CHAPTER 3

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

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3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

In this chapter, discussions of the affected environment for each resource provide general descriptions of regional conditions followed, as appropriate, by project site-specific discussions for the Land Water Interface (LWI) and Service Pier Extension (SPE) projects. Because the LWI and SPE projects are independent, their environmental impacts are evaluated separately in this chapter. The combined impacts that would occur if both projects are implemented are evaluated at the end of each resource section in Chapter 3. Current schedules indicate construction of the two projects would not overlap but would occur sequentially, extending the duration of impacts beyond what would occur under either of the projects alone. The contributions of the proposed actions to cumulative impacts in the region are evaluated in Chapter 4.

3.1. MARINE WATER RESOURCES

3.1.1. Affected Environment

Marine water resources focus on hydrography (circulation and sediment transport patterns), water quality (physical and chemical properties of a water body), and sediment quality (physical and chemical properties of bottom sediments).

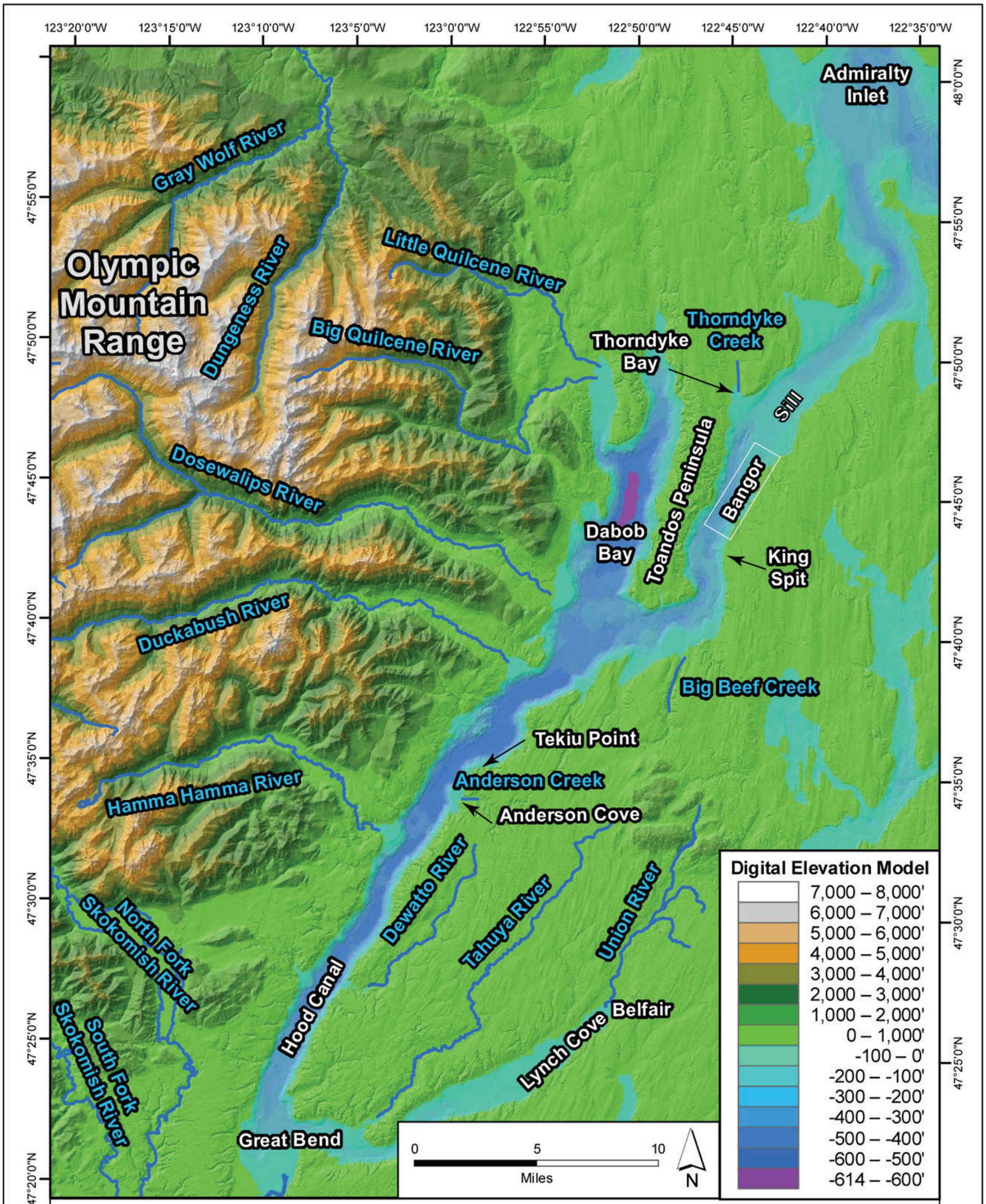
3.1.1.1. EXISTING CONDITIONS

3.1.1.1.1. HYDROGRAPHY

Hydrography focuses on circulation (water movement) patterns as affected by the seafloor topography (bathymetry), currents, and tides, as well as the characteristics (density) of the different water masses in the project vicinity. Hydrographic processes are important because they affect the dispersion and mixing of sediments resuspended from in-water construction activities, the rate of sediment accumulation or erosion from the seafloor, and processes that transport sediments along the shoreline. Hydrographic processes also influence other resources such as water quality, marine vegetation, fish, and benthic communities. This section summarizes the hydrographic setting of Hood Canal and areas around the LWI and SPE project sites.

Hood Canal is a long, narrow, fjord-like basin in western Puget Sound. Oriented northeast to southwest, the canal is 52 miles (84 kilometers) long from Admiralty Inlet to the Great Bend, at Skokomish, Washington. East of the Great Bend, the canal extends an additional 15 miles (24 kilometers) to the headwaters at Belfair (Figure 3.1–1). Throughout its 67-mile (110-kilometer) length, the width of Hood Canal varies from approximately 1 to 2 miles (1.6 to 3.2 kilometers). The entire length of Hood Canal basin shoreline, inclusive of the many embayments and coves, is approximately 288 miles (460 kilometers).

Although no official boundaries exist along the waterway, the northeastern section of the canal extending from the mouth of the canal at Admiralty Inlet to the southern tip of Toandos Peninsula is referred to as northern Hood Canal, while the region from Toandos Peninsula south to Great Bend is considered mid-Hood Canal, and the reach from Great Bend to Lynch Cove is referred to as southern Hood Canal. The Naval Base (NAVBASE) Kitsap Bangor project sites are located in northern Hood Canal.



Source: Morris et al. 2008

NOTE:
Coordinate System: WA State Plane (North)
Horizontal Datum: NAD83
Vertical Datum: MHW
Units: feet
DEM provided by University of Washington

Figure 3.1–1. Hood Canal Bathymetry, Surface Water, and Physical Relief

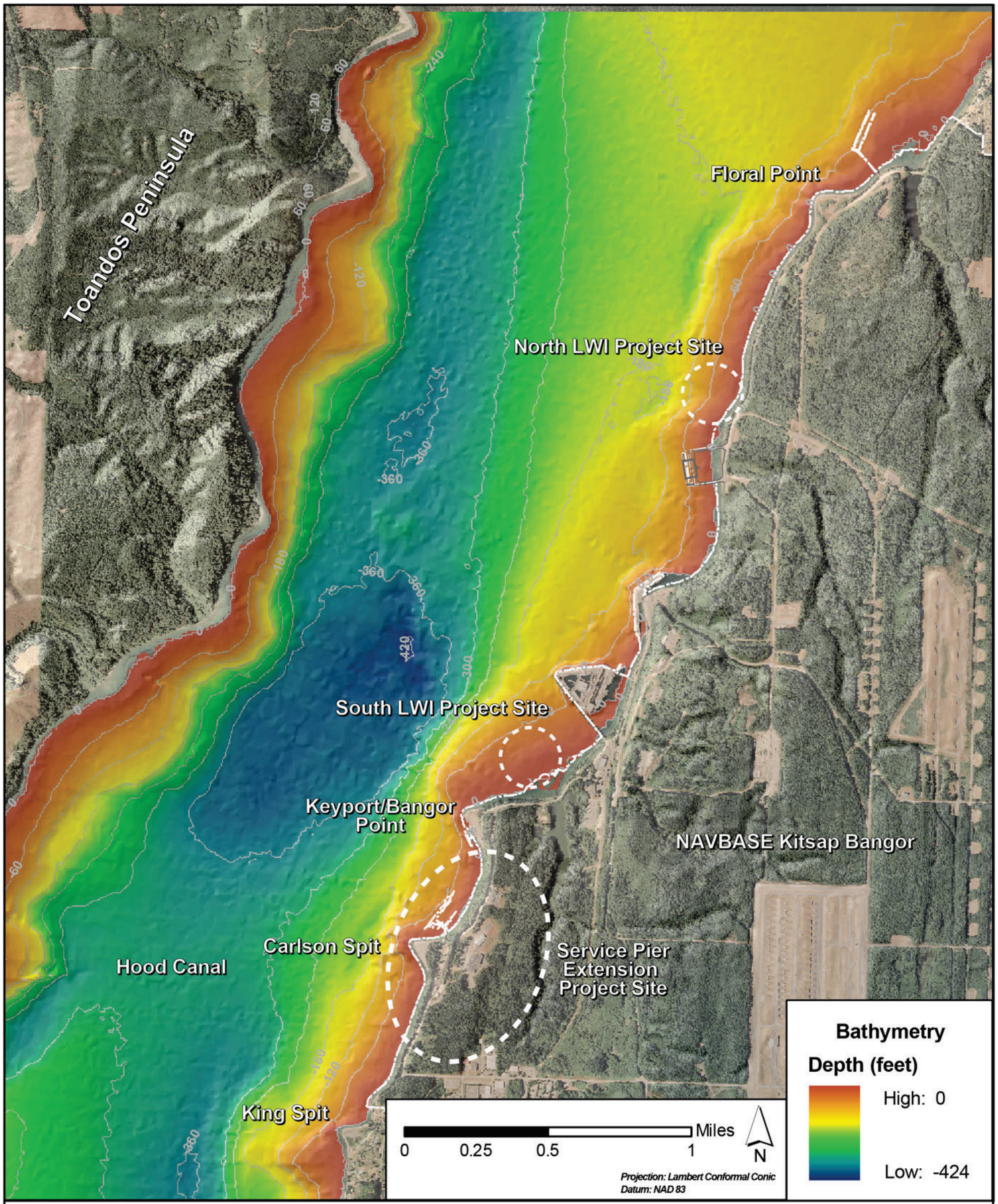
BATHYMETRIC SETTING

Hood Canal is characterized by relatively steep sides and irregular seafloor topography. In northern Hood Canal, water depths in the center of the waterway near Admiralty Inlet vary from 300 to 420 feet (91 to 128 meters). As the canal extends southwestward toward the Olympic Mountain Range and Thorndyke Bay, the water depth decreases to approximately 160 feet (49 meters) over a moraine deposit. This deposit forms a sill across the canal in the vicinity of Thorndyke Bay, which limits seawater exchange with the rest of Puget Sound. Southwest of Thorndyke Bay, the seafloor rapidly falls away to depths in excess of 300 feet (91 meters) adjacent to Brown Point on the Toandos Peninsula. The NAVBASE Kitsap Bangor waterfront occupies approximately 5 miles (8 kilometers) of the shoreline within northern Hood Canal (1.7 percent of the entire Hood Canal coastline) and lies just south of the sill feature. The width of the canal near the project sites ranges from approximately 1 to 2 miles (1.6 to 3.2 kilometers) (Figure 3.1–2).

Globally, sea level has been rising for the past 10,000 years as a result of the end of the last glacial epoch (Gornitz 2007). However, there is evidence that the rate of sea level rise (SLR) is accelerating due to ocean warming (thermal expansion), continental ice melt, and land elevation changes (Cayan et al. 2006). U.S. Army Corps of Engineers (USACE) guidance for incorporating sea level change considerations in civil works programs recommends evaluating project alternatives using three scenarios for SLR: low, intermediate, and high (USACE 2011). Projections of SLR for Puget Sound under low and high scenarios range from 3 to 22 inches (0.08 to 0.6 meter) by 2050 and from 6 to 50 inches (0.15 to 1.3 meters) by 2100 (Littell et al. 2009). For the proposed SPE project alternatives, SLR is not an issue because the pier and pile caps are designed to match those of the existing structure, and the pier is high enough above the water level to not be impacted within the design life of the project (50 years). The elevation of the bottom of the Service Pier deck is approximately 16 feet (4.9 meters) above mean lower low water (MLLW) or approximately 5 feet (1.5 meters) above current mean higher high water (MHHW). With a worst-case SLR of 22 inches by the year 2050, the pier bottom would be approximately 3.2 feet (1 meter) above the new MHHW. With a worst-case SLR of 50 inches by 2100, the pier bottom would still be above the new MHHW. The most likely scenario is that the pier bottom would be several feet above the new MHHW over the 50-year design life of the project. Similarly, over the 50-year design life of the proposed LWI piers (Alternative 2), the pier bottoms would be high enough above the water (17 feet [5.2 meters] above MHHW) that they would not be affected. Effects on the north and south LWI abutments and observation posts would be negligible under any SLR scenario. In addition, the floating Port Security Barriers (PSBs) would not be affected by SLR. For these reasons, the effects of SLR on the LWI and SPE project alternatives are not addressed further in this environmental impact statement (EIS).

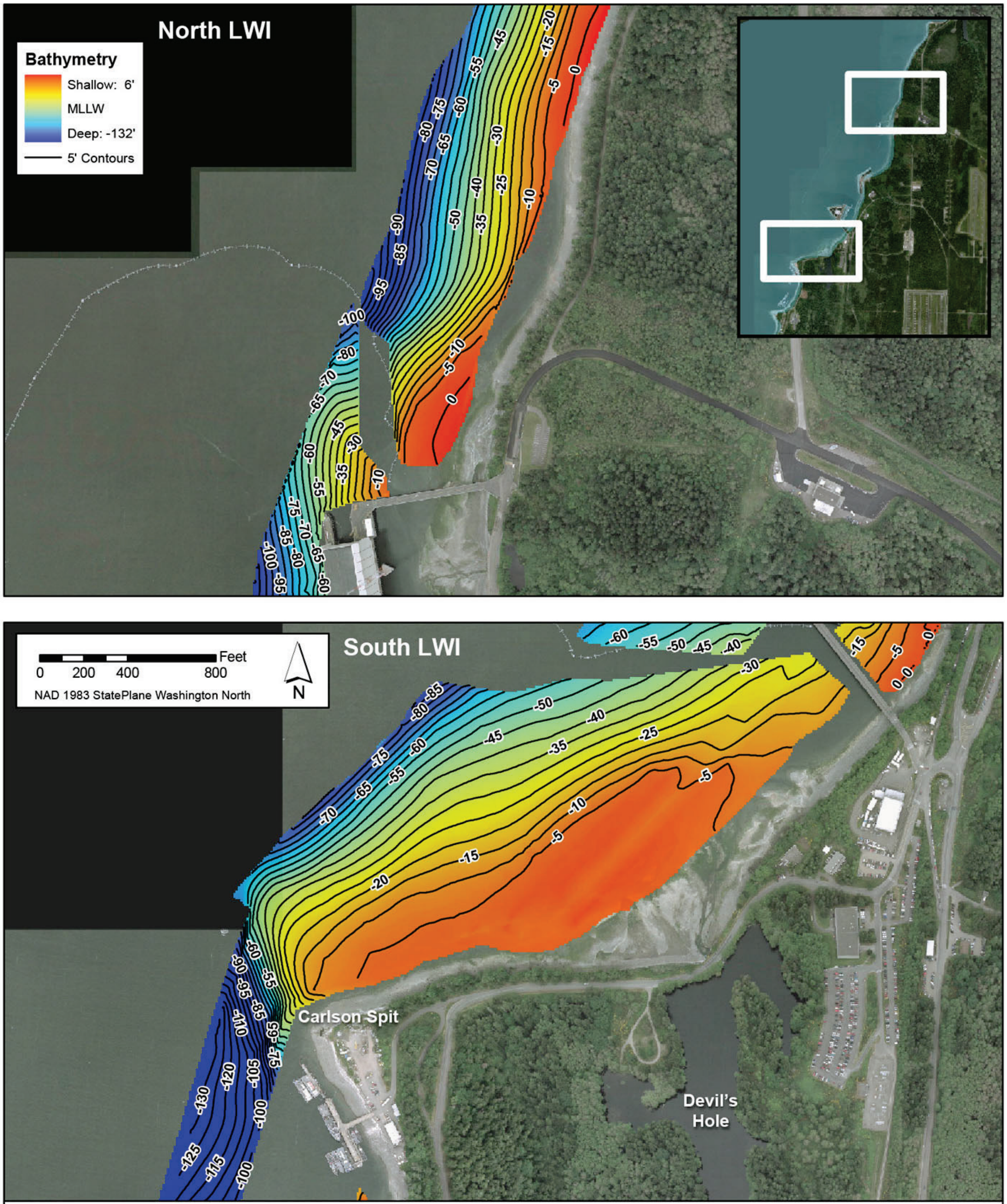
BATHYMETRY OF THE LWI PROJECT SITES

The bathymetry of the Bangor waterfront is illustrated in Figure 3.1–2, and the nearshore bathymetry of the north and south LWI project sites is shown in Figure 3.1–3. At the south LWI project site, the deltaic formation immediately offshore from Devil's Hole slopes gradually with distance from the shore, whereas at the north LWI project site the slope of the intertidal and shallow subtidal areas is comparatively steeper. The -15 feet (-5 meter) MLLW depth contours occur at distances of approximately 300 and 700 feet (91 and 213 meters) from shore at the



Source: Morris et al. 2008

Figure 3.1–2. Bathymetry in the Vicinity of the NAVBASE Kitsap Bangor Shoreline



Source: SAIC 2009

Figure 3.1–3. LWI Project Site Bathymetry north and south LWI project sites, respectively. Mean high water (MHW) and MHHW elevations at the LWI project sites are approximately 7 feet above MLLW and 11 feet above MLLW, respectively.

BATHYMETRY OF THE SPE PROJECT SITE

Bathymetry in the vicinity of the SPE project site is shown in Figure 3.1–4. Depth contours generally follow the shape of Carlson Spit that extends into Hood Canal immediately south of the existing Service Pier. Water depths at the southern end of Service Pier are approximately 40 feet (13 meters), and depths increase to approximately 100 feet (30 meters) at a distance of about 400 feet (120 meters) from the tip of Carlson Spit.

CIRCULATION AND CURRENTS

Circulation patterns within Hood Canal are complex due to the configuration of the basin and the tidal regime. Tides in Hood Canal are mixed diurnal-semidiurnal with one flood and one ebb tidal event characterized by a small to moderate range (1 to 6 feet [0.3 to 2 meters]) and a second flood and second ebb with a larger range (8 to 16 feet [2 to 5 meters]) during a 24.8-hour tide cycle. As a result, higher high, lower high, higher low, and lower low water levels occur within each tide day (URS 1994; Morris et al. 2008). Larger tidal ranges promote higher velocity currents and increased flushing of the basin, whereas small to moderate tidal ranges are associated with weaker currents and comparatively smaller volumes of seawater exchanged between Hood Canal and Puget Sound.

Because the tides are mixed diurnal-semidiurnal, Hood Canal is subject to one major flushing event per tide day, when approximately 3 percent of the total canal volume is exchanged over a 6-hour period. Due to the wide range of tidal heights, the actual seawater exchange volume for Hood Canal ranges from 1 percent during a minor tide to 4 percent during a major tide.

The shallow sill feature near Thorndyke Bay does not inhibit surface water flows into and out of the canal as part of normal tidal exchange. However, the sill restricts deep-water circulation and the outflow volume into Puget Sound during major ebb tide events. Seawater that enters the canal from Puget Sound during an incoming flood tide tends to be cooler, more saline, and well-oxygenated compared to Hood Canal waters. As a result of its higher density, incoming Puget Sound water has a tendency to sink to the bottom of the canal as it flows over the sill and moves south during each flood tide, while the lower density Hood Canal water tends to remain in the upper water column. Despite the large volume of water that moves into and out of Hood Canal with each tidal cycle, this density-driven circulation contributes to net inward flow at depths greater than 160 feet (49 meters) and a net outward flow at depths shallower than 160 feet. Historical values for average current velocities and transport measured along the axis of the Hood Canal trough are low, with a net subsurface (below 100 feet [30 meters]) southeastward (inward) flow of 0.07 foot/second (2 centimeters per second), and a net northward (outward) surface (0 to 30 feet [0 to 9 meters]) flow of 0.11 foot/second (3 centimeters per second) (Evans Hamilton and D.R. Systems 1987). This circulation pattern affects the overall flushing of the mid and southern portions of Hood Canal. Despite considerable tidally driven seawater influx within the basin, water residence times in the southern and middle portions of Hood Canal can be up to one year due to the natural limitation (i.e., bathymetry) on seawater exchange (Warner et al. 2001; Warner 2007).

Source: Informed Land Survey 2012

Figure 3.1–4. SPE Project Site Bathymetry

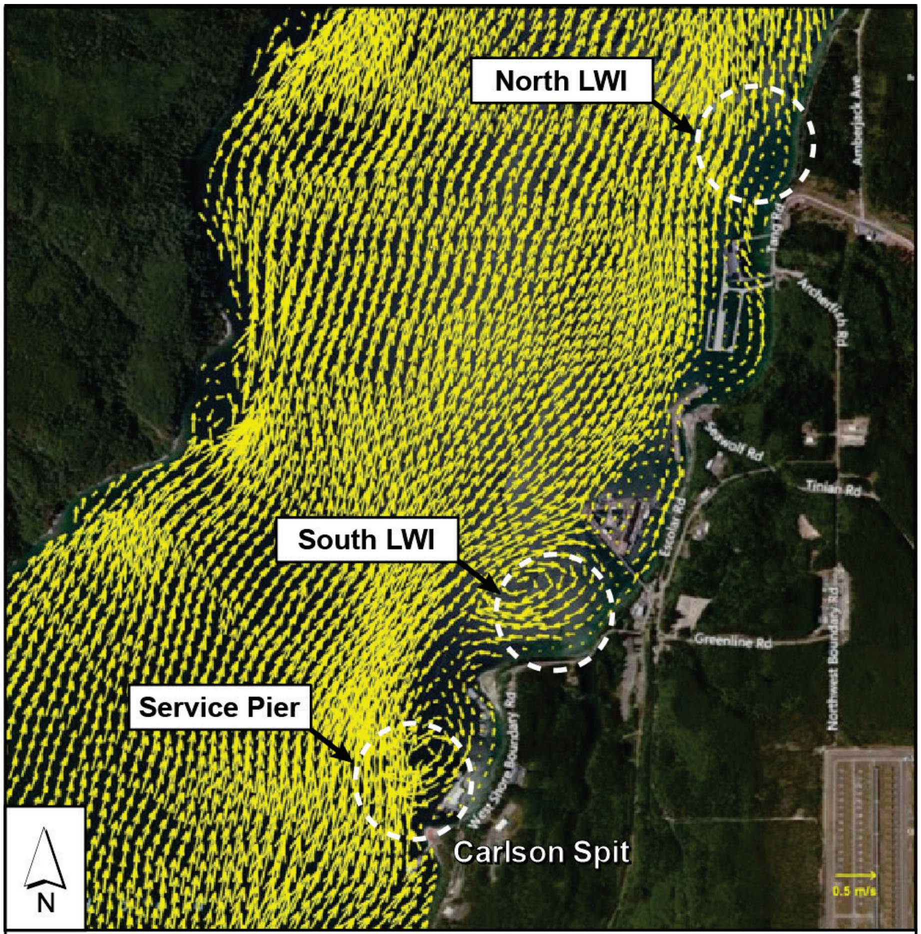
Due to the shape of the basin and local bathymetry, seawater within Hood Canal has a tendency to move easterly into the Bangor waterfront area during both flood and ebb tides (Morris et al.2008). As the water mass driven by each phase of the tide begins to interact with the sloping seafloor and headland features along the eastern shoreline of Hood Canal (e.g., Floral Point, Keyport/Bangor (KB) Point, and Carlson Spit), hydrostatic pressure increases, resulting in a reduction in linear flow velocity toward the shore. As the tidal flow into the area continues and resulting pressure builds against the beach face, the water mass over the shallow (less than 50 feet [15 meters]) areas tends to move in the direction of least resistance. Consequently, depending on the phase of the tide and conditions at the time of the observation, the water mass over the shallower areas occupied by NAVBASE Kitsap Bangor can move along shore in the opposite direction from the water mass over the deeper portions of northern Hood Canal. This accounts for the northeasterly currents during flood tides and southwesterly currents during ebb tides in nearshore areas of NAVBASE Kitsap Bangor (Morris et al. 2008).

Historical drift studies performed near pier structures at the Bangor waterfront observed the formation of distinct eddies (URS 1994). Eddies were readily apparent on the water surface during both strong flood and ebb tides and were attributed to the complexity in flow dynamics along the shoreline. Anticyclonic (clockwise) eddies formed immediately south of two major waterfront wharves during ebb tides and cyclonic (counterclockwise) eddies formed north of these wharves during flood tide (URS 1994). Eddies were also established adjacent to many of the headland features (e.g., Carlson Spit, KB Point, and Floral Point). Modeled ebb tide current patterns in portions of Hood Canal (cbec 2013) illustrate the nearshore eddies and complexity of flows adjacent to NAVBASE Kitsap Bangor (Figure 3.1–5). These eddies serve as pumps that move water along the shoreline and around the pier structures on NAVBASE Kitsap Bangor and, consequently, are an important factor for increasing suspended load transport and seawater mixing in shallow water (less than 50 feet [15 meters]) near the shoreline.

Seasonal variability in Hood Canal circulation patterns can occur as a result of strong meteorological events (e.g., storms, high winds) in the winter. Regardless of direction, winds with velocities in excess of 25 knots (42 feet/second) occur relatively infrequently in the Puget Sound region (Morris et al. 2008). The surrounding highlands (Olympic and Cascade Mountain Ranges), coupled with the fetch-limited environment of Hood Canal, result in relatively calm wind conditions throughout most of the year. However, during the winter months, storm events associated with the passing of frontal systems, predominantly from the south, are more common and are responsible for stronger winds in the region. The topography adjacent to Hood Canal results in funneling of strong southwesterly winds during periods of southerly flow (Figure 3.1–6). Due to the southwest to northeast orientation of the northern and middle sections of Hood Canal, and increased fetch, southwesterly flows with wind speeds in excess of 20 knots (34 feet/second) have the capability of generating wind waves and/or altering normal tidal flow within the basin. Sustained wind events over the long axis of Hood Canal can disrupt the normal surface current patterns and vertically mix the water column, which tends to break down stratification and promote upwelling of colder, saline subsurface waters (Golder Associates 2010).

CIRCULATION AND CURRENTS AT THE LWI PROJECT SITES

Currents (speed and direction) at the LWI project sites are primarily a function of tidal action based on the phase and range of each tide within the mixed diurnal-semidiurnal regime, although

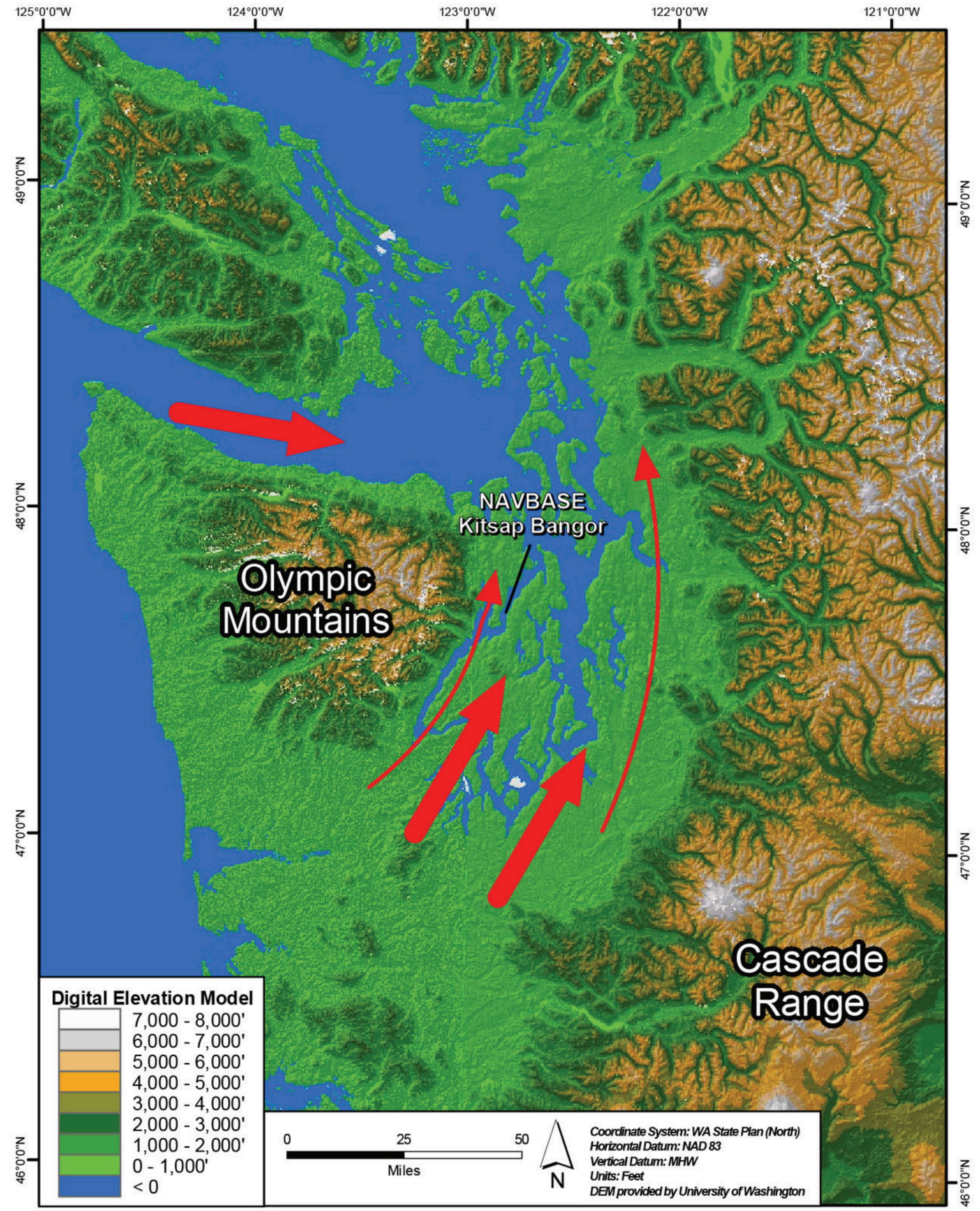


Source: cbec 2013

Figure 3.1–5. Modeled Current Patterns, Ebb Tide during a Peak 2-Year Storm Event

seafloor topography and the presence of fixed structures along the shoreline also affect nearshore current patterns along the Bangor waterfront (Morris et al. 2008). Currents in shallower (less than 50 feet [15 meters]) portions of the sites are weak and complex as related to the irregular bathymetry and shoreline features such as headlands and embayments. The time-averaged net flow is within the 0.07 to 0.10 foot/second (2 to 3 centimeters per second) range in the upper water column and less than 0.03 foot/second (1 centimeter per second) close to the seafloor. The magnitude or instantaneous velocity of fluctuating water column currents ranges from 0 to 0.88 foot/second (0 to 27 centimeters per second) within the 30- to 65-foot (9- to 20-meter) water depth interval (Morris et al. 2008). However, current flow in any one direction is short-lived and inconsistent in magnitude, with relatively few time periods when current velocities are sufficient (approximately 0.7 foot/second [20 centimeters per second]) to exceed the threshold for resuspending deposits of unconsolidated material on the seafloor (Boggs 1995)

In deeper portions of the LWI project sites (i.e., water depths from 13 to 59 feet [4 to 18 meters]), currents are variable in direction and magnitude within the mid and upper water



Source: Morris et al. 2008

Figure 3.1–6. Major Wind Patterns in the Puget Sound Region

column throughout each tidal phase, while flow in the lower water column is more consistent (Morris et al. 2008). Although variability is present in both the magnitude and direction of water column currents, the general flow trends are in north-northeast and south-southwest directions. Maximum flows in excess of 0.7 foot/second (20 centimeters/second) were documented in the upper (13 feet [4 meters]), mid (36 feet [11 meters]), and lower (59 feet [18 meters]) water column and typically corresponded to the time of high tide (maximum water level). Current velocities were also elevated at the time of low tide (minimum water level), but at speeds that ranged from 0.3 to 0.5 foot/second (9 to 15 centimeters/second) (Morris et al. 2008).

The majority of the daily volume of seawater exchange at the LWI project sites flows directly across the Bangor waterfront area. As a result, the degree of flushing that occurs at the LWI project sites is relatively high. Due to the substantial seawater exchange in this portion of Hood Canal, the hydrographic conditions at the LWI project sites are more similar to those of Puget Sound than to the southern portions of Hood Canal.

Annual and seasonal variability of circulation and currents near the LWI project sites follows the same patterns as the remainder of Hood Canal. Winter storm events originating from the southwest, as well as fair weather systems producing higher winds out of the northeast, have the capability to affect normal circulation patterns dominated by tidal flow based on the southwest to northeast orientation of Hood Canal. However, the project sites are afforded some protection by the coastlines of both Kitsap and Toandos Peninsulas (Figure 3.1–7).

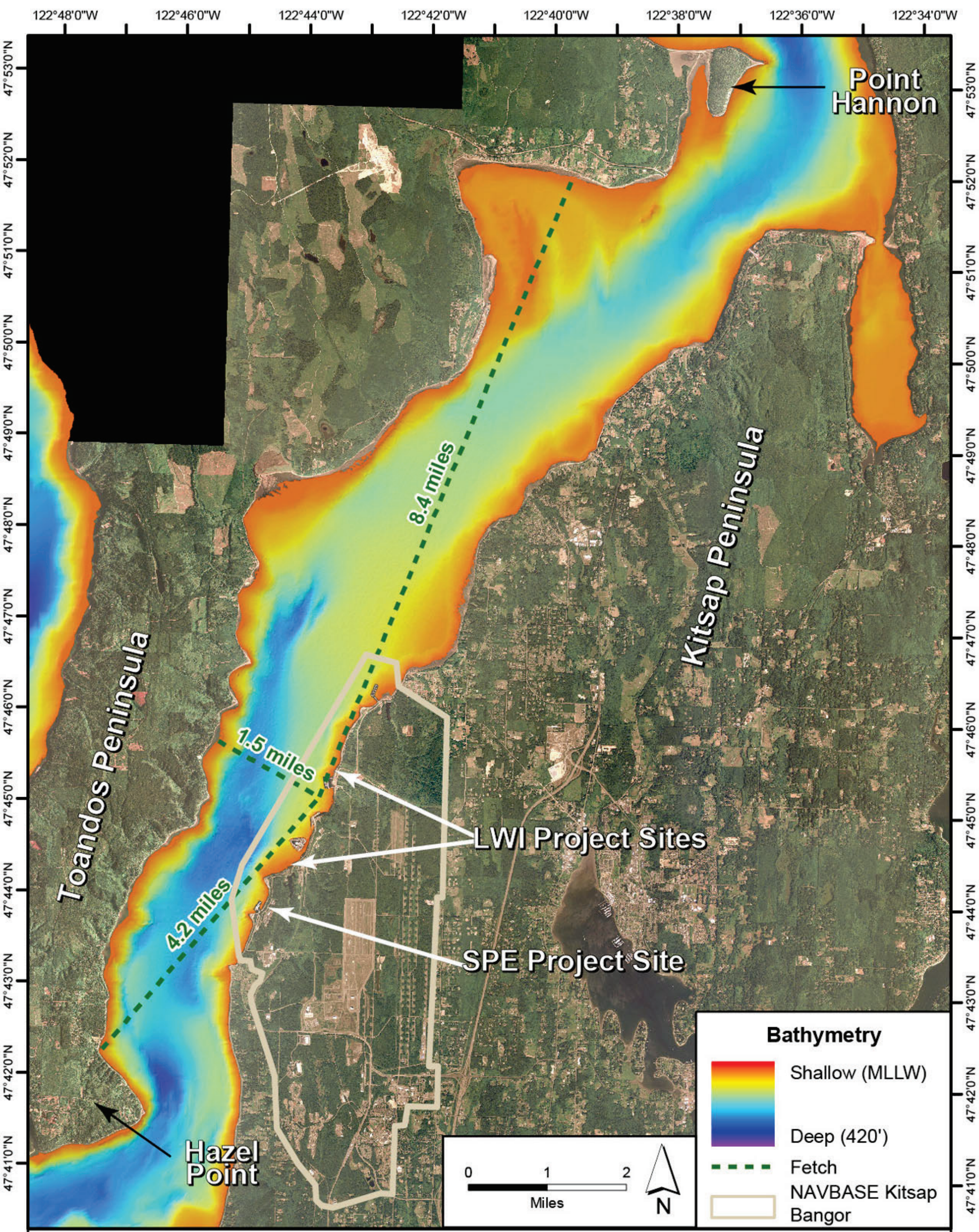
CIRCULATION AND CURRENTS AT THE SPE PROJECT SITE

Currents at the SPE project site are similar to those discussed for the LWI sites, although the presence of Carlson Spit deflects flows to the west during ebb tides and promotes the formation of eddies in the lee (downcurrent side) of the headland (Figure 3.1–5). These features contribute to variability in current flows as well as mixing of water masses in the vicinity of the Service Pier (Morris et al. 2008).

Similar to the LWI sites, water movement in the vicinity of Service Pier is primarily related to tidal action. However, the structure of water flow varies at different locations along the Bangor waterfront, suggesting that the dynamics controlling water mass movement are strongly affected by localized seafloor topography and shoreline structures (Morris et al. 2008).

LONGSHORE SEDIMENT TRANSPORT

Storm waves are the principal mechanism driving longshore sediment transport and are responsible for shaping many of the coastal morphologic features such as spits and points along the Hood Canal shoreline (Golder Associates 2010). Wave energy and the magnitude of sediment transport in Hood Canal are related to the direction and speed of the regional winds. The general wave environment in Hood Canal is characterized as low energy. Significant wave heights (the average wave height of the one-third largest waves) range from approximately 0.16 to 0.49 foot (0.05 to 0.15 meter). The primary wave directions in the vicinity of NAVBASE Kitsap Bangor are from the southwest and northeast, parallel to the axis of Hood Canal. Waves from northerly storms tend to be locally larger than waves generated by the more severe southerly storms due to longer fetch to the north. While northerly waves are of greater magnitude, the probability of occurrence of the extreme winds from northerly directions is appreciably lower than from the



Source: Morris et al. 2008

NOTE:
Coordinate System: WA State Plane (North)
Horizontal Datum: NAD83
Vertical Datum: MHW
Units: feet
DEM provided by University of Washington

Figure 3.1–7. Maximum Fetch Diagram

south. Using a maximum fetch of 8.4 miles (14 kilometers) between the NAVBASE Kitsap Bangor project site and the north shore of Thorndyke Bay to the north-northeast, a 20-knot (34 feet/second) sustained wind has the capability of generating average wave heights of 1.9 feet (0.6 meter), and a 30-knot (45 feet/second) wind event could produce wave heights of 3.1 feet (0.4 meter) (Coastal Engineering Research Center 1984). The maximum fetch to the southwest is one-half that to the northeast (4.2 miles [6.8 kilometers]), and could yield average waves of 1.3 feet (1 meter) in height in a 20-knot (34 feet/second) wind, and 1.9 feet (0.6 meter) in a 30-knot (45 feet/second) wind.

Maximum wave heights expected in these weather conditions would actually be 67 percent higher than the average estimates reported above. Thus, a weather event capable of generating waves with an average height of 3.1 feet (1 meter) could also yield waves with maximum heights of 5.1 feet (1.6 meter) (Coastal Engineering Research Center 1984).

Because tidal currents rarely exceed 0.6 foot/second (20 centimeters per second) (Morris et al. 2008), surface waves likely are the primary source of energy that prevents the long-term deposition of fine-grained sediments and results in the well-sorted sandy seafloor and gravel beaches within the shallow (<33 feet [10 meters]) seabed and intertidal zones at the project sites. The instantaneous velocity associated with passing waves is likely sufficient to lift finer-grained unconsolidated sediments (silt and clay) into the water column. Once in suspension, the speed and direction of sediment transport is a function of exposure to tidal current flow. Unconsolidated material transported toward the center of Hood Canal likely remains in suspension indefinitely as water column currents closer to the centerline of northern Hood Canal provide sufficient energy to keep fine-grained sediments in suspension and prevent settlement and deposition. Entrained sediments that are transported closer to the shoreline and away from areas displaying coherent current flow are subject to re-deposition when energy levels associated with the local wave field diminish. Over time, fine-grained sediments are systematically resuspended and transported with subsequent storm-related wave events until they reach the centerline of Hood Canal or are deposited along the shoreline in locations offering sufficient protection from wave action.

The NAVBASE Kitsap Bangor shoreline is relatively unaltered compared with other regions of Hood Canal. Approximately 6 percent of the shoreline is modified with bulwarks, riprap, or other structures (Judd 2010), compared to approximately 27 percent for Hood Canal as a whole (Puget Sound Partnership 2008) and 25 percent for Kitsap County portions of Hood Canal (Judd 2010).

Kitsap County conducted an assessment of nearshore habitat in West Kitsap County that included the Bangor waterfront (Judd 2010). The north and south LWI and SPE project sites are within Drift Cells 18, 19, and 20, respectively. These drift cells have low disturbance rankings for longshore transport processes, reflecting, in part, the general absence or low density of armoring/bulkheads, groins, boat launches, and other shoreline structures that otherwise restrict sediment supply and transport (Judd 2010).

Typical sediment delivery rates from feeder bluffs in Hood Canal are approximately 1.5 to 4 inches (3.8 to 10 centimeters)/year (Keuler 1988). Feeder bluffs refer to eroding shoreline bluffs that provide the majority of sediment to Puget Sound beaches and littoral cells (Johannessen 2010). No quantitative information presently exists on the rates of sediment supply from the shoreline areas in the vicinity of the proposed north and south LWI abutments. The bluff near the proposed north LWI project site is composed mostly of fine-grained glacial till, with a relatively small proportion of interbedded gravel/cobble (cbec 2013). The shoreline in the vicinity of the south LWI project site has a moderate slope, with alluvium, colluvium, and fill (Section 3.7, Geology, Soils, and Water Resources), and is on the down-drift side of KB Point and adjacent to a coastal lagoon (Devil's Hole). The risk of seismic-induced slope instability is low, and there is a low potential for lateral spreading, for both the north and south LWI sites (Shannon & Wilson 2012). Thus, it is unlikely that the proposed sites for the north and south LWI abutments represent feeder bluffs or substantial sources of sediments to Hood Canal.

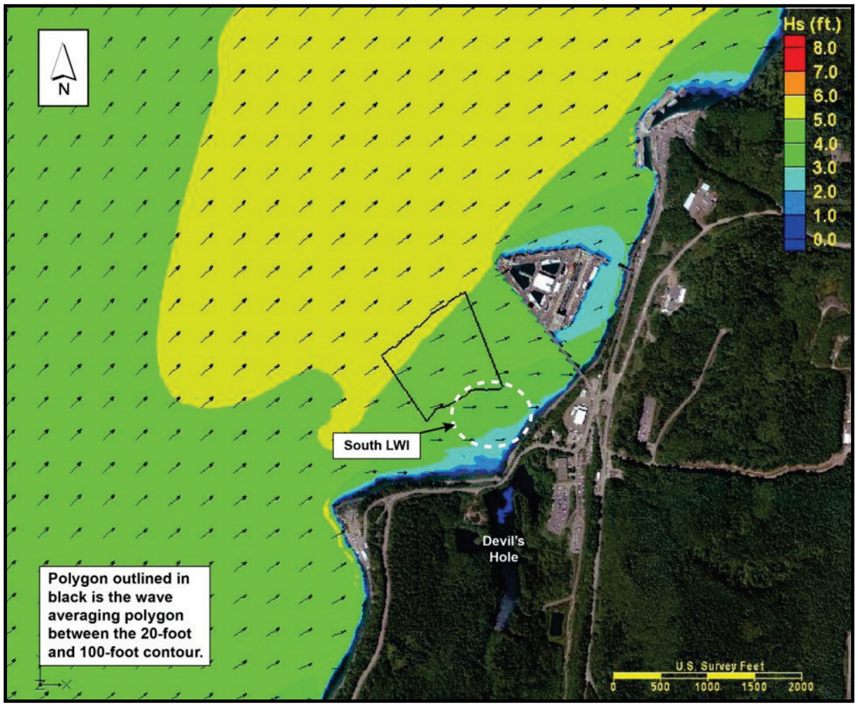
The existing waterfront facilities on NAVBASE Kitsap Bangor occur at substantial distances from each other, with relatively long expanses of uninterrupted shoreline and open water between them. Depending on the direction and intensity of the local winds, each facility offers varying amounts of fetch for the generation of wind waves, as well as protection from the effects of those waves. In most cases, the various pier facilities were constructed on a foundation of solid piles configured in a manner that serves to disrupt well-organized wave fields approaching the shoreline from open water. This reduces the amount of energy reaching the shallow subtidal and intertidal zones adjacent to each pier facility and the capacity of the waves to resuspend and transport unconsolidated seafloor sediments.

Evidence from bathymetric surveys and aerial photographs confirms the presence of sediment deposits along the shoreline near the pier facilities, resulting in localized changes in shoreline morphology (Morris et al. 2008). Some of these areas of increased sedimentation are co-located with the pier facilities, suggesting that the piles in the pier foundations promote a depositional environment and the accretion of unconsolidated material in the form of shallow subtidal shoals and broadening intertidal beaches. However, in other cases, the co-occurrence of shoreline structures and shoals may be coincidental. For example, an aerial photograph of Explosives Handling Wharf-1 (EHW-1) shortly after the structure was constructed shows the presence of a shoal inshore of the wharf, suggesting that the shoal was present at the time the wharf was constructed (Prinslow et al. 1979; Plate 1). Golder Associates (2010) evaluated historical topographic sheets and photographs to assess the magnitude of shoreline change that has occurred in the project vicinity. These assessments show that relatively little shoreline change has occurred over the last two decades and only moderate change has occurred since 1876, indicating that the shoreline in the region is fairly stable as a result of the relatively sheltered environment and low net erosion and longshore transport rates.

LONGSHORE SEDIMENT TRANSPORT AT THE LWI PROJECT SITES

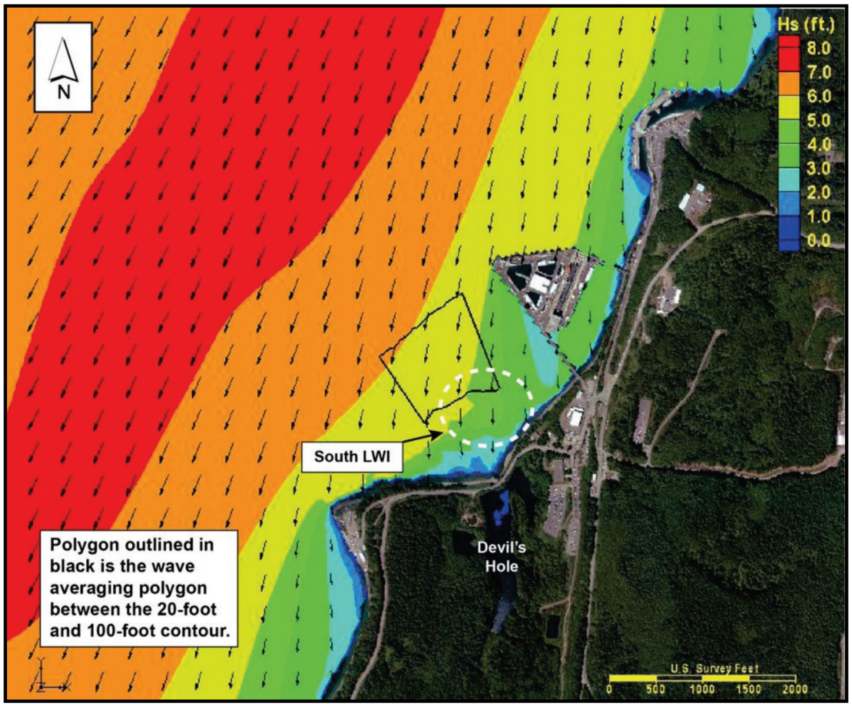
Calculated wave fields in the vicinity of the south LWI project site that are associated with 100-year storm events based on southerly and northerly winds are shown in Figures 3.1–8 and 3.1–9, respectively. These figures illustrate the reduced wave heights in areas immediately adjacent to the shoreline compared with those immediately offshore of Devil's Hole (Golder Associates 2010). This study did not extend to the north LWI project site; therefore, comparable information is not available for this location.

Figures 3.1–10 and 3.1–11 provide examples of calculated sediment transport for representative flooding and ebbing tides, respectively. These figures show that the areas of the south LWI



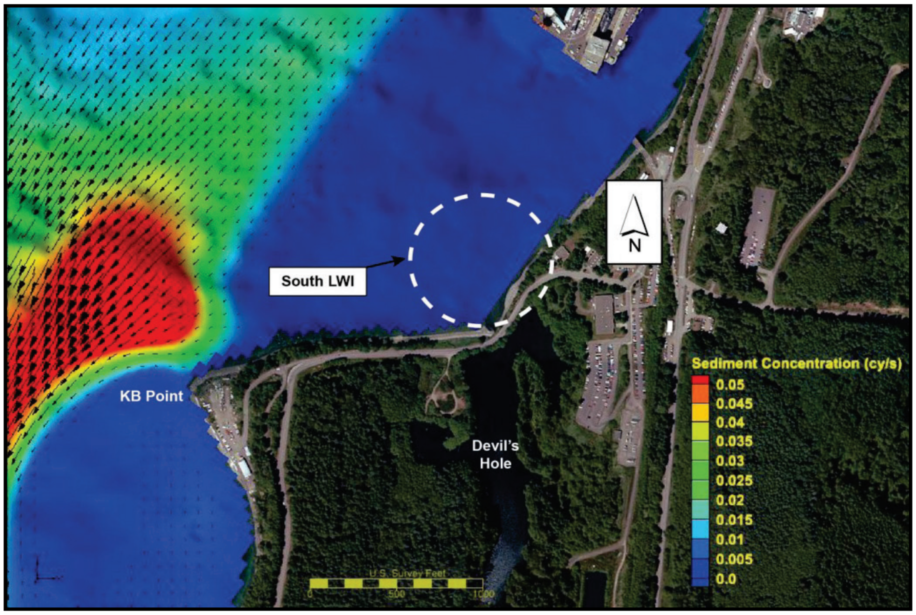
Source: Golder 2010

Figure 3.1–8. Calculated Wave Field in the Vicinity of the South LWI Project Site Associated with 100-Year Storm Event with Southerly Winds



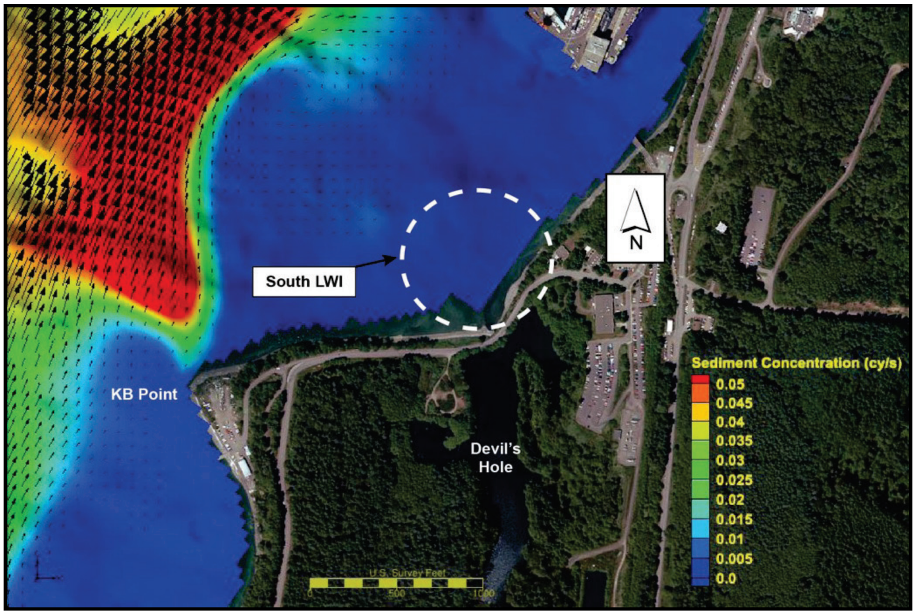
Source: Golder 2010

Figure 3.1–9. Calculated Wave Field in the Vicinity of the South LWI Project Site Associated with 100-Year Storm Event with Northerly Winds



Source: Golder 2010

Figure 3.1–10. Calculated Sediment Concentration (contours) and Sediment Transport Rates (vectors) during Flood Tide for Hood Canal in the Vicinity of the South LWI Project Site



Source: Golder 2010

Figure 3.1–11. Calculated Sediment Concentration (contours) and Sediment Transport Rates (vectors) during Ebb Tide for Hood Canal in the Vicinity of the South LWI Project Site

project site and the sediment delta off the mouth of Devil's Hole tend to have relatively little transport during average conditions. This may be primarily attributed to sheltering of the area by the configuration of the shoreline (e.g., the point at KB Docks) to the west and the Delta Pier facility to the north. The greatest transport rates occur immediately offshore of KB Point, which has a shallow shelf that protrudes into the primary Hood Canal current. Under severe storm wave forcing, offshore transport changes very little because of the relatively short period and low-amplitude waves that reach the local site. However, within the swash zone, breaking waves act as a mechanism to mobilize and mix sediment into the current for further transport.

Golder Associates (2010) estimated that the net longshore transport rate over the delta adjacent to Devil's Hole (near the south LWI project site) was 150 cubic yards (115 cubic meters) per year to the northeast. While this value is only an estimate of annual littoral drift, the direction of net transport agrees with regional transport directions presented by Kitsap County Department of Community Development (2007) and geomorphologic indicators such as shoreline orientation and delta asymmetry.

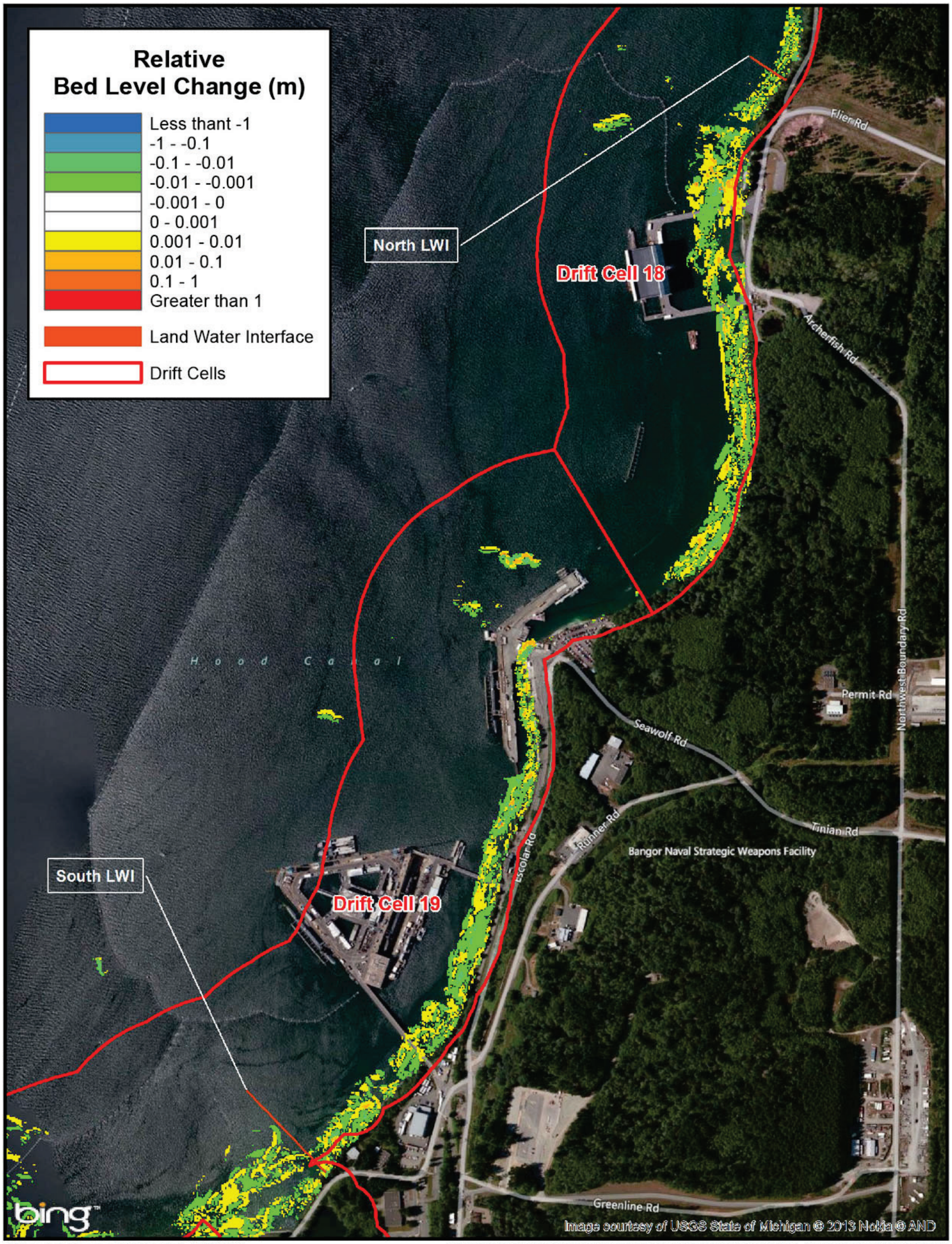
Longshore sediment transport in the vicinity of the north and south LWI project sites was modeled by cbec (2013). This portion of the Hood Canal shoreline corresponds to Drift Cells DC-18 and DC-19, in the West Kitsap County Nearshore Assessment (Judd 2010). Changes to seabed levels, as measures of erosion and deposition, following typical (2-year recurrence event) storm conditions, in the absence of the proposed LWI structures, are shown in Figure 3.1–12. Changes in bed levels generally are less than 0.3 foot (0.1 meter). Relatively larger changes are predicted to occur following strong, infrequent (i.e., 50-year recurrence) storm events. Within the Bangor waterfront region, areas with the greatest bed level changes largely coincide with the presence of aquatic vegetation.

