Millennium Bulk Terminals–Longview SEPA Environmental Impact Statement

SEPA Vessel Transportation Technical Report

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Acronyms and Abbreviations

°F	degrees Fahrenheit
ACP	Northwest Area Contingency Plan
AIS	Automatic Identification System
ANT	Aids to Navigation Team
Applicant	Millennium Bulk Terminals—Longview, LLC
ATB	articulated tug-barge
Bar	Columbia River Bar
Bar Pilots	Columbia River Bar Pilots
BNSF	BNSF Railway Company
BWM	ballast water management
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
City	City of Longview
River Pilots	Columbia River Pilots
Corps	U.S. Army Corps of Engineers
COTP	Captain of the Port
County	Cowlitz County
DNR	Washington Department of Natural Resources
dwt	deadweight ton
Ecology	Washington State Department of Ecology
ERTS	Environmental Report Tracking System
FOSC	Federal On-Scene Coordinator
fps	feet per second
Groundfish FMP	Pacific Coast Groundfish Fishery Management Plan
GRP	geographic response plan
HSP	Harbor Safety Plan
LVSW	Longview Switching Company
MARPOL	International Convention for the Prevention of Pollution from Ships
MFSA	Maritime Fire & Safety Association
MISLE	Marine Information for Safety and Law Enforcement
mph	miles per hour
MSU	Marine Safety Unit
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NISA	National Invasive Species Act
NOA	Notice of Arrival
NOAA	National Oceanic and Atmospheric Administration
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
OPA 90	Oil Pollution Act of 1990

ORS	Oregon Revised Standards
PDXMEX	Merchants Exchange of Portland, Oregon
PORTS	Physical Oceanographic Real-Time System
PTSA	Port and Tanker Safety Act
PWSA	Ports and Waterways Safety Act
RCW	Revised Code of Washington
River Pilots	Columbia River Pilots
RM	river mile
SEPA	Washington State Environmental Policy Act
SOLAS	Safety of Life at Sea
SOSC	State On-Scene Coordinator
SPIIS	Spills Program Incident Information
TV32	Transview 32
UP	Union Pacific Railroad
USC	United States Code
USCG	U.S. Coast Guard
VEAT	Vessel Entries And Transits
VTIS	Vessel Traffic Information System
WAC	Washington Administrative Code

Chapter 1
Introduction

This technical report assesses the potential vessel transportation impacts of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and No-Action Alternative. For the purposes of this assessment, vessel transportation refers to the movement of vessels within the Columbia River, including capacity of the river, historical and projected traffic levels, and vessel traffic management, safety, and emergency response. This report describes the regulatory setting, establishes the methods for assessing potential vessel transportation impacts, presents the historical and current vessel transportation conditions in the study area, and assesses potential impacts.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) is proposing to construct and operate a coal export terminal (Proposed Action) in Cowlitz County, Washington along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming, and the Uinta Basin in Utah and Colorado via rail shipment. The coal export terminal would receive, stockpile, and load coal onto vessels and transport the coal via the Columbia River and Pacific Ocean to overseas markets in Asia.

1.1.1 Proposed Action

Under the Proposed Action, the Applicant would develop the coal export terminal on 190 acres (project area) primarily within an existing 540-acre site that is currently leased by the Applicant (Applicant's leased area). The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview, Washington (Figure 2). The Applicant currently operates and would continue to operate a bulk product terminal within the Applicant's leased area.

BNSF Railway Company (BNSF) or Union Pacific Railroad (UP) trains would transport coal on BNSF main line routes in Washington State, and the BNSF Spur and Reynolds Lead in Cowlitz County to the project area. Coal would be unloaded from rail cars, stockpiled, and loaded by conveyor onto ocean-going vessels for export at two new docks (Docks 2 and 3) located in the Columbia River.

Once construction is complete, the Proposed Action could have a maximum annual throughput capacity of up to 44 million metric tons of coal per year. The coal export terminal would consist of one operating rail track, eight rail tracks for storing up to eight unit trains, rail car unloading facilities, a stockpile area for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and shiploading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432), and vessels would access the project area via the Columbia River. The Reynolds Lead and BNSF Spur track—both jointly owned by BNSF and UP and operated by Longview Switching Company (LVSW)—provide rail access to the project area from a point on the BNSF main line (Longview Junction) located to the east in Kelso, Washington. Coal export terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

At full terminal operations, approximately 8 loaded unit trains each day would carry coal to the export terminal, 8 empty unit trains each day would leave the export terminal, and an average of 70 vessels per month or 840 vessels per year would be loaded, which would equate to 1,680 vessel transits in the Columbia River annually.

Figure 1. Project Vicinity

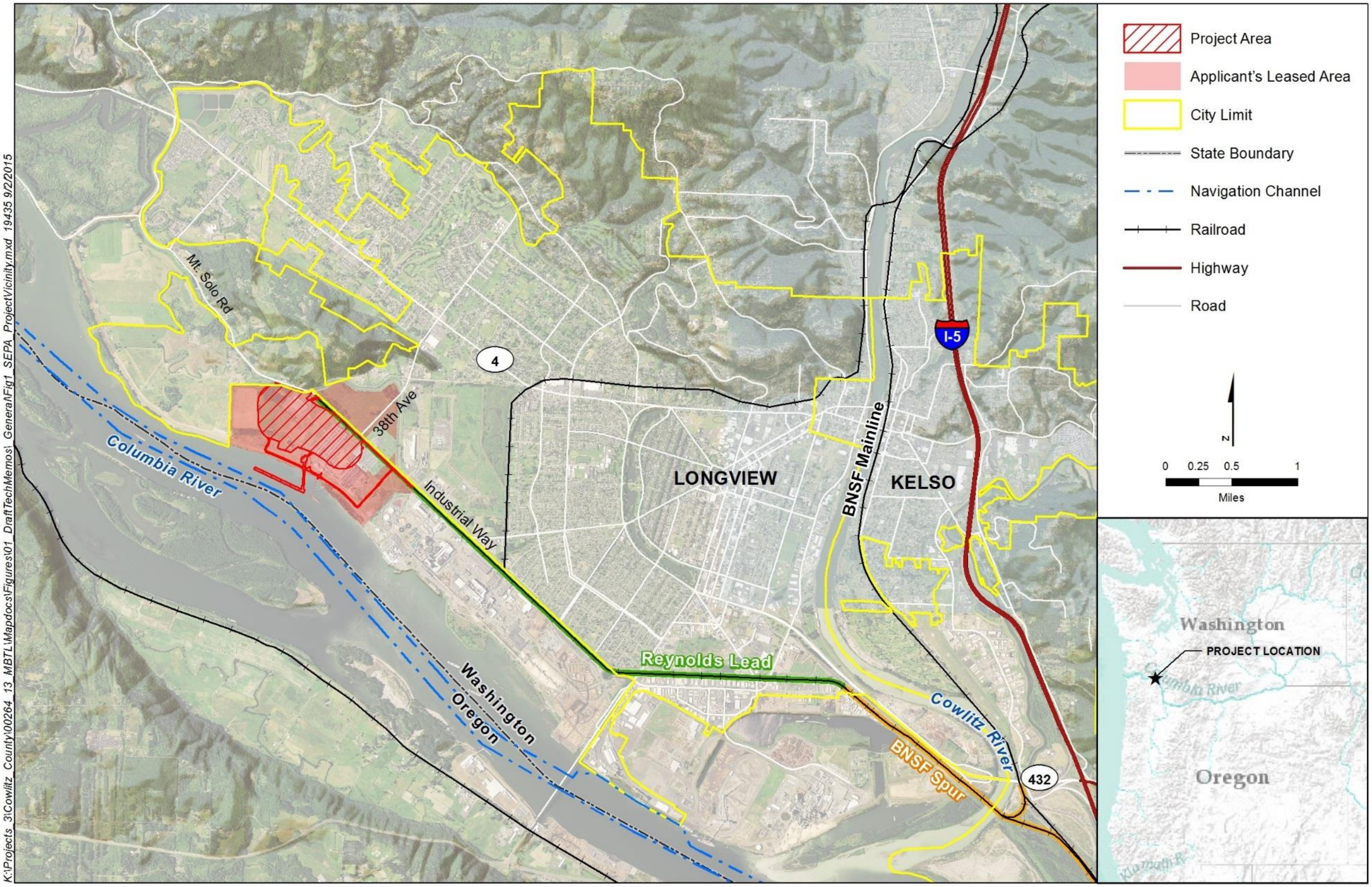
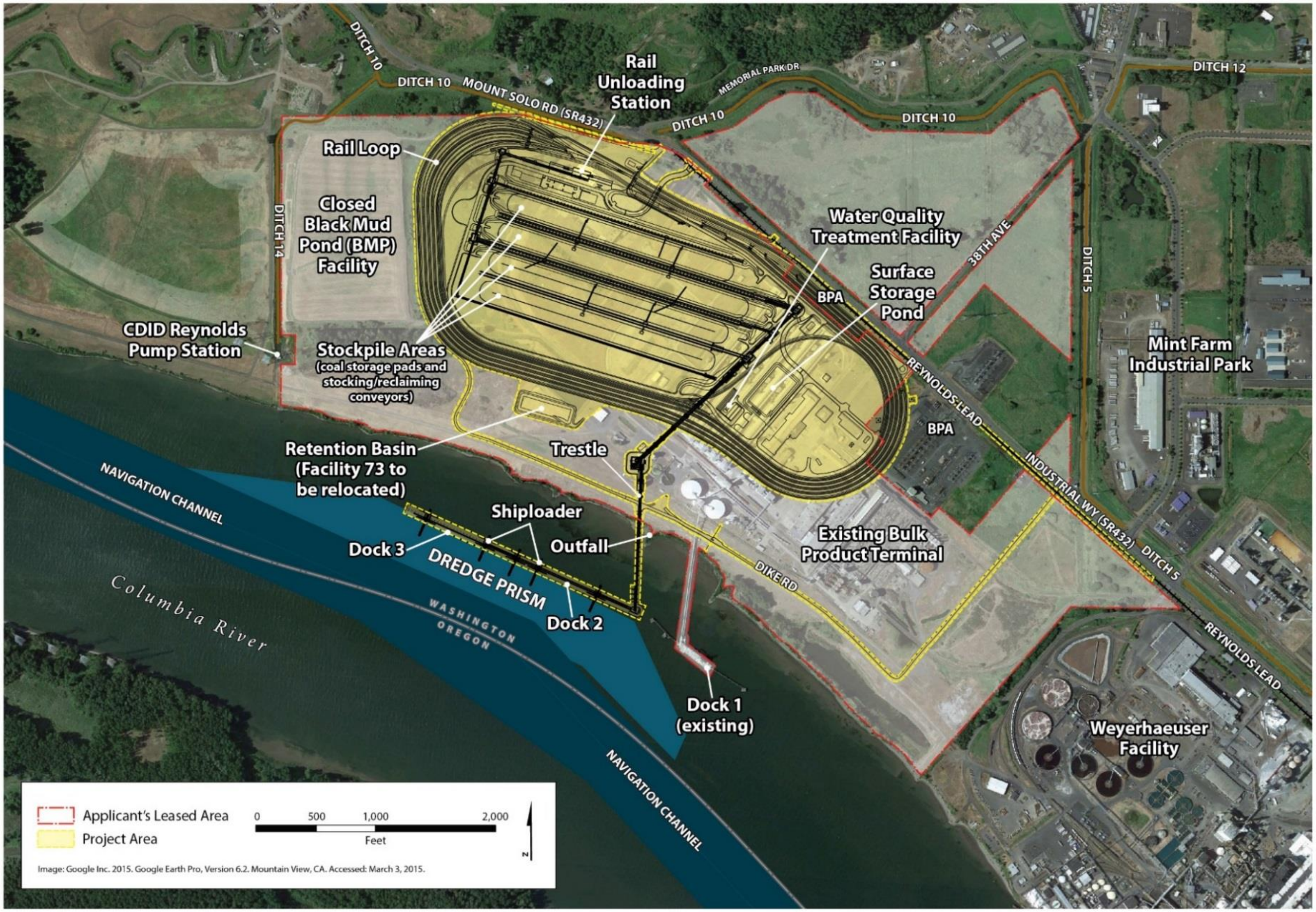


Figure 2. Proposed Action



1.1.2 No-Action Alternative

The Applicant plans to continue operating its existing bulk product terminal located adjacent to the project area. Ongoing operations would include storing and transporting alumina and small quantities of coal, and continued use of Dock 1. Maintenance of the existing bulk product terminal would continue, including maintenance dredging at the existing dock every 2 to 3 years. The Applicant plans to expand operations at the existing bulk product terminal, which could include increased storage and upland transfer of bulk products utilizing new and existing buildings. The Applicant would likely need to undertake demolition, construction, and other related activities to develop expanded bulk product terminal facilities.

If the coal export terminal is not constructed, the Applicant would likely propose expansion of the bulk product terminal onto areas that would have been subject to construction and operation of the proposed coal export terminal. Additional bulk product transfer activities could involve products such as a calcined pet coke, coal tar pitch, cement, fly ash, and sand or gravel. Any new operations would be evaluated under applicable regulations. Upland areas of the project area are zoned Heavy Industrial and it is assumed future proposed industrial uses in these upland areas could be permitted. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations.

1.2 Regulatory Setting

Different jurisdictions are responsible for the regulation of vessel transportation. These jurisdictions and their regulations, statutes, and guidance that apply to vessel transportation are summarized in Table 1. Proposed Action-related vessels would carry fuel oil for the purposes of engine propulsion. Therefore, Table 1 also includes laws and regulations related to oil spill preparedness and response.

Table 1. Conventions, Regulations, Statutes, and Guidelines for Vessel Transportation

Convention, Regulation, Statute, Guideline	Description
International	
International Convention for the Safety of Life at Seas (SOLAS)	Maintains global safety standards for international maritime shipping. In addition to the construction, navigation, life-saving, communications, and fire equipment requirements inherent to Chapters I through V of the Convention, SOLAS Chapter XII, Additional Safety Measures for Bulk Carriers, adopted by Conference in November 1997 and entered into force on 1 July 1999 covers specific, mandatory requirements for bulk carriers. The regulations provide structural and detection and alarm equipment requirements to prevent the catastrophic flooding of bulk carriers if a cargo hold is damaged.

Convention, Regulation, Statute, Guideline	Description
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) Annex I: Prevention of Pollution by Oil Annex II: Control of Pollution by Noxious Liquid Substances Annex IV: Prevention of Pollution by Sewage from Ships Annex V: Prevention of Pollution by Garbage from Ships Annex VI Prevention of Air Pollution from Ships	International convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. Includes six technical annexes of which five apply to this project. Annexes I and II are implemented within U.S. legislation and require covered ships to carry a shipboard oil pollution emergency plan or SOPEP. Annexes III through VI are optional. The U.S. has accepted Annex V, which came into force on 31 December 1988, and Annex VI which was adopted by the U.S. on October 8, 2008.
International Ship and Port Facility Security (ISPS) Code	Adopted under SOLAS in 2002; entered into force in 2004. Contains detailed security-related requirements for Governments, port authorities, and shipping companies.
International Maritime Solid Bulk Cargoes Code (IMSBC Code)	Adopted under SOLAS in 2008; entered into force in 2011. The aim of the mandatory IMSBC Code is to facilitate the safe stowage and shipment of solid bulk cargoes by providing information on the dangers associated with the shipment of certain types of cargo and instructions on the appropriate procedures to be adopted.
International Regulations for Preventing Collisions at Sea, 1972 (known as 72 COLREGS)	COLREGS are regulations which aid mariners in safe navigation in International Waters or waters outside the COLREGS demarcation line which, for the Columbia River entrance, is a line drawn from the seaward extremity of the Columbia River North Jetty to the seaward extremity of the Columbia River South jetty.
Standards of Training, Certification, and Watchkeeping (STCW) 1978 revised in 1995 and 2010	STCW standardizes the training, certification, and watchkeeping requirements for seafarers worldwide.
Federal	
National Environmental Policy Act (42 USC 4321 et seq.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
International Navigational Rules Act of 1977 (Public Law 95-75; 91 Statute 308; 33 USC 1601-1608) (33 CFR 80-82)	Establishes the navigation rules for international waters.
Inland Navigational Rules Act of 1980 (Public Law 96-591) known as "Rules of the Road" (33 CFR 84-90)	Establishes the navigation rules for U.S. waters.
46 USC (Shipping) Chapter 33 (Inspection)	Consolidates the laws governing the inspection and certification of vessels by USCG.

Convention, Regulation, Statute, Guideline	Description
Ports and Waterways Safety Act of 1972 (33 USC 1221 et seq.)	Provides for the protection and “safe use” of a U.S. port (includes the marine environment, the navigation channel, and structures in, on, or immediately adjacent to the navigable waters) and for the protection against the degradation of the marine environment.
Port and Tanker Safety Act of 1978 (amended the PWSA). Relevant regulations are 33 CFR 161 and 164.	Addresses improvements in the supervision and control over all types of vessels, foreign and domestic, operating in the U.S. navigable waters. Additionally, the PTSA addresses improvements in the control and monitoring of vessels operating in offshore waters near U.S. coastline, and vessel manning and piloting standards.
Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 as amended by the National Invasive Species Act of 1996 (16 USC 4711(c)(2)) Relevant regulations are 33 CFR 151 and 46 CFR 162.	Requires the Secretary of Homeland Security to ensure to the maximum extent practicable that aquatic nuisance species are not discharged into waters of the U.S. from vessels. Also allows the Secretary to approve the use of certain alternative BWM methods.
Maritime Transportation Security Act of 2002 (46 USC 701). Relevant regulations are 33 CFR 101 and 105.	Requires a comprehensive maritime security framework that includes planning, personnel security, and monitoring of port facilities, and cargo. Aligned, where appropriate, the requirements of domestic maritime security regulations with the international maritime security standards in the International Convention for the Safety of Life at Sea, 1974, and the International Code for the Security of Ships and of Port Facilities to ensure security arrangements in the U.S. are as compatible as possible for vessels trading internationally.
Federal Water Pollution Control Act, as amended by Section 4202 of the Oil and Pollution Act of 1990 (33 USC 1321). Relevant regulations are the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300) and 33 CFR 155.5010–5075.	40 CFR 300 establishes a national response system for oil spills and hazardous material releases. Provides a framework and establishes guidelines for area contingency planning for oil spills and hazardous material releases. 33 CFR 155.5010-5075 requires cargo (referred to as nontank vessels) vessels to prepare and submit oil or hazardous substance discharge response plans when operating on the navigable waters of the United States.
The Act to Prevent Pollution from Ships (33 USC 1901 et seq.)	Implementing U.S. legislation for MARPOL and Annexes I and II.
Maritime Transportation Act of 2004; Coast Guard and Maritime Transportation Act of 2006. Amended 311(a) and (j) of the Federal Water Pollution Control Act (CFR 151, 155, and 160)	Requires cargo vessel owners or operators to prepare and submit oil or hazardous substance discharge response plans.

Convention, Regulation, Statute, Guideline	Description
33 CFR, 46 CFR, and 49 CFR	These regulations incorporate international laws to which the U.S. is signatory as well as various classification society and industry technical standards governing the inspection, control, and pollution prevention requirements for vessels. For example, MTSA 2002 requirements for vessels are regulated in accordance with 33 CFR Part 104.
Washington State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Washington State Ballast Water Management Rules (WAC 220-150) (Statutory Authority: RCW 77.120).	Requires the owner/operator in charge of a vessel 300 gross tons or more, U.S. and foreign, carrying or capable of carrying ballast water into the waters of the State to file a ballast water reporting form at least 24 hours prior to arrival into waters of the State and to ensure that the vessel does not discharge ballast water into the waters of the State except as authorized by the law.
Washington State Bunkering Operations (WAC 317-40) (Statutory Authority: RCW 88.46.170)	Establishes minimum standards for safe bunkering (transfer of fuel to a vessel) operations to reduce the likelihood of an oil spill.
Washington State Oil Spill Contingency Plan Requirements (WAC 173-182) (Statutory Authority: RCW 88.46, 90.56, and 90.48)	Requires that cargo vessels (self-propelled ships in commerce) 300 or more gross tons (other than a passenger vessel or tank vessel) submit a contingency plan for the containment and cleanup of oil spills from the covered vessel into the waters of the State and for the protection of fisheries and wildlife, shellfish beds, natural resources, and public and private property from such spills. Alternatively, the contingency plan for a cargo vessel may be submitted by the agent for the vessel or by a nonprofit corporation established for the purpose of oil spill response and contingency plan coverage and of which the owner/operator is a member.
Washington State Vessel Oil Transfer Advance Notice and Containment Requirements (WAC 173-184)	Requires facility or vessel operators who transfer oil to provide the state with a 24-hour advance notice of transfer.
Washington State Cargo Vessel Boarding and Inspection (WAC 317-31)	Cargo vessels 300 or more gross tons shall submit a notice of entry at least 24 hours before the vessel enters state waters and be subject to boarding and inspection by state inspectors to ensure compliance with accepted industry standards.
Oregon State	
Oregon State Board of Maritime Pilots Rules (OAR 856-010-0003 through 0060 and 856-030-0000 through 0045; Statutory Authority: 58 ORS 776).	Sets rules for pilotage of vessels in Oregon state waters, including the Columbia River.
Oregon DEQ State Oil Spill Contingency Plan (OAR 340-141; Statutory Authority: ORS 468.020, 468B.345–468B-390).	Establishes requirements for cargo vessels (self-propelled ships in commerce) 300 or more gross tons (other than a tank vessel or a passenger vessel).

Convention, Regulation, Statute, Guideline	Description
Local	
There are no local laws and regulations relevant to vessel transportation.	
Notes: USC = United States Code; NEPA = National Environmental Policy Act; CFR = Code of Federal Regulations; CEQ = Council on Environmental Quality; PWSA = Ports and Waterways Safety Act; PTSA = Port and Tanker Safety Act; NANPCA = Nonindigenous Aquatic Nuisance Prevention and Control Act; NISA = National Invasive Species Act; BWM = ballast water management; OPA 90 = Oil and Pollution Act of 1990; WAC = Washington Administrative Code; RCW = Revised Code of Washington; ORS = Oregon Revised Standards; USCG = U.S. Coast Guard; SEPA = Washington State Environmental Policy Act; City = City of Longview; County = Cowlitz County; OAR = Oregon Administrative Rules; DEQ = Department of Environmental Quality; MARPOL = International Convention for the Prevention of Pollution from Ships	

1.3 Study Area

The study area for direct impacts is the area surrounding the proposed docks (Docks 2 and 3) where vessel loading would occur. The study area for vessel transportation includes the waterways that would be used by or could be affected by vessels calling at the project area. It includes the waters out to 3 nautical miles seaward of the mouth of the Columbia River, the Columbia River Bar (Bar), the Columbia River upstream to Vancouver, Washington[1], and the Willamette River upstream to the Port of Portland (Figure 3).

[1] The Port of Vancouver is the furthest upstream port receiving large commercial vessels.

Figure 3. Study Area for Vessel Transportation

Chapter 2
Existing Conditions

This chapter describes the existing conditions in the study area as they pertain to vessel transportation. The chapter explains the methods for assessing the existing conditions and determining impacts, then describes the existing conditions in the study area as they pertain to vessel transportation.

2.1 Methods

This section describes the sources of information and methods used to characterize existing conditions and assess the potential impacts of the Proposed Action and No-Action Alternative on vessel transportation.

2.1.1 Data Sources

Data for the vessel transportation analysis were obtained from stakeholder interviews and the following sources of information.

- Detailed vessel transportation data from the Columbia River Bar Pilots (Bar Pilots) included in information provided by the Applicant (URS Corporation 2014) was validated during a meeting with the Bar Pilots. That report and other data obtained from the pilots are the basis for historical vessel transportation type and volumes. In addition, Washington State Department of Ecology (Ecology)] Vessel Entries And Transits (VEAT) data were used for comparison with the Bar Pilot data.
- The Columbia River Pilots (River Pilots) representatives provided information on vessel traffic management within the Columbia River and vessel docking issues at the existing dock at the project area.
- Merchants Exchange of Portland, Oregon (PDXMEX), representatives provided a synopsis of its operations, which consist of vessel tracking (through the Automatic Identification System [AIS]), data collection, and information exchange (via telephone, radio, and website). AIS data from 2014 were also provided and served as the basis for characterizing current vessel traffic mix and densities, as described further in Section 2.1.2, *Impact Analysis*.
- AIS data from 2014 were used to characterize existing (2014) vessel distribution and density.
- *Coast Pilot 7 (Pacific Coast: California, Oregon, Washington, Hawaii, and Pacific Islands)* (National Oceanic and Atmospheric Administration 2014) and the *Lower Columbia Region Harbor Safety Plan* (Lower Columbia Region Harbor Safety Committee 2013) provided information on the vessel transportation characteristics of the study area.
- The following data sources were used as part of the risk analysis.
    - AIS data to establish baseline (2014) vessel types, sizes, routes, and transit frequencies between the Columbia River mouth and Longview.

  - Historical data on vessel incidents and severity, based on the U.S. Coast Guard (USCG) Marine Information for Safety and Law Enforcement (MISLE) database from 2001 to 2014.
  - Data on reported oil spills in the Columbia and Willamette Rivers from the following three databases for the period between January 1, 2004, and December 31, 2014:[2] USCG MISLE database, Ecology's Environmental Report Tracking System (ERTS) database, which records all incidents reported to the state, and Ecology's Spills Program Incident Information (SPIIS) database, which records spills reported to the state.
- Information also was collected during visits to the project area on October 14, 2014.

2.1.2 Impact Analysis

For the purposes of this analysis, construction impacts are based on the peak construction period, and operations impacts are based on maximum coal export terminal throughput capacity (up to 44 million metric tons per year). The following methods were used to evaluate the potential impacts of the Proposed Action and No-Action Alternative on vessel transportation.

- The vessel transportation route, navigational considerations, historical and current vessel traffic patterns, and the systems in place to monitor and control vessel traffic along that route were described based on information gathered through the sources described in Section 2.1.1, *Data Sources*.
- Construction-related impacts were qualitatively assessed based on the relative increase in activity in and around the project area and the potential to disturb ongoing vessel transportation.
- Operations-related impacts at the project area (direct impacts) were qualitatively evaluated in terms of the increased potential for vessel-related incidents to occur.
- Operations-related impacts during vessel transit (indirect impacts) were evaluated both qualitatively and quantitatively to determine the potential for increased risks. Historical vessel incident data were evaluated to characterize the nature and magnitude of vessel incidents that have occurred on the Columbia River in the project area.
- The potential for vessel incidents (i.e., allisions[3] at the project area, collisions, groundings, and fire/explosions by project-related vessels during transit) was modeled for existing conditions, the Proposed Action, and No-Action Alternative. The potential for allisions during transit was qualitatively assessed.
  - The incident frequencies were estimated using the Marine Accident Risk Calculation System model and were limited to the area evaluated in the study (Appendix A, *Navigation Risk Study*).
  - The number of trips for non-Proposed Action-related vessels were derived from 2014 AIS data for all vessel types. An increase of 1% per year was applied to the 2014 AIS data through 2028 for the No-Action Alternative. The number of vessels under the Proposed

[2] When the information from these three datasets were combined, all duplicate entries were removed and only incidents with actual reported spills of petroleum or petroleum products were considered in the development of the baseline oil spill frequency for the study area.

[3] An allision occurs when a vessel strikes a fixed structure, such as a dock or a vessel at berth.

Action was added to this total to determine the incremental increase in the likelihood of the modeled incidents occurring.

- To provide context for understanding the relative consequences of a collision, grounding or allision incident, a survey of USCG MISLE database was conducted for years 2001 to 2014. This period was chosen because it covers over 99% of all reported collision, grounding, and allision incidents in the dataset. Data surveys were conducted for the national dataset and for the study area separately to test for the differences in the distribution of incident severity between the two.
- Increased risks of bunker oil spills were addressed both quantitatively and qualitatively.
    - The potential for a bunker oil spill to occur as the result of an incident was modeled using the NAPA model (DNV GL 2016). Using Monte Carlo simulations, in accordance with International Maritime Organization Resolution MEPC.110(49)[4] - Probabilistic Methodology for Calculating Oil Outflow, the model estimates oil outflow volumes based on the number of damaged cargo tanks and interaction with tidal influences. Monte Carlo simulations were run for 50,000 damage cases to estimate the potential variability in impact and oil outflow volumes.
    - The potential for releases to occur during bunkering was qualitatively assessed based on the relative increase in vessel transportation.

2.2 Existing Conditions

This section addresses the existing conditions related to vessel transportation in the study area, including the marine environment, navigation channel and other features; vessel traffic, vessel traffic management, vessel casualty and spill surveys; and incident management.

2.2.1 Marine Environment

Conditions of the marine environment in the study area that can affect vessel transportation include winds, longshore and tidal currents, river flows, swells and waves, and extreme weather. These elements are described below by portion of the study area

2.2.1.1 Pacific Ocean—Offshore of the Columbia River

Conditions in the Pacific Ocean near the mouth of the Columbia River can vary greatly depending upon the time of year. Prevailing winds and seasonal patterns have the greatest effect on offshore conditions. *Coast Pilot 7* (National Oceanic and Atmospheric Administration 2014: 261–265) provides a thorough discussion of weather in the Pacific Ocean off the West Coast and a brief synopsis of what vessel captains transiting along the U.S. coastline can expect:

> The route along the California-Oregon-Washington coast frequently must be navigated in thick weather. Most of the courses are long, and the effect of currents is uncertain (p. 265).

Longshore currents that generally flow to the north in winter and to the south in summer also affect vessel navigators, although not as much as tidal current and river flows near the river system.

[4] The Marine Environment Protection Committee (MEPC) is a subsidiary body of the International Maritime Organization Council.

River current always flows out, but with wide variations in flow rate and volume. The outflow from the Columbia River is a combination of tidal currents with river discharge. At times, currents reach a velocity of over 5 knots on the ebb; on the flood they seldom exceed a velocity of 4 knots. Offshore swells close to the river system can vary more than several feet with the current flow and can result in breaking waves.

2.2.1.2 Columbia River Bar

The Columbia River Bar is just seaward of the mouth of the Columbia River (Figure 3). The bar is about 3 miles wide and 6 miles long, and is where the energy of the river's current dissipates into the Pacific Ocean, often as large standing waves (one meter/3.28 feet or more) (Jordan pers. comm. B). The waves result from the bottom contours of the bar area, the mixing of fresh and saltwater, and environmental conditions.

Tide, current, swell, and wind—direction and velocity—all affect bar conditions. Current velocity typically ranges from 4 to 7 knots westward into the predominantly westerly winds and ocean swells, creating significant disturbances of the water column and waves. There are two full tidal current ebb and flood cycles each day, and conditions at the bar can change unpredictably in a short time period with the tidal flow. Worst-case conditions typically occur when onshore winds and tidal ebb combine with the river flow; when this happens, the effects can change unpredictably in a very short time as the tidal flow cycles.

2.2.1.3 Columbia River

The tidal range at the mouth of the Columbia River is approximately 5.6 feet with mean higher high water measured at 7.5 feet in 2013 (National Oceanic and Atmospheric Administration 2014). At Portland and Vancouver the tidal range is approximately 2.3 feet with mean higher high water measured at 8.7 feet in 2013 (National Oceanic and Atmospheric Administration [NOAA] tides and water levels station 9440083). The Columbia River experiences a mixed semidiurnal tide cycle. This means that there are two high and two low high tides of different size every lunar day. Moreover, the river flow combines with the tides to influence tidal heights. For example, during the spring when the river flow peaks, tidal height is increased by additional water flowing through the river. This phenomenon is referred to as *freshet* (National Oceanic and Atmospheric Administration 2009).

Annual freshets have little effect on the tide range at the mouth of the Columbia River; however, at Portland and Vancouver they average about 12 feet with the highest-known level of 33 feet at Portland. Typically, tidal influence reaches as far as the Portland/Vancouver area. However, tidal effects can be felt as far as 140 miles upriver under low-flow conditions.

The average annual flow for the Columbia River at Beaver Army Terminal near Quincy, Oregon,[5] is approximately 236,600 cubic feet per second (cfs) (1 cfs = 448.8 gallons per minute). The river's annual discharge rate fluctuates with precipitation and ranges from 63,600 cfs in a low water year to 864,000 cfs in a high water year (U.S. Geological Survey 2014). The flow is driven primarily by the outflow from the dams on the upper portion of the river, which varies with both snowmelt and rainfall.

Average winter daytime temperatures vary from the upper forties (48 to 49) of degrees Fahrenheit (°F) near the mouth to the upper thirties (39°F) at Vancouver, Washington, and Portland, Oregon. At

[5] Approximately 12 river miles downstream of the project area.

night, the coastal temperatures range within the mid- to high-thirties (35 to 37°F) compared to the low- to mid-thirties (32 to 37°F) further inland near Vancouver and Portland. Snowfall is not common west of Vancouver. Average annual snowfall in Vancouver is 2 inches and occurs in higher elevations of the city.

Although winds are strongest in late fall and winter, they seldom reach gale force along the Columbia River. The strongest winds are usually out of the south or southwest. Wind flow is generally from the east through southeast in winter, and wind speeds reach 17 knots or more about 5 to 10% of the time.

Spring temperatures rise slowly near the Columbia River mouth, compared to the rate of temperature rise further upriver. By April, daytime temperatures in Vancouver average in the low-60s (°F) versus the mid-50s in the towns closer to the Columbia River mouth. Spring and summer typically have northwest and west wind patterns that often clash with river outflows. The volume of water flowing from the Columbia River and the force of impact with ocean conditions can combine to create daunting sea conditions. Nevertheless. Summer winds generally remain light and have a cooling effect keeping average daytime temperatures below 70°F at Astoria and below 80°F at Portland. Toward late summer, fog becomes a hazard near the river mouth and visibilities fall below 0.5 mile on about 4 days in August. Fog spreads upstream to Portland by September. During the fall, fog reduces visibility to less than 0.5 mile on 4 to 8 days per month.

2.2.2 Columbia River Navigation Channel

The Washington-Oregon border follows the Columbia River (Figure 3). The portion of the channel at the mouth of the Columbia River referred to as the Bar, is 6 miles long, extending 3 nautical miles[6] into the Pacific Ocean from the mouth of the river to 3 miles up the river. From this point at 3 miles upstream, the channel continues along the Columbia River upstream to river mile (RM) 106.5, at the Port of Vancouver, and 11.6 miles along the Willamette River from its confluence with the Columbia River to Broadway Bridge in Portland. These portions of the channel are described in more detail below.

Although some areas of the navigation channel are dredged into rock, the channel sides (river banks) consist primarily of loose, unconsolidated sediments. However, there may be areas of submerged objects or rocky bottom. The River Pilots describe the banks of the river and the edges of the channel as generally soft with no major risks to vessels from a potential grounding (Amos pers. comm.).

The channel is shown on NOAA charts beginning with Chart No. 18521 at the mouth of the river, progressing to Chart No. 18524 at Longview and to Chart Numbers 18526 and 18527 at Portland and Vancouver (National Oceanic and Atmospheric Administration 2014).

2.2.2.1 Columbia River Bar

Descriptions on the U.S. Army Corps of Engineers (Corps), Portland District website note that “the Columbia River bar is the second-most treacherous in the world and the most treacherous in the United States” (U.S. Army Corps of Engineers 2015a). The Corps also notes that maintaining the channel to its authorized depth ensures safe passage for commercial and recreational vessels. The

[6] Offshore distances are recorded in terms of nautical miles and inshore distances and river distances are given in terms of statute miles.

channel varies from 2,000 feet wide and 55 feet deep to 640 feet wide and 48 feet deep. Dredging is possible only during the calmer weather period from June to early November. Up to 5 feet of over-depth dredging may be approved to ensure authorized project depth in between dredging cycles. In some locations an additional 1 to 2 feet of depth may be authorized.

The Corps maintains three jetties at the mouth of the Columbia River (Figure 3). The north jetty (2.5 miles long) and Jetty "A" 0.3-mile long) are on the Washington side of the mouth. The south jetty (6.6 miles long) is on the Oregon side. The jetties do not block waves but are aligned to focus the river flow to help keep the channel at the mouth of the river clear.

2.2.2.2 Columbia River

The Rivers and Harbors Act of 1878, authorized the original channel, and subsequent acts increased the authorized dimensions. The Water Resources Development Act of 1999 authorized deepening the channel to its present 43 feet from 40 feet. Depths are referenced to the Columbia River Datum, which is 2.32 feet above the North American Vertical Datum of 1988 at RM 61.7.

The deepening of the channel was undertaken to "accommodate the current fleet of international bulk cargo and container ships" and was completed in 2010 (U.S. Army Corps of Engineers 2015a). Detailed information is available on the Corps' Portland District website, including the *Columbia River Federal Navigation Channel Operations and Maintenance Dredging and Dredged Material Placement Network Update, River Miles 3 to 106.5, Washington and Oregon* (U.S. Army Corps of Engineers 2014).

The Columbia River navigation channel is maintained to the following dimensions (U.S. Army Corps of Engineers 2015b).

- From the Columbia River entrance at RM 3.0 to Vancouver, at RM 101.4: 43 feet deep and 600 feet wide.
- From RM 101.4 to RM 105.5 at Vancouver: 43 feet deep and 400 feet wide.
- From RM 105.5 to RM 106.5 at Vancouver: 35 feet deep and 500 feet wide.

The navigation channel also includes anchorages and turning basins, discussed below in Section 2.2.3.2, *Anchorages and Turning Basins.*

2.2.2.3 Willamette River

The portion of the navigation channel in the Willamette River is 43 feet deep and runs along the lower 11.6 miles of the Willamette River from its confluence with the Columbia River to the Broadway Bridge in Portland, at Willamette RM 11.6.[7]

2.2.3 Ports, Anchorages, and Other Features

This section describes ports, anchorages, and other physical features along the navigation channel.

[7] Unless specifically referred to as Willamette RM, all references to river mile (RM) in this report apply to the Columbia River.

2.2.3.1 Ports

Table 2 lists the ports in the study area with berthing for large vessels along with their locations and facilities. Figure 3 shows the locations of these ports.

Table 2. Ports in the Study Area

Port	Location	Facilities
Port of Astoria, Oregon	RM 12	Three deep-draft berths; additional berths for small commercial fishing vessels and research vessels; two marinas and a boatyard; two anchorages
Port of St. Helens, Port Westward Industrial Facility, near Clatskanie, OR	RM 53	Port of Westward Industrial Facility. One dock and one deep-water berth
Port of Longview, WA	RM 65	Eight marine terminals containing a total of eight berths
Port of Kalama, WA	RM 75	Seven marine terminals: two grain elevators, one general cargo dock, one barge dock, one liquid bulk facility, one lumber barge berth, and one deep-draft wharf
Port of Portland, OR	RM 100	Four marine terminals containing a total of 18 berths
Port of Vancouver, WA	RM 106.5	Four marine terminals containing a total of 13 berths

Notes:
RM = river mile

2.2.3.2 Anchorages and Turning Basins

This section describes anchorages and turning basins in the study area.

Vessels anchor within the Columbia River system for a variety of reasons, planned (e.g., to take on fuel, to wait for a berth) or unplanned (e.g., mechanical repairs, to wait for better weather conditions). In anticipation of this need, USCG has designated 11 locations for vessels to anchor. Each location has specific characteristics with which vessel masters, crews, and pilots must be familiar. Designated anchorages, as identified by USCG and described in 33 Code of Federal Regulations (CFR) 110.228 (Columbia River, Oregon and Washington), are listed in Table 3 and depicted in Figure 3.

The Corps' regulations establish the operational rules for the anchorages, including a requirement that vessels desiring to anchor must contact the pilot office that manages the anchorage to request a position assignment. The Bar Pilots manage Astoria North and Astoria South anchorages. The River Pilots manage the anchorages upriver from Astoria. The rules also specify that no vessel may occupy a designated anchorage for more than 30 consecutive days without permission from the USCG Captain of the Port (COTP).

The Lower Vancouver and Upper Vancouver anchorages are the only anchorage areas maintained by the Corps as part of the Columbia River navigation channel. The other designated anchorages are at sites identified as naturally deep locations, although shoaling does occur to some extent and dredging is occasionally necessary.

Although the anchorages downstream of the project area (Astoria North and South) can accommodate deep-draft vessels, use by vessels with drafts of more than 28 feet (at the Astoria North Anchorage) are not recommended due to the probability of dragging anchor. However, a deep anchorage position at Astoria North, referred to as The Hole, is normally kept vacant for deep-draft vessels in unusual situations or emergencies or for short-term anchoring (Lower Columbia Region Harbor Safety Committee 2013: 9). The Prescott and Upper Vancouver anchorages have stern mooring buoys that help prevent larger vessels using the anchorage from swinging into the navigation channel while at anchorage.

Table 3. Anchorages in the Study Area

ID[a]	Anchorage Name	River Miles	Range of Depth(s) (feet)	Maximum Vessel Size	Vessel Capacity	Stern Buoy?[b]
A	Astoria North[c]	14–17.8	24–45+	Panamax	6	No
B	Astoria South	15–18.2	20–45+	Handymax	4	No
C	Longview	64–66	29–40+	Handymax	5	No
D	Cottonwood Island	66.7–71.2	19–40+	Handymax	13	No
E	Prescott	72.1–72.5	52–65+	Panamax	1	Yes (1)
F	Kalama	73.2–76.2	26–40+	Panamax	7	No
G	Woodland[d]	83.6–84.3	8–40+	<600 feet LOA	3	No
H	Henrici Bard	91.6–93.9	22–33+	<600 feet LOA	8	No
I	Lower Vancouver	96.2–101.0	Minimum of 50	<600 feet LOA	14	No
J	Kelly Point	101.6–102.0	25–40+	Panamax	1	No
K	Upper Vancouver	102.6–105.2	35–50+	Panamax or larger	7	Yes (2)

Notes:
[a] Identification letter corresponds to letters in Figure 3.
[b] Number in parentheses reflects the number of stern buoys maintained at the anchorage.
[c] This anchorage is generally reserved for large and deeply laden vessels as determined by Columbia River Pilots.
[d] Remote and not currently in use.
Source: Lower Columbia Region Harbor Safety Committee 2013; U.S. Army Corps of Engineers 2015b
LOA = length overall

Four turning basins are in the study area (Figure 3). Turning basins are generally wider areas along a channel dredged to the same depth as the channel, where vessel masters and pilots have maneuvering room to turn vessels for the purposes of pointing the bow of the vessel in the direction of transit.

2.2.3.3 Bridges

Two bridges cross the navigation channel at and downstream of the Longview area: the Lewis and Clark Bridge and Astoria-Megler Bridge.

- Lewis and Clark Bridge crosses the Columbia River between Longview, Washington, and Rainier, Oregon. It has a vertical clearance of 187 feet and a horizontal clearance of 1,120 feet. This bridge is upstream from the project area, and project-related vessels would not pass through this bridge under normal operations.

- Astoria-Megler Bridge crosses the Columbia River between Astoria, Oregon, just inland of the Port of Astoria, and Point Ellice, near Megler, Washington. It has a vertical clearance of 205 feet and a horizontal clearance of 1,070 feet.

2.2.3.4 Ferries

One ferry, the Wahkiakum County, Ferry, crosses the river between Puget Island, Washington, and Westport, Oregon, at RM 37.4 (Figure 3). It is the only ferry crossing downstream of the project area.

2.2.4 Large Commercial Vessel Traffic

This section focuses on commercial vessels—excluding fishing vessels and smaller commercial passenger vessels[8]—calling at ports in the study area. For the purposes of this report, these vessels are referred to as *large commercial vessels*. They are primarily cargo vessels, more than 99% of large commercial vessels,[9] and include ships and barges carrying various cargo (i.e., dry bulk, automobiles, containers, bulk liquids, and other general cargo). These vessels comprise most, if not all, of the deep-draft vessels, which are restricted to movement in the navigation channel, as well as other commercial vessels with shallower drafts that are able to navigate outside of the channel. Commercial fishing vessels and smaller commercial passenger vessels, as well as recreational vessels and service vessels, are discussed in Section 2.2.5, *Other Vessel Traffic*.

The following sections describe types and amounts of cargo transported, vessel types, and traffic volumes for commercial vessels in the study area.

2.2.4.1 Cargo Types and Tonnages

Table 4 presents the types and amounts of cargo transported along the Columbia River. The amounts and percentages in the table reflect average annual gross tonnage for the period 2004 to 2014, based on Bar Pilots data (Jordan pers. comm.). The primary growth areas in recent years have been in the dry bulk and automobile traffic.

[8] Includes passenger car ferry and overnight and daytime vessels.

[9] Cruise ships account for less than 1% of large commercial vessel traffic in the study area. *Historical Traffic Volumes* provides a detailed discussion of vessel traffic by vessel type over a recent 11-year period.

Table 4. Cargo Types and Corresponding Average Annual Gross Tonnage (2004–2014)

Cargo Type	Gross Tonnage	Percentage[a] of Total Cargo Moved
Dry bulk	44,551,063	47.3
Automobiles	20,986,525	22.3
Containers	11,187,455	11.9
General cargo	7,447,913	7.9
Bulk liquid	4,127,333	4.4
Other[b]	5,912,903	6.3
Total	**94,213,193**	**100**

Notes:
[a] Percentages refer to gross tonnage to better represent the approximate quantities of various commodities moved along the Columbia River.
[b] Miscellaneous gross tonnage accounting for vessel movements from one berth to another, passenger vessels, tugs, and empty barge movements.
[c] Numbers are rounded up.
Source: Jordan pers. comm. A.

2.2.4.2 Types of Large Commercial Vessels

The types of large commercial vessels in the study area are listed below by four broad categories.

- Cargo ships
  - Tankers carrying bulk liquids
  - Container ships carrying containerized cargo
  - Dry bulk carriers carrying forest products and steel, ore, grain, potash, and other dry bulk cargoes
  - General cargo ships carrying steel, machinery, and other general cargo that is not containerized or bulk.
  - Automobile carriers
- Barges
  - Tank barges (including articulated tug barges [ATBs][10]) carrying bulk liquids
  - Other cargo barges carrying dry bulk, containerized and other cargo
- Passenger cruise ships
- Other[11]

Table 5 presents typical specifications for these vessels and example images.

[10] An articulated tug barge, or ATB, is a tank barge that is propelled and maneuvered by a high-powered tug positioned in a notch in its stern.

[11] Includes bunkers and other vessel types that occur only occasionally (e.g., military, research, and industrial/marine construction vessels).

Table 5. Types of Large Commercial Vessels in the Study Area

Vessel Category	Vessel Types	Typical Vessel Specifications	Example Photos
Cargo ships	Dry bulk cargo ships (bulkers), container ships, general cargo ships, automobile carriers	**Dry bulk, container, and general cargo ships:** DWT: 50,000–80,000, Length: 650–965 feet Beam: 100- 106 feet Draft: 33–39.5 feet	 Bulk cargo ship (bulk carrier)
		Automobile Carriers: DWT: 18,638 Length 650 feet Bean: 105 feet Draft: 27 feet	 Automobile Carrier
		Container ships: DWT: 57,088 Length: 260 feet Beam: 33 feet Draft: 12.5 feet	 Container Ship

Vessel Category	Vessel Types	Typical Vessel Specifications	Example Photos
		Tankers DWT: 65,000–80,000 Length: 965 feet Beam: 106 feet Draft: 41 feet	 Tanker
Barges	Cargo barges including tank barges, dry cargo barges and container barges	Length: 132–286 feet Beam: 40–55 feet Draft: 8–17 feet DWT: N/A (Gross tons: 559–2,700)	 Dry cargo barge
Passenger cruise ships		Length: 560–965 feet Beam: 78–125 feet Draft: 18–29 feet DWT: 2,700–13,290	 Cruise ship

Notes:
DWT = deadweight tons; ATB = articulated tug barge
Photo sources: MarineTraffic.com except for tanker, worldmaritimenews.com; and dry cargo barge, Tidewater.com.

The vessels discussed in this section come in various sizes, as reflected by the ranges (e.g., width, draft) shown in Table 6. Cargo ships are categorized[12] by their capacity and dimensions. The vessel classes that can be accommodated in the study area are listed in Table 6 with their typical dimensions and cargo capacities.

[12] These category names often reflect the canal through which the vessels are designed to travel.

Table 6. Vessel Classes in Use on the Columbia River Navigation Channel

Vessel Class	Deadweight (tons)	Length (feet)	Beam (feet)	Design Draft (feet)
Handymax	10,000–49,999	490–655	75–105	36–39
Panamax	50,000–79,999	965	106	39.5
Post-Panamax[a]	Over 80,000	965 or greater	106 or greater	39.5 or greater

Notes:
[a] The Post-Panamax class, also referred to as New Panamax, is a new vessel class that reflects the expanded Panama Canal dimensions.
Source: INTERCARGO 2015

2.2.4.3 Tug Assistance

Cargo and cruise ships require tugs (generally a minimum of two) to provide assistance during docking and undocking, because these vessels lack adequate maneuverability at slower speeds. These vessels also may rely on tugs in emergencies to assist, escort, and in some cases provide fire suppression. Tug escorts on the Columbia River are generally engaged only in unusual conditions (e.g., electronic equipment issue that would prevent safe navigation or inoperable vessel propulsion system at normal power levels) that can be mitigated by the tug escort. Most likely an unusual condition that requires a tug escort would be in effect for all portions of the transit (from crossing the bar to the final destination).

Tugs are assigned, primarily for docking assistance, based on the minimum bollard pull required for a particular vessel type or operation. Shaver Transportation Company, Foss Maritime, and Olympic Tug and Barge, all based in Portland, provide tugs suitable for assisting large commercial vessels in the study area. Nine of Shaver's 13 study-area tugs would be appropriate to assist vessels calling at the project area (Rich pers. comm.). Six of Foss's study-area tugs (Hendricks pers. comm.) and 13 of Olympic's study-area tugs would be suitable for assisting Panamax and Handymax ships (Bonnin pers. comm.) at the project area.

Tugs also are used to tow and push barges between destinations in the study area for bunkering, fuel transport, and hauling cargo. The following companies provide barge towing in the study area: Bernert Barge Lines, Brusco, and Tidewater.

2.2.4.4 Vessel Speed and Travel Times

The vessels discussed in this section are primarily restricted to the navigation channel where traffic moves in two lanes: one lane inbound and one lane outbound. Vessel speeds generally range between 9 and 15 knots in the study area, with the slower speeds in that range occurring while passing port areas; still slower speeds of between 6 and 9 knots occur while passing through anchorages (Appendix A, *Navigation Risk Study*).

Travel time across the bar, between the offshore Pilot Station and Tongue Point, takes approximately 2 hours in either direction. River transits depend on the study area terminal origination or destination. As an example, the travel time from Tongue Point to Longview is approximately 5 hours inbound (generally vessels in ballast[13]) and about 6 hours outbound

[13] Vessels *in ballast* are not loaded with cargo, but have had their tanks loaded with water to increase vessel stability; these vessels have less of a draft than when loaded.

(generally loaded vessels). Outbound transits generally take longer than inbound transits for two reasons: the majority of outbound vessels are loaded and travel at reduced speeds; outbound transits are scheduled during high-tide conditions to maximize underkeel clearance [14] and, thus, are usually running against the force of a flood (incoming) tide.

2.2.4.5 Existing and Historical Traffic

This section describes existing (2014) vessel activity and distribution in the study area. It also describes the existing and historical traffic volumes over the past 11 years in the context of historical peak volumes prior to this period.

Existing Commercial Vessel Traffic

This section describes the volume and distribution of existing vessel traffic throughout most of the study area,[15] based on 2014 AIS data (Appendix A, *Navigation Risk Study*). Figure 4 depicts activity by vessel type at eight locations (shown in Figure 5) on the lower Columbia River based on 2014 AIS data. The categories shown in Figure 4 that apply to large commercial vessels are Cargo Ships, Passenger (cruise ships and other large commercial passenger vessels), and, Tug/Tug with Barge.[16] As shown in the figure, vessel activity is greatest near the mouth of the Columbia River. Much of this increased activity at these locations (Ilwaco West, Ilwaco East, and Astoria) is related to service and fishing vessel activity, discussed in Section 2.2.5, *Other Vessel Traffic*. Cargo ship activity is consistent between the project area and the mouth of Columbia River.

[14] *Underkeel clearance* is the amount of space between the hull of the vessel and the bottom of the channel.

[15] The 2014 AIS data were analyzed as part of the risk study (Appendix A, *Navigation Risk Study*). The upstream extent of the study area for risk is Longview. Therefore, this discussion does not include vessel activity in the study area upstream of Longview.

[16] Because barges do not have AIS receivers, barge numbers are captured as part of the tug data. The tug numbers include tugs traveling independently and tugs towing or pushing barges. Only the latter are considered large commercial vessels. The number of tug and barge units (cargo barges), including ATBs, entering and exiting the river are best represented by transits recorded for the Ilwaco locations; the increased tug activity in the upstream portions of the study area, especially near Longview and Wauna, likely represents tugs traveling independently to provide docking services and tugs shifting cargo barges between ports.

Figure 4. Number of Transits per Location by Vessel Type (based on 2014 AIS Data)

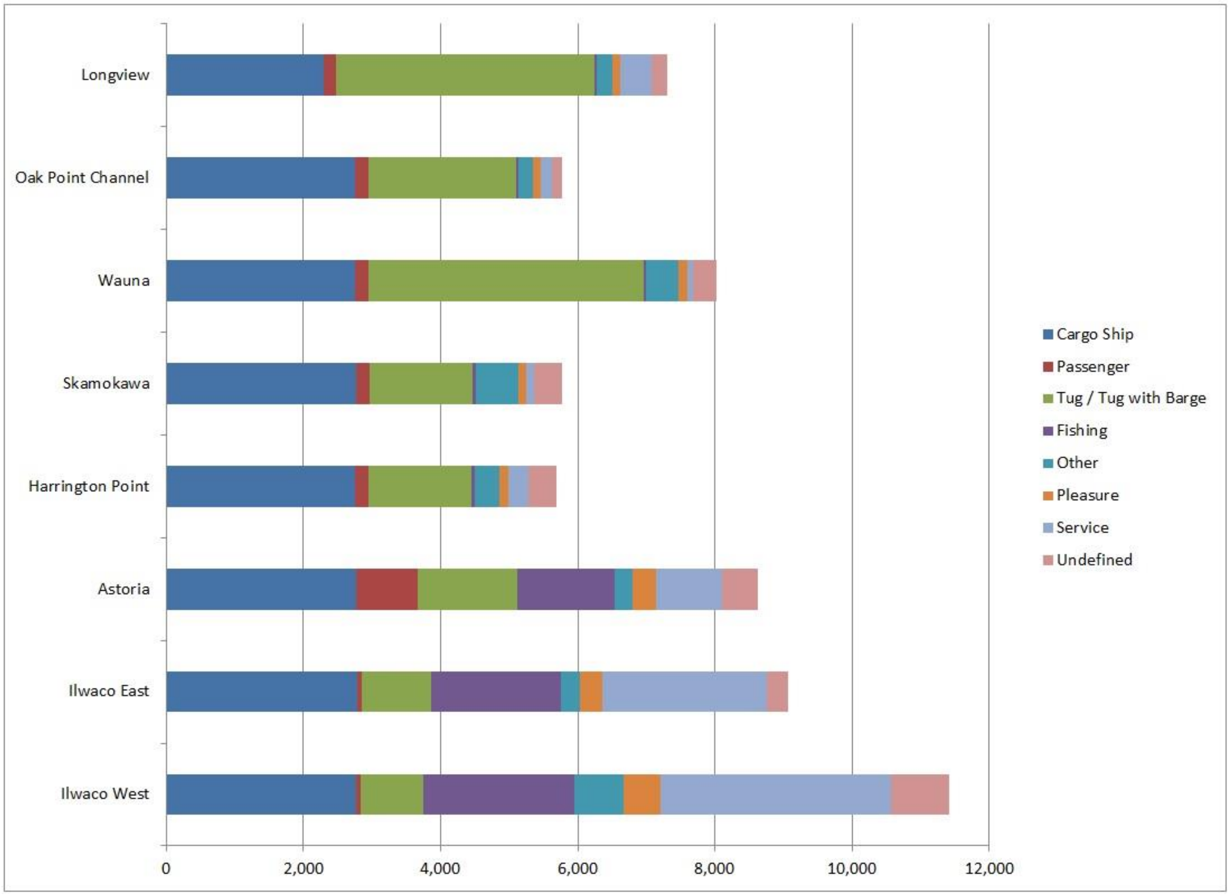
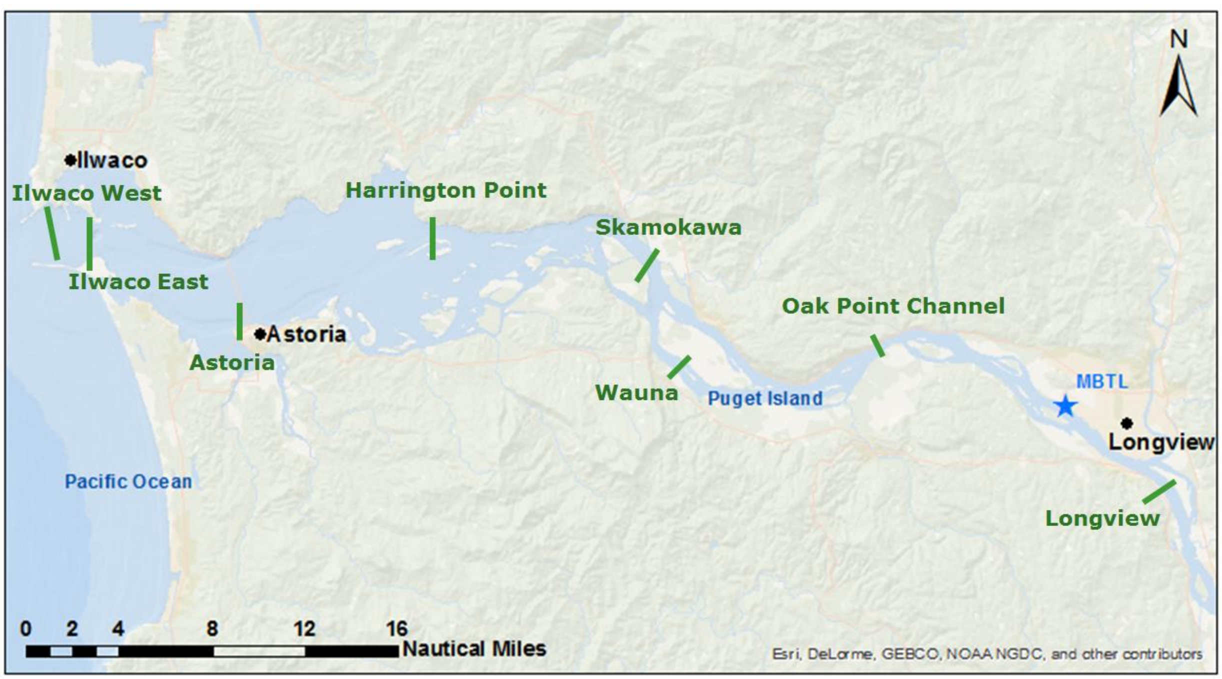


Figure 5. Vessel Data Location Points



Characterizing existing port activity is another way to understand large commercial vessel activity. Types and uses of vessels calling at ports in the study area (Figure 3) are described below.

