nautical miles)	Round Trips per Year	Annual Port Fees	Annual Broker Fees	Loaded Cargo Units	Fuel Use in MT/Day	Bunker Fuel Cost $/MT	Annual Fuel Costs	Total Annual Costs
Crude Oil Tanker	1	Small Ship (<10k dwt)	4,700	11.0	$74,030	$17,118	32,850	5.3	$460	$779,787	$2,518,693
Crude Oil Tanker	2	Handy Size (10k-19.9k dwt)	4,700	11.1	$223,772	$39,316	98,550	11.4	$460	$1,658,447	$4,842,767
Crude Oil Tanker	3	Handy Size (20k-29.9k dwt)	4,700	11.7	$392,323	$60,666	164,250	19.1	$460	$2,745,053	$7,023,587
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	4,700	11.6	$584,979	$81,737	246,375	24.8	$460	$3,537,158	$8,949,723
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	4,700	11.6	$814,713	$104,653	344,925	30.7	$460	$4,364,282	$10,964,706
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	4,700	11.7	$1,094,324	$130,815	459,900	38.5	$460	$5,430,179	$13,618,951
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	4,700	11.6	$1,553,833	$169,899	657,000	48.3	$460	$6,781,220	$16,564,371
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	4,700	11.7	$2,508,530	$243,880	1,051,200	69.3	$460	$9,619,539	$22,145,944
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	4,700	11.9	$4,152,359	$357,551	1,708,200	104.2	$460	$14,263,785	$33,053,694
Crude Oil Tanker	10	ULCC (320k dwt & over)	4,700	12.2	$7,437,873	$556,348	3,000,000	167.2	$460	$22,486,139	$49,960,406

Exhibit C-6: Characterization of Tanker Costs and Rates (4 of 4)

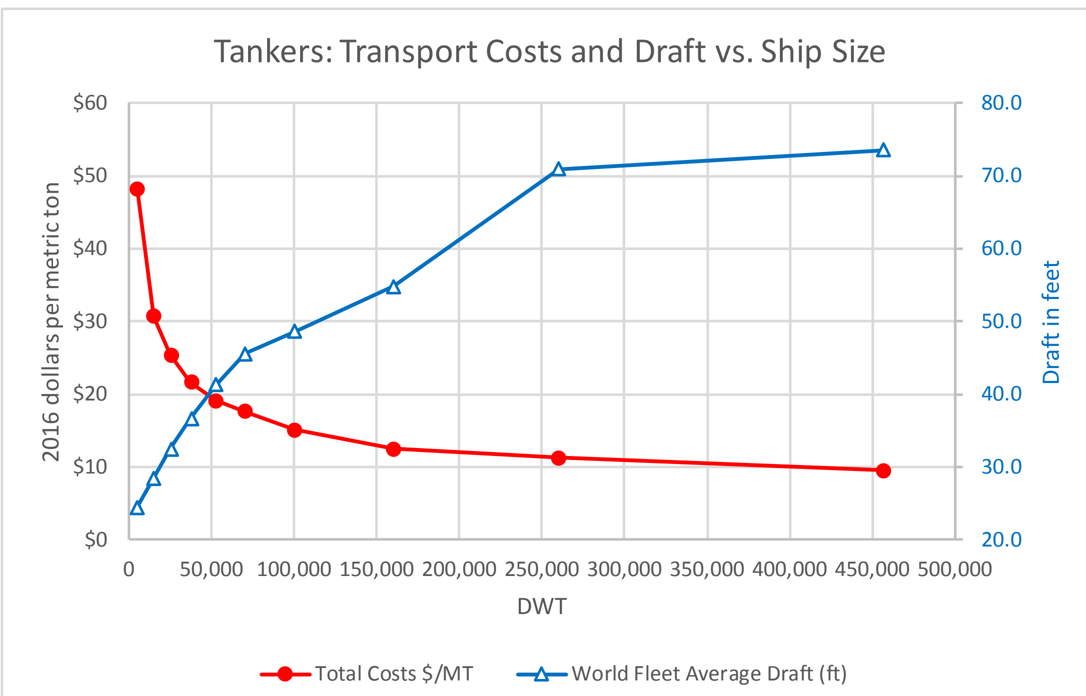
Label	Class #	Vessel Class	Total Costs $/bbl	Total Costs $/MT	Implied Daily Charter Rate	*Max Market Charter Rate 2007-18*	*Min Market Charter Rate 2007-18*	*Avg. Market Charter Rate 2007-18*	Implied Daily Fuel, Port, Broker Charges	Implied Daily Charter Rate + Other Costs	*All Costs $/hr*	*Cents per Ton Mile*
Crude Oil Tanker	1	Small Ship (<10k dwt)	$6.94	$48.23	$4,776				$2,524	$7,301	$304	1.03
Crude Oil Tanker	2	Handy Size (10k-19.9k dwt)	$4.41	$30.68	$8,467				$5,570	$14,037	$585	0.65
Crude Oil Tanker	3	Handy Size (20k-29.9k dwt)	$3.65	$25.38	$11,089				$9,270	$20,358	$848	0.54
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	$3.12	$21.69	$13,756				$12,185	$25,941	$1,081	0.46
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	$2.74	$19.08	$16,467	*$24,917*	*$12,604*	*$15,723*	$15,315	$31,782	$1,324	0.41
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	$2.54	$17.64	$20,184	*$28,250*	*$12,746*	*$17,702*	$19,291	$39,475	$1,645	0.38
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	$2.17	$15.11	$23,361	*$33,500*	*$12,609*	*$19,770*	$24,652	$48,013	$2,001	0.32
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	$1.80	$12.51	$28,330	*$46,833*	*$15,818*	*$25,963*	$35,861	$64,191	$2,675	0.27
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	$1.62	$11.28	$41,391	*$69,583*	*$19,346*	*$35,180*	$54,417	$95,808	$3,992	0.24
Crude Oil Tanker	10	ULCC (320k dwt & over)	$1.37	$9.52	$56,464				$88,349	$144,813	$6,034	0.20

Exhibit C-7: Historical All-inclusive Tanker Rates vs. Ship size



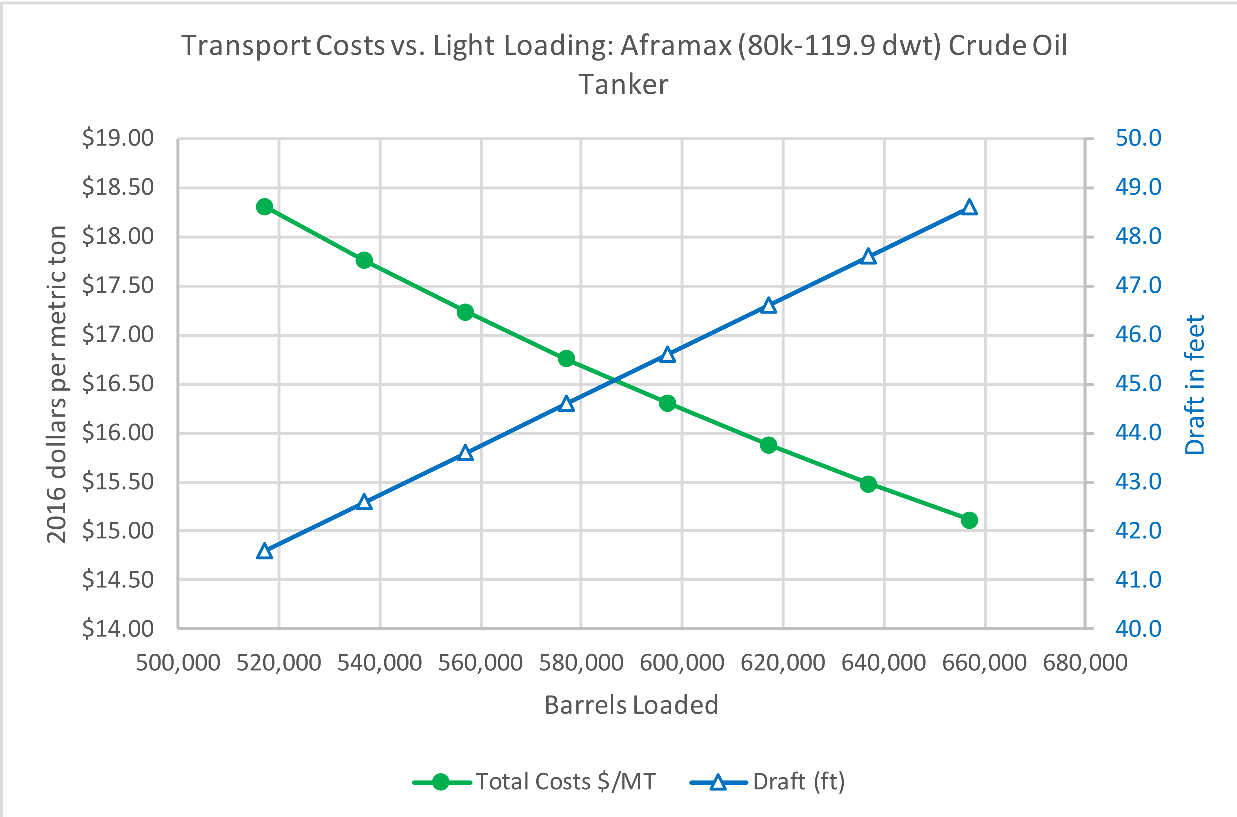
Avg. Laden Voyage Distances 2009-2015	
VLCC (200k-319.9k dwt)	7,498
Suezmax (120k-199.9k dwt)	4,487
Aframax (80k-119.9 dwt)	2,075
Source: Poten & Partners	

Exhibit C-8: Tanker Costs and Draft vs. Ship Size



Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Exhibit C-9: Example of Light-loading of a Tanker



Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Exhibit C-10: Light-loading Various Sizes of Tankers: Cost Penalty per Foot of Insufficient Draft Clearance

Sensitivty of Light-loading Results to Ship Size							
Label	Class #	Vessel Class	Full-load Draft (ft)	Cargo Units	Cargo Loss per ft.	Cost Penalty in $/MT/ft	Cost Penalty /ft as % of full-load cost
Crude Oil Tanker	4	Handy Size (30k-44.9k dwt)	36.7	bbl	8,978	$0.84	3.9%
Crude Oil Tanker	5	Handy Size (45k-59.9k dwt)	41.3	bbl	11,020	$0.62	3.3%
Crude Oil Tanker	6	Panamax (60k-79.9 dwt)	45.6	bbl	13,155	$0.50	2.8%
Crude Oil Tanker	7	Aframax (80k-119.9 dwt)	48.6	bbl	20,000	$0.46	3.0%
Crude Oil Tanker	8	Suezmax (120k-199.9k dwt)	54.8	bbl	24,207	$0.26	2.1%
Crude Oil Tanker	9	VLCC (200k-319.9k dwt)	70.9	bbl	29,819	$0.17	1.5%
Crude Oil Tanker	10	ULCC (320k dwt & over)	73.5	bbl	49,392	$0.13	1.4%

Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Exhibit C-11: Examples of the Cost of Part-Load Lightering or Reverse-Lightering of Various Sizes of Tankers

Examples of Cost of Lightering or Reverse Lightering (part load lightered)

Long-haul Tanker	Panamax (60k-79.9 dwt)	Aframax (80k-119.9 dwt)	Suezmax (120k-199.9k dwt)
Draft at Full-load	45.6	48.6	54.8
Long-haul Tanker Capacity (bbl)	459,900	657,000	1,051,200
Long-haul Tanker Daily Charter Rate	$20,184	$23,361	$28,330
Draft Feet Shortfall	10.2	13.5	20.3
Implied Barrels Shortfall Caused by Insufficient Channel Depth	133,657	269,200	490,922
Lightering Tanker	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)
Lightering Tanker Capacity (bbl)	98,550	98,550	98,550
Lightering Tanker Daily Charter + Fuel Rate $/day	$14,037	$14,037	$14,037
Number of Lightering Tankers Required	2.0	3.0	5.0
Added Cost for Lightering Services	$48,258	$65,472	$98,515
Added Cost for Lightering Services $/bbl	$0.10	$0.10	$0.09
Time Value of Money for 1 Day Delay $/bbl	$0.01	$0.01	$0.01
Total Added Cost $/MT	$0.81	$0.78	$0.74
Cost without Lightering $/MT	$17.64	$15.11	$12.51
Cost with Lightering $/MT	$18.46	$15.89	$13.25
Total Added by Lightering as % of Cost w/o Lightering	4.6%	5.2%	5.9%
Total Added by Lightering as % of Cost w/o Lightering PER FOOT OF DRAFT SHORTFALL	0.5%	0.4%	0.3%

Note: Examples are based on 4,700 nautical mile one-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price). Time value of money computed at 6% per annum. Assumed channel depth is 40 feet and required under keel clearance is 10% of static draft.

