# Soft Shore Protection/Structure Removal Blueprint for San Juan County Forage Fish Beaches

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Friends of the San Juans

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## Introduction

This study was conducted as part of the Friends of the San Juans Blue Print Project, a restoration prioritization effort that integrates biological data, with coastal process analyses and homeowner willingness surveys. Coastal Geologic Services was contracted by the Friends of the San Juans (FRIENDS) to assess and prioritize modified shores for bulkhead removal and soft shore restoration feasibility. The aim of the prioritization assessment was to identify the best beach enhancement projects based on the presence of valuable nearshore habitats, site characteristics that determine project sustainability, and land-owner willingness data.

The study area includes the approximately 9 miles backshore roads and the 85-100 private properties that currently are armored with potential forage fish habitat, as identified by FRIENDS. These beaches were combined with additional modified shores from the Washington State Department of Natural Resources (DNR) Shorezone Database (2001) that overlapped with priority habitat areas mapped by Friends of the San Juans in consultation with Washington State Department of Fish and Wildlife (WDFW). Priority areas share the following characteristics: spawn activity of multiple forage fish documented in the region, multiple spawning sites documented in close proximity, spawn activity documented in multiple seasons, spawn activity documented in region by historic WDFW surveys (1989-1999) and the San Juan County Forage Fish Spawning Habitat Assessment Project (2000-2003), and the presence of eelgrass prairies. Analysis was conducted using and ArcGIS database, air photo analysis, and field studies. The specific methods applied in this study are described below.

## Background

The San Juan Islands are located within the Puget Trough in northwestern Washington State. The Puget Trough lies between the Cascade Mountain Range on the east and the Olympic Mountains and Vancouver Island on the west and contains a series of interconnected marine and estuarine waterways extending 180 miles inland from the Pacific Ocean. The San Juan Archipelago consists of over 172 islands (US Army Corps of Engineers 1971). Orcas, San Juan and Lopez Islands are the largest and most populated islands in the county. Intermediate-sized islands in the archipelago include Blakely, Decatur, Shaw and Waldron Islands, and the smallest islands are only isolated rocks. Most of the islands have moderate relief for their size, generally ranging from 550-875 ft in elevation at their highest points. Orcas Island has the greatest relief with 2,407 ft high Mount Constitution. The total length of shore in San Juan County is approximately 350 miles (US Army Corps of Engineers 1971).

### *San Juan County Bluffs*

The San Juan Islands and adjacent waters of the “Northern Straits” consist of a complex of islands with numerous north-south trending sounds and bays. These waterways and straits surrounding the archipelago were created by the repeated advance and scouring of glacial ice-sheets, the most recent of which advanced into the area approximately 15,000 years ago (Easterbrook 1999). These ice sheet advance removed massive quantities of the complex bedrock formations of the island surfaces, and shaped the islands into near present form.

Glacially derived sediment dominates the region (Easterbrook 1976), and along with less common interglacial sediment, that are exposed in coastal bluffs. The Unconsolidated bluffs, sometimes referred to as sea cliffs in the literature, are present along a large amount of the length of county shores. Bluffs are relatively recent landforms, which formed in the “fresh” landscape left behind after the most recent ice-sheet advance (Vashon advance). Sea levels were generally rising with the global melting of ice-sheets up until approximately 5,000 years ago. This is thought to be the time when the current configuration of bluffs began to evolve (Downing 1983).

Unconsolidated bluff heights generally reach up to 100 ft in the county. The elevation and morphology of coastal bluffs in the study area varies greatly due to differences in upland relief, geologic composition and stratigraphy, hydrology, orientation and exposure, erosion rates, mass wasting mechanisms, and vegetation (Shipman 2004). Marine bluffs are subjected to wave attack at the toe of the slope, which contributes to intermittent bluff retreat through mass wasting events (commonly referred to as landslides) such as slumps and debris avalanches. Much of the unconsolidated bluff length on the county was mapped is “unstable” in the Coastal Zone Atlas (WDOE 1978). Although landslides can also be initiated by hydrologic processes and land use/development changes, wave attack is a long-term driving force in bluff failures in the region. As forwarded by Emery and Kuhn (1982), a steep, sharp-crested, unvegetated bluff profile with sparse debris at the toe of the bluff is indicative of an actively retreating marine bluff dominated by marine erosion.

***San Juan County Beaches***
San Juan County beaches are mixed beaches, composed of gravel and sand. Beaches are present along approximately half of the county shore, whether at the toe of bluffs or along very low elevation backshores. The other half of the shore is composed of high relief bedrock cliffs with no appreciable accumulation of sediment (Johannessen 1992). The morphology and composition of beaches in the study area are controlled by sediment input, wave climate, and shore orientation. Bluff sediment input, primarily glacially deposited units, is the primary source of beach sediment in Puget Sound and the Northern Straits (Downing 1983). Landslides and erosion of these bluffs deliver sediment to the beach in moderate quantities with river and stream input a secondary sediment source. The majority (approximately 90%) originates from bluff landslides and erosion (Keuler 1988). Stream input is undoubtedly lower than 10% in San Juan County.

The most basic control over beach characteristics is wave climate, which is controlled by the open water distance over which winds blow unobstructed (fetch), and the orientation of a shore relative to incoming waves. Low wave energy beaches are composed of poorly sorted sediment with a relatively narrow backshore and intermittent vegetation. Higher wave energy beaches contain areas with well-sorted sediment, often consisting of cobble, over a broad intertidal and supratidal area. Beach sediment size is strongly influenced by the available sediment coming from bluff erosion as well as wave energy, and therefore varies considerably across the county.

Beaches are accumulations of sediment along a shore. As sediment is transported along a beach, it must be continuously replaced for the beach to maintain its integrity. The erosional nature of the majority of Puget Sound and Northern Straits beaches is evident in that most beaches generally consist of a thin veneer of sediment that is only 2-10 inches thick vertically, atop eroding glacial deposits. San Juan County beaches show a wide range of sediment grain sizes. Some of the more exposed beaches are very well sorted gravel beaches of different size classes, while many are mixed gravel and sand. Limited areas have primarily sand beaches, such as several sites on Lopez Island where the bluffs contain relatively high percentages of sand.

A beach serves as a buffer against direct wave attack at the bluff toe. The value of a "healthy" beach fronting a coastal bluff should not be underestimated for absorbing storm wave energy. A gravel berm can serve as a resilient landform with an ability to alter shape under different wave conditions, effectively dissipating most wave energy. Extreme waves do reach bluffs causing erosion, which delivers sediment to the beach and is vital to maintaining the beach. Therefore, bluffs, beaches, and nearshore areas are *completely connected as integral parts of a coastal system*. Past and current management typically treated the bluffs and beaches as separate parts of the coastal system, which has resulted in substantial negative impacts to coastal erosion, nearshore habitats and wildlife.

***Net Shore-drift***
To understand the processes controlling nearshore systems and their continued evolution, the three-dimensional sediment transport system must be examined. The basic coastal processes that control the “behavior” of the beach will be explained first and then put into the context of “drift cells.” Shore drift is the combined effect of longshore drift, the sediment transported along a

coast in the nearshore waters, and beach drift, the wave-induced motion of sediment on the beachface in an alongshore direction. While shore drift may vary in direction seasonally, net shore-drift is the long-term, net effect of shore drift occurring over a period of time along a particular coastal sector (Jacobsen and Schwartz 1981).

The concept of a **drift cell** has been employed in coastal studies to represent a sediment transport sector from source to terminus along a coast. A drift cell is defined as consisting of three components: a site (erosional feature or river mouth) that serves as the sediment source and origin of a drift cell; a zone of transport, where wave energy moves drift material alongshore; and an area of deposition that is the terminus of a drift cell. Deposition of sediment occurs where wave energy is no longer sufficient to transport the sediment in the drift cell.

Net shore-drift mapping in San Juan County was completed in 1992 by Johannessen, under the direction of Dr. Maurice Schwartz at Western Washington University. Net shore-drift mapping was conducted through systematic field investigations of the entire coast to identify geomorphologic and sedimentologic indicators that revealed net shore-drift cells and drift direction. The methods employed in net shore-drift mapping utilized 9-10 well-documented, isolated indicators of net shore-drift in a systematic fashion (Jacobsen and Schwartz 1981). Another previous drift cell mapping effort, the Coastal Zone Atlas of Washington (WDOE 1978), relied exclusively on historic wind records. That method is known as wave hindcasting, where inland wind data records were used for the determination of net shore-drift, without consideration of local variations in winds, landforms, or coastal morphology. Drift directions indicated in the atlas series have commonly been proven inaccurate by extensive field reconnaissance (i.e. Jacobsen and Schwartz 1981, Johannessen 1993).

Net shore-drift is strongly influenced by several oceanographic parameters. The most important of which are waves, which provide the primary mechanism for sediment erosion, inclusion of sediment into the littoral system, and transport. Fetch has been proven to be the most important factor controlling net shore-drift in fetch-limited environments (Nordstrom 1992, Downing 1983). Due to the elimination of ocean swell in most of the county, waves generated by local winds are the primary transport agents in the littoral zone. San Juan County exhibits an extreme range of wave regimes. Storm wave heights reach relatively large size during prolonged winds in more exposed sites, in contrast to chop formed during light winds, which have little geomorphic effect on coasts (Komar 1976). The direction of maximum fetch at a shoreline segment corresponds with the direction of the largest possible wave generation, and subsequently the direction of greatest potential shore-drift.

***Nearshore Habitat***

Shore modifications, almost without exception, impact the ecological functioning of nearshore coastal systems. The proliferation of these structures has been viewed as one of the greatest threats to the ecological functioning of coastal systems (PSAT 2003, Thom et al. 1994). Modifications often result in the loss of the very feature that attracted coastal property owners in the first place, the beach (Fletcher et al. 1997).

With bulkheading and other shore modifications such as filling and dredging, net shore-drift input from bluffs is reduced and beaches become “sediment starved.” The installation of structures typically results in the direct burial of the backshore area and portions of the beachface, resulting in reduced beach width (Griggs 2005) and loss of habitat area. Beaches would also become more coarse-grained as sand is winnowed out and transported away. When fines are removed from the upper intertidal beach due to bulkhead-induced impacts, the beach is often converted to a gravel beach (MacDonald et al. 1994). A gravel beach does not provide the same quality of habitat as a finer grain beach (Thom et al. 1994). Large woody debris (LWD) is usually also transported away from the shore following installation of bulkheads, with corresponding changes in habitat. This leads to a direct loss of nearshore habitats due to reduction in habitat patch area.

Habitats of particular value to the local nearshore system that are substantially impacted by shore modifications include forage fish (such as surf smelt and sandlance) spawning habitat. These habitat areas are only found in the upper intertidal portion of fine gravel and sand beaches, with a high percentage of 1-7 mm sediment (Pentilla 1978), which is fine gravel (smaller than pea gravel) to coarse sand. Sandlance require 0.5-3.0 mm sediment for spawning. Beach sediment coarsening can also affect hardshell clam habitat, by decreasing or locally eliminating habitat.

A recent study by C. Rice documented the effects of shoreline modifications on a Puget Sound beach on surf melt mortality. Results of the study show that anthropogenic alteration of the shoreline typically makes beaches less suitable for surf smelt embryo survival when compared with unmodified shores. The loss of shade caused by a vegetated riparian area exposed beaches to greater sun, increased temperature extremes and variation in the physical environment, creating a harsher environment for life (Rice 2006). The reduction in beach sediment supply can also lead to an increase in coastal flooding and wave-induced erosion of existing low elevation armoring structures and homes.

Loss of marine riparian areas is commonly associated with shoreline development and anthropogenically modified shores. Loss of these valuable areas ensues loss of the ecosystem services or function. Several functions were identified as taking place in a fully functioning marine riparian area in a recent document by Brennan and Culverwell (2004) including: water quality/pollution abatement, soil and slope stability, sediment control, wildlife habitat, microclimate control, shade, nutrient inputs, fish prey production, and habitat structure/LWD. These functions are not just beneficial to humans, fish and wildlife but their health and the integrity of the nearshore marine ecosystem depends upon riparian areas due to their location uniqueness and their valuable inherent functions.

