PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION

APPENDIX I

ECONOMICS

Integrated Feasibility Report and Environmental Impact Statement

US Army Corps of Engineers®
Seattle District

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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 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 and Recommended Plan
- 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 and Chapter 4 of the feasibility report.

To effectively evaluate the 36 sites presented for initial evaluation in Chapter 4 of the feasibility report, 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.

2.1.1 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:

Quantity Quality

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

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). Corps headquarters (HQ) has reviewed and approved this model for one-time use.

2.1.2 Evaluation of Site Costs

Costs were estimated for the 36 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, including 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 conceptual design reports. 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. Costs developed for the cost effectiveness and incremental cost analysis (CE/ICA analysis) utilized costs at the October 2011 price level and were annualized using a 4% discount rate (FY12 rate) and assumed similar construction durations across sites. Monitoring and adaptive management costs were included as a cost contingency and were confirmed to not to vary considerably among sites, with the study team concluding that these costs would not impact the outcomes of the CE/ICA analysis. Monitoring costs ranged from 0.9-0.95% and adaptive management costs ranged from 2.58-2.85% for each of the sites.

Operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs were not included in this phase of evaluation because little was known about the cost of OMRR&R at the conceptual design level. Expected changes to OMRR&R was evaluated at a conceptual level, but it was subsequently determined that inclusion of OMRR&R costs had a moderate level of uncertainty but would not affect the screening of alternatives at this phase. OMRR&R is evaluated and presented in the project costs for the recommended plan in Chapter 6 of the feasibility report.

Certified Class 3 cost estimates were developed for the recommended plan based on feasibility-level designs. Final feasibility-level cost estimates are presented in Section 6.7 of the feasibility report and the Cost Engineering Annex of Appendix B.

2.1.3 Summary of Site Benefits and Costs

An additional round of qualitative evaluation and screening was completed based on site benefits, preliminary costs, technical feasibility, and overall readiness to proceed. After this step, 24 sites were carried forward for additional analysis, evaluation, and screening.

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

Table 2-1 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 2-1. Benefits and Costs for 31 Site Designs, by Strategy (October 2011 price level)

		Costs ($1,000s)		Benefits	
Strategy	Site Design Name	First Costs[1]	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output (Net EO)
Delta	Big Quilcene Partial	$35,073	$1,632	25.5	0.6
	Deepwater Slough Partial	$6,652	$310	269.6	90.2
	Duckabush Full	$71,085	$3,309	39.4	12.9
	Duckabush Partial	$58,403	$2,719	38.1	12.3
	Everett Marshland Full	$357,549	$16,644	829.1	349.3
	Everett Marshland Partial	$154,286	$7,182	427.4	167.8
	Milltown Island Partial	$4,246	$198	214.2	64
	Nooksack River Delta Partial	$331,473	$14,132	1,807	650.5
	North Fork Skagit Delta Full	$64,393	$2,998	256.1	53.7
	Spencer Island Partial	$16,916	$787	313.2	136
	Telegraph Slough Full	$188,613	$8,779	832.2	253.9
	Telegraph Slough Partial	$93,922	$4,372	146.9	16.3
Beach	Beaconsfield Feeder Bluff Full	$7,929	$369	6.9	2.2
	Beaconsfield Feeder Bluff Partial	$3,027	$141	5.5	1.3
	Twin Rivers Partial	$5,546	$258	4.3	0.2
	WDNR Budd Inlet Beach Full	$9,569	$446	2	1.1
Barrier Embayment	Big Beef Creek Estuary Full	$32,629	$1,519	29.6	7.9
	Dugualla Bay Partial	$72,289	$3,365	572	162.6
	Livingston Bay Full	$12,863	$599	244.6	41.6
	Livingston Bay Partial	$12,062	$561	238.7	40.5
	Point Whitney Lagoon Full	$9,522	$443	6.1	2
Coastal Inlet	Chambers Bay Full	$288,020	$13,408	83.5	8.5
	Chambers Bay Partial	$96,699	$4,502	47	3.4
	Deer Harbor Estuary Full	$6,679	$311	16.1	4.8
	Harper Estuary Full	$12,240	$569	6.2	1.7
	Harper Estuary Partial	$16,025	$746	5.7	1.1
	Lilliwaup Partial	$30,619	$1,425	19.6	1.1
	Sequalitchew Full	$166,320	$7,743	4.5	0.9
	Snow/Salmon Creek Estuary Partial	$37,798	$1,760	52.2	6.8
	Tahuya River Estuary Full	$28,917	$1,346	36.1	7.6
	Washington Harbor Partial	$17,666	$822	14	0.6

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

3 FORMULATION OF ALTERNATIVE PLANS

Level 5 of the plan formulation strategy included cost effective and incremental cost analysis for the 36 sites carried forward from the previous step. As discussed in Section 4.1.2 of the feasibility report, 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). Alternative plans were initially formulated to 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.

