Appendix B – 11: South Hood Canal Sub-Region

Table of Contents

South Hood Canal Sub-Region

Sub-Region Summary

Geographic Location

The South Hood Canal sub-region includes shorelines along both the Olympic and the Kitsap peninsulas. On the Olympic Peninsula shoreline, this extends from a sediment divergence zone just north of Ayock Point to a divergence zone just east of Dalby Creek, which is located east of the Skokomish River (Figure 1). On the Kitsap Peninsula shoreline, the sub-region extends from a divergence zone just north of the Dewatto River to a divergence zone at Ayres Point located just southeast of Tahuya Bay.

Geology and Shoreline Sediment Drift

The coastal geology of the South Hood Canal sub-region is comprised mainly of glacial deposits, although many of these deposits, particularly along the Kitsap coastline, are outwash derived from pre-Fraser alpine glaciers (Logan 1987; Gerstel and Lingley 2003). The geology just inland from the shoreline is dominated by Fraser glacial till and outwash. Large landslide deposits make up extensive areas of the shoreline, particularly from north of Ayock Point extending south of Lilliwaup Creek, and on the east shore at the mouth of Tahuya Bay. Alluvium occurs at the Skokomish River estuary, Tahuya River, Lilliwaup Creek, and smaller streams in the sub-region.

With few exceptions, net shore drift is predominantly in a south-to-north direction along both shorelines north of the Skokomish River on the Olympic Peninsula and north of Rendsland Creek on the Kitsap Peninsula. East of these stream-deltas and into the "hook" of Hood Canal, the net shore drift is primarily in a west-to-east direction (WDOE 2000, based on Blankenship 1983)(Figure 1).

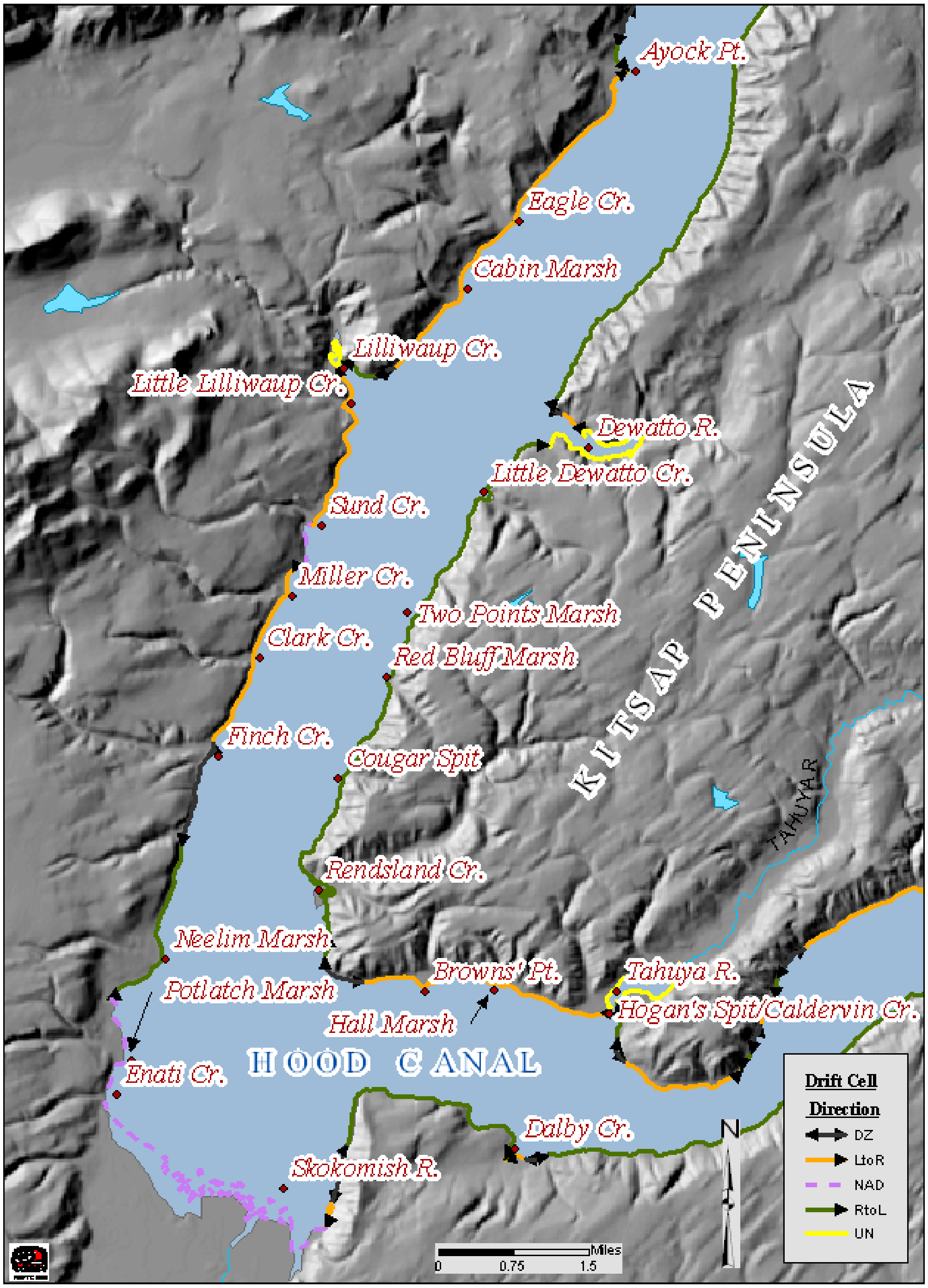


Figure 1. Habitat complexes and net shore sediment drift (WDOE 2000, based on Blankenship 1983) in the South Hood Canal sub-region. The sediment divergence zone (DZ) located just north of Ayock Point is not shown on the map. Notice the dominance of south-to-north sediment drift along shorelines running north and south, and west-to-east drift as one enters the southeast "hook" section of Hood Canal. Legend items NAD refers to "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 land).

Information Sources (see details in Appendix A)

- 1884 T sheets (T1560a, T1560b, T1561a)
- 1857, 1861, 1873, and 1874 GLO survey notes
- 1938, 1939, 1942, 1957, 1958, 2000, 2003 vertical air photos (various sources)
- 1977, 1993, 2001 oblique air photos (WDOE 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 24 habitat complexes in the South Hood Canal sub-region, 14 are located along the Olympic Peninsula shoreline and 10 along the Kitsap Peninsula (Figure 1). Fourteen of the complexes are considered stream-deltas, and 10 are spit/marshes. The Skokomish estuary is the largest habitat complex in the study area (historically at 799 hectares), and dominates the sub-region in terms of quantity of tidal wetland habitat. About 84% of the historical tidal wetland habitat (i.e., marsh, channel, and lagoon) in the South Hood Canal sub-region was contained in the Skokomish estuary. The next largest complexes are the Tahuya and Dewatto river complexes, historically 40 ha and 35 ha in size, respectively (Figure 2; habitat complex scale is based on our historical combined estimate of spit, tidal flat, marsh, channel, and lagoon habitat). Four additional complexes were historically between 10-20 ha (Lilliwaup, Rendsland, Eagle, and Sund creeks). Nine habitat complexes were between one and ten hectares in size, and eight complexes were historically less than one hectare in size.

Based on our delineation of the 1884 T sheets, there were 270 hectares of salt marsh, associated tidal channel, and lagoon habitat in the South Hood Canal sub-region distributed across 19 habitat complexes. Today, 326 ha are contributed by 19 complexes (21% increase). Two habitat complexes that historically supported marsh or lagoon habitat no longer contribute this habitat, and two complexes that historically did not show marsh or lagoon, now support this habitat (Figures 3 and 4). Summary information for individual habitat complexes in the South Hood Canal sub-region can also be found in Appendix A, Table 16.

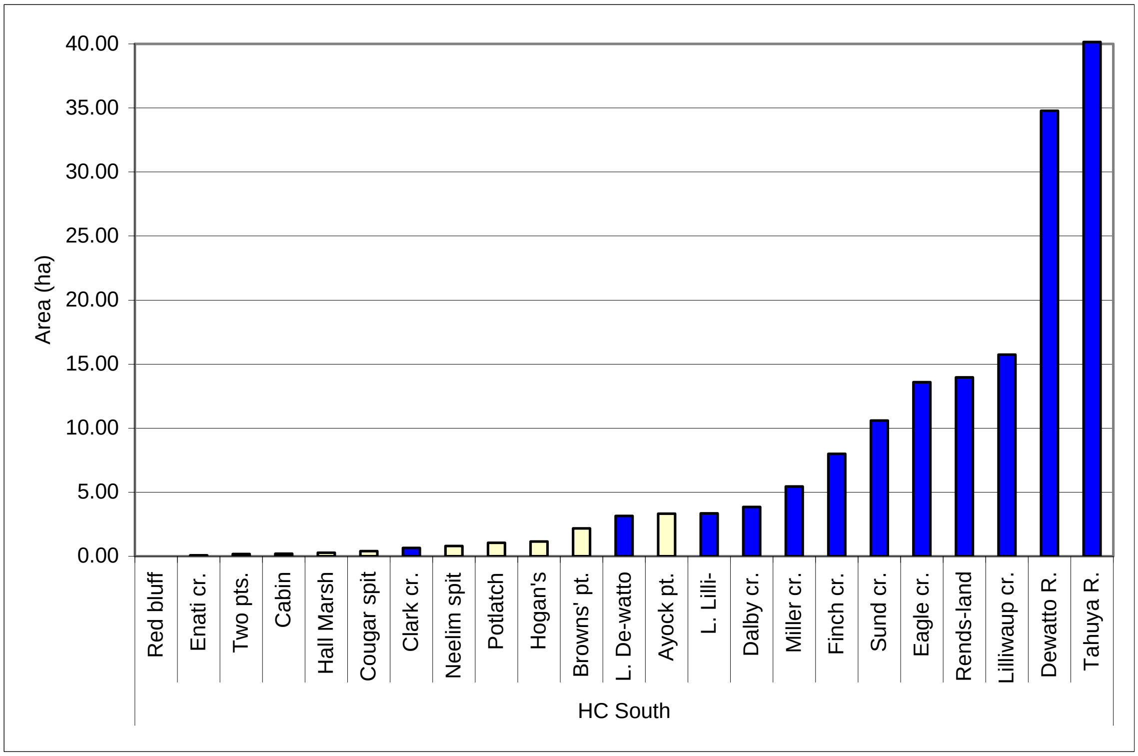


Figure 2. Historical scale, in ascending order, of habitat complexes in the South Hood Canal sub-region. Blue columns represent stream-delta complexes, including the very small Enati Creek. The Skokomish estuary complex is not shown in this graphic because, at 799 hectares, it dwarfs all other complexes. 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

Tidal wetland habitat (i.e., marsh, lagoon, and associated channels) associated with stream-delta complexes in the South Hood Canal sub-region has increased from 262 ha to 323 ha (23%). The Skokomish estuary is by far the largest stream delta complex in the South Hood Canal sub-region, and entire study area. Our estimates, based on the 1884 T sheet, indicate about 228 hectares of tidal marsh, associated channel, and lagoon habitat associated with the Skokomish, has increased to about 284 ha (25% gain). Most of this gain in habitat is the result of the growth of salt marsh associated with delta progradation at the river mouth. We also suspect that the historical maps may have failed to map salt marsh in locations where we find marsh today. Therefore, we have reason to think that the historical T sheet underestimated the amount of salt marsh in the Skokomish. In addition, much of the area that we consider salt marsh today has been altered by extensive diking.

Of the 13 other stream delta complexes in the sub-region, ten either historically or currently support tidal marsh or lagoon habitat (Figure 3). Outside the Skokomish estuary, the cumulative changes in tidal marsh and lagoon habitat are significant (34 ha historically compared with 39 ha today; 15% increase). Notable gains in tidal marsh occurred in the Tahuya River and Lilliwaup Creek complexes (Figure 3), and increases were made in the comparatively smaller complexes including Little Dewatto, Sund, Enati, and Dalby creek. It appears that tidal marsh in each of these instances is growing seaward of its historical extent, and has displaced tidal flat habitat, probably the result of fluvial sediment deposition at the deltas of these streams. The accretion of sediment has probably been facilitated at the Tahuya River and Lilliwaup Creek by road causeways that now artificially confine the deltas and impair tidal exchange, effectively trapping sediment upstream of the roads. The net change in tidal wetland habitat at the Dewatto River complex is minimal (5% gain), while losses at smaller stream delta complexes (i.e., Rendsland, Eagle, and Miller creeks) are severe.

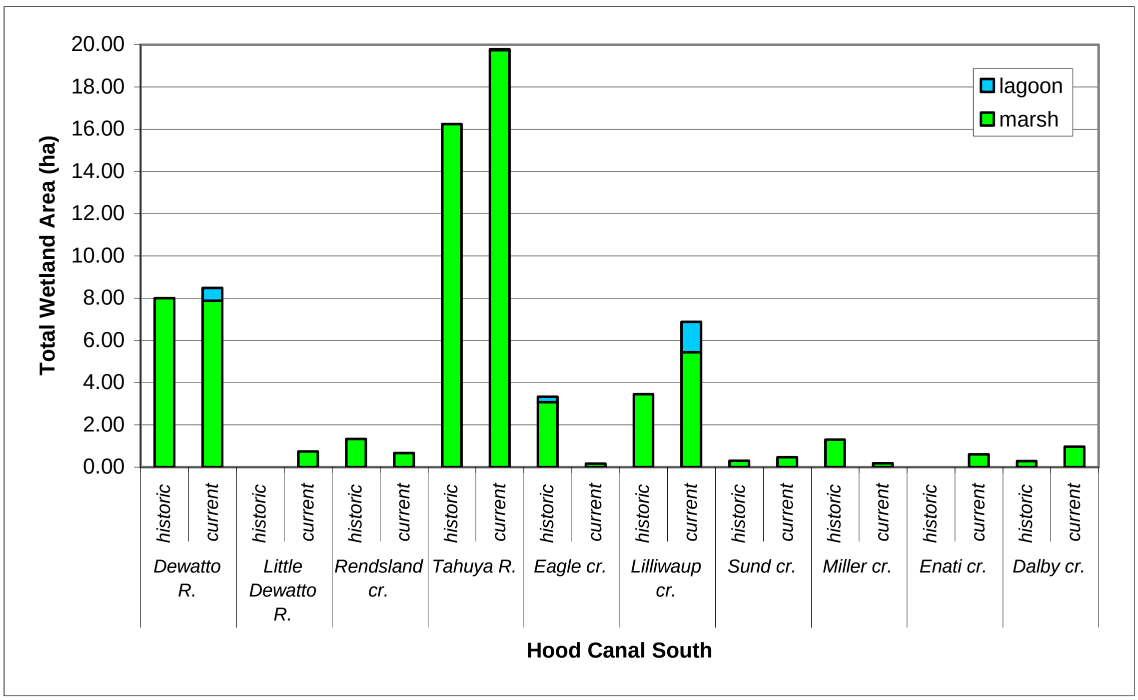


Figure 3. Historical changes in area of tidal marsh and lagoon habitat associated with stream-delta complexes in the South Hood Canal sub-region. The Skokomish estuary is not shown in this graphic because it dwarfs all other complexes, and if included would obscure the historical changes in these complexes. Clark, Little Lilliwaup, and Finch Creek habitat complexes are also not shown in this graphic because they historically and currently lack tidal marsh or lagoon habitat.

Spit/marsh Complexes

Just four of the ten spit/marsh complexes in the South Hood Canal sub-region were historically larger than one hectare in size: Ayock Point, Brown's Point, Hogan's Spit/Caldervin Creek, and Potlatch Marsh. The cumulative historical changes to spit/marsh complexes in the South Hood Canal sub-region are significant. Historically, nine complexes contributed 7.93 ha of tidal marsh and lagoon habitat. Today, seven complexes provide just 2.89 ha of this habitat (64% decrease). The historical tidal marsh and lagoon habitat (cumulatively 2.22 ha) associated with the Cabin Marsh, Potlatch Marsh, and Hogan's Spit/Caldervin Creek complexes has been entirely eliminated (Figure 4). The two largest spit/marsh complexes in the sub-region, Ayock Point and Brown's Point, have also had substantial decreases to their historical wetland habitat. Cougar and Neelim spit habitat complexes have seen no net change or even slight gains in tidal wetland habitat, and a small amount of salt marsh appears today at the Red Bluff Marsh complex where it was absent according to the historical T sheet.

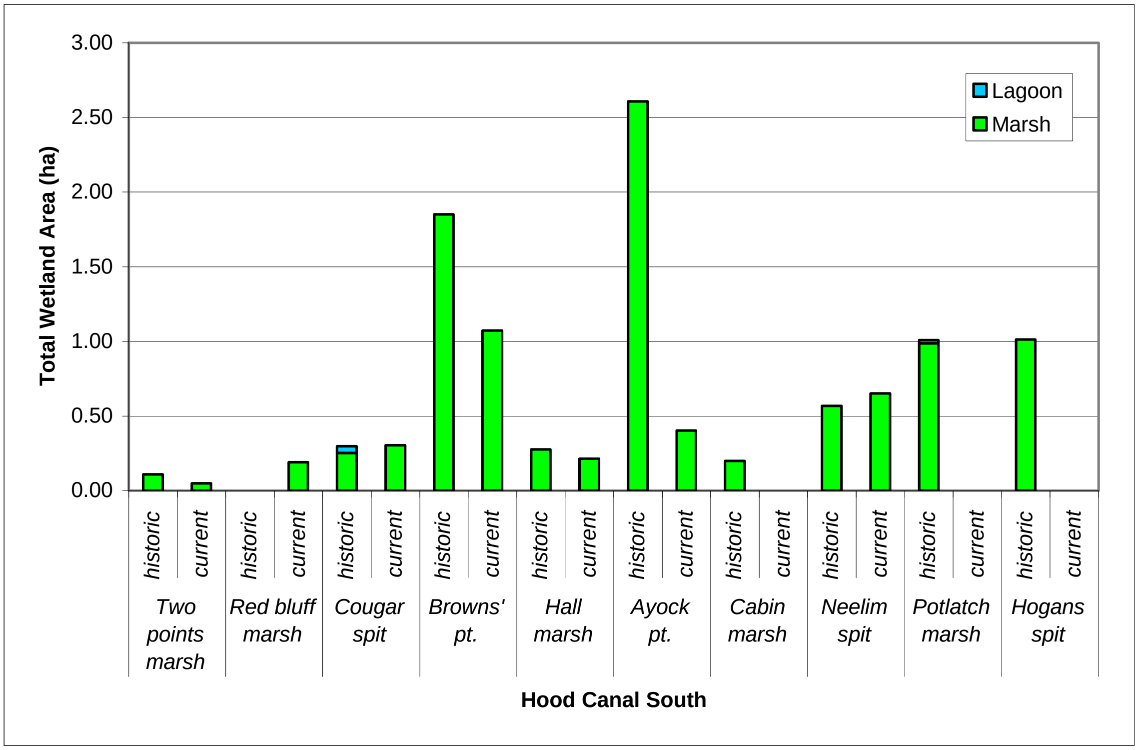


Figure 4. Historical changes in area of salt marsh and lagoon habitat associated with spit/marsh complexes in the South Hood Canal sub-region.

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.

Five spit/marsh complexes in the sub-region show sufficient evidence in the historical record of a surface water connection with the adjacent open waters (i.e. Hood Canal)(Figure 5). Four of these five complexes are also known to receive freshwater inputs. Only two (Ayock Point and Brown's Point) of the five historically surface water connected complexes today appear to have a regular surface water connection, although both of these complexes are considered severely impaired (Table 1 and Figure 6). Our estimates show a sharp decline in the amount of tidal marsh and lagoon habitat associated with spit/marsh complexes that were historically connected to marine waters, from 7.05 to 1.48 hectares today (79% decrease).

Only 0.88 hectares of salt marsh and lagoon habitat historically existed in association with the five spit/marsh complexes that did not show a surface water connection with adjacent waters. This has been reduced only slightly to 0.76 ha (14% decrease).

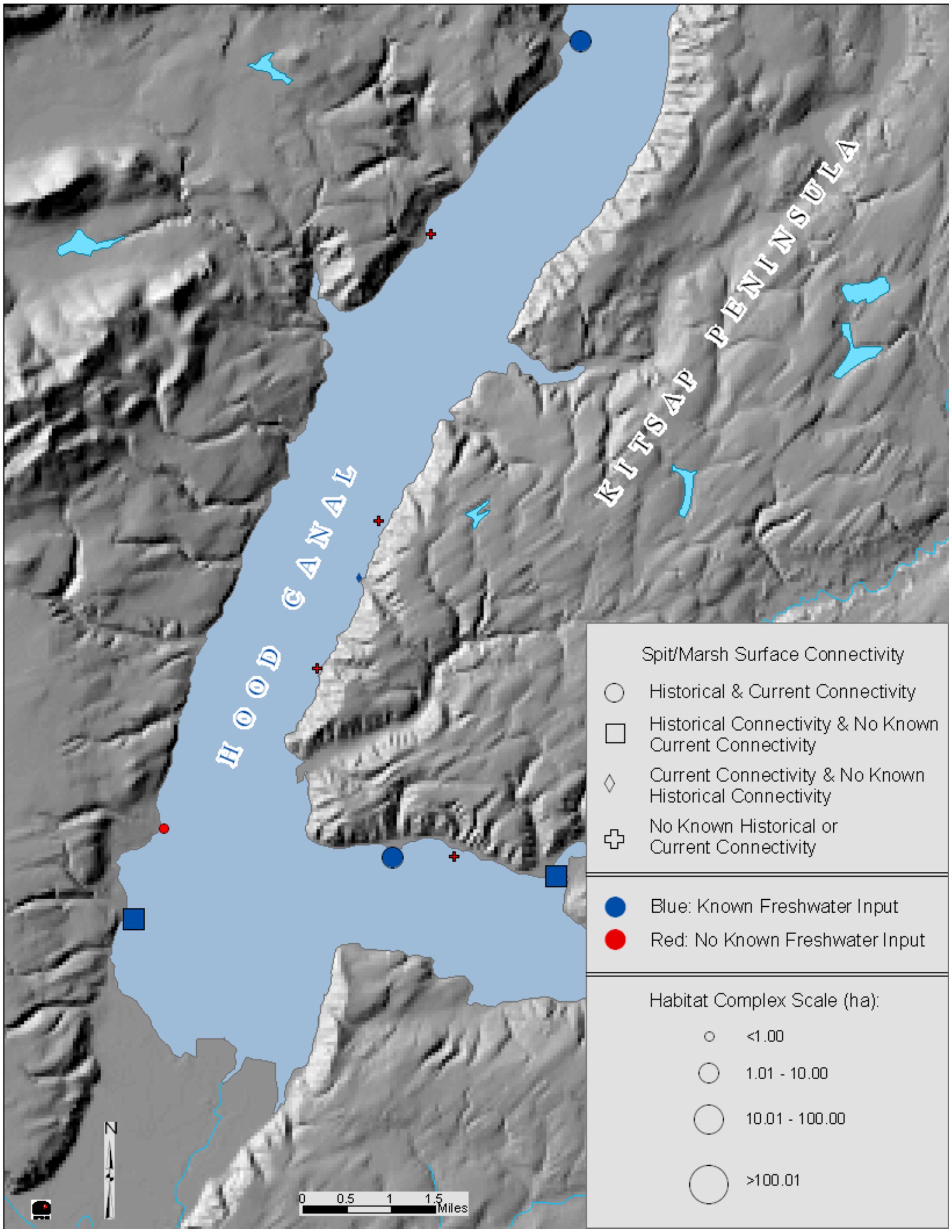


Figure 5. Spit/marsh habitat complexes of the South Hood Canal sub-region, including the scale, status of freshwater inputs, and surface water connectivity with adjacent open waters.