Exhibit C-12: Examples of the Cost of Full-Load Lightering or Reverse-Lightering of Various Sizes of Tankers

Examples of Cost of Lightering or Reverse Lightering (full load lightered)

Long-haul Tanker	Panamax (60k-79.9 dwt)	Aframax (80k-119.9 dwt)	Suezmax (120k-199.9k dwt)
Draft at Full-load	45.6	48.6	54.8
Long-haul Tanker Capacity (bbl)	459,900	657,000	1,051,200
Long-haul Tanker Daily Charter Rate	$20,184	$23,361	$28,330
Draft Feet Shortfall	*full load lightered*	*full load lightered*	*full load lightered*
Implied Barrels Shortfall Caused by Insufficient Channel Depth	459,900	657,000	1,051,200
Lightering Tanker	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)	Handy Size (10k-19.9k dwt)
Lightering Tanker Capacity (bbl)	98,550	98,550	98,550
Lightering Tanker Daily Charter + Fuel Rate $/day	$14,037	$14,037	$14,037
Number of Lightering Tankers Required	5.0	7.0	11.0
Added Cost for Lightering Services	$90,369	$121,620	$182,738
Added Cost for Lightering Services $/bbl	$0.20	$0.19	$0.17
Time Value of Money for 1 Day Delay $/bbl	$0.01	$0.01	$0.01
Total Added Cost $/MT	$1.45	$1.37	$1.29
Cost without Lightering $/MT	$17.64	$15.11	$12.51
Cost with Lightering $/MT	$19.09	$16.48	$13.81
Total Added by Lightering as % of Cost w/o Lightering	8.2%	9.1%	10.3%
Total Added by Lightering as % of Cost w/o Lightering PER FOOT OF DRAFT SHORTFALL	0.8%	0.7%	0.5%

Note: Examples are based on 4,700 nautical mile one-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price). Time value of money computed at 6% per annum. Assumed channel depth is 40 feet and under keel clearance is 10% of static draft.

Exhibit C-13: Cost of New Container Ships 2007 to 2017

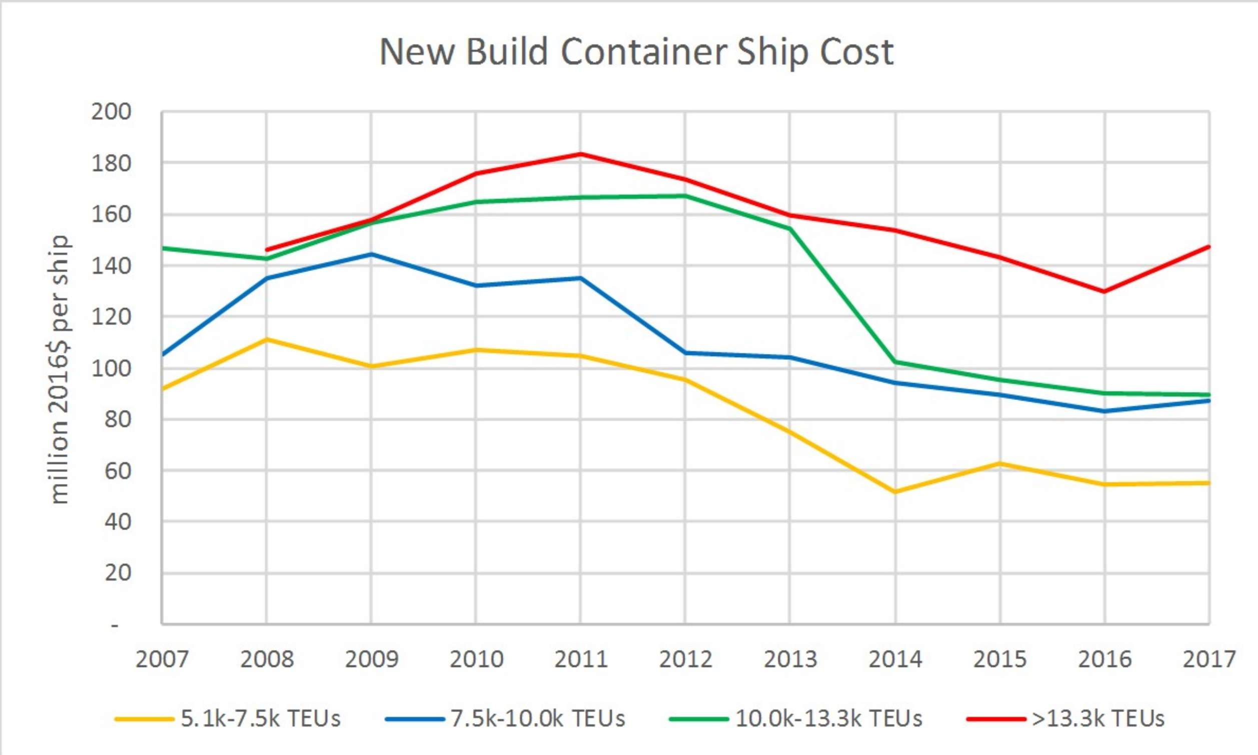


Exhibit C-14: Cost of New Container Ships vs Size

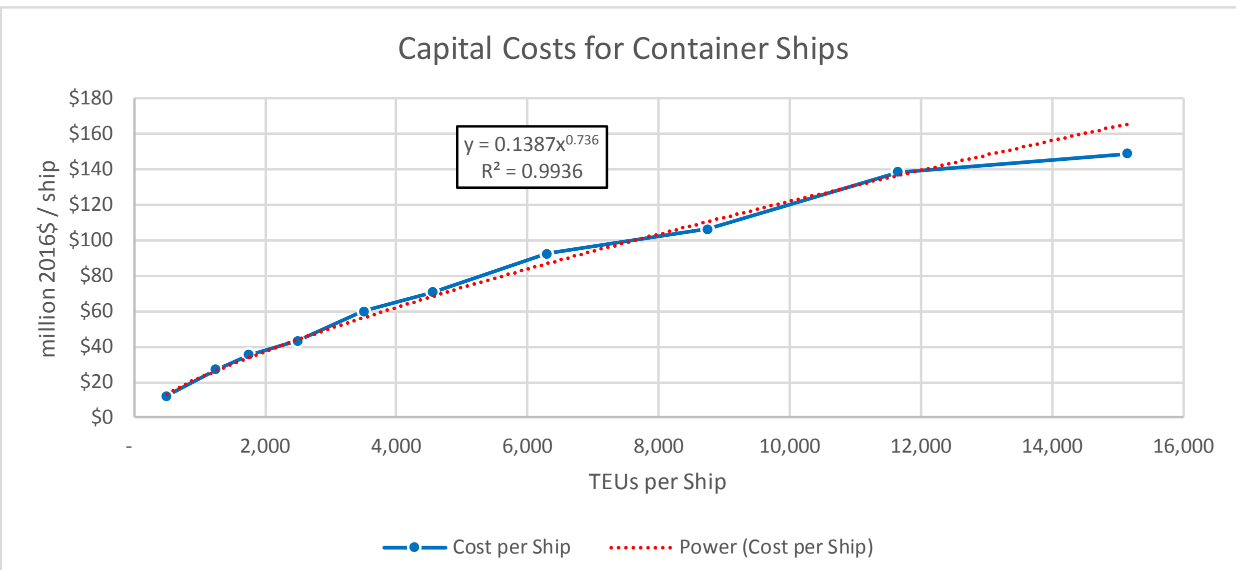


Exhibit C-15: Characterization of Container Ship Costs and Rates (1 of 4)

Label	Class #	Vessel Class	Modeled DWT	Cargo Units	Modeled Cargo Unit Capacity	World Ship Count (1/2016)	Total DWT (1,000s)	World Fleet Average DWT	World Fleet Average Lenght (ft)	World Fleet Average Beam (ft)	World Fleet Average Draft (ft)	World Fleet Average Speed (knots)
Containership	1	Small Ship (<100 TEU)	650	TEU	50			650			15.5	15.8
Containership	2	Feeder (100-999 TEU)	6,984	TEU	550	1,070	8,770	8,196	401	64.3	23.0	16.1
Containership	3	Handy+ (1,000-1,999 TEU)	18,638	TEU	1,500	1,103	21,070	19,102	545	84.0	30.5	19.2
Containership	4	Sub-Panamax (2,000-2,999 TEU)	30,350	TEU	2,500	780	27,120	34,769	682	100.1	37.4	21.7
Containership	5	Panamax (3,000-5,100 TEU)	47,420	TEU	4,000	844	45,174	53,524	872	105.6	41.0	23.8
Containership	6	Post-Panamax (5,101-7,999 TEU)	75,205	TEU	6,500	680	48,902	71,915	919	130.3	44.9	24.1
Containership	7	Post-Panamax (8,000-11,999 TEU)	112,844	TEU	10,000	533	57,670	108,198	1,080	148.3	47.6	23.0
Containership	8	Suez/Cape Size (12,000 TEU & over)	159,500	TEU	14,500	239	37,757	157,978	1,228	169.0	50.5	23.9

Source: ICF pro forma model of container ship operator costs. World fleet inventory is from the American Association of Port Authorities.

Exhibit C-16: Characterization of Container Ship Costs and Rates (2 of 4)

Label	Class #	Vessel Class	Capital Costs $mm	Capital Costs $dwt	Displacement (MT)	Ratio Disp./DWT	Annual Capital Recovery	Annual Non-Fuel Operating	Drydock Days per Year
Containership	1	Small Ship (<100 TEU)	$2	$2,465	938	144.3%	$176,149	$155,250	20
Containership	2	Feeder (100-999 TEU)	$16	$2,267	10,057	144.0%	$1,741,627	$1,522,508	20
Containership	3	Handy+ (1,000-1,999 TEU)	$31	$1,660	26,776	143.7%	$3,402,902	$2,302,727	20
Containership	4	Sub-Panamax (2,000-2,999 TEU)	$43	$1,433	43,502	143.3%	$4,784,346	$2,842,132	20
Containership	5	Panamax (3,000-5,100 TEU)	$60	$1,255	67,811	143.0%	$6,545,919	$3,449,385	20
Containership	6	Post-Panamax (5,101-7,999 TEU)	$82	$1,094	107,292	142.7%	$9,049,192	$4,213,211	20
Containership	7	Post-Panamax (8,000-11,999 TEU)	$110	$972	160,615	142.3%	$12,060,966	$5,031,344	20
Containership	8	Suez/Cape Size (12,000 TEU & over)	$140	$881	226,490	142.0%	$15,453,578	$5,863,765	20

Exhibit C-17: Characterization of Container Ship Costs and Rates (3 of 4)

