1.0 INTRODUCTION
Moffatt & Nichol (M&N) has been retained by the Port of Seattle (Port) to provide design support services, including support for the State Environmental Policy Act (SEPA) review for the Terminal 5 (T5) Cargo Wharf Rehabilitation, Berth Deepening and Improvements Project (the Project). Part of this effort includes assessing the potential for project-related short-term and long-term effects relating to existing vessel traffic and navigation.

This memorandum describes existing vessel traffic and navigation in the study area, vessel traffic management, and what potential changes in vessel traffic or navigation could occur. Measures to avoid, minimize, or compensate for potential adverse effects are identified and include:

- Current regulations (e.g. requirement for a licensed Pilot on board large commercial vessels) and communications with the VTS and other vessels will continue and minimize risks of traffic collisions, delays, or accidents.

- Communication between the Port and Muckleshoot and Suquamish Indian Tribes, with the objective of avoiding and minimizing potential disruption to Treaty fishing activities. This includes scheduling of construction activities (to avoid specific fishing periods and controlling the location and timing of construction activities) and the advance sharing of vessel arrivals and departures during fishing periods to avoid and minimize potential net and vessel conflicts.

Information is provided in a format that can be incorporated into the Project’s in-development Environmental Impact Statement (EIS) as a separate chapter or as part of other existing EIS sections.

2.0 STUDY AREA
The study area for vessel traffic and navigation includes the southern edge of Elliott Bay into the Duwamish River West Waterway and the existing T5 wharf (Figure 1).
Figure 1: Port of Seattle Terminal 5 on the Duwamish River
3.0 EXISTING CONDITIONS WEST WATERWAY DUWAMISH RIVER

The existing Duwamish River Waterway is an artificially deepened and straightened industrial waterway that supports a number of water-dependent industries and facilities. Deep draft navigational access into the Duwamish River is through the West and East Waterways, both of which are located on either side of Harbor Island (Figure 1).

The U.S. Army Corps of Engineers (USACE) manages the federally authorized channels within the Duwamish River for vessel navigation. Authorized depths of the northern end of the Duwamish River into Elliott Bay are shown in Figure 2. Specific USACE authorizations related to the West Waterway are listed in Table 1.

The Duwamish River West Waterway extends south from pierhead line Elliott Bay for 5,200 feet (USACE and POS 2014). The waterway is 750 feet wide and authorized to -34 feet Mean Lower Low Water (MLLW), although existing depths range up to -56 feet MLLW (USACE and POS 2014). The West Waterway accesses the narrower 200-foot wide Lower Duwamish Waterway at river mile (RM) 0.

![Figure 2: Port of Seattle Terminal 5 on the Duwamish River](image-url)
Table 1: West Waterway Authorizing Language (USACE and POS 2014)

<table>
<thead>
<tr>
<th>Document</th>
<th>Date</th>
<th>Citation</th>
<th>Authorization Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senate Doc 313 15 Dec 1918</td>
<td></td>
<td>S.D. 313, 65th Cong, 3d Sess.</td>
<td>…the United States take over and assume the maintenance of these portions of the East and West Waterways for distances of 6,500 feet and 5,200 feet, respectively, from the pierhead line at Elliott Bay… maintaining the East and West Waterways to a depth of 34 feet…</td>
</tr>
<tr>
<td>River and Harbor Act (RHA) 1919</td>
<td>2 Mar 1919</td>
<td>40 Stat. 1285</td>
<td>Construction, completion, repair, and preservation of the works hereinafter named:… maintenance of East and West Waterways, Seattle Harbor, in accordance with the report in Senate Document numbered 313, Sixty-fifth Congress, third Session…</td>
</tr>
<tr>
<td>RHA 1935</td>
<td>30 Aug 1935</td>
<td>74 Pub. L. 409</td>
<td>That the following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized, to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans… designated and subject to the conditions set forth in…; Seattle Harbor, Washington; House Document Numbered 211, Seventy-second Congress…</td>
</tr>
<tr>
<td>Water Resources development Act (WRDA) 1986</td>
<td>17 Nov 1986</td>
<td>99 Pub. L. 662</td>
<td>Sec. 202 GENERAL CARGO AND SHALLOW HARBOR PROJECTS (a) AUTHORIZATION FOR CONSTRUCTION - The following projects for harbors are authorized… subject to the conditions recommended in the respective reports designated in this subsection, except as otherwise provided in this subsection: EAST, WEST, AND DUWAMISH WATERWAYS, WA…</td>
</tr>
</tbody>
</table>

The Southwest Spokane Street Swing Bridge crosses the Duwamish River at mile 0.2 with 44 feet of vertical clearance at MHHW (55 feet at center) and 250 feet of horizontal clearance (NOAA 2015). A second fixed bridge, the West Seattle Bridge is located just above the swing bridge and has a vertical clearance of 140 feet and a horizontal clearance of 150 feet. A third rail bridge, the Bascule Bridge, is located just south of the West Seattle Bridge and has a vertical clearance of 7 feet and a horizontal clearance of 150 feet (NOAA 2015).