Habitat Changes and Impairment of Ecological Processes

The dominant physical processes responsible in the formation and maintenance of stream-delta and spit/marsh complexes are fluvial (predominant in stream-deltas) and wave (predominant in spit/marshes) deposition, and tidal erosion (which 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 resulting from human actions are brought about through direct and indirect means. A direct change occurs from, for example, an action such as the filling of a tidal marsh for a residential development or a transportation corridor. This action directly affects tidal processes in a habitat complex that is subject to tidal erosion. Another example would be filling along a spit which can affect wave processes, particularly the deposition of sediment. Indirect changes occur when off-site alterations change the supply or transport of longshore-derived sediment, or when upstream land use or channel modifications affect hydrology and/or sediment regimes downstream, ultimately having an influence on the characteristics and function of habitat at the estuary.

Historical habitat changes affecting the Skokomish estuary complex involve both direct and indirect impacts. The most apparent direct causes for changes to tidal marsh and associated channels are the diking systems, primarily in the central part of the estuary, at Nalley Island between the main river and primary distributary (Nalley Slough) channels, and to the west of Nalley Slough. This complex system of dikes, drainage (borrow) ditches, ponds, and roads was put in place in the late 1930s/early 40s for agricultural purposes, and it has affected the hydrology of a large portion of tidal marsh. The dikes directly facing Hood Canal at Nalley Island have been progressively failing since the mid-1990s, the result of repeated storm surges, and the area landward of this failing dike is again being tidally influenced as there has been no apparent attempt to repair the dike. The dikes to the west of Nalley Slough are scheduled for removal or setback in the near future. Some tidal marsh along the far east side of the estuary has been filled over, probably since WWII, and tidal marsh along the west section has been impacted by an access road built by Tacoma Power probably in the early 1940s-mid 1950s period. Several transmission towers that carry electricity generated from the Cushman Dam powerhouse on Hood Canal have been built across the Skokomish estuary, and the footprint of at least one of these towers appears to have resulted in the partial filling of a large blind tidal channel in the far west portion of the estuary.

Indirect impacts to the Skokomish estuary include a significant reduction in stream flows from the North Fork of the river that came with construction of the Cushman and Kokanee Dam projects in the early 1900s. Intensive channelization, diking, and wood removal from the mainstem Skokomish River has affected streambank stability and floodplain connectivity in the lower river for decades, affecting how sediment is conveyed through the lower watershed and ultimately to the delta. In addition, upstream logging, road building, and floodplain development have likely had a profound impact on the amount of sediment supply in the river channel and its discharge to the estuary.

Highway 101 along the west shore of Hood Canal has a direct impact on all of the stream-delta habitat complexes in the South Hood Canal sub-region, including Eagle, Lilliwaup, Little Lilliwaup, Sund, Miller, Clark, Finch, and Enati creeks. The location of the highway has also facilitated shoreline development for commercial, recreational, and residential purposes, particularly in the vicinity of Hoodsport, but also at Ayock Point and at the historical Potlatch Marsh at Potlatch State Park.

Along the Kitsap Peninsula shoreline, habitat changes are the result of extensive filling of historical salt marsh and tidal flat habitat associated with a road, and dredging related to residential development at the Rendsland Creek complex. The Tahuya River complex has been impacted by a relatively minor level of fill, diking and wetland drainage and the Dewatto has received some diking and dredging activity affecting tidal processes in its estuary. The Dewatto, Rendsland, and Tahuya complexes are all potentially affected by upstream watershed land use practices, particularly floodplain modification, channelization and the reduction of large woody debris, and logging and road construction that have likely contributed to increased sediment loads to the streams. The Cougar Spit, Brown’s Point, Hall Marsh, and Hogan’s Spit/Caldervin Creek spit/marsh complexes have all been directly impacted by residential development, filling over and eliminating much of the historical salt marsh habitat associated with these complexes. In addition, bulkheading and other shoreline development are extensive along the drift cells along the Kitsap Peninsula shoreline (in this sub-region), particularly south of Cougar Spit where it tends to cover at least 50% of the shoreline length. Shoreline armoring at this level likely impairs sediment processes that affect the longterm stability of spit features.

Relative Condition of Habitat Complexes

Based on the percentage of historical tidal wetland habitat (i.e. tidal marsh, channel, lagoon, and spit) lost and the degree of overall impairment to habitat connectivity within habitat complexes, we applied a "relative condition" rating to each of the 24 habitat complexes in the South Hood Canal sub-region [(Table 1) A description of the methodology for applying the relative condition rating is provided in the Methodology section of the main body of the report]. The spatial distribution of the habitat complexes and their relative condition ratings are shown in Figure 6.

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

Functional	Moderately Impaired	Severely Impaired	Lost
Dewatto River	Cougar Spit	Rendsland Creek	Hogan's Spit
Little Dewatto Creek	Lilliwaup Creek	Brown's Point	Cabin Marsh
Two Points Marsh	Little Lilliwaup Creek	Hall Marsh	Potlatch Marsh
Red Bluff Marsh	Neelim Marsh	Ayock Point	
Tahuya River	Enati Creek	Eagle Creek	
	Dalby Creek	Sund Creek	
		Miller Creek	
		Clark Creek	
		Finch Creek	
		Skokomish River	

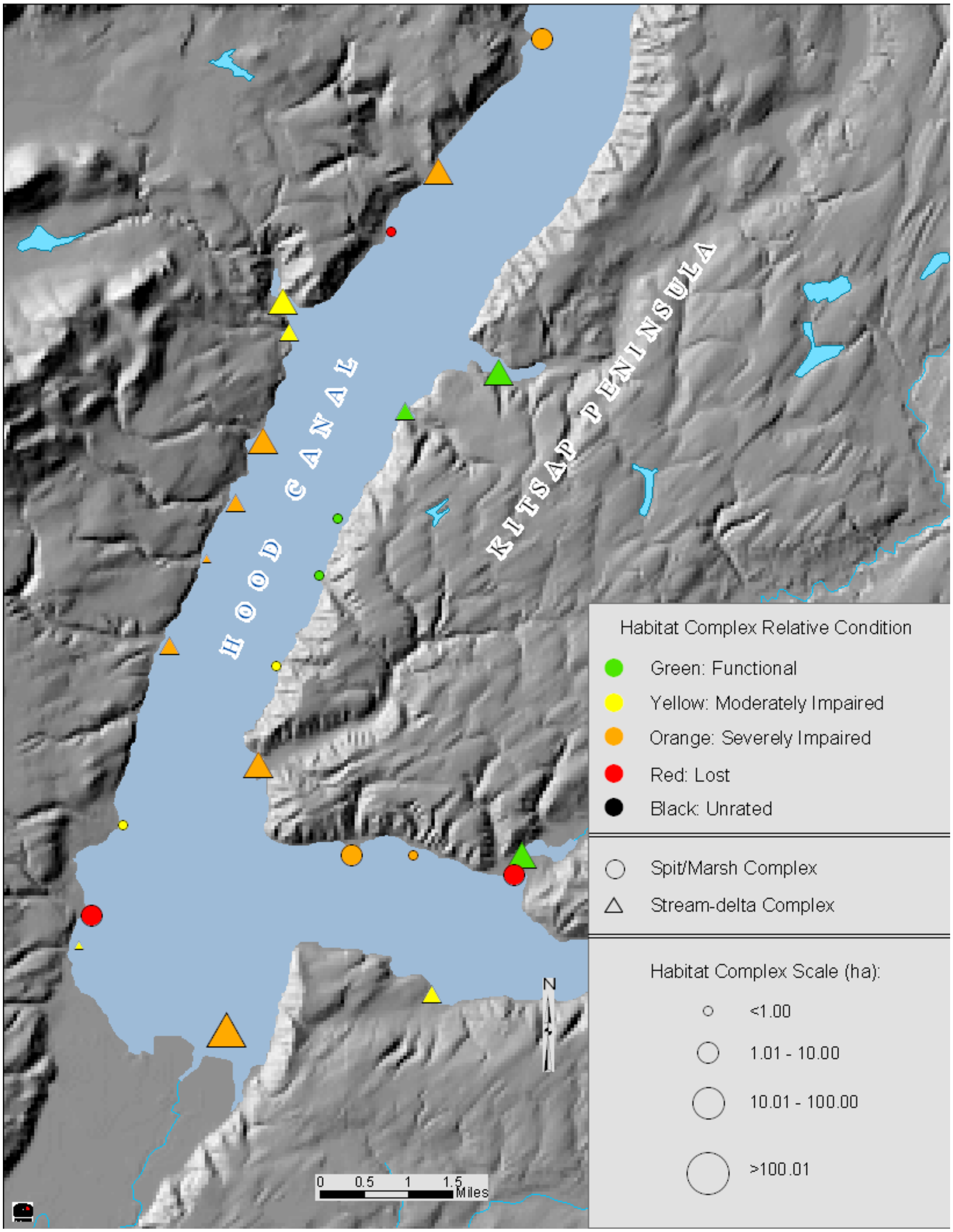


Figure 6. Relative condition of habitat complexes in the South Hood Canal sub-region.

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) 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 (and protection) opportunities may be particularly beneficial to salmon habitat in the Skokomish estuary, including the removal or setback of dikes, enlargement of tidal channel openings beneath the road in the west portion of the tidal marsh, and river dike removal or setback to increase riverine/floodplain and upper estuarine connectivity. We believe significant benefits would be provided through restoration actions in the Lilliwaup River complex (dike removal and broadening of Hwy. 101 span at the mouth), Dewatto River (remnant dike removal), Eagle Creek (removal of fill adjacent to Hwy. 101, and reconnection of former salt marsh with stream channel processes), Rendsland Creek (removal of fill seaward of road). To recover significant habitat benefits and connectivity at a number of complexes would likely require either or both substantial property acquisition and removal of existing infrastructure and landfill at Finch Creek (removal of fill associated with the Hoodsport hatchery facility at the mouth), Potlatch Marsh (current location of Potlatch State Park), Ayock Point, Hogan's Spit/Caldervin Creek (at mouth of Tahuya Bay), Brown's Point, Sund Creek, and Miller Creek. Our assessment suggests that particular attention to habitat protection is warranted in the Dewatto and Tahuya river complexes.

Habitat Complex Narratives

The following narratives provide more detailed information on historical habitat changes to individual habitat complexes in the South Hood Canal sub-region. The sequence of narratives begins with the Dewatto River complex at the north end of the sub-region on the Hood Canal east shore and progresses south to the Tahuya River complex. Then the sequence moves to the Ayock Point complex at the north end of the Hood Canal west shore and moves south to the Skokomish River complex, followed by the final narrative on the Dalby Creek complex just east of the Skokomish River (Figure 1).

Habitat Complex: Dewatto River
Complex Type: Stream-delta

Physical Description

The Dewatto River enters the head of a narrow protected embayment along the east shore of Hood Canal, and much of the embayment includes tidal marsh and tide flats (Figure 7).

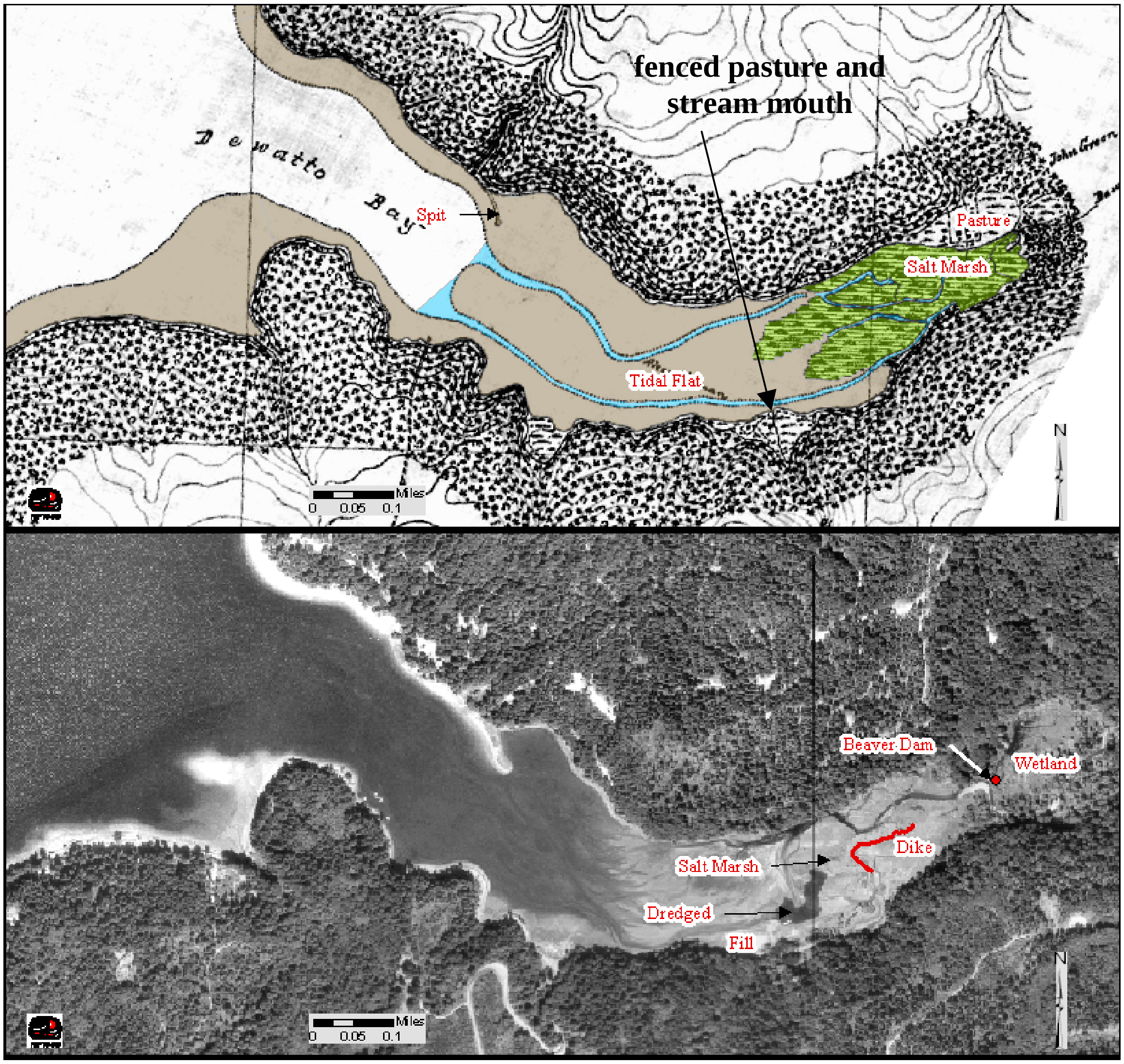


Figure 7. 1884 T sheet (at top) and 2000 WDNR orthophoto (bottom) showing the Dewatto River estuary. The current day (as of 2005) positions of a dike and beaver dam (obtained using a GPS in the field) are shown on the 2000 WDNR image.

Description of Historical Habitat Changes

Euro-American influence on the Dewatto River estuary and surrounding landscape is evident quite early in the historical record. In 1874, the north-south section line between sections 27 and 28 that runs through the bay was described as "all logged off" (Shoecraft 1874). The name "Alex Dillman" (sp?) is given in the 1874 GLO survey notes and in the 1884 T sheet along the south shore of the bay just downstream of the edge of the historical tidal marsh where a fenced grassland or pasture is shown near a small stream entering the bay (Figure 7 above). An oyster plant, built mostly on fill, has occupied this location for the past several decades, and tide flat has been dredged just off shore to create a deepwater port for boats accessing the oyster plant (Figure 8). A 1939 air photo of Dewatto Bay indicates that the dredging and filling had probably not occurred at this location yet. The T sheet also shows that "John Green" had an orchard and clearing along the north bank of the river near the present-day upper extent of tidal influence and a beaver pond wetland. Other indications of settlement in 1884 include a road leading to a log chute from the uplands to Dewatto Bay along its south shore. In later decades log rafting would occur throughout the bay seaward of the salt marsh, as evident in both 1939 and 1942 air photos.

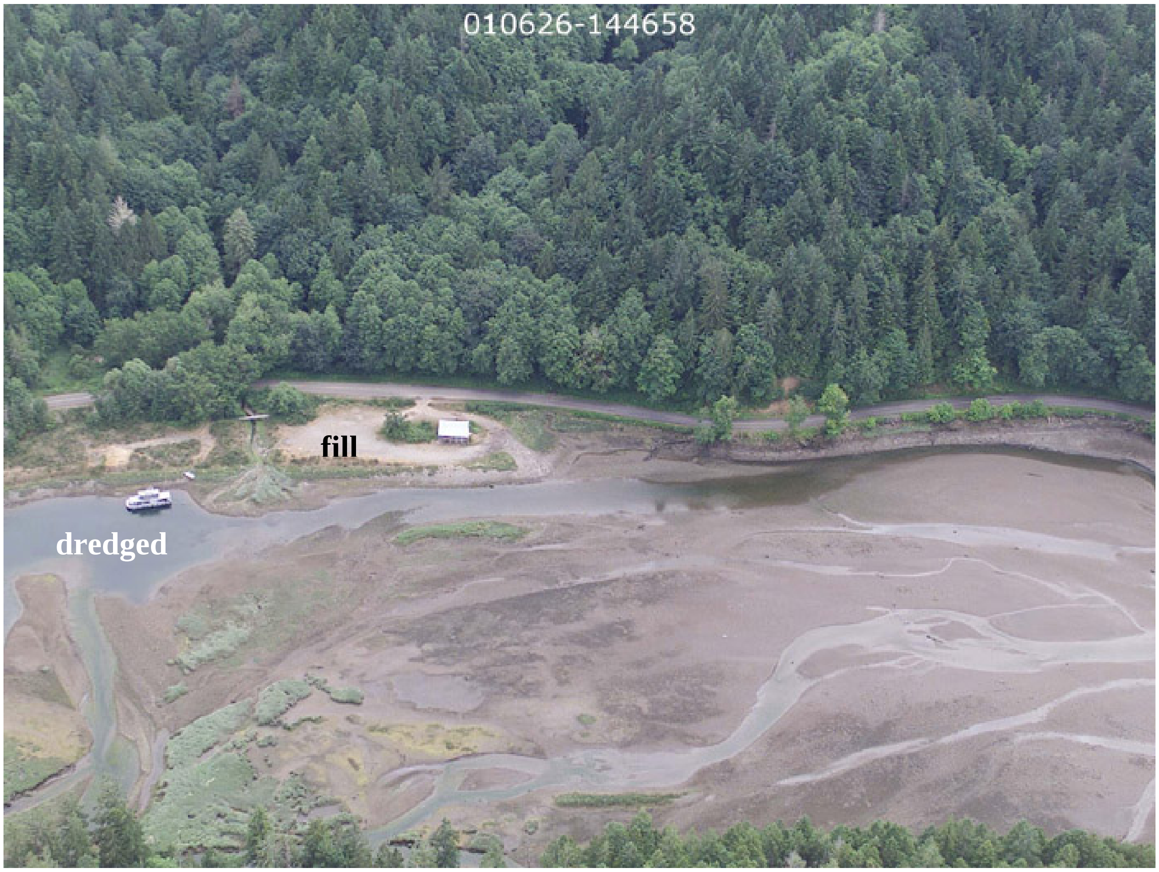


Figure 8. 2001 WDOE oblique photo showing dredged and filled tide flat associated with an old oyster plant in Dewatto Bay. Note the small stream entering the bay near the boat.

A quantitative summary of historical habitat changes to the Dewatto River complex is provided in Table 2. The Dewatto River estuary is often considered one of the more functional (in relation to historical) estuaries in the Hood Canal region. However, the Dewatto estuary has certainly not escaped some level of human manipulation. A road currently lies adjacent to the bay along nearly the entire length of the south shoreline. Perhaps the most noticeable impacts are the dredging mentioned above associated with the oyster plant along the south shore, and a dike near the center of the tidal marsh (Figure 7 above and Figure 9 below). This diking is not seen from a crude 1939 air photo (though it may have been present), but is certainly shown in place in a 1977 WDOE oblique photo. The initial and present-day purpose of the diking is unknown, and the impacts on the hydrology of the estuary are not well understood.

We do not see evidence of sediment progradation in the Dewatto delta as we find in many Hood Canal estuaries. The outer edge of salt marsh in the 1884 T sheet is approximately where we find it today (Figure 7 above). It is possible that we have even seen a relatively small net retreat in salt marsh during the past 120 years (Table 2). Possibly more interesting is that the T sheet indicates the landward edge of salt marsh to be some distance upstream from where we find it today. In fact, a beaver pond wetland that receives seasonal flood tide waters, occupies the area where the coast surveyors mapped the upper extent of salt marsh in 1884.

A narrow spit that protrudes from the north shore about two-third the distance from the Dewatto creek mouth and the mouth of Dewatto Bay, is similar in configuration but is about 28% reduced in its length according to our estimates between 1884 and today (Figure 7 above).

