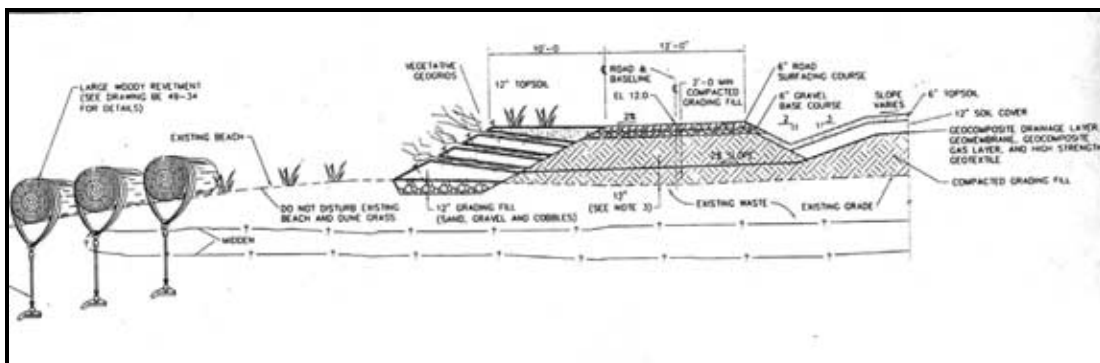


# Alternative Bank Protection Methods for Puget Sound Shorelines



Ian Zelo,  
Hugh Shipman,  
and  
Jim Brennan

*May, 2000*



Ecology Publication # 00-06-012



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# **Alternative Bank Protection Methods for Puget Sound Shorelines**

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May, 2000

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Photographs in this report, unless otherwise noted, are by the authors.



## **Preface**

During recent years, we have witnessed increasing concern among resource managers, local governments, and the general public about the environmental impact of shoreline armoring on Puget Sound. Armoring, in the form of seawalls, bulkheads, and riprap revetments, has been linked to reductions in littoral sediment budgets that lead to narrowing and coarsening of beaches, increased beach scour and erosion of adjacent property, and loss of riparian vegetation and associated habitats, in addition to adverse effects on beach access and aesthetics. Recent listing of several species of salmon under the Endangered Species Act has intensified the scrutiny of shoreline armoring by regulators.

As a result, agencies and property owners are searching for alternative methods of bank protection that address underlying concerns about erosion, but that minimize the potential adverse impacts on the environment. Unfortunately, little technical guidance is available to those interested in recommending, designing, or constructing alternative erosion control measures and no formal demonstration projects exist. Numerous projects have been carried out, however, but they have received no systematic review or documentation.

This report describes fifteen projects from around Puget Sound where creativity has been applied in reducing shoreline erosion. Applications include beach nourishment, bioengineering and other vegetation techniques, structural use of drift logs and woody debris, and intertidal benches. Ultimately, we need design standards and well-documented demonstrations of these technologies, but in the meantime, we hope this report helps document existing sites, increases awareness of the basic approaches, and encourages additional innovative, environmentally sound projects.

Hugh Shipman  
Department of Ecology  
May, 2000

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## Introduction

Rapid population growth in the Puget Sound region has brought increasing numbers of people to the shore, transforming a rural shoreline into an urban and suburban one. Vacation cabins are giving way to permanent residences and previously undeveloped shorelines are becoming waterfront communities. Natural shorelines are giving way to bulkheads, stair towers, and heavily landscaped yards.

People are drawn to the shoreline by spectacular views, beach access, and simply the pleasure of living near the water. Shoreline bluffs and beaches are dynamic environments, however, where erosion and storms are the rule rather than the exception. The shoreline actually depends on continuing erosion to maintain beaches and to support nearshore habitat, yet development is often intolerant of even relatively gradual erosion and landowners go to great expense to engineer rock and concrete structures to stabilize eroding property.

In recent years, scientists and resource managers have expressed concern about the impact of traditional erosion control measures such as seawalls and revetments both on nearshore ecology and on the public use and enjoyment of the shoreline [Canning and Shipman, 1995]. Armoring deprives beaches of their natural sources of sediment and can degrade the ecological functions of the shoreline. The cumulative impact of numerous bulkheads along a reach of shoreline may be long-term, irreversible loss of habitat and increased erosion on the property of others. One result of this is that resource agencies are carefully scrutinizing erosion control proposals in order to evaluate their potential environmental impacts and to ascertain the necessity of the project in the first place.

Property owners continue to have legitimate concerns about the effect of erosion on their land, however, and therefore considerable interest has arisen in engineering measures that protect property from serious erosion, yet have less impact on shoreline ecology and on nearby beaches. While little guidance is available on such alternative approaches, numerous projects of this nature have been constructed. This report was prompted largely by a desire to publicize these efforts and to encourage additional work in this area.

This report is intended to serve two purposes. First, it documents several recent soft bank and alternative erosion protection projects in the Puget Sound region. Second, it provides information about issues and designs that should better guide and inform future projects.

The projects in this report were carried out by different property owners, for different reasons, and in different jurisdictions. There was little awareness of other similar projects and little opportunity to learn from the experiences of others. In addition, many of these projects occur in locations where ownership or

access prevents them from becoming public demonstrations (the public parks in this report are the notable exception). By describing these projects in this report, we hope that property owners and resource managers can learn of some of the types of approaches that have been tried elsewhere and some of the issues that drove their selection or influenced their design. By identifying individuals involved with the projects, whether they be contractors or agency staff, we hope to improve the sharing of information and the transfer of emerging technologies to a broader group - an audience expected to include property owners, consultants, contractors, planners and permit reviewers, resource managers, and local officials.

## ***Puget Sound Shorelines and Beaches***

---

Puget Sound's shoreline is extremely diverse and includes rocky shores, large river deltas, tidal inlets, and many hundreds of miles of mixed sand and gravel beaches. These beaches are formed of sediment supplied by the erosion of coastal bluffs and moved by wave action and littoral drift along the shoreline. This results in a complex shoreline consisting of eroding bluffs and what geologists refer to as barrier beaches (sand spits, for example). The beaches are fairly ephemeral, always in motion, and their health depends on continued littoral sediment transport. When the supply of sediment is blocked, either by a groin or a large intertidal fill, or because the bluffs that supplied the sediment can no longer erode due to bulkheading, beaches begin to erode and to change. These physical changes to the beach impact both the survival of specific biota and degrade the larger shoreline ecosystem.

Most of Puget Sound's shoreline is residential -- much less than ten percent is commercially developed and lies in the major urban embayments [Broadhurst, 1998] -- but regulation of activities on residential property is typically less restrictive than that of non-residential sites<sup>1</sup>. As the locus of development has shifted in recent decades from industrial and commercial uses to residential and recreational ones, management concerns about activities such as bulkheading and small dock construction has increased. At the same time, there is growing interest in restoring heavily urbanized sites and in building habitat enhancements into commercial and industrial shoreline projects.

### **Shoreline and beach ecology**

Estuarine beaches such as those found in Puget Sound can be characterized as medium to low energy systems. This lower energy allows a diverse habitat to develop along a tidal gradient from the shallow subtidal across the intertidal beach and extending into the supra-tidal backshore or riparian zones. This is

## Introduction

an extremely rich and productive ecological system that supports not only organisms in the narrow nearshore zone, but that affects the biological character of the entire Sound,

The beaches of Puget Sound provide important feeding habitat for juvenile fish, including threatened salmonids. They are also critical habitat for spawning adults and provide forage for shorebirds. Beach sediments support shellfish, epibenthic zooplankton, and other animal species. The beaches are important to flora as well: from sub-tidal *Zostera* (eel grass) to intertidal *Fucus* (rock weed) and *Salicornia* (pickleweed) communities and *Elymus* (American beach grass) in berm and backshore environments. Aquatic vegetation dominates the primary productivity and the base of the food web in these nearshore areas, but the flora also provides forage, refuge, and a variety of other habitat functions for many marine species including juvenile salmon.

In recent months, the listing of Puget Sound salmonids (bull trout, chinook, and summer chum salmon) under the Endangered Species Act<sup>2</sup> has renewed attention on the natural functions that our beaches provide. The beaches have been identified as critical habitat for juvenile salmon as they mature and migrate out to sea. The shallow water provides protection from larger predators, allowing more fish to survive this critical period during their rearing. Sand and gravel beaches provide necessary spawning areas for surf smelt and other forage fish on which salmon depend. Significantly, spawning depends not simply on the presence of a beach, but on the availability of a narrow range of sediment sizes in a limited tidal range on the uppermost beach [Penttila, 1995], and is therefore very sensitive to physical changes in the beach.

## ***Shoreline Erosion***

---

Many shorelines on Puget Sound are eroding, although long-term erosion rates are generally quite slow. The rate and character of erosion varies considerably from one site to another, however, due to variations in wave energy, local geology and hydrology, beach condition, and other factors [Shipman, 1995]. Typical erosion rates are in the range of one foot per decade (0.1 foot/year), often reflecting the loss of several feet of bluff or bank in a landslide every twenty or thirty years. In areas of greater exposure and higher wave energy, such as parts of northern Puget Sound, rates may climb to several inches per year or more [Keuler, 1988].

---

<sup>1</sup> The Shoreline Management Act (1971) exempts the construction of single-family residences and "normal protective bulkheads" from a Shoreline Substantial Development Permit (these activities must still conform to the policies of a local Shoreline Master Program and an SSDP exemption does not necessarily confer approval). In addition, the Hydraulics Code, administered by the Washington Department of Fish and Wildlife, applies a less restrictive standard to residential shoreline bulkhead projects than it does to non-residential ones.

<sup>2</sup> The National Marine Fisheries Service (NMFS) was recently petitioned to consider 18 other marine species for review. Seven marine species, in addition to coho salmon, are currently under review.

Erosion is a significant concern for shoreline property owners and for many shoreline communities. Often, the problem is related to historical land use decisions that led to development in inappropriate or risky locations. In other cases, concern about erosion stems from false perceptions about the rate or nature of erosion. Regardless of the motivation, however, the choices individuals and groups make to prevent property loss and protect shorelines fall into four broad categories: no action, land use controls, static engineering solutions, and manipulations to restore or increase beach function [Nordstrom, 1992].

## No Action

In some cases, the simplest and best response to shoreline erosion is to do nothing. Threats to upland structures may be minimal as a result of prudent setbacks and slow erosion rates and the high costs and potential impacts of erosion control measures may not be readily justified. On undeveloped shorelines, it may be far more effective and prudent to simply avoid hazardous development in the first place, rather than allow building that will require engineering measures to maintain safety into the future. This is particularly true in geologically unstable areas or in areas of rapid erosion, where proposals for structural stabilization and erosion control are likely once development begins.

Where shoreline stability is a complex function of historic shoreline erosion and upland mass-wasting (landslides) related to geology and hydrology (drainage), conventional bulkheading is often an inappropriate or ineffective solution. In these cases, which apply to many shorelines, "no action" may be appropriate because the only viable solutions are far more technically sophisticated and expensive than justified by the value of the property. It may be much cheaper and more effective to relocate a house or a septic system than to address stability directly.

Along shorelines where the ecological value of the shore is particularly high or where continued erosion is necessary to maintain nearby beaches (*feeder bluffs*), a policy of no action may be necessary to protect the public interest. On the other hand, on developed property where an existing home or public facility is threatened by erosion, doing nothing is often not a palatable or practical solution, resulting in a compromise between private and public interests.

## Land Use Decisions

Land use management includes zoning restrictions, local land use designations and development regulations. Such measures can be used to keep structures out of harm's way by increasing required setbacks from the water. They can establish performance standards for erosion protection projects and shoreline structures. They can also be used to mandate post-construction standards such as revegetation or beach and backshore restoration requirements.

## Introduction

Setbacks are a simple and effective way to both protect resident investment and the natural beach environment. Land use controls have much potential for controlling future problems but are of more limited utility when focused on structures that have already been constructed. Other alternatives than setbacks must be typically be considered in these cases, although in some regions relocation of structures threatened by erosion is relatively common.

## Static Structures

Erosion control on Puget Sound has traditionally been achieved through the use of engineered<sup>3</sup> structures such as seawalls, bulkheads, revetments, and upland retaining walls. They can be constructed of rock, concrete, wood, metal, or other materials, but are generally intended as static devices to resist wave action or to retain upland soils. A thorough description of these approaches is not appropriate here, but a number of references can be found [Cox and others, 1994; Corps of Engineers, 1981; Downing, 1983].

These common erosion control structures have several benefits: 1) engineering standards may have been developed and tested and consultants and contractors have extensive experience building them; 2) if designed correctly, such structures can effectively protect the upland from erosion; 3) costs may be more predictable (even if high), due to familiarity and experience; and 4) well-built structures often require minimal maintenance over an extended period of time. Among the disadvantages of these structures is that they do nothing to protect the beach itself and may exacerbate its loss, they displace critical shoreline and adjacent riparian habitat, they reflect wave energy back onto the beach, and they cutoff sources of sediment needed to maintain nearby beaches.

## Concerns about erosion control measures on Puget Sound

The conventional response to shoreline erosion in the Puget Sound region has been the construction of rock or concrete bulkheads. Although often effective at protecting against wave-induced erosion, these structures can cause a suite of negative side effects. Among the documented adverse impacts of bulkheading [Canning and Shipman, 1994; Macdonald and others, 1994; Thom and others, 1994] are the following:

- Shoreline armoring or "hardening" can cut off the sediments supplied to the beaches by erosion. This leads to sediment starved conditions that exacerbate erosion and alter beach composition.

---

<sup>3</sup> Here, we use the term "engineered" to describe built structures, as opposed to landuse controls, for example. Relatively few erosion control structures are actually designed and certified by engineers on a project-specific basis. Although many contractors employ designs that are based on solid engineering principles, we also observe many structures that do not even conform to standard industry standards. In addition, sites with complex stability issues often require geotechnical or geological engineering input - it is not enough to have a well-engineered bulkhead if the slope above it fails due to hydrologic factors.

## Alternative Bank Protection Methods on Puget Sound

- Hard structures, especially when vertical, reflect wave energy back onto the beach, causing scour and modifying the energy regime on the beach.
- Increased wave energy and loss of sediment supplies can lead to coarsening of the beach as sand and small gravel is progressively winnowed from the beach. The result is a shift to coarser gravel and cobble beaches and more frequent exposure of underlying hardpan (glacial sediment) or bedrock.
- Installation of bulkheads often requires that upland vegetation be removed and can prevent mature native vegetation from becoming re-established in the riparian zone.

Bulkheads and related bank protection measures have *cumulative* impacts. Whereas individual structures may not lead to large, short-term beach changes, the effect in aggregate of many such structures may be significant, particularly as they affect littoral sediment supplies and beach substrate. Much of Puget Sound's shoreline is residential and as a consequence, large portions of the shoreline are, or are likely in the future be, armored. Currently, approximately 30% of the shoreline is armored [Bailey and others, 1998], and in many areas, this proportion approaches 100% over extensive reaches of shoreline.

### Alternative means of erosion control

Beaches in their natural state have a certain amount of built in erosion protection. Gradual beach slopes dissipate wave energy and protect the toe of the bluff from direct wave action except at the highest tides. The movement of beach sediment also dissipates wave energy. Coarse, permeable beaches (such as the gravel-dominated beaches found in this region) allow incoming waves (swash) to drain rapidly into the beach, reducing the erosive backwash. Gravel beaches can actually build up during storms. Beach and bluff erosion provides sediment to the littoral system, maintains the volume of nearby beaches, and reduces erosion elsewhere. The presence of drift logs and other large woody debris helps to retain sediments and absorb wave energy. Dune grass and berm vegetation can greatly increase the resilience of beaches to storm waves.

Just as human efforts to control erosion can cause degradation of these natural systems, engineering design can be applied to address the adverse impacts of conventional structures as well as to restore or enhance beach functions that have been lost. Beach nourishment projects, where sediment is artificially added to the beach, and biotechnical bank stabilization measures and bioengineering, where vegetation is planted specifically to address erosion and slope stability, are examples of such efforts, as are more elaborate efforts at beach reconstruction and shoreline habitat restoration. The success of these



## Introduction

alternative approaches will be measured by their ability to provide bank protection while also preserving or restoring natural physical and biological shoreline processes.



## Case Examples

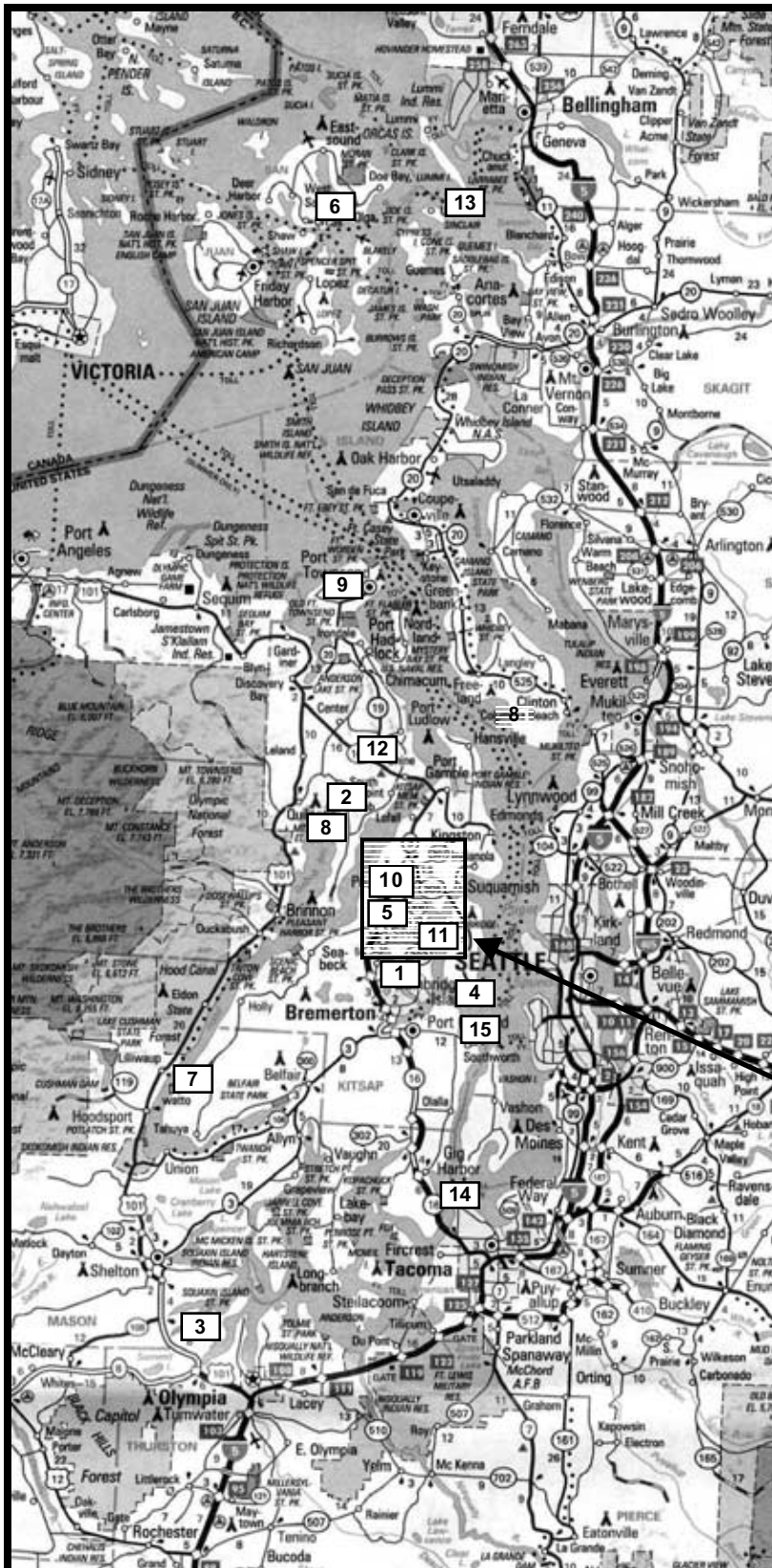
The primary objective of this report was to identify and describe a variety of projects where creative approaches had been taken to address shoreline erosion. The following section contains detailed descriptions of fifteen projects from around the Puget Sound region (see Figures 1 and 2). A summary of the projects is provided in Table 1.

We began this project with an initial list of projects and contact people. Phone interviews, meetings, and site visits were carried out, primarily by the first author of this report (Zelo). From our discussions with individuals involved with these projects we identified several additional sites to add to the survey. Some sites were eventually dropped due to lack of information or because they turned out to be inappropriate examples for this particular study.

Although several beach nourishment projects were included, we chose to focus on other types of examples since Puget Sound nourishment projects will be covered more completely in a report to be completed later this spring by Shipman (we are aware of approximately 30 nourishment projects in Puget Sound).

We attempted to acquire a common slate of information on each site, in addition to photographs and design drawings. This information was obtained from individuals involved with the projects, permit files, or reports where available. We found that documentation of these projects was inconsistent and some types of data were simply unavailable. For example, cost information was particularly difficult to obtain and where it was available, was often difficult to interpret (costs often included project costs unrelated to the shoreline work or failed to include the costs associated with volunteer or in-house efforts).

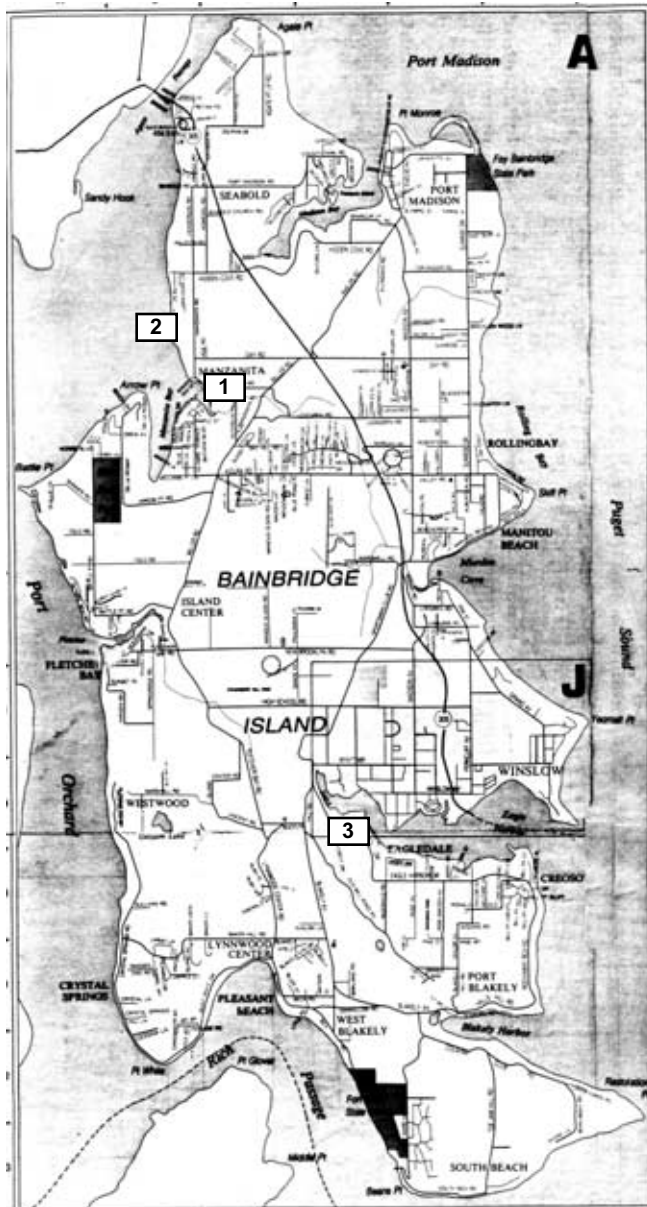
**Figure 1. Puget Sound Location Map**



1. Blake Island
2. Blomquist Residence
3. Baum Residence
4. Cormorant Cove
5. Dick Residence
6. Driftwood Beach
7. Dully Residence
8. Floral Point
9. Indian Island
10. Odermat Residence
11. Place Eighteen
12. Salsbury Point Park
13. Samish Beach
14. USG/Thermofiber
15. Weather Watch Park

**See Figure 2,  
Bainbridge  
Island detail**

**Figure 2. Bainbridge Island Location Map**



- 1. Dick Residence**
- 2. Odermat Residence**
- 3. Place Eighteen Condos**

**Table 1. Overview of Projects**

Site	Region	Wave Energy	Beach Type	Project Type	Date completed
Blake Island State Park	Puget Sound, West of Seattle	High	Beach	Beach nourishment, buried sheet pile wall, large woody debris	Planned
Baum Residence	Budd Inlet, Olympia	Low	Bluff	Rock bulkhead, soil nails, drainage system, geogrid, revegetation	Summer 1999
Blomquist Residence	Hood Canal	Medium	Beach / Stream mouth	Anchored logs, revegetation	September 1999
Cormorant Cove	Alki Beach	High	Beach / Low bluff	Perched pocket beach, rock toe	Planned
Dick Residence	Manzanita Bay, Bainbridge Island	Very Low	Low bluff	Quarry spall toe protection, anchored logs	Summer 1998
Driftwood Beach, Blakely Island	San Juan Islands	Medium	Beach	Beach nourishment, revegetation	March 1999
Dully Residence	South Hood Canal	Low	Beach	Anchored logs, buried rock revetment	Summer 1998
Floral Point, SUBASE Bangor	Hood Canal	Medium	Beach / Filled spit and lagoon	Beach nourishment, drift logs, revegetation	November 1997
Indian Island	North end of Indian Island, South of Port Townsend	High to Very Low	Beach / Filled spit and lagoon	Anchored logs, geogrid, rip-rap revetment	June 1997
Odermat Residence	West side of Bainbridge Island	Low	Bluff	Rip-rap bulkhead, quarry spall toe protection, habitat enhancement rocks	1998
Place Eighteen	Eagle Harbor, Bainbridge Island	Low	Beach / Low Bluff	Quarry spall toe protection, beach nourishment	Summer 1997
Salsbury Point Park	Hood Canal, N. of Hood Canal Bridge	Medium	Beach / Historic Spit	Beach nourishment	October 1995
Samish Island	North side of Samish Island	High	Beach	Beach nourishment , groin	Fall 1998
USG/Thermafiber	Hylebos Waterway, Commencement Bay	Very Low	Industrial waterway	Gabion mattresses, benched revetment	August 1997
Weather Watch Park	West Seattle	High	Beach	Large woody debris, revegetation	Summer 1991

## ***Baum Residence***

---

Address: **French Loop Road NW, Olympia**

Region: **West Shore of Budd Inlet**

Designer: **Agua Tierra Environmental Consulting**

Contractor: **ATEC  
Sound Bulkhead (rock work)**

Owner: **Baum**

Shoreline Type: **Steep Bluff**

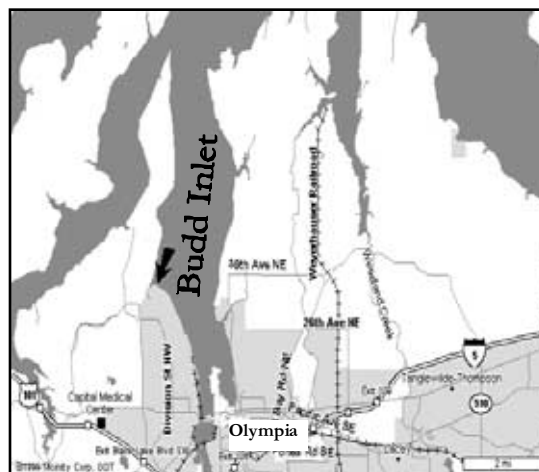
Project Type: **Rip-Rap Bulkhead, Soil Nails,  
Biotechnical Measures**

Wave Energy: **Low**

Tides: **MHHW: +14.4  
Extreme High: +17.56  
Extreme Low: -4.5**

Cost: **\$160,000  
Rip-Rap - \$60K (\$235/ft)  
Soil Nails - \$60K  
Slope Work - \$40K**

Date Completed: **Summer 1999**



Location: Baum residence in Budd Inlet

### **Site History / Description**

The Baum house is situated at the top of a very steep bluff on the west shore of Budd Inlet (Olympia, WA). The site is fronted by 255' of shoreline in a relatively low energy environment. The house was build circa 1930 and the present owner bought it approximately two years ago (1997). The house is situated on a nearly vertical bluff that was masked



by a 12-18" thick mat of Old English Ivy. The toe of the slope was faced with a 30-year-old timber bulkhead that was failing. Before the project began the driveway ran parallel to the shore between the house and the edge of the bluff. The homeowner noticed tension cracks in the driveway, which motivated him to have the slope stabilized.

## Project Description

Due to the nature and diversity of the problems present, this project was very complicated. There were five stages of construction. The project began with extensive preparatory work which was then followed by upper slope stabilization, slope face stabilization, toe protection and drainage improvements.

