WOOD DEBRIS ASSESSMENT AND REMOVAL OPTIONS REPORT

CLIFFSIDE BEACH WOOD DEBRIS REMOVAL PROJECT PHASE I



Prepared for

Whatcom County Public Works – Stormwater
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Bellingham, Washington 98225-4052

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1 INTRODUCTION

Cliffside Beach is a south- and west-facing beach located to the east of the Nooksack River delta in Bellingham Bay, Washington (Figure 1). For many years, heavy accumulations of wood debris, including small twigs, sawdust-like material, and decomposing leaves have been noted overlying the sand and gravel substrate along the beach. In this context, wood debris refers to fine wood particles and small wood pieces (i.e., generally less than 6 inches long)—not the larger drift logs typically referred to as large woody debris. Cliffside Beach is not the site of a historic mill and the source(s) of the woody debris are unknown. A commonly held perception, although only partially substantiated, is that historic mill operations contributed unnaturally high amounts of material into Bellingham Bay that ultimately deposited at Cliffside Beach. Another hypothesis is that the wood debris is of natural origin coming from the Nooksack River, although this perspective is lacking adequate supporting data at present. Other similar Northwest rivers have not been reported to produce a comparable quantity or quality of such wood debris. In recent years, there has been an interest in exploring the sources of the wood debris, as well as the feasibility of removing the surficial wood debris layer in terms of the ecological benefits, sustainability of the restored beach, and the logistics of a removal and disposal/reuse action.

This report presents the results of an assessment conducted as Phase I of a Cliffside Beach Wood Debris Removal Project. This assessment focused on the logistics of the removal and disposal/reuse of the surficial wood debris layer, as well as the historic trends and possible sources of wood debris accumulations along the beach. Although not a focus of the assessment, some insights on the ecological benefits and the sustainability of a removal action were gained during the work and are presented in this report. If implemented, Phase II of the project will entail the removal of wood debris and the restoration of the beach.

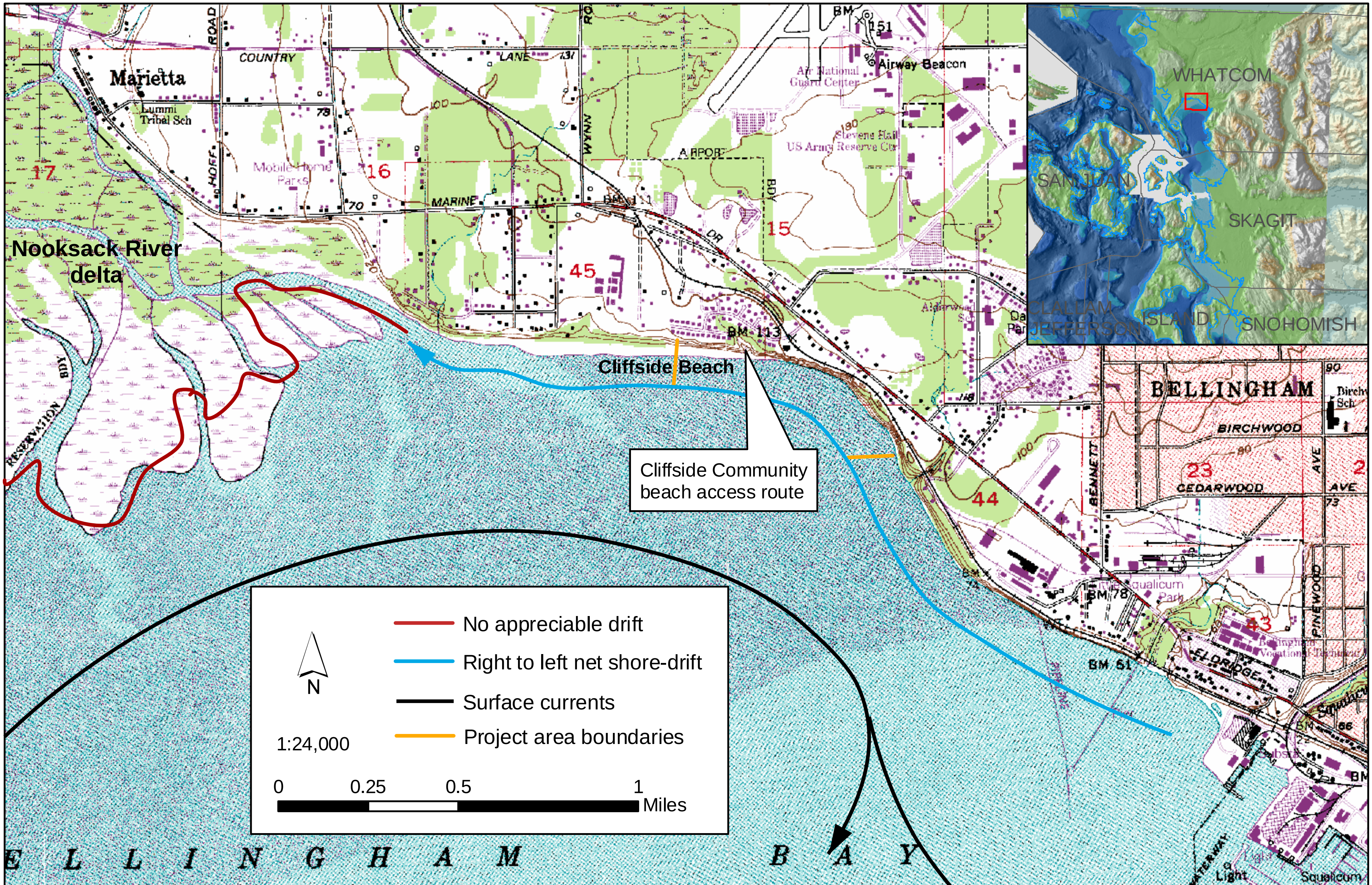

Figure 1. Cliffside Beach, Whatcom County, Washington, and vicinity.
Net shore-drift (Schwartz et al. 1991) and water surface currents (Collias et al. 1966) buffered off shore.

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2 PROJECT AREA

Cliffside Beach is situated just east of the Nooksack River delta. The westernmost point of Cliffside Beach lies at the current position of the mouth of the east distributary of the Nooksack River delta where it drains into Bellingham Bay. Steep, sandy bluffs line the entire project area, although a wide backshore separates the bluffs from the intertidal zone in the central and western portions. The Cliffside Beach foreshore profile zone is characterized by a sloping beach from approximately +11 feet mean lower low water (MLLW) down to approximately +5 feet MLLW. In front of the sloping beach is a wide sand flat that extends waterward for over 1,000 feet along the length of the project area.

The project area is an approximately 3,400-foot-long stretch of Cliffside Beach spanning from approximately 2,700 feet east of the Cliffside Community's beach access route to approximately 700 feet west of the Cliffside Community's beach access route. The endpoints of this project area were based on the configuration of the surficial wood debris accumulations during the assessment.

The study focused on the upper intertidal beachface extending from the waterward margin of the abundant drift log accumulations at approximately +11 feet MLLW to the inshore margin of the sand flat (approximately +5 feet MLLW). This subset of the beach was the focus of the assessment because initial site reconnaissance revealed that this is the intertidal range in which surficial wood debris accumulates.

3 INVESTIGATION OF HISTORIC CONDITIONS

Historic wood debris deposition trends at Cliffside Beach and possible wood debris sources were investigated. The information sources for this investigation included: 1) historic aerial photographs (aerial photographs are shown in Figures 2, 3, and 4) that were interpreted for apparent surficial wood debris accumulations and shoreline location changes (referred to as shore change); 2) interviews with local historians, tribal representatives, and community members; and 3) review of related reports. The findings of this investigation are presented in Appendix A and are summarized in the remainder of this section.

3.1 Historic Surficial Wood Debris Accumulations

Historic aerial photographs between 1961 and 2004 were interpreted to delineate the spatial extent of woody debris on the surface of the upper intertidal beachface of Cliffside Beach. Earlier photos from the 1950s were not used in this analysis due to low resolution of one image (1955) and a higher tide that prevented interpretation of intertidal wood debris accumulations (1951).

The aerial photographs indicate surficial wood debris has been apparent along Cliffside Beach throughout the 1951 to 2004 period of analysis. Between 1961 and 2004, there appears to be an overall decrease in wood debris coverage across the study area (Figure 2; Table 1). Much of this decrease appears to be due to the surficial wood debris previously extending into the sand flat. More recently, the surficial wood debris accumulations have been limited to the upper beachface. The 1951 aerial photograph did not show all of the beach due to tide height, but the photograph seemed to show a relatively limited amount of surficial wood debris in a narrow band high on the beach. Although not of suitable quality to delineate polygons of surficial wood debris, the 1955 photograph was adequate to show that smaller quantities of wood debris were on the beach compared to subsequent years, consistent with observations from the 1951 photograph.

Table 1
Historic Aerial Photo-interpretation of Areal Extent of Surficial Wood Debris

Year	Area (square feet)
1961	1,174,192
1969	1,021,113
1978	443,763
1987	328,676
2004	312,834

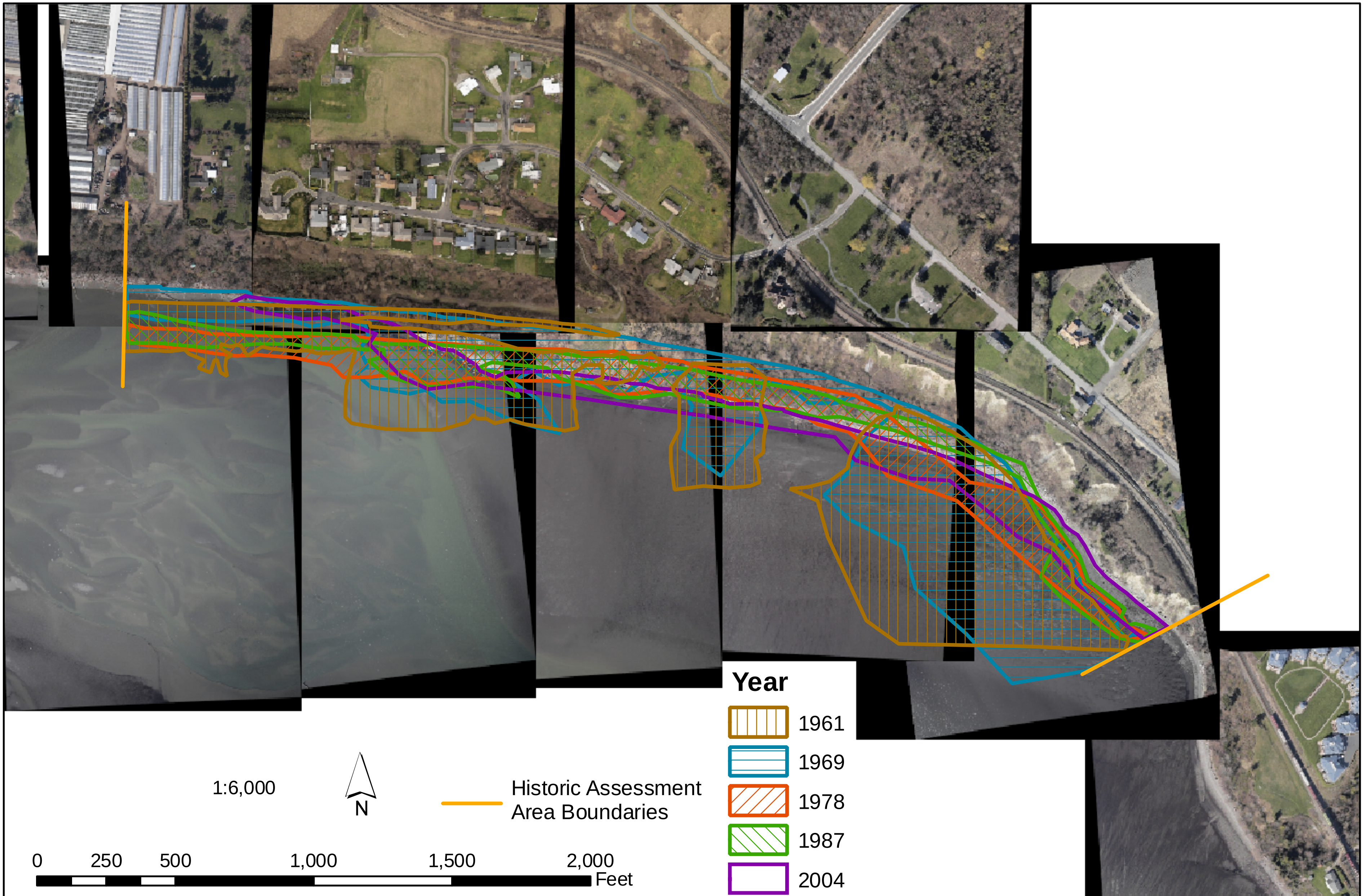

Figure 2. Apparent Surficial Wood Debris at Cliffside Beach Digitized from Aerial Photographs (1961 to 2004)

Photos shown from 2004 (Pictometry International Corp.)

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The photo-interpretation finding that there was less surficial wood debris in 1955 compared to later years is consistent with local residents' recollections that the abundant volumes of small wood debris had not yet been deposited on the beach in 1955. However, subsequent trends in decreasing surficial wood debris accumulations documented between 1961 and 2004 by photo-interpretation contrast with local resident recollections. The local residents report that the wood debris was far less extensive in the decades prior to the 1970s, and has grown considerably since that time. Waterward progradation of the delta likely altered deposition patterns at Cliffside Beach, as discussed in Section 4.1.

3.2 Historic Shore Change Analysis

The shore change analysis was conducted to investigate changes in the shoreline configuration over the period of analysis (1951 to 2004). The shore change analysis indicates that the location of the top of the beach (measured as the waterward margin of the drift log line) along the central portion of the project area has moved waterward more than 175 feet since 1951 (Figure 4). The western end of the project area exhibited the greatest fluctuation in shoreline location as several periods of rapid progradation (building waterward) followed by recession (eroding landward) were observed between 1951 and 2004. The beach in the western area prograded the most rapidly in the 1970s and then eroded rapidly after 2004 (7.4 feet per year). The least amount of shore change was detected in the east end of the project area. In this area, the shoreline location receded 23 feet between 1951 and 2004.

