May 7, 2024

Debbi and Larry Vanselow
1010 57th Street
Port Townsend, WA 98368

Laura Mason and Keith Flyckt
1022 57th Street
Port Townsend, WA 98368

**Re: Shoreline Geotechnical Assessment of Bulkhead Replacement Project**
1010 57th Street and 1022 57th Street
Port Townsend, Washington
Project No. AS240151

Dear Mr. and Ms. Vanselow and Ms. Mason and Mr. Flyckt:

This letter summarizes Aspect Consulting's (Aspect) observations, conclusions, and recommendations for replacing the existing rock bulkhead (Project) along the waterfront of two adjacent single-family residential properties at 1010 and 1022 57th Street in Port Townsend, Washington (Site), also known as Jefferson County (County) parcel numbers 972905801 and 972905105, respectively.

The purpose of our study was to observe current Site conditions, evaluate shoreline and slope geomorphic processes, assess impacts of these processes on the stability of the uplands, and provide design recommendation for the Project. Aspect completed this evaluation in accordance with our agreed-upon scope of work dated April 17, 2024.

# Project Description

The Site is located on the northern shoreline of the Quimper Peninsula adjacent to the southern waters of the Strait of Juan de Fuca within the Puget Sound. Wave and tidal action have damaged the existing bulkhead; it is no longer providing adequate protection to the Site shoreline and is at risk of complete failure. Replacement of the damaged bulkhead will provide long-term protection to the residences.

This letter provides our recommendations and opinions regarding geotechnical elements of the Project and is intended to satisfy the County's Shoreline Management Program (SMP) and Washington State Fish and Wildlife (WDFW) requirements. A detailed discussion of our observations, conclusions, and recommendations is presented below.

# Surface Conditions

On March 28, 2024, we assessed the surface conditions of the Site with a geologic reconnaissance. To supplement our field observations, we reviewed the following: geologic maps; geohazard maps; Light Detection and Ranging (LiDAR) studies and images; County parcel maps and information;

historical aerial photographs, oblique coastal photographs, and topographic maps. The following sections discuss the results of our assessment.

### Site Conditions

The Site consists of two adjacent single-family residential properties (Graphic 1, below):

- Vanselow Parcel: 1010 57th Street (herein referred to as the East Lot), also known as County Parcel Number 972905801.
- Mason and Flyckt Parcel: 1022 57th Street (herein referred to as the West Lot), also known as County Parcel Number 972905105.

The Site is bordered by single-family residences to the west and south, an undeveloped parcel to the east, and the waters of the Puget Sound to the north (Photograph 1). The residences are accessed by separate gravel driveways extending north from 57th Street. Both Lots are connected to the City of Port Townsend (City) sewer system to the east. A continuous rock bulkhead spans the shoreline for the entire extent of both parcels and extends onto adjacent properties (Photograph 2). The date of bulkhead construction is unknown. Access to the beach is via a set of timber beach stairs shared by both residences.


***Graphic 1.*** *County Parcel Map (County; 2024)*

The East Lot consists of a 0.36-acre, roughly rectangular parcel that spans about 177 to 188 feet north-to-south and about 100 feet east-to-west. The East Lot is developed with a two-story, 2,678-square-foot residence with a 1,024-square-foot attached garage and a 1,596-square-foot deck on the north side of the residence, all of which were built in 1967 (County, 2024). We measured the residence foundation to be 7 feet south of the top of the steep shoreline slope at its closest point.

The West Lot consists of a 0.35-acre, roughly rectangular parcel that spans about 305 to 322 feet north-to-south and about 50 feet east-to-west. The West Lot is developed with a three-story, 2,506-square-foot residence with a 572-square-foot attached garage built in 2006 (County, 2024). The 1,298 square-foot residence foundation footprint was measured 15 feet landward of the top of the steep shoreline slope at its closest point. A set of timber stairs provides access to the shoreline just north of the residence (Photograph 3).

***Photograph 1.*** *View of the bulkhead and residences from the shoreline, view to the southwest.*

***Photograph 2.*** *Bulkhead along the shoreline north of the residences, view to the south.*

### *Topography*

The ground surface from 57th Street to the residences slopes slightly down to the east-northeast with about 17 feet of elevation loss over about 180 feet for an average inclination of 9 percent, 5 degrees (County, 2024). North of the residences, the ground surface slopes steeply down to the north-northwest towards the shoreline with about 44 feet of elevation loss over 65 feet for an average inclination of 68 percent, 34 degrees, at the west end of the Site and 32 feet of elevation loss over about 50 feet for an average inclination of 64 percent, 32.5 degrees, at the east end. Areas of locally steeper slopes are present near the top and base of the steep shoreline slope. In general, the slope becomes steeper and taller from the south-southeast to the north-northwest. Near the base of the timber beach stairs, we observed up to 15 feet of near-vertical, exposed sand (Photograph 4).

