SEATTLE HARBOR NAVIGATION IMPROVEMENT PROJECT SEATTLE, WASHINGTON

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

AUGUST 2016

US Army Corps of Engineers®
Seattle District

Port of Seattle®

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Executive Summary

This integrated feasibility report and environmental assessment presents the results of a U.S. Army Corps of Engineers (Corps) Deep Draft Navigation feasibility study undertaken to identify and evaluate alternatives to improve the safety and efficiency of the navigation system in the East and West Waterways of Seattle Harbor, Washington. This study is authorized by Section 216 of the Flood Control Act of 1970 (33 U.S.C. § 426 *et seq.*) as amended. The Corps is undertaking this action in partnership with the Port of Seattle, the study's non-Federal sponsor. This report provides documentation of the plan formulation process to select a recommended navigation improvements plan, along with environmental, engineering, and cost details of the recommended plan, which will allow additional design and construction to proceed following approval of this report.

The federally authorized Seattle Harbor navigation project, consisting of the East, West, and Duwamish Waterways, is located in Puget Sound's Elliott Bay at Seattle, Washington. While the study area includes the East, West, and Duwamish Waterways, the project area for the feasibility study includes only the East and West Waterways (figure below), as they have been identified by the Corps and Port as the areas of critical importance for navigation improvements. The purpose of the proposed Federal action is to achieve transportation cost savings (increased economic efficiencies) at the East and West Waterways of Seattle Harbor. Navigational challenges have been identified in both the East and West Waterways of Seattle Harbor and authorized depths do not meet the draft requirements of today's fleet of larger container ships. Tide restrictions, light loading, or other operational inefficiencies created by inadequate channel depth result in economic inefficiencies that translate into costs for the national economy.

The plan formulation process identified several structural and non-structural measures to improve the safety and efficiency of the navigation system. The following measures were carried forward for alternatives formulation and analysis: channel deepening, channel widening, entrance channel deepening and widening, and disposal (open-water, upland, or beneficial reuse).

An initial array of six alternatives (four alternatives for the East Waterway and two alternatives for the West Waterway) underwent early rounds of qualitative screening. The three alternatives that did not include a wider approach channel reach were screened out from further consideration, as they do not directly address navigation safety considerations in the future without-project condition. Additional evaluation, comparison, and optimization of alternatives assisted the study team in identifying and evaluating the final array of three action alternatives (one alternative in the West Waterway and two alternatives in the East Waterway). Economic evaluation focused on optimizing the alternatives for increasing depth (i.e., up to -57 feet below mean lower low water [MLLW]). Alternatives were evaluated individually by waterway (action in the East Waterway only and action in the West Waterway only), as well as evaluated as a combination of both waterways.

The National Economic Development (NED) Plan is the alternative that reasonably maximizes net NED benefits while remaining consistent with the Federal objective of protecting the environment. The NED Plan is -56 MLLW in both the East and West Waterways. This is the depth where the net benefits are maximized. The quantities of sediment that would need to be dredged to achieve this improvement are approximately 653,000 cubic yards (cy) from the West Waterway and approximately 251,000 cy from the East Waterway. The estimated project first cost of the NED Plan is $64,086,000 (October 2015 price level).

Based on the results of the economic analysis summarized above and in this report, the Port of Seattle requested a Locally Preferred Plan (LPP). The LPP is -57 MLLW in both the East and West Waterways. The quantities of sediment that would need to be dredged to achieve this improvement are up to approximately 777,000 cy from the West Waterway and approximately 341,000 cy from the East Waterway. The estimated project first cost of the LPP is $78,112,000 (October 2015 price level).

The table below summarizes costs and benefits for the NED Plan (-56 MLLW in both waterways) and LPP (-57 MLLW in both waterways) developed for the evaluation of alternatives.

Combined Alternative	Total AAEQ[1] Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio (BCR)
-56 MLLW	$13,722,000	$108,807,000	$95,085,000	--	7.9
-57 MLLW	$14,592,000	$109,592,000	$94,900,000	-$185,000	7.5

[1] AAEQ = Average Annual Equivalent

There are three primary effects from channel deepening that induce changes in the future fleet at Seattle. The first is an increase in a vessel's maximum practicable loading capacity. Channel restrictions limit a vessels capacity by limiting its draft. Deepening the channel reduces this constraint and the vessel's maximum practicable capacity increases towards its design capacity. This increase in vessel capacity results in fewer vessel trips being required to transport the forecasted cargo. The second effect of increased channel depth is the increased reliability of water depth, which encourages the deployment of

larger vessels to Seattle. The third effect is a consequence of the second. The increase in Post-Panamax vessels displaces the less economically efficient Panamax class vessels.

No compensatory mitigation is proposed for the NED Plan or LPP as no loss of wetlands, no significant adverse effects to protected species, and no significant impacts to commercially important species or protected marine mammals are anticipated to occur based on the analyses in this document. Several avoidance and minimization measures are proposed to ensure that impacts are insignificant.

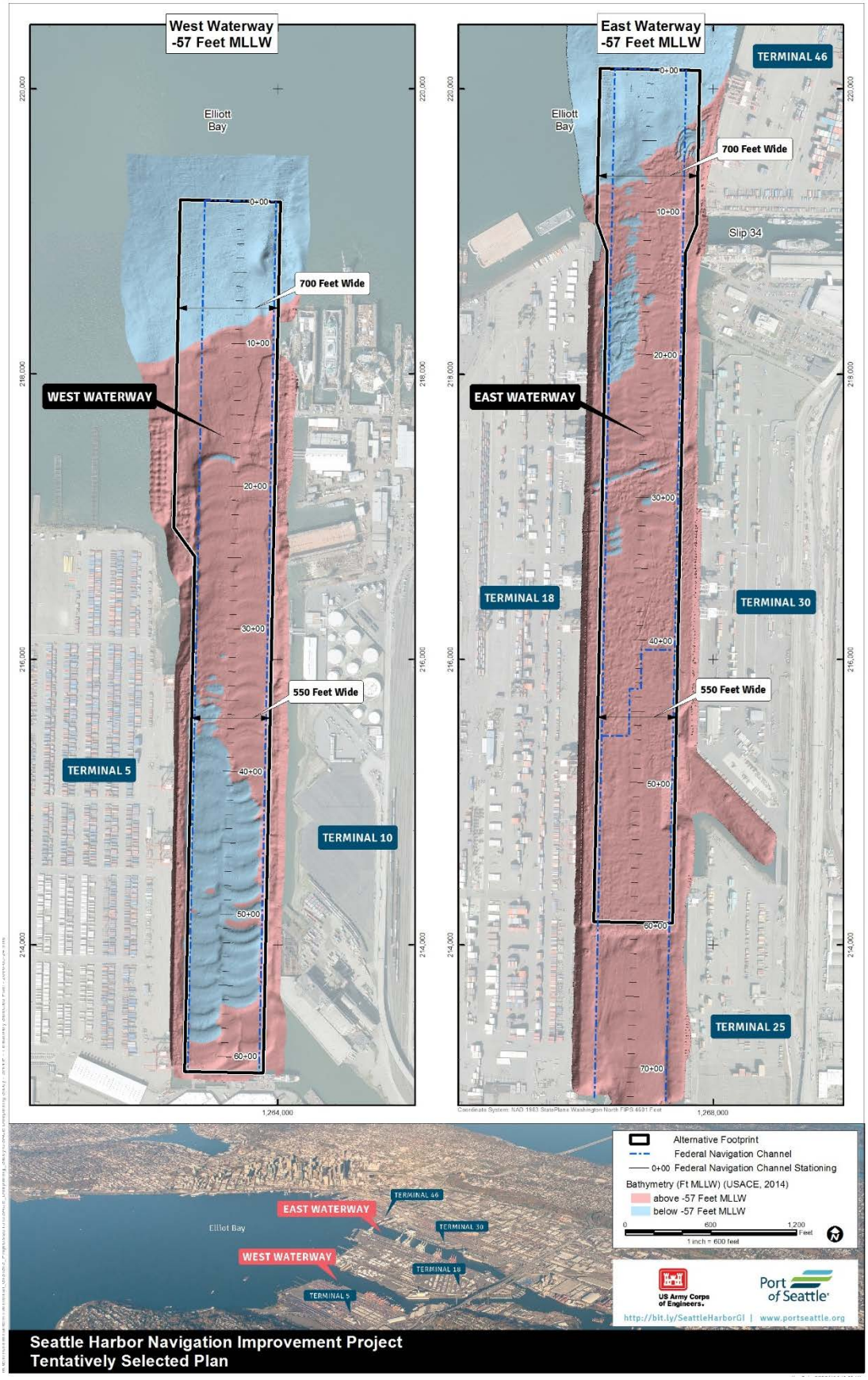

West Waterway
-57 Feet MLLW
East Waterway
-57 Feet MLLW
Elliott Bay
700 Feet Wide
550 Feet Wide
WEST WATERWAY
EAST WATERWAY
TERMINAL 46
TERMINAL 18
TERMINAL 30
TERMINAL 5
TERMINAL 10
TERMINAL 25
Slip 34
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
220,000
218,000
216,000
214,000
1,264,000
1,268,000
Alternative Footprint
Federal Navigation Channel
0+00 Federal Navigation Channel Stationing
Bathymetry (Ft MLLW) (USACE, 2014)
above -57 Feet MLLW
below -57 Feet MLLW
0
600
1,200
Feet
1 inch = 600 feet
US Army Corps of Engineers
Port of Seattle
http://bit.ly/SeattleHarborGI | www.portseattle.org
Seattle Harbor Navigation Improvement Project
Tentatively Selected Plan

Table of Contents

***Sections marked with an asterisk are required content for compliance with the National Environmental Policy Act**

Executive Summary i
1 Introduction 1
1.1 Study Purpose and Scope 1
1.2 Study Authority* 1
1.3 Lead Federal Agency and Non-Federal Sponsor* 1
1.4 Location and Description of the Study Area* 1
1.5 Project Area Overview 3
1.6 Proposal for Federal Action* 8
1.7 Overview of Integrated FR/EA 8
2 Need for and Objectives of Action 9
2.1 Problems and Opportunities 9
2.2 Purpose and Need for Action* 9
2.3 National Objective 9
2.4 Planning Objectives 10
2.5 Planning Constraints 10
2.6 Public Scoping Comments and Resources of Concern* 10
3 Plan Formulation 11
3.1 Management Measures and Screening 11
3.2 Formulation of Alternatives 12
3.3 Evaluation of Alternatives 15
3.4 Final Array of Alternatives 15
3.5 Evaluation and Comparison of Final Array of Alternatives* 19
3.6 Summary of the National Economic Development Plan 23
3.7 Summary of the Locally Preferred Plan (Agency Preferred Alternative)* 23
4 Affected Environment and Environmental Consequences of the Alternatives* 25
4.1 Alternatives Analyzed for Environmental Effects 25
4.2 Resources Analyzed and Resources Screened from Detailed Analysis 27
4.3 Context for Cumulative Effects Analysis 29
4.4 Navigation and Economic Conditions 33
4.5 Hydraulics and Geomorphology 41
4.6 Water Quality 44
4.7 Air Quality 47
4.8 Greenhouse Gas Emissions 52
4.9 Sea Level Change 54
4.10 Hazardous, Toxic, and Radiological Waste 56
4.11 Benthic Organisms 60
4.12 Fish 62
4.13 Wildlife 65
4.14 Threatened and Endangered Species 65
4.15 Underwater Noise 72
4.16 Cultural Resources 75
4.17 Public Health and Safety 76

5 Tentatively Selected Plan - Agency Preferred Alternative 79
5.1 Description of the Tentatively Selected Plan (Locally Preferred Plan) 79
5.2 Dredging and Dredged Material Management 81
5.3 Real Estate Considerations 83
5.4 Cost Estimate and Economic Summary 83
5.5 Fish and Wildlife Coordination Act Considerations* 87
5.6 Summary of Environmental Consequences and Cumulative Effects of the Tentatively Selected Plan (Agency Preferred Alternative) 88
5.7 Mitigation for Adverse Environmental Effects* 90
5.8 Implementation Requirements 90
5.9 Risk and Uncertainty 91
5.10 Environmental Operating Principles and Campaign Plan 93
6 Compliance with Environmental Statutes* 94
6.1 National Environmental Policy Act 94
6.2 Endangered Species Act of 1973 94
6.3 Clean Water Act of 1972 94
6.4 Coastal Zone Management Act of 1972 95
6.5 Clean Air Act of 1972 95
6.6 National Historic Preservation Act of 1966 95
6.7 Federal Trust Responsibility 96
6.8 Fish and Wildlife Coordination Act of 1934 96
6.9 Magnuson-Stevens Fishery Conservation and Management Act of 1976 97
6.10 Marine Mammal Protection Act of 1972 97
6.11 Bald and Golden Eagle Projection Act 97
6.12 Migratory Bird Treaty Act of 1918 and Executive Order 13186 Migratory Bird Habitat Protection 98
6.13 Executive Order 13175 Consultation and Coordination with Indian Tribal Governments 98
6.14 Executive Order 12898 Environmental Justice 98
6.15 Executive Order 11990 Protection of Wetlands 99
6.16 Executive Order 13045 Protection of Children from Environmental Health Risks and Safety Risks 99
7 Public Involvement, Review, and Consultation 100
7.1 Public Involvement Process 100
7.2 Tribal Government Consultation and Coordination Process 100
7.3 Agencies and Persons Consulted* 100
8 Recommendations 101
9 References 104

List of Figures

Figure 1-1. Study Area (East, West, and Duwamish Waterways) 2
Figure 1-2. Project Area (East and West Waterways) 3
Figure 1-3. Seattle Harbor Container Terminals. 6
Figure 1-4. Port of Seattle Hinterland 7
Figure 3-1. West Waterway Alternative 2 16

Figure 3-2. East Waterway Alternative 2 17
Figure 3-3. East Waterway Alternative 4 18
Figure 4-1. United States Coast & Geodetic Survey Topographic sheet T-1406; Duwamish Bay, 1875..... 31
Figure 4-2. View from Seattle of trestles on creosote pilings over mudflats 1903. Image courtesy of MOHAI, PEMCO Webster & Stevens Collection (Image #1983.10.7767). 32
Figure 4-3. View from West Seattle of Harbor Island trestles and industrial development 1912. Image courtesy of MOHAI, PEMCO Webster & Stevens Collection (Image #1983.10.9428.1) 32
Figure 4-4. The CMA CGM Benjamin Franklin calls the Port of Seattle in 2016 (Photo Credit: Don Wilson) 35
Figure 4-5. Seattle Vessel Calls by Class, 2006-2014 36
Figure 4-6. Total Tonnage by Vessel Class, 2010-2014 36
Figure 4-7. Baseline Forecast of Vessel Calls for Port of Seattle by Year 39
Figure 4-8. Current meter (red) and water level (green) observation stations in the East Waterway (EHI 2009). 42
Figure 4-9. Wind Rose at West Point Coastal-Marine Automated Network station (1984-2007). Wind speeds are shown in feet per second, and directions are in degrees from true north (0°). 43
Figure 4-10. CERCLA Superfund sites/OUs in the vicinity of East and West Waterways..... 58
Figure 5-1. Tentatively Selected Plan 80
Figure 5-2. Elliott Bay open-water dredged material placement site..... 82

List of Tables

Table 3-1. Measures Screened from Further Evaluation and Cause for Screening 12
Table 3-2. Design Vessel Parameters 13
Table 3-3. Initial Array of Alternatives 15
Table 3-4. Alternative Conceptual Cost Estimates (October 2015 price level)..... 20
Table 3-5. Origin-Destination Benefit Cost Analysis 21
Table 3-6. Origin-Destination Benefit Cost Analysis for East and West Waterway Plan Combinations..... 21
Table 3-7. Principles and Guidelines Criteria 23
Table 3-8. Comparison of NED Plan and Locally Preferred Plan 23
Table 4-1. List of resources considered for detailed effects analysis and rationale for inclusion or exclusion. 28
Table 4-2. Seattle Harbor Baseline Commodity Forecast, Year 2014 (Metric Tons) 33
Table 4-3. Seattle Carriers Services by Terminal (2015) 34
Table 4-4. Fleet Subdivisions on Draft, Beam, and LOA (in feet) 35
Table 4-5. Seattle Route Groups and World Regions 37
Table 4-6. Seattle Total TEU Forecast by Route for Imports and Exports (TEUs) 38
Table 4-7. Seattle Containerized Trade Forecast – Import and Export Tons 38
Table 4-8. Vessel Calls by Year, Class, and Alternative 40
Table 4-9. Tidal Data at Seattle NOS/CO-OPS station 9447130 (1983-2001 tidal epoch) 41
Table 4-10. NAAQS as adopted by the State of Washington** 47

Table 4-11. CAA Maintenance Area Information for Seattle Harbor 48
Table 4-12. Estimated annual emissions associated with construction of the NED plan. 50
Table 4-14. Estimated annual emissions associated with construction of the Locally Preferred plan. 51
Table 4-13. Estimated shipping NAAQS pollutant emissions of Alternatives 2 and 3 compared to the No-Action Alternative (2020-2034). 51
Table 4-15. Greenhouse Gas Emissions for the NED Alternative 53
Table 4-16. Estimated shipping GHG emissions after completion of the alternatives compared to the No-Action Alternative (2020 – 2034) 53
Table 4-17. Greenhouse Gas Emissions for the Locally Preferred Plan Alternative 54
Table 4-18. Predicted sea level change (in feet) at Seattle, Washington per EC 1165-2-212. (The base year and economic life cycle year are in bold). 55
Table 4-19. Deck height of each Terminal at Seattle Harbor and predicted SLC scenarios 55
Table 4-20. ESA-listed species that may occur in the project area according to USFWS and NMFS. 66
Table 4-21. Preliminary effects determinations for ESA-listed species and their critical habitat where applicable under the proposed Federal action. 71
Table 5-1. Cost Sharing Allocation for Navigation Construction and OMRR&R Costs 84
Table 5-2. Cost Summary for the Seattle Harbor NED Plan 85
Table 5-3. Cost Summary for the Seattle Harbor LPP 86
Table 5-4. Average Annual Equivalent (AAEQ) Benefits and Costs of the Seattle Harbor LPP 87
Table 5-5. Summary of Environmental Consequences of the Tentatively Selected Plan (Agency Preferred Alternative) 88
Table 5-6. O&M dredging assumptions of the Tentatively Selected Plan 91

List of Appendices

Appendix A: Economics
Appendix B: Engineering
Appendix C: Supplemental Information on the Affected Environment
Appendix D: Compliance Documents
Appendix E: Cost Estimate
Appendix F: Real Estate Plan
Appendix G: Phase I Environmental Site Assessment

List of Acronyms and Abbreviations

AAEQ	Average Annual Equivalent		MSL	Mean Sea Level
AEP	Annual Exceedance Probability		MTL	Mean Tide Level
APE	Area of Potential Effects		MOHAI	Museum of History and Industry
BCR	Benefit Cost Ratio		MSI	Maritime Strategies, Inc.
BA	Biological Assessment		N_2O	nitrous oxide
BMP	Best Management Practice		NAAQS	National Ambient Air Quality Standards
CAA	Clean Air Act		NAVD	North American Vertical Datum
CAGR	Compound Average Growth Rate		NED	National Economic Development
CAR	Coordination Act Report		NEPA	National Environmental Policy Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act		NHPA	National Historic Preservation Act
			NMFS	National Marine Fisheries Service
CFR	Code of Federal Regulations		NOAA	National Oceanic and Atmospheric Administration
CH_4	methane		NOx	nitrogen oxides
CO	carbon monoxide		NRHP	National Register of Historic Places
CO_2	carbon dioxide		NWPCAS	Northwest Ports Clean Air Strategy
cPAH	carcinogenic polycyclic aromatic hydrocarbon		O_3	ozone
			O&M	Operations and Maintenance
cy	cubic yards		OD	Origin-Destination
CZMA	Coastal Zone Management Act		OMRR&R	Operations, Maintenance, Rehabilitation, Repair, and Replacement
DA	Design Agreement			
DMMP	Dredged Material Management Program		OU	Operable Unit
DO	dissolved oxygen		PAH	polycyclic aromatic hydrocarbons
DPM	diesel particulate matter		PAL	Planning Aid Letter
DPS	Distinct Population Segment		PIANC	Permanent International Association of Navigation Congresses
EFH	Essential Fish Habitat			
EOP	Environmental Operating Principles		PCB	polychlorinated biphenyl
EPA	Environmental Protection Agency		PM	particulate matter
ER	Engineering Regulation		ppt	parts per thousand
ESA	Endangered Species Act		PPA	Project Partnership Agreement
EW	East Waterway		PPX	Post-Panamax
FCSA	Feasibility Cost Sharing Agreement		RCW	Revised Code of Washington
FR/EA	Feasibility Report and Environmental Assessment		RED	Regional Economic Development
			RFID	Radio Frequency Identification
FWCA	Fish and Wildlife Coordination Act		ROD	Record of Decision
GHG	Greenhouse Gas		ROGs	reactive organic gases
GNF	General Navigation Features		SCAQMD	South Coast Air Quality Management District
HPAH	(molecular weight) polycyclic aromatic hydrocarbons		SHPO	State Historic Preservation Officer
			SLC	sea level change
HTRW	Hazardous, Toxic, and Radiological Waste		SOx	sulfur oxides
IWR	Institute for Water Resources		TBT	tributyltin
LERRD	Lands, Easements, Rights-of-Way, Relocations, and Disposal		TEU	Twenty-foot Equivalent Unit
			TPY	tons per year
LOA	Length Overall		TSP	Tentatively Selected Plan
LPP	Locally Preferred Plan		TWL	total water level
LSF	Local Service Facility		U.S.	United States
MHHW	Mean Higher High Water		USCG	United States Coast Guard
MHW	Mean High Water		USFWS	US Fish and Wildlife Service
MLLW	Mean Lower Low Water		USGS	United States Geological Survey
MLW	Mean Low Water		WAC	Washington Administrative Code
MMPA	Marine Mammal Protection Act		WW	West Waterway
			WDFW	Washington Department of Fish & Wildlife

1 Introduction

The U.S. Army Corps of Engineers, Seattle District (Corps) is investigating the feasibility of navigation channel improvements in the East and West Waterways of Seattle Harbor, Washington. This report documents the planning process for navigation improvements to demonstrate consistency with Corps planning policy and to meet the regulations that implement the National Environmental Policy Act (NEPA). The following sections provide background information regarding the basis for this study. The sections that are required for NEPA compliance are denoted with an asterisk (*).

1.1 Study Purpose and Scope

This feasibility study will analyze alternatives for navigation improvements to Seattle Harbor's East and West Waterways, including potential waterway deepening. The study will identify and evaluate a full range of all reasonable alternatives including the No-Action Alternative.

1.2 Study Authority*

This study is authorized by Section 216 of the Flood Control Act of 1970 (33 USC 426 et seq.) as amended:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

1.3 Lead Federal Agency and Non-Federal Sponsor*

The study documented herein has been conducted by the Corps (lead Federal agency) and the Port of Seattle (Port). As the non-Federal sponsor, the Port contributes 50% of the total feasibility study costs in the form of cash or in-kind contributions. A Feasibility Cost Sharing Agreement (FCSA) was executed in September 2014.

While the Port of Seattle is the non-Federal sponsor, the Corps also worked closely with the Northwest Seaport Alliance (NWSA) during the study. The NWSA was established in August 2015 and is a marine cargo operating partnership of the ports of Seattle and Tacoma. The NWSA unifies management of marine cargo facilities and cargo business to strengthen the Puget Sound gateway and attract more marine cargo and jobs for the region.

1.4 Location and Description of the Study Area*

The federally authorized Seattle Harbor navigation project, consisting of the East, West, and Duwamish Waterways, is located in Puget Sound's Elliott Bay at Seattle, Washington (Figure 1-1). The authorized project is located from Elliott Bay to the head of the Federal navigation channel upstream approximately five miles. The authorized project consists of the East Waterway, -34 to -51 feet below mean lower low water (MLLW) (hereafter expressed as -X MLLW; which indicates number of feet below MLLW); the West Waterway, -34 MLLW; the Duwamish Waterway, -30 MLLW for 2.6 miles, -20 MLLW for 0.8 miles, and -15 MLLW for 1.8 miles to the head of navigation. These three waterways provide over 7 miles of deep draft navigation accessible from Elliott Bay, Puget Sound, and the Pacific Ocean.

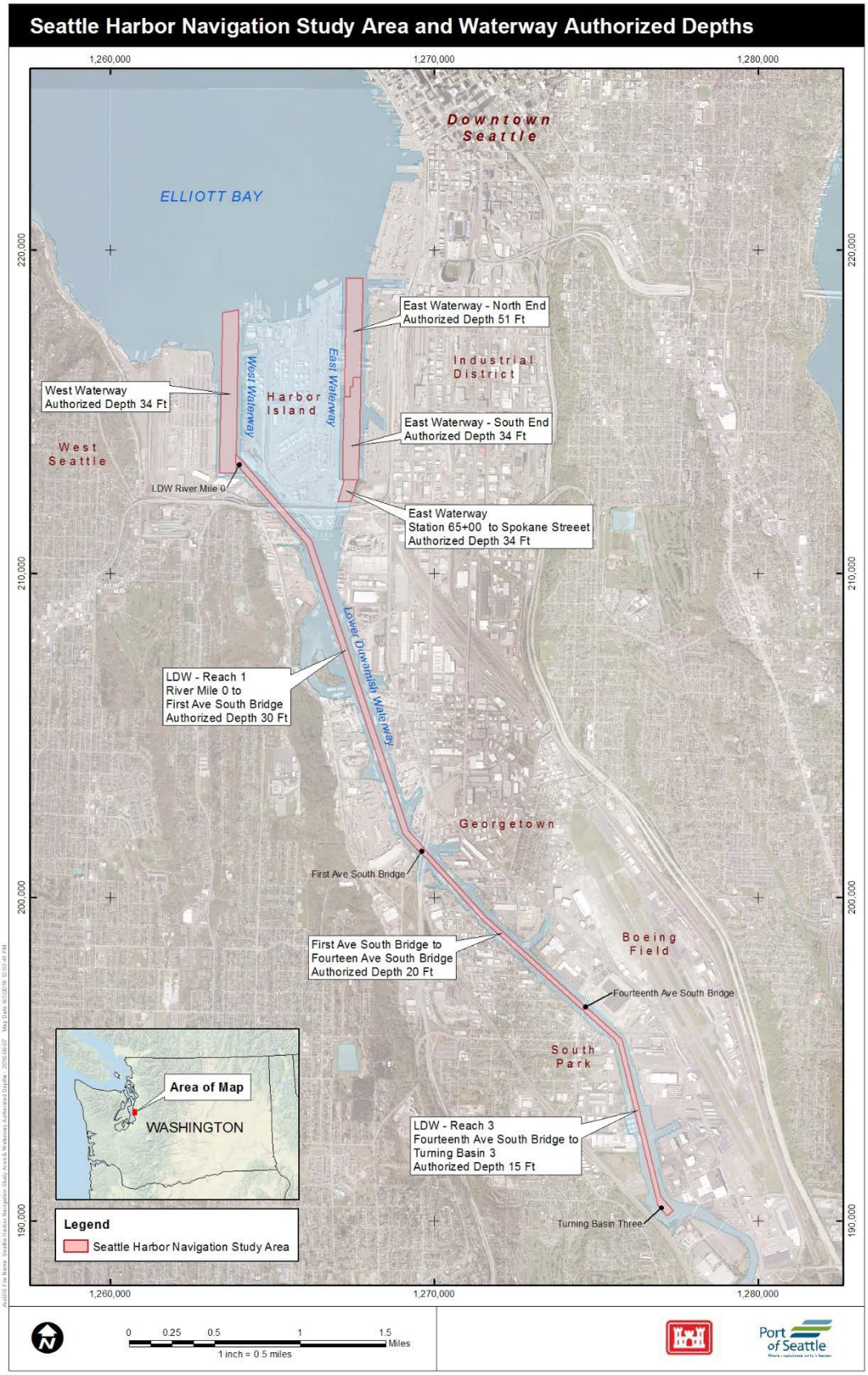


Figure 1-1. Study Area (East, West, and Duwamish Waterways)

Below is a summary of effective authorized boundaries for each waterway:

> **West Waterway**: from the pierhead line at Elliott Bay, 5,200 feet long, effective width of 500 feet, and depth of -34 MLLW. Note: Existing depths in this waterway range from 50 to 60 feet due to historical overdredge of the waterway.
>
> **East Waterway**: from the pierhead line at Elliott Bay, 6,500 feet long, effective width of 500 feet; from that point an additional 700 feet long and effective width of 500 feet and terminating at Spokane Street. In the area defined as "Stage I" in the East Waterway Channel Deepening Stage I Project Report, the authorized depth is -51 MLLW. In all other areas of the East Waterway, the authorized depth is -34 MLLW. Note: Existing depths in this waterway range from 34 to 53 feet.

While the study area includes the East, West, and Duwamish Waterways, the project area for the feasibility study will include only the East and West Waterways (Figure 1-2), as they have been identified by the Corps and Port as the areas of critical importance for navigation improvements.

Figure 1-2. Project Area (East and West Waterways)

1.5 Project Area Overview

The Port of Seattle is a nationally significant port and a critical regional and national export gateway. The Port of Seattle ranks as the 24th largest U.S. port in terms of total tonnage, and 13th in terms of cargo value. Average imports to Seattle from all World regions are estimated to total 4.1 million metric tons from 2012 to 2014. Trade with the Far East including China, North Asia, and Southeast Asia dominates Seattle's market, accounting for nearly 89% of import tonnage. The Port's inland markets extend to Chicago,

Memphis, and St. Louis, making it an ideal gateway for import and export of goods moving between Asia and the U.S. Midwest. The Midwest makes up nearly two-thirds of the Port's hinterlands.

Major lines calling at the Port of Seattle include Cosco, Hanjin, CMA CGM, OOCL, MSC, Hyundai, and Maersk. Most services call from Asia via trans-Pacific routes. In 2014, the East and West Waterway Terminals at the Port of Seattle received 755 vessel calls. These facilities handled 1 million TEUs weighing a total of 9.5 million tons.

Seattle is already handling a significant number of Post-Panamax ships with drafts up to 48 feet. From 2010 through 2015, approximately 52 percent of all calls to Seattle were Post-Panamax calls. Of all containership calls in this same period, 1,099 transits were deeper than current Panamax draft (45 feet). Existing authorized depths for the East and West Waterways do not meet the draft requirements of today's fleet of container ships as well as the draft of the study's design vessel (53 feet).

Navigation improvements are critical to increase the efficiency of cargo vessel operations on Post-Panamax containerships, which are already calling on the Port of Seattle and are projected to call with increased frequency in the future. There is a significant need to accommodate recent and anticipated future growth of containerized cargo and containership traffic, improve the efficiency of operations for containerships within the East and West Waterways of Seattle Harbor, and allow larger and more efficient containerships to use the Port.

Facilities and Infrastructure

The Port of Seattle's seaport is one of the most diverse in the United States (U.S.). It is home to a wide range of maritime activities that bring trade to the region. The seaport is made up of 1,543 acres of waterfront land and nearby properties including container terminals, general purpose/cargo terminals, break-bulk cargo, and refrigerated cargo and storage. The Port of Seattle's four international shipping container terminals, shown in Figure 1-3 include the following: Terminal 5 (T-5), Terminal 18 (T-18), Terminal 30 (T-30), and Terminal 46 (T-46). A description of each terminal is summarized below.

West Waterway – Terminal 5: T-5 is a 182-acre container terminal located along the West Waterway at the mouth of the Duwamish River. Currently, acreage is leased on an interim basis while modernization of this terminal to accommodate ultra-large containerships is underway, including upgrade of cranes. This terminal includes two berths with an overall length of 2,900 feet. Berths currently vary in depth from -45 to -50 MLLW and will be deepened to -56 MLLW as part of the modernization. This modernization effort is being accomplished by the Port and is not part of the Corps proposal for Federal action.

East Waterway – Terminal 18: T-18 is a 196-acre multipurpose terminal located along the west side of East Waterway on Harbor Island. This terminal includes four berths with an overall length of 4,400 feet, one used for breakbulk and three used for containerships. Berths vary in depth from -40 MLLW for breakbulk berths to -50 MLLW for containerships at the north end of the terminal, which includes seven super post-Panamax cranes and 10 cranes total.

East Waterway – Terminal 30: T-30 is a 70-acre container terminal located along the east side of the East Waterway. This terminal includes two non-continuous berths with an overall length of 2,700 feet.

The north berth is 1,500 feet at -50 MLLW and the south berth is at -45 MLLW; there are 3 super post-Panamax cranes, and six cranes total.

Other Container Terminals: T-46 is a container terminal located outside of the East and West Waterways near downtown Seattle. This terminal has two berths that are 50 feet deep, varied crane sizes including three super post-Panamax cranes of five cranes total, and near-dock rail. Terminal 115 is located along the Duwamish River upstream of the West Waterway entrance. This terminal is used for domestic shipping to Alaska and Hawaii by barge service.

Other Port Facilities: The Port of Seattle owns two properties in the West Waterway that handle liquid bulk commodities. At the north end of T-18, petroleum barges and small tankers are handled, moving fuel to/from an adjacent tank farm. At the south end, acreage is leased to private company handling molasses moving to/from barges and small tanker vessels to adjacent tanks.

Both the East and West Waterways have effective authorized widths of 500 feet. As such, berthing areas are effectively 125 feet wide on each side of the Federal navigation channel.

The majority of Port of Seattle's container traffic is currently handled at T-46 and T-18. Annual throughput capacity at all terminals is over 4 million TEUs. Ongoing expansion projects at T-5 should add to this capacity as described in section 4.4. Given the forecasted container growth during the study period, capacity at the Port of Seattle is not expected to be exceeded.

Terminal Expansions and Landside Infrastructure

T-5 is undergoing an infrastructure development project to upgrade the berthing area to handle ultra-large containerships. The dock infrastructure (including crane rail beams) is being strengthened to handle up to 12 dual-hoist, super post-Panamax container gantry cranes. The power infrastructure is being increased to accommodate new gantry cranes. Slope stabilization and a new toe wall will be constructed to allow deepening to -56 MLLW, and dredging will be conducted to bring 2,900 feet of berth to -56 MLLW. These efforts are being accomplished by the Port and are not part of the Corps proposal for Federal action. Combined with upland improvements and investments in equipment expected to be made by a new tenant, these improvements will create a capacity of over one million TEUs at T-5. Finally, prospective terminal operating tenants of T-5 may also consider automation as a way to provide higher levels of efficiencies to their customers and create additional capacity.

Terminals 18, 30, and 46 have already undergone dock improvement projects that were finished in 2009. Investments were made in 10 super post-Panamax cranes at that time. Six of the cranes at T-18 have a height and outreach to accommodate 14,000- to 18,000-TEU ships. Design and permitting is complete to lengthen the crane rail beams at T-46 to accommodate two large ships at once. Additionally, two new super post-Panamax cranes will be purchased for T-46.

Figure 1-3. Seattle Harbor Container Terminals.

In addition to infrastructure development projects at the terminals, the Port, City of Seattle, State of Washington, and Federal government have made significant investments in the harbor area to facilitate

an increased flow of freight traffic. These improvements include grade separations at East Marginal Way and Atlantic Street to separate truck and rail traffic allowing all terminals to be fully accessible at all times of day. The North Argo Access project created a dedicated truck entrance to Union Pacific Railroad's intermodal yard with improved access to multiple terminals. The Spokane Street viaduct project widened the upper structure to accommodate more traffic, reconfigured exits, and improved the at-grade road surface for heavy vehicles. The City of Seattle has approved a Heavy Haul Corridor for the Seattle Harbor area. The Port will contribute up to $20 million in road structure improvements for heavy vehicle traffic.

Port Hinterland

The Port of Seattle is a natural gateway to move import cargo – primarily transpacific cargo from Asia – to the large population centers in the Midwest and Northeast (Figure 1-4). Nearly 70% of international intermodal containers that move through the Puget Sound market are destined for the Midwest and Northeast, with 30% of the cargo remaining in the Pacific Northwest. Seattle is directly served by the Burlington Northern Santa Fe Railway and Union Pacific Railroad. Corridor investments such as double tracking, new track, facility expansion, and equipment upgrades have been made to increase the velocity between the gateway and key markets.