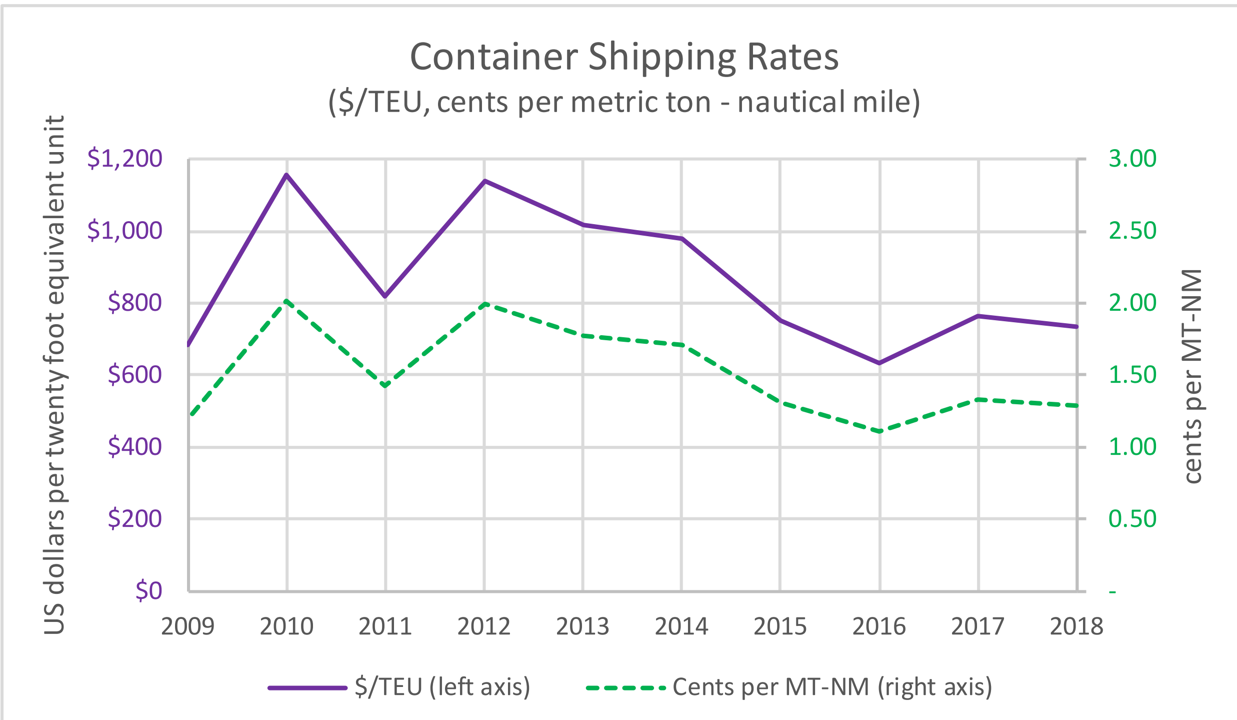
Label	Class #	Vessel Class	1-Way Distance (nautical miles)	Round Trips per Year	Annual Port Fees	Annual Broker Fees	Loaded Cargo Units	Fuel Use in MT/Day	Bunker Fuel Cost $/MT	Annual Fuel Costs	Total Annual Costs
Containership	1	Small Ship (<100 TEU)	6,360	9.1	$7,920	$3,050	42	2.4	$460	$340,616	$682,986
Containership	2	Feeder (100-999 TEU)	6,360	8.8	$82,421	$17,531	462	12.5	$460	$1,662,789	$5,026,876
Containership	3	Handy+ (1,000-1,999 TEU)	6,360	9.9	$247,228	$41,142	1,260	40.5	$460	$5,098,656	$11,092,655
Containership	4	Sub-Panamax (2,000-2,999 TEU)	6,360	10.7	$435,460	$64,150	2,100	80.7	$460	$9,720,831	$17,846,918
Containership	5	Panamax (3,000-5,100 TEU)	6,360	11.3	$716,289	$94,381	3,360	143.0	$460	$16,523,859	$27,329,833
Containership	6	Post-Panamax (5,101-7,999 TEU)	6,360	11.2	$1,124,237	$132,003	5,460	201.3	$460	$22,729,842	$37,248,484
Containership	7	Post-Panamax (8,000-11,999 TEU)	6,360	10.6	$1,603,309	$170,092	8,400	228.5	$460	$25,703,346	$44,569,058
Containership	8	Suez/Cape Size (12,000 TEU & over)	6,360	10.7	$2,291,691	$222,973	12,180	321.8	$460	$35,227,970	$59,059,977

Exhibit C-18: Characterization of Container Ship Costs and Rates (4 of 4)

Label	Class #	Vessel Class	Total Costs $/TEU	Total Costs $/MT	Implied Daily Charter Rate	*Max Market Rate 2010-18 ($/day)*	*Min Market Rate 2010-18 ($/day)*	*Avg. Market Rate 2010-18 ($/day)*	Implied Daily Fuel, Port, Broker Charges	Implied Daily Charter Rate + Other Costs	*All Costs $/hr*	*Cents per Ton Mile*
Containership	1	Small Ship (<100 TEU)	$1,788	$198.62	$961				$1,019	$1,980	$82	3.12
Containership	2	Feeder (100-999 TEU)	$1,237	$137.40	$9,461	$10,000	$5,000	$6,800	$5,109	$14,571	$607	2.16
Containership	3	Handy+ (1,000-1,999 TEU)	$889	$98.81	$16,538	$12,000	$5,000	$7,700	$15,615	$32,153	$1,340	1.55
Containership	4	Sub-Panamax (2,000-2,999 TEU)	$794	$88.19	$22,106	$21,000	$7,000	$10,300	$29,624	$51,730	$2,155	1.39
Containership	5	Panamax (3,000-5,100 TEU)	$722	$80.17	$28,972	$28,000	$7,000	$12,800	$50,245	$79,217	$3,301	1.26
Containership	6	Post-Panamax (5,101-7,999 TEU)	$612	$67.95	$38,442				$69,525	$107,967	$4,499	1.07
Containership	7	Post-Panamax (8,000-11,999 TEU)	$500	$55.60	$49,543				$79,643	$129,186	$5,383	0.87
Containership	8	Suez/Cape Size (12,000 TEU & over)	$452	$50.25	$61,789				$109,399	$171,188	$7,133	0.79

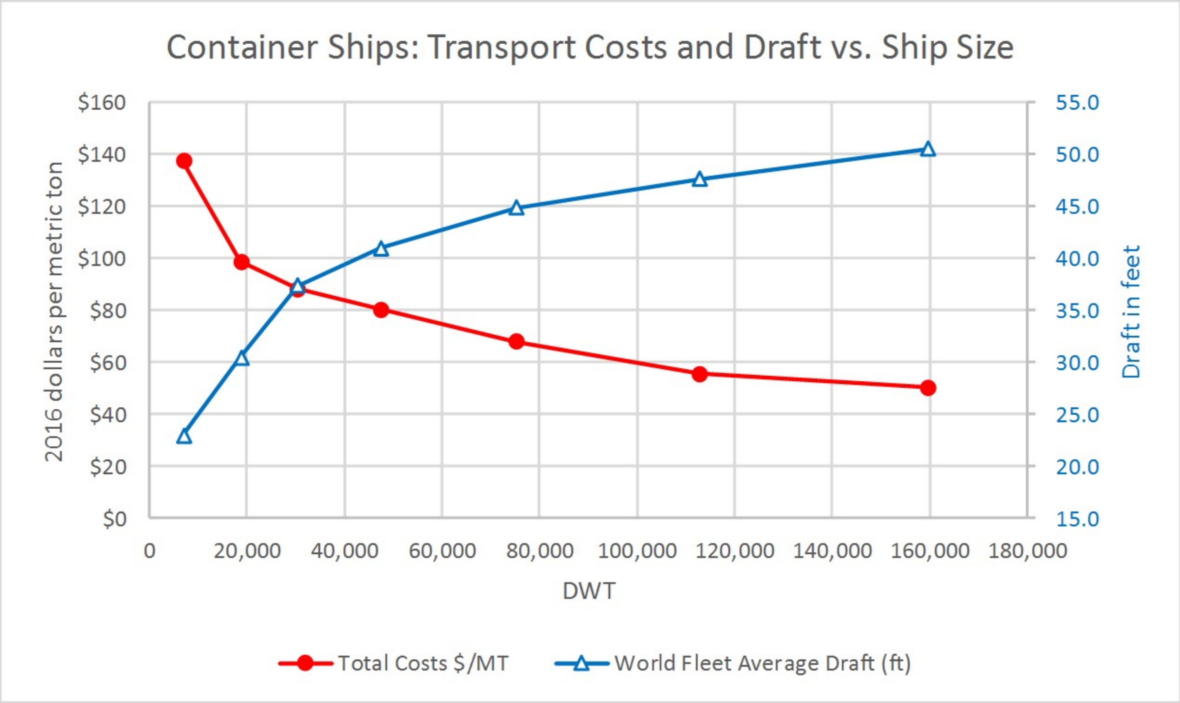
Note: Published $/TEU liner rates from Asia to US Pacific Coast from 2010-18 averaged $888/TEU with a range of $634 to $1,154/TEU. These rates may include additional services such as storage, packing and insurance.

Exhibit C-19: Historical Container Shipping Rates



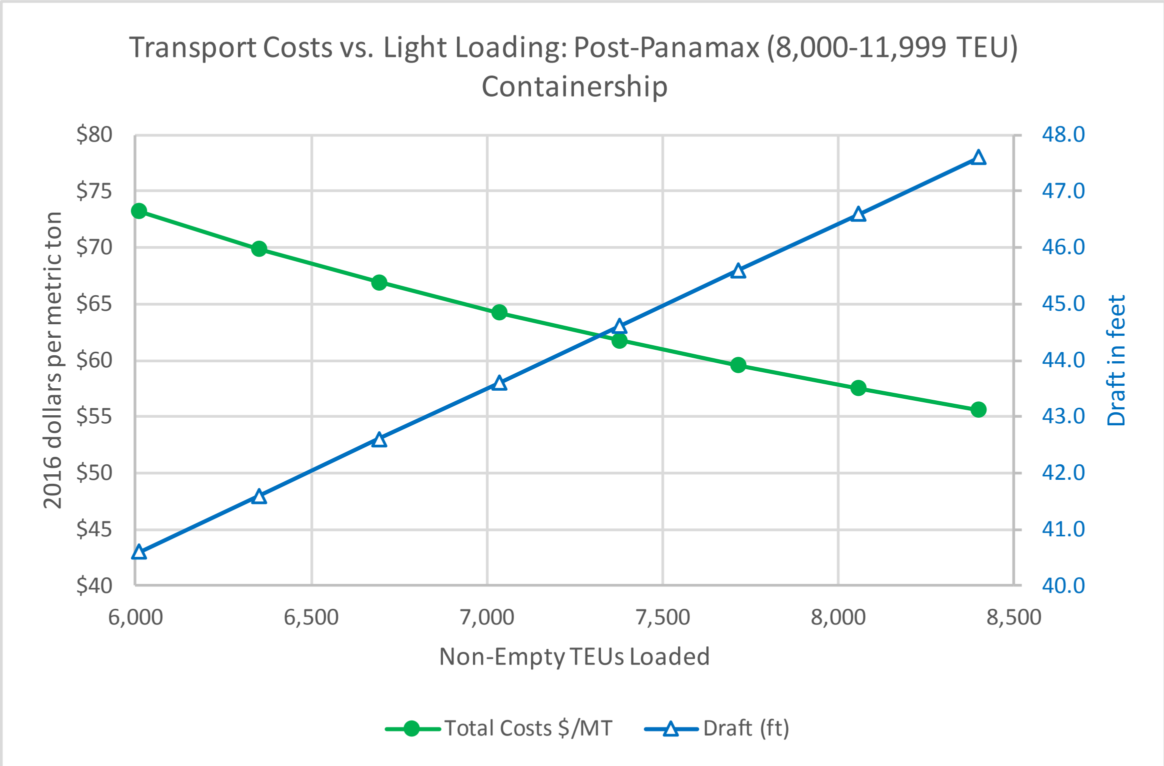
Note: Annual average container shipping rates from China to U.S. Pacific Coast reported by Bloomberg and UNCTAD. Computation of cents per MT-NM based on 6,360 NM 1-way distance and 9 tons per TEU.

Exhibit C-20: Container Ship Costs and Draft vs. Ship Size



Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Exhibit C-21: Example of Light-loading of a Container Ship



Note: Examples are based on 4,700 nautical mile 1-way distance and $460/MT for bunker fuel (approx. $75/bbl crude oil price).