- Port of Astoria primarily receives cruise ships, loggers and other cargo vessels, and other types of vessels (e.g., USCG, pollution control, commercial fishing, and recreational vessels). The Port reports approximately 230 vessel calls [17] at the Waterfront and Tongue Point berths in 2015 (McGrath pers. comm.).
- Port of St. Helens, Port Westward Industrial Facility receives tankers and tank barges.
- Port of Longview receives cargo ships and barges transporting various types of general and bulk cargo, including steel, lumber, logs, grain, minerals, alumina, fertilizers, pulp, paper, wind energy components, and heavy-lift cargo. The port reported 222 vessel calls in 2015, with a 5-year average of 205 vessel calls per year (Hendriksen pers. comm.).
- Port of Kalama receives cargo ships and barges primarily transporting grain, but also bulk liquid chemicals and general cargo. The port reported 205 vessel calls in 2014 (Port of Kalama 2015).
- Port of Portland receives cargo ships (mostly Handymax and Panamax) and barges, cruise ships, and other vessel types (e.g., other commercial passenger vessels, dredges, pollution control vessels). The cargo vessels transport all types of cargo. The port reported 513 and 352 vessel calls in 2014 and 2015, respectively (Myer pers. comm.).
- Port of Vancouver receives cargo ships (Handymax and Panamax) and barges transporting grain, scrap, steel, automobiles, petroleum products, other dry and liquid bulk cargo, and other products. The port also receives commercial passenger vessels (not cruise ships) and dredges. The port reported 450 vessel calls per year in 2014 and 2015 (Uglum pers. comm.).

Historical Traffic Volumes

This section describes historical commercial vessel traffic volumes in the study area. Table 7 shows annual vessel traffic volumes in the study area over an 11-year period (2004 to 2014), based on VEAT data and Bar Pilots' records. The VEAT numbers reflect vessels entering the Columbia River, which is equivalent to vessel calls. The Bar Pilots record bar crossings, or entries to and exits from the Columbia River, which are equivalent to transits. A call typically results in two transits—an inbound transit and an outbound transit; therefore, the Bar Pilot transits were divided by two for ease of comparison with the VEAT calls in Table 7. As shown in the table, the calls based on Bar Pilots data are slightly higher than those based on VEAT data; this difference reflects that the Bar Pilots record some vessels that are not reported in the VEAT database and vice versa.[18] As shown in Figure 6, despite these relatively minor differences, the two datasets produce very similar traffic volume curves over the 11-year period.

[17] A call represents a visit to a port terminal. A vessel call typically results in two vessel transits: one inbound and one outbound.

[18] The Bar Pilots record several vessel types not recorded in the VEAT data: military vessels, research vessels, industrial/marine construction vessels, and dredges. The VEAT database records some passenger vessels not recorded by the Bar Pilots; while both record cruise ships, the VEAT data also include passenger ferries and inland passenger vessels used for such purposes as day trips and dinner cruises.

Table 7. Columbia River Vessel Traffic[a] Levels

	Calls[b]	
Year	**Bar Pilots Data**	**VEAT Database**
2004	1,777	1,669
2005	1,718	1,654
2006	1,809	1,720
2007	1,929	1,872
2008	1,891	1,806
2009	1,463	1,397
2010	1,683	1,583
2011	1,581	1,466
2012	1,589	1,431
2013	1,724	1,457
2014	1,819	1,662

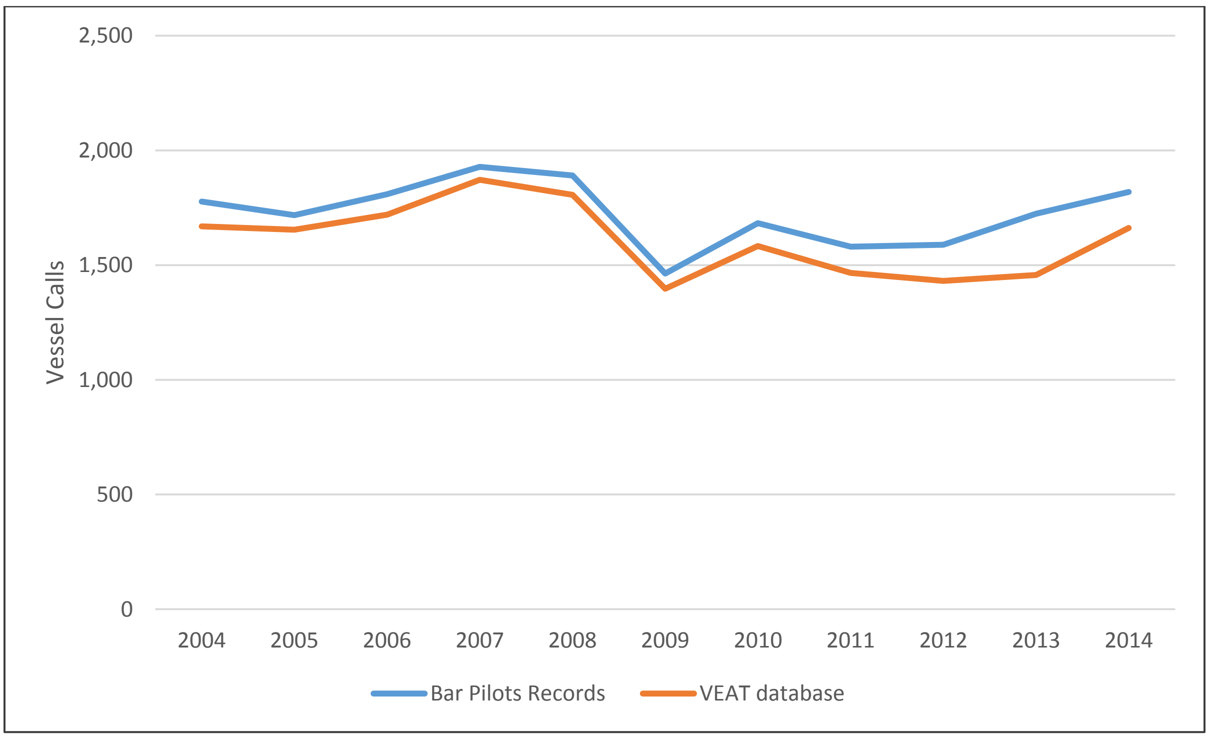
Notes:

[a] Tows consisting of tug and barge traffic, mostly for grain and wood products are not included in the data evaluated. For the most part, that traffic stops upriver from the project area and is not monitored as closely as the deep-draft vessel traffic.

[b] A vessel call represents a vessel's entry to the river or its visit to a port.

Sources: Jordan pers. comm. A; VEAT (Washington State Department of Ecology 2015).

Figure 6. Comparison of Vessel Calls Based on Bar Pilot and VEAT Data (2004–2014)



As shown in Table 7 and Figure 6, traffic volumes were similar in 2004 and 2014, but fluctuated within that period. For comparison, the historical peak vessel traffic year for the Columbia River is 1999 with 2,269 calls based on VEAT data (Washington State Department of Ecology 2014), and 1979 with 2,376 calls, based on the Bar Pilots data (Jordan pers. comm. A). Although vessel traffic volumes have been considerably lower since 2004 compared to these peaks, vessel sizes and total cargo tonnages have increased in recent years.

The overall decrease in vessel traffic levels can be attributed to general economic conditions. The deepening of the Columbia River channel from 40 feet to 43 feet has allowed larger vessels with greater drafts to call at river ports, and vessels that previously had to be light-loaded can now be loaded to deeper drafts. This has resulted in the need for fewer, but larger, vessels with greater drafts to move a given volume of cargo. This is especially the case for the dry bulk cargo vessels that make up a high percentage of the river traffic (Krug pers. comm.; Myer pers. comm.; Amos pers. comm.; Jordan pers. comm. B). The changing nature of vessel design and the likely partial impact on vessel volumes in the study area is illustrative of the multiple factors that can affect vessel traffic volumes over time.

Figure 7 shows annual vessel transits[19] over the past 11 years by the four vessel categories: cargo ships, barges, passenger ships, and other (based on the Bar Pilots data [Jordan pers. comm. A). As shown in the figure, cargo ships[20] (including tankers) constitute the largest percentage of vessel traffic in the study area (around 90% annually on average) over the 11-year period, while barges represent 3 to 10% and cruise ships less than 1%. Approximately 3% consists of a mixture of other vessel types.[21]

This cargo ship traffic can be broken down further into specific vessel types, based on the Bar Pilots records. Figure 8 shows transits of the cargo ship category shown in Figure 7 by cargo ship type. Dry cargo ship transits represent over half (between 50 and 60%) of the cargo ship traffic annually. The remainder (in descending order of magnitude) were automobile carriers, general cargo ships, container ships, and tankers.

[19] These numbers only account for transits across the bar in either direction. They do not include any in-river transits from one terminal or port to another. Moreover, transit lengths vary: one transit may stop at Astoria while another may extend the length of the study area.

[20] Vessels categorized as *cargo ships* include vessels recorded in Bar Pilot data as general cargo ships, tankers, bulkers, loggers, auto carriers, chippers, and container ships.

[21] Vessels categorized as *other* include vessels recorded in Bar Pilot data as miscellaneous (occasional military vessel, research vessels, industrial/marine construction, dredges), bunkers, shipyard, and shifts.

Figure 7. Vessel Traffic Volumes by Major Vessel Category (2004–2014)

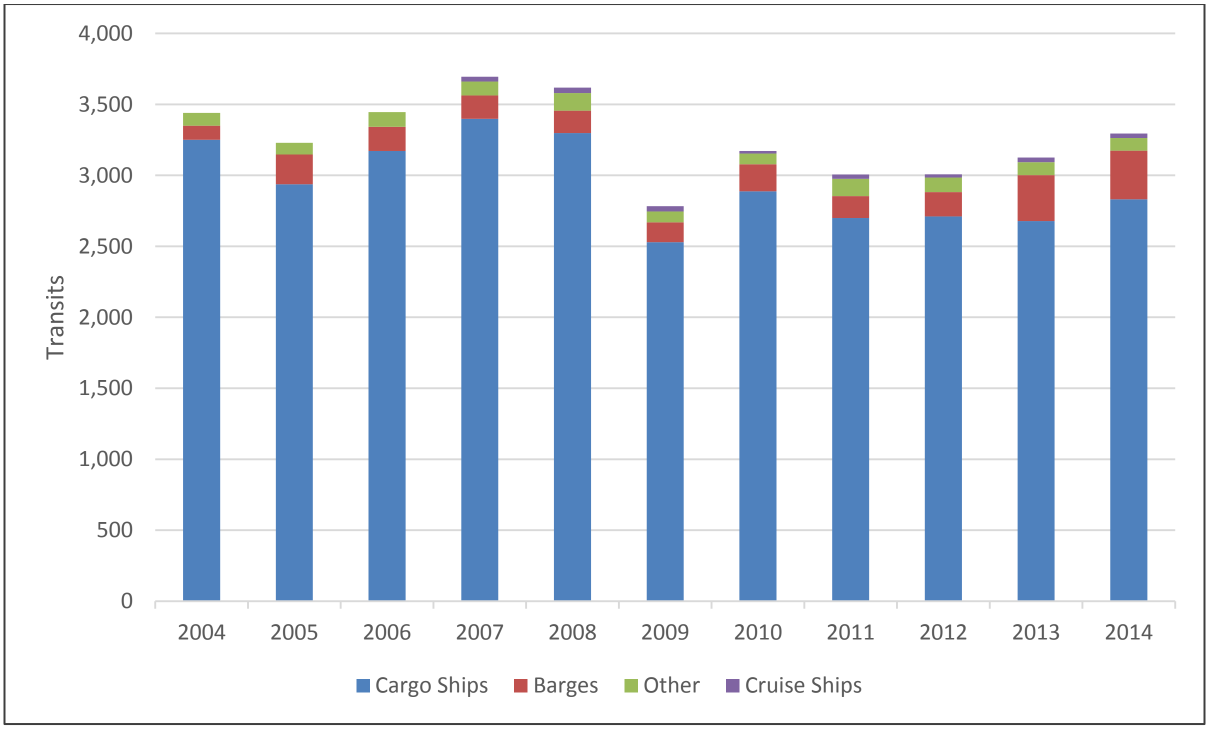
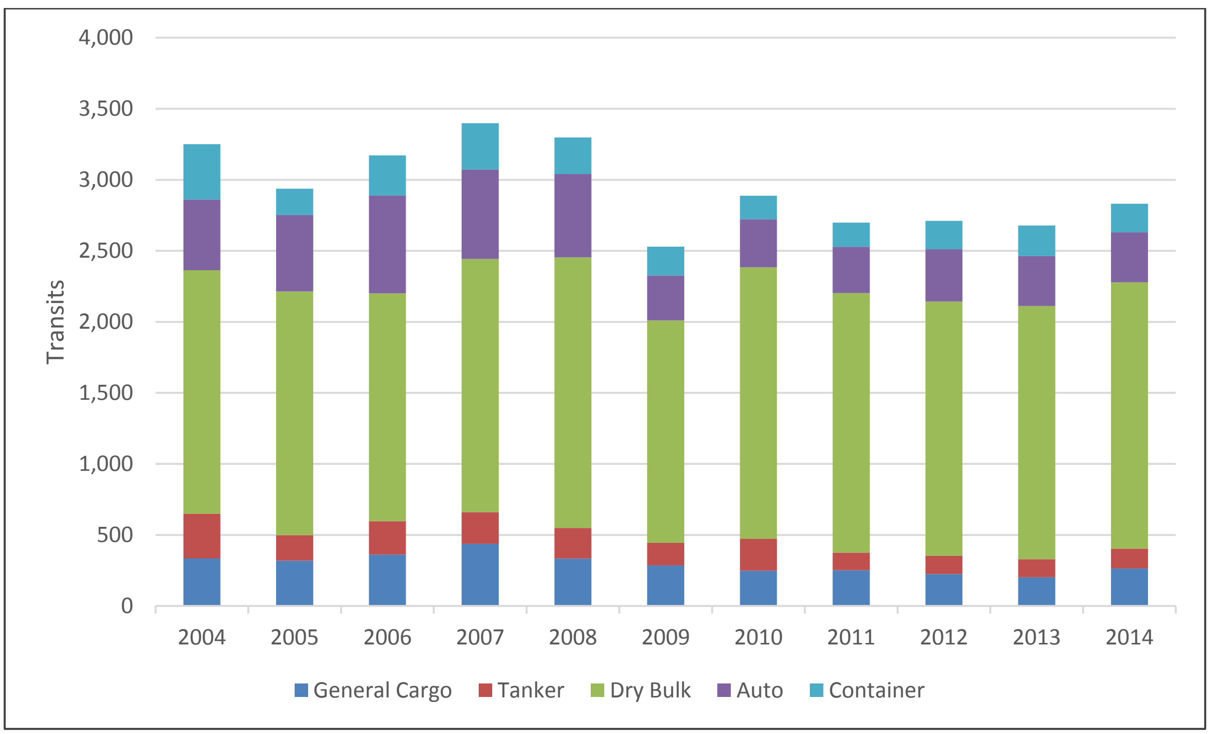


Figure 8. Percentage of Annual Cargo Ships by Vessel/Cargo Type (2004–2014)



2.2.5 Other Vessel Traffic

Other vessels include commercial fishing, recreational, smaller commercial passenger, and service vessels. These vessels are generally much smaller than the vessels discussed in the previous section and have different activity and transit patterns. Most can move about the river without being restricted to the navigation channel. Table 8 presents typical specifications for these vessels and example images.

Table 8. Other Vessel Types in the Study Area

Vessel Type	Typical Specifications	Example Image
Fishing vessels	Length: 20–180 feet Beam: 8–45 feet Draft:: 3–15 feet	 Fishing (gillnetter) vessel
Other commercial passenger vessels: car ferries, inland passenger ships, passenger ferries	**Car ferry:** Length: 109.2 feet Breadth: 47.5 feet Draft: 6 feet **Other commercial passenger vessel:** Gross Tons: < 100 Length: 80–150 feet Beam: 30–40 feet Draft: 6–12 feet	 Car ferry “Oscar B”  River cruise vessel

Vessel Type	Typical Specifications	Example Image
Recreational vessels, including pleasure boats, yachts, sailing vessels	Length: 20–150 feet Beam: 8–40 feet Draft: 3–15 feet	 Pleasure craft
Service vessels Military (USCG), law enforcement, pilot, and Aids to Navigation vessels	U.S. Coast Guard vessels range in length from 22 feet to over 300 feet. **Vessel shown:** Length: 47 feet Beam: 14 feet	 U.S. Coast Guard search and rescue vessel
	Pilot vessel (shown): Length: 72 feet Beam: 20 feet Pollution control vessels: Length: 20–40 feet Beam: 6–20 feet	 Pilot vessel COLUMBIA

Vessel Type	Typical Specifications	Example Image
Tugs	Length: 50–150 feet Beam: 26–35 feet Draft: 9–16 feet	 General tug
Dredge vessels	**Vessel shown:** Length: 200 feet Beam: 58 feet Draft: 16 feet	 Dredge vessel YAQUINA

Notes:
Photo sources: MarineTraffic.com, except fishing (gillnetter) vessel, WDFW Image Gallery; car ferry "Oscar B," Daily Astorian; search and rescue vessel, News Lincoln County.

2.2.5.1 Commercial Fishing

Columbia River

The Columbia River is divided into six commercial fishery management zones; of these, Zones 1 through 3 and a portion of Zone 4 occur in the study area (NOAA Fisheries 2016). The commercial fisheries in these zones are managed by the states of Oregon and Washington.

Zones 1, 2, and 3 support important commercial shad, anchovy, herring, smelt, and salmon fisheries. Commercial fishers deploy gillnets, tangle-nets, or seins depending on species, season, and zone. Anchovies and herring may be taken for commercial purposes at any time in the Columbia River seaward of the Astoria-Megler Bridge (Figure 3). Commercial salmon seasons and authorized fishing gear are shown in Table 9. Shad typically can be taken for commercial purposes from the study area zones during commercial salmon seasons with the same fishing gear authorized for the taking of salmon. The retention of green sturgeon and white sturgeon was prohibited in the Columbia River downstream of Bonneville Dam beginning in 2006 and 2014, respectively.

Table 9. Major Columbia River Salmon Commercial Fishery Seasons in the Study Area

Season[a]	Primary Species	Areas	Authorized Method/Gear
Winter (February–March)	Spring Chinook	Select Area Fisheries[b]	Gillnets and tangle-nets
Spring (April–June)	Spring Chinook	Select Area Fisheries[b] and Columbia River mainstem[c]	Gillnets and tangle-nets
Summer (June–July)[c]	Sockeye and Summer Chinook	Columbia mainstem and Select Area Fisheries[b]	Gillnets
Early Fall (August–mid-September)	Summer and Fall Chinook	Columbia River mainstem and Select Area Fisheries[b]	Gillnets
Late Fall (mid-September–mid-November)	Fall Chinook and Coho	Columbia River mainstem and Select Area Fisheries[b]	Gillnets, tangle nets, and experimental seines

Notes:

[a] Dates and areas subject to stock abundance and management decisions.

[b] Select Area Fisheries include Youngs Bay, Blind Slough/Knappa Slough, Tongue Point/South Channel, and Deep River.

[c] Columbia River mainstem areas include Zones 1 (Columbia River mouth) to 5 (Beacon Rock at RM 142).

Source: Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife 2015a (winter, spring, and summer) and 2015b (fall fisheries).

Approximately 2,046,747 pounds of shad and salmon (Chinook, coho, pink, and sockeye) were harvested (160,821 landings) on the Columbia River in 2015; the late-fall salmon season accounted for approximately 85% of this total harvest, making the late-fall salmon season the busiest time of year for commercial fishing on the Lower Columbia River (Oregon Department of Fish and Wildlife 2015b).

Coastal, Nearshore, and Ocean Commercial Fishing

Several coastal, nearshore, and offshore open-ocean fisheries, including groundfish, halibut, salmon, albacore, pacific whiting, sardines, and shellfish (primarily Dungeness crab and pink shrimp) are present within or adjacent to the study area. Activities range from harvesting to delivery to shore-based processors, depending on the fishery. The mouth of the Columbia River is the busiest part of the study area for commercial fishing vessel traffic, though numbers of operating vessels fluctuate by season and license by fishery. Fisheries with the greatest likelihood of vessels operating within the study area are discussed below.

Commercial coastal and nearshore fishing in the study area include vessels operating within 3 nautical miles and reporting to the Ports of Astoria, Chinook, and Ilwaco. The U.S. West Coast nearshore groundfish commercial fleet operates in the study area and consists of vessels from 10 to 50 feet long, with an average length of 25 feet (NOAA Fisheries 2016). Fixed gear includes hand-lines, cable gear, fishing poles, and pots (traps). Gear is set to retrieve catch multiple times a day and catch is generally landed on a daily basis.

Regulations for nearshore fisheries are set by both the Pacific Management Council and the states; each state manages its nearshore fleet independently by issuing regulations on the cumulative trip limits of nearshore species in their state waters (NOAA Fisheries 2016). The State of Washington does not allow commercial fishing within its territorial waters (0 to 3 mile from the coastline); therefore, a commercial fixed-gear fleet does not operate in Washington nearshore waters of the study area (NOAA Fisheries 2016). The nearshore commercial fixed-gear fleet in Oregon typically fishes shallow water and targets cabezon, greenlings, and several species of rockfish (NOAA Fisheries 2016).

The Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP) was implemented in 1982 and has since been amended 20 times by the Pacific Fishery Management Council in response to changes in the fishery, reauthorizations of the Magnuson-Stevens Act, and litigation that invalidated provisions of earlier amendments (Pacific Fishery Management Council 2008). The Groundfish FMP guides the management of groundfish fisheries in federal waters, 3 to 200 nautical miles offshore.

The Pacific Coast Salmon Fishery Management Plan guides the management of salmon fisheries in federal waters. Oregon and Washington's commercial ocean salmon fisheries are hook-and-line troll fisheries. This fishery largely targets Chinook salmon, with minor coho salmon seasons in some years (Oregon Department of Fish and Wildlife 2015c). In odd-numbered years, catches of pink salmon can also be significant off Washington and Oregon coastlines (Pacific Fishery Management Council 2014). This is a limited-entry fishery in both states, meaning that a permit is required to participate actively in the fishery each year.

Commercial fishing for Dungeness crab occurs in the study area along the Washington and Oregon coastlines. The ocean crab season begins December 1 and continues through August 14, with peak harvest occurring during the first 8 weeks of the season. Dungeness crabs are caught using circular steel traps with a length of line and a buoy attached to mark its location. The average commercial Dungeness crab fishing vessel fishes 300 to 500 pots in depths of 30 to 600 feet (Oregon Dungeness Crab Commission 2014).

Oregon and Washington have a limited entry system in-place on the Dungeness crab fishery, with more than 350 vessels in Oregon and 200 vessels in Washington operating the fishery (Oregon Dungeness Crab Commission 2014; Washington Department of Fish and Wildlife 2016a). Vessels range from small wooden trollers to large steel combination vessels. The Columbia River estuary is an important location for commercial Dungeness crab fishing with three main landing locations located in the study area: the Port of Astoria, Port of Ilwaco, and Port of Chinook,

Commercial pink shrimp fishing occurs adjacent to the study area in offshore waters of Oregon and Washington (3 to 200 miles offshore) with processing facilities located at the Port of Ilwaco and the Port of Astoria. A limited entry system for the pink shrimp fishery is in place for Oregon and Washington, with 83 active licenses in Washington.

The pink shrimp season begins April 1 and continues through October 31. Fishing occurs during daylight hours using trawl gear, most commonly utilizing double-rigged, semipelagic, fine-meshed shrimp nets (Washington Department of Fish and Wildlife 2016b). Pink shrimp trawl vessels range in size from 38 to 105 feet long, with an average length of 65 feet.

2.2.5.2 Tribal Fishing

The treaties of 1855 between the United States and individual tribal governments reserved tribal rights to fish, hunt, and gather traditional foods and medicines throughout ceded lands identified in the treaties.

The Columbia River and its tributaries support a variety of tribal resources, including six species of salmon and Pacific lamprey, which have been a reliable and important source of food and trade items to Columbia River. The Columbia River tribes are the Confederated Tribes and Bands of the

Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of Warm Springs, and the Nez Perce Tribe. These four tribes in the Columbia River Basin have reserved rights to anadromous fish in treaties with the United States (Columbia River Inter-Tribal Fish Commission 2016). Zone 6, upstream of the study area from Bonneville Dam to McNary Dam, is managed as an exclusive treaty commercial fishing zone. The Draft Environmental Impact Statement assesses the potential impacts of the Proposed Action on tribal resources.

2.2.5.3 Recreational Fishing and Boating

The Columbia and Willamette Rivers are popular areas for recreational boating (motorized and nonmotorized), fishing, and other recreational activities (Port of Portland 2010). More than 30 water access and boat launch sites along the Columbia and Willamette Rivers in the study area provide public and private river access for recreational boating and fishing (Table 10).

Table 10. Water Access Sites in the Study Area[a]

Boating Facility Name	Owner	Waterbody	County (State)
17th Street Transient Dock	City of Astoria	Columbia River	Clatsop (OR)
Courthouse Docks	City of St. Helens	Columbia River	Columbia (OR)
East Mooring Basin	Port of Astoria	Columbia River	Clatsop (OR)
Hammond Marina	City of Warrenton	Columbia River	Clatsop (OR)
Pier 39	Private	Columbia River	Clatsop (OR)
Rainier City Marina	City of Rainier	Columbia River	Columbia (OR)
Riverfront Park	City of Rainier	Columbia River	Columbia (OR)
Sand Island Marine Park	City of St. Helens	Columbia River	Columbia (OR)
Sand Island Marine Park North	City of St. Helens	Columbia River	Columbia (OR)
Scipio's Goble Landing	Private	Columbia River	Columbia (OR)
St. Helens Marina	Private	Columbia River	Columbia (OR)
West Mooring Basin	Port of Astoria	Columbia River	Clatsop (OR)
Westport Ramp	Clatsop County	Columbia River	Clatsop (OR)
Sportsman Club	WDFW	Columbia River	Cowlitz (WA)
Woodland Bottoms	WDFW	Columbia River	Cowlitz (WA)
Knappton	WDFW	Columbia River	Pacific (WA)
Puget Island	WDFW	Columbia River	Wahkiakum (WA)
Port of Ilwaco Marina	Port of Ilwaco	Columbia River	Pacific (WA)
Port of Chinook	Pacific County	Columbia River	Pacific (WA)
Port of Wahkiakum County No. 1	Wahkiakum County	Columbia River	Wahkiakum (WA)
Port of Wahkiakum County No. 2	Wahkiakum County	Columbia River	Wahkiakum (WA)
Elochoman Slough Marina	Wahkiakum Port District 1	Columbia River	Wahkiakum (WA)
Port of Kalama Marina	Port of Kalama	Columbia River	Cowlitz (WA)
McCuddy's Ridgefield Marina	Private	Columbia River	Cowlitz (WA)
Port of Longview Marinas	Port of Longview	Columbia River	Cowlitz (WA)
Port of Woodland Marina	Port of Woodland	Columbia River	Cowlitz (WA)
Riverplace Marina	Private	Willamette River	Multnomah (OR)
Cathedral Park	City of Portland	Willamette River	Multnomah (OR)

Boating Facility Name	Owner	Waterbody	County (State)
Willamette Park	City of Portland	Willamette River	Multnomah (OR)
Kelley Point Park	City of Portland	Willamette/Columbia Rivers	Multnomah (OR)
Hayden Island Marinas (numerous)	Private and Public	Columbia River	Multnomah (OR)

Notes:
[a] This table does not represent an all-inclusive list of water access points in the study area; additional private, municipal, county, and state facilities may be operational in the study area.
Sources: State of Oregon 2016; Washington Public Ports Association 2016; Washington Department of Fish and Wildlife 2016c; Port of Portland 2010
WDFW = Washington Department of Fish and Wildlife; WA = Washington; OR = Oregon

The Columbia River is the most boated waterbody in the State of Oregon with 524,091 boat use days, followed by the Willamette River with 281,176 boat use days. Hayden Island—which is located on the Columbia River, between Vancouver, Washington, and Portland, Oregon—serves as a key location for recreational boaters traveling to different sections of the Columbia and Willamette Rivers. Marinas in the vicinity report that recreational boating is highest during summer months and that 100% of 3,600 boat slips on Hayden Island are leased between April and October (Port of Portland 2010). The Columbia River Water Trail is a designated area for canoes and kayaks that travels through the study area to the mouth of the river.

The Columbia and Willamette Rivers support numerous aquatic species including salmon, steelhead, small mouth bass, shad, and sturgeon fisheries. Greenling, rockfish, lingcod, and perch are caught from the jetties, and flounder are common on sandy flats. Recreational fishing seasons vary by target species, but fishing occurs year-round for many species. Recreational catch-and-release fishing for green and white sturgeon is currently allowed year-round (Oregon Department of Fish and Wildlife 2015c). Warm-water game fish species season is also year-round in the study area (Oregon Department of Fish and Wildlife 2015c). The spring Chinook and steelhead fishery for the Columbia River is open from January to March depending on fishery management decisions, and Chinook and coho salmon fishing season runs from August to December.

The spring Chinook fishery in the Hayden Island area of the Columbia River is extremely popular and fishing participation rates have increased over recent years. During the spring Chinook season, between 135,000 and 145,000 angler days are documented on this section of the Columbia River between March 1 and June 1 (Port of Portland 2010). Also, the area between the mouth of the river and Tongue Point, which includes Youngs Bay, is a popular area for recreational fishing year-round (Oregon Department of Fish and Wildlife 2016:25). This area is popular, especially during the fall Chinook and coho salmon season, which generally peaks in the last 2 weeks of August (Washington Department of Fish and Wildlife 2016d).

Dungeness crabs are caught in the estuary and in nearshore and offshore areas beyond the mouth of the river, and razor clams are harvested along the ocean beaches north and south of the mouth of the river.

2.2.5.4 Commercial Passenger Vessels (Non-Cruise Ships)

Commercial passenger (noncruise ship) vessels transit from one port to another within the Columbia River; they include a range of vessels up to 100 gross tons carrying from six to over 150 passengers. Examples of these vessels include the Portland Spirit and Columbia Gorge Sternwheeler, which provide dinner cruises and day trips, respectively, and the Waikiakum County ferry, the only ferry on the Lower Columbia River, which shuttles passengers and up to 12 cars at a time between Puget Island, Washington, and Westport, Oregon.

2.2.5.5 Service Vessels

Service vessels, including USCG, law enforcement, pilot, spill response, tugs, and dredges operate throughout the study area and could be found anywhere on the lower Columbia River at any time. The vessel types and activities are summarized below.

U.S. Coast Guard Vessels

USCG vessels in the study area are stationed primarily at the Port of Astoria, Cape Disappointment, and Portland, Oregon. These vessels are used for search and rescue, maritime law enforcement, boating safety, Aids to Navigation, and homeland security. The area of responsibility for the Coast Guard Aids to Navigation Team (ANT) in Astoria, Oregon, includes the Columbia River up to Portland, Oregon. The ANT stations two medium endurance cutters (USCG Cutter ALERT and USCG Cutter STEADFAST), which operate offshore and near the mouth of the Columbia River providing search and rescue, and illegal drug and immigrant interdictions. The ANT also stations the USCGC Fir, which is a seagoing buoy tender that maintains 150 aids to navigation along the Washington and Oregon coasts, as well as the Columbia River.

USCG Station Cape Disappointment is situated at the mouth of the Columbia River at Ilwaco, Washington, and is the largest search and rescue station on the Northwest Coast. The station has five search and rescue boats, including the 52-foot moto lifeboat Triumph II, two 47-foot motor lifeboats, and two 29-foot second-generation Defender-class response boats. These vessels operate primarily offshore and within the Bar.

Operational responsibilities of the USCG Marine Safety Unit (MSU) in Portland include ship inspections, commercial fishing vessel safety, investigations, waterway management, shoreline facility inspections, and aids to navigation. MSU Portland is homeport to the 100-foot inland buoy tender (USCG Bluebell) responsible for serving aids to navigation throughout the Columbia River and nearby waterways.

Each of the USCG stations described above also has access to a mixture of response and trailerable boats and skiffs.

Local Law Enforcement Vessels

In addition to the USCG law enforcement vessels, Oregon State Police and Washington State Police also operated law enforcement vessels on the Columbia River to coordinate the enforcement of commercial fishery and sport angling regulations and for special investigations. County governments along the Columbia River also staff full-time deputies assigned to patrol the waters of the Columbia River and conduct boat inspections. These local law enforcement vessels can be found operating within their respective jurisdictions of the Columbia River and its adjacent waterways.

Pilot Vessels

Pilot vessels are used to transport Bar Pilots and River Pilots to large vessels for pilotage duties described above in *Large Commercial Vessels, Vessel Traffic Management*. The Bar Pilots use one of two pilot boats, the Astoria or the Columbia, both 72-feet long, for offshore transfers.[22] For transfers within the Columbia River, the River Pilots and the Bar Pilots use the Connor Foss, a 63-foot-by-17-foot aluminum vessel designed specifically for pilot transfers. The Bar Pilots make approximately 3,600 vessel crossings of the bar each year with vessels ranging from 100-foot tugs to 1,100-foot cargo ships. River Pilots pilot vessels upriver from Astoria including along 13 miles of the Willamette River from its confluence with the Columbia River to the seawall in downtown Portland (Columbia River Pilots 2014).

Spill Response Vessels

Three marine spill response vessels are prestaged in the study area at the Port of Astoria. These vessels belong to Marine Spill Response Corporation – Northwest, which is a cooperative that member companies rely on for oil spill response equipment and support.

Tugs

Tugs operating in the study area include those towing or pushing barges from or to destinations beyond the study area and those from tug companies located along the Columbia River. The latter tug companies provide cargo barge movement services between ports along the river; move bunkers (fuel oil barges) to vessels requiring fuel; and provide docking, escort, and other assistance, as described above under *Large Commercial Vessel Traffic, Tug Assistance*. Figure 4 shows tug traffic levels (with and without barges) at eight cross sections in the study area. Tug activity is much higher in the upstream portions of the study area, especially near Longview and Wauna. This activity likely represents tugs transits to and from terminals to provide docking services and tugs shifting cargo barges between ports.

Dredges

Dredging vessels are used to maintain the navigation channel by removing excess sand, silt, and mud that naturally settles to the bottom and on the sides of the channel over time. Maintenance dredging or channel improvement projects, whereby channel dimensions are altered to accommodate larger sizes and/or more loaded commercial vessels, are accomplished by the Corps. In the past, the Corps has used mechanical dredges in the Columbia River (U.S. Army Corps of Engineers 2003:6-6). These types of dredges remove material by scooping it from the bottom and then placing it into a waiting barge or directly into the disposal area, depending upon the location of the dredging. Dredging operations are always advertised to mariners transiting in the Columbia River and are conducted in such a manner as to generally not impede vessel traffic.

2.2.6 Vessel Traffic Management

Management of vessel traffic in the study area is primarily a real-time activity between the Bar Pilots and River Pilots, the vessel master, and the PDXMEX. Deep-draft vessel traffic moves along the navigation channel in a two-way pattern: one lane inbound and one lane outbound. This simplistic layout constitutes the foundation of the traffic management system.

[22] Embarking and disembarking of Columbia River Bar Pilots offshore can be by boat or helicopter. It is the individual pilot's choice whether to use the boat or helicopter for transfers offshore, with the helicopter being used about 70% of the time (Jordan pers. comm. B).

Oversight and active participation in the vessel traffic management process involves coordination of all stakeholders in the Lower Columbia Region Harbor Safety Committee comprising representatives from the following.

- USCG
- The Corps
- Ecology
- Oregon Department of Environmental Quality (ODEQ)
- River Pilots
- Bar Pilots
- Shipping agents
- Terminal operators
- Vessel operators (tug and barge companies)
- Associations (such as PDXMEX, the Columbia River Yachting Association, and the Maritime Fire & Safety Association [MFSA])
- Port and vessel services (such as Clean Rivers Cooperative)

The Lower Columbia Region Harbor Safety Committee is an open forum that allows for the discussion of the membership's vital interests in assuring safe navigation and maritime practices to protect the public, mariners, the environment, and property. The committee meets approximately every 2 months to review old and new information on the agenda and to hear reports from the active committees (bridges, harbor safety plan, navigation, outreach, and executive steering). The committee publishes and maintains a *Lower Columbia Region Harbor Safety Plan* (last edition published January 2013) which provides users of the Columbia River guidelines to the aids to navigation, anchorages, bunkering, dam lockage, incident management and other navigation practices.

2.2.6.1 Pretransit Planning and Scheduling

Large commercial vessels are required to provide an advance Notice of Arrival (NOA) to USCG at least 96 hours before arrival at the bar in most cases, or upon departure from the last port of call for shorter voyages. This information is provided electronically and shared almost instantaneously with the PDXMEX and the Bar and River Pilots.[23]

Upon receipt of the NOA a coordination process is initiated between the pilots and the shipping agent representing the vessel interests. The Bar Pilots and River Pilots work closely with each other and PDXMEX[24] during the pretransit scheduling. The pilots use information provided in the NOA, as well as weather conditions, pilot availability, tidal and river conditions, and anchorage and berth availability to determine scheduling. Federal (USCG, U.S. Immigration and Customs Enforcement)

[23] In addition to serving as an arrival notification the NOA includes vital information about the vessel, voyage information (specifics about the last five ports visited, name and telephone number of a 24-hour point of contact, etc.), cargo information, information about each crewmember and other people onboard, operational condition of equipment, and documentation specifics.

[24] An information and communication center for ports and stakeholders along the Columbia River.

and state agencies (Ecology, ODEQ) will schedule visits to the vessel once it is docked as required for vessel and crew documentation and cargo checks.

For inbound vessels, tracking and coordination begins when the vessel is approximately 2 to 3 hours away from the pilot boarding station (Jordan pers. comm. B). Traffic management for vessels crossing the bar is the responsibility of the Bar Pilots. Decisions on vessel movements are made by the Bar Pilots alone although other considerations by or affecting the Columbia River Pilots could result in delaying a vessel's transit. Bar Pilots typically start their transits approximately 2 hours before high tide.

The Bar Pilots coordinate closely with the USCG on navigation conditions and safety. While only the USCG COTP can close the bar to vessel traffic, the Bar Pilots can suspend traffic movements when the overall circumstances dictate. In assessing navigation conditions, the pilots use these decision criteria. (Jordan pers. comm.)

- Is it safe for the vessel to cross? Factors considered include the expected underkeel clearance, the vessel's maneuverability and horsepower rating, and other aspects of the vessel's condition.
- Can the pilot get on or off the vessel safely?
- Once the pilot is on board, can the pilot boat or helicopter return to base safely?

Some of the factors that could influence a decision are swell and sea height, swell period, current flow direction, wind speed and direction, coastal jet winds in certain circumstances, and timing relative to storm conditions. Low river flow combined with ebb current creates the worst conditions. Movements of larger ships with deeper drafts are influenced more by the tide and current conditions than smaller vessels with a commensurate effect on vessel speed.

The Bar Pilots give the River Pilots a "window of opportunity" for getting an outbound vessel over the bar (Amos pers. comm.). The River Pilots then develop their transit plans to match that window. Transit planning for draft-constrained vessels varies with river flows. For example, during the low-water season, pilots can only count on having sufficient water under keel during one of the daily high tides. Outbound transit plans are developed at least 8 hours and as much as 24 hours in advance. Vessels may be permitted to sail with the maximum freshwater draft of 43 feet if the river level, tide, and conditions permit (Columbia River Pilots 2016).

The decision to sail outbound is more critical than the decision to bring a vessel in. For outbound traffic, once the vessel starts downriver there is no place to stop or turn around unless the vessel is in extremis and requests to anchor; inbound vessels can stop before approaching the bar (Jordan pers. comm. B). Nevertheless, there is a point at which a vessel approaching the bar from sea or from the river is fully committed to the crossing. This is why the pre-transit planning is key to safe passage across the bar in either direction. As discussed in Section 2.2.4.3, *Tug Assistance,* tug escorts for vessel transits in the study area are rare (Rich pers. comm.).

The Bar Pilot–River Pilot exchange location is at Tongue Point near Astoria with the vessel underway. Vessel size is a significant factor in transit planning. The River Pilots typically place just one pilot on each vessel, but in some circumstances, including vessels with a beam greater than 140 feet, two pilots are assigned.

2.2.6.2 Methods for Managing River Traffic

Marine pilots are highly trained mariners who are experts in vessel navigation and the characteristics of a particular waterway. They are responsible for safely maneuvering vessels on the Columbia River. Their expertise is supported by the vessel master's knowledge of their own vessel and how it maneuvers; the use of electronic navigation tools and information provided by those tools; tug assistance, if required; and the existence of inland rules of the road, regulations, and coordination principles specific to the Columbia River.

Pilotage

The Bar Pilots board inbound vessels outside the bar, at a predetermined site suitable for safe boarding, and are responsible for piloting the vessel to Tongue Point, near Astoria. At Tongue Point, the Bar Pilot disembarks and the River Pilot boards. The River Pilot guides the vessel to the terminal until it is safely moored. For departing vessels, the process is reversed.

Upon boarding, each pilot will conduct an initial safety briefing with the vessel's master, exchanging information prior to assuming pilotage duties (Master-Pilot Exchange). This information typically includes the following.

- Any vessel deficiencies
- Drafts fore and aft
- Air draft corrected for trim.
- Location of navigation equipment
- Type of propulsion
- Propeller type and rotation
- Engine notice requirements
- Thruster status/horsepower, if equipped
- Maneuvering speeds of vessel
- Known errors in the gyrocompass
- Any deficiencies or unusual characteristics of the navigation or ship control systems

The Master/Pilot Exchange will also confirm the following.

- The Captain is immediately available at all times.
- An officer fluent in English is to be on the bridge at all times.
- The helm is manned with a qualified helmsman.
- A proper lookout is posted and direct communications are available.
- Anchors stations are sufficiently manned, ready for immediate and controlled release.
- The intended Passage Plan including:
    - Anticipated traffic.
    - Anticipated tides, currents, and weather.

- Speed restrictions.
- Minimum underkeel/airdraft clearances.
- Berthing/unberthing plan.

If, at any time during the transit, it becomes necessary to anchor a commercial vessel for an unexpected reason the USCG COTP will be contacted (contact could be by the vessel master, the shipping agent, or the pilot) to be informed about the specific reason for anchoring. The USCG COTP will direct the anchoring of the vessel upon consultation with the individual master and pilot, the circumstances, and the weather. The Lower Columbia Region Harbor Safety Plan Anchorage Guidelines provide details about the anchorages and raises awareness about potential hazards (local weather patterns, vessel traffic, recreational river usage, etc.) that could affect the decision where to anchor a vessel and how to maintain the vessel safely at anchorage.

The River Pilots work with the tug companies providing tug-assist services in the study area to ensure that appropriate tugs are available upon request. As discussed in Section 2.2.4.3, *Tug Assistance*, tugs are assigned primarily for docking assistance, based on the minimum bollard pull required for a particular vessel type or operation. Pilots requesting tug support also consider other tug features such as type of propulsion, deck machinery, or number of propellers. Section 2.2.4.3 provides information on companies providing tug services in the study area.

Pilotage Tools

Pilots use a variety of tools to manage traffic on the river and rely mostly on Transview 32 (TV32) Vessel Traffic Information System (VTIS) software, LOADMAX software, and back-up AIS towers.

Bar Pilots and River Pilots carry Portable Pilot Units that they use along with installed navigation equipment on vessels to monitor real-time vessel traffic and data on current weather and tidal conditions. To prevent potential groundings of vessels, they also run underkeel clearance programs that have been customized for each class of vessel; the pilots picked the most critical vessel types for the modeling (Jordan pers. comm. B). Input includes the Corps bottom survey data for the navigation channel and vessel maneuvering information, including squat.[25] Other data are received from tide gages and wave buoys located strategically near the bar and mouth of the river.

There are four NOAA data buoys in the area located as much as 287 nautical miles offshore that provide wave forecasts for periods from 1 to 19 hours before the waves reach the mouth of the river. There are also a number of wave buoys managed by the Scripps Institute; the latter measure waves differently than the NOAA data buoys. They generally show greater wave heights than the NOAA data buoys (as much as twice the height), and the Bar Pilots consider them a better indicator of actual conditions. The Bar Pilots generally consider suspending movement when the buoys show significant wave heights of 20 feet. Data are also received from the NOAA Northwest River Forecast Center.

The computer program includes a Columbia River Estuary Operational Forecast System model, which uses the input data to determine current velocity and estimates ship motion in response to

[25] The squat effect is the hydrodynamic phenomenon by which a vessel moving quickly through shallow water creates an area of lowered pressure that causes the ship to be closer to the seabed than would otherwise be expected.

environmental conditions. It collects real time data from monitoring stations on the waterway and provides forecast guidance for water levels, currents, water temperature, and salinity.

The computer program shows the expected underkeel clearance from the bar to Tongue Point at Astoria, which is where the Bar Pilots and River Pilots exchange duties. The Bar Pilots use the output to forecast the conditions that the vessel will encounter. The vessel's installed AIS system provides continuous information on the vessel's speed over the ground, speed through the water, and position in the channel. The pilot can compare that information to the forecast underkeel conditions. Bar Pilots prefer that the clearance be equal to 2 feet plus the expected squat (Jordan pers. comm. B). If the results show that underkeel clearance will be insufficient for a particular transit, then the pilot can adjust start time or transit speed to ensure that there is adequate clearance at each critical point along the route.

Pilot dispatchers and individual pilots continuously monitor waterway traffic and communications, especially AIS data and TV32 data. Pilots can observe and compare predicted conditions and real-time data at any point in the transit, and historically, those predicted and actual conditions match very closely. The pilot dispatchers also monitor anchorage status and availability. The tug company dispatch offices also have AIS- and communications-monitoring capabilities; however, individual tugs do not.

While operating, every pilot has access to Corps survey data that include channel depths, the 43-foot contour, and cross sections, along with NOAA Physical Oceanographic Real-Time System (PORTS[26]) and LOADMAX data, as well as the vessel's own navigation system information displays. Using this information, pilots can predict vessel meeting points and display those locations when two ships are as much as 70 miles apart. The pilots can then adjust vessel speeds to ensure that the meetings take place in suitable locations and avoid the few places on the river where meeting situations must be avoided (Jordan pers. comm.). The River Pilots also monitor shoaling developments and assess how those might affect transit plans.

The River Pilots note that the well-defined edges of the channel create a bank effect for virtually the entire transit that aids navigation and helps keep vessels away from the sides of the channel (Amos pers. comm.).

Washington and Oregon have separate vessel-tracking requirements that they obtain through a shared Columbia River Plan with PDXMEX. Membership in PDXMEX is a requirement for all commercial vessels of more than 300 gross tons and all vessels carrying oil. Individual vessels may also enroll for spill and incident response services through MFSA.

Merchants Exchange of Portland, Oregon

PDXMEX serves as an information and communication center for all of the ports and various stakeholders along Columbia River. By way of a subscription service, PDXMEX provides a monitoring system that allows users to locate vessels on the Columbia and Willamette Rivers. PDMEX also operates a dispatch center that assists in vessel traffic management by coordinating with the River Pilots and Bar Pilots dispatch centers to ensure proper vessel traffic management. PDXMEX is also a central point of contact for vessel agents, who provide necessary shore-side services for vessels.

[26] PORTS measures surface current speeds, water depth, wind direction, and wind speed. Data are transmitted and displayed on the TV32 interface every 6 minutes.

Transview 32

TV32 is real-time, vessel traffic information and management system software that portrays vessel movements and interactions on the river, along with water depth, current flow information, and updated bathymetry charts. It combines the following systems to provide extremely high spatial resolution accuracy: AIS[27], ENC and ECDIS, NOAA nautical charts, NOAA PORTS, and differential global positioning system. TV32 allows pilots to determine vessel meeting points to facilitate informed decision making regarding navigation, anchorage, and traffic coordination.

TV32 is considered a VTIS. In a VTIS, vessel location, course, and speed data are made available directly to vessels operating in the area so that navigation decisions can be made and agreed upon between the pilots. For the most part, this is a “pull” type of system in that the user (pilots) must deliberately access information in order to have situational awareness. For comparison, the Vessel Traffic Service in Puget Sound is managed within a Vessel Traffic Center that is manned by continuously receiving and disseminating navigation safety information to those vessels asking for or requiring it via VHF-FM communications.

LOADMAX

LOADMAX is a system made up of seven computer-connected PORTS gages along the Columbia River, from RM 17 at Astoria, Oregon, to RM 106.5 at Vancouver, Washington. These gages measure water level in real time and are tied into a system that produces daily email forecasts of river stage and velocity at 1-hour intervals, with a forecast horizon of 10 days. Pilots routinely use these data to time river transits. Pilots operating draft-constrained vessels transiting the Columbia River have to adjust the time of their transit to allow for 2 feet of underkeel clearance on the river (Columbia River Pilots 2016).

AIS and Aids to Navigation

The River Pilots have specifically credited AIS towers and virtual aids as important to their navigation. Pilots have two relay towers that allow them to see the entire length of the route and monitor traffic using the waterway. It is a requirement of the International Convention for the Safety of Life at Sea (SOLAS). SOLAS requires that AIS transmitters are active onboard all vessels of more than 300 gross tons, a requirement that River Pilots actively enforce.

Aids to navigation allow vessels to identify and locate other vessels and increase situational awareness of hazards and route features not otherwise physically marked (or would require extra time and resources to mark).

USCG is responsible for maintaining the aids to navigation systems on the Columbia River. The aids include a series of fixed and floating aids, which are visual, aural, electronic or any combination of all three. Visual aids include buoys, beacons, day marks, and lights. In the navigation system in place on the Columbia River entering from seaward, red buoys and marks are kept to starboard, and green buoys and marks are kept to port. Preferred channel markers, buoys, and markers with alternating red and green stripes may also be employed to identify junctions and obstructions and indicate the preferred route to avoid obstruction.

[27] AIS is required on large commercial vessels, vessels over 65 feet, and passenger vessels (33 CFR 64.01 and 164.46). AIS technology ensures that basic identification and movement information for these vessels is available to government agencies, cooperative public/private associations, port managers, and pilots with the most basic computer equipment and an internet (or wireless) connection.

Aural aids (sound-producing devices) include bells, whistles, and fog signals. Bells and whistles are typically buoy-mounted and activated by wave action. Fog signals are shore-based, mounted on buoys or mounted on offshore structures.

Nautical charts depict the location and characteristics of aids to navigation, both fixed and floating. The abbreviations used to describe the aids are specified by the International Hydrography Organization.

Inland Rules and Other Applicable Regulations

The navigation of commercial vessels worldwide is subject to a set of international rules formalized in the Convention on the International Regulations for Preventing Collisions at Sea, 1972, effective July 15, 1977. The rules (commonly called 72 COLREGS) are part of the convention, and vessels that enter the study area, foreign and domestic, must adhere to the rules where applicable.[28] The rules are applicable on waters outside of established navigational lines of demarcation. These COLREGS Demarcation Lines delineate the waters upon which mariners must comply with the Inland and International Rules. The Demarcation Lines for U.S. ports are listed in 33 CFR 80. The Demarcation Line at the Columbia River entrance (between Oregon and Washington states) is a line drawn from the seaward extremity of the Columbia River North Jetty to the seaward extremity of the Columbia River South Jetty.

In 1980, Congress passed the Inland Navigational Rules Act. This legislation set out Rules 1 through 38 constituting the Inland Rules (Rules of the Road) which mariners follow upon passing across the Demarcation Line inland into the Columbia River. The International and Inland Rules are, for the most part, very similar in both content and format.[29]

USCG is responsible for establishing and enforcing the Rules of the Road, which are defined and described in 33 CFR E – Inland Navigation Rules. The primary objective of the Rules of the Road is to facilitate safe maritime travel. All vessels, both recreational and commercial, in the study area are required to understand and comply with the Rules of the Road.

Cooperative Coordination

Cooperative coordination between the Bar Pilots and River Pilots, primarily used in meeting situations on specific portions of the route, is a unique local practice that is an effective method of collision avoidance. As a standard practice, River Pilots avoid meeting situations in the following areas of the river.

- Miller Sands (RMs 22 through 25)
- Skamokawa/Abernathy (RMs 28 through 34)
- Bugby Hole(RMs 39 through 40)
- Bunker Hill (RMs 55.5 through 56.5).
- Longview Bridge (RMs 65 through 67)

[28] Congress adopted the 72 COLREGS as the International Navigational Rules Act of 1977 and other countries signatory to the International Convention similarly adopted the rules.

[29] Annex V to the Inland Rules, Pilot Rules, are for obvious reasons unique to the inland waters of the United States.

In general, the Bar Pilots and River Pilots avoid overtaking situations where one vessel passes another from behind. The Bar Pilots do not engage in cooperative coordination at specific locations on the Columbia River navigation channel; rather, they coordinate with each other to ensure that deep-draft vessels do not pass each other on the bar.

2.2.6.3 Limitations and Restrictions for Vessel Traffic

Commercial vessel traffic on the Columbia River may be affected by weather patterns, river and tidal conditions, and other (smaller) vessel traffic.

Environmental Conditions

Weather along the Columbia River consists of a series of microclimates that have the potential to cause operational issues. Environmental restrictions can result from fog, high winds, and tidal currents.

When coastal fog restricts visibility on the Bar and its approaches, the vessel's master and pilot (if employed) should assess all variables and determine whether it is safe for a vessel to enter the river. In some cases, it may be safer to wait offshore until visibility improves. In situations of restricted visibility, a vessel that is underway on the Columbia River may proceed along its intended passage with caution. Vessels intending to dock in restricted visibility should be able to see the intended wharf for the entire length of the vessel. However, the vessel's master and pilot may assess all variables and determine that the best course of action is to proceed to the dock. Vessels at dock or anchored in a safe anchorage should not commence movement if visibility is less than 0.5 mile unless the master and pilot assess all variables and determine that the vessel can proceed safely.

In all cases, the vessel's master and pilot should evaluate the current and forecasted weather and the impact on vessel movement, and if necessary, delay movement, call for additional tugs, or take other appropriate measures to ensure safe operations. Masters and pilots should consult the Coast Pilot and other sources of local knowledge when transiting high risk areas, and be prepared for strong tides, currents, and weather conditions.

2.2.6.4 Recreational and Fishing Vessels

The USCG is the primary federal maritime law enforcement agency on the Columbia River. Oregon State Police and Oregon county law enforcement (Clatsop County Sheriff Marine Patrol) also patrol on the Columbia River (Oregon.gov 2016). Vessels in these state and local law enforcement units are used to regulate recreational and fishing vessel traffic on the river in accordance with state and local laws.

USCG boards commercial fishing vessels at sea to ensure compliance with safety equipment requirements required by the Commercial Fishing Industry Vessel Safety Act of 1988. The USCG auxiliary conducts dockside inspections of commercial fishing vessels to supplement the at-sea boardings and educate anglers on safety equipment and training requirements. USCG vessels participate with state and local law enforcement in joint operations on a periodic basis to manage vessel traffic and maintain boater safety (U.S. Coast Guard 2014a). For example, during August and September each year, the Coast Guard Auxiliary, in conjunction with USCG Station Cape Disappointment, Clatsop County Sheriff's Office, and Oregon State Police, engage in a Recreational Boating Safety surge operation to educate and inform boaters participating in Columbia River recreational salmon season. USCG also hosts Operation Make Way, a yearly joint recreational boater education and enforcement campaign, to educate recreational boat users about the need to give way and stay clear of large commercial vessels operating within the Columbia and Willamette navigation channels. The program aligns with the states' and counties' recreational boating safety missions.

2.2.7 Ship Casualty Survey

The information presented in this section is based on data from the USCG (2014) MISLE database (2001 through 2014) (Appendix A, *Navigation Risk Study*). The data are collected for 26 vessel incident types and are not predictive of cargo vessel casualties. Three primary incident types—collision, allision, and a combination of grounding/set adrift—are representative of the navigational incidents that could occur and compare best to the results of the incident modeling (Table 11).

The database notes the severity of each incident and describes vessel damage. Table 11 presents the outcome distribution in three categories—total loss,[30] damaged, and undamaged—for marine incidents that took place between the Columbia River mouth and the Port of Portland.

The results of the data surveys are very similar to those from nationwide incidents in that approximately two-thirds of incidents resulted in no damage, one-third in some damage, and slightly less than 3% in total loss.

Table 11. Incident Severity by Incident Type for Study Area (Total Incidents)

Damage Status	Total Loss (% of Total)	Damaged (% of Total)	Undamaged (% of Total)	Total
Allision	3 (5%)	24 (43%)	29 (52%)	56
Collision	1 (5%)	9 (47%)	9 (47%)	19
Grounding /Adrift	1 (1%)	16 (21%)	59 (78%)	76
Total[a]	**5 (3%)**	**49 (32%)**	**97 (64%)**	**151**

Notes:
[a] Total may not sum due to rounding.
Source: Appendix A, *Navigation Risk Study*

Groundings were the most common type of incident, followed by allisions, then collisions. Although collisions represented less than 13% of total incidents during the survey period, they resulted in the highest severity outcomes, followed closely by allisions; groundings resulted in significantly less severe outcomes (78% of grounding resulted in no vessel damage).

Table 12 presents the distribution of incident severity in the study area for all incidents by vessel type. The table shows that the higher severity events more typically involved smaller craft (e.g., fishing or recreational vessels).

[30] For the purposes of this analysis, *actual total loss*, *total constructive loss: salvaged*, and *total constructive loss: unsalvaged* were combined into a single *total loss* category.

Table 12. Outcome Distribution for All Marine Incidents in the Study Area by Vessel Type

Vessel Type	Total Loss (%)	Damaged (%)	Undamaged (%)	Total (%)
General Dry Cargo	0	1	3	4
Bulk Carrier	0	2	16	18
Ro-Ro Cargo	0	1	1	2
Tank	0	0	2	2
Barge	0	2	7	9
Military	0	1	0	1
Passenger	1	8	7	15
Recreational	1	3	0	3
Fishing	2	5	13	21
Towing	0	7	13	20
Miscellaneous	0	1	0	1
Unspecified	0	1	3	4
Total[a]	**3**	**32**	**64**	**100**

Notes:
[a] Total may not sum due to rounding.
Source: Appendix A, *Navigation Risk Study*

Tables 13 through 15 present the distribution of incident severity by vessel type and by incident type for the study area. These tables show that collisions appear to result in the highest severity outcomes, with 5% resulting in a vessel loss and 47% resulting in damage to the vessel(s) involved in the incident. Allisions have the second highest severity outcomes with 5% vessel loss and 43% damage. Groundings result in only 1% vessel loss and 21% vessel damage.

Table 13. Outcome Distribution for Allisions in the Study Area by Vessel Type

Vessel Type	Total Loss (%)	Damaged (%)	Undamaged (%)	Total (%)
General Dry Cargo	0	4	0	4
Bulk Carrier	0	4	5	9
Ro-Ro Cargo	0	2	0	2
Barge	0	2	14	16
Passenger	0	13	4	16
Towing	0	11	23	34
Recreational	0	2	0	2
Fishing	5	2	4	11
Miscellaneous	0	2	0	2
Unspecified	0	4	2	5
Total[a]	**5**	**43**	**52**	**100**

Notes:
[a] Total may not sum due to rounding.
Source: Appendix A, *Navigation Risk Study*

Table 14. Outcome Distribution for Collisions in the Study Area by Vessel Type

Vessel Type	Total Loss (%)	Damaged (%)	Undamaged (%)	Total (%)
Tank	0	0	5	5
Barge	0	0	11	11
Military	0	5	0	5
Passenger	0	5	5	11
Towing	0	5	11	16
Recreational	5	16	0	21
Fishing	0	11	11	21
Miscellaneous	0	5	0	5
Unspecified	0	0	5	5
Total[a]	**5**	**47**	**47**	**100**

Notes:
[a] Total may not sum due to rounding.
Source: Appendix A, *Navigation Risk Study*

Table 15. Outcome Distribution for Groundings in the Study Area by Vessel Type

Vessel Type	Total Loss (%)	Damaged (%)	Undamaged (%)	Total (%)
General Dry Cargo	0	0	5	5
Bulk Carrier	0	1	28	29
Ro-Ro Cargo	0	0	3	3
Tank	0	0	3	3
Barge	0	3	1	4
Passenger	1	5	9	16
Fishing	0	7	21	28
Towing	0	5	5	11
Unspecified	0	0	3	3
Total[a]	**1**	**21**	**78**	**100**

Notes:
[a] Total may not sum due to rounding.
Source: Appendix A, *Navigation Risk Study*

2.2.8 Marine Oil Spill Survey

Vessel-related oil spills that occurred in the study area from 2004 through 2014 are presented in Table 16 by spill volume and incident type, based on MISLE, SPIIS, and ERTS data. Spill volumes per incident ranged from 0.1 gallon to 1,603 gallons. An average 15.6 oil spills per year occurred during the study period; of these, 84% had a volume of less than 10 gallons. As reflected in Table 16, most of the spills were not related to a vessel incident. Spills greater than 100 gallons occurred at a frequency of 0.4 per year or once every 2.2 years. The average size of these spills was approximately 630 gallons.