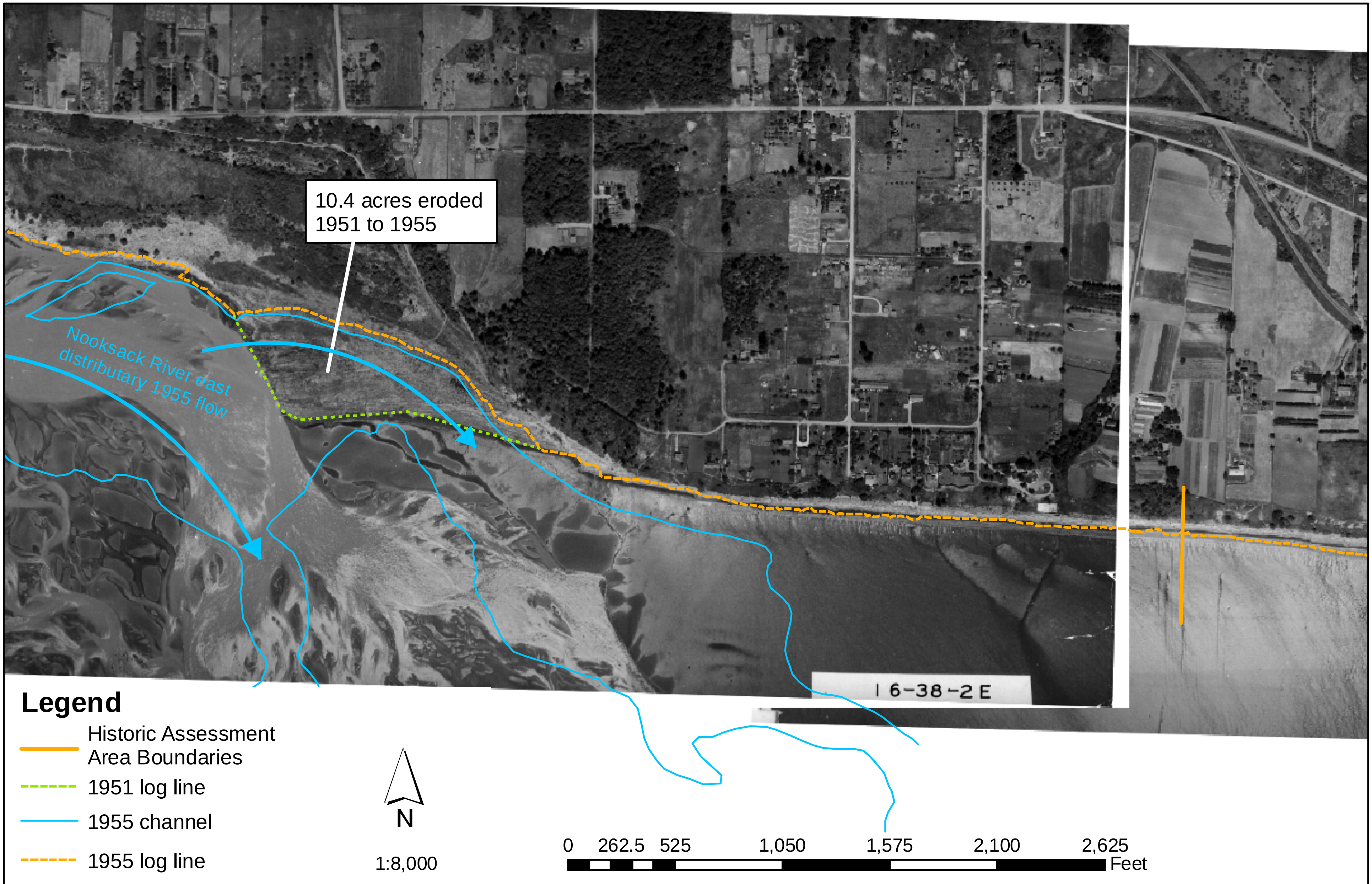

Figure 3. Nooksack River East Distributary Avulsion between 1951 and 1955.
Photos shown from 1951 (Whatcom County).

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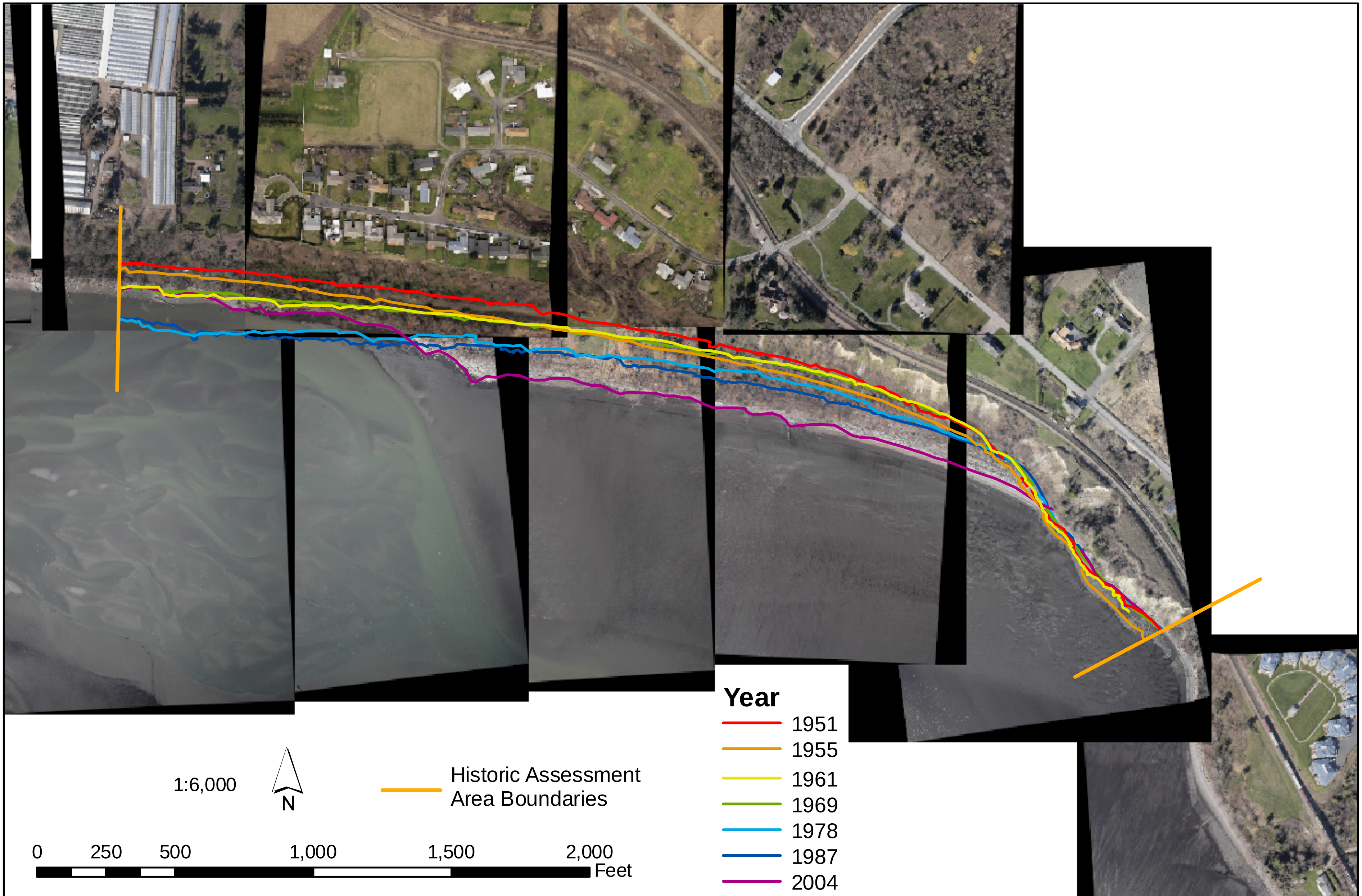

Figure 4. Waterward Edge of Drift Log Zone at Cliffside Beach from Aerial Photographs, 1951 to 2004

Photos shown from 2004 (Pictometry International Corp.)

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3.3 Historic Nooksack River Delta Changes

Over the course of recent history (1880 to the present), the Nooksack River delta has experienced considerable progradation, channel development, and avulsion and migration of the eastern distributary, which flows closest to Cliffside Beach. Reconnaissance of the historic conditions in the delta was conducted to determine how the delta progradation and modern channel configuration might have contributed to the current conditions at Cliffside Beach. Reconnaissance of these processes was performed using historic maps, geographic information system (GIS) data from Collins and Sheikh (2004), historic charts, and aerial photography from 1951 to 2004. .

Results of the review revealed that the landward limit of the Nooksack River delta flats has prograded waterward 1.2 to 1.3 miles between 1880 and 1998, and the eastern distributary appears to have extended to the southeast (Figure 5). Delta front progradation has resulted in a net gain of subaerial land of about 1.2 square miles, and intertidal areas have increased by 0.7 square mile since 1880 (Bortelson et al. 1980).

Maps of the Nooksack River delta in 1880 show the landward limit of the tidal flats approximately 1 mile northwest of Cliffside Beach. The waterward limit of the tidal flats was located slightly west of the project area. In 1886, the Nooksack River changed in flow dominance from the Lummi to the Nooksack distributary (Gilbert 1887), which resulted in noticeable new accumulations of sediment in Bellingham Bay and very rapid delta progradation (waterward growth) (Bortelson et al. 1980; Collins and Sheikh 2004). By 1938, the landward limit of the tidal flats prograded approximately 0.8 mile waterward, encompassing the Cliffside Beach project area. From 1938 to 1998, the tidal flats prograded 0.3 to 0.6 mile waterward, with tidal flat progradation waterward of Cliffside Beach of about 0.4 mile. Cumulatively, since 1880, the nearshore at Cliffside Beach has prograded over 0.5 mile waterward (Collins and Sheikh 2004).

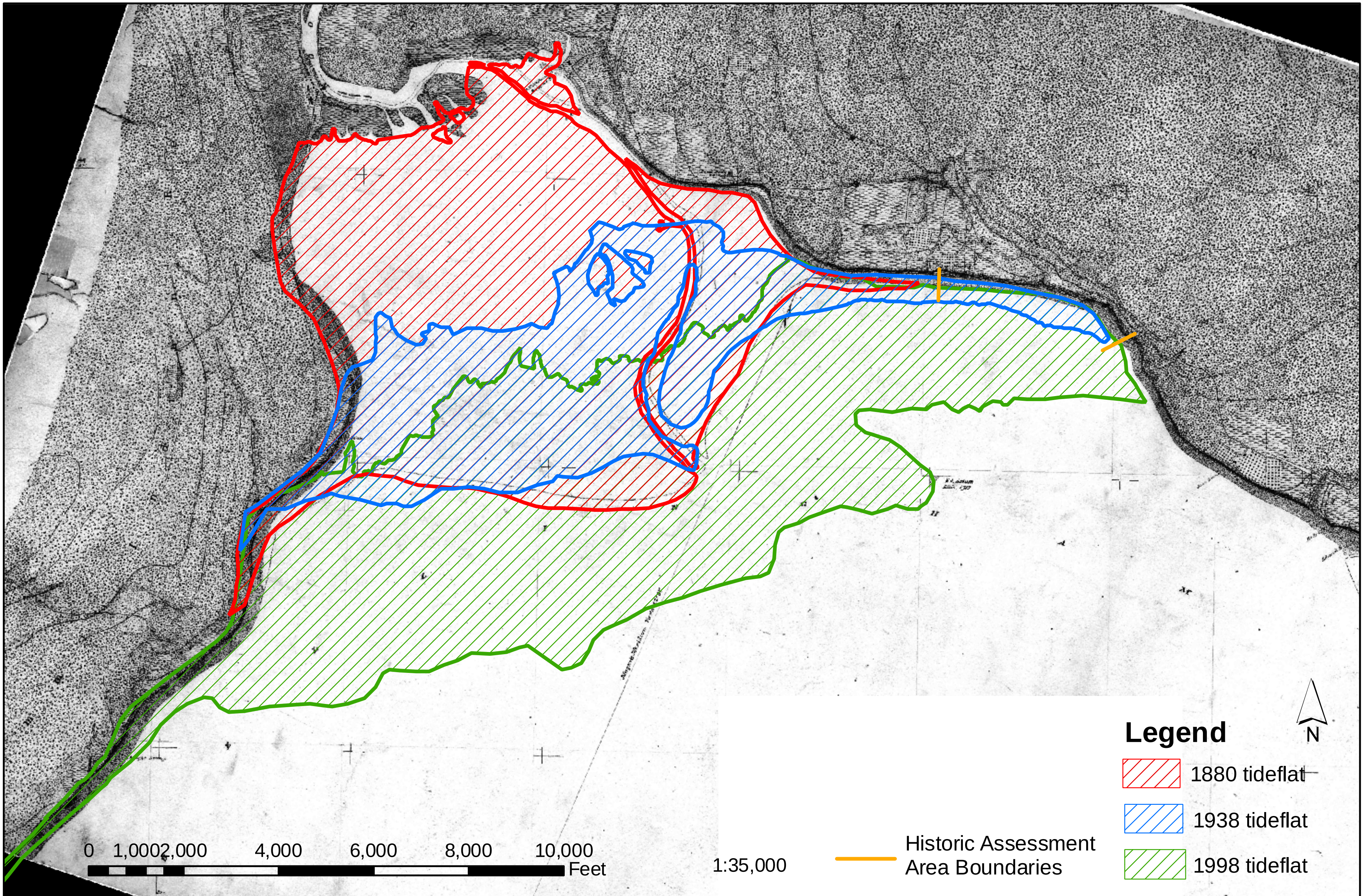

Figure 5. Nooksack River Delta Tideflat Progradation 1880 to 1998 (Collins and Sheikh 2004)

Tsheet no. 1798 (US Coast and Geodetic Service)

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Historically, the Nooksack River delta distributary channels not only repeatedly avulsed but also migrated and extended waterward, incising new channels across the expanding delta flats of Bellingham Bay (Collins and Sheikh 2004; Deardorff 1992). The 1880 map shows a single main stem channel at the mouth, with two, short distributaries, and a single blind channel that drained from the east (Figure 6). By 1938, two major distributaries flowed into the bay, the largest of which was located along the central eastern shore. The larger distributary bifurcated twice into multiple smaller channels. These channels extended at least 0.75 mile waterward of the 1880 channel locations, thereby delivering sediment and debris farther south into the bay. By 1998, the eastern distributary gained considerable channel complexity with multiple bifurcations, side and blind channels, and extended another 0.5 mile further into Bellingham Bay. One of the easternmost channels eventually migrated into the western edge of the study area, initiating rapid erosion of the prograded nearshore at western Cliffside Beach.