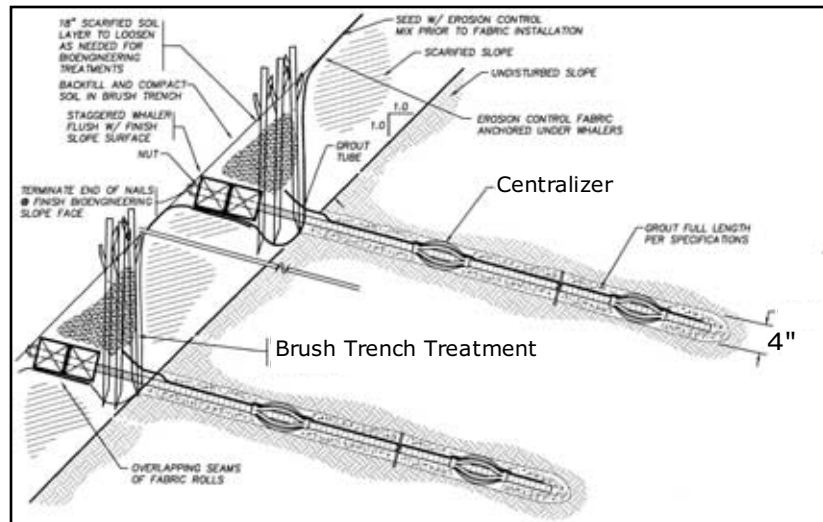
### I. Preparation: Fall 1998

Pre-construction the slope was vertical with areas that were actually undercut. To begin the process the English Ivy was removed using manual and chemical methods. Ivy can be seen on many slopes around the Sound. It is actually a false positive. While the slope may look heavily vegetated, the root system is very shallow and it does not do much more than prevent some very superficial, precipitation derived, erosion. When the ivy was gone the slope was cut back to 1V:1H and any undercuts were filled in. This grade is about the maximum that can be maintained with a sand dominated slope like the one on site.

### II. Soil nails: Fall of 1998

The soils on the site were glacially compacted and the slope is failing in blocks. Soil nails prevent this. At the face of the bluff each nail has a zone of support about 6-8' in diameter. The amount of support decreases deeper into the slope. Similarly, the slope is under the greatest pressure to fail at the face and becomes less stressed at depth. Nails are placed so that their areas of support overlap or touch at the slope surface (6' on center). The upper portion of the slope was secured using the following method.

Soil nailing is the process of running re-bar into the slope to help hold it together. Holes were drilled back into the slope using a drill rig lowered down the bluff from a boom truck. These holes were 4" in diameter and ranged from 15-32' deep. The nails are epoxy-coated re-bar with "centralizers" (4" donut-like spacers) placed every few feet to keep the nails in the



Detail: Soil Nailing

middle of the hole. When the nails were all in place, the holes were filled by pumping in "grout". This consisted of Portland cement with some added sand. The grout bonds the nails to the earth. About 48

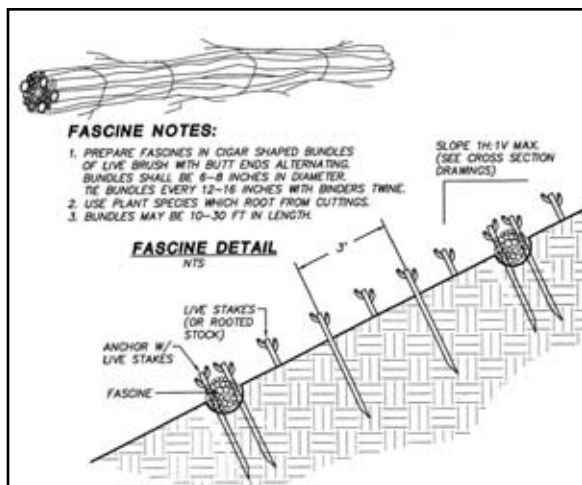


nails were put in. To insure the ivy would be dead in the spring the slope was covered with black plastic and left over the winter (98-99).

*III. Slope stabilization – lower ¾ of the slope, Spring 1999*

In this stage the lower slope was secured together using vegetative techniques.

a) “Windrow” trenches or “Brush” trenches. These reinforce the surface and shallow mantle. Shallow trenches were cut bluff for every 6’ of elevation. "Cigar" bundles (8"x 30') of rootable whips (Hooker, Scouler & Sitka willows) were in the trenched. These will grow into the and their root systems will provide substantial support.



Detail: Brush Trench

the  
into the  
shaped  
then laid  
slope

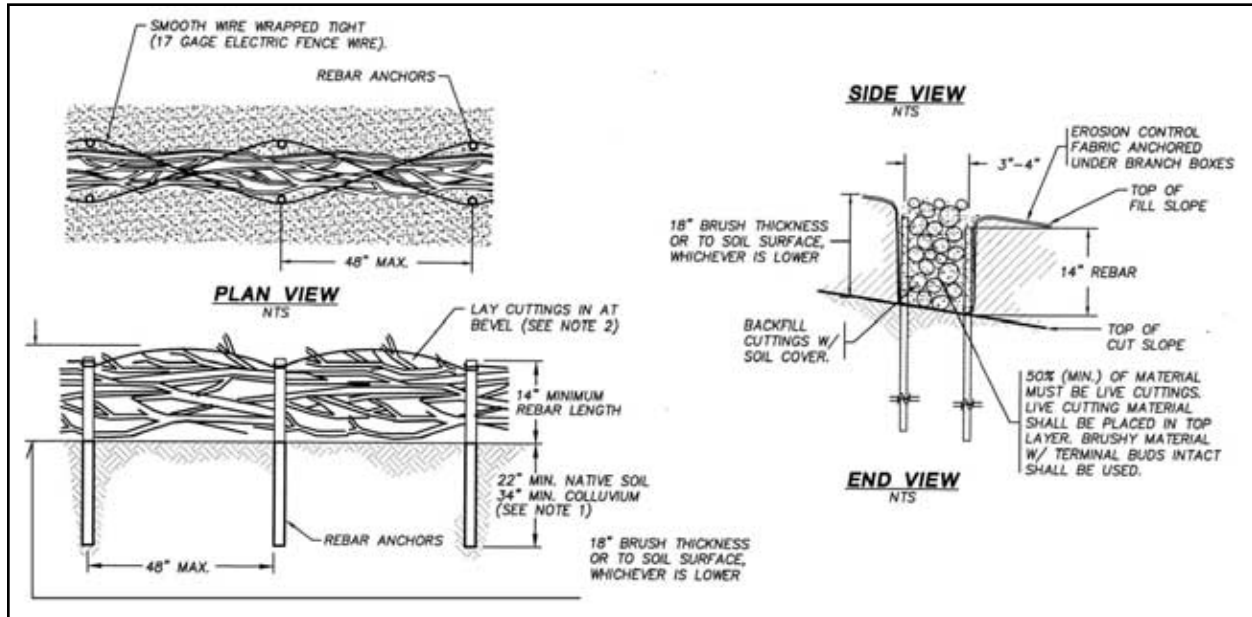
b) Live staking – Cuttings of three willow and dogwood that were about 2’ long and 1-1 ½ inches thick were driven into the ground so that 4-5” remained above ground. The stakes were cut for ATEC specifically for the job. They were chosen for their species, size and even the location they were harvested from (lower slope/upper slope) so they would match the new environment as closely as possible. These measures insured that the establishment would be successful. If the installation is done with care, 90% of the installed stakes may grow well. Poor technique can result in 50-70% mortality.

species

c) Branch Boxes - These are similar to Brush trenches in that they use cuttings of the three willow species but they hold the material deeper in the ground. Grooves were cut into the slope (3"Wx14'D) and filled with the rootable cuttings. Re-bar stakes were then driven 3-4' into the slope every 48" on either side of the box. These were used to wire the cuttings into the slope.

d) Ground Cover Plantings - Ground cover plantings followed the brush trenches, lives stakes and branch boxes. The species included vine maple, evergreen huckleberry, salal, red elderberry and ocean spray. This rooted stock was alternated up the slope with the branch boxes and brush trenches depending on the segment of slope. In addition the slope was seeded with a custom native grass mix.

## Alternative Bank Protection Methods on Puget Sound



Detail: Branch Boxes

The whole slope was covered with the coir. This material will provide support and protection during the vegetation establishment period and will rot out in about three years. This third phase was completed in the spring of 1999 and the entire slope was growing vigorously by the first week in September 1999. A temporary irrigation system was installed that will be taken down after the first two growing seasons.

### IV. Toe Protection

The old timber bulkhead was removed and replaced with a new 5' rip-rap bulkhead (6V:1H) of 6-man rock. It is 6' deep, backfilled with quarry spall and keyed into the beach 2.5-3.5 feet. After the rock was installed, pea gravel was added to the beach in front of the wall to improve the habitat for fish spawning. This was completed in the last week of August 1999 and some trail construction had yet to be completed in early September 1999.

### V. Drainage

The drainage system on the site was improved to capture 90% of the direct precipitation that lands on the property. This prevents the water from soaking into the slope and weakening it. The water is directed into a new system that culminates in a dissipater built into the bulkhead. The water reaches the bottom of the slope and is spread out within the rock to emerge on the beach over a wide area. This reduces the possibility of beach erosion resulting from the outfall.

## Monitoring

## Baum Residence

ATEC will be monitoring the site for 2-3 growing seasons. They will use established photo points and a slope stability checklist they created for the Indian Island site.

### **Success**

The project is too new for success to be determined. It is also sufficiently complex that phases II through IV might be best evaluated independently.

### **Alternatives Considered**

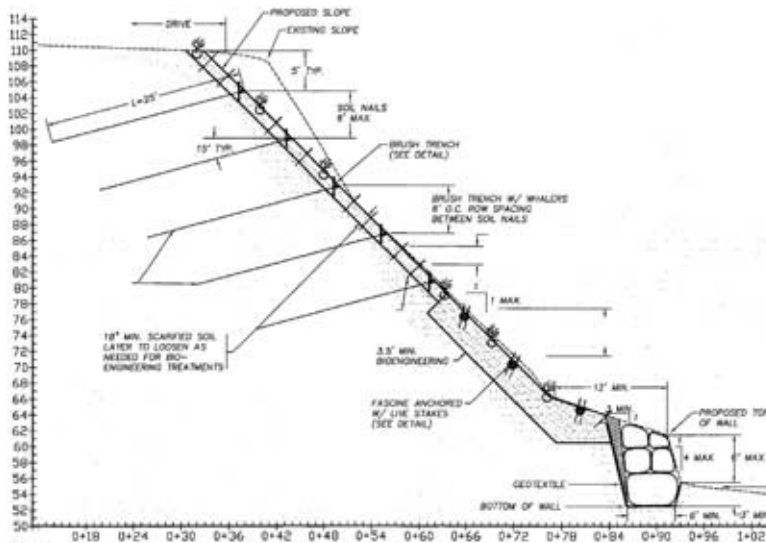
The homeowner was initially interested in a concrete bulkhead. He also wanted to maintain the vertical slope so that the driveway could remain where it was. Both of these options were discarded for the project alternative that was chosen.

### **Contacts**

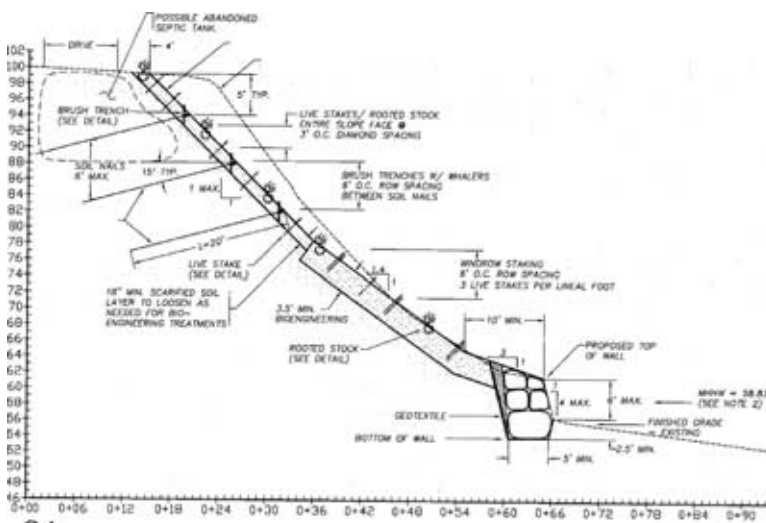
Washington Department of Fish and Wildlife:	M. Schirato
Thurston County	R. Giebelhuas
Agua Tierra Environmental Consulting, Inc.:	C. Fromuth

Project Design Profiles

Segment A



Segment B



Segment C

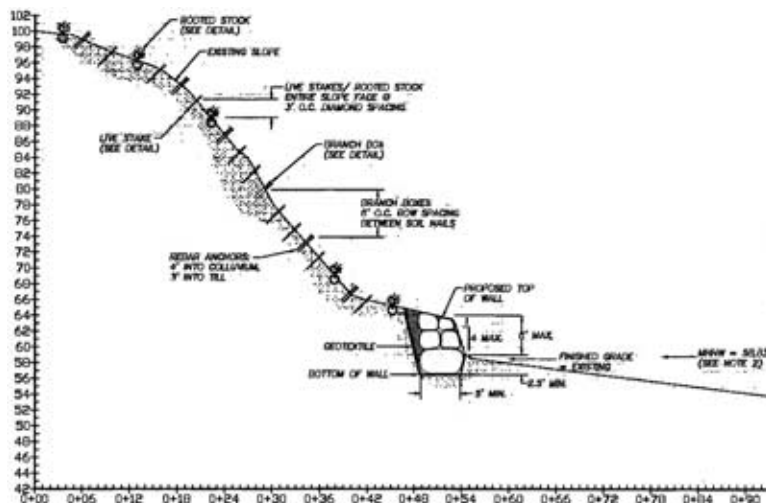




Figure 1. Vegetative slope stabilization. The bands of vegetation correspond to individual geogrid lifts. The hose in the foreground is part of new drainage system and flows into a diffuser behind the bulkhead.



Figure 2. View from the beach. The lift layers can be seen. The slope is approximately 1H:1V, compared to its original near-vertical pre-construction state. The bluff is 30+ feet tall (the rock bulkhead is 5-6 feet high).



Figure 3. Path in front of house. Prior to construction this was part of the driveway, but narrowing the path allowed more room for laying back the slope.



Figure 4. Live staking. When willow stakes are installed there is no growth - just a 1.5" portion of a 2-foot stake driven into the substrate. Four months later, vigorous growth has begun to secure soils in place.

## ***Blake Island State Park***

Address: **Blake Island State Park**  
 Region: **NE corner of Blake Island**  
 Designer: **Worthy & Associates**  
 Contractor: **Not Assigned Yet**  
 Owner: **WA State Parks**  
 Shoreline Type: **Beach**  
 Project Type: **Regrade / Nourishment  
 Coarse Woody Debris  
 Buried Sheet Pile Wall**  
 Wave Energy: **High**  
 Tides: **MHHW: +11.46  
 Extreme High: +15.5  
 Extreme Low: -4.5**  
 Cost: **Excluding Sheet Pile: ~\$18,000 (\$30/ft)  
 Sheet Pile Wall: ~\$120,000 (\$198/ft)  
 Total: ~\$138,000 (\$228/ft)**  
 Date Completed: **Scheduled - Spring 2000**

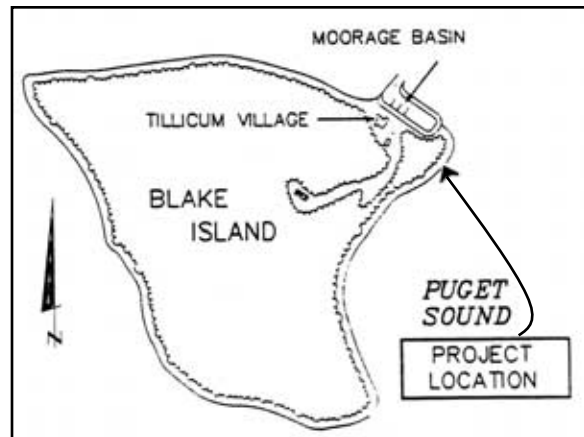


Location: Blake Island in Puget Sound

### **Site History / Description**

Blake Island is located in Puget Sound about equidistant between the southern tip of Bainbridge Island and the north end of Vashon Island. The State Park encompasses the entire island and the project site is just south of the boat basin in the northeast corner.

The site is approximately 600 feet long and stretches from the USCG navigation aid north to the eastern end of the rubble breakwater. Work on the backside of the breakwater (dredging and rockwork) was also proposed as part of a separate boat basin restoration project, but this element of the project has been withdrawn.

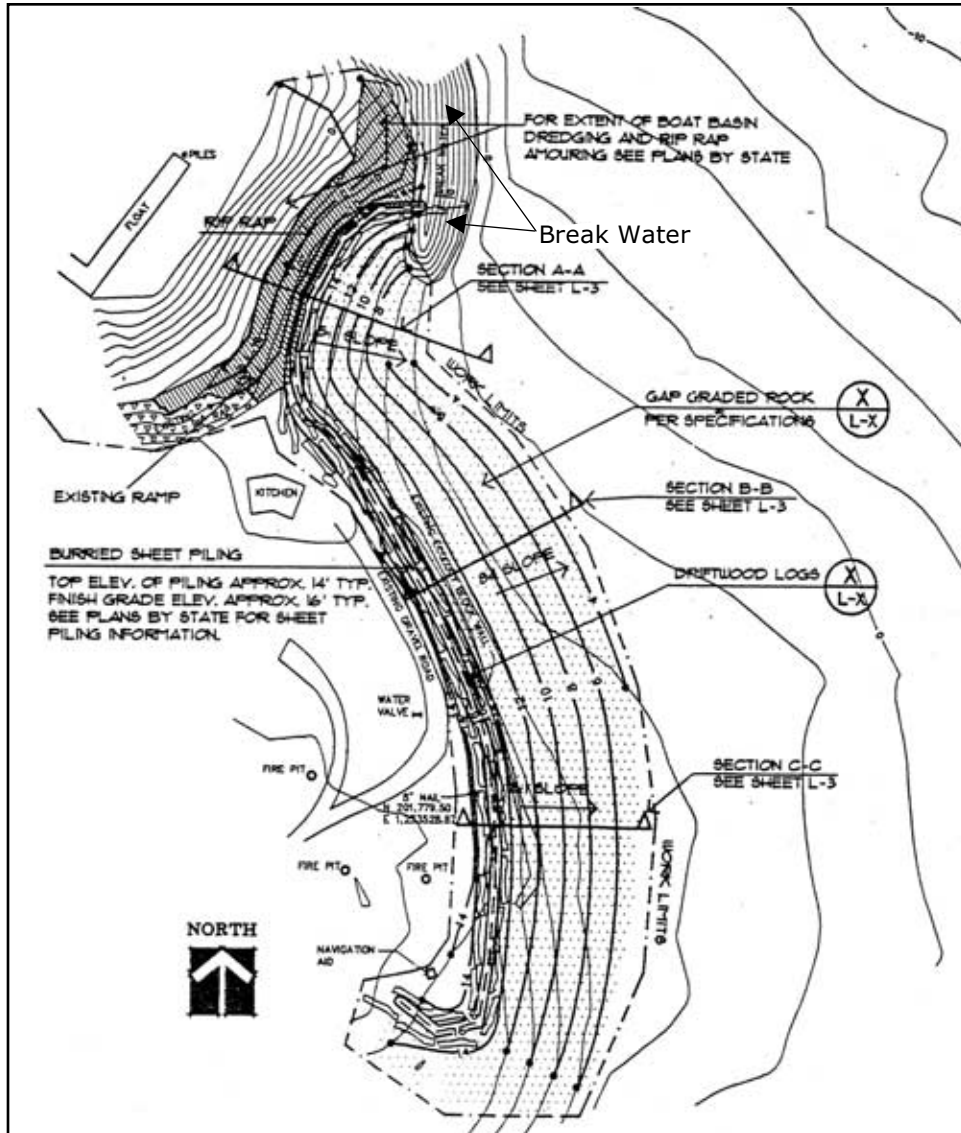


Location: Project on Blake Island

The site was originally an accretion beach fed from both the north and the south. When the boat basin was constructed in the 1970s, much of the excavated material was placed on the low-lying point where the current project is now proposed. The boat basin effectively cut off sediment input from the north and

Alternative Bank Protection Methods on Puget Sound

the modification of the point affected the movement of littoral drift from the south. Between the changes in littoral sediment supply and the placement of fine grained fill over the backshore and beach, erosion has been rapid. Following the severe northerly storms of late 1990, ecology blocks were placed as a temporary erosion control measure, but this structure has fared poorly and erosion has continued.

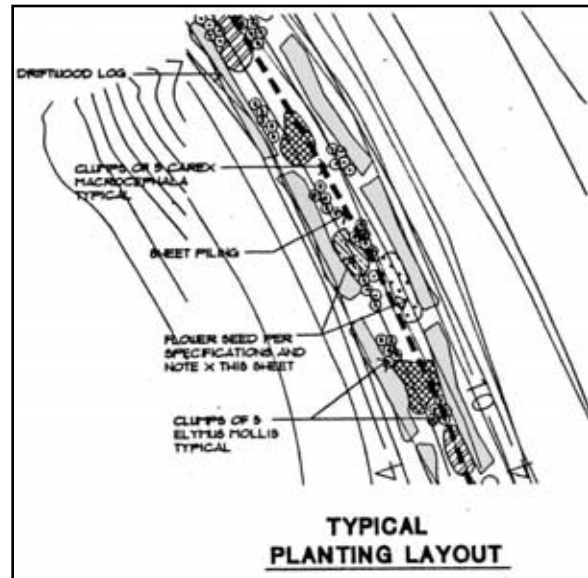


Blake Island: Site Plan



## Project Description

The beach restoration and protection will require at least five stages. It will begin with the removal of the ecology blocks that were placed as temporary erosion protection. Some of these will be reused as anchors for large woody debris. The next stage will use the dredge material from the marina and an additional 3500 yd<sup>3</sup> of 3" minus gravel to regrade the beach and build a 10'-wide berm. The new material will be much coarser and more permeable than the old fill material. This will help absorb wave swash and reduce erosive forces acting on the beach. The backshore elevation will be between +14' and +16'. A 10' sheet pile wall will be buried in the middle of the bench. It will extend vertically between +14' and +4'. Large woody debris will be anchored to buried ecology blocks and located on either side of the buried sheet pile wall for most of its length. Where the wall stretches between the kitchen and the beginning of the breakwater the logs will not be located on the marina side. Ecology blocks will be salvaged from those initially removed from the beach. The berm/backshore will be revegetated with native species.



Revegetation plan

This effort will increase the quantity and quality of natural habitat on site. It will help protect the beach against future erosion and will restore the boat basin to its former level of service.

## Monitoring

Profile monitoring will be used to track changes in the site and determine when or if additional nourishment will be necessary in the future. Three profiles will be established and measured immediately before and after the project. They will then be surveyed annually in either April or September for a period of five years. The reports will be submitted to WA Department of Ecology, WA Department of Fish and Wildlife, Kitsap County, and the Army Corps of Engineers.

## Success

The project is currently proposed to be built in spring or summer of 2000.

## Alternatives Considered

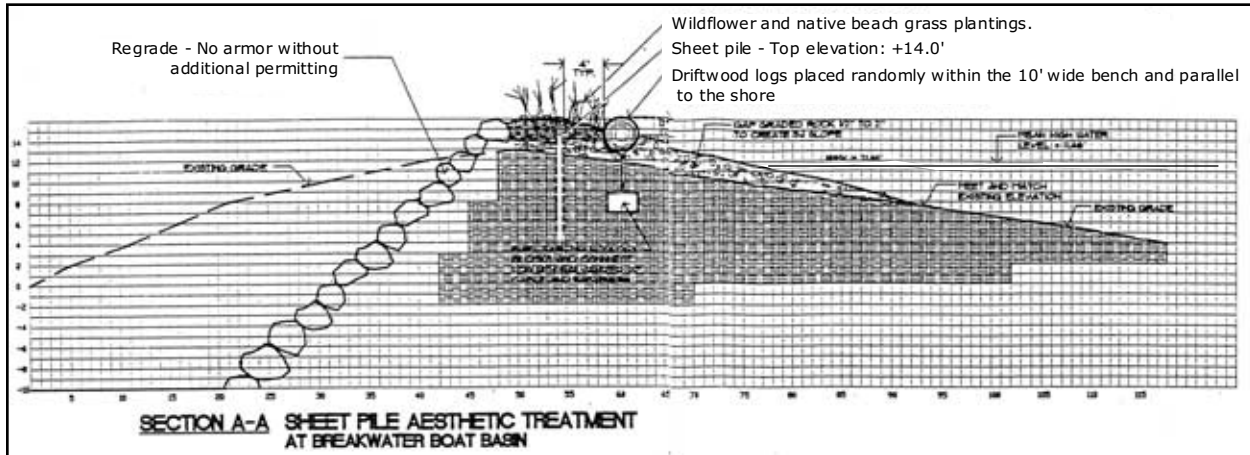
## Alternative Bank Protection Methods on Puget Sound

Several alternatives were considered for this project. The no action alternative was disregarded due to concerns about the kitchen shelter, picnic tables, and bathrooms. In addition the temporary protection is further damaging the site and needs to be removed. A rip rap revetment was considered. This was an improvement from vertical protection but it would have been poor for habitat. It is the position of the Parks and Recreation Commission to maximize natural conditions and habitat whenever possible. The third alternative was to install a rip rap revetment on the breakwater and a gravel berm on the remainder of the site. It was found that the rip-rap was unnecessary.

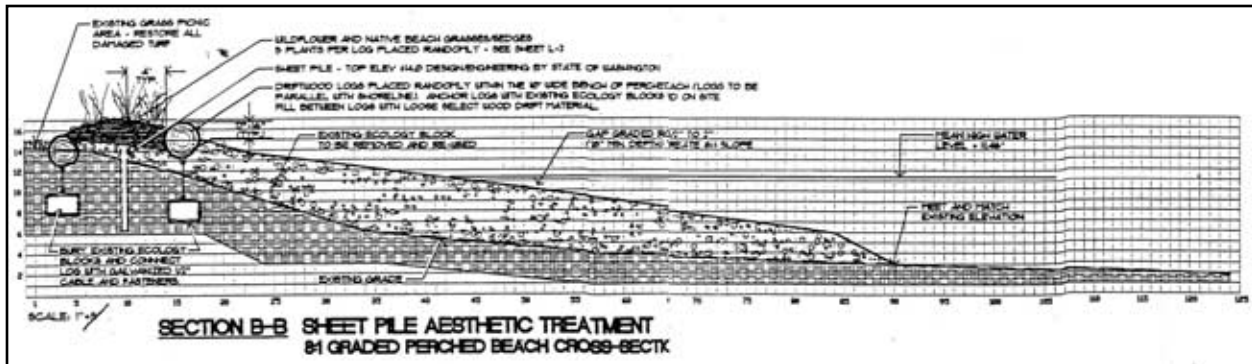
### **Contacts**

Department of Fish and Wildlife:	D. Small J. Brennan (now with King County DNR)
Department of Ecology:	H. Shipman
WA State Parks	K. Martin, J. Ward
Worthy & Associates	S. Worthy
Army Corp of Engineers	C. Barger

Project Design Profiles



Beach Profile: Transect A-A



Beach Profile: Transect B-B

Alternative Bank Protection Methods on Puget Sound



Figure 1. Aerial view of Blake Island site.  
*Photo: Ecology, KIT#707, 5-20-1992.*



Figure 2. View northwest showing temporary "ecology block" erosion protection. Note significant damage done to temporary structure. Breakwater for boat basin is in background.

## ***Blomquist Residence***

---

Address: **Shorebrook Dr. NW**

Region: **Eastern Shore of Hood Canal just south of  
the Hood Canal Bridge**

Designer: **Bart Berg Landscape**

Contractor: **Bart Berg Landscape**

Owner: **G. Stenman**

Shoreline Type: **Historic Beach with stream**

Project Type: **Large Woody Debris  
Minor Nourishment**

Wave Energy: **Medium**

Tides: **MHHW: +10.71  
Extreme High: +14.0  
Extreme Low: -4.5**

Cost: **~\$15500 (\$166/ft)**

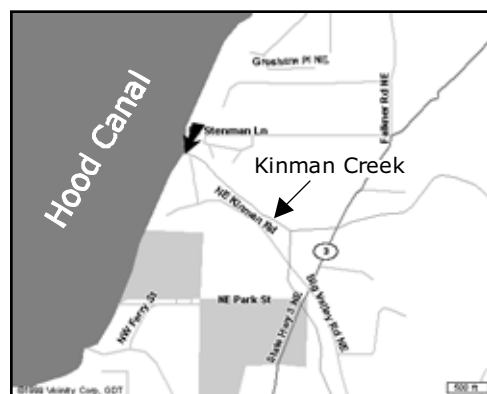
Date Completed: **September 1999**



Location: Blomquist in Puget Sound

### **Site History / Description**

The site is located on Hood Canal just south of the Hood Canal Bridge. It is unique in this report in that it is situated such that a small creek passes down the north side of the property adding to erosion concerns and the complexity of the erosion protection. Kinman Creek may have once had a healthy salmon run but at this time there are few returning fish due to a culvert up the creek just past the site. The topography offshore is shallow and is exposed at low tide for at least 100-200 feet, marking the stream's delta. Finally, neighboring properties to both sides are heavily armored and the beaches in front of these houses are significantly damaged by scour. The rip-rap bulkhead to the north is of particular interest because wave energy appears to reflect off of it onto the Blomquist beach.



