PHILIP WILLIAMS & ASSOCIATES
CONSULTANTS IN HYDROLOGY

322 NW 5th Avenue, Suite 234
Portland, OR 97209
Phone 503.226.6810
Fax 503.226.6816
www.pwa-ltd.com

DRAFT REPORT

BIRCH BAY SHORELINE IMPROVEMENT PLAN AND CONCEPTUAL DESIGN

Prepared for

Whatcom County Council of Governments

Prepared by

Philip Williams & Associates, Ltd.

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1. INTRODUCTION

1.1 BACKGROUND

Birch Bay, WA is a small community on the northeastern coast of Puget Sound about 30 miles north of Bellingham, WA. It is a very popular recreational and tourist destination. Birch Bay is a small, shallow crescent-shaped bay (approximately 2.5 miles wide with a maximum depth of 30 ft) that is backed by narrow to moderately wide gravel, cobble, and sand beaches. The northern and central portions of Birch Bay have been highly developed with residential homes, some commercial structures, and public infrastructure (roads, power lines, etc.) that have been constructed very close to the shoreline. The sediment budget and sediment transport processes that maintain the Bay's cobble beaches have been highly disturbed. To maintain beach widths and to protect the shoreline development, a mixture of bulkheads, rip-rap revetments, and groins have been constructed along the shoreline. At present, the cobble/sand beaches, particularly along the central and northern reaches of the Bay, are narrow and degraded, offering limited recreational opportunities and reduced flood protection for inland development.

1.2 PROJECT UNDERSTANDING

There is an interest within the Birch Bay Community and by local agencies to improve a portion of the Birch Bay shoreline. The improvement could involve removing a series of concrete groins along the eastern part of the shoreline and constructing a more natural beach berm.

Philip Williams & Associates, Ltd. (PWA) has been retained by the Whatcom Council of Governments (WCOG) to provide coastal geomorphology and engineering consulting services under CZM306 Grant Agreement G0200087 as part of a preliminary planning process to evaluate potential enhancements to the shoreline. The objectives of this work were to:

1) Perform an initial evaluation of the coastal processes at work in the bay and in the local section of shoreline of the proposed berm and, with an understanding for these processes,
2) prepare a conceptual design of the beach berm.

This phase of the project relied on existing information on the littoral processes operating in Birch Bay and a two-day site visit to develop preliminary, concept-level designs for a shoreline improvement plan.

2. SITE CHARACTERIZATION

2.1 LITERATURE AND EXISTING DATA REVIEW

To characterize the littoral processes in Birch Bay, PWA relied primarily on existing reports by other researchers and on data from a recent FEMA flood study completed by PWA for the Whatcom County River and Flood Section. The use of these data was augmented by a two-day site visit to verify previous researchers' conclusions, to gather limited additional data on current beach conditions and geometries, and to collect additional published studies and maps of the area from the Washington Department of Ecology and Western Washington University's Huxley Map Library.

2.1.1 Regional Setting

Located on the northeastern coast of Puget Sound, Birch Bay is a small, shallow crescent-shaped bay (approximately 2.5 miles wide with a maximum depth of 30 ft) that is backed by narrow to moderately wide beaches composed of a mix of gravel, cobbles, and sand (Figure 1). Puget Sound is characterized by semi-diurnal tides. The closest NOAA tidal gage to Birch Bay, located at Cherry Point (approximately 3 miles to the south), indicates that the mean diurnal tidal range is 9.1 ft between mean higher high tide (MHHW) and mean lower low tide (MLLW).

Birch Bay is exposed to waves approaching from the northwest to southeast. Waves from the northwest are generated in the Strait of Georgia over a 103-mile long fetch and, as a result, can be quite large. The southeasterly waves tend to be less powerful due to the smaller fetch.

In the construction of a large shoreline project, such as this gravel berm, consideration should also be given to the longer term effects of relative sea level rise (RSLR). RSLR could increase or decrease the design life of such a structure. In the north Puget Sound area (Friday Harbor), one estimate of sea level rise is 5.5-inches per century (Shipman, 1990). When this estimate is viewed together with an estimated 2-inch per century rate of land subsidence (Shipman, 1990), the RSLR may be as much as 7.5-inches per century or nearly an inch per year.

The principal sediment sources have been identified as the eroding headlands that form the end points of Birch Bay — Birch Point in the north and Point Whitehorn in the south (Bauer, 1975; Terich, 1977). These "feeder" bluffs composed of glacial till, provide a mixed source of sand, gravel, and cobbles for Birch Bay beaches (Downing, 1983). The net littoral transport has been identified as moving to the north from Point Whitehorn and to the east from Birch Point, converging at the northern end of the Cottonwood reach (Figure 2; Bauer, 1975; Terich, 1977). Geomorphic evidence corroborates these transport directions: (1) the mouth of Terrell Creek has been consistently deflected north in the central reaches, indicative of northerly transport; (2) sediment placement at the mouth of Terrell Creek has been observed to be consistently transported north; and (3) a small accretionary fillet is maintained on the western side of the harbor jetty, indicative of easterly transport. A small tidal lagoon historically occupied the northern end of the Cottonwood reach and served as a sink for the fine sand and mud in transport, but this area was filled for development (USGS, 1907).

The shoreline sediment sources and transport pathways have been significantly disrupted by development in Birch Bay. The harbor jetties disrupt the transport of sediment to the east from Birch Pt into Birch Bay (Bauer, 1974). To some degree, harbor dredging and gravel placement on the adjacent downcoast beach may mitigate this disruption. Upland development has likely modified the hydrology and flux of sediment from Terrell Creek, reducing sediment inputs to the littoral zone. Preventing “break-out” of the creek during high discharge may have limited the sediment supply to the western shores, and limited sediment discharge to the Bay in general. By constructing a road and building structures along the Birch Bay shoreline, the back beach position has been fixed, and, as a result, the backshore has not been able to migrate landward during severe storm events to re-establish an equilibrium position.

The northern and central reaches of Birch Bay have been highly developed with residential homes, some commercial structures, and public infrastructure (roads, power lines, etc.) that have been constructed very close to the shoreline. To maintain beach widths and to protect the shoreline development, a mixture of bulkheads, rip-rap revetments, and groins have been constructed along shoreline. At present, the cobble/sand beaches, particularly along the central and northern reaches of the Bay, are in a narrow, degraded state, offering limited recreational opportunities and inadequate flood protection for inland development.

2.2 SITE RECONAISSANCE

PWA staff spent two days in the field in Birch Bay and Bellingham, WA on October 21-22, 2002 to assess the current condition of the Birch Bay shoreline, to gather limited field data on beach conditions, and to meet with Washington Department of Ecology staff and residents of Birch Bay active in the shoreline improvement planning process.

2.2.1 Field Observations of Beach Conditions

To gain a better quantitative understanding of the morphology of the Birch Bay beaches, beach slopes and berm crest elevations were measured relative to the tidal elevation (defined by the Cherry Point tide gage) using a hand level, folding ruler and tape measure. Grain size information was captured by digital camera with a scale reference included in the photo frame to enable grain size to be measured quantitatively. At this phase of the project, the grain size was only assessed qualitatively. Three reaches were chosen to measure the local beach characteristics listed above: (1) Semi-Ah-Moo, (2) North-Central reach, and (3) Birch Bay State Park reach (Figure 1).

The Semi-Ah-Moo reach was chosen to serve as a reference site to compare its morphology to the Birch Bay beaches. The Semi-Ah-Moo reach is located north of Birch Pointt, forming more than a mile long gravel spit that encloses Drayton Harbor. The Semi-Ah-Moo spit beaches are in a relatively pristine condition, with only minor disturbances to the local sediment budget and few coastal structures impacting sediment transport. Although they are relatively close to the Birch Bay beaches, the Semi-Ah-Moo beaches receive more direct wave energy from the northwest. The southern-most portion of the Semi-Ah-Moo spit was surveyed in two locations (Figure 3). Table 1 summarizes the average berm crest height and slope of the beach face. The trend in grain size moving along profile at Semi-Ah-Moo is similar to the other beach sites: the beach is composed of cobbles at intersection of the beach face and low tide terrace (~10cm diameter), smaller cobbles and gravels in the lower beach face, pea-sized gravel in the upper beach face, and large gravels on the berm crest (Figure 4). The Semi-Ah-Moo beaches have the coarsest cobbles and gravels, although, on average, its slope is similar to the other beach sites (Table 1; Figure 5).

