

SPIT SCIENCE SUMMARY

POINT MONROE



Prepared for
City of Bainbridge Island
Planning & Community Development



Prepared by
Herrera Environmental Consultants



Note:

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Prepared for
City of Bainbridge Island
Planning & Community Development
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INTRODUCTION

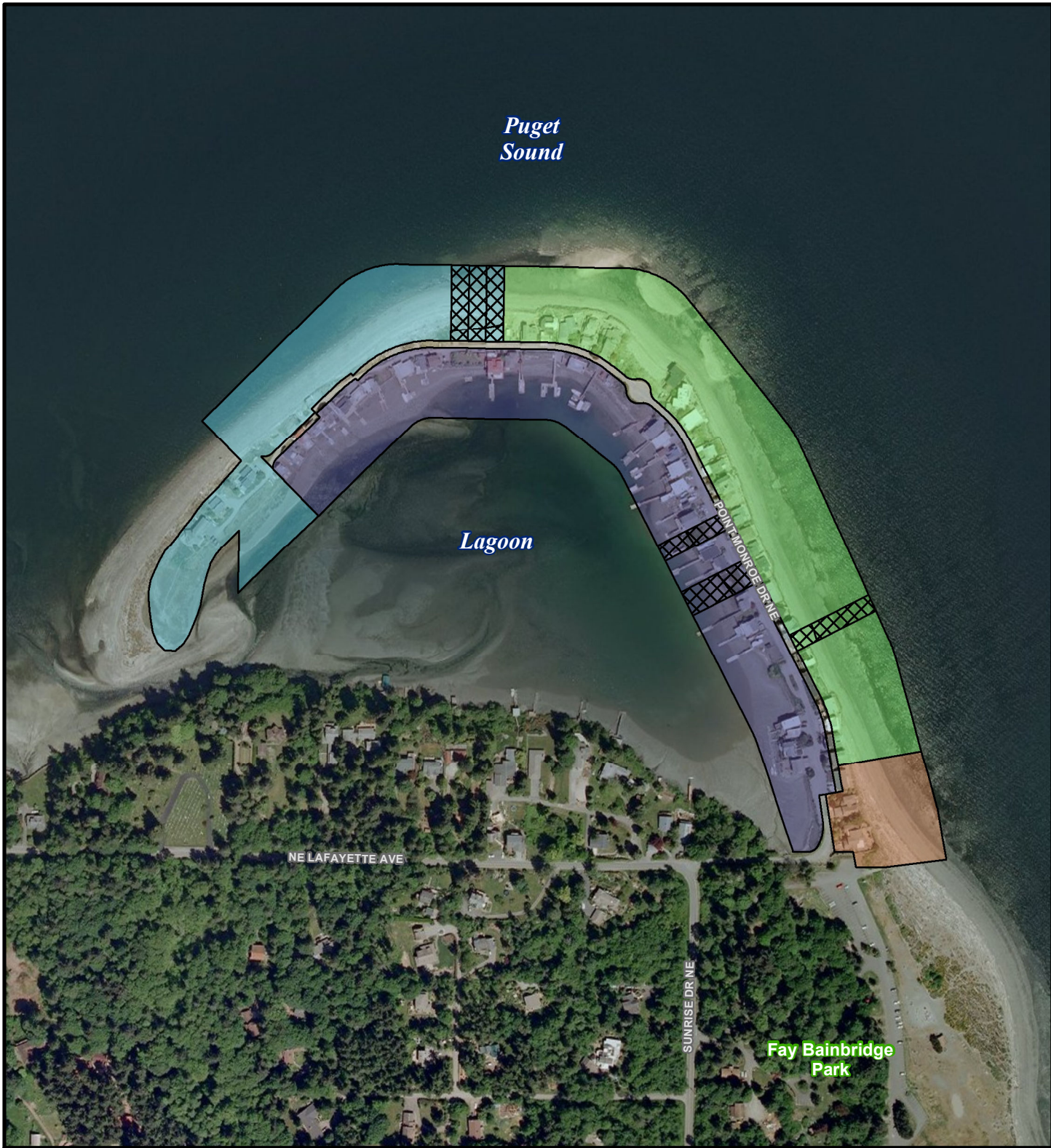
Point Monroe spit is approximately two-thirds of a mile long on the northeastern end of Bainbridge Island, Washington, and its entire extent constitutes the study area (Figure 1). It is bisected by Point Monroe Drive NE, which is a public roadway for the first third of a mile from the neck of the spit, with the remainder in private ownership. The entire study area is within the City of Bainbridge Island (City) shoreline jurisdiction boundary.

The purpose of this science summary is to provide the scientific basis for applicable Shoreline Management Act regulation of future development on Point Monroe. The spit is unique in the City because of its physical environment, the density of development, and lack of opportunities to mitigate for future impacts. Although the focus of the summary is not to assess the future ongoing ecological consequences associated with maintenance of existing shoreline infrastructure, some discussion of past impacts is included as it relates to the ecological ramifications of future development and recommendations for mitigation. Therefore, only expansion of existing or placement of new 1) shoreline protection structures, 2) overwater structures, and 3) impervious surfaces are discussed in this document. New fill and expansion of existing residential overwater homes are not discussed as these actions are currently prohibited under the existing shoreline management plan and state law. It is also assumed that the maximum structure height restriction of 30 feet will continue to be enforced.


This report summarizes the state of scientific understanding of Puget Sound spits and barrier lagoons (geomorphic features), particularly information related to Point Monroe and its lagoon. It also describes existing Point Monroe conditions, including physical and ecological processes, and anticipated environmental impacts from new development.

The following parameters limit the scope of this document:

- Only one site visit was scoped for this report. It occurred during relatively low tidal conditions in the summer.
- The study included no topographic survey.
- Biological monitoring of species present at the site was not within the scope of this report; only existing data sources were used to identify species use.
- The discussion does not cover aquatic designations, nonconforming/conforming uses or other island-wide issues not specific to Point Monroe.
- Sea level rise and geohazards are a significant issue for residents living on Point Monroe; however, a discussion of sea level rise and geohazards known to occur on spits was not within the scope of this report.
- A detailed analysis of whether on-site septic systems at Point Monroe are an environmental concern was outside the scope of this report.
- No special provisions were identified associated with overwater residences because overwater residences are prohibited by WAC 173-26-241(3)(j); however, overwater residences are acknowledged as an extensive, existing use on the spit.





Legend

 Undeveloped

Geomorphic areas

 Lagoon

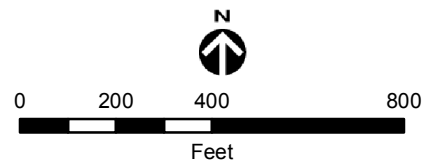
 Outer middle

 Outer neck

 Tip



Figure 1. Point Monroe vicinity map, City of Bainbridge Island, Washington.



Photography: Aerials Express (2009)
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METHODS

Analysis and conclusions presented in this report are based primarily on examination of the existing scientific literature of Puget Sound spits and barrier lagoons. A site visit was made to the area and the entire length of the spit was walked by a Herrera geomorphologist, along with three local residents and two City staff. Geomorphic indicators were photographed and noted. No physical or biological measurements were made. Plants were identified where possible, but no formal assessment of vegetation conditions was made. Several residents were interviewed during the site visit about past occurrences and their observations of site conditions, and these observations were verified with other publically available information where possible.

