Appendix B – 12: Hood Canal Hook Sub-Region

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Hood Canal Hook Sub-region

Sub-Region Summary

Geographic Location

The Hood Canal Hook sub-region includes shorelines east of Tahuya Bay along the north shore and directly across the water from Tahuya Bay along the south shore, extending east to the head of Hood Canal at Lynch Cove and the Union River (Figure 1). Following first, is an overview description of the sub-region and second, more detailed narrative descriptions of habitat complexes within the sub-region.

Geology and Shoreline Sediment Drift

The surface geology of the Hood Canal Hook sub-region consists mainly of glacial till in the uplands, Fraser advance outwash deposits along the shoreline, and outwash near the Big and Little Mission creeks area. Pre-Fraser outwash from alpine glaciers is present on the south shore from about Twanoh Creek, extending west to the Skokomish delta; it also occurs on the north shore in the vicinity of Tahuya Head just east of the Tahuya River.

A few landslide deposits appear near Tahuya Head and a small landslide unit exists along the south shore west of Twanoh Creek. Significant peat deposits are associated with Lynch Cove, and alluvium occurs at the Union River, Devereaux, Stimson, and smaller creeks (Logan 1987; Walsh 1987). Net shoreline sediment drift occurs in a primarily west-to-east direction on both the north and south shorelines (WDOE 2002, based on Blankenship 1983)(Figure 1).

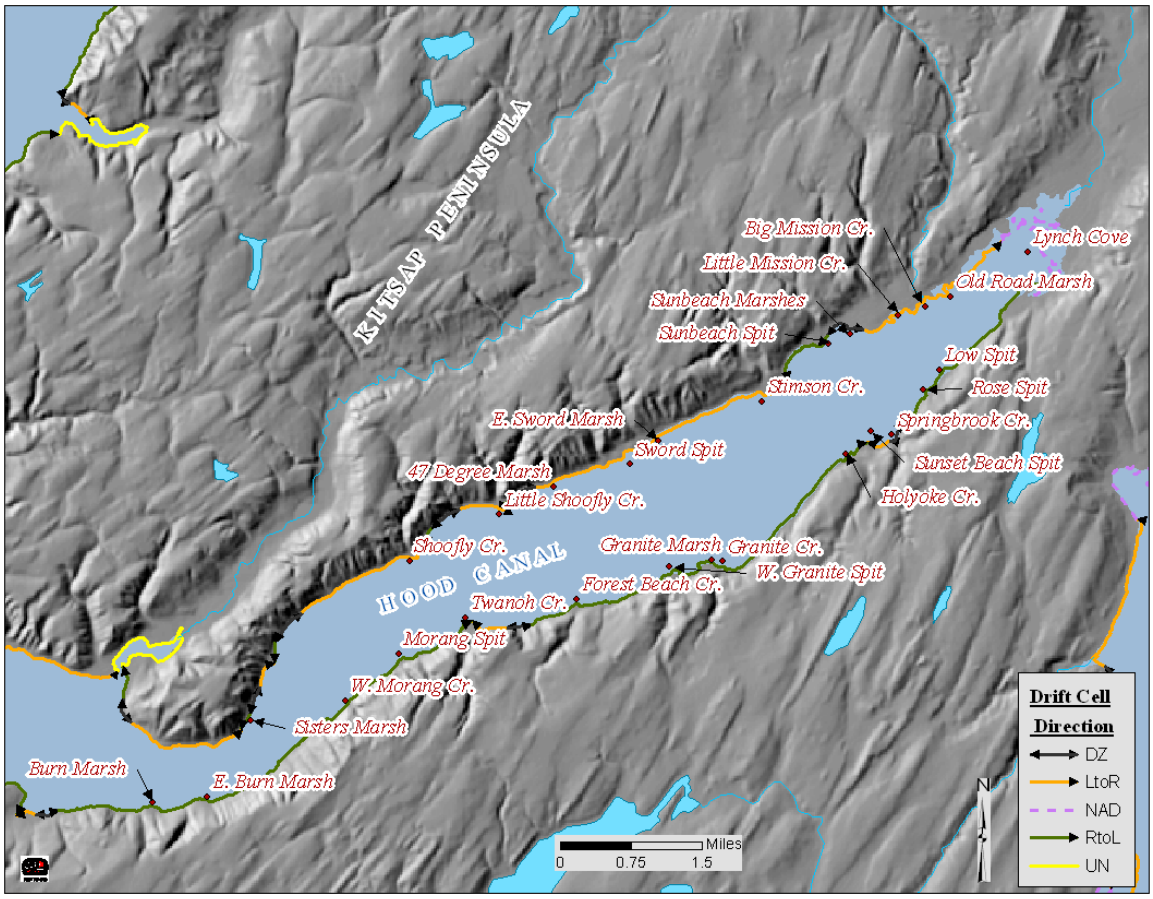

Figure 1. Hood Canal Hook sub-region, including habitat complexes and net sediment drift (WDOE 2002, based on Blankenship 1983). Net shore drift in the Hook on both the north and south shorelines is predominantly in a west-to-east direction. Legend items DZ = "divergence zone", NAD = "no appreciable drift", UN = "unknown", LtoR = "left-to-right", and RtoL = "right-to-left" (from the perspective of someone in a boat and facing the shoreline).

Information Sources (see Appendix A for details)

- 1861, 1872 GLO survey notes
- 1884 T sheets (T1561a and T1561b)
- 1939, 1942, 1946, 1956, 1957 (various sources), 1999 Mason County, 2000 WDNR, 2003 WDNR vertical air photos
- 1977, 1993, 2001 WDOE oblique air photos (on-line series)

The below narrative for this sub-region often refers to specific figures embedded in the text that have been imported from the listed information sources. Sometimes the narrative may simply cite one of these sources. In the latter case, the reader may choose to access the cited information source for first hand information.

Description of Sub-region Habitat Complexes

We identified 27 habitat complexes in the Hood Canal Hook sub-region, 12 are considered stream-delta complexes, and 15 are spit/marsh complexes. The Lynch Cove/Union River habitat complex is one of the largest complexes in the study area at 387 hectares (habitat complex scale is based on the combined estimates of spit, tidal flat, marsh, channel, and lagoon habitat as delineated from the early T sheets). Indeed, about 83% of the habitat area in the Hook sub-region, based on historical estimates, is attributed to the Lynch Cove/Union River complex. Only one other habitat complex in the sub-region even exceeded 10 hectares – Stimson Creek/Peirce Spit (Figure 2). Several other complexes were in the range of near 5 to 9 hectares in size, including Little Mission Creek, Shoofly Creek/Big Spit, Holyoke Creek, Twanoh Creek, Old Road Marsh, Granite Creek, and Little Shoofly Creek. The remaining 18 habitat complexes in the sub-region were historically all less than 3 hectares in size. Summary information for individual habitat complexes in the Hood Canal Hook sub-region can also be found in Appendix A, Table 17.

An important note that may have more relevance in the Hood Canal Hook sub-region than in any other sub-region in the study area is that the delineated habitat boundaries used in estimating the scale of individual habitat complexes are somewhat arbitrary, particularly with the delineation of the tidal flat. The close proximity of many of the complexes in the Hook sub-region to one another, for example Little Mission and Big Mission creeks, leads us to assume that there is probably a great degree of spatial overlap between the specific habitats of one complex with habitats from another, or several other, complexes. Therefore, although only 1.43 ha is attributed to the Big Mission Creek complex, its close proximity (almost contiguity) with the Little Mission Creek (to the west) and Old Road Marsh (to the east) complexes should be considered if we assume that scale and contiguity are important in determining the overall value of a habitat complex to salmonids.

Historically, there were about 121 hectares of tidal marsh, channel, and lagoon habitat associated with 19 habitat complexes in the sub-region (8 complexes historically did not contribute these habitat types and only supported a spit and/or tidal flat associated with a creek mouth). Today, about 108 hectares of these habitat types exist (10% decrease from historical), spread across just 13 habitat complexes (14 of the historical complexes do not currently contribute any tidal marsh, channel, or lagoon habitat). Although a number of habitat complexes that historically supported tidal marsh and lagoon habitat do not support these habitat types today, there are a few complexes that currently support salt marsh but did not do so historically (Figures 3 and 4).

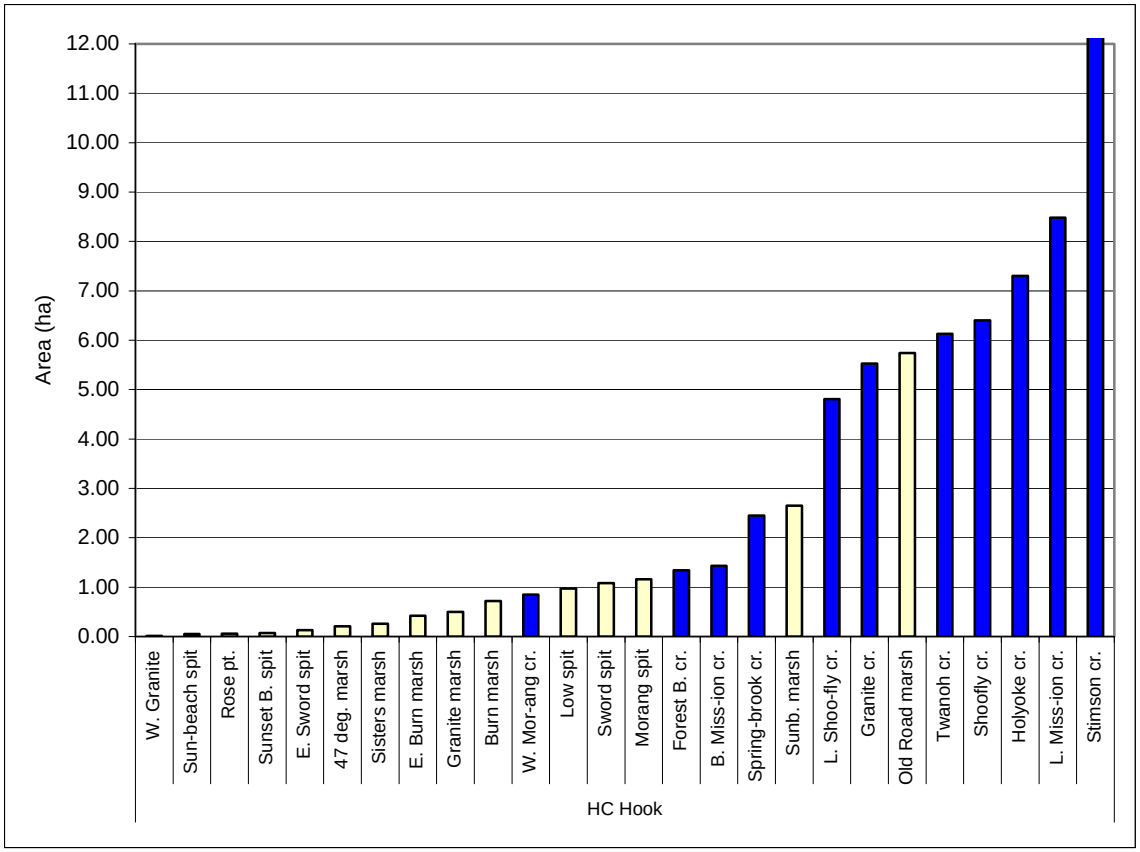

Figure 2. Scale, in ascending order, of habitat complexes in the Hood Canal Hook sub-region. Blue columns represent stream-delta complexes. The largest complex, by far, at 387 hectares, is Lynch Cove (including the Union River), is not shown in this graphic because it dwarfs the other complexes. Scale was determined by summing the area of tidal flat, spit, tidal marsh, channel, and lagoon habitat features associated with each complex, based on the early T sheet delineations (1884).

Stream Delta Complexes

As mentioned, the Lynch Cove/Union River habitat complex dominates the sub-region in terms of the amount of tidal wetland habitat. Historically, 91 of the 108 ha (84%) of tidal marsh and lagoon habitat associated with stream delta complexes in the sub-region, came from the Lynch Cove/Union River complex. This spatial distribution has only become more skewed since early settlement as today about 93 of 99 hectares (94%) of tidal marsh and lagoon habitat associated with stream delta complexes in the sub-region comes from the Lynch Cove/Union River complex. Although our estimates show virtually no net surface area change (1% increase) in tidal marsh at Lynch Cove/Union River since 1884, several sections of the marsh have been diked and converted to upland or non-tidal wetland. A couple of additional parts of the marsh may have been diked and converted to grassland pasture in 1884, though this is thought to be minimal at most. However, salt marsh, or a transitional marsh and scrub-shrub wetland or upland occurs today in several locations that were clearly shown as forested in the 1884 T sheet. It may be that these

landward boundaries of salt marsh were mapped inaccurately in the T sheet in a few locations. Alternatively, though unsubstantiated, it may also be that these areas have subsided and become subject to tidal inundation and the development of salt-tolerant plant communities, possibly facilitated by the clearing of low-lying forest adjacent to the historical salt marsh.

Each of the six other stream delta complexes that either historically or currently support tidal marsh or lagoon habitat have seen this habitat reduced since 1884, with one of these complexes, Twanoh Creek, having lost all of its historical 1.67 ha (Figure 3). Little Mission Creek, the third largest habitat complex in the sub-region, has lost 62% of its historical 8.36 ha of tidal marsh. The Springbrook, Holyoke, Granite, Forest Beach, and West Morang Creek stream deltas are not known to have ever supported measurable tidal marsh or lagoon habitat.

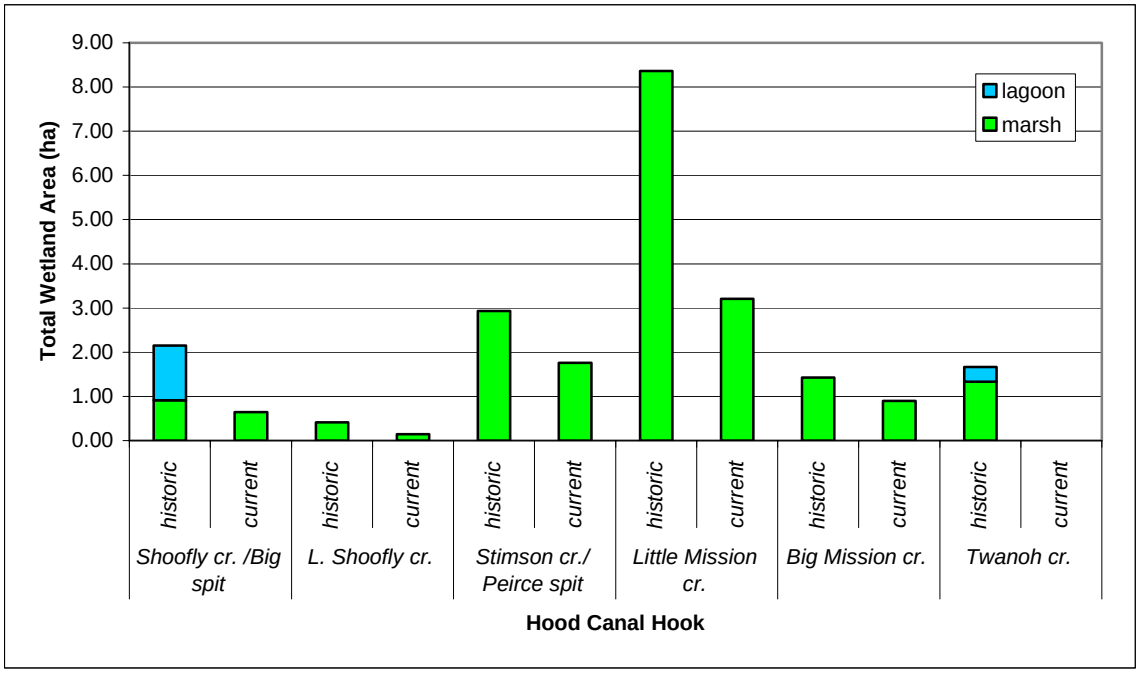

Figure 3. Historical changes in area of tidal marsh and lagoon habitat associated with stream-delta complexes in the Hood Canal Hook sub-region. The Lynch Cove/Union River complex is not shown in this graphic because the amount of salt marsh associated with the complex would dwarf all other complexes. The Springbrook, Holyoke, Granite, Forest Beach, and West Morang Creek stream-delta complexes are not shown in this graphic because they historically and currently lack tidal marsh and lagoon habitat.

Spit/marsh Complexes

The amount of salt marsh and lagoon habitat associated with spit/marsh complexes in the Hook sub-region has decreased from 12.3 to 8.8 hectares (28% loss). Historically, 12 spit/marsh complexes supported marsh or lagoon habitat. Today, just 6 of these complexes still support marsh or lagoon habitat. An additional complex, (Sunset Beach

Spit), that did not historically have marsh or lagoon habitat today supports 0.07 hectares (Figure 4).

The degree of surface water connectivity between marsh and lagoon habitats associated with a spit/marsh complex and its adjacent open waters, and the presence of freshwater inputs to a habitat complex can have important implications for the potential use of these habitats by juvenile salmonids. The degree of surface water connectivity influences whether or how often fish are able to access these relatively protective habitats; and the presence and quantity of freshwater input to a spit/marsh complex influences the salinity, which can be critical in facilitating the osmoregulatory changes required of juvenile salmonids transitioning from a freshwater to saltwater environment. Recognizing the importance of these factors, surface water connectivity and freshwater inputs, the following discussion is framed around the distribution and historical and current status of spit/marsh complexes in the sub-region.

Historically, 11 spit/marsh complexes in the sub-region showed a surface water connection with adjacent open waters, suggesting potential access for juvenile salmonids. Three of these 11 complexes have known freshwater inputs (Sword Spit, Sunbeach Marshes, and Morang Spit (Figure 5). Today, 8 spit/marsh complexes show such a connection. The Granite Marsh, West Granite Spit, and Morang Spit complexes have all been filled over for residential development. Since 1884, the amount of tidal marsh and lagoon habitat associated with spit/marsh complexes with surface water connectivity has decreased in the sub-region from 10.9 to 8.8 hectares (19% decrease).

Four spit/marsh complexes (Forty-Seven Degree Marsh, East Sword Marsh, East Burn Marsh, and Burn Marsh) did not show evidence of a surface water connection in the 1884 T sheet, and cumulatively they contributed 1.37 hectares of salt marsh and lagoon habitat. All four of these complexes have had all of their historical marsh and lagoon habitat eliminated.

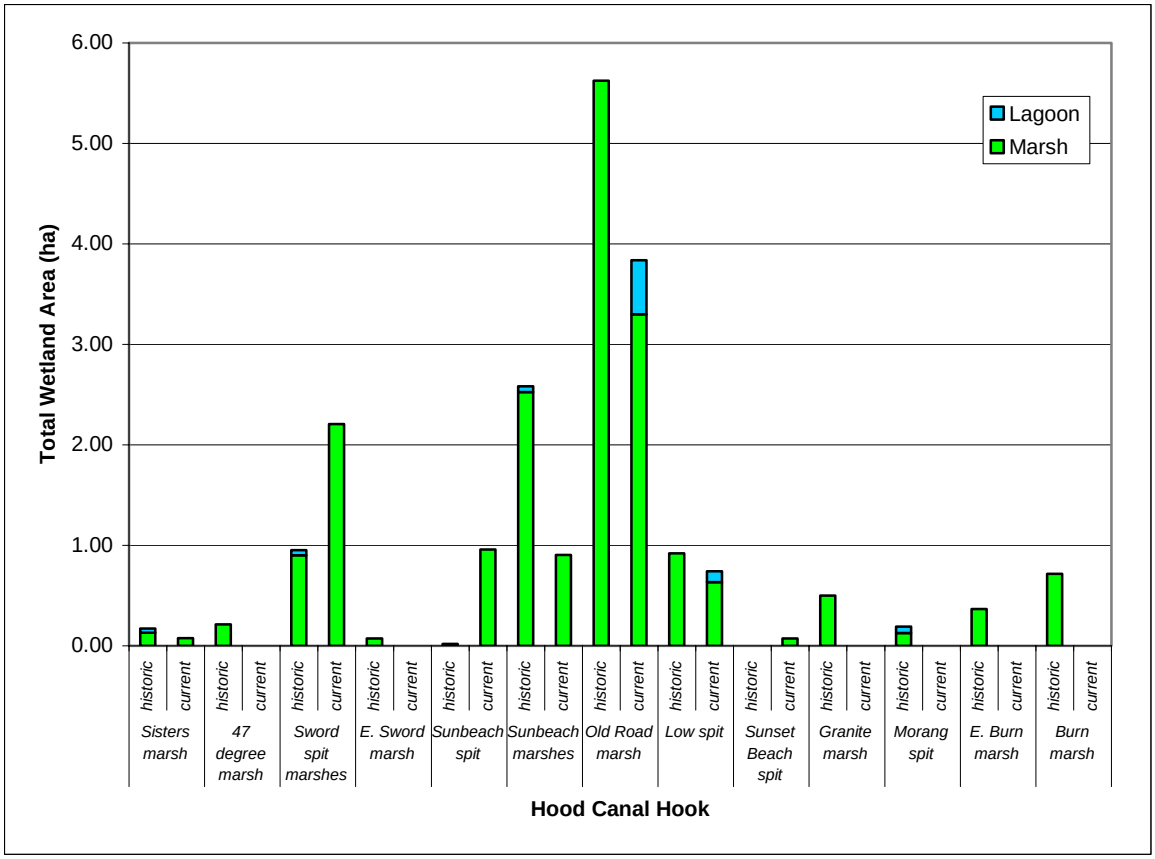

Figure 4. Historical changes in surface area of tidal marsh and lagoon habitat associated with spit/marsh complexes in the Hood Canal Hook sub-region. The Sunbeach Spit, Rose Spit, and West Granite Spit habitat complexes are not included because they historically and currently lack tidal marsh and lagoon habitat.