Exhibit C-22: Light-loading Various Sizes of Container Ships: Cost Penalty per Foot of Insufficient Draft Clearance

Sensitivty of Light-loading Results to Ship Size							
Label	Class #	Vessel Class	Full-load Draft (ft)	Cargo Units	Cargo Loss per ft.	Cost Penalty in $/MT/ft.	Cost Penalty /ft. as % of full-load cost
Containership	3	Handy+ (1,000-1,999 TEU)	30.5	TEU	90	$11.95	12.1%
Containership	4	Sub-Panamax (2,000-2,999 TEU)	37.4	TEU	119	$6.77	7.7%
Containership	5	Panamax (3,000-5,100 TEU)	41.0	TEU	168	$4.93	6.1%
Containership	6	Post-Panamax (5,101-7,999 TEU)	44.9	TEU	242	$3.46	5.1%
Containership	7	Post-Panamax (8,000-11,999 TEU)	47.6	TEU	341	$2.51	4.5%
Containership	8	Suez/Cape Size (12,000 TEU & over)	50.5	TEU	452	$1.97	3.9%

Exhibit C-23: Cost of New Dry Bulk Carriers 2007 to 2018

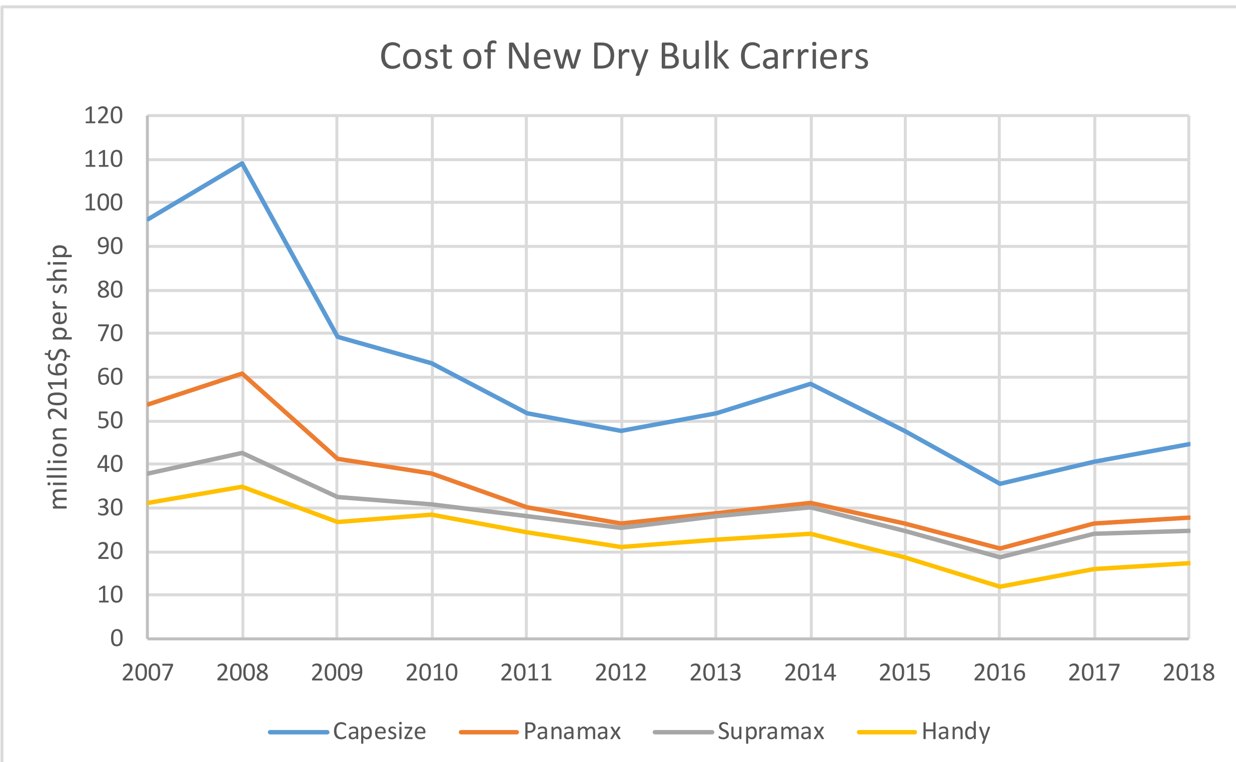


Exhibit C-24: Cost of New Dry Bulk Carriers vs Size

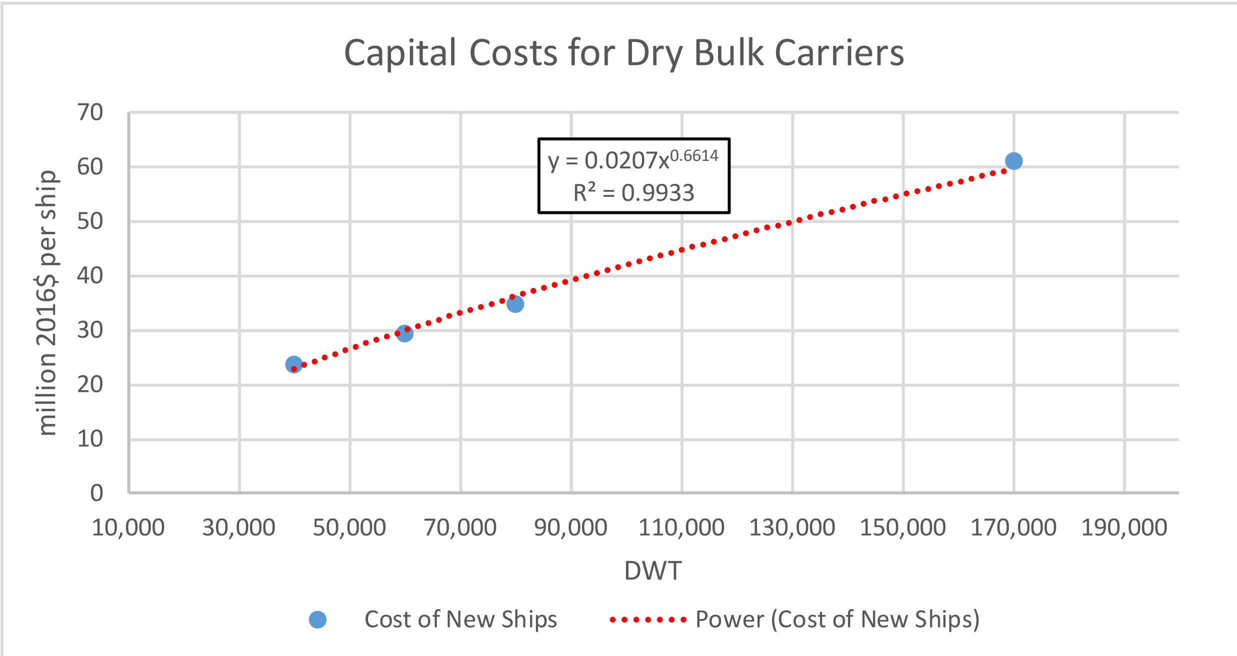


Exhibit C-25: Characterization of Dry Bulk Carrier Costs and Rates (1 of 4)

Label	Class #	Vessel Class	Modeled DWT	Cargo Units	Modeled Cargo Unit Capacity	World Ship Count (1/2016)	Total DWT (1,000s)	World Fleet Average DWT	World Fleet Average Lenght (ft)	World Fleet Average Beam (ft)	World Fleet Average Draft (ft)	World Fleet Average Speed (knots)
Bulk Carrier	1	Small Ship (<10k dwt)	5,000	MT	4,500			5,000			22.6	12.8
Bulk Carrier	2	Handy Size (10k-19.9k dwt)	15,000	MT	13,500	614	9,031	14,708	455	70.2	26.9	13.1
Bulk Carrier	3	Handy Size (20k-24.9k dwt)	22,500	MT	20,250	348	7,954	22,855	519	81.0	31.2	13.6
Bulk Carrier	4	Handy Size (25k-29.9k dwt)	27,500	MT	24,750	745	20,834	27,965	561	86.3	32.2	13.9
Bulk Carrier	5	Handymax (30k-39.9k dwt)	35,000	MT	31,500	1,551	54,049	34,848	595	93.8	33.8	14.2
Bulk Carrier	6	Handymax (40k-49.9k dwt)	45,000	MT	40,500	838	38,388	45,809	625	102.4	37.4	14.2
Bulk Carrier	7	Handymax (50k-59.9k dwt)	55,000	MT	49,500	2,482	141,021	56,818	634	106.0	41.3	14.3
Bulk Carrier	8	Panamax (60k-79.9k dwt)	70,000	MT	63,000	1,329	99,195	74,639	739	106.3	45.6	14.2
Bulk Carrier	9	Post-Panamax (80k-99.9k dwt)	90,000	MT	81,000	1,124	96,222	85,607	785	113.2	47.2	14.3
Bulk Carrier	10	Post-Panamax (100k-119.9k dwt)	110,000	MT	99,000	125	14,079	112,635	828	141.1	46.9	14.6
Bulk Carrier	11	Suez Size (120k-159.9 dwt)	140,000	MT	126,000	69	10,193	147,720	889	142.7	55.8	14.0
Bulk Carrier	12	Cape Size (160k dwt & over)	200,000	MT	180,000	1,437	285,094	198,395	979	156.5	60.4	14.8

Source: ICF pro forma model of dry bulk carrier operator costs. World fleet inventory is from the American Association of Port Authorities.

Exhibit C-26: Characterization of Dry Bulk Carrier Costs and Rates (2 of 4)

Label	Class #	Vessel Class	Capital Costs $mm	Capital Costs $/dwt	Displacement (MT)	Ratio Disp./DWT	Annual Capital Recovery	Annual Non-Fuel Operating	Drydock Days per Year
Bulk Carrier	1	Small Ship (<10k dwt)	$5.8	$1,154	6,330	126.6%	$634,669	$725,740	20
Bulk Carrier	2	Handy Size (10k-19.9k dwt)	$11.8	$800	18,900	126.0%	$1,295,042	$1,126,241	20
Bulk Carrier	3	Handy Size (20k-24.9k dwt)	$15.8	$689	28,215	125.4%	$1,733,075	$1,324,549	20
Bulk Carrier	4	Handy Size (25k-29.9k dwt)	$18.0	$644	34,320	124.8%	$1,980,356	$1,435,251	20
Bulk Carrier	5	Handymax (30k-39.9k dwt)	$20.8	$598	43,470	124.2%	$2,290,395	$1,580,601	20
Bulk Carrier	6	Handymax (40k-49.9k dwt)	$24.9	$545	55,620	123.6%	$2,744,223	$1,747,752	20
Bulk Carrier	7	Handymax (50k-59.9k dwt)	$28.8	$506	67,650	123.0%	$3,164,070	$1,893,826	20
Bulk Carrier	8	Panamax (60k-79.9k dwt)	$34.4	$462	85,680	122.4%	$3,789,320	$2,085,615	20
Bulk Carrier	9	Post-Panamax (80k-99.9k dwt)	$37.7	$441	109,620	121.8%	$4,148,771	$2,306,173	20
Bulk Carrier	10	Post-Panamax (100k-119.9k dwt)	$45.2	$401	133,320	121.2%	$4,973,784	$2,498,918	20
Bulk Carrier	11	Suez Size (120k-159.9 dwt)	$54.1	$366	168,840	120.6%	$5,950,182	$2,751,985	20
Bulk Carrier	12	Cape Size (160k dwt & over)	$65.7	$331	240,000	120.0%	$7,231,005	$3,174,000	20

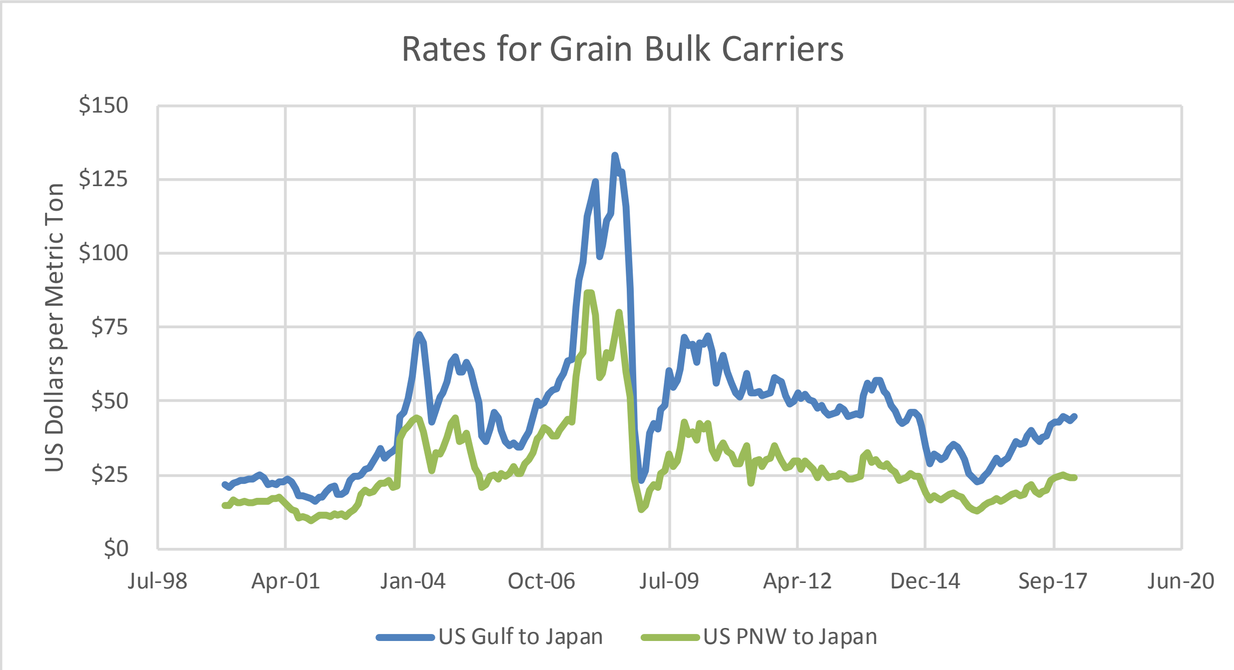
Exhibit C-27: Characterization of Dry Bulk Carrier Costs and Rates (3 of 4)