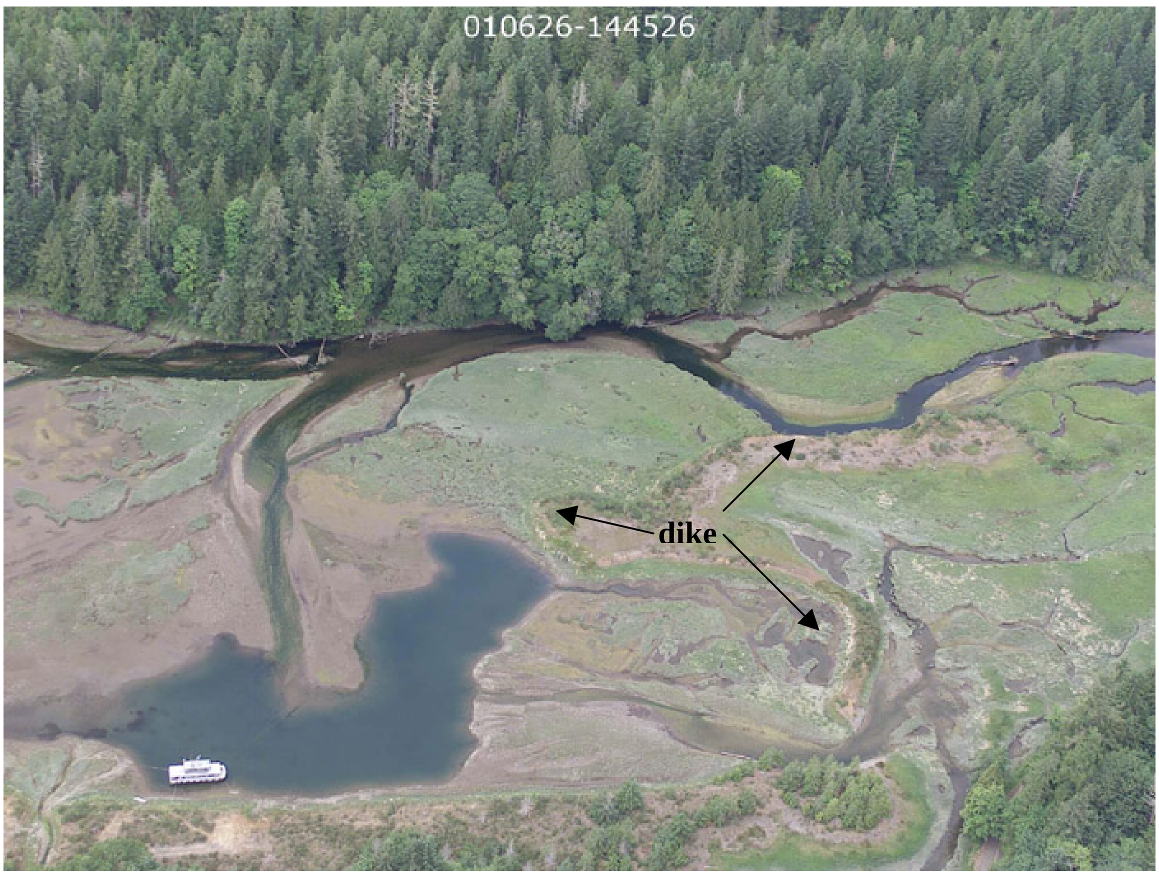


Figure 9. 2001 WDOE oblique photo showing a dredged boat basin and old dike in the Dewatto River estuary.

Table 2. Summary of habitat changes to the Dewatto River 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 (length)	250 ft	180 ft	- 70 ft	- 28
Spit (area)	0.06 ha	0.09 ha	+ 0.03 ha	+ 50
Tidal marsh (and channels)	8.00 ha	7.88 ha	- 0.12 ha	- 2
Lagoon	0 ha	0.61 ha *	+ 0.61 ha	+ 100 *
Tidal flat	26.72 ha	? ha **	? ha	?
Total (spit, marsh, lagoon)	8.06 ha	8.58 ha	+ 0.52 ha	+ 6

* Current day "lagoon" habitat is artificially dredged out of the tidal flat.
** 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 few overall historical changes to tidal marsh habitat in the complex, we consider the Dewatto estuary "Functional".

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

Physical Description

Little Dewatto Creek is a steep confined stream entering a small cove on Hood Canal south of Dewatto Bay. A small delta absent of salt marsh is evident from the 1884 T sheet. The north-south section line between sections 32 and 33 that crosses the mouth of Little Dewatto Creek was described in the 1874 GLO survey as "timber small, all logged off in the water front". A "logging road" was described running from the mouth up the left bank (~ 100 ft. from the stream?)(Shoecraft 1874). The same road is seen in the 1884 T sheet. The mouth of the creek was just 3 links (2 ft.) wide in April 1874 (Shoecraft 1874).

Description of Historical Habitat Changes

A 1939 air photo of the area is too coarse in resolution to be very useful. One obvious observation is the large clearings that run from the ridge-top to the creek along the left bank not far upstream of the mouth. A few small cabins or houses occur near the mouth, and salt marsh appears in 1977, 1993, and 2001 (Figure 10) oblique photos. It is unknown whether this salt marsh (0.56 hectares) has developed over time, possibly related to land clearing activities over the past 130+ years resulting in sediment aggradation. It might also be that the T sheet surveyors simply failed to map the marsh, though this seems unlikely as early surveys in the nearby area did map quite small patches of marsh.

Relative Condition

We consider the relative condition of Little Dewatto Creek “Functional”.

Figure 10. 2001 WDOE oblique photo of the Little Dewatto Creek habitat complex.

Habitat Complex: Two Points Marsh
Complex Type: Spit/marsh

Physical Description

The 1884 T sheets (1560a and 1560b) show a small fringing salt marsh surrounded by steep forested uplands. A surface water connection through the narrow berm to the marsh is not evident, and freshwater sources are unknown at this site.

Description of Historical Habitat Changes

Though our estimates of habitat changes suggest a considerable loss of marsh habitat at this site (Table 3), we see no clear evidence of human modifications to this marsh since the 1884 T sheet. A house is partially hidden in the forested uplands above the marsh, otherwise adjacent riparian vegetation appears intact (based on 1977, 1993, 2001 oblique photos; see 2001 oblique in Figure 11). Up-drift of the Two Points Marsh, bulkheading makes up about 20% of the length of the shoreline (Hirschi et al. 2003 and review of unpublished PNPTC data).

Table 3. Summary of habitat changes to the Two Points Marsh 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	0.07 ha	0 ha	- 0.07 ha	- 100
Salt marsh	0.11 ha	0.05 ha	- 0.06 ha	- 55
Total	0.18 ha	0.05 ha	- 0.13 ha	- 72

Figure 11. 2001 WDOE oblique photo showing the tiny fringing Two Points Marsh complex, left of center on shoreline.

Relative Condition

Our estimates indicate a substantial decrease in marsh habitat since 1884. However, because the overall size of the complex is so small and the variation in salt marsh size may well be a natural occurrence or reflect mapping inaccuracies, we consider the relative condition “Functional”.

Habitat Complex: Red Bluff Marsh
Complex Type: Spit/marsh

Physical Description

The name “Red Bluff” comes from the 1884 T sheet that shows these words at a small eroding bluff along the shoreline just north of this site. Salt marsh was either absent at this site historically, as the T sheet did not indicate its presence, or the surveyors simply failed to show a very small patch of salt marsh near the mouth of a small creek.

Description of Historical Habitat Changes

Today we see a patch of fringing low elevation salt marsh (0.19 hectares) just north of the stream mouth in 1977, 1993, and 2001 (Figure 12) oblique photos. The marsh is available to the tides though no spit or channel development is evident. A cabin is located along the shoreline just north of the marsh and is evident at least as far back as 1977 (WDOE oblique photo). Shoreline modifications up-drift of the Red Bluff Marsh complex include about 20% bulkheading (based on Hirschi et al. 2003 and informal review of unpublished PNPTC data).

Figure 12. 2001 WDOE oblique photo showing the Red Bluff marsh complex in the left part of the image. Notice the stream entering just right of the small patch of marsh.

Relative Condition

Based on few noticeable alterations at this site and an apparent gain in salt marsh, we consider the relative condition "Functional".

Habitat Complex: Cougar Spit (Shed)
Complex Type: Spit/marsh

Physical Description

According to the 1884 T sheet (T1560b), this small spit showed salt marsh and a small lagoon behind a narrow berm. We find no evidence of a surface water connection or freshwater inputs to the marsh itself, though a small stream, evident in both the T sheet and in modern day air photos, occurs just north of the spit. The T sheet also shows a road accessed the marsh from the uplands north of the spit.

Description of Historical Habitat Changes

Oblique air photos from 1977, the 1993, and 2001 (WDOE on-line series) indicate a few homes adjacent to or built on the former marsh, and it appears some of the historical salt marsh is now lawn. The tiny lagoon evident in the 1884 T sheet is no longer present (Figure 13 and Table 4 for a quantitative summary of historical habitat changes). Drift logs occur along the narrow berm of the spit. We estimate that bulkheading occurs along at least 50% of the shoreline up-drift (to the south) of Cougar Spit (based on informal review of Hirschi et al. 2003 and unpublished PNPTC data), although most of this bulkheading and a roadbed occur in the stretch between the divergence zone and Rendsland Creek.

Figure 13. 2001 WDOE oblique photo of the Cougar Spit habitat complex (at the right side of the image). A small stream, as evident by the presence of a delta fan, enters Hood Canal left of the marsh.

Table 4. Summary of habitat changes to the Cougar 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	0.12 ha	0 ha	- 0.12 ha	- 100
Salt marsh	0.25 ha	0.31 ha *	+ 0.06 ha	+ 24
Lagoon	0.04 ha	0 ha	- 0.04 ha	- 100
Total	0.41 ha	0.31 ha	- 0.10 ha	- 24

* Includes salt marsh and spit combined, as air photo resolution was inadequate for detecting a distinct boundary.

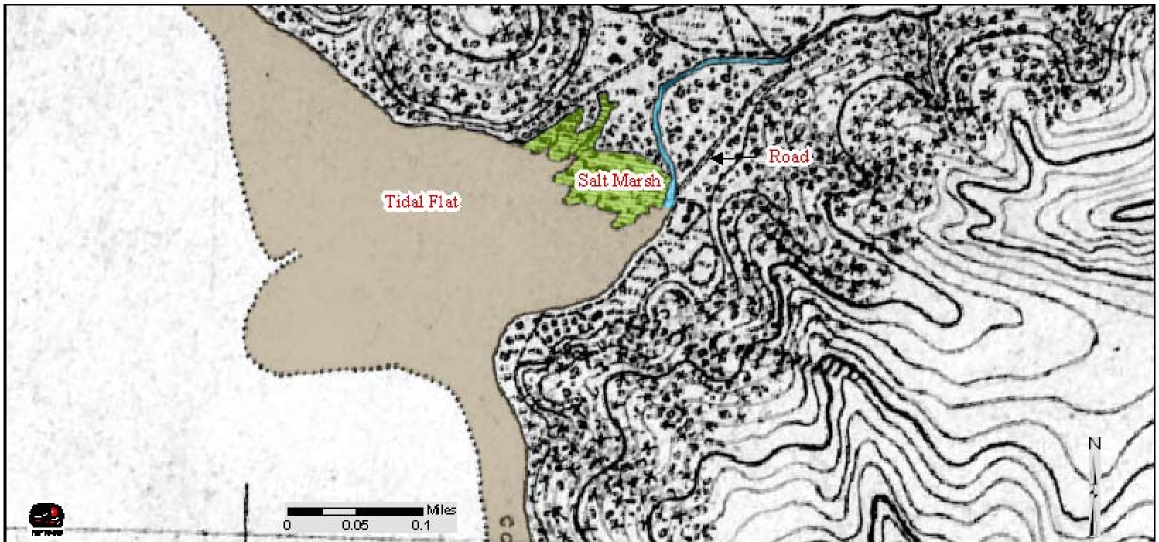
Relative Condition

Because of a measurable loss of former wetland habitat (i.e. salt marsh and lagoon), and encroachment by homes, we consider the relative condition “Moderately Impaired”.

Habitat Complex: Rendsland Creek (Dry Creek)
Complex Type: Stream-delta

Physical Description

Rendsland Creek drains from the southwestern tip of the Kitsap Peninsula. In September 1861, the GLO survey recorded a “dry stream bed”, 20 links (~ 13 ft.) wide both 1500 feet upstream and 3500 feet upstream of the mouth in mid September 1861. Just two weeks later, the stream width at the mouth was 15 links (10 ft.)(Terrill 1861). Did the first freshet of the season deliver water during that two week period, or is this the nature of hydrology in the watershed where stream flow can become sub-surface at the mouth during base flow conditions? “Dry Creek” was the name shown in the 1884 T sheet (Figure 14). The 1861 GLO notes suggest that the mouth of the stream entered Hood Canal in a position similar to where it is today, and where it appears in a 1942 air photo, in the north part of the estuary. The 1884 T sheet shows the mouth entering the estuary in a tide flat to the immediate south of the large patch of salt marsh, in the approximate current location of the artificially dredged channel that has occupied the estuary for the past several decades. A number of signs of Euro-American settlement are evident in the 1884 T sheet, with roads, fences, dwellings or other buildings, and apparent cleared forest areas in much of the lower valley.



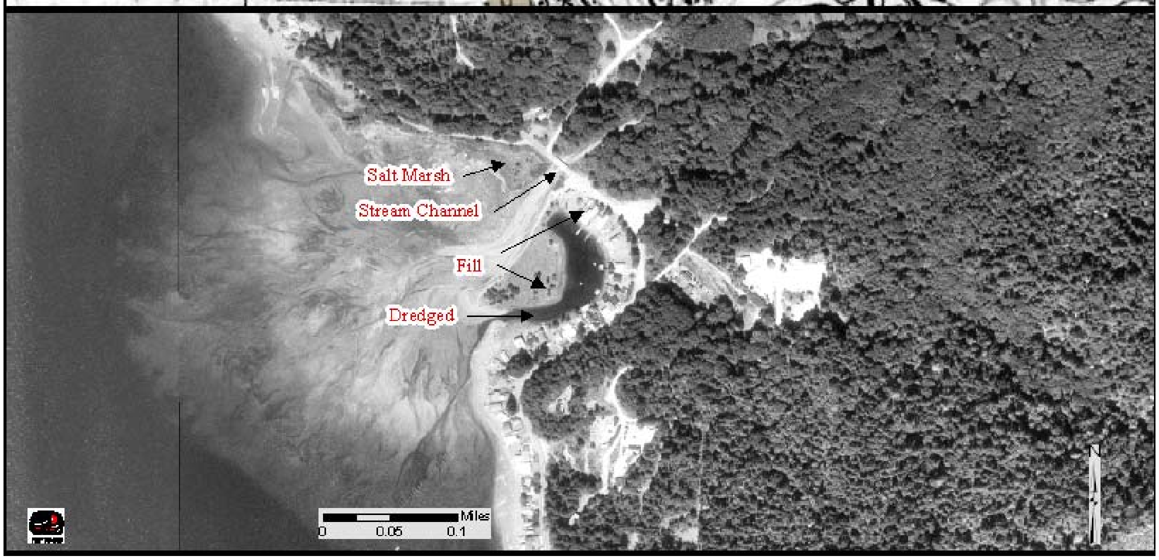


Figure 14. 1884 T sheet (at top) and 2000 WDNR orthophoto (bottom) showing the Rendsland Creek (Dry Creek) habitat complex. Notice the significant signs of settlement, with roads, fencelines, and evidently cleared forest in the lower stream valley in the 1884 T sheet and dramatic alterations to tidal wetland habitat since that time.

Description of Historical Habitat Changes

Major modifications have occurred to this estuary. A road crosses the stream mouth, and a large arm of fill and an artificial lagoon have replaced virtually all the historical tidal marsh and significant tide flat habitat (Figures 14 and 15, and Table 5 provides a quantitative summary of historical habitat changes). The dredge spoils from the artificial lagoon were likely placed on the delta to create the fill sometime between 1942 and 1977 (air photos). Houses line the east side of the lagoon and the lagoon entrance is regularly dredged (see Kuttel 2003). The filling of the tidal flat separates the artificial lagoon from the stream channel and a "new" tidal marsh has now grown in the delta (Figure 15). The Rendsland Creek delta occurs a short distance down-drift of a divergence zone at Ayres

Point located to the south. The entire shoreline between this divergence zone and the delta has been armored and much of the upper intertidal zone has been filled over for residential development (see Figure 16 in the Brown's Point Marsh habitat complex narrative below).

Table 5. Summary of habitat changes to the Rendsland Creek 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
Salt marsh	1.33 ha	0.66 ha	- 0.67 ha	- 50
Lagoon	0 ha	0.74 ha *	+ 0.74 ha	+ 100
Tidal flat	12.64 ha	? ha **	? ha	?

* An artificially-dredged "lagoon" has been created in recent decades for the purposes of boat access to private docks. We did not estimate the surface area of this feature. Juvenile salmonids are known to enter this lagoon (Ron Hirschi, personal communication).

** 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 15. 2001 WDOE oblique photo of the Rendsland Creek habitat complex. The artificially-dredged "lagoon" is separated from the creek channel and tidal marsh by the large isthmus of fill in the center of the image. This photo was taken in late June and notice the channel is mostly dry. The 1861 GLO surveyors also found no water at the mouth in the month of September.

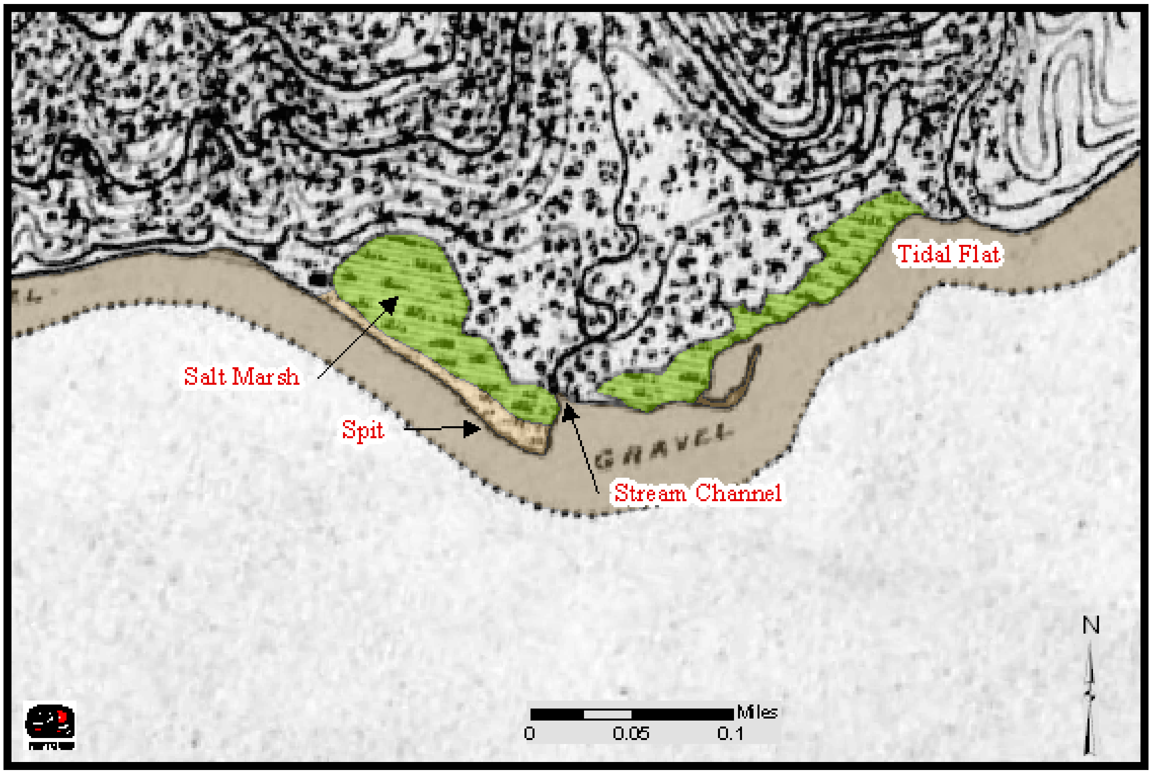
Relative Condition

Based on a substantial loss of historical tidal marsh habitat, and severe impairment of overall connectivity in this estuary, we consider the relative condition "Severely Impaired".

Habitat Complex: Brown's Point
Complex Type: Spit/marsh

Physical Description

Brown's Creek historically formed a delta that was framed to the east and west by salt marsh and a small spit protected a small tidally-accessible lagoon (Figure 16). We consider Brown's Point a spit/marsh complex because we consider longshore wave processes more dominant than fluvial processes in the forming of salt marsh and lagoon habitats at the site.



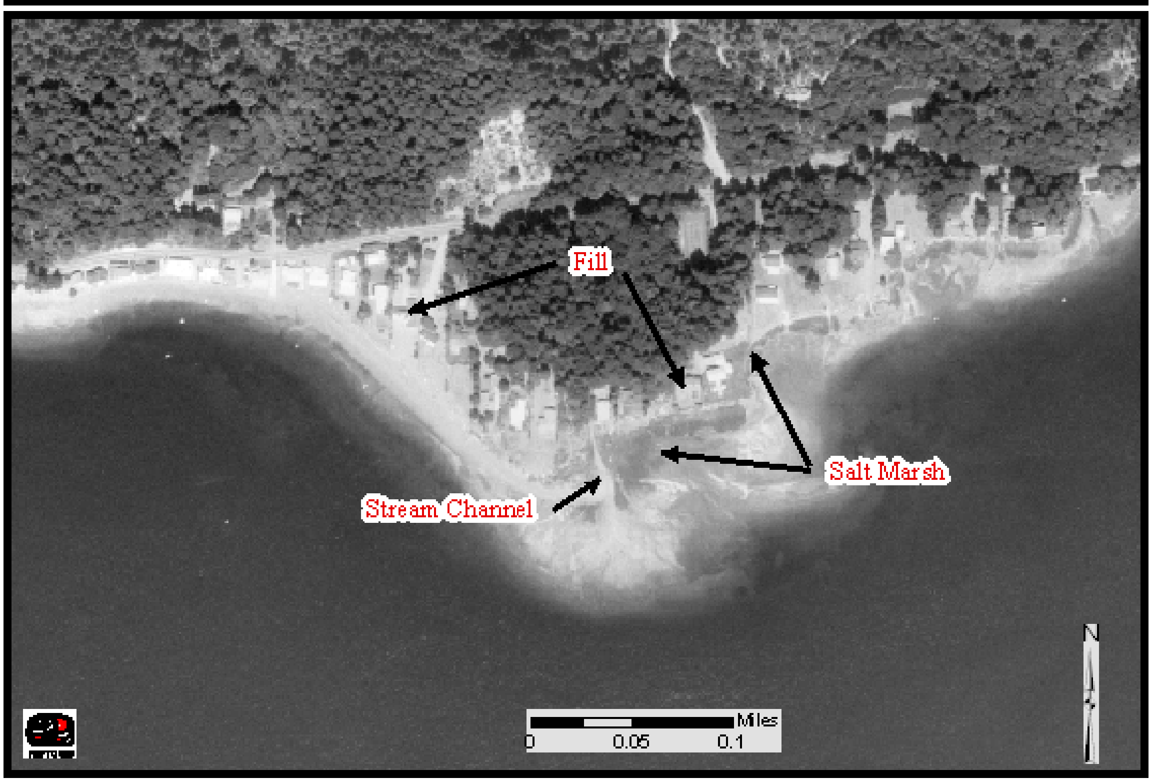


Figure 16. 1884 T sheet (top) and 2000 WDNR orthophoto showing habitat changes to the Brown's Point complex.

Description of Historical Habitat Changes

Table 6 provides a quantitative summary of historical habitat changes to the Brown's Point Marsh. A 1942 air photo of this area is too poor to make conclusions regarding habitat changes at that time. Certainly by 1977, most of the former marsh had been filled for houses (1977 WDOE oblique photo). A remnant of the marsh and a spit occurs today, though it may be submerged at high tides. It appears that some salt marsh may be developing out in front of armored as well as more natural shorelines (Figure 17). A number of houses have their own boat ramps or have cleared marsh for beach access (see 2001 WDOE oblique photos). The Brown's Point Marsh occurs just down-drift from a divergence zone at Ayres Point, and virtually the entire length of shoreline up-drift of the habitat complex has been armored and much of the upper intertidal zone filled over by houses with bulkheads and by North Shore Road (Hirschi et al. 2003 and informal review of WDOE oblique air photos)(Figure 18).