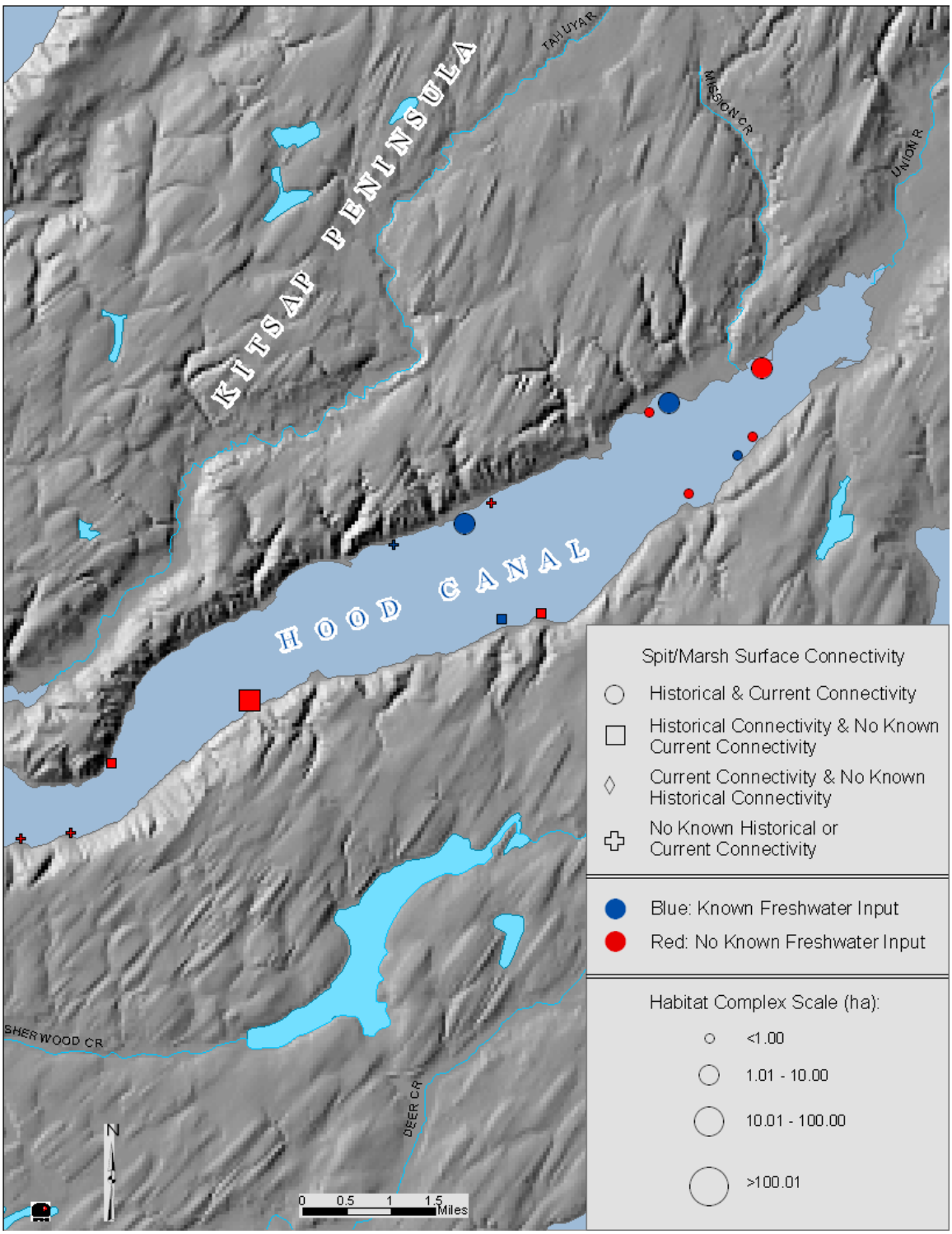

Figure 5. Spit/marsh habitat complexes of the Hood Canal Hook sub-region, including historical scale, the historical and current status of surface water connectivity with adjacent open waters, and freshwater inputs.

Habitat Changes and Impairments of Ecological Processes

The physical processes responsible for the formation and maintenance of stream-delta and spit/marsh habitat complexes are fluvial (predominant in stream-deltas) and wave deposition (predominant in spit/marshes), and tidal erosion (can occur in both stream-delta and spit/marsh complexes). Changes to habitat structure can often be attributed to alterations in one or more of these physical processes.

Habitat changes in stream-delta and spit/marsh complexes can be brought about through direct and indirect means. A direct change occurs at the site such as with the filling of a tidal marsh for a residential development or construction of a road causeway through a marsh. These actions directly affect tidal processes in a complex that is subject to tidal erosion. Impairing this process can result in the reduction of tidal prism or complete elimination of marsh and lagoon habitat. Filling along a spit itself can affect wave-deposited sediment processes. Indirect changes occur when off-site alterations or changes in the supply or transport of longshore sediment take place, or when upstream land use or channel modifications occur that affect hydrology and/or sediment regimes in a stream, ultimately affecting the characteristics of habitat at the delta or estuary.

Many of the historical changes we have been able to detect in habitat complexes in the Hood Canal Hook sub-region are considered the result of direct impacts on physical processes. Because of the spatial and temporal complexities of sediment and hydrology pathways, it is typically more challenging to determine the effects of indirect impacts on habitat complexes, particularly the disruption of longshore sediment processes that potentially affect the characteristics of spit features.

The North Shore and South Shore (Highway 106) roads were constructed quite early along both shorelines in the Hook, and facilitated early development and impacts to stream delta and spit/marsh habitat complexes, primarily with residential development. Nearly the entire shoreline along both the north and south shores had roadbeds built at or quite near the historical shoreline. There were a few locations where filling of upper intertidal habitat most probably occurred to accommodate the roadbed. The roads likely brought significant and immediate disruption of nearshore sediment and hydrologic processes. When homes were constructed, often on fill and associated with bulkheading, the potential for impairment to sediment source, transport, and deposition zones along shorelines in the Hook was probably exacerbated.

A recent inventory of bulkheads and other shoreline modifications reveals that drift cells in the Hook sub-region are generally among the most extensively modified in the Hood Canal region (Hirschi et al. 2003). Indeed, there are few contiguous stretches of shoreline that are free of bulkheads or other structures. Perhaps the least modified area (in terms of anthropogenic structures) occurs in the vicinity of Lynch Cove/Union River.

Nearly all of the stream-delta and spit/marsh complexes in the sub-region have been profoundly altered, and several eliminated altogether, as a result of the cumulative

impacts of the shoreline roads and residential development. The habitat complex that has probably been least impacted is also the largest, Lynch Cove/Union River. Its size alone likely gives it some resilience to development, though even the tidal marshes at Lynch Cove have been diked and drained in several places, and habitat connectivity has been impaired. In addition, much of the Union River watershed, particularly the lower end, is likely to see significant human population growth and related development, which poses a risk to estuarine function at Lynch Cove, particularly from increases in sediment discharge, water withdrawals, and storm drainage.

Associated with several spit/marsh complexes in the Hook sub-region is the presence of salt marsh growing seaward of its apparent historical extent. Most, if not all of these complexes, have had much or all of their historical salt marsh eliminated by mostly residential-related development, and a newly emerged marsh is often seen growing along the shoreline, sometimes in front of bulkheads. An explanation for this phenomenon is found in literature describing the diking of estuarine marshes around the world (R. Johnson, personal communication; see Hood 2004; several references cited in Haring 1999). It appears related to the impairment of tidal processes that takes place when a marsh is diked or filled over, particularly in low wave energy environments such as we see in the Hook sub-region and in upper Quilcene Bay. A reduction in tidal prism results from the filling and development of former marsh habitat. This allows for the accretion of finer-grained sediments in front of bulkheaded or diked shorelines, where historically these sediments may have readily been transported off-site because of adequate tidal energy. Instead, these sediments become more easily colonized by low-elevation salt marsh vegetation such as *Salicornia virginica* and *Distichlis spicata*.

Spit features in the Hood Canal Hook sub-region, including those closely associated with stream delta complexes such as at Stimson Creek/Peirce Spit and at Shoofly Creek/Big Spit, seem to be relatively low elevation accumulations of sand and gravel often with salt marsh growing on them, instead of higher elevation berms with grassland and terrestrial vegetation as seen in other parts of the study area. We do not know if spits prior to large-scale shoreline development in the Hook were more robust features, and they are gradually eroding away, leaving a skeletal coarser-grained material behind that is difficult to erode because of its grain size, or if even in historical times (1800s) the spits in the Hook were of low stature, possibly reflective of the relatively low wave energy environment.

Relative Condition of Habitat Complexes

Based on the percentage of historical tidal wetland habitat (i.e. salt marsh, channel, lagoon, and spit) lost and the degree of overall impairment to habitat connectivity within habitat complexes, a “relative condition” rating was applied to each of the 27 complexes in the Hood Canal Hook sub-region ([Table 1] A description of the methodology for applying the relative condition rating is provided in the Methodology section in the main body of the report). Figure 6 displays the spatial distribution of the habitat complexes in the sub-region and their relative condition.

None of complexes in the sub-region is considered "functional". Although the Lynch Cove/Union River complex is considered "moderately impaired", significant sections of the historical tidal marsh have been diked and now function as either upland, disconnected predominantly freshwater marsh, or impaired tidal marsh. Several additional habitat complexes that are considered locally important to salmonid production, or historically supported substantial tidal marsh habitat, such as Shoofly Creek, Stimson Creek, and Little and Big Mission creeks, and Old Road Marsh, all occurring along the north shore of the Hook, are considered "severely impaired". One significant (by sub-regional standards) stream delta complex, Twanoh Creek, has had all of its historical tidal marsh and lagoon habitat eliminated by fill for a state park, and it is considered "lost". In all, eight complexes are considered "lost", cumulatively resulting in the elimination of 3.73 ha of marsh and lagoon habitat.

Table 1. Relative condition of habitat complexes in the Hood Canal Hook sub-region.

Functional	Moderately Impaired	Severely Impaired	Lost
	Lynch Cove/Union River	Sisters Marsh	47 Degree Marsh
	Low Spit	Shoofly Cr/Big Spit	East Sword Marsh
	Springbrook Creek	Little Shoofly Cr.	Granite Marsh
	Sunset Spit	Sword Spit	W. Granite Marsh
	Holyoke Creek	Stimson Cr/Peirce Spit	Twanoh Creek
	Granite Creek	Sunbeach Spit	Morang Spit
		Sunbeach Marshes	East Burn Marsh
		Little Mission Creek	Burn Marsh
		Big Mission Creek	
		Old Road Marsh	
		Rose Point	
		Forest Beach Creek	
		West Morang Creek	

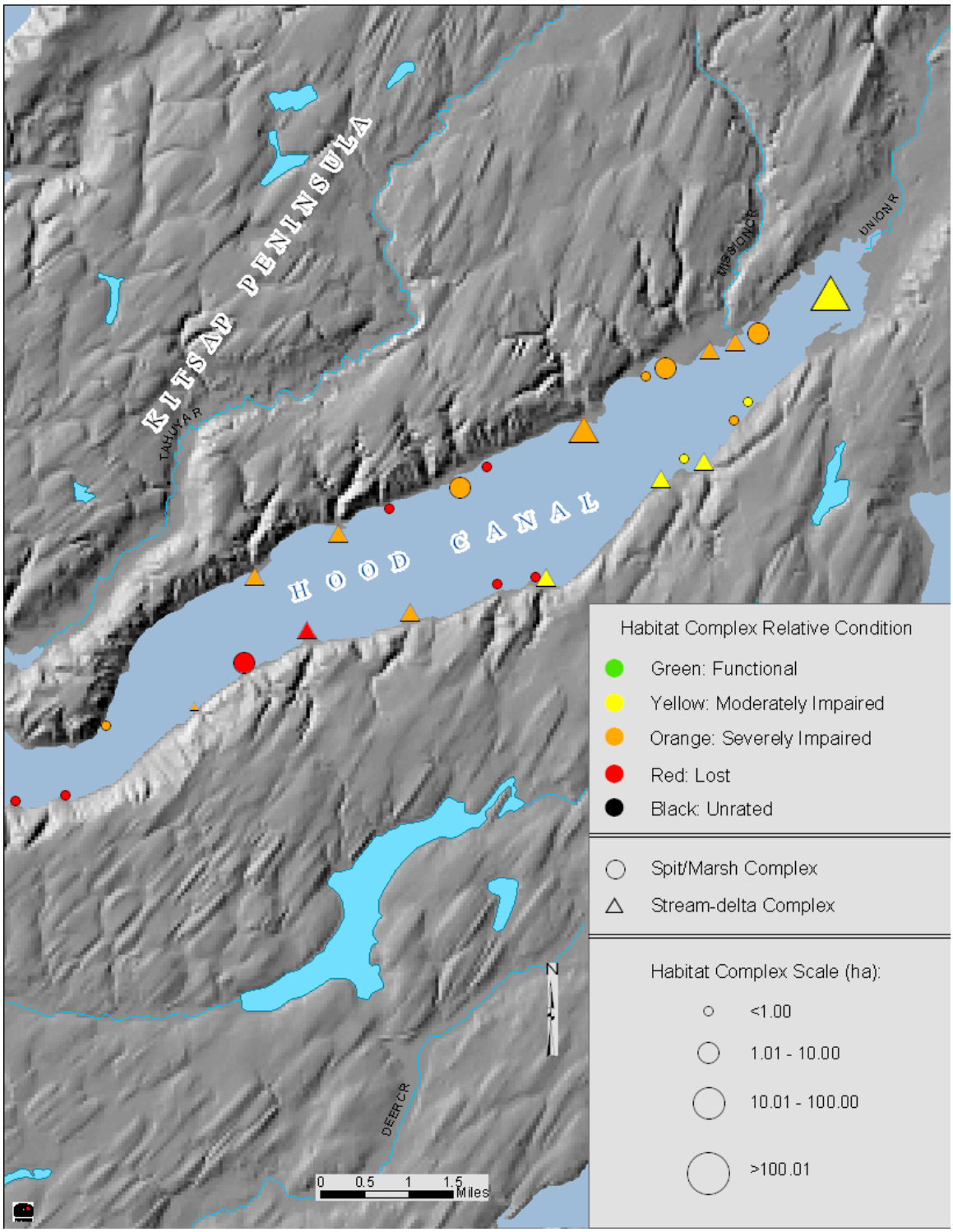

Figure 6. Relative condition of habitat complexes in the Hood Canal Hook sub-region.

Management Recommendations

The Hood Canal Coordinating Council (HCCC) has developed a conservation strategy and project list for the Hood Canal/west Admiralty Inlet (HCCC 2004) region to address implementation of salmon habitat recovery actions. This strategy drew heavily on recommendations from the Limiting Factors Analysis (LFA) reports completed for Water Resource Inventory Areas (WRIA) 14, 15 (Kuttel 2003) and 16 (Correa 2003). In addition, recovery plans have been drafted for ESA-listed Hood Canal/Eastern Strait summer chum (HCCC 2005), and Dungeness, Elwha, Hood Canal Chinook salmon populations (Shared Strategy Development Committee 2005; http://www.sharedsalmonstrategy.org/plan/). These recovery plans include specific actions, including habitat protection and restoration, intended to help recover the listed populations. We encourage the reader to consult these documents. Also, in Appendix A, Tables 18 - 31 of this report, we provide summary information describing individual habitat complexes according to several factors potentially used in consideration of habitat protection and restoration decisions.

Our recommendations focus on the protection and restoration of tidal wetland habitat, and the connectivity of these habitats, by addressing the protection and recovery of the underlying processes responsible in the formation, maintenance, and natural evolution of these habitats – namely fluvial, littoral, and tidal processes.

In considering habitat protection associated with spit/marsh complexes, or of stream-delta complexes that possess longshore depositional features such as spits, the implication is that not only should the spit and associated tidal wetland habitats receive protection, but the drift cell processes that contribute sediment to these spits need to be adequately preserved. Similarly, protection of tidal wetland and other habitats associated with stream-delta complexes requires that watershed and fluvial processes, including floodplain/riparian function, be a priority for protection. The same logic applies to stream-delta and spit/marsh complexes that we have identified from this analysis as good candidates for restoration action. For example, it would not be prudent to carry out restoration of salt marsh habitat through dike removal while simultaneously (or in the future) allowing for bulkhead construction or other shoreline development to occur up-drift that potentially disrupts sediment supply to the spit that is associated with the salt marsh. Nor would it be sensible to remove fill within an estuary but continue to permit floodplain development and encroachment on riparian corridors that potentially affects hydrology and sediment/organic transport processes, ultimately having negative effects on habitat formation in the estuary.

Our assessment suggests that a number of habitat restoration opportunities may be particularly beneficial to salmon habitat at Lynch Cove/Union River, Big Mission, Little Mission, and Old Road Marsh complexes, all of which occur along the north shore and near the head of Hood Canal. Dikes impair the connectivity of tidal marsh and lagoon habitats in each of these complexes, and in Big and Little Mission creeks, lower stream

reach channelization further limits the connectivity with adjacent tidal marsh habitats. The Twanoh Creek complex (in Twanoh State Park), though it has lost all of its historical tidal marsh and lagoon habitat, may offer excellent habitat restoration alternatives within the park, including the removal of large amounts of intertidal fill. Additional potential restoration opportunities should be examined associated with the Stimson Creek/Peirce Spit, Shoofly Creek/Big Spit, and Little Shoofly Creek complexes.

In the Hook sub-region, there are few, if any, opportunities for habitat protection that would not entail considerable restoration actions as well. However, as is often the case, many of the complexes that we recommend for restoration would likely involve property acquisition or conservation easements as prerequisites to implementing restoration measures.

Habitat Complex Narratives

The following narratives provide detailed information on historical habitat changes to individual habitat complexes in the Hood Canal Hook sub-region. The sequence of narratives begins with the Sisters Marsh complex at the west end of the sub-region on the north shore, progresses east to the Lynch Cove/Union River, then continues back to the west along the south shore, ending at the Burn Marsh complex (Figure 1).

Habitat Complex: Sisters Marsh
Complex Type: Spit/marsh

Physical Description

Sisters Marsh historically consisted of two small spits partly enclosing a tidal lagoon surrounded by salt marsh. We are unaware of freshwater inputs to the marsh.

Description of Historical Habitat Changes

A remnant of this marsh occurs today along the southwest part of the former marsh (Table 2 provides a quantitative summary of historical habitat changes), but no regular tidal access is evident (Figure 7). The north side of the historical marsh has been filled for houses, and the northern-most house is built partially on fill out beyond the high water, and includes vertical bulkheading and a dock that appears grounded to the beach. This marsh occurs near the west boundary of a divergence zone that is 40% bulkheaded (Hirschi et al. 2003).

Table 2. Summary of habitat changes to the Sisters Marsh habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area-Length		Change	
	Historical	Today	Area-Length	Percent
Spit (area)	0.09 ha	0 ha *	- 0.09 ha	- 100
Spit (length)	W (170 ft), E (160 ft)	0 ft *	- 330 ft **	- 100
Salt marsh	0.13 ha	0.08 ha	- 0.05 ha	- 38
Lagoon	0.04 ha	0 ha	- 0.04 ha	- 100
Total (spit, salt marsh)	0.26 ha	0.08 ha	- 0.18 ha	- 69

* Spit has been developed over or fragmented.
** Combined loss of both west and east spits

Relative Condition

Because of the reduction of salt marsh and lagoon habitat, development along much of the spit, and the loss of historical surface water connection, we consider the relative condition of this complex "severely impaired".