Within the last year, the Nooksack River flow has shifted west on the delta, avulsing from the eastern distributary to a more central delta distributary due to a new log jam (Maudlin, personal communication; MacKay, personal communication 2007). This alteration of flow across the delta may mean that Cliffside Beach may no longer receive large quantities of fluvial-derived wood debris, and erosion at the west shore of Cliffside Beach may stop in the near future.

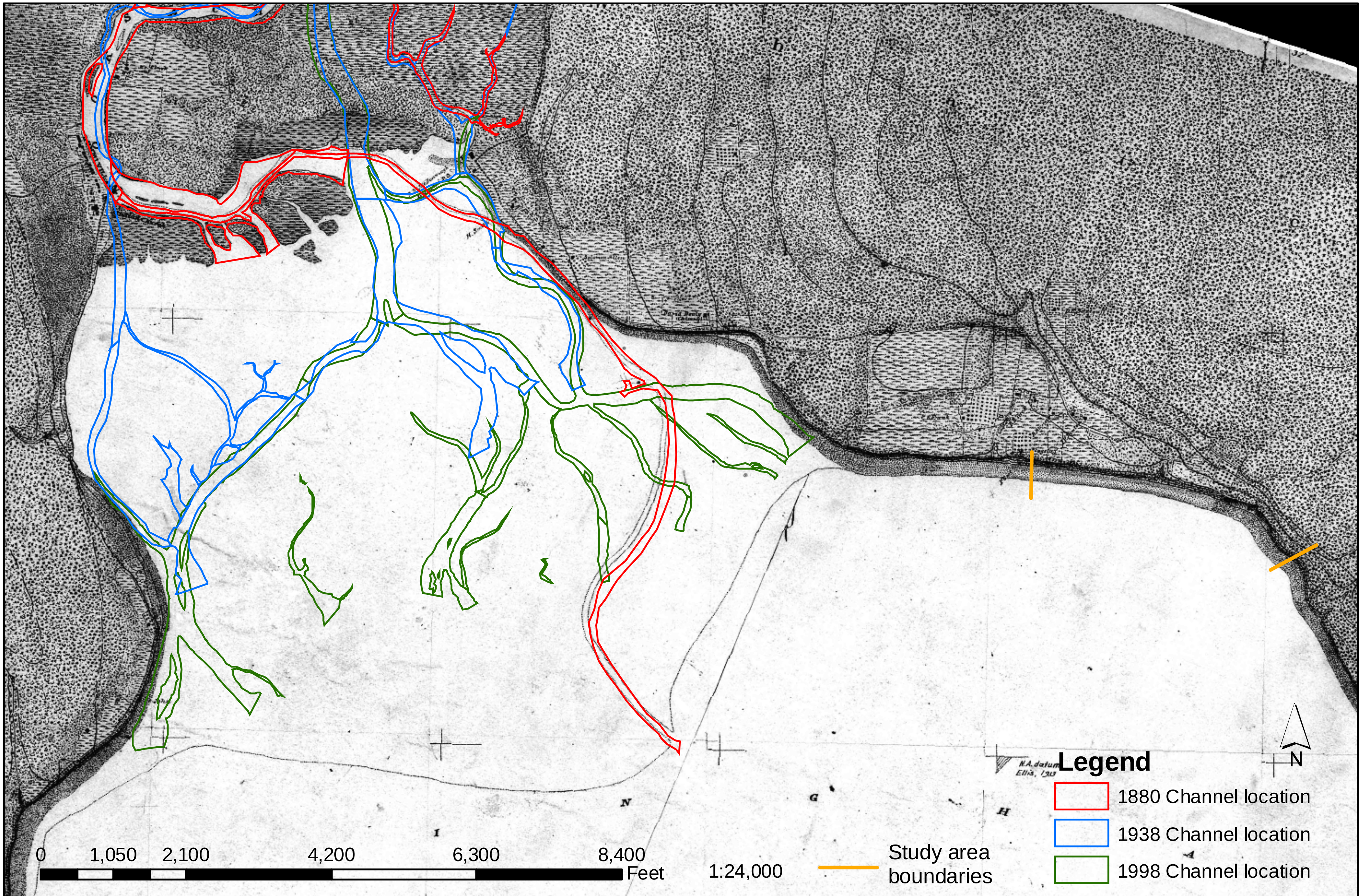

Figure 6. 1880 Nooksack River Delta Historic Channel Locations, Mapped from T-sheet (Collins and Sheikh 2004)

T-sheet No. 1798 (US Coast and Geodetic Service)

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4 POSSIBLE WOOD DEBRIS SOURCES

The project area setting is naturally positioned to receive material transported from other areas. The project area is located in a drift cell that originates at the beach near Mount Baker Plywood (near Squalicum Beach and the northwest extent of downtown Bellingham), approximately 2 miles south-southeast of Cliffside Beach. Net shore-drift in the drift cell is northwestward towards the Nooksack River delta (Jacobson 1980). Surface currents mapped by Collias et al. (1966) show a (clockwise rotating) gyre in northern Bellingham Bay. Prevailing and predominant winds in the region are from the south, and winds are the dominant influence on littoral drift throughout the region. The area is characterized by a moderately high fetch 12 to 19 miles from the south. When these factors are considered in total, it appears that the Cliffside Beach study area is positioned to receive sediment (and flotsam) input from both marine and fluvial systems.

The issue of identifying possible wood sources includes not only whether the wood debris is river- or marine-derived, but also whether anthropogenic activities influenced the volume of material delivered to Cliffside Beach. For the purposes of this investigation, river-derived wood debris refers to wood debris from the Nooksack River. Marine-derived wood debris refers to wood debris that was transported to the site via surface water currents and littoral drift. In this way, marine-derived wood debris includes material entering through the estuaries of rivers or creeks (i.e., freshwater systems other than the Nooksack River and which would require marine transport to reach the site) that was transported through Bellingham Bay currents or longshore drift to the project area.

4.1 River-derived Sources

The Nooksack River has historically been characterized as having an abundance of large woody debris and log jams. As early as the 1880s, U.S. Army Corps of Engineers (Corps) began efforts to clear wood and log jams from the river to improve commerce and safety on the river and floodplain. Lumber mills were operated on the river to process logs cut higher in the watershed. During the rafting of these logs, logs commonly broke loose and were considered lost (Sedell and Duval 1985). Due to anthropogenic and biogenic influences, the Nooksack River continued to carry a high volume of wood and major log jams were re-established. Eradication of these jams continued through the early 20th century.

Log jams also have a history of persisting in the eastern distributary channel of the Nooksack River delta. A Corps report documents an observer noting that the east channel "…could not flush itself….it was a collector of wood unlike any other mouth, indicating of course that it wanted to shut itself right back up" (T. Wahl, personal communication).

The natural decomposition of wood debris associated with logging in the Nooksack River watershed, as well as smaller material introduced by the destruction of log jams (especially when dynamite was used), could have released large volumes of wood debris into the vicinity of Cliffside Beach in the past. The log jam destruction and mill operations have not occurred in the river for many years and therefore cannot be considered as ongoing sources of material. However, the legacy of such activities and continued logging in the watershed could continue to provide a source of woody debris from logs or log jams that may break free during flood events and shifting distributary channels.

The changes in the Nooksack River delta and the Cliffside Beach shoreline over the last 60 years appear to influence the delivery of wood debris to Cliffside Beach. The appearance of more surficial wood debris in the 1961 aerial photographs may have been due in part to the delta expansion and shifting channels during the 1950s. In 1951, a large accretionary spit occurred west of the project area (Figure 3). The spit had a backshore as much as 500 feet wide and covered with large woody debris. By 1955, the spit was completely eroded away by the migration of the eastern distributary channel. The large woody debris likely would have abraded during high water events and storms, producing smaller debris. This redistribution of old wood deposits may have contributed considerable volumes of small wood debris to Cliffside Beach and may explain in part the larger amounts of surficial wood debris seen in the 1961 aerial photograph.

Over the last 60 years, the rapid progradation of the delta front encompassed Cliffside Beach, likely shifting it to a more river-dominated beach. In particular, the migration of the east distributary channel likely increased the depositional mechanism for fluvial-derived material to deposit within the study area. Mike MacKay (personal communication 2007), an employee of the Lummi Nation Natural Resources Department, mentioned that there has been a recent increase in the volume of wood deposited in the east channel in the last few years. He evidences the increase in wood debris with an increase in the size and extent of a large log jam located upriver from the delta.

An important finding from interviews was that the mainstem of the Nooksack River transports moderate amounts of small and large woody debris when the stage reaches the level to flood upstream gravel bars and lift and transport material downstream. Observers at the Lummi Nation research fish trap at the bridge in Ferndale (approximately river mile 5) have documented in datasheets and anecdotally that wood debris routinely clogs the fish trap during floods (MacKay, personal communication 2007). Although not specifically examined, it was learned that the datasheets contain general observations of the relative quantity (broken down by none, light, medium, and high) and general composition of wood debris (bark, sticks, leaves, and logs) for different length seasons starting March or earlier since 1999. High concentrations of wood debris at the fish trap were reported to require almost constant cleaning of the trap to keep it functioning during flood stages (MacKay, personal communication 2007).

4.2 Marine-derived Sources

Potential marine-derived wood sources are abundant due to the prolific history of the forest products industry in Bellingham Bay and beyond and the industry's use of coastal areas for log handling, storage, and transport. The center of the local forest products industry was located in the nearshore surrounding downtown Bellingham, which is located approximately 2 miles up-drift of the study area. At least five large mills were located within Bellingham Bay. Interviews with local historians and elders with the Lummi Tribe report that large volumes of sawdust entered the bay through mill-related activities, including the moorage of sawdust barges and saw blades within one or more of the mills positioned over the water. Sawdust generated during these operations was much coarser then sawdust from modern saws as the historic saws used had larger teeth (Jewel, personal communication 2007).

Although much of the sawdust was reportedly burned, considerable volumes were likely dumped and/or blown into the water. Sawdust, wood scraps, and lumber were also used to fill the mudflats of the bay.

Expansive log storage also occurred within the bay, which could have contributed large volumes of wood particles, debris, and bark. Small wood debris is commonly associated with log storage areas as bark and wood is abraded from logs as they bump into one another, especially during storms and due to boat wakes. Large log-carrying barges that dumped large volumes of raw logs directly into Bellingham Bay (such as the Haida Brave) operated for a number of years, up until the late-1990s. These could also be a source of bark and small wood pieces. Log dumps are also associated with accumulations of small woody debris, which are known to persist for as much as 30 to 40 years (Sedell and Duval 1985). The log dump, historically located just north of Boulevard Park, operated and stored logs for approximately 50 years (Jewel, personal communication 2007) providing the opportunity to contribute considerable volumes of wood debris to the nearshore. Log booming grounds were located between Boulevard Park and Cornwall Avenue and near Squalicum Creek from the 1920s to 1930s for the Whatcom Falls Mill (Jewel, personal communication 2007). Additional sources of wood could be attributed to activities at Mount Baker Plywood, including log peeling beginning in the 1940s and log rafting as recently as the 1980s.

Additional mills may have been located in closer proximity to the study area; however, it has been more difficult to document these locations. Several of the documents from the 1970s report on Cliffside Beach and note the origin of the wood debris as being derived from sawmills (e.g., Phillabaum 1973, Bauer 1974, and Jacobson 1980). R. Kinley and G. Wilson (personal communication 2007), elders with the Lummi Tribe, believe that the wood at Cliffside is marine-derived and not derived from the Nooksack River as the wood debris is unique to the lower eastern corner of the delta only. They also claimed that the local tribes would routinely complain about the saw debris in the water, both in the bay and the lower, eastern portion of the river that they fished, a reach they referred to as "Sawdust Drift." They firmly believe the wood at Cliffside was derived from industry downtown, especially from the period around the 1960s and 1970s. In a nearby fishing location referred to as “Sawdust Drift,” a fisherman could only “hold in net in the water for a few seconds before it would fill with wood debris and sink.” The tribal elders also noted that the changed channel configuration of the river and delta progradation has changed where the wood debris deposited.

The changed conditions at Cliffside Beach since the 1950s have increased the likelihood of marine-derived material depositing there. Rapid delta progradation has altered the bathymetry so that the deepest water in Bellingham Bay is located just waterward of Cliffside Beach. This has enabled floating debris from throughout the bay to funnel into and deposit within the northeastern corner of the delta. Reconnaissance of western delta beaches within comparable proximity to the Nooksack River as Cliffside Beach had only minor amounts of small woody debris. It is important to note that western delta beaches are not located down-drift of the large-scale historic milling operations, like the northeastern shores of Bellingham Bay. However, there is insufficient information to draw any conclusions regarding the relative contribution of river- and marine-derived sources from these western delta observations.

When considering milling operations, the potential for mills as a source of wood debris, such as log rafts and uncovered sawdust piles, likely reached its maximum abundance around the mid-1970s, and substantially decreased though the 1980s. Therefore, even if mills contributed to the amount of wood debris historically, it is unlikely that wood debris from such sources continues to deposit at Cliffside Beach.

4.3 Synthesis of Possible Wood Debris Sources Findings

This investigation of the possible sources of wood debris at Cliffside Beach has identified potential river- and marine-derived sources for the material. The site appears to naturally receive material due to its close proximity to the Nooksack River delta and the combination of wind waves, water currents, and littoral drift processes in Bellingham Bay, which transport large and small wood from throughout the bay into this portion of the bay.

The following hypotheses for wood debris sources and trends at Cliffside Beach have been developed based on the research (presented above in this section) and fieldwork (presented below in Section 5) conducted in this assessment. Historically, logging and mill activities in the river and on the bay appear to have contributed substantial amounts of wood debris to the water, including wood chips, sawdust, and bark. The high volumes of wood debris transported to Cliffside Beach appear to have contributed to the rapid accretion rate documented along most of the project area. The wood debris that is the focus of this project, large woody debris, and large volumes of sand from the expanding river delta were presumably continually deposited at Cliffside Beach and buried during the period of beach accretion.

