PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION STUDY

APPENDIX I

ECONOMICS

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1 OVERVIEW

This appendix describes the cost effectiveness and incremental cost analysis (CE/ICA) performed for the Puget Sound Nearshore Ecosystem Restoration Project Draft Integrated Feasibility Report and Environmental Impact Statement (Nearshore Study). This process helps in the formulation of efficient and effective restoration solutions throughout Puget Sound, Washington. Because there is no currently accepted method for quantifying environmental benefits (or environmental outputs) in monetary terms, it is not possible to conduct a traditional benefit-cost analysis for the evaluation of project alternatives. Cost effectiveness and incremental cost analyses offer approaches that are consistent with the Principles and Guidelines (U.S. Water Resources Council, 1983; referred to as the "P&G") planning paradigm. Cost effectiveness will ensure that the least cost solution is identified for each possible level of environmental output. Subsequent incremental cost analysis will reveal changes in cost for increasing levels of environmental outputs. While these analyses will usually not lead, and are not intended to lead, to a single best solution (as in economic benefit-cost analysis), they will improve the quality of decision making by ensuring that a rational, supportable, focused and traceable approach is used for considering and selecting alternatives for environmental restoration.

This report briefly summarizes some of the plan formulation and modeling of environmental outputs that focused the scope and inputs of the cost effectiveness and incremental cost analyses. The contents of this appendix are as follows:

- Section 2, Plan Formulation and Identification of Restoration Projects
- Section 3, Formulation of Alternative Plans
- Section 4, Initial Array of Alternatives
- Section 5, Focused Array of Alternatives
- Section 6, Final Array of Alternatives
- Section 7, Tentatively Selected Plan (TSP)
- Section 8, References

2 PLAN FORMULATION AND IDENTIFICATION OF RESTORATION PROJECTS

The planning process which includes the identification of problems, opportunities, objectives and constraints, as well as the identification of management measures, siting of management measures, and screening is documented in Chapter 2 of the draft feasibility report.

Based on the problems identified in the study area, planning objectives include the following:

Table 2-1. Planning Objectives

Planning Objectives	Sub-objectives	Problems	Representative Species Affected
1. Restore connectivity and size of large river delta estuaries	a. Restore tidal flow and inundation area in river deltas b. Restore quality and quantity of tidal wetlands in river deltas with emphasis on oligohaline and tidal freshwater wetlands c. Improve connectivity between the nearshore zone and adjacent uplands/ watershed d. Increase the shoreline length of large river deltas	• Large River Delta Impacts • Estuarine Wetland Loss • Shortening and Simplification of Shoreline • Multiple Stressors	• Puget Sound Chinook salmon and other salmonids* • Great blue herons • Peregrine falcons • Shorebirds (>30 species) • Killer whales*

Planning Objectives	Sub-objectives	Problems	Representative Species Affected
2. Restore the number and quality of coastal embayments	a. Restore embayment shoreline length that has been reduced through fill placement b. Restore embayments that have transitioned to an artificial landform or have been lost through conversion to uplands c. Restore degraded embayments d. Restore quality and quantity of tidal wetlands in coastal embayments	• Coastal Embayment Loss or Disconnection • Estuarine Wetland Loss • Shortening and Simplification of Shoreline • Multiple Stressors	• Puget Sound Chinook salmon and other salmonids* • Shellfish • Olympia oysters** • Forage fish • Kelp and Eelgrass
3. Restore the size and quality of beaches	a. Restore sediment input processes at bluff-backed beaches in divergence zones and transport zones of sediment drift cells b. Improve sediment transport and accretion processes by removing subtidal and intertidal stressors contributing to shoreline degradation	• Beaches and Bluffs Disconnection • Multiple Stressors • Shortening and Simplification of Shoreline	• Puget Sound Chinook salmon and other salmonids* • Forage fish • Shellfish • Olympia oysters**
4. Increase understanding of natural process restoration in order to improve effectiveness of project actions	a. Gather and analyze data to inform adaptive management and ensure project success b. Gather and analyze data to inform future restoration efforts by the Corps and others	• Large River Delta Impacts • Estuarine Wetland Loss • Coastal Embayment Loss or Disconnection • Beaches and Bluffs Disconnection • Shortening and Simplification of Shoreline • Multiple Stressors	• Puget Sound Chinook salmon and other salmonids* • Great blue herons • Peregrine falcons • Shorebirds (>30 species) • Killer whales* • Olympia oysters** • Shellfish • Kelp and Eelgrass

These planning objectives were the bases for identifying restorative management measures, restoration strategies, site identification and assessment. An initial screening of 543 sites was conducted to identify sites that included one or more measures considered to have a strong effect on a strategy (i.e., those most able to restore the associated process or processes). Those 198 sites were retained for further consideration. These sites were further reviewed and narrowed down to 46 sites thought to be suitable for development of conceptual designs, cost estimates, and additional evaluation.

2.1 SITE CONCEPTUAL DESIGNS

An interdisciplinary Conceptual Design Team (CDT) comprised of Study Team members and expert consultants conducted field visits to each of the 46 candidate restoration sites. The CDT assessed site conditions, gathered data to characterize the site, obtained photographs, and evaluated "on-the-ground" opportunities and constraints. The CDT evaluated each site using a set of screening criteria to determine whether the proposed action is likely to achieve the Nearshore Study's restoration objectives. Screening criteria was meant to identify any "fatal flaws" of the sites and included the following: (1) whether the site was sufficiently described and spatially defined to allow the Study Team to develop conceptual designs and determine quantity estimates, (2) whether the site was consistent with one or more of the Nearshore Study's restoration strategies, and (3) whether local proponents had precluded the Study Team from including the site when developing conceptual designs. The results of this work are documented in characterization reports that describe the potential restoration opportunities in terms of ecological effectiveness and engineering feasibility (Strategic Restoration Conceptual Engineering — Final Design Report (aka "Conceptual Design Report", ESA et al. 2011b). As a result of this evaluation and screening, six sites were removed from further consideration as they did not meet the "fatal flaw" evaluation using the screening criteria described above. Additionally, the four Big Quilcene River sites were combined into one site, and the two Telegraph Slough sites were combined, leaving 36 sites ready for design work.

Two site designs, one "full" and one "partial," were developed for each of the remaining 36 sites. The CDT used the proponent's description of each candidate site as captured in the Nearshore Database (and/or any design plans that existed) as a guide in developing the site designs; however, the CDT's designs may differ from what the proponent initially proposed with deviations made to meet the Nearshore Study's process-based restoration objectives.

A "full" design includes management measure(s) to fully remove site-specific stressors, maximize the area of influence, and maximize improvements in ecosystem benefits. Land ownership was not considered as a potential constraint in developing the full restoration alternative; however, the continued existence of major durable infrastructure (e.g., transmission lines, highways, utilities, railroads) was generally assumed. The full design can be understood as a way to maximize site potential for process based restoration by removal of stressors to the fullest extent possible, often expanding upon the original proposal for the site.

A second "partial" design was developed that addressed known constraints and concerns (from landowners, user groups, and the community) while still achieving process-based restoration. The partial design could differ from the full design in the number or type of management measures implemented, the area over which a management measure was applied, and/or the size or type of tidal openings. The partial restoration design was often similar to the description initially submitted to the Nearshore Database by the project proponent.

This step resulted in 72 designs at 36 sites, shown in Figure 4-3. Narrative descriptions of the sites, designs, assumptions, and future needs, along with the conceptual design plans, are documented in the Conceptual Design Report (ESA et al. 2011b) and are summarized in Section 4.6.

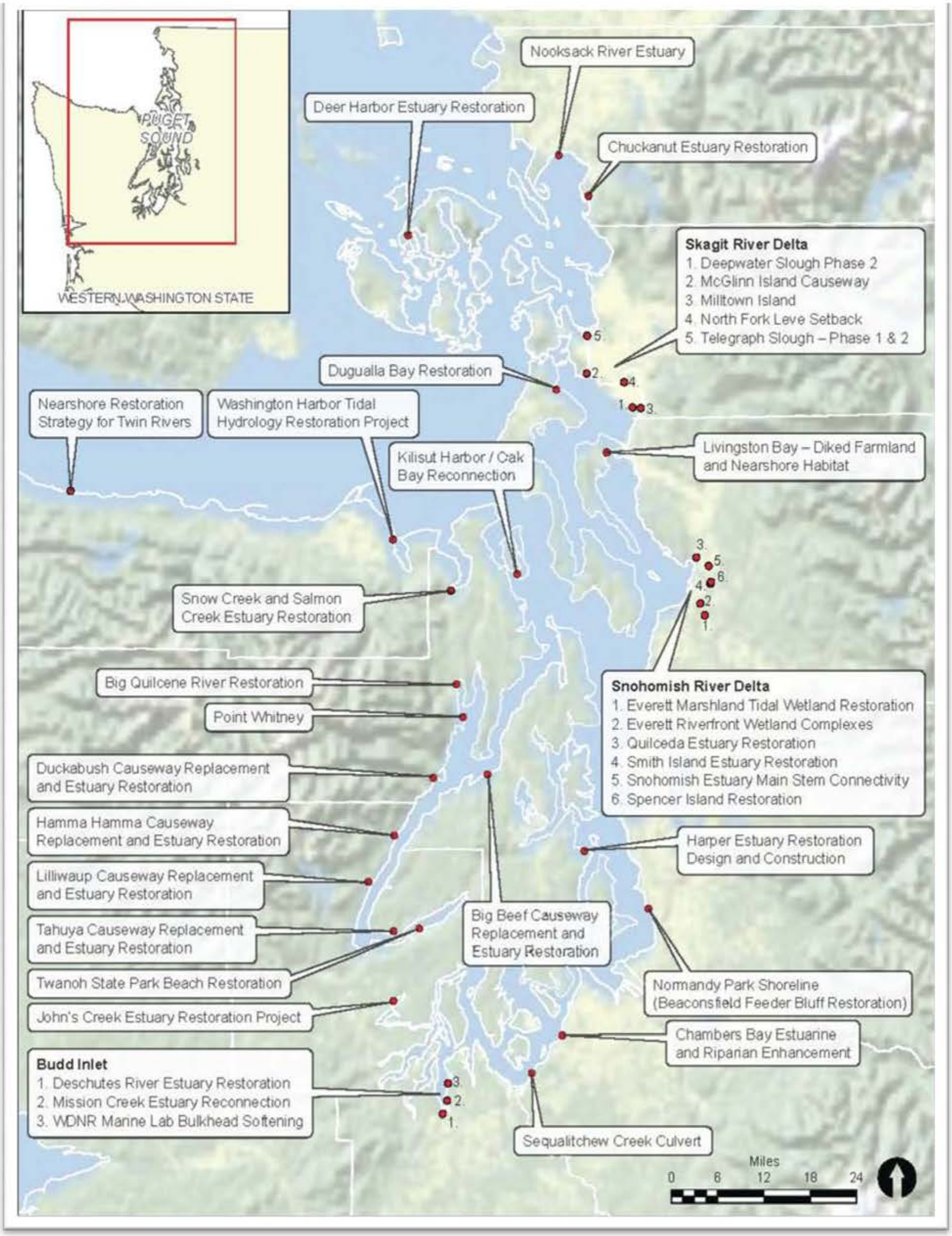

Figure 2-1. Location of 36 Sites for Conceptul Design Work

2.1.1 Site Design Review

Informed by the greater detail provided in the Conceptual Design Report, the Corps hosted a workshop in March 2011 for the Nearshore Study team to re-evaluate the proposed restoration designs for consistency with Nearshore Study guiding principles and strategies. The Study Team assessed each design for its potential to substantially restore ecosystem processes. Screening criteria included the following:

- Principles of process-based restoration, as assessed by the Nearshore Science Team
- Assessment for consistency with the recommendations from the Strategies Report
- Likelihood that the work may be completed by other project proponents (e.g., a local municipality or tribe) outside of the Nearshore Study effort
- General readiness such as technical feasibility, landowner willingness, social acceptability, and site-specific constraints based on up-to-date information

After designs were evaluated based on these screening criteria, 11 sites were characterized as offering some opportunity to improve nearshore conditions but better suited for implementation by other programs. As a result of this step, the team reduced the number of sites for further consideration from 36 to 25.

Based on the screening criteria outlined above, the Study Team also identified one of the two designs (full or partial) to carry forward for each site. This determination was made by qualitatively evaluating each site based on the screening criteria outlined in the bullets above; ranking criteria of "high," "medium," and "low" were assigned to each of the four criteria listed above. In addition, each site was also assigned to prioritized categories (e.g., Category "A" included sites that meet the screening criteria outlined above and also represent a significant opportunity to advance nearshore process-based restoration) to further screen sites to be carried forward at this step. For 18 of the 25 sites, a single design was advanced for further consideration. For the remaining seven sites, the criteria used did not identify a clearly preferred design and both designs were carried forward for further consideration. Thus, 32 (18 + 14) site designs at 25 sites remained for further consideration. Subsequently, the local proponents of one site, Smith Island, identified alternative means to implement the project, reducing the count to 31 designs at 24 sites.