Figure 7. 2001 WDOE oblique photo showing the remnant Sisters Marsh (left side of photo). The right side (north side) has been filled over for homes.

Habitat Complex: Shoofly Creek/Big Spit
Complex Type: Stream Delta

Physical Description

Recognizing their close proximity and probable sediment and hydrology linkages, we combined Shoofly Creek and Big Spit together as one habitat complex. Shoofly Creek historically entered a salt marsh partly enclosed by an eastward pointed spit (Figure 8). The creek was reported as 6 links (4 ft.) wide in September 1861 (Terrill 1861). A road is shown in the 1884 T sheet leading up the Shoofly Creek draw. Just east of Shoofly Creek, Big Spit historically consisted of two spits, one long re-curved spit with a tidal lagoon and salt marsh, and a small spit to the far northeast. A tidal opening to the lagoon occurred between the two spits. No direct freshwater inputs are known to have occurred to the lagoon, though it is not inconceivable that Shoofly Creek would have drained or overflowed to the lagoon in historical times. The 1884 T sheet also shows an "abandoned camp" near the base of the spit on a broad low-lying grassland, and a dock or log dump occurred along the shore at the base of the spit.

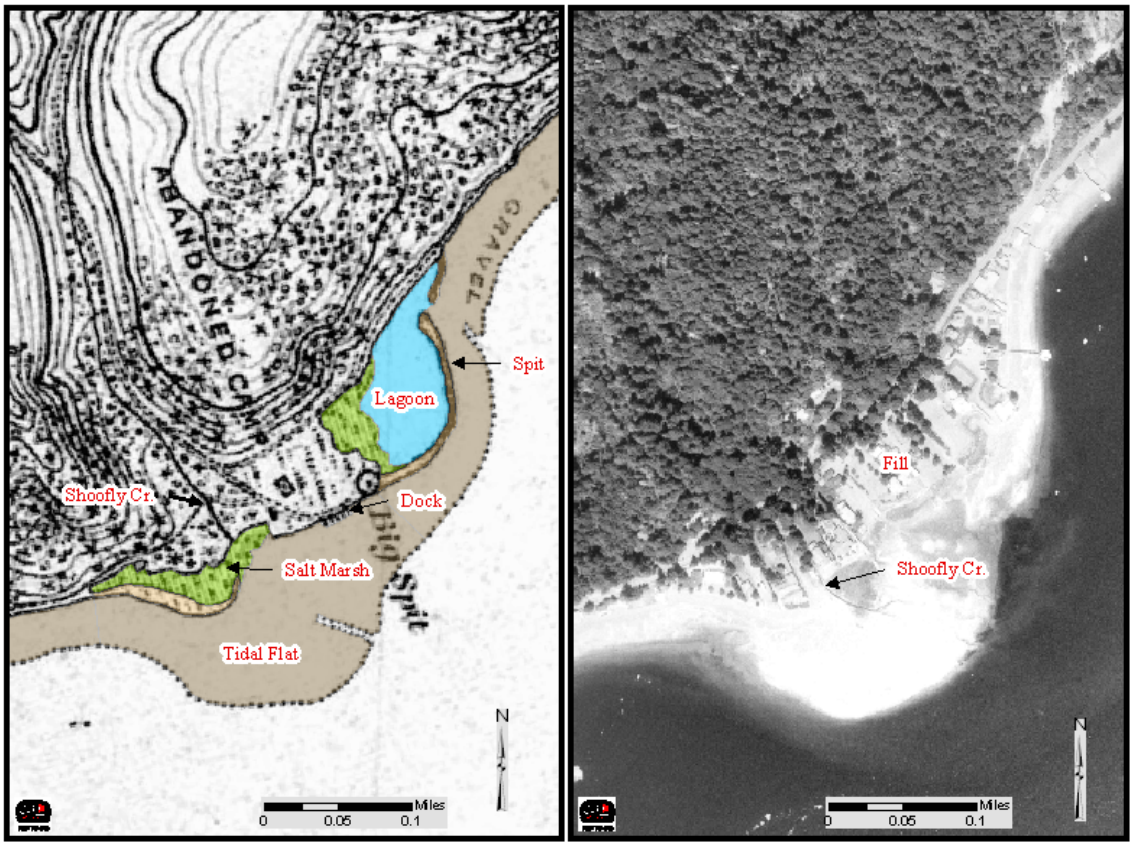

Figure 8. 1884 T sheet (at left) and 2000 WDNR orthophoto (at right) showing the Shoofly Creek/Big Spit habitat complex.

Description of Historical Habitat Changes

A poor-quality air photo from 1942 shows much of the historical lagoon and salt marsh was still likely intact at the time (Figure 9). By 1957 (Figure 10), however, the Shoofly Creek salt marsh and lagoon located to the east of the creek mouth had already been largely filled by this time (Table 3 provides a quantitative summary of historical habitat changes). Today, the historical marsh is completely eliminated, and we see "new" marsh developing out in front of bulkheads (Figure 11). The lower reach of Shoofly Creek runs very close to a house, and the channel has been periodically dredged and was "cleaned out" by the Washington Department of Fisheries Stream Improvement Division in 1970 (Kuttel 2003). Shoofly Creek can transport high sediment loads and the lower channel bed has apparently aggraded (Kuttel 2003). Historically this might have caused the channel to avulse near the mouth; however artificial confinement prevents this dynamic and instead tends to necessitate further channel dredging activity when nearby houses and roads are at risk of flooding.

The eastern portion of the habitat complex, that associated with Big Spit, has been completely filled since 1884, though some salt marsh may have developed seaward of the historical marsh. We can see that the loss of the historical marsh occurred incrementally. An air photo from 1957 indicates that the far northeast end of the historical lagoon, associated with the small spit in 1884, had been filled for houses and driveways (Figure 10). A road apparently had been built across the lagoon to the spit, and the tidal opening is shown just south of the road. Some remnant of the historical lagoon and marsh is evident though it was obviously impacted by this time. By 1977, the entire lagoon and marsh found in 1884 was filled for houses. A narrow band of salt marsh occurs today out in front of bulkheaded and unarmored waterfront properties. It looks like a couple of property owners have dredged out their own private coves, probably to accommodate easier docking for boats.

The Shoofly Creek/Big Spit habitat complex occurs at the convergence of west and east sediment drift. The much longer drift cell from the west (including a divergence zone) is 63% bulkheaded, and the short (329 m) drift cell to the east is 100% bulkheaded (Hirschi et al. 2003). North Shore Road and numerous homes built on fill below high tide water occur along the entire sediment divergence zone to the east of Shoofly/Big Spit (Figure 12).

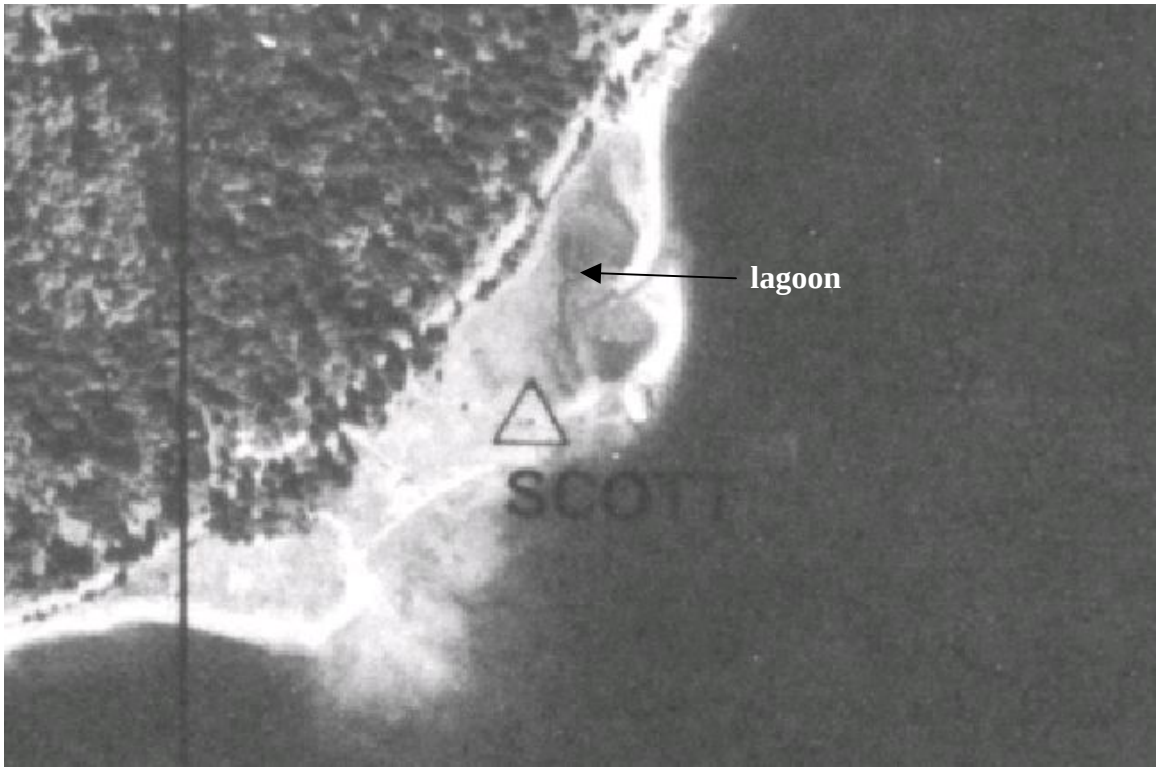

Figure 9. 1942 air photo showing the Shoofly Creek/Big Spit habitat complex.

Table 3. Summary of habitat changes to the Shoofly Creek/Big Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area-Length (ha/ft)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	1580 ft *	0 ft **	- 1580 ft	- 100
Spit (area)	0.49 ha *	0 ha **	- 0.49 ha	- 100
Salt marsh	0.92 ha	0.65 ha	- 0.27 ha	- 29
Lagoon	1.23 ha	0 ha	- 1.23 ha	- 100
Tidal flat	4.19 ha	? ha ***	? ha	?
Total (spit, marsh, lagoon)	2.64 ha	0.65 ha	- 1.99 ha	- 75

* This is the combined historical length of 3 spits associated with this complex. The spit in front of Shoofly Creek was 620 ft., the west spit of Big Spit was 770 ft., and the east spit of Big Spit was 190 ft. in length.

** All spits have been completely developed over.

*** Current day surface area estimates of tidal flat habitat were not made because we felt that these estimates would not provide a valid comparison with the historical estimates of tidal flat that were derived from the T sheets, where the mean lower low water line (MLLW) was often interpolated from actual surveyed points.

Figure 10. 1957 air photo showing the Shoofly Creek/Big Spit habitat complex. Notice the filling and road or pier across the lagoon at Big Spit. Compare with the 1942 air photo above.

Relative Condition

Based on the complete loss of the spits and tidal lagoon habitat associated with Big Spit, and substantial loss of salt marsh at this complex, we consider the relative condition "Severely Impaired".

Figure 11. 1993 WDOE oblique photo showing Shoofly Creek (delta) and site of Big Spit, the latter by this time appearing to be completely filled over.

Figure 12. 2001 WDOE oblique photo showing the sediment divergence zone just east of Shoofly Creek/Big Spit and west of Little Shoofly Creek.

Habitat Complex: Little Shoofly Creek
Complex Type: Stream-delta

Physical Description

Little Shoofly Creek historically entered a semi-protected lagoon just inside of a narrow spit and salt marsh (Figure 13). The September 1861 GLO survey recorded the width of the creek at 8 links (~ 5 ft.) where it joined Hood Canal (Terrill 1861).

Description of Historical Habitat Changes

A 1942 air photo of this site is inconclusive, but habitat does not appear nearly as modified as in more recent historical sources (Table 4 provides a summary of quantitative habitat changes to the complex). By 1977 (and possibly even in the 1942 image), the stream had been diverted out of the former marsh and dumped directly into Hood Canal, where its small delta has been developing. The former marsh and lagoon was filled over by this time for houses, and an artificially constructed lagoon occurs in its place. A large gravel pit occurs just above North Shore Road in the 1977 image and appears active in air photos since that time. Apparently, gravel mined from the pit was used to fill over the historical spit and salt marsh to facilitate residential development (L. Boad, personal communication referenced in Kuttel 2003). A comparison of 1977, 1993 (Figure 14), and 2001 oblique air photos indicates that salt marsh is developing along the margins of this deep dredged lagoon. A massive rock bulkhead associated with a couple of shoreline homes is apparent in the 2001 oblique photo along the Hood Canal side of the lagoon. The Little Shoofly Creek complex lies at the convergence of two relatively short drift cells. Shoreline modifications include 69% bulkheading in the drift cell to the west of the complex, and 54% bulkheading in the drift cell (including the divergence zone) to the east (Hirschi et al. 2003).

Table 4. Summary of habitat changes to the Little Shoofly Creek habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area-Length (ha/ft)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	670 ft	0 ft *	- 670 ft	- 100
Spit (area)	0.15 ha	0 ha *	- 0.15 ha	- 100
Salt marsh	0.42 ha	0.14 ha	- 0.28 ha	- 67
Tidal flat	4.24 ha	? ha **	? ha	?
Total (spit, salt marsh)	0.57 ha	0.14 ha	- 0.43 ha	- 75

* Spit has been completely filled over and bulkheaded.
** Current day surface area estimates of tidal flat habitat were not made because we felt that these estimates would not provide a valid comparison with the historical estimates of tidal flat that were derived from the T sheets, where the mean lower low water line (MLLW) was often interpolated from actual surveyed points.

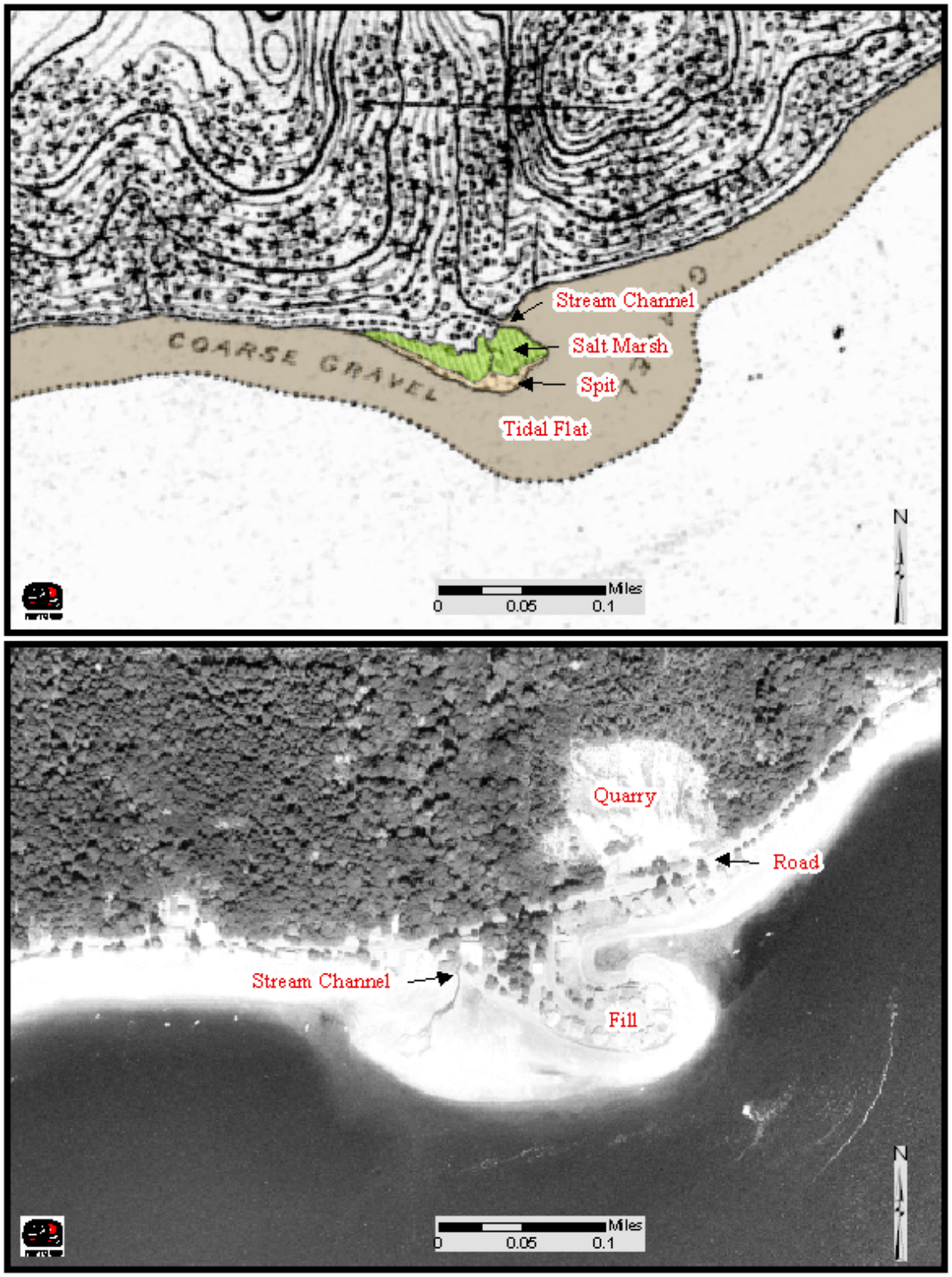

Figure 13. 1884 T sheet (top) and 2000 orthophoto (bottom) showing changes to the Little Shoofly Creek habitat complex.

Figure 14. 1993 WDOE oblique photo of the Little Shoofly Creek habitat complex. Notice how the creek now enters west of a historically present spit. The spit has now been developed over and an artificial "cove" dredged out. A gravel or sand quarry is seen just above North Shore Road.

Relative Condition

Based on the loss of the majority of historical salt marsh at this complex, and considerable alteration to the spit by filling and dredging, and drift cell impairment, we consider this complex "Severely Impaired".

Habitat Complex: Forty-Seven Degree Marsh
Complex Type: Spit/marsh

Physical Description

Forty-Seven Degree Marsh was historically a small salt marsh (0.21 hectares) separated from Hood Canal by a narrow spit with no apparent surface water connection with Hood Canal. The 1884 T sheet indicates a stream entering the marsh.

Description of Historical Habitat Changes

None of the former salt marsh remains. A 1942 air photo is inconclusive, but it is possible that by this time the marsh had been already filled in to large degree, in part by North Shore Road, and by homes. Oblique air photos from 1977, the 1993, and 2001 (Figure 15) indicate several older homes at this site. The entire shoreline along the

former marsh appears bulkheaded and at least one home along the east end is built out over high water. The marsh occurs just east of a divergence zone that is 42% bulkheaded (Hirschi et al. 2003).

Figure 15. 2001 WDOE oblique photo of the site of the historical 47 Degree Marsh. None of the small historical marsh exists today due to residential development.

Relative Condition

Because historical salt marsh has been completely eliminated from this site, we consider the relative condition "Lost".

Habitat Complex: Sword Spit
Complex Type: Spit/marsh

Physical Description

The Sword Spit habitat complex includes a low-lying grassland spit area that in the 1884 T sheet consisted of two salt marshes without apparent tidal connection, two small streams, and a re-curved spit and tidally connected lagoon and salt marsh (Figure 16). The September 1861 GLO survey measured the width of the creek entering Hood Canal at 5 links (3.3 ft.)(Terrill 1861).