3.1 Navigation Improvements – West Waterway

In 1955, the Port purchased property on the west side of the West Waterway from the Ames Shipping Company. Ames Shipping had operated a shipyard at the site between 1916 and 1920, and then a breakbulk cargo terminal between 1920 and 1955. Upon purchase, the site included piling supported piers, warehouses, cargo marshaling areas, and moorage depth to between -25 feet MLLW and -40 feet MLLW. Immediately after purchasing the property, the Port set to work replacing docks, stabilizing slopes, and deepening berths. Between 1961 and 1964, the port dredged the berths to a uniform depth of -40 feet MLLW.

In the early 1990’s, as part of the Southwest Harbor Redevelopment Project, the Port added several parcels to the Terminal 5 facility, including the former Lockheed Shipyard 2 and PSR/Wykoff properties. The new, larger facility was to be built out to support deeper draft vessels, and the Port dredged the berths to their present depths at that time (-45 feet MLLW at Station 1+50 to 9+00 and -50 feet MLLW at Station 9+00 to 29+50). An EIS was completed to assess the environmental impacts of the expanded facility, including its deeper berths.

Subsequent to the Southwest Harbor Redevelopment Project, the Port completed several dredging projects to maintain the current -45 feet MLLW to -50 feet MLLW depth configuration originally approved in the 1990s.

High spots and narrow areas at the entrance to the West Waterway (Figure 3) cause consistent delays for ships (USACE and POS 2014). In addition, the current bathymetry has only a narrow “key way” at all times. Tide restrictions, light loading and other operational inefficiencies created by inadequate channel depth limit the Port’s competitiveness with other West Coast ports.
Figure 3: NOAA 2013 Bathymetry of the Duwamish River – West Waterway
Figure 4: NOAA 2013 Bathymetry of the Duwamish River – West Waterway to Lower Duwamish Waterway
3.2 Existing Vessel Traffic – West Waterway

Only the West Waterway provides access from Puget Sound up the Duwamish Waterway to RM 5.1 near the south end of King County International Airport (Boeing Field). The East Waterway provides access to Terminals 18, 25, and 30 and is limited by low clearance, non-opening highway and railroad bridges at its upstream end (USACE and POS 2014).

Existing vessel traffic into the West Waterway includes commercial vessels navigating to/from Port and private terminals up the Duwamish River and recreational and Tribal fishing vessels. Several wharves near the waterway entrance, receive deep-draft vessels, including T5, (Vigor Shipyards, BP/ARCO, Pacific Terminals, and Sea-Pac Transport Services/Island Tug and Barge Seattle).

Characterization of this existing traffic scheme was completed by M&N with historical shipborne Automatic Identification Systems (AIS) collected over the past two years (August 2013 to April 2015). The data was first compiled to complete a Passing Ship Analysis Report (M&N 2015a), which reveals the characterization of the existing navigation patterns around T5. Figure 2 presents a visual representation of all large vessel traffic (length overall greater than 100 meters or 330 feet) occurring while a ship is berthed at T5. Query extents were limited to a 1-km (3280-foot) radius around the terminal. More recent AIS data, collected for the period of January 2014 through January 2015 shows the different sizes of vessels that use the West Waterway (Figures 3 through 5). These three figures include all vessels regardless of where they are in the channel (i.e., they may or may not pass all the way through to the swing bridge). It should be noted that AIS tracking beacons are located on ships only, not on barges that may be towed by tugs within the waterway. Figures 6 and 7 identify only large vessels (have a Length Overall [LOA] greater than 100 m). Figures 6 and 7 only include ships passing through the waterway. Ships that enter the north side but do not reach the swinging bridge are excluded from the counts.

To further understand existing vessel use of the West Waterway, the data showing the number of times that the SW Spokane Bridge was opened was obtained for a two-year period from January 1, 2014 through December 31, 2015 (SDOT 2016). During this period, there were 3,0651 bridge openings (allowing for the passage of taller vessels), an average of 116 per month and about five per day. Openings peaked at about 160 openings per month (Figure 8). These numbers are used to determine the number and frequency of larger vessels that use the Duwamish River and pass by T5. They do not account for vessels that stop prior to the swing bridge or for smaller vessels that do not require the swing bridge to be opened (recreational power boats, small sailboats). Most of the vessels identified were cargo vessels supported by one to two tugboats (tugs) (Table 1).

