APPENDIX C
BENEFITS ANALYSIS
COMPREHENSIVE ECONOMIC REANALYSIS
DELAWARE RIVER MAIN CHANNEL DEEPENING

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1. INTRODUCTION

This appendix presents the results of a comprehensive reanalysis of the benefits that would result from the authorized project to deepen the Delaware River Main Channel from –40 feet mean low water (MLW) to –45 feet MLW. The reanalysis effort is intended to determine whether improvements to the existing Federal navigation project will contribute positively to increases in net national income.

1.1. Procedures, Guidance and Regulations

National Economic Development (NED) benefits were estimated for this Comprehensive Economic Reanalysis Report following the guidelines and procedures established in the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, February 3, 1983; the Planning Guidance Notebook, ER 1105-2-100, 22 April 2000; and the National Economic Development Procedures Manual – Deep Draft Navigation, IWR–91–R-13, dated November 1991.

The Principles and Guidelines defines NED benefits as follows:

> *"Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed."*

1.2. Benefit Categories

The NED benefits quantified in this analysis include the reduced costs of transportation realized through operational efficiencies (reduced lightering and lightloading), and the use of larger, more efficient vessels, both resulting from navigation improvements at the harbor. Reduced transportation costs result in reduced production and distribution costs and thereby increase the net value of the national output of goods and services.

Benefits will result from the decrease in the cost per ton for shipping commodities into or out of the Delaware River Port System. A deeper channel depth will allow some current vessels to carry more cargo as well as allow a fleet shift to larger vessels, thus more efficiently apportioning operating costs over a greater amount of tonnage. Other vessels, such as large crude oil vessels that currently lighter in the naturally deep water of the lower Delaware Bay, will continue to carry equivalent tonnage but will be able to operate more efficiently with a deepened channel, thereby reducing lightering costs. Benefits are also claimed for a reduction in tidal delays. No induced tonnage (i.e., commodity shifts from other ports) is anticipated from the project deepening, therefore a multiport analysis has not been conducted for this study. As per ER 1105-2-100, page E-47:

> *"Commerce with final origins and destinations within the confines of the study harbor is normally noncompetitive with other harbors and need not be considered for diversion unless unusual circumstances exist."*

Finally, ecological benefits and cost savings will result from the beneficial use of dredged material for ecosystem restoration and storm damage protection.

The quantification of NED benefits involved computing and comparing total transportation costs under with and without project conditions for each vessel class, by trade route, by commodity, and by terminal destination. Benefits have been estimated for liquid bulk (primarily crude oil imports), petroleum products, dry bulk (including blast furnace slag and steel slabs), and containerized cargo.

1.3. Prior Corps of Engineers Studies and Reports

The Delaware River Comprehensive Navigation Study Main Channel Deepening Interim Feasibility Report and Environmental Impact Statement was completed in February 1992. This report contained an analysis of project benefits that provided the economic justification for selection of the 45-foot deepening project as the NED plan. The NED plan was subsequently authorized for construction by Congress in the Water Resources Development Act of 1992 (Public Law 102-580).

The Delaware River Study Main Channel Deepening Project Limited Reevaluation Report (LRR) was completed in February 1998 to obtain approval to initiate construction and serve as the decision document for budgetary purposes. The LRR contained a reanalysis of the benefits of the authorized 45-foot deepening project.

1.4. Organization of the Appendix

Section 2 – General Methodology, describes the methodology used in conducting this economic reanalysis effort. Section 3 – Existing Conditions, contains information about the Delaware River Port System and its hinterlands. It includes a physical profile of the port complex and a socioeconomic profile of the port region and its domestic economic hinterlands. Section 3 also contains an institutional profile of the port, a description of marine terminals in the port complex, and a description of port operations. Section 3 describes existing waterborne commerce, including current commodity imports and exports; describes the existing deep-draft vessel fleet calling at the Delaware River Port System; and calculates the transportation costs associated with current commodity movements.

Section 4 – Trade Forecast, describes expected conditions at the port over the 50-year period of analysis (2009-2058). This section provides a forecast of future commodity movements over the 50-year period and describes the methodology used to prepare the commodity forecast.

Section 5 - Economic Benefits of Navigation Improvements, describes the sources of benefits calculated in the analysis. Any limitations or constraints on benefits are described. Future transportation costs are computed under both the future without project condition (continued operation of the existing 40-foot navigation project) and the future with project condition (deepening of the Federal navigation project to 45 feet). With and without project conditions are then compared in order to calculate the transportation cost savings (NED benefits) of the deepening project.

Section 6 – Risk and Uncertainty, describes the sources of uncertainty in the analysis of project benefits and presents several sensitivity analyses that quantify the impacts of uncertainty on several critical variables that affect the benefits of the deepening project.

2. GENERAL METHODOLOGY

The Planning Guidance Notebook (ER 1105-2-100) describes a nine-step process to be used in computing NED benefits for deep draft navigation projects. This process has been employed in the economic reanalysis of the Delaware River Main Channel Deepening Project.

Step 1 – Determine the Economic Study Area

Step 2 – Identify Types and Volumes of Commodity Flow

Step 3 – Project Waterborne Commerce

Step 4 – Determine Vessel Fleet Composition and Cost

Step 5 – Determine Current Cost of Commodity Movements

Step 6 – Determine Current Cost of Alternative Movements

Step 7 – Determine Future Cost of Commodity Movements

Step 8 – Determine Use of Harbor and Channel With and Without Project

Step 9 – Compute NED Benefits.

The methodologies used to conduct these steps and the results are discussed in the subsequent sections of this appendix.

Vessel operating costs used to compute transportation cost savings were taken from the most recent CECW-P Economic Guidance Memorandum (EGM) 02-02, Deep Draft Vessel Operating Costs, 12 August 2002 (prepared for HQUSACE by the Institute for Water Resources (IWR)). Regression equations were computed from tables provided in the EGM to interpolate operating costs for vessel sizes that fell between those listed in the tables. In addition, vessel specific operating costs were developed by IWR for the Maritrans lightering fleet.

Economic benefits are calculated for the 50-year study period (2009 – 2058). In addition, benefits would accrue to facilities south of and including the Marcus Hook reach that will have access to the 45-foot project in the year 2008, one year prior to full completion of construction (2009). These “pre-base year” benefits are also included in the analysis.

All project benefits are computed at May 2002 Price Levels and are discounted using the current prevailing Federal Fiscal Year 2003 discount rate of 5-7/8%.

3. EXISTING CONDITIONS

This section outlines existing conditions in the Delaware River Port System, and includes descriptions of the physical conditions, socioeconomic conditions, institutions, marine terminals, and operations of deep-draft marine transportation in the study area. As discussed in the Main Report, the project under consideration in this document would involve deepening the main channel Delaware River from deep water in Delaware Bay to the Beckett Street Terminal in Camden, New Jersey, a distance of approximately 102.5 miles. The profile of existing conditions focuses on port facilities and operations that would potentially be affected by deepening of the main channel Delaware River to from -40 to -45 feet MLW.

3.1. Physical Profile of the Delaware River Port System

Physical conditions within the Delaware River and Bay directly affect movements of deep-draft vessels and the economics of marine transportation. The following physical profile of the Delaware River Port System includes descriptions of: (1) commercial channels directly affected by the main channel deepening, and (2) tidal influences in the Delaware River and Bay.

3.1.1. Channel Dimensions

The Delaware River is the boundary between Pennsylvania and Delaware on the west side and New Jersey on the east side. The mouth of Delaware Bay is bounded by Cape Henlopen (Delaware) to the south and Cape May (New Jersey) to the north. As commercial vessels arrive at Delaware Bay from the Atlantic Ocean, they enter a commercial navigation system comprised of a variety of Federal and non-Federal channels. The system also contains a variety of anchorages and berths to support commercial navigation. In general, the deep-draft channels and anchorages have been constructed by the Corps and are maintained as part of Federal navigation projects. Non-Federal parties (e.g., state agencies, regional port authorities, private concerns) are responsible for providing the infrastructure necessary to utilize the Federal channels, including dredging of access channels and berthing areas and installation and maintenance of docks and landside handling, warehousing, and transportation facilities. The various Federal channels in the Port System have been authorized by Congress and constructed over time as separate projects. They include six deep-draft projects and 16 shallow-draft projects. Federal deep-draft projects include the Delaware River, Philadelphia to the Sea; Delaware River in the Vicinity of Camden (Beckett St. Terminal); Delaware River, Philadelphia to Trenton; Wilmington Harbor (Christina River); Inland Waterway - Delaware River to Chesapeake Bay (C & D Canal); and the Schuylkill River.

As part of deepening the main channel of the Delaware River, two Federal channels would be modified: (1) Delaware River, Philadelphia to the Sea, and (2) Delaware River in the Vicinity of Camden. Specifically, the northern terminus of main channel deepening would be the Beckett Street Terminal in Camden. The Beckett Street access portion of the Delaware River, Vicinity of Camden project would be deepened as well.

A study to deepen the Wilmington Harbor (Christina River) beyond its current depth of 38 feet was initiated under the Corps of Engineers Continuing Authorities Program (Section 107 River and Harbor Act of 1960, as amended). This Section 107 study was suspended pending initiation of the Delaware River Main Channel Deepening Project. The Wilmington Harbor (Christina River) project will require incremental justification and approval. Therefore, although the potential for benefits are recognized, no benefits are quantified in this reanalysis for the Port of Wilmington.

Existing conditions of the Delaware River, Philadelphia to the Sea and Delaware River in the Vicinity of Camden projects are summarized below.

<u>Delaware River, Philadelphia To The Sea.</u> This project consists of a 40-foot deep channel from Allegheny Avenue in Philadelphia to deep water in Delaware Bay. Channel widths range from 400 feet in Philadelphia Harbor to 1,000 feet in the bay. Through Philadelphia Harbor the channel is 40 feet deep on the west side and 37 feet deep on the east side. There are nineteen anchorages on the Delaware River; six are authorized under the Philadelphia to the Sea project

(Mantua Creek, Marcus Hook, Deepwater Point, Reedy Point, Gloucester and Port Richmond), and the remaining thirteen are natural deep-water anchorages.

Delaware River In The Vicinity Of Camden. This project provides for a 30-foot-deep channel from Newton Creek at the Broadway Terminal, and for a 40-foot access channel to the Beckett Street Terminal.

3.1.2. Tidal Hydraulics

Tidal conditions significantly affect movements of deep-draft vessels within the Delaware River Port System. The tides of the Delaware River are semidiurnal, with two nearly equal high waters and two nearly equal low waters per lunar day. The mean range is about 4.2 feet at the mouth of Delaware Bay. As the tidal undulation propagates upriver, the tide range increases. The mean range at the mouth of the Christina River is 5.6 feet, at the mouth of the Schuylkill River, 5.7 feet, and at the Benjamin Franklin Bridge in Philadelphia, 6.2 feet. Wind speed and direction can significantly affect water levels at a given time and location.

Based on tidal current charts compiled by the National Ocean Survey, maximum spring ebb and flood current velocities in the Delaware Bay range from 0.8 to 2.7 knots and from 0.9 to 2.4 knots, respectively, depending on location. The Delaware River opposite Wilmington has peak tidal currents of 1.4 knots while 2.4 knots at Philadelphia opposite the Navy Yard is the highest current predicted on the Delaware River below Trenton.

3.2. Socioeconomic Profile of the Domestic Economic Hinterland

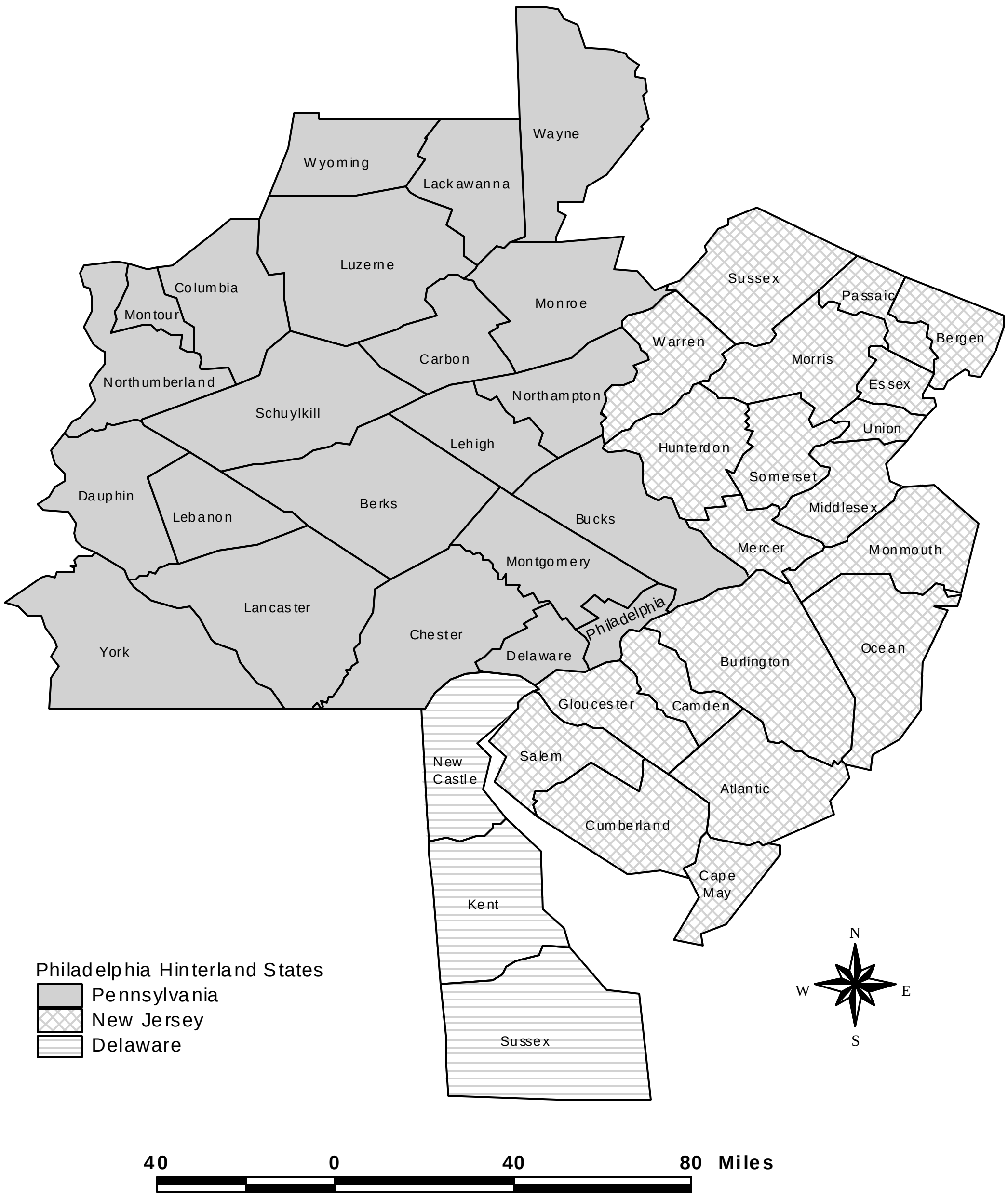
The Port's hinterlands encompass the domestic origins and destinations for waterborne commodities that pass through the Port. These interior origins and destinations are linked to the Port through the existing intermodal network, which includes rail, truck, air, pipeline, and water (barges). In general, the extent of the economic hinterlands of the Port is the result of shipping decisions made by individual commercial enterprises in the hinterlands and overseas. Their shipping decisions involve: (1) selection of the port that will be the marine terminus of overseas commerce; and (2) intermodal connections to or from the selected port. These choices are typically made on the basis of shipping costs, delivery schedules, and cargo handling requirements.

3.2.1. Domestic Economic Hinterland Delineation

Three zones were selected to describe the hinterland of the Delaware River Port System. These zones are a core hinterland, a four-state hinterland, and a 17-state hinterland. As shown in Figure C-1, the core hinterland is the greater Philadelphia metropolitan area. This area includes 45 counties: 22 counties in eastern Pennsylvania; 20 counties in New Jersey; and the three counties of Delaware.

The second, larger hinterland zone consists of the four states that are near the Delaware River Port System (see Figure C-2). The 4-state region encompasses all of Pennsylvania, New Jersey, Delaware, Maryland, and the District of Columbia. The third, largest hinterland zone is comprised of the 17-state region (plus the District of Columbia) that extends from Maine to Virginia and west to Illinois. The 17-state region encompasses Pennsylvania, New Jersey, New York, Massachusetts, Rhode Island, New Hampshire, Vermont, Connecticut, Maine, Delaware, Maryland, Ohio, Michigan, Indiana, Illinois, Virginia, West Virginia, and the District of Columbia (see Figure C-3).

Figure C-1
Core Hinterland



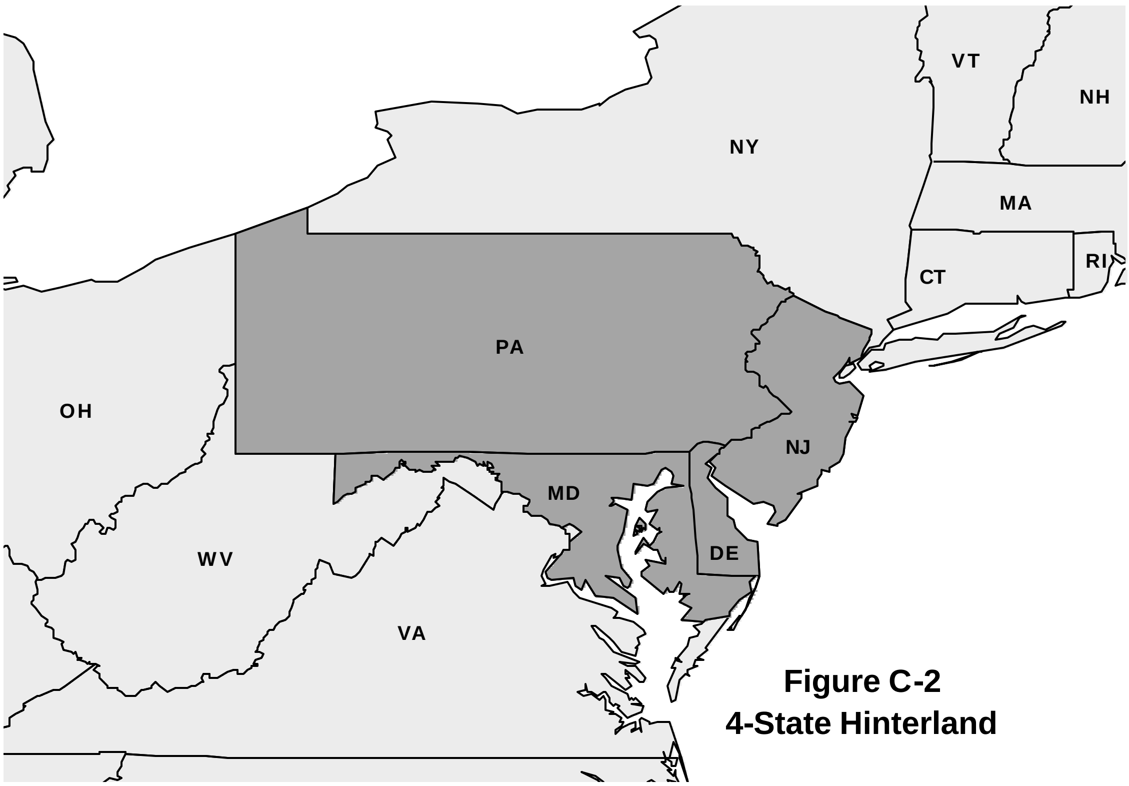
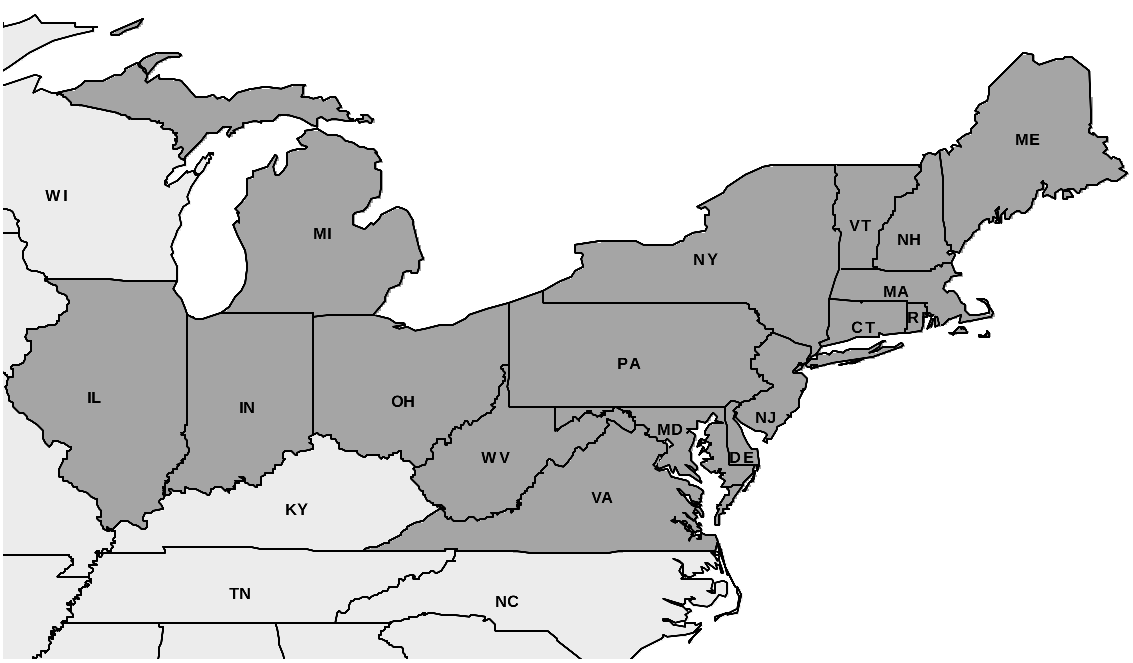


Figure C-2
4-State Hinterland

Figure C-3
17-State Hinterland



3.2.2. Economic Hinterland Population, Income, and Employment

Current socio-economic data for the counties in the core hinterland and 4-state hinterland were obtained from the 2000 Census data presented by the U.S. Bureau of the Census. Projections to the year 2045 were estimated by applying the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) projected growth rates for the states and income to the Census data. The U.S. Bureau of the Census conducts an economic census every five years, with the most recent being 1997. Therefore, data presented in Table C-3 for the year 2000 are BEA estimates for 2000, and not primary data based on Census collection. For the 17-state hinterland, state-level data were obtained from the BEA. Regional data were aggregated from BEA state-level data. Data for the continental United States were calculated by subtracting individual state data for Alaska and Hawaii from BEA data for the entire United States.

Population

Table C-1 shows projected population levels for the three hinterland zones. The 17-state hinterland contains almost 40 percent of the population of the continental United States. The populations in the core hinterland and four-state hinterland are expected to grow more slowly than the national average due to the rapid population increases anticipated for the western states.

Income

Income levels in the three hinterland zones suggest their potential to generate imports and exports for the Delaware River Port System, because they imply consumer spending power and serve as broad measures of economic activity. Table C-2 shows projected per capita and total personal income levels for the hinterland zones. Per capita incomes in the core region, the four-state region, and the 17-state (plus the District of Columbia) region exceed the national average by 16-, 11-, and 8-percent, respectively. Estimates of 2000 total personal income indicate that the 17-state (plus the District of Columbia) region accounts for approximately 42 percent of the nation's total personal income. Total personal income is expected to grow by a smaller percentage in the 45-county sub-region than in the 4-state or 17-state (plus the District of Columbia) region.

Employment

Table C-3 shows estimated employment by sector for the core hinterland, the four-state hinterland, and the 17-state hinterland for the years 2000, 2015, and 2045. For the 2000-2045 period, all-industry employment growth rates in the 45-county metropolitan area, in the four-state region and in the 17-state (plus the District of Columbia) region are expected to be slower than projected national growth rates. This is consistent with the expected slower growth in total population for these regions relative to the nation.

The 2000-2045 sectoral employment forecasts suggest that the three hinterland zones – and the nation as a whole – will continue their current transitions from manufacturing to service economies. For the core hinterland, the four-state hinterland, and the 17-state hinterland, manufacturing employment is expected to decline, while employment in the construction and services sectors is expected to grow significantly.

Table C-1
Estimated Population of Port Hinterlands (000s)

Year	Core Hinterland	4-State Hinterland*	17-State Hinterland*	Continental U.S.*
2000	15,835	27,348	108,925	279,583
2015	17,430	30,163	118,824	310,857
% change 2000-2015	10.1%	10.3%	9.1%	11.2%
2045	20,755	35,990	140,557	378,986
% change 2015-2045	19.1%	19.3%	18.3%	21.9%

Sources: U.S. Department of Commerce, Bureau of Economic Analysis & Bureau of the Census
* includes Washington D.C.

Table C-2
Estimated Per Capita and Total Income of Port Hinterlands

Income Category	Year	Core Hinterland	4-State Hinterland*	17-State Region*	Continental U.S.*
Per Capita Income (dollars)	2000	$34,149	$32,897	$32,000	$29,550
	2015	$39,135	$37,728	$36,896	$34,880
	% change 2000-2015	14.6%	14.7%	15.3%	18.0%
	2045	$49,069	$47,437	$46,763	$44,474
	% change 2015-2045	25.4%	25.7%	26.7%	27.5%
Total Income (millions of dollars)	2000	$540,769	$899,639	$3,485,546	$8,261,665
	2015	$682,117	$1,137,983	$4,384,174	$10,842,821
	% change 2000-2015	26.1%	26.5%	25.8%	31.2%
	2045	$1,018,425	$1,707,263	$6,572,872	$16,854,919
	% change 2015-2045	49.3%	50.0%	49.9%	55.4%

Sources: U.S. Department of Commerce, Bureau of Economic Analysis and Bureau of the Census
* includes Washington D.C.

Table C-3
Estimated Employment Characteristics of the Port Hinterlands
Thousands of Jobs (percent change from 2000)

Employment	Year	Core Hinterland	4-State Hinterland*	17-State Region*	Continental U.S.*
All-Industry Total	2000	9,153	15,748	61,618	156,423
	2015	10,271 (12%)	17,692.1 (12%)	68,904 (12%)	180,751 (16%)
	2045	11,425 (25%)	19,757.6 (25%)	76,950 (25%)	207,133 (32%)
Farm	2000	58.2	115.9	665.4	3,000.3
	2015	53.7 (-8%)	106.6 (-8%)	605.2 (-9%)	2,766.9 (-8%)
	2045	46.6 (-20%)	92.2 (-20%)	517.6 (-22%)	2,400.6 (-20%)
Mining	2000	6.0	30.8	151.8	816.1
	2015	5.1 (-15%)	26.2 (-15%)	129.9 (-14%)	729.9 (-11%)
	2045	4.4 (-27%)	22.4 (-27%)	110.1 (-27%)	632.1 (-23%)
Construction	2000	451.0	740.5	2,827.3	7,794.6
	2015	504.4 (12%)	823.6 (11%)	3,149.9 (11%)	9,015.3 (16%)
	2045	559.8 (24%)	910.7 (23%)	3,511.1 (24%)	10,338.1 (33%)
Manufacturing	2000	1,061.8	1,687.2	7,790.2	18,847.9
	2015	969.3 (-9%)	1,548.1 (-8%)	7,358.8 (-6%)	18,696.9 (-1%)
	2045	914.8 (-14%)	1,469.6 (-13%)	7,223.4 (-7%)	19,145.5 (2%)
Transportation, Communication, Utilities	2000	488.3	774.8	2,808.7	7,270.4
	2015	533.7 (9%)	845.0 (9%)	3,052.1 (9%)	8,229.8 (13%)
	2045	580.6 (19%)	920.2 (19%)	3,323.1 (18%)	9,268.4 (27%)
Wholesale & Retail Trade	2000	1,936.2	3,271.7	12,957.0	33,559.7
	2015	2,137.7 (10%)	3,614.6 (10%)	14,315.3 (10%)	38,434.3 (15%)
	2045	2,347.7 (21%)	3,982.4 (22%)	15,843.2 (22%)	43,751.7 (30%)
Financial, Insurance & Real Estate	2000	845.2	1,246.2	4,886.4	11,392.3
	2015	947.3 (12%)	1,395.9 (12%)	5,424.5 (11%)	13,042.1 (14%)
	2045	1,055.5 (25%)	1,558.1 (25%)	6,026.2 (23%)	14,859.1 (30%)
Services	2000	3,130.5	5,415.6	20,310.7	49,108.1
	2015	3,872.0 (24%)	6,705.5 (24%)	24,970.6 (23%)	62,435.1 (27%)
	2045	4,589.5 (47%)	7,983.1 (47%)	29,707.2 (46%)	76,313.2 (55%)

Sources: U.S. Department of Commerce, Bureau of Economic Analysis and Bureau of the Census

* includes Washington D.C.

3.3. Institutional Profile of the Port

A variety of public and private organizations are involved with the operation of the Delaware River Port System. These organizations are profiled below, arranged into three categories: Federal agencies, state and regional agencies and organizations, and other organizations. The institutional profile is not intended to be comprehensive. Instead, the purpose is to identify the most important organizations involved with the port and describe their involvement.

3.3.1. Federal Agencies

The following Federal agencies are involved with operation of the Delaware River Port System and implementation of navigation improvements to waterways within the complex.

- **U.S. Army Corps of Engineers (Corps)**: The Corps is the Federal agency with primary responsibility for navigation improvements. The Federal interest in navigation improvements stems from the Commerce Clause of the Constitution. Subsequent Supreme Court decisions have established that the Federal obligation to regulate navigation includes the right to make necessary improvements in waterways. The primary objective of navigation improvements is to assist in the development, safety, and conduct of waterborne commerce. This is done by deepening and widening waterways so commercial vessels can move efficiently and safely.
- **U.S. Coast Guard (USCG)**: USCG authority includes maritime law enforcement, placement and maintenance of aids to navigation, supervision over the anchorage and movement of vessels, the handling of explosives and other dangerous vessel cargoes, and safeguarding life and property on the high seas. It also enforces laws relating to oil pollution, immigration, quarantine and numerous statutes under the jurisdiction of other Federal agencies that require marine personnel and facilities.
- **Environmental Protection Agency (EPA)**: The EPA and the Corps have established the guidelines for evaluation of water quality impacts associated with the disposal of dredged material as required by Section 404(b) (1) of the Clean Water Act of 1977 (CWA). Similarly, the EPA and the Corps have developed the evaluative criteria for the specification of ocean dumping sites in accordance with the Marine Protection, Research, and Sanctuaries Act. EPA also maintains a veto authority over decisions made by the Corps regarding specification of disposal sites under section 404(c) of the CWA.
- **U.S. Fish and Wildlife Service (USFWS)**: USFWS is responsible for evaluation of project impacts to fish and wildlife resources and recommendations concerning the conservation of those resources and mitigation of impacts. Those recommendations must be considered in project planning (Fish and Wildlife Coordination Act). Enforcement and coordination under the Endangered Species Act is primarily the responsibility of the USFWS.
- **National Marine Fisheries Service (NMFS)**: NMFS is responsible for evaluation of project impacts on marine life and enforcement coordination under the Endangered Species Act for endangered species in the marine environment.
- **National Park Service, Office of Archeological Services (OAS)**: OAS is charged with overseeing the historic preservation program established as a result of the Archeological and Historic Preservation Act of 1974. A primary function is the review of historic preservation reports prepared by various Federal agencies.
- **Federal Maritime Commission (FMC)**: FMC is involved in two areas of commercial navigation: regulating shipping practices and ensuring financial responsibility for water pollution cleanup. The FMC licenses ocean freight forwarders and maintains surveillance over services, practices, and agreements to assure equitable treatment to all segments of the maritime industry and the general public. The FMC also administers a provision of the Water Pollution Control Act of 1970 (PL 92-500) requiring the owner or

operator of every vessel over three hundred gross tons to establish and maintain evidence of financial responsibility for assuming the cost of removing oil discharged into navigable waters.

- **Maritime Administration (MARAD)**: MARAD administers Federal laws designed to promote and maintain a U.S. merchant marine fleet capable of meeting the Nation's shipping needs for both domestic and foreign commerce and national security. To carry out its mandate, MARAD assists the maritime community in the areas of ship design and construction, development of advanced transportation systems and equipment, and promotion of the use of U.S. flag vessels.

3.3.2. State and Regional Agencies and Organizations

The following state agencies and regional organizations are involved with operation of the Delaware River Port System.

- **Delaware River Port Authority (DRPA)**: DRPA is a Federally chartered, bi-state (Pennsylvania and New Jersey) authority. In its charter, DRPA is charged with promoting commerce for the public and private port facilities along the Delaware River. DRPA's World Trade Division provides international and domestic marketing services for these terminals. In 1988, the governors of Pennsylvania and New Jersey proposed a program to unify the port facilities under DRPA's direction. That commitment was reinforced in 1991 by a joint letter signed by the two governors in which they publicly supported changes in DRPA's compact giving it broader authority over port enhancement and regional economic development.
- **Philadelphia Regional Port Authority (PRPA)**: PRPA is an independent agency of the Commonwealth of Pennsylvania charged with the management, maintenance, marketing, and promotion of the public port facilities along the Delaware River in Philadelphia. PRPA was established in 1990 by the Commonwealth of Pennsylvania to increase coordination of port facilities and projects within an established regional port zone along the Delaware River. PRPA's jurisdiction includes the function and property of the Philadelphia Port Corporation, including the Tioga and Packer Avenue Marine Terminals.
- **South Jersey Port Corporation (SJPC)**: SJPC was created as an agency of the New Jersey Department of Commerce and Economic Development in 1968. SJPC has jurisdiction over port facilities between Trenton and Cape May. Jurisdiction of the ports in the area is shared with the Delaware River Port Authority and the Delaware River and Bay Authority. The SJPC operates two terminal facilities (Beckett Street and Broadway Terminals) under an agreement with the Camden Municipal Port Authority.
- **Diamond State Port Corporation (DSPC)**: DSPC was created in 1995 as a subsidiary corporation owned by the state of Delaware to operate, maintain, and improve the Port of Wilmington.
- **State Government Agencies**: The six state agencies listed below are the principal state agencies involved with operation of the Delaware River Port System and with implementation of navigation improvements. Each of the state environmental agencies is tasked with the responsibility to conserve and maintain natural, scenic and aesthetic

values of the environment and to assure its residents clean air and clean water. All three environmental agencies are responsible for their respective state's Coastal Zone Management Program, and issue Water Quality certificates for disposal of dredged or fill material under Section 401 of the Clean Water Act. All three state transportation departments have indirect navigational responsibility in planning and developing highway and rail access to port facilities.

- Delaware Department of Natural Resources and Environmental Control,
- New Jersey Department of Environmental Protection,
- Pennsylvania Department of Environmental Resources,
- Delaware Department of Transportation,
- New Jersey Department of Transportation, and
- Pennsylvania Department of Transportation.

3.3.3. Other Organizations

Other organizations are actively involved with operation of the Delaware River Port System. These organizations include the Pilots' Associations for the Bay and Delaware River, the International Longshoremen's Association, and several local business associations. These organizations are profiled below.

- **Pilots' Association for the Bay and River Delaware**: The Delaware River pilots are responsible for safe passage of deep-draft vessels through the commercial waterways of the Delaware River Port System. Pilotage of international trade vessels in the United States is regulated by the individual states, each of which maintains a pilotage system that is suited to the particular needs and circumstances of its own waters. Every foreign-flag vessel and every United States-flag vessel engaged in international trade moving in the waters of a state is required by the state(s) to take a pilot licensed by the state. Navigation of a vessel in U.S. pilotage waters is considered to be a shared responsibility between the pilot and the master/bridge crew. Pilots are expected to act in the public interest and to maintain professional judgment consistent with the needs of maritime safety.
- **International Longshoremen's Association, AFL-CIO (ILA)**: The ILA is the largest union of maritime workers in North America, representing upwards of 65,000 longshoremen on the Atlantic and Gulf Coasts, Great Lakes, major U.S. rivers, Puerto Rico and Eastern Canada. In October 1996, the ILA and Carriers Container Council negotiated an unprecedented five-year Master Contract agreement for container handling at ILA ports from Maine to Texas.
- **Local Business Associations**: Private interests in port development along the Delaware River have formed two prominent organizations. The first, the Joint Executive Committee for the Improvement and Development of the Ports of Philadelphia, is an organization primarily interested in channel and harbor development in the tri-state area. The second, the PENJERDEL Council, seeks to promote port commerce as part of its concern for the region's economic prosperity.

3.4. Delaware River Marine Terminals and Associated Maritime Operations

The Delaware River Port System is comprised of liquid bulk, dry bulk, container, and general cargo facilities. Facilities that are potentially affected by main channel deepening are profiled below. Figure C-4 shows the approximate locations of these terminals.

3.4.1. Liquid Bulk Terminals

The liquid bulk terminals include six refineries and a variety of smaller liquid bulk terminals that primarily handle petroleum products.

Refineries

The six Delaware River refineries bring in crude oil via tanker for refinement and distribution to regional markets primarily via pipeline. The throughput capacity of these facilities and receipts of crude oil for 1999, 2000, and 2001 are summarized in Table C-4. Descriptions of these facilities and their maritime transportation operations are provided below. As part of this investigation, all of these facilities (with the exception of Motiva) were visited, and interviews were conducted with the management to assess their potential to benefit from deepening the main channel Delaware River. Specifically, refinery managers were queried about the following subjects:

- Current and future refinery capacity (processing and storage),
- Current and future crude oil requirements,
- Current and future marine transportation operations (e.g., vessels used, lightering activities) under without project conditions, and
- Potential responses to channel deepening (e.g., vessels, lightering, infrastructure modifications).

Table C-4
Profile of Delaware River Refineries

Refinery	Crude Oil Received (barrels/day)			Throughput Capacity (barrels/day)	Capacity Utilization Rate		
	1999	2000	2001	2000	1999	2000	2001
Coastal Eagle Point	127,825	140,049	119,090	143,000	89.4%	97.9%	83.3%
Valero Refining	153,614	154,386	149,047	155,000	99.1%	99.6%	96.2%
Sunoco - Marcus Hook*	163,970	205,181	268,953	175,000	93.7%	117.2%	153.7%
Sunoco – Fort Mifflin*	313,907	264,989	194,649	330,000	95.1%	80.3%	59.0%
Phillips 66 (Tosco)	164,405	174,858	140,537	180,000	91.3%	97.1%	78.1%
Motiva	158,956	145,142	159,334	175,000	90.8%	82.9%	91.1%

* the Sunoco refineries are physically connected and operationally integrated, combined capacity utilization is 90 percent
Source: Energy Information Administration of the U.S. Department of Energy

As will be evident in the profiles, all of the refineries have marine transportation operations that are constrained by the 40-foot depth of the Delaware River main channel. In addition, Motiva is further constrained by rapid shoaling of its access channel. Economies of scale dictate that crude oil is transported on the largest vessel possible. Very large crude carriers (VLCCs) have design drafts of 70 feet or more. Suezmax tankers typically draw between 55 and 57 feet. The prevailing pattern of crude transport operations in response to current Delaware River channel dimensions is to bring fully loaded Suezmax tankers into the Delaware Bay through naturally deep water up to Big Stone Beach anchorage. This anchorage is on the Delaware side of the Bay approximately five and one-half nautical miles northeast of Cape Henlopen. At the anchorage, the tankers discharge (lighter) a portion of their cargo sufficient to allow them to proceed upriver to their respective destinations. At this time, commercial lightering operations are conducted by one company, Maritrans Inc. Several of the refineries also conduct their own lightering or transshipment operations at other locations. Lightering operations and economics will be discussed in more detail in subsequent sections of this appendix.

Sun Oil Company

Sun Oil Company (Sunoco) and Sun Pipeline Company, a Master Limited Partnership with Sunoco as general partner, operates two refineries on the Delaware River: one at Marcus Hook, Pennsylvania, and one in south Philadelphia. The two Sun Oil refineries are served by three deep-draft terminals: Ft. Mifflin, Hog Island, and Marcus Hook. Each of the terminals currently accommodates vessels drawing up to 40 feet, with additional berths for barges.

The three Sunoco facilities are operationally integrated and physically interconnected. Their combined crude oil capacity is 500,000 barrels (bbl) per day, and their aggregate storage capacity is approximately 15.4 million bbl. The irregular capacity utilization rates contained in Table G-4 reflect "turnaround" (i.e., maintenance downtime and equipment modifications). A representative long-term capacity utilization factor for the combined Sunoco facilities would be 90% per year. No expansions of capacity are anticipated in the foreseeable future, and no significant increase in crude oil requirements is anticipated.

The three Sunoco facilities require 15 one million bbl lots of crude oil per month. Sunoco brings in primarily West African crude, and some crude from other sources (e.g., North Sea), on large tankers that require lightering. Sunoco has chartered two custom-built VLCCs that have the ability to access Big Stone Beach anchorage (55 feet MLW depth) fully loaded, without offshore lightering (prior to entering Delaware Bay). These wide-beamed vessels (the *Stena Victory* and the *Stena Vision*) carry two million bbl each, when fully loaded to 55 feet. Currently, Sunoco typically brings in two Stenas (two million bbl each) and 11 Suezmax tankers (one million bbl each) per month. If market conditions dictate, Sunoco would consider shifting their fleet to three Stenas and nine Suezmax tankers.

The Stenas and the Suezmax tankers are lightered at Big Stone Beach anchorage to allow them to proceed upriver with light loads. The Stena-class VLCCs are lightered to 36 feet, which is less than the 40-foot standard operating draft for the Suezmax tankers, due to concerns about their squat, which is potentially exaggerated by their wide beam. The Stenas and the Suezmax tankers come slowly upriver "drifting" the rising tide to provide additional underkeel clearance.

Sunoco also imports some non-crude liquid bulk by tanker, generally Panamax-class vessels from Europe or South America. Commodities include assorted feedstock for refinery operations and gasoline for blending. There are also some shipments of refined product from the refinery. Due to changes in the industry, shipments of product to/from the refinery are expected to significantly increase in the future.

If the main channel is deepened to 45 feet, Sunoco would likely deepen their tanker berths to 45 feet, specifically Dock A at Ft. Mifflin and/or Dock 3C at Marcus Hook. The principal benefit of the project to Sunoco would be the reduced lightering costs associated with lightering to 45 feet, rather than 40 feet. Sunoco would also consider increasing their usage of Stena VLCCs. No change in landside facilities would be required, since there are currently no storage or landside capacity constraints. Lighter barges can be offloaded at different facilities than the tanker, providing operational flexibility. Sunoco also expressed an interest in moving refinery feedstock and/or product in/out on larger Afromax tankers, which draw 40 to 45 feet when fully loaded.

The benefits of channel deepening to Sunoco have been compared to the associated costs Sunoco would have to incur to deepen their berths. Benefits to Sunoco exceed their costs by a factor of 13 to 1, indicating that it would be in Sunoco's interest to invest in the facility improvements necessary to benefit from the deepening project.

Valero Enterprises

Valero Enterprises operates a refinery in Paulsboro, New Jersey. The refinery has approximately 195,000 bbl/day throughput capacity, of which approximately 155,000 is crude with other feedstock accounting for remainder. The capacity utilization rates estimated in Table C-4 are accurate (>95% per year), including "turnaround" (e.g., maintenance downtime and equipment modifications). No expansions of refinery capacity are anticipated in the foreseeable future (5-8 year planning horizon). While refinery upgrades are ongoing to produce cleaner auto and diesel fuels, no increases in overall capacity are anticipated (i.e., no significant increase in crude imports).

Currently Valero brings in Mideast sour crude on ships that can navigate the existing channel fully loaded without lightering. In response to constrained depths in the Delaware River, Valero carries crude on VLCCs to a deep-water Caribbean port (St. Eustacius), where the oil is transshipped to smaller tankers. Valero uses the existing channel depth to the maximum extent possible. Average sailing drafts of the smaller tankers arriving at Valero in the year 2000 was 39 feet. Valero actively avoids lightering at Big Stone Beach. During the year 2000, Valero conducted a trial experiment and brought in several larger vessels that were lightered at Big Stone Beach and found it to be more expensive than current operations, due to lightering and demurrage charges.

With the main channel deepened to 45 feet, Valero indicated that they would likely deepen their tanker berth (Berth 1) to 45 feet. Valero would then bring in crude on fewer, larger vessels that could navigate the deepened channel fully loaded without lightering, consistent with current operations. Valero uses vessels obtained from the charter market, so there is not a major cost in shifting their fleet. Also, two thirds of the vessels calling at Valero in the year 2000 had design drafts of 45 feet or greater, so only the smallest one third of the fleet would need to be upgraded to larger vessels in order to take advantage of the deepening project.

Valero does not anticipate changing Caribbean transshipment operations or adopting lightering as a regular operation at this time. However, if the project were deepened to 45 feet, and if Valero decides to invest in additional storage (see discussion below), then they would evaluate shifting to a lightering operation similar to that employed by Sunoco. Valero officials indicated that they would change operational practices only if they determine that the cost savings would exceed the amount they will save by continuing their current operational practices in a deepened 45-foot channel.

To accommodate larger shipments associated with larger tankers, Valero would need to expand landside storage. Valero has conducted preliminary studies of expanding storage capacity under without project conditions as part of refinery improvements. A deepened channel would provide additional impetus for this action. Valero has conducted preliminary analyses of storage augmentation and has estimated that the cost would be in the $20-$40 million range. Most of these costs would be for operational efficiency improvements (i.e., they are not required for the deepening project). In its preliminary analysis, Valero estimated that approximately $5 million of the total storage costs would be needed to augment storage in response to the navigation project.