***Photograph 3.*** *Steep shoreline slope from the residences to the shoreline, view to the west.*

***Photograph 4.*** *Erosion observed at toe of steep shoreline slope under existing beach stairs, view to the southwest.*

### *Vegetation*

The vegetation in the uplands and around the residences consists of mature conifers and wind-gnarled Douglas fir and is landscaped with grass, ferns, and ornamental shrubs. The steep shoreline slope is vegetated with grasses, ivy, salal, blackberry, ferns, and small cedar shrubs. We did not observe hydrophilic vegetation that would indicate saturated or perennially wet soil conditions.

### *Drainage*

The roof-gutter downspouts from both residences are connected to underground stormwater drainage systems. We did not observe outlets for these drainage systems. We did not observe any stormwater pipes or outfalls on the steep shoreline slope. Surface drainage conditions, as well as groundwater conditions, at the Site will vary with fluctuations in precipitation, Site usage (such as irrigation), and off-Site land use.

### *Shoreline Structures*

An existing rock bulkhead spans the entire toe of the steep shoreline slope, which is about 150 feet in length at the Site. The construction date of the bulkhead is not known; however, based on our records review it has been present since at least July 12, 1994 (Photograph 5; Google, 2024; NETR, 2024; Ecology, 2024). The bulkhead consists of 1- to 5-foot-diameter rocks stacked up to 4 feet tall above the shoreline with no fill or filter fabric present behind. We observed bulkhead rocks almost fully embedded in the beach face material. The bulkhead has been damaged over time by wave and tidal erosion. In many places along the length of the Site, we observed gaps of up to 10 feet between armor rocks. In areas where the rock bulkhead was damaged or missing, we observed localized erosion and retreat of the slope toe (Photograph 6).


***Photograph 5.*** *Coastal Oblique Aerial Photograph taken July 12, 1994 (Ecology, 2024)*

The rock bulkhead continues onto the City-owned parcel to the east and onto the residential parcel to the west of the Site. About 70 feet northeast of the Site, there is a newly constructed, 10-foot-tall gravity rock bulkhead armoring the shoreline at 920 58th Street. This bulkhead is situated about 17 feet waterward of the slope toe at the Site.

Access to the beach is provided by a set of timber beach stairs between the two residences. The base of the stairs has been undermined as the bluff face has retreated landward. We observed that the timber stair support beams were unsupported and just hanging in the air about 10 feet above the beach surface (Photograph 7). Near the stairs, we observed erosion of the slope for another 2 feet upslope of the unsupported beams. In the vicinity of the stairs, for a total length of about 20 feet, the slope has retreated up to 7 feet landward relative to the surrounding toe. We understand that much of this erosion has occurred since January 2024 (Vanselow, 2024).

***Photograph 6.*** *Erosion behind area of missing face rocks, view to the southwest.*

***Photograph 7.*** *Erosion under beach stairs, yellow arrow pointing to unsupported posts, view to the south.*

### *Surficial Beach and Tidal Conditions*

The beach surface, comprised of coarse sand with rounded to subangular gravel, cobbles, and boulders extends from the steep slope shoreline toe down to the north towards Puget Sound at about 6 to 7 degrees (3.5 to 4 percent). A beach berm comprised of coarse gravel and cobbles extended about 10 to 12 feet waterward of the slope toe. On the morning of our Site visit on March 28, 2024, the falling tide was near a plus 1.7 feet (NOAA, 2024), at which time the water was about 107 feet from the toe of the slope near the beach stairs. Logs and woody debris were rare on the upper beach and are transient. About 50 feet waterward of the slope toe, we observed exposures of hard, glacially consolidated sandy silt with gravel in the beach face.

## Geology

The geologic map for the Site area indicates that three different geologic units underlie the Site (Schasse and Slaughter, 2005). Pleistocene-age, undivided Fraser and pre-Fraser glacial and nonglacial deposits line the shoreline; while recessional outwash associated with the retreat of the Vashon Stade of the Fraser Glaciation underlies the northern portion of the residences at the top of the steep shoreline slope. Lastly, the southern portion of the residences is underlain by lodgment till deposited during the Vashon Stade of the Fraser Glaciation. The recessional outwash overlies the lodgment till, which overlies the older, undivided glacial and nonglacial deposits. These units are further described as:

- **Recessional Outwash** (Qgo) is a fluvial deposit laid down during the retreat of the Vashon-age glacier. Typically, the deposit consists of loose, gray to tan, unconsolidated, cross-bedded, rounded gravel, and sand.

- **Lodgment Till** (Qgt) was deposited as subglacial basal till and is generally described as a very dense, poorly sorted diamict of silt and sand with gravel, cobbles, and scattered boulders. Till is a low permeability soil due to high silt content and very dense configuration, with low compressibility and high strength characteristics.