Nearshore habitat assessments in the Puget Sound region have found that large estuaries and small “pocket” estuaries provide very high value nearshore habitat for salmon as well as other species (Beamer et al. 2003, Redman and Fresh 2005). Reduction in net shore-drift volumes due to bulkheading and other modifications and site-specific impacts induced by modifications can cause partial or major loss of spits that form estuaries and embayments. Therefore, with consideration of all these factors, shore modifications can have substantial negative impacts on nearshore habitats.

***Global Warming and Sea Level Rise***

The predicted increased rate of sea-level rise, as a result of global warming, will generally lead to higher coastal water levels, thereby altering geomorphologic configurations, displacing ecosystems and increasing the vulnerability of infrastructure (IPCC 2001, Pethick 2001).

Recent research has also reported that non-bedrock shores, such as the post-glacial material that makes up most of the region’s bluffs, are likely to retreat more rapidly in the future due to increase toe erosion resulting from sea-level rise. Retreat rates may also be amplified in many areas due to increase precipitation, storminess (wave energy) and storm frequency and higher ground water levels (Stone et al. 2003, Hosking and McInnes 2002, Pierre and Lahousse 2006).

Changes in sea level will also result in a spatial response of coastal geomorphology, landward and upwards, in a concept known as the Bruun law (1962). This basic idea (though its accurate application to individual beach is not well understood) appears to apply to all coastal landforms (Pethick 2001). The landward migration of the shoreline is a response to the changes in energy inputs brought about by sea-level rise. Knowing that this translation is to occur offers resource managers a tool, allowing decisions to be made to accommodate, and where possible, facilitate such migration (Pethick 2001).

Accommodating space to enable shoreline translation can enable salt marshes, sand dunes, and beaches to transgress (move landwards while maintaining their overall form). This concept is commonly referred to as “managed retreat” (Cooper 2003). Accommodating sea level rise prevents the diminishment and loss of natural features such as intertidal, upper beach and dune habitats, from being lost between a static backshore (such as a bulkhead or rock revetment) and rising sea level. The concept is commonly referred to "the coastal squeeze".

As a result of these processes related to global climate change, San Juan County will undoubtedly incur considerable habitat loss along its many modified shores, unless managers choose to take a pro-active approach and start initiating programs focused on accommodating sea level rise and utilizing strategies such as managed retreat. There will also be further pressure to construct emergency erosion control structures as a result of increase erosion rates, storminess and storm frequency. Permitting the building of additional bulkheads are not likely to provide a long term solution to the erosion control and will only amplify habitat loss caused by the coastal squeeze.

## Methods

The following methods were applied using best available science and collaboration between Coastal Geologic Services, Friends of the San Juans and technical advisory team selected for their knowledge of local nearshore habitat science and policy. Members of the technical advisory team included: Hugh Shipman, coastal geologist with Washington State Department of Ecology (DOE), Dan Pentilla, WDFW fisheries researcher, Barbara Rosenkotter, SJC salmon recovery lead entity coordinator, Jim Slocomb, SJC Marine Resources Committee vice-chair and spatial analyst, Laura Arnold, SJC Marine Resources Committee member, past SJC planning director, and Larry Moulton, fisheries researcher, co-author- potential forage fish spawning habitat in SJC and spawning habitat assessment methodology manual.

### *Initial Prioritization*

The project was performed using GIS analyses in combination with field assessments to identify and prioritize sites for habitat enhancement/restoration. The initial screening GIS analysis assessed a large number of potential sites and provided data that was used to eliminate sites that were not feasible for enhancement. The initial data set was comprised of 171 beaches derived from the FRIENDS database, which was combined with an additional 10 beaches selected from the Shorezone database, resulting in a combine total of 181 beach segments.

Beach segments included in the FRIENDS database encompassed approximately 9 miles of backshore roads and 89 private properties that were currently armored and were within potential or documented forage fish habitat. Shorezone segments that were >30% modified, and within 300 ft of a WDFW forage fish spawning beach, 300 ft of a herring spawning site and 2,500 ft of the "outer" eelgrass line were added to the FRIENDS list of potential sites. All beach segments were then transposed onto the Shorezone shoreline and linked with additional nearshore attributes. All sites that were rated semi-exposed in the Shorezone database were eliminated, due to the considerable potential for regular high wave energy events, which would reduce the likelihood of long-term project success.

Other site characteristics that are known to influence soft shore protection project success were measured at each site using orthorectified air photos and GIS. These variables included the setback distance of the house/major improvement from the top of bank and measured fetch (the open water distance over which the wind waves can form). The distance from the Mean High Water line (Shorezone shoreline, DNR 2001) to the nearest infrastructure (home, road, structure) was measured in feet and recorded in the GIS attribute file. Fetch influences the level of wave energy to which a given beach is exposed to. Beaches with higher wave energy have greater erosion potential, thus are not optimal sites for bulkhead removal. Shore segments with greater than 15 miles of fetch were eliminated, due to the heightened erosion potential. Additionally, higher energy beaches are typically less successful sites for beach nourishment projects, as they often do not retain beach nourishment sediment as long as sites with less erosion potential (Shipman in prep).

For similar reasons, beaches that were rated semi-protected by Shorezone with less than 15 ft setback were also eliminated from the analysis. The minimal setback distance of 15 ft leaves a very narrow buffer in the upland to provide shoreline erosion management alternatives. Additionally if the erosion cannot be stopped with alternatives, just dramatically slowed, having such a narrow setback distance may cause homeowner anxiety and would likely increase the difficulty of obtaining homeowner willingness. Following elimination of the previously mentioned sites, the number of potential sites was reduced to 34 beach segments (Shorezone segments). Multiple modifications exist in many of these segments. These 34 sites were chosen for field assessment and more detailed analysis.

Prior to field analysis, additional site characteristics relating to the landscape context of the site were assessed using the best available data. The slope stability up-drift of each site was determined using the Coastal Zone Atlas (WDOE 1978) and drift cell descriptions from Johannessen (1992). The location of the site within the larger net shore-drift cell was also recorded. The surface geology of each site was determined using DNR surficial geology layer (1:100,000). The aspect or shoreline orientation of each site was also recorded using the orthophotos.

***Field Reconnaissance***

A detailed field reconnaissance was performed for each shore segment identified in the initial prioritization (34 selected beaches) during April of 2006. Several sites were soon eliminated from the analysis due to lack of property owner permission to access their beach or a blatant lack of feasibility. The bullets below detail why certain sites were eliminated during field reconnaissance:

- ***4 sites eliminated*** – *(Thatcher Bay, Blakely Island; east of the Orcas Ferry Terminal, Eastsound)* **-** Cooperation with property owners highly unlikely due to loss of revenue or high risk to private property and/or infrastructure (if structures were removed or significantly modified), and beach nourishment did not seem sustainable.
- ***6 sites eliminated*** *(San Juan-97, Orcas-132, Orcas-87, Orcas-40, Orcas-128, Lopez-51)* **-** Minimal habitat benefits due to high elevation of the shore modification (well beyond intertidal), or structure was constructed on bedrock and not directly covering habitat
- ***4 sites eliminated*** *(Orcas-60, Orcas-61, Orcas-73, San Juan-54)* **-** Lack of homeowner permission to access property

A number of sites were broken into smaller segments in the field to allow for accurate data collection for individual reaches with different characteristics within Shorezone segments. This was commonly done where individual or groups of bulkheads were present in a larger Shorezone segment, and bulkhead or revetment characteristics changed substantially alongshore. Unique modified reaches within larger segments were delineated into A, B, C, etc. for later scoring. Site naming convention was later altered to the final descriptive names used in results.

Various types of data were collected during the site visits. Data fell in to the following categories: general site information, beach characteristics, shore modification information, upland characteristics, and infrastructure. Beach characteristic data was aimed at conveying the site context, degree of impacts to the beach, the inherent value of the site as habitat today (percent riparian cover, freshwater presence, intertidal vegetation, presence of algae, and sediment characterization). Shore modification data was aimed at assessing the necessity, dimension and degree of impact the modification was having on the associated beach. Data describing the upland characteristic provided useful information regarding local sediment sources, the occurrence of active erosion (landslide or bluff toe erosion), bank height, setback distance, bluff or bank slope, the presence of seeps or springs, and the vegetation characteristics (maturity, community type).

The dimensions of each shore modifications were recorded using a GPS, and then later brought into GIS for digitizing. A shapefile was created of the final modifications to be prioritized for bulkhead removal.

***Final Prioritization***

The final prioritization of potential bulkhead removal projects was conducted using a scoring system that rated a number of variables and site characteristics that are influential to both bulkhead removal feasibility and habitat enhancement value. The scoring system was designed to reflect the objectives of this study in identifying and ranking optimal sites for enhancing forage fish spawning habitat. The scoring variables, associated points, and the general rationale for scoring are outlined in Table 1 (bulkhead removal feasibility) and Table 2 (habitat enhancement feasibility).

This scoring system was applied to all sites that were not eliminated following field reconnaissance. A slight variation was employed for roads versus residential sites. This was done because “setback distance” was not used in scoring roads (as the generally recommended management response is to relocate the road). As a result, residential modifications had the potential to score 4 points higher than roads (59 vs. 63 points possible). The results of how each shore segment scored are displayed in Table 3 (appendix). To allow comparison between mod-types, all scores were reported as a ratio of the total points possible. The 'rank score' displays this number. The 'total score' column displays the total number of points that segment was awarded (out of either 59 or 63 points, as mentioned above).

Scoring was conducted using data primarily collected during site surveys, however additional data sources were used including net shore-drift data (Johannessen 1992), forage fish spawning data from FRIENDS and priority habitat area maps provided by FRIENDS (in consultation with WA Department of Fish and Wildlife (WDFW)). The top ranking sites represent optimal beaches for enhancement. When multiple sites had equally ‘rank scores’, the beach with the highest habitat enhancement value was used to break the tie and determine the higher ranked site for restoration.

***Landowner Willingness Assessment***

The final stage of the larger San Juan County blueprint study integrates social feasibility information with the ecological and physical data analysis results to identify and rank the most optimal soft shore restoration sites. This social feasibility data was collected by distributing shoreline erosion surveys to approximately 240 public and private shoreline landowners on beaches with shoreline armoring to aid in assessing site conditions and evaluate landowner interest in soft shore protection and restoration as an alternative to traditional bulkheading.

Survey distribution included owners of shoreline parcels with armoring, as well as owners of parcels adjacent to or in close proximity and along the same beach reach as parcels with shoreline armoring.

To minimize mailing costs and the effort required by landowners to respond to the survey while also supporting accurate assessment of beach conditions, duplicate landowners were addressed in the following way: landowners with adjacent shoreline properties received one survey, while landowners with multiple, non-adjacent shoreline properties received one survey per independent tax parcel. All survey information included the relevant tax parcel number(s) on the cover letter and landowners with multiple parcels received surveys with parcel data on each survey form. A total of 260 surveys were sent.