Label	Class #	Vessel Class	1-Way Distance (nautical miles)	Round Trips per Year	Annual Port Fees	Annual Broker Fees	Loaded Cargo Units	Fuel Use in MT/Day	Bunker Fuel Cost $/MT	Annual Fuel Costs	Total Annual Costs
Bulk Carrier	1	Small Ship (<10k dwt)	4,700	10.1	$30,397	$19,111	4,500	4.7	$460	$670,766	$2,080,683
Bulk Carrier	2	Handy Size (10k-19.9k dwt)	4,700	10.2	$91,414	$43,670	13,500	10.4	$460	$1,460,351	$4,016,718
Bulk Carrier	3	Handy Size (20k-24.9k dwt)	4,700	10.4	$140,615	$60,699	20,250	15.3	$460	$2,108,306	$5,367,244
Bulk Carrier	4	Handy Size (25k-29.9k dwt)	4,700	10.6	$174,440	$71,616	24,750	18.6	$460	$2,547,196	$6,208,859
Bulk Carrier	5	Handymax (30k-39.9k dwt)	4,700	10.7	$224,987	$86,964	31,500	23.2	$460	$3,153,655	$7,336,602
Bulk Carrier	6	Handymax (40k-49.9k dwt)	4,700	10.7	$287,684	$104,426	40,500	27.3	$460	$3,696,478	$8,580,564
Bulk Carrier	7	Handymax (50k-59.9k dwt)	4,700	10.7	$352,117	$121,561	49,500	31.8	$460	$4,277,560	$9,809,134
Bulk Carrier	8	Panamax (60k-79.9k dwt)	4,700	10.5	$443,011	$143,992	63,000	36.4	$460	$4,880,908	$11,342,846
Bulk Carrier	9	Post-Panamax (80k-99.9k dwt)	4,700	10.5	$569,516	$173,837	81,000	43.9	$460	$5,832,875	$13,031,172
Bulk Carrier	10	Post-Panamax (100k-119.9k dwt)	4,700	10.7	$704,695	$204,574	99,000	53.2	$460	$7,013,452	$15,395,423
Bulk Carrier	11	Suez Size (120k-159.9 dwt)	4,700	10.2	$860,870	$235,290	126,000	54.9	$460	$7,245,525	$17,043,852
Bulk Carrier	12	Cape Size (160k dwt & over)	4,700	10.6	$1,275,260	$318,815	180,000	82.0	$460	$10,615,011	$22,614,091

Exhibit C-28: Characterization of Dry Bulk Carrier Costs and Rates (4 of 4)

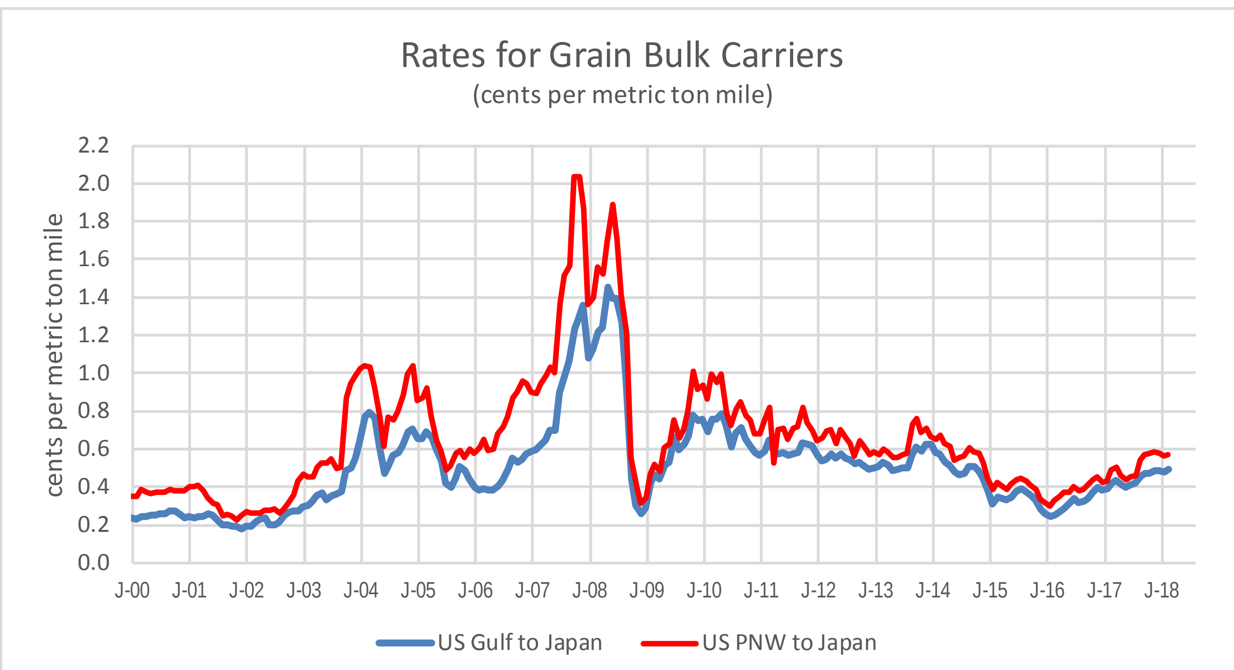
Label	Class #	Vessel Class	Total Costs $/MT	Implied Daily Charter Rate	*Max Market Rate 2010-18 ($/day)*	*Min Market Rate 2010-18 ($/day)*	*Avg. Market Rate 2010-18 ($/day)*	Implied Daily Fuel, Port, Broker Charges	Implied Daily Charter Rate + Other Costs	*All Costs $/hr*	*Cents per Ton Mile*
Bulk Carrier	1	Small Ship (<10k dwt)	$45.63	$3,943				$2,088	$6,031	$251	0.97
Bulk Carrier	2	Handy Size (10k-19.9k dwt)	$29.29	$7,018				$4,624	$11,643	$485	0.62
Bulk Carrier	3	Handy Size (20k-24.9k dwt)	$25.45	$8,863				$6,695	$15,557	$648	0.54
Bulk Carrier	4	Handy Size (25k-29.9k dwt)	$23.73	$9,900				$8,096	$17,997	$750	0.50
Bulk Carrier	5	Handymax (30k-39.9k dwt)	$21.74	$11,220				$10,045	$21,266	$886	0.46
Bulk Carrier	6	Handymax (40k-49.9k dwt)	$19.88	$13,020	$32,000	$5,250	$12,727	$11,851	$24,871	$1,036	0.42
Bulk Carrier	7	Handymax (50k-59.9k dwt)	$18.57	$14,661	$55,250	$5,500	$17,955	$13,772	$28,432	$1,185	0.40
Bulk Carrier	8	Panamax (60k-79.9k dwt)	$17.07	$17,029	$56,500	$5,750	$19,432	$15,849	$32,878	$1,370	0.36
Bulk Carrier	9	Post-Panamax (80k-99.9k dwt)	$15.25	$18,710				$19,062	$37,772	$1,574	0.32
Bulk Carrier	10	Post-Panamax (100k-119.9k dwt)	$14.56	$21,660				$22,964	$44,624	$1,859	0.31
Bulk Carrier	11	Suez Size (120k-159.9 dwt)	$13.20	$25,224				$24,179	$49,402	$2,058	0.28
Bulk Carrier	12	Cape Size (160k dwt & over)	$11.82	$30,159	$109,000	$6,000	$33,727	$35,389	$65,548	$2,731	0.25