Upon completion of the site evaluation and screening steps described above, including identification of management measures and potential restoration sites, development of site designs, and additional qualitative screening, 31 restoration designs at 24 sites were identified as candidates for the final array of alternatives to be evaluated and considered for inclusion in the tentatively selected plan (TSP). Section 4.6 describes the restoration features proposed at each site as well as discussion of whether the full or partial design was carried forward for each site.

2.2 SITE BENEFITS AND COSTS

To effectively evaluate the 24 sites carried forward, the Nearshore Study Team completed additional analysis including development of parametric cost estimates and evaluation of environmental outputs. Based on these parameters, a Cost Effectiveness/Incremental Cost Analysis (CE/ICA) was completed to help evaluate and quantify significant contributions or effects of individual plans. The following sections outline the assumptions and outcomes of this work in addition to the results of the CE/ICA.

2.2.1 Evaluation of Site Benefits

An interdisciplinary team including Corps staff, members of the Nearshore Science Team (NST), and contractor support staff developed an ecosystem output (EO) model to quantify the benefits that each site would provide. The framework of this model is consistent with the Nearshore Study's approach of restoring the ecosystem process, structure, and function that provide habitat and other ecosystem services. The model output is a product of quantity and quality. The quantity component of the model equation is defined as the area of restored process (in acres), and the quality component is comprised of multiple components that capture process, structure, and function. These three quality components are derived from calculations based on spatially explicit data in the Nearshore Geodatabase[1]:

- The process component is represented by one index: process degradation.
- The structure component is represented by five landscape indices: scarcity of landforms, heterogeneity of landforms, long-shore connectivity, cross-shore connectivity, and sinuosity.

[1] The Nearshore Geodatabase was initially compiled as part of the Change Analysis (Simenstad et al. 2011)

- The function component is represented by one index: a site's ability to provide ecosystem functions, goods, and services (EFG&S).

The model equation combines these components as follows:

$$EO = \overbrace{A}^{\text{Quantity}} * \overbrace{[(P^2 + S + F)/\text{maximum possible score}]}^{\text{Quality}}$$

Where:

EO – ecosystem output (project benefits)

A – area of restored process, in acres (Quantity score)

P – process degradation index score, scale 0 – 10 (process component of Quality score)

S – 2 (Sc + H + Lc + Cc + Sn), scale 0 – 10 (structure component of Quality score)

- Sc- scarcity, scale 0-1
- H- heterogeneity, scale 0-1
- Lc- long-shore connectivity, scale 0-1
- Cc- cross-shore connectivity, scale 0-1
- Sn- sinuosity, scale 0-1

F – EFG&S Tier 2 score, scale 0 – 10 (function component of Quality score)

Maximum possible score for quality: 120

A documentation report titled "Puget Sound Nearshore Ecosystem Output Model Documentation Report" describes the theory, framework, and detailed methodology of this model and the associated indices listed above (see Appendix G). The Nearshore Study's Strategic Science Peer Review Panel (SSPRP, described in further detail in Section 8.4) reviewed the documentation report. Corps headquarters (HQ) has reviewed and approved this model for one-time use.

2.2.2 Evaluation of Site Costs

Costs were estimated for the 31 site designs at 24 sites and input into IWR Plan for generation of alternatives and for CE/ICA. Costs used in the formulation and evaluation of alternatives are the economic costs of each site design; they include project first costs and net operations and maintenance (O&M) costs. Project first costs include pre-construction, engineering, and design (PED) costs; construction and construction management costs; and real estate costs.

Costs for PED and for construction and construction management were developed by Corps cost engineers in Micro-Computer Aided Cost Estimating System (MCACES)[2] using the quantities provided with the conceptual designs, standard features and rates, and input from the PDT. When necessary, quantities were developed by the cost engineer if not provided in the Engineering Appendix. Items such as the fuel rates, rock pricing, haul distances, and markups were discussed within the team and held consistent throughout all site designs. Certain features, such as some bridges and levees, were assumed to have similar designs but were sized according to the needs of each alternative site design. It was assumed that fill for each site design would be imported unless specifically noted otherwise in the design report. In addition, each site design was evaluated to determine whether barge access was necessary. Input was gathered from the PDT on each of the site designs to reflect the scope most accurately. The PDT was consulted for an abbreviated risk analysis. These discussions informed development of site design-specific construction cost contingency rates using the risk analysis template developed by the Corps' Cost Engineering Directory of Expertise. Cost contingencies were included for PED, construction, and construction management.

Initial real estate costs were developed using the site design footprint maps. Parcel numbers were identified by comparing the footprint boundaries to the respective county assessor's property records. Using the parcel data, costs were developed based on the county assessed value for the land and any improvements (buildings) listed for the affected parcels. All real estate costs assumed fee title with contingency rates ranging from 15% to 30% depending on the complexity of the respective project lands (reference Appendix C for individual Land Cost Estimates associated with each site).

Typically, operations and maintenance (O&M) costs reflect required ongoing maintenance to ensure functionality of a project. However, no ongoing O&M costs are directly associated with the restoration activities planned for the sites. Instead there will be a change in O&M costs associated with other site features, such as changes to transportation infrastructure (removing a road, lengthening a bridge, etc.). Net O&M costs may be either positive or negative. These changes to O&M are captured in the average annual O&M estimate.

[2] MCASES is cost estimating software used by Corps cost engineers.

2.2.3 Summary of Site Benefits and Costs

Table 2-3 provides an overview of the benefits and costs for the 31 site designs located at 24 sites. The site designs are grouped by strategy, which is shown in the left-most column.

Table 2-2. Benefits and Costs for 31 Site Designs, by Strategy (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output (Net EO)
Delta	Big Quilcene Partial	$35,073	-$4	$1,628	25.5	0.6
	Deepwater Slough Partial	$6,652	-$66	$244	269.6	90.2
	Duckabush Full	$71,085	$0	$3,309	39.4	12.9
	Duckabush Partial	$58,403	-$1	$2,718	38.1	12.3
	Everett Marshland Full	$357,549	$38	$16,682	829.1	349.3
	Everett Marshland Partial	$154,286	$0	$7,182	427.4	167.8
	Milltown Island Partial	$4,246	-$2	$196	214.2	64.0
	Nooksack River Delta Partial	$331,473	$127	$14,259	1,807	650.5
	North Fork Skagit Delta Full	$64,393	-$25	$2,973	256.1	53.7
	Spencer Island Partial	$16,916	-$25	$762	313.2	136.0
	Telegraph Slough Full	$188,613	$11	$8,790	832.2	253.9
	Telegraph Slough Partial	$93,922	$52	$4,424	146.9	16.3
Beach	Beaconsfield Feeder Bluff Full	$7,929	$0	$369	6.9	2.2
	Beaconsfield Feeder Bluff Partial	$3,027	$0	$141	5.5	1.3
	Twin Rivers Partial	$5,546	$0	$258	4.3	0.2
	WDNR Budd Inlet Beach Full	$9,569	-$1	$445	2	1.1
Barrier Embayment	Big Beef Creek Estuary Full	$32,629	$0	$1,519	29.6	7.9
	Dugualla Bay Partial	$72,289	-$2	$3,363	572	162.6
	Livingston Bay Full	$12,863	-$19	$580	244.6	41.6
	Livingston Bay Partial	$12,062	-$14	$547	238.7	40.5
	Point Whitney Lagoon Full	$9,522	-$1	$442	6.1	2.0
Coastal Inlet	Chambers Bay Full	$288,020	-$1	$13,407	83.5	8.5
	Chambers Bay Partial	$96,699	-$1	$4,501	47	3.4
	Deer Harbor Estuary Full	$6,679	$0	$311	16.1	4.8
	Harper Estuary Full	$12,240	$0	$569	6.2	1.7
	Harper Estuary Partial	$16,025	$5	$751	5.7	1.1
	Lilliwaup Partial	$30,619	$0	$1,425	19.6	1.1
	Sequalitchew Full	$166,320	$7	$7,750	4.5	0.9
	Snow/Salmon Creek Estuary Partial	$37,798	$4	$1,764	52.2	6.8
	Tahuya River Estuary Full	$28,917	$0	$1,346	36.1	7.6
	Washington Harbor Partial	$17,666	$5	$827	14	0.6

Note: 1. First costs include real estate, design, construction, and construction management.

3 FORMULATION OF ALTERNATIVE PLANS

As discussed previously, four restoration strategies were developed to address the planning objectives, with one strategy to address Objective 1 (deltas), two to address Objective 2 (embayments - one strategy for barrier embayments and one for coastal inlets), and one to address Objective 3 (beaches). It is critical to formulate alternative plans that address each strategy because of the broad variety of and differences between ecological benefits that accrue from restoration of the different landforms. Restoration of the different landforms can have not only cumulative benefits, but potentially synergistic benefits as well. For example, restoring a large river delta site would benefit rearing salmonids, while restoring a beach would restore spawning habitat for forage fish, a primary prey resource for salmonids and many other species. The complexity of interactions among biota dependent on the nearshore zone means restoration benefits are needed across each strategy.

Water resource projects are generally directed to use a watershed approach. In that vein, the Nearshore Study uses a holistic view of the entire Puget Sound shoreline to address the variety of needs across all landforms and strategies of the nearshore zone.

Because outputs from sites of one strategy are not directly comparable to outputs from sites of the other three strategies, and in order to ensure that the final set of alternative plans includes sites from each strategy, alternative plans were generated through a multi-step process:

- First, sites were organized into four subgroups, one for each strategy.
- Second, IWR Planning Suite (certified version 2.0.6.0, also referred to as IWR Plan) was used to generate an initial array of alternative plans comprised of all possible combinations of sites within each strategy. Based on this evaluation, one or more cost effective sites within each strategy were carried forward.
- Third, IWR Planning Suite was used to generate a focused array of alternative plans comprised of all possible combinations of the sites across all strategies carried forward from the previous step. Based on this evaluation, a focused array of 23 best buy plans was identified.

- Finally, a final array of three alternatives was carried forward for evaluation and comparison to inform selection of the tentatively selected plan (TSP). Each alternative in the final array is comprised of multiple sites and addresses all four of the study's strategies.

The USACE Institute for Water Resources (IWR) developed IWR Planning Suite (certified version 2.0.6.0) to assist with the formulation and comparison of alternative plans. The software can assist with plan formulation by combining solutions to planning problems and calculating the additive effect of each combination, or "plan", by utilizing inputs on outputs (for this study we may refer to the outputs as benefits, average annual habitat units or AAHU's, or average annual net ecosystem outputs or net EO), costs, and rules (combinability and dependency relationships) for combining solutions into plans. Plans are then compared in IWR Planning Suite by conducting cost effectiveness and incremental cost analyses (CE/ICA), identifying the plans which are the best financial investments, and displaying the effects of each on a range of decision variables.

Cost effectiveness and incremental cost analyses are useful tools to assist in decision making and support recommendations of environmental restoration projects. Two analytical processes are conducted to meet these requirements. First, cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental output. Subsequent incremental cost analysis of the least cost solutions (cost effective plans) is conducted to reveal changes in costs for increasing levels of environmental outputs.

A more detailed explanation of this process and the alternative plans selected as a result is presented in the upcoming sections.

3.1 BY-STRATEGY SUBGROUPS

After estimating costs and benefits, the 31 site designs at 24 sites were grouped by strategy they most prominently addressed. This step ensured that sites addressing each of the four strategies (and by extension all planning objectives) would ultimately be included in the Tentatively Selected Plan (TSP). The 31 site designs were grouped by strategy as shown in Table 2-2 and summarized below.

River Delta Strategy (9 sites; 12 site designs):

- Big Quilcene Partial
- Deepwater Slough Partial
- Duckabush Full
- Duckabush Partial
- Everett Marshland Full
- Everett Marshland Partial
- Milltown Island Partial
- Nooksack River Delta Partial
- North Fork Skagit Delta Full
- Spencer Island Partial
- Telegraph Slough Full
- Telegraph Slough Partial

Beach Strategy (3 sites; 4 site designs):

- Beaconsfield Feeder Bluff Full
- Beaconsfield Feeder Bluff Partial
- Twin Rivers Partial
- WDNR Budd Inlet Beach Full

Barrier Embayment Strategy (4 sites; 5 site designs):

- Big Beef Creek Estuary Full
- Dugualla Bay Partial
- Livingston Bay Full
- Livingston Bay Partial
- Point Whitney Lagoon Full

Coastal Inlet Strategy (8 sites; 10 site designs):

- Chambers Bay Full
- Chambers Bay Partial
- Deer Harbor Estuary Full
- Harper Estuary Full
- Harper Estuary Partial
- Lilliwaup Partial
- Sequalitchew Full
- Snow/Salmon Creek Estuary Partial
- Tahuya River Estuary Full
- Washington Harbor Partial

4 INITIAL ARRAY OF ALTERNATIVES

IWR Planning Suite (certified version 2.0.6.0) was used to generate an initial array of alternative plans comprised of all possible combinations of sites within each of the four strategies described above. This approach was taken due to the software limitations of IWR Planning Suite which limit the possible number of plan combinations. Not all 31 sites could be analyzed together due to this limitation and therefore the team first ran IWR Planning Suite for each of the four strategies (River Delta, Beach, Barrier Embayment, and Coastal Inlet).