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

- First, the sites were organized into four subgroups, one for each.
- Second, 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 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 (including the No Action plan) was identified.
- Finally, a final array of four alternatives was carried forward. Each alternative 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 implementation strategy described in Section 4.3 of the feasibility report. The sites were grouped by strategy as shown in Table 2-1 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 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. For these runs of IWR Planning Suite, all sites within each strategy were identified as combinable with the exception of the sites that had multiple scales (full and partial). This approach ensured that the initial array of alternatives only included a single scale (full or partial) at each site. No sites were dependent on any other sites.

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 using the process outlined in ER 1105-2-100 for identification of a NER plan. For each of the four IWR Plan software runs (one for each strategy), the Study team evaluated costs per output for each plan to determine whether it was "worth it" in terms of costs and outputs to carry forward the next cost effective increment. Based on this analysis, one or more plans were identified to be carried forward to the next step of the alternatives formulation process, while some plans were not carried forward due to exceptionally high incremental costs per unit.

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	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Delta	Big Quilcene Partial	$35,073	$1,632	25.5	0.6
	Deepwater Slough Partial	$6,652	$310	269.6	90.2
	Duckabush Full	$71,085	$3,309	39.4	12.9
	Duckabush Partial	$58,403	$2,719	38.1	12.3
	Everett Marshland Full	$357,549	$16,644	829.1	349.3
	Everett Marshland Partial	$154,286	$7,182	427.4	167.8
	Milltown Island Partial	$4,246	$198	214.2	64
	Nooksack River Delta Partial	$331,473	$14,132	1,807	650.5
	North Fork Skagit Delta Full	$64,393	$2,998	256.1	53.7
	Spencer Island Partial	$16,916	$787	313.2	136
	Telegraph Slough Full	$188,613	$8,779	832.2	253.9
	Telegraph Slough Partial	$93,922	$4,372	146.9	16.3