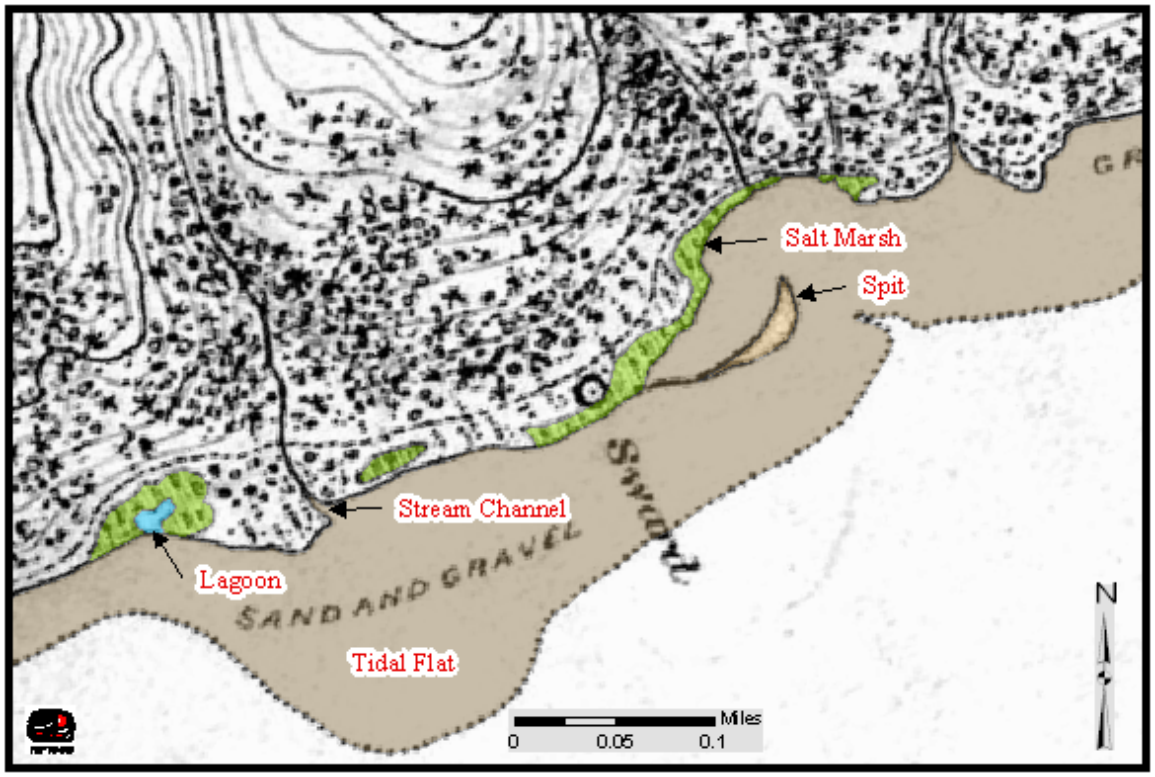

Figure 16. 1884 T sheet showing the Sword Spit habitat complex and associated marshes to the west.

Description of Historical Habitat Changes

The far west portion of salt marsh in this habitat complex has been entirely eliminated, and probably quite early based on the age of the houses that have filled the marsh (Table 5 provides a quantitative summary of historical habitat changes). Today the stream runs between houses and enters its small delta where apparently "new" salt marsh occurs (Figure 17). The small historical salt marsh located just east of the stream delta was eliminated by fill for houses probably many decades ago. Sword Spit itself has seen modifications to its shape since 1884. The re-curved form of the spit as seen in 1884 has not been seen in our recent air photo sources, 1977, 1993 (Figure 18), and 2001. In fact, a spit is hardly evident at all in the 1977 image. By 2001, the spit is oriented roughly parallel with the shoreline. The cause for the apparent change in shape of this spit is not known. The fringing marsh immediately west of the base of Sword Spit and inside the spit, directly associated with the tidal lagoon have been filled for houses. A substantial amount of the historical tidal lagoon has also been filled for houses inside of Sword Spit (earliest definitive evidence 1977, though likely much earlier). Salt marsh has apparently developed seaward of bulkheaded and un-bulkheaded shorelines, though some property owners are evidently excluding salt marsh from developing along their beach as salt marsh boundaries commonly coincide with property boundaries (1977, 1993, 2001 oblique photos), much the way we observed along the northeast shore of Quilcene Bay in the Dabob Bay sub-region. The Sword Spit occurs about half way along the length of a

west-to-east drift cell that is 70% bulkheaded. Six jetties and 8 boat launch ramps also occur in this drift cell (Hirschi et al. 2003).

Table 5. Summary of habitat changes to the Sword Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area (ha)		Change	
	Historical	Today	Area	Percent
Spit (area) *	0.13 ha	0 ha **	- 0.13 ha	- 100
Salt marsh	0.90 ha	2.19 ha	+ 1.29 ha	+ 143
Lagoon	0.05 ha	0 ha	- 0.05 ha	- 100
Total (spit, marsh, lagoon)	1.08 ha	2.19 ha	+ 1.11 ha	+ 103

* Spit length estimates were not made for Sword Spit because of the difficulty in determining the origin of the spit historically compared with that seen in current day.
** Spit has been completely developed over.

Figure 17. 1993 WDOE oblique photo showing the west portion of the Sword Spit habitat complex. The Sword Spit itself is actually at the far right of this image where only the base of the spit is evident west of the stream outlet. Small patches of salt marsh historically occurred at the base of the spit. The immediately following figure shows all of Sword Spit.

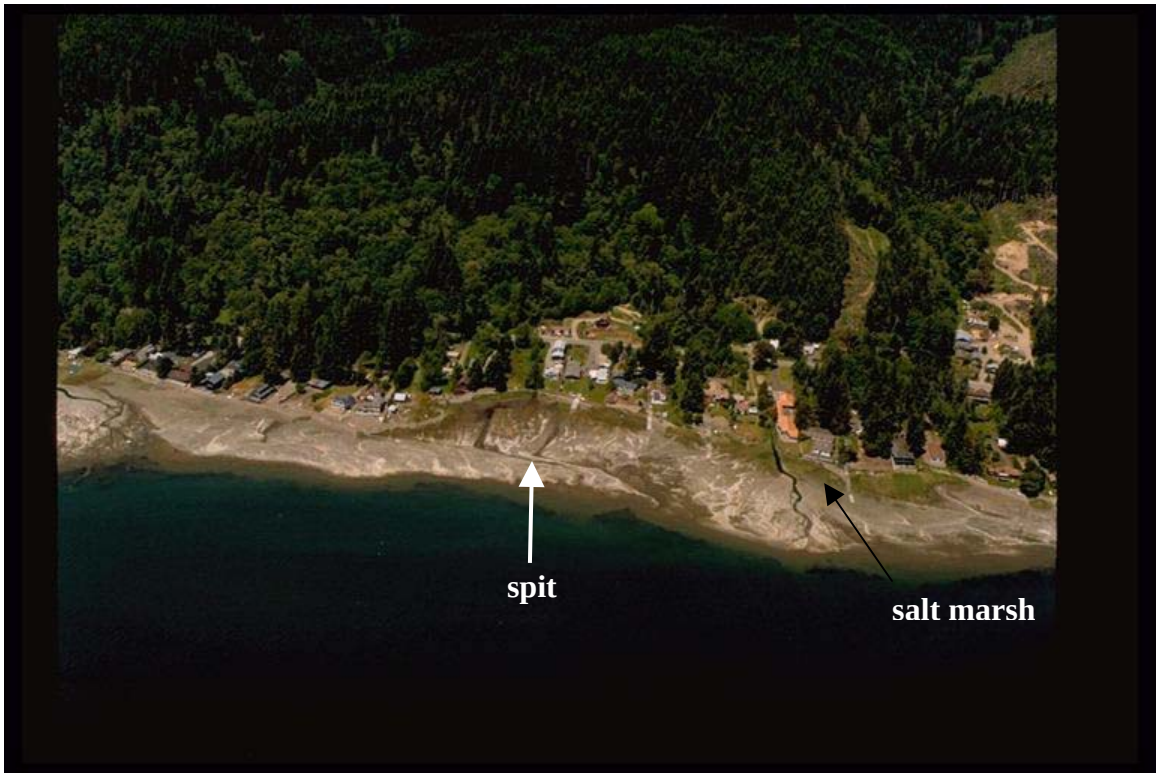

Figure 18. 1993 WDOE oblique photo showing the Sword Spit habitat complex. The spit is the low elevation bar running parallel with the shoreline near the center of the image. Patches of salt marsh occur behind the spit, often growing seaward of bulkheads.

Relative Condition

Though our estimates show the surface area of salt marsh has roughly doubled at this complex, the new salt marsh has come at the expense of tidal flat, and homes have probably filled over tide flat as well. In addition, tidal wetland habitat is fragmented, and drift cell processes affecting the spit have likely been highly disrupted. For these reasons, we consider the relative condition "Severely Impaired".

Habitat Complex: East Sword Marsh
Complex Type: Spit/marsh

Physical Description

This tiny salt marsh (0.07 hectares) was historically fronted by a narrow spit, and evidently no surface connection with Hood Canal occurred. Freshwater inputs to the marsh are unknown.

Description of Historical Habitat Changes

Based on the age of the houses that now occupy the site, this salt marsh was likely filled over quite early, probably by 1942. North Shore Road occurs directly behind the homes.

Relative Condition

This complex is considered “Lost”.

Habitat Complex: Stimson Creek/Peirce Spit
Complex Type: Stream-delta

Physical Description

Stimson Creek enters Hood Canal just west of Peirce Spit, and it may be that the creek has supplied sediments in the building of the spit over time. It is because of this possible direct linkage, and their close proximity to one another that we combined Stimson Creek and Peirce Spit as one habitat complex. No salt marsh was shown in the 1884 T sheet directly associated with the Stimson Creek delta, but Peirce Spit enclosed a substantial tidally-accessible lagoon and salt marsh (Figure 19). “Fairburn’s Logging Camp” is shown at the mouth of Stimson Creek, and log chutes occurred just west of the mouth and north of the spit. The creek width just upstream of the mouth was 10 links (6.6 ft.) in September 1861 (Terrill 1861).

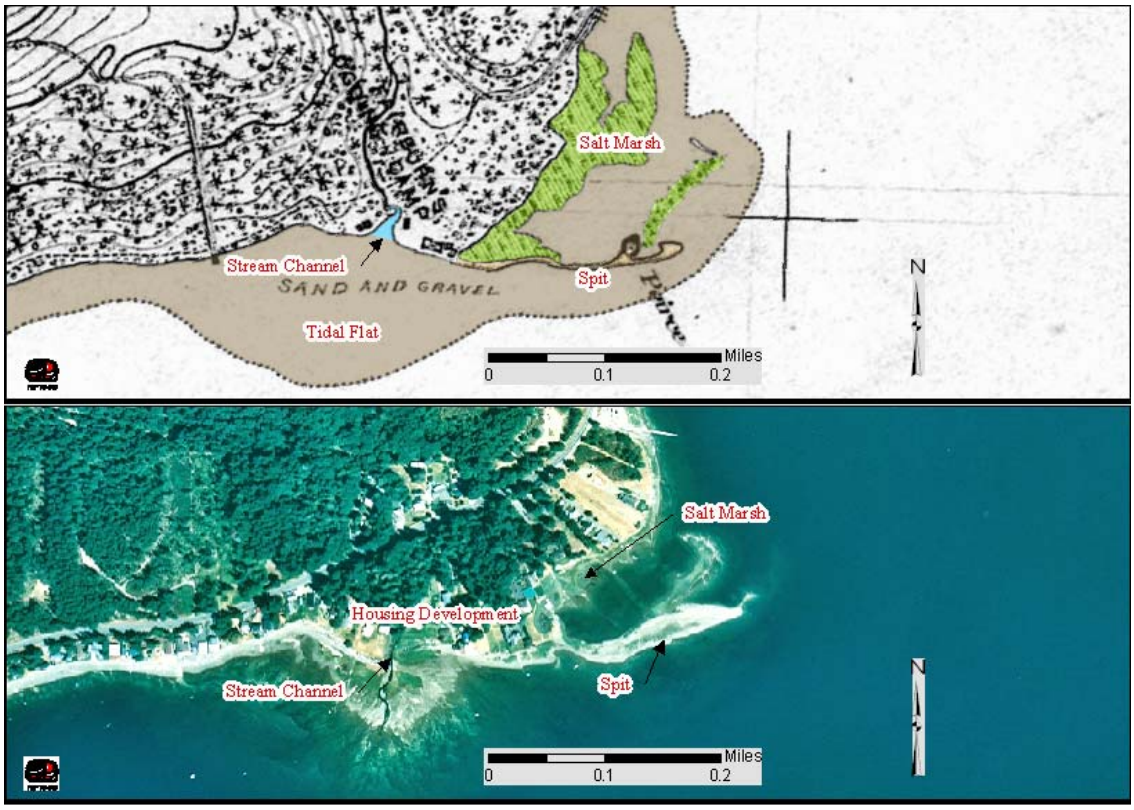

Figure 19. 1884 T sheet (top) and 2003 WDNR air photo (bottom) showing the Stimson Creek/Peirce Spit habitat complex. Notice the presence of a log chute just west of the mouth of Stimson Creek in 1884, and the logging camp centered around the creek mouth itself. The creek mouth and salt marsh associated with Big Spit have been filled over for a housing development and roads.

Description of Historical Habitat Changes

Table 6 provides a quantitative summary of historical habitat changes to this complex. A 1956 air photo of this site is of poor quality, but relatively little development appears near the delta of Stimson Creek, aside from perhaps old buildings from logging camp days (Figure 20). By the 1970s, a few houses are found near the mouth of the creek (which appears channelized) and part of the delta has been filled over. Salt marsh appears to be gradually developing at this site, with small patches in 1977 and bigger patches in both the 1993 (Figure 21) and 2001 images (based on WDOE oblique photos). The salt marsh and lagoon near the base of Peirce Spit, however, may have already been filled over by 1956, and the north part of the lagoon and marsh appears in the process of being filled for houses. There is a long pier near the mouth of the lagoon in the 1956 image. By 1977, the lagoon and marsh areas had been entirely filled. The length and shape of the spit itself appeared relatively unchanged upon comparison of the 1884 map with modern day imagery, though a possible eastward shift in the spit is evident (see Figure 19 above). The Stimson Creek/Peirce Spit complex occurs at the convergence of net shore drift, with the drift cell to the west having 70% of its length bulkheaded, and the drift cell to the east 59% of its length bulkheaded (Hirschi et al. 2003).

Table 6. Summary of habitat changes to the Stimson Creek/Peirce Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area (ha)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	1050 ft	1000 ft	- 50 ft	- 5
Spit (area)	0.28 ha	0.58 ha	+ 0.30 ha	+ 107
Salt marsh	2.93 ha	1.76 ha	- 1.17 ha	- 40
Tidal flat *	14.42 ha *	? ha **	? ha	?
Total (spit, marsh)	3.21 ha	2.34 ha	- 0.87 ha	- 27

* Tidal flat associated with the delta of Stimson Creek was 7.20 ha, and associated with the Peirce Spit (lagoon) was 7.22 ha.
** Current day surface area estimates of tidal flat habitat were not made because we felt that these estimates would not provide a valid comparison with the historical estimates of tidal flat that were derived from the T sheets, where the mean lower low water line (MLLW) was often interpolated from actual surveyed points.

Figure 20. 1956 air photo showing the Stimson Creek/Peirce Spit habitat complex. A road and pier extended out into the tidal lagoon at the east end of the complex at this time.

Figure 21. 1993 WDOE oblique photo of the Stimson Creek/Peirce Spit habitat complex. Stimson Creek is shown on the left side of the image.

Relative Condition

Because of the substantial loss of historical salt marsh and the filling around the mouth of Stimson Creek we consider the relative condition of this complex "Severely Impaired".

Habitat Complex: Sunbeach Spit
Complex Type: Spit/marsh

Physical Description

The 1884 T sheet shows a tiny spit partly enclosing an equally small lagoon. A dock and roads along the shore occurred at this time (see Figure 23 in the Sunbeach Marshes habitat complex narrative below). Freshwater inputs to the lagoon are not known.

Description of Historical Habitat Changes

Table 7 provides a quantitative summary of historical habitat changes to this complex. A 1956 air photo indicates that the spit and lagoon may have been filled by this time. More recent oblique photographs from 1977, 1993, and 2001 (Figure 22) also appear to confirm this. Currently (see Figure 22), most of the shoreline adjacent to this site is bulkheaded, and salt marsh is developing seaward of the bulkheads, a condition not uncommon in Hood Canal, particularly in low wave-energy environments such as the Hook. The likely explanation for this is that the bulkheads (or fill) result in a reduction in tidal energy that tends to trap and deposit sediments immediately seaward of the bulkheads. Over time, salt marsh vegetation can then establish in the newly accreted sediments. The tiny former spit occurs just west of the origin of an east-to-west drift cell near the boundary of a divergence zone that is 33% bulkheaded (Hirschi et al. 2003). However, the northward pointed direction of the historical spit may indicate at least some influence of sediment drift from the west. The two drift cells (coded in the WDOE database as MA-11-2 and MA-11-1) immediately west of the spit, from east-to-west, are currently 59% and 70% bulkheaded (Hirschi et al. 2003). Two long piers exist just east of the complex site.

Table 7. Summary of habitat changes to the Sunbeach Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length (ft)/Area (ha)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	100 ft	0 ft	- 100 ft	- 100
Spit (area)	0.03 ha	0 ha	- 0.03 ha	- 100
Salt marsh	0 ha	0.96 ha *	+ 0.96 ha	+ 100
Lagoon	0.02 ha	0 ha	- 0.02 ha	- 100
Total (spit, marsh, lagoon)	0.05 ha	0.96 ha	+ 0.91 ha	+ 1,820

* Apparently newly emerged fringing salt marsh, much of it growing immediately seaward of bulkheaded shoreline in the vicinity of the historical spit.

Figure 22. 2001 WDOE oblique photo showing the site of the tiny historical Sunbeach Spit complex. Note the salt marsh growing in front of bulkheads along this stretch of beach, and one of two piers that occurs just east of the former habitat complex.

Relative Condition

Though the tiny historical spit and lagoon is no longer present at this site, a considerable fringing salt marsh has grown in front of bulkheads at this site. Assuming some compensatory benefit from the new salt marsh, even though the historical habitat has been lost, we consider the relative condition of the Sunbeach Spit complex "Severely Impaired".

Habitat Complex: Sunbeach Marshes
Complex Type: Spit/marsh

Physical Description

This habitat complex actually consists of two marshes, one that protruded seaward of the shoreline, and another that was directly associated with a spit (Figure 23). A small creek is evident in both the 1884 T sheet and modern day photos draining into what was historically the site of the west marsh.

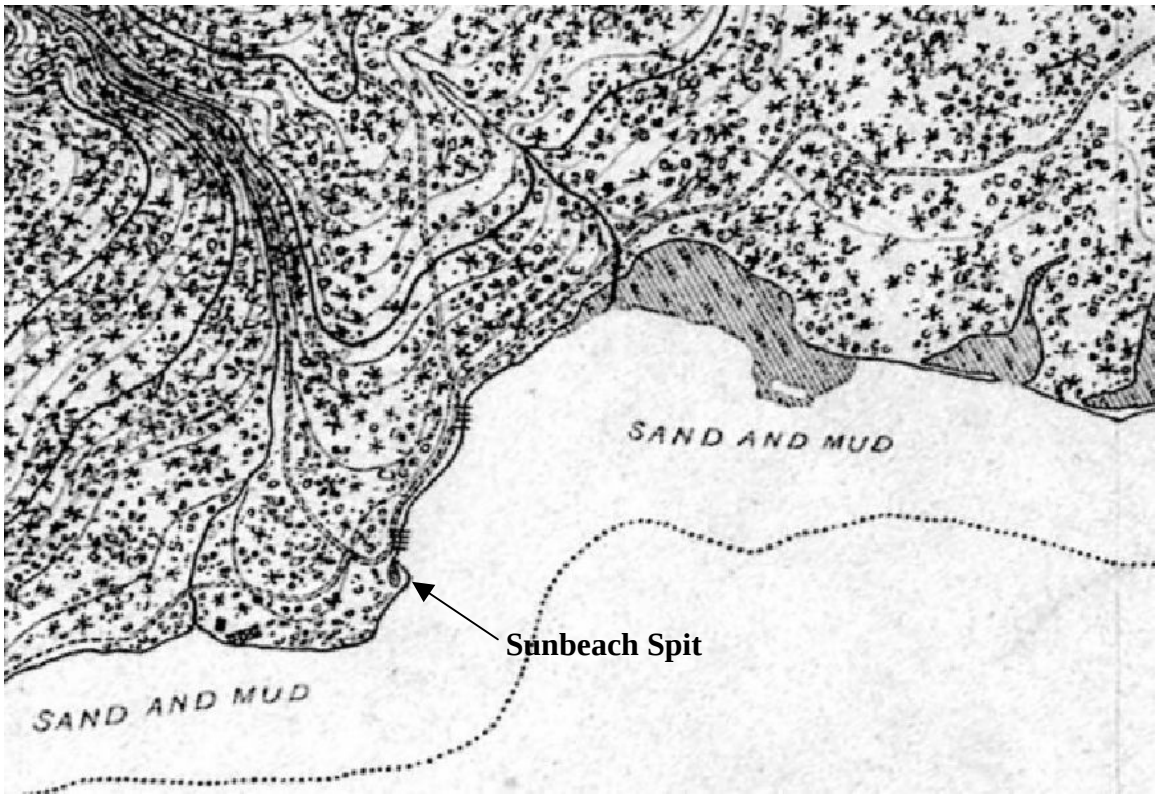

Figure 23. 1884 T sheet showing the Sunbeach Marshes habitat complex (at the center and right part of the image). The tiny Sunbeach Spit complex occurs just left of the center where the shoreline begins to run north and south. At the far right is a partial section of salt marsh associated with the adjacent Little Mission Creek complex. Notice the presence of roads, buildings and docks along the shoreline.