Site Visit

The site visit occurred between approximately 2 and 4 PM on July 19, 2012. The road (Point Monroe Drive NE) was walked from the northern parking lot within Fay Bainbridge Park along the length of public roadway. Along the way, access to two residences was graciously provided by Harold Snow and Peter McCormick to examine each side of the spit (sound side and lagoon side). From the end of the public roadway, the sound side beach was walked to the tip of the spit. The lagoon side of the spit was then walked from the tip of the spit to the point on the spit, where homes begin on the south side of the privately owned portion of Point Monroe Drive NE. The visit occurred during a flood tide, between an observed low tide of -1.4 feet mean lower low water (MLLW) at 11:48 AM and a high tide of 11.3 feet MLLW at 6:54 PM at Seattle (NOAA 2012). Seattle's tides are virtually indistinguishable from tides at Point Monroe during this time of year.

Literature Review

The approach to the literature review was to identify those peer-reviewed publications that were directly applicable to the ecology and geomorphology of spits in Puget Sound, and those that addressed ecological impacts from the types of development that may be expected to occur at Point Monroe. The peer reviewed literature was accessed using Web of Knowledge™ searches using a variety of search terms including, but not limited to, “spit setback”, “Puget Sound spits”, and “spit mitigation”. Web of Knowledge™ is a commonly used database of the scientific literature and contains bibliographic information from over 23,000 scientific journals.

Once peer-reviewed literature was identified, agency literature, called gray literature, was identified that addressed these same topics. These materials include those referenced in the primary peer-reviewed literature and studies that Herrera was familiar with from working throughout Puget Sound at locations similar to Point Monroe. Gray literature sources were primarily references that investigated development impacts.

Herrera also used collections of best available science developed specifically for the City (Williams et al. 2003; Herrera 2011) and for Washington Department of Fish and Wildlife (Herrera 2007). In addition, a master's thesis that summarized the ecology and fish use observations at Point Monroe (Ericson 2011) was used to document existing fish, bird, and invertebrate use of the spit.

Predevelopment Processes at Point Monroe

Because of the paucity of data available on undisturbed Puget Sound spits, conditions are heavily based on historical documents, such as the T-sheet (U.S. Coast and Geodetic Survey 1916), H-sheet (U.S. Coast and Geodetic Survey 1868), and gray literature available for reference sites, such as Ala Spit (Herrera 2008), Ediz Hook (Galster 1989; Herrera 2009) and West Point (Troost and Stein 1995).

Existing Conditions at Point Monroe

Existing conditions were primarily assessed on the site visit, professional experience working on other Puget Sound spits and similar nearshore environments, and on literature retrieved in the literature review. Where possible, the existing conditions assessment draws on publically available information including the Washington Coastal Atlas (Ecology 2012), Google Earth imagery, and Kitsap County public records.

RESULTS

Site Visit

Nearly all of the independently owned parcels have been built upon. Six parcels are identified by the City as undeveloped but developable, including three located in the middle portion of the spit. These three lots are only developable as one lot due to septic system requirements that limit full development on all three (R. Ericson, personal communication). Of the three remaining undeveloped properties, two are located in the Lagoon side of the spit and one is located in the Outer Middle (Figure 1). However, the parcel located in the Outer Middle is currently undergoing development (R. Ericson, personal communication).

Literature Review

The results of Web of Knowledge™ searches of the peer-reviewed literature yielded very little useful information. For instance, the search term “Puget Sound spits” generated no results and “Puget Sound lagoons” resulted in only four results, none of which were related to the type of barrier lagoon present at Point Monroe. Other references for “spits” in general did appear; however, they primarily were related to studies on the U.S. East Coast. It is questionable whether science and planning strategies in these locales are relevant to tectonically active sites devoid of large tropical cyclones, where the primary concern is salmonid and forage fish habitat. However, there have been a few peer-reviewed references regarding the geomorphology of Dungeness Spit (Schwartz et al. 1987) and Ediz Hook (Galster 1989), both on the Strait of Juan de Fuca. These spits are fundamentally different from Point Monroe in that they are exposed to ocean swell, which does not occur within the confines of Puget Sound (Finlayson 2006), and they are supplied largely by rivers updrift from them. However, these spits do have much more in common with the ecology of Point Monroe than spits elsewhere (such as spits on the East Coast or California) because they are formed from the same physical processes (namely, overwash deposition) and most of the species that occur at those locations are the same as at Point Monroe. In fact, Finlayson (2006) suggested that paraglacial environments in Alaska, the British Isles and New Zealand make for better analogs than spit sites closer to Washington such as in California (Neal et al. 2003).

Fortunately, in addition to the peer-reviewed literature, there are several gray literature studies on spits in Puget Sound. As most spits in Puget Sound have been developed, there are a number of reports produced to evaluate various actions on spits throughout the area. Probably the most exhaustive reporting was done on Ala Spit on the northeastern shoreline of Whidbey Island (Herrera 2008). Several other sites in Puget Sound, such as at West Point in Seattle (which was a spit prior to the Seattle Fault Earthquake approximately 1,100 years ago: Troost and Stein 1995) are also relevant. Although no longer a true spit, partly due to human modifications, West Point is probably the most similar feature to Point Monroe in Puget Sound, in that it is less than 5 miles away, on the same basin in Puget Sound (i.e., the main basin) and has been similarly influenced by Mount Rainier lahar sediment pulses and tectonic

subsidence from the Seattle Fault Earthquake. As a result, the evolution of West Point through the recent geologic past (in the last 6,000 years since sea level stabilized) is extremely similar to Point Monroe. Further, its intensive use from earliest European settlement of the region provides a useful comparison to the types of actions taken and the physical responses of the spit to those actions. However, because of subtle geographic differences and the significant differences in the use of the site (the principal use of West Point is now as a waste treatment facility), current conditions do differ.

Predevelopment Processes at Point Monroe

Point Monroe was likely a typical Puget Sound spit prior to development. That is, it was supplied by sediment originating primarily from the bluffs as far south as Skiff Point and northerly transport from dominant southerly winds (Williams et al. 2004). It likely began to form about 6,000 years ago when sea level stabilized following the retreat of the last glaciation, which formed the present Puget Sound (Finlayson 2006). The sediment supplied to the spit contained both sand and gravel, as is typical in Puget Sound (Finlayson 2006). The spit was (and is) highly recurved, meaning that the spit itself was influenced by wave refraction and waves originating from multiple directions. The eastern half of the spit is dominated by southerly waves that refracted around the shoal that supports the spit, while the less common and smaller northerly wave events, and weak summertime transport have forced the west end of the spit to arc southward, nearly enclosing the lagoon (Figure 1).