**Table 1**. Bulkhead removal/nourishment feasibility scoring and rationale.

| **Bulkhead Removal Feasibility** | |
|---|---|
| **Category and (points awarded)** | **Rationale** |
| Swash aligned (3 pts)<br>Drift aligned (0 pts) | Swash aligned beaches (parallel to prevailing waves) have less erosion potential and greater success in maintaining beach nourishment material (Shipman in prep) |
| Fetch<br>>12 mi (0 pts), 8.1-12 mi (1), 5.1-8 mi (2), 3.1-5 mi (3), 0-3 mi (4) | Higher energy beaches have greater erosion potential and are less successful nourishment projects (Dean 2002, Shipman in prep) |
| Aspect/Orientation<br>S (0 pts), N (1), W&E (2) | Exposure to prevailing/predominant winds (southerlies) is associated with more frequent high wave energy events thus more rapid erosion rates (Downing 1983, Cox 1996) |
| Adequate setback<br>0-25 ft (0 pts), 26-35 ft (1), 36-49 ft (2), 50-65 ft (3), >65 ft (4) | Enables some erosion to occur over the long-term, reduces risk to homes/infrastructure, fewer litigation worries. No setback score was used for road segments |
| Necessity<br>High (0 pts), Moderate (1), Minimal (3), Not (5) | If the erosion control structure is proving minimal function (not necessary or minimal necessity), alternatives may be more appropriate/feasible |
| Adjacent shores (left and right)<br>Modified (0 pts), No mod low bank (1), No mod high bank (2) Bedrock shores (3) | Modifications can result in end effects or exacerbated erosion on the adjacent shore (Plant and Griggs 1992). No mod high bank may provide natural sediment into the beach system. Bedrock often acts as headland - and traps sediment, thus increases the long-term sustainability of a beach project |
| Location in drift cell<br>Origin (0 pts), Mid-cell (2), No appreciable drift (2), Convergence or Drift cell terminus (5) | Sites near origin are more likely to be erosive (Schwartz and Jacobson 1981), mid cell and NAD areas typically have negligible erosion/accretion, and the cell terminus is often accretionary - thus possessing greater long-term sustainability (sediment retention) |

**Table 2**. Habitat enhancement value scoring and rationale.

| **Habitat Value Of Bulkhead/Modification Removal** | |
|---|---|
| Documented surf smelt spawning (10 pts)<br>Potential surf smelt spawning (0 pts) | Documented forage fish spawning habitat is of more value due to their known presence and the species' propensity for site fidelity (Pentilla 2006 pers comm. with FRIENDS'-Tina Whitman) |
| 30-50 % Riparian vegetation (1 pt)<br>>50% Riparian vegetation (2 pts) | Microclimate effects of MRA~Shade decreases egg mortality etc. (Rice 2006) Riparian vegetation measured estimated across Shorezone segment |
| Bulkhead elevation<br>0 – -0.5 ft (2 pts), -0.5 - -1.0 ft (3), -1 - -1.5 ft (4), -1.5 - -2 ft (5), -2 - -2.5 ft (6), -2.5 - -3 ft (7), <-3 ft (8 pts) | **Modification elevations are relative to MHHW**. Low elevation modifications eliminate forage fish spawning habitat, reduce shoreline connectivity, and increase the risk of predation of migrating juvenile salmon (Williams and Thom 2001). |
| Freshwater<br>Present (3 pts) Absent (0) | Estuarine conditions (osmoregulation for juvenile salmonids) |
| Length of modification<br><50 ft (1 pt), 51-150 ft (2), 151-300 ft (3), 301-500 ft (4), 500+ ft (5) | Rehabilitation of long modifications provide greater benefits as greater length of intertidal beach/spawning habitat is typically more cost effective (greater benefit-cost) |
| Priority Area (5 pts) | Areas identified by Friends and WDFW that are of heightened biological value due to presence of multiple forage fish species, spawning within these areas 3 out of 4 seasons |

## Results

The final prioritization methods (described above) were applied to 51 individual beach modifications. All sites not eliminated for the reasons described above were scored and ranked. The top-scoring sites were a combination of beaches within private residential properties and beaches backed by predominantly county-owned roads. As previously mentioned, the scoring results, final ranking and site characteristics subject to scoring are listed in Table 3. The maximum scoring segment received 43 points, normalized to 7.3 out of 10 points, or 73% of the maximum points possible.

The highest rated segments for restoration had the highest cumulative total score. In most cases segments scored very well for either bulkhead removal or habitat enhancement value, but not necessarily both. However, the highest scoring bulkhead removal feasibility and habitat enhancement segments were both included in the top ten sites. The minimum-scoring segment received 16 points, and the average score was 28.7.

The 51 sites scored were spread across the County, with the exception of the far north and eastern coats, where exposure is great, there are fewer beaches and more surf smelt spawning sites were located (Figure 1). Out of the total sites, 13 were on Lopez Island, 16 were on Orcas Island, 7 on were Shaw Island and 15 were on San Juan Island. Thirty-two of the sites were residential bulkhead sites and the remaining 19 were at roads. General issues of road and residential sites will be discussed below, followed by specific discussion of the top 5 sites. Enhancement recommendations follow site summaries. Sites ranked 6-10 will be briefly characterized.

### *General Roads Issues*

In most cases where roads infringe upon intertidal beaches, the beaches are heavily riprapped, with the rock covering what would otherwise be valuable forage fish spawning habitat. Due to their position in the reach of storm waves, many roads and associated rocks likely require periodic maintenance following winter storms. Intermittent road washouts tend to occur along coastal roadways, due to their vulnerable and static position along a migrating landform (the shoreline). The frequency of road washouts is likely to increase as a result of global climate change along roads that are in close vicinity to beaches. Loose riprap tends to topple and move waterward over time, increasing the impact on habitats and necessitating ongoing maintenance. This is particularly true where riprap was not engineered, tightly placed, or keyed into the substrate well.

The presence of riprap shore protection associated with coastal roads presents an ongoing threat to the quality and quantity of intertidal habitat, and will further degrade the beaches for as long as they are present (Macdonald et al. 1994). Shore protection structures in this area typically consist of rock revetments (sloping loose rock), bulkheads (constructed out of concrete, wood or rock) and seawalls (large scale bulkhead in more industrial or urban settings). These structures often bury important nearshore habitats in the intertidal and backshore (Thom et al. 1994), including forage fish spawning habitat. Wave energy reflects off of a shore modification rather than being dissipated by a storm berm, causing the loss of additional beach sediment from modified beaches (Miles et al. 2001). Increased wave reflection and hydraulic turbulence can also remove sand and fine gravel from areas waterward of bulkheads or revetments, sometimes causing the loss of sediment suitable for forage fish spawning (Thom et al. 1994, Rice 2006).

In addition, shore modifications preclude the input of sediment into the beach system. This process-impairment, known as sediment impoundment, exacerbates pre-existing erosional threats (Pilkey 1988). This leads to beach sediment coarsening over time, and the ensuing loss of valuable (forage fish) beach spawning habitat. This impact to beaches will only increase with local sea level rise as the intertidal beaches of modified shores continually narrow and degrade in the coastal squeeze.

Roads have been relocated in the past in San Juan County. In the late 1990s the southern portion of Deer Harbor Road was relocated due to the short- and long-term threat of coastal erosion and the associated environmental impacts caused by the road and bluff armoring. The road removal project was successful and was positively received by agencies and the community. A popular walking path with park benches now occupies the scenic old road site.

*photo taken by H. Shipman*

***Roads Prioritization***

The highest scoring roads for relocation based on the results of this study are displayed in Table 4. All roads that were ranked within the final prioritization of ten sites/areas are displayed in Figure 2.

Ten of the top 14 scoring sites were modified beaches backed by roads. The additional beaches beyond 10 that ranked a little below the top-ten were included in the top-ten list *if* relocating a particular stretch of road enabled the restoration of multiple segments of modified shore within the same immediate area. For example, by bypassing and decommissioning Blind Bay Road, which hugs the perimeter of Blind Bay on Shaw Island, two large stretches of modified beach could be enhanced (southern Blind Bay and eastern Blind Bay). Removing the infringing riprap associated with this road would enable the recovery of a total of over 15,000 square ft of valuable intertidal habitat. Specific recommendations for relocation and habitat enhancement will be outline later in the report.

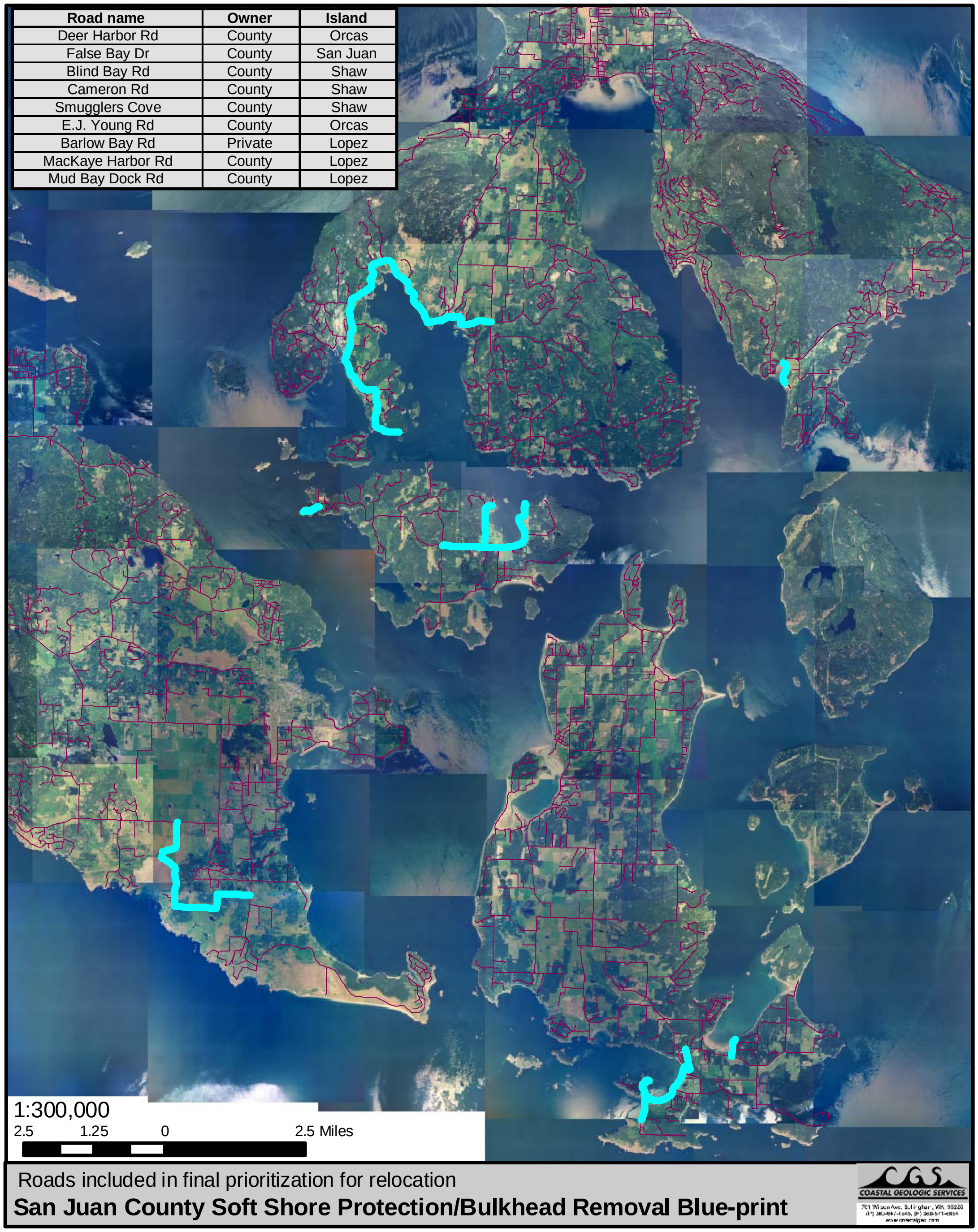
Several roads that also could be relocated were eliminated from this analysis due to high exposure or a lack of obvious relocation site.

**Table 4**. Roads rated for relocation resulting from this analysis. Potential habitat recovered calculations were conducted using the length of the shore modification, its distance from MHHW, and an assumed beach slope of 1:10. Multiple numbers are listed where multiple modifications could be removed resulting from a single road relocation project.

| Road & Island | Potential Habitat Recovered |
|---|---|
| Blind Bay Rd, Shaw Is. | 5,918 sq ft, 9207 sq ft |
| Barlow Bay Rd, Lopez Is. | 4,314 sq ft |
| Smuggler's Cove Rd, Shaw Is. | 1,685 sq ft |
| Private Rd, West Blind Bay | 1,237 sq ft, 349 sq ft, 3,218 sq ft |
| MacKaye Harbor Rd, Lopez Is. | 2,853 sq ft (above MHHW),<br>7,411 sq ft (above MHHW), |
| Deer Harbor Rd, West Sound, Orcas Is. | 2,018 sq ft and at least<br>611 sq ft (above MHHW) |

* all sq ft measurements were calculated using an assumed 1:10 ft upper beach slope.