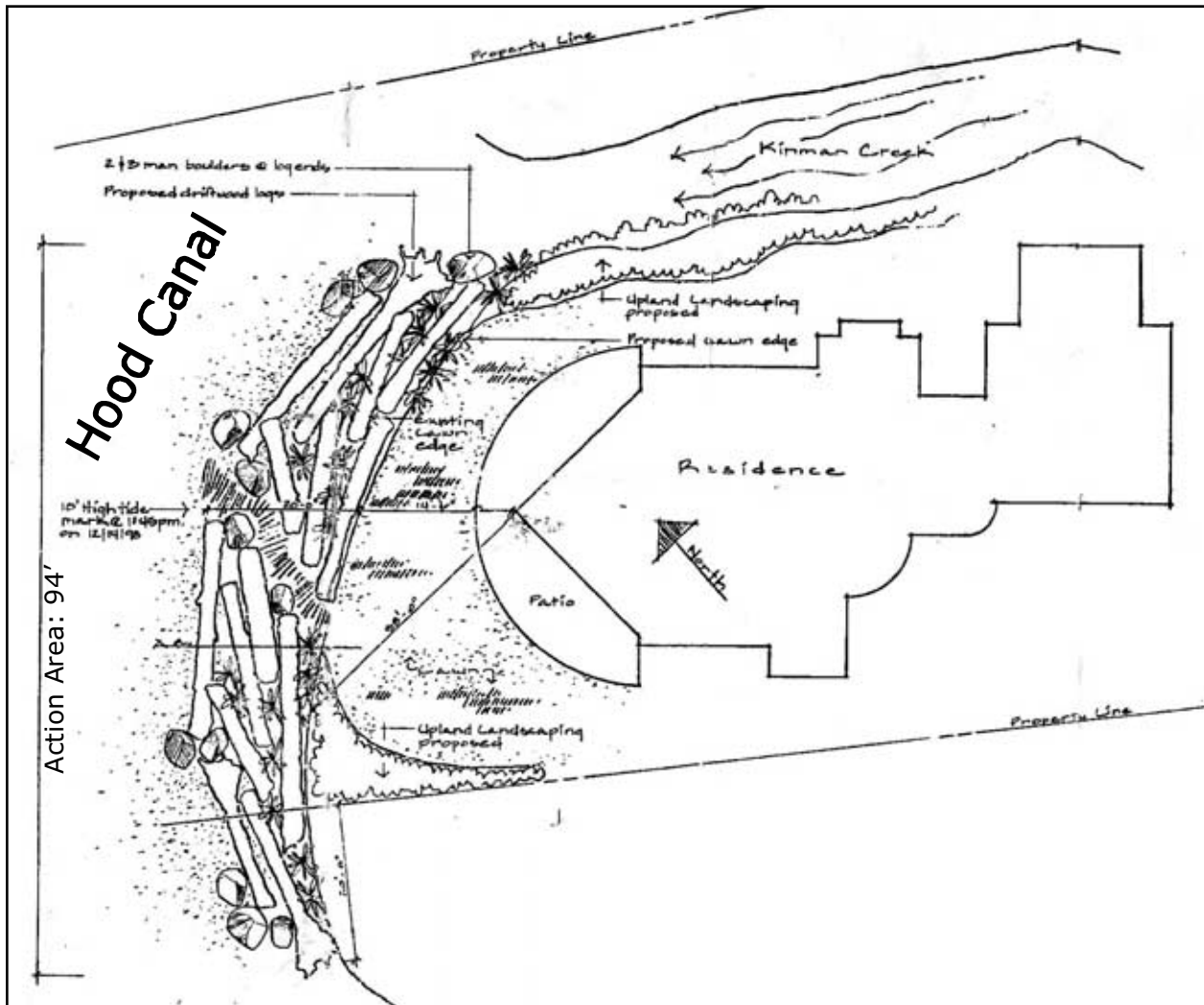
Location: Blomquist close up

The house on the site was built in 1993 relatively close to the water. In 1996, approximately ten feet of beach/backshore was lost during storms. The homeowner at that time proposed to construct a rock bulkhead, but the application was denied by the Department of Fish & Wildlife due to biological

concerns. The home was sold the following year to Blomquist, who attempted to prevent further erosion by placing riprap along the shoreline. This was done without permits and as a result, WDFW required its removal, but allowed replacement with the softer solution described here.

### Project Description

The project area begins at Kinman Creek and stretches south for 94'. This extends the project area into the neighboring, undeveloped lot which the homeowner would like to purchase. The project entails filling the beach with a 7/8" gravel mix and anchoring coarse woody debris to dissipate wave energy and retain sediment. The logs are anchored with concrete parking curbs or ecology blocks depending on their size. The ecology block can be used on this site because access to the beach by heavy machinery is not limited and large blocks could be brought in. They allow the larger logs to be anchored with just two cables (4 curbs would have been needed). The owner was concerned that the cables would ruin the



Site Plan: Blomquist Residence

## Blomquist Residence

natural effect the design was attempting to achieve. Using ecology block is a way to reduce the number of visible cables by reducing the number of anchors per log.

### **Monitoring**

There is no official monitoring plan for the site. The homeowner expects that the site will need periodic renourishment and intends to maintain the level of access he now possesses so that this can be accomplished easily and cost effectively in the future.

### **Success**

The project just been completed and success can not be determined yet.

### **Alternatives Considered**

Like on many other sites the first proposal was to build a rock bulkhead or revetment.

### **Contacts**

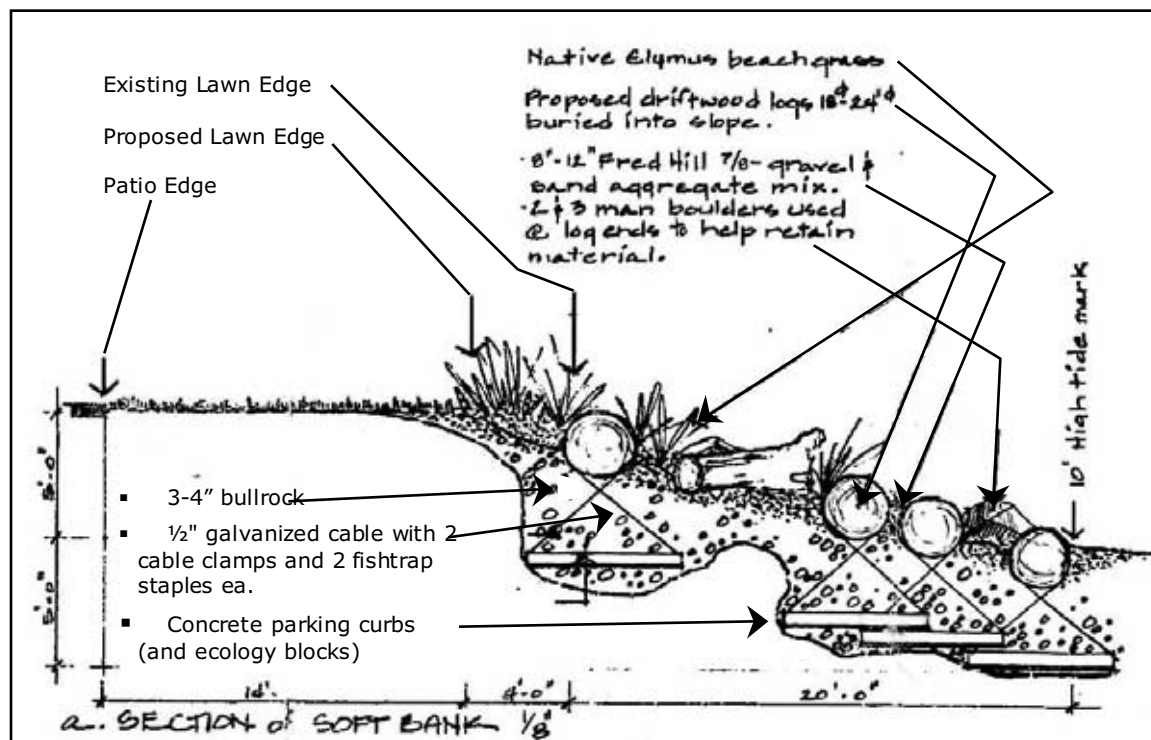
Department of Fish and Wildlife:

J. Brennan (now with King County DNR)

Bart Berg Landscape:

B. Berg

**Project Design Profile**



Blomquist Residence: Project Profile



Blomquist Residence



Figure 1. View north toward mouth of Kinman Creek, prior to construction. One concern was that waves reflecting off of bulkhead north of creek impacted the Blomquist beach.



Figure 2. Construction. Note minimal setback and broad gravelly beach.



## Cormorant Cove

**Address:** 3707 Beach Drive SW  
**Region:** Alki Beach  
**Designer:** Galloway & Barker  
**Contractor:** Not Yet Built  
**Owner:** Seattle Parks Dept.  
**Shoreline Type:** Historic Beach  
**Project Type:** Bulkhead redesign and relocation  
 Beach reconstruction  
**Wave Energy:** High  
**Tides:** MHHW: +11.40  
 Extreme High: +15.0  
 Extreme Low: -4.5  
**Cost:** \$250,000 (projected)  
**Date Completed:** Not yet built



Location: Cormorant Cove in Puget Sound

### Site History / Description

Cormorant Cove is a 1/3 acre site located on the west side of Alki Beach. It has approximately 215 feet of marine shoreline. There is a 5-9' tall vertical rock bulkhead that runs for 204' from the north end of the site towards the south. Below the bulkhead is a sandy beach with concrete rubble strewn at the south end. Above the rockery there is a lawn area that gently slopes from Beach Drive down to the top of the rip-rap. The property is flanked by multi-family residences to the north and south. The property to the north is protected by a vertical bulkhead while the one to the south is a large condo complex built on pilings out over the water.

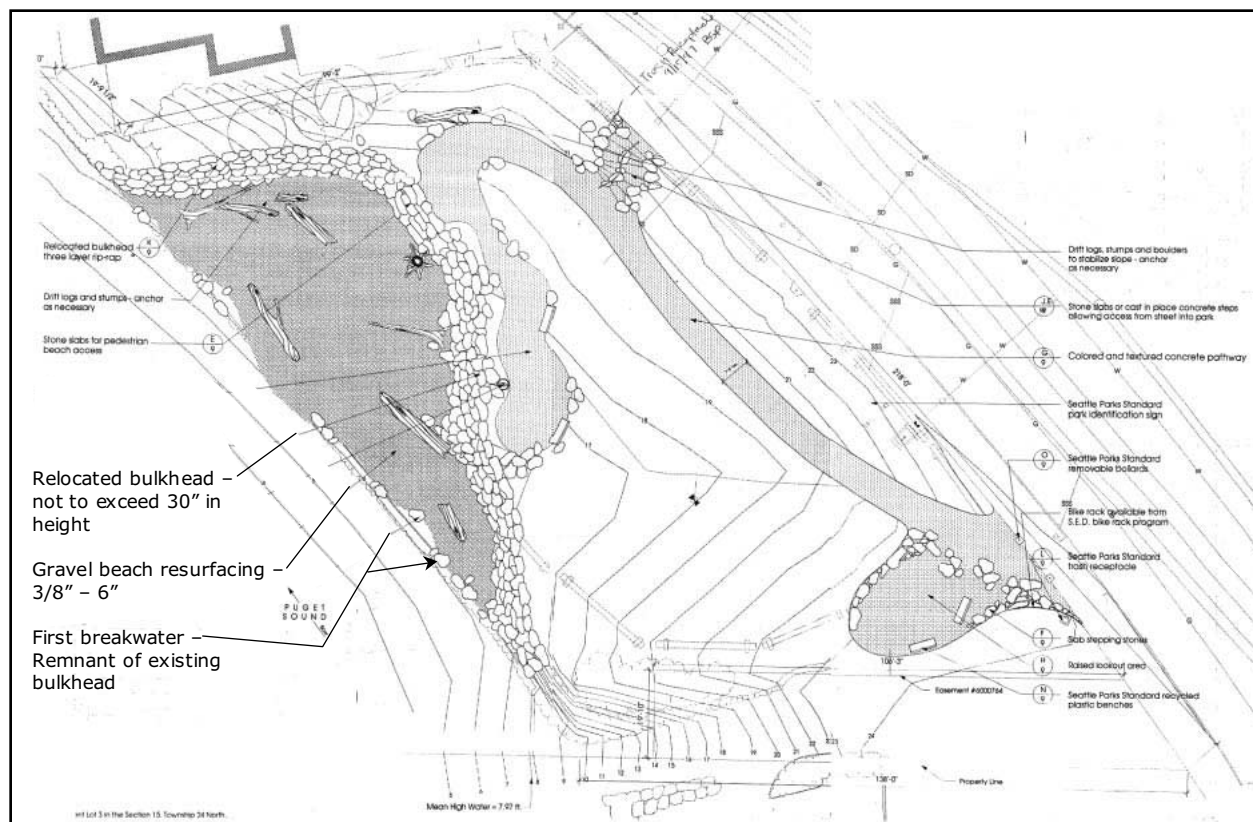


Location: Cormorant Cove on Alki Beach

The Cormorant Cove project is a result of the citizens of Alki Beach, the Alki Community Council and the Beach Drive Shoreline Parks Committee. Significant community involvement has gone into the project at all levels. The site was purchased by the Seattle Parks Department in 1995 with funds from the Shoreline Park Improvement Fund. Final permitting is pending and additional funds are being raised for construction, which is hoped to occur in the summer of 2000.

## Project Description

The Cormorant Cove project will result in the creation of a perched, pocket beach by removing most of the existing bulkhead, reestablishing the bankline landward of the existing bulkhead, and adding sand and gravel to the regraded beach. The addition of a sloping, partially buried revetment along the bankline will be added to prevent further toe erosion, and woody debris will be incorporated into the beach to add stability and habitat structure. The bankline and uplands will be landscaped to include a path to the beach, a narrow vegetative buffer at the top of the bank, and lawn and landscape plantings on the upland portion of the site. A southern promontory will be maintained on the uplands as a view point and picnic



area.

The project will begin by removing all but the lowest tier of the existing vertical rock bulkhead. This last level of rock, which is presently found below beach grade, will be left in place to act as a sill for the new pocket beach. A new rip-rap revetment will be built up to 45' landward of the present bulkhead. The structure will be no more than 30" tall and the face will be angled at a minimum of 2H:1V.

## Cormorant Cove

The area between the old bulkhead and the new revetment will be a pocket beach or “cove”. It is designed not only as an aesthetic improvement but as a depositional area and a habitat improvement. To create this new beach 820 yd<sup>3</sup> of material will be excavated. Once the appropriate grade is reached the beach will be resurfaced with a 3/8”-6” gravel/cobble mix with most of the material falling into the 2-3” range. Coarse woody debris will be anchored to the beach as necessary to further protect the site from erosion.

To create the uplands, 1468 yd<sup>3</sup> will be added. The 820 yd<sup>3</sup> cut from the beach will make up a substantial part of this fill. Once the land is graded and the concrete pathway is built, 920 native plants will be added to the site. These will help secure the sediments against erosion and improve habitat.

### **Monitoring**

N/A

### **Success**

N/A

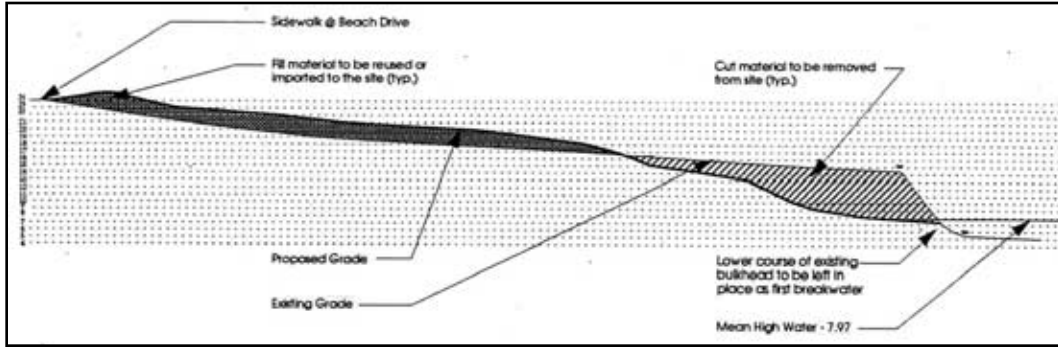
### **Alternatives Considered**

N/A

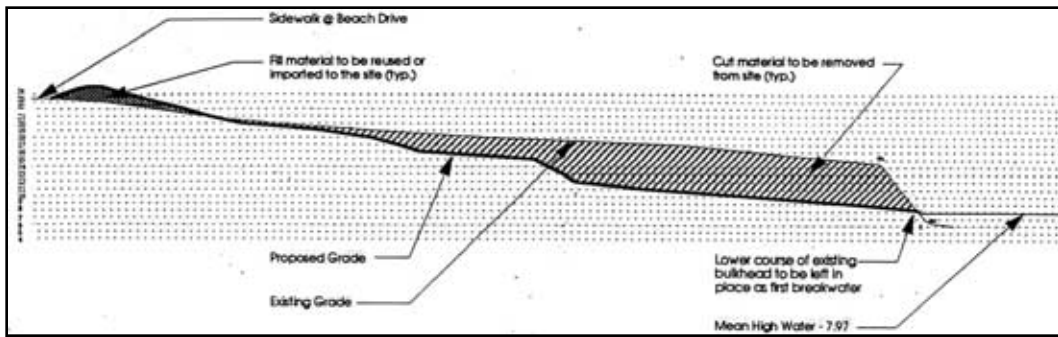
### **Contacts**

Seattle Parks Department	K. Stoops
Alki Community Council	L. Jane
Galloway & Barker	J. Barker
King County DNR	J. Brennan
Coastal Geologic Services	J. Johannessen

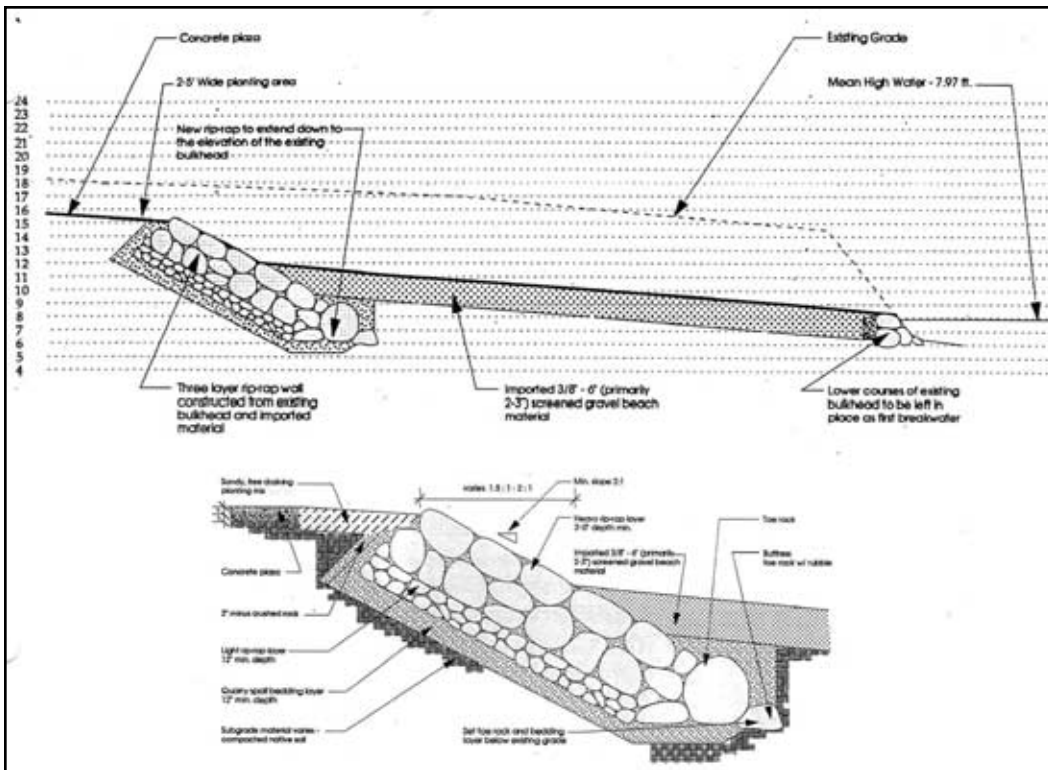
### Project Design Profiles



Typical Profile: North End.



Typical Profile: South End.



Rip-Rap Revetment: Three layer design with first breakwater

## Cormorant Cove



Figure 1. View of Cormorant Cove site from the beach at low tide. Much of the rock bulkhead will be removed when the project is constructed.



Figure 2. View to the north from 3701 Beach Drive, showing hardened shoreline and intrusion of bulkhead onto upper beach.





## Dick residence

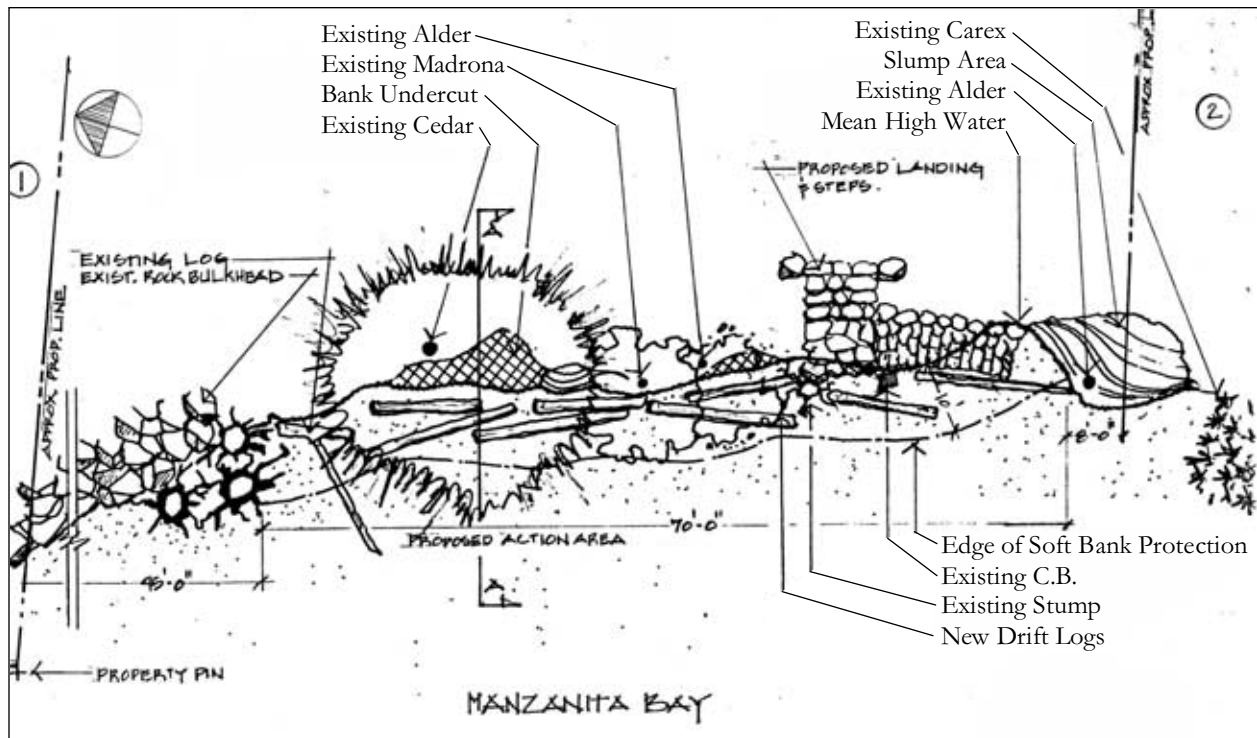
**Address:** Bergman Rd., Bainbridge Island  
**Region:** NW side of Bainbridge Island, Manzanita Bay  
**Designer:** Bart Berg Landscape  
**Contractor:** Bart Berg Landscape  
**Owner:** Lee & Elizabeth Dick  
**Shoreline Type:** 14' Bluff  
**Project Type:** Fill undercut and add geotextile, spall, logs and plants.  
**Wave Energy:** Very Low  
**Tides:** MHHW: +11.4  
 Extreme High: +15.5  
 Extreme Low: -4.5  
**Cost:** N/A  
**Date Completed:** Summer 1998



Location: Dick Res. in Manzanita Bay

### Site History / Description

The Dick site runs for a total of 123' along the shore of Little Manzanita Bay, on the northwest side of



Dick Residence: Bird's Eye View of the Site.

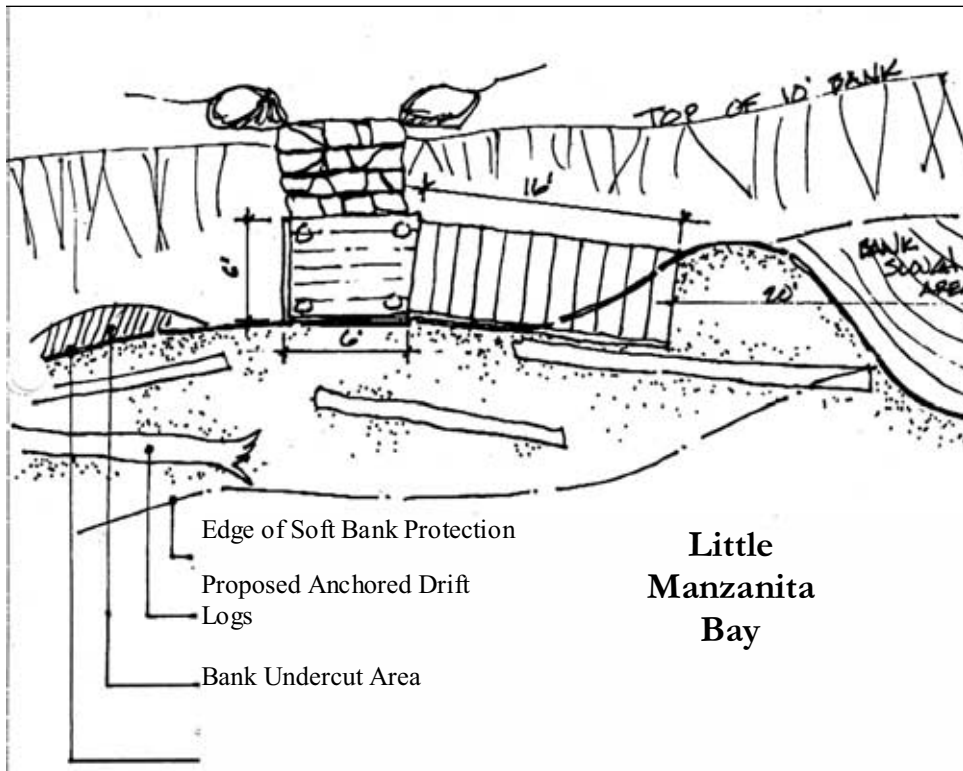
Bainbridge Island. The steep, 14-foot bank is topped by several existing trees (cedar, madrone, and alder). An existing riprap revetment, placed as an emergency action for bank failure on the adjacent property several years earlier, lies to the north.

Prior to this project a short segment of the bank spanning the south property line was slumping and at least two sections were being undercut by wave action. The property owner applied for a rock bulkhead, but was persuaded by the Department of Fish and Wildlife to select a more environmentally sound approach.

### Project Description

The project was constructed in several stages. The undercut areas were protected with geotextile and hand-packed 4-6 inch basalt quarry spalls. Bank protection was accomplished by burying and anchoring logs into the beach. The beach and spalls were then capped with sand and gravel that slightly increased beach slope and elevation. The logs helped retain the beach sediment. American dune grass (*Elymus*) was planted to help stabilize the upper portion of the beach and the toe of the bank.

Where the bank had slumped onto the beach, existing vegetation was retained and the face of the



Dick Residence: Project Proposal

colluvium was lined with quarry spall and gravel to dissipate wave energy and reduce erosion. Finally, a rock stair was added to provide the homeowner access to the beach.

## Dick Residence

The project involved the placement of 70 cubic yards of mixed sand and gravel over approximately 70 lineal feet of shoreline.

### **Monitoring**

There is no monitoring plan in place.

### **Success**

The beach is quite natural in appearance and is protected sufficiently for the level of wave energy present. The WDFW habitat biologist for the site was extremely pleased with the final result.

### **Alternatives Considered**

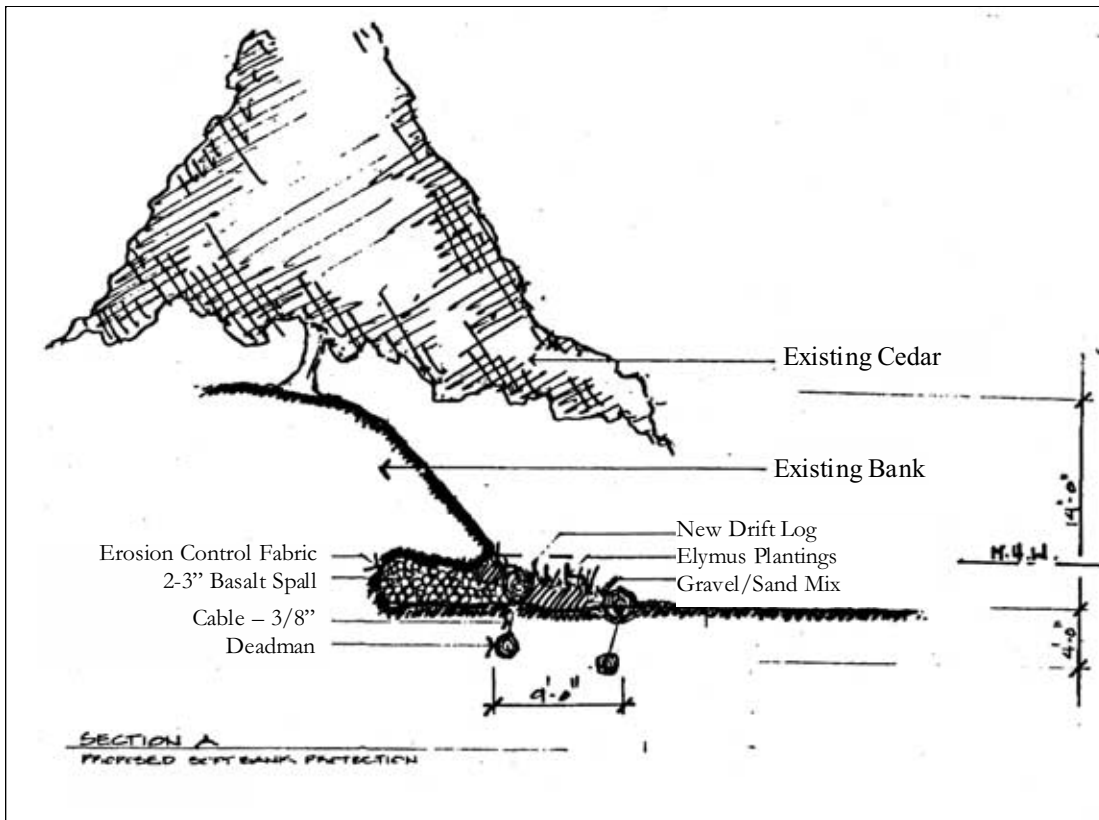
N/A

### **Contacts**

Washington Department of Fish and Wildlife: J. Brennan (now with King County DNR)

Bart Berg Landscaping: B. Berg

### Project Design Profile



Dick Residence: Project Profile

## Dick Residence



Figure 1. The Dick residence is sited well back from the water and trees north of the house were left. The riprap bulkhead on the north end of the site was installed by neighbors as an emergency measure prior to construction of the Dick's home (Photo: Jim Brennan).