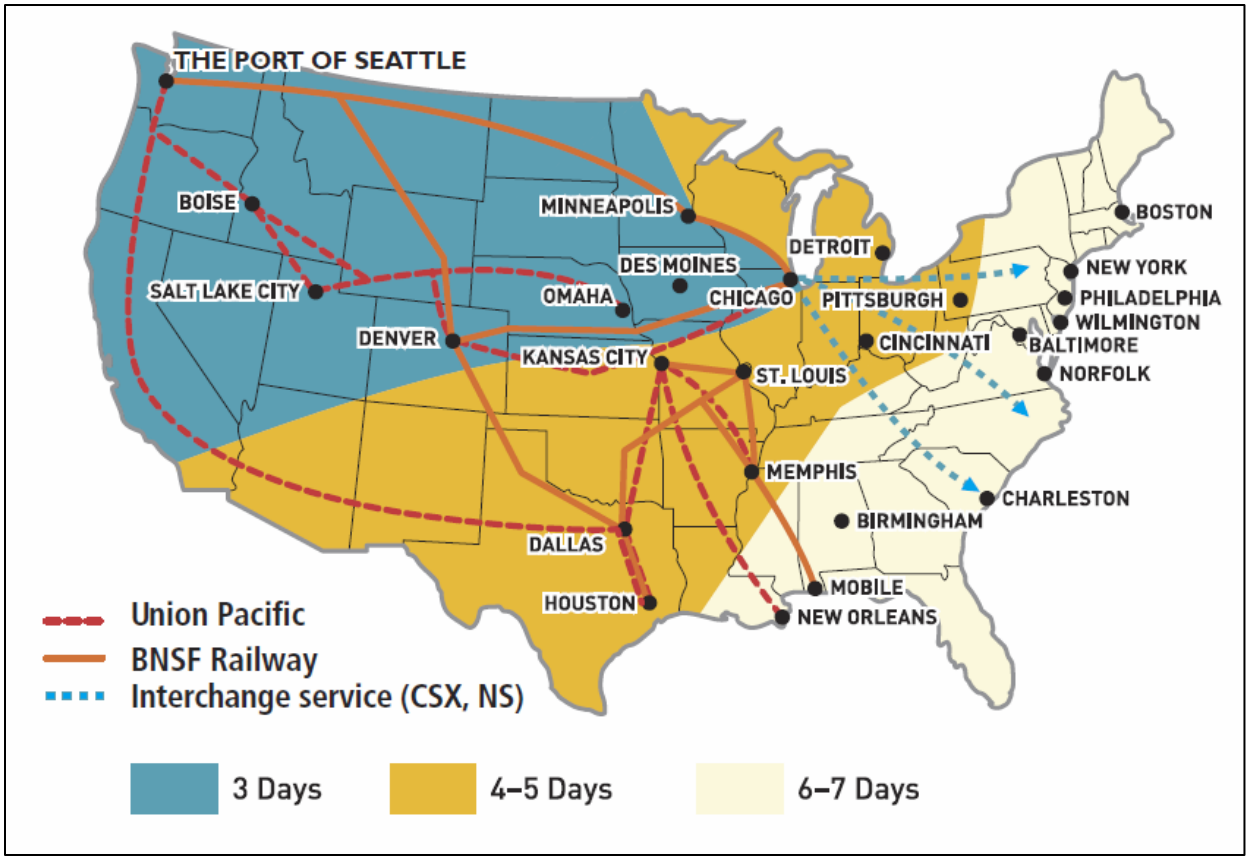


Figure 1-4. Port of Seattle Hinterland

The Port of Seattle is also a critical transportation link for export of containerized agricultural products from the Pacific Northwest and the U.S. heartland. Nearly $20.7 billion of food and agricultural products were exported from the Pacific Northwest states of Oregon, Idaho, and Washington in 2014. Over 70% of these products originated in the State of Washington – the third largest exporter of food and agriculture

commodities in the nation. The Port of Seattle's strategic location, in close geographic proximity to Washington's agricultural heartland via Interstate 90, and on the Pacific Rim, make it a natural gateway for agricultural exports from the region destined for Asian export markets. Furthermore, because export commodities (e.g. apples and forest products) are typically much heavier than imports, vessels require deeper departure drafts. The heavy weight of these export commodities loaded in Seattle means that ships can depart very close to full draft. Export and import commodities are discussed in greater detail in Section 2.1.4 of Appendix A, Economics.

Key Actions in the Project Area

Due to the highly industrialized nature of the project area, many hazardous cleanup sites exist. The Lockheed West Seattle Superfund site and the Harbor Island Superfund site are located within the East and West Waterways of Seattle Harbor. Remedies have been identified and implemented for some operable units (OU) within the Superfund sites, and some remediation actions are ongoing or planned. Section 4.10 describes the status of cleanup actions in both waterways and section 5.2.2 describes assumptions for dredged material disposal based on suitability determination and CERCLA testing results.

1.6 Proposal for Federal Action*

The proposal for navigation improvements triggered analysis under NEPA. For analysis of potential environmental impacts of the range of alternatives, the Corps analyzed a range of length, width, and depth of improvements, including an economically optimized plan. The plan formulation process described in Chapter 3 led to the proposal to deepen the East and West Waterways up to -57 MLLW with an approach reach at each waterway to improve safety. The study period is 50 years from 2024 to 2073 (see section 4.1 for additional details).

1.7 Overview of Integrated FR/EA

This document is an integrated Draft Feasibility Report and Environmental Assessment (FR/EA). The purpose of the feasibility report is to identify the plan that reasonably maximizes the national economic development benefits, is technically feasible, and environmentally sustainable. The purpose of the EA portions of the report is to identify and analyze environmental effects of the alternatives, incorporate environmental concerns into the decision-making process, and to determine whether any environmental impacts are significant and warrant the preparation of an Environmental Impact Statement.

The six steps of the Corps planning process each align with a NEPA requirement. The planning steps are listed below followed by the document chapter and NEPA element to which they relate:

Planning Step	NEPA Element and Document Chapter
Step 1: Problems and Opportunities	Purpose and Need for Action; Chapter 2
Step 2: Inventory and Forecast of Conditions	Affected Environment; Chapter 4
Step 3: Formulate Alternative Plans	Alternatives including Proposed Action; Chapter 3
Step 4: Evaluate Effects of Alternative Plans	Environmental Consequences; Chapter 4
Step 5: Compare Alternative Plans	Alternatives including Proposed Action; Chapters 3 and 4
Step 6: Select Recommended Plan	Agency Preferred Alternative; Chapter 5

2 Need for and Objectives of Action

This chapter presents results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the study area. The chapter also establishes the planning objectives and planning constraints, which are the basis for formulation of alternative plans.

2.1 Problems and Opportunities

The problems for the study include the following:

1. Existing authorized depths for the East and West Waterways do not meet the draft requirements of today's fleet of container ships. Ships often light load or experience tidal restrictions, causing lost transportation efficiencies and lost cost efficiencies at Seattle Harbor.
2. There are navigational challenges at the entrances to both waterways. High spots at the entrance of the West Waterway as well as a narrow "key way" cause tidal delays for ships. In the East Waterway, high spots at the north end of T-30 and south of Slip 27 pose additional vessel safety and navigational challenges.
3. Ships departing Seattle are not realizing economies of scale afforded by the larger ships currently being deployed and even larger ships in the future. Tide restrictions, light loading, or other operational inefficiencies created by inadequate channel depth will limit Port of Seattle competitiveness to maintain its share of cargo among West Coast ports. This is especially true with nearby Canadian ports as major ocean carriers reduce the number of calls and call at Canadian ports.

Opportunities to address problems for this study include the following:

1. Increase safety while improving the efficiency of vessels transiting Seattle Harbor's East and West Waterways.
2. Reduce fuel consumption and reduce air emissions due to larger capacity vessel services associated with navigation improvements to the East and West Waterways.
3. Take advantage of existing, naturally deep waterways while limiting full-scale dredging throughout the entire channel.

2.2 Purpose and Need for Action*

The purpose of the proposed Federal action is to achieve transportation cost savings (increased economic efficiencies) at the East and West Waterways of Seattle Harbor. Navigational challenges have been identified in both the East and West Waterways of Seattle Harbor and authorized depths do not meet the draft requirements of some of the current and projected future fleet of larger container ships. Tide restrictions, light loading, or other operational inefficiencies created by inadequate channel depth result in economic inefficiencies that translate into costs for the national economy.

2.3 National Objective

The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

2.4 Planning Objectives

The primary and secondary planning objectives for the study include the following:

1. Achieve transportation cost savings to and from Seattle Harbor to the extent possible over the 50-year period of analysis;
2. Reduce navigation challenges in Seattle Harbor facing harbor pilots and their operating practices for the 50-year period of analysis.

2.5 Planning Constraints

The following constraints have been identified for the study:

1. The project area is within treaty-reserved usual and accustomed fishing areas for the Muckleshoot and Suquamish Indian Tribes. Plans will avoid or minimize impacts to tribal fishing areas consistent with treaty obligations.
2. There are threatened and endangered species within the project footprint. Avoidance and minimization of impacts to endangered species will be consistent with applicable laws and consultation under the Endangered Species Act.

2.6 Public Scoping Comments and Resources of Concern*

Scoping the feasibility study used several outreach strategies including notifying local Native American tribes and natural resource agencies via letters, and by mailing postcards to residents within the study area and surrounding communities. The Corps published a Notice of Preparation of an Environmental Assessment to solicit public comments on scoping. The Port posted information on their social media outlets. Additionally, the Corps and Port of Seattle hosted a public meeting on November 19, 2014 to gather comments on issues of concern and to scope the feasibility study to the appropriate area and resources. To date, no public comments have been submitted. The Corps and Port based the scope of the study on issues raised by the tribes and natural resources agencies at a meeting held for this purpose on August 12, 2015. The study team also included issues that commonly arise during other dredging and port facility construction projects. Table 4-1 in section 4.2 provides the results of scoping of resources studied.

3 Plan Formulation

The guidance for conducting civil works planning studies, Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, requires the systematic formulation of alternative plans that contribute to the Federal objective. To ensure that sound decisions are made with respect to development of alternatives and ultimately with respect to plan selection, the plan formulation process requires a systematic and repeatable approach. This chapter presents the results of the plan formulation process. Alternatives were developed in consideration of study area problems and opportunities as well as study objectives and constraints with respect to the four evaluation criteria described in the Principles and Guidelines (completeness, effectiveness, efficiency, and acceptability).

3.1 Management Measures and Screening

A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. A preliminary list of structural and non-structural management measures is included below.

Non-Structural Measures

- **Tug Assists:** Use additional tug assists to help larger vessels and vessels with decreased maneuverability transit the harbor.
- **High-Tide Transiting:** Time transits to use high tide to allow the current fleet to transit the harbor under existing project conditions.
- **Light-Loading:** Light-load the larger vessels to allow the current fleet (larger than the existing project's design vessel) to transit the harbor under existing project conditions.
- **Lightering:** Transfer cargo between vessels of different sizes to allow vessels to enter and transit the harbor.

Structural Measures

- **Channel Deepening:** Deepen the channels to allow for passage of larger, deep-draft vessels.
- **Channel Widening:** Widen the channels to allow for passage of wider vessels.[1]
- **Entrance Channel Deepening and Widening:** Deepen and/or widen the entrance channel area of the waterway to allow for passage of larger vessels and safer access to terminals for vessels.
- **Widen and/or Lengthen Turning Basins:** Increase the size of the turning basin(s) to allow for additional maneuverability of vessels.
- **Entrance Channel Breakwaters/Jetties**: Construct breakwaters or jetties to allow for less wind/current impact to vessels entering the waterways.
- **Port Expansion:** Build new docks, terminals, and/or Port facilities in the Seattle Harbor vicinity.
- **Disposal:** Dispose dredged material at an open-water site, upland site, or beneficially reuse dredged material. This measure is dependent on other navigation improvement measures; disposal is generally required when other structural measures (e.g., channel deepening) are implemented.

[1]This measure recommends widening the effective channel width only; there are no proposals for widening beyond the 750-foot physical limitations of the channels (i.e., no removal or modifications of piers, etc.). Channel widening is solely a consideration for safe transit in the waterway. Maintaining one-way traffic is assumed under this measure given the physical limitations to widen either waterway.

Screening of Measures

Screening is the ongoing process of eliminating, based on planning criteria, those measures that will not be carried forward for consideration. Criteria are derived for the specific planning study, based on the planning objectives, constraints, and the opportunities and problems of the study/project area. Criteria used to screen measures as well as qualitative metrics associated with each criteria included the following:

- Is the measure already being carried out by a non-Federal entity? (YES/NO)
- Does the measure meet the primary planning objective? "Achieve transportation cost savings to and from Seattle Harbor to the extent possible." (YES/NO)
- Can the measure be designed to avoid or minimize the impacts outlined in the planning constraints? (YES/NO)
- Do site-specific conditions cause the measure to be technically infeasible or not applicable as a navigation improvement measure? (YES/NO)

Table 3-1. Measures Screened from Further Evaluation and Cause for Screening

Measure Screened	Screening Criteria			
	Already carried out by non-Federal entity?	**Meets primary planning objective?**	**Avoids planning constraints?**	**Technically infeasible?**
Tug Assists	Yes	No		
High-Tide Transiting	Yes	No		
Light Loading	Yes	No		
Lightering		No	No	
Widen/Lengthen Turning Basins		No	No	Yes
Breakwaters/Jetties		No	No	Yes
Port Expansion		No	No	Yes

Based on this screening, the following measures were carried forward for additional analysis:

- Channel Deepening
- Channel Widening
- Entrance Channel Deepening and Widening
- Disposal – Open-water, Upland, or Beneficial Reuse

3.2 Formulation of Alternatives

Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. An initial array of alternative plans has been formulated through combinations of management measures. Because proposed plans in the East and West Waterways will be justified independently of each other, separate alternatives have been formulated for each waterway.

Design Vessel Assumptions

Identification of a design vessel assists the study team by informing design parameters for alternatives. For deep draft projects, the design ship or ships is/are selected on the basis of economic studies of the types and sizes of the ship fleet expected to use the proposed channel over the project life. The design vessel is chosen as the maximum or near maximum size ship in the forecasted fleet.

The economics and coastal hydraulics team, in consultation with the Institute for Water Resources, recommended consideration of two containerized design vessels for the study. The design vessels include the Post-Panamax Generation III and Post-Panamax Generation IV. An analysis of the projected needs for Seattle Harbor has determined that both the East and West Waterways will likely support the largest containerships that will serve the harbor via Pacific crossing routes from Asia, where a Post-Panamax Generation IV is expected to call the Port of Seattle regularly in the future and benefit from deeper channels. Both waterways will need to be designed to support Post-Panamax Generation I-III range vessels projected to serve the U.S. West Coast over the next several years with the potential to eventually support Generation IV or analogous vessels subject to timing and frequency. These two vessels have informed alternative design parameters and are the basis for channel design assumptions as summarized in the following sections. The following table summarizes the approximate design vessel parameters for the two design vessels based on latest available information for these vessels. The economic evaluation uses the beam width parameter for Post-Panamax Generation III and IV containerships.

Table 3-2. Design Vessel Parameters

Parameter	Post-Panamax Generation III	Post-Panamax Generation IV
Beam (Extreme Breadth)	168 feet	185 to 190 feet
Length overall (LOA)	1,200-1,220 feet	1,300-1,315 feet
Maximum summer loadline draft (MXSLLD)	51.2	51.4 to 52.6 (assumed to be 51.7 on average)
Nominal TEU intake	12,800-14,000 TEUs	14,200-15,800 TEUs
Deadweight rating	154,000-165,000 metric tons	157,000 metric tons
Air draft	Up to 175 feet above immersed waterline	198-203 feet

Channel Length Assumptions

Proposed channel lengths for each alternative have been determined based on the physical limitations of the channel. The East Waterway is 7,232 feet long (Station 0+00 to 72+32) and the West Waterway is 6,109 feet long (Station 0+00 to 61+09); there is no proposed lengthening of waterways beyond the physical limitations of the channels.

Channel Width Assumptions

Proposed channel widths for each alternative were determined based on the existing physical limitations of the channel as well as the design vessel for the study. Both waterways are 750 feet wide (pierhead to pierhead); there is no proposed widening beyond the physical limitations of the channel. According to the recommendations in the Engineering Manual for Deep Draft Navigation projects, the minimum channel width should be three times the design ship beam for the inner channels or approximately 550 feet wide (USACE 2006). These channel widths would allow safe, efficient access to each waterway.

Approach Channel Assumptions

To specifically address navigational challenges at the entrances of the East and West Waterways, the channels have been divided into reaches for the purpose of alternative formulation. Each alternative presented below includes proposed alternatives for reaches near the entrance of each waterway (approach channel), with varying dimensions for each reach. The proposed actions for the approach

channel of each waterway are generally wider to allow for safe, efficient access for vessels to the inner channel and berthing areas of the East and West Waterways.

Based on PIANC (1995) recommendations for approach channels, the approach channels require an additional 0.8 times the design vessel beam width (or 150 feet for a total width of 700 feet). These dimensions account for vessel speed, cross wind, cross current, longitudinal current, wave height, aids to navigation, bottom surface, depth of waterway, and cargo hazard level. The approach channel for the East Waterway is 1,200 feet long (Station 0+00 to 12+00) and 700 feet wide. The approach channel for the West Waterway is 2,500 feet long (Station 0+00 to 25+00) and 700 feet wide. The approach channel length is designed to extend offshore to naturally deep waters. This ensures the approach reach is authorized for O&M dredging to naturally deep waters over the project life.

Channel Depth Assumptions

Proposed channel depths for each alternative have been determined based on existing bathymetry (most areas of the channel are already at least -51 MLLW) as well as draft requirements for the design vessel. The current limiting depths are -42 MLLW in the West Waterway and -51 MLLW in the East Waterway. The Corps analyzed costs and impacts of alternatives ranging in depths from -52 MLLW to -57 MLLW. Alternatives shallower than existing depths did not meet study objectives; alternatives deeper than -57 MLLW would require extensive slope stabilization measures in the channel and were not recommended for detailed evaluation. Determining the appropriate depth for each alternative will be an economic optimization process, with incremental evaluation of 1-foot depth increments.

Disposal Assumptions

Disposal measures are evaluated as a part of each alternative. At this stage of alternatives formulation and evaluation, two of the three disposal measures identified (open-water and upland) are being carried forward. The beneficial reuse measure was screened from further consideration; this measure was determined to be cost prohibitive. If a beneficial reuse measure became cost effective at a later date, it could be evaluated for environmental compliance at that time. Dredging will occur with a clamshell bucket, so there would be an additional cost for equipment to place the material on shore. In addition, although some of the dredged material is suitable for open water disposal, the material may not be recommended for beneficial reuse. The Tentatively Selected Plan (TSP) will most likely include more than one measure for disposal (e.g., an alternative may include both open-water and upland disposal).

A summary of the initial array of alternatives is included Table 3-3.

Table 3-3. Initial Array of Alternatives

Alternative Name / Number	Segment	Station	Length (in feet)	Width (in feet)	Depth
East Waterway Alternative 1	Approach + Inner Channel	Sta. 0+00 to 60+00	6,000	550	Up to -57 MLLW
East Waterway Alternative 2	Approach	Sta. 0+00 to 12+00	1,200	700	Up to -57 MLLW
	Inner Channel	Sta. 12+00 to 60+00	4,800	550	Up to -57 MLLW
East Waterway Alternative 3	Approach + Inner Channel	Sta. 0+00 to 60+00	6,000	550	Up to -57 MLLW
	South End Channel	Sta. 60+00 to 72+32	1,232	500	Up to -40 MLLW
East Waterway Alternative 4	Approach	Sta. 0+00 to 12+00	1,200	700	Up to -57 MLLW
	Inner Channel	Sta. 12+00 to 60+00	4,800	550	Up to -57 MLLW
	South End Channel	Sta. 60+00 to 72+32	1,232	500	Up to -40 MLLW
West Waterway Alternative 1	Approach + Inner Channel	Sta. 0+00 to 61+09	6,109	550	Up to -57 MLLW
West Waterway Alternative 2	Approach	Sta. 0+00 to 25+00	2,500	700	Up to -57 MLLW
	Inner Channel	Sta. 25+00 to 61+09	3,609	550	Up to -57 MLLW

3.3 Evaluation of Alternatives

The array of six alternatives (four alternatives for the East Waterway and two alternatives for the West Waterway) underwent an initial round of qualitative screening. This screening was based primarily on whether the alternative improves navigation safety at the approach of each waterway, as these areas were identified by the Puget Sound Pilots as critical for navigation improvements to allow vessels to safely access each waterway. The PIANC guidelines and input from the Puget Sound Pilots assisted the study team to carry forward East Waterway Alternative 2, East Waterway Alternative 4, and West Waterway Alternative 2 into the final array. These alternatives all include a wider approach channel reach to improve navigation safety in the project area. The three alternatives that do not include a wider entrance channel reach were screened out from further consideration, as they do not directly address navigation safety considerations in the existing conditions and future without-project condition.

3.4 Final Array of Alternatives

A summary of the final array of alternatives is included below. Maps of the final array of alternatives are presented in figures as listed below.

- No-Action Alternative
- West Waterway Alternative 2 (Figure 3-1)
- East Waterway Alternative 2 (Figure 3-2)
- East Waterway Alternative 4 (Figure 3-3)

To complete additional evaluation, comparison, and optimization of alternatives to identify the TSP, the analysis will consider alternatives for each waterway on their own and in combination. Economic evaluation focuses on optimizing the alternatives for depth (i.e., up to -57 MLLW) as presented in Section 3.5.1.

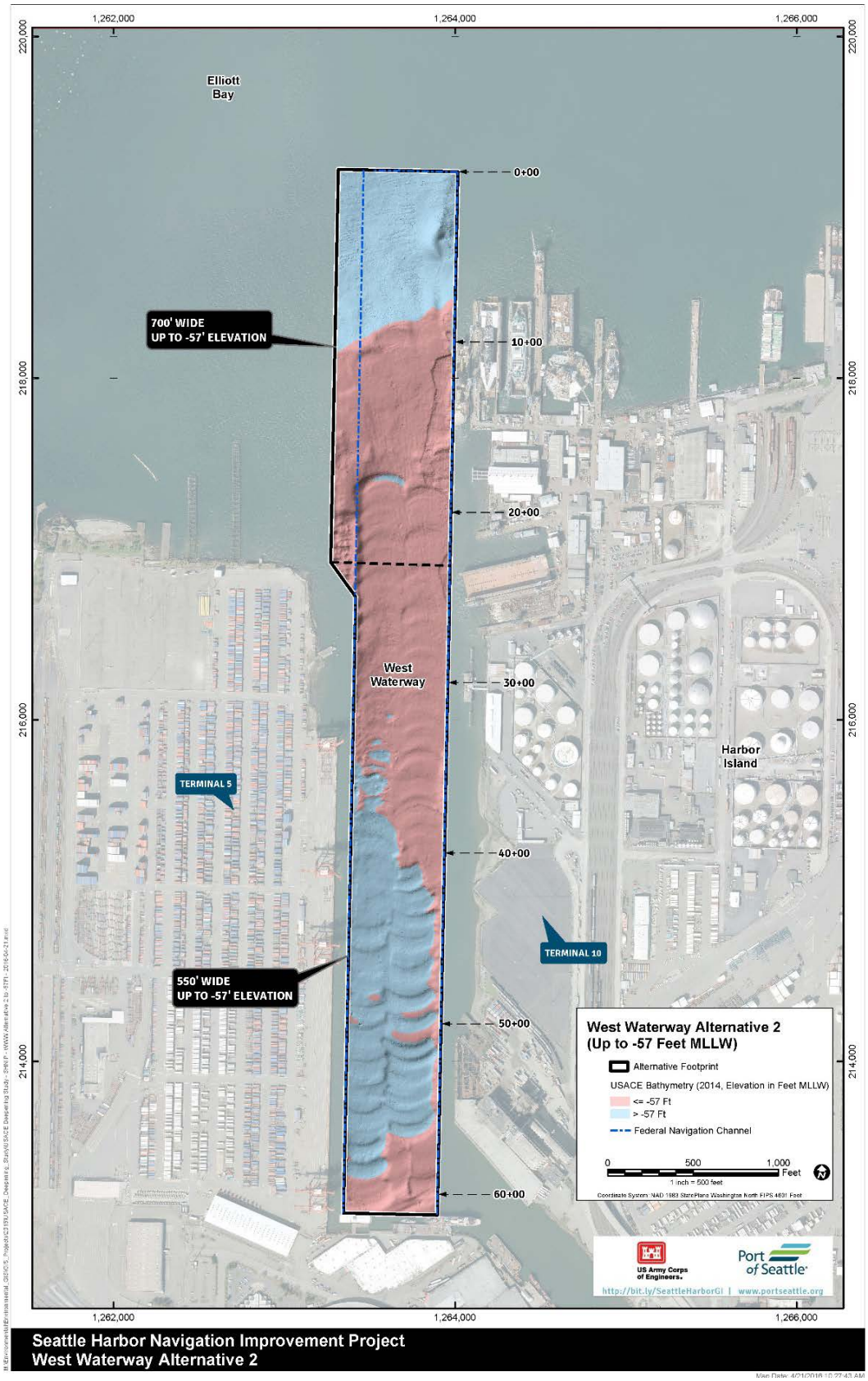


Figure 3-1. West Waterway Alternative 2

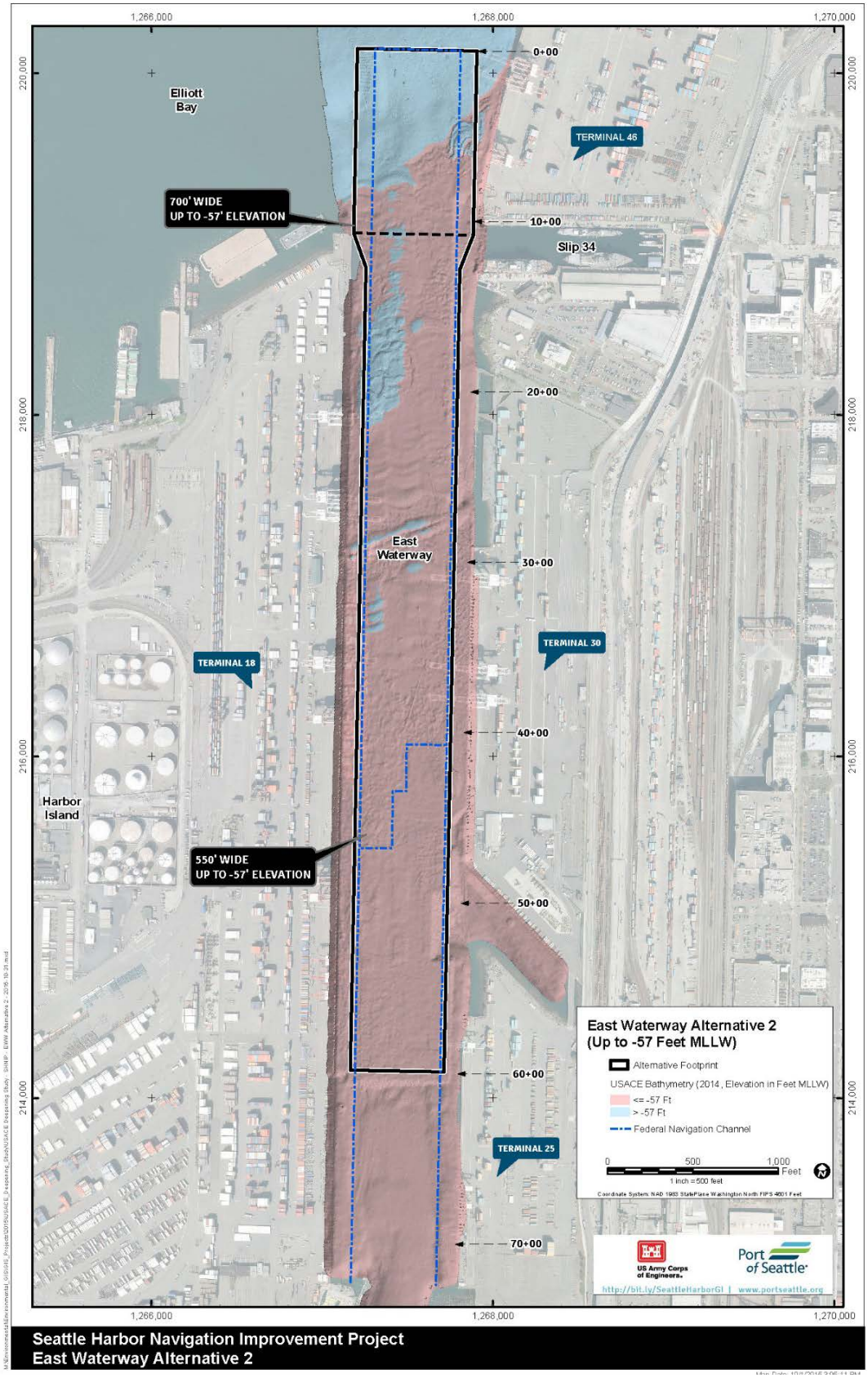


Figure 3-2. East Waterway Alternative 2

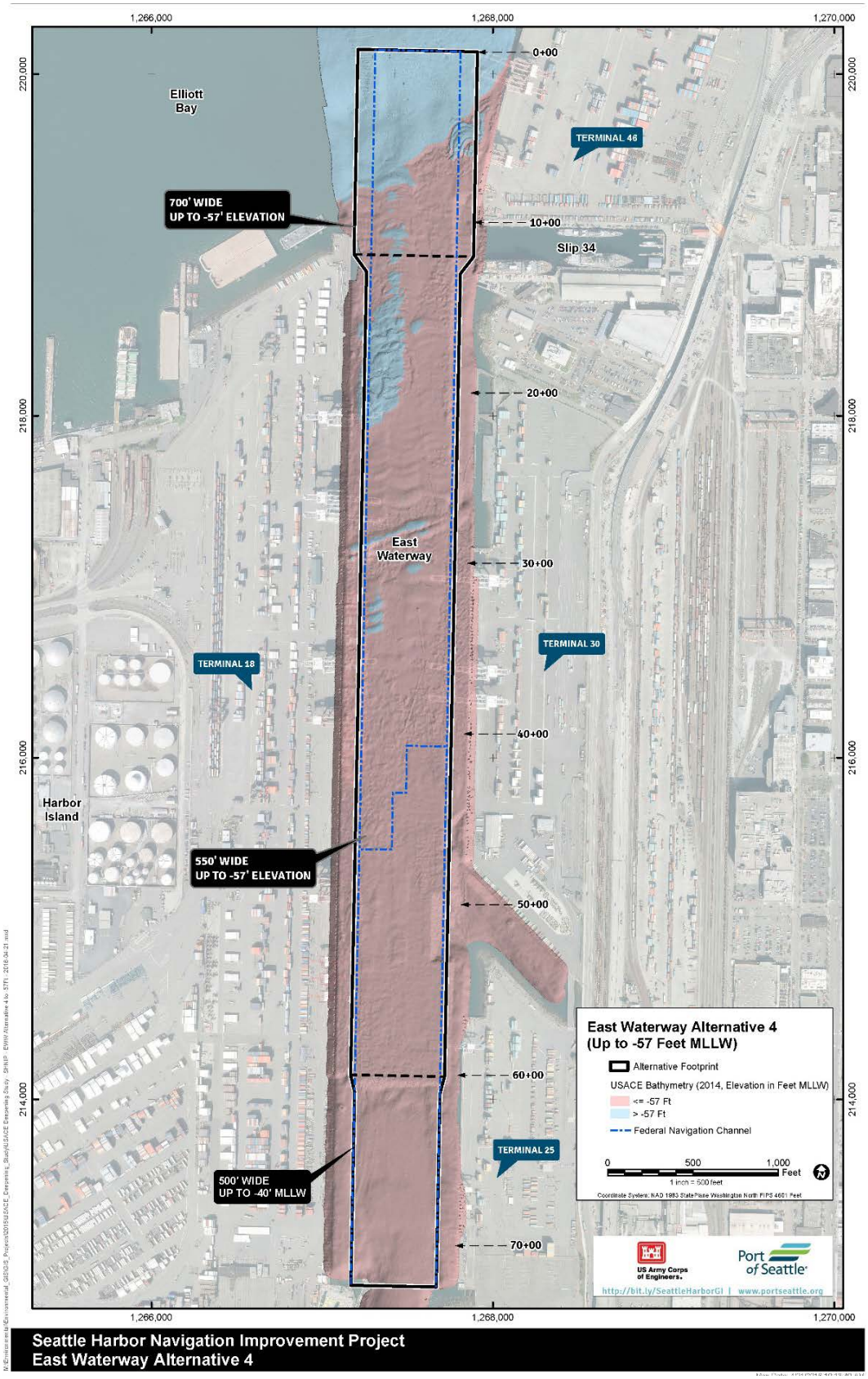


Figure 3-3. East Waterway Alternative 4

3.5 Evaluation and Comparison of Final Array of Alternatives*

The evaluation and comparison process incorporates four accounts to facilitate evaluation and display of effects of alternative plans. The four accounts are national economic development (NED), environmental quality, regional economic development (RED), and other social effects. The Federal objective is to determine the project alternative with maximum net benefits while protecting or minimizing impacts to the environment.

Prior to evaluation and screening of the final array of three action alternatives, East Waterway Alternative 4 was screened from detailed analysis. Based on forecasted vessel fleets and commodities for the south end of the East Waterway, change to the authorization for this specific reach is not being recommended. Action in the south end of the East Waterway is not economically justified; thus, East Waterway Alternative 4 was not carried forward for final evaluation and comparison.

3.5.1 National Economic Development

The NED account displays changes in the economic value of the national output of goods and services. The benefit-cost analysis presented in this section was conducted for each incremental foot of deepening evaluated to -57 MLLW in each waterway and considered origin-destination (OD) benefits for East Waterway Alternative 2 and West Waterway Alternative 2. Economic evaluation of the final array of alternatives focused on optimizing the alternatives for depth (i.e., up to -57 MLLW) and evaluated action in each waterway individually as well as combined. The economic evaluation results presented below include action on the East Waterway only, the West Waterway only, and a combination of both waterways.

The plan formulation process also evaluated local service facility (LSF) requirements (e.g., terminals and transfer facilities, docks, berthing areas, etc.) for each alternative. LSF improvements are assumed at T-18, causing a large jump in total average annual equivalent (AAEQ) cost from East Waterway Alternative 2 at -54 MLLW to -55 MLLW. Berth deepening would also be required at T-5 for channel deepening beyond -55 MLLW.

Conceptual cost estimates for the alternatives, and combinations of alternatives in the East and West Waterways are displayed in Table 3-4 at the October 2015 price level. Costs have been annualized using the current discount rate of 3.125% and are presented at the October 2015 price level, presented as an AAEQ cost. The costs include all economic costs including project first costs (construction cost) for the Federal project, associated LSF improvements at T-18 on the East Waterway and T-5 on the West Waterway, interest during construction, and 10-year cycles for operations and maintenance (or operations, maintenance, rehabilitation, repair, and replacement, also shown as O&M or OMRR&R) dredging expenses. Given large incremental costs for deepening the East Waterway beyond -54 MLLW, the combination of the -54 MLLW depth on the East Waterway with -56 MLLW depth on the West Waterway was considered in the evaluation of alternatives given relatively high annual benefits for low annual costs. Other plan combinations were less efficient and are therefore not displayed. Additional cost estimate information is presented in Appendix E.

Table 3-4. Alternative Conceptual Cost Estimates (October 2015 price level)

Alternative	Construction Cost	LSF	Total Cost	10-year OMRR&R Cost	AAEQ Cost
East Waterway Alternative 2					
EW Alt 2 -52 MLLW	$6,984,000	$8,458,000	$15,442,000	4,744,000	$759,000
EW Alt 2 -53 MLLW	$8,245,000	$16,112,000	$24,357,000	5,076,000	$1,142,000
EW Alt 2 -54 MLLW	$10,207,000	$24,428,000	$34,635,000	5,291,400	$1,581,000
EW Alt 2 -55 MLLW	$13,833,000	$253,206,000	$267,039,000	5,424,000	$10,984,000
EW Alt 2 -56 MLLW	$16,562,000	$261,758,000	$278,320,000	5,521,000	$11,357,000
EW Alt 2 -57 MLLW	$21,268,000	$270,311,000	$291,579,000	5,577,000	$12,114,000
West Waterway Alternative 2					
WW Alt 2 -52 MLLW	$25,941,000	$0	$25,941,000	$4,716,000	$1,181,000
WW Alt 2 -53 MLLW	$29,318,000	$0	$29,318,000	$4,833,000	$1,328,000
WW Alt 2 -54 MLLW	$33,674,000	$0	$33,674,000	$4,901,000	$1,510,000
WW Alt 2 -55 MLLW	$39,714,000	$0	$39,714,000	$4,939,000	$1,757,000
WW Alt 2 -56 MLLW	$47,525,000	$837,000	$48,362,000	$4,986,000	$2,165,000
WW Alt 2 -57 MLLW	$56,844,000	$1,674,000	$58,518,000	$5,046,000	$2,561,000
Combined Alternative (East Waterway Alternative 2 and West Waterway Alternative 2)					
Combined -52 MLLW	$32,925,000	$8,458,000	$41,383,000	$9,460,000	$1,940,000
Combined -53 MLLW	$37,563,000	$16,112,000	$53,675,000	$9,909,000	$2,470,000
Combined -54 MLLW	$43,881,000	$24,428,000	$68,309,000	$10,192,400	$3,091,000
Combined -55 MLLW	$53,547,000	$253,206,000	$306,753,000	$10,363,000	$12,741,000
Combined -56 MLLW	$64,087,000	$262,595,000	$326,682,000	$10,507,000	$13,522,000
Combined -57 MLLW	$78,112,000	$271,985,000	$350,097,000	$10,623,000	$14,675,000
EW Alt 2 -54 MLLW + WW Alt 2 -56 MLLW	$57,732,000	$25,265,000	$82,997,000	$10,277,400	$3,746,000

The results of the origin-destination (OD) transportation cost saving benefit analysis are displayed in Table 3-5 for each waterway individually. Table 3-6 presents the results for combinations of depths for each waterway. As shown, the -56 MLLW depth provides the greatest total net benefits in the OD analysis for each individual waterway, as well as in combination. At this time, LSF costs of the combined -56 MLLW alternative are estimated to be $263 million and construction costs of the proposed channel are $64 million, with a total economic cost of approximately $327 million before interest during construction, and associated OMRR&R of $10.5 million every 10 years. The combined -56 MLLW alternative provides the greatest contribution to net benefits of $94,857,000 and is therefore identified as the National Economic Development (NED) plan. The benefit-cost ratio (BCR) of the NED plan is 7.8 based on conceptual cost estimates.