---

1 Openings conducted for testing, training, or maintenance were removed from the raw data.
Figure 2: Vessel Use in the Duwamish River West Waterway
Figure 3: Total Vessel Use in the Duwamish River West Waterway by Size

Figure 4: Total Vessel Use in the Duwamish River West Waterway by Month

Figure 5: Total Vessel Use in the Duwamish River West Waterway by Time of Day
Figure 6: Total Large Vessel Use in the Duwamish River West Waterway by Size

Figure 7: Total Large Vessel Use in the Duwamish River West Waterway by Time of Day
Figure 8: Total Duration/Year SW Spokane Swing Bridge Was Open, 2014 and 2015 (SDOT 2016)

Table 1: Example of SW Spokane Bridge Data (SDOT 2016)

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Minutes Open</th>
<th>Vessel in Tow</th>
<th>No. of Support Tugs</th>
<th>Vessel Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/02/2014 06:25</td>
<td>12</td>
<td>TAKU PROVIDER</td>
<td>T,T</td>
<td>143,92</td>
</tr>
<tr>
<td>01/02/2014 07:38</td>
<td>16</td>
<td>NANA PROVIDER</td>
<td>T,T</td>
<td>143,92</td>
</tr>
<tr>
<td>01/02/2014 20:58</td>
<td>13</td>
<td>CRANE BARGE</td>
<td>T</td>
<td>150</td>
</tr>
<tr>
<td>01/02/2014 23:03</td>
<td>13</td>
<td>DB Tacoma</td>
<td>T</td>
<td>150</td>
</tr>
<tr>
<td>01/03/2014 16:10</td>
<td>13</td>
<td>ANCHORAGE TRADER</td>
<td>TT</td>
<td>143, 92</td>
</tr>
<tr>
<td>01/03/2014 16:50</td>
<td>12</td>
<td>TAKU PROVIDER</td>
<td>TT</td>
<td>92, 143</td>
</tr>
</tbody>
</table>

3.3 Existing Terminal 5 Facility

T5 is located on the west side of the Duwamish River West Waterway and includes the existing marine cargo facility, approximately 197 acres of existing upland, 7.3 acres of existing cargo wharf (the wharf being 2900 feet long), and approximately 200 feet of subtidal aquatic area managed as a berth area for commercial cargo vessels adjacent to the terminal wharf (Figure 9).
Figure 9: Terminal 5 – Aquatic Property Boundaries
The T5 berths were last deepened in the late-1990s by stabilizing the slope toe with soldier piles and constructing a steel sheet pile toe wall. Soldier piles were installed at the wharf face between Bents 27S and 13.5, and a steel sheet pile toe wall, approximately 10-feet tall, was installed at the wharf face between Bents 14.5 and 85. The existing berth depth south of Bent 14.5 is -45 feet MLLW, and the existing berth depth north of Bent 14.5 is -50 feet MLLW. The top of the existing toe wall is generally at -41.5 feet MLLW (Figure 10).

Container cargo vessel forecast changes in the container cargo industry have occurred subsequently, resulting in shippers using larger vessels to reduce operating costs. Vessels capable of carrying 10,000 to 14,000 TEU capacities are starting to be used on routes to other West Coast cargo terminals, with 18,000 TEU capacity vessels also emerging. These larger vessels would typically call on a number of ports during one trip, discharging only a portion of their capacity at any one port.

### 3.4 Existing Vessel Traffic to Terminal 5

Until recently, T5 received up to 195 to 235 container vessel calls per year between 2010 and 2013, about one call every two days or about 18 per month (Figure 11). The average hours at berth ranged from an average of 128 to 153 hours per week between 2010 and 2013 (Figure 12). The Port is planning to lease T5 to a new tenant. Vessel traffic will commence again and anticipated vessel calls are further detailed for each of three alternatives in Section 5.
4.0 PROJECT DESCRIPTION

In response to industry changes in marine cargo shipping practices, the Port is evaluating upgrades to ensure that Terminal 5 will be capable of meeting industry needs. Three alternatives are being considered as part of the Project EIS and are described in brief detail below. Alternative 1, the No Action Alternative, provides a baseline of conditions for comparison when discussing the action alternatives.

- **Alternative 1 or No Action Alternative.**

  The No Action Alternative assumes that no improvements would be made to the existing site. It is anticipated that repair, remodeling, maintenance, or minor alterations would take place, including facilities and equipment, however, no material expansion in use or change in marine cargo capability or capacity would result.
This alternative assumes that T5 would continue to be capable of accommodating four to six vessel calls per week, serving vessels similar to the most recent marine cargo operations at the site, container ships with capacities of 4,500 to 5,000 TEUs. Annual throughput is estimated at up to 647,000 TEUs and berth utilization would be approximately 35 percent (the percentage of time a ship occupies each berth). Ships are anticipated to require between 22 to 30 hours at berth for loading and unloading activities, with approximately 148 total berth hours per week.