LONGSHORE SEDIMENT TRANSPORT AT THE SPE PROJECT SITE

Longshore sediment transport in the vicinity of the SPE project site was modeled by cbec (2013). This portion of the Hood Canal shoreline corresponds to Drift Cell DC-20 in the West Kitsap County Nearshore Assessment (Judd 2010). Changes to seabed levels following typical (2-year recurrence event) storm conditions near the Service Pier, in the absence of the proposed SPE structure, are shown in Figure 3.1–13. As noted for the LWI project sites, changes in bed levels in the vicinity of Service Pier generally are less than 0.3 foot (0.1 meter). Relatively larger changes are predicted to occur following 50-year recurrence storms. Regions with the greatest bed level changes largely coincide with the presence of aquatic vegetation.

3.1.1.1.2. WATER QUALITY

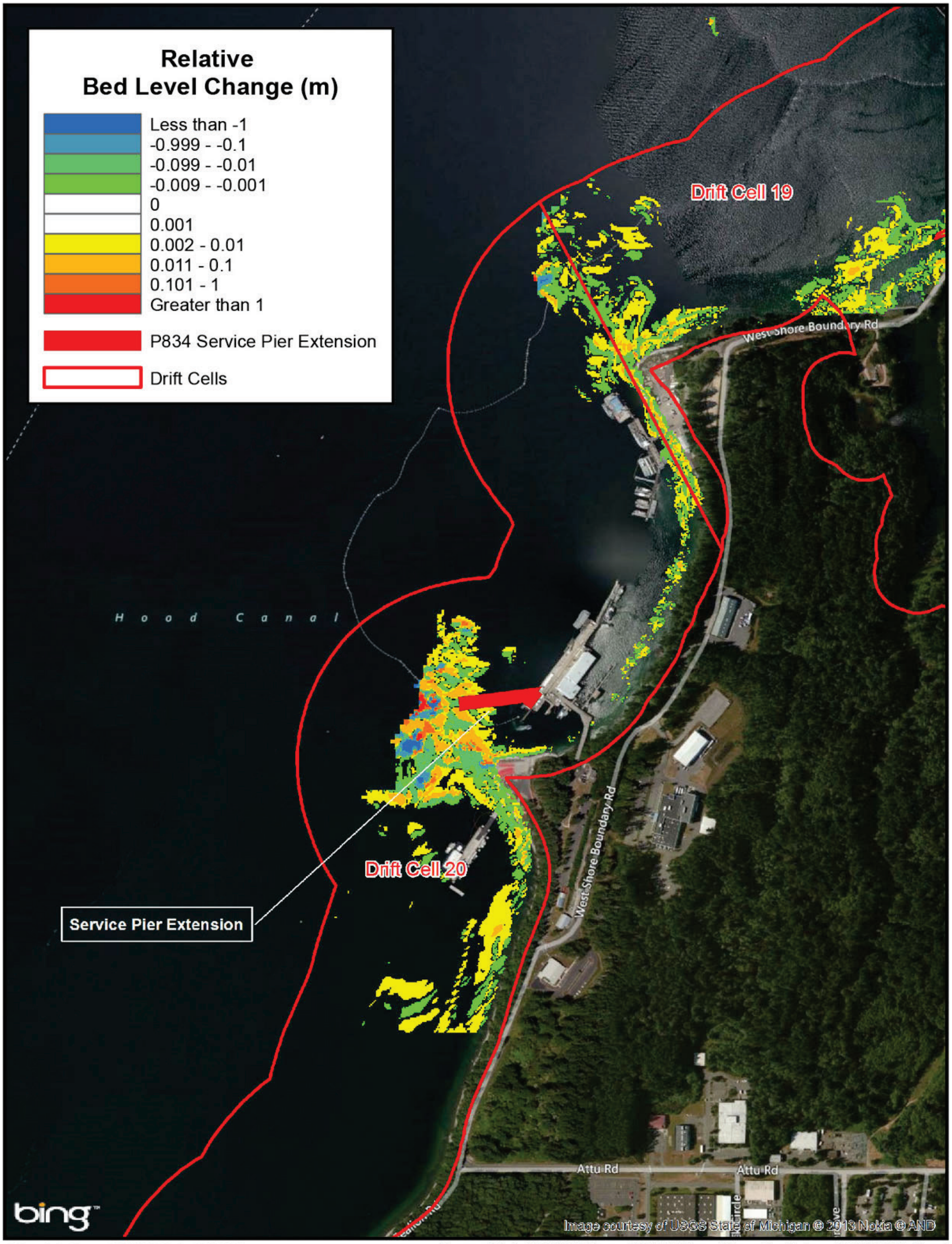
Water quality parameters include temperature and salinity, which affect density layering and stratification, as well as chemical characteristics such as dissolved oxygen (DO), nutrients, pH, turbidity/water clarity, and contaminant levels that affect the suitability of the water body as habitat for marine organisms and other beneficial uses. Washington Administrative Code (WAC) 173-201A establishes four water body quality classifications as summarized in Table 3.1–1.



Author: John Evans | SAIC | Date: 10/3/2013 Document Path: C:\GISPJ13\Bangor LWI\SAIC Figures\50 year Flood - Scenario 5 LWI BLC v2.mxd

Source: cbec 2013

Figure 3.1–12. Modeled Changes in Seabed Elevations Near the North and South LWI Project Sites Following a Peak 2-Year Storm Event, Existing Conditions



Author: John Evans | SAIC | Date: 10/3/2013 Document Path: C:\GISPJ13\Bangor LWI\SAIC Figures\50 year Flood - Scenario 2 SPE BLC v2.mxd

Source: cbec 2013

Figure 3.1–13. Modeled Changes in Seabed Elevations Near the SPE Project Site Following a Peak 2-Year Storm Event, Existing Conditions

Table 3.1–1. Marine Water Quality Criteria

Water Quality Classification	**Water Quality Criteria**			
Aquatic Life	**Temperature**[1]	**Dissolved Oxygen**[2]	**Turbidity**[3]	**pH**
Extraordinary Quality	13°C (55°F)	7.0 mg/L	+5 NTU or +10%[4]	7.0 – 8.5[6]
Excellent Quality	16°C (61°F)	6.0 mg/L	+5 NTU or +10%[4]	7.0 – 8.5[7]
Good Quality	19°C (66°F)	5.0 mg/L	+10 NTU or +20%[5]	7.0 – 8.5[7]
Fair Quality	22°C (72°F)	4.0 mg/L	+10 NTU or +20%[5]	6.5 – 9.0[7]
	Coliform Bacteria			
Shellfish Harvesting	Geometric mean not to exceed 14 MPN/100 mL fecal coliforms[8]			
Recreation				
Primary Contact	Geometric mean not to exceed 14 MPN/100 mL fecal coliforms[8]			
Secondary Contact	Geometric mean not to exceed 70 MPN/100 mL enterococci [9]			

Source: WAC 173-201A-210, as amended in May 2011

°C = degrees Celsius; DO = dissolved oxygen; °F = degrees Fahrenheit; mg/L = milligrams per liter; mL = milliliter; MPN = most probable number; NTU = Nephelometric Turbidity Unit

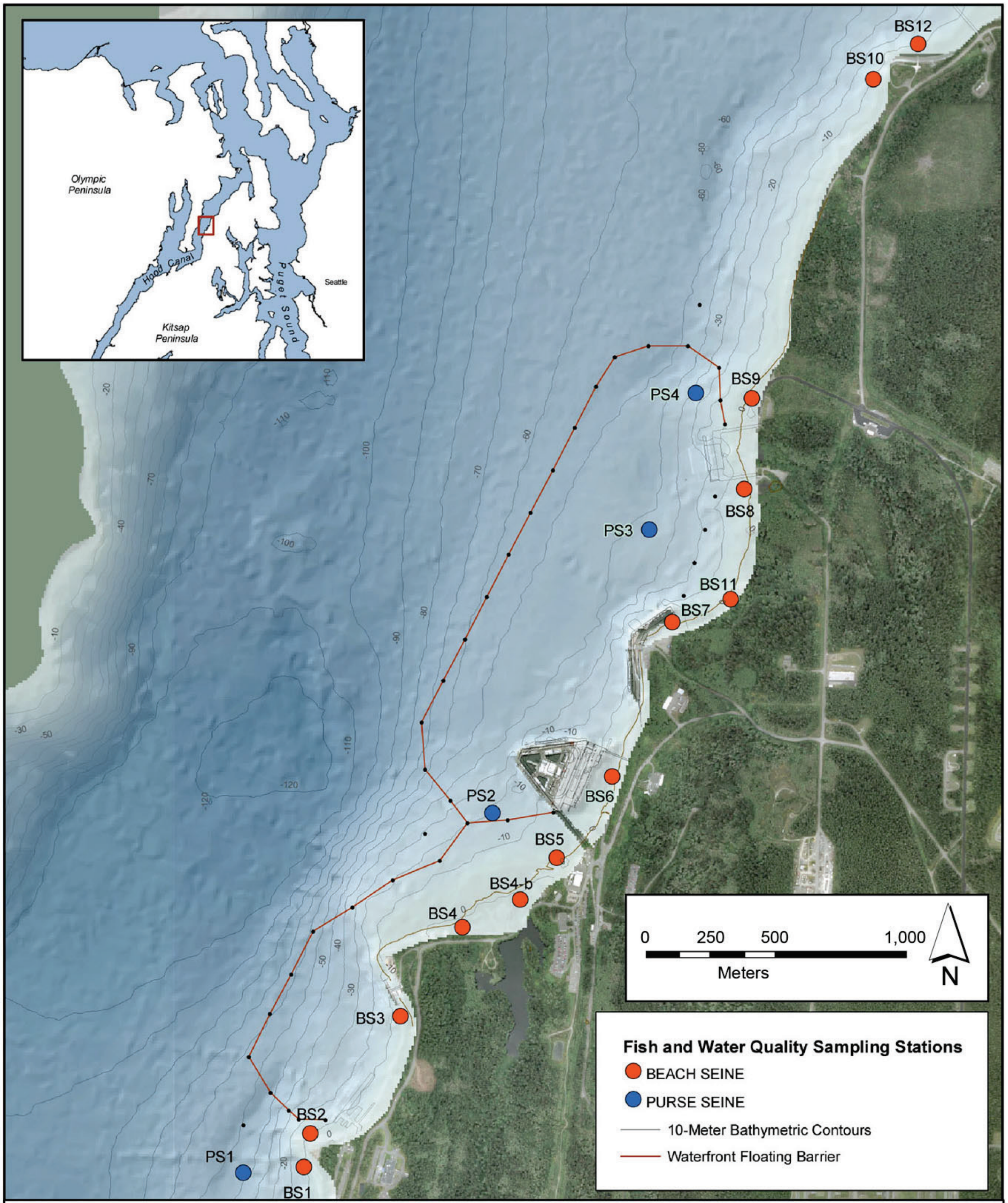
1. One-day maximum (°C [°F]). Temperature measurements should be taken to represent the dominant aquatic habitat of the monitoring site. Measurements should not be taken at the water's edge, the surface, or shallow stagnant backwater areas.
2. One-day minimum (mg/L). When DO is lower than the criteria or within 0.2 mg/L, then human actions considered cumulatively may not cause the DO to decrease more than 0.2 mg/L. DO measurements should be taken to represent the dominant aquatic habitat of the monitoring site. Measurements should not be taken at the water's edge, the surface, or shallow stagnant backwater areas.
3. Measured in NTU; point of compliance for non-flowing marine waters — turbidity not to exceed criteria at a radius of 150 feet (46 meters) from activity causing the exceedance.
4. 5 NTU over background when the background is 50 NTU or less; or 10 percent increase in turbidity when background turbidity is more than 50 NTU.
5. 10 NTU over background when the background is 50 NTU or less; or 20 percent increase in turbidity when the background turbidity is more than 50 NTU.
6. Human-caused variation within range must be less than 0.2 units.
7. Human-caused variation within range must be less than 0.5 units.
8. No more than 10 percent of all samples used to calculate geometric mean may exceed 43 MPN/100 mL; when averaging data, it is preferable to average by season and include five or more data collection events per period.
9. No more than 10 percent of all samples used to calculate geometric mean may exceed 208 MPN/100 mL; when averaging data, it is preferable to average by season and include five or more data collection events per period.

This section summarizes the existing marine water quality conditions of Hood Canal and the areas around the LWI and SPE project sites. The quality of surface waters in the upland portions of the project area, including stormwater runoff, is discussed in Section 3.7. The following discussion provides ranges in values for several of the water quality parameters (temperature, salinity, DO, and turbidity) that were measured at a series of shallow, nearshore, and deeper, offshore sampling locations along the Bangor waterfront in 2005 and 2006 (Phillips et al. 2009) and in 2007 and 2008 (Hafner and Dolan 2009). The sampling stations shown in Figure 3.1–14 include locations near the LWI and SPE project sites. Existing conditions for these parameters are also based on information collected as part of regional monitoring programs, such as the Washington Department of Ecology (WDOE) Marine Water Quality Monitoring Program (WDOE 2013a). In particular, the WDOE program monitors water quality at a series of core and rotating sites. The monitoring locations closest to NAVBASE Kitsap Bangor, HCB008 (King Spit Bangor) and HCB009 (Hazel Point), are rotating sites that were last sampled in 2005 and 2003, respectively. Monitoring site HCB010 (Hood Canal Sand Creek) is located off the southern tip of the Toandos Peninsula and is the closest core monitoring site that is sampled annually.

WAC 173-201A-612 designates Hood Canal as extraordinary for aquatic life uses (salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; and crustaceans and other shellfish rearing and spawning), with additional use designations for shellfish harvest, recreational use (primary contact), and miscellaneous (wildlife habitat, harvesting, commercial/navigation, boating, and aesthetics). Water quality along the Bangor waterfront is good by most measures and meets applicable standards. Although DO concentrations are low in much of Hood Canal, this problem is less pronounced in northern Hood Canal, the location of NAVBASE Kitsap Bangor, than elsewhere in Hood Canal. Based on measurements performed during 2005 through 2008 (Phillips et al. 2009; Hafner and Dolan 2009), DO concentrations in nearshore waters at the LWI and SPE project sites almost always meet water quality standards, as discussed below under the un-numbered subsection titled Dissolved Oxygen. WDOE (2013a) has not determined marine water conditions index values or assessed temporal trends in water quality for northern Hood Canal.

STRATIFICATION, SALINITY, AND TEMPERATURE

Temperature, salinity, and stratification conditions in Hood Canal are influenced by natural processes with seasonal and inter-annual cycles. Coastal upwelling and the California Current are the primary mechanisms producing the cool water mass that moves into Puget Sound with a relatively narrow range of temperatures throughout the year. Water temperatures in Puget Sound typically range from 44 to 46 degrees Fahrenheit (°F) (6.7 to 7.8 degrees Centigrade [°C]) throughout winter months (mid-December through mid-March). Surface waters slowly warm throughout the spring and summer due to increased solar heating, reaching temperatures of 50°F (10°C) in mid-May or early June to a maximum temperature of 54°F (12°C) during the month of August. Beginning in September, water temperatures begin to decrease by several degrees over the next three months due to decreasing levels of solar radiation. Variations in this pattern of heating and cooling occur, but they are often short in duration (one to two weeks) and likely driven by small variations in circulation patterns in the North Pacific Current and/or California Current.



Source: Phillips et al. 2009

NOTE:
Coordinate System: WA State Plane (North)
Horizontal Datum: NAD83
Vertical Datum: MHW
Units: feet
DEM provided by University of Washington

Figure 3.1–14. Water Quality Monitoring Stations for 2005 and 2006

Annual variability is related primarily to El Niño/La Niña cycles. El Niño conditions are influenced by atmospheric circulation within the Southern Oscillation in the equatorial Pacific that leads to a large-scale warming of the Pacific Ocean and is associated with a slackening, or even cessation, of the upwelling conditions that normally occur in proximity to the Strait of Juan de Fuca. The onset of El Niño conditions usually results in a warming trend in surface waters along the Washington and Oregon coasts, in addition to drier winters within the Pacific Northwest (Western Regional Climate Center 1998). In contrast, La Niña conditions lead to large-scale cooling of the Pacific Ocean, as well as colder air temperatures and an increase in precipitation in the late fall and early winter. Since the winter of 1999 to 2000, atmospheric and oceanic conditions associated with the Southern Oscillation have not exhibited strong El Niño or La Niña characteristics (Western Regional Climate Center 2008).

The waters of Hood Canal surrounding the LWI and SPE project sites are stratified with less saline, warmer surface water overlying colder, more saline bottom water. The salinity of the upper water layer reflects in part the amount of freshwater input and may become more diluted during heavy precipitation (URS 1994). Variances due to seasonal changes (such as freshwater input, wind-induced mixing, and solar heating) are common (URS 1994).

Freshwater input into Hood Canal comes from creeks, rivers, groundwater (including artesian wells), and stormwater outfalls. Artesian well contributions have estimated flows of 2,000 to 2,500 gallons (7,600 to 9,500 liters) per minute (WDOE 1981). Overland flow from much of the western portion of NAVBASE Kitsap Bangor is routed to Hood Canal through a series of stormwater outfalls. Saltwater and freshwater mixing zones exist at the mouths of each of these outflows and outfalls (URS 1994). Some locations along the Bangor waterfront are influenced to a greater extent by localized inputs from freshwater sources. For example, Phillips et al. (2008) noted that nearshore waters off Devil's Hole, near the south LWI project site, exhibited higher temperatures and lower salinities that were attributed in part to freshwater flows from Devil's Hole.

During the 2005 through 2008 water quality surveys, average surface water salinity values along the Bangor waterfront ranged from 24 to 34 practical salinity units (PSU) (Table 3.1–2). Based on vertical profile measurements, the transition between the lower salinity surface waters and higher salinity subsurface waters occurs at a depth of about 33 feet (10 meters) (Phillips et al. 2009). The lowest surface water salinity (18.4 PSU) was measured in February 2007 when fresh water (low salinity) input may have been high due to winter storms and runoff (Hafner and Dolan 2009). The range in salinity values along the Bangor waterfront measured during the 2005 through 2008 water quality surveys is typical for marine waters in Puget Sound (Newton et al. 1998, 2002).

Per the state's water quality classification, the temperature of marine surface waters designated as extraordinary quality should not exceed 13°C (55°F). When a water body's temperature is warmer than 13°C (55°F) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the temperature of the water body to increase more than 0.3°C (0.5°F) (WAC 173-201A). Minimum, maximum, and mean surface water temperatures along the Bangor waterfront in 2005 through 2008 are summarized in Table 3.1–2. Average water temperatures along the Bangor waterfront ranged from 8.1 to 17.4 °C (46.6 to 63.3°F), and temperatures exceeded 13°C (55°F) during late spring through summer (May through September). Nearshore areas are susceptible to greater temperature variations due to seasonal differences in solar radiation. WDOE, through the Section 303(d) program (Water Quality Assessment for Washington), has not classified the water quality in the area of NAVBASE Kitsap Bangor as impaired (i.e., chronic or recurring monitored violations of the applicable numeric and/or narrative water quality criteria) for temperature (WDOE 2013b).

Table 3.1–2. Minimum, Maximum, and Mean Values of Water Quality Parameters at Nearshore Locations along the NAVBASE Kitsap Bangor Waterfront during the 2005–2008 Water Quality Surveys

Dates	Year	DO (mg/L)			Salinity (PSU)			Temperature (°C)			Turbidity (NTU)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
1/22–1/28	2005	7.2	11.3	9.1	25.9	27.3	26.6	7.7	8.2	8.1	0.2	12.4	1.1
2/5–2/11	2005	7.1	10.6	8.8	26.5	29.8	28.3	7.4	8.4	8.0	0.3	26.4	1.3
2/26–3/4	2005	8.8	11.3	9.4	28.5	30.1	29.3	6.9	8.3	8.1	0.2	12.7	1.1
3/5–3/11	2005	8.9	10.3	9.3	26.4	28.7	28.1	7.4	8.4	8.3	0.0	12.0	1.0
3/12–3/18	2005	8.8	10.6	9.4	29.5	30.8	30.1	7.0	8.4	8.2	-0.1	41.8	2.6
3/19–3/25	2005	9.2	12.1	10.8	26.3	29.4	27.4	8.3	9.9	9.0	-0.3	42.9	1.3
3/26–4/1	2005	9.9	10.3	9.3	26.9	28.2	27.5	8.6	9.5	8.9	-0.1	15.7	1.2
4/2–4/8	2005	9.0	11.0	9.8	25.2	28.3	27.4	8.8	9.8	9.3	-0.2	8.0	0.7
4/9–4/15	2005	9.9	13.0	11.6	30.5	31.7	30.9	9.2	10.0	9.8	-0.1	3.8	0.5
4/16–4/22	2005	9.0	12.7	11.5	28.7	29.9	29.2	10.0	10.3	10.1	0.1	3.5	0.4
4/23–4/29	2005	9.5	10.8	9.5	33.7	34.9	34.5	9.6	10.9	10.1	-0.2	7.8	0.9
4/30–5/6	2005	10.2	10.8	9.8	25.8	27.6	26.7	9.6	11.4	10.6	0.1	12.5	1.3
5/7–5/13	2005	9.9	11.3	9.6	29.9	31.3	30.4	10.0	11.7	11.2	-0.7	29.4	1.5
5/14–5/20	2005	9.3	10.1	9.1	30.1	31.4	30.6	10.6	12.8	11.9	-2.6	6.5	-1.0
5/21–5/27	2005	7.6	10.0	8.8	29.3	31.7	30.2	11.1	13.9	12.4	†	†	†
5/28–6/3	2005	7.9	10.5	9.3	29.1	32.0	30.5	11.2	13.9	12.6	†	†	†
6/11–6/17	2005	8.1	10.5	10.0	29.6	31.1	30.0	11.9	13.9	13.3	†	†	†
6/29–7/1	2005	8.5	11.4	10.1	27.4	30.3	28.9	15.3	17.8	16.7	-2.4	6	-0.2
7/14–7/16	2005	8.3	11.2	9.2	27.3	32.5	31.7	13.2	16.9	14.5	-0.5	8.9	1
7/21–7/22	2005	6.9	11	8.3	26.8	28.1	27.6	11.9	16.4	13.7	-0.4	18	1
7/27–7/29	2005	7.2	9.4	8.2	34	35.1	34.5	13.3	15.8	14.5	0	11.8	0.7
8/3–8/4	2005	5.9	12.4	9	27.9	29.4	28.9	11.9	17.8	14.9	0	14.5	1.4
8/10–8/12	2005	7.8	9.2	8.6	29.9	31.6	30.6	15.1	19.1	17.4	0	15.7	1
8/15–8/16	2005	6.5	9.7	8.3	30.5	31.2	30.8	12.6	15.5	14.2	0.6	15.9	1.8
8/22–8/23	2005	5.3	8.7	6.9	30.3	31.3	30.9	12.4	15.5	13.8	0.1	4.8	0.5
8/29–8/30	2005	8.2	10.3	9.3	30.1	31.5	30.9	16.3	18.6	17.3	0.2	6	0.6
9/9–9/10	2005	7.9	9.2	8.7	28.1	29.5	28.9	13.5	15.6	14.8	0	12.6	0.7
9/12	2005	7	9.6	8.8	27.8	28.9	28.3	13.5	15.9	15.2	0.1	8.4	0.7
1/26–1/27	2006	7.2	11.3	9.1	25.9	27.3	26.6	7.7	8.2	8.1	0.2	12.4	1.1
2/7–2/8	2006	7.1	10.6	8.8	26.5	29.8	28.3	7.4	8.4	8	0.3	26.4	1.3
3/1–3/2	2006	8.8	11.3	9.4	28.5	30.1	29.3	6.9	8.3	8.1	0.2	12.7	1.1
3/7–3/8	2006	8.9	10.3	9.3	26.4	28.7	28.1	7.4	8.4	8.3	0	12	1
3/13–3/14	2006	8.8	10.6	9.4	29.5	30.8	30.1	7	8.4	8.2	-0.1	41.8	2.6

Table 3.1–2. Minimum, Maximum, and Mean Values of Water Quality Parameters at Nearshore Locations along the NAVBASE Kitsap Bangor Waterfront during the 2005–2008 Water Quality Surveys (continued)

Dates	Year	DO (mg/L)			Salinity (PSU)			Temperature (°C)			Turbidity (NTU)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
3/23–3/24	2006	9.2	12.1	10.8	26.3	29.4	27.4	8.3	9.9	9	-0.3	42.9	1.3
3/27–3/28	2006	9.9	10.3	9.3	26.9	28.2	27.5	8.6	9.5	8.9	-0.1	15.7	1.2
4/4–4/5	2006	9	11	9.8	25.2	28.3	27.4	8.8	9.8	9.3	-0.2	8	0.7
4/11–4/12	2006	9.9	13	11.6	30.5	31.7	30.9	9.2	10	9.8	-0.1	3.8	0.5
4/20	2006	9	12.7	11.5	28.7	29.9	29.2	10	10.3	10.1	0.1	3.5	0.4
4/24–4/25	2006	9.5	10.8	9.5	33.7	34.9	34.5	9.6	10.9	10.1	-0.2	7.8	0.9
5/2–5/3	2006	10.2	10.8	9.8	25.8	27.6	26.7	9.6	11.4	10.6	0.1	12.5	1.3
5/11–5/12	2006	9.9	11.3	9.6	29.9	31.3	30.4	10	11.7	11.2	-0.7	29.4	1.5
5/15–5/16	2006	9.3	10.1	9.1	30.1	31.4	30.6	10.6	12.8	11.9	-2.6	6.5	-1
5/25–5/26	2006	7.6	10	8.8	29.3	31.7	30.2	11.1	13.9	12.4	†	†	†
5/30–5/31	2006	7.9	10.5	9.3	29.1	32	30.5	11.2	13.9	12.6	†	†	†
5/16	2006	8.1	10.5	10	29.6	31.1	30	11.9	13.9	13.3	†	†	†
1/25–1/26	2007	8.9	10.1	9.4	27.9	29.5	28.8	7.8	8.2	8.1	-0.2	0.6	0.0
2/8–2/9	2007	10.4	14.0	12.3	18.4	29.4	23.7	8.0	8.7	8.2	-1.0	8.3	0.0
3/1–3/2	2007	9.4	11.4	10.3	27.5	28.6	28.3	7.6	8.2	8.0	9.5	11.0	9.9
3/8–3/9	2007	3.9	8.0	6.5	23.9	25.7	24.9	8.3	9.0	8.7	-0.1	10.1	0.9
4/24–4/25	2007	9.1	10.6	10.0	25.4	27.0	26.5	10.8	11.5	11.2	-1.1	4.7	0.0
4/30–5/1	2007	8.8	12.3	10.0	27.5	28.8	28.3	9.3	12.1	10.3	-0.2	16.7	1.2
5/14–5/15	2007	8.3	12.3	10.2	28.3	29.4	28.9	9.9	12.1	10.8	-0.3	3.1	0.4
5/24–5/25	2007	8.8	11.7	10.2	30.4	31.9	31.1	11.4	14.1	12.6	-1.0	29.9	1.4
6/7–6/8	2007	9.2	12.0	11.3	30.2	31.1	30.8	12.6	13.5	13.1	0.0	11.7	1.3
2/2–2/3	2008	†	†	†	28.8	30.0	29.4	6.6	7.6	7.4	†	†	†
2/8–2/9	2008	†	†	†	29.3	29.7	29.6	7.4	7.7	7.6	†	†	†
3/12–3/13	2008	†	†	†	29.5	30.3	30.0	7.8	8.3	8.2	†	†	†
3/24–3/25	2008	†	†	†	30.0	30.4	30.3	7.8	8.5	8.1	†	†	†
4/1–4/2	2008	†	†	†	29.8	31.5	30.3	6.3	8.8	8.1	†	†	†
4/15–4/16	2008	†	†	†	31.8	32.4	32.2	8.5	9.1	8.8	0.1	0.8	0.4
4/29–4/30	2008	†	†	†	30.9	32.3	31.8	8.7	10.8	9.4	0.0	13.0	0.9
5/8–5/9	2008	†	†	†	31.2	32.8	32.2	8.4	10.3	9.3	0.1	9.4	1.3
5/21–5/22	2008	†	†	†	28.4	32.4	31.1	9.7	13.6	11.3	0.1	7.3	1.5
6/9–6/10	2008	†	†	†	26.7	28.0	27.3	10.4	12.8	11.6	-1.4	9.0	-0.2

Sources: Phillips et al. 2009; Hafner and Dolan 2009

† No data collected due to sensor malfunction.

°C = degrees Celsius; DO = dissolved oxygen; mg/L = milligrams per liter; NTU = Nephelometric Turbidity Units; PSU = practical salinity units

STRATIFICATION, SALINITY, AND TEMPERATURE AT THE LWI PROJECT SITES

Stratification, salinity, and temperature at the LWI project sites are consistent with conditions discussed above for the Bangor waterfront in general. Representative vertical profiles of water temperature, salinity, and density near the south LWI project site during summer (July 2007) are shown in Figure 3.1–15.

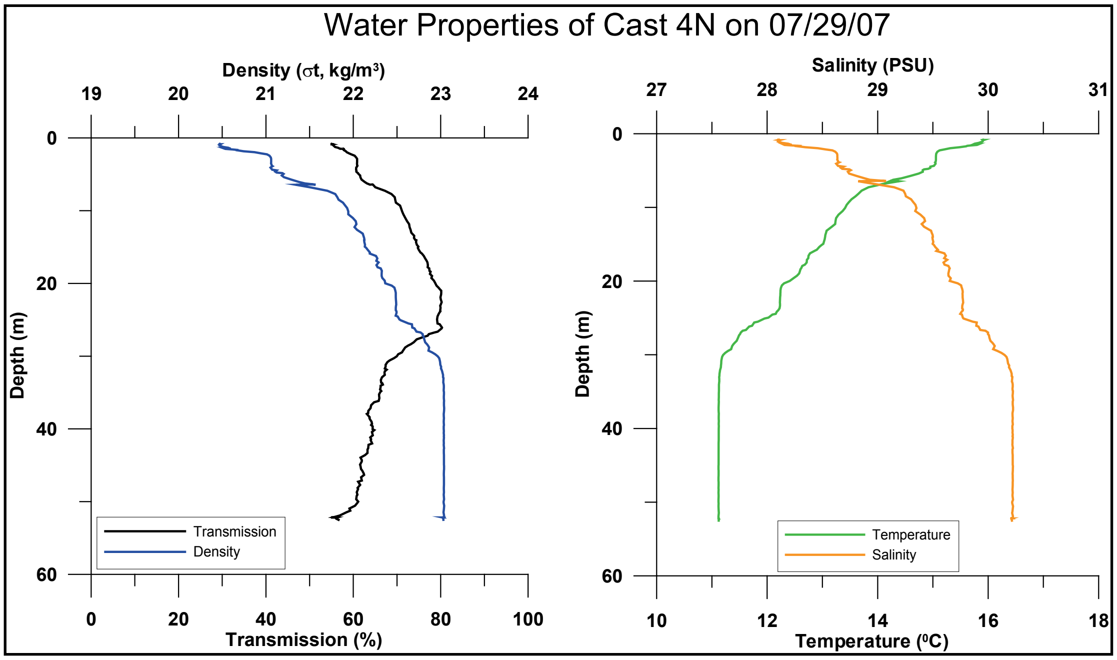
STRATIFICATION, SALINITY, AND TEMPERATURE AT THE SPE PROJECT SITE

Stratification, salinity, and temperature at the SPE project site are consistent with conditions discussed above for the Bangor waterfront in general. Representative vertical profiles of water temperature, salinity, and density near the Service Pier during summer (July 2007) are shown in Figure 3.1–16.

DISSOLVED OXYGEN

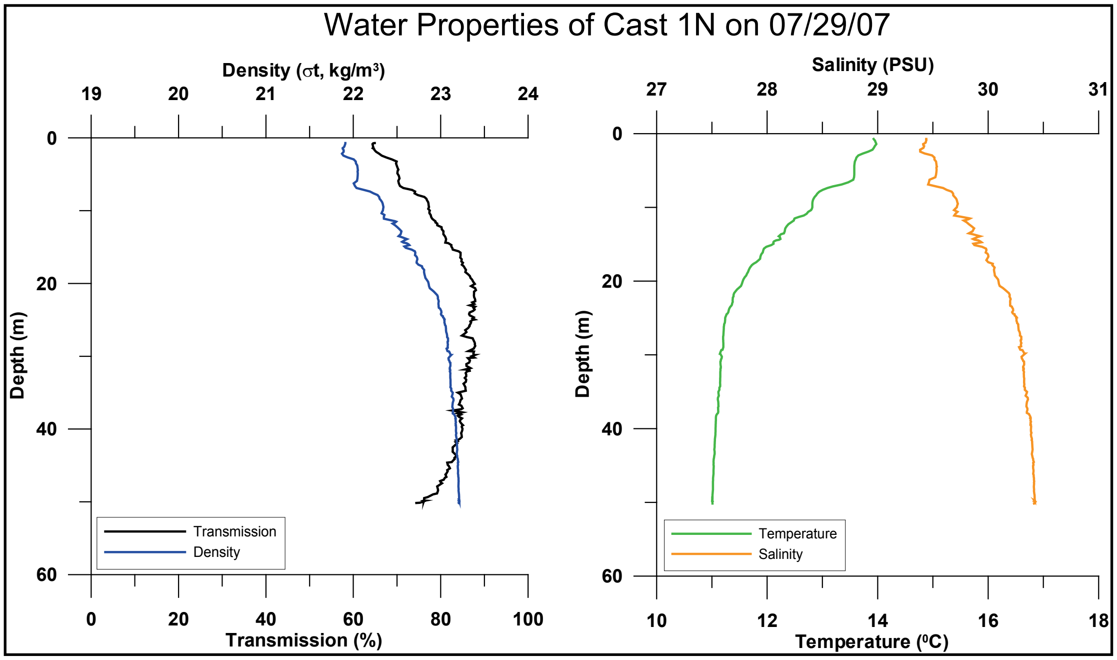
The DO concentrations in Hood Canal waters are affected by a number of physical and biological factors, some of which are influenced by human activities. Per the state's water quality classification, concentrations of DO in extraordinary quality marine surface waters, such as Hood Canal, should exceed 7.0 milligrams per liter (mg/L), allowing for only 0.2 mg/L reductions in the natural condition by human-caused activities (WAC 173-201A). However, physical and biological conditions contribute to DO concentrations below 7.0 mg/L within portions of Hood Canal. In these cases, state guidelines [WAC 173-201A-210(1)(d)] specify that "when a water body's DO is lower than the criteria in Table 210(1)(d) (or within 0.2 mg/L of the criteria) and that condition is due to natural conditions, the human action considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L."

Hood Canal is a deep, fjord-like basin with slow circulation, and these conditions are conducive to low DO conditions (Newton et al. 2011). Low DO concentrations in Hood Canal were reported as early as the 1930s and during the 1950s to 1960s (Collias et al. 1974), but at that time these conditions were largely confined to southern Hood Canal and lasted for three to six months. However, since the mid-1990s, the frequency, duration, and spatial extent of the hypoxia (low oxygen levels) have increased. Data from WDOE's Marine Water Quality Monitoring Program for 1998 to 2000 and the Hood Canal Dissolved Oxygen Program (HCDOP) for 2002 to 2004 show that seasonally low DO can also be found in the mainstem (northern and central reach) of Hood Canal (Newton et al. 2011). Scientists have proposed the following possible causes for the lower DO concentrations in Hood Canal: (1) changes in production or input of organic matter due to naturally better growth conditions, such as increased sunlight (or other climate factors), increased nutrient availability, or human loading of nutrients or organic material; (2) changes in ocean properties, such as seawater density that affects flushing of the canal's waters, oxygen concentration, or nutrients in the incoming ocean water; (3) changes in river input or timing from natural causes (e.g., drought) or from human actions (e.g., diversion) that affect both flushing and mixing in the canal; and (4) changes in weather conditions, such as wind direction and speed, which affect the flushing and/or oxygen concentration distribution. There is supporting evidence for all of these hypotheses (HCDOP 2009a).



Source: Morris et al. 2008

Figure 3.1–15. Water Quality (Temperature, Salinity, and Stratification/Density) Conditions Near the South LWI Project Site in Summer 2007



Source: Morris et al. 2008

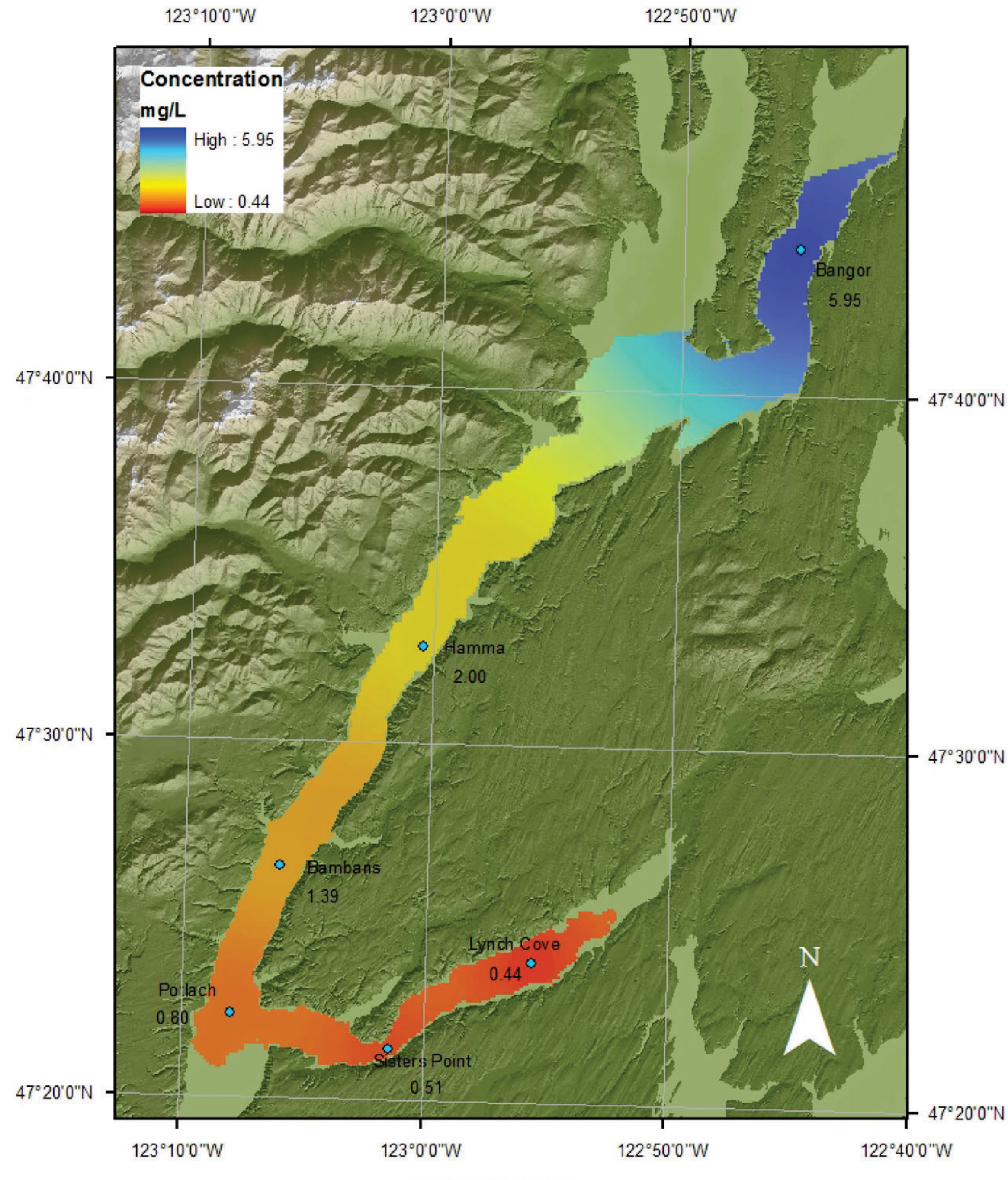
Figure 3.1–16. Water Quality (Temperature, Salinity, and Stratification/Density) Conditions Near the SPE Project Site in Summer 2007

The Bangor waterfront is located along the northern stretch of Hood Canal, which is less affected by these seasonal episodes of low DO (Figure 3.1–17) than other areas of the canal. From 2003 through 2008, DO concentrations in Hood Canal offshore from the southern boundary of NAVBASE Kitsap Bangor ranged from approximately 4 to 12 mg/L at depths of 33 feet (10 meters) (HCDOP 2009b). For this same time period, DO concentrations in surface waters ranged from approximately 5 to 14 mg/L. The concentrations fluctuated seasonally, with higher DO concentrations in the spring and early summer and lower DO concentrations in late summer and fall. Dissolved oxygen concentrations in Hood Canal between Dabob Bay and the Great Bend (south of the NAVBASE Kitsap Bangor area) ranged from approximately 3 to 5 mg/L at depths greater than 66 feet (20 meters) (Warner 2007). Monitoring data for core site HCB010 (off the southern tip of Toandos Peninsula) from 2012 (WDOE 2013a) indicated seasonal patterns in DO concentrations similar to those reported by HCDOP (2009b).

The 2012 303(d) list, the most recent list approved by the United States (U.S.) Environmental Protection Agency (USEPA), includes seven segments near NAVBASE Kitsap Bangor impaired by low DO levels (WDOE 2013b). Two of these (IDs 40984 and 10271) are located along the Bangor waterfront (Figure 3.1–18). Segment 10271 is just north of the south LWI project site. While the most recent (2009) data for segment 40984 showed no DO concentrations below the criterion (7.0 mg/L), both sites were determined to be category 5 (polluted sites requiring a total maximum daily load [TMDL]). The previously reported low DO concentrations at these locations were not attributable solely to natural conditions (WDOE 2013c).

Although some waters along the Bangor waterfront are on the 303(d) list, mean DO measurements during 2005 through 2008 indicated that nearshore stations at the waterfront consistently met extraordinary quality standards for DO (Table 3.1–2). Mean DO concentrations were above 7.0 mg/L during all but two surveys (August 22–23, 2005, and March 8–9, 2007), although it should be noted that water quality surveys during 2006 through 2008 did not extend into late summer and fall when the lowest seasonal DO concentrations are expected to occur (Hafner and Dolan 2009; Phillips et al. 2009). The 2005 to 2008 surveys of nearshore water quality off NAVBASE Kitsap Bangor did not detect any consistent spatial patterns in DO levels along the shoreline, as were noted for temperature and salinity.

At the offshore water quality sampling locations, water quality ratings based on DO concentrations ranged from fair to extraordinary quality during 2005 to 2006 (Phillips et al. 2009), whereas all DO concentrations measured at the offshore water quality sampling locations in 2007 were above 7.0 mg/L and met extraordinary quality standards (Hafner and Dolan 2009). The DO concentrations measured during the water quality surveys along the Bangor waterfront were on the upper range of DO conditions measured historically throughout Hood Canal during the late summer and fall periods (Warner 2007; WDOE 2013a).



Source: August 2006 Oxygen data provided by HCDOP Citizen Monitoring data, and image produced by University of Washington Spatial Analysis Lab.

Figure 3.1–17. Dissolved Oxygen Concentration in Hood Canal

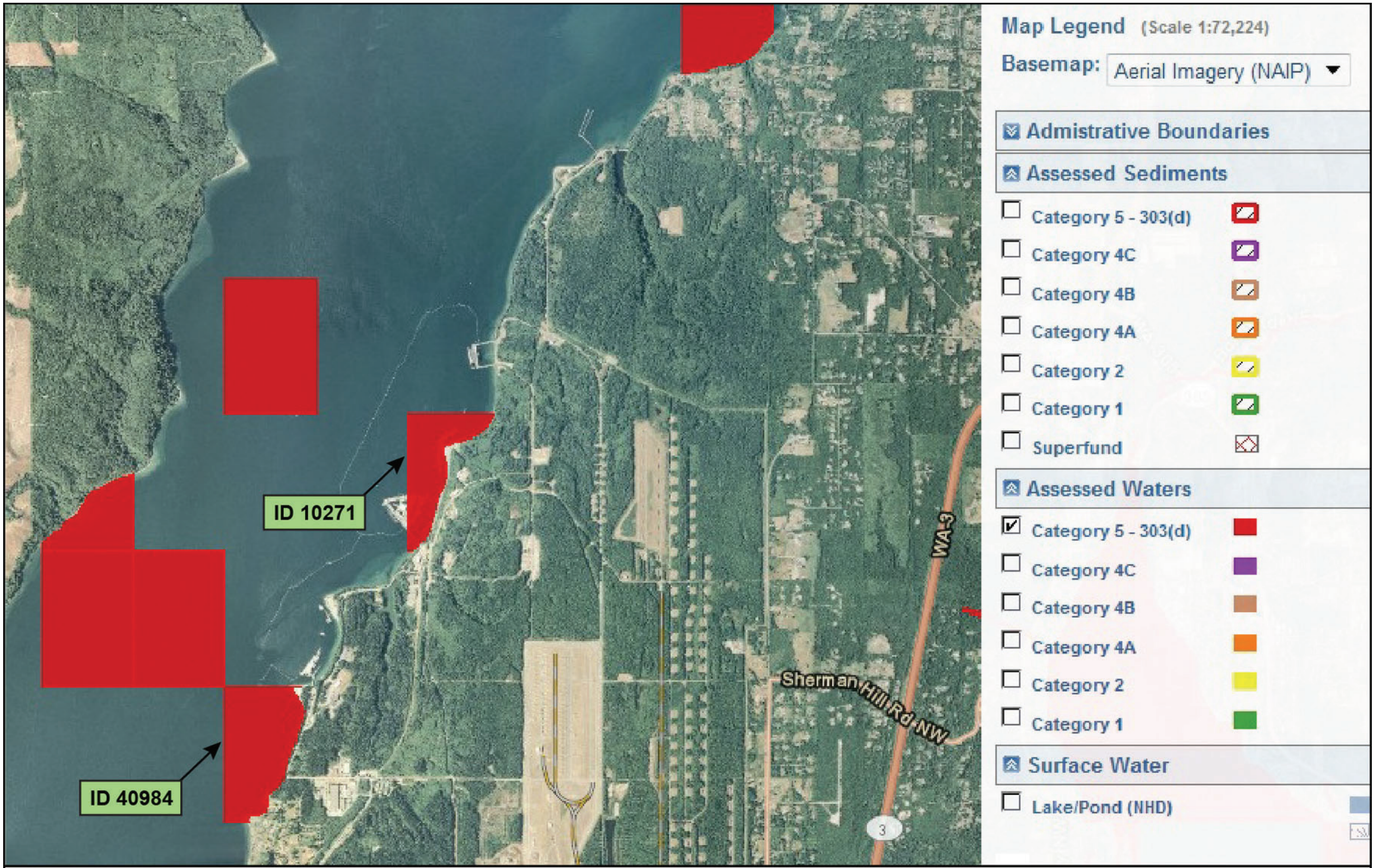


Figure 3.1–18. Washington State 2012 303(d) List Map for the NAVBASE Kitsap Bangor Area

DISSOLVED OXYGEN CONCENTRATIONS AT THE LWI PROJECT SITES

Dissolved oxygen concentrations measured near the LWI project sites during the 2005 to 2008 water quality surveys (Hafner and Dolan 2009; Phillips et al. 2009) were consistent with the patterns discussed above for the Bangor waterfront and ranged from fair to extraordinary conditions.

DISSOLVED OXYGEN CONCENTRATIONS AT THE SPE PROJECT SITE

Dissolved oxygen concentrations at the SPE project site measured during the 2005 to 2008 water quality surveys (Hafner and Dolan 2009; Phillips et al. 2009) were consistent with the patterns discussed above for the NAVBASE Kitsap Bangor shoreline and ranged from fair to extraordinary conditions.

TURBIDITY

Turbidity, measured in Nephelometric Turbidity Units (NTU), is a measure of the amount of light scatter related to total suspended solids (TSS) in the water column. Sources of turbidity in Hood Canal waters may include plankton, organic detritus from streams and other storm or wastewater sources, fine suspended sediments (silts and clays), and resuspended bottom sediments and organic particles. Suspended particles in the water have the ability to absorb heat in the sunlight, which then raises water temperature and reduces light available for photosynthesis.

Washington State-designated extraordinary quality marine surface waters have an average turbidity reading of less than 5 NTU (WAC 173-201A). Turbidity measurements conducted along the Bangor waterfront, including the vicinity of the LWI and SPE project sites during the 2005 through 2008 water quality surveys (Hafner and Dolan 2009; Phillips et al. 2009), are summarized in Table 3.1–2. The mean monthly turbidity measurements for nearshore waters ranged from 0.0 to 9.9 NTU and, for all but one survey (March 1–2, 2007), were within the Washington State standards for extraordinary water quality. The 2005 to 2008 surveys of nearshore water quality off the Bangor waterfront did not detect any consistent spatial patterns in turbidity levels along the waterfront, as were noted for temperature and salinity.

TURBIDITY AT THE LWI PROJECT SITES

Turbidity levels at the LWI project sites measured during the 2005 to 2008 water quality surveys (Hafner and Dolan 2009; Phillips et al. 2009) were consistent with the patterns discussed above for the NAVBASE Kitsap Bangor shoreline and typically reflected extraordinary water quality conditions.

TURBIDITY AT THE SPE PROJECT SITE

Turbidity levels at the SPE project site measured during the 2005 to 2008 water quality surveys (Hafner and Dolan 2009; Phillips et al. 2009) were consistent with the patterns discussed above for the NAVBASE Kitsap Bangor shoreline and typically reflected extraordinary water quality conditions.

NUTRIENTS

Nutrients (particularly nitrogen-based compounds), sunlight, and a stratified water column play important roles in algae productivity in Hood Canal. Nitrogen enters Hood Canal from the ocean, rivers, and the atmosphere. However, as more nitrogen enters the system through uncontrolled sources (e.g., runoff, fertilizer use, leaking septic systems), algae growth is stimulated, which can then reduce oxygen levels when the algae die and decompose in the late summer and early fall (HCDOP 2005).

WDOE's Marine Water Monitoring Program periodically monitors nutrients in the vicinity of the Bangor waterfront (WDOE 2013a). Concentrations of nitrate and phosphate during the 2005 monitoring year ranged from 0.02 to 2 mg/L and from 0.04 to 0.4 mg/L, respectively. Specific water quality standards for nutrients are not established, but the ranges observed near the LWI/SPE project sites are typical for marine waters in Puget Sound (Newton et al. 1998, 2002).

NUTRIENTS AT THE LWI PROJECT SITES

Nutrient concentrations in waters near the LWI project sites were not measured during the 2005 to 2008 water quality surveys of the Bangor waterfront; however, levels are expected to be similar to those reported by WDOE's Marine Water Monitoring Program (WDOE 2013a) for marine waters in the vicinity of the Bangor waterfront, as discussed above.

NUTRIENTS AT THE SPE PROJECT SITE

Nutrient concentrations in waters near the SPE project site were not measured during the 2005 to 2008 water quality surveys of the Bangor waterfront; however, levels are expected to be similar to those reported by WDOE's Marine Water Monitoring Program (WDOE 2013a) for marine waters, as discussed above.

FECAL COLIFORM BACTERIA

Fecal coliform covers two bacteria groups (coliforms and fecal streptococci) that are commonly found in animal and human feces and are used as indicators of possible sewage contamination in marine waters (USEPA 1997). Although fecal indicator bacteria typically are not harmful to humans, they indicate the possible presence of pathogenic bacteria, viruses, and protozoa that also live in animal and human digestive systems. Therefore, their presence in marine waters at elevated levels may indicate the presence of pathogenic microorganisms that pose a health risk.

The Washington Department of Health (WDOH) Office of Food Safety and Shellfish Programs conducts annual fecal coliform bacteria monitoring in Hood Canal including stations near the Bangor waterfront. The standard for approved shellfish growing waters is a fecal coliform geometric mean not greater than 14 most probable number (MPN)/100 milliliters (mL) and an estimate of the 90th percentile not greater than 43 MPN/100 mL (Table 3.1–1). When this standard is met, the water is considered safe for shellfish harvesting and for water contact use by humans (also referred to as primary human contact).

WDOH summarized the annual fecal coliform bacteria monitoring results in Hood Canal and the rest of Puget Sound in the form of an index rating system ranging from bad to good, where lower index values indicate lower fecal coliform. Most of the NAVBASE Kitsap Bangor shellfish areas are classified by WDOH as Approved for harvest (WDOH 2012); however, one area just south of Cattail Lake is classified as Prohibited.

FECAL COLIFORM BACTERIA AT THE LWI PROJECT SITES

The most recent WDOH data fecal coliform data for the closest sampling stations to the LWI project sites (85 and 87) indicate that these stations meet the WDOE water quality standard (WDOH 2012). A waterbody segment (Listing ID 40015) of Hood Canal off Devil's Hole (Hood Canal #2 87 and 88) is a category 2 listing (waters of concern, no TMDL required) on the current 303(d) list for elevated bacterial levels. The category determination was based on one exceedance in 2007. More recent data, which met the standard, are not sufficient to demonstrate that this waterbody currently is meeting water quality standards for bacteria because the determination is based on multiple measurements, specifically a rolling average of about 30 samples for classification of shellfish growing areas.

FECAL COLIFORM BACTERIA AT THE SPE PROJECT SITE

Similar to the LWI project sites, the most recent WDOH fecal coliform data for the area near the SPE project site (Station 88), indicates that this sampling station meets the WDOE water quality standard (WDOH 2012).

PH

The term *pH* is a measure of alkalinity or acidity and affects many chemical and biological processes in water. For example, low pH can affect the mobility (solubility) of toxic elements and their availability for uptake by aquatic plants and animals, which can produce conditions toxic to aquatic life, particularly to juvenile organisms. Washington State-designated extraordinary quality marine surface waters should have a pH reading between 7.0 and 8.5 (WAC 173-201A). WDOE's Marine Water Monitoring Program monitors pH in the vicinity of the Bangor waterfront. The pH levels at the rotating site HCB008 ranged from 7.6 to 8.1 during 2005, and all values were within extraordinary quality standards (WDOE 2013a).

PH LEVELS AT THE LWI PROJECT SITES

The pH of waters near the LWI project sites was not measured during the 2005 to 2008 water quality surveys of the Bangor waterfront. However, values are expected to be consistent with those discussed above for the WDOE Marine Water Monitoring Program and meet extraordinary water quality standards.

PH LEVELS AT THE SPE PROJECT SITE

The pH of waters near the SPE project site was not measured during the 2005 to 2008 water quality surveys of the Bangor waterfront. However, values are expected to be consistent with those discussed above for the WDOE Marine Water Monitoring Program and meet extraordinary water quality standards.

3.1.1.1.3. SEDIMENT QUALITY

Sediment quality focuses on the physical and chemical properties of bottom sediments. Physical parameters include grain size, which is a quantitative description of the proportions of gravel, sand, silt, and clay-size particles and the dominant size classes for the sediment matrix. Sediment quality also considers concentrations of total organic carbon (TOC), as well as the concentrations of trace constituents, including metals, petroleum-derived hydrocarbons, and chlorinated organic compounds, which may reflect a combination of natural and human-derived sources. The combination of sediment texture (grain size), organic content, and contaminant levels affect the suitability of the sediments as habitat for marine organisms and other beneficial uses.

PHYSICAL AND CHEMICAL PROPERTIES OF SEDIMENTS

Existing information on the physical and chemical properties of sediments in the vicinity of the LWI and SPE project sites is based on results from sampling during 2007 (Hammermeister and Hafner 2009). Sampling locations at the north and south LWI project sites are shown in Figures 3.1–19 and 3.1–20, respectively, and sampling locations in the vicinity of Service Pier are shown in Figure 3.1–21.

Marine sediments in the general project area are composed of gravelly sands with some cobbles in the intertidal zone, transitioning to silty sands in the subtidal zone (Hammermeister and Hafner 2009). Subsurface coring studies conducted in 1994 encountered glacial till approximately 6 feet (2 meters) below the mud line in the intertidal zone, increasing to over 10 feet (3 meters) in the subtidal zone (URS 1994).