The Birch Bay State Park reach was chosen to serve as an adjacent reference site to compare its morphology to the more disturbed beaches in central Birch Bay. Located within the State Park, this reach has experienced fewer disturbances from development than the northern and central reaches of the Bay. This shoreline reach is oriented perpendicular to the northwesterly swell. Three locations distributed from north to south along the state park were surveyed (Figure 6). Table 1 summarizes the average berm crest height and slope of the beach face. The beach profiles in the State Park show the same trends as Semi-Ah-Moo, moving from coarsest at the intersection of the beach face and low tide terrace, fining up the beach face, and coarsening again at the berm crest. Overall, the State Park beaches were not as coarse as at Semi-Ah-Moo, but on average the beach slopes are the same (Table 1; Figure 7).

Four locations in the groin field in the North-Central reach were surveyed. This reach is the area that the community is most interested in improving. Figure 8 depicts a typical portion of this reach with the degraded groins extending from the back beach down the beach face. The beaches are noticeably finer in the North-Central reach than at the above sites. In fact, a trend of decreasing grain size was qualitatively observed moving northwards through the groin field. The implication of this trend on littoral transport will be discussed in Section 2.2.2. Slightly different along profile tends in grain size were observed in the North-Central reach. The low tide terrace was composed of fine sand and silt. The beach face was more uniform in grain size, consisting of a mix of small cobbles, gravel, and sand. The upper beach face consisted of more sand than gravel, and the berm crest was composed of fine gravel. Table 1 summarizes the average berm crest height and slope of the beach face. On average, the beach slopes of the North-Central reach were slightly less steep than the other sites (Figure 9).

Table 1. Field Surveyed Beach Characteristics

Site	Average Berm Crest Elevation (ft, NGVD)	Average Slope of Beach Face (%)
Semi-Ah-Moo	7.95	0.117
North-Central	6.04	0.117
Birch Bay State Park	5.60	0.107

2.2.2 Field Observations of Existing Groin Field

To maintain beach widths and to protect the shoreline development, a series of groins have been constructed along North-Central reach shoreline. Approximately 30 groins have been built about 100 ft apart from just to the north of the restaurant on the bay side of Birch Bay Drive north to the intersection of Harbor View Road (about 3,500 ft of shoreline). From conversations with local residents and regulatory staff, it is not clear exactly when or how these groins were constructed. Anecdotal evidence suggests that they were constructed incrementally (versus as a coordinated, planned construction effort) in the 1950's and early 1960's. The concrete groins appear to have been poured directly on the beach without a foundation and without reinforcing rebar. As a result, the groins are in various states of disrepair: some have broken in one of more places, some are tilting over to one side, and all have experienced significant weathering. The exact dimension of the groins varies also, but in general, they are about 60 ft long, 2 ft wide, and 1.5 ft tall. Most of the groins extend from the back beach down the beach face, terminating at or just before the intersection of the beach face and the low tide terrace. Due to their low height, the groins do not significantly impede beach access, and some beachgoers were observed using them as a bench to sit on. The Washington Department of Ecology initiated a survey of the groins, measuring the groin's dimension, the beach profile, and the sediment characteristics along the profile.

Cobble Transport

An interesting trend in decreasing grain size was qualitatively observed moving from south to north through the groin field (Figure 10). Moving to the north, the beach face changes from predominantly cobbles to a mix of gravels and sand (Figure 10). This trend suggests that a sediment transport potential exists. The groins appear to have a winnowing effect on the material in transport, such that the sands and fine gravels are preferentially transported downcoast, leaving behind the coarser cobbles at the southern end of the groin field and reducing transport volumes downcoast. This trend corroborates previous researchers conclusions that the net sediment transport direction in the North-Central reach is to the north (Bauer, 1974; Terich, 1977). A high-resolution color aerial photo taken for PWA's Whatcom County FEMA flood study (PWA, 2002) shows accretionary fillets on the south sides of the groins, further evidence of northward transport. By trapping cobbles in the southern end of the groin field, the beaches and backshore in the central and northern portions of the North-Central reach are left more vulnerable to erosion and overtopping.

3. SHORELINE IMPROVEMENT PLAN CONCEPTUAL DESIGN

3.1 GOALS AND OBJECTIVES

3.1.1 Goals

The Whatcom Council of Governments, the Washington Department of Ecology, and Birch Bay residents have set a number of goals for the shoreline improvement plan, including:

- Widening the beaches to increase recreational opportunities;
- Raising the beach berm crest to enhance flood protection;
- Incorporating a pedestrian promenade to improve coastal access and recreational opportunities;
- Improving the aesthetic qualities of the shoreline.

At this phase of the project planning, PWA will present one preliminary conceptual design alternative for a shoreline restoration to meet the goals listed above, including a typical shoreline cross-section and preliminary estimate of beach fill volume. However, the goals listed above could be met by a number of shoreline designs. While this report will not present more than one design alternative, alternative designs will be described for future planning discussions.

3.1.2 Objectives

Based on the goals listed above, PWA has identified a number of general planning objectives to consider when comparing design options to meet the project goals:

- Engineering/construction objectives
- Transportation design objectives
- Aesthetic design objectives
- Permitting objectives

These general planning objectives are supported by more specific objectives later in the report for use in eventual ranking of design alternatives (Table 4).

3.2 DESIGN APPROACH

3.2.1 Methodology

The morphology of gravel beaches in the Birch Bay region is a function of external forces—such as tidal range, wave height, wave period—and local beach and nearshore characteristics, including nearshore bathymetry, beach grain size, and beach slope. A beach restoration design must reconcile the geometry of the beach, to the beach sediment composition, and local wave and tidal regime.

There are a number of methods to determine the appropriate beach sediment composition and geometry for a given wave and tidal regime including:

- Geomorphic methods:
  - Base geometry and composition of a designed beach to a nearby reference beach that is similar to the beach restoration site;
  - Base geometry and composition of a designed beach on historical data that provides information on beach site's undisturbed morphology.
- Empirical methods:
  - Use various empirical relationships developed in field or lab experiments to predict beach morphology based on wave climate, tidal regime, and beach composition.
- Physical modeling methods:
  - Use knowledge actual physical forces acting on the reference site to predict beach morphology.

In this preliminary design phase, we have followed a geomorphic approach. No detailed historical data was made available to PWA to describe the Birch Bay beach morphology before the local sediment budget was disrupted. Therefore, key beach geometry characteristics—such as beach face slope, berm crest elevation, and grain size—are based on relatively undisturbed beaches in the vicinity that are exposed to similar wave and tidal conditions as the project site. As explained in Section 2.2.1, two reference beaches were chosen to measure beach slope, berm crest elevation, and grain size. The two reference beach characteristics are compared to the average conditions in the North-Central reach in Table 1. The following section will discuss the berm design elements in more detail.

3.2.2 Berm Design Elements

An evaluation of the basic berm design elements is provided this section. These elements are intended to constitute the conceptual design of a shoreline berm. In general, berm design elements were adopted from Wolf Bauer's earlier work (Bauer, 1975) and validated or refined using the previously described reference beach field survey findings, and recent topographic, tide and wave data from PWA's coastal flood study of Birch Bay (PWA, 2002).

Bauer's Alternative 2 enhanced beach profile was adopted for this effort, in part because it preserves the existing road alignment and width. This profile includes a berm crest elevation equivalent to the adjacent road elevation (+8.5 to +9.0 ft NGVD) which is roughly 4.0 ft higher than MHHW and slightly greater than the maximum recorded water level at the Cherry Point, WA tide gage (3.8 ft above MHHW). A cross-section of the conceptual berm design is shown in Figure 10. Design elements of the berm are described below together with an analysis of its impact on wave run-up during storm events.

Berm geometry

A gravel beach berm crest is formed by the deposition of sediment carried up the beach face by the wave swash. The berm crest elevation is determined by the size and density of the beach material relative to the entrainment forces of the wave swash, the frequency of wave action, and the runup height (Lorang, 2002). The berm crest that is observed at a natural beach site most likely reflects the maximum runup elevation during the one- to five-year storm event. A berm design that sought to mimic a natural beach would therefore incorporate a berm crest elevation and beach slope comparable to natural beaches in the vicinity. In the Birch Bay vicinity, the berm crest elevation appears to form at 1.5 ft (at Birch Bay survey sites) to 3.8 ft (at Semi-Ah-Moo survey site) above MHHW, and all beaches surveyed had a beach slope between 1:6 and 1:5. The bayside slope of Bauer's Alternative berm profile is approximately 1:6, so this slope was retained for further analysis. However, this berm crest is likely overtopped by wave run-up during more severe storm events. Since one of the goals identified in Section 3.1.1 is to enhance flood protection, a higher berm elevation than what occurs naturally was desirable. The disadvantage of a higher berm are (1) a greater amount of beach fill will be required (and therefore more expensive), (2) berm crests exceeding the elevation of the road (about +9 ft NGVD) may obscure views, and (3) an engineered condition divergent from geometry found in reference sites, and therefore potentially subject to greater effort to maintain the constructed geometry.