Each run of IWR Planning Suite identified an initial array of cost effective and best buy alternatives comprised of one or more sites within each strategy. Through comparison of incremental costs and benefits of the best buy plans for each strategy, the PDT identified the sites within each strategy that made sense for inclusion in the next step of alternative formulation and evaluation. The outcomes of these analyses are presented in Sections 4.1 through 4.4.

4.1 RIVER DELTA

IWR Planning Suite was used to generate an initial array of alternative plans comprised of all possible combinations of sites within the river delta strategy using total average annual costs and average annual net ecosystem outputs displayed in Table 4-1. All sites were combinable with exception of the sites which have multiple scales (full and partial). No sites were dependent on any other sites. All possible combinations of sites are displayed in Figure 4-1.

Table 4-1. River Delta Strategy – Benefit and Cost Model Inputs (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Delta	Big Quilcene Partial	$35,073	-$4	$1,628	25.5	0.6
	Deepwater Slough Partial	$6,652	-$66	$244	269.6	90.2
	Duckabush Full	$71,085	$0	$3,309	39.4	12.9
	Duckabush Partial	$58,403	-$1	$2,718	38.1	12.3
	Everett Marshland Full	$357,549	$38	$16,682	829.1	349.3
	Everett Marshland Partial	$154,286	$0	$7,182	427.4	167.8
	Milltown Island Partial	$4,246	-$2	$196	214.2	64.0
	Nooksack River Delta Partial	$331,473	$127	$14,259	1,807	650.5
	North Fork Skagit Delta Full	$64,393	-$25	$2,973	256.1	53.7
	Spencer Island Partial	$16,916	-$25	$762	313.2	136.0
	Telegraph Slough Full	$188,613	$11	$8,790	832.2	253.9
	Telegraph Slough Partial	$93,922	$52	$4,424	146.9	16.3

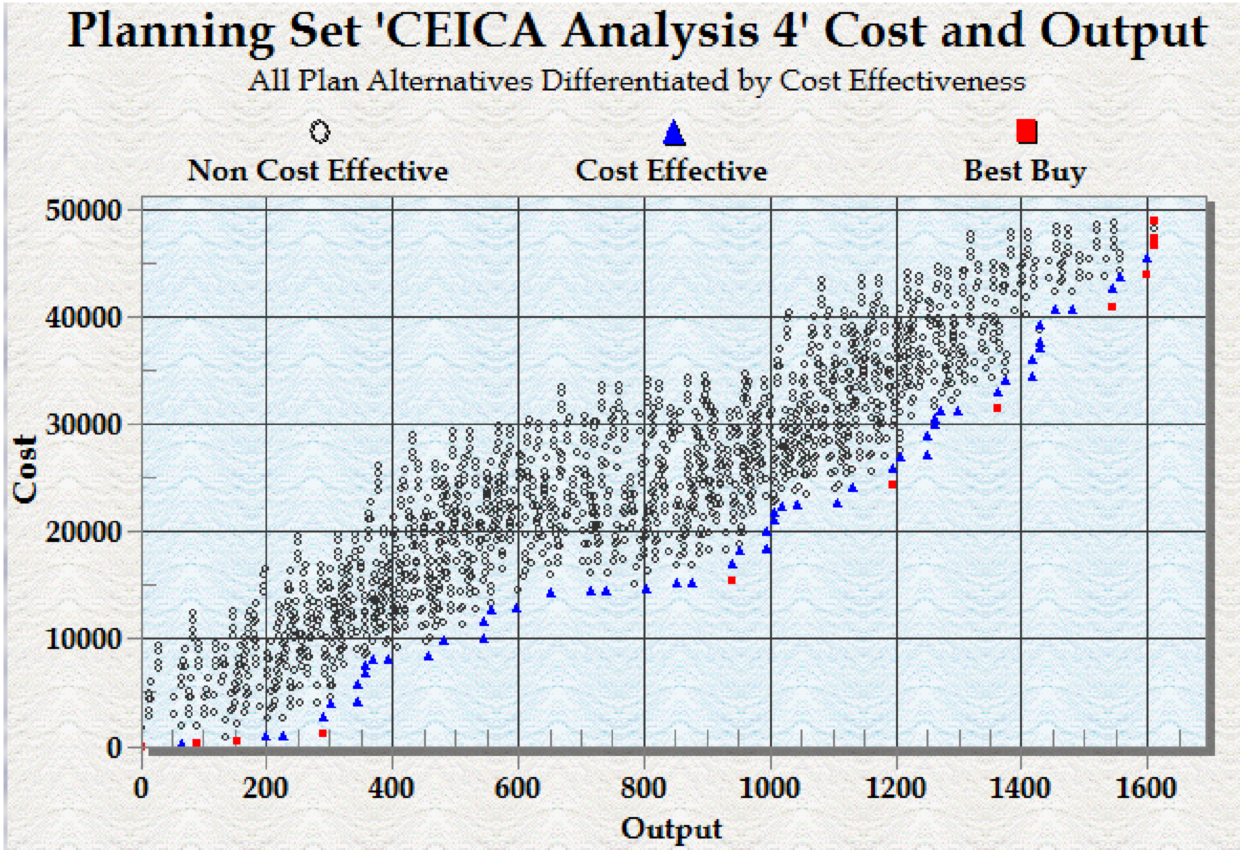

Figure 4-1. River Delta Strategy – Plot of Possible Plan Combinations

The cost effectiveness and incremental cost analysis resulted in 12 best buy plans which effectively and efficiently provide ecosystem restoration outputs, including the No Action plan. These plans are displayed in Table 4-2 and the best buy incremental bar graph in Figure 4-2. The following sections describe the river delta sites that were carried forward for further analysis.

Table 4-2. River Delta Strategy – Incremental Costs of Best Buy Alternative Plans

Alternative Plan	Average Annual Cost ($1,000s)	Average Annual Output (Net EO)	Average Annual Cost/ Output ($1,000s)	Incremental Cost ($1,000s)	Incremental Output (Net EO)	Incremental Cost/Output ($1,000s)
No Action Plan	$0	-	$0.00	$0	-	$0
Deepwater Partial	$244	90.2	$2.7	$244	90.2	$2.7
Deepwater Partial and Milltown Partial	$440	154.2	$2.9	$196	64.0	$3.1
Deepwater Partial, Milltown Partial, and Spencer Island Partial	$1,202	290.2	$4.1	$762	136.0	$5.6
Deepwater Partial, Milltown Partial, Spencer Island Partial and Nooksack Partial	$15,461	940.7	$16.4	$14,259	650.5	$21.9
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial and Telegraph Full	$24,251	1,194.6	$20.3	$8,790	253.9	$34.6
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, and Everett Marshland Partial	$31,433	1,362.4	$23.1	$7,182	167.8	$42.8
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, and Everett Marshland Full	$40,933	1,543.9	$26.5	$9,500	181.5	$52.3
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, and North Fork Skagit Full	$43,906	1,597.6	$27.5	$2,973	53.7	$55.4
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, and Duckabush Partial	$46,624	1,609.9	$29.0	$2,718	12.3	$221.0
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, and Duckabush Full	$47,215	1,610.5	$29.3	$591	0.5	$985.0
Deepwater Partial, Milltown Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, Duckabush Full,	$48,843	1,611.1	$30.3	$1,628	0.6	$2,713.3

Alternative Plan	Average Annual Cost ($1,000s)	Average Annual Output (Net EO)	Average Annual Cost/ Output ($1,000s)	Incremental Cost ($1,000s)	Incremental Output (Net EO)	Incremental Cost/Output ($1,000s)
and Big Quilcene Partial						

Note: Pink highlighted plan advanced.

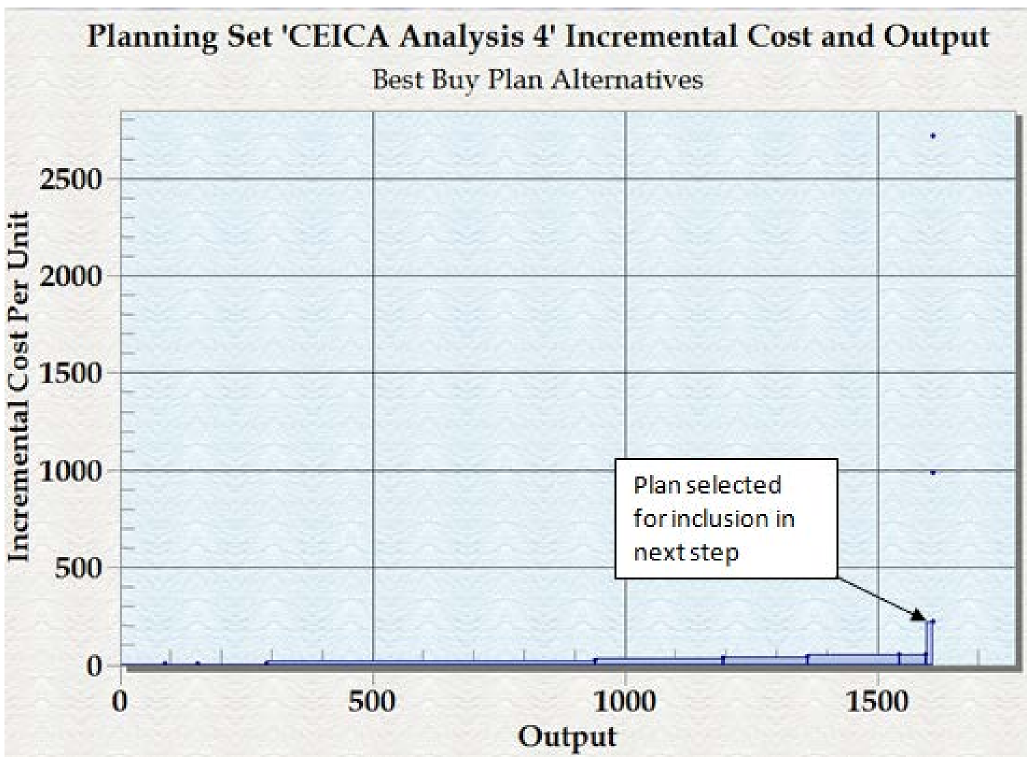

Figure 4-2. River Delta Strategy – Best Buy Plans

4.1.1 Sites included in River Delta Strategy

There are eight best buy sites included in the final array of alternatives that address the river delta strategy. The restoration objective associated with this strategy is to increase the size and quantity of large river delta estuaries by restoring tidal processes and freshwater input where major river floodplains meet marine waters. Target ecosystem processes for river delta restoration include the following:

- Tidal flow

- Freshwater input (including alluvial sediment delivery)
- Erosion and accretion of sediments
- Distributary channel migration
- Tidal channel formation and maintenance
- Detritus recruitment and retention
- Exchange of aquatic organisms

Detailed information about the eight river delta sites is included in the main report.

4.1.2 Ecosystem Benefits of Restoration Sites in River Deltas

Qualitative benefits of these eight river delta sites would derive from restoring tidal inundation and hydrology to over 4,000 acres of highly productive estuarine mixing and tidal freshwater marshes. As these tidal marshes evolve, channel networks would form, water quality would improve, vegetation would reestablish and, if a source is present, large woody debris would accumulate. The marshes would be used by steelhead3, bull trout3, and all five species of Pacific salmon, including Chinook3. Restoration in the Duckabush River would provide valuable rearing habitat for Hood Canal summer chum3. Three of the river deltas represented by these sites, the Nooksack, Skagit, and Snohomish, support some of the largest runs of salmon in the Puget Sound. Increased habitat for salmon, particularly Chinook and chum, would benefit marine mammals, including ESA-listed southern resident killer whales (who feed on these species preferentially for much of the year). Puget Sound is an important stop on the Pacific flyway for migratory birds. Restored tidal marshes would also function as foraging and resting habitat for birds and waterfowl with an abundance of vegetation, invertebrates, and amphibians. Benefits of restoring wetlands in large river deltas will extend to the eelgrass beds located along their fringes by way of improved water quality, sediment delivery, and nutrient supply.

[3] Federal ESA-listed species

4.2 BEACH

IWR Planning Suite was used to generate an initial array of alternative plans comprised of all possible combinations of sites within the beach strategy using total average annual costs and average annual net ecosystem outputs displayed in Table 4-3. All sites were combinable with exception of the sites which have multiple scales (full and partial). No sites were dependent on any other sites. All possible combinations of sites are displayed in Figure 4-3.