Figure 2. The toe of the bank had been undercut prior to construction. Quarry spall was placed in undercut area and logs anchored into the beach. Anchor cables are just visible.



Figure 3. View southeast along beach shows anchored logs and added gravel. Compare to Figure 4 below of property to the north.



Figure 4. Riprap bulkhead/revetment located on northern end of Dick property and neighboring property.

## ***Driftwood Beach, Blakely Island***

---

Address: **Driftwood Beach, NE Blakely Island, WA**

Region: **West Shore of Rosario Strait,  
San Juan Islands**

Designer: **Coastal Geologic Services, Inc., Bellingham**

Contractor: **JTC, Inc., Seattle**

Owners: **Blakely Island Maintenance Commission**

Shoreline Type: **Historic Barrier Berm**

Project Type: **Beach Nourishment**

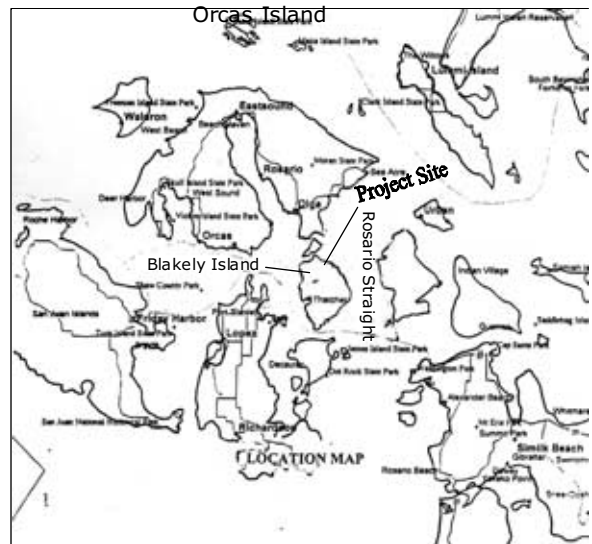
Wave Energy: **Medium**

Tides: **MHHW: +8.2  
Extreme High: +10.5-11.0  
Extreme Low: -4.0**

Cost: **\$90,000 + volunteer contributions.  
(\$100/ft)**

Date Completed: **March 1999**

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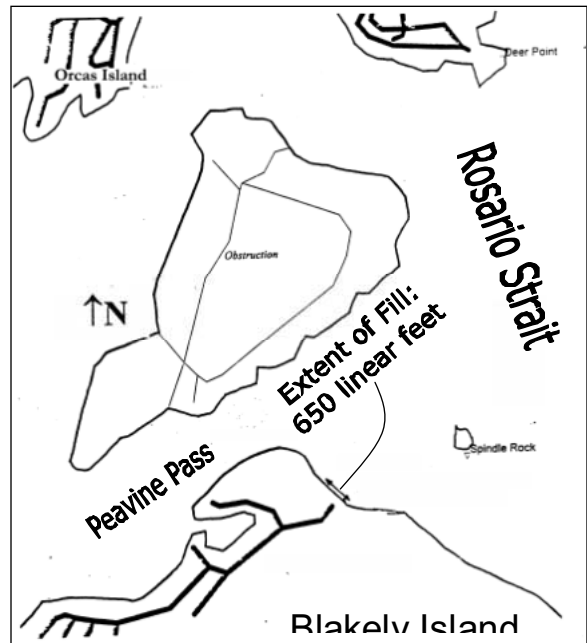
Location: Blakely Island in San Juan Islands

### **Site History / Description**

Driftwood Beach is located at the north end of Blakely Island in San Juan County. The beach is 900 feet in length. Six hundred feet are owned by BIMC while the remaining 300 are divided between two individual owners.

The site was historically a gravel barrier berm that fronted a salt-water lagoon. The lagoon has been filled and is now a grass field. The beach was originally mined for road fill between 30 and 35 years ago. The beach was partially filled ten to twenty years ago with stumps and debris.

The wave energy at the site can be described as medium to high for Puget Sound. This is especially true in the winter months when severe northeast and southeast storm conditions are common.

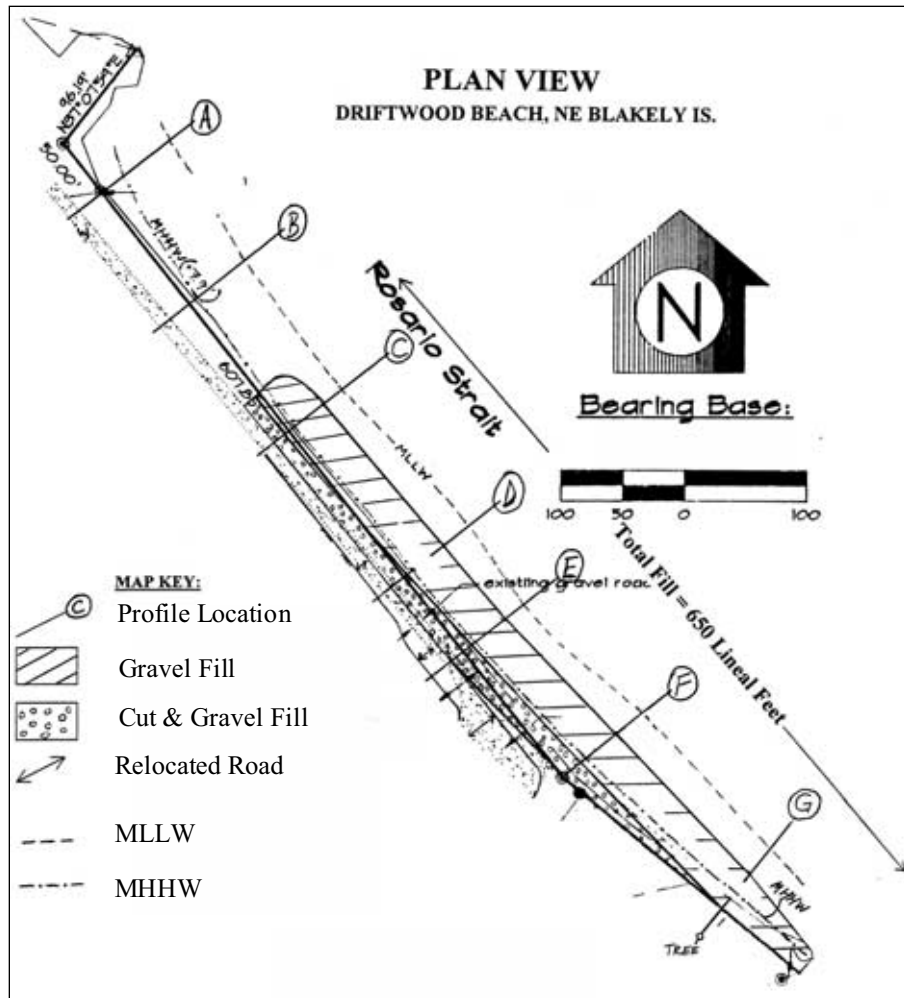


Location: Driftwood Beach in Blakely Is.

## Alternative Bank Protection Methods on Puget Sound

The Blakely Island Maintenance Commission owns a narrow strip of land (25-40' wide) that runs the length of the site. This strip is located between privately held uplands and tidelands. This narrow piece of land provides the only public access to the site. The BIMC was concerned that they could lose this site as a valuable recreation area if the beach was allowed to further erode and access was lost.

The beach was subject to significant erosion during the winter of 1996-1997. Most of the backshore was scarped which reduced the width of the beach access road. Before the nourishment the majority of beach sediment was cobble (1.25" – 10.0") and pebble (1/8" – 1.25").



Driftwood Beach Plan / Profile Locations

### Project Description

Driftwood Beach was completed using nourishment to rebuild the beach and vegetation and woody debris to secure and protect it. The project was intended to restore the degraded beach in terms of form and function to something approximating its predevelopment state.



## Driftwood Beach, Blakely Island

Approximately 210 cubic yards of gravelly, silty sand was cut from the waterward side of the existing roadway and 1600 cubic yards of gravel were brought to the site by barge. These were added to the beach and worked to create a berm and backshore area between 10 and 15 feet wide. The backshore was then used to hold logs which in turn provided protection for vegetation (*Salicornia* and other salt tolerant species). In addition the uplands were planted extensively with additional native species including Douglas fir, shore pine, American dune grass, and ocean spray by community volunteers.

### **Monitoring**

Both the profile and the sediments of the beach are being monitored yearly. This will occur for five years in the month of June or July. The profile is measured along seven predetermined transects (see site plan). Sediments are sampled at three elevations along transects B, D, & F (9 samples). This will:

- Provide information about changes in beach volume and sediment transport.
- Supply precise information about sediment size and composition along the site.

Coastal Geologic Services submitted the initial monitoring report to agencies in March, 2000, based on surveys conducted in May and August of 1999. [*Johannessen, J., 2000, 1999 Beach Monitoring Report for Protective Berm-Beach, Driftwood Beach, Blakely Island Maintenance Commission, NE Blakely Island, San Juan County, WA.*]

### **Success**

The project looks good. The construction had been completed for almost six month at the time photos for this report were taken. However, the site has not passed through its first winter. The cobble was not feathered into the beach at the ends as well as the designer had hoped and the site in general still needs to be reworked. Winter storms should provide the energy to do both of these. Revegetation was carried out promptly and with great diligence. The level of community involvement has been exceptional.

### **Alternatives Considered**

In addition to nourishment, a rip rap revetment and no action were considered. There were problems with both of these alternatives.

In this location a rip rap revetment, even if constructed of five foot rock, might not be stable. The beach is pure sand and gravel and the rock would have been undermined. Failure would be likely in this environment. A rip rap revetment would also increase erosion at the site. The hard surfaces would increase turbulence at the base of the structure as well as increase reflected wave energy. Both of these effects would combine to increase erosion and undermine the structure.

## Alternative Bank Protection Methods on Puget Sound

No action would have allowed the continued, gradual erosion of the site. In other words, the problem would have continued to worsen until something was done or the community beach access was lost.

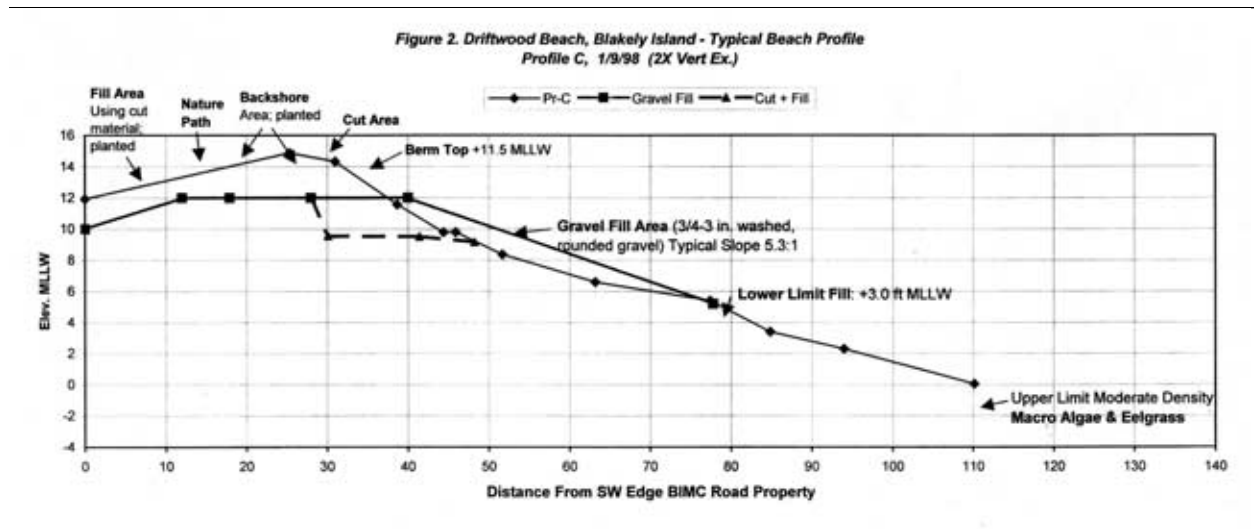
Nourishment will increase the beach's capacity to absorb wave energy. It will create a "dynamic revetment" that can shape itself to best dissipate incoming waves.

### **Contacts**

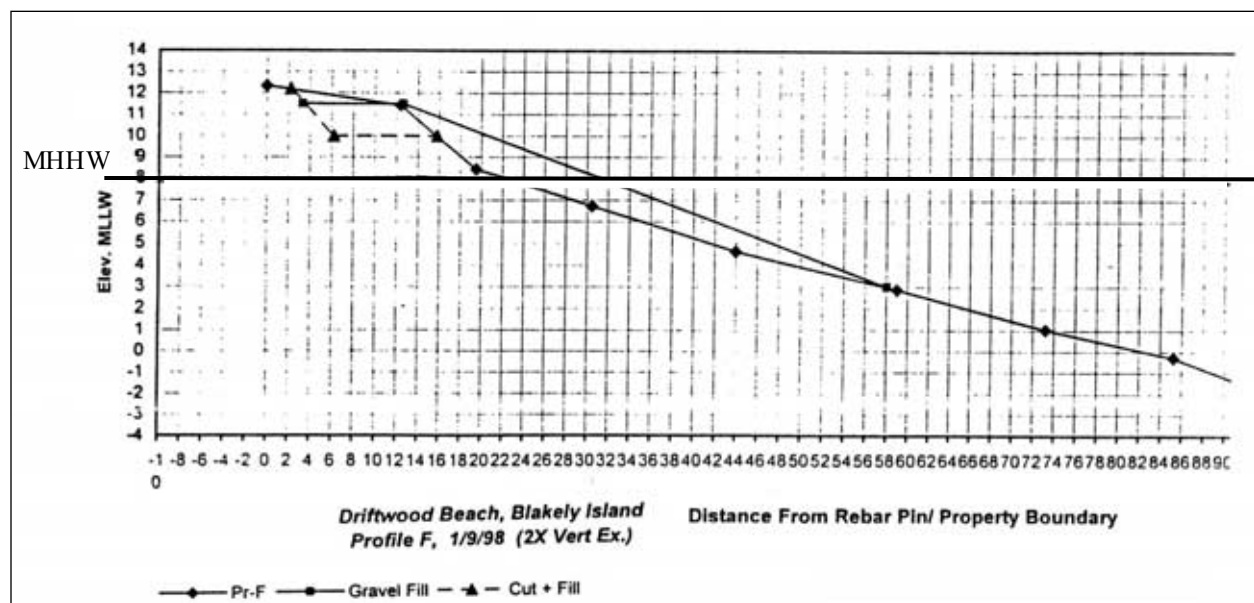
Department of Fish and Wildlife:	B. Williams
Department of Ecology:	H. Shipman
United States Army Corp of Engineers:	C. Quate
Blakely Island Maintenance Commission:	L. Douglas
Coastal Geologic Services, Inc.	J. Johannessen

Driftwood Beach, Blakely Island

Project Design Profiles: Transects C & F



Profile for Transect C



Profile for Transect F



Figure 1. Aerial view of Driftwood Beach. Upland revegetation and restoration extends entire length of beach, whereas beach nourishment was limited to area indicated by arrows. Lawn area on right side of photo was marsh prior to filling several decades ago.



Figure 2. Close up view of berm and backshore. Note coarse gravel berm and drift logs. Also, a sandy berm has been created farther landward and planted with American Beach Grass.

Driftwood Beach, Blakely Island



Figure 3. View north of completed gravel beach.



Figure 4. View north showing gravel berm, drift logs, and vegetated backshore. Road has been relocated landward.



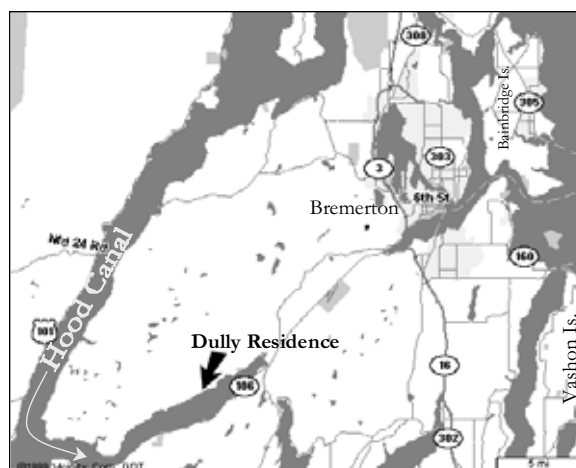
Figure 5. View north of project area prior to construction, showing erosional scarp in old fill, damage to road, and riprap (*Photo: provided by Jim Johannessen, Coastal Geologic Services, and Blakely Island Maintenance Commission*).

## ***Dully Residence***

---

Address: **NE Landon Road, Belfair, WA**  
Region: **Southern end of the Hood Canal**  
Designer: **Michael Dully**  
Contractor: **Butch's Bulldozing**  
Owner: **M. Dully**  
Shoreline Type: **Beach**  
Project Type: **Large Woody Debris  
Buried Rock Revetment**  
Wave Energy: **Low**  
Tides: **MHHW: +11.4  
Extreme High: +15.0  
Extreme Low: -4.5**  
Cost: **\$15,500**  
Date Completed: **September 1998**

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Location: Dully Residence in Puget Sound

### **Site History / Description**

The Dully residence is located at the southern end of the Hood Canal approximately 20 miles south southeast of Bremerton, WA. It is on the northern shore of the canal and the prevailing winds and waves are from the southwest.

The property's 137' of marine shoreline are situated on a no-bank shoreline with two vertical concrete bulkheads on adjacent preproperties. These structures were constructed between 1989 and 1990 while the homeowner was living on the East

Coast. By 1994, when the Dullys returned to Washington, between 10 and 15 feet of beach had eroded. The loss was most dramatic on the west end of the sight where reflected wave energy from the neighboring bulkhead is severe.

The site had once been protected by a log bulkhead that had long since failed and rotted away. The landowner was concerned about losing additional beach and originally wanted to install a bulkhead, but was convinced by WDFW personnel that an alternative approach could serve the same function and



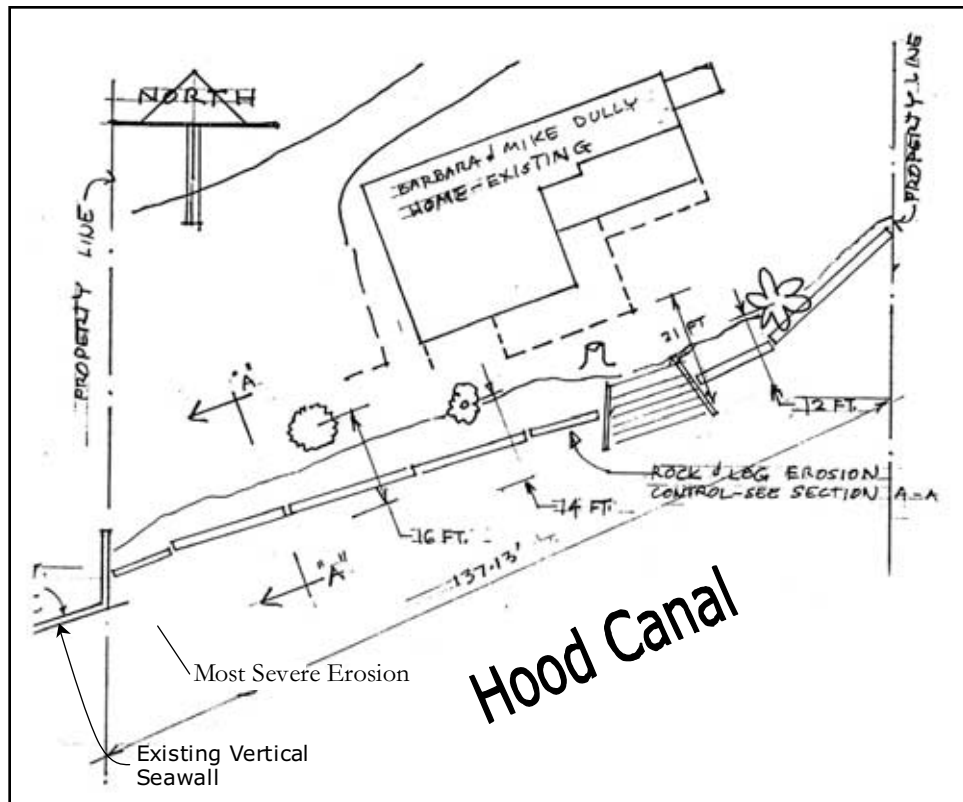
Location: Dully Residence on Hood Canal

reduce impacts to the beach. The landowner was very enthusiastic about preserving the beach and developed the design himself.

### Project Description

The project was composed of three basic steps. 1) A wide trench was cut into the beach for placement of a buried rock revetment; 2) logs were anchored; and 3) the backshore was replanted with native beach grasses.

The rock revetment is about 10' wide and was cut into the beach. It begins where the beach surface is at +11.8' and ends at +14'. The bottom of the revetment is approximately level at the +10' elevation. At +11.8' the revetment is cut in two feet into the beach and by +14' the revetment is 4' beneath the sand. After placement the rock was covered with six inches of gravel and the beach was brought back up to its original grade. This structure runs for almost the entire width of the property.



Dully Residence: Site Plan

Logs 20' long and 18" in diameter were then run down the middle of the revetment. They were spaced several feet apart and were anchored into the beach with Manta Ray type earth anchors. These logs were partially keyed into the beach as well.

Finally the space between the logs and the top of the bank was replanted with native beach grass.

## **Monitoring**

No official monitoring is being performed at the site. There still seems to be a small erosion problem at the west end where problems were the most extreme prior to the project. However, during the first winter (1998-'99) a significant amount of gravel was deposited on the beach and was retained above the anchored logs. One year after installation, when the photos for this report were taken, the logs were buried across most of the site rising out of the sand at either end of the site.

## **Success**

The project has been successful to date.

## **Alternatives Considered**

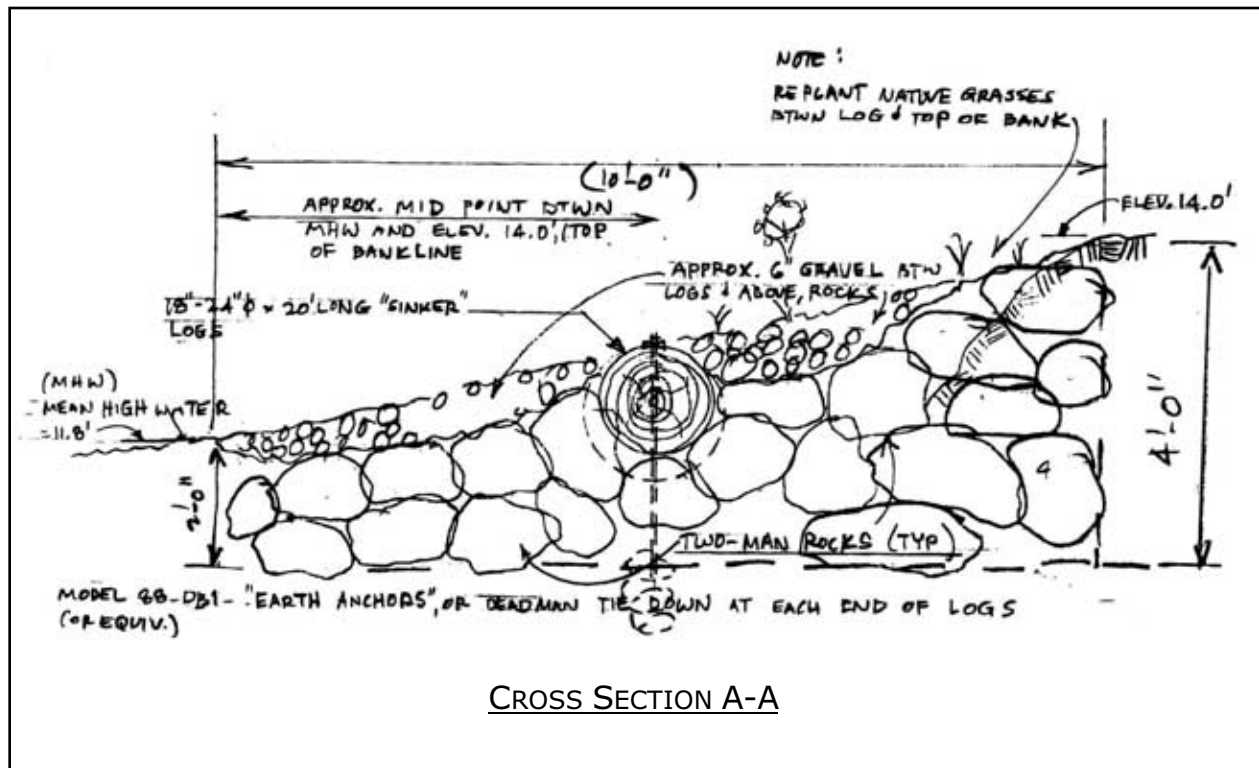
Initially, the landowner was interested in installing a bulkhead similar to the ones on the adjacent properties, but the WDFW would have required that the bulkhead be installed further landward (i.e. at or landward of Ordinary High Water). This requirement, in conjunction with the loss of natural beach conditions, discouraged the Dully's from pursuing this alternative. A mostly buried rock wall was initially proposed. Through discussions with WDFW, the plans underwent several transformations in the volume of construction materials and position of the logs (i.e. from almost perpendicular to the bank to parallel to the bank). In the end, it was determined that a single row of logs, installed parallel to the bank, would be sufficient to achieve the desired protection and beach functions.

## **Contacts**

Department of Fish and Wildlife:	J. Brennan (now with King County DNR)
	N. Rickard
Mason Co. Dept. of Community Development:	A. Borden
King Co. DNR:	J. Brennan
Designer:	M. Dully



Project Design Profile



Dully Residence



Figure 1. West end of site prior to construction. Note significant scarping and the amount of the neighboring bulkhead's wing wall that is exposed.



Figure 2. View of west end of site during construction. Large amount of rock provides an emergency bottom in the event that the beach drops (*Photo: Jim Brennan*).



Figure 3. View of east end of site following completion of project. The logs rise out of beach and curve back to meet neighbor's bulkhead.



Figure 4. View of site from the west. Logs have been covered by accretion along much of beach. The logs reemerge at the far (west) end where a pile of rock reduces the impacts of the neighboring bulkhead.