Once a berm crest elevation was chosen a back beach width and slope were selected to complete the beach geometry. The 15-foot width of the back beach (the distance from the berm crest to the landward end of the beach) was adopted from Bauer's Alternative 2 enhanced beach profile. We selected a beach slope of 1:6 based on the average slope observed in our beach surveys.

Finally, to assess the significance of the berm crest elevation on wave run-up and overtopping during storm events, the run-up methodology used in the PWA coastal flood study was applied to the new beach profile. The run-up model was adjusted, to account for porosity changes due to the new gravel/cobble fill, and re-run to estimate the run-up height under the conceptual design conditions versus existing conditions.

Incorporating the data and methodology from the PWA flood study, the impact of the berm crest on run-up heights was assessed for FEMA's 100-yr storm events (Cases A, B, and C represent different combinations of wave and tidal heights). While the berm is still overtopped during the 100-yr event, the increased berm height, beach width, and berm porosity reduce the run-up heights by 25%, on average (Table 2).

Table 2. Run-up Heights for FEMA 100-yr Storm with Existing Conditions and with Berm in North-Central Reach

100-yr Storm Event	Water Level (ft, NGVD)	Wave Height (ft, NGVD)	Wave Period (s)	Run-up Above Water Level (ft)		Run-up Elevation (ft, NGVD)	
				Existing	with Berm	Existing	with Berm
Case A							
	8.75	4.0	7.7	8.7	3.8	17.5	12.5
	8.75	4.0	8.1	9.5	4.2	18.2	12.9
	8.75	4.0	7.3	7.3	3.4	16.1	12.1

100-yr Storm Event	Water Level (ft, NGVD)	Wave Height (ft, NGVD)	Wave Period (s)	Run-up Above Water Level (ft)		Run-up Elevation (ft, NGVD)	
				Existing	with Berm	Existing	with Berm
Case B							
	8.37	3.5	11.0	11.2	6.3	19.6	14.7
	8.37	3.5	8.3	8.2	4.3	16.6	12.7
	8.37	3.5	6.3	5.6	2.9	14.0	11.2
Case C							
	8.58	3.0	11.0	10.0	6.2	18.6	14.7
	8.58	3.0	9.1	8.4	4.3	17.0	12.8
	8.58	3.0	7.1	6.6	2.6	15.2	11.1

The above estimates of wave run-up were accomplished using RUNUP 2.0 software which is pre-approved by FEMA for coastal flood studies. Wherever the wave run-up elevations exceed the existing high point in a profile (say, the berm crest), the run-up value is a potential based on extrapolating the last sloe upward to the theoretical limit of run-up. The actual elevation will be lower, and the inland extent of flooding will be largely controlled by friction-induced losses associated with overland travel. A more detailed analysis of wave run-up can be employed to estimate the inland extent of the run-up limit for a range of profiles geometries. This analysis then provides information allowing assessment of the benefits of a wider beach toward reducing coastal flooding. However, this analysis is beyond the scope of this study.

Constructing a berm high enough to stop overtopping during the 100-yr event will likely not be feasible due to the high cost associated with the large beach fill required and/or visual impacts. Additional run-up analysis should be incorporated into the next design phase of the shoreline improvement plan to find the right balance between flood protection, cost, visual impacts, and recreation opportunities.

Storm Performance

During storm events, a restored cobble berm has the potential to damage nearby structures and property. Cobbles are transported up the shoreface building a higher berm crest during the high swash run-up associated with storms. While moving up the shoreface, the cobbles may get launched inland beyond the beach at high velocities, posing a risk to individuals or structures in the vicinity.

Berm composition

Based on the reference beach surveys, the berm sediment composition should vary in grain size from moderate sized cobbles (~10cm) at the berm toe to a cobble/gravel mix along the shoreface to a primarily gravel berm crest. Grain size analysis of references sites (both along profile and with depth) will be necessary for final berm design. A mix of grain sizes similar to the existing site and reference sites will provide a more “beach-like” geometry, or shore face morphology. A more uniform grain size distribution of primarily cobbles would increase permeability and result in a steeper berm face and potentially a crest with a decreasing back slope. In our conceptual design, we have used the natural geometry and gradations as guides.

Berm volume

A digital elevation model (DEM) of the Birch Bay shoreline was developed as a part of the county coastal flood study. PWA adopted the DEM for this project to enable a more accurate estimation of material volumes for the proposed shoreline berm. Both the DEM and elevation data for Wolf Bauer's Alternative 2 enhanced beach profile were input to a Computer Aided Drawing (CAD) program in an initial effort to estimate volume of gravel for Bauer's design and compare these volumes to Bauer's original volume estimates. Bauer's berm crest elevation was assumed to vary and match the adjacent roadway elevation and the bayside edge of the berm was assumed to be located 34-feet from the bayside top edge of Birch Bay Drive, as shown in his oversize figure of the Alternative 2 profile. The resulting 3-dimensional surface of the berm was intersected with the 3-dimensional surface of the shoreline topography resulting in a volume estimate between the two surfaces. Bauer's volume estimate was higher than our estimates and a comparison is shown in Table 3

Table 3. Comparison Between Bauer and PWA Berm Volume Estimates

Reach	Bauer volume estimate [CY]	PWA volume estimate [CY]
1	31,200	17,400
2	23,250	29,500
3	7,150	5,900
4	16,200	6,400
Totals	77,800	59,200

NOTE: PWA volume estimates do not include the four mini-parks. Refer to Bauer (1975) Figure 12 for reaches identified in a north to south direction.

In the next phase of the project, PWA can readily estimate material volumes for refined berm designs using the method developed above. An accurate estimate of gravel required for the construction of the berm is important because the bulk of the total cost to construct the project will likely involve the cost to import these materials.

Berm end and backshore treatments

Specific berm end and backshore treatments cannot be specifically addressed until the project extent is better defined and the berm end points are identified. However, one option to minimize end effects of end treatments is to tie the berm into the existing groin that serves as an end treatment for the beach berm project in front of the Coasthaven Condominiums. Any end treatment design must assess downcoast impacts.

3.3 DESIGN ALTERNATIVES

A series of design alternatives are presented below. All alternatives incorporate the basic conceptual berm design elements, but involve increasing levels of effort for construction implementation. Design decisions on the demolition/removal of the existing groins, berm crest height, parking areas, and the road are the key design variables. A no-action alternative is presented first to provide a point of comparison for the design alternatives.

3.3.1 Alternative 1: No-action

Alternative 1 involves taking no action to restore the shoreline in Birch Bay. The no action alternative has several negative impacts over both the short and long term. In the short-term, there are several locations along the road that are being undermined by beach erosion that can be expected to continue, requiring road repair or shoreline armoring in the near future. In the long-term, the number of erosion hot spots and areas threatened by erosion may increase, requiring more extensive road repairs and shoreline armoring that will reduce the beach area for recreation and public access. The structures along the shoreline will continue to be highly susceptible to wave run-up and overtopping.

3.3.2 Alternative 2: Construct Berm With Groins In Place

Alternative 2 involves placing a beach fill over the existing groins. Leaving the groins in place offers three important advantages: (1) reduces total volume of fill; (2) eliminates cost of groin removal; and (3) provides lateral support for the fill and should increase the life of the project. Figure 10 illustrates a typical cross-section of the beach fill over the existing profile in the North-Central reach. Based on Bauer's (1975) Alternative 2 design after comparison to adjacent reference beaches, the beach crest is set at +8.5 to +9.0 ft NGVD (approximately level with the road) with a 15 ft wide, flat back beach area that should be planted with native vegetation to enhance stability, and a beach face that extends approximately 45 to 60 feet from the berm crest to the low tide terrace at a slope of 10˚. Using the 2001 topography from the PWA FEMA study, about 60,000 yd^3 of gravel, cobble, and sand would be necessary to construct the design beach from the mouth of Terrell Creek northward to the northeast corner of the bay. At this time, a definitive composition of berm sediment mixture of material has not been determined (more detailed grain size analysis of the reference beaches will be necessary) because a feasible sediment source has not been identified. However, to match adjacent beaches, rounded gravel and cobbles will be necessary. Potential sources include in-stream mining (probably not feasible due to environmental regulations), inland stream deposits, inland glacial deposits, and offshore glacial deposits. Based on the previous discussion of the CAD volume analysis, the groins may be exposed in some areas of the beach fill. Additional analysis of the along coast variation in topography and groin dimensions is necessary to determine if groins will be completely covered by the beach fill. Therefore, the design cross-section and total volume of fill may have to adjusted accordingly or some groins may need to be removed.