- **Alternative 2: Wharf improvements, increased cargo-handling efficiency and volume.**

  Alternative 2 would rehabilitate the existing T5 container cargo pier and deepen the existing navigational vessel berth access. In-water and over-water work includes strengthening the existing 2,900 linear feet existing cargo pier in order to receive larger, heavier container cranes capable of serving larger, higher and wider, cargo vessels. Approximately 234,460 square feet of area adjacent to T5 would be dredged to a required depth of -56 feet MLLW with a maximum over-dredge depth to -58 feet MLLW. Upland improvements could also be constructed to support the above wharf upgrades.

  With improvements to the berth depth, wharf and cranes, T5 could accommodate up to two 18,000 TEU ships simultaneously. A lower percentage of cargo would be unloaded/loaded for larger ships than for smaller ships. This operational scenario anticipates that each week T5 will have 4 vessel calls, two 14,000 TEU ships and two 8,000 TEU ships. Annual throughput is estimated at up to 1.3 million TEUs and berth utilization will be on the order of 57 percent. Ships are anticipated to require between 25 to 50 hours at berth for loading and unloading activities, with approximately 150 total berth hours per week.

- **Alternative 3: Wharf improvements, relocate buildings, densify rail yard, optimized cargo-handling efficiency and volume.**

  In-water and over-water construction including berth deepening, and upland construction activities would be the same as described for Alternative 2. However, increased throughput and upland improvements are anticipated (wharf and crane improvements would allow simultaneous loading and unloading of the two 18,000 TEU vessels). This operational scenario anticipates that each week T5 will have four vessel calls, two 14,000 TEU ships and two 8,000 TEU ships. The vessel call scenario generates annual throughput of up to 1.7 million TEUs and a berth utilization on order of 59 percent. Ships are anticipated to require between 22 to 30 hours at berth for loading and unloading activities, with approximately 142 total berth hours per week.

Both Alternatives 2 and 3 will deepen the berths to -54 feet MLLW by installing an additional toe wall outboard of the existing toe wall, installing pinch piling to increase slope stability, increasing the crane rail capacity, and replacing the fender system. The top of the toe wall is proposed to be -45 feet MLLW between Bents 32S and 14 and -50 feet MLLW between Bents 14 and 114. The proposed toe wall will be approximately 9-feet-tall south of Bent 14 and 4-feet-tall north of Bent 14.

The Port’s draft Terminal 5 Berth Modernization – Basis of Design dated January 23, 2015 (Port 2015) specifies the toe wall to be designed to a dredge depth of -58 feet MLLW. This increased dredge depth will allow for potential future berth deepening.
5.0 VESSEL NAVIGATION MANAGEMENT

This section describes the laws and regulations in place that helped to identify potential impacts to vessel traffic and navigation.

5.1 Laws and Regulations

The U.S. Coast Guard (USCG) and the Puget Sound Harbor Safety Committee have developed a Harbor Safety Plan that formally establishes a set of Standards of Care for the Puget Sound area, which supplement existing federal, state, and local laws (Table 2). The applicable federal, state and local laws are listed here to aid in better understanding vessel traffic and navigation within the Duwamish River and determining potential impacts on existing uses. For example:

- Each commercial vessel arriving in Elliott Bay from the Strait of Juan de Fuca is under the direction of a Puget Sound Pilot, with tug aid to the final berth. Ships discharge and load cargo and are then piloted with tug assist off berth though Elliott Bay and out to the open ocean. Pilotage for Puget Sound is regulated under the Federal Pilotage Requirements (46 CFR 15.610 and 15.812). Even light tugs (tugs without a tow) must be under the direction and control of either a first class pilot or a deck officer with authority to “act as pilot” when underway in designated pilotage waters. This mandated expertise minimizes the risk for collision in busy or narrow waterways.

- The USCG Vessel Traffic Service (VTS) regulates vessel traffic and safety in Puget Sound by monitoring and directing vessel movements to maintain appropriate navigation corridors and vessel transit separation, with the coincident benefit of minimizing shipping interruptions and delays. VTS encompasses a wide range of capabilities to prevent vessel collisions and support harbor approach and inland waterway navigation. They are also designed to expedite ship movements, increase transportation system efficiency, and improve all-weather operating capability. Transiting vessels make position reports to the VTS center, located at Pier 36, and are, in turn, provided with accurate, complete, and timely navigational safety information. The addition of a network of radars, AIS, and close circuit television cameras and computer-assisted tracking, similar to that used in air traffic control, results in VTS being an important element of marine traffic management, thereby decreasing vessel congestion, critical encounter situations, and the probability of a marine casualty resulting in environmental damage.

- A “Notice to Mariners” and “Local Notice to Mariners” are both means used to report current or future information and navigation changes that could affect existing vessels and waterways (Navigation and Navigable Waters, 33 CFR 72.01). These notices are published weekly and incorporate upcoming marine events (regattas), new chart information, danger areas or obstructions, weather warnings, and pending marine construction projects.