The lagoon had begun to close prior to development of the spit (Figures 2 and 3). Tidal flushing was essential to the maintenance of the lagoon. Note that tidal flushing capacity is a function of the lagoon area (volume) of inundation or tidal prism. Tidal prism is the volume of water exchanged between higher high and lower low tides. It is likely that the flushing included areas that have been subsequently filled to the south to provide access to the shoreline (such as for Point Monroe Drive NE and Fay Bainbridge Park). It is also likely that the spit subsided during the last Seattle Earthquake about 1,100 years ago, which may have led to the narrowing of the middle of the spit (Troost and Stein 1995; Figures 2 and 3). Further, it is common for there to be areas where spits become narrow along their length (Hugh Shipman, personal communication), particularly here where tectonic subsidence has occurred (Troost and Stein 1995). These narrow spit areas were maintained and reinforced by overwash. Overwash is a common physical process on coarse-clastic (sand and gravel) spits (Neal et al. 2003), and served as the primary mechanism by which the Point Monroe spit as well as associated habitats were likely maintained. Such habitats typically include dune communities, which provide habitat for wildlife species; the upper beach areas where forage fish spawn; lower beach and subtidal areas where shellfish typically occur (on the sound side of the spit); and salt marsh communities, including pickleweed (*Salicornia virginica*) and mudflats (on the lagoon side of the spit) that serve as nurseries for juvenile salmonids, their prey, and some bird species.

It is worth mentioning one less obvious, but important, geomorphic aspect of the spit prior to development. Prior to 1906, the White River, which drains the northern and eastern flank of Mt. Rainier, discharged most of its water and sediment load via the Duwamish River to Elliott Bay. Over the last few thousand years (since sea level stabilized and the spit began to grow), several massive lahars discharged copious amounts of fine sediment to Elliott Bay, moving the

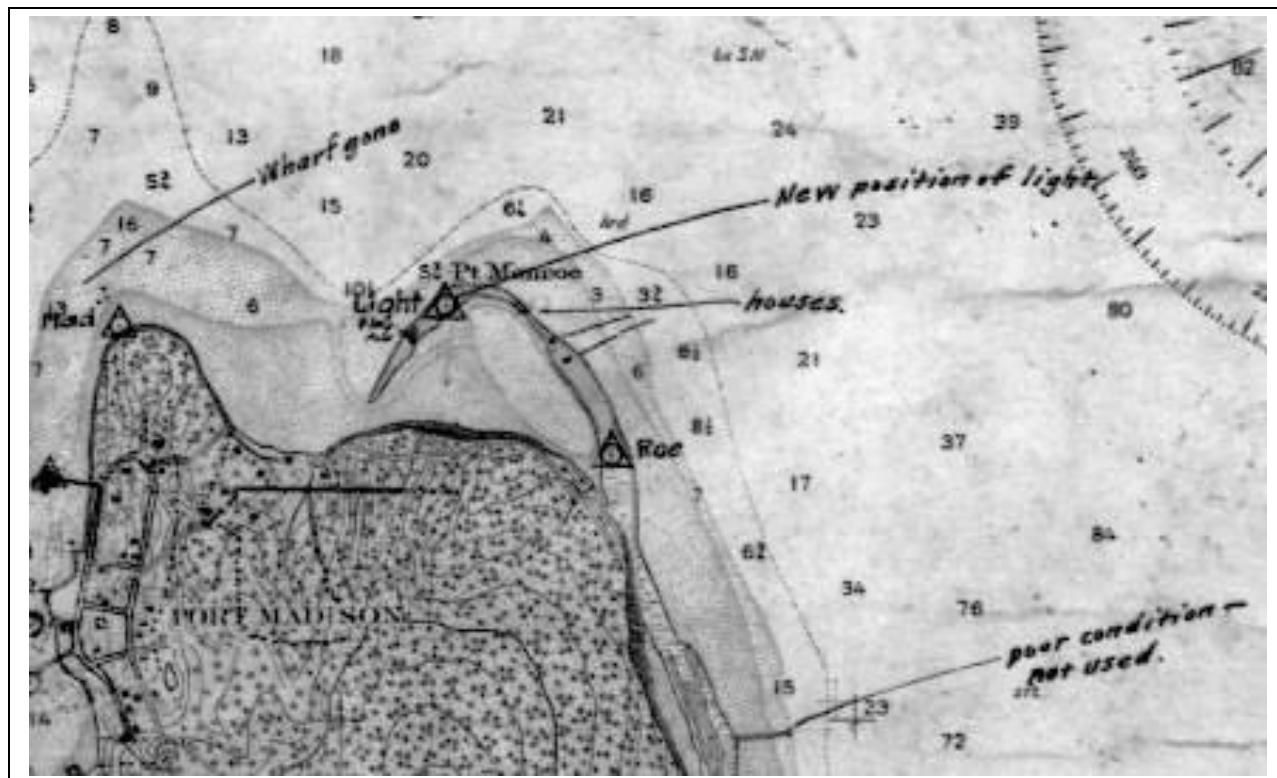


Figure 2. T-sheet Map of Point Monroe (U.S. Coast and Geodetic Survey 1916).

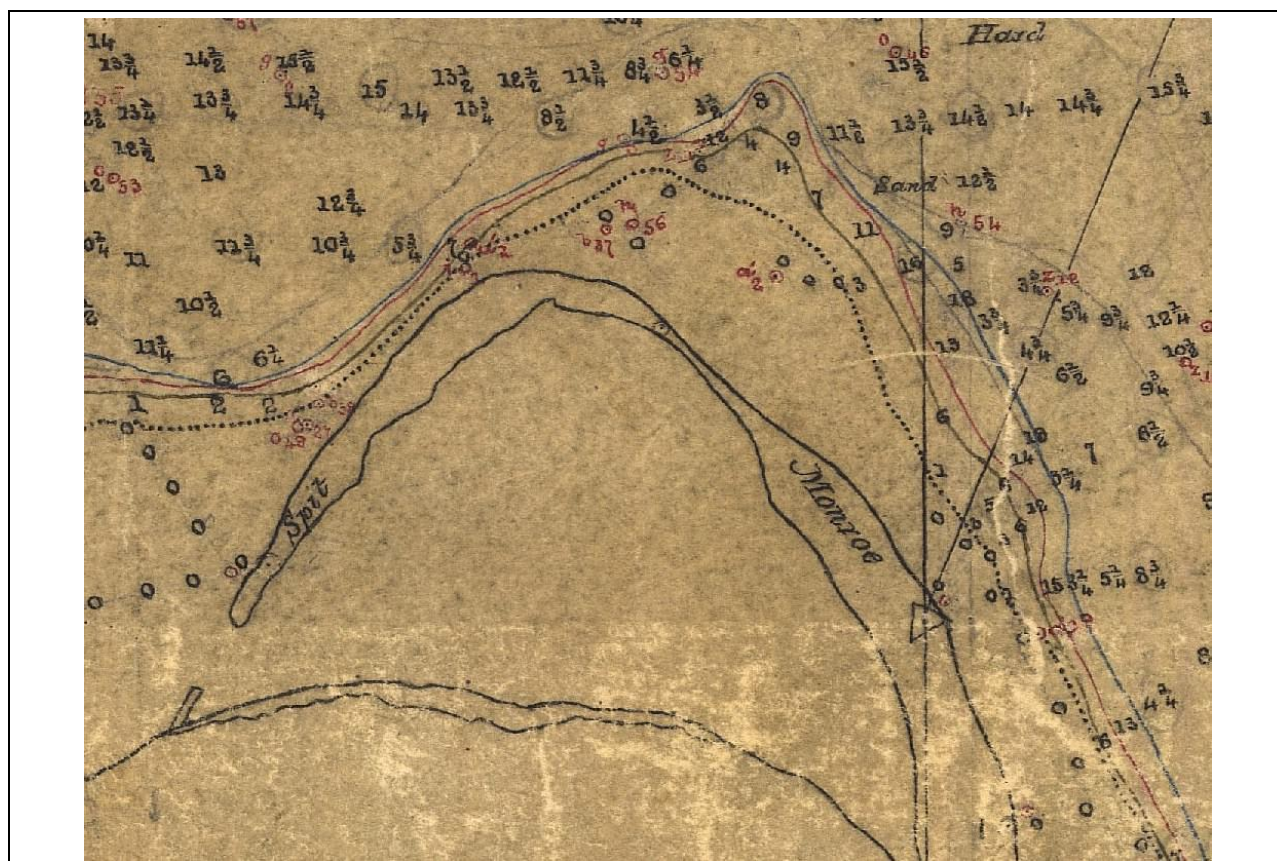


Figure 3. H-sheet of Point Monroe (U.S. Coast and Geodetic Survey 1868).