Exhibit C-29: Rates for International Marine Shipments of Grains



Source: U.S. Department of Agriculture, Transportation & Marketing Program

Exhibit C-30: Rates for International Marine Shipments of Grains



Source: U.S. Department of Agriculture, Transportation & Marketing Program

Exhibit C-31: Dry Bulk Carrier Costs and Draft vs. Ship Size

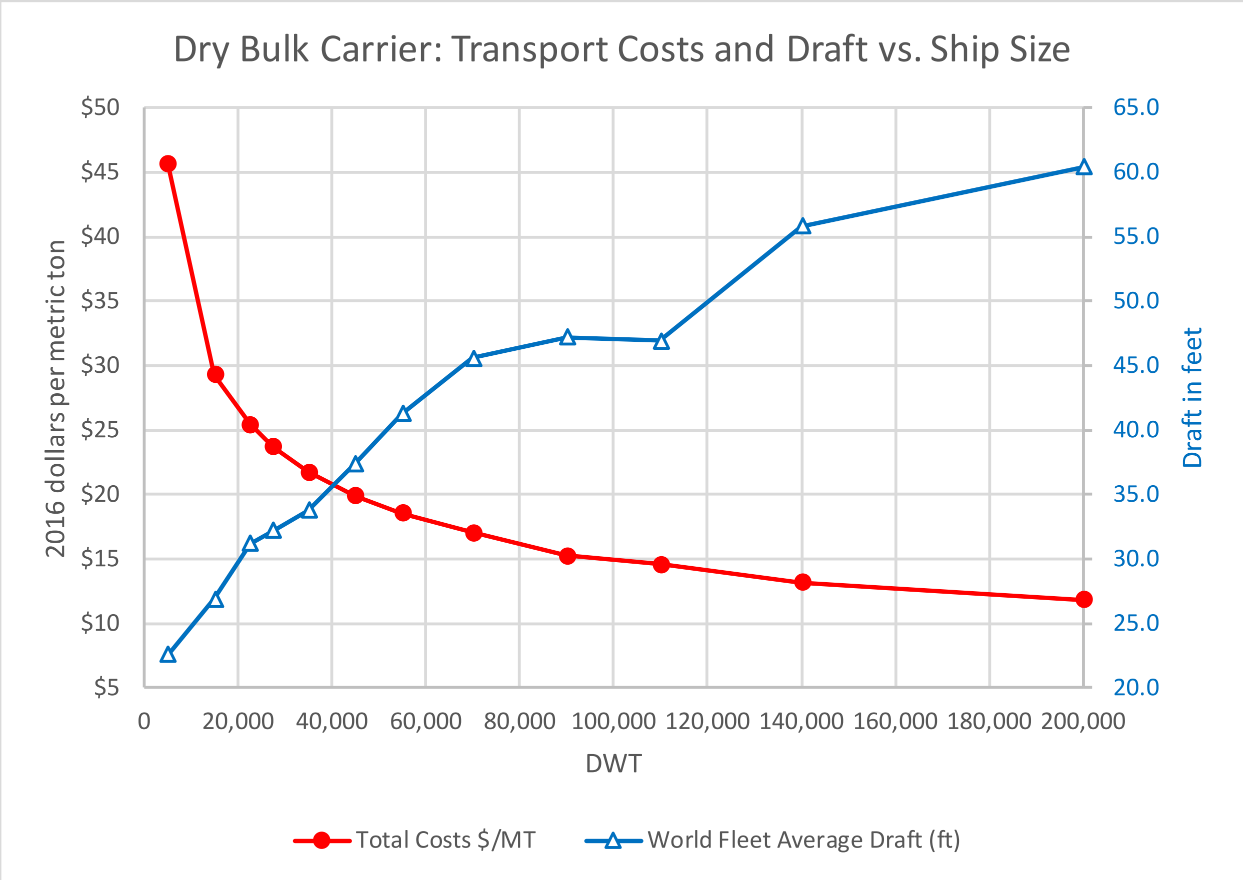


Exhibit C-32: Example of Light-loading of a Dry Bulk Carrier

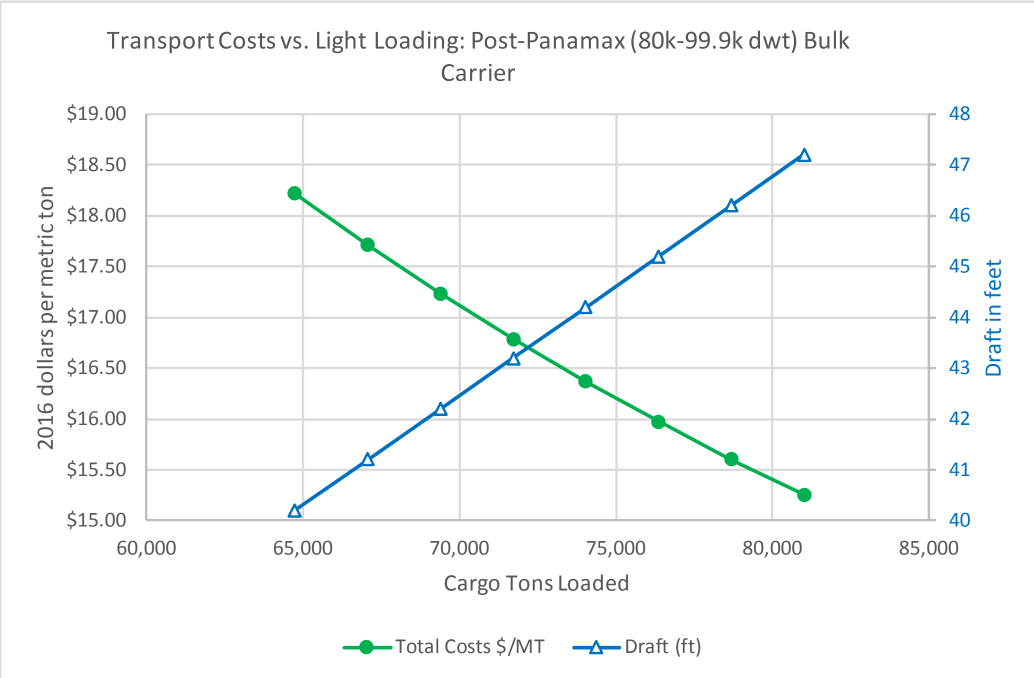


Exhibit C-33: Light-loading Various Sizes of Dry Bulk Carrier: Cost Penalty per Foot of Insufficient Draft Clearance

Sensitivty of Light-loading Results to Ship Size							
Label	Class #	Vessel Class	Full-load Draft (ft)	Cargo Units	Cargo Loss per ft.	Cost Penalty in $/MT/ft	Cost Penalty /ft. as % of full-load cost
Bulk Carrier	6	Handymax (40k-49.9k dwt)	37.4	MT	1,487	$0.77	3.9%
Bulk Carrier	7	Handymax (50k-59.9k dwt)	41.3	MT	1,638	$0.62	3.4%
Bulk Carrier	8	Panamax (60k-79.9k dwt)	45.6	MT	1,879	$0.50	3.0%
Bulk Carrier	9	Post-Panamax (80k-99.9k dwt)	47.2	MT	2,322	$0.42	2.8%
Bulk Carrier	10	Post-Panamax (100k-119.9k dwt)	46.9	MT	2,843	$0.40	2.8%
Bulk Carrier	11	Suez Size (120k-159.9 dwt)	55.8	MT	3,026	$0.30	2.3%
Bulk Carrier	12	Cape Size (160k dwt & over)	60.4	MT	3,974	$0.23	2.0%

Exhibit C-34: Barge Transportation Rates for Grain Movements ($/metric ton)

Indexed Benchmark in $/metric ton	2010	2011	2012	2013	2014	2015	2016	2017	2018
Twin Cities (TWC)	$31.68	$35.22	$32.11	$28.94	$39.23	$31.92	$29.39	$26.08	$42.25
Mid-Mississippi (MM)	$24.41	$27.19	$24.26	$22.54	$31.25	$25.42	$22.34	$19.67	$34.39
St. Louis	$14.77	$15.63	$16.22	$14.12	$18.84	$14.89	$11.68	$11.19	$21.33
Illinois	$20.80	$23.18	$20.44	$18.74	$26.66	$20.25	$18.39	$17.25	$29.72
Cincinnati	$20.51	$22.62	$19.58	$17.40	$23.92	$18.98	$14.81	$15.67	$27.35
Lower Ohio	$19.50	$21.52	$18.62	$16.54	$22.73	$18.04	$14.04	$14.90	$26.32
Cairo-Mem	$10.95	$11.57	$12.33	$10.10	$13.79	$10.68	$8.51	$8.32	$14.79

Based on indexes from April to October in each year. Year 2018 reflects one month (April) only. Heavy rain in March/April 2018 caused flooding along the lower and middle Mississippi and Ohio Rivers bringing delays and disruption to barge movements, driving up barge rates and USGC grain prices. Source: USDA Grain Transportation Report, www.ams.usda.gov/GTR.

Exhibit C-35: Barge Transportation Rate for Grain Movements (cents/metric ton-mile)

Indexed Benchmark in cents/ metric ton - mile	2010	2011	2012	2013	2014	2015	2016	2017	2018
Twin Cities (TWC)	1.77	1.96	1.79	1.61	2.19	1.78	1.64	1.45	2.36
Mid-Mississippi (MM)	1.70	1.90	1.69	1.57	2.18	1.77	1.56	1.37	2.40
St. Louis	1.30	1.38	1.43	1.25	1.66	1.31	1.03	0.99	1.88
Illinois	1.65	1.84	1.62	1.49	2.11	1.61	1.46	1.37	2.36
Cincinnati	1.40	1.55	1.34	1.19	1.63	1.30	1.01	1.07	1.87
Lower Ohio	1.46	1.62	1.40	1.24	1.71	1.35	1.05	1.12	1.98
Cairo-Mem	1.15	1.21	1.29	1.06	1.45	1.12	0.89	0.87	1.55

Based on indexes from April to October in each year. Year 2018 reflects one month (April) only. Source: USDA Grain Transportation Report, www.ams.usda.gov/GTR.

	Twin Cities to NOLA	Mid-Mississippi	Lower Illinois River	St. Louis to NOLA	Cincinnati to NOLA	Lower Ohio	Cairo-Memphis to NOLA	Simple Average
miles from port distances book	1,800	1,534	1,330	1,134	1,463	1,332	734	1,332
onroad vs river distance ratio	149%	151%	151%	167%	142%	189%	186%	162%

Exhibit C-36: Barge Transportation Rates for Coal ($/metric ton-mile)

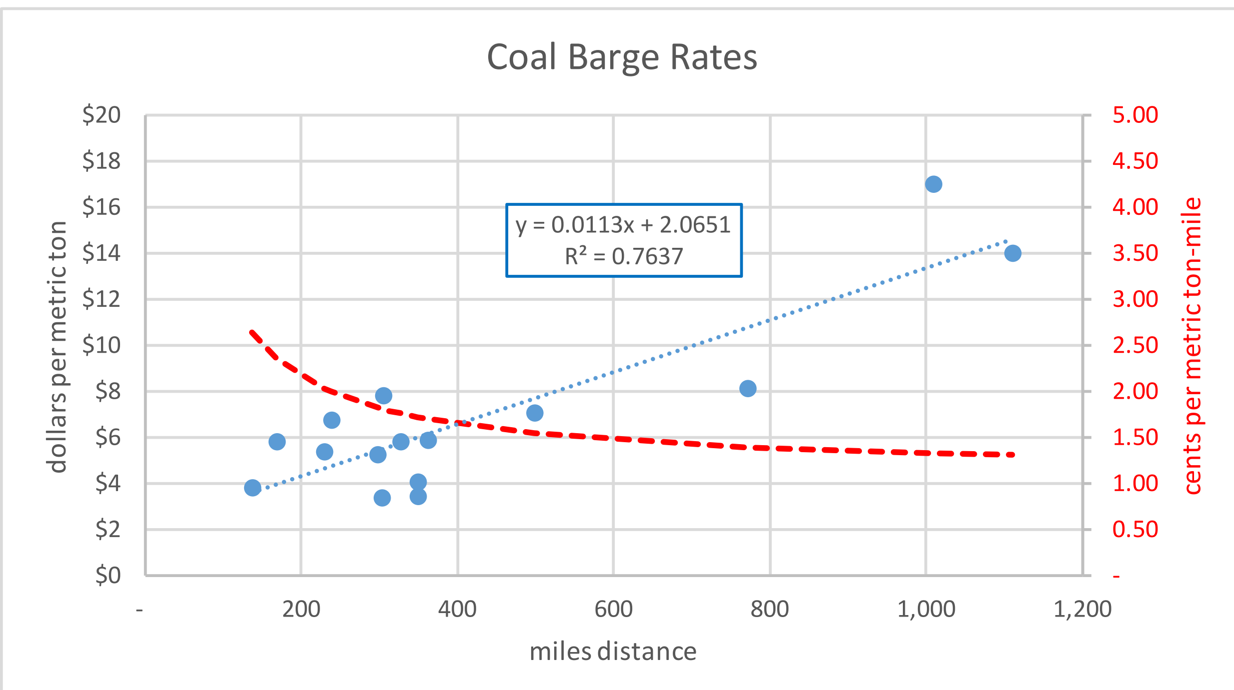


Exhibit C-37: U.S. Barge Inventory 2016

Inventory of U.S. Barges 2016

ICST Code	Vessel Type	Count	Average Capacity (tons)	Average Liq. Capacity (bbl.)	Average Length (ft.)	Average Breadth (ft.)	Average Load Draft (ft.)	Average Light Draft (ft.)
141	Liquid Tank Barge (Single Hull)	97	2,211	16,185	180.8	41.1	10.2	2.4
142	Liquid Tank Barge (Double Hull)	4,141	3,547	25,943	250.3	46.7	10.9	2.2
143	Liquid Tank Barge (Double Sided Only)	59	2,528	35,216	252.1	51.7	9.2	2.2
144	Liquid Tank Barge (Double Bottom Only)	2	2,498	22,323	249.3	45.1	11.2	1.8
149	Liquid Tank Barge (Other)	746	3,249	23,885	248.8	47.4	11.1	2.1
341	Dry Cargo Deck Barge	7,774	1,805		179.0	37.9	10.1	2.1
344	Open Dry Cargo Barge	8,283	1,695		195.6	35.1	9.7	1.7
345	Dry Cargo Covered Barge	11,086	1,913		201.0	35.5	10.4	1.7
349	Dry Cargo Other Barge	166	3,411		219.4	53.8	9.4	3.6
	All Barges	32,354	2,081		201.9	37.8	10.2	1.9

Source: USACE Waterborne Transportation Lines of the United States vessel database 2016.

Exhibit C-38: New Barge Capital Costs

Assumptions for New Barge Dimensions and Capital Costs

	Length (ft.)	Width (ft.)	Hull Depth (ft.)	Capacity (s.t.)	Load Draft (ft.)	Light Draft (ft.)	Capital Cost ($mm)
New Tank Barge (double hull)	260	47	16	4,000	10.9	2.5	$3.60
New Deck Barge	195	35	6	2,200	11.6	2.3	$1.00
New Dry Open Barge	195	35	12	2,200	11.4	1.7	$1.20
New Dry Covered Barge	195	35	12	2,200	11.5	2.0	$1.30
Average	210	38	11	2,606	11.4	2.2	$1.70

Source: Dimensions are averages for 2014-16 period from USACE Waterborne Transportation Lines of the United States vessel database 2016. Capital costs are ICF estimates.

Exhibit C-39: U.S. Towboat and Pushboat Inventory 2016

Inventory of U.S. Towboats and Pushboats 2016

ICST Code	Vessel Type	Count	Average Capacity (tons)	Average H.P	Average Length (ft.)	Average Breadth (ft.)	Average Load Draft (ft.)	Average Light Draft (ft.)
431	Tugboats	2,387	157	2,411	78.1	27.0	10.5	8.8
432	Pushboats	3,216	255	2,011	75.4	26.7	8.1	6.7

Exhibit C-40: New Tugboat and Pushboat Capital Costs

Assumptions for Tugboat and Pushboat Dimensions and Capital Costs

	Length (ft.)	Breadth (ft.)	H.P.	Load Draft (ft.)	Light Draft (ft.)	Capital Cost ($mm)
Tugboat	85	34	4,160	12.7	10.0	$8.0
Pushboat	80	31	2,307	9.6	6.5	$5.1

Source: Dimensions are averages for 2014-16 period from USACE Waterborne Transportation Lines of the United States vessel database 2016. Capital costs are ICF estimates.