Table 6. Summary of habitat changes to the Brown's Point 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)	W (740 ft.); E (270 ft.)	0 ft. *	- 1010 ft. *	- 100
Spit (area)	0.33 ha	0 ha	- 0.33 ha	- 100
Salt marsh	1.85 ha	1.07 ha	- 0.78 ha	- 42
Total	2.18 ha	1.07 ha	- 1.11 ha	- 51

* Current day West Spit is narrow and fragmented by development along the shoreline, and thus we did not measure its length or area. The East Spit may now be reduced to a submerged spit during high tide.

Figure 17. 1993 WDOE oblique photo showing the Brown's Point Marsh complex. Brown's Creek can be seen entering Hood Canal just left of the center of the image.

Figure 18. 1993 WDOE oblique photo in which the headland shoreline shown in the foreground (Ayres Point) is a divergence zone where net shore drift of sediment is transported to the left toward Rendsland Creek in the background, and to the right (east) toward the Brown's Point Marsh habitat complex. This entire divergence zone and the short stretch of shoreline off the map to the right are completely armored by the road, and a number of homes are built on fill within the intertidal zone.

Relative Condition

Based on the substantial loss of historical salt marsh and the apparent erosion of a former spit feature, we consider the relative condition "Severely Impaired".

Habitat Complex: Hall Marsh
Complex Type: Spit/marsh

Physical Description

Based on the 1884 T sheet, this small backshore salt marsh (0.28 hectares) had no apparent surface water connectivity with adjacent open waters. Although freshwater inputs to the marsh itself are unknown, two small streams enter Hood Canal to the immediate west (Hodd Creek) and east (Hall Creek) of the marsh.

Description of Historical Habitat Changes

This marsh has been filled over for residential development (Figure 19). A remnant or newly emerged salt marsh (0.21 hectares), evident at least as far back as 1977 (WDOE oblique photo) appears out in front of a bulkheaded and partly driftwood-strewn shoreline. The drift cell between Ayres Point at a divergence zone and its termination at Tahuya Bay has been bulkheaded along 55% of its length (Hirschi et al. 2003). The North Shore Road occurs along much of this shoreline.

Figure 19. 2001 WDOE oblique photo of the Hall Marsh habitat complex, showing low-elevation salt marsh growing seaward of the shoreline.

Relative Condition

Based on the near complete filling of the former marsh for houses, we consider this habitat complex "Severely Impaired". Only the presence of a new marsh developing out in front of the shoreline prevents us from rating this complex "Lost".

Habitat Complex: Hogan's Spit/Caldervin Creek
Complex Type: Spit/marsh

Physical Description

We included the stream mouth of the steep Caldervin Creek, a narrow spit at the mouth of Tahuya Bay, and a salt marsh immediately west of the spit as one habitat complex due primarily to their close proximity to one another (Figure 20). Caldervin Creek has a very small delta and Hogan's Spit was formed by longshore sediment processes from the west.

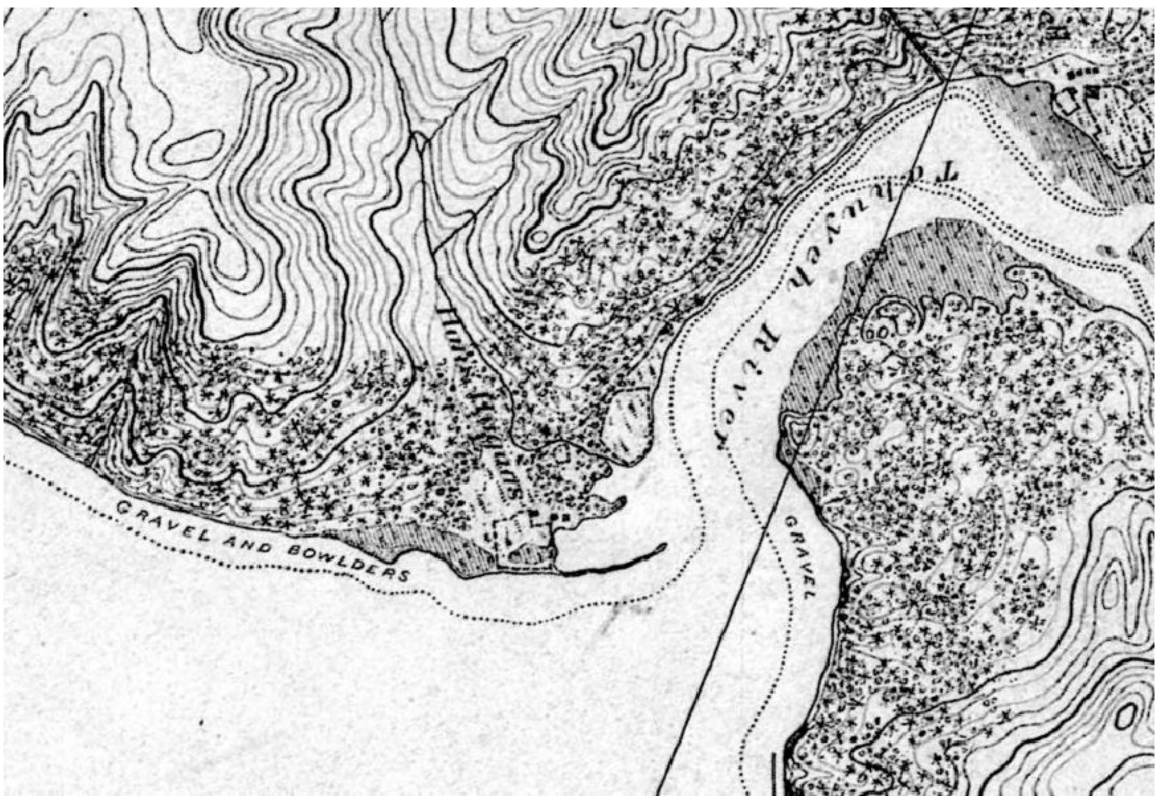


Figure 20. 1884 T sheet showing the Hogan's Spit/Caldervin Creek spit/marsh complex at the west entrance to Tahuya Bay where the Tahuya River enters. Caldervin Creek enters the bay north of the spit. A salt marsh is evident along the shoreline just west of the Hogan's Spit.

Description of Historical Habitat Changes

At the time of the 1884 T sheet, Hank Hogan had cleared and fenced an area near the base of the spit and the larger salt marsh to the west of the spit. One wonders if already the salt marsh had been manipulated or partially filled, although this is just speculation. A 1942 air photo, though crude, still shows a shape of Hogan's Spit resembling that seen in 1884, and there is reason to believe that little development had occurred at the site (Figure 21). By 1977 (WDOE oblique photo), however, the salt marsh had been entirely filled, and the tide flat and salt marsh behind the spit had been filled for houses (Figure 22). Habitat changes at the Hogan's Spit/Caldervin Creek complex are summarized in Table 7.

Hogan's Spit defines the termination of a drift cell that originates at a divergence zone at Ayres Point to the west. This drift cell is 55% bulkheaded (Hirschi et al. 2003), and much of it is associated with the North Shore Road.

Table 7. Summary of habitat changes to the Hogan's Spit/Caldervin 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)	560 ft	0 ft. *	- 560 ft.	- 100
Spit (area)	0.13 ha	0 ha	- 0.13 ha	- 100
Salt marsh	1.01 ha	0 ha	- 1.01 ha	- 100
Total	1.14 ha	0 ha	1.14 ha	- 100

* The spit has been completely developed over.

Figure 21. 1942 U.S. Army air photo showing Hogan's Spit and associated tidal marsh to the north associated with Caldervin Creek prior to major development of this site.

Figure 22. 1977 WDOE oblique photo showing the Hogan's Spit/Caldervin Creek habitat complex at the entrance to Tahuya Bay (compare with the 1942 air photo – Figure 21, and 1884 T sheet – Figure 20, both shown above).

Relative Condition

Based on the complete loss of the historical spit and marsh, we consider the relative condition of this complex as "Lost".

Habitat Complex: Tahuya River
Complex Type: Stream-delta

Physical Description

Similar to the Dewatto River, the Tahuya River enters the head of a long narrow protected embayment, where a relatively extensive tidal marsh occurs. Euro-American land use activity was already apparent at the time of the 1861 GLO and 1884 T sheet surveys. The GLO survey notes from September 1861 (Terrill 1861) provide the widths and positions of the major Tahuya River tide channels and sloughs, and they tend to agree with the 1884 T sheet (Figure 23). The positions of logging roads in the 1861 GLO surveys correspond well with the locations of roads shown in the T sheet 23 years later. At least two settlers' names are shown in the 1884 map. One is William Stowell, who apparently had cleared land for pasture and had fencing in what is today immediately upstream of the bridge crossing along the right bank. Near the upper tidal extent of the estuary, the name "J. Ross" appears on the 1884 map, and several clearings and fencings are evident.

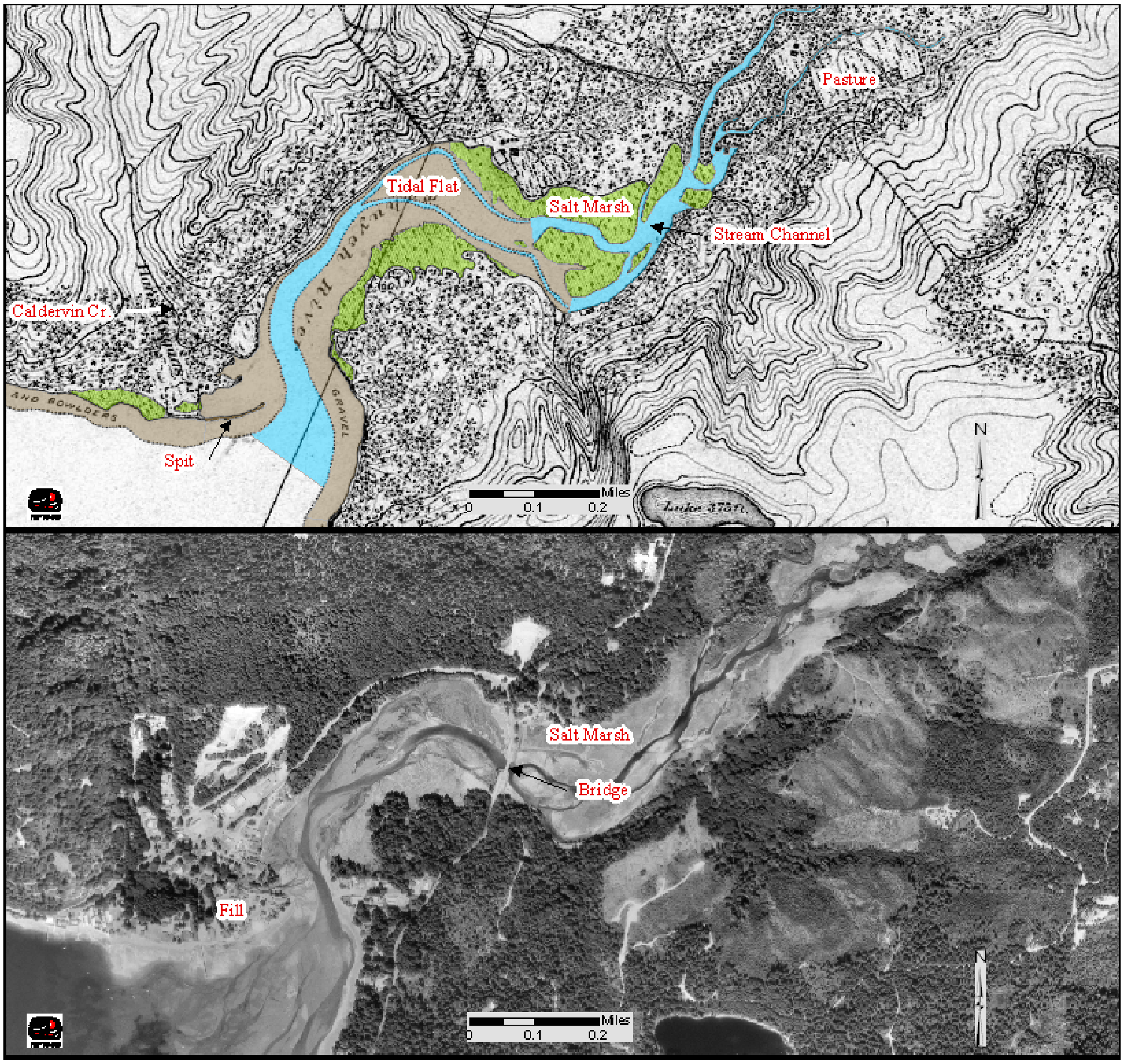


Figure 23. 1884 T sheet (at top) and 2000 WDNR orthophoto (bottom) showing the Tahuya River estuary. The Hogan's Spit/Caldervin Creek complex occurs at the southwest entrance of the embayment.

Description of Historical Habitat Changes

Table 8 provides a quantitative summary of historical habitat changes to the Tahuya estuary. The bridge causeway across the estuary has eliminated some former salt marsh and tide flat habitat, and reduced tidal exchange under the bridge to a single channel (Figure 24). Immediately upstream of the bridge in the old Stowell settlement along the right bank, a channel has been dredged, and the upper margins of the salt marsh as shown in 1884 have probably been modified for agricultural development.

Table 8. Summary of habitat changes to the Tahuya 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
Salt marsh (and channels)	16.24 ha	19.75 ha	+ 3.51 ha	+ 22
Tidal flat	23.90 ha	? ha *	? 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.

It appears that the estuary upstream of the bridge crossing may be filling in with salt marsh in places that were formerly tide flat, which could be the result of a reduction in tidal exchange through the bridge causeway. A 1942 air photo indicates channel patterns and major salt marsh patches that resemble those seen in the 1884 T sheet. Though the bridge was certainly in place by the early 1940s, the bridge opening may have been narrowed since that time with a causeway.

Though it seems likely that upper tidal channels and the main river channel have been manipulated during the past 100-150 years with farming, roads, logging, and removal of large woody debris, we find no obvious lasting signs of any such changes today.

Logging and road construction activities are the primary land uses in the watershed. However, land use impacts on fluvial processes also include floodplain and riparian modification associated with agricultural and residential development, the systematic removal of large woody debris, and the conversion of wetlands to reservoirs that include residential developments (see Kuttel 2003 and WDFW and PNPTT 2000).

Relative Condition

Although some modifications to the Tahuya estuary are evident, a net gain in tidal marsh is estimated, and the overall connectivity has been relatively unimpaired. For these reasons, we consider the relative condition "Functional".

Figure 24. 2001 WDOE oblique photo of the bridge crossing and causeway in the Tahuya River estuary.

Habitat Complex: Ayock Point
Complex Type: Spit/marsh

Physical Description

Ayock Point is a cuspate spit at the convergence of drift cells. Historically, the spit supported marsh at the north, and a narrow north-south spit with fringing marsh and a tidal opening to a lagoon to the south. The 1884 T sheet shows a stream entering near the south edge of the spit (Figure 25).

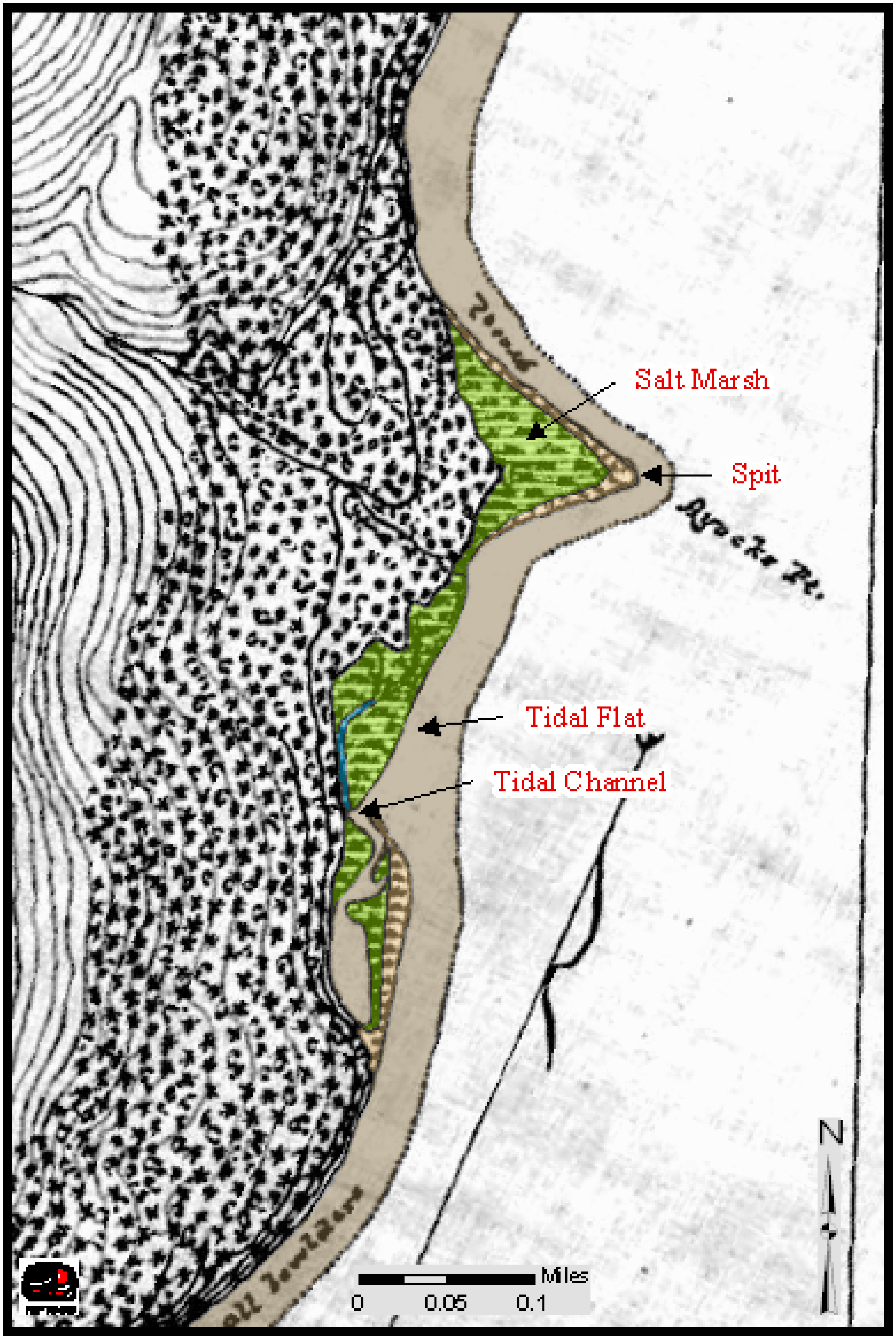


Figure 25. 1884 T sheet of the Ayock Point habitat complex.

Description of Historical Habitat Changes

Overall historical habitat changes are summarized in Table 9. A 1942 air photo, though lacking detail, suggests that most of this complex probably was in a condition resembling the 1884 map at the time. By 1977, however, the entire Ayock Point spit had been developed for houses, and all of its former marsh had been filled. A remnant marsh exists today in association with the stream channel, though it appears fragmented and surrounded by houses and yards (Figure 26).

Shoreline modifications up-drift of Ayock Point to the north include 30% bulkheading along the spit itself and a short divergence zone just north of the spit. Bulkheads occur along 41% of the drift cell to the south of Ayock Point (Hirschi et al. 2003), with Highway 101 adjacent to the shoreline along most of this length.

Table 9. Summary of habitat changes to the Ayock Point 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)	0.72 ha	0 ha *	- 0.72 ha	- 100
Salt marsh	2.61 ha	0.40 ha	- 2.21 ha	- 85
Total	3.33 ha	0.40 ha	- 2.93 ha	- 88

* Historical spit has been filled over.

Figure 26. 1993 WDOE oblique photo of the Ayock Point Marsh habitat complex.

Relative Condition

Based on the loss of most of its historical marsh habitat and complete development of the spit feature, we consider the relative condition "Severely Impaired".

Habitat Complex: Eagle Creek
Complex Type: Stream-delta

Physical Description

The 1884 T sheet shows Eagle Creek entering a tide flat and salt marsh was protected behind a spit to the immediate south (Figure 27). A road is shown in the T sheet leading from the estuary along Eagle Creek to the uplands. The April 1873 GLO notes report the width of Eagle Creek at 10 links (6.6 ft.) not far upstream of the mouth. The 1874 GLO survey described the north-south section line to the immediate west of the Eagle Creek estuary as "partly logged off" (Shoecraft 1874).

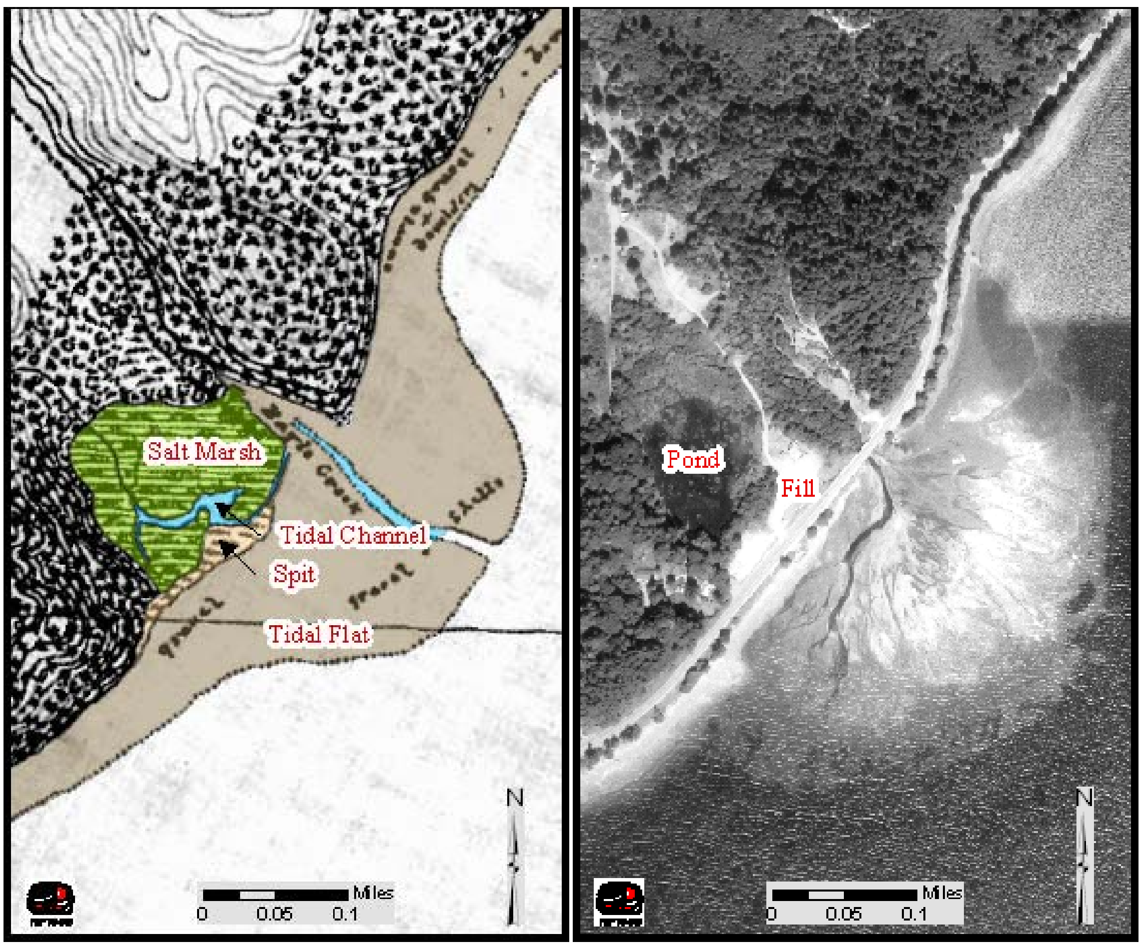


Figure 27. 1884 T sheet (at left) and 2000 WDNR orthophoto (at right) showing the Eagle Creek estuary in Hood Canal.