## ***Floral Point, SUBASE Bangor***

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Address: **Bangor, WA**

Region: **West Shore of the Hood Canal**

Designer: **Foster Wheeler Environmental Corp.**

Contractor: **Foster Wheeler Environmental Corp.**

Owners: **US NAVY**

Shoreline Type: **Former Sand Spit & Lagoon**

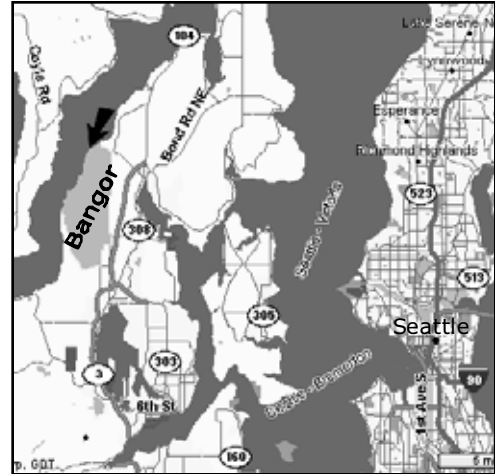
Project Type: **Beach Nourishment**

Wave Energy: **Medium**

Tides: **MHHW: +11.13**  
**Extreme High: +14.0**  
**Extreme Low: -4.5**

Cost: **N/A**

Date Completed: **11/97**

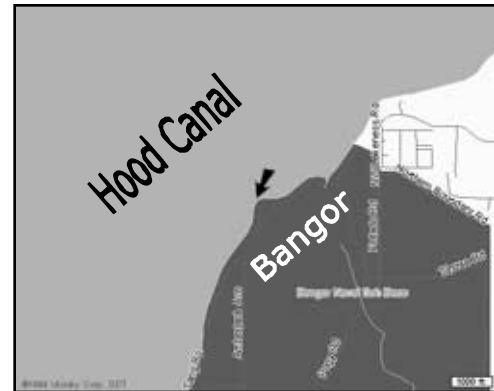


Location: SUBASE Bangor in Puget Sound

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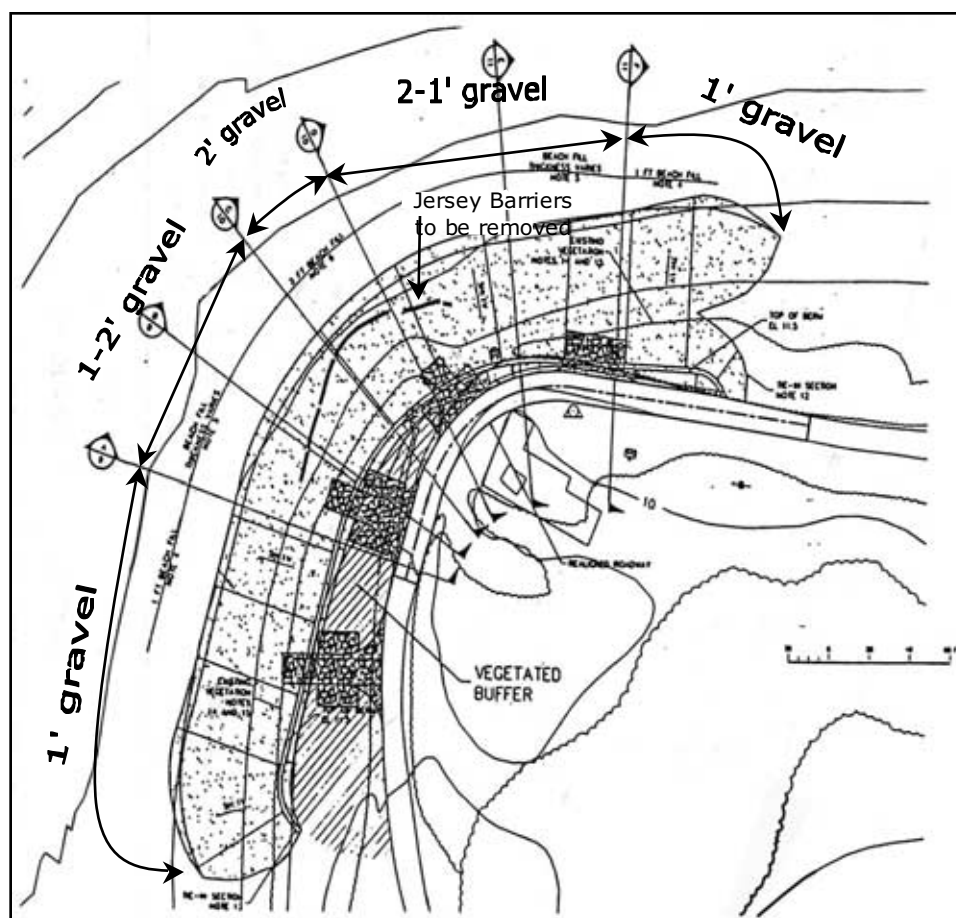
### **Site History / Description**

Floral Point is a 4.7 acre site on the eastern shore of Hood Canal within the Bangor Submarine Base. There are 500 feet of marine shoreline and 2 wetland areas on site. Historically it was a sand spit with a lagoon behind it. The lagoon was filled between 1950 and 1968. During this period the site was used as a pyrotechnic testing site. From 1967 through 1972 the site was used as a disposal area for solid waste from the Naval Undersea Warfare Engineering Station. Since 1972 the site has been used for dumping construction refuse.



Location: Floral Point at Bangor

In 1990 Floral Point was identified as a CERCLA site and put on the National Priority List. The authority of the Superfund legislation was the driving force for the site cleanup. It was determined that the level of contamination present required only a cap to prevent human contact with the toxic material. Concerns about erosion releasing contaminants from the fill or damaging the cap also needed to be addressed. The site is subject to significant wind-generated wave action.



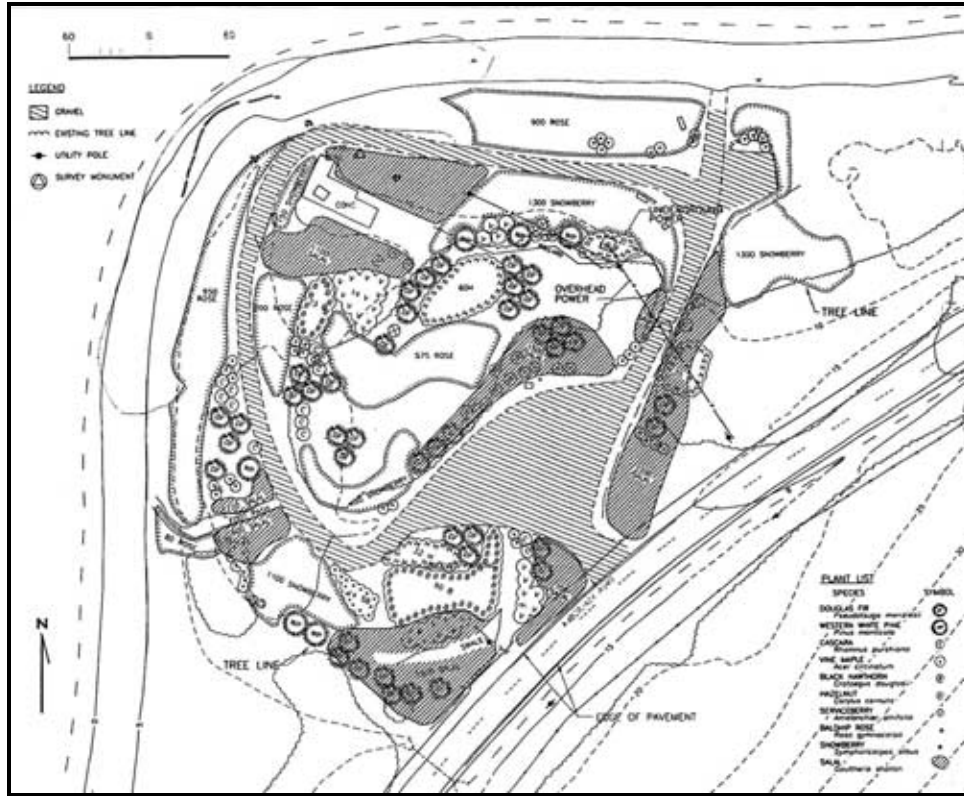
Site Plan: Floral Point, Bangor Submarine Base

## Project Description

The Floral Point project started with beach stabilization (i.e. nourishment) and was completed with upland construction and restoration. Following the removal of jersey barriers, which had been placed as a temporary erosion protection measure, 3310 tons of gravel/sand blend were placed on the beach. In some areas, the fill was between one and two feet thick. This was graded to a slope that ranged between 7H:1V and 5H:1V and a thin layer of coarse sand (65 tons) was layered on top of the base material. The purpose of the sand and gravel beach nourishment (Foster Wheeler, 1999) was to dissipate wave energy and to act as a soft barrier to upland erosion. The nourishment was planned so as to provide suitable spawning habitat for surf smelt and sand lance.

The purpose of the upland fill was to cap the contaminated soils to prevent any possible future contact with the hazardous material and create a marsh habitat. A one-foot thick cap was built over the former landfill. It consisted of a 2832 yd<sup>3</sup> of topsoil mix that was compacted in 4-inch layers. When the cap was in place, 200 yards of mulch were spread on the surface and 5100 plants were used to vegetate the berm and build a wetland area.

Floral Point, SUBASE Bangor



Floral Point: Planting Diagram

**Monitoring**

During work on the berm, 10 survey monuments were installed. These are used to do profile monitoring at the site. The monitoring schedule is as follows:

	March	April	May	June	July	August	September	October
1998		✓	✓		✓			✓
1999	✓	✓	✓	✓				✓
2000	✓							✓
2001	✓							✓
2002	✓							✓

In addition to these scheduled examinations there will be monitoring after major storm events as well. After the fifth year the monitoring will switch to visual inspection if the beach has been stable during the first five.

**Success**

## Alternative Bank Protection Methods on Puget Sound

Initial reports suggest some sediment has been lost from the south end of the beach, as littoral drift has moved toward the point or the beach on the north side. Some readjustment of the beach profile was expected. Renourishment with gravel can occur if monitoring indicates significant erosion in coming years.

There is evidence that surf smelt and sand lance are both using the new beach for spawning.

### **Alternatives Considered**

N/A

### **Contact**

Department of Fish and Wildlife:	J. Boettner (now with WA State DNR)
	J. Brennan (now with King County DNR)
Department of Ecology:	M. Abbett
Agua Tierra Environmental Consulting, Inc.	C. Fromuth
SUBASE Bangor	P. Kelly

### **References**

Foster Wheeler Environmental Corp. 1999. Remedial Action Report – Floral Point, Site B, Operable Unit 7, Naval Submarine Base Bangor, WA. Contract No. N44255-95-D-6030.



Figure 1. Southwest facing portion of site. Southern limit of project area is marked with arrow.



Figure 2. View south from western point. Photo provides good profile perspective of the work. Note that vegetation has established on the bench and a vegetated berm has begun to form on the upper beach.





Figure 3. Wetland reconstruction on cap. This area was relatively dry when photos were taken (July), but the area in the center is wet and marshy earlier in the year.



Figure 4. Slope and backshore with road. The position of the road affected the overall design of the project and the grade chosen for the upper beach.

## ***Indian Island***

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Address: **Naval Ordinance Center Pacific  
Division, Detachment Port Hadlock,  
Port Hadlock**

Region: **North East Jefferson County, southeast  
side of Port Townsend Bay**

Designer: **Agua Tierra Environmental  
Consulting, subcontractor to Ebasco  
Services Inc.**

Contractor: **Ebasco Services**

Owner: **NAVY**

Shoreline Type: **Former Tidal Lagoon**

Project Type: **Rock Revetment, Large  
Woody Debris,  
Bioengineering**

Wave Energy: **High/Low/Very Low**

Tides: **MHHW: 8.45  
Extreme High: +11.77**

Cost: **N/A**

Date Completed: **June 1997**

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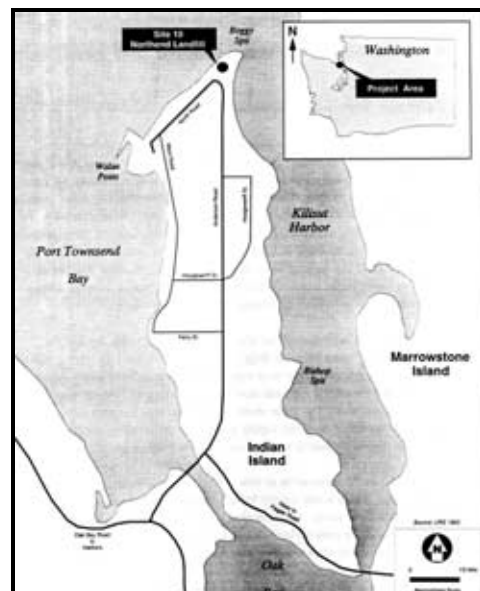


### **Site History / Description**

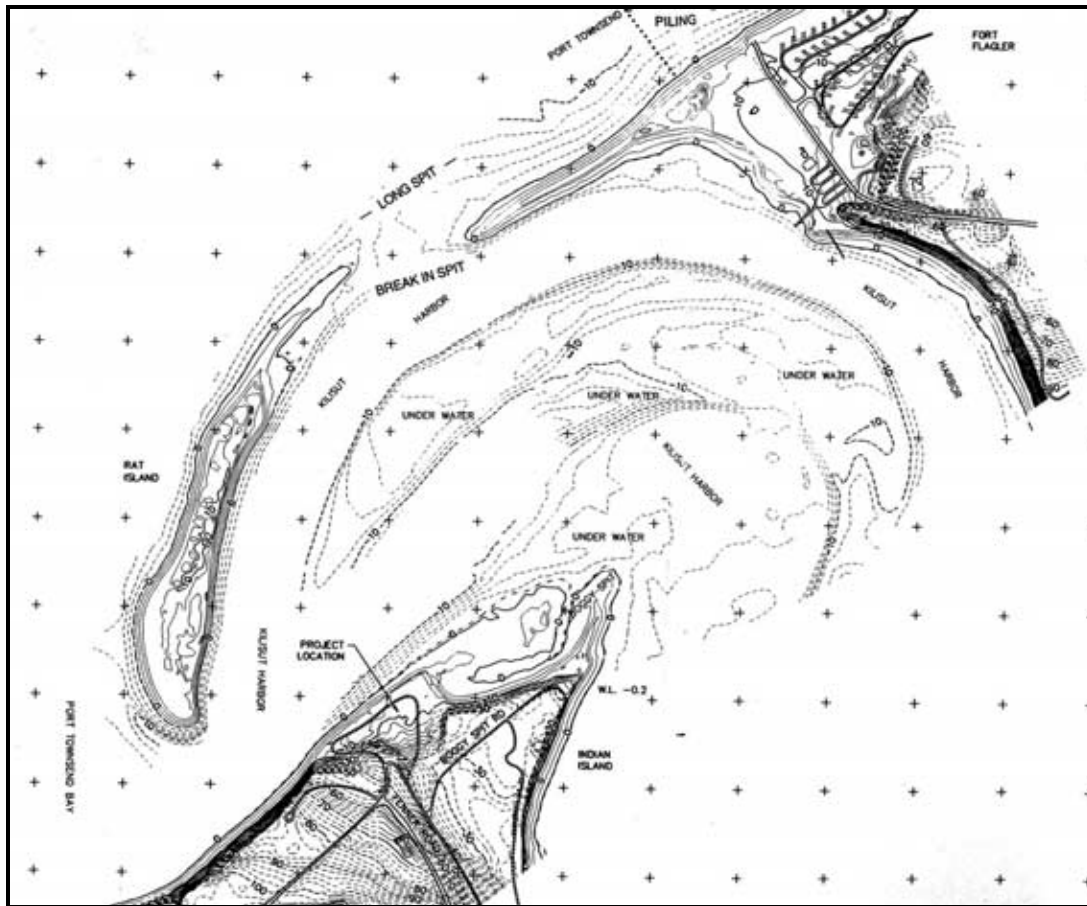
The Site 10 Northend Landfill site is located at the north end of Indian Island (approximately 3 miles south southeast of Port Townsend across Port Townsend Bay).

Historically the site was a tidal lagoon but since has been used as a landfill by the United States Navy. From the 1940's through the 1970's solid wastes, petroleum and paint wastes and ash and slag from an adjacent incinerator were disposed of at Site 10. In 1994 the location was identified as a Comprehensive Environmental Response Compensation & Liability Act (CERCLA) site. Remedial actions included capping 3.7 acres of contaminated

sediments and constructing shore protection along 900' of shoreline to prevent erosion from exposing toxic substances and debris.



Site 10 is bound by Port Townsend Bay to the Northwest and by a tidal lagoon to the Northeast. The site can be divided into three distinct zones of wave energy. These zones are a result of the complexity of the surrounding geomorphology. While Rat Island and Sandy Spit shelter the site from heavy waves originating from the North or Northwest, the gap between them allows a segment of each wave through to impact the site. Once through the gap, the complex bottom topography refracts the waves creating High, Low and Very Low energy zones on the Northend Landfill.



Map showing location of project at north tip of Indian Island, at mouth of Kilisut Harbor.

### **Project Description**

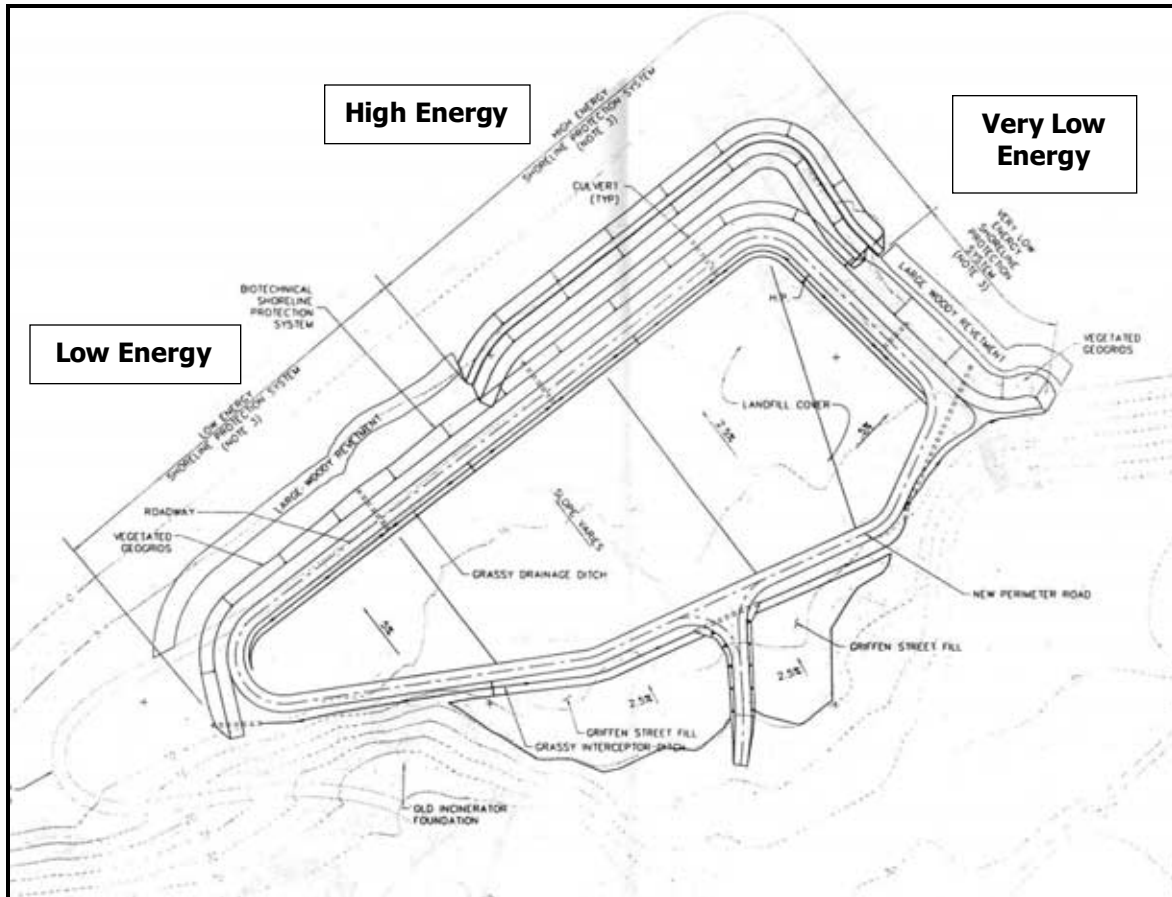
The erosion protection at the North End Landfill is a combination of rip rap, large woody debris placement, and bioengineering. The exact design varies with the level of wave energy in each segment of the site.

High Energy: This segment begins with an excavated rock toe over-laid with a rock revetment.

Following the rock is a cobble bench that merges into a 2H:1V vegetated geogrid. The geogrid is a series

## Indian Island

of geogrid lifts laid on top of one another to create a stepped berm. The lifts are geotextile wraps (coir and Tensar® geogrid) filled with compacted sediment. Both the geogrid and the top of the bank were planted with appropriate species. (see profiles)



Site plan, showing areas of different wave exposure.

**Low Energy:** In this section of beach large woody debris was substituted for rock. This follows the concept of softer protection for lower energy sites. The woody debris is secured to the beach with derivable anchors (no excavation necessary).

**Very Low Energy:** The final section, adjacent to the tidal lagoon, is very similar to the low energy solution. It differs in that it uses a larger quarry spall toe and has reduced quantities of woody debris.

### Monitoring

The profile of the beach is being monitored to determine where accretion and erosion are occurring along the site. This began in October of 1997, is being performed along eleven transects and occurs in the spring, the fall and potentially after severe storm events.

**Success**

The project has been successful to date.

**Alternatives Considered**

The original proposal for this project was a modified riprap revetment. The denial of this proposal by the WDFW prompted the Navy and consultants to redesign the project, using both rock and bioengineering elements.

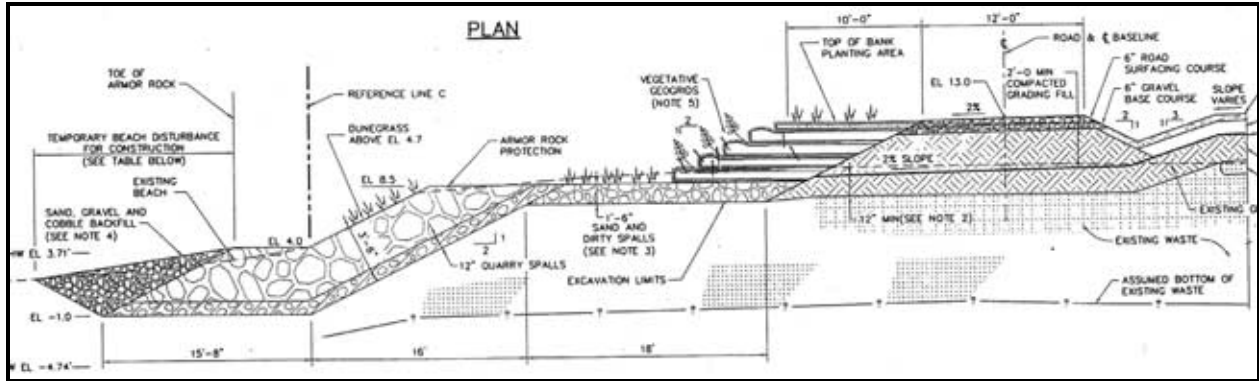
**Contacts**

Department of Fish and Wildlife:	J. Boettner (now with WA State DNR)
Department of Ecology:	M. Abbett
United States Navy:	B. Kalina
Agua Tierra Environmental Consulting, Inc.:	C. Fromuth

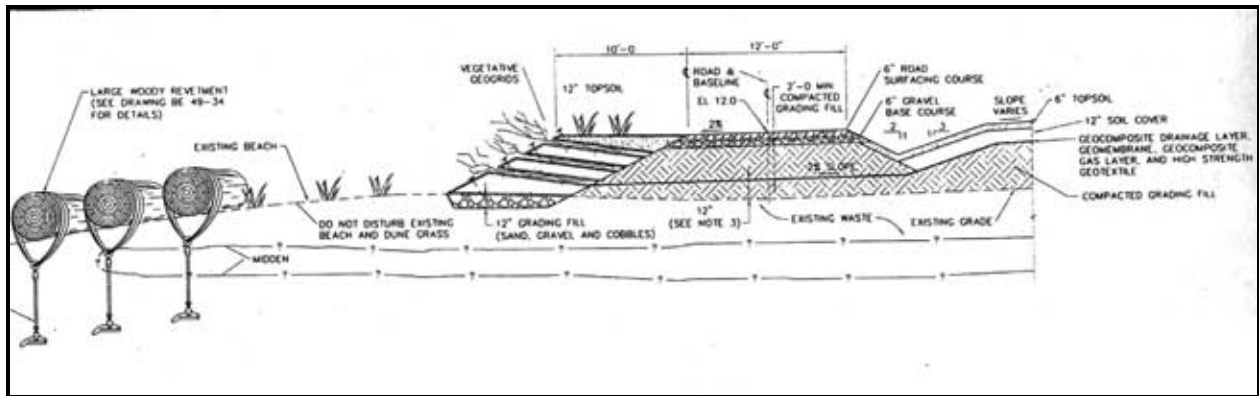
**References**

Ebasco Environmental. 1995. Site Work Plan – Construction of Landfill Cap and Shoreline Protection System, Site 10 Northend Landfill, Naval Ordnance Center Pacific Division Detachment Port Hadlock, WA. Contract No. N44255-93-D-4050.

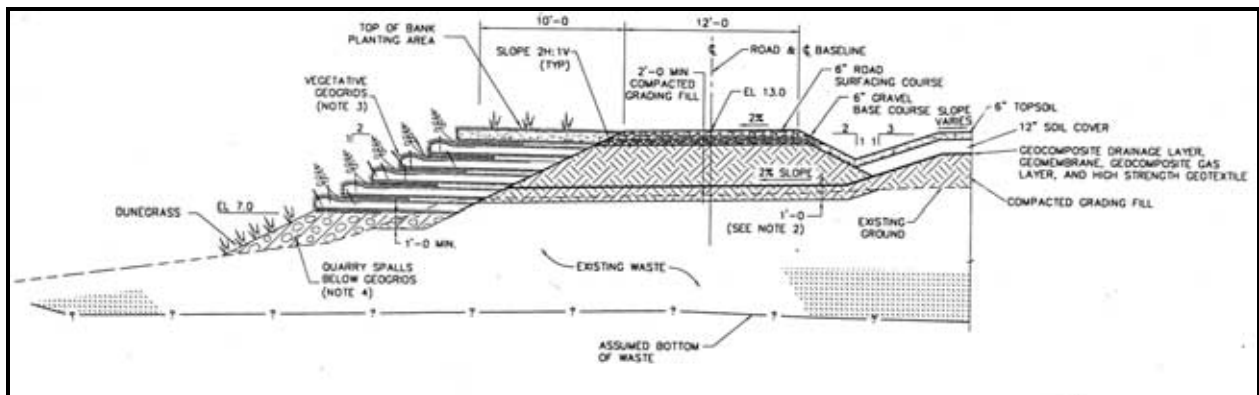
**Project Design Profiles: High Low and Very Low Energy Zones**



High energy zone



Low Energy Zone



Very Low Energy Zone

Alternative Bank Protection Methods on Puget Sound



Photo 1. Low energy zone. Coarse woody debris anchored to the beach, with vegetation planted on berm between upper logs.



Photo 2. View southwest from northern end of project. A rock revetment is used in the high energy zone.

Indian Island



Photo 3. Erosional scarp in bank prior to construction, exposing waste from former landfill (*Photo: courtesy of Bill Kalina, Navy*).



Photo 4. Geogrid lifts are obvious immediately following construction. Geotextile fabric completely covers lifts, but was quickly obscured by vegetation (*Photo: courtesy of Bill Kalina, Navy*).





Figure 5. Natural fiber geotextile. Coir fabric is exposed on the face of a geogrid lift.

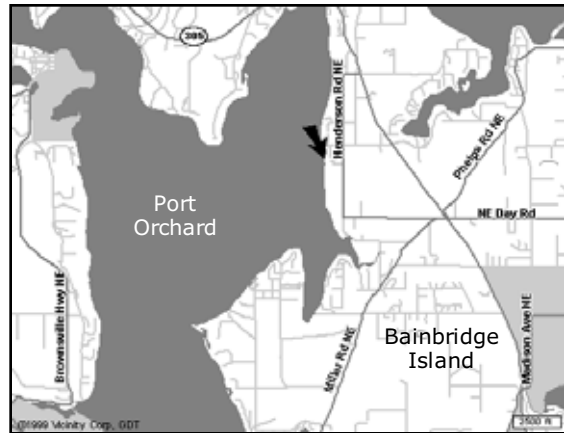


Figure 6. Tensar type geotextile. Plastic grid is used for long-term structural support.

## Odermat Residence

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Address: **Manzanita Rd.**  
Region: **Agate Pass, NW Bainbridge Is.**  
Designer: **Shannon & Wilson**  
Contractor: **Waterfront Construction**  
Owner: **M. Odermat**  
Shoreline Type: **Beach backed by high bluff**  
Wave Energy: **Low**  
Tides: **MHHW: +11.40**  
**Extreme High: +15.5**  
**Extreme Low: -4.5**  
Cost: **N/A**  
Date Completed: **1998**



Location: Odermat Residence on Bainbridge Island

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### Site History / Description

The Odermat residence is located along 375 feet of shoreline on the northwest shore of Bainbridge Island. The house is situated well back from a steep 40-foot bluff. The toe of the bluff along the northern two thirds of the site is buried by the colluvium from previous slides. The southern third of the shoreline had been previously armored with a rock bulkhead and sacrete (concrete-filled sandbags) wall.

The original path to the beach was cut between 30 and 40 years ago. The excavated material was placed on the beach in front of the bluff as fill and protected with the sacrete bulkhead. Part of this bulkhead (below where the new dock now stands) jutted out onto the beach forming a small promontory.

The property has poor drainage and the bluff contained abundant seeps. The shoreline along the bluff is a documented surf smelt spawning beach.

### Project Description

The Odermat project consisted of several phases: removal of the promontory; toe protection along the waterward edge of the colluvium; placement of imbedded rocks in the beach and beach nourishment; and construction of a rock bulkhead to support the sacrete wall and the portion of the bank where the promontory was cut back.

Prior to this project, the colluvium in front of the bluff was subject to erosion by wave action at the highest tides and had undercut in two areas. The north section of this project was designed to address this

problem. The undercut areas were packed with 8-inch minus quarry spalls and a 45 degree revetment of spalls was placed along the colluvium toe the entire length of the northern section. Quarry rock, approximately 24 inches in diameter, was excavated into the beach approximately 20 feet waterward of the colluvium such that no more than 8 inches of rock was exposed above beach grade. A 1-foot zone of 3-inch minus gravel was placed landward of the buried rock to provide drainage and help prevent winnowing of finer sediments between the larger rock voids. The spall revetment and area between the buried rock and colluvium were then capped with 3/8ths inch pea gravel to both nourish the beach and provide spawning substrate for surf smelt. Overall, the procedure changed the upper beach grade from approximately 11 percent to approximately 5 percent, creating a "berm" waterward of the colluvium.

The Department of Fish and Wildlife required the removal of the promontory and beach nourishment to compensate as partial mitigation for the negative impacts of shoreline armoring and other construction impacts (i.e. pier installation). Initially, the new rock bulkhead was to be placed in front of the old sacrete wall and colluvium. Following removal of the promontory (bulkhead and fill), a new rock bulkhead was constructed against the newly established bankline and sacrete wall. During construction, the sacrete wall collapsed and it was discovered that a large void existed landward of the wall; probably a result of upland drainage and wave induced erosion. The wall was removed and the rock bulkhead was constructed further back than originally thought possible. Three-foot base rock was keyed into the beach and the upper courses of 2-foot diameter rock were keyed into the bank to create an approximately 6-foot high wall.