- **Glacial and Nonglacial Deposits** (Qguc) is a catch-all unit due to poor exposures or the map scale does not allow detailed delineation of older materials deposited prior to the Vashon State of the Fraser Glaciation. The unit may include advance outwash sands; Possession-age glacial till and/or glaciomarine drift; Olympia-age non-glacial silt, sand, and clay; and interglacial Whidbey Formation deposits.

Although not mapped, human-placed fill and colluvium may also be present at the Site. Fill consists of soils of any composition that are human placed and are typically derived from construction of residences. Colluvium is generally loose to medium-dense soil that accumulates on slopes due to the processes of soil creep, slope wash, and sloughing.

Exposures of dense,[1] tan, sandy silt (ML)[2] with fine to coarse gravels were exposed at the beach face about 50 feet waterward of the bulkhead. This material is interpreted to be within the undivided Fraser and pre-Fraser glacial and nonglacial unit, in agreement with the geologic map.

Where the toe of the steep shoreline slope was freshly eroded and unvegetated, we observed that the exposed material consisted of loose to very loose, gray-tan, medium to coarse sand with few rounded to subangular gravel and trace cobbles. We interpreted this material to be recessional outwash, in agreement with the geologic map.

### *Subsurface Explorations*

We advanced two shallow hand explorations, AHA-01 and AHA-02, to 2.1 and 4 feet below the ground surface (bgs), respectively (Figure 1). In AHA-01, located near the top edge of the bluff east of the East Lot residence, we encountered about 0.75 feet of topsoil underlain by brown, moist sand with silt (SP-SM) and few rounded cobbles to 2.1 feet bgs, which we interpreted to be topsoil. In AHA-02, about 8 feet down the slope between the residences, we encountered very loose to loose, brown sand with trace gravel from the surface extending to 2 feet bgs. We interpreted this material to be weathered recessional outwash or colluvium. This was underlain from 2 feet to 4 feet bgs by loose, gray brown, medium to coarse sand which we interpreted to be recessional outwash.

We advanced a ½-inch-diameter, pointed, steel T-probe through the beach surface adjacent to the bulkhead and the uplands near the top of the steep shoreline slope to evaluate the depth to a competent soil stratum. We were able to advance the T-probe a total of up to 4 inches into the beach deposits along the base of the bulkhead and up to 3 feet in the uplands.

[1] Relative density was assessed with a 1/2-inch-diameter, pointed, steel T-probe. Based on this, a relative density was assigned to the unit.

[2] Soils were described according to ASTM International (ASTM) D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure; ASTM, 2022).


***Figure 1.*** *Locations of hand explorations AHA-01 and AHA-02 at Site (Google, 2024).*

# Landslide Hazard

Three types of landslides (Varnes, 1978) are common on steep slopes along the Puget Sound shoreline: deep-seated rotational slides, topples, and surficial landslides. Landslides may be triggered by natural causes, such as precipitation, freeze-thaw cycles, or a seismic event, or be man-made (e.g., broken water pipes or stormwater flow).

The Site and surrounding area is mapped as "Stable" (Ecology, 1979). We reviewed historical coastal aerial photographs (Ecology, 2024) and historical aerial photographs (Google, 2024 and NETR, 2024) of the Site and surrounding area from 1951 through 2023 and did not observe evidence of recent landslides at or adjacent to the Site. Aspect reviewed the newest publicly available LiDAR data for the Site and surrounding area and did not observe evidence of deep, rotational landslides (DNR, 2019).

During our reconnaissance, we did observe a surficial landslide directly on the western adjacent property, west of the end of the bulkhead about 50 feet west of the Site's west property line. We also observed disturbed vegetation and exposed soils in the landslide area in imagery from 2009 to 2023. We understand that a large spruce (at least 65 feet tall) slid from near the top of the shoreline slope to the shoreline in early 2024 (Vanselow, 2024). We did not observe any evidence of deep-seated rotational slides or topples at or nearby to the Site.

***Photograph 8.*** *Yellow line points to end of bulkhead on west-adjacent property at the start of the landslide and red arrow points to residence on West Lot, view to the south.*

***Photograph 9.*** *Landslide on adjacent property, about 50 feet west of Site, view to the east.*

# Shoreline Processes

Littoral sediment transport (direction of sediment movement parallel to the beach) is predominantly a function of wind and wave direction. The Site is directly exposed to waves from the north, west, and east. It has a maximum over-water fetch (the horizontal distance over open water where the wind generates waves) of approximately 35 miles to the north and 40 miles to the northeast. To the northwest, the Site is directly exposed to wind and waves originating within the Strait of Juan de Fuca for about 95 miles. The Strait then opens to the Pacific Ocean.