Description of Historical Habitat Changes

It appears that Highway 101 may have been the first major direct impact to this estuary. Air photos from 1942 and particularly 1957 (Figure 28) indicate filling along the former spit and a bridge crossing at the creek mouth, and substantial filling immediately landward of the highway in historical salt marsh. A comparison of oblique photos from 1977, 1993, and 2001 indicate even more extensive filling even since 1993, resulting in what appears to be the near complete elimination of the former salt marsh. Sometime since 1993 a road was built through part of a marsh that was historically tidally influenced and is now apparently entirely freshwater marsh and disconnected from the tides (Figure 29). The potential exists to reconnect this currently freshwater wetland to the tides and Eagle Creek. Overall, both the extent of salt marsh (Table 10) and the overall connectivity have been severely impaired at Eagle Creek.

Bulkheads occur along 41% of the drift cell that Eagle Creek occurs within (Hirschi et al. 2003), and Highway 101 lies adjacent to the shoreline along nearly the entire length of this drift cell.

Figure 28. 1957 air photo of the Eagle Creek habitat complex when the marsh upstream of Highway 101 was probably still tidally influenced.

Figure 29. 2001 WDOE oblique photo showing the Eagle Creek habitat complex. The large marsh and pond visible in the image was shown as a salt marsh in the 1884 T sheet (see Figure 27 above), and is now a freshwater wetland.

Table 10. Summary of habitat changes to the Eagle Creek 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)	0.48 ha	0 ha *	- 0.48 ha	- 100
Salt marsh	3.07 ha	0.17 ha	- 2.90 ha	- 94
Lagoon	0.27 ha	0 ha	- 0.27 ha	- 100
Tidal flat	9.77 ha	? ha **	? ha	?
Total (spit, marsh, lagoon)	3.82 ha	0.17 ha	- 3.65 ha	- 96

***** Historical spit has been completely filled over by Highway 101.

** 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

Because nearly all historical tidal wetland has been eliminated at this complex, we consider the relative condition “Severely Impaired”.

Habitat Complex: Cabin Marsh
Complex Type: Spit/marsh

Physical Description

The 1884 T sheet shows a tiny narrow fringing salt marsh (0.20 hectares). The ink seems to have been smeared on the original chart, and so it is difficult to determine whether any surface connection existed at the time. No freshwater inputs are known at this site. Just south of the marsh was a small apparently wooded spit or headland with the word “Cabin” indicated on the T sheet, and a log chute from the uplands to the shoreline is shown just south of the site.

Description of Historical Habitat Changes

This salt marsh has been filled probably sometime since 1957 (air photo), though the 1957 photo is of relatively poor quality. A 1977 oblique air photo seems to show a remnant patch of salt marsh along the north end of the former marsh, the rest having been developed for homes. Since 1977, it appears that the remnant has since been filled (Figure 30).

The drift cell along which the Cabin Marsh complex occurs is 41% bulkheaded (Hirschi et al. 2003), and Highway 101 occurs adjacent to the shoreline nearly the entire length.

Relative Condition

This habitat complex is considered “Lost”.

Figure 30. 2001 WDOE oblique photo showing the site of the historically tiny (0.20 ha) Cabin Marsh complex. The marsh was developed over probably between the late 1950s and 1977.

Habitat Complex: Lilliwaup Creek
Complex Type: Stream-delta

Physical Description

Lilliwaup Creek enters a tidal marsh at the head of a narrow embayment. The 1884 T sheet indicates that pasture and orchard had been established along the left bank of the lower stream and estuary, and the name W. J. Taylor is the name shown on the map (Figure 31). It is difficult to tell from the T sheet alone whether some loss of salt marsh may have occurred by this time from diking. The width of the creek was 70 links (46 ft.) at its mouth in April 1873 (Shoecraft 1874).

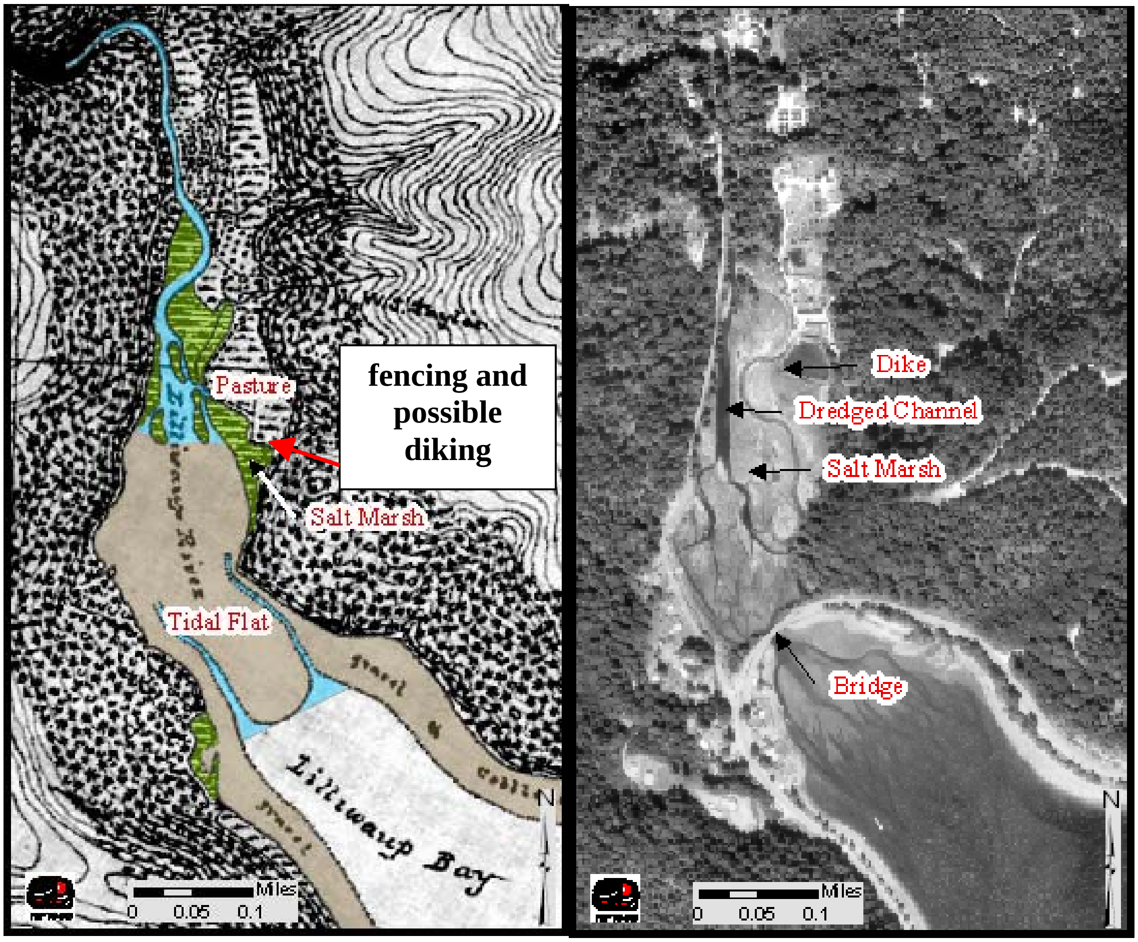


Figure 31. 1884 T sheet (at left) and 2000 WDNR orthophoto (at right) of the Lilliwaup Creek estuary. The area immediately east of the historical salt marsh was largely fenced (and possibly diked) and either grazed or in cultivation in 1884. Today this area is mostly diked off and a trout pond has been constructed. The current day tidal marsh extends well south of the extent indicated in the 1884 T sheet.

Description of Historical Habitat Changes

Table 11 provides a quantitative summary of historical habitat changes in the Lilliwaup Creek estuary. Like most watersheds in the Hood Canal region, logging has figured prominently in changes to salmon habitat, primarily through increases in sedimentation and reductions in large woody debris loading to streams. The Lilliwaup watershed was logged by the 1930s (Correa 2003). A 1958 air photo shows the left bank area that was being grazed or cultivated in 1884 is lacking obvious signs of diking, filling or buildings (Figure 32). By 1977, however, much of this area had been diked off. One interesting change has occurred more recently. It appears that sometime between 1977 and the 1993, the main channel was switched to the west and obvious signs of dredging and straightening are found in the 1993 and 2001 oblique imagery (Figure 33). The east channel that was the main channel in 1958 and in 1977 became a secondary distributary channel by 1993 and 2001.

The Highway 101 bridge crossing was put in place in about the 1920s-30s. Direct filling of tide flat and some salt marsh occurred as a result of the bridge causeway and placement of the highway itself along the west shore of the bay especially. A comparison between the 1884 T sheet, 1958 air photo, 1977, 1993, and 2001 oblique air photos suggest that a southerly advance in salt marsh has taken place since 1884. This seaward advance was evident by 1958, and less change is evident since that time. The relationship between this salt marsh advance and the bridge restriction further to the south is uncertain, but seems likely. We find a similar pattern in other naturally confined estuaries that become even more confined with fill or road crossings, for example in the Tahuya River estuary. In contrast, where we do not have artificial confinements we do not see this noticeable advance in salt marsh, which we take as indicative of sediment accretion. Also contributing to the sediment aggradation is a long history of logging throughout the watershed and more recent residential development in the lower stream corridor that have probably increased sediment yield and transport to the estuary.

Table 11. Summary of habitat changes to the Lilliwaup Creek 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
Tidal marsh	3.46 ha *	5.44 ha	+ 1.98 ha	+ 57
Lagoon	0 ha	1.43 ha **	+ 1.43 ha	+ 100
Tidal flat	12.27 ha	? ha ***	? ha	?
Total (marsh, channels, lagoon)	3.46 ha	6.87 ha	+ 3.41 ha	+ 99

* Though unsubstantiated, it is possible that this underestimates the amount of historical tidal marsh because some marsh may have already been diked off at the time of the 1884 T sheet.

** The current day "lagoon" is actually tidal flat and associated channels located immediately upstream of the Hwy. 101 fill. We consider it lagoon because it is relatively protected behind the highway causeway.

*** 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.

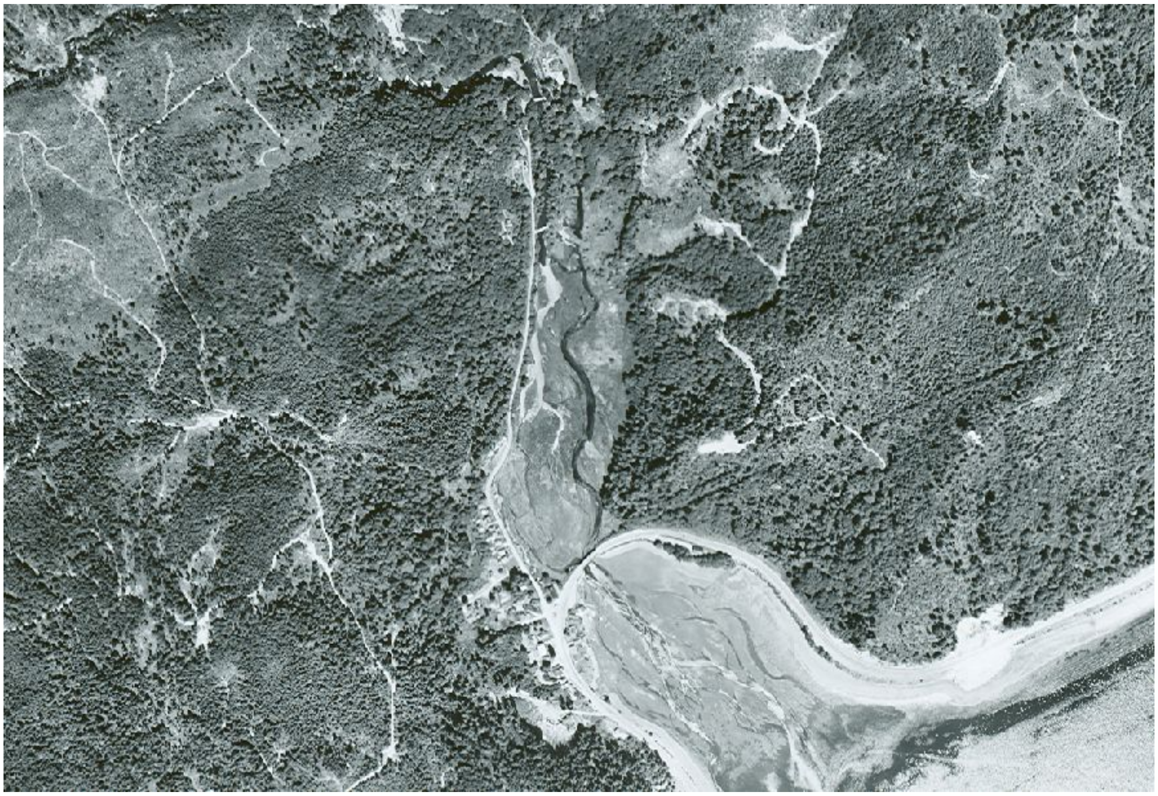


Figure 32. 1958 air photo of the Lilliwaup Creek habitat complex.

Figure 33. 2001 WDOE oblique photo of the Lilliwaup Creek estuary, looking downstream. The Highway 101 Bridge crossing is at the top of the image. The left side (north side) of the estuary is largely diked and filled for roads and a few residences. The 1884 T sheet also indicates this area was being grazed and cultivated and possibly diked off at the time, though this is not corroborated by other sources.

Relative Condition

Though considerable gains in tidal marsh since 1884 are estimated, most of this gain is probably owing to a progradation of salt marsh at the expense of tidal flat. In addition, the connectivity of the estuary has been impaired by the Highway 101 Bridge and causeway and by diking of salt marsh and channel dredging in the estuarine reach. For these reasons, we consider the relative condition “Moderately Impaired”.

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

Physical Description

Little Lilliwaup Creek is a steep naturally confined channel and a small delta (based on the 1884 T sheet, our estimate of the historical surface area of tidal flat associated with the delta is 3.35 hectares). The April 1873 GLO survey recorded the width at the mouth at 20 links (13.5 ft.)(Shoecraft 1874). The T sheet shows no salt marsh present at this site, and very little occurs there today.

Description of Historical Habitat Changes

Highway 101 crosses the mouth of the stream and its construction appears to have resulted in the filling of much of the upper portion of the tide flats (Figure 34). It is unknown how the highway and stream crossing might impair tidal exchange and fluvial processes at this site.

Relative Condition

It is difficult to apply a relative condition rating where there is so little habitat to consider and virtually no saltmarsh. However, because the upper tidal portion of the delta has been filled by the highway we consider the stream delta complex "Moderately Impaired".

Figure 34. 1993 WDOE oblique photo showing the Little Lilliwaup Creek delta (just right of center) entering Hood Canal under Highway 101. A smaller stream also enters the canal near the center of the image. The homes shown at left center of the image are built on fill below high water and bulkheaded.

Habitat Complex: Sund Creek
Complex Type: Stream-delta

Physical Description

Sund Creek is a steep stream entering a limited estuary. The 1884 T sheet indicates two separate channels entering either side of an accretion feature along the shoreline (Figure 35). The seaward edge of this accretion form supported a narrow band of salt marsh.

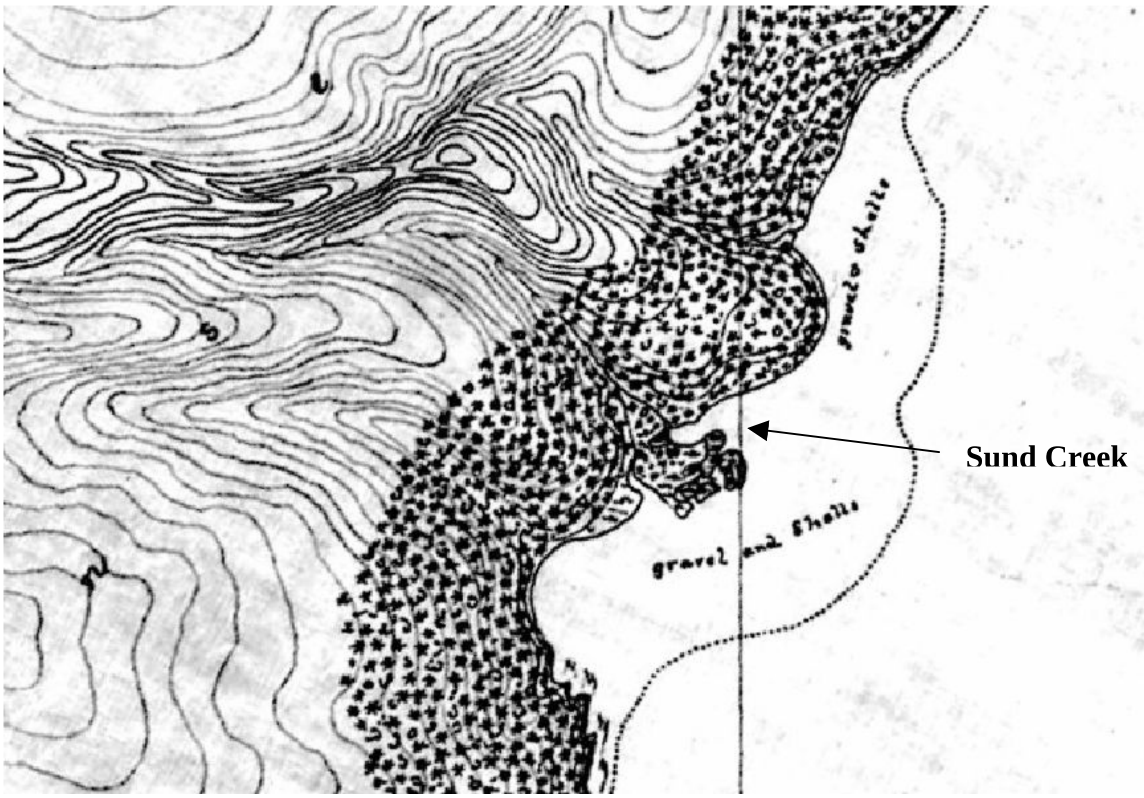


Figure 35. 1884 T sheet showing the small Sund Creek stream-delta.

Description of Historical Habitat Changes

Today, Highway 101 crosses the mouth and causing substantial filling of former tide flat to the immediate south and north of the mouth, as is evident from the 1977 and more recent oblique photos (Figure 36). A trailer park and additional large structure has been constructed north of the delta on fill extending out past the high water mark. Land use adjacent to the complex, in addition to the highway and trailer park, includes a gravel pit just west of the highway. Despite historical modifications, we estimate that more salt marsh exists today than did in 1884 (Table 12), most of it occurring out in front of the trailer park, approximately where it was located historically, and an additional patch of marsh at the creek mouth, probably related to stream sediment accretion at the delta.

Figure 36. 2001 WDOE oblique photo of the Sund Creek habitat complex.

Table 12. Summary of habitat changes to the Sund Creek 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 (grassland)	0.54 ha *	0 ha	- 0.54 ha	- 100
Salt marsh	0.30 ha	0.46 ha	+ 0.16 ha	+ 53
Tidal flat	9.75 ha	? ha **	? ha	?
Total (spit, marsh)	0.84 ha	0.46 ha	- 0.38 ha	- 45

* Historical "spit" consisted of a low-lying grassland immediately south of the creek inlet and another patch of grassland immediately landward of the salt marsh.
** 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

Though total salt marsh has increased in association with Sund Creek, some tidal flat has been filled. In addition, the overall habitat connectivity has been impaired by the highway crossing and other development at the creek mouth. For these reasons, we consider the relative condition "Severely Impaired".

Habitat Complex: Miller Creek
Complex Type: Stream-delta

Physical Description

The GLO survey measured the width of Miller Creek at its mouth at 13 links (~ 9 ft.) in March 1873 (Jameson 1873). The 1884 T sheet shows a substantial patch of salt marsh to the immediate north of the creek mouth (Figure 37).

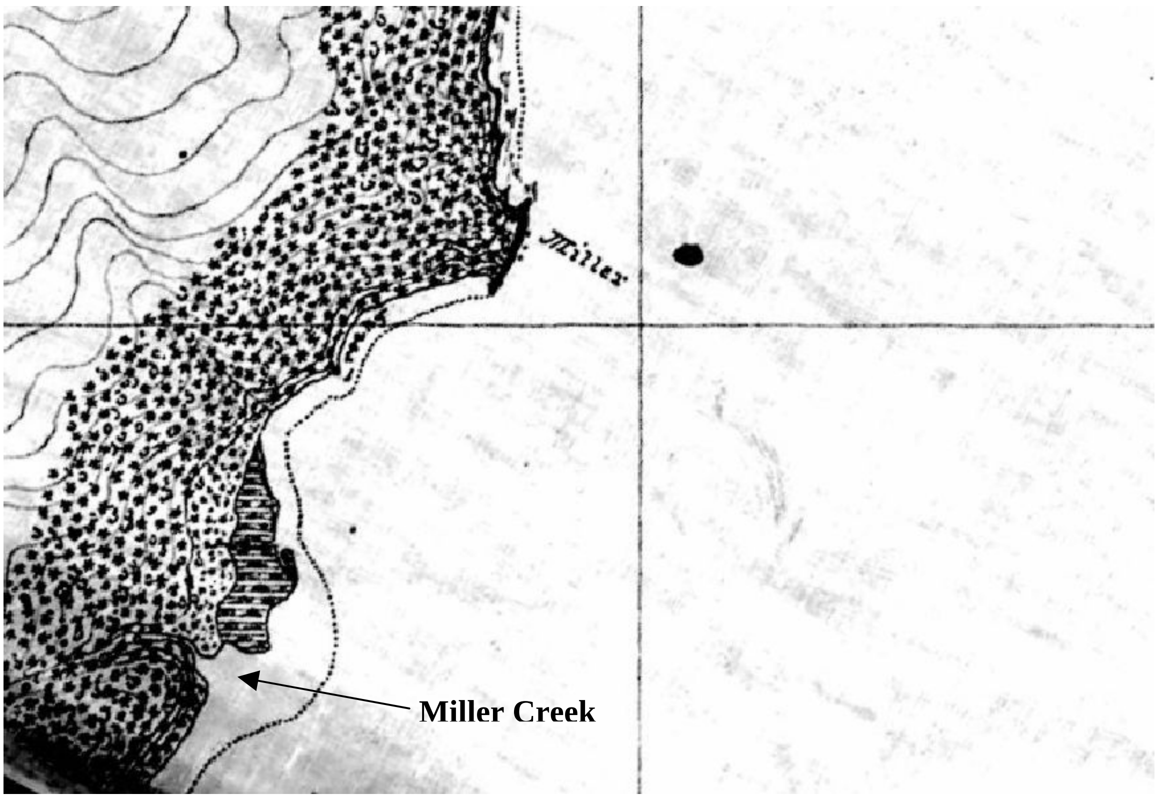


Figure 37. 1884 T sheet (T1560a) showing the Miller Creek stream delta complex near the south end of the image. The adjacent T sheet to the south (T1560b) captured the southern part of this habitat complex, and interestingly, indicated a patch of low-elevation salt marsh at the creek inlet immediately south of the large patch of salt marsh shown in this image. Therefore, our historical estimate of salt marsh may be somewhat conservative since our calculation is based on the northern T sheet. Of more importance, this also raises the broader issue of mapping inconsistencies in the early T sheets (see Discussion section in the main report). In this case, T sheets 1560a and 1560b were both mapped by J. J. Gilbert.