### **Monitoring**

No formal monitoring exists for this project. However, the site has been visually inspected and photographed on several occasions. The project has passed through two winters and is in good condition. After the first winter, there appears to be accretion landward of the buried rocks, with some materials moving from south to north along the shoreline and onto the adjacent property. Seasonal erosion of finer sediments along the face of the buried rocks has also been noted, resulting in greater exposure of the rocks.

### **Success**

The project has so far limited erosion of the colluvium and resulted in a relatively stable beach. Surf smelt eggs were discovered at the site several months after its installation.

**Alternatives Considered**

The original project design called for a rock bulkhead along the entire length of the shoreline. Washington Department of Fish and Wildlife required mitigation and recommended use of an alternative approach. The final plan was a negotiated compromise between the consulting engineer, landowner, and WDFW Habitat Biologist.

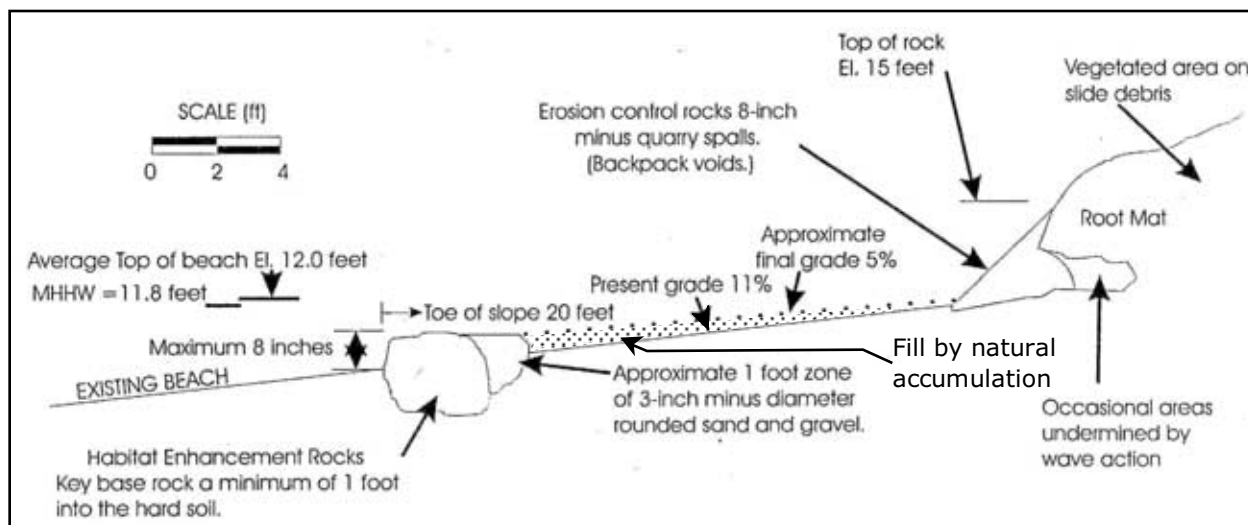
**Contacts**

Washington State Dept. of Fish & Wildlife      J. Brennan (now with King County DNR)

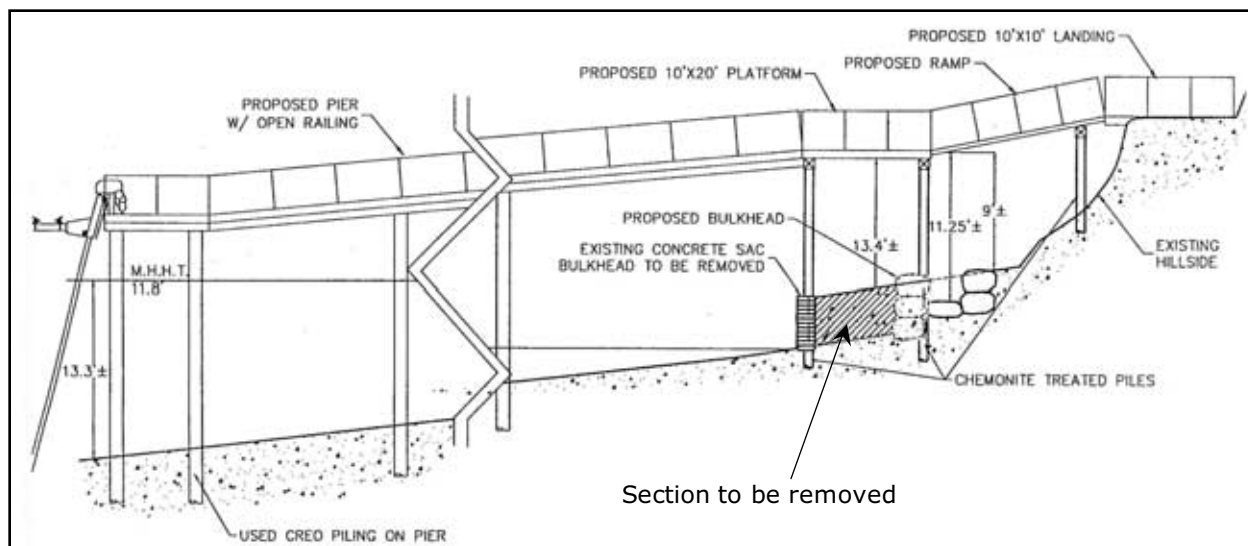
Shannon & Wilson      B. Dorwart

Bainbridge Island Planning Department.      K. James, K. Morrisson

**Project Design Profiles**



Profile: West end of the site – toe protection and habitat enhancement rocks



Profile: Central section – removal of existing bulkhead and fill as mitigation

Odermat Residence



Figure 1. View of Odermat site showing bluff, base of pier, and row of rocks buried in the beach.



Figure 2. Rock bulkhead constructed on shore south of pier.



Figure 3. This row of boulders was placed to help stabilize upper portion of gravel beach.

## ***Place Eighteen Condominium***

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Address: **1811 Eagle Harbor Dr., Bainbridge Island**

Region: **South Shore - Western Eagle Harbor**

Designer: **Myers Biodynamics, Inc.**

Contractor: **Sea Level Construction**

Owner: **Place 18 Homeowners Association**

Shoreline Type: **Beach / Mudflat / Low bluff**

Project Type: **Toe protection,  
Beach Nourishment**

Wave Energy: **Low**

Tides: **MHHW: +11.6  
Extreme High: +15.0  
Extreme Low: -4.5**

Cost: **N/A**

Date Completed: **August 1997**



Location: Place 18 in Eagle Harbor

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### **Site History / Description**

The Place Eighteen Condominium Complex was built at the head of Eagle Harbor on Bainbridge Island. The site has 575' of marine shoreline, consisting of a 4-8-foot high bank. This property is designated as a conservancy shoreline under the Bainbridge Island Shoreline Master Program, which in turn led to a no-bulkheading condition when the condominiums were first constructed.

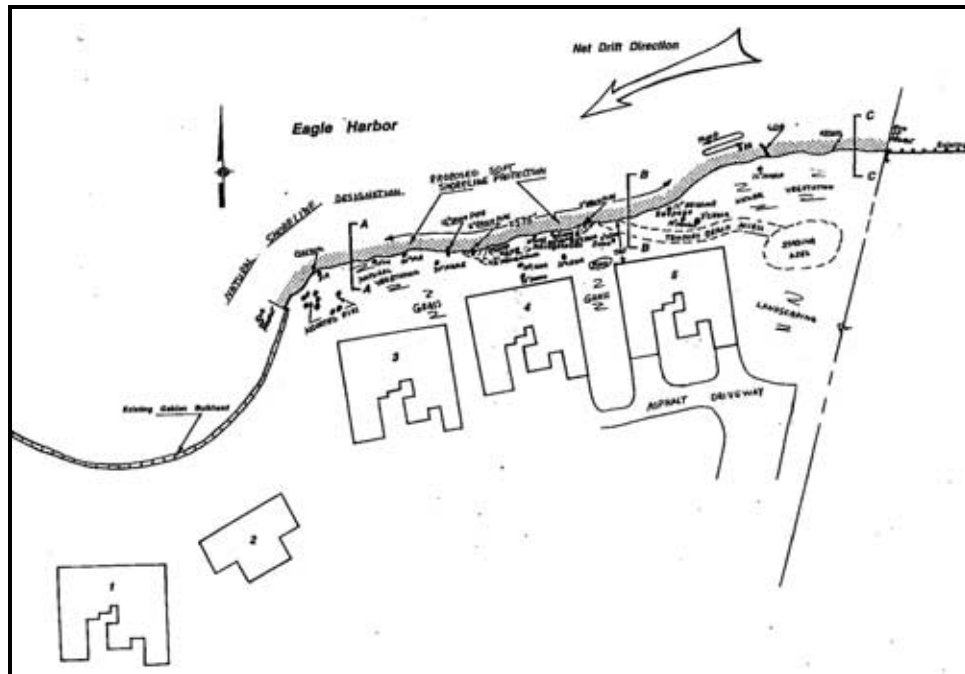
The site is marked by poor drainage, limited vegetation coverage, and was subject to freeze-thaw cleaving during the winter months. These factors, in addition to tidal action, resulted in significant undercutting of the bank. This erosion extended across all but the easternmost 100' of the site.

Both the erosion issue and the shoreline designation were well documented prior to siting and constructing the complex and the developers were aware that no erosion control measures would be permitted. The resulting soft-bank project reflected a compromise between property owners concerned about erosion and the conditions imposed on the site regarding conventional erosion control structures.



## Project Description

The project combined armoring of the undercut areas and the placement of mixed gravel on the beach. Vegetation was pruned back to provide open access to the bankline. The voids were lined with geotextile fabric. Quarry spalls, 4-8 inches in diameter, were hand placed in the undercut voids and the beach and bankline (spalls) were covered with gravel/sand mix that ranged in size from 3-inch minus down to course sand. The gravel cap extended from the bankline out approximately 20 feet. The eastern portion of the project did not require quarry spalls and was simply capped with the mixed gravel and sand.



Prior to construction, the WDFW habitat biologist required that a gravel work mat be laid down before any heavy equipment was allowed on the beach. This work mat consisted of two layers of 3/8ths minus "pea" gravel separated by a layer of geotextile filter fabric. The mat was approximately 15 feet wide and ran the full length of the site. This requirement reduced siltation and protected the beach from being churned up by large tires and tracks of the construction equipment. When the mat was no longer needed, the top gravel layer was removed by peeling back the fabric. The gravel was then integrated with the additional gravel used on the beach.

## Monitoring

No official monitoring is being performed, although periodic site inspections and photographs have been made.

**Success**

The project has been successful in preventing erosion on site. The addition of gravel into a mudflat community has had some effect on the biotic community. A large colony of rockweed (*fucus*) has established which would not have been present on the finer substrate that existed prior to the project, but overall the beach appears to be biologically productive. In addition, fine sediment is beginning to settle on the gravel and may gradually reclaim the beach surface.

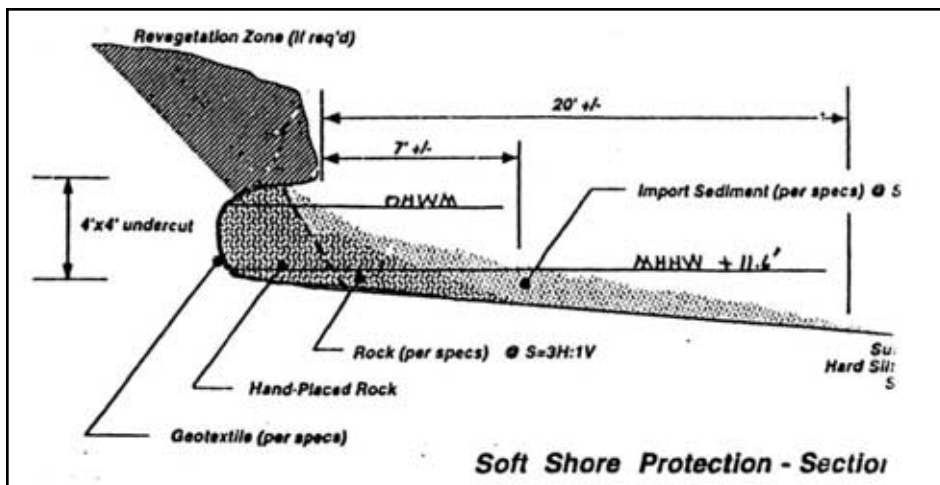
**Alternatives Considered**

The property owners initially proposed a rock bulkhead. Conditions on the original development, along with the site's Conservancy shoreline designation, removed this alternative from serious consideration.

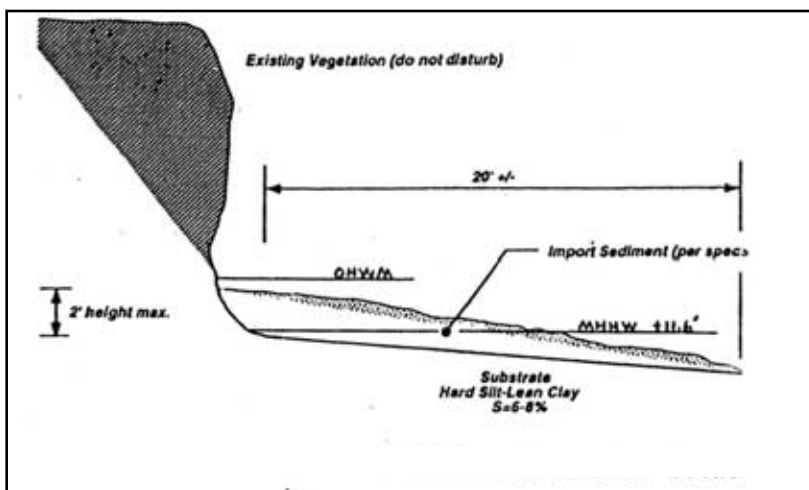
**Contacts**

Bainbridge Island Planning Department.	K. James
WA Department of Fish & Wildlife:	J. Brennan (now with King County DNR)
	J. Boettner (now with WA State DNR)
Washington Department of Ecology	H. Shipman
Myers Biodynamics:	R. Myers

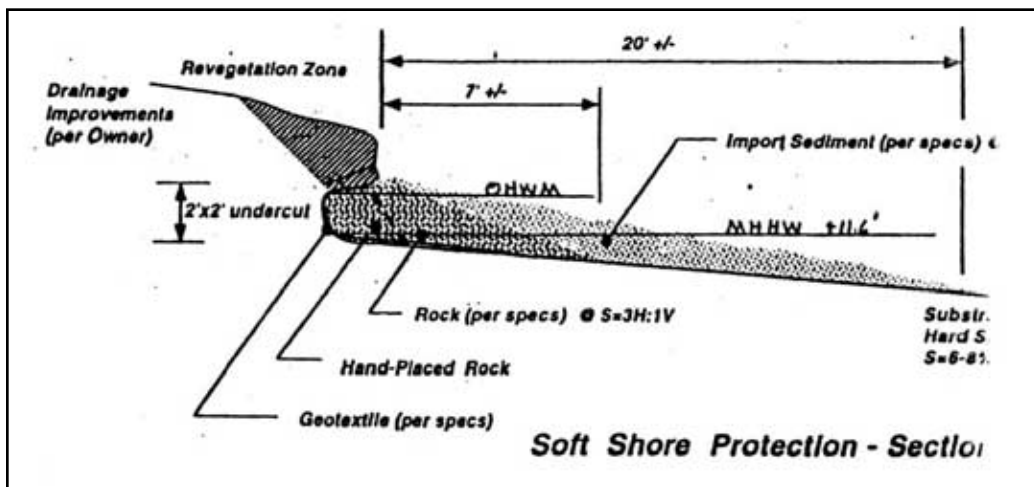
Project Design Profile



Profile: Section A



Profile: Section C



Profile: Section B



Figure 1. Gravel beach and vegetated bank. Quarry spall was placed at the toe of the slope and is largely covered with gravel. Aquatic vegetation is colonizing the coarse gravel, which is relatively stable in this low energy environment.



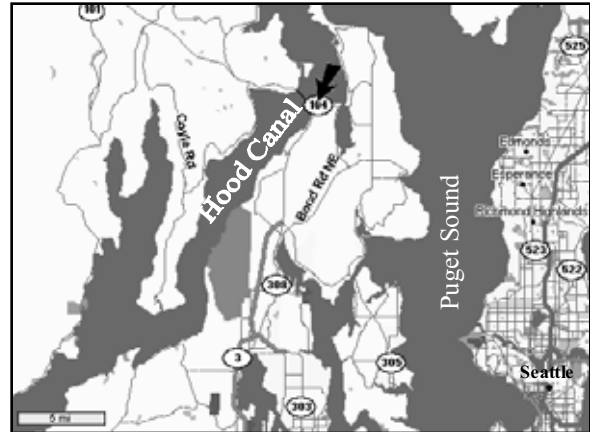
Figure 2. View of central portion of site, looking east. Note recent high tide line and wrack on gravel. By raising beach elevation, opportunities for waves to erode the toe of the bank are greatly reduced.



Figure 3. Beach and bank, looking west.

## Salsbury Point Park

Address: **Salsbury Point Park, Kitsap County**  
Region: **East side of the Hood Canal -just north of the Hood Canal Floating Bridge**  
Designer: **Kitsap County Parks Department**  
Contractor: **Kitsap Co. Public Works Department**  
Owner: **Kitsap County Parks Department**  
Shoreline Type: **Historic Beach**  
Project Type: **Nourishment**  
Wave Energy: **Medium**  
Tides: **MHHW: +8.45**  
**Extreme High: +11.77**  
**Extreme Low: -4.5**  
Cost: **\$389,000 (all work)**  
Date Completed: **October 1995 (upland park improvements completed in 1999)**

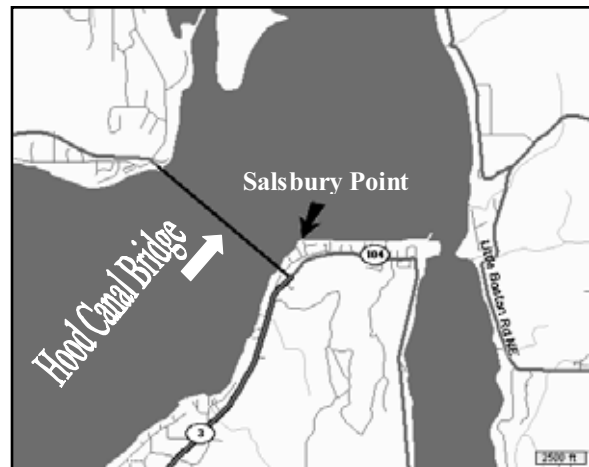


Location: Salsbury Point in Puget Sound

### Site History / Description

Salsbury Point Park is located on the east shore of Hood Canal just north of the Hood Canal floating bridge. The site includes six and a half acres and has 512' of marine shoreline. The beach was originally part of a sand spit, salt marsh system. The wetland was filled in the 1960s. The Hood Canal Bridge reduces wave action from the south and appears to have reduced littoral drift to this site.

The northeast end of the site is marked by a pair of concrete boat ramps and an easement for a cable crossing that has been armored with small rock and spalls. Significant historic erosion of the site had been addressed by periodic dumping of rock and debris, which had limited success and had compromised the public and recreational value of the site.



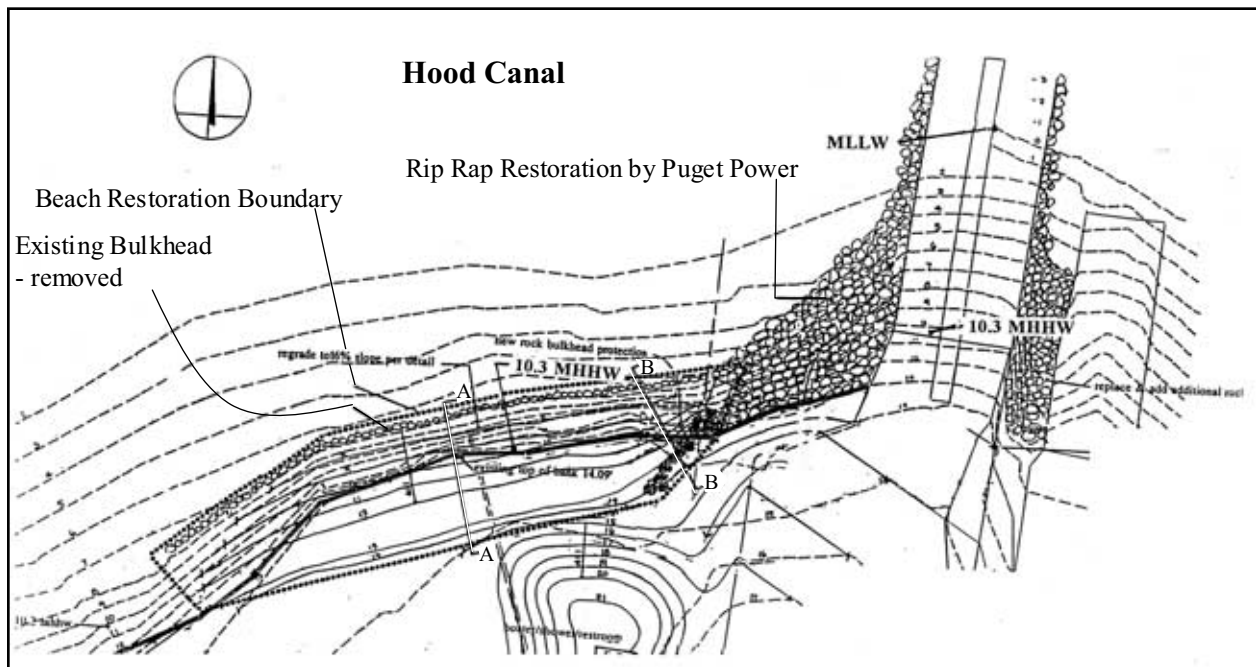
Location: site on Hood Canal

### Project Description

The Salsbury Point project involved beach nourishment of about 300' of shoreline (Profile A-A') and the construction of a rock wall at the eastern end of the beach (profile B-B'). The rock wall is perpendicular

to the beach. Continuation of the beach farther east was prevented by the rockwork at the cable crossing and the boat ramps, which project a considerable distance across the beach. The wall was constructed of rocks previously placed as erosion protection in the area of the restored beach.

Beach construction involved the removal of the large rock and excavation of the existing substrate to a depth of two to three feet. Approximately 2000 cubic yards of 3"-minus gravel was imported to create a beach slope of about 6H:1V from the berm (about 12 feet MHHW) down to a mid-tidal elevation of 7 feet MHHW. Approximately 6 inches of beach sand was placed on the berm, in addition to logs and several large boulders.



Salsbury Point Park: Plan

The beach work was tapered into the existing beach to the west. Hay bales were placed along the upland edge of the project to prevent upland runoff from eroding the newly placed beach sand in the backshore.

It is important to note that the cost of the project includes not only the beach enhancement work, but the cost of the new boat ramp and the upland park renovations.

### Monitoring

The project was closely monitored monthly for a period of 24 months by Hugh Shipman with the Washington Department of Ecology. He has followed its progress since then but not as rigorously. A strong northerly storm in November, 1996, resulted in significant erosion of the eastern end of the beach which would not have been evident except from measured beach profiles.

## Salsbury Point Park

### **Success**

The project appears to be performing well. It is susceptible to northerly storms, but more common southerly storms have resulted in the accretion of sand during some winters. Beach grasses and other backshore vegetation were never planted deliberately, but have gradually re-established on their own. The site is expected to require periodic nourishment, although in relatively minor volumes.

### **Alternatives Considered**

A rock bulkhead was originally considered for the site but nourishment proved to be the preferable alternative.

### **Contacts**

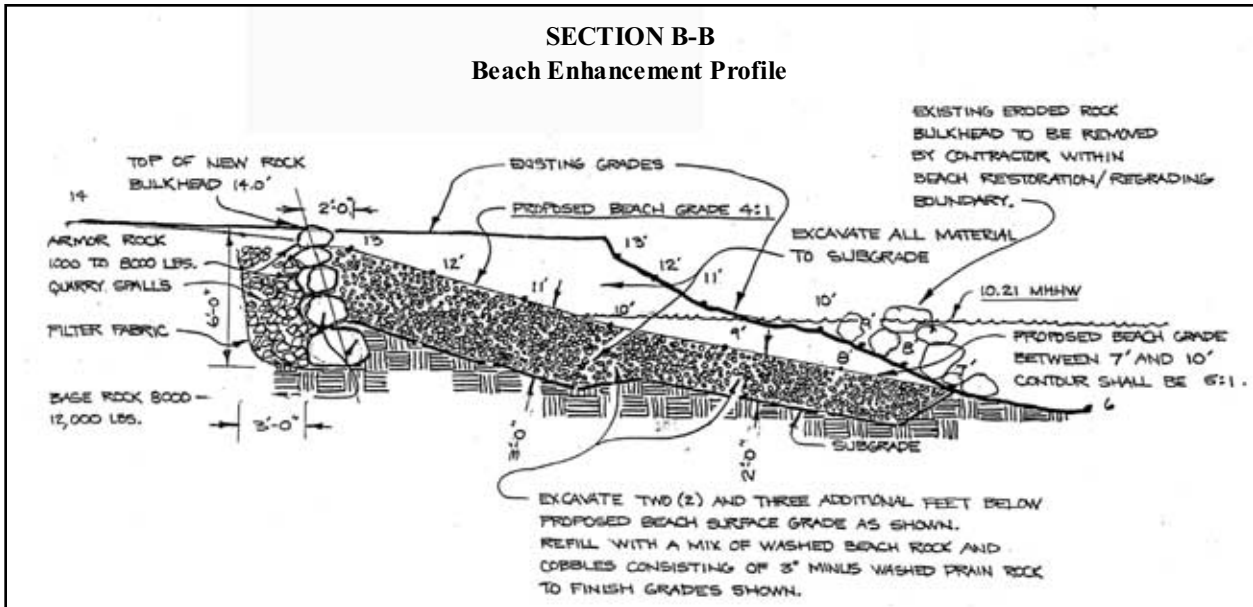
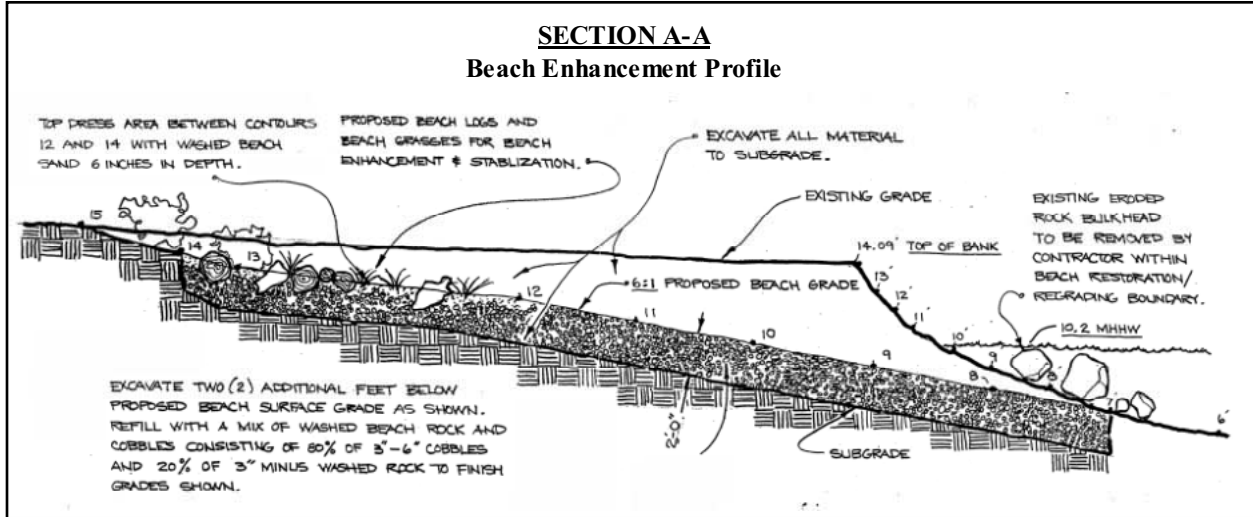
Department of Ecology: H. Shipman

Kitsap County Parks Department: L. Cote

Washington Department of Fish and Wildlife J. Boettner (now with WA State DNR)



**Project Design Profiles: With and Without Rock Bulkhead**



Salsbury Point Park



Figure 1. View west showing gravel beach and backshore. Large logs in the backshore were placed at construction, whereas most vegetation has reestablished naturally (1999).



Figure 2. Second view to west, showing more of beach and Hood Canal Bridge in background (1999).



Figure 3. View east of project area prior to nourishment. Note scarp in eroding artificial fill and rocks placed in effort to reduce erosion (1995).



Figure 4. View to the east immediately following construction (Fall, 1995), showing gravel beach and recent high tide line. Note sand placed on landward portion of the berm.

Salsbury Point Park



Figure 5. 1999 photo shows an erosional scarp in sandy berm. This sand was deposited during the winter of 1998-1999 by movement of drift from the south and was gradually eroded by summer wave action from the north. This illustrates natural variability common to both natural and nourished beaches.