The benefits of channel deepening to Valero have been compared to the associated costs Valero would have to incur to deepen their berths and supplement existing storage capacity. Benefits to Valero exceed their costs by a factor of 12 to 1, indicating that it would be in Valero's interest to invest in the facility improvements necessary to benefit from the deepening project.

Coastal Eagle Point Refining Company

Coastal Eagle Point Refining Company is a subsidiary of El Paso Energy Corporation. Coastal has the capacity to process approximately 140,000 bbl/day of crude on a regular basis (i.e., including maintenance and downtime associated with plant modifications). While refinery processes and products will change over time, Coastal does not anticipate significant changes in the volume of crude oil imports.

Typically, Coastal uses Suezmax tankers, which are lightered at Big Stone Beach anchorage. Occasionally, Panamax tankers, which do not require lightering when fully-loaded, are used. Refinery products are shipped primarily by pipeline, with some barge shipment. Occasionally, small tankers are used to bring in non-crude feedstock or product (for blending) or to ship product to refinery customers. Coastal anticipates continued use of these vessels and these operations under with project and without project conditions.

Coastal does not expect to benefit from channel deepening because of their concern that lightering fees will be raised. Based on this concern, Coastal considers it possible that their transportation costs could increase under with project conditions. Their rationale is based upon their view of the dominant position that Maritrans has in the lightering market. Coastal officials believe that reduced lightering activity in Delaware Bay associated with channel deepening could potentially induce Maritrans to raise lightering fees to maintain revenues in the face of declining lightered volumes, or abandon lightering operations at Big Stone Beach, forcing Coastal to invest in their own lightering equipment and operations. Given their position, Coastal will not consider investments in berth modifications to take advantage of a deeper channel at this time. However, Coastal officials also indicated, and preliminary engineering investigations confirmed, that their berth is subject to scour and therefore berth modifications and the incremental maintenance needed to benefit from the 45 foot project would be minimal. No storage augmentation beyond their existing 8.6 million bbl would be required under with project conditions.

Coastal acknowledges that the 45-foot project could reduce their transportation costs if lightering fees remain stable and could make berth modification economical, but they expect lightering fees to increase. For this reason, their position is to wait and see, and to respond to prevailing conditions (physical and economic) that accompany channel deepening.

The benefits of channel deepening to Coastal have been compared to the associated costs Coastal would have to incur to deepen their berths. Benefits to Coastal exceed their costs by a factor of 97 to 1, assuming the lightering charge/bbl remains stable. As a sensitivity analysis, transportation cost savings were recomputed for Coastal, assuming that the representative rate that Maritrans stated they currently charge for lightering ($0.37/bbl) is increased by 20 percent under with project conditions (to $0.42/bbl). Under this scenario, average annual transportation cost savings for Coastal would drop by $459,704 to $1,735,051. Even with a lightering rate change of this magnitude, which is considered to be highly unlikely based upon historical pricing practices by Maritrans, project-related improvements would still be a highly justified expenditure for Coastal. In fact, the Maritrans' lightering charge would have to increase to over $0.59/bbl (an increase of over 59 percent) for transportation costs savings to decrease for Coastal to the "break even" point. This indicates that it would be in Coastal's interest to invest in the facility improvements necessary to benefit from the deepening project.

Phillips 66

Phillips 66 operates a refinery (formerly owned by Tosco) in Trainer, Pennsylvania. The Trainer refinery has the capacity to process approximately 180,000 bbl/day of crude on a regular basis (i.e., including maintenance and downtime associated with plant modifications). The mix of products changes over time depending on market conditions and environmental regulations. No expansion of total crude refining capacity is anticipated in the near future.

The refinery has approximately 3.5 million bbl of total storage (i.e., for crude and product), which limits their ability to handle larger shipments of crude. With current storage, tankers are sometimes forced to wait at berth for tank space to become available.

The Boroughs of Trainer and Marcus Hook physically hem in the Trainer refinery. This space limitation constrains installation of additional process or storage facilities. Phillips has applied for permits to fill an adjacent wetland area along the Delaware River (with mitigative wetland creation) to augment area for the Trainer facility. The need for additional processing facilities is the impetus for this expansion. It is uncertain whether this additional area would be used to augment storage capacity.

Refinery products are shipped primarily by pipeline, although barges also handle a variety of products. Tankers are not generally used to bring in feedstock or product (for blending) or to ship product to customers.

The Trainer refinery is operated in conjunction with Phillips' Bayway, New Jersey refinery located on the Arthur Kill in New York / New Jersey Harbor. Both facilities receive crude from a variety of sources around the Atlantic Basin, typically carried on Suezmax tankers (1 million bbl capacity, drawing 57 feet fully-loaded). The Suezmax tankers are lightered offshore in deep water by Phillips onto custom-built Eagle-class tankers (700,000 bbl capacity, drawing 42 feet fully-loaded), which are on long-term charter. Typically, the Eagle tankers carry approximately 650,000 bbl when entering the Delaware River. They are light-loaded to allow them passage up the Delaware River or into New York harbor, and the amount transferred from the Suezmax tanker is sufficient to allow it to also enter port at high tide. Although the small and large tankers typically proceed to the same port, they can proceed to different facilities, as needed.

Phillips expects to continue its own lightering operations regardless of deepening of the main channel (i.e., under both with project and without project conditions). Phillips has four of these Eagle class tankers on long-term charter, with five more on order. In addition to their use as lighters for New York Harbor and the Delaware River, these tankers are used for other Phillips operations.

Occasionally, larger Phillips tankers are lightered by Maritrans onto barges at Big Stone Beach anchorage in Delaware Bay, if weather conditions do not support offshore ship-to-ship lightering. Approximately 11 percent of Phillips' delivered tonnage was lightered by Maritrans in 2000. No ship-to-ship transfers are conducted within the Bay.

There is only one refinery berth at the Trainer facility suitable for the Suezmax or Eagle tankers. Deepening this berth would be relatively expensive due to rock underlying the current 40-foot depth, and lack of structural integrity of the dock. The berth accumulates significant amounts of sediment, approximately 100,000 to 150,000 cubic yards per year, requiring costly yearly maintenance dredging to maintain 40 feet.

Due to their relatively high associated costs and current operational practices, Phillips' officials were uncertain about their potential to benefit from the project during their interview. This uncertainty is based on their physical, economic, and operational constraints. Phillips will evaluate investments necessary to take advantage of a deeper channel if/when the project is implemented. In evaluating their potential response to channel deepening, Phillips would compare the following costs against potential transportation savings: (1) the cost of berth and dock modifications (including rock removal), (2) the potential for increased maintenance dredging cost if the channel and berth are deepened, and (3) the need for additional storage to accommodate larger deliveries at one time from the Suezmax tankers

The benefits of channel deepening to Phillips have been compared to the associated costs Phillips would have to incur to deepen and modify their berth. Benefits to Phillips exceed their costs by a factor of nearly 5 to 1, indicating that it would be in Phillips' interest to invest in the facility improvements necessary to benefit from the deepening project.

Motiva Enterprises

Motiva Enterprises operates the former Getty refinery in Delaware City, Delaware. This refinery has a throughput capacity of approximately 175,000 bbl/day. The Motiva facility has approximately 8.9 million bbl of storage capacity. This refinery typically brings in Suezmax tankers, which are lightered by Maritrans at Big Stone Beach anchorage.

The Motiva tanker berth is approximately 38 feet deep. However, rapid sedimentation of the berths and access channel results in costly maintenance dredging and reduces channel depths. Motiva attempts to maintain a 38-foot access channel, but excessive shoaling can reduce access channel depths to 32 to 33 feet between maintenance cycles. Motiva is concerned that their shoaling problems could be exacerbated by deepening the Delaware River main channel. As a result, Motiva is not supportive of main channel deepening. However, a shoaling analysis conducted during Preconstruction Engineering and Design (PED) does not support this conclusion, indicating that no increase in shoaling is anticipated in Motiva's entrance channel.

Other Liquid Bulk Terminals

There are a variety of smaller liquid bulk terminals along reaches of the Delaware River that are under consideration in this study. Most of these facilities handle petroleum products. Based on an analysis of vessel sailing drafts and commodities handled, as well as contacts with selected terminals, Delaware Terminal, located at the Port of Wilmington, is the only non-refinery liquid bulk facility that has a potential to benefit from main channel deepening.

Delaware Terminal

Delaware Terminal Company currently brings in petroleum products (#6 fuel oil, diesel, and home heating oil) by tanker to their facility within the Port of Wilmington along the Christina River (authorized depth of Federal channel, - 38 feet MLW).

Delaware Terminal currently has 1.6 million bbl of storage capacity. They have applied for a permit to augment storage by 1 million bbl. If the permit is approved, officials have indicated that they would construct 340,000 bbl of this additional capacity immediately.

Delaware Terminal currently brings in approximately one tanker per month. The tankers bring petroleum products from a variety of sources. Venezuela is their most important source. The tankers have design drafts in the 41- to 43-foot range. However, due to shoaling problems in the Christina River, the authorized 38-foot depth is frequently not available. Consequently, the tankers must be either lightered or lightloaded to achieve sailing drafts in the 33- to 37-foot range. Delaware Terminal's products are shipped out by barge and pipeline.

Delaware Terminal is evaluating the feasibility of installing a berth at Pigeon Point south of the new auto facility in naturally deep water. A pipeline would be needed to connect to their storage facilities in the Port of Wilmington complex. Delaware Terminal has retained an engineering consultant to conduct pre-construction engineering studies and have scheduled construction of the new facility for 2007. With access to the 40-foot main channel of the Delaware River, there would be immediate savings due to reduced lightering and lightloading. These savings would accrue to the without project condition.

With main channel deepening to 45 feet, Delaware Terminal could bring in larger tankers than currently used, further reducing transportation costs beyond the without project condition (40 feet). Under the with project conditions, there could also be new opportunities for Delaware Terminal beyond their current operations. For instance, Delaware Terminal has discussed with Motiva in Delaware City the potential to have Delaware Terminal receive crude from large tankers for the Motiva refinery and ship it via pipeline (unbuilt) to Delaware City.

3.4.2. Container, Bulk, Breakbulk, and General Cargo Terminals

Existing conditions are described below for those bulk, breakbulk, and general cargo (including container) facilities that are expected to benefit from Delaware River main channel deepening. There are a wide variety of marine terminals in the Delaware River Port System actively involved in bulk, breakbulk, container, and general cargo shipping. An in-depth analysis was conducted for each facility to evaluate its potential to benefit from main channel deepening. The analysis included the following considerations:

- Location relative to reaches of the Delaware River under consideration for deepening,
- Landside storage and handling capacity,
- Current and potential commodities handled (type and volume),
- Current and potential trade routes associated with those commodities (including depth at foreign ports),
- Current and potential depth at facility berth(s), and
- Current and potential vessels employed.

In addition, interviews were conducted with owners and operators of facilities with potential to benefit. Through the interviews, some facilities were screened out as potential beneficiaries. For those marine terminals that could take advantage of a deeper main channel, their current and future operations were discussed in detail during the interviews. Those bulk, breakbulk, container, and general cargo facilities that have firm potential to benefit from main channel deepening are profiled in Table C-5 and the discussions below. The focus on these facilities is not intended to diminish the potential of other facilities to benefit from main channel deepening. Rather, the intent is to identify those marine terminals that clearly would achieve transportation cost savings and thereby increase the net value of the national output of goods and services (i.e., generate NED benefits).

Table C-5
Bulk, Breakbulk, and General Cargo Facilities
Anticipated to Benefit from Main Channel Deepening

Terminal	Depth of Access Channel & Berths (feet MLW)	Owner	Operator	Cargo Currently Handled
Packer Avenue Philadelphia, PA	40	PRPA	Greenwich Terminals	containers, steel, frozen meat, fruit
Beckett Street Terminal Camden, NJ	40	SJPC	SJPC	breakbulk, dry bulk (blast furnace slag, wood products, cocoa beans)
Port of Wilmington, DE	38	DSPC	DSPC	fruit, bananas, juice concentrate, meat

Packer Avenue Marine Terminal

The Philadelphia Regional Port Authority (PRPA) is the owner of the Packer Avenue Marine Terminal, which is leased to Greenwich Terminals (formerly Holt Cargo Systems, Inc.) for an extended term (more than 60 years remaining on a 100-year lease). The Packer Avenue Marine Terminal handles containerized and conventional general cargo, roll-on/roll-off vehicle cargo, steel, and fruit. The terminal, which occupies 106 acres, has a refrigerated warehouse and 380 reefer outlets. This facility, which regularly handles containerized cargo as well as a variety of other cargos, is profiled below.

Packer Avenue Marine Terminal is used by several container lines that: (1) have regular service to Philadelphia, and (2) utilize ships that have design drafts in excess of 40 feet. The PRPA estimates current throughput capacity at 140,000 TEUs and an expansion of throughput capacity up to 300,000 TEUs by 2010. The container lines and routes calling at Packer Avenue that could benefit from main channel deepening are discussed below.

The container service that would most likely benefit from main channel deepening is a new eastbound, round-the-world service from Australia and New Zealand that runs through the Panama Canal to the East Coast of the United States. Upon departing the East Coast of the United States this service will cross the Atlantic to the Mediterranean before transiting the Suez Canal and continuing eastward towards Australia. Full service will commence on a weekly schedule in December 2002. The new service will use the new P&O Nedlloyd "Albatross" class vessels that are designed to carry 4,112 TEUs with 1300 reefer slots and a design draft of 12.5 meters (41 feet). Similarly sized vessels owned/leased by vessel sharing agreement (VSA) partners Contship Containerlines and Columbus Lines will also be used on this service prior to April 2003.

In preparation for the full weekly service, two of these vessels, the P&O Nedlloyd (PONL) Remuera and the P&O Nedlloyd Encounter, have already called at the Packer Avenue terminal in Philadelphia in the summer of 2002. The P&O Nedlloyd Remuera will make the first call of the weekly service in mid-December 2002. Three other PONL "Albatross" class vessels, the Botany, Palliser, and Pegasus, are also scheduled for this service prior to April 2003. In addition, multiple containership lines, including P&O Nedlloyd, Columbus Lines, Hamburg-Sud, and Contship entered into a VSA in September 2002 that allows the lines to share cargo space on the P&O Nedlloyd "Albatross" class vessels and others deployed on this service. Three similar 4100+ TEU vessels owned/operated by Contship, the Aurora, Borealis, and Australis, are scheduled for the service, as is the Columbus Lines vessel, New Zealand; bringing the number of 4100+ TEU vessels on the service to nine.

Delaware River main channel deepening would allow these 4100+ TEU vessels to be deployed more efficiently by reducing the total miles traveled from the Panama Canal to the East Coast of the United States leg of each voyage. The without project controlling depth in the Delaware River (40 feet) restricts containerships to 37 feet sailing drafts and is the shallowest controlling depth on this leg of the service. The service originates in Australia and New Zealand carrying frozen meat and other cargo primarily for the East Coast of the United States and Europe. In order to pass through the Panama Canal, these vessels must be lightloaded to no more than 39.5 feet. From the Canal, they will proceed to Savannah, then Philadelphia, which has a controlling depth of 40 that restricts the containerships to 37 feet sailing draft.

The carriers and the Philadelphia Port Authority anticipate that approximately 1,100 TEUs (50% - 80% reefer) will be offloaded weekly at Packer Avenue beginning in late 2002. In the initial phase of the new service, Savannah will be the first port of call after the Panama Canal on the U.S. East Coast, followed by Philadelphia and New York. This rotation will continue until the service is fully established and vessels achieve targeted load levels at Philadelphia and Savannah. At this point, New York will likely be dropped from the rotation. As loads on the service continue to grow, it will become necessary to stop at Philadelphia before Savannah under without project conditions, because depth limitations in the Delaware River will not allow the vessels to arrive fully loaded from Savannah. According to PONL officials, these ships then will sail southward to Savannah, where they will pick up additional reefer cargo (primarily vegetables and chicken) and transit the Atlantic Ocean to Europe. There will be a net gain in cargo and sailing draft at Savannah, which has a controlling depth of 42 feet in the main channel and a tide range of more than seven feet.

The containership carriers make limited use of tidal advantage at the Delaware River because of the extreme channel length and the slow speeds required to maintain tidal advantage to Packer Avenue. Discussions with the Pilots Association and the carriers concerning the influence of tide delays confirm that tide delays for containerships arriving at the Delaware River include the time spent waiting for the appropriate tide and the additional time required to transit the channel at slow speeds in order to maintain tidal advantage through the entire length of the channel to the Packer Avenue Terminal. The total time caused by tide delays may be as much as 10 hours or more per journey and would significantly impact containership schedules. The carriers have indicated that continual occurrences of tide delays could be cause to permanently by-pass Philadelphia as a major port on this rotation.

Interviews with P&O Nedlloyd personnel, Port Authority officials, and industry experts indicate that if the Delaware River main channel were deepened to 45 feet, P&O Nedlloyd would re-route their vessels to gain operational efficiency. Specifically, they would change their port rotation back to Panama Canal, to Savannah, to Philadelphia, to Europe thereby avoiding the additional reverse direction leg from Philadelphia to Savannah. The vessels would sail at the controlling depth of the Panama Canal (39.5 feet) from Australia and New Zealand, increase sailing draft at Savannah to as much as 41 feet, and then continue northward to Philadelphia.

Avoidance of the additional reverse leg from Philadelphia to Savannah would allow more efficient loading of their vessels and reduce voyage lengths. Transportation cost savings (NED benefits) would result from the reduced distance traveled on the Panama Canal to the East Coast of the United States leg of the round-the-world voyage. Interviews with the carriers indicate that the time savings resulting from reduced travel distances would allow the service to call at additional ports currently not in the schedule.

Potential transportation time and cost savings are not expected to be reduced by time spent waiting for a "daytime shift" arrival at Packer Avenue. Analysis of arrival times, as reported by the Pilots Association and confirmed by the PRPA, indicate that arrival time of day is not a constraint on containership operations at Packer Avenue. In the past, vessels have arrived and been offloaded during early morning or night hours. The PRPA expects the occurrence of off-peak, non-daytime arrivals to increase in the future.

It should be noted that the first year that benefits are claimed for this section of the channel is 2009, six years into the new service. Analysis of cargo forecasts for the ANZ to the U.S. East Coast, ANZ to Europe, and U.S. East Coast to Europe trades (see Section 4.6 Trade Forecasts for Specific Commodity Groups) indicate that there is more than enough forecasted tonnage to support this service and that far more tonnage will be on loaded at Savannah than will be off loaded, supporting the claim that vessels on this service will depart Savannah at sailing drafts greater than arrival drafts. Also, according to the shipper, a significant amount of refrigerated cargo tonnage on these trades will come from load shifts from smaller, refrigerated cargo vessels to the newer, containerized reefer vessels. This is expected to accelerate the rate at which vessels on this new service will be filled to capacity.

In addition to the new eastbound round-the-world service, a weekly container service from the east coast of South America (primarily Brazil) to the east coast of the United States by Aliança could also potentially benefit from main channel deepening. Aliança would prefer to have Philadelphia as their first port of call with subsequent visits to New York and various ports along the southeast U.S. coast (e.g., Charleston, South Carolina). The first port of call allows the timeliest delivery of time-sensitive cargo. However, Aliança's use of container ships drawing 41 feet fully-loaded has forced them to lightload and/or wait for the tide. Rather than incur these costs, they have reluctantly diverted traffic to New York with Philadelphia as a second stop. Unloading at New York reduces sailing drafts sufficiently to allow access to Philadelphia. The potential impact of delays associated with diversions to New York prior to Philadelphia cannot be quantified at this time, therefore there are no benefits calculated this service. The issue is customer satisfaction and the potential loss of customers who are not receiving their desired service. In this case, several important, time sensitive customers would like Philadelphia to be the first stop from Brazil.

In addition to containerized cargo, shipments of steel slabs to Packer Avenue Marine Terminal are constrained by available depths in the Delaware River main channel. The slabs typically arrive on bulk vessels with design drafts ranging from 35 feet to 45 feet, with an average design draft of 38 feet, and an average sailing draft of 37 feet. The vessels with design drafts of 38 feet and less tend to arrive fully loaded (after accounting for fuel burnoff). The vessels with design drafts greater than the channel depth (40 feet) tend to arrive at sailing drafts of 39 feet to 40 feet. Interviews with the operator of Packer Avenue (Greenwich Terminals), Port Authority personnel, and industry experts indicate that under with project conditions there would be a shift to larger vessels arriving at sailing drafts that could take advantage of a 45-foot channel.

Beckett Street Terminal

As indicated in Table C-5, the Beckett Street Terminal is owned and operated by the South Jersey Port Corporation (SJPC). This facility, which has 40-foot access channels and berths, currently handles bulk and breakbulk cargo, including steel, blast furnace slag, wood products, ores, salt, and cocoa beans. The Beckett Street Terminal also has the facilities to handle conventional and containerized general cargo. Principal export shipments from the Beckett Street Terminal are scrap metal.

The benefiting commodity movement at Beckett Street Terminal is blast furnace slag imported from Italy. This is a new commodity movement shown in the 2001 and 2002 Maritime Exchange database, destined for the nearby St. Lawrence Cement facility. St. Lawrence Cement leases land from the South Jersey Port Corporation, but the port facility is operated by SJPC. St. Lawrence Cement has initiated a 45-year contract with SJPC and has invested approximately $60 million in a Granulated Blast Furnace Slag (GBFS) processing facility capable of processing one million tons of imported slag per year. GBFS is ground into fine granules that can be used as an additive to strengthen Portland cement. St. Lawrence Cement markets the processed GBFS under the trade name, GranCem®.

Blast furnace slag is currently being transported to the Beckett Street Terminal on bulk vessels averaging 67,000 DWT, with average design drafts of 43 feet and average sailing drafts of 40 feet. Under with project conditions, SJPC officials indicated that it was likely that the shipper would shift to larger vessels that could take full advantage of a 45-foot channel.

Port of Wilmington

The Port of Wilmington is owned and operated by the State of Delaware through the Diamond State Port Corporation (DSPC). The Port is located along the Christina River near its confluence with the Delaware River. The Christina River channel is a distinct Federal project which is entirely separable from the main channel Delaware River. The Christina Federal channel has been authorized (and maintained) to a depth of 38 feet. Depths at Port of Wilmington berths are also maintained at 38 feet.

As discussed above, Delaware Terminal is located within the Port of Wilmington complex. In addition to this liquid bulk operation, the Port of Wilmington handles both containerized and conventional cargo, including: fresh fruit, bulk commodities (steel, forest products, ores and minerals), juice concentrate, automobiles and other rolling cargo (RoRo), and frozen meat and fish.

The Port of Wilmington has a Master Plan that includes development of new facilities along the Delaware River south (downstream) of the mouth of the Christina River. The impetus for this development is to diversify and expand their facilities and to take advantage of the deeper channel in the Delaware River (40 feet currently; 45 feet with deepening). The Port of Wilmington has recently completed a new auto and RoRo berth 900 feet offshore on the northern Port boundary and parallel to the river's north-south shoreline. A dedicated three-lane, fenced and lighted causeway links the Auto & RoRo berth to staging and storage areas in the port complex. The new berth is the Port of Wilmington's first facility on the Delaware River. Other planned facilities along the Delaware River contained in the Port of Wilmington's Master Plan are conceptual at this time.

The Port of Wilmington would like to take advantage of main channel deepening. If the main channel were deepened to 45 feet, the Port of Wilmington would likely deepen their Christina River berths to 42 feet. The main pier sits on approximately 100 feet of piling; five feet of additional dredging should not require major structural modifications.

Deepening the Christina River Federal channel would be necessary for Port of Wilmington facilities to take advantage of a 45-foot Delaware River main channel. The Philadelphia District of the Corps of Engineers has notified the Port that channel modifications to the Christina River could be evaluated and potentially implemented by re-activating a suspended Section 107 study (for small navigation projects). This study was suspended in the fall of 2000, pending deepening of the main channel Delaware River and resolution of dredge material management issues along the Christina River. Main channel deepening could significantly lessen the costs and increase the benefits of modifying the Christina River channel. In particular, dredging and dredged material disposal associated with deepening the Christina River could potentially be undertaken concurrently with main channel deepening, resulting in significant cost savings.

Deepening the Delaware River main channel to 45 feet and the Christina River to 42 feet would immediately result in benefits from reduced lightloading of existing vessels and from use of larger and potentially fewer vessels carrying existing commodity volumes. There is also significant potential for these navigation improvements to attract to the Port of Wilmington: (1) a greater volume of existing commodities (particularly dry bulk commodities such as steel) and (2) new types of cargo, consistent with their handling and storage capacity. Although it is not possible to specify their trade volumes or vessels at this time, the new port facilities to be developed along the Delaware River would very likely benefit from channel deepening.

The Port of Wilmington has firm potential to benefit from deepening the Delaware River main channel. However, realization of these benefits would require modification of a separate Federal channel, the Christina River. This action would be subject to a separate cost-benefit analysis, which would be conducted upon reactivation of the Christina River Section 107 Study. Consequently, the Port of Wilmington is recognized as a likely beneficiary of main channel deepening, but the only Port of Wilmington facility that will be carried forward in this investigation is the planned new petroleum products berth of Delaware Terminal on the main Delaware River channel.

3.5. Port Operations

The following profile of operations within the Delaware River Port System focuses on movements of deep-draft vessels within the system and responses of shippers to depth constraints in the Delaware River main channel.

3.5.1. Movement of Deep-Draft Vessels Within Delaware River and Bay

Deep-draft vessels entering or departing the Delaware River Port System typically move independently. Operating within the Federal and non-Federal channels marked by USCG aids to navigation, deep-draft vessels under the direction of local pilots make their way between their respective marine terminals and the Atlantic Ocean. Anchorages are used as needed when delays are encountered, such as waiting for lighters, berths, tides, crews, or tugs. Berthing operations of deep-draft vessels are supported by one or more assisting tugs.

Vessel movements within the Port System take place 24 hours per day, 365 days per year. Inclement weather can restrict vessel movements due to poor visibility or high winds.

Typically, vessel traffic on the main channel Delaware River is two-way. However, when VLCCs are brought upriver to a Delaware River refinery, the enormous size (particularly beam) and limited maneuverability of these vessels requires one-way operation of the channel in their vicinity. These vessels also come upriver only during daylight hours.

The underkeel clearance of deep-draft vessels moving in the Port System depends on the discretion of the pilot and the owner/operator of the vessel and cargo. Before guiding a vessel upriver, pilots will consider a variety of factors, including: draft of the vessel, destination terminal, depth and substrate of the access channels and berth, and wind and tide conditions. Some vessel owners/operators are particularly risk averse regarding underkeel clearance and will require that their vessels have maximum underkeel clearances.

3.5.2. Responses to Depth Constraints

In order to achieve economies of scale, maritime shippers prefer to fully load the largest vessels available consistent with the volume of commodities to be transported. The current depth of the Delaware River main channel constrains maritime operations for large vessels drafting in excess of 37 feet. In response, vessel owners/operators can use tidal advantage, use a smaller vessel than preferred, lightload larger vessels, transship to smaller vessels, and/or lighter large tankers to reduce their sailing drafts. All of these responses, which translate into higher transportation costs relative to a less depth-constrained channel, are discussed below.

Tidal Advantage

By riding the high tide up or down the river vessels can achieve additional underkeel clearance, allowing deeper loading of a given vessel or use of a larger vessel. The tradeoff is the additional time required to wait for a favorable tide, and the additional steaming time required to reach the dock when “drifting” the tide.

Tankers typically move upriver with the tide, maximizing their drafts to 40 feet while still maintaining adequate underkeel clearance. Drifting with the tide takes 8 hours from the Big Stone light to the vicinity of Camden, New Jersey or 6 hours to the vicinity of Marcus Hook, Pennsylvania, compared to 4 and 3 hours, respectively, if they do not need to use tidal advantage.

Based on discussions with representatives of the Pilots' Associations for the Bay and Delaware River, container vessels typically arrive drawing no more than 38 feet with the flood tide. If arriving without the tide, they draw no more than 37 feet. Container vessels following the tide require 12 hours from the sea, while vessels not using the tide take 6 hours from the sea. All vessels deeper than 37 feet need to arrive with the tide.

Vessel Size

Some shippers respond to depth constraints by limiting the size of their vessels. Implicit in this decision is that it is less costly to carry a particular commodity on a fully loaded smaller vessel than on a lightloaded larger vessel. In cases where a shift to larger vessels is anticipated under with project conditions, a comparison of vessel operating costs for large and small vessels has been performed to confirm this expectation.

Lightloading

Other shippers respond to depth constraints by lightloading larger vessels. Typically, lightloading would be economically advantageous only if a relatively small percentage of carrying capacity was unused or if the ship had prior destinations with deeper channels where it off-loaded more than it on-loaded.

Transshipment

Another response to channel depth constraints is to transport commodities on large vessels for the longest leg of a journey, then transship commodities at a deep water port to smaller vessels for the shorter leg into the constrained channel. One of the refineries, Valero, conducts transshipment operations in the Caribbean for crude oil imported from the Mideast.

Lightering

As discussed above in the refinery profiles, all of the refineries in the Delaware River Port System have customized their maritime operations to respond to the main channel depth constraints. Most of the refineries lighter large tankers in Delaware Bay at Big Stone Beach anchorage. One of the refineries, Phillips, conducts its' own offshore lightering operation. Lightering operations are discussed below. The discussions revolve around lightering services provided at Big Stone Beach by Maritrans Inc.

Lightering Fleet

For decades, Maritrans Inc. (or its predecessors) has been the primary supplier of lightering services in Delaware Bay. Their lightering operations at Big Stone Beach anchorage have been continually improved to reduce lightering time and to avoid spills. Due to their specialized equipment and efficient operations, very few other marine transportation companies currently compete with Maritrans to lighter tankers in Delaware Bay (although some refineries do have their own offshore lightering operations).

Maritrans operates a fleet of tankers, tank barges, and tugboats in the Delaware River and Gulf Coast. In the Delaware River, Maritrans has exclusive multi-year contracts with most of the Delaware River refineries to lighter crude from incoming tankers. Very little refined petroleum products are handled by Maritrans in the Delaware River. Maritrans conducts approximately 300 lightering operations per year, with approximately 70 million bbl lightered.

In the Delaware River, Maritrans uses three double-hulled vessels to conduct lightering operations:

- Maritrans 400 (62,000 DWT barge; capacity: 380,000 bbl; coupled with the 11,000 hp Tug Constitution);
- Maritrans 300 (33,000 DWT barge; capacity: 265,000 bbl; coupled with the 7,000 hp Tug Liberty);
- Integrity (42,000 DWT tanker; capacity: 265,000 bbl).

Over the years, Maritrans has increased the size of lightering vessels to increase efficiency. The Maritrans 400 barge alone can lighter a Suezmax tanker sufficiently to allow passage upriver. Maritrans expects to continue operating these vessels in the Delaware River for the foreseeable future. However, the company could upgrade or redeploy its equipment as necessary to meet regulatory and customer requirements.

The refineries typically alert Maritrans about the expected arrival dates of tankers to be lightered at the Big Stone Beach anchorage (55-foot depth). One month lead times are typical. Maritrans arranges for one of their three lightering vessels to tie up with the tanker at the anchorage and receive a sufficient portion of the tanker's cargo to allow the tanker to safely navigate the 40-foot deep Delaware River main channel. Upon completion of lightering, the lightering vessel and tanker separately make their way upriver to the destination refinery. In general, the lightering vessels arrive well in advance of the tanker due to their earlier departure (when they disengage from the tanker) and their desire to discharge at the dock and return quickly to service the next vessel. In addition, because the refineries wish to minimize their lightering charges, tankers are typically lightered to the minimum depth necessary to drift the tide to the refinery and therefore must travel at lesser speeds than the lightering vessels.

Occasionally, Maritrans' customers have relatively small loads to lighter. Maritrans tries to avoid making a trip with a small load. In such cases, Maritrans' lightering barges, which can segregate cargo, will lighter a second tanker before traveling upriver to the refinery docks.

The Maritrans fleet is sized to meet their customers' needs the majority of the time. Maritrans has increased the size of lightering vessels over the years to achieve faster lightering. The Maritrans 400 barge alone can lighter a Suezmax tanker (1 million barrel capacity, 55+ foot design draft) sufficiently to allow its safe passage upriver. Maritrans' vessels are available 365 days a year, but are actively employed in lightering significantly less than full time, to accommodate the unscheduled arrival of tankers. Nevertheless, there are some occasions when tankers experience delays because all three Maritrans vessels are occupied. However, Maritrans avoids queuing to the extent possible. The advance notice of vessel arrivals allows Maritrans to carefully schedule use of their vessels, and the three vessels provide highly efficient service in most cases.

Time at Anchorage

Time spent lightering at Big Stone Beach varies with each tanker. Often, time at anchorage significantly exceeds time required for lightering. Based on discussions with Maritrans, the

Pilots Association, and Sunoco, there are a variety of potential explanations for excess time spent at anchorage, including:

- **Weather Delays**: Inclement weather can delay lightering operations and/or upriver transit of the tanker and lightering vessel.
- **U.S.C.G. Inspection**: All foreign-flag vessels require a U.S.C.G. Tank Vessel Exam (TVE) letter, which is renewed annually after U.S.C.G. inspection. Waiting to obtain TVE letters can affect a significant number of incoming tankers, and this is a source of anchorage residence time.
- **Availability of Lighter Vessels**: There are instances when Maritrans cannot service all arriving tankers. Queues form, and delays result.
- **Early or Late Arrival by Tankers**: Crude tankers may arrive at the anchorage earlier or later than originally scheduled. In general, charterers would prefer to wait fully-loaded in Delaware Bay for available lightering, berthing or storage at the receiving facility.
- **Availability of Refinery Berth Space or Tankage**: Delays can be experienced if there is insufficient berth space or tankage at the receiving refinery.
- **Crude Grade Mix at Refineries**: There have been cases when two tankers destined for the same refinery arrived within a day or two of each other. The refinery requested that Maritrans not service the first tanker immediately in order to service the second. The reason was that one of the refineries was running a certain grade of crude, and the second tanker carried the same or similar grade. Consequently, delays at anchorage occurred in order to avoid adjusting the refinery equipment to process a different grade of crude.

Lightering Price

Maritrans' contractual lightering rates (i.e., prices charged) to each refinery are customer-specific and proprietary, and therefore could not be obtained for this analysis. Maritrans indicated that the rates charged specific customers are based on a variety of factors, including: volume, facility location, and customer requirements. They stated that a representative rate to use in the analysis would be $0.37/bbl. The $0.37 per barrel rate provided by Maritrans has been quite stable and is less (in real dollars) than the $0.3543 rate cited by Maritrans during earlier interviews in 1995.

The principal reason for this observed rate stability is that Maritrans prices their services recognizing that refineries have other transportation options. Even though Maritrans is the only independent lightering operation in the Delaware, their prices are still constrained by market forces related to alternative transportation options available to the refineries. As an alternative to using Maritrans' services, oil companies could use smaller tankers to avoid lightering (as in the case of Valero). They could also establish their own lightering operations within Delaware Bay or offshore (as in the case of Phillips 66). There is also the potential for other marine transportation companies to enter the lightering market. This recognition applies downward pressure on the Maritrans rate structure, despite their dominance of the market and considerable barriers to new entries.

As stated previously, one of Maritrans clients (Coastal) anticipates that the company may raise lightering rates in response to reduced lightering volumes resulting from a deeper channel. This possibility has been evaluated, but is considered to be unlikely. In the past, Maritrans has responded to reduced lightering volumes by keeping prices stable, but increasing operational efficiency in order to maintain profitability. For example, when Tosco bought the British Petroleum refinery in 1995-1996, they changed tanker operations, resulting in a 20-million bbl/yr reduction in their use of Maritrans' lightering services. According to Maritrans, rates were raised at this time to partially offset their reduced lightering volume. However, even with this rate increase, the lightering charge has remained quite stable over time. While the rate has increased slightly in nominal terms, in real terms the representative lightering price identified in 2002 ($0.37/bbl) is slightly less than the price representative lightering price identified by Maritrans in 1995 ($0.3543/bbl). Over this same period, Maritrans has upgraded and retrofitted its lightering fleet, in order to achieve operational efficiency and preserve profits in a shrinking market.

The price charged by Maritrans is an important factor in refineries' decisions regarding whether to use Maritrans services, or to conduct their own lightering operations, or to transship to smaller vessels at an intermediate deepwater port. The potential cost savings to refineries from reduced lightering requirements is also an important determinant of whether they would make the investments in berth deepening and dockside infrastructure necessary to benefit from main channel deepening. For these reasons, the representative price charged by Maritrans is used in several sensitivity analyses to evaluate the potential fiscal impacts on refineries of reduced lightering charges.

Lightering Costs

Potential changes in the resource costs incurred to conduct lightering operations is the appropriate measure of the NED benefits of reduced lightering under with project conditions. The Planning Guidance Notebook, ER 1105-2-100 (Section 3-2.c.(1)) states that:

> *"The base economic benefit of a navigation project is the reduction in the value of resources required to transport commodities.*
>
> *Navigation benefits can be categorized as follows:*
> *(a) Cost reduction benefits for commodities for the same origin and destination and the same mode of transit thus increasing the efficiency of current users. This reduction represents a NED gain because resources will be released for productive use elsewhere in the economy. … Examples for deep draft navigation are reductions in costs associated with the use of larger vessels, with more efficient use of existing vessels, with more efficient use of larger vessels, with reductions in transit time, with lower cargo handling and tug assistance costs, and with reduced interest and storage costs.*

The cost of deploying the Maritrans fleet to lighter tankers to a sufficient depth to transit the Delaware River channel is a cargo handling cost, as defined in Principles and Guidelines and the Planning Guidance Notebook. To the extent that the deepening project reduces the amount of lightering that needs to be done (since tankers would need to be only lightered to 45 feet, rather than 40 feet), the cost of owning and operating a fleet of vessels sufficient to handle the reduced volume of lightering would also be reduced. This will result in a resource cost savings that can be claimed as a NED benefit of the deepening project.

An analysis of lightering costs under both without and with project conditions has been performed for the project. Vessel operating costs for both at-sea and at-port categories for the existing Delaware Bay lightering fleet were developed by IWR specifically for this study and compared to a number of maritime sources, including tug and barge companies, marine brokers, and the annually published generalized VOC's for similar vessels. Weighted average at-sea and at-port cost costs per barrel were developed separately for without and with project conditions. At-sea and at-port cost costs per barrel vary by year, based on the volume lightered. The without project condition cost per bbl was calculated based on the existing Maritrans lightering fleet. An analysis of with project conditions was then conducted to determine whether the reduction in lightering volumes would be sufficient to eliminate the need for the least efficient of the existing lightering vessels, or to cause a replacement of one of the existing vessels with a smaller vessel. The with project condition cost/bbl was calculated based upon a reconfigured lightering fleet that was sized to handle the reduced lightering volume at a comparable level of efficiency to without project conditions.

Lightering Vessel Operating Costs

IWR develops, and HQUSACE publishes, vessel operating costs (VOCs) approximately every two years as guidance to Corps Districts for use in estimating changes in water transportation costs. The values in the VOC estimates are based on the major cost items to acquire and operate an ocean-going vessel in typical usage in international and coastwise trade. In examining the specific vessels and operating characteristics used in lightering operations in the Delaware River port complex, it became obvious that the published general IWR VOCs are not appropriate to estimate lightering vessel costs for the Delaware Bay. For example, the published VOCs assumes that the average vessel in the fleet is seven (7) years old and that they are typically in ocean service for approximately twenty (20) years. This means that over the period of analysis the vessel would need to be replaced with a new vessel. The general IWR VOC analysis also assumes that the vessel is used for extended voyages resulting in relatively full employment (345 to 350 days per year) necessitating round the clock manning and requiring the crew to be deployed away from home for extended periods.

An in-depth investigation of Delaware River lightering vessels revealed that they are typically much older than that assumed in the published VOC values. In addition, they are in service for a much longer time period than the twenty years generally assumed in the standard VOCs. In many instances, lightering vessels were formerly used in international shipping then overhauled and refitted for use in lightering. As a consequence, hulls converted to lightering service are sometimes acquired via the secondary vessel market. Lightering vessels also do not typically engage in extended voyages, resulting in reduced manning requirements. Additionally, two of the Delaware River lightering vessels are tug/barge units (TBU) that are not included in the published IWR VOC tables. All of these differences imply that the costs of operating the Delaware River lightering vessels are significantly different from a similar or comparable vessel used in ocean-going trade.

To estimate VOCs for lightering vessels (tanker and TBU), costs were constructed following the basic structure of the IWR VOCs, but using vessel specific information. Table 1 shows the cost items used to estimate VOCs for the Delaware River lightering vessels.

Table C-6
Basic Cost Items in IWR Vessel Operating Costs

Fixed Annual Capital Cost(s)	Computed based on current replacement costs of the vessel assuming the Federal discount rate and composition of the world fleet for vessels similar in type and class.
Fixed Annual Operating Cost(s)	
Crew Cost(s)	Based on ocean voyage manning requirements and extended voyage labor rates. Generally includes direct compensation, benefits, and subsistence (as appropriate)
Lubes & Stores	Accounts for lubricants, oils, and vessel stores (minor in-operation maintenance supplies, lines, etc.) required for daily or routine operation of the vessel and its systems while in port and at sea
Maintenance & Repair	Average annual equivalent value or cost for typical maintenance costs on a yearly basis in addition to minor refits and overhauls expected over a typical or average service life
Insurance	Includes protection and indemnity (P&I) particular to given vessel and for most circumstances coverage for significant hull damage and catastrophic hull loss
Administration	Costs associated with administrative tasks for management and operation of a given vessel including requirements for oversight of registry, manning, insurance, regulatory compliance, etc.
Total Annual Fixed Cost(s)	Sum of fixed annual cost
Applied Number of Operational Days Per Year	Typically ranges from 340 to 350 days per year for relatively full employment (average of 344 days per year for tankers or liquid bulk vessels)
Total Daily Fixed Cost	Total annual fixed costs divided by number of operational days per year
Daily Fuel Costs	
Daily Fuel Cost; at Sea	Daily fuel consumption under power (based on the horsepower and requirements of the propulsion system; typically for service speed of the vessel; and any additional requirements for auxiliaries and supporting or basic service power requirements) multiplied by per unit fuel price
Daily Fuel Cost; in Port	Daily fuel consumption at the dock or often when stationary; usually for auxiliaries and basic service power requirements (i.e., typically excluding requirements for propulsion) multiplied by the per unit fuel price
Daily Total Costs	
Daily Total Cost; at Sea	Sum of daily fixed costs and daily at-sea fuel costs
Daily Total Cost; in Port	Sum of daily fixed costs and daily in-port fuel costs
Applied Number of Operational Hours Per Day	Typically 24 hours per day
Hourly Total Costs	
Hourly Total Cost; at Sea	Daily total costs at sea divided by 24 hours
Hourly Total Cost; in Port	Daily total costs in port divided by 24 hours

The lightering VOCs developed for this study followed the same basic calculation procedures as those applied for published IWR VOCs. However, adjustments were made to several items to account for the age of vessel, and differences in the mode of employment or service relative to the operational environment of lightering vessels.

Fixed Annual Capital Cost

1. Vessel Replacement or Acquisition Costs -- an estimate was developed for lightering vessel hull costs at the age and time of acquisition. Overhaul and refit costs were added to maintain class and bring the vessel into lightering service.
2. Vessel Amortization Costs -- the amortization period is the remaining life at the time of acquisition or 25 years, which ever is smaller. The interest rate used is 5 7/8%.
3. Fixed Annual Operating Costs
    1. Crew\Manning Costs -- Crew cost relationships were estimated from the IWR VOCs by regressing vessel size (as measured by deadweight tonnage or DWT) on manning costs for the IWR fiscal year (FY) 2000 release of costs for double-hull tankers of US registry\flag and similar DWT class (as of November 2002, available information indicates FY 2000 costs for specified items are more appropriate as opposed to FY 2002 estimates). Using this equation the annual crew cost for each vessel (tanker and TBU) was estimated. This result was then adjusted by multiplying by the ratio of the actual manning for each vessel to the IWR VOC average manning. Further adjustments were made based on the nature of crew deployment (lightering service versus deployment for extended voyages to support vessel transit to\from foreign ports). The actual manning was based on interviews and adjusted to a full-time equivalent basis.
    2. Lubes & Stores Costs -- Lubes and stores cost relationships were estimated from the IWR VOCs by regressing vessel size (DWT) on lubes and stores costs for IWR FY 2000 costs for US flag double hull tankers. Using this equation the annual lubes and stores costs for each vessel were estimated. Resulting costs were not further adjusted as available information at the time of studies indicated resulting estimates were reasonable according to DWT class and given the level of assumed employment.
    3. Maintenance & Repair Costs -- Maintenance and repair cost relationships were estimated from the IWR VOCs by regressing vessel size (DWT) on FY 2000 maintenance and repair costs US double hull tankers. Using this equation the annual maintenance and repair cost for each vessel was estimated. Resulting costs were not further adjusted as available information at the time of studies indicated resulting estimates were reasonable according to DWT class and given the level of assumed employment.
    4. Insurance -- An insurance cost relationship was estimated from the FY 2000 IWR VOCs by regressing vessel size (DWT) on insurance costs for US double hull tankers. Using this equation, the annual insurance cost for each vessel was estimated. This result was then adjusted to attempt to reflect the lower lightering vessel capital costs, lower manning, and liability or safety record currently associated most lightering operations compared to that of the baseline IWR VOCs.