Currently, it appears that Cliffside Beach receives some small, but persistent, amounts of wood debris from river- and marine-derived sources as well as episodic inputs of larger volumes of wood debris during events such as river floods and/or strong southerly wind events that push material into the northern portion of the bay. The episodic pulses of wood debris include material from the Nooksack River watershed and potentially throughout the marine area from as far south as Padilla Bay. In addition, it is hypothesized that episodic pulses include wood debris material that was previously buried, but has been re-exposed through the migration of the eastern distributary channel and storm events. That is, as the eastern distributary channel has migrated east toward Cliffside Beach, it has carved channels through deltaic and beach formations with presumably large quantities of logs and wood debris, and therefore re-engaged previously buried wood debris.

It is hypothesized that the close proximity of the eastern distributary channel to Cliffside Beach has contributed significantly to the transport of "new" material (i.e., fresh leaves and branches) and redistributed material (i.e., previously buried wood) to the beach. In this hypothesis, the eastern distributary channel migration re-entrains wood debris that had previously been deposited on the delta as well as beach and backshore areas along the shoreline bounding the eastern margin of the delta. In addition, the distributary channel migration also eroded beach and backshore areas (including the western portion of the project area), which had been accreting with a high volume of wood debris, as observed in historic aerial photos. Through the erosion of these areas, historic wood debris was re-mobilized into the water column and has likely been transported to Cliffside Beach.

5 ASSESSMENT TO QUANTIFY VOLUME OF WOOD DEBRIS AND SUITABILITY FOR DISPOSAL/REUSE

A field assessment was conducted on April 3 and April 4, 2007, to characterize the distribution and volume of surficial wood debris in the project area. Representative samples of surficial wood debris materials were collected for chemical testing to assess potential suitability for upland beneficial reuse following current Washington State Department of Ecology (Ecology) guidance. Due to unexpected volume needs during the laboratory analysis, samples needed to be recollected on May 1, 2007. These samples were collected from the same locations as the earlier samples, except for the easternmost sample (AN-CLF-01), which had to be relocated approximately 80 feet west because the original sample location no longer had a surficial wood debris layer. Despite the separate sampling dates, the samples are representative of the wood debris material in the project area.

Photographs taken during the field investigation are provided in 10 photo pages in Appendix B. Details of the methods and findings of the field assessment are provided in Appendix C. The field datasheets are provided in Appendix D.

Surficial wood debris was characterized by sampling along 35 transects spaced throughout the project area at 100-foot intervals (Figure 7). At the time of sampling, the westernmost transect was located along the western margin of the surficial wood debris accumulation and only a thin, scattered layer of wood debris was noted further west of this boundary location. Similarly, surficial wood debris diminished to the east of the easternmost transect.

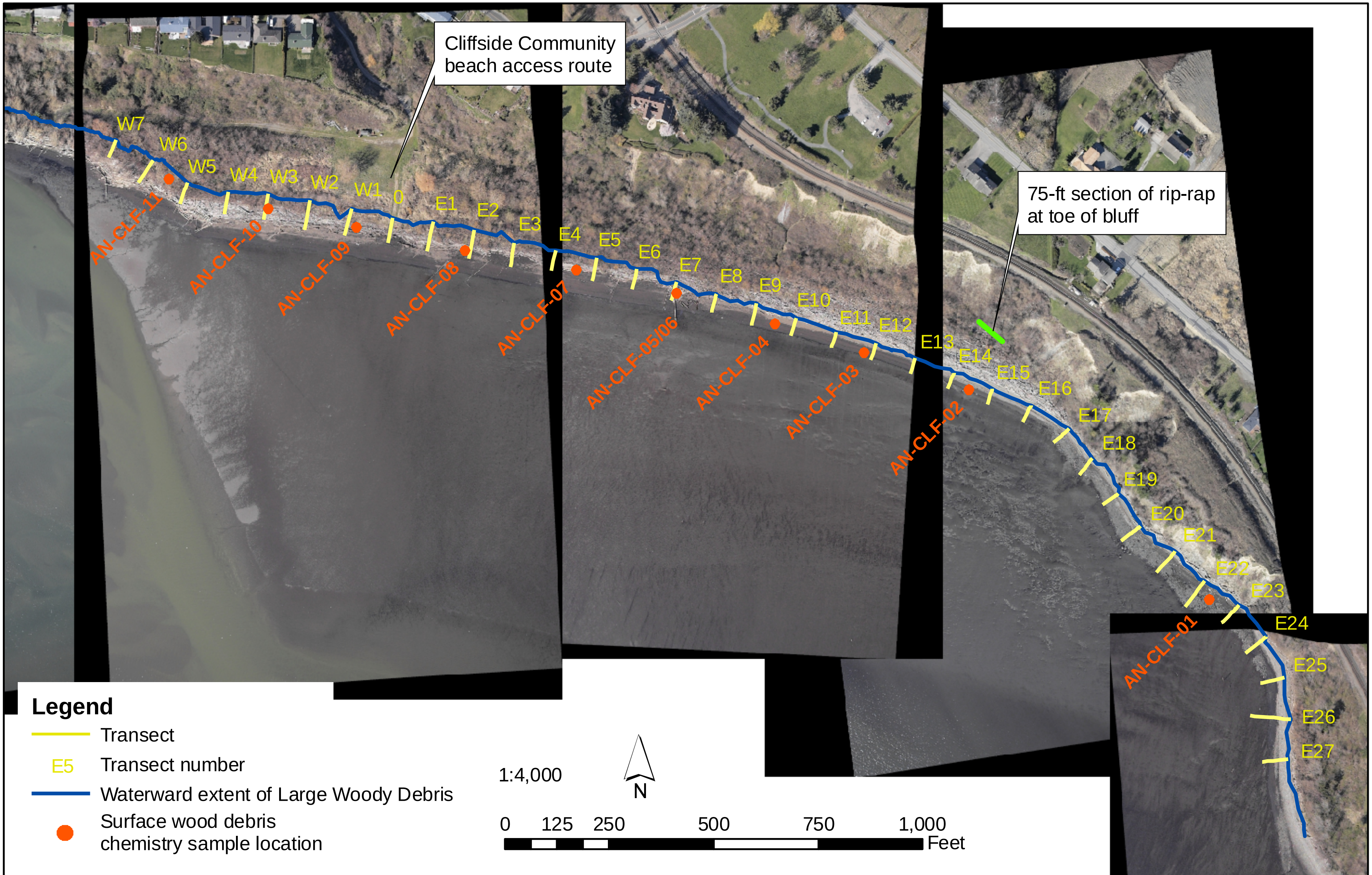

Figure 7. Upper Intertidal Beachface Transect Locations and Surface Wood Debris Chemistry Sample Collection Locations

Photos shown from 2004 (Pictometry International Corp.) Wood debris chemistry sample locations AN-CLF-05 and AN-CLF-06 are co-located to provide a field duplicate for quality control purposes.

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5.1 Surficial Wood Debris Material Composition

Based on field observations, the surficial wood debris layer appeared to be river- and marine-derived and was characterized by a continuum of degradation stages. Three primary categories of wood debris were defined in the field and used in the observations recorded on the datasheets. These wood types were roots and leaves, fine fibrous plant matter, and medium-fine fibrous plant matter. Two additional types of wood debris were noted (small woody debris and wood fragments), but these types were uncommon and scattered to such a degree that they were excluded from presentation in the figures. All observed wood types are shown in Appendix B, Photo Page 6 and described as follows:

- Roots and leaves – long root fibers; twigs; and whole, dead leaves with some feathers and small, fresh, plant matter
- Fine fibrous plant matter – decomposed wood and leaf material characterized by a dark brown appearance with a very fine texture (particle size less than 0.25 inch) and no long fibers
- Medium-fine fibrous plant matter – typically a lighter color than fine fibrous plant matter and contained leaf fragments and wood pieces of small sizes (particle size 0.25 to 0.5 inch)
- Small woody debris – small pieces of smooth twigs, typically up to 0.5 inch in diameter and 6-inches long and generally not containing bark
- Wood fragments – small wood pieces, generally 0.25 inch in diameter and 1-inch long

Along the lower elevations of the project area, the surficial wood debris consisted of the roots and leaves material. Along the upper elevations of the project area, the surficial wood debris consisted of a mix of fine fibrous and medium-fine fibrous plant matter.

5.2 Surficial Wood Debris Layer Distribution

Surficial wood debris accumulations occurred along almost the entire project area (Figure 8; Appendix B, Photo Page 1). The exception was a short section located near where the beach turns from south-facing to west-facing. Along most transects, wood debris was observed along the entire transect (i.e., the entire upper intertidal beachface). At each transect, the waterward margin of the surficial wood debris accumulation was identifiable. That is, contiguous surficial wood debris accumulations did not extend into the adjacent portions of

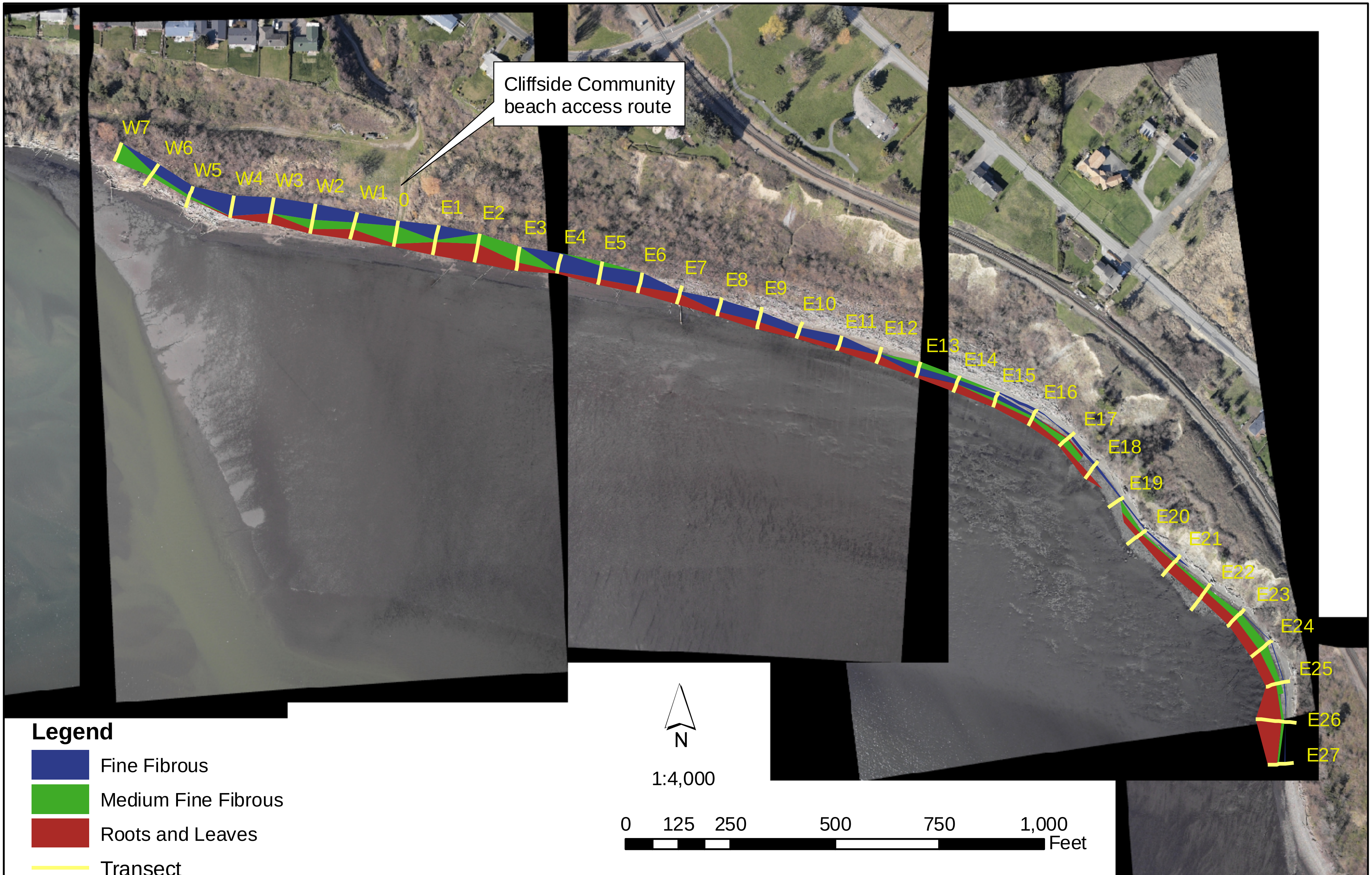

Figure 8. Surface Wood Debris Layer Distribution by Type as Determined by Visual Observation

Photos shown from 2004 (Pictometry International Corp.)

Cliffside Beach Wood Debris Removal Project

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the sand flat. However, widely scattered patches of surficial wood debris were visible further offshore on the broad sand flat.

5.3 Surficial Wood Debris Layer Thickness

The thickness of the surficial wood debris layer ranged from 0 to 33 inches. Table 2 presents the approximate acreage of coverage of each surficial wood debris thickness interval. The thickest accumulations of surficial wood debris occurred along an approximately 1,000-foot-long section centered on the Cliffside Community beach access route (Transects W6 to E4; Figure 9). Much of the beach in this area was covered by more than 12 inches of wood debris with a narrower band that had more than 18 inches of wood debris in places (Appendix B, Photo Page 2).

Table 2
Approximate Area Coverage of Each Surficial Wood Debris Thickness Interval

Thickness Interval (inches)	Approximate Area (acres)
0 to 0.5	0.68
0.5 to 1	0.40
1 to 3	1.13
3 to 6	0.94
6 to 12	0.46
12 to 18	0.45
18 to 24	0.14
24 to 30	0.02
30 to 33	0.00
Total	4.21

Along the next 1,200 feet of beach to the east (Transects E5 to E16), wood debris was noted in a nearly uniform thickness between 3 and 6 inches (Appendix B, Photo Pages 3 and 4). Further east along Transects E17 to E22, relatively minimal accumulations of surficial wood debris were observed. Along much of this area, the substrate was a mix of medium and large pebbles, and the wood debris did not fully cover the substrate (Appendix B, Photo Page 1). Between Transects E23 and E27, another thicker accumulation of surficial wood debris was documented. The surficial wood debris layer in this area was as much as 12 inches thick (Appendix B, Photo Page 5).