- Vessel speed within the Duwamish River is limited to 7-knots throughout the river. Most larger vessels within the narrow West Waterway travel at lower speeds ranging from 2.5 to about 3.5 knots, the highest speeds of 4 to 5 knots observed for outbound commercial vessels (M&N 2015a).
Table 2: Laws and Regulations for Vessel Traffic

<table>
<thead>
<tr>
<th>Laws and Regulations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Federal</strong></td>
<td></td>
</tr>
<tr>
<td>Ports and Waterways Safety Act of 1972 (31 U.S.C. 1221 et seq.)</td>
<td>Authorizes USCG to provide for navigation and vessel safety; protect the marine environment; and protect life, property, and structures in, on, or adjacent to U.S. navigable waters.</td>
</tr>
<tr>
<td>Navigation and Navigable Waters, Subchapter E: Inland Navigation Rules (33 CFR 83 – 90)</td>
<td>Applies to all vessels on the inland waters of the U.S. Complements the International Regulations for Preventing Collisions at Sea 1972, applicable in International Waters.</td>
</tr>
<tr>
<td>Federal Pilotage Requirements (46 CFR 15.610 and 15.812)</td>
<td>Identifies the type of vessels that require a federally licensed master or mate and federal pilotage requirements for U.S.-inspected vessels on coastwise voyages¹.</td>
</tr>
<tr>
<td><strong>State</strong></td>
<td></td>
</tr>
<tr>
<td>Washington State Pilotage Act (RCW 88.16)</td>
<td>Identifies requirements for compulsory pilotage provisions in certain waters of the state, including Puget Sound.</td>
</tr>
<tr>
<td><strong>Local</strong></td>
<td></td>
</tr>
<tr>
<td>Puget Sound Harbor Safety Committee and the Puget Sound Harbor Safety Plan</td>
<td>In partnership with the USCG, established a set of Standards of Care for the Puget Sound area, which supplement existing federal, state, and local laws.</td>
</tr>
</tbody>
</table>


¹ A coastwise voyage by sea is a voyage in which a U.S.-flagged vessel proceeds from one port or place in the U.S. to another port or place in the U.S. while engaged in trade (46 CFR 46.05–15).

6.0 POTENTIAL IMPACTS TO VESSEL TRAFFIC AND NAVIGATION

Impacts to existing vessel traffic and navigation may include:

- Short-term (temporary) impacts from construction activities, include changes in vessel traffic within the waterway due to project demolition, dredging, and wharf construction. Specifically, vessels may be used to transport project debris, dredged material, equipment, and materials to and from the Project site.
- Long-term (operational) impacts from changes in vessel traffic and modifications to existing navigation channels and access could result in:
  - Conflicts with other large commercial vessels, including bulk carriers and barge/tug traffic, commercial and Tribal fishing vessels, and recreational vessels.
  - Changes to navigation, specifically to channel capacity. The ease and ability of vessels to pass T5 when a large vessel is in berth may be altered, impacting existing waterway access and navigability of the West Waterway.

To better quantify the above potential impacts to existing vessel traffic, the short-term and long-term changes in vessel traffic were summarized in Table 3.
Table 3: Potential Vessel Use at T5 for Three Project Alternatives

<table>
<thead>
<tr>
<th>Vessel Use</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. No. of Vessels at site any one time.</td>
<td>No change in existing vessel traffic</td>
<td>3 derricks, 3 supply barges/scows, 2 support tugs</td>
<td>3 derricks, 3 supply barges/scows, 2 support tugs</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max TEU/Vessel</td>
<td>5,500</td>
<td>18,000</td>
<td>18,000</td>
</tr>
<tr>
<td>Vessel Length Overall</td>
<td>294 m (965 feet)</td>
<td>399 m (1,309 ft)</td>
<td>399 m (1,309 ft)</td>
</tr>
<tr>
<td>Vessel Beam¹</td>
<td>46 m (150 feet)</td>
<td>59 m (194 ft)</td>
<td>59 m (194 ft)</td>
</tr>
<tr>
<td>Maximum Possible Calls</td>
<td>6/week</td>
<td>4/week</td>
<td>4/week</td>
</tr>
<tr>
<td>Maximum Berth Utilization</td>
<td>35%</td>
<td>57%</td>
<td>59%</td>
</tr>
<tr>
<td>Time at Berth/Vessel</td>
<td>22 to 30 hrs</td>
<td>25 to 50 hrs</td>
<td>25 to 46 hrs</td>
</tr>
<tr>
<td>Average Total Time for all vessels at Berth/Week</td>
<td>148 hrs</td>
<td>150 hrs</td>
<td>142 hours</td>
</tr>
</tbody>
</table>

¹ A vessel’s width is referred to as its beam.

6.1 Alternative 1
The No Action Alternative is not anticipated to result in significant impacts to existing vessel traffic or navigation. Strengthening and improving the existing Terminal 5 cargo pier will not take place and vessel use at the existing site is anticipated to return to conditions typical of previous operations, including up to six vessel calls per week.