5. Administration -- An administration cost relationship was estimated from the FY 2000 IWR VOCs by regressing vessel size (DWT) on administration costs for US double hull tankers. Using this equation, the annual administration cost for each vessel was estimated. This result was then adjusted to attempt to reflect the lower manning requirements for lightering vessels compared to that of the baseline IWR VOCs.

Daily Fuel Cost

1. Daily Fuel Consumption at Sea -- Daily fuel consumption under power at sea was estimated from the FY 2000 IWR VOC regression equations that estimate fuel consumption as a function of horsepower for ocean-going self-propelled tankers. No adjustment was made for the tanker. Specific to the TBU's, fuel consumption for tankers may not be applicable to ocean-going tug\barge units due to relationships of hull form and applied speed, hydraulic resistance, and scale or type of propulsion unit. Therefore, fuel consumption of the TBU's was also estimated using IWR inland waterway VOCs for comparable plant or horsepower. Although there was a relatively small differences between the estimates as derived from inland and ocean-going vessel relationships, an average of the tanker and tug fuel consumption was used for the TBU's.
2. Daily Fuel Consumptions in Port -- Estimated from the FY 2000 IWR self-propelled VOC vessel data by regressing vessel size (DWT) on daily in-port fuel consumption. Using this equation in-port fuel consumption was estimated based on the DWT of each vessel.
3. Unit fuel cost -- A cost of $183 per metric ton for MDO was used for all vessels based on the class(es) of horsepower and available information concerning scale and type of propulsion units.

Lightering Times and Rates

One major change from previous analyses concerns the rates at which crude oil is lightered at Big Stone Beach Anchorage and the rate at which crude is discharged from tankers at the dock. These are important input variables because the time required to discharge crude is incorporated into both with and without project transportation costs. The relationship between lightering and at-dock discharge rates is also important, because one of the effects of the deepening project will be to allow tankers to transit the navigation channel more fully-loaded, thereby reducing the amount of lightering at the anchorage and correspondingly increasing the amount of crude discharged at the dock.

Table G-7 shows the lightering and dock-side discharge rates used in the 1998 LRR and GAO's 2002 review. Table C-8 displays the lightering and dock-side discharge rates used in this reanalysis effort.

Lightering and dock-side pump-out rates shown in Table C-8 and used in the reanalysis were developed based on:

- interviews with the lightering company (Maritrans);

- interviews with two of the oil refineries that extensively lighter, Sunoco (Maritrans' largest customer), and Phillips 66/Tosco (who conduct their own lightering operation);
- review of vessel specifications available from ship builders.

Table C-7
Lightering and Dockside Discharge Rates from Previous Analyses

	Discharge Rate per Hour		
Source	**Short Tons**	**Metric Tons**	**Barrels[1]**
Corps 1998			
Lightering Rate	1,500	1,361	10,000
At Dock Rate	3,000	2,722	20,000
GAO 2002			
Lightering Rate	3,000	2,722	20,000
At Dock Rate	1,500	1,361	10,000

[1] Rounded barrel equivalents are based on an average 7.35 bbl per metric ton conversion rate

Table C-8
Lightering and Dockside Discharge Rates In Current Analysis
(Without Project Conditions)

Reanalysis 2002	**Barrels Per Hour**
Lightering Transfer Rate for Without Project Conditions (Weighted Average of Three Vessels Below)	59,412
Maritrans 400	70,000
Integrity	60,000
Maritrans 300	40,000
Lightering Transfer Rate for With Project Conditions (Weighted Average of Maritrans 400 and Maritrans 300)	59,091
At Dock Pump-out Rate (by Tanker Size)	
<= 80,000 DWT	18,000
80,001 to 100,000 DWT	21,500
100,001 to 120,000 DWT	25,000
120,001 to 160,000 DWT	30,000
> 160,000 DWT	35,000

Lightering rates exceed dockside discharge rates due to shorter pumping distances, gravity assistance, and lack of back pressure during lightering operations. Dockside discharge rates are a function of tanker size and pump capacity. These rates were confirmed in discussions with Maritrans and Sunoco. Lightering time under without project conditions was calculated using the weighted average of the lightering rates for the three Maritrans vessels (59,412 bbl/hr). Weighted average lightering rates under with project conditions (59,091 bbl/hr) were calculated for a reconfigured fleet consisting of the Maritrans 400 and Maritrans 300.

When computing the time necessary for lightering, two hours of lash/unlash (hookup and disconnect) time and four hours for anchoring operations have been added to the lightering pump-out time to compute total time to lighter (per discussions with Maritrans, the Pilots Association, and confirmed by Sunoco).

Conversion Rates Used in Lightering Calculations

Crude oil is a complex mixture consisting of up to 200 or more different organic compounds, mostly hydrocarbons. Different crude oils contain different combinations and concentrations of these various compounds. As a result, crude oils from different fields, and from different formations within a field, can have significantly different densities (hence weights). These differences in crude oil weight need to be reflected in the conversion rates from barrels to metric tons. Table C-9 shows the barrel to metric ton conversion rates used in the reanalysis effort. These country specific conversion rates were obtained from the Energy Information Administration of the U.S. Department of Energy. These are the same conversion rates used by the Waterborne Commerce Statistics Center in calculating tonnage for vessels whose manifests were recorded only in barrels in the Port Import Export Reporting Service **(**PIERS) dataset.

Table C-9

Barrel to Metric Ton Conversion Rates by Point of Origin

Point of Origin	Barrels/Ton	Point of Origin	Barrels/Ton
ABIDJAN	7.285	LUCINA	7.305
BALAO	7.130	LUCINA / TCHATAMBA	7.305
BALBOA	7.080	MALONGO	7.410
BRASS RIVER	7.411	MONGSTAD	7.644
CABINDA	7.410	NIGG BAY	7.523
CALETA CORDOV	7.120	PALANCA	7.410
CAPE LOPEZ	7.305	PNT TUPPER	7.186
CAPE LOPEZ / CABINDA	7.358	PNT TUPPER / WHIFFENHEAD	7.186
COVENAS	7.080	PTO LA CRUZ	7.127
CUL DE SAC	7.332	PTO MIRANDA	7.127
DJENO	7.506	PUNTA DE PALM	7.127
ESCRAVOS	7.411	PUNTA PALMAS	7.127
ESMARALDAS	7.130	QUA IBOE	7.411
FLOTTA	7.523	QUINFUQUENA	7.410
FORCADOS	7.411	QUINFUQUENA / YOMBO	7.458

Point of Origin	Barrels/Ton	Point of Origin	Barrels/Ton
FREDERICIA	7.405	SCAPA FLOW	7.523
GABON	7.305	SIDI KERIR	7.260
GABON / ABIDJAN	7.295	ST EUSTATIUS	7.332
GABON / TCHATAMBA	7.305	ST EUSTATIUS / ST LUCIA	7.332
GAMBA	7.305	ST LUCIA	7.332
KIRKWALL	7.523	TCHATAMBA	7.305
LIVERPOOL	7.523	TEES	7.523
LOMBO	7.410	WHIFFENHEAD	7.186

Potential Effects of Channel Deepening on Lightering Operations

Maritrans anticipates that channel deepening could result in a reduction of 25 to 30 percent of their total lightering volume, and lightering of Suezmax tankers could be reduced by as much as one-third. This is generally consistent with our analysis of with and without project conditions, which predicts a reduction in total lightering volumes of approximately 31 percent in 2008 (lightering volumes would thereafter gradually increase as total crude volumes increased). Maritrans indicated that they would consider the following actions in response to expected lightering decreases under with project conditions: (1) reconfigure their fleet by perhaps swapping a Delaware Bay barge with a smaller barge from the Gulf Coast fleet to optimize vessel utilization across their total fleet; (2) raise per barrel lightering charges to help maintain revenues; (3) pursue other uses of their vessels to compensate for lost lightering volumes; or (4) if necessary, reduce the level of service.

While the actual response by Maritrans to reduced lightering volumes cannot be known at this time, the appropriate measure of NED cost savings is the reduction in resource costs needed to provide an equivalent level of service. To determine this, an analysis was conducted to first compare current lightering volumes with current fleet capacity. According to Maritrans, their Delaware River lightering fleet of three vessels currently lighter approximately 70 million barrels per year.

These without project condition results were then compared to reduced lightering volumes under future with project conditions to determine the future fleet capacity required to lighter at the same relative level of efficiency. Under with project conditions, it was estimated that total lightering volumes in the Delaware River would be reduced by 31 percent to approximately 48 million barrels in 2008 (the first year of full 45-foot channel availability to the refineries). This reduction in lightering volume indicated that the lightering tanker Integrity (which represents 29 percent of the lightering fleet capacity) could be freed for other productive uses under with project conditions, without a significant impact on remaining lightering capacity or efficiency.

The analysis also examined lightering volumes in the last two years of the analysis period (2057/2058) to determine whether the growth in lightering volumes over time could still be accommodated by a reduced size fleet. Because of the extremely low expected growth rate for crude oil imports (0.2 percent per year) and the significant amount of underutilized time for the existing lightering fleet, it was determined that additional lightering capacity would not be required over the period of analysis. In order to test this assumption, a simulation analysis was conducted to compare the expected frequency of queuing and average wait times in the final two years of the forecast period (2057 and 2058). The simulation analysis indicated that the percentage of vessels that must wait to lighter with a three vessel lightering fleet would be 13 percent, with an average wait time of 5.3 hours. The percentage of vessels that must wait to lighter with a two vessel fleet would is estimated to grow to 32 percent, with an average wait time of 10.9 hours. Given that the average time spent at anchorage for tankers that lighter was more than 50 hours in 2000 and that a Suezmax tanker can be lightered in less than 12 hours, the additional waiting time would not be expected to impact tanker operations and may not result in an overall increase in time spent at anchorage. Therefore, the additional time spent waiting to lighter was not considered to be significant enough to warrant an additional Maritrans vessel.

Finally, it should be noted that the expected decrease in lightering volumes may be partially offset if channel deepening results in a shift to larger, more efficient tankers. If there is a shift to larger tankers under with project conditions that results in a smaller than expected decrease in total lightering volume, the overall transportation origin to destination savings would be greater than currently is claimed in the benefit analysis, because of the allocation of vessel costs over higher cargo payloads.

3.6 Existing Commodity Movements through the Port

Existing commodity movements through the Delaware River Port System are described below.

3.6.1 Data and Data Sources

The primary data sources used to identify existing and forecast future commodity movements through the port complex are shown in Table C-10 below.

These data sources (in particular the WCSC and Maritime Exchange data) allowed for a commodity-by-commodity analysis of each individual trip movement within the harbor complex to each individual terminal. As a result, benefits have been modeled at the individual ship call level of detail.

Table C-10
Data Sources for Commodity Movements

Database	Information
Journal of Commerce (JOC)	Direction of trade
Port Import Export Reporting Service (PIERS)	Foreign Port Code and Name
	U.S. Port Code and Name
	Country Code and Name
	Date of Vessel Call
	Vessel Name
	Sailing Draft
	Location Code (Channel)
	Dock Code
United States Army Corps of Engineers Waterborne Commerce Statistics Center (WCSC) Domestic and Foreign incorporates JOC Piers data	Weight in Kilos
	Value
	Vessel Name
	District Code
	Port Code
	EC Date
	NRT
Clarkson's Research Data	Vessel Type
	Deadweight Tonnes
	Design Draft
	Vessel TEU capacity
Maritime Exchange (Delaware River cargo vessel traffic for 2000, 2001, and 1st half 2002)	Vessel Arrival Records only
	Arrival Data
	Vessel Name
	Port Name
	Length
	Breadth
	Gross Tonnage
	Net Tonnage
	DWT
	Arrival Sailing Drafts (feet)
	Company Alias
	C&D Canal traffic

3.6.2 Imports and Exports

Table C-11 below shows the major import and export commodities in the Delaware River Port System in the year 2000. The channels, ports, and harbors of the Delaware River Port System are responsible for 32% of total tons traded into the U.S. North Atlantic region. Approximately 75 million metric tons of maritime commodity trade traveled through the Delaware River Port System in the year 2000, carried on 1200 vessels with over 2000 vessel calls. Over 80 percent of the tonnage was crude oil and refined product carried on tankers.

Table C-11
Top 20 Delaware River Imports and Exports Year 2000

Imports (thousands of metric tons)			Exports (thousands of metric tons)		
Commodity	**Tons**	**Market Share%**	**Commodity**	**Tons**	**Market Share%**
Crude Petroleum	57,274.2	78.2%	Residual Petroleum Products	343.5	21.3%
Iron and Steel	4,131.3	5.6%	Petroleum Refineries	282.6	17.5%
Stone, Clay and Other Crude Minerals	2,326.3	3.2%	Organic Chemicals	141.9	8.8%
Petroleum Refineries	2,207.4	3.0%	Paper and Paperboard and Products	97.3	6.0%
Vegetables, Fruits and Eggs - Req. Ref.	2,185.6	3.0%	Motor Vehicles	83.5	5.2%
Organic Chemicals	819.8	1.1%	Iron and Steel	71.8	4.5%
Paper and Paperboard and Products	649.6	0.9%	Synthetic Resins	54.6	3.4%
Non-Metallic Products, nec.	499.9	0.7%	Ores	46.3	2.9%
Meat/Dairy/Fish Req. Ref.	451.6	0.6%	Misc.	38.4	2.4%
Wood Products	324.5	0.4%	Other Food	36.4	2.3%
Other Food	255.2	0.3%	Natural Gas	33.2	2.1%
Other Req. Ref.	198.9	0.3%	Inorganic Chemicals	24.3	1.5%
Inorganic Chemicals	184.8	0.3%	Coal and Coke	23.3	1.4%
Fertilizers and Pesticides	178.2	0.2%	Waste Paper	21.5	1.3%
Chemical Products, nec.	146.0	0.2%	Metal Products	21.0	1.3%
Other Manufacturing, nec.	141.2	0.2%	Chemical Products, nec.	20.6	1.3%
Ores	127.3	0.2%	Meat/Dairy/Fish Req. Ref.	16.5	1.0%
Motor Vehicles	120.2	0.2%	Vegetables and Fruits - Non Ref.	16.0	1.0%
Non-Ferrous Metals	114.5	0.2%	Textiles	15.5	1.0%
Residual Petroleum Products	101.0	0.1%	Vegetables, Fruits and Eggs - Req. Ref.	15.5	1.0%
Other	794.0	1.1%	Other	209.0	13.0%
Total	**73,231.4**	**100%**		**1,612.6**	**100.0%**

The trade imbalance that is evident in total U.S. and North Atlantic trade is even more exaggerated in the Delaware River Port System. Imports constituted nearly 98% of total tonnage in the year 2000 WCSC data. Crude oil delivered to the Delaware River refineries is by far the largest commodity moved through the port complex, accounting for 78% and 77% of total imports and total commodity movements, respectively.

A large portion of the North Atlantic region's crude is brought up the Delaware River. Crude oil imports to the Delaware River are nearly double those of other North Atlantic ports as a percentage of total imports.

Other major commodities of note include: iron and steel; stone, clay and other crude minerals; petroleum products; vegetables, fruits and eggs – requiring refrigeration; and meat/dairy/fish products requiring refrigeration. Along with crude oil imports, these other major import commodities tend to be transported on the largest vessels accessing the port complex.

Crude Oil Imports

As stated previously, the destinations of total crude oil imports in the year 2000 within the Delaware River Port System were determined and used in the benefit analysis. Volumes and destinations are shown in Table C-12.

Table C-12
Crude Oil Imports by Facility

Facility	Metric Tons	Percent of Total
Eagle Point	6,050,164	11%
Philips 66 (Tosco)	9,714,120	17%
Motiva	7,279,557	13%
Valero	7,432,115	13%
Sun Facilities	21,930,613	38%
Other facilities (not benefiting)	2,925,062	5%
Incomplete vessel data	1,942,551	3%
Total	**57,274,182**	**100%**

Source: Waterborne Commerce Statistics Center

Major origins of crude oil imports to the Delaware River refineries include Africa, North America, South America, and Europe. Trade with Africa in the year 2000 primarily consisted of crude petroleum and accounted for nearly 50% of total crude inbound tonnage. Over three-quarters of North American (including Caribbean) tonnage resulted from trade in crude petroleum. South America, another important exporter of crude to the Delaware River Region, was the third largest trading partner in 2000.

Historic PIERS crude oil tonnage import data was provided by the Delaware River Port Authority (DRPA) for Pennsylvania and New Jersey and is shown in Table C-13 below. Note that this dataset does not include tonnage for the Motiva Refinery, which is located in the State of Delaware.

It should be noted that the year 2000 crude oil import data used in the benefit analysis as the baseline condition (Table C-13) has been adjusted to correct for inaccuracies in the PIERS dataset resulting from the use by PIERS of inappropriate conversion factors from barrels to metric tons. This inaccuracy was corrected by WCSC for the year 2000, but not for prior years. As a result, the historical data presented in Table C-13, which applied the old PIERS conversion factors, is presented here only to show the trends in crude oil import tonnage over time.

Table C-13
Historic Crude Oil Import Tonnage, 1990 - 2001

	Region of Origin					
Year	**Africa**	**Others**	**Caribbean**	**No. Europe**	**E. Coast So. America**	**Total**
1990	30,420,393	8,131,214	5,019,798	1,592,658	2,802,313	47,966,376
1991	29,327,912	8,927,754	5,283,320	836,473	3,136,753	47,512,211
1992	29,662,109	6,011,609	5,591,473	2,289,575	4,368,224	47,922,989
1993	30,909,919	5,837,902	5,105,627	4,711,581	5,295,616	51,860,644
1994	25,717,209	4,609,135	10,517,761	5,353,472	4,240,920	50,438,498
1995	27,093,475	3,971,482	10,459,991	6,096,589	3,535,830	51,157,367
1996	23,160,343	1,643,118	6,423,088	6,689,019	4,451,938	42,367,507
1997	26,172,750	8,328,433	4,940,300	5,532,561	4,019,743	48,993,786
1998	28,884,368	12,090,305	5,955,450	5,561,810	4,473,563	56,965,496
1999	26,374,998	12,838,351	5,924,061	5,793,195	4,978,405	55,909,009
2000	26,576,980	13,938,143	6,076,839	5,718,539	4,942,810	57,253,311
2001	25,474,609	11,663,616	6,238,594	5,528,290	3,349,588	52,254,697

Source: Journal of Commerce, PIERS (provided by DRPA)

Crude oil imports have displayed slow, upward growth over the historic period of 1990-2001. Import tonnage in 1996 showed a significant downward "blip", because Tosco purchased the British Petroleum refinery and shut down operations for that year to complete a modernization program. Compound annual growth for 1990 to the study year of 2000 in the benefit analysis is equal to 1.8%. 2001 has displayed lower tonnage than 2000, but the compound annual growth from 1990-2001 of 0.8% is still well in excess of the future growth rate applied in the crude oil benefit analysis of 0.21% per year.

2001 tonnage was lower than 2000 tonnage for the following reasons: 1) for the last part of calendar year 2001, U.S. oil demand declined as a direct result of the aftermath of the 9/11 terrorist attacks (particularly for gasoline), 2) a relatively warm winter contributed to lowered demand for heating oil, and 3) recessionary pressures within the U.S. economy contributed to reduced demand for crude oil imports.

Containerized Commodities

Containerized cargo imports to the Delaware River Port System consist primarily of vegetables, fruits and eggs – requiring refrigeration; meat/dairy/fish products requiring refrigeration; other food, and other goods requiring refrigeration. In the year 2000, these import categories totaled over 3 million metric tons.

Total container tonnage and Australia/New Zealand trade route tonnage display compound annual historic growth for the period from 1990-2001 of 1.3% and 2.2% per year, respectively (see Table C-14). The last five years (from 1996-2001) specifically for the benefiting trade route of Australia/New Zealand shows an compound annual growth rate of 6.5%. The future compound annual growth rate of 3.4% applied in the benefit analysis for this trade route compares well with the historic data.

Table C-14
Containerized Imports from Australia & New Zealand
(All Delaware River Ports – Short Tons)

Year	Austr/NZ
1990	453,988
1991	462,086
1992	530,359
1993	538,094
1994	491,878
1995	453,195
1996	420,788
1997	454,080
1998	524,298
1999	509,184
2000	483,602
2001	576,954

Source: Journal of Commerce, PIERS (provided by DRPA)

Forty-eight percent of total imported container tons are reported to originate from Central America, including Guatemala, Honduras, and El Salvador. Other regions reporting significant tonnages include Australia/New Zealand (20%), Europe, and the East Coast of South America (including Brazil).

The major container terminals in the Delaware River Port System include the Port of Wilmington and the Packer Avenue Terminal. The Port of Wilmington handled over 1.25 million tons of containerized cargo in 2000, and is the nation's leading port for imports of fresh fruit, meat, fish, and juice concentrate. The Port of Wilmington handles over 200,000 twenty-foot equivalent units (TEUs) per year for Dole Fresh Fruit Company and Chiquita Banana North America.

The Philadelphia Regional Port Authority (PRPA) is the owner of the Packer Avenue Marine Terminal, which handled over 179,000 TEUs in the year 2000. Three of the largest operators providing reefer container service that operate out of Packer Avenue include: P&O Nedlloyd, the Columbus Lines, and Aliança.

Dry Bulk

Many dry bulk commodities are imported through the Delaware River Port System, including: iron and steel; stone, clay and other minerals; paper, paperboard and products; wood products; fertilizers and pesticides; and ores, among others. The most relevant dry bulk commodities for the purposes of this benefit analysis are described below.

Blast Furnace Slag

Nearly 370,000 metric tons of blast furnace slag was imported from Italy through the South Jersey Port Corporation's Beckett Street Terminal in 2001. The blast furnace slag was identified as a result of direct interviews with the receiving terminals and confirmed in the pilots' logs. Blast furnace slag is a new import commodity that, once processed, is used as an additive in Portland cement to enhance its strength and durability. Preliminary data obtained from Maritime Exchange records indicate that 2002 slag imports will be 25 to 50 percent above 2001 levels.

The blast furnace slag is being shipped to a new granulated blast furnace slag (GBFS) processing facility that has been built by the St. Lawrence Cement Group in nearby in Camden, NJ. The plant has an annual throughput capacity of 1,000,000 metric tons and is in the process of ramping up to full production. St. Lawrence Cement Group, a subsidiary of Holcim, Ltd. (previously named Holderbank Financiere Glaris Ltd.), has initiated a 45-year contract with SJPC and has invested approximately $60 million in the GBFS facility.

Steel Slabs

Over 2.3 million tons of steel slabs and ingots were imported through the Delaware River port complex in 2001. Of this total, over 830,000 metric tons of steel slabs were imported from Brazil through the Packer Avenue Terminal in 2001. The remaining tonnage transits through shallow water terminals that will not benefit from channel deepening.

While import tonnage has been volatile from year to year, steel slabs have shown very significant growth over the longer term, with the 2001 total exceeding the 1990 total by a factor of twenty-seven (see Table C-15 below). The last five years from 1996-2001 has displayed compound annual growth of 13.2%.

Table C-15
Imports Of Steel Slab/Ingots
(All Delaware River Ports)

Year	Import Tonnage
1990	84,371
1991	46,874
1992	15,791
1993	18,342
1994	156,637
1995	311,268
1996	1,248,021
1997	1,806,897
1998	1,348,179
1999	3,168,883
2000	2,700,976
2001	2,315,047

Petroleum Products

Refined petroleum products are also a major import to the Delaware River Port System, with over 2 million metric tons landed in the year 2000. Delaware Terminal currently brings in petroleum products (#6 fuel oil, diesel, and home heating oil) and crude by barge and tanker to their facility within the Port of Wilmington along the Christina River. Delaware Terminal accounted for over 560,000 metric tons of imports in the year 2000, primarily from Venezuela.

3.7 Existing and Future Fleet Characteristics

As indicated in Figure C-5, the vast majority of the nearly 75 million metric tons of commodities transported to the Delaware River consists of crude oil delivered on tankers (57 million), followed by bulk (7 million), combination (3 million), and containerized cargo (3 million).

Table C-16 shows total commodity tonnage by the size of vessel, in deadweight tons (DWT). Tanker vessels constitute the largest portion of vessel traffic. Nearly 44 percent of total tonnage was carried on vessels in excess of 100,000 deadweight tons. Over 21 percent of total tonnage was carried on vessels in excess of 140,000 DWT.

Figure C-5
Vessel Tonnage by Ship Type, 2000

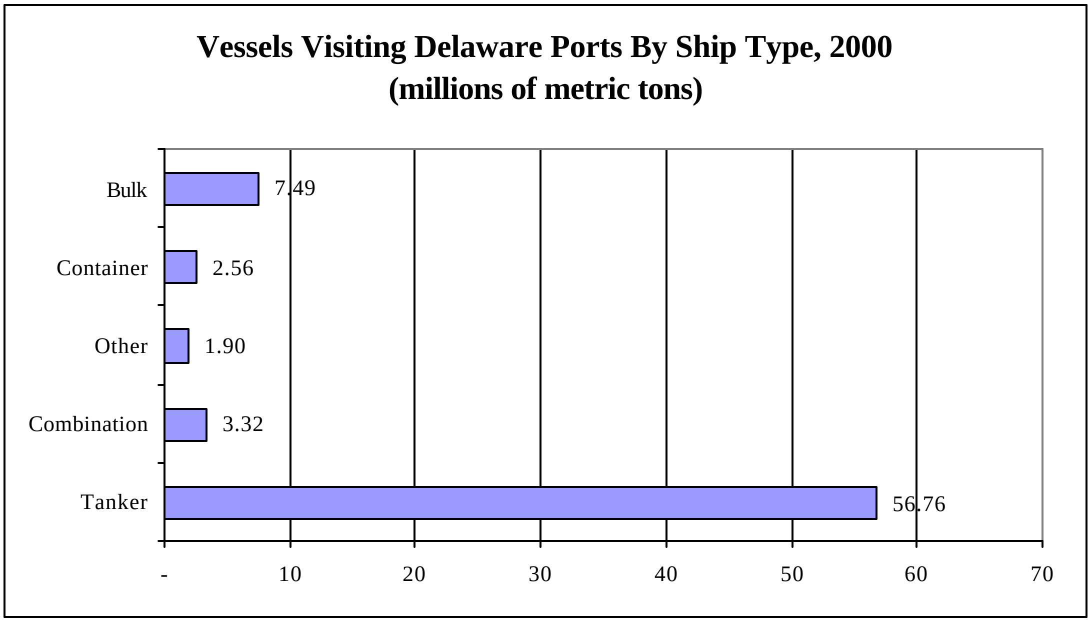


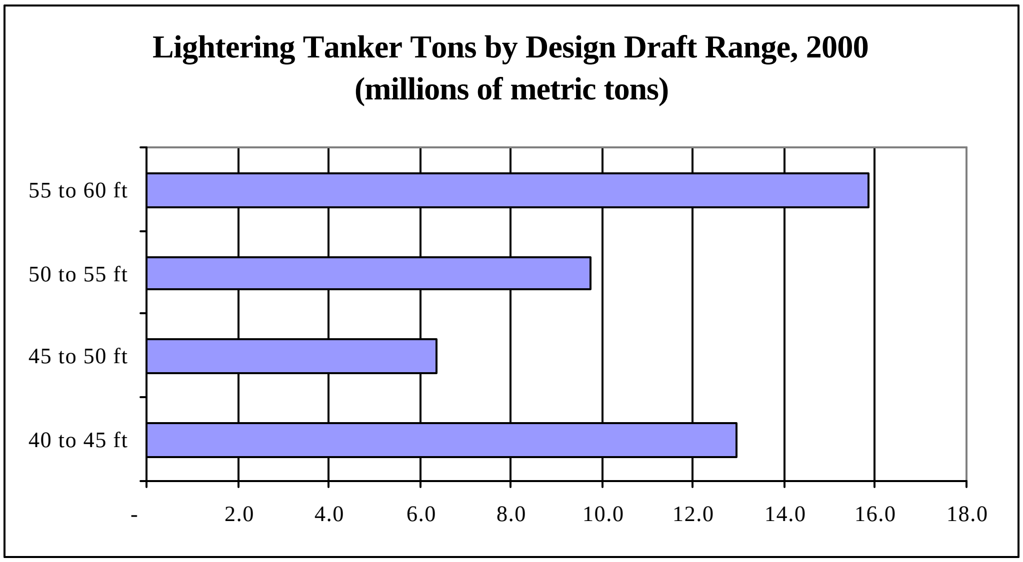
Table C-16
Delaware River Vessel Traffic by Deadweight Tons: 2000

Vessel Type	Range of DWT	Metric Tons	% Share of Total Tons
Tanker	90,000 to 99,999	13,691,023	18.29%
Tanker	150,000 to 159,000	11,779,294	15.74%
Tanker	140,000 to 149,000	10,130,930	13.54%
Tanker	100,000 to 109,999	4,958,059	6.62%
Tanker	300,000 to 309,000	4,189,135	5.60%
Tanker	80,000 to 89,999	3,238,261	4.33%
Bulk	40,000 to 49,999	2,560,000	3.42%
Bulk	30,000 to 39,999	2,050,000	2.74%
Tanker	60,000 to 69,999	1,860,178	2.49%
Tanker	130,000 to 139,000	1,682,977	2.25%
Other	Not Reported	18,704,117	24.99%
Total Tons		**74,843,974**	**100%**

3.7.1 Tankers

Figure C-6 shows tonnage carried on liquid bulk vessels with design drafts in excess of 40 feet, the depth of the existing channel. Nearly 45 million metric tons were carried on these vessels in 2000, or nearly 60 percent of all Delaware River tonnage. Of the tonnage carried on vessels with design drafts greater than or equal to 40 feet, 35% of the tonnage was carried on vessels with design drafts between 55 feet and 60 feet, and 22% of the tonnage was carried on vessels with design drafts between 50 feet and 55 feet

Figure C-6
Tanker Tonnage by Vessel Design Draft



There are a variety of foreign ports that are the origins of crude imports to the Delaware River. In general, vessels in the larger sizes carried cargo from the further origins in Africa and the North Sea. Vessels in the smaller size ranges generally carried cargo from closer origins in the Caribbean Sea and Canada. Many of these closer origins are actually transshipment facilities at Point Tupper, Nova Scotia (Phillips/Tosco) and St. Eustacius (Valero).

The previous figure illustrates the quantity of tanker cargo carried on vessels that were lightered in the year 2000. The vessels included in the above population have design drafts in excess of 40 feet and sailing drafts over 37 feet.

Non-lightering tankers (and combinations) include vessels that have sailing drafts, though not necessarily design drafts, below 40 feet. The majority of traffic within this category, 73.2 percent, was transported in vessels ranging between 90,000 and 120,000 deadweight tons.

Table C-17 below shows the average DWT and design drafts of tankers calling at the principal Delaware River refineries.

Table C-17
Average DWT and Design Drafts
Delaware River Refineries: 2000

Refinery	Average DWT	Average Design Draft (feet)
Valero	93,117	45
Phillips 66 (Tosco)	120,108	48
Sun Facilities	171,515	53
Motiva	97,698	45
Coastal	140,170	53

3.7.2 Bulk Vessels

This section analyzes the bulk cargoes (primarily iron and steel) which are carried in vessels with design drafts above 40 feet and which could benefit from deepening of the Delaware River Main Channel. An 80,000-ton bulk carrier would save costs if loaded to 45 feet instead of 40 feet when sailing approximately 4,500-mile distances to the Delaware River from Brazil and Latvia. The benefits associated with iron and steel are a function of the tons that are included in the benefiting category. In year 2000, approximately 700,000 tons were carried in vessels drawing more than 40 feet.

This analysis also shows significant tonnages of stone, clay and other crude minerals from Canada in vessels with design drafts above 40 feet. However, these vessels arrive with sailing drafts below 35 feet and not currently constrained in the existing 40-foot project. Therefore, these vessel movements are not projected to benefit from a deeper channel.

Furnace Slag Fleet

As stated previously, future commodity projections include 1,000,000 tons of blast furnace slag entering the port destined for the new St. Lawrence Cement GBFS production facility located near the Beckett Street Terminal. Approximately 370,000 metric tons of blast furnace slag arrived at Beckett Street between February 2001 and December 2001, according to the Maritime Exchange database.

This product has been arriving since early 2001on bulk vessels in the 65,000 to 74,000 DWT range, with design drafts ranging from 41 to 46 feet and sailing drafts of 40 feet. Data on vessel characteristics, sailing drafts, and import tonnage for the existing slag fleet are shown in Table C-18 below. As can be seen from this table, all vessels currently transporting furnace slag have design drafts sufficient to take full advantage of the existing channel depth, and are depth constrained, having arrived at (or near) the maximum sailing draft allowed by the channel. Based on sailing drafts at their destination in the Delaware Bay, it is likely that these vessels actually departed their port of origin full, or nearly full, after accounting for fuel burn-off.

Table C-18
Furnace Slag Fleet Characteristics

Vessel Name	Arrival Date	Origin	DWT	Design Draft	Arrival Draft	Tons Carried 2001
CIC SPLENDOUR	02/21/01	TARANTO	64,919	42	40	61,130
CIC SPLENDOUR	09/01/01	TARANTO	64,919	42	40	61,130
HEBEI DIAMOND	07/26/01	TARANTO	66,767	43	40	60,983
KONKAR THEODORA	12/06/01	TARANTO	65,282	42	40	61,480
MARIA SALAMON	11/01/01	KIMITSU	74,117	46	39	59,713
MICHELE IULIANO	04/10/01	ITALY	64,850	41	40	62,957

The existing fleet was used for future without project conditions, since it appears to be optimally sized based on existing channel depth. However, to transport anticipated growth in tonnage, additional vessels will need to be added to the service in future years. Therefore, a synthetic representative vessel was created based on the arithmetic average of the deadweight tonnage of the existing fleet (excluding the Maria Salamon, which appears to be an inefficient outlier). At-sea and at-port vessel operating costs for this synthetic 65,347 DWT vessel were calculated using regression equations that were calculated from the FY 2002 EGM vessel operating cost tables for foreign flag dry bulk vessels. These additional vessels were then added to the fleet and allowed to fill to 40 feet as needed in any given year to accommodate the total tonnage forecast growth.

Interviews with terminal operators have indicated that furnace slag imports would shift to larger bulk vessels with design drafts in excess of 45 feet under with project conditions. Existing bulk vessels are obtained from the charter market and there are no barriers to fleet replacement. Therefore, a 80,000 DWT foreign flag bulk vessel drafting 46 feet was selected from the FY 2002 EGM operating cost tables to represent the with project condition fleet. Vessels were allowed to fill to channel depth (45 feet) and a sufficient number brought into service in each year in order to accommodate that year's total tonnage.

Steel Slab Fleet

Shipments of steel slabs to the Packer Avenue Marine Terminal typically arrive on bulk vessels averaging 45,000 dead weight tons (DWT), with an average design draft of 38 feet (range 34 to 45 feet), and an average sailing draft of 37 feet (range 35 to 40 feet).

Under with project conditions, the operator of Packer Avenue (Greenwich Terminals) has indicated that it is likely that there will be a shift to larger vessels that could take full advantage of a 45-foot channel.

Again, these dry bulk vessels come from the charter market, therefore there are not any sunk investment costs that would militate against a fleet shift. The current steel slab fleet contains greater variability in design draft and sailing draft than the furnace slag fleet, and contains some vessels that cannot take full advantage of the existing 40-foot channel. For this reason, two vessels were chosen to represent the with project fleet: a 60,000 DWT, 42-foot bulker (which could not take full advantage of the 45-foot channel); and an 86,667 DWT, 47-foot bulker (which could load to maximum channel depth). Vessel operating costs for these bulkers were taken from the CECW-P Economic Guidance Memorandum 02-02, Deep Draft Vessel Operating Costs, 12 August 2002. Vessel loading patterns observed in the 2000 database were also applied to the with project condition, i.e., the smaller bulkers were allowed to fill to their design draft (42 feet), while the larger bulkers were allowed to fill to one foot less than channel depth (44 feet).

Analysis of Bulker Fleet Shift

The economic basis for a shift to larger vessels in response to channel deepening can be established by comparing the with-project and without-project depths and the cost per ton for the smaller vessels and the larger vessels potentially responding to an increase in project depth. Whether there is a shift to larger vessels is determined by the long run savings in cargo delivery costs from the introduction of higher payload ships.

An analysis was conducted to test the reasonableness of the with-project vessel fleet selection and loading patterns. The results of this analysis are shown in Table C-19. Transportation cost savings will result from the shift to larger vessels under with project conditions. The average cost per ton for transporting furnace slag will decrease by $1.71/ton (from $10.35 to $8.64) and the average cost per ton for transporting steel slabs will decrease by $2.33/ton (from $10.73 to $8.40). The impact of shift in the slag vessel fleet under with project conditions would result in a reduction in transportation costs of $1.71/ton. Compared to a slag cost of $8.60/ton (source: USGS 2002 Iron and Steel Slag Mineral Commodity Summary), the transportation cost differential provides a significant incentive for a shift to larger vessels (and a significant competitive advantage for imported slag from Italy).

Table C-19
With and Without Project Bulker Fleet
Average Transportation Cost Per Ton (2009)

40 Ft. Channel And Without-Project Fleet		
	Slag	**Slabs**
Total Costs	$ 10,354,192	$ 10,814,543
Total Tonnage	1,000,000	1,007,880
Avg. Cost/Ton	$ 10.35	$ 10.73
45 Ft. Channel And With-Project Fleet		
Total Costs	$ 8,643,216	$ 8,465,780
Total Tonnage	1,000,000	1,007,880
Avg. Cost/Ton	$ 8.64	$ 8.40

3.7.3 Containerships

A review of container cargo in the Delaware River in 2000 showed limited containership calls with sailing drafts above 35 feet. In addition, almost half of the container tons originate in Central America in vessels with sailing drafts below 35 feet. Almost fifty percent (48.7%) of total imported container tons are reported to be from Central America, including Guatemala, Honduras, and El Salvador. Other regions reporting significant tonnages include Australia/New Zealand (20%), Europe and the east coast of South America.

Refrigerated commodities constituted over one-half of total container traffic in the year 2000. Most container cargo is carried in refrigerated, climate-controlled “reefer” containerships with design drafts greater than 35 feet. Vessels with design drafts in the 36 to 40 foot range carried cargo from the east coast of South America and Australia/New Zealand. Vessels carrying refrigerated goods to the U.S. East Coast from Australia/New Zealand have typically been scheduled as a direct service that returns to Australia/New Zealand after calling at the US East Coast. Historic and projected trade growth for refrigerated goods (see Section 4.6) from Australia/New Zealand to the U.S. East Coast and Europe, and for refrigerated goods from the U.S. to Europe has prompted P&0 Nedlloyd and others to initiate a new service specifically designed to meet the growing needs of the eastbound refrigerated trade.

A new fleet of larger 4100+ TEU containerships is currently being phased into a new Australia-New Zealand to U.S. East Coast to Europe service. The service is operated by a consortium of carriers that share space on VSA member vessels, including P&O Nedlloyd, Columbus Lines, Hamburg-Sud, Contship, and others. One of the main consortium members providing refrigerated container service, P&O Nedlloyd, is introducing their “Albatross” Class vessels (4,112 TEU) on this new eastbound round-the-world service originating in Australia and New Zealand and calling at Philadelphia and other U. S. East Coast ports, as described in Section 3.4.2. The first two of these vessels, the Remuera and the Encounter are in service and have already called at Packer Avenue. Three more PONL “Albatross” Class vessels, the Botany, Palliser, and Pegasus, are scheduled for this service, as well as three similarly sized Contship Containerlines vessels (the Aurora, Borealis, and Australis) and one similarly sized Columbus Line vessel (New Zealand). In December 2002, the new eastbound round-the-world service will be initiated on a weekly schedule calling at the Packer Avenue terminal every 7 days, or 52 times per year.

Whereas the P&O Nedlloyd liner service identified in the 2000 and 2001 data files was an end-to-end service between Philadelphia and New Zealand, this new service will use 4,100+ TEU capacity vessels with design drafts of 41 feet. Service will continue from the U.S. East Coast to Europe, returning to New Zealand via the Suez Canal, creating a round-the-world service. While the vessels will be coming through Panama with a 39.5-foot draft limitation, they will be picking up export cargo from Savannah (poultry and fruit destined for Europe) prior to making their call in Philadelphia. According to P&O Nedlloyd, once the service is fully established, this will cause the ships to draw around 41 feet when leaving Savannah and coming up the Delaware River channel. Data for containership departures from Savannah in 2001, although not bound for Philadelphia as the next port of call, indicate that there were 39 departures at drafts greater than 37 feet and 16 departures at drafts greater than 40 feet. Current operating practices and service schedules limit containership sailing drafts in the Delaware River to 37 feet. According to both the shippers and the pilots, because of their service schedules and the potential for tide delays as long as 10 hours (considering the length of channel that must be ridden with the tide), these large liner service containerships are unwilling to wait for and spend the additional time necessary to ride the tides. This will require the carriers to reroute the service to call at Philadelphia before Savannah, until/unless the Delaware River is deepened to 45 feet.

4. TRADE FORECAST

This section of the benefits analysis describes the data, methodologies, and results of future with and without project commodity projections and fleet forecasts prepared for the period from 2000 to 2060.

Future trade forecasts for the Delaware River Port System were prepared by DRI-WEFA. DRI-WEFA forecasts and analysis are based on DRI-WEFA's World Trade Service Forecast methodology and the most recent update of the National Dredging Needs Study (NDNS). The base year data originates from the WCSC and Journal of Commerce data for the year 2000 and trade forecasts from DRI-WEFA. Trade forecasts for new commodity movements subsequent to 2000 were identified in the Maritime Exchange database for 2001 and the first half of 2002. Projections for these new commodities were developed separately and used to supplement the DRI-WEFA forecasts. A comprehensive report describing DRI-WEFA forecasts is provided in Attachment 1 to this appendix and is summarized below.

4.1 World Trade Model Description and Methodology

The purpose of this section is to describe the standard forecast methodology of DRI-WEFA's World Trade Service (WTS) model. This forecasting methodology was used to create a customized forecast of trade volume through the port system of the Delaware River extending into the future, by decade, from 2000 to 2060. A more detailed description of model methodology is provided in Attachment 1.

DRI-WEFA's global trade forecasts include all commodities that have physical volume. Commodities are grouped into categories derived from the International Standard Industrial Classification (ISIC). The forecast covers 77 ISIC commodity categories.

The WTS forecast tracks 54 major countries individually, then groups the rest of the countries in the world into 16 regions according to their geographic location. Therefore, the forecast involves 77 commodities traded among 70 country/regions. This is a framework of $77 \times 70 \times (70-1)$, or 371,910 potential trade flows.

World trade is first forecast in nominal and real commodity value and then translated into physical volume by transportation mode.

The primary source of historic global trade data is the United Nations' (UN) world trade statistics distributed by Statistics Canada. These data are collected from member countries' customs records and includes all member countries. The WTS employs the Statistics Canada version of the UN data, which is cleaned to remove inconsistencies between different countries' trade statistics. For some important economies that are not covered by the United Nations, such as Taiwan, data are obtained directly from government statistics. In addition, U.S. Customs data are used to verify these sources on a commodity and route-specific basis.

The WTS forecast incorporates DRI-WEFA's comprehensive macroeconomic databases and forecasts. The data used include gross domestic product (GDP), industrial output, foreign exchange rates, export prices, etc., by country. These data serve as exogenous variables in the WTS forecast model. For international commodity prices, data are obtained from the U.S. Bureau of Labor Statistics' International Price Program.

The basic structure of each model for the trade flow of a commodity is that a country's import from another country is derived from the importing country's demand forces. Demand forces are commodity specific. The 77 commodities are grouped into two types. For the first type, the major demand forces are the importing country's population and income growth. For the other commodities, the major demand forces are the importing country's production and technology development.

A country's export capacity for a commodity is estimated based on the country's capacity to produce this commodity and its ability to export it. The capital and resources that are needed for production determine production capacity. Export ability is determined by the quality and cost of the product in competition with the world market.

The models are constructed in real value terms. For example, the trade flow of a commodity is measured in the 1997 value of this commodity, and GDP of a country is measured in its real value of GDP. The models are constructed in real terms, because only in real terms do imports show clear responses to changes in demand, supply, and price.

The WTS forecast uses a modified top-down approach where the forecasts are controlled. To implement this approach, detailed trade flows are aggregated to the top three levels. The detailed trade flows are labeled Level 4 (the lowest level), Level 3, Level 2, and Level 1. The following structure illustrates how they are aggregated:

Level 1

L1: World trade of total commodities,

$1 \times 1 = 1$ series.

Level 2

L2M: Total commodities that each country/region imports from the world,

$1 \times 70 = 70$ series.

L2X: Total commodities that each country/region exports to the world,

$1 \times 70 = 70$ series.

L2C: World trade by commodity,

$77 \times 1 = 77$ series.

Level 3

L3M: Commodities that each country/region imports from the world,

$77 \times 70 = 5{,}390$ series maximum.

L3X: Commodities that each country/region exports to the world,

$77 \times 70 = 5{,}390$ series maximum.

Level 4

L4: Commodities traded between each pair of countries/regions,

$77 \times 70 \times (70-1) = 371{,}910$ series maximum.

For this analysis, the future demands for maritime cargo movements through the Delaware River ports were forecast using DRI-WEFA's state-of-the-art World Trade Model (WTM). As explained previously, a "top down" approach was employed to develop the U.S. coastal region import and export forecasts consistent with the commodity trade forecasts for the United States as a whole. From the coastal region forecasts, the North Atlantic coastal region forecast was then disaggregated to estimate future trade for the Delaware River ports.