Table 16. Oil Spill Incident Count and Frequency—Lower Columbia River (2004–2014)

Incident Type	Oil Spill Incident Count by Spill Volume					Oil Spills per Year
	< 1 gal	1–10 gal	10–100 gal	> 100 gal	Total gal	
Allision	1	-	-	-	1	0.1
Capsize	1	-	-	-	1	0.1
Environmental Damage	123	57	28	6	214	15.3
Grounding	-	-	1	-	1	0.1
Sinking	-	2	-	-	2	0.1
Total	**125**	**59**	**29**	**6**	**219**	**15.6**
Spills per Year	**8.9**	**4.2**	**2.1**	**0.4**	**15.6**	

Notes:
gal = gallons

The vessel-related spill survey was largely confined to the specified period of 2004 through 2014, to develop a baseline representative of existing risk. Additionally, this period provided the best overlap in data available from the three datasets. Larger-scale incidents involving the release of oil have occurred in previous years; however, these events predate legislation targeted at and largely successful in reducing the likelihood of oil spills from vessels or diminishing the impact of a spill should it occur, namely, the enforcement in U.S. waters of the International Convention for the Prevention of Pollution from Ships (MARPOL) and the Oil Pollution Act of 1990. The latter brought about more stringent planning and spill prevention activities than the previous U.S. legislation (the Federal Water Pollution Control Act as amended by the Clean Water Act) and improved preparedness and response capability (public and private), and established a double hull requirement for tank vessels.

2.2.9 Incident Management and Response Systems

The National Contingency Plan (NCP) codified in 40 CFR 300 establishes Federal On-Scene Coordinators (FOSCs) for oil spills and hazardous material releases within the inland zone and coastal environments. The NCP is the foundation document for state, regional, and local planning documents governing pollution response; it provides organizational focus for the related emergencies that can lead to oil spills, such as vessel groundings, collisions, allisions, and fires.[31] Under the NCP, the FOSC is designated as either USCG or U.S. Environmental Protection Agency, depending on the location of the spill. The project vessel route and site are located within the USCG FOSC and COTP zones (Sector Columbia River and MSU Portland hold these authorities). Ecology is the designated state on-the-scene coordinator for spill response (Revised Code of Washington 90.56.020). The Washington Emergency Management Division is the designated State On-Scene Coordinator (SOSC) for natural disasters. The Washington State Patrol or state fire marshal is the designated SOSC for fires. The Washington State Emergency Response system is designed to provide coordinated state agency response, in cooperation with federal agencies for effective clean-up of oil or hazardous substance spills. Within Oregon State, DEQ is the lead agency for oil or hazardous material spills. The Oregon Office of Emergency Management coordinates support from other state agencies, when required, and the Office of the State (Oregon) Fire Marshal provides hazardous

[31] Washington and Oregon legislative and regulatory requirements for state oil spill contingency plans applicable to vessels calling under the Proposed Action are listed in Table 1.

materials/fire incident response coordination and support from unaffected state jurisdictions when a situation exceeds local response capabilities.

The Northwest Area Contingency Plan (ACP) is the regional planning framework for oil and hazardous substance spill response in Washington, Idaho, and Oregon. Representatives from the federal and state agencies listed here and local governments plan for spill response emergencies together and come together to implement the ACP when an incident occurs. The plan includes but is not limited to the following elements.

- A description of the area covered by the plan, including the areas of special economic or environmental importance that might be damaged by a spill.
- Roles and responsibilities of an owner or operator and of federal, state, and local agencies in spill response and in mitigating or preventing a substantial threat of a discharge.
- A link to an online list of equipment available to respond to oil spills.
- Site-specific geographic response plan (GRP).

GRPs are part of the ACP. Each plan is written for a specific area, including the Lower Columbia River, and includes tactical response strategies tailored to a particular shore or waterway at risk of injury from oil. GRPs have two main objectives: to identify sensitive resources at risk of injury from oil spills and to direct response actions related to sensitive resource protection during the initial hours of a response. Strategies in the plan are deployed by a part of the response organization as soon as potential impacts (generally with real-time weather data and oil spill trajectories) are evaluated even while other parts of the response organization may still be addressing immediate concern of controlling and containing the source of a spill.

In addition to the ACP and the GRP governing spill response within the Lower Columbia River the Lower Columbia Region Harbor Safety Committee[32] meets on a regular basis to discuss waterway issues in the river, including emergency procedures in case of a vessel incident. The standards, guidelines, and protocols agreed upon by members of the committee are promulgated and maintained within the Harbor Safety Plan (HSP). The HSP complements existing regulations by advising mariners of unique conditions and requirements associated with transiting the Lower Columbia River. The HSP includes incident management guidelines, emergency communications, notification requirements in case of an oil spill, steps to take in case of a vessel grounding, vessel collision, bridge allision, and mechanical or equipment failures.

These government and agency plans all help coordinate response efforts by the responsible party (the spiller, in this case the vessel owner/operator) and federal and state agencies.

Since the proposed coal export terminal would not transfer oil to project-related vessels in bulk, the Proposed Action would not be required to submit a federal facility response plan for oil spills. The coal export terminal would likely be a designated waterfront facility under 33 CFR 126.13, which means that the coal export terminal would be designated for handling, storing, loading, and discharging a hazardous material whose transport is subject to the Dangerous Cargoes Regulations contained in 49 CFR 170–179.

[32] The Lower Columbia Region Harbor Safety Committee comprises public and private stakeholders with vital interest in assuring safe navigation and maritime practices on the Columbia River.

Under SOLAS, coal is defined as dangerous goods in solid form when in bulk. Consequently, this designation requires that the Applicant meet certain conditions at the project area (applicable USCG regulations are contained in 33 CFR 126.15) including the following.

- Fire extinguishing equipment (automatic sprinklers, hydrants, hose connections, and firefighting water supplies) must be available and maintained in adequate quantities and locations.
- The location of fire appliances such as fire hydrants, standpipes, hose stations, fire extinguishers, and fire alarm boxes must be conspicuously marked and readily accessible (according to National Fire Protection Association).
- Warning signs must be posted.
- If coal is transferred between sunset and sunrise then the Applicant must install outdoor lighting that adequately illuminates the transfer work area.
- Access restrictions whenever the cargo is transferred or stored at the terminal.
- Security measures must be in place to deter and detect unlawful entrance; to detect and report fire hazards, fires, and releases of dangerous cargo and hazardous materials.

The security measures described above could be guards or "equivalent controls" such as alarm systems, closed-circuit television cameras and monitors, or a combination of both. In case of an emergency the situation must be reported to USCG personnel as soon as they are discovered. Since the facility is not a covered facility under Washington State law for oil spill contingency planning, the Applicant is not required to have an oil spill response plan under state law.

Vessel owners/operators of the project-related vessels would be required to prepare and submit oil spill response plans under federal requirements (33 CFR 155.5010-155.5075) and state requirements (Washington Administrative Code 173-182 and Oregon State Administrative Rules 340-141) to ensure that resources, including equipment, are in place for a spill of the vessel's fuel oil and of any oil carried as secondary cargo. The Non-tank Vessel Response Plans would include notification procedures, shipboard spill mitigation procedures, shore-based response activities, a list of contacts, and training and exercise procedures.

The vessel owner/operator would be required to have available through contract or other approved means an oil spill removal organization and a spill management team. It is customary for owners/operators of vessels to contract with cooperative organizations that specialize in oil spill response and personnel that maintain, train, and exercise the equipment. MFSA generally serves this role in the Columbia River and has access to oil spill response equipment on the river system (through a sharing agreement with Clean Rivers Cooperative).[33]

The MFSA vessel response plan is an umbrella plan for enrolled vessels entering the Columbia River. MFSA recently updated the Master Oil Spill Contingency Plan for Covered Vessels and submitted it to Ecology for approval. Ecology has approved the update.

[33] Working with federal granting agencies and local jurisdictions, Astoria Fire Department/Port of Astoria, Clark County Fire & Rescue, Scappoose Rural Fire District and Vancouver Fire Department achieved funding to acquire new Quick Response Vessels in 2014. The Quick Response Vessels provide enhanced response capabilities between Vancouver and Astoria.

2.2.9.1 Oil Spill Incident Response

This section describes the incident response system in place on the Columbia River, as spelled out in the MFSA response plan.

USCG is the FOSC for oil and hazardous materials spills on the Lower Columbia River. Ecology and ODEQ are the SOSCs for spills and impacts on state waters. These agencies and the responsible party (as represented by the MFSA for a covered vessel) represent the Unified Command. The Unified Command coordinates responses, mitigation, and cleanup efforts for spills on the Lower Columbia River to protect public health and safety, response personnel, and the environment (Maritime Fire & Safety Association 2013).

For vessels covered under MFSA, these general steps are followed when a bunker spill occurs.

1. Ignition is shut down, personnel are warned, containment is initiated, and vessel is secured.
2. Vessel representative initiates MFSA and federal and state response plans by notifying the Merchants Exchange, USCG, and state emergency management offices.
3. Vessel representative designates MFSA as Incident Commander representing company interests.
4. MFSA representative assesses situation, makes necessary notifications for response resources, and participates in Unified Command.
5. MFSA returns control to the vessel representative for completion of clean-up, damage assessment, decontamination, disposal, and demobilization.

The contract between the vessel owner/operator and the MFSA and the incident specifics determine when steps three and five take place.

2.2.9.2 Shipboard Fire Incident Response

Under the Federal Fire Prevention and Control Act of 1974, fire prevention remains a local and state responsibility (Northwest Area Committee 2015). The local fire jurisdiction is the first responder to a shipboard fire. If the incident is beyond the local jurisdiction's capacity, mutual aid resources[34] are requested through the MFSA Fire Protection Agencies Advisory Council. The council's mutual aid network extends to 13 fire agencies along the Lower Columbia and Willamette Rivers. If local and mutual aid resources are exhausted, the local fire chief requests assistance from the state emergency management office. With appropriate approvals, the state fire chief (Oregon) or state fire marshal mobilization coordinator (Washington) takes control over the response (Office of State Fire Marshal 2015; Washington State Patrol 2015).

The USCG COTP will act as the FOSC if there is a shipboard fire outside a fire agency's jurisdiction but within the Sector Columbia River COTP zone, or if a vessel fire is treated as a search-and-rescue case (Northwest Area Committee 2015).

2.2.9.3 Collision and Grounding Incident Response

For collision and grounding incidents, the vessel must immediately secure all necessary watertight closures in accordance with the ship's emergency procedures and contact the USCG COTP, Ecology, and ODEQ. The USCG COTP may establish a communications schedule and request the vessel to

[34] Local and state firefighting organizations enter into reciprocal agreements to provide mutual aid when resources are overwhelmed.

update its situation periodically. If the waterway is blocked or needs to be closed, a safety marine information broadcast will be issued, including providing information of the incident, including location, vessel type and cargo, incident description, and other details.

In response to a collision, USCG response personnel and state investigators may respond to the scene for initial assessment and on-scene communications and supervision and may form a Unified Command. The Unified Command will instruct the responsible parties on standard procedures for separating vessels, if joined, and moving them to an available dock, anchorage, or directly to a shipyard for repairs. The USCG COTP will work with the vessel and Unified Command to initiate pollution response measures as necessary. In most cases, a surveyor will be required to inspect damage and verify repairs.

In response to a grounding, the objective is to refloat the vessel and minimize damage to the vessel and environment. Upon grounding, the responsible party must contact the USCG COTP to provide vessel and incident information and a safety marine information broadcast is issued. The responsible party must submit a salvage plan to the USCG COTP or Unified Command for approval prior to attempting to refloat. If calculations determine that the vessel cannot be refloated at the recorded draft just prior to grounding the lightering[35] of vessel cargo and/or fuel may take place to lighten the vessel. This transfer of coal or fuel would be completed only after all other options were evaluated for refloating the vessel and the salvage and lightering plan is approved by the USCG.[36] Most likely, approval of the salvage and lightering plan will include a requirement that the responsible party activate the vessel response plan to mitigate any pollution threat prior to refloating. The type of bottom (mud, sand, gravel, rock) and the speed of the vessel (underway, maneuvering with tugs, dragged anchor in high winds) prior to grounding will most often determine the severity of the incident and the precautions to be taken until the vessel refloats. In most cases, a surveyor is required either on scene or to inspect damage and verify repairs.

[35] Lightering is the process of transferring cargo between vessels of different sizes, usually between a barge and a bulker or oil tanker.

[36] Depending on the severity of the grounding (determined by length of time the vessel is grounded, whether or not the navigation channel is blocked, and if lightering must take place to refloat) a Unified Command may be formed. In this case the Unified Command would review and approve the salvage and lightering plan.

Chapter 3
Impacts

This chapter describes the impacts related to vessel transportation that would result from construction and operation of the Proposed Action or the ongoing conditions under the No-Action Alternative.

3.1 Proposed Action

Potential impacts related to vessel transportation from the Proposed Action are described below. The Proposed Action would load 70 vessels a month or 840 vessels a year. This equates to 1,680 vessel transits in the Columbia River. Proposed Action-related cargo vessels would be required by federal and state law to meet vessel standards and plan requirements. These include structural, fire-fighting and personnel requirements as well as oil spill contingency and response plans as previously described

3.1.1 Construction: Direct Impacts

Construction of the Proposed Action would result in the following direct impacts.

In-water dock construction (pile-driving, dredging, and general construction of above water elements) would occur over a 6-month to 1-year period (Grette Associates, LLC 2014:12). For this work, barges would be located near the proposed docks (Docks 2 and 3). The barges would be positioned outside of the navigation channel to not impede vessels traveling within the channel. The barges would also be placed outside of the area used by vessels accessing Dock 1, so they would not affect these activities. Additional information on dredging and pile driving is included in the SEPA Water Quality Technical Report (ICF 2017a).

3.1.2 Construction: Indirect Impacts

Construction of the Proposed Action would result in the following indirect impacts.

If supplies and equipment for construction are delivered to or removed from the project area by barge, there would be a temporary increase in barge activity in the study area.

The Applicant has identified three construction-material-delivery scenarios: delivery by truck, rail, or barge. If material is delivered by barge, it is assumed that approximately 1,130 barge trips would be required over the construction period. Approximately two-thirds of the barge trips would occur during the peak construction year, assumed to be 2018. Approximately 750 barge trips in the study area would be required during the peak construction year to deliver construction materials. Because the project area does not have an existing barge dock, the material would be off-loaded at an existing dock elsewhere on the Columbia River and transported to the project area by truck.

Barges are shallower in draft and could transit the Columbia River navigation channel during periods of low water to avoid interfering with larger vessel traffic. Coordination would take place with the River Pilots prior to and during transit. Moreover, the construction barges would be transiting a portion of the navigation channel during construction near the project area and not the entire study area. Therefore, impacts on vessel traffic in the study area as a result of construction-related barge traffic would be low because barge traffic would avoid interfere with larger vessels and would only traverse a portion of the Lower Columbia River.

3.1.3 Operations: Direct Impacts

Operation of the Proposed Action would result in the following direct impacts. The Proposed Action would load 70 vessels a month or 840 vessels a year. This equates to 1,680 vessel transits in the Columbia River.

The Proposed Action would add two docks (Docks 2 and 3) and eventually have the capacity to export 44 million metric tons of coal by vessel. Loading coal onto vessels for export is the only activity proposed for the new docks. Vessel loading would be performed using an electric-powered, single-traveling shiploader. One shiploader would be installed on each new dock. Each shiploader would have an average capacity of 6,500 metric tons per hour. At maximum throughput, an average of 70 vessels per month (an average of over two per day) would be loaded at the new docks. The berths for the new docks are expected to be occupied by Proposed Action-related vessels 365 days per year.

River Pilots would pilot the incoming and outgoing vessels (from Astoria inland and vice versa) and direct docking and undocking maneuvers. At least two tugs would be used to assist with docking and undocking maneuvers for each arriving and departing project-related vessel (Gill pers. comm.). Therefore, at least two tugs would be active near the docks four times per day on average. The pilot determines the appropriate size and horsepower of the tugs depending on a number of factors such as the size of the vessel, weather conditions, and currents at the time of maneuvers (Gill pers. comm.).

Docks 2 and 3 would be designed to accommodate dry bulk cargo ships up to 830 feet long and 130 feet wide, which would accommodate standard Panamax vessels and the somewhat smaller Handymax vessels. The berths at Docks 2 and 3 would have a depth of 43 feet, which is the depth at which the Columbia River navigation channel is maintained (U.S. Army Corps of Engineers 2015b).

The expected fleet mix is 80% Panamax and 20% Handymax vessels. Table 17 contains the size and dimensions of these types of vessels assumed for the risk analysis (Appendix A, *Navigation Risk Study*).

Table 17. Vessel Sizes and Dimensions for Panamax and Handymax Vessels Assumed in the Risk Analysis

Vessel Class[a]	Deadweight Tons	Length Overall (feet)	Beam (feet)	Draft (feet)
Handymax	46,101	600	106	36.1
Panamax	68,541	738	106	43.6

Notes:

[a] These specifications chosen to represent the size and dimensions for Panamax and Handymax class vessels are representative of an "average-sized" Panamax class vessel and an "average-sized" Handymax class vessel.

Source: Appendix A, *Navigation Risk Study*

Operational impacts related to the Proposed Action are based on the following assumptions:

- The River Pilots anticipate turning the ships in the project area in loaded condition—in preparation for departure, as opposed to turning downstream upon arrival (Gill pers. comm.).[37] Thus, inbound ships would approach Docks 2 and 3 in ballast (headed upstream), maneuver out of the navigation channel toward the dock, and align parallel to the dock, docking with the assistance of tugs. Figure 9 depicts typical maneuvering of a ship approaching the downstream berth, Dock 3, with a Panamax ship already at Dock 2.
- Pilots estimate that operations at the project area (Docks 2 and 3) would require the two assisting tugs to have bollard pull ratings of at least 30 tons operating ahead and at least 22.5 tons operating astern. Those tugs would be in the 3,000 to 4,000 horsepower range (Gill pers. comm.). Pilots would determine tug assistance needs.
- The River Pilots anticipate that they would turn vessels off the dock, as opposed to using the turning basin upstream of the project area (Gill pers. comm.). If river conditions were not suitable or the vessel was too long, however, they would use the turning basin. A typical departure of a loaded vessel (Figure 10) with the assistance of the tugs, would involve moving the bow out into the channel, while keeping the stern near the dock to give the pilot accurate positioning of the vessel during the turn, and allowing the current to rotate the bow until the vessel points downriver and can begin moving downriver. The width of the channel at this point is approximately 1,200 feet, which provides a turning area approximately 1.6 times the length of the vessel.
- Currently, maneuvering a vessel to the existing berth (Dock 1) upstream of the proposed docks can be challenging (Amos pers. comm.). The outflow from the bank at that dock creates the need for more tugs, vessel power, and time to dock safely. Pilots expect that conditions for Docks 2 and 3 would require similar operations as at Dock 1 (Gill pers. comm.). Pilots would be aware of this issue and would consider it during planning and operations.

[37] Currents in the river at the project area are typically directed downriver or ebbing due to the river flow overriding the tidal currents. It is expected to be more efficient and safer to dock the ship heading into the current using the forward power of the engines which is stronger than the vessel's backing power. When the loaded vessel leaves the dock with the bow pointing upstream, the currents assist the vessel turning in the channel by pushing the bow around and downstream. Pilots are responsible for vessel movements and would determine the appropriate actions for vessel arrivals and departures.

Figure 9. Typical Approach of a Panamax Bulk Carrier in Ballast Condition to Dock 3

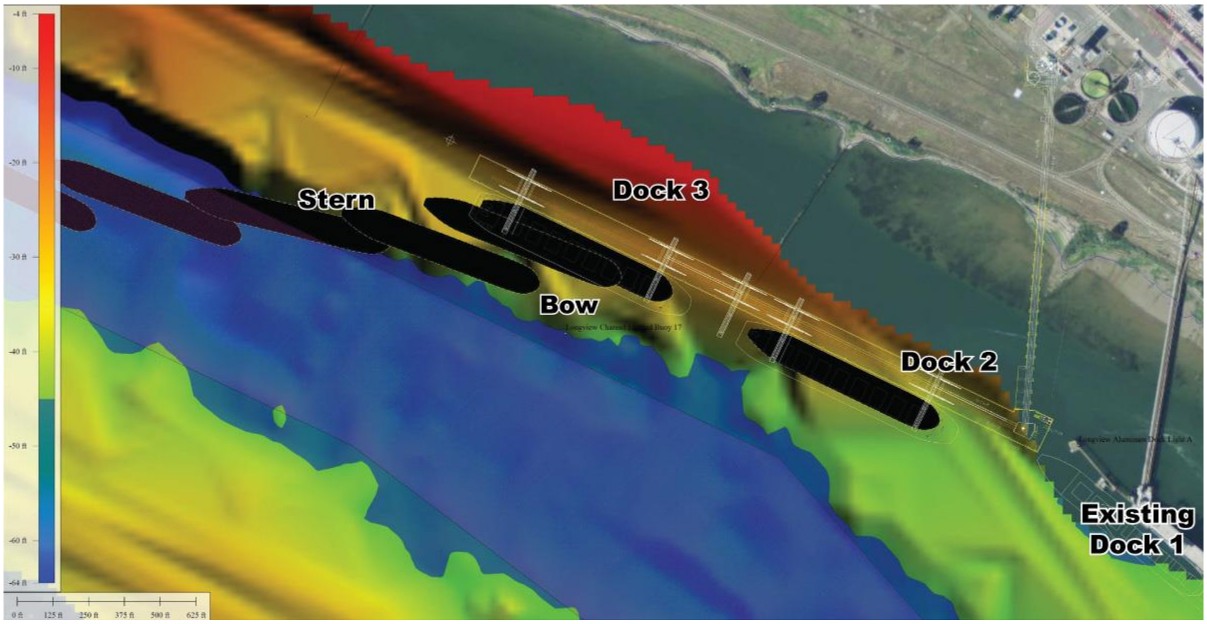


Figure 10. Typical Departure of a Panamax Bulk Carrier in Loaded Condition from Dock 3

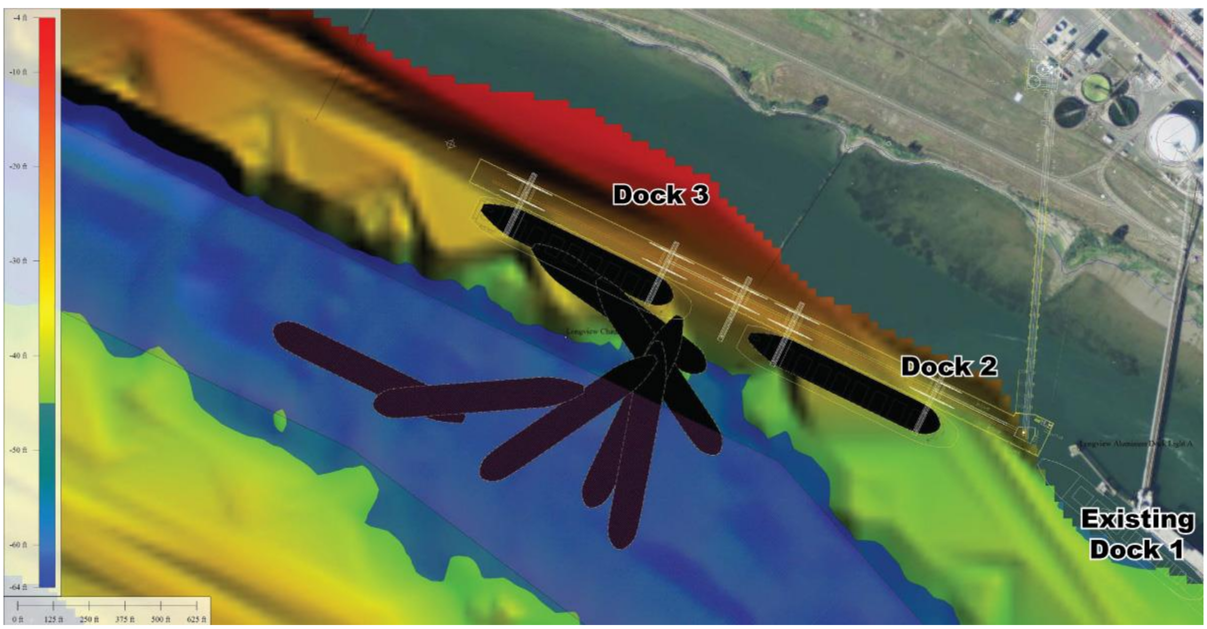
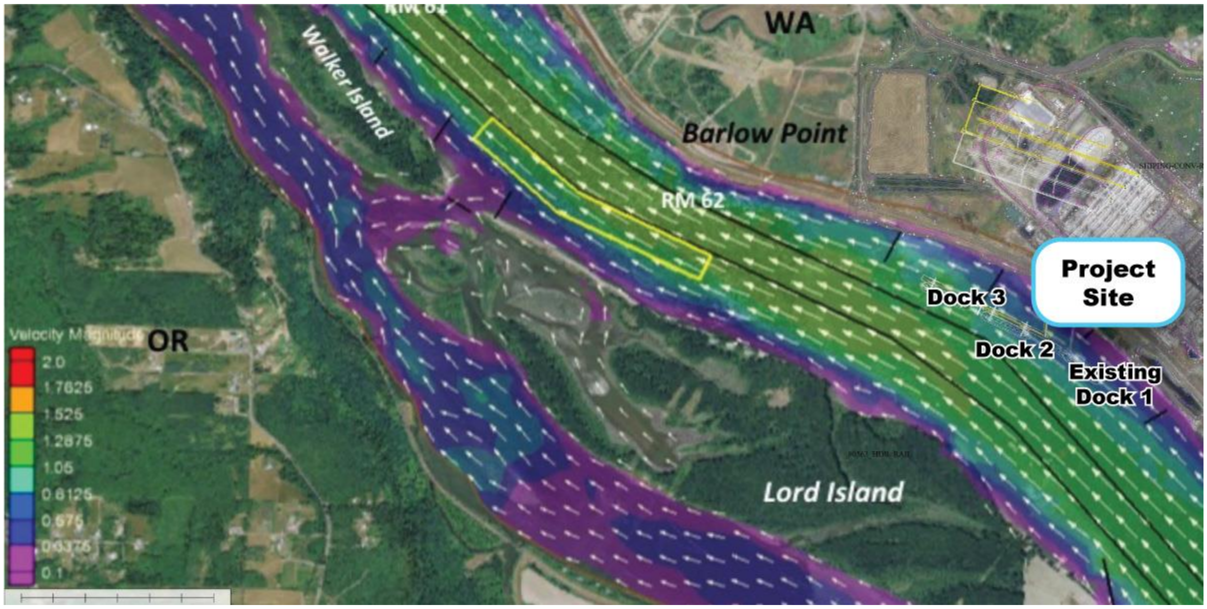


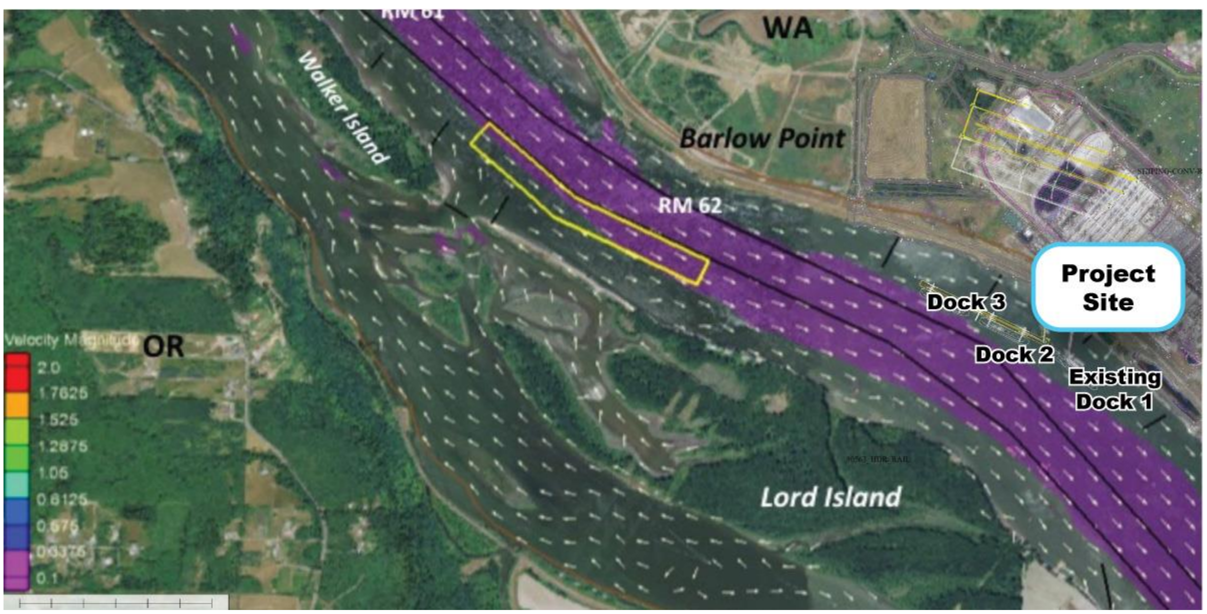
Figure 11 shows the computed current vector plot of the peak ebb period in mid-June 2009. This figure shows that the currents are relatively parallel to both the existing and proposed berths except at the upriver end of Dock 2 where the currents have a component that would push the ship onto the dock and could make moving off the dock more difficult. The magnitude of the current at Dock 1 is approximately 0.7 to 0.8 feet per second (fps), while at the down-river berth, Dock 3, the velocity magnitude would be approximately 1.5 to 1.8 fps.

Figure 11. Computed Peak Ebb Flow in Mid-June 2009



A plot of the flood currents during a low river discharge period is shown in Figure 12. The velocity vectors are aligned with all three berths with this flow, and the magnitudes of the velocities are very low, below 0.1 fps.

Figure 12. Computed Peak Flood Flow in Early October 2009



These vector plots of depth-averaged velocities do not provide any evidence showing why the pilots would have difficulty moving a ship onto the existing berth. However, the computational grid of these plots indicates that the data resolution in the area of the docks is low, and it is questionable as to whether the dikes along the shoreline near the docks are included in the computational grid.

These dikes could have a significant impact on the velocities along the shoreline that could cause eddies to form, as well as redirection of the currents away from the shoreline.

Should an incident occur during operations, it would most likely be attributable to increased risk of a vessel fire at the dock, an increased risk of an oil spill while at the dock, or an increased risk of a vessel allision while at the dock. Each of these situations is discussed below.

Increased Risk of a Vessel Fire While at Dock

Coal, in any form, is a combustible material, making it susceptible to a variety of ignition scenarios. Coal fires during transfer and loading operations are typically caused by one of two sources of ignition: the coal itself (self-ignition) or the conveyor belt used in the transport of coal (e.g., over-heating due to damaged bearings, roller, belt slip). Safety requirements prohibit open flames near coal-loading operations.

A fire in the vessel's machinery spaces or accommodation areas is a potential emergency scenario. Vessel design standards, fire equipment requirements, and crew training are in place to prevent or to facilitate rapid response to a vessel emergency while at the dock. All of these standards and requirements are implemented in accordance with SOLAS in foreign and domestic cargo vessels (and codified in U.S. regulations) and enforced by USCG. Therefore, an onboard emergency is unlikely to affect resources other than the vessel itself.

A bulk carrier such as the project-related vessels would have the following fire prevention and response features.

- Structural fire protection, including certain bulkheads constructed to prevent the passage of flame and smoke for one hour. Other bulkheads must be constructed of incombustible materials. Current regulations require that risk of fire hazards be eliminated as much as possible in other construction features of the vessel (46 CFR 92).
- Structural insulation around compartments containing the emergency source of power (such as the ship's service generators). Other approved materials capable of preventing an excessive temperature rise in the space may also be used to eliminate the spread of a fire that originates in this type of compartment (46 CFR 92).
- Fire pumps, hydrants, hoses, and nozzles for the purposes of onboard firefighting. In additional certain spaces must have approved hand portable fire extinguishers and semiportable fire extinguishing systems (46 CFR 95).
- Officers and crewmembers with a basic level of training that includes fire prevention and firefighting (U.S. Coast Guard 2014b).

Within the hold of a vessel, coal can be susceptible to ignition due primarily to self-heating and/or the creation and subsequent ignition of certain gases, including methane and hydrogen. Fire-detection systems including carbon monoxide detection and infrared scanning would be in place to monitor and minimize the potential for onboard coal fires. Additionally, manual scanning by workers would enhance built-in mechanical detection systems. Automated fire suppression systems that are activated in the early stages of fire development are critical to reducing the potential for flame spread. These typically include water sprinklers combined with a fire-extinguishing agent such as wetting agents or foam. Therefore, an onboard emergency is unlikely to affect resources other than the vessel itself.

Increased Risk of an Oil Spill While at Dock

An oil spill at the dock would most likely occur during bunkering (i.e., a ship receiving fuel while at the dock). The Applicant has committed to not allowing vessel bunkering at Docks 2 and 3; therefore, there would be no risk of an oil spill at docks associated with oil transfers under the Proposed Action. Oil spill risks that might occur during transit are addressed under Section 3.1.4, *Operations: Indirect Impacts*.

Increased Risk of a Vessel Allision at the Dock

An allision occurs when a vessel strikes a fixed structure, such as a project-related vessel striking the proposed docks at the project area or another vessel striking a project-related vessel at berth.

Pilots sometimes experience difficulties getting a ship to the berth at Dock 1, which is just upstream of the proposed Docks 2 and 3. The reason for this cannot be determined from the examination of current vectors provided by the Corps, making it difficult to link the maneuvering challenges at Dock 1 with potential maneuvering challenges due to currents and river flow at the proposed docks. A vessel allision with the dock is a potential outcome when there are strong currents near the dock during vessel maneuvers. An allision may also occur if there were a loss of steering or loss of propulsion during transit or maneuvering at the dock. Despite the uncertainty associated with vessel maneuvers at the dock, the likelihood of a vessel allision is lessened due to the presence of tug power while docking and undocking.

Risk of allision could also involve another vessel striking a project-related vessel while the vessel was at berth. All large commercial vessel traffic bound for Longview or ports further upriver, including the Port of Portland and Port of Vancouver, pass the project area. Based on incident modeling (Appendix A, *Navigation Risk Study*), the likelihood of an allision under the Proposed Action is once in 39 years (2028) and once in 25 years (2038). However, as noted in Section 2.2.7, *Ship Casualty Survey*, most allisions do not result in substantial consequences, such as a total vessel loss. Between 2001 and 2014, 5% of allisions resulted in substantial consequences, such as total vessel loss, and all of these events involved fishing vessels only.[38]

3.1.4 Operations: Indirect Impacts

Operations of the Proposed Action would result in the following indirect impacts.

As noted above, all large commercial vessel traffic bound for ports further upriver pass the project area. Transiting project-related vessels could affect or be affected by other vessel movements in the study area. Moreover, increased vessel traffic could result in changes in wake patterns, increased propeller wake, increased underwater noise, and vessel emissions that could affect environmental resources. These impacts are addressed in the SEPA Water Quality Technical Report (ICF 2017a), SEPA Noise and Vibration Technical Report (ICF and Wilson Ihrig 2017), and SEPA Air Quality Technical Report (ICF 2017b). Impacts on the vessel transportation system and related environmental resources along the Columbia River navigation channel due to vessel operations are considered to be indirect impacts under SEPA.

[38] The data also show that between 2001 and 2014, 4% of the allisions resulting in some damage were bulk carrier allisions.

As discussed in in Appendix A, *Navigation Risk Study*, vessel traffic for existing conditions (2014) was based on AIS data. Table 18 compares large commercial vessel traffic under existing conditions (based on 2014 AIS data), the No-Action Alternative (2028), and with the Proposed Action (2028). Vessel traffic unrelated to the Proposed Action was projected using a 1% growth rate and is included for 2028, the year of full build-out.

Table 18. Existing and Projected Large Commercial Vessel Traffic in the Lower Columbia River

Condition	Vessel Transits per Year
Existing Conditions (2014)	3,862
No-Action Alternative (2028)	4,440
Proposed Action (2028)	6,120

Notes:
Source: Based on 2014 AIS data for Cargo/Carrier, Tanker, Tug, and Passenger vessel types; a projected growth rate of 1% was applied to the 2014 transits to obtain the 2028 vessel transits under the no-action alternative; and proposed vessel transits (1,680) were added to the no-action transits to obtain transits with the Proposed Action.

For the purposes of incident modeling, the baseline traffic year of 2014 was selected to represent relatively recent traffic conditions on the river. The VTIS in operation in the study area and other risk-reduction factors were considered in the analysis of the potential for increased risks during vessel transit as discussed in Appendix A, *Navigation Risk Study*.

The vessel incidents evaluated in the modeling include allision, collision, grounding (powered or drift), and fire/explosion, (Section 2.2.7, *Ship Casualty Survey*). Incident modeling considered the interaction between project-related vessels and other large commercial vessels using the channel, as well as smaller vessels (e.g., recreational boats or commercial fishing vessels) not limited to the channel. The potential increases in these risks are discussed below.

Increased Risk of a Vessel Allision (with a Fixed Object) during Transit

For vessels outbound from the project area, no fixed structures or waterfront facilities are close to the edge of the navigation channel until the Port Westward dock at RM 53 (Figure 3) and after that a small barge terminal dock at RM 36. Thereafter, there are no facilities or structures until reaching the Port of Astoria, and those are well clear of the channel. The Astoria-Megler Bridge is the next structure encountered, and once past that, the remaining structures are the jetties at the entrance of the river.[39] Due to the minimal impediments to vessel traffic within the navigation channel, the likelihood of a project-related vessel alliding with a fixed structure while in transit is low and was not quantitatively evaluated in the risk assessment (Appendix A, *Navigation Risk Study*). As shown in Table 11, 56 vessel allisions occurred in the study area from 2001 to 2014 (compared to an average of more than 3,000 large commercial vessel transits annual during this time). Of these, just over half (52%) resulted in no damage. Of the remaining incidents, 43% resulted in some level of damage and 5% resulted in total loss[40]. Therefore,

[39] Since they are piloted, large commercial vessels have an advantage over fishing and recreational vessels as pilots are specifically trained to keep a large commercial vessel from alliding with a known object in the navigation route, including a bridge. Approximately 30 years ago, there was an allision at the Astoria-Megler Bridge that involved a piloted vessel. Since this incident, Bar Pilots have implemented risk-reduction measures to reduce the probability of allisions at the bridge: they avoid meeting other piloted vessels at the bridge, observe weather and river current conditions, and review weather forecasts before transiting under the bridge (Appendix A, *Navigation Risk Study*).

[40] All total losses resulting from allision were to fishing vessels.

although there would be an increase in risks compared to existing conditions, the overall risk of a project-related vessel resulting in an allision to or from the project area would be low.

Increased Risk of Other Incidents during Transit

While a collision may seem to be a more likely incident scenario in the two-lane channel, the vessel casualty data (Table 11) and incident modeling results (Table 19) show that groundings, specifically powered groundings, are more likely under all traffic scenarios.

As presented in Table 19, the Proposed Action would result in an increased potential for incidents compared to both existing condition (2014) and the No-Action Alternative (2028). The predicted increase in incidents is primarily because of the increase in the number of vessels transiting the Lower Columbia River. It should be noted that the consequences of a modeled incident can vary greatly from no damage to total loss and that the increase in likelihood alone is not representative of the magnitude of the potential consequences. In other words, not all of these incidents are likely to result in notable damages. For example, of the 151 reported incidents that occurred in the study area from 2001 through 2014 (Table 11), over half (64%) resulted in no damage, 32% resulted in damage, and 3% resulted in total loss.

Additionally, it is important to note the incident frequencies predicted for existing conditions are from a single year (2014); while this year accounts for higher vessel traffic compared to more recent years, it does not account for the wide variation in vessel traffic that has occurred prior to the recession or the historical highs for traffic on the Columbia River. Further, because the Proposed Action would ramp up over time, it is important to note that comparing the addition of 840 vessels to the existing condition is a conservative approach. Therefore, it is important to also consider how the No-Action Alternative would compare to the existing condition and how the Proposed Action would compare to the No-Action Alternative. As shown in Table 19, a relative increase in the likelihood of all incident types would occur over time unrelated to the Proposed Action.

Table 19. Predicted Incident Frequencies per Year in the Study Area

Scenario	Predicted Collision Incident Frequency	Predicted Powered Grounding Incident Frequency	Predicted Drift Grounding Incident Frequency	Predicted Fire/Explosion Incident Frequency	Total Incident Frequency
Existing Condition (2014)	1.94	11.8	2.8	0.0032	16.6
No Action (2028)	2.53	13.6	3.3	0.0037	19.4
Proposed Action (2028)	3.06	15.2	3.9	0.0043	22.2

Notes:
Source: Appendix A, *Navigation Risk Study*

Collisions. As noted in Section 2.2.6.2, *Methods for Managing River Traffic*, the River Pilots and Bar Pilots generally avoid overtaking situations where one vessel passes another from behind. Thus, the most likely collision scenario is an inbound vessel meeting an outbound vessel. The River Pilots have identified specific points on the river where conditions are not suitable for vessels to pass each other, and they carefully manage transits to avoid two vessels meeting in those locations. Instead, they manage the vessel transits so if they do need to pass each other, it is done in a safe area. Avoidance of these areas was taken into consideration in the calculation of incident frequencies (i.e., estimating the likelihood of a collision due to the Proposed Action) in the incident modeling.

The most likely collision scenarios are bow-to-bow and side-to-side contact involving two large commercial vessels transiting the navigation channel. Bow-to-side is a possibility, but the channel width and the sizes of the vessels would likely make it more of a glancing impact rather than a straight on "T" impact.

Bow-to-bow contact is generally viewed as the easiest type to avoid because the target area is small and either vessel can act independently to avoid it. Also, a vessel's bow is its strongest structural point and bow-to-bow collisions would not be expected to result in cargo hold damage or fuel oil release. In addition, the hydrodynamic interaction between ships meeting causes the bows to be pushed away from each other as they approach.

Side-to-side or a glancing bow-to-side collision could result in damage to the hull, but the likelihood of catastrophic damage is relatively low. For dry cargo vessels—including bulk carriers—it is unlikely that any coal cargo would be released into the water in the event of an angle of impact less than 22.5 degrees (Appendix A, *Navigation Risk Study*). For tank vessels—including ATBs carrying oil in bulk—the risk of an oil spill cannot be ruled out; however, modern tank vessel design standards, including double hull construction of tankers, significantly reduce that potential.

As noted in Section 2.2.5, *Other Vessel Traffic*, the Columbia and Willamette Rivers provide important fisheries for commercial, tribal, and recreational purposes. Although these smaller vessels are not restricted to the navigation channel, they do often cross the river to access various locations within the study area. Particularly during periods of high fishing activity, there would be an increased chance for a vessel collision to occur. However, in general, because these smaller vessels are not restricted to the channel and must by law yield to oncoming large commercial vessels, the potential for a collision between a smaller vessel and a project-related vessel would be low. Although it is not possible to predict the types of vessels that might be involved in a future incident, the incident modeling does show a very small increase in the potential for collisions involving fishing vessels (0.05 incident per year) and recreational vessels (0.01 incident per year).

Groundings. The River Pilots noted that there are few areas where waterway conditions create a substantial chance for a grounding to occur. Awareness of river conditions and timing vessel transits with tidal heights and currents allows the River Pilots to avoid hazardous conditions conducive to grounding. They also note that the nature of the river channel is such that there is a bank cushion effect that helps to keep vessels away from the channel edges.[41] (Amos pers. comm.) The vessel drafts assumed in the analysis and presented in Table 17 are representative of fully loaded vessels; the actual draft of any given transiting vessel would depend on the amount of cargo or ballast water onboard. Actual draft information is provided to pilots prior to transiting the Columbia River. As described in Section 2.2.6, *Vessel Traffic Management*, pilots make the final decisions for vessel movements and determine if the planned operation can be successfully completed. The Columbia River Pilots' Vessel Movement Guidelines (Columbia

[41] When the ship is near the bank, the water is forced between the narrowing gap between the ship's bow and the bank. This water tends to create a "cushion" that pushes the ship away from the bank.

River Pilots 2016) state, "vessels may be permitted to sail with the maximum freshwater draft of 43 feet if the river level, tide, and conditions permit." As stated in Section 2.2.6, *Vessel Traffic Management*, pilots operating draft-constrained vessels in the study area have to adjust the time of their transit to allow for at least 2 feet of underkeel clearance on the river plus expected squat to reduce the risk of groundings.

Fires, Explosions, and Other Emergencies. Equipment failure affecting power or steering while the vessel is underway could lead to loss of control of a vessel. A fire in the vessel's machinery spaces or accommodation areas is also a potential emergency scenario. For any of these situations the vessel master would do what is necessary to protect the safety of his crew first, and avoid damage to the vessel second. A prudent action would be to remove the vessel from the navigation channel to a safe haven, i.e., a location where appropriate actions can be taken by the vessel crew without compounding the emergency by involving another vessel or structure.

Safe haven opportunities on the river are minimal. Marine terminals at the port areas and designated anchorages are the only places where vessels can stop to manage an emergency. Two anchorages at Astoria can accommodate five deep-draft vessels, at most, depending on their sizes. There are no other anchorage areas until reaching Longview (past the project area). Once a loaded vessel gets underway inbound to or outbound from the Longview area, it is committed to completing the planned transit.[42]

Nothing prevents a vessel's master from anchoring anywhere in the river under emergency conditions; however, there is no way to predict how successful such an action might be in stopping the vessel. Anchoring effectiveness is dependent on factors such as the nature and condition of the waterway bottom, water depth, and vessel speed at the time of the anchoring. Risks include the potential for the anchor to damage the vessel if the water is not sufficiently deep. The vessel's location in or near the channel could also hamper or endanger other vessels depending on their locations at the time. Dropping an anchor or anchors in an attempt to stop a vessel would be done only if other control measures failed. Opportunities for these emergency measures would be discussed as part of the pretransit planning between the master and the pilot.

In an emergency, a vessel could anchor in the channel at some locations; however, that presents significant risks for the vessel with respect to the narrow channel and most likely would block virtually all other traffic. The likelihood of a vessel emergency causing a collision is low. Safe haven limitations (described above) mean that vessel transit would not begin until everyone involved is satisfied that the vessel is fully capable of completing the transit.

Although a vessel emergency increases the likelihood of indirect impacts on the Columbia River navigation channel, the likelihood of such an emergency occurring is minimal. As shown in Table 19, the likelihood of fires/explosions is substantially lower than any other type of incident considered in the risk assessment. If such an emergency were to occur, the presence of a qualified vessel master and the pilot, in addition to crew training, vessel design, and equipment would help minimize the harmful impact on human safety and the environment.

[42] A number of potential sites for additional anchorages are being discussed by the waterway stakeholders; however, they are generally shallow water sites. Reportedly, the discussions include the possibility of the Corps maintaining those areas as part of the federal channel project. Provision of additional stern buoys is also being considered.

Increased Risk of an Oil Spill during Transit or at Anchorages

An oil spill involving diesel or heavy fuel oil could occur as the result of an incident during transit or during bunkering transfers at locations other than the proposed docks. If an incident occurred that resulted in an impact, there is a possibility that a fuel tank could be damaged and fuel spilled. Oil spills could also occur during bunkering at anchorages within the study area. In general, the risks of spills would increase under the Proposed Action due to an increase in the number of vessels calling at the project area and the resultant increase to overall vessel traffic in the study area. To provide additional information about the relative likelihood of various sized oil spills, the risk assessment also quantitatively evaluated the incremental increase in risks of a spill (in the event of a collision or grounding) due to the Proposed Action.

Tables 20 and 21 present the likelihood (in terms of return periods[43]) of representative spill sizes that could occur as the result of the modeled increased risk of collisions or groundings, respectively.

Table 20. Example Bunker Oil Spill Volumes and Frequencies due to Collisions Related to the Proposed Action (2028 and 2038)

Return Period (years)[a]		
2028	2038	Oil Spill Volume (gallons)
341	224	20,900 or less
581	381	59,300 or less
676	444	107,400 or less
3,748	2,461	166,500 or less

Notes:
[a] Frequency of collisions in 2038 is higher compared to 2028 due to an increase in the overall vessel traffic in the study area.
Source: Appendix A, *Navigation Risk Study*

Table 21. Example Bunker Oil Spill Volumes and Frequencies due to Groundings Related to the Proposed Action (2028 and 2038)

Return Period (years)[a]	Oil Spill Volume (gallons)
140	5,700 or less
182	10,700 or less
403	39,700 or less
4,299	45,800 or less

Notes:
[a] Grounding frequencies do not vary from 2028 to 2038 since the number of project vessels remains at 840 in both years.
Source: Appendix A, *Navigation Risk Study*

As shown in the tables, the likelihood of bunker oil spills from a vessel incident is relatively low with the most likely scenarios occurring in the range of once every 244 years for collisions (2038 traffic levels) and once every 140 years for groundings (2028 or 2038 traffic levels). As noted in Section 2.2.8, *Marine Oil Spill Survey*, spills that have historically occurred in the study

[43] Estimated period of time between occurrences of an event.

area are much smaller than the quantities indicated in Tables 20 and 21 and have ranged from 0.1 gallon to 1,603 gallons.[44] The average number of oil spills within this same timeframe (2004 through 2014) is 15.6 spills per year with 84% having a volume of less than 10 gallons. Spills of more than 100 gallons have occurred at a frequency of 0.4 per year or once every 2.2 years. The average size of these relatively larger spills is approximately 630 gallons.

The reason that the potential spill sizes modeled for the Proposed Action are larger is because the spill scenarios presented above are associated with large-scale vessel incidents: collisions or groundings. For such an incident to result in a release of bunker oil, the energy involved in the initial incident must be great enough to puncture the vessel's tanks. Increases in the types of oil spills of a scale more similar to those that have occurred over the last 10 years would also be expected under the Proposed Action to be somewhat commensurate with the relative increase in vessel traffic. Expansion of the casualty survey to a longer (beyond 11 years) timeframe, would include more unlikely events of a larger scale more in line with those addressed by the incident modeling.

An amendment to the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex that went into force in 2007, included a new Annex I Regulation, 12A, on oil fuel tank protection. That regulation applies to any ship that has an aggregate oil fuel capacity of 785 cubic yards—3,774 barrels (158,508 gallons) of oil equivalent—or more and was contracted for on or after August 1, 2007; or had a keel laying date on or after February 1, 2008; or was delivered on or after August 1, 2010. The regulation limits an individual fuel tank to a maximum capacity limit of 3,270 cubic yards—15,725 barrels (660,450 gallons) —and includes requirements for the protected location of the fuel tanks and performance standards for accidental oil fuel outflow. It requires consideration of general safety aspects, including maintenance and inspection needs, when approving the vessel's design and construction. These improvements are intended to reduce the extent of releases in the event of a vessel incident.

Increased vessel traffic associated with the Proposed Action also has the potential to result in an increased risk of oil spills during bunkering activities. Causes of oil spills during bunkering transfers include overflow of the tank, parting the hose due to mooring fault, operator error in connecting the hose, failure of the hose or pipework, and failure of bunker tanks (HSE 2012). Experience from insurance claims (Gard 2002) is that most bunker spills result from an overflow of the bunker tank due to carelessness or negligence, either on the part of those supplying the bunkers, or those on board the vessel receiving them.

The main safeguards against the occurrence of bunker spills are use of bunkering best practices, including attentive tank-level monitoring and valve alignment, use of bunkering procedures and checklists, and supervision of the bunkering operation by a qualified person.[45] Standard/ABS (2012) lists the main features of such procedures.

The consequences of a spill of heavy fuel oil into the marine environment are, in general, considered more severe than for other fuels, although this may depend on the sensitivity of the

[44] The data presented in Section 2.2.8, *Marine Oil Spill Survey*, include all reported vessel-related spills from 2004 to 2014, not just those caused by vessel incidents such as groundings and collisions.

[45] *Bunkering Best Practices: A Reference Manual for Safe Bunkering Operations in Washington State* (Washington State Department of Ecology 2014) and Bunkering Guidelines in *Lower Columbia Region Harbor Safety Plan* (January 2013). These references provide extensive guidelines related to winds, sea states, mooring equipment, tug availability, and regulatory requirements to provide for safe, spill-free bunkering operations.

local environment to acute toxicity (DNV GL 2011). Undoubtedly, spills of heavy fuel oil will be more persistent, taking longer to weather naturally and being more difficult to clean-up. The average clean-up costs per metric ton of oil spilled have been estimated as more than 7 times higher for heavy fuel oil than for diesel (Etkin 2000).

There were nine oil spills during refueling of large cargo vessels in the study area from 2004 to 2014. Spills of oil cargoes are better documented than spills from bunkering. Therefore, previous risk analyses have assumed the frequency of spills during bunkering is the same as during transfer of liquid cargoes: 1.8×10^{-4} (one spill every 5,555 years) per bunkering operation for spills exceeding 1 metric ton (7.3 barrels or 308 gallons). The frequency of smaller spills is likely to be much greater. This implies that the annual likelihood depends on the number of bunkering operations. If the vessel bunkers 10 times per year, the likelihood of a spill of 1 metric ton or more would be 1.8×10^{-3} per year, or approximately 1 chance in 500 per year. Although it is not possible to predict the number of vessels that may bunker or where they would bunker, the risks of a spill during transfer would increase slightly due to the increase in vessel trips under the Proposed Action.

Increased Vessel Activity

Increased vessel traffic associated with the Proposed Action would also have the potential to result in other impacts from increased activity, vessel wake, propeller wash, underwater noise and vibration, and vessel emissions. The potential impacts on cultural resources, water quality, surface water and floodplains, vegetation, fish, and wildlife are addressed in the SEPA Water Quality Technical Report (ICF 2017a), SEPA Surface Water and Floodplains Technical Report (ICF 2017c), SEPA Vegetation Technical Report (ICF 2017d), SEPA Fish Technical Report (ICF 2017e), and SEPA Wildlife Technical Report (ICF 2017f), respectively. The magnitude of these vessel-related impacts would depend on a variety of interrelated factors, including but not limited to, the distance of the channel from the shoreline, depth of the intervening riverbed, placement and size of dredged materials, the presence of particularly sensitive species, the speed and size of the vessels, the prevailing river and tidal currents, and otherwise natural-occurring wave action. Many of these factors are regulated by the federal government, including dredging activities, the placement of dredged spoils, and vessel traffic management within the study area. In general, the increase in deep-draft vessels associated with the Proposed Action would result in the increased potential for vessel-related impacts to occur.

3.2 No-Action Alternative

Under the No-Action Alternative, the Applicant would not construct the coal export terminal, including Docks 2 and 3. Dock 1 would continue to be used for bulk cargo, primarily alumina, and could also be used for general cargo. The largest vessels currently calling at this facility are in the Handymax class, typically in the 35,000 deadweight tons range; however, the dock might be modified to accept somewhat larger Panamax-class vessels. The project area could be developed for other industrial uses, including an expanded bulk product terminal. The Applicant has indicated that, over the long term, it would expand the existing bulk product terminal and develop new facilities to handle more products such as calcined petroleum coke, coal tar pitch, and cement. No new docks would be built under the No-Action Alternative.

Table 22 describes the extent of these planned activities. When compared to the existing operations, this represents an additional 8 vessel calls (16 transits) per year.

Table 22. Planned Activities and Transport Operations at the Existing Bulk Product Terminal

Commodity	Vessel Class	Facility Activity	Vessel Activity (includes existing operations)
Alumina	Handymax	Vessels deliver alumina to Dock 1. Alumina is stored on site and then shipped to Chelan County by train.	8 ships/year
Other Commodities	Not provided	Other commodities that are assumed to be delivered by vessel, stored, and shipped via truck and train to various locations.	6 ships/year

Notes:
[a] See typical dimensions of a Handymax-class vessel in Table 6.
Source: URS Corporation 2014.

3.2.1.1 Potential Future Marine Terminal Activities

In addition to current and planned activities, the Applicant is considering the receipt and shipment of any products permitted by the terms of the Washington State Department of Natural Resources (DNR) lease,[46] including calcine pet coke, coal tar pitch, cement, fly ash, and sand (Table 23). Before the existing bulk product terminal could expand to accept additional products, it would need to obtain the necessary permit modifications or approvals. The following are estimates of the amount and method for transporting each of these commodities.

- Calcine pet coke would be imported by ship from Asia, unloaded from ships using a vacuum unloader, and stored in an existing on-site building. Approximately 600,000 tons of calcine pet coke per year could be imported.
- Coal tar pitch would arrive by ship via super-sacks, and unloaded from either vessel mounted unloading gear or new equipment. Approximately 200,000 tons of coal tar pitch per year could be imported.
- Cement would arrive by ship and be distributed either by rail or truck.
- Fly ash would come in by rail and depart by truck, or come in by truck and depart by rail.
- Sand or gravel would likely come in by rail and depart by truck, or come in by truck and depart by rail.

[46] Northwest Alloys holds a 30-year aquatic lease (20-B09222) with DNR allowing the use of DNR property for three ship docks. The lease expires on January 2, 2038. Per the DNR Lease Exhibit B Plan of Development, Operations and Maintenance Docks:

- The existing dock can be used for off-loading alumina ore from ships for transfer to railcar or trucks, off-loading cement for transfer to railcars and trucks, and off-loading any product that can be moved by vacuum including any type powder or granulated product.
- Two new fixed docks can be used for products not compatible with the existing system on Dock 1. The products would include coal, silica sand, dry fertilizer, potash, coke, cement clinker and other general bulk cargo.

Table 23. Potential Future Commodities Transported to Existing Site by Vessel

Commodity	Vessel Class	Facility Activity	Vessel Activity (includes existing operations)
Calcine pet coke Coal tar pitch Cement Fly ash Sand or gravel	Not provided	Ships deliver cargo over Dock 1; the cargo is temporarily stored and then shipped out by ground transport	10 to 12 additional ships/year

Notes:
Source: URS Corporation 2014.

3.2.1.2 Total Vessel Traffic

If all planned and potential activities are implemented, combined with existing storage and transport operations at the existing site, the vessel calls listed in Table 24 are anticipated by year 2020.

Table 24. Vessel Calls for Existing, Planned, and Potential Future Activities at Existing Bulk Product Terminal

Commodity	Vessel Class	Facility Activity	Vessel Activity (includes existing operations)
Existing, Planned, and Potential Future	Not provided	Ships deliver cargo over Dock 1; the cargo is temporarily stored and then shipped out by ground transport	26 vessels/year

Notes:
Source: URS Corporation 2014.