6.2 Alternatives 2 and 3
6.2.1 Construction
Construction for Alternatives 2 and 3 would require vessel support for in-water work (dredging, pile driving) or equipment and material transport (dredged sediment, piles, demolition and construction debris). Demolition, transportation of piles and other material used to strengthen the berth, and dredging would require derrick barges, along with support barges and tugs. Table 1 summarizes the potential maximum number of vessels that could be located at T5 at any one time during in-water work.

The Project is expected to begin following receipt of City of Seattle, Washington State and federal authorizations, with completion within three years following commencement. In-water work is restricted between February 16 and August 15 and is anticipated to take two or three in-water work seasons to complete. In-water construction activities may be coincident, with wharf strengthening and slope stability actions taking place simultaneously, while berth deepening dredging is anticipated to be implemented during final phases of in-water construction, following substantial completion of wharf strengthening and slope stability improvements.

At most, eight vessels are anticipated to be working off the T5 wharf within the West Waterway at any one time during construction, 3 of them derricks each with a support barge. The 3 derricks would most
likely be 100 feet by 300 feet in size and positioned directly next to a scow or supply barge of similar dimensions. This total width (from herein referred to as the vessel beam) of about 200 feet for the side-to-side arrangement of construction vessels is similar to the beam of the anticipated 18,000 TEU ship (194 feet), discussed further in Section 5.2.3.

Construction vessels may also be stationed perpendicular to the wharf or east of the berth being dredged. In both cases, the beam of these vessels could extend up to 400 feet into the waterway from the wharf. This will not impede smaller vessels, which can maneuver around the barges. Additionally, the Navigation and Navigable Waters, Subchapter E: Inland Navigation Rules aligns with the 1972 International Regulations for Prevention of Collisions at Sea. Vessels with more maneuverability are required to “give way” to those more restricted in their ability to move within a navigation channel. It is general practice for construction vessels to yield to larger cargo vessels within working port areas.

6.2.2 Berth Modifications

While the new sheet pile wall will be constructed waterward of the pierhead line, wall improvements proposed for Alternatives 2 and 3 will ensure slope stability remains comparable to existing conditions. Even though vessels may be berthed closer to the wall under Alternatives 2 and 3, slope stability, and therefore channel navigability, remains unchanged (M&N 2015b).

6.2.3 Traffic

For both Alternatives 2 and 3, the number of vessel calls is anticipated to decrease to about 4 calls per week from 6 calls per week for the No Action Alternative. This reduction in vessels is a reduction of 20%.

Berth utilization (the percentage of time a ship is occupying each berth) will increase from about 35% (Alternative 1) to 57 to 59% (Alternatives 2 and 3 respectively). The impacts of this change can be viewed in Figure 5 which compares the three alternatives. Fewer vessels will occupy T5 in Alternatives 2 and 3 but they will use more of the berth. The average overall hours that berth at T5 for one week will remain relatively constant (148 hours/week for Alternative 1, 150 hours/week for Alternative 2, 142 hours/week for Alternative 3). Alternative 3 results in a slight decrease in vessel hours at berth/week. In past years at T5, vessel hours at berth has ranged from as low as 128 hours/week to 153 hours/week (Figure 13). All alternatives remain well within this variability, although both Alternatives 2 and 3 result in higher berth utilization (57 percent and 59 percent respectively).
Figure 13: Alternative Comparison of Berth Utilization
6.2.4 Channel Navigation

The existing Duwamish River West Waterway is 750 feet wide. The largest proposed vessel that could call at T5 under Alternatives 2 and 3 would need to accommodate 18,000 TEU. As shown in Table 3, this vessel is assumed to be similar to vessels referred to as Ultra Post-Panamax or New Post-Panamax, with approximately 1,250 to 1,300 feet Length Overall (LOA) and a beam of about 160 to 200 feet. Two vessel passing scenarios were considered:

1. **Scenario 1:** In this scenario, an 18,000 TEU vessel with a beam of 200 feet is in berth at T5 and is being passed by the largest anticipated vessel that could move past T5 into the Lower Duwamish Waterway, at low speed (about 3 knots), typical of vessels using the West Waterway, with a beam of about 90 feet and a draft of 30 feet.

2. **Scenario 2:** In this scenario, an 18,000 TEU vessel with a beam of 200 feet is in berth at T5 and is being passed by another 18,000 TEU vessel, which is also preparing to berth at T5. The passing vessel is also traveling at low speed (less than 3 knots) as it prepares to berth. Both 18,000 TEU vessels have drafts of 50 feet, requiring about 2 feet of depth clearance.

Table 4 summarizes the types and sizes of the vessels used to determine the remaining channel width with an 18,000 TEU vessel in berth at T5.