Description of Historical Habitat Changes

A 1957 air photo is poor in quality, but both of these marshes may have remained undeveloped at this time. By the 1970s, however, they had been filled over for houses (Figure 24, and Table 8 provides a quantitative summary of historical habitat changes). It appears that a substantial amount of fringing salt marsh occurs at the site today, possibly remnants of the historical marsh, or newly emerged salt marsh (see above explanation in the Sunbeach Spit habitat complex narrative and in the main report). These marshes occur in a sediment divergence zone that is 33% bulkheaded (Hirschi et al. 2003).

Table 8. Summary of habitat changes to the Sunbeach Marshes habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length (ft)/Area (ha)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	280 ft	0 ft	- 280 ft	- 100
Spit (area)	0.06 ha	0 ha	- 0.06 ha	- 100
Salt marsh	2.53 ha	0.90 ha	- 1.63 ha	- 64
Lagoon	0.06 ha	0 ha	- 0.06 ha	- 100
Total (spit, marsh, lagoon)	2.65 ha	0.90 ha	- 1.75 ha	- 66

Figure 24. 1993 WDOE oblique photo showing the shoreline of the historical Sunbeach Spit (see narrative above) and Sunbeach Marshes habitat complexes. Sunbeach Spit was located just left of the longer pier, left of the center of the image. The Sunbeach Marshes were located near the center of the image and extending to the extreme right of the image, an area that has been developed over. Salt marsh is growing along parts of this shoreline today, much of it appears to be newly emerged and growing in front of bulkheads.

Relative Condition

Although much of the historical marsh was eliminated by fill, a remnant or what appears to be new marsh is apparently developing seaward of the shoreline. For this reason, we consider the relative condition “Severely Impaired”.

Habitat Complex: Little Mission Creek
Complex Type: Stream-delta

Physical Description

The 1884 T sheet shows a contiguous salt marsh surrounding the stream mouth of Little Mission Creek (Figure 25). Some fencing is shown through the far east marsh, and other signs of settlement are evident, such as a road, and buildings north of the marsh, and a bridge crossed the creek in roughly the vicinity of the North Shore Road today. In August 1861, the GLO surveyor measured the width of Little Mission Creek at 10 links (6.6 ft.) about 2500 feet upstream of the mouth (Terrill 1861). Little else from this early GLO survey is useful to our assessment.

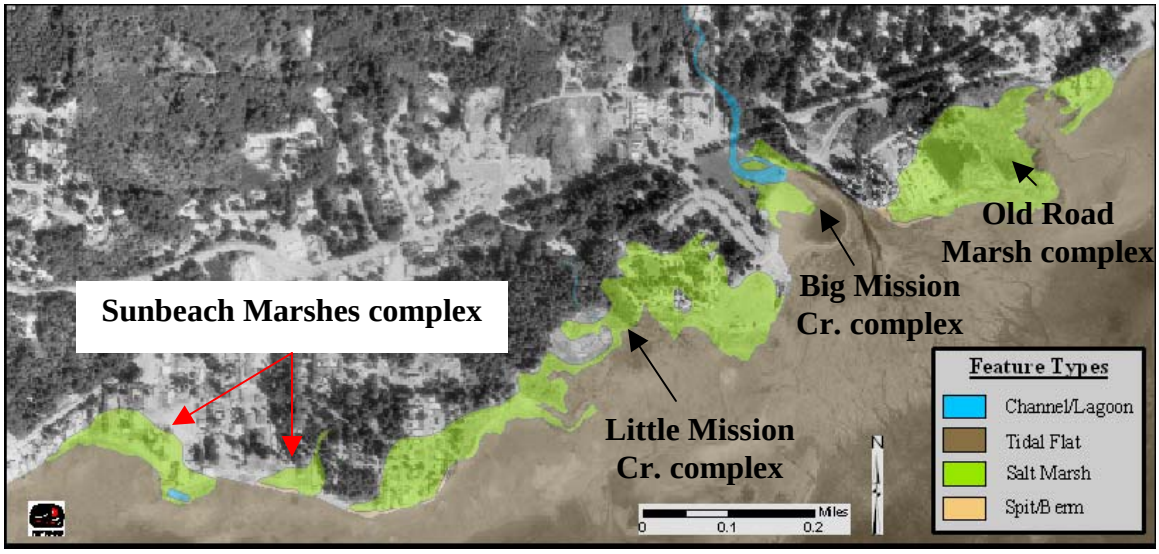

Figure 25. 1884 T sheet showing the Little and Big Mission Creek complexes. The salt marshes shown at the far left and far right of the image are the Sunbeach Marshes and Old Road Marsh habitat complexes, respectively (see Figures 23 and 28-30 for reference).

Description of Historical Habitat Changes

Table 9 provides a quantitative summary of historical habitat changes to the Little Mission Creek complex. The west part of the Little Mission marsh has been filled and developed for residential use, the middle part has remained relatively unchanged, and the east part has been mostly filled (Figure 28). Looking at air photos of the west part of the marsh from 1939, 1957, and 1977 indicates that this area was filled for houses sometime between 1957 and 1977 (Figures 26 and 27).

The middle marsh has remained relatively unaltered. An additional patch of salt marsh that was not present in the 1884 T sheet now occurs in association with the creek mouth, and is probably the result of diversion of lower Little Mission Creek. Log storage and log rafting is evident from air photos in 1946 (courtesy Deb Peterson, WSP) and 1957 in

the area near the large east marsh. It appears that some diking may have been in place at this time. By 1977, the Belfair State Park had nearly completely filled this east marsh for campsites. Lower Little Mission Creek has been repeatedly channelized, and with development of the massive campsite area before 1977, it appears it was diverted to its current western mouth location.

Table 9. Summary of habitat changes to the Little Mission Creek habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length (ft)/Area (ha)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	770 ft	630 ft	- 140 ft	- 18
Spit (area)	0.13 ha	0.22 ha	+ 0.09 ha	+ 69
Salt marsh	8.35 ha	3.21 ha	- 5.14 ha	- 62
Total (spit, marsh)	8.48 ha	3.43 ha	- 5.05 ha	- 60

Figure 26. 1957 air photo of the Little and Big Mission Creek habitat complexes.

Relative Condition

Based on the near complete loss of tidal marsh habitat in the west and east parts of the Little Mission Creek estuary, and severe impairment of lower stream channel and marsh habitat, particularly in the east part associated with the State Park, we consider the relative condition of this complex to be “Severely Impaired”.

Figure 27. 1977 WDOE oblique photo showing the Little and Big Mission Creek habitat complexes.

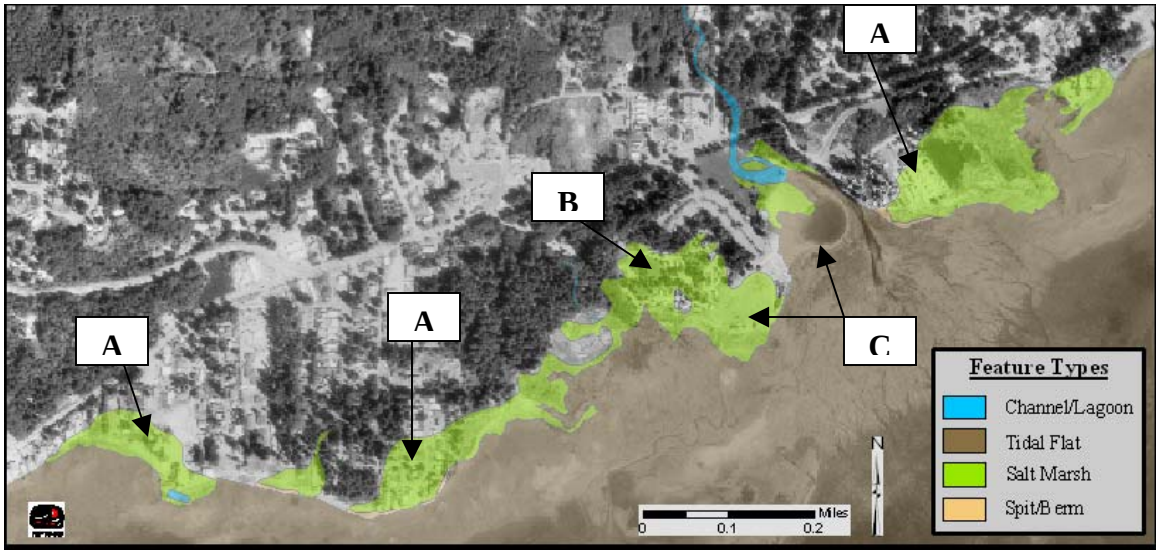

Figure 28. 2000 WDNR ortho-photo of the Mission Creeks estuary complex overlaid with habitat features (color-coded) from the 1884 T sheet. Letter A indicate the locations of housing developments, B is an area of developed campsites at Belfair State Park, and C are diked and filled portions of former marsh and tidal flat. The large patch of salt marsh at the far right of the image is the Old Road Marsh habitat complex (see narrative below).

Habitat Complex: Big Mission Creek
Complex Type: Stream-delta

Physical Description

A relatively small amount of salt marsh (0.97 hectares) occurred at the mouth of Big Mission Creek in 1884 (see Figures 25 and 28 above in the Little Mission Creek habitat complex narrative). A settlement was evident along the right bank at the mouth of Big Mission Creek, and a bridge crossed the creek in roughly the same place that North Shore Road crosses today. The September 1861 GLO survey included a measurement of 30 links (20 ft.) for the width of Big Mission Creek at its mouth (Terrill 1861).

Description of Historical Habitat Changes

The stream mouths (shown in the 1861, 1884, 1939, 1942, and 1946 images), appear to be in similar locations; additionally, at least in the 1884 T sheet and the 1939, 1942 and 1946 (air photos), lower channel configurations appear fairly similar, with a bow shape swinging to the westerly location. By 1946, however, it appears that the lower channel may have been channelized somewhat and a log rafting operation near the mouth may have dredged a former salt marsh for log storage.

The biggest changes occur between the 1946 (image provided by Deb Peterson, Wash. State Parks) and 1957 air photos, a time period when the State Parks apparently took over management of this site. The main parking lot for Belfair State Park appears in the 1957 air photo (see Figure 26 above in the Little Mission Creek habitat complex narrative)

immediately west of the historical channel, and the historically active channel has been reduced to a side channel; it appears that the mainstem has been diverted into its easterly (and present day) location, where a large tidal channel and salt marsh existed in the 1946 image. By 1957, the log rafts evident in 1946 are also missing. Jumping ahead 20 years to 1977 (see Figure 27 above in the Little Mission Creek habitat complex narrative), the State Parks had filled the entire former salt marsh and they have since contained Big Mission Creek against the far east side of the historical marsh, armoring the stream banks. They have also built sea dikes along the front of the delta and constructed a swimming lagoon. Some salt marsh has developed immediately seaward of this dike (0.65 hectares). The historical configuration and function of the Big Mission Creek estuary has been modified extensively, with major losses occurring in the 1940s and 1950s.

Relative Condition

Primarily owing to severe alterations in the lower creek channel, and disconnection of the channel with a historical tidal marsh, we consider the relative condition "Severely Impaired".

Habitat Complex: Old Road Marsh
Complex Type: Spit/marsh

Physical Description

Located just east of Big Mission Creek, Old Road Marsh was a substantial fringing salt marsh with a short spit fronting the western part of the marsh, and open to tidal access. A road paralleled the marsh in 1884 (see Figure 25 in the Little Mission Creek habitat complex narrative above). No freshwater inputs are known to directly enter the marsh.

Description of Historical Habitat Changes

Air photos from 1939 and 1946 show little to no alterations to this habitat complex. By 1957 (Figure 29), however, the upper marsh near the base of the spit and a small patch along the north margin near the road were evidently filled or altered in some way. By 1977, the far west part of the marsh was developed for houses and trailers, and a dike appears north-south across the salt marsh (1977 WDOE oblique). It appears that attempts to build perhaps a second dike even further east may have been abandoned. Also, the far northeast part of the salt marsh appeared to be filled by 1977. Examination of oblique air photos from 1977, the 1993, and 2001 shows that the area was diked off by 1977 has since breached along the former spit; subsequently more water filled this diked salt marsh (as shown in the 1993 oblique photo; Figure 30) than in 1977, and it appears the area is even more inundated in the 2001 oblique and 2003 images (WDNR air photo). The extent of salt marsh has been reduced from 1884 (Table 10), and connectivity of this salt marsh has been substantially impaired since the historical period. Water quality impacts to this marsh from the adjacent houses and trailers are unknown.

Table 10. Summary of habitat changes to the Old Road Marsh habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area		Change	
	Historical	Today	Area	Percent
Spit (area)	0.12 ha	0 ha	- 0.12 ha	- 100
Salt marsh	5.62 ha	3.30 ha	- 2.32 ha	- 41
Lagoon	0 ha	0.54 ha	+ 0.54 ha	+ 100
Total (spit, marsh, lagoon)	5.74 ha	3.84	- 1.90 ha	- 33

Figure 29. 1957 air photo of the Old Road Marsh complex. Note the filling near the west part of the marsh and spit located just east of Big Mission Creek in the left part of the image.

Figure 30. 1993 WDOE oblique photo showing the Old Road Marsh just east of Big Mission Creek, shown in the left part of the image. Notice the dike across the Old Road Marsh and development at the west end of the marsh.

Relative Condition

Based on the loss of tidal marsh habitat, and impaired habitat connectivity, we consider the relative condition of this complex "Severely Impaired".

Habitat Complex: Lynch Cove/Union River
Complex Type: Stream-delta

Physical Description

One of the largest in the study area, the Lynch Cove habitat complex at the terminus of Hood Canal includes the Union River delta and associated tidal marsh, a small tidal inlet associated with Devereaux Creek, and a tiny isolated backshore salt marsh (referred to as "Bulkhead Marsh") along the south shore of Hood Canal that was present at the time of the 1884 T sheet.

At the time of the 1884 T sheet, a number of settlers occupied the north shore of Lynch Cove, and had evidently cleared some forest adjacent to the tidal marsh (Figure 31). The McCreavy logging camp was located along the right bank near the upper extent of tidal influence, and a logging railroad ran up the Union River valley starting from a dock on the river bank. The T sheet shows possible, though unsubstantiated, evidence of early diking of tidal marsh in the north part of the estuary that might result (in our use of the T

sheet to represent historical conditions) in underestimating the amount of historical tidal marsh (Figures 32 and 33). The 1872 GLO survey also refers to “hay marsh” in the southern part of the tidal marsh (Jameson 1872), suggesting its use at the time for grazing livestock, as was common at the time in many Puget Sound tidal marshes (Nesbit 1885; Collins and Sheikh 2005).

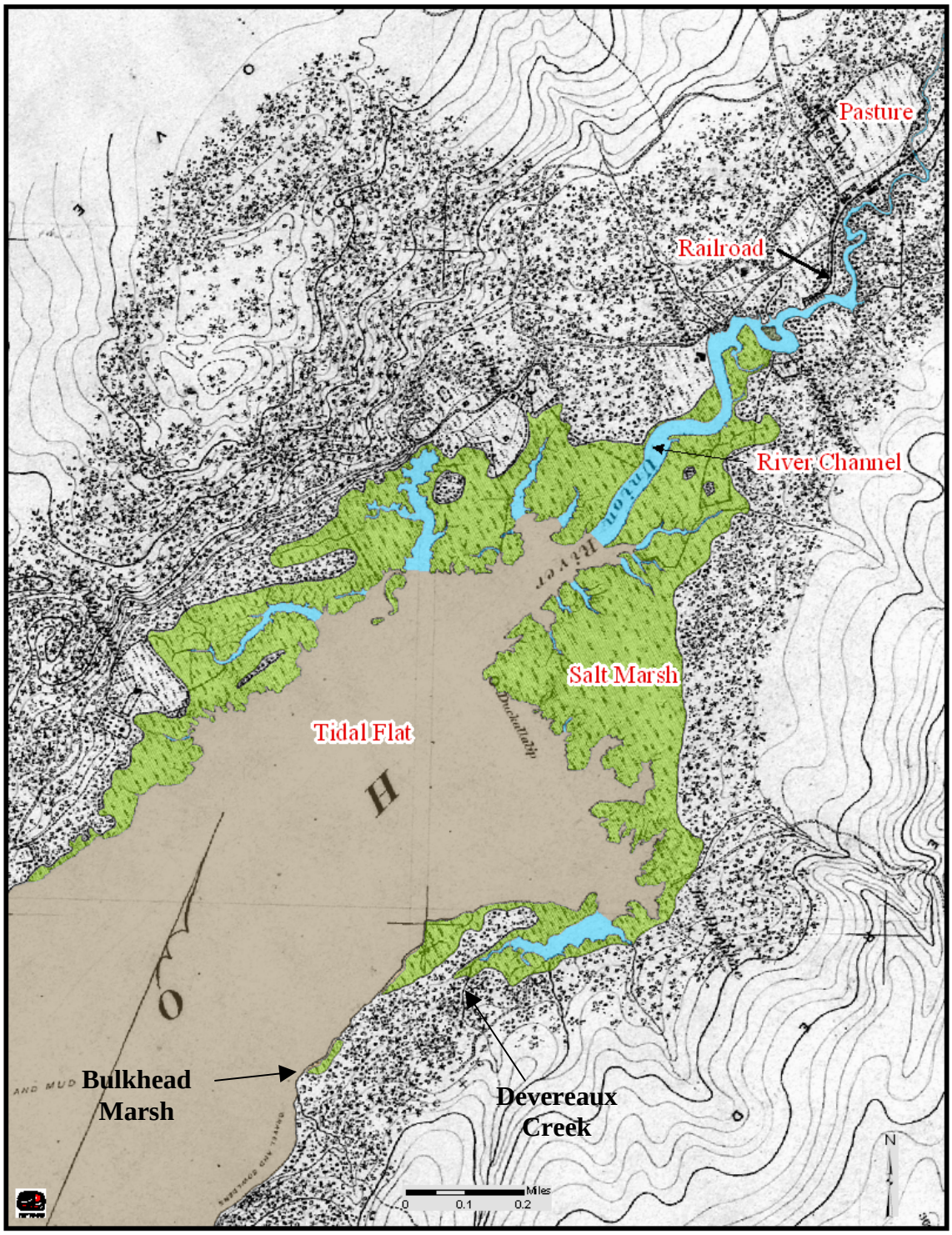

Figure 31. 1884 T sheet showing the Lynch Cove/Union River estuary complex, including the Devereaux and Bulkhead marsh portions of the complex.

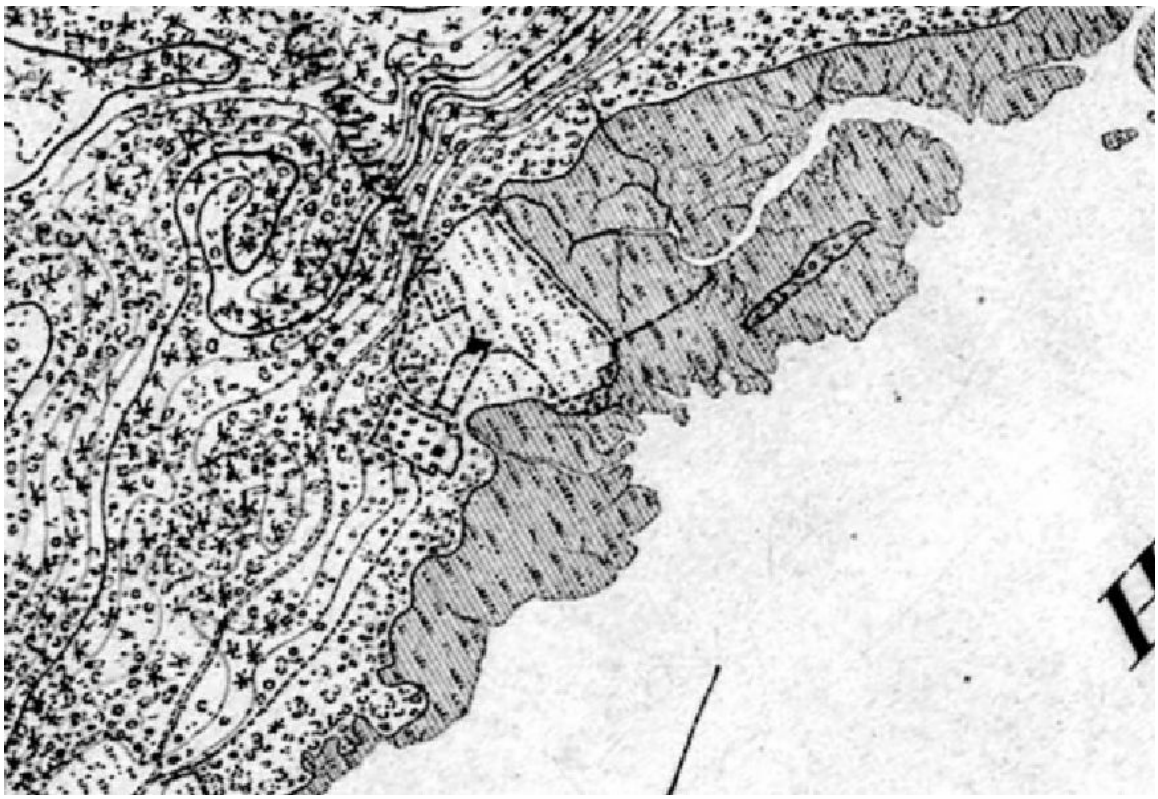

Figure 32. 1884 T sheet of the west end of the Lynch Cove/Union River complex on the north shore, showing a possibly diked portion of tidal marsh near the center of the image.