Further assessment and feasibility could be focused on nearshore restoration along road corridors in San Juan County.




| Road name | Owner | Island |
|---|---|---|
| Deer Harbor Rd | County | Orcas |
| False Bay Dr | County | San Juan |
| Blind Bay Rd | County | Shaw |
| Cameron Rd | County | Shaw |
| Smugglers Cove | County | Shaw |
| E.J. Young Rd | County | Orcas |
| Barlow Bay Rd | Private | Lopez |
| MacKaye Harbor Rd | County | Lopez |
| Mud Bay Dock Rd | County | Lopez |

**Figure 2**. Roads included in final prioritization.

# Top-Ten Bulkhead Removal/Rehabilitation Sites

***Highest Priority Sites***
This section summarized site geomorphic and habitat conditions at each of the top ten bulkhead removal sites resulting from this analysis. Short narratives of the top 5 sites are included below. Sites rated 6-10 are also briefly described. Tables 5 and 6 (found in appendix) display additional data summarizing the conditions of each beach and shore modification.

<u>Site 1. Blind Bay(-S) Road Relocation, Shaw Island</u> - The Blind Bay Road segment road relocation would encompass two potential enhancement projects in southern Blind Bay. These two top rated modifications for removal are located along the southern and eastern shores of the bay. The southern shore grades from no bank (Figure 3) to low bank (approximately 20 ft high) forested uplands. Modifications in this reach include an old riprap revetment, loose rock on the beach and a number of small groins on the high tide beach at the no-low bank shore and heavy riprap at the base of the low bank shore. East of this segment is Blind Bay Rd-east, which is heavily rip rapped low bank shore (Figure 4). The lowest extent of the shore modifications observed in this region was measured at approximately +6.5 ft MLLW.

Southern-most Blind Bay is considered a protected site with maximum fetch measuring less than 2 miles at each beach. Two net shore-drift cells were present that converge at the center of the southern beach (cells SH-3 and SH-4; Johannessen 1992). The modifications are in moderate condition, with some toppling of rock along both shores with more along the eastern shore. Toe erosion or bluff undercutting was observed along the unbulkheaded medium bank shore. The slope of the bank face was measured at 45 degrees during the field assessment. The unbulkheaded area is one of the few sediment sources in the bay and the local drift cell. Additional sediment sources are found up-drift in both cells (Johannessen 1992), in exposed low elevation bluffs composed of glacial till (WA DOE 1978). These two segments have little erosion potential, and if it were not for the extreme close proximity of Blind Bay Road (3-6 ft from bluff crest), erosion control would not be necessary along these shores.

The beaches of Blind Bay encompass valuable forage fish spawning habitat. Mid beach sediment was composed of pebble-sand dominant with minor quantities of granules. Upper beachface/lower backshore sediment was composed of sand with shell and some granules. Some upper beach areas appear to have been filled either to reclaim backshore wetlands, or as part of the road revetment. Scattered riparian vegetation is found along the Blind Bay shores, excluding the higher bank shore in the south-central portion of the Bay, where forested uplands with ample overhanging riparian vegetation are found (Figure 5). Marsh vegetation (*Distichlis spicata*, *Salicornia virginica*, *Triglochin maritimum*) was observed growing along the upper beach in the southwestern corner of the bay. Marsh vegetation is indicative of both a low energy environment, affirming the relatively low need for (substantial) erosion control along this shore.

<u>Site 1. Enhancement Recommendations</u> – The southern shore of Blind Bay provides an excellent opportunity for sustainable beach restoration for a variety of reasons. There is documented surf smelt spawning in the immediate area, the beach is at a drift cell convergence, the erosion potential is low, and the road appears to have minimal traffic. The sustainability of an enhancement project at this sites appears fairly high as the site is only exposed to northerly quadrant winds with limited fetch and Blind Island and adjacent rocks provide minor protection from north winds.

The best long-term solution for forage fish habitat restoration would be to bypass and remove the coastal road in southern Blind Bay altogether. The revetment and small groins could be completely removed and the upper beach and backshore profile restored. This would allow ample room for beach nourishment with appropriate grain size sediment for surf smelt spawning. Overhanging riparian vegetation could also be reestablished, which would effectively shade the upper beach on this north-facing shore. Drainage from the large low elevation area south of the road could be routed into a wetland for water pollution abatement and discharged to the shore in an open channel if the road were removed.

If bypassing the road is not an option, then relocating the road further landward could be beneficial, assuming the distance were great enough to preclude the need for new shore protection in the coming decades. It does not seem worth the expense and effort to move the road a short distance (on the order of 15 ft), as has been done in other counties in recent years (such as at Madrone Way in Coupeville, Island County).

If the above options were not feasible for circulation issues or cost, then beach nourishment and removal and restacking of rock from the upper beach should provide modest habitat benefits for surf smelt. Nourishment would use sediment similar to nearby reference beaches without shore protection. The entire beach profile would need to be nourished as the relatively fine grain sediment requires a gently slope to be stable. This may involve impacts to aquatic vegetation surrounding the MLLW line, and hence would have to be examined in detail with known distribution of resources at the site.

**Figure 3**. Blind Bay Rd - South

**Figure 4**. Blind Bay Rd – East

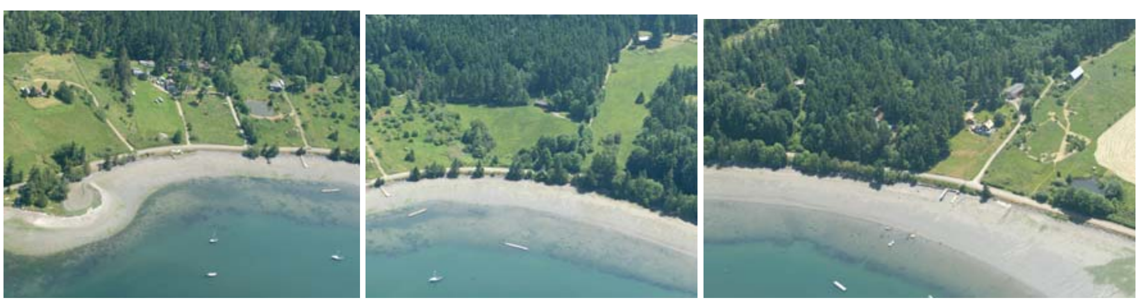


**Figure 5**. Blind Bay Rd (2002 oblique aerial images, WA Dept. of Ecology).

Site 2. Private Rd, West Blind Bay-SW, Shaw Island - The second rated site for bulkhead removal is also found in Blind Bay, Shaw Island. Riprap associated with a road that accesses private property is a priority for removal. Due to the similarity and close proximity of sites Private Rd-West-s Blind Bay (50 ft long) and Private Rd-West Blind Bay (460 ft long) are discussed along with Site 2 (the highest ranking of these sites). The modifications are located between numerous small bedrock prominences that create minor pocket beaches, which make ideal sites for beach nourishment (Figure 6). The roads along much of the shore of Blind Bay appear to have been in place right against the shore of the bay for over 100 years (Figure 7), suggesting that the location was picked for a simple track originally and not for long term use.

As discussed for Site 1, located just east of this site, the low wave exposure makes this area very favorable for enhancement. Similar to the other sites in Blind Bay, these shores are exposed to relatively low wave energy, with the maximum measured fetch of 1.3 miles. Waves approach at near to a 90-degree angle at the site, so these beaches are swash aligned. The combination of shore-normal wave approach, the pocket beach characteristics of this reach and relatively low potential for wave energy, result in very low erosion potential at these sites. Minor toe erosion was evident in some places. Various sizes of rock were used for these erosion control structures.

Forage fish spawning has been documented along several beaches in Blind Bay. Despite the fact that spawning has not been documented along this particular stretch of beach, spawning has been noted along both adjacent beaches to the north and east such that utilization seems fairly likely (the segment was scored as a documented forage fish spawning habitat). Intertidal sediments are pebble-dominant with sand. Backshore sediment was composed of sand with a high quantity of shell. A narrow band of riparian vegetation (confers and shrubs) lines the landward side of riprap along most of these beach reaches.

Site 2. Enhancement Recommendations – The best long-term beach enhancement would be to relocate the private road and remove the shore modifications in all three segments along this private road. As previously mentioned, this could encompass two other highly rated priority restoration sites that resulted from this analysis. Cumulative removal of the three modification areas could recover approximately 4,300 sq ft of intertidal habitat as well as additional supratidal/backshore habitat. The removal would encompass approximately 1,000 ft in total length between the two pockets. This would allow for restoration of the beach profile and backshore and lower bank vegetation. Ample land is available for road relocation, though relocation of the road may infringe on agricultural fields.

Nourishment of the pocket beaches and removal of the rock on the upper beach should be suitable as a short-term enhancement option in this relatively low wave energy environment. This would entail a more direct project with as complete a rock removal as possible, with rock removed from the beach placed atop the upper portion of the revetment. Suitable sediment would be transported to the site with nourishment focused upon the beach profile landward of lower-mid tide beach. As with Site 1, the location of the aquatic vegetation would need to be mapped in detail, however it appears that it is far enough waterward from the private road such that nourishment should be feasible without substantially impacting lower intertidal and subtidal habitats.

**Figure 6**. Shoreline oblique of private rd and shoreline modifications in southwest Blind Bay, Shaw Island. (Image 2002, WA Dept. of Ecology).

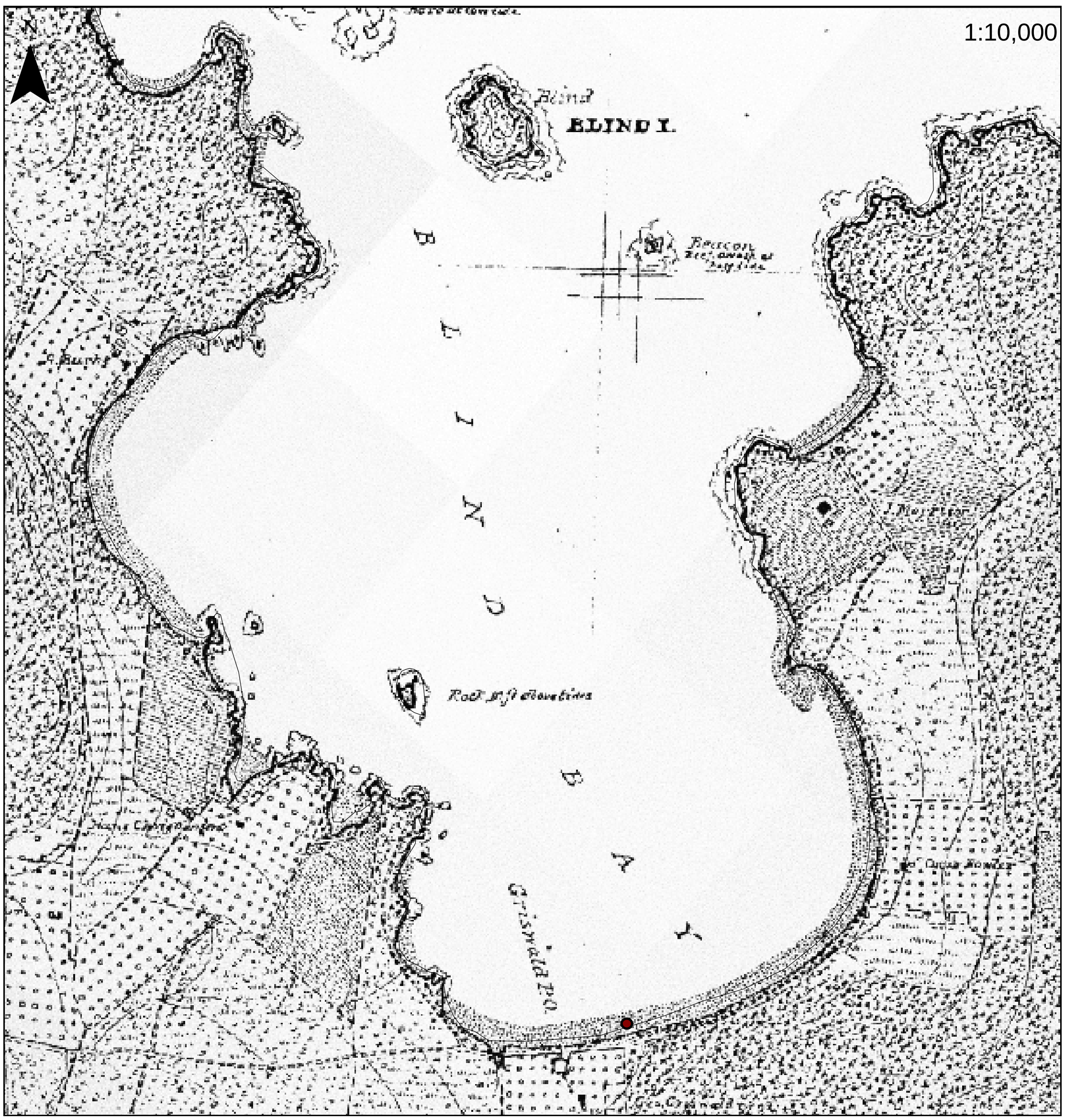



**Figure 7**. Historic Blind Bay conditions, Shaw Island (T-sheet T2230, USC&GS 1895).

Site 3. Barlow Bay Rd, Lopez Island - This segment of modified shore protects Barlow Bay Rd., which extends westward from southern Barlow Bay out to John's Point. The shoreline modification is comprised of 2-3.5 ft riprap intended to curb erosion along Barlow Bay Rd (Figures 8 and 9). However, there were no signs of active erosion occurring along the beach, even following the large on February 4$^{th}$, 2006 storm event. As a result, removing this 173 ft stretch of riprap from the intertidal and upper beach could enhance over 4,314 sq ft of beach habitat.