Table 4-3. Beach Strategy – Benefit and Cost Model Inputs (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Beach	Beaconsfield Feeder Bluff Full	$7,929	$0	$369	6.9	2.2
	Beaconsfield Feeder Bluff Partial	$3,027	$0	$141	5.5	1.3
	Twin Rivers Partial	$5,546	$0	$258	4.3	0.2
	WDNR Budd Inlet Beach Full	$9,569	-$1	$445	2	1.1

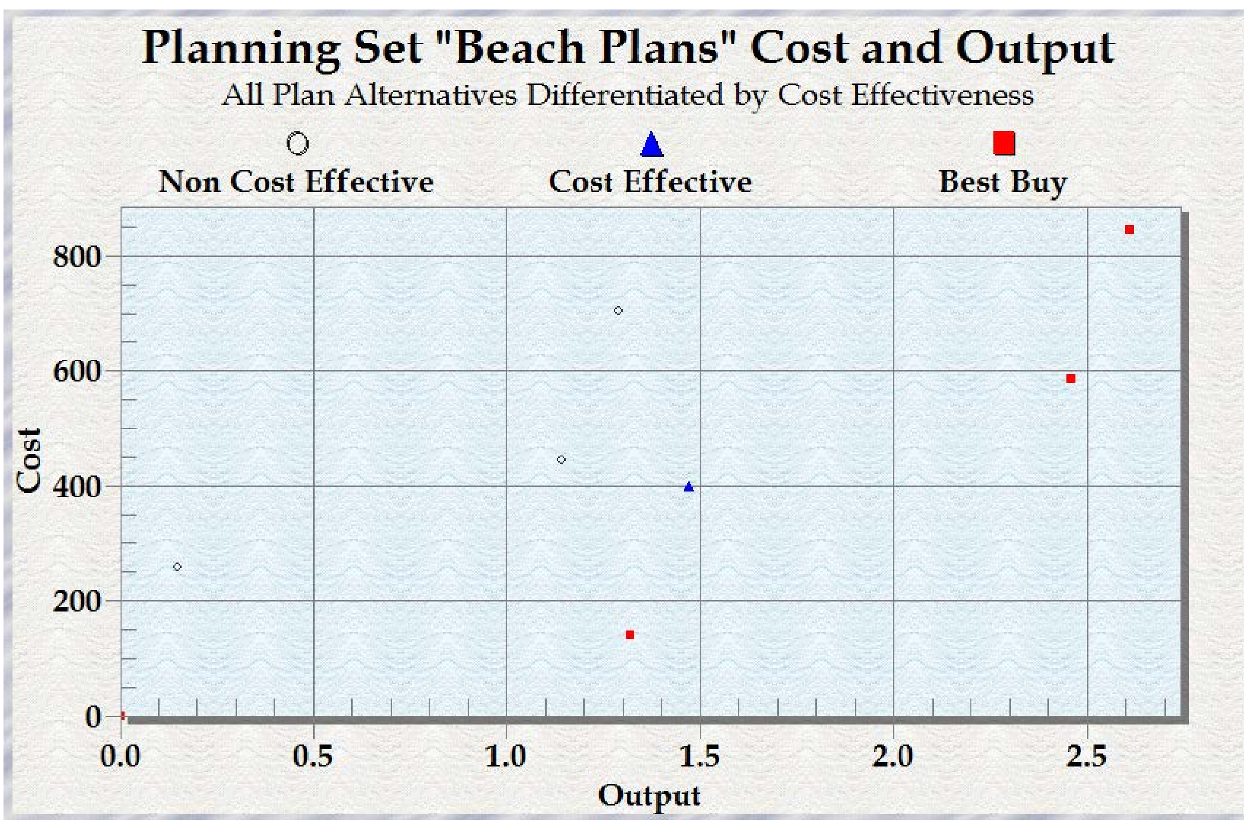

Figure 4-3. Beach Strategy – Plot of Possible Plan Combinations

The cost effectiveness and incremental cost analysis resulted in four best buy plans which effectively and efficiently provide ecosystem restoration outputs, including the No Action plan. These plans are displayed in Table 4-4 and the best buy incremental bar graph in Figure 4-3. The following sections describe the beach sites that were carried forward for further analysis.

Table 4-4. Beach Strategy – Incremental Costs of Best Buy Alternative Plans

Alternative Plan	Average Annual Cost ($1,000s)	Average Annual Output (Net EO)	Average Annual Cost/ Output ($1,000s)	Incremental Cost ($1,000s)	Incremental Output (Net EO)	Incremental Cost/Output ($1,000s)
No Action	$0	0.0	$0	$0	0.0	$0
Beaconsfield Partial	$141	1.3	$107	$141	1.3	$107
Beaconsfield Partial and WDNR Budd Inlet Beach	$586	2.5	$238	$445	1.1	$390
Beaconsfield Partial, WDNR Budd Inlet Beach, and Twin Rivers Partial	$844	2.6	$323	$258	0.2	$1,721

Note: Pink highlighted plan advanced.

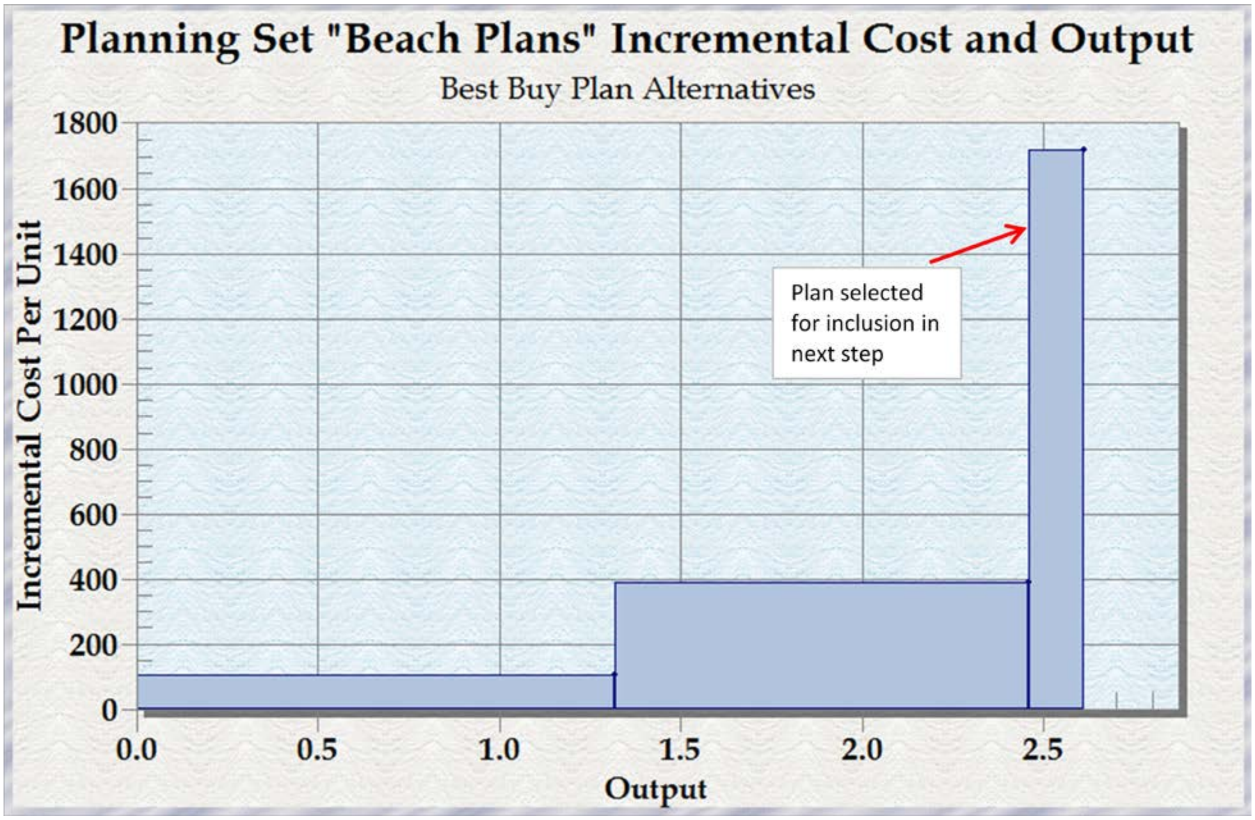

Figure 4-4. Beach Strategy – Best Buy Plans

4.2.1 Sites included in Beach Strategy

There are three best buy sites included in the final array of alternatives that address the beach strategy. Restoration objectives associated with this strategy are to restore the size and quality of beaches by removing or modifying barriers to sediment supply and transport processes to littoral drift cells. Target ecosystem processes for beach restoration include the following:

- Sediment supply
- Sediment transport
- Erosion and accretion of sediments
- Detritus recruitment and retention
- Freshwater input

- Solar incidence

Detailed information about the three beach sites is included in the main report.

4.2.2 Ecosystem Benefits of Restoration Sites on Beaches

Qualitative benefits of these two beach restoration sites would derive from restoring erosion of the feeder bluffs (currently located behind armoring), as well as sediment transport and deposition. This erosion provides sediment to down-drift areas creating gently sloping beach profiles with shallow water habitat for migration of juvenile salmonids and natural barriers for small coastal embayments. In addition, a variety of substrate sizes provided by the bluff erosion will support colonization of a variety of biota. Populations of epi- and endo-benthic invertebrates like clams, worms and amphipods, as well as forage fish spawning and rearing would likely increase. Backshore vegetation will establish and large woody debris will accumulative on the beach, functioning as thermal refuge and structure for upper intertidal fauna. Benefits to these lower trophic levels would provide a forage base for marine predators like salmon and nearshore birds. Increased sediment delivery and nutrient input (via detritus) would lead to healthier eelgrass beds along the shoreline. Removal of shoreline armoring and fill from intertidal areas increases upper beach area and connectivity between terrestrial and marine components of nearshore ecosystems.

4.3 BARRIER EMBAYMENT

IWR Planning Suite was used to generate an initial array of alternative plans comprised of all possible combinations of sites within the barrier embayment strategy using total average annual costs and average annual net ecosystem outputs displayed in Table 4-5. All sites were combinable with exception of the sites which have multiple scales (full and partial). No sites were dependent on any other sites. All possible combinations of sites are displayed in Figure 4-5.

Table 4-5. Barrier Embayment Strategy – Benefit and Cost Model Inputs (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Barrier Embayment	Big Beef Creek Estuary Full	$32,629	$0	$1,519	29.6	7.9
	Dugualla Bay Partial	$72,289	-$2	$3,363	572	162.6
	Livingston Bay Full	$12,863	-$19	$580	244.6	41.6

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
	Livingston Bay Partial	$12,062	-$14	$547	238.7	40.5
	Point Whitney Lagoon Full	$9,522	-$1	$442	6.1	2.0

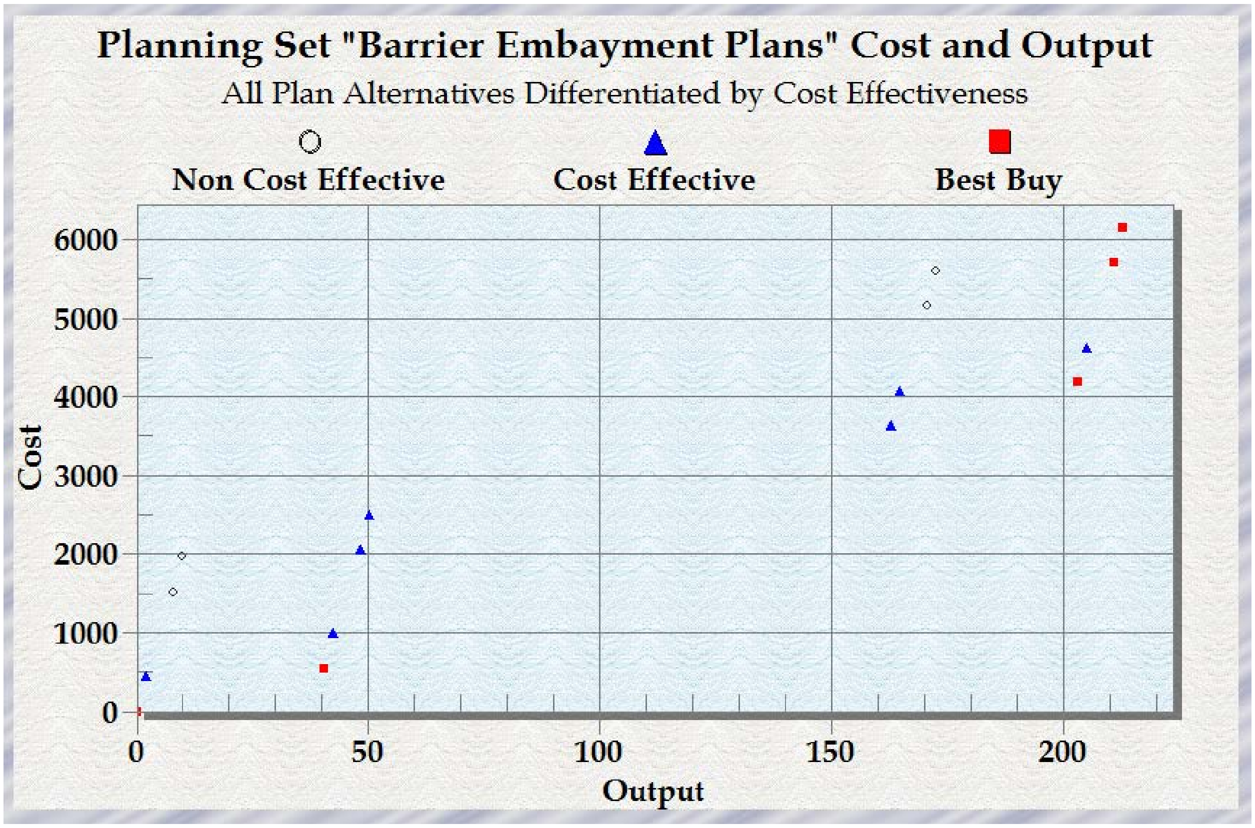

Figure 4-5. Barrier Embayment Strategy – Plot of Possible Plan Combinations

The cost effectiveness and incremental cost analysis resulted in five best buy plans which effectively and efficiently provide ecosystem restoration outputs, including the No Action plan. These plans are displayed in Table 4-6 and the best buy incremental bar graph in Figure 4-6. The following sections describe the barrier embayment sites that were carried forward for further analysis.