### Table 4: Vessel Dimensions Used for Channel Width Evaluation

<table>
<thead>
<tr>
<th>Vessel Characteristics</th>
<th>Vessel in Berth</th>
<th>Passing Vessel Scenario 1</th>
<th>Passing Vessel Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Type</td>
<td>Ultra Post-Panamax, New Post-Panamax</td>
<td>Handymax</td>
<td>Ultra Post-Panamax, New Post-Panamax</td>
</tr>
<tr>
<td>Vessel Length Overall</td>
<td>Approximately 300-400 m (1,250-1300 feet)</td>
<td>Approximately 190 m (623 feet)</td>
<td>Approximately 300-400 m (1,250-1300 feet)</td>
</tr>
<tr>
<td>Vessel Beam</td>
<td>Approximately 48-60 m (160-200 feet)</td>
<td>Approximately 27 m (90 feet)</td>
<td>Approximately 48-60 m (160-200 feet)</td>
</tr>
<tr>
<td>Vessel Draft</td>
<td>50 feet</td>
<td>30 feet</td>
<td>50 feet</td>
</tr>
</tbody>
</table>

1 Largest cargo vessels typically serving Duwamish Waterway industrial and commercial facilities.
2 Passing vessel LOA and beam values derived from 1982 ACOE, East, West, and Duwamish Waterways, Navigation Improvements Study, Appendix C.

In both scenarios, M&N used a number of different methods to determine if there was available channel width and space between vessels to pass the berthed 18,000 TEU vessel in berth. These methods were for straight, single-lane ship traffic and included:

1. **Desktop USACE Evaluation Method.** The USACE method (EM 1110-2-1613) takes into account five variables: current speed, navigation aid quality, channel section type, channel variability, and ship beam.

2. **Desktop PIANC Evaluation Method.** The PIANC method (Report No 121 – 2014) is more complex, taking into account additional factors such as wind, waves, current direction, and ship maneuverability.

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2 The Duwamish Waterway has an authorized bottom width of 150 to 200 feet as it extends from the West Waterway to the Lower Duwamish Waterway. The Bascule Bridge has a horizontal clearance of 150 feet. Both limit the width of vessels that can pass T5 when an 18,000 TEU vessel is in berth.
3. **Desktop Evaluation for Channel Width, referred to as the Spanish ROM Method.** This method is the most complex. The Spanish Recommendations for Maritime Works (in Spanish: Recomendaciones para Obras Marítimas [ROM]) method (Puertos del Estado 2007) is an empirically based, spreadsheet-level approach for determining a channel width. It is one of the major references used in the Permanent International Association of Navigation Congresses (PIANC) guidelines for approach channel design (PIANC 2014). In addition to the previously mentioned variables for the USACE and PIANC methods, the ROM method also estimates a tug correction, ship drift angle, and incorporates additional ship dimension into the environmental factor (Figure 14).

![Figure 14: Width Elements for Straight Channel: Spanish ROM Method](image)

The equation for nominal width of a single-lane fairway \(B_n\) is:

\[
B_n = B + L_{bp} \sin \beta + 2(b_e + b_b) + 2b_r + b_{sf}
\]

Where:

- \(B\) is the beam of the vessel.
- \(L_{bp} \sin \beta\) represents the additional width due to the drift or crab angle. The crab angle is primarily created by currents and winds, and is countered by tugs. It is a function of vessel parameters, vessel speed, current speed and direction, and wind speed and direction.
- The crab angle increases (as expected) with increasing relative currents and wind speeds, and is greater for cross currents and cross winds.
- \(b_e\) and \(b_b\) represent uncertainties in vessel position.
  - \(b_e\) is additional width associated with the type of positioning (e.g., visual positioning) and whether an experienced pilot is guiding the vessel.
  - \(b_b\) represents errors or uncertainties associated with navigation aids (e.g., errors in range marker position). These errors are both independent of vessel characteristics; the \(2(b_e + b_b)\) term ranges from 30 to 120 feet.
- \(b_r\) is an additional width proportional to the beam of the vessel and represents positioning errors due to the limited responsiveness of the vessel. This width also incorporates risk elements (economic repercussions and potential for loss of life associated with any incidents).
- \(b_{sf}\) represents a safety factor proportional to the vessel beam, providing a margin of safety while accounting for bank conditions; i.e., a higher factor of safety is required for rocky banks than for gentle, sandy shoals. The safety margin term \(2(b_{tr} + b_{su})\) ranges from 144 to 269 feet.
All three methods are more commonly used to design approach channels (vessels transiting a channel at speeds greater than four knots). The three methods all follow the same general approach of applying design factors which are then summed and multiplied by the vessel’s beam. All three methods also require input of channel width and depths.

While the West Waterway is a 750 foot-wide channel, shoaling and side slopes reduce the usable channel width and depth, as do any channel “high spots” from sediment caps. Bathymetry was used to account for these above factors, and determined that the usable channel width, that which reached a 32-foot depth for Scenario 1, was 700 feet (Figure 16). This assumes a 50-foot allowance from either edge of the channel. For Scenario 2, the existing usable channel width is observed to be as narrow as 390 feet in some areas (Figure 16). Dredging may be required if additional channel width is desirable. At this time, a 650-foot wide usable channel width is assumed.