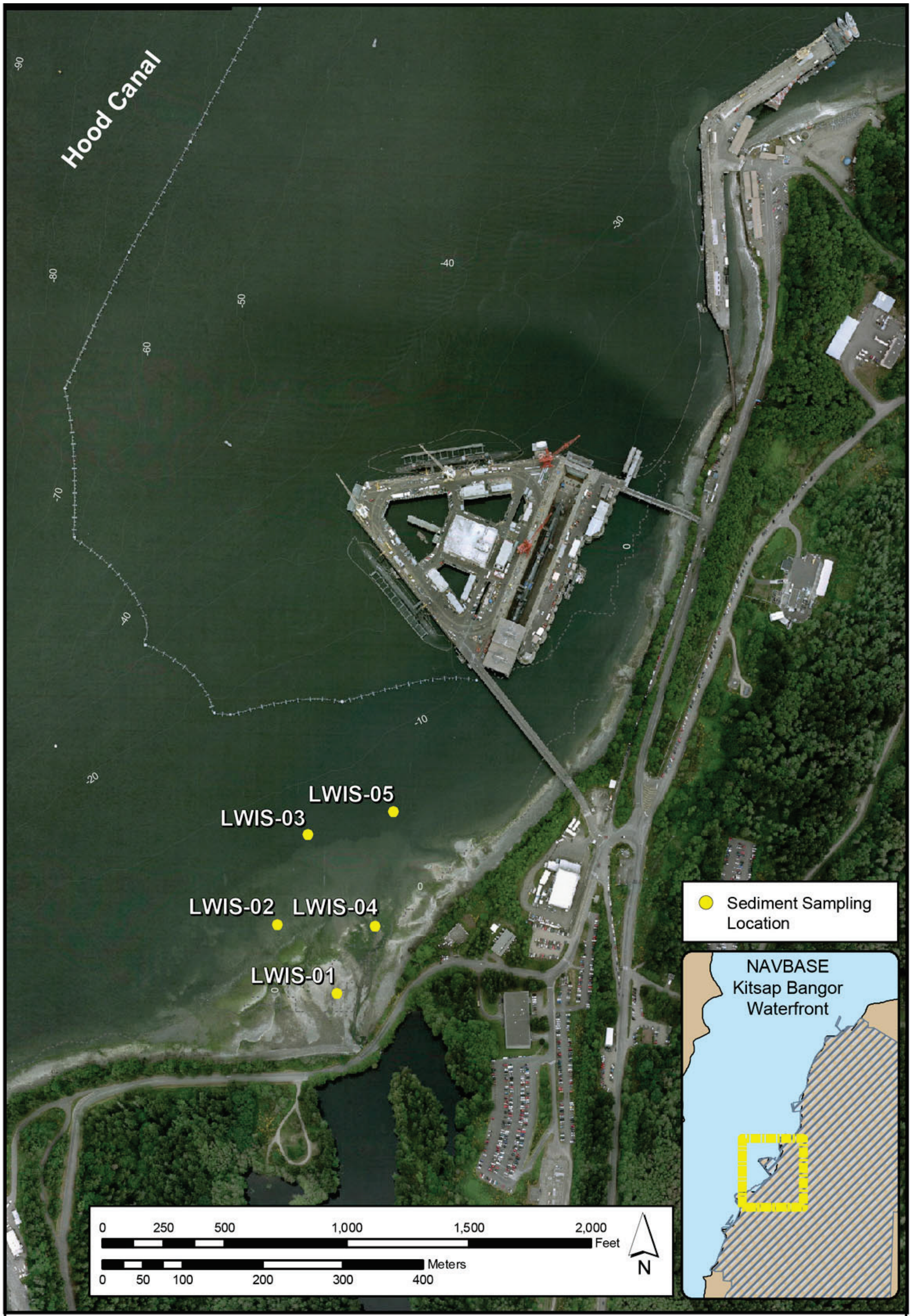
PHYSICAL AND CHEMICAL PROPERTIES OF SEDIMENTS AT THE LWI PROJECT SITES

Sediments from the north and south LWI project sites consist primarily of sand-sized particles (83 to 99 percent and 30 to 97 percent, respectively) with variable gravel fractions (1 to 4 percent and 1 to 70 percent, respectively) and small silt plus clay fractions (4 to 17 percent and 2 to 7 percent, respectively) (Table 3.1–3). Other than the comparatively higher gravel fraction in the south LWI sediments, the texture of bottom sediments at both locations is similar.

Sediment parameters (such as TOC, metals, and organic contaminants) were used to characterize sediment quality. TOC, which provides a measure of how much organic matter occurs in the sediments, is less than 1 percent at the north LWI and south LWI project sites (Table 3.1–3). A range of 0.5 to 3 percent is typical for Puget Sound marine sediments, particularly those in the main basin and in the central portions of urban bays (Puget Sound Water Quality Action Team and Puget Sound Estuary Program 1997). Total sulfide concentrations range from not detected (ND) (i.e., below the detection limit of 0.4 milligrams per kilogram [mg/kg]) to 259 mg/kg, and ammonia concentrations range from 4.8 to 14.5 mg/kg across both the north LWI and south LWI project sites. Table 3.1–3 lists marine sediment quality standards for selected parameters (marine sediment quality standards are discussed in Section 3.1.1.2.1). No marine sediment quality standards have been established for TOC, sulfides, or ammonia concentrations. In general, the TOC, sulfides, and ammonia concentrations in the north LWI and south LWI sediments are similar.

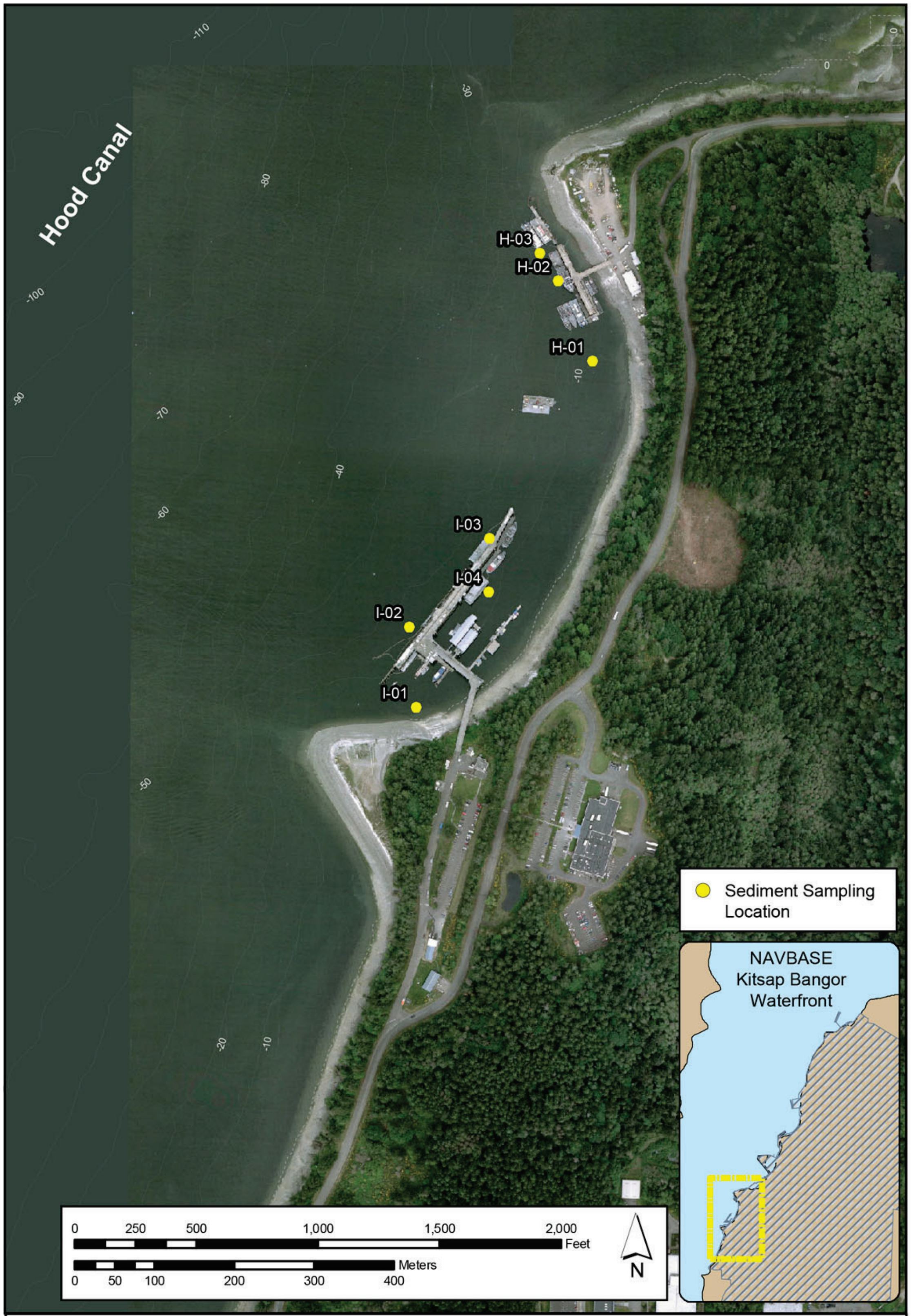
Source: Hammermeister and Hafner 2009

Figure 3.1–19. Sediment Sampling Locations at the North LWI Project Site



Source: Hammermeister and Hafner 2009

Figure 3.1–20. Sediment Sampling Locations at the South LWI Project Site



Source: Hammermeister and Hafner 2009

1:4500, WA State Plane North NAD83

Figure 3.1–21. Sediment Sampling Locations at the SPE Project Site

Table 3.1–3. Physical and Chemical Characteristics of Surface Sediments at the North and South LWI Project Sites

Parameter	Marine Sediment Quality Standards	North LWI Site[1] (Minimum – Maximum Values)	South LWI Site[1] (Minimum – Maximum Values)
Conventionals			
Total Organic Carbon (TOC) (%)	—	0.19 – 0.56	0.16 – 0.54
Total Volatile Solids (%)	—	1.6 – 2.4	1.36 – 2.94
Total Solids (%)	—	67 – 75	73 – 86
Ammonia (mg-N/kg)	—	6.9 – 11	4.8 – 14
Total Sulfides (mg/kg)	—	3.7 – 210	ND – 259
Grain Size			
Percent Gravel (>2.0 mm)	—	0.91 – 3.99	1.18 – 69.9
Percent Sand (<2.0 mm – 0.06 mm)	—	82.6 – 99.3	30.5 – 96.8
Percent Silt (0.06 mm – 0.004 mm)	—	2.14 – 13.0	0.79 – 3.36
Percent Fines (<0.06 mm)	—	3.81 – 17.1	2.44 – 6.83
Percent Clay (<0.004 mm)	—	1.67 – 4.14	1.39 – 3.48
Metals (mg/kg)			
Antimony	—	0.05	0.03 – 0.10
Arsenic	57	2.29 – 3.37	1.42 – 2.55
Cadmium	5.1	0.18 – 0.37	0.04 – 0.35
Chromium	260	18.5 – 22.2	17.9 – 33.5
Copper	390	10.3 – 12.7	7.20 – 19.0
Lead	450	2.30 – 3.23	2.33 – 3.26
Mercury	0.41	0.01 – 0.03	0.01
Nickel	—	20.5 – 26.2	20.1 – 35.3
Selenium	—	0.40 – 0.60	0.40 – 0.50
Silver	6.1	0.02 – 0.04	0.02 – 0.03
Zinc	410	32.4 – 35.5	27.3 – 40.4
Butyltins (µg/kg)			
Di-n-butyltin	—	ND – 0.26	ND – 0.39
Tri-n-butyltin	—	ND	ND – 0.97
Tetra-n-butyltin	—	ND	ND
n-butyltin	—	ND	ND
LPAH (mg/kg TOC)			
Naphthalene	99	ND	ND
Acenaphthylene	66	ND	ND – 1.05
Acenaphthene	16	ND	ND
Fluorene	23	ND	ND – 0.74
Phenanthrene	100	1.59 – 2.58	1.39 – 9.52
Anthracene	220	ND – 0.48	ND – 2.19
2-Methylnaphthalene	38	ND	ND
Total LPAH[2]	370	1.59 – 2.80	1.39 – 13.5

Table 3.1–3. Physical and Chemical Characteristics of Surface Sediments at the North and South LWI Project Sites (continued)

Parameter	Marine Sediment Quality Standards	North LWI Site[1] (Minimum – Maximum Values)	South LWI Site[1] (Minimum – Maximum Values)
HPAH (mg/kg TOC)			
Fluoranthene	160	2.16 – 4.29	4.29 – 12.4
Pyrene	1,000	1.95 – 3.75	3.36 – 12.4
Benz(a)anthracene	110	ND – 1.55	ND – 5.00
Chrysene	110	ND – 2.32	1.93 – 5.71
Benzofluoranthenes[3]	230	ND – 2.80	4.00 – 7.38
Benzo(a)pyrene	99	ND – 1.66	1.18 – 5.24
Indeno(1,2,3-cd)pyrene	34	ND – 1.07	0.86 – 3.10
Dibenz(a,h)anthracene	12	ND	ND – 0.69
Benzo(g,h,i)perylene	31	ND – 0.91	0.71 – 2.62
Total HPAH[4]	960	4.11 – 21.2	21.8 – 61.9
Chlorinated Aromatics (mg/kg TOC)			
1,3-Dichlorobenzene	—	ND	ND
1,2-Dichlorobenzene	2.3	ND	ND
1,4-Dichlorobenzene	3.1	ND	ND
1,2,4-Trichlorobenzene	0.81	ND	ND
Hexachlorobenzene	0.38	ND	ND
Phthalate Esters (mg/kg TOC)			
Dimethylphthalate	53	ND	ND
Diethylphthalate	61	1.39 – 5.59	ND – 1.00
Di-n-Butylphthalate	220	4.82 – 10.0	4.29 – 11.9
Butylbenzylphthalate	4.9	ND	ND – 1.82
bis(2-Ethylhexyl)phthalate	47	ND – 3.39	ND – 4.17
Di-n-Octylphthalate	58	ND	ND
Phenols (µg/kg dw)			
Phenol	420	30.0 – 47.0	16.0 – 84.0
2-Methylphenol	63	ND	ND
4-Methylphenol	670	20.0 – 37.0	ND – 160
2,4-Dimethylphenol	29	ND	ND
Pentachlorophenol	360	ND	ND
Misc. Extractables (mg/kg TOC)			
Benzyl Alcohol	57	ND	ND – 1.07
Benzoic Acid	650	ND	ND
Dibenzofuran	15	ND	ND
Hexachloroethane	—	ND	ND
Hexachlorobutadiene	3.9	ND	ND
N-Nitrosodiphenylamine	28	ND	ND

Table 3.1–3. Physical and Chemical Characteristics of Surface Sediments at the North and South LWI Project Sites (continued)

Parameter	Marine Sediment Quality Standards	North LWI Site[1] (Minimum – Maximum Values)	South LWI Site[1] (Minimum – Maximum Values)
Pesticides and PCBs (mg/kg TOC)			
Total DDT[5]	—	ND	ND – 0.02
Aldrin	—	ND	ND
alpha-Chlordane	—	ND	ND
Dieldrin	—	ND	ND
Heptachlor	—	ND	ND
gamma-BHC (Lindane)	—	ND	ND
Total PCBs[6]	12	ND	ND

Source: Marine sediment quality standards from WAC 173-204-320; LWI data are from Hammermeister and Hafner (2009).

— = No sediment quality standard or screening levels exist; dw = dry weight; HPAH = high molecular weight polycyclic aromatic hydrocarbon; LPAH = low molecular weight polycyclic aromatic hydrocarbon; mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram; mm = millimeter; ND = not detected; PCB = polychlorinated biphenyl; TOC = total organic carbon

1. Samples taken at depths from 0–10 cm. Values represent the ranges for samples from three locations near the north LWI project site and four locations from the south LWI project site as shown in Figures 3.1–19 and 3.1–20.
2. Sum of detected LPAH results for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. LPAH does not include 2-methylnaphthalene.
3. Sum of benzo(b)fluoranthene and benzo(k)fluoranthene.
4. Sum of detected HPAH results for fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
5. Sum of 4,4'-DDD, 4-4'-DDE, and 4-4'-DDT.
6. Sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260.

PHYSICAL AND CHEMICAL PROPERTIES OF SEDIMENTS AT THE SPE PROJECT SITE

Sediments at the SPE project site are primarily sand and gravel, and sediment quality is generally good based on contaminant levels that are below marine sediment quality standards (Table 3.1–4).

Table 3.1–4. Physical and Chemical Characteristics of Surface Sediments at the SPE Project Site

Parameter	Marine Sediment Quality Standards	SPE (Minimum – Maximum Values)[1]
Conventionals		
Total Organic Carbon (TOC) (%)	—	0.44 – 1.96
Total Volatile Solids (%)	—	1.4 – 6.8
Total Solids (%)	—	52 – 73
Ammonia (mg-N/kg)	—	7.6 – 29
Total Sulfides (mg/kg)	—	5.7 – 1330
Grain Size		
Percent Gravel (>2.0 mm)	—	1.4 – 36.5
Percent Sand (<2.0 mm – 0.06 mm)	—	37 – 96
Percent Silt (0.06 mm – 0.004 mm)	—	4.4 – 20

Table 3.1–4. Physical and Chemical Characteristics of Surface Sediments at the SPE Project Site (continued)

Parameter	Marine Sediment Quality Standards	SPE (Minimum – Maximum Values)[1]
Percent Fines (<0.06 mm)	—	6.9 – 28
Percent Clay (<0.004 mm)	—	2.6 – 8.3
Metals (mg/kg)		
Antimony	—	0.06 – 0.09
Arsenic	57	2.01 – 4.15
Cadmium	5.1	0.19 – 0.71
Chromium	260	18.3 – 22.1
Copper	390	8.6 – 23.9
Lead	450	3.29 – 9.32
Mercury	0.41	0.02 – 0.04
Nickel	—	18.7 – 25.4
Selenium	—	0.40 – 1.20
Silver	6.1	0.03 – 0.08
Zinc	410	31.6 – 77.5
Butyltins (µg/kg)		
Di-n-butyltin	—	ND – 0.65
Tri-n-butyltin	—	ND
Tetra-n-butyltin	—	ND
n-butyltin	—	ND – 0.24
LPAH (mg/kg TOC)		
Naphthalene	99	0.34 – 7.0
Acenaphthylene	66	1.5 – 5.0
Acenaphthene	16	0.22 – 3.6
Fluorene	23	0.31 – 5.4
Phenanthrene	100	3.3 - 30
Anthracene	220	1.0 - 14
2-Methylnaphthalene	38	0.29 – 2.9
Total LPAH[2]	370	5.4 – 62
HPAH (mg/kg TOC)		
Fluoranthene	160	12 – 61
Pyrene	1,000	10 – 54
Benz(a)anthracene	110	2.9 – 21
Chrysene	110	6.3 – 41
Benzofluoranthenes[3]	230	7.9 – 102
Benzo(a)pyrene	99	2.9 – 50
Indeno(1,2,3-cd)pyrene	34	2.0 – 21
Dibenz(a,h)anthracene	12	0.46 – 5.4
Benzo(g,h,i)perylene	31	1.7 – 15
Total HPAH[4]	960	57 – 372
Chlorinated Aromatics (mg/kg TOC)		
1,3-Dichlorobenzene	—	ND
1,2-Dichlorobenzene	2.3	ND
1,4-Dichlorobenzene	3.1	ND

Table 3.1–4. Physical and Chemical Characteristics of Surface Sediments at the SPE Project Site (continued)

Parameter	Marine Sediment Quality Standards	SPE (Minimum – Maximum Values)[1]
1,2,4-Trichlorobenzene	0.81	ND
Hexachlorobenzene	0.38	ND
Phthalate Esters (mg/kg TOC)		
Dimethylphthalate	53	ND – 0.30
Diethylphthalate	61	ND – 0.45
Di-n-Butylphthalate	220	2.8 – 4.4
Butylbenzylphthalate	4.9	ND – 1.0
bis(2-Ethylhexyl)phthalate	47	1.9 – 6.1
Di-n-Octylphthalate	58	ND
Phenols (µg/kg dw)		
Phenol	420	28 – 54
2-Methylphenol	63	ND
4-Methylphenol	670	2.7 – 260
2,4-Dimethylphenol	29	ND
Pentachlorophenol	360	ND
Misc. Extractables (mg/kg TOC)		
Benzyl Alcohol	57	ND – 0.73
Benzoic Acid	650	ND
Dibenzofuran	15	ND – 3.9
Hexachloroethane	__	ND
Hexachlorobutadiene	3.9	ND
N-Nitrosodiphenylamine	28	ND
Pesticides and PCBs (mg/kg TOC)		
Total DDT[5]	—	ND
Aldrin	—	ND
alpha-Chlordane	—	ND
Dieldrin	—	ND
Heptachlor	—	ND
gamma-BHC (Lindane)	—	ND
Total PCBs[6]	12	ND

Source: Marine sediment quality standards from WAC 173-204-320;
SPE data are from Hammermeister and Hafner (2009).

— = No sediment quality standard or screening levels exist; dw = dry weight; HPAH = high molecular weight polycyclic aromatic hydrocarbon; LPAH = low molecular weight polycyclic aromatic hydrocarbon; mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram; mm = millimeter; ND = not detected; PCB = polychlorinated biphenyl; TOC = total organic carbon

1. Samples taken at depths from 0–10 cm. Values represent the ranges for samples from four locations near the SPE project site as shown in Figure 3.1–21.
2. Sum of detected LPAH results for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. LPAH does not include 2-methylnaphthalene.
3. Sum of benzo(b)fluoranthene and benzo(k)fluoranthene.
4. Sum of detected HPAH results for fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
5. Sum of 4,4'-DDD, 4-4'-DDE, and 4-4'-DDT.
6. Sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260.

METALS

METALS IN SEDIMENTS AT THE LWI PROJECT SITES

Table 3.1–3 shows the concentrations of metals in sediments at the north LWI and south LWI project sites based on sampling conducted by Hammermeister and Hafner (2009). These concentrations are comparable to background levels for Puget Sound and are well below marine sediment quality standards. For example, maximum cadmium concentrations are 0.37 and 0.35 mg/kg, respectively, which are below the marine sediment quality standard of 5.1 mg/kg. In general, the metal concentrations in the north LWI and south LWI sediments are similar.

METALS IN SEDIMENTS AT THE SPE PROJECT SITE

Table 3.1–4 shows the concentrations of metals in sediments at the SPE project site based on sampling conducted by Hammermeister and Hafner (2009). These concentrations are comparable to background levels for Puget Sound and are well below marine sediment quality standards.

ORGANIC CONTAMINANTS

The primary source of organotin (butyltin) compounds in marine sediments is residues from anti-fouling paints applied to vessel hulls (Danish EPA 1999). Use of organotins in anti-fouling paints for ships less than 82 feet (25 meters) in length and for ships with non-aluminum hulls was banned in 1988 by the Organotin Anti-Fouling Paint Control Act (33 United States Code [USC] 2401-2410).

ORGANIC CONTAMINANTS IN SEDIMENTS AT THE LWI PROJECT SITES

Sediments at the LWI project sites contain trace concentrations (less than 1 microgram per kilogram [µg/kg] or approximately 200 µg/kg TOC) of di-n-butyltin and tri-n-butyltin (Table 3.1–3). There is no existing marine sediment quality standard for organotins; however, Meador et al. (2002) proposed a threshold value of 6,000 µg/kg TOC for tributyltin in sediments as being protective of juvenile salmonids. Concentrations in sediments near the project sites are well below this threshold.

Concentrations of individual polycyclic aromatic hydrocarbon (PAH) compounds in sediments near the project sites vary from not detected (ND) to 12.4 mg/kg TOC (Table 3.1–3). Concentrations of individual PAH compounds, as well as the summed concentrations (i.e., total low molecular weight polycyclic aromatic hydrocarbons [LPAHs] and total high molecular weight polycyclic aromatic hydrocarbons [HPAHs]) are below the corresponding marine sediment quality standards.

Concentrations of other classes of organic contaminants, such as chlorinated aromatics, phthalate esters, phenols, and other miscellaneous extractable compounds, typically are at or below the analytical detection limits and consistently below the marine sediment quality standards. Concentrations of organic contaminants in the north LWI and south LWI sediments are similar.

ORGANIC CONTAMINANTS IN SEDIMENTS AT THE SPE PROJECT SITE

Sediments at the SPE project site contain trace concentrations (less than 1 microgram per kilogram [µg/kg] or approximately 200 µg/kg TOC) of di-n-butyltin and tri-n-butyltin (Table 3.1–4) that are well below the threshold value (6,000 µg/kg TOC for tributyltin) considered protective of juvenile salmonids (Meador et al. 2002).

Concentrations of individual PAH compounds, as well as the summed concentrations (i.e., total LPAHs and total HPAHs), in sediments at the SPE project site are below the corresponding marine sediment quality standards.

Concentrations of other classes of organic contaminants, such as chlorinated aromatics, phthalate esters, phenols, and other miscellaneous extractable compounds, typically are at or below the analytical detection limits and consistently below the marine sediment quality standards.

3.1.1.2. CURRENT REQUIREMENTS AND PRACTICES

3.1.1.2.1. REGULATORY COMPLIANCE

HYDROGRAPHY

Section 10 of the Rivers and Harbors Act (33 USC 401 et seq.) requires authorization from U.S. Army Corps of Engineers (USACE) for development of any structure in or over navigable water of the United States, as well as the excavation/dredging or deposition of material in these waters, or alteration of navigable waters. Navigable waters of the U.S. are those subject to the ebb and flow of the tide shoreward to the mean high water mark and/or which have been used, are currently used, or may be used in the future for transporting interstate or foreign commerce. The term includes navigable coastal and inland waters, lakes, rivers, streams, and the territorial seas.

The Coastal Zone Management Act (CZMA) created a partnership of federal and state governments to reduce conflicts over land and water uses in the coastal zone, protect fragile coastal resources, and provide for economic development (15 Code of Federal Regulations [CFR], Chapter IX, Section 930.30 et seq.). To this end, the CZMA seeks a balance between preservation and economic development and promotes the sustainable use of the valuable resources of the nation's shoreline. The CZMA requires that federal actions that have reasonably foreseeable effects on coastal users or resources must be consistent to the maximum extent practicable with the enforceable policies of approved state coastal management programs. Activities and development impacting coastal resources that involve the federal government are evaluated through a process called federal consistency, in which the proponent agency is required to prepare a Coastal Consistency Determination (CCD) for concurrence from the affected state, in this case Washington.

WATER QUALITY

The Federal Water Pollution Control Act Amendments of 1972, as amended in 1977 and 2002, and commonly known as the Clean Water Act (CWA) (33 USC 1251), established the basic structure for regulating discharges of pollutants into waters of the U.S. The CWA contains the requirements to set water quality standards for all contaminants in surface waters. The USEPA is the designated regulatory authority to implement pollution control programs and other requirements of the CWA.

For Washington State, the responsibility for reviewing, establishing, and revising water quality standards has been delegated by the USEPA to WDOE. State water quality standards must be at least as stringent as the federal standards. As long as state standards meet this criterion, WDOE may modify the water quality standards to reflect site-specific conditions or adopt standards based on other scientifically defensible methods. WDOE also has responsibility for identifying impaired waters that do not meet applicable surface water quality standards. This list of impaired water bodies is referred to as the 303(d) list, referring to the section of the CWA that requires the development of a cleanup plan for those waters not meeting the standards. The current 303(d) list includes two segments impaired by low DO levels along the Bangor waterfront. Waters of Hood Canal immediately north of the NAVBASE Kitsap Bangor boundary are on the current 303(d) list for low DO concentrations (WDOE 2013b,c). No TMDL has been developed by WDOE for this area.

The state water quality standards are defined in the Washington State Water Pollution Control Act (Revised Code of Washington [RCW] 90.48) and implemented in WAC 173-201A.

With respect to water quality, CWA Section 401 (water quality certification) and Section 402 (National Pollutant Discharge Elimination System [NPDES] permits) are applicable to these projects, and Section 404 (discharge of dredged or fill material into waters of the U.S.) is applicable to the LWI project. The project proponent applies for permits under CWA sections 401 and 404, as well as Section 10 of the Rivers and Harbors Act, through the Joint Aquatic Resources Permit Application (JARPA) process. The proponent submits the JARPA to USACE who coordinates the overall approval process. WDOE is responsible for administering Section 401, while USACE is responsible for Section 404 and Section 10. The Section 401 Certification documents the WDOE determination that the action is consistent with state water quality standards and other water quality goals. WDOE sets water quality standards to maintain the overall desired water quality in Hood Canal (in this case extraordinary water quality).

The USEPA administers Section 402 at federal facilities such as NAVBASE Kitsap Bangor. Section 402 establishes the NPDES permit program to regulate point source discharges of pollutants into waters of the U.S. An NPDES permit sets specific discharge limits and conditions for point sources discharging pollutants into waters of the U.S. and establishes monitoring and reporting requirements.

The USEPA issued the NPDES General Permit for Storm Water Associated with Construction Activities (Construction General Permit) that provides permit coverage for federal construction site operators engaged in clearing, grading, and excavating activities that disturb one acre or more. Ecology's *Stormwater Management Manual for Western Washington* (WDOE 2012) provides technical guidance on measures to control the quantity and quality of stormwater runoff from development projects for compliance with CWA permit conditions.

NAVBASE Kitsap Bangor currently holds an USEPA-issued NPDES permit for stormwater discharges associated with industrial activity. The permit, titled *Multi-Sector General Permit for*

Stormwater Discharges Associated with Industrial Activity (MSGP), requires stormwater monitoring, inspections, training/awareness, documentation, reporting, and implementation of control measures (including Best Management Practices [BMPs]) to reduce and/or eliminate stormwater pollutant discharges. NAVBASE Kitsap Bangor staff regularly review changes in facility infrastructure and operations related to MSGP coverage. If a new facility conducts an industrial activity, it would be incorporated under existing MSGP coverage.

Section 438 of the Energy Independence and Security Act of 2007 (Public Law 110-140) requires federal development projects with a footprint exceeding 5,000 square feet (460 square meters) to "maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to temperature, rate, volume, and duration of flow." According to USEPA guidance on implementing Section 438 of the Act (USEPA 2009a), the intent of Section 438 is to "require federal agencies to develop and redevelop applicable facilities in a manner that maintains or restores stormwater runoff to the maximum extent technically feasible" and to "replicate the pre-development hydrology to protect and preserve both the water resources onsite and those downstream."

The USEPA and Department of Defense (DoD) jointly promulgated Phase I of Uniform National Discharge Standard program, 40 CFR Part 1700, on May 10, 1999 (64 Federal Register [FR] 25126). Phase I of the program concluded that 25 out of 39 liquid discharges from vessels of the Armed Forces would require pollution control. The USEPA and DoD have developed discharge marine pollution control device performance standards for 11 of the 25 discharges that were identified as requiring control, including Seawater Cooling Overboard Discharges. Discharges of non-contact cooling water are covered by the Uniform National Discharge Standard program, but discharge-specific requirements have not been promulgated to date. Once promulgated, these standards are expected to apply to cooling water discharges from submarines berthed at NAVBASE Kitsap Bangor. The performance discharge standards will closely mirror the USEPA's Vessel General Permit 2013 requirements.

The CZMA requires that federal permit activities having reasonably foreseeable effects on coastal water quality must be fully consistent with the enforceable policies of state coastal management programs. Section 3.1.2 addresses the potential for construction and operation of the proposed projects to significantly degrade water quality.

SEDIMENT QUALITY

The Washington State Sediment Management Standards (SMS) (WAC 173-204) provide the framework for long-term management of marine sediment quality in Washington State. The purpose of the SMS is to reduce and ultimately eliminate adverse biological impacts and threats to human health from sediment contamination. The SMS establishes standards for sediment quality as the basis for management and reduction of pollutant discharges by providing a management and decision-making process for contaminated sediments.

WAC 173-204-320 defines chemical concentration criteria for marine sediments. These chemical concentrations establish the marine sediment quality standards chemical criteria for designation of sediments. Per WAC 173-204-310, "sediments with chemical concentrations equal to or less than all the applicable chemical and human health criteria are designated as having no adverse effects on biological resources or posing a significant health threat to humans, and pass the applicable sediment quality standards of WAC 173-204-320 through 173-204-340, pending confirmatory designation."

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also commonly known as Superfund, was enacted to address hazardous waste sites. The law has subsequently been amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and is implemented by the National Oil and Hazardous Substances Contingency Plan. CERCLA is administered by the USEPA and provides for site identification and listing on the National Priorities List (NPL). CERCLA provides for state participation, and WDOE is the lead regulatory agency for contaminated sites on NAVBASE Kitsap Bangor. The Model Toxics Control Act (MTCA) is the state regulation (WAC 173-340) that addresses the identification, investigation, and cleanup of hazardous waste sites in Washington.

Sites on NAVBASE Kitsap Bangor have been listed on the NPL because of contamination associated with a number of hazardous waste sites at the base. Under Executive Order (EO) 12580, the U.S. Department of the Navy (Navy) is the lead agency for investigation and cleanup of contaminated sites on NAVBASE Kitsap Bangor. Investigations were conducted from 1988 to 1994 in Site 26, Hood Canal Sediments, which was part of Operable Unit (OU) 7. In January 1990, the Navy, USEPA, and WDOE entered into a Federal Facilities Agreement for the study and cleanup of possible contamination on NAVBASE Kitsap Bangor. As of 2005, all required actions have been completed for Site 26, and WDOE concurred that there was no increasing trend of contaminants of concern or evidence of groundwater transport of contaminants of concern from the Floral Point landfill to the marine environment, and additional sampling was not needed (Madakor 2005).

The CZMA requires that federal permit activities having reasonably foreseeable effects on coastal sediment quality must be fully consistent with the enforceable policies of state coastal management programs. Section 3.1.2 addresses the potential for the proposed projects to significantly degrade sediment quality, such as from stormwater discharges, spills, or physical perturbations that could affect the chemical or physical composition of bottom sediments in the project vicinity.

3.1.1.2.2. CONSULTATION AND PERMIT COMPLIANCE STATUS

Because the proposed projects would involve in-water construction work, the Navy would obtain a Rivers and Harbors Act Section 10 permit from USACE; submit a JARPA to USACE and other regulatory agencies, requesting permits under CWA Sections 401 and 402; and, in accordance with the CZMA, prepare and submit a CCD to WDOE.

3.1.1.2.3. BEST MANAGEMENT PRACTICES AND CURRENT PRACTICES

BMPs and current practices that would apply to the proposed projects include the following:

- The construction contractor would be required to prepare and implement a spill response plan (e.g., Spill Prevention, Control, and Countermeasure [SPCC] plan).

- The Navy would require the construction contractor to deploy debris barriers and oil absorbent booms around in-water and above-water construction sites as required by the Section 401 Water Quality Certification for protection of water quality.
- Debris would be prevented from entering the water during all demolition or new construction work. During in-water construction activities, floating booms would be deployed and maintained to collect and contain floatable materials. Any accidental release of equipment or materials would be immediately retrieved and removed from the water. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed previously. Retrieved debris would be disposed of at an upland disposal site.
- Removed creosote-treated piles and associated sediments (if any) would be contained on a barge or, if a barge is not utilized, stored in a containment area near the construction site. All creosote-treated material and associated sediments would be disposed of in a landfill that meets the liner and leachate standards of the WAC.
- Piles would be removed by cutting below the mudline and filling the resulting hole with clean sediment.
- Tugboat operations would be managed to avoid anchor drag and minimize suspension of bottom sediments from propeller wash.
- To prevent impacts to the seafloor and benthic community, barges and other construction vessels would not be allowed to run aground.
- BMPs would be implemented to control runoff and siltation and minimize impacts to surface water, per the *Stormwater Management Manual for Western Washington* (WDOE 2012).
- To reduce the likelihood of any petroleum products, chemicals, or other toxic or deleterious materials from entering the water, fuel hoses, oil or fuel transfer valves and fittings would be checked regularly for drips or leaks and maintained and stored properly to prevent spills from construction and pile driving equipment into state waters.
- The existing NAVBASE Kitsap Bangor fuel spill prevention and response plans (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) would apply to construction and operation of the proposed projects.

Stormwater discharges during project construction would be in accordance with the USEPA general construction stormwater discharge permit. Operation of the LWI and SPE would be in compliance with state water quality standards, including the MSGP. Construction and operation of the LWI and SPE projects would be in compliance with the Energy Independence and Security Act of 2007 with respect to maintenance of existing marine water quality.

3.1.2. Environmental Consequences

3.1.2.1. APPROACH TO ANALYSIS

The evaluations of environmental consequences to hydrography, water quality, and sediment quality assume that project construction and operation are in accordance with applicable regulations (Section 3.1.1.2.1) as well as permit conditions, BMPs, and current practices (Section 3.1.1.2.3).

3.1.2.1.1. HYDROGRAPHY

The evaluation of impacts on marine water resources and the natural hydrographic setting considers whether substantial changes would occur to the bathymetric setting (seafloor topography), tides, circulation and current patterns, or longshore sediment transport, either directly or indirectly, due to construction and operation of alternative configurations for the LWI and the SPE projects. A substantial change is defined as a degradation of the characteristics of Hood Canal in a manner that reduces or negates its overall value to the resources that naturally occur in the marine environment. Construction activities that physically alter the bathymetric profile of the area, substantially increase or decrease current velocities, or modify the tidal regime in the immediate area would be considered a direct impact on the hydrographic setting. Direct impacts are assessed by identifying the types and locations of construction activities and evaluating the extent of the disturbance. Indirect impacts could result from project-induced changes to the water column, seafloor, or shoreline following construction, from long-term planned uses or the physical presence of the LWI and/or SPE projects in the waterway. Results from modeling longshore sediment transport processes near NAVBASE Kitsap Bangor (cbec 2013) are used to evaluate the potential impacts on hydrographic processes from the project alternatives.

3.1.2.1.2. WATER QUALITY

The evaluation of impacts on marine water quality considers whether and to what extent project-related construction and operation activities would create conditions that violate state water quality standards or interfere with beneficial uses of the water body.

During construction of the in-water barriers, stormwater discharges would be in accordance with a NPDES Construction General Permit. A *Stormwater Pollution Prevention Plan* (SWPPP) would be developed, following USEPA's NPDES General Permit for Discharges from Construction Activities and guidance in WDOE's *Stormwater Management Manual for Western Washington* (WDOE 2012). The SWPPP would specify what BMPs would be implemented during construction to limit contaminant discharges to Hood Canal. The effects of construction and operation of the upland portions of the LWI structures on stormwater discharges are addressed in Section 3.7. During operation of the LWI and SPE facilities, stormwater discharges would be controlled by NAVBASE Kitsap Bangor's NPDES MSGP for industrial stormwater discharges and the NAVBASE Kitsap Bangor industrial activity SWPPP (USEPA 2008; Navy 2009a).

3.1.2.1.3. SEDIMENT QUALITY

The evaluation of impacts on marine sediments considers whether project-related construction and operation activities would create conditions, such as sediment contaminant concentrations or physical changes, that exceed marine sediment quality standards or interfere with beneficial uses of the water body. Measures to minimize potential impacts on sediment quality would be the same as those to minimize impacts on water quality and include BMPs and current practices identified in Section 3.1.1.2.3.

3.1.2.2. LWI PROJECT ALTERNATIVES

3.1.2.2.1. LWI ALTERNATIVE 1: NO ACTION

The LWI would not be built under the No Action Alternative and overall operations would not change from current levels. Therefore, existing hydrography, water quality, and sediment quality would not be impacted under the LWI No Action Alternative.

3.1.2.2.2. LWI ALTERNATIVE 2: PILE-SUPPORTED PIER

HYDROGRAPHY FOR LWI ALTERNATIVE 2

CONSTRUCTION OF LWI ALTERNATIVE 2

Construction of LWI Alternative 2 would involve installing the LWI pier and temporary trestle structures, including piles and the underwater portion of a mesh and steel plate anchor, construction of a temporary pile-supported trestle, relocation of existing PSB sections and associated mooring anchors, and construction of shoreline abutments and observation posts within intertidal and subtidal areas of the project sites. Construction is expected to require one barge with a crane, one supply barge, a tugboat, and work skiffs. Pier piles and vessel hulls can alter current flow and wave patterns in a manner that reduces turbulence, and work vessels can generate wakes and propeller wash that induce or increase turbulence in localized portions of the water column and at the seafloor. Pile driving, PSB mooring anchor removal and placement, propeller wash and vessel movement, anchor and spud deployment, and abutment construction could disturb bottom sediments. Measures would be implemented to prevent underwater anchor drag and line drag, and barges and workboats would be prohibited from grounding to minimize the potential for sediment disturbances (Section 3.1.1.2.3). Using the design footprints of the piers, along with an approximately 100-foot (30-meter) wide construction corridor (Section 2.3.2.1), the area of seafloor potentially disturbed by LWI construction activities is 13.1 acres (5.3 hectares); the actual area disturbed is expected to be considerably less.

Bathymetric Setting

Construction of the LWI shoreline abutments would require excavation below the mean higher high water (MHHW) of approximately 4,000 square feet [372 square meters] and up to 500 cubic yards [382 cubic meters] for each abutment. Abutment work would be conducted at low tide and therefore “in the dry.” Following installation, the beach in front of the abutments would be re-contoured to pre-construction conditions. However, the abutment stair landings would lie below the MHHW line. With the exception of the footprints for the stair landings (12 square feet [2 square meters]) for each north and south LWI, construction of the abutments would not alter bathymetric conditions in the long term. Construction of the observation posts would be from land during low tide and would not affect bathymetric conditions.

LWI construction would also require placement of steel plate anchors for the mesh, removal and placement of PSB mooring anchors, as well as temporary anchors and spuds for work vessels on the seafloor. Localized mounding or trenching would occur within the 100-foot (30-meter) wide construction corridors as a result of anchor and spud placement, mooring ground tackle, and vessel propeller wash. Barge grounding would be prohibited and, therefore, would not contribute to changes in bathymetry. Some localized mounding and depressions would result from installation and removal of piles for the temporary trestle. These small-scale bathymetric features would not be expected to exceed 3 feet (1 meter) in displacement and would likely be temporary because natural processes that occur at the sediment-water interface (bedload transport, bioturbation [mixing of surface sediment by benthic infaunal organisms], etc.), particularly during storm events, would reshape the seabed to the surrounding environment. The seafloor topography would return to near the original profile over a period of approximately 6 to 12 months without intervention or mitigation. Although some displacement and redistribution of in-place sediments is anticipated, no substantial changes to bathymetry would occur.

Circulation and Currents

Circulation patterns in the surface layer (upper 10 to 15 feet [3 to 5 meters] of water) over the project area would be subject to minor, short-term changes in the direction and intensity of flow over periods of hours due to the presence of construction equipment and barges. However, overall circulation patterns, current velocities, and water levels along the Bangor waterfront would be relatively unaffected because currents and water circulation patterns are driven by tides, which would not be impacted by the presence of construction equipment or barges. Similarly, because the LWI piers, temporary trestle structure, and observation posts would be constructed on foundations of piles, water flow would not be impeded at the project sites. Thus, in-water construction activities would cause only minor, localized, and temporary (i.e., for the duration of in-water construction activities) changes to circulation and currents.

Longshore Sediment Transport

The presence of in-water construction equipment would have a negligible effect on the frequency or magnitude of conditions responsible for longshore sediment transport. This is because the spatial scale of wave dampening from vessels and barges would be small relative to the size of the drift cell.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

The submerged portions of the LWI piers (i.e., support piles, mesh, and mesh anchor) constructed for LWI Alternative 2 would alter current and wave patterns in the immediate vicinity of the structures. The metal plates that would be used to anchor the mesh to the seafloor would have a minimal vertical profile (i.e., thickness of the metal plates) and, therefore, would not be expected to alter current or wave patterns. Minor restrictions in water flow, due to the presence of fouling materials on the mesh, would not affect tides and circulation patterns in the project area because the LWI structures would allow water exchange with adjacent areas of Hood Canal. The LWI abutment stair landings and some of the observation post piles would lie below the MHHW line. However, the base of these structures would be submerged infrequently, and they would not restrict water flow or otherwise affect hydrological conditions at the project site except on a very localized basis (i.e., within meters of the structures).

Bathymetric Setting

Support piles installed for the LWI piers would alter current flows and wave propagation locally, which would cause localized erosion of fine-grained sediments near the base of some piles and settling and accumulation of fine-grained sediments at the base of others (Chiew and Melville

1987). Such bathymetric changes would not exceed 3 feet (1 meter). The metal plates that would be used to anchor the mesh to the seafloor would not be expected to alter the bathymetry because they would have a minimal vertical profile and, therefore, would not promote sediment deposition and accumulation. The operational effects of these structures on longshore sediment transport are discussed below. The lower portion of the abutment stair landings and observation post piles would lie just below MHHW and consequently would be inundated infrequently and for brief periods. The resulting potential for erosion or mounding would be highly localized (within meters of the structures) and minor, not exceeding 1 foot (0.3 meter) vertically.

Circulation and Currents

The overall flow volume of water adjacent to the project site would not be affected by the presence of the LWI structures. However, it is anticipated that flow patterns in the immediate vicinity of the LWI piles would become turbulent locally as the water mass driven by tidal currents moves between and around the piles, especially during periods of peak flow. Turbulence in the water column would be a function of small-scale increases in the instantaneous velocity of water flow between the individual pile structures relative to the remainder of the water column. This occurs when the pressure exerted by a moving water body forces the flow around obstructions or into channels between the piles (Potter and Wiggert 1991). The result would be a decrease in water column current velocities downcurrent of the barriers, but an overall increase in turbulence and mixing in the water mass passing directly under the structures. Turbulence in the water column can be beneficial to water quality through the deflection of linear flow downward and laterally, promoting increased mixing between water layers. Along the seafloor, turbulent flow at the pier piles could cause some erosion of fine-grained material, resulting in a coarsening of surficial sediments and thin scouring around each pile (Chiew and Melville 1987; Sumer et al. 2001).

The underwater portion of the mesh could retain drift algae and/or floating debris that would partially restrict water flow through the structure and result in some small-scale changes in flow. Similarly, biofouling of the mesh also would partially restrict water flow at the structure. Routine inspections and maintenance would reduce the magnitude of any long-term effects associated with fouling on water flow through the structure. Minor restrictions in water flow, due to the presence of fouling materials on the mesh structure, would not affect circulation patterns in the project area because the structures would allow water exchange with adjacent areas of Hood Canal. Maintenance of the LWI structures, consisting of routine inspections, repair, and replacement of facility components as required, would not affect hydrographic conditions.

The LWI structures would not affect the tidal range along the NAVBASE Kitsap Bangor shoreline or immediate project area because the LWI piers and observation posts would be constructed on a foundation of piles that would allow water exchange between the inside and outside of the barriers. The flow of water as driven by tidal currents could be slightly impeded in the immediate vicinity of the structures due to the presence of the piles and mesh structure, but this would not affect tidal processes or tidal elevations in the project area.

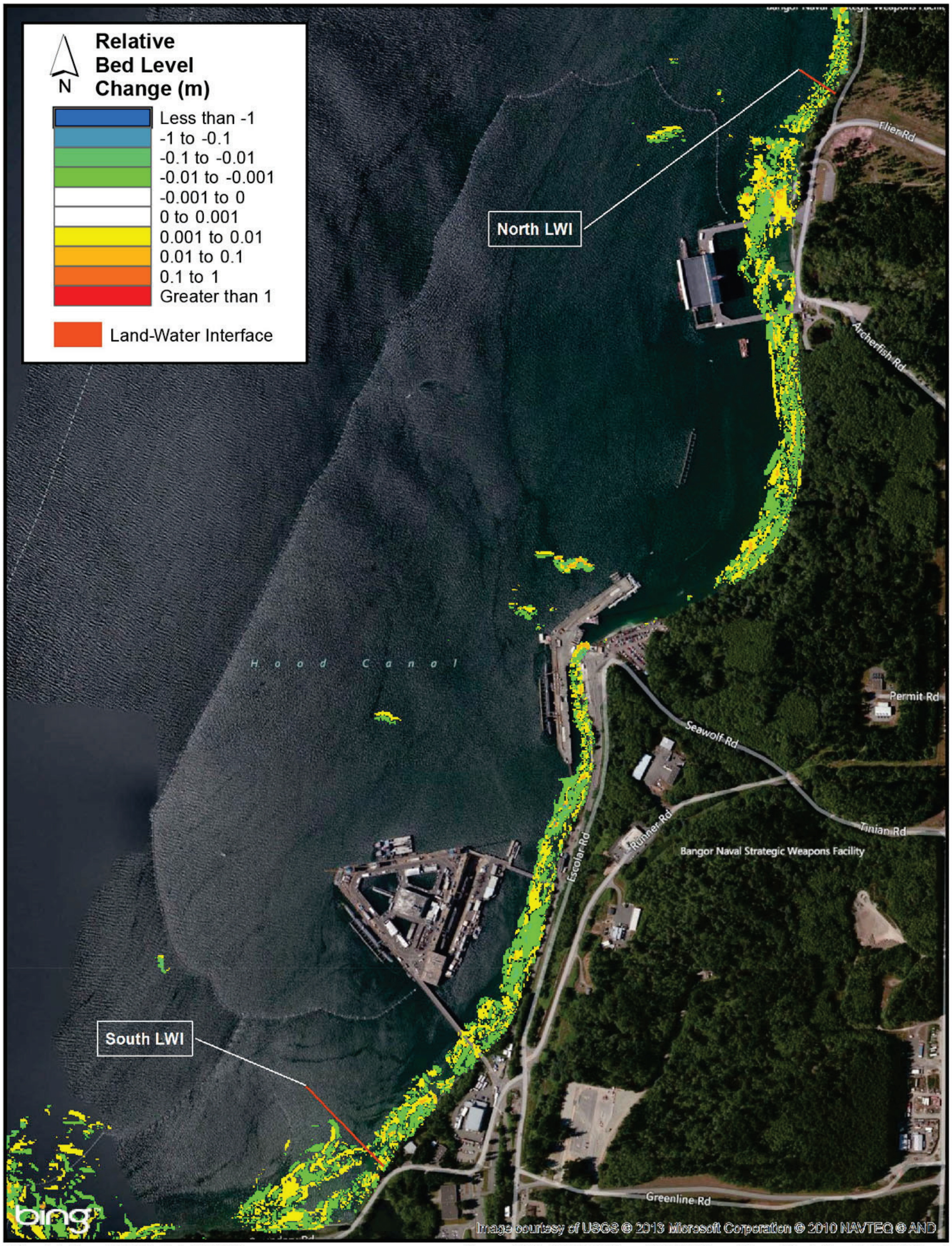
Longshore Sediment Transport

The piles and mesh associated with the LWI structures would attenuate some of the energy of surface waves and currents associated with storm events approaching the project sites from the north and south. This reduction in wave energy in areas shoreward of the barriers would reduce the frequency and magnitude of sediment resuspension events and promote conditions more conducive to long-term deposition of sediments and accumulation of fine-grained sediment in the form of a shoal area or comparatively broader intertidal area (Kelty and Bliven 2003).

As discussed in Section 3.1.1.1, Hood Canal is characterized as a low-energy environment, and longshore sediment transport rates are low. The pile-supported LWI structures could have a minor effect on the magnitude of storm-related wave events that have sufficient energy to resuspend bottom sediments in the immediate, nearshore areas of the project site. However, the structures are not expected to result in substantial, long-term reductions in the longshore sediment transport rates for the drift cell that includes the Bangor waterfront.

The effects of the LWI pile-supported pier structures on sediment transport along the Bangor waterfront were evaluated by cbec (2013). Results from hydrodynamic modeling indicated that the presence of the proposed north and south LWI structures would cause only marginal changes in current velocities. For both 2-year and 50-year storm event scenarios, average changes in seabed elevations from the LWI pile-supported pier structures would range from -0.28 to -0.16 inch (-7 to -4 millimeters), which is similar to the average change in the seabed elevation of -0.24 inch (-6 millimeters) under existing conditions (i.e., without LWI structures). Relative changes in sedimentation patterns between existing conditions (no LWI structures) and project conditions (with the north and south LWI structures) for the 50-year storm event are shown on Figure 3.1–22. Net changes in the sedimentation patterns under less severe, 2-year storm events would be relatively smaller. Based on these results, operation of the LWI would not be expected to cause appreciable erosion or deposition of sediments within the project area.

The bathymetry at the location of the south LWI site reflects sediment inputs from Devil's Hole, the influence of Carlson Spit and KB Point on wave and current energy, and sediment accumulation in the adjacent nearshore area of Hood Canal between KB Point and Delta Pier. During periods with low storm activity, reductions in wave and current energy near the south LWI structure could promote comparatively greater deposition of sediments within the delta area that occurs north of KB Point and offshore from Devil's Hole. Over time, the area of the deltaic formation may expand and increase the overall area of the intertidal zone. The south LWI structure would not prevent the longshore sediment transport from this location, but it could reduce the annual sediment load slightly until equilibrium conditions are achieved. Once equilibrium is reached, there would be no long-term impediment to littoral transport along the shoreline and no significant reduction in sediment supplies to adjacent areas of the Bangor shoreline.



Author: John Evans | SAIC | Date: 7/10/2013 Document Path: C:\GISPJ13\Bangor LWI\SAIC Figures\50 year Flood - Scenario 5 LWI BLC.mxd

Source: cbec 2013

Figure 3.1–22. Model-Predicted Changes in Relative Seabed Elevations with Installation of the North and South LWI Structures under a 50-Year Storm Scenario

The abutment and stairs constructed at the south LWI project site would armor a small (approximately 85 feet [26 meters]) section of the existing, largely unarmored, shoreline. The observation post would be supported on seven piles located in the upper intertidal zone. The abutment and observation post piles would be exposed to wave run-up only during extreme high tides. This impact on sediment supplies to the drift cells associated with the south LWI project site or drift cells to the north of the site would be inconsequential because infrequent, short, and highly localized interactions would not interfere with alongshore currents or sediment transport processes.

While the project would replace the natural shoreline with a cement structure, the size of this structure would be small in comparison to the overall length of unarmored shoreline in the area, and the effect on the shoreline would be minimal. This conclusion is consistent with results from previous studies (Golder Associates 2010) indicating that the shoreline in the vicinity of the south LWI project site is fairly stable as a result of the relatively sheltered environment and relatively low net longshore transport rates.

The north LWI site is located near the middle of the drift cell (Drift Cell DC-18 in Judd 2010), which probably functions as the sediment transport region of the drift cell. The presence of piles and underwater mesh structures at the north LWI would likely promote deposition and accretion of finer-grained sediments transported by the alongshore currents. Some of the sediment accumulation would be seasonal, as storm waves would resuspend and redistribute sediments that were deposited initially near the structures. Because the north LWI structure would be shorter than the south LWI, sediment accumulation at the north LWI would be comparatively smaller, and it is not expected to appreciably reduce the alongshore sediment supply or result in erosion of the shoreline in areas north of the boundary.

Similar to the south LWI site, the abutment and stairs constructed at the north LWI project site would armor a 75-foot (23-meter) section of the existing shoreline. Construction and operation of the north LWI abutment would not substantially affect sediment supplies to the drift cells associated with the north LWI project site or drift cells to the north of the site because the amount of shoreline armoring associated with the abutment would be minimal. The observation post would be supported on seven piles located in the upper intertidal zone. Because the abutment and observation post piles would not substantially alter sediment supply rates within the drift cell, they would have minimal effects on nearshore sediment supply and transport processes.

Therefore, while operation of the pile-supported pier structures for LWI Alternative 2 may retain some sediments, it is not expected to significantly interrupt longshore sediment transport processes or result in erosion of the shoreline within or adjacent to NAVBASE Kitsap Bangor. This conclusion is supported by the Golder Associates (2010) study findings that the presence of other Navy structures along the NAVBASE Kitsap Bangor shoreline has not caused appreciable changes in the morphology of the shoreline.

WATER QUALITY FOR LWI ALTERNATIVE 2

CONSTRUCTION OF LWI ALTERNATIVE 2

Construction of LWI Alternative 2 would involve installing the LWI pier and temporary trestle structures, including permanent piles and the underwater portion of a mesh and steel plate anchor, requiring use of barges, work vessels, and cranes; construction of a temporary pile-supported trestle; and construction of shoreline abutment stair landings within intertidal and subtidal areas of the project sites. This alternative would also construct observation posts at the north and south LWI locations. However, these structures would be constructed in the dry, so construction activities associated with these structures would have no effect on marine water quality.

Direct discharges of waste, other than stormwater runoff, to the marine environment would not occur during construction. BMPs and current practices (Section 3.1.1.2.3) applicable to construction of LWI Alternative 2 would include preparation and implementation of debris management procedures for retrieving and cleaning up any accidental spills. The contractor would also prepare and implement a spill response plan (e.g., SPCC) to clean up any fuel or fluid spills. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups.

Construction-related impacts on water quality would be limited to short-term and localized changes associated with resuspension of bottom sediments from pile installation, other in-water construction activities, barge and tug operations such as anchoring and propeller wash, as well as accidental losses or spills of construction debris into Hood Canal. These changes would be spatially limited to the construction corridor, including areas potentially impacted by anchor drag and areas immediately adjacent to the corridor (i.e., up to approximately 50 feet [15 meters] from the edge of the LWI and temporary trestle structures) that could be impacted by plumes of resuspended bottom sediments.

Stratification, Salinity, and Temperature

Construction of LWI Alternative 2 would not impact water temperature or salinity because construction activities would not discharge wastewaters other than stormwater runoff, in accordance with the SWPPP. Since no project-related discharges are anticipated, construction of the LWI would not alter stratification, salinity, or temperature in Hood Canal.