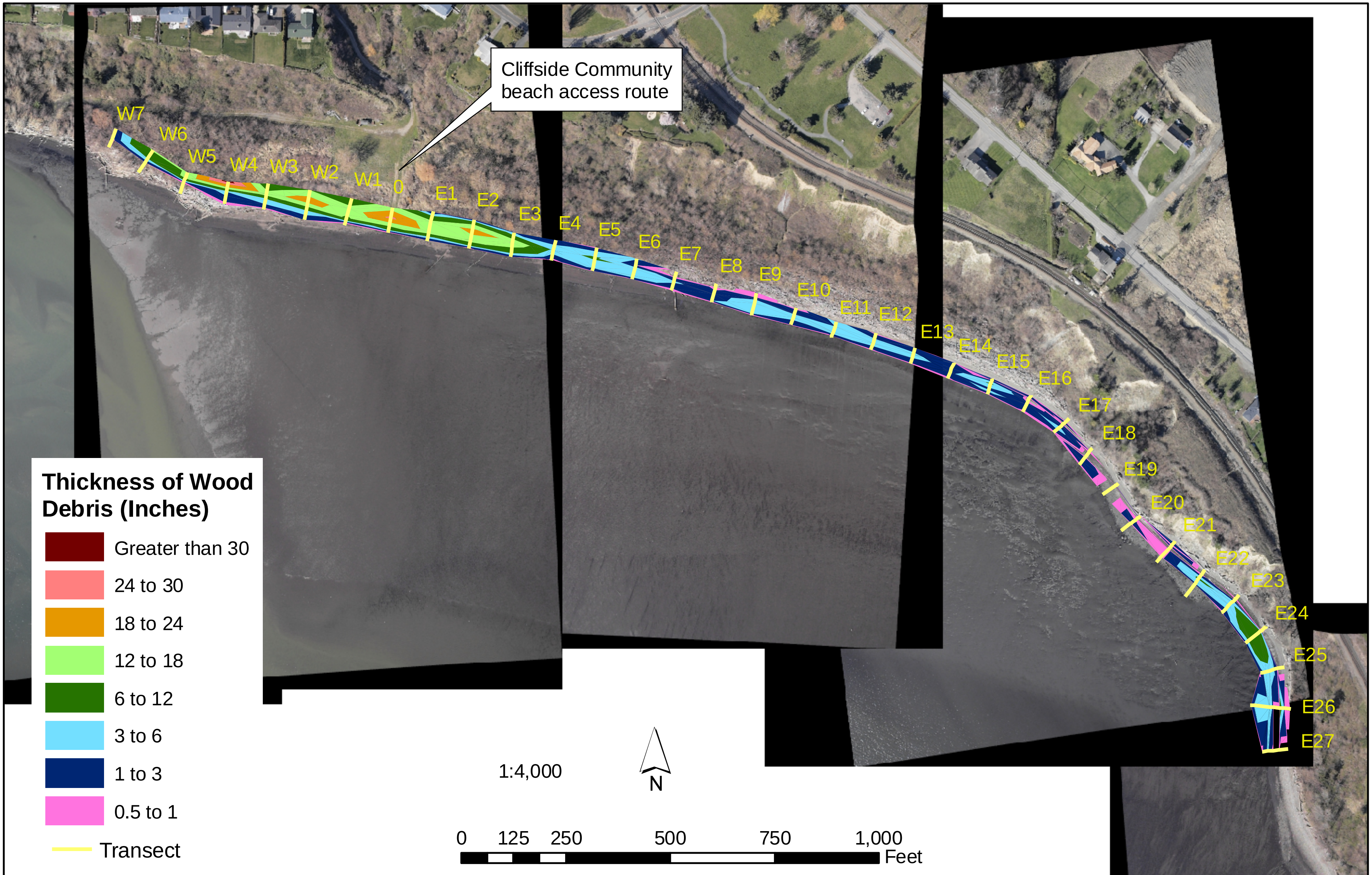

Figure 9. Thickness of Surface Wood Debris Layer as Determined by Direct Measurement

Photos shown from 2004 (Pictometry International Corp.)
Thickness measurements are reported to the nearest 0.5 inch.

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5.4 Substrate Underlying Surficial Wood Debris Layer

From the western margin of the project area to Transect E16, sand comprised the substrate observed below the surficial wood debris in the lower elevations of the project area (i.e., approximately +7.5 feet MLLW and lower). From Transect E17 to the eastern end of the project area, a mix of cobbles (2.5 to 10 inches in diameter) and sand with some medium pebbles (0.4 to 1.2 inches in diameter) were observed below the surficial wood debris in the middle and lower elevations of the project area. Along the upper elevations of the project area (i.e., approximately +7.5 feet MLLW and higher), the substrate size became gradually larger from west to east. From the western margin of the project area to the Cliffside Community beach access route, sand was the substrate observed below the surficial wood debris in the upper elevations of the project area. Moving east along the upper elevations, sand was mixed with small pebbles (0.16 to 0.4 inch in diameter) between Transects 0 and E9. Between Transects E10 and E20, more medium pebbles and large pebbles (1.2 to 2.5 inches in diameter) were observed. Cobbles and large and medium pebbles were the dominant substrates in the upper elevations of the easternmost portion of the project area.

5.5 Volume of Wood Debris Layer

Based on the survey data, the "neatline" volume of surficial wood debris in the project area was approximately 2,800 cubic yards (CY; i.e., excluding additional entrained volumes common to excavation projects). For the purposes of identifying and evaluating potential alternatives for the removal and reuse/disposal of the wood debris material, an assumed "over-excavation depth" of 6 inches was added to all portions of the project area with mapped surficial wood debris accumulations. The over-excavation depth refers to the depth into the underlying substrate that a removal contractor would potentially remove using conventional equipment and operating accuracies in order to ensure complete excavation of the wood debris. The over-excavation depth is a common consideration in shoreline remediation projects and is based on the anticipated precision of the removal contractor's equipment and operators. Including the over-excavation allowance, the prospective total volume of material that could potentially be targeted for removal is approximately 5,700 CY when conventional excavation techniques and equipment are used.

Figure 10 shows the cumulative volume of surficial wood debris present in the project area, including the neatline volume with the prospective over-excavation allowance, ordered by thickness range. Figure 10 also depicts the cumulative percentage of the surficial wood debris by thickness range.

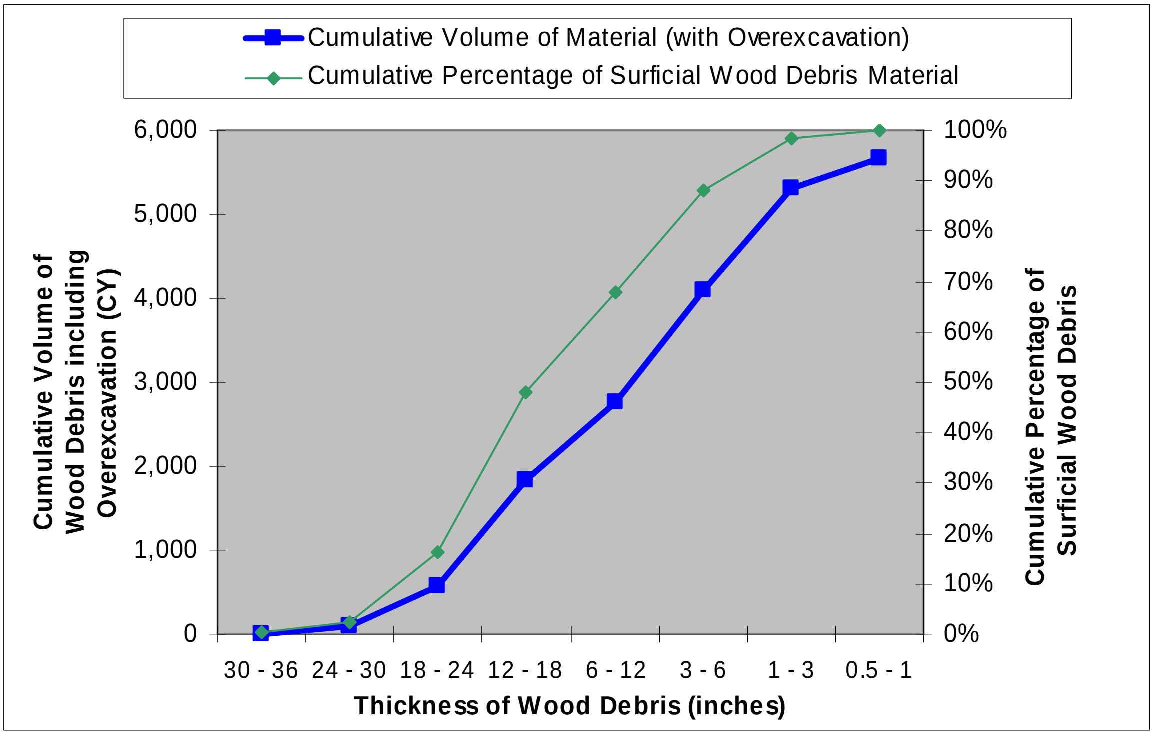

Figure 10
Cumulative Surficial Wood Debris Volume with Prospective Over-excavation Allowance and Cumulative Percentage of Surficial Wood Debris Volume Ranked by the Thickness of the Surficial Wood Debris Layer

Figure 10 may be useful for informing decisions regarding what minimum thickness of material to remove. For example, the figure illustrates that there are diminishing efficiencies associated with removal in areas with less than a 3-inch-thick layer of surficial wood debris. Nearly 90 percent of the neatline wood debris volume would be removed if excavation occurred only in those areas with 3 inches or greater thickness. Nearly 70 percent of the surficial wood debris would be removed if removal occurred in those areas with 6 inches or greater thickness.

The surficial wood debris volume and distribution identified in the field assessment provides useful data for the identification of response options and project planning, but it is important to note that the material appears to redistribute frequently along the beach. Thus, the volume and location of material may need to be re-assessed prior to implementing a removal action.

5.6 Chemical Analysis of Surficial Wood Debris Material

Representative samples of surficial wood debris materials were collected for chemical testing to assess potential suitability for upland beneficial reuse following current Ecology guidance. Samples were collected from 10 stations with one field duplicate also collected (see Figure 7). Based on the relative consistency of total organic carbon, total volatile solids, and total solids (Appendix E), as well as field observations of wood debris material type, compositing across sampling stations was considered appropriate for determinations of chemical suitability for reuse and/or disposal. Thus, the following samples were submitted to the testing laboratory:

- AN-CLF-01 – sample collected in easternmost accumulation within the project area
- AN-CLF-COMP-1 – composite of stations AN-CLF-02, AN-CLF-03, and AN-CLF-04 along the eastern part of the central project area
- AN-CLF-05 – sample centrally located and was the location of field duplicate AN-CLF-06
- AN-CLF-COMP-2 – composite of stations AN-CLF-07, AN-CLF-08, AN-CLF-09, AN-CLF-10, and AN-CLF-11 along the central and western portion of the project area

Data validation of the laboratory results was conducted to evaluate data quality. All data met quality control standards and all data are considered useable. Test results were compared to the Sediment Management Standards (SMS; Chapter 173-340 Washington Administrative Code [WAC]) Sediment Quality Standards (SQS) chemical criteria in order to determine if the surficial wood debris contains chemicals above concentrations that may potentially impact benthic infauna (Table 3). Test results were also compared to the Model Toxics Control Act (MTCA; Chapter 173-204 WAC) chemical criteria for unrestricted soil cleanup to evaluate suitability for beneficial reuse (see Table 3).

Table 3
Sediment Chemistry Compared to Applicable Criteria

	SQS LAET	MTCA B Unrestricted Soil	AN-CLF-01	AN-CLF-05	AN-CLF-COMP-1	AN-CLF-COMP-2
Conventionals						
Total solids (%)	--	--	11.80	17.80	17.70	18.30
Total organic carbon (%)	--	--	90.8	39.7	56.1	58.2
Metals (mg/kg)						
Antimony	--	--	50 U	60 U	30 U	30 U
Arsenic	57	20	50 U	60 U	30 U	30 U
Cadmium	5.1	2	2 U	2 U	1 U	1 U
Chromium	260	--	41	33	27	27
Copper	390	2,960	100	93	73	65
Lead	450	250	20 U	20 U	10 U	10 U
Mercury	0.41	2	0.4 U	0.5 U	0.3 U	0.2 U
Nickel	--	1,600	90	100	82	72
Silver	--	400	3 U	4 U	2 U	2 U
Zinc	410	24,000	120	160	108	45
PCBs (µg/kg)						
Aroclor 1016	--	--	9.8 U	9.8 U	9.8 U	9.8 U
Aroclor 1221	--	--	9.8 U	9.8 U	15 UY	20 UY
Aroclor 1232	--	--	9.8 U	15 UY	15 UY	20 UY
Aroclor 1242	--	--	9.8 U	9.8 U	9.8 U	9.8 U
Aroclor 1248	--	--	9.8 U	9.8 U	9.8 U	9.8 U
Aroclor 1254	--	--	9.8 U	9.8 U	9.8 U	9.8 U
Aroclor 1260	--	--	9.8 U	9.8 U	9.8 U	9.8 U
Total PCBs	130	1,000	9.8 U	15 U	15 U	20 U
SVOCs (µg/kg)						
1,2,4-Trichlorobenzene	31	800,000	20 U	20 U	20 U	20 U
1,2-Dichlorobenzene	35	7,200,000	20 U	20 U	20 U	20 U
1,3-Dichlorobenzene	--	--	20 U	20 U	20 U	20 U
1,4-Dichlorobenzene	110	42,000	20 U	20 U	20 U	20 U
2,4-Dimethylphenol	29	1,600,000	20 U	20 U	20 U	20 U
2-Methylnaphthalene	670	5,000	14 J	23	26	17 J
2-Methylphenol	63	--	20 U	20 U	20 U	20 U
4-Methylphenol	670	--	20 U	20 U	25	20 U
Acenaphthene	500	4,800	24	30	16 J	20 U
Acenaphthylene	1300	--	20 U	20 U	20 U	20 U
Anthracene	960	24,000,000	180	330	110	52
Benzo(a)anthracene	1300	1,370	61	42	39	34
Benzo(a)pyrene	1600	137	44	20 U	39	18 J
Benzo(b)fluoranthene	--	1,370	93	28	65	32
Benzo(g,h,i)perylene	670	--	20 U	20 U	20 U	20 U
Benzo(k)fluoranthene	--	1,370	74	41	83	23
Benzoic acid	650	320,000,000	200 J	230	600	200 U
Benzyl alcohol	57	24,000,000	100	130	440	21