Exhibit C-41: Contribution of Fuel to Barge Operator's Costs

Year	Wholesale Diesel Price $/gallon	Approx. Dock-side Diesel Prices ($/gallon)	Inland Waterways Tax ($/gallon)	Cost to Barge Operators ($/gallon)	Fuel cost to Barge Operators (cents/ metric ton-mile)
2010	$2.21	$2.32	$0.20	$2.52	0.45
2011	$3.03	$3.14	$0.20	$3.34	0.60
2012	$3.11	$3.22	$0.20	$3.42	0.61
2013	$3.03	$3.14	$0.20	$3.34	0.60
2014	$2.82	$2.93	$0.20	$3.13	0.56
2015	$1.67	$1.78	$0.27	$2.04	0.37
2016	$1.37	$1.48	$0.29	$1.77	0.32
2017	$1.69	$1.80	$0.29	$2.09	0.37

Source: Wholesale diesel prices from EIA. https://www.eia.gov/dnav/pet/pet_pri_refoth_dcu_nus_m.htm
Assumes 559 metric-ton-miles per gallon energy efficiency.

Exhibit C-42: Pro Forma Barge Operator Costs (1 of 2)

	Pushboat (2,300 HP)	Pushboat (5,000 HP)	Dry Covered Barge	Tank Barge	Deck Barge	Dry Open Barge
Capital Cost	$5,100,000	$8,100,000	$1,300,000	$3,600,000	$1,000,000	$1,200,000
Capacity (short tons/barge)			2,200	4,000	2,200	2,200
Capacity (metric tons/barge)			1,996	3,630	1,996	1,996
Annual capital cost	$614,211	$975,512	$156,564	$433,561	$120,434	$144,520
Days employed per year	330	330	330	330	330	330
$/day	$1,861	$2,956	$474	$1,314	$365	$438
Fuel use metric ton-miles/gallon	559		Cents/ton-mile	0.32		
2016$/gallon diesel	$1.48		Miles per day	100		
Inland Waterways Tax	$0.29		MPH	4.2		
2016$/gallon diesel w/tax	$1.77					
Barges per Pushboat			15	4	15	15
Barge Load as % of Capacity			100%	100%	100%	100%
Tons of Cargo per Pushboat			29,946	14,519	29,946	29,946

Exhibit C-43: Pro Forma Barge Operator Costs (2 of 2)

$/Day	Dry Covered Barge	Tank Barge	Deck Barge	Dry Open Barge
Barge Cost	$7,117	$5,255	$5,474	$6,569
Pushboat Capital Recovery	$2,956	$1,861	$2,956	$2,956
Pushboat O&M	$8,430	$7,025	$8,430	$8,430
Fuel	$9,493	$4,603	$9,493	$9,493
Overhead @15%	$4,199	$2,812	$3,953	$4,117
Total Cost	$32,195	$21,556	$30,307	$31,566
Cents/Metric-Ton-Mile				
Barge	0.24	0.36	0.18	0.22
Pushboat Capital	0.10	0.13	0.10	0.10
Pushboat O&M	0.28	0.48	0.28	0.28
Fuel	0.32	0.32	0.32	0.32
Overhead @%15%	0.14	0.19	0.13	0.14
Total Boat & Barge	1.08	1.48	1.01	1.05

Alternative Cases (cents/MT-mile)				
Base Case	1.08	1.48	1.01	1.05
Reduced Speed to 2.7 MPH	1.47	2.11	1.37	1.44
78% Loading (9 ft. lock depth)	1.31	1.84	1.23	1.29
50% Loading (e.g. due to draught)	1.91	2.73	1.78	1.87
Equipment Used for One Direction Hauls	1.90	2.97	2.02	2.11

Note: Actual 2016 rates were roughly 1.5 c/MT-mile from Northern locations (more locks, slower speeds, fewer barges per push boat and 1.0 c/MT-mile from Southern locations)

Exhibit C-44: Rates for U.S. Rail Transportation of Grains (excludes cost of railcar lease)

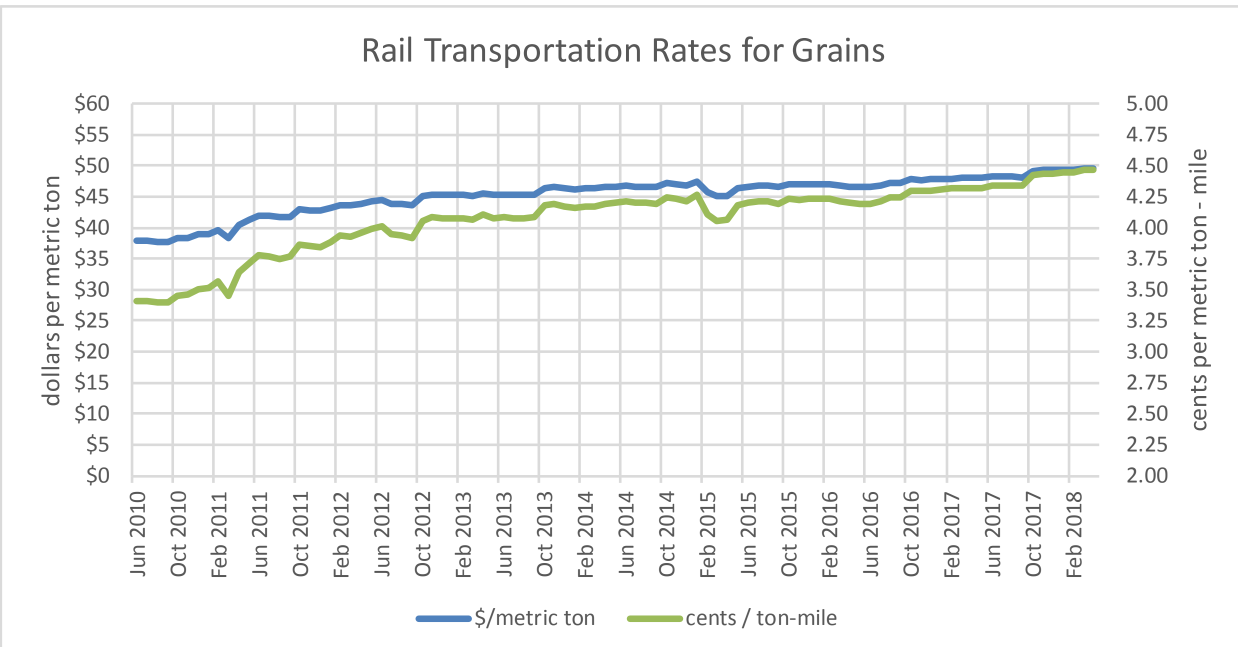


Exhibit C-45: Railcar Lease Costs, Inventory, and Loadings

Car Type	Example Cargo	Estimated Monthly Lease Rate (full service, $/month)	Inventory of Rail Freight Cars 2015 RR Owned	PVT Owned	Total	Avg. Loading per Car (short tons)	Avg. Length of Haul (miles)	Originating Car Loadings* 2015	Million Short Tons 2015	Million Short Ton-Miles 2015
Box Car	paper, wood, and food products	$620	89,730	24,032	113,762	78.6	1,066	0.94	74	79,109
Covered Hopper	grain, chemicals, nonmetallic minerals	$450	137,479	364,132	501,611	96.8	824	3.86	374	307,770
Refrigerated	food products	$750	11,053	2,862	13,915	68.1	1,776	0.14	9	16,533
Gondola	coal, nonmetallic minerals, metals, scrap	$400	118,645	114,184	232,829	109.0	763	4.74	517	394,617
Open-Top Hopper	coal, metallic ores, nonmetallic minerals	$380	55,701	92,518	148,219	108.0	514	4.68	505	259,745
Flat Car*	intermodal containers, lumber, steel, autos	$700	60,715	136,089	196,804	15.9	1,305	15.79	251	327,591
Tank	petroleum, chemicals, food products	$880	867	371,854	372,721	87.9	820	2.62	230	188,936
Other	miscellaneous	$600	1,149	2,855	4,004	87.9	135	0.07	6	797
	Total	$619	475,339	1,108,526	1,583,865	59.9	801	32.84	1,967	1,575,098

Flat car category include multi-unit intermodal cars whereby each loaded container is counted as a loading.

Source: ICF estimate derived from Freight Analysis Framework, FTR Associates, and National Steel Car Ltd. Loadings include Class I and Non-Class I railroads.

Exhibit C-46: Contribution of Fuel to Railroad Costs

Year	Wholesale Diesel Price $/gallon	Approx. Delivered Diesel Prices ($/gallon)	Sales Tax Paid by RRs ($/gallon)	Cost to Railroads ($/gallon)	Fuel Cost for Railroads (cents/ metric ton-mile)
2010	$2.21	$2.32	$0.02	$2.34	0.54
2011	$3.03	$3.14	$0.03	$3.17	0.73
2012	$3.11	$3.22	$0.03	$3.25	0.75
2013	$3.03	$3.14	$0.03	$3.17	0.73
2014	$2.82	$2.93	$0.02	$2.96	0.69
2015	$1.67	$1.78	$0.01	$1.79	0.42
2016	$1.37	$1.48	$0.01	$1.49	0.35
2017	$1.69	$1.80	$0.01	$1.81	0.42

Source: Wholesale diesel prices from EIA. https://www.eia.gov/dnav/pet/pet_pri_refoth_dcu_nus_m.htm

There is no federal fuel tax on railroads, but 10 state impose sales tax.

Assumes 431 metric-ton-miles per gallon energy efficiency.

Exhibit C-47: Assumed Cost of Rail Transportation Alternative (for estimating potential cost of unwanted modal switches)

Commodity Code	Commodity Name	Cents per metric ton-mile for rail transportation service (ex. fuel)	Cents per metric ton-mile for fuel (@$2/gallon)	Cents per metric ton-mile for railcar lease	Total cents per metric ton-mile
1000	Coal, Lignite, and Coal Coke	4.03	0.46	0.25	4.75
2100	Crude Petroleum	4.03	0.46	0.56	5.06
2229	Petroleum Products	4.03	0.46	0.56	5.06
3100	Chemical Fertilizers	4.03	0.46	0.34	4.83
3200	Chemicals excluding Fertilizers	4.03	0.46	0.56	5.06
4142	Lumber, Logs, Wood Chips, and Pulp	4.03	0.46	0.27	4.77
4349	Sand, Gravel, Shells, Clay, Salt, and Slag	4.03	0.46	0.25	4.75
4400	Iron Ore, Iron, and Steel Waste and Scrap	4.03	0.46	0.27	4.76
4600	Non-Ferrous Ores and Scrap	4.03	0.46	0.27	4.76
5155	Primary Non-Metal Products	4.03	0.46	1.06	5.56
5354	Primary Metal Products	4.03	0.46	1.06	5.56
6168	Food and Food Products	4.03	0.46	0.31	4.81
7000	Manufactured Goods	4.03	0.46	1.06	5.56
8099	Unknown and Not Elsewhere Classified Products	4.03	0.46	0.54	5.04

Exhibit C-48: Trucking Costs

Average Marginal Costs per Mile, 2008-2014								ICF Estimate- NOT survey		
Motor Carrier Costs	2008	2009	2010	2011	2012	2013	2014	2015	2016	2016
Vehicle-based										
Fuel Costs	$0.633	$0.405	$0.486	$0.590	$0.641	$0.645	$0.583	$0.430	$0.366	$0.421
Truck/Trailer Lease or Purchase Payments	$0.213	$0.257	$0.184	$0.189	$0.174	$0.163	$0.215	$0.188	$0.192	$0.202
Repair & Maintenance	$0.103	$0.123	$0.124	$0.152	$0.138	$0.148	$0.158	$0.151	$0.155	$0.158
Truck Insurance Premiums	$0.055	$0.054	$0.059	$0.067	$0.063	$0.064	$0.071	$0.067	$0.069	$0.070
Permits and Licenses	$0.016	$0.029	$0.040	$0.038	$0.022	$0.026	$0.019	$0.023	$0.023	$0.022
Tires	$0.030	$0.029	$0.035	$0.042	$0.044	$0.041	$0.044	$0.044	$0.044	$0.045
Tolls	$0.024	$0.024	$0.012	$0.017	$0.019	$0.019	$0.023	$0.021	$0.021	$0.022
Driver-based										
Driver Wages	$0.435	$0.403	$0.446	$0.460	$0.417	$0.440	$0.462	$0.448	$0.459	$0.466
Driver Benefits	$0.144	$0.128	$0.162	$0.151	$0.116	$0.129	$0.129	$0.127	$0.131	$0.132
TOTAL	$1.653	$1.451	$1.548	$1.706	$1.633	$1.676	$1.703	$1.499	$1.461	$1.538
Total approx. cents/metric ton-mile	13.0	11.4	12.2	13.4	12.9	13.2	13.4	11.8	11.5	12.1
ICF estimates from http://atri-online.org/wp-content/uploads/2015/09/ATRI-Operational-Costs-of-Trucking-2015-FINAL-09-2015.pdf										

Appendix D: Glossary

Aframax Tanker: A vessel of 70,000 to 119,000 DWT capacity. The largest tanker size in the AFRA (average freight rate assessment) tanker rate system.