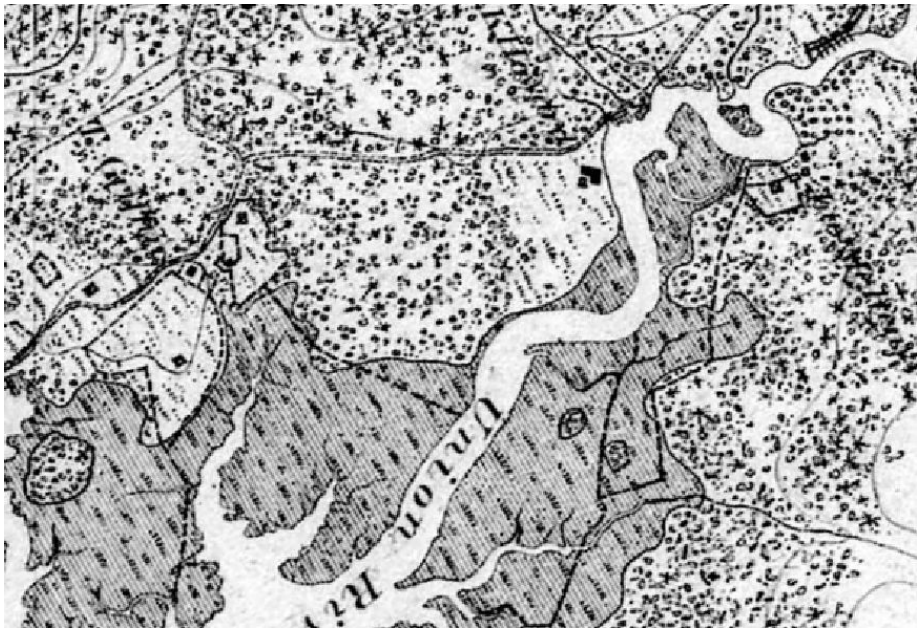

Figure 33. 1884 T sheet showing possible signs of diked tidal marsh at the time where fencing occurs across portions of the marsh. The dock in the upper right corner of this image is the terminus of a logging railroad that ran up the Union River valley.

Description of Historical Habitat Changes

Few parts of the Lynch Cove/Union River estuary have remained unaltered by human activities. However, large sections of tidal marsh in the complex that have been altered by past diking and drainage of wetlands, appear somewhat resilient in that breaching of the old dikes has occurred and areas that may have been excluded or reduced from tidal inundation are reverting back to salt marsh. Still, drainage patterns have been impaired. There are also major sections that have been heavily modified and where tidal exchange has been largely eliminated. We emphasize the changes of these sections here.

Two large chunks of historical tidal marsh have been completely modified along the north shore of Lynch Cove. A comparison of 1939 and 1957 air photos of this area shows that the far west section near the head of a substantial blind tidal channel that had possibly been diked to some degree in 1939 (Figure 34) was diked more completely certainly by 1957 (Figure 35). Today, in total about 4.5 hectares of tidal marsh has been diked off at this location and the area behind the dike is converting mostly to a scrub/shrub plant community (Figure 36).

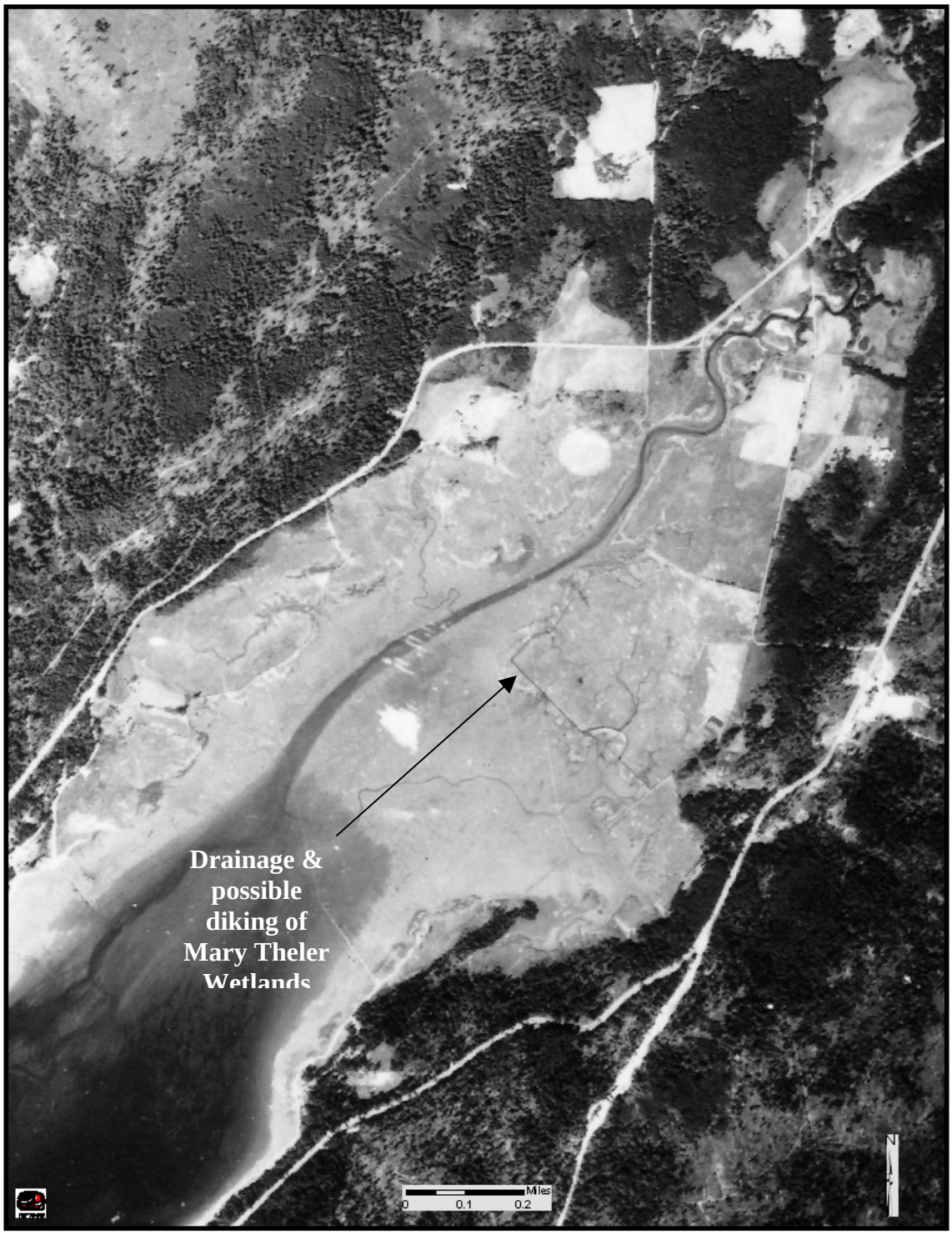

Figure 34. 1939 air photo (USGS) of the Lynch Cove/Union River estuary complex.

Figure 35. 1957 air photo of the western part of the Lynch Cove/Union River estuary complex. Note the extensive diking of sections of tidal marsh, and log rafting (lower right corner) near the mouth of Devereaux Creek.

Figure 36. 2001 WDOE oblique photo showing an area (~ 4.5 ha) of tidal marsh in the northwest part of Lynch Cove that may have received early attempts at diking. By the time of the 1957 air photo, it had been convincingly diked.

Possibly very early attempts to dike the east section of marsh along the north shore are suggested in the 1884 T sheet (see Figure 33 above), and scars from possible old dikes in this same area are evident from the 1957 air photo (see Figure 35 above). Still, this area remained minimally altered until sometime between 1957 and 1977 when much of the old marsh was filled for a road that now leads to a swimming pool (see WDOE 1977, 1993, and 2001 oblique photos)(Figure 37). Where it has not been filled over, much of the tidal marsh in this area appears to be diked, and though some of the former marsh may still be accessible to the tides, tidal exchange appears to be reduced or impaired by old borrow ditches or remnant pieces of diking material.

Figure 37. 2001 WDOE oblique photo showing an area (~ 3.2 ha) of historical tidal marsh along the north shore of Lynch Cove that has been filled over by a road that leads to a swimming pool (left side of image).

The largest contiguous area (about 7.8 hectares) of historical tidal marsh that is currently diked occurs adjacent to the Mary Theler Wetlands in the south part of the estuary (Figures 38 and 43). This area has been diked at least as early as 1939 (see Figure 34 above). Streams are ditched through an open field and a substantial amount of water becomes impounded behind the dikes. Water is released from behind the dikes through tide gates. Another smaller dike was built more recently (perhaps in the 1960s) apparently to support duck hunting. The water and vegetation behind this dike is believed to be primarily freshwater and probably not tidally-accessible.

Figure 38. 2001 WDOE oblique photo showing the large diked area of tidal marsh (~ 7.8 ha) in the left part of the image. Notice evidence of old diking and modifications of drainage patterns in the tidal marsh at the center and right side of the image. The upper part of this tidal marsh near the center of the image was shown as a lowland forest in the 1884 T sheet.

The salt marsh associated with Devereaux Creek that enters a small cove along the south shore of Lynch Cove has been modified though it retains many of the same characteristics it had in 1884 (Figure 39). The 1957 air photo shows a road/dike cutting across the marsh leading to the shore where several log rafts occur in the tide flat (Figure 40). This dike is still evident today (Figure 41). This part of the Union River/Lynch Cove habitat complex has been recommended as a candidate estuarine "sanctuary" by the Washington State Department of Natural Resources Natural Heritage Program. A vegetation description of this site is provided by Kunze (1984).

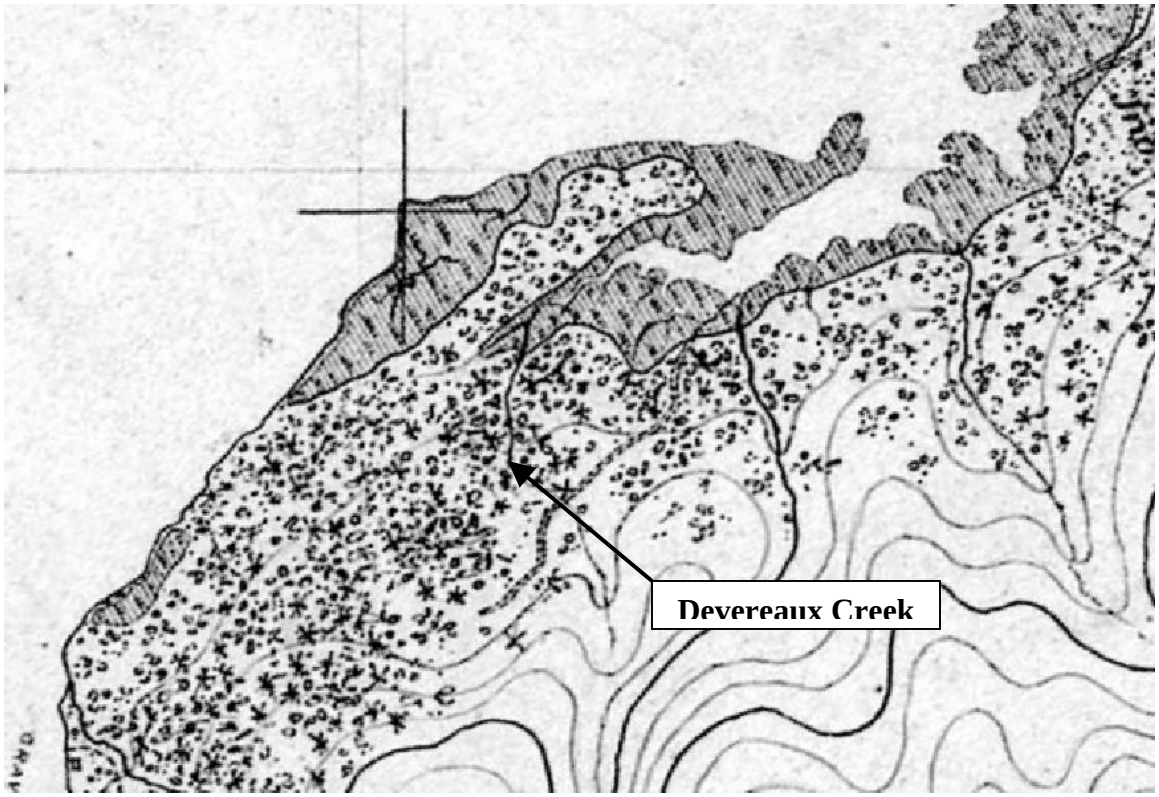

Figure 39. 1884 T sheet showing the southwest portion of the Lynch Cove/Union River estuary complex, including the tiny Bulkhead Marsh near the lower left corner of the image. The larger salt marsh shown is that associated with Devereaux Creek. The tiny Bulkhead Marsh has been filled over and bulkheads occur along the shoreline, though "new" salt marsh is now developing in front of the bulkheading (see Figure 42 below).

Figure 40. 1957 air photo showing the Devereaux Creek portion of the Lynch Cove/Union River estuary complex. Notice the road/dike crossing the tidal marsh to access a log dump and log rafting.

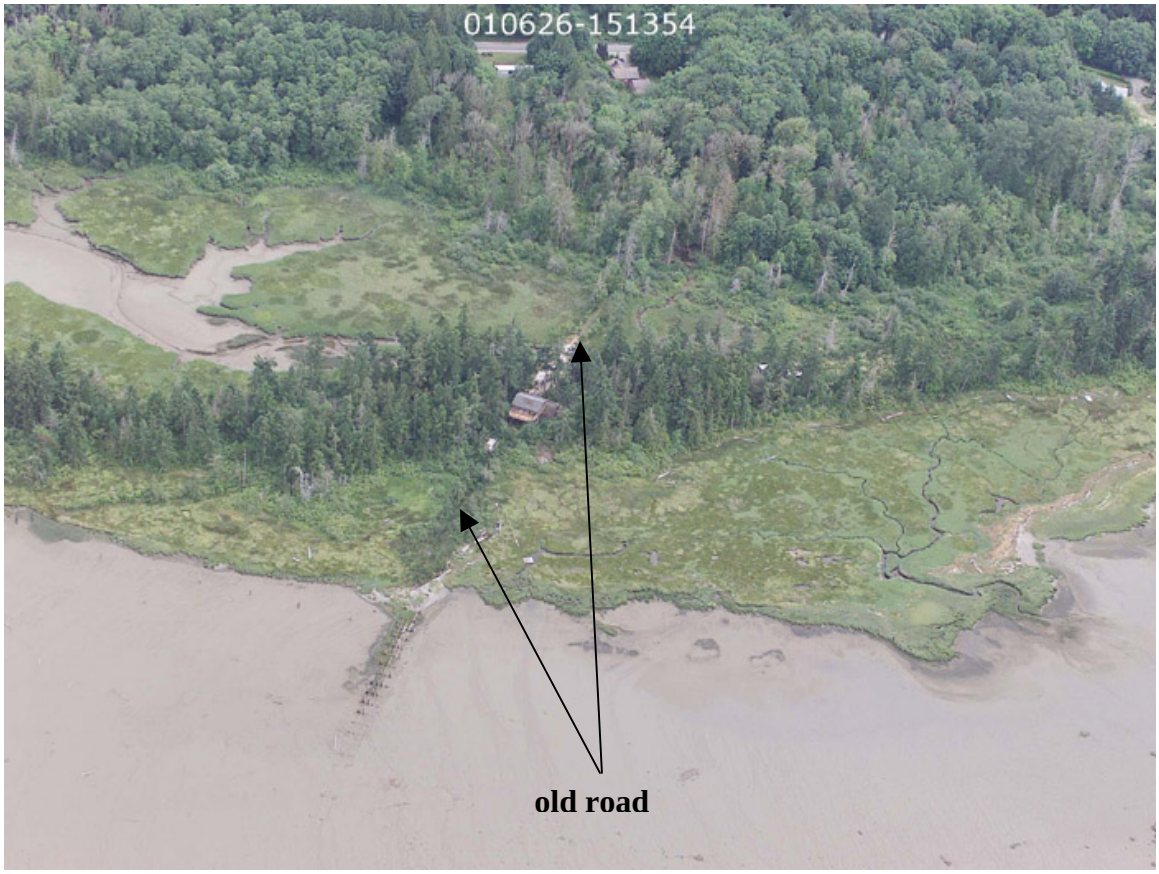

Figure 41. 2001 WDOE oblique photo showing the south portion of the Lynch Cove/Union River estuary (Devereaux Creek area). Notice the old road through the marsh present in the 1957 air photo (see Figure 40 above).

Figure 42. 2001 WDOE oblique photo showing salt marsh growing seaward of bulkheads in the vicinity of the historical "Bulkhead Marsh", that was filled for the building of houses.

Interestingly, there are a few significant locations within the Lynch Cove estuary that were characterized as upland woods in the 1884 T sheet and now appear to be salt marsh, or at least transitional between tidal scrub-shrub and salt marsh. Nearly 11 hectares are affected by this change. The most notable is about 5 hectares along the south shore associated with the current Mary Theler Wetlands Center and the public paths (Figure 43). It is not clear how much of this apparent change in habitat cover type we can attribute to inaccuracies in the mapping of the upper boundary of salt marsh on the part of the T sheet surveyors, as we know that this upper boundary was typically more prone to mapping error than the lower boundary of salt marsh (Shalowitz 1964 and Collins and Sheikh 2005). Another possibility is a broad-scale subsidence that has been reported in the Hamma Hamma and Duckabush river deltas located in the southern or middle Hood Canal region (Barnard 2004 and ESA 2003). This subsidence is thought to be the result of primarily tectonic shifting that is effectively lowering the landmass relative to sea level, which, if the rate of landmass lowering is sufficient, would tend to convert over many decades or centuries already low-lying, and possibly wooded wetland areas, into salt marsh. This type of conversion might be accelerated given common Euro-American land use practices adjacent to Puget Sound river deltas, which suggests a third and potentially-related explanation for the "new" upper elevation tidal marsh we see in our analysis. Though unsubstantiated at this location, land use practices such as the removal

of forest stands that border tidal marsh as appears to be the case in much of Lynch Cove, might increase tidal inundation to previously forested areas, and given enough time, result in the conversion of predominantly woody vegetation to mainly salt tolerant herbaceous plant growth (based on conversation with R. Brocksmith, HCCC, who related this information from L. Boad). It is possible that some combination of each of these three explanations has produced the outcome in our analysis, and we recommend a more rigorous investigation into the subject as it pertains specifically to Lynch Cove and the greater study area. The implications for restoration of lost or impaired tidal marshes may be significant in some instances.

Our estimates indicate that the overall extent of tidal marsh in the Lynch Cove estuary has changed very little, though much of the marsh has been impaired, mainly by a history of diking and attempts to drain sections of tidal marsh (Table 11 provides a quantitative summary of historical habitat changes). Also, our 1884 T sheet delineation of salt marsh may actually under-estimate the historical amount of tidal marsh in this estuary because of possible inaccuracies in the depiction of the upper boundary of salt marsh, and some suggestion of early diking of tidal marsh at the time of the T sheet.

Table 11. Summary of habitat changes to the Lynch Cove/Union River habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area		Change	
	Historical	Today	Area	Percent
Spit (area)	0.20 ha	0 ha	- 0.20 ha	- 100
Tidal marsh (and channels)	91.33 ha	92.28 ha	+ 0.95 ha	+ 1
Lagoon	0 ha	0.55 ha	+ 0.55 ha	+ 100
Tidal flat	295.95 ha	? ha *	? ha	?
Total (spit, marsh, lagoon)	91.53 ha	92.83 ha	+ 1.30 ha	+ 1

* Current day surface area estimates of tidal flat habitat were not made because we felt that these estimates would not provide a valid comparison with the historical estimates of tidal flat that were derived from the T sheets, where the mean lower low water line (MLLW) was often interpolated from actual surveyed points.