Description of Historical Habitat Changes

Like most streams in this part of Hood Canal, Highway 101 crosses the mouth and resulted in the loss of tidal flat habitat. Our estimates are that 92% of the historical salt marsh (1.31 ha) has been lost (our current day estimate of salt marsh is just 0.11 ha), mainly to the development of houses, at least as early as 1977 (WDOE oblique air photo). The creek is channelized both upstream and downstream of the highway crossing, with the channel running within a couple of feet of the corner of a house in at least one case (Figure 38). A long pier occurs immediately south of the creek mouth. Miller Creek occurs near the terminus of a south-to-north drift cell that starts at the mouth of Finch Creek. Bulkheads occur along 65% of the length of this drift cell (Hirschi et al. 2003).

Figure 38. 2001 WDOE oblique photo of the Miller Creek habitat complex. The lower reach of the creek channel is often dry by mid-spring, as shown in this photo. Note how confined the channel becomes, particularly just upstream of the highway where it flows in very close proximity to houses. Note also the filling of upper intertidal beach for residential development to the left of the creek mouth in this image.

Relative Condition

Based on the near complete loss of historical salt marsh and encroachment of residential and transportation infrastructure on the lower end of the creek, we consider the relative condition of the Miller Creek complex "Severely Impaired".

Habitat Complex: Clark Creek
Complex Type: Stream-delta

Physical Description

Clark Creek is a steep stream with little to no estuary. Salt marsh is absent in the 1884 map, though the lower reach of the creek is surrounded by grassland or fenced pasture (Figure 39). It is possible, though unsubstantiated, that some marsh existed at the site historically but had been diked off for grazing or cultivation by 1884. The March 1873 GLO survey measured the width at 10 links (6.6 ft.) at the mouth (Jameson 1873).

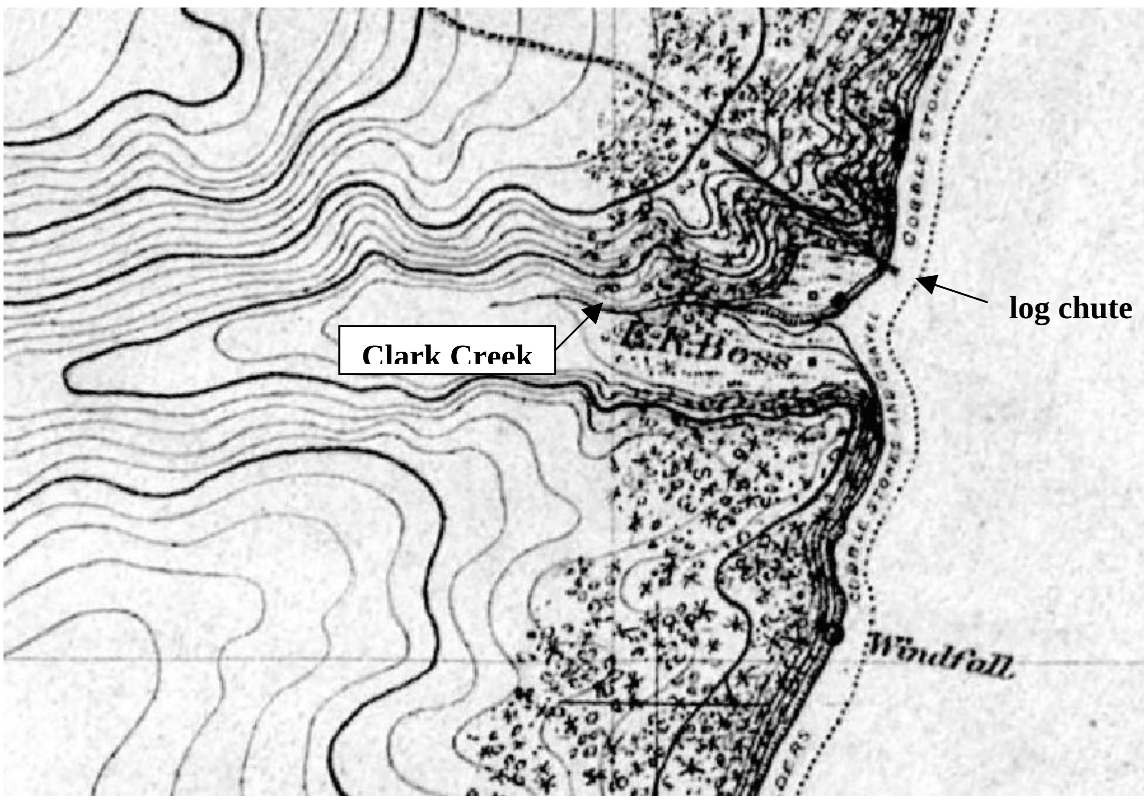


Figure 39. 1884 T sheet of the Clark Creek stream-delta complex. A log chute from the uplands to Hood Canal is shown just north of the creek with a road leading to the chute.

Description of Historical Habitat Changes

Probably the most important direct impact to this stream-delta is the filling of tide flat at the mouth, associated with Highway 101. The creek channel just upstream of the highway is dredged on an annual basis just before it passes under Highway 101 through an undersized culvert (Correa 2003). Similar to Sund Creek and possibly other comparable-sized streams draining to the southwest part of Hood Canal, the lower reach of Clark Creek loses surface flow beginning sometime in mid-to-late spring at least in recent years (Steve Todd, personal observation). Upstream reaches apparently maintain surface flow and support resident trout (Marty Ereth, cited in Correa 2003). Other than the highway, the 1942 air photo shows no other evidence of development in the lower stream corridor at that time. A trailer park was built above the left bank just upstream of the highway sometime between 1942 (air photo) and 1977 (WDOE oblique photo; see Figure 40 for 2001 oblique photo). No salt marsh occurs in association with this habitat complex today.

Figure 40. May 22, 2001 WDOE oblique photo of the Clark Creek habitat complex. Highway 101 and the paved parking lot and trailer park immediately to the right of the creek are the primary impacts to the tiny stream delta.

Relative Condition

Because of the level of transportation and other development immediately adjacent to Clark Creek, we consider the relative condition "Severely Impaired".

Habitat Complex: Finch Creek
Complex Type: Stream-delta

Physical Description

The 1884 T sheet shows the name "Finch" and indicates Finch's house just north of the creek mouth. A sinuous creek is shown winding through grassland, at least some of which may have been cleared for pasture (Figure 41). No salt marsh is shown in 1884 and none exists today. The 1873 GLO survey indicates that "P. Doyle" owned a claim on Finch Creek, probably along the right bank (Jameson 1873). The same survey measured the width of Finch Creek at the mouth and about 1000 feet upstream at 15 links (10 ft.) in February and March, respectively.

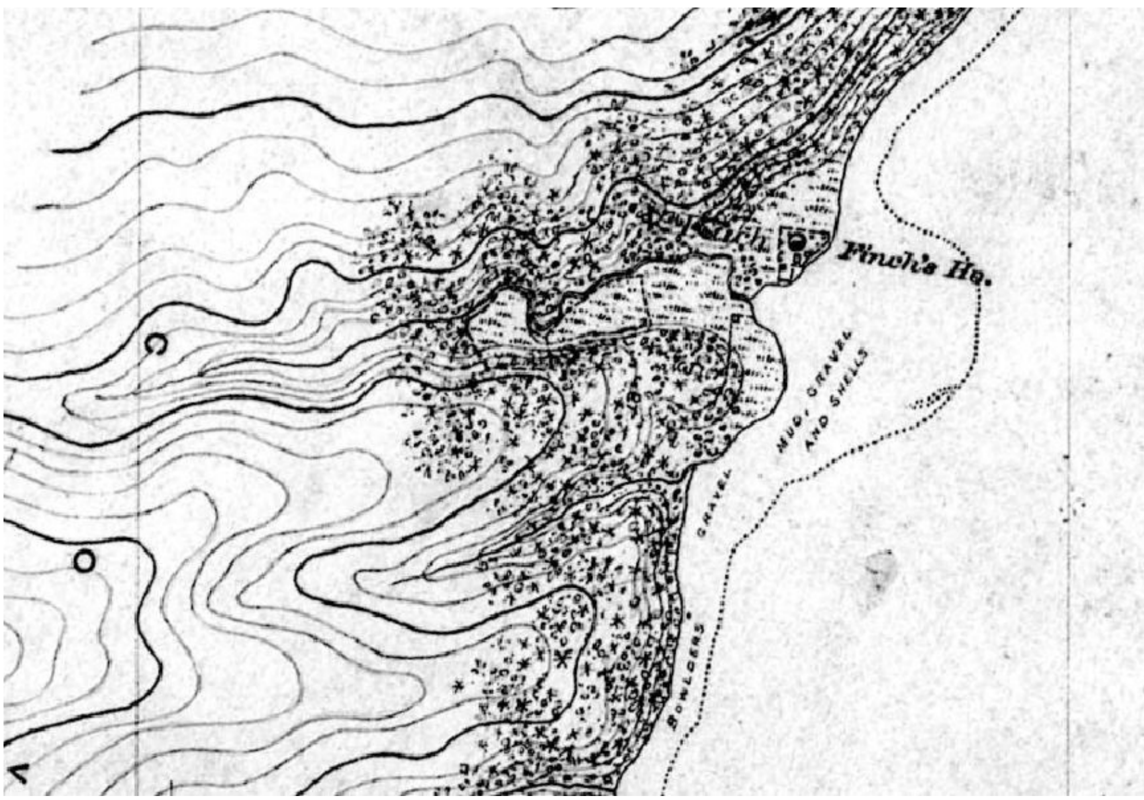


Figure 41. 1884 T sheet showing the Finch Creek habitat complex.

Description of Historical Habitat Changes

Today Finch Creek flows through the town of Hoodsport. It has been channelized through this lower reach, and its small delta has been filled over by the Hoodsport Salmon Hatchery to the north and houses and commercial development along the shoreline to the south and north of its estuary (Figure 42). Highway 101 also crosses the creek just upstream of its mouth. Finch Creek enters the shoreline within a sediment divergence zone that is 73% bulkheaded along its length (Hirschi et al. 2003), and much of the shoreline in this segment has been filled below the high water line.

Figure 42. 2001 WDOE oblique photo of the Finch Creek stream delta.

Relative Condition

Based on the severe channelization and filling along the lower left bank associated with the hatchery facility, we consider the relative condition of the Finch Creek complex "Severely Impaired".

Habitat Complex: Neelim Marsh
Complex Type: Spit/marsh

Physical Description

Historically, Neelim Marsh was a narrow fringing marsh that probably had a surface connection with adjacent open waters based on the fact that little or no berm is indicated along the south part of the marsh (Figure 43). No freshwater sources are known at this site. The 1873 GLO survey indicates an Indian Camp on the north end of this "spit", and an "Indian Graveyard" is mentioned just south of the marsh (Jameson 1873). This graveyard is also shown in the 1884 T sheet with crosses.

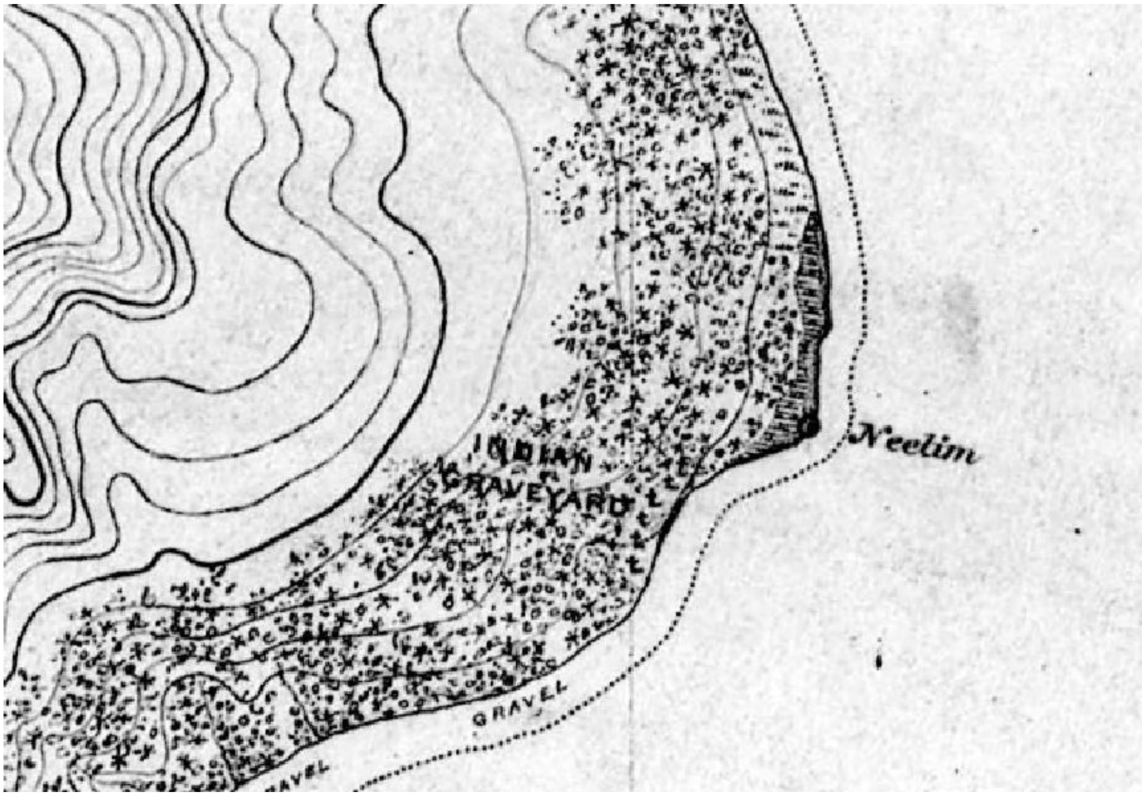


Figure 43. 1884 T sheet showing the Neelim Marsh habitat complex.

Description of Historical Habitat Changes

It appears that much of the former marsh has been developed over by houses, at least as early as 1977, and likely much earlier. However, our estimates indicate slightly more salt marsh today than in 1884 (Table 13), primarily because of a significant patch of apparently "new" salt marsh that is developing along the shoreline, some of which occurs seaward of bulkheads (Figure 44). This low-elevation salt marsh lacks channel development though it is certainly accessible to the tides. Neelim Marsh occurs within a north-to-south drift cell that is 56% bulkheaded (including a divergence zone to the north), and a large number of rail launches occur within this drift cell (Hirschi et al. 2003).

Table 13. Summary of habitat changes to the Neelim Marsh 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)	930 ft.	0 ft. *	- 930 ft.	- 100
Spit (area)	0.23 ha	0 ha *	- 0.23 ha	- 100
Salt marsh	0.57 ha	0.65 ha	+ 0.08 ha	+ 14
Total (spit, marsh)	0.80 ha	0.65 ha	- 0.15 ha	- 19

* Much of the current day spit is bulkheaded or has been otherwise fragmented.

Figure 44. 2001 WDOE oblique photo showing the Neelim Marsh. Much of the historical salt marsh that was present at this site has been eliminated by the development of homes, but a "new" salt marsh is evident, particularly near the center and left in the image, growing seaward of bulkheads and more natural shorelines.

Relative Condition

Though considerable development has occurred that has affected the historical marsh present at this site, it appears that a recent salt marsh has grown seaward of a partially bulkheaded shoreline. For this reason, we consider the relative condition "Moderately Impaired".

Habitat Complex: Potlatch Marsh
Complex Type: Spit/marsh

Physical Description

The 1884 T sheet indicates a fringing salt marsh that has an apparent tidal channel connection with the adjacent open waters (Figure 45). An "Indian house" is shown located in a fenced pasture or grassland immediately north of the marsh. Freshwater inputs (i.e., Potlatch Creek and possibly other seepages) are known at this site.

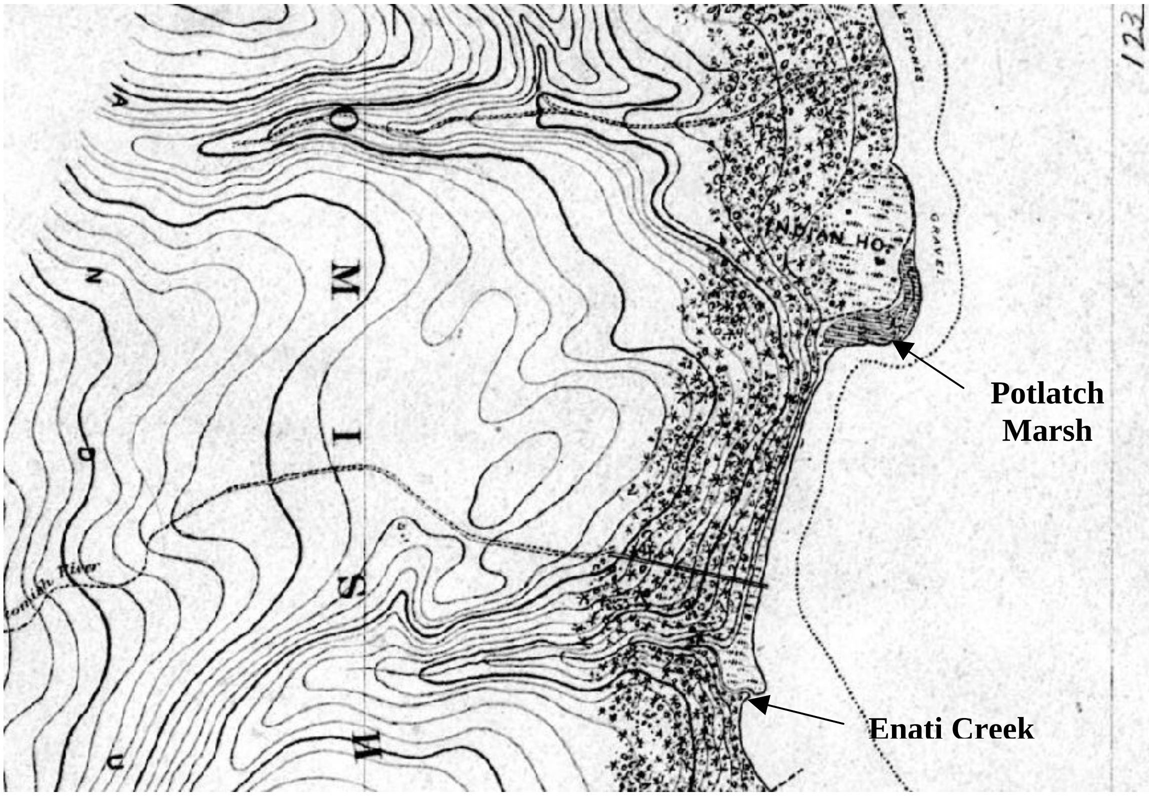


Figure 45. 1884 T sheet showing the Potlatch Marsh habitat complex (immediately south of the grassland and "Indian House", and the Enati Creek stream delta complex found to the south, immediately south of a log chute and low-lying grassland protrusion along the shoreline.

Description of Historical Habitat Changes

Even as early as 1942 (air photo) there are indications of development at the marsh site and in the location of the grassland pasture and Indian house as shown in the 1884 T sheet. Today this is the site of Potlatch State Park, and the former salt marsh has been filled by grass lawns, roads, and parking lots (Figure 46). Table 14 provides a quantitative summary of historical habitat changes. The area immediately north of the historical salt marsh is now a trailer park, with some forest, and a residential area along the water. Much of the shoreline is heavily armored to the north of the marsh.

Table 14. Summary of habitat changes to the Potlatch Marsh 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 (area)	0.04 ha	0 ha	- 0.04 ha	- 100
Salt marsh	0.99 ha	0 ha	- 0.99 ha	- 100
Lagoon	0.02 ha	0 ha	- 0.02 ha	- 100
Total (spit, marsh, lagoon)	1.05 ha	0 ha	- 1.05 ha	- 100

Relative Condition

Because historical tidal wetland has been eliminated at this site, we consider the complex "Lost".

Figure 46. 2001 WDOE oblique photo showing the site of the historical Potlatch Marsh habitat complex, now the site of Potlatch State Park with lawns, parking lots, and roads.

Habitat Complex: Enati Creek
Complex Type: Stream-delta

Physical Description

Enati Creek is a small steep stream that enters Hood Canal just north of the Skokomish River estuary. The 1884 T sheet shows a low-lying patch of grassland protruding along the shoreline just north of the creek mouth. No salt marsh is indicated in the T sheet at this location. A log chute also entered the canal near the north end of the spit (see Figure 45 in the Potlatch Marsh habitat complex narrative above). The March 1873 GLO survey measured the width of Enati Creek at 8 links (~ 5 ft.) just upstream of the mouth, and at 15 links (10 ft.) at the mouth in October 1873 (Reed 1873).

Description of Historical Habitat Changes

Today, Highway 101 crosses the creek just upstream of the mouth, and a small fish hatchery occurs along the left bank of the stream immediately upstream of the highway (Figure 47). Salt marsh (0.60 hectares) appears around the mouth of the creek today where it apparently did not exist historically. A 1958 air photo of this site indicates an access road to a building near the mouth. An adult fish trap associated with the small hatchery exists today between the highway and the mouth of the creek.

Figure 47. 2001 WDOE oblique photo showing the tiny Enati Creek complex, located just north (to the right in the image) of the Skokomish River estuary, the largest habitat complex in the study area.

Relative Condition

Although salt marsh appears today at this site where it apparently was absent in 1884, because of encroachment from the highway, an old road near the mouth, and the small hatchery facilities, we consider the relative condition “Moderately Impaired”.

Habitat Complex: Skokomish River
Complex Type: Stream-delta

Physical Description

The Skokomish estuary is the largest and most complex estuarine system in our study area. Like many of the larger estuaries in Hood Canal and in the Strait, it is impossible to make a meaningful assessment of estuarine changes to the Skokomish without considering the potential alterations to watershed processes, including diversion of water from the North Fork out of the basin (see Jay and Simenstad 1994 and Correa 2003), effects of logging and road building, diking of floodplain reaches, and removal of large woody debris from the mainstem and South Fork (see US Forest Service 1997; Amato 1996; Correa 2003). However, it is beyond the scope of this project to assess at any depth the impacts of watershed-scale land use practices on changes in the estuary. Instead, we focus on more direct changes and modifications to the estuary, and we attempt to ascertain the most probable causes for these changes.