Table 3-5. Origin-Destination Benefit Cost Analysis

Alternative	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit-Cost Ratio
East Waterway Alternative 2					
EW Alt 2 -52 MLLW	$1,030,000	$17,371,000	$16,340,000		16.9
EW Alt 2 -53 MLLW	$1,415,000	$30,395,000	$28,980,000	$12,640,000	21.5
EW Alt 2 -54 MLLW	$1,843,000	$42,903,000	$41,059,000	$12,079,000	23.3
EW Alt 2 -55 MLLW	$11,105,000	$54,060,000	$42,955,000	$1,896,000	4.9
EW Alt 2 -56 MLLW	$11,564,000	$63,099,000	***$51,535,000***	$8,580,000	5.5
EW Alt 2 -57 MLLW	$12,100,000	$63,570,000	$51,470,000	-$65,000	5.3
West Waterway Alternative 2					
WW Alt 2 -52 MLLW	$1,457,000	$12,829,000	$11,371,000		8.8
WW Alt 2 -53 MLLW	$1,604,000	$21,072,000	$19,468,000	$8,097,000	13.1
WW Alt 2 -54 MLLW	$1,786,000	$30,196,000	$28,410,000	$8,942,000	16.9
WW Alt 2 -55 MLLW	$2,033,000	$38,890,000	$36,857,000	$8,447,000	19.1
WW Alt 2 -56 MLLW	$2,386,000	$45,708,000	***$43,322,000***	$6,465,000	19.2
WW Alt 2 -57 MLLW	$2,802,000	$46,022,000	$43,221,000	-$101,000	16.4

Table 3-6. Origin-Destination Benefit Cost Analysis for East and West Waterway Plan Combinations

Combined Alternative	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit-Cost Ratio
-52 MLLW	$2,487,000	$30,200,000	$27,711,000		12.1
-53 MLLW	$3,019,000	$51,467,000	$48,448,000	$20,737,000	17.0
-54 MLLW	$3,629,000	$73,099,000	$69,469,000	$21,021,000	20.1
-54 MLLW East & -56 MLLW West	$4,229,000	$88,611,000	$84,382,000	$14,913,000	21.0
-55 MLLW	$13,138,000	$92,950,000	$79,812,000	-$4,570,000	7.1
-56 MLLW	$13,950,000	$108,807,000	***$94,857,000***	$15,045,000	7.8
-57 MLLW	$14,902,000	$109,592,000	$94,691,000	-$166,000	7.4

It should be noted that the analysis of project benefits assumes Seattle would retain its share of West Coast and North American cargo over the period-of-analysis; thus no benefits are claimed from a change in cargo share as ports continue to make individual improvements and compete for discretionary cargo. Details of the economic evaluation as well as sensitivity analysis, primarily with regards to uncertainties in vessel or commodity fleet forecasts, is presented in Appendix A.

3.5.2 Regional Economic Development

The RED account measures changes in the distribution of regional economic activity that would result from each alternative plan. Evaluations of regional effects are measured using nationally consistent projections of income, employment, output, and population. All alternatives would require a financial outlay that is expected to have a positive effect on regional jobs and income. This account will be further evaluated using the USACE online Regional Economic System to provide estimates of regional, state, and national contributions of Federal spending associated with the NED plan. The RED analysis will be included in the final report when more detailed costs for alternatives have been developed.

3.5.3 Environmental Quality

The environmental quality account considers non-monetary effects on ecological, cultural, and aesthetic resources. Under this account, the preferred plan should avoid or minimize environmental impacts in the project area to the extent practicable considering other criteria and planning objectives. Detailed descriptions of the analysis and impacts can be found in Chapter 4. Table 4-1 provides the list of resources considered in the study and the rationale for inclusion or exclusion from detailed analysis. Table 5-5 summarizes the environmental consequences of the TSP.

3.5.4 Other Social Effects

The amount of cargo moving through the East and West Waterways is predicted to increase over time. That increase is expected to occur with or without navigation improvements. Without improvements, more vessels would be required to transport the increased cargo volumes that are forecasted. However, with implementation any of the deepening alternatives, the total number of vessels could decrease and transportation costs could be reduced compared to future without-project conditions. Similarly, channel improvements would not induce additional growth including additional traffic, noise, or lighting compared to the future without-project condition.

Since the total cargo throughput is not predicted to increase as a result of deepening, no landside changes in air pollutant emissions would result from channel improvements. Implementation of any of the action alternatives could reduce the number of vessel calls used to transport cargo. As a result, total air emissions within the harbor and at each terminal could decrease. Additionally, increased depths could reduce congestion and allow vessels more flexibility of movement than in the future without-project conditions. This could allow traffic to be spread over wider time ranges rather than concentrating all of the largest vessel traffic during high tides.

No significant construction or operational impacts to the human environment are expected. Populations of minority, juvenile, elderly, and low-income families would not experience disproportionately high and adverse effects from any of the proposed alternatives. Schools/childcare facilities and hospitals are dispersed throughout the area and are not disproportionately located near the project area. Thus, no disproportionately high and adverse impacts to children are expected. Overall, based on the absence of adverse impacts to human health, environmental health risks, and safety risk, this project would not have disproportionately high and adverse impacts to any communities, including environmental justice communities or children.

3.5.5 Completeness, Effectiveness, Efficiency, and Acceptability

Completeness, effectiveness, efficiency, and acceptability are the four evaluation criteria specified in the Council for Environmental Quality Principles and Guidelines (Paragraph 1.6.2(c)) in the evaluation and screening of alternative plans. Alternatives considered in any planning study should meet minimum subjective standards of these criteria to qualify for further consideration and comparison with other plans.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment.

Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities, tribes, and the public and compatibility with existing laws, regulations, and public policies.

Table 3-7 compares the alternatives against this criteria. Combined alternatives at the -55 and -57 MLLW depths are effective at achieving benefits, but have a higher incremental cost relative to incremental benefits when considered against lower cost plans and are therefore shown as not efficient under the efficiency criteria. However, all alternatives analyzed are effective at reducing transportation costs.

Table 3-7. Principles and Guidelines Criteria

Alternative (Combined)	Completeness	Effectiveness	Efficiency	Acceptability
-52 MLLW	Yes	Yes	Yes	Yes
-53 MLLW	Yes	Yes	Yes	Yes
-54 MLLW	Yes	Yes	Yes	Yes
-54 East WW -56 West WW	Yes	Yes	Yes	Yes
-55 MLLW	Yes	Yes	No	Yes
-56 MLLW	Yes	Yes	Yes	Yes
-57 MLLW	Yes	Yes	No	Yes

3.6 Summary of the National Economic Development Plan

The primary decision criteria for identifying the NED Plan includes reasonably maximizing net benefits while remaining consistent with the Federal objective of protecting the nation's environment. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. For this study, the contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. The NED Plan is -56 MLLW in both the East and West Waterways. This is the depth where the net benefits are maximized.

3.7 Summary of the Locally Preferred Plan (Agency Preferred Alternative)*

The economic analysis summarized above evaluated the costs and benefits for channel depth alternatives up to -57 MLLW. Based on the results of this analysis, the non-Federal sponsor has requested a Locally Preferred Plan (LPP) of -57 MLLW in both the East and West Waterways. There are positive net benefits at this depth. Table 3-8 summarizes the costs and benefits of the NED Plan and LPP which reflects updates to costs as described further in Section 5.4.

Table 3-8. Comparison of NED Plan and Locally Preferred Plan

Alternative (Combined)	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio (BCR)
-56 MLLW	$13,722,000	$108,807,000	***$95,085,000***	--	7.9
-57 MLLW	$14,692,000	$109,592,000	$94,900,000	-$185,000	7.5

The Port of Seattle is a strategic gateway for cargo entering the U.S. and vital for Northwest exports. The Port believes it is critical for their infrastructure to keep pace with the rapid evolution of larger ships with deeper drafts to remain competitive and stem the diversion of ships and U.S. cargo to the Canadian gateway. The Port of Seattle and the NWSA are undertaking major capital improvement projects to ensure their docks and berths have sufficient depth and strength to meet the needs of these ships into the future. In recommending a LPP of -57 MLLW in the East and West Waterways, the Port is planning for the future of U.S. commerce and trade by planning for waterway depths to accommodate larger ships.

The LPP provides roughly the same AAEQ benefits (cost savings between future with project and future without project) as the NED plan at $109,592,000, and total net benefits of $94,900,000. The overall BCR is 7.5 when all economic costs of this plan are taken into consideration. These benefits are attributable to the reduction in vessel calls required to satisfy the forecasted commodity demand. The difference in AAEQ benefits and net benefits are within a margin of error between the NED plan and LPP. The economic analysis assumes a design vessel with an approximate 51.7-foot design draft will call regularly at the Port of Seattle in the near future; however, there is great uncertainty in the parameters of this particular containership and drafts could be up to 2 feet greater. These large containerships are forecasted to make up the majority of calls to the Port of Seattle in the future, primarily from Asia. Given the uncertainty in the vessel parameters, the LPP allows sufficient depth for the fully anticipated future fleet of containerships to call both the East and West Waterways to allow for efficient operations and little to no tidal delays.

4 Affected Environment and Environmental Consequences of the Alternatives*

This chapter provides the existing conditions and regulatory setting for each of the resources that could be affected by implementing any of the alternatives as identified in section 3.4. Existing conditions are the physical, chemical, biological, and sociological characteristics of the project area. The assessment of environmental effects is based on a comparison of conditions with and without implementation of the proposed plan and a reasonable range of alternatives; in this case, various scales of two action alternatives were formulated through the screening process and are compared to the No-Action Alternative. The spatial scale of analysis focuses on the East and West Waterways, and surrounding environment. The time scale for analysis is a 50-year period beginning in 2024 and extending to 2074.

4.1 Alternatives Analyzed for Environmental Effects

Chapter 3 outlines the formulation, evaluation, and screening of alternatives for determining the action that maximizes net benefits (difference in AAEQ benefits and costs over the period of analysis) for NED. This chapter provides a comparison of potential environmental effects of a full range of all reasonable alternatives. Therefore, the alternatives analyzed in this chapter include the No-Action Alternative, the NED Plan to characterize the plan that reasonably maximizes the economic benefits, and the LPP, which allows sufficient depth for the fully anticipated future fleet of containerships to call both the East and West Waterways to allow for efficient operations and little to no tidal delays. An overview of these alternatives follows. The Corps analyzed costs and impacts of alternatives ranging in depths from -52 MLLW to -57 MLLW. Alternatives shallower than existing depths did not meet study objectives; alternatives deeper than -57 MLLW would require extensive slope stabilization measures in the channel and were not recommended for detailed evaluation.

4.1.1 Alternative 1 – No-Action Alternative

The No-Action Alternative is analyzed as the future without-project conditions for comparison with the action alternatives. In this case, taking no action would mean continuing standard operations at the Port of Seattle with no improvements to the Federal navigation channel. All physical conditions existing at the time of this analysis are assumed to remain with exception of planned terminal and facility upgrades described in Section 1.5. It is assumed that current maintenance dredging operations would be executed within the existing Federal navigation channel at existing authorized depths (-34 MLLW or -51 MLLW depending on waterway).

4.1.2 Alternative 2 – National Economic Development Plan

Based on the evaluation and comparison of alternatives summarized in Chapter 3, the NED plan is -56 MLLW in both the East and West Waterways. Under this alternative, the proposal analyzed is summarized below:

West Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW to -56 MLLW (6,109 feet long)
- Widen the approach reach to 700 feet wide (2,500 feet long)
- Widen the inner reach to 550 feet wide (3,609 feet long)

East Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW or -51 MLLW to -56 MLLW (6,000 feet long)
- Widen the approach reach to 700 feet wide (1,200 feet long)
- Widen the inner reach to 550 feet wide (4,800 feet long)
- The 1,232 feet at southern end of the East Waterway would maintain its currently authorized width of 500 feet and depth of -34 MLLW

The quantities of sediment that would need to be dredged to achieve this improvement are approximately 653,000 cubic yards (cy) from the West Waterway and approximately 251,000 cy from the East Waterway. These quantities assume the proposed depth of -56 MLLW, an accumulation of approximately 10% more material between the current channel survey and the initiation of construction, and that the contractor removes half of the 2-foot allowable overdepth while dredging the channels. It is also assumed that CERCLA cleanup actions at the East Waterway OU and at the Lockheed West Superfund Site will be completed prior to construction (refer to section 4.10 for more information). Dredged material volume calculations as well as assumptions for disposal are summarized in section 5.2 and Appendix B.

The method for dredging is mechanical (using a clamshell bucket dredge), which would use a digging bucket to remove the material suitable for open-water placement, while an environmental bucket would be used for material unsuitable for open-water placement. Dredged material would be placed on a barge adjacent to the dredge.

Disposal of dredged material that meets open-water disposal criteria would occur at the Elliott Bay open-water disposal site. The quantity estimated for open-water disposal is approximately 500,000 cy from the West Waterway and 226,000 cy from the East Waterway. Material suitable for open-water placement would be transported to the Elliott Bay aquatic disposal site and released to fall to the sea floor. The remaining 153,000 in the West Waterway and 25,000 cy in the East Waterway that does not meet open-water disposal would be transported by barge to a transloading facility to be hauled by train to an appropriate upland disposal site. The dredging is estimated to require two years to complete both waterways, partly due to limiting the work to the in-water work windows for protection of early life stages of sensitive fish species, and with a single dredge working at a time.

To execute the construction for the NED Plan, several pieces of equipment would be operating for about 16-20 hours per day. Only one dredge would be operating at a time and would be running continuously except for breaks for crew change or machinery maintenance. Vessels associated with the proposed transport and disposal activities are primarily tugboats with barges. One tugboat for towing barges is expected to be employed for the duration of this project transiting between the waterways and the Elliott Bay open-water disposal site. A survey vessel would slowly transit the area to measure dredging progress. The duration of work would most likely be throughout the seven-month work window in two consecutive years to accomplish the channel deepening. O&M dredging is anticipated to be needed every 10 years and would take approximately 42 days for each maintenance dredging event.

4.1.3 Alternative 3 – Locally Preferred Plan (Agency Preferred Alternative)

Within the range of depths analyzed for improving the East and West Waterways, the Corps and Port of Seattle determined the deepest channel that is still economically justified is -57 MLLW. Under this alternative, the proposal analyzed is summarized below:

West Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW to -57 MLLW (6,109 feet long)
- Widen the approach reach to 700 feet wide (2,500 feet long)
- Widen the inner reach to 550 feet wide (3,609 feet long)

East Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW or -51 MLLW to -57 MLLW (6,000 feet long)
- Widen the approach reach to 700 feet wide (1,200 feet long)
- Widen the inner reach to 550 feet wide (4,800 feet long)
- The 1,232 feet at southern end of the East Waterway would maintain its currently authorized width of 500 feet and depth of -34 MLLW

The quantities of sediment that would need to be dredged to achieve this improvement are up to approximately 777,000 cy from the West Waterway and approximately 341,000 cy from the East Waterway. These quantities assume the proposed depth of -57 MLLW, an accumulation of approximately 10% more material between the current channel survey and the initiation of construction, and that the contractor removes half of the 2-foot allowable overdepth while dredging the channels.

The method for dredging is mechanical with the same usage of a digging bucket and an environmental bucket as described for Alternative 2.

Disposal of dredged material that meets open-water disposal criteria would occur at the Elliott Bay open-water disposal site. The quantity estimated for open-water disposal is approximately 594,000 cy from the West Waterway and 307,000 cy from the East Waterway. The remaining 183,000 in the West Waterway and 34,000 cy in the East Waterway that does not meet open-water disposal criteria would be disposed upland. The dredging is estimated to take two years to complete both waterways with a single dredge working in a waterway at a time, partly due to limiting the work to the in-water work windows for protection of early life stages sensitive fish species.

To execute the construction for the LPP, the same equipment as described for the NED plan would be employed for the work. The only difference would be that construction for the LPP would take one month longer to remove the additional sediment.

4.2 Resources Analyzed and Resources Screened from Detailed Analysis

The environmental analysis conducted in the NEPA process should provide the decision maker with relevant and timely information about the environmental effects of the decision and reasonable alternatives to mitigate those impacts. Table 4-1 identifies the resources evaluated for detailed analysis with a rationale for inclusion or exclusion. Resources were excluded from detailed analysis if they are not potentially affected by the alternatives or have no material bearing on the decision-making process.

Table 4-1. List of resources considered for detailed effects analysis and rationale for inclusion or exclusion.

Resource	Included in Detailed Analysis (Y/N)	Rationale for inclusion or exclusion
Navigation and Economic Conditions	Y	The purpose of the project is to contribute to national economic development. Analysis is required to determine whether there are sufficient economic benefits to support justification of the project.
Hydraulics and Geomorphology	Y	Problems identified center on the relationship between hydraulics and geomorphology. The proposed action requires study of these characteristics.
Groundwater	N	The proposed action is limited to the subtidal environment. No groundwater will be affected.
Water Quality	Y	Analysis is required to determine the intensity of potential changes to turbidity, dissolved oxygen, and/or salinity.
Air Quality	Y	The air-pollutant concentrations in the project area have consistently been below the National Ambient Air Quality Standards; however, an analysis of diesel particulate matter emitted during construction is important as it is the most harmful emission for human health. Additionally, analysis of potential changes in ship traffic emissions is warranted because the proposed alternatives could accommodate containerships more efficiently.
Greenhouse Gas Emissions	Y	Required to be analyzed by guidance issued by the Council for Environmental Quality in February 2010. Emissions that would occur during construction and the potential changes to long-term vessel emissions are analyzed for impacts.
Sea Level Change	Y	Required to be analyzed by Corps policy in Engineering Regulation 1100-2-8162 (USACE 2013).
Underwater Noise	Y	Underwater noise from construction would occur during periods when sensitive receptors may be present. These include marine mammals, fish, and diving birds. Analysis is required to determine the intensity of effects, and how to avoid or minimize impacts.
Airborne Noise	N	Airborne noise from the action would be attenuated by distance from the source to any sensitive receptors, and would not be audible above the ambient noise of the Port activities. Birds in the project area are assumed to be habituated to the level of disturbance around Seattle Harbor. Noise from construction and any change in ship traffic due to the project would have no effect and would continue to adhere to the City of Seattle noise ordinance.
Hazardous, Toxic, and Radiological Waste	Y	The project area is known to have contaminants. Analysis is required to determine the level of effect due to construction activities for the proposed action.
Benthic Organisms	Y	Benthic macroinvertebrate populations are known to recover quickly from the type of action proposed. Significant effects are not anticipated, but analysis is required to determine intensity of effects.

Fish	Y	Many different fish species may be present. Analysis is required to determine which species would be present, the intensity of effects, and how to avoid or minimize effects.
Wildlife	Y	Marine mammals that may occur in the project area include harbor seals, killer whales, and sea lions and their prey species. Terrestrial and marine birds may be present around the industrial port facilities.
Vegetation	N	The project area contains no aquatic vegetation, and the minor alteration of the reach of the saltwater wedge would not have any effect on nearby wetlands in the estuary upstream from the project.
Threatened and Endangered Species	Y	The proposed action may affect protected species in the project area. Analysis is required to determine the intensity of effects.
Invasive Species	N	The vectors for invasive species for this project are ship fouling and exchange of ballast water by foreign vessels. Vessels must exchange ballast water at least 50 nautical miles offshore (RCW 77.120). Two sampling expeditions identified 21 exotic species in Elliott Bay; however, none appeared dominant or common (Cohen et al. 2001). This project has low risk for introduction of invasive species.
Cultural Resources	Y	Analysis is required to investigate cultural resources and to determine the extent of any potential effects.
Indian Trust Assets	Y	The project area is within treaty-reserved fishing areas, called Usual & Accustomed areas. Analysis is required to determine whether substantial negative effects are anticipated. Analysis appears in section 6.13.
Environmental Justice Communities	Y	Required to be analyzed by presidential executive order. Analysis appears in Section 3.5.4 with additional information in Appendix A.
Aesthetics	N	The proposed action would have no effect to scenic resources or visual characteristics of the project area.
Recreation Resources	N	No significant recreational resources occur in the project area as this is an international shipping port with substantial industrial infrastructure. Recreational boat traffic and public access would not be affected.
Public Services and Utilities	N	The proposed action would have no substantial effect on electricity, water, wastewater and stormwater collection, sewer and solid waste, natural gas, oil/petroleum, or telecommunications services.
Public Health and Safety	Y	Removal of sediments for navigation improvement can cause resuspension of chemicals that bioaccumulate in fish tissues, which may be consumed by humans who fish in the project area.
Land-based Transportation and Traffic	N	None of the alternatives would cause changes to local traffic or surface transport of import and export goods and commodities. The same amount of material would move through the area in the future with- and without-project conditions.

4.3 Context for Cumulative Effects Analysis

Cumulative effects can result from the incremental effects of the proposed action when added to the effects of other past, present, and future actions, regardless of which government agency or private entity undertakes such actions. When effects that are individually minor combine over space or time, the cumulative effects can be significant. NEPA requires analyzing whether the incremental effect of the proposed action will cause a significant impact to the environment when added to past, present, and

reasonably foreseeable future actions. This section summarizes past actions that have affected the environment of the project area. Each resource in sections 4.4 through 4.17 is analyzed for direct and indirect effects and whether these would accrue a significant cumulative effect.

Past Conditions and Actions

The Duwamish River estuary was historically an area of very low gradient with a sinuous, meandering main channel and an extensive tidally influenced mosaic of swamp and marsh wetlands over 4,000 acres (Blomberg et al. 1988). Most of the coarser sediment had been deposited in the middle river, and the lower river had a primarily sand and mud substrate. Large woody debris was carried into the lower river and estuary from the upper watershed during floods (Perkins 1993). A vast area of mudflats stretched between the areas now known as Seattle and West Seattle (Figure 4-1). There was likely a large and sustainable salmon and clam fishery in the Duwamish River and Elliott Bay available to Native Americans before Euro-American settlement.

Development began in the early 1900s. Trestles were constructed across the mouth of the Duwamish River and sat atop thousands of creosote pilings by 1903 (Figure 4-2; Blomberg et al. 1988). The Puget Sound Bridge and Dredging Company dredged the mouth of the estuary and used the material for constructing the entirely artificial Harbor Island in 1909 for the Port Improvement District (Figure 4-3; King County 2001).

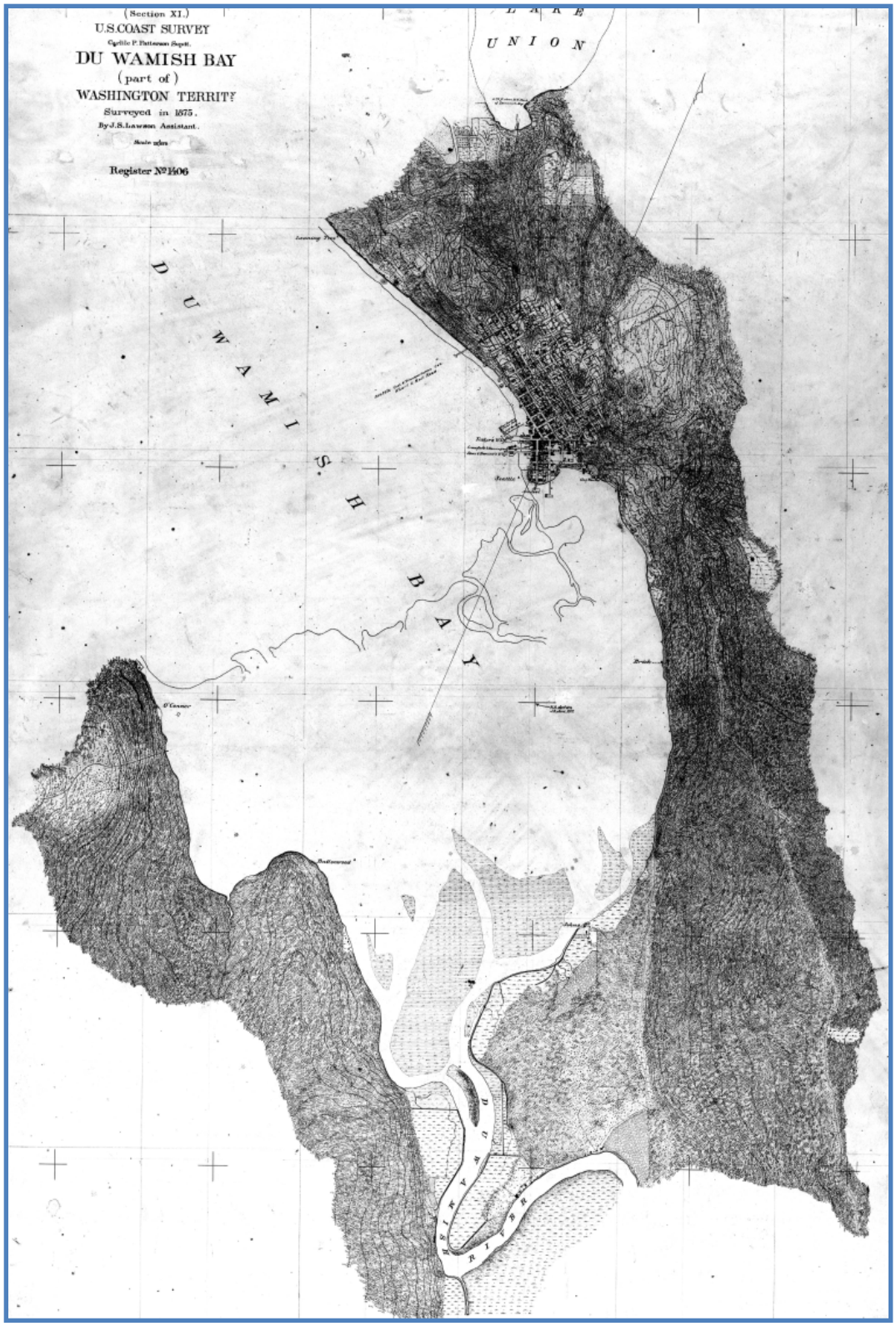


Figure 4-1. United States Coast & Geodetic Survey Topographic sheet T-1406; Duwamish Bay, 1875.

Figure 4-2. View from Seattle of trestles on creosote pilings over mudflats 1903. Image courtesy of MOHAI, PEMCO Webster & Stevens Collection (Image #1983.10.7767).

Figure 4-3. View from West Seattle of Harbor Island trestles and industrial development 1912. Image courtesy of MOHAI, PEMCO Webster & Stevens Collection (Image #1983.10.9428.1)

Over the last 100 years, the braided flows of the lower river have been extensively channelized and reduced to a single permanent channel (the Duwamish Waterway) through dredging and construction of uplands and bank armoring. Dredging has reduced 9.3 miles of meandering tidal channel habitat to the 5.5 miles of channel habitat that exists today (Blomberg et al. 1988). Nearly all intertidal wetlands and shallow subtidal aquatic habitats around Elliott Bay, the East and West Waterways, and the Duwamish Waterway have been eliminated as a result of urban and industrial development; only about 1% of the estimated 4,000 acres of tidal and intertidal habitat remain. The shoreline along East and West Waterways is developed for industrial and commercial operations and the upland areas are heavily industrialized. The Duwamish Waterway segment similarly contains dense industrial, commercial, and residential development. The main navigation channel, a major shipping route for containerized and bulk cargo, is consequently subject to high volumes of marine traffic.

Present Conditions and Actions

Air quality has been a local concern in the neighborhoods surrounding Seattle's industrial area including the project area. The Port of Seattle has been implementing emissions reduction programs and achieving a net reduction. Section 4.7 provides more detail on air quality.

Sediments in the project area have been determined to be contaminated and require clean-up actions, which are already completed at some sites while work continues at others. Section 4.10 describes these cleanup actions in more detail.

Future Conditions and Actions

For the foreseeable future, the Port of Seattle and The Northwest Seaport Alliance have one infrastructure improvement project planned at T-5. The project at T-5 will upgrade the beams, pilings, and deck panels to handle the weight of larger cranes suitable for ships up to 18,000 TEU size and add infrastructure for providing shore-power to ships (cold-ironing). Creosote-treated wooden pilings will be replaced with an environmentally friendly panelized fender system. A new underwater toe wall and other improvements will stabilize the slope to support berth deepening up to -57 MLLW. Dredging the berth areas up to -56

MLLW is included. Power upgrades will serve the larger cranes and will create the potential for greater electrification of the terminal operations for quieter and more energy-efficient operations.

The Northwest Seaport Alliance will pursue and implement capital improvement projects, which may include berth deepening, slope stabilization, or other upgrades. These activities will meet changing commodity and vessel fleet demands to remain globally competitive. Upgrades will occur due to the forecast that ultra-large containerships will call at the Port of Seattle; berths will need to be sufficiently deep to accommodate these ships. The upgrades are not dependent upon the proposed Federal action of deepening the Waterways and the terminal improvements have independent utility regardless of the outcome of this feasibility study.

4.4 Navigation and Economic Conditions

The economic evaluation used to estimate benefits for NED included estimated transportation costs savings for containerized cargos primarily from the Far East via the Pacific Ocean that result from more efficient loading of vessels and reductions in the number of calls required to satisfy the commodity demand. The same commodity demand is expected under both future without- and future with-project conditions as briefly summarized in the following sections. Additional detail on the economic conditions and economic evaluations can be found in Appendix A.

Commodity and TEU Volume: Existing Condition

Average imports to Seattle from all World regions are estimated to total 4.1 million metric tons over 2012 to 2014. Trade with the Far East, including China, North Asia, and Southeast Asia, dominates Seattle's market, accounting for nearly 89% of import tonnage. The top containerized imports based on 2014 tonnages include non-metallic products, furniture and fixtures, machinery and equipment, motor vehicle parts, and iron and steel. A high percentage of imports to Seattle are either consumer goods or raw or intermediate goods that will become consumer goods after going through a manufacturing process. Overall international imports have declined from nearly 6 million metric tons in 2010 to 3.2 million metric tons in 2014.

Average exports from Seattle to all World regions are estimated to total 5.4 million metric tons over 2012 to 2014. Trade with the Far East accounts for nearly 87% of export tonnage. The top containerized exports based on 2014 tonnages include animal feed, fruits and vegetables, and paper or newspaper. Overall international exports have declined from 6.5 million metric tons in 2010 to 4.6 million metric tons in 2014. It should be noted that exports did increase between 2014 and 2015 based on weight but not TEUs. Table 4-2 summarizes the baseline for both imports and exports by route group in year 2014. Average TEU box weight for loaded boxes is 11.2 metric tons for Route 1 to Asia and 12.3 metric tons for Route 2 to Europe, and includes an average 2-metric-ton box weight.

Table 4-2. Seattle Harbor Baseline Commodity Forecast, Year 2014 (Metric Tons)

Route Group	Imports	Exports	Total
Route 1: Asia, Oceania, and Middle East/Indian Subcontinent	2,717,803	3,967,765	6,685,568
Route 2: Europe, Latin America, Africa, and Middle East/Indian Subcontinent	511,327	598,771	1,110,098
Total	3,229,130	4,566,536	7,795,666

Vessel Fleet Characteristics: Existing Condition

Major lines calling at the Port of Seattle include Cosco, Hanjin, CMA CGM, OOCL, Hyundai, MSC, and Maersk. Table 4-3 summarizes services that were considered for the economic evaluation, including the terminal, carrier(s), service name, vessel rotation, number of ships, and ship sizes at that time. Most services call from Asia via trans-Pacific routes.

Table 4-3. Seattle Carriers Services by Terminal (2015)

Carrier(s)	Service Name	Terminal(s)	Vessel Rotation	Ship Sizes (TEUs)
Cosco, K-Line, Yang Ming, Hanjin	MD1	T-18/T-46	SE Asia – S China – N Asia – US West Coast – N Asia – S China	10,000
APL, MOL, Hyundai, Hapag Lloyd, NYK, OOCL, ZIM	NP1	T-18	SE Asia – S China – West Coast Canada – US West Coast – N Asia – S China – SE Asia	8,050-10,000
APL, MOL, Hyundai, Hamburg Sud, Hapag Lloyd, NYK, OOCL, ZIM	NP2	T-18	S China – N Asia – US West Coast – West Coast Canada – N Asia – S China	7,900-8,600
China Shipping, CMA CGM, UASC, PIL, Hamburg Sud, ANL-US Lines	ANW1/ AWN1/Columbus PNW	T-18/T-30	SE Asia – S China – N Asia – US West Coast – West Coast Canada – N Asia – S China – SE Asia	8,500
Cosco, Yang Ming, Hanjin	PNH	T-46	N Asia – West Coast Canada – US West Coast – West Coast Canada – N Asia	4,500-5,500
Maersk, MSC, Safmarine	TP9	T-46	SE Asia – S China – N Asia – West Coast Canada – US West Coast – N Asia – S China – SE Asia	5,000
MSC	CAX	T-46	Med – Panama – US West Coast – West Coast Canada – US West Coast – Panama - Med	5,000

Data for the container fleet was obtained from the Puget Sound Pilots logs and the Sea-web database maintained by IHS Global Insight. From 2006 to 2014, a variety of container ships called to the Port of Seattle. These ships are classified as sub-Panamax, Panamax, Post-Panamax Generation 1 (PPX Gen I), Post-Panamax Generation II (PPX Gen II), and Post-Panamax Generation III (PPX Gen III) depending on their capacity. The vessels are distinguished based on physical and operation characteristics, including lengths overall (LOA), design draft, beam, speed, and TEU capacity. It is common practice to separate the containership fleet in TEU bands or classes to analyze supply within the industry. However, due to the evolution of vessel design over time, these TEU bands do not correspond to a breakdown of the fleet by dimensions such as beam or draft. Accordingly, breakdowns in terms of beam and draft straddle different classes. For instance, within the 3,900 to 5,200 TEU band, which is generally regarded as the Panamax range, several ships fall within that category yet have beams that are too large to pass safely through the current Panama Canal, despite what their name suggests. Conversely, there are many Panamax vessels in the world fleet that fit easily through the Panama Canal while carrying large volumes of TEUs. To minimize the overlap, the beam band or range was used to distinguish container vessels into six vessel classes as shown in Table 4-4.