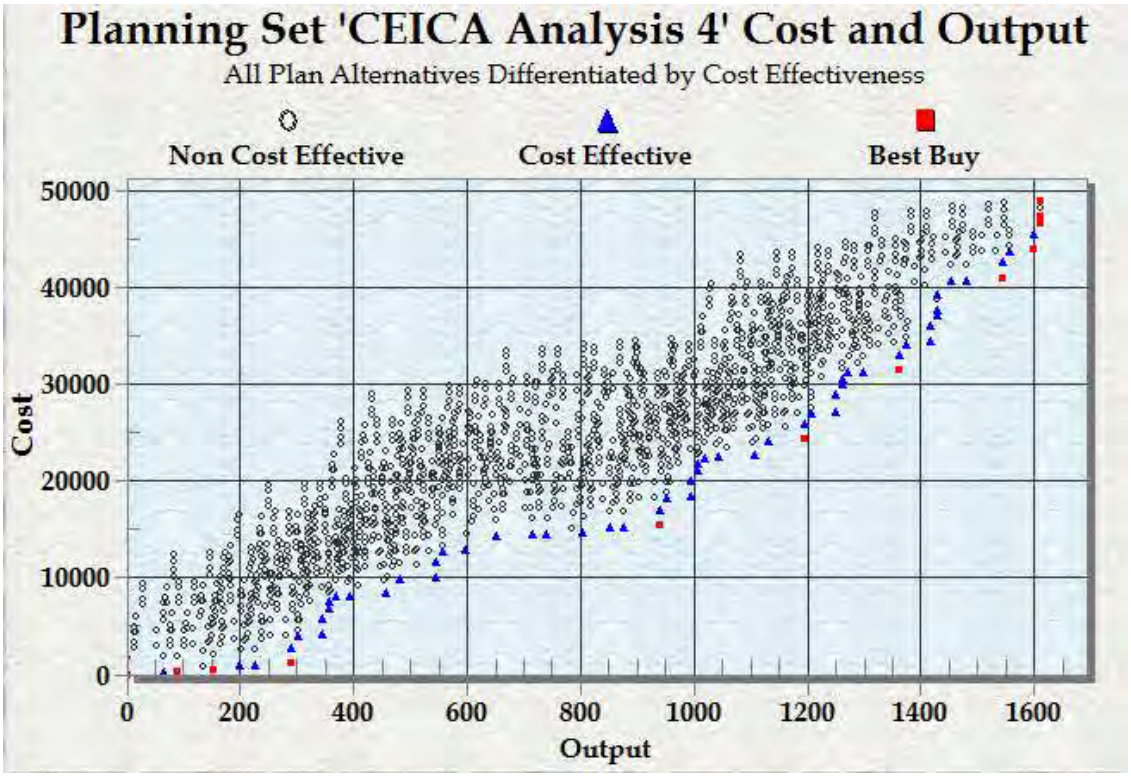

Figure 4-1. River Delta Strategy – Plot of Possible Plan Combinations

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	$0	-	$0
Milltown Partial	$198	64	$3.1	$198	64	$3.1
Milltown Partial and Deepwater Partial	$310	90.2	$3.4	$310	90.2	$3.4
Milltown Partial, Deepwater Partial and Spencer Island Partial	$1,295	290.2	$4.5	$787	136	$5.8
Milltown Partial, Deepwater Partial, Spencer Island Partial and Nooksack Partial	$15,427	940.7	$16.4	$14,132	650.5	$21.7
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial and Telegraph Full	$24,206	1194.6	$20.3	$8,779	253.9	$34.6
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, and Everett Marshland Partial	$31,388	1362.4	$23.0	$7,182	167.8	$42.8
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, and Everett Marshland Full	$48,032	1711.7	$28.1	$16,644	349.3	$47.6
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, and North Fork Skagit Full	$51,030	1765.4	$28.9	$2,998	53.7	$55.8
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, and Duckabush Partial	$53,749	1777.7	$30.2	$2,719	12.3	$221.1
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, and Duckabush Full	$57,058	1790.6	$31.9	$3,309	12.9	$256.5
Milltown Partial, Deepwater Partial, Spencer Island Partial, Nooksack Partial, Telegraph Full, Everett Marshland Full, North Fork Skagit Full, Duckabush Full, and Big Quilcene Partial	$61,430	1806.9	$34.0	$4,372	16.3	$268.2

Note: Pink highlighted plan advanced.