The western most portion of Barlow Bay is a sheltered corner of an already low (wave) exposure shore. The beach faces directly north, but being located in the southern corner of MacKaye Bay, the beach is protected by southwest Lopez Island. The maximum fetch at this site measures less than one mile. A minor headland to the west (or tombolo), and a bedrock prominence to the north, further protect this shore from wave attack. The beach is low gradient, no bank shore with low relief uplands.

The modified beach is composed of pebble and sand with cobbles. Upper beach sediment is comprised of sand with minor pebble and shell hash. Several species of algae are found along this beach including *Fucus spc.*, *Ulva spc*. and *Enteromorpha spc.*. Overhanging riparian vegetation is found landward of the modification, offering shade to approximately 70% of the uppermost beach. Historically an extensive wetland, likely sat marsh, was located landward of the beach (Figure 10). The beach actually appears to have been a spit that extended west to a tidal inlet. The inlet and wetlands are now mostly filled and the remaining wetland areas are hydrologically controlled by tide gates.

Site 3. Enhancement Recommendations - There are a number of opportunities to enhance the condition of the nearshore at Barlow Bay (Barlow Bay Rd. and adjacent MacKaye Harbor Rd.). Removal of the riprap adjacent to Barlow Bay Rd should be the highest priority restoration action (Figure 8). This site does not appear to require shore protection along most of its length for erosion control. The site is in a very low (wave) energy environment and there is a buffer of variable width between the rock and the road. This would allow for rehabilitation of the valuable spawning habitat that the rock is infringing upon. Following rock removal, the beach would be nourished to restore upper beach sediment suitable for forage fish spawning and reduce erosion potential.

Several additional restoration opportunities exist in Barlow Bay east of the area described above. This included: removal of derelict piles, piers and (concrete) debris on the upper beach and decommissioning and bypassing MacKaye Harbor Rd and restoring the hydrology and associated wetlands landward of the beach. Because considerable modification has taken place at this site prior to early mapping (1897), restoration feasibility studies need to be conducted prior to undergoing the latter of these restoration actions.

Historic mapping showed a barrier spit with a small backshore lagoon in the southwestern corner of the bay (Figure 10). A similar barrier beach and low elevation backshore appears to have been present east of the spit with wetlands, that appear diked off by 1897. Numerous nearshore habitat values were likely lost with the filling of this area, including a loss of shoreline complexity, and shallow water and salt marsh habitats. Each of these enhancement opportunities would be positive steps toward a larger effort to restore this valuable but degraded beach system.

**Figure 8.** Barlow Bay Rd –Southwest, looking west.

**Figure 9.** Barlow Bay Rd, 2002 DOE oblique.

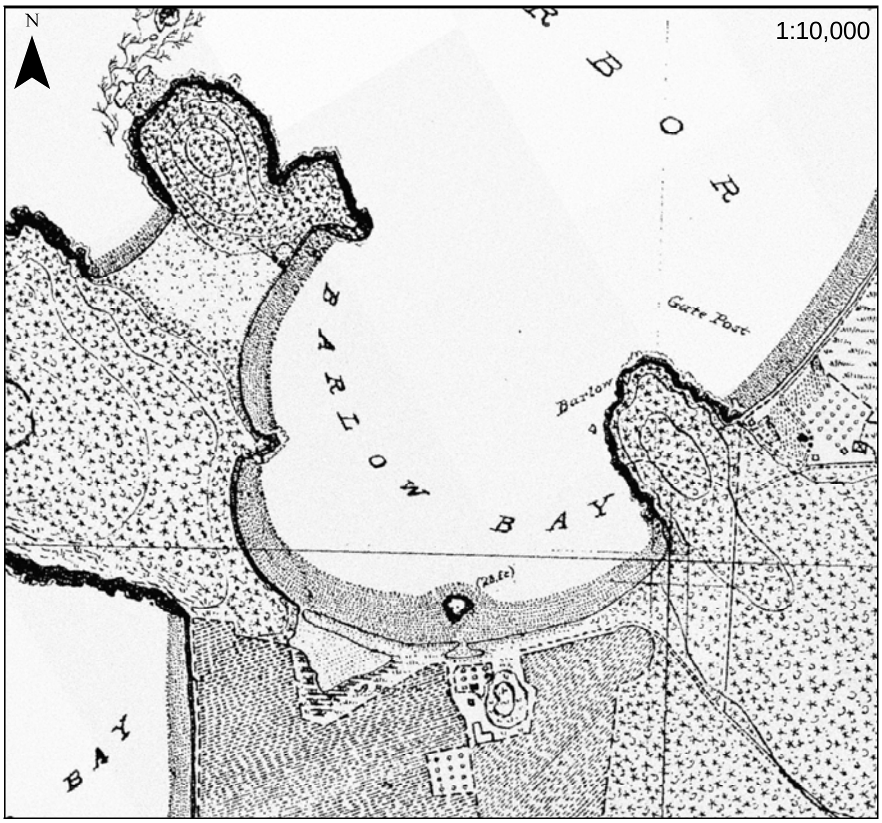



**Figure 10.** Historic Barlow Bay 1897, T-sheet no. 2302, USC&GS 1897.

<u>Site 4. Smuggler's Cove Rd. (northwestern Blind Bay), Shaw Island</u> - The fourth-ranking shore modification for removal/enhancement was located in northwestern Blind Bay, adjacent to Smuggler's Cove Rd. Smuggler's Cover Rd. extends north along the western shore of Blind Bay (Figure 11), where it links with Runnymede Lane and Newton Beach Rd. The modification consists of a low elevation rock revetment along road edge. The structure protects Smuggler's Cove Rd.. West of where the road setback is least, is the base of Cooper Hill.

This beach faces east and similar to other Blind Bay sites, has low erosion potential due to limited wave energy. Fetch measures approximately 1.5 miles. The distance from the edge of the road to MHHW was generally around 4 ft. The beach is swash aligned, and is found in the middle of drift cell SH-2. This cell exhibits southward drift, evident by decreasing sediment size and a stream mouth offset to the south (Johannessen 1992). The sediment source for the cell is glacial till, which occurs at the cell origin and over most of the length of the cell (Johannessen 1992). A small stream appears to drain through the north-central portion of this site.

WDFW has documented forage fish spawning along the southern half of this beach. Adjacent no-back shorelines possess a narrow band of driftwood. Riparian vegetation is patchy, and found both north and south of the road revetment. Sediment is composed of sand with overlying pebble.

<u>Site 4. Enhancement Recommendations</u> - Removing the 240 ft of riprap overlying this beach could recover approximately 1,685 sq ft of forage fish spawning habitat. Rock prominences located at either end of the beach minimize large losses of sediment from the beach system, making this shore well suited for beach nourishment. The area around the small stream could be enhanced and provides additional restoration opportunities.

Due to the very close proximity of the road and the intertidal, the most obvious and viable long-term restoration action at this site is to setback Smuggler's Cove Rd. to the base of Cooper Hill. This would allow for full restoration of the beach profile (including the berm and backshore) and enhancement of forage fish spawning areas. It would also allow for marine riparian enhancement adjacent to the shore, which could have numerous positive effects on the beach. Beach nourishment could be used to reestablish the beach and backshore profile and augment potential spawning habitat. If road setback were minimal, composite large woody debris (LWD) structures could be used to help retain nourishment sediment, especially along the central portion of the beach, which appeared to be more impacted by the road. However, this would offer more limited habitat improvement than the option described above.

**Figure 11.** Smuggler's Cove Rd, Northwest Blind Bay, Shaw Island (2002 DOE oblique).

Site 5. West Shoal Bay, Lopez Island - This residential property spans across two adjacent lots in southwestern Shoal Bay, located on northern Lopez Island. This fifth-rated site for enhancement is found at the toe of a moderate height bank (approximately 30 ft). The modified area extends approximately 69 ft alongshore and is in very poor condition (Figures 12 and 13). It appears that boulders were dumped from the bank crest down the bank face to curb toe erosion. The lack of careful and targeted rock placement and presence of additional rock on the slope has caused the rock to migrate waterward (down to mid-tide level) during high tides, resulting in the burial of the natural intertidal beach. It is unlikely that the modification is providing much erosion control it its poor state, and is clearly degrading beach habitat. The beach sediment surrounding the modified was composed of sand with moderate pebble and granules, and has been documented as valuable forage fish spawning habitat. Removing this shore modification would recover approximately 1,665 sq ft of intertidal area.

West Shoal Bay faces directly north with fetch measuring approximately 5 miles to southern Orcas Island. This beach is swash aligned with wave fronts approaching directly towards the shore. Following the field reconnaissance, this shore segment was determined to have low-moderate erosion potential. The homes located atop the bluff are setback approximately 75 ft from the bluff crest. The modification is located within drift cell LO-1, which exhibits eastward drift (Johannessen 1992). Up-drift sediment sources, including landslides and toe erosion were observed during the field reconnaissance.

The beaches of Shoal Bay encompass valuable forage fish spawning beaches. Mid beach sediment was composed of sand with scattered pebbles and minor quantities of granules. Upper beachface/lower backshore sediment was composed of sand with moderate pebble and some granules making it very good habitat. Scattered riparian vegetation is found along south-central Shoal Bay, however the western and eastern shores have more heavily forested uplands with ample overhanging riparian vegetation. Several sources of freshwater are found within southern Shoal Bay, however no source of freshwater is found within this section of modified shoreline.

Site 5. Enhancement Recommendations - There are several restoration opportunities in Shoal Bay, including Site 5, removal of an upper beach concrete pad further east at the base of the spit, and at the mouth of the lagoon. Because the shore modification at Site 5 infringes upon forage fish spawning habitat further than the area at the base of the spit, it should be of the highest priority. The beach enhancement action at this site is to simply remove the rock that is currently covering the intertidal beach, and to the extent possible, from the backshore area. Because the rock debris is scattered over only 69 ft this should not require considerable effort or funding, however alternative erosion control for the upland property and managing the rock removal from the beach will require additional consideration.

Additional enhancement opportunities in Shoal Bay include removal of a concrete section of upper beach that appears to be an old shuffleboard court (now listing) in the southeastern end of bay (west of lagoon), and a degraded soldier pile bulkhead that runs adjacent to the shuffleboard. This area appears to be fairly stable (originally an accretion beach), and shore modifications do not appear to be necessary. Removing the shuffleboard court and pile wall presents homeowners with a low-cost opportunity to enhance the ecology of their shoreline.