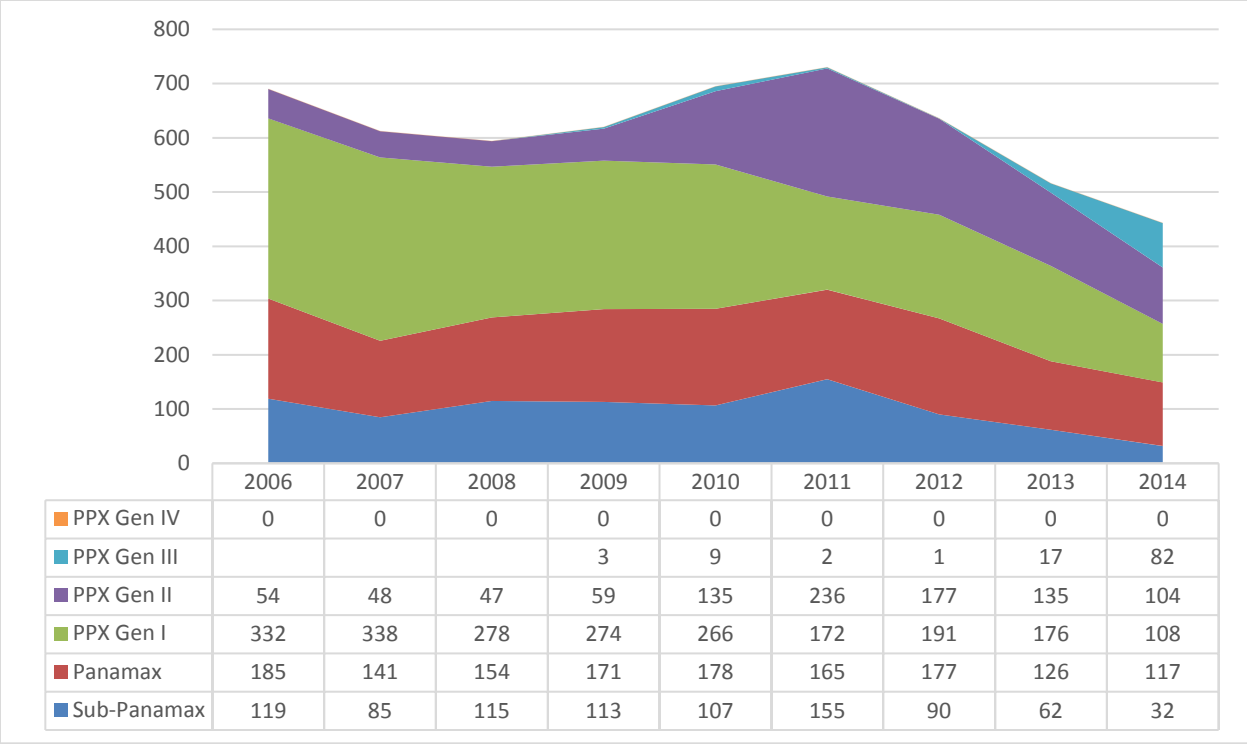
Table 4-4. Fleet Subdivisions on Draft, Beam, and LOA (in feet)

Vessel Fleet Subdivision (Containerships)		From (feet)	To (feet)
Sub Panamax (MSI[1] size brackets: 0.1-1.3, 1.3-2.9 k TEU)	**Beam**		98
	Draft	8.2	38.1
	LOA	222	813.3
Panamax (MSI size brackets: 1.3-2.9, 2.9-3.9, 3.9-5.2, 5.2-7.6 k TEU)	**Beam**	98	106
	Draft	30.8	44.8
	LOA	572	970
Post-Panamax (Generation I Post-Panamax) (MSI size brackets: 2.9-3.9, 3.9-5.2, 5.2-7.6, 7.6-12 k TEU)	**Beam**	106	138
	Draft	35.4	47.6
	LOA	661	1045
Super Post-Panamax (Generation II Post-Panamax) (MSI size brackets: 5.2-7.6, 7.6-12 k TEU)	**Beam**	138	144
	Draft	39.4	49.2
	LOA	911	1205
Ultra Post-Panamax (New Panamax, or Generation III Post-Panamax) (MSI size brackets: 5.2-7.6, 7.6-12, 12 k + TEU)	**Beam**	144	168
	LOA	Up to 1220	
New Post-Panamax (or Generation IV Post-Panamax) (MSI size brackets: 12 k + TEU)	**Beam**	168	200

[1] MSI = Maritime Strategies Inc.

Figure 4-5 shows vessel calls at the Port of Seattle from 2006-2014, broken down by vessel class. It should be noted that the 18,000 nominal TEU capacity ship CMA CGM Benjamin Franklin (Figure 4-4), a New Post-Panamax vessel, called the Port of Seattle on February 29, 2016 as part of a trial deployment of these ultra-large containerships to U.S. West Coast ports from Asia.

Figure 4-4. The CMA CGM Benjamin Franklin calls the Port of Seattle in 2016 (Photo Credit: Don Wilson)



	2006	2007	2008	2009	2010	2011	2012	2013	2014
PPX Gen IV	0	0	0	0	0	0	0	0	0
PPX Gen III				3	9	2	1	17	82
PPX Gen II	54	48	47	59	135	236	177	135	104
PPX Gen I	332	338	278	274	266	172	191	176	108
Panamax	185	141	154	171	178	165	177	126	117
Sub-Panamax	119	85	115	113	107	155	90	62	32

Figure 4-5. Seattle Vessel Calls by Class, 2006-2014

Figure 4-6 displays percent cargo by vessel class for years 2010 to 2014. Total cargo movements on PPX Gen II or larger containerships grew from 32% in 2010 to 71% in 2014.

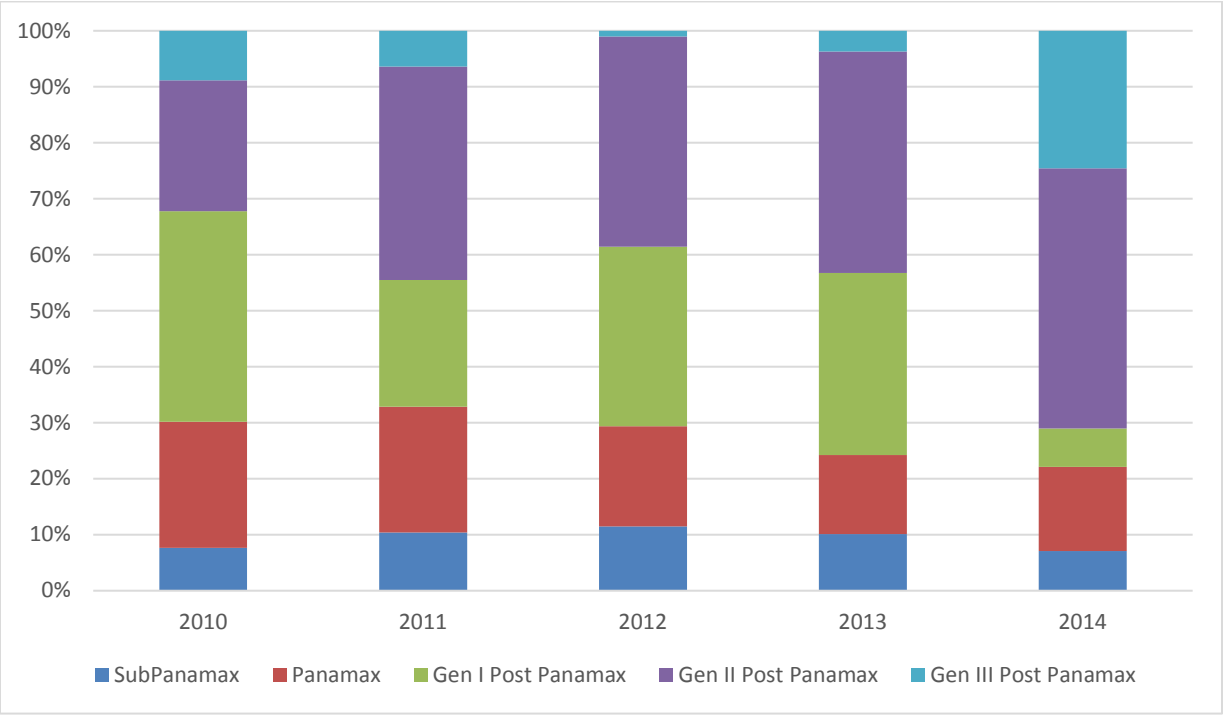


Figure 4-6. Total Tonnage by Vessel Class, 2010-2014

4.4.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

No changes to port hinterland are projected under the future without-project condition.

Commodity and TEU Volume: Future Without-Project Condition

To analyze the future without-project condition for Seattle Harbor, IHS Global Insight completed a trade forecast in 2015 specifically on containerized cargoes at the Port of Seattle for this feasibility study. The results of this forecast are summarized below. Additional information on the forecast is provided in Appendix A. The IHS Global Insight trade forecast for Seattle included 82 countries (e.g., China) or regions (e.g., Other Northeast Asia). First, the data by trade location was grouped by the world region where they are geographically located. The world regions included Asia, Middle East/Indian Subcontinent, Europe, Latin America and Caribbean, Oceania, Africa, and Canada. As presented in Table 4-5, these world regions were then combined into two route groups for Seattle Harbor based on historical services calling the Port, broadly defined as Route 1: Asia, and Route 2: Mediterranean. The Asia route group includes all trade with Asia, Oceania, and approximately half of the trade with the Middle East/Indian Subcontinent. The Mediterranean route group includes trade with Europe, Latin America and the Caribbean, Africa, and the remaining half of trade with the Middle East/Indian Subcontinent. Although Canada is a major trading partner with the United States, most of these cargos are not in the form of ocean transported containers; therefore, Canada was not included in the forecasts for these two route groupings.

Table 4-5. Seattle Route Groups and World Regions

Route Group	World Regions
Route 1: Asia	Asia, Oceania, and 50% of Middle East/Indian Subcontinent
Route 2: Mediterranean	Europe, Latin America & Caribbean, Africa, and 50% of Middle East/Indian Subcontinent

According to the IHS Global Insight forecast, Asian countries will rise in prominence as Seattle's premier trading partners. These countries will be demanding agriculture products and other raw commodities for growing populations and for processing into final goods for sale domestically and abroad. Examples of high-volume, high-growth containerized commodities moving out of Seattle include animal feed, fruits and vegetables, paper, and newspaper. Relatively slower growth rates for the Asia World Region in 2014-2020 compared to 2020-2035 reflect weaker world economic growth and a stronger U.S. dollar.

A loaded container forecast was developed using the containerized trade forecast for imports and exports and the average weight per loaded container (in terms of TEUs). Table 4-6 presents the total number of TEUs, including loaded and empty containers, by import and export as well as route group. Import TEUs are forecasted to grow from 793,000 TEUs in 2024 to 1.1 million TEUs in 2034 (an increase of 42.2%). Export TEUs are forecasted to grow from 1,095,000 TEUs in 2024 to 1,660,000 TEUs in 2034 (an increase of 51.6%). The compound average growth rate (CAGR) for each route represents the geometric average growth of imports and exports, which accounts for the effect of compounding over time. For Asia trade, exports are projected to grow from 972,000 TEUs to 1.5 million TEUs over the 10-year period at a CAGR of 4.2% per year. Further, Table 4-7 displays the forecasted metric tonnage used in the economic evaluation.

Table 4-6. Seattle Total TEU Forecast by Route for Imports and Exports (TEUs)

Total TEUs - Imports	2024	2029	2034	CAGR
Asia	703,100	863,227	999,993	3.59%
Mediterranean	90,211	107,670	128,464	3.60%
Total	**793,311**	**970,897**	**1,128,457**	3.59%
Total TEUs - Exports	**2024**	**2029**	**2034**	**CAGR**
Asia	975,331	1,240,854	1,473,717	4.21%
Mediterranean	119,456	152,453	186,300	4.54%
Total	**1,094,787**	**1,393,307**	**1,660,017**	4.25%
Total Overall TEUs	**2024**	**2029**	**2034**	**CAGR**
Asia	1,678,431	2,104,081	2,473,710	3.95%
Mediterranean	209,667	260,123	314,764	4.15%
Total	**1,888,098**	**2,364,204**	**2,788,474**	**3.98%**

Table 4-7. Seattle Containerized Trade Forecast – Import and Export Tons

Route Group	2014 Baseline	2024	2029	2034
Imports				
Asia	2,717,803	4,188,657	5,133,773	5,932,367
Mediterranean	511,327	687,702	813,330	962,668
Total Imports	3,229,130	4,876,359	5,947,103	6,895,035
Exports				
Asia	3,967,765	6,363,367	8,093,702	9,606,623
Mediterranean	598,771	962,723	1,221,085	1,484,168
Total Exports	4,566,536	7,326,090	9,314,787	11,090,791
Total Tonnage				
Asia	4,479,092	7,051,069	8,907,032	10,569,291
Mediterranean	3,827,901	5,839,082	7,168,188	8,379,203
Total Tons	8,534,301	13,689,457	17,408,489	20,697,414

Vessel Fleet Characteristics: Future Without-Project Condition

In addition to a commodity forecast, a forecast of the future vessel fleet is required when evaluating navigation projects. To develop projections of the future fleet calling at Seattle Harbor, the study team obtained a World Fleet forecast of containerships developed by Maritime Strategies Inc. (MSI). MSI used a methodology to forecast total capacity calling at Seattle Harbor and a breakdown of that capacity calling into containership size and TEU classes. The methodology developed by MSI was linked to the IHS commodity forecast data for U.S. West Coast and Seattle.

The initial forecast of containerized vessels through the year 2034 is depicted in Figure 4-7 and Table 4-7. These values were input into the Corps certified planning model HarborSym's Container Loading Tool (version 1.5.5.0), which then estimated the number of vessel calls required to satisfy the commodity forecast given the available fleet (see Section 4 of Appendix A).

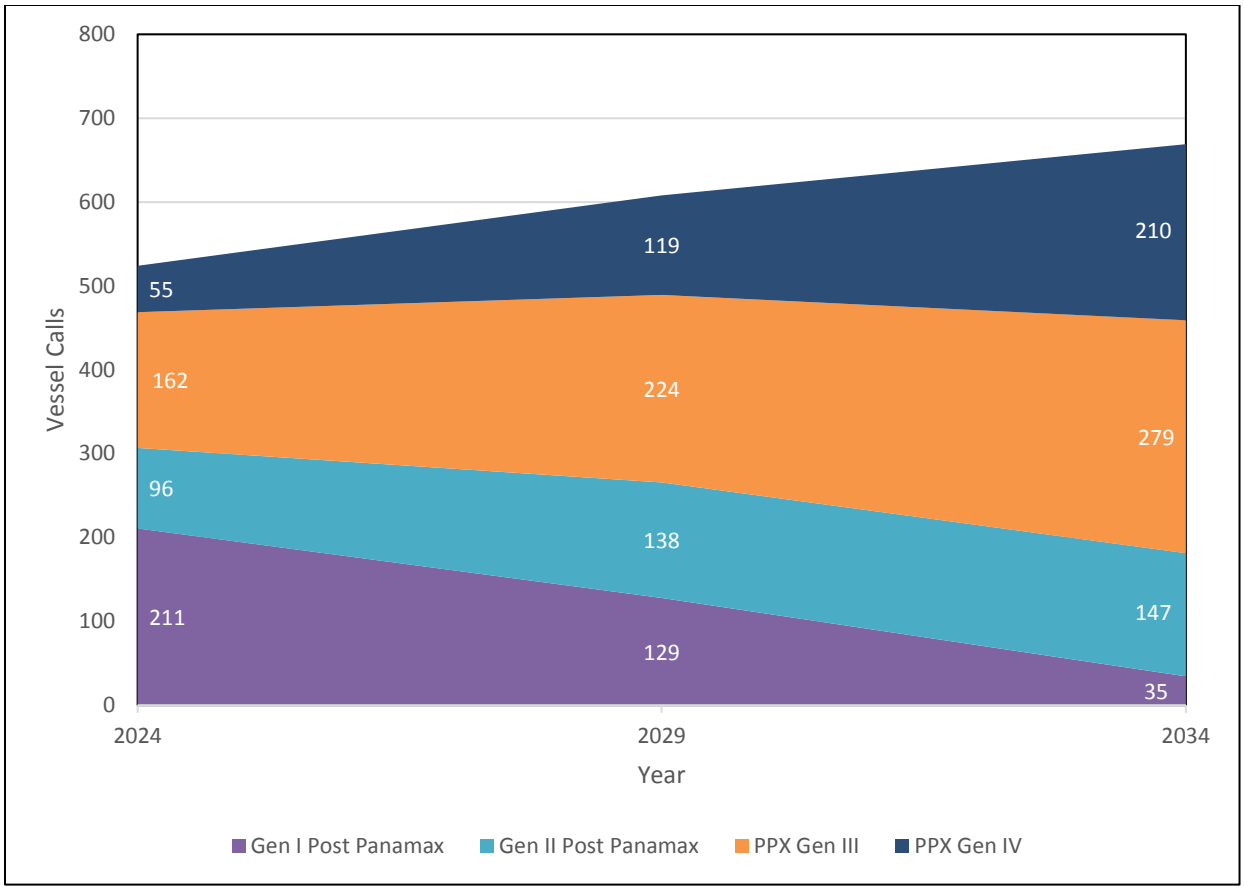


Figure 4-7. Baseline Forecast of Vessel Calls for Port of Seattle by Year

Transportation Costs

Transportation cost benefits were estimated using the HarborSym Economic Reporter, a tool under development by the Institute for Water Resources (IWR) that summarizes and annualizes HarborSym results from multiple simulations. This tool collects transportation costs from various model run output files and generates the transportation cost reduction for all project years, and then produces an Average Annual Equivalent (AAEQ). Results and calculations were verified using spreadsheet models as well.

Transportation costs were estimated for a 50-year period of analysis for the years 2024 through 2073. Transportation costs were estimated using HarborSym for the years 2024, 2029, and 2034. Since terminal capacity is not expected to be reached during the planning period of analysis, the transportation costs were held constant beyond 2034. The present value was estimated by interpolating between the modeled years. Transportation costs were annualized to determine AAEQ costs and savings by discounting the cost stream from year 2024 to 2034 at the current fiscal year 2016 Federal Discount rate of 3.125% using the transportation cost and savings information.

AAEQ transportation costs for the future without-project condition are estimated at $919,719,000, with a standard deviation of $6,247,000. Approximately 92-93% of this transportation cost is for time at-sea and the remainder is attributed to in-port costs from Port Angeles to the Port of Seattle. This cost serves as the baseline of comparison for cost savings afforded by the evaluated alternatives.

4.4.2 Alternative 2 – National Economic Development Plan

Under the NED plan, the economic analysis assumes the same commodity demand will exist in the future under this alternative as Alternative 1; however, the demand can be accomplished more efficiently with fewer vessel calls and increased loading of the future fleet. Vessel calls would be reduced in the future with-project condition due to more efficient loading (economies of scale) of the future fleet of containerships forecasted to call the Port of Seattle. For example, the total calls in 2024 would have an estimated reduction of 63 PPX Gen I calls to meet the forecasted commodity demand as a result of deepening the channel to -56 MLLW in the East and West Waterways. Further, estimated reductions of calls in 2029 is 94, consisting of 67 fewer PPX Gen I calls and 27 fewer PPX Gen II calls, and an estimated reduction of calls in 2034 is 101, consisting of 15 fewer PPX Gen I calls, 32 fewer PPX Gen II calls and 54 fewer PPX Gen III calls. Table 4-8 summarizes the vessel calls by year, class, and alternative.

Table 4-8. Vessel Calls by Year, Class, and Alternative

	Alternative 1: No Action	Alternative 2: National Economic Development Plan	Alternative 3: Locally Preferred Plan
Year 2024			
Panamax	0	0	0
PPX 1	211	148	148
PPX 2	96	96	96
PPX 3	162	162	162
PPX 4	55	55	55
Total	**524**	**491**	**491**
Year 2029			
Panamax	0	0	0
PPX 1	129	62	62
PPX 2	138	111	111
PPX 3	224	223	223
PPX 4	119	119	119
Total	**609**	**515**	**515**
Year 2034			
Panamax	0	0	0
PPX 1	35	20	20
PPX 2	147	115	115
PPX 3	279	225	225
PPX 4	210	210	210
Total	**671**	**570**	**570**

AAEQ transportation costs for the NED plan are estimated at $840,192,000. Approximately 92-93% of this transportation cost is for time at-sea and the remainder is attributed to in-port costs from Port Angeles to the Port of Seattle. The NED plan provides the greatest AAEQ benefits (cost savings between future with-project and future without-project conditions) of $108,807,000 and total net benefits of $94,857,000, and an overall BCR of 7.8 when all economic costs of this plan are taken into consideration. These benefits are attributable to the reduction in vessel calls required to satisfy the forecasted commodity demand.

4.4.3 Alternative 3 –Locally Preferred Plan

Under the LPP, the economic analysis assumes the same commodity demand will exist in the future under this alternative as Alternative 1; however, the demand can be accomplished more efficiently with fewer vessel calls and increased loading of the future fleet. Similar to Alternative 2 (NED plan), vessel calls would be reduced in the future with-project condition as the result of more efficient loading (economies of scale) of the future fleet of containerships forecasted to call the Port of Seattle under Alternative 3. Total calls are projected to be the same as Alternative 2 given current fleet projections. Given uncertainty in future design drafts and sailing drafts, this alternative may eliminate tidal delays for fully laden PPX Generation III and Generation IV containerships. This depth would meet the Puget Sound Pilots operating guidelines for underkeel clearance by providing a 10% underkeel clearance for all vessels transiting the East and West Waterways regardless of tide.

AAEQ transportation costs for the LPP are estimated at $839,407,000. Approximately 92-93% of this transportation cost is for time at-sea and the remainder is attributed to in-port costs from Port Angeles to the Port of Seattle. The LPP provides AAEQ benefits (cost savings between future with-project and future without-project) less than 0.1% lower than Alternative 2 at $109,592,000 and total net benefits of $94,691,000, and an overall BCR of 7.4 when all economic costs of this plan are taken into consideration. These benefits are attributable to the reduction in vessel calls required to satisfy the forecasted commodity demand.

4.5 Hydraulics and Geomorphology

The East and West Waterways flank Harbor Island, which is a large artificial island constructed on the delta of the Duwamish River in 1909. The Duwamish River has the seventh largest mean annual freshwater discharge into Puget Sound (Czuba et al. 2011). At its mouth, the Duwamish River empties into Elliott Bay, which is a naturally deep bay situated within the Central Puget Sound. Depths in Elliott Bay reach over 400 feet and it is sheltered by Alki Point to the south and West Point to the north.

Tides in Puget Sound are mixed semidiurnal in type. The mean tidal range published by the National Oceanic and Atmospheric Administration (NOAA) for Seattle, Washington is 7.66 feet. The greatest diurnal tidal range is 11.36 feet. Tidal data for Seattle, Washington are listed in Table 4-9.

Table 4-9. Tidal Data at Seattle NOS/CO-OPS station 9447130 (1983-2001 tidal epoch)

Datum	Value (feet)	Description
MHHW	11.36	Mean Higher-High Water
MHW	10.49	Mean High Water
MTL	6.66	Mean Tide Level
MSL	6.64	Mean Sea Level
MLW	2.83	Mean Low Water
NAVD	2.34	North American Vertical Datum
MLLW	0	Mean Lower-Low Water
Maximum	14.48	Highest Observed Water Level
Minimum	-5.04	Lowest Observed Water Level

The strongest and most frequent winds at Seattle are oriented from the north and south due to the geometry of the Central Puget Sound basin as shown in the wind rose in Figure 4-9. However, due to the

orientation of Elliott Bay, Seattle Harbor is predominantly sheltered from southerly winds and wind-generated waves.

Tidal currents in the East Waterway are relatively slow but stratified with depth. The bathymetry in the channel where the East Waterway connects to the Duwamish Waterway is very shallow (known as the "sill" between stations S3 and S4 in Figure 4-8) and limits the tidal flow through the waterway. Current speeds were observed to be less than 0.8 feet per second (ft/s) during the majority of four separate Acoustic Doppler Current Profiler deployments ranging from May to August 2009 (Anchor QEA 2012). At S1 at the mouth of the East Waterway, currents are faster in the upper 6m (20 feet) of the water column and decrease in speed with depth. The maximum current observed near the surface was 1.2 ft/s, while the maximum speed observed at the seabed was 0.9 ft/s. The net direction of flow in the top layer is north toward Elliott Bay while flow in the bottom layer is south toward the Duwamish Waterway.

Tidal currents in the West Waterway are stronger as the waterway conveys the majority of the tidal prism and Green/Duwamish freshwater discharge. The general circulation pattern in the inner bay is counterclockwise with Duwamish River flows discharging to the bay. This pattern can create eddies at the mouth of West Waterway during high river flows and during ebb tides. During flood tides with low river flow, long shore currents are reported to be in the range of 0.2 ft/sec. West Waterway flows reach as high as 1.4 ft/sec just below the water surface. The combination of tidal and river flows results in a consistent flow across the Site from west to east (EPA 1993, McLaren and Ren 1994, Tetra Tech 2008).

Figure 4-8. Current meter (red) and water level (green) observation stations in the East Waterway (EHI 2009).

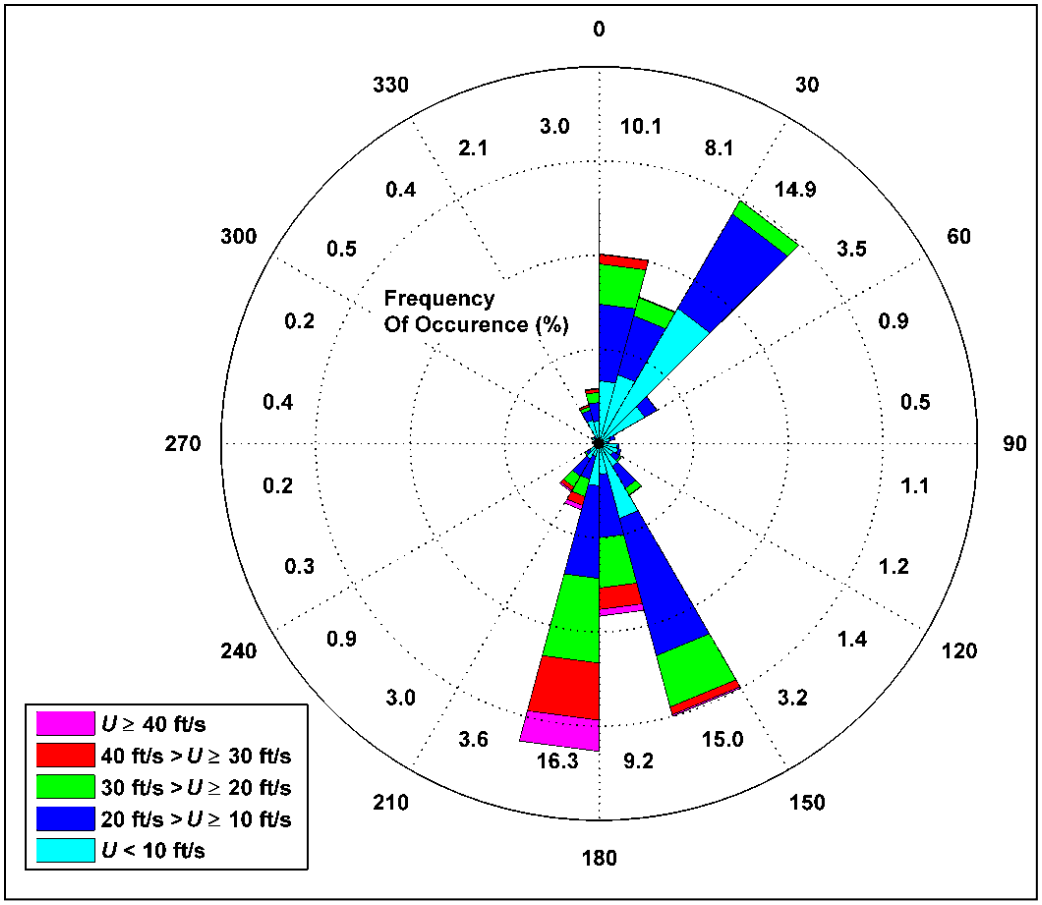


Figure 4-9. Wind Rose at West Point Coastal-Marine Automated Network station (1984-2007). Wind speeds are shown in feet per second, and directions are in degrees from true north (0°).

4.5.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

River discharge is regulated by Howard Hanson Dam and thus is not expected to significantly change. Periodic maintenance dredging in the Duwamish Waterway is assumed to continue, which limits the volume of sediment reaching the East and West Waterways. Therefore, due to the relatively low sedimentation rates in each waterway, it is anticipated the currents in the East and West Waterway would remain largely unchanged in the No-Action Alternative. Localized shoaling near the entrance to the West Waterway where bank encroachment (i.e. channel constriction) has been observed and in the "sill" area in the East Waterway north of the Spokane Street Bridge may result in localized changes in flow patterns.

In the West Waterway, the currents combined with the constriction of navigable depth at the entrance of the waterway are anticipated to continue to pose challenges for vessels serving T-5 during ebb flows and cross winds. In the future, as the vessel fleet continues to increase in size, the conditions will likely adversely impact the number of vessel calls in the future. The limiting depth in the West Waterway is currently -42 MLLW for the effective authorized width of 500 feet. Vessels would need to be light loaded or transit the harbor during high tides above MHHW (+11 feet), which significantly impacts the efficiency and could result in shippers finding ports with more hospitable conditions.

In the East Waterway, cross winds would continue to pose a challenge for vessels serving T-30. Due to obstructions including vessels berthed on T-18 and T-46, vessels are typically required to enter the

waterway with an orientation off center, which increases the effective beam width of the vessel. Without improvement to include a wider entrance channel reach, it is likely that impacts to efficiency would result in requiring transits to occur only during favorable wind conditions.

In 1949, both the East and West Waterways were dredged below their authorized depths by the Port of Seattle and others (USACE 1983). In 2000, the East Waterway was reauthorized and deepened to -51 MLLW from Sta. 0+00 to 60+00. O&M dredging has not been conducted since 1949 as the shoaling has not shoaled significantly enough above the authorized depth of -34 MLLW in the West Waterway and -34 to -51 MLLW in the East Waterway. Under the No-Action Alternative, based on historic shoaling patterns it is estimated the East Waterway would require approximately 100,000 cy of O&M dredging every 25 years to maintain the authorized depth of -51 MLLW. The West Waterway would require approximately 10,000 cy of O&M dredging every 25 years to maintain the authorized depth of -34 MLLW.

4.5.2 Alternative 2 – National Economic Development Plan

Removing the constriction in the West Waterway would result in more uniform currents throughout the waterway and minimize localized flow accelerations, which result in challenges for pilots transiting the entrance. The deeper channel is estimated to increase the amount of sedimentation in the waterway by trapping more sediment coming through the waterway. This is anticipated to cause an increase in O&M dredging quantities compared to the No-Action Alternative. Shoaling is estimated to increase by 3,000 to 6,000 cy a year on average in both waterways. In the West Waterway, it is estimated that 50,000 cy of O&M dredging would be required every 10 years. In the East Waterway, it is estimated that 75,000 cy of O&M dredging would be required every 10 years.

4.5.3 Alternative 3 – Locally Preferred Plan

Deepening and widening the approach reaches in each waterway would allow more efficient operation in each waterway, with similar effects as Alternative 2. The deeper channel would slightly increase the amount of sedimentation in the waterway by trapping more sediment coming through the waterway. This is anticipated to cause an increase in O&M dredging requirements. An additional 1-foot of depth associated with the LPP would cause an insignificant increase in sedimentation versus the NED plan.

4.6 Water Quality

Under the Clean Water Act, Washington Department of Ecology (Ecology) establishes standards for physical parameters of water such as temperature, pH level, dissolved oxygen, and chemical concentrations. Waters that do not meet standards are considered “polluted waters” and placed on a 303(d) list that Ecology publishes regularly (in reference to Section 303(d) of the Clean Water Act). Waters that have signs of diminished health but still meet standards are “waters of concern” on the 303(d) list (see Appendix C for a map of 303(d) listed waters in the project area). Portions of Elliott Bay and the Duwamish Waterway are on Ecology’s 303(d) list of threatened and impaired waters, listed as “polluted” for specific parameters, although the trend for water quality in the action area is one of overall improvement. The West Waterway is listed for polychlorinated biphenyl (PCB), dissolved oxygen (DO), and bacteria; the East Waterway is listed for high molecular weight polycyclic aromatic hydrocarbons (HPAHs). Turbidity is regulated as it pertains to healthy habitat for fish, invertebrates, and aquatic plants. In estuaries such as the project area, salinity is measured to determine the area and depth of fresh and

saltwater mixing; this information helps determine where specific aquatic species are expected to find suitable habitat. This section of the report covers the parameters of turbidity, DO, and salinity, while issues related to contaminants are covered in section 4.10, section 4.12, and section 4.17.

Turbidity refers to the clarity or clearness of the water. The greater the amount of total suspended solids in the water, the murkier it appears and the higher the measured turbidity. The East and West Waterways experience occasional high levels of suspended sediment typically occurring during the winter and late spring, which are likely due to intense precipitation of seasonal storm events. Data from U.S. Geological Survey (USGS) monitoring show that the Duwamish Waterway reaches its maximum suspended sediment levels generally from December through March.

DO in marine waters is essential for most healthy aquatic life. If levels are too low, it can be a sign of human-induced impacts such as excessive runoff or nutrients, or of natural causes such as seasonal variations. Healthy conditions for aquatic life exist when DO is above 5.0 milligrams per liter (mg/L). Concentrations between 5.0 mg/L and 3.5 mg/L are generally healthy, except for the most sensitive species. When concentrations fall below 3.5 mg/L, conditions become unhealthy. DO levels in the lower Duwamish do not always meet Ecology's standard of 6.5 mg/L. Excursions occur in middle and late summer when DO concentration drops due to increased ambient temperatures and reduced freshwater input. In the winter months, DO is typically well over 9 mg/L (USGS unpublished data).

Temperature has a strong influence on the aquatic organisms that can survive and thrive any particular habitat and can affect numbers, sizes, and distributions of biota. Temperature in the marine water of Elliott Bay is colder than the Duwamish River for most of the year, except for during the late summer when surface temperatures in the Bay may be slightly higher (King County 2014). The range of temperatures in the lower Duwamish Waterway fluctuates seasonally, throughout depths, and with tidal stage with a strong influence from Elliott Bay, which provides cool refuge for juvenile salmonids migrating through the area (Warner and Fritz 1995). The annual seasonal trend in Elliott Bay fluctuates from a low of 8°C in March to a high of 13°C in September measured at a depth of 10 meters (King County 2014). Long-term temperature data are not available for Puget Sound specifically; however, other Pacific Northwest locations indicate a long-term warming trend with an increase of 1°C from 1950 to 2005 (Snover et al. 2005).

The Green/Duwamish estuary is highly stratified regarding its salinity gradient. A distinct freshwater lens routinely flows over a saltwater wedge of higher density. The upstream excursion of the saltwater wedge varies based on the tidal stage and freshwater discharge on the Green/Duwamish River. At inflow rates less than 600 cfs and tide heights greater than 10 feet, some salinity has been detected up to river mile 10 (Santos and Stoner 1972). Recent Conductivity-Temperature-Depth measurements observed the toe of the saltwater wedge varying from river mile 3.75 (upstream of the 1st Avenue Bridge) to river mile 6.5 near the Duwamish River Turning Basin (McKeon and Horner-Devine 2015). The upstream extent of the salt wedge is dependent on freshwater inflow to the Lower Duwamish Waterway and tidal range.

4.6.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Turbidity and salinity within the project area are not anticipated to see any changes over the 50-year study period primarily because the general conditions of the two contributing waterbodies, the

Green/Duwamish River and Puget Sound, are not predicted to see substantial changes that would affect these parameters. The amount of DO in water is partly related to water temperature, which may be affected by global climate change over the 50-year period of analysis. As water temperature increases, less total DO can be concentrated within a given volume of water. The No-Action Alternative would not have any effect on the changes predicted to occur. The predicted rate of sea level change (SLC) for Seattle is expected to be a sea level rise between 0.5 and 2.8 feet by 2080. Salinity in the estuary may have a minimal increase to its upstream extent due to SLC (Hayter et al. 2015). The No-Action Alternative would have no effect to the long-term levels of temperature, turbidity, salinity, or dissolved oxygen. O&M dredging to maintain authorized depths is expected to be limited to approximately 100,000 cy every 25 years for the East Waterway and about 10,000 cy every 25 years for the West Waterway.

4.6.2 Alternative 2 – National Economic Development Plan

The duration of work would most likely be slightly less than the seven-month work window in two consecutive years to accomplish the channel deepening. Some dredged material may contain sediment with biological and/or chemical oxygen demand that could temporarily lower ambient DO levels during dredging. The sandy sediment is not especially hard-packed and is inhabited by infaunal and benthic organisms, thus the likelihood of finding much anaerobic sediment during dredging is small. Sediment with a biological oxygen demand will likely be a minor fraction, if any, of the material dredged (USACE 1983); therefore, the Corps anticipates little or no reduction in ambient DO during dredging. Removing material from the marine environment that has been determined unsuitable for aquatic disposal would be a net long-term benefit to water quality in the project area.