Barge: A large, flat-bottomed boat used to carry cargo within a port, between seaports or along inland river and lake waterways. Barges carry dry bulk (grain, coal, lumber, gravel, etc.), liquid bulk (petroleum, vegetable oils, molasses, etc.) and packaged cargo (pallets, containers, etc.).

Beam: The width of a ship.

Berth: The wharf space at which a ship docks. A wharf may have several berths, depending on the length of incoming ships.

Bill of Lading: A contract between a shipper and carrier listing the terms for moving freight between specified points.

Bulk Cargo: Loose cargo (dry or liquid) that is loaded (shoveled, scooped, forked, mechanically conveyed or pumped) in volume directly into a ship's hold; e.g., grain, coal and oil.

Cargo: The freight (goods, products) carried by a ship, barge, train, truck or plane.

Coastwise: Water transportation along the coast or on the high seas between seaports.

Container Terminal: A specialized facility where ocean container vessels dock to discharge and load containers. These are usually equipped with cranes with a safe lifting capacity of 35-40 tons, with booms having an outreach of up to 120 feet in order to reach the outside cells of vessels.

Customs: A duty or tax on imported goods. The U. S. Customs Department collects these fees and also works to prevent the importation of illegal drugs and contraband.

Dead Weight Tonnage (DWT): The number of tons of 2,240 pounds that a vessel can transport of cargo, stores and bunker fuel. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces when submerged to the "load line."

Demurrage: An extra fee assessed by a port authority when cargo isn't moved off a wharf before the free time allowance ends. Also refers to extra fees charged by ship owners for delays.

Dock: A dock is a structure built along, or at an angle from, a navigable waterway so that vessels may lie alongside to receive or discharge cargo. Sometimes, the whole wharf is informally called a dock.

Dockage: A charge by a port authority for the length of water frontage used by a vessel tied up at a wharf.

D.O.T. or U.S. Department of Transportation. The executive branch department that coordinates and oversees transportation functions in the United States.

Draft: The depth of a loaded vessel in the water taken from the level of the waterline to the lowest point of the hull of the vessel.

Dredge: A waterborne machine that removes unwanted silt accumulations from the bottom of a waterway. Also refers to the process of removing sediment from harbor or river bottoms for safety purposes and to allow for deeper vessels.

Dry Bulk: Minerals or grains stored in loose piles moving without mark or count. Examples are potash, industrial sands, wheat, soybeans and peanuts.

Duty: A government tax on imported merchandise.

Handymax Vessel: A dry bulk vessel of 35,000 to 49,000dwt. (Note that a “Handy” drybulk carrier is from 10,000 to 34,000dwt.) A “Handymax Tanker” is a liquid bulk carrier of 10,000 to 60,000dwt.

Length Overall (LOA): Linear measurement of a vessel from bow to stern.

Lightering: A process by which a vessel discharges part of its cargo at deepwater anchor into a lighter (smaller) vessel to reduce the vessel’s draft so it can pass through a shallow channel to a dock.

Locks: A section of a waterway in which gates are used to raise or lower the water level to allow ships to move between water bodies of different elevations.

Long Ton: A long ton equals 2,240 pounds.

Metric Ton: 2,204.6 pounds or 1,000 kilograms.

Panamax Tanker: A liquid cargo vessel of 50,000 to 70,000dwt.

Pilot: A licensed navigational guide with thorough knowledge of a particular section of a waterway who pilots ships along a coast or into and out of a harbor.

Port: This term is used both for the harbor area where ships are docked and for the agency (port authority), which administers use of public wharves and port properties.

Ro/Ro: Short for roll on/roll/off. A ro/ro ship is designed with ramps that can be lowered to the dock so cars, buses, trucks or other vehicles can drive into the belly of the ship, rather than be lifted aboard.

Short Ton: A short ton equals 2,000 pounds. Lifting capacity and cargo measurements in the U.S. are typically designated in short tons.

Suezmax Tanker: A tanker of 120,000 to 199,000dwt.

Tank Barges: Used for transporting bulk liquids, such as petroleum, chemicals, molasses, vegetable oils and liquefied gases.

Tariff: Schedule, system of duties imposed by a government on the import/export of goods; also, the charges, rates and rules of a transportation company as listed in published industry tables.

Terminal: The place where cargo is handled is called a terminal (or a wharf).

Ton–Mile: A unit used in comparing freight earnings or expenses. The amount earned from the cost of hauling a ton of freight one mile.

Towboat: A snub-nosed boat with push knees used for pushing barges.

Transshipment: The unloading of cargo at a port or point where it is then reloaded, sometimes into another mode of transportation, for transfer to a final destination.

Tugboat: A v-hull shaped boat used for maneuvering ships into and out of port and to carry supplies.

Twenty Foot Equivalent Unit (TEU): A unit of measurement equal to the space occupied by a standard twenty foot container. Used in stating the capacity of container vessel or storage area. One 40 ft. container is equal to two TEU's.

ULCC: Ultra Large Crude Carrier. A tanker in excess of 320,000 dwt.

U. S. Army Corps of Engineers: This department of the U. S. Army is responsible for flood protection and providing safe navigation channels. The Corps builds and maintains the levees, flood walls and spillways that keep major rivers out of low lying communities. The Corps is vital to keeping navigation channels open by dredging sand, silt and gravel that accumulate on river and harbor bottoms.

Vessel: A ship or large boat.

Vessel Operator: A firm that charters vessels for its service requirements, which are handled by their own offices or appointed agents at ports of call. Vessel operators also handle the operation of vessels on behalf of owners.

VLCC: Very Large Crude Carrier. A tanker of 200,000 to 319,000dwt. It can carry about 2 million barrels of crude oil.

Wharfage Fee: A charge assessed by a pier or wharf owner for handling incoming or outgoing cargo.

Glossary sources include*:*

American Association of Port Authorities **www.aapa-ports.org**, citing *The Port of New Orleans* **www.pola.com**, *Georgia Ports Authority* **www.gaports.com**, *and the Port of Halifax* **www.portofhalifax.com**.
MARAD**: https://www.marad.dot.gov/wp-content/uploads/pdf/Glossary_final.pdf**
Great Lakes Maritime Shipping Glossary:
http://wupcenter.mtu.edu/education/great_lakes_maritime/lessons/Great_Lakes_Shipping_Glossary_GLMRI.pdf

Appendix E: Abbreviations and Acronyms

Item	Definition
$/MT	U.S. dollars per metric ton
3x3x3 Rule	A USACE rule stating that feasibility reports will be produced in a target goal of 18 months but no more than three years, with a cost not greater than $3 million, and involve all three levels of Corps review (district, division, and headquarters) through the entire study process.
ACC	American Chemistry Council
AEO	EIA Annual Energy Outlook
bbl	Barrels
Bcf	Billion cubic feet of gas
BCR	Benefit to Cost Ratio (concept used by USACE in its economic analyses)
Btu	British thermal unit, used to measure fuels by their energy content.
CAPEX	Capital expenditures
CIF	Cost, Insurance and Freight, a transaction basis in which the seller pays the costs of freight and insurance to bring the goods to the port of destination. (Compare to FOB)
CRS	Congressional Research Service
CSCMP	Council of Supply Chain Management Professionals
CWA	Clean Water Act of 1972
DES	Delivered Ex Ship
DOT	U.S. Department of Transportation
DWT	Dead Weight Tons
EA	Environmental Assessment, a document that a Federal agency prepares under NEPA to provide sufficient evidence and analysis to determine whether a proposed agency action would require preparation of an EIS or a finding of no significant impact.
EC	Engineering circular, an occasional USACE publication establishing processes and procedures
EIA	Energy Information Administration
EIS	Environmental Impact Statement, a document required by NEPA for certain actions "significantly affecting the quality of the human environment"
EQ	Environmental Quality (concept used by USACE in its economic analyses)
F&I	Freight and Insurance
FAF	Freight Analysis Framework, a Bureau of Transportation Statistics (DOT) system for analyzing historical and future demands for transportation services
FERC	Federal Energy Regulatory Agency
FOB	Free on board or freight on board, a transaction basis in which liability and ownership of goods is transferred from a seller to a buyer at an originating port. Buyer then pays freight and insurance to ship goods to destination port. (Compare to CIF).
GAO	Government Accountability Office
GDP	Gross Domestic Product
HMTF	The Harbor Maintenance Trust Fund, a mechanism was created by Congress to provide funding for maintenance dredging for federally maintained harbors and channels through a 0.125% ad valorem tax on imports
IMO	International Maritimes Organization
IMPLAN	Input-output model used for economic analysis
IWTF	The Inland Waterways Trust Fund, a mechanism established by Congress to help provide funding for construction and major rehabilitation of the nation's inland waterway system. Funds are generated through a $0.29 per gallon tax on the diesel fuel used on the inland waterway system.
k	Thousands (e.g. 50k is 50,000)
LNG	Liquefied Natural Gas

Item	Definition
LOP	Letters of Permission, a type of individual permit issued through an abbreviated processing procedure which includes coordination with Federal and state fish and wildlife agencies, and a public interest evaluation, but without the publishing of an individual public notice. This differs from Standard Permit applications which are processed through public interest review procedures, requiring both public notice and receipt and review of comments.
LPG	Liquefied Petroleum Gas
MARAD	U.S. Maritime Administration
Mcf	Thousand standard cubic feet (volume measurement for natural gas)
MMbbl	Million barrels of oil or liquids
MMBOE	Million barrels of oil equivalent wherein each barrel contains 5.8 million Btus.
MMBtu	Million British Thermal Units. Equivalent to approximately one thousand cubic feet of gas
MMcf	Million standard cubic feet (of natural gas)
MOU	Memorandum of Understanding, a nonbinding document signed by two or entities outlining the terms and details of an understanding, including each parties' requirements and responsibilities
MPH	Miles per hour
MT	Metric ton
MTBE	Methyl Tertiary Butyl Ether
MTPA	Million metric tons per annum
MWh	Megawatt hour of electricity
NAICS	North American Industry Classification System
NED	National Economic Development (concept used by USACE in its economic analyses)
NEMS	National Energy Modeling System (used to prepare EIA's AEO)
NEPA	National Environmental Policy Act of 1970
NG	Natural gas
NGLs	Natural gas liquids (ethane, propane, butanes, pentanes plus)
NHPA	National Historic Preservation Act
NWP	Nationwide Permit, a form of streamlined general permit that preauthorizes a category of activities throughout the nation that result in minimal individual and cumulative adverse effects on the aquatic environment
O&M	Operating and maintenance cost
OES	Other Social Effects (concept used by USACE in its economic analyses)
OMB	Office of Management and Budget, the executive branch agency that (among many other duties) reviews the benefit to cost ratio analysis carried out by the USACE
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, guidelines originally written in 1983 to provide direction to USACE when evaluating and selecting water resource projects
PDH	Propane Dehydrogenation Plant
PGP	Programmatic General Permits, a form of streamlined general permits issued when existing state, local, or other Federal programs exists that meets the requirements of the Corps' regulatory obligations
RED	Regional Economic Development (concept used by USACE in its economic analyses)
RGP	Regional General Permits, a form of streamlined general permits issued on a regional basis
RHA	Rivers and Harbors Act of 1899
ROD	Record of Decision, a public document that records a Federal agency's decision concerning a proposed action for which the agency has prepared an EIS under NEPA
SNWW	Sabine-Neches Waterway
SWT	Shipping weight (weight of the commodity and normal packaging (boxes, crates, barrels, etc.)
Tcf	Trillion cubic feet (of natural gas)

Item	Definition
TEU	Twenty foot equivalent unit (a standard quantity measure for containerized shipping)
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geologic Survey
WACC	Weighted average cost of capital
WOTUS	Waters of the U.S. Regulations, rules issued in 2015 to define which wetlands and small waterways are protected under the Clean Water Act of 1972
WRDA	Water Resources Development Act, the authority through which Congress may authorize the construction of specific USACE Public Works projects.