Table 4-6. Barrier Embayment Strategy – Incremental Costs of Best Buy Alternative Plans

Alternative Plan	Average Annual Cost ($1,000s)	Average Annual Output (Net EO)	Average Annual Cost/ Output ($1,000s)	Incremental Cost ($1,000s)	Incremental Output (Net EO)	Incremental Cost/Output ($1,000s)
No Action	$0	0.0	$0	$0	0.0	$0
Livingston Bay Partial	$547	40.5	$14	$547	40.5	$14
Livingston Bay Partial, Dugualla Bay Partial	$3,910	203.1	$19	$3,363	162.6	$21
Livingston Bay Partial, Dugualla Bay Partial, and Big Beef Full	$5,430	210.9	$26	$1,519	7.9	$193
Livingston Bay Partial, Dugualla Bay Partial, Big Beef Full, and Point Whitney Full	$5,872	212.9	$28	$442	1.9	$227

Note: Pink highlighted plan advanced.

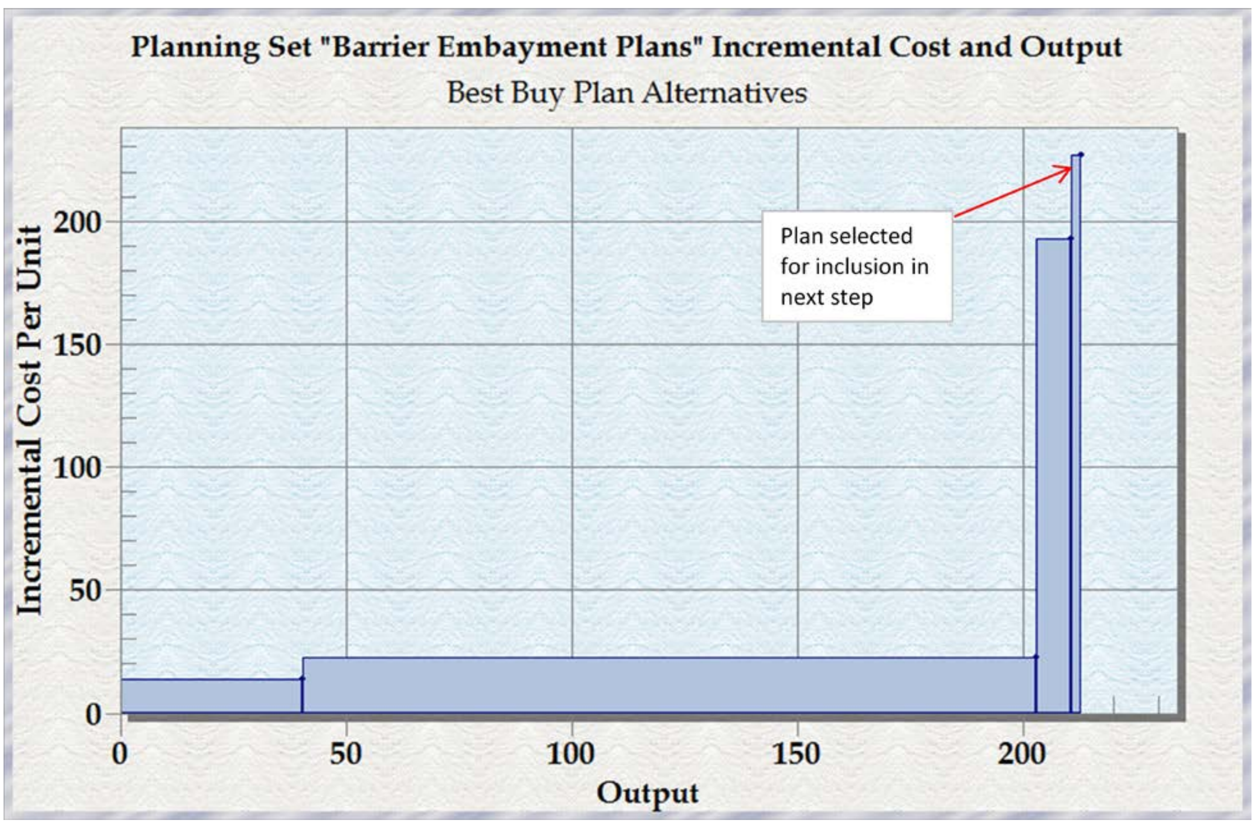

Figure 4-6. Barrier Embayment Strategy – Best Buy Plans

4.3.1 Sites included in Barrier Embayment Strategy

There are four best buy sites included in the final array of alternatives that address the barrier embayment strategy: Big Beef Creek Estuary, Dugualla Bay, Livingston Bay, and Point Whitney Lagoon. Barrier embayment restoration objectives are to restore the sediment input and transport processes that sustain the barrier beaches that form these sheltered bays. Objectives also include the restoration of the tidal flow processes within these partially closed systems, often cut off by fill or other constrictions from a tidal connection to Puget Sound. Target ecosystem processes for barrier embayments vary based on extent of freshwater input and nature of the barrier, but in general they include the following:

- Tidal hydrology
- Sediment supply and transport
- Erosion and accretion of sediment
- Tidal channel formation and maintenance
- Detritus recruitment and retention

Detailed information about the four barrier embayment sites is included in the main report.

4.3.2 Ecosystem Benefits of Barrier Embayment Sites

Qualitative benefits of these four barrier embayment sites would derive from restoring or improving tidal influence to 846 acres of marsh, mudflats and tidal channels. Barrier beaches associated with these partially enclosed embayments would also be restored or enhanced. Ecological benefits are similar to those described for open coastal inlets, although there are added benefits of barrier beaches. The presence of this type of beach provides more protection to the embayment as well as structure on the beach itself for invertebrate colonization and forage fish spawning. Restoring barrier embayments also adds to the complexity and length of Puget Sound's shoreline. These ecosystems have high ecological value, providing essential foraging and rearing habitat for migratory species of birds and juvenile salmonids.

4.4 COASTAL INLET

IWR Planning Suite was used to generate an initial array of alternative plans comprised of all possible combinations of sites within the coastal inlet strategy using total average annual costs and average annual net ecosystem outputs displayed in Table 4-7. All sites were combinable with exception of the sites which have multiple scales (full and partial). No sites were dependent on any other sites. All possible combinations of sites are displayed in Figure 4-7.

Table 4-7. Coastal Inlet Strategy – Cost and Benefit Model Inputs (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Coastal Inlet	Chambers Bay Full	$288,020	-$1	$13,407	83.5	8.5
	Chambers Bay Partial	$96,699	-$1	$4,501	47	3.4
	Deer Harbor Estuary Full	$6,679	$0	$311	16.1	4.8
	Harper Estuary Full	$12,240	$0	$569	6.2	1.7
	Harper Estuary Partial	$16,025	$5	$751	5.7	1.1
	Lilliwaup Partial	$30,619	$0	$1,425	19.6	1.1
	Sequalitchew Full	$166,320	$7	$7,750	4.5	0.9
	Snow/Salmon Creek Estuary Partial	$37,798	$4	$1,764	52.2	6.8
	Tahuya River Estuary Full	$28,917	$0	$1,346	36.1	7.6
	Washington Harbor Partial	$17,666	$5	$827	14	0.6

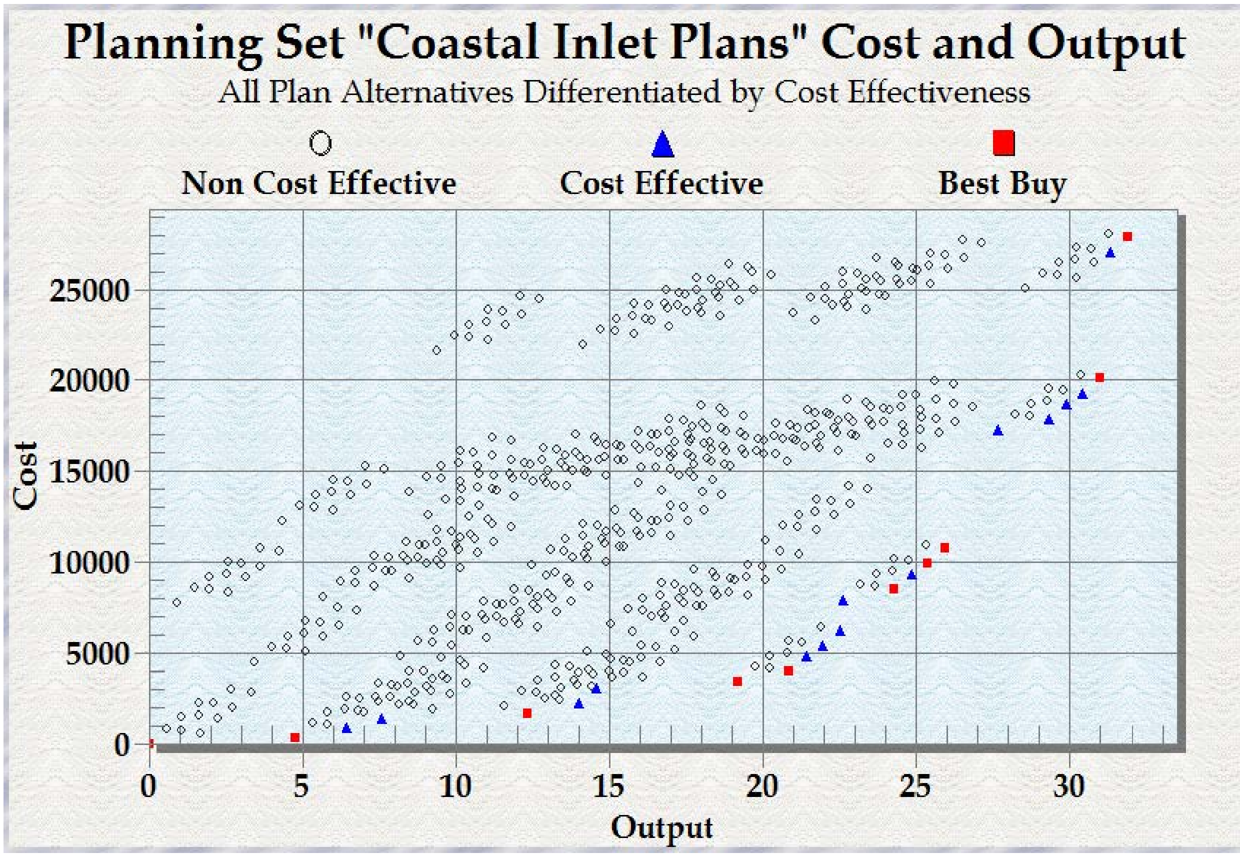

Figure 4-7. Coastal Inlet Strategy – Plot of Possible Plan Combinations

The cost effectiveness and incremental cost analysis resulted in 10 best buy plans which effectively and efficiently provide ecosystem restoration outputs, including the No Action plan. These plans are displayed in Table 4-8 and the best buy incremental bar graph in Figure 4-8. The following sections describe the coastal inlet sites that were carried forward for further analysis.