Dissolved Oxygen

Construction of LWI Alternative 2 would not discharge any wastes containing materials with an oxygen demand into Hood Canal. However, pile installation would temporarily resuspend bottom sediments, which may contain small amounts of chemically-reduced organic materials. Subsequent oxidation of sulfides, reduced iron, and organic matter associated with the suspended sediments would consume some DO in the water column. The amount of oxygen consumed would depend on the magnitude of the oxygen demand associated with suspended sediments (Jabusch et al. 2008). The organic carbon content of sediments at the LWI project sites is low (0.16 to 0.56 percent), and total sulfides concentrations are non-detectable to 259 mg/kg (Table 3.1–3). Thus, the oxygen demand of sediments resuspended during LWI construction activities also would be low, and resulting changes to DO concentrations in the water column would be minimal due to rapid mixing and dispersion of particles and low oxygen demand.

A bubble curtain would be used to reduce in-water noise levels generated during pile driving (Section 2.3.3), although the exact type of bubble curtain that would be used has not yet been specified by the Navy. Type I (unconfined) bubble curtains use pressurized air injected from small holes in aluminum or PVC (polyvinyl chloride) pipe from an air compressor located on the pile driving barge. Type II (confined) bubble curtains keep the bubbles "inside" a jacket (usually rigid or fabric). While the primary purpose of employing a bubble curtain would be to reduce in-water noise levels, a Type I bubble curtain would also increase DO concentrations in marine waters at the project site by (1) increasing the rate of vertical mixing of site waters and (2) promoting dissolution of air bubbles, thereby increasing oxygen saturation levels. The effect on DO concentrations from use of a Type I bubble curtain would be greater than that associated with sediment resuspension, and a net increase in DO levels would be expected. Use of a Type II confined bubble curtain would not aerate the water column and thus would not increase DO concentrations in project site waters.

Stormwater discharges would be addressed by a construction stormwater discharge permit and SWPPP. Consequently, stormwater discharges are not expected to alter DO concentrations at the project site. Construction activities would not result in decreases in DO concentrations, cause changes that would violate water quality standards, or exacerbate low DO concentrations that occur seasonally within portions of Hood Canal.

Turbidity

Installation of pier piles and mesh anchors, and other in-water construction activities for LWI Alternative 2, would resuspend bottom sediments within the immediate construction area, resulting in short-term and localized increases in suspended sediment concentrations that in turn would cause increases in turbidity levels. Suspended sediment/turbidity plumes associated with in-water construction activities would be generated intermittently during construction.

The amount of bottom sediments that would be resuspended into the water column, and the duration and spatial extent of the resulting suspended sediment/turbidity plume, would reflect the composition of the sediments and the source of the disturbance. Surface sediments at the project site are primarily coarse-grained, ranging from 88 to 97 percent sand and gravel (Hammermeister and Hafner 2009; see Table 3.1–3). In general, the coarse-grained sediments that occur in most areas of the project site are more resistant to resuspension and have a faster settling speed than fine-grained sediments. Higher settling rates would result in a shorter water column residence time and a smaller horizontal displacement by local currents (Herbich and Brahme 1991; LaSalle et al. 1991; Herbich 2000).

As noted for DO, a bubble curtain would be used to reduce in-water noise levels generated during pile driving, although the type of bubble curtain that could be used has not been specified by the Navy. With a Type I (unconfined) bubble curtain, the bottom ring is located on the soil/substrate/overburden, and it is likely that bubbling action would increase turbidity in the vicinity. Because the Type II (confined) bubble curtain keeps the bubbles "inside" a jacket (usually rigid or fabric), the majority of suspended sediments would be likewise confined within the curtain. After the pile is driven and the curtain removed, there would still be some residual plume, although less than with an unconfined bubble curtain.

Construction activities associated with LWI Alternative 2 would primarily occur in water depths up to approximately 15 feet (5 meters) MLLW, with some PSB reconfiguration occurring in deeper waters. Assuming conservative conditions that bottom sediments are disturbed during construction and resuspended to the surface (15 feet [5 meters] above the seafloor), the maximum water column residence time for sand-size particles would be approximately 50 seconds, assuming a particle settling rate of approximately 0.3 foot/second (9 centimeters per second). The water column residence time for suspended particles would be proportionately shorter in shallower portions of the construction area and/or instances where the turbidity plumes do not extend to the water surface. With a current velocity of 1 foot/second (30 centimeters per second), the maximum dispersion distance would be approximately 50 feet (15 meters). That is, it would take 50 seconds for a sand particle to settle 15 feet (5 meters) through the water column, at which time the horizontal transport rate of the particle would be 1 foot/second (30 centimeters per second]) with a resulting horizontal displacement of 50 feet (15 meters). Silt and clay particles resuspended during construction activities could have relatively longer water column residence times because they have slower settling speeds. However, fine-grained particles typically contribute less than 20 percent of bottom sediments within the project area. Also, resuspended, fine-grained sediments would be subject to rapid dilution by currents and eventual flushing during subsequent tidal exchanges (Morris et al. 2008). Therefore, the duration and spatial extent of turbidity plumes generated by in-water construction activities would be minimal.

Per WAC 173-201A-210, "[t]he turbidity criteria established under WAC 173-201A-210 (1)(e) shall be modified, without specific written authorization from the department, to allow a temporary area of mixing during and immediately after necessary in-water construction activities that result in the disturbance of in-place sediments. This temporary area of mixing is subject to the constraints of WAC 173-201A-400 (4) and (6) and can occur only after the activity has received all other necessary local and state permits and approvals, and after the implementation of appropriate best management practices to avoid or minimize disturbance of in-place sediments and exceedances of the turbidity criteria. A temporary area of mixing shall be as follows:

> "D. For projects working within or along lakes, ponds, wetlands, estuaries, marine waters or other nonflowing waters, the point of compliance shall be at a radius of one hundred fifty feet from the activity causing the turbidity exceedance."

Per the discussion above regarding the settling time for resuspended particles, turbidity conditions are not expected to increase by more than 5 NTU above background at the point of compliance, 150 feet (45 meters) from the disturbance. Within the intertidal portions of the LWI alignments, in-water construction activities with the potential for generating turbidity conditions would be discontinuous and intermittent. Any turbidity resulting from sediment resuspension would be minimal due to rapid mixing and dispersion of particles.

Empirical information demonstrating compliance with the water quality criterion for turbidity during in-water construction projects similar to those of LWI Alternative 2 is unavailable. However, turbidity measurements were performed as part of a water quality monitoring program conducted in association with a project at Jimmycomelately Creek that removed creosote-treated wood piles at a former log storage facility in Lower Sequim Bay (Weston Solutions 2006). Monitoring results indicated substantial sediment resuspension associated with prop wash from the tug, whereas activation of the vibratory hammer and removal of piles and dolphins resulted in only localized increases in turbidity levels that were less than 5 NTU above background. In comparison, turbidity levels associated with pile placement activities for LWI Alternative 2 would be lower because sediments at the LWI project site are coarser than those at the Jimmycomelately Creek site and pile placement would create less of a disturbance to bottom sediments than pile pulling. Thus, by extension, turbidity levels associated with in-water construction for LWI Alternative 2 would not be expected to exceed the water quality criterion.

Construction of the observation posts and abutments at the north and south LWI sites would disturb sediments in the upper intertidal zone. However, construction work would only occur "in the dry" during low tides. Thus, construction of the observation posts and abutments would not contribute to increased turbidity levels. For other project-related construction activities, such as spud use and barge anchoring, fine-grained particles resuspended from the bottom would disperse rapidly as a result of particle settling and current mixing. Propeller wash impacts could occur in shallow waters, although current practices would be employed to prevent or minimize these effects.

Stormwater discharges would be in accordance with a stormwater discharge permit and SWPPP, which would minimize the potential for discharges to affect turbidity levels at the project site.

Consequently, construction activities would not result in persistent increases in turbidity levels or cause changes that would violate water quality standards because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and processes that generate suspended sediments and increase turbidity levels would be short-term and localized and suspended sediments would disperse and/or settle rapidly (within a period of minutes to hours) after construction activities cease.

Nutrients

Construction activities associated with LWI Alternative 2 would not result in the discharge of wastes containing nutrients. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, construction activities would not result in increases in nutrient levels or cause changes that would violate water quality standards. Because sediments at the project site do not contain high concentrations of nutrients, such as ammonia (Hammermeister and Hafner 2009), sediment resuspension during in-water construction activities would not release nutrients to site waters in amounts that would violate water quality standards.

Fecal Coliform Bacteria

Construction activities associated with LWI Alternative 2 would not impact bacteria (fecal indicator bacteria) levels because this alternative would not discharge untreated wastes or other materials containing bacteria. Stormwater discharges would be controlled in accordance with a stormwater discharge permit and SWPPP. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, construction activities would not result in increases in bacteria levels or cause changes that would violate water quality standards. Coliform bacteria levels in the Hood Canal waters near the project site generally are low and within the shellfish harvesting and recreation standard for fecal coliform. Consequently, bacterial levels in coarse-grained marine sediments at the project site also are expected to be low, and resuspension of sediments during construction activities would not release bacteria to site waters in amounts that would violate water quality standards.

pH

Construction activities associated with LWI Alternative 2 would not impact the pH levels of local waters because this alternative would not discharge pH-affecting wastes at the project site. There is a potential for cement spillage that could affect pH; however, measures to prevent losses and cleanup of spills would be addressed by debris management procedures. Also, seawater has a high buffering capacity that minimizes the potential for substantial changes in pH in well-mixed marine settings such as the project sites (Jabusch et al. 2008). Stormwater discharges would be controlled in accordance with a stormwater discharge permit and SWPPP. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and spill-related releases would be controlled by debris management procedures (Section 3.1.1.2.3), construction activities would not result in changes in pH that would violate water quality standards.

Other Contaminants

Accidental spills of debris, fuel, or other contaminants from barges or construction platforms into Hood Canal represent a possible source of construction-related impacts on water quality. Some types of construction debris inadvertently lost into the water would be recovered, as specified in the debris management procedures, and would have no impact, while other materials such as hydraulic fluids or fuel (marine diesel) may impact turbidity, pH, DO, or other water quality parameters in a localized area. Typically, spills are prevented by a number of measures, including containing and cleaning up materials leaked on the deck of work vessels, prohibiting washdown of materials into the water, and prohibiting refueling in non-authorized areas. Generally, these types of spills are not anticipated to have a large impact on water quality because the spills would likely be small and the impact would be highly localized. The size of the area affected would depend on a number of factors, such as the volume spilled, wind, wave, and current conditions at the time of the spill, and the timing and effectiveness of the response effort. The existing facility response and prevention plans for the Bangor waterfront (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) provide guidance that would be used in a spill response, such as a response procedures, notification, and communication plan; roles and responsibilities; and response equipment inventories. In the event of an accidental spill, response measures would be implemented immediately to minimize potential impacts on the surrounding environment.

The Navy would require the construction contractor to prepare and implement debris management procedures for preventing discharge of debris to marine water and retrieving and cleaning up any debris spilled into Hood Canal (Section 3.1.1.2.3). Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups. With implementation of the existing facility response and prevention plans for the Bangor waterfront and the debris management procedures, construction activities associated with LWI Alternative 2 would not be expected to release contaminants or otherwise cause any water quality standards to be violated.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

Operation of LWI Alternative 2 would not result in discharges of wastes to Hood Canal. The project would be operated in accordance with the NPDES permit and implement stormwater BMPs. Stormwater runoff from the LWI structures would not require treatment and could discharge directly into Hood Canal since the structure surfaces are expected to consist largely of inert materials and would not represent a source of substantial pollutant loadings to Hood Canal. Similarly, because there would be no vehicular traffic associated with the LWIs there would be no requirement to collect and treat runoff from the LWI structures, and drainage would be to Hood Canal. Some of the materials used for the LWI pier structures and observation posts would be galvanized metal, which could leach zinc, and thereby contribute to zinc loading to Hood Canal (WDOE 2008a). However, this is not expected to affect water quality at the project site because most surfaces would consist of inert materials, so the magnitude of the zinc input from galvanized metals used in the LWI structure would be minimal. The in-water mesh would not be composed of materials that would have the potential to degrade water quality at the project sites.

Stratification, Salinity, and Temperature

Operation of the LWI Alternative 2 would not result in any discharges into local waters. Also, the LWI structures would not interfere with tides, currents, or other natural processes that are responsible for mixing Hood Canal waters. Therefore, operations would not result in impacts on stratification, salinity, or temperature conditions or cause changes that would violate water quality standards.

Dissolved Oxygen

Periodic cleaning of the in-water mesh and PSB guard panels would release organic material into the water and subsequent decomposition of this material would result in localized increases in oxygen demand. However, these materials would be dispersed by waves and currents so effects on DO would be transient and inconsequential. Therefore, no general or widespread effects on DO levels at the Bangor waterfront are expected. Otherwise, operation of the LWI would not result in discharges with the potential for altering DO concentrations in waters near the project site. Also, these structures would not interfere with tides, currents, or other natural processes that are responsible for mixing Hood Canal waters. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, operations would not result in impacts on DO conditions or cause changes that would violate water quality standards.

Turbidity

Because the LWI Alternative 2 would not result in any discharges, other than stormwater that would be discharged in accordance with permit conditions, or resuspend bottom sediments, operations would not result in changes to turbidity levels that would violate water quality standards. Periodic cleaning of the submerged portions of the in-water mesh and PSB guard panels would release particulate material into the water that would increase turbidity levels locally. However, these materials would be dispersed by waves and currents so effects on water clarity would be transient and inconsequential.

Nutrients

Operation of the LWI Alternative 2 would not result in any discharges, other than stormwater that would be discharged in accordance with permit conditions, or alter site conditions. The LWI pier structures would provide roosting sites for marine birds, which would produce droppings (bacterial input) and associated nutrient loading to Hood Canal. However, nutrients would be rapidly mixed and dispersed by currents, and the magnitude of this input source would not cause eutrophication. Therefore, operations would not result in impacts on nutrient levels or cause changes that would violate water quality standards.

Fecal Coliform Bacteria

Operation of the LWI Alternative 2 would not affect fecal coliform bacteria levels in marine waters at the project site because the project would not result in any discharges or alter site conditions in a manner that would release bacteria to local waters. Birds roosting on the LWI pier structures would contribute to bacterial input, but this would be rapidly mixed and dispersed by currents. Because the existing PSBs and other in-water structures provide similar roosting sites, this alternative would not represent a new or substantial source for bacterial input from wildlife. Therefore, operations would not result in impacts on bacteria levels or cause changes that would violate water quality standards.

pH

Operation of the LWI Alternative 2 would not create discharges that have the potential to impact the pH of marine waters. Therefore, operations would not result in impacts on pH levels or cause changes that would violate water quality standards.

Other Contaminants

Spills of fuel, explosives, cleaning solvents, and other contaminants could impact water quality in Hood Canal. However, operation of LWI Alternative 2 would not increase the risk of accidental spills because, other than minor, small boat operations, project operations would not require use of explosives, solvents, or other contaminants. The existing NAVBASE Kitsap Bangor fuel spill prevention and response plans (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) would help minimize the risk of fuel spills from small boat operations. In the event of an accidental spill, emergency cleanup measures would be implemented immediately in accordance with state and federal regulations. The cleanup would minimize impacts on the surrounding environment.

Placement of aluminum anodes (for cathodic protection) on pier and observation post piles would represent a source for inputs of aluminum to Hood Canal waters. Aluminum anodes typically contain approximately 95 percent aluminum, 5 percent zinc, up to 0.001 percent mercury, and small amounts of silicon and iridium (USEPA 1999). As the anode is consumed (oxidized), aluminum and other trace constituents are released to surrounding waters. Based on modeling performed by USEPA (1999), the estimated flux of aluminum from an anode is 2.2×10^{-6} pounds (1 milligram) of aluminum per pound of anode per hour. USEPA (1999) concluded that the resulting concentrations in seawater would be well below the Federal and the most stringent state water quality criteria. Consequently, metal leaching from aluminum anodes placed on the LWI piles is not expected to impact water quality in the project area.

With implementation of the existing facility response and prevention plans for the Bangor waterfront, LWI Alternative 2 operations would not be expected to release other contaminants or otherwise cause any water quality standards to be violated.

SEDIMENT QUALITY FOR LWI ALTERNATIVE 2

CONSTRUCTION OF LWI ALTERNATIVE 2

Construction of LWI Alternative 2 would entail pile installation for the pier structure and temporary trestle structure, as well as excavation of shoreline sediments for abutment construction, but no dredging, trenching, or dredged material disposal would be required. There would be no direct discharges of wastes, other than stormwater runoff, to the marine environment during construction that would affect sediment quality. Setting spuds and anchors for the barges, and propeller wash from tugs used to construct the facilities would represent other, construction-related sources for disturbance of bottom sediments. Current practices (Section 3.1.1.2.3) would be implemented to prevent underwater anchor drag and line drag. Therefore, construction-related impacts on sediment quality would be limited to localized changes associated with physical disturbances of bottom sediments and from accidental losses or spills of construction debris into Hood Canal.

Another possible source for construction-related impacts on sediments would be from accidental debris spills from barges or construction platforms into Hood Canal or releases of cement from construction of underwater footings. Debris spills and/or cement releases could impact bottom sediments and create nuisance conditions by adding materials that could represent obstructions. The construction contractor would be required to retrieve and clean up any accidental spills in accordance with the existing NAVBASE Kitsap Bangor fuel spill prevention and response plans and as a current practice in accordance with the debris management procedures that would be developed and implemented (Section 3.1.1.2.3). Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups.

Construction-related changes to sediment quality would be spatially limited to the construction corridor including areas potentially impacted by anchor drag.

Physical Properties of Sediments

Some degree of localized changes in sediment composition would occur as a result of in-water construction activities. Sediments that are resuspended by pile installation and anchoring activities would be dispersed by currents and eventually redeposited on the bottom (Barnard 1978; Hitchcock et al. 1999). Depending on the distance suspended sediments are transported before settling, this process could result in minor changes to sediment texture (i.e., grain-size characteristics), particularly if coarse-grained sediments are transported from shallow to deeper portions of the project site or fine-grained sediments are transported from deeper to shallower areas. The distance over which suspended sediments are dispersed would depend on a number of factors, such as the sediment characteristics, particle settling rates, and current speeds.

Surface sediments at the LWI project sites are primarily coarse-grained, ranging from 88 to 97 percent sand and gravel (Hammermeister and Hafner 2009) (Section 3.1.1.1.3). In general, the coarse-grained sediments are more resistant to resuspension and have a faster settling speed than fine-grained sediments. Higher settling rates would result in a shorter water column residence time and a smaller horizontal displacement by local currents (Herbich and Brahme 1991; LaSalle et al. 1991; Herbich 2000).

In-water construction activities associated with LWI Alternative 2 would occur in water depths up to about 15 feet (5 meters) MLLW. Assuming that bottom sediments are disturbed during construction and resuspended to the surface (15 feet [5 meters] above the seafloor), the maximum estimated horizontal displacement of 50 feet (15 meters), as discussed in Section 3.1.2.2.2 (under Turbidity). Silt and clay particles would be dispersed over relatively larger distances (greater than 150 feet [46 meters]) because they have slower settling speeds. Also, resuspended, fine grained sediments would be subject to rapid dilution by currents and eventual flushing during subsequent tidal exchanges (Morris et al. 2008). Because fines represent a small proportion of sediments, they would probably not result in appreciable changes in the physical composition of bottom sediments as they settle. Also, rapid dilution and dispersion would minimize the potential for fine-grained sediments to settle and accumulate within sensitive habitat areas near the project site, such as nearshore eelgrass beds.

Metals

Construction activities for LWI Alternative 2 would not result in the discharge of wastes containing metals or otherwise alter the concentrations of trace metals in bottom sediments. Because the magnitude of metal concentrations in sediment can vary as a function of grain size (higher concentrations typically are associated with fine-grained sediments) (Schiff and Weisberg 1999), small changes to grain size associated with construction-related disturbances to bottom sediments could result in minor changes in bulk metal concentrations. However, the magnitude of the project-related changes is expected to be minimal. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and spill-related releases would be controlled by the debris management procedures (Section 3.1.1.2.3), construction activities would not cause chemical constituents to exceed marine sediment quality standards.

Organic Contaminants

Construction activities for LWI Alternative 2 would not result in the discharge of contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Similar to metal concentrations (discussed above), construction would not impact sediment quality with the possible exception of minor changes in the bulk concentrations of organic compounds that would result from changes in grain size. These changes would be minimal.

Accidental fuel spills or releases of other materials (e.g., hydraulic fluids) to Hood Canal could add contaminants (petroleum hydrocarbons) that could also impact sediment quality. However, as noted in Section 3.1.2.2.2, under Water Quality, the spill cleanup response would minimize impacts on the surrounding environment.

Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and spill-related releases would be controlled by a spill cleanup response (Section 3.1.1.2.3), construction activities would not cause chemical constituents to exceed marine sediment quality standards.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

Operation of LWI Alternative 2 would not discharge wastes other than untreated stormwater, increase contaminant inputs from vessels, or increase the frequency or size of possible spills into Hood Canal that would affect marine sediment quality. Maintenance of the LWI would include routine inspections, repair, and replacement of facility components as required. Periodic cleaning of the in-water mesh and PSB guard panels would release organic material into the water and decomposition of this material would result in localized increases in oxygen demand. If these conditions persisted, they could lead to locally reduced DO levels in the sediments. However, these materials would be dispersed by waves and currents, so that effects on DO would be transient. Therefore, no general or widespread effects on sediment DO at the LWI project sites are expected. BMPs and current practices (Section 3.1.1.2.3) would be employed to prevent discharges of chemical contaminants to the marine environment. Operation of LWI Alternative 2 would not affect sediment quality.

Physical Properties of Sediments

Anchor plates used to secure the mesh would represent a permanent change in substrate covering a seafloor area of 0.13 acre (0.052 hectare). The LWI Alternative 2 pier structures would alter current speeds, particularly near the piles, which would cause both erosion of fine-grained sediments near some piles impacted by turbulent flows and settling and accumulation of fine-grained sediments at the base of other piles (Section 3.1.2.2.2, under Hydrography). Shells and decaying organic matter from animals would slough from the piles and accumulate on the bottom, contributing to localized changes in sediment grain size immediately adjacent to the piles (Hanson et al. 2003). Similarly, fouling of the mesh from drift materials, floating debris, or attached organisms could reduce water flow sufficiently to promote settling of suspended particles and accumulation on the seafloor (snow-fence effect). Because fine-grained sediments have a greater affinity for some metal and organic contaminants from both local and regional sources, the spatial distribution of contaminants in bottom sediments may change slightly relative to existing conditions. Specifically, based on typical sediment-contaminant relationships, fine-grained sediments trapped by the piles could have higher contaminant concentrations compared to the coarse-grained sediments that presently occur at the site. However, these changes would only be expected immediately adjacent to the LWI and would not extend beyond the footprint of the LWI structures. The observation posts and abutments would be exposed to waves only during extreme high tides and would not be expected to alter sediment properties.

Metals

Operation of LWI Alternative 2 would not result in the discharge of contaminants or otherwise alter the concentrations of trace metal in bottom sediments. Therefore, no chemical constituents would exceed marine sediment quality standards.

Organic Contaminants

Operation of LWI Alternative 2 would not result in the discharge of organic contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Therefore, no chemical constituents would exceed marine sediment quality standards.

Operation of LWI Alternative 2 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact sediment quality in Hood Canal. In the event of an accidental spill, emergency cleanup measures would be implemented immediately, and the spill response would minimize impacts on the surrounding environment.

3.1.2.2.3. LWI ALTERNATIVE 3: PSB MODIFICATIONS (PREFERRED)

HYDROGRAPHY FOR LWI ALTERNATIVE 3

CONSTRUCTION

Construction of LWI Alternative 3 would involve relocating and installing new PSB sections. This construction would extend the existing PSB system across the intertidal zone and terminate at concrete abutments on the shoreline. The abutments and pile-supported observation posts would be the same as those described above for LWI Alternative 2. Unlike the pile-supported LWI, the new PSB units would not deploy underwater mesh. The PSB units would have guard panels that extend into the water to an approximate depth of 1 foot (30 centimeters). However, these guard panels would not affect hydrographic conditions at the project sites during construction or operations.

Four of the existing mooring buoys would be relocated at the north LWI location. The mooring system for two of the four relocated buoys would be reduced from three anchor legs to two anchor legs. Three of the existing mooring buoys would be relocated at the south LWI location. The mooring system for one of the three relocated buoys would be reduced from three anchor legs to two anchor legs. In addition, one new buoy with two mooring anchor legs would be installed at the south LWI location (Section 2.1.1.3.3). The net effect of relocating and reconfiguring existing mooring anchors and adding new mooring anchors would be a decrease in the anchor footprint at the north LWI location by approximately 193 square feet (18 square meters), and an increase in the anchor footprint by approximately 42.5 square feet (4 square meters) at the south LWI location. The observation post structures at the north and south LWI locations would be supported by piles installed along the shoreline at elevations from 7 to 10 feet (2 to 3 meters) above MLLW and from 4 to 7 feet (1.2 to 2 meters) above MLLW, respectively. With an approximately 100-foot (30-meter) wide construction corridor (Section 2.3.2.1), the estimated area of seafloor potentially disturbed by construction activities is 12.7 acres (5.2 hectares); the actual area that would be disturbed is expected to be considerably less.

Bathymetric Setting

Installation of new PSB segments would not alter bathymetric conditions other than minor disturbances associated with relocating and installing PSB moorings. Typical mooring installation consists of lowering the anchor with a floating crane using a slow, controlled descent to minimize disturbance to the seafloor. Installation of the abutments and piles for the observation posts in the upper part of the intertidal zone would cause some minor, localized mounding and depressions, which would not be expected to exceed 1 foot (0.3 meter) in displacement, representing a negligible change in the project bathymetry. These bathymetric features would likely be temporary because natural processes that occur at the sediment-water interface (bedload transport, bioturbation, etc.), particularly during storm events, would reshape the seabed to the surrounding environment. The seafloor topography would return to near its original profile over a period of approximately 6 to 12 months without intervention or mitigation.

Circulation and Currents

The presence of work vessels (estimated to be one barge with a crane plus one supply barge and work skiffs, based on previous NAVBASE Kitsap Bangor waterfront projects) associated with construction of LWI Alternative 3 would result in minor and localized effects on circulation patterns, which would not persist beyond the in-water construction phase, similar to those described for LWI Alternative 2.

Longshore Sediment Transport

The presence of two barges and work skiffs is expected to have a negligible effect on the conditions responsible for longshore sediment transport. This is because the spatial scale of wave dampening from barges would be small relative to the length of the shoreline.

OPERATION/LONG-TERM IMPACTS

The PSBs are a passive floating barrier system. Operation of the system would consist of opening and closing the barrier system to allow vessel passage by disconnecting the PSB gate units at the mooring locations and moving the barrier out of the way. The movable PSB units would not be anchored to the seafloor, so opening the barrier system would not require moving anchors or otherwise disturbing seafloor sediments. Also, opening and closing the PSB gate unit would not affect circulation patterns or other hydrographic processes. However, it is estimated that approximately 2,594 square feet (241 square meters) of the intertidal zone would be disturbed over the long term by the PSB units and buoys grounding out during low tide stages (Section 2.1.1.3.3).

Bathymetric Setting

The PSB sections and buoys would be moored so that there would be little slack, resulting in minimal lateral movement of the PSB sections and buoys during that portion of the tidal cycle when the PSB "feet" contact the seafloor. Regardless, considering that the PSBs and buoys would not always come to rest at the same point on the seafloor, it is estimated that the PSB feet and buoys would disturb a maximum area of 2,594 square feet (241 square meters). These footprints are small relative to the size of the project site, and the potential for the PSB to alter the seafloor bathymetry would be minimal. Similarly, small portions of the mooring anchor chain would be expected to move during each tidal cycle. Anchor chain associated with each mooring leg is expected to affect a 5-square foot area of the seafloor. Each mooring would have either two or three anchor legs, and eight moorings would be deployed for LWI Alternative 3, representing a total area of 100 square feet (9.3 square meters) of seafloor that would be affected by anchor chain movement. However, this alternative would also relocate seven existing moorings with a total of 21 anchor legs, so the net effect would be a slight decrease in seafloor area disturbed by anchor chain movement.

Grounding of the PSB feet and buoys and small movements of anchor chain are expected to result in small (less than 3 feet), localized changes in the sea bed elevations due to compression or displacement of surface layer sediments. The contact pressure associated with the pontoon feet is estimated at 4.5 pounds per square inch (psi), which is similar to that of a person walking on a beach. Minor changes in bathymetry associated with disturbances of the seafloor from the PSB pontoons and buoys would not alter circulation patterns or tidal elevations at the project sites.

Circulation and Currents

Operation of the PSB structures would not affect water circulation or tidal range within the project area, but small-scale turbulence would occur near the individual PSB pontoons, abutments, and observation post piles. However, the effects on circulation and currents from minor, localized turbulence would be negligible and less than for LWI Alternative 2.

Longshore Sediment Transport

Operation of the PSB segments for LWI Alternative 3 would not be expected to affect sediment transport processes along the NAVBASE Kitsap Bangor shoreline because the submerged portions of the PSB units and mooring/anchor systems would have small profiles that would not trap or promote accumulation of sediments. Thus, the overall effect would be minor and localized and would not affect longshore sediment transport processes.

Similar to LWI Alternative 2, the abutments constructed at the south and north LWI for LWI Alternative 3 would armor small sections of the existing shoreline. However, these areas do not represent significant sources of sediments to the drift cell. As a result, the presence of the onshore abutments for LWI Alternative 3 would not affect sediment supplies to the drift cells associated with the north and south LWI sites or drift cells to the north of these sites. Like LWI Alternative 2, the abutment stairways that extend over a small area below MHHW would be inundated infrequently and for short periods, and therefore are not expected to affect hydrodynamics or sediment transport processes. Because the piles for the observation posts would be at elevations between 6 and 12 feet (1.8 and 3.7 meters) above MLLW, and MHHW at the project site is 11 feet (3.4 meters) above MLLW, the base of the piles would be below the water surface during some high tide cycles. However, like the abutments, the piles would be inundated infrequently and for short periods and so would have a negligible effect on sediment transport. Therefore, the abutments and observation post piles would have minimal effects on nearshore processes and littoral drift.

WATER QUALITY FOR LWI ALTERNATIVE 3

CONSTRUCTION

Construction of LWI Alternative 3 would involve relocating and installing new PSB sections, relocating seven existing mooring buoys and adding one additional mooring buoy. These activities have the potential for resuspending bottom sediments, which could have minor, temporary effects on water quality at the project site. The PSB units would have guard panels that extend into the water to an approximate depth of 1 foot (0.3 meter). However, these guard panels would not affect water quality conditions at the project sites during construction or operations. This alternative would also construct observation posts at the north and south LWI locations. However, these structures would be constructed in the dry, so construction activities associated with these structures would have no effect on marine water quality.

Stratification, Salinity, and Temperature

Construction of LWI Alternative 3 would not impact water temperature or salinity because construction activities would not discharge wastewaters other than stormwater runoff, in accordance with the stormwater pollution prevention plan. In the absence of project-related discharges, construction of LWI Alternative 3 would not alter stratification, salinity, or temperature in Hood Canal.

Dissolved Oxygen

Construction of LWI Alternative 3 would not discharge any wastes containing materials with an oxygen demand into Hood Canal. Relocation of existing PSB mooring anchors and placement of the new PSB mooring anchors would not affect DO concentrations in site waters, other than minor, temporary and localized effects associated with resuspension of bottom sediments. Similar to LWI Alternative 2, resuspension of existing bottom sediments would not result in substantial oxygen depletion or reductions in DO levels. This is because the sediments have a low organic content and waves and currents provide rapid mixing and dispersion of suspended sediments.

Stormwater discharges would be controlled consistent with a construction stormwater discharge permit and stormwater pollution prevention plan. Consequently, stormwater discharges are not expected to alter DO concentrations at the project site. Construction activities would not result in decreases in DO concentrations, cause changes that would violate water quality standards, or exacerbate low DO concentrations that occur seasonally within portions of Hood Canal.

Turbidity

Construction of LWI Alternative 3 would temporarily increase suspended sediment concentrations and turbidity levels in Hood Canal as a result of resuspension of bottom sediments during placement of PSB mooring anchors. The PSB mooring anchors would be deployed with a barge-mounted crane using a controlled placement method that would minimize disturbances to bottom sediments. Regardless, resuspended sediment would contribute temporarily to elevated turbidity levels and reduced water clarity conditions. As particles settle and current and wave conditions mix and disperse the suspended particles, turbidity levels would decline. The time required to reach baseline conditions would depend on the composition of the resuspended particles, particle settling speeds, and dilution and dispersion rates related to current and wave conditions. Typically, these time periods are on the order of minutes to hours.

Similarly, for other project-related construction activities, such as anchoring work boats, fine-grained particles resuspended from the bottom would disperse rapidly as a result of particle settling and current mixing. Propeller wash impacts could occur in shallow waters, although the need for vessel operations in shallow waters and, thus, the extent of sediment resuspension is expected to be minimal.

Stormwater discharges would be in accordance with a stormwater discharge permit and stormwater pollution prevention plan, which would minimize the potential for discharges to affect turbidity levels at the project site.

Similar to LWI Alternative 2, construction of the abutments at the north and south LWI Alternative 3 sites would disturb sediments in the upper intertidal zone. These sediments would be subject to resuspension during high tide stages, which could contribute locally to increased turbidity levels. However, the magnitude of this effect would be minimal because sediments are mostly coarse-grained and the duration of inundation by high tides would be limited.

Consequently, construction activities would not result in persistent increases in turbidity levels or cause changes that would violate water quality standards. This is because processes that generate suspended sediments and increase turbidity levels would be short-term and localized and suspended sediments would disperse and/or settle rapidly (within a period of minutes to hours) after construction activities cease.

Nutrients

Construction activities for LWI Alternative 3 would not result in the discharge of wastes containing nutrients. Because sediments at the project site do not contain high concentrations of nutrients, such as ammonia (Hammermeister and Hafner 2009), sediment resuspension during construction would not release nutrients to site waters in amounts that would violate water quality standards. Construction activities would not cause increases in nutrient levels or produce conditions that would violate water quality standards.

Fecal Coliform Bacteria

Construction activities for LWI Alternative 3 would not impact bacteria (fecal indicator bacteria) levels because this alternative would not discharge untreated wastes or other materials containing bacteria. Bacterial levels in coarse-grained marine sediments at the project site also are expected to be low, and resuspension of sediments during construction activities would not release bacteria to site waters in amounts that would violate water quality standards. Stormwater discharges would be controlled in accordance with a stormwater discharge permit and stormwater pollution prevention plan. Construction activities would not result in increases in bacteria levels or cause changes that would violate water quality standards.

pH

Construction activities for LWI Alternative 3 would not impact the pH levels of local waters because this alternative would not discharge pH-affecting wastes at the project site. Similar to Alternative 2, there is a potential for cement spillage during construction of the platforms. The chemical composition of cement can influence pH under some conditions, although this is unlikely to be a consideration for the project site and proposed construction methods. Further, measures to prevent losses and cleanup of spills would be addressed in the debris management procedures. Stormwater discharges would be controlled in accordance with a stormwater discharge permit and stormwater pollution prevention plan. Consequently, construction activities would not result in changes in pH that would violate water quality standards.

Other Contaminants

Another possible source of construction-related impacts on water quality for LWI Alternative 3 would be accidental spills into Hood Canal of debris, fuel, or other contaminants from barges or construction platforms. Typically, spills are prevented by a number of measures, including containing and cleaning up materials leaked on the deck of work vessels, prohibiting washdown of materials into the water, and prohibiting refueling in unauthorized areas. The existing facility response and prevention plans for the Bangor waterfront (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) provide guidance that would be used in a spill response, such as a response procedures, notification, and communication plan; roles and responsibilities; and response equipment inventories. In the event of an accidental spill, response measures would be implemented immediately to minimize potential impacts on the environment.

The Navy would require the construction contractor to prepare and implement debris management procedures for preventing discharge of debris to marine water and retrieving and cleaning up any debris spilled into Hood Canal. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups. Overall, construction activities associated with Alternative 3 would not be expected to release contaminants or otherwise cause any water quality standards to be violated.

OPERATION/LONG-TERM IMPACTS

Operation of LWI Alternative 3 would not discharge wastes into Hood Canal. Wastewater from sinks and toilets in the observation posts would be transferred via transmission lines to the existing NAVBASE Kitsap Bangor wastewater infrastructure. Stormwater runoff from the PSB segments would not require treatment and could discharge directly into Hood Canal since the structure surfaces would consist largely of inert materials and would not represent a substantial source of pollutant loadings into Hood Canal. The PSB pontoons, which would provide the greatest surface area contact with seawater, would be constructed of HDPE (high density polyethylene), which is durable and inert. However, some of the materials used for the PSB and mooring units likely would be galvanized metal or steel, which can leach zinc and contribute to zinc loading in stormwater runoff (WDOE 2008a). However, this is not expected to affect water quality at the project site because the magnitude of the zinc input would be minimal, and the project would implement and operate stormwater BMPs in accordance with the NPDES permit.

Stratification, Salinity, and Temperature

Operation of the LWI Alternative 3 would not result in discharges into local waters. Also, these structures would not interfere with tides, currents, or other natural processes that are responsible for mixing Hood Canal waters. Therefore, operations would not result in impacts on stratification, salinity, or temperature conditions or cause changes that would violate water quality standards.

Dissolved Oxygen

Periodic cleaning of the PSB in-water guard panels would release organic material into the water and subsequent decomposition of this material would result in localized increases in oxygen demand. However, these materials would be dispersed by waves and currents so effects on DO would be transient and inconsequential. Also, these structures would not interfere with tides, currents, or other natural processes that are responsible for mixing Hood Canal waters. Therefore, operations of LWI Alternative 3 would not result in impacts on DO conditions or cause changes that would violate water quality standards.

Turbidity

Operation of the LWI Alternative 3 would not result in discharges or resuspend bottom sediments that have the potential for affecting turbidity levels at the project site. Some temporary and localized increases in turbidity could occur as a result of the PSB feet and buoy grounding during low tides. Small boat operations would be infrequent and boat operators would be required to use low power and speeds in shallow water, minimizing the potential for propeller wash to cause suspension of bottom sediments. Therefore, operations would not result in changes to turbidity levels that would violate water quality standards.

Nutrients

Operation of the LWI Alternative 3 would not result in discharges that would affect nutrient concentrations in marine waters at the project site. The PSB units would provide a roosting site for marine birds, which would produce feces and associated nutrient loading to Hood Canal. However, nutrients would be rapidly mixed and dispersed by currents, and the magnitude of this input source would not cause eutrophication. Further, since the existing PSBs provide similar roosting sites, this alternative would not represent a new source for nutrient loading. Therefore, operations would not violate water quality standards.

Fecal Coliform Bacteria

Operation of the LWI Alternative 3 would not affect fecal coliform bacteria levels in marine waters at the project site because the project would not result in any discharges or alter site conditions in a manner that would release bacteria to local waters. Birds roosting on the PSB sections would contribute to bacterial loading, but inputs would be rapidly mixed and dispersed by currents. Because the existing PSBs provide similar roosting sites, this alternative would not represent a new source for bacterial loading. Therefore, operations would not result in impacts on bacteria levels or cause changes that would violate water quality standards.

pH

Operation of the LWI Alternative 3 would not result in discharges with the potential for impacting the pH of marine waters. Therefore, operations would not result in impacts on pH levels or cause changes that would violate water quality standards.

Other Contaminants

Operation of the LWI Alternative 3 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact water quality in Hood Canal. This is because the existing NAVBASE Kitsap Bangor fuel spill prevention and response plans would help ensure the avoidance of fuel spills. In the event of an accidental spill, emergency cleanup measures would be implemented immediately in accordance with state and federal regulations. The cleanup would minimize impacts on the surrounding environment.

SEDIMENT QUALITY FOR LWI ALTERNATIVE 3

CONSTRUCTION

A possible source for construction-related impacts on sediments would be from accidental debris spills from barges or construction platforms into Hood Canal. Debris spills could impact bottom sediments and create nuisance conditions by adding materials that could represent obstructions. The construction contractor would be required to retrieve and clean up any accidental spills as a current practice in accordance with the debris management procedures that would be implemented per the Mitigation Action Plan (Appendix C). Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups. Construction-related changes to sediment quality would be spatially limited to the construction corridor, including areas potentially impacted by anchor drag.

Physical Properties of Sediments

Anchor placement during relocation of existing PSB units and installation of new PSB units would cause minor disturbances of bottom sediments. Sediments that are resuspended by anchoring activities would be dispersed by currents and eventually redeposited on the bottom (Barnard 1978; Hitchcock et al. 1999). Depending on the distance, suspended sediments would be transported before settling on the bottom. This process could result in minor changes to sediment texture (i.e., grain-size characteristics), particularly if coarse-grained sediments are transported from shallow to deeper portions of the project site or fine-grained sediments are transported from deeper to shallower areas. The distance over which suspended sediments are dispersed would depend on a number of factors, including sediment characteristics, current speeds, and distance above the bottom.

Metals

Construction activities for LWI Alternative 3 would not result in the discharge of wastes containing metals or otherwise alter the concentrations of trace metals in bottom sediments. Consequently, because construction-related disturbances to bottom sediments would be minor, any changes in bulk metal concentrations associated with localized effects on sediment grain size would be negligible. Changes would not cause chemical constituents to exceed marine sediment quality standards because the magnitude of the project-related changes would be minimal.

Organic Contaminants

Construction activities for LWI Alternative 3 would not result in the discharge of contaminants or otherwise alter concentrations of organic contaminants in bottom sediments. Similar to metals concentrations (discussed above), construction activities would not impact sediment quality except for minor changes in the concentrations of organic compounds that would result from changes in grain size. However, these changes would not cause chemical constituents to exceed marine sediment quality standards because the magnitude of project-related changes is expected to be minimal.

Accidental fuel spills or releases of other materials (e.g., hydraulic fluids) to Hood Canal could add contaminants (petroleum hydrocarbons) that could also impact sediment quality. However, the spill cleanup response (Section 2.3.2) would minimize impacts on the surrounding environment.

OPERATION/LONG-TERM IMPACTS

Other than untreated stormwater, operation of the LWI Alternative 3 would not discharge any wastes or increase contaminant inputs from vessels or the frequency or size of possible spills into Hood Canal that would affect marine sediment quality. Measures would be employed to prevent discharges of contaminants to the marine environment. These activities would not affect sediment quality.

Physical Properties of Sediments

Operation of the PSB segments could cause minor changes to sediment texture in the intertidal zone where the PSB “feet” and buoys contact the bottom during low tide stages. In particular, the periodic (tidal-dependent) but repeated disturbance of the seafloor would promote selective resuspension and dispersion of finer grained sediment particles, resulting in comparatively higher percentages of coarse-grained particles. However, the sediments of the intertidal areas of the LWI project sites consist primarily of coarse sand and gravel-sized particles. Thus, changes to sediment texture in areas subject to disturbances by the PSB feet and buoys would be minor, and the estimated maximum area of disturbance would be 2,594 square feet (241 square meters) of seafloor. Similarly, movement of portions of the anchor chain used on the PSB moorings would affect an estimated 100 square feet (9.3 square meters) of seafloor. However, this alternative would also relocate seven existing moorings, so the net effect would be a slight decrease in seafloor area disturbed by anchor chain movement.

Metals

Operation of LWI Alternative 3 would not result in the discharge of contaminants or otherwise alter the concentrations of trace metal in bottom sediments. Leaching of metals from PSBs is not expected to affect sediment quality at the project site because the magnitude of the metal inputs would be minimal. Therefore, no chemical constituents for metals would exceed marine sediment quality standards.

Organic Contaminants

Operation of LWI Alternative 3 would not result in the discharge of organic contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Therefore, no chemical constituents for organic contaminants would exceed marine sediment quality standards.

Spills of fuel, explosives, cleaning solvents, and other contaminants could impact sediment quality in Hood Canal. However, operation of the LWI Alternative 3 would not increase the risk of accidental spills because, other than minor, small boat operations, the project operations would not require use of explosives, solvents, or other contaminants. In the event of an accidental spill, emergency cleanup measures would be implemented immediately, and the spill response would minimize impacts on the surrounding environment. No changes are currently anticipated in the number or types of vessels on the Bangor waterfront as a result of construction of in-water barriers. In addition, operations would not increase the mass loading of contaminants, such as copper or zinc from anti-fouling hull paints and sacrificial anodes, to marine sediments at the project site. This is because there would be no increase in the number of vessels using the Bangor waterfront as a result of construction of the LWI.

3.1.2.2.4. SUMMARY OF IMPACTS FOR LWI PROJECT ALTERNATIVES

Impacts on marine water resources associated with the construction and operation phases of the LWI project alternatives, along with mitigation measures and consultation and permit status, are summarized in Table 3.1–5.

Table 3.1–5. Summary of LWI Impacts on Marine Water Resources

Alternative	Environmental Impacts on Marine Water Resources
Impact	
LWI Alternative 1: No Action	The No Action Alternative would not result in any changes to existing hydrography, water quality, or sediment quality.
LWI Alternative 2: Pile-Supported Pier	*Construction*: Temporary and localized disturbances of bottom sediments (bathymetry) from anchor dragging, spud deployment, and propeller wash within the construction footprint (maximum 13.1 acres [5.3 hectares]), and small-scale changes in wave and current patterns. Project construction activities could result in temporary and localized changes in water quality associated with resuspension of bottom sediments (increased suspended sediment concentrations and turbidity levels), stormwater discharges (contaminant loading), and spills (contaminant releases), but conditions are not expected to exceed water quality standards. Project construction activities would result in disturbance of bottom sediments through pile installation and anchoring of barges and vessels, which would affect physical characteristics of the sediments such as grain size. Impacts on sediment contaminant levels are unlikely, and conditions are not expected to exceed marine sediment quality standards. Changes to marine water resources associated with project construction activities could occur throughout the in-water construction phase of the project. Changes to water quality conditions likely would persist for minutes to hours following disturbances, whereas changes to sediment conditions would persist for weeks to months. Construction-related changes would not be expected to occur beyond the immediate project site. *Operation/Long-term Impacts*: Small-scale changes in flow patterns could result in localized scouring or accumulation of sediments in the immediate vicinity of the support piles and underwater mesh. These changes likely would be seasonal, as storm waves would resuspend and redistribute sediments that were deposited initially near the structures. Release of organic matter from periodic cleaning of the in-water mesh could increase oxygen demand on a localized and temporary basis. Other project operations would not involve discharges of waste or other materials with the potential for impacting water quality. The presence of the LWI structures and abutments would not cause measurable changes in deposition or erosion patterns or average seabed elevations, and would not affect local or regional sediment transport processes.

Table 3.1–5. Summary of LWI Impacts on Marine Water Resources (continued)

Alternative	Environmental Impacts on Marine Water Resources
LWI Alternative 3: PSB Modifications (Preferred)	*Construction*: Temporary and localized disturbances of bottom sediments (bathymetry) from anchor placement within the construction footprint (maximum 12.7 acres [5.2 hectares]) and from construction of the shoreline abutments and observation posts. Project construction activities could result in temporary and localized changes in water quality associated with resuspension of bottom sediments (increased suspended sediment concentrations and turbidity levels), stormwater discharges (contaminant loading), and spills (contaminant releases), but conditions are not expected to exceed water quality standards. Project construction activities would disturb bottom sediments through anchoring of barges and vessels, which would affect physical characteristics of the sediments such as grain size. However, impacts on sediment contaminant levels are unlikely, and conditions are not expected to exceed marine sediment quality standards. Construction impacts on the seafloor would be less under LWI Alternative 3 than for LWI Alternative 2 because of the slightly smaller construction corridor (12.7 acres vs. 13.1 acres (5.2 vs. 5.3 hectares) for LWI Alternative 2) and less intensive construction required to place PSB buoy anchors compared to the installation of plate anchors and more numerous piles for the piers. *Operation/Long-term Impacts*: PSBs would not result in changes in flow patterns. Project operations would not involve discharges of waste or other materials with the potential for impacting water quality. The presence of the PSB units, observation post piles, and abutments would not cause measurable changes in deposition or erosion patterns or average seabed elevations and would not affect local or regional sediment transport processes.
Mitigation: BMPs and current practices to reduce and minimize impacts on marine water resources from the proposed LWI project are described in Section 3.1.1.2.3. No mitigation measures are necessary beyond BMPs and current practices.	
Consultation and Permit Status: The Navy will obtain permits from USACE for this project under CWA Section 404 and Rivers and Harbors Act Section 10, and request a CWA Section 401 Water Quality Certification, as well as concurrence with the Navy's CCD under CZMA, from WDOE. Alternative 3 is the Least Environmentally Damaging Practicable Alternative according to the CWA Section 404(b)(1) guidelines.	

BMP = best management practices; CCD = Coastal Consistency Determination; CWA = Clean Water Act; CZMA = Coastal Zone Management Act; DO = dissolved oxygen; USACE = U.S. Army Corps of Engineers; WDOE = Washington Department of Ecology

3.1.2.3. SPE PROJECT ALTERNATIVES

3.1.2.3.1. SPE ALTERNATIVE 1: NO ACTION

The SPE would not be constructed under the No Action Alternative and operations would not change from current levels. Therefore, existing hydrography, nearshore water quality, and sediment quality would not be impacted under the SPE No Action Alternative.

3.1.2.3.2. SPE ALTERNATIVE 2: SHORT PIER (PREFERRED)

HYDROGRAPHY FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

SPE Alternative 2 would extend the Service Pier to the southwest from the south end of the existing service pier (Section 2.2.1.3.2). Water depths in this area range from 30 to 75 feet (9 to 23 meters) below MLLW. The pier extension would demolish a portion of the existing pier and fender piles, install new, concrete-filled, steel pipe piles, and relocate the existing wave screen. Construction of the proposed SPE facilities is anticipated to take approximately 24 months. In-water construction, including pile driving, would take no more than 13 weeks and would occur within the allowable in-water work window (July 16 to January 15). The SPE Alternative 2 would not require construction activities in the intertidal zone.

Bathymetric Setting

Construction of SPE Alternative 2 would have some temporary impacts on the bathymetry (seafloor topography) within the immediate construction site. Given the deep-water setting of the SPE project site, there is no anticipated need for dredging within the construction corridor. However, removal of existing piles, anchor placement, and construction equipment mooring ground tackle, in addition to effects from pile driving, would result in some physical disturbance to the seafloor, such as mounding and displacement or movement of bottom sediments.

Changes to bathymetry, resulting from pile removal, pile driving, and anchor placement during construction activities, would be limited to highly localized areas within the 100-foot (30-meter) wide construction corridor. The magnitude of sediment displacement is estimated to be between 0.5 and 3 feet (0.2 to 1 meter), representing the potential displacement of sediment by a typical vessel or barge anchor (width of up to 3 feet [1 meter]). However, the majority of localized sediment disturbance from construction activities is expected to be much less than the maximum.

These impacts are anticipated to be temporary because natural processes that occur at the sediment-water interface (bedload transport, bioturbation [mixing of surface sediment by benthic infaunal organisms], etc.) following completion of construction activity would return the seafloor topography to near its original profile over time (6 to 12 months) without intervention or mitigation. A period of 6 to 12 months would allow for a full seasonal cycle of storm and wind events, tidal influence, and resumption of ambient sediment transport patterns that would degrade temporary boundary roughness and reshape the seabed to the surrounding environment. Although some movement and redistribution of in-place sediments is anticipated, no substantial changes to bathymetry would occur.

Circulation and Currents

Circulation patterns in the surface water layer (upper 10 to 15 feet [3 to 5 meters] of water) in the immediate vicinity of the SPE Alternative 2 site would be affected by short-term and temporary changes due to the presence of construction equipment and barges, which would partially obstruct flows. However, these effects would be localized and would not alter the overall circulation pattern and velocities in the nearshore and deeper water areas along the Bangor waterfront.

Construction of SPE Alternative 2 would have no impact on the tidal range or water levels in Hood Canal or the immediate project area because the pier would be constructed on a foundation of piles that would not interfere with tidal cycles. Thus, water levels at the project site would be similar to other, adjacent areas of northern Hood Canal.

Longshore Sediment Transport

Construction activities for the SPE Alternative 2 structure would not affect longshore sediment transport processes along the NAVBASE Kitsap Bangor shoreline because the influence of construction equipment on wave and current energy that are responsible for resuspending and transporting sediments along the shoreline would be negligible.

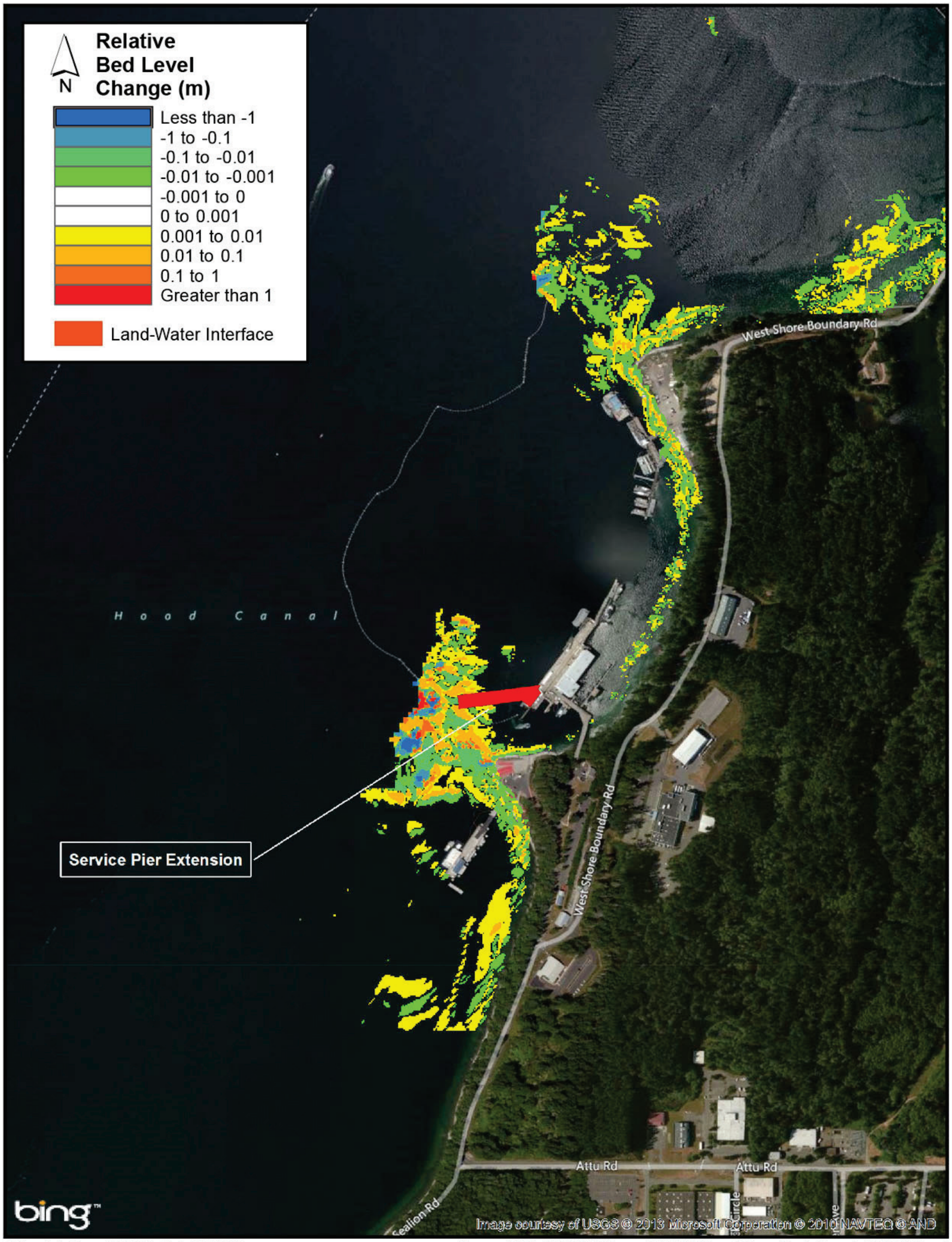
OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

The in-water portion of the SPE Alternative 2 structure (piles and wave screen) would dampen wave energy within the immediate vicinity of the pier, resulting in long-term but localized effects on water circulation and currents. Water levels and tidal exchange volumes in the basin would be unaffected by the continued presence and use of the SPE because the pier piles and wave screen would not prevent water flow. Maintenance of the SPE would include routine inspections, repair, and replacement of facility components as required. These activities would not affect hydrographic conditions. Relocating and berthing two additional SEAWOLF Class submarines (SSN) to the Service Pier would not affect bathymetry, tides, circulation patterns, or sediment transport processes at NAVBASE Kitsap Bangor, other than very minor, localized effects of submarine hulls dampening surface flows and waves in the immediate vicinity of the SPE project site.

Bathymetric Setting

The support piles installed for the SPE would alter current speeds beneath the pier, which would cause erosion of fine-grained sediments near some piles impacted by turbulent flows, as well as settling and accumulation of fine-grained sediments at the base of other piles (Chiew and Melville 1987). Over the lifetime of the SPE, tidal currents would result in thin scouring around the perimeter of the pier piles (Sumer et al. 2001). However, shells and barnacles that accumulate on the pier piles would also slough off over time and contribute to the sediment content below the piles. The loss of fine-grained sediment would be offset by the accumulation of shell and barnacle particles. These two processes would result in no net impact to seafloor bathymetry below the pier support piles.