The following discussion describes the methodology used to forecast foreign waterborne cargo through the Delaware River ports for the period of analysis. The development of trade forecasts for the Delaware River ports employed a methodology where the U.S. coastal trade for the North Atlantic region was apportioned to the local (Delaware River ports) region using historic shares calculated from the U.S. Waterborne Commerce Statistics for these ports, on a commodity, direction of trade and trade partner basis. The historic waterborne commerce statistics for the Delaware River ports were aggregated to the dimensions of trade used in the DRI-WEFA World Trade Model for the purposes of forecasting the Delaware River ports' trade. This meant that the harmonized system commodity classifications of the waterborne commerce statistics were aggregated up to the same 77 commodity categories of the world trade forecast at the world, national, and U.S. coastal range level, using the same commodity mapping. Similarly, the individual trade partner countries in the waterborne commerce statistics were aggregated up to the same trade partner country and region definitions used in the world, national and U.S. coastal range forecasts. The geographic definition used for the Delaware River ports' trade was also matched to the same Waterborne Commerce Statistics port codes used in the definition of the study area.

For most of the 77 commodity categories forecast for world trade and U.S. trade at the coastal level, the Delaware River port forecast represents a constant 2000 share of U.S. North Atlantic coast trade for each commodity with each individual trade partner country and region in the World Trade Model. Because the forecast growth rates vary by commodity and trade partner country, the total trade of the Delaware River ports as a share of the total trade of the North Atlantic coastal region is not constant. Instead the aggregate trade share varies in accordance with the shifting mix of commodities and trade partners over time for both imports and exports.

This approach is consistent with the approach used for the coastal region level. Trade patterns follow previously established routes with a limited ability to quickly shift among sources or destinations. At a commodity-specific and trade-partner specific level, the relative competitiveness of the Delaware River ports is held constant measured against the other ports in the U.S. North Atlantic coastal range with respect to their position in the year 2000. This approach makes no assumptions about new differential price or production advantages or disadvantages of the Delaware River ports in comparison with other ports in the U.S. North Atlantic for the forecast period, since market shares are determined by the sum of all influences that resulted in the relative competitiveness of the ports through the year 2000.

For the crude petroleum and refined petroleum product commodity categories, the Delaware River ports' share of the U.S. total and U.S. North Atlantic coastal trade forecast was not permitted to grow with the growth in U.S. demand. Instead the trade shares were permitted to change as a result of imposing an external forecast assumption that no new refineries will be constructed at these ports in the forecast period. This assumption constrains the total volume of imports of crude oil and outbound shipments of petroleum products for the Delaware River ports to those volumes that can be expected from technological improvements to existing refinery operations and marginal increases in annual capacity utilization rates.

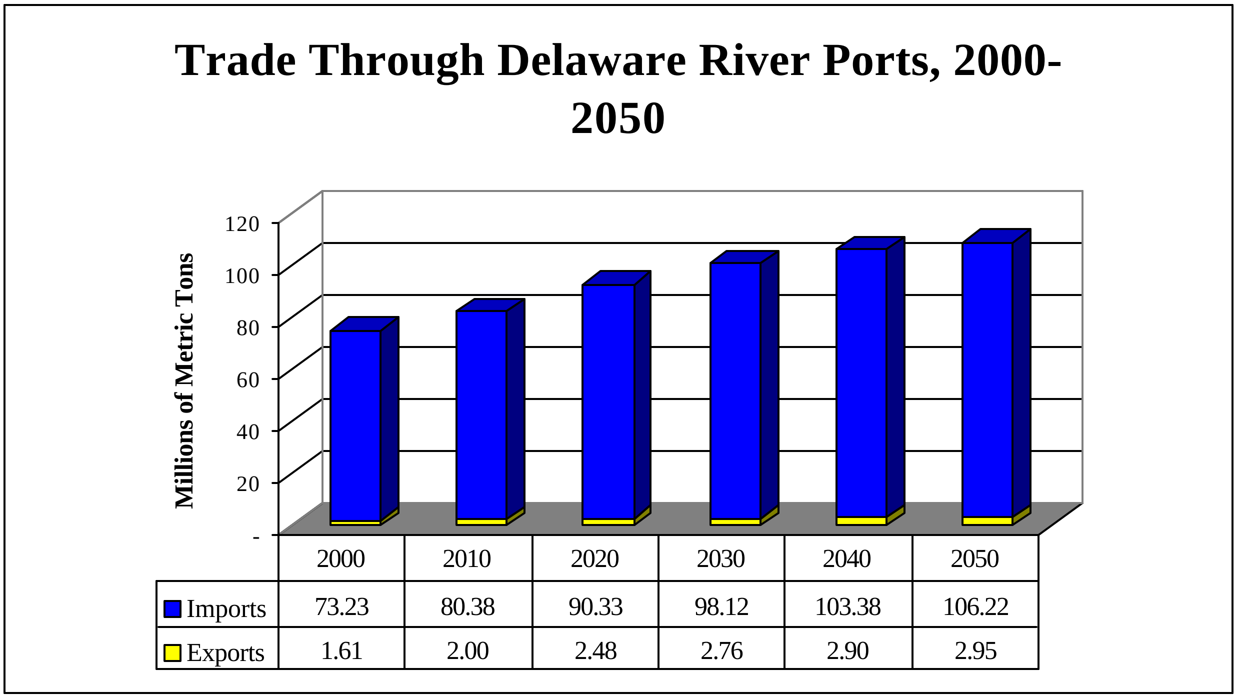
4.2 Future Trade Volumes through Delaware River Port System

As indicated in Figure C-7, imports are expected to continue to dominate trade through the Delaware River Port System through the 50-year period of analysis. Export growth exhibits only marginal growth through this period. The forecast for imports is primarily a factor of crude oil imports. The refineries of the Delaware River Port System are expected to experience continuing marginal growth in oil imports at less than the national average, due to constraints imposed by more modest expected productivity gains in oil refinery processing capacity.

4.3 Future Tanker, Dry Bulk, and Container Volumes

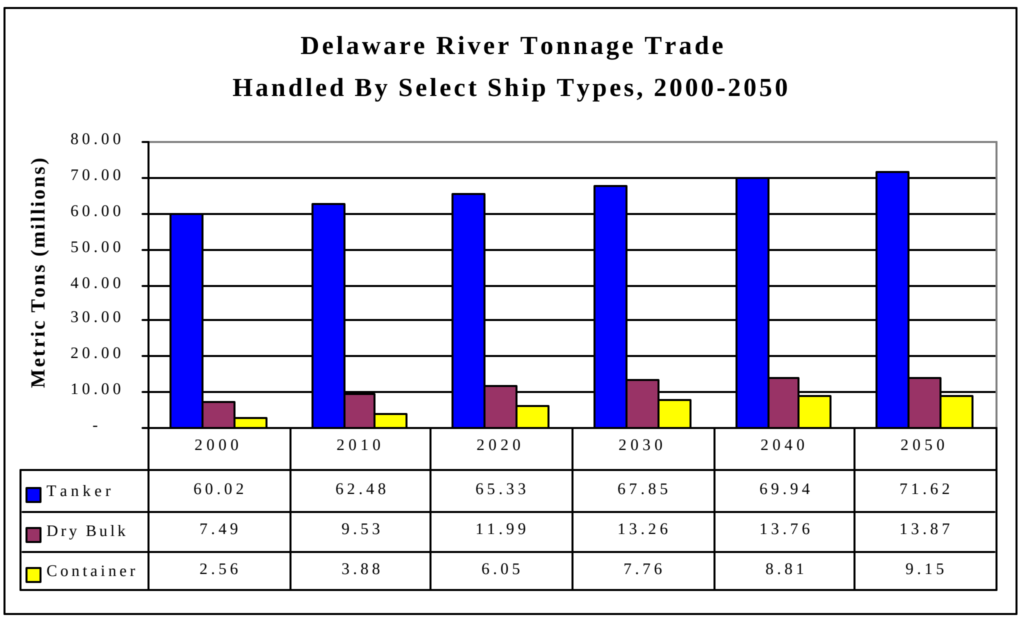
As indicated in Figure C-8, tanker vessels dominate vessel traffic within the Delaware River Port System, repeating a trend in overall U.S. trade traffic. Tanker totals in this figure include both imports and exports of crude and petroleum products.

Figure C-7
Export and Import Projections



	2000	2010	2020	2030	2040	2050
Imports	73.23	80.38	90.33	98.12	103.38	106.22
Exports	1.61	2.00	2.48	2.76	2.90	2.95

Figure C-8
Tonnage Projections by Ship Type



	2000	2010	2020	2030	2040	2050
Tanker	60.02	62.48	65.33	67.85	69.94	71.62
Dry Bulk	7.49	9.53	11.99	13.26	13.76	13.87
Container	2.56	3.88	6.05	7.76	8.81	9.15

4.4 Future Growth of Delaware River Ports

Table C-20 displays the projected growth in Delaware River Port System tonnage from 2000 to 2060, by location within the port. Tonnage is projected to increase modestly, increasing from 75 million tons in 2000 to 112 million tons in 2060. Imports dominate trade in this region with 98% of total tons in 2000 and 97% of projected total tons in 2060. Increasing at an average annual rate of 1.01%, exports are projected to reach nearly 3 million metric tons by the end of the forecast horizon (2060). There are no commodities moving in the export direction in volumes approaching the major import commodities. The largest export tonnages are residual and refined petroleum and organic chemicals. Refined petroleum products topped the list of exports with 343,469 metric tons in 2000.

4.5 Future Volumes of Import and Export Commodities

Tables C-21 and C-22 display the projected growth in Delaware River Port System imports and exports from 2000 to 2060, by commodity type. As indicated in Table C-21, crude petroleum accounted for 78% of year 2000 import tonnage. However, due to low growth through 2060, crude oil is projected to decline to 60% of total imports. Increases in shares of total import tonnage are projected for: (1) iron and steel, and (2) vegetables, fruits, eggs (requiring refrigeration). The latter is expected to grow from the 5th largest import category in 2000 (2.2 million tons) to the 2nd largest import category in 2060 (16.2 million tons).

Rates of tonnage growth for crude oil and petroleum products have been held nearly constant in the long-run, based on capacity expectations. Refining capacity along the Delaware River is not expected to expand, except for modest technological improvements. As a result, rates of tonnage growth for crude and petroleum products will be slower than the average growth in trade.

Export commodity projections are shown in Table C-22. Four of the top five export commodities in 2000 (residual petroleum products, petroleum products, organic chemicals, paper and paperboard and products, and motor vehicles) are expected to retain their position in the top five export categories in 2060. The most rapid rate of growth is expected in the vegetables, fruits, eggs (requiring refrigeration), increasing from 15.5 thousand metric tons in 2000 to 186 thousand metric tons in 2060.

Table C-20
Forecast of Total Trade In Metric Tons (2000-2060)

Exports	2000	2010	2020	2030	2040	2050	2060
Wilmington	547,931	740,313	969,845	1,114,741	1,213,300	1,256,495	1,301,228
Philadelphia	493,244	558,528	645,334	684,628	690,032	684,921	679,847
Chester	227,292	279,059	345,329	378,236	388,196	388,061	387,926
Marcus Hook	160,047	192,621	224,217	236,841	243,251	245,405	247,578
Gloucester City	81,679	109,668	153,106	183,998	200,704	204,996	209,380
Camden	59,805	75,039	96,342	109,686	115,758	116,882	118,018
Paulsboro	38,952	41,037	43,720	45,884	47,378	48,400	49,444
Eagle Point	2,745	2,761	2,582	2,352	2,139	2,022	1,912
Pennsauken	551	678	850	946	974	965	956
Export Total	**1,612,245**	**1,999,704**	**2,481,325**	**2,757,312**	**2,901,733**	**2,948,147**	**2,995,305**
Avg. Annual Growth		2.18%	2.18%	1.06%	0.51%	0.16%	0.16%
Percent of Total	2.2%	2.4%	2.7%	2.7%	2.7%	2.7%	2.7%
Imports	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Philadelphia	33,867,646	37,742,561	43,121,460	47,158,827	49,801,164	51,196,698	52,631,338
Chester	11,310,121	11,871,394	12,522,409	13,056,596	13,465,320	13,772,663	14,087,021
Wilmington	11,863,116	13,508,842	16,057,146	18,142,887	19,541,052	20,173,802	20,827,042
Paulsboro	8,260,010	8,623,903	9,078,781	9,493,479	9,834,213	10,093,058	10,358,716
Marcus Hook	5,942,532	6,173,561	6,426,868	6,653,363	6,844,573	7,003,879	7,166,892
Camden	998,687	1,287,155	1,655,165	1,879,281	1,976,635	1,987,532	1,998,488
Ft. Mifflin	481,665	494,260	505,060	516,102	527,392	538,935	550,730
Gloucester City	210,309	360,162	636,803	880,775	1,051,266	1,120,043	1,193,319
Pennsauken	105,344	108,099	110,461	112,876	115,345	117,869	120,449
Eagle Point	95,829	98,335	100,484	102,680	104,927	107,223	109,570
Burlington	79,574	93,310	104,446	105,700	102,092	98,670	95,362
Westville	16,896	15,772	14,909	14,422	14,195	14,065	13,936
Import Total	**73,231,729**	**80,377,354**	**90,333,992**	**98,116,988**	**103,378,174**	**106,224,437**	**109,152,863**
Avg. Annual Growth		0.94%	1.17%	0.83%	0.52%	0.27%	0.27%
Percent of Total	97.8%	97.6%	97.3%	97.3%	97.3%	97.3%	97.3%
Total	**74,843,974**	**82,377,058**	**92,815,317**	**100,874,300**	**106,279,907**	**109,172,584**	**112,148,168**

Table C-21
Forecasted Tonnage for Top Delaware River Imports
(Thousands of Metric Tons)

Forecasted Tonnage for Top Delaware River Imports
(thousands of metric tons)

Commodity	2000	2010	2020	2030	2040	2050	2060	% annual growth
Crude Petroleum	57,274.2	58,488.4	59,728.3	60,994.5	62,287.6	63,608.0	64,956.5	0.2%
Iron and Steel	4,131.3	5,125.1	6,400.7	7,037.5	7,283.1	7,378.2	7,474.6	1.0%
Stone, Clay and Other Crude Minerals	2,326.3	2,807.8	3,255.0	3,379.1	3,324.7	3,243.5	3,164.3	0.5%
Petroleum Products	2,207.4	2,295.0	2,386.1	2,480.8	2,579.3	2,681.7	2,788.1	0.4%
Vegetables, Fruits & Eggs - Req. Ref.	2,185.6	4,132.2	7,978.6	11,521.5	14,057.1	15,087.5	16,193.4	3.4%
Organic Chemicals	819.8	1,510.7	2,716.7	3,690.8	4,304.3	4,552.4	4,814.7	3.0%
Paper and Paperboard and Products	649.6	874.3	1,123.3	1,216.3	1,208.2	1,182.3	1,156.8	1.0%
Non-Metallic Products, nec.*	499.9	782.4	1,167.8	1,433.2	1,598.2	1,670.3	1,745.6	2.1%
Meat/Dairy/Fish Req. Ref.	451.6	536.8	601.6	611.0	595.3	578.3	561.8	0.4%
Wood Products	324.5	597.9	988.5	1,292.9	1,458.0	1,488.1	1,518.8	2.6%
Other Food	255.2	345.6	460.7	521.7	537.8	531.6	525.4	1.2%
Other Req. Ref.	198.9	262.6	324.5	354.2	364.5	364.4	364.3	1.0%
Inorganic Chemicals	184.8	256.4	367.7	439.9	470.8	477.4	484.2	1.6%
Fertilizers and Pesticides	178.2	207.1	216.9	208.2	195.7	188.0	180.7	0.0%
Chemical Products, nec.	146.0	205.5	263.8	276.6	270.9	263.4	256.1	0.9%
Other Manufacturing, nec.	141.2	256.3	445.6	604.7	708.6	749.2	792.2	2.9%
Ores	127.3	137.2	150.3	152.0	146.2	141.7	137.3	0.1%
Motor Vehicles	120.2	174.9	251.5	305.5	338.5	353.6	369.4	1.9%
Non-Ferrous Metals	114.5	166.2	228.0	252.5	250.7	243.3	236.2	1.2%
Residual Petroleum Products	101.0	93.7	88.1	84.9	83.4	82.5	81.7	-0.4%

Table C-22
Forecasted Tonnage for Top Delaware River Exports
(Thousands of Metric Tons)

Forecasted Tonnage for Top Delaware River Exports
(thousands of metric tons)

Commodity	2000	2010	2020	2030	2040	2050	2060	% annual growth
Residual Petroleum Products	343.5	469.5	586.7	639.1	675.8	688.6	701.6	1.2%
Petroleum Products	282.6	310.0	312.8	295.2	275.2	265.2	255.6	-0.2%
Organic Chemicals	141.9	171.1	211.5	225.5	222.0	215.2	208.6	0.6%
Paper and Paperboard and Products	97.3	116.4	134.8	136.4	129.5	124.2	119.0	0.3%
Motor Vehicles	83.5	115.7	160.1	190.3	207.9	215.7	223.8	1.7%
Iron and Steel	71.8	79.0	86.6	87.2	85.2	83.8	82.4	0.2%
Synthetic Resins	54.6	70.1	88.3	96.0	97.4	97.1	96.8	1.0%
Ores	46.3	44.0	42.8	40.2	36.9	35.1	33.3	-0.5%
Misc.	38.4	69.3	121.3	160.6	182.8	188.7	194.7	2.7%
Other Food	36.4	50.4	72.4	90.2	102.5	108.6	115.1	1.9%
Natural Gas	33.2	33.0	31.1	28.4	26.1	24.8	23.7	-0.6%
Inorganic Chemicals	24.3	27.1	30.8	32.2	32.0	31.4	30.9	0.4%
Coal and Coke	23.3	23.3	23.2	22.9	22.1	21.6	21.1	-0.2%
Waste Paper	21.5	19.8	20.4	20.1	19.3	18.6	18.0	-0.3%
Metal Products	21.0	24.7	29.2	30.6	29.8	28.7	27.7	0.5%
Chemical Products, nec.	20.6	26.6	31.7	32.3	30.9	29.8	28.7	0.6%
Meat/Dairy/Fish Req. Ref.	16.5	21.6	28.2	32.2	34.1	34.7	35.2	1.3%
Vegetables and Fruits - Non-Ref.	16.0	19.9	23.4	24.4	23.7	22.8	21.9	0.5%
Textiles	15.5	19.6	23.6	25.1	24.8	23.9	23.0	0.7%
Vegetables, Fruits and Eggs - Req. Ref	15.5	33.3	71.1	111.2	146.0	164.8	186.0	4.2%

* not elsewhere classified

Table C-23 identifies those import categories with the highest rates of expected growth during the period of analysis. The last column is the compound annual growth rate (CAGR). Based on volume of imports, the most significant of the rapidly growing import commodities are vegetables, fruits, eggs (requiring refrigeration); organic chemicals; miscellaneous, and other agriculture.

Table C-23
Delaware River Ports' 15 Fastest-Growing Imports, 2000 – 2060
(Thousands Metric Tons)

Commodity	2000	2010	2020	2030	2040	2050	2060	CAGR 00-60
Office and Computing Machinery	0.4	0.9	2.6	4.5	6.4	7.4	8.7	5.43%
Miscellaneous	79.3	178.0	387.9	604.5	796.1	906.9	1033.0	4.37%
Semi-Conductors	0.0	0.0	0.1	0.1	0.2	0.2	0.2	3.98%
Footwear	14.6	30.1	59.9	88.6	109.1	117.2	126.0	3.66%
Electrical Industrial Machinery	1.6	3.3	6.5	9.7	12.0	12.7	13.5	3.61%
Professional Equipment	1.5	3.0	5.8	8.5	10.6	11.3	12.1	3.53%
Electrical Apparatus, nec.*	4.3	8.8	17.1	24.1	29.0	31.2	33.6	3.49%
Vegetables, Fruits and Eggs - req refrig.	2185.6	4132.2	7978.6	11521.5	14057.1	15087.5	16193.4	3.39%
Engines and Turbines	16.0	30.7	57.4	80.6	96.5	103.1	110.1	3.27%
Other Communications Equipment	0.2	0.4	0.8	1.1	1.3	1.4	1.4	3.24%
Wearing Apparel	8.3	15.7	29.9	43.2	51.4	53.4	55.4	3.21%
Drugs and Medicines	6.5	11.7	21.6	30.4	36.4	38.8	41.4	3.13%
Organic Chemicals	819.8	1510.7	2716.7	3690.8	4304.3	4552.4	4814.7	2.99%
Other Agriculture	77.0	139.4	245.0	335.5	394.7	421.4	450.0	2.99%
Furniture and Fixtures	4.6	8.5	15.4	21.1	24.3	25.2	26.2	2.94%

* not elsewhere classified

Similarly, Table C-24 identifies those export categories with the highest level of expected growth. The export commodities that experience the strongest growth in tonnage tend towards higher value per unit commodities such as vegetables, fruits, eggs (requiring refrigeration); wearing apparel; and other food.

Table C-24
Delaware River Ports' 15 Fastest-Growing Exports, 2000 – 2060
(Thousands Metric Tons)

Commodity	2000	2010	2020	2030	2040	2050	2060	CAGR 00-60
Office and Computing Machinery	0.7	1.9	5.4	10.0	14.9	18.1	22.1	5.83%
Electrical Industrial Machinery	1.1	2.2	4.6	7.6	10.5	12.2	14.1	4.42%
Vegetables, Fruits and Eggs - Req. Ref	15.5	33.3	71.1	111.2	146.0	164.8	186.0	4.23%
Wearing Apparel	7.1	15.3	32.6	51.7	67.7	75.1	83.5	4.20%
Semi-Conductors	0.2	0.5	1.1	1.6	2.0	2.2	2.3	3.85%
Oil Seeds	0.2	0.4	0.7	1.0	1.3	1.5	1.7	3.69%
Footwear	0.2	0.4	0.7	1.1	1.3	1.5	1.6	3.52%
Professional Equipment	2.5	4.3	7.3	10.0	11.8	12.5	13.2	2.82%
Electrical Appliances and Houseware	1.3	2.3	4.1	5.6	6.5	6.7	6.8	2.80%
Miscellaneous	38.4	69.3	121.3	160.6	182.8	188.7	194.7	2.74%
Drugs and Medicines	5.8	10.3	17.4	22.8	25.9	26.7	27.6	2.64%
Other Communications Equipment	1.0	1.6	2.6	3.4	3.8	4.0	4.2	2.35%
Wood Products	2.5	3.8	5.7	7.2	8.1	8.3	8.6	2.07%
Other Manufacturing, nec.*	3.3	4.8	7.1	8.8	9.8	10.2	10.5	1.97%
Other Food	36.4	50.4	72.4	90.2	102.5	108.6	115.1	1.94%

* not elsewhere classified

4.6 Trade Forecasts for Specific Commodity Groups

For the period of analysis, forecasts for specific commodities were developed using the DRI-WEFA WTS model and/or interviews with owners/operators of marine terminals in the Delaware River Port System. Table C-26 contains annual growth rates for the period of analysis for those commodities that are moving on vessels that are constrained by depths in the Delaware River main channel. These commodities include: petroleum products, blast furnace slag, steel slabs, containers, and crude oil. The growth rate for steel slabs was based on the growth rate shown in Table C-26 for iron and steel.

Blast Furnace Slag

The future growth in imported blast furnace slag tonnage (which was not present in the 2000 database upon which DRI-WEFA based its projections) was developed exogenously to the DRI-WEFA model and was based on: interviews, the capacity of the newly constructed St Lawrence cement plant, and information on the U.S. market for the final product, processed Granulated Blast Furnace Slag (GBFS). The annual capacity of the plant is one million tons. Slag destined for St Lawrence is expected by the facility operator to achieve plant capacity before the project base year (2009). Therefore the forecast volume for slag in the base year is 1 million tons, which is kept constant thereafter throughout the period of analysis.

Blast furnace slag is new business that has occurred in the years 2001 and 2002. No historical trends are available to compare to the projections developed for this analysis. For this reason, information from the producer and the U.S. market for GBFS has been obtained to provide additional support for the projections used in the analysis.

St. Lawrence Cement operates four cement plants and numerous other facilities to serve 15,000 customers in Canada and on the Eastern Seaboard of the United States. The company's Canadian operations include a cement plant in Joliette, Quebec and 13 cement distribution terminals, one mineral components distribution terminal, 46 ready-mix concrete plants, 22 quarries and sand pits and two construction companies. These assets are located in Ontario, Quebec, and the Maritimes.

In the United States, the company operates two cement plants, one in Catskill, NY, and another in Hagerstown, MD. Its U.S. operations also include nine cement distribution terminals and sources and markets fly ash and ground slag, both mineral components. In mid-1999, upgrades to the two Canadian plants increased production capacity by 180,000 metric tons. Plans are underway for the construction of a two million metric ton cement plant in Greenport, N.Y. St. Lawrence also owns and operated two new facilities in Sault Ste. Marie, Ontario, and Camden, New Jersey. These new facilities produce a performance enhancing cementitious material (granulated blast furnace slag) from a by-product of iron and steel manufacturing.

The Slag Cement Association is a trade association whose membership is comprised of the major U.S. GBFS processors. Members include: St. Lawrence Cement, Essroc Cement Corp., Holcim (U.S.) Ltd., Lafarge North America, Lehigh Cement Company, Lone Star Industries, and St. Mary's Cement Inc. (U.S.). Included below is a press release from the Slag Cement Association describing recent trends in the GBFS market:

> *"New Record Set for Slag Cement Shipments in 2001*
>
> *Concrete specifiers and producers continued to use record amounts of slag cement in their concrete in 2001, the fifth consecutive year. Slag cement is a hydraulic cement which replaces a portion of the portland cement in a concrete mixture. It is shipped both as a separate finely-ground hydraulic cement and as a blended cement combined with portland cement. Both forms exceeded the previous year's record levels. Use of slag cement shipped as a separate product increased by 17% in 2001, for a total of 2.26 million metric tons. Use of blast-furnace slag blended cement increased by 43%, for a total of 560 thousand metric tons. Annual growth of slag cement and blended cement has averaged 16% and 50%, respectively, from 1996 – 2001. "*

Also provided below are excerpts from St Lawrence Cement's 2nd Quarter 2002 Earnings Announcement

> *"The Company's cement plants are operating at high capacity levels and we are also benefiting from additional volume from the recently acquired aggregate quarry in Acton, Ontario, the new crushing facility at the Varennes quarry near Montreal* ***and higher production rates at our GranCem® facility in Camden, New Jersey****."* (emphasis added)
>
> *"Camden GranCem(R) Facility Update*
>
> *We are pleased to report that the Camden GranCem® facility is producing at target levels and achieving strong customer acceptance. GranCem® is used to enhance cement mixes in specific applications… "*

Additional information concerning the U.S. Market for GBFS was obtained from the U.S. Geological Survey. The USGS Mineral Resources Program provides and communicates current, impartial information on the occurrence, quality, quantity, and availability of mineral resources.

Discussions with the USGS Commodity Specialist for iron and steel scrap (the category in which blast furnace slag falls) yielded the following information.

U.S. imports of blast furnace slag are now ranging between 1.2 and 2 million metric tons. Import tonnage is expected to increase by another 1+ million metric tons in the next several years, primarily because of increasing demand for processed GBFS and decreasing U.S. steel production that is resulting in less domestically produced slag byproducts.

Source supply of raw materials (furnace slag) and GBFS processing capacity, rather than final product demand, is the current constraint on U.S. GBFS production volumes. In general, U.S. GBFS processing facilities are able to sell all they can produce, due to extremely high demand for their product resulting from the huge size of the U.S. Portland cement market (85 million tons produced in 2001) relative to GBFS processing capacity (2.26 million tons in 2001).

Additional market data for blast furnace slag was obtained from the USGS Mineral Commodities Summary 2002 and Minerals Yearbook 2001. An excerpt is shown below.

> *"In 2001, the United States imported 2.6 Mt of ferrous slags. Granulated BF slag (GGBFS), which commands the highest price among ferrous slags, led the imports. In 2001, 1.8 Mt of GGBFS was imported. Imports of GGBFS, in descending order, were mainly from Canada, Italy, Brazil, Japan, and France. Principal discharge ports were Tampa, FL, New Orleans, LA, Philadelphia, PA, and Detroit, MI. In 2001, imports accounted for 15% of total ferrous slag shipments in the United States. This significant increase in imports was the result of a decline in the U.S. iron and steel production in 2001."*

In summary, based on interviews and analysis of U.S. market conditions, it is expected that the St. Lawrence Cement GBFS facility will reach full processing capacity (one million metric tons/year) at or before the project base year (2009). Sensitivity analyses described later in Section 6 of this appendix portray the impacts on project benefits should the facility either not reach full capacity by the base year, or exceed it (due to plant expansion or processing efficiency improvements).

Steel Slabs

Import volumes are expected to grow to nearly 1 million metric tons by the project base year, based on the DRI-WEFA projected growth rates for iron and steel shown in Table C-26.

A recent factor affecting this commodity movement is the imposition of tariffs on imported steel. As part of the Section 201 Investigation on steel imports initiated by the Bush Administration (Trade Act of 1974 (as amended)), the U.S. International Trade Commission (ITC) recommended on December 7, 2001 that the President impose a range of tariffs and quotas on steel imports into the United States. On March 5, 2002, President Bush announced his decision to impose temporary safeguards to help give America's steel industry and its workers the chance to adapt to the large influx of foreign steel. Specific quotas and tariffs were imposed on imported steel that vary according to the type of steel product and country of origin. The benefiting steel commodity movements considered in this analysis, steel slab imports from Brazil, are subject to these tariffs.

Imports of steel slabs are currently subject to a tariff rate quota (TRQ) of 5.4 million short tons. The out-of-quota tariff is 30%. Quotas and tariffs decline annually and expire at the end of three years. The quotas and tariffs for the three-year period are:

Year 1: 5.4 million short tons with over-quota tariff of 30%
Year 2: 5.9 million short tons with over-quota tariff of 24%
Year 3: 6.4 million short tons with over-quota tariff of 18%

The following information, obtained from a DRI-WEFA steel industry expert, was considered in estimating the impacts of temporary tariffs on future projections for imported steel slabs. Steel slabs, even from Brazil, will likely not be subject to tariffs as high as finished steel products going forward. This will help the growth in slab imports to continue at a more rapid pace than overall iron and steel imports into the U.S. The key factor contributing to more rapid growth is the linkage between foreign basic slab producers and U.S. domestic rolling mills. The U.S. will not protect the domestic raw steel production from competition from imported slabs as much as it will protect by tariff the U.S. finished steel products from domestic steel producers, which is the higher value-added production. Because of linkages with the finished steel product producers within the U.S., foreign steel slab producers will have the political support domestically to continue to expand their share of the U.S. market.

For these reasons, basing future steel slab import projections on the DRI-WEFA projections for the broader iron and steel group is considered to be conservative.

Container Forecast

The benefits of the deepening project for containerized trade are based largely on forecasts for meat/dairy/fish products requiring refrigeration, which are the major import commodities in the Australia/New Zealand – U.S. East Coast and Europe trades and the U.S. East Coast to Europe trade. The new weekly eastbound round-the-world service is being operated with vessels that have a significantly higher proportion of refrigerated container slots (1,300 on a 4100+ TEU vessel) than other vessels of similar size. The major U.S. East Coast ports-of-call for this liner service are Savannah, Philadelphia, and currently New York.

Vessels in this eastbound round-the-world service will arrive at Philadelphia carrying a variety of goods, including cargo from Australia/New Zealand bound for Philadelphia, cargo from Australia/New Zealand bound for Europe, and cargo loaded at Savannah also bound for Europe. The forecasts of TEUs to be offloaded at the Packer Avenue terminal are based upon the DRI-WEFA Delaware River containerized cargo growth rates and the PRPA projected TEUs per call for the eastbound round the world service. The TEU forecast for Packer Avenue alone does not provide a full perspective on containership operations however, because a majority of the cargo onboard the vessel as it arrives at Philadelphia will not be offloaded at Philadelphia. In order to understand containership operations and containership draft requirements it is also necessary to look at trade from Australia/New Zealand to Europe and trade from Savannah to Europe, the two trades that provide most of the cargo that will be onboard the vessel as it arrives at Philadelphia.

Trade in refrigerated cargo from Australia/New Zealand to Europe and from the South Atlantic region of the U.S., which includes Savannah, to Europe are both projected to grow at a faster rate than trade in refrigerated cargo from Australia/New Zealand to the North Atlantic region of the U.S., which includes Philadelphia. Although the faster growth in these trades does not affect the number of TEUs offloaded at Philadelphia, this growth does impact vessel drafts on the

Delaware River because this cargo will be onboard the vessel when it arrives and departs Philadelphia on its way to Europe.

Although port level forecasts of trade from Australia/New Zealand to Europe and trade from Savannah to Europe were not conducted for this analysis, regional forecasts were available to provide perspective on the volume of cargo on these trades. Table C-25 presents abbreviated regional forecasts for these trades and the forecast of available slot space on the eastbound round-the-world service (total slot space less slots taken by Philadelphia-bound goods). These regional forecasts present the total volume of trade that will be serviced by a variety of carriers on a variety of routes. Port share or carrier market share forecasts were not available for this analysis, however, P&O Nedlloyd has been the major carrier on the Australia/New Zealand to Philadelphia route and they have also set up their South Atlantic Regional Load Center in Savannah, indicating that the consortium will continue to have a strong market presence.

The total potential share of trade from Australia/New Zealand to Europe and trade from the South Atlantic region of the U.S. East Coast to Europe allocated to the eastbound round-the-world service is assumed to be 8.2% in 2010 decreasing to 4.8% in 2020, as more slots are allocated to the Philadelphia-bound trade. The cargo volume potential indicated in these forecasts and the strong presence of P&O Nedlloyd and other consortium members in the market support projected 4100+ TEU class containership arrival drafts at Packer Avenue that are greater than 37 feet, by the project base year (2009).

Table C-25
Eastbound Round-the-World TEU Trade Shares

Regional Trade Partners	TEU Forecast 2010	TEU Forecast 2020
Australia/New Zealand to the US East Coast North Atlantic Region	59,856	88,631
Australia/New Zealand to Europe	311,806	409,495
US East Coast South Atlantic region to Europe and Suez Route Countries	1,404,994	1,878,645
Total TEU Potential	1,776,656	2,376,771
Europe et al., capacity on eastbound round-the-world service*	145,229	113,931
Percentage of total TEU potential	8.2%	4.8%

*Total vessel capacity less Philadelphia-bound cargo

Source: DRI-WEFA

The projected number of calls at Philadelphia for the eastbound round-the-world service is based upon the initiation of a weekly service in December 2002 and the proportion of Philadelphia-bound cargo onboard the vessel. As the volume of Philadelphia-bound cargo increases, the number of slots available for Europe-bound cargo decreases. At some point the growth in Philadelphia bound cargo requires additional vessel calls so that the carriers can continue to provide service to the regularly scheduled ports-of-call. This analysis assumes that as much as 50% of vessel capacity can be allocated to Philadelphia-bound cargo. Under this assumption, additional vessel calls to the weekly service are not required until 2019, more than 16 years into the initiation of the weekly service. This assumption is based on the recognition that there are alternative liner services that are capable of transporting goods from Australia/New Zealand to Europe and from Savannah to Europe.

Commodity Growth Rates

Table C-26 presents the commodity trade growth rates used in the analysis. These rates are based upon DRI-WEFA trade forecasts. The containerized commodity growth rates are based upon a slightly more recent and updated version of DRI-WEFA's containerized commodity forecasts than what is presented in the World Trade Model Appendix. The DRI-WEFA model relied on 2000 WCSC data as a base for projections, and so did not identify blast furnace slag as a commodity type, since it did not arrive at the port until 2001. Therefore, alternative sources were used for the blast furnace slag projections. Import levels for blast furnace slag are based upon published industry information and interviews with local operators. Imported blast furnace slag is projected to grow to 1 million tons by 2009, then is held constant throughout the period of analysis.

Table C-26
Commodity Trade Growth Rates
Delaware River Ports

Commodity	2000-2010	2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
Petroleum Products	0.37%	0.26%	0.18%	0.17%	0.18%	0.18%
Iron & Steel	2.18%	2.25%	0.95%	0.34%	0.13%	0.13%
Steel Slab						
Containers	4.39%	4.57%	2.54%	1.33%	0.45%	0.47%
Crude Petroleum	0.27%	0.22%	0.21%	0.21%	0.21%	0.21%

5. ECONOMIC BENEFITS OF NAVIGATION IMPROVEMENTS

5.1 Introduction

The economic benefits considered in this analysis are National Economic Development (NED) benefits that increase the value of the national output of goods and services. Specifically, the benefits quantified in this analysis are the reduced costs of transportation realized through the use of larger more efficient vessels and operational efficiencies resulting from navigation improvements at the harbor. Reduced transportation costs result in reduced production and distribution costs thereby increasing the net value of the national output of goods and services.

The benefit estimation process described in this section relies on observed existing conditions and practices as a guide to developing future scenarios. As stated in the future conditions section of this appendix, which describes the commodity and fleet forecast methods, there is a large degree of uncertainty in projecting future conditions and practices in the ocean shipping industry. Given this level of uncertainty, extreme assumptions are avoided and each step of the process must pass a test of reasonableness. As described below, types of economic benefits with high levels of uncertainty are identified but not quantified in this analysis. Therefore, the economic benefits quantified in this analysis represent the minimum value of NED benefits that would result from navigation improvements to the Delaware River Channel.

Economic benefits are calculated for each of the 50 years of the study period, 2009 – 2058. In addition, benefits are also calculated in 2008 for facilities that are downriver of the Marcus Hook reach, since the 45-foot deepening will be completed to this point by the end of 2007 (i.e., pre-base year benefits). . All project costs and benefits are discounted at the current FY 2003 Federal discount rate of 5-7/8 percent.

The remainder of this section of the Benefits Appendix focuses on the development of project benefit estimates. First, there is a discussion of potential benefits and of the sub-set of potential benefits selected for estimation. Data and data sources are then presented and reviewed. Next, the method of benefit estimation is presented, including discussions of the constraints imposed on the estimation process and a discussion of the calculations used in the analysis. Finally, there is a discussion and presentation of the benefit estimates for individual facilities along the river and for total project benefits.

5.2 Sources of Benefits

Numerous sources of transportation cost savings have been identified through analyses of vessel operations, port and terminal operations, and vessel deployments. The sources of transportation cost savings can be categorized as:

- Vessel efficiencies, such as vessels being more fully utilized;
- Operational efficiencies, such as reduced lightering and reduced travel distances;
- Improved safety due to fewer vessel calls and less lightering; and
- Beneficial uses of dredged material.

5.2.1 Efficiencies in Vessel Loading

In the category of transportation cost savings resulting from vessel efficiencies, sources of benefits include: the increased utilization of vessels that are currently lightloaded; the shift to larger oil tankers for oil facilities that do not typically lighter in the river; and the shift to larger dry bulk carriers.

5.2.2 Reduced Travel Distances

Transportation cost savings will accrue to large, 4,100+ TEU container vessels that are able to reroute under the with project condition. P&O Nedlloyd's "Albatross" Class vessels, and Contship and Columbus lines similarly sized vessels, travel through the Panama Canal from Australia and New Zealand to the U.S. East Coast before heading to Europe.

Under the without project condition, these 4100+ TEU vessels will travel north from the Panama Canal directly to the Packer Avenue Terminal once the service has developed to the point that their sailing drafts out of Savannah exceed the Delaware River channel depth limitations. From Packer Avenue, the vessels will head back south to Savannah, Georgia, where they will be loaded with additional cargo for Europe to drafts greater than can be accommodated in the Delaware River.

Under the with project condition, P&O Nedlloyd vessels can proceed directly from the Panama Canal to Savannah, take on the additional load for Europe, and then continue north to discharge cargo in Philadelphia before heading to Europe. The major component of transportation cost savings is the reduced travel time and distance from Philadelphia back to Savannah. Interviews with the carriers have indicated that this time and distance savings will allow the carriers to call on additional ports that are not currently included in the service.

5.2.3 Reduced Lightering

Under the without project condition, lightering is required for crude oil tankers arriving at the Delaware River with sailing drafts greater than 40 feet. Under with project conditions, lightering would be required only for tankers arriving with sailing drafts greater than 45 feet. Transportation cost savings due to reduced lightering have three components: reduced lightering costs, reduced sailing costs resulting from increased channel speed, and reduced tidal delays. Standard operating procedures in the Delaware River require that vessels with drafts greater than 37 feet (42 feet under the with project condition) must wait for and travel with the tide at a reduced speed.

Amount Lightered

The amount lightered for any vessel call under both with and without project conditions was calculated based on data for actual lightering operations in 2000. Actual lightering practices were determined through review of the Maritime Exchange data that showed vessel sailing drafts entering the Big Stone Beach anchorage, exiting the anchorage, and arriving at the dock. The amount lightered was calculated as the minimum amount required to bring the vessel to either the maximum channel sailing draft (40 feet without project, 45 feet with project) or to the maximum channel sailing draft that allows normal speed (37 feet with out project, 42 feet with project). Most vessels are currently lightered to 40-foot draft and drift the tide, although some vessels (especially the Stena Class VLCCs) consistently lighter to 37 feet or less sailing draft in order to travel unimpeded with a meter of underkeel clearance.

Country specific conversion rates obtained from Energy Information Administration of the U.S. Department of Energy, in combination with vessel immersion rates, were used to convert observed reduced sailing drafts to estimates of lightered tons and lightered barrels for each vessel movement, based upon the specific gravity of the crude from each country of origin. The country specific conversion rates used in the analysis are shown in Table C-9.

Lightering Costs

Without and with project lightering costs are calculated as the cost per barrel to lighter, multiplied by the volume of lightering required to bring tankers to depths that allow transit up the Delaware River. In addition, lightering costs include the value of the total time required for lightering. The total time required for lightering is calculated as the volume lightered multiplied by the pump out rate (from Table C-8, Lightering and Dockside Discharge Rates, Reanalysis 2002), plus the time it takes for lightering equipment set up and break down (2 hours), plus the time it takes to maneuver in and out of the anchorage (4 hours). The estimates for operating, set up and break down, and maneuvering times were verified with the lightering company and the Pilots Association. Time spent waiting at anchorage for the availability of a lightering vessel was not included in the benefit analysis, due to the uncertainty associated with isolating that time from other factors affecting wait time in the anchorage area that would not be changed by the project.

Reduced lightering costs accrue for tankers that are required to lighter under the without project condition but will not need to lighter under the with project condition (sailing drafts between 40 feet and 45 feet). Reduced lightering costs also accrue for tankers that require less lightering under the with project condition, due to the additional five feet of available channel depth. The effect of both of these factors results in a significant reduction in total lightering requirements and a corresponding reduction in the resource costs required to maintain a lightering fleet capable of handling the reduced lightering volumes.

Reduced sailing costs accrue to vessels that lightered to drafts between 37 feet and 40 feet under the without project condition, and that lighter to drafts less than 42 feet under the with project condition. Transportation cost savings due to reduced lightering are somewhat offset by the additional time and cost of offloading more cargo at the dock, which occurs at a slower rate per barrel than when lightering.

The cost to lighter crude oil tankers is a critical input variable in the benefit analysis, since reduction in lightering costs represents the major category of transportation cost savings for crude oil tankers (with the exception of Valero, which does not lighter, but benefits from reduced lightloading).

ER 1105-2-100, Page E-48, E-10, Section d. Evaluation Procedures: General, subsection (9) (a) (1), Cost Reduction Benefits describes the appropriate treatment of lightering costs in navigation economic analysis:

> *"Traffic with same commodity, origin-destination, and harbor. For traffic now using the harbor or expected to use it, both with and without the proposed project, the transportation benefit is the difference between current and future transportation cost for*

> *the movement by the existing project (without project condition) and the cost with the proposed improvement (with project condition)."*

ER 1105-2-100, Page E-47, E-10, section d (5), defines the relevant components of transportation costs:

> *"Transportation costs include the full origin-to-destination cost, including necessary handling, transfer, storage, and other accessory charges."*

Benefit-cost analyses are based upon direct costs, which include transportation costs for the potentially benefiting commodity movements, including transfer charges such as lightering. The lightering cost is part of the total cost to transfer cargo from ship to shore and is a significant component in the total transportation costs borne by the refineries to deliver crude oil to their production facilities.

As stated in Section 3.5.2, vessel operating costs for the lightering fleet were developed and compared to the total volume lightered under with and without project conditions to develop weighted average per barrel at sea and at port lightering costs. Data on existing vessel movements in the year 2000 were used to determine the proportion of at sea versus at port time for the fleet. Future lightering volumes were calculated for with and without project conditions for each year of the period of analysis (2009-2058). For without project conditions, it was projected that the lightering fleet would not need to change, since there is minimal projected growth in future crude oil imports. For with project conditions, a fleet change is projected because less resources will be required to handle reduced lightering volumes (31 percent), freeing lightering resources for other productive uses. The difference between weighted average per barrel lightering costs multiplied by lightering volumes under with and without project conditions is the measure of lightering cost savings that will result from the deepening project.

5.2.4 Tidal Delays

Tidal delays are identified as the amount of time a vessel would be expected to spend waiting for the tide to rise to a level that would allow adequate clearance for the vessel to enter the channel. Tidal delays are calculated for vessels with sailing drafts greater than 37 feet in the without project condition and 42 feet in the with project condition. The tide in the Delaware River is semi-diurnal with a period of approximately 12.5 hours. The expected amount of tidal delay depends on the vessel sailing draft, the probability that the vessel arrives at the low tide portion of the tidal cycle, and the probability of where in the low tide cycle the vessel arrives. Tidal delays occur in both the without and the with project conditions. Expected tidal delays range from 0.38 hours for vessels requiring one foot of tide to 2.2 hours for vessels requiring three feet of tide. Calculated tidal delays do not include time spent waiting for anchorage space, berthing space, or lightering services. Benefits due to reduced tidal delays result only from projected vessel calls that require tidal advantage in the without project condition, but do not require tidal advantage in the with project condition.