**Figure 12**. West Shoal Bay modification.

**Figure 13.** West Shoal Bay modification (2002 DOE oblique).

***Additional High Priority Sites***

Site 6. Jasper Bay, Lopez Island - Jasper Bay is a small pocket beach located on the southeast shore of Lopez Island in Lopez Sound (Figures 14 and 15). A single property owner owns the uplands, though the tidelands are apparently held by DNR. The beach has potential forage fish spawning habitat, overhanging riparian vegetation across most of the shore, and small stream mouth with mature conifers surrounding the stream. An approximately 150 ft long rock revetment covers the upper intertidal and backshore area. This structure, comprise mainly of glacial erratic, was judged to be generally unnecessary for erosion control during field reconnaissance. The revetment contained several places were small boats were stored and the end of a rough track from the uplands. The revetment is recommended for removal along with beach nourishment if any structures were to remain.

**Figure 14.** Jasper Bay beach, riparian cover and riprap (2002 DOE oblique).

**Figure 15.** Jasper Bay beach and rockery.

Site 7. Deer Harbor pool, Orcas Island - This derelict concrete community pool is located on the upper intertidal of a beach in northeastern Deer Harbor (Figure 16). The concrete pool frame was built into the beach and encompasses the entire upper intertidal and backshore of the beach. The structure has completely failed and the walls were cracked and falling in several places. Estuarine marsh vegetation covers the adjacent northern shore (Figure 17). Cayou Valley Creek estuary resides north of the site, contributing to the estuarine condition of northern Deer Harbor. It is probable that this creek was historically salmonid bearing (Deer Harbor Restoration Project Team 2005), thus increasing the restoration value of this site. This beach in this area was mapped as potential forage fish spawning habitat (if the site were not infringed upon by modifications).

Recommendations for enhancement at this site include removing the entire cement pool walls and footings, followed by backfilling sediment into the old footing areas (minor beach nourishment). Whether the concrete is anchored into bedrock would influence the removal. Riparian vegetation should be enhanced where damaged by removal work and marsh vegetation including *Distichlis spicata* and *Salicornia virginica,* should be planted to initiate recreation of estuarine-marsh conditions.

**Figure 16.** Deer Harbor pool, looking north.

**Figure 17.** Deer Harbor pool, looking south.

Site 8. Aleck Bay (west), Lopez Island - This site scored quite well for habitat values, and moderately well for bulkhead removal feasibility. However, based on professional judgment of CGS staff this project should not be pursued for bulkhead removal. The apparently recent construction of the wooden soldier pile bulkhead and small setback distance of the house, make homeowner willingness highly unlikely (Figure 18). There are however, additional opportunities to enhance this beach, including removing the concrete pier footings on the beach (see arrows in Figure 18), restoring the hydrologic connectivity of the large marsh (located southwest of this site) to the marine environment and removing the large bulkhead and reconfiguring the community beach access at the eastern end of the site, which extends well into the intertidal (Figure 19).

**Figure 18.** Aleck Bay soldier pile bulkhead.

**Figure 19.** Aleck Bay beach access opportunity.

Site 9. MacKaye Harbor Rd. - Two sections of modified shore (comprised of loose rock revetment), found in the central and eastern portions of the bay, provide minimal function and could easily be removed (Figures 20 and 21). This would help reestablish dune and marsh vegetation found in the upper intertidal and backshore. Additionally, removing derelict piers, piles and debris from the intertidal would require minimal cost and effort, while providing considerable benefit.

Restoration of the natural hydrology of the Barlow Bay coastal wetlands presents a great opportunity to enhance the ecological value of the bay. At least two major tide gates (10" cement pipes) restrict flow and prohibit marine water from flowing into the backshore wetlands. It is likely that prior to installation of these tide gates an extensive tidal wetland complex was found landward of the modern beach. Freshwater wetlands have also likely been reduced by filling, draining and other hydrologic control. This large scale restoration would require a feasibility study to define the exact restoration potential of the area.

Relocation of the MacKaye Harbor Rd. to a more landward (higher elevation) location would prevent the road from infringing on the beach any further. It would also avoid the need for additional protection of the road, which will likely experience repeated overtopping and/or inundation based on anticipated sea level rise projections. Relocating the road could provide room for natural shoreline translation (an implication of sea level rise), without the loss of habitat.

**Figure 20.** MacKaye Harbor Rd, looking west.

**Figure 21.** MacKaye Harbor Rd (2002 DOE oblique).

Site 10. Deer Harbor Rd. Relocation – The Deer Harbor Rd., near the West Sound Grange Hall and the Yacht Club, is located over what would be the upper beach and backshore. A large rockery and riprap revetment were constructed at this low bank shore, apparently to defend the road. These structures infringe upon and degrade potential forage fish spawning habitat and impound bank sediment at this site. The integrity of much of the structures was observed to be poor, as it appears to have experienced numerous recent failures in the rock (Figure 22), likely resulting from the February 4th, 2006 windstorm. There was a considerable volume of toppled boulders on the beach that have fallen from the revetment. This has buried valuable intertidal habitat (Figure 23).

Habitat infringement and revetment damage resulting from storms are likely to be exacerbated as a result of sea level rise and global climate change. As a result the most sustainable management strategy is to bypass or relocate Deer Harbor Rd. at this location and remove this failing rockery and revetment and restore the beach. Beach restoration should include beach nourishment and planting a riparian buffer of native vegetation.

**Figure 22**. West Sound revetment failure.

**Figure 23.** Toppling boulders over intertidal.

## Landowner Willingness Assessment (Preliminary) Results

One hundred and thirteen surveys (a response rate of 40%) were returned by shoreline landowners; providing quantitative information on landowner interest in soft shore restoration. These results are preliminary as additional landowner surveys are waiting to be received. When (preliminary) land owner willingness data is applied to the CGS results the sites that surface as the most feasible to pursue restoration at include:

- The Deer Harbor Pool, previously ranked site #7
- The central modified sections in West Friday Harbor, previously ranked #33
- A county-owned property located near Turn Point, previously ranked #39.

Details of how to enhance these sites will be provided upon request.

# Further Work

***Additional Restoration Opportunities Similar in Nature in SJC***

A number of sites were identified in the course of the GIS and field work that showed high potential for enhancement and further study.

Neck Point Restoration, Shaw Island - Reconfiguring Neck Cove, located on western Shaw Island, to its original form would restore a number of lost intertidal habitats. Fill has been placed over the historic lagoon and the northern spit has been filled to create an isthmus and roadway between Neck Point and Shaw Island. This fill could be removed with a bridge built in its place, which would allow for cutting a new tide channel where it once was prior to alteration.

Recreating the original configuration of the shore would restore the natural tidal flushing between Neck Point and Shaw Island, which could have numerous indirect benefits to the habitat conditions historically found therein. For example, local elders on Shaw Island have made observations of the gradual infilling of the northern bay, and the associated reduction in eelgrass beds. Restoring this section of shoreline could recover lost shoreline complexity, a coastal lagoon and tide channel, as well as backshore, dune and salt marsh habitat (Figures 24 and 25). The original configuration of the shore in this area would need additional investigation as part of a larger feasibility study that could result in restoration designs. It is likely that the original configuration was similar to the shores visible in Figures 24 and 25.

**Figure 24.** Camera copy of flyer publicizing Neck Point from 1940s-1950s era.

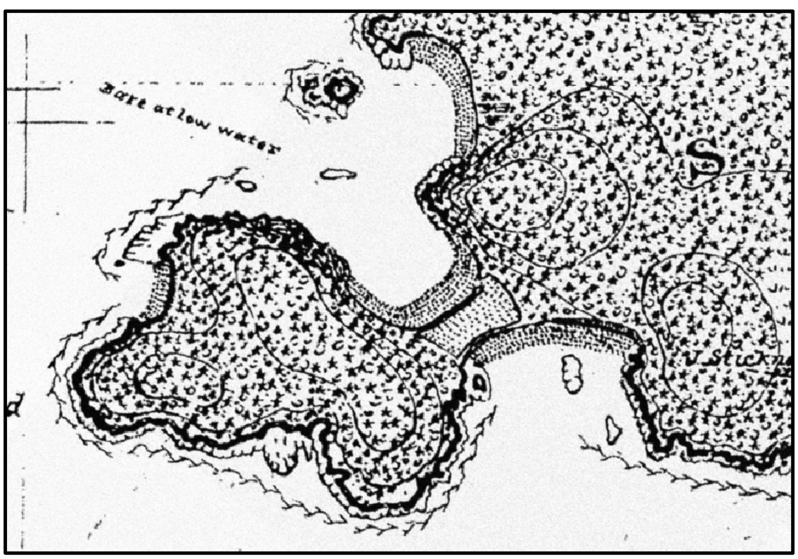



**Figure 25.** Portion of T-sheet no. t2229, showing Neck Point, 1885.

Crescent Beach Road Bypass, Orcas Island - This opportunity entails bypassing Crescent Rd. where it runs adjacent to the bayhead beach in northern Eastsound (Figure 26). The road suffered considerable damage from the February 4$^{th}$, 2006 windstorm, affirming the vulnerability of roads that directly abut higher energy beaches. This shore has considerable exposure to predominant southerly wind waves. The elevation of the road is only slightly higher than the beach and was likely built atop the original storm berm of the historic beach profile. The presence of the large backshore wetland (located immediately north of the road) is evidence of continual overtopping of the road and/or historic storm berm, and represents a common beach configuration. As a result continued overtopping of the road should be expected. Overtopping, washouts and storm damage will also likely occur at this site with greater frequency as an implication of accelerated sea level rise. If additional shore protection were permitted, impacts to nearshore habitats would inevitably be incurred as a result of “the coastal squeeze”.

Bypassing this road would allow for removal of the road, recreation of the beach profile (and storm berm), restoration of the hydrologic connectivity of the backshore wetland and preservation of numerous valuable nearshore habitats. Recreating the natural beach profile would require beach nourishment. Nourishment material would be configured to form a functioning storm berm with a natural transition to dune habitat and the coastal wetland. Restoring the beach profile would allow for natural shoreline translation, which will prevent unnecessary habitat loss as a result of sea level rise. Due to the close proximity to town, this restoration opportunity would be highly visible and could provide considerable recreational value.

**Figure 26.** Crescent Beach road by-pass and beach restoration, 2004 air photo.

<u>Cove South of Indian Point, West Sound, Orcas Island</u> - This site scored well for restoration, however after an additional step in reviewing historic maps of the site was completed, the site appears to be even higher restoration value. The current shoreline is armored with logs, and a culvert controls the outflow of freshwater from a wetland (with ponded water) just landward of the bank crest. If the property owners are willing, fill could be removed from the low bank shore to recreate a mini-estuary comprised of a lagoon, two converging spits and a tide channel (Figure 27, 28). The shore modifications could be removed and the natural beach profile restored along with tidal flow to the lagoon. This unique opportunity could cumulatively restore considerable shallow water intertidal area (with high edge-to-area ratio), a pocket estuary and marsh habitat. In addition, this proposed project offers sustainability, as it would recreate original conditions and the site has low erosion potential.