The No-Action Alternative would result in 26 vessel calls (54 transits) per year, an increase of 20 vessel calls (40 transits) over existing operations. In addition, vessel traffic in the study area in general would continue to increase over time with further industrial development along the river. As assumed for the incident modeling, large commercial vessel traffic would reach approximately 2,200 vessel calls (4,400 transits) per year by 2028. Therefore, there would be an increase in the number of incidents likely to occur compared to existing conditions unrelated to the Proposed Action.

Management of vessel traffic on the Lower Columbia River will be an ongoing concern for federal (USCG and Corps) and state (Ecology and ODEQ) agencies, local coastal jurisdictions, the Bar Pilots and River Pilots, maritime associations (such as PDXMEX and MFSA), and private interests. With or without the Proposed Action, vessel traffic volume is expected to be variable along the Lower Columbia River due to economic and market fluctuations, changes in port infrastructure, and vessel design modifications. The Columbia River VTIS and the Lower Columbia Region Harbor Safety Committee are both part of a system that adapts the processes currently in place in the Columbia

River to changes in the nature and the volume of vessel traffic.[47] These systems would continue to operate under the No-Action Alternative and help reduce the impacts related to the anticipated increases in vessel traffic in the Lower Columbia River.

[47] The Lower Columbia Region Harbor Safety Committee consists of federal, state, and local government representatives, port employees, vessel and facility operators, vessel agents, spill response cooperatives, and any other stakeholders that meet on a regular basis to exchange information, plan for contingencies, and review current operating procedures in light of any recent incidents. The *Lower Columbia Region Harbor Safety Plan* includes regularly revised guidelines on current traffic management practices and procedures for port users and is available via the Harbor Safety Committee's website (http://www.lcrhsc.org/).

Chapter 4
Required Permits

The Proposed Action would not require permits or approvals related to vessel transportation.

Chapter 5
References

5.1 Written References

Columbia River Inter-Tribal Fishing Commission. 2016. *The Tribes' Treaty Reserved Rights*. Available: http://plan.critfc.org/2013/spirit-of-the-salmon-plan/about-spirit-of-the-salmon/the-tribes-treaty-reserved-fishing-rights/. Accessed: January 6, 2016.

Columbia River Pilots. 2014. *Columbia River Pilots' Vessel Movement Guidelines*. March 18. Available: http://colrip.com/wp-content/uploads/2014/03/COLRIP_VMG_18March2014_FINAL.pdf

Columbia River Pilots. 2016. Vessel Movement Guidelines. December 15. Available: http://colrip.com/wp-content/uploads/2016/12/COLRIP_VMG_15Dec2016_FINAL.pdf.

Etkin, D.S. 2000. *Worldwide Analysis of Marine Oil Spill Cleanup Cost Factors*. Arctic and Marine Oil Spill Program Technical Seminar.

DNV GL. 2011. *Assessment of the Risk of Pollution from Marine Oil Spills in Australian Ports and Waters*. DNV Report PP002916 for Australian Maritime Safety Authority. Available: https://www.amsa.gov.au/forms-and-publications/environment/publications/Other-Reports/index.asp

DNV GL. 2016. Millennium Bulk Terminals Longview Project Navigation Risk Study. January. DNV GL Oil & Gas Risk Advisory Services, Katy, TX.

Gard. 2002. *Bunkers and bunkering - It's nothing to do with your golf swing*. Gard Insight 165. Available: http://www.gard.no/web/updates/content/53288/bunkers-and-bunkering-its-nothing-to-do-with-your-golf-swing.

Grette Associates, LLC. 2014. *Millennium Coal Export, Longview, WA*. Final. Wenatchee, WA. Prepared for Millennium Bulk Terminals – Longview, Longview, WA.

HSE. 2012. *Failure Rate and Event Data for use within Risk Assessments (28/06/2012*). Available: http://news.hse.gov.uk/2010/03/25/failure-rate-and-event-data-for-use-within-land-use-planning-risk-assessments/. Accessed: March 8, 2016.

ICF. 2017a. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Water Quality Technical Report*. April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF. 2017b. *Millennium Bulk Terminal—Longview, SEPA Environmental Impact Statement, SEPA Air Quality Technical Report.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF. 2017c. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Surface Water and Floodplains Technical Report*. April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF. 2017d. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Vegetation Technical Report.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF. 2017e. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Fish Technical Report.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF. 2017f. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Wildlife Technical Report.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

ICF and Wilson Ihrig. 2017. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Noise and Vibration Technical Report.* April. Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

INTERCARGO. 2015. Dry Bulk Trades. Available: http://www.intercargo.org/en/about-us/the-dry-cargo-industry/58-trades.html#industry-statistics. Last updated July 10. Accessed: January 16, 2016.

International Maritime Organization. 2015. *Ballast Water Management*. Available: http://www.imo.org/OurWork/Environment/BallastWaterManagement/Pages/Default.aspx. Accessed: March 23, 2015.

Lower Columbia Region Harbor Safety Committee. 2013. *Lower Columbia Region Harbor Safety Plan*. Available: http://lcrhsc.org/index.cfm?display=showcase&sub=c.

Maritime Fire & Safety Association. 2013. *MFSA Vessel Response Plan*. Available: http://www.mfsa.com/mfsa-vessel-response-plan. Accessed: January 29, 2016.

National Oceanic and Atmospheric Administration. 2009. Glossary <freshet>. Available: http://w1.weather.gov/glossary/index.php?letter=f. Accessed: January 8, 2016.

National Oceanic and Atmospheric Administration. 2014. *Coast Pilot 7, Pacific Coast: California, Oregon, Washington, Hawaii, and Pacific Islands*. 46th Edition.

National Oceanic and Atmospheric Administration – Northwest Fisheries Science Center (NOAA Fisheries). 2016. Nearshore Fixed Gear. Available: http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/nearshore_gear.cfm. Accessed January 14, 2016.

Northwest Area Committee. 2015. *Northwest Area Contingency Plan Section Columbia River's Marine Firefighting Contingency Plan*. Available: http://rrt10nwac.com/Files/NWACP/2016/Chapter%208000%20v17.pdf

Office of State Fire Marshal. 2015. *Oregon Fire Service Mobilization Plan*. 2015. Available: http://www.oregon.gov/osp/SFM/docs/2015MobPlan.pdf. Accessed: January 29, 2016.

Office of the State Fire Marshal, Washington State Patrol. 2015. *Washington State All Risk Services Resource Mobilization Plan*. Available: http://www.wsp.wa.gov/fire/docs/mobilization/mobeplan_cover_allsections.pdf. Accessed: January 29, 2016.

Oregon.gov. 2016. *OSMB Law Enforcement Program*. Available: http://www.oregon.gov/OSMB/BoatLaws/pages/leprogram.aspx. Accessed: January 19, 2016.

Oregon Department of Fish and Wildlife. 2015a. *Columbia River Commercial Fishery Below Bonneville Dam – Commercial Fishing Area and Gear Restrictions*. Oregon Administrative Rules – Division 042. Available: http://www.dfw.state.or.us/OARs/42.pdf. Accessed: December 31, 2015.

Oregon Department of Fish and Wildlife. 2015b. *2015 Summary of Lower Columbia River Commercial Landings*. Available: http://www.dfw.state.or.us/fish/OSCRP/CRM/landings/15/2015_Year_End_Col_R_Landings_TABLE_22_HANDOUT.pdf. Accessed: January 6, 2016.

Oregon Department of Fish and Wildlife. 2015c. *Oregon's Ocean Commercial Fisheries*. Available: http://www.dfw.state.or.us/MRP/docs/Backgrounder_Comm_Fishing.pdf. Accessed: January 15, 2016.

Oregon Department of Fish and Wildlife. 2016. *Mainstream Commercial Fishing Zones Map and Descriptions*. Available: http://www.dfw.state.or.us/OARs/42.pdf. Accessed: January 6, 2016.

Oregon Dungeness Crab Commission. 2014. *The Fishery*. Available: http://oregondungeness.org/general-info/the-fishery/. Accessed: January 14, 2016.

Pacific Fishery Management Council. 2008. *Pacific Coast Groundfish Plan*. Available: http://www.pcouncil.org/wp-content/uploads/fmpthru19.pdf. Accessed: January 15, 2016.

Pacific Fishery Management Council. 2014. *Pacific Coast Salmon Fishery Management Plan*. Available: http://www.pcouncil.org/wp-content/uploads/FMP_through_A-18_Final.pdf. Accessed: January 15, 2016.

Port of Kalama. 2015. Facts and Figures. Available: http://portofkalama.com/media-center/facts-and-figures. Accessed: February 18, 2016.

Port of Portland. 2010. *Recreation Participation, Development Potential, and Current Value on and Around West Hayden Island*. Available: https://www.portlandoregon.gov/bps/article/303415). Accessed: January 7, 2016.

State of Oregon. 2016. *Boating Access Sites in Oregon - Columbia River Boat Ramps*. Available: https://data.oregon.gov/Recreation/Columbia-River-Boat-Ramps/368p-69z5. Accessed: January 7, 2016.

URS Corporation. 2014. *Traffic and Transportation Resource Report*. Seattle, WA. Prepared for: Millennium Coal Export Terminal Longview, Washington.

U.S. Army Corps of Engineers. 2003. *Columbia River Channel Improvement Project Final Supplemental Integrated Feasibility Report and Environmental Impact Statement*. Portland, OR.

U.S. Army Corps of Engineers, Portland District. 2014. *Columbia River Federal Navigation Channel Operations and Maintenance Dredging and Dredged Material Placement Network Update, River Miles 3 to 106.5, Washington and Oregon.* Available: http://www.nwp.usace.army.mil/Portals/24/docs/announcements/EA/Draft_EA_2Apr2014_CR-FNC.pdf. Accessed: April 7, 2015.

U. S. Army Corps of Engineers, Portland District. 2015a. *Building Strong at the Columbia and Lower Willamette Rivers Project.* Available:

http://www.nwp.usace.army.mil/Missions/Navigation/Channels/ColumbiaLWillamette.aspx. Accessed: March 23, 2015.

U.S. Army Corps of Engineers, Portland District. 2015b. *Building Strong at the Mouth of the Columbia River*. Available: http://www.nwp.usace.army.mil/Locations/OregonCoast/MouthoftheColumbia.aspx. Accessed: March 23, 2015.

U.S. Army Corps of Engineers, Portland District. 2015c. *Columbia and Lower Willamette Rivers Project*. Available: http://www.nwp.usace.army.mil/Missions/Navigation/Channels/ColumbiaLWillamette.aspx. Accessed: March 31, 2015.

U.S. Army Corps of Engineers, Portland District. 2015d. *Permit regulations*. Available: http://www.nwp.usace.army.mil/Missions/Regulatory/Apply.aspx. Accessed: April 9, 2015.

U.S. Coast Guard. 2014a. Marine Information for Safety and Law Enforcement (MISLE) database.

U.S. Coast Guard. 2014b. Commandant Publication 16721. Navigation and Vessel Inspection Circular No. 08-14. *Guidelines for Qualification for STCW Endorsements in Basic Training (Formerly Basic Safety Training)*. Available: http://www.uscg.mil/nmc/regulations/NVIC/NVIC_2014/nvic.asp. Accessed: January 17, 2014.

U.S. Geological Survey. 2014. USGS 14246900. Columbia River at Beaver Army Terminal near Quincy, OR. Available: http://wdr.water.usgs.gov/wy2013/pdfs/14246900.2013.pdf?1423677243767.

Washington Department of Fish and Wildlife. 2016a. *Commercial Dungeness Crab Fishery*. Available: http://wdfw.wa.gov/fishing/commercial/crab/. Accessed: January 14, 2016.

Washington Department of Fish and Wildlife. 2016b. *Coastal Commercial Pink Shrimp Fishery*. Available: http://wdfw.wa.gov/fishing/commercial/shrimp.

Washington Department of Fish and Wildlife. 2016c. *Water Access Sites – Columbia River*. Available: http://wdfw.wa.gov/lands/water_access/search/search.php?searchby=simple&search=Columbia+River&Submit=Search. Accessed: January 7, 2016.

Washington Department of Fish and Wildlife. 2016d. *Recreational Salmon Fishing, When & Where to Fish for Salmon*. Available: http://wdfw.wa.gov/fishing/salmon/whenwhere/month.html. Accessed: January 15, 2016.

Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. January 21. Joint Columbia River Management Staff.

Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. 2015b. 2015 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. January 21. Joint Columbia River Management Staff.

Washington Public Ports Association. 2016. *Port Directory*. Available: http://washingtonports.org/washington-ports/port-directory/. Accessed: January 7, 2016.

Washington State Department of Ecology. 2014. *Federal Permits Home: 401 Water Quality Certification*. Available: http://www.ecy.wa.gov/Programs/sea/fed-permit/index.html#What_is_a_401_Water_Quality_Certification. Accessed: April 9, 2015.

Washington State Department of Ecology. 2015. *Vessel Entries and Transits (VEAT) Counts for Washington Waters by Calendar Year*. Available: http://www.ecy.wa.gov/programs/spills/publications/publications.htm. Accessed: April 7, 2015.

5.2 Personal Communications

Amos, Paul, Captain. President. Columbia River Pilots, Portland, OR. October 17, 2014—Meeting with Captain Tom Rodino (retired) and Larry Daggett, Rodino, Inc., regarding River Pilots' procedures for vessel transits on Columbia River including cooperative relationship with Bar Pilots, size of work force, and vessel sizes that are normally piloted by River Pilots..

Gill, Rick, Captain. Vice-President. Columbia River Pilots, Portland, OR. April 3, 2015—Telephone call with Captain Tom Rodino (retired), Rodino, Inc., regarding vessel docking and undocking operations/practices at Longview.

Hendriksen, Lisa. Director of Planning & Environmental Services. Port of Longview, Longview, WA. January 14, 2016—Email to Alex Bartlett, ICF, Denver, CO, regarding recent port activity.

Jordan, Captain Dan [A]. President. Columbia River Bar Pilots. February 2, 2015—Email to Captain Tom Rodino (retired), Rodino, Inc., containing Bar Pilot data on vessel transits by vessel type for the years 2004 to 2014.

Jordan, Captain Dan [B]. President. Columbia River Bar Pilots. October 15, 2014—Meeting with Captain Tom Rodino (retired) and Larry Daggett, Rodino, Inc., regarding Bar Pilots procedures, river conditions considered for vessel transits, and other vessel transit considerations for the Columbia River Bar.

Krug, Jeff, General Manager of Marine Operations, and Fred Myer, Senior Waterways Planner, Port of Portland. October 15, 2014—Meeting with Captain Tom Rodino (retired) and Larry Daggett, Rodino, Inc., regarding Port of Portland vessel operations and the Columbia River Shipping Channel Reporting and Forecasting System, LOADMAX.

McGrath, Matt. Operations Manager. Port of Astoria, Astoria, OR. January 26, 2016—Email to Alex Bartlett, ICF, Denver, CO, regarding recent port activity.

Myer, Fred. Port of Portland. January 26, 2016—Email to Alex Bartlett, ICF, Denver, CO, regarding recent port activity.

Rich, Rob. Vice-President, Marine Services. Shaver Transportation Company, Portland, OR. October 17, 2014—In-person meeting with Captain Tom Rodino (retired), Rodino, Inc.

Uglum, Lars. Operations Superintendent. Port of Vancouver, Vancouver, WA. January 14, 2016—Email to Alex Bartlett, ICF, Denver, CO, regarding recent port activity.

Appendix A

Navigation Risk Study

MILLENNIUM BULK TERMINALS LONGVIEW (MBTL) PROJECT

Navigation Risk Study

ICF Jones & Stokes, Inc.

Report No.: PP141993-2, Rev. 1
Document No.: PP141993-2
Date: January 19, 2016

Project name:	Millennium Bulk Terminals Longview (MBTL) Project	DNV GL Oil & Gas
Report title:	Navigation Risk Study	Risk Advisory Services
Customer:	ICF Jones & Stokes, Inc., 630 K. Street, Suite 400, Sacramento, CA 95814	1400 Ravello Drive Katy, TX
Contact person:	Linda Amato	77449
Date of issue:	January 19, 2016	USA
Project No.:	PP141993	Tel: +1 281 396 1000
Organization unit:	Environmental & Navigational Risk	[Company Reg No]
Report No.:	PP141993-2, Rev. 1	
Document No.:	PP141993-2	

Applicable contract(s) governing the provision of this Report:

Objective:

Prepared by:	Verified by:	Approved by:
Mia Matuszak Consultant	Frederico Allevato Senior Consultant	Cheryl Stahl Deputy Head of Section
Danielle Holden Consultant	Dennis O'Mara Principal Consultant	
Vincent Demay Consultant		

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Keywords:
Navigation study, navigation incidents, incident frequency, MARCS, bunker spills, spill frequency, spill consequence, hazard zones, pool fires, PHAST.

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
0	2015-12-21	First issue	MMATU	FALL	CSTAHL
1	2016-01-19	Second issue	MMATU	FALL	CSTAHL

Table of contents

1 EXECUTIVE SUMMARY

DNV GL was hired as subcontractor to ICF International who was tasked by Cowlitz County, the Washington State Department of Ecology, and the U.S. Army Corps of Engineers to estimate the impact of the proposed Millennium Bulk Terminals—Longview project—a coal export terminal in Cowlitz County, Washington, along the Columbia River—on navigational safety, marine incident and oil spill risk in the Lower Columbia River. There would be 840 vessel calls to the terminal per year with 80% being Panamax class bulk carriers and 20% being Handymax class bulk carriers.

The study addresses impacts incrementally over a 24-year period (Base Case in 2014, Project Impact in 2028 and Cumulative Impact in 2038) in order to understand the contribution of the proposed project to future navigation safety. The study area for this study includes the waterways that would be used by or could be affected by vessels calling at the project sites. It includes the waters out to 3 nautical miles seaward of the mouth of the Columbia River, the Columbia River Bar, and the Columbia River upstream to Vancouver, Washington.

DNV GL's proprietary model, Marine Accident Risk Calculation (MARCS) was used to estimate navigation incident frequencies and bunker spill frequencies of project vessels and other vessel traffic; and the Naval Architecture Package (NAPA) was used to estimate the conditional probabilities of bunker oil spill volumes for project vessels. A survey of marine incident data was also performed in order to establish a severity distribution for marine incident outcomes. Finally, further data analysis was performed to measure the incremental impact of the proposed project on navigational safety.

MARCS combines processed AIS data for vessel traffic (e.g., vessel types, sizes, routes, and transit frequencies), the marine environment (e.g., location of shallow water, visibility data, and wind data) and operational aspects of shipping (e.g., pilotage, escort tugs) to predict the frequency of incidents at sea, including:

- Collision
- Allision
- Drift grounding
- Powered grounding
- Fire / Explosion

Collisions generally occur in the navigable part of the channel where the traffic is most dense. Drift and powered groundings occur near the shoreline or in shallow waters.

Preliminary MARCS and NAPA results were presented in a stakeholder workshop with DNV GL, ICF International, Washington State Department of Ecology (Ecology), Cowlitz County, U.S. Environmental Protection Agency (EPA), U.S. Coast Guard (USCG), and the U.S. Army Corp of Engineers Sector Columbia River (USACE) on November 9, 2015.

1.1 Incremental Contribution to Marine Incidents

The total incremental incident frequency due to proposed project in 2028 is 1.5 incidents per year which equates to an 8% increase over the no-action scenario in 2028. Of these 1.6 incidents, 0.8 are powered groundings, 0.34 are drift groundings, 0.38 are collisions and 0.03 are allisions.

The total incremental incident frequency due to proposed project in 2038 is 1.6 incidents per year which equates to a 6% increase over the no-action scenario in 2038. Of these 1.7 incidents, 0.8 are powered groundings, 0.34 are drift groundings, 0.47 are collisions and 0.04 are allisions.

In order to provide context around the consequences of a collision, grounding or allision incident, a survey of USCG Marine Information for Safety and Law Enforcement (MISLE) database was conducted for years 2001 to 2014. For the purposes of this study, the various categories used to describe incident severity for each reported incident were aggregated into “Total Loss”, “Damage” and “No Damage”. The data coverage period of 2001 to 2014 was chosen, as it covers over 99% of all reported collision, grounding, and allision incidents in the dataset. Data surveys were conducted for the national dataset and for the study area separately in order to test for differences in the distribution of incident severity between the two. Survey findings show that for a given incident type, the severity distributions were very similar for national incident data compared to Lower Columbia River incident data.

Using the results of the data survey, we can therefore comment on the likely severity of the incremental contribution of marine incidents contributed by the project.

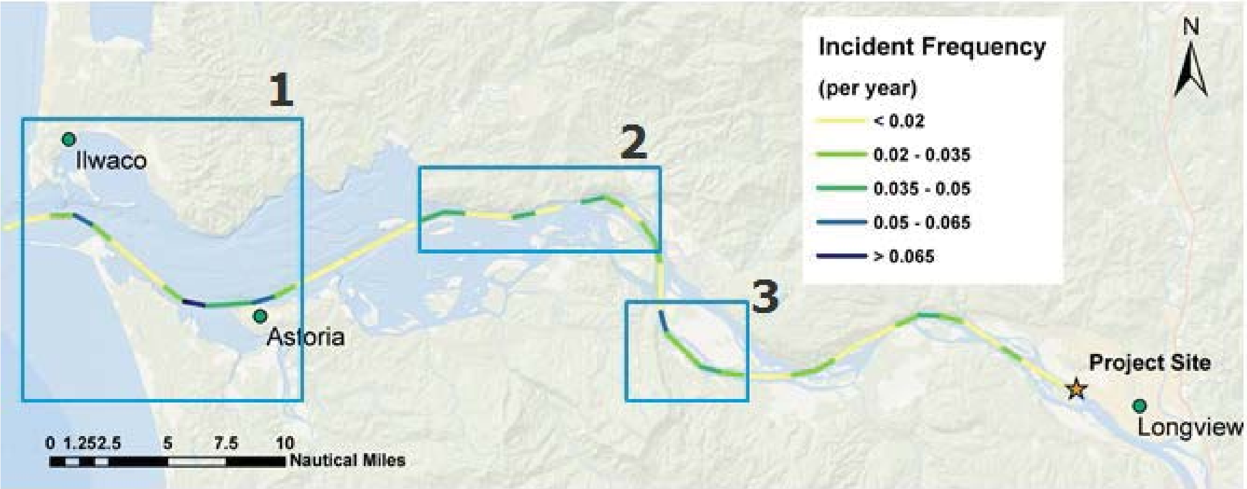
- Based on a survey of historical incident severity, 1-2% of the grounding events contributed by the project are likely to result in a total loss of the vessel, 21-24% are likely to result in damage to vessel and 74-78% are likely to result in no reported damage. Note: None of the total loss events reported due to grounding involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a grounding event were passenger vessels.
- Based on a survey of historical incident severity, 3-5% of the collision events contributed by the project are likely to result in a total loss of one or more vessels, 47-53% are likely to result in damage to one more vessels and 44-47% are likely to result in no reported damage.
  Note: None of the total loss events reported due to collision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a collision event were recreational vessels.
- Based on a survey of historical incident severity, 1-5% of the allision events surveyed resulted in a total loss of the vessel, 43-45% resulted in vessel damage and 52-54% resulted in no reported damage.
  Note: None of the total loss events reported due to allision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in an allision event were fishing vessels.

Assuming the distributions described above, the project would contribute to an incident resulting in the total loss of a vessel roughly once every 30 years, incidents resulting in reportable damage once every 2 years and approximately 1 incident per year resulting in no damage.

The incremental contribution appears to decrease from 2028 (8%) to 2038 (6%) because non-project vessel traffic continues to increase over this ten-year time period while the number of project vessels remains constant at 840 per year. Therefore the relative contribution in 2038 is lower because project vessels make up a smaller portion of overall vessel traffic.

Figure 1-1 below presents marine incident frequencies for project vessels in 2028 and 2038 along the proposed route. Notes explaining primary drivers are provided.

Figure 1-1 Incident Frequency – 2028 & 2038 With-Project



1) River Mile (RM) 2-14: Primary Driver of increased incident frequency is Powered Grounding but this area also contributes the highest collision frequencies of the study area.
2) RM 22-33 & 3) RM 36-40: Primary Driver of increased incident frequency is Powered Grounding. No variation was found in grounding frequency between 2028 and 2038 as number of project vessels remains constant.

1.2 Incremental Contribution to Oil Spill Risk

Less than 1% of the collision, grounding and allision incidents involving project vessels are expected to result in a bunker oil spill. As a result, the frequency of a bunker spill of any size due to a marine incident involving a project vessel is estimated to be 1.02×10^{-2} in 2028 and 1.17×10^{-2} in 2038. This equates to roughly one spill (of any size) every 98 years in 2028 and one spill (of any size) every 85 years in 2038. Based on a survey of oil spill data from 2004 to 2014, the Lower Columbia River has experienced a spill of greater than 100 gallons approximately once every 2.2 years. Therefore, the proposed project would increase the frequency of a spill greater than 100 gallons by approximately 2 to 3% to approximately once in every 2.15 years.

In the event that a collision or grounding event resulted in a bunker oil spill, the smallest estimated bunker oil spill volume from a project vessel would be roughly 20 m^3 for grounding and 80 m^3 for collisions (5,700 and 20,900 gallons, respectively). The frequency of various bunker oil spill sizes is provided in Table 1-1 for grounding scenarios. Since the number of project vessels does not change between 2028 and 2038, frequencies are the same in both years. The frequency of various bunker oil spill sizes is provided in Table 1-2 and Table 1-3 for collision scenarios. Since the number of non-project vessels increases between 2028 and 2038, collision frequencies vary across those years. It is important to note that this study did not assess the risk of small spills due to activities such as bunkering, damage to the environment and other causes unrelated to navigational incidents.

Table 1-1 Example Bunker Oil Spill Volumes & Frequencies due to Grounding (2028/2038)

Return Period (Years)	Spill Volume (gal)
140	5,700 or less
182	10,700 or less
403	39,700 or less
4,299	45,800 or less

Table 1-2 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2028)

Return Period (Years)	Spill Volume (gal)
341	20,900 or less
581	59,300 or less
676	107,400 or less
3,748	166,500 or less

Table 1-3 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2038)

Return Period (Years)	Spill Volume (gal)
224	20,900 or less
381	59,300 or less
444	107,400 or less
2,461	166,500 or less

2 INTRODUCTION

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Longview, WA along the Lower Columbia River. The terminal would receive coal via rail shipment, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean. There would be 840 vessel calls to the terminal per annum; 80% of vessels calling the terminal would be Panamax class bulk carriers and 20% would be Handymax class bulk carriers.

DNV GL was tasked to estimate the impact of the proposed project and associated increases in vessel calls on navigation safety on the Columbia River. DNV GL's study estimates the impact of the proposed project to other vessel traffic from the precautionary zone in the Pacific Ocean to the proposed terminal facility. The study addresses impacts incrementally over a 24-year period (Base Case in 2014, Project Impact in 2028 and Cumulative Impact in 2038) to understand future trends in navigation safety. DNV GL's findings will supplement the environmental impact statement (EIS) for the proposed project, and is expected to address public concerns regarding navigation safety.

2.1 Stated Objectives

The primary objective of this study is to quantify the incremental risk in 2028 and 2038 posed by project vessels to other vessel traffic on the river in terms of the increased likelihood of any incident. The secondary objective was to provide additional information about the potential consequences of these incidents, more specifically, qualification of the magnitude or severity of potential outcomes using 1. Comparisons to historical data and 2. Modeling likelihood for different bunker oil release volumes. To achieve these objectives the following four questions are addressed:

1. Could there be an incident?
2. If so, how severe would the incident be?
3. Could the incident result in a release of bunker oil?
4. If so, how much bunker oil would be released?

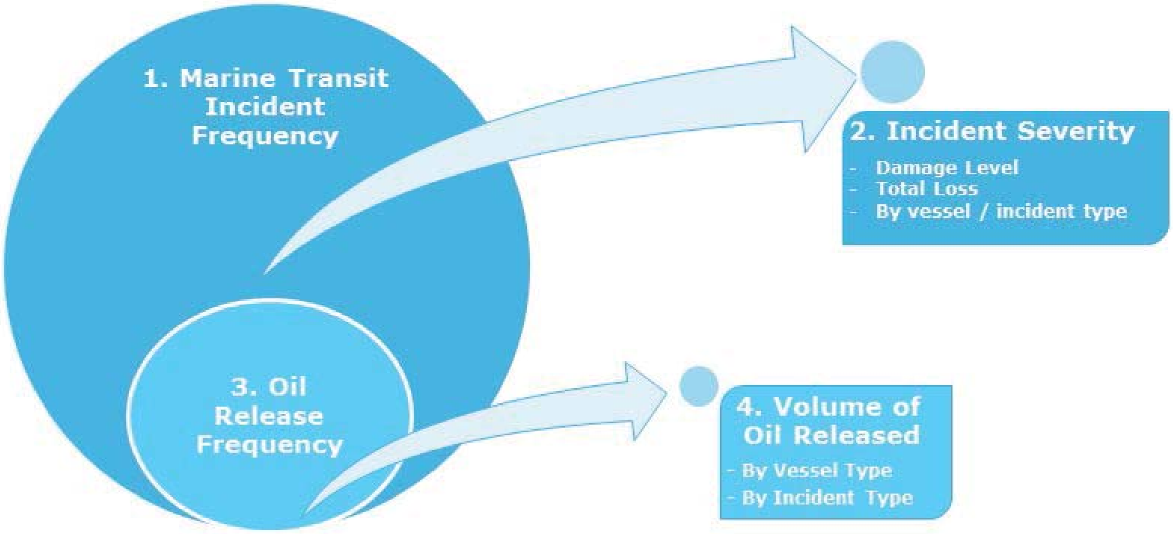


Figure 2-1 Navigational Risk Study Objectives

To achieve these goals, the following modeling outputs were obtained from this navigational risk study:

1. The incremental difference of navigation incident frequencies of project and non-project vessels in traffic conditions with and without proposed project are estimated for years 2028 and 2038.
2. A distribution of incident severity is developed based on a survey of historical marine incident data.
3. Bunker spill frequencies contributed by project vessels at full build-out in 2028 and 2038.
4. Conditional probabilities of bunker spill volumes contributed by project vessels at full build-out in 2028 and 2038.

2.2 Study Area

The study area for this study includes the waterways that would be used by or could be affected by vessels calling at the project sites. It includes the waters out to 3 nautical miles seaward of the mouth of the Columbia River, the Columbia River Bar, and the Columbia River upstream to Vancouver, Washington.

3 DESCRIPTION OF VESSEL TRAFFIC

This section describes the AIS data and assumptions related to vessels and vessel traffic that are applied in the study.

3.1 Project Vessel Specifications and Number of Transits

Two design vessels have been chosen to represent an average sized Panamax class vessel and an average sized Handymax class vessel.

The design vessels chosen to represent the Panamax class and the Handymax class are the MP Panamax 6 and the Advance II, respectively. The vessels' specifications are outlined in Table 3-1(Ref. /1/, /2/)

Table 3-1 Vessels' Specifications (Ref. /1/)

	MP Panamax 6	Advance II
Deadweight Tonnage (DWT)	68,541 tons	46,101 tons
Gross Tonnage (GT)	36,097 tons	30,032 tons
Length Overall (LOA)	225.0 meters	183.0 meters
Length Between Perpendiculars (LBP)	216.0 meters	173.9 meters
Breadth (B)	32.2 meters	32.3 meters
Draught (D)	13.3 meters	11.0 meters

It is expected that the proposed project would result in 672 Panamax vessels per year and 168 Handymax vessels per year in 2028 and 2038, for a total of 840 MBTL vessel calls a year.

Results will be presented as total incident frequencies for all project vessel calls and will not differentiate between Handymax and Panamax vessels.

3.1.1 Bunker Oil Capacity

For the purposes of estimating potential bunker spill volumes, bunker oil capacity and bunker tank locations from a typical Panamax class vessel are assumed.

Figure 3-1 shows the locations of the bunker oil / heavy fuel oil (HFO) tanks for a typical Panamax class vessel (shown in red at the stern of the vessel). Based on a review of DNV GL-classed Panamax-class carriers, the typical Bunker Oil capacity for these vessels is assumed to between 2400 and 2500 m^3.

Figure 3-1 Bunker Oil / HFO tank locations for typical Panamax class carrier

3.2 Use of AIS 2014 Data

The MARCS model (described in detail in Section 4) for this study requires Automatic Identification System (AIS) data for the area around the terminal and shipping routes. Tracks are created from the AIS data points and are used to establish vessel traffic patterns and densities within the study area.

Figure 3-2 presents the general methodology used to treat the AIS dataset. Once the data for a full calendar year is received, it is then plotted geospatially in a geographic information system (GIS). The dataset was plotted as individual points for each data entry in the study area. From the plotted dataset, the vessel density, speed and traffic patterns are determined for analysis and use in the MARCS model.

To determine the traffic density, the AIS dataset was translated into the number of AIS points per grid cell (0.005 x 0.005 decimal degrees), which is interpreted as vessel density. The vessel density was not used as input into the MARCS model, but as a method of understanding vessel behavior in the study area. A vessel density ‘heat’ map was created for the overall traffic and each defined vessel category used in MARCS.

Speed profiles were created to determine the vessel category speeds to be used as an input to the MARCS model. The timestamp in the AIS data for a single vessel is used to determine the speed of the vessel when travelling between two given AIS data entries. An average speed for each vessel category at a given location is applied in MARCS. A map of the varying speeds along the route was created for each vessel category.

The entries of each vessel in the AIS dataset are linked throughout the study area based on the location and time stamp to create vessel tracks. The tracks present the general traffic patterns and route in the study area. To input the information into the MARCS model, it is necessary to consolidate the vessel tracks into the main traffic routes for the study area. The vessel frequency for each vessel type travelling along (co-flow and counter flow traffic) the defined main traffic route is inputted into the model. A vessel track frequency is included in the count of a given route if it is within a 27°degree angle of the defined main traffic route. The vast majority of vessel tracks are captured on one of the defined main routes. This method allows for the large amount of AIS dataset to be accurately and efficiently utilized in the MARCS model.

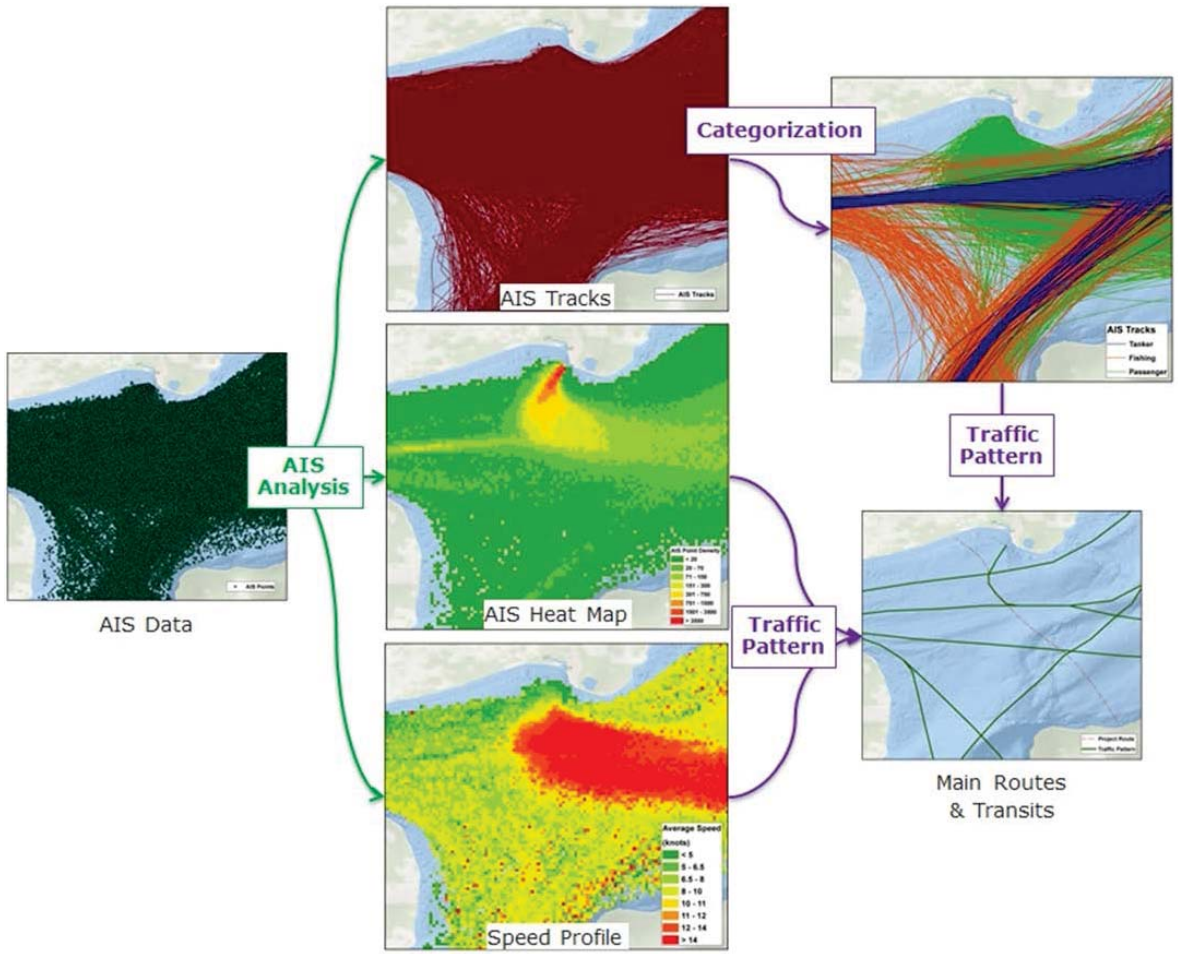


Figure 3-2 AIS Data Treatment Methodology

The AIS dataset, presented in Figure 3-3, was obtained from Merchants Exchange in Portland, OR. The period of coverage for the AIS data is from ‘2014-01-1 00:00’ to ‘2014-12-31 23:59’ (Ref. /3/).

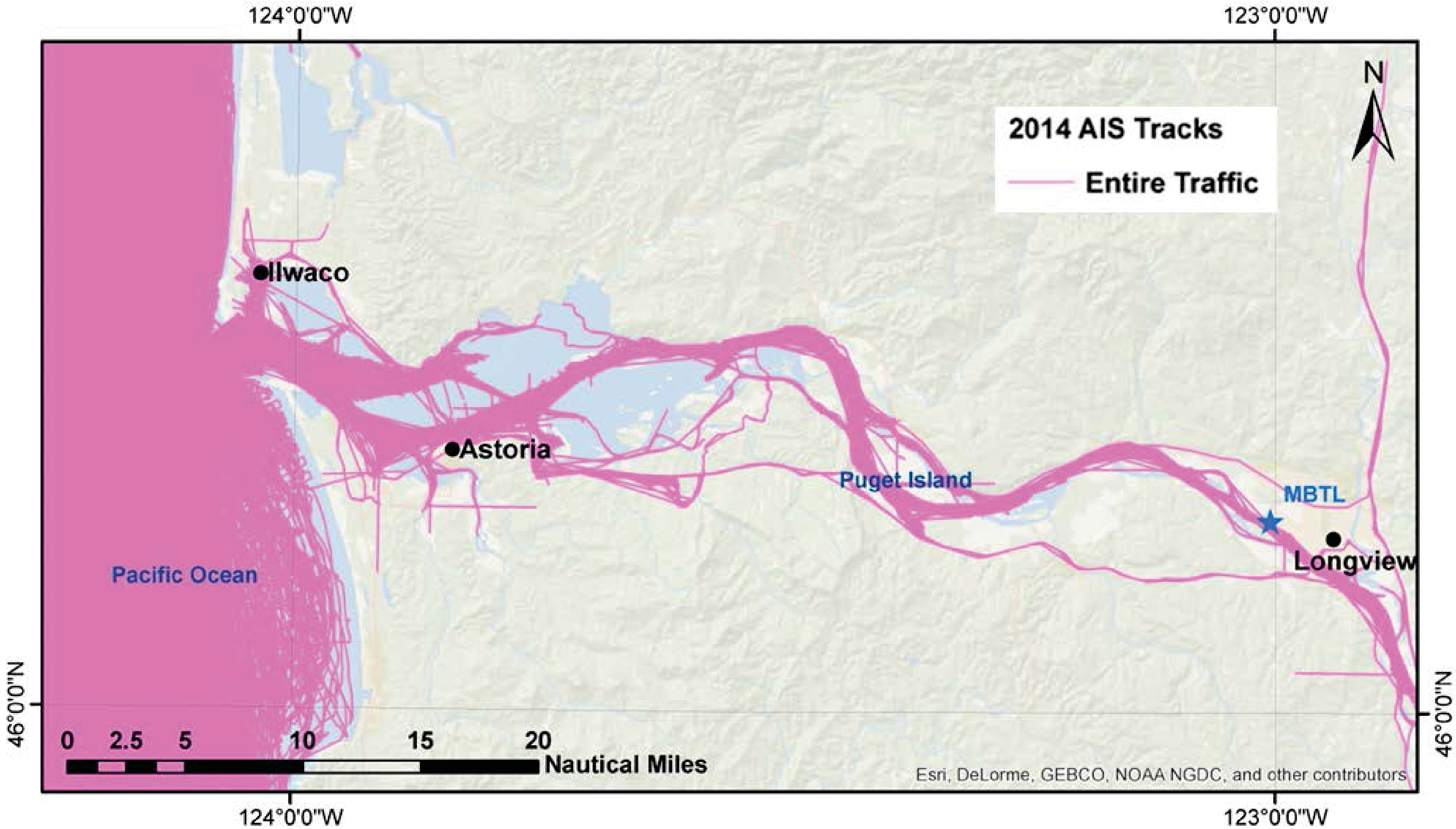


Figure 3-3 2014 AIS Tracks for All Transits

Figure 3-4 provides a close-up of the project vessel route and AIS tracks near the proposed terminal location.

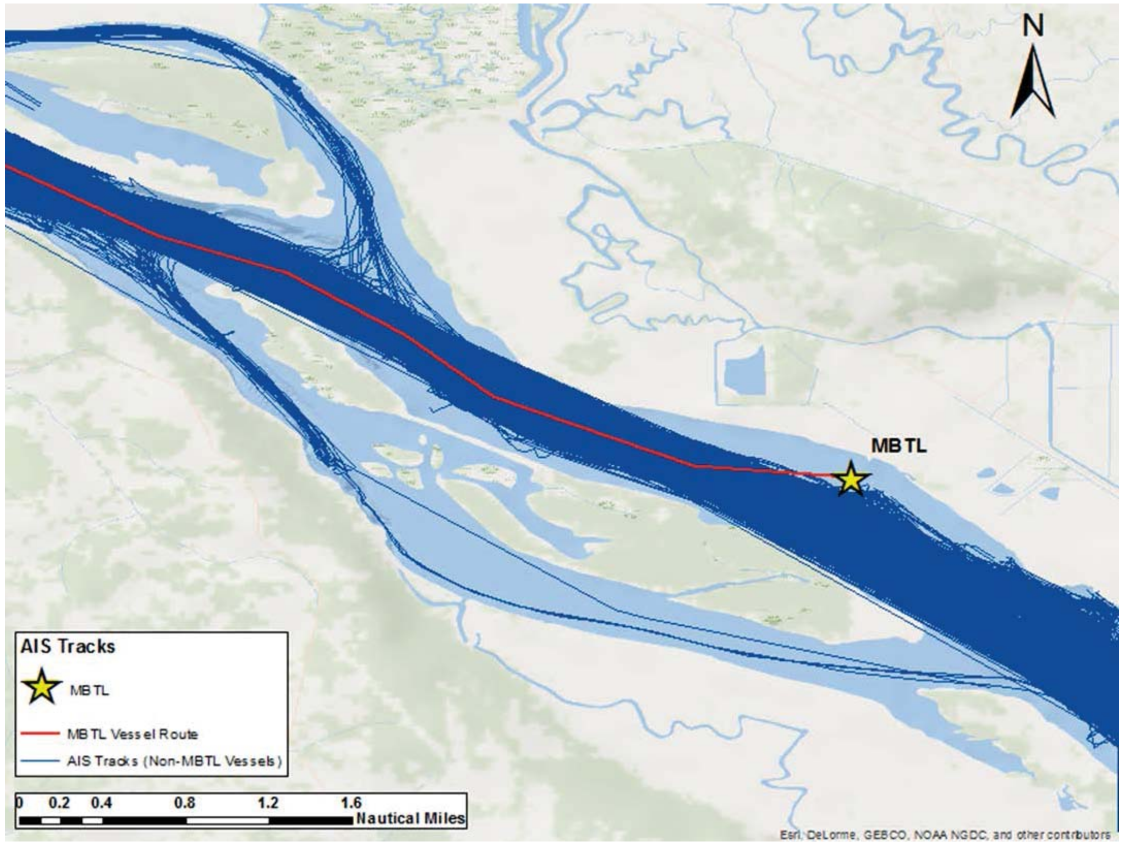


Figure 3-4 AIS Tracks near Project Location

3.3 Vessel Type Categories

The vessel categories are used to group AIS descriptors together in categories. Each category of vessels has a common specified average speed, average size (DWT, LOA, and B) and set of risk reductions that are applied to each vessel. The average speed and size of vessel categories are derived from the AIS data.

3.3.1 Vessel Type Descriptions

The marine traffic risk assessment used AIS data to characterize vessel traffic. Vessel categories used in the navigational risk model included:

- Cargo/Carrier
- Passenger
- Service
- Tug
- Fishing
- Pleasure
- Tanker
- Other
- Undefined

Table 3-2 provides a summary description of the typical vessel types operating on the Columbia River that correspond to the AIS vessel types used in the marine traffic risk assessment. A description of the information found in each column of Table 3-2 is summarized below.

- Vessel Category: Grouping of vessel types from the AIS Data. These are grouped by commonalities in function/service as well as vessel dimensions.
- AIS Vessel Types: Vessel categories extracted directly from AIS data which are then grouped into the “Vessel Category” field.
- Service Description: Functions and operations typical to each vessel category.
- Vessel Specifications: typical vessel dimensions including length, beam, draft and Dead Weight Tonnage (DWT)
- Image: Photograph of a typical vessel from each category.

Table 3-2 Typical Vessel Types Operating on the Columbia River

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Cargo/ Carrier	Bulk carriers, container ships, general cargo ships, automobile carriers, timber carriers	Cargo/carrier vessels include a wide range of vessels commonly seen on the Columbia River carrying forest products; steel, ore, grain, potash, and other dry bulk cargoes; general cargo; containerships; and automobiles.	Bulk Carriers (may include bulk, timber, general cargo): DWT: 50,000 - 80,000, Length: 650 - 965 ft Beam: 100- 106 ft Draft: 33 - 39.5 ft Car Carriers: DWT: 18,638 Length 650 ft Beam: 105 ft Draft: 27 ft	 Example of a Bulk Carrier  Example of Car Carrier[1]

[1] Marine Traffic. *Photos of PASSERO (MMSI: 236111887).* Available at: http://www.marinetraffic.com/en/photos/of/ships/shipid:204314/shipname:PASSERO/#forward

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
			Container ships: DWT: 57,088 Length: 260 ft Beam: 33 ft Draft: 12.5	 Example of Containership[2]
Tanker	LPG tankers, oil tankers, chemical tankers	Carriage of bulk liquid or gas petroleum, hydrocarbon or chemical products	DWT: 65,000 – 80,000 Length: 965 ft Beam: 106 ft Draft: 41 ft	 Example of an oil tanker

[2] Marine Traffic. *Photos of HORIZON SPIRIT (MMSI: 366629000)*. Available at: http://www.marinetraffic.com/en/photos/of/ships/shipid:426112/shipname:HORIZON%20SPIRIT/mmsi:366629000

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Tug	General tugs, towing vessels, , towing long and wide	All tugs are included in this category, regardless of their service or configuration of tow (e.g., towing, pushing, ATB). This category also includes barges attached to tugs.	Tugs: Length: 50 ft – 150 ft Beam: 26 ft – 35 ft Draft: 9 ft – 16 ft	 Example of a general tug[3]
Fishing	Trawlers, all commercial and recreational fishing vessels	This category includes all commercial and fishing vessels.	Length: 100 – 180 ft Beam: 25 – 45 ft Draft:: 9 – 15 ft	 Example of a fishing vessel[4]

[3] Marine Traffic. *Photos of STACY T (MMSI: 367516730)*. Available at: http://www.marinetraffic.com/en/photos/of/ships/shipid:448629/#forward
[4] Vessel Finder. *JOYCE MARIE – Fishing Vessel*. Available at : https://www.vesselfinder.com/vessels/ship-photo/0-367406690-99eacfaa3613eade55f4610e76c36c78/1

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Service	Military, law enforcement, search and rescue vessels, pilot vessels, pollution control vessels	U.S. Coast Guard vessels are captured in AIS as either Military, Law Enforcement, or SAR vessels.	Coast Guard vessels range in length from 22 ft to over 300 ft.	 Example of U.S. Coast Guard Search and Rescue vessel
		Pilot vessels are vessels whose specific function is the transport of pilots to/from vessels subject to pilotage.	Length: 72 ft Beam: 20 ft	 Pilot Vessel COLUMBIA[5]
		Pollution control vessels inlcude vessels specifically designated for pollution response.	Length: 20 ft - 40 ft Beam: 6 ft – 20 ft	

[5] Marine Traffic. *COLUMBIA*. Available at: http://www.marinetraffic.com/en/ais/details/ships/shipid:441374/mmsi:367331730/vessel:COLUMBIA

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Passenger	Ro-Ro/Passenger ships (i.e., car ferries), inland passenger ships, passenger ferries	The Oscar B (Waikiakum County ferry) is the only car ferry on the Lower Columbia River. Passenger vessels include cruise ships, passenger ferries, small passenger vessels (SPV) (as defined in 46 U.S.C. §2101) used for such purposes as day trips and dinner cruises..	Ro-Ro Passenger Vessel: Length: 109.2 ft Breadth: 47.5 ft Draft: 6 ft Inland Passenger Ship: GT: < 100 Length: 80-150 ft Beam: 30-40 ft Draft: 6-12 ft	 Example of a Ferry (Ro-Ro Passenger Vessel)[6]  Example of an SPV, American Empress[7]

[6] Churchill, D. *Astoria Day Trips, Bridges and Ferries.* Available at: https://astoriadaytrips.wordpress.com/bridge-and-ferry/
[7] FleetMon. *Photo of AMERICAN EMPRESS*. Available at: https://www.fleetmon.com/vessels/american-empress_9263538_15186/photos/1221103/

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Pleasure	Pleasure crafts, yachts, sailing vessels	Wide range	Length: 20 ft – 150 ft Beam: 8 ft – 40 ft Draft: 3 ft – 15 ft	 Example of a pleasure craft[8]
Other	Dredgers, Cable Layers, Offshore Supply Vessels, Replenishment Vessels, Heavy Lift Vessels	Wide range.	Length: 150 - 800 ft Beam: 30 - 180 ft Draft: 13 – 30 ft	 Dredge vessel YAQUINA[9]

[8] Marine Traffic. *Photos of GEORGE EMERGY (MMSI: 367465340)*. Available at: http://www.marinetraffic.com/en/photos/of/ships/shipid:446392/#forward
[9] Marine Traffic. *YAQUINA*. Available at: http://www.marinetraffic.com/en/ais/details/ships/shipid:430981/mmsi:366971000/vessel:YAQUINA

Vessel Category	AIS Vessel Types	Service Description	Typical Vessel Specifications	Image
Undefined	Vessels where vessel type is missing from AIS data	Sometimes vessel operators fail to enter the proper Vessel Type in AIS. This results in the receipt of an AIS signal, but the signal does not include sufficient data to provide identifying characteristics about the vessel.	N/A	N/A

3.4 Vessel Traffic Cross Sections

Cross sections were placed at various locations to perform an analysis of the type of traffic transiting the Columbia River. At each cross section, the number of vessels that passed through the defined section was taken to be a transit.

Cross sections are areas where "slices" of 2014 AIS vessel traffic data were extracted to retrieve information on vessel traffic density. More specifically, cross sections were used to identify where vessels transit, classify vessel traffic trends and patterns, and understand the composition of vessel types over the study area. Findings from cross sections are then used to understand how traffic trends, patterns and composition can affect quantitative model results generated in MARCS, DNV GL's proprietary navigation risk model (see Section 4).

Figure 3-5 presents the locations of the defined cross sections.

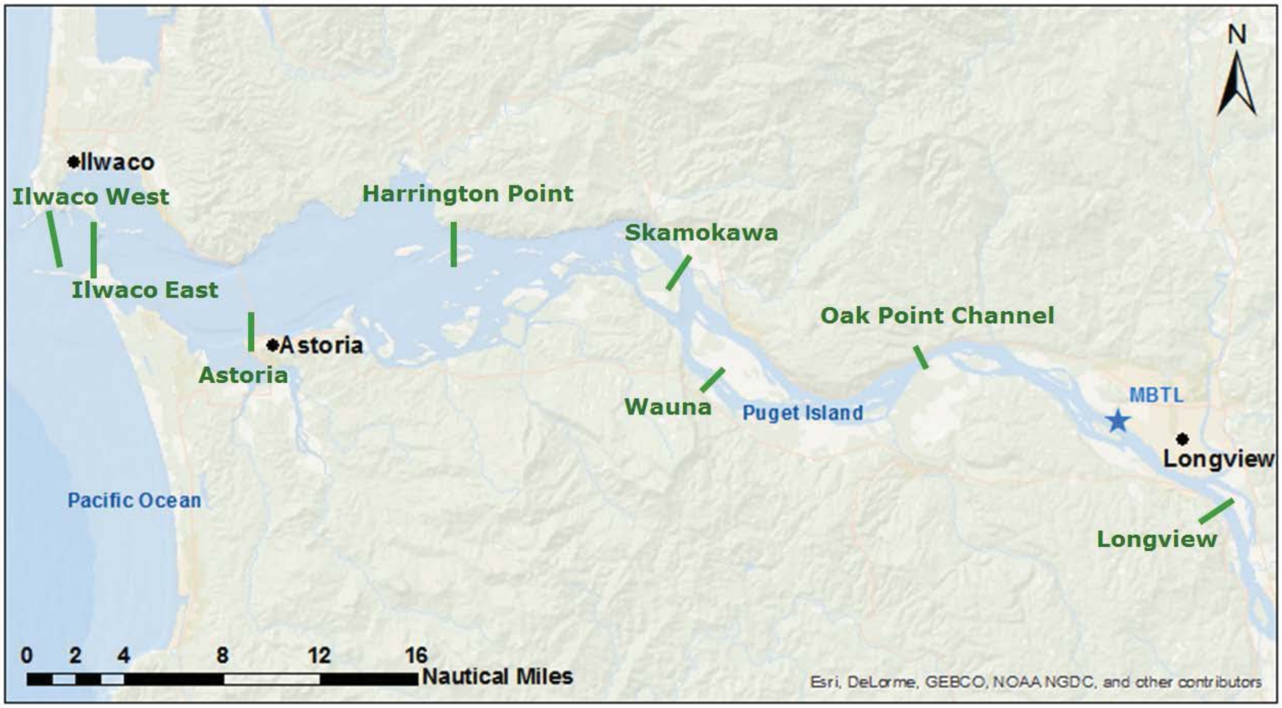


Figure 3-5 Cross Sections for Traffic Analysis

Figure 3-6 presents the distribution of vessel types that transit through each cross section.

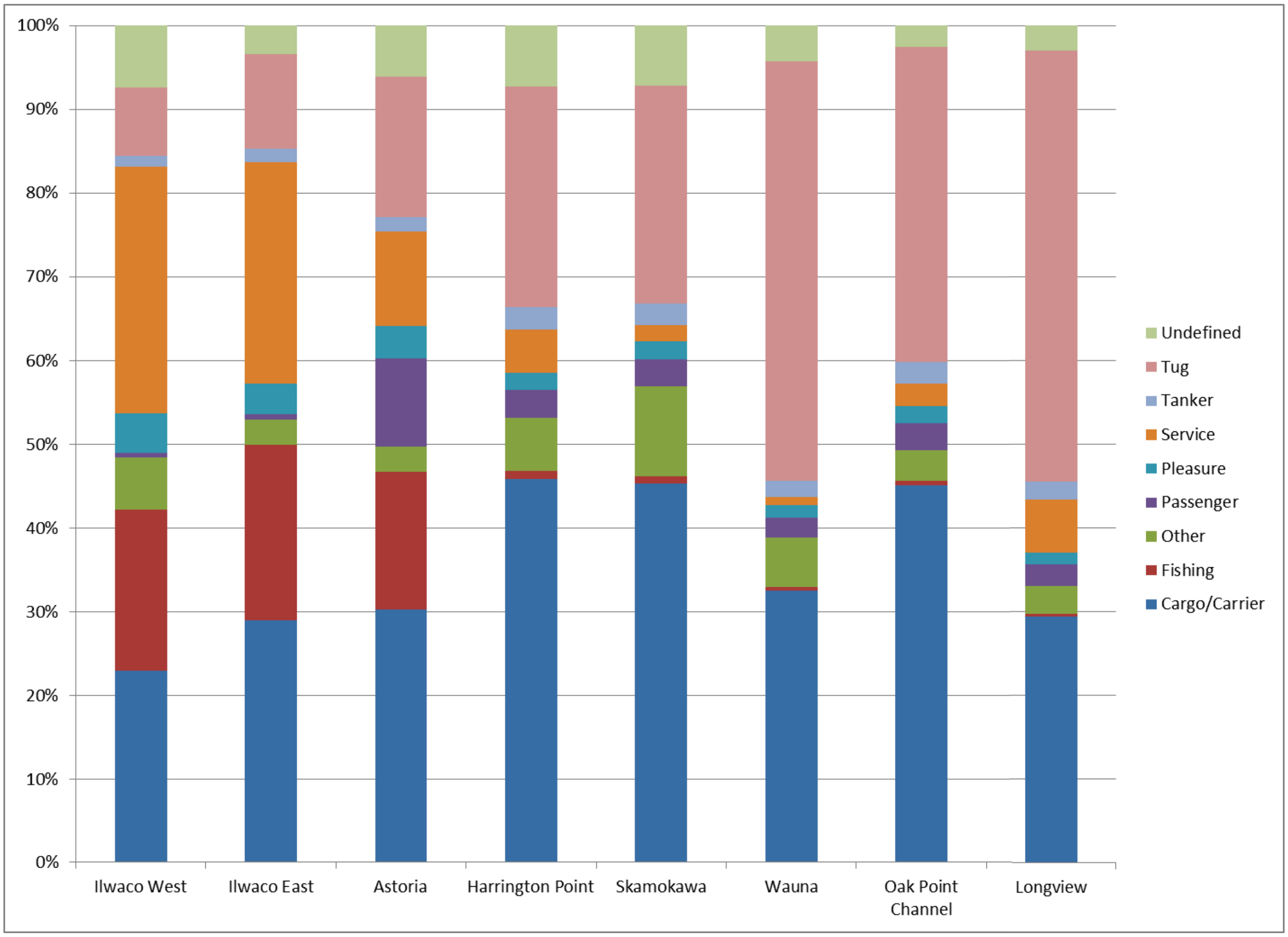


Figure 3-6 Vessel Type Distribution at Cross Sections (2014 AIS Data)

Figure 3-6 presents the number of transits through the defined cross sections, combined with the number of transits contributed by each vessel type. It can be seen that more vessels passed through the cross sections at the mouth of the Columbia River.