Adaptive Management and Maintenance

Due to the longshore transport potential evident from the winnowing of the beach moving north through the groin field (see Section 2.2.2), regular maintenance will be required to maintain the beach fill. An adaptive management should be incorporated into Alternative 2 that includes monitoring beach changes through the year and initiates periodic additions of material to the beach when previously identified thresholds of beach width or crest height are reached.

3.3.3 Alternative 3: Construct Berm With Groins Moved To Upper Shore

A preliminary Alternative 3 is identical to Alternative 2 except that the groins are removed and placed along the back beach. Advantages of this design include reducing the amount of fill needed in the back beach zone and providing some additional shore protection to the existing back beach. However, removing the groins may reduce the stability of the beach fill, increase longshore transport, and may increase maintenance requirements.

3.3.4 Alternative 4: Construct Berm With Groins Removed And Hauled Away

Alternative 4 is identical to Alternative 2 except that the groins are removed and disposed of. Removeal of the groins will slightly increase the cost of the beach fill and will require offsite disposal costs. In addition, removing the groins may reduce the stability of the beach fill, increase longshore transport, and may increase maintenance requirements. However, a benefit is a more natural beach system, and associated aesthetics.

3.3.5 Alternative 5: Construct Berm With Road Converted To One Way

Alternative 5 involves converting the road to one way allowing the berm to be setback landward to reduce the volume of the beach fill. Short-term disadvantages of this option are the decreased traffic capacity and the increased cost of removing utility infrastructure (i.e. power lines) seaward to the road. However, this alternative provides a larger buffer for shoreline retreat in the long-term.

3.3.6 Alternative 6: Construct Berm With Road Removed

Alternative 6 involves removing the road allowing the berm to be setback landward to reduce the volume of the beach fill. Due to the significant impact to traffic and access of structures along the shoreline, this alternative is likely not feasible, but has been considered at this level of concept design.

3.4 CONSTRUCTION PHASING/PILOT PROJECTS

Further analysis should be carried out in a second phase of planning to consider pilot projects to field test the beach berm concept design or other construction phasing alternatives. Given the relatively small amount of quantitative data on longshore transport or beach fill performance in Birch Bay, a pilot beach fill project may be a good intermediate alternative. Any pilot projects need to assess impacts to downcoast reaches in the design and planning process and should be monitored. Monitoring plans and procedures could be developed with assistance from PWA with the actual monitoring performed by local residents. Three potential monitoring techniques are described below:

1. Longshore drift monitoring could be performed by establishing bands of fluorescent spray painted beach sediments at a low tide and monitoring the subsequent longshore movement and dispersion over a specified period of time.
2. Photo points could be established for drift monitoring and future flood documentation.
3. Repetitive beach transect surveys could be made, for example by reoccupying key transects from the FEMA coastal flood study, and changes in transect elevations could be documented to estimate changes in beach volumes and longshore drift.

3.5 ALTERNATIVE COMPARISON

A number of design objectives and alternatives to the construction of a basic berm design have been introduced in Sections 3.2 and 3.3. Public discussion of the objectives and alternatives is the next logical step in the shoreline planning process. In order to stimulate this process PWA, to the best of our current knowledge of the project, has compiled a number of specific design objectives grouped under the general planning objectives introduced in Section 3.1.2. Table 4 organizes these design objectives and provides an initial ranking to semi-quantitatively compare the alternatives. The design objectives presented in Table 4 also articulate other potential design issues that need to be studied further and public policy decisions that need to be made before an alternative is selected, designed and constructed. It is our intent that this matrix be adopted and refined by the local community, regulators and other interested parties, as part of the continued process for the design of the shoreline berm.

Table 4. Weighting and Ranking of Berm Implementation Alternatives

DESIGN OBJECTIVES	Weighting (1 to 5) 5 is best	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Engineering Design/Construction Objectives							
Reduce severity of coastal flooding	5						
Minimize beach fill material/costs	5						
Minimize need for waste hauling	5						
Incorporate groins in design	4						
Accommodate potential RSLR impacts	2						
Minimize impacts to backshore drainage	2						
Minimize impacts to existing outfalls	2						
Reduce beach nourishment needs	3						
Reduce erosion potential at ends of berm	3						
Reduce impacts to adjacent properties	4						
Minimize beach maintenance needs	3						
Optimize design with pending CIP work	2						
Optimize design with land use planning	2						
Transportation design objectives							
Maintain existing traffic volumes	4						
Maintain two-way traffic pattern	4						
Maintain existing bay-side parking	3						
Reduce road maintenance needs	4						
Minimize traffic disruption during construction	2						
Aesthetic design objectives							
Improve pedestrian access/mobility	5						
Reduce visual impacts of groins	4						
Reduce visual impacts of power lines	3						
Create a more natural beach	4						
Minimize impacts to current recreation	3						
Minimize shift of high tideline seaward	2						
Permitting objectives							
Minimize impacts to shellfish habitat	4						
Minimize impacts to fisheries habitat	5						
Minimize impacts to intertidal benthics	3						
Minimize impacts to archeological sites	4						
Minimize potential for road/parking spills	2						
Minimize land/bldg. Acquisition needs	3						
Optimize use of in-water work period	2						
TOTAL SCORE	**--**						

4. FINDINGS AND RECOMMENDATIONS

Based on PWA's site visit, literature review, and conceptual design, the primary findings and recommendations for the Birch Bay Shoreline Improvement Plan are presented below:

- F-1: Restoring a beach with a high elevation, protective berm crest along Birch Bay is a feasible option to increase recreational opportunities and to improve flood protection of inland structures;
- F-2: A beach berm design similar to Alternative 2.0 (berm height level with the road) will not provide protection from overtopping during the 100-yr storm event, but may provide protection from the 5-yr, 10-yr, or 25-yr event. If maintained, the new beach geometry will reduce flood hazards during the above events;
- F-3: A key design element that has yet to be identified is an appropriate sediment source for the beach fill;
- R-1: PWA recommends that more specific design objectives need to be agreed upon by local stakeholders, including level of flood protection desired, maximum height of crest height;
- R-2: PWA recommends that existing data gaps listed below be filled to enable procedure to the preliminary design phase.

4.1 DATA GAPS

1. Historical beach change:
    a. Historic beach planform and section
    b. Timeline of interventions and events
    c. An updated description of littoral conditions, including sediment budget
    d. Estimates of seasonal and storm fluctuations
2. Longshore transport:
    a. Flood Control beach nourishment activities at Terrell Creek
    b. Marina dredging schedule
3. Detailed beach composition data:
    a. Grain size analysis of material along profile and change in grain size with depth
    b. Sediment density

4.2 PRELIMENARY DESIGN PHASE SCOPING

1. Additional fieldwork (i.e., beach surveys and sediment grain-size analysis) at the project or reference site to better define the berm design geometry and composition;
2. Additional run-up analysis to optimize beach berm crest elevation;
3. A refined specification for the grading of gravels/cobbles;
4. An refined estimate of the volume of gravel/cobbles required for the berm;
5. Identification of potential sources of suitable gravel/cobbles;

6. Identification of potential temporary gravel/cobble storage areas along the beach to allow stockpiling prior to construction;
7. Development of a monitoring and maintenance plan, which will be adaptive and based on both the needs of the beach as it evolves and opportunities related to gravel/cobble availability.