## Samish Beach

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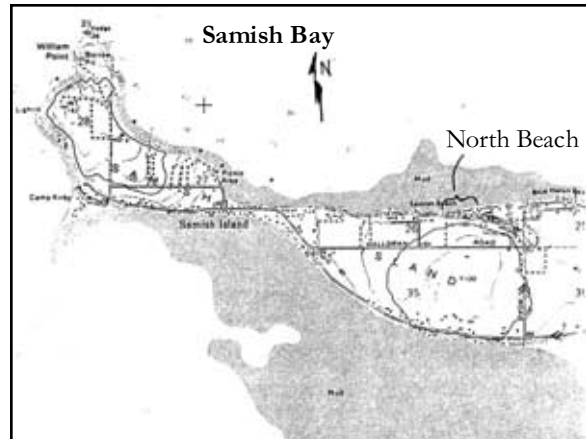
Address: **West North Beach, Samish Is.**  
 Region: **North Puget Sound, Samish Bay**  
 Designer: **Coastal Geologic Services Inc.**  
 Contractor: **Waterfront Construction**  
 Owner: **16 Private Properties**  
 Shoreline Type: **Historic Beach / mudflat.**  
 Project Type: **Protective Gravel Berm, Drift Sill**  
 Wave Energy: **High**  
 Tides: **MHHW: +8.6**  
           **Extreme High: +11.5**  
           **Extreme Low: -4.5**  
 Cost: **\$250,000**  
 Date Completed: **Fall 1998**



Location: Samish Is. In Northern Puget Sound

### Site History / Description

Samish Island is a peninsula that juts westward into northern Puget Sound just south of Bellingham. The past 100 years have seen it transformed from a true island into a peninsula by the expanding Skagit/Samish River delta. There used to be more marsh and mudflat on the island but significant areas have been diked and filled to create agricultural land.



Location: North Beach on Samish Island

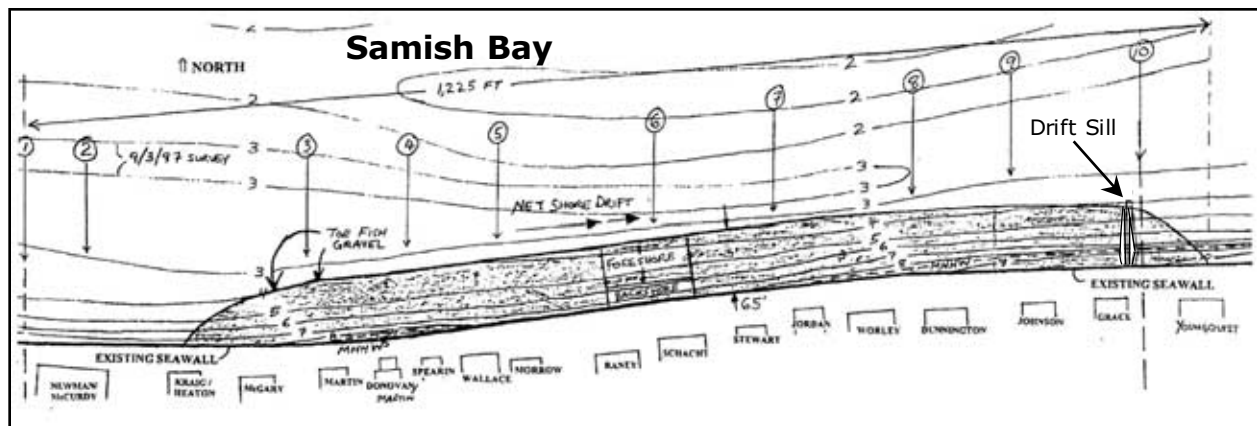
North Beach is on the north shore of the island just east of its center. Historically it was a beach with a gradual berm. A high bluff is located upland (south) of the beach and there is an extensive offshore flat at low tide. Development in the area began as early as 100 years ago. Cottages were constructed between the bluff and the beach. The predominant longshore drift on site is from west to east therefore manmade changes to the west (updrift) are of most importance.

There are a number of significant structures. A groin was built on the west end of the beach in the early part of the century (probably 1920's or 30's). This artificially increased the width of the beach in this

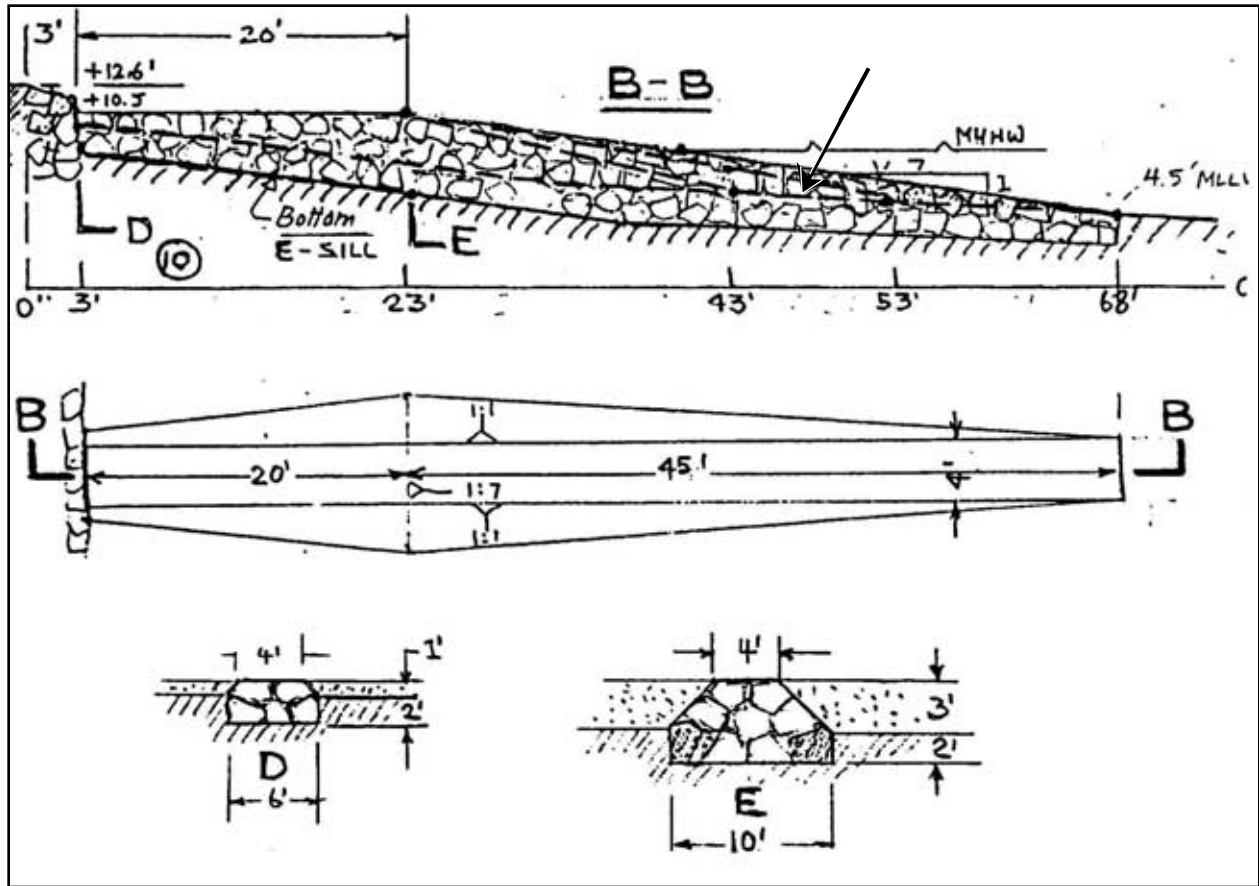
## Alternative Bank Protection Methods on Puget Sound

area, but the structure was gone by the 1960s. The beach is now seeking to reestablish a natural equilibrium and erosion is cutting into the deposit. To the west are two manmade promontories. These extend into the water as much as 100' blocking a significant amount of sediment moving toward North Beach and possibly divert more sediment offshore. A series of groins occur west of the beach and two more small groins are present on the west end of North Beach. These are also trapping and diverting sediment. Finally, extensive bulkheading has cut off the primary sediment source to the beach. Erosion of the bluffs was the primary source of sediment maintaining beaches along the north side of Samish Island. Now the source has been cut off and the system is starved of sediment, exacerbating the effects of the other structures.

The changes to the beach in the past century have created significant impacts to the beach and resulted in serious erosion problems during the past two decades. North Beach residents installed bulkheads from the late 1970's through 1982 in an attempt to protect their properties from erosion. The bulkheads increased wave energy on the beach which in turn scoured out the fine sediments and lowered the beach significantly. In 1996 three bulkheads failed and the residents began to aggressively consider alternatives to erosion control.



North Beach Plan / Profile Locations



North Beach: Details of drift sill (groin)

## Project Description

Coastal Geologic Services designed the project with additional design input from Wolf Bauer. The project on North Beach consisted of two parts. A drift sill (groin) was constructed at the east end of the beach. This was followed but the construction of a protective berm in front of the 16 properties involved.

The drift sill was built at the east end of the beach. Essentially it is a groin constructed flush with the new beach grade (7H:1V) at the down drift end of the site. The sill is designed to retain the nourishment that was added by the project while still allowing long shore drift to carry sediment normally down the beach above the new grade. Eighty tons of rock were used in its creation.

The second phase of the project was constructing the new berm. The nourishment stretches from the Grace residence west for approximately 1000 feet. The berm is composed of two layers. Seven thousand yards of berm gravel (3/4"-3") make up the majority of the fill. This was molded to create the bench and a 4.5H:1V grade beach. Then the beach slope was brought up to 7H:1V by adding 1500 yd<sup>3</sup> of smaller gravel (3/4" minus). This material is intended to provide habitat favorable for surf smelt spawning. The



site was a documented surf smelt spawning beach, albeit in significantly degraded condition. The goal of adding this finer gravel was to mitigate the damage done by the project, not to restore the beach to its historical condition. In addition to the gravel, 260 yd<sup>3</sup> of sand were added to the berm.

### **Monitoring**

The project has passed through one winter to date and looks to be in good condition. Some vegetation has established itself naturally but no formal plantings have been done yet.

There is an official monitoring program to be performed by Coastal Geologic Services, Inc.. Monitoring will be performed twice a year for the first three years and will be composed of profile (8 transects) and sediment (4 upper intertidal samples) monitoring. The sampling will be performed once in each of years four and five.

### **Success**

The project has been successful to date.

### **Alternatives Considered**

Four Alternatives were considered for North Beach: no action, new beach and backshore plus bulkhead removal, nourishment without building a new berm and new beach and backshore with present bulkheads. The no action alternative was not appealing to most property owners. It would have resulted in continued beach loss and additional bulkhead failures. The designers felt that the ideal solution would have included removing all the present bulkheads and building a protective beach and berm, but the landowners were reluctant to do so. Nourishing the site without building a berm was discarded because it would have been a short-term solution requiring continuing and possibly frequent renourishment. The alternative that was chosen was a compromise between what the designer thought would provide the best protection and the homeowners' desire to have bulkheads between their homes and the water. The result is a berm and backshore that are narrower than optimal but the project will still provide adequate protection with minimal upkeep. This alternative was also the one that 16 separate landowners could agree on. This ability to achieve consensus was a critical deciding factor.

## Samish Beach

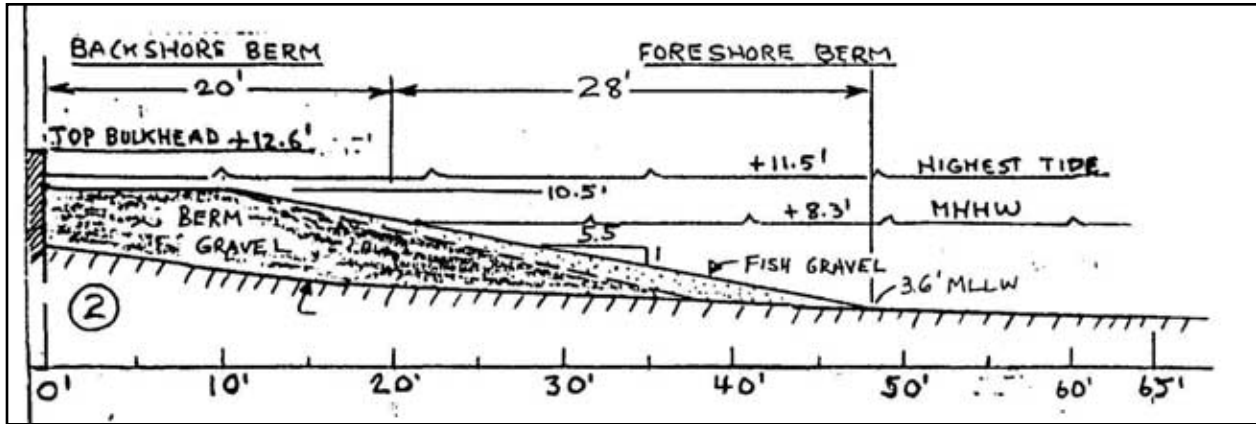
### Contacts

Washington Department of Ecology:	H. Shipman
Washington Department of Fish & Wildlife	B. Williams
Coastal Geologic Services, Inc.:	J. Johannessen
Army Corp of Engineers	C. Barger

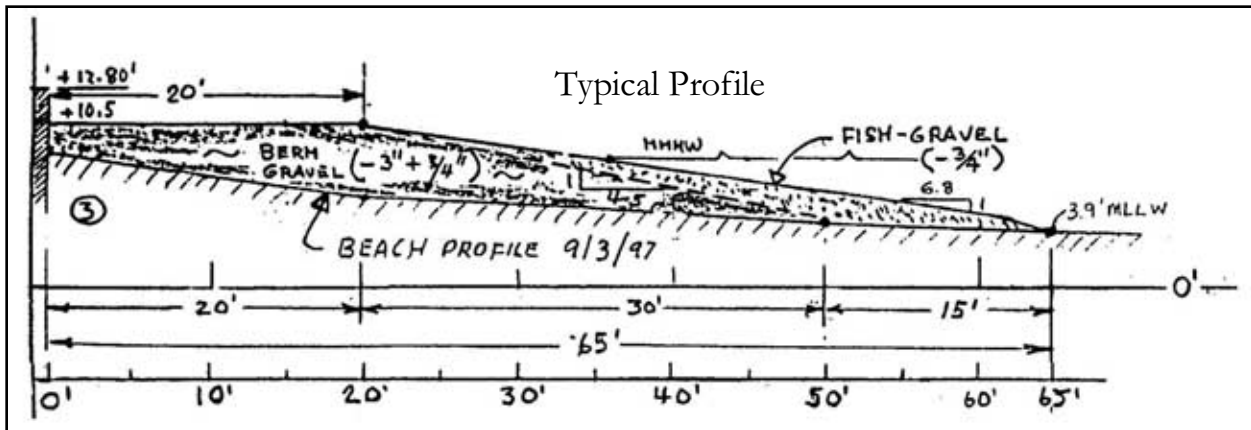
### References

Shipman, H. 1998. *Shoreline Changes at North Beach, Samish Island*. Shorelands and Environmental Assistance Program, Washington Department of Ecology, Olympia, Publication # 98-101.

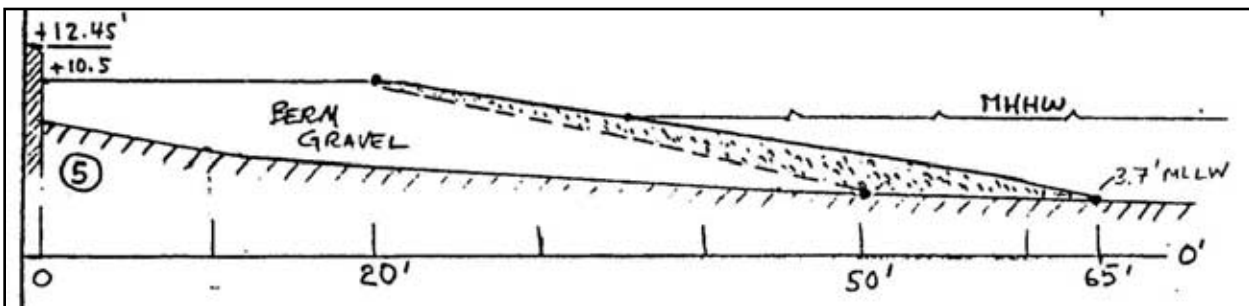
Project Design Profiles



Profile: North Beach Transect # 2



Typical Profile: North Beach Transect #3



Profile: North Beach Transect #5

## Samish Beach



Figure 1. View west from the east end of the project. Note broad gravel berm and recent accumulation of beach wrack. Prior to nourishment, the bulkheads at the left were in danger of undermining.



Figure 2. Looking west at project, including drift sill (groin) that forms eastern end of nourishment. Note that beach is considerably lower on east (left) side of structure. It is important that gravel be able to continue to bypass the structure in order to feed downdrift beaches.



Figure 3. View west along bulkhead line in central portion of project. The bulkhead in the foreground failed in the winter of 1996-1997 (see Figure 6). Note elevation of backshore and placement of sand to facilitate revegetation.



Figure 4. Ecology-block bulkhead located immediately west of project area.. Riprap has been added to protect base from scour.



Figure 5. Photo taken immediately prior to bulkhead construction in 1982 along east-central portion of project site. Note line of drift logs and narrow berm  
(Photo: courtesy of Marge Dunnington)



Figure 6. Ecology-block wall prior to nourishment. Failure occurred in the winter of 1996-1997 by undermining and excess hydrostatic pressure - upper tier has been restacked in this photo. Note erosion of upland area behind wall.

## USG/Thermafiber

Address: **2301 Taylor Way, Tacoma**  
 Region: **Hylebos Waterway, Commencement Bay**  
 Designer: **AGI Technologies**  
 Contractor:  
 Owner: **Thermafiber LLC**  
 Shoreline Type: **Industrial Canal**  
 Project Type: **CERCLA Restoration  
 Re-grade, Gabion Mattresses**  
 Wave Energy: **Very Low**  
 Tides: **MHHW: +11.84  
 Extreme High: +14.9  
 Extreme Low: -3.84**  
 Cost: **N/A**  
 Date Completed: **August 1997**

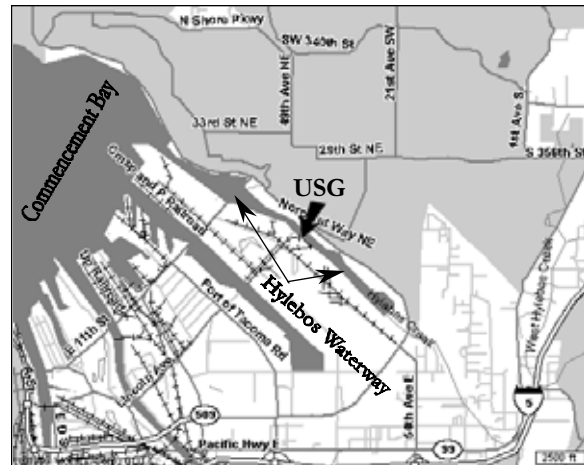


Location: USG in Commencement Bay

### Site History / Description

The USG / Thermafiber site is a 9.4 acre parcel located on the southwestern shore of the Hylebos Waterway in the Commencement Bay Nearshore Tidel flats Area (Tacoma, Washington).

The USG Corporation owned the site from 1959 through the spring of 1996 when they sold it to Thermafiber LLC. The plant on site is used to produce mineral fiber insulation ("rock wool"). In this process slag from iron production and basalt are heated and spun out into a product that looks

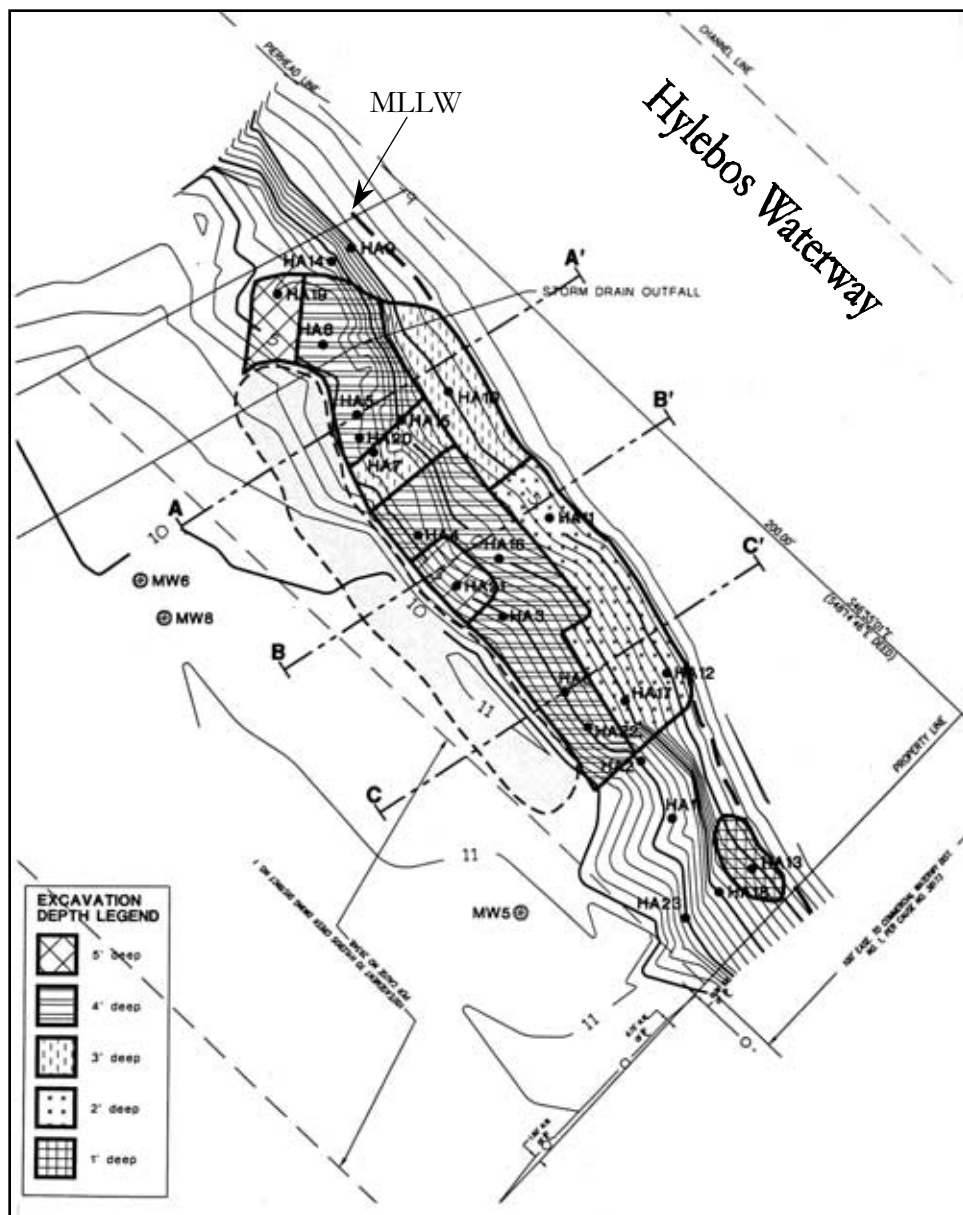


Location: USG on Hylebos Waterway

much like fiberglass insulation. While USG owned the plant contaminated slag was used and the byproducts of production were disposed of in the Hylebos. The location was declared a CERCLA site because the upland and intertidal soils had concentrations of metals exceeding cleanup levels. Cleanup and restoration was performed in the summer of 1997.

### Project Description

The USG project was complicated by the fact that it was a CERLA site. Unlike the Indian Island and Floral Point projects, USG started with a large excavation component. Following the removal of



USG / Thermafiber: Site and excavation plan.

contaminated sediments, the site was backfilled and then erosion protection measures were installed. Remediation began with the removal of 1,072 tons of material from the upland zone and 2062 tons from the intertidal slope area.



The upland area was backfilled with quarry spalls, pit run sand and gravel and topsoil. The spall was used where the excavation went below the water table. This was then covered with sand and gravel. At this point the fill was compacted to the proposed grade. The sand and gravel was then covered with a layer of topsoil to support revegetation.

The intertidal slope was approached differently. The backfill began with an even, thin layer of quarry spall tamped into the silt/clay bank. This created a structural interlock between the silt clay and the pit run sand and gravel that followed. The original plan called for a layer of geotextile fabric instead of spalls. The plan had to be modified, however. Silt and clay had not been expected. If they had used the geotextile an artificial slip plane would have been created in the bank. The sand and gravel was used to bring the slope up to grade and to create a habitat bench. The height for this bench was set to match that formed by a clay layer immediately to the northwest. The design sought to preserve this existing bench because it was covered with healthy pickleweed. The sand and gravel mix was followed by a layer of geotextile fabric (filter fabric). This fabric allows water to pass through (ensures that hydrostatic pressure does not build up) but retains fine sediments. The next layer was a 9" gabion mattress. This was composed of PVC coated wire mesh baskets that are 12'x6'x9". These were laid down and wired together in rows running parallel to the Hylebos waterway. The baskets are designed to last a minimum of 20 years. The gabion revetment was covered with 6"-8" of topsoil. Large woody debris and rocks were placed on the bench to improve the habitat and aid revegetation.

### **Monitoring**

No official monitoring plan is in place. A band of the gabions have become exposed since the project was finished. This area is approximately 8' wide and runs most of the width of the site. There has also been significant settlement by seaweeds on the exposed baskets.

### **Success**

The project is too new and there is too little information available from which to judge success. One of the key objectives of this project was to enhance habitat by creating a bench at the appropriate upper intertidal elevation. The ultimate success of this project will depend to a large extent on how well the bench is colonized by intertidal and riparian vegetation. Another indicator of success will be the extent to which fine sediment is retained in the lower part of the gabion slope and the degree to which the infauna within this fine sediment reflects the biota found on unaltered shorelines in the vicinity.

## Alternative Bank Protection Methods on Puget Sound

The gabion baskets have been exposed on the waterward edge of the bench (Figure 4). This does not indicate any serious problem for the project, only that the intertidal slope may have been too steep. The geometry was constrained by the inflexibility in moving the shoreline landward and by space required by the bench itself.

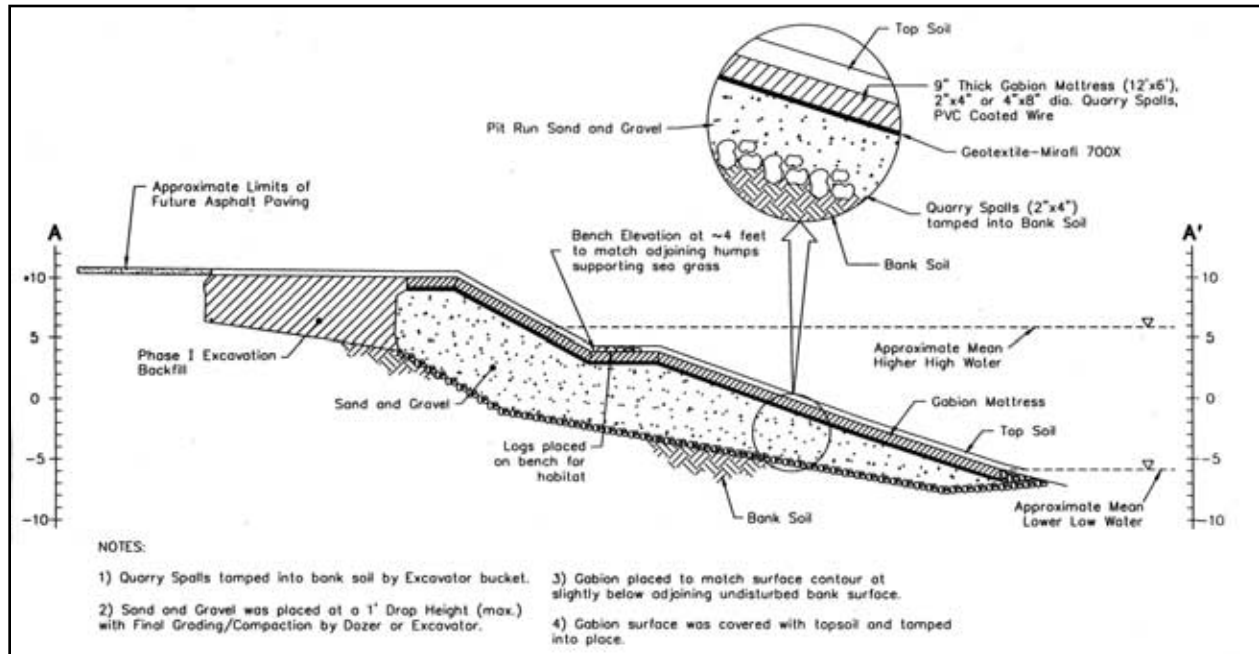
### **Alternatives Considered**

The alternatives for this project included using rock instead of gabions and using gabions but not constructing a habitat bench. Neither of these made it to the design stage, however.

### **Contacts**

Washington Department of Fish and Wildlife:	J. Boettner (now with WA. State DNR)
Department of Ecology:	J. Mercuri
AGI Technologies.:	M. Carlson

Project Design Profile



Profile: USG/Thermafibre



Figure 1. View south of site prior to construction. Note vegetated upper intertidal benches.



Figure 2. View southwest of site after construction. Fine sediment covers gabion mattresses except in area immediately below bench (people standing).



Figure 3. Installation of gabion mattresses over geotextile (*Photo: Joyce Mercuri*)



Figure 4. Detail at waterward edge of bench showing exposure of gabions.



## ***Weather Watch Park***

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Address: **4035 Beach Dr. SW, Alki Beach**  
Region: **West side of Alki Beach**  
Designer: **Lezlie Jane (for the Alki Community Council)**  
Contractor: **Lezlie Jane**  
Owner: **Seattle Engineering Department**  
Shoreline Type: **Historic Beach**  
Project Type: **Opportunistic beach.**  
Wave Energy: **Very Low**  
Tides: **MHHW: +11.40**  
**Extreme High: +15.0**  
**Extreme Low: -4.5**  
Cost: **\$87,000 + in kind contributions**  
**(includes benches, column etc)**  
Date Completed: **Summer 1991**



Location: Weather Watch Park on Alki Beach

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### **Site History / Description**

Weather Watch Park is technically a Seattle street end. In 1907, the site was a ferry dock for the mosquito fleet. When service was discontinued in 1920, the dock was dismantled and the site became a vacant lot. Some rubble accumulated on the site as did a large supply of coarse woody debris. The site is immediately adjacent to Beach Drive and is 135' long. There is a small upland area between the road and a seven-foot bank that leads down to the beach.