shoreline miles closer to Point Monroe (Zehfuss et al. 2003). Some fine sediment derived from lahars likely was transported to Point Monroe. Fine sediment may have even been transported there during large conventional floods, just as has been documented at Ala Spit from floods on the Skagit (Herrera 2008). Since the White River has been diverted and dammed, this source of fine sediment (primarily to the lagoon) has been effectively turned off. Transport of fine sediment is common several miles away from river mouths for relatively common flood events (Curran et al. 2002). The types of events in question produced many orders of magnitude more sediment (these events moved the shoreline miles [Zehfuss et al. 2003]; while floods only cause shoreline migration on the order of feet) and, therefore, the White River would likely have contributed significant sediment in the vicinity of Point Monroe.

The relevance of the physical context is important for understanding the types of habitat that could have occurred on the spit. Most certainly the spit possessed pickleweed meadows in high marsh areas (pickleweed zone), which is common at Ala Spit and undisturbed portions of Point Monroe in the present day. Currently the width of this zone at Point Monroe is approximately 30 feet in undisturbed portions of the spit.

On the beach ridge itself, where Point Monroe Drive NE and many of the residences now exist, accumulations of exposed unvegetated sediment were interspersed with dunegrass (*Leymus mollis*) and other dune plant communities, as currently occurs just to the south in Fay Bainbridge Park.

In the lower intertidal it is likely that eelgrass (*Zostera marina*) was common on the outer portion of the spit, as it is today. Although the Washington Coastal Atlas denotes the lagoon as having patchy eelgrass (Ecology 2012), Ericson (2011) found no eelgrass present, and existing eelgrass stands were not observed on the site visit. It is likely that eelgrass is minimally present, if at all, within the lagoon. Moreover, it is unlikely that eelgrass meadows were extensive within the confines of the lagoon in recent history due to the high clay content of the substrate (partially from erosion of adjacent clays, but also from past input from nearby rivers, including the White River), as well as the frequency of desiccation that would occur from tide changes given the lagoon bathymetry. Further aging stormwater infrastructure currently conveys a large volume of fine sediments to the lagoon, ensuring that eelgrass will not recur, even if conditions become more favorable in the future.

Existing Ecological Conditions at Point Monroe

A central aspect to beach spit formation in coarse-clastic (i.e., where gravel is prevalent) environments that were once glaciated is overwash (Neal et al. 2003). The importance of overwash to sustain spits has been described in several studies within the Puget Sound area (Herrera 2008; Shipman 2008). From on-site observations, this has largely ceased to occur throughout much of the spit, with the exception of near the tip. Most notably the foreshore elevation on the outer middle portion of the spit is quite low as compared to the height of the existing shoreline protection structures. It is uncertain whether this is caused by a large amount of fill being placed on the former beach or whether it has been caused by erosive forces. The overwash sediment supply has also been reduced to the lagoon portion of the shoreline. This is similar to conditions that occurred at Ala Spit due to shoreline armoring prior to restoration activities (Herrera 2008).

Despite the extensive armoring along the sound side of the spit, it is clear from examination of the shoreline and changes in recent aerial photographs that there is an intact foreshore, transporting sediment to the tip of the spit. Further, between the 1990 and 2010 aerials, the pickleweed area near the tip expanded eastward by about 5 to 10 feet. While this expansion rate of the spit is slow compared to Ala Spit or Ediz Hook (Herrera 2009), it indicates that there remains some sediment supply to the tip. This is not unusual for spits where sediment supply, by definition, is high, even when there have been impairments to that supply, as is the case at Point Monroe. Both Ala Spit prior, and Ediz Hook under existing conditions have intact foreshores even though they have narrowed and lost sediment offshore due to placed infrastructure along the necks of the spits (Galster 1989; Herrera 2008, 2009).

The growth of the spit at Point Monroe indicates that the sediment supply from the bluffs south of the spit is not entirely shut off. It has been well documented that some armoring in the drift cell to the south has starved the drift cell of predevelopment volumes of sediment (Coastal Geologic Services, Inc. 2010; Herrera 2011); however, the length of the drift cell in question and the presence of some intact bluffs does mean some sediment is actively delivered. While there are also likely increased losses of sediment to areas offshore from the armoring as is evident by the elevation of the beach as compared to the base of the shoreline protection structures, these losses do not completely eliminate sediment supply to the tip of the spit, particularly in light of on-site observations of mobile sand along the entire base of the armored portions of the spit.

The remaining vegetation communities on Point Monroe spit also appear to be relatively intact, despite the elimination of overwash, and the intensity of development and land use, which has removed dune and strand communities that historically covered the spit. Other vegetation, including Pacific madrone (*Arbutus menziesii*), which is not typical of spits is present. The most common plant found was pickleweed, a key indicator species for pocket estuarine marshes (Beamer et al. 2003; Beamer 2007). Most of the residences occupy dune community habitat and thus its historic extent has been reduced.

Another factor in assessing the ecological condition of the shoreline is the presence of large woody debris. Wood has been shown to be important for a range of nearshore biota, including, but not necessarily limited to, macroinvertebrates and other salmonid food sources (Sobocinski 2003; Sobocinski et al. 2010; Tonnes 2008). Spits are noted repositories for large woody debris. In fact, at Ala Spit, the tip of the spit is covered almost entirely with large woody debris (Herrera 2008). At Point Monroe, the fill and protective structures have prevented wood from accumulating on many portions of the spit. However, there are portions, such as the sound side of the spit where wood does actively accumulate and provides many of the ecological functions typically found in backshore areas (Sobocinski 2003).

Existing fish use of the area has been documented by a single set of seine observations at the tip of the spit within the lagoon (Ericson 2011). These observations indicated that at least three salmon species are present, including Chinook (*Oncorhynchus tshawytscha*), pink (*O. gorbusha*), and chum (*O. keta*) at various life stages. Habitat use of the spit by these species is likely for rearing and foraging within the lagoon and as a migration corridor outside

the lagoon along the spit. Although not detectable as part of a seine survey like this, some shellfish species are also likely present in this area.

Nearby seining at Fay Bainbridge indicates that coastal cutthroat trout (*O. clarki clarki*) are also present in the nearshore (Ericson 2011). Anecdotal observations of herring spawning on the eelgrass on the bench on the sound side of the spit are also consistent with the conditions observed on site. Finally, various species of shrimp and crab are found in the mud flats in the lagoon (Ericson 2011; Jim Brennan, personal communication). No data on bird use specific to the spit were available for this report; however, it is likely used by a number of marine birds such as great blue herons, grebes, sandpipers, and scoters.