5.2.5 Shift to Larger Tanker and Dry Bulk Vessels

Under with project conditions, the deeper channel would allow some commodities to be transported on larger vessels, thereby reducing the total number of calls required to move a given volume of commodity. For liquid bulk tankers, only two facilities are expected to reconfigure their fleet to include larger vessels under the with project condition: Valero and Delaware Terminal. Interviews with the operators of these facilities and review of the data confirm that vessels arriving at these facilities typically do not engage in lightering operations within the study area.

Valero currently brings in Mideast sour crude on ships that can navigate the existing channel fully-loaded without lightering (drafts of 39 feet to 40 feet). Crude is transshipped at a Caribbean facility from large tankers arriving from the Mideast onto smaller tankers that deliver the sour crude to the Valero facility. Interviews with terminal operators at Valero indicate that the practice of filling vessels to the maximum allowable channel draft will continue under both with and without project conditions. Under with project conditions Valero has indicated that they would shift to a fleet of larger vessels that could take better advantage of the deeper channel draft. At the present time, 66 percent of their vessel fleet has design drafts of 45 feet or greater, so a fleet shift would only involve the smallest one-third of the fleet currently serving Valero, the remainder of their fleet could load to the full channel depth.

Delaware Terminal is currently depth-constrained by rapid shoaling of the Christina River. The Delaware Terminal has indicated that they will build a new facility on the Delaware River in 2007. Under the without project condition, Delaware Terminal will have access to the existing 40-foot project on a naturally deep reach of the Delaware River adjacent to the Port of Wilmington auto terminal. Delaware Terminal generally handles refined petroleum products that are not lightered in the study area. This practice is expected to continue under both with project and without project conditions. Discussions with the operators of Delaware Terminal indicate that a fleet of larger vessels would be employed to take advantage of the deeper 45-foot channel under the with project condition, especially since their new berthing area will be in a reach of the Delaware River that is naturally deep to 45 feet.

Two dry bulk commodities currently imported through the Delaware River are expected to be delivered on vessels sufficiently large to benefit from the project under the with project condition: steel slabs destined for the U.S. Midwest; and blast furnace slag from Italy which is processed at a new granulated blast furnace slag (GBFS) processing facility in Camden, NJ.

Steel slabs are currently imported through Packer Avenue on a variety of vessels with design drafts ranging from 35 feet to 45 feet and sailing drafts ranging from 36 to 40 feet. This fleet is expected to remain the same under the without project condition, with the addition of similarly sized vessels to handle future commodity growth. Under the with project condition, the fleet is expected to shift to a distribution of larger vessels of the type and size already calling at Beckett Street. The primary port of origin for imported steel slabs has a depth of 51 feet, so that does not pose a constraint on the expected fleet shift.

Blast furnace slag, used in the production of a cement additive (GBFS), is currently imported from Italy to the Camden Marine Terminal at Beckett Street. The existing fleet exhibits design drafts ranging from 42 feet to 46 feet and sailing drafts averaging 40 feet. This fleet is expected to remain the same under the without project condition. Under the with project condition, the fleet is expected to shift to larger vessels (of the type and size already calling at Camden Marine Terminal) that can take advantage of the deeper channel depth. The primary port of origin for imported steel slabs has a depth of 74 feet, so that does not pose a constraint on the expected fleet shift.

5.2.6 Benefits of Improved Safety

Identified benefits resulting from improved safety in the Delaware River and Bay include:

- Reduced natural resource injury: Deeper channels would reduce the overall number of vessel calls, reduce congestion, and reduce lightering operations in the river. All other things being equal, reductions in each of these elements would reduce the probability of oil spills or other contaminant spills that would injure natural resources in the river and bay, thereby reducing the expected value of natural resource damages.
- Reduced disruptions of services: As described above, deeper channels would reduce the probability of oil spills or other contaminant spills in the river. Reducing the probability of such incidents in the river would also reduce the probability of waterway closures and service disruptions that result from related clean-up, salvage, and restoration activities. The reduction in incident probability would reduce the expected value of damages related to disruptions of waterway services.

5.2.7 Beneficial Uses of Dredged Material

As described in Section 2, dredged material from Delaware Bay (Reach E) will be used to restore the eroding beaches, protect the tidal wetlands that are behind the beaches, enhance horseshoe crab and migratory bird habitat, and protect property from storm damage, respectively, at Kelly Island, Delaware and Egg Island Point, New Jersey; and Broadkill Beach in the State of Delaware.

Ecosystem Restoration at Kelly Island and Egg Island Point

Millions of migratory birds pass through Delaware Bay during spring and fall migrations. The beaches and adjacent intertidal wetlands are especially important as migratory stopover points for shorebirds. Delaware Bay ranks as the largest spring staging site for shorebirds in eastern North America. Staging sites, such as Kelly Island and Egg Island Point, serve to link wintering areas with breeding grounds, and are critical to the survival of hundreds of thousands of migrating shorebirds. The largest population of spawning horseshoe crabs in the world is found in Delaware Bay. The eggs of spawning horseshoe crabs provide a critical food source for the hundreds of thousands of shorebirds that migrate through Delaware Bay each spring. Wetland restoration will restore and enhance habitat for these species, as well as many other species that use these wetlands in Delaware Bay. In addition, wetland restoration and shoreline protection will protect many acres of wetlands that would otherwise be lost to continuing erosion. These tidal marshes are used by migratory shorebirds, waterfowl and wading birds, as well as provide nursery areas for many fish species.

At Kelly Island, approximately 60 acres of salt marsh will be restored and 80 acres of salt marsh will be protected from erosion over the life of the project (50 years). At Egg Island Point, approximately 135 acres of salt marsh will be restored and 110 acres will have reduced erosion over an estimated 25-year period.

The primary species of concern at Kelly Island under its present condition are the horseshoe crabs that spawn at nearby sand beaches, the migrating and feeding shorebirds, waterfowl, and waterbirds in general. Presently less than 50% of the shoreline of Kelly Island is suitable for horseshoe crab spawning (Weber, 2002). Wetland restoration should more than double the available spawning habitat as well as create an additional 1,000 feet of sandy shoreline suitable for spawning. Wetland restoration will enhance habitat for all of these species, and in addition, will provide a sheltered intertidal area for juvenile fish species during certain times of the year. Wetland restoration at Egg Island Point will create a sandy beach about 700 feet long, suitable for spawning.

There are a number of other species that will benefit from protection of the southeast Egg Island Point site, such as waterbirds, shorebirds, and juvenile fish. All of these species will use the low marsh and tidal pools. Overwash sandy areas would provide both additional crab-spawning areas along fringes and potential tern, gull, and other waterbird nesting areas.

Beach Nourishment at Broadkill Beach

The Corps of Engineers conducted studies along Delaware Bay to determine Federal interest in providing shoreline and environmental projects for various communities. Authorization to undertake these studies was established in a resolution adopted by the Public Works and Transportation Committee, United States House of Representatives, in October 1986. Based on the results of these investigations, a Federal project was recommended at Broadkill Beach. Subsequently, a feasibility study was initiated in January 1993. This study was cost shared between the Federal Government and the State of Delaware, Department of Natural Resources and Environmental Control. In September 1996, a final Feasibility Report and Environmental Impact Statement was completed for Broadkill Beach. The project calls for beach nourishment utilizing sand obtained from offshore borrow areas to provide storm damage and erosion control protection. Beach nourishment will consist of a berm and dune restoration along 13,500 linear feet of the bay front.

The Broadkill Beach Project is a stand-alone project whose federal funding is separate from the Delaware River Main Channel Deepening Project. The Broadkill Beach Project has been authorized for construction and plans and specifications have been completed. When funding is provided, the Broadkill Beach Project will continue. Because of delays in construction funding, the project has exceeded criteria for dated economic data. In order to move forward a limited economic analysis needs to be completed prior to budgeting for a "new start".

For the Delaware River Main Channel Deepening project, dredged material in Reach E consists of a sand quality suitable for beach restoration at Broadkill Beach. Material would otherwise be disposed of at an existing federally-owned upland confined disposal facility at Artificial Island.

Benefits would be realized due to cost savings resulting from "jointly" developing both projects rather than developing them independently. The Delaware River Main Channel Deepening Project has the primary requirement for disposing of its dredged material and therefore is assigned the cost of placement. In doing so, the project also is assigned the NED cost savings from beneficial use of the material.

5.2.8 Quantified Benefits

Each of the benefit types identified above are reasonable and anticipated benefits of navigation improvements to the channel. However, not all of the benefit types can be quantified to a reasonable level of certainty. Therefore only a sub-set of benefit types is quantified in this analysis. Economic benefit calculations include the transportation cost savings associated with vessel and operational efficiencies for tankers, dry bulk carriers, and containerships; and beneficial reuse cost savings from beach replenishment at Broadkill Beach. The benefits of improved safety and beneficial reuse for ecosystem restoration at Kelly Island and Egg Island Point have not been quantified for this analysis.

5.3 Potential Limitations / Constraints on Benefits

5.3.1 Facility / Capacity Constraints

Capacity and throughput constraints have been carefully considered in this analysis. Refinery storage and processing capacities (see previous section) have been verified with refinery operators. The growth rate for crude imports into the study area (0.21% per year) reflects the assumption (shared with the refinery operators) that the refineries will maintain existing facilities to industry standards, but no major expansion or shutdown is expected. Significant expansion of storage capacity is expected for Delaware Terminal (1.6 million bbl to 2.6 million bbl) under the without project condition, however, the projected growth in commodity volume (0.23% average per year) does not reflect the increased storage capability. For the purpose of this analysis, it remains uncertain as to what commodities might be serviced by the additional storage, as well as what the new fleet and trade route point of origin might be. Therefore, the benefits estimated for Delaware Terminal are based on representative vessels and trade routes from the existing fleet and commodity volumes that do not account for the expansion in storage.

Bulk handling facility capacities have been identified through interviews with terminal operators and officials at the Philadelphia Regional Port Authority (PRPA). Typically, existing capacities are underutilized. Packer Avenue has a throughput capacity of at least 2 million tons per year for steel slabs. Estimated volumes of steel slabs handled at Packer Avenue range from approximately 1 million tons in 2009 to 1.6 million tons in 2059. Similarly, the slag handling capacity at Camden Marine Terminals is estimated to be 2 million tons per year, but 1 million tons per year is the projected volume.

Container handling capacity at Packer Avenue is currently underutilized. Year 2002 throughput capacity for Packer Avenue is estimated by the PRPA at 233,200 TEUs. Projected TEU movements through the facility in 2002 are projected to be 128,000. In the first year that project benefits accrue to Packer Avenue (2008), the total volume of containers in the benefiting trade routes will be equivalent to approximately 26% of the total projected container volume at the facility and 13% of the projected total throughput capacity. By the end of the study period (2059) the projected volume of TEUs for the benefiting trade routes is estimated to be approximately 35% of the total throughput capacity.

5.3.2 Port Operational Constraints

All benefits estimated in this analysis are constrained by the operating procedures outlined in the "Advisories for Transit of the Delaware River" developed by the Mariner's Advisory Committee of the Pilots' Association for the Bay and River Delaware.

5.3.3 Associated Cost Constraints

The capacity of facilities to benefit from the deepening project is also constrained by the non-Federal expenditures that would need to be made to upgrade non-Federal channels, docks, and dock-side facilities. The Main Report and Appendix A – Project Costs provide detail on these associated cost items, which have been included in calculations of the total economic cost of the deepening project. Whether these future improvements will or will not be made by the potentially benefiting facilities is open to speculation. Therefore, a "reasonableness test" has been conducted in this analysis, comparing the associated costs to the potential transportation cost savings for each facility to determine whether it would be economically rational for them to incur these expenses (i.e., whether they would incur a positive rate of return from making the necessary investments). The results of this reasonableness test are presented later in this appendix.

5.4 Vessel Operating Costs

Vessel operating costs were taken from the regression equations provided in the CECW-P Economic Guidance Memorandum 02-02, Deep Draft Vessel Operating Costs, 12 August 2002.

5.5 Projected Benefiting Commodity Flow

In general, a limited number of the types of commodities transported along the Delaware River are included in the benefit calculations. All commodity and vessel types were screened for evidence of being effected by channel depth constraints. Sailing draft and design draft data were provided by the WCSC for 2000 and by the Delaware River Maritime Exchange (2000 – July 2002). The data were reviewed for evidence of constrained vessel operations. Interviews were conducted with officials at the port authorities, officials of maritime organizations, lightering service operators, terminal operators, carriers, and industry consultants.

5.5.1 Commodity Trades Included in the Benefit Calculations

The following commodities are included in the benefit calculations:

- crude oil imports to refineries;
- refined petroleum product imports (Delaware Terminal only);
- imported blast furnace slag to be processed into an additive used in cement production (Camden Marine Terminal / Beckett Street only);
- imported steel slabs (Packer Avenue Terminal only); and
- containerized refrigerated meat imports from Australia and New Zealand and U.S. fruits, vegetables, and frozen poultry for export to Europe (Packer Avenue Terminal only).

Although many types of commodities are also being carried on container vessels, those commodities identified above are the major commodities being carried on the relevant legs of the liner service that use vessels sufficiently large to benefit from the deepening project.

5.5.2 Commodity Trades Excluded in the Benefit Calculations

The following commodities were identified in previous studies as benefiting commodities, but are not included in this benefit analysis, either due to reduced trade volumes, shallow sailing drafts, or insufficient information to calculate benefits:

- Scrap exports;
- Iron ore imports; and

- Coal imports and exports.

5.6 Transportation Costs

Transportation costs are calculated as the total cost of the voyage from the port of origin to the berth at the Delaware River facility. This total cost includes the at-sea cost from the port of origin to the Delaware River, the cost of lightering (if any), the cost of steaming up the channel, and the cost of offloading at the berth. The at-sea cost is based upon the distance traveled, the speed of the vessel, and the hourly at-sea cost of the vessel. If larger vessels are used in the with project fleet, there will be fewer vessel calls for the projected commodity volume, therefore, round trip distances are calculated in both the without and with project conditions in order to identify the full transportation cost savings associated with reducing the number of vessel calls. Hourly at-sea costs are based upon vessel size, so larger vessels have higher hourly at-sea costs. If larger vessels are used in the with project condition, the benefits of reducing the number of vessel calls is somewhat offset by the increased at-sea cost for the larger vessel.

Lightering costs are calculated as the sum of: the total costs to operate the lightering fleet(cost per barrel x the number of barrels); plus the time it takes to lighter priced at the hourly at-port costs (based on the volume lightered, the pump-out rate, an additional two hours for lightering equipment set up and break down, and an additional four hours for maneuvering in the anchorage).

Tidal delay costs are calculated as a product of the time a vessel would be expected to spend waiting for the tide to rise to a level that would allow adequate clearance for the vessel to enter the channel, times the at port vessel costs. Tide delays are calculated for vessels with sailing drafts greater than 37 feet in the without project condition and 42 feet in the with project condition. Tide delays occur in both the without and the with project conditions. Calculated tide delays do not include time spent waiting for anchorage space, berthing space, or lightering services. Benefits due to reduced tide delays result only from projected vessel calls that require tidal advantage in the without project condition, but do not require tidal advantage in the with project condition.

The cost of steaming up the channel is calculated as the at-sea hourly cost multiplied by the time it takes to transit the channel. Channel transit time depends upon the sailing draft of the vessel as reported by the Pilots' Association and whether the vessel can steam unimpeded in the channel, or must drift the tide.

Table C-27
Channel Transit Times

	Without Project			With Project		
Sail Draft	**Wilmington**	**Marcus Hook**	**Philadelphia**	**Wilmington**	**Marcus Hook**	**Philadelphia**
Less than or equal to 37 ft	3 hours	4 hours	6 hours	3 hours	4 hours	4 hours
Greater than 37 ft, no more than 40 ft	6 hours	8 hours	12 hours	3 hours	4 hours	4 hours
Less than or equal to 42 ft	N/A	N/A	N/A	3 hours	4 hours	6 hours
Greater than 42 ft, no more than 45 ft	N/A	N/A	N/A	6 hours	8 hours	12 hours

The cost of offloading at the berth is calculated as the volume of commodity being offloaded from the vessel divided by the pump out or offloading rate (volume/hour). This time spent offloading is priced at the hourly at-port vessel rate. The time spent offloading typically increases when lightering is reduced or when larger vessels are used under the with project condition. Any increase in the cost of offloading at the berth offsets some of the cost reductions associated with fewer vessel calls and less lightering.

5.6.1 Transportation Cost by Commodity

Tables C-28 to C-31 present the transportation costs, under with and without project conditions, for the commodities used in the benefits calculations. Costs shown in Table C-31 do not include transportation costs for tonnage on vessels with incomplete data. These incomplete records did record terminal destination and tonnage, but not point of origin or other data necessary to directly compute transportation cost savings. In the final step of the analysis, this tonnage was assigned to the appropriate facility and multiplied by the average transportation cost savings for that facility, then added to the facility benefits. Detailed spreadsheet models used to calculate cost savings are on file in the Philadelphia District.

Table C-28
Dry Bulk
With and Without Project Average Annual Transportation Costs

Bulk Type	With Project	Without Project
Blast Furnace Slag	$ 9,151,005	$ 10,962,501
Steel Slabs	$ 11,298,645	$ 14,896,642

Table C-29
Containerized Cargo
With and Without Project Average Annual Transportation Costs

Cargo	With Project	Without Project
Containerized	$ 26,977,222	$ 30,467,939

Table C-30
Petroleum Products
With and Without Project Average Annual Transportation Costs

Cargo	With Project	Without Project
Petroleum Product	$ 2,718,230	$ 3,073,238

Table C-31
Crude Oil
With and Without Project Average Annual Transportation Costs

Facility	With Project	Without Project
Eagle Point	$18,178,181	$19,560,765
Philips 66 (Tosco)	$26,560,530	$27,589,961
Motiva	$17,535,893	$18,192,203
Valero	$26,999,610	$31,578,224
Sun Fort Mifflin	$42,142,044	$45,074,406
Sun Marcus Hook	$21,137,648	$22,729,968
Sun Hog Island	$13,033,745	$13,869,600
Total Tanker	**$165,587,651**	**$178,595,126**

5.7 NED Benefits

Transportation cost savings are calculated for each year of the study period, 2009 – 2058, and for 2008 for facilities south of and including the Marcus Hook reach of the river. All project costs and benefits are discounted at the FY 2003 federal discount rate of 5.875 %. An average annual equivalent value over the 50-year study period is calculated to facilitate the comparison of costs and benefits across time periods.

5.7.1 Transportation Cost Savings

Table C-32 presents total average annual equivalent benefits by commodity type. It should be noted that crude oil benefits were adjusted to account for incomplete data that showed the tonnage and destinations of crude oil imports, but not foreign origin information. For these incomplete records, the transportation cost savings per ton for each facility were multiplied by the volume of commodities with incomplete records that offloaded at each facility, and facility benefits were adjusted accordingly.

Table C-32
Average Annual Benefits by Commodity Type

Benefit Type	Average Annual Benefits
Transportation Cost Savings	
Crude Oil (Imports)	$14,798,714
Petroleum Products (Imports)	$355,008
Containerized Cargo (Imports) (Vegetables, Fruit, Eggs, Meat requiring refrigeration)	$3,490,717
Blast Furnace Slag (Imports)	$1,811,496
Steel Slabs (Imports)	$3,597,997
Subtotal Transportation Cost Savings	**$24,053,932**
Beneficial Use Cost Savings at Broadkill Beach	$604,698
Total	**$24,658,630**

5.7.2 Pre-Base Year Benefits

Pre-base year benefits will accrue to facilities south of and including the Marcus Hook reach that will have access to the 45-foot project in the year prior to full completion of construction (2008). This includes the crude oil refineries and Delaware Terminal. These pre-base year benefits are included in the total benefits listed in the tables above, and equal approximately $853,000 in average annual benefits, or 3.5 percent of total transportation cost savings.

5.7.3 Total Average Annual Benefits

Table C-33 below displays the total average annual benefits, by facility, for the 45-foot Delaware River Main Channel Deepening Project.

Table C-33
Average Annual Benefits by Facility

Facility	Average Annual Benefits
Sunoco Facilities (Ft. Mifflin, Marcus Hook, Hog Island)	$6,223,318
Valero	$4,744,061
Phillips 66 (Tosco)	$1,305,021
Coastal Eagle Point	$1,789,715
Motiva	$736,600
Subtotal Refineries	**$14,798,714**
Beckett Street Terminal	$1,811,496
Packer Ave. Terminal	$7,088,714
Delaware Terminals	$355,008
Total Facility Benefits	**$24,053,932**
Beneficial Use Cost Savings at Broadkill Beach	$604,698
Total All Benefits	**$24,658,630**

6. RISK AND UNCERTAINTY

This section of the report describes the risks and uncertainties inherent in estimating the benefits and costs of the deepening project, and how the sources of risk and uncertainty were addressed in the reanalysis effort. Several potential sources of uncertainty in estimating the cost of the deepening project have also been addressed through sensitivity analysis. Sensitivity analysis on project costs are contained in Appendix A – Cost Estimate.

6.1. Guidance

The Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, February 3, 1983 (P&G); and the Planning Guidance Notebook, ER 1105-2-100, 22 April 2000; discuss the role of risk and uncertainty analysis in Corps of Engineers civil works projects (P&G, Paragraph 10):

> *"Planners shall identify areas of risk and uncertainty in their analysis and describe them clearly, so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans."*

Planning Guidance Notebook (ER 1105-2-100), 2-4. Principles of Analysis. g. Risk and Uncertainty:

"The P&G state that planners shall characterize, to the extent possible, the different degrees of risk and uncertainty inherent in water resources planning and to describe them clearly so decisions can be based on the best available information. Risk-based analysis is defined as an approach to evaluation and decision making that explicitly, and to the extent practical, analytically incorporates considerations of risk and uncertainty. Risk-based analysis shall be used to compare plans in terms of the likelihood and variability of their physical performance, economic success and residual risks. A risk-based approach to water resources planning captures and quantifies the extent of risk and uncertainty in the various planning and design components of an investment project. The total effect of risk and uncertainty on the project's design and viability can be examined and conscious decisions made reflecting an explicit trade-off between risk and costs."

6.2. Definitions

There is extensive public and academic literature devoted to the area of risk and uncertainty and yet there is still considerable confusion regarding what the terms mean. "Risk" can generally be defined as the possibility that various outcomes, events or actions can occur, at least some of which could be undesirable. "Uncertainty" describes a situation where a number of possibilities exist and which of them will occur is unknown. In navigation projects, risk most often refers to the potential for events with adverse physical consequences, for example, groundings, collisions, or environmental damage, such as oil spills. Uncertainty in the costs and benefits of navigation projects can result from many factors, including: fleet composition; commodity movements; transportation costs; dredge material composition, quantities, quality, and disposal locations; and many others.

This analysis is intended to deal with uncertainty in the estimation of the benefits and costs of the Delaware River Main Channel Deepening project. There are some issues of risk as well, as briefly described in Section 3.1.3, Improved Safety. However, inadequate information is available to quantitatively assess the impacts of the deepening project on risk issues in the port complex. Also, as a general rule, experts in Delaware River navigation issues (including pilots, terminal operators, and shipping lines) did not indicate that navigation safety was a significant problem at present, and was not a primary impetus for the deepening project. Safety issues related to the potential for environmental damage resulting from the deepening project were analyzed extensively and discussed in the Final Supplemental Environmental Impact Statement that was filed with U.S. Environmental Protection Agency in July 1997.

6.3. Uncertainties in the Estimation of Costs and Benefits

As stated previously, there are many sources of potential uncertainty in estimating the costs and benefits of navigation projects. The major sources of uncertainty relate to the characterization of existing conditions and projections of what will happen in the future, under both without project conditions (continued operation of the 40-foot project) and with project conditions (project deepening to 45 feet).

One of the primary goals in any navigation analysis is to first identify the major sources of uncertainty and then attempt to reduce them through collection and analysis of additional information. Attempts to reduce uncertainty during the reanalysis effort included extensive interviews and follow-ups with port representatives, shipping lines, terminal operators, refineries, pilots, and other knowledgeable individuals. Information provided by interviewees was also checked against shipping data for verification and any discrepancies were noted.

6.3.1. Uncertainty in Benefit Estimation

Several potential sources of remaining uncertainty in benefit estimation have been identified and will be addressed through sensitivity analysis. These are listed below, with the affected benefit category shown in parentheses:

- Commodity growth rates (all benefiting commodities);
- Cost and price of lightering operations (crude oil benefits);
- Containership operating costs (container benefits)
- Dry bulk with project condition fleet shift (steel slab and furnace slag benefits)
- Timing of refinery responses to project deepening (crude oil benefits).

6.3.2. Uncertainty in the Estimation of Project Costs

Several potential sources of uncertainty in estimating project costs have also been addressed through sensitivity analysis. Sensitivity analyses on project costs are contained in Appendix A – Cost Estimate.

6.4. Sensitivity Analysis – Project Benefits

Sensitivity analyses were conducted to analyze the effects of uncertainty on project benefits. This information is provided so that an informed investment decision can be made, recognizing that inevitable uncertainties exist in estimating the future benefits of any deep draft navigation project. There are a nearly limitless number of sensitivity analyses that could be performed on the myriad of assumptions, data sources, methodologies, and analytical estimates that were used to calculate benefits for the deepening project. The final set of sensitivity analyses were selected based on several factors, including: analyst judgment regarding the degree of uncertainty in each of the key input parameters; the potential impact (i.e., significance) of changes in key variables on final benefit results; and the inevitable uncertainty associated with benefits that rely to some extent on assumptions regarding the future behavior of others, and future economic conditions. Because of these uncertainties, the sensitivity analyses show the impact on project benefits of alternative scenarios, but cannot quantitatively estimate the probability of such scenarios occurring. The specific sensitivity analyses conducted for this study are listed below and the results discussed in subsequent paragraphs:

- Commodity growth rates
  - Crude Oil: 0% growth; growth at the base case rate, but only to the year benefits first accrue (2008); 0.7% growth; and negative of base case growth (i.e., since base case is +0.2%, negative of base case is –0.2%)
  - Delaware Terminal: 0% growth and negative of base case growth (–0.2%); growth at the base case rate, but only to the year benefits first accrue (2008); and U.S. DOE petroleum product growth estimates (greater than base case)

  - Containerships: 0% growth, 75% and 125% of base case growth; growth at the base case rate, but only to the year benefits first accrue (2009)
  - Steel Slabs: 0% growth, 75% and 125% of base case growth; growth at the base case rate, but only to the year benefits first accrue (2009)
  - Blast Furnace Slag: 0% growth (369,450 tons), 700,000 tons by 2009, 1.3 million tons by 2009; growth at the base case rate, but only to the year benefits first accrue (2009)

- Cost of lightering operations
  - Range of at-sea and at-port operating costs for the Maritrans fleet of lightering vessels
  - Unchanged Maritrans fleet costs under without and with project conditions
  - Removal of Maritrans 300 instead of Integrity from the lightering fleet under with project conditions
  - Replacement of the Integrity with a smaller vessel from Maritrans Gulf fleet
- Price of lightering operations charged by Maritrans
  - Representative price of $0.37/bbl under without and with project conditions
  - Representative price of $0.37/bbl without project and $0.42/bbl with project
- Capital cost of "Albatross" Class containerships;
  - $52 million capital cost (costs of vessel in the actual P&O Nedlloyd fleet)
  - With-project condition bulker fleet design draft
  - Steel slabs: with project design draft two feet greater and two feet less than base case
  - No steel slab fleet shift under with project condition
  - Blast furnace slag: with project design draft two feet greater and two feet less than base case
  - No blast furnace slag fleet shift under with project condition
- The year in which benefits commence for the refineries that have indicated they will "wait and see" before they commit to berth improvements (Coastal Eagle Point and Phillips 66 (Tosco))
- Benefits commence in 2010 (rather than 2008) for Coastal and Tosco.

These sensitivity analysis scenarios were identified by study team members and internal and external technical reviewers. Each sensitivity analysis and its results are described below. A composite sensitivity analysis that incorporates high, low, and most likely growth rate scenarios for all commodities is also provided.

6.4.1. Commodity Growth Rate Sensitivity Analyses

Sensitivity analysis results are presented below for alternative growth rate scenarios for crude oil, petroleum products, containerized goods, steel slabs, and blast furnace slag. Each of the alternative growth rates examined in the sensitivity analyses were applied to the most recent year's data for each commodity group (either 2000 or 2001, depending on the commodity), then projected to the base year (2009) and throughout the planning period (2009 to 2058).

Crude Oil Growth Rate Sensitivity Analysis

The most probable crude oil growth rate used in the benefit estimates is 0.2 percent per year, which is very conservative compared to Department of Energy projections of future U.S. crude oil imports to 2020 (ranging from 0.6%/year to 1.6%/year). Alternative growth rate scenarios addressed in the sensitivity analysis include: zero growth beyond the forecast base year (2000); negative of the base case growth (-0.2%); growth at the base case rate, but only to the year benefits first accrue (2008); and a higher growth rate based on the lower range of U.S. imported crude oil growth forecasts (0.7%) calculated from the DOE Energy Outlook 2002. The rationale for the negative growth scenario is that reductions in crude oil imports have occurred for brief historic periods for the Delaware River refineries when some individual refineries have been temporarily shut down for plant modifications and upgrades. There is also the potential that one or more of the refineries could go out of business, although this is unlikely since domestic demand for petroleum products continues to expand and it is extremely difficult to obtain the permits required to build new, or replace existing, refineries.

The rationale for the higher growth scenario is that the current refineries could achieve a growth rate of 0.7% annually through continued technological and process improvements (also called "refinery capacity creep"). For comparison purposes, this growth rate is less than the historic growth rate of crude oil imports to the Delaware River refineries from 1990-2001 (0.8% annually).

The no growth scenario reduces tanker benefits to $13,520,649 (91% of base case). The negative growth scenario reduces tanker benefits to $12,441,241 (84% of base case). The growth at the base case rate, but only to the year benefits first accrue (2008) reduces tanker benefits to $14,027,601 (95% of base case). The growth rate calculated from the DOE projections increases benefits to $16,267,082 (112% of base case).

Petroleum Products (Delaware Terminal) Growth Rate Sensitivity Analysis

The most probable growth rate for petroleum products used in the benefit estimates is 0.23 percent per year. Alternative petroleum product annual growth rates include no growth (0%); growth negative of the base case (-0.23%); growth at the base case rate, but only to the year benefits first accrue (2008); and the significantly higher U.S. imported petroleum product growth forecast (4.7%) calculated from the DOE Energy Outlook 2002. The rationale for the zero and negative growth rates is that Delaware Terminal is a single customer and may reduce, or choose not to expand, throughput at their facility. The negative and no growth scenarios are considered to be unlikely, since Delaware Terminal has committed to a major capital improvement project to build a new docking facility in the Delaware River and neither of these scenarios would allow them to recoup their investment costs. The rationale for the high growth scenario is that, as domestic demand for petroleum products continues to expand, Delaware Terminal will expand throughput capacity to meet that demand.

The no growth scenario reduces Delaware Terminal benefits to $261,787 (74% of base case). The negative growth scenario reduces Delaware Terminal benefits to $168,567 (48% of base case). The growth at the base case rate, but only to the year benefits first accrue (2008) reduces

Delaware Terminal benefits to $266,374 (75% of base case). The growth rate calculated from the DOE Energy Outlook 2002 increases benefits to $984,312 (277% of base case).

Containerized Commodity Growth Rate Sensitivity Analysis

The most probable growth rate used in the benefit estimates for containerized commodities is 2.2 percent per year (note that this is an average compound growth rate over the planning horizon – actual growth rates in the container model are in decennial increments). Alternative containerized commodity annual growth rates were calculated to provide an illustrative range of potential benefits under no growth (0%), low growth (75% of the base case growth rate), and high growth (125% of the base case growth rate) scenarios. Growth at the base case rate, but only to the year benefits first accrue (2009) was also analyzed. Potential events that could lead to the no growth or low growth scenarios could include slower than expected development of the new Australia/New Zealand liner service, slower than expected GDP growth in the trading partner countries, or reduction in final consumer demand for the containerized commodities on this route. Potential events that could lead to the high growth scenario could include diverted tonnage to this liner service due to greater transportation cost efficiencies, increased demand for the commodities transported, or increased GDP in the trading partner countries.

The no growth scenario reduces containership benefits to $2,913,309 (84% of base case). The low growth scenario reduces containership benefits to $3,069,793 (88% of base case). The growth at the base case rate, but only to the year benefits first accrue (2009) reduces containership benefits to $2,913,309 (83% of base case). The high growth scenario increases containership benefits to $4,096,127 (117% of base case).

Dry Bulk Commodity Growth Rate Sensitivity Analysis

The most probable growth rate for steel slabs used in the benefit estimates is 1.1 percent per year (note that this is an average compound growth rate over the planning horizon – actual growth rates in the steel slab model are in decennial increments). Alternative steel slab annual growth rates were calculated to provide an illustrative range of potential benefits for no growth (0%), low growth (75% of the base case growth rate), and higher growth (125% of the base case growth rate) scenarios. Growth at the base case rate, but only to the year benefits first accrue (2009) was also analyzed.

Potential events that could lead to the no growth or low growth scenarios could include continuation of import tariffs beyond the current three year period, further reduction in U.S. steel production affecting demand for imported steel slabs, or economic recessions or depressions affecting demand for final steel products. Potential events that could lead to the higher growth scenario could include early termination of tariffs or exemption/suspension of the tariff for steel slabs (note that a number of U.S. steel manufacturers are recommending the latter action), early recovery of the U.S. steel industry, or faster domestic economic recovery, in general. The no growth or low growth scenarios are considered unlikely since steel slabs through the Delaware River port system have increased by a factor of twenty-seven since 1990, and more recently, by 13.2% per year, from 1996 to 2001.

The no growth scenario reduces steel slab benefits to $2,270,454 (63% of base case). The low growth scenario reduces steel slab benefits to $3,204,268 (89% of base case). The growth at the base case rate, but only to the year benefits first accrue (2009) reduces steel slab benefits to

$2,486,756 (69% of base case). The higher growth scenario increases steel slab benefits to $4,090,977 (114% of base case).

The most probable (base case) for blast furnace slag is 1 million metric tons by the base year (2009), then constant thereafter throughout the remainder of the period of analysis. Alternative blast furnace slag annual growth scenarios were formulated to provide an illustrative range for no growth, low growth, and high growth scenarios. Growth at the base case rate, but only to the year benefits first accrue (2009) was also analyzed. The no growth scenario represents the 2001 level of slag imports (369,450 tons). The low growth scenario (700,000 tons) is approximately mid-way between the no growth scenario and the base case (1,000,000 tons). The high growth scenario was formulated at 1,300,000 tons.

The rationale for the zero and low growth rates scenarios is that St. Lawrence Cement is a single customer and may reduce, or choose not to fully use, GBFS processing capacity at their facility. Note that the zero growth rate (2001 tonnage levels) is unlikely because early indications obtained from shippers' records are that 2002 shipments will exceed 2001 shipments by 25 to 50 percent. Additional factors that could result in no or low growth scenarios are potential increases in domestic steel (hence slag) production that could compete with imported slag, development of alternative cement additives, or a significant reduction in Portland cement production or demand. Factors that could result in the high growth scenario would include increasing demand for furnace slag and/or increased Portland cement production that could increase prices for GBFS and therefore provide an incentive for St. Lawrence Cement to increase production capacity at their Newark facility. The significant investment in the facility by St. Lawrence Cement and data from the Slag Cement Association and the USGS support the most likely and higher growth scenarios.

The no growth scenario reduces blast furnace slag benefits to $977,015 (54% of base case). The low growth scenario reduces blast furnace slag benefits to $1,388,752 (77% of base case). The growth at the base case rate, but only to the year benefits first accrue (2009) scenario does not result in a change of benefits for furnace slag, since growth remains constant in the base case at one million tons/year beyond 2008. The high growth scenario increases blast furnace slag benefits to $2,229,238 (123% of base case).

Table C-34 presents a sensitivity analysis summary comparing the no growth, growth until the year benefits first accrue, and high growth scenarios (discussed above) to the base case. The no growth scenario combines the effects of no annual growth for all benefiting commodities throughout the entire study period. The growth until benefits first accrue (2008 or 2009, depending on commodity) combines the effects of using the base case growth rate only until 2008/2009, then keeping commodity levels constant thereafter. The higher growth scenario combines the effects of using the high-end growth rate estimates for all benefiting commodities. The most likely scenario, the base case, is presented for comparison purposes.

In all cases, the project benefit cost ratio remains above unity, regardless of the change in any individual commodity's growth rate. A further analysis was performed combining zero growth rates from 2000/2001, zero to the base year (2009) growth rates, and higher growth rates, for all commodities. The results of this sensitivity analysis indicated that the project benefit cost ratio would range from 0.95 (zero growth rate beyond 2000/2001) to 1.32 (higher growth rate). The BCRs for these two scenarios, excluding PED costs, are 0.99 and 1.37, respectively.

Table C-34
Sensitivity Analysis Summary
Alternative Growth Scenarios: All Benefiting Commodities

Benefit Source	No Growth	Growth Only to Year Benefits First Accrue[1]	Base Case	High Growth
Tankers –Crude Oil	$13,520,649	$14,027,601	$14,798,714	$16,639,402
Delaware Terminal – Petroleum Products	$261,787	$266,374	$355,008	$984,312
Containerships	$2,913,309	$2,913,309	$3,490,717	$4,096,127
Bulkers – Steel Slabs and Blast Furnace Slag	$3,247,468	$4,298,251	$5,409,493	$6,320,215
Broadkill Beach	$604,698	$604,698	$604,698	$604,698
Total Annual Benefits	**$20,547,912**	**$22,110,234**	**$24,658,630**	**$28,644,754**
Total Annual Costs	$21,688,446	$21,688,446	$21,688,446	$21,688,446
Annual Net Benefits	(1,140,534)	$421,788	$2,970,184	$6,956,308
Benefit/Cost Ratio	0.95	1.02	1.14	1.32
Benefit/Cost Ratio[2] (No PED Costs)	0.99	1.06	1.18	1.37

[1] Benefits first accrue for tankers and petroleum products in 2008; and for containers and bulk commodities in 2009
[2] Resulting BCR if sunk Preconstruction Engineering and Design costs are excluded from the analysis

6.4.2. Sensitivity Analysis: Lightering Fleet Operating Costs

Reductions in the costs of lightering operations are a significant percentage of crude oil benefits. Lightering costs, in turn, are based in large part on the cost of owning and operating the lightering fleet. Vessel operating costs for the Maritrans fleet were estimated using data and information obtained from the Corps of Engineers Institute for Water Resources' ongoing vessel cost information programs, supplemented by maritime industry sources and Maritrans fleet information. Key areas of uncertainty in the lightering fleet vessel cost estimates include costs for crew, lubes, stores, maintenance and repairs.

The lower cost scenario for crew, lubes, stores, maintenance and repairs reduces total crude oil benefits to $13,861,465 (94% of base case). The higher cost scenario for crew, lubes, stores, maintenance and repairs increases total crude oil benefits to $15,388,136 (104% of base case). The benefit cost ratio for the deepening project remains above unity in both of the alternative cost of lightering operations scenarios (1.09 and 1.16, respectively; or 1.14 and 1.21 with no PED costs).

6.4.3. Sensitivity Analysis: Lightering Fleet Configuration

In the most likely base case scenario, it is assumed that Maritrans will respond to reduced lightering volumes (and revenues) under with project conditions, in an economically rational manner, by reducing lightering resources and re-assigning the Integrity to other productive uses (i.e., non-anchorage area lightering operations). This assumed fleet shift reduces the overall cost of the lightering fleet by reducing the fleet size needed to service anchorage area lightering activities from three vessels to two vessels (Maritrans 400 and Maritrans 300). A sensitivity analysis was conducted to assess what effects alternative Maritrans' fleet configurations would have on project benefits. These alternative scenarios would be less economically efficient than the most likely scenario, but are included here because they were identified by Maritrans as a potential response to channel deepening.

Because the Integrity and the Maritrans 300 have the same cargo capacity (265,000 bbl), one alternative fleet configuration includes the Integrity and the Maritrans 400, with the Maritrans 300 removed from lightering service. This with project lightering fleet alternative scenario reduces tanker benefits to $11,697,246 (79% of base case). The benefit cost ratio for the deepening project falls slightly below unity (0.99) in this scenario. Excluding PED costs, the BCR is marginally justified at 1.03.

A second alternative lightering fleet scenario assumes that Maritrans does not reduce fleet size and would continue to use all three vessels under with project conditions. The three vessel fleet scenario reduces tanker benefits to $7,291,500 (49% of base case). The benefit cost ratio for the deepening project falls below unity (0.79) in this scenario (or 0.82 with no PED costs).

Both of these two scenarios are considered to be unlikely. In the first scenario, since the Maritrans 300 and Integrity have the same capacity, but the Integrity costs more to own and operate, Maritrans would be choosing to remove a more efficient vessel in lieu of a less efficient one, increasing the average and marginal costs of their lightering operations.

The second scenario is considered to be even more unlikely. Maritrans charges customers on a per barrel basis. Therefore, Maritrans would need to raise the rates they charge for lightering services significantly to recover the costs of owning and operating their existing fleet across a significantly (31 percent) reduced lightering volume. For reasons cited in Section 3.5.2 above, it is unlikely that Maritrans has the pricing power necessary to impose a rate increase of this magnitude. Therefore, maintaining their existing fleet in the face of declining revenues would result in a significance decrease in profits.

A third alternative fleet configuration consists of a three vessel with project fleet that replaces the relatively high cost Integrity with a smaller, lower cost vessel from Maritrans' Gulf fleet. The Maritrans Gulf fleet contains numerous small tankers and barges of various sizes, making the selection of replacement vessel for service in the Delaware River highly uncertain. Qualitative assessment of this modified three vessel fleet configuration is based on the assumption that whichever Gulf vessel may be selected for service in the Delaware River, the Gulf vessel cost will be less than the cost of the Integrity or the Maritrans 300, since it would be considerably smaller than either of these existing fleet vessels (and also because it would not be economically rational to replace it with a more costly vessel). The lower cost of the Gulf vessel implies that the benefits of a three vessel with project fleet that includes a Gulf vessel (in lieu of the Integrity) would be greater than the benefits resulting from the existing fleet (Integrity, Maritrans 400, and

Maritrans 300) but would be less than the benefits resulting from a two-vessel fleet containing only the Maritrans 300 and the Maritrans 400 (i.e., between $7,291,500 and $14,798,714).

6.4.4. Sensitivity Analysis: Lightering Rate Change

Although benefits calculated throughout this analysis are based upon the cost of lightering operations, a sensitivity analysis was conducted to assess the impact of a potential lightering rate increase under with project conditions. Interviews with the lightering company indicated that one potential response to the deepening project might be an increase in the rate charged for lightering services towards the high end of the existing rate scale. The interview identified $0.37/bbl. as the best representative without project lightering rate. A lightering rate of $0.42/bbl. was selected as the alternative with project rate scenario. Basing the benefits analysis on $0.37/bbl. under both without and with project conditions increases tanker benefits to 16,686,737 (113% of base case). Tanker benefits under the different with and without project rate scenario ($0.37/bbl. without project, $0.42/bbl. with project) are reduced to $14,145,998 (96% of base case). The benefit cost ratio remains above unity in both of these alternative rate change scenarios at 1.22 and 1.11, respectively (1.27 and 1.15 with no PED costs).

6.4.5. Sensitivity Analysis: Containership Capital Costs

The containerships to be deployed on the benefiting liner service include recently constructed P&O Nedlloyd (PONL) vessels (PONL Remuera, PONL Encounter, PONL Palliser, PONL Pegasus, and PONL Botany), Contship Containerlines vessels (Aurora, Borealis, and Australis) and a Columbus Line vessel (New Zealand). All of these vessels were constructed in 2002. The IWR vessel operating costs used for these vessels (4,000 TEU foreign flag containerships) are based upon the standard IWR methodology the uses a ten-year moving average of vessel construction costs. A ten-year moving average is used to balance the impact of short-term fluctuations in the ship construction market, and minimize variations in vessel costs due to the year vessels were built, shipyard locations, and other factors.

Given the recent short-term trend towards lower containership construction costs, the ten-year moving average is higher than current containership construction costs. Since the fleet employed on the benefiting Australia/New Zealand to U.S. East Coast liner service is new, it can be expected to cost less than the 10-year moving average. Therefore, a sensitivity analysis was conducted using the estimated construction cost of the new vessel fleet. The vessel construction cost used in the sensitivity analysis is $52 million, which is the reported price for construction of the P&O Nedlloyd vessels. The ten-year moving average vessel construction cost from the IWR EGM VOCs used in the base case analysis is approximately $59.5 million. Using the $52 million construction cost to calculate VOCs reduces containership benefits to $3,287,508 (94% of base case). The BCR for the deepening project remains above unity in this scenario at 1.13 (1.17 with no PED costs).

6.4.6. Sensitivity Analysis: Alternative Bulker Fleet – Steel Slabs

Three alternative fleet configurations for steel slab imports under with project conditions were assessed in the sensitivity analysis. The alternative fleet configurations include: deployment of the without project fleet under with project conditions, deployment of larger vessels under with project conditions (design drafts two feet greater than base case fleet), and deployment of smaller vessels under the with project condition (design drafts two feet less than base case fleet).