	SQS LAET	MTCA B Unrestricted Soil	AN-CLF-01	AN-CLF-05	AN-CLF-COMP-1	AN-CLF-COMP-2
bis(2-ethylhexyl)phthalate	1300	71,000	73	340	88	25
Butylbenzylphthalate	63	16,000,000	160 UY	240 UY	140 UY	73 UY
Chrysene	1400	13,700	94	70	130	55
Dibenzo(a,h)anthracene	230	343	20 U	20 U	20 U	20 U
Dibenzofuran	540	--	24	45	20	13 J
Diethylphthalate	200	64,000,000	20 U	20 U	20 U	20 U
Dimethylphthalate	71	80,000,000	20 U	20 U	20 U	20 U
Di-n-butylphthalate	1400	8,000,000	20 U	20 U	20 U	20 U
Di-n-octylphthalate	6200	1,600,000	20 U	20 U	20 U	20 U
Fluoranthene	1700	3,200,000	360	310	420	160
Fluorene	540	3,200,000	37	84	23	16 J
Hexachlorobenzene	22	625	20 U	20 U	20 U	20 U
Hexachlorobutadiene	11	12,800	20 U	20 U	20 U	20 U
Hexachloroethane	--	--	20 U	20 U	20 U	20 U
Indeno(1,2,3-cd)pyrene	600	1,370	20 U	20 U	20 U	20 U
Naphthalene	2100	5,000	19 J	16 J	22	13 J
n-Nitroso-di-phenylamine	28	204,000	20 U	20 U	20 U	20 U
Pentachlorophenol	360	8,330	100 U	100 U	100 U	66 J
Phenanthrene	1500	--	180	330	170	90
Phenol	420	48,000,000	35 UY	34 UY	60 UY	20 U
Pyrene	2600	2,400,000	180	280	230	110
Total benzofluoranthenes[1]	3200	--	167	69	148	55
Total HPAH[2]	12000	--	906	771	1006	432
Total LPAH[2, 3]	5200	--	440	790	341	171
Total cPAHs (BaP EQ)	--	137	67.7	11.8	59	27.5

Notes:

-- indicates that criteria are not applicable.

J indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U indicates the analyte was not detected at the detection limit shown.

Y qualifier is equivalent to the U qualifier with a raised reporting limit due to chromatographic interference.

(1) Total benzofluoranthene criterion represents the sum of the detected concentrations of the b and k isomers (the j isomer co-elutes with k). When all isomers were not detected, the highest detection limit was reported as the sum. Qualifiers were attached to the total benzofluoranthenes value if any of the contributing concentrations were denoted with that qualifier.

(2) Total LPAHs and HPAHs are the sum of all detected contaminants within the subheading. When all isomers were not detected, the highest detection limit was reported as the sum. Qualifiers were attached to the Total LPAHs or HPAHs value if any of the contributing concentrations were denoted with that qualifier.

(3) 2-Methylnaphthalene is not included in the total LPAH calculation.

Yellow shaded box denotes exceedance of SQS (LAET) criteria.

The samples met SMS criteria for all parameters, except benzyl alcohol. Three of the four samples had exceedences for benzyl alcohol. Benzyl alcohol is a natural derivative of wood decomposition and is not expected to limit the ability to reuse the material. No MTCA criteria were exceeded. Because the wood content is greater than 50 percent by volume, the material would be required to undergo biological testing to assess the suitability of the material for unconfined open-water disposal through the Corps' Puget Sound Dredged Disposal Analysis Program. However, the sediment chemistry results indicate no restrictions on upland disposal/reuse options.

Salinity of the existing leachate draining/discharging from the surficial wood debris materials was measured in the field at two locations. The salinity of such drainage water averaged approximately 4.9 parts per thousand (ppt) at both locations. This salinity level could limit the suitability of the wood debris material as soil or mulch for upland vegetation restoration projects until salinity is reduced to near 0.5 ppt (see Section 6.1.3). However, the salinity would not be expected to limit reuse of the material for estuarine or marine restoration projects.

6 OPTIONS FOR REMOVAL AND DISPOSAL/REUSE OF WOOD DEBRIS

Identified options for the removal and disposal/reuse of wood debris are presented in the following sections. Cost estimates for two selected options are presented in Section 7.

If it is decided that wood debris will be removed, then a decision will need to be made whether to fully or partially remove the material. The advantages of a full removal action include maximizing the area of beach restored and reducing the potential for re-accumulation through the redistribution of material that is already in the project area; however, it is possible that re-distribution could occur over tide cycles during the construction period, which could result in a need to "chase" material in order to facilitate a full removal action. The full removal action would provide the best opportunity for understanding re-accumulation rates and investigating ecological function differences between the baseline and restored conditions. Depending upon the specific removal design, a negative impact could be the removal of valuable, prime sand/fine gravel habitat suitable for important target restoration species such as forage fish and juvenile salmonids. However, the beach currently contains relatively vast quantities of fine gravel and coarse sand with likely continued accretion in the future. A partial removal option would cost less and allow for some investigation of the changes in ecological function between restored and unrestored areas. A partial removal provides less certainty that the desired datasets could be collected because of the enhanced likelihood of re-accumulation soon after removal due to the redistribution of material from other portions of the project area.

6.1 Removal and Disposal/Reuse Options

The removal and disposal/reuse of surficial wood debris from Cliffside Beach has three main components: 1) excavation of the material from the beach, 2) transportation of material from the project area, and 3) disposal/reuse. There are multiple options for each of these components. Following is a description of the identified options, including a discussion of logistical constraints at the site. A particularly important aspect in assessing the feasibility of the options is the cooperation of the Cliffside Community, as access to and from the project area via the community road has been assumed. It is our understanding that the Cliffside Community has been very supportive of the project in general but has expressed some concerns about the project using the community road. We have proceeded on the assumption that the community concerns can be addressed through appropriate project design and that their cooperation will continue.

6.1.1 Excavation of Surficial Wood Debris from the Beach

For the purposes of identifying options for excavating surficial wood debris from the beach, it is assumed that the equipment would access the beach through the Cliffside Community beach access route. There are two main techniques that can be employed. Conventional excavation techniques typically allow for up to 6 inches of over-excavation by the contractor—although tighter control may be possible because the site can be accessed and work completed "in the dry" during low tide. That is, in order to ensure excavation of the wood debris, the removal contractor might remove as much as 6 inches of the underlying material (i.e., sand and gravel). An assumed over-excavation depth of 6 inches to 1 foot is a typical consideration in shoreline remediation projects where work is occurring in-water and is based on the anticipated precision of the removal contractor's equipment and operators, as well as the logistical difficulty of working with limited visibility due to the presence of the water. Because the site has access at low and mid-tide levels, it is anticipated that conventional excavation would be conducted using a front-end loader, bulldozer, excavator, or other land-based earthwork equipment, and the contractor may be able to work with a tighter over-excavation allowance. Since the potential contractor's methods and precision are unknown, a 6-inch over-excavation allowance has been assumed.

Precision excavation techniques would entail more accurate removal of the surficial wood debris layer. Precision techniques would entail a smaller amount of over-excavation and/or some areas with a thin layer of surficial wood debris left on the beach. Precision excavation techniques could be accomplished using conventional earthwork equipment operating at a slower pace than compared to conventional excavation techniques. Other equipment that could potentially facilitate precision excavation includes a vacuum truck or bark spreader. However, there are no known uses of this type of construction in the marine environment, and vacuum technologies are still limited by horizontal and vertical positioning accuracy.. The availability and suitability of this equipment for collecting the surficial wood debris would need to be explored further directly with specific contractors, as it is unknown whether such specialty equipment and/or contractors are available who would be willing to use this specialized equipment in a marine environment. Our preliminary estimates on the use of this type of equipment suggest that the unit costs for this construction could be substantially higher than the unit costs for using conventional earthwork equipment, thus potentially offsetting any savings gained by the smaller volume of material that would be removed. However, if this type of construction is of interest, we recommend that a short list of potentially qualified contractors be developed and further discussions occur directly with these contractors.

The advantages and disadvantages associated with each excavation option are described in Table 4.

Table 4
Advantages and Disadvantages of Excavation Techniques and Equipment Identified

Excavation Technique and Equipment	Advantages	Disadvantages
Conventional Excavation – Front-end Loader	• Full removal of surficial wood debris in targeted areas • Low unit cost rate • Relatively short period of time to complete work	• Significant disturbance and removal of substrate underlying surficial wood debris • Increased volume of material to be handled and disposed/reused • Excavated material has a large percentage of sand and gravel, which may eliminate some landscape reuse options
Precision Excavation – Front-end Loader	• Minimized disturbance and removal of substrate underlying surficial wood debris • Decreased volume of material to be handled and disposed; reuse limited to wood debris	• May leave thin layer of wood debris on beach surface • Higher unit cost rate • Longer period of time to complete work is likely
Precision Excavation – Vacuum Truck or Bark Spreader	• Minimized disturbance and removal of substrate underlying surficial wood debris (potentially improved compared to precision excavation with front-end loader) • Decreased volume of material to be handled and disposed; reuse limited to wood debris • May better accommodate on-site disposal	• May leave thin layer of wood debris on beach surface • Higher unit cost rate for excavation and transportation • Longer period of time to complete work is likely • Uncertain availability of suitable equipment for this purpose • Specialty techniques have not been tested in similar applications

6.1.2 Transportation of Surficial Wood Debris from the Project Area

Transporting the surficial wood debris from the project area can be conducted immediately provided the post-excavation water content of the material is suitable for transportation. Alternatively, the material can be stockpiled for a period of time and allowed to dewater. The Cliffside Community access area includes a large area where material could be stockpiled, although it may not be large enough to stockpile the entire surficial wood debris volume. One disadvantage of stockpiling in the access area is that there is a significant potential for infestation of the material by invasive plants such as Japanese knotweed (*Polygonum cuspidatum*), Scot's broom (*Cytisus scoparius*), and Himalayan blackberry (*Rubus discolor*), which are present nearby. If accompanied by watering and/or extended storage, stockpiling would provide an opportunity to purge salt from the material through sparging. In this context, sparging refers to the application of water to rinse the salt from the material. Salinities lower than the 4.9 ppt recorded for the material are likely to be needed to ensure the suitability of potential reuse options described in Section 6.1.3. Sparging is currently being used to reduce salinities in wood debris removed from the marine environment at Port Gamble, and a similar process could be implemented at the Cliffside Beach site. If a water line can be provided to the stockpiling area, the sparging process may be completed within weeks or months depending on the depth of the stockpile and the volume of water applied. Timing the project to take advantage of autumn rains would potentially reduce the need for supplemental water to facilitate sparging.

The options identified for transporting the material from the project area (if necessary) are large trucks (10 CY capacity), small trucks (6 CY capacity), a barge, and a conveyor. The two truck sizes were identified based on the size of the Cliffside Community access road and the community's concern that the road could potentially be damaged by heavy trucks. The dimensions and route of the road would allow large or small trucks to be used. A structural analysis of the road has not been performed to evaluate the impact of repeated use of the road by large trucks. It is possible that the road may need to be improved, and/or repaired or rebuilt at the completion of the project if large trucks are used and the community concerns are valid. Depending on the specific transport method, it is possible that the existing road may be capable of accommodating construction equipment loads with minor impact to the road surface. Further design analysis would be required to determine if road improvements may be necessary.

Barge transport from the project area could occur if a barge could access the area from the sand flats or possibly use the east distributary of the Nooksack River for part of its approach. Due to the wide sand flat at approximately +4.5 to +5.5 feet MLLW, the barge would have to be grounded during the low tides in which the removal activities would occur. The likelihood of regulatory agencies approving the short-term grounding of the barge is uncertain at this time. One barge known to work in the area may be particularly well suited for this project as it is relatively small (capacity of approximately 400 tons), self-powered, and has a bow door that opens into a large ramp. Marine contractors typically do not prefer their equipment to intentionally ground during a project; although, preliminary conversations were conducted and the relatively flat and boulder free conditions at the study area are favorable for temporary grounding. The water depths need to be more carefully determined, but preliminary information suggest that it should be suitable for small barge work as the unit under consideration would have a 3.5 to 4 feet of total draft when loaded with wood debris. It was estimated that the barge could carry about 450 to 500 CY fully loaded, with an estimated weight of 200 tons per trip.

Transport using a conveyor is considered infeasible given the project area setting. The beach is bounded by steep, high bluffs that are bordered by railroad tracks, making a straight conveyor alignment costly and difficult to implement. The existing road is not straight, which would require a complicated conveyor setup that would likely by cost-prohibitive. The instability of the bluffs is apparent along the length of the project area. Crossing the railroad tracks would present another challenge that would be expensive to overcome. For safety reasons, the BNSF Railway would be very unlikely to allow any structure or weight along the bluff length.

The advantages and disadvantages associated with each transportation option are described in Table 5.

Table 5
Advantages and Disadvantages of Transportation Options Identified

Transportation Equipment	Advantages	Disadvantages
Large Trucks	• More rapid removal of material from site • Fewer truck loads necessary to complete project • Lower unit cost rate for longer hauls (5 or more miles) than small trucks	• More likely to damage access road than small trucks • Higher unit cost rate for short hauls than small trucks
Small Trucks	• Less likely to damage access road • Lower unit cost rate for short hauls than large trucks	• More truck loads necessary to complete project • Slower removal of material from site • Higher unit cost rate for longer hauls (5 or more miles) than large trucks
Barge	• Avoids need to use access road and backshore • Easy transport of material to marine or estuarine reuse area	• Will require grounding in intertidal zone • May cause scour as barge moves from loading area at lower margin of the beach and returns to the river channel
Conveyor	• Not applicable	• Cost prohibitive due to unstable, steep, high bluffs and winding access road corridor

6.1.3 Disposal or Reuse of Surficial Wood Debris from the Project Area

Based on the comparison of the surficial wood debris chemistry to Ecology's SMS and MTCA criteria, there are no restrictions on the upland reuse or disposal of the Cliffside Beach wood debris for beneficial reuse at upland locations. The exceedance of the SMS criterion for benzyl alcohol prevents the marine disposal or reuse of the material.