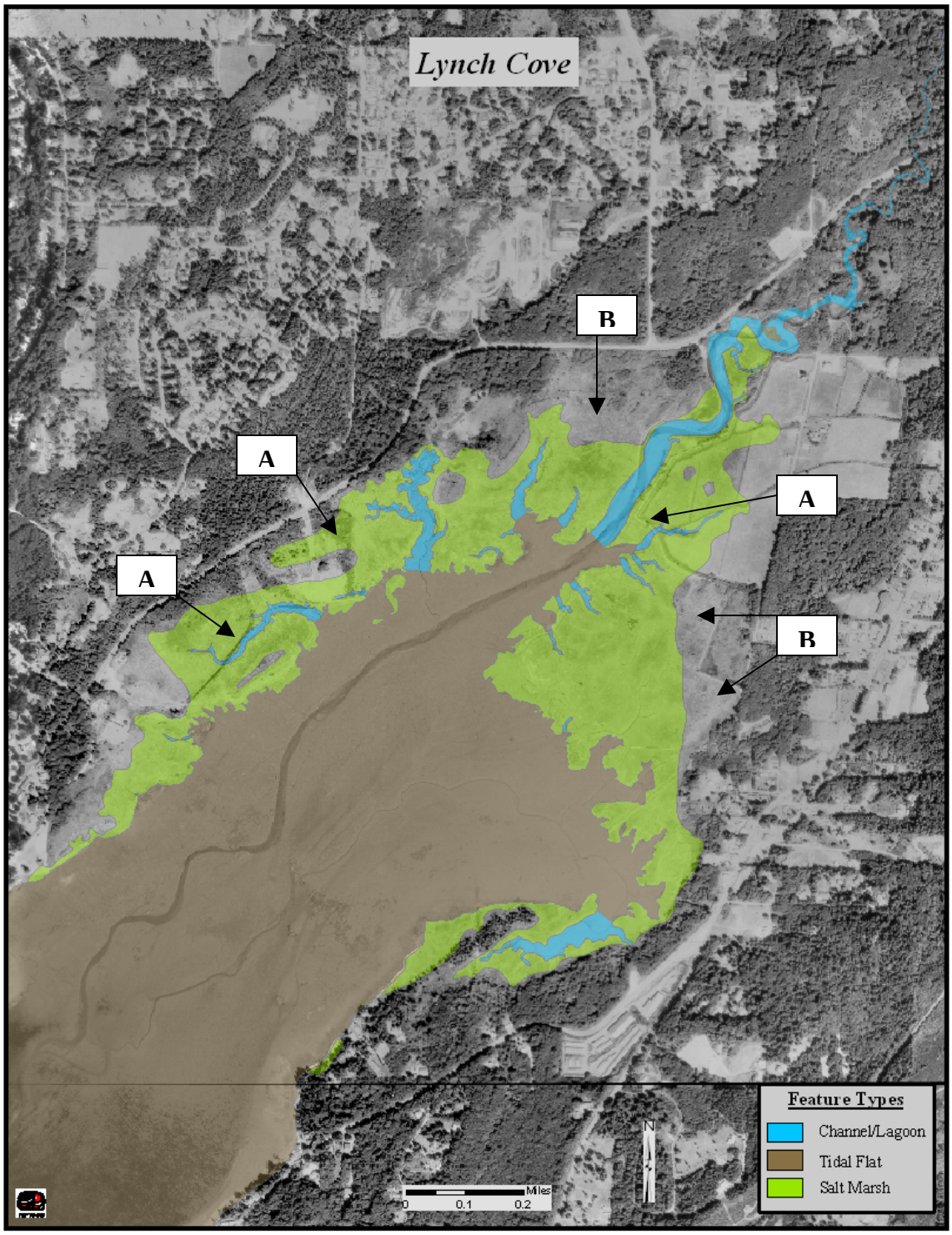

Figure 43. 2000 WDNR ortho-photo of the Lynch Cove/Union River estuary, overlaid with color-coded habitat features from the 1884 T sheet indicating major salt marsh areas that have been diked or filled, denoted with the letter A. Areas denoted by the letter B are currently salt marsh that were indicated as forest in the 1884 T sheet.

Relative Condition

Although overall changes in the extent of tidal marsh are minimal according to our assessment, the habitat connectivity is impaired in substantial parts of the estuary, primarily from diking of tidal marsh. For this reason, we consider the relative condition of the estuary "Moderately Impaired".

Habitat Complex: Low Spit
Complex Type: Spit/marsh

Physical Description

Low Spit historically included a small tidally-accessible lagoon and submerged marsh out in front of the spit (Figure 44). No freshwater inputs are known to exist at this site.

Figure 44. 1884 T sheet showing the tiny Low Spit habitat complex, and to the south, the Rose Spit complex (the small narrow protrusion from the coastline).

Description of Historical Habitat Changes

Table 12 provides a quantitative summary of historical habitat changes to the Low Spit complex. Air photos from 1939, 1957, and oblique photos from 1977, 1993 and 2001 (Figure 45) indicate that some modifications have taken place to this habitat complex, most noticeable beginning sometime between the 1957 and 1977 air photos. A couple of small paths, dikes, or docks have been built across the lagoon, apparently by the adjacent

land owners, and this has impaired connectivity of the lagoon and salt marsh. The spit has evidently breached in recent decades, possibly in response to the dike and dock, or deliberately breached for boat access (see 1977 WDOE oblique). Like most spits in the Hook sub-region, it appears to be low in elevation, and if it supports vegetation, it is often salt marsh (e.g., *Salicornia virginica*) rather than upland species. A few houses have been built to the immediate east of the spit and are built below high water and heavily bulkheaded. Low Spit occurs in a west-to-east drift cell that is 68% bulkheaded (Hirschi et al. 2003).

Table 12. Summary of habitat changes to the Low Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Area		Change	
	Historical	Today	Area	Percent
Spit (area)	0.05 ha	0 ha	- 0.05 ha	- 100
Salt marsh	0.92 ha	0.63 ha	- 0.29 ha	- 32
Lagoon	0 ha	0.11 ha	+ 0.11 ha	+ 100
Total (spit, marsh, lagoon)	0.97 ha	0.74	- 0.23 ha	- 24

Figure 45. 2001 WDOE oblique photo of the Low Spit habitat complex.

Relative Condition

Based on some loss of historical salt marsh and impairment to overall habitat connectivity, we consider the relative condition “Moderately Impaired”.

Habitat Complex: Rose Spit
Complex Type: Spit/marsh

Physical Description

The name of this complex is taken from “Rose Point” shown on a 1942 Army air photo of the area. This tiny spit (historically 190 ft. long and just 0.06 hectares in surface area) and tidally accessible lagoon has been modified since historical times (see Figure 44 in the Low Spit habitat complex narrative above). In September 1861, the GLO survey recorded a stream entering this lagoon at 2 links (1.3 ft.) wide (Terrill 1861). We do not see a stream entering the lagoon today, though it is possible one still exists.

Description of Historical Habitat Changes

Differences in habitat structure are evident at this site when comparing the 1957 and 1977 air photos. A house appears immediately adjacent to this habitat complex by the time of the 1977 photo. The outer edge of the spit has been filled and bulkheaded since the 1970s, if not earlier (Figure 46). Also, it appears the lagoon is dredged, perhaps to allow boat access.

Figure 46. 2001 WDOE oblique photo showing the tiny Rose Spit complex, now bulkheaded and filled with a small pond or lagoon.

Relative Condition

Based on the considerable modifications to this spit and dredging evident behind the spit, the relative condition is "Severely Impaired".

Habitat Complex: Springbrook Creek
Complex Type: Stream-delta

Physical Description

Springbrook Creek enters a small cove in Hood Canal out of a confined ravine (Figure 47). In September 1861, the GLO survey measured its width at 10 links (6.6 ft.) at the mouth (Terrill 1861).

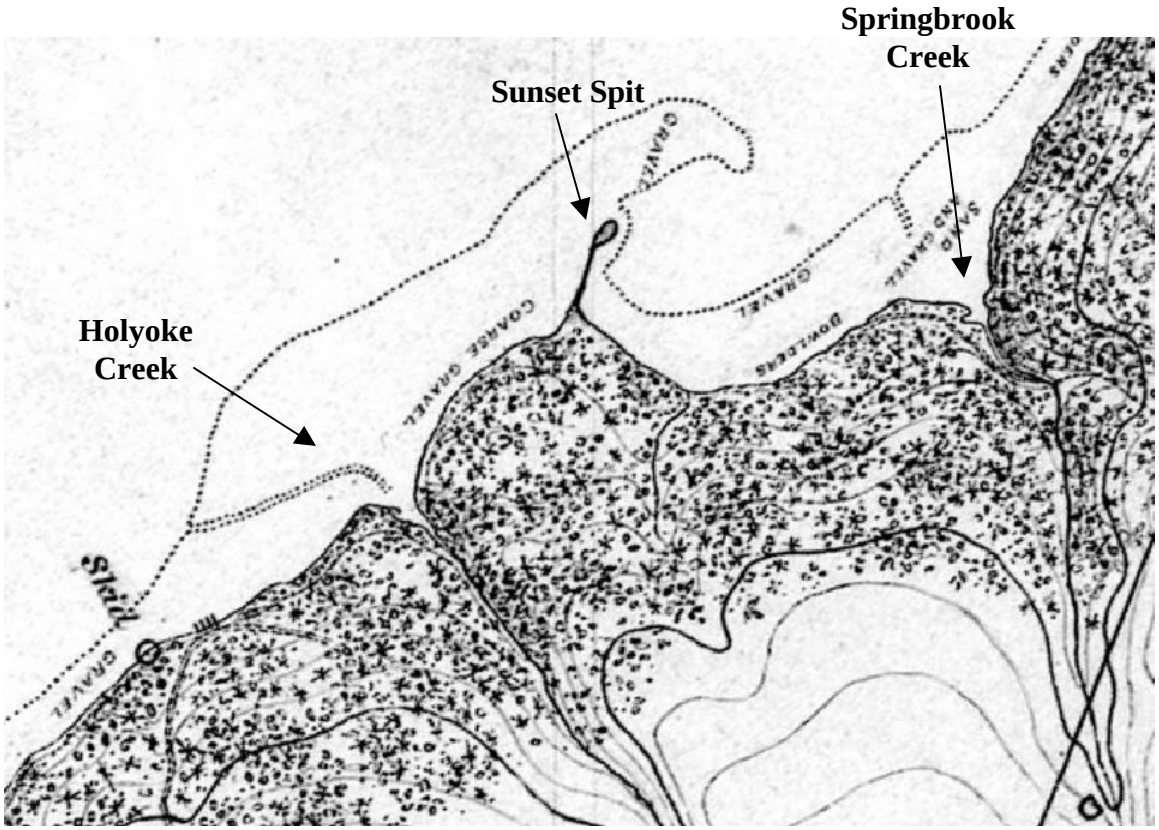

Figure 47. 1884 T sheet showing three habitat complexes, from east to west (right to left), Springbrook Creek, Sunset Spit, and Holyoke Creek.

Description of Historical Habitat Changes

Probably the biggest direct impact to this small stream delta is the presence of Highway 106 across the mouth of the creek (Figure 48). Bulkheading occurs along the shoreline to the east and west of the creek mouth, and has probably resulted in some filling near the mouth.

Figure 48. 2001 WDOE oblique photo showing the mouth of Springbrook Creek, partially filled over by Highway 106.

Relative Condition

Because the tidal inlet of the creek has been partially filled by Highway 106, we consider the relative condition of this complex "Moderately Impaired".

Habitat Complex: Sunset Spit
Complex Type: Spit/marsh

Physical Description

Sunset Spit is shown as a very narrow, apparently unvegetated spit projecting roughly 10-20 degrees northeast from the shoreline in the 1884 T sheet (see Figure 47 in the Springbrook Creek habitat complex narrative above).

Description of Historical Habitat Changes

Table 13 provides a quantitative summary of historical habitat changes to this complex. Air photos from 1942, 1957, 1977, 1993 (Figure 49), and 2001 indicate few direct changes from that found in the T sheet, although a couple of homes have been built, probably between 1957 and 1977, at the base of the spit. Typical of the Hook sub-region,

this spit is low in elevation and parts of it may become submerged during higher tides, as is evident from our series of historical air photos.

Sunset Spit occurs at the convergence of drift cells. The longer drift cell to the west (including a divergence zone) is 79% bulkheaded, and the relatively short drift cell to the east is 86% bulkheaded (including a divergence zone)(Hirschi et al. 2003).

Table 13. Summary of habitat changes to the Sunset Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length/Area		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	360 ft	420 ft	+ 60 ft	+ 17
Spit (area)	0.07 ha	0.18 ha	+ 0.11 ha	+ 157
Salt marsh	0 ha	0.07 ha	+ 0.07 ha	+ 100
Total (spit, marsh)	0.07 ha	0.25 ha	+ 0.18 ha	+ 257

Figure 49. 1993 WDOE oblique photo showing the Sunset Spit complex (left side of image). Springbrook Creek is shown in the far left part of the image, and Holyoke Creek is shown in the right side of the image. This photo illustrates the extent of bulkheading and residential development along this shoreline.

Relative Condition

Based primarily on the development at the base of the spit, we consider the relative condition “Moderately Impaired”.

Habitat Complex: Holyoke Creek
Complex Type: Stream-delta

Physical Description

Holyoke Creek enters Hood Canal through a narrow draw and small embayment. A small dock or log dump and a road leading to the uplands are shown to the southwest of the creek mouth in the 1884 T sheet (see Figure 47 in the Springbrook Creek habitat complex narrative above). Slightly further east the word “Skid” is shown on the map, possibly referring to a skid road from the uplands to the dock. On August 27, 1861, the mouth of Holyoke Creek was measured at 10 links (6.6 ft.) wide (Terrill 1861).

Description of Historical Habitat Changes

Highway 106 now crosses the mouth of the stream through a culvert, and has resulted in filling over of the upper intertidal area (1957 air photo). See WDOE oblique photos from 1942, 1977, 1993, and 2001 (Figure 50).

Figure 50. 2001 WDOE oblique photo of the Holyoke Creek mouth, partially filled over by Highway 106.

Relative Condition

Based on the filling of upper intertidal habitat and impairment of connectivity at the creek mouth, we consider the relative condition “Moderately Impaired”.

Habitat Complex: Granite Creek
Complex Type: Stream-delta

Physical Description

Granite Creek is a name we gave this stream because of the benchmark “Granite” just west of the stream mouth on the 1884 T sheet (Figure 51). The T sheet shows a small narrow inlet along the coastline where the stream enters Hood Canal, and a tidal channel across the tidal flat with the channel shifted toward the west, similar to Holyoke Creek (see above habitat complex narrative). In September 1861, it was 5 links (3.3 ft.) wide at the mouth (Terrill 1861).

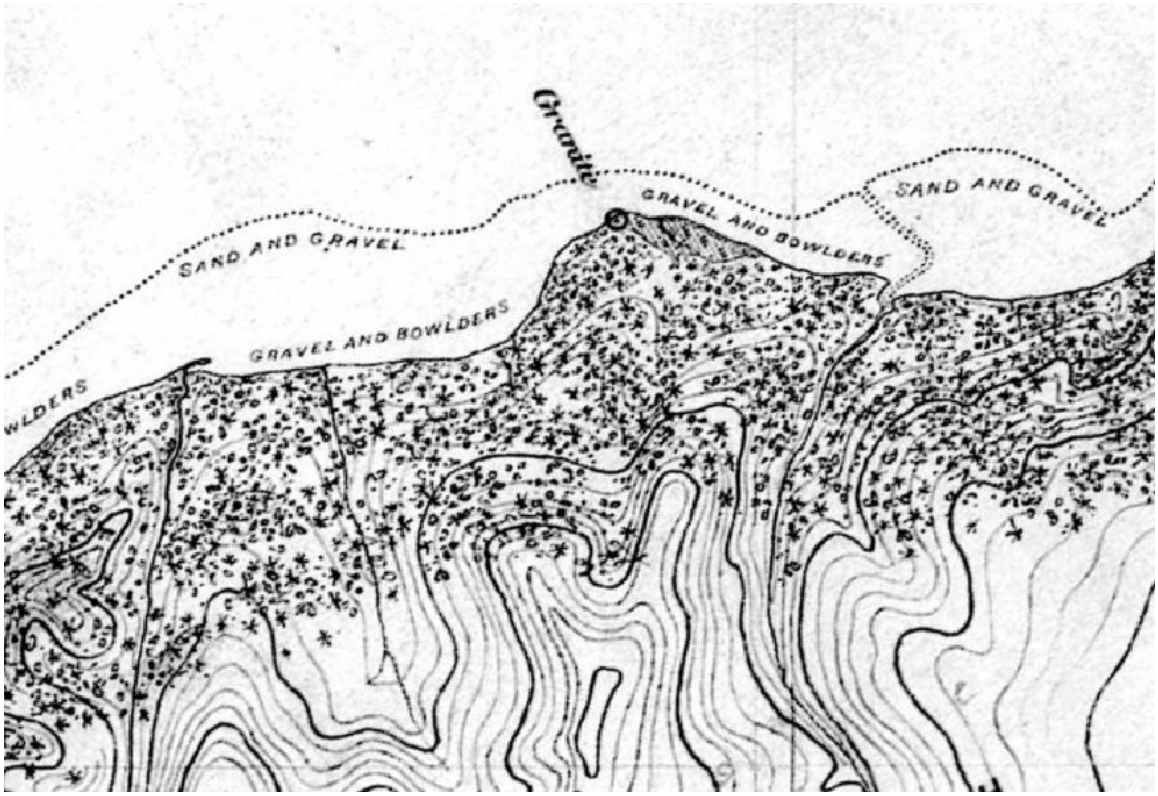

Figure 51. 1884 T sheet showing, from east to west, Granite Creek, Granite Marsh (near the benchmark “Granite”), and the tiny West Granite Spit habitat complexes.

Description of Historical Habitat Changes

Highway 106 crosses the mouth and upper intertidal associated with the creek, and salt marsh occurs in the small delta just downstream of the highway, evident in WDOE

oblique air photos from 1977, the 1993, and 2001 (Figure 52). The small amount of salt marsh present has apparently grown since the 1880s, displacing historical tidal flat. Adjacent home sites built at the waters edge also encroach upon the small creek mouth.

Figure 52. 2001 WDOE oblique photo of the Granite Creek habitat complex, indicating salt marsh at the mouth where it was not indicated in the 1884 T sheet.

Relative Condition

Though a small amount of salt marsh has apparently grown at the delta of this stream, we consider the other habitat changes described above to be critical to the function of this small system. For these reasons, we consider the relative condition "Moderately Impaired".

Habitat Complex: Granite Marsh
Complex Type: Spit/marsh

Physical Description

Granite Marsh was shown in the 1884 T sheet as a fringing marsh (0.50 hectares) with possible tidal connection, though it is unclear from the map (see Figure 51 in the Granite Creek habitat complex narrative above). Freshwater inputs to the historical marsh are unknown.

Description of Historical Habitat Changes

The marsh has been completely lost to the development of homes, and Highway 106 occurs behind the houses (Figure 53). This development probably occurred fairly early as a 1953 USGS map (USGS, Lake Wooten quadrangle) indicates a number of homes in the vicinity of the historical marsh.

Figure 53. 2001 WDOE oblique photo showing the site of the historical Granite Marsh habitat complex, now filled over for residential development.

Relative Condition

This complex is considered "Lost".

Habitat Complex: West Granite Spit
Complex Type: Spit/marsh

Physical Description

This tiny eastward oriented spit (0.01 hectare, 110 feet long) was shown in the 1884 T sheet (see Figure 51 in the Granite Creek habitat complex narrative above) with a stream entering behind the spit. A modern day USGS map (USGS, Lake Wooten quadrangle)

also indicates a stream at this location. The September 1861 GLO survey did not note a stream at this site, although they did note a stream of 4 links wide east of the spit about 550 feet away in the direction of a stream also shown on modern maps (Terrill 1861; USGS, Lake Wooten quadrangle).

Description of Historical Habitat Changes

A 1953 USGS map (USGS, Lake Wooten quadrangle) indicates homes along this entire shoreline in the vicinity of the spit, and the spit itself is not indicated in this map. More recent imagery also shows no spit at this site (Figure 54). Though only speculation, being such a small feature (in the 1884 T sheet) it may be that the spit was destabilized and eroded quite rapidly with early development of the South Shore Road (Hwy. 106) and adjacent homes.