Deployment of the without project fleet under with project conditions reduces steel slab benefits to $502,603 (14% of base case) and reduces the project BCR to slightly below unity (0.99). With no PED costs, the BCR is marginally justified at 1.03. This scenario is considered unlikely, since significant reductions in transportation costs will result from chartering larger, more efficient vessels. Also, because these vessels come from the charter market, there are no sunk investment costs that might cause resistance by shippers to a fleet shift. Deployment of larger (2 foot greater design draft) vessels increases steel slab benefits to $3,756,310 (104% of base case) and deployment of smaller (2 foot less design draft) vessels reduces steel slab benefits to $3,244,617 (90% of base case). The BCR for the deepening project remains above unity in each of these two scenarios (1.14 and 1.12, respectively; or 1.19 and 1.17 with no PED costs).

6.4.7. Sensitivity Analysis: Alternative Bulker Fleet – Blast Furnace Slag

Three alternative fleet configurations for blast furnace slag imports under with project conditions were assessed in the sensitivity analysis. The alternative fleet configurations include: no change in the existing fleet under with project conditions, deployment of larger vessels under with project conditions (design drafts two feet greater than base case fleet), and deployment of smaller vessels under the with project condition (design drafts two feet less than base case fleet).

Deployment of the without project fleet under with project conditions reduces blast furnace slag benefits to $619,335 (34% of base case). This is considered unlikely, since significant reductions in transportation costs will result from chartering larger, more efficient vessels. Also, because these vessels come from the charter market, there are no sunk investment costs that might cause resistance by shippers to a fleet shift. Deployment of larger vessels (2 foot greater design draft) increases blast furnace slag benefits to $1,925,480 (106% of base case) and deployment of smaller vessels (2 foot less design draft) reduces blast furnace slag benefits to $989,852 (55% of base case). The BCR for the deepening project remains above unity in each of these scenarios at 1.08 for existing fleet, 1.14 for two feet greater design drafts, and 1.10 for two feet less design drafts (or 1.13, 1.19, and 1.14 with no PED costs).

6.4.8. Sensitivity Analysis: Refinery Berth Improvements

Interviews with refinery personnel indicate that two refineries, Coastal Eagle Point and Phillips (Tosco), may choose to delay initiating construction of berth improvements until the main channel has been deepened. This "wait and see" approach could delay the realization of benefits related to these two facilities. A sensitivity analysis was conducted under the assumption that benefits at these two facilities would not commence until 2010 (the base case is 2008). Under the "wait and see" scenario tanker benefits are reduced to $14,468,031 (98% of base case). The BCR for the deepening project remains above unity at 1.12 (or 1.17 with no PED costs).

This scenario is considered to be unlikely for three reasons. First, this would put Coastal and Phillips at a competitive disadvantage relative to the other refineries, since they would be incurring higher transportation costs that would need to be passed through to the costs of final refined products. Second, the reasonableness test on associated costs presented in Section 6.5 indicates that these expenditures have a very high rate of return and it would be in the refineries' financial interest to incur these costs as soon as possible to obtain the resulting cost savings. Third, with the five-year construction period for the project, initiation of construction would provide advance assurance to these two refineries that the deepened channel would become a reality. Initiation of construction would occur a number of years prior to the deepened channel extending to these refineries, allowing them more than sufficient time to complete berth improvements prior to 2008.

6.4.9. Vulnerability of Benefits to Actions of Individual Decision-Makers

A number of the benefits quantified in this analysis are subject to the actions of a small number of decision-makers. Implicit in conventional analyses of shipping trends and operations is the assumption that broad trends dictate the behavior of the numerous firms involved. This is analogous to the "law of large numbers" in statistical analyses. Large ports typically serve numerous ocean carriers and a multitude of commodities and customers. Under those conditions, individual carrier or shipper decisions are relatively insignificant in the larger aggregate market. However, in the case of incremental deepening of an already deepwater port (such as the Delaware River) benefits typically accrue to only a small number of major carriers and commodity groups that use the largest liquid bulk, dry bulk and container vessels. In the case of the Delaware River, this includes containerships, tankers, and bulk carriers that require more than 40 feet of channel depth when fully loaded. The level of uncertainty, and the likelihood of significant impacts to project benefits due to the actions of individual decision makers, varies among the different commodity groups that contribute to project benefits.

Blast Furnace Slag

The significance of single decision maker actions may be most evident for blast furnace slag, which is delivered to a single facility and user, St. Lawrence Cement. The sensitivity analysis of commodity volumes considers an unlikely no growth scenario for blast furnace slag, even though growth is evident in the partial data available for 2002. A further reduction in benefits attributable to blast furnace slag imports would occur if the facility were to shut down. Closing the facility is unlikely given the recent success of the facility in meeting start-up target production levels and the growing market for the facility's product, granulated blast furnace slag, which has been growing 16% per year on average since 1996, according to materials published by the Slag Cement Association. Nonetheless, a catastrophic occurrence could cause the plant to shut down, thereby eliminating this source of benefits. The impact of facility closure would be a reduction of project benefits to $22,847,134 and a benefit cost ratio of 1.05, or 1.1 with no PED costs.

Steel Slabs

The number of decision makers is less of an issue for steel slab imports because there are multiple firms that import steel slabs and the slabs come from multiple sources. However, the current tariffs on imported steel do add a degree of additional uncertainty to this benefit category.

Imported steel slabs are used as raw steel inputs into the making of domestic finished steel products. The domestic finished steel has a higher value than the raw steel input and the profitability and competitiveness of domestic finished steel is, in part, dependent upon low cost raw steel inputs. For these reasons steel slab imports have grown at an average annual rate of more than 13% between 1996 and 2001. Tariffs on imported steel slabs are expected to be less restrictive than tariffs on finished steel because of the importance of low cost inputs to domestic finished steel production. In fact, a number of U.S. steel manufacturers have recommended that the tariffs on imported steel slabs be removed due to the lack of reliable domestic sources for this input to finished steel production. Given the indications of continued growth in steel slab imports, the zero growth scenario presented above is considered to be an unlikely scenario.

The full removal of steel slabs from commodity movements along the Delaware River is unlikely; however, there is an alternative port facility north of the study area (Novalog) that also handles imported steel slabs. Channel deepening to Packer Avenue would enhance its competitive advantage over Novalog by increasing the existing draft differential (Packer Avenue currently has 40 feet and Novalog can only accommodate vessels up to 38 feet in draft). The benefit analysis did not include any transfer of existing steel slab imports from Novalog to Packer Avenue. Given channel deepening, the prospect of Packer Avenue losing additional market share to Novalog is considered to be unlikely.

Containerized Commodities

The containership benefits calculated in this analysis are dependent upon a single liner service and the actions of a consortium of carriers that are sharing space on new vessels built for this service. These 4100+ TEU vessels are separately owned/operated by at least three carriers (P&O Nedlloyd, ContShip, and Columbus Lines). Typically, the purpose of vessel sharing agreements among carriers is to reduce the risk to any single carrier and to expand the market share of the service. If a member of the consortium were to drop out, the eastbound round-the-world service might continue to operate with fewer members or new members may be engaged. Therefore, it is not necessarily the case that the decision of a single member would shut down the service.

Container benefits are also dependent upon trade that involves multiple partners including trade between Australia/New Zealand and the U.S. East Coast, Australia/New Zealand and Europe, and the U.S. East Coast and Europe. Given the diversity of consortium members and vessel ownership and the multiple trade partners that are expected to use the eastbound round-the-world service, it appears unlikely that decisions by single entities will significantly impact container benefits.

A significant component of container benefits are based upon trade in refrigerated commodities from Australia/New Zealand and refrigerated commodities from the South Atlantic region of the U.S. East Coast. The reliance upon refrigerated commodities decreases the likelihood that Philadelphia could be by-passed or replaced by another port-of-call. The landside infrastructure required to handle and transport refrigerated commodities at Packer Avenue's current and projected volumes is not typically available at other North Atlantic region ports. The PRPA has indicated its intention to maintain a competitive advantage in the handling and transport of refrigerated commodities.

Perhaps the most significant decision affecting containerized commodity projections is port rotation on the U.S. East Coast. Published sailing schedules indicate that the initial port rotation for this liner service when it begins in December 2002 will be from Australia/New Zealand through the Panama Canal to Savannah, then to Philadelphia and New York, before heading for Europe. According to officials from VSA member P&O Nedlloyd, this rotation will continue until the service is fully established and vessels achieve targeted load levels at Philadelphia and Savannah. At this point, New York will likely be dropped from the rotation. As loads on the service continue to grow, it will become necessary under without project conditions to stop at Philadelphia before Savannah, because depth limitations in the Delaware River would not allow the vessels to arrive fully loaded from Savannah. According to PONL officials, a port rotation shift would occur and these vessels would call first at Philadelphia after the Panama Canal, then will sail southward to Savannah, Georgia, where they would pick up additional reefer cargo (primarily vegetables and chicken) and transit the Atlantic Ocean to Europe. Under with project conditions, the original Panama Canal to Savannah to Philadelphia rotation can be maintained, resulting in reduced travel distances and transportation costs. This is the basis for the benefits computed in the analysis.

Liner service port rotations are highly dynamic and change frequently in response to market demand, commodity levels between trading partners, shifting carrier alliances, vessel availability, and other factors. If either the without project or with project port rotations differ from what is described above, then the containership benefits claimed in this analysis would need to be recomputed to reflect the changed scenarios.

Crude Oil

Lightering based benefits are dependent upon decisions made by the lightering firm (Maritrans) and the refineries. The preceding sensitivity analyses addressed a number of alternative scenarios concerning lightering fleet configuration and cost, as well as prices charged to the refineries. These are the most significant factors that could impact project benefits. The reduction in lightering caused by the deepening project (approximately 31 percent in the base year) would not be considered sufficient to cause Maritrans to end Delaware River operations.

The benefit analysis anticipates that the refineries will continue to use Maritrans for anchorage area lightering under without and with project conditions in the same manner that they currently use Maritrans. It appears unlikely that a refinery that currently uses Maritrans would choose not to use Maritrans in the future. It may be the case, however, that under with project conditions one of the refineries that does not currently use Maritrans, Valero, could switch to larger vessels that require lightering. If this occurred, it would result in an increase in project benefits.

Another possibility raised during review of previous drafts of this report was the potential that one or more of the refineries might go out of business, resulting in a significant drop in crude oil imports (and therefore benefits). However, given the history of continued operation of these refineries and the successful transfer of ownership and operation of these facilities in the recent past, it appears unlikely that any of the refineries would be shut down for an extended period of time. It is considered unlikely (due to regulatory restrictions) that alternative refineries could be built elsewhere along the U.S. East Coast, or that demand for refined petroleum products would decrease in the service region. Therefore, there are no reasonable assumptions that would result in a reduction in the number of operating refineries along the Delaware River.

6.5. Reasonableness Test on Associated Costs

As stated in Section 5.3.3, the capacity of facilities to benefit from the deepening project is also constrained by the non-Federal expenditures that would need to be made to upgrade non-Federal channels, docks, and dock-side facilities. Therefore, a "reasonableness test" has been conducted in this analysis, comparing the associated costs to the potential benefits for each facility to determine whether it would be economically rational for them to incur these expenses (i.e., whether they would incur a positive rate of return from making the necessary investments). The results of this reasonableness test are presented in Table C-35 below.

The total associated costs by facility were annualized using the project discount rate of 5.875 percent and a 50-year project life. These average annual facility associated costs were then compared to the facility benefits in order to determine whether the investments in berth and/or storage modifications would be justified by the benefits resulting from the deepening project. For the oil refineries, the appropriate measure of benefits to be used in this comparison includes the *price* of lightering services, rather than the *costs* of lightering, since what the refineries must pay for this service is the relevant factor in their decision making to invest the associated costs necessary to deepen their berths and reduce their lightering expenditures. For this reason, the sum of benefits listed in Table C-35 do not match the NED benefits presented earlier (since the NED benefits for the refineries are based in part on reduced lightering *costs*, rather than *prices*).

The net benefits shown in Table C-35 indicate that it would be economically rational for all of the benefiting facilities to make the requisite investments. Average annual facility associated costs were also computed using a 15 percent discount rate and a 10-year payback period, which is generally more indicative of the type of rate of return analysis used in private sector investment decision making. All facilities improvements were still justified using these higher rates.

On this basis, benefits were claimed in the final analysis for all of the facilities. A brief discussion of each facility is presented below.

Table C-35
Associated Cost Reasonableness Test

Facility	Total Facility Associated Cost	Facility Average Annual Associated Costs [1]	Facility Average Annual Benefits[2]	Net Benefits
SJPC – Beckett Street	$2,752,000	$173,111	$1,811,496	$1,638,384
PRPA - Packer Avenue	$719,000	$100,003	$7,088,714	$6,988,711
Valero	$6,109,000	$380,835	$4,744,061	$4,363,226
Sunoco Facilities	$8,166,000	$568,130	$7,760,325	$7,192,195
Phillips 66	$4,453,000	$299,299	$1,531,029	$1,231,730
Coastal Eagle Point Oil Co.	$362,000	$22,567	$2,194,756	$2,172,188
Delaware Terminal	$0	$0	$355,008	$355,008
Motiva	$0	$0	$456,566	$456,566
Total	**$22,561,000**	**$1,543,946**	**$25,941,954**	**$24,398,009**

[1] Average annual associated costs include annualized total facility associated costs plus annual incremental operations and maintenance costs
[2] Refinery benefits based on $0.37/bbl lightering charge under with and without project conditions

SJPC - Beckett Street

SJPC representatives indicated during our interviews that they expected to benefit from the deepening project and would make the necessary facility improvements to accommodate the larger bulk vessels expected to call at the facility under with project conditions. In addition, SJPC has entered into a long-term lease agreement with the firm that receives the benefiting commodity (blast furnace slag). Comparing average annual associated facility costs and average annual benefits indicates that this would be a highly justified expenditure on their part. Therefore, the benefits and associated costs for Beckett Street are included in project justification

PRPA – Packer Avenue

PRPA representatives indicated during our interviews that they expected to benefit from the deepening project and would make the necessary facility improvements to accommodate the larger bulk vessels and containerships expected to call at the facility under with project conditions. Comparing average annual associated facility costs and average annual benefits indicates that this would be a highly justified expenditure on their part. Therefore, the benefits and associated costs for Packer Avenue are included in project justification.

Valero

Under with-project conditions, Valero officials indicated that they would likely: 1) deepen its crude berth (Berth 1) to 45 ft. (consistent with their letter to DRPA); 2) bring in larger vessels that could navigate the deepened channel fully-loaded without lightering, consistent with current operations; 3) not change Caribbean transshipment operations (i.e., voyage length unchanged); and 4) not adopt lightering in regular operations.

The major associated costs for Valero are additional tankage and berth deepening. Valero has conducted preliminary analyses of storage augmentation and estimate them to be in the $20-$40 million range. According to Valero, most of these costs should not be applied to the deepening project, since it is intended to serve current needs. In its preliminary analysis, Valero estimated that less than $5 million would be needed to augment additional storage in response fewer, larger vessels under the with project condition. The remaining associated costs are for berth dredging at Valero. Comparing average annual associated facility costs and average annual benefits indicates that these project-related improvements would be a highly justified expenditure for Valero. Therefore, the benefits and associated costs for Valero are included in project justification.

Sunoco Facilities

Under with-project conditions, Sunoco representatives indicated that they would likely: 1) deepen crude berths to 45 feet, specifically Dock A at Ft. Mifflin and/or Dock 3C at Marcus Hook; 2) bring in larger vessels, specifically more VLCCs; 3) not change landside facilities, since there are currently no storage or landside capacity constraints; 4) perhaps move feedstock and/or product in/out on Afromax tankers (45-foot draft fully-loaded); and 5) make no modifications at Hog Island, since it is interconnected via pipeline with Marcus Hook.

Associated costs have been included in the analysis for berth modifications and dredging at Marcus Hook Berth 3C and dredging at Fort Mifflin Berth A. Comparing average annual associated facility costs and average annual benefits indicates that these project-related improvements would be a highly justified expenditure for Sunoco. Therefore, the benefits and associated costs for Sunoco are included in project justification.

Phillips 66

Phillips officials supported main channel deepening in general but were uncertain of their potential to benefit from the project. This uncertainty is based on physical, economic, and operational constraints.

Operationally, Phillips receives crude from the North Sea, West Africa, and a variety of sources around the Atlantic Basin, typically carried on large Suezmax tankers. The Suezmax tankers are lightered offshore by Phillips onto custom-built Eagle-class tankers that they have on long term charter. These smaller tankers are light-loaded to allow them passage up the Delaware River. Typically, the Eagle tankers can enter the port with delay at high tide. The lightered Suezmax tanker then either follows the Eagle-class tankers to the dock, or proceeds to Phillips' other facility at Bayway in New York/New Jersey Harbor.

Phillips expects to continue these lightering operations under with-project and without-project conditions. Occasionally, Suezmax tankers are lightered by Maritrans onto barges at the Big Stone Beach Anchorage in Delaware Bay if weather conditions do not support Phillips' offshore ship-to-ship lightering operations.

Phillips' Berth No. 1 is the only refinery berth suitable for the Suezmax or Eagle tankers. Deepening this berth would be expensive due to rock underlying the current 40-foot depth, and lack of structural integrity of the dock.

In evaluating their potential response to channel deepening, Phillips indicated that they would compare their costs to potential transportation savings.

The economic reanalysis compared the potential transportation cost savings to the associated costs that would be borne by Phillips to benefit from the deepening project. The associated costs included major structural modifications to Dock No. 1 and berth dredging. Transportation cost savings were computed assuming that Phillips would continue its' current mode of operations, i.e. primarily off-shore lightering with occasional lightering at Big Stone Beach anchorage. Benefits will accrue primarily from reduced transportation time due to reduction in the need to drift the tide, and reduced lightering amounts for those occasions that they do lighter at Big Stone Anchorage.

Comparing average annual associated facility costs and average annual benefits indicates that these project-related improvements would be a justified expenditure for Phillips. Therefore, the benefits and associated costs for Phillips are included in project justification.

Coastal Eagle Point Oil Co.

Coastal Eagle Point officials stated that they do not expect to benefit from channel deepening. In fact, Coastal considers it possible that their transportation costs could increase under with-project conditions. Their rationale is based upon their view of the dominant position that Maritrans has in the lightering market. Coastal officials anticipate that reduced lightering activity in Delaware Bay associated with channel deepening could induce Maritrans to: 1) raise lightering fees (i.e., $/bbl) to maintain revenues in the face of declining lightered volumes, or 2) abandon lightering operation at Big Stone Beach, forcing Coastal to invest in their own lightering equipment and operations.

Typically, Coastal uses Suezmax tankers, which are lightered by Maritrans onto barges at Big Stone Beach Anchorage. Occasionally, Panamax tankers, which do not require lightering when fully-loaded, are used. Refinery products are shipped primarily by pipeline, with some barge shipment. Occasionally, small tankers are used to bring in non-crude feedstock or product (for blending) or to ship product to refinery customers. Coastal anticipates continued use of these vessels and these operations under with-project and without-project conditions.

Coastal officials will not consider investments in berth modifications to take advantage of a deeper channel at this time. However, Coastal officials indicated that their berth is subject to scour, and berth modifications or maintenance may not be prohibitively expensive.

Coastal acknowledges that with-project conditions could reduce their transportation costs and make berth modification economical, but they fully expect otherwise. For this reason, their position is to wait and see, and to respond to prevailing conditions (physical and economic) that accompany channel deepening.

The economic reanalysis compared the potential transportation cost savings to the associated costs that Coastal would have to incur in order to benefit from the deepening project. The associated costs include dredging at Piers No. 2 and No. 3. Transportation cost savings were computed assuming that Phillips would continue its' current mode of operations, i.e. primarily lightering large tankers at Big Stone Beach Anchorage and continuing to use smaller tankers consistent with current practices. Benefits would accrue primarily from reduced transportation time and costs due to reduction in the need to drift the tide, and reduced lightering amounts and costs.

Comparing average annual associated facility costs and average annual benefits indicates that these project-related improvements would be a highly justified expenditure for Coastal. However, because of Coastal officials' concern that any savings due to reduce lightering amounts might be offset by increases in rates charged them by Maritrans, a further sensitivity analysis was conducted.

Transportation cost savings were recomputed for Coastal, assuming that the representative rate that Maritrans stated they currently charge for lightering ($0.37/bbl) is increased by approximately 15 percent under with project conditions (to $0.42/bbl). Under this scenario, average annual transportation cost savings for Coastal would drop by $459,704 to $1,735,051. Even with a lightering rate change of this magnitude, which is considered to be highly unlikely based upon historical pricing practices by Maritrans, project-related improvements would still be a highly justified expenditure for Coastal. In fact, the Maritrans' lightering charge would have to increase to over $0.59/bbl (an increase of over 59 percent) for transportation costs savings to decrease for Coastal to the "break even" point. Based on the competitive pressures affecting Maritrans described earlier in this appendix, we believe either of these scenarios to be unlikely. Therefore, the benefits and associated costs for Phillips are included in project justification.

Delaware Terminal

Delaware Terminal currently brings in petroleum products by barge and tanker to their facility within the Port of Wilmington along the Christina River (authorized depth of Federal channel - 38 feet). According to company officials, when channel depths are insufficient to accommodate incoming tankers, the tankers must be lightered or lightloaded. Delaware Terminal is currently planning to establish a berth on a naturally deep section of the Delaware River in 2007. Access to the current 40-foot channel would result in significant transportation cost savings associated with reductions in lightering and lightloading. With access to the 40-foot main channel of the Delaware River, there would be immediate savings due to reduced lightering and lightloading. This savings is considered to be part of the without-project condition.

Discussions with the operators of Delaware Terminal indicate that a fleet of larger vessels would be employed to take advantage of the deeper 45-foot channel under the with project condition, especially since their new berthing area will be in a reach of the Delaware River that is naturally deep to 45 feet. Transportation cost savings are based on this shift to a larger vessel fleet. No associated costs were calculated for Delaware Terminal since their new berthing area is naturally deep. Therefore, the benefits for Delaware Terminal are included in project justification.

Motiva

Motiva officials were not interviewed during this study, but have publicly expressed their opposition to the project based on concerns that existing shoaling problems in their access channel could be exacerbated by deepening the Delaware River main channel.

The Motiva tanker berth is approximately 38 feet deep. However, rapid sedimentation of the berths and access channel results in costly maintenance dredging and reduces channel depths. Motiva attempts to maintain a 38-foot access channel, but excessive shoaling can reduce access channel depths to 32 to 33 feet between maintenance cycles.

Motiva typically brings in Suezmax tankers, which are lightered at Big Stone Beach Anchorage then drift the tide to access the berth at Motiva. Because of their opposition to the project, it was assumed that Motiva would not make the necessary expenditures to deepen their access channel and berth to 45-feet. However, our analysis of transportation costs indicated that Motiva would marginally benefit from reduced transportation costs in the deepened portion of the Federal channel where they would no longer need to drift the tide on the longest segment of their route from the Big Stone Beach Anchorage to their facility. Since these transportation cost savings could be achieved with no expenditures on Motiva's part, they were claimed as benefits in the economic analysis.

DELAWARE RIVER MAIN CHANNEL DEEPENING STUDY

COMMODITY PROJECTIONS AND FLEET FORECAST

FINAL REPORT

For:

PHILADELPHIA DISTRICT
U.S. ARMY CORPS OF ENGINEERS

Submitted by:

DRI·WEFA
A Global Insight Company

This report presents commodity projections and fleet forecasts for the Delaware River Region to be used in the Delaware River Main Channel Deepening Study Review: Analysis and Update.

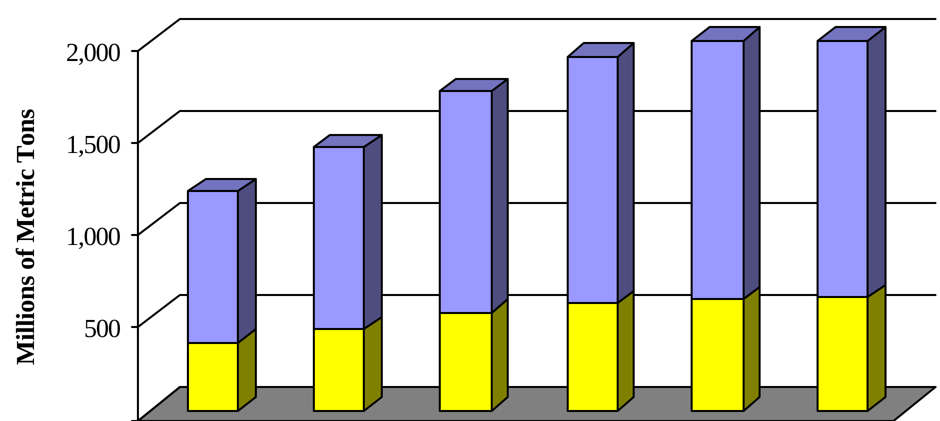
The forecast is validated following procedures to confirm the performance of the model. These validation procedures include comparisons to both internal and external sources. To measure the success of U.S.-specific container and commodity trade estimates, the World Trade Service (WTS) uses current Journal of Commerce Port Import Export Reporting Service (PIERS) data through side-by-side, country-by-country comparisons. Additionally, for each of the forecasted series, the new trade forecast is compared to the forecast produced in the previous period at a more detailed level, commodity by commodity across trading partners. Lastly, the WTS forecast is regularly compared against proprietary shipping data provided to us from our subscribing customers, which include steamship lines, airlines, and international ports. To ensure that the forecast produced is consistent and of high quality, this process continues from forecast to forecast. (See Appendix B of this Attachment– Commodity Trade Forecast Methodology for further validation procedures).

1. OVERVIEW OF DELAWARE REGIONAL COMMODITY FLOWS

The channels, ports, harbors of the Delaware River port system are responsible for 32% of total tons traded into the U.S. North Atlantic. Approximately 75 million metric tons of maritime commodity trade traveled through the Delaware River system in the year 2000, carried on 1200 vessels with over 2000 vessel calls. Over the forecast period, tonnage growth will be modest, averaging 0.68% per year between 2000 and 2060. The strongest period of growth lies between 2010 and 2020, where total trade is expected to grow at a rate of nearly 2% per year. After this peak, in the long-term growth rates will decline—moving from 0.83% in 2030 to 0.27% in 2050 for the duration of the forecast.

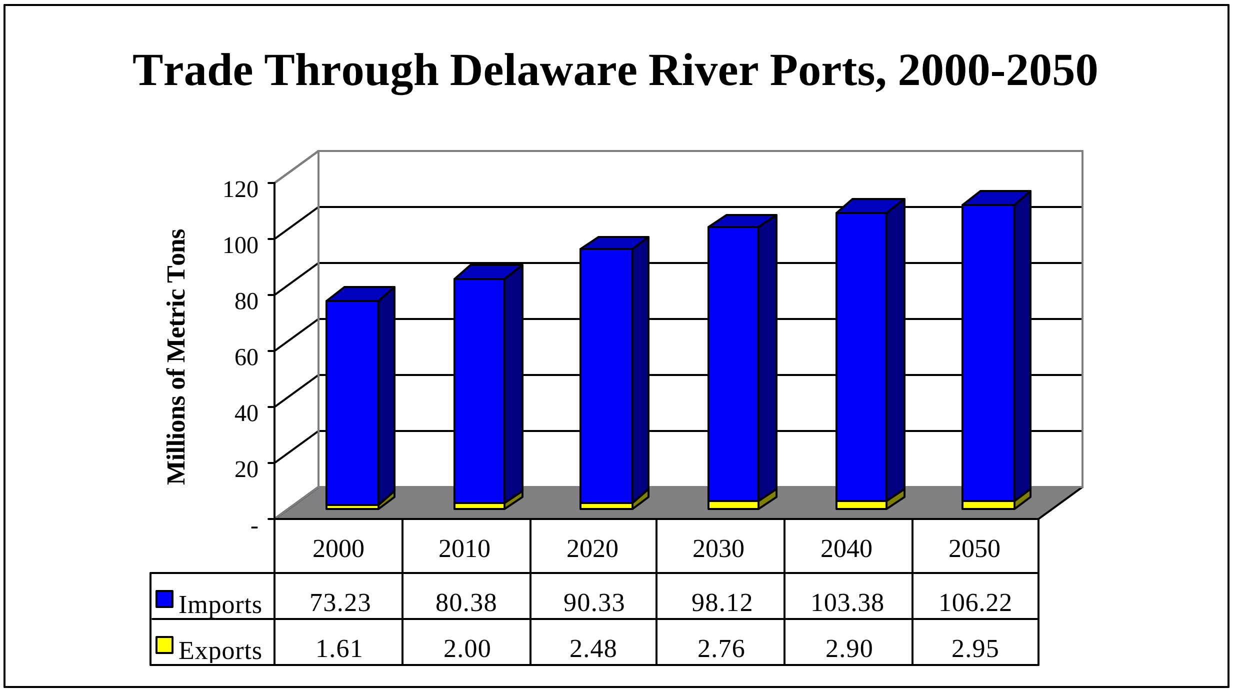
The trade imbalance that is evident in total U.S. trade, as well as trade through the North Atlantic region, is exaggerated in the trade balance of the Delaware River. Imports, primarily crude oil serving the refineries, constituted the majority of this traffic, accounting for 98% of total tonnage in the base year of the forecast.

Trade through United States Ports, 2000 - 2050



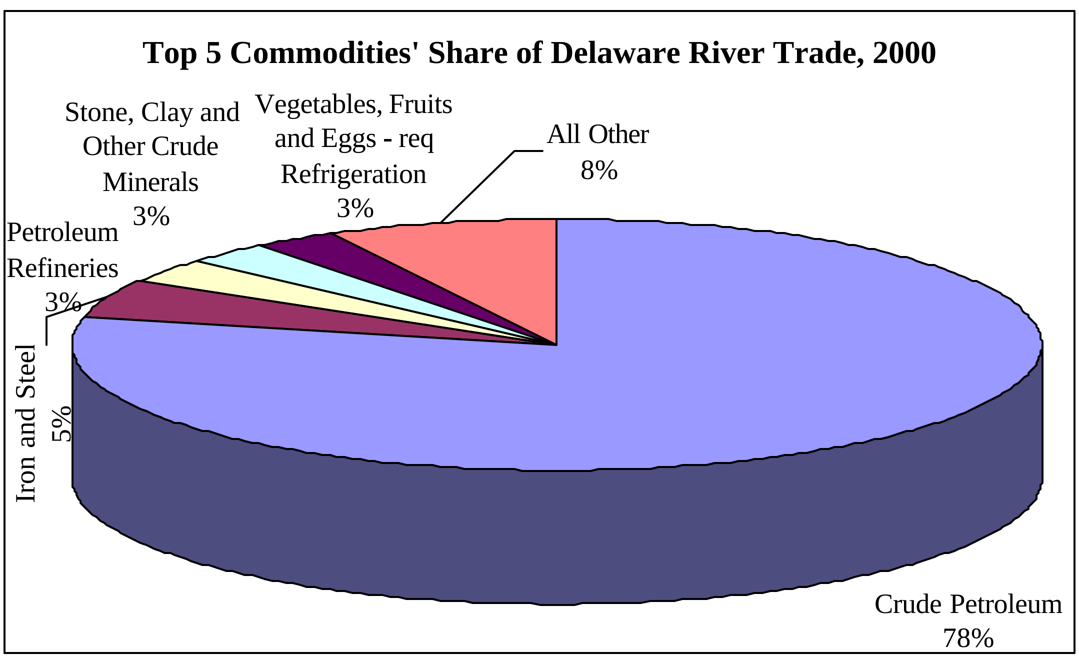
	2000	2010	2020	2030	2040	2050
Imports	816.4	984.3	1,196.1	1,335.2	1,408.9	1,436.5
Exports	369.1	439.6	528.3	578.9	601.9	608.5

The decline in the growth rates projected past 2030, primarily due declining oil imports, is apparent in the graphic above. Export growth exhibits only marginal growth in the long term. The forecast for the Delaware River Ports does however go against this national trend. This is due to the continuing marginal growth in oil imports due to productivity gains in the oil refineries. These are however very small over time.

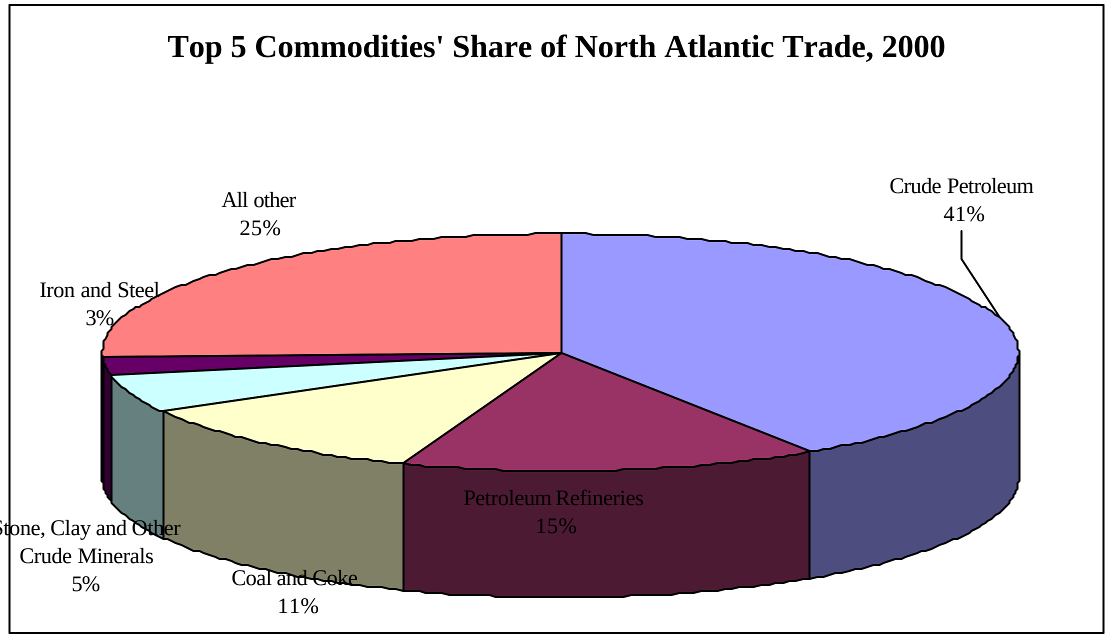


	2000	2010	2020	2030	2040	2050
Imports	73.23	80.38	90.33	98.12	103.38	106.22
Exports	1.61	2.00	2.48	2.76	2.90	2.95

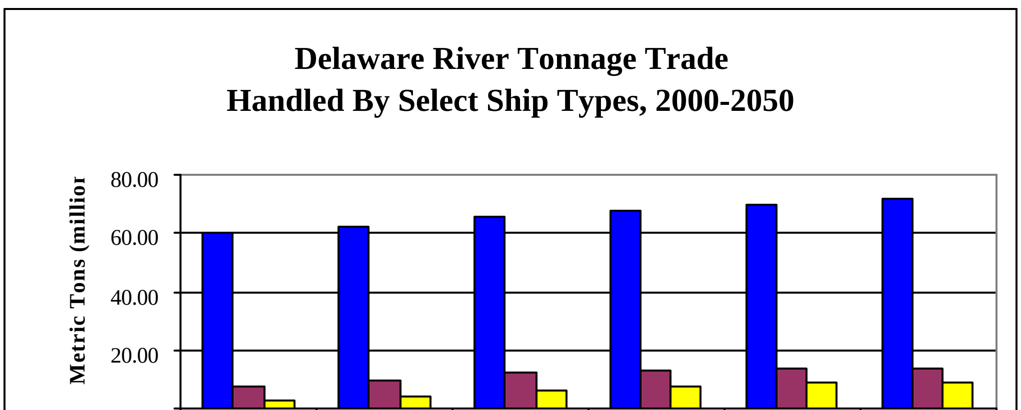
As evidenced in the following graphics, the major commodities of Delaware River System reflect trends at both the regional and national level. Crude Petroleum is the largest imported commodity in terms of tonnage and, it should be noted, a large portion of the North Atlantic region's crude is brought up the Delaware River.



Crude oil to the Delaware River Ports is nearly double the proportion of the North Atlantic distribution.



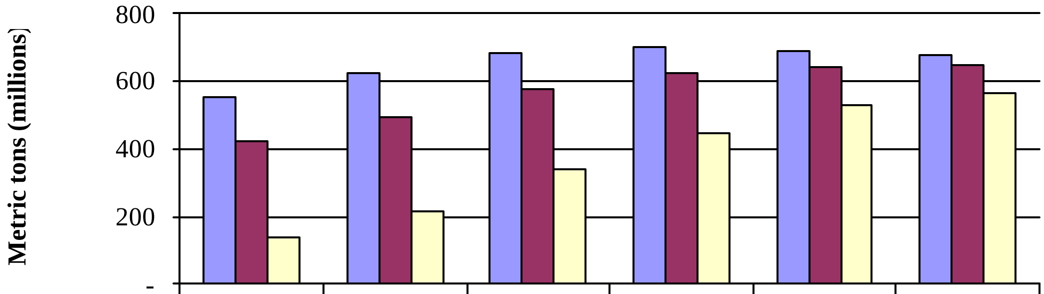
Tanker vessels dominate vessel traffic within the ports of the Delaware River region; once again, evidencing a trend in overall U.S. trade traffic. As illustrated in the following tables, tanker vessels carried 60.02 million metric tons of cargo in the year 2000—11% of similarly transported U.S. tonnage.



	2000	2010	2020	2030	2040	2050
Tanker	60.02	62.48	65.33	67.85	69.94	71.62
Dry Bulk	7.49	9.53	11.99	13.26	13.76	13.87
Container	2.56	3.88	6.05	7.76	8.81	9.15

There is a greater balance, by ship type, as evidenced for the whole of the U.S. trade when comparing tankers and dry bulk vessels.

United States Tonnage Trade
Handled by Selected Ship Types, 2000 - 2050



	2000	2010	2020	2030	2040	2050
Tanker	553.9	622.7	681.8	698.9	688.0	676.2
Dry Bulk	421.3	494.0	578.8	622.9	641.1	645.5
Container	139.1	214.9	341.8	449.1	526.2	563.3

2. COMMODITY FORECAST FOR DELAWARE RIVER SHIP CHANNEL

2.1 TRADE BY COMMODITY

Overall forecast tons for the Delaware River ship channel are projected to increase modestly, increasing from 75 million tons in 2000 to 112 million tons in 2060. Trade in the Delaware Bay region is projected to grow at 0.67% per year over this same period. Imports dominate trade in this region with 97.8% of total tons in 2000 and 97.3% of projected total tons in 2060.

Forecast of Customs District 11 Total Trade							
PORTNAME							
Exports	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Wilmington	547,931	740,313	969,845	1,114,741	1,213,300	1,256,495	1,301,228
Philadelphia	493,244	558,528	645,334	684,628	690,032	684,921	679,847
Chester	227,292	279,059	345,329	378,236	388,196	388,061	387,926
Marcus Hook	160,047	192,621	224,217	236,841	243,251	245,405	247,578
Gloucester City	81,679	109,668	153,106	183,998	200,704	204,996	209,380
Camden	59,805	75,039	96,342	109,686	115,758	116,882	118,018
Paulsboro	38,952	41,037	43,720	45,884	47,378	48,400	49,444
Eagle Point	2,745	2,761	2,582	2,352	2,139	2,022	1,912
Pennsauken	551	678	850	946	974	965	956
Export Total	1,612,245	1,999,704	2,481,325	2,757,312	2,901,733	2,948,147	2,995,305
Average Annual Growth		2.18%	2.18%	1.06%	0.51%	0.16%	0.16%
Percent of Total	2.2%	2.4%	2.7%	2.7%	2.7%	2.7%	2.7%
Imports	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Philadelphia	33,867,646	37,742,561	43,121,460	47,158,827	49,801,164	51,196,698	52,631,338
Chester	11,310,121	11,871,394	12,522,409	13,056,596	13,465,320	13,772,663	14,087,021
Wilmington	11,863,116	13,508,842	16,057,146	18,142,887	19,541,052	20,173,802	20,827,042
Paulsboro	8,260,010	8,623,903	9,078,781	9,493,479	9,834,213	10,093,058	10,358,716
Marcus Hook	5,942,532	6,173,561	6,426,868	6,653,363	6,844,573	7,003,879	7,166,892
Camden	998,687	1,287,155	1,655,165	1,879,281	1,976,635	1,987,532	1,998,488
Ft Mifflin	481,665	494,260	505,060	516,102	527,392	538,935	550,730
Gloucester City	210,309	360,162	636,803	880,775	1,051,266	1,120,043	1,193,319
Pennsauken	105,344	108,099	110,461	112,876	115,345	117,869	120,449
Eagle Point	95,829	98,335	100,484	102,680	104,927	107,223	109,570
Burlington	79,574	93,310	104,446	105,700	102,092	98,670	95,362
Westville	16,896	15,772	14,909	14,422	14,195	14,065	13,936
Import Total	73,231,729	80,377,354	90,333,992	98,116,988	103,378,174	106,224,437	109,152,863
Average Annual Growth		0.94%	1.17%	0.83%	0.52%	0.27%	0.27%
Percent of Total	97.8%	97.6%	97.3%	97.3%	97.3%	97.3%	97.3%
Total	74,843,974	82,377,058	92,815,317	100,874,300	106,279,907	109,172,584	112,148,168

Increasing at an average annual rate of 1.01%, exports are projected to reach nearly 3 million metric tons by the end of the forecast horizon (2060). There are no commodities moving in the export direction in volumes approaching the major import commodities. The largest export tonnages are noted for residual and refined petroleum and organic chemicals--refined petroleum products, which topped the list of exports with 343,469 metric tons in 2000.

Top 20 Delaware River Commodities by Direction of Trade and Weight, 2000 (thousands of metric tons)					
Imports			**Exports**		
Commodity	Tons	Market Share%	Commodity	Tons	Market Share%
Crude Petroleum	57,274.2	78.2%	Residual Petroleum Products	343.5	21.3%
Iron and Steel	4,131.3	5.6%	Petroleum Refineries	282.6	17.5%
Stone, Clay and Other Crude Minerals	2,326.3	3.2%	Organic Chemicals	141.9	8.8%
Petroleum Refineries	2,207.4	3.0%	Paper and Paperboard and Products	97.3	6.0%
Vegetables, Fruits and Eggs - Req. Ref.	2,185.6	3.0%	Motor Vehicles	83.5	5.2%
Organic Chemicals	819.8	1.1%	Iron and Steel	71.8	4.5%
Paper and Paperboard and Products	649.6	0.9%	Synthetic Resins	54.6	3.4%
Non-Metallic Products, nec.	499.9	0.7%	Ores	46.3	2.9%
Meat/Dairy/Fish Req. Ref.	451.6	0.6%	Misc.	38.4	2.4%
Wood Products	324.5	0.4%	Other Food	36.4	2.3%
Other Food	255.2	0.3%	Natural Gas	33.2	2.1%
Other Req. Ref.	198.9	0.3%	Inorganic Chemicals	24.3	1.5%
Inorganic Chemicals	184.8	0.3%	Coal and Coke	23.3	1.4%
Fertilizers and Pesticides	178.2	0.2%	Waste Paper	21.5	1.3%
Chemical Products, nec.	146.0	0.2%	Metal Products	21.0	1.3%
Other Manufacturing, nec.	141.2	0.2%	Chemical Products, nec.	20.6	1.3%
Ores	127.3	0.2%	Meat/Dairy/Fish Req. Ref.	16.5	1.0%
Motor Vehicles	120.2	0.2%	Vegetables and Fruits - Non Ref.	16.0	1.0%
Non-Ferrous Metals	114.5	0.2%	Textiles	15.5	1.0%
Residual Petroleum Products	101.0	0.1%	Vegetables, Fruits and Eggs - Req. Ref.	15.5	1.0%
Other	794.0	1.1%	Other	209.0	13.0%
Total	73,231.4	100%		1,612.6	100.0%

Crude Petroleum accounted for 78.2% of 2000 import tonnage, but due to low growth through 2060 is projected to fall to 59.5% of total imports. Increases in shares of total import tonnage are projected for Iron and Steel; and Vegetables, Fruits, Eggs-Requiring Refrigeration.

Rates of tonnage growth for crude oil and petroleum products have been held constant in the long run and are based on these commodities maintaining maximum levels of trade, based on capacity expectations, to the end of the forecast period. This forecast also operates under the assumption that refining capacity in Delaware River region will not expand, except for modest technological improvements, and will therefore be restricted to low levels of growth in the future (0.2% annually). As a result, rates of tonnage growth for crude and petroleum products will be slower than the average growth in trade (See Appendix C – World Energy Markets of this attachment for a more in depth discussion of these assumptions). The commodities that experience the strongest growth in tonnage tend towards higher value per unit commodities such as refrigerated products and office and computing machinery.