Clamshell dredging typically results in short-term increases in turbidity in a linear plume downcurrent from the dredging activity. Turbidity would be monitored during dredging to adhere to State water quality requirements as provided by the project's Water Quality Certification. Aquatic disposal can also impact turbidity, although in a more vertical column as dredged sediment falls to the sea floor in the target disposal zone. Monitoring is not required for disposal because according to the June 1988 Puget Sound Dredged Disposal Analysis Management Plan Report, the assumption is that disposal at the unconfined open-water sites will be limited to dredged material that meets specific management conditions and will have a minimal loss of fines to the water column (PSDDA Agencies 1988). Consequently, water column and surface monitoring will not be undertaken. Instead, monitoring conducted for the Dredged Material Management Program at the Elliott Bay site will focus on the benthic environment on or near the site. Monitoring at other disposal sites across the country has shown that maximum concentrations of suspended sediments during disposal activities were less than 1,000 mg/l (Pequegnat 1983), which would be a negligible effect at the Elliott Bay open-water disposal site. No long-term changes to any water quality parameters would result from construction.

Similar short-term effects would occur for each O&M dredging event anticipated to be required every 10 years for each waterway with a quantity of approximately 75,000 cy in the East Waterway and 50,000 cy in the West Waterway. Each maintenance dredging episode, based on a production rate of approximately 3,000 cy per day, this maintenance work would take approximately 42 days to achieve the authorized depth of -56 MLLW. No long-term changes to water quality parameters would result from construction.

To evaluate potential changes in salinity from deepening, the Corps used a predictive hydrodynamic model developed specifically for this waterway. Results indicate minor differences that never exceed +/- 1.5 practical salinity units; the change would be that the deepened channels would allow the salt wedge to propagate up to a half mile farther upstream during flood tides (Hayter et al. 2015). This study, conducted specifically for this project, indicated that SLC would have a greater effect on the saltwater wedge extent than would deepening both channels to -56 MLLW. With such a minor change of up to a half mile of the average upstream extent of the saltwater wedge within the maximum 10-mile extent, the salinity changes resulting from this alternative would not have a significant impact on environmental resources. The maximum extent would not change and the change in average extent would not alter any habitat types. For more detailed information, see Appendix B.

4.6.3 Alternative 3 – Locally Preferred Plan

The duration of work would most likely be throughout the seven-month work window in two consecutive years to accomplish the channel deepening. Similar to Alternative 2, the Corps anticipates little or no reduction in ambient DO during dredging. No aspects of the project could change the temperature regime. Although temporary increases in turbidity would occur, no long-term changes to any water quality parameters would result from construction. As with Alternative 2, the proposed channel improvement may cause a half-mile upstream migration of the maximum extent of the saltwater wedge; however, this change would not have any measurable effect to the types of habitat available in this reach of river. Effects of O&M for Alternative 3 would be essentially the same as for Alternative 2 to dredge the quantities that accumulate between O&M dredging events. Initial construction for Alternative 3 would take approximately one to two months longer than Alternative 2 and O&M dredging would have the same duration due to the expectation of a similar quantity of sediment accumulation for both alternatives.

4.7 Air Quality

The agencies with jurisdiction over ambient air quality in the project area are the U.S. Environmental Protection Agency (EPA), Ecology, and the Puget Sound Clean Air Agency. EPA is responsible for establishing the National Ambient Air Quality Standards (NAAQS). The NAAQS criteria pollutants of concern in the project area are carbon monoxide (CO), ozone (often evaluated by measuring ozone precursors such as reactive organic gases [ROGs] or volatile organic compounds [VOCs]), lead, nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM). PM is classified by size: PM_{10} refers to all PM 10 microns in diameter or smaller and $PM_{2.5}$ refers to all PM 2.5 microns in diameter or smaller. Ambient air quality standards as adopted by the State of Washington (WAC 173-476) appear in Table 4-10.

Table 4-10. NAAQS as adopted by the State of Washington**

Pollutant		Averaging Time	Level	Remarks	Measurement Method	Interpretation Method
Particle Pollution	PM-10	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year averaged over 3 years	40 C.F.R. Part 50, Appendix J	40 C.F.R. Part 50, Appendix K
	PM-2.5	Annual	12.0 $\mu g/m^3$	Annual mean, averaged over 3 years	40 C.F.R. Part 50, Appendix L	40 C.F.R. Part 50, Appendix N
		24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years		

Lead	Rolling 3-month average	0.15 $\mu g/m^3$	Not to be exceeded	40 C.F.R. Part 50, Appendix G	40 C.F.R. Part 50, Appendix R
Sulfur Dioxide	Annual*	0.02 ppmv	Not to be exceeded in a calendar year	40 C.F.R. Part 50, Appendix A-1 or A-2	WAC 173-476-130(3)
	24-hour*	0.14 ppmv	Not to be exceeded more than once per year		
	3-hour	0.5 ppmv	Not to be exceeded more than once per year		
	1-hour	75 ppbv	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years		
Nitrogen Dioxide	Annual	53 ppbv	Annual Mean	40 C.F.R. Part 50, Appendix F	40 C.F.R. Part 50, Appendix S
	1-hour	100 ppbv	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years		
Ozone	8-hour	0.075 ppmv	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years	40 C.F.R. Part 50, Appendix D	40 C.F.R. Part 50, Appendix P
Carbon Monoxide	8-hour	9 ppmv	Not to be exceeded more than once per year	40 C.F.R. Part 50, Appendix C	WAC 173-476-160(3)
	1-hour	35 ppmv			

*Annual and 24-hour SO2 standards have a "sunset provision". They will no longer apply to those areas that have been in attainment status (designated by EPA) for the one-hour SO2 standard for one year. (See WAC 173-476-130 and 40 C.F.R. 50.17 for additional details.)
**Table taken from http://www.ecy.wa.gov/programs/air/sips/pollutants/naaqs.htm
ppmv – parts per million (ppm) by volume, ppbv – parts per billion (ppb) by volume, $\mu g/m^3$- micrograms per cubic meter of air

Human exposure to diesel exhaust (a component of this project) and its associated release of PM, can contribute to increased risk of negative health effects such as lung cancer, chronic respiratory problems, and cardiovascular disease. Diesel emissions also are associated with impaired visibility, acid deposition, and climate change.

Where air quality does not meet NAAQS, the area is designated as a Non-Attainment Area. Areas that have always met NAAQS are designated as Attainment Areas. At areas previously designated as Non-Attainment, and where air quality has improved above NAAQS, the area is designated as a Maintenance Area. The Site is located in Attainment Areas for NOx, SOx, and lead; the Site is in Maintenance areas for ozone, carbon monoxide, and PM_{10}. Information about the Maintenance Areas for Seattle Harbor are detailed in Table 4-11. PM levels measured during the past three years at nearby monitoring stations (at Duwamish Valley, South Park, and 10th & Weller, Seattle) comply with the NAAQS for PM (Puget Sound Clean Air Agency 2016).

Table 4-11. CAA Maintenance Area Information for Seattle Harbor

Chemical	NAAQS	Date of Maintenance Area Designation
Ozone	0.12 ppm/1-hour period	6/15/2005
Carbon Monoxide	9 ppm/8-hour period	10/11/1996
PM_{10}	150 $\mu g/m^3$/24-hour period	5/14/2001

Since 2007, the Port has jointly developed and carried out the Northwest Ports Clean Air Strategy (NWPCAS). Emission reduction programs by the Port have included a voluntary At Berth Clean Fuels program for 2007 to 2014, which has eliminated over 850 metric tons of sulfur emissions (and associated PM). In 2015, At Berth Clean Fuels was replace by the North American Emissions Control Area (ECA) standard of 0.1% low sulfur fuel with 200 miles of the coast. In 2009 to 2010, the Port scrapped nearly 300 drayage trucks (i.e. short hauling distance of freight) and all pre-1994 engines were removed from the Port's drayage fleet. In 2014 to mid-2016, the Port scrapped over 200 additional drayage trucks and replaced them with trucks having model year 2007 or newer engines; funding is available for additional truck replacements. The scrapping program supports the NWPCAS target for port-found trucks to have a model year 2007 or newer engine by 2018. Radio frequency identification (RFID) is used to track clean truck compliance and terminal operators can use the same RFID for more efficient gate operations. In addition, more than half of the eligible cargo handling equipment has been retrofitted with exhaust controls, and the Port has piloted a program to install idle-reduction equipment on yard trucks. The 2011 Puget Sound Air emissions inventory estimated that Port of Seattle emissions of diesel PM dropped 27% - 38% from the 2005 baseline, reductions of other pollutants dropped 5% - 38% (Puget Sound Maritime Air Forum 2012).

Sources of air pollution during dredging projects would include the dredge vessel, tugboat, derrick machinery, and scow. For the alternatives analysis in this section, the quantity of potential air emissions was estimated using the following emissions factors:

- Non-road diesel equipment: emissions factors from the South Coast Air Quality Management District (SCAQMD). SCAQMD is the regulatory authority over air emissions in the south coast air basin in southern California.
- Harbor craft: emissions factors from EPA (2009).

The emissions estimate accounts for emissions associated with the operation of vessels and machinery with diesel engines used during dredging activities. These estimates are not intended as an exact calculation of the emissions associated with this project but rather as a means for comparison among the alternatives. Metric tons of CO; ROGs, which are ozone precursors; NOx; and PM were estimated and are reported below. Details about the emission estimates and emissions factors appear in Appendix C.

The ocean-going vessels that call at the Port of Seattle typically use large Category 3 marine diesel engines. Emissions from these vessels relevant to this discussion are quantified and reported as Diesel Particulate Matter (DPM) tons per year and goals are set to reduce total DPM output. These large ships contribute 78% of DPM emissions associated with port activities in Puget Sound with an output of 296 tons recorded for Port of Seattle in 2011 (Puget Sound Clean Air Agency 2013). The NWPCAS goal for DPM is to reduce emissions per ton of cargo by 80% from 2005 levels by 2020. Emissions from ships are expected to decrease significantly since the establishment of the North American Emission Control Areas (ECA). In 2010, the International Maritime Organization (IMO) designated the North American ECA, which includes waters 200 nautical miles or less from the coast. All vessels within the ECA must burn lower-sulfur fuel or achieve an equivalent emission reduction. The maximum allowable fuel sulfur limit was decreased to 1% in August 2012 and further decreased to 0.1% in January 2015.

4.7.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Taking no action to dredge the navigation channel would mean no short-term effects of construction equipment that has an output of diesel exhaust; however, there could be greater long-term effects to air quality if the transit efficiency of the channel is not improved compared to the action alternatives. Much of the existing containership fleet is comprised of Panamax or greater size vessels, with a shift to even larger vessels in the future. Without the proposed navigation improvements, these larger, deeper draft ships will have a narrower range of depths available through tidal restrictions for entry into the waterways. Therefore, ships may have to idle offshore from the Port while waiting for tidal conditions that allow depth for entry into the harbor. The gained efficiency in freight transport will not be realized and reduction in DPM emissions per ton of cargo may not be achieved through reduction of ship turn-around time. DPM emission reductions would still be expected through other strategies such as technology advancements and regulatory requirements. To meet targeted reductions in DPM emissions without increasing efficiency of ship turn-around time at the Port, the economic cost of achieving reductions may be shifted to more expensive upgrades in infrastructure or land-based equipment. The emissions for analysis is the 296 tons of DPM as recorded for 2011 (Puget Sound Clean Air Agency 2013), although this could increase if there are no improvements for transit efficiency. Annual DPM emissions for the year 2020 under the No-Action Alternative are estimated at 81.2 metric tons.

4.7.2 Alternative 2 – National Economic Development Plan

To analyze short-term construction effects of dredging on air quality, the Corps estimated dredging equipment emissions. The emissions estimate assumed one dredge operating with its associated tugboat, scow, and survey boat running 16 hours per day for 90 days in the East Waterway and 210 days in the West Waterway to achieve the length, width, and depths proposed. The total time for completion of the dredging for this alternative is 300 days over a two year period during the fish work window. It represents the most likely scenario for estimated material to achieve the goal in this alternative and is based on the same assumptions and quantities used for the cost analysis.

$PM_{2.5}$ enters the air through direct emissions and precursors. The precursors include SOx, NOx, ROGs, and ammonia. The EPA established 100 tons per year (TPY) as the *de minimis* emission level for NAAQS pollutants; the 100 TPY threshold applies separately to each pollutant (40 CFR 93 § 153). As shown in Table 4-12, based on the SCAQMD model for non-road emissions (2016), the estimated annual emissions from the operation of the dredges and associated vessels in Seattle Harbor would be 91.8 TPY and would not exceed the 100 TPY threshold. Ammonia is excluded as it is not an expected emission in this project. Emissions include numbers from both open water disposal and upland disposal. Total emissions for this alternative would be 183.6 tons for the 2 year duration of dredging.

Table 4-12. Estimated annual emissions associated with construction of the NED plan.

Air Pollutant	Estimated annual emissions in metric tons
Reactive Organic Gasses (ROGs)	3.5
Carbon Monoxide (CO)	10.5
Nitrogen Oxides (NOx)	68.5
Sulfur Dioxide (SOx)	5.8
Particulate Matter (PM2.5)	3.5

The short-term construction effects to air quality from dredging would not exceed *de minimis* levels for any NAAQS pollutants; therefore, a General Conformity Determination is not required.

Emissions due to O&M activities (i.e. maintenance dredging) were not estimated. The level of effort required for O&M activities will likely be higher under the NED Plan due to increased shoaling (see section 5.8.3 Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R)). Dredging events associated with OMRR&R are estimated to be needed once per 10 years. The volume of dredged material generated during maintenance dredging under the NED would be higher than under the No-Action Alternative. Associated air emissions would likewise be higher. However, the magnitude of air emissions associated with maintenance dredging activities are likely much smaller than those associated with regularly occurring port activities. It is likely that the air emissions reductions due to efficiencies gained under the NED would greatly outweigh any increases in emissions due to increased maintenance activities.

4.7.3 Alternative 3 – Locally Preferred Plan

For the LPP Alternative, the emissions estimate assumed one dredge operating simultaneously with its associated tugboat, scow, and survey boat running 16 hours per day for 114 days in the East Waterway and 268 days in the West Waterway to achieve the length, width, and depths proposed. This represents the most likely scenario for estimated material to achieve the depth goal, is based on the same assumptions and quantities used for the cost analysis, and comply with the required work windows.

The estimated annual emissions from the operation of the dredge and associated vessels in Seattle Harbor would be 101.1 TPY (Table 4-14). The short-term construction effects to air quality from dredging would not exceed *de minimis* levels for any NAAQS pollutants; therefore, a General Conformity Determination is not required. Emissions include numbers from both open water disposal and upland disposal. Total emissions for this alternative would be 202.2 tons for the 2 year duration of dredging.

Table 4-13. Estimated annual emissions associated with construction of the Locally Preferred plan.

Air Pollutant	Estimated annual emissions in metric tons
Reactive Organic Gasses (ROGs)	3.9
Carbon Monoxide (CO)	11.6
Nitrogen Oxides (NOx)	75.5
Sulfur Dioxide (SOx)	6.3
Particulate Matter (PM)	3.8

Under the No Action alternative, shipping total emissions would be 77,080 metric tons from 2020 through 2034. Deepening the two waterways would improve navigation efficiencies reducing the amount of emissions to 68,330 metric tons (Table 4-13).

Table 4-14. Estimated shipping NAAQS pollutant emissions of Alternatives 2 and 3 compared to the No-Action Alternative (2020-2034).

Air Emissions (figures in metric tons)	ROG	CO	NOX	SOX	PM	Totals
Alternative 1: No Action	2,840	4,910	59,270	8,430	1,630	77,080
Alternatives 2 and 3	2,510	4,350	52,570	7,460	1,440	68,330
Difference from No Action	-320	-560	-6,700	-970	-190	-8,750

Note: emissions estimated from ocean going vessels in transit, maneuvering and hoteling modes.

The long-term effects of improving navigation efficiency under the LPP at the Port of Seattle would mean the reduction in DPM emissions of approximately 190 metric tons as a cumulative total over the first 14 years following construction. The difference between emissions of all NAAQS pollutants under the No-Action Alternative and the LPP alternative are estimated in Table 4-13.

As described in Alternative 2, maintenance dredging would increase to being required on an approximately 10-year cycle compared to a 25-year cycle for the No-Action Alternative. Likely, the air emissions reductions due to efficiencies gained under the LPP could outweigh any increases in emissions due to increased maintenance activities.

4.8 Greenhouse Gas Emissions

The Earth's atmosphere is changing, the climate system is warming, and the changes are likely due in part to human activities that produce greenhouse gases (GHGs). GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and some hydrocarbons and chlorofluorocarbons. These compounds create a greenhouse effect when they accumulate in the Earth's atmosphere. They act as a layer of insulation, retaining within the Earth's atmosphere some of the thermal radiation that originated from the sun. GHGs can be produced both naturally and by human activities such as the combustion of fossil fuels and production of cement. CO_2 is naturally absorbed during some physiochemical and biological processes, but human activities can affect these processes. Projections for future emissions vary greatly based on the assumptions made about trends in human activities related to CO_2 production and absorption. Generally, however, the scientific community agrees that without significant changes to current policies and practices, CO_2 concentrations in the atmosphere will continue to increase.

Concern regarding the implications of global climate change is increasing across both the public and private sectors and within Federal, state, and local governments. The concern for Federal projects is the contribution of GHGs to the atmosphere in such large quantities as to outweigh the benefit of executing the proposed action. The most common source of anthropogenic GHG emissions is the burning of fossil fuels either by vehicles/equipment (e.g., vessels used to accomplish dredging and placement of dredged material) or to generate heat and power for buildings.

Sources of GHGs under the various project alternatives under consideration include mechanical bucket dredge, dump truck, excavator, bulldozer, tugboat, and locomotive. Emissions models that estimate total GHG emissions, expressed in metric tons CO_2 equivalent, were created for each project alternative. These estimates are not intended as an exact calculation of the emissions associated with this project but rather as a means for comparison among the alternatives.

4.8.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, the Corps would undertake no deepening activities; maintenance dredging would continue as usual in the Duwamish Waterway, and the Port of Seattle would continue to maintain its berths and areas adjacent to the Federal navigation channel. The Corps may conduct maintenance dredging to the currently authorized depth, which is anticipated to be required on a 25-year cycle. It is likely that the EPA will initiate construction associated with remediation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program for East Waterway OU and Lockheed West Seattle Superfund Site. It is unknown what the timing and scope of the

CERCLA projects, as well as the Corps maintenance dredging, would be. No effects from deepening would occur under the No-Action Alternative.

Estimated GHG emissions due to long-term, indirect effects under the No-Action Alternative are approximately 256,000,000 metric tons CO_2 equivalent. A comparison of GHG emissions under the No-Action Alternative to emissions under other alternatives can be found in Table 4-16.

4.8.2 Alternative 2 – National Economic Development Plan

A direct impact of dredging under the NED proposal will be the generation of 16,911 metric tons CO_2 equivalent GHG emissions (Table 4-15). These emissions would occur during the two-year construction season, adhering to the limitations of work windows. Statewide GHG emissions in 2012 were estimated at 92 million metric ton CO_2 equivalent (Ecology 2015). Assuming statewide GHG emissions are constant in the near future, the direct annual GHG emissions from the NED Alternative would comprise approximately 0.00009% of the total statewide annual GHG emissions.

Table 4-15. Greenhouse Gas Emissions for the NED Alternative

Greenhouse Gas	Estimated emissions in metric tons CO_2 equivalent
*Carbon Dioxide (CO_2)	16,875
**Methane (CH_4)	36
TOTAL GHG Emissions	16,911

*Estimate for CO_2 includes emissions for all work elements (dredge, tug, and upland disposal)
**Estimate for CH4 includes emissions for dredge and associated equipment only.

Improved shipping efficiencies associated with the NED Alternative could result in a net reduction of approximately 29.8 metric tons CO_2 equivalent as compared with the No-Action Alternative (Table 4-16).

Table 4-16. Estimated shipping GHG emissions after completion of the alternatives compared to the No-Action Alternative (2020 – 2034)

	Metric Tons of GHG		Metric Tons CO_2 equivalent	Difference from No Action
No Action	CO_2	256,333,300	256,333,300	-
	CH_4	31,800	1,081,000	-
	Total:	256,365,000	257,414,300	-
NED Alternative	CO_2	226,700,300	226,700,300	-29,633,000
	CH_4	28,100	956,000	-125,000
	Total:	226,728,400	227,656,400	-29,757,900
LPP Alternative	CO_2	226,700,300	226,700,300	-29,633,000
	CH_4	28,100	956,000	-125,000
	Total:	226,728,400	227,656,400	-29,757,900

Note: emissions estimated from ocean going vessels in transit, maneuvering, and hoteling modes.

GHG emissions due to O&M activities (i.e. maintenance dredging) were not estimated. The level of effort required for O&M activities will likely be higher under the NED due to increased shoaling (see section 5.8.3 Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R)). Dredging events associated with OMRR&R are estimated to be needed once per 10 years. The volume of dredged material generated during maintenance dredging under the NED would be higher than under the No-Action Alternative. Associated GHG emissions would likewise be higher. However, the magnitude of GHG emissions associated with maintenance dredging activities are likely much smaller than those associated

with regularly occurring port activities. It is likely that the GHG emissions efficiencies gained under the NED would greatly outweigh any increases in emissions due to maintenance activities.

4.8.3 Alternative 3 – Locally Preferred Plan

A direct impact of dredging under the LPP Alternative will be the generation of 18,931 metric tons CO_2 equivalent GHG emissions. These emissions would occur during the two-year construction season, adhering to the limitations of work windows. Statewide GHG emissions in 2012 were estimated at 92 million metric tons CO_2 equivalent (Ecology 2015). Assuming statewide GHG emissions are constant in the near future, the direct annual GHG emissions from the LPP Alternative would comprise approximately 0.0001% of the total statewide annual GHG emissions, or roughly 10% greater than Alternative 2.

Table 4-17. Greenhouse Gas Emissions for the Locally Preferred Plan Alternative

Greenhouse Gas	Estimated emissions in metric tons CO_2 equivalent
*Carbon Dioxide (CO_2)	18,891
**Methane (CH_4)	40
TOTAL GHG Emissions	18,931

*Estimate for CO_2 includes emissions for all work elements (dredge, tug, and upland disposal)
**Estimate for CH_4 includes emissions for dredge and associated equipment only.

Improved shipping efficiencies resulting from the LPP Alternative include a net reduction of approximately 29.8 metric tons CO_2 equivalent as compared with the No-Action Alternative (Table 4-16). Maintenance dredging would increase compared to the No-Action alternative, and would be required on an approximately 10-year cycle. The Corps anticipates that the Port of Seattle's continuing efforts toward reducing GHG emissions could outweigh the slight additional emissions from maintenance dredging.

4.9 Sea Level Change

Sea level change (SLC) is an uncertainty, potentially increasing the frequency of extreme water levels. Planning guidance in the form of an USACE Engineering Regulation (ER), USACE ER 1100-2-8162 (USACE 2013), incorporates new information including projections by the Intergovernmental Panel on Climate Change and National Research Council (IPCC 2007, NRC 2012). The ER requires that projects be evaluated to determine how sensitive they are to various scenarios of future SLC. Since predictions of future SLC have uncertainty, the risks associated with three SLC scenarios are addressed. These scenarios are termed low, intermediate, and high and correspond to different rates of global sea level acceleration starting from year 1992. Historically, this global (eustatic) sea level rise rate has been approximately 1.7 mm per year.

Locally, SLC varies geographically as it is the difference between the global SLC (1.7 mm/year according to IPCC 2007) and local vertical land movement. The accuracy of local mean sea level rates is a function of the period of record of the water level time series. ER 1100-2-8162 recommends that a NOAA water level station should be used with a period of record of at least 40 years. Table 4-18 lists the predicted SLC at Seattle, Washington for the low, intermediate, and high scenarios.

The project footprint includes only the East and West Waterways, thus there are no bridge clearance concerns associated with the project. The biggest potential risk associated with SLC is inundation to the LSF, including the piers, sea cranes, and utilities serving the berthing areas.

Table 4-18. Predicted sea level change (in feet) at Seattle, Washington per EC 1165-2-212. (The base year and economic life cycle year are in bold).

Year	Low	Int	High	Year	Low	Int	High
1992	0.00	0.00	0.00	2070	0.53	1.07	2.78
2015	0.16	0.20	0.35	**2074**	**0.55**	**1.15**	**3.05**
2024	**0.22**	**0.31**	**0.60**	2080	0.60	1.28	3.47
2025	0.22	0.32	0.63	2085	0.63	1.40	3.84
2030	0.26	0.39	0.79	2090	0.66	1.52	4.22
2035	0.29	0.46	0.98	2095	0.70	1.64	4.63
2040	0.32	0.53	1.18	2100	0.73	1.77	5.05
2045	0.36	0.61	1.40	2105	0.76	1.90	5.50
2050	0.39	0.69	1.64	2110	0.80	2.04	5.96
2055	0.43	0.78	1.90	2115	0.83	2.18	6.44
2060	0.46	0.87	2.17	2120	0.87	2.32	6.94
2065	0.49	0.97	2.47	2124	0.89	2.44	7.35

Impacts to the LSF are assessed using statistics from historical water levels combined with the predicted SLC scenarios. The 99% annual exceedance probability (AEP; or 1-year return period) of the measured total water level (TWL) at the Seattle tide gauge is added to each SLC scenario. If SLC coupled with the 99% AEP total water level exceeds the deck height of the terminals on the waterways, it is assumed to be in a condition that would require significant structural modifications. Table 4-19 indicates that the deck height of the terminals are presently high enough to avoid inundation for all scenarios with the exception of the 2124 High SLC scenario. This indicates there is a low overall risk to the LSF at the project over the 50-year project life cycle.

Table 4-19. Deck height of each Terminal at Seattle Harbor and predicted SLC scenarios

Terminal	Deck Height (feet, MLLW)	2074 Low/High + 1-year TWL[1] (feet, MLLW)	2124 Low/High SLC + 1-year TWL[1] (feet, MLLW)
T-5	18.5	13.4 / 15.9	13.7 / 20.2
T-18	18.5		
T-30	18.5		
T-46	18.0		

[1] 1-year TWL (99% Annual Exceedance Probability) is 12.82 feet MLLW (NOAA 2015);

4.9.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Due to the low sedimentation rate in each waterway, it is assumed SLC would increase the navigable depth over time and reduce the amount of O&M dredging required to maintain the authorized depths. Appendix B describes the predicted shoaling rate in each waterway in more detail. However, the amount of SLC would not significantly improve the conditions in either waterway to achieve project objectives. The limiting depth in the West Waterway is currently -42 MLLW. It is anticipated that the average infill over the 50-year project life in each waterway is approximately 1 foot. Thus, only the intermediate and high level SLC scenario would produce an increase in navigable depth. This increase in navigable depth would range between approximately 0 and 2 feet over the 50-year project life cycle.

4.9.2 Alternative 2 – National Economic Development Plan

Following implementation of the NED plan, it is anticipated that the historical shoaling rate in the navigation channel will increase. It is anticipated that the average infill of over the project life in each waterway is approximately 1 foot every 10 years. O&M dredging would occur on a 10-year interval to maintain the authorized channel depth. SLC is expected to reduce the amount of O&M dredging required to maintain the authorized channel depth. The intermediate and high level SLC scenarios may also decrease the frequency of O&M dredging events.

4.9.3 Alternative 3 – Locally Preferred Plan

Following implementation of the LPP, it is anticipated that the historical shoaling rate in the navigation channel will increase. It is anticipated that the average infill over the project life in each waterway is approximately 1 foot every 10 years. O&M dredging would occur on a 10-year interval to maintain the authorized channel depth. SLC is expected to reduce the amount of O&M dredging required to maintain the authorized channel depth. The intermediate and high level SLC scenarios may also decrease the frequency of O&M dredging events

4.10 Hazardous, Toxic, and Radiological Waste

Due to the highly industrialized nature of the project area, numerous sites containing hazardous substances as described in ER 1165-2-132, *Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects*, exist in and near the project area. Two CERCLA sites exist within the project area: The Lockheed West Seattle Superfund Site and the Harbor Island Superfund Site. Figure 4-10 identifies these Superfund Sites and OUs (areas designated to manage various cleanup strategies on different schedules) in the vicinity of the East and West Waterways. This section summarizes what CERCLA action has been taken or is planned to occur in the vicinity of the project area.

West Waterway Superfund Sites & Operable Units

Lockheed West Seattle Superfund Site: The Lockheed West Seattle Superfund is located at the entrance to West Waterway on the western corner adjacent to T-5. A ROD for the site was issued in August 2013. The selected remedy calls for dredging of more than 151,000 cy of sediment from the subtidal area and an additional 16,000 cy excavated or dredged from the shoreline and intertidal area. Design and construction of the remedy is being initiated.

Harbor Island Superfund Site:

Todd & Lockheed Shipyard Operable Units (2): Todd and Lockheed Shipyards are two smaller OUs within the Harbor Island Superfund Site. The Record of Decision (ROD) for the Lockheed and Todd Shipyard OUs was signed in November 1996 (EPA 2010). These OUs were remediated in 2007 and 2005, respectively. No future remediation actions are anticipated for these OUs.

West Waterway Operable Unit: Sediments in the West Waterway OU are less contaminated than sediments in adjacent shipyard areas (i.e., Lockheed West Superfund Site, Todd and Lockheed shipyard OUs). Environmental investigations and site-specific risk assessments found that chemical concentrations in marine sediments within the West Waterway OU do not pose unacceptable risks to human health and the environment and the selected remedy was the “no action” alternative (EPA 2003). No future remediation actions are anticipated for this OU.

East Waterway Superfund Sites & Operable Units

Harbor Island Superfund Site:

East Waterway Operable Unit: A ROD for the East Waterway OU of the Harbor Island Superfund Site has not yet been completed. A draft feasibility study for the site was completed in January 2014 and provided an evaluation of the contamination at the site and an array of remediation alternatives for potential implementation. A final feasibility study is estimated to be complete in late 2016. Following finalization of the East Waterway remediation supplemental feasibility study, EPA will issue a Proposed Plan and ROD to identify the selected alternative for design and construction of a remedy in East Waterway (Anchor QEA and WindWard Environmental, LLC 2014).

The draft CERCLA supplemental feasibility study for the East Waterway (Anchor QEA and WindWard Environmental, LLC 2014) proposed a range of alternatives to address the contamination in the sediments. The alternatives vary in their emphasis and combinations of technologies for remediation. Several remedial technologies are common to all the alternatives. These include physical removal (e.g., dredging) of contaminated sediments, containment (e.g., isolation capping) of contaminated sediments, enhanced natural recovery (i.e., placement of a thin layer of material to accelerate natural recovery processes), in situ treatment that adds activated carbon or other sequestering agents to sediments to reduce the bioavailability and toxicity of contaminants, or monitored natural recovery that reduces surface sediment concentrations. The final feasibility study anticipated by the end of 2016 may recommend one or more of these technologies in a recommended alternative.

Figure 4-10 identifies the Superfund Sites and OUs in the vicinity of the East and West Waterways.

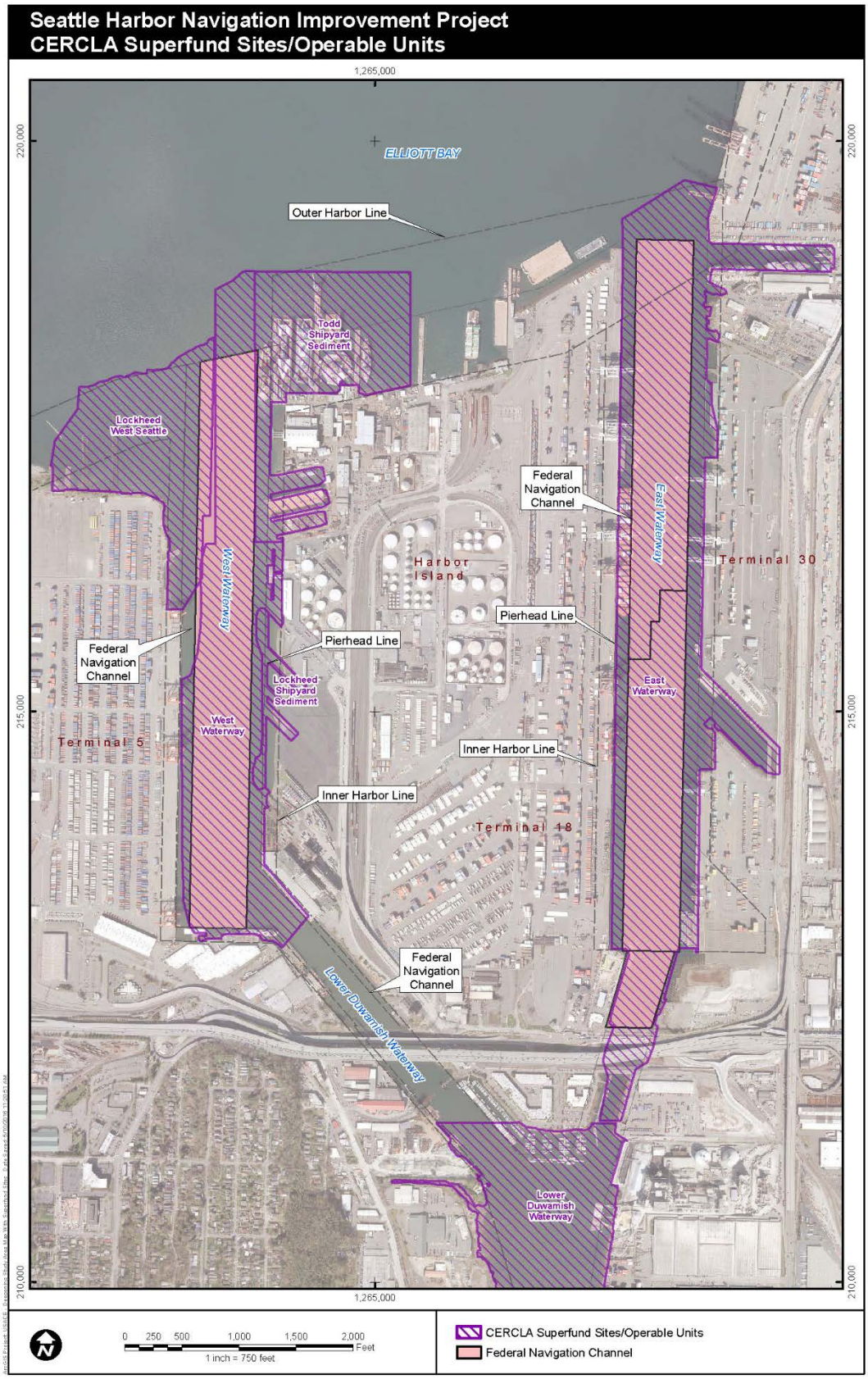


Figure 4-10. CERCLA Superfund sites/OUs in the vicinity of East and West Waterways

4.10.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

In the future without-project condition, CERCLA actions will continue to move forward on the East Waterway OU and Lockheed West Superfund Site. For the East Waterway OU, EPA will issue a Proposed Plan and ROD to identify a selected alternative for design and construction. For the East Waterway OU, it is assumed that action at Seattle Harbor under the Civil Works GI program would occur after actions under CERCLA. For the Lockheed West Superfund Site, design and construction is being initiated. For the West Waterway OU, Lockheed Shipyard OU, and Todd Shipyard OU, no additional actions are assumed to occur.

4.10.2 Alternative 2 – National Economic Development Plan

Under the NED plan, contaminated sediments in West and East Waterways would be dredged. Approximately 726,000 cy of material suitable for open-water disposal and 178,000 cy of material unsuitable for open-water disposal would be generated by this action. Furthermore, some of the dredged material generated by this action would meet the CERCLA definition of HTRW.

Key Assumptions

It is assumed that action at Seattle Harbor under the Civil Works GI program would occur after actions under CERCLA. Section 5.2.2 describes assumptions for dredged material disposal based on suitability determination and CERCLA testing results. Material that meets suitability requirements of the DMMP will be disposed of at the Elliott Bay open-water disposal site (USACE 2015a). Material unsuitable for open-water disposal will require upland disposal. It is assumed that all material unsuitable for open-water disposal generated during construction of the Seattle Harbor project would meet the definition of HTRW according to ER 1165-2-132, *Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects*. It is further assumed that costs of removal and disposal of unsuitable material will be treated as HTRW for cost sharing purposes and the non-Federal sponsor will bear 100% of these costs (USACE 2015b).

Suitability Determination and Disposal Assumptions

Assumptions regarding quantities of dredged material requiring upland disposal are based on Dredged Material Management Program (DMMP) and CERCLA testing results. These testing results and associated assumptions regarding quantities for upland disposal may not provide sufficient data to confirm in-water or upland disposal assumptions during the feasibility phase. More or less upland disposal may be required, which is a more costly disposal method. Section 5.2 describes key assumptions regarding suitability determination and disposal assumptions for each waterway. The study team has developed conservative estimates for the quantity of material requiring upland disposal. In addition, the risk of potential change in quantities for upland disposal has been included in the cost schedule risk analysis and associated cost contingency.