Figure 54. 2001 WDOE oblique photo showing the site of the West Granite Spit in the 1884 T sheet, which was located near the center of the image where a small stream runs past a house and enters Hood Canal.

Relative Condition

This tiny spit complex is considered “Lost”.

Habitat Complex: Forest Beach Creek
Complex Type: Stream-delta

Physical Description

The 1884 T sheet shows a jetty-like structure partly enclosing the mouth of Forest Beach Creek (Figure 55). The jetty was likely built for protection of "Whiteys Logging Camp" that was shown at the site. The September 1861 GLO meander surveyor did not indicate the presence of the jetty at that early date, though they described the creek as 6 links (4 ft.) wide (Terrill 1861). The T sheet shows at least one building located just east of the creek mouth and a road leading from the building up the narrow ravine of Forest Beach Creek.

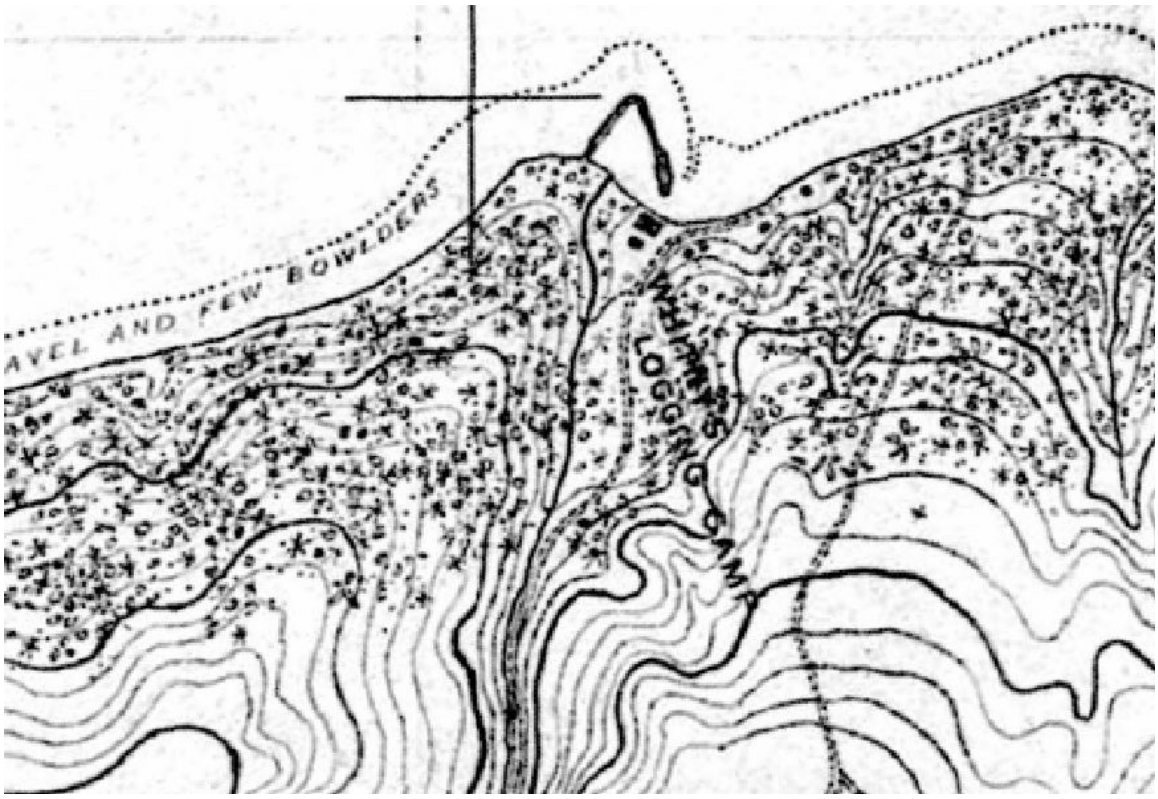

Figure 55. 1884 T sheet showing the Forest Beach Creek habitat complex, and a jetty-like structure at the creek mouth probably associated with the logging camp present at the time, perhaps used to corral logs near the mouth of the creek.

Description of Historical Habitat Changes

A 1953 USGS map (USGS, Lake Wooten quadrangle) indicates a long pier at the historical location of the jetty, and a number of houses or other buildings are indicated all along the shoreline in the vicinity of the creek mouth. The lower creek channel appears straightened and riparian vegetation is lacking or poorly developed from Highway 106 to the mouth (Figure 56).

Figure 56. 2001 WDOE oblique photo of the Forest Beach Creek stream delta. Notice the level of shoreline armoring at the mouth and immediately left of the creek mouth.

Relative Condition

Based on the level of fill and infrastructure around the mouth of this creek, we consider the relative condition "Severely Impaired".

Habitat Complex: Twanoh Creek
Complex Type: Stream-delta

Physical Description

Twanoh Creek is shown in the 1884 T sheet entering a fringing salt marsh (Figure 57). To the immediate west of the stream mouth is a patch of grassland and another small patch of salt marsh is separated from the grassland by a road. It is possible that this early road may have already fragmented the west end of the Twanoh Creek marsh in 1884. A long narrow spit feature partly enclosed a tidal lagoon at the east end of the historical habitat complex. The September 1861 survey measured the mouth of Twanoh Creek at 10 links (6.6 ft.) wide (Terrill 1861).

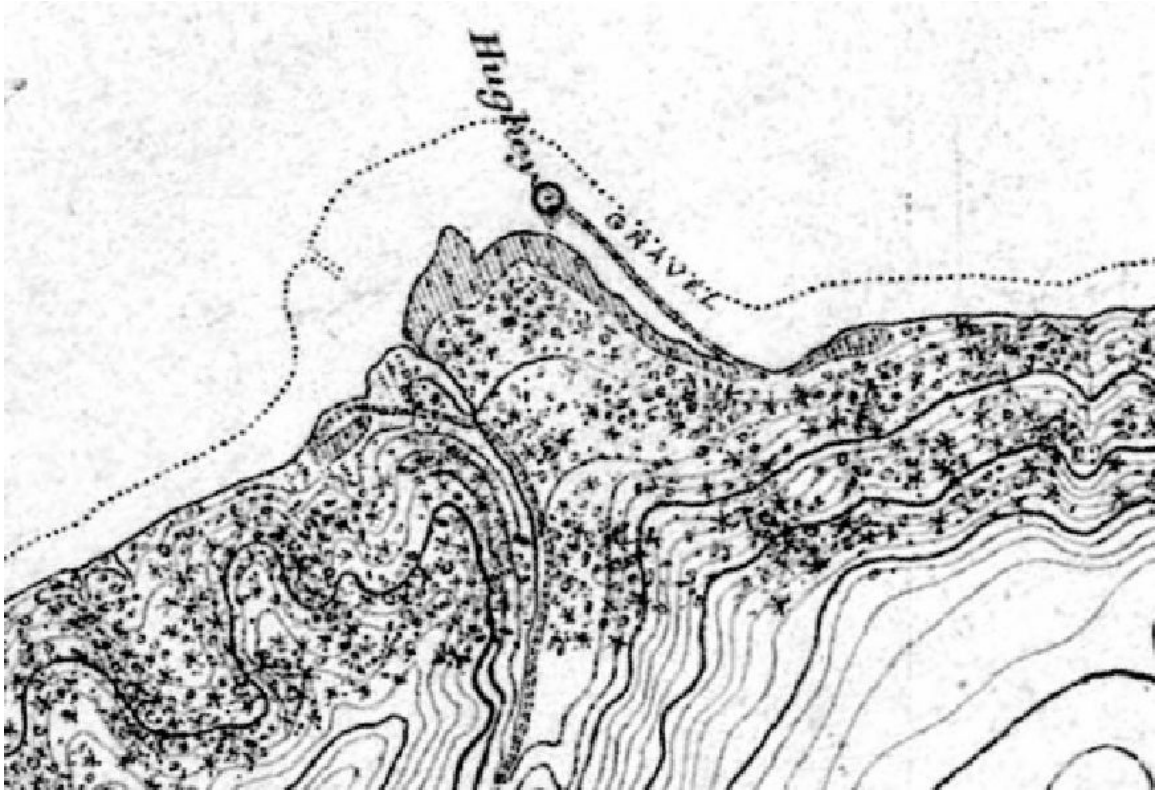

Figure 57. 1884 T sheet showing the Twanoh Creek habitat complex.

Description of Historical Habitat Changes

Table 14 provides a quantitative summary of historical habitat changes to this complex. The site is now owned by Washington State Parks and managed as Twanoh State Park. Most, if not all, of the former marsh has been replaced by fill for parking and grass lawns. The shoreline surrounding the creek mouth has been heavily armored and filled over, including a large boat ramp just west of the creek mouth. The only remaining "natural" feature is perhaps part of the former lagoon that was behind the historical spit, though the spit appears either greatly diminished in elevation or non-existent today (Figure 58). Twanoh Creek is located at a convergence of net sediment drift with the much longer drift cell from the west bulkheaded along 71% of its length (including a divergence zone near Dalby Creek in the South Hood Canal sub-region). The shorter east-to-west drift cell and a divergence zone to the east of Twanoh Creek are 36% bulkheaded (Hirschi et al. 2003).

Figure 58. 2001 WDOE oblique photo of the Twanoh Creek habitat complex. The former salt marsh associated with this creek has been entirely filled over, primarily for a parking lot for the Twanoh State Park. Note the upper end of a boat ramp at the far right of the image.

Table 14. Summary of habitat changes to the Twanoh Creek habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length /Area		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	810 ft	0 ft	- 810 ft	- 100
Spit (area)	0.36 ha *	0 ha	- 0.36 ha	- 100
Salt marsh	1.33 ha	0 ha	- 1.33 ha	- 100
Lagoon	0.34 ha	0 ha	- 0.34 ha	- 100
Tidal flat	4.10 ha	? ha **	? ha	?
Total (spit, marsh, lagoon)	2.03 ha	0 ha	- 2.03 ha	- 100

* Historical spit surface area estimate combines the east spit (0.22 ha) and west spit (0.14 ha).

** Current day surface area estimates of tidal flat habitat were not made because we felt that these estimates would not provide a valid comparison with the historical estimates of tidal flat that were derived from the T sheets, where the mean lower low water line (MLLW) was often interpolated from actual surveyed points.

Relative Condition

Based on the complete loss of historical tidal wetland habitat at this site, we consider the relative condition “Lost”.

Habitat Complex: Morang Spit
Complex Type: Spit/marsh

Physical Description

Morang Spit gets its name from the name shown on the 1884 T sheet (Figure 59). The spit was oriented toward the west and protected a small tidal lagoon and patch of salt marsh. A small stream was located (and still is according to modern maps) just west of the tip of the spit, though the creek itself apparently did not enter the small lagoon or tide marsh.

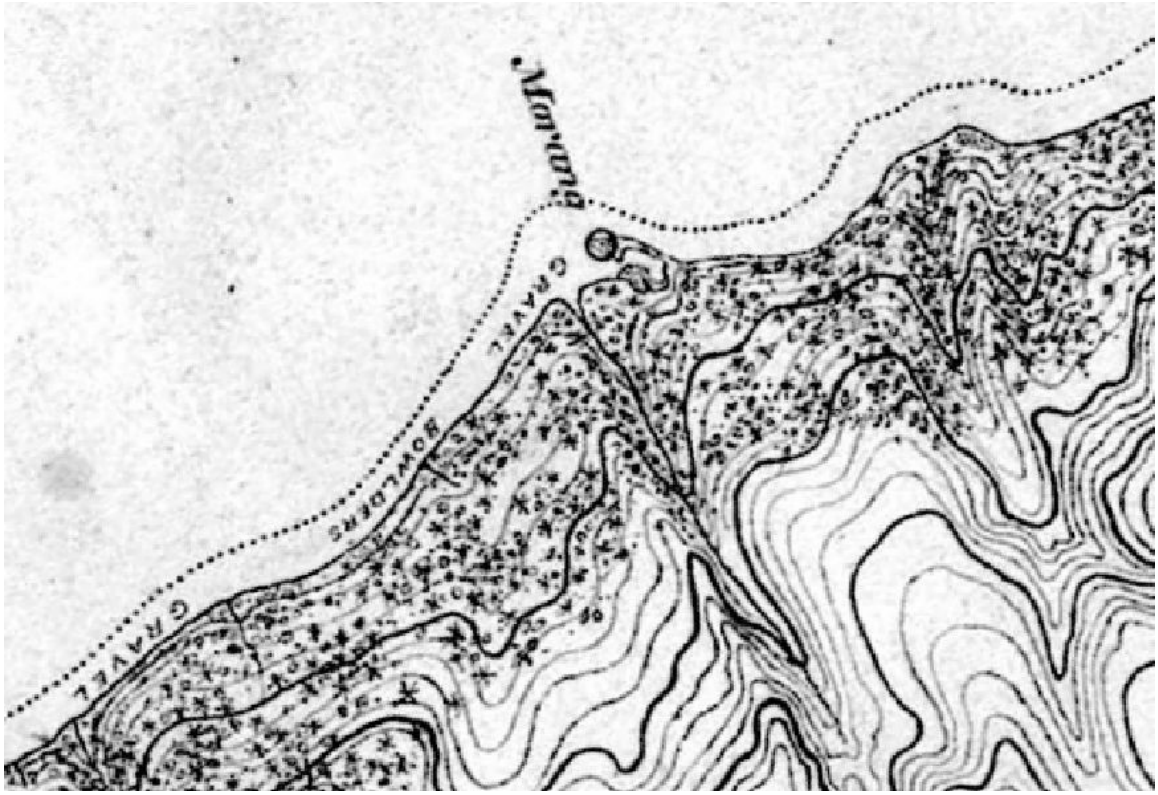

Figure 59. 1884 T sheet showing the small Morang Spit habitat complex.

Description of Historical Habitat Changes

There are no signs of the historical habitat today (Figure 60 and Table 15). The 1993 WDOE oblique photo of the site shows homes fronted with vertical bulkheads and possible filling below high water at this location. The west-to-east drift cell that extends from about Dalby Creek to Twanoh Creek is 71% bulkheaded (Hirschi et al. 2003).

Figure 60. 2001 WDOE oblique photo of the site of the historical Morang Spit complex. The small spit and associated lagoon and marsh is not evident in air photos from recent decades (1977, 1993, 2001), apparently filled over for residential development and associated bulkheading.

Table 15. Summary of habitat changes to the Morang Spit habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length/Area		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	280 ft	0 ft	- 280 ft	- 100
Spit (area)	0.08 ha	0 ha	- 0.08 ha	- 100
Salt marsh	0.13 ha	0 ha	- 0.13 ha	- 100
Lagoon	0.06 ha	0 ha	- 0.06 ha	- 100
Total (spit, marsh, lagoon)	0.27 ha	0 ha	- 0.27 ha	- 100

Relative Condition

This habitat complex is considered “Lost”.

Habitat Complex: West Morang Creek
Complex Type: Stream-delta

Physical Description

The 1884 T sheet shows a stream channel entering the intertidal and a log chute enters Hood Canal just southwest of the creek mouth. This small steep stream was measured in late September 1861 at 6 links (4 ft.) wide at the mouth (Terrill 1861).

Description of Historical Habitat Changes

Highway 106 now crosses at the stream mouth and houses along the shoreline occur adjacent to the small delta (Figure 61).

Figure 61. 2001 WDOE oblique photo showing the West Morang Creek stream-delta (center of image).

Relative Condition

Based on the filling over of the creek inlet by Highway 106 and adjacent homes along the shoreline, we consider the relative condition of this stream delta "Severely Impaired".

Habitat Complex: East Burn Marsh
Complex Type: Spit/marsh

Physical Description

This fringing marsh historically was surrounded by upland forest and grassland (Figure 62). Though the 1884 T sheet does not indicate any streams entering the marsh, modern day maps indicate at least two small streams entering the site of the historical marsh.

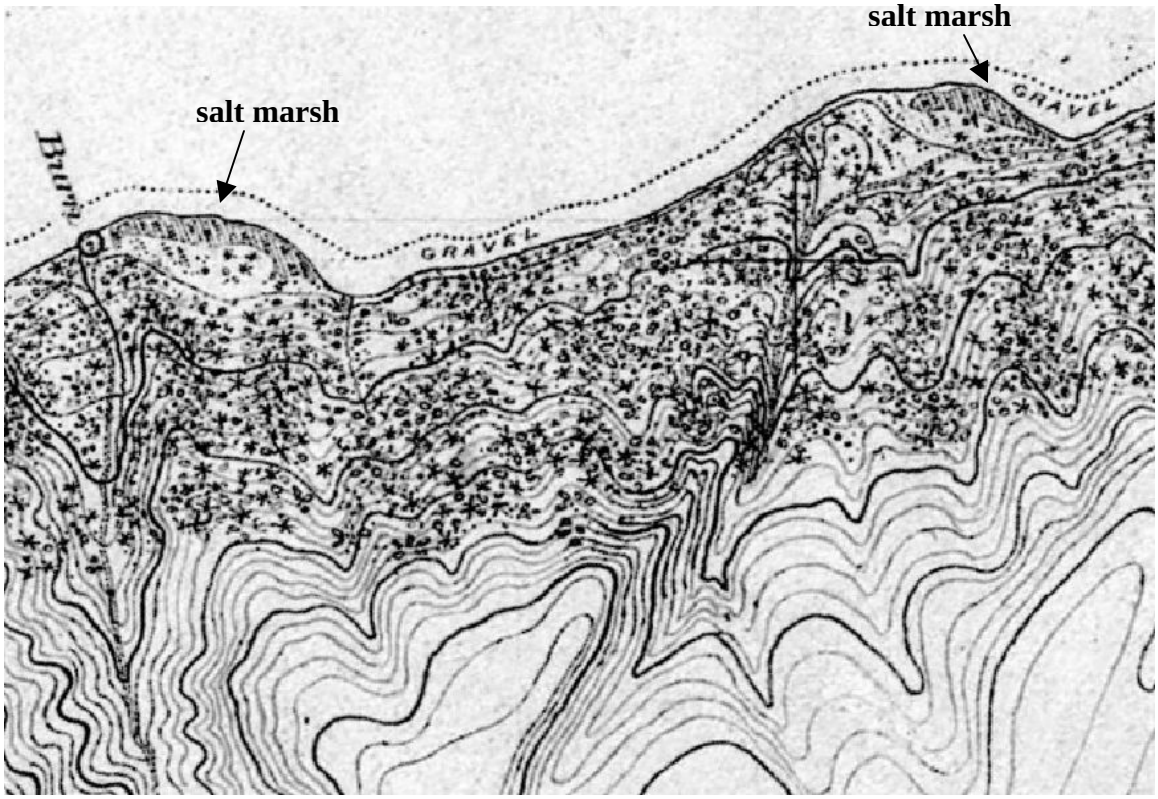

Figure 62. 1884 T sheet showing the East Burn Marsh (right side of image) and Burn Marsh (left side) habitat complexes.

Description of Historical Habitat Changes

The marsh has been filled over for houses and former habitat features have been completely lost (Table 16 and Figure 63). Many of the houses along this shoreline are constructed very near the shoreline and bulkheading often fills out below high water. Highway 106 occurs directly behind the houses.

Table 16. Summary of habitat changes to the East Burn Marsh habitat complex based on a comparison of the 1884 T sheet with current day air photo delineation of habitat features.

Habitat Type	Length (ft)/Area (ha)		Change	
	Historical	Today	Area-Length	Percent
Spit (length)	220 ft	0 ft	- 220 ft	- 100
Spit (area)	0.05 ha	0 ha	- 0.05 ha	- 100
Salt marsh	0.37 ha	0 ha	- 0.37 ha	- 100
Total (spit, marsh)	0.42 ha	0 ha	- 0.42 ha	- 100

Relative Condition

This complex is considered “Lost”.

Figure 63. 2001 WDOE oblique photo showing the site of the historical East Burn Marsh, now filled by residential development.

Habitat Complex: Burn Marsh
Complex Type: Spit/marsh

Physical Description

The 1884 T sheet shows Burn Marsh as a narrow fringing salt marsh (0.72 hectares) with two streams entering Hood Canal just west and east of the marsh (see Figure 62 in the East Burn Marsh habitat complex narrative above). It is not clear in the T sheet if a regular surface water connection occurred between the marsh and Hood Canal.

Description of Historical Habitat Changes

WDOE oblique photos going back to 1977 all indicate this marsh has been completely filled by residential development, and bulkheads front most of these houses and a few docks occur at the site today (Figure 64). Highway 106 runs almost immediately behind many of the houses.

Relative Condition

This complex is considered "lost".

Figure 64. 2001 WDOE oblique photo showing the site of the former Burn Marsh complex, now filled by homes.

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