For both Scenarios, the PIANC and USACE methods reflect similar minimum fairway widths as the ROM Method (Table 5). Using a 2B Rule of Thumb (PIANC 2011), the minimum separation distance required for both scenarios was calculated:

- Scenario 1 is 54 m (178 feet), as shown using the ROM, PIANC and USACE methods. Even with this narrower channel, an 80- to 90-foot wide (beam) vessel could still pass a 200-foot wide container cargo vessel moored at T5 (the largest vessel proposed to visit T5 under Alternatives 2 and 3) with appropriate separation of between the two vessels and given 650 feet of usable channel width (accounting for side slopes and narrower regions of the channel). With a vessel of 90 feet in width and a separation distance of 180 feet (rounded), 380 feet remains for maneuverability.

- Scenario 2 does not accommodate a 2B Rule of Thumb using the ROM, PIANC and USACE methods. However, these methods are more appropriate for vessels passing open channels at speed (greater than 3 knots). Scenario 2 is more of a berthing activity, rather than a passing activity. For very slow vessels the required separation distance decreases. Therefore a fourth Desktop Evaluation for Channel Beam was also used.

<table>
<thead>
<tr>
<th>Table 5: Channel Width Evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaluation Method</strong></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>Scenario 1</strong></td>
</tr>
<tr>
<td><strong>ROM</strong></td>
</tr>
<tr>
<td><strong>PIANC</strong></td>
</tr>
<tr>
<td><strong>USACE</strong></td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
</tr>
<tr>
<td><strong>ROM</strong></td>
</tr>
<tr>
<td><strong>PIANC</strong></td>
</tr>
<tr>
<td><strong>USACE</strong></td>
</tr>
</tbody>
</table>
4. **Desktop Navy/ROM Evaluation Method.** Both the US Navy DOD and ROM address separation distance while berthing in more or less a similar fashion as a multiplier of the beam plus an allowance for tug maneuvering. The method allows a beam width on either side of the maneuvering vessel.

For Scenario 2, a beam of 59 meters (194 ft), the recommended slip beam would be about 261 m (856 ft). This allows a maneuvering lane of 3B (plus length of tug) plus the beam of the ship at berth (4B plus length of tug). If available width is less, then vessel simulations are used to prove the concept, incorporating other factors such as current, wind, etc. Often times a much lower multiplier provides adequate access. Recent work by M&N at a port on the west coast showed that a straight 3B multiplier was adequate. Additional studies, completed prior to construction, may demonstrate that the available 3.35B at T5 (Figure 15) is adequate for two berthing 18,000 TEU vessels. Additional studies may also clarify if further dredging is desirable.

![Diagram](image-url)

*Figure 15: Scenario 2 Berthing Separation Distance Using Navy/ROM Evaluation Method*
6.3 Potential Mitigation Measures

6.3.1 During Construction

Vessel traffic and navigation impacts during construction will be temporary. Minor delays could occur during dredging or wharf construction. However, the current communication practices used within Puget Sound, and the applicable maritime regulations and guidelines, described in Section 4.1, minimize delay and collision risks. Additionally, all Port in-water construction activities are coordinated with the Muckleshoot and Suquamish Indian Tribes, with the objective of avoiding and minimizing potential
disruption to Treaty fishing activities. This includes scheduling of construction activities to avoid specific fishing periods and controlling the location and timing of construction activities. Therefore, adverse impacts to existing vessel traffic and navigation are not anticipated and mitigation measures are not proposed.

6.3.2 Traffic and Navigation

The number of vessels that could call at T5 under either Alternative 2 or 3 decreases compared to the No Action Alternative. These fewer vessels will be larger (specifically wider), however, adequate channel width for passing remains for vessels of about 90-feet in beam. For vessels with a beam of 200 feet, additional maneuvering analysis is recommended and additional channel dredging may be required. Similar to existing conditions, commercial, Tribal, and recreational vessels will be able to pass and continue transiting the West Waterway.

Current regulations (e.g. requirement for a licensed Pilot on board large commercial vessels) and communications with the VTS and other vessels will continue and minimize risks of traffic collisions, delays, or accidents. Additionally, the Port works with the Muckleshoot and Suquamish Indian Tribes on Port operations, to ensure that vessel arrivals and departures during fishing periods are known in advance to avoid and minimize potential net and vessel conflicts. Therefore, adverse impacts to existing vessel traffic and navigation are not anticipated and mitigation measures are not proposed.

6.4 Significant Unavoidable Adverse Impacts

No significant impacts to vessel traffic and navigation would be anticipated from any of the Alternatives.

7.0 REFERENCES