Potential Effects

Resuspension of contaminated sediments are proportional to the amount of dredging and the concentration of contamination. Assuming a 1% sediment resuspension rate, approximately 9,000 cy of material would be resuspended during the course of construction. Only a portion of this amount would consist of resuspended material from the upper contaminated layers of sediments. Coarser sediments redeposit close to the dredge location; finer particles travel further downstream before resettling. Dredging of contaminated sediments also releases contaminants into the dissolved phase (i.e. into the

water column). Resuspended contamination will tend to settle downstream; finer particles from Seattle Harbor dredging may reach Elliott Bay before settling. Resuspension occurs with much greater severity when subsurface debris is encountered. This is due to the dredging bucket not being able to close fully (because it is obstructed by debris) before removing sediments to the surface.

Contaminant resuspension and dissolved phase effects can be mitigated to a degree by environmental dredging best management practices (BMPs). It is assumed that all appropriate and feasible BMPs to reduce contaminant resuspension will be implemented depending on the nature of the sediment. However, some resuspension of contaminants during dredging is unavoidable, even with implementation of BMPs. It is assumed that dredging of the most contaminated material will occur under EPA direction according to CERCLA and will not be part of this deepening action.

4.10.3 Alternative 3 – Locally Preferred Plan

Impacts due to resuspension of contaminated sediments under the LPP are similar to the impacts under the NED plan. This is due to the fact that the areal extent of the dredging is similar between the two plans and because the contaminated sediments are located in the uppermost layers of sediments in West and East Waterways. Dredging an additional 1 foot in the relatively cleaner sediment at depth will not add substantially to the exposure of downstream waterway users and organisms to contamination. However, additional sediment would be resuspended from the additional dredging (approximately 2,000 cubic yards more than under the NED Plan, assuming a 1% sediment resuspension rate). No additional HTRW concerns would apply to this additional resuspended sediment. See 4.17.3 for a description of changes to human health risks under the LPP.

4.11 Benthic Organisms

Several factors determine which benthic macroinvertebrate species inhabit estuarine and marine habitats. These factors are primarily the substrate, period of inundation, and salinity as well as energy, typically in the form of currents and/or wave action. The area where work is proposed, also known as the affected environment, is at the bottom of the channels of the East and West Waterways. The habitat classification is estuarine subtidal (Dethier 1990). The Waterways are deep channels with polyhaline salinity levels. Due to extensive dredging to create these navigable channels and the entirely artificial Harbor Island, the estuarine habitat was excavated much deeper than an average estuary. The depth of the waterways ranges from -39 MLLW to -59 MLLW. The average speed of water currents at these depths is around 0.2 ft/s (McLaren and Ren 1994). The substrate is primarily sand and silty sand (USACE 2015a).

Given these habitat conditions of deepwater, polyhaline, low energy, and primarily sandy substrate, the benthic invertebrate community most likely consists of tube-dwelling polychaete worms, the Ostracod class of Crustaceans, deposit feeding clams, and brittle stars (Dethier 1990). Since the East and West Waterways are known to suffer from pollution, they are likely dominated by the Capitellidae and Cirratulidae families of polychaete worms, and nematodes (Dethier 1990). Limited characterization of the benthic invertebrate community in the Waterways has been conducted. Targeted sampling for tissue collection by Windward (2009) found six crab species including Dungeness and red rock crab, various bivalve species, sea stars, sea urchins, and anemones.

While dredging typically causes short-term loss of non-mobile benthic invertebrates and a temporary reduction in abundance and diversity, many of these areas become recolonized by benthic fauna that move in from neighboring habitat (McCauley et al. 1977, Richardson et al. 1977). Abundance and diversity of the benthic assemblage may be able to recover and become similar to those of the benthic community that existed previously depending on depth, substrate, and other factors.

Benthic invertebrates typically occupy the top few millimeters of sediment; therefore, differing dredging quantities among the alternatives do not make a substantial difference in the numbers of organisms lost to dredging. The total surface area of disturbance for each alternative provides the best parameter to compare environmental effects of the alternatives to benthic organisms.

4.11.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, no changes to the Federal navigation channel substrates would occur for the purpose of improved navigation. The CERCLA remediation actions will occur regardless of which alternative is selected in this navigation improvement feasibility study. The sediment removal operations that will be part of the remediation actions under CERCLA will remove the benthic invertebrates associated with the substrate being excavated for clean-up, which is a small footprint within the large area of the waterways. The purpose of these actions is to result in a less polluted substrate, which may lead to changes in community structure, diversity, or abundance of organisms toward a more diverse community that is more representative of natural conditions with greater abundance of organisms.

4.11.2 Alternative 2 – National Economic Development Plan

As stated above, surface area dredged is the key parameter to analyze rather than quantities for effect to benthic organisms. The surface area that would be dredged in each waterway for this alternative is 84.8 acres in the East Waterway and 93.0 acres in the West Waterway for a total of 177.8 acres. The dredging would take two years to complete, largely due to the limitation of the in-water work window of July 16 through February 15; therefore, the areas in which the benthic organisms are eliminated would not be the total surface area in a single dredging event. This would allow organisms to migrate from undisturbed areas into the deepened segments. Recovery begins with the early colonizers and takes less than a year for the short-lived organisms with rapid growth and re-population strategies; this is followed by the longer-lived species that generally grow larger but have a slower recovery time of two to three years (Newell et al. 1998). The benthic community at the depth range in these waterways is not an important prey source to the federally protected species or other commercially important species present; therefore, the effects to benthic organisms from dredging, which would only endure for up to three years after dredging is complete, are not a significant impact to this ecosystem. Additionally, O&M dredging would likely occur on a 10-year cycle or less as SLC may reduce the need, and the dredging area for maintenance would be much smaller than the area for deepening; therefore, the benthic organisms would likely reach an equilibrium community condition between O&M dredging events.

4.11.3 Alternative 3 – Locally Preferred Plan

Alternative 3 differs from Alternative 2 primarily in depth, with only a slightly larger area (i.e. less than 1%) due to the need for stable side slopes in the channel substrate. Therefore, the scale of effects to

benthic macroinvertebrates resulting from Alternative 3 would be expected to be nearly indiscernible from the effects of Alternative 2.

4.12 Fish

The estuarine waters of the mouth of the Duwamish Waterway provide habitat for various fish species. For this analysis, fish are separated into two categories: resident marine/estuarine species and anadromous salmonid species.

Resident Marine/Estuarine Species

Abundant marine fishes in the area include Pacific staghorn sculpin, starry flounder, English sole, shiner perch, threespine stickleback, and Pacific herring. This area provides rearing habitat for herring, perch, sculpins and other fishes. The flatfish such as starry flounder and sole rest on the bottom and are associated with finer substrates. Sculpins are also found near the bottom and are associated with rocky or armored substrates in the project area.

Forage fish present include Pacific herring, surf smelt, longfin smelt, and sand lance. These fish are primarily pelagic and would be swimming through the area looking for food; sand lance burrow into sandy substrate and remain from dusk to dawn. Forage fish larvae are ubiquitous in Puget Sound and are a common component of the nearshore plankton. None of these forage fish species spawn within the lower Duwamish Waterway, likely due to the modified shoreline and lack of intertidal gravel and sandy beaches. Larvae and juveniles prey on epibenthic invertebrates and crustaceans and are themselves important prey items for larger juvenile salmon and bull trout.

Anadromous Salmonid Species

Nine stocks of anadromous salmonid species have been documented in the Duwamish Waterway: summer/fall Chinook salmon, fall coho salmon, fall chum salmon, sockeye salmon, pink salmon, summer/winter steelhead, coastal cutthroat trout, bull trout, and Dolly Varden. These multiple migratory runs of native and hatchery-reared salmonid stocks occur seasonally in Elliott Bay and the Duwamish Waterway. Salmonid use of Elliott Bay is predominantly as a migration corridor. However, some rearing and foraging by juvenile salmonids is likely, particularly in the limited shoreline areas with some structural diversity. Returning adult salmon congregate at the mouth of the Duwamish prior to upstream migration and juvenile salmonids may use the nearshore reaches to transition into marine waters.

Fish, especially salmon and steelhead, are considered a tribal resource. The Muckleshoot and Suquamish tribes have fisheries for these species in the project area. The Corps has carefully analyzed impacts to tribal resources along with the environmental impacts to fish. Documentation of coordination with tribes and a description of effects to tribal resources appear in Chapters 6 and 7 of this document.

Habitat Conditions

Fish habitat along the shorelines of the project area is limited by shoreline armoring and overwater structures. The shorelines of the project area are nearly 100% modified to artificial condition, covered in riprap and sheet pile to stabilize the shoreline and retain fill for the industrial development, which began in the early 1900s (King County 2001). Studies that have investigated effects of shoreline armoring indicate that salmonid densities and species diversity are lower along riprap banks than natural banks (Knudsen and Dilley 1987, Beamer and Henderson 1998). Toft et al. (2007) found that shoreline modifications have

the greatest effect on nearshore fish communities where the modifications extend from above the high tide line down to the subtidal zone, which is the case in the project area. Overwater structures in the form of piers for ship loading are prevalent along the shorelines of the project area. This shading affects the community of the subtidal organisms that serve as fish food, or habitat structure in the form of eelgrass and kelp (Nightingale and Simenstad 2001). Piers and other overwater structures can inhibit juvenile salmon migration as physical barriers, shading that causes avoidance, and by causing susceptibility to predation (Simenstad et al. 1982). The project area contains no kelp or eelgrass patches.

Section 4.10 in this report discusses contaminants in the sediments of the project area and risk of resuspension. Several areas have been determined to require remediation due to their levels of PCBs, PAHs, TBT and other contaminants. Effects of PCBs to salmon include impaired growth and increased mortality after disease (Varanasi et al 1993, Arkoosh et al. 1998). PAHs and PCBs have been detected in fish from the Duwamish estuary and these are correlated to sub-lethal health effects in fish including reproductive impairment and liver tumors (Malins et al. 1984, Stein et al. 1992).

Baseline conditions include regular disruptions every two to four years to the aquatic habitat for fish from maintenance dredging of ship berths adjacent to the federally authorized navigation channels of the East and West Waterways. Dredging can cause fish to avoid areas due to noise of dredges and associated vessels. To minimize impacts to salmonids, dredging schedules observe fish work windows, which are timing restrictions to times of year when juvenile salmonids are least likely to be present. The in-water work window for protection of salmonids in the East and West Waterways is July 16 through February 15. Other minor disturbance in the fish migration corridor occurs when large shipping vessels transit the channel and displace fish due to underwater noise and physical presence.

4.12.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, the depth and substrate of the Federal navigation channels would not change for the purpose of improved navigation, and the disturbance regime of routine maintenance dredging in the berths would continue. Remediation actions under CERCLA would occur and result in short-term construction effects. Intermittent effects from O&M dredging come from the anticipated need for dredging approximately 100,000 cy from the East Waterway and 10,000 cy from the West Waterway every 25 years. In a long-term effects analysis, according to economic forecasting, the No-Action Alternative would have approximately 671 calls per year of the Post-Panamax size classes.

4.12.2 Alternative 2 – National Economic Development Plan

Dredging for deepening is expected to temporarily displace the bottom-dwelling resident fishes such as flounder, sole, and sculpins. Dredging activity affects only a small area at any given time of the total construction project and the benthic fishes are expected to return the area as the dredge moves to each sequential portion of the channel. The dredge equipment operates in a very small footprint compared to the 84.8 acres of the East Waterway channel and 93.0 acres of the West Waterway channel; therefore the mobile and migratory fish have a broad area for avoidance of the dredge equipment. The duration of construction would be two construction seasons using only the allowable in-water work windows to avoid disturbance effects to the most sensitive species.

Most forage fish do not occur in the benthic areas of the water column of navigation channels and thus are not affected by maintenance dredging. Those that might be transiting navigation channels are not associated with one location, are highly mobile, and can avoid dredging operations, especially clamshell dredges due to the extremely low risk of entrainment. Although sand lance burrow into sandy substrates, it is assumed they would not select an area undergoing active dredging, and if dredging commenced where sand lance were present, they are at low risk of entrainment by clamshell dredges. The effect to the school of fish would be discountable. The Corps does not anticipate any detectable effect of maintenance dredging on forage fish.

Effects of dredging on the anadromous salmonids are short-term and include noise and visual disturbance from the dredging activities and increased turbidity during dredging that may cause a minor delay of adults during upstream spawning migration. However, adult migrating salmonids are unlikely to be delayed or diverted by an active dredge because the adults can easily swim around a dredge operation without any delay in their migration. Any turbidity plume would be localized and of short duration as the sand settles quickly through the water column and would not be expected to extend more than several hundred feet downcurrent from the dredge. Juvenile salmonids typically move downstream in spring, generally follow the shoreline away from dredge equipment, and are substantially protected by the in-water work closures; therefore, they are unlikely to be affected by dredge and disposal operations. The same is true for the O&M dredging that would be required for both action alternatives at approximately 75,000 cy in the East Waterway and 50,000 cy in the West Waterway every 10 years, which would take approximately 42 days to accomplish in each event. The effects of the project on threatened and endangered species are discussed in more detail in section 4.13.

The planned upgrades at T-5 will require the Port of Seattle to install sheet piles along a reach of the West Waterway. The negative effect to fish from this work would be the underwater noise, which is discussed in section 4.14. This is considered a short-term effect and is not a change to the type of habitat under the piers because the area is already armored with overwater structures. Although not part of the Federal action, it is included here as a cumulative effect because this work is reasonably certain to occur.

Any sediments determined to be unsuitable for aquatic disposal will be hauled off site to an appropriate upland disposal site. While this removes contaminated sediment from the aquatic environment, some amount of resuspension will occur during the dredging process, estimated at approximately 1% or 9,000 cy for the proposed action (see section 4.10.2 for discussion of resuspension). Bioaccumulative toxins appear in fish tissues collected throughout the Puget Sound region, and especially in urban areas (Puget Sound Action Team 2007). Concentrations of PCBs and other bioavailable contaminants in biota, including edible species, will have a minor increase during dredging. The increase in contamination concentrations in biota is a temporary effect which will persist for a number of years following cessation of dredging. The resulting removal of sediment would be a net long-term benefit to the aquatic environment in the Waterways, especially for bottom-dwelling fish that often test positive for contaminants in Puget Sound.

Economic forecasting has identified a substantial long-term benefit for the aquatic habitat: by the year 2034, navigation improvement is expected to reduce the number of vessel calls from 671 per year to 570 per year compared to the No-Action Alternative. This 15% reduction in vessel calls would reduce disturbance not only to fish in the Waterways, but also throughout the shipping channel in Puget Sound.

4.12.3 Alternative 3 – Locally Preferred Plan

All short-term and long-term effects described for the NED Plan are essentially the same for the LPP. Dredging to 1 foot deeper would have no discernible difference for bottom-dwelling fish, forage fish, or salmonids as they migrate through the area. The only difference would be that construction for the LPP would take one month longer to remove the additional sediment. As discussed in section 4.10.3, the additional sediment would not measurably contribute to the quantity of contaminants that may become resuspended. The need for O&M dredging would be the same 10-year cycle as for Alternative 2, compared to the 25-year cycle for Alternative 1. The LPP would achieve the same long-term benefit as the NED plan of a 15% reduction in forecasted vessel calls, which could not be achieved by the No-Action Alternative.

4.13 Wildlife

The project area is primarily the aquatic habitat of the high-use navigation channels surrounded by the industrial port infrastructure and activities. The marine mammals most likely to be present include harbor seals, California sea lions, and rarely orca whales. A variety of marine birds typical of developed areas in Western Washington occur within the project area. Other significant bird species recorded in the project area include bald eagle, Peregrine falcon, osprey, Caspian tern, and great blue heron. Birds and marine mammals in the project area are assumed to be habituated to the industrial port activities.

4.13.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, no dredging for deepening the East or West Waterways would occur and the O&M cycle of approximately 25 years would continue as maintenance is needed to maintain the currently authorized channel depths. The existing baseline conditions are expected to continue.

4.13.2 Alternative 2 – National Economic Development Plan

Noise effects of dredging for deepening may temporarily displace a small number of marine mammals and birds from the immediate area surrounding the dredge, but effects would not be widespread or even reach to the other waterway (see section 4.15 for discussion of underwater noise). The minor amount of turbidity would have a discountable effect on foraging opportunities for diving birds and marine mammals. Concentrations of PCBs and other bioavailable contaminants in biota may increase during dredging. The increase in contamination concentrations in biota is a temporary effect, which would persist for a number of years following cessation of dredging. The resulting removal of sediment would be a net long-term benefit to the aquatic environment in the Waterways. No long-term changes to wildlife use of the project area is anticipated.

4.13.3 Alternative 3 – Locally Preferred Plan

The effects described for the NED Plan would be essentially the same for the LPP. The additional quantity of material would take about one month longer to dredge; however, it would not be expected to contain bioaccumulative toxins since it is deeper than the depth where these primarily occur.

4.14 Threatened and Endangered Species

Nine species or distinct population segments (DPS), that are listed as threatened or endangered under the Endangered Species Act (ESA) potentially occur in the Elliott Bay reach of Puget Sound or the lower Duwamish Waterway (M. Longenbaugh, pers. comm., 2016). These are provided in Table 4-20 with their listing status and critical habitat status.

Table 4-20. ESA-listed species that may occur in the project area according to USFWS and NMFS.

Species	Listing Status	Critical Habitat
Bull trout (Coastal/Puget Sound DPS) (*Salvelinus confluentus*)	Threatened	Designated
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Designated
Puget Sound Steelhead (*Oncorhynchus mykiss*)	Threatened	Proposed; navigation channels only
Bocaccio (*Sebastes paucispinis*)	Endangered	Designated; disposal site only
Canary rockfish (*Sebastes pinniger*)	Threatened	Designated; disposal site only
Yelloweye rockfish (*Sebastes ruberrimus*)	Threatened	Designated; disposal site only
Green sturgeon (southern DPS) (*Acipenser medirostris*)	Threatened	Designated; none in project area
Southern resident killer whale (*Orcinus orca*)	Endangered	Designated; disposal site only
Marbled murrelet (*Brachyramphus marmoratus marmoratus*)	Threatened	Designated; none in project area

The proposed Federal action considered under NEPA includes dredging in the waterways, aquatic and upland disposal. Under ESA, the future capital improvement projects such as berth deepening or slope stabilization are not considered a Federal action for consultation because this work does not depend on the Federal action for its justification and because it has independent utility apart from the Federal action. Future non-Federal improvements would be executed by the Port of Seattle or Northwest Seaport Alliance and would undergo their own ESA compliance. The disposal of material at the Elliott Bay Open-Water Disposal site has already undergone ESA Section 7 consultation and is therefore not included in the ESA effects determination for the proposed deepening. Therefore, effects of non-Federal improvements and disposal are analyzed for cumulative impacts under NEPA, but only the effects of Federal navigation channel dredging are analyzed for an effects determination under ESA. The Corps will prepare a Biological Assessment (BA) to analyze the Tentatively Selected Plan during feasibility-level design phase. The BA will be submitted to NMFS and USFWS pursuant to ESA Section 7 consultation procedures. A preliminary determination appears in this document.

The action area for this analysis includes the East and West Waterways from approximately 500 feet downstream from the West Seattle Bridge northward to include inner Elliott Bay. The areas identified for proposed navigation improvement do not extend downstream from the federally authorized navigation channels; however, the directional flow of the river toward Elliott Bay can cause effects of dredging to transit beyond the immediate construction area.

Chinook and steelhead use the action area as a migratory corridor; bull trout do not spawn in the Green/Duwamish watershed but may use the action area for foraging and overwintering. The components

of this estuary that rearing juvenile Chinook and steelhead typically use, such as shallow water habitat and distributary channels, were eliminated more than a century ago. Juvenile rearing occurs upstream from the action area in the Duwamish Waterway. While residing in upper estuaries as fry, juvenile Chinook have an affinity for benthic and epibenthic prey items. As the juveniles grow and move to deeper waters with higher salinities, this preference changes to pelagic items such as decapod larvae, larval and juvenile fish, drift insects, and euphausiids (Simenstad et al. 1982). It is assumed that by the time juvenile Chinook reach the action area, with its depths at -34 to -51 MLLW, their diet preference has shifted to pelagic prey. Steelhead are typically age 2+ when emigrating from their natal watersheds and seaward outmigration occurs in spring. Once they have reached the action area, they are moving through rapidly according to their life history (Clements et al. 2012). The nearshore zones of the action area do not likely support much feeding or refuge due to extensive armoring of the shoreline.

The three ESA-listed species of rockfish tend to inhabit deeper water with rocky substrate and only water with salinity greater than 28 parts per thousand (ppt; MBC Applied Environmental Sciences 1987, Yamanaka et al. 2006); the East and West Waterways are considered an estuarine mixing zone generally ranging from 12-28 ppt. Therefore, few if any adult rockfish are expected to inhabit the Waterways. Although juveniles inhabit shallower water than adults, they are also associated with rocky areas with kelp cover and sandy areas with eelgrass beds. None of these habitats are present in the action area. There is only a slight chance the larval stage of these species would be present at the project site because at this life stage they are pelagic drifters at the mercy of the currents. All three life stages of rockfish are very unlikely to be in the action area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation (kelp and eelgrass).

Green sturgeon are rare in Puget Sound, but tagged fish have been detected in summer as well as winter months in relatively low numbers (Lindley et al. 2011). No spawning occurs in Puget Sound, so the vulnerable larval and juvenile life stages would not be present.

The southern resident killer whales spend considerable time in the Salish Sea from late spring to early autumn, with concentrated activity in the inland waters of the state of Washington around the San Juan Islands, and then move south into Puget Sound in early autumn. While the southern resident killer whales are annually sighted in Elliott Bay, they are not known to enter the navigation channels around Harbor Island. Several factors affect survival and well-being of killer whales, but the main factors are physical disturbance of behavior patterns by boat noise or intrusive boating activities, reduction of food source (primarily adult resident Chinook salmon), and bioaccumulation of persistent bioaccumulative toxins.

Marbled murrelets are permanent residents of Puget Sound, but the species is not abundant anywhere in Puget Sound (Speich and Wahl 1995); they are only rarely sighted in Elliott Bay (Seattle Audubon Society 2015). The primary prey items for marbled murrelets in Puget Sound include Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea harengus*), and krill (euphausiids) (Burkett 1995). Since marbled murrelets generally stay close to shore and away from populated and industrial areas, they are unlikely to be present in the navigation channels or the Elliott Bay disposal site.

4.14.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, no dredging for deepening the East or West Waterways would occur and the O&M cycle of approximately 25 years would continue. With the channels remaining at their current depths, ships would continue to observe and increase their implementation of some of the non-structural measures identified in section 3.1 such as tug assists, high tide transiting, and light loading. The additional tug assists required due to shallow channels would mean increased tugboat traffic over the study period. High tide transiting would mean that ships slow down as they navigate southward through Puget Sound to time their arrival at the Port of Seattle. Light loading would have the effect of causing a higher number of ships to transit Puget Sound to carry all the anticipated cargo. The existing baseline conditions are expected to continue. If no channel deepening occurs, according to economic forecasting through the year 2034, approximately 671 vessel calls would be required per year among the Post-Panamax size classes to be able to load and unload the quantity of cargo and commodities predicted.

4.14.2 Alternative 2 – National Economic Development Plan

Dredging for the NED plan would likely involve deployment of one operating dredging plant with associated scows and tugboats. These would be operating 16-20 hours per day for the entire work window and would take two years of operating six to seven months per year to complete the work during the in-water work windows. The majority of the material is expected to be suitable for aquatic disposal and will be placed at the Elliott Bay Multi-user Dredged Material Disposal site in Puget Sound (Figure 5-2), for which ESA consultation has been concluded (see Appendix D for consultation documents). Any sediments determined unsuitable for aquatic disposal will be hauled off site to an appropriate upland disposal site, which would have no effect to any ESA-listed species. O&M dredging would involve removal of 75,000 cy from the East Waterway and 50,000 cy from the West Waterway every 10 years.

Salmonid Species

Dredging effects to Coastal/Puget Sound bull trout, Puget Sound steelhead, and Puget Sound Chinook salmon would be limited to short-term disturbance primarily during the adult migration period. Dredging via clamshell in Puget Sound is conducted mid-July to mid-February, when bull trout are not expected to be present (Goetz et al. 2004). Summer run steelhead immigration occurs May to October and winter run steelhead immigration occurs from December through April. While construction overlaps each run, adult steelhead can easily avoid the dredging operation in the wide area of aquatic habitat available. Since juvenile steelhead typically emigrate in spring and move quickly though nearshore areas, they would not encounter dredge and disposal operations due to the work window closure during their migration. Adult Chinook immigrate through the project area in late July through September and are also capable of avoiding dredging operations. Juvenile Chinook initiate their arrival in late January, but the majority of outmigrants arrive after the in-water work window has closed; therefore, very few juveniles would experience the minor effects of elevated turbidity directly downstream from the dredge in a narrow band within the waterways that are over 700 feet wide. Clamshell dredge buckets have almost no risk for entrainment or other mortality for salmonids. Dredging the waterways would allow fish passage along either shoreline away from the dredge operation. Because of construction timing, dredge type, and location of dredges, there will be discountable effects to bull trout, steelhead, and Chinook.

Potential effects to salmonids from disposal of the dredged material are discountable due to numerous factors. First, the disposal action is unlikely to affect navigation of adults and is located at sufficient distance from the mouth of the river to not affect their migratory path. Second, salmonids are not likely to be present in the disposal area because there are no physical features that attract congregations of salmon. Third, the potential for bioaccumulation for contaminants of concern from the material being disposed has been found to be discountable (USACE 2007).

Habitat limiting factors for salmonids in the Green/Duwamish estuary are listed as dredging and channelization that eliminated mudflats and marshes, reduced riparian function, a straightened and shortened channel, and polluted stormwater and wastewater effluent (Kerwin and Nelson 2001). None of these factors would be affected by the proposed action. The Corps' preliminary analysis of effects to the primary constituent elements of critical habitat for bull trout (USFWS 2005), Chinook (NMFS 2005), and steelhead (NMFS 2005) is that dredging would have either no effect or discountable effects.

Georgia Basin Rockfish Species

The navigation channels and disposal sites are considered separately in the analysis of impacts to rockfish. Three life stages are considered: larvae are not able to swim directionally, juveniles are larger and able to swim to preferred habitats, and adults are strongly associated with rocky substrates deeper than 160 feet (Love et al. 2002). Larval rockfish are present in surface waters in central and south Puget Sound apparently with two peaks of seasonal abundance that occur in early spring and late summer (Greene and Godersky 2012). According to Love et al. (2002), the larval stage of the ESA-listed rockfish species do not occur in the intertidal, nearshore, or shallow shelf habitats of Puget Sound; therefore, dredging would have no effect to larval rockfish. Juveniles settle in nearshore rocky habitat or in kelp forests (Love et al. 1991), but this habitat type is not associated with the proposed dredging in the East and West Waterways primarily because the nearshore zone is at least 150 feet away from the channels and has a variety of armoring types that are not suitable rocky habitat. Adult rockfish are not expected to occur in navigation channels as the channels are in shallower brackish water away from marine deep, rocky habitat and are not near typical spawning locations. Dredging in the navigation channels would have a discountable effect to rockfish due to the extremely low likelihood of their presence.

Adults of all three ESA-listed rockfish species have been documented within 1 mile of the Elliott Bay open-water disposal site and likely use the area periodically (Greene and Godersky 2012); therefore, there is potential for exposure of adult as well as larval rockfish to disposal of dredged material. Juveniles would not be present due to their use of nearshore rocky habitats and kelp forests, which are not present at the deepwater disposal site. Disposal at the Elliott Bay site may have adverse effects to larval rockfish, which is covered in a recent Biological Opinion issued by NMFS for continued use of the DMMP sites (NMFS 2015). The conclusions in this document, dated December 17, 2015 are that larval rockfish would be harmed or killed if they are exposed to the dumping of dredged sediments; however, the number of larval rockfish lost due to disposal of sediment is so small as to have an inconsequential impact on abundance, productivity, and diversity for each species as a whole. Adult yelloweye rockfish are unlikely to be present at the Elliott Bay site due to a lack of suitable habitat; adult canary rockfish and bocaccio may be present, but would be able to avoid the dumping of dredged material and suspended sediment levels would rapidly drop to background levels. Effects of disposal of material on rockfish are discountable.

The East and West Waterways are excluded from rockfish critical habitat; however, the Elliott Bay non-dispersive disposal site is within designated deepwater (deeper than 90 feet) critical habitat for adult rockfish. Overall effects to the primary constituent elements of the rockfish critical habitat, such as prey resources, water quality, and habitat structure would not be substantially altered and effects for initial construction as well as maintenance dredging on a 10-year cycle are considered discountable.

In a cumulative effects analysis under NEPA, construction at T-5 may temporarily displace any rockfish associated with the riprap; however, few rockfish are expected to be in such shallow water compared to their preferred depths of greater than 160 feet.

Green Sturgeon

Any adults present during dredging and disposal would be able to avoid construction disturbances; therefore, impacts are considered discountable. Critical habitat does not include Puget Sound.

Southern Resident Killer Whale

Noise from dredging operations and transport to the Elliott Bay disposal site would attenuate in a short enough distance as to not cause harm (see section 4.15 Underwater Noise). Effects to prey species from the proposed action are negligible and will not reduce populations; therefore, there are no effects to killer whales from this factor. Tugboats with barges are slow moving, follow a predictable course, do not target whales, and should be easily detected by all marine mammals. Vessel strikes are unlikely and potential for effects from vessel strikes is therefore discountable. The rate of resuspension is estimated at 2-5% of PCBs by mass with an increased bioavailability for approximately two years. This minor fraction would have a negligible effect to killer whale prey items and an undetectable contribution to the whales themselves. Analysis for the ESA consultation on continued use of the DMMP disposal sites concluded that effects of transport and disposal of dredged material containing biomagnifying substances to killer whales are discountable. A summary of the rationale provided is that the DMMP uses rigorous testing procedures to quantify effects and disposal sites are showing generally similar or lower concentrations of contaminants compared to nearby locations. The complete analysis appears in the USACE (2015c) Biological Assessment and the NMFS (2015) Biological Opinion, which are hereby incorporated by reference. The NED plan would result in 15% fewer vessel trips to transport the forecasted cargo, which would mean reduced underwater noise throughout the northern half of Puget Sound on a daily basis, year-round.

Critical habitat includes marine waters of Puget Sound, but rivers and streams flowing into Puget Sound are excluded; the northern ends of the East and West Waterways overlap the demarcation line of critical habitat and the Elliott Bay disposal site is included. The proposed action may have negligible effects to Southern resident killer whales and their critical habitat due to minor underwater noise from dredging, but these effects would not be significant or have a longer duration than the dredging operations.

Marbled Murrelet

The preference for forage fish, which tend to remain in nearshore environments, means marbled murrelet exposure to contaminants through the proposed dredging is discountable, since the forage fish themselves have little chance to encounter contaminants through bioaccumulation as a result of dredging. Should a marbled murrelet coincidentally be present in the disposal area during a discharge event, potential take from collisions is extremely unlikely as tugs and barges travel slowly, allowing marbled murrelets to quickly flee from the approaching barge. Marbled murrelets would be expected to avoid any

sediment plume while feeding, especially since their prey would likely avoid a sediment plume as well. Effects to marbled murrelets from dredging and disposal would be minor in intensity and brief duration.

Summary of Impact Assessment

Disturbances to ESA-listed species have been determined to be of minor intensity and short duration. Considering cumulative effects, the anticipated construction for T-5 on the West Waterway would occur during the in-water work window for protection of salmonids and would not change any characteristics of the lack of suitable habitat under the pier decking. Effects of underwater noise are described in section 4.14 and have been determined to be insignificant. As stated in earlier sections, economic forecasting has identified a substantial long-term benefit for the aquatic habitat: by the year 2034, navigation improvement to -56 MLLW is expected to reduce the number of vessel calls from 671 per year to 570 per year compared to the No-Action Alternative representing a 15% reduction in vessel calls. The combined effects of dredging, disposal, and slope stabilization would not constitute a significant impact to the ESA-listed species in the project area.

4.14.3 Alternative 3 – Locally Preferred Plan

All short-term and long-term effects described for the NED Plan are essentially the same for the LPP. Dredging to 1 foot deeper would have no discernible difference for ESA-listed species. The only difference would be that construction for the LPP would take one month longer to remove the additional sediment. O&M dredging would be needed on the same 10-year cycle as for Alternative 2. Deepening the channel to -57 MLLW would achieve the same long-term benefit of a 15% reduction in forecasted vessel calls by 2034 compared to the No-Action Alternative.

The Corps' preliminary effects determinations for the two action alternatives are presented in Table 4-21. As stated previously, the Federal action considered under ESA is only the dredging work and does not include disposal that has already undergone ESA consultation, or construction that would be executed by the Port of Seattle. Analysis is provided here to determine whether effects are significant under NEPA.

Table 4-21. Preliminary effects determinations for ESA-listed species and their critical habitat where applicable under the proposed Federal action.

Species	Effects Determination for Alternatives 2 and 3	Critical Habitat Effect Determination
Bull trout (Coastal/Puget Sound DPS) (*Salvelinus confluentus*)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Puget Sound Steelhead (*Oncorhynchus mykiss*)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Bocaccio (*Sebastes paucispinis*)	May Affect, Not Likely to Adversely Affect	N/A
Canary rockfish (*Sebastes pinniger*)	May Affect, Not Likely to Adversely Affect	N/A
Yelloweye rockfish (*Sebastes ruberrimus*)	May Affect, Not Likely to Adversely Affect	N/A
Green sturgeon (southern DPS) (*Acipenser medirostris*)	No Effect	N/A

Southern resident killer whale (*Orcinus orca*)	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Marbled murrelet (*Brachyramphus marmoratus marmoratus*)	No Effect	N/A

4.15 Underwater Noise

Ambient noise conditions underwater in Puget Sound have many contributors including shipping traffic to the Ports of Everett, Seattle, and Tacoma, U.S. Navy activities, the Washington State ferries, cruise ships, commercial fishing vessels, and recreational boats. The mean ambient level in most marine waters is 80-100dB_{RMS} (Richardson et al. 1995). Activities at the Port of Seattle that directly generate or contribute to underwater noise include container ships, tugboats, cargo handling equipment, and rail and truck traffic that cause ground vibrations around the project area.

The major groups of animals in Puget Sound that can be affected by underwater noise are fish, diving birds, pinnipeds (seals and sea lions), sea otters, and the two types of whales, mysticetes (baleen whales) and odontocetes (toothed whales). The species of focus for this analysis are the ESA-listed salmonids and rockfish, and the marine mammals most likely to occur in the project area, primarily harbor seals and sea lions, and rarely killer whales. Marbled murrelets are not known to be present in the area and other diving birds are assumed to be capable of fleeing the area at the onset of noise disturbance.

Intrusive noise levels can have behavioral and physiological effects on animals. Behavioral consequences are actions such as abandoning hunting, diving or increasing swimming speed to flee the area, interrupted communication between individuals or pods, attempts to shield the young, and even panic and stranding (Richardson et al. 1995). Physiological consequences range from minor to lethal and can include temporary and permanent hearing loss, weight loss if prey cannot be captured, stress-induced health decline, and the lethal effect of hemorrhaging of the brain or other organs. Consequences from masked sounds can include other effects such as inability to avoid predators, being separated from the pod, or missed opportunities for group hunting. Chronic noise pollution can affect not only individuals, but also whole populations. Further information on the underwater noise analysis is presented in Appendix D.

4.15.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, no deepening of the East or West Waterways would occur. With the channels remaining at their current depths, ships would continue to observe and increase their implementation of some of the non-structural measures identified in section 3.1 such as tug assists, high tide transiting, and light loading. The additional tug assists required due to shallow channels would mean increased tugboat traffic, which would increase underwater noise over the study period. Tugboats have a dominant frequency range of 100-500Hz with a peak output at 170dB_{RMS}, which is above the threshold for Level B harassment for the species of concern in close proximity to the tug but attenuates quickly with distance from the vessel. High tide transiting would mean that ships slow down as they navigate southward through Puget Sound to time their arrival at the Port of Seattle, which would cause a longer duration of their underwater noise. Light loading would have the effect of causing a higher number of ships to transit Puget Sound to carry all the anticipated cargo. If no channel deepening occurs, according to economic forecasting through the year 2034, approximately 671 vessel calls would be required per year among the Post-Panamax size classes and each of these vessels uses tug assists.

The improvements at T-5 will occur without the proposed channel deepening action. Effects from this work have been analyzed by the Port of Seattle and all environmental compliance is under the Port's responsibility (Hart Crowser 2015).