Existing Development Conditions at Point Monroe

The main distinguishing feature associated with the development of the Point Monroe spit is the physical loss of the habitat areas that the footprint of each development occupies. This habitat loss is a direct impact of the development, and has likely affected the fish and wildlife species that depend upon such habitat to reproduce, rear, and forage. Nonetheless, such development has likely caused other more indirect impacts that may not be readily apparent, including impacts to water quality. Stormwater discharges from roofs and residential septic systems are two potential sources of water quality impacts. In general, direct stormwater discharge to Puget Sound is a well-documented contributor to poor water quality in the sound (Herrera 2011) and thus does not require additional discussion in this document, except to discuss specific areas of the Point Monroe spit where this is most likely an issue. A detailed analysis of whether on-site septic systems at Point Monroe are an environmental concern was also outside the scope of this report; however, some mention of environmental concerns is appropriate and thus is provided below.

The Kitsap County Board of Health regulates the permitting of on-site septic systems within the City of Bainbridge Island through Ordinance 2008A-01. The ordinance allows new septic system construction based on lot size, soil type, and system design, and specifies setback requirements accordingly. Although City staff has recommended that sewer service for Point Monroe be provided, currently homes on the spit are serviced by on-site septic systems.

Septic system setbacks required by the ordinance are variable and range from 100 feet to 50 feet (if a variance is obtained) (R. Ericson, personal communication). No monitoring of water quality within the lagoon or sound side of the spit occurs therefore, it is unknown whether the required septic system setbacks are sufficient to protect water quality, particularly in the lagoon where leaking nitrogen and phosphate could trigger microalgae blooms or excessive growth of macroalgae. Both, microalgae blooms and excessive growth of macroalgae can affect the habitat conditions in the lagoon by creating eutrophic conditions (eutrophication) or even physically impairing pickleweed growth and altering the substrate conditions.

There is limited research on whether septic systems affect marine ecosystems via polluted groundwater discharging directly to the ocean. However, California Sea Grant researchers found elevated levels of nitrogen and phosphate in the surf zone during periods of high groundwater flows to the beach from septic effluent. Their conclusion was that septic

systems could affect coastal water quality through submarine groundwater discharge (see <http://www-csgc.ucsd.edu/NEWSROOM/NEWSRELEASES/2009/CoastalWaterQuality.html>). Similarly, monitoring data from sample wells and thermal infrared aerial imagery allowed researchers in Rhode Island to identify the sources and location of nitrogen discharges and determined that the largest contributor of nitrogen was septic systems (~80 percent), and that total sewerage to eliminate on-site disposal system wastewater discharges would alter the nitrogen budget by 78 percent (Urish and Gomez 1998).

Although, the general link between eutrophication and algal blooms is widely recognized for both marine and freshwater ecosystems, the ecological effect of on-site wastewater treatment at Point Monroe is unknown as there is no monitoring of water quality. Nevertheless, eutrophication is an important environmental concern and may require additional regulatory attention.

Because the spit has been effectively separated by Point Monroe Drive NE, and the separation itself is different in different locations, it is helpful to subdivide the spit into specific geomorphic areas as the impacts from existing development vary throughout the spit. This is not to say that future modifications made in one area do not have impacts on another. It is rather that the types of environmental impacts (both existing and future) from existing infrastructure and the mitigation strategies will be different in each area. These geomorphic areas are identified on Figure 1 and described separately in each subsection below.

Outer Neck

The primary existing impact to natural processes in this portion of the study area is the placement of impervious surfaces in areas that were formerly vegetated by dune communities. These impervious surfaces have degraded the spit ecosystem and have caused a loss of dune habitat area (equal to their footprint), and thus likely also the loss of wildlife species that depend upon such habitat. One of the homes in this geomorphic zone is constructed on fill and two homes have a riprap shoreline protection structure at or between mean higher high and extreme high water elevation on all or a portion of their property (R. Ericson, personal communication). The wave energy in this area may be somewhat increased by ship traffic, but that effect is unknown, although it has been observed elsewhere (Finlayson 2006). Sediment supply reductions in the drift cell to the south could also increase the propensity for erosion to occur, but these changes have not had a measurable impact on geomorphic conditions on these properties according recent aerial photographs. Compared to historic conditions, these energy increases and sediment supply reductions may have affected the forage fish spawning habitat and potentially shellfish habitat along this portion of the spit.

Outer Middle

The homes located on the outer middle are in the most geomorphically active, energetic portion of the spit. These parcels experience intense wave activity from both natural and possibly from human sources such as ship traffic; however, Finlayson (2006) documented that ship traffic was insignificant compared to wave energy on energetic shorelines, albeit in a less travelled place. Regardless, the presence of shoreline protective structures likely results in energy increases and thus impacts to forage fish habitat, as discussed above for the Outer

Neck of the spit. In addition, these shoreline protective structures likely significantly reduce the frequency of spit inundation during large storms and extreme tides. The parcels in this portion of the spit have the largest number of human modifications. Those modifications and their impacts are:

- Fill - Not all of the parcels have been filled, but it is clear from visual elevation interpretation of some of the residences that fill has been placed to raise the properties above high marine water levels. The fill and associated shoreline protection structures reduces overwash events.
- Shoreline protection structures (i.e., bulkheads) - All of the developed parcels have shoreline protection structures on them. Only a short stretch of the shoreline is not armored. This area shows signs of active erosion and retreat of the beach, likely from loss of sediment supply to areas offshore. Recent aerial photographic analysis also indicates signs of erosion since 1993 (Coastal Solutions 2010). The erosion has caused the beach to lowered as is typical with shoreline protection structures (Herrera 2007) and impairs or precludes the presence of forage fish habitat as well as juvenile salmon feeding, refuge, and migration habitat. It could also have an impact on shellfish habitat.
- Native vegetation removal - The residences currently occupy areas that were likely the site of dune plant communities thus native habitat was removed and thus wildlife species impacted (for example, through loss of bird nesting habitat).
- Loss of large woody debris - Large woody debris plays an important role in the maintenance of healthy backshore areas (Sobocinski 2003; Herrera 2007). The removal of large woody debris from these areas has eliminated the ecological functions it provides. This ecological function loss has likely resulted in a loss of rearing, nesting, and foraging opportunities for wildlife species that would have used the dune communities.
- Impervious surfaces - Because these parcels are nearly entirely built out, there has been conversion from pervious to impervious conditions, which necessitate roof drainage via small drainpipes that drain directly to the beach. This discharge causes the direct discharge of stormwater to Puget Sound, which as stated earlier is a well-documented contributor to poor water quality in the sound (Herrera 2011).

Lagoon

The lagoon parcels are separated from Puget Sound by Point Monroe Drive NE. Prior to development the lagoon parcels were intermittently inundated by marine waters from overwash during marine high water events. This overwash was also a major source of sediment to the lagoon. This source of sediment has been cut off by fill, structures, and residences on the outer portion of the spit. Many homes in this area are located overwater. Although erosion rates and hazards are less for these properties, they often have fill associated with them that requires structural protection. Placement of fill and the residences themselves likely eliminated pickleweed habitat, a key nursery for juvenile salmonids (Beamer 2007). Based on visual observations during the site visit, the structures themselves

now have vigorous attached biological communities that are more typical of rocky environments. Hence, a habitat type transformation has also resulted from development as has also been documented elsewhere (Bulleri and Chapman 2010).