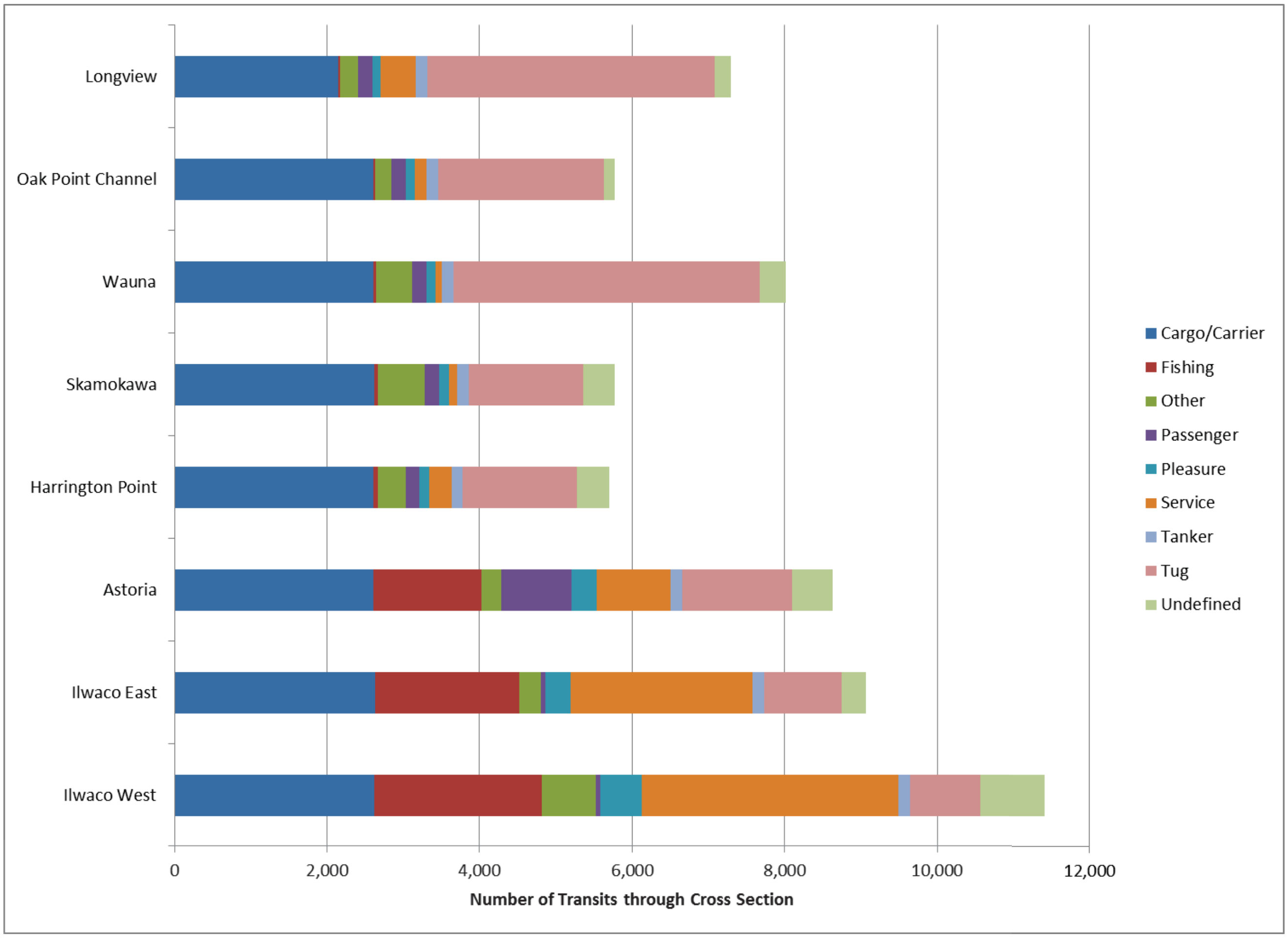


Figure 3-7 Number of Transits per Cross Section by Vessel Type (2014 AIS Data)

3.5 Vessel Traffic Density by Vessel Type

AIS data was used to map the traffic density in the study area. The AIS dataset was translated into the number of AIS points per grid cell (0.005 x 0.005 decimal degrees), which was interpreted as vessel density.

Figure 3-7 to Figure 3-16 present the density of each ship type as a 'heat map' with yellow representing the least dense areas and dark blue represent the densest areas.

It is noteworthy that areas of slower speeds, such as direction changes in the channel, are shown as higher density areas on the heat maps. This is assumed to occur because when vessels travel at a slower speed, they are transmitting more AIS data while in that area than if they were travelling at higher speeds. The figure shows that areas of relatively greater density begin to occur around the Columbia River bar and persist in the navigable channel past Longview.

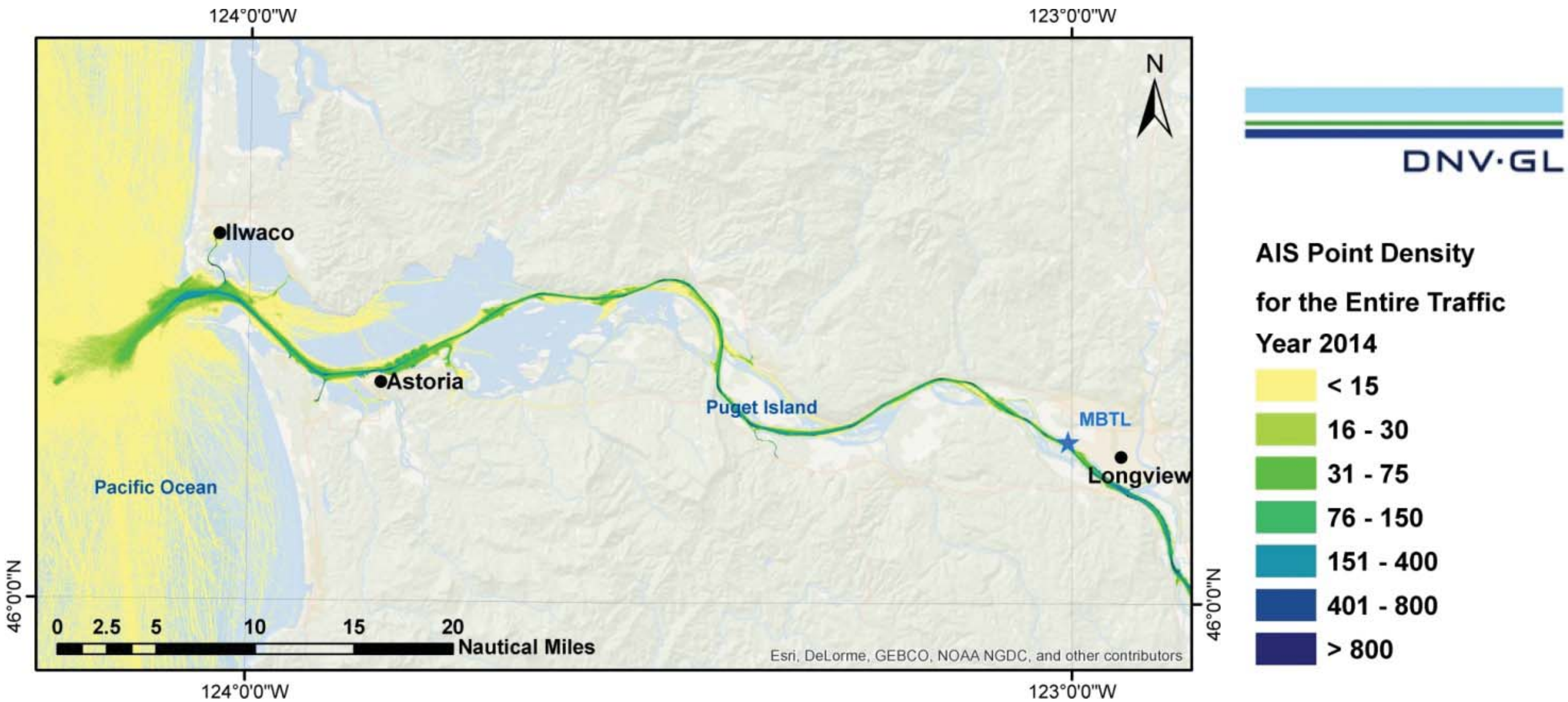


Figure 3-8 2014 AIS Density Profile for All Vessels Transits

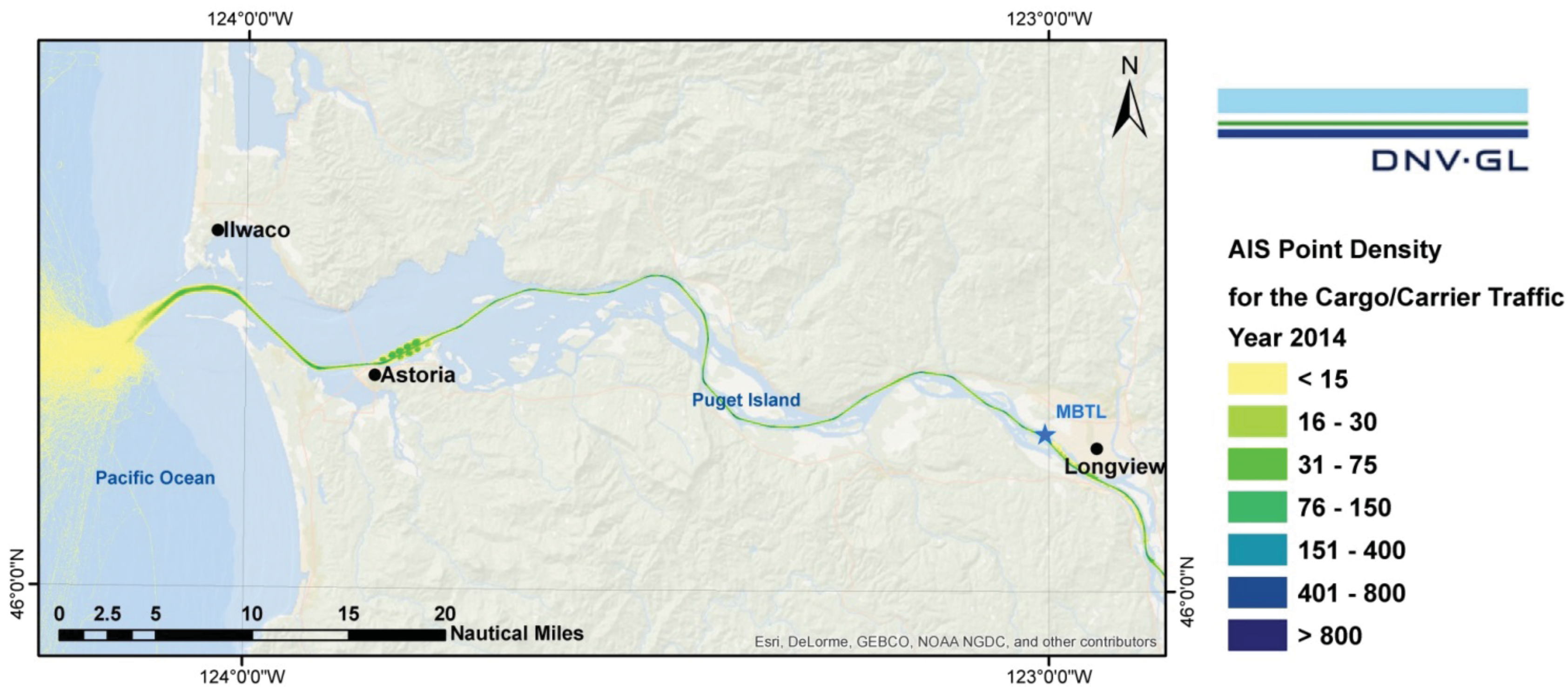


Figure 3-9 2014 AIS Density Profile for Cargo/Carrier Transits

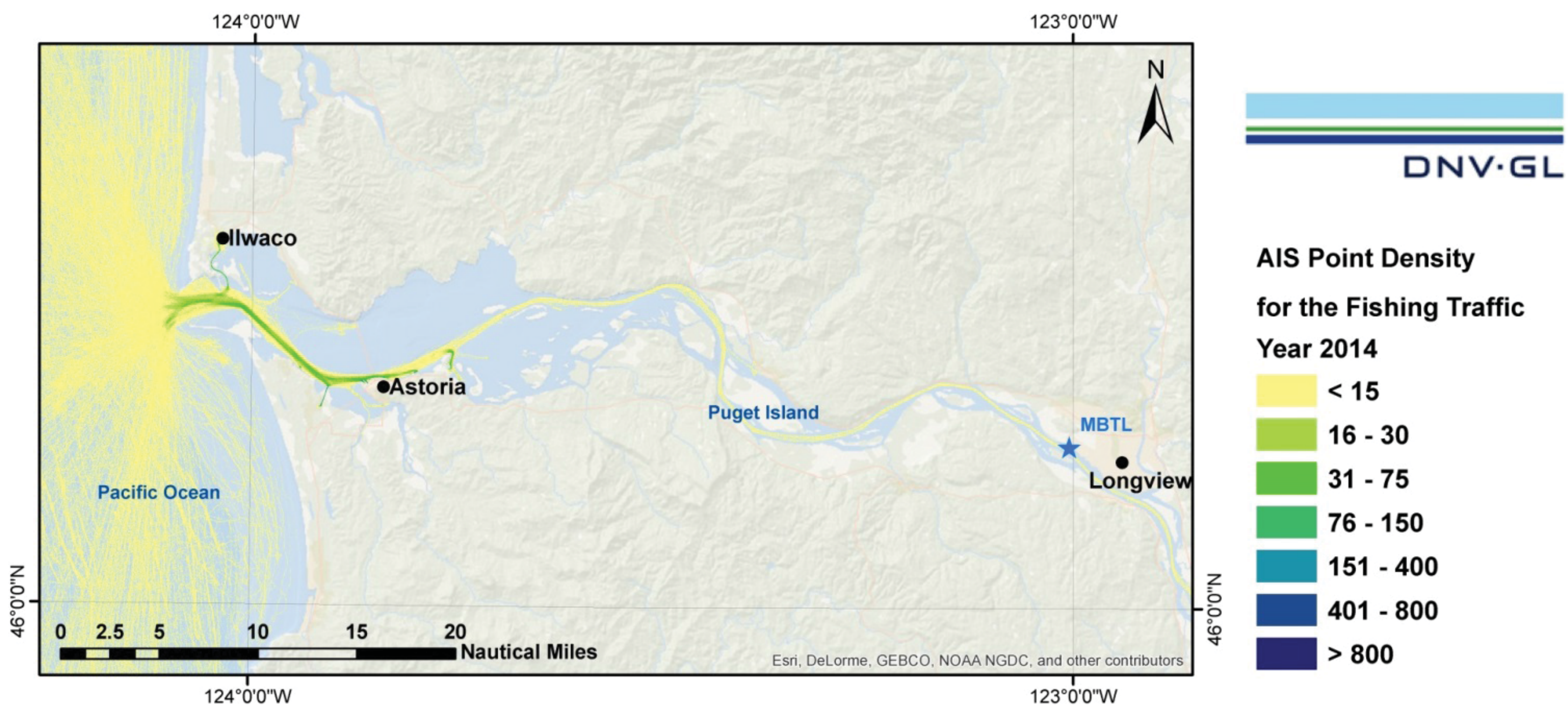


Figure 3-10 2014 AIS Density Profile for Fishing Transits

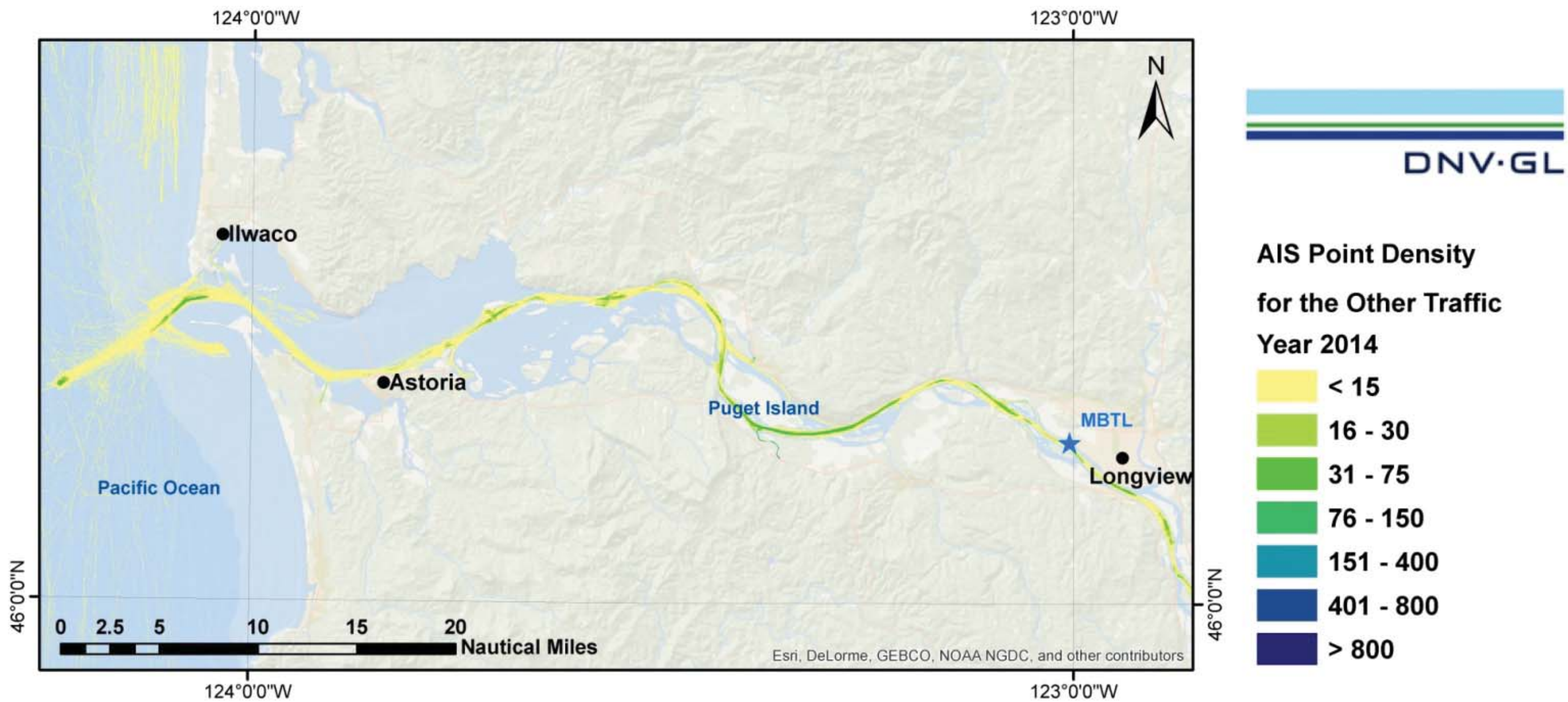


Figure 3-11 2014 AIS Density Profile for Other Transits

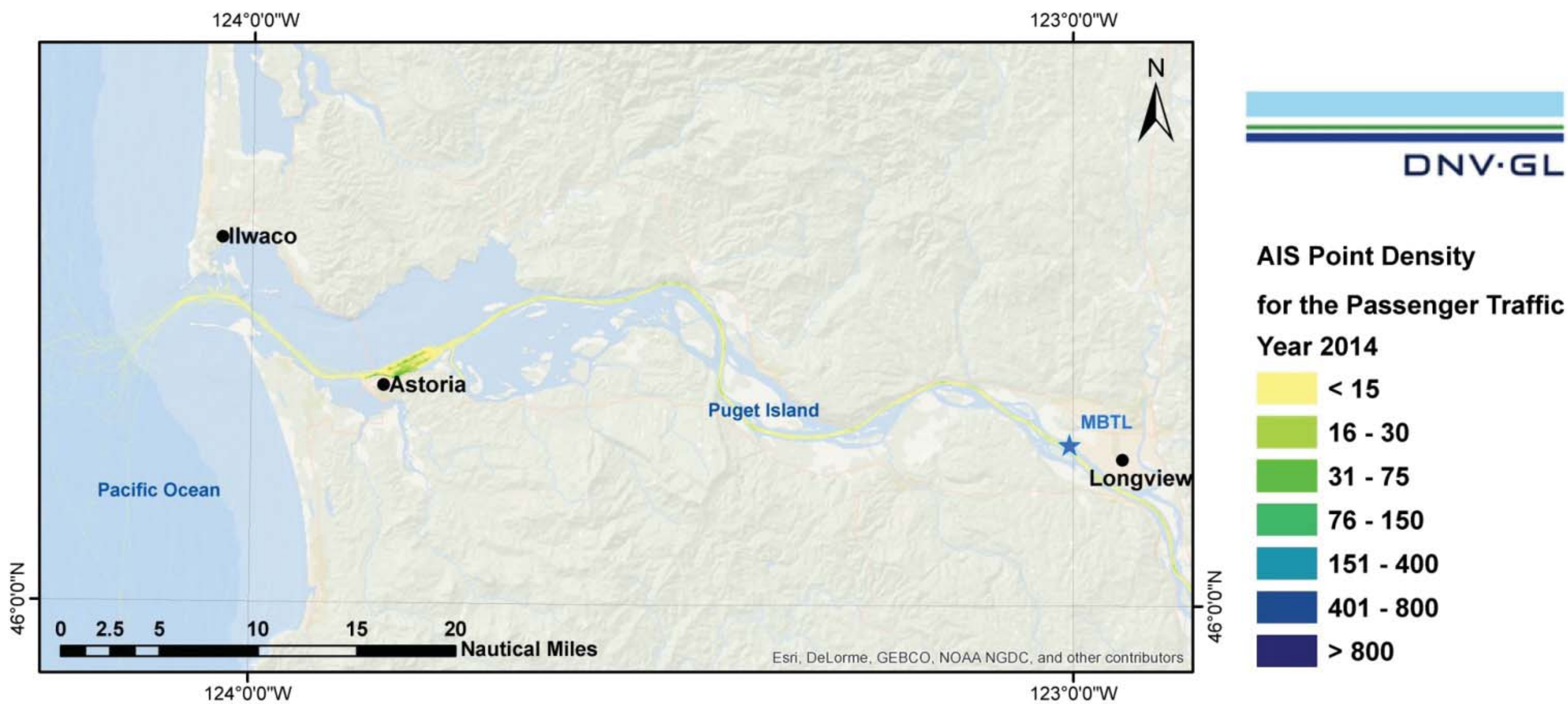


Figure 3-12 2014 AIS Density Profile for Passenger Transits

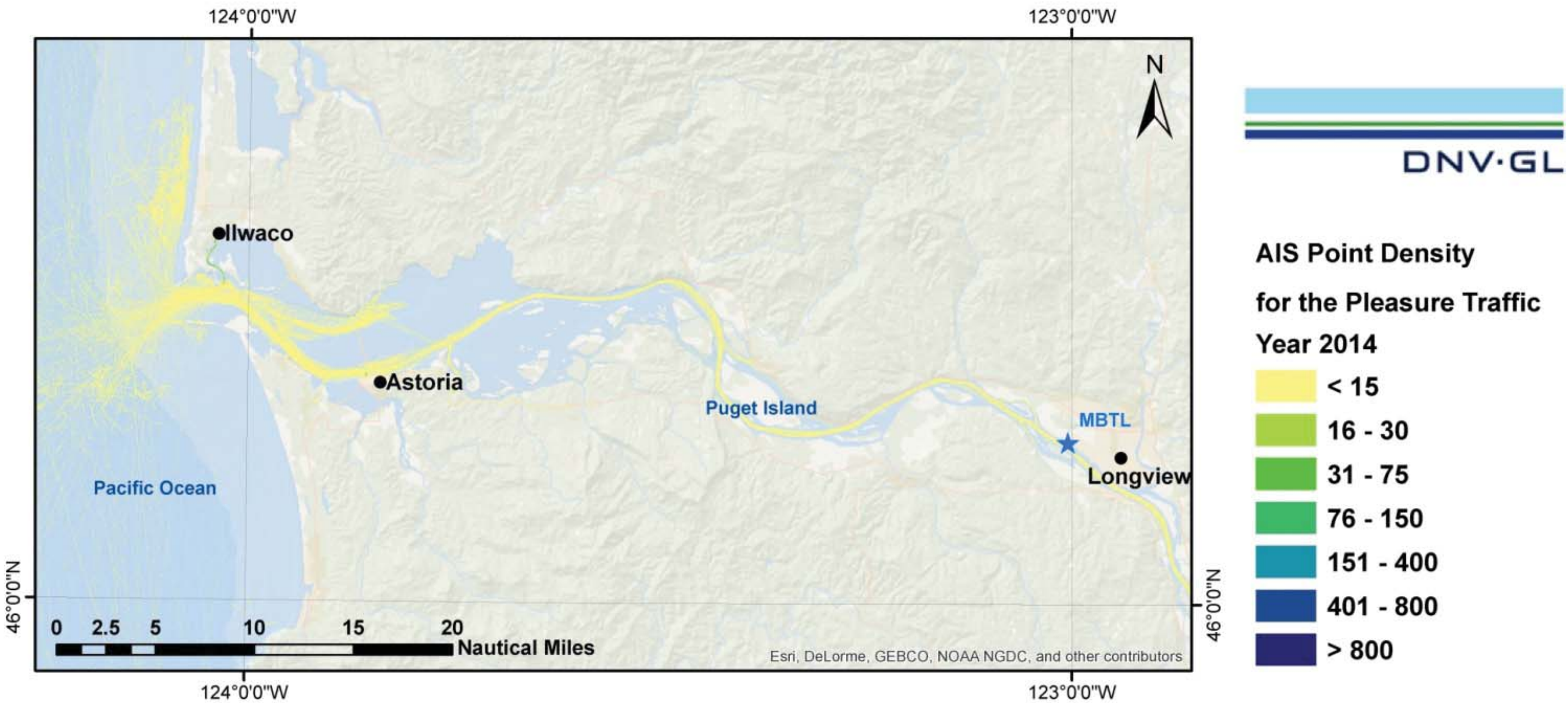


Figure 3-13 2014 AIS Density Profile for Pleasure Transits

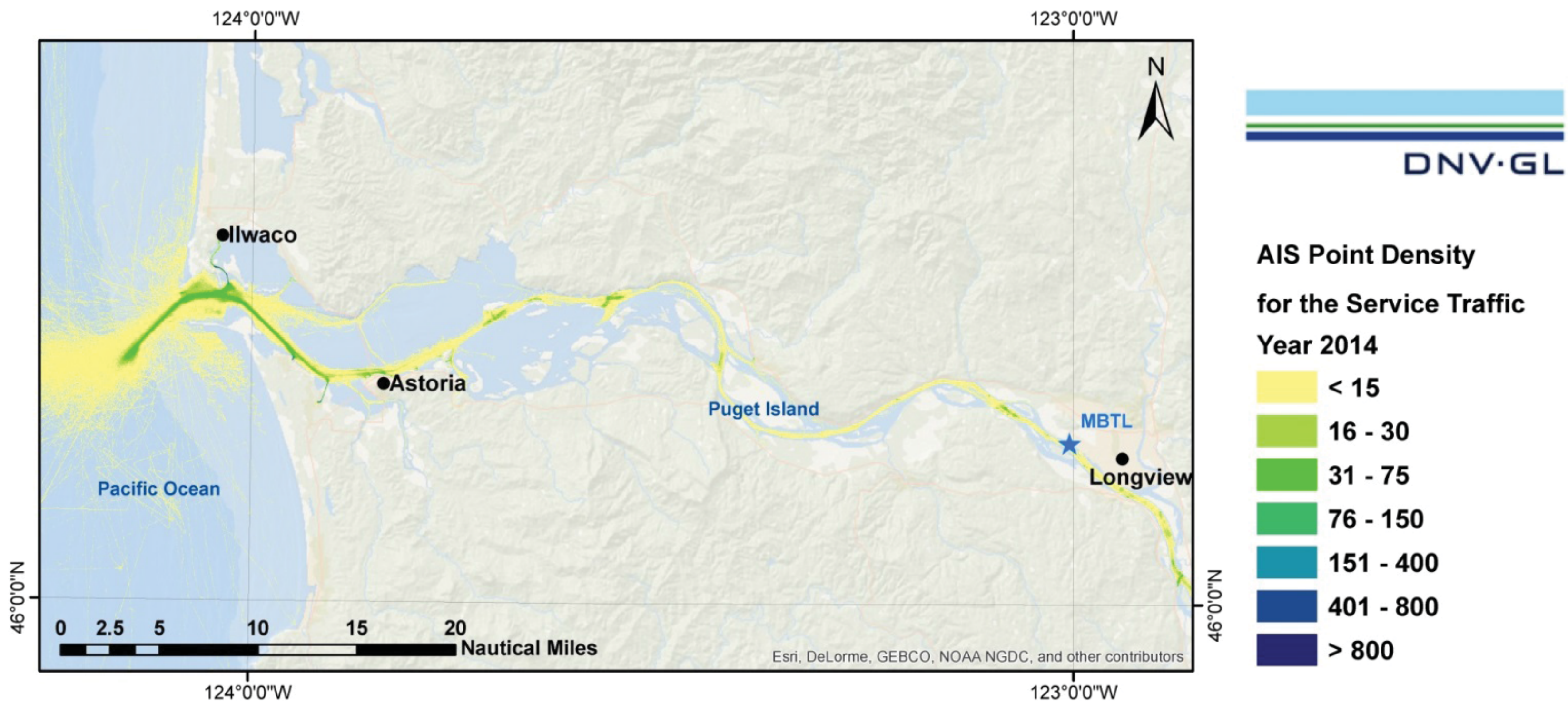


Figure 3-14 2014 AIS Density Profile for Service Transits

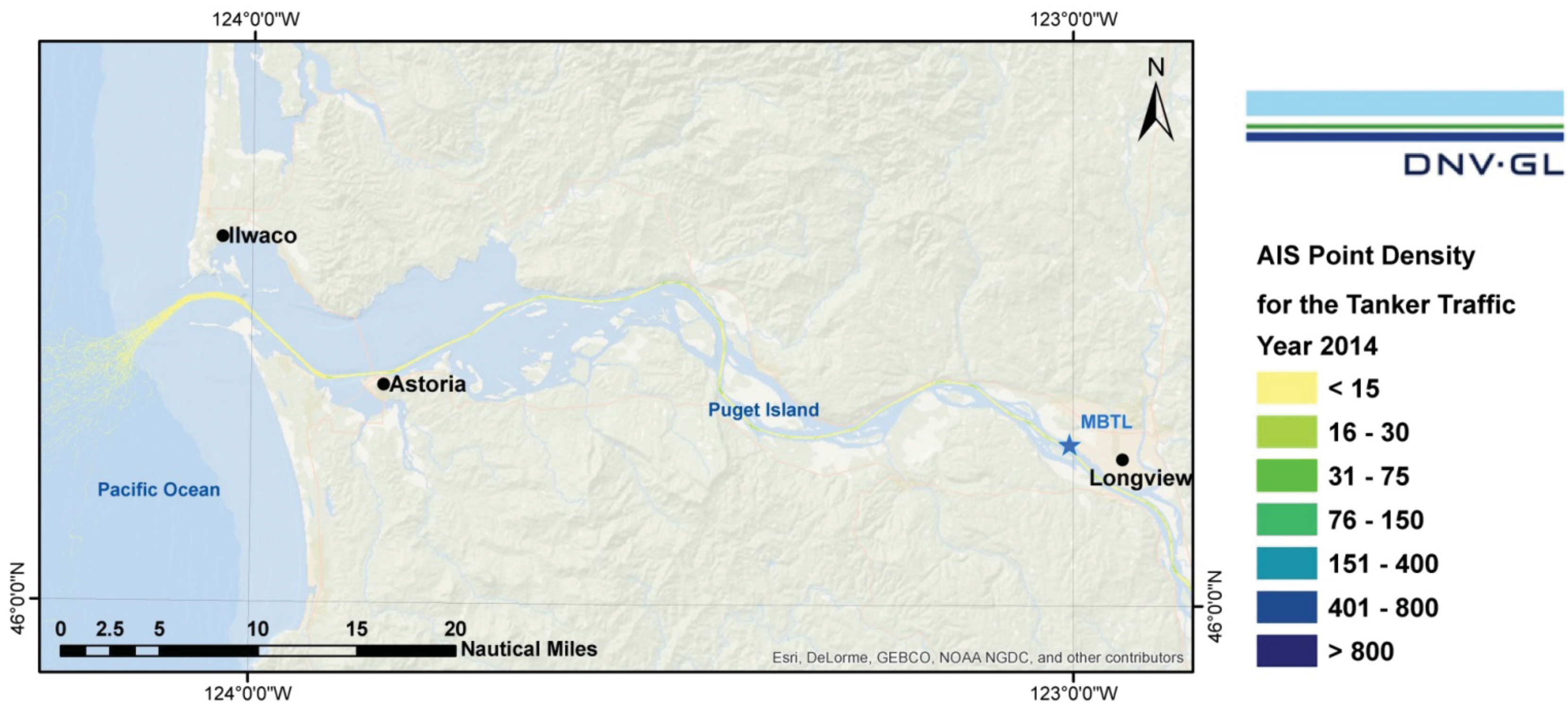


Figure 3-15 2014 AIS Density Profile for Tanker Transits

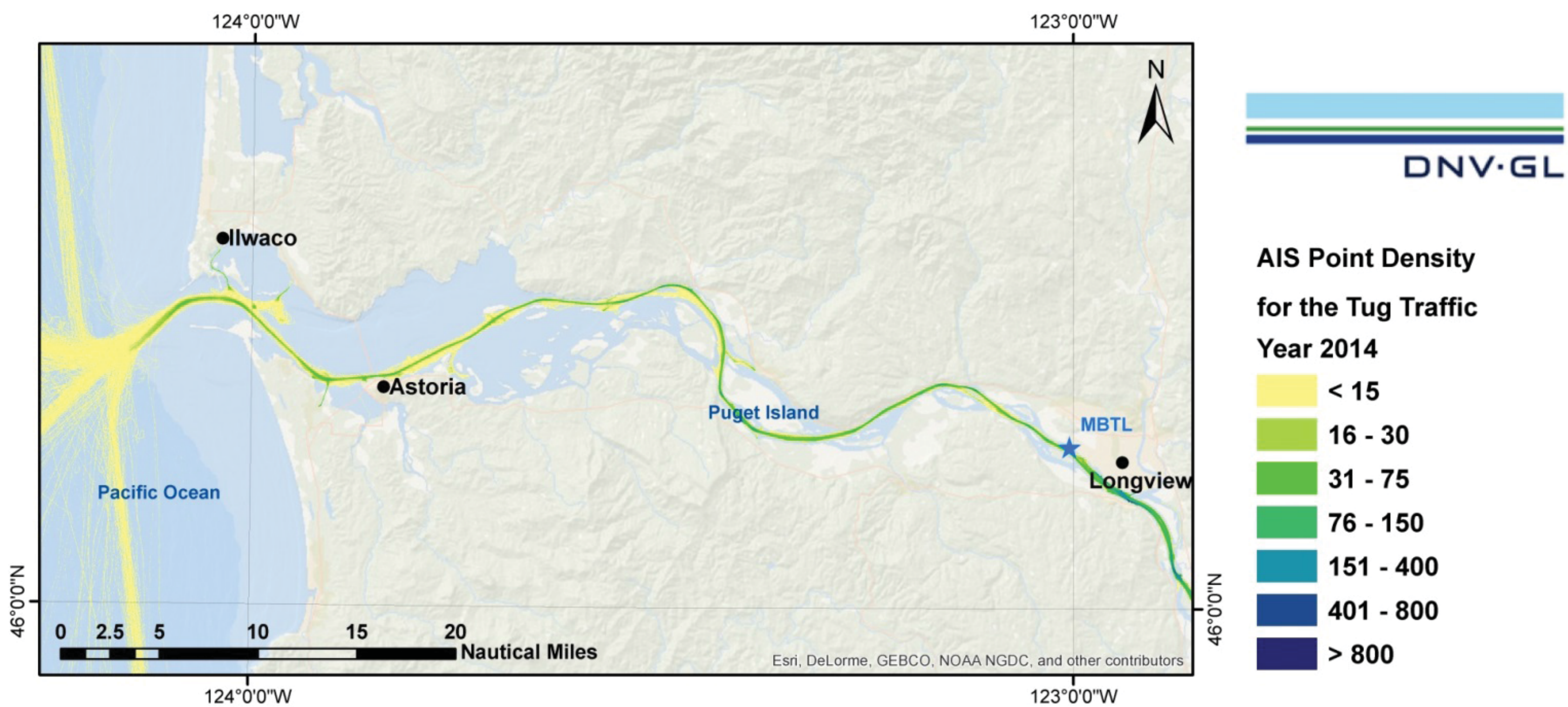


Figure 3-16 2014 AIS Density Profile for Tug Transits

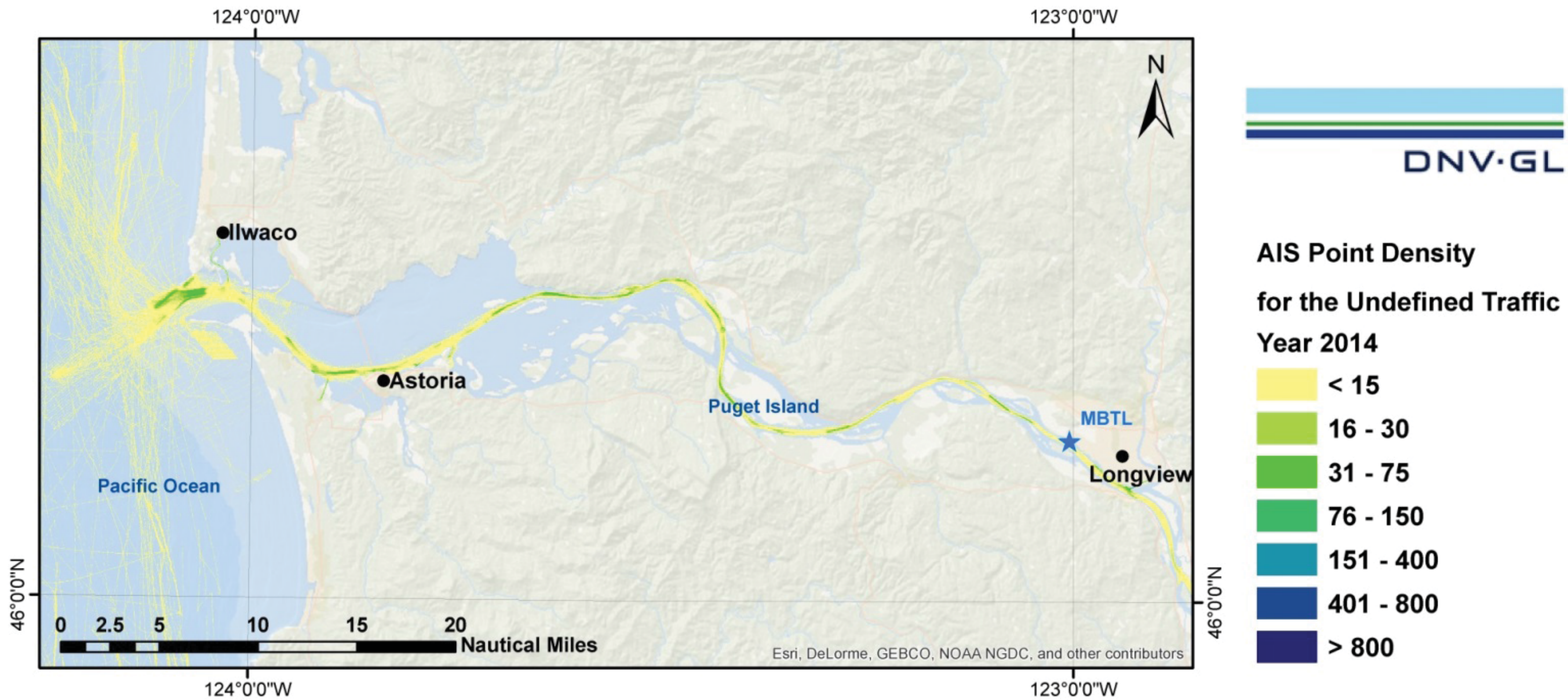


Figure 3-17 2014 AIS Density Profile for Undefined Transits

3.6 Vessel Traffic by Vessel Transit Speed

Figure 3-17 to Figure 3-26 present the average speeds determined from the time stamps in the AIS dataset. The figures show that the vessels along the project vessel route generally transit at a speed between 6 and 12 knots. The estimated average speeds for each vessel type (based on the AIS data) are presented in Table 3-3.

Table 3-3 Average Speed by Vessel Types

Vessel Category	Speed (knots)
Cargo/Carrier	12
Fishing	9
Other / Undefined	9
Passenger	10
Pleasure	9
Service	15
Tanker	12
Tug	8

Figure 3-18 presents the speed profile for all vessel transits.

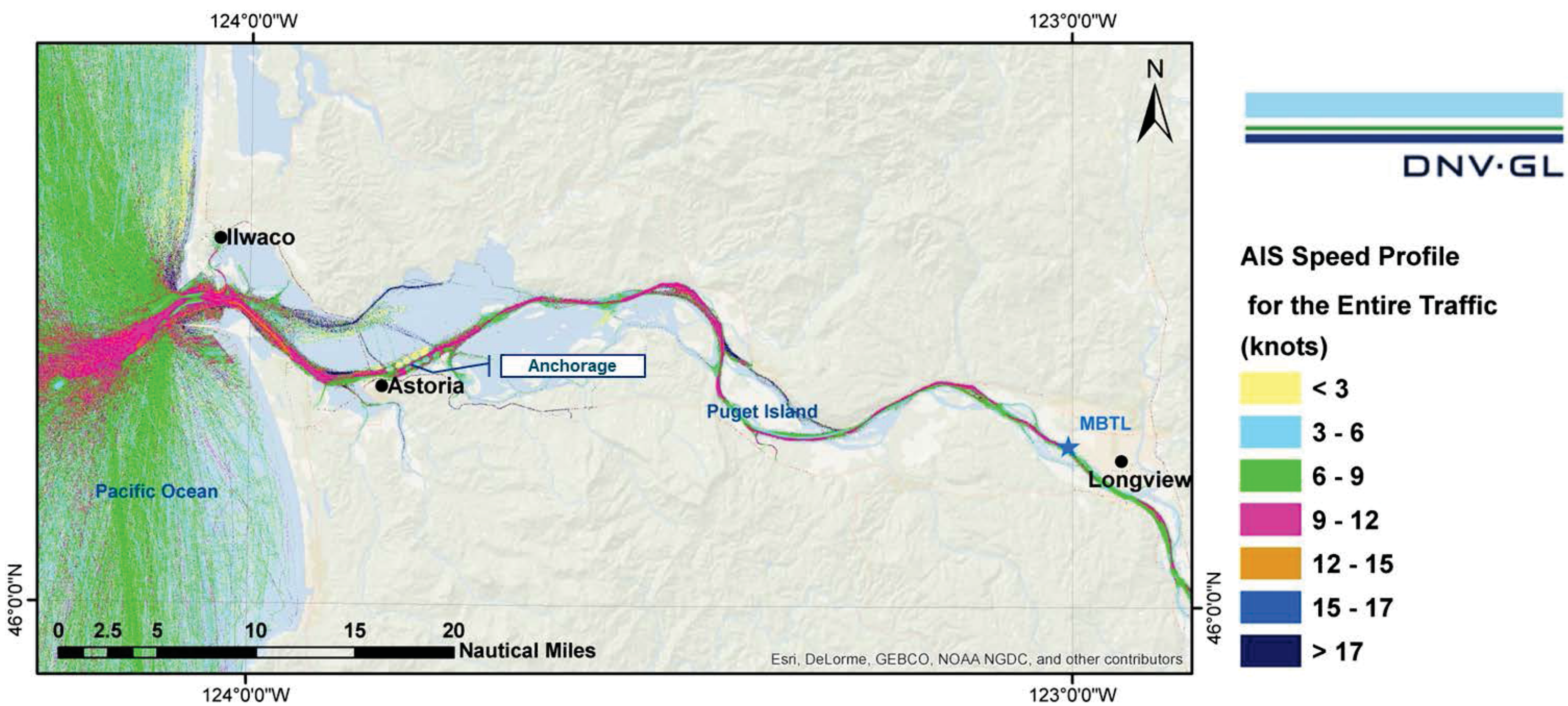


Figure 3-18 2014 AIS Speed Profile for All Vessels Transits

The speed profile of cargo/carrier vessels, Figure 3-19, shows a consistent speed distribution between 9 knots and 15 knots along the navigable channel. Slower speeds due to anchorage areas are present near Astoria.

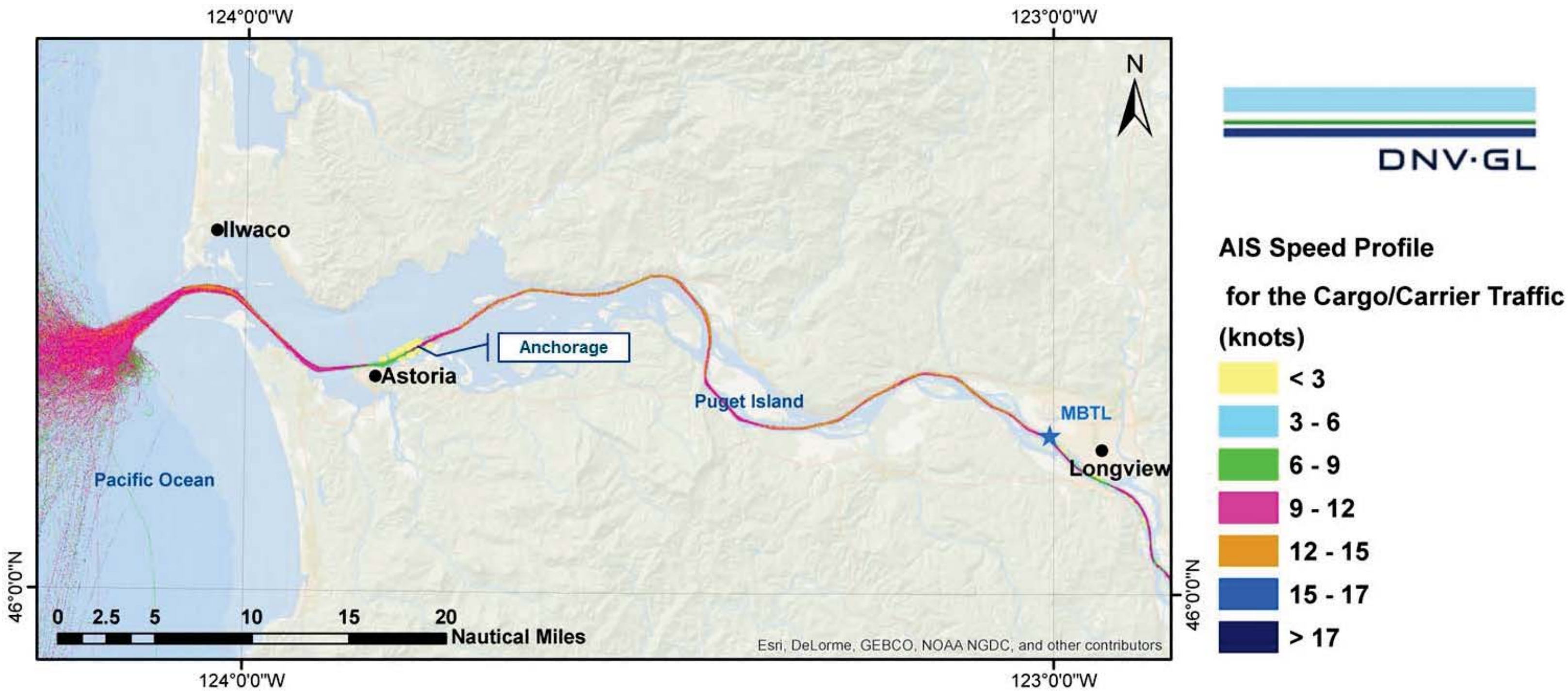


Figure 3-19 AIS Speed Profile for Cargo/Carrier Transits

The speed profile of fishing vessels, Figure 3-20, shows a speed distribution between 6 knots and 12 knots along the navigable channel.

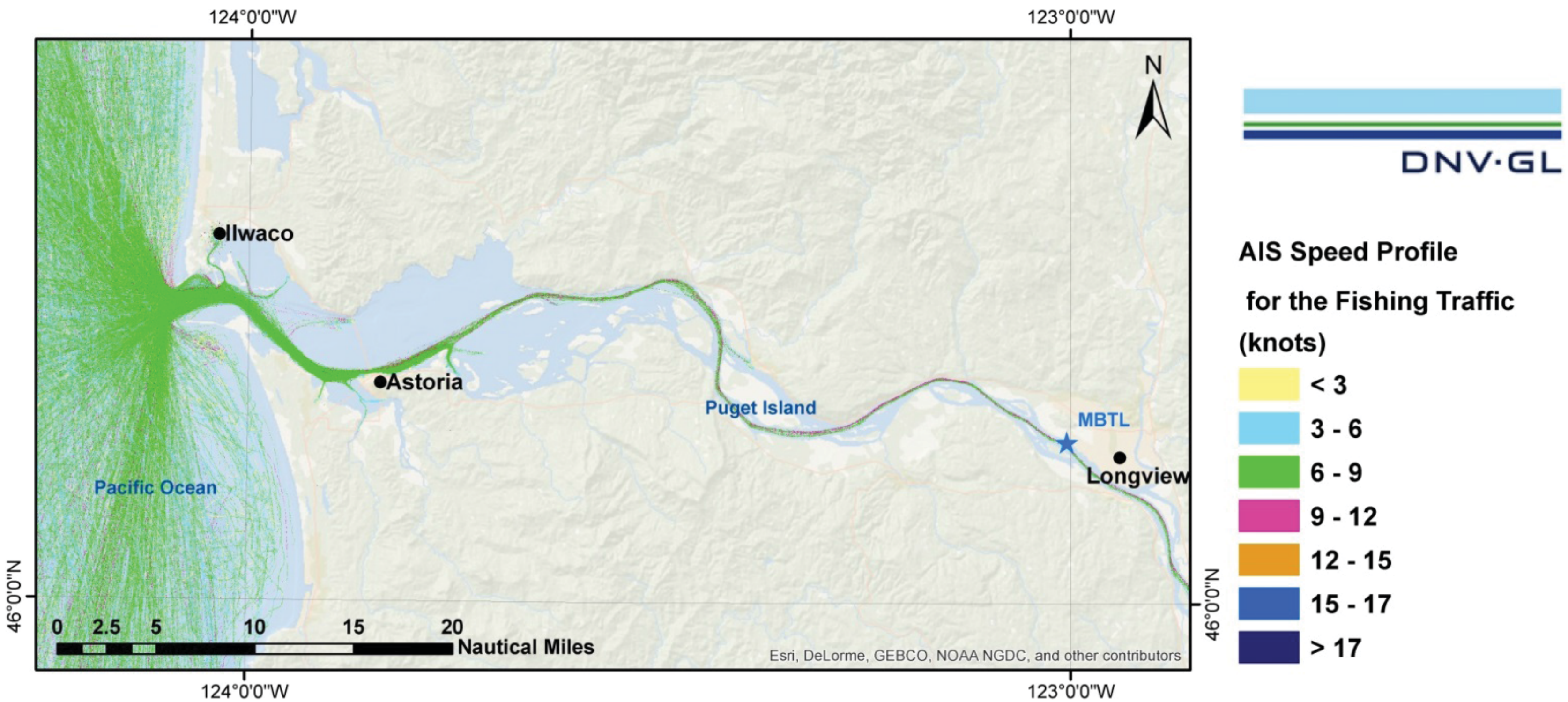


Figure 3-20 AIS Speed Profile for Fishing Transits

The speed profile of other vessels, Figure 3-21, shows many variations in speed along the waterway. The areas of highest speed are on the northeast side of Tenasillahe Island and Puget Island, where the AIS data shows other vessels reach speeds of over 17 knots.

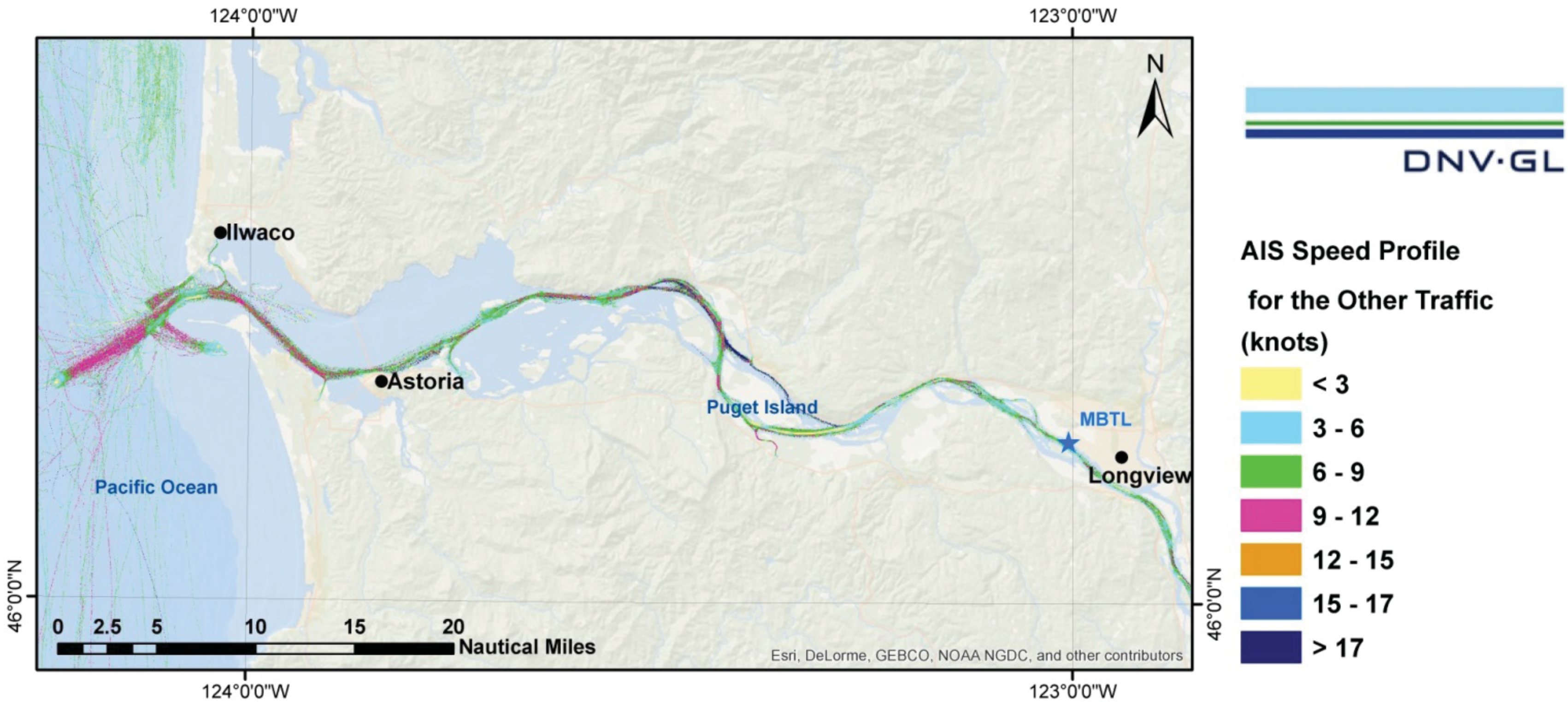


Figure 3-21 AIS Speed Profile for Other Transits

The speed profile of passenger vessels, Figure 3-22, shows a consistent speed distribution between 9 knots and 12 knots along the navigable channel. Areas of reduced speed, between 6 and 9 knots, are present near Astoria.

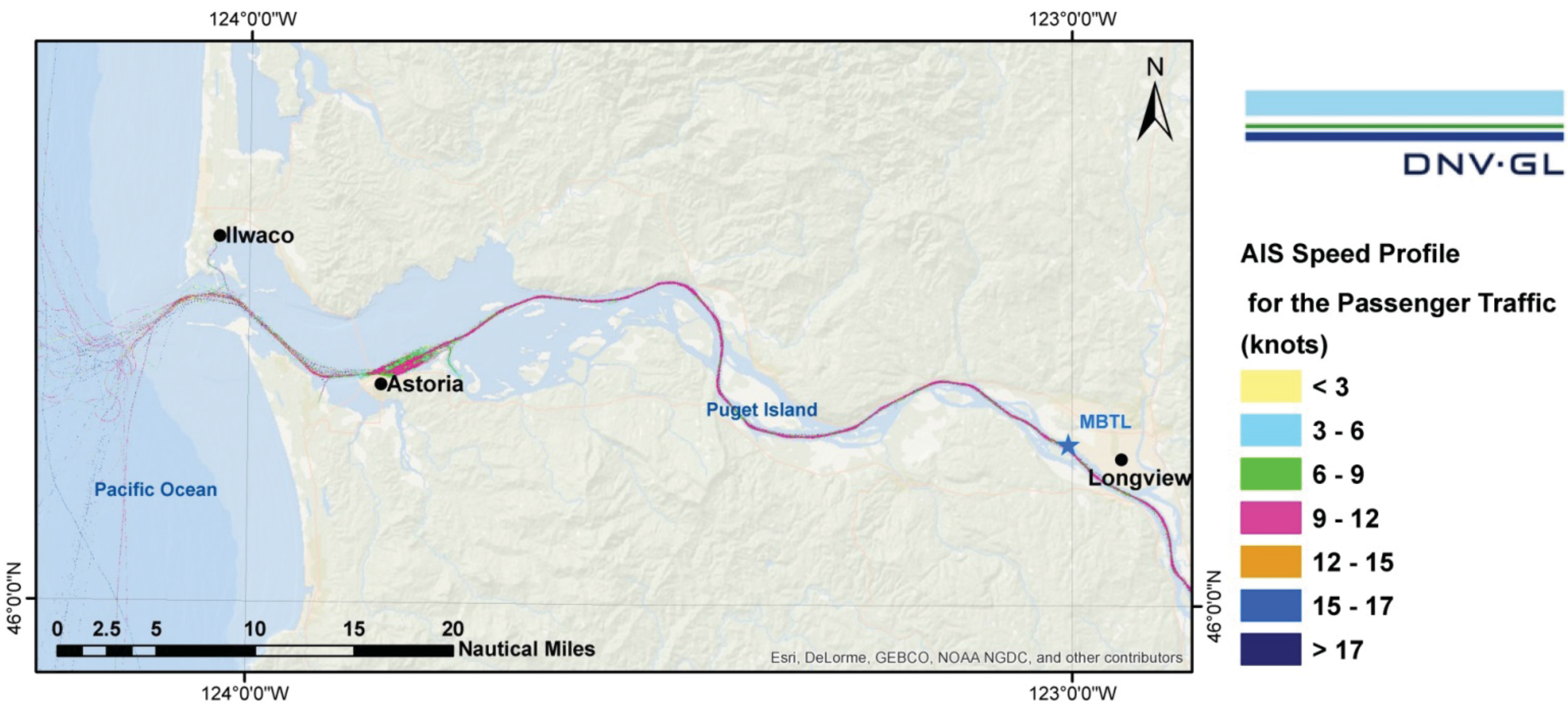


Figure 3-22 AIS Speed Profile for Passenger Transits

Figure 3-23 presents the speed profile for pleasure vessels. Pleasure vessels typically travel at approximately 9 knots, with slower speeds near Astoria.