4.15.2 Alternative 2 – National Economic Development Plan

As described in section 4.1.2, several pieces of equipment would be operating and producing underwater noise for about 16-20 hours per day. It is assumed only one dredge would be operating at a time and would be running nearly continuously. One tugboat for towing barges would be transiting between the waterways and the Elliott Bay open-water disposal site. A survey vessel would slowly transit the area to measure dredging progress. The duration of work would most likely be throughout the seven-month work window in two consecutive years to accomplish the channel deepening. All of these sound producing vessels would add to the ambient sound in the waterways as a cumulative effect during construction. O&M dredging is anticipated to be needed every 10 years and would take approximately 42 days for each maintenance dredging event.

Tugboats have a dominant frequency range of 100-500Hz with a peak output at $170dB_{RMS}$, which is above the threshold for Level B harassment for the species of concern in close proximity to the tug but is expected to attenuate quickly with distance from the vessel. When in motion, sound produced by the tugboats will be transient and expected to be below background levels a short distance from the moving vessel with no lasting effects, and therefore insignificant. Measurements of sound levels generated by dredging in the Snohomish River (north of Seattle) were as high as $170dB_{RMS}$ for a clamshell dredge (SAIC and RPS Evans Hamilton 2011). However, this sound was subsumed into background within 150 meters. The substrate in the East and West Waterways is softer than that of the Snohomish River and is therefore likely to better attenuate noise for overall lower sound levels. Since the aquatic habitat in the waterways is nearly 300 meters wide, even when the dredge is in the center of the channel, there would be an area available for avoidance of harassment noise levels.

Dredging within the established work window of July 16 to February 15, which is designed in part to avoid juvenile salmon outmigration, would avoid causing noise impacts. This window may be adjusted as a result of coordination with NMFS and USFWS. Any juveniles that are present in the waterways during the dredging months would likely be migrating along the shoreline, away from the dredge. Adult salmon may be present in the waterways during dredging since the work window overlaps with their entry into the estuary after returning from the ocean; however, the adult fish have ample space in the waterways to avoid noise from dredging operations.

Diving bird species that have been recorded during Seattle Audubon Society seabird surveys at shore sites along Elliott Bay include grebe species, cormorant species, common and Barrow's goldeneyes, rhinoceros auklets, surf scoters, and pigeon guillemots (Seattle Audubon Society 2015). Yellow-billed and Pacific loons and Caspian terns have also been sighted around the project area. These birds primarily forage relatively closer to the shoreline and much less in the East and West Waterways or over the deep disposal site where the proposed dredging and disposal activities would occur. None of the seabird survey records show sightings of the ESA-listed marbled murrelets; therefore, no effects are anticipated.

Marine mammals typically avoid the high-traffic area around Seattle Harbor and there are no seal or sea lion haul out sites for several miles surrounding the port. The two nearest haul out sites are on navigational buoys off West Point to the north and off Alki Point to the west of the harbor area (see Appendix C for more information); these are reported to host California sea lions only, not the ESA-listed Steller sea lions (Jeffries et al. 2000). Each site is well over 3 miles away from where the dredging and disposal activity would occur, which is well beyond the noise attenuation distance. The Puget Sound population of approximately 300-500 California sea lions, primarily present from fall to spring, are only males as females do not migrate from their breeding grounds in California and Mexico (Jeffries et al. 2000). Of the small number of sea lions present year round, an occasional two to three of these at a time have been sighted following salmon upstream through the project area during summer months. Houghton et al. (2015) found that vessel speed is the greatest predictor of noise levels received by killer whales. Dredges and associated work vessels would be either stationary or traveling slowly for the purpose of surveying the bottom surface, maneuvering the dredge and barge, or transiting the barge to the disposal site. The slow rate of travel should minimize sound emitted from each vessel.

Based on the short distance of sound attenuation from the dredges and associated work vessels, the very few marine mammals and diving birds present, and the work window to avoid sensitive life stages of ESA-listed species, effects of underwater noise from dredging would be short duration, low intensity, and therefore discountable.

Construction of upgrades at T-5 as well as future non-Federal capital improvements are assumed to have underwater noise effects resulting from pile driving, deepening, and reconstruction of docks. Environmental effects analysis for the T-5 upgrade showed that the bird, fish, and marine mammal injury and disturbance zones do not extend beyond the southern or northern ends of Harbor Island (Hart Crowser 2015).

It is assumed that similar future work will have the same relative disturbance zone. Effects to diving birds and marine mammals are considered discountable due to their absence or ability to flee without injury. Effects to the ESA-listed salmonids may include injury from pile driving noise; the injury zone would extend approximately half the distance of each waterway and this would only occur during adult migration and not affect juveniles due to adherence to the work window; adults would have substantial available aquatic habitat to avoid the injury zone (Hart Crowser 2015). Future non-Federal capital improvements would be conducted by the Port of Seattle or Northwest Seaport Alliance and will undergo full environmental compliance prior to the Port's construction action.

4.15.3 Alternative 3 – Locally Preferred Plan

All short-term and long-term effects described for the NED Plan are essentially the same for the LPP. Dredging to 1 foot deeper and the associated noise from the machinery and engines would have no discernible difference in the underwater noise impacts for diving birds, marine mammals, or salmonids compared to Alternative 2. The only difference would be that construction for the LPP would take one month longer to remove the additional sediment. The additional dredging time would not substantially contribute to the underwater noise generated in the industrial port environment. The LPP would achieve the same long-term benefit of a 15% reduction in forecasted vessel calls.

4.16 Cultural Resources

Cultural resources are locations on the physical landscape of past human activity, occupation, or use and typically include archaeological sites such as lithic scatters, villages, procurement areas, resource extraction sites, rock shelters, rock art, shell middens; submerged resource types such as fish traps, weirs, or watercraft; historic era sites such as trash scatters, homesteads, railroads, ranches, logging camps; and any structures or buildings that are over 50 years old. Cultural resources include traditional cultural properties, which are aspects of the landscape that are a part of traditional lifeways and practices and are considered important to a community. Properties protected under Section 106 of the National Historic Preservation Act (NHPA) are those that are listed or eligible for listing in the National Register of Historic Places (NRHP). Eligible properties must generally be at least 50 years old and possess integrity of physical characteristics, meaning it must "possess integrity of location, design, setting, materials, workmanship, feeling and association" (36 CFR 60.4). Finally, a historic property must be significant under one or more of the following criteria.

- Criterion A. Be associated with events that have made a significant contribution to broad patterns of our history.
- Criterion B. Be associated with the lives of persons significant to our history.
- Criterion C. Embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.
- Criterion D. Have yielded, or may be likely to yield, information important in prehistory or history.

A review of the Washington Information System for Architectural and Archaeological Records Data was conducted for the proposed project area including disposal areas. The disposal sites consists of the open water Elliott Bay Disposal site and the existing upland disposal sites already permitted to take contaminated sediments. Of the 21 cultural resource surveys conducted in close proximity to the Seattle Harbor Project area, two surveys (removal of pilings and a replacement of a bulkhead on Harbor Island) are directly adjacent to the project area. Two cultural resources surveys are related to the Elliott Bay Disposal site. A side scan sonar survey was undertaken in 1988 prior to the creation of the Elliott Bay Disposal Site. Further work was undertaken using a remote operated vehicle to further identify the shipwrecks (EHI 1988; Underwater Archaeological Consortium Evans-Hamilton, Inc. 1988). Subsequently, the location of the Elliott Bay disposal site was moved to avoid impacts to the shipwrecks (Wakeman 1998).

The remaining cultural resource surveys are associated with transportation related projects. No cultural resource surveys have been conducted within either the East or West Waterways themselves. The review of the database revealed that there are no known archaeological sites or submerged resources located within the East or West Waterways.

Historic geo-referenced T-sheets and historic maps were reviewed to understand how the East and West Waterways developed over time. An 1854 U.S. Coast Survey map of Duwamish Bay shows the tidal flats that occupied the mouth of the Duwamish River and several channels meandering through the tidal flats into Elliott Bay. The map notes that the surrounding land was thickly timbered as well as the locations of early settlers' cabins, the location of the small settlement of Seattle, wildlife observations, and the

location of large rocks. As early as 1895, the tidal flats and saltwater marshes around Seattle were filled in and by 1903 the construction of Harbor Island had begun when the East and West Waterway and navigation channels were dredged. Both the East and West waterway have been repeatedly dredged beginning in the early 1900s. A 1918 nautical chart shows that the West Waterway ranged in depth between 5 to 8 feet and the East Waterway ranged in depth from 5.5 to 8 feet. By 1934, the depth of the East Waterway ranged from -30 to -48 MLLW and the West Waterway ranged from -32 to -52 MLLW (U.S. Coast and Geodetic Survey 1934). Subsequent dredging has resulted in the current depths for the East and West Waterways. More recently, in June 2015, the Corps conducted a multi-beam hydrosurvey to map the Duwamish delta seafloor. In 2015, a sediment characterization investigation was conducted for the West Waterway. A total of 27 vibracores were placed within the boundary of the west waterway navigation channel and ranged in depth between -51.5 to -59 MLLW (Anchor QEA 2015). A review of the vibracore sediment logs and photographs of each vibracore do not indicate the presence of any submerged resources.

4.16.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

With no action implemented from this feasibility study, no impacts to cultural or historical resources would be anticipated. No cultural resources are located within the East or West Waterway. No impacts would occur to the archaeological sites located within a half mile of the project area.

4.16.2 Alternative 2 – National Economic Development Plan

Under the NED plan, which would deepen the channel to a proposed depth of -56 MLLW, no impacts to cultural or historic resources are anticipated. Both waterways have been repeatedly dredged to their current depths of -30 to -53 MLLW for the East Waterway and -34 to -59 MLLW for the West Waterway. No known cultural resources are located within the East or West Waterway and there is a low probability of intact archaeological deposits located beneath the currently dredged depth.

4.16.3 Alternative 3 – Locally Preferred Plan

Under the LPP, which would deepen the channel to a proposed depth of -57 MLLW, no impacts to cultural or historic resources are anticipated. Both the waterways have been repeatedly dredged to their current depths of -30 to -53 MLLW for the East Waterway and -34 to -59 MLLW for the West Waterway. No known cultural resources are located within the East or West Waterway and there is a low probability of intact archaeological deposits located beneath the currently maintained depth.

4.17 Public Health and Safety

Regarding public health and safety and the proposed navigation improvement action, resuspension of contaminated sediments during dredging could affect the risk of bioaccumulation of toxic substances in fish and benthic invertebrate tissues, which could then be consumed by humans. Resuspension of contaminated sediment is a well-documented, short-term impact during dredging. Coarser material settles closest to the activity while finer material may be transported beyond the operating area. Dredging also releases contaminants into the water column. These releases can be reduced by using BMPs such as reducing work speed and equipment selection, but not eliminated.

When analyzing potential impacts to humans through fish consumption, the spatial scope of analysis is broadened from the immediate project area to the adjacent water bodies of Elliott Bay and the Lower

Duwamish Waterway. This expanded range of the project area hosts several popular species of fish that are harvested for human consumption, and the home range of these fish is unknown, so the greater area is analyzed. Public fishing access and tribal fishing occur at multiple points around the project area. The seafood of concern in human consumption from Elliott Bay, the East and West Waterways, and Lower Duwamish Waterway include rockfish, English sole, perch, clams, mussels, geoduck, and crab (Port of Seattle 2014). Salmon are not a significant concern for seafood consumption since very little of their time is spent in the project area relative to their total life span and the majority of growth occurs in the ocean. The contaminants of concern that can occur in these seafood species are arsenic, cadmium, cPAHs, TBT, and PCBs (Port of Seattle 2014).

Consumption of resident seafood that occurs during and immediately after construction operations such as dredging, despite the current Washington Department of Health advisory against consuming any such seafood, presents short-term risks to the community because contaminants in resident seafood are likely to be higher during and immediately after construction as a result of contaminated sediment resuspension and biological uptake. Children can be at greater risk due to their developing bodily systems, and a greater consumption of food relative to body size. The increase in contamination concentrations in biota is a temporary effect that will persist for a number of years following cessation of dredging. The resulting removal of sediment would be a net long-term benefit to public health.

Human health risk assessments conducted for the East Waterway and Lower Duwamish Waterway Feasibility Studies provide the best available information on the existing conditions regarding the risk to humans from consumption of resident fish, shellfish, and crabs (see Environmental Solutions Group 1999). Analysis of existing conditions in the East Waterway and Lower Duwamish Waterway shows that the lifetime excess cancer risk and non-cancer health risks are already elevated above acceptable levels. It is the intent of the CERCLA program to address these risks through remediation in the East Waterway and the Lower Duwamish Waterway. The EPA's remediation actions under CERCLA planned for the OUs described in section 4.10 regarding HTRW would occur with or without any Corps actions.

4.17.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the No-Action Alternative, the Corps would not implement any dredging and would therefore pose no risk of elevating contaminant accumulation in fish tissues that could be consumed by humans. However, dredging of East Waterway under CERCLA would likely proceed under the No-Action Alternative, causing resuspension of contaminated sediments and a corresponding short-term increase of exposure to toxic substances. Therefore, the effects of the CERCLA action will occur under the No-Action Alternative.

4.17.2 Alternative 2 – National Economic Development Plan

Sediment in the proposed footprint will undergo testing to determine its suitability for in-water disposal, which would mean the contaminants of concern are below the thresholds that pose a risk to humans. This testing will also determine which sediment is unsuitable for aquatic disposal and must be hauled off site for appropriate upland disposal. The Corps has estimated that approximately 178,000 cy of the total dredged in this alternative may be unsuitable for aquatic disposal, with an estimated 153,000 cy coming from the West Waterway. This would mean that dredging this material poses a risk of resuspension of a fraction of those contaminated sediments. The typical quantity of resuspension is 1% of sediment dredged

with a clamshell bucket; therefore it is estimated that approximately 17,800 cy of material deemed unsuitable for aquatic disposal may be resuspended in the NED plan.

Dredging in contaminated sediments poses a risk for elevated bioaccumulation of contaminants in fish tissues during construction (Port of Seattle 2014). Concentrations of PCBs and other bioavailable contaminants in biota, including edible species, would increase during construction at West Waterway. The increase in contaminant concentrations in biota is a temporary effect, but may persist for a number of years following cessation of dredging. The quantifiable health effects from resuspension of contaminated sediment is unknown. It is possible that additional health advisories will be required during and immediately after construction.

4.17.3 Alternative 3 – Locally Preferred Plan

The Corps has estimated that approximately 217,000 cy of the total dredged in this alternative may be unsuitable for aquatic disposal, with an estimated 183,000 cy coming from the West Waterway. Dredging this material poses a risk of resuspension of a fraction of those contaminated sediments. The typical quantity of resuspension is 1% of sediment dredged with a clamshell bucket.

The change to public health risks due to resuspension of contaminated sediments under the LPP, including resuspension due to dredging at West Waterway, are similar to the impacts under the NED plan. The quantity of dredging is similar between the two plans and contaminated sediments are located in the uppermost layers of sediments in West and East Waterways. Dredging of an additional 1 foot for this alternative in the relatively cleaner sediment at depth will not add substantially to the exposure of downstream waterway users and organisms to contamination.

5 Tentatively Selected Plan - Agency Preferred Alternative

This chapter discusses the details of the TSP, which include material quantities and classifications, requirements for operations, maintenance, repair, rehabilitation, and replacement (OMRR&R), dredged material placement, cost and benefits, and risk and uncertainty. The navigation improvements included in the TSP respond to local needs and desires as well as the economic and environmental criteria used to screen, evaluate, select, and refine measures and alternatives. If implemented, the TSP would handle the current and forecasted vessel fleets and cargo volumes with improved safety, fewer delays, and less congestion and damages than under the No-Action Alternative while avoiding all unacceptable adverse environmental impacts.

5.1 Description of the Tentatively Selected Plan (Locally Preferred Plan)

The TSP is the Locally Preferred Plan (LPP), originally identified in section 3.7. The LPP is the combination of deepening in both waterways to a depth of -57 MLLW, increasing channel width to 550 feet wide, and widening of approach reaches to 700 feet for improving navigation safety at the entrance to each channel (Figure 5-1). The quantities of sediment that would need to be dredged to achieve this improvement are up to approximately 777,000 cy from the West Waterway and approximately 341,000 cy from the East Waterway.

5.1.1 General Navigation Features

The proposed general navigation features are described in more detail in the bullets and text that follow:

West Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW to -57 MLLW (6,109 feet long)
- Widen the approach reach to 700 feet wide (2,500 feet long)
- Widen the inner reach to 550 feet wide (3,609 feet long)

East Waterway

- Deepen the existing channel from an authorized depth of -34 MLLW or -51 MLLW to -57 MLLW (6,000 feet long)
- Widen the approach reach to 700 feet wide (1,200 feet long)
- Widen the inner reach to 550 feet wide (4,800 feet long)
- The 1,232 feet at southern end of the East Waterway would maintain its currently authorized width of 500 feet and depth of -34 MLLW

5.1.2 Local Service Facilities

LSFs include terminals and transfer facilities, docks, berthing areas, and local access channels. The LSFs assumed for this project include berthing area deepening at T-5 and T-18 to match the depth of the proposed channel depth. LSFs will be provided at 100% non-Federal cost and are included as an economic cost in the economic evaluation.

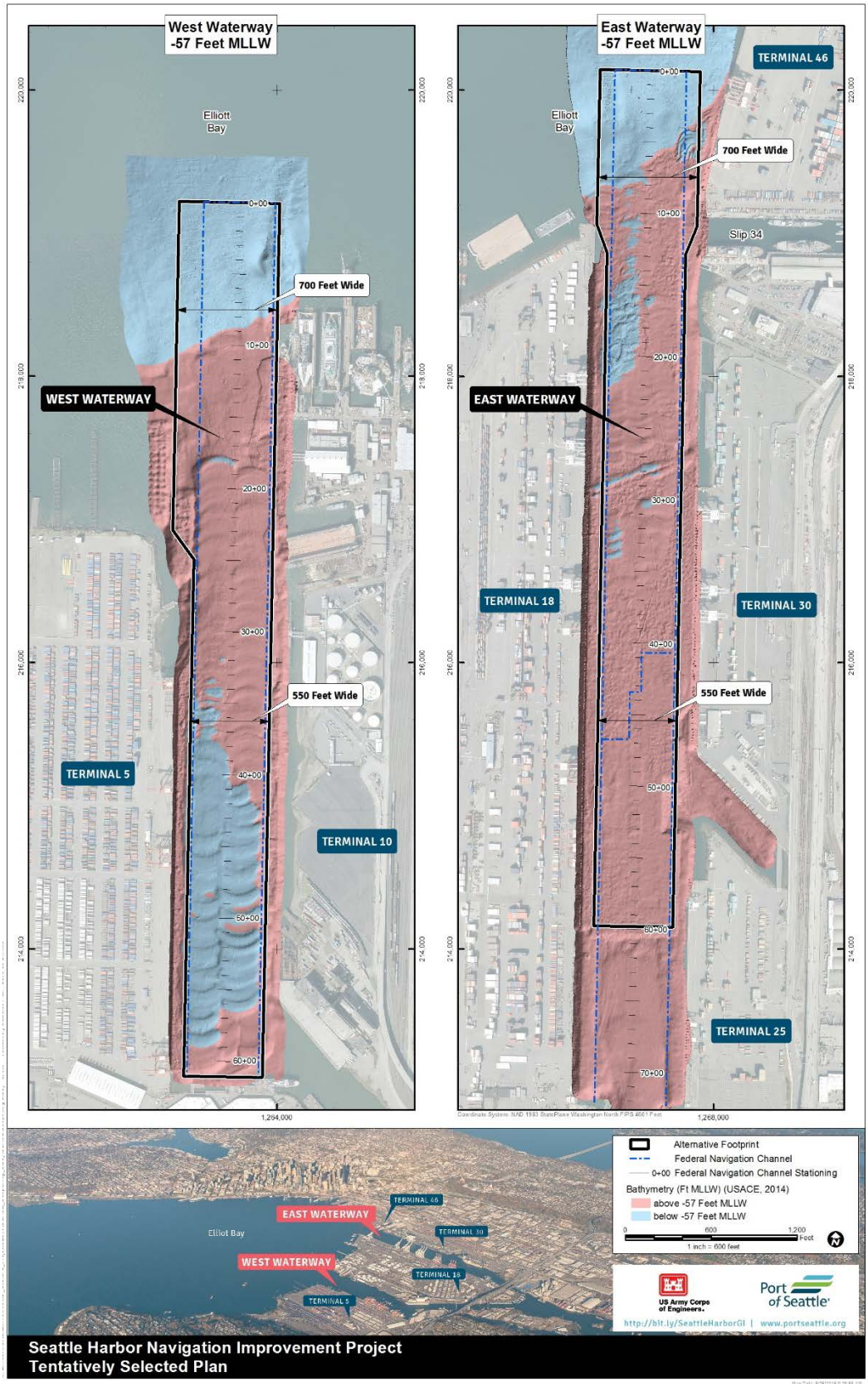


Figure 5-1. Tentatively Selected Plan

5.1.3 Aids to Navigation

The U.S. Coast Guard (USCG) provides the data for any aids to navigation costs, such as costs to relocate range markers due to a change in the centerline of the channel with widening. The Corps has completed initial coordination with the USCG; further coordination will occur to finalize an estimated cost for aids to navigation prior to study completion. Aids to navigation will be provided at 100% Federal cost.

5.2 Dredging and Dredged Material Management

The dredging is estimated to take two years to complete both waterways, partly due to adhering to the work windows for protection of sensitive fish species. Dredging would occur using a clamshell dredge. A digging bucket would be used to remove the material suitable for open-water placement, while an environmental bucket would be used for unsuitable material. If significant debris is encountered, a 1-foot by 1-foot grid grizzly will be utilized to screen the material prior to loading into the scow barge for open-water placement. It is assumed a 1,200-cy to 3,000-cy size bottom dump scow barge would be utilized to load, transport, and place dredged material suitable for open-water disposal. A contained, flat deck material barge would be utilized to transport unsuitable material to a transloading facility where it would be mechanically rehandled for placement at a designated upland landfill.

The production rates will depend on the actual dredging equipment used, nature of the dredged material, and environmental conditions. Dredged material in the West Waterway is classified as a sandy silt while material in the East Waterway is a slightly finer silty sand. Dredging operations are assumed to occur continuously with routine breaks associated with dredge and tug maintenance and crew shifts. Production rates are estimated to range between 2,000 and 3,000 cy per day (refer to Appendix B for additional detail). Most of the material unsuitable for open-water disposal is located in the top 4 feet below the mudline. Thus, production rates will likely start slow at the beginning of construction and speed up as the project progresses.

5.2.1 Dredged Material Suitability Determination

The interagency Dredged Material Management Program (DMMP) consists of four agencies that work collaboratively to manage and regulate the disposal of dredged material from dredging projects in Washington State. These agencies include the U.S. Army Corps of Engineers, Seattle District; the U.S. Environmental Protection Agency, Region 10; Ecology; and the Washington State Department of Natural Resources. The DMMP agencies determine what dredged material can be disposed of at open-water disposal sites. The DMMP does not manage contaminated sediment cleanups; those are managed by cleanup programs within Ecology and EPA.

5.2.2 Assumptions for Dredged Materials

West Waterway Assumptions

Sediment sampling and partial DMMP testing (including dioxin) were conducted in the West Waterway to estimate the volume of dredged material that would be suitable for in-water disposal versus upland confined disposal. Due to time constraints on the acceptability of data for construction (3-year limit for data acceptability under the DMMP guidelines), a full DMMP suitability determination will be completed during the Pre-Construction, Engineering, and Design (PED) phase. For the portion of West Waterway where the alternatives' footprints overlap with the Lockheed West Seattle Superfund Site, volumes and suitability were based on the likely future scenario assuming that the selected remedy outlined in the

Lockheed West Seattle Superfund Site ROD (EPA 2013) is implemented. Probabilities of meeting open water disposal suitability criteria were assigned to distinct segments and depth strata within the waterway based on sediment core data (USACE 2015a). These probabilities were then utilized to develop quantities to inform cost estimates and associated cost contingencies for each alternative. Under the most likely scenario, it was determined that approximately 24% of the dredged material (183,000 cy) would require upland disposal from the West Waterway. Approximately 594,000 cy was estimated to meet the suitability requirements of the DMMP and would be disposed of at the Elliott Bay DMMP open-water disposal site (USACE 2015a) (Figure 5-2).

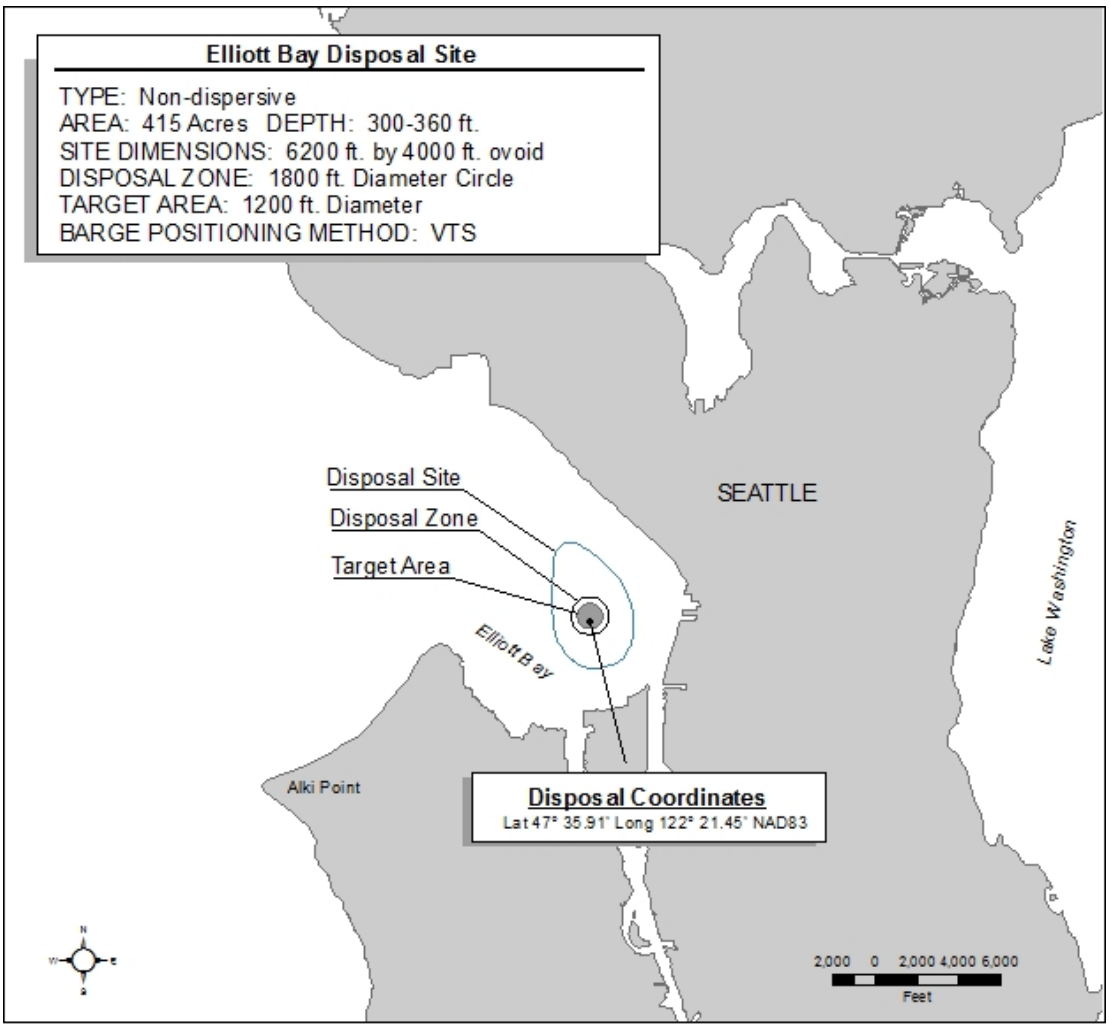


Figure 5-2. Elliott Bay open-water dredged material placement site

East Waterway Assumptions

Feasibility-level sampling will not occur in the East Waterway because existing sampling data in this area is adequate to support development of quantities and associated cost estimates during the feasibility phase. Since a remedy for the CERCLA alternative has not yet been identified, assumptions regarding the suitability of the sediments remaining after construction of a CERCLA remedy were made. The Corps used data from the draft CERCLA RI/FS (Anchor QEA 2014) for the East Waterway to estimate the volume of dredged material that would be suitable for in-water versus upland disposal. The Corps study

assumes one of three CERCLA actions (Anchor QEA 2014) would be implemented prior to construction of the Corps' recommended plan. The CERCLA alternatives include a combination of removal, partial removal, and capping. Under the assumed most likely scenario, the majority of the material remaining after a CERCLA action would be suitable for open-water disposal. It was determined that approximately 10% of the material (34,000 cy) would require upland disposal from the East Waterway. Approximately 307,000 cy of suitable material would be disposed of at the Elliott Bay open-water disposal site.

Summary of Assumptions

Based on the DMMP and CERCLA testing results as well as other assumptions described above, approximately 183,000 cy in the West Waterway and 34,000 cy in the East Waterway do not meet open-water disposal criteria and upland disposal will be required. It is assumed that all material unsuitable for open-water disposal generated during construction of the Seattle Harbor project would be transloaded and disposed upland at a facility suitable for accepting contaminated sediments. It is further assumed that costs of removal and disposal of unsuitable material will be treated as HTRW for cost-sharing purposes and the non-Federal sponsor will bear 100% of these costs (USACE 2015b).

5.3 Real Estate Considerations

The deepening and widening footprints of the TSP are within the navigable waters of the U.S. and are available to the Federal government by navigation servitude. The proposed project will entail 100% in-water construction. Disposal of dredged materials will either be in-water or the material will be transported off-site to a commercial disposal facility. Therefore, there will be no lands, easements, rights-of-way, relocations, or disposal (LERRD) required to support the proposed project.

5.4 Cost Estimate and Economic Summary

Class 4 level estimates were developed for each of the alternatives considered in the economic evaluation. Cost estimates for various depths were developed based on technical information provided for each alternative and from assumptions based on historical similar work. This included quantities, type of material, disposal options, dredge plant, etc. A detailed "Basis of Cost Estimate" that outlines cost assumptions is included in Appendix E. Potential risk events were evaluated and incorporated into a risk model to determine contingency levels.

Based on October 2015 price levels, the estimated project cost is $350,446,000 (with contingency), which includes project first costs at $78,112,000 for general navigation features (GNF). In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended {33 U.S.C. 2213(c)}, the Federal share of the project first cost of the LPP is estimated to be $13,343,000 and the non-Federal share is estimated to be $64,768,000, which includes a 75% Federal and 25% non-Federal cost-share for GNF above -45 MLLW, and a 50% Federal and 50% non-Federal cost share for GNF below -45 MLLW. Costs in excess of the NED plan are 100% non-Federal expense. Other non-Federal expenses include estimates for LSFs including berth deepening and dock improvements, and any upland disposal of dredged material. Aids to navigation are a Federal expense to the U.S. Coast Guard (USCG). The value of LERRDs are 100% non-Federal and are estimated to be $0. Cost sharing allocation for construction and operations, maintenance, relocations, rehabilitation, and replacement (OMRR&R) costs are shown in Table 5-1. Table 5-2 outlines the project first costs, associated costs, and cost share of the NED plan price level and Table 5-3 outlines the project first costs of the LPP at the October 2015 price

level, where additional costs of the LPP above those of the NED plan are 100% non-Federal expense. Note that the West Waterway has material below -45 MLLW in the approach channel that is subject to a different cost share than other portions of the alternatives.

Table 5-1. Cost Sharing Allocation for Navigation Construction and OMRR&R Costs

Cost Category	Federal Cost Share	Non-Federal Cost Share
For Project Depths > -20 MLLW and < -45 MLLW		
General Navigation Features (GNF)	75%	25% + 10% (1)
LERR (2)	0%	100%
Mitigation (included in GNF)	75%	25%
Local Service Facilities (LSF)	0%	100%
OMRR&R of GNF (3)	100%	0%
OMRR&R of LSF (4)	0%	100%
OMRR&R of Aids to Navigation (4)	100%	0%
For Project Depths > -45 MLLW		
GNF	50%	50% + 10% (1)
LERR	0%	100%
Mitigation (included in GNF)	50%	50%
Local Service Facilities (LSF)	0%	100%
OMRR&R of GNF	50%	50%
GNF in excess of NED plan cost for LPP (4)	0%	100%
1 – 10% post-construction contribution less credit for LERR over 30 years 2 – LERR: Lands, easements, rights-of-way, and relocations 3 – OMRR&R: Operations, maintenance, relocations, rehabilitation and replacements 4 – Cost share does not depend on project depth		

Table 5-2. Cost Summary for the Seattle Harbor NED Plan

Federal/Non-Federal Cost Apportionment - NED Plan			
	Total Cost Allocated	**Federal**	**Non-Federal**
Cost Sharing for > -20 MLLW and < -45 MLLW General Navigation Features (GNF) [75% Federal / 25% Non-Federal]			
Dredging--West Waterway > -20 MLLW and < -45 MLLW (including Preconstruction, Engineering & Design, and Construction Management)	$2,779,000	$2,084,000	$695,000
Upland Disposal (100% Non-Federal)	$5,544,000	$0	$5,544,000
Mobilization & Demobilization (9% of total dredged material)	$275,000	$206,000	$69,000
Subtotal GNF for > -20 MLLW and < -45 MLLW	***$8,598,000***	***$2,290,000***	***$6,308,000***
Cost Sharing for > -45 MLLW GNF (50% Federal / 50% Non-Federal)			
Dredging--East and West Waterway Alternative 2 > -45 MLLW (including Preconstruction, Engineering & Design, and Construction Management)	$19,454,000	$9,727,000	$9,727,000
Dredging--Upland Disposal (100% Non-Federal)	$33,383,000	$0	$33,383,000
Mobilization & Demobilization (91% of total dredged material)	$2,652,000	$1,326,000	$1,326,000
Subtotal GNF for > -45 MLLW	***$55,489,000***	***$11,053,000***	***$44,436,000***
Total GNF	**$64,086,000**	**$13,343,000**	**$50,744,000**
Lands, Easements, Rights-of-Way, and Relocations (LERR) [100% Non-Federal]	**$0**	**$0**	**$0**
Subtotal - Project First Costs (rounded)	**$64,086,000**	**$13,343,000**	**$50,744,000**
		21%	***79%***
Additional 10% of GNF over time less LERR (100% non-Federal expense over 30 years)	**$0**	**-$6,409,000**	**$6,409,000**
Subtotal - Project First Costs with 10% GNF adjustment over time	**$64,086,000**	**$6,934,000**	**$57,153,000**
		11%	***89%***
Non-Federal Local Service Facilities (LSF) [100% Non-Federal]			
Berthing Area Dredging (T-5 on West Waterway and T-18 on East Waterway)	$42,275,000	$0	$42,275,000
T-18 Dock Improvements/Strengthening	$220,320,000	$0	$220,320,000
Total Non-Federal LSF	**$262,595,000**	**$0**	**$262,595,000**
USCG Aids to Navigation (100% USCG Federal Cost)	**$349,000**	**$349,000**	**$0**
Project Costs - NED Plan (rounded)	**$327,030,000**	**$7,283,000**	**$319,747,000**
		2%	***98%***

Table 5-3. Cost Summary for the Seattle Harbor LPP

Federal/Non-Federal Cost Apportionment - LPP			
	Total Cost Allocated	**Federal**	**Non-Federal**
Cost Sharing for > -20 MLLW and < -45 MLLW General Navigation Features (GNF) [75% Federal / 25% Non-Federal]			
Dredging--West Waterway > -20 MLLW and < -45 MLLW (including Preconstruction, Engineering & Design, and Construction Management)	$2,779,000	$2,084,000	$695,000
Upland Disposal (100% Non-Federal)	$5,544,000	$0	$5,544,000
Mobilization & Demobilization (9% of total dredged material)	$275,000	$206,000	$69,000
Subtotal GNF for > -20 MLLW and < -45 MLLW	***$8,598,000***	***$2,290,000***	***$6,308,000***
Cost Sharing for > -45 MLLW GNF (50% Federal / 50% Non-Federal)			
Dredging--East and West Waterway Alternative 2 > -45 MLLW (including Preconstruction, Engineering & Design, and Construction Management)	$21,154,000	$9,727,000	$11,427,000
Dredging--Upland Disposal (100% Non-Federal)	$45,707,000	$0	$45,707,000
Mobilization & Demobilization (91% of total dredged material)	$2,652,000	$1,326,000	$1,326,000
Subtotal GNF for > -45 MLLW	***$69,513,000***	***$11,053,000***	***$58,460,000***
Total GNF	***$78,112,000***	***$13,343,000***	***$64,768,000***
Lands, Easements, Rights-of-Way, and Relocations (LERR) [100% Non-Federal]	**$0**	**$0**	**$0**
Subtotal - Project First Costs (rounded)	**$78,112,000**	**$13,343,000**	**$64,768,000**
		17%	***83%***
Additional 10% of (NED plan) GNF over time less LERR (100% non-Federal expense over 30 years)	**$0**	**-$6,409,000**	**$6,409,000**
Subtotal - Project First Costs with 10% GNF adjustment over time	**$78,112,000**	**$6,934,000**	**$71,177,000**
		9%	***91%***
Non-Federal Local Service Facilities (LSF) [100% Non-Federal]			
Berthing Area Dredging (T-5 on West Waterway and T-18 on East Waterway)	$51,665,000	$0	$51,665,000
T-18 Dock Improvements/Strengthening	$220,320,000	$0	$220,320,000
Total Non-Federal LSF	**$271,985,000**	**$0**	**$271,985,000**
USCG Aids to Navigation (100% USCG Federal Cost)	**$349,000**	**$349,000**	**$0**
Project Costs - LPP (rounded)	**$350,446,000**	**$7,283,000**	**$343,162,000**
		2%	***98%***

Table 5-4 provides an economic summary of the costs and benefits of the LPP. Interest during construction was computed using estimated project costs at the October 2015 price level, anticipated construction

durations, and the current Federal discount rate (3.125% for fiscal year 2016), bringing total investment costs to $360,991,000. Operations and maintenance dredging expenses have been estimated to occur every 10 years at $3,768,000 per dredge cycle for both waterways at the October 2015 price level. Average annual equivalent (AAEQ) costs were developed for the current cost estimate at the October 2015 price level. AAEQ cost is estimated at $14,692,000, which includes an AAEQ cost for O&M of $327,000. AAEQ benefits include origin-to-destination (OD) transportation cost savings of approximately $109,592,000, resulting in total net benefits of $94,900,000 (AAEQ benefits minus AAEQ costs) and a 7.5 BCR. First costs for authorization purposes are estimated at $78,112,000 (October 2015 price level) and the fully funded cost estimate to the mid-point of construction is estimated at $82,806,000.