In 1990 the Alki Community Council organized the local public and in 1991 they created Weather Watch Park. The project was performed to improve the local community but serves as a perfect example of what is possible, even with a small site in a heavily armored area.

### **Project Description**

Weather Watch Park is not an example of a project designed to resist erosion as much as one designed to avoid erosion. The project began by removing rubble that had accumulated on site over the course of seventy years as a vacant lot. The bank was not regraded or reconstructed -- it was only reinforced with several large rocks. The woody debris was not placed on site -- it is what accumulated naturally in the pocket beach. Once the bank was cleaned up, extensive revegetation was performed. Paths down to the beach were built and a park like atmosphere was created in a small area at the street level.

## Alternative Bank Protection Methods on Puget Sound

The entire project is set at least 30' farther back than the vertical cement bulkheads on either side. This is a significant factor contributing to the effective accumulation of sediments and drift logs, as well as the protection of the bank itself from wave erosion.

### **Monitoring**

There is no monitoring plan in place. The site has been stable for eight years.

### **Success**

Weather Watch Park is stable, despite the fact that it is located in a zone of relatively high wave energy and is flanked by heavy armoring. The project stands out in this report, not due to technological sophistication, but simply as an example of what is possible on a single property if the physical processes are allowed to establish a natural equilibrium.

### **Alternatives Considered**

N/A

### **Contacts**

Alki Community Council

L. Jane

Bart Berg Landscaping:

B. Berg



Weather Watch Park



Figure 1. View south of Weather Watch Park. Note vegetated bank and drift accumulation along berm



Figure 2. View of park illustrating adjacent bulkheads. This photo emphasizes why it is difficult to restore, or maintain, natural beaches when human action has encroached into the intertidal.



## Summary

The fifteen projects described in the previous part of this report represent a variety of erosion control techniques, including bioengineering, gravel beach nourishment, and the active use of logs and woody debris - which have received little attention in the published literature on marine shorelines. We found it difficult to categorize or classify these projects since each has unique aspects that distinguish it from others in the study. What we have done, however, is attempted to look at the types of sites and circumstances that allowed the projects to be carried out (ownership, wave energy, geologic setting) and the broad categories of technical approaches (beach nourishment, bioengineering, anchored logs) taken in each case. We conclude with some thoughts and recommendations.

## ***Circumstances***

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These projects occurred in a wide variety of circumstances - under different types of ownership, for different reasons, under different geological conditions, and on shorelines with unique histories.

### Ownership

The private residential sites included individual parcels, homeowner's associations, and cooperative efforts of multiple property owners. The only private commercial/ industrial site was **USG/Thermofibre** in Tacoma, where Superfund status led to substantial agency involvement in remediation and shoreline stabilization work. At **Indian Island** and **Floral Point**, property was owned by the Department of Defense (Navy) and shoreline work occurred under the auspices of cleanup actions. Several sites involved public parks, such as **Blake Island** (State Park), **Salsbury Point** (Kitsap County Park), and **Weather Watch Park** (Seattle City Park). Ownership, at least in itself, does not seem to be a critical factor in developing alternative approaches.

### Driver

Most of these projects occurred on properties where erosion control was the property owner's major concern, but where public agencies expressed early concerns about the potential environmental impacts of standard armoring solutions. In some cases, proponents were receptive to alternative approaches, whereas in others the choice of a non-traditional solution was strongly resisted. Willingness to consider softer measures depends to some extent on perceived benefits beyond erosion control. At public parks, such as **Cormorant Cove**, the choice of an alternative solution may also be key to improving public access and enjoyment.

On the cleanup sites - **Indian Island, Floral Point, USG/Thermafiber** - several factors would normally have driven a highly conventional solution. The involvement of large engineering firms, including coastal engineering specialists, and strong concerns about the potential consequences of failure (contamination, federal cleanup laws) typically drives conservative approaches. We believe the fact that alternatives were considered and chosen reflects a collaborative process where consulting engineers and agency biologists were both at the table and where desire for an expedient solution drove project managers to consider compromise. We also suspect that the ability to meet both engineering demands and biological concerns was aided by the financial resources and interdisciplinary talent that Superfund sites can mobilize (Alternative approaches are also being pursued for parts of several other cleanup actions around Puget Sound, including the ASARCO smelter site in Tacoma and the Jackson Park and Manchester/Clam Bay Navy sites in Kitsap County).

Our work did not indicate sites where the softer solution was chosen simply because it was less expensive than a traditional structure, although it appears that in some cases cost savings may have occurred. Unfortunately, cost information was difficult to obtain for many projects and was often difficult to interpret with confidence. As the public and environmental costs of conventional projects are increasingly factored into overall projects costs (typically through design improvements, public review, impact assessments, and mitigation requirements) alternative approaches may become increasingly more economical.

## Exposure and Wave Energy

Looking at the physical characteristics of the sites, we note that the examples occur under a variety of energy conditions (defined by wave action, which on Puget Sound is controlled primarily by the fetch and orientation of the beach). It is important to note that high energy sites do not preclude the use of alternatives, although they may limit the range of options available. The success of pocket beaches or of beach nourishment appears to depend on a favorable site orientation - typically a configuration that limits the loss of sediment in a longshore direction.

## Geomorphological setting

Several of the sites were located on shorelines that, prior to human modification, were relatively stable depositional beaches (sand spits or locally, *accretion* beaches). Examples include **Salsbury Point, Samish Island, Blake Island, Blakely Island, Indian Island, and Floral Point**. Interestingly, at each of these sites, the erosion problem occurred primarily in historic fill placed over the backshore and upper beach. Although erosion may affect such landforms naturally, rates are typically slow and rarely

## Summary

threatening (in other words, many of these problems would never have arisen had fill not been placed over the beach in the first place).

A few sites were along shoreline bluffs or eroding banks (**Baum, Odermat, Dick, Place Eighteen**). Such sites differ from beach and other low bank sites in that often the stability of the slope itself is an issue - and may or may not be directly addressed by stabilization of the beach or toe of the slope. Thus at Baum, for example, the portion of the project most relevant to this report is the bioengineering used on the steep slope - but the toe of the slope is marked by a large rock bulkhead.

The **USG/Thermafiber** site was unique in that it occurs on a heavily modified industrial waterway (the mouth of Hylebos Creek) within the larger Puyallup river delta. This site resembles a riverine environment more than a marine one. It is dominated by current action and wake wash, has no true beach, and the entire bank and intertidal slope consists of fine grained delta and floodplain sediments.

## Timing

We note that virtually all of the projects discussed in this report occurred in the last several years. This reflects, in part, the tendency of a study such as this to preferentially identify and successfully acquire information for more recent projects and in part, the very real fact that many more of these projects are being considered now due to environmental concerns.

## ***Types of projects***

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The techniques employed on these sites range broadly and are not always classified readily. This reflects the limited number of projects and their innovative nature. Several general types of projects can be identified, however, including beach nourishment, bioengineering and other applications of vegetation, structural use of drift logs and large woody debris, and modification of traditional structures in order to reduce biological impacts or enhance specific ecological functions.

### Beach nourishment

Beach nourishment describes the intentional placement of sand and gravel on a beach, both to replace sediment lost to erosion and to enhance beach function (for recreation, biology, or erosion protection). Increasing the elevation and width of the beach with nourishment can reduce bank erosion, limit backshore flooding, and can restore upper intertidal sand and fine gravel habitats. Although nourishment may result in short-term impacts to beach ecology, it is increasingly viewed as an environmentally preferable approach to managing shoreline erosion (when contrasted to traditional seawalls or revetments). Nourishment's advantages lie in that it mimics native substrates, that it doesn't alter the

underlying beach processes, and that it is typically reversible (if it fails, or is not maintained, the shoreline reverts to its pre-project condition - no permanent structure or alteration occurs).

The application of beach nourishment on Puget Sound has been described by several authors [Downing, 1983; Johannessen, 1996; Shipman, 1996]. Unlike nourishment as it is more commonly employed on sandy, open ocean shorelines (East Coast barrier islands, for example), beach nourishment on Puget Sound typically involves the use of coarse gravel on relatively small sites. Little guidance exists for the design and construction of these coarse-grained gravel beaches in the technical literature.

**Samish Beach, Salsbury Point, Driftwood Beach, Place Eighteen, Blake Island, Floral Point** are nourishment projects included in this report. Shipman [in preparation], describes 30 beach nourishment projects throughout Puget Sound (including these), ranging from small gravel pocket beaches on heavily urbanized and modified shorelines to the large artificial island and spit/lagoon complex created with dredged sand at Jetty Island in Everett and the cobble beach feeding project that maintains Ediz Hook in Port Angeles.

## Anchoring of large woody material

Large woody material such as logs and root wads have been installed in stream restoration projects for many years, but although logs and woody debris are a fundamental part of Puget Sound beaches, no systematic examination of the use of wood in restoration or erosion control projects on marine shorelines has occurred. The conventional wisdom is that large woody debris generally helps stabilize the beach and may actually enhance deposition of sediment in the proper circumstances, but that during extreme storms and high water levels logs may increase damage to property or aggravate erosion. For decades, property owners have chained or fixed large logs at the toe of the bank to help reduce erosion, but the long-term effectiveness of such actions is not known.

Logs are anchored in a variety of ways, although in the projects described in this report, the method usually involves cabling the wood into deadmen (typically precast concrete blocks - ecology blocks, jersey barriers, parking curbs) buried beneath the beach surface. Screw anchors have also been employed. Examples include **the Dully, Blomquist, Dick Residences** and **Indian Island**. Anchoring provides a designer and a property owner with a sense of enhanced project durability, but may create some additional problems. In storm events, logs move with wave and tide action and when anchored can result in considerable scour. Cables work loose when beach levels rise and fall. Under extreme conditions, the cables and deadmen may become exposed. Any design using anchored wood should consider likely wave action and fluctuations in beach elevation.

## Summary

One key question that arises relates to the necessity or the wisdom of anchoring large woody material. Under natural conditions, logs are clearly not anchored in place. Their stability depends on whether the root wad or limbs are attached, the presence of a level berm on which logs can accumulate, and the occurrence of high water levels that can bring logs in or that can float them off a site. It is useful to note that logs are generally not present on beaches that lack a berm (which is a large reason why logs are typically not found on armored shorelines). Attempting to place logs on the sloping portion of the foreshore (below MHHW, for example) can be expected to require anchoring, since logs are rarely stable for long in such a location.

### Modification of structural measures

Structures, such as revetments or seawalls, often displace or alter habitat simply by their shape. Their steep slopes result in less habitat within any given tidal range. In addition, the steepness reduces the likelihood of fine-grained sediment retention or deposition and causes wave action to be focused in a narrow zone. These two factors result in little habitat of the sort normally found on gradually sloping sand or gravel beaches. By building a bench into a riprapped slope, the amount of potential habitat at a particular tidal range can be enhanced and the hydraulic conditions changed so as to allow vegetation and retention of sediment (see the **USG/Thermafiber** example).

Another example (not illustrated in this report) might include the construction of a low vegetated bench above a bulkhead and below a higher retaining wall on the bluff face. Increasingly, we find landowners constructing retaining walls up the face of a bluff after a slope failure has occurred above an existing bulkhead (a reminder that bulkheads may do little to prevent an incipient failure of a slope due to hydrologic factors). Such structures typically result in severe impacts to riparian vegetation, but where they cannot be avoided, it may be possible to bench them in such a way as to facilitate the establishment of native woody vegetation as near the toe of the slope as possible - allowing vegetation to hang over the shoreline.

### Vegetation and Bioengineering

Riparian vegetation is a key element of shoreline ecological function and has a significant influence on habitat value, both in the riparian zone itself and in adjacent aquatic areas. Vegetation provides physical structure and complexity and surface area, organic input, shade and temperature modulation, insects (fish prey) and wildlife habitat. It also provides a transitional zone between upland and aquatic areas, filters surface runoff, retains sediment, and supplies large woody debris to the aquatic system.

Natural shorelines clearly vary on the degree and character of riparian vegetation - for example, the micro-dunal backshore of a sand spit differs markedly from a heavily forested bluff. One objective of soft

structures is generally to restore some element of natural vegetation and riparian function to the shoreline. The simplest approach is to encourage revegetation in native species and to design stabilization measures that facilitate this. Concrete bulkheads with grassy lawns above clearly diminish riparian function, whereas rock bulkheads that incorporate woody material and that are accompanied by aggressive planting of appropriate vegetation above and behind them provide riparian function - at least to some extent.

**Bioengineering**<sup>4</sup> refers to the use of vegetation as an active component in engineering solutions to unstable slopes and shoreline erosion. It has received considerable attention in river and stream work [Gray and Sotir, 1996; Soil Conservation Service, 1992; Hollis and Leech, 1997; Barker, 1995], but very little work has been done on its application to marine settings [Ranwell, 1983]. The Department of Ecology publishes two booklets on the use of vegetation on coastal bluffs - one applies to managing existing vegetation [*Vegetation Management on Coastal Bluffs*, Menashe, 1993]; the other describes more active biotechnical approaches to slope stabilization and landslide repair [*Slope Stabilization using Vegetation*, Myers, 1993].<sup>5</sup>

Biotechnical approaches include a variety of techniques, including wattling, live staking, and brush boxes that increase root strength in soils, interconnect soils units to reduce potential for larger failures, and reduce erosion by surface runoff, groundwater seepage, or waves and currents. Bioengineering on coastal slopes may not differ significantly from bioengineering on northwest rivers and streams - the soils and vegetation are similar - except on highly exposed shorelines where salt influence is extreme.

The primary difference arises in the treatment of the slope toe. Numerous plants and trees can withstand periodic inundation with fresh water during riverine flood events, but few native woody species can survive in tidal waters, limiting the options for using vegetation at the toe of the bank. River and marine shorelines differ in several other important ways that should influence the selection and application of bioengineering methods developed for fluvial systems: 1) river banks are exposed to more extreme inundation than marine shorelines due to floods; 2) riverbanks are eroded by current, whereas the toe of marine banks are eroded by wave action - which is very different in its direction and behavior; and 3) wave-dominated shorelines usually have beaches, whereas erosional riverine banks do not.

The **Baum Residence** in Thurston County is a good example of an aggressive bioengineering solution to a steep slope, used in conjunction with soil-nailing. It should be noted, however, that the toe of the slope is not bioengineered, but rather is stabilized with a substantial rock seawall. In this case, bioengineering

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<sup>4</sup> The terms biotechnical slope stabilization and soil bioengineering are preferred, in part because the term *bioengineering* means many very different things in other contexts, such as in agriculture or medicine.

<sup>5</sup> A third booklet in this series addresses drainage issues on coastal bluffs and their importance to slope stability (*Groundwater Management on Coastal Bluffs*, Myers and others, 1995).



## Summary

is intended to stabilize the slope while providing limited riparian functions, but the project does not address potential beach impacts associated with the bulkhead or with the permanent stabilization of the slope. It illustrates techniques, however, that may be widely applicable to bluff properties where bulkheads already exist or where bulkheads are likely to be approved in the future.

### Opportunistic beaches and setback bulkheads

Habitat impacts often occur simply due to the waterward position of a hard structure. By relocating an existing structure farther landward, considerable habitat value can be recovered. By constructing a new structure farther landward, some habitat loss can be avoided. In addition, the farther landward a structure is constructed, the less wave energy it is exposed to and the less robust, and thus expensive, the structure need be. Often, the sacrifice of ten to twenty feet of lawn may allow the creation of a viable natural beach and avoid the need to spend money on a standard bulkhead. **Weather Watch Park** in Seattle illustrates how a relatively natural beach can exist on an otherwise heavily armored shoreline, simply because the beach profile remains relatively undisturbed. **Cormorant Cove**, when completed, will take advantage of the same principle by removing much of an existing bulkhead and restoring a more beach gradient. Another West Seattle example of this occurs at Lowman Beach Park, where the removal of 100 feet of concrete bulkhead allowed a beach to rapidly re-establish.

### Combination approaches

Many of these projects combine approaches. At some sites, different measures were used on different sections of shoreline (at **Indian Island**, three basic treatments were used for three different segments of the beach, based primarily on changes in exposure and different existing geometries). In other situations, one measure may be adopted lower on the site while a second is used on landward areas. The combination of a rock bulkhead at the toe of a slope with a bioengineered slope, as at **Baum Site**, or of beach nourishment with backshore plantings, as at **Driftwood Beach (Blakely Island)**.

Nourishment projects often incorporate structural elements, such as groins (**Samish Beach**) or existing pockets in otherwise riprapped shorelines (**Cormorant Cove**). At **Salsbury Point**, nourishment was placed adjacent to a modified rock bulkhead. Another variation is demonstrated at **Blake Island**, where nourishment will be accompanied by a largely buried sheetpile retaining wall. This wall appears to serve little purpose except as a landscape feature as the project is built, but provides a structural backup in case the nourishment does not perform as anticipated. Clearly, such a measure adds appreciably to the cost of a project. Also, any structure built to serve as a seawall in the future must be built to the appropriate standard, even though it maybe tempting to compromise on the design of a structure that will be largely hidden when first built.

## ***Monitoring***

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Monitoring implies a periodic survey or review of a project. It may be as simple as qualitative observations and photographs or it may entail extensive and scientifically rigorous biological surveys of the beach. Typically, monitoring might fall between these end points. Few of the projects described in this report have been regularly monitored and even fewer have a formal monitoring plan as a condition of their approval. Projects in this report that had monitoring requirements include **Driftwood Beach (Blakely Island), Blake Island, Indian Island, Samish Beach, and Floral Point**. A number of projects have been monitored informally by those involved in their design, largely in an effort to learn how the projects behave and to use this information to guide future designs.

Monitoring is valuable for several reasons:

- Monitoring of project performance provides the property owner with a way of identifying problems and the need for future action. In some cases, monitoring is the property owner's tool for demonstrating that a soft approach isn't working and that a traditional solution may be appropriate or necessary.
- Projects that involve vegetation or beach nourishment may have a maintenance component. Monitoring can guide the frequency and extent of periodic maintenance and can guide future adjustments to the project's design.
- Monitoring is a tool that agencies can use for evaluating the impacts of a project on ecological resources or on neighboring beaches.
- Monitoring provides the broader community of consultants, scientists, and resource managers with critical information that can be used to better understand the application of specific techniques and the effectiveness of project requirements and conditions. Monitoring allows everyone to learn from both the successes and failures of projects and facilitates, which we hope leads to better projects and better regulation.

There are no standard guidelines for monitoring beach projects on Puget Sound, nor even general agreement on what aspects of a project require monitoring. The objectives for monitoring vary from one project to another and reflect the nature of the particular project. For example, vegetation-based projects may include a monitoring element to document plant survival and the need for replanting as well as a measure of the extent to which the project provides riparian functions such as shade or insect production.

## Summary

Beach projects, and nourishment projects in particular, benefit from periodic surveys of beach topography that allow evaluation of sediment movement, changes in beach elevation, storm erosion, the potential need for future renourishment, and possible off-site beach changes. Beach profiles can be fairly simple to collect, once a basic reference system is established. Annual surveys provide information about chronic beach changes, but often it is necessary to observe the beach semi-annually in order to determine seasonal variations.

Biological monitoring of shoreline projects is made difficult by the lack of understanding of biological processes in this environment and by the increased complexity of the types of observations and statistical procedures that must be followed to draw valid conclusions. Significant inferences about biology can be made from physical observations of beach profile, short-term disturbance (storms and landslides), or sediment size, but what is increasingly needed is better guidance as to what biological variables should be monitored and how to best incorporate this monitoring at practical level.

## ***Project performance***

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Most of the projects examined in this report were built recently and there has been too little time to allow assessment of their success. In addition, few are being actively monitored (see previous section), so there is little information from which to evaluate performance, other than qualitative observations of distinct features such as erosion scarps, exposed anchor cables, or movement of placed logs.

With beach nourishment projects [Shipman, in preparation], we are finding that success is relative -- for example, a project may be viewed as successful in addressing past erosion, yet fail to achieve biological restoration. Also, standards of success vary. Most nourishment projects gradually erode and generally require renourishment. Some individuals accept this as part of the design whereas others see this as an indication of a project that cannot be naturally sustained. Failures do not necessarily reflect on the technique itself, but the appropriateness of the choice for the site or the design of the overall site. Some soft-bank projects succeed locally in reducing the biological impacts that might have resulted from a traditional seawall, yet do not address more systemic ecological concerns, such as the long term supply of sediment to the littoral system.

Perhaps in an area of innovation and experimentation such as alternative erosion control, we should view as successful those projects where the documentation of the project is sufficiently rigorous so that we can learn from our mistakes.

## **Conclusions**

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The fifteen projects outlined in this report illustrate a number of techniques for managing shoreline erosion that reduce the environmental impacts associated with conventional erosion control measures such as bulkheads and rock revetments. Few of these projects have been in existence long enough for final conclusions to be drawn about their success, but the initial success of most has been favorable. All warrant close observation during coming years.

Based on this study, we offer the following recommendations:

- *Monitoring.* Monitoring is key to evaluating both the impacts and the performance of shoreline projects and should be routinely carried out. Some basic guidelines for monitoring reports would benefit both project proponents and regulators. This is particularly true in the case of biological monitoring, where much work needs to be done to establish appropriate measures and methods of assessing beach ecology. Monitoring should include careful documentation of pre-project condition and the project as actually constructed. It may be helpful for the state to provide assistance in monitoring or at least in compiling and reviewing monitoring data.
- *Outreach and education.* There is great demand for information about alternative approaches from property owners, consultants, local governments, and resource agencies. A series of short information sheets might be prepared that describe, in fairly general terms, the types of approaches outlined in this report. Many property owners and project applicants would find a resource guide that identifies potential consultants and helps walk people through the process of selecting a method. This information could be very effectively distributed on the internet. A publication similar to those already produced by the Department of Ecology on Vegetation Management and Drainage would be valuable.
- *Engineering Guidance and Design Standards.* Given the wide variety of circumstances and types of projects and the lack of technical data on which to base designs, it may be impractical to develop detailed design and construction guidelines. In addition, detailed requirements may limit the ability of applicants and designers to propose and develop innovative approaches. What might be more useful is some broader guidance as to the types of projects that are appropriate in what types of settings, the types of information that should be collected and presented in an application and design, and sources of technical information and expertise on specific techniques.
- *Demonstrations.* Efforts should be made to encourage and publicize projects that employ environmentally friendly techniques. Agencies should investigate means of providing funds or

## Summary

incentives to encourage demonstration projects. Resource agencies might consider collaborating with parks departments (state and local) and other public landowners on shoreline erosion projects.

- *Regulatory Requirements.* Increasingly, resource agencies are discouraging traditional seawalls and revetments and promoting the consideration of softer methods. Unfortunately, whereas traditional erosion control methods often receive minimal scrutiny and may be exempted from more rigorous permit review, many preferred methods are not. Regulations should encourage, not discourage, the selection of more environmentally benign measures.

Finally, this report should be used with caution. The inclusion of a shoreline project here is neither an endorsement of the design for application elsewhere nor a guarantee of a project's likely success. We welcome the use of this document as an educational tool to inform people of the wide range of options available and provide reassurance that others have also been willing to try creative solutions. On the other hand, we discourage readers from adopting specific design elements from these examples without careful consideration of their site and the nature of their problem, presumably with professional guidance. The fact that alternatives may be applicable in *some* situations does not mean that an alternative is appropriate in *all* situations.

Many of the measures described in this report entail significant modifications of the shoreline and of natural shoreline processes. Many will require ongoing maintenance and few guarantee that a property will never experience erosion or storm damage. The preferred alternative on most shoreline sites remains adapting the land use to the natural processes on a site and avoiding manipulation of the shore.

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# Glossary

*Armoring* - Term used to describe the construction of seawalls or revetments along a shoreline.

*Backshore* - The portion of the beach beyond the reach of most high tides and landward of the berm.

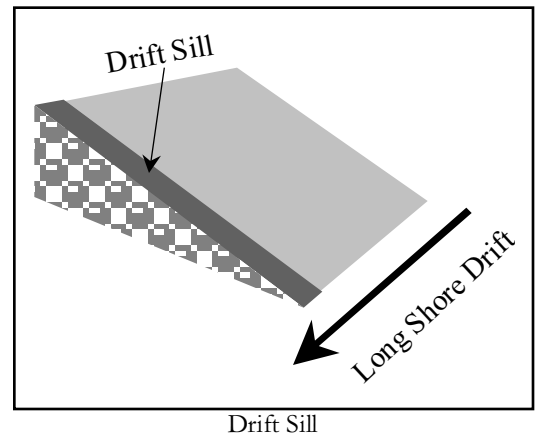
*Berm* - The relatively level bench found high on a beach where sediment is deposited and, at least on Puget Sound, where drift logs accumulate.

*Breakwater* – A structure built specifically to protect a boat basin or harbor from wave action. These are often constructed with rip-rap.

*Bulkhead* – A wall, usually of rock, concrete, or wood, built parallel to the shoreline to protect the bank from wave erosion and to retain soils.

*Bull rock* – Rock from a river or stream. It is naturally rounded, unlike quarry spall.

*Drift Sill* – A groin built level with the beach surface. Designed to allow bypassing of littoral sediment while maintaining a prescribed beach grade.



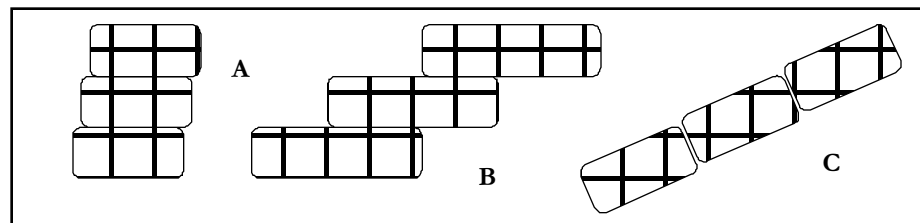
*Ecology Block* – Large precast cement blocks that are approximately 4'L x 2'H x 2'D. They have a reinforcement steel (rebar) loop embedded in them for lifting and anchoring.

*Feeder Bluff*: A eroding bluff that provides sediment to the beach and to long shore drift.

*Fish Rock (Fish Mix)* – A gravel mix that is of suitable size for bait fish spawning (pea gravel).

*Fishtrap Staples* – Heavy staples used to temporarily anchor cable to logs while cable clamps are being applied.

*Gabion*: An erosion protection system that employs wire mesh baskets filled with rock to protect shorelines. These may be stacked to create a bulkhead (A), set up like the geogrid to create a stepped revetment (B) or laid flat to create a smooth slope (C).



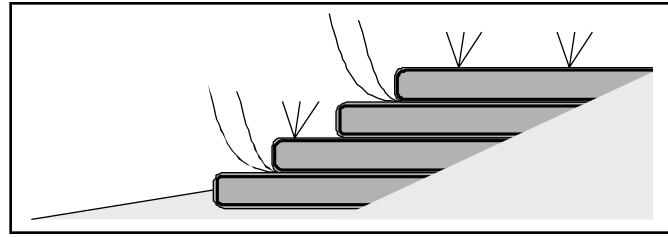
Gabions



## Glossary

*Geogrid* – A bank stabilization system composed of multiple *geogrid lifts* and a planned vegetation system.

*Geogrid lift* – A layer of compacted soils wrapped in geotextile (usually a combination of both natural fiber and plastics).



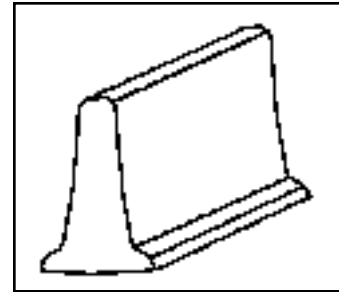
Geogrid

*Geotextile Fabric* – Fabrics used in soft bank structures that serve several purposes. Coir and other natural fiber fabrics (woven straw matting) are used to secure sediments and reduce erosion temporarily as vegetation takes hold. They are designed to deteriorate after the establishment period has passed (~3 years). Filter fabrics are used to maintain fine sediments (behind a bulkhead for example) while allowing water to pass. This prevents the loss of fines from projects while still allowing the release of hydrostatic pressure that may develop. Tensar® and other plastic type materials are used to provide long term structural support.

*Groin* – A structure, built perpendicular to the shoreline, designed to trap sand being moved along the shore by long shore drift.

*Jersey Barriers* – Sectional concrete barriers that often used in highway construction projects.

*Parking Curb* – The cement stops that are often found at the head of parking spaces. They have two or three holes through them that cable can be fed through for anchoring logs into the beach.



Jersey Barrier

*Quarry Spall* – Rock fragments obtained from quarry operations - typically angular and several inches to a foot or so in size.

*Rip-Rap* – Rock boulders placed to form a breakwater or revetment.

*2-man Rock* – A classification for rock size, based in theory on the number of men it would take to lift the rock.

*Revetment* – Rock or concrete armor placed on a slope to dissipate or resist wave action.

*Sacrete* – A structure made of bags filled with hardened concrete.

*Seawall* – A wall built parallel to the shore to protect against wave action - similar to a bulkhead but of a more massive scale.

*Soil Nails* - Soil Nails are a method for deep slope stabilization. They are epoxy-coated rebar driven 15 – 30' into the bank and then encased in a 4" diameter shaft of cement. The nails provide the most support at the face of the bluff where the slope is weakest.