Forecasted Tonnage for Top Delaware River Imports (thousands of metric tons)								
Commodity	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**% annual growth**
Crude Petroleum	57,274.2	58,488.4	59,728.3	60,994.5	62,287.6	63,608.0	64,956.5	0.2%
Iron and Steel	4,131.3	5,125.1	6,400.7	7,037.5	7,283.1	7,378.2	7,474.6	1.0%
Stone, Clay and Other Crude Minerals	2,326.3	2,807.8	3,255.0	3,379.1	3,324.7	3,243.5	3,164.3	0.5%
Petroleum Refineries	2,207.4	2,295.0	2,386.1	2,480.8	2,579.3	2,681.7	2,788.1	0.4%
Vegetables, Fruits and Eggs - Req.Ref.	2,185.6	4,132.2	7,978.6	11,521.5	14,057.1	15,087.5	16,193.4	3.4%
Organic Chemicals	819.8	1,510.7	2,716.7	3,690.8	4,304.3	4,552.4	4,814.7	3.0%
Paper and Paperboard and Products	649.6	874.3	1,123.3	1,216.3	1,208.2	1,182.3	1,156.8	1.0%
Non-Metallic Products, nec.	499.9	782.4	1,167.8	1,433.2	1,598.2	1,670.3	1,745.6	2.1%
Meat/Dairy/Fish Req.Ref.	451.6	536.8	601.6	611.0	595.3	578.3	561.8	0.4%
Wood Products	324.5	597.9	988.5	1,292.9	1,458.0	1,488.1	1,518.8	2.6%
Other Food	255.2	345.6	460.7	521.7	537.8	531.6	525.4	1.2%
Other Req.Ref.	198.9	262.6	324.5	354.2	364.5	364.4	364.3	1.0%
Inorganic Chemicals	184.8	256.4	367.7	439.9	470.8	477.4	484.2	1.6%
Fertilizers and Pesticides	178.2	207.1	216.9	208.2	195.7	188.0	180.7	0.0%
Chemical Products, nec.	146.0	205.5	263.8	276.6	270.9	263.4	256.1	0.9%
Other Manufacturing, nec.	141.2	256.3	445.6	604.7	708.6	749.2	792.2	2.9%
Ores	127.3	137.2	150.3	152.0	146.2	141.7	137.3	0.1%
Motor Ve hicles	120.2	174.9	251.5	305.5	338.5	353.6	369.4	1.9%
Non-Ferrous Metals	114.5	166.2	228.0	252.5	250.7	243.3	236.2	1.2%
Residual Petroleum Products	101.0	93.7	88.1	84.9	83.4	82.5	81.7	-0.4%

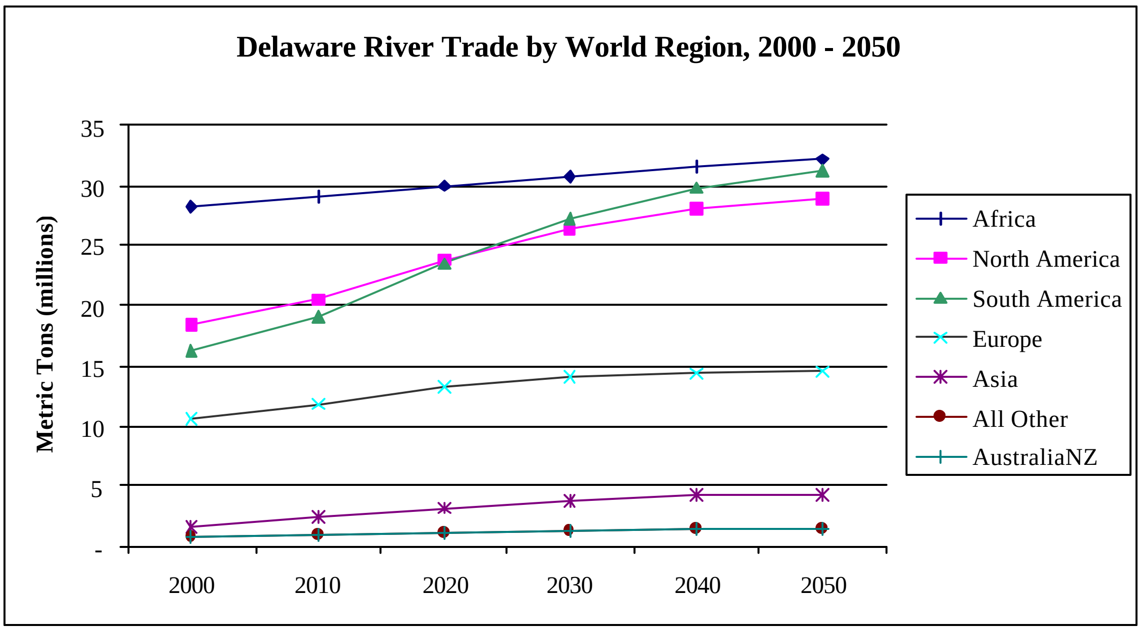
Forecasted Tonnage for Top Delaware River Exports (thousands of metric tons)								
Commodity	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**% annual growth**
Residual Petroleum Products	343.5	469.5	586.7	639.1	675.8	688.6	701.6	1.2%
Petroleum Refineries	282.6	310.0	312.8	295.2	275.2	265.2	255.6	-0.2%
Organic Chemicals	141.9	171.1	211.5	225.5	222.0	215.2	208.6	0.6%
Paper and Paperboard and Products	97.3	116.4	134.8	136.4	129.5	124.2	119.0	0.3%
Motor Vehicles	83.5	115.7	160.1	190.3	207.9	215.7	223.8	1.7%
Iron and Steel	71.8	79.0	86.6	87.2	85.2	83.8	82.4	0.2%
Synthetic Resins	54.6	70.1	88.3	96.0	97.4	97.1	96.8	1.0%
Ores	46.3	44.0	42.8	40.2	36.9	35.1	33.3	-0.5%
Misc.	38.4	69.3	121.3	160.6	182.8	188.7	194.7	2.7%
Other Food	36.4	50.4	72.4	90.2	102.5	108.6	115.1	1.9%
Natural Gas	33.2	33.0	31.1	28.4	26.1	24.8	23.7	-0.6%
Inorganic Chemicals	24.3	27.1	30.8	32.2	32.0	31.4	30.9	0.4%
Coal and Coke	23.3	23.3	23.2	22.9	22.1	21.6	21.1	-0.2%
Waste Paper	21.5	19.8	20.4	20.1	19.3	18.6	18.0	-0.3%
Metal Products	21.0	24.7	29.2	30.6	29.8	28.7	27.7	0.5%
Chemical Products, nec.	20.6	26.6	31.7	32.3	30.9	29.8	28.7	0.6%
Meat/Dairy/Fish Req.Ref.	16.5	21.6	28.2	32.2	34.1	34.7	35.2	1.3%
Vegetables and Fruits - Non-Ref.	16.0	19.9	23.4	24.4	23.7	22.8	21.9	0.5%
Textiles	15.5	19.6	23.6	25.1	24.8	23.9	23.0	0.7%
Vegetables, Fruits and Eggs - Req.Ref	15.5	33.3	71.1	111.2	146.0	164.8	186.0	4.2%

Delaware River Ports' 15 Fastest-Growing Imports, 2000 - 2060 (thousands metric tons)								
Commodity	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**CAGR 00-60**
Office and Computing Machinery	0.4	0.9	2.6	4.5	6.4	7.4	8.7	5.43%
Misc.	79.3	178.0	387.9	604.5	796.1	906.9	1033.0	4.37%
Semi-Conductors	0.0	0.0	0.1	0.1	0.2	0.2	0.2	3.98%
Footwear	14.6	30.1	59.9	88.6	109.1	117.2	126.0	3.66%
Electrical Industrial Machinery	1.6	3.3	6.5	9.7	12.0	12.7	13.5	3.61%
Professional Equipment	1.5	3.0	5.8	8.5	10.6	11.3	12.1	3.53%
Electrical Apparatus, nec.	4.3	8.8	17.1	24.1	29.0	31.2	33.6	3.49%
Vegetables, Fruits and Eggs - req Refrigeration	2185.6	4132.2	7978.6	11521.5	14057.1	15087.5	16193.4	3.39%
Engines and Turbines	16.0	30.7	57.4	80.6	96.5	103.1	110.1	3.27%
Other Communications Equipment	0.2	0.4	0.8	1.1	1.3	1.4	1.4	3.24%
Wearing Apparel	8.3	15.7	29.9	43.2	51.4	53.4	55.4	3.21%
Drugs and Medicines	6.5	11.7	21.6	30.4	36.4	38.8	41.4	3.13%
Organic Chemicals	819.8	1510.7	2716.7	3690.8	4304.3	4552.4	4814.7	2.99%
Other Agriculture	77.0	139.4	245.0	335.5	394.7	421.4	450.0	2.99%
Furniture and Fixtures	4.6	8.5	15.4	21.1	24.3	25.2	26.2	2.94%

Delaware River Ports' 15 Fastest-Growing Exports, 2000 - 2060 (thousands metric tons)								
Commodity	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**CAGR 00-60**
Office and Computing Machinery	0.7	1.9	5.4	10.0	14.9	18.1	22.1	5.83%
Electrical Industrial Machinery	1.1	2.2	4.6	7.6	10.5	12.2	14.1	4.42%
Vegetables, Fruits and Eggs - Req.Ref	15.5	33.3	71.1	111.2	146.0	164.8	186.0	4.23%
Wearing Apparel	7.1	15.3	32.6	51.7	67.7	75.1	83.5	4.20%
Semi-Conductors	0.2	0.5	1.1	1.6	2.0	2.2	2.3	3.85%
Oil Seeds	0.2	0.4	0.7	1.0	1.3	1.5	1.7	3.69%
Footwear	0.2	0.4	0.7	1.1	1.3	1.5	1.6	3.52%
Professional Equipment	2.5	4.3	7.3	10.0	11.8	12.5	13.2	2.82%
Electrical Appliances and Houseware	1.3	2.3	4.1	5.6	6.5	6.7	6.8	2.80%
Misc.	38.4	69.3	121.3	160.6	182.8	188.7	194.7	2.74%
Drugs and Medicines	5.8	10.3	17.4	22.8	25.9	26.7	27.6	2.64%
Other Communications Equipment	1.0	1.6	2.6	3.4	3.8	4.0	4.2	2.35%
Wood Products	2.5	3.8	5.7	7.2	8.1	8.3	8.6	2.07%
Other Manufacturing, nec.	3.3	4.8	7.1	8.8	9.8	10.2	10.5	1.97%
Other Food	36.4	50.4	72.4	90.2	102.5	108.6	115.1	1.94%

2.2 TRADE BY ORIGIN/DESTINATION REGION

The high levels of foreign trade traffic with Africa, North America, and South America are due to the high quantities of petroleum products and refrigerated goods flowing through the ports of the Delaware River Region. Trade with Africa in the year 2000 exceeded 28 million metric tons. Most of this trade, 27 million metric tons, consisted of crude petroleum--accounting for nearly 50% of total crude inbound tonnage. Over three-quarters of North American (including Caribbean) tonnage resulted from trade in crude petroleum. South America, another important exporter of crude to the Delaware River Region, was the third largest trading partner in 2000. Petroleum imports from these countries reached 7.6 million tons. Of the top trade routes, North America and South American trade experience the strongest growth between 2010 and 2050. The following figures depict top commodities by trading partner presented as the 7 major world regions.



Delaware River Top 10 Trading Partners, 2000 - 2050								
PORT NAME	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**CAGR**	**%share 2000**
Western Africa	19.59	20.16	20.68	21.17	21.63	22.09	0.24%	23.91%
Caribbean Basin	10.06	10.45	10.82	11.12	11.36	11.57	0.28%	12.28%
Venezuela	8.97	9.32	9.67	9.97	10.22	10.44	0.30%	10.95%
Other Southern Africa	7.82	8.02	8.20	8.38	8.56	8.75	0.22%	9.55%
Canada	6.53	7.06	7.66	8.06	8.28	8.42	0.51%	7.97%
Other Region	6.20	6.39	6.54	6.66	6.74	6.84	0.20%	7.57%
Norway	3.50	3.59	3.68	3.76	3.84	3.92	0.23%	4.27%
Brazil	2.81	4.16	6.16	7.57	8.44	8.84	2.29%	3.43%
Colombia	2.63	3.10	4.05	5.03	5.85	6.30	1.75%	3.21%
United Kingdom	2.59	2.70	2.81	2.90	2.98	3.04	0.32%	3.16%

Top 10 Traded Commodities between Delaware River Ports and Africa by Year 2000 Tonnage					
Imports			Exports		
Commodity	Tons		Commodity	Tons	
Crude Petroleum	26,986,680		Cork and Wood	3,150	
Other Food	153,745		Engines and Turbines	2,183	
Iron and Steel	106,440		Special Industrial Machinery	2,061	
Petroleum Refineries	80,178		Motor Vehicles	1,202	
Refrigerated Produce	38,559		Non-Ferrous Metals	303	
Ores	33,134		Refrigerated Meat/Dairy/Fish	295	
Organic Chemicals	22,165		Vegetables and Fruits - non-Refrigerated	286	
Fertilizers and Pesticides	13,159		Machinery and Equipment, nec.	272	
Wood Products	11,055		Synthetic Resins	250	
Cork and Wood	9,649		Rubber Products	250	

Top 10 Traded Commodities between Delaware River Ports and S.America by Year 2000 Tonnage					
Imports			Exports		
Commodity	Tons		Commodity	Tons	
Crude Petroleum	6,655,592		Residual Petroleum Products	246,810	
Iron and Steel	1,544,962		Paper and Paperboard and Products	24,065	
Petroleum Refineries	1,066,725		Natural Gas	9,434	
Refrigerated Produce	792,915		Fertilizers and Pesticides	6,087	
Crude Minerals	593,268		Photographic and Optical Goods	5,982	
Organic Chemicals	280,864		Synthetic Resins	4,554	
Other Meat/Dairy/Fish/Fruit/Vegetables	131,836		Non-Ferrous Metals	4,096	
Chemical Products, nec.	96,224		Misc.	3,642	
Inorganic Chemicals	95,992		Iron and Steel	3,375	
Non-Ferrous Metals	77,112		Parts of Motor Vehicles	2,221	

Top 10 Traded Commodities between Delaware River Ports and N.America by Year 2000 Tonnage					
Imports			Exports		
Commodity	Tons		Commodity	Tons	
Crude Petroleum	9,442,899		Petroleum Refineries	151,724	
Refrigerated Produce	1,225,989		Paper and Paperboard and Products	68,225	
Crude Minerals	1,044,168		Other Food	31,192	
Petroleum Refineries	366,108		Misc.	29,719	
Iron and Steel	169,440		Motor Vehicles	26,968	
Other Manufacturing, nec.	138,749		Natural Gas	20,920	
Organic Chemicals	118,283		Waste Paper	19,850	
Paper and Paperboard and Products	79,568		Organic Chemicals	17,246	
Motor Vehicles	44,889		Residual Petroleum Products	16,070	
Vegetables and Fruits - non-Refrigerated	37,685		Coal and Coke	14,805	

Top 10 Traded Commodities between Delaware River Ports and AUS/NZ by Year 2000 Tonnage					
Imports			Exports		
Commodity	Tons		Commodity	Tons	
Refrigerated Meat/Dairy/Fish	424,981		Refrigerated Meat/Dairy/Fish	7,305	
Refrigerated Produce	52,341		Non-Ferrous Metals	4,528	
Iron and Steel	40,396		Paper and Paperboard and Products	3,775	
Other Meat/Dairy/Fish/Produce	29,235		Synthetic Resins	3,567	
Chemical Products, nec.	28,198		Crude Minerals	3,518	
Other Food	20,293		Vegetables and Fruits - non-Refrigerated	3,470	
Ores	18,434		Other Food	2,359	
Beverages	13,229		Chemical Products, nec.	2,029	
Cork and Wood	7,814		Rubber Products	1,652	
Other Raw Textile Materials	6,005		Parts of Motor Vehicles	1,348	

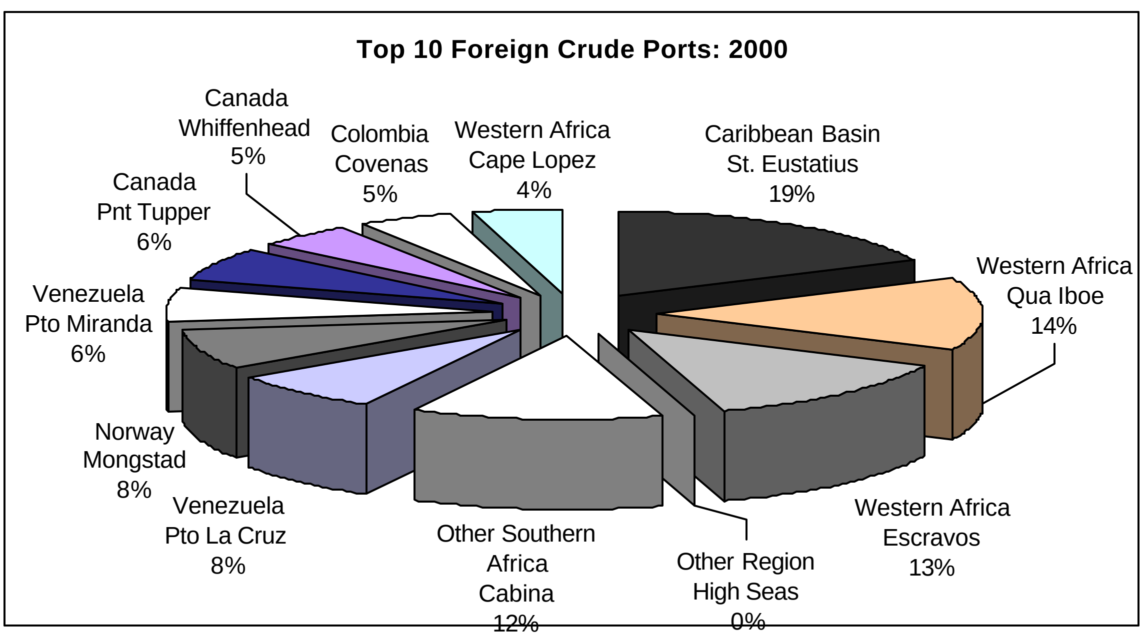
Top 10 Traded Commodities between Delaware River Ports and Europe by Year 2000 Tonnage					
Imports			**Exports**		
Commodity	**Tons**		**Commodity**	**Tons**	
Crude Petroleum	6,077,187		Organic Chemicals	109,790	
Iron and Steel	1,704,972		Petroleum Refineries	89,278	
Paper and Paperboard and Products	553,124		Residual Petroleum Products	80,562	
Crude Minerals	458,007		Iron and Steel	64,135	
Petroleum Refineries	245,830		Ores	46,285	
Organic Chemicals	180,296		Synthetic Resins	38,599	
Fertilizers and Pesticides	86,068		Inorganic Chemicals	18,404	
Inorganic Chemicals	76,859		Metal Products	15,321	
Refrigerated Produce	75,760		Chemical Products, nec.	12,958	
Motor Vehicles	73,451		Coal and Coke	8,508	

Top 10 Traded Commodities between Delaware River Ports and Middle East by Year 2000 Tonnage					
Imports			**Exports**		
Commodity	**Tons**		**Commodity**	**Tons**	
Organic Chemicals	38,409		Motor Vehicles	53,240	
Fertilizers and Pesticides	10,744		Parts of Motor Vehicles	1,914	
Iron and Steel	126		Engines and Turbines	1,073	
Soap and Cleaning Preparations	99		Machinery and Equipment, nec.	720	
Chemical Products, nec.	54		Special Industrial Machinery	298	
Wood Products	53		Agricultural Machinery	157	
Metal Products	44		Misc.	32	
Synthetic Resins	40		Metal and Wood Working Machinery	16	
Rubber Products	38		Metal Products	10	
Machinery and Equipment, nec.	23		Wood Products	4	

Top 10 Traded Commodities between Delaware River Ports and Asia by Year 2000 Tonnage					
Imports			**Exports**		
Commodity	**Tons**		**Commodity**	**Tons**	
Iron and Steel	564,257		Organic Chemicals	10,233	
Non-Metallic Products, nec.	446,204		Special Industrial Machinery	3,363	
Wood Products	237,248		Petroleum Refineries	2,804	
Crude Minerals	129,027		Machinery and Equipment, nec.	1,283	
Residual Petroleum Products	82,468		Misc.	1,138	
Other Food	41,724		Electrical Industrial Machinery	299	
Metal Products	29,332		Metal and Wood Working Machinery	206	
Non-Ferrous Metals	16,686		Motor Vehicles	187	
Machinery and Equipment, nec.	14,734		Iron and Steel	69	
Petroleum Refineries	12,332		Engines and Turbines	67	

Top 20 Foreign Ports Handling U.S. Inbound Cargo by Tonnage, 2000			Top 20 Foreign Ports Handling U.S. Outbound Cargo by Tonnage, 2000		
Port	**Tonnage (millions)**	**% market share**	**Port**	**Tonnage (millions)**	**% market share**
ST EUSTATIUS	8.34	10.39%	ANTWERP	.21	12.81%
HIGH SEAS	6.30	7.85%	PT LIMON	.10	6.31%
QUA IBOE	6.27	7.81%	ROTTERDAM	.09	5.52%
ESCRAVOS	5.95	7.40%	FORTALEZA	.07	4.57%
CABINDA	5.65	7.03%	SEPETIBA BAY	.06	3.80%
PTO LA CRUZ	3.78	4.71%	HALIFAX	.06	3.69%
MONGSTAD	3.42	4.26%	GIBRALTAR	.06	3.49%
PNT TUPPER	3.09	3.84%	ARACAJU	.05	3.09%
PTO MIRANDA	2.91	3.62%	UDDEVALLA	.04	2.78%
WHIFFENHEAD	2.17	2.70%	HAMILTON	.04	2.55%
COVENAS	2.15	2.68%	PTO BARRIOS	.04	2.22%
CAPE LOPEZ	1.95	2.43%	MONTREAL	.04	2.21%
TEES	1.40	1.74%	COME BY CHANC	.04	2.20%
PALANCA	1.22	1.52%	CABEDELO	.03	2.09%
TCHATAMBA	1.03	1.28%	PTO CORTES	.03	2.06%
ST LUCIA	.97	1.21%	HAINA	.03	2.04%
DJENO	.92	1.14%	TROMBETAS RVR	.03	1.74%
BAJO GRANDE	.90	1.12%	FREEPORT	.03	1.73%
GABON	.84	1.04%	SAVONA	.03	1.67%
AMUAY	.80	1.00%	LIVERPOOL	.03	1.64%

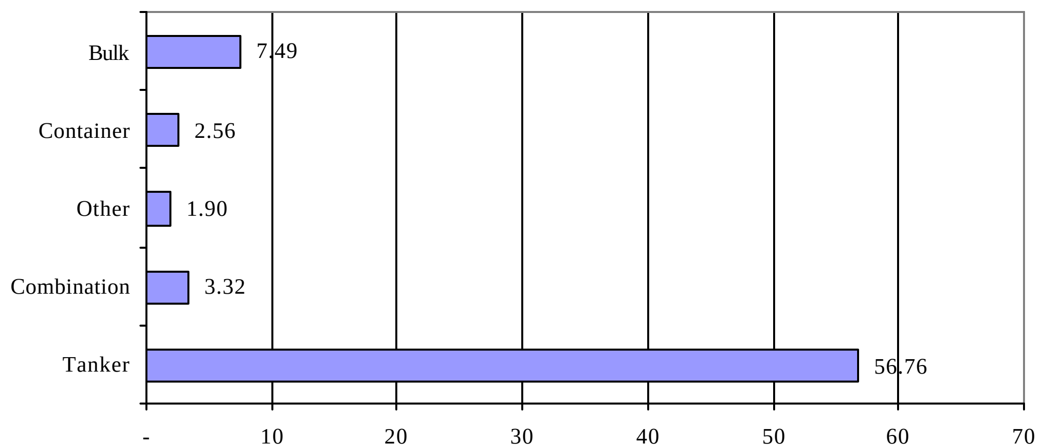
*High Seas is not representative of a specific port, but rather lightering location in the open ocean.



2.3 TRADE BY VESSEL TYPE AND SIZE

Over 1,200 vessels called upon the Delaware River port system throughout the year 2000. Though representative of a diverse population, as evidenced in the tables below, the vast majority of the nearly 75 million metric tons of commodities transported to the Delaware River consists of crude oil delivered on tankers (57 million), followed by bulk (7 million), combination (3 million), and containerized cargo (3 million). Tanker vessels constitute the largest portion of vessel traffic. Nearly 44 percent of total tonnage was carried on vessels in excess of 100,000 deadweight tons. Over 21 percent of total tonnage was carried on vessels in excess of 140,000 DWT.

Vessels Visiting Delaware Ports By Ship Type, 2000
(millions of metric tons)

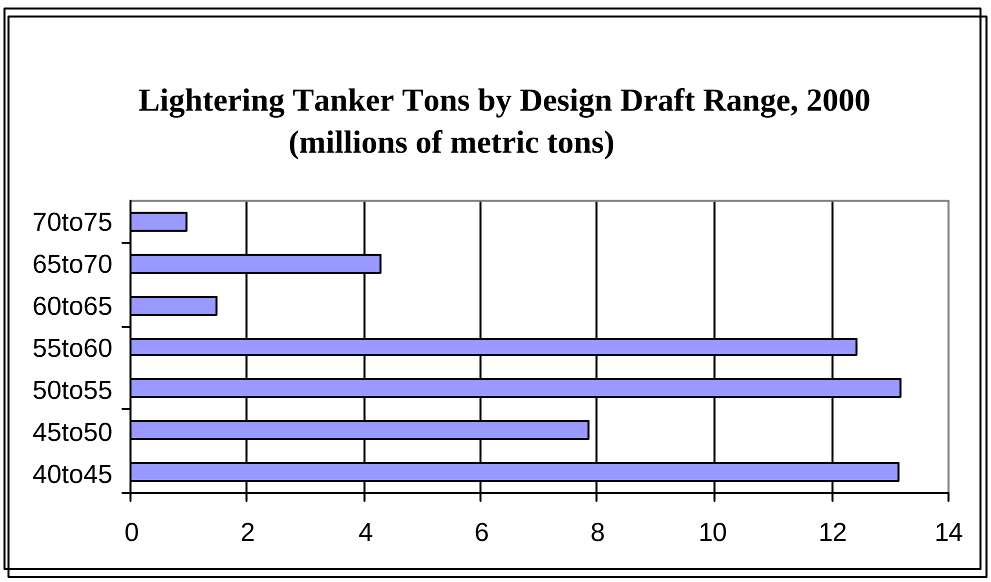


Delaware River Vessel Traffic by Deadweight Tons: 2000
Top 20 by Tonnage

Vessel Type	DWT Group	Range of DWT	Metric Tons	% of share of total tons
TANKER	10	90,000 to 99,999	13,691,023	18.29%
TANKER	16	150,000 to 159,000	11,779,294	15.74%
TANKER	15	140,000 to 149,000	10,130,930	13.54%
TANKER	11	100,000 to 109,999	4,958,059	6.62%
TANKER	31	300,000 to 309,000	4,189,135	5.60%
TANKER	9	80,000 to 89,999	3,238,261	4.33%
BULK	5	40,000 to 49,999	2,560,000	3.42%
BULK	4	30,000 to 39,999	2,050,000	2.74%
TANKER	7	60,000 to 69,999	1,860,178	2.49%
TANKER	14	130,000 to 139,000	1,682,977	2.25%
OTHER		Not Reported	18,704,117	24.99%
TOTAL TONS			74,843,974	100%

Tankers

Liquid bulk vessels, such as tankers or combination ships, with sailing drafts in excess of the 40 foot depth of the existing channel require lightering to enter the Delaware River region. Furthermore, because most operators require minimum one meter clearance, vessels with sailing drafts between 37 and 40 feet are required to either drift the tide or to lighter. Of vessels greater than or equal to 40 feet, 15% of the tonnage is carried by vessels with deadweight tons (DWT) between 280,000 and 310,000 DWT, while 76.5% were carried in vessels in the range between 130,000 and 170,000 DWT. The remaining 8.3% were in vessels with deadweight tons around 100,000 DWT.



There are a variety of foreign ports that are the origins of the crude imports. In general, vessels in the larger sizes carried cargo from the further origins in Africa and the North Sea. Vessels in the smaller size ranges carried cargo from closer origins in the Caribbean and Canada.

The above table illustrates the quantity of tanker cargo carried on lightering vessels in the year 2000. The vessels included in the above population have design drafts in excess of 40 ft and sailing drafts over 37.

Non-lightering tankers (and combinations) include vessels that have sailing drafts, though not necessarily design drafts, below 40 feet. The majority of traffic within this category, 73.2 percent, was transported in vessels ranging between 90,000 and 120,000 deadweight tons.

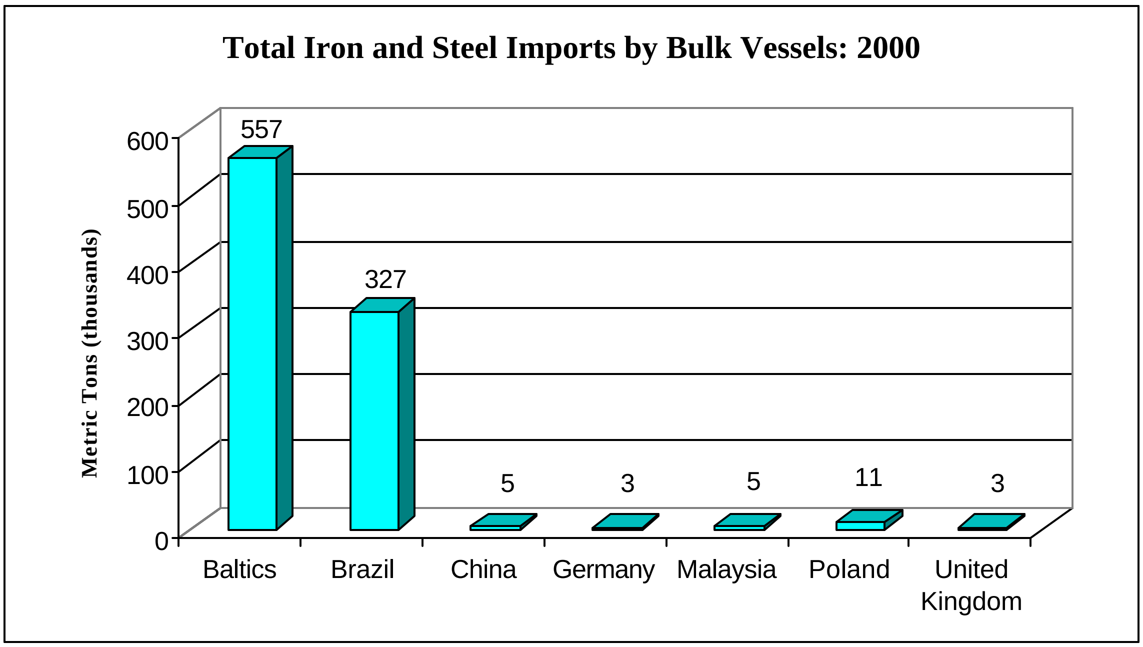
Bulk Vessels

This section analyzes the bulk cargoes (primarily iron and steel) which are carried in vessels with design drafts above 40 feet and which could benefit from deepening of the Delaware River Ship Channel. An 80,000 ton bulk carrier would save cost if loaded to 45 feet instead of 40 feet when sailing approximately 4,500 mile distances to the Delaware River Ship Channel from Brazil and

Latvia. The benefits associated with iron and steel are a function of the tons that are included in the benefiting category. Approximately 700,000 tons were carried in vessels above 40 feet in 2000. If all iron and steel tons from Brazil and Latvia were included, the benefiting tonnage would be 1,860,224 tons.

This analysis also shows significant tonnages of Stone, Clay and Other Crude Minerals from Canada in vessels with design drafts above 40 feet. However, these vessels arrive with sailing drafts below 35 feet and therefore are not projected to benefit from a deeper channel.

Though not evident in the history, namely the 2000 WCSC database, provision has been included for 1,000,000 tons of cement, "clinker", entering the port destined for a production facility near the Beckett Street Terminal. This facility currently demands half of this amount, but is expected to reach full capacity by 2009, the first year under project conditions. This cargo, which was identified as a result of direct interviews with the receiving terminals, is effectively new business that has occurred since the year 2000. .

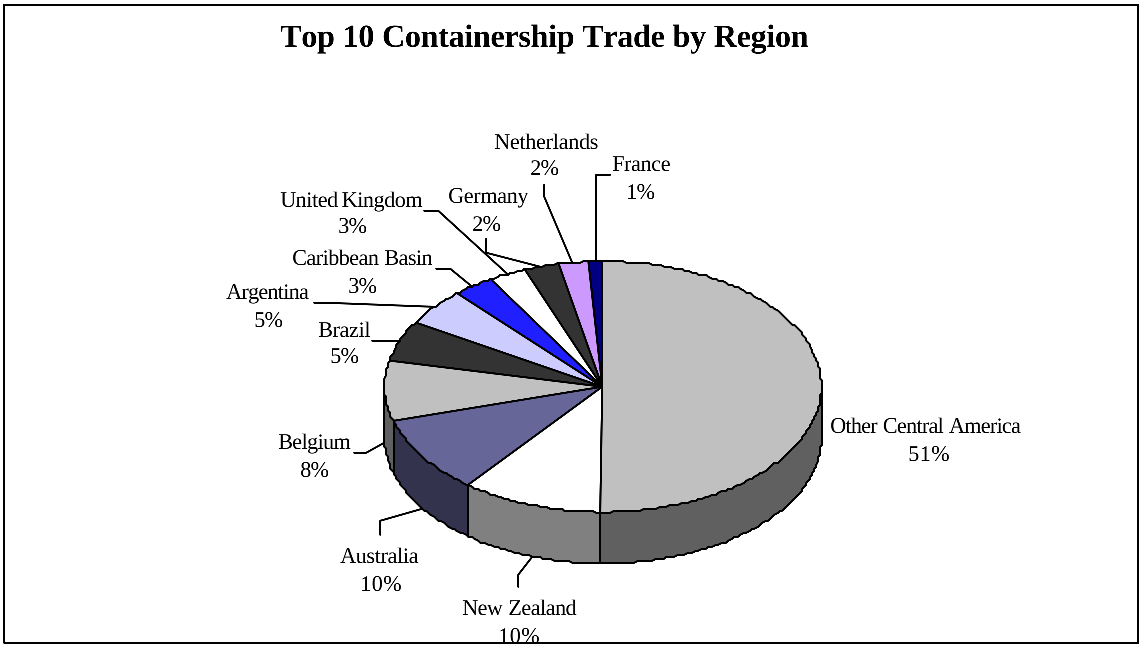


Containerships

A review of container cargo in the Delaware River Ship Channel showed limited containership calls with sailing drafts above 35 feet. In addition, almost half of the container tons originate in Central America in vessels with sailing drafts below 35 feet. As a result, potentially benefiting container tons are limited.

48.7% of total imported container tons are reported from Other Central America, including Guatemala, Honduras, and El Salvador. Other regions reporting significant tonnages include Australia/New Zealand (20%), Europe and the East Coast of South America.

Refrigerated commodities constituted over half of total container traffic in the year 2000. Most container cargo is carried in refrigerated vessels with design drafts below 35 feet. Only 2.4% of total import container tons were in vessels with sailing drafts above 35 feet. Vessels with design drafts in the 36 to 40 foot range carried cargo from the East Coast of South America and Australia/New Zealand. However, only 4 vessel calls reported a sailing draft above 35 feet in 2000 (four other calls indicated sailing drafts above 35 feet but the design drafts are reported as below 35 feet so these records are questionable.)



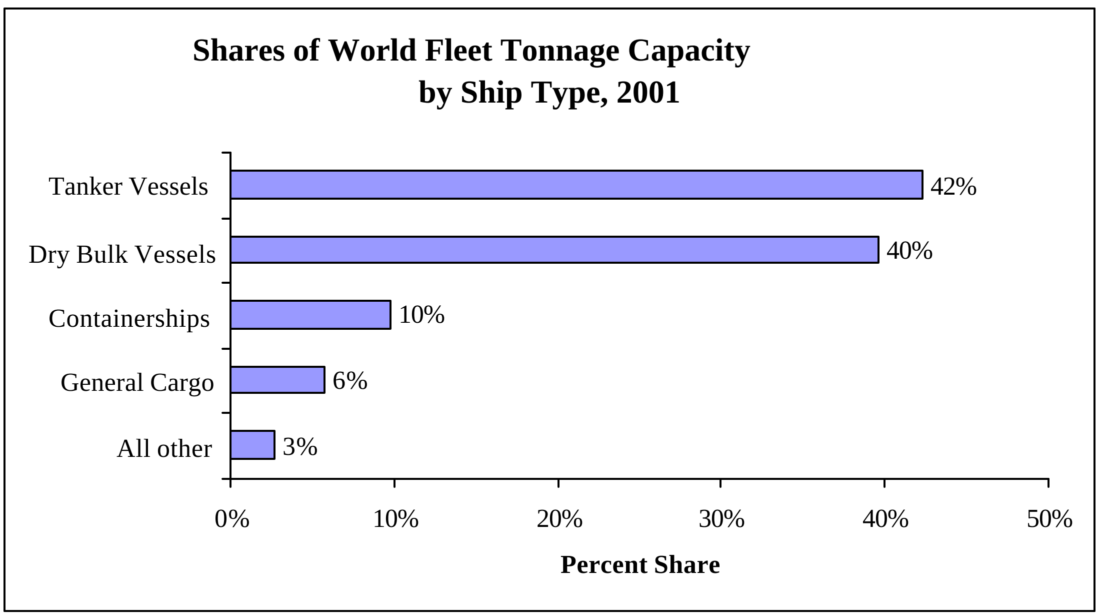
One of the main operators providing refrigerated container service, P&O Nedllyod, are in the process of introducing larger vessels on a revised service schedule. The first of these vessels has already called, and, as the remainder of the service comes on stream, one can expect to see a change in the draft requirements of the vessels. Whereas the service identified in the 2000 and 2001 data files was an end-to-end service between Philadelphia and New Zealand. This new service will be with vessels of 4,300 TEU capacity and a design draft of 43 feet. It will continue on from the U.S. to Europe, returning to New Zealand via the Suez Canal, effectively a round the world service. Whilst the vessels will be coming through Panama with limitations to draft, they will be picking up export cargo from Savannah prior to making their call in Philadelphia. According to P&O Nedllyod, this will cause the ships to draw around 41 feet of water coming up the Delaware River Channel prior to discharging the import refrigerated cargo.

With most cargo carried short distances with smaller vessels and with limited numbers of sailing drafts above 35 feet, the requirement for a deeper channel for container cargo is limited. Over time cargo will shift to larger vessels, however, for the Delaware River Port services this shift is expected to take an extended period of time. Therefore, container tonnage is expected to have a small impact on benefits.

3. PROFILE OF WORLD SHIPPING FLEET

Many carriers will be forced to replace a significant portion of their deep-sea fleet over the next few years. Vessels built during the construction boom in the years 1974-1977 are reaching 25-plus years of service, the average retirement age. For tankers, environmental regulations imposed by the U.S. and the International Maritime Organization (IMO) will require carriers to scrap most single-hull tankers to reduce the risk of oil spills. The Oil Pollution Act of 1990 requires phasing out of single-hull tankers servicing U.S. ports by 2005. IMO regulations require old tankers servicing foreign ports to be retrofitted with double hulls.

Altogether, the tonnage capacity of the world merchant fleet has not changed drastically since the mid-1990s. Tankers, Dry Bulks, and Containers continue to comprise the largest portion of the world merchant fleet; together these ships type account for over 92% of total capacity. Though Tanker capacity hovers around 40%, it still comprises the largest portion of the world fleet. Over time, this share is expected to decline as scrapping diminishes the single-hull portion of the fleet. Due to the slow rate of double-hull construction, the tanker fleet should not recover until well into 2004. Bulk ships have also retained their market share over time, comprising 40% of world fleet capacity. Not surprisingly, containership capacity has seen the most positive growth over the past five years, increasing to 10% of the world merchant fleet. In the future, both the global bulk and global containership capacity will expand, spurred by industry demand.



Though the general cargo ship is in permanent decline, assailed on all sides by the encroachment of containerships and bulk carriers into their traditional territory, there remains a niche for this ship type. The flexibility of multipurpose vessels continues to keep break-bulk ships in demand.

The largest general cargo vessels are also the oldest, with an average age of almost 20 years. The youngest portion of the fleet is vessels between 20,000 and 30,000 DWT, demonstrating that most investment in newer ships is geared into this category. Averaging 18.4 years, the relative old age of the general cargo fleet suggests that recent construction activity is focused elsewhere in the industry.

The most important changes to the tanker fleet over the past two years were the result of both changes in policy and in demand. A key factor in the lower rate of growth in the tanker fleet will be a shift from long haul to shorter haul crude oil trades. Single-hull tankers are being scrapped, as changing environmental policy requires double-hull construction for tanker vessels. Both effects, however, will be somewhat offset by the rapid growth in demand for oil in the developing countries of the Far East.

In the past two years, as a result of a weak freight market, the dry bulk fleet has decreased in size. This aspect of the shipping market is expected to recover; the dry bulk shipping fleet will revive as worldwide demand for oil seeds and other grains rise in the wake of globalization.

Though certainly fewer in number, vessels between 10,000 and 35, 000 DWT continue to make up the most substantial portion of the world's dry cargo fleet, 40.7%. In recent history, larger bulk carriers, those between 50,000 and 80,000 DWT, have experienced growth in fleet size as well as capacity share. Dry bulk carriers in excess of 160,000 deadweight tons have grown 20% since 1999, and, now, comprise 19% of fleet capacity (compared to 15% in previous years).

The combination of strength of trade flows and the need to consolidate to survive competitive pressures has resulted in the container shipping industry striving to achieve ever-increasing economies of scale. Containerships, port terminals, cranes, and companies are all getting larger. In the 1970s, the same happened with tankers, before the Suez Canal reopened. Similarly, dry bulk vessel sizes grew rapidly in the 1980s.

Today, nearly two thirds of containerships on order are post Panamax (4,000 TEU and over), with a significant number with capacities in excess of 7,000 TEU. Designs are on drawing boards for the next generation of 10,000+ TEU vessels, including even huge Malacca-max 18,000 TEU vessels. The rationale is that for two trade routes (Europe-Asia and the transpacific), sufficient volume exists to provide economies of scale that make these vessels viable. The underlying assumption is that there will be no let-up in the growth of trade and that the number of port calls by individual vessels will need to be reduced. Considering the current state of the world's economies, neither one of these is a safe assumption.

According to Clarkson's Research, the cellular fleet over 4,000 TEU has 302 vessels with a total TEU container capacity equivalent to over 27% of the entire fleet. According to the Journal of Commerce, total container capacity is expected to reach 6 million TEU by the end of 2003. However, in the wake of a contracting container ship market, many companies are considering, or are already, canceling or suspending orders for 8,000+ TEU vessels.

Design Draft Characteristics of the World Merchant Fleet, 2001						
Containership Fleet						
Vessel Capacity (TEU)	**Number of Vessels**	**% of Fleet Capacity**	**Average Draft (ft.)**	**Max (ft.)**	**Min (ft.)**	**Deviation (ft.)**
500-1000	533	7.5%	25.8	36.2	17.3	3.3
1-2,000	863	24.2%	32.1	39.5	21.3	3.2
2-3,000	420	20.8%	37.8	43.1	32.8	2.2
3-4,000	249	16.9%	39.8	45.9	33.1	2.4
4-5,000	165	14.6%	42.9	46.0	35.4	1.8
>5,000	137	16.1%	45.2	47.6	39.4	1.9
Dry Bulk Fleet						
Vessel Capacity (DWT)	**Number of Vessels**	**% of Fleet Capacity**	**Average Draft (ft.)**	**Max (ft.)**	**Min (ft.)**	**Deviation (ft.)**
10-35,000	2387	19.3%	31.9	44.6	21.1	2.9
35-50,000	1425	19.8%	36.8	42.9	25.4	1.9
50-80,000	1235	27.7%	42.9	49.9	19.7	2.7
80-160,000	351	15.5%	53.0	59.1	34.1	5.1
>160,000	282	17.7%	58.6	75.6	38.1	4.2
Tanker Fleet						
Vessel Capacity (DWT)	**Number of Vessels**	**% of Fleet Capacity**	**Average Draft (ft.)**	**Max (ft.)**	**Min (ft.)**	**Deviation (ft.)**
Handymax (10-60,000 DWT)	2167	21.3%	34.1	47.3	17.6	5.0
Panamax (60-80,000 DWT)	320	7.0%	41.0	49.6	35.4	3.1
Aframax (80-120,000 DWT)	559	17.0%	45.2	54.8	34.1	3.3
Suezmax (120,000-200,000 DWT)	286	13.3%	54.0	61.9	43.0	2.6
ULCC/VLCC (>200,000 DWT)	441	41.4%	69.3	93.8	59.6	4.7
General Cargo Fleet						
Vessel Capacity (DWT)	**Number of Vessels**	**% of Fleet Capacity**	**Average Draft (ft.)**	**Max (ft.)**	**Min (ft.)**	**Deviation (ft.)**
10-20,000 DWT	1764	68.5%	29.7	51.5	16.2	2.7
20-30,000 DWT	393	24.2%	33.2	90.0	20.8	3.9
30-40,000 DWT	32	2.9%	36.1	42.0	28.9	2.8
>40,000 DWT	34	4.3%	37.3	40.7	23.0	3.6
Source: DRI-WEFA Analysis of Clarkson Research Data						

Recently, the most notable changes that have occurred to draft design characteristics of the world merchant fleet are a direct result of the increasing tendency of the industry towards economies of scale. Increasing populations of large vessels, such as Post-Panamax container vessels and ULCC/VLCC tanker ships, have pushed world ports to dredge their harbors to increasingly greater depths. Currently, the biggest vessels in the world have design drafts in excess of 90ft.