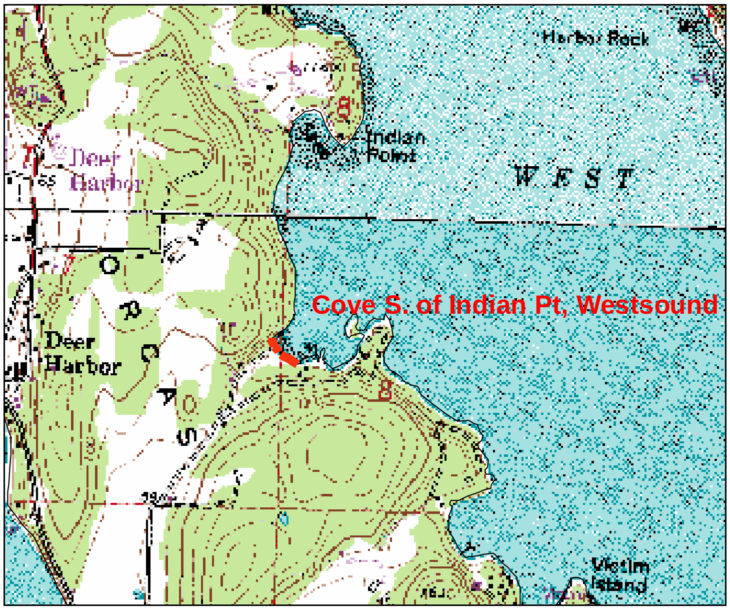



**Figure 27.** Location of potential restoration site (in red) south of Indian Point.

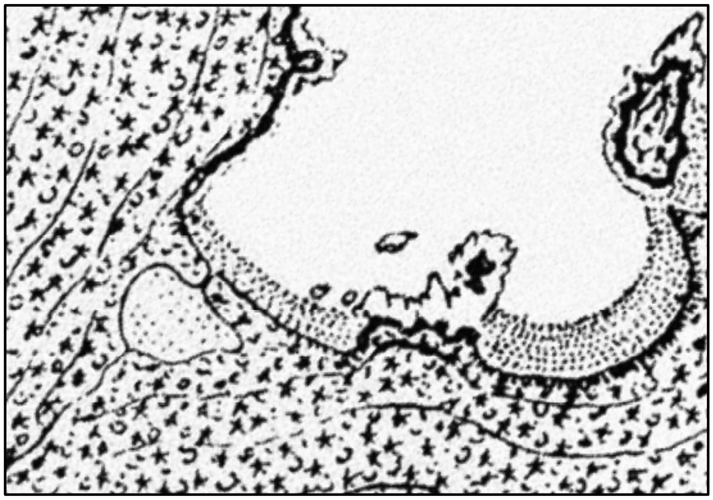


**Figure 28.** T-sheet no t2229 showing southern Cove, 1895.

Shoal Bay Lagoon Tide Gate Removal - There are several additional restoration opportunities in Shoal Bay. Removal of the large cement tide gate located within the tide channel waterward of the lagoon in the eastern corner of the bay should be of high priority. The tide gates do not appear to be functional, and the tide channel is scoured out on either side of the cement walls (Figure 29). The structure appears to constrict flow and impede fish passage through the channel at lower water due to its artificially high concrete base in addition to other impacts. The Department of Fish and Wildlife (WDFW) has mapped the lagoon wetland system and the Shoal and Swift's Bays estuarine system as priority habitat and species areas, as these areas are used by several species. Additionally the lagoon is located within a conservation area. Additional study of the tide channel hydraulics and morphology should be conducted prior to initiating structure removal.

**Figure 29.** Failed tide gate and constriction at the mouth of Shoal Bay lagoon.

## Conclusions

The results of this county-wide analysis can be used to take action on numerous restoration and beach enhancement projects in the area. Both physical and ecological attributes, including project sustainability, were assessed at each recommended site to assure restoration success. In total over 80,071 sq ft of intertidal habitat and 37,573 sq ft of backshore habitat were identified for restoration, all of which was located within either potential or documented forage fish spawning habitat.

Nineteen enhancement opportunities were identified along predominantly county-owned roads. One opportunity along a county-owned beach was identified, and 31 sites were identified on private property. Several additional restoration opportunities outside the scope of this study were also reported. In addition to the previously mentioned opportunities for further research and restoration action, CGS has outlined a number of future research endeavors, which could provide considerable benefit to the nearshore and those that manage this valuable resource.

***Additional Research to be Conducted in San Juan County***

- Research focused on local and regional (geomorphic) implications of sea level rise. Identify high-risk areas for increased erosion rates, inundation and habitat loss.
- Restoration feasibility study of Barlow Bay/MacKaye Harbor Rd. coastal wetlands.
- Restore armored creek mouth in western Shoal Bay.
- Restoration feasibility study of reconnecting hydrology between Aleck Bay and cattail marsh in backshore (historically salt marsh, T-sheet 2302).

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# Appendix

**Table 3.** Results of final prioritization of potential enhancement sites in SJC i
**Table 5.** General attributes of top ten sites for enhancement in SJC ii
**Table 6.** Physical attributes of top ten sites for enhancement in SJC iii
**Figure 1.** San Juan County potential restoration sites subject to scoring and top ten ranked sites iv

**Table 3.** Results of final prioritization of potential bulkhead removal projects in San Juan County. Multiple rankings (1, 2, & 9) represent restoration opportunities that encompass multiple shore modifications.

| Rank Summaries | | | | | | | Variables that contribute toward bulkhead removal and nourishment feasibility | | | | | | | | | Variables that effect habitat enhancement value | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All Sites Rank | Rank Score (nrml) | BRF-subtotal (nrmlzd) | HEV-subtotal (nrmlzd) | Score Total | CGS/FSJ Name | Type | Alignment | Fetch (mi) | Aspect | Setback (ft) | Necessity | Adjacent-L | Adjacent-R | NSD Cell Setting | Bank Type | Doc/Pot | Riparian (%) | Freshwater | Priority | MOD elv (reltv to MHHW) | Length (ft) | IT Area Recovered (sq ft) |
| 1 | 7.3 | 7.0 | 7.5 | 43 | Shaw, Blind Bay Rd-S | road | swash | 1.7 | N | 4 | moderate | bedrock | mod | CONVG | no bank | 1 | 20 | y | 1 | -1.2 | 493 | 5,919 |
| 2 | 6.9 | 6.3 | 7.5 | 41 | Shaw, Blind Bay Private Rd-SW | road | swash | 1.3 | N | 10 | moderate | mod | bedrock | CONVG | low bank | 1 | 60 | y | 1 | -0.7 | 177 | 1,238 |
| 3 | 6.6 | 4.1 | 8.8 | 39 | Lopez, S. MacKaye A-Barlow B Rd | road | swash | 1 | N | 1 | high | low bank no mod | mod | NAD | low bank | 1 | 70 | y | 1 | -2.5 | 173 | 4,315 |
| 4 | 6.6 | 6.3 | 6.9 | 39 | Shaw, Smuggler's Cove Rd | road | drift | 1.5 | E | 4 | moderate | bedrock | bedrock | MID-CELL | no bank | 1 | 10 | y | 1 | -0.7 | 241 | 1,685 |
| 5 | 6.5 | 6.8 | 6.3 | 41 | Lopez, West Shoal Bay | residential | swash | 5 | N | 75 | moderate | no mod high | no mod high | CONVG | mod bank | 1 | 70 | n | 0 | -2.4 | 69 | 1,665 |
| 6 | 6.2 | 7.7 | 4.7 | 39 | Lopez, Jasper Bay | residential | swash | 2 | SSE | 100 | not | bedrock | bedrock | NAD | high bank | 0 | 80 | y | 1 | -1.6 | 149 | 2,385 |
| 7 | 6.2 | 7.7 | 4.7 | 39 | Orcas, Deer Harbor -pool | residential | drift | 0.4 | W | 125 | not | low bank no mod | bedrock | TERM | low bank | 0 | 80 | y | 0 | -3.2 | 200 | 6,397 |
| 2 | 6.1 | 5.2 | 6.9 | 36 | Shaw, Blind Bay Private Rd-W-s | road | drift | 0.4 | NE | 18 | moderate | mod | bedrock | CONVG | low bank | 1 | 70 | y | 1 | -0.7 | 50 | 350 |
| 2 | 5.9 | 3.7 | 7.8 | 35 | Shaw, Blind Bay Private Rd-W | road | drift | 0.4 | NE | 18 | moderate | mod | no mod high | MID-CELL | low bank | 1 | 70 | y | 1 | -0.7 | 460 | 3,219 |
| 1 | 5.9 | 4.4 | 7.2 | 35 | Shaw, Blind Bay Rd-E | road | drift | 0.6 | W | 1 | moderate | low bank no mod | no mod high | ORI | no bank | 1 | 30 | n | 1 | -0.7 | 1,315 | 9,208 |
| 8 | 5.7 | 5.2 | 6.3 | 36 | Lopez, Aleck Bay-s | residential | swash | 10 | SE | 35 | moderate | bedrock | no mod high | NAD | no bank | 1 | 80 | y | 0 | -1.1 | 166 | 1,821 |
| 9 | 5.6 | 4.4 | 6.6 | 33 | Lopez, MacKaye Hbr Rd-s | road | swash | 1 | N | 1 | high | mod | mod | NAD | no bank | 1 | 0 | y | 1 | 0.4 | 713 | -2,854 |
| 9 | 5.6 | 4.4 | 6.6 | 33 | Lopez, MacKaye Hbr Rd-se | road | swash | 1 | N | 0 | high | mod | mod | NAD | no bank | 1 | 0 | y | 1 | 1.3 | 570 | -7,411 |
| 10 | 5.6 | 5.6 | 5.6 | 33 | Orcas, Deer Harbor Rd east-ctr | road | swash | 3 | S | 30 | not | mod | mod | MID-CELL | mod bank | 1 | 0 | y | 1 | 1.3 | 33 | -427 |
| | 5.6 | 6.5 | 4.7 | 35 | SanJuan, Friday Harbor W-north | residential | swash | 2 | E | 50 | minimal | bedrock | mod | NAD | mod bank | 0 | 60 | y | 0 | -3.4 | 224 | 7,599 |
| | 5.6 | 6.8 | 4.4 | 35 | Lopez, East Shoal Bay-spit | residential | drift | 5 | N | 100 | not | low bank no mod | mod | CONVG | no bank | 1 | 70 | n | 0 | 1 | 65 | -645 |
| | 5.4 | 5.8 | 5.0 | 34 | Lopez, East Shoal Bay-west | residential | swash | 5 | N | 25 | not | mod | mod | CONVG | mod bank | 1 | 70 | y | 0 | 1.3 | 104 | -1,349 |
| | 5.2 | 4.8 | 5.6 | 33 | Lopez, Aleck Bay-n | residential | swash | 10 | SE | 100 | moderate | no mod high | no mod high | NAD | mod bank | 1 | 80 | n | 0 | -1.9 | 65 | 1,234 |
| | 5.1 | 5.2 | 5.0 | 30 | Orcas, Deer Harbor Rd east | road | swash | 3 | S | 15 | not | mod | mod | MID-CELL | mod bank | 1 | 0 | n | 1 | 1.3 | 14 | -184 |
| | 5.1 | 7.4 | 2.8 | 32 | SanJuan, Turn Pt east (marsh) | residential | swash | 9 | W | 100 | not | bedrock | low bank no mod | NAD | no bank | 0 | 10 | y | 0 | -1.8 | 191 | 3,433 |
| | 4.9 | 4.5 | 5.3 | 31 | Lopez, East Shoal Bay-e | residential | swash | 5 | N | 25 | moderate | mod | mod | CONVG | mod bank | 1 | 70 | y | 0 | 1.2 | 205 | -2,460 |
| | 4.9 | 6.5 | 3.4 | 31 | Orcas, West Sound S.Indian Cv-ctr | residential | swash | 1 | NE | 100 | minimal | bedrock | mod | NAD | low bank | 0 | 65 | y | 1 | 0 | 78 | 0 |
| | 4.9 | 3.3 | 6.3 | 29 | Orcas, Deer Harbor Rd -west ctr | road | swash | 3 | S | 3 | high | mod | mod | MID-CELL | mod bank | 1 | 0 | y | 1 | -0.5 | 343 | 1,713 |
| | 4.9 | 3.3 | 6.3 | 29 | Orcas, Deer Harbor Rd west | road | swash | 3 | S | 13 | high | mod | mod | MID-CELL | mod bank | 1 | 0 | y | 1 | -0.1 | 306 | 306 |
| | 4.8 | 4.5 | 5.0 | 30 | Lopez, E Shoal Bay - ctr | residential | swash | 5 | N | 25 | moderate | mod | mod | CONVG | mod bank | 1 | 70 | y | 0 | 1 | 124 | -1,243 |
| | 4.6 | 5.5 | 3.8 | 29 | Orcas, West Sound S. Indian Cv-s | residential | swash | 1 | NE | 100 | minimal | mod | mod | NAD | low bank | 0 | 65 | y | 1 | 0 | 199 | 0 |
| | 4.6 | 6.5 | 2.8 | 29 | Orcas, N Pole Pass Cove -n | residential | swash | 5 | SSW | 40 | not | bedrock | no mod high | NAD | mod bank | 0 | 70 | y | 0 | -1.2 | 137 | 1,646 |
| | 4.4 | 5.5 | 3.4 | 28 | Orcas-West Sound S.Indian Cv-n | residential | swash | 1 | NE | 60 | moderate | mod | bedrock | NAD | low bank | 0 | 65 | y | 1 | 0 | 88 | 0 |
| | 4.4 | 2.6 | 5.9 | 26 | SanJuan, FalseBay-e | road | swash | 28 | SW | 4 | high | mod | no mod high | MID-CELL | mod bank | 1 | 15 | y | 0 | -1.2 | 596 | 7,151 |
| | 4.4 | 3.7 | 5.0 | 26 | SanJuan, FalseBay-n | road | swash | 28 | SW | 4 | high | no mod high | mod | TERM | mod bank | 1 | 15 | y | 0 | 1.5 | 610 | -9,146 |
| | 4.2 | 2.6 | 5.6 | 25 | Lopez, MudBay-n | road | drift | 13 | NNE | 3 | moderate | mod | bedrock | MID-CELL | low bank | 1 | 40 | n | 1 | 2.2 | 50 | -1,102 |
| | 4.1 | 5.5 | 2.8 | 26 | SanJuan, Friday Hbr S-s ctr | residential | drift | 3 | W | 100 | not | mod | mod | NAD | mod bank | 0 | 40 | n | 0 | -2.2 | 144 | 3,160 |
| | 4.1 | 6.5 | 1.9 | 26 | SanJuan, Friday Harbor W-s | residential | swash | 2 | E | 50 | minimal | mod | bedrock | NAD | mod bank | 0 | 30 | y | 0 | 0.8 | 240 | -1,916 |
| | 4.0 | 6.5 | 1.6 | 25 | Orcas, N Pole Pass Cove - S-s | residential | drift | 5 | NW | 60 | not | bedrock | bedrock | NAD | mod bank | 0 | 70 | y | 0 | -0.4 | 13 | 51 |
| | 3.8 | 4.8 | 2.8 | 24 | SanJuan, Friday Hbr S-s | residential | drift | 3 | W | 38 | not | mod | mod | NAD | mod bank | 0 | 100 | n | 0 | -1.7 | 192 | 3,263 |
| | 3.7 | 1.5 | 5.6 | 22 | Lopez, MudBay-s | road | drift | 13 | NNE | 3 | moderate | mod | mod | MID-CELL | low bank | 1 | 40 | n | 1 | 2.2 | 146 | -3,205 |
| | 3.7 | 5.2 | 2.2 | 23 | SanJuan, Friday Harbor W-ctr | residential | swash | 2 | E | 40 | minimal | mod | mod | NAD | mod bank | 0 | 5 | y | 0 | -0.6 | 304 | 1,822 |
| | 3.7 | 5.5 | 1.9 | 23 | SanJuan, Turn Pt -west ctr | residential | swash | 9 | NNE | 60 | not | mod | mod | NAD | no bank | 0 | 10 | y | 0 | 0.5 | 484 | -2,419 |
| | 3.6 | 6.3 | 1.3 | 21 | Shaw, Neck Cove | road | swash | 15 | NW | 60 | high | bedrock | bedrock | NAD | no bank | 0 | 25 | n | 0 | 0 | 449 | 0 |
| | 3.5 | 5.2 | 1.9 | 22 | Orcas, N Pole Pass Cove - S-ctr | residential | drift | 5 | NW | 35 | not | mod | bedrock | NAD | mod bank | 0 | 70 | y | 0 | -0.4 | 68 | 272 |
| | 3.5 | 5.8 | 1.3 | 22 | SanJuan, Friday Hbr S-n | residential | drift | 3 | W | 100 | not | low bank no mod | mod | NAD | mod bank | 0 | 100 | n | 0 | 0 | 109 | 0 |
| | 3.5 | 6.1 | 0.9 | 22 | Orcas, North Pole Pass-n | residential | drift | 5 | SSW | 80 | not | no mod high | bedrock | NAD | mod bank | 0 | 35 | n | 0 | -0.4 | 67 | 269 |
| | 3.5 | 6.1 | 0.9 | 22 | SanJuan, Turn Pt -west | county | swash | 9 | NNE | 100 | not | mod | bedrock | NAD | low bank | 0 | 10 | y | 0 | 0 | 47 | 0 |
| | 3.3 | 5.5 | 1.3 | 21 | Orcas, North Pole Pass-s | residential | drift | 5 | SSW | 100 | not | mod | bedrock | NAD | mod bank | 0 | 35 | n | 0 | -0.4 | 261 | 1,046 |
| | 3.3 | 5.5 | 1.3 | 21 | SanJuan, Friday Hbr S-n ctr | residential | drift | 3 | W | 100 | not | mod | mod | NAD | mod bank | 0 | 40 | n | 0 | 0.3 | 171 | -512 |
| | 3.2 | 4.8 | 1.6 | 20 | Orcas, N Pole Pass Cove - S-n | residential | drift | 5 | SSW | 15 | not | no mod high | bedrock | NAD | mod bank | 0 | 70 | y | 0 | -0.4 | 48 | 193 |
| | 3.0 | 4.5 | 1.6 | 19 | SanJuan, Turn pt - east | residential | swash | 9 | N | 50 | minimal | low bank no mod | mod | NAD | low bank | 0 | 0 | n | 0 | -0.9 | 352 | 3,171 |
| | 3.0 | 5.2 | 0.9 | 19 | SanJuan, Turn Pt - east ctr | residential | swash | 9 | NNE | 70 | not | mod | mod | NAD | low bank | 0 | 10 | n | 0 | 1.1 | 212 | -2,336 |
| | 3.0 | 5.5 | 0.6 | 19 | Orcas, North Pole Pass-s | residential | drift | 5 | SSW | 80 | not | bedrock | mod | NAD | mod bank | 0 | 35 | n | 0 | -0.4 | 18 | 73 |
| | 2.9 | 5.2 | 0.6 | 18 | SanJuan, Turn Pt - ctr | residential | swash | 9 | NNE | 65 | not | mod | mod | NAD | low bank | 0 | 10 | n | 0 | 0.5 | 73 | -364 |
| | 2.7 | 2.6 | 2.8 | 16 | Orcas, Buck Bay | road | drift | 12 | WSW | 5 | high | mod | no mod high | NAD | mod bank | 0 | 35 | y | 0 | -1.5 | 365 | 5,470 |