5. LIST OF PREPARERS

This report was prepared by the following PWA staff:

Kevin Coulton, P.E., Project Director
Cope Willis, Ph.D., Project Manager
Carmela Chandrasekera, Ph.D., Associate
Jeffery Blank, Associate
Bob Battalio, P.E., Technical Review

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List of Figures

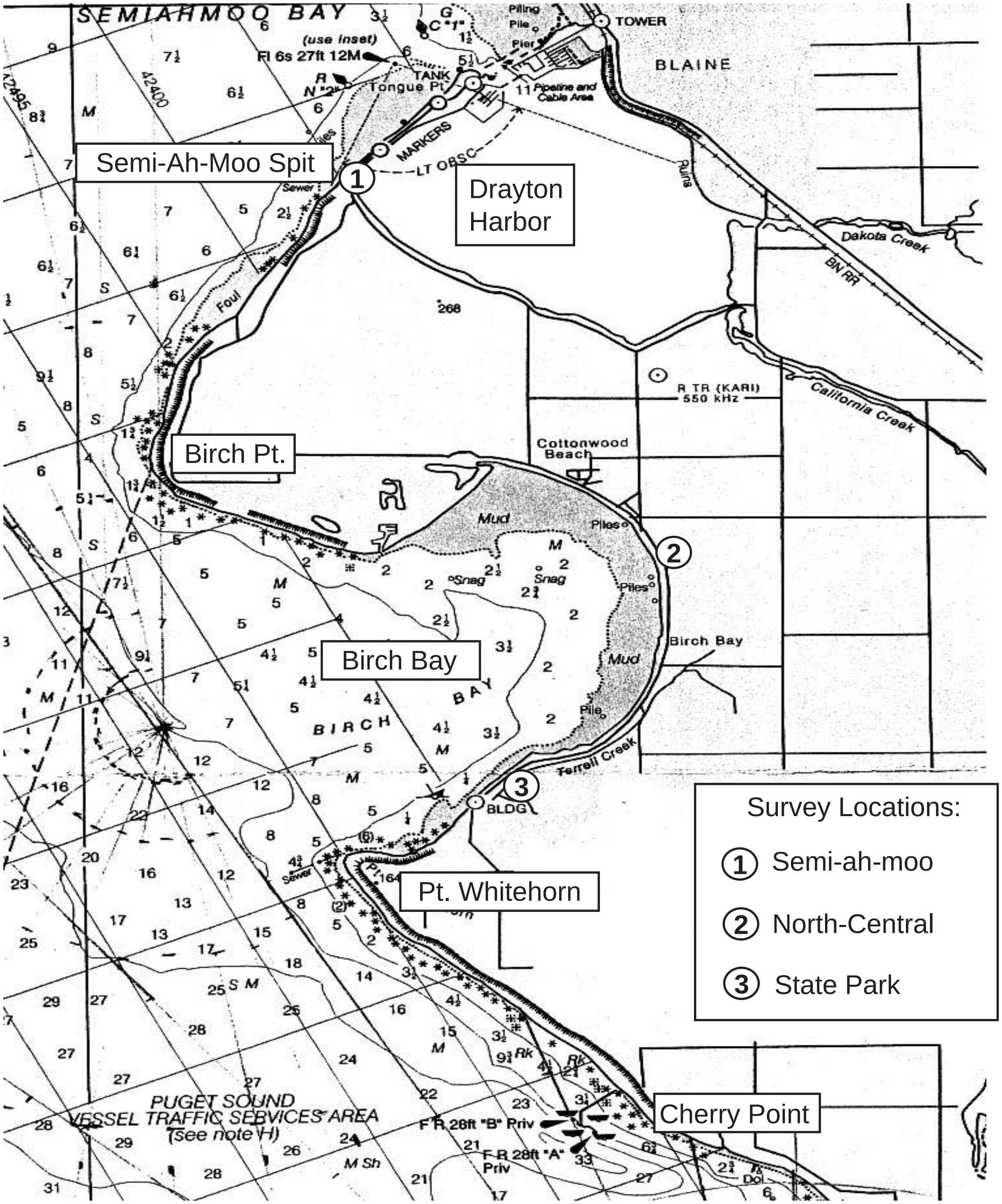

figure **1**

Birch Bay Shoreline Improvement Plan

NOAA Nautical Chart of Birch Bay Region

PWA#1627.03

PWA

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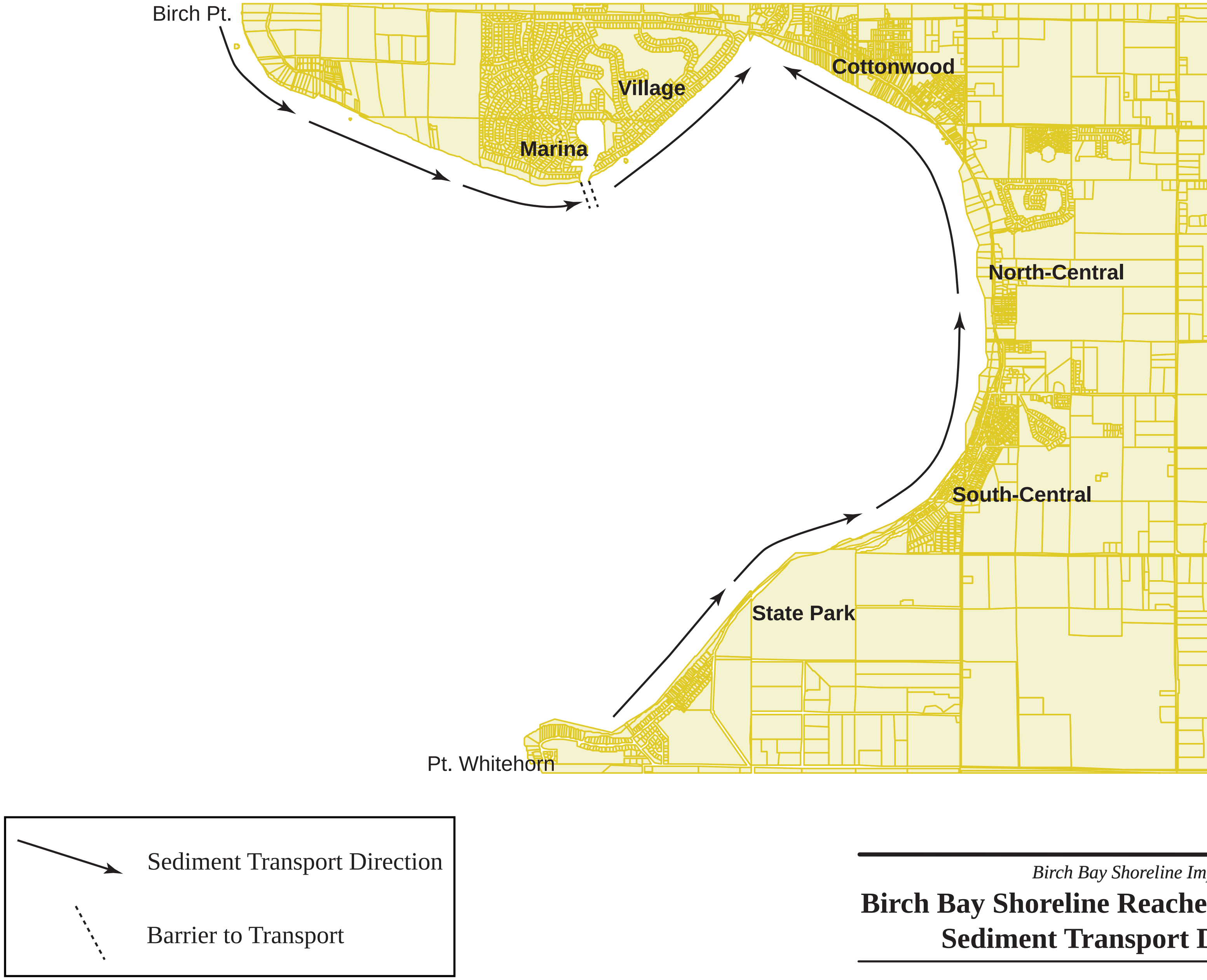

figure **2**

Birch Bay Shoreline Improvement Plan

Birch Bay Shoreline Reaches and Net Sediment Transport Directions

PWA#1627.03

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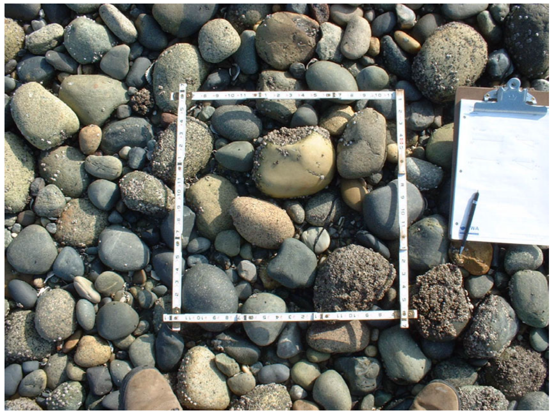
figure **3**