While the predominant direction of low-pressure systems entering the Puget Sound area during the winter months is from the south and southwest, strong westerly wind events regularly occur within the Strait of Juan de Fuca. These wind events subject the Site to high energy waves, as observed by evidence of the conifers at the top of the steep shoreline slope across the Site and surrounding properties (Mass, et al., 2014). The Site is also impacted by waves generated by strong northerly winds flowing down the Strait of Georgia and the Fraser River Valley. Due to the relatively long over-water fetch and susceptibility to storms from several directions, the Site represents a high-energy shoreline environment for the Puget Sound. The Site is also susceptible to wave action from passing shipping and military vessels.

Drift sectors are defined as discrete zones along the shoreline containing areas of sediment erosion, transport corridors, and deposition or accretion areas. Data regarding coastal processes indicates that the Site lies within a drift sector that begins approximately 3.5 miles to the southwest between McCurdy Point and Protection Island and terminates at Point Wilson in the east (Ecology, 2003). The net shoreward drift direction is right to left (when facing the bluff from the water), or from the southwest to the east-northeast.

The Site and adjacent properties are mapped as a feeder bluff, which is defined as an eroding coastal bluff that delivers sediment to the nearby beaches (Ecology, 2003). This classification is characterized by active erosion, toppled trees, and landslides. The shoreline about 50 feet east of the

Site's east property line is mapped as a transport zone for about 490 feet and then becomes a feeder bluff. A transport zone area does not contribute appreciable amounts of sediment. The shoreline for 0.3 miles east of the Site is armored.

Beach levels tend to fluctuate based on the season and as a result of storms. Storm-driven wind, currents, and wave forces tend to remove beach material from the base of a bulkhead and cause the beach to lower (degrade). Calmer periods (such as during the summer) may result in material accumulating on the beach and at the base of the bulkhead, causing the beach to raise (aggrade). Based on our observations of the embedded toe of the bulkhead along the shoreline, the beach level at the Site appears to be in equilibrium, as we would expect the bulkhead to have been built with some embedment into the beach surface.

### *Cumulative Risk Determination*

Strictly using the Marine Shoreline Design Guidelines (MSDG; Johannessen et al., 2014) for the Site, we completed the Cumulative Risk Model (selections circled in green, Figure 2, below) and calculated high risk for the Site.

| CUMULATIVE RISK MODEL | | | |
|---|---|---|---|
| **EROSION POTENTIAL** | | | |
| **Shoretype** | **Score** | **Fetch** | **Score** |
| No Appreciable Drift (NAD)-Bedrock/Low Energy | 0 | 0–1 mile | 1 |
| Modified, Accretion Shoreform, NAD-Delta | 1 | | |
| NAD- Artificial , Transport Zone, Pocket Beach | 2 | 1–5 miles | 2 |
| Feeder Bluff | 3 | 5–15 miles | 3 |
| Feeder Bluff Exceptional | 4 | 15+ miles | 4 |
| **Erosion Potential Score =** | **Shoretype Score + Fetch Score** | | **7** |
| **INFRASTRUCTURE THREAT** | | | |
| **Setback** | **Score** | **Infrastructure Type** | **Score** |
| >60 ft | 1 | Property without structures | 1 |
| 36–60 ft | 2 | Septic drainfield or unattached residential infrastructure, not lived in | 2 |
| 21–35 ft | 3 | Home or residential building | 3 |
| 0–20 ft | 4 | Major infrastructure | 4 |
| **Infrastructure Threat Score =** | **Setback Score + Infrastructure Type Score** | | **7** |
| **CUMULATIVE RISK TOTAL (product):** | **Erosion Potential x Infrastructure Threat** | | **49** |

Examination of the cumulative risk model results (Appendix A) allowed for determination of different risk classes (e.g., low, medium, high) as follows:

- Low risk scores between 0–15
- Moderate risk scores between 16–36
- High risk scores greater than 36

The cumulative risk model score helps to distinguish the perceived and actual need for erosion control at the subject site. The risk model score along with other site characteristics will help define which design techniques are appropriate for the subject site.

***Figure 2***. *Cumulative Risk Model (excerpt from Johannessen et al., 2014).*

The Cumulative Risk Model, used in conjunction with the decision tree from the MSDG (Figure 3, below), model can provide some level of guidance for the Project to identify appropriate design techniques for controlling erosion (Johannessen, et. al., 2014), but the final design selection should be based on all Site observations, engineering judgement, as well as the alternatives analysis described in the next section.

Using the decision tree, hard armor is appropriate at the Site under high risk conditions, as determined by the Cumulative Risk Model (selections circled in green on Figure 3).