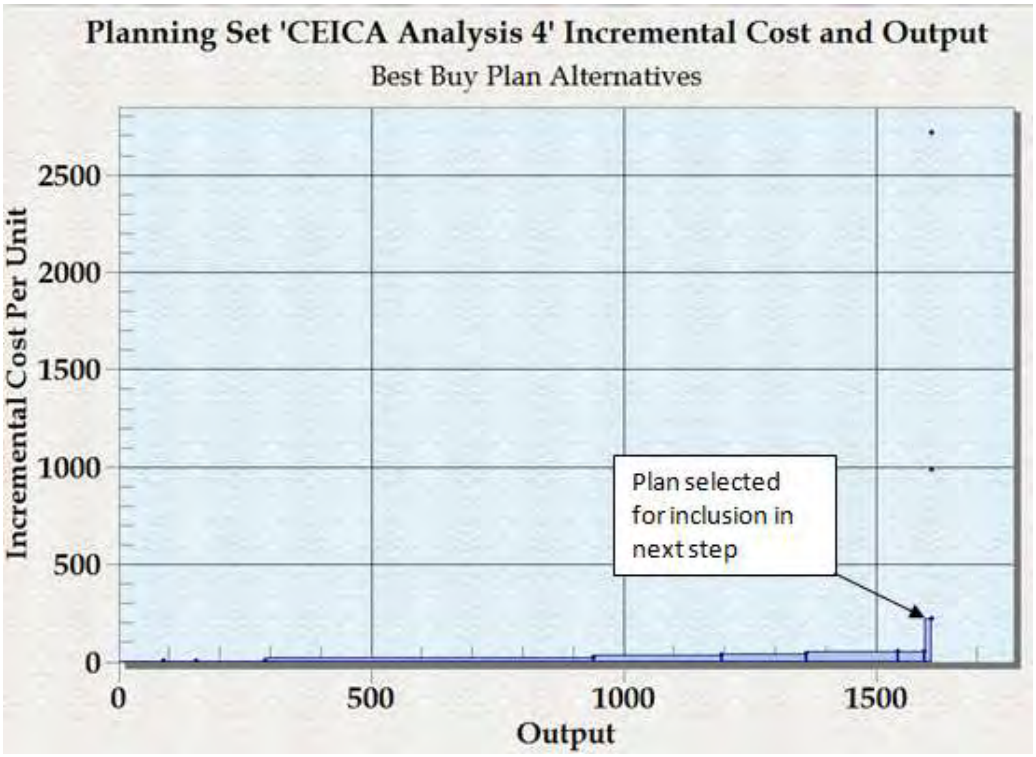

Figure 4-2. River Delta Strategy – Best Buy Plans

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 alternative carried forward for the river delta strategy was selected due to inclusion of the Duckabush River Estuary site, which is located in the Hood Canal sub-basin. Smaller best buy plans do not include sites in the Hood Canal sub-basin, which is a partially isolated geographic section of Puget Sound. Inclusion of the Duckabush River Estuary would provide valuable rearing habitat for Hood Canal summer chum. This best buy plan is more geographically representative of restoration across Puget Sound.

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

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 steelhead[3], bull trout, and all five species of Pacific salmon, including Chinook. Restoration in the Duckabush River would provide valuable rearing habitat for Hood Canal summer chum. 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.

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

[3] ESA Species

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]	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Beach	Beaconsfield Feeder Bluff Full	$7,929	$369	6.9	2.2
	Beaconsfield Feeder Bluff Partial	$3,027	$141	5.5	1.3
	Twin Rivers Partial	$5,546	$258	4.3	0.2
	WDNR Budd Inlet Beach Full	$9,569	$446	2	1.1