Over the long term, small changes to the bathymetry inshore of the SPE structure could occur due to attenuation (reduction in energy) by the pier piles of surface waves approaching from the west. The effects of the SPE structure on bathymetry were evaluated by cbec (2013). Results from hydrodynamic modeling indicated that the presence of the SPE structure would have a negligible effect on the average seabed elevations in the project area. The net change in seabed elevations at the SPE project site for a 50-year storm event scenario is shown in Figure 3.1–23. For the 50-year recurrence event scenarios, average changes in seabed elevations with the SPE in place would range from -0.28 to -0.16 inch (-7 to -4 millimeters), which is similar to the average change in the seabed elevation (-0.24 inch [-6 millimeters]) under existing conditions (i.e., no SPE). Net changes in the sedimentation patterns under less severe, 2-year storm events would be relatively smaller. Based on these results, operation of the SPE is not predicted to cause appreciable changes to bathymetry within the project area. Effects of the proposed SPE on sediment transport processes are discussed below.



Author: John Evans | SAIC | Date: 7/10/2013 Document Path: C:\GISPJ13\Bangor LWI\SAIC Figures\50 year Flood - Scenario 2 SPE BLC.mxd

Source: cbec 2013

Figure 3.1–23. Model-Predicted Changes in Relative Seabed Elevations with Installation of the SPE Structure under a 50-Year Storm Scenario

Circulation and Currents

Since the SPE Alternative 2 pier would be constructed on a foundation of piles, the overall volume of water flowing into the nearshore and deeper water areas adjacent to the project site would not be affected by the structures. It is anticipated that the flow pattern immediately under the SPE would become more disturbed (turbulent) as the water mass driven by tidal currents moves between and around the piles, especially during periods of peak flow. The presence of up to two additional submarines berthed at the SPE would be expected to reflect surface waves. Similarly, the presence of the wave screen relocated beneath the inboard portion of the SPE would also continue to reflect and dampen surface waves and currents. The resulting impact would be a small decrease in water column current velocities downcurrent of the SPE, but an overall increase in the turbulence and mixing in the water mass passing directly under the structure.

Turbulence in the water column would be a function of small-scale increases in the instantaneous velocity of water flow between the individual pile structures relative to the remainder of the water column. The impact of turbulence in the water column is beneficial to water quality through the deflection of linear flow downward and laterally, promoting increased mixing of the water column.

Modeling of hydrodynamic conditions with and without the SPE structure indicated only marginal changes in current velocities for 2-year storm and 50-year storm conditions (cbec 2013). This may be due in part to the location of the proposed SPE structure in the lee (down current) side of Carlson Spit, where current speeds are already lower than in the deeper open-water region offshore from the Service Pier.

Operation of the SPE Alternative 2 would not affect the tidal range along the shoreline or the immediate project area. This is because the pier extension would be constructed on a foundation of piles that allows water exchange with portions of Hood Canal immediately offshore, and operation of the SPE would not alter bathymetry within the project region (discussed above).

Longshore Sediment Transport

The SPE Alternative 2 would increase the combined footprint of pile-supported structures along the Bangor shoreline. However, based on data presented in Section 3.1.1.1, as well as results from longshore sediment transport modeling (cbec 2013), the proposed extension of the existing structure is not expected to reduce the local sediment budget or result in significant changes to the NAVBASE Kitsap Bangor shoreline. Piles installed to support the SPE are expected to attenuate the energy of surface waves associated with storm events approaching the project site from the north and south. This reduction in wave energy in areas shoreward of the structure would reduce the frequency and magnitude of sediment resuspension events and promote conditions more conducive to long-term deposition of sediments and accumulation of fine-grained sediment in the form of a shoal area or comparatively broader intertidal area. Regardless, results from modeling sediment transport processes in the vicinity of the SPE project area (cbec 2013) predict that the presence of the SPE structure would not cause measurable changes in average seabed elevation within the project area under 50-year storm or 2-year storm scenarios (Figure 3.1–23). Thus, the project would not affect the sediment budget and rates of erosion/accretion outside of the project footprint. This conclusion is supported by a Golder Associates (2010) study, which concluded that the presence of other Navy structures along the NAVBASE Kitsap Bangor shoreline has not caused appreciable changes in the morphology of the shoreline. Similarly, operation of the SPE is not expected to interrupt longshore sediment transport processes or result in changes to the NAVBASE Kitsap Bangor or West Kitsap County shoreline.

WATER QUALITY FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

In-water construction of SPE Alternative 2 facilities and supporting components would not require dredging or placement of fill. Direct discharges of waste to the marine environment would not occur, other than stormwater runoff during construction. Construction-related impacts to water quality would be limited to short-term and localized changes associated with resuspension of bottom sediments from pile removal, pile installation, and barge and tug operations, such as anchoring, as well as accidental losses or spills of construction debris into Hood Canal. These changes would be spatially limited to the construction corridor, including areas potentially impacted by anchor drag and areas immediately adjacent to the corridor (i.e., up to approximately 130 feet [40 meters] from the offshore edge of the construction corridor) that could be impacted by plumes of resuspended bottom sediments. Construction-related impacts would not violate applicable state or federal water quality standards.

Stratification, Salinity, and Temperature

Construction of SPE Alternative 2 would not impact water temperature or salinity because construction activities would not discharge wastewaters other than stormwater runoff, in accordance with the SWPPP. In the absence of project-related discharges, construction of SPE Alternative 2 would not alter stratification, salinity, or temperature in Hood Canal.

Dissolved Oxygen

Construction of SPE Alternative 2 would not discharge any waste-containing materials with an oxygen demand into Hood Canal. However, pile removal and pile installation would resuspend bottom sediments, which may contain chemically reduced organic materials. Subsequent oxidation of sulfides, reduced iron, and organic matter associated with the suspended sediments would consume some DO in the water column. The amount of oxygen consumed would depend on the magnitude of the oxygen demand associated with suspended sediments (Jabusch et al. 2008). As discussed in Section 3.1.1.1.3, the organic carbon content of sediments at the SPE project site is low (0.4 to 2 percent), although total sulfides concentrations vary from 6 to 1,330 mg/kg. Therefore, the impacts of sediment resuspension from pile installation to DO concentrations would be minimal. Additionally, a bubble curtain would be used to reduce in-water noise levels during some construction activities (see discussion of impacts from underwater noise in Appendix D). Use of a Type I bubble curtain would increase DO concentrations in marine waters at the SPE project site by increasing the rate of vertical mixing of site waters and promoting dissolution of air bubbles, thereby increasing oxygen saturation levels. The effect on DO concentrations from use of a bubble curtain would be greater than that associated with sediment resuspension, and a net increase in DO levels would be expected. Use of a Type II confined bubble curtain would not increase DO concentrations in marine waters. Stormwater discharges would be addressed by a construction stormwater discharge permit and SWPPP. Consequently, stormwater discharges would not alter DO concentrations at the project site. Because the project would not discharge wastewaters, other than stormwater that would be discharged in accordance with a permit and SWPPP, construction activities would not result in decreases in DO concentrations, cause changes that would violate water quality standards, or exacerbate low DO concentrations that occur seasonally in Hood Canal waters.

Turbidity

Removal of existing piles and installation of new piles for the SPE Alternative 2 pier extension would resuspend bottom sediments within the immediate construction area, resulting in short-term and localized increases in suspended sediment concentrations that, in turn, would cause increases in turbidity levels. The suspended sediment/turbidity plumes would be generated periodically, in relation to the level of in-water construction activities, during the in-water work window. The amount of bottom sediments that would be resuspended into the water column during pile removal and pile placement, and the duration and spatial extent of the resulting suspended sediment/turbidity plume, would reflect the composition of the sediments. Surface sediments at the SPE project site are mostly coarse-grained, ranging from 72 to 93 percent sand and gravel (Hammermeister and Hafner 2009). In general, the coarse-grained sediments that occur in most areas of the SPE project site are more resistant to resuspension and have a faster settling speed than fine-grained sediments. Higher settling rates would result in a shorter water column residence time and a smaller horizontal displacement by local currents (Herbich and Brahme 1991; LaSalle et al. 1991; Herbich 2000).

Assuming that bottom sediments are disturbed during construction, and resuspended into the water column (a conservative assumption of 40 feet (13 meters), the maximum water column residence of sand sized particles would be approximately 130 seconds. A sand particle settles through the water column at a velocity of approximately 0.3 foot/second (9 centimeters/second). With a current velocity of 1 foot/second (30 centimeters/second) (Section 3.1.1.1.1), the maximum dispersion distance would be approximately 130 feet (40 meters), (i.e., it would take 130 seconds for a sand particle to settle 40 feet (13 meters) through the water column, at which time the particle is being transported horizontally at a rate of 1 foot/second (30 centimeters/second), resulting in horizontal displacement of 130 feet (40 meters). Silt and clay particles that are resuspended during construction activities could have relatively longer water column residence times because they have slower settling speeds. Based on the size of sediment particles typical of the project site, the settling period for individual particles could be up to several hours depending on the water depth and initial distance above the bottom. Suspended silt- and clay-sized particles would form weak (low particle density) plumes, which would be subject to rapid dilution by currents and eventual flushing during subsequent tidal exchanges (Morris et al. 2008). Therefore, relatively greater dispersion of these fine-grained suspended sediments would occur.

For other project-related construction activities, such as barge anchoring, fine-grained particles resuspended from the bottom would be confined to the near-bottom depth layers by natural density stratification of the water column. The subsurface suspended sediment plume would disperse rapidly as a result of particle settling and current mixing. In most cases, suspended sediment/turbidity plumes would not be visible at the surface. Propeller wash impacts would not be expected at depths where the SPE would be constructed. Stormwater discharges would be in accordance with a stormwater discharge permit and SWPPP, which would minimize the potential for discharges to affect turbidity levels at the SPE project site.

As mentioned above in the discussion of DO, a bubble curtain could be used to reduce in-water noise during some construction activities (Section 2.3.3), although the type of bubble curtain that could be used has not yet been specified by the Navy. The type of bubble curtain used will affect the suspended sediment concentrations and turbidity levels. After a pile is driven and the curtain is removed; there would still be some residual plume, although less than with an unconfined bubble curtain. Nevertheless, construction activities would not result in persistent increases in turbidity levels or cause changes that would violate water quality standards because processes that generate suspended sediments, which result in turbid conditions, would be short-term and localized, and suspended sediments would disperse and/or settle rapidly (within a period of minutes to hours) after construction activities cease.

Per WAC 173-201a-210, "[t]he turbidity criteria established under WAC 173-201A-210 (1)(e) shall be modified, without specific written authorization from the department, to allow a temporary area of mixing during and immediately after necessary in-water construction activities that result in the disturbance of in-place sediments. This temporary area of mixing is subject to the constraints of WAC 173-201A-400 (4) and (6) and can occur only after the activity has received all other necessary local and state permits and approvals, and after the implementation of appropriate best management practices to avoid or minimize disturbance of in-place sediments and exceedances of the turbidity criteria. A temporary area of mixing shall be as follows:

> D. For projects working within or along lakes, ponds, wetlands, estuaries, marine waters or other nonflowing waters, the point of compliance shall be at a radius of one hundred fifty feet from the activity causing the turbidity exceedance."

Per the discussion above regarding the settling time for resuspended particles, turbidity conditions are not expected to increase by more than 5 NTU above background at the point of compliance, 150 feet (45 meters) from the disturbance.

Nutrients

Construction activities associated with SPE Alternative 2 would not result in the discharge of wastes containing nutrients. Because sediments at the SPE project site do not contain high concentrations of nutrients, such as ammonia (Hammermeister and Hafner 2009), sediment resuspension during construction would not release nutrients to site waters in amounts that would violate water quality standards. Construction activities would not result in increases in nutrient levels or cause changes that would violate water quality standards.

Fecal Coliform Bacteria

Construction activities associated with SPE Alternative 2 would not impact bacteria (fecal indicator bacteria) levels because this alternative would not discharge untreated wastes or other materials containing bacteria. Stormwater discharges would be controlled in accordance with a stormwater discharge permit and SWPPP. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, construction activities would not result in increases in bacteria levels or cause changes that would violate water quality standards. Levels of coliform bacteria in the Hood Canal waters near the SPE project site generally are low and within the shellfish harvesting and recreation standard for fecal coliform (Section 3.1.1.1.2). Consequently, bacterial levels in coarse-grained marine sediments at the SPE project site also are expected to be low, and resuspension of sediments during construction activities would not release bacteria to site waters in amounts that would violate water quality standards.

pH

Construction activities associated with SPE Alternative 2 would not impact the pH levels of local waters because this alternative would not discharge wastes at the SPE project site. During construction, there is a potential for concrete to spill into Hood Canal, which could cause small, localized changes in pH levels. Debris management procedures (Section 3.1.1.2.3) would be implemented to prevent concrete spillage and to clean up any spilled material before or after it contacts site waters. Also, seawater has a high buffering capacity that minimizes the potential for substantial changes to pH in well-mixed marine settings (Jabusch et al. 2008). Stormwater discharges would be controlled in accordance with a stormwater discharge permit and SWPPP. Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and debris management procedures would be implemented as a current practice (Section 3.1.1.2.3), construction activities would not result in changes in pH that would violate water quality standards.

Other Contaminants

Another possible source of construction-related impacts to water quality would be accidental spills of debris, fuel, or other contaminants from barges or construction platforms into Hood Canal. Some types of construction debris such as wood scraps spilled into the water would be recovered and would have no impact, while other materials such as hydraulic fluids or fuel (marine diesel) may impact turbidity, pH, DO, or other water quality parameters in a localized area. Typically, risks of spills are managed by BMPs and current practices (Section 3.1.1.2.3), including containing and cleaning up materials leaked on the deck of work vessels, prohibiting washdown of materials into the water, and prohibiting refueling in non-authorized areas. Generally, these types of spills are not anticipated to have a large impact to water quality because the spills would likely be small and the impact would be highly localized. The size of the area affected would depend on a number of factors, such as the volume spilled, wind, wave, and current conditions at the time of the spill, and the timing and effectiveness of the response effort. The existing facility response and prevention plans for the Bangor waterfront (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) provide guidance that would be used in a spill response, such as a response procedures, notification, and communication plan; roles and responsibilities; and response equipment inventories. In the event of an accidental spill, response measures would be implemented immediately to minimize potential impacts to the surrounding environment.

The potential for releases of creosote from treated piles removed during construction of SPE Alternative 2 would be managed by BMPs and current practices (Section 3.1.1.2.3) that would minimize the potentials for formation of surface sheens or other changes in water quality. The Navy would require the construction contractor to prepare and implement debris management procedures for preventing discharge of debris to marine water and retrieving and cleaning up any debris spilled into Hood Canal. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups. Overall, with implementation of the existing facility response and prevention plans for the Bangor waterfront and debris management procedures, construction activities associated with SPE Alternative 2 would not cause any water quality standards to be violated.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

Operation of SPE Alternative 2 would not discharge wastes to Hood Canal. Drainage water from the SPE project site would be collected in a trench drain on the pier, treated using an in-line canister system designed to meet the basic treatment requirements of the WDOE Stormwater Management Manual for Western Washington, and then discharged to Hood Canal in accordance with an NPDES permit. Collection and treatment of pier drainage would be required to remove contaminants resulting from routine vehicle access to the pier. Thus, operations would not intentionally release materials that would have a potential to impact marine water quality and WDOE stormwater standards would be maintained. Additionally, wastewater (sewage and grey water wastes) from the two additional SEAWOLF Class submarines that would be relocated to and berthed at the Service Pier as part of SPE Alternative 2 would be retained in holding tanks and eventually transferred via transmission lines on the pier to the existing NAVBASE Kitsap Bangor wastewater infrastructure. This would be similar to current practices at the existing Service Pier. Wastewater from new facilities on the pier also would be pumped ashore for treatment. Therefore, shipboard and pier wastes would not affect long-term water quality conditions near the SPE project site. The risk of an accidental spill, such as a fuel or oil spill, would be expected to increase slightly due to the addition of two submarines to the project site. Spill containment practices would be consistent with those for other Bangor waterfront structures, including the use of in-water containment booms, and the existing NAVBASE Kitsap Bangor fuel spill prevention and response plans would be implemented to minimize the risk of spills during operations.

Maintenance of the SPE would include routine inspections, repair, and replacement of facility components (no pile replacement) as required. BMPs and current practices (Section 3.1.1.2.3) would be employed to avoid discharge of contaminants to the marine environment. The project would implement stormwater BMPs and be operated in accordance with the NPDES permit. With implementation of BMPs and current practices (Section 3.1.1.2.3), including the existing NAVBASE Kitsap Bangor fuel spill prevention and response plans, operation of SPE Alternative 2 would not affect water quality. Similar water quality protection measures are implemented as part of SEAWOLF operations at NAVBASE Kitsap Bremerton. Therefore, cessation of these operations would not be expected to result in significant changes in water quality at NAVBASE Kitsap Bremerton.

Stratification, Salinity, and Temperature

Operation of SPE Alternative 2 would not result in discharges, other than treated stormwater, into local waters. Therefore, operations would not result in impacts to stratification, salinity, or temperature conditions or cause changes that would violate water quality standards.

Dissolved Oxygen

Operation of SPE Alternative 2 would not result in discharges with the potential for altering DO concentrations in waters near the SPE project site. Therefore, operations would not result in impacts to DO conditions or cause changes that would violate water quality standards.

Turbidity

Vessel berthing activities associated with routine SPE operations would occur at the berthing areas in water depths of 80 to 90 feet (24 to 27 meters) MLLW. Episodic sediment resuspension would not likely occur because propeller wash-induced turbulence near the surface would not reach the seafloor at those water depths.

Nutrients

Operation of SPE Alternative 2 would not affect nutrient concentrations in marine waters at the project site because wastewater from vessels would be pumped ashore for treatment, similar to existing conditions. Therefore, because the project would not discharge wastewaters, other than stormwater that would be discharged in accordance with a stormwater permit, operations would not result in impacts to nutrient levels or cause changes that would violate water quality standards.

Fecal Coliform Bacteria

Operation of SPE Alternative 2 would not affect fecal coliform bacteria levels in marine waters at the proposed project site because wastewater from vessels would be pumped ashore for treatment, similar to existing conditions. Therefore, because the project would not discharge wastewaters, operations would not result in impacts to bacteria levels or cause changes that would violate water quality standards.

pH

Operation of SPE Alternative 2 would not result in discharges with the potential for impacting the pH of marine waters. Therefore, because the project would not discharge wastewaters, operations would not result in impacts to pH levels or cause changes that would violate water quality standards.

Other Contaminants

Operation of SPE Alternative 2 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact water quality in Hood Canal. This is because BMPs and current practices (Section 3.1.1.2.3), including the existing NAVBASE Kitsap Bangor spill prevention and response plans, would minimize the risk from fuel spills. In the event of an accidental spill, emergency cleanup measures would be implemented immediately in accordance with state and federal regulations. The cleanup would minimize impacts to the surrounding environment. Therefore, with implementation of BMPs and current practices, operation of SPE Alternative 2 would not violate water quality standards.

Placement of sacrificial aluminum anodes (for cathodic protection) on individual piles would represent a source for input of aluminum to Hood Canal waters. Aluminum anodes typically contain approximately 95 percent aluminum, 5 percent zinc, up to 0.001 percent mercury, and small amounts of silicon and iridium (USEPA 1999). As the anode is consumed (oxidized), aluminum and other trace constituents are released to surrounding waters. Based on modeling performed by USEPA (1999), the estimated flux of aluminum from an anode is 2.2×10^{-6} pounds of aluminum per pound of anode per hour. USEPA (1999) concluded that the resulting concentrations in seawater would be well below the federal and the most stringent state water quality criteria. Consequently, metal leaching from aluminum anodes placed on the wharf piles is not expected to impact water quality in the project area.

SEDIMENT QUALITY FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

No in-water dredging or placement of fill would occur under SPE Alternative 2. There would be no direct discharges of wastes, other than stormwater runoff, to the marine environment during construction. Stormwater discharges would meet the requirements of a construction stormwater discharge permit. Therefore, construction-related impacts to sediment quality would be limited to localized changes associated with disturbances of bottom sediments from removal of existing piles and installation of up to 385 piles and/or from accidental losses or spills of construction debris into Hood Canal. Setting anchors for the barges represents other, potential construction-related sources for disturbance of bottom sediments. BMPs and current practices (Section 3.1.1.2.3) would be implemented to avoid underwater anchor drag and line drag.

Another possible source for construction-related impacts to sediments would be from accidental debris spills from barges or construction platforms into Hood Canal. Debris spills could impact bottom sediments and create nuisance conditions by adding materials that could represent obstructions. The construction contractor would be required to retrieve and clean up any accidental spills as a current practice in accordance with the debris management procedures that would be developed and implemented (Section 3.1.1.2.3). Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups.

Construction-related changes to sediment quality would be spatially limited to the construction corridor, including areas potentially impacted by anchor drag.

Physical Properties of Sediments

Some degree of localized changes in sediment composition would occur as a result of in-water construction activities. In particular, sediments that are resuspended by pile installation and anchoring activities would be dispersed by currents and eventually redeposited on the bottom (Barnard 1978; Hitchcock et al. 1999). The distance over which suspended sediments are dispersed would depend on a number of factors, such as the sediment characteristics, particle settling rates, current speeds, and distance above the bottom. Depending on the distance suspended sediments are transported before settling on the bottom, this process could result in minor changes to sediment texture (grain size characteristics).

Surface sediments at the SPE project site range from 72 to 93 percent sand and gravel (Hammermeister and Hafner 2009). The maximum dispersion distance for bottom sediments disturbed during construction would be approximately 130 feet (40 meters), assuming a horizontal current velocity of 1 foot/second (30 centimeters/second) (Section 3.1.1.1.1) and a particle settling velocity of 0.3 foot/second (settling speed for a sand particle). Silt and clay particles would be dispersed over relatively larger distances (greater than 130 feet [40 meters]) because they have slower settling speeds. Rapid dilution and dispersion would minimize the potential for fine-grained sediments to settle and accumulate within sensitive habitat areas near the project site. Also, because fines represent a small proportion of the existing sediments, they would probably not result in appreciable changes in the physical composition of bottom sediments as they settle.

During construction, there is a potential for concrete to spill into Hood Canal, which could cause small, localized changes in pH levels and physical properties of sediments such as grain size. Measures to prevent concrete spillage, and clean up of any spilled material before or after it contacts site waters, would be addressed in the debris management procedures (Section 3.1.1.2.3).

Metals

Construction activities associated with SPE Alternative 2 would not result in the discharge of wastes containing metals or otherwise alter the concentrations of trace metals in bottom sediments. However, because the magnitude of metal concentrations in sediment can vary as a function of grain size (higher concentrations typically are associated with fine-grained sediments) (Schiff and Weisberg 1999), small changes to grain size associated with construction-related disturbances to bottom sediments could result in minor changes in metal concentrations. However, these changes would not cause chemical constituents to exceed marine sediment quality standards because current sediment concentrations are below the standards and the project-related changes are expected to be minimal.

Organic Contaminants

Construction activities associated with SPE Alternative 2 would not result in the discharge of contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Similar to metal concentrations (discussed above), construction would not impact sediment quality with the exception of minor changes in the concentrations of organic compounds that would result from changes in grain size. Accidental fuel spills or releases of other materials (e.g., hydraulic fluids) to Hood Canal could add contaminants (petroleum hydrocarbons) that could also impact sediment quality. However, the spill cleanup response would minimize impacts to the surrounding environment, including sediment quality.

Because the proposed project would not result in wastewater discharges, other than stormwater that would be discharged in accordance with permit conditions, and spill-related releases would be controlled by the debris management procedures and existing spill response plan (Section 3.1.1.2.3), construction activities would not cause chemical constituents to exceed marine sediment quality standards.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

Operation of SPE Alternative 2 would not discharge any wastes, other than treated stormwater, or increase contaminant loadings from vessels or the frequency or size of possible spills into Hood Canal that would affect marine sediment quality. Additionally, the two SEAWOLF Class submarines that would be relocated to and berthed at the Service Pier as part of SPE Alternative 2 would not discharge wastes to Hood Canal and would not affect long-term sediment quality conditions near the SPE project site. Maintenance of the SPE would include routine inspections, repair, and replacement of facility components (no pile replacement) as required. BMPs and current practices (Section 3.1.1.2.3) would be employed to avoid discharges of contaminants to the marine environment. Operations associated with SPE Alternative 2 would not affect sediment quality. Similar water and sediment quality protection measures are implemented as part of SEAWOLF operations at NAVBASE Kitsap Bremerton. Therefore, cessation of these operations would not be expected to result in significant changes in sediment quality at NAVBASE Kitsap Bremerton.

Physical Properties of Sediments

Current flow around the support piles installed for the SPE would cause both erosion of fine-grained sediments near some piles impacted by turbulent flows and settling and accumulation of fine-grained sediments at the base of other piles. Shells and decaying organic matter from animals would slough from the pier piles and accumulate on the bottom, contributing to localized changes in sediment grain size immediately adjacent to the piles (Hanson et al. 2003). Fine-grained sediments trapped by the pier piles could have higher contaminant concentrations compared to the coarse-grained sediments that presently occur at the site. However, these changes would only be expected to occur immediately adjacent to the pile and would not extend beyond the footprint of the SPE.

Metals

Operation of SPE Alternative 2 would not result in the discharge of contaminants that would alter the concentrations of trace metal in bottom sediments. Therefore, no chemical constituents would exceed the marine sediment quality standards.

Organic Contaminants

Operation of SPE Alternative 2 would not result in the discharge of organic contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Therefore, no chemical constituents would exceed the marine sediment quality standards.

Operation of SPE Alternative 2 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact sediment quality in Hood Canal. In the event of an accidental spill, measures specified in the existing

NAVBASE Kitsap Bangor fuel spill prevention and response plans would be implemented immediately, and the spill response would minimize impacts to the surrounding environment.

3.1.2.3.3. SPE ALTERNATIVE 3: LONG PIER

HYDROGRAPHY FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

The pier extension structure constructed under SPE Alternative 3 and the locations of the PSBs attached to the end of the longer pier extension would extend farther into Hood Canal compared with SPE Alternative 2. All other aspects of Alternative 3 would be the same as Alternative 2, including upland features and overall construction schedule.

Bathymetric Setting

Similar to SPE Alternative 2, construction of SPE Alternative 3 would have some temporary impacts to the bathymetry (seafloor topography) within the immediate construction site. Anchor placement and construction equipment mooring ground tackle, in addition to effects from pile removal and pile driving, would result in physical disturbance to the seafloor, such as mounding and displacement or movement of sediments that would result in small-scale changes to bathymetry.

Changes to bathymetry would be highly localized and less than 3 feet (1 meter) in displacement. These impacts are anticipated to be temporary because natural processes that occur at the sediment-water interface (bedload transport, bioturbation, etc.) following completion of the construction activity would return seafloor topography to near the original profile over time (6 to 12 months) without intervention or mitigation. Thus, no substantial changes to the bathymetric setting would occur.

Circulation and Currents

The circulation patterns in the surface water layer (upper 10 to 15 feet [3 to 5 meters] of water) in the immediate vicinity of the SPE Alternative 3 structure would be affected by short-term and temporary changes due to the presence of construction equipment and barges, which would partially obstruct flow. However, these effects would be localized and would not alter the overall circulation pattern and velocities in the nearshore and deeper water areas along the Bangor waterfront.

Similar to SPE Alternative 2, the presence of the SPE Alternative 3 structure would not interfere with tidal cycles and water levels at the project site would be similar to other, adjacent areas of northern Hood Canal.

Longshore Sediment Transport

Construction activities for the SPE Alternative 3 structure would not affect longshore sediment transport processes along the NAVBASE Kitsap Bangor shoreline because the influence of construction equipment on wave and current energy that are responsible for resuspending and transporting sediments along the shoreline would be negligible.

Operation/Long-term Impacts of SPE Alternative 3

Similar to SPE Alternative 2, support piles for the SPE Alternative 3 structure would dampen wave energy within the immediate vicinity of the pier, resulting in a long-term but localized effect on water circulation and currents. Water levels and tidal exchange volumes in the basin would be unaffected by the continued presence and use of the Service Pier because the pier piles would not prevent water flow. Maintenance of the SPE Alternative 3 would include routine inspections, repair, and replacement of facility components as required. These activities would not affect hydrographic conditions. Additionally, relocating and berthing two additional SEAWOLF Class submarines to the SPE Alternative 3 structure at NAVBASE Kitsap Bangor would not affect long-term bathymetry, currents, tides, or sediment transport processes near the SPE project site.

Bathymetric Setting

Support piles installed for the SPE Alternative 3 structure would alter current speeds beneath the pier, which would cause minor erosion of fine-grained sediments near some piles impacted by turbulent flows, as well as settling and accumulation of fine-grained sediments at the base of other piles (Chiew and Melville 1987). The loss of fine-grained sediment would be offset by the accumulation of shell and barnacle particles. These two processes would result in no net impact to seafloor bathymetry.

As discussed for SPE Alternative 2, the presence of the SPE structure would not affect seabed elevations within the project area and, therefore, would have negligible impact on the bathymetric setting.

Circulation and Currents

Since the SPE Alternative 3 structure would be constructed on a foundation of piles, the overall flow volume of water into the nearshore and deeper water areas adjacent to the project site would not be affected. It is anticipated that a small decrease in water column current velocities would occur downcurrent of the SPE, but there would be an overall increase in the turbulence and mixing in the water mass passing directly under the structure. Overall, the presence of the SPE Alternative 3 structure would have a negligible effect on hydrodynamic processes within the project region.

The SPE Alternative 3 structure would not affect the tidal range along the NAVBASE Kitsap Bangor shoreline or the immediate project area because the pier extension would be constructed on a foundation of piles that allows water exchange with portions of Hood Canal immediately offshore from the SPE. Water depths would remain the same in the subtidal areas adjacent to the SPE project site, and the tidal range along the shoreline would not change as a result of the SPE structure.

Longshore Sediment Transport

Similar to SPE Alternative 2, the presence of the SPE Alternative 3 structure is not expected to result in net deposition or erosion of sediments within the project area. Thus, the SPE Alternative 3 project is not expected to affect the sediment budget and rates of erosion/accretion outside of the project footprint, significantly interrupt longshore sediment transport processes, or result in changes to the NAVBASE Kitsap Bangor or West Kitsap County shoreline.

WATER QUALITY FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

Impacts on marine water quality from in-water construction of SPE Alternative 3 would be short-term, localized, and similar to those noted for SPE Alternative 2. Construction activities would not impact water salinity, temperature, DO, nutrients, and pH, and would not increase concentrations of fecal coliform bacteria or other contaminants in the water. These parameters would remain in compliance with applicable water quality standards. As discussed for SPE Alternative 2, BMPs and current practices (Section 3.1.1.2.3) would be implemented to avoid changes to water quality from releases of creosote during pile removal activities.

An estimated 660 piles are proposed for installation under SPE Alternative 3, compared to 385 piles under SPE Alternative 2. The in-water construction period for SPE Alternative 3 would be proportionately longer (up to 205 days of pile driving) compared to SPE Alternative 2 (up to 161 days of pile driving) due to the greater number of piles. Installation of additional piles would result in resuspension of bottom sediments (turbidity) within the immediate construction area for a longer duration compared to SPE Alternative 2. Thus, the potential for water quality impacts during pile driving under SPE Alternative 3 would be greater than for SPE Alternative 2.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 3

Impacts to water quality from operation of SPE Alternative 3 would be the same as noted for SPE Alternative 2. This alternative would not result in direct discharges into Hood Canal or in activities that would have direct or indirect impacts to water quality. Additionally, the two additional SEAWOLF Class submarines that would be relocated to and berthed at the Service Pier as part of SPE Alternative 3 would not discharge wastes to Hood Canal and would not affect long-term water quality conditions near the SPE project site. Maintenance of the SPE under Alternative 3 would have the same water quality impacts as SPE Alternative 2. Similar water quality protection measures are implemented as part of SEAWOLF operations at NAVBASE Kitsap Bremerton. Therefore, cessation of these operations would not be expected to result in significant changes in water quality at NAVBASE Kitsap Bremerton.

SEDIMENT QUALITY FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

Similar to SPE Alternative 2, no in-water dredging or placement of fill would occur under SPE Alternative 3. There would be no direct discharges of wastes, other than stormwater runoff, to the marine environment during construction. Stormwater discharges would meet the requirements of a construction stormwater discharge permit. Therefore, construction-related impacts to sediment quality would be limited to localized changes associated with disturbances of bottom sediments from installation of piles and from accidental losses or spills of construction debris into Hood Canal. Setting anchors for the barges represent other, construction-related sources for disturbances of bottom sediments. BMPs and current practices would be implemented (Section 3.1.1.2.3) to avoid underwater anchor drag and line drag.

The construction contractor would be required to retrieve and clean up any accidental spills, including concrete, in accordance with the debris management procedures that would be developed and implemented per the BMPs and current practices (Section 3.1.1.2.3). Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups.

Physical Properties of Sediments

Sediments that are resuspended by pile removal, pile installation, and anchoring activities would be dispersed by currents and eventually redeposited (Barnard 1978; Hitchcock et al. 1999). Depending on the distance suspended sediments are transported before settling on the bottom, this process could result in minor changes to sediment texture (grain size characteristics).

Sand sized particles disturbed during construction could be displaced horizontally by an estimated distance of 130 feet (40 meters). Silt and clay particles would be dispersed over relatively larger distances because they have slower settling speeds. However, because these resuspended fines represent a small proportion of sediments, they probably would not result in appreciable changes in the physical composition of bottom sediments as they settle. Rapid dilution and dispersion would minimize the potential for fine-grained sediments to settle and accumulate within sensitive habitat areas near the project site.

Metals

Construction activities associated with SPE Alternative 3 would not result in the discharge of wastes containing metals or otherwise alter the concentrations of trace metals in bottom sediments. However, small changes to grain size associated with construction-related disturbances to bottom sediments could result in minor changes in metal concentrations. However, these changes would not cause chemical constituents to exceed marine sediment quality standards because current sediment concentrations are below the standards and the project-related changes are expected to be minimal.

Organic Contaminants

Construction activities associated with SPE Alternative 3 would not result in the discharge of contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Similar to metal concentrations (discussed above), construction would not impact sediment quality with the exception of minor changes in the concentrations of organic compounds that would result from changes in grain size. These changes would not cause chemical constituents to exceed marine sediment quality standards because current sediment concentrations are below the standards and the project-related changes are expected to be minimal.

Accidental fuel spills or releases of other materials (e.g., hydraulic fluids) to Hood Canal could add contaminants (petroleum hydrocarbons) that could also impact sediment quality. However, the existing NAVBASE Kitsap Bangor fuel spill prevention and response plans would minimize impacts to the surrounding environment.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 3

Operation of SPE Alternative 3 would not discharge any wastes, other than treated stormwater, or increase contaminant loadings from vessels or the frequency or size of possible spills into Hood Canal that would affect marine sediment quality. The two SEAWOLF Class submarines that would be relocated to and berthed at the Service Pier as part of SPE Alternative 3 would not discharge wastes to Hood Canal and would not affect long-term sediment quality conditions near the SPE project site. Maintenance of the SPE would include routine inspections, repair, and replacement of facility components (no pile replacement) as required. BMPs and current practices (Section 3.1.1.2.3) would be employed to avoid discharges of contaminants to the marine environment. Operation of SPE Alternative 3 would not affect sediment quality. Similar water and sediment quality protection measures are implemented as part of SEAWOLF operations at NAVBASE Kitsap Bremerton. Therefore, cessation of these operations would not be expected to result in significant changes in sediment quality at NAVBASE Kitsap Bremerton.

Physical Properties of Sediments

The support piles installed for the SPE would cause both erosion of fine-grained sediments near some piles impacted by turbulent flows and settling and accumulation of fine-grained sediments at the base of other piles. Shells and decaying organic matter from animals would slough from the pier piles and accumulate on the bottom, contributing to localized changes in sediment grain size immediately adjacent to the piles (Hanson et al. 2003). However, these changes would only be expected immediately adjacent to the pile and would not extend beyond the footprint of the SPE.

Metals

Operation of SPE Alternative 3 would not result in the discharge of contaminants that would alter the concentrations of trace metals in bottom sediments. Therefore, no chemical constituents for metals would exceed the marine sediment quality standards.

Organic Contaminants

Operation of SPE Alternative 3 would not result in the discharge of organic contaminants or otherwise alter the concentrations of organic contaminants in bottom sediments. Therefore, no chemical constituents for organic contaminants would exceed marine sediment quality standards.

Operation of SPE Alternative 3 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact sediment quality in Hood Canal. In the event of an accidental spill, emergency cleanup measures would be implemented immediately, and the spill response would minimize impacts to the surrounding environment.

3.1.2.3.4. SUMMARY OF IMPACTS FOR SPE PROJECT ALTERNATIVES

Impacts on marine water resources associated with the construction and operation phases of the SPE project alternatives, along with mitigation measures and consultation and permit status, are summarized in Table 3.1–6.

Table 3.1–6. Summary of SPE Impacts on Marine Water Resources

Alternative	Environmental Impacts on Marine Water Resources
Impact	
SPE Alternative 1: No Action	No impact.
SPE Alternative 2: Short Pier (Preferred)	*Construction*: Temporary and localized alterations of bottom bathymetry from pile removal and installation and anchor dragging, within the construction footprint (maximum 3.9 acres [1.6 hectares]), and small-scale changes in wave and current patterns. Project construction activities could result in temporary and localized changes in water quality associated with resuspension of bottom sediments (increased suspended sediment concentrations and turbidity levels), stormwater discharges (contaminant loading), and spills (contaminant releases), but conditions are not expected to exceed water quality standards. Project construction activities would result in disturbance of bottom sediments through pile removal and installation and anchoring of barges and vessels, which would affect physical characteristics of the sediments such as grain size. Impacts on sediment contaminant levels are unlikely, and conditions are not expected to exceed marine sediment quality standards. Changes to marine water resources associated with project construction activities could occur throughout the in-water construction phase of the project. Changes to water quality conditions likely would persist for minutes to hours following disturbances, whereas changes to sediment conditions would persist for weeks to months. Construction-related changes would not be expected to occur beyond the immediate project site. *Operation/Long-term Impacts*: Small-scale changes in flow patterns could result in localized scouring or accumulation of sediments in the immediate vicinity of the support piles. These changes likely would be seasonal, as storm waves would resuspend and redistribute sediments that were deposited initially near the structures. Project operations would not involve discharges of waste or other materials with the potential for impacting water or sediment quality. The presence of the SPE structure would result in marginal changes in current velocity but would not affect sediment deposition/erosion patterns or longshore sediment transport processes within the project area.
SPE Alternative 3: Long Pier	*Construction:* Same as SPE Alternative 2 except larger potential construction footprint of 6.6 acres (2.7 hectares). Temporary and localized alterations of bottom bathymetry from pile removal and installation and anchor dragging, within the construction footprint, and small-scale changes in wave and current patterns. Project construction activities could result in temporary and localized changes in water quality associated with resuspension of bottom sediments (increased suspended sediment concentrations and turbidity levels), stormwater discharges (contaminant loading), and spills (contaminant releases), but conditions are not expected to exceed water quality standards. Project construction activities would result in disturbance of bottom sediments through pile removal and installation and anchoring of barges and vessels, which would affect physical characteristics of the sediments such as grain size. Impacts on sediment contaminant levels are unlikely, and conditions are not expected to exceed marine sediment quality standards.

Table 3.1–6. Summary of SPE Impacts on Marine Water Resources (continued)

Alternative	Environmental Impacts on Marine Water Resources
	Operation/Long-term Impacts: Same as SPE Alternative 2. Small-scale changes in flow patterns could result in localized scouring or accumulation of sediments in the immediate vicinity of the support piles. These changes likely would be seasonal, as storm waves would resuspend and redistribute sediments that were deposited initially near the structures. Project operations would not involve discharges of waste or other materials with the potential for impacting water or sediment quality. The presence of the SPE structure would result in marginal changes in current velocity but would not affect sediment deposition/erosion patterns or longshore sediment transport processes within the project area.
Mitigation: BMPs and current practices to reduce and minimize impacts on marine water resources from the proposed SPE project are described in Section 3.1.1.2.3. No mitigation measures are necessary beyond BMPs and current practices.	
Consultation and Permit Status: The Navy will obtain permits from USACE for this project under CWA Section 401 and Rivers and Harbors Act Section 10 and request concurrence from WDOE with the Navy's CCD under CZMA. Alternative 2 is the Least Environmentally Damaging Practicable Alternative according to the CWA Section 404(b)(1) guidelines.	

BMP = best management practices; CCD = Coastal Consistency Determination; CWA = Clean Water Act; CZMA = Coastal Zone Management Act; DO = dissolved oxygen; USACE = U.S. Army Corps of Engineers; WDOE = Washington Department of Ecology

3.1.2.3.5 COMBINED IMPACTS OF THE LWI AND SPE PROJECT ALTERNATIVES

HYDROGRAPHY

Results from hydrodynamic modeling indicated that the presence of the proposed LWI and SPE structures would cause only marginal changes in current velocities. LWI Alternative 3 has little potential to affect hydrographic conditions or sediment transport. LWI Alternative 2, the pile-supported pier, has greater potential to have combined impacts with the SPE and therefore is the focus of the following discussion. For both typical and infrequent conditions (2-year and 50-year storm event scenarios, respectively), average changes in seabed elevations with the proposed LWI and SPE pile-supported pier structures in place would be similar to the average changes in seabed elevations under existing conditions (i.e., without the proposed LWI and SPE pier structures). Based on these results, combined impacts from construction and operation of the LWI and SPE pier structures would not be expected to cause appreciable erosion or deposition of sediments within the project area or affect littoral transport processes with the Region of Influence (ROI).

LWI Alternative 2 and the SPE would construct in-water structures resulting in localized changes in flow patterns. Combined, these projects would not alter the larger circulation patterns in Hood Canal; result in current conditions that would prevent or restrict other uses of Hood Canal (for example, strong currents that would endanger recreational boaters or fishermen); alter the migration pathways for marine organisms; or create stagnant water conditions that adversely affect water quality. Differences between the LWI and SPE alternatives in their contribution to the cumulative affected area would be minor for marine water resources. Thus, the other project alternatives would not contribute to significant impacts on hydrology.

WATER QUALITY

The proposed LWI and SPE projects would not involve direct discharges of wastes with the potential for impacting marine water quality in Hood Canal. Stormwater would be discharged in accordance with discharge permits and stormwater pollution prevention plans. Construction activities associated with both projects would result in temporary and localized effects, including disturbances to bottom sediments and elevated suspended sediment concentrations and turbidity levels. However, because these effects would be temporary and localized, and project-related construction and operation activities would be conducted in accordance with permit conditions, BMPs, and current practices (Section 3.1.1.2.3), the proposed LWI and SPE projects combined would not create conditions that would violate state water quality standards or interfere with beneficial uses of the water body.

SEDIMENT QUALITY

The proposed LWI and SPE projects would not involve direct discharges of wastes to Hood Canal with the potential for impacting sediment quality, and stormwater discharges would be in accordance with discharge permits and stormwater pollution prevention plans. Construction activities associated with both projects would result in temporary and localized disturbances to bottom sediments. However, because these effects would be temporary and localized, and project-related construction and operation activities would be conducted in accordance with permit conditions, BMPs, and current practices (Section 3.1.1.2.3), the proposed LWI and SPE projects combined would not create conditions that would violate state sediment quality standards or interfere with beneficial uses of the water body. The LWI overwater area would impact 0.12 to 0.36 acre (0.047 to 0.15 hectare), depending on the alternative, and the overwater area for LWI. The SPE overwater area would impact 1.0 to 1.6 acres (0.41 to 0.65 hectare), depending on the alternative. The combined total for both projects would be up to 2 acres (0.8 hectare) of affected bottom sediments.

The combined impacts of the LWI and SPE projects on hydrography, water quality, and sediment quality are summarized below in Table 3.1–7.

Table 3.1–7. Summary of Combined LWI/SPE Impacts for Marine Water Resources

Resource	Combined LWI/SPE Impacts
Hydrography	The effects of the LWI and SPE projects on currents, circulation, and sediment transport would be minor and localized. Therefore, the combined effects of the two projects would not overlap in space and would not affect currents, circulation, and sediment transport along the NAVBASE Kitsap Bangor waterfront in general.
Marine Water Quality	Construction of the LWI and SPE projects would result in localized and temporary increases in turbidity; BMPs would prevent adverse impacts from spills. Operation of the LWI and SPE would not result in adverse discharges to water bodies (stormwater would be treated). Therefore, the combined effects of the two projects on marine water quality would be no greater than localized and temporary.
Marine Sediment Quality	Construction of the LWI and SPE could disturb sediments in a combined area of 2 acres (0.8 hectare); BMPs would prevent adverse impacts from spills. Operation of the LWI and SPE would not result in adverse discharges to water bodies (stormwater would be treated). Therefore, the combined effects of the two projects on marine sediment quality would be minimal.

3.2. MARINE VEGETATION AND INVERTEBRATES

3.2.1. Affected Environment

Marine vegetation communities include species of aquatic plants such as eelgrass and macroalgae. Benthic communities inhabit the bottom of a body of water such as a lake or ocean and include sea snails and worms, sea stars, and shellfish such as oysters, clams, crabs, and shrimp. Plankton are single-celled algae and multi-cellular animals that reside in the water column and form the foundation of the marine food web.

3.2.1.1. EXISTING CONDITIONS

3.2.1.1.1. NEARSHORE HABITATS

The nearshore marine environment extends from the upper intertidal to subtidal nonphotic zone (below a level supporting plant growth). Nearshore habitats include bluffs, beaches, mudflats, kelp and eelgrass beds, salt marshes, gravel spits, and estuaries. Bottom types in the nearshore include consolidated (rock) and unconsolidated (cobble, gravel, sand, and mud) substrate. For evaluating habitat impacts and mitigation in a regulatory context, the 30 feet [9 meters] below MLLW line is used to define nearshore habitat. Nearshore habitats are critical to biological resources, including shellfish, salmon, groundfish, seabirds, and marine mammals.

3.2.1.1.2. MARINE VEGETATION COMMUNITIES

Marine vegetation includes macrophytes and macroalgae. Macrophytes are aquatic rooted, flowering plants. Macrophyte genera that occur in the Pacific Northwest include *Salicornia* (sea asparagus), *Zostera* (eelgrasses), and *Phyllospadix* (surfgrasses). Algae are a diverse group of simple plants that are mainly aquatic. These organisms are capable of photosynthesis and range in size from single-celled organisms (i.e., phytoplankton, discussed in Section 3.2.1.1.4) to large plants often referred to as seaweeds. Macroalgae lack true roots, stems, and leaves. They are divided into three taxonomic groups based upon their dominant photosynthetic pigmentation: green, red, and brown (Lamb and Hanby 2005).

Aquatic marine vegetation of the NAVBASE Kitsap Bangor shoreline is composed of intertidal and subtidal species, as well as floating and attached species. Distribution maps of key species are presented below under Marine Vegetation Types. Eelgrass is high-quality habitat and is most abundant in low-energy areas in the lower intertidal and shallow subtidal photic zone where organic matter and nutrients are abundant (Johnson and O'Neil 2001). Dense to patchy bands of eelgrass are located in the vicinity of the north and south LWI project sites (Science Applications International Corporation [SAIC] 2009). Green algae grow mainly in the lower intertidal and subtidal zones and include common species, such as sea lettuce (*Ulva* spp.). Red algae are located in the cobble and gravel upper intertidal zone but also occur subtidally. Brown algae, which include understory kelps (*Saccharina* sp.[1]) and the non-native Sargasso weed, or wireweed (*Sargassum muticum*), are found in nearshore environments of the Bangor shoreline from lower intertidal to subtidal zones (SAIC 2009).

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[1] *Laminaria* in the Pacific Northwest have recently been reclassified as *Saccharina* sp. except for *L. yezoensis*, which does not occur in Washington waters.

MARINE VEGETATION TYPES

Marine vegetation within the NAVBASE Kitsap Bangor shoreline includes eelgrass; kelp; *Sargassum*; and green, red, and brown algae (Table 3.2–1). Marine vegetation in the vicinity of the north and south LWI project sites includes primarily eelgrass, green and red algae, and kelp (a type of brown algae that includes *Saccharina* sp.). Most forms of macroalgae were documented in the shallow subtidal zone between 0 and 10 feet (0 and 3 meters) below MLLW, often growing with eelgrass (SAIC 2009; Leidos and Grette Associates 2013a).

A survey of the Bangor shoreline was conducted in 2007 to characterize and document the presence and relative abundance of marine vegetation (SAIC 2009). The 2007 survey area extended to a depth of approximately 50 feet (15 meters) below MLLW. Eelgrass beds and macroalgae communities were mapped and relative densities were determined along the entire shoreline. In 2012, a focused survey was conducted of the SPE project area (Anchor QEA 2012). This survey documented the distribution of eelgrass and eelgrass shoot density, and reported general observations of macroflora and macrofauna in the project area, but did not map the extent of macroalgae or determine macroalgae densities. In 2013, a focused survey was conducted of the areas within 25 feet (8 meters) on each side of the centerlines of the proposed north and south LWI structures (Leidos and Grette Associates 2013a). This survey documented the distribution of eelgrass and macroalgae, eelgrass shoot density, and relative abundance of macroalgae in the project areas.

Table 3.2–1. Abundance of Marine Vegetation Classified as Percent of Linear Shoreline, NAVBASE Kitsap Bangor

Vegetation Type	Percent Linear Shoreline[1]	Acreage (hectares)[2,3]
Eelgrass (*Zostera* sp.)	81.9	37.7 (15.3)
Green Algae (e.g., *Ulva* spp.)	97.4	202.1 (82)
Red Algae (e.g., *Gracilaria* spp.)	76.8	73.8 (30)
Brown Algae		
(*Fucus*-Barnacle Assemblage)[2]	60.4	Not determined
Kelp (*Saccharina* sp.)	75.8	58.4 (23.6)
Sargassum muticum	15.9	11.8 (4.8)

Sources: Washington Department of Natural Resources (WDNR) 2006; SAIC 2009

1. Percent represented by proportionate amount in sampled area.
2. Macroalgae coverage data collected by Science Applications International Corporation (SAIC) in 2007 were concentrated in the lower intertidal and shallow (less than 70 feet [21 meters]) zones along the Bangor shoreline. *Fucus* occurrence in the upper intertidal of the Bangor shoreline is based on the Washington State Shorezone Inventory (WDNR 2006). These data are not included in algal distribution figures.
3. Eelgrass and macroalgae overlap in their occurrence along the Bangor shoreline; therefore, the total shoreline length or acreage of marine vegetation cannot be calculated by simply summing the values for each vegetation type.

EELGRASS

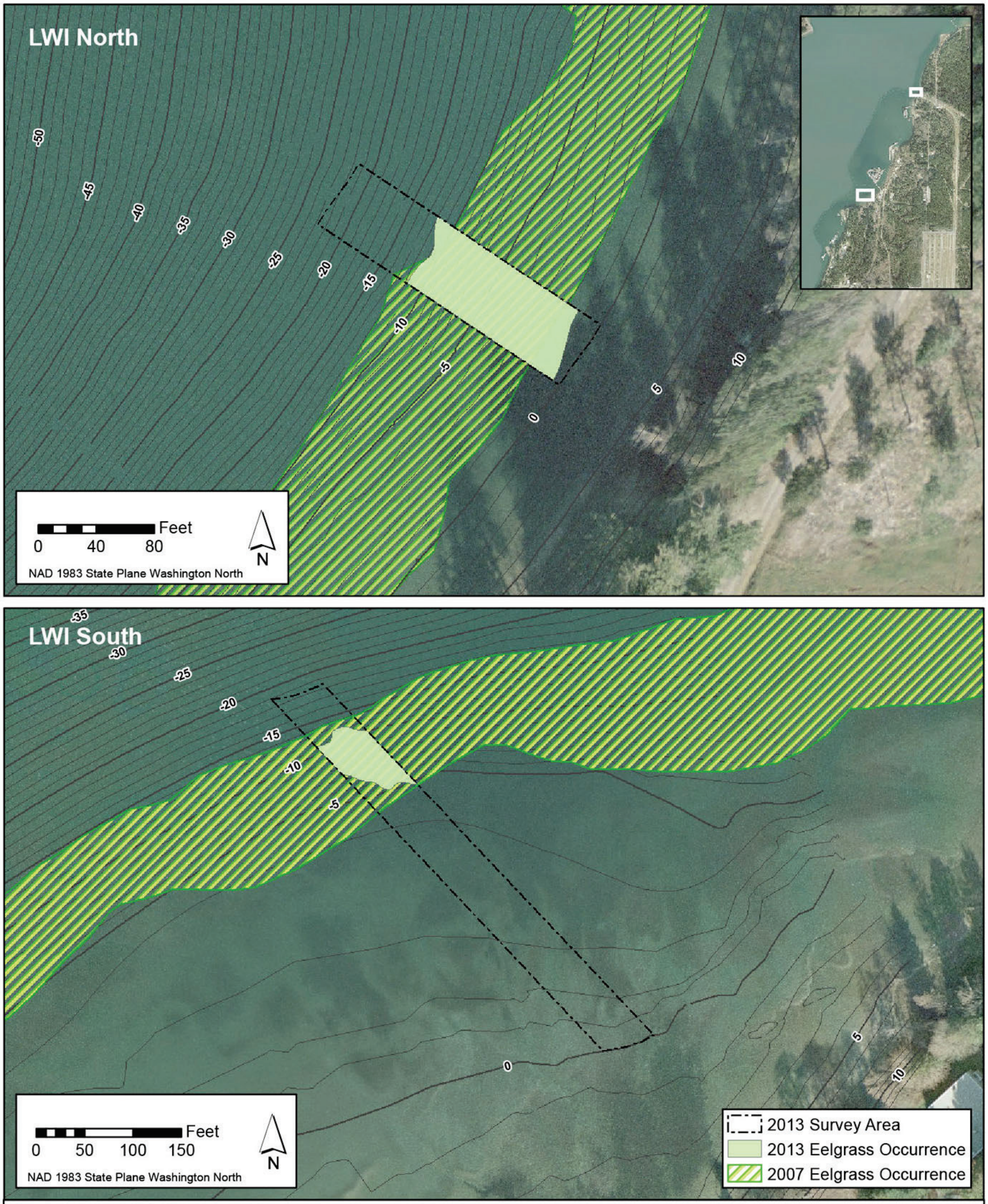
Eelgrass is one of the most important vegetation types in the marine ecosystem because eelgrass beds produce large amounts of carbon that fuel nearshore food webs and offer habitat to many marine species (Mumford 2007). Eelgrass beds build up in the spring and summer and decay in the fall and winter (Puget Sound Water Quality Action Team 2001). Shellfish, such as crabs and bivalves, use eelgrass beds for habitat and nursery areas. Eelgrass is an important habitat for juvenile salmonids, which use eelgrass beds as migratory corridors, for protection from predators, and for foraging (review in Mumford 2007). Kitsap County has one of the state's highest percentages of estuary and nearshore marine habitats occupied by eelgrass (WDNR 2006). Eelgrass depth distributions are related to water clarity, and in Hood Canal eelgrass can be found at maximum depths of about 24 feet (7 meters) (review in Mumford 2007). Well-established eelgrass beds were documented in 2007 in all survey areas along the Bangor shoreline in shallow water depths ranging from 0 to 20 feet (0 to 6 meters) below MLLW (SAIC 2009).

Eelgrass at the LWI Project Sites

North LWI Project Site. Based on the results of the 2007 surveys, an eelgrass bed of just over 12 acres (4.9 hectares) occurs in a continuous, narrow band along the shoreline north of EHW-1, ending at the Magnetic Silencing Facility (MSF) (SAIC 2009). The upper limits of this eelgrass bed corresponded to the MLLW line and extended out to water depths of about 14 feet (4 meters) below MLLW (Figure 3.2-1). In 2013 this bed was approximately 120 feet (37 meters) wide and extended to just over 12 feet (4 meters) below MLLW at the north LWI location (Leidos and Grette Associates 2013a). Average shoot density of the eelgrass in 2013 was 9.8 shoots per square foot (105.5 shoots per square meter). In 2013 a narrow band (approximately 15 feet [4.5 meters wide]) of *Z. japonica* was present along the shallow edge of the eelgrass bed at depths between 0 and 5 feet (1.5 meters) below MLLW.

Given that viable eelgrass habitat is limited to the zone between the MLLW line and the photocompensation depth (the depth where photosynthesis is unable to meet the metabolic demands of the plant to sustain net growth), the narrow width of this eelgrass bed is a result of the steep profile of the coastline in this area (SAIC 2009) as well as wave action in this exposed location (Leidos and Grette Associates 2013a). The continuous bed extends south from Floral Point and then broadens within the suitable substrate into a large area of dense coverage where the physical conditions (light, substrate type, etc.) can support many large-bladed plants. As the eelgrass bed continues south toward EHW-1, it narrows again to a swath of moderate to dense coverage, more consistent with the beds typical of Hood Canal.

South LWI Project Site. Based on the results of the 2007 surveys, a large eelgrass bed covering 7.6 acres (3.1 hectares) occurs in the shallow waters south of Delta Pier (SAIC 2009). This bed is restricted to water depths between 0 and 20 feet (0 to 6 meters) below MLLW. Bathymetry data indicated the presence of a large subtidal flat (0 to 5 feet [0 to 1.5 meters] below MLLW) occupying much of that area, which likely represents an outwash plain associated with sediment discharged from Devil's Hole. In addition to sediment, this inland pond and wetland also discharges fresh water into the shallow area between Delta Pier and the point at KB Dock.



Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–1. Eelgrass Distribution within the LWI Alignments

This freshwater discharge gradually mixes with the saline Hood Canal water, creating a mixing zone of brackish water along the immediate coast that likely decreases the salinity over the subtidal flat to a concentration too low to support eelgrass growth. As a result, the direct input of fresh water may have a role in preventing the eelgrass bed from expanding inshore and exploiting most of the shallow, subtidal seabed. At the location of the proposed south LWI, the bed is narrow, approximately 40 to 80 feet (12 to 24 meters) wide, and extends from 5 to 17 feet (1.5 to 5.2 meters) below MLLW (Leidos and Grette Associates 2013a). Average shoot density of the eelgrass in 2013 was 8.4 shoots per square foot (90.7 shoots per square meter). No *Z. japonica* was observed in this area during the 2013 survey.

Eelgrass at the SPE Project Site

Two small eelgrass beds were documented to the south and southwest of the existing Service Pier in a September 2012 survey (Figure 3.2–2; Anchor QEA 2012). The beds covered 0.25 and 0.14 acre (0.10 and 0.057 hectare), respectively. The 2012 survey did not extend beyond the area delineated for the southwest bed and so the total extent of that bed is unknown. Based on the 2007 survey (SAIC 2009), these two beds were one continuous band that continued to the southwest and ended just beyond Carlson Spit, covering a total of 0.69 acre (0.28 hectare). The apparent gap between the two areas of eelgrass shown in Figure 3.2–2 indicates that the more extensive eelgrass bed observed in 2007 fragmented during the years between surveys. It is unknown if the fragmentation is an artifact of inter-annual or inter-survey variability or an actual loss of eelgrass coverage at this location. In 2012, eelgrass bed elevations varied from approximately 3 to 15 feet (1 to 5 meters) below MLLW. Eelgrass shoot densities were high, ranging from 7.1 to 12.6 shoots per square foot (76 to 136 shoots per square meter) with an average density of 9.5 shoots per square foot (102 shoots per square meter) and a median density of 9.7 shoots per square foot (104 shoots per square meter). There was a slight trend of increasing shoot density in the deeper water.

MACROALGAE

Green Macroalgae

Sea lettuce (*Ulva* spp.) is the most common green algae at the Bangor shoreline. It grows from the lower-intertidal subzone to depths of more than 50 feet (15 meters) below MLLW in protected areas. However, the *Ulva* community is concentrated at depths less than about 30 feet (9 meters) below MLLW and occurs only sparsely (less than 10 percent coverage) at greater depths (Pentec 2003; SAIC 2009). Boulders in the nearshore marine habitats are typically encrusted with sea lettuce (Pentec 2003). Sea lettuce has a high nutrient content (Kirby 2001) which, when it dies and decomposes, provides an important source of nitrogen, as detritus, that supports eelgrass growth. Another green macroalga, *Ulvaria,* tends to occur in more subtidal waters in Puget Sound than does *Ulva* (Nelson et al. 2003). This macroalga was observed in only one survey quadrat in 2013, within deeper waters of the south LWI project site.

Red Macroalgae

Red algae of the genera *Endocladia*, *Mastocarpus*, *Ceramium, Porphyra*, *Gracilaria*, *Chondracanthus*, *Gracilariopsis*, *Smithora*, *Polyneura*, and *Sparlingia* are present on NAVBASE Kitsap Bangor in the intertidal zones (Pentec 2003; SAIC 2009; Leidos and Grette Associates 2013a). *Smithora naidum* is a thin, short, epiphytic red macroalgae that was observed

Source: Anchor QEA 2012

Figure 3.2–2. Eelgrass Distribution at the SPE Project Site on eelgrass in 2013 (Leidos and Grette Associates 2013a). Red algae such as those found on NAVBASE Kitsap Bangor are ecologically important as primary producers and for providing habitat for other marine organisms.

Brown Macroalgae

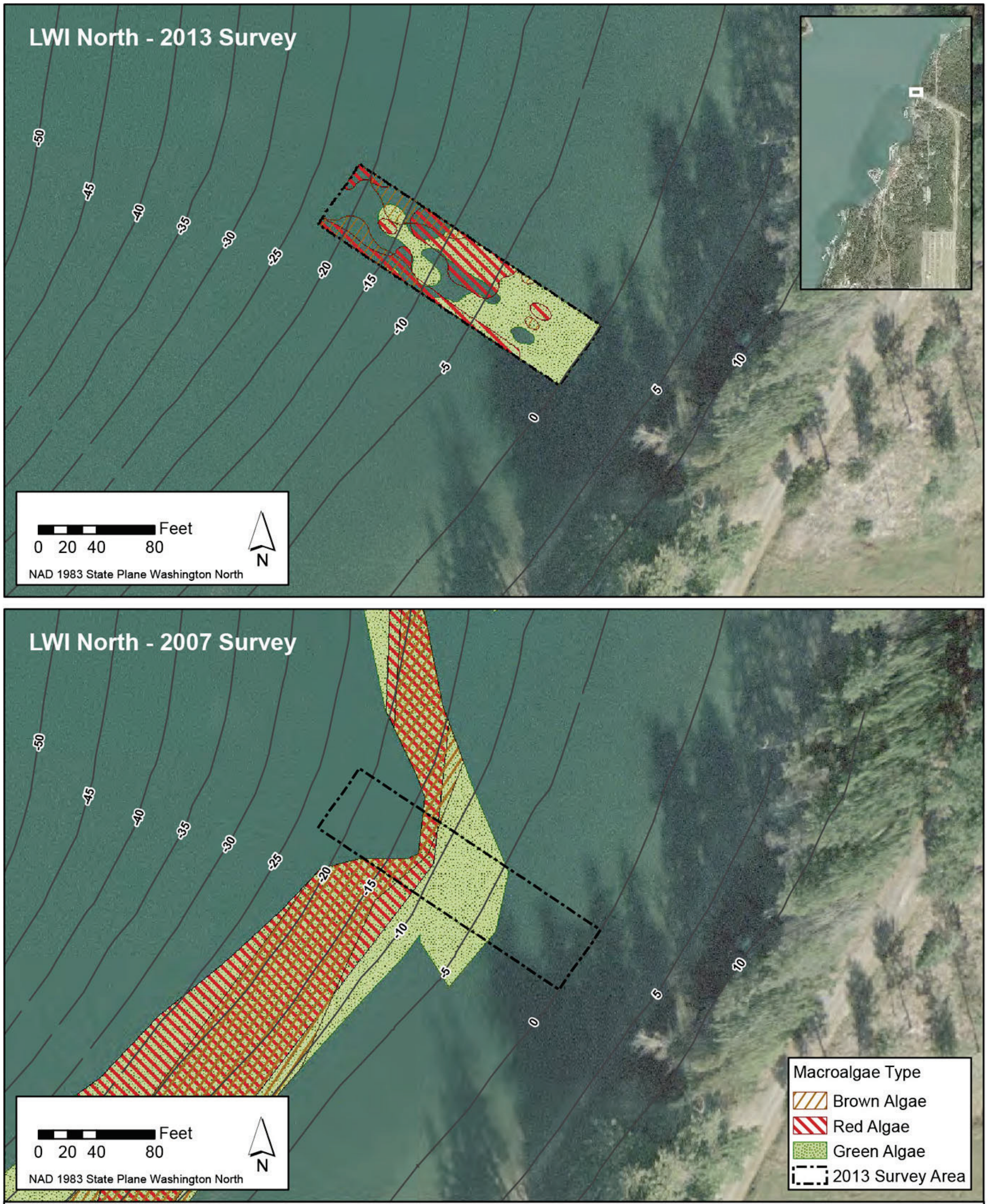
Brown algae occur in a variety of forms, including encrusting, filamentous, and leafy varieties, on rocks and boulders. A key brown alga, the understory kelp *Saccharina* sp., is discussed below under Kelp. Several leafy brown algae species (e.g., *Egregia* and *Desmarestia*) are present on NAVBASE Kitsap Bangor (Pentec 2003; Leidos and Grette Associates 2013a). Rock weed (*Fucus* spp.) attached to rocks and cobble in the intertidal barnacle zone is common in the project areas (Pentec 2003) (Table 3.2–1).

Kelp. Understory kelp (*Saccharina* sp.) provide an important source of nutrients to the seafloor (from fragmentation and decomposition) and multi-species vertical habitat in deeper marine waters (Mumford 2007). The kelp beds on NAVBASE Kitsap Bangor occur to depths of about 25 feet (8 meters) below MLLW. Most kelp in the lower-intertidal subzone and the nearshore marine habitats of NAVBASE Kitsap Bangor are *Saccharina* sp., but traces of the genera *Desmarestia* and *Pilayella* also have been documented (Pentec 2003; SAIC 2009). No attached, canopy-forming kelp beds (e.g., bull kelp) occur at the Bangor shoreline (SAIC 2009).

Sargassum muticum. Sargassum muticum is a brown macroalga native to the Sea of Japan, but it now occurs in most areas of the Pacific Coast of North America. It was first documented in Washington State waters in the 1950s and was likely introduced when Pacific oysters were planted in the early 1900s. The complex branching of *Sargassum* plants provides habitat for amphipods and other invertebrates and their predators; however, where *Sargassum* overlaps with native marine vegetation (such as eelgrass, kelp, and other macroalgae), it outcompetes those species by shading (Whatcom County Marine Resources Committee 2005). Further, *Sargassum* "may negatively affect water movement, light penetration, sediment accumulation, and [DO concentrations] at night" (Williams et al. 2001). Two large beds of *Sargassum* occur along the Bangor shoreline between the outlet of Devil's Hole and Carlson Spit. Other pockets of *Sargassum* on the base are small and isolated.

Macroalgae at the LWI Project Sites

North LWI Project Site. Based on the 2007 surveys, the predominant algae type documented in this area is *Ulva*, often accompanied by *Saccharina* and *Gracilaria* (SAIC 2009) (Figure 3.2–3). In 2013, *Ulva* spp. and *Saccharina latissima* were the dominant macroalgae species where eelgrass was absent (Leidos and Grette Associates 2013a). No *Sargassum* was detected in the vicinity of the north LWI project site in 2007 or 2013. Rockweed was attached to rocks and cobble in this area during the 2008 shellfish survey (Delwiche et al. 2008). The full extent of macroalgae coverage may not have been surveyed during 2007 since many transects did not extend to the MLLW line due to insufficient water depth for the survey vessel.



Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–3. Macroalgae Distribution within the North LWI Alignment

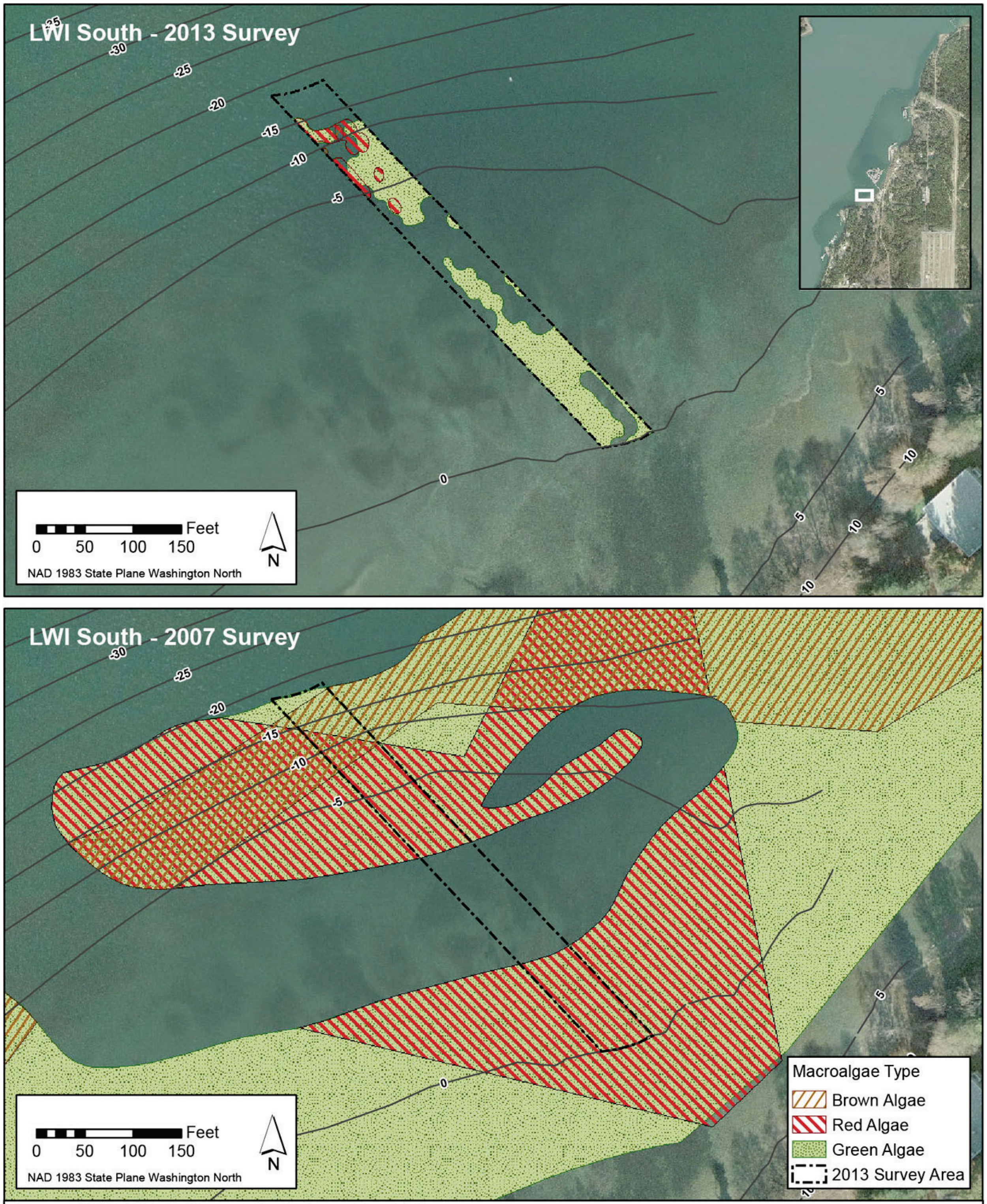
South LWI Project Site. Based on the 2007 and 2013 surveys, the predominant algae in this area are *Ulva*, *Saccharina*, and *Gracilaria* (SAIC 2009; Leidos and Grette Associates 2013a), although no *Saccharina* was observed in 2013 (Figure 3.2–4). There were mats of *Ulva* on the flats and oyster beds in this area during the 2008 shellfish survey (Delwiche et al. 2008). In 2007, *Sargassum* was detected only on the southwest side of the Devil's Hole outflow, more than 1,000 feet (300 meters) from this project area (SAIC 2009). In 2013, *Sargassum* was observed in four of the 130 survey quadrats in the south LWI project area (Leidos and Grette Associates 2013a). This species generally occurred as an individual plant, with percent coverage ranging from 1 to 5 percent in each of the four quadrats in which it was detected.

Macroalgae at the SPE Project Site

In the 2007 survey, green macroalgae (primarily *Ulva*) and kelp (*Saccharina*) were documented to the north and south and shoreward of the Service Pier (SAIC 2009) (Figure 3.2–5). Red macroalgae (primarily *Gracilaria*) were only observed to the south of the Service Pier. A long *Sargassum* bed was observed from just south of the KB Dock, running parallel to the shoreline and shoreward of the Service Pier and terminating north of the trestle, and a small pocket was observed west of the Service Pier trestle. High-percentage macroalgae coverage was limited to small areas behind the western portion of the Service Pier and at the tip of the point to the west (SAIC 2009). Species observed during the 2012 eelgrass survey included *Ulva*, *Saccharina*, *Desmarestia*, *Gracilaria*, *Sarcodiotheca*, and *Palmaria* (Anchor QEA 2012). No *Sargassum* was observed west of the Service Pier trestle within the construction area during the 2012 eelgrass survey.

3.2.1.1.3. BENTHIC COMMUNITIES

Benthic organisms, including both infaunal and epifaunal species, are abundant and diverse along the NAVBASE Kitsap Bangor waterfront (Pentec 2003; Weston 2006; Delwiche et al. 2008; Leidos and Grette Associates 2013b). Oyster beds occur along approximately 72 percent of the Bangor shoreline and occasionally co-occur with beds of mussels (Delwiche et al. 2008). Five beaches on NAVBASE Kitsap Bangor were open to shellfish harvest by residents until 2002 when increased security measures closed the beaches to shellfish gathering. The exception is that American Indian tribes continue to harvest oysters and clams on NAVBASE Kitsap Bangor at the shellfish bed at the proposed south LWI project site, off the Devil's Hole outlet (Section 3.14).



Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–4. Macroalgae Distribution within the South LWI Alignment

Source: SAIC 2009

Figure 3.2–5. Macroalgae Distribution at the SPE Project Site

BENTHIC ABUNDANCE AND DIVERSITY

Local patterns of benthic community structure are influenced by physical and chemical characteristics; therefore, benthic organisms are useful indicators of habitat differences and quality. Hood Canal has been divided into nine biotic subregions based on soft-bottom benthic community structure, dominant taxa, sediment fines (i.e., the percent of silt and clay material), TOC content of bottom sediments, and depth (WDOE 2007). NAVBASE Kitsap Bangor and the LWI and SPE project sites are within the north Hood Canal biotic subregion, which is characterized by coarser sediment, lower TOC, and higher DO values than the other biotic subregions of Hood Canal. These conditions support a relatively more abundant and diverse benthic community, including stress-sensitive species such as the seed-shrimp, a small ostracod crustacean (WDOE 2007). Table 3.2–2 provides a list of some of the benthic invertebrates and shellfish occurring on NAVBASE Kitsap Bangor. In a 2005 survey of four locations along the Bangor shoreline, abundance and diversity of benthic organisms increased from intertidal to subtidal depths (Weston 2006).

Table 3.2–2. Benthic Invertebrates along the NAVBASE Kitsap Bangor Shoreline

Phylum	Major Taxa	Genus or Species	Typical Location	Common Name or Description
Mollusca	**Gastropods**	*Alvania compacta*	Sand, silt, clay or mixed substrate, vegetated shallow subtidal	Snail
		Lirularia acuticostata	Mixed substrate, intertidal-subtidal	Sharp-keeled lirularia
	Bivalves	*Macoma* sp.	Mixed substrate, intertidal-subtidal	Macoma clam
		Nutricola spp.	Sandy subtidal	Clam
		Saxidomus gigantea	Sandy subtidal	Butter clam
		Panopea generosa	Sandy intertidal-subtidal	Geoduck clam
		Venerupis philippinarum	Gravel, sand, mud above half-tide	Manila clam
		Rochefortia tumida	Sandy intertidal-subtidal	Robust mysella
		Axinopsida serricata	Sandy or mixed substrate with organic enrichment subtidal	Silky axinopsid
		Leukoma staminea	Sandy intertidal-subtidal	Native littleneck clam
		Tellina carpenteri	Sandy or mixed sand/silt intertidal-subtidal	Clam
		Mytilus spp. [prob. *M. trossulus*]	Intertidal-subtidal, hard substrates	Blue mussel
		Pododesmus macroschisma	Hard substrates	Jingle shell
		Crassidoma gigantea	Rocky substrates subtidal, rarely intertidal under boulders	Giant rock scallop
		Crassostrea gigas	Rocky substrates	Pacific oyster

Table 3.2–2. Benthic Invertebrates at the Bangor Shoreline (continued)

Phylum	Major Taxa	Genus or Species	Typical Location	Common Name or Description
Crustaceans	**Ostracods**	*Euphilomedes carcharodonta*	All soft substrates	Seed-shrimp
	Tanaids	*Leptochelia dubia*	Mixed substrate, vegetated habitat, manmade structures	Tanaid
	Barnacles	*Balanus* sp. could also include *Semibalanus* spp.	Rocky, manmade structures	Barnacle
	Amphipods	*Protomedeia* sp.	All soft substrates	Gammarid
		Aoroides spp.	Detritus, sand, vegetated habitats	Corophiid
		Rhepoxynius boreovariatus	Sandy subtidal	Gammarid
		Corophium and *Monocorophium* spp.	Sandy subtidal, manmade structures	Corophiid
	Crabs	*Hemigrapsus oregonensis*	Quiet water, rocky habitats, gravel	Yellow shore crab
		Pagurus granosimanus	Mixed substrate, eelgrass, subtidal	Hermit crab
		Pugettia spp.	Sand/silt/clay subtidal, eelgrass	Kelp crab
		Cancer gracilis	Intertidal and subtidal, eelgrass	Graceful crab
		Cancer magister	Intertidal and subtidal, eelgrass	Dungeness crab
		Cancer oregonensis	Rocky and manmade structures, intertidal-subtidal	Oregon Cancer crab
		Cancer productus	Sandy, protected rocky areas, eelgrass, intertidal-subtidal	Red rock crab
	Shrimp	*Crangon* sp.	Shallow waters, sandy substrates	True shrimp
		Pandalus sp.	Mixed sand substrate intertidal and shallow subtidal	Spot shrimp
		Neotrypaea sp.	Mixed sand substrate intertidal and shallow subtidal	Ghost shrimp
Annelida	***Polychaetes***	*Platynereis bicanaliculata*	Mixed substrates, manmade structures, eelgrass	Nereidae
		Pectinaria californiensis	Sandy, low intertidal and subtidal	Cone worm
		Owenia collaris	Sandy, intertidal-subtidal	Oweniidae
Echinodermata	***Echinoderms***	*Pisaster brevispinus*	Subtidal eelgrass	Pink sea star
		Pisaster ochraceus	Lower intertidal, hard structures	Purple star
		Amphiodia urtica/periercta	Subtidal silty mud	Burrowing brittle star
		Pycnopodia helianthoides	Lower intertidal to subtidal soft substrates	Sunflower star
		Dendraster excentricus	Flat, sandy subtidal	Sand dollar
Chordata	***Tunicates***	*Corella willmeriana*	Subtidal to deep water	Transparent tunicate
		Distaplia occidentalis	Intertidal to subtidal	Mushroom compound tunicate

Sources: Abbott and Reish 1980; Barnard et al. 1980; Lee and Miller 1980; Kozloff 1983; URS 1994; WDOE 1998; Pentec 2003; Weston 2006; Leidos and Grette Associates 2013b

BENTHIC ABUNDANCE AND DIVERSITY AT THE LWI AND SPE PROJECT SITES

Surveys indicate the intertidal benthic community at the north LWI project site is dominated by the clam *Rochefortia tumida*, oligochaetes, the tanaid *Leptochelia dubia*, nematodes, and the polychaete *Owenia collaris* (Weston 2006). The subtidal benthic community at the north LWI project site is dominated by the gastropod *Alvania compacta*, the polychaete *Platynereis bicanaliculata*, the clam *Axinopsida serricata*, and nematodes. The intertidal benthic community at the south LWI project site is dominated by the nemertean *Anopla*, the clam *R. tumida*, the tanaid *L. dubia*, nematodes, and the snail *Haminoae vesicula*. The subtidal benthic community at the south LWI project site is dominated by the gastropod *A. compacta*, the ostracod *Euphilomedes carcharodonta*, the polychaete *P. bicanaliculata*, *Nutricola* clams, the clam *A. serricata*, and nematodes. Substrates behind the Service Pier on the north side in the intertidal are cobble and large gravel in sand and did not contain any evidence of clams in the 2008 shellfish survey (Delwiche et al. 2008). In the 2007 eelgrass survey, no bivalve siphons were seen extending from sediments shoreward of this pier (SAIC 2009).

Several factors likely contribute to local variability in benthic communities, including proportions of relatively coarser to finer sediment fractions associated with mixed sand and gravel substrates. Organic content of sediments is low along the shoreline but may range higher in depositional areas near wharves (Section 3.1.1.1.3) and would be expected to be greater in areas with submerged aquatic vegetation. In addition, proximity to freshwater tributaries influences the composition of the benthic community along the shoreline (Weston 2006).

MOLLUSCS

Molluscs are invertebrates that have soft, unsegmented bodies and are usually protected by a shell. Those occurring at NAVBASE Kitsap Bangor include two major classes: gastropods (slugs and snails) and bivalves (having two-part shells, such as clams, oysters, and mussels). In contrast to mussels and oysters, which attach to hard substrate, clams live fully buried in the substrate and gastropods live on the substrate surface. Oysters and many species of clams are filter feeders on plankton. Some clams also feed on organic matter at the sediment surface. Gastropods feed on vegetation and organic matter at the sediment surface and/or prey on other invertebrates.

The gastropod snail *Alvania compacta* was a numerical dominant of shallow subtidal waters at both LWI project sites (Weston 2006); it is commonly found in mixed sediments including fine gravels (Kozloff 1983). Other snails (e.g., sharp-keeled lirularia) are associated with eelgrass beds, and limpets occur intertidally on hard substrates (e.g., docks, cobble, and rocks). Common species on hard substrates (manmade structures and rocks) include blue mussels, jingle shell, rock scallop, and Pacific oyster (Navy 1988; Washington Department of Fish and Wildlife [WDFW] 2013a).

Bivalves are ecologically important because, as filter feeders, they uptake and recycle organic matter, help control phytoplankton levels, and improve water clarity, thereby allowing greater light penetration for the growth of seagrass and other marine vegetation. Molluscs are an important food source for some fish species (WDOE 2007).

MOLLUSCS AT THE LWI PROJECT SITES

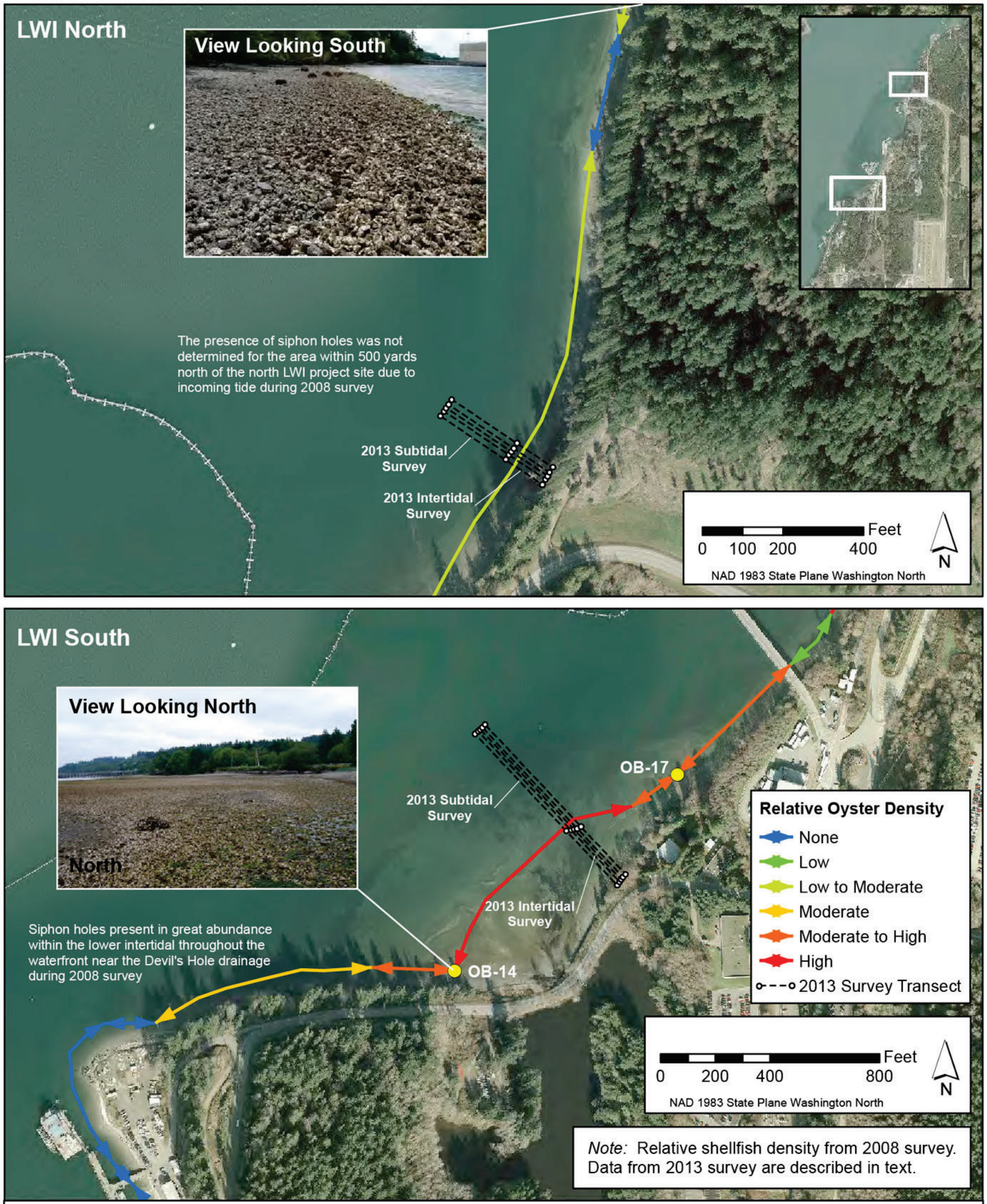
A variety of bivalves occur within the proposed LWI project sites, ranging from intertidal to subtidal depths (Table 3.2–2). Common intertidal species include Macoma clams, robust mysella, butter clams, littleneck clams, horse clams, and soft-shelled clams (Pentec 2003; Weston 2006; Delwiche 2008). In 2005, the most abundant species in subtidal waters include silky axinopsid, various dwarf venus clams, fine-lined lucine, and robust mysella (Weston 2006). Robust mysella live in semi-permanent burrows and can be an indicator of a more stable habitat (Ockelmann and Muus 1978). Based on the 2013 shellfish survey of the north LWI site (Leidos and Grette Associates 2013b), bent nose clams were the most abundant clams in the intertidal region, followed by butter clams and native little necks (Table 3.2–3). At the south LWI project site, bent nose clams were the most abundant clams in the intertidal region, followed by Manila clams and native little necks. Other species were present in lesser numbers. In the 2013 subtidal survey, only 9 percent of the north LWI survey locations contained clam siphons. All were identified as horse clams. Similarly, in the 2013 subtidal survey of the south LWI project site, only 9 of 130 sample locations (7 percent) contained infaunal shellfish. These included geoduck, false geoduck (*Zirfaea pilsbryii*), horse clam, and cockle (*Clinocardium nuttallii*).

Table 3.2–3. Average Intertidal Shellfish Densities (number per square feet) at the North and South LWI Project Sites

Location	Oyster	Bent Nose Macoma	Manila Clam	Butter Clam	Horse Clam	Native Little Neck	Eastern Softshell Clam	Purple Varnish Clam	Cockle
North LWI	1.7	6.6	0.14	2.2	1.1	1.7	NA	NA	NA
South LWI	2.3	4.0	1.2	0.26	0.06	0.95	0.03	0.76	0.14

Source: Leidos and Grette Associates 2013b
NA = species not observed at location.

During the 2007 comprehensive eelgrass survey, bivalve siphons were generally detected at the north LWI project site at depths greater than 15 feet (5 meters) below MLLW and at the south LWI project site at depths greater than 20 feet (6 meters) below MLLW (SAIC 2009). In general, the siphons associated with geoduck clams occurred in both sand and silt substrate within each survey area, but the occurrence of bivalve siphons was higher in both deeper water and siltier sediment than in the sand and gravel material in the shallow depths. The north LWI project site contained a higher concentration of geoduck clams than the south LWI project site, possibly due to the siltier nature of the sediments at the north site compared to the sandier sediments at the south site (SAIC 2009). Based on the 2013 subtidal surveys (Leidos and Grette Associates 2013b), no geoducks were observed at the north LWI project site and three geoducks were observed at the south LWI project site. However, these surveys only extended to depths of approximately 22 feet (6.7 meters) and 20 feet (6 meters) below MLLW at the north and south LWI sites, respectively – depths where geoducks would not be expected to be abundant based on data obtained from the 2007 survey (SAIC 2009). Figure 3.2–6 presents the distribution of oysters and clams from a 2008 survey of the shoreline at the north and south LWI project sites and shows the 2013 survey locations (Delwiche et al. 2008; Leidos and Grette Associates 2013b).



The presence of siphon holes was not determined for the area within 500 yards north of the north LWI project site due to incoming tide during 2008 survey

Siphon holes present in great abundance within the lower intertidal throughout the waterfront near the Devil's Hole drainage during 2008 survey

Note: Relative shellfish density from 2008 survey. Data from 2013 survey are described in text.

Source: Delwiche et al. 2008

Figure 3.2–6. Shellfish Resources near the LWI Project Sites

A 1971 WDFW survey for the commercial tract (#21150), on which both LWI project sites would be located, reported geoduck densities of 0.09 per square foot (0.9 per square meter) (Sizemore et al. 2003). This tract is inactive and no recent survey information is available. Surveys conducted at NAVBASE Kitsap Bangor in support of the 1974 TRIDENT Fleet Ballistic Missile (TRIDENT) Final Environmental Impact Statement (FEIS) found geoduck densities of 0.15 per square foot (1.5 per square meter) near the outlet from Hunter's Marsh, which is approximately 1,300 feet (400 meters) south of the north LWI project site (Navy 1974). No other geoduck survey data are available for the Bangor waterfront. More recent WDFW geoduck studies conducted in Hood Canal from 2004 to 2007 found densities ranging from 0.0029 per square foot at Quatsap (approximately 10 miles [16 kilometers] southwest of the south LWI project site) to 0.676 per square foot at Lofall/Vinland (1.5 to 5.5 miles [2.4 to 8.9 kilometers] north of the north LWI project site) (Sizemore et al. 2007).

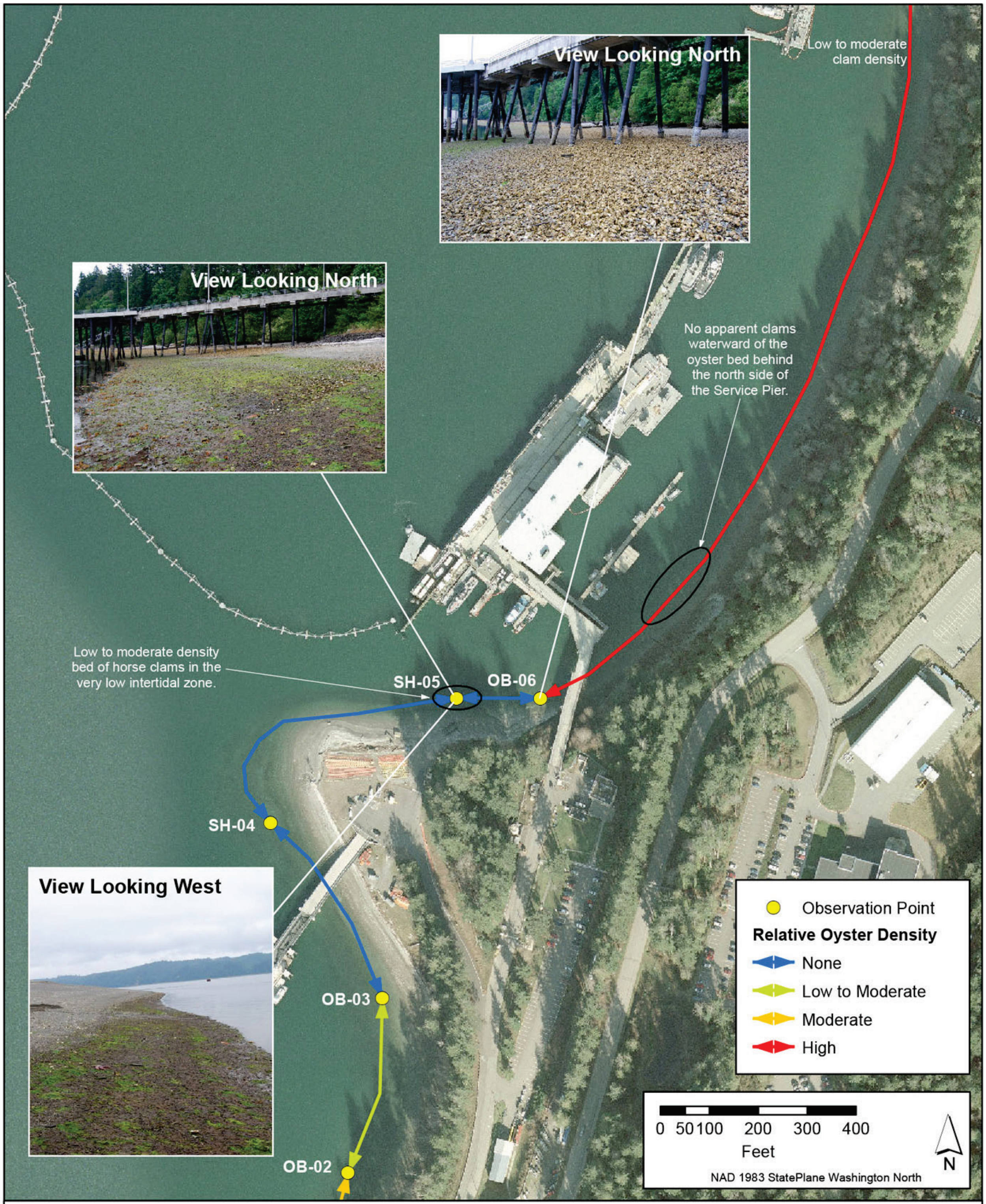
Oysters have a limited elevational distribution at the north LWI project site, representing a band across the intertidal habitat (Delwiche et al. 2008; Leidos and Grette Associates 2013b). Tidal heights over which this band occurred ranged from 2.5 to 7 feet (0.8 to 2.1 meters) above MLLW, with no oysters detected in the subtidal region. Though not a dense band, the average width of the oyster bed at this location is approximately 40 feet (12 meters). This bed runs from the EHW-1 north trestle to the north for a distance of about 1,700 feet (518 meters). A total of 102 oysters were detected at the north LWI project site in the 2013 survey, equating to an average density of 1.7 oysters per square foot (18.3 per square meter).

Oysters at the south LWI project site occur as a dense band across the intertidal and shallow subtidal habitat (Delwiche et al. 2008; Leidos and Grette Associates 2013b). Tidal heights over which this band occurs range from 0.5 feet (0.12 meter) below to 4 feet (1.2 meters) above MLLW. This bed runs approximately 440 feet (134 meters) across the Devil's Hole outfall delta. The average width of the oyster bed at this location is approximately 140 feet (43 meters). A total of 291 oysters were detected at the south LWI site in the 2013 survey, equating to an average density of 2.35 oysters per square foot (25.3 per square meter).

MOLLUSCS AT THE SPE PROJECT SITE

An approximately 63-foot wide (19-meter) dense oyster bed runs from just south of the Service Pier trestle to the north approximately 1,800 feet (550 meters), ending just south of KB Dock (Figure 3.2–7; Delwiche et al. 2008). There is a moderate to low-density bed of horse clams in the very low intertidal zone just south of the Service Pier. The 2007 eelgrass survey did not detect bivalve siphons behind the Service Pier (SAIC 2009). Opalescent nudibranchs (*Hermissenda crassicornis*, a gastropod mollusc) were observed at this site during the 2012 eelgrass survey (Anchor QEA 2012).

There are no recent geoduck survey data for the SPE project site. The 1971 WDFW survey for the commercial tract (#21150), on which the SPE project site would be located, reported geoduck densities of 0.09 per square foot (0.9 per square meter) (Sizemore et al. 2003). The 1974 survey for TRIDENT near the mouth of Hunters Marsh (approximately 1.8 miles [2.9 kilometers] north of the SPE project site) found geoduck densities of 0.15 per square foot (Navy 1974).



Source: Delwiche et al. 2008; SAIC 2009

Figure 3.2–7. Shellfish Resources near the SPE Project Site

The Quatsop survey site, which found geoduck densities of 0.0029 per square foot, is approximately 8 miles (13 kilometers) southwest of the SPE site (Sizemore et al. 2007). Similarly, the Lofall/Vinland survey site, which found geoduck densities of 0.676 per square foot, is approximately 4 to 8 miles (6.4 to 13 kilometers) north of the SPE project site.

CRUSTACEANS

Crustaceans are aquatic arthropods with an exoskeleton or shell, a pair of appendages on each segment, and two pairs of antennae. Examples are shrimps, crabs, barnacles, and amphipods. Crustaceans are associated with all soft-bottom and hard substrate habitats (rocky outcrops, manmade structures) and also occur in the water column. Crustaceans, particularly small epibenthic species, provide a primary ecological value as an important food source for fish, birds, marine mammals, and other animals. For example, gammarid amphipods (small, shrimp-like crustaceans) are the primary food source for chum salmon along the Bangor shoreline (Simenstad and Kinney 1978). Dungeness crabs and spot prawns are WDFW-regulated species that are subject to commercial and sport harvest in Hood Canal.

Small epibenthic crustaceans (such as amphipods, copepods, cumaceans, isopods, ostracods, and tanaids) are associated with soft-bottom habitat. Benthic ostracods are minute crustaceans that are protected by a bivalve-like shell and typically feed on detritus in the subtidal nearshore marine habitats. Based on 2005 benthic sediment sampling along the Bangor shoreline the seed-shrimp, an ostracod, is the most abundant species (Weston 2006). Seed-shrimp comprised almost 30 percent of the individual benthic organisms in the sandy deltaic subtidal zones along the shoreline (Weston 2006). In previous studies (WDOE 1998), this species was numerically dominant in other areas of the north Hood Canal biotic subregion. Other common species in soft-bottom habitats include amphipods and tanaids (Weston 2006). Most amphipods are detritus-feeders or scavengers, and tanaids are associated with vegetated habitats and/or organic detritus (Barnard et al. 1980; Lee and Miller 1980).

Barnacles, amphipods, copepods, cumaceans, and isopods are common members of marine fouling communities (organisms that attach to and live on manmade structures such as docks). Amphipods often account for the greatest variety of crustaceans on manmade structures. Several of these fouling species are non-native in Puget Sound (e.g., *Ampithoe valida*, *Corophium acherusicum*, and *Parapleustes derzhavini*) (Cohen et al. 1998). During the 2008 survey, barnacles were frequently seen attached to cobble, oyster shells, and pier structures throughout the intertidal areas of the Bangor shoreline (Delwiche et al. 2008).

CRUSTACEANS AT THE LWI AND SPE PROJECT SITES

Larger crabs and shrimps, which are mobile and evasive during sampling, are not well quantified near the proposed LWI or SPE project sites. Several species have been commonly observed (Pentec 2003; Weston 2006). Dungeness crabs range from intertidal to subtidal depths in sandy habitats and may use eelgrass beds as nursery areas (LFR 2004). Hermit crabs, *Cancer* crabs, kelp crabs, and shore crabs occur in rocky and/or vegetated habitats (Table 3.2–2). Red rock crabs, kelp crabs, graceful crabs, and Dungeness crabs were observed during the 2013 LWI shellfish surveys (Leidos and Grette Associates 2013b). Red rock crabs, hermit crabs, kelp crabs, and ghost shrimp were observed during the 2012 SPE eelgrass survey (Anchor QEA 2012).

ANNELIDS

Annelids are segmented worms that occur in soils (e.g., earthworms) and freshwater and marine environments (e.g., leeches and polychaetes). Polychaetes are a major component of the benthic community and occupy intertidal and subtidal soft- and hard-bottom habitats (Weston 2006). Sessile polychaetes are often tube-building while other species may be active burrowers (Kozloff 1983). Polychaetes are typically more abundant in the nearshore subtidal zone than in the intertidal zone (Weston 2006; WDOE 2007). Several species of polychaetes live among fouling organisms on manmade structures. Suspension-deposit spionids, herbivorous nereids, predatory syllids, and scale worms were found during rapid assessment of several marinas in Puget Sound (Cohen et al. 1998).

ANNELIDS AT THE LWI AND SPE PROJECT SITES

The polychaete *Platynereis bicanaliculata* was abundant in subtidal samples at all three stations at the north LWI project site and at one of three stations at the south LWI project site (Weston 2006). No benthic invertebrate surveys have been conducted in the vicinity of Service Pier. However, annelids in this area would likely include those typical of Puget Sound hard and soft-bottom habitats, as noted for the LWI project sites.

ECHINODERMS

Echinoderms are a group of marine invertebrates that usually have a symmetry of five and skin typically covered in spines. Examples include sea stars (starfish), sea urchins, and sea cucumbers.

ECHINODERMS AT THE LWI AND SPE PROJECT SITES

Echinoderms contributed up to 6 percent of benthic organisms in sediment sampling conducted in 2005 along the shoreline, but they represented less than 1 percent of the abundance of benthic organisms at the LWI project sites (Weston 2006). Echinoderms at the LWI project sites include brittle stars and green sea urchins (Navy 1988; Weston 2006). However, sea stars have also been observed at many locations along the shoreline (Navy 1988; Delwiche et al. 2008). Purple stars are found primarily in the lower-intertidal zone on piles where they feed on mussels. Pink sea stars are often found in subtidal eelgrass beds (Pentec 2003). Sunflower, pink, and false ochre sea stars were observed at the SPE project site during the 2012 eelgrass survey (Anchor QEA 2012).

The red sea urchin has not been documented near the LWI or SPE project sites but typically lives in rocky areas, which have not been extensively surveyed at the shoreline. Red sea urchin habitat ranges from protected shallow subtidal zones to marine deeper water and nearshore marine habitats.

OTHER MINOR PHYLA

Other minor phyla at the Bangor shoreline include Nemertea (ribbon worms), Nematoda (round worms), Platyhelminthes (flat worms, which are mostly oyster leaches), Chordata (e.g., transparent tunicate and mushroom compound tunicate), Cnidaria (jellyfish, polyps, the frilled anemone *Metridium senile*), and Sipuncula (unsegmented worms) (Navy 1988, 1992; Weston 2006).

OTHER MINOR PHYLA AT THE LWI AND SPE PROJECT SITES

During the 2007 comprehensive eelgrass survey, frilled anemones were less prevalent at the proposed LWI and SPE project sites than at the more central area of the shoreline (SAIC 2009).

3.2.1.1.4. PLANKTON

Plankton are often divided into two groups: photosynthetic species that transform light energy from the sun into chemical energy (phytoplankton) and heterotrophic species that derive nutrition by consuming other organisms (zooplankton). Zooplankton are an important part of the food chain for other marine organisms, such as threatened and endangered salmon species.

The plankton community in Hood Canal includes phytoplankton (e.g., diatoms and dinoflagellates), zooplankton such as calanoid copepods, hyperiid amphipods, and euphausiids (krill), larval life stages of some invertebrate species, and fish larvae and eggs (called ichthyoplankton) (Schreiner 1977; Simenstad and Kinney 1978; Salo et al. 1980; Llansó 1998; WDOE 1998). Crustacean larvae are the most common type of zooplankton in Hood Canal. Phytoplankton and zooplankton are critical components of the Hood Canal food web, but their abundance and distribution are not well known or characterized (Puget Sound Action Team [PSAT] 2007a).

PHYTOPLANKTON

In Hood Canal, phytoplankton are composed mainly of diatoms (unicellular algae with silica shells) and dinoflagellates (microscopic organisms with self-propulsion) (Strickland 1983). Diatoms account for most of the phytoplankton biomass in Hood Canal (PSAT 2007a).

Phytoplankton abundance in the Puget Sound region follows a seasonal pattern. In the summer, increased abundance is influenced by weak tidal mixing, reduced circulation, and increased heat from the sun, which contributes to strong stratification in the upper water column. In the fall, local wind events or strong tidal exchange can mix the stratified water and upwell nutrients from lower in the water column, causing a phytoplankton bloom. Phytoplankton abundance then decreases as winter approaches due to decreased sunlight and increased mixing and outflow from heavy rains (Newton and Mote 2005). Between 2001 and 2005, blooms were recorded in the waters adjacent to NAVBASE Kitsap Bangor from February through June (PSAT 2007a).

Phytoplankton populations may become problematic during bloom periods because, once they die off, DO levels can decrease dramatically as bacteria consume the organic materials. Only a few dozen species are associated with harmful algal blooms (Boesch et al. 1997; Horner 1998; PSAT 2007a). Examples of toxic species that occur in Hood Canal include diatoms in the genus *Pseudo-nitzschia*, which produce domoic acid that causes shellfish poisoning in humans (domoic acid acts as a neurotoxin, causing permanent short-term memory loss, brain damage, and death in severe cases), and dinoflagellates in the genus *Alexandrium* that can produce a toxin (saxitoxin, a neurotoxin) that causes paralytic shellfish poisoning (Boesch et al. 1997; Newton 2006). Poisoning of humans and wildlife can occur when filter-feeding shellfish concentrate these toxins to dangerous levels. There are usually periods each year when clam and/or oyster harvest at the Devil's Hole shellfish beach is curtailed due to saxitoxin or *Vibrio* (a bacterium) contamination (Kalina 2012, personal communication). In addition, several diatom species of the genus

Chaetoceros have barbed spines that can damage fish gills and can cause fish kills during bloom conditions (Boesch et al. 1997).

ZOOPLANKTON

The most abundant types of zooplankton in Hood Canal are crustaceans (including various types of copepods, amphipods, ostracods, isopods, shrimp, and cumaceans) and crustacean larvae (Simenstad and Kinney 1978; Strickland 1983). Some zooplankton spend their entire life as planktonic organisms (resident plankton) while some spend only a portion of their life cycle as plankton (meroplankton) such as in egg or larval stages of development. The larvae of many fish are planktonic. Zooplankton do not occur in blooms, but their populations increase with phytoplankton abundance (PSAT 2007a).

Zooplankton depend on the availability of phytoplankton as a food source, which fluctuates seasonally, annually, and geographically. An increase in the abundance of zooplankton occurs locally near fish and invertebrate spawning sites, with the emergence of large clouds of meroplankton (planktonic larvae) during the winter and spring months. Other species contribute to the meroplankton population during other times of the year, such as bivalves and sand dollars that spawn in the summer (Strickland 1983; WDFW 2000; Snow et al. 2005). Zooplankton may remain in the meroplankton stage for up to 7 weeks.

3.2.1.2. CURRENT REQUIREMENTS AND PRACTICES

3.2.1.2.1. EELGRASS POLICIES

The Washington Department of Natural Resources (WDNR) monitors the status and trends of eelgrass abundance and depth throughout Puget Sound, including in Hood Canal. The policy of WDNR and the other agencies is to prevent loss and promote expansion of eelgrass in Hood Canal and Puget Sound. Specific regulatory protections for eelgrass are discussed in the following section.

3.2.1.2.2. REGULATORY COMPLIANCE

VEGETATION COMMUNITIES

Eelgrass is protected under several federal laws. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 1801-1881 et seq.) established procedures designed to identify, conserve, and enhance Essential Fish Habitat (EFH) including eelgrass for those species regulated under a federal Fisheries Management Plan (FMP). The MSA requires federal agencies to consult with National Marine Fisheries Service (NMFS) on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH (MSA 305(b)(2)). EFH protects waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity for federally managed (commercially harvested) fisheries. In addition to EFH designations, Habitat Areas of Particular Concern (HAPCs) are also designated by the regional Fishery Management Councils (FMCs). Designated HAPCs are discrete subsets of EFH that provide important ecological functions or are especially vulnerable to degradation (50 Code of Federal Regulations [CFR] 600.805-600.815). The seagrasses HAPC for Pacific coast groundfish includes eelgrass beds in estuaries (Pacific Fishery Management Council [PFMC]

2008). EFH existing conditions and impacts are evaluated in the Marine Fish resource (Section 3.3).

Under the provisions of CWA Section 404 implemented by USACE and USEPA, eelgrass beds are also considered Special Aquatic Sites that receive special protection. Section 404 pertains to discharges of dredged or fill material in waters of the U.S., which include areas suitable for supporting eelgrass. The jurisdictional limit for Section 404 in tidal waters is the high tide line. Construction of the LWI abutments would require excavation below MHHW and the abutment stair landings would be below MHHW, thus requiring a CWA Section 404 permit from USACE. In accordance with USEPA Section 404(b)(1) guidelines, permits for discharges of dredged or fill material in eelgrass beds may not be issued if practicable alternatives would avoid such impacts. Loss of eelgrass habitat due to construction of the LWI project would require compensatory mitigation as described in the Mitigation Action Plan (Appendix C).

Section 404 activities permitted by USACE require that a Section 401 water quality certification be issued or waived by WDOE. Thus, separate Section 401 water quality certification would be required for the in-water work for both the proposed LWI and SPE project. The Navy would apply for a Section 404 permit (LWI project only) and Section 401 certifications (LWI and SPE projects) by submitting a JARPA for review by USACE and state agencies. The WDFW regulates non-federal, in-water construction actions through the State Hydraulic Code (RCW 77.55) and specifically protects eelgrass and kelp (*Saccharina* sp.) resources through WAC 220-110-300, which requires "no-net-loss of productive capacity of fish and shellfish habitat." Eelgrass and kelp are also considered saltwater habitats of special concern (WAC 220-110-250(3)). However, NAVBASE Kitsap Bangor is exempt from these requirements because it is a federal installation.

WDFW and WDNR may comment and provide recommendations on federal construction projects through the JARPA and National Environmental Policy Act (NEPA) processes. Permitting agencies (USACE and WDOE) may incorporate these comments and recommendations into permits and authorizations.

Section 10 of the Rivers and Harbors Act (33 USC 401 et seq.) requires authorization from USACE for the development of any structure in or over any navigable water of the United States. The Navy would request separate Section 10 permits for construction of the overwater portions of the LWI and for the SPE. The permit process for Section 10 of the Rivers and Harbors Act of 1899 would result in an evaluation of project impacts on eelgrass beds. While not subject to specifications of the CWA 404(b)(1) guidelines, USACE would consider impacts on eelgrass (as part of the public interest review) in their evaluation of permit applications for structures or work in navigable waters pursuant to Section 10. This would apply to non-fill activities such as pile-supported structures, moorings, floats, excavation, and other structures or work conducted beyond mean high water in tidal waters.

Under Kitsap County's Shoreline Management Plan (SMP), Section 22.28.030, General Policies (which is applicable under the CZMA), development activities are directed to avoid eelgrass, kelp, and estuarine ecosystems because of their high ecological value. As a federal agency, the Navy prepares a CCD in compliance with the CZMA explaining how their action would be "consistent to the maximum extent practicable" with the state's Coastal Zone Management Plan (CZMP), which in Washington invokes the applicable local shorelines management program (i.e., Kitsap County's program). WDOE would review the CCD and make a federal consistency determination in the form of concurrence, conditional concurrence, or objection.

BENTHIC COMMUNITIES

No federally listed benthic species within the vicinity of the LWI and SPE project sites are subject to regulation under the Endangered Species Act (ESA). However, benthic invertebrates that constitute food for salmon listed under the ESA are indirectly protected. Activities that alter or eliminate benthic invertebrates or their habitats are evaluated for their significance to federally listed species during ESA consultations with NMFS. The MSA, through the EFH provision, protects substrate necessary for federally managed fisheries. In this context, "substrate" includes the associated benthic communities that make these areas suitable fish habitats. USACE also considers protection of shellfish under Section 404 of the CWA (e.g., Nationwide Permit regional conditions prohibit construction in special aquatic sites, which include oyster beds).

At the state level, WDFW is tasked with providing protection to benthic organisms, including shellfish, as required under the Washington State Hydraulic Code (RCW 77.55). The code is implemented through WAC 220-110, which states that there should be "no net-loss of productive capacity of the habitat of food fish and shellfish resources of the state." However, NAVBASE Kitsap Bangor is exempt from these requirements because it is a federal installation.

WDOH monitors beaches in Hood Canal, including those at the Bangor shoreline, for shellfish contamination to protect consumers from illness caused by eating shellfish contaminated by fecal pathogens, biotoxins, or other pollutants. The shellfish bed at the south LWI project site off the Devil's Hole outfall is harvested for oysters and clams by tribes (Kalina 2012, personal communication). The beach areas at the north LWI and SPE project sites (Figures 3.2–6 and 3.2–7) are closed to any shellfish harvest due to security restrictions.

PLANKTON

There are no federal or state regulations pertaining directly to plankton or requirements for regulatory consultation. Regulations indirectly affecting plankton include water quality criteria for parameters related to excessive nutrient loading, which can cause algal blooms (larger accumulations of phytoplankton) that can adversely affect water quality (Section 3.1.1.1.2).

3.2.1.2.3. CONSULTATION AND PERMIT COMPLIANCE STATUS

The Navy will include impacts on marine vegetation and benthic communities as part of its consultation with the NMFS West Coast Region office under the ESA and MSA. A biological assessment and EFH assessment will be prepared and submitted to the NMFS West Coast Region office. In addition, the Navy will submit a JARPA to USACE and other regulatory agencies, requesting permits under CWA Section 401 (for both the proposed LWI and SPE projects) and Section 404 (for the proposed LWI project), and Rivers and Harbors Act Section 10 (for both the proposed LWI and SPE projects). In accordance with the CZMA, the Navy will prepare and submit a CCD to WDOE.