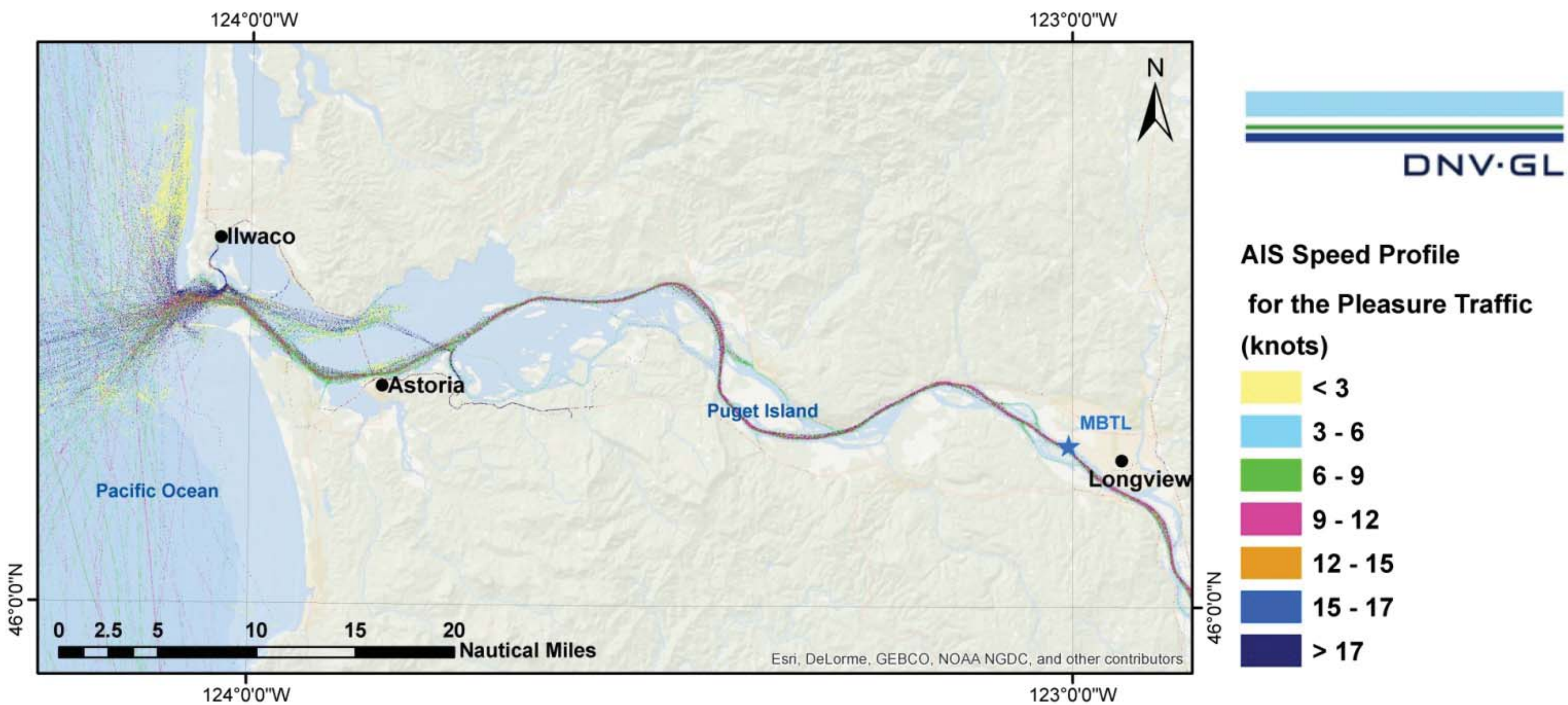


Figure 3-23 AIS Speed Profile for Pleasure Transits

Figure 3-24 presents the speed profile for service vessels. Service vessels travel at approximately 15 knots. Areas of speeds between 6 and 9 knots are present along the route.

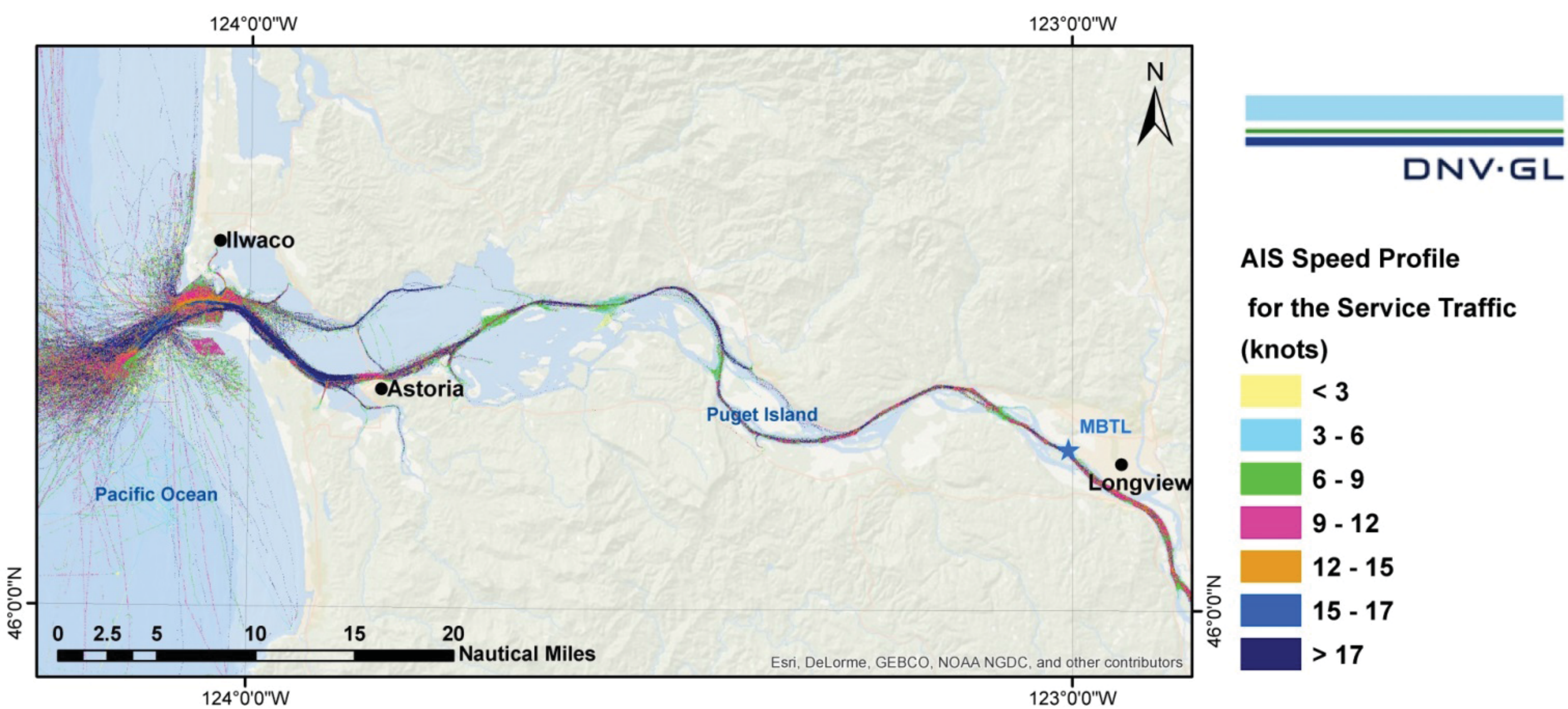


Figure 3-24 AIS Speed Profile for Service Transits

Figure 3-25 presents the speed profile for tankers. The profile shows that tankers travel at a generally uniform speed between 9 and 12 knots.

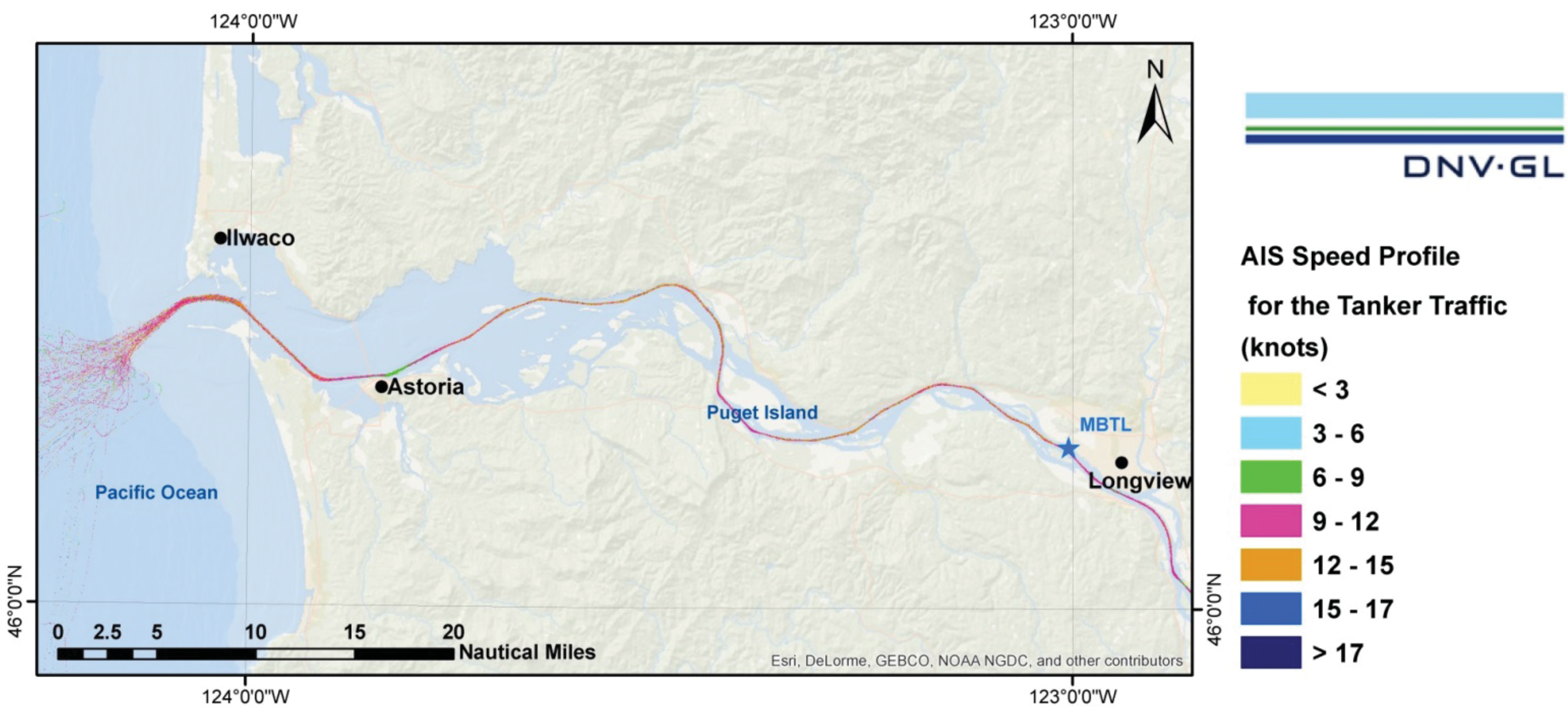


Figure 3-25 AIS Speed Profile for Tanker Transits

Figure 3-26 presents the speed profile for tug transits. Tugs typically travel between 6 and 9 knots, with some areas along the route reaching speeds between 9 and 12 knots.

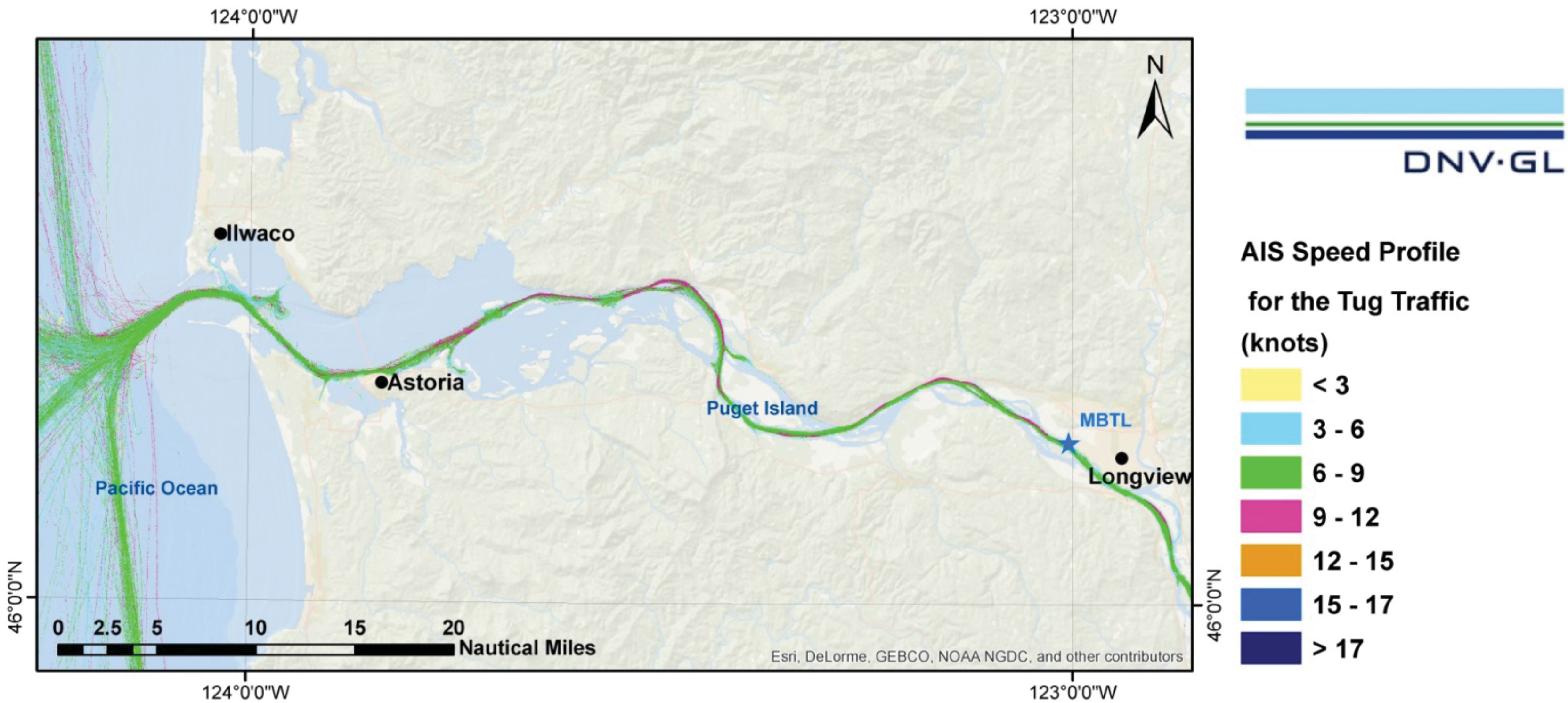


Figure 3-26 AIS Speed Profile for Tug Transits

Figure 3-27 presents the traffic profile for undefined vessels. Typically undefined vessels travel between 9 and 12 knots. However, due to the nature of the “undefined” vessel category, this is much variation in speed.

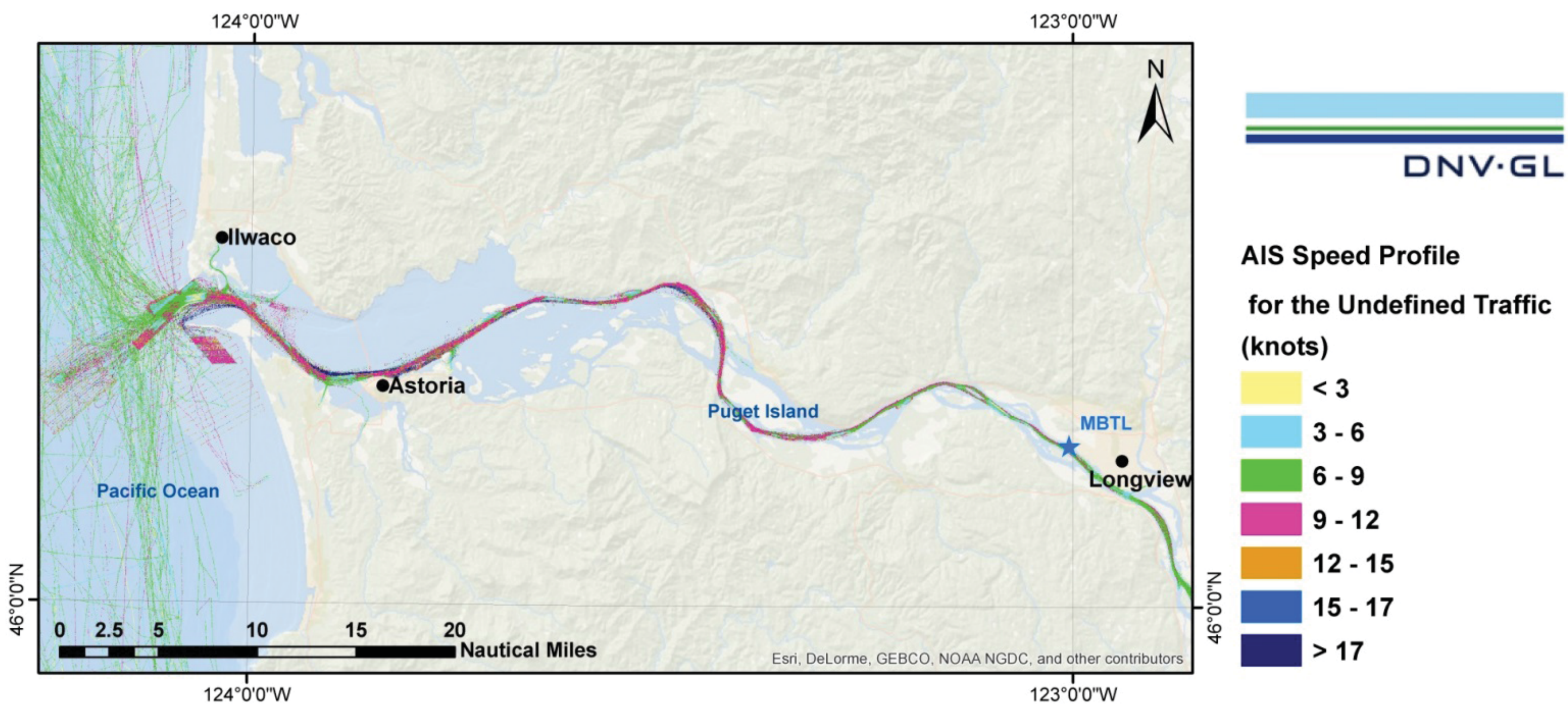


Figure 3-27 AIS Speed Profile for Undefined Transits

4 MARINE INCIDENT AND OIL SPILL DATA SURVEYS

This section presents the results of a survey describing typical damage outcome or severity of marine incidents as well as frequency and severity of reported oil spills in the study area. This survey also provides a coarse review of severity from marine incidents in U.S. waters. The purpose of these data surveys is to provide a basis for evaluating the incremental risk from the proposed project, as estimated in this study.

Figure 4-1 and Figure 4-2 describe the data processing and categorization that were applied for the two objectives listed in Section 2.1.

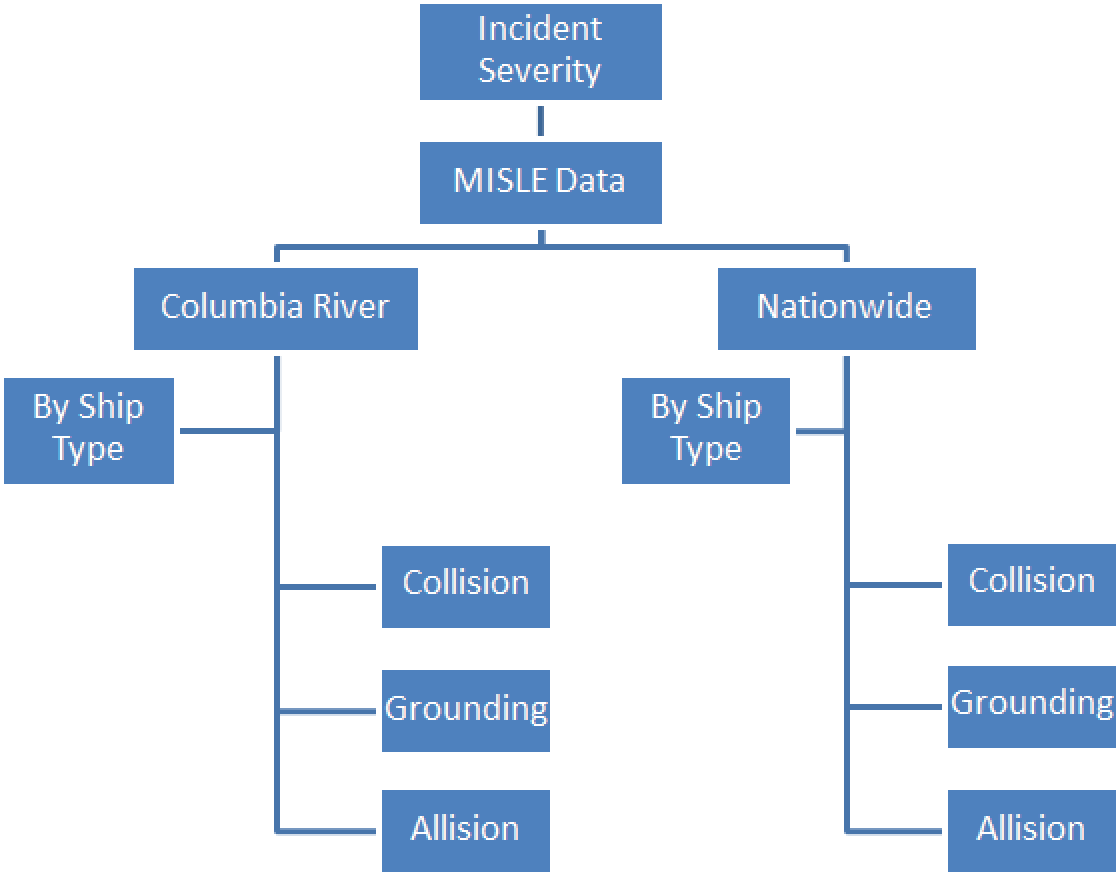


Figure 4-1 Incident Severity Data Survey Methodology

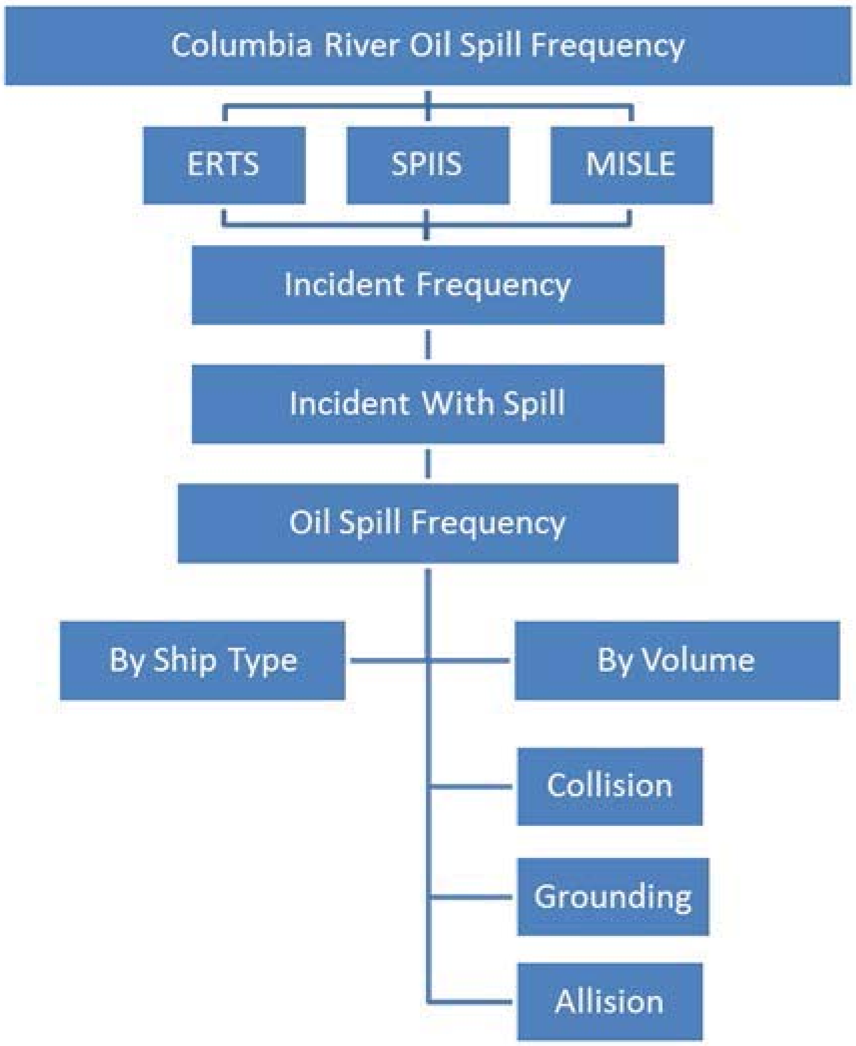


Figure 4-2 Oil Spill Frequency Data Survey Methodology

4.1 Review of Incident Severity in U.S. Waters

The information presented in this section is based on data obtained from the U.S. Coast Guard's Marine Information for Safety and Law Enforcement (MISLE) database and covers all available data from 2001 through 2014 (Ref. /4/). This period was chosen as it covers over 99% of all collision, grounding, and allision incidents reported in the dataset. The remaining 1% of data are sparsely distributed 1900 to 2000. The data are presented for the vessel types reported in the MISLE database, which are comparable to those identified in the AIS data, and are not predictive of bulk carrier casualties.

The "Accident Type" field includes 26 different entry categories. Of these, only incident types *collision*, *allision*, and a combination of *grounding / set adrift* were analyzed because the objective of this data survey is to provide context around the consequences of the incidents evaluated in this navigational risk study which are limited to collisions, powered and drift groundings, and allisions.

The severity of a marine incident is captured in the “Damage Status” field of the MISLE data, which describes damage to the vessel(s) implicated in the incident and includes five different categories. For the purposes of this analysis, the categories *Actual Total Loss*, *Total Constructive Loss: Salvaged*, and *Total Constructive Loss: Unsalvaged* were combined into a single category called “Total Loss”. The other two categories are *Damaged* and *Undamaged*.

Table 4-1 and Table 4-2 present the severity distribution for the three incident types discussed above.

Table 4-1 Incident Severity by Incident Type for U.S. Waters – Incident Count (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Allision	149	4,525	5,479	10,153
Collision	114	2,092	1,727	3,933
Grounding / Adrift	364	3,929	12,162	16,455
TOTAL	**627**	**10,546**	**19,368**	**30541**

Table 4-2 Incident Severity by Incident Type for U.S. Waters - % of incidents (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Allision	1%	45%	54%	100%
Collision	3%	53%	44%	100%
Grounding / Adrift	2%	24%	74%	100%
TOTAL	**2%**	**35%**	**63%**	**100%**

4.2 Review of Incident Severity in the Lower Columbia River

The same approach was applied to data covering incidents within the study area. Table 4-3 and Table 4-4 present the outcome distribution for marine incidents that took place between the Columbia River mouth and the Port of Portland.

The results of this data survey are very similar to those from nation-wide incidents in that approximately two-thirds of incidents result in no damage, one-third in some damage to the vessel(s) involved and slightly less than 3% result in a vessel total loss.

Table 4-3 Incident Severity by Incident Type for Study Area – Incident Count (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Allision	3	24	29	56
Collision	1	9	9	19
Grounding / Adrift	1	16	59	76
TOTAL	**5**	**49**	**97**	**151**

Table 4-4 Incident Severity by Incident Type for Study Area - % of incidents (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total*
Allision	5%	43%	52%	100%
Collision	5%	47%	47%	100%
Grounding / Adrift	1%	21%	78%	100%
TOTAL	**3%**	**32%**	**64%**	**100%**

*Note: Sum of percentages do not always add up to 100% due to rounding.

This data was further parsed to show incident severity by incident type and vessel type. All vessel types presented found in the AIS data and described in Section 3.3 are covered in the USCG MISLE database.

Table 4-5 presents the distribution of incident severity for all incident types by vessel type for the study area. Table 4-6 to Table 4-8 present the distribution of incident severity by incident type and vessel type for the study area. These tables show that collisions appear to result in the highest severity outcomes, with 5% resulting in a vessel loss and 47% resulting in damage to the vessel(s) involved in the incident. Allisions have the second highest severity outcomes with 5% vessel loss and 43% damage. Groundings result in only 1% vessel loss and 21% vessel damage .

It is worth noting that none of the total loss outcomes reported in the data were due to grounding, collision or allision incidents involved carriers or vessels of similar size. The only vessel categories reported as a total loss in any of these incident types were passenger vessels, fishing vessels and recreational vessels.

Table 4-5 Outcome Distribution for All Marine Incidents - Study Area Only (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Barge	0%	2%	7%	9%
Bulk Carrier	0%	2%	16%	18%
Fishing Vessel	2%	5%	13%	21%
General Dry Cargo Ship	0%	1%	3%	4%
Miscellaneous Vessel	0%	1%	0%	1%
Passenger Ship	1%	8%	7%	15%
Recreational	1%	3%	0%	3%
Ro-Ro Cargo Ship	0%	1%	1%	2%
Tank Ship	0%	0%	2%	2%
Towing Vessel	0%	7%	13%	20%
UNSPECIFIED	0%	1%	3%	4%
Warship	0%	1%	0%	1%
TOTAL	**3%**	**32%**	**64%**	**100%**

Table 4-6 Outcome Distribution for Allisions - Study Area Only (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Barge	0%	2%	14%	16%
Bulk Carrier	0%	4%	5%	9%
Fishing Vessel	5%	2%	4%	11%
General Dry Cargo Ship	0%	4%	0%	4%
Miscellaneous Vessel	0%	2%	0%	2%
Passenger Ship	0%	13%	4%	16%
Recreational	0%	2%	0%	2%
Ro-Ro Cargo Ship	0%	2%	0%	2%
Towing Vessel	0%	11%	23%	34%
UNSPECIFIED	0%	4%	2%	5%
TOTAL	**5%**	**43%**	**52%**	**100%**

Table 4-7 Outcome Distribution for Collisions - Study Area Only (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Barge	0%	0%	11%	11%
Fishing Vessel	0%	11%	11%	21%
Miscellaneous Vessel	0%	5%	0%	5%
Passenger Ship	0%	5%	5%	11%
Recreational	5%	16%	0%	21%
Tank Ship	0%	0%	5%	5%
Towing Vessel	0%	5%	11%	16%
UNSPECIFIED	0%	0%	5%	5%
Warship	0%	5%	0%	5%
TOTAL	**5%**	**47%**	**47%**	**100%**

Table 4-8 Outcome Distribution for Groundings - Study Area Only (USCG MISLE data 2001-2014)

Damage Status	Total Loss	Damaged	Undamaged	Total
Barge	0%	3%	1%	4%
Bulk Carrier	0%	1%	28%	29%
Fishing Vessel	0%	7%	21%	28%
General Dry Cargo Ship	0%	0%	5%	5%
Passenger Ship	1%	5%	9%	16%
Ro-Ro Cargo Ship	0%	0%	3%	3%
Tank Ship	0%	0%	3%	3%
Towing Vessel	0%	5%	5%	11%
UNSPECIFIED	0%	0%	3%	3%
TOTAL	**1%**	**21%**	**78%**	**100%**

4.3 Review of Oil Spill Data from the Lower Columbia River

In order to properly assess the potential bunker oil spill risk contributed by the project in 2028 and 2038, a survey of historical oil spill data from the Lower Columbia River was performed. The purpose of this data survey is to establish the baseline risk of any hydrocarbon spill for the study area, and is not limited to spills of bunker oil. Additionally, all vessel and incident types included in the data are considered. Estimates of the oil spill risk contributed by the project can then be compared to this baseline in order to quantify the increase in risk contributed by the project in 2028 and 2038.

Data on all reported oil spills, including bunker oil spills, were reviewed from the following three databases for the period between January 1, 2004 and December 31, 2014. All three datasets overlap during this eleven year time period therefore providing the most complete data coverage of oil spill risk available for the study area.

- USCG MISLE Data: described in Section 4.1.
- SPIIS Data from Washington State Department of Ecology: The Spills Program Incident Information System (SPIIS) tracks Spill Program incidents and actions. The data only include vessels that are "covered" by state requirements for planning, preparedness, and liability in case of any vessel emergency that results in the discharge or substantial threat of discharge of oil into state waters. A "covered" vessel is a commercial vessel of 300 or more gross tons and can be a tank vessel, cargo vessel, or passenger vessel.
- The Washington State's Environmental Report Tracking System (ERTS) database collects data on all incidents reported to the state as required by law (RCW 88.46.100 for "covered" vessels; and RCW 90.56.280 duty of anyone with knowledge of a discharge into the waters of the state to notify Coast Guard and State Division of Emergency Management) that could result in the discharge or substantial threat of discharge oil into state waters.

When combining these three datasets, all duplicative entries were removed and only incidents with actual reported spills of petroleum or petroleum products were considered. All vessel categories and incident types are considered in the data survey as the objective of this survey is to establish the baseline oil spill frequency for the study area.

Table 4-9 and Figure 4-3 present oil spill incident counts and spill frequencies by spill volume and incident type. Spill volumes per incident range from 0.1 to 1,603 gallons. The average oil spill frequency for the study area is 15.6 spills per year with 84% of these spills having a volume of less than 10 gallons. Spills of more than 100 gallons have occurred at a frequency of 0.4 per year or once every 2.2 years. The average size of these larger spills is approximately 630 gallons with the largest being a 1600 gallon spill from a barge in 2011.

Other datasets with sparser coverage of the oil spills on the Columbia River do exist and include records of some larger spills including a 4,600 gallon bunker oil spill from a chemical tanker in 2003. These datasets are not included in this survey as their sparseness makes spill frequency estimates unreliable but they do provide data points on the historical size of oil spills on the Lower Columbia River including several spills larger than 1600 gallons.

Table 4-9 Oil Spill Incident Count and Frequency - Lower Columbia River (2004-2014)

Incident Type	Oil Spill Incident Count by Spill Volume					*Oil Spills /year*
	< 1 gal	1 - 10 gal	10 - 100 gal	> 100 gal	Total	
Allision	1	-	-	-	**1**	***0.1***
Capsize	1	-	-	-	**1**	***0.1***
Damage to the Environment	123	57	28	6	**214**	***15.3***
Grounding	-	-	1	-	**1**	***0.1***
Sinking	-	2	-	-	**2**	***0.1***
Total	**125**	**59**	**29**	**6**	**219**	***15.6***
Spills /year	***8.9***	***4.2***	***2.1***	***0.4***	***15.6***	

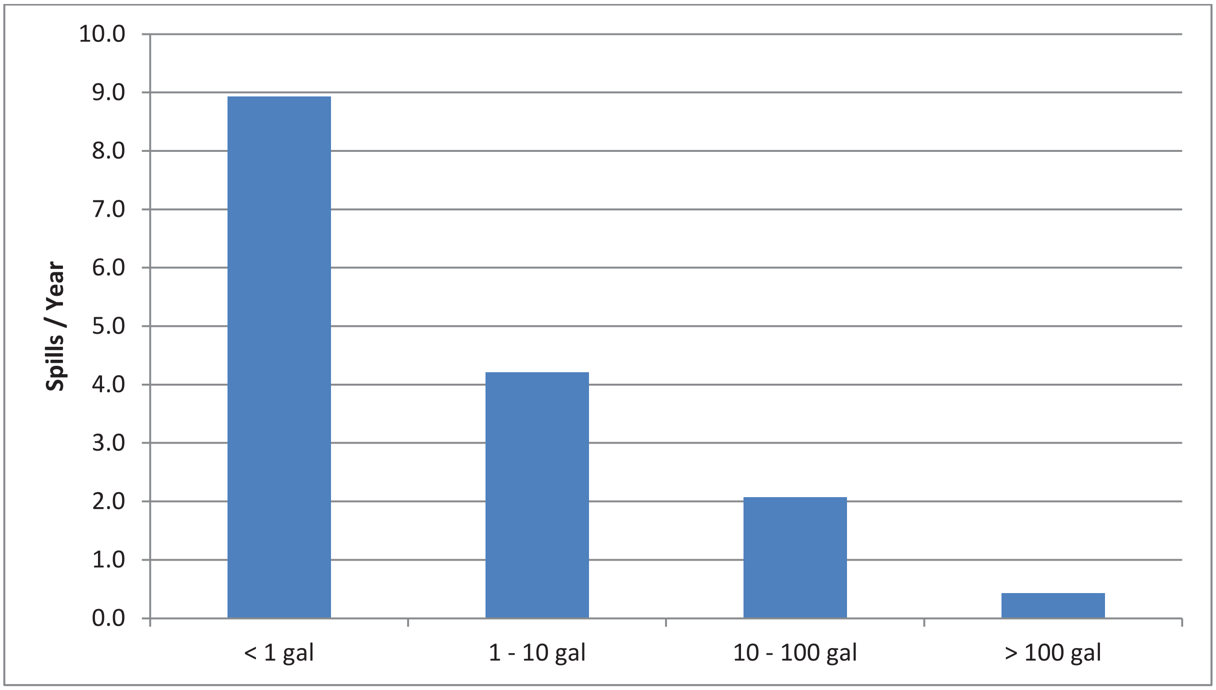


Figure 4-3 Oil Spill Frequency by Volume (Lower Columbia River 2004-2014)

5 MODELING APPROACH

Figure 5-1 presents general approach to DNV GL's navigation study. Inputs and assumptions were applied to two models. DNV GL's proprietary model, Marine Accident Risk Calculation (MARCS) and the allision calculation were used to estimate navigation incident frequencies; further data analysis was performed to measure the incremental impact of the proposed project. MARCS and the oil spill methodology was used to estimate bunker spill frequencies of project and non-project vessels; the Naval Architecture Package (NAPA) was then used to estimate the conditional probabilities of bunker oil spill volumes for project vessels. Further data analysis was performed to measure the incremental impact of the proposed project.

Preliminary MARCS and NAPA results were presented in a stakeholder workshop with DNV GL, ICF International, Washington State Department of Ecology (Ecology), Cowlitz County, U.S. Environmental Protection Agency (EPA), U.S. Coast Guard (USCG), and the U.S. Army Corp of Engineers Sector Columbia River (USACE) on November 9, 2015. Study conclusions are based on the incremental impact of the proposed project in 2028 and 2038, and the conditional probability of bunker oil spill volumes.

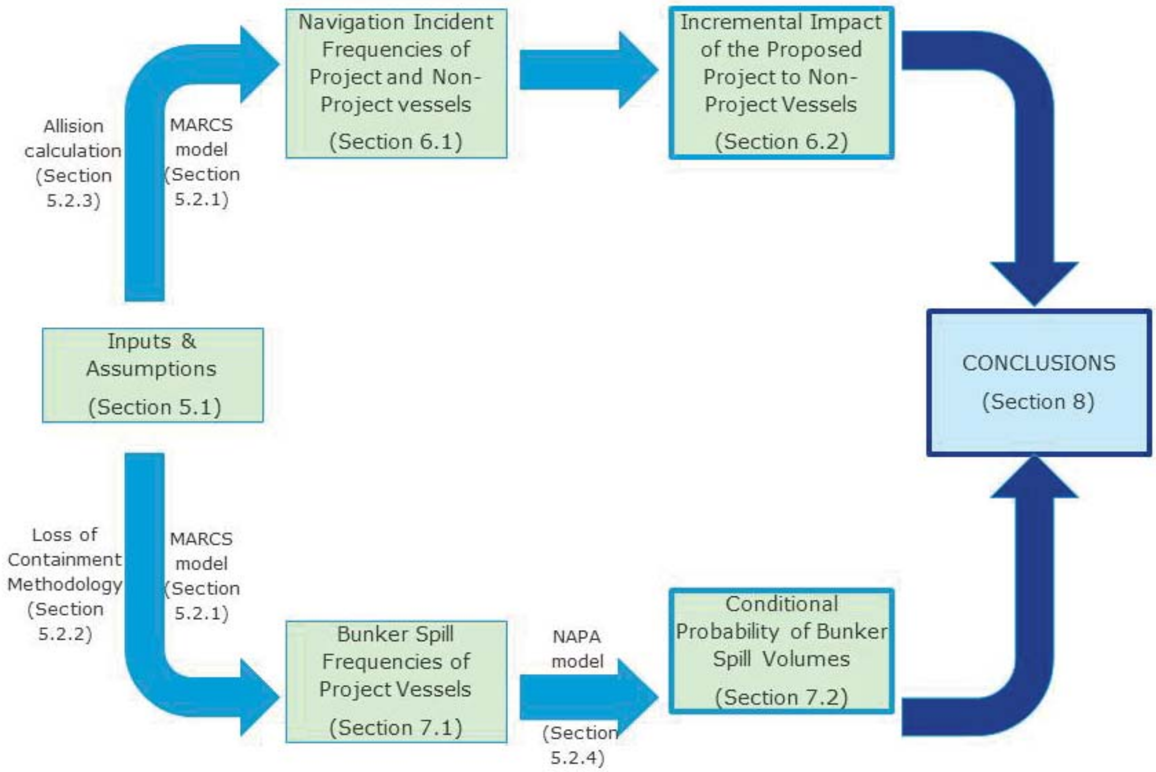


Figure 5-1 General Approach to DNV GL's Navigation Study

5.1 Inputs and Assumptions

5.1.1 Case Definitions

DNV GL has modelled five cases to present a full picture of the risks on the Columbia River due to the proposed project. The cases are defined in Table 5-1.

Table 5-1 Case Definitions

Scenario	1. Existing Conditions 2014	2. No Action 2028	3. Proposed Project 2028	4. No Action 2038	5. Proposed Project 2038
Non-project vessels	2014 AIS data	AIS (including projected growth rate to 2028)	AIS (including projected growth rate to 2028)	AIS (including projected growth rate to 2038) + additional traffic from future projects	AIS (including projected growth rate to 2038) + additional traffic from future projects
Project vessels	6 calls / year (1 ship type)*	26 calls / year (3 ship types)*	840 calls / year (2 ship types)	26 calls / year (3 ship types)*	840 calls / year (2 ship types)

*Will not be studied separately from non-project vessels

The projected growth rate will be further discussed in Section 5.1.3.

5.1.2 Route

The geographic extent of the work is from 0.5 nautical mile (NM) upriver of the proposed terminal to the mouth of the Columbia River at the boundary of the Territorial Sea. The route is presented in Figure 5-2.

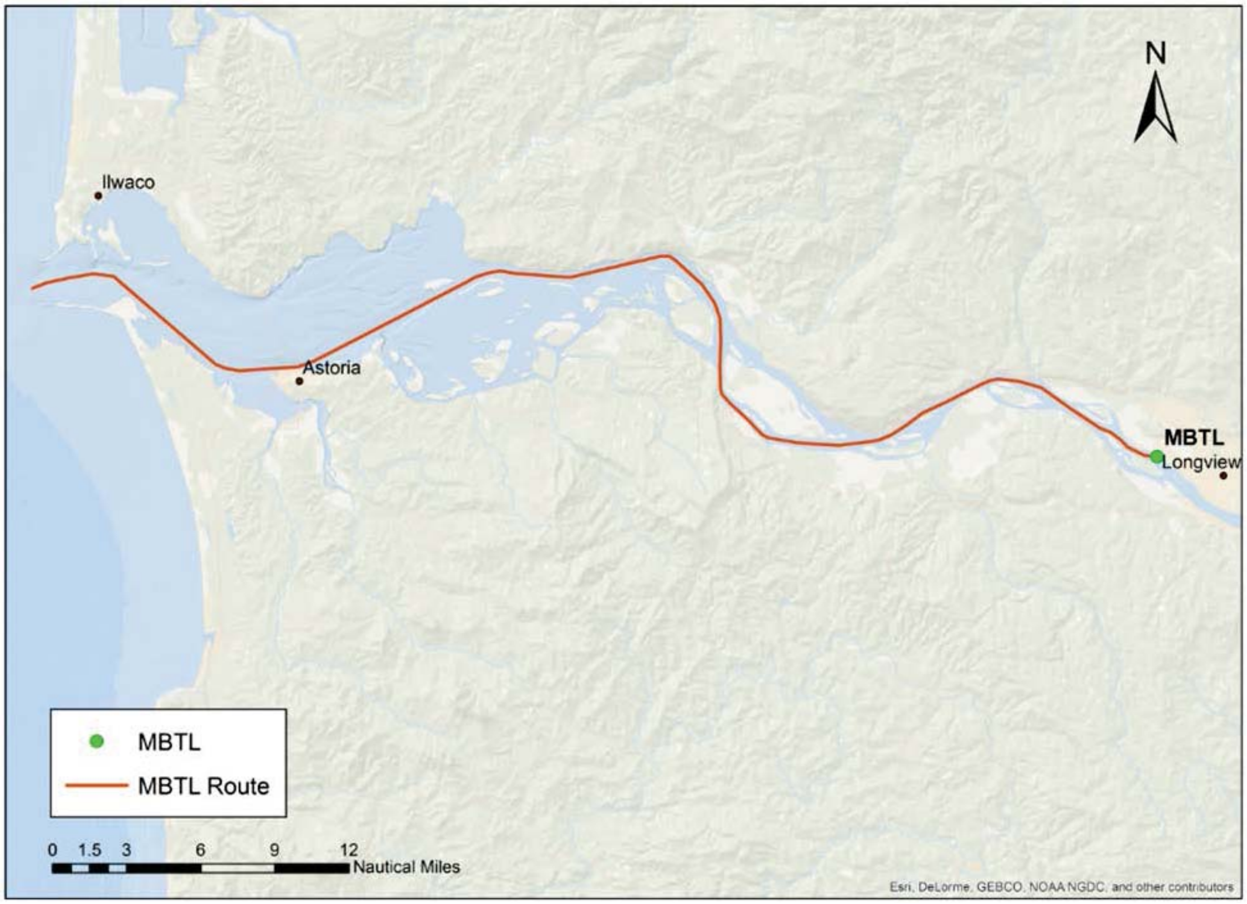


Figure 5-2 Project Vessel Inbound and Outbound Route

5.1.3 Traffic Increase and Potential Projects

An increase of 1% per year was applied to the 2014 baseline traffic data for all vessel categories; with the exceptions of project vessels which will remain constant from 2028 on (Ref. /5/).

Projected increases in vessel traffic from reasonably foreseeable future projects were also included in the analysis. These projects were identified through research and conversations with various stakeholders in the study area. The number of vessels expected to be added to river traffic was added to specified areas after the 1% per year increase has been applied. Vessel traffic from potential future projects are shown in

Table 5-2 and Figure 5-3 below – this additional vessel traffic is applied in case 4 and case 5 only (2038 with and without the project).

Table 5-2 Vessel Traffic from Potential Future Projects

Project	Location	Vessels per Year *	Anticipated Vessel Type and Cargo
Columbia Pacific Bio-Refinery	Port Westward – Clatskanie, OR	108	Tanker – Crude Oil
Columbia River Carbonates	Woodland, WA	24	Cargo – Calcium Carbonate Stone
Coyote Island Terminal Project	Port of Morrow – Broardman, OR	133	Cargo - Coal
Kalama Manufacturing and Marine Export facility	Port of Kalama-Cowlitz County, WA	54	Carrier - Methanol
LPG Facility – Pembina Pipeline Corp.	Port of Portland	30	Carrier - Propane
Northwest Innovation Works, LLC	Port Westward in Clatskanie, OR	54	Carrier - Methanol
Oregon LNG	Warrenton, OR	125	Carrier - LNG
Riverside Refinery	Port of Longview, WA	24	Tanker – Crude Oil
Vancouver Energy Project	Port of Vancouver, WA	290	Tanker - Crude Oil
Vancouver Transportation Logistic Improvement	Port of Vancouver, WA	18	Tanker – Crude Oil
Washington Energy Storage and Transfer	Port of Longview, WA	54	Carrier - LPG

*Included in 2038 MARCS models, no-project and with-project scenarios.

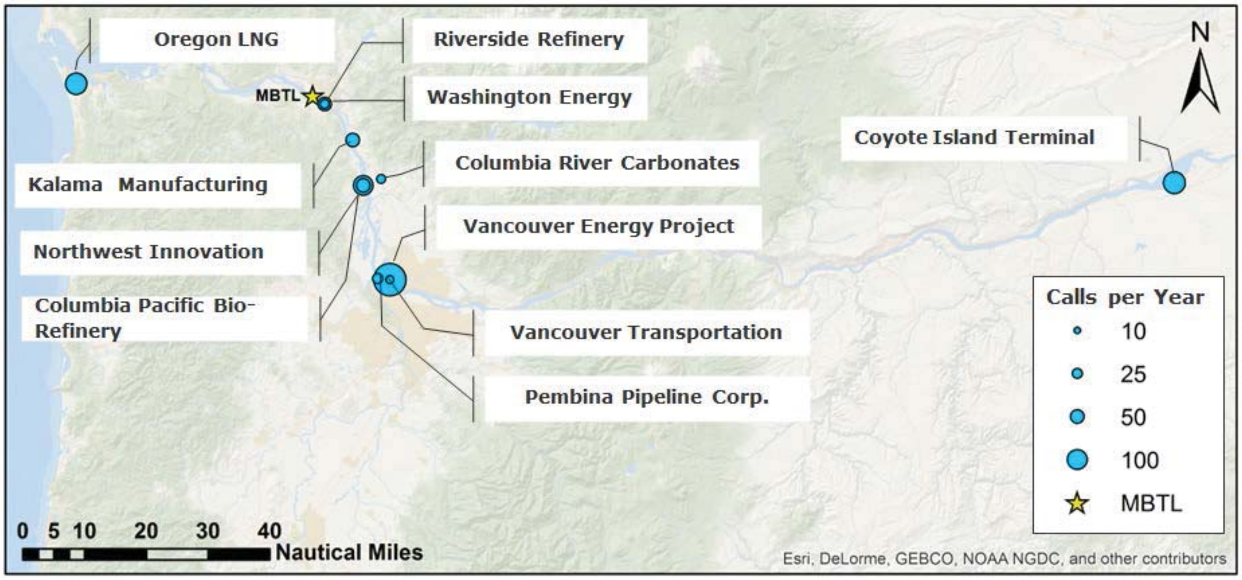


Figure 5-3 Terminal Locations and Annual Call Frequency for Potential Future Projects

5.1.4 Environmental Data

The MARCS model utilized met-ocean data that include wind speed, wind direction, and visibility statistics for the study area. To ensure high levels of accuracy, these data should cover areas in close proximity to the shipping route that project vessels will use at the approach to and from the terminal. The categories of data that would be implemented are as follows:

- Visibility data
- Wind data
- Sea-state data

The stations from which data were obtained are presented in Figure 5-4.

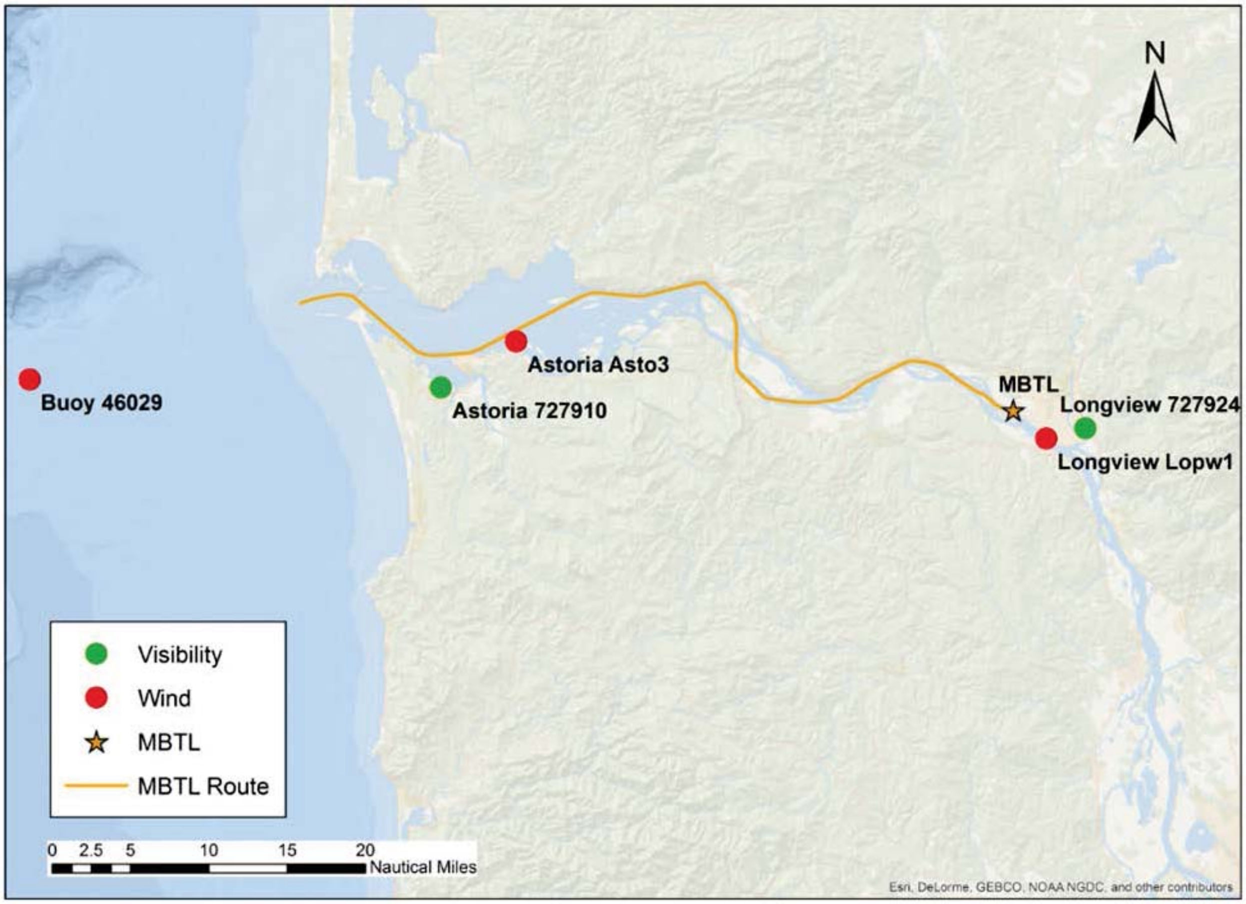


Figure 5-4 Weather Data Station Locations

Each station has a particular area of coverage that must be assigned in the MARCS model. The coverage areas for each station are presented in Figure 5-5.

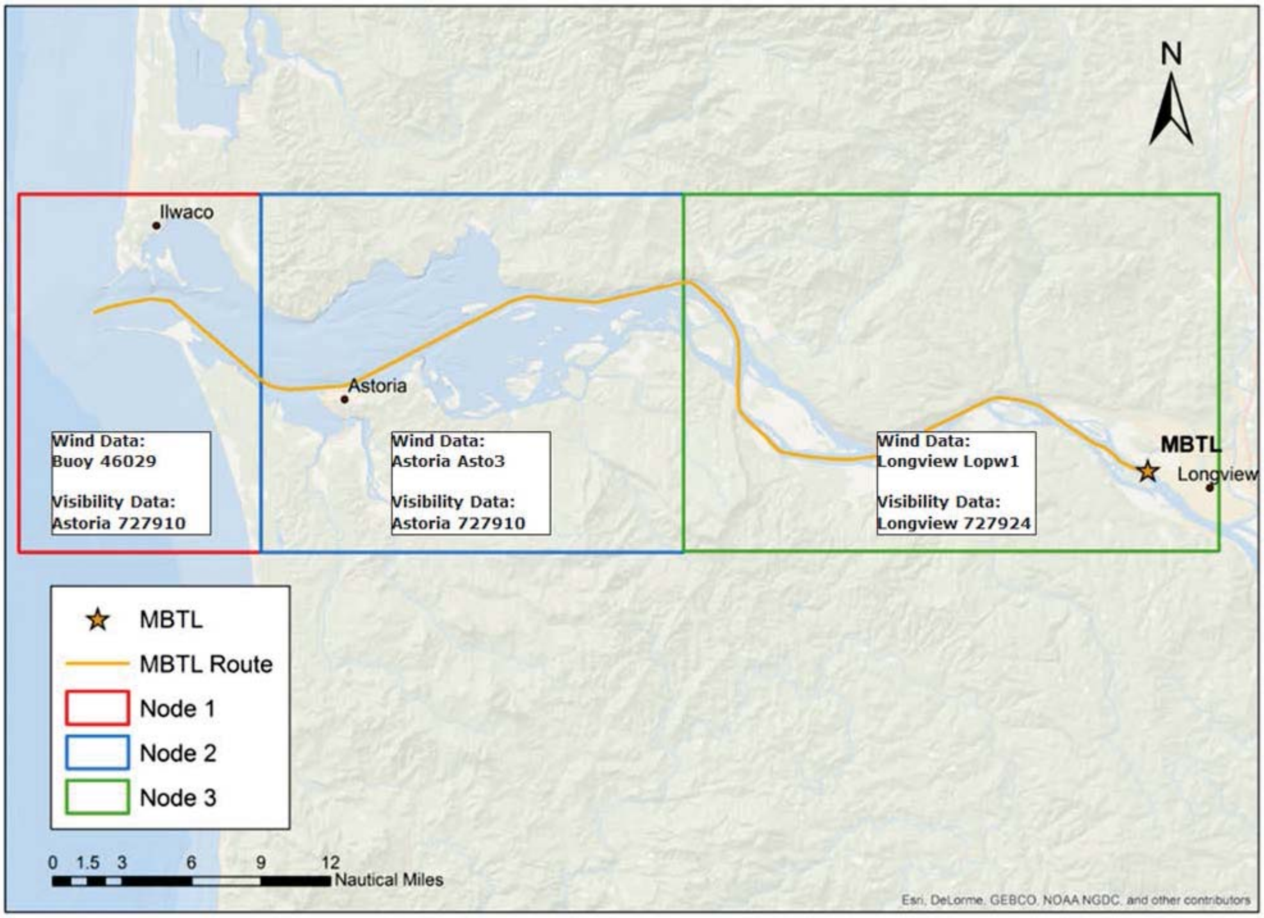


Figure 5-5 Areas of Coverage for Weather Stations

5.1.4.1 Wind Data

The wind data provide magnitude and corresponding probabilities for all relevant scenarios which were input into MARCS as factors that affect grounding frequencies. The wind data were divided into four speed categories (0-20, 20-30, 30-45, 45+ knots).

The probability of occurrence for the wind speed categories applied in MARCS is presented in Table 5-3.

Table 5-3 Wind Speeds Applied in MARCS (probability of occurrence) (Ref. /6/, /7/, /8/, /9/)

Weather Station	0-20 knots	20-30 knots	30-45 knots	>45 knots
Buoy 46029	0.88	0.11	0.01	0.00
Astoria	0.99	0.00	0.00	0.00
Longview	1.00	0.00	0.00	0.00

Due to lack of available sea state data, sea-state is taken as a function of wind speed.

5.1.4.2 Visibility Data

The probability of occurrence for good and poor visibility applied in MARCS is presented in Table 5-4.

Table 5-4 Visibility Data Applied in MARCS (probability of occurrence) (Ref. /7/,/8/,/9/)

Weather Station	Good (>2 nm)	Poor (<2 nm)
Astoria	0.87	0.13
Longview	0.98	0.02

Good visibility is defined as visibility greater than 2 nm; poor visibility is defined as visibility less than 2 nm.

5.1.5 Existing & Assumed Risk Reduction Measures

Risk reduction options are applied to vessels transiting the study area based on vessel type and location. The risk reductions applied in the modeling per vessel category are shown in Table 5-5.