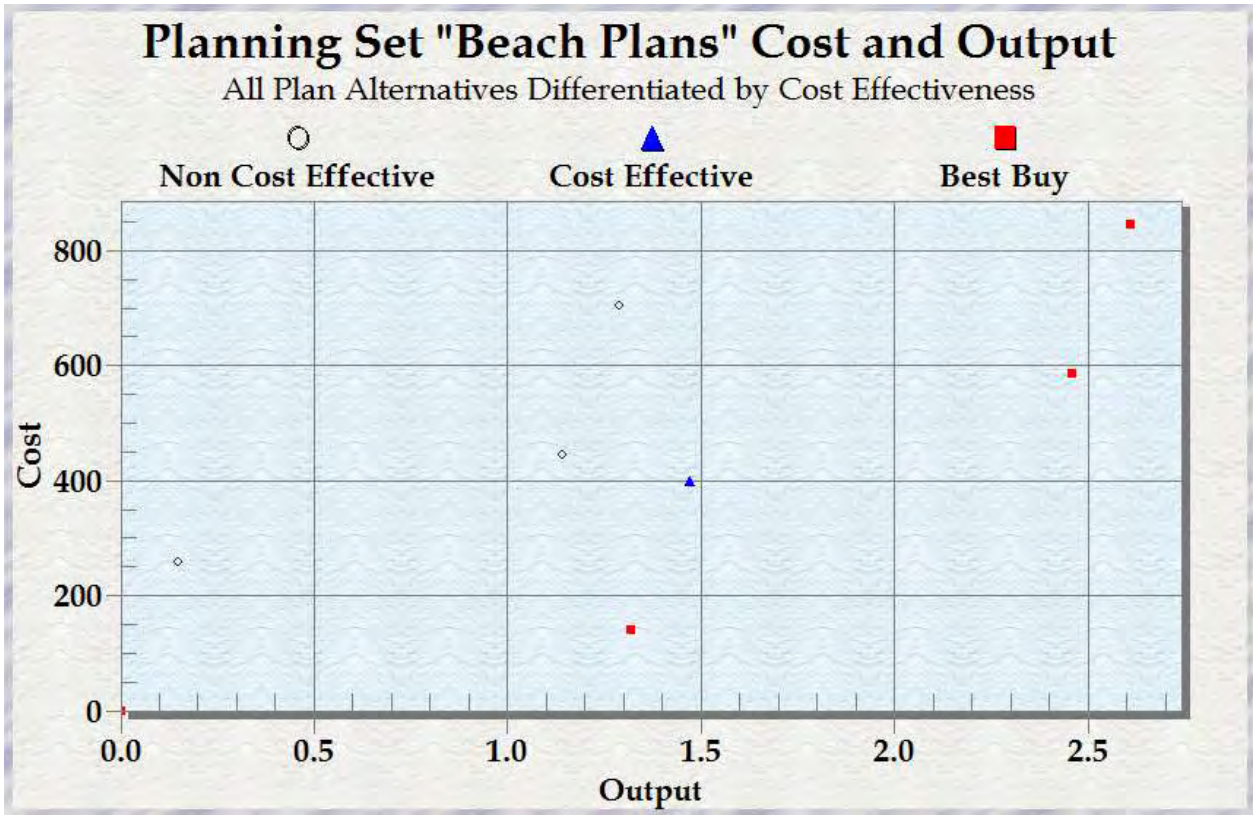

Figure 4-3. Beach Strategy – Plot of Possible Plan Combinations

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 4-4. 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	$108	141	1.3	$108
Beaconsfield Partial and WDNR Budd Inlet Beach	$587	2.4	$245	446	1.1	$405
Beaconsfield Partial, WDNR Budd Inlet Beach, and Twin Rivers Partial	$845	2.6	$325	258	0.2	$1,290

Note: Pink highlighted plan advanced.