Tip

Like the neck of the spit, the homes in this area are generally setback from the active foreshore. These properties exhibit ongoing sediment deposition (such as the sand present in front of the anchored wood in Figure 4). Unlike the neck, wave energy is much reduced from areas on the spit further east, due to the protection from main Puget Sound basin waves by the northerly arc of the spit itself. The primary impacts to the nearshore ecosystem have been the placement of residences themselves (resulting in loss of habitat), and the placement of impervious surfaces (potentially resulting in water quality impacts). While habitat area has been lost and has likely impacted wildlife species that depended on such habitat, the presence of the residences seems to have not affected the viability of the remaining and reduced pickleweed and dune communities in their immediate vicinity. This is possibly because these residences are spaced further apart than in other areas of the spit.



Figure 4. Recent Sand Deposited in Front of Anchored Wood.

RECOMMENDATIONS FOR MITIGATION OF FUTURE IMPACTS

The best approach to address potential ecological impacts is avoidance. When avoidance is not feasible, then minimization by design is preferred. Any remaining impacts should be mitigated. Since it is likely that future development will occur at Point Monroe, recommendations for mitigation are provided here. While mitigation can compensate for habitat impacts and potentially benefit species over time, in the short term, habitat loss results in immediate impacts on species.

Although the extent and intensity of development on the spit is significant and has disrupted historical geomorphic processes and habitat functions, remaining natural areas of the spit are relatively stable and provide some ecological functions. The most significant and probable future development on the spit is the construction of new residences on at least three undeveloped parcels identified by the City (R. Ericson, personal communication). Two of these parcels have existing bulkheads that would be grandfathered in as existing structures. The third, which has a permit under review for a new septic system, is on the sound side Tip area and likely does not require structural shoreline protection to accommodate a residence, though soft shore protection may be desired. This action should be subject to the City's standard approach to installation of soft shore protection.

Aside from the new residences, most of potential actions covered by new City regulation will be expansion of existing infrastructure. Table 1 summarizes the impacts to fish (finfish and shellfish) and wildlife habitat from these and other possible actions and ranks them as to whether they are high, medium or low. Impacts are characterized in terms of the following categories: hydraulic changes, geomorphic changes, substrate changes, habitat area loss, pickleweed removal, dunegrass removal, water quality degradation, aquatic habitat shading, and fish behavioral changes.

Table 1 draws heavily on Herrera (2007), which describes the impacts associated with shoreline modifications, as adapted to the particular conditions found at Point Monroe. Most of the impacts are comparable to what would occur elsewhere on City shorelines. However, there are several particular actions where impacts will be significantly different from similar actions elsewhere in the City. Key actions and impacts that are different on the spit from other areas in the City are:

- Overwater structures in the Point Monroe lagoon may not have easy-to-measure impacts associated with changing predation risk (by predatory fish) on juvenile salmonids. This is because the predator species responsible for the increased risk (e.g., adult rockfish and sculpin) are generally not likely present in the lagoon, due to regular complete tidal flushing. Hence, such predatory fish, which typically display affinity to structures such as piles, cannot likely establish permanent residence in the lagoon or

Table 1. Summary of Potential Actions and Associated Impacts.

Actions		Potential Impacts on Fish (fin and shellfish) and Wildlife Habitats								
		Hydraulic Changes	Geomorphic Changes	Substrate Changes	Habitat Area Loss ^a	Pickleweed Removal ^b	Dunegrass Removal ^b	Water Quality Degradation ^c	Aquatic Habitat Shading	Fish Behavioral Changes
Residential buildings (not including impervious surface impacts)	New	H ^e	H ^e	H ^e	H ^e	H ^e	H		M	L
	Expansion	M ^e	M ^e	M ^e	M ^e	M ^e	M		M	L
Impervious surface	New							M		
	Expansion							L		
Traditional shoreline protection structure	New	H	H	M	H		M			H
	Expansion	M	M	L	M		M			M
Soft-shore protection structure ^d	New		L		L					
	Expansion		L		L					
Overwater structures	New					H	M			
	Expansion					M	M			
Piles	New	L		L	L	L			L	L

Notes:

H = High, M = Medium, L = Low

^a Only includes aquatic habitat

^b If present

^c If treatment is not provided

^d Assumes there is also associated dunegrass planting

^e Only in Tip geomorphic area where overwash currently occurs

hover for long periods under the dock structures waiting for juvenile salmon to prey upon. However, to the extent that these overwater structures may attract predatory fish during periods of high tides and during the months when juvenile salmon may be migrating along City's shorelines, increased predation risk could exist. Likewise, to the extent that these overwater structures may attract predatory birds, an increased predation risk from such birds may be an issue. Overwater structures also will have impact on the footprint of where piles are placed.

- Shading impacts from residences may affect juvenile salmonid migration by forcing juveniles away from the water's edge and causing an increased predation risk by species such as adult and pre-adult coastal cutthroat trout. It is important to mention that because migration only occurs on the outside of the spit (the lagoon is likely mostly used for rearing and foraging), and existing height requirements limit potential shading envelopes, this impact will only be incurred in the Outer Middle geomorphic area.
- Impacts may occur with expanding impervious area, but they could be mitigated by on-site infiltration due to porous geology, and generally well-drained conditions. This statement implicitly refers to future development that will be in areas previously filled and/or protected by existing bulkheads. Placement of new impervious surfaces in areas not previously filled and protected with an existing bulkhead may have other impacts to physical habitat that will also have to be addressed. In addition, infiltration potential may be limited given the lot sizes on the spit, and the leach field and setback requirements for septic systems.
- Vegetation impacts would occur in only certain geographic areas associated with important plant communities (dunegrass and pickleweed). Areas of existing fill have already experienced these impacts and generally do not possess this type of vegetation.
- By disrupting the overwash and deposition process, shoreline stabilization structures on the spit have cut off sediment supply that nourishes beach formation. Due to the extent and location, there are likely cumulative effects (both geographic and over time) as well as direct impacts from individual structures. There is also a possibility of additional impacts associated with new shoreline armoring and development.

Spits are generally susceptible to flooding and storm surge damage. The National Marine Fisheries Service (NMFS) issued a Biological Opinion (BiOp) concerning the effects of structures located in the flood zone on endangered species and their habitats. In response, FEMA has provided guidance on habitat assessment and mitigation required according to the National Flood Insurance Program (NFIP). In return for federally supported flood insurance, local governments had to agree to regulate development in their floodplains in accordance with the Program's criteria. Hence, the City is required to consider the impacts on Endangered Species Act (ESA) listed species and their habitat as well as Essential Fish Habitat (EFH, defined by the Magnuson-Stevens Fishery Conservation and Management Act) when issuing a permit for a structure, including conventional shoreline protection structures within the flood zone.