The accompanying table summarizes draft characteristics of the world merchant fleet of 2001. The largest tankers and bulk vessels have drafts well over 70 ft. For instance, Frontline Ltd.'s Sea Giant, a ULCC class tanker, has a design draft of approx. 93.8 ft. The largest container ships currently have drafts around 50 ft. The size range of containerships that constitutes the largest share of fleet capacity is in the over 4,000 TEU range (+42.9 ft. design draft, on average), which comprise 30.7% of total container fleet capacity. The most significant range for the dry bulk fleet, in terms of capacity, is the 50,000-80,000 DWT range, which has over a quarter of overall capacity. With tankers, the ULCC/VLCC class (ships over 200,000 DWT), make up 42.5% of tanker capacity. In contrast, general cargo ships have the most capacity, 68.5%, in the smallest range, 10,000-20,000 DWT.

The most numerically significant size range of containerships is the 1,000-2,000 TEU range. With dry bulk vessels, the smallest group, the 10,000-35,000 range, contains the most vessels. The Handymax class of tankers (10,000-60,000 DWT) is the most numerous, accounting for over one half of all tanker ships. And the smallest size range of general cargo vessels, 10,000-20,000 DWT, has by far the most ships; 80% of all general cargo vessels are within that size range.

The following table summarizes the characteristics of the world fleet calling on U.S. ports.

Design Draft Characteristics of World Fleet Calling on U.S. Ports in 2001

Vessel Type	**Average Draft**	**Max (ft.)**	**Min (ft.)**	**Standard Deviation**
Container	36.5	47.6	15.4	5.9
Dry Bulk	37.3	60.7	22.7	5.8
General cargo	27.8	52.5	11.9	5.4
Miscellaneous	25.8	37.5	10.4	5.2
Tanker	39.1	74.9	17.5	8.8

Source: DRI-WEFA Analysis of WCSC Data

APPENDICES

APPENDIX A: DATA SOURCES

Commodity flow and vessel data sources used in economic analysis

The table that follows outlines the data sources DRI-WEFA is using to create the database of baseline Delaware River cargo vessel traffic and commodity movements.

Data Sources	
Database	**Information**
United States Army Corps of Engineers Waterborne Commerce Statistics Center (2000 includes processed United States Customs domestic and foreign waterborne statistics and processed Journal of Commerce Port Import Export Reporting Service data. 2001 includes unprocessed PIERS data only.	Direction of trade Foreign Port Code and Name Country Code and Name U.S. Port Code and Name U.S. Customs District Origin/Destination Channel Location Vessel Name Vessel Class Design Draft (feet) Sailing Draft (feet) Location Code (Channel) Dock Code HS6 and SITC3 Commodity Code Commodity Quantity (Kilos) Commodity Value (US$) EC Date NRT
Clarkson's Research (2001 World Vessel Fleet Characteristics)	Vessel Name Vessel Type Deadweight Tonnes Design Draft Vessel TEU Capacity
Delaware River Maritime Exchange (Delaware River cargo vessel traffic for 2000 and 2001)	Vessel Arrival Records only Arrival Data Vessel Name Port Name Length Breadth Gross Tonnage Net Tonnage DWT Arrival Sailing Drafts (feet) Company_Alias C&D Canal traffic(denoted by 'TO BALT' or 'FROM BALT'
United States Census Foreign Trade Division Merchandise Trade Statistics 1998-2000	Country of Origin/Destination of Trade U.S. Customs District Origin/Destination HS6 Commodity Quantity (metric tons)
United Nations World Trade Statistics 1994-2000	Country of Origin/Destination of Trade SITC 3 Commodity Quantity (units vary)

APPENDIX B: COMMODITY TRADE FORECAST METHODOLOGY

The purpose of this appendix is to document the standard forecast methodology of DRI-WEFA's World Trade Service(WTS) model. This forecasting methodology was used to create a customized forecast of trade volume through the port system of Delaware River extending to 2060. The following description refers to the methodology and procedure applied to the WTS's regularly updated quarterly trade forecast.

DRI-WEFA's global trade forecasts include all commodities that have physical volume, but not services or commodities without physical volume, such as electricity. Commodities are grouped into categories derived from the International Standard Industrial Classification (ISIC). The forecast covers 77 ISIC commodity categories, as listed in Table 1.

The WTS forecast tracks 54 major countries individually, then groups the rest of the countries in the world into 16 regions according to their geographic location. Table 2 lists the 54 countries and 16 regions covered in the forecast. Therefore, the forecast involves 77 commodities traded among 70 country/regions. This is a framework of $77 \times 70 \times (70-1)$, or 371,910 potential trade flows.

World trade is first forecast in nominal and real commodity value and then translated into physical volume by transportation mode. Table 3 shows the 18 data series of the world trade that are forecast.

The primary historic global trade data source, is the United Nations' (UN) world trade statistics as distributed by Statistics Canada. These data are collected from member countries' customs records. The UN data cover all member countries. The WTS employs the Statistics Canada version of the UN data, which is cleaned to remove inconsistencies between different countries trade statistics. For some important economies that are not covered by the United Nations, such as Taiwan, we go directly to their government statistics to get the data. In addition, U.S Customs Data is used to verify these sources on a commodity and route specific basis.

The World Trade Services forecasts incorporate DRI•WEFA's comprehensive macroeconomic databases and forecasts. The data used include GDP, industrial output, foreign exchange rates, export prices, etc., by country. This data serve as exogenous variables in the WTS forecast model. For international commodity prices, data is obtained from the U.S. Bureau of Labor Statistics' International Price Program.

The basic structure of each model for the trade flow of a commodity is that a country's import from another country is derived from the importing country's demand forces. Demand forces are commodity specific. For purposes of explanation, we can group our 77 commodities into two types. For the first type, the major demand forces are the importing country's population and income growth. For the other commodities, the major demand forces are the importing country's production and technology development.

A country's export capacity for a commodity is estimated based on the country's capacity to produce this commodity and its ability to export it. The capital and resources that are needed for production determine production capacity. Export ability is determined by the quality and cost of the product in competition with the world market.

The 77 commodities are divided into three groups to control the estimation of the impacts of export prices on a country's imports of each commodity. These three groups are price inelastic, low price elastic, and price elastic.

The models are constructed in real value terms. That is, value type variables are in terms of real value. For example, the trade flow of a commodity is measured in the 1997 value of this commodity, and GDP of a country is measured in its real value of GDP. They are constructed in real terms, because only in real terms do imports show clear responses to changes in demand, supply, and price.

There are two conditions that influence the choice of forecasting approach. One is the scale of the forecast, and the other is the reality of international trade conditions. The set of real world of international trade conditions includes economic resource constraints, heterogeneous import behavior, and overall supply and demand equilibrium.

In forecasting practice, the prevailing forecast approaches are a bottom-up approach, a top-down approach, and sometimes a hybrid approach. However, neither of the first two alone is suitable under WTS long-term forecast conditions. The bottom-up approach requires that the individual commodity trades to be forecast are not subject to total resource constraints or overall equilibrium. However, there are resource constraints in international trade. For example, a country's imports are subject to its income constraint. There is also overall equilibrium in international trade in the long run. For example, no country can export more than what other countries are willing to import from it. The top-down approach requires that individual items to be forecast have identical dynamic patterns. Since it is difficult to show that a country's imports of a commodity from two different countries have the same dynamic pattern, this approach alone is not appropriate either in the long run. To overcome the shortcomings of using the bottom-up or top-down approaches alone, some modelers forecast individual series and their aggregates simultaneously and then manually reconcile the difference between the sum of individual forecasts and the aggregate forecast. This is called a hybrid approach. Unfortunately, the manual reconciliation is very time consuming, so it cannot apply to forecasts such as the WTS, which include more than a quarter million series.

The World Trade Service forecast uses a modified top-down approach where the forecasts are controlled. To implement this approach, detailed trade flows are aggregated to the top three levels. The detailed trade flows are labeled Level 4, the lowest level, Level 3, Level 2, and Level 1.The following structure illustrates how they are aggregated:

Level 1

L1: World trade of total commodities,
$1\times1 = 1$ series.

Level 2

L2M: Total commodities that each country/region imports from the world,
$1\times70 = 70$ series.
L2X: Total commodities that each country/region exports to the world,
$1\times70 = 70$ series.
L2C: World trade by commodity,
$77\times1 = 77$ series.

Level 3

L3M: Commodities that each country/region imports from the world,
$77\times70 = 5{,}390$ series maximum.
L3X: Commodities that each country/region exports to the world,
$77\times70 = 5{,}390$ series maximum.

Level 4

L4: Commodities traded between each pair of countries/regions,
$77\times70\times(70-1) = 371{,}910$ series maximum.

In this hierarchical structure, each series in L2C, L3M, L3X, and L4 levels has its own behavioral equation in the model structure.. In the modified top-down forecasting approach, each series is forecast by its own behavioral equation, but the forecast of individual items at the lower level are controlled by the forecast of their aggregate at the higher level. The forecasting program detects the difference between the sum of lower level forecasts and the aggregate higher level forecast, identifies at the lower level individual items that cause the differences, and adjusts the forecast of them accordingly. The identification and adjustment are based on the historical, dynamic relationship between each individual item and the aggregate. Such an adjustment must be non-linear and gradual, thus it requires iteration until no adjustment can reduce the discrepancy further. This process runs through series by series and observation by observation. Only when the forecasts at each point in time complete this process does the forecast move on to the next period. The model design guarantees that the dynamic direction or turning point forecast by the behavioral models will not be altered by the adjustments. With such a design, the top-down-controlled forecast adheres to the reality that international trade is subject to economic resource constraints, has heterogeneous behavior, and will attain overall supply and demand equilibrium.

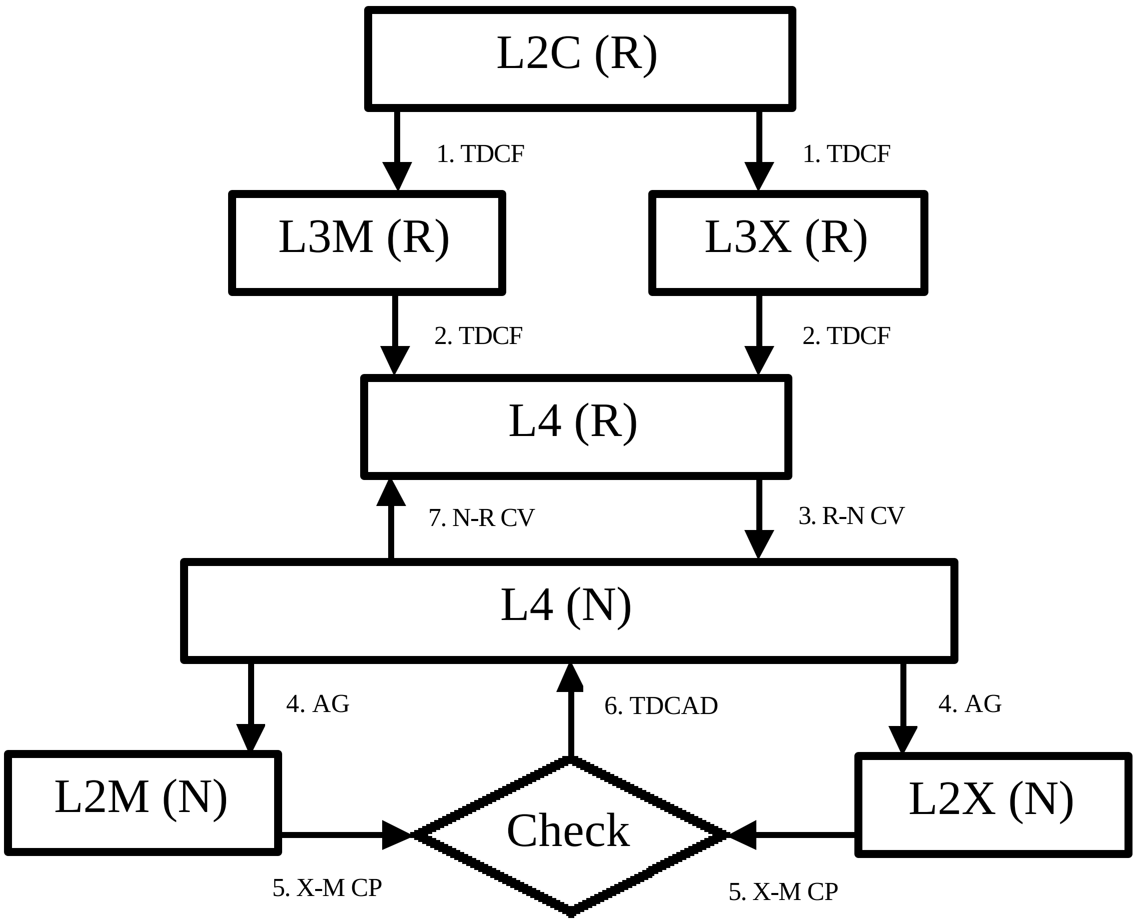
DRI-WEFA's WTS forecast approach determines the forecasting process, as shown by the flowchart that follows. The numbers in the flowchart indicate the sequence of the forecasting. The forecast starts from L2C. These are the top-level forecasts. These are then used to do top-down-controlled forecasting of L3M and L3X and, in turn use L3M and L3X to do top-down-controlled forecasting of L4. All of the variables are all forecast in real commodity value.

After obtaining the detailed forecasts of global trade in real commodity value, to validate the forecast, a check is performed to determine whether the overall forecast implies a trade balance for every country/region consistent with the current environment and with future expectations. Trade balance is a financial concept that needs to be examined in nominal, not real, value terms. Real value of level L4 is converted into nominal value at level L4 and then aggregated to import and export by country/region, i.e., L2M and L2X in nominal value. Though the commodity forecast output does not include service sectors, the development of services trade for each country/region is considered when examining the trade balance between L2M and L2X. If the long-run forecasted trade balance for a country/region is determined to be unsustainable, L2M or L2X, or both, is adjusted and then used to do a modified top-down adjustment of the nominal L4 detailed trade. Because the trade of these countries/regions link to each other, adjusting the trade balance of one country/region affects the trade balance of other country/regions. Therefore, great care is taken to observe each impact of any alteration made.

The forecasting model flow chart offers a visual representation of this process.

DRI· WEFA World Trade Service Forecasting

Model Process Flow Chart



L1 – World trade of total commodities
L2M – Total commodities that each country/region imports from the world
L2X – Total commodities that each country/region exports to the world
L2C – World trade by commodity
L3M: Commodities that each country/region imports from the world
L3X: Commodities that each country/region exports to the world
L4: Commodities traded between each pair of countries/regions
R – real commodity value
N – nominal value

TDCF – top-down-controlled forecast

R-N CV – Real-nominal value conversion
AG – aggregation
X-M CP – export-import balance comparison

TDCAD – top-down-controlled adjustment
N-R CV – nominal-real value conversion

After obtaining the final forecasts of global trade in real commodity value for each of the 77 commodities across the full spectrum of routes (70x70 origins and destinations), DRI-WEFA then use the latest volume figures available from the United Nations to establish values for the last year of historical data. The UN data are converted into the same commodity classifications used in deriving the real values. This then uses the growth rates of the real values, by commodity, to project to volumes, using the UN base year data. This approach, while detailed, provides the best forecast because it automatically incorporates the top-down derived fluctuations that may be foreseen in the various macroeconomic country forecasts that drive the overall structure of the World Trade Service model. Also, it is possible to split the tonnage figures into modes, as shown in Table 3. These are the final forecast concepts that are provided to customers for their use in operations and strategic and policy planning.

Finally, the forecast is validated following procedures to confirm the performance of the model. These validation procedures include comparisons to both internal and external sources. To measure the success of U.S.-specific container and commodity trade estimates, the World Trade Service (WTS) uses current Journal of Commerce Port Import Export Reporting Service (PIERS) data through side-by-side, country-by-country comparisons. Additionally, for each of the 18 forecasted series, the new trade forecast is compared to the forecast produced in the previous period at a more detailed level, commodity by commodity across trading partners. Lastly, the WTS forecast is regularly compared against proprietary shipping data provided to us from our subscribing customers, which include steamship lines, airlines, and international ports. To ensure that the forecast produced is consistent and of high quality, this process continues from forecast to forecast.

Table 1. World Trade Service Forecasting Commodity Coverage

Count	***ISIC***	***Definition***
1	1A	Grain
2	1B	Oil Seeds
3	1C	Vegetables, Fruits and Eggs - req Refrigeration
4	1D	Vegetables and Fruits - non-Refrigerated
5	1E	Cork and Wood
6	1F	Natural Rubber
7	1G	Cotton
8	1H	Other Raw Textile Materials
9	1I	Other Agriculture
10	2A	Stone, Clay and Other Crude Minerals
11	2B	Crude Fertilizers
12	2C	Ores and Scrap
13	2D	Coal
14	2E	Crude Petroleum
15	2F	Natural Gas
16	2G	Scrap
17	311A	Meat/Dairy/Fish Requiring Refrigeration
18	311B	Other Meat/Dairy/Fish/Fruit/Vegetables
19	311C	Sugar
20	311D	Animal Feed
21	311E	Animal and Vegetable Oils
22	311F	Other Food
23	313	Beverages
24	314	Tobacco
25	321	Textiles
26	322	Wearing Apparel
27	323	Leather and Products
28	324	Footwear
29	331	Wood Products
30	332	Furniture and Fixtures
31	341A	Waste Paper
32	341B	Pulp
33	341C	Paper and Paperboard and Products
34	342	Printing and Publishing
35	3511A	Organic Chemicals
36	3511B	Inorganic Chemicals
37	3512	Fertilizers and Pesticides
38	3513	Synthetic Resins
39	3521	Paints, Varnishes and Lacquers
40	3522	Drugs and Medicines

41	3523	Soap and Cleaning Preparations
42	3529	Chemical Products, nec.
43	353	Petroleum Refineries
44	354A	Briquettes and Coke
45	354B	Residual Petroleum Products
46	355	Rubber Products
47	356	Plastic Products, nec.
48	361	Pottery, China etc.
49	362	Glass and Products
50	369	Non-Metallic Products, nec.
51	371	Iron and Steel
52	372	Non-Ferrous Metals
53	381	Metal Products
54	3821	Engines and Turbines
55	3822	Agricultural Machinery
56	3823	Metal and Wood Working Machinery
57	3824	Special Industrial Machinery
58	3825	Office and Computing Machinery
59	3829	Machinery and Equipment, nec.
60	3831	Electrical Industrial Machinery
61	3832A	Radio and TV
62	3832B	Semi-conductors, Electronic Tubes, etc.
63	3832C	Other Communications Equipment
64	3833	Electrical Appliances and Houseware
65	3839	Electrical Apparatus, nec.
66	3841	Shipbuilding and Repairing
67	3842	Railroad Equipment
68	3843A	Motor Vehicles
69	3843B	Parts of Motor Vehicles
70	3844	Motorcycles and Bicycles
71	3845	Aircraft
72	3849	Transport Equipment, nec.
73	3851	Professional Equipment
74	3852	Photographic and Optical Goods
75	3853	Watches and Clocks
76	390	Other Manufacturing, nes.
77	399	Goods not classified by kind

Table 2. World Trade Service Forecasting Country/region Coverage

54 Major Countries		Count	Country Name
Count	Country Name	41	Pakistan
1	United States	42	Venezuela
2	Canada	43	Brazil
3	Japan	44	Argentina
4	Germany	45	Colombia
5	France	46	Peru
6	United Kingdom	47	Chile
7	Italy	48	Mexico
8	Austria	49	Israel
9	Belgium	50	Saudi Arabia
10	Denmark	51	United Arab Emirates
11	Finland	52	Egypt
12	Greece	53	Kenya
13	Ireland	54	South Africa
14	Netherlands		
15	Norway	***16 Other Regions***	
16	Portugal	Count	Region Name
17	Spain	55	Other Western Europe
18	Sweden	56	Baltic
19	Switzerland	57	CIS West
20	Turkey	58	CIS Southeast
21	Russia	59	Other Indian Subcontinent
22	Poland	60	Other East Coast of South America
23	Czech Republic	61	Other West Coast of South America
24	Slovak Republic	62	Caribbean Basin
25	Hungary	63	Other Central America
26	Romania	64	Other Persian Gulf
27	Bulgaria	65	Other Mediterranean Region
28	Australia	66	Other North Africa
29	New Zealand	67	Other East Africa
30	China	68	Western Africa
31	Taiwan	69	Other South Africa
32	Hong Kong	70	Other Region
33	South Korea		
34	Indonesia		
35	Philippines		
36	Singapore		
37	Malaysia		
38	Thailand		
39	Vietnam		
40	India		

Table 3. World Trade Service Forecasting Concept Coverage

	Concept Name
1	Nominal Value
2	Real Value
3	Airborne Nominal Value
4	Seaborne Nominal Value
5	Airborne Real Value
6	Seaborne Real Value
7	Airborne Metric Tons
8	Seaborne Metric Tons
9	Liquid Bulk (Tanker) Metric Tons
10	Dry Bulk (Tramp) Metric Tons
11	General Cargo/Neobulk Metric Tons
12	Container Metric Tons
13	Number of 20 foot containers
14	Number of 40 foot containers
15	20 foot container equivalent units
16	Over Land/Other Transportation nominal value
17	Over Land/Other Transportation Metric Tons
18	All Transportation Mode Metric Tons

APPENDIX C: WORLD ENERGY MARKETS

Consumption Fundamentals: The economic recovery in the U.S. is expected to eventually spread to Europe and Asia, but ongoing problems in Latin America will prevent that region from fully participating in the broader recovery.

With the global economy expected to return to trend growth over the next five years, demand for oil over the medium and long term is expected to be on a fairly steady 2% per year growth path. Nearly half of all oil consumption is expected in the transportation sector. Rising rates of motorization in developing countries are being balanced by stagnant vehicle densities in developed countries. Some developing countries, such as China, are re-thinking their plans for transport infrastructure investments as a result of today's financial difficulties. Where possible, electricity and natural gas are preferred for their greater efficiencies in end-use applications. Moreover, natural gas is a cleaner fuel than is oil. Although electricity generated by coal plants has higher levels of emissions than oil plants, coal is much cheaper to use in base load applications. Furthermore, some of the larger developing nations, mainly China and India, have much larger indigenous resource base of coal than of oil. The combination of the foregoing factors should combine to restrict oil demand growth to about 2% per year over the long-term forecast horizon that terminates in 2020. Long-run oil demand will be more dependent on economic growth and environmental policies than on oil prices. The high oil prices of the 1970s and early 1980s spurred technological advances in oil exploration, in alternative fuel development, and in fuel-using equipment that have kept the long-term price path for oil in check.

The developing regions of Latin America, Middle East, Africa, and Asia/Pacific are expected to register the largest economic growth rates over the forecast interval. Oil demand in the Asia/Pacific region is expected to increase by 2.7% annually, raising Asia to the largest oil-consuming region, and accounting for 31% of world demand by 2020. In Latin America, demand is projected to grow by 3.8% annually, reaching a consumption level 14.6 million barrels per day (b/d) by 2020. Demand from the Africa/Middle East region is expected to grow by about three percent over the forecast interval, raising consumption to near 13 million b/d by 2020. The developed regions of North America and Western Europe should post combined growth of approximately one percent through 2020, as demand moves from 36.5 million b/d to 46 million b/d.

The share of oil in world energy demand should remain fairly constant at about 37% through 2020. Natural gas and solid fuels should gain shares in our forecast while hydro and nuclear power are expected to lose shares along with non-commercial fuels. Integrated gasification combined cycle turbines are probably the single largest reason why oil is likely to lag natural gas in consumption growth rates. The efficiency of gas in electricity generation is projected to outweigh its higher fuel cost when compared with oil. Furthermore, the greater availability of low-cost electricity should improve the penetration of electricity in stationary, end-use, sectors around the world. In the developed world, there is almost no market for oil in space conditioning new residential and commercial construction.

Supply Fundamentals: DRI· WEFA expects the OPEC cartel to eventually raise quotas recognizing the need for more oil. Even if quotas are not raised, cheating will likely increase in the face of relatively strong crude prices and rising non-OPEC production.

In the medium-term, the outlook for non-OPEC production growth has been elevated, with total non-OPEC output moving above 48 million b/d in 2005. The sustained high state of oil prices in 2001 and the expected strength in prices this year should spur exploration and production efforts, yielding fruition over the next 2 to 4 years. OPEC's production, boosted particularly by Iraq's output, should also rise over the medium term, to a total crude output of more than 33 million b/d.

Iraq's oil production is expected to grow at a faster rate than the rest of the cartel's members, putting its output on par with Iran's by 2015. Currently at 41%, the share of OPEC output of global production will continue to gain, picking up nearly 4 percentage points to 45% by 2020. To meet the projected rise in long-term demand, OPEC's output is forecast to rise by 16 million b/d from 2005 to 2020, with non-OPEC production increasing by 14 million b/d over the same period. Growth in non-OPEC production over this period growth will come primarily from Russia, Mexico, Brazil, Columbia, and Azerbaijan and Kazakhstan in the Caspian region.

US Energy Market

The nature and performance of the US petroleum market over the medium to long term forecast horizon will be guided by several economic, demographic, and regulatory factors impinging on the US energy market.

Economic Recovery Is Underway: In terms of economic activity, the 2001-02 recession has been a relatively shallow one. Over the longer term, we expect demographic forces to slow the pace of real economic growth. Although total population growth is expected to slow only slightly, growth in the available work force will decelerate more markedly, while retiring baby boomers constitute a rising share of the population. Slower work force expansion, offset only partially by productivity gains, will reduce the growth potential for GDP. Real GDP growth over the medium term through 2020 should average 3.0% per year, just slightly below the average for the past 20 years.

Key Drivers of Energy Demand Will Lag GDP Growth: Increases in energy demand are more closely tied to specific segments of the economy than to broad-based economic growth indicators. Many of the key drivers indicate a considerably slower long-term pace for energy demand than GDP growth. The traditional heavy industries, which are more intensive energy consumers, will generally experience below-average gains, stemming from slower demand or the expansion of those industries overseas where production costs are lower. Population's slow expansion—averaging only 0.8%—will also restrain energy demand growth. Population is influential in the size of the housing and motor-vehicle stocks, which are expected to average 1.2% and 1.6% increases, respectively. Real personal income growth should offset just some of the effects of slow population gains, with real per capita personal income growth of 2.1% explaining in part the somewhat faster advances in housing and vehicle stocks compared with that of population.

Population Shifts Will Affect Regional Patterns: The regional population shifts that have occurred in the past several years are expected to continue to varying degrees over the longer-term horizon. The Northeast and Midwest will see weak growth, ranging from 0.2% to 0.5%, while population gains in several southern and western regions should exceed 1%. The Mountain regions will average around 2% growth. These regional patterns will drive regional variations in growth for housing, motor vehicles, building construction, and other key drivers of energy demand.

Inflation Should Be Moderate: Inflation, as measured by the GDP deflator, is expected to average a moderate 2.6%, rising gradually from even lower rates to 3.6% by 2020.

The Potential for Higher Fuel Economy: There is new legislation on fuel economy that includes a tightening of the federal corporate average fuel economy (CAFE) for light duty vehicles. Currently, new car fleets must average 27.5 miles per gallon while new light trucks have a lower limit of 20.7 mpg. The standards were enacted years ago before the popularity of mini-vans and sport/utility vehicles, which are used more as personal vehicles than as trucks, despite their light-truck classification. One proposal would apply a combined 35-mpg standard to cars and light trucks. Another proposal has little change to CAFE. It is not clear what proposal, if any, will win a majority in the Congress. The motor-vehicle industry complains those high standards would force discontinuation of some lines of popular vehicles. The President has not made any specific proposal, but has requested a study of the issue. With this issue still far from consensus, our long-term demand projections incorporate only the amount of mpg improvement that could be expected to evolve naturally as technology advances.

Drilling in ANWR Not Assumed for Now: There have been recent efforts by the President to allow oil and gas drilling in the Coastal Plain section of Alaska's Arctic National Wildlife Refuge (ANWR), an area considered environmentally sensitive but potentially rich in oil. Chances of this passing Congress are small. The forecast does not assume ANWR drilling will be permitted.

New Emissions Caps Are Proposed: President Bush has proposed legislation that would establish new nationwide caps on emissions from sulfur dioxide, nitrogen oxide, and mercury. Market-based emission allowance trading would help facilitate achieving these targets. These caps appear to be incremental to existing Clean Air Act measures, though. The proposed ceilings would be phased down, with the final limits put into place by2018. The outcome of new proposals on Clean Air is not clear other than the existing controls with not be relaxed.

Policy to Cut Greenhouse Gas Emissions Is Not on the Horizon: Supporters of global warming mitigation policy, already disappointed by the U.S. refusal to participate in the international Kyoto treaty, were further frustrated by the greenhouse gas measures in the president's emissions legislation. President Bush is asking energy consumers to voluntarily reduce greenhouse gas emissions per dollar of GDP by 18% over the next ten years. Opponents argue that voluntary programs of this sort achieve little; meanwhile total emissions would continue to increase. Indeed, in both their latest energy projections, DRI-WEFA and the Department of Energy expect nearly this much reduction in the ratio to be achieved simply through the continued reduction in energy consumption per GDP dollar.

Electricity Market Issues Are Being Addressed on Several Fronts: The Federal Energy Regulatory Commission (FERC) took the lead over the past several years in opening electricity markets up to competition and in attempting to handle issues arising from this transformation. FERC is now focusing on market design and transmission issues. Particularly in view of the breakup of formerly integrated utilities, FERC believes that integrated regional transmission operators are necessary in order to ensure reliability. Both FERC and Congress are seeking ways to ensure further necessary development of the nation's transmission network so as to remove bottlenecks and keep up with expected generating capacity expansion.

Retail regulation is still squarely in the purview of the states, though. As such, several states are proceeding with retail restructuring, including retail choice of providers and in some cases mandatory divestiture of generating assets by utilities. Results have been mixed, but none as dramatic as in California. Other states, nervous about the possibility of more volatile electricity rates, are now hesitating.

DRI-WEFA Includes Most-Likely Policies: Because there is no clear indication what significant energy or environmental policy changes, if any, will emerge from Washington, the long-term energy outlook is based largely on energy laws and regulations that have already been enacted. Though changes are possible, it would be risky to incorporate them in the projections until their exact timing and dimensions are known. All fully implemented Clean Air Act regulations are incorporated into the forecasts. CAFE standards are set at current levels, although some mpg improvement is expected in the absence of any new standards. Also assumed is that renewable portfolio standards and other "green" energy mandates applying to electricity suppliers only where states have enacted them. Appliance efficiency standards should improve in some cases by this assumption, given that existing federal law grants regulators the authority to revise standards as appropriate.

Policy, Price, and Industrial Trends Are Important to Future Energy Demand Growth: Appliances, motor vehicles, equipment, and buildings are expected to be more energy-efficient in the future, while the role of energy-intensive industries in overall economic growth should continue to shrink. These developments should partially offset the impacts of rising population and output, and limit energy demand growth to less than one-half the rate of general economic growth. Even so, total primary energy consumption is projected to expand by more than one-fourth by 2020. Roughly 25 quadrillion Btu of additional energy supplies will be called for—not including the additional supply needed to offset the depletion of existing producing properties.

Strong real growth in per-capita personal income will be a key reason behind the upward in trend in energy consumption per person. Per-capita energy consumption growth should remain strong in the transportation sector, led by fuel use in passenger vehicles. With no real growth in gasoline prices projected, achieving more than the modest projected improvement in miles per gallon for motor vehicles would require an act of Congress. Meanwhile, continued efficiency improvements in buildings and appliances should result from federal standards and technology advancement.

US Oil Import Forecasts

Without CAFE Tightening, Higher Import Dependence Is Expected: Oil demand in the United States, although advancing somewhat more slowly than natural gas, is expected to have the biggest absolute increase by 2020. Most of this increase will come from the transportation sector, about half of it from cars and light trucks, which include vans and sport/utility vehicles. Driven by the rise in motor vehicle fuels, our dependence on imported oil will increase from just over half today to about two-thirds of total oil requirements by 2020. Proponents of increasing the federal corporate average fuel economy (CAFE) standards for cars and light trucks have not been successful so far, but improvements in fleet fuel economy from alternative fuel vehicles will continue over the long term.

Energy Demand in the Middle Atlantic Region

Energy demand in the Middle Atlantic Region will be determined by several end-use energy demand needs, with the transportation sector and the demand for light products accounting for the biggest share of demand needs over the forecast horizon. The end-market demands in turn depend on economic, climatic, and demographic factors.

Demographics: A cool climate and high cost of living will sustain the out-migration to other regions, holding population growth in the Middle Atlantic region to just 0.2% through 2020. The Middle Atlantic population growth will be the slowest in the nation.

Total Final Energy Demand: With housing, motor vehicle, and commercial floor space trends either directly or indirectly linked to population, end-use energy demand increases are expected to be among the slowest in the nation.

Residential: Slow expansion in housing stock will restrain residential housing demand growth. The high heating requirement in this cool region will also contribute to slow total demand growth in this sector. Because heating is a saturated use and there are good prospects for efficiency improvements, heating will face a weaker growth relative to the other residential energy uses. Thus oil, which is traditionally one of the most important home heating sources in the Northeast, is expected to lose share.

Commercial: With slow population gains and high costs limiting expansion of commercial floor space, energy demand growth rates in the commercial sector are expected to be the lowest in the nation.

Industrial: The outlook for growth in the industrial sector's energy demand in the Middle Atlantic Region is weak, because the region has a high concentration of traditional heavy industries. Together with high business costs and slow growth in the available work force, a projected decline in the number of energy-intensive heavy industries will limit industrial output and energy demand in the Mid-Atlantic.

Transportation: Slow population growth will restrain increases in both motor-vehicle ownership and the demand for travel. As a result, on-road consumption of gasoline in the Middle Atlantic Region will be slower than in the other regions.

Power Generation: New power plant construction is taking place in the North East, including the Middle Atlantic region. Deregulation and high electricity rates have created a flurry of new construction. Most of the new plants are gas-fired, and thus will be accompanied by a sizable expansion of gas delivery infrastructure into this traditionally gas-short region. Like New England, the Middle Atlantic Region has a large base of aging oil- and gas-fueled boilers that will be replaced eventually with more efficient gas-fired combined-cycle units in base load operations. Coal will fuel some new generating plants, but most of the additions will merely replace the aging coal-fired plants to be retired. Installing new coal plants in the Northeast is particularly difficult because congested population centers and unfavorable climate conditions have led to fairly strict environmental controls. Nuclear generation has an above-average share of the Northeast's power generation plants and several plants are expected to be retired during the forecast period. Renewable energy should make modest inroads in the region as some states have enacted renewable energy mandates.

Overall, demand for energy products, particularly light products such as gasoline, jet fuel, and distillates, are projected to grow in the Middle Atlantic Region over the long-term forecast horizon.

Oil Refining Activity in the Philadelphia Region

The end-market demands will be satisfied by the supply of energy products to the region from a variety of sources, such as imports, inter-regional flows, and production in the Middle Atlantic Region.

According to EIA Petroleum Supply Monthly, there are significant differences between different parts of the United States in terms of their involvement in and dependence on international trade. Most of these differences are the direct result of the uneven distribution of both production and refining activities across the United States. The East Coast imports over half of all the products that come to the United States, because it is the largest consuming area in the United States. But, for historical reasons, it has only enough capacity to meet around 1/3 of those needs from its own refining. It fills the product gap with supplies from other parts of the United States, particularly the Gulf Coast, and with imports. Its limited volume of refining capacity also keeps it a distant third as a crude importer. Nonetheless, because its local crude oil production is so insignificant, its crude import dependency is the highest of all, at almost 100 percent. The Gulf Coast is the only other region that imports significant amounts of products. Unlike the East Coast, though, its focus is not on imported products that could be supplied directly to the consumer. Its imports are mainly refinery feedstocks and blendstocks to support its role as the main U.S. refining and petrochemical center. In this capacity, the Gulf Coast is also by far the most important crude oil importing region in the United States, accounting for nearly two-thirds of the total.

Together with the Midwest, the East Coast accounts for 90 percent of the inter-regional flow, or the flow between Petroleum Administration for Defense Districts (PADD). The Gulf Coast is by far the largest supplier, accounting for more than 80% of the inter-PADD flow. The easy flow of petroleum from the Gulf Coast (PADD3) to the Midwest (PADD2) and the East Coast (PADD1) means that incremental supply is more readily available to these markets in the event of a demand surge or supply drop.

Thus pipeline and barge movements of light products are critical to the regional supply dynamics. The East Coast is most dependent on distant production. Over half of its light product needs comes by pipeline or barge. But of that product moving from other PADD's, almost 80% comes by pipeline. The future need for inter-PADD product flows and imports will depend on how each PADD demand is growing relative to its own refinery capacity.

Demand for light products are expected to grow in all regions of the United States by about 1.8% per year, following the typical long-term demand trends. But regionally, growth will vary, with the absolute volume growths conditioned by demand for gasoline and diesel in PADD1. The expected increases in East Coast consumption over the forecast period will be satisfied by the Philadelphia and other East Coast refineries plus importers and inter-PADD flows.

Therefore, the limit to how much crude imports will flow to the Philadelphia area refineries will be the effective capacity of these refineries assuming a 100% utilization rate. The projected effective capacity in turn depends on the outlook for additional capacity additions, refinery shutdowns, and technological improvement in refinery capacity utilization over the forecast period.

DRI-WEFA does not expect any additions of refinery capacity in the East Coast over the forecast period. Over the last 10 years no new refineries have been built despite the rising demand for petroleum products. The reason for this is twofold. The primary explanation lies in environmental regulations, which make it infeasible to build new refineries in the East Coast with its high population density. Secondly, there are alternative sources of cheap supply via imports and inter-PADD pipeline flows. In the Mid West, there have been a large number of refinery shutdowns as additional pipelines come into existence.

For instance, with the recent opening of the Centennial Pipeline and the expansion of the Explorer, a number of shutdowns followed in the Midwest. According to EIA Petroleum Supply Monthly, Premcor closed the 80 thousand barrel per day (MB/D) Blue Island refinery, and announced the sale or closure of the 64 MB/D Hartford refinery. The closure of the Hartford refinery may very well have been influenced by the Centennial's startup. Nonetheless, DRI-WEFA does not expect any shutdowns in the East Coast. Thus the East Coast capacity and capacity in the Philadelphia region will remain little changed over the forecast period. The only additions to capacity will be due to technical and operational improvements to the existing refineries. Table 1 below summarizes refinery capacity and average utilization for the Delaware River refineries.

Table 1. Delaware River Refineries – Capacity Utilization Rate

Processing Company Processing Facility City	**Crude Oil Received** 1999 (bbl/day)	**Crude Oil Received** 2000 (bbl/day)	**Crude Oil Received** 2001 (bbl/day)	**Capacity Jan, 2000** (bbl/day)
Coastal Eagle Point Westville, NJ	127,825	140,049	119,090	143,000
Valero Refining Paulsboro, NJ	153,614	154,386	149,047	155,000
Sunoco Markus Hook & Philadelphia, PA	477,877	470,170	463,603	505,000
Tosco Refining Trainer, PA	164,405	174,858	140,537	180,000
Motiva Enterprises Delaware City, DE	158,956	145,142	159,334	157,000
Citgo Asphalt Refining Paulsboro, NJ	41,641	47,395	42,348	40,000
Delaware River Refineries	1,124,318	1,132,000	1,073,959	1,180,000
Three-Year Average Crude Oil Received				1,110,092
Three-Year Average Utilization Rate				94.1%

With demand growth for light products expected to be moderately strong in the region, capacity utilization should be very high over the forecast period, possibly approaching 100%. DRI-WEFA expects crude oil imports to grow, but limited by refinery capacity, over the forecast period. Marginal improvement in refinery utilization technology will raise the overall effective capacity of the Delaware River refineries above its current actual capacity of 1,180,000 bbl/day, thus allowing for a slightly higher volume of imported crude over the forecast period.

World Steel Market

In 2002, the United States implemented tariffs on steel under Section 201 safeguard provisions. The action has enraged trading partners leading to retaliatory tariffs against U.S. producers' exports. More importantly, the action has altered international flows of steel and disrupted production worldwide.

The U.S. tariffs vary by product, with a maximum of 30% for flat products and carbon bar. These fall to 24% in 2003 and to 18% in 2004. A second group of products, including rebar and some stainless grades face tariffs that start at 15% and fall to 9% by 2004. Stainless wire faces an 8% tariff for all three years, while several products important to the auto industry escape tariffs altogether. NAFTA partners Mexico and Canada face no restrictions. Some countries are hit only partially, while others, most notably Japan, Korea, and the European Union, face the full impact.

The U.S. action has caused reaction in many parts of the globe. Western Europe, Mexico, and Canada all fear that steel destined for the U.S. will be diverted to them, and are thus considering safeguard tariffs as well. The European Union has joined with Korea and Japan in filing formal complaints with the WTO, contending that the legal foundation for the U.S. action was flawed, because safeguard measures are only allowed when imports are rising, whereas U.S. imports had been fallen since 1998. The U.S. counters that the period since the Asian crisis is the appropriate interval.

The effects of the U.S. action will be dramatic. The world has too much steel making capacity, and in recent years the U.S. has been the destination of choice for much of the excess steel. With the U.S. market for imports limited, exporting nations will initially look to divert steel to other strong nations. But with the European Union, Canada, and Mexico contemplating their own safeguard measures, soon there will be fewer customers for the excess.

As the tariffs shrink in 2003 and 2004, though, more imports will return to the United States, speeded by the price differential between steel in NAFTA and EU countries with limited imports and the rest of the world with depressed prices.

United States Steel Industry Outlook

The imposition of the tariffs in 2002, in addition to other economic recovery factors, has improved the situation for U.S. steel producers. There has been relief under Section 201, older mills with obsolete technology are being shut down for competitive reasons, capacity utilization is climbing, and shipments to end markets are beginning to firm.

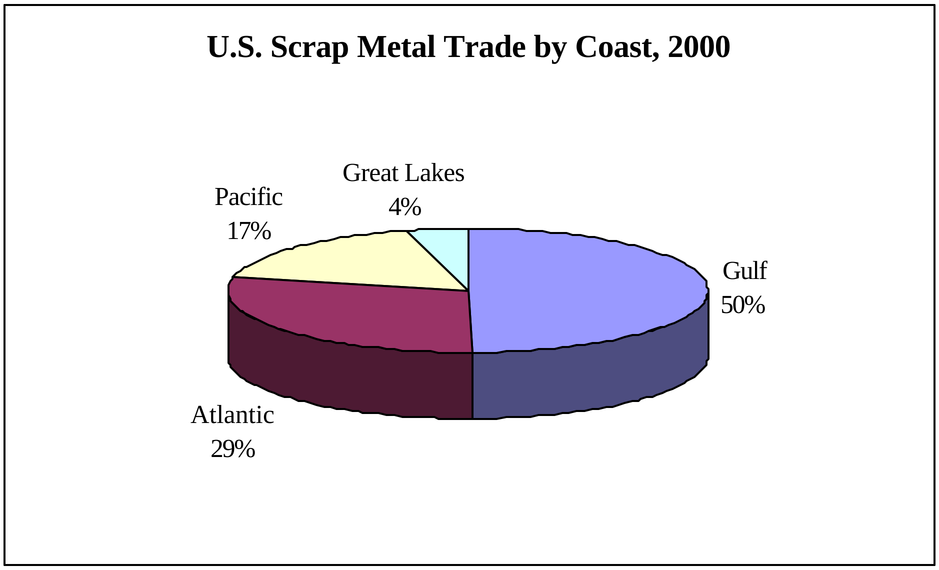
The return of trend economic growth of about three percent per year over the next 25 years in the United States should boost manufacturing production in the long run. Thus, buoyed by capacity constraints in domestic finished steel production and rising demand, U.S. import tonnage will increase in the long run, despite the tariffs. By 2011, imported steel—finished products and for conversion—should be about 1.9% above their 1998 levels.

Exports, which have plunged from their 1999 levels, will recover by the end of 2002 following the expected recovery of the global economy. Thereafter, exports of finished steel products should grow returning to about 1.2% above their 1999 levels by 2011. However, the United States is traditionally a net importer of finished steel, and domestic demand for finished steel and cheaper foreign supplies will not allow for significant growth of U.S. finished steel products in overseas markets.

United States Exports of Ferrous Scrap To Turkey

In 2000, 29% of U.S. trade in scrap, over 350 million metric tons, came through ports along the U.S. Atlantic Coast. Of this, nearly 60 million tons, or 17.5% of all Atlantic traffic sailed into or out of the ports of the Delaware River system.

U.S. scrap prices are recovering. With the closure of U.S. integrated steel mills such as LTV, electric mills are running at a high percent of capacity, increasing scrap demand in the United States. Adding significantly to U.S. scrap demand, though, is demand from overseas markets, including Turkey.



Turkey once had been a key outlet for many U.S. scrap yards but in recent years had come to rely more heavily on supplies of ferrous scrap from the former Soviet Union, especially Russia and Ukraine. The demise of the former Soviet Union made many factories, cars, and industrial equipment obsolete, turning the steel goods in these items into steel scrap and a bonanza for Eastern European scrap exporters. With the proximity of Russia and Ukraine to Turkey and ferrous scrap being a world commodity, transportation cost considerations alone caused U.S. exports of scrap to Turkey to become uncompetitive.

But the flow of scrap from Russia and Ukraine to Turkey has declined steadily since 2001 due to stronger demand and higher prices for scrap in their domestic markets. Significant taxes on scrap exports have been imposed, contributing to the flow decline. As a result the U.S. export market for scrap in Turkey is beginning to recover.

Over the medium to longer term, DRI-WEFA expects U.S. exports to Turkey to return to the strength seen before the supply boom from Russia and Ukraine, as the scrap flow from theses countries slows significantly following the continuing depletion in their stocks of obsolete steel.