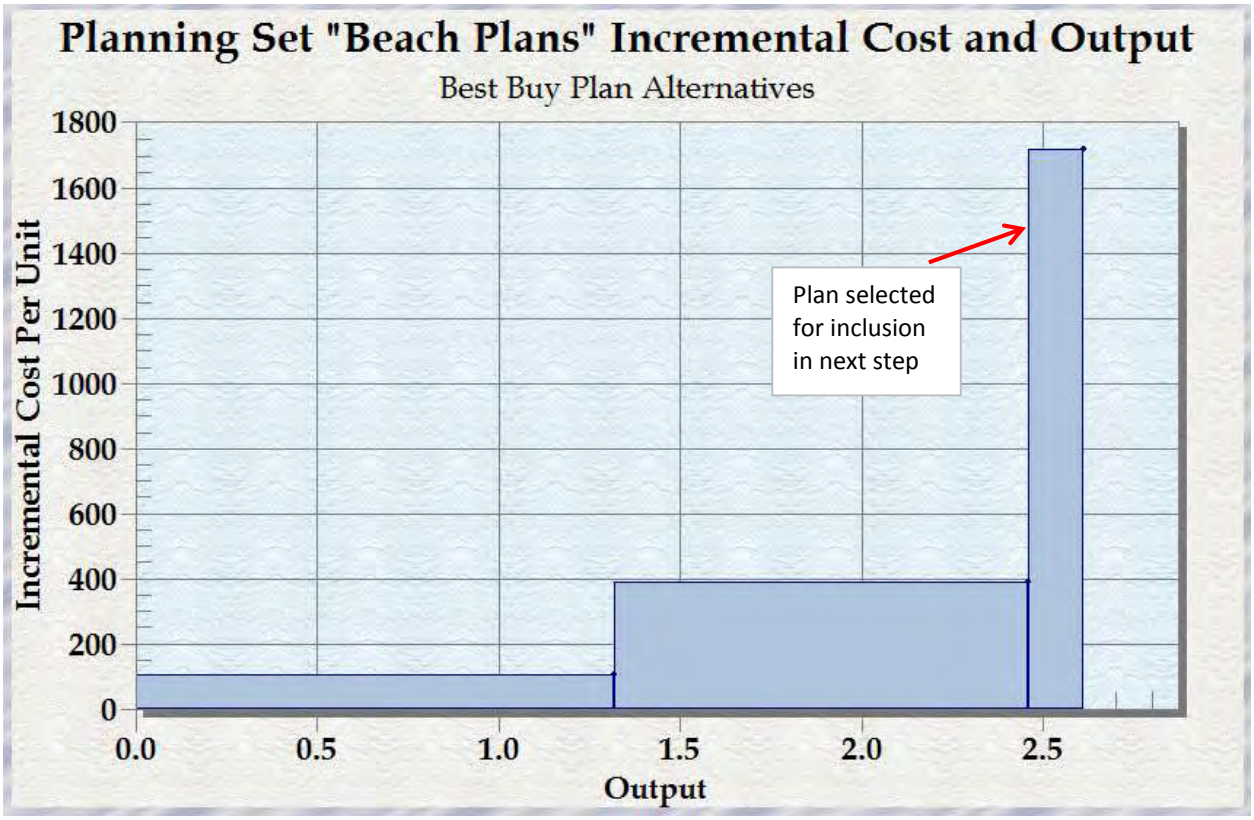

Figure 4-4. Beach Strategy – Best Buy Plans

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. Although beach restoration is a critical need for restoration of Puget Sound, the majority of beach real estate is privately held and there is generally a lack of landowner willingness for armor removal and sediment transport restoration. Thus, only three beach sites were identified for initial analysis and all three sites (representing the largest best buy plan) were carried forward. The best buy plan carrying forward three beach sites was selected because these areas represent scarce, high-value nearshore habitat that supports terrestrial and marine components of nearshore ecosystems. Bluff-backed beaches are a key component of the sediment transport process in the nearshore zone and restoration of these sites is extremely valuable. Carrying forward the largest best buy plan for the beach strategy is worth the additional cost of doing so.

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

4.2.2 Ecosystem Benefits of Restoration Sites on Beaches

Qualitative benefits of these three 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]	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Barrier Embayment	Big Beef Creek Estuary Full	$32,629	$1,519	29.6	7.9
	Dugualla Bay Partial	$72,289	$3,365	572	162.6
	Livingston Bay Full	$12,863	$599	244.6	41.6
	Livingston Bay Partial	$12,062	$561	238.7	40.5
	Point Whitney Lagoon Full	$9,522	$443	6.1	2

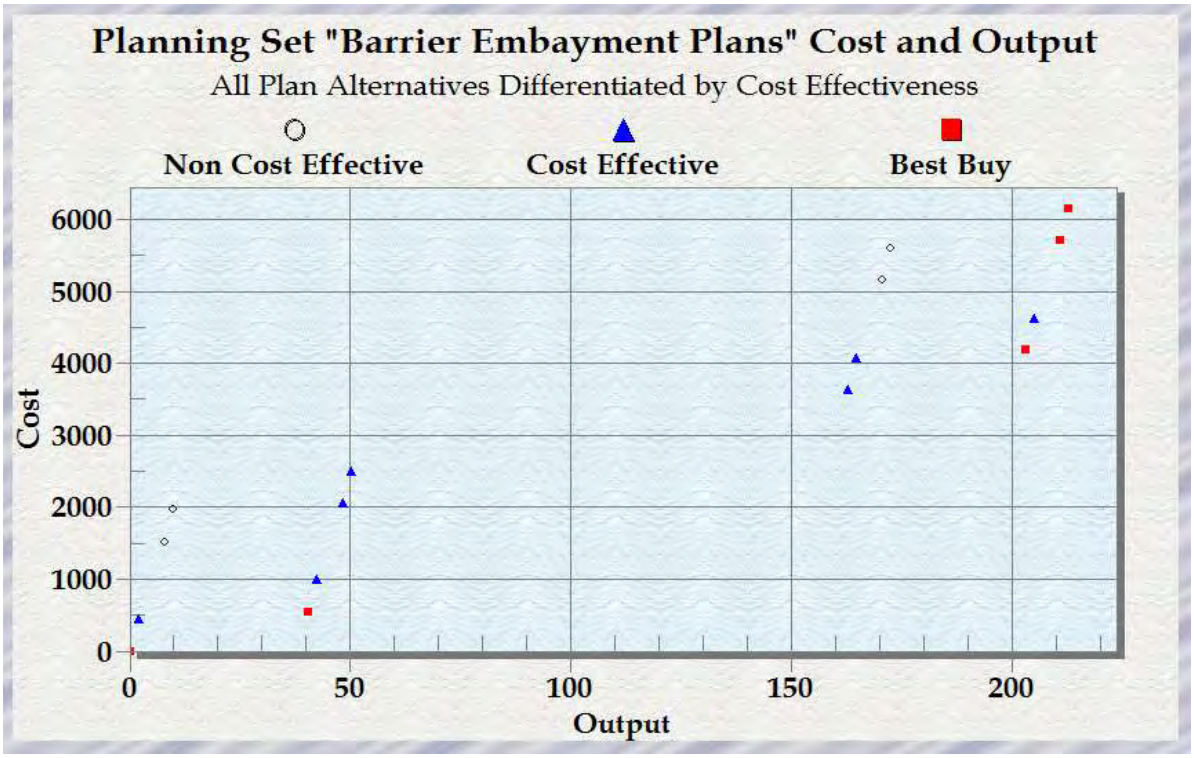

Figure 4-5. Barrier Embayment Strategy – Plot of Possible Plan Combinations

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	$561	40.5	$14	$561	40.5	$14
Livingston Bay Partial, Dugualla Bay Partial	$3,926	203.1	$19	$3,365	162.6	$21
Livingston Bay Partial, Dugualla Bay Partial, and Big Beef Full	$5,445	211	$26	$1,519	7.9	$192
Livingston Bay Partial, Dugualla Bay Partial, Big Beef Full, and Point Whitney Full	$5,888	213	$28	$443	2	$222

Note: Pink highlighted plan advanced.