Specific to Point Monroe, the BiOp and FEMA guidance pertinent to NFIP requires the City to consider impacts on Chinook salmon, steelhead, and bull trout (listed species). While only Chinook are documented to use the lagoon (Ericson 2011), the potential exist for juvenile steelhead and pre-adult bull trout to use the lagoon for rearing and foraging. It also requires the City to consider critical habitat for Chinook salmon, steelhead, and bull trout, and EFH, all of which have been mapped by NMFS and the US Fish and Wildlife Service (USFWS) along the City's shoreline. On one hand, because the lagoon is open to Puget Sound, and these listed species would therefore not be stranded if swept into the lagoon by extreme tides or large storm events, it is unlikely that such species would be adversely affected from stranding by structures located above the mean higher high water elevation. These fish species would be expected to seek the lagoon outlet as waters recede. On the other hand, structures could result in impacts to critical habitat for these species, even if located above the mean higher high water elevation. These impacts are similar to those discussed earlier in this section of the document.

A summary table of potential mitigation options for each category of impact listed in Table 1 is provided in Table 2. In addition, there is significant variability in the ecological impacts of the actions likely to occur throughout the spit based on geomorphic area. Specific recommendations for each geomorphic area are discussed below in individual subsections.

Note that there is no scientific research specifying mitigation ratios for the pickleweed and dunegrass plant communities as recommended in Table 2. However, a greater than 1:1 ratio of mitigation area to impacted area is recommended since plantings do not all survive. Dunegrass communities are recommended at a 2:1 mitigation ratio because when well rooted and deeply planted, dunegrass will generally successfully establish. A higher mitigation ratio of 4:1 is recommended for pickleweed because while dunegrass is commercially available and can be planted, pickleweed is generally not commercially available and mitigation of impacts would depend on natural colonization, which necessarily implies more risk. However, the odds of natural colonization on Point Monroe are high given that most undisturbed areas of the lagoon have pickleweed present at the preferred elevations. In most cases, mitigation will have to occur on-site unless additional properties are acquired considering that the spit is largely intact outside existing development. If additional properties are acquired to provide off-site mitigation, it should be in-kind and in the closest proximity to Point Monroe as possible.

It is recommended that a site-specific analysis be required for any new residential development planned for undisturbed areas on currently undeveloped lots. This is to ensure that all potential effects are evaluated prior to construction, and sufficient mitigation is provided to prevent no further degradation of remaining ecological functions associated with Point Monroe. In addition, a site-specific analysis is recommended for expansion of residential structures in the Tip area. This is because the Tip has extensive native vegetation and is regularly overtopped during extreme high tides; thus expansion of residences could have numerous impacts.

Sediment supply to Point Monroe is impaired due to placement of traditional shoreline protection structures. In some cases, new or expanded traditional shoreline protection structures could be allowed if mitigation is provided to restore updrift feeder bluffs that

Table 2. Summary of Recommended Mitigation Options for Associated Impacts.

Actions		Impacts and Recommended Mitigation								
		Hydraulic Changes	Geomorphic Changes	Substrate Changes	Habitat Area Loss	Pickleweed Removal	Dunegrass Removal	Water Quality Degradation	Aquatic Habitat Shading	Fish Behavioral Changes
Residential buildings (not including impervious surface impacts)	New	Site-specific analysis if new construction is planned for undisturbed areas on undeveloped lots	Site-specific analysis if new construction is planned for undisturbed areas on undeveloped lots	Site-specific analysis if new construction is planned for undisturbed areas on undeveloped lots	Site-specific analysis if new construction is planned for undisturbed areas on undeveloped lots	Recreate pickleweed elevation of 4x area through nourishment	Plant 2x equivalent area		Nourishment sufficient to move active salmon migration corridor seaward and outside of dominantly shaded area ^b	Covered by nourishment for shading ^c
	Expansion	Site-specific analysis if expansion is into undisturbed areas located on Tip	Site-specific analysis if expansion is into undisturbed areas located on Tip	Site-specific analysis if expansion is into undisturbed areas located on Tip	Site-specific analysis if expansion is into undisturbed areas located on Tip	Recreate pickleweed elevation of 4x area through nourishment	Plant 2x equivalent area		Nourishment sufficient to move active salmon migration corridor seaward and outside of dominantly shaded area ^b	Covered by nourishment for shading ^c
Impervious surface	New							Infiltrate on-site		
	Expansion							Infiltrate on-site		
Traditional shoreline protection structure ^a	New	Site-specific analysis recommended	Site-specific analysis recommended	Site-specific analysis recommended	Site-specific analysis recommended		Site-specific analysis recommended			New bulkheads are not recommended
	Expansion	Site-specific analysis recommended	Site-specific analysis recommended	Site-specific analysis recommended	Site-specific analysis recommended		Site-specific analysis recommended			Expanded bulkheads are not recommended
Soft-shore protection structure ^b	New		Nourishment sufficient to counteract future losses		Nourishment sufficient to counteract future losses					
	Expansion		Nourishment sufficient to counteract future losses		Nourishment sufficient to counteract future losses					
Overwater structures	New					Recreate pickleweed elevation of 4x area through nourishment	Plant 2x equivalent area			
	Expansion					Recreate pickleweed elevation of 4x area through nourishment	Plant 2x equivalent area			
Piles	New	Minimize number/footprint of piles		Minimize number/footprint of piles	Minimize number/footprint of piles	Minimize number/footprint of piles			Minimize number/footprint of piles	Minimize number/footprint of piles

Notes:

^a Sediment supply to Point Monroe is impaired due to placement of traditional shoreline protection structures. It is recommended that no new or expanded structures of this type be allowed unless a site-specific analysis indicates that spit conditions would not be further impaired.

^b Assumes there is also associated dunegrass planting.

^c If erosion is expected, consideration should be given to the need for additional nourishment over time.

would effectively increase sediment supply to the spit (Coastal Geologic Services, Inc. 2010). In fact, restoration of the drift cell culminating at Fay Bainbridge State Park located immediately south of Point Monroe is specifically identified in *Strategies for Nearshore Protection and Restoration in Puget Sound* as an important project for Bainbridge Island and the South Central Sub-basin of Puget Sound (Cereghino et al. 2012). However, this option should be carefully evaluated in a site-specific analysis to ensure sediment supply to the spit is improved and no further degradation occurs as a consequence.

Therefore, it is recommended that no new or expanded traditional shoreline protection structures be allowed unless a site-specific analysis indicates that spit conditions would not be further impaired. In addition, all properties currently at risk from erosion have structures in place that can be maintained or replaced under the City's shoreline regulations. A site-specific analysis should address all the potential impacts identified in Tables 1 and 2. These include hydraulic changes, geomorphic changes, substrate changes, habitat loss, pickleweed removal, dunegrass removal, water quality degradation, aquatic habitat shading and fish behavioral changes.

All mitigation projects should include a monitoring plan, which should be implemented for at least 5 years. The monitoring plan should include adaptive management strategies indicating how to proceed in the event that the restoration projects are found not to be performing as expected from the design.

A potential source for mitigation requirements for repair or replacement of traditional shoreline protection structures can be found in the City of Bainbridge Island *Single Family Residence Shoreline Mitigation Manual*.