Table 4-8. Coastal Inlet Strategy – Incremental Costs of Best Buy Alternative Plans

Alternative Plan	Average Annual Cost ($1,000s)	Average Annual Output (Net EO)	Average Annual Cost/ Output ($1,000s)	Incremental Cost ($1,000s)	Incremental Output (Net EO)	Incremental Cost/Output ($1,000s)
No Action	$0	0.0	$0	$0	0.0	$0
Deer Harbor Full	$311	4.8	$65	$311	4.8	$65
Deer Harbor Full andTahuya Causeway Full	$1,657	12.3	$134	$1,346	7.6	$178
Deer Harbor Full , Tahuya Causeway Full, Snow Salmon Partial,	$3,421	19.2	$178	$1,764	6.8	$258
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, and Harper Full	$3,990	20.8	$191	$569	1.7	$341
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, and Chambers Bay Partial	$8,491	24.3	$350	$4,501	3.4	$1,308
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, and Chambers Bay Partial, Lilliwaup Partial	$9,917	25.4	$391	$1,425	1.1	$1,320
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Chambers Bay Partial, Lilliwaup Partial, and Washington Harbor Partial	$10,741	25.9	$414	$824	0.6	$1,421
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Lilliwaup Partial, Washington Harbor Partial, and Chambers Bay Full	$20,112	31.0	$649	$9,371	5.0	$1,863
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Lilliwaup Partial, Washington Harbor Partial, Chambers Bay Full, and Sequalitchew Full	$27,862	31.9	$874	$7,750	0.9	$8,516

Note: Pink highlighted plan advanced.

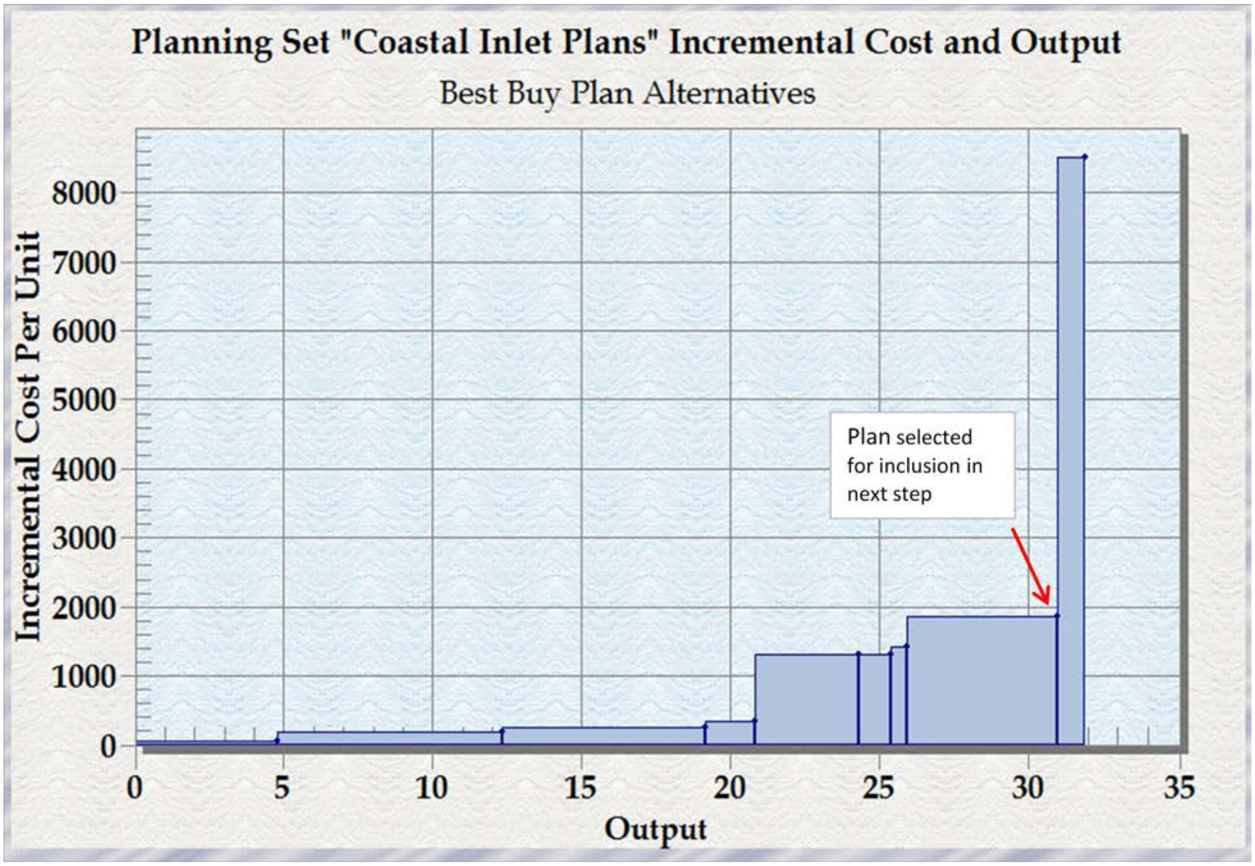

Figure 4-8. Coastal Inlet Strategy – Best Buy Plans

4.4.1 Sites included in Coastal Inlet Strategy

There are seven best buy sites included in the final array of alternatives that address the open coastal inlet strategy. Restoration objectives associated with this strategy are to remove barriers to tidal flow and freshwater input, restoring the quantity and quality of open coastal inlets. Target ecosystem processes for open coastal inlet restoration include the following:

- Tidal flow
- Freshwater input (including alluvial sediment delivery)
- Tidal channel formation and maintenance
- Detritus recruitment and retention

Detailed information about the seven coastal inlet is included in the main report.

4.4.2 Ecosystem Benefits of Restoration Sites in Coastal Inlets

Qualitative benefits of these four open coastal inlet sites would derive from restoring and/or improving 1) tidal flow to 110 acres of estuarine wetlands and 2) freshwater and sediment input to adjacent nearshore areas. Restoration of these shoreforms adds complexity and length to the Puget Sound shoreline. Estuarine wetlands and associated vegetation, tidal channels and woody debris provide valuable nursery habitat for juvenile salmonids, including ESA-listed Chinook and Hood Canal Summer Chum. Although small in acreage compared with the large river deltas, coastal inlets are essential foraging and rearing "pit stops" for juvenile salmonids during shoreline migration. The improved water quality and exchange of sediment would support the expansion of shellfish populations and highly productive eelgrass beds. Benefits to these lower trophic levels would increase the forage base for birds, mammals, and predatory fish, such as surf scoters, Southern Resident killer whales4, and bull trout4.

5 FOCUSED ARRAY OF ALTERNATIVES

IWR Planning Suite was then used to generate a focused array of alternative plans comprised of all possible combinations of the 22 sites carried forward from the previous step. This analysis identified 23 best buy alternative plans that contain one or more sites and address one or more strategies. The 23 best buy plans are shown in Table 5-1 along with the associated average annual cost per output and incremental cost per output for each best buy plan. Each plan builds on the previous plan. Beginning with plan number 2, Deepwater Slough Partial is the only site included in this alternative. Plan number 3 includes Deepwater Slough Partial plus Milltown Island Partial, and plan number 4 includes those two plus Spencer Island Partial. This pattern continues until Chambers Bay Full is added to create the most expensive, highest output plan, plan number 23, which includes 22 sites. The last site added is the site with the highest incremental costs per output. Plans highlighted in green in Table 5-1 were carried forward to the final array of alternatives (described in Section 6).

[4] Federal ESA-listed species

Table 5-1. Incremental Cost Analysis of Best Buy Plans (October 2011 price level)

Plan No.	Plan Name	Average Annual Output (AAHU or Net EO)	Average Annual Cost ($,1000)	Average Cost / Output ($1,000/AAHU)	Incremental Output (AAHU)	Incremental Cost ($1,000)	Incr. Cost Per Output ($1,000)
1	No Action	0.0	$0	$0	0.0	$0	$0
2	Deepwater Slough	90.2	$244	$2.7	90.2	$244	$2.7
3	plus Milltown Island Partial	154.2	$440	$3.1	64.0	$196	$3.1
4	plus Spencer Island Partial	290.2	$1,202	$5.6	136.0	$762	$5.6
5	plus Livingston Bay	330.7	$1,749	$13.5	40.5	$547	$13.5
6	plus Dugualla Bay	493.3	$5,112	$20.7	162.6	$3,363	$20.7
7	plus Nooksack Delta Partial	1,143.8	$19,371	$21.9	650.5	$14,259	$21.9
8	plus Telegraph Slough Full	1,397.7	$28,161	$34.6	253.9	$8,790	$34.6
9	plus Everett Marshland	1,747.0	$44,843	$47.8	349.3	$16,682	$47.8
10	plus N. Fork Skagit River	1,800.7	$47,816	$55.4	53.7	$2,973	$55.4
11	plus Deer Harbor Estuary	1,805.5	$48,127	$64.8	4.8	$311	$64.8
12	plus Beaconsfield Bluff	1,806.8	$48,268	$108.5	1.3	$141	$108.5
13	plus Tahuya River Estuary	1,814.4	$49,614	$177.1	7.6	$1,346	$177.1
14	plus Big Beef Creek Estuary	1,822.3	$51,133	$192.3	7.9	$1,519	$192.3
15	plus Duckabush Delta	1,834.6	$53,851	$221.0	12.3	$2,718	$221.0
16	plus Point Whitney Lagoon	1,836.6	$54,293	$221.0	2.0	$442	$221.0
17	plus Snow/SalmonCreek	1,843.4	$56,057	$259.4	6.8	$1,764	$259.4
18	plus Harper Estuary Full	1,845.1	$56,626	$334.7	1.7	$569	$334.7
19	plus WDNR Budd Inlet	1,846.2	$57,071	$404.5	1.1	$445	$404.5
20	plusTwin Rivers Partial	1,846.4	$57,329	$1,290.0	0.2	$258	$1,290.0
21	plus Lilliwaup Partial	1,847.5	$58,754	$1,295.5	1.1	$1,425	$1,295.5
22	plus Washington Harbor	1,848.1	$59,581	$1,378.3	0.6	$827	$1,378.3
23	plus Chambers Bay Full	1,856.6	$72,988	$1,577.3	8.5	$13,407	$1,577.3

The following figures show the plot of possible plan combinations for the combined strategies in Figure 5-1 and the incremental cost analysis results graphically in Figure 5-2. As shown in Table 5-1 and Figure 5-2, the incremental average annual cost per output ranges from a low $0/ per output to $1,577 per output. The first 11 plans range in incremental average annual cost per output from $0 per output to $109 per output, while the next 7 plans range in incremental average annual cost per output of $177 per output to $405 per output. A significant increase in cost per output occurs between plans 19 and 20 where the incremental cost per output increases from $405 per output to $1,290 per output. Figure 5-2 shows the incremental cost analysis graphically and indicates the two action alternatives that have been selected for final evaluation and consideration for the TSP, which are listed in Table 5-1 as plan number 12 and plan number 19.