Table 5-5 Risk Reduction Options Applied by Vessel Category

	Project Vessels	Tankers / Cargo Carriers	Tug	All Other Vessels
TV32	Yes	Yes	Yes	No
Pilotage	Yes	Yes	Yes	No
Portable Pilotage Unit	Yes	Yes	Yes	No
Digital Global Positioning Satellite	Yes	Yes	No	No
Conventional Aids to Navigation	Yes	Yes	Yes	Yes
Electronic Chart Display and Information System	Yes	Yes	No	No
Port State Control	Yes	Yes	No	No
Under Keel Clearance Management	Yes	Yes	No	No

The subsequent sections detail the effects of the above risk reduction options.

5.1.5.1 Transview32

TV32 is a real time, vessel traffic information and management system that provides a real-time portrayal of vessel movements and interactions on the river along with water depth, current flow information and updated bathymetry charts. It combines four different systems that provided 2-centimeter spatial resolution accuracy (Ref. /10/):

- AIS
- ENC and ECDIS

- NOAA Nautical Charts
- NOAA Physical Oceanographic Real-Time System (PORTS)
- DGPS

PORTS creates a layered architecture of ocean technologies (i.e., three acoustic sensors, with a back-up pressure sensor for freezing conditions) to measure surface current speeds, water depth, and wind direction and speed. The resolution of all acoustic and pressure sensors is 1 mm and the sample interval is every six minutes. Data are transmitted and displayed on the TV32 interface every six minutes.

TV32 may enhance Bar and River Pilot’s performance by:

- Providing redundancy against ship navigational equipment failure or incorrect calibration.
- Providing improved accuracy compared to the ship’s own equipment.
- Providing fine spatial and time resolutions
- Providing a layered architecture of technology systems for increased situational awareness.
- Allowing Pilots to accurately determine vessel meeting points to facilitate informed decision making regarding navigation, anchorage, and traffic coordination.

TV32 is considered a Vessel Traffic Information System (VTIS). The risk reduction factor of TV32, as its own unique navigation tool, was not quantified.

Risk reduction factors for a Vessel Traffic Service (VTS) have been quantified by DNV GL. The USCG operates Vessel Traffic Centers (VTC) which provide a VTS in 12 ports in the U.S. One of the differences between a VTS and a VTIS is that in a VTS, vessel location, speed and course data are consolidated in a centralized location, such as a control room (typically staffed by USCG personnel who, when necessary, are authorized by the local Captain of the Port to provide direction to vessel masters) and relevant information is disseminated from the control room to ships in the area. In a VTIS, vessel location, course, and speed data are made available directly to vessels operating in the area so that navigation decisions can be agreed upon between the pilots. As such, TV32 is regarded to be an efficient form of data dissemination given the nature of vessel traffic management on the Columbia River where navigation decisions are made by Columbia River Bar Pilots and Columbia River Pilots.

Table 5-6 summarizes a selection of relevant studies addressing the reduction in collision and grounding frequencies based on implementation of a VTS.

Table 5-6 Summary of Studies that Quantify the Effects of VTS

Study	Information
COST-301: Shore-based Marine Navigation Aid Systems (Ref. /11/)	Estimated radar-based VTS would provide a 40% risk reduction for collisions and groundings
Ship Collision with Bridges (Ref. /12/)	Found a 50% to 67% risk reduction
The Estimation of Collision Risk for Marin Traffic in UK Waters (Ref. /13/)	Indicated that the effects of VTS were most prominent in thick fog Example: In the case of crossing encounters with 99% clear and 1% thick fog, a 57% reduction was found
Safety of Shipping in Coastal Waters Summary Report (Ref. /14/)	Quoted data from the Western Sheldt estuary that indicated a 40% risk reduction for collisions and a 20% risk reduction for powered groundings
Summary Report on Evaluating VTS and Pilotage as Risk Reduction Measures (Ref. /15/)	Reports various studies in the Baltic area obtaining a 55% to 80% risk reduction

The progressive adoption of VTS may contribute to an overall decrease in global incident frequencies of collisions and groundings, as the studies indicate. This collectively resulted in a 43% risk reduction for groundings and 30% risk reduction for collisions.

TV32 does not have USCG 24/7 oversight as a VTS does, although for the purposes of this study, DNV GL finds it appropriate to give TV32 the same level of risk reduction as VTS.

5.1.5.2 Pilotage

Pilotage would be compulsory for all project vessels. The presence of Bar and River Pilots was accounted for in MARCS for project vessels, as well as on cargo/carriers, tankers, and tugs . Pilotage was included as a risk control measure, decreasing the frequency of collision and powered grounding.

When representing the effects of Pilotage, or any risk reduction option, in MARCS, the model parameters are modified according to Performance Shaping Factors (PSFs). A performance shaping factor is a factor that accounts for a risk reduction and is defined as:

$$PSF = \frac{Probability\ of\ model\ parameter\ without\ risk\ reduction\ option}{Probability\ of\ model\ parameter\ with\ risk\ reduction\ option}$$

Previous worldwide research listed in Table 5-7 quantified the effects of Pilotage. PSFs for Pilotage were used to account for an estimated 26% reduction of incident frequency for collision, and a 51% reduction of incident frequency for powered grounding.

Table 5-7 Summary of Studies that Quantify the Effects of Pilotage

Study	Information
Ship Collision with Bridges (Ref. /12/)	Indicates that a Pilot on board reduced incident frequency by 83%
Risk Assessment of Pollution from Oil and Chemical Spills in Australian Ports and Waters (Ref. /16/)	49% risk reduction for compulsory Pilotage for majority of ships
Assessment of the Risk of Pollution from Marine Oil Spills in Australian Ports and Waters (Ref. /16/)	Updated 1999 DNV study recently as a 50% risk reduction for "non-compulsory Pilotage"
Summary Report on Evaluating Pilotage as Risk Reduction Measures (Ref. /15/)	Reports various studies using risk reduction factors in the range of 50%-97% reduction. Note: No data in this report is used in this study to support specific risk reduction factors.

5.1.5.3 Portable Pilotage Unit

The Portable Pilotage Unit (PPU) is a portable GPS unit, which gives Pilots their own source of accurate heading and positioning data, displayed on an electronic chart. It can be seen as a support tool to enhance the pilot's navigational performance. PPUs' benefits include:

- Familiarity to Pilots.
- Provides additional redundancy against ship navigation equipment failure or incorrect calibration.
- Provides onboard VTIS to a Pilot in real time.

Combined with pilotage, it is judged that PPU was modelled to improve the pilot's human error performance with respect to powered grounding by 10%. The effects of collisions are assumed to be negligible in comparison.

5.1.5.4 Differential Global Positioning Systems

Differential Global Positioning Systems (DGPS) signals allow a receiver to calculate its position based on signals received from triangulation of GPS satellites, thereby enhancing GPS.

The advantages of DGPS over conventional aids to navigation (AtoN) are that:

- It provides a very accurate and continuously updated calculation of the ship's position in all weather conditions.
- It requires less time than conventional navigation and hence reduces bridge workload (i.e., by plotting on a conventional chart).

Although DGPS is widely believed to make a major contribution to the safety of navigation, there are no known studies that provide a comparison between incident rates of vessels equipped with DGPS versus vessels with conventional (non-GPS) navigation. Figure 5-6 shows the global historical trend in the frequency of groundings in the world-wide fleet, most of which are powered groundings. The frequency of total losses has declined at an average rate of approximately 5.5% per year. However, when serious casualties and non-serious incidents are included, the frequency appears to increase from 2002 to 2007. The causes were not entirely clear, but the effect was that the global historical trend does not show any clear decline that could be apportioned into its various causes, including aids to navigation, changes in operating procedures and safety management.

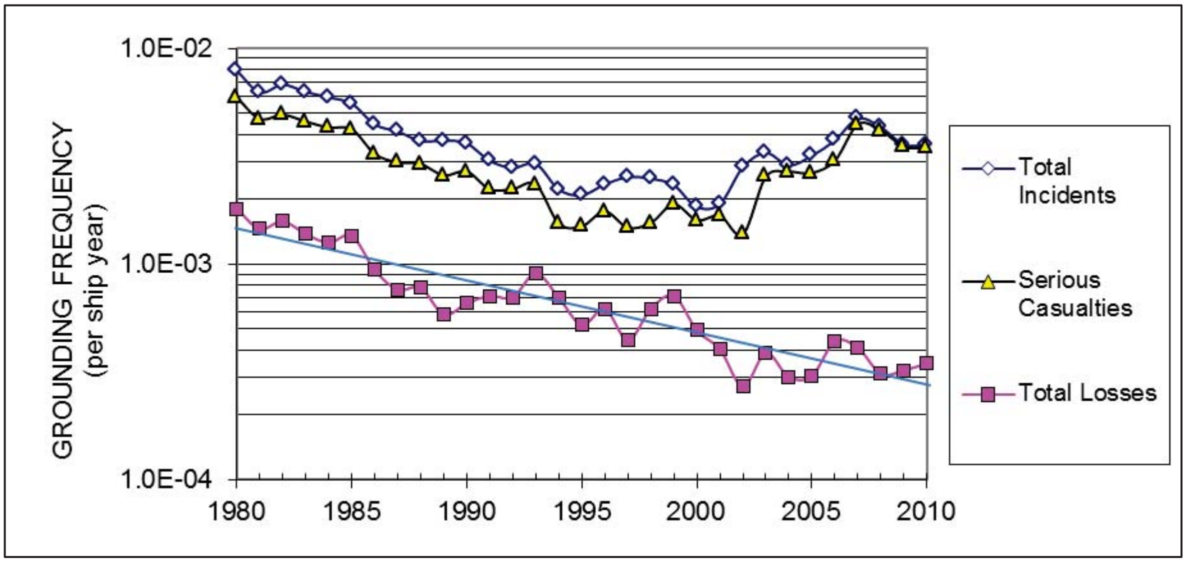


Figure 5-6 Global Grounding Frequency Trends, 1980-2010

The best available data concerning causes of grounding incidents studied Norwegian registered ships over 1,600 Gross register tonnage (GRT) during 1970 to 1978. It described the main causal areas as shown in Table 5-8.

Table 5-8 Causal Factors in Groundings, 1970-78 (Ref. /17/)

Causal Factor		Contribution	
External conditions		**39.9%**	
	Channel and shallow water		18.9%
	Reduced visibility		12.6%
	Fault/deficiency of lights, marks etc.		6.4%
	Other external conditions		2.0%
Technical failure		**8.8%**	
	Fault in the ship's technical systems		5.7%
	Other technical failures		3.1%
Inadequate navigational factors		**18.9%**	
	Bridge manning/organization		8.4%
	Error/deficiency in charts/publications		8.1%
	Other navigational factors		2.4%
Navigational error		**22.9%**	
	Navigation and maneuvering factors		11.7%
	Misinterpretation of lights/marks		8.4%
	Other navigational error		2.8%
Non-compliance		**8.1%**	
	Inadequate coverage of the watch		5.7%
	Other non-compliance		2.4%
Other ship		**1.4%**	**1.4%**
Total		**100.0%**	**100.0%**

Errors in conventional navigation, which might be prevented by GPS, were represented by "misinterpretation of lights/marks", and amounted to 8.4% of incidents. GPS would not necessarily prevent all such errors, and indeed may have some negative impacts that would not be visible in data from this period. However, GPS might have indirect benefits on all navigational errors. Therefore a reduction in groundings of 8.4% is justified by this data as all project vessels will be equipped with GPS.

5.1.5.5 Conventional Aids to Navigation

Conventional aids to navigation are key enablers for spatial awareness, leading to safe navigation. Aids on the Columbia River comprise a group of interacting external reference devices intended to collectively provide sufficient and timely information with which to safely navigate (Ref. /18/). The aids include a series of fixed and floating aids, which are visual, aural, electronic or any combination of all three.

There is no obvious baseline (i.e. risk without AtoN) that could be used for comparison. However, it is possible to consider the benefits of improvements in conventional AtoN.

Data shown in Table 5-8 were used to indicate the effects of conventional AtoN in reducing powered grounding. Using conventional AtoN decreases the number of incidents related to deficiency or fault of lights and markings by 6.4%. Therefore, a reduction in groundings by 6.4% can be justified by these data.

5.1.5.6 Electronic Navigation Charts on ECDIS

An Electronic Chart Display and Information System (ECDIS) is an electronic navigation aid that can be used instead of paper charts and publications to plan and display a ship's route and plot, and monitor its position throughout a voyage.

ECDIS's benefits include:

- It provides a continuous display of a vessel's position in relation to land, charted objects, aids to navigation and possible unseen hazards.
- It provides an improved representation of the vessel's position, compared to paper charts.
- It reduces the workload due to position plotting.
- It can be located where convenient on the bridge, so as to enable the watch-keeper to maintain a good lookout, instead of needing a screened chart table.
- It allows charts to be updated in a more efficient way by inserting a CD into the ECDIS computer, instead of manually annotating paper charts.
- It allows route planning and continuous monitoring.
- It provides improved functionality, such as:
    - o Location polygons can be defined and alarms set if the ship exits defined safe areas.
    - o AIS data can be displayed.
    - o Radar targets can be superimposed on the ECDIS.

The potential risk reduction achieved by implementation of ECDIS was evaluated in previous research. A Formal Safety Assessment (FSA) was submitted to IMO Marine Safety Committee in 2006 in connection with a proposal for ECDIS carriage requirements. The assessment concluded that ECDIS reduced grounding risk by approximately 36%. This was due to a combination of more time available on the bridge for situational awareness, more efficient plotting of the ship's position and more efficient updating routines. A subsequent study (Ref. /19/) that took account of 11 different routes and a mix of ship types found reductions in grounding risk between 11% and 38% due to variations in ECDIS coverage. Where ECDIS coverage was 100% the reduction in grounding risk was 38%.

A 38% reduction in powered grounding was applied because the Columbia River was considered to have 100% ECDIS coverage.

While ECDIS provides a continuous display of a vessel's position in relation to land, charted objects and AtoN, it does not display another vessel's position. Seeing another vessel's location is necessary to reduce the risk of collision. Therefore, no reduction was applied for collision.

5.1.5.7 Port State Control

Port State Control (PSC) is the inspection of ships in national ports to verify that the condition of the ship and its equipment complies with the requirements of international regulations and that the ship is also manned and operated in compliance with these rules. In this report, the term PSC was also used to include other general shipping industry initiatives with similar goals, such as: classification society rules; enhanced surveys; vessel design standards; and bunker fuel oil quality testing.

Knapp et. al., (Ref. /20/) estimated the survival gains for different ship types in the years 2003 to 2007 based on individual ship loss experience and PSC inspections in Australia and the USA. PSC inspections were associated with ship survival gains of 0.1% to 0.5% on base risk rates of 1-3%. Combining the data for four cargo ship types over five years, the average gain was 12% of the risk of total loss. The average benefit may be smaller because not all ships are inspected. On the other hand, the benefit may be increased through the targeting of inspections of high-risk ships, and the possibility that any ship may be inspected and detained if not compliant. Overall, this analysis was considered to provide the best estimate of the benefit of PSC.

The effect of PSC was represented by:

- Applying a PSF of 0.88 for all the technical failure rates in the risk model. This directly affects the frequency of drift grounding, fire / explosion and foundering. It also has a very minor impact on collision and powered grounding (which are dominated by human error and human incapacitation).
- Applying a human error and human incapacitation PSF of 0.88 in the collision and powered grounding incident models. This represents the emphasis placed on International Safety Management (ISM) regulations by PSC inspections and should help ensure reductions in the likelihood of excessively fatigued navigating officers.

5.1.5.8 Underkeel Clearance Management

Underkeel clearance (UKC) is managed by the Pilots and vessel masters and is required by a ship's Safety Management System (SMS). Vessels calling at the Project terminal depart a dock or enter the river only when they can make the transit of the entire river with a minimum 2 feet of underkeel clearance and 10 feet across the bar. UKC management takes into account tide, weather, and vessel characteristics to ensure the underkeel clearance standard is maintained. The availability of water level sensor data via PORTS is a key component of the UKC management system on the Columbia River.

The main benefit of UKC management system is that it ensures adequate clearance between a vessel's keel and the river bottom to avoid grounding by providing improved information to navigators on underkeel clearance.

For an individual transit of a deep-draft vessel, an UKC management system is expected to make a significant reduction in grounding probability. Since UKC management is required on the river and at the port, a 10% reduction in powered grounding probability is reasonable.

5.2 DNV GL Methodologies

This section provides an overview of the methodologies applied in this study. First a description of the method for modeling marine incident frequencies is provided (Section 5.2.1), followed by the method for estimating whether each incident leads to a bunker oil spill (Section 5.2.2 and 5.2.3) and finally the method for estimating the spill volume given a bunker oil spill event has occurred (Section 5.2.4).

5.2.1 MARCS Model

The frequency of marine incidents involving project vessels was estimated using MARCS software. MARCS was developed by DNV GL to support its navigational risk consultancy services.

MARCS combines data for vessel traffic (e.g., vessel types, sizes, routes, and transit frequencies), the marine environment (e.g., location of shallow water, visibility data, and wind data) and operational aspects of shipping (e.g., pilotage, escort tugs) to predict the frequency of incidents at sea, such as:

- Collision
- Drift grounding
- Powered grounding
- Fire / Explosion

Collisions generally occur in the navigable part of the channel where the traffic is most dense. Drift and powered groundings occur near the shoreline or in shallow waters.

Incident frequencies were estimated using MARCS for the proposed route.

5.2.1.1 The Collision Model

The collision model calculates the frequency of serious inter-ship powered collisions at a given geographical location in two stages. The model first estimates the frequency of encounters (critical situations for collision - when two vessels pass within 0.5 nautical miles of each other) from the traffic image data using a pair-wise summation technique, assuming no collision avoidance actions are taken. This enables the calculation of either total encounter frequencies, or encounter frequencies involving specific vessel types.

The model then applies a probability of a collision for each encounter, obtained from fault tree analysis, to give the collision frequency. The collision probability value depends on a number of factors including, for example, visibility or the presence of a Pilot.

Figure 5-7 shows a graphical representation of the way in which the collision model operates.

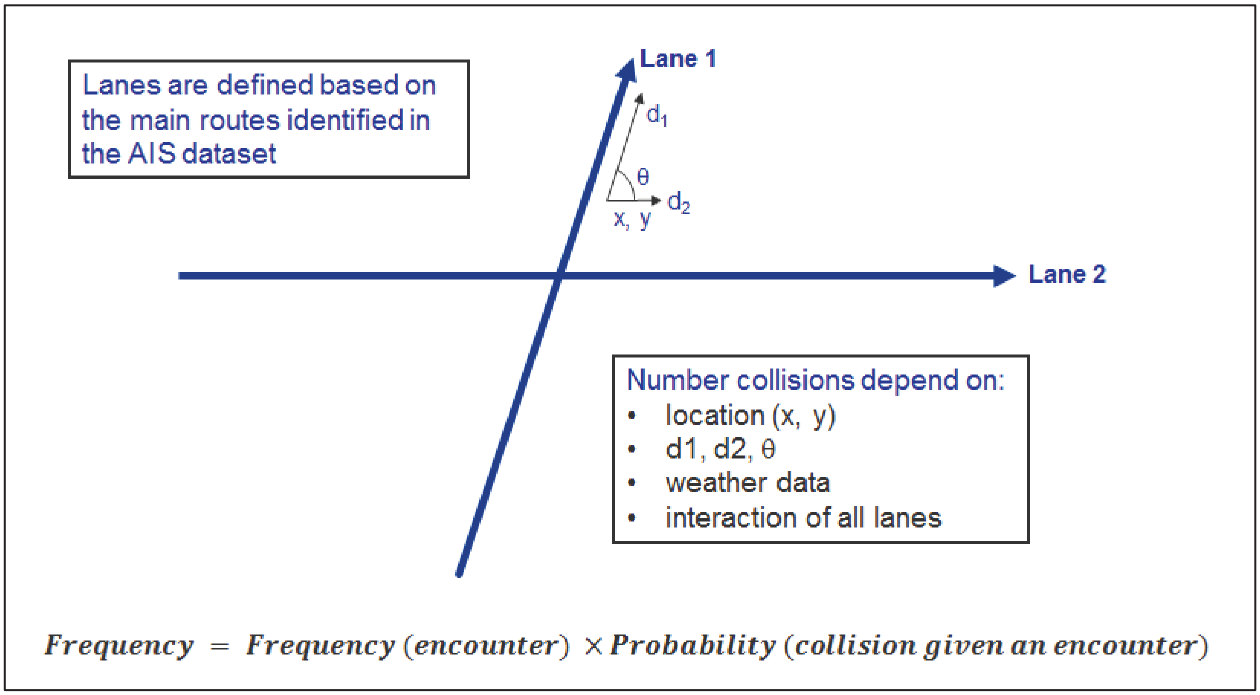


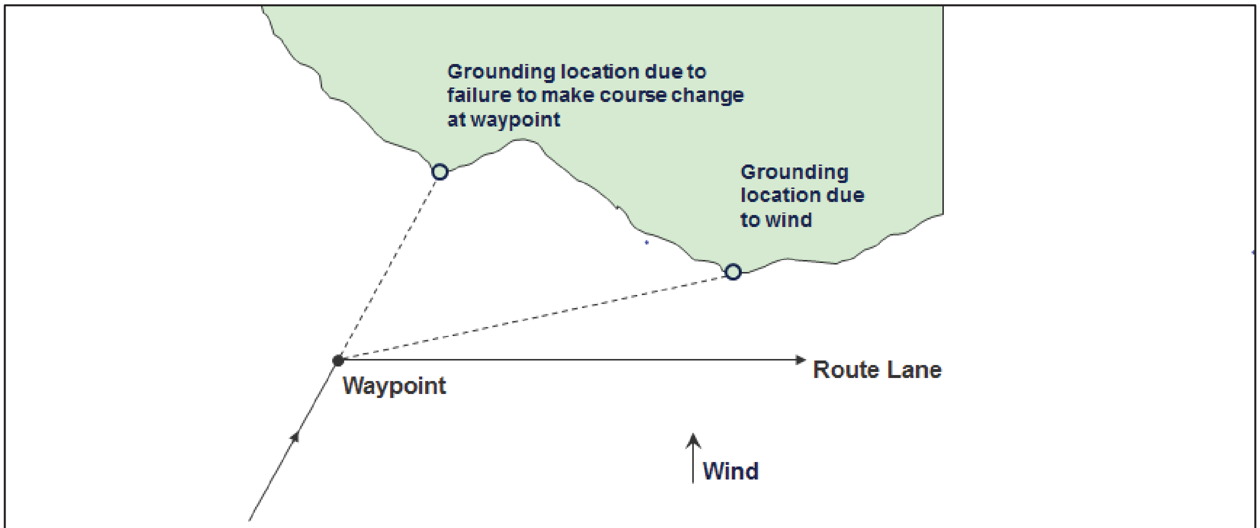
Figure 5-7 Graphical Representation of the Collision Model

In Figure 5-7, d_1 refers to the density of traffic associated with Lane 1 at the location (x, y). The frequency of encounters at location (x, y) through the interaction of Lanes 1 and 2 is proportional to the product of d_1, d_2 and the relative velocity between the lane densities.

5.2.1.2 The Powered Grounding Model

The powered grounding frequency model calculates the frequency of serious powered grounding incidents in two stages. The model first calculates the frequency of critical situations (sometimes called 'dangerous courses' for powered grounding incidents). Two types of critical situations are defined as illustrated in Figure 5-8. The first critical situation arises when a course change point (waypoint) is located such that failure to make the course change would result in grounding within 20 minutes navigation from the planned course change point if the course change is not made successfully. The second critical situation results when a grounding location is within 20 minutes navigation of the course centerline. In this case, crew inattention combined with wind, current or other factors could result in a powered grounding.

The frequency of serious powered groundings is calculated as the frequency of critical situations multiplied by the probability of failure to avoid grounding.



$$Frequency = (Frequency\ of\ vessels\ on\ lane\ aligned\ on\ location)\ x\ (Probability\ of\ failure\ to\ make\ course\ change)$$

$$Frequency = (Frequency\ of\ vessels\ in\ lane)\ x\ (Probability\ of\ inattention)\ x\ (Probability\ of\ wind\ to\ shore)$$

Figure 5-8 Graphical Representation of the Powered Grounding Model

The powered grounding probabilities are derived from the fault tree analysis of powered grounding. The powered grounding fault tree contains two main branches:

- Powered grounding through failure to make a course change whilst on a dangerous course. A dangerous course is defined as one that would ground the vessel within 20 minutes if the course change were not made.
- Powered grounding caused by crew inattention and wind or current from the side when the ship lane runs parallel to a shore within 20 minutes sailing.

Both these branches are illustrated in Figure 5-8. The powered grounding frequency model takes into account internal and external vigilance, visibility and the presence of navigational tools (e.g., radar) in deducing failure parameters.

5.2.1.3 The Drift Grounding Model

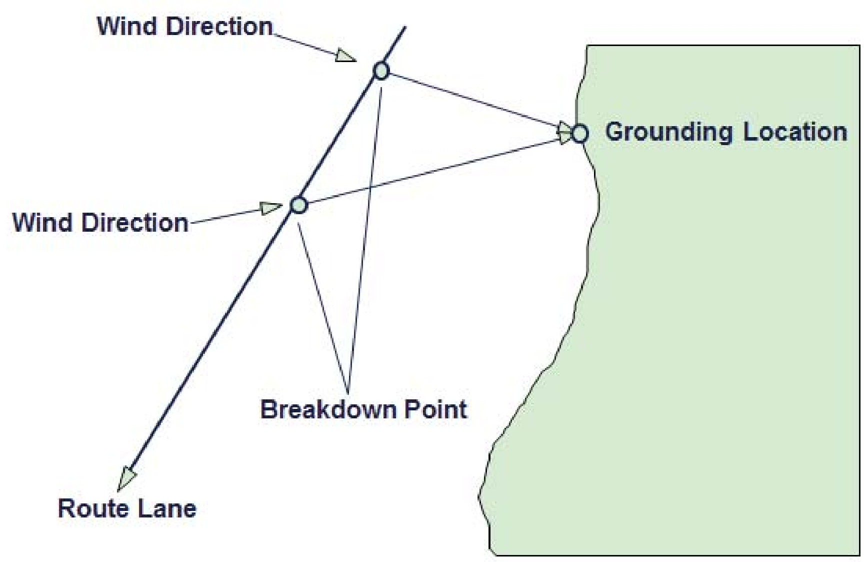
The drift grounding frequency model consists of two main elements: first, the ship traffic image is combined with the ship breakdown frequency factor to generate the location and frequency of vessel breakdowns; second, the recovery of control of drifting ships can be regained by one of three mechanisms:

- Repair
- Emergency tow vessel assistance
- Anchoring

Those drifting ships that are not saved by one of these three mechanisms (and do not drift out into the open sea) contribute to the serious drift grounding incident frequency results.

The number and size distribution of ships which start to drift is determined from the ship breakdown frequency, the annual number of transits along the lane and the size distribution of vessels using the lane.

The proportion of drifting vessels that are saved (fail to ground) is determined from the vessel recovery models. The drift grounding frequency model is illustrated in Figure 5-9.



$$Frequency = (Frequency\ of\ breakdown)\ x\ (Probability\ ship\ drifts\ to\ location)\ x\ (Probability\ ship\ not\ saved)$$

Figure 5-9 Graphical Representation of the Drift Grounding Model

Implicit in Figure 5-9 is the importance of the time taken for the ship to drift aground. When this time is lengthy (because the distance to the shore is large and / or because the drift velocity is small) then the probability that the ship will recover control before grounding (via repair or tug assistance) will be increased.

5.2.1.4 The Fire and Explosion Model

The fire / explosion accident frequency model applies the accident frequency parameters derived from accident data or fault tree analysis with calculations of the ship exposure time to obtain the serious accident frequency. The total ship exposure time (number of vessel hours) in any area can be calculated from the traffic image parameters (locations of lanes, frequencies of movements and vessel speeds). The fire / explosion serious accident frequency is then obtained by multiplying these vessel exposure times by the appropriate fire / explosion frequency factor (accidents per vessel-hour). It should be noted that fire / explosion frequency factors are assumed to be independent of environmental conditions outside the vessel.

5.2.2 Oil Spill Frequency Methodology

Incident frequency results from MARCS are used as input to determine the oil spill frequency. This section describes the methodology used to determine which incidents from MARCS results in an oil spill.

5.2.2.1 Collision

In calculating the conditional release probability for collision incidents, the amount of energy required to breach the bunker tank, referred to as the energy threshold. The energy threshold was taken as 13 MJ, which corresponds with the minimum distance from the bunker tank to the outer hull (1m) as specified by MARPOL requirements (Ref. /21/). The correlation between the indentation depth and the energy absorbed is presented in the Figure 5-10. The graph is based on a DNV GL finite element analysis of vessel collisions.

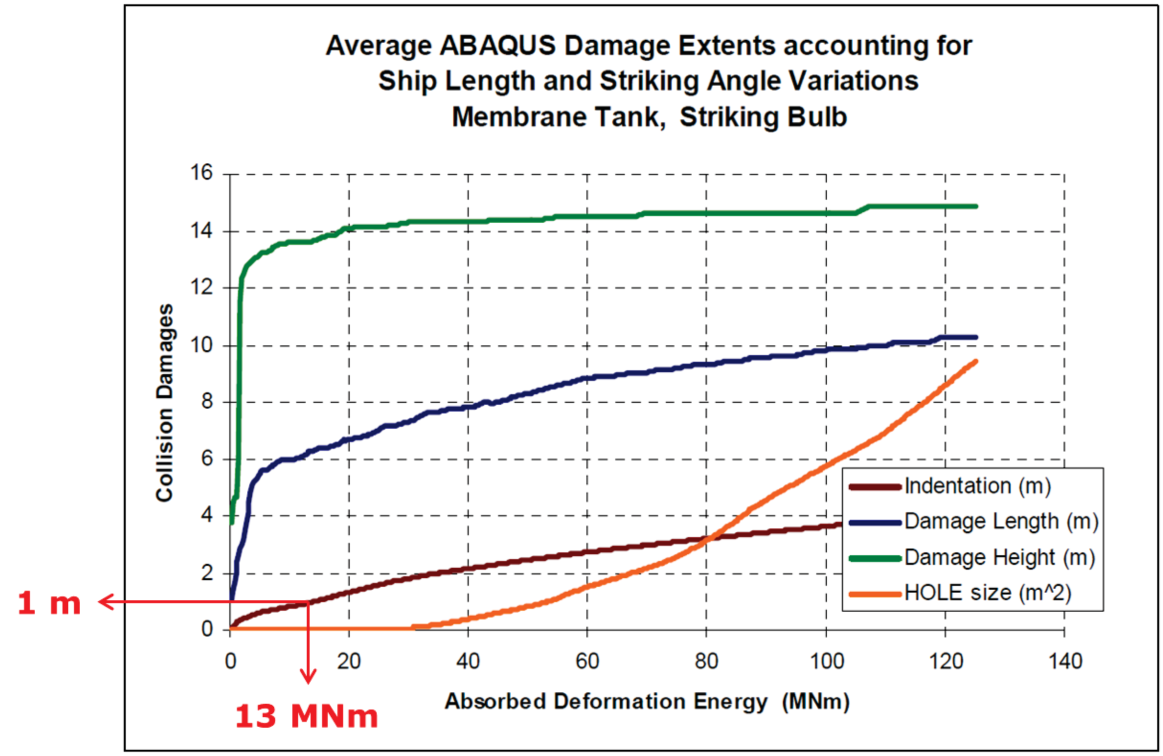


Figure 5-10 Relationship between Indentation Depth and Absorbed Energy

In estimating collision energy, information about vessels' masses and relative velocities is used to estimate the amount of energy involved in the collision, and therefore in the deformation, of the project vessel that could cause a loss of bunker oil to the environment.

The equation for assessing the estimated frequency of a bunker oil release is as follows:

$$F_{Bunker\ Oil\ Release} = F_{Collision} \times P_{E_{abs} > E_{crit}} \times P_{Geometric}$$

Where,

$F_{Collision} = Annual\ collision\ frequency$

$P_{E_{abs} > E_{crit}} = The\ probability\ that\ the\ energy\ absobed\ by\ the\ MBTL\ vessel\ exceeds\ the\ energy\ threshold$

$P_{Geometric} = Geometric\ probability\ of\ striking\ the\ vessel\ at\ a\ location\ of\ bunker\ tank$

As part of applying the theoretical methods to postulated events, several key assumptions are made:

1. 25% of the available impact energy is used towards deformation of the striking vessel. The remainder of the energy is assumed to deform the project vessel.
2. Angles of impact less than 22.5° or greater than 157.5° do not breach a cargo tank. These glancing impacts do not have a sufficiently steep angle to penetrate a project vessel.
3. A release of bunker oil is only credible if a project vessel is struck at a location with a bunker oil tank behind it.

Figure 5-11 provides an overview of the collision oil spill methodology.

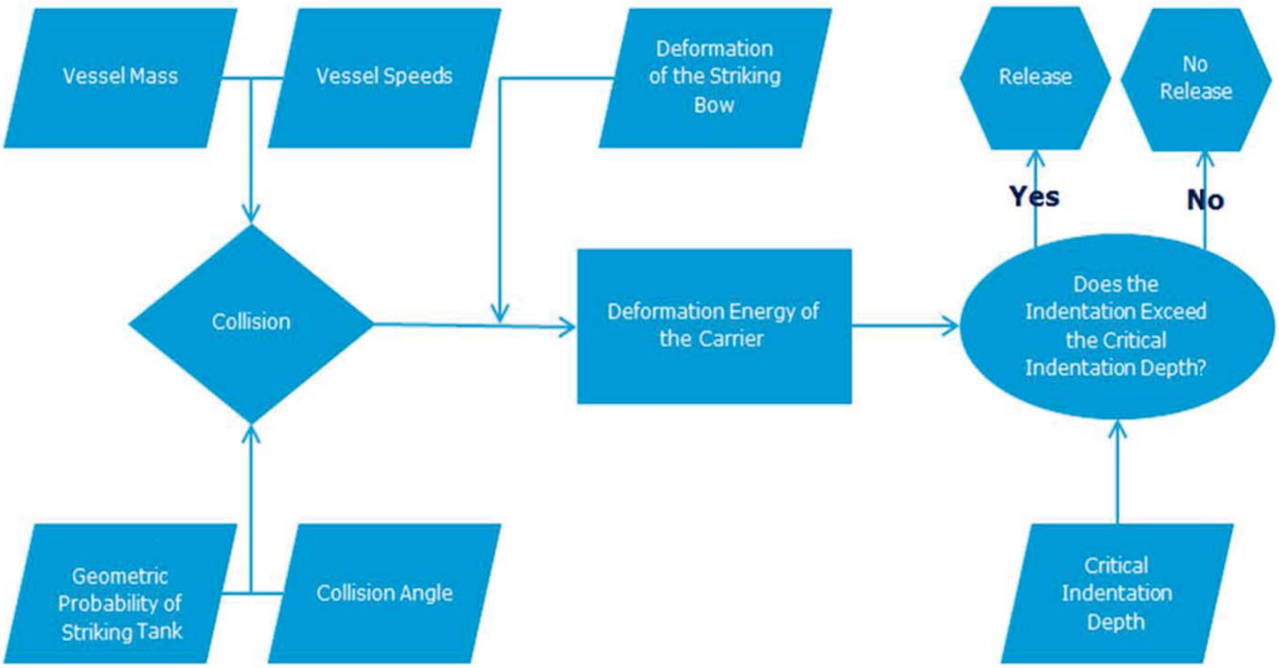


Figure 5-11 Collision Oil spill Methodology

5.2.2.2 Grounding

In order to estimate the probability of oil spill due to drift and powered grounding incidents, historical data are used in combination with route specific characteristics to estimate the potential for a release of bunker fuel. This approach utilizes a best fit cumulative distribution function to determine the probability that the indentation depth, caused by a grounding incident, exceeds the depth required to puncture the bunker oil tank. Based on MARPOL requirements (Ref. /21/), the distance between the outer hull and the bunker tank is assumed to be 1.6 m.

Based on impact data from the European Union-funded HARDER (Harmonisation of Rules and Design Rationale) studies and participation in the GOALDS (goal-based damage stability) project, DNV GL has developed an empirical formulation to estimate the probability of oil spill due to grounding. Vessels with lengths between perpendiculars greater than 100 m were included in the assessment. A narrower filter on the dataset was not possible without reducing the number of observations to an insignificant sample size.

The results of this analysis were done using a probability distribution estimation tool that showed that the best fit cumulative distribution function of the indentation depth was the Fréchet distribution. By definition, the Fréchet distribution gives the probability that the actual value will be less than the value (I_d) supplied to it. However, in this portion of the assessment we are interested in when the grounding might cause a bunker oil spill. Therefore, to get the probability that the indentation depth exceeds 2 m we subtract the Fréchet distribution from 1 as shown in the below equation and let $I_d = 1.6$.

$$F(I_d) = 1 - \exp\left(-\left(\frac{\beta}{I_d - \gamma}\right)^{\alpha}\right)$$

Where

$\alpha\ (shape\ parameter) = 2.629$
$\beta\ (scale\ parameter) = 1.9368$
$\gamma\ (location\ parameter) = 0$

5.2.3 Allision Calculation

The annual allision frequency is estimated as the likelihood that a non-project vessel will strike a project vessel at berth. The method was developed based on guidelines for vessel collision and bridges from the American Association of State Highway and Transportation Officials (AASHTO). Project vessel characteristics (such as ultimate resistance of the tanker), waterway characteristics, geometry, and marine traffic characteristics were compared to standard acceptance criteria to estimate the extent of damage to a project vessel.

The annual failure rate caused by vessel collisions, A_F, can be expressed as:

$$A_F = N \times P_A \times P_C \times P_G$$

Where:

$N =$ Number of vessels and type that transit the waterway.

$P_A =$ Probability of vessel aberrancy (to stray away from normal navigation channel).

$P_C =$ Probability that the study vessel's bunker tank will be punctured given that a passing vessel struck the study vessel.

$P_G =$ Geometric Probability associated with striking vessel type and the study vessel.

5.2.3.1 Probability of Aberrancy, P_A

The probability of aberrancy is a measure of the risk of a vessel losing control as a result of pilot error, adverse environmental conditions, or mechanical failure. The evaluation of accident statistics indicates that human error (causing 60% to 85% of the aberrancy cases) and environmental conditions are the primary causes of accidents. To evaluate probability of aberrancy, DNV GL accounted for the following factors: the geometry of the navigation channel and the location of project vessels in the channel; the current direction and speed; vessel traffic density; and cross currents.

The equation is:

$$P_A = BR\,(R_B)\,(R_C)\,(R_{XC})\,(R_D)$$

Where:

BR = aberrancy base rate (0.6×10^{-4} for vessel or 1.2×10^{-4} for barges);

R_B = correction factor for Sample Vessel location. $R_B = (1 + \frac{\theta}{90°})$

R_c = correction factor for current acting parallel to vessel path. $R_C = (1 + \frac{V_C}{10})$, with V_C specific to the proposed project.

R_{xc} = correction factor for crosscurrents acting perpendicular to vessel transit path. $R_{XC} = (1 + V_{XC})$, with V_{XC} specific to the proposed project.

R_D = correction factor for vessel traffic density depending on the frequency of vessels.

The specific risk controls that are accounted for in this portion of the analysis are:

- Electronic Chart Display & Information System.
- Pilotage.
- Vessel Traffic Information Service (TV32).

5.2.3.2 Probability of Bunker Tank Puncture, P_C

P_C must be interpreted as if a vessel has become aberrant and struck a project vessel at berth. In order to determine the potential to breach a bunker tank, it is necessary to calculate the available impact energy from the striking vessel. The available energy in the proximity of a project vessel is therefore assessed based on the speed and mass of the ships passing the berth.

The ship movements are defined by average speed and deadweight tonnage for each ship type. From these inputs, the maximum impact energy is estimated. The ratio of ultimate lateral resistance to the vessel impact force is also calculated to estimate the probability of sufficient energy to breach the hull and bunker tank of a project vessel.

5.2.3.3 Geometric Probability of Striking, P_G

In order to estimate geometric probability of striking, the assumption must be made that the striking vessel already strayed away from the navigation channel. Once a vessel has become aberrant, it is then necessary to estimate the probability that the vessel will strike a project vessel. To do this, geometric considerations are necessary.

The geometric probability is based on a number of parameters including the geometry of the waterway, location of the dock, sailing path of vessel, location, heading and velocity of vessel, environmental conditions, width, length, and shape of vessel, and vessel draft.

The lateral position of a vessel in the waterway follows a normal distribution with a mean value centered on the required path line (center line of navigation route). The standard deviation of this lateral position distribution is equal to the overall length of vessel designated as LOA. The use of a standard deviation equal to length of the vessel was justified based on accident data to reflect the influence of the size of the colliding vessel.

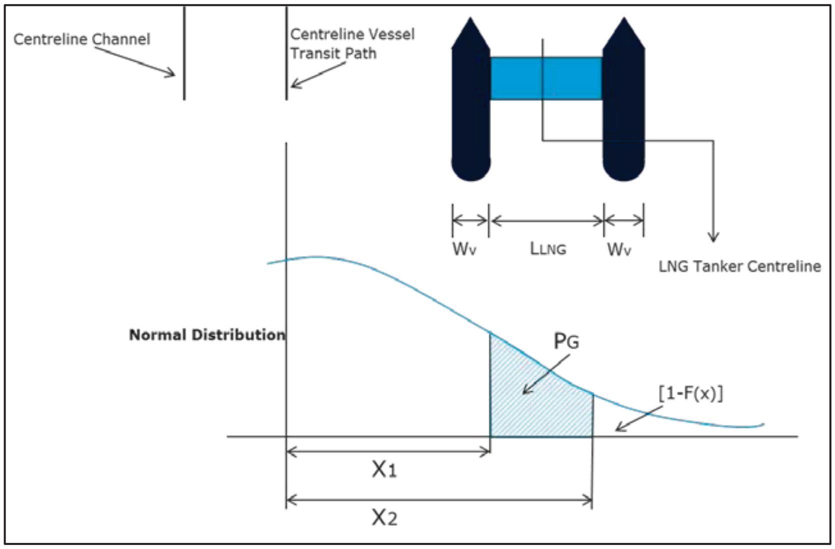


Figure 5-12 Model for Geometric Probability of Vessel Collision with the Sample Vessel

5.2.3.4 Omitting Analysis on Astoria-Megler Bridge

The decision to omit the allision analysis on the Astoria-Megler Bridge was based on feedback from Columbia Bar and River Pilots.

There was an allision at the Astoria-Megler Bridge that involved a piloted vessel approximately 30 years ago. Since this incident, Bar Pilots have implemented risk reduction measures to reduce the probability of allisions at the bridge; they avoid meeting other piloted vessels at the bridge, observe weather and river current conditions, and review weather forecasts before transiting under the bridge.

Given the very low historical frequency of allision at the Astoria-Megler Bridge and the assessment by the Bar and River Pilots that the bridge does not present an allision risk for piloted vessels, this structure has been omitted from the allision analysis.

5.2.4 NAPA Model

A commercial naval architecture package called NAPA is used to estimate the probability of oil outflow from project vessels. Using Monte Carlo simulations, in accordance with IMO Resolution MEPC.110(49) - Probabilistic Methodology for Calculating Oil Outflow, the model estimates oil outflow volumes based on the number of damaged cargo tanks and interaction with tidal influences. Monte Carlo simulations were run for 50,000 damage cases to estimate the potential variability in impact and in oil outflow volumes.

6 INCREMENTAL IMPACT OF PROJECT VESSELS ON RIVER NAVIGATION

6.1 Estimated Navigation Incident Frequencies

For each of the five cases presented in Section 5.1.1, incident frequencies for project vessel transits were estimated. These incident frequencies were estimated using the MARCS model and are limited to the study area. For this analysis, a marine incident was defined as an unintentional event (not a near miss), which may or may not result in a spill event. Incident frequencies were calculated for the following events:

- Collision
- Powered grounding
- Drift grounding
- Fire / Explosion
- Allision at Berth

6.1.1 2014 Existing Traffic

Table 6-1 provides estimated incident frequencies by vessel type for existing conditions (2014).

Table 6-1 Incident Frequency by Vessel Type for Non-Project Vessels (2014)

	Cargo / Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Total Incident Frequency
Collision	3.96E-01	3.41E-01	3.77E-01	8.53E-02	8.34E-02	3.24E-01	2.29E-02	3.09E-01	1.94E+00
Fire / Explosion	1.02E-03	2.79E-04	4.32E-04	9.21E-05	9.12E-05	1.96E-04	5.85E-05	9.88E-04	3.15E-03
Powered Grounding	2.20E+00	1.70E+00	2.69E+00	6.77E-01	5.25E-01	1.81E+00	1.27E-01	2.07E+00	1.18E+01
Drift Grounding	9.13E-01	2.39E-01	3.85E-01	8.32E-02	8.04E-02	1.68E-01	5.26E-02	9.01E-01	2.82E+00
Total Incident Frequency	3.51E+00	2.28E+00	3.46E+00	8.46E-01	6.89E-01	2.30E+00	2.02E-01	3.29E+00	1.66E+01

6.1.2 2028 No-Action Traffic

Table 6-2 provides estimated incident frequencies by vessel type for 2028 without project vessels.

Table 6-2 Incident Frequency by Vessel Type for Non-Project Vessels (2028 No Action)

	Cargo / Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Total Incident Frequency
Collision	4.81E-01	4.53E-01	5.01E-01	1.13E-01	1.11E-01	4.29E-01	2.75E-02	4.10E-01	2.53E+00
Fire / Explosion	1.19E-03	3.21E-04	4.97E-04	1.06E-04	1.05E-04	2.26E-04	6.73E-05	1.14E-03	3.65E-03
Powered Grounding	2.56E+00	1.95E+00	3.10E+00	7.79E-01	6.03E-01	2.08E+00	1.46E-01	2.38E+00	1.36E+01
Drift Grounding	1.07E+00	2.74E-01	4.42E-01	9.56E-02	9.24E-02	1.94E-01	6.05E-02	1.04E+00	3.27E+00
Total Incident Frequency	4.11E+00	2.68E+00	4.04E+00	9.88E-01	8.07E-01	2.70E+00	2.34E-01	3.83E+00	1.94E+01

6.1.3 2028 With-Project Traffic

Table 6-3 provides estimated incident frequencies by vessel type for non-project vessels under 2028 with-project conditions.

Table 6-3 Incident Frequency by Vessel Type for Non-Project Vessels (2028 With-Project)

	Cargo / Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Total Incident Frequency
Collision	5.16E-01	4.91E-01	5.54E-01	1.25E-01	1.22E-01	4.63E-01	2.99E-02	4.56E-01	2.91E+00
Fire / Explosion	1.17E-03	3.21E-04	4.97E-04	1.06E-04	1.05E-04	2.26E-04	6.73E-05	1.14E-03	4.01E-03
Powered Grounding	2.52E+00	1.95E+00	3.10E+00	7.79E-01	6.03E-01	2.08E+00	1.46E-01	2.38E+00	1.44E+01
Drift Grounding	1.05E+00	2.74E-01	4.42E-01	9.56E-02	9.24E-02	1.94E-01	6.05E-02	1.04E+00	3.59E+00
Total Incident Frequency	4.09E+00	2.72E+00	4.10E+00	1.00E+00	8.18E-01	2.74E+00	2.37E-01	3.88E+00	2.09E+01

Table 6-4 provides estimated incident frequencies for project vessels in 2028.

Table 6-4 Incident Frequency by Vessel Type for Project Vessels (2028 With-Project)

	Project vessel (inbound)	Project vessel (outbound)	Total Incident Frequency
Collision	7.63E-02	7.49E-02	1.51E-01
Fire/Explosion	1.90E-04	1.90E-04	3.80E-04
Powered Ground	3.98E-01	4.10E-01	8.07E-01
Drift Ground	1.71E-01	1.71E-01	3.42E-01
Allision at Berth	N/A	N/A	2.56E-02
Total Incident Frequency	6.46E-01	6.57E-01	1.33E+00

Figure 6-1 to Figure 6-3 present the incident results for collision, powered grounding and drift grounding for project vessels in 2028, respectively. It is noteworthy that the results for grounding of project vessels in 2028 are the same as the results for grounding of project vessels in 2038 because the number of project vessels is the same in both cases. Additionally, the reader should note that Figure 6-1 to Figure 6-3 have **different legend categories** and thus, need to be interpreted separately.

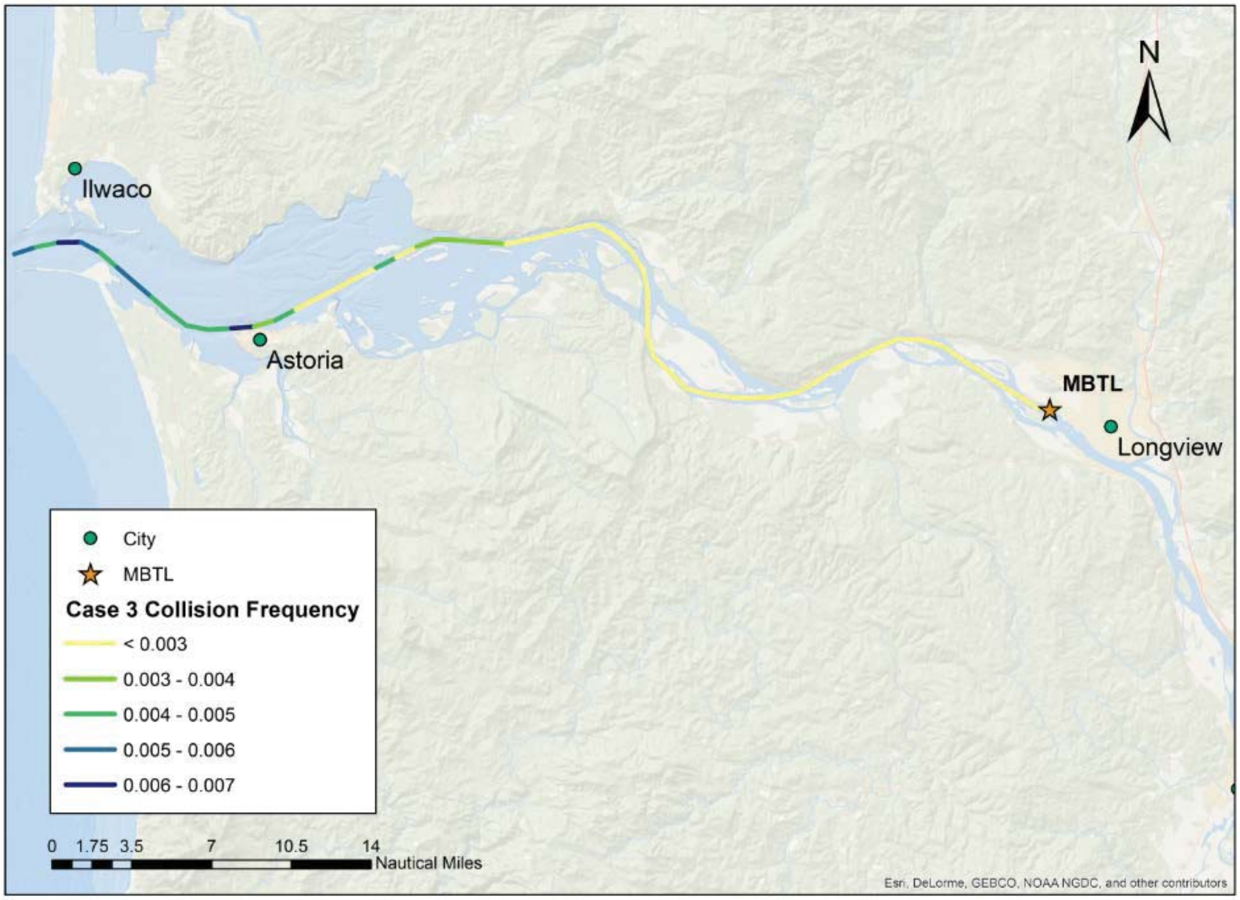


Figure 6-1 2028 Project Vessel Collision Incident Frequency Results

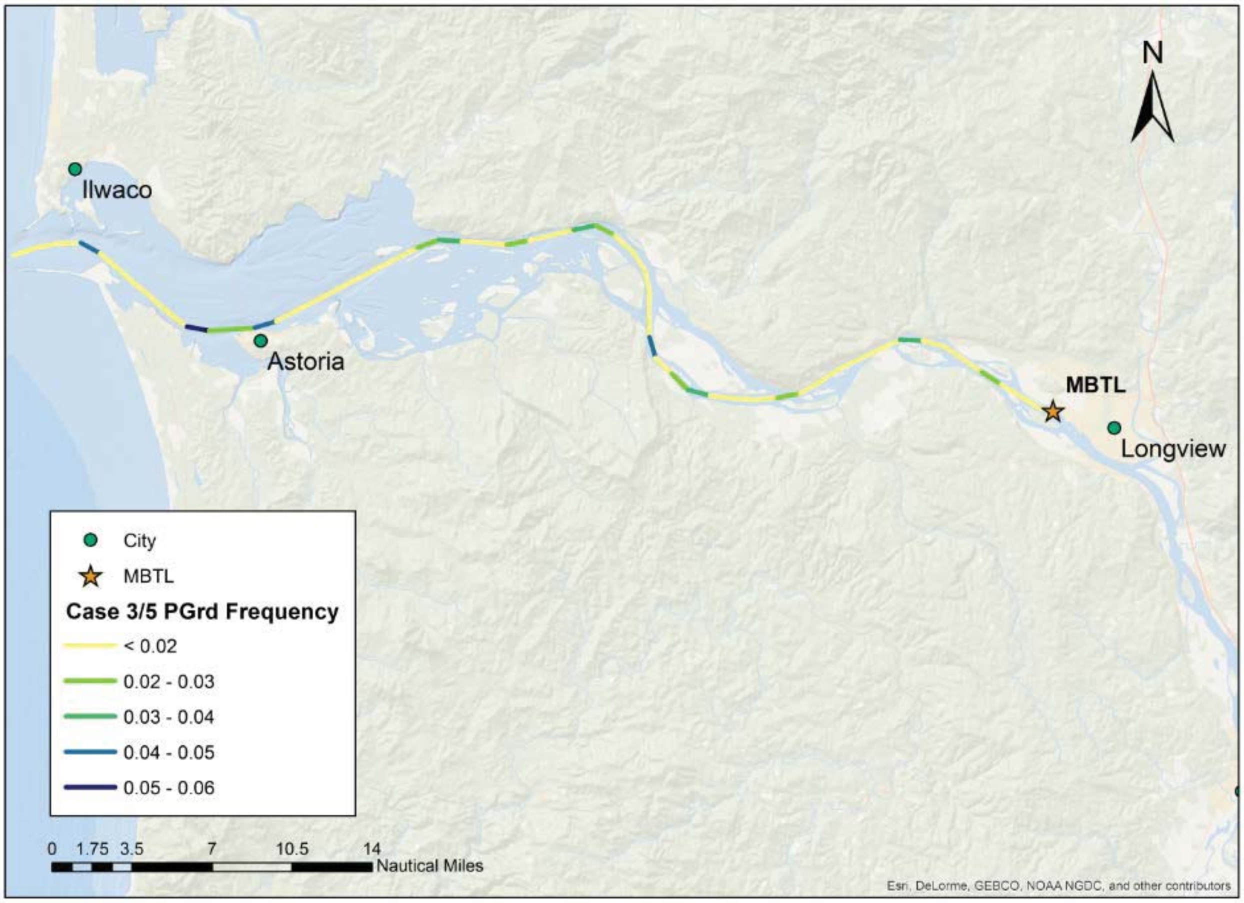


Figure 6-2 2028 Project Vessel Powered Grounding Incident Frequency Results

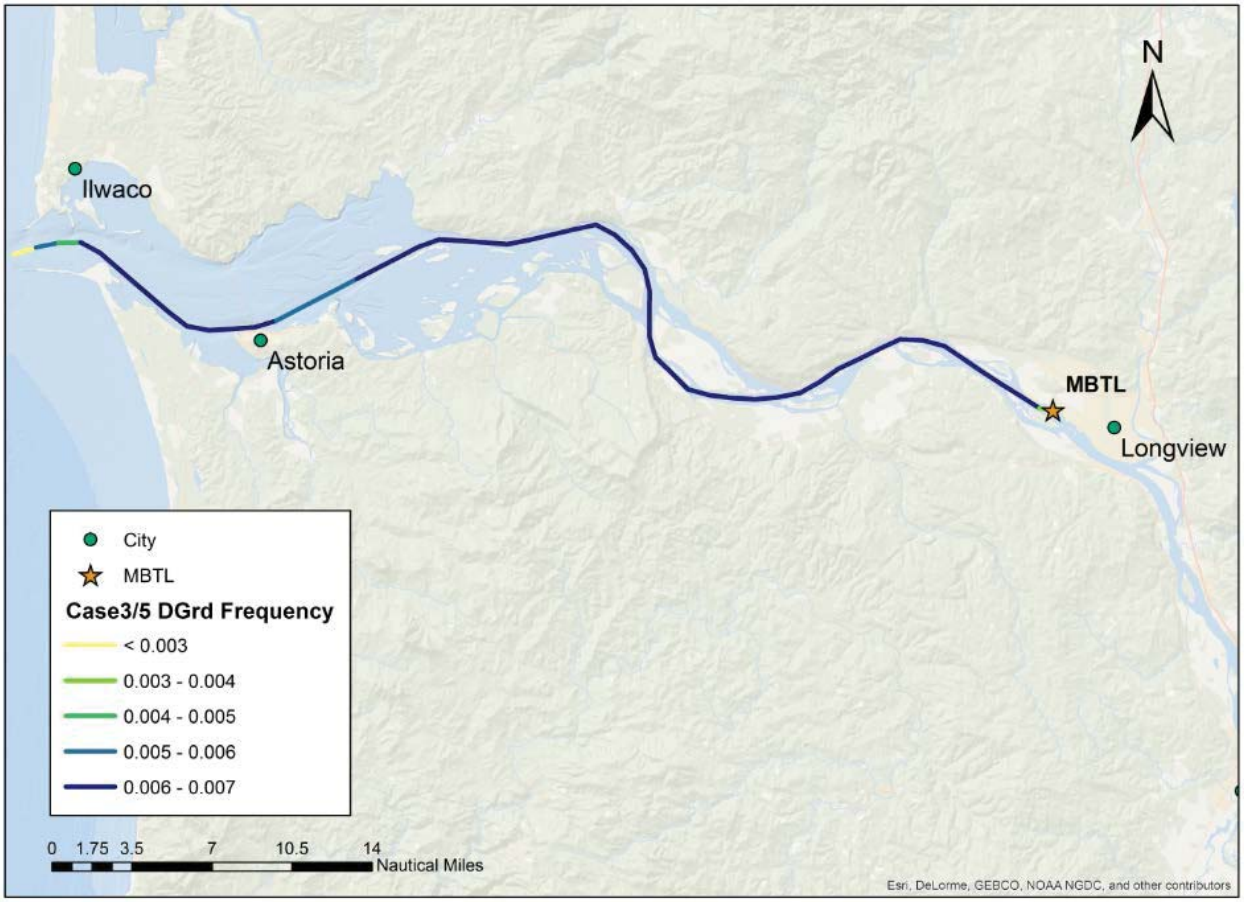


Figure 6-3 2028 Project Vessel Drift Grounding Incident Frequency Results

6.1.4 2038 No-Action Traffic

Table 6-5 provides estimated incident frequencies by vessel type for 2038 without project vessels.