The Skokomish estuary and watershed has long been the home to the Twana (and inland Vance Creek) people, ancestors to the modern day Skokomish Tribe. The Twana occupied a number of villages along the main forks of the Skokomish and in the estuary, and they used most of the watershed for fishing, hunting, and foraging. The main Twana settlement before contact with Euro-Americans was a large permanent winter village along the right bank of the mainstem just downstream of the confluence of the South and North Forks. However, a number of additional camp and fishing sites occurred along the river, including major ones along the left bank of the mainstem near the present day Highway 101 bridge and at the mouths of Weaver and Purdy creeks. Sites were also located near the mouth of the Skokomish River (Elmendorf cited in Amato 1996). Near the present day town of Union, at the east end of the Skokomish estuary, was where George Vancouver encountered Twana people at a temporary fishing camp in 1792, the first recorded contact of Twana and Europeans (Vancouver 1798 cited in Amato 1996). Later in 1841, Lieutenant August Case of the Wilkes Expedition noted a Skokomish (Twana) village at the mouth of the river (Case 1841 cited in Amato 1996). The Skokomish were co-signers to the Point No Point Treaty in 1855, and the Skokomish Reservation was established in 1859 at the southern end of the Skokomish estuary “island” (Amato 1996).

The earliest settlers to the lower Skokomish had arrived during the 1850s and the first big wave of Euro-Americans came between 1890-1895. These early settlers were primarily interested in clearing the land for livestock and other agricultural purposes, while a later surge of settlers during the period 1900-1910 were mainly interested in logging and mining. Apparently by the early 1900s, much of the Skokomish Valley bottom had been cleared of timber for farming (Amato 1996).

The GLO conducted surveys of the lower Skokomish River, including the estuary as early as 1857 and the early 1860s, as they were required to survey all Indian Reservations at an unusually fine scale. From review of the 1873 GLO notes and map, and the 1884 T sheet, Euro-American alterations to the landscape had already occurred in the lower Skokomish watershed and estuary by this time. The 1884 T sheet shows a number of buildings on the reservation (Indian Agency land was centered along the side of the delta "island") and it is possible, though unsubstantiated, that in establishing the reservation, some attempt was made to dike off some of the landward edge of the historical salt marsh for pasture or crops (Figure 48). A fence line in 1884 tends to correspond with a dike apparent in a 1938 air photo (Figure 49). Along the lower river, a lot of forest clearing is evident in the 1884 T sheet for development of pasture, orchard, and cropland.

The General Description provided in the GLO survey of Township 22 North, Range 4 West (includes north part of Skokomish estuary and much of North Fork Skokomish watershed) from March 1873 describes vegetation and the potential for logging the area.

> … [A]bout one half (of the Township) has considerable amount of bunch grass on it. There is about one third covered with excellent fir timber available to the Skokomish River. The Skokomish River, with an average width of 2 chains (132 ft.) is a good stream for driving logs, it also runs through a large body of choice fir timber, it is likewise fed by numerous streams that run through large bodies of timber. Game is abundant" (Jameson 1873).

In October 1873, the General Description of the GLO survey of the Skokomish Indian Reservation suggests the early wishes for manipulating the hydrology of the Skokomish estuary and lower river wetlands.

> By proper drainage (which I regard as feasible) and the ordinary appliances for cultivation, the greater portion of the lands embraced within the limits of this Reservation, except on the western border, might be brought into a rich and profitable state of productiveness to the farmer or owners. Except in sections 3 and 10, all that portion of the Reserve in Township 21 North, Ranges 3 and 4 West is low and level and the soil very rich.
>
> Much of the surface, however, is at present covered by two large swamps in which water is standing from 6 inches to 6 or 8 feet deep. These swamps cover most of sections 11 and portions of sections 12, 13, and 14. There are also other portions of low swampy land, through which pass many deep and ugly sloughs. All these obstacles, however, can be greatly overcome or remedied, and the soil made useful and productive, by

> drainage, dyking, and other needed attention, at comparatively trifling cost.
>
> … Along the borders of the river are many small meadows and potato fields, but all show the want of proper attention, and the slight and careless efforts of the Indians in striving to make them yield abundantly from the rich soil beneath, as they should.
>
> Two logging camps are in successful operation on the Reserve, conducted by the Indians – and much valuable timber is being prepared for market. There is still much good timber on the north of western portion of the Reserve, although there have evidently been large amounts extracted" (Reed 1873).

Description of Historical Habitat Changes

Because of the large extent of the Skokomish estuary, we have chosen to discuss historical changes in three main sections of the estuary, the "West Marsh", "Central Marsh", and "Nalley Island/East Marsh" (Figure 48). In a GIS, we intersected polygons representing the historical and current-day habitat delineations to look for parts of the estuary that appear to have changed dramatically as well as areas that have remained relatively stable in terms of broad geomorphic and vegetation classes (e.g., spit, salt marsh/tidal channels).

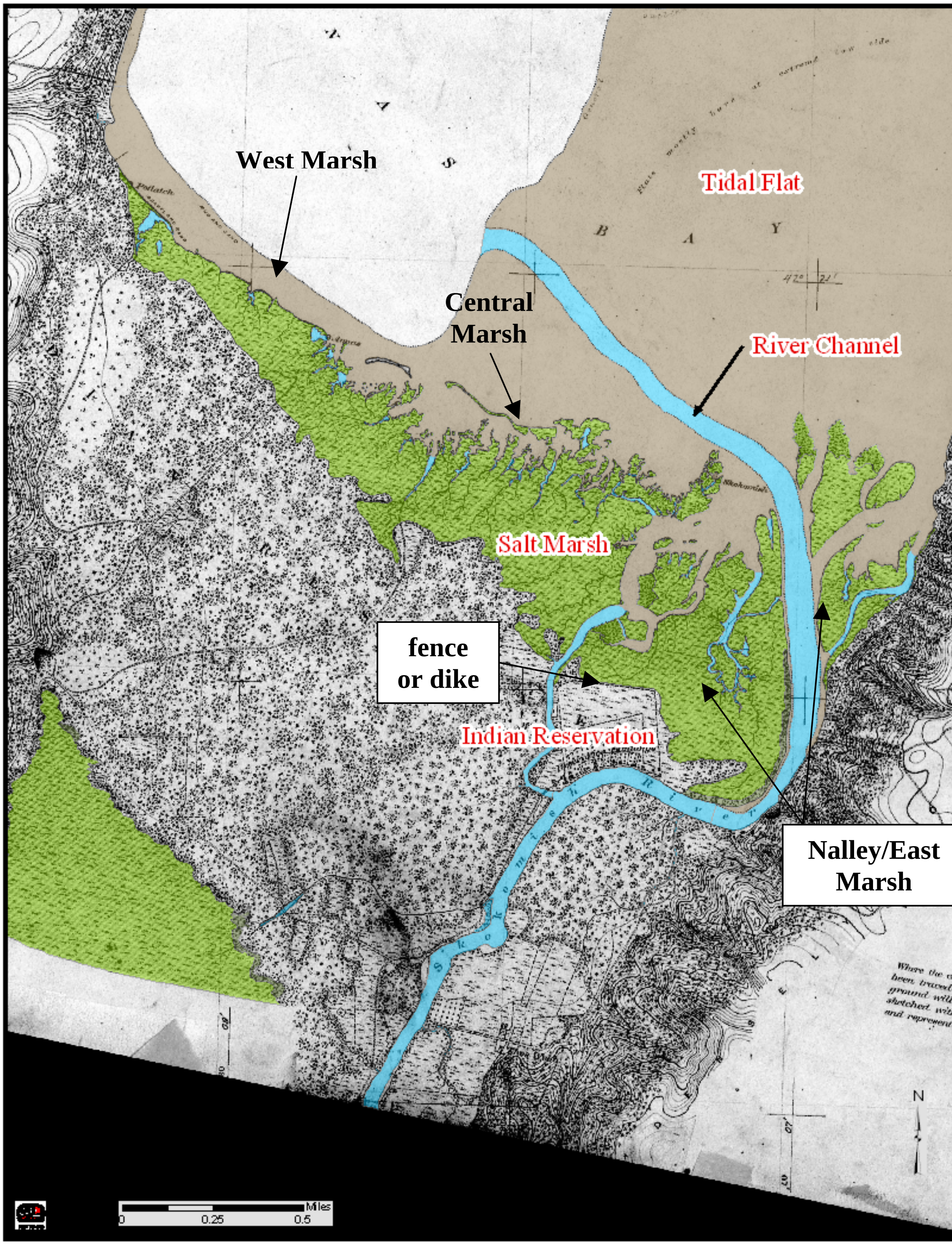


Figure 48. 1884 T sheet showing the Skokomish estuary and the three sections (West Marsh, Central Marsh, Nalley/East Marsh) discussed in the report. The Skokomish Indian Reservation in 1884 was located at the south part of what is today called Nalley Island, near the center of the image. This area was either fenced or diked off from the salt marsh at the time.

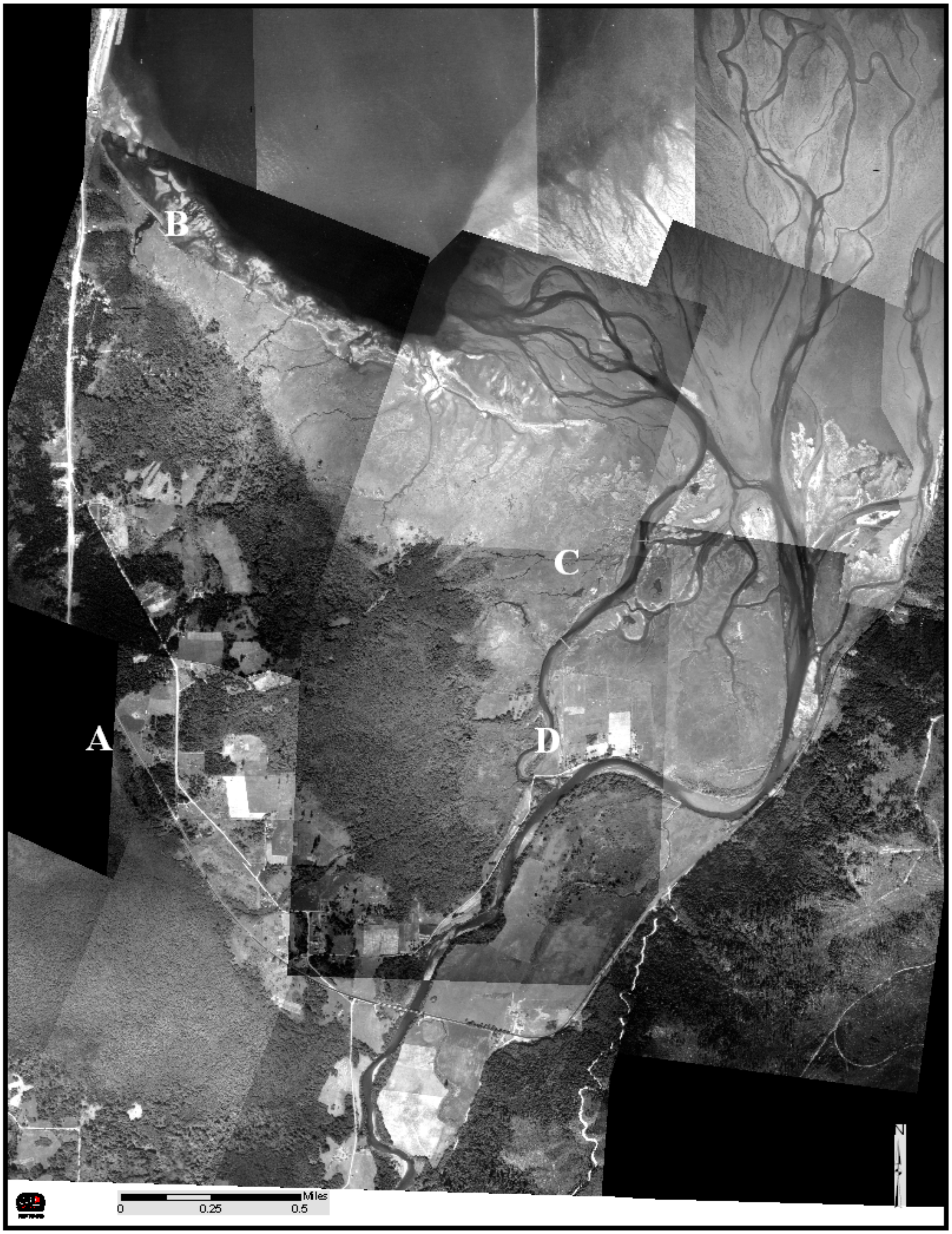
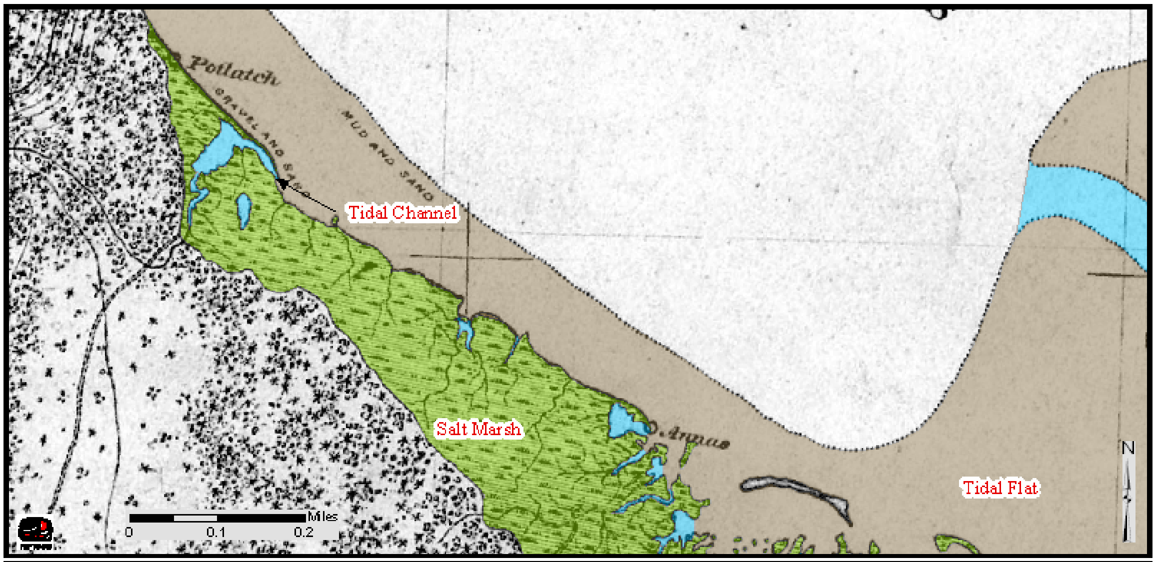


Figure 49. 1938 mosaic of air photos. The large wetland area shown as salt marsh in the 1884 T sheet near the lower left corner of the image (see Figure 48 above), was not included in our historical or current day surface area estimates of tidal marsh (see text and Table 15). Letters A – D indicate the locations of key descriptions from the early GLO survey notes. A) From August 1857, going east, "leave cranberry marsh containing about 160 acres, bearing north and south, enter heavy fir timber".

B) October 1873, “creek 20 links (~ 13 ft) wide”. C) September 1873, “Big slough 287 links (189 ft.) wide, north 35 degrees east, south 35 degrees west”. D) August 1857, “slough 100 links (66 ft.), north 20 degrees west”. And in September 1873, “slough 250 links (150 ft.), north and south”. A large number of GLO note descriptions of the Skokomish estuary were collected for this project in a GIS, and the Point No Point Treaty Council can make these GIS files available upon request.

The 1860 GLO section line (Terrill 1860) and 1873 meander survey notes (Reed 1873) in the west marsh of the estuary (see Figure 49 above) seem to agree well with the 1884 T sheet along the outer edge of the salt marsh and at major tide channels, but we have reason to think the 1884 T sheet surveyors mapped the landward boundary of salt marsh (often with forest) inaccurately in many places (see Materials and Methods and Discussion sections of Main Report). It appears in the 1884 T sheet that surveyors mapped the landward boundary of salt marsh seaward of its actual extent (Figure 50). We compared geo-referenced 1938 and 2000 air photos, and found close agreement between the two with respect to the landward edge of salt marsh in the west marsh of the estuary, but the 1938 and 2000 air photos do not always agree well with the 1884 T sheet delineation at this landward edge. Therefore, it may be that the T sheet surveyors under-estimated the overall amount of salt marsh/tidal channel habitat in this area. Another possible explanation for the apparent current day gain in salt marsh along the landward edge is that either localized or a broader scale subsidence has resulted in the gradual conversion from wooded or scrub-shrub vegetation to a salt marsh.

The West Marsh of the Skokomish estuary includes a relatively narrow zone of salt marsh and numerous tidal channels (Figure 50). Spit features front the marsh and it appears that some of the larger tidal channels (and possibly those fed by small freshwater streams) tend to breach the spit in places. In comparison with other sections of the estuary, the West Marsh shows relatively little overall change since the 1860, 1873, and 1884 surveys. Many features, such as spits and the configurations of salt marsh and large tidal channels appear relatively stable. There are, however, some notable changes that we observed in comparing early survey and air photos with more current day photos and field reconnaissance. The most prominent channel feature in the West Marsh is fed by a freshwater stream and was described by the GLO surveyors on October 8, 1873 as 20 links (~13 ft.) wide at the point where the channel left the salt marsh around a spit and entered the tide flat (Reed 1873)(Figures 49 and 50). We do not know the width of this channel opening today, though a comparison of the tidal lagoon associated with the channel shown in the 1884 T sheet with 1938, 1958, and modern day imagery suggests the size of the lagoon (in area) may be substantially smaller today than it was shown in the 1884 T sheet. Sometime between 1938 and 1958, Tacoma Power built an access road network and transmission towers out into the west end of the estuary. It appears that with construction of the far west end tower, much of the former tidal lagoon described above was filled (Figures 50 and 51). The width of the lagoon at its broadest in the 1938 air photo was approximately 125 feet or greater. It is considerably narrower by 1958 and in more recent air photos. The utility road appears to have altered the hydrology of at least some of the numerous tidal channels in this west end, and a distinct change in marsh vegetation pattern occurs at the road, as evidenced by our recent field reconnaissance of this area indicating that tidal exchange is altered by the presence of the utility road. A comparison of the 1938 and 2000 air photos reveals that the area upstream of where the utility road occurs today may be converting from salt marsh to a transitional zone or scrub/shrub wetland.


Potlatch
GRAVEL AND SAND
MUD AND SAND
Tidal Channel
Salt Marsh
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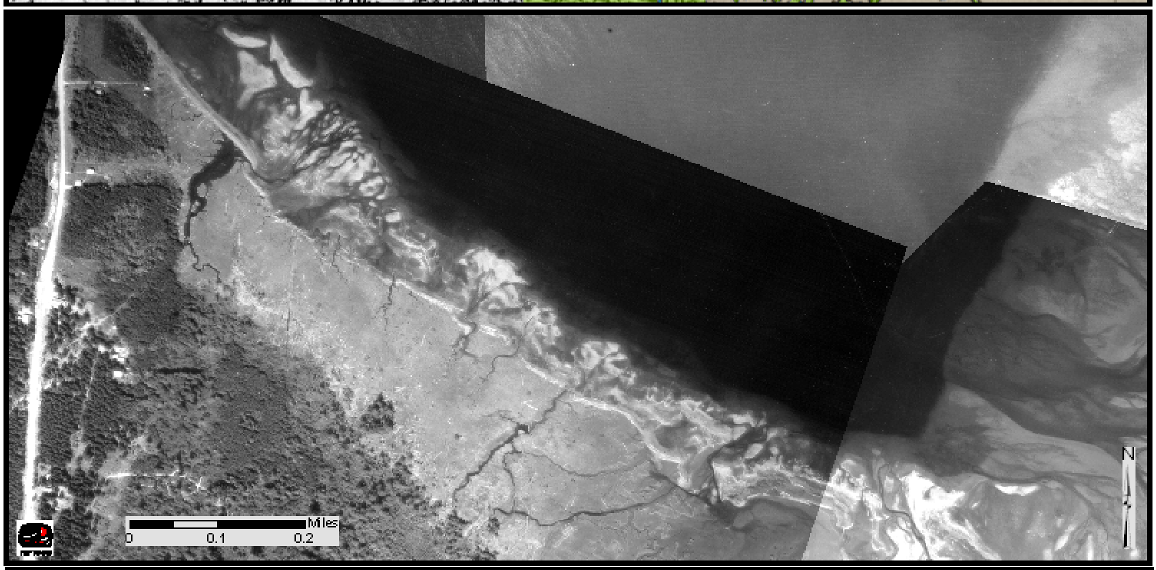
N
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Transmission Tower
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Miles
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Figure 50 (previous page). West Marsh of the Skokomish estuary, with the 1884 T sheet (at top), 1938 air photo (center), and 2000 WDNR orthophoto (bottom). Note the reduction in size of the largest tidal feature located at the west end between the time steps 1938 and 2000.

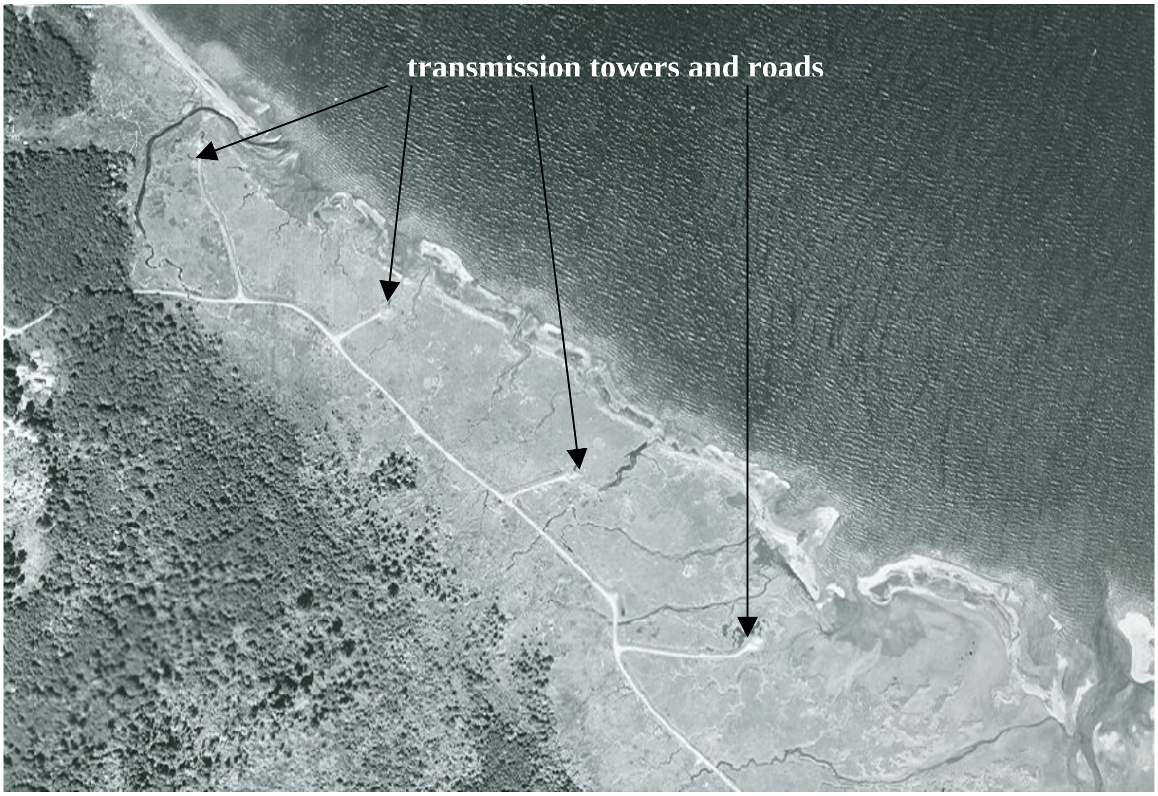

Figure 51. 1958 air photo showing the West Marsh of the Skokomish estuary. Compare with the above figure 50, from 1884, 1938, and 2000 of the same area. Note the dramatic reduction in the size of the tidal feature at the west end, apparently impacted by the construction of a transmission tower and road sometime between 1938 and 1958.