Birch Bay Shoreline Improvement Plan

Photo of Semi-Ah-Moo Beach Survey Location

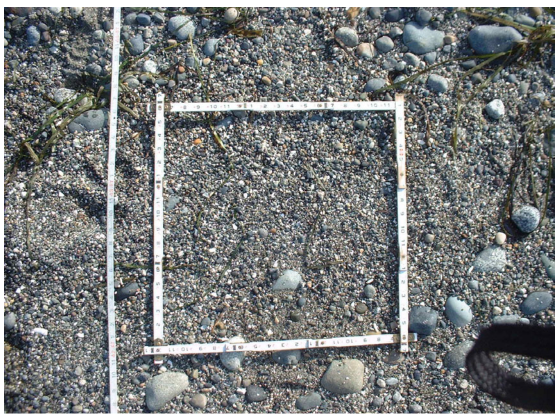
PWA Ref #1627.03

PWA

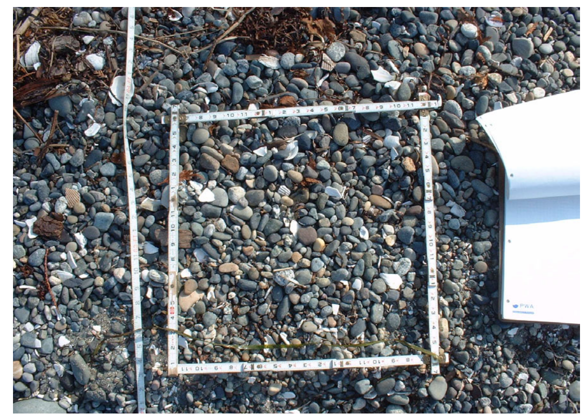


a. Intersection of the beach face and low tide terrace

b. Lower Beach Face



c. Upper Beach Face



d. Berm Crest

figure **4**

Birch Bay Shoreline Improvement Plan

Photos of Grain Size Variations Along Profile at Semi-Ah-Moo

#1627.03

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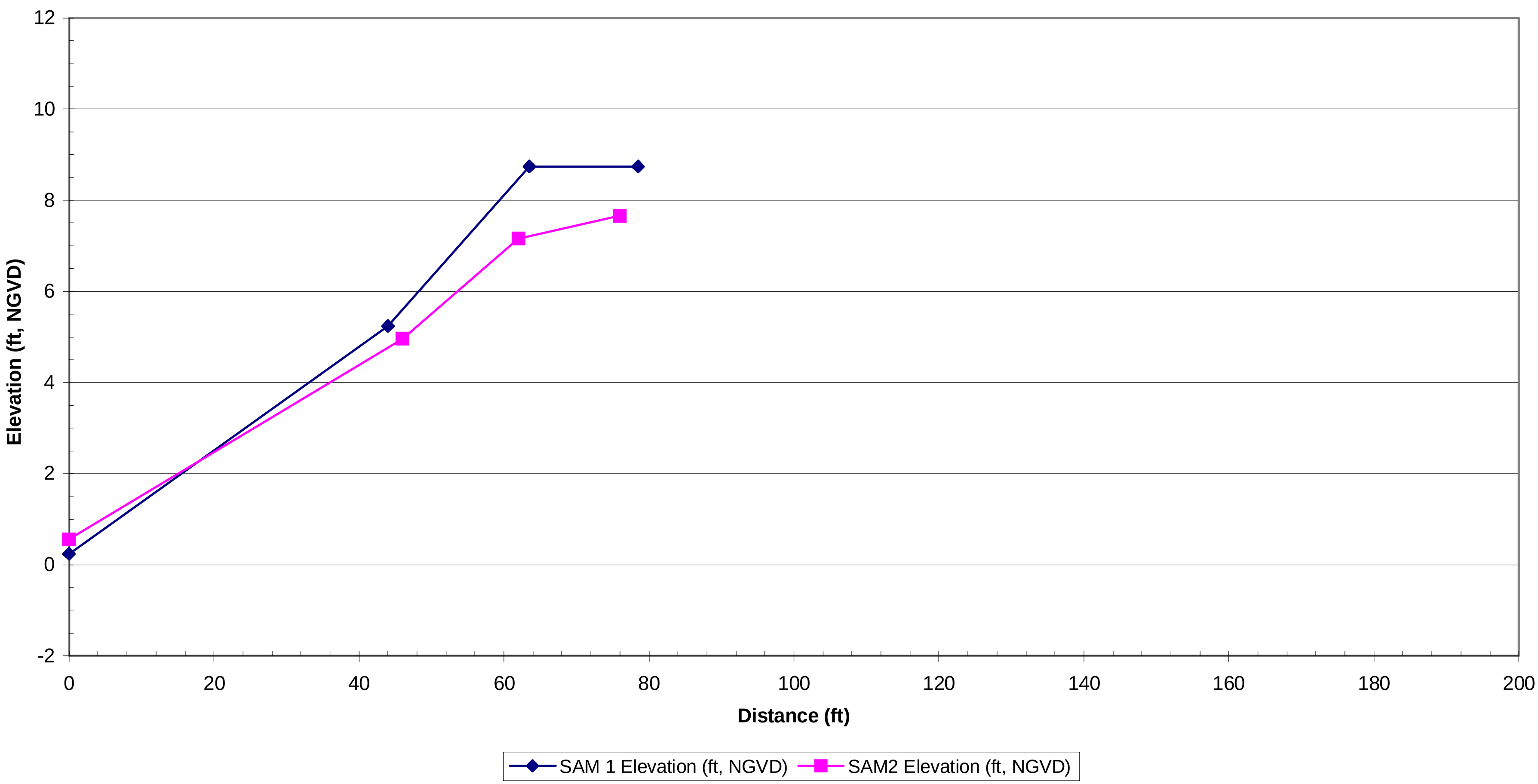

figure **5**

Birch Bay Shoreline Improvement Plan

Semi-Ah-Moo Beach Surveys

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f igure **6**

Birch Bay Shoreline Improvement Plan

Photo of Birch Bay State Park Beach Survey Location

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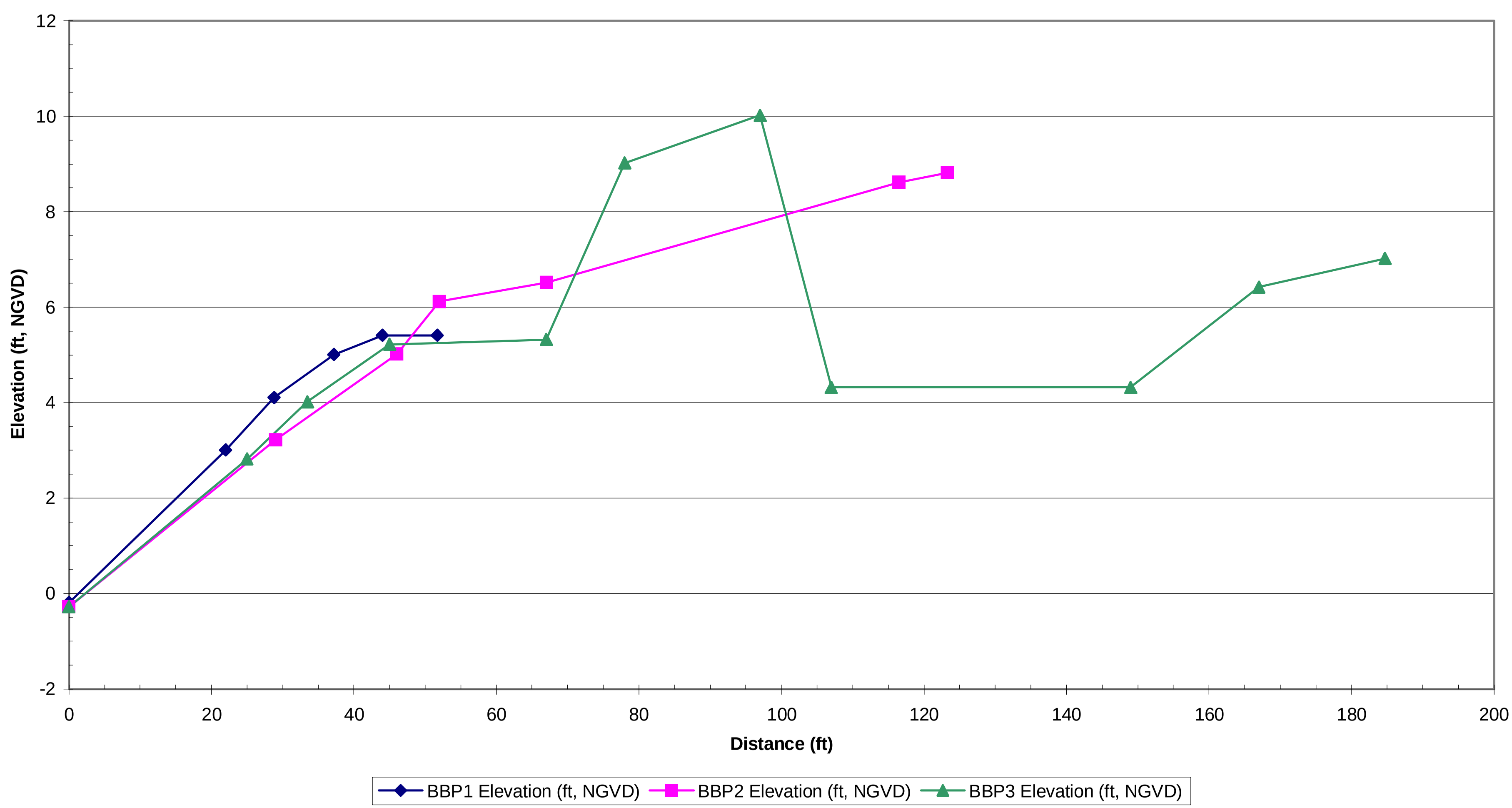