Table 5-4. Average Annual Equivalent (AAEQ) Benefits and Costs of the Seattle Harbor LPP

	Cost and Benefit Summary of the LPP (October 2015 price level)
Interest Rate (Fiscal Year 2016)	3.125%
Interest Rate, Monthly	0.257%
Construction Period, Months	24
Period of Analysis, Years	50
Estimated First Costs	$78,112,000
Estimated Local Service Facilities	$271,985,000
Estimated Aids to Navigation	$349,000
Estimated Project Costs (Oct 2015 price level)	***$350,446,000***
Interest During Construction	$10,545,000
Total Economic Investment Cost	**$360,991,000**
AAEQ Costs	
Amortized Cost	$14,365,000
OMRR&R	$327,000
Total AAEQ Costs	***$14,692,000***
AAEQ Benefits	
Origin-to-Destination Transportation Cost Savings	$109,592,000
Total AAEQ Benefits	***$109,592,000***
AAEQ Net Benefits (AAEQ Benefits – AAEQ Costs)	**$94,900,000**
Benefit-to-Cost Ratio (computed at 3.125%)	**7.5**

5.5 Fish and Wildlife Coordination Act Considerations*

The Fish and Wildlife Coordination Act (FWCA) requires that fish and wildlife resources receive equal consideration to other project features in any Federal proposal for water resources development. Pursuant to Section 2(b) of the Act, USFWS provided a Planning Aid Letter (PAL) followed by a Draft Coordination Act Report (CAR) that describes fish and wildlife resources in the project area, potential negative effects of the proposed project, and recommendations for mitigating the effects. The PAL and Draft CAR appear in Appendix D. The potential negative effects identified include the following:

- Increased turbidity from dredging that can cause lethal, sublethal, and behavioral effects to fish
- Physical and habitat problems for macroinvertebrates due to suspended solids

- Potential resuspension of contaminants from dredged sediments
- Channel modifications that can affect estuarine circulation and habitat

Recommendations included the following:

- Mitigation for long-term habitat loss in the estuary
- Development of an in-lieu fee program for conservation banks
- Creating a shallow-water migratory corridor for salmonids through the waterways by installing habitat benches under the piers and light-penetrating panels in the pier decking material
- Coordinating throughout the development of alternatives and design to expedite ESA section 7 consultation

After initial coordination and receipt of the PAL, the Corps considered the four key items identified as potential negative effects and incorporated analyses of these points into the environmental effects analysis in Chapter 4. The Corps is considering the draft recommendations and will analyze their applicability during the feasibility level design phase.

5.6 Summary of Environmental Consequences and Cumulative Effects of the Tentatively Selected Plan (Agency Preferred Alternative)

Effects of an action can be additive, synergistic, or countervailing. After direct and indirect effects were identified, the potential for cumulative impacts on many resources were considered as part of this study. The majority of resources were determined to have little risk of being cumulatively impacted. Direct and indirect effects are summarized in (Table 5-5) followed by a discussion of cumulative effects.

Table 5-5. Summary of Environmental Consequences of the Tentatively Selected Plan (Agency Preferred Alternative)

Resource	Short- and Long-term Consequences of the TSP (Agency Preferred Alternative)
Navigation and Economic Conditions	Short-term: Helps the nation remain competitive in global commerce and boosts regional economy. Long-term: The Corps and Port are predicting improvement to regional economic conditions due to increased efficiency of throughput at Port terminals. The project would allow for more efficient loading and a 15% reduction in the number of vessel calls of the future fleet of containerships for the forecasted commodity demand.
Hydraulics and Geomorphology	Short-term: No short-term effects to hydraulics and geomorphology have been identified. Long-term: Deepening the East and West Waterways would cause a slight increase to O&M dredging requirements.
Water Quality	Short-term: Brief, minor pulses of turbidity and nearly undetectable decreases in DO may occur during dredging. Long-term: Slight upstream expansion of the saltwater wedge may occur, but not substantial enough to alter any aquatic habitats for an overall discountable effect.
Air Quality	Short-term: Estimated air-pollutant concentrations from construction and O&M will stay below the threshold for NAAQS. Long-term: Potential change in ship traffic emissions are predicted to result in a reduction in DPM emissions of approximately 134 metric tons over the first 14 years after construction.

Greenhouse Gas Emissions	Short-term: Construction and O&M would contribute a tiny fraction of statewide GHG emissions over the two construction seasons. Long-term: Changes in vessel traffic are predicted to result in a net reduction of 23.5 million metric tons of CO_2 equivalent per year by 2034.
Sea Level Change	Short-term: Near future SLC would not affect the navigability of the waterways. Long-term: The intermediate and high level scenario predictions show a potential increase in navigable depth ranging between 0 and 2 feet in the next 50 years, which may have a reduced need for O&M dredging if appropriate depths remain.
Underwater Noise	Short-term: Underwater noise from construction would occur when sensitive receptors may be present. These include marine mammals, fish, and diving birds. Long-term: Navigation improvement are predicted to result in a 15% reduction in the Post-Panamax size vessels transiting Puget Sound to call at the Port of Seattle. This would have a net reduction in the cumulative effects of ambient underwater noise in Puget Sound, which would benefit the ESA-listed Southern Resident killer whales. Noise would decrease with the reduction in vessel calls at the Port.
Hazardous, Toxic, and Radiological Waste	Short-term: Clamshell dredging may cause resuspension of approximately 11,000 cy of sediments; a minor fraction of this may be determined as unsuitable for aquatic disposal and therefore cause release of contaminants. Long-term: Removal of any remaining contaminated sediment would reduce contamination in the project area.
Benthic Organisms	Short-term: Dredging would cause mortality in the patch of area being dredged. Long-term: Benthic macroinvertebrate populations are known to recover quickly from the type of action proposed, as in up to three years. No long-term change to the benthic community is predicted to occur.
Fish	Short-term: Construction would cause temporary displacement of bottom-dwelling fish and has potential for minor resuspension of some bioaccumulative toxins. Long-term: Removal of sediments would remove contaminants that can affect fish health.
Wildlife	Short-term: Construction may cause temporary displacement and has potential for minor resuspension of some bioaccumulative toxins. Long-term: Removal of sediments would remove contaminants that can affect health of marine mammals and birds through their prey species.
Threatened and Endangered Species	Short-term: Dredging would cause noise and minor turbidity disturbance to the ESA-listed salmonids. Adherence to work windows and conservation measures would avoid potential significant impacts to juvenile salmonids. Long-term: The overall reduction in ambient noise due to reducing the number of ships that call at the Port would benefit the ESA-listed species, especially the Southern Resident killer whales due to their use of echolocation to find prey.
Cultural Resources	Short-term: No Historic Properties Affected Long-term: No Historic Properties Affected
Indian Trust Assets	Short-term: The Corps will coordinate early and often with the tribes that have U&A fishing rights in the project area to avoid effects to tribal fishing. Long-term: Coordination with the tribes would be necessary in advance of any O&M dredging and would maintain the goal of no effect to tribal fishing.
Environmental Justice Communities	Short-term: No disproportionately high and adverse human health impacts to any environmental justice communities Long-term: No long-term negative effects are anticipated.

Public Health and Safety	Short-term: Dredging may cause resuspension of a very small quantity of chemicals that bioaccumulate in fish tissues, which may be consumed by humans who fish in the project area although this is minimized by posted health advisories. Long-term: Dredging may remove contaminated sediments from the project area thereby having a minor improvement for seafood items in the project area.

The only cumulative effects identified in this study would be for two year classes of adult salmonids that would be migrating through the Waterways during dredging and would encounter turbidity pulses near the dredge, minor underwater noise disturbance from dredging, as well as the same types of effects from the CERCLA action anticipated in the East Waterway and the T-5 upgrades on the West Waterway. This combination of effects would only occur if dredging in each waterway is simultaneous T-5 construction or other non-Federal capital improvements. These same fish would not be affected by the potential resuspension of bioaccumulative toxins from this because they are no longer eating prey during their upstream spawning migration; however, these fish may have encountered contaminants in their juvenile life stage during their outmigration from the Duwamish Waterway.

The 15% reduction from 671 to 570 Post-Panamax ships per year by 2034 is considered a countervailing effect for air quality, GHG emissions, underwater noise, and disturbance to fish and ESA-listed species because the reduced vessel traffic would be a long-term benefit.

5.7 Mitigation for Adverse Environmental Effects*

No compensatory mitigation is proposed for this action as no loss of wetlands, no significant adverse effects to ESA-listed species, and no significant impacts to commercially important species or protected marine mammals are anticipated to occur based on the analyses in this document. Several avoidance and minimization measures are proposed to ensure that impacts are insignificant; these include the following:

1) Comply with all water quality standards and conditions issued in the water quality certification and adhere to monitoring protocols in the water quality monitoring plan.

2) Dredge only within the designated work window of July 16 through February 15. This window may narrow and specific sequencing may be recommended through consultation and coordination with USFWS, NMFS, and WDFW.

3) Implement additional conservation measures required by NMFS and USWFS for ESA-listed species.

4) Use of an environmental bucket while dredging material determined unsuitable for aquatic disposal to minimize resuspension of contaminated sediments.

5.8 Implementation Requirements

The following sections outline the requirements for implementation of the recommended plan.

5.8.1 Non-Federal Sponsor

The Port of Seattle has provided a letter of support for the LPP. The Port of Seattle has also provided a letter of support to continue moving forward with this feasibility study. Self-certification of financial capability documentation will be included in the Final FR/EA.

5.8.2 Implementation

The schedule for project implementation is dependent on project authorization. After project authorization, the project would be eligible for construction funding. The project would be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and the budget constraints at the time of funding. If Congress appropriates Federal construction funds, the Corps and the non-Federal sponsor would enter into a Design Agreement (DA) and eventually a Project Partnership Agreement (PPA). The DA would define the Federal and non-Federal responsibilities for completion of final designs for the project. The PPA would define the Federal and non-Federal responsibilities for implementing, operating, and maintaining the project.

5.8.3 Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R)

Non-Federal sponsor cost requirements are described in section 5.4. Cost sharing allocation for construction and operations, maintenance, relocations, rehabilitation and replacement (OMRR&R) costs are shown in Table 5-1. Following implementation of the TSP, it is anticipated that the historical shoaling rate in the navigation channel will increase by 5,000 to 10,000 cy per year due to the deeper channel depths. In the Federal navigation channel of the West Waterway, it is estimated 50,000 cy of O&M dredging would be required every 10 years. In the Federal navigation channel of the East Waterway, it is estimated 75,000 cy of O&M dredging would be required every 10 years. These estimates are presented in Table 5-6. Based on a production rate of 3,000 cy per day, this would require approximately 42 days to complete, which could occur in a single dredge cycle. It is anticipated that the average infill over the project life in each waterway is approximately one foot every 10 years. Based on this infill rate, O&M dredging is assumed to occur on a 10-year interval to maintain the authorized channel depth. SLC is expected to reduce the amount of OMRR&R required to maintain the authorized channel depth. The intermediate and high level SLC scenarios may increase the interval between OMRR&R dredging events. Total estimated cost of each dredge cycle is $3,768,000.

Table 5-6. O&M dredging assumptions of the Tentatively Selected Plan

Waterway	East Waterway	West Waterway
Quantity	75,000 cy every 10 years	50,000 cy every 10 years
Estimated Cost	Approx. $2.3 million every 10 years	Approx. $1.5 million every 10 years

Other non-Federal expenses include OMRR&R for berthing areas as well as LSF (i.e., bulkheads) required to serve the Federal navigation channel.

5.9 Risk and Uncertainty

The study team has used a risk-based strategy in their approach to formulating and evaluating alternatives. Key risks, uncertainties, or assumptions for the study are summarized below.

Ongoing CERLCA Actions

As described in section 4.10, the Lockheed West Seattle Superfund site and the Harbor Island Superfund site are located within the West and East Waterways of Seattle Harbor. Remedies have been identified and implemented for some OUs within the Superfund sites, while some remediation actions are still under

investigation. RODs have been signed for each of the three OUs located in or adjacent to the West Waterway, including a no-action ROD for the West Waterway OU.

A CERCLA feasibility study is ongoing for the East Waterway OU. If the Corps' recommended alternative overlaps with an area in the East Waterway that is proposed for remedy by EPA, and that remedy has not been finalized in a ROD, there may be schedule limitations to the completion of the feasibility phase. It is assumed that a remedy for the East Waterway OU would be implemented prior to construction of the Corps recommended plan. The Corps will continue to actively coordinate with EPA and Ecology throughout the feasibility study to manage compatibility of the proposed remedy with the deepening project as well as manage schedule constraints as the project progresses.

Suitability Determination and Disposal Assumptions

Assumptions regarding quantities of dredged material requiring upland disposal are based on Dredged Material Management Program (DMMP) and CERCLA testing results. These testing results and associated assumptions regarding quantities for upland disposal may not provide sufficient data to confirm in-water or upland disposal assumptions during the feasibility phase. More upland disposal may be required, which is a more costly disposal method. Section 5.2 describes key assumptions regarding suitability determination and disposal assumptions for each waterway. The study team has developed conservative estimates for the quantity of material requiring upland disposal. In addition, the risk of potential change in quantities for upland disposal has been included in the cost schedule risk analysis and associated cost contingency.

Economics Assumptions

Panamax vessels were considered in the evaluation of alternatives; however, as larger containerships become more efficient and available in the World fleet, it is anticipated that the fleet of smaller Panamax vessels will transition away from Seattle. Recent trends in the upsizing of ships has been attributable to mega shipping alliances on Far East services to the North American West Coast, has led to an overall reduction in the number of services calling the West Coast. Trade with the Far East accounts for approximately 90% of trade in Seattle. Forecasts for containerships calling the West Coast suggest sub-Panamax and Panamax vessels will not call prior to the base year 2024, as confirmed observed in historic trends for the Port of Seattle and as reflected in MSI projections. Therefore, there is a reasonable likelihood that these Panamax vessels would not deploy on international routes to Seattle by year 2024. The economic evaluation presented in this study is based on the assumption that these sub-Panamax and Panamax would likely not call Seattle during the future without and future with project conditions.

Next, incremental evaluation of channel widths was considered but not conducted at this time as widths were based on design vessel channel recommendations in PIANC for safe navigation of the harbor. Narrower channels would not satisfy the study objective to improve navigational safety for harbor pilots operating ultralarge containerships. Widening measures are not intended and will not change one-way traffic or other navigational practices in either the East or West Waterways. Further, given existing channel depths, the incremental cost of widening each waterway approximately 50 feet is not expected to change the outcomes of the economic analysis.

Finally, vessel speeds at sea may affect vessel operating costs, which could change the analysis of economic benefits. The analysis presented includes economic slow-steaming speeds and operating costs. Service speeds were considered and resulted in slightly lower economic benefits, but the same relative outcomes of the economic evaluation as is presented in Section 3.5.1. The analysis presented utilizes the most recent Corps-approved vessel operating costs from Economic Guidance Memorandum (EGM) 15-04 (USACE 2015d).

5.10 Environmental Operating Principles and Campaign Plan

The Corps has reaffirmed its long-standing commitment to environmental conservation by formalizing a set of Environmental Operating Principles (EOPs) applicable to decision-making in all programs. The EOPs outline the Corps' role and responsibility to sustainably use and restore our natural resources in a world that is complex and changing. The recommended plan meets the intent of the EOPs. In coordination with agencies and other stakeholders, the Corps proactively considered the environmental consequences of the proposed deepening project. The project will be constructed in compliance with all applicable environmental laws and regulations. In accordance with the EOPs, the Corps has proposed a project that supports economic and environmentally sustainable solutions.

The Corps' Campaign Plan includes specific goals and objectives to deliver integrated, sustainable, water resources solutions. This project primarily supports the Corps' Campaign Plan Goals 2 and 4. These goals include transformation of the Civil Works process to deliver enduring and essential water resource solutions using effective transformation strategies as well as build resilient people, teams, systems, and processes to sustain a diverse culture of collaboration, innovation, and participation to shape and deliver strategic solutions. The project meets the intent of these Campaign Plan goals by working within the Civil Works transformation framework to recommend a plan that is intended to improve safety and efficiency.

6 Compliance with Environmental Statutes*

This chapter provides documentation of how the recommended plan (agency preferred alternative) complies with all applicable Federal environmental laws, statutes, and executive orders.

6.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 U.S.C. §4321 et seq.) commits Federal agencies to considering, documenting, and publicly disclosing the environmental effects of their actions. This Draft integrated FR/EA is intended to achieve NEPA compliance for the proposed project. Before preparing this document, the Corps published a Notice of Preparation of an EA and held a public informational meeting in the study area. All comments received to date were considered in determining whether it will be in the public interest to proceed with the proposed project and which resources must be considered in a detailed analysis. Progress of the feasibility study is regularly reported to decision makers. This Draft FR/EA is being published for a 30-day public comment period per NEPA requirement. A Final FR/EA which takes into account all comments received will be published prior to project implementation.

6.2 Endangered Species Act of 1973

The Endangered Species Act (ESA) (16 U.S.C. §1531-1544), Section 7(a) requires that Federal agencies consult with NMFS and USFWS, as appropriate, to ensure that proposed actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats. The Corps will produce a BA based on the feasibility-level design and will submit the BA to NMFS and USFWS per consultation procedures under Section 7 of the ESA. Results of the consultation will be reported in the Final FR/EA.

6.3 Clean Water Act of 1972

The Clean Water Act (33 U.S.C. §1251 et seq.) requires Federal agencies to protect waters of the U.S. The regulation implementing the Act disallows the placement of dredged or fill material into water unless it can be demonstrated there are no practical alternatives that are less environmentally damaging. The sections of the Clean Water Act that apply to the proposal are 401 regarding discharges to waterways and 404 regarding fill material in waters and wetlands.

Section 401

Any project that involves placing dredged or fill material in waters of the U.S. or wetlands, or mechanized clearing of wetlands requires a water quality certification from the state agency as delegated by EPA. For the Seattle Harbor project, the delegated authority is Ecology. The Corps has initiated coordination with Ecology to certify that the proposed Federal action will not violate established water quality standards. The Corps will produce and submit documentation necessary for Ecology's individual 401 review based on the feasibility-level design.

Section 404

The fundamental principle of Section 404 is that no discharge of dredged or fill material should be permitted if there is a practicable alternative that would be less damaging to aquatic resources or if significant degradation would occur to the nation's waters. To comply with Section 404, it is necessary to avoid negative effects to waters of the U.S. wherever practicable, minimize effects where they are unavoidable, and compensate for effects in some cases. The Corps has prepared a Section 404(b)(1)

Evaluation and public interest review, which appears in Appendix D. The findings are that there would be no significant adverse effects to aquatic ecosystems functions and values, both proposed action alternatives are essentially equivalent in their effects to the environment, and that this project is within the public interest.

6.4 Coastal Zone Management Act of 1972

The Coastal Zone Management Act (CZMA) of 1972 as amended (16 U.S.C. §1451-1464) requires Federal agencies to conduct activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved State Coastal Zone Management Program. The Corps expects to be substantively consistent with the enforceable polices of the City of Seattle's Shoreline Master Program. The Corps has initiated coordination with Ecology and will prepare a CZMA Consistency Determination for the project according to the relevant enforceable policies.

6.5 Clean Air Act of 1972

The Clean Air Act (CAA) as Amended (42 U.S.C. §7401, et seq.) prohibits Federal agencies from approving any action that does not conform to an approved state, tribal, or Federal implementation plan. Under the CAA General Conformity Rule (Section 176(c)(4)), Federal agencies are prohibited from approving any action that causes or contributes to a violation of a NAAQS in a nonattainment area. Construction activities associated with the proposal will create air emissions, but these would not affect implementation of Washington State's CAA implementation plan. The proposed action would not occur in a nonattainment or maintenance area. Construction work of the magnitude included in the proposal is not typically a concern in attainment areas. The estimated emissions are expected to meet the standards set forth by the EPA and implemented by Washington State.

6.6 National Historic Preservation Act of 1966

Section 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. §470), as amended through 1992 (Public Law 102-575) requires Federal agencies to account for the indirect, direct, and cumulative effects of their undertakings on Historic Properties (i.e., archaeological sites, Traditional Cultural Properties, buildings, structures, objects, districts, and landscapes listed in or eligible for listing in the National Register of Historic Places). Section 106 and its implementing regulations at 36 CFR 800 establish procedures for Federal agencies to follow in identifying Historic Properties and assessing and resolving effects of their undertaking on them in consultation with State Historic Preservation Officers (SHPO), Indian tribes, Native Hawaiians, and the Advisory Council for Historic Preservation (ACHP), as appropriate.

No cultural resources have been identified within either the East or West Waterways. Depths in proposed dredge areas are deeper than historic depths. The Corps has consulted with the SHPO, the Muckleshoot Indian Tribe, and the Suquamish Indian Tribe. On December 15, 2014, the Corps sent an area of potential effects (APE) letter to the SHPO describing the project and APE. The SHPO responded on December 15, 2014 and agreed with the APE. On December 15, 2014, the Corps sent letters to the Muckleshoot and the Suquamish describing the project and asking if there are any properties of cultural or religious significance that would be affected by the project. To date, the Corps has not received a response. On April 27, 2016, the Corps sent a letter to the SHPO detailing the Corps' finding of "no historic properties affected". The SHPO responded on April 27, 2016, concurring with the Corps' determination of "no historic properties

affected". The Corps also sent letters to the Muckleshoot and the Suquamish detailing the finding. To date, the Corps has not received a response from the Tribes.

The Corp had previously consulted with the Washington SHPO in 1988/1989 regarding the open water Elliott Bay disposal site and the open water disposal site has been in continuous use since. No cultural resource impacts will occur during the use of the Elliott Bay disposal site. The upland disposal locations are existing facilities that are permitted to take contaminated sediments.

6.7 Federal Trust Responsibility

The Federal trust responsibility to Native American Tribes arises from the treaties signed between the Tribes and the U.S. Government. Under Article VI, Clause 2 of the U.S. Constitution, treaties with the Tribes are superior to State laws, and equal to Federal laws. In these treaties, the U.S. made a set of commitments in exchange for tribal lands, including the promise that the U.S. would protect the tribes' people. The Supreme Court has held that these commitments create a trust relationship between the U.S. and each treaty tribe, and impose upon the Federal government "moral obligations of the highest responsibility and trust." The scope of the Federal trust responsibility is broad and incumbent upon all Federal agencies. The U.S. Government has an obligation to protect tribal land, assets, and resources that it holds in trust for the tribes, and a responsibility to ensure that its actions do not abrogate treaty rights.

Both of the federally-recognized tribes in the project area, Muckleshoot Indian Tribe and Suquamish Indian Tribe, have signed treaties with the U.S. Government and have treaty-reserved Usual and Accustomed fishing areas and sites in and near the East and West Waterways (additional information appears in Appendix C). These tribes have had representation in this feasibility study planning phase through the environmental coordination process as well as the tribal government consultation process. The Corps has coordinated with the tribes to hear their concerns, especially the timing and locations of tribal fisheries activities. The short-term effects of the TSP on treaty fishing rights are expected to be minimized through continual coordination on the timing and location of the proposed dredging during the fishing season. The long-term effect is that the TSP is predicted to result in a small reduction in cargo vessel traffic to East and West Waterways, which would reduce the number of interactions between ships and tribal fishing vessels and activities. To the maximum extent practicable, the Corps will ensure that fishing practices are not disrupted by the proposed deepening project and will continue to coordinate with the tribes throughout each dredging cycle. This coordination is consistent with the Federal Government's trust responsibility.

6.8 Fish and Wildlife Coordination Act of 1934

The Fish and Wildlife Coordination Act of 1934 as amended (16 U.S.C. §661-667e) ensures that fish and wildlife conservation is given equal consideration as is given to other features of water-resource development programs. This law provides that whenever any water body is proposed to be impounded, diverted, deepened or otherwise controlled or modified, the Corps shall consult with the USFWS and NMFS as appropriate, and the agency administering the wildlife resources of the state. Any reports and recommendations of the wildlife agencies shall be included in authorization documents for construction or modification of projects. Recommendations provided by the USFWS in Coordination Act Reports must be specifically addressed in Corps feasibility reports.

The Corps initiated coordination for consideration of fish and wildlife species in July 2015 and by hosting a meeting with all relevant natural resource agencies on August 12, 2015. Further coordination has occurred through informal emails and via phone with NMFS and USFWS and will continue throughout feasibility level design phase. The Corps received a Planning Aid Letter (PAL) and Draft Coordination Act Report (CAR) from USFWS (see Appendix D) and a final CAR is expected prior to finalizing this FR/EA. Results of the coordination and USFWS recommendations will be discussed in the final FR/EA.

6.9 Magnuson-Stevens Fishery Conservation and Management Act of 1976

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), (16 U.S.C. §1801 et. seq.) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) "may adversely affect" designated EFH for relevant commercial, federally managed fisheries species within the proposed action area. The assessment also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

Estuaries of Washington, including Puget Sound, are designated as EFH for various ground fish, coastal pelagic species, and three species of Pacific salmon. The Corps will prepare an EFH determination to be included in the BA prepared for ESA Section 7 consultation during feasibility level design phase. Results of the consultation will be reported in the final FR/EA.

6.10 Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §1361-1407) restricts harassment of marine mammals and requires interagency consultation in conjunction with the ESA consultation for Federal activities. All marine mammals are protected under the MMPA regardless of whether they are endangered, threatened, or depleted. Marine mammal species that have been observed in the project area include harbor seal (*Phoca vitulina*), killer whale (*Orcinus orca*), and California sea lion (*Zalophus californianus*). Other species that may occur in Puget Sound, but are unlikely to enter Elliott Bay include Steller sea lion (*Eumetopias jubatus*), Northern elephant seal (*Mirounga angustirostris*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Minke whale (*Balaenoptera acutorostrata*), and gray whale (*Eschrichtius robustus*).

The primary concern for protection of marine mammals is underwater noise from construction, which is described in detail in 4.15. The Corps will consult with NMFS on effects to marine mammals in conjunction with the ESA Section 7 consultation. The Corps anticipates implementing all practicable conservation measures and will use BMPs as appropriate to avoid and minimize impacts of noise to marine mammals.

6.11 Bald and Golden Eagle Projection Act

The Bald and Golden Eagle Protection Act (16 U.S.C. §668-668c) applies to Corps civil works projects through the protection of bald and golden eagles from disturbance. Review of the WDFW database of Priority Habitats and Species showed there are no recorded eagle nesting sites within two miles of the project area. Eagles perch near and fly over the project area, but these individuals are assumed to be habituated to the noise and activity of the industrial seaport. No aspects of the proposed project are anticipated to have any effect to eagles.

6.12 Migratory Bird Treaty Act of 1918 and Executive Order 13186 Migratory Bird Habitat Protection

The Migratory Bird Treaty Act (16 U.S.C. §703-712) as amended protects over 800 bird species and their habitat, and commits that the U.S. will take measures to protect identified ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations. EO 13186 directs Federal agencies to evaluate the effects of their actions on migratory birds, with emphasis on species of concern, and inform the USFWS of potential negative effects to migratory birds. Implementation of the preferred alternative would not have any negative effects to migratory bird habitat and would only have minor and temporary effects to a small number of individual birds that may be present in the project area (See section 4.13). These birds are assumed to be habituated to the noise and activity of the industrial seaport.

6.13 Executive Order 13175 Consultation and Coordination with Indian Tribal Governments

Executive Order 13175 (November 6, 2000) reaffirmed the Federal government's commitment to a government-to-government relationship with Indian tribes, and directed Federal agencies to establish procedures to consult and collaborate with tribal governments when new agency regulations would have tribal implications. The Corps has a government-to-government consultation policy to facilitate the interchange between decision makers to obtain mutually acceptable decisions. In accordance with this Executive Order, the Corps has engaged in regular and meaningful consultation and collaboration with the federally recognized tribes (Muckleshoot and Suquamish), as well as one local tribe without Federal recognition (Duwamish) throughout the course of the study. The complete consultation process is described in section 7.2.

6.14 Executive Order 12898 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" provides that each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Environmental justice concerns may arise from impacts on the natural and physical environment, such as human health or ecological impacts on minority populations, low-income populations, and Indian tribes or from related social or economic impacts.

The NEPA procedures are important in identifying and addressing environmental justice concerns. The Corps evaluated the nature and location of the proposed construction site and used the EPA Environmental Justice Viewer to determine whether minority populations, low-income populations, or Indian tribes are present in the action area and may be affected. The Corps has analyzed the potential effects of the alternatives on communities within a 3-mile radius of the proposed action and found that there would be no disproportionately high and adverse human health impacts to any environmental justice communities.

6.15 Executive Order 11990 Protection of Wetlands

Executive Order 11990 entitled Protection of Wetlands (May 24, 1977) requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order. No wetlands will be affected by the proposal. Aquatic disposal is approved under the DMMP approval for use of the Elliott Bay aquatic disposal site.

6.16 Executive Order 13045 Protection of Children from Environmental Health Risks and Safety Risks

Executive Order 13045 (April 21, 1997) points out that children may suffer disproportionately from environmental health and safety risks due to their bodily systems still developing at the same time of eating, drinking, and breathing greater quantities in proportion to their size compared to adults. Federal agencies are required to identify and assess environmental health risks that may disproportionately affect children and ensure that activities address disproportionate risks to children that result from environmental health or safety risks.

The Corps has identified a discountable risk of elevated contaminants in seafood in the project area and will rely on the Washington Department of Health to issue advisories as appropriate. There is no disproportionate risk to children from the proposed action as children are accounted for in the health risk advisories.

7 Public Involvement, Review, and Consultation

Public involvement activities and agency coordination are summarized in this chapter.

7.1 Public Involvement Process

Corps Planning Policy and NEPA emphasize public involvement in government actions affecting the environment by requiring that the benefits and risks associated with the proposed actions be assessed and publicly disclosed. In accordance with NEPA public involvement requirements (40 CFR 1506.6) and Corps Planning Policy (ER 1105-2-100), opportunities were presented for the public to provide oral or written comments on potentially affected resources, environmental issues to be considered, and the agency's approach to the analysis. Efforts to involve the public included a notice of preparation of an EA with public comment period issued 7 November 2014, a public scoping meeting held 19 November 2014, soliciting relevant information from the public, and explaining procedures of how interested parties can get information on the planning process.

7.2 Tribal Government Consultation and Coordination Process

Consultation began with introductory letters describing the proposed study, which were sent during reconnaissance phase to three tribes (Duwamish, Muckleshoot, and Suquamish Tribes) near the project area. The Suquamish Tribe and Muckleshoot Tribe provided natural resources specialists from their staffs to participate in a meeting regarding protection of natural resources held August 12, 2015. The tribes' natural resources departments were provided a copy of the DFR/EA for their review and comment. Tribal coordination will continue throughout the feasibility phase, PED phase, and construction in accordance with Executive Order 13175 Consultation and Coordination with Indian Tribal Governments.

7.3 Agencies and Persons Consulted*

The following list of agencies and individuals were consulted by the Corps during the plan formulation and environmental compliance of this feasibility study and preparation of the Integrated FR/EA.

- U.S. Environmental Protection Agency, Region 10
- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- Muckleshoot Indian Tribe
- Suquamish Indian Tribe
- Duwamish Indian Tribe
- Washington Department of Archaeology and Historic Preservation
- Washington Department of Fish and Wildlife
- Washington Department of Ecology
- Washington Department of Natural Resources
- Puget Sound Pilots
- IHS Global Insight
- Maritime Strategies, Inc.

8 Recommendations

The following language outlines the Corps' recommendations for project approval and authorization for implementation.

I concur with the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that navigation improvements for Seattle Harbor be authorized in accordance with the reporting officers' recommended plan with such modifications as in the discretion of the Chief of Engineers may be advisable. The estimated project first cost of the recommended plan is $78,112,000 (October 2015 price level). The Federal portion of the estimated first cost is $13,343,000. The non-Federal sponsors' portion of the required cost share of total project first costs is $64,768,000. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal and state laws and policies, including Section 101 of WRDA 1986, as amended. This recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and policies including that the non-Federal sponsor must agree with the following requirements prior to project implementation:

a. Provide, during the periods of design and construction, funds necessary to make its total contribution for commercial navigation equal to:

   (1) 25% of the cost of design and construction of the GNFs attributable to dredging to a depth between -20 MLLW and -45 MLLW,

   (2) 50% of the cost of design and construction of the GNFs attributable to dredging to a depth in excess of -45 MLLW but not in excess of -56 MLLW, plus

   (3) 100% of the costs attributable to dredging to a depth over -56 MLLW.

b. Provide all lands, easements, rights-of-way, and relocations (LERR), including those necessary for the borrowing of material and placement of dredged or excavated material, and perform or assure performance of all relocations, including utility relocations, all as determined by the government to be necessary for the construction or operation and maintenance of the GNFs. Provide and maintain during the authorized life of the project the mitigation lands determined to be required for mitigation for impacts for the project.

c. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the GNFs, an additional amount equal to 10% of the total cost of construction of the NED GNFs less the amount of credit afforded by the government for the value of the LERR and relocations, including utility relocations, provided by the non-federal sponsor for the GNFs. If the amount of credit afforded by the government for the value of LERR, and relocations, including utility relocations, provided by the non-federal sponsor equals or exceeds 10% of the total cost of construction of the GNFs, the non-federal sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of LERR and relocations, including utility relocations, in excess of 10% of the total costs of construction of the GNFs.

d. Provide, operate, and maintain, at no cost to the government, the local service facilities in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the government.

e. Provide 50% of operation and maintenance of the project for depth greater than -50 MLLW up to -56 MLLW for the NED plan.

f. Provide 100% of the excess cost of operation and maintenance of the project over that cost which the government determines would be incurred for operation and maintenance a project depth in excess of the NED plan.

g. Accomplish all removals determined necessary by the Federal government other than those removals specifically assigned to the Federal government.

h. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the Sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating and maintaining the GNFs.

i. Hold and save the United States free from all damages arising from the construction or operation and maintenance of the project, any betterments, and the local service facilities, except for damages due to the fault or negligence of the United States or its contractors.

j. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under LERR that the government determines to be necessary for the construction or operation and maintenance of the GNFs. However, for lands, easements, or rights-of-way that the government determines to be subject to the navigation servitude, only the government shall perform such investigation unless the government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

k. Assume complete financial responsibility, as between the government and the non-Federal sponsor, for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under LERR that the government determines to be necessary for the construction or operation and maintenance of the project.

l. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the local service facilities for the purpose of CERCLA liability.

m. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA.

n. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1% of the total amount authorized to be appropriated for the project.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may

be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the State of Washington, the Port of Seattle (the non-Federal sponsor), interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

JOHN G. BUCK

Colonel, Corps of Engineers

District Commander

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