A separate issue affecting the disposal and reuse options is the observed salinity of the interstitial water in the wood debris. The 4.9 ppt salinity of the material would likely need to be reduced to less than 0.5 ppt to achieve the secondary contaminant (taste/odor) criteria of Ecology's Water Quality Standards for Ground Waters of the State of Washington (WAC 173-200). In upland reuse settings where the Ground Water Standards are potentially applicable, total dissolved solids in the wood debris leachate may need to be reduced to less than 500 milligrams per Liter (i.e., 0.5 ppt). That is, for upland beneficial reuse applications in which leachate and/or runoff from the material may potentially enter groundwater aquifers, the surficial wood debris would first need to be sparged to reduce salinity. This would require a location to stockpile the material, perimeter containment to manage the leachate and stormwater, a conveyance pipeline to drain the leachate and stormwater back to the bay, and the establishment of a sprinkler system to water down the material. In addition, the leachate and stormwater may require testing and/or monitoring to demonstrate that drainage back to the bay is not causing adverse impacts to water quality. As described in Section 6.1.2, sparging could take weeks or months. Sparging would take longer if no sprinkler system could be constructed at the site and if natural rainfall was the only source of freshwater to the stockpile.

One disposal/reuse option is to deposit the surficial wood debris into the backshore of the project area. This could potentially be accomplished through manual placement with a front-end loader, provided that access lanes could be cleared to the backshore and an uneven distribution was acceptable. A broader and more even backshore distribution could potentially be achieved by using equipment that projects the material into the backshore (e.g., bark spreader), provided that a willing contractor and equipment can be located. Some of the material is naturally deposited into the backshore during extreme high tides and storm events at present. A reconnaissance of the backshore during the field assessment indicated large quantities of small and large woody debris already in the backshore.

Wood debris appears to have been a continual component of the expansion of the beach backshore based on the persistence of surficial wood debris in historic aerial photographs, community member recollections, and the progradation of the backshore over the last 50 years. Therefore, the input of additional wood debris would not likely significantly alter the composition of the backshore habitats. This option potentially reduces costs by avoiding transportation and disposal/reuse fees, and this option would likely not require sparging. This option also meets the Cliffside Community's apparent desire to avoid transporting material using their road. However, it is our understanding that the community has expressed some concerns about placing the material in the backshore. These concerns would need to be understood and addressed. Based on available land ownership information, the Washington State Department of Natural Resources (WDNR) owns the tidelands of Cliffside Beach. Upland parcels landward of mean higher high water (which is approximately +8.5 feet MLLW) are in private ownership.

Another on-site option for reuse of the material is to use it for restoration of the marine riparian zone of Cliffside Beach. The hillside landward of the Cliffside Community access area is overrun with invasive vegetation. The surficial wood debris could be used as mulch for a revegetation effort of the hillside as well as other riparian areas at the site that are also dominated by invasive vegetation. The salinity of the material may initially be useful in deterring invasive vegetation growth. As the salinity washes away, the material would provide good topsoil and mulch for such revegetation efforts. This option would eliminate transportation and disposal/reuse fees and would avoid the need to transport materials using the Cliffside Community access road.

Similar off-site uses for habitat restoration and revegetation purposes may be possible by partnering with the City of Bellingham (City), Port of Bellingham (Port), Nooksack Salmon Enhancement Association (NSEA), and/or the Lummi Nation. Tim Wahl (City) has expressed an interest in using the material for riparian vegetation restoration at Little Squalicum Park. These potential partners may have an area to stockpile some or all of the material prior to placement and to allow time for sparging. Reuse for habitat restoration projects in estuarine environments would not require sparging. The material could potentially contribute to good substrate to establish marsh vegetation. The Lummi Nation's restoration project in Smuggler's Slough is one option. Another option is the City's planned restoration at Little Squalicum Creek.

The surficial wood debris could be used by a commercial landscaping or composting company. For example, Green Earth Technology in Lynden makes compost of yard waste and may accept the Cliffside Beach material. The Sanitary Service Company in Whatcom County recycles materials and may accept the Cliffside Beach material. However, initial communications with two local commercial landscaping and nursery companies, Starkenberg Shavings and Smith Gardens, indicated no identified use for the material due to its time in the marine environment.

The surficial wood debris material could be disposed of in a landfill if the chemical composition of the material were determined to be unsuitable for beneficial reuse or if reuse options prove impracticable. Marine disposal at an open water facility would be possible; however, additional chemical testing would be required under the Corps Dredge Material Management Program (DMMP) to determine if the material would be suitable for open-water disposal.

The advantages and disadvantages associated with each disposal/reuse option are described in Table 6.

Table 6
Advantages and Disadvantages of Disposal/Reuse Options Identified

Disposal/Reuse Option	Advantages	Disadvantages
Deposit material along backshore of beach	• No transportation or disposal/reuse fees • Avoids access road concerns of the Cliffside Community • Eliminates issues regarding salinity • Continuation of a natural process at the site	• Uncertain availability of suitable equipment for this purpose • Depending on technique, equipment may be expensive • May require coordination with multiple landowners
Mulch for revegetation of the hillside located landward of the Cliffside Community access area and other marine riparian areas along the beach	• No transportation or disposal/reuse fees • Avoids access road concerns of the Cliffside Community • Eliminates issues regarding salinity • Uses material for restoration purposes • Addresses habitat enhancement opportunity at the site • Fosters enhanced stewardship among participating community volunteers	• Would require maintenance to avoid recolonization by invasive vegetation • May require coordination with multiple landowners
Mulch for revegetation at habitat restoration sites of potential project partners (e.g., City, Port, NSEA, and Lummi Nation)	• No disposal/reuse fees • Fosters partnering among multiple organizations conducting habitat restoration in the region • Uses material for restoration purposes	• Transportation costs will apply • Requires use of Cliffside Community access road for transport of material from site • May require stockpiling and sparging before transferring material to partner • May require extensive coordination with multiple partners
Composting or recycling by local business (e.g., Green Earth Technology and Sanitary Service Company)	• Material will be beneficially reused	• Transportation costs will apply • Requires use of Cliffside Community access road for transport of material from site • May require stockpiling and sparging before transferring material to partner • May entail disposal fee
Landfill	• One facility will accept full volume • Less coordination necessary • No sparging necessary	• Transportation costs will apply • Will entail disposal fee • Loss of good material for other beneficial reuse purposes
Open water disposal	• No sparging necessary	• Barge transportation would be required; access by barge for loading would be difficult • Transportation costs will apply • Will entail disposal fee • Loss of good material for other beneficial reuse purposes • Additional chemical testing necessary • Buoyancy of material may make it ineligible for this option

7 COST ESTIMATES FOR TWO SELECTED WOOD DEBRIS REMOVAL AND DISPOSAL/REUSE OPTIONS

A meeting[1] was held on May 17, 2007, to review the options presented in Section 6 and to identify two options for which cost estimates will be prepared. The removal techniques selected were for full removal using conventional and precision removal techniques. Both of these removal techniques will assume use of a front-end loader. For disposal/reuse, the two selected options were 1) disposal of material in the backshore of the project area and 2) reuse of the material as mulch for revegetation of the hillside located landward of the Cliffside Community access area and other marine riparian areas along the beach on either side of the Cliffside Community access area.

Generally, costs for this type of work include mobilization/demobilization of equipment, site preparation, and construction. Construction costs can be further broken down into excavation, transportation, and disposal, as well as any contractor support such as surveying and erosion control. There are additional project costs for design, permitting, construction management, and monitoring during and after construction, which have not been estimated for this report since the scope of these components is not well known at this time.

The excavation costs were estimated assuming that conventional earthwork equipment would be used (front-end loader, bulldozer, off-highway dump truck, etc.) and that the work would be limited to periods of low and mid-tide with a daily production rate of approximately 200 CY per day. The precision excavation cost was estimated assuming a slower production rate (approximately 150 CY per day) compared to the conventional excavation cost.

Both disposal/reuse options are expected to have similar costs because disposal/reuse will occur on site. This cost item covers transportation (which would be relatively equal in both cases) and any disposal fees (which are none in these cases). Thus, the disposal/reuse cost for each

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[1] Attendees at the meeting included Atina Casas and Erika Stroebel from Whatcom County Public Works, Barry Wenger and Lucy McInerney (phone) from Ecology, Lisa Kaufman from WDNR, Hilary Culverwell and Sabrina Ratliffe from the Puget Sound Action Team, and Joan Drinkwin from the Northwest Straits Foundation. Paul Schlenger and Clay Patmont from Anchor Environmental, L.L.C., and Jim Johannessen from Coastal Geologic Services, Inc., were the participating consultants in attendance.

alternative was not separated from the excavation cost; both costs have been lumped together and are reported on a per CY basis and a total construction project basis.

Approximately 70 percent of the material could be removed if deposits thicker than 6 inches are targeted. These deposits are expected to be the easiest (and most efficient) to excavate, and the unit cost for excavation would be lower than it would be to remove the final 30 percent of the material, which is spread over a larger area. In order to evaluate any efficiency from a partial removal, we prepared cost estimates for both a complete removal and a partial removal, assuming that deposits 6 inches or thicker are targeted. Table 7 presents a summary of the estimated project costs for the various options reviewed.

Table 7
Summary of Estimated Project Costs

Item	Conventional Excavation		Precision Excavation	
	Full Removal	Partial Removal[1]	Full Removal	Partial Removal[1]
Volume (CY)	5,700	4,000	2,800	2,000
Excavate, Transport, and Place ($/CY)	$10 to $15	$10 to $12	$15 to $20	$15 to $18
Total Project Cost[2] ($/CY)	$17 to $24	$19 to $21	$28 to $35	$30 to $35
Total Estimated Project Cost[3]	$100,000 to $140,000	$75,000 to $85,000	$80,000 to $100,000	$60,000 to $70,000

1. Partial removal targets deposits of 6 or more inches in thickness.
2. Total project cost includes mobilization/demobilization, site preparation, 30 percent contingency, and sales tax.
3. Total estimated project costs are rounded to the nearest $5,000.

As stated previously, the selection of a placement area is not expected to result in a large difference to the project cost for the two options evaluated. Costs of both options for on-site reuse of the material include some preparation of the placement area—either log cutting or moving logs to create a pathway to the backshore, or brush clearing in areas where the material would be reused. In either case, the bulk of the construction cost is in the excavation of the material itself and the transportation of the material to the placement area. In both cases, the average travel distances to the placement areas (and corresponding cost) were considered to be similar since all work was limited to the on-site area.

The estimated costs for excavation and transportation are higher than what would normally be seen in a typical upland earthwork project. Significant differences for this work include the limited site access described in Section 6 and the fact that the contractor would be limited to working during lower tide periods and thus, daily production is expected to be much lower.

The costs presented in this section are construction costs (including contingency). Potential additional costs beyond the construction costs include permitting, construction management, and pre- and post-construction monitoring.

8 ADDITIONAL RESTORATION ACTIONS FOLLOWING WOOD DEBRIS REMOVAL

The method of wood debris removal, if implemented, will determine the degree of potential impact to the intertidal and waterward portion of the backshore at the site. Precision removal techniques, designed to keep the degree of disturbance of the underlying substrate to a minimum, should have the least impact on the substrate and ecologic community of the two general removal options. Conventional wood debris removal techniques are anticipated to remove up to 6 inches of upper beach substrate from the beach system, as described in Section 6.1.1. However, considering that the ecologic community of the upper beach is assumed to be significantly impacted by wood debris at present, it appears that the impact should be minimal to organisms that are characteristic of a healthy upper intertidal area. The dynamic and regularly changing nature of the upper intertidal and active backshore areas, and the location of the site within the deposition area for marine organisms, lead to the conclusion that natural recovery in a relatively short period is highly likely, even after removal of 6 inches of sediment.

Sediment recruitment appears to be occurring at the upper intertidal beach in the study area as the documented accretion rate in recent decades is high (see Section 3). Therefore, with precision or conventional removal techniques, no major restoration of the upper beach or adjacent backshore should be required. The area is characterized by a moderately high fetch 12 to 19 miles from the south. This area is known for relatively high wave energy and adjustment of the beach surface would be fairly quick—within several days to weeks. In addition, any removal activities will likely be timed for late summer or early fall, due to fish windows and tides. Thus, the timing of the work would be just before fall windstorms, which typically begin by early or mid-October, which would be certain to fully re-shape the beach and bring large wrack deposits and associated larva, seed, etc.

9 PERMITTING REQUIREMENTS FOR WOOD DEBRIS REMOVAL

Table 8 provides a list of permits needed for the project. If Ecology pursues reuse of the material, then the habitat restoration aspects of the project may allow for some streamlining of the permitting process, reducing both the time and number of permits required. However, preliminary conversations with the Corps indicate that they may not consider the project as a restoration project; therefore, the expedited permitting process may not apply.

Environmental review and permitting is expected to span a total of 9 to 12 months, but this timeline can change depending on permit issues in review. A general schedule and sequencing of recommendations are provided below.

1. Prepare an Endangered Species Act (ESA) and Essential Fish Habitat (EFH) document for submittal to the Corps. The ESA document will evaluate the potential effects of the project on ESA-listed species (plants, fish, and wildlife) and designated critical habitat; review period is approximately 2 months for an informal consultation and approximately 270 days for a formal consultation.
2. Prepare a State Environmental Policy Act (SEPA) Checklist for submittal to Whatcom County; review period is approximately 3 months.
3. Prepare Shoreline Permit and Critical Areas documents for submittal to Whatcom County; review period is approximately 3 to 4 months.
4. Prepare a draft and final Joint Aquatic Resources Permit Application (JARPA) to obtain Corps permits (Individual 404 Permit), Washington Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA), Shoreline Permit and Critical Areas approval from Whatcom County, and Section 401 Water Quality Certification and Coastal Zone Management Act (CZMA) Consistency Determination from Ecology; review periods vary, but they are approximately 9 to 12 months for all permits.
5. Prepare Aquatic Use Authorization for submittal to WDNR; review period is approximately 1.5 to 2 months.

If the project is considered a habitat restoration project or qualifies as an Ecology-led cleanup project, then the permit review period could be reduced to 4 to 6 months for all permits.