Table 6-5 Incident Frequency by Vessel Type for Non-Project Vessels (2038 No Action)

	Cargo / Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Total Incident Frequency
Collision	1.02E+00	6.45E-01	7.29E-01	1.62E-01	1.60E-01	6.03E-01	3.87E-02	5.97E-01	3.95E+00
Fire / Explosion	2.00E-03	3.54E-04	5.49E-04	1.17E-04	1.16E-04	2.49E-04	7.43E-05	1.26E-03	4.72E-03
Powered Grounding	4.33E+00	2.16E+00	3.42E+00	8.60E-01	6.67E-01	2.30E+00	1.61E-01	2.63E+00	1.65E+01
Drift Grounding	1.80E+00	3.03E-01	4.88E-01	1.06E-01	1.02E-01	2.14E-01	6.68E-02	1.14E+00	4.22E+00
Total Incident Frequency	7.16E+00	3.11E+00	4.64E+00	1.13E+00	9.29E-01	3.12E+00	2.67E-01	4.37E+00	2.47E+01

6.1.5 2038 With-Project Traffic

Table 6-6 provides estimated incident frequencies by vessel type for 2038 non-project vessels under with-project conditions.

Table 6-6 Incident Frequency by Vessel Type for Non-Project Vessels (2038 With-Project)

	Cargo / Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Total Incident Frequency
Collision	1.08E+00	6.87E-01	7.88E-01	1.75E-01	1.72E-01	6.40E-01	4.13E-02	6.48E-01	4.42E+00
Fire / Explosion	1.99E-03	3.54E-04	5.49E-04	1.17E-04	1.16E-04	2.49E-04	7.43E-05	1.26E-03	5.09E-03
Powered Grounding	4.29E+00	2.16E+00	3.42E+00	8.60E-01	6.67E-01	2.30E+00	1.61E-01	2.63E+00	1.73E+01
Drift Grounding	1.78E+00	3.03E-01	4.88E-01	1.06E-01	1.02E-01	2.14E-01	6.68E-02	1.14E+00	4.54E+00
Total Incident Frequency	7.16E+00	3.15E+00	4.70E+00	1.14E+00	9.41E-01	3.15E+00	2.69E-01	4.42E+00	2.63E+01

Table 6-7 provides estimated incident frequencies for project vessels in 2038.

Table 6-7 Incident Frequency by Vessel Type for Project Vessels (2038 With-Project)

	Project vessel (inbound)	Project vessel (outbound)	Total Incident Frequency
Collision	9.64E-02	9.49E-02	1.91E-01
Fire / Explosion	1.90E-04	1.90E-04	3.80E-04
Powered Ground	3.98E-01	4.10E-01	8.07E-01
Drift Ground	1.71E-01	1.71E-01	3.42E-01
Allision at Berth	N/A	N/A	3.97E-02
Total Incident Frequency	6.66E-01	6.77E-01	1.38E+00

The reader should note Figure 6-4 to Figure 6-6 have **different legend categories** and thus, need to be interpreted separately.

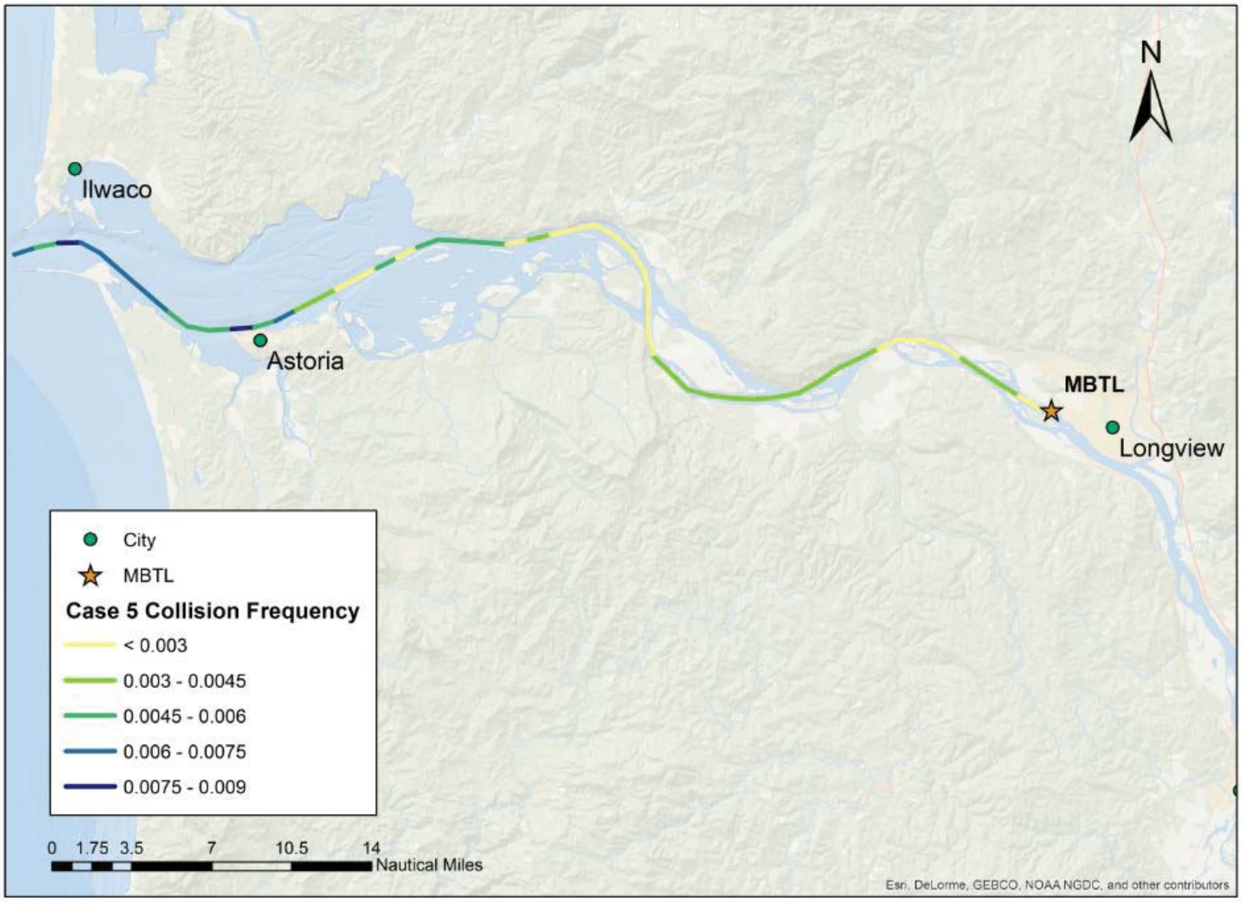


Figure 6-4 2038 Project Vessel Collision Incident Frequency Results

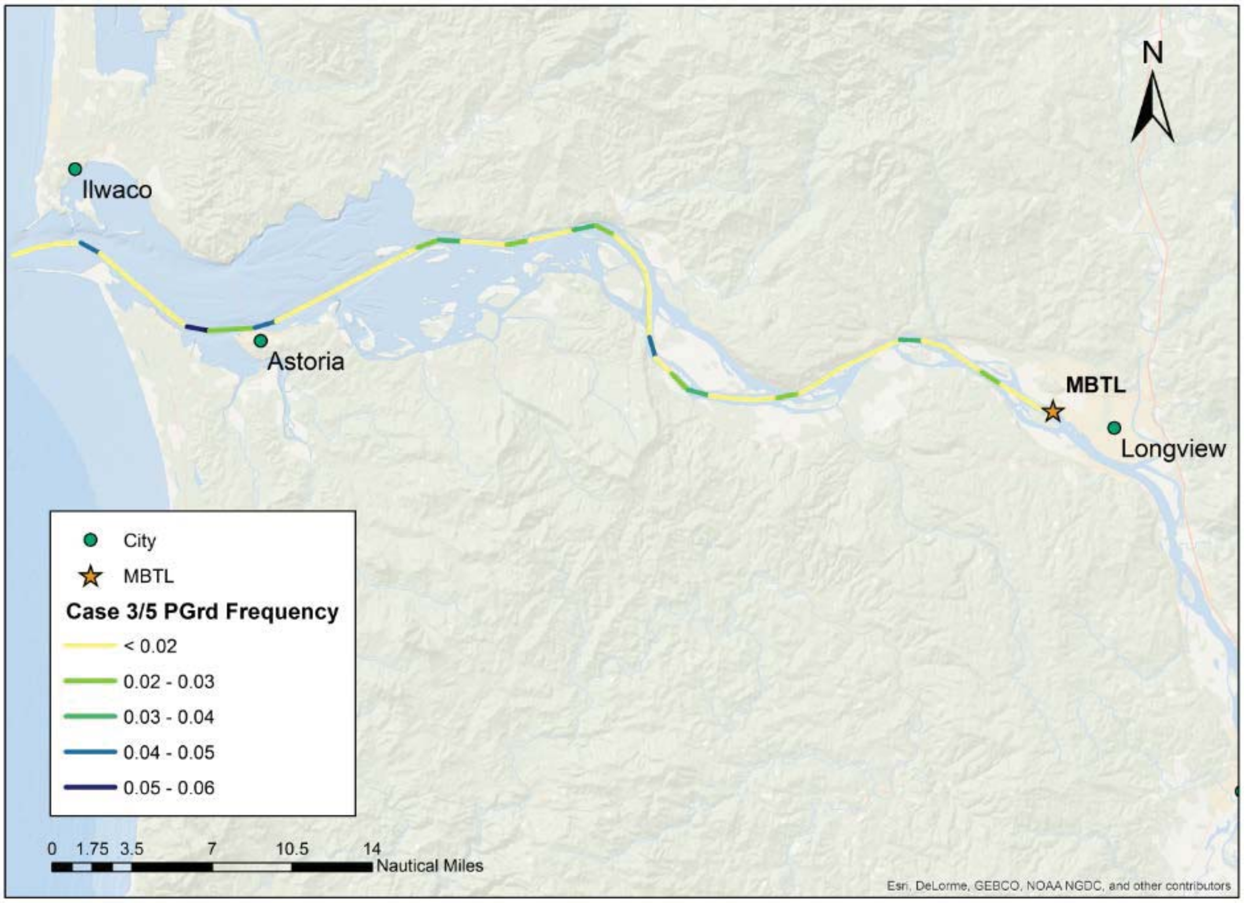


Figure 6-5 2038 Project Vessel Powered Grounding Incident Frequency Results

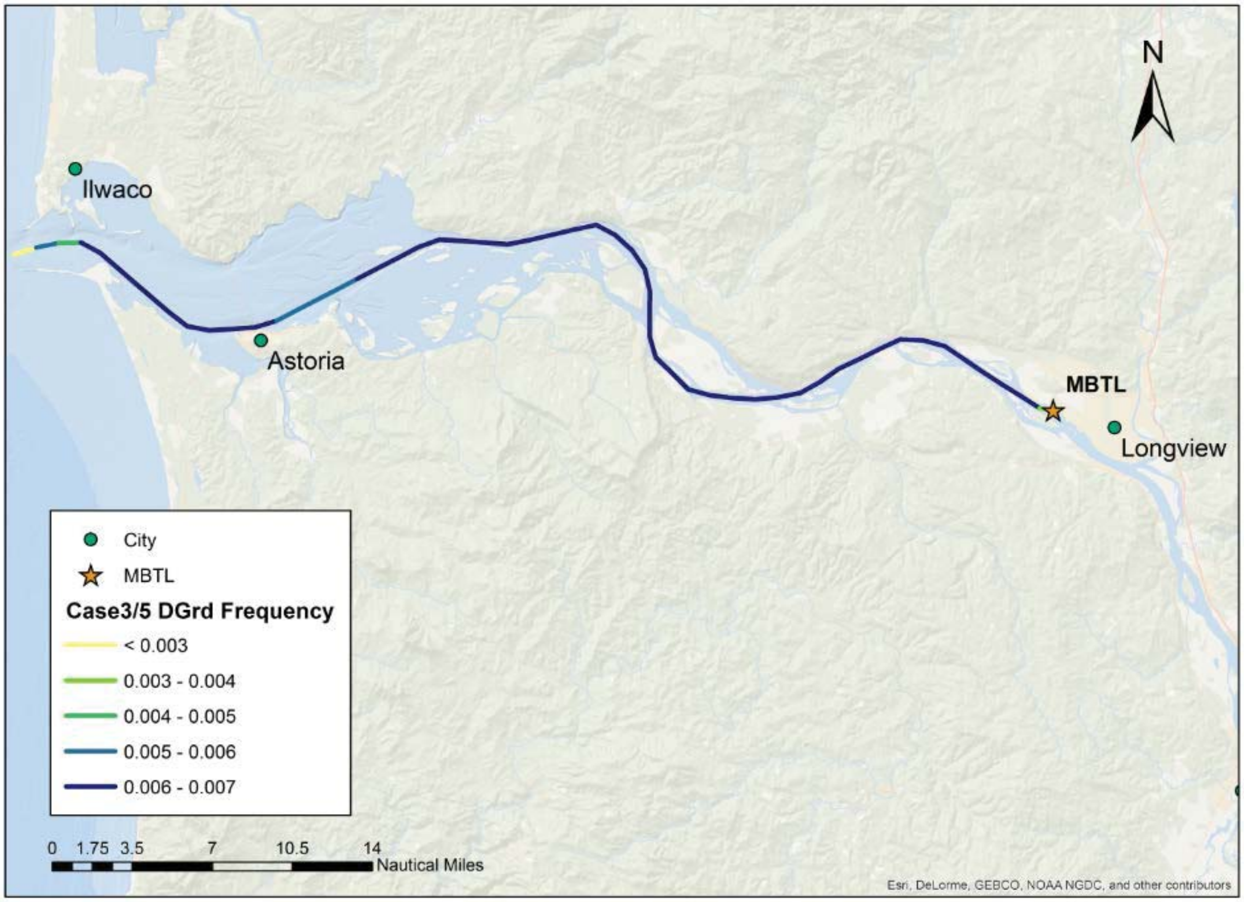


Figure 6-6 2038 Project Vessel Drift Grounding Incident Frequency Results

6.2 Incremental Contribution due to the Proposed Project

Table 6-8 presents the incremental risk that the proposed project contributes to vessel traffic incidents in 2028 and in 2038. These results are presented both in terms of annual frequency for each incident type as well as the percentage increase contributed by the project.

The total incremental incident frequency due to proposed project in 2028 is 1.5 incidents per year which equates to an 8% increase over the no-action scenario in 2028. Of these 1.6 incidents 0.8 are powered groundings, 0.34 are drift groundings, 0.38 are collisions and 0.03 are allisions.

The total incremental incident frequency due to proposed project in 2038 is 1.6 incidents per year which equates to a 6% increase over the no-action scenario in 2038. Of these 1.7 incidents 0.8 are powered groundings, 0.34 are drift groundings, 0.47 are collisions and 0.04 are allisions.

Using the results of the data survey presented in Section 4.1 and 4.2, we can comment on the likely severity of the incremental contribution of marine incidents contributed by the project.

- Based on a survey of historical incident severity, 1--2% of the grounding events contributed by the project are likely to result in a total loss of the vessel, 21-24% are likely to result in damage to vessel and 74-78% are likely to result in no reported damage. Note: None of the total loss events reported due to grounding involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a grounding event were passenger vessels.

- Based on a survey of historical incident severity, 3--5% of the collision events contributed by the project are likely to result in a total loss of one or more vessels, 47-53% are likely to result in damage to one more vessels and 44-47% are likely to result in no reported damage.
  Note: None of the total loss events reported due to collision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a collision event were recreational vessels.
- Based on a survey of historical incident severity, 1--5% of the allision events surveyed resulted in a total loss of the vessel, 43-45% resulted in vessel damage and 52-54% resulted in no reported damage.
  Note: None of the total loss events reported due to allision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in an allision event were fishing vessels.

Assuming the distributions described above, the project would contribute fewer than 0.05 incidents with a total loss per year, fewer than 0.5 incidents resulting in reportable damage per year and approximately 1 incident per year resulting in no damage.

The incremental contribution appears to decrease from 2028 (8%) to 2038 (6%) because non-project vessel traffic continues to increase over this 10-year time period while the number of project vessels remains constant at 840 per year. Therefore the relative contribution in 2038 is lower because project vessels make up a smaller portion of overall vessel traffic.

Table 6-8 Incremental Change in Incident Frequency Contributed by Proposed Project

	2028		2038	
	Frequency	% increase	Frequency	% increase
Collision	3.83E-01	15%	4.68E-01	12%
Fire/Explosion	3.80E-04	10%	3.80E-04	8%
Powered Grounding	8.07E-01	6%	8.07E-01	5%
Drift Grounding	3.42E-01	10%	3.42E-01	8%
Allision at Berth	2.56E-02	N/A	3.97E-02	N/A
Total Incident Frequency	1.56E+00	8%	1.66E+00	6%

6.2.1 In 2028 Traffic Conditions

Table 6-9 presents incremental collision frequencies by vessel type for 2028 due to project vessels. This table shows how the total incremental increase in collision incidents is distributed across vessel types.

Table 6-9 Incremental Collision Frequency/Percentage by Vessel Type Contributed by the Proposed Project in 2028

Impacted Vessel	Cargo/ Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Project Vessels	Total
Collision No Action	4.81E-01	4.53E-01	5.01E-01	1.13E-01	1.11E-01	4.29E-01	2.75E-02	4.10E-01	N/A	2.53E+00
Collision With-Project	5.16E-01	4.91E-01	5.54E-01	1.25E-01	1.22E-01	4.63E-01	2.99E-02	4.56E-01	1.51E-01	2.91E+00
Incremental TIF Increase	3.50E-02	3.80E-02	5.30E-02	1.20E-02	1.10E-02	3.40E-02	2.40E-03	4.60E-02	1.51E-01	3.83E-01
Incremental % Increase	7.3%	8.4%	10.6%	10.6%	9.9%	7.9%	8.7%	11.2%	N/A	15%

Figure 6-7 shows how the incremental incident frequency varies by incident type for each river mile segment along the proposed route in 2028.

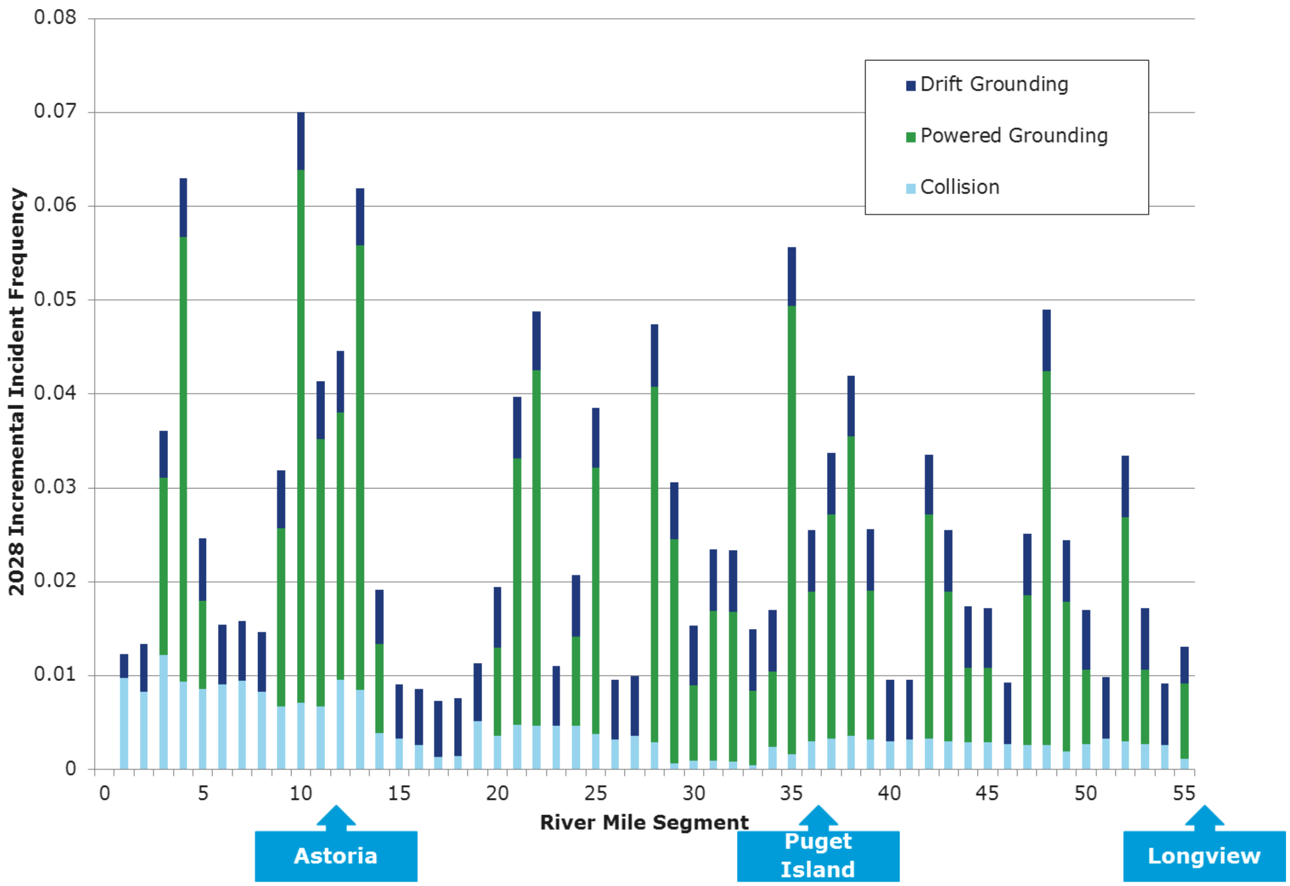


Figure 6-7 Incremental Incident Frequency by Incident Type Contributed by Proposed Project in 2028

6.2.2 In 2038 Traffic Conditions

Table 6-10 presents incremental collision frequencies by vessel type for 2038 due to project vessels. This table shows how the total incremental increase in collision incidents is distributed across vessel types.

Table 6-10 Incremental Collision Frequency/Percentage by Vessel Type Contributed by Proposed Project in 2038

Impacted Vessel	Cargo/ Carrier	Fishing	Other / Undefined	Passenger	Pleasure	Service	Tanker	Tug	Project Vessels	Total
Collision No Action	1.02E+00	6.45E-01	7.29E-01	1.62E-01	1.60E-01	6.03E-01	3.87E-02	5.97E-01	N/A	3.95E+00
Collision With-Project	1.08E+00	6.87E-01	7.88E-01	1.75E-01	1.72E-01	6.40E-01	4.13E-02	6.48E-01	1.91E-01	4.42E+00
Incremental TIF Increase	6.00E-02	4.20E-02	5.90E-02	1.30E-02	1.20E-02	3.70E-02	2.60E-03	5.10E-02	1.91E-01	4.68E-01
Incremental % Increase	5.9%	6.5%	8.1%	8.0%	7.5%	6.1%	6.7%	8.5%	N/A	12%

Figure 6-8 shows how the incremental incident frequency varies by incident type for each river mile segment along the proposed route in 2038.

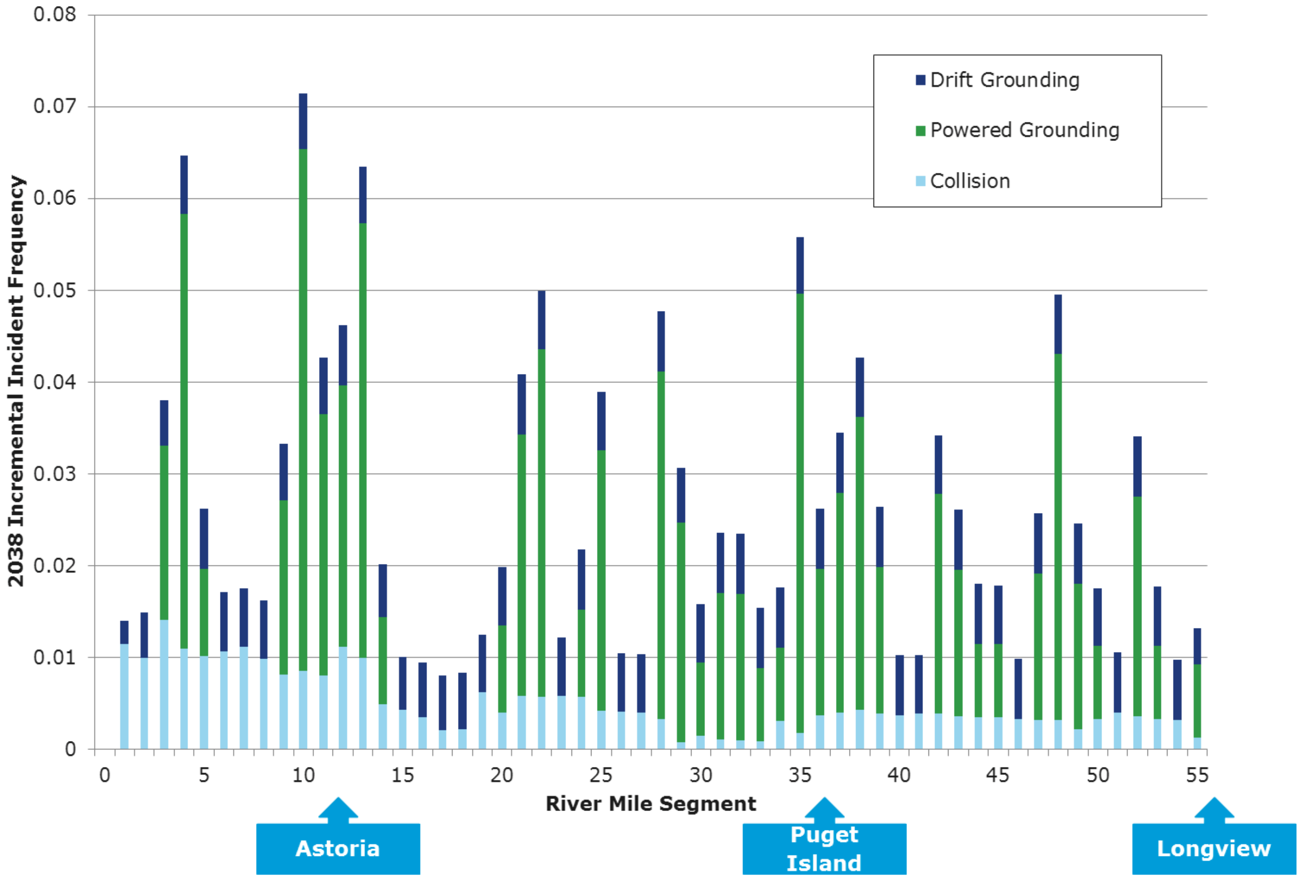


Figure 6-8 Incremental Incident Frequency by Vessel Type Contributed by the Proposed Project in 2038

7 ESTIMATED BUNKER SPILL RISK OF PROJECT VESSELS AT FULL BUILD OUT

The annual bunker spill frequency is calculated for project vessels for collision (grouped with allision at berth for this analysis), powered grounding and drift grounding. To assess the frequency of a release from the bunker tank due to collision the following probabilities are used: the probability that a collision results in sufficient energy to puncture the bunker tank and the geometric probability of striking the location of the bunker tank on the vessel. To assess the frequency of a release from the bunker tank due to drift grounding the following probabilities are used: the probability that the indentation depth exceeds the critical indentation depth required to puncture the bunker tank, the geometric probability of striking the location of the bunker tank on the vessel and the probability that the project vessel grounds on a rocky shoreline. The frequency of a release from the bunker tank due to powered grounding is assumed to be 0.01% of the total incidents. This is applied because a powered grounding that results in a release of bunker fuel is a very unlikely event as the bunker tanks are located in the stern of the vessel while the impact location is almost always near the bow.

7.1 Estimated Bunker Spill Frequencies

As shown below, the estimated bunker spill frequency due to the proposed project is 1.02×10^{-2} in 2028 and 1.17×10^{-2} in 2038. This equates to roughly one spill (of any size) every 98 years in 2028 and one spill every 85 years in 2038. Recall that, based on the survey of oil spill data from 2004 to 2014 (Section 4.3), the Lower Columbia River has experienced a spill greater than 100 gallons approximately once every 2.2 years.

7.1.1 In 2028 Traffic Conditions

Table 7-1 provides estimated bunker oil spill frequencies (of any size) by incident type for project vessels in 2028.

Table 7-1 2028 Bunker Oil Spill Frequency from Project Vessels

	Project Vessel (inbound)	Project Vessel (outbound)	Total Incident Frequency
Collision	1.54E-04	1.54E-04	3.09E-04
Powered Ground	3.98E-05	4.10E-05	8.07E-05
Drift Ground	3.56E-03	3.57E-03	7.13E-03
Allision at Berth	N/A	N/A	2.65E-03
Total Incident Frequency	3.75E-03	3.77E-03	1.02E-02

Figure 7-1 shows how the bunker oil spill frequency varies across each river mile segment along the proposed route in 2028.

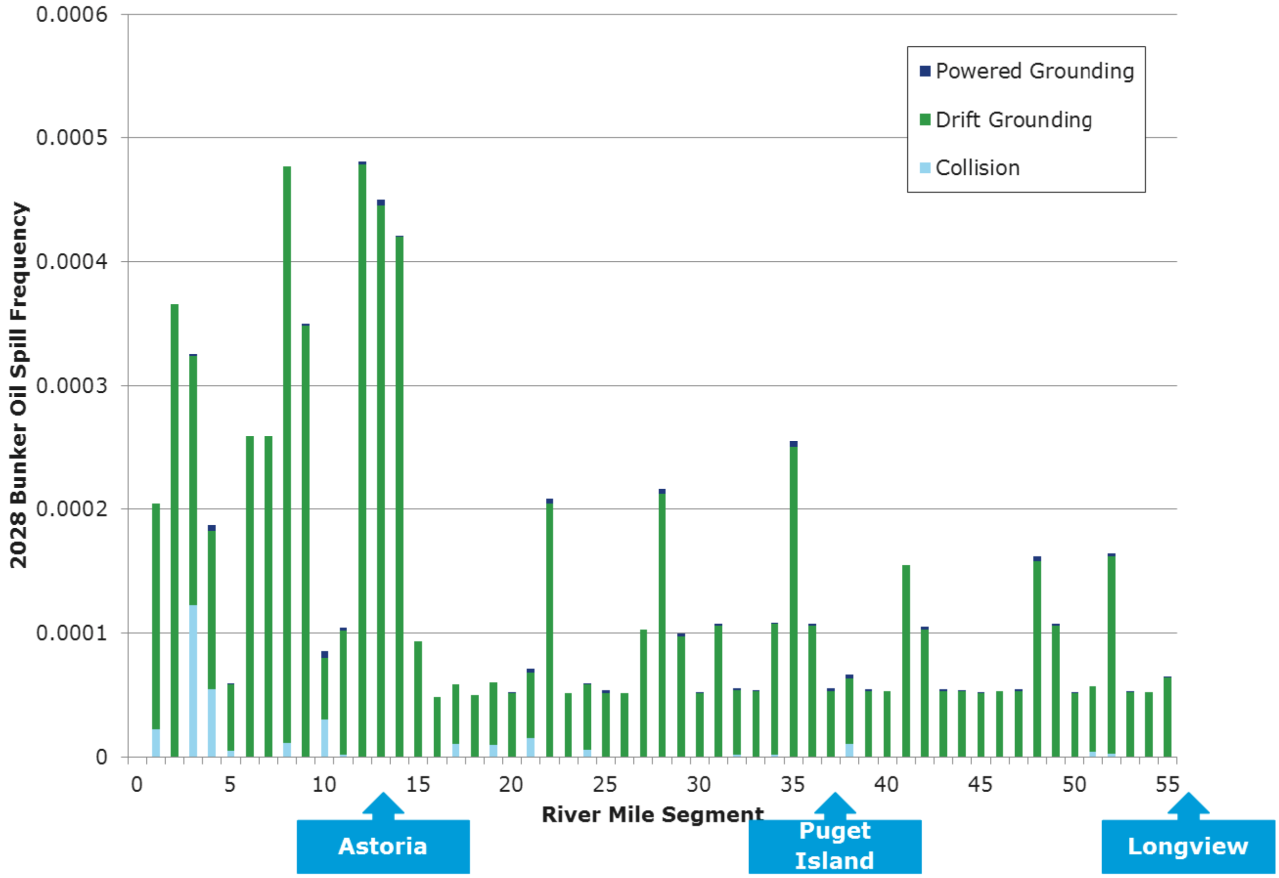


Figure 7-1 2028 Annual Incremental Bunker Oil Spill Frequency

Table 7-2 provides the percentage of incidents that result in a bunker oil spill (of any size) for project vessels in 2028.

Table 7-2 Percentage of Incidents Leading to Bunker Oil Spill (2028)

	Project Vessel (inbound)	Project Vessel (outbound)	Total Incident Frequency
Collision	0.20%	0.21%	0.21%
Powered Ground	0.01%	0.01%	0.01%
Drift Ground	2.08%	2.09%	2.08%
Allision at Berth	N/A	N/A	10.4%
Total Incident Frequency	0.58%	0.57%	0.77%

7.1.2 In 2038 Traffic Conditions

Table 7-3 provides estimated bunker oil spill frequencies by incident type for project vessels in 2038.

Table 7-3 2038 Bunker Spill Frequency from Project Vessels

	Project Vessel (inbound)	Project Vessel (outbound)	Total Incident Frequency
Collision	1.73E-04	1.73E-04	3.47E-04
Powered Ground	3.98E-05	4.10E-05	8.07E-05
Drift Ground	3.56E-03	3.57E-03	7.13E-03
Allision at Berth	N/A	N/A	4.16E-03
Total Incident Frequency	3.77E-03	3.78E-03	1.17E-02

Figure 7-2 shows how the bunker oil spill frequency varies across each river mile segment along the proposed route in 2038.

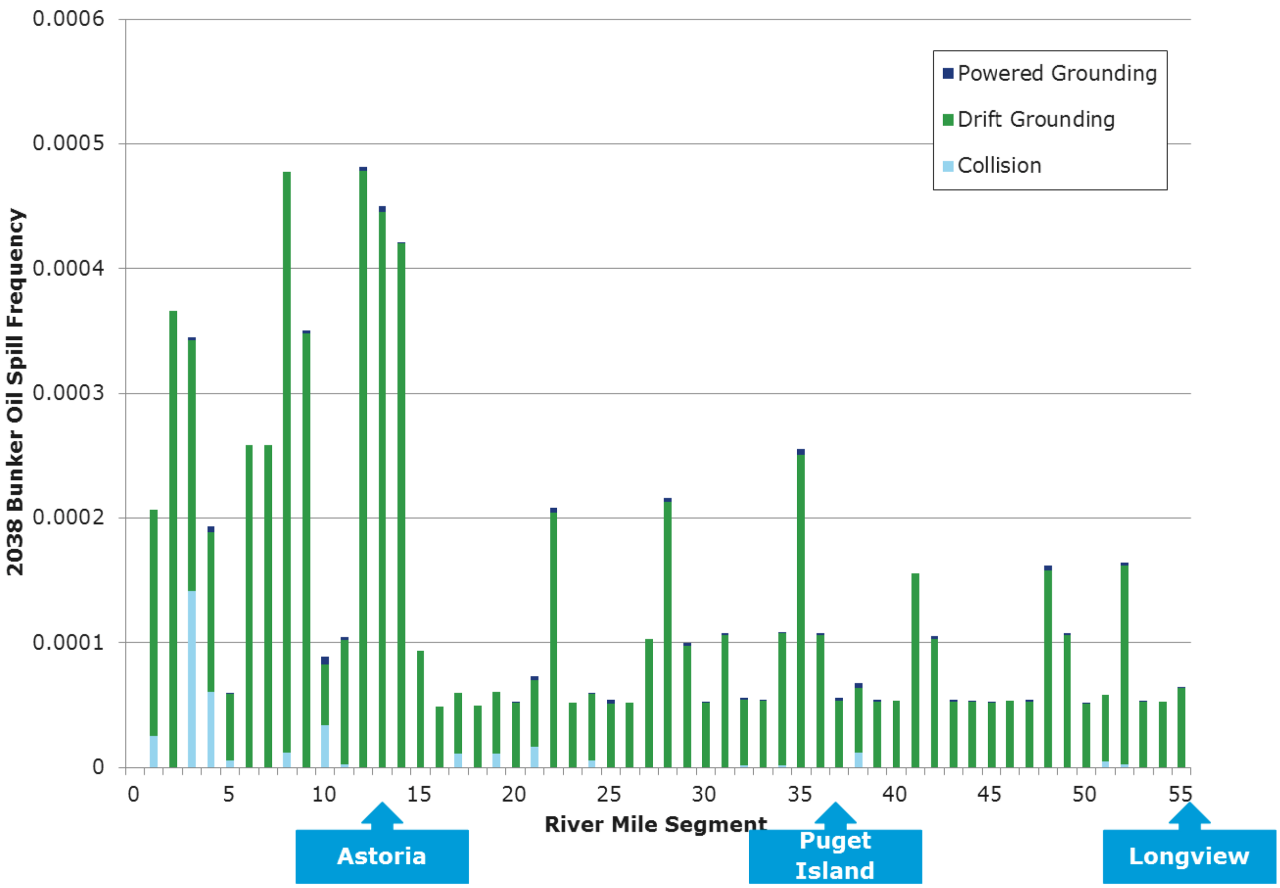


Figure 7-2 2038 Annual Incremental Bunker Oil Spill Frequency

Table 7-4 provides the percentage of incidents that result in a bunker oil spill (of any size) for project vessels in 2038.

Table 7-4 Percentage of Incidents Leading to Bunker Oil Spill (2038)

	Project Vessel (inbound)	Project Vessel (outbound)	Total Incident Frequency
Collision	0.18%	0.18%	0.18%
Powered Ground	0.01%	0.01%	0.01%
Drift Ground	2.08%	2.09%	2.08%
Allision at Berth	N/A	N/A	10.47%
Total Incident Frequency	0.57%	0.56%	0.85%

7.2 Estimated Conditional Probabilities of Spill Volumes

This section presents conditional spill volume probabilities of bunker oil from a project vessel, which was assessed using the Naval Architecture Package (NAPA) model.

These results are presented as curves showing the conditional probability of the volume of bunker oil that would be released given that a bunker oil tank has been breached and oil is flowing out of the tank(s). Figure 7-3 presents these results in gallons for a representative Panamax vessel assuming bunker tanks are 100% full.

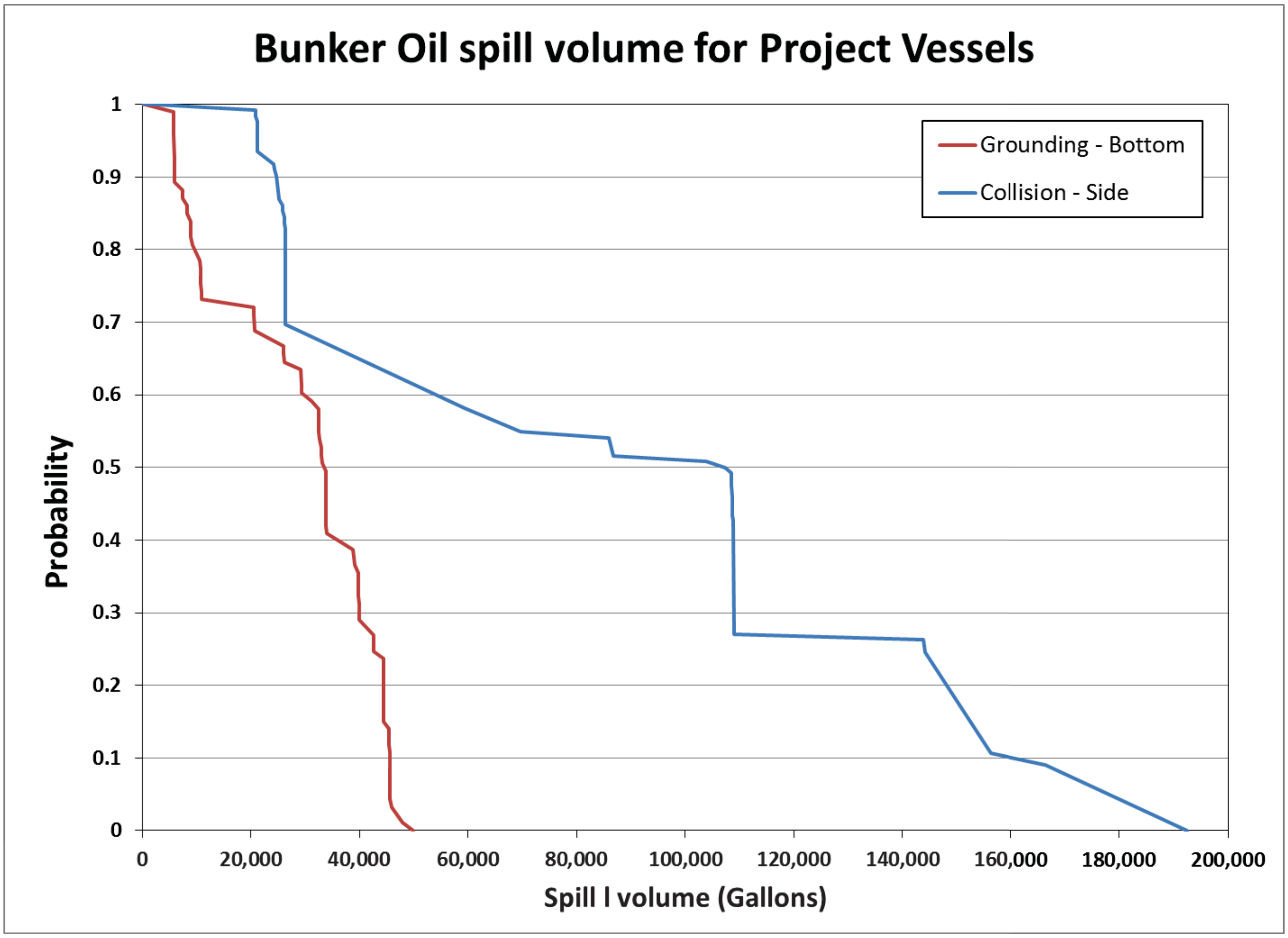


Figure 7-3 NAPA Results - Bunker Oil Spill (gallons)

As shown in Figure 7-3, if a collision or grounding event resulted in a bunker oil spill, the smallest estimated spill volume would be roughly 20 m^3 for a grounding and 80 m^3 for a collision. This equates to 5,700 and 20,900 gallons of bunker oil (respectively).

These volumes can then be paired with the Bunker Oil Spill Frequencies provided in Section 7.1 for a more complete picture of bunker oil spill risk. The frequency of bunker oil spill volumes is provided in Figure 7-4 and Figure 7-5 below for grounding and collision events, respectively. Note that grounding frequencies do not vary from 2028 to 2038 since the number of project vessels remains at 840 in both years. Frequency of collision incidents is higher in 2038 compared to 2028 due to an increase in the overall vessel traffic in the study area.

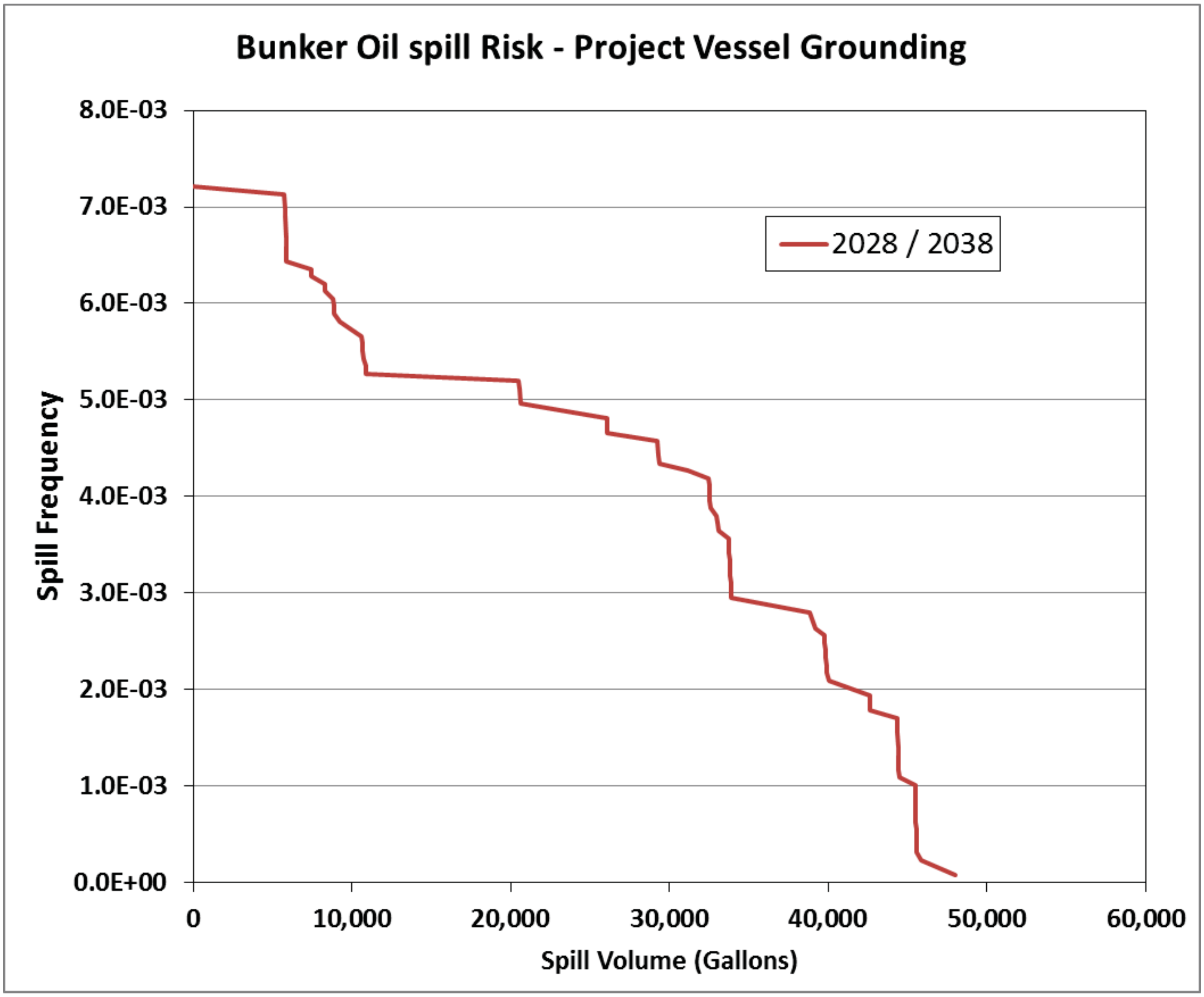


Figure 7-4 Frequency vs volume of Bunker Oil Spill due to Grounding of Project Vessel

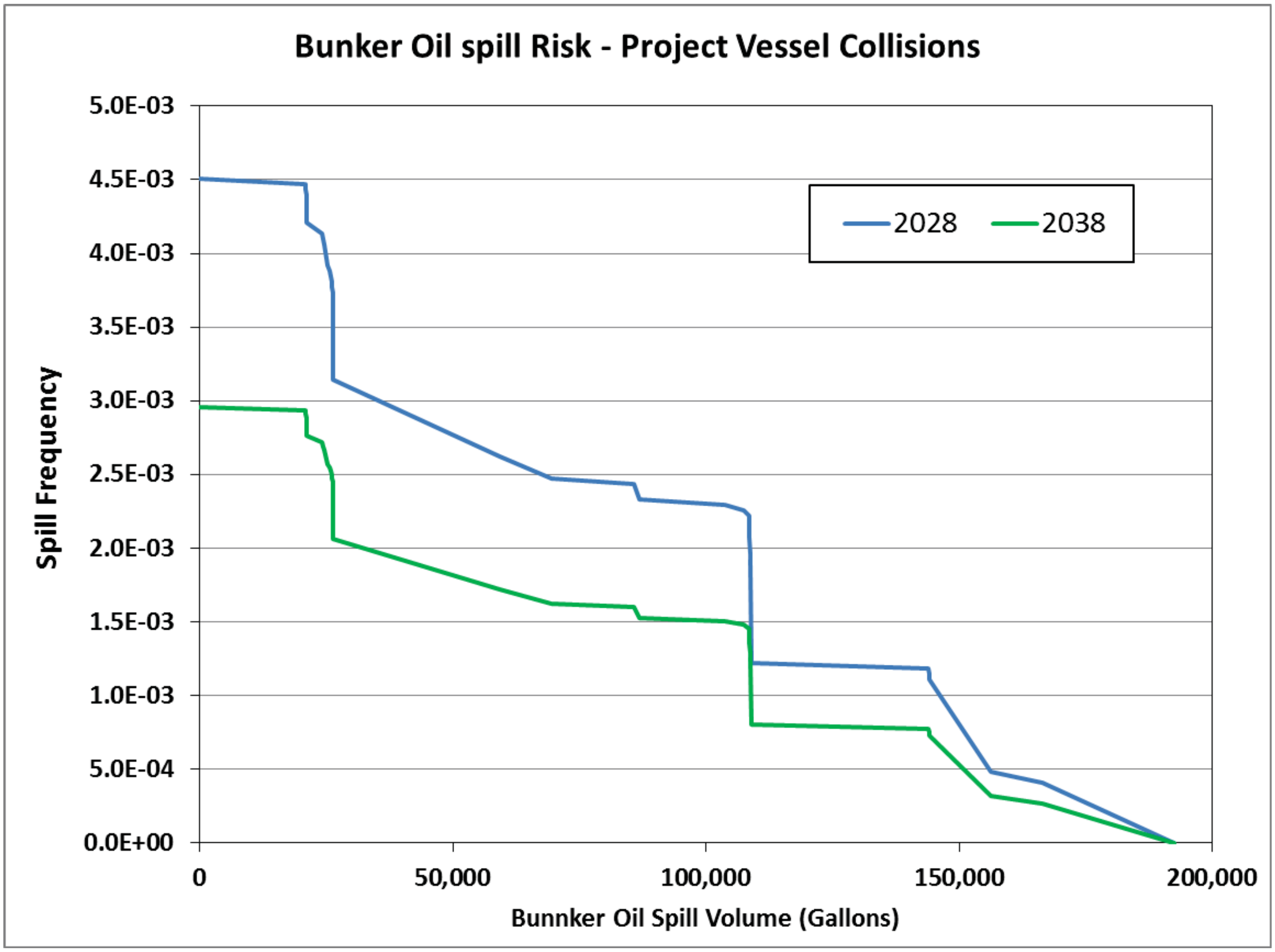


Figure 7-5 Frequency vs volume of Bunker Oil Spill due to Collision involving Project Vessel

Examples of frequency- spill size pairs are provided in Table 7-5 to Table 7-7. It is important to note that this study did not assess the risk of small spills due to activities such as bunkering, damage to the environment and other causes unrelated to navigational incidents.

Table 7-5 Example Bunker Oil Spill Volumes & Frequencies due to Grounding (2028/2038)

Return Period (Years)	Spill Volume (gal)
140	5,700 or less
182	10,700 or less
403	39,700 or less
4,299	45,800 or less

Table 7-6 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2028)

Return Period (Years)	Spill Volume (gal)
341	20,900 or less
581	59,300 or less
676	107,400 or less
3,748	166,500 or less

Table 7-7 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2038)

Return Period (Years)	Spill Volume (gal)
224	20,900 or less
381	59,300 or less
444	107,400 or less
2,461	166,500 or less

8 CONCLUSIONS

8.1 Incremental Contribution to Marine Incidents

The total incremental incident frequency due to proposed project in 2028 is 1.5 incidents per year which equates to an 8% increase over the no-action scenario in 2028. Of these 1.6 incidents 0.8 are powered groundings, 0.34 are drift groundings, 0.38 are collisions and 0.03 are allisions.

The total incremental incident frequency due to proposed project in 2038 is 1.6 incidents per year which equates to a 6% increase over the no-action scenario in 2038. Of these 1.7 incidents 0.8 are powered groundings, 0.34 are drift groundings, 0.47 are collisions and 0.04 are allisions.

In order to provide context around the consequences of a collision, grounding or allision incident, a survey of USCG Marine Information for Safety and Law Enforcement (MISLE) database was conducted for years 2001 to 2014. For the purposes of this study, the various categories used to describe incident severity for each reported incident were aggregated into “Total Loss”, “Damage” and “No Damage”. The data coverage period of 2001 to 2014 was chosen as it covers over 99% of all reported collision, grounding, and allision incidents in the dataset. Data surveys were conducted for the national dataset and for the study area separately in order to test for differences in the distribution of incident severity between the two. Our findings show that for a given incident type, the severity distributions were very similar for national incident data compared to Lower Columbia River incident data.

Using the results of the data survey, we can therefore comment on the likely severity of the incremental contribution of marine incidents contributed by the project.

- Based on a survey of historical incident severity, 1--2% of the grounding events contributed by the project are likely to result in a total loss of the vessel, 21-24% are likely to result in damage to vessel and 74-78% are likely to result in no reported damage. Note: None of the total loss events reported due to grounding involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a grounding event were passenger vessels.
- Based on a survey of historical incident severity, 3--5% of the collision events contributed by the project are likely to result in a total loss of one or more vessels, 47-53% are likely to result in damage to one more vessels and 44-47% are likely to result in no reported damage.
  Note: None of the total loss events reported due to collision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in a collision event were recreational vessels.
- Based on a survey of historical incident severity, 1--5% of the allision events surveyed resulted in a total loss of the vessel, 43-45% resulted in vessel damage and 52-54% resulted in no reported damage.
  Note: None of the total loss events reported due to allision involved carriers or vessels of similar size. The only vessel categories reported as a total loss in an allision event were fishing vessels.

Assuming the distributions described above, the project would contribute fewer than 0.05 incidents with a total loss per year, fewer than 0.5 incidents resulting in reportable damage per year and approximately 1 incident per year resulting in no damage.

The incremental contribution appears to decrease from 2028 (8%) to 2038 (6%) because non-project vessel traffic continues to increase over this ten-year time period while the number of project vessels remains constant at 840 per year. Therefore the relative contribution in 2038 is lower because project vessels make up a smaller portion of overall vessel traffic.

8.2 Incremental Contribution to Oil Spill Risk

Less than 1% of the collision, grounding and allision incidents involving project vessels are expected to result in a bunker oil spill. As a result, the frequency of a bunker spill of any size due to a marine incident involving a project vessel is estimated to be $1.02x10^{-2}$ in 2028 and $1.17\ x10^{-2}$ in 2038. This equates to roughly one spill (of any size) every 98 years in 2028 and one spill (of any size) every 85 years in 2038. Based on a survey of oil spill data from 2004 to 2014, the Lower Columbia River has experienced a spill of greater than 100 gallons approximately once every 2.2 years. Therefore, the proposed project would increase the frequency of a spill greater than 100 gallons by approximately 2 to 3% to approximately once in every 2.15 years.

In the unlikely event that a collision or grounding event resulted in a bunker oil spill, the smallest estimated bunker oil spill volume from a project vessel would be roughly 20 m^3 for grounding and 80 m^3 for collisions (5,700 and 20,900 gallons, respectively). The frequency of various bunker oil spill sizes is provided in Table 8-1 for grounding scenarios. Since the number of project vessels does not change between 2028 and 2038, frequencies are the same in both years. The frequency of various bunker oil spill sizes is provided in Table 8-2 and Table 8-3 for collision scenarios. Since the number of non-project vessels increases between 2028 and 2038, collision frequencies vary across those years. It is important to note that this study did not assess the risk of small spills due to activities such as bunkering, damage to the environment and other causes unrelated to navigational incidents.

Table 8-1 Example Bunker Oil Spill Volumes & Frequencies due to Grounding (2028/2038)

Return Period (Years)	Spill Volume (gal)
140	5,700 or less
182	10,700 or less
403	39,700 or less
4,299	45,800 or less

Table 8-2 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2028)

Return Period (Years)	Spill Volume (gal)
341	20,900 or less
581	59,300 or less
676	107,400 or less
3,748	166,500 or less

Table 8-3 Example Bunker Oil Spill Volumes & Frequencies due to Collision (2038)

Return Period (Years)	Spill Volume (gal)
224	20,900 or less
381	59,300 or less
444	107,400 or less
2,461	166,500 or less

9 REFERENCES

/1/ DNV GL Vessel Database. https://exchange.dnv.com/Exchange/main.aspx?extool=vessel&subview=dimensions&vesselid=18908. Accessed October 2015.

/2/ DNV GL Vessel Database. https://exchange.dnv.com/Exchange/main.aspx?extool=vessel&subview=dimensions&vesselid=25452. Accessed October 2015.

/3/ Merchants Exchange in Portland, Oregon (2015).

/4/ Maritime Intelligence & Publications. IHS Maritime. IHS Fairplay Incident database, http://www.ihs.com/products/maritime-information/ships/sea-web.aspx (IHS 2012). Accessed December 01, 2015.

/5/ "URS_TrafficTransportationReport_Sept2014.doc", Millennium Coal Export Terminal Longview, Washington - Traffic and Transportation Resource Report, September 2014.

/6/ NOAA Wind Station: Buoy 46029. 01/01/2005 - 12/31/2014. Accessed October 2015.

/7/ NOAA Weather Station: Astoria OR, Wind: 01/01/2005 – 12/31/2014. Visibility: 01/01/2006 – 12/31/2014. Accessed October 2015.

/8/ NOAA Weather Station: Longview WA, Wind: 01/01/2005 – 12/31/2014. Visibility: 01/01/2006 – 12/31/2014. Accessed October 2015.

/9/ NOAA National Climate Data Center. Climate Data Online, 2014. http://cdo.ncdc.noaa.gov/pls/plclimprod/poemain.accessrouter?datasetabbv=DS3505. Accessed October 2015.

/10/ "Environmental Measurement Systems Sensor Specifications and Measurement Algorithm" issued by NOAA's Center for Operational Oceanographic Products and Services. Accessed November 2014: http://www.co-ops.nos.noaa.gov/publications/CO-OPS_Measurement_SpecUpdated_4.pdf.

/11/ CEC (1988), "COST-301: Shore-based Marine Navigation Aid Systems", Report EUR-11304 EN, Commission of the European Communities.

/12/ Larsen, O.L. (1993), "Ship Collision with Bridges", International Association for Bridge and Structural Engineering, Zurich.

/13/ Lewison, G.R.G. (1980), "The Estimation of Collision Risk for Marine Traffic in UK Waters," Journal of Navigation, Sept 1980 (also in NMI Report R91).

/14/ SAFECO I (1998). Safety of Shipping in Coastal Waters (SAFECO) Summary Report. DNV Report No. 98-2038

/15/ SSPA (2012), "Summary Report on Evaluating VTS and Pilotage as Risk Reduction Measures", Efficiency Sea Project, document W-WP6-5-04, January 2012.

/16/ DNV (1999), "Risk Assessment of Pollution from Oil and Chemical Spills in Australian Ports and Waters", Det Norske Veritas Project 9330-3972, December 1999.

/17/ Drager, K.H., Kristiansen, S., Karlsen, J.E. & Wienke, P.M. (1981), “Cause Relationships of Collisions and Groundings - Conclusions of Statistical Analysis”, Norwegian Maritime Research No. 3.

/18/ US Coast Guard, *Aids to Navigation Manual*, Commandant Instruction, M16500.3A, April 6, 2010.

/19/ International Maritime Organization, *FSA Study on ECDIS / ENCs*, MSC/81/24/5, February 2006.

/20/ Knapp, S., Bijwaard, G. & Heij, C. (2011), “Estimated Incident Cost Savings in Shipping due to Inspections”, Accident Analysis and Prevention, vol 43, no 4, July 2011.

/21/ MARPOL 73/78 Annex I, Regulation 12A: Fuel Oil Tank Protection.

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