f igure **7**

Birch Bay Shoreline Improvement Plan

Birch Bay State Park Beach Surveys

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figure **8**

Birch Bay Shoreline Improvement Plan

Photo of North-Central Reach Beach Survey Location

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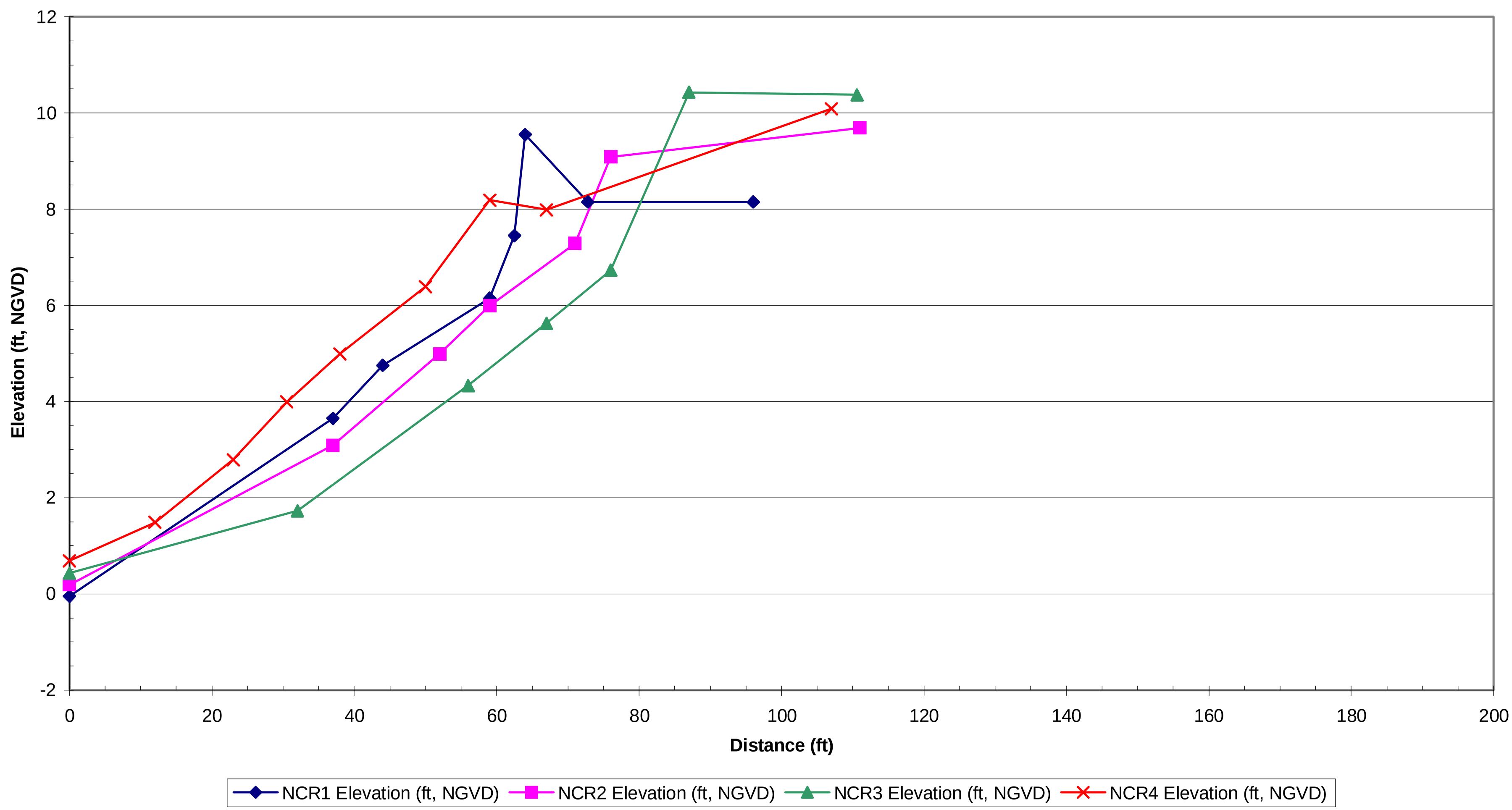

f igure **9**

Birch Bay Shoreline Improvement Plan

North-Central Reach Beach Surveys

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a.

b.

c.

d.

f *igure* **10**

Birch Bay Shoreline Improvement Plan

Grain Size Decrease From a to b, Moving North in Groin Field

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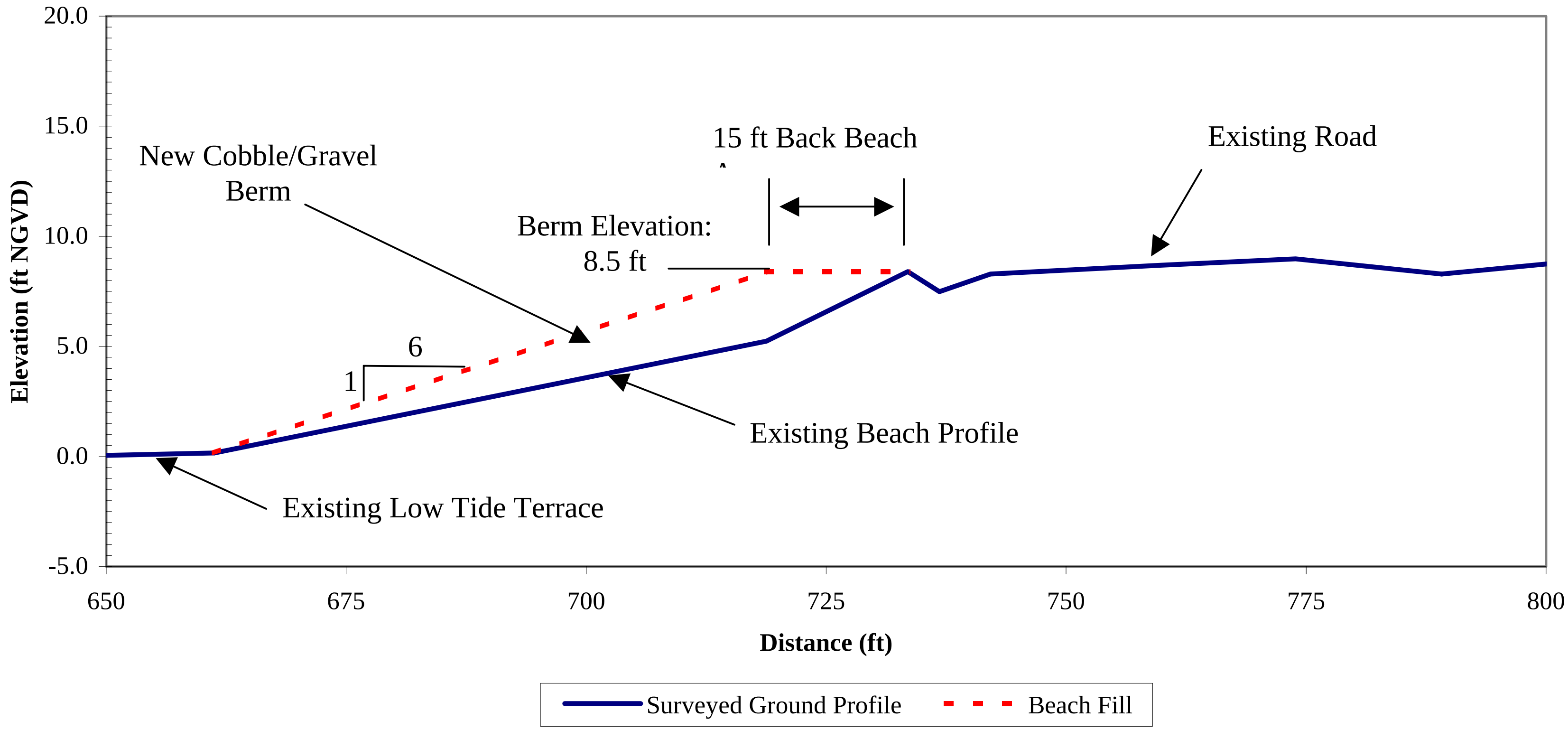