Table 8
Federal, State, and Local Permits and Approvals Required for this Project

Regulatory Agency or Agencies	Permit/ Approval Name	Applicable Document	Reason for Permit/ Approval	Streamlining Potential for Habitat Restoration or Cleanup
Corps	404 Individual Permit (Coordination with Dredge Material Management Office [DMMO] may be needed)	JARPA	Involves filling in waters of the United States	Habitat restoration aspects may allow use of nationwide permit (NWP) 27 or 38, which would eliminate the need for public notice and thus reduce the timeframe for permit issuance
NOAA National Marine Fisheries Service (NOAA Fisheries) and the United States Fish and Wildlife Service (USFWS)	ESA Concurrence	Biological Evaluation (BE) to Corps	Review of the BE and concurrence that Corps Permit is ESA compliant	Required for NWP 27 and NWP 38
NOAA Fisheries	Magnusen-Stevens Act EFH Compliance	Include EFH analysis in BE to Corps	Review of the BE and concurrence that Corps Permit is EFH compliant	Required for NWP 27 and NWP 38
WDFW	HPA	JARPA	Work changes the natural flow or bed of state waters	Habitat restoration aspects may allow for expedited review process; if the project qualifies as an Ecology-led cleanup, then the HPA is eliminated per Revised Code of Washington 70.105D.090
Ecology	Section 401 Water Quality Certification	JARPA	To ensure compliance with State Water Quality Standards	Required for NWP 38; may potentially be waived for NWP 27
Ecology	CZMA	CZMA Form	To ensure consistency with state and federal acts	Required, as the project will require a federal permit
WDNR	Aquatic Use Authorization – Long Form	Long Form submitted to Whatcom County and accompanies JARPA	Project occurs within state-owned aquatic bed	Required
Whatcom County	SEPA Determination	SEPA Checklist	To ensure compliance with state environmental policies	Not required if project provides fish, wildlife, and/or wetland enhancement activities (Whatcom County Municipal Code 16.08.070); required if the project qualifies as an Ecology-led cleanup project
Whatcom County	Critical Area	SEPA Checklist	Work occurs in locally designated critical areas	
Whatcom County	Shoreline Permit	Shoreline Permit	Improvements are proposed within 200 feet of the shoreline	Not required if the project is considered a “watershed restoration project” per Whatcom County’s Shoreline Management Program; not required if the project qualifies as an Ecology-led cleanup

10 MONITORING STRATEGY

Monitoring is essential to document and characterize baseline conditions (prior to wood debris removal), to better understand present dynamics and to observe changes to the study area following project completion (Gelfenbaum et al. 2006). This project provides an excellent opportunity to increase understanding of physical and ecological processes at a small wood debris site and their interaction along an estuarine shore. Monitoring data are almost non-existent for the site at present and the collection of these data would help address the existing uncertainties and better inform decisions on whether removal actions are warranted for the site and what actions to take, as well as for adaptive management (Fresh et al. 2004).

The U.S. Geological Survey (USGS) has expressed interest in participating in monitoring, if funding could be secured. Grant applications have recently been submitted. Initial recommendations for monitoring were formulated based on the author's experience with coastal restoration project monitoring in the region. Recommended monitoring elements will be outlined here as a first step toward planning monitoring efforts that are robust enough to address the issues at Cliffside Beach.

Physical monitoring of the beach is recommended both before and following debris removal, ideally both at Cliffside Beach and a representative reference beach. Following are recommended monitoring tasks with recommended equipment in parentheses, followed by frequency:

1. Perimeter of surficial layer of small wood debris (global positioning system [GPS]) – quarterly
2. Volume of surficial layer of small wood debris (shovel/probe for depth measurements along transects) – summer and winter
3. Photograph points alongshore (high-resolution digital camera) – quarterly
4. Beach topography mapping (total station) – summer and winter
5. Beach sediment grain size analysis (sieves) – summer and winter

Biological monitoring of the beach is recommended both before and following debris removal, ideally both at Cliffside Beach and a representative reference beach. Recommended monitoring tasks include the following:

1. Forage fish spawning (WDFW methods) – monthly, April through September

2. Benthic and epibenthic invertebrates, including shellfish – quarterly
3. Marine riparian vegetation – annually

It is recommended that data be collected for each of the physical and biological parameters even if the recommended frequency of data collection is not attainable. Collecting a complete baseline (pre-removal) dataset is a particularly important stage for obtaining a complete dataset because it is the dataset against which all subsequent data are compared.

Volunteers could assist in the collection of several of the recommended datasets. The monitoring could also provide the basis for a research project for students from Western Washington University or other area schools. This provides an excellent opportunity to get the community involved and to reduce monitoring costs.

There are additional datasets that are not part of a monitoring strategy per se, but these datasets would add to the scientific understanding of site conditions. These datasets include:

- Deep cores into the backshore to determine small woody debris deposition history
- Small woody debris volume entering the bay via the eastern (and central if the east channel has low flow) distributary channel of Nooksack River during floods and moderate flow
- Contribution of marine versus freshwater materials in the surficial and subsurface (historic) wood layers
- Recent landslides along bluffs
- Juvenile salmon utilization
- Shorebird utilization

11 CONSIDERATIONS FOR DETERMINING THE AMOUNT OF WOOD DEBRIS TO REMOVE

Several considerations can factor into the decision to remove all, some, or none of the surficial wood debris material at Cliffside Beach:

- Sources of material
- Potential for re-accumulation of material
- Ecological impacts of leaving material in place
- Ecological benefits of removing material
- Costs of removal

These considerations are discussed below.

11.1 Sources of Material

This investigation of the possible sources of wood debris at Cliffside Beach has identified river and marine sources for the material. The wood debris at and near the surface appears to be a mix of new (e.g., roots, leaves, and eelgrass blades) and older material (e.g., fine fibrous material and small wood pieces). The site appears to naturally receive material due to its close proximity to the Nooksack River delta and the combination of wind waves, water currents, and littoral drift processes in Bellingham Bay, which transport large and small wood from throughout the bay into this portion of the bay.

The hypothesis presented in Section 4.3 that previously deposited wood debris in the delta, beach, and backshore has been re-mobilized through channel migration and storm events is consistent with the mix of wood debris sizes and stages of decomposition observed in the wood debris at Cliffside Beach. The variability of wood debris sizes in the project area suggests that there were multiple source events, and perhaps multiple opportunities for wood to be reworked and broken down into smaller pieces, as it was eroded and deposited within the delta, beach, and backshore. Buried wood debris that was later exposed and redistributed could also explain how wood chips and sawdust debris from historic wood handling on the river and/or the bay may continue to persist in the nearshore. Wood debris that was buried was likely in anoxic conditions, and therefore decomposed very slowly. In this way, wood debris that was at or near the surface has likely decomposed much more rapidly than deeper buried wood.

The dynamic nature of surficial wood debris accumulations on Cliffside Beach and the continual changing of the shoreline, as evidenced in the shore change analysis, suggest that most of the wood debris currently comprising the surface layer of Cliffside Beach has been deposited within the last 10 years. The shore change analysis and deeper excavations at the beach (limited to 3.5 feet) suggest that wood debris at the site has continually been buried and contributes to the shoreline expansion waterward. In this way, older wood debris deposits have likely been buried; however, the sedimentary processes where sand/gravel are in close proximity to wood debris are not understood. Based on the information gathered in this assessment, it is hypothesized that the surficial wood debris on Cliffside Beach is a combination of "new" material (i.e., fresh leaves, eelgrass blades, and branches) and previously buried material that has been re-mobilized as the east distributary channel of the Nooksack River carves through the delta and the shoreline adjacent to the delta. The wood debris currently forming the lower elevation of the surficial wood debris layer appears to be naturally derived from river and marine sources, but much of the finer, fibrous material may have been older deposits that have been re-mobilized and may have been of anthropogenic origin (e.g. sawmills, log rafts, etc.).

11.2 Potential for Wood Debris Re-accumulation

In general, it appears that Cliffside Beach may receive ongoing wood debris input with episodic inputs of larger volumes during events such as river floods and/or strong southerly wind events that push material into the northern portion of the bay. If this hypothesis of the role of the eastern distributary channel on wood debris deposition at Cliffside Beach is correct, then the volume of wood transported to the beach in coming years may decrease if recent observations are correct that the Nooksack River flow is shifting away from the eastern distributary.

Some amount of surficial wood debris is likely to re-accumulate on the beach following a removal action because of the project area's orientation, local currents, and littoral drift processes. Due to the range of potential sources and transport processes that occur in the site area, as well as the unpredictable episodic nature of deposition events, there is insufficient information to accurately predict whether such re-accumulation will occur over a period of months or years. Based solely on visual observations at the site, it is estimated that small amounts of wood debris would re-accumulate each year with the potential that a major storm or Nooksack River distributary shift may transport larger volumes of material to the project area. However, the volume of new small wood and the rate of decomposition are unknown. A rough estimation would be that within 5 years, the gradual accumulation of material (e.g., no large episodic events) could result in enough material on the upper intertidal beachface to cover it with several inches or more of wood debris, although the continual redistribution of the material along the beach could be expected to result in some areas with deeper accumulations and other areas with no surficial wood debris.

11.3 Ecological Impacts of Leaving Material in Place

Considerable uncertainties exist regarding the degree of ecological impacts associated with the existing surficial wood debris accumulations on Cliffside Beach. The accumulation of the surficial wood debris can significantly impair the beach's habitat quality for organisms that rely upon sand and gravel substrate for burrowing, foraging, or depositing eggs (e.g., benthic macroinvertebrates, shellfish, forage fish, and shorebirds). Because the depth of the wood debris is variable across the project area, the degree and distribution of impaired habitat is also not likely to be uniform. In those portions of the project area with only minimal wood debris accumulations (e.g., less than 1 inch deep), the impact of the surficial wood debris is likely lessened (but not eliminated) compared to more deeply buried areas. Moreover, the ecological effects of the surficial wood debris accumulations may not be entirely detrimental, especially in areas where wood debris does not entirely preclude access to beach sediment. For example, while wood debris may suppress settlement and colonization of some shellfish species, invertebrate shredders (detritivores) in the upper beachface may thrive in the habitat. The lower elevations of the upper beachface near the sand flat may be a particularly productive area for amphipods and juvenile salmon that may feed upon such prey.

Further, based on historical data and interviews, the surficial wood debris accumulations appear to be a manifestation of conditions that have continued within the site area for at least 45 years. During this time period, the backshore has widened significantly, concurrently developing new backshore habitats with maturing marine riparian vegetation. That is, accumulation of surficial wood debris on the upper beachface may have contributed to the natural expansion of the beach (foreshore) and backshore through the addition of material volume. Thus, absent hazardous substance concerns, the net ecological impacts associated with the existing surficial wood debris accumulations may be difficult to assess considering the potential benefits along the beachface-sand flat interface, the potential detrimental impacts along the upper beachface, and potential contributions of the wood debris accumulations to backshore expansion.

11.4 Ecological Benefits of Removing Material

The potential ecological benefits associated with removal of surficial wood debris accumulations from Cliffside Beach could include reclamation of currently buried habitat for burrowing benthic macroinvertebrates, shellfish, forage fish, and shorebirds. The substrate underlying the surficial wood debris is a mix of sand and lesser amounts of gravel along the western and central portions of the project area with larger substrate located in the eastern portion of the project area. These substrate sizes are typically very productive for invertebrates, including shellfish. Forage fish, such as surf smelt and sand lance, spawn in sand or gravel substrates in the upper intertidal zone and may utilize Cliffside Beach for spawning if the surficial wood debris were removed. Surf smelt are known to spawn in high densities both east of the site near Little Squalicum Creek and southwest of the site at Lummi Shore Road.

In addition to the uncertainties regarding the pace of potential re-accumulation of material, the net impact of a relatively thin layer of surficial wood debris on the ecological function of the beach is unknown. That is, if a beach has a thin layer of surficial wood debris, the degree to which salmon, forage fish, or shorebirds use the habitat is unknown. The abundance and diversity of shellfish, however, will likely be seriously suppressed. Also unknown is the degree to which benthic infauna and epifauna production will continue with a thin layer of wood debris material. There is not a scientific consensus on this topic, in part due to site-specific factors that contribute to the potential effects of the material and the ecological function of the beach. As noted in Section 10, a monitoring program should include the collection of data to address these unknowns.

11.5 Costs of Removal

The costs of removing the surficial wood debris material are relatively low when considering the potential to restore the ecological function of nearly 3,400 feet of intertidal shoreline habitat (see Table 7). The estimated costs are substantially lower than other similarly sized marine nearshore restoration projects. However, the potential for re-accumulation of material described in Section 11.2 should be considered when evaluating costs because the ecological improvement may not be long lasting.

12 CONCLUSIONS

The current surficial wood debris at Cliffside Beach appears to be a combination of naturally derived material from river and marine sources, and what appears to be re-mobilized small wood deposits from erosion of the west end of Cliffside Beach. The accumulation of surficial wood debris on the beach appears to be the result of natural transport processes carrying materials to the generally south-facing beach, with augmented sources of material over recent decades.

Regarding the decision of whether to remove the surficial wood debris layer, significant questions remain regarding: 1) the rate of re-accumulation of material that could be expected following a removal action and 2) the net amount of improved habitat function that could be expected from the removal of the material. These questions do not necessarily mean that the material should be left in place; rather, any removal action should be viewed as a restoration project without a high certainty of success and for which monitoring is particularly important in order to better understand the project's ecological benefit. Baseline and post-construction monitoring of a removal action would provide data on the ecological impairments associated with excessive wood debris accumulations and the corresponding ecological improvements of wood debris removal. These ecological issues are relevant to Cliffside Beach as well as other wood debris sites around Puget Sound.

The full removal of material from the site is perhaps the best and most certain way to investigate the rate of wood debris re-accumulation. The estimated cost of restoring the 3,400-foot-long section of beach is relatively low compared to other beach restoration projects and its close proximity to a major salmon-bearing river adds further value to any ecological benefits gained by the project. In this way, the removal of wood debris would provide relatively inexpensive habitat enhancement whose ecological benefits could be monitored and applied to other restoration efforts in the region.

In conclusion, the removal of wood debris from Cliffside Beach should be undertaken only if the project sponsors and funding source(s) are willing to accept the uncertainties regarding the net-ecological benefits and the sustainability of the restored conditions. Whether such a wood debris removal action occurs now or remains a possibility for the future, data should be collected to address these uncertainties.

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