The Central Marsh area is shown in the 1884 T sheet as a broad salt marsh littered with tidal channels and larger tide sloughs (Figure 52). Some of the most robust spit features in the Skokomish system front the salt marsh in this area. Between 1938 and 1942 (air photos), a dike and drainage system had been built to exclude tidal inundation (Figure 52). By 1958, additional dikes and roads atop the dikes had been constructed within the original ~ 1940 era dike configuration (Figure 53). Portions of the salt marsh apparently were dredged and the dredge material was used for diking, giving the appearance of large "borrow pits" and channels running parallel to the dikes. This diking project resulted in the severe truncation of several major tidal channels and sloughs and a vast network of dendritic channels and associated salt marsh. This area was evidently farmed for several decades, beginning in the early 1940s. The Skokomish Tribe is preparing a restoration project in this area that will remove much of the diking system.

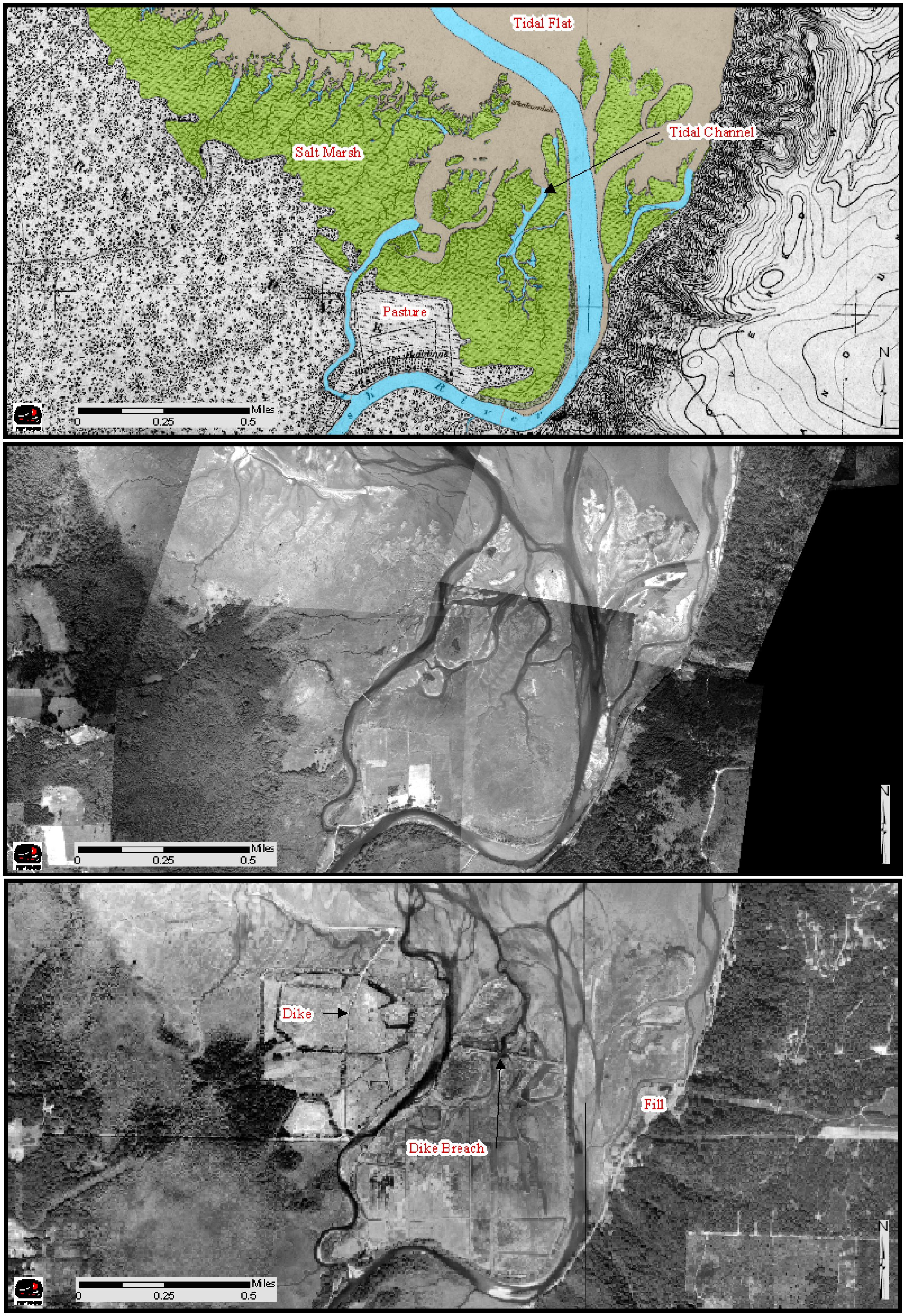

Figure 52. Central and Nalley/East Marsh sections of the Skokomish estuary, with

the 1884 T sheet (at top), 1938 air photo (center), and 2000 WDNR orthophoto (bottom). The 1938 image was taken just prior to large scale diking of much of this portion of the estuary that is evident in the 2000 image, and in a 1958 air photo below.

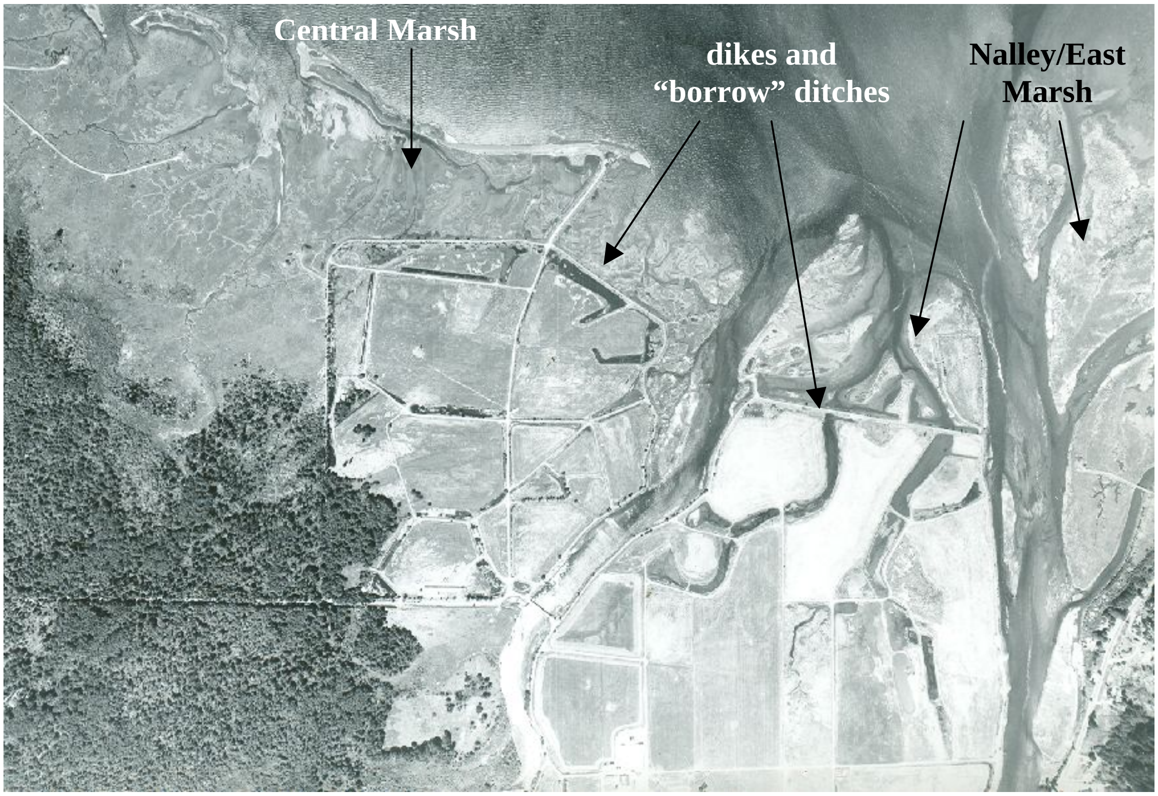

Figure 53. 1958 air photo showing the system of dikes and borrow ditches and pits, most of which was put in place between 1938 and 1942.

The area we refer to as the Nalley/East Marsh includes the area between the main river channel and the largest distributary channel, as well as the east part of the estuary (Figure 52 above). Sea dikes and drainage canals were put in place between 1938 and 1942 along the margins of Nalley Island, constructed in the same fashion as the dikes built in the Central Marsh to the west at about the same time (Figure 52 above). This diking completely altered the hydrology and vegetation patterns of this salt marsh/tidal channel system. The area inside and behind the dikes was farmed for several decades until agriculture was abandoned in the 1960s and the dikes were no longer maintained. Flooding during winter 1994/95 resulted in an 80 foot wide breach in the sea-facing dike, allowing for saltwater inundation to a major part of the historical salt marsh (Amato 1996). By 2000, this system of dikes was beginning to breach in several places, with tidal channels head-cutting and developing landward of the dikes (Figure 54). The Skokomish Tribe has been monitoring vegetation changes since the breaching began (M. Ereth, personal communication).

Figure 54. 2001 WDOE oblique photo showing one of several dike sections in the Nalley Island portion of the Skokomish estuary that has been breaching since the mid-1990s.

An area along the east side of the Skokomish estuary was starting to see major human alteration sometime between about 1940 and 1958 with a road extending out across several tidal sloughs and distributaries. By the 1970s a significant part along the margin of the historical marsh at this site had been filled (Figure 55).

Figure 55. 1977 WDOE oblique photo showing a section of the Nalley/East Marsh of the Skokomish Estuary where filling of former salt marsh had apparently recently taken place or was occurring at the time. Notice the extensive diking and dredged ("borrow pits") on the right side of the image.

The time between the 1938 and 1942 "snapshots" appears to have been a critical window in terms of direct habitat alterations in the Skokomish estuary. Both the Central Marsh and the Nalley Marsh were diked off during this time, with one estimate that about half of the Skokomish intertidal habitat had been "destroyed" with these dikes (Amato 1996).

Our GIS intersection of current day and historical polygons (based on the 1884 T sheet) reveals that some major patches of salt marsh now occur in the mainstem river channel and in the major distributary where tidal flat occurred in 1884, and apparently in the 1938 and 1942 air photos as well. By 1958, however, it appears that the river channel was beginning to shallow and possibly develop salt marsh islands in locations where we find relatively large salt marsh patches today. This may be consistent with the hypothesis that the lower mainstem and estuarine portion of the river channels have experienced a reduction in sediment transport capacity, primarily due to a decrease in river discharge (caused by the Cushman Project's diversion of the North Fork directly into Hood Canal), an increase in sediment supply (due primarily to upslope logging and road building), and river channel diking (see Jay and Simenstad 1994).

Another portion of the estuary that we looked at is a large area north of the main river channel depicted in the 1884 T sheet as a salt marsh with channels and sloughs well upstream of the salt marsh adjacent to the tidal flats (Figures 48 and 49). The August 1857 and September 1873 GLO survey notes (Reed 1873) of this area describe vegetation and hydrology differently than the 1884 T sheet classification. The 1857 survey describes a "cranberry marsh" along a section line in the north part of this wetland (Berry and Carlton 1857), and the 1873 survey describes a "swampy land" and uses the descriptor "sloughy", along a section line in the south (Reed 1873). The National Wetlands Inventory (NWI) describes this area as a mosaic of palustrine scrub-shrub, emergent and forested wetlands that, for the most part, are considered non-tidal (USFWS, NWI).

In summary, we focused on historical changes that tend to directly affect tidal processes and habitat features caused primarily by diking and/or filling of salt marsh and tidal channel habitats. In the West Marsh, these changes have been relatively minor, though they may have major implications for estuarine fish production with the apparent reduction in tidal channel area that can result from diking/filling and the related decrease of tidal prism (see Discussion section of the Main Report). Habitat alterations are more obvious in the Central Marsh and Nalley/East Marsh areas with extensive diking and some direct filling of former salt marsh and tide channel habitats. Table 15 provides a quantitative summary of historical habitat changes in the Skokomish estuary.

Table 15. Summary of habitat changes to the Skokomish estuary 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-Length	Percent
Tidal marsh (and channels)	226.07 ha *	272.30 ha *	+ 46.23 ha	+ 20
Lagoon	1.83 ha	11.89 ha	+ 10.06 ha	+ 550
Tidal flat	570.95 ha	? ha **	? ha	?
Total (salt marsh, channels, lagoon)	227.90 ha	284.19 ha	+ 56.29 ha	+ 25

* Historical and current day estimates of tidal marsh surface area do not include the large interior wetland that was shown as a salt marsh in the 1884 T sheet. The T sheet actually did not include this entire wetland (the map cuts it off), and the GLO notes and current day National Wetland Inventory (USF&WS) descriptions of the wetland are not entirely consistent with that of a tidally-influenced salt marsh (see text).
** 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

Though the net changes in surface area of tidal marsh, channel, and lagoon habitat are not substantial, the overall habitat connectivity of the estuary has been impaired by diking and drainage of tidal wetlands, particularly in the areas associated with Nalley Island and immediately west of Nalley Slough. In addition, river channelization activities within the tidal extent have reduced the connectivity of main river channels with adjacent floodplain and tidal wetlands. These impacts, as well as watershed-scale effects on hydrology and sediment regimes from the Cushman dams and associated water diversion from the watershed, and logging and road building activity, have affected estuarine habitat. For these reasons, we consider the relative condition of the Skokomish estuary “Severely Impaired”.

Habitat Complex: Dalby Creek
Complex Type: Stream-delta

Physical Description

Dalby Creek enters a small semi-protected cove east of the Skokomish River along the south arm of Hood Canal. In the September 1861 GLO survey, the creek was measured at 10 links (6.6 ft.) wide at the mouth (Terrill 1861). The 1884 T sheet indicates a small patch of salt marsh along the west shore just north of the creek mouth (Figure 56). A second stream enters the south side of the cove. An “abandoned camp” is shown at the mouth on the left bank and a road leads from the camp to the uplands where “McReavy’s” (sp?) camp was located at the time.

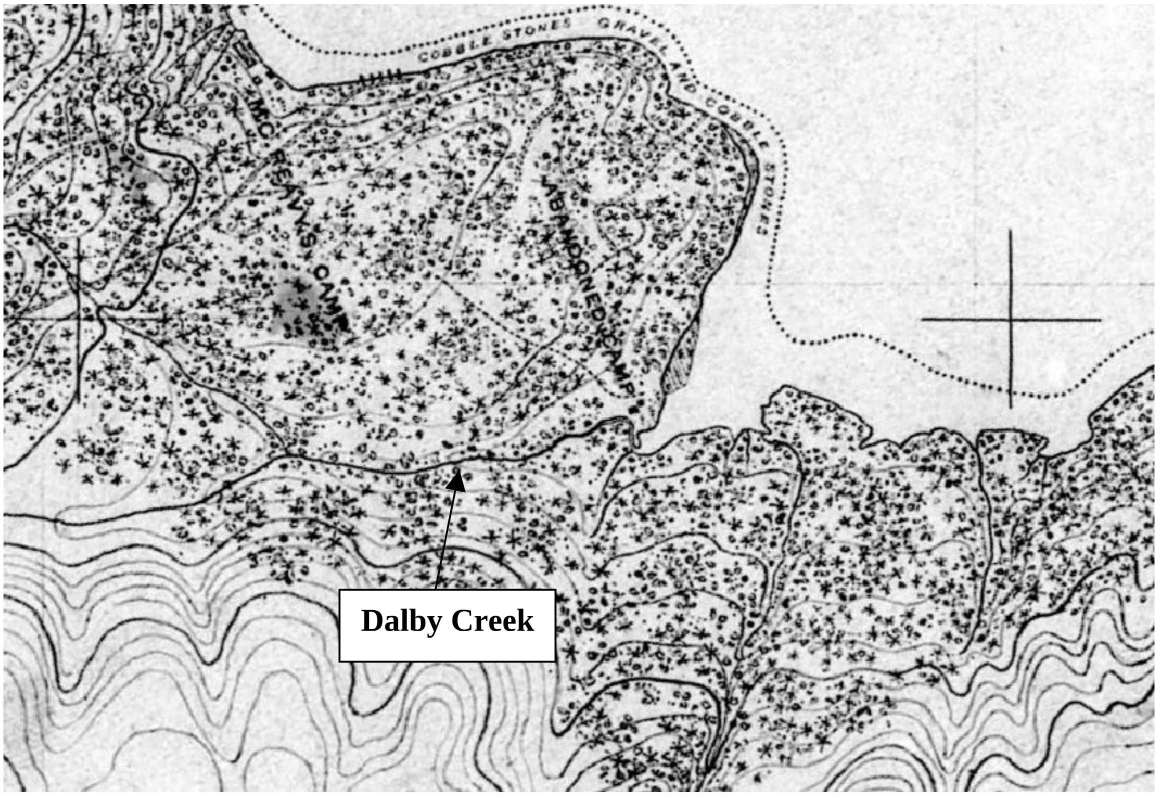

Figure 56. 1884 T sheet showing the Dalby Creek complex within a cove where an apparent abandoned logging camp was found at the time.

Description of Historical Habitat Changes

The historical patch of salt marsh has long been filled over for waterfront houses (at least as far back as 1977), and a new patch of salt marsh has evidently developed since 1884 just downstream of the road crossing and opposite the channel on the south side of the cove, possibly associated with the second stream mentioned above (Figure 57). Dalby Creek passes under a bridge at Highway 106 at its mouth, but the road seems to result in minimal filling compared with other creek mouths in south Hood Canal. An abandoned boat or other structure appears in the 1993 and 2001 oblique photos along the left bank immediately downstream of the highway crossing. Table 16 provides a quantitative summary of historical habitat changes.

Table 16. Summary of habitat changes to the Dalby Creek 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
Tidal marsh	0.29 ha	0.97 ha	+ 0.68 ha	+ 234
Tidal flat	3.55 ha	? ha *	? 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 57. 2001 WDOE oblique photo of the tiny Dalby Creek habitat complex located east of the Skokomish estuary. Notice the number of docks in the image, one even appears in the main channel of the creek at a low tide.

Relative Condition

Though the historically tiny historical salt marsh has been eliminated, a new salt marsh has apparently grown (roughly twice the size of the historical patch). However, Highway 106 has probably filled over the creek inlet and a number of docks occur within the small cove, and have a footprint impact on tidal flat habitat. For these reasons, we consider the relative condition of the Dalby Creek complex “Moderately Impaired”.

References

Amato, C. 1996. Historical changes affecting freshwater habitat of coho salmon in the Hood Canal Basin, pre-1850 to the present. Point No Point Treaty Council, Kingston, Washington. 81 pages.

Berry, T.F., and W.N. Carlton. 1857. Field notes for the line survey of Township 21 North, Range 4 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

Blankenship, D.G. 1983. Net Shore-Drift of Mason County, Washington. M.S. Thesis. Western Washington University, Bellingham. 172 pages + maps.

Correa, G. 2003. Salmonid Habitat Limiting Factors Water Resource Inventory Area 16 West (Skokomish-Dosewallips Basin). Washington Conservation Commission. Olympia, Washington.

Gerstel, W.J.; Lingley, W.S., Jr., 2003 (Schuster, J.E., digital geology). Geologic map of the Mount Olympus 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 2003-4, 1 sheet, scale 1:100,000.

Hirschi, R., Labbe T., and Carter-Mortimer, A. 2003. Shoreline Alterations in Hood Canal and the Eastern Strait of Juan de Fuca. Point No Point Treaty Council Technical Report 03-1. 62 pages.

Hood Canal Coordinating Council (HCCC). 2004. Salmon Habitat Recovery Strategy for the Hood Canal and Eastern Strait of Juan de Fuca. Version 3-2004. 72 pages.

Hood Canal Coordinating Council (HCCC). 2005. Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan. Version November 15, 2005.

Jameson, W. 1873. Field notes for the line and meander survey of Township 22 North, Range 4 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

Jay, D. A., and C. A. Simenstad. 1994. Downstream effects of water withdrawal in a small, high-gradient basin: erosion and deposition on the Skokomish River delta. Estuaries 17 (3): 702-715.

Kuttel, M., Jr. 2003. Salmonid Habitat Limiting Factors Water Resource Inventory Areas 15 West (Kitsap Basin) and 14 North (Kennedy-Goldsborough Basin). Washington Conservation Commission. Olympia, Washington. 312 pages.

Logan, R. L., compiler. 1987. Geologic map of the south half of the Shelton and south half of the Copalis Beach quadrangles, Washington: Washington Division of Geology and Earth Resources Open File Report 87-9, 15 p., 1 plate, scale 1:100,000.

Reed, T. 1873. Field notes for the meander surveys of Townships 21 and 22 North, Range 4 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

Shared Strategy Development Committee. 2005. Draft Puget Sound Salmon Recovery Plan. December, 2005. Shared Strategy for Puget Sound. Seattle, Washington. http://www.sharedsalmonstrategy.org/plan/

Shoecraft, R. P. 1874. Field notes for the survey of Township 23 North, Range 3 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

Terrill, N. G. 1860. Field notes for the survey of Township 21 North, Range 4 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

Terrill, N. G. 1861. Field notes for the survey of Township 22 North, Range 3 West, Washington Territory. General Land Office Survey, U.S. Dept. of the Interior, Bur. Of Land Mgmt., Portland, Or.

USDA Forest Service. 1997. South Fork Skokomish Watershed Analysis. Olympic National Forest. Olympia, WA.

U. S. Fish and Wildlife Service. 1980. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, St. Petersburg, FL http://www.nwi.fws.gov.

Washington Department of Fish and Wildlife (WDFW) and Point No Point Treaty Tribes (PNPTT). 2000. Summer Chum Salmon Conservation Initiative – An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region. Wash. Dept. Fish. and Wildlife. Olympia, WA. 800 p.