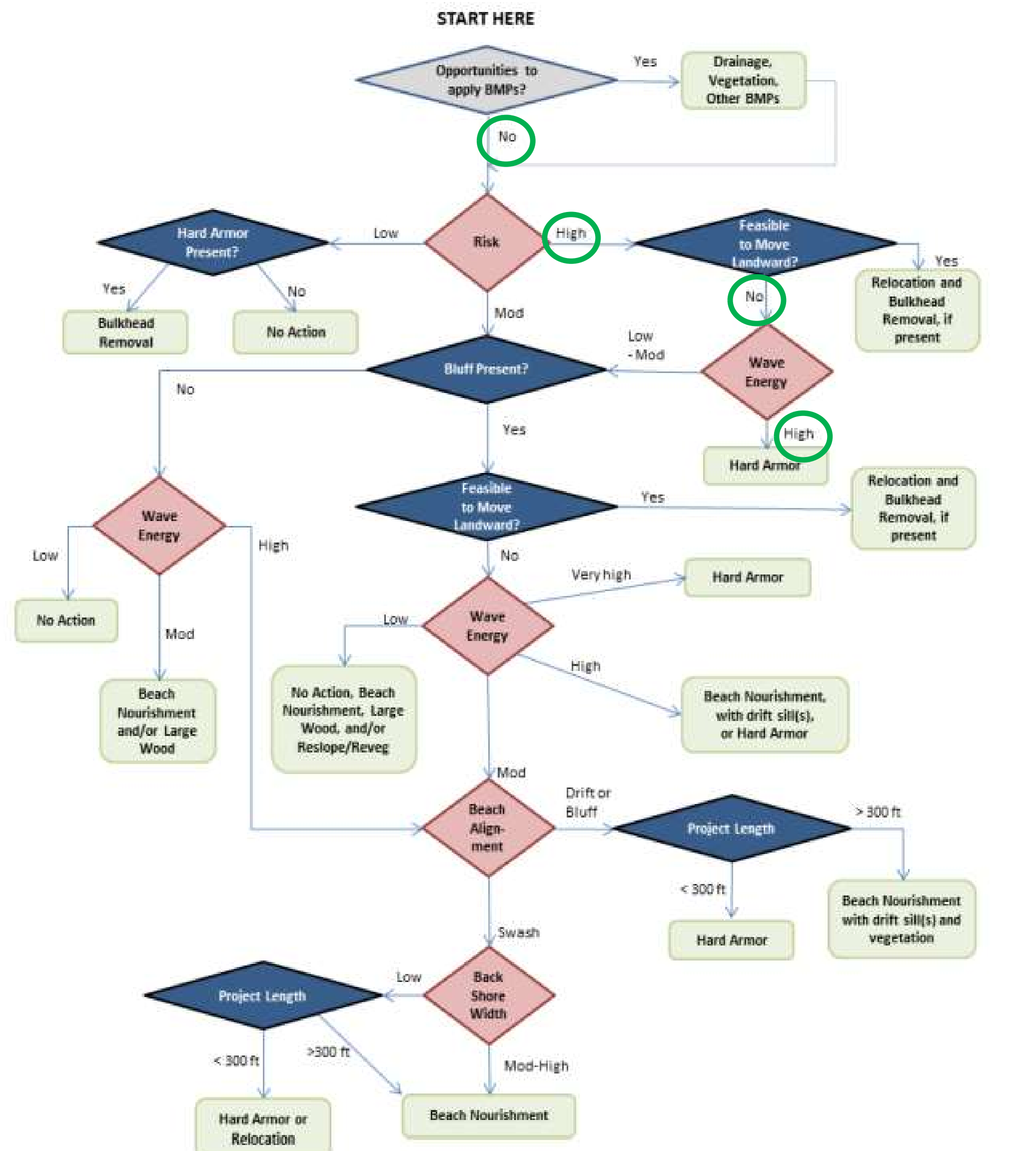


**Figure 5-11.** Decision tree for identifying appropriate design techniques for a given site. Read top to bottom. Refer to site and coastal processes assessment data, Table 3-4 for risk, Tables 5-6 for wave energy, and 5-7 for backshore width categories.

***Figure 3.*** *Decision Tree (excerpt from Johannessen et al., 2014).*

# Alternatives Analysis

Washington Administrative Code (WAC) Section 220-660-370 (WSL, 2022) requires an alternatives analysis that follows a prescribed flow chart and considers options ranging from beach restoration to hard structure replacement. The state alternatives required to be considered, from most preferred to least preferred, are presented in Table 1.