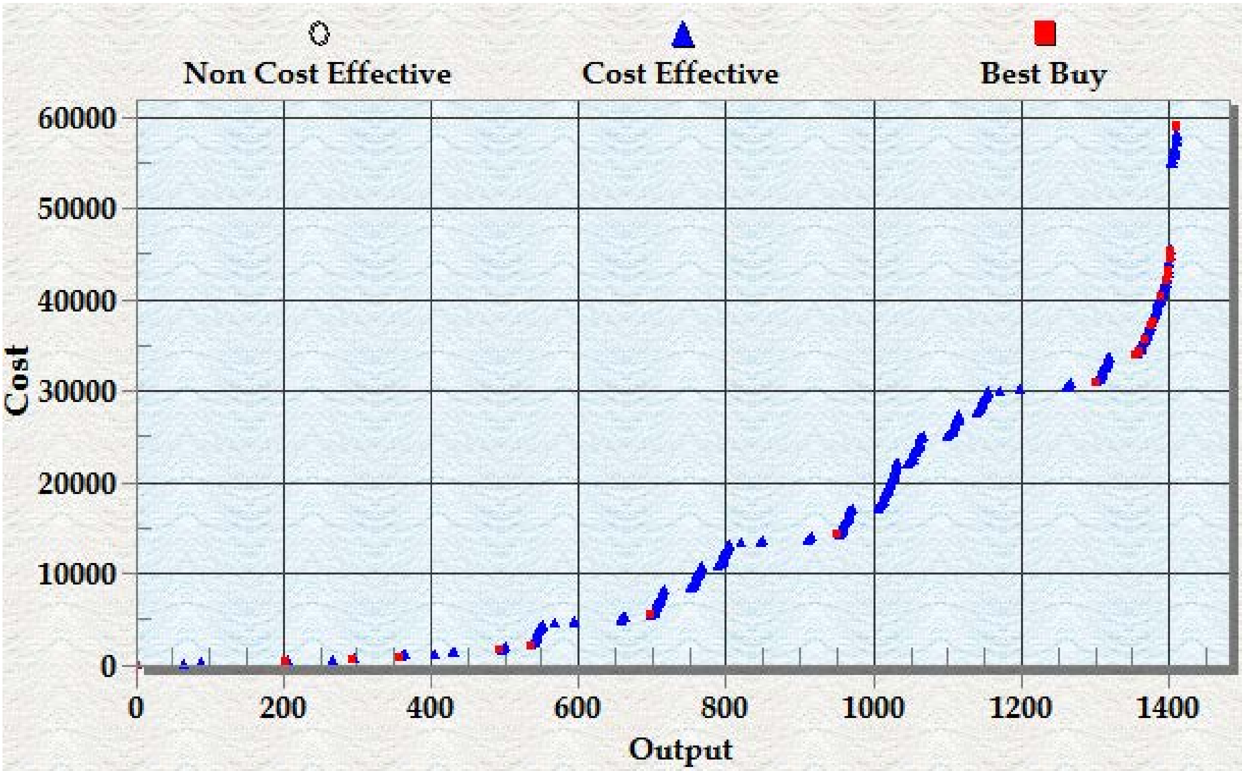

Figure 5-1. Plot of Benefits and Costs for Combined Strategies

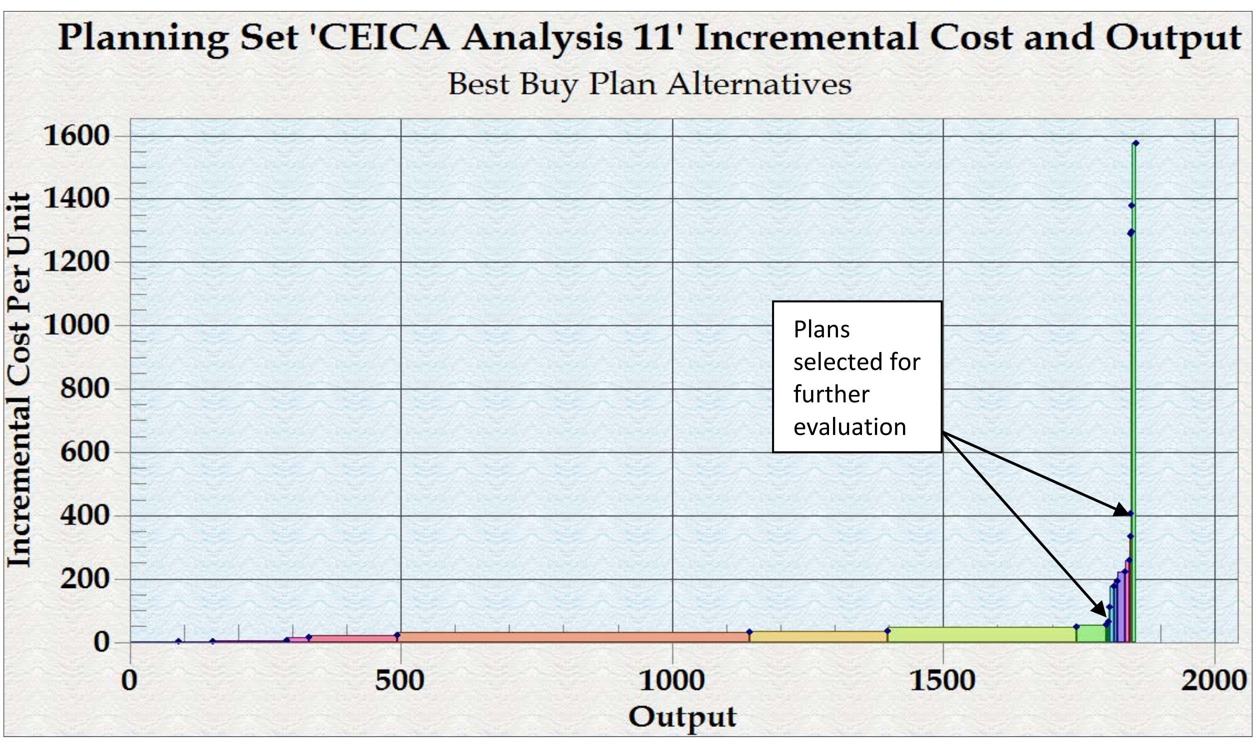

Figure 5-2. Incremental Cost Analysis for Combined Strategies

6 FINAL ARRAY OF ALTERNATIVES

After reviewing the analyses described above, the PDT identified a final array of three best buy alternatives to be carried forward for final evaluation, comparison, and selection of the Preferred Alternative. The plans selected for inclusion in the next step of the process are Plan 1, the No Action Plan; Plan 12, which includes 11 sites; and Plan 19, which includes 18 sites.

Plans 2 through 10 were not carried forward because they do not address all four restoration strategies (river deltas, beaches, barrier embayments, and coastal inlets). Because the Nearshore Study aims to recommend a comprehensive restoration plan that addresses ecosystem degradation across different habitat types and sub basins, these alternatives are not considered complete and were not carried forward for further analysis or evaluation.

Plan 12 was carried forward in the final array because it is the first alternative that addresses all four restoration strategies, including beaches. Inclusion of at least one beach site (Beaconsfield) in the final array of alternatives is critical to making progress towards comprehensive restoration across different ecosystem types in Puget Sound. It is critical to formulate alternative plans that address each of the four restoration strategies because of the broad variety of and differences between ecological benefits that accrue from restoration of the different landforms. Restoration of the different landforms can have not only cumulative benefits, but potentially synergistic benefits as well. Bluff-backed beaches are a key component of the sediment transport process in the nearshore zone, which is why the Beaconsfield site was carried forward. Reference Section 4.6.4 of the main report for additional discussion of ecosystem benefits associated with restoration of beaches.

Plans 13 through 18 were not carried forward in the final array of alternatives; the next plan carried forward for additional analysis was Plan 19. Plan 19 was selected due to the significant increase in incremental cost/output that occurs between Plan 19 and 20 (from $405/output to $1,290/output), as well as the PDT's desire to evaluate a plan that, to the fullest extent possible, takes advantage of identified opportunities to implement cost-effective, high-quality restoration. Compared to Plan 12, Plan 19 contains three additional coastal inlet sites, two additional barrier embayment sites, two additional beach sites, and one additional river delta site. The value of each of these seven sites is discussed below:

Four sites included in Plan 19 – Big Beef Creek Estuary, Duckabush River Estuary, Point Whitney Lagoon, and Tahuya River Estuary – are located in the Hood Canal reach of Puget Sound, a 60 mile long fjord with over 200 miles of shoreline and estuaries fed by large river systems.

Big Beef Creek Estuary hosts three species of salmon and is an intensively monitored watershed due to large property ownership by the University of Washington; it serves as a reference creek for the entire Hood Canal area for coho salmon. The rest of this watershed is largely undeveloped, so restoring the estuary with its eelgrass and shellfish habitats could produce the rare condition of a minimally artificial watershed. The Tahuya watershed is similarly minimally developed and is at the southernmost reach of Hood Canal where restoration would connect other reaches of less impaired shoreline process units.

The Duckabush Estuary hosts a wide variety of fish and wildlife populations including a great blue heron rookery, eelgrass beds with herring spawning areas, shellfish beds, seal haulouts and pupping areas, trumpeter swan feeding areas, and waterfowl concentrations, and serves as part of the winter range for Roosevelt elk. The Duckabush also hosts six salmonid populations including three ESA-listed species.

The Point Whitney site is a tidal lagoon with nearby osprey and bald eagle nests. Just outside the inlet of this lagoon, there is clam and oyster habitat as well as spawning habitat for three species of forage fish, which are critical prey items for many Puget Sound aquatic species. WDNR Budd Inlet Beach, along the southernmost inlet of Puget Sound, is another area of forage fish spawning where restoration could expand the area of habitat available for this critical ecosystem component.

Harper Estuary is the only proposed site on the west side of Puget Sound's main basin. Inclusion of this site would mean a more comprehensive geographical distribution of restoration actions in the overall plan. There is a forage fish pre-spawning holding area just offshore from this estuary. Adjacent shorelines have been altered, so restoration at this area is important to provide refuge for aquatic species in the disturbed shoreline reach.

The Snow Creek and Salmon Creek Estuary is the only proposed site along the Strait of Juan de Fuca. The area provides diverse and abundant wildlife habitat including spawning habitat for three forage fish species, a great blue heron rookery, waterfowl and shorebird concentrations, and shellfish habitat. These two streams and their estuary are known to host multiple ESA-listed fish, bird, and mammal species.

Constructing these seven additional sites in Plan 12 would have far-reaching benefits well beyond the project sites. These sites would provide supporting habitat for many highly migratory species, provide connectivity between less disturbed shoreline reaches, or provide refuge between highly modified shoreline reaches. The relatively small length of 22 miles of stressors removed from these sites would add significant regional environmental benefits for the relatively small investment of doing so.

While Plans 20 through 23 have noteworthy environmental benefits, the incremental cost/output increases significantly for each of these plans. Although these plans would more completely address the broad restoration needs in the study area, it was determined that the proposed Federal investment of these plans is not justifiable and viable from a cost perspective.

A summary of the final array of three alternatives is included below. Formal evaluation and comparison of these alternatives is presented in Sections 4.7 and 4.8 of the main report.

No Action Alternative

The No-Action Alternative is synonymous with the "Future Without-Project Condition." The assumption for this Alternative is that no project would be implemented by the Corps to achieve the planning objectives.

Alternative 2 (referenced as Plan 12 above)

Eleven sites were selected for Alternative 2. These sites address all four of the Nearshore Study strategies and are geographically representative of the entire study area (Figure 4-5).

Sites included in Alternative 2 are the following:

- Beaconsfield Feeder Bluff
- Deepwater Slough
- Deer Harbor Estuary
- Dugualla Bay
- Everett Marshland
- Livingston Bay
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Spencer Island
- Telegraph Slough

Alternative 3 (referenced as Plan 19 above)

A total of 18 sites were selected for Alternative 3. Similar to Alternative 2, the sites included in Alternative 3 address all four of the Nearshore Study strategies and are geographically representative of the entire study area (Figure 4-5). Sites included in Alternative 3 are the following:

- Beaconsfield Feeder Bluff
- Big Beef Creek Estuary
- Deepwater Slough
- Deer Harbor Estuary
- Duckabush River Estuary
- Dugualla Bay
- Everett Marshland
- Harper Estuary
- Livingston Bay
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Point Whitney Lagoon
- Snow Creek and Salmon Creek Estuary
- Spencer Island
- Tahuya River Estuary
- Telegraph Slough
- WDNR Budd Inlet Beach

Figure 6-1 shows the geographic locations of the sites included in the final array of alternatives. The following sections provide an overview of each site included in Alternatives 2 and 3, including a short description and overview of restoration features. For more detailed information on the site designs, see Appendix A (Restoration Site Fact Sheets) and Appendix B (Engineering Appendix).

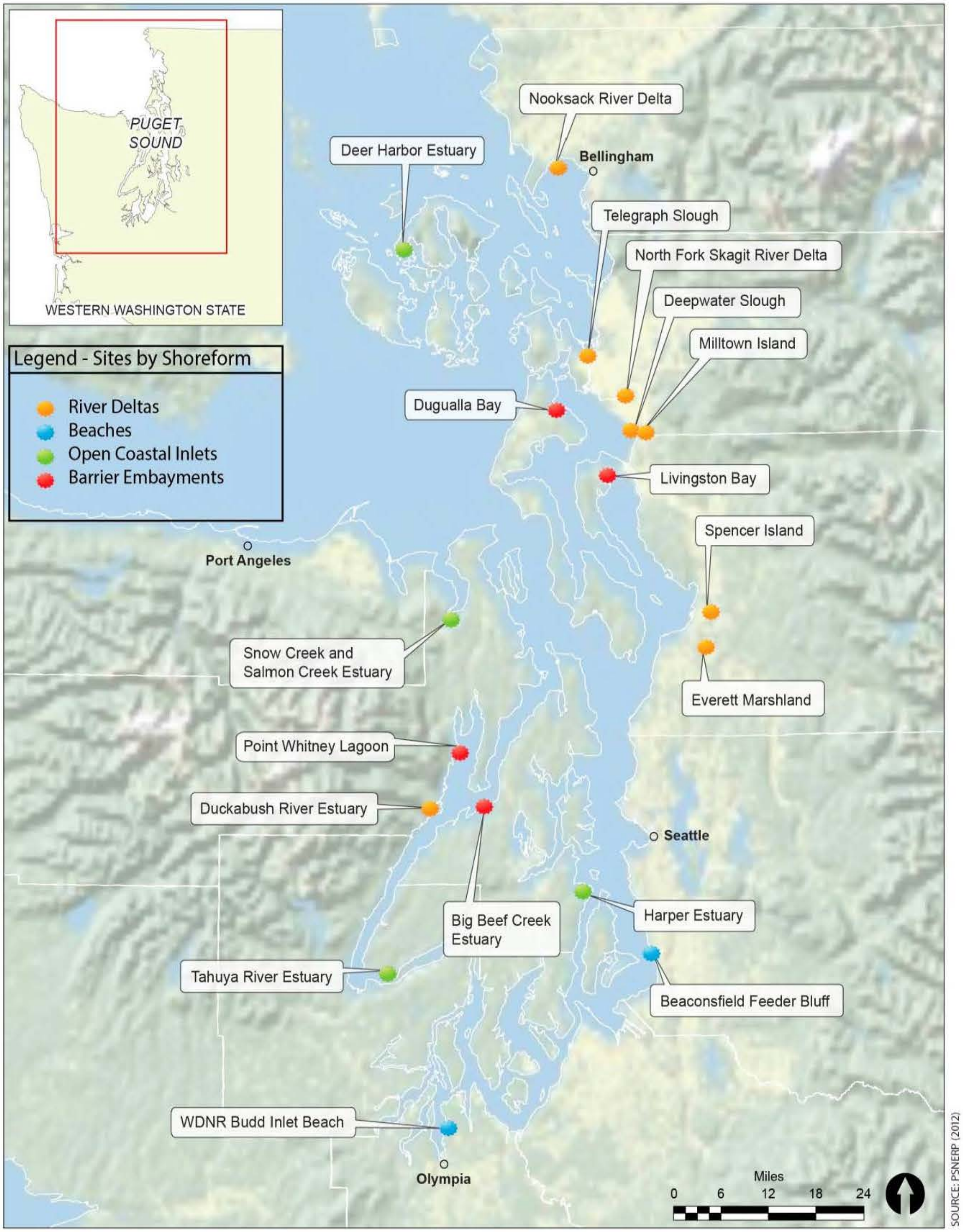

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Figure 6-1. Geographic Locations of the Sites included in the Final Array of Alternatives