Outer Neck

The outer neck is completely built out. These three developed parcels are setback from the ordinary high water mark and the active and intact foreshore. The absence of existing shoreline protection structures and intact sediment supply indicate that erosion on these parcels, if it occurs at all, is primarily episodic and slow in the long term. As a result, no hard shoreline structures should be required to protect the existing residences; however, performing a risk assessment on such properties was not part of the science summary scope of work. If shoreline protection is proposed, it is recommended that a soft-shore approach be used (beach nourishment may also be an option if feasible)¹. It is assumed that new overwater structures will not occur in this area due to an energetic nearshore. Expansion of the existing residences will not have negative ecological consequences if they are expanded in a landward direction within already disturbed areas. Expansion in the seaward direction could affect important intact vegetation communities, and if large enough, could have shading impacts.

¹ While nourishment would have positive ecological benefits to all portions of the outer spit and could help reduce adverse effects that loss of sediment has on habitat at places further down-drift, the financial and operational efficacy of nourishment would need to be evaluated.

Outer Middle

It appears that these parcels have the greatest geomorphic risk; however, as previously stated, performing a risk assessment on such properties was not part of the science summary scope of work. They experience intense wave activity from both natural and potentially human sources such as ship traffic. The fill and associated structures with these properties also provide some protection to the spit from inundation during large storms and extreme high tide events. All of these parcels require protection for residences. Consequently, all developed parcels have some form of existing shoreline protection structure. Only three parcels are not protected. One is owned by the United States Government, and presumably will not be developed in the future, while the other two are owned by an adjacent landowner. Further development of the privately owned parcels would likely necessitate the placement of fill owing to the small footprint available due to past erosion; however, new fill is not allowed by the SMA WAC 173-26-231(c). Expansion of the residences upward could trigger shading impacts on the nearshore, though these impacts will be highly dependent on the specific details of the action and could be shown to be negligible if a shading analysis is performed. Increased runoff from additional impervious surface area could be mitigated by on-site infiltration such as discharging to a rain garden, or use of pervious pavement or other pervious materials due to well-drained soils. None of the parcels on this side of the spit have docks or other related overwater structures, and it is assumed that the wave energy in this area will continue to preclude the construction of these structures in the future.

Lagoon

The lagoon parcels are separated from Puget Sound by Point Monroe Drive NE and shoreline protection structures on the outer portion of the spit. These parcels typically have homes that are overwater structures. Because the erosion rates and hazards are less than that in most other parts of the City, new bulkheads should not be necessary to protect new or expanded residences. Previously placed fill areas are generally already protected by existing shoreline protection structures. Therefore, it is not expected that new shoreline protection structures will be required in the Lagoon geomorphic area; however, performing a risk assessment on such properties was not part of the science summary scope of work.

Docks are common in this section of the spit. Expansion of existing docks in the lagoon seaward direction may not have significant ecological impacts beyond the impacts caused by the structures that already exist on the lagoon, particularly if new piles are not required. Expansion of existing docks alongshore in areas already disturbed and free of native vegetation (pickleweed) may also have minimal effects, although would preclude future vegetation colonization if the possibility exists based on site conditions. However, destruction or loss of pickleweed meadows would constitute a significant ecological impact and would require mitigation through the creation of pickleweed meadows elsewhere in the lagoon. New docks would only have ecological impacts from piles if the docks could be constructed without causing a loss of pickleweed meadows or dune plant communities. In addition, to the extent that overwater structures may attract predatory fish during periods of high tides and during the months when juvenile salmon may be migrating along City's shorelines, increased predation risk could exist. Likewise, to the extent that these overwater structures may

attract predatory birds, an increased predation risk from such birds could be also a resulting impact. Expanded height of upland structures would not have shading impacts due to the orientation of the shoreline and existing height restrictions. Expanded residences on existing fill likely will have only impervious surface impacts. The increased runoff from impervious surfaces could be mitigated by infiltrating the runoff on-site which also would protect water quality.

Tip

Like the neck of the spit, the homes in this area are generally setback from the active foreshore, probably because the spit has historically been wider in this area (Figures 2 and 3). These properties also show signs that sediment deposition is occurring. Wave energy is significantly less than the outer portions of the spit. Hence, all further protection if desired should consist of soft shore protection structures. Expansion of existing residences will likely not have significant ecological impacts, if the expansion does not induce the loss of native vegetation communities, excepting the increase in impervious surface, which can be mitigated by on-site infiltration. Because of extensive native vegetation and generally low topography (i.e., it is regularly overtopped during extreme high tides), new construction or expansion of residences will likely have numerous impacts (see Table 1) that should be examined in detail in a site-specific analysis provided to the City as part of a development application.

CONCLUSION

Point Monroe is distinguished by significant development, which has largely resulted in the direct loss of fish and wildlife habitat and has thus likely affected the fish and wildlife species that depend upon such habitat to reproduce, rear, and forage. In addition, development has likely caused other more indirect impacts that may not be readily apparent, including impacts to water quality. Most significantly, sediment supply to Point Monroe is impaired due to placement of traditional shoreline protection structures both updrift and on the spit.

In most cases, mitigation for new or expanded structures on Point Monroe should occur on the spit where the impact can be directly mitigated. The exception to this general recommendation is when restoration of up drift feeder bluffs would improve sediment supply to Point Monroe. Existing development on the spit and the relatively intact habitat that remains allows few opportunities for local mitigation. Considering that the spit is largely intact outside existing development, mitigation should be directed to restore existing disturbed areas or potentially on remaining undeveloped properties. In the case of Point Monroe, it may make sense to allow permanent preservation of existing undeveloped properties as mitigation in order to prevent further habitat loss from development.

GLOSSARY

Downdrift - In the direction of dominant, alongshore sediment transport, which on Point Monroe follows the spit from east to west.

Desiccation - The removal of moisture from something, as in the loss of water due to low tide conditions.

Eutrophication - The ecosystem response or process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen.

Forage fish - A term for a variety of small fish species that commonly use the Puget Sound nearshore, including sand lance (*Ammodytidae* sp.), surf smelt (*Hypomesus pretiosus*), and Pacific herring (*Clupea pallasii*).

Foreshore - The steep part of the beach that is generally composed of gravel, although it can contain sand or even boulders. The foreshore on the shoreline of Bainbridge Island extends from approximately 1 to 3 feet above MLLW to MHHW. It is the most sedimentologically active portion of the nearshore.

Littoral fish - Those fish that are found in the intertidal zone, moving in and out with the tide. They include anadromous salmonids, forage fish, and many marine fish species.

Mean higher-high water (MHHW) - The average elevation of the two high tides in each day over a tidal epoch (19 years).

Mean lower-low water (MLLW) - The average elevation of the two low tides in each day over a tidal epoch (19 years).

Nourishment - Where sediment (usually sand) is placed to protect an eroding beach.

Ordinary High Water Mark (OHWM) - The point on all water bodies that will be found by examining the bed and banks and ascertaining where the presence and action of water are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland as it may naturally change thereafter provided where such mark cannot be found on marine shorelines such point shall be the mean higher high tide line, and on freshwater shall be the mean high water line.

Overwash - The process by which waves overtop a spit and deposit on the landward/lagoon side of a spit.

Overwash splays - Deposits from overwash.

Pocket estuary - A small estuary that forms behind spit or barrier beach landform at a submerged, tectonically- or glacially-derived valley or at a small creek delta (Beamer et al. 2003).

Updrift - In the direction opposite of dominant alongshore sediment transport.

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