**Table 1. Shoreline Stabilization Alternatives**

| No. | Alternative |
|---|---|
| i | Remove any existing shoreline stabilization structure and restore the beach |
| ii | Control upland drainage |
| iii | Protect, enhance, and replace native vegetation |
| iv | Relocate buildings and improvements |
| v | Construct a soft structure |
| vi | Construct upland retaining walls |
| vii | Construct a hard structure landward of the ordinary high water line [OHWM] |
| viii | Construct a hard structure at the ordinary high water line [OHWM] |

Below we present our considerations for each alternative and our conclusions on the most feasible approach to protecting the Site infrastructure. “Feasible” means available and capable of being done after taking into consideration the cost, existing technology, and logistics in light of overall Project purposes per WAC 200-660-370(3)(a) (WSL, 2022).

### *Alternative i: Remove any existing shoreline stabilization structure and restore the beach*

The existing rockery bulkhead measures up to 4 feet in height (above the beach surface), spans the entire width of the Site, and continues onto the adjacent properties. Rapid erosion of the toe of the steep shoreline slope below the residences is occurring where the bulkhead has been damaged. We also observed evidence of significant erosion around the landing for the beach stairs; either there was not historically a bulkhead or the bulkhead has been completely demolished. If the bulkhead were to be removed, rapid erosion of the shoreline slope toe would compromise the soils between the bulkhead and the residence and eventually leave the residence foundations unsupported. High wave energy at the Site would wash soft armoring away almost immediately.

***Conclusion:*** A hard structure along the shoreline should remain to provide long-term protection of the residences and life safety of the inhabitants. Therefore, Alternative i is not feasible.

### *Alternative ii: Control upland drainage*

The stormwater systems for both residences are connected to underground systems. The discharges were not observed; however, it is possible they discharge down the steep shoreline slope and onto the beach. These drainlines are not exacerbating the erosion of the shoreline; however, during

Project construction, we recommend these lines (and any others) be maintained and/or replaced if necessary, and be routed to discharge near the base of the bluff (just above the ordinary high water mark).

***Conclusion:*** Alternative ii alone will not stop the bulkhead from failing but should be incorporated into Project plans.

### *Alternative iii: Protect, enhance, and replace native vegetation*

Plantings in front of the existing bulkhead will not survive normal high tide processes and wave action. Existing native vegetation on the steep shoreline slope is not preventing ongoing erosion from coastal processes. Replacing the bulkhead with native vegetation would stabilize the shoreline up to a 10-degree slope, but given that the inclination from the shoreline to the residences would be greater than 32.5 degrees if the bulkhead were removed, native vegetation alone will not provide adequate long-term protection.

***Conclusion:*** Alternative iii alone will not provide long-term protection of the residences and life safety of the inhabitants.

### *Alternative iv: Relocate buildings and improvements*

The residence on the East Lot is located on the south end of the property and there is no ability to move the residence. In our experience, contractors that move residences are typically scheduled 2 to 3 years, and cost for such an undertaking will be far in excess of $250,000. While it may be possible to move the West Lot residence in theory, the schedule and cost would be prohibitive. It is also our experience that foundations cannot be moved. Half of the residence is supported on a concrete slab foundation and this portion of the residence would need to be demolished; therefore, only the upper two stories of the residence on the West Lot could potentially be moved.

***Conclusion:*** Alternative iv is infeasible.

### *Alternative v: Construct a soft structure*

“Soft” bulkhead techniques include the combined use of beach nourishment and restrained large woody debris (beach logs). Beach logs are restrained using cables and an earth retention system such as dead-man anchors or tie-back style anchors. The logs are arranged in such a way as to impede wave energy acting on the existing shoreline below the ordinary high water mark (OHWM). Imported beach sediments are then placed to embed the logs aiding in energy dissipation. The beach nourishment also provides “sacrificial” sediment that is actively recruited by the natural coastal processes acting on the shore. In areas of diminished littoral transport volume and areas where sediment recruitment is high, soft bank protection typically results in a net loss of nourished sediment. As the sediment is eroded over time, additional nourishing sand is placed to maintain the erosion control function of the system. The amount of beach nourishment is estimated using average bank retreat rates for the project site.

Although local governments often prefer soft bulkheads over hard bulkheads, soft bank protection is not practical for certain environments. Soft bank protection is best suited for low-height-banks and low-wave-energy-environments, where damage to mobile but restrained logs is less likely and long-term sediment replacement can be performed economically and effectively. Low energy environments retain imported beach nourishment sediments over longer periods of time. Soft bank protection placed along shorelines with vertical heights in excess of a few feet are not effective and would require frequent maintenance and repair. In order to be effective, a soft shoreline needs the angle of repose to be 10 degrees or less (Johannessen et al., 2014).

The approximate inclination of the steep shoreline slope from is between 32.5 and 34 degrees (64 and 68 percent), an inclination too steep for soft bank protection to be effective.

***Conclusion:*** Alternative v is not feasible at this Site.

### *Alternative vi: Construct upland retaining walls*

The distance between the bulkhead to the residences to the crest of the steep bluff (7 to 15 feet) is limited, creating insufficient space to construct upland retaining walls.