3.2.1.2.4. BEST MANAGEMENT PRACTICES AND CURRENT PRACTICES

BMPs and current practices that would avoid or minimize impacts of the proposed projects on marine vegetation and invertebrates would include those described in Section 3.1.1.2.3 for protection of marine water resources including hydrography, water quality, and sediments. Specifically, prevention of vessel and barge grounding, minimization of propeller wash, prevention of line and anchor drag, and protection of water quality all would minimize impacts to marine vegetation and invertebrates. BMPs and current practices to minimize and avoid impacts on marine vegetation and invertebrates include the following:

- Construction of the LWI would be conducted from barges in deep waters during high tides, from land, from a temporary trestle (south LWI only), and/or from already constructed parts of the LWI itself. Construction of the SPE would be conducted from barges in deep water.
- Spuds would be used to prevent barges from grounding in shallow areas including eelgrass beds.
- Vessel traffic would be excluded from the shallow areas outside of the 100-foot (30-meter) construction zones, which would be demarcated with clearly visible markers.
- Vessel operators would be provided maps of the project sites with eelgrass beds clearly marked so that the beds can be avoided.
- The Navy would require the construction contractor to prepare and implement debris management procedures for preventing discharge of debris to marine water and retrieving and cleaning up any accidentally discharged spills.
- The existing NAVBASE Kitsap Bangor fuel spill prevention and response plans (the *Commander Navy Region Northwest Oil and Hazardous Substance Integrated Contingency Plan* and the *NAVBASE Kitsap Bangor Spill Prevention, Control, and Countermeasure Plan* [COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G]) would apply to construction and operation of the proposed projects.
- The Navy would require the construction contractor to comply with RCW 77.15.290 (*Unlawful transportation of fish or wildlife — Unlawful transport of aquatic plants — Penalty*) and U.S. Coast Guard regulations to ensure vessels do not transport invasive aquatic plants.

In addition, the vessels used during construction would comply with U.S. Coast Guard regulations designed to minimize the spread of exotic species such as *Sargassum*. Mitigation measures are described in Appendix C, Mitigation Action Plan.

3.2.2. Environmental Consequences

3.2.2.1. APPROACH TO ANALYSIS

3.2.2.1.1. VEGETATION COMMUNITIES

The evaluation of impacts on marine vegetation considers whether there would be loss or degradation of marine vegetation including eelgrass or kelp, which are protected under federal or state law, or if there would be introduction of an exotic species, such as *Sargassum*, that would impact the growth of protected or native species. Construction activities that significantly degrade or eliminate marine vegetation habitat would be considered a direct impact on marine vegetation communities. Construction impacts include a 100-foot (30-meter) area of potential disturbance; actual impacts would likely be less. Operational changes to marine vegetation habitat, such as the introduction of shading over these habitats, would also be considered direct impacts on marine vegetation communities. The evaluation assumes that project construction and operation are in accordance with applicable regulations (Section 3.2.1.2.2) as well as permit conditions, BMPs, and current practices (Section 3.2.1.2.4).

3.2.2.1.2. BENTHIC COMMUNITIES

The evaluation of impacts on benthic communities and shellfish considered whether the conditions resulting from project construction and operation would cause significant loss of benthic habitat or decreases in habitat value for benthic invertebrates or decreases in benthic invertebrate populations over the life of the project. The analysis considered the habitat displaced by new structures, potentially disturbed by construction vessels and activities, shaded by new structures, or otherwise altered. The evaluation assumes that project construction and operation are in accordance with applicable regulations (Section 3.2.1.2.2) as well as permit conditions, BMPs, and current practices (Section 3.2.1.2.4).

3.2.2.1.3. PLANKTON

The evaluation of impacts on plankton considers whether an increase of phytoplankton blooms or a decrease in plankton abundance would impact the aquatic organisms dependent on this food supply. The evaluation assumes that project construction and operation are in accordance with applicable regulations (Section 3.2.1.2.2) as well as permit conditions, BMPs, and current practices (Section 3.2.1.2.4).

3.2.2.2. LWI PROJECT ALTERNATIVES

3.2.2.2.1. LWI ALTERNATIVE 1: NO ACTION

Under the No Action Alternative, the LWI would not be built and operations in the area would not change from current levels. Therefore, there would be no impacts on marine vegetation, benthic communities, or plankton.

3.2.2.2.2. LWI ALTERNATIVE 2: PILE-SUPPORTED PIER

VEGETATION COMMUNITIES FOR LWI ALTERNATIVE 2

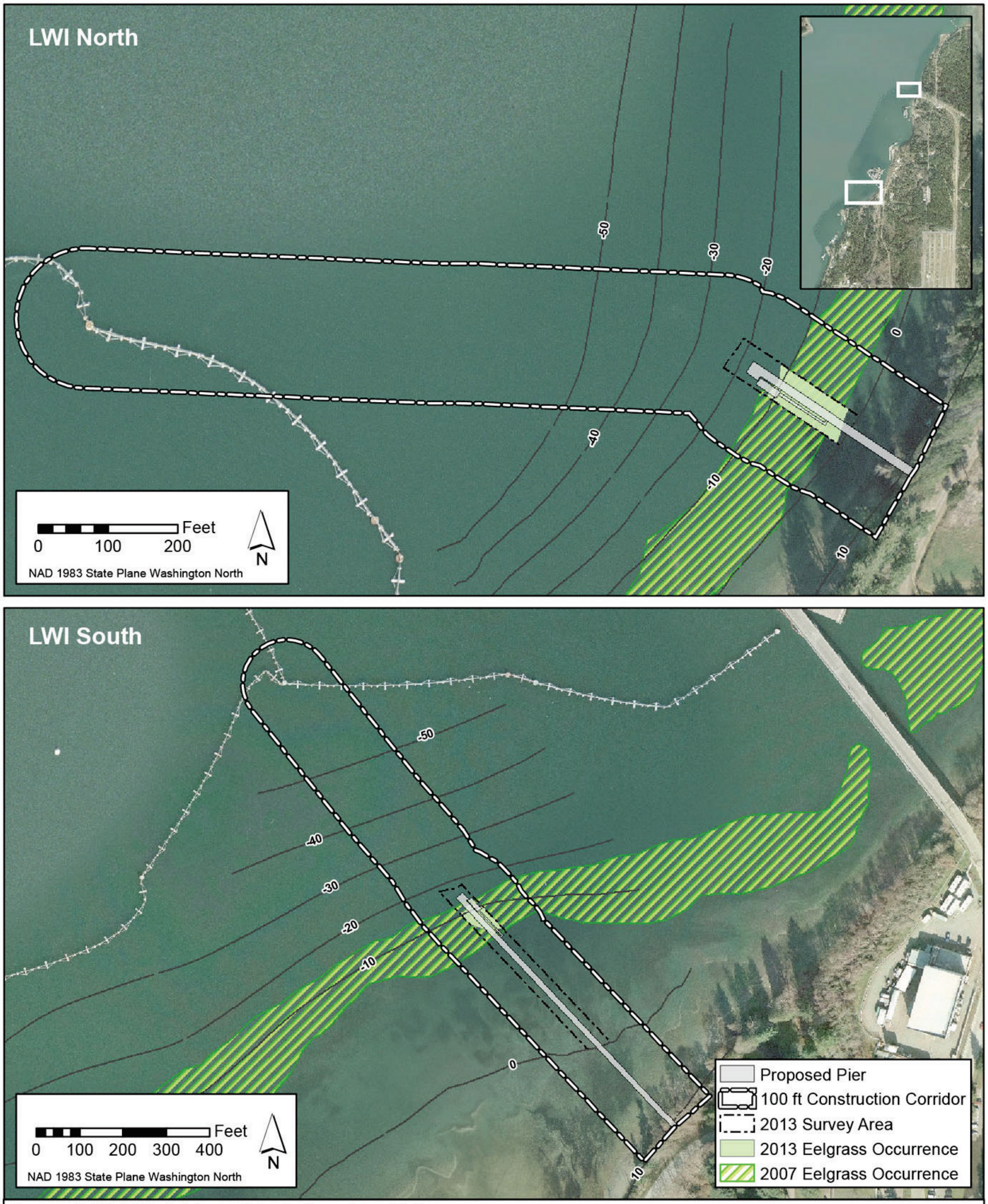
The total area of habitat potentially disturbed during construction of LWI Alternative 2 would be 6.2 acres (2.5 hectares) in the nearshore (shallower than 30 feet [9 meters] below MLLW) and 6.9 acres (2.8 hectares) in deep water (deeper than 30 feet below MLLW) (Figure 3.2–8). Of those 13.1 acres (5.3 hectares), approximately 3 acres (1.2 hectares) support marine vegetation communities. Construction activities for Alternative 2 would result in impacts on approximately 1.1 acres (0.43 hectare) of eelgrass beds (approximately 3 percent of the eelgrass at the NAVBASE Kitsap shoreline), 2.6 acres (1.1 hectares) of green macroalgae community, 2 acres

(0.81 hectare) of red macroalgae community, and 0.57 acre (0.23 hectare) of kelp beds (Table 3.2–4; Figures 3.2–8, 3.2–9, and 3.2–10). Areas with less than 10 percent coverage of a particular vegetation type were not considered beds or communities of that type. The various types of macroalgae are expected to return to the area following construction. The hard substrate associated with the pier piles and steel plate anchors would provide habitat for marine vegetation species such as *Ulva*. The Mitigation Action Plan (Appendix C) describes the compensatory aquatic habitat mitigation action that the Navy would undertake as part of the proposed action. This habitat mitigation action, including mitigation for eelgrass, would compensate for the impacts of the proposed action to marine habitat and species.

Table 3.2–4. Marine Habitat Impacted by LWI Alternative 2

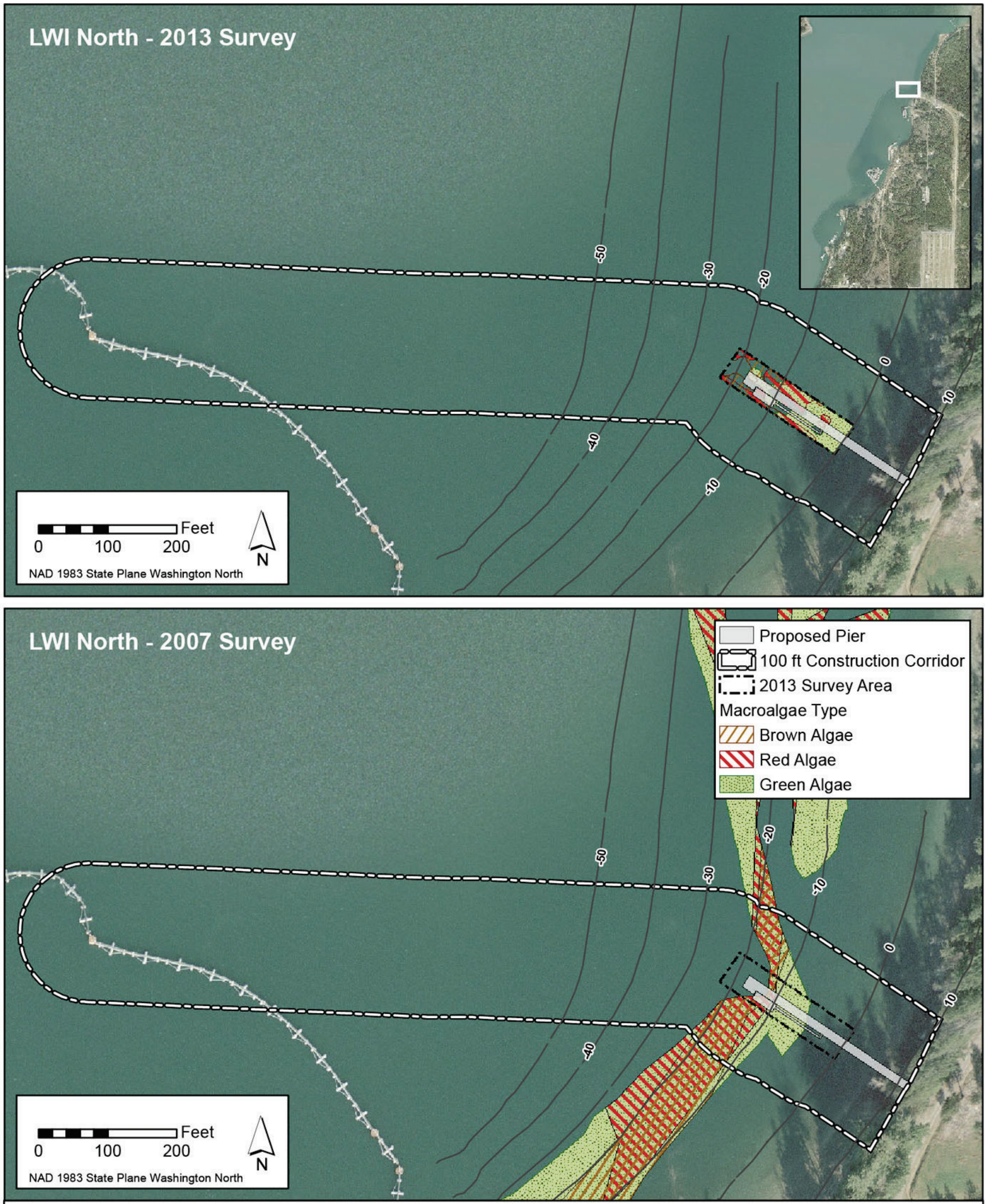
Habitat Type	Potential Temporary Construction Disturbance Area in Acres (Hectares)[1]	Area Permanently Displaced by Structures[2] in Acres (Hectares)[3]	Operational Full Shading Area in Acres (Hectares)[3]	Operational Partial Shading Area in Acres (Hectares)[3]
Nearshore[4]	6.2 (2.5)	0.14 (0.056)	0.014 (0.0056)	0.34 (0.14)
Deep Water[5]	6.9 (2.8)	0	0	0
Vegetation Type[6]				
Eelgrass[7]	1.1 (0.43)	0.024 (0.01)	0	0.076 (0.031)
Green Macroalgae	2.6 (1.1)	0.069 (0.028)	0	0.14 (0.058)
Red Macroalgae	2.0 (0.81)	0.016 (0.0066)	0	0.038 (0.015)
Brown Macroalgae (Kelp)	0.57 (0.23)	0.0025 (0.0010)	0	0.0072 (0.0029)

1. The potential construction disturbance area includes the LWI structure footprints and the areas within 100 feet (30 meters) of the proposed LWI structures. Areas actually disturbed by construction are likely to be substantially less. Calculated based on 2007 survey, which covered the entire 100-foot corridor.
2. Structures include piles, steel plate anchors, and the concrete pads supporting the observation post stairs.
3. Operational impacts on marine vegetation were calculated based on results of the 2013 survey, which covered the area 25 feet (7.6 meters) to either side of the centerline of the proposed LWI structures. Partially shaded areas would be the areas under the piers, gangways, floating docks, and observation post stairs, which would be built with grating. Fully shaded areas would be those areas under the observation posts, which would be constructed in the upper intertidal at elevations above where marine vegetation occurs.
4. Nearshore = the area shallower than 30 feet (9 meters) below mean lower low water (MLLW).
5. Deep water = the area deeper than 30 feet below MLLW.
6. Eelgrass and macroalgae overlap in their occurrence along the Bangor shoreline (e.g., Figure 3.2–3). Therefore, the total acreage of marine vegetation potentially impacted cannot be calculated by summing the values for each vegetation type.
7. Barges would avoid placing spuds or anchors in eelgrass beds wherever possible.



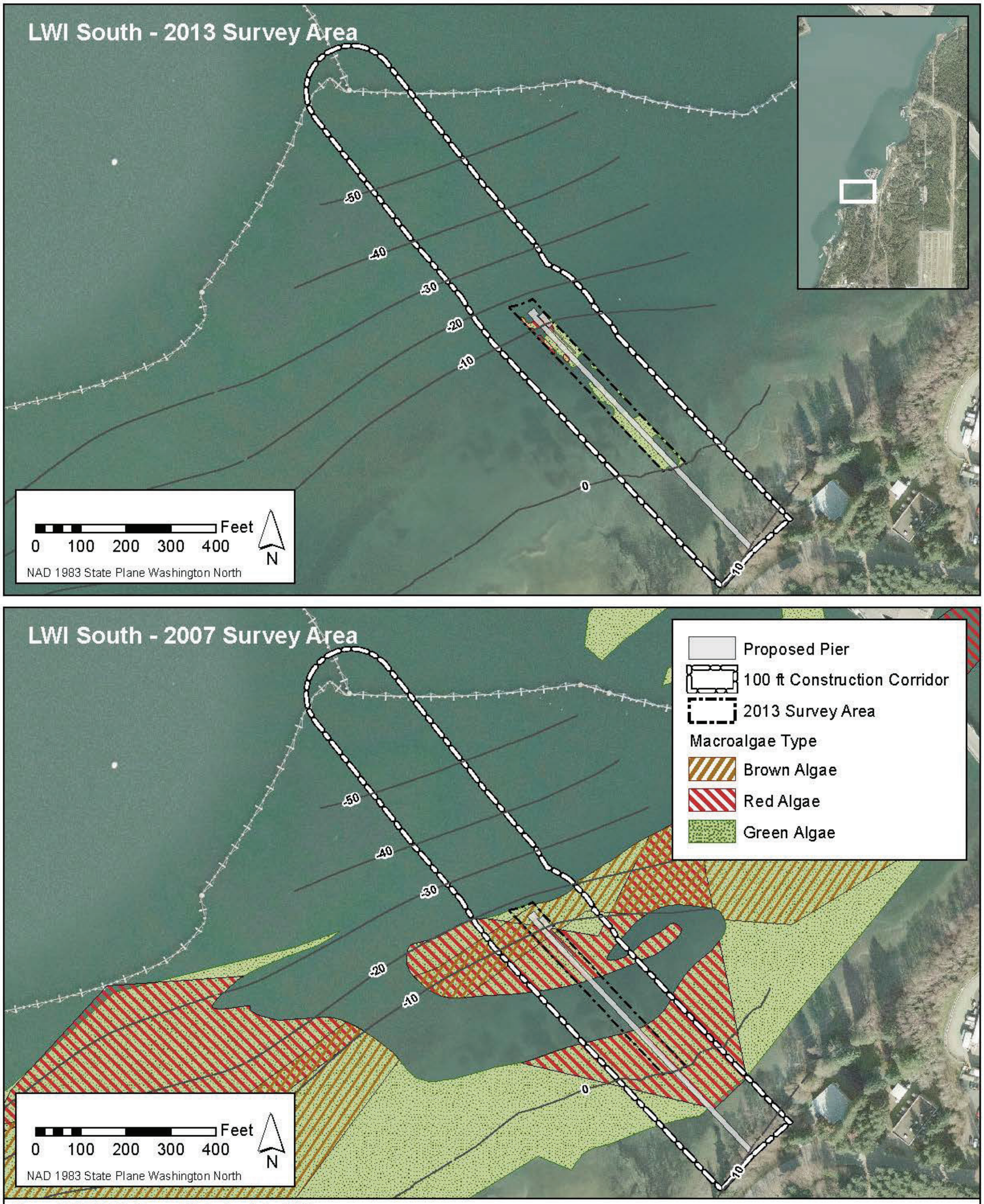
Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–8. Disturbance Areas for Eelgrass near the LWI Alignments, Alternative 2



Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–9. Disturbance Area for Macroalgae near the North LWI Alignment, Alternative 2



Source: SAIC, 2009; Leidos and Grette Associates, 2013a

Figure 3.2-10. Disturbance Area for Macroalgae near the South LWI Alignment, Alternative 2

CONSTRUCTION OF LWI ALTERNATIVE 2

Barges, tugboats, and other vessels (e.g., skiffs) would be stationed at the LWI project sites during construction. Tugboats would bring in and position barges and then leave the sites. While the vessels would be directed to avoid grounding and damaging marine vegetation on the seafloor, the vegetation would be directly impacted by seafloor disturbance from anchor, spud, and steel plate anchor placement, pile installation, and vessel shading. Measures would be implemented to avoid underwater line drag and anchor drag (Appendix C). The impact area would consist of the LWI footprints where piles would be driven and pier construction would occur, as well as a 100-foot (30-meter) wide corridor where barges would be stationed and tugboats would maneuver the barges during pile installation and steel plate anchor placement. A possible source for construction-related impacts on marine vegetation would be from accidental debris spills from barges or construction platforms into Hood Canal. Debris spills could smother bottom vegetation. The Navy would require the construction contractor to prepare and implement debris management procedures for preventing discharge of debris to marine water and retrieving and cleaning up any accidental spills. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups.

As shown in Table 3.2–4, the potential construction disturbance area for Alternative 2 would include 1.1 acres (0.43 hectare) of eelgrass beds, 2.6 acres (1.1 hectares) of green macroalgae community, 2 acres (0.81 hectare) of red macroalgae community, and 0.57 acre (0.23 hectare) of brown macroalgae (primarily kelp). Potential impacts for north and south LWI sites are given under each vegetation type. Because vegetated communities comprise a mixture of vegetation types, the acreages are not additive. The total marine vegetation area potentially impacted by in-water construction activities would be 3 acres (1.2 hectares) (0.74 and 2.2 acres [0.3 and 0.91 hectare] for the north and south LWI project sites, respectively). The observation posts would be located above the areas of marine vegetation. Construction of the observation posts would be done in the dry at low tides, and would not impact marine vegetation. Reconfiguration of the PSBs would require removing some existing PSB segments and their associated anchors and repositioning them to connect with the new LWI piers. As described in Chapter 2, there would be a net reduction of two PSB buoys and their associated mooring anchors.

While construction activities would be limited to the LWI piers and 100-foot (30-meter) surrounding area, not all of the seafloor within the 100-foot corridor would be disturbed. The only areas likely to be highly disturbed during construction of Alternative 2 would be where the steel plate anchors are placed under the piers (approximately 0.035 acre [0.014 hectare] at the north LWI and 0.092 acre [0.037 hectare] at the south LWI) and where the permanent and temporary piles are placed (approximately 0.0039 acre [0.0016 hectare] at the north LWI and 0.0087 acre [0.0035 hectare] at the south LWI). (Pile disturbance contributes less than 10 percent of the total permanent seafloor displacement shown in Table 3.2–4.) Therefore, construction impacts to marine vegetation communities that would occur within the 100-foot corridor identified in this section are conservative; the actual impact is expected to be substantially less.

Eelgrass

The north LWI would cross the southern portion of the eelgrass bed located immediately north of EHW-1 (Figure 3.2–8). A maximum of 0.51 acre (0.21 hectare) of the 12-acre (4.9-hectare) north LWI eelgrass bed would be impacted during construction. The south LWI would cross the northeastern portion of the eelgrass bed located immediately south of Delta Pier. A maximum of 0.54 acre (0.22 hectare) of the 7.6-acre (3.1-hectare) south LWI bed would be impacted during construction. These areas include eelgrass directly under the proposed piers, as well as within 100 feet (30 meters) of the structures. None of the temporary trestle piles would be installed within the south LWI eelgrass bed. The PSB anchoring systems installed at the end of the LWI piers would not be installed within eelgrass beds. The total eelgrass potentially disturbed during construction would be 1.1 acres (0.43 hectare).

Approximately 0.014 and 0.0075 acre (0.0057 and 0.003 hectare) of the north and south LWI eelgrass habitat, respectively, would be permanently eliminated when the steel plate anchors are installed. An additional 0.0017 and 0.00073 acre (0.00067 and 0.00029 hectare) would be permanently eliminated by the piles. Eelgrass is a rooted aquatic plant that depends on biogeochemical processes in sediment to maintain growth (Hart Crowser 1997; Thom et al. 1998; review in Mumford 2007). Sediments also protect the roots from drying out and being eaten by herbivores. Repeated disturbance around individual plants, such as would occur from pile driving, can result in death or shifting of the bed location (Hart Crowser 1997). Over time, events causing erosion would remove sediments from the root system and expose below-ground plant parts to degradative processes. In addition, vessel propeller wash can scour and redistribute sediments and reduce the amount of light energy reaching the plants at the sea floor (Thom et al. 1998). Barges and boats involved in pile installation and steel plate anchor placement would be expected to impact existing eelgrass beds (e.g., by anchor and spud placement) in those areas where the proposed pier structures would cross existing beds, extending 100 feet laterally from the pier footprints to include areas where the vessels would be stationed and most boat movement activities would occur. Propeller wash impacts on marine vegetation would be limited to shallower waters.

Eelgrass is sensitive to low light levels (reviews in Nightingale and Simenstad 2001a and Mumford 2007), and marine plant communities in Washington, including eelgrass, can be limited by light availability (Thom and Albright 1990). Portions of the eelgrass beds at the north and south LWI project sites disturbed by the construction activities would be expected to lose individual plants and become less dense but would be expected to recover after construction is completed.

Eelgrass within the 100-foot (30-meter) wide construction corridor that is not directly impacted would potentially experience reduced growth due to increased turbidity and particle settlement on individual plant blades, as well as between the plants. In the shallow areas where eelgrass occurs, sediment resuspension would be associated with pile installation, steel plate anchor placement, and barge operations. Due to the sandy composition of the surficial sediments, the nature of the water column currents in those areas, and the shallow depths at the sites, the majority of the sediment particles would quickly fall out of suspension (see discussion of impacts on water quality in Section 3.1.2.2.2). Resuspended, fine-grained sediments would be subject to rapid dilution by currents and eventual flushing during subsequent tidal exchanges. Therefore, the duration and spatial extent of turbidity plumes generated by in-water construction activities would be minimal and there would be minimal settling of fines on eelgrass. In addition, eelgrass would experience lower irradiance during construction due to vessel shading. The eelgrass area subject to shading by construction vessels and barges during the construction period is assumed to be equal to that within the 100-foot construction area (0.51 and 0.55 acre [0.21 and 0.22 hectare] at the north and south LWI project sites, respectively); however, this is a highly conservative estimate because the vessels would not be stationary for the entire construction period and would be positioned to avoid eelgrass beds to the extent possible (Appendix C, Section 5.1.2).

Studies of seagrass recoveries in natural systems following clearing or declines due to turbidity plumes found full recoveries ranging from 2 to 6 years (Rasheed 1999; review in Erftemeijer and Lewis 2006). Factors that would influence the rate and success of eelgrass recovery include the extent of sediment disturbance and competition from macroalgae such as *Ulva*.

Oil spills could potentially occur during construction, which could result in the loss of eelgrass. As described in Section 3.1.2.2.2, under Water Quality, the existing facility response and prevention plans for the Bangor shoreline provide guidance that would be used in the event of a spill, including a response procedures, notification, and communication plan; roles and responsibilities; and response equipment availability. The contractor would also prepare and implement a spill response plan (e.g., an SPCC Plan) to clean up fuel or fluid spills. In the event of an accidental spill, response measures would be implemented immediately to reduce the potential for exposure to the environment.

In summary, placement of the steel plate anchors and piles would permanently eliminate an estimated 0.016 and 0.0083 acre (0.0064 and 0.0034 hectare) of eelgrass from the north and south LWI eelgrass beds, respectively. In addition, some disturbances to eelgrass beds would occur within the construction corridor, potentially affecting up to 0.51 acre (0.21 hectare) of the 12-acre (4.9-hectare) north LWI eelgrass bed and 0.55 acre (0.22 hectare) of the south LWI 7.6-acre (3.1-hectare) eelgrass bed. Eelgrass is expected to recover in disturbed areas within 2 to 6 years, depending on the extent of the disturbance. The permanent and temporary losses of eelgrass would be mitigated as described in the Mitigation Action Plan (Appendix C).

Macroalgae

Macroalgae, which occur at a greater range of depths than eelgrass at the LWI project sites (SAIC 2009), require lower light levels than eelgrass for growth (Frankenstein 2000; Nightingale and Simenstad 2001a), and would be expected to recruit back to the seafloor following construction. As described in above in Section 3.2.1.1.2, green macroalgae, such as sea lettuce, have rapid growth rates during summer and early fall months when light intensity is highest in the Pacific Northwest (Nelson et al. 2003). Macroalgae communities in the construction zones would be at their maximum biomass prior to the onset of pile driving activities in mid-July, which would contribute to rapid recovery after construction is completed.

A maximum of 2.6 acres of seafloor supporting green macroalgae (0.40 and 2.2 acres [0.16 and 0.9 hectare] at the north and south LWI project sites, respectively), 2 acres (0.81 hectare) of red macroalgae (0.21 and 1.8 acres [0.086 and 0.72 hectare] at the north and south LWI project sites, respectively), and 0.57 acre (0.23 hectare) of seafloor supporting brown macroalgae (0.19 and

0.39 acre [0.075 and 0.16 hectare] at the north and south LWI project sites, respectively) would be impacted during construction (Table 3.2–4; Figures 3.2–9 and 3.2–10). The impact area would primarily occur within 100 feet (30 meters) of the LWI project sites where most direct (e.g., vessel shading), and indirect (e.g., turbidity, sedimentation) impacts would occur. Installation of the steel plate anchors on the seafloor would eliminate approximately 0.065, 0.015, and 0.0024 acre (0.026, 0.0062, and 0.001 hectare) of green, red, and brown macroalgae community, respectively. Installation of the temporary trestle piles at the south LWI would impact approximately 0.009 acre (0.0035 hectare) of green and red macroalgae. Reconfiguration of the PSBs would result in the net reduction of two PSB buoys and their associated mooring anchors, one at each of the LWI project sites. This action would result in a minimal loss of macroalgae fouling community associated with anchors that are removed entirely, elimination of the community where anchors are relocated, and recolonization of areas where anchors are removed.

Propeller wash impacts on marine vegetation would be limited to shallower waters. No impacts on macroalgae would be expected beyond the 100-foot (30-meter) areas. Oil spills could also potentially occur during construction, which could result in the loss of macroalgae. In the event of an accidental spill, response measures as noted above would be implemented immediately to reduce potential exposure to the environment.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

The total area of marine habitat impacted by operation of LWI Alternative 2 would be 0.15 acre (0.061 hectare) in the nearshore (Table 3.2–4), which is the total area fully shaded by the observation posts (0.014 acre [0.0056 hectare]) plus the pile, steel plate, and concrete pad displacement areas (0.14 acre [0.056 hectare]), a total of 0.07 acre (0.028 hectare) of which is vegetated. Marine habitats in deep water (deeper than 30 feet [9 meters] below MLLW) would not be impacted by the LWI structures. Operational activities would primarily impact marine vegetation through the habitat fragmentation that would occur from the piles and steel plate anchors in eelgrass (total of 0.024 acre), although the piles and steel plates would serve as attachment sites for macroalgae species. Partially shaded areas would continue to support eelgrass and macroalgae. The observation posts would be located above the areas of marine vegetation and would not impact marine vegetation during operations. The relocated PSB systems at the end of the LWI piers would be located beyond the eelgrass beds.

Maintenance of the LWI piers would include routine inspections, repair, and replacement of facility components as required. These activities would not directly affect marine vegetation, however fouling organisms, including macroalgae, would be periodically cleared from the below-pier mesh and PSB guard panels. Debris released by mesh and PSB guard panel cleaning would be small and dispersed by currents such that it would not smother underlying or nearby marine vegetation. Measures such as those documented under Section 3.1.2, would be employed to avoid discharges of contaminants to the marine environment during LWI operations. Propeller wash from small boat operations at the floating docks would have the potential to cause scour and suspension of bottom sediments, but these operations would be infrequent.

Eelgrass

The seafloor areas shaded by the piers would be minimized by the use of grating in the piers that allows 65 percent of light to pass through, restriction of pier widths to the minimum necessary to meet structural and program requirements, and the height of the piers over the water (approximately 17 feet [5 meters] above MLLW). The gangways and floating docks also would be constructed using grating. An increased structure height over the water diminishes the degree of shading by providing a greater distance for light to diffuse and refract around its surface as the sun arcs across the sky (review in Nightingale and Simenstad 2001a). The shading effect of the piers would be greatest at higher tides when the pier heights over water would range from 1 to 5 feet (0.3 to 1.5 meters). This daytime shadow effect would occur during less than 1 percent of all daylight hours throughout the year. During the rest of the time, the pier clearances would be 5 feet (1.5 meters) or more over the water. An overwater trestle at Indian Island, Washington, constructed with grating material allows approximately 50 percent of the light to pass through. Eelgrass and other marine vegetation continue to be present under this trestle, which is nearly four times as wide as the proposed LWI piers (approximately 45 feet [14 meters] wide) (Kalina 2011, personal communication). Therefore, it is expected that the areas under the piers, floating docks, and gangways outside of the steel plate and pile footprints would continue to support eelgrass growth.

As described in Section 3.1.2.2.2, support piles installed for the in-water barriers would alter current flows and wave propagation locally, which would cause localized erosion of fine-grained sediments near the base of some piles and settling and accumulation of fine-grained sediments at the base of other piles (Chiew and Melville 1987). Turbulence associated with tidal current flows around the piles would result in a gradual coarsening of surface sediments and thin scouring initially around the perimeter of each pile and groups of piles (Sumer et al. 2001). Where eelgrass occurs under the piers, the presence of the beds would retard erosion to some degree due to the eelgrass root systems and the slowing of water velocities over eelgrass beds (reviews in Davison and Hughes 1998 and Bos et al. 2007). Further, shells and barnacles that accumulate on the piles would also slough off over time and contribute to the sediment content below the piles. The loss of fine-grained sediment would be offset by the accumulation of shell and barnacle particles. Similar effects on the bathymetric setting would be expected from the mesh. The presence of these structures would promote temporary sediment accumulation on one side, which could vary depending on the direction of storm-related waves and strength of wave-induced turbulence. While these changes would occur gradually over time, the presence of the steel plates and mesh would result in some fragmentation of the eelgrass beds in which they are placed.

The PSBs and associated anchoring systems for the segments connected to the north and south LWI piers would lie outside of, and therefore would not impact, the existing eelgrass beds.

The floating dock would be located in shallow waters and there would be a potential for propeller wash from the security boats to disturb eelgrass due to periodic increases in turbidity associated with resuspended bottom sediments. However, small boat operations would be infrequent. No mitigation measures beyond current practices in place would be required.

Macroalgae

The north and south LWI structures would partially shade approximately 0.042 acre (0.017 hectare) and 0.1 acre (0.041 hectare) of green macroalgae, respectively. The north and south LWI structures would each partially shade approximately 0.019 acre (0.0078 hectare) of red macroalgae. The north LWI and south LWI structures would partially shade approximately 0.005 acre (0.002 hectare) and 0.0024 acre (0.001 hectare) of brown macroalgae, respectively. As with eelgrass, the extent of macroalgae shading by the overwater structures would be minimized by the design of the structures: the use of light transmitting materials, the height of the piers over water, and the narrow width of the piers. Because macroalgae have considerably lower light requirements than eelgrass (Frankenstein 2000; Nightingale and Simenstad 2001a), macroalgae under the piers, gangways, and floating docks also would not be expected to die off, and these areas would not be negatively impacted for this marine vegetation type.

The piles and other underwater structures such as anchors would create new substrate to support colonization of algae common to marine fouling communities, such as sea lettuce (*Ulva*) and acid weeds (*Desmarestia*) (Goyette and Brooks 2001) (Figure 3.2–11). Colonization would vary among piles and water depth associated with light availability and overwater shading (e.g., Navy 1988). Macroalgae would colonize the piles within months (Kozloff 1983) and should be well established within a year (Goyette and Brooks 2001). Macroalgae colonizing the mesh and PSB guard panels, however, would be periodically removed during maintenance.

Figure 3.2–11. Green Macroalgae (*Ulva*) Attached to a Shoreline Pier on NAVBASE Kitsap Bangor

The floating docks would be located in shallow waters and there would be a potential for propeller wash from the security boats to disturb macroalgae due to increased turbidity from resuspended sediments. However, small boat operations would be infrequent.

BENTHIC COMMUNITIES FOR LWI ALTERNATIVE 2

Construction of the pile-supported piers would result in several impacts on the benthic community, including loss of soft-bottom habitat from pile and steel plate anchor placement, disturbance to the soft-bottom habitat from propeller wash, increased turbidity and suspended solids, and increased noise and vibration during pile placement. Operational impacts would include overwater shading and permanent replacement of soft-bottom habitat with hard-bottom habitat due to the installation of piles and steel plate anchors. These changes would adversely impact some species and benefit others, resulting in some localized changes in the number and composition of benthic species.

CONSTRUCTION OF LWI ALTERNATIVE 2

The benthic and shellfish communities would be directly impacted by substrate disturbance by anchor, spud, and steel plate anchor placement, and pile installation. Benthic communities would also be impacted by turbidity and sediment redeposition resulting from these activities and vessel propeller wash, as well as by vessel shading. The impact area would consist of the north and south LWI footprints where piles would be driven, steel plate anchors placed, and new pier construction would occur, as well as a 100-foot (30-meter) wide area surrounding the sites where barges would be stationed, tugboats would maneuver the barges during pile installation and steel anchor placement, and other boat-based construction activity would occur. In addition, there would be additional pile installation and pile removal of a temporary trestle at the south LWI pier. There would also be some benthic community disturbance during the PSB reconfiguration where the anchors are removed and repositioned. Long-term conversion of these areas from soft to hard bottom is discussed below under Operation/Long-term Impacts.

It is expected that benthic and shellfish communities would be disturbed and partially eliminated in the direct construction areas and the 100-foot (30-meter) wide corridors around these areas. Total potential disturbance area for the benthic community would be approximately 13.1 acres (5.3 hectares) (Table 3.2–5), including 6.2 acres (2.5 hectares) at the north LWI project site and 6.9 acres (2.8 hectares) at the south LWI project site. Areas beyond the 100-foot wide corridors would be protected by limiting construction equipment and activities to the construction corridor. The only areas potentially highly disturbed during construction of Alternative 2 would be where the piles and steel plate anchors are placed under the piers and observation posts, and where excavation for the abutments is conducted. The areas covered by the piles, steel plate anchors, and concrete pads for the north and south LWI piers, observation posts, and abutment stairs would be approximately 0.039 and 0.1 acre (0.016 and 0.04 hectare), respectively. Therefore, the 100-foot wide corridor construction impacts identified in this section are conservative; the actual impact is expected to be substantially less. The abutment stair landings would be located above the elevations where shellfish have been observed. Most piles for the observation posts would be largely located at elevations above where concentrations of shellfish have been observed.

Table 3.2–5. Benthic Community Resources Impacted by LWI Alternative 2

Impact Type	Benthic Community Area in Acres (Hectares)	Oyster Bed Area in Acres (Hectares)
Potential Temporary Construction Disturbance[1]	13.1 (5.3)	0.88 (0.35)
Permanent loss under piles	0.011 (0.0044)	0.00058 (0.00023)
Permanent loss under steel plates, and concrete pads[2]	0.13 (0.051)	0.023 (0.0092)
Permanent loss under abutments	0.0068 (0.0028)	0
Operational Partial Shading[3]	0.35 (0.14)	0.054 (0.022)
Operational Full Shading[3]	0.05 (0.020)	0

1. The area within the 100-foot (30-meter) wide construction corridor.
2. The impact area for the benthic community would include the oyster beds and the areas in the pile footprints; thus, the oyster bed impact areas are subsets of the benthic community impact areas. The oyster bed area lost under steel plates was calculated using the width of the steel plates and average width of the north and south LWI oyster beds of 40 and 140 feet (12 and 43 meters), respectively.
3. Partially shaded areas would be the areas under the piers, floating docks, gangways, and stairs, which would be built with grating; fully shaded areas would be those areas under the observation posts and dolphin platforms.

Repositioning of the PSB anchors would result in minor increases in turbidity at those sites. Excavation for the abutments would be conducted above the oyster beds at both locations and would not impact oysters or other shellfish below in the intertidal zones. Potential impacts on the benthic community from erosion and turbidity during abutment construction would be reduced by limiting construction activities to low tides (i.e., constructing in the dry only). The abutments themselves would be located above MHHW, which is above the benthic community habitats. Only the abutment stair landings (12 square feet [2 square meters] at each LWI) would be placed below MHHW.

The increased potential for spills during construction, spill response, and debris cleanup would be as described above for marine vegetation under Vegetation Communities.

Disturbance from Placement of Piles, Anchors, and Steel Plate Anchors

Construction of LWI Alternative 2 would impact benthic communities through disruption of the sediment surface, which would result in at least partial loss of the community, including geoducks, in the affected areas. Barges used during construction typically have drafts (amount of barge below the water surface) up to 3 feet (1 meter) and would normally operate in water depths of 6 feet (2 meters) or more to prevent grounding. The barges would be at the construction site for up to 2 years and would cause shading under the barges, which could impact survival of the benthic community. An extensive oyster bed occurs at the south LWI Site (average width approximately 140 feet [43 meters]), and a more narrow, fringe oyster bed occurs north of EHW-1 at the north LWI site (average width approximately 40 feet [12 meters]) (Figure 3.2–5). Piles and steel plate anchors for the piers for Alternative 2 would be placed in these beds, and oysters and other benthic organisms in the footprints would be permanently lost. Assuming 100-foot (30-meter) wide construction corridors, up to 0.19 acre (0.079 hectare) of the north LWI oyster bed and 0.68 acre (0.28 hectare) of the south LWI oyster bed could be disturbed during construction. However, impacts on shellfish, including geoducks, due to sediment disturbance and increases in turbidity most likely would be within the narrower zone where the piles and steel plate anchors are installed; there would be fewer impacts on shellfish in the larger 100-foot wide corridor.

Some benthic organisms in the footprints of the barge anchors and spuds, as well as the temporary and permanent piles and steel plate anchors, would be physically crushed. Construction activities would also cause turbidity and sediment redeposition that would impact the benthic community. The areas within the 100-foot (30-meter) wide construction corridors would have higher levels of turbidity and disturbed sediments that would settle on top of the existing benthic community (see discussion of turbidity and suspended sediments in Section 3.1.2.2.2, under Water Quality). Suspension and surface deposit feeders would be the most susceptible to burial. Mobile infaunal deposit feeders would be more likely to survive burial due to their ability to burrow upward through the newly deposited material. Based on various studies of critical burial depths for different benthic organisms, critical burial depths appear to range from 2 inches (5 centimeters) for suspension and surface deposit feeders, to 12 inches (30 centimeters) for active burrowers (Maurer et al. 1978; Nichols et al. 1978). Turbidity plumes would be short lived and settling of resuspended fines on benthic communities would be minimal. Burial depths in the 100-foot wide construction corridor may exceed 2 inches (5 centimeters) in limited areas but would not approach 12 inches (30 centimeters) except in localized areas, such as where anchors and spuds would be placed and where temporary piles are installed and then pulled. The only areas potentially highly disturbed during construction of Alternative 2 would be the areas where the steel plate anchors for the mesh would be installed under the piers and where the temporary trestle piles would be installed at the south LWI project site. The observation posts would be constructed in the dry during low tides, which would minimize impacts on benthic communities at these locations.

Filter- and suspension-feeding invertebrates (e.g., bivalves, tunicates, crustaceans, and some polychaetes) may close their shells, suspend feeding, or increase feeding rates in response to turbidity increases (LaSalle et al. 1991; Cruz-Rodriguez and Chu 2002). Marine invertebrates have been shown to be tolerant of relatively high suspended solid concentrations over periods of hours to days, with adverse impacts limited to prolonged exposures (e.g., continuously up to 21 days) and/or to high concentrations (e.g., fluid mud) (reviews in LaSalle et al. 1991; O'Connor 1991; Clarke and Wilber 2000; and Wilber and Clarke 2001). However, the length of time for construction (5 to 6 days per week for up to 6 months for construction of the pier plus up to another 6 months for installation of the mesh) and the increased turbidity levels would likely result in short- to long-term loss of localized areas of the benthic community, including geoducks, within 100 feet of the project site.

Complete loss, however, would be limited to highly disturbed areas such as the small areas disturbed by anchor and spud placement, and the areas where the permanent and temporary piles and steel plate anchors are installed. Most affected areas would experience some reduction in diversity and abundance of benthic species. Opportunistic species, such as small tubiculous, surface-dwelling polychaetes, would be favored for recolonization where sediments accumulate.

Previous studies of dredged and other disturbed sites show that benthic and epibenthic invertebrates rapidly recolonize disturbed bottom areas within 2 years of disturbance (CH2M Hill 1995; Parametrix 1994a, 1999; Anchor Environmental 2002; Romberg 2005; Vivan et al. 2009). The benthic organisms lost due to turbidity and bottom disturbances by barges, tugboats, anchors, and spuds would be expected to become reestablished over a 3-year period after sediment disturbance at the sites have ceased.

Noise

Indirect impacts associated with increased underwater sound and vibration during pile driving would occur during construction. No studies have been identified that document invertebrate responses to pile driving sound. Although there are few studies of underwater sound impacts on invertebrates, available information suggests a variety of species (crabs, shrimp, clams, mussels, squid, sea cucumbers) tolerate temporary exposures to increased sound levels within the range expected with pile driving without long-term adverse impacts (Stocker 2001; Christian et al. 2003; Moriyasu et al. 2004; Kent and McCauley 2006).

Sound thresholds associated with sublethal physiological or behavioral responses are not well understood and apparently vary among invertebrate species. For example, egg development of snow crabs was delayed by exposure to seismic air gun peak sound decibel (dB) levels of 201 to 227 dB peak (Christian et al. 2003), but no impacts on Dungeness crab larvae were observed at mean sound pressures as high as 231 dB (Root Mean Square [RMS]) (Pearson et al. 1994). Continuous exposure of sand shrimp in aquaria to a high sound-level increase (30 dB in the 25 to 400 hertz [Hz] bandwidth) resulted in sublethal behavioral changes and reduced growth and reproduction (review in Moriyasu et al. 2004). Consequently, invertebrates may experience acoustic stress and disturbance as a result of impact hammer pile driving. Based on evidence from the limited scientific studies conducted to date, reproductive impairment of some invertebrate species, in the form of delayed egg maturity, could result from pile driving for Alternative 2. These impacts would not be expected to extend beyond the duration of pile driving (up to 80 days), and the peak sound levels with the potential to cause these impacts would occur only within the 33-foot (10-meter) radius around any pile being proofed with an impact hammer. As described in Chapter 2 and Appendix D (Noise Analysis), most of the piles would be driven using the vibratory method, which would result in much lower noise levels that are not expected to result in impacts on benthic species.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

The overwater structures of Alternative 2 would introduce limited shading in the immediate area of 0.4 acre (0.16 hectare) (Table 3.2–5), including 0.012 acre (0.0048 hectare) of the oyster bed at the north LWI and 0.042 acre (0.017 hectare) of the oyster bed at the south LWI. Regional studies have shown that light-blocking overwater structures can directly impact benthic productivity (Simenstad et al. 1999). For Alternative 2, the shaded area would be functionally minimized due to design elements incorporated into the structure, including the use of grating or other light-transmitting materials in the piers, floating docks, and gangways, the height of the piers over the water (approximately 17 feet [5 meters] above MLLW, which allows more sunlight to pass under the pier as the sun arcs across the sky), and the relatively narrow width. Only the areas under the observation posts and dolphin platforms would be fully shaded; however, these structures would not be located above the oyster beds. Therefore, there would be no shading impacts on oysters and very limited full shading impacts (0.05 acre [0.02 hectare]) on the rest of the benthic community.

Because there would be no vehicular traffic associated with the LWIs, there would be no requirement to collect and treat runoff from the LWI structures, and drainage would be to Hood Canal. Small boat operations at the floating docks would be infrequent (estimated two per day), minimizing the potential for propeller wash to cause suspension of bottom sediments. The risk of spills during operation would be minimized through adherence to COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G. Containment practices would be consistent with the existing Bangor shoreline structures, including the use of in-water containment booms and response plans (for more detail on impact reducing measures see Section 2.3.4 and Appendix C). Therefore, operation of the LWIs would not degrade water quality or impact benthic and shellfish communities.

Placement of piles and steel plate anchors would result in the long-term conversion of up to 0.039 acre (0.016 hectare) and 0.098 acre (0.04 hectare) of soft-bottom to hard-bottom habitat at the north and south LWIs, respectively. The abutment stair landings would be placed below MHHW, resulting in conversion of a total of 0.0006 acre (00002 hectare) of soft-bottom habitat, but these would be located at elevations well above shellfish habitats. Reconfiguration of the PSB anchors would result in the net gain of soft-bottom habitat where existing anchors are removed. However, the piles and anchors would increase the available in-water surface area and create colonization sites for hard-bottom species such as mussels (*Mytilus* sp.), tunicates, and sea anemones that would attach to the piles and anchors (the fouling community). The new community also would support other species such as amphipods, annelids, gastropods, and predatory sea stars that feed and take refuge in the newly created environment (Kozloff 1983; Cohen et al. 1998; Brooks 2004; Cordell 2006; PSAT 2006). The decrease in soft-bottom habitat and increase in hard substrate habitat would result in a localized change in species composition (Glasby 1999; Atilla et al. 2003), particularly in the areas where eelgrass abundance is reduced. However, there would not be a substantial loss of biological productivity in the area due to the creation of vertical structure for colonization. Colonization of new hard surfaces would begin within months (Schoener and Schoener 1981; Kozloff 1983; Goyette and Brooks 2001; Brooks 2004). A study of wooden piles at a Pacific Northwest location found that the pile community had twice as many species and nearly eight times the density as is typically found in Pacific Northwest sediments (Brooks 2004). However, steel piles would not be expected to attain the same epifaunal diversity as wood piles because steel loses more heat than wood during cold winter conditions, resulting in possible unfavorable conditions for the animals (Brooks 2009, personal communication).

The habitat value of the LWI sites would be significantly reduced in the steel plate anchor areas for species that utilize eelgrass. For example, Dungeness and red rock crabs use eelgrass for larval settlement, as refuge from predators, and as feeding sites (review in Mumford 2007). Macroalgae such as kelp, which also provide some habitat value for benthic organisms, would be expected to recover and to colonize the surface of the anchors.

As discussed for hydrography and sediment impacts in Section 3.1.2.2.2, the presence of the mesh would promote settling of suspended particles and accumulation on the seafloor (snow-fence effect). These changes would occur gradually over time, would be localized at the piles and mesh, and would not adversely impact benthic communities.

Maintenance of the LWIs would include routine inspections, repair, and replacement of facility components (no pile replacement) as required. Measures would be employed to minimize the likelihood of discharging contaminants to the marine environment (Section 3.1.2.2.2, under Water Quality). Any benthic fouling community that established on the underwater mesh and PSB guard panels would be scraped free during annual maintenance and carried on currents until they sink to the bottom. Most of these organisms would not survive due to their need for attachment and/or for specific water depths for habitat (e.g., mussels). There would be periodic impacts on turbidity and DO when the pier mesh and PSB guard panels are cleaned during maintenance activities. Any reductions in DO as a result of mesh and guard panel cleaning activities would be localized and transient, and would not impact benthic communities. Debris released by mesh and guard panel cleaning would be small and dispersed by currents such that it would not smother underlying or nearby benthic organisms.

PLANKTON FOR LWI ALTERNATIVE 2

During construction and operation of Alternative 2, there would be minimal changes in plankton distribution and abundance.

CONSTRUCTION OF LWI ALTERNATIVE 2

No direct impacts on plankton would occur during construction because plankton are not sessile and subject to impacts associated with placement of the piles and other in-water structures for the LWI. However, as described for construction impacts on water quality in Section 3.1.2.2.2, pile installation and propeller wash from construction vessels would result in suspension of bottom sediments and formation of a turbidity plume. Turbid conditions would be short-term and localized, and suspended sediments would disperse and/or settle rapidly (within a period of minutes to hours) after construction activities cease (see discussion of impacts on water quality in Section 3.1.2.2.2). Increases in turbidity associated with dredging, backfilling, or other large-scale bottom disturbances, can temporarily alter phytoplankton communities (Hanson et al. 2003). However, sediment disturbances from pile installation and anchor movement would not create such high levels of turbidity. Pile driving would occur between mid-July and mid-January, outside of the most productive period for phytoplankton in Puget Sound (May) (Strickland 1983). Further, because Alternative 2 would not increase nutrients in Hood Canal, construction of the LWI piers and PSB connections would not cause increases in toxin-associated species such as *Pseudo-nitzschia*, which could harm other aquatic organisms.

Potential impacts of increased water column turbidity on zooplankton include entrapment and sinking of plankton due to particle ingestion or adhesion, and decreased survival, growth rates, and body weight resulting from clogged and damaged feeding appendages (Pequegnat et al. 1978; O'Connor 1991; USACE 1993). However, the majority of zooplankton are filter-feeders and are well adapted to suspended materials in the water. Studies in freshwater and marine systems have found that some zooplankton actively migrate to areas of turbidity (review in O'Connor 1991). Some non-selective, filter-feeding zooplankton, including calanoid copepods commonly found in Puget Sound, may decrease their feeding rates in response to high TSS (O'Connor 1991).

The increased potential for spills during construction, spill response, and debris cleanup would be as described above for marine vegetation under Vegetation Communities. Sediments at the north and south LWI project sites have low organic carbon levels (Section 3.1.1.1.3), which correspond to low levels of organic nutrients. Therefore, releases of nutrients to the water column due to sediment resuspension during construction would not be of sufficient magnitude to cause an increase in phytoplankton blooms, including harmful algal blooms, along the Bangor shoreline. Construction of LWI Alternative 2 would not decrease the existing plankton abundance or alter the plankton community.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 2

Piles supporting the piers and observation posts would create colonization sites for common marine fouling communities, including filter-feeders that prey on plankton. Hard surfaces are known to support a variety of planktonic organisms including protozoa, foraminiferans (Kozloff 1983), and benthic diatoms (Stark et al. 2000). Planktonic harpacticoid copepods, ostracods, amphipods, and isopods are often abundant around docks and piers that provide a habitat and food source of algae, diatoms, and hydroids (Kozloff 1983).

LWI Alternative 2 would increase overwater shading at the project site by approximately 0.4 acre (0.16 hectare). However, the use of grating in the pier decks, floating docks, and gangways would permit light transmission to the water. Other design elements of the structures (e.g., height of the piers over the water and narrow width) would also minimize the area shaded. The only areas fully shaded would be those under the observation posts and dolphin platforms (total of 0.05 acre [0.02 hectare]). The observation posts would be located high in the intertidal zone. In aquatic systems with static water, such as lakes, overwater shading can substantially reduce the productivity of plankton (review in Kahler et al. 2000). However, given surface currents of approximately 0.07 to 0.1 foot (2 to 3 centimeters) per second (Section 3.1.1.1.1) in the project vicinity, potential residence times for plankton under either of the LWI piers would be on the order of minutes, depending on local variations in flow direction. Therefore, although the LWI structures would create new overwater shading, no appreciable reduction in primary production of phytoplankton communities would occur due to the localized nature of the shading; the design of the structures, which would minimize shading (use of light transmitting materials in the piers, floating docks, and gangways, height of the piers over water, narrow width); and the short residence time of plankton under structures.

Observed effects of artificial nighttime lighting on plankton include increased feeding opportunities by predators, including salmonids (Nightingale and Simenstad 2001a). Studies of freshwater plankton in a lake setting found potential inhibition of grazing of zooplankton that migrate toward the water surface at night to feed (Moore et al. 2006). However, as described above, surface currents would quickly move planktonic organisms through the area. Further, the pier security lighting directed at the water would not operate constantly, but on an as-needed basis, such as during security responses. Therefore, artificial lighting of the LWIs and observation posts would not significantly impact plankton resources.

Small boat operations at the floating docks would be infrequent, minimizing the potential for propeller wash to resuspend bottom sediments. Maintenance of the LWI piers would include routine inspections, repair, and replacement of facility components as required. Planktonic organisms residing amongst the fouling vegetation and other organisms on the underwater mesh and PSB guard panels would be periodically removed during maintenance when the mesh is cleaned. Measures would be employed to avoid discharge of contaminants to the marine environment (Section 3.1.2.2.2).

3.2.2.2.3. LWI ALTERNATIVE 3: PSB MODIFICATIONS (PREFERRED)

VEGETATION COMMUNITIES FOR LWI ALTERNATIVE 3

As described in Chapter 2, Alternative 3 differs from Alternative 2 in that pile-supported piers would not be installed and PSBs would be extended all the way to shore.

CONSTRUCTION OF LWI ALTERNATIVE 3

Construction impacts on marine vegetation would be much less under this alternative than Alternative 2, due to the less intensive nature of in-water construction required to place PSB buoy anchors compared to installing piles used to construct the piers in Alternative 2. Also, less substrate would be disturbed in this alternative compared to Alternative 2 and only one in-water construction season would be required.

As shown in Table 3.2–6, an estimated 0.46 acre (0.19 hectare) and 0.5 acres (0.2 hectare) of eelgrass potentially would be impacted within the 100-foot (30-meter) wide construction corridors of the north and south LWI, respectively (Figure 3.2–12). Similarly, an estimated 0.36 acre (0.15 hectare) and 2.1 acres (0.84 hectares) of green macroalgae, 0.18 acre (0.075 hectare) and 1.7 acres (0.68 hectare) of red macroalgae, and 0.16 acre (0.065 hectare) and 0.35 acre (0.14 hectare) of brown macroalgae potentially would be impacted within the 100-foot wide construction corridors of the north and south LWI, respectively (Figures 3.2–13 and 3.2–14). The observation posts would be located above the areas of marine vegetation. Construction of the observation posts would be done in the dry at low tides, and would not impact marine vegetation.