figure **11**

Birch Bay Shoreline Improvement Plan

Typical Berm Cross-Section, North-Central Reach

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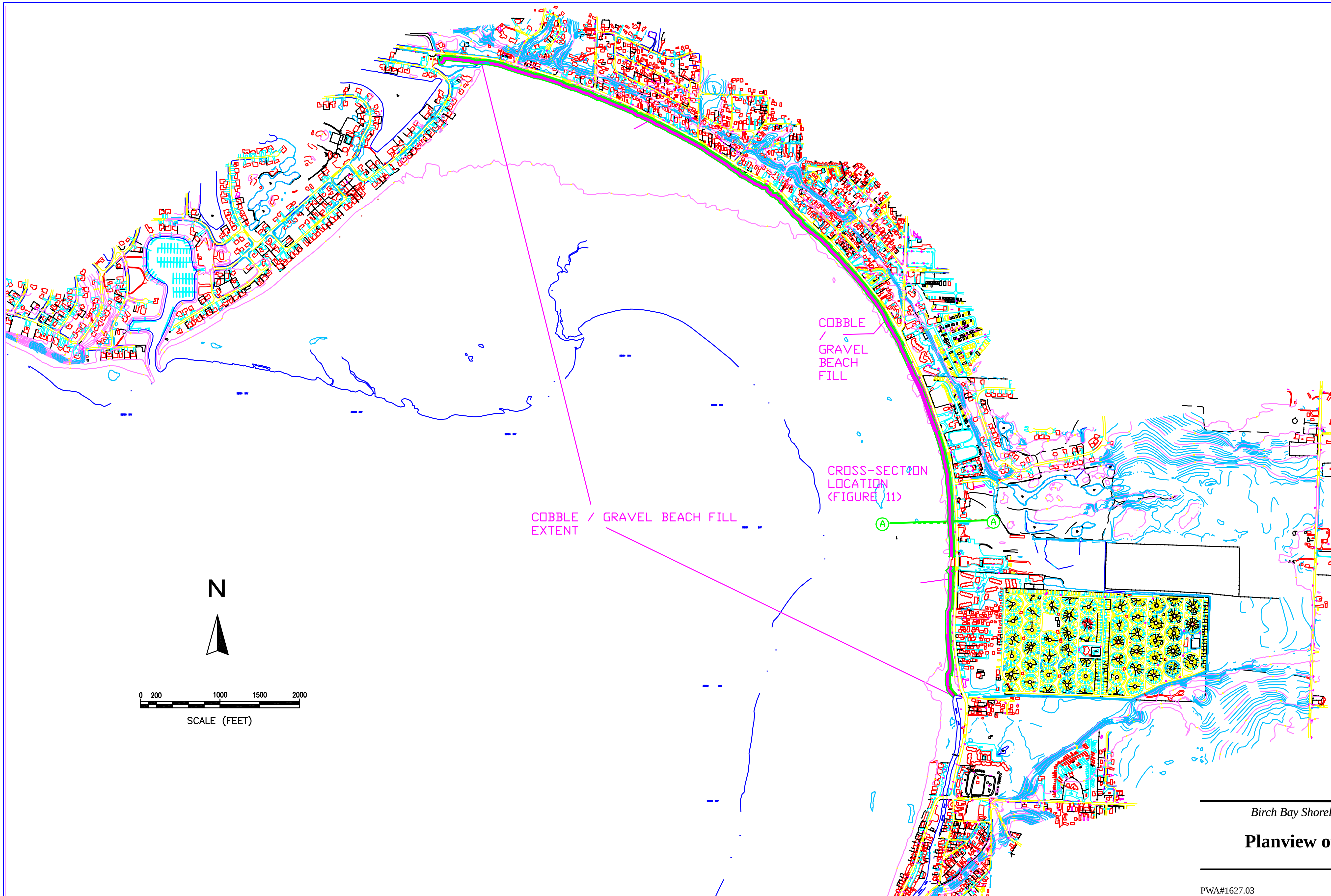

figure **12**

Birch Bay Shoreline Improvement Plan

Planview of Beach Berm

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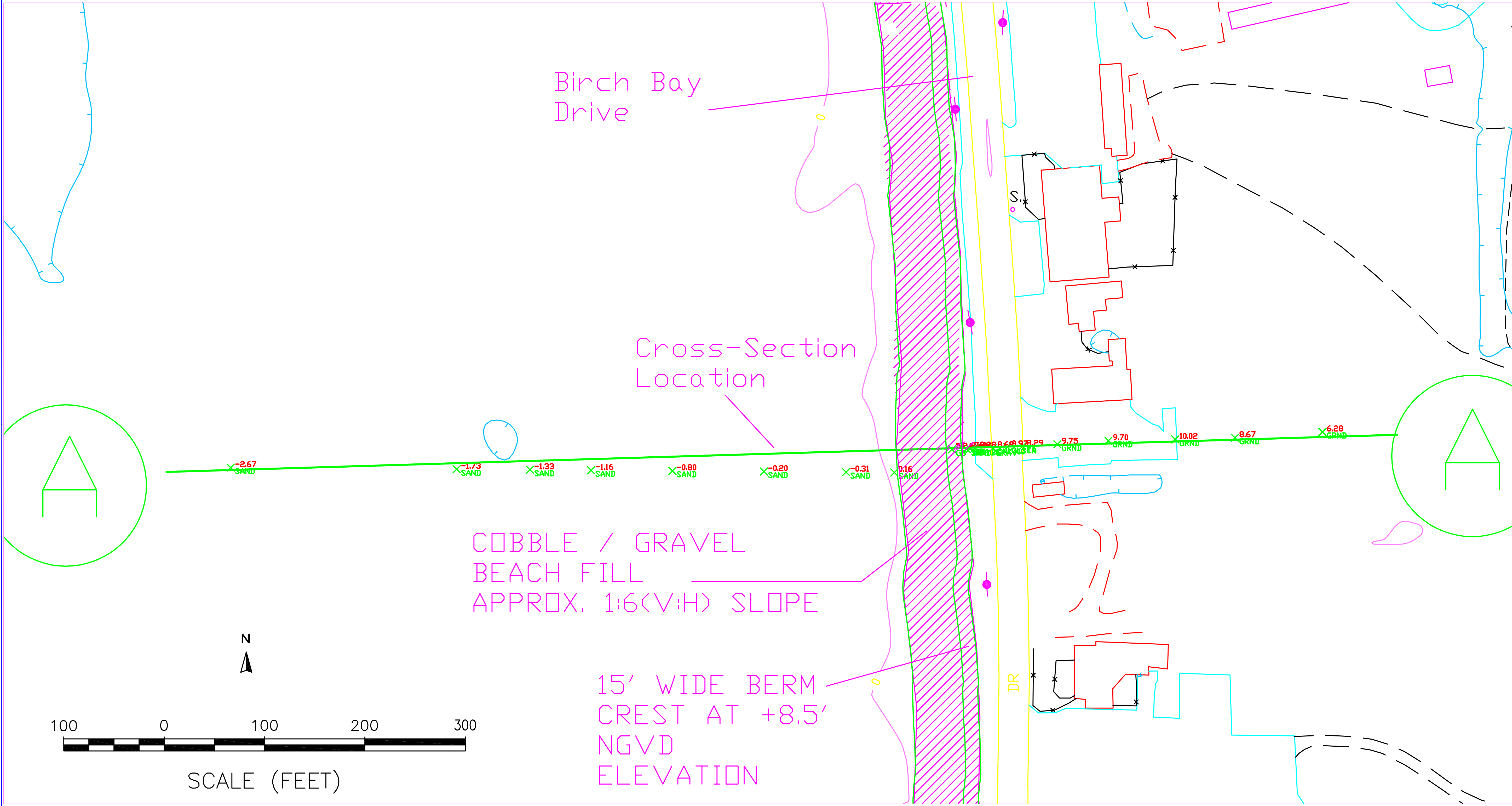

figure **13**

Birch Bay Shoreline Improvement Plan

Planview of Beach Berm at Cross-section

PWA#1627.03

PWA

Seaward Extent of Berm:

CERTIFICATIONS:

APPROVED	DATE
APPROVED	DATE

Birch Bay Shoreline Improvement Plan

Birch Bay, Washington

Whatcom Co. Council of Governments

PREPARED BY:

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD.
322 NW 5TH AVENUE, SUITE 234
PORTLAND, OREGON 97209
PHONE (503) 226-6810 FAX (503) 226-6816

IN COOPERATION WITH:

figure **14**

Seaward Extent of Beach Berm

HORIZONTAL PROJECTION	VERTICAL DATUM	SCALE	CONTOUR INTERVAL	DATE	JOB NO.	SHEET	OF
Washington State Plane	NAVD88	AS SHOWN	2'	12/1/02	1627	1	1