***Conclusion:*** Alternative vi is not feasible.

### *Alternatives vii: Construct a hard structure landward of the ordinary high water line [OHWM]*

This is the chosen alternative for this Site. Alternative vii calls for a hard bulkhead located just inside, or landward of, the existing bulkhead. In our opinion, a new rock revetment can be feasibly constructed 3 to 5 feet landward of the existing bulkhead and the existing bulkhead removed. The armor replacement will extend 150 feet from property line to property line.

## Conclusions and Recommendations

The existing rockery bulkhead at the Site is in poor condition and no longer functioning as intended. The rockery has been damaged by wave and tidal action. Gaps up to 10 feet wide were observed where rocks had been washed out from the base of the bulkhead and/or fully buried in the beach face. Where waves can directly impact the bluff, we observed erosion and landward retreat of up to 7 feet creating a 10- to 12-foot-tall vertical scarp of loose sand. If damage were to continue, the steep shoreline slope—and ultimately the residences—would be at risk. Replacement of the bulkhead with a gravity rock bulkhead will provide effective shore protection at the Site and long-term protection for the residences.

High-energy coastal processes are occurring at the Site. The shoreline is subject to concentrated impacts from long-fetch, storm-driven waves, large vessel and container ship wakes, and sediment transport due to tidal fluctuations.

The Project plan includes placing the new structure about 3 to 5 feet landward of the existing bulkhead, which will create a new gain of ecological function as there will be about 5 feet of restored shoreline environment. The sediment supply will be unchanged.

### *Gravity Rock Bulkhead Design*

Rock wall construction should generally follow Section 8-24.3 of the Washington State Department of Transportation (WSDOT) *Standard Specifications Road, Bridge and Municipal Construction* (Standard Specifications; WSDOT, 2024). Our design recommendations and construction considerations for the rock bulkhead include the following:

- Erosion-control filter fabric should be installed on the temporary cut slope behind the rock bulkhead to prevent migration of upland soils.

- Quarry spalls meeting the requirements of Section 9-13.1(5) of the Standard Specifications (WSDOT, 2024) should be placed between the filter fabric on the cut slope and the armor rocks to provide drainage and improve wall stability. The thickness of the spall layer will vary based on the distance between the wall and the cut slope covered with filter fabric with the goal being 1 foot wide.

- The armor face rocks should consist of angular and cubical-, tabular-, or rectangular-shaped granite rocks oriented such that the long dimension of the rocks extend back into the embankment. Placement of rocks should avoid continuous joint planes in vertical or lateral directions wherever possible. The armor rocks should bear on two or more rocks below with good contact between the rows.

- Due to the poor quality of the existing bulkhead rocks, they are not suitable for reuse and should not be used.

- The rock wall should be battered towards the upland side at 1H:5V to 1H:6V (horizontal:vertical). The final permanent ground slope inclination within 5 feet behind the rock bulkhead should be no steeper than 3H:1V.

- All voids between the armor rocks greater than 6 inches should be inspected for consistent contact between the individual rocks throughout the thickness of the wall. If there is deficient contact between the armor rocks, the void should be ‘chinked’ with a smaller piece of angular rock. All ‘chinking’ should be completed from the rear of the armor rocks to limit the potential for wave action to pull and remove the smaller rocks away from the wall.

# Construction Recommendations

Site preparation within the proposed construction area footprint should include removal of all debris and any other deleterious material. The Contractor must use care during site preparation and excavation operations so that any bearing surfaces are not disturbed. If this occurs, the disturbed material should be removed to expose undisturbed material.

All bearing surface excavations should be trimmed neat and the bottom of the excavation should be carefully prepared. All loose or softened soil should be removed from the bearing surface excavation. We recommend that excavation for the planned rockery bulkhead be observed by the geotechnical engineer prior to placement to verify that the recommendations of this letter report have been followed.

Appropriate erosion control measures should be implemented prior to beginning earthwork activities in accordance with the local best management practices (BMPs).

## *Temporary and Excavation Slopes*

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the Contractor. Unshored temporary cuts taller than 4 feet should be sloped in accordance with Part N of WAC 296-155 (WSL, 2023).

In general, shallow surface soils that will be subject to excavation and sloping on the Site will consist of beach deposits and undifferentiated glacial deposits. These soils classify as Type C and are anticipated to stand as steep as 1.5H:1V. However, with tidal fluctuation, presence of groundwater seepage, and/or heavy precipitation, the stability of temporary unsupported cut slopes can be significantly reduced. The Contractor should monitor the stability of the temporary cut slopes and adjust the construction schedule and slope inclinations accordingly. Vibrations created by traffic and construction equipment should be minimized.