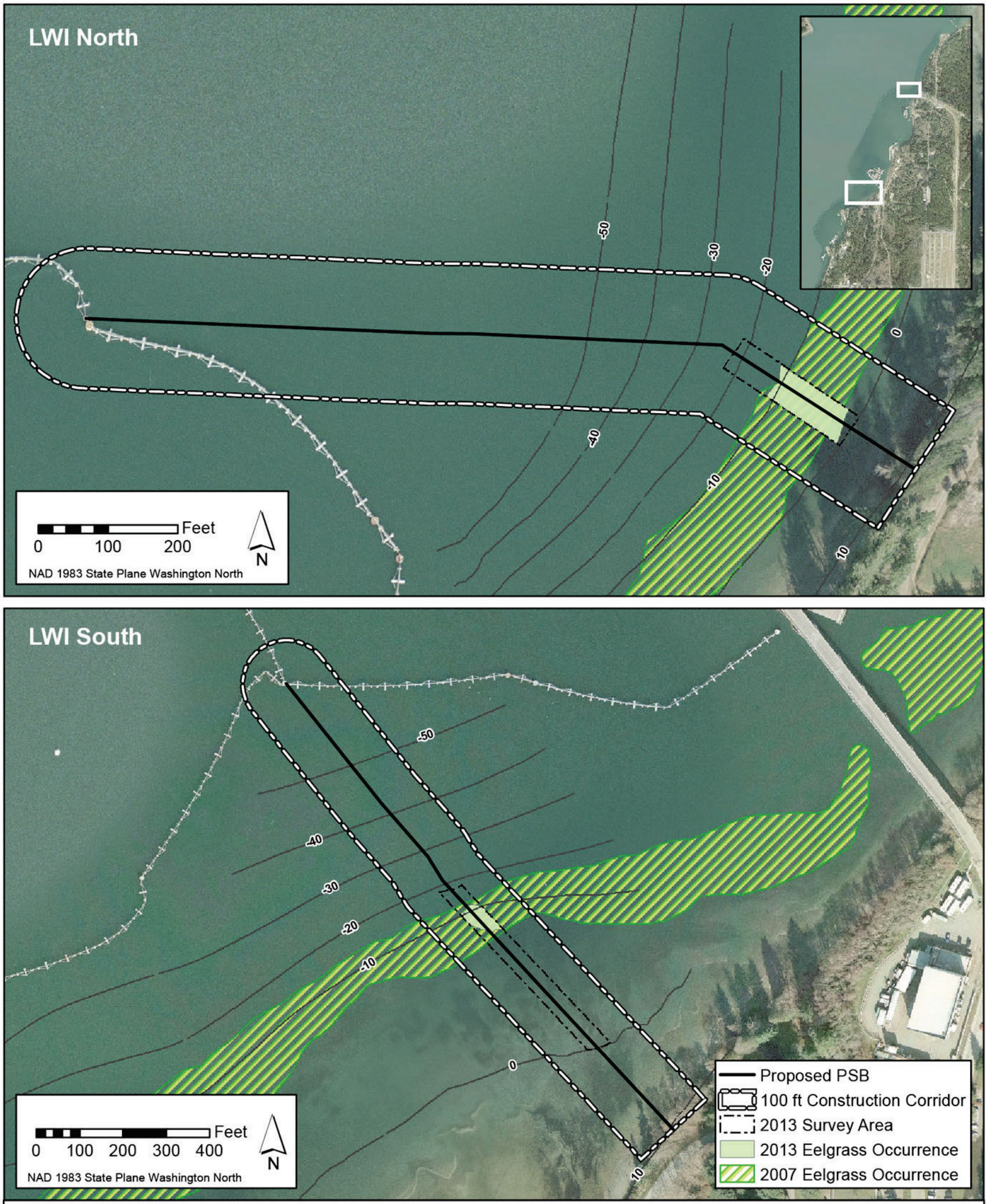
Because vegetated communities comprise a mixture of vegetation types, the acreages are not additive and the total marine vegetation area potentially impacted by in-water construction activities would be 2.8 acres (0.67 and 2.1 acres [0.27 and 0.85 hectare] for the north and south LWI project sites, respectively). As with Alternative 2, construction impacts in the 100-foot wide construction corridor identified in this section are conservative; the actual impact are expected to be substantially less. The eelgrass beds would be avoided when placing the PSB buoy mooring anchors.

As described in Section 3.1.2.2.3, installation of the LWI PSBs would temporarily increase suspended sediment concentrations and turbidity levels as a result of resuspension of bottom sediments during relocation and placement of PSB mooring anchors. Propeller wash impacts could occur in shallow waters, although current practices would be employed to prevent or minimize these effects. Construction activities would not result in persistent increases in turbidity levels, and increases in turbidity levels would be short-term and localized as suspended sediments would disperse and/or settle rapidly (within a period of minutes to hours) after construction activities cease. Therefore, turbidity impacts on marine vegetation would be localized and temporary.

Table 3.2–6. Marine Habitat Impacted by LWI Alternative 3

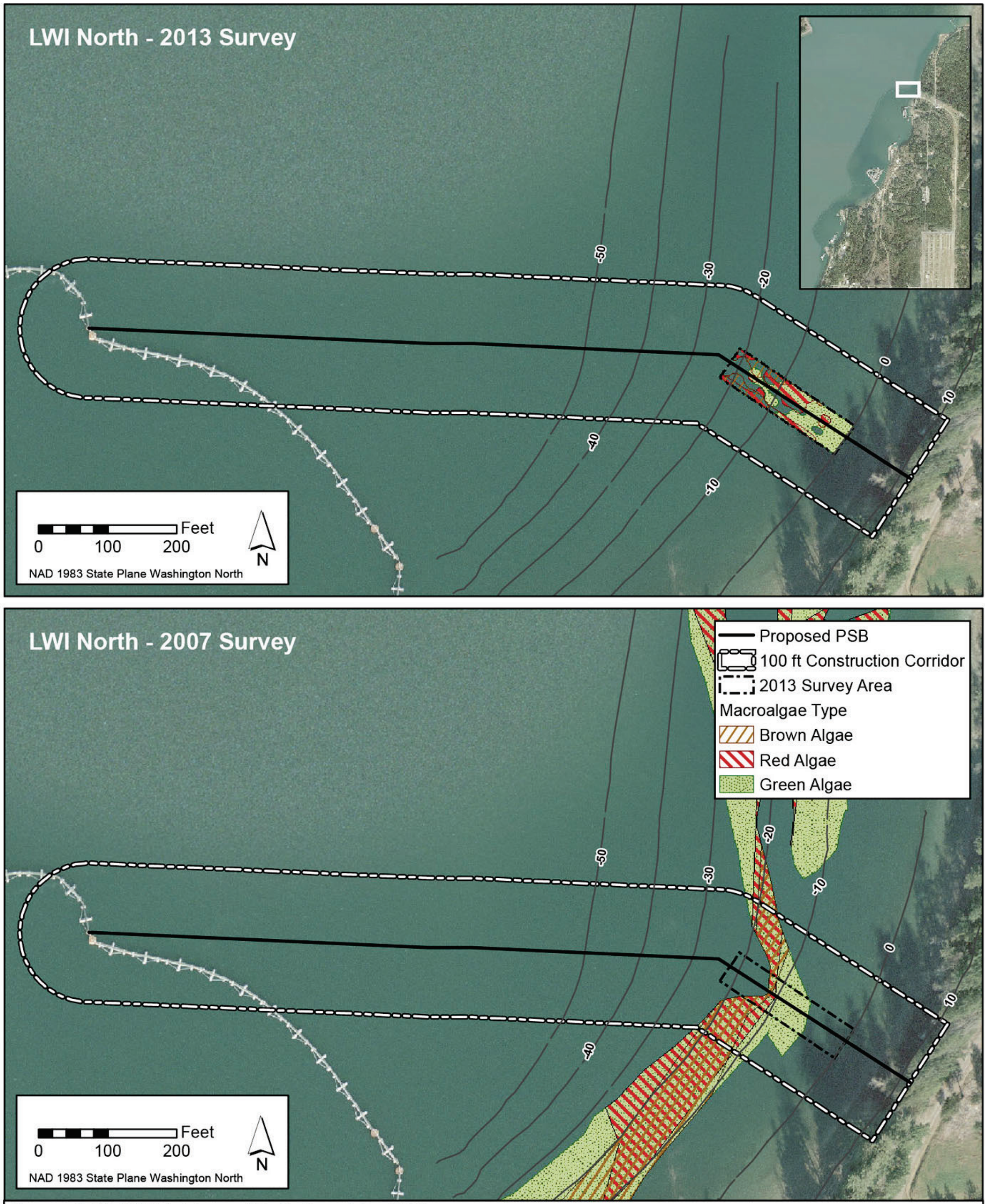
Habitat Type	Potential Temporary Construction Disturbance Area in Acres (Hectares)[1]	Operational Full Shading in Acres (Hectares)[2]	Operational Partial Shading in Acres (Hectares)[2]	Permanent Losses due to PSB & Buoy Grounding in Acres (Hectares)[3]
Nearshore	5.9 (2.4)	0.046 (0.019)	0.07 (0.029)	0.06 (0.024)
Deep Water	6.8 (2.8)	0	Reduction[4]	0
Vegetation Type[5]				
Eelgrass[6]	1.0 (0.39)	0	0.01 (0.0039)	0.013 (0.0054)
Green Macroalgae	2.4 (1.0)	0	0.027 (0.011)	0.043 (0.018)[7]
Red Macroalgae	1.9 (0.75)	0	0.0072 (0.0029)	0.01 (0.0039)
Brown Macroalgae (Kelp)	0.51 (0.21)	0	Negligible	Negligible

1. The potential construction disturbance area includes the structure footprint and the area within 100 feet of the proposed LWI structures. Calculated based on results of the 2007 survey, which covered the entire 100-foot (30-meter) construction corridor.
2. Full shading would be from the observation posts. Partial shading includes contributions from nearshore PSB pontoons (estimated 8 modules at the north LWI project site and 18 modules at the south LWI project site; shade from each module is 105 square feet) and the observation post stairs. Operational impacts on marine vegetation were calculated based on results of the 2013 survey, which covered the area 25 feet (7.6 meters) to either side of the centerline of the proposed LWI structures.
3. There would be some overlap in the areas partially shaded by the PSB pontoons and the areas impacted by grounded PSBs. Impact calculations for vegetated habitats include relocated and/or new PSB mooring anchors; the nearshore habitat calculation does not include mooring anchors because there will be an overall net reduction in the area of mooring anchors.
4. There would be a net reduction in deep water PSB mooring anchors and shading due to relocation of some PSB segments to nearshore waters. The amount of reduction was not calculated due to the variability in deep-water pontoon positions as tides change.
5. Eelgrass and macroalgae overlap in their occurrence along the Bangor shoreline. Therefore, the total acreage of marine vegetation potentially impacted cannot be calculated by summing the values for each vegetation type.
6. Barges would avoid placing spuds or anchors in eelgrass beds wherever possible.
7. PSB mooring anchors would create hard surface attachment sites for new macroalgae growth.



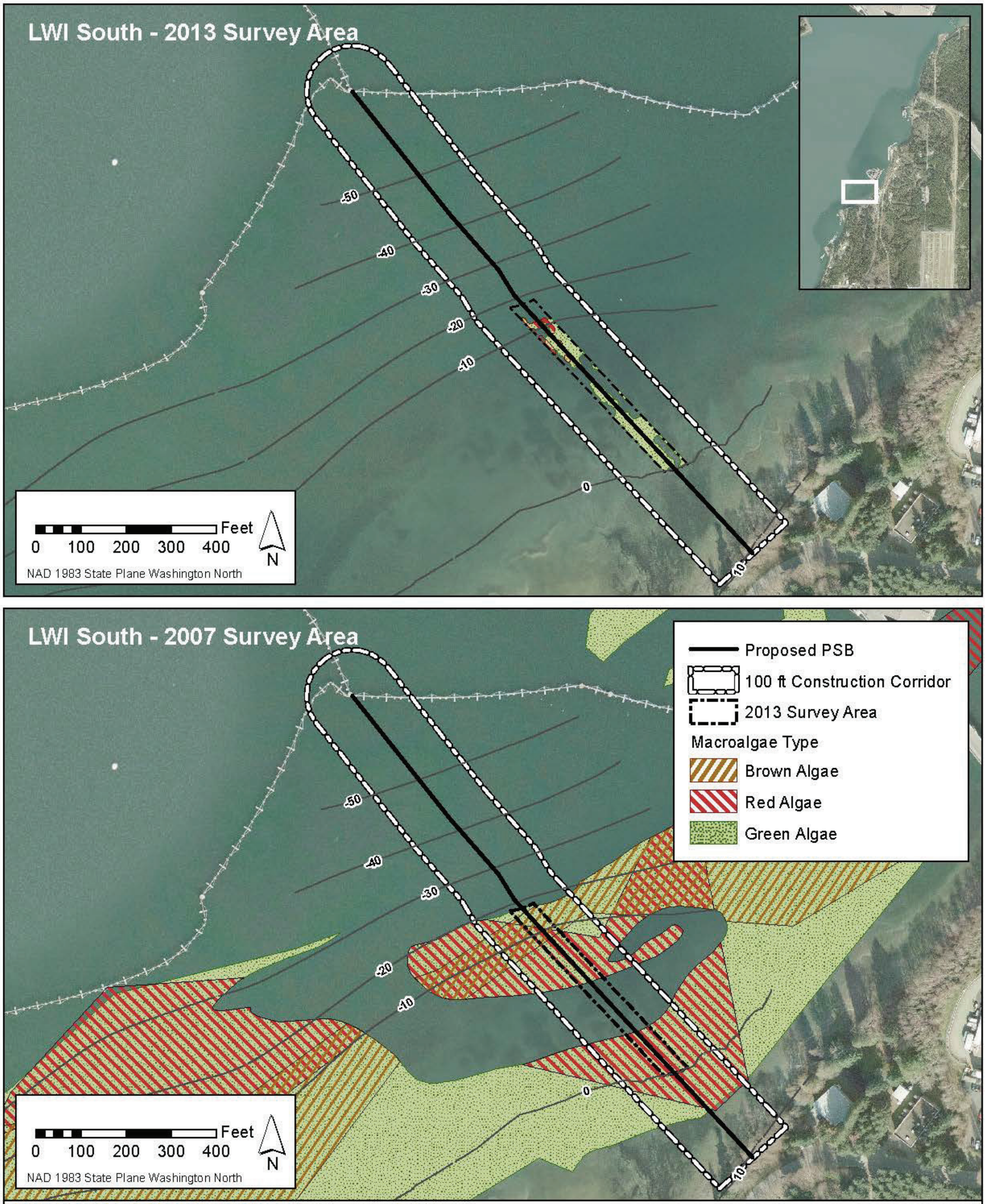
Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–12. Disturbance Areas for Eelgrass near the LWI Alignments, Alternative 3



Source: SAIC 2009; Leidos and Grette Associates 2013a

Figure 3.2–13. Disturbance Area for Macroalgae near the North LWI Alignment, Alternative 3



Source: SAIC, 2009; Leidos and Grette Associates, 2013a

Figure 3.2-14. Disturbance Area for Macroalgae near the South LWI Alignment, Alternative 3

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 3

It is anticipated that during lower low water conditions, no more than 5 PSB modules on the north LWI and 13 on the south LWI would “ground out” (i.e., touch the bottom). On average, however, between mean high and MLLW, approximately 11 PSB units including a total of 33 pontoons would ground out in the intertidal zone. To minimize the resulting disturbance of the intertidal zone, each pontoon would be fitted with metal “feet” that would prevent the entire pontoon from contacting the surface. The PSB sections and buoys would be moored to minimize side to side movement. Combined with the local bathymetry and predictable flood and ebb influence on PSB pontoon position, this is expected to result in clean grounding with little to no scouring. Over the long term, it is estimated that PSB feet and buoys would disturb approximately 2,594 square feet (241 square meters) of the intertidal zone.

During very low tides, up to two PSB units and one buoy are anticipated to ground out in the north LWI eelgrass bed and one PSB unit would ground out in the south LWI eelgrass bed. Up to 0.013 acre (0.0054 hectare) of eelgrass habitat, 0.043 acre (0.018 hectare) of green macroalgae, and lesser amounts of red and brown macroalgae habitat would be eliminated under PSB buoy mooring anchors and over time due to PSB and buoy grounding. The anchors, however, would create additional hard substrate for macroalgae colonization.

Partial shading effects from Alternative 3 on marine vegetation would be from the nearshore PSB units. Each PSB unit would create 0.0024 acre (0.00098 hectare) of shading, for a total of approximately 0.063 acre (0.025 hectare) of shading in the nearshore area. However, the PSBs would move with the tides and currents and would not continually shade or limit marine vegetation growth at the depths where there is no grounding. There would be a net reduction in shading of deep water due to the relocation of PSB units from deep water to nearshore areas. The observation posts would be located above the areas of marine vegetation; therefore, operation of these posts would not impact marine vegetation.

BENTHIC COMMUNITIES FOR LWI ALTERNATIVE 3

As described in Chapter 2, Alternative 3 would not construct piers, but would construct and install new floating PSB systems that would connect to new shoreline abutments and the existing but reconfigured floating PSB systems. The alignments and lengths of the LWIs would be the same as for Alternative 2, but substrate disturbance would be less in Alternative 3.

CONSTRUCTION OF LWI ALTERNATIVE 3

Construction impacts on benthic communities would be less under this alternative because of the slightly smaller construction corridor (12.7 acres for Alternative 3 vs. 13.1 acres for Alternative 2), and the less intensive construction required to place buoy anchors and a small number of piles in the upper intertidal that would be installed from land (Table 3.2–7). Further, LWI Alternative 3 would require only one in-water construction season versus two in-water seasons for Alternative 2. An estimated 6.1 acres (2.5 hectares) and 6.6 acres (2.7 hectares) of benthic habitat potentially would be impacted within the 100-foot (30-meter) wide construction corridors of the north and south LWI, respectively. The benthic communities in the footprints of the PSB anchors used to moor the eight buoys (total of 236 square feet [22 square meters] for each 3-anchor leg buoy and 139 square feet [13 square meters] for each 2-anchor leg buoy) would be eliminated when they are installed. Assuming 100-foot wide construction corridors, up to 0.18 acre (0.074 hectare) of the north LWI oyster bed and 0.64 acre (0.26 hectare) of the south LWI oyster bed, for a total of 0.83 acre (0.33 hectare) could be disturbed during construction.

Table 3.2–7. Benthic Community Resources Impacted by LWI Alternative 3

Impact Type	Benthic Community Area[1] in Acres (Hectares)	Oyster Bed Area[2] in Acres (Hectares)
Potential Temporary Construction Disturbance	12.7 (5.2)	0.83 (0.33)
Permanent Loss under Piles and Concrete Pads	0.0016 (0.00063)	0
Nearshore Operational Shading	0.12 (0.047)	0.0027 (0.0011)
Operational Substrate Disturbance (under pontoon feet and buoys)	0.06 (0.024)	0.013 (0.0052)

1. Benthic community area in the 100-foot (30-meter) wide construction corridor around the PSB system area.
2. The impact area for the benthic community includes the oyster bed; thus, the oyster bed is a subset of the benthic community.

As described in Section 3.1.2.2.3, construction of LWI Alternative 3 would temporarily increase suspended sediment concentrations and turbidity levels as a result of resuspension of bottom sediments during relocation and placement of PSB mooring anchors. Propeller wash impacts could occur in shallow waters, although current practices would be employed to prevent or minimize these effects.

There would be little potential for noise impacts because there would be no in-water pile driving for this alternative. The observation post piles, with a total footprint of 0.001 acre (0.00041 hectare), would be located in the upper intertidal zone above the oyster beds and driven in the dry. No piles would be driven in the oyster beds. While construction equipment and boats would emit noise, this would be temporary and generally of the same magnitude as other industrial activities along the Bangor shoreline.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 3

Under Alternative 3 there would be a small net decrease in the number of PSB anchors and in the amount of seafloor disturbed by anchor chains. The observation post piles and PSB anchors would be colonized by hard-bottom species and common fouling communities and would effectively result in soft-bottom benthos converted to hard-bottom benthos. These communities are known to support a variety of organisms including a number of green and red algae species, mussels (*Mytilus* spp.), copepods, and amphipods. This conversion from soft-bottom benthos to hard-bottom substrate would result in minor localized faunal and floral changes, but it would not result in any loss of biological productivity.

Up to 18 PSB pontoon units and 3 buoys would touch the intertidal substrates during lower low tides, 5 PSBs and 1 buoy at the north LWI and 13 PSBs and 2 buoys at the south LWI. Over time, each pontoon foot would disturb an area approximately 10 times its size, given shifts of the PSB systems during tidal cycles and buoys would disturb an area approximately five times their size. The total area disturbed is estimated at 0.06 acre (0.024 hectare), with 0.017 acre

(0.0067 hectare) at the north LWI project site and 0.043 acre (0.0017 hectare) at the south LWI project site. Repeated disturbance to the sediment surface in these localized areas would substantially reduce the habitat value for benthic organisms.

The total area of nearshore benthic habitats shaded by the PSB pontoons in Alternative 3 would be considerably less than the shading from Alternative 2 (0.063 acre vs. 0.34 acre [0.025 vs. 0.14 hectare]), although nearly all of the LWI Alternative 2 shading would be by grated piers, floating docks, and gangways that would transmit some light. Observation posts would contribute the same amount of full shading in the upper intertidal zone under either alternative (total of 0.046 acre [0.019 hectare] for both north and south observation posts). Benthic habitat conversion (0.01 acre [0.004 hectare]) due to placement of the abutment stair landings and observation post piles and stairs below MHHW would be the same under either alternative. There would be no net gain in deep water shading due to relocation of existing PSB units from deep water to nearshore areas when the LWI is constructed.

PLANKTON FOR LWI ALTERNATIVE 3

As described in Chapter 2, LWI Alternative 3 would not construct piers, but would construct and install new floating PSB systems that would connect to new shoreline abutments and the existing but reconfigured floating PSB systems. The alignments and lengths of the LWIs would be the same as for LWI Alternative 2.

CONSTRUCTION OF LWI ALTERNATIVE 3

Potential impacts on plankton from construction of LWI Alternative 3 would be similar to those described for LWI Alternative 2. The construction disturbance area would be slightly smaller under LWI Alternative 3 due to the slightly smaller construction corridor (12.7 vs. 13.1 acres [5.2 vs. 5.3 hectares]) and less intensive construction, and only one in-water construction season would be required versus two for LWI Alternative 2.

As described in Section 3.1.2.2, construction of the PSBs would temporarily increase suspended sediment concentrations and turbidity levels as a result of resuspension of bottom sediments during relocation and placement of PSB mooring anchors. Propeller wash impacts could occur in shallow waters, although current practices would be employed to prevent or minimize these effects. Releases of nutrients to the water column due to sediment resuspension during construction would not be of sufficient magnitude to cause an increase in phytoplankton blooms, including harmful algal blooms, along the Bangor shoreline.

OPERATION/LONG-TERM IMPACTS OF LWI ALTERNATIVE 3

Operational impacts on plankton from LWI Alternative 3would be primarily due to impacts from shading. Potential impacts on plankton from artificial lighting would be minimal and similar to those described for Alternative 2. Operational shading from this alternative would be limited to the observation posts, which would be located high in the intertidal zone, and the pontoons in the PSB units in the nearshore where horizontal movement is limited. Observation post shading would be minimized by the height of these structures over the water and the use of grating for the stairs and walkways. Planktonic organisms residing among the fouling vegetation and other organisms on the PSB guard panels would be periodically removed during maintenance when the guard panels are cleaned.

3.2.2.2.4. SUMMARY OF IMPACTS FOR LWI PROJECT ALTERNATIVES

Impacts on marine vegetation and invertebrates during the construction and operation phases of the LWI project alternatives, along with mitigation and consultation and permit status, are summarized in Table 3.2–8.

Table 3.2–8. Summary of LWI Impacts on Marine Vegetation and Invertebrates

Alternative	Environmental Impacts on Marine Vegetation and Invertebrates
Impact	
LWI Alternative 1: No Action	No impact.
LWI Alternative 2: Pile-Supported Pier	**Marine Vegetation** *Construction:* Would temporarily disturb marine vegetation in a localized area. Potential disturbance of 6.2 acres (2.5 hectares) of shallow water habitat including 1.1 acres (0.43 hectare) of eelgrass, 2.6 acres (1.1 hectare) of green macroalgae, 2.0 acres (0.81 hectare) of red macroalgae, and 0.57 acre (0.23 hectare) of brown macroalgae (primarily kelp). Construction would be conducted over two in-water work seasons: one to build the piers and one to install the mesh. *Operation/Long-term Impacts:* Permanent loss of eelgrass (0.024 acre [0.01 hectare]) in steel plate anchor and pile footprints. This represents less than 0.13 percent of the existing eelgrass beds at those locations. No full shading in areas of marine vegetation; partial shading from grated structures not expected to impact marine vegetation. **Benthic Invertebrates** *Construction:* Temporary disturbance of community in maximum of 13.1 acres (5.3 hectares); loss of 0.14 acre (0.056 hectare) of benthic organisms in footprints (piles, steel plate anchors, and concrete pads); construction would be conducted over two in-water work seasons, with no more than 80 days of in-water pile driving in the first season and mesh installation in the second season. *Operation/Long-term Impacts:* Full overwater shading (0.05 acre [0.02 hectare]) may slightly affect sessile benthic organism productivity but would primarily be located high in the intertidal zone above oyster beds; steel piles, plate anchors, and abutment stair landings would result in permanent loss of 0.14 acre (0.058 hectare) of soft-bottom habitat and an increase in hard surface habitat. **Plankton** *Construction:* Indirect and localized effects from increased turbidity and settling of resuspended sediments from in-water construction and vessel activity. Construction would be conducted over two in-water work seasons. *Operation/Long-term Impacts:* No appreciable reduction in primary production of phytoplankton.

Table 3.2–8. Summary of LWI Impacts on Marine Vegetation and Invertebrates (continued)

Alternative	Environmental Impacts on Marine Vegetation and Invertebrates
LWI Alternative 3: PSB Modifications (Preferred)	**Marine Vegetation** *Construction:* Slightly smaller area of potential construction disturbance in shallow water (5.9 acres [2.4 hectares]) including 1 acre (0.39 hectare) of eelgrass, 2.4 acres (1 hectare) of green macroalgae, 1.9 acres (0.75 hectare) of red macroalgae, and 0.51 acre (0.21 hectare) of brown macroalgae (primarily kelp). Construction would be conducted over one in-water work season. *Operation/Long-term Impacts:* No full shading in areas with marine vegetation. PSB anchors, and PSB and buoy grounding would impact 0.013 acre (0.0054 hectare) of eelgrass, and less than 0.05 acre (0.02 hectare) of macroalgae habitat. **Benthic Invertebrates** *Construction:* Slightly smaller area of potential construction disturbance of 12.7 acres (5.2 hectares) (versus 13.1 acres [5.3 hectares]) of benthic habitat; loss of 0.0016 acre (0.00063 hectare) of benthic organisms in pile and abutment stair landing footprints; no in-water pile driving; construction would be conducted over one in-water work season. *Operation/Long-term Impacts:* Smaller permanent loss of 0.0016 acre (0.00063 hectare) of soft-bottom habitat from piles and abutment stair landings; however, grounding of pontoon feet and buoys would scour small areas of intertidal habitat (estimated 0.06 acre [0.024 hectare]) over time. Full overwater shading from observation posts in the upper intertidal zone (0.046 acre [0.019 hectare]), slightly less than Alternative 2. **Plankton** *Construction:* Lower potential for impacts than Alternative 2 due to less intensive construction required, less turbidity, and one less in-water work season. *Operation/Long-term Impacts:* No appreciable reduction in primary production of phytoplankton.
Mitigation: BMPs and current practices to reduce and minimize impacts on marine vegetation and invertebrates are described in Section 3.2.1.2.4 under Current Requirements and Practices. Under either alternative, proposed compensatory aquatic mitigation (Appendix C, Section 6.0) would compensate for the remaining impacts of the LWI.	
Consultation and Permit Status: The Navy will include impacts on marine vegetation and benthic communities as part of its consultation with the NMFS West Coast Region office under the ESA and MSA. A biological assessment and EFH assessment will be prepared and submitted to the NMFS West Coast Region office. The Navy will submit a JARPA to USACE and other regulatory agencies, requesting permits under CWA Sections 401 and 404, and Rivers and Harbors Act Section 10. Alternative 3 is the Least Environmentally Damaging Practicable Alternative according to the CWA Section 404(b)(1) guidelines. The Navy will prepare and submit a CCD to WDOE.	

BMP = best management practice; CCD = Coastal Consistency Determination; CWA = Clean Water Act; EFH = Essential Fish Habitat; ESA = Endangered Species Act; JARPA = Joint Aquatic Resources Permit Application; MSA = Magnuson-Stevens Fishery Conservation and Management Act; NMFS = National Marine Fisheries Service; USACE = U.S. Army Corps of Engineers; WDOE = Washington Department of Ecology

3.2.2.3. SPE PROJECT ALTERNATIVES

3.2.2.3.1. SPE ALTERNATIVE 1: NO ACTION

Under the No Action Alternative, the SPE would not be built and operations in the area would not change from current levels. Therefore, there would be no impacts on marine vegetation, benthic communities, or plankton.

3.2.2.3.2. SPE ALTERNATIVE 2: SHORT PIER (PREFERRED)

VEGETATION COMMUNITIES FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

The total area of habitat in the potentially disturbed construction area for SPE Alternative 2 would be 1 acre (0.42 hectare) in the nearshore and 2.9 acres (1.2 hectares) in deep water (Table 3.2–9; Figures 3.2–15 and 3.2–16). Of those 3.9 acres (1.6 hectares), approximately 0.45 acre (0.18 hectare) (11 percent) supports marine vegetation communities, primarily green macroalgae. However, construction activities would largely be restricted to deep waters (30 feet [9 meters] below MLLW and deeper) beyond the depths where marine vegetation occurs. The impact area would consist of the SPE footprint where existing piles would be removed and new piles would be driven and a 100-foot (30-meter) wide corridor where barges would be stationed and tugboats would maneuver the barges during construction. The only seafloor areas that would be highly disturbed would be where the piles are removed or installed, which are located beyond the depths where marine vegetation occurs at the site. Most of the sediments at the SPE site are coarse grained and resuspended sediments would settle close to the disturbance area (Section 3.1.2.2.2, under Water Quality). Given the distance of the site to marine vegetation and the low percentage of fines, turbidity plumes would be short-lived and settling of resuspended fines on submerged vegetation is expected to be minimal.

Table 3.2–9. Marine Habitat Impacted by SPE Alternative 2

Habitat Type	Potential Temporary Construction Disturbance Area in Acres (Hectares)[1]	Area Permanently Displaced by Piles in Acres (Hectares)[2]	Operational Shading in Acres (Hectares)
Nearshore	1.0 (0.42)	0	0
Deep Water	2.9 (1.2)	0.045 (0.018)	1.0 (0.41)
Vegetation Type[3]			
Eelgrass[4]	Negligible	0	0
Green Macroalgae	0.27 (0.11)	0	0
Red Macroalgae	Negligible	0	0
Brown Macroalgae (Kelp)	Negligible	0	0

1. The potential temporary construction disturbance area includes the structure footprint and the area within 100 feet (30 meters) of the proposed SPE structure.
2. Includes the area displaced by the proposed pier extension piles minus the area of piles being removed from the existing Service Pier.
3. Eelgrass and macroalgae overlap in their occurrence along the Bangor shoreline. Therefore, the total acreage of marine vegetation potentially impacted cannot be calculated by summing the values for each vegetation type.
4. No piles would be installed in eelgrass and barges would avoid anchoring in eelgrass beds wherever possible.

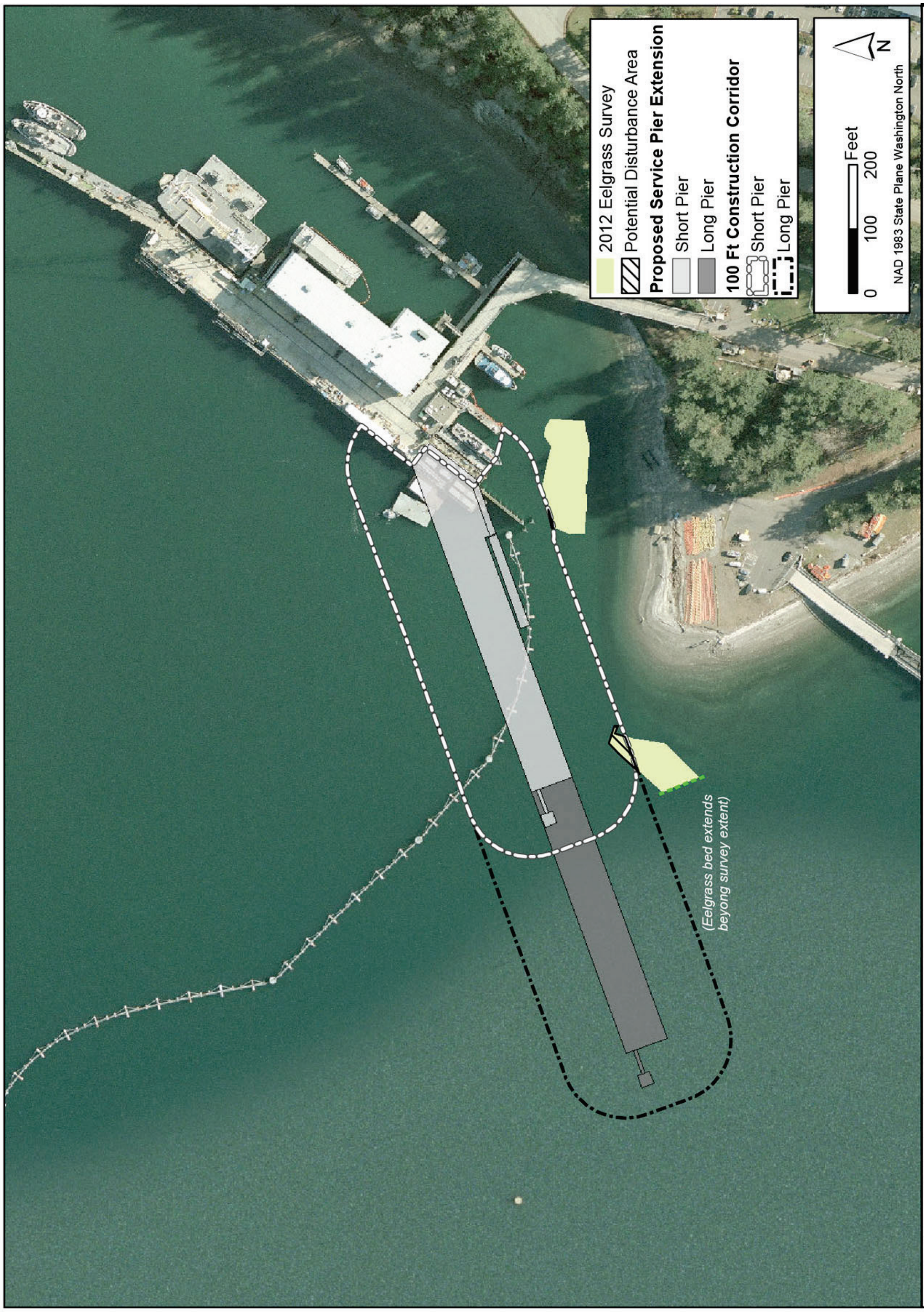
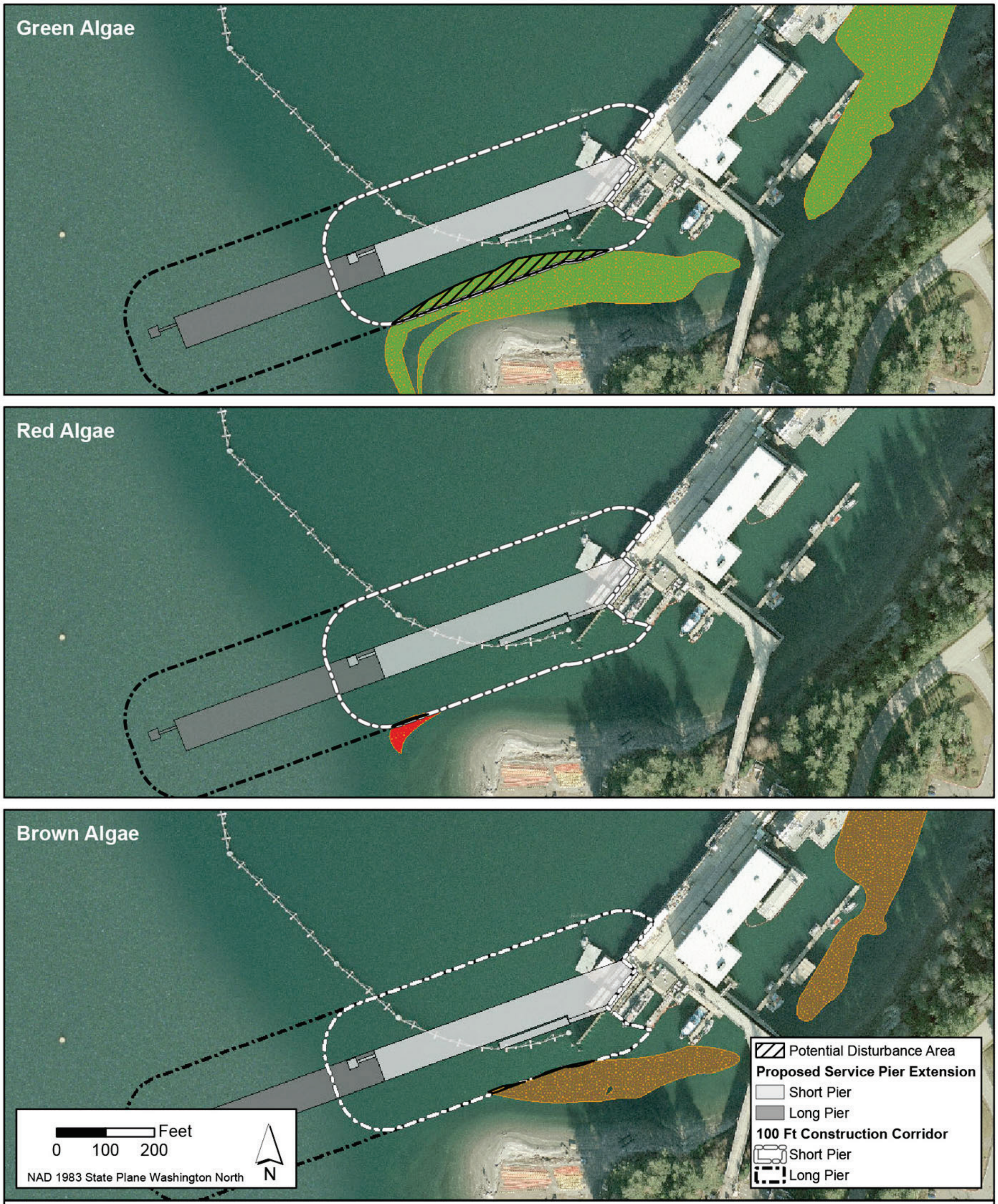


Figure 3.2–15. Disturbance Area for Eelgrass near SPE Alternatives 2 and 3

Source: Anchor QEA 2012



Source: SAIC 2009

Figure 3.2–16. Disturbance Area for Macroalgae near SPE Alternatives 2 and 3

Sargassum is an invasive algal species that can be introduced to new areas by distribution on the hulls of barges, tugboats, and other boats, and on propellers or anchors (review in Josefsson and Jansson 2007). Given the existing *Sargassum* in the SPE construction area, contractors constructing the SPE would be required to comply with RCW 77.15.290 (*Unlawful transportation of fish or wildlife — Unlawful transport of aquatic plants — Penalty*), which imposes penalties for transporting invasive aquatic plants and requires recreational and commercial boats be decontaminated. The piles and other materials for the structures would be new and therefore would not be sources of attached exotic organisms. In addition, the vessels used during construction would also be required to comply with U.S. Coast Guard regulations designed to minimize the spread of exotic species. As a result, construction of the SPE would not introduce exotic species from foreign water bodies or increase the prevalence of existing exotic species in Hood Canal.

The potential for spills during construction is described for Other Contaminants in Section 3.1.2.3.2. The existing facility response and prevention plans for the Bangor shoreline provide guidance that would be used in a spill response, such as a response procedures, notification, and communication plan; roles and responsibilities; and response equipment inventories. In the event of an accidental spill, response measures would be implemented immediately to minimize potential impacts on the surrounding environment. Following completion of in-water construction activities, an underwater survey would be conducted to remove any remaining construction materials that may have been missed during previous cleanups. Therefore, overall construction activities associated with SPE Alternative 2 would not cause long-term impacts on marine vegetation.

Given the water depths at the project site and restriction of construction vessels to the construction corridor and deep waters, there would be no significant impacts on marine vegetation from construction of SPE Alternative 2.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

While the SPE would shade 1.0 acre (0.41 hectare), this shading would be in deep waters that do not support marine vegetation as of the 2007 survey (Table 3.2–9). The piles would create new substrate to support colonization of algae common to marine fouling communities, such as *Ulva*.

Operation of SPE Alternative 2 would not increase the risk of accidental spills of fuel, explosives, cleaning solvents, and other contaminants that, if spilled, would impact marine vegetation. This is because the existing NAVBASE Kitsap Bangor spill prevention and response plans would help prevent fuel spills. In the event of an accidental spill, emergency cleanup measures would be implemented immediately in accordance with state and federal regulations. The cleanup would minimize impacts on the surrounding environment. Therefore, there would be no operational impacts on marine vegetation from SPE Alternative 2.

BENTHIC COMMUNITIES FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

Construction impacts of SPE Alternative 2 on the benthic community would be due primarily to pile removal and installation activities, with disruption of the sediment and at least partial loss of the community in the affected area. There would be some minor loss of encrusting species (e.g., mussels) on the piles removed from the existing Service Pier.

Potential noise impacts (e.g., reproductive impairment of some invertebrate species, in the form of delayed egg maturity [Christian et al. 2003]) would be limited to the immediate area around piles being driven by impact hammer and to the period of construction. However, most of the piles would be driven using the vibratory method, which would result in noise levels that are not expected to result in impacts on benthic species.

An estimated 3.9 acres (1.6 hectares) of benthic habitat potentially would be impacted within the 100-foot (30-meter) wide construction corridor of SPE Alternative 2 (Table 3.2–10). The benthic communities in the footprints of the piles (0.046 acre [0.019 hectare]) would be eliminated when the piles are installed. A total of 0.0012 acre (0.00051 hectare) of piles would be removed, for a net conversion of 0.045 acre (0.018 hectare) of benthic habitat. There would be some disturbance to sediments and benthic community from pile removal and vessel anchors, but there would be little potential disturbance from propeller wash and no potential for barge grounding due to the water depths at the site. Intertidal habitats, including clam and oyster beds, would be outside the 100-foot wide construction zone and would not be impacted by construction of SPE Alternative 2. The potential for releases of creosote from treated piles removed during construction of SPE Alternative 2 would be managed by BMPs and current practices (Section 3.1.1.2.3) that would minimize the potential for releases of creosote to the water column, which could affect benthic organisms.

Table 3.2–10. Benthic Community Resources Impacted by SPE Alternative 2

Impact Type	Benthic Community Area in Acres (Hectares)
Potential Temporary Construction Disturbance	3.9 (1.6)
Permanent loss under piles[1]	0.045 (0.018)
Operational Shading	1.0 (0.41)

1. Includes the area displaced by the proposed pier extension piles minus the area of piles being removed from the existing Service Pier.

Previous studies of dredged and other disturbed sites show that benthic and epibenthic invertebrates rapidly recolonize disturbed bottom areas within 2 years of disturbance (CH2M Hill 1995; Parametrix 1994a, 1999; Anchor Environmental 2002; Romberg 2005; Vivan et al. 2009). The benthic organisms lost due to turbidity and bottom disturbances by barges, tugboats, and anchors would be expected to become reestablished over a 3-year period after sediment disturbance at the site has ceased.

The increased potential for spills during construction, spill response, and debris cleanup would be as described above for marine vegetation, under Vegetation Communities.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

Operation impacts of the SPE on the benthic community would be due primarily to the conversion of soft-bottom habitat to hard-bottom habitat (0.045 acre [0.018 hectare]). The piles would increase the available in-water surface area and create colonization sites for hard-bottom species such as mussels (*Mytilus* sp.) and sea anemones that would attach to the piles (the fouling community). The new community also would support other species such as amphipods, annelids, gastropods, and predatory sea stars that feed and take refuge in the newly created environment (Kozloff 1983; Cohen et al. 1998; Brooks 2004; Cordell 2006; PSAT 2006). The decrease in soft-bottom habitat and increase in hard substrate habitat would result in a localized change in species composition (Glasby 1999; Atilla et al. 2003), but would not result in substantial loss of biological productivity in the area due to the creation of vertical structure for colonization. Impacts due to shading of benthic habitat would be unlikely due to the depth of the water at the pier site.

Impacts on the physical properties of sediments are discussed in Section 3.1.2.3.2, under Sediment Quality; as noted in that section, the SPE would have a minor localized effect on sediment texture due to scouring and deposition related to flow patterns around the individual piles. However, these changes would occur gradually over time, would be localized at the piles, and would not adversely impact benthic communities.

As described for Marine Water Resources (Section 3.1), operation of the SPE would not impact water quality near the project site. The slight increase in potential for spills during operations would be as described in Section 3.1.2.3.2.

PLANKTON FOR SPE ALTERNATIVE 2

CONSTRUCTION OF SPE ALTERNATIVE 2

Construction impacts on plankton from SPE Alternative 2 would be related to localized and temporary increases in turbidity levels. Turbidity plumes would be short-lived (minutes to hours). Turbidity increases would occur during the in-water work season, which is outside of the period of greatest phytoplankton productivity in Puget Sound (May). Sediments at the SPE project site have low organic carbon levels (less than 2 percent) (Section 3.1.1.1.3, under Physical and Chemical Properties of Sediments). Therefore, releases of nutrients to the water column due to sediment resuspension during SPE construction would not be of sufficient magnitude to cause an increase in phytoplankton productivity, including harmful algal blooms, along the Bangor shoreline. The increased potential for spills during construction, spill response, and debris cleanup would be as described above for marine vegetation, under Vegetation Communities.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 2

Impacts on plankton from SPE Alternative 2 operations would be due primarily to artificial lighting and shading, and the creation of habitat for both planktonic species and predators that feed on plankton. Shading created by SPE Alternative 2 would be approximately 1.0 acre (0.41 hectare) (Table 3.2–10). Security lighting directed at the water would come on only when needed, and surface currents would quickly move planktonic organisms through the area. Therefore, shading and artificial lighting from the SPE pier would not significantly impact plankton resources. Due to water depth at the site, turbidity resulting from propeller wash would be minimal. The potential for spills during operations would be as described in Section 3.1.2.3.2. Therefore, there would be no operational impacts on plankton from SPE Alternative 2.

3.2.2.3.3. SPE ALTERNATIVE 3: LONG PIER

VEGETATION COMMUNITIES FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

Potential construction impacts on marine vegetation from SPE Alternative 3 would be the same as described for Alternative 2 (Table 3.2–11; Figures 3.2–15 and 3.2–16) except that there would be slightly less substrate disturbance due to the smaller diameter of piles installed under this alternative. Although the area of potential impacts would be greater (6.6 acres vs. 3.9 acres [2.7 vs. 1.6 hectares] for SPE Alternative 2) due to the increased length of the pier extension, the only seafloor areas that would be highly disturbed would be where the existing piles would be removed and new piles would be installed, which are at depths beyond where marine vegetation occurs in this area.

Table 3.2–11. Marine Habitat Impacted by SPE Alternative 3

Habitat Type	Potential Temporary Construction Disturbance Area in Acres (Hectares)[1]	Area Permanently Displaced By Piles in Acres (Hectares)[2]	Operational Shading in Acres (Hectares)
Nearshore	1.0 (0.42)	0	0
Deep Water	5.5 (2.2)	0.043 (0.017)	1.6 (0.65)
Vegetation Type[3]			
Eelgrass[4]	Negligible	0	0
Green Macroalgae	0.27 (0.11)	0	0
Red Macroalgae	Negligible	0	0
Brown Macroalgae (Kelp)	Negligible	0	0

1. The potential temporary construction disturbance area includes the structure footprint and the area within 100 feet (30 meters) of the proposed SPE structures.
2. Includes the area displaced by the proposed pier extension piles minus the area of piles being removed from the existing Service Pier.
3. Eelgrass and macroalgae overlap in their occurrence along the Bangor shoreline. Therefore, the total acreage of marine vegetation potentially impacted cannot be calculated by summing the values for each vegetation type.
4. No piles would be installed in eelgrass and barges would avoid anchoring in eelgrass beds wherever possible.

There would be some minor loss of fouling vegetation on the piles removed from the existing Service Pier. As with SPE Alternative 2, contractors would be required to comply with RCW 77.15.290 (*Unlawful transportation of fish or wildlife — Unlawful transport of aquatic plants — Penalty*) and U.S. Coast Guard regulations designed to minimize the spread of exotic species including *Sargassum*, which has been documented in the area.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 3

The operation and long-term impacts of SPE Alternative 3 would be similar to those described for SPE Alternative 2, including shading and localized effects of the piles on the substrate. The piles and the shaded areas would be in depths of 30 to 100 feet (9 to 30 meters) below MLLW or deeper, which is beyond the depths where marine vegetation occurs in this area of the shoreline. Therefore, there would be no operational impacts on marine vegetation.

BENTHIC COMMUNITIES FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

Benthic community impacts from construction of SPE Alternative 3 would be the same as described for SPE Alternative 2 except that the potential disturbance area would be larger (6.6 vs. 3.9 acres [1.6 vs. 2.7 hectares]), the benthic community lost in the pile footprints would be slightly less (0.043 vs. 0.045 acre [0.017 vs. 0.018 hectare]), and the duration of pile driving would be greater (up to 205 days vs. up to 161 days for Alternative 2) (Table 3.2–12).

Table 3.2–12. Benthic Community Resources Impacted by SPE Alternative 3

Impact Type	Benthic Community Area in Acres (Hectares)
Potential Temporary Construction Disturbance	6.6 (2.7)
Permanent loss under piles[1]	0.043 (0.017)
Operational Shading	1.6 (0.65)

1. Includes the area displaced by the proposed pier extension piles minus the area of piles being removed from the existing Service Pier.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 3

Benthic community impacts from operation of SPE Alternative 3 would be the same as described for SPE Alternative 2 except that the area of operational shading would be greater (1.6 vs. 1.0 acres [0.65 vs. 0.41 hectare]) and the amount of hard-bottom habitat created by the piles would be greater (660 vs. 385 piles). As noted for SPE Alternative 2, shading would be limited to deeper waters and would not be expected to impact the benthic community. Sediment changes would be as described for SPE Alternative 2, would occur gradually over time, and would not adversely impact benthic communities.

PLANKTON FOR SPE ALTERNATIVE 3

CONSTRUCTION OF SPE ALTERNATIVE 3

Construction impacts on plankton for SPE Alternative 3 would be similar to those described for SPE Alternative 2, but the area of potential impacts would be greater (6.6 acres vs. 3.9 acres [2.7 vs. 1.6 hectares]) due to the larger structural footprint of this alternative.

OPERATION/LONG-TERM IMPACTS OF SPE ALTERNATIVE 3

Operational impacts of SPE Alternative 3 (increased feeding opportunities for plankton predators due to pier lighting) would be similar to those described for SPE Alternative 2 but the area of potential impacts would be greater due to the larger structural footprint of this alternative (1.6 vs. 1.0 acres [0.65 vs. 0.41 hectare]).

3.2.2.3.4. SUMMARY OF IMPACTS FOR SPE PROJECT ALTERNATIVES

Impacts on marine vegetation and invertebrates during the construction and operation phases of the SPE project alternatives, along with mitigation and consultation and permit status, are summarized in Table 3.2–13.

Table 3.2–13. Summary of SPE Impacts on Marine Vegetation and Invertebrates

Alternative	Environmental Impacts on Marine Vegetation and Invertebrates
Impact	
SPE Alternative 1: No Action	No impact.
SPE Alternative 2: Short Pier (Preferred)	**Marine Vegetation** *Construction:* Small areas of marine vegetation (primarily green macroalgae) potentially would be disturbed in the construction corridor, but construction would largely occur in water depths that are greater than macroalgae habitat. Construction would be conducted over two in-water work seasons. *Operation/Long-term Impacts:* No overwater shading of existing marine vegetation communities; increase in hard-surface habitat for encrusting species (e.g., *Ulva*). **Benthic Resources** *Construction:* Temporary disturbance of community in maximum of 3.9 acres (1.6 hectares); loss of 0.045 acre (0.018 hectare) of benthic habitat in pile footprints; construction would be conducted over two in-water work seasons, with no more than 161 days of in-water pile driving. *Operation/Long-term Impacts:* Overwater shading (1.0 acre [0.41 hectare]) unlikely to impact sessile benthic organism productivity; permanent loss of 0.045 acre (0.018 hectare) of soft-bottom habitat, increase in hard surface habitat on piles. **Plankton** *Construction:* Indirect and localized effects from increased turbidity and settling of resuspended sediments from in-water construction and vessel activity. *Operation/Long-term Impacts:* No appreciable reduction in primary production of phytoplankton; increased feeding opportunities for plankton predators due to pier lighting.

Table 3.2–13. Summary of SPE Impacts on Marine Vegetation and Invertebrates (continued)

Alternative	Environmental Impacts on Marine Vegetation and Invertebrates
SPE Alternative 3: Long Pier	**Marine Vegetation** *Construction:* Same areas of marine vegetation (primarily green macroalgae) potentially disturbed in the construction corridor as SPE Alternative 2. Construction would be conducted over two in-water work seasons. *Operation/Long-term Impacts:* Same as SPE Alternative 2 but larger increase in hard-surface habitat created due to greater number of piles (660 vs. 385). **Benthic Resources** *Construction:* Greater temporary disturbance of community than SPE Alternative 2 in maximum of 6.6 acres (2.7 hectares); loss of 0.043 acre (0.017 hectare) of benthic organisms in pile footprints; construction would be conducted over two in-water work seasons, with no more than 205 days of in-water pile driving. *Operation/Long-term Impacts:* Overwater shading (1.6 acres [0.65 hectare]) unlikely to impact sessile benthic organism productivity; permanent loss of 0.043 acre (0.017 hectare) of soft-bottom habitat, increase in hard surface habitat on piles. **Plankton** *Construction:* Greater potential for impacts than SPE Alternative 2 due to 68 percent larger construction area. *Operation/Long-term Impacts:* No appreciable reduction in primary production of phytoplankton; increased feeding opportunities for plankton predators due to pier lighting.
Mitigation: BMPs and current practices to reduce and minimize impacts on marine vegetation and invertebrates are described in Section 3.2.1.2.4 under Current Requirements and Practices. Under either alternative, proposed compensatory aquatic mitigation (Appendix C, Section 6.0) would compensate for the remaining impacts of the SPE.	
Consultation and Permit Status: The Navy will include impacts on marine vegetation and benthic communities as part of its consultation with the NMFS West Coast Region office under the ESA and MSA. A biological assessment and EFH assessment will be prepared and submitted to the NMFS West Coast Region office. The Navy will submit a JARPA to USACE and other regulatory agencies, requesting permits under CWA Section 401 and Rivers and Harbors Act Section 10. Alternative 2 is the Least Environmentally Damaging Practicable Alternative according to the CWA Section 404(b)(1) guidelines. The Navy will prepare and submit a CCD to WDOE.	

BMP = best management practice; CCD = Coastal Consistency Determination; CWA = Clean Water Act; EFH = Essential Fish Habitat; ESA = Endangered Species Act; JARPA = Joint Aquatic Resources Permit Application; MSA = Magnuson-Stevens Fishery Conservation and Management Act; NMFS = National Marine Fisheries Service; USACE = U.S. Army Corps of Engineers; WDOE = Washington Department of Ecology

3.2.2.4. COMBINED IMPACTS OF LWI AND SPE PROJECTS

3.2.2.4.1. MARINE VEGETATION

The LWI would impact up to 3 acres (1.2 hectares) of marine vegetation during construction and would contribute up to 0.024 acre (0.01 hectare) loss of eelgrass in Hood Canal during operation. Macroalgae losses would total approximately 0.08 acre (0.032 hectare) for LWI (much less for LWI Alternative 3), but this amount would be functionally decreased by the hard surface attachment habitat created by the steel plates, piles, and anchors. Both SPE alternatives would contribute only minor (0.28 acre [0.1 hectare]) impacts on marine vegetation (primarily green macroalgae), during construction only, due to the deep project bottom depths. There would be no operational contribution of the SPE to marine vegetation impacts.

3.2.2.4.2. BENTHIC COMMUNITIES

The LWI piles (Alternative 2) and observation post piles (either alternative), steel plate anchors (LWI Alternative 2), and abutment stair landings (either alternative) would contribute 0.0016 to 0.14 acre (0.00063 to 0.058 hectare) of soft-bottom habitat conversion in Hood Canal, and the SPE piles would contribute 0.043 to 0.045 acre (0.017 to 0.018 hectare), depending on the alternative, of soft-bottom habitat conversion, for a combined total of up to 0.18 acre (0.074 hectare). Both projects would increase hard surface habitat for benthic species adapted to these surfaces, such as mussels and anemones.

3.2.2.4.3. PLANKTON

Individually and combined, the LWI and SPE projects would have minimal, localized impacts on plankton through shading, artificial lighting, and creation of habitat for filter feeders on plankton.

The combined impacts of the LWI and SPE projects on marine vegetation, benthic communities, and plankton are summarized below in Table 3.2–14.

Table 3.2–14. Summary of Combined LWI/SPE Impacts for Marine Vegetation, Benthic Communities, and Plankton

Resource	Combined LWI/SPE Impacts
Marine Vegetation	The combined effects of the LWI and SPE projects on marine vegetation would be minor and localized, except for eelgrass losses, which would be up to 0.024 acre (0.01 hectare) and require mitigation.
Benthic Communities	Construction and operation of the LWI and SPE projects combined would result in primarily localized and temporary impacts on benthic communities, with the exception of the permanent conversion of up to 0.18 acre (0.074 hectare) of soft-bottom benthic habitat to hard-bottom habitat for both projects combined.
Plankton	Construction of the LWI and SPE projects would result in temporary impacts on plankton that would be localized and immeasurable. Therefore, the combined effects of the two projects on plankton would be no greater than localized and temporary.