7 TENTATIVELY SELECTED PLAN

The Corps objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Selecting the NER Plan requires careful consideration of planning goals, objectives, and constraints. The NER Plan is a plan that reasonably maximizes ecosystem restoration benefits considering cost effectiveness and incremental cost analysis, significance of outputs, completeness, effectiveness, efficiency, and acceptability. The selected plan must be shown to be cost effective and justified to achieve the desired level of output.

The information developed by the CE/ICA and evaluation, comparision, and trade-off analyses presented throughout this chapter have informed the decision-making process by helping to answer whether the proposed Federal investment of each alternative in the final array of justifiable and viable from a cost perspective; that is, whether the environmental benefit of the additional output in the next level of investment is worth its additional cost. Per the general decision-making guidelines outlined in Appendix E of ER 1105-2-100, the following factors assist in determining a justifiable and viable alternative: output target and threshold, and cost affordability.

In consideration of the steps taken to formulate scientifically sound, sustainable solutions to solve the stated problems of Puget Sound nearshore ecosystem degradation, and upon review of the results of the evaluation and comparison of alternatives presented throughout the main report, Alternative 2 has been identified as the NER Plan and is selected as the Preferred Alternative. Alternative 2 is a best buy plan that completely and effectively addresses nearshore ecosystem degradation around Puget Sound. Alternative 2 is an acceptable plan from the perspective of Federal and state agencies, tribes, and study stakeholders. Alternative 2 offers a complex and geographically extensive set of solutions to the stated problems, benefiting a large area and a significant number of ESA-listed and other species that either inhabit Puget Sound's nearshore zone or depend on such species as part of their food chain. Alternative 2 is the Preferred Alternative and TSP.

Sites included in the TSP range from six to 1,800 acres with costs ranging from $4 million to over $300 million per site. The total area of the proposed sites is 5,354 acres, and the estimated cost of all these sites is approximately $1.1 billion at the July 2014 price level.

There are no costs or features (local betterments) over the National Ecosystem Restoration (NER) Plan that has been identified for implementation.

7.1 DESCRIPTION OF TENTATIVELY SELECTED PLAN

Based on the Nearshore Study results over more than 10 years, the Corps is proposing a suite of ecosystem restoration sites throughout the Puget Sound nearshore zone. The types of features identified for restoration include freshwater and tidal wetlands, coastal embayments, intertidal mudflats, estuarine tidal channels, beaches, and coastal bluffs. Restoration of these features and the natural processes that sustain them requires removal of anthropogenic stressors that have reduced ecosystem functions in the nearshore zone. The proposed restoration measures remove stressors such as shoreline armoring and bank stabilization, tidal barriers, wetland fill, overwater structures, and tidal channel restrictions including levees to allow natural processes to recover.

The TSP includes 11 sites that, taken together, address all four of the formulated strategies for process-based restoration. The TSP would restore 5,354 acres of tidally influenced wetlands and would remove 75,172 feet of stressors from the nearshore zone, restoring the natural processes that support VECs and promoting the ecosystem structures and functions provided by wetlands, kelp and eelgrass beds, and riparian vegetation.

The 11 sites included in the TSP are geographically representative of a large portion of the study area, with a majority of sites focused around the Skagit and Snohomish River Deltas, with one site on the stretch of shoreline between Tacoma and Seattle (Beaconsfield) and one to the north in the San Juan Islands (Deer Harbor). Sites included in the TSP are located in four of the seven sub-basins around Puget Sound, with 8 of the 11 sites located in one sub-basin (Whidbey). The TSP includes seven sites in major river deltas, one beach site, one open coastal inlet site, and two barrier embayment sites. All 11 sites of the TSP include critical habitat for ESA-listed species.

Please reference Sections 4.6 and 6.2 of the main report for detailed information regarding the 11 sites in the TSP. A map of the 11 sites included in the TSP is presented in Figure 7-1.

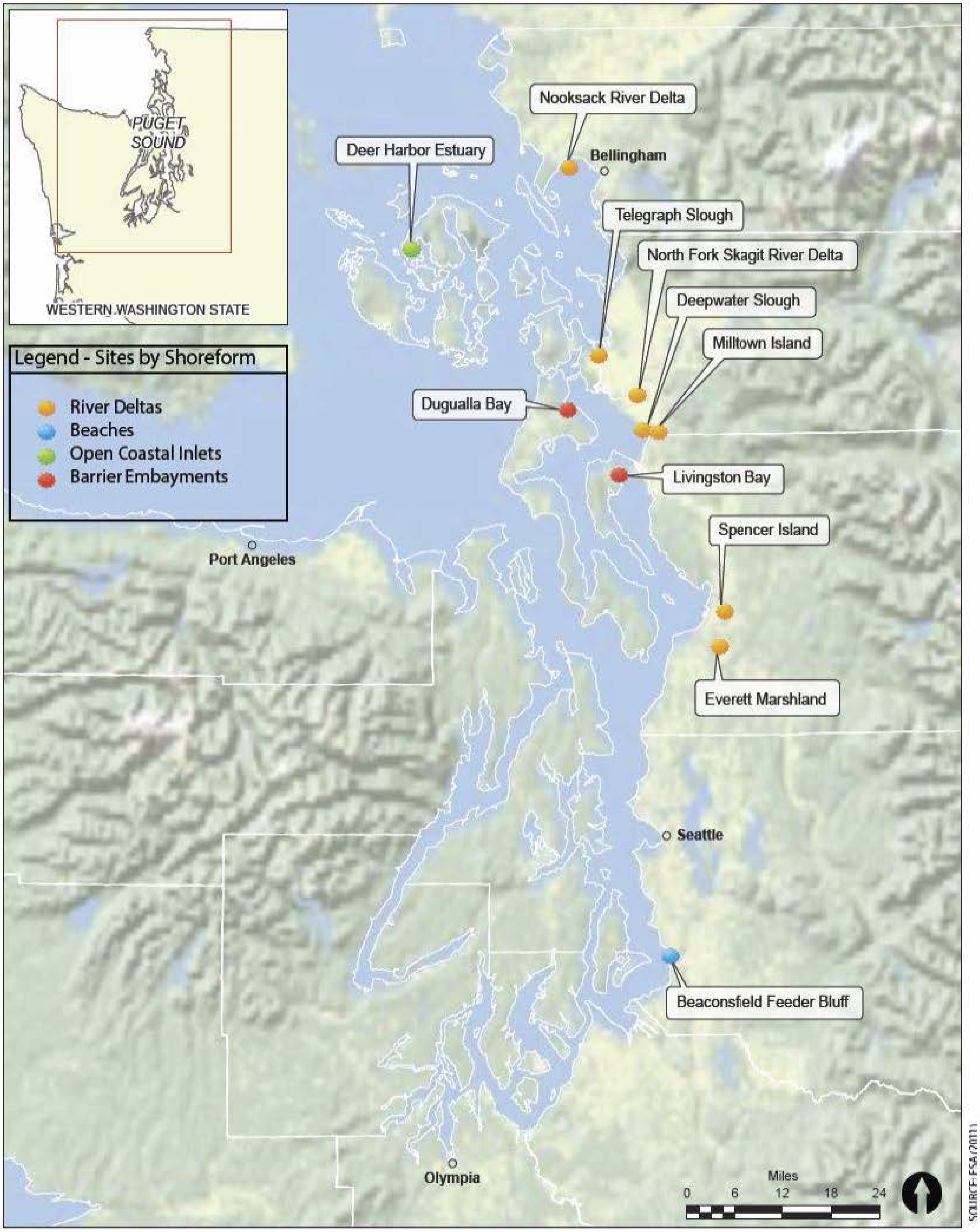

Figure 7-1. Geographic Locations of the Sites included in the Tentatively Selected Plan

7.2 ECONOMIC/COST SUMMARY OF THE TSP

Based on October 2014 price levels, the estimated project cost is $1,126,340,000 (with contingency), which includes monitoring costs of $5,799,000 and adaptive management costs of $17,398,000 (before contingency). In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended {33 U.S.C. 2213(c)}, the Federal share of the project first cost is estimated to be $693,092,000 and the non-Federal share is estimated to be $433,278,000, which includes a 65% Federal and 35% non-Federal cost-share for restoration features. The non-Federal costs include the value of lands, easements, rights of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated to be $433,278,000. The LERRD estimate exceeds the 35% non-Federal cost share for restoration features by $39,059,000, and these excess LERRD are not cost-shared and are a non-Federal responsibility. The overall cost-share of the estimated cost is 62% Federal and 38% non-Federal. Table 7-1 outlines the project first costs of the TSP at the October 2014 price level. Table 7-2 displays the cost-share information for the TSP based on project first costs at the October 2014 price level.

Table 7-1. Estimated Cost of the TSP*

Project Cost Component	Project First Cost (in $1,000, Oct 2014 price level)
Construction and Real Estate	
Construction Costs	$297,527
Real Estate Costs (including relocations)	$358,942
Contingency	$227,179
Planning, Engineering and Design (PED)	$130,149
Construction Management (CM)	$89,347
Monitoring	$5,799
Adaptive Management	$17,398
Total Estimated Cost	$1,126,340

Table 7-2. Cost-Share Estimate of the TSP

	Federal Cost ($1,000, Oct 2014 price level)	Non-Federal Cost ($1,000, Oct 2014 price level)
LERRD (non-Federal cost creditable up to 35% of non-Federal cost share for Ecosystem Restoration features)	$0	$394,219
Excess LERRDs (100% non-Federal)	$0	$39,059
Ecosystem Restoration, less excess LERRDs (65% Federal/35% non-Federal)	$693,062	$0
Total Cost Share	$693,062	$433,278
Overall Cost Share Percentage	62%	38%

Table 7-3 provides an economic summary of the TSP. Interest during construction was computed using estimated project costs at the October 2014 price level, anticipated construction durations for each of the 11 TSP sites (they range from 1 year to 6 years each), and the current Federal discount rate (3.5% for fiscal year 2014), bringing total investment costs to $1,189,463,000. Operations and maintenance expenses have been estimated for the 11 sites and detailed O&M manuals will be developed for each site during the PED phase. Annual costs were updated using the current cost estimate at the October 2014 price level. Total average annual cost is estimated at $50,788,000, with an average annual cost of $28,000 per AAHU (or net EO).

Table 7-3. Economic Summary of the TSP

	Cost and Benefit Summary of TSP (Oct 2014 price level)
Interest Rate (Fiscal Year 2014)	3.50%
Interest Rate, Monthly	0.29%
Construction Period, Years	22
Period of Analysis, Years	50
Estimated Cost	$1,126,340,000
Interest During Construction	$63,123,000
Investment Cost	$1,189,463,000
Average Annual Cost	
Amortized Cost	$50,751,000
OMRR&R	$37,000
Total Annual Cost	$50,788,000
Average Annual Benefits	
Average Annual Habitat Units (AAHUs, or Net EO)	1806.8
Average Annual Cost/AAHU	$28,000

* O&M costs have been estimated for the 11 sites recommended in the TSP and are based on the changes in O&M estimated in Table 2-2. Detailed O&M manuals will be developed for each site during the PED phase.

First costs for authorization purposes are estimated at $1.1 billion (October 2014 price levels) and the fully funded cost estimate to the mid-point of construction is estimated at $1.7 billion.

8 REFERENCES

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