# Additional Project Design and Construction Monitoring

At the time of this letter report, site grading and construction methods have not been finalized and the recommendations presented herein are based on preliminary Project information. If Project development results in changes to the assumptions made herein, we should be contacted to determine if our recommendations should be revised.

This letter report is issued with the understanding that the information and recommendations contained herein will be brought to the attention of the appropriate design team personnel and incorporated into the Project plans and specifications, and the necessary steps will be taken to verify that the Contractor and subcontractors carry out such recommendations in the field. We do not direct the Contractor's operations, and we cannot be responsible for the safety of personnel other than our own on the Site; the safety of others is the responsibility of the Contractor. The Contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.

We are available to provide geotechnical engineering and monitoring services during construction. The integrity of the foundation depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field if variations in subsurface conditions become apparent.

# References

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# Limitations

Work for this project was performed for Debbi and Larry Vanselow, Larua Mason, and Keith Flyckt (Client), and this report was prepared consistent with recognized standards of professionals in the same locality and involving similar conditions, at the time the work was performed. No other warranty, expressed or implied, is made by Aspect Consulting (Aspect).

Recommendations presented herein are based on our interpretation of site conditions, geotechnical engineering calculations, and judgment in accordance with our mutually agreed-upon scope of work. Our recommendations are unique and specific to the project, site, and Client. Application of this report for any purpose other than the project should be done only after consultation with Aspect.

Variations may exist between the soil and groundwater conditions reported and those actually underlying the site. The nature and extent of such soil variations may change over time and may not be evident before construction begins. If any soil conditions are encountered at the site that are different from those described in this report, Aspect should be notified immediately to review the applicability of our recommendations.

Risks are inherent with any site involving slopes and no recommendations, geologic analysis, or engineering design can assure slope stability. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the Client.

It is the Client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, and agents, are made aware of this report in its entirety. At the time of this report, design plans and construction methods have not been finalized, and the recommendations presented herein are based on preliminary project information. If project developments result in changes from the preliminary project information, Aspect should be contacted to determine if our recommendations contained in this report should be revised and/or expanded upon.

The scope of work does not include services related to construction safety precautions. Site safety is typically the responsibility of the contractor, and our recommendations are not intended to direct the contractor’s site safety methods, techniques, sequences, or procedures. The scope of our work also does not include the assessment of environmental characteristics, particularly those involving potentially hazardous substances in soil or groundwater.

All reports prepared by Aspect for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect. Aspect’s original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

**Please refer to Appendix A titled “Report Limitations and Guidelines for Use” for additional information governing the use of this report.**

We appreciate the opportunity to perform these services.

Sincerely,

Aspect consulting, LLC

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Attachments: Appendix A – Report Limitations and Guidelines for Use

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# APPENDIX A

# Report Limitations and Guidelines for Use

# REPORT LIMITATIONS AND GUIDELINES FOR USE

## Geoscience is Not Exact

The geoscience practices (geotechnical engineering, geology, and environmental science) are far less exact than other engineering and natural science disciplines. It is important to recognize this limitation in evaluating the content of the report. If you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or property, you should contact Aspect Consulting, LLC (Aspect).

## This Report and Project-Specific Factors

Aspect's services are designed to meet the specific needs of our clients. Aspect has performed the services in general accordance with our agreement (the Agreement) with the Client (defined under the Limitations section of this project's work product). This report has been prepared for the exclusive use of the Client. This report should not be applied for any purpose or project except the purpose described in the Agreement.

Aspect considered many unique, project-specific factors when establishing the Scope of Work for this project and report. You should not rely on this report if it was:

- Not prepared for you;
- Not prepared for the specific purpose identified in the Agreement;
- Not prepared for the specific subject property assessed; or
- Completed before important changes occurred concerning the subject property, project, or governmental regulatory actions.

If changes are made to the project or subject property after the date of this report, Aspect should be retained to assess the impact of the changes with respect to the conclusions contained in the report.

## Reliance Conditions for Third Parties

This report was prepared for the exclusive use of the Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against liability claims by third parties with whom there would otherwise be no contractual limitations. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with our Agreement with the Client and recognized geoscience practices in the same locality and involving similar conditions at the time this report was prepared.

## Property Conditions Change Over Time

This report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by events such as a change in property use or occupancy, or by natural events, such as floods, earthquakes, slope instability, or groundwater fluctuations. If any of the described events may have occurred following the issuance of the report, you should contact Aspect so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

## Geotechnical, Geologic, and Environmental Reports Are Not Interchangeable

The equipment, techniques, and personnel used to perform a geotechnical or geologic study differ significantly from those used to perform an environmental study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually address any environmental findings, conclusions, or recommendations (e.g., about the likelihood of encountering underground storage tanks or regulated contaminants). Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding the subject property.

We appreciate the opportunity to perform these services. If you have any questions, please contact the Aspect Project Manager for this project.