**Table 5.** General attributes of top ten enhancement opportunitis in SJC. Negative intertidal area indicates recoverable habitat above MHHW.

| Rank | Site Name | Owner | No. owners | Toe elv | Length | IT area | Necessity | Integrity |
|---|---|---|---|---|---|---|---|---|
| 1 | Blind Bay Rd-S, Shaw Is. | county road | County | -1.2 | 493 | 5919 | moderate | fair |
| 2 | Blind Bay Private Rd-SW, Shaw Is. | Fowler/Wheatley | County | -0.7 | 177 | 1238 | moderate | fair |
| 3 | Barlow Bay Rd, Lopez Is. | county road | County | -2.5 | 173 | 4315 | high | fair |
| 4 | Smugglers Cove Rd, Shaw Is. | unknown if rd is private or county owned | County | -0.7 | 241 | 1685 | moderate | fair |
| 5 | West Shoal Bay, Lopez Island | Higginson & Alpaugh residents | 2 | -2.4 | 69 | 1665 | moderate | poor |
| 6 | Jasper Bay, Lopez Island | Dean O Hoshizaki & Karen L Flemming TTEES | 1 | -1.6 | 149 | 2385 | not | fair |
| 7 | Deer Harbor pool, Orcas Island | San Juan County Landbank | 1 | -3.2 | 200 | 6397 | not | poor |
| 2 | Blind Bay Private Rd-W-s, Shaw Island | Fowler/Wheatley | 1 | -0.7 | 50 | 350 | moderate | fair |
| 2 | Blind Bay Private Rd-W, Shaw Island | Fowler/Wheatley | 1 | -0.7 | 460 | 3219 | moderate | fair |
| 1 | Blind Bay Rd-E, Shaw Island | county road | 1 | -0.7 | 1,315 | 9208 | moderate | fair |
| 8 | Aleck Bay-s, Lopez Island | George & Mary L Hestad | 1 | -1.1 | 166 | 1821 | moderate | good |
| 9 | MacKaye Harbor Rd-s, Lopez Island | county road | County | 0.4 | 713 | -2854 | high | poor |
| 9 | MacKaye Harbor Rd-se, Lopez Island | county road | County | 1.3 | 570 | -7411 | high | poor |
| 10 | Deer Harbor Rd e-ctr, Westsound, Orcas Is. | county road | County | 1.3 | 33 | -427 | not | poor |

**Table 6**. Attributes of top ten sites ranked for enhancement in SJC with restoration actions and ehancement options. Potential habitat increase numbers are based on a 1:10 beach slope and negative numbers indicated recoverable backshore habitat (above MHHW). Enhancement options include beach nourishment (following structure removal) and rock removal (exclusively). IT=intertidal, reveg=revegetate dune/riparian

| Rank | Site Name, Island | Bluff Sediment Connectivity | Alignment | Fetch (mi) | Aspect | Updrift Slope Stability | Forage Fish Habitat | Potential Hab. Increase (sq ft) | Restoration / Recommended Action | Enhancement Option |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Blind Bay Rd-S, Shaw Is. | low | swash | 1.7 | N | unstable | doc | 5,919 | remove rd, nourish, reveg. | nourish, remove IT rock and groins |
| 2 | Blind Bay Private Rd-SW, Shaw Is. | high | swash | 1.3 | N | stable | doc | 4,806 | setback rd, remove all rock, nourish and reveg | nourish, remove IT rock |
| 3 | Barlow Bay Rd, Lopez Is. | low | swash | 1 | N | stable | doc | 4,315 | remove rock, nourish, remove debris | nourish |
| 4 | Smugglers Cove Rd, Shaw Is. | mod | drift | 1.5 | E | stable | doc | 1,685 | setback rd, remove all rock, nourish and reveg | nourish, install LWD |
| 5 | West Shoal Bay, Lopez Island | mod | swash | 5 | N | stable | doc | 1,665 | remove rock debric covering intertidal | remove rock from IT |
| 6 | Jasper Bay, Lopez Island | low | swash | 2 | SSE | stable | pot | 2,385 | removal all rock and nourish | nourish, remove most rock |
| 7 | Deer Harbor pool, Orcas Island | mod | drift | 0.4 | W | stable | pot | 6,397 | remove all concrete, nourish, reveg. | remove concrete, nourish |
| 2 | Blind Bay Private Rd-W-s, Shaw Island | high | drift | 0.4 | NE | stable | doc | 350 | setback rd, remove all rock, nourish and reveg | nourish, remove IT rock |
| 2 | Blind Bay Private Rd-W, Shaw Island | high | drift | 0.4 | NE | stable | doc | 3,219 | setback rd, remove all rock, nourish and reveg | nourish, remove IT rock |
| 1 | Blind Bay Rd-E, Shaw Island | low | drift | 0.6 | W | unstable | doc | 9,208 | remove rd, nourish, reveg. | nourish, remove IT rock |
| 8 | Aleck Bay-s, Lopez Island | high | swash | 10 | SE | stab/unstab | doc | 1,821 | not applicable | remove debris |
| 9 | MacKaye Harbor Rd-s, Lopez Island | low | swash | 1 | N | stable | doc | -2,854 | relocate rd., remove rock, nourish, restore wetlands | nourish, remove IT rock |
| 9 | MacKaye Harbor Rd-se, Lopez Island | low | swash | 1 | N | stable | doc | -7,411 | relocate rd., remove rock, nourish, restore wetlands | nourish, remove IT rock |
| 10 | Deer Harbor Rd e-ctr, Westsound, Orcas | low | swash | 3 | S | stable | doc | -427 | relocate rd., remove rock, nourish, reveg | NA |


Figure 1. Top 10 soft shore restoration opportunities (red) and additional soft shore restoration opportunities (yellow) in San Juan County

**San Juan County Soft Shore Protection/Bulkhead Removal Blueprint**