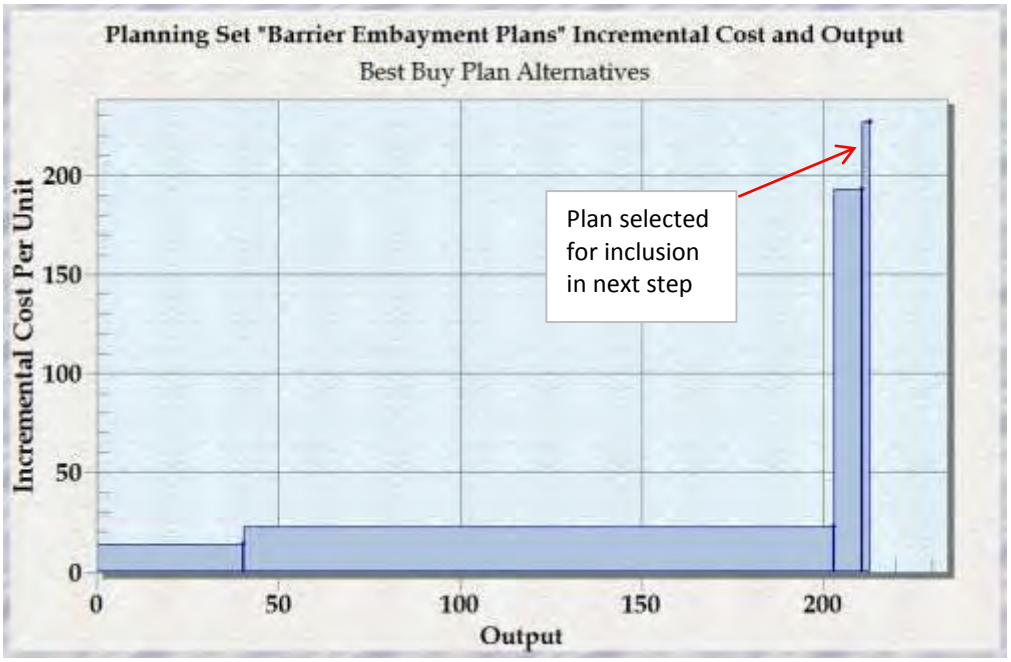

Figure 4-6. Barrier Embayment Strategy – Best Buy Plans

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. The best buy plan carrying forward four barrier embayment sites was selected because these areas represent scarce, high-value nearshore habitat that supports

terrestrial and marine components of nearshore ecosystems. Although there is an increase in incremental cost per output between the best buy plans containing more than two sites, the inclusion of Big Beef Creek Estuary and Point Whitney Lagoon represent an opportunity for restoration in Hood Canal, which is a partially isolated geographic section of Puget Sound. The Point Whitney Lagoon site supports a native oyster population within the lagoon. The Big Beef Creek watershed is largely undeveloped, so restoring the estuary with its eelgrass and shellfish habitats would produce the rare condition of a minimally artificial watershed. Carrying forward the largest best buy plan for the barrier embayment strategy is worth the additional cost of doing so and allows for restoration of a more geographically diverse area.

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

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	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Coastal Inlet	Chambers Bay Full	$288,020	$13,408	83.5	8.5
	Chambers Bay Partial	$96,699	$4,502	47	3.4
	Deer Harbor Estuary Full	$6,679	$311	16.1	4.8
	Harper Estuary Full	$12,240	$569	6.2	1.7
	Harper Estuary Partial	$16,025	$746	5.7	1.1
	Lilliwaup Partial	$30,619	$1,425	19.6	1.1
	Sequalitchew Full	$166,320	$7,743	4.5	0.9
	Snow/Salmon Creek Estuary Partial	$37,798	$1,760	52.2	6.8
	Tahuya River Estuary Full	$28,917	$1,346	36.1	7.6
	Washington Harbor Partial	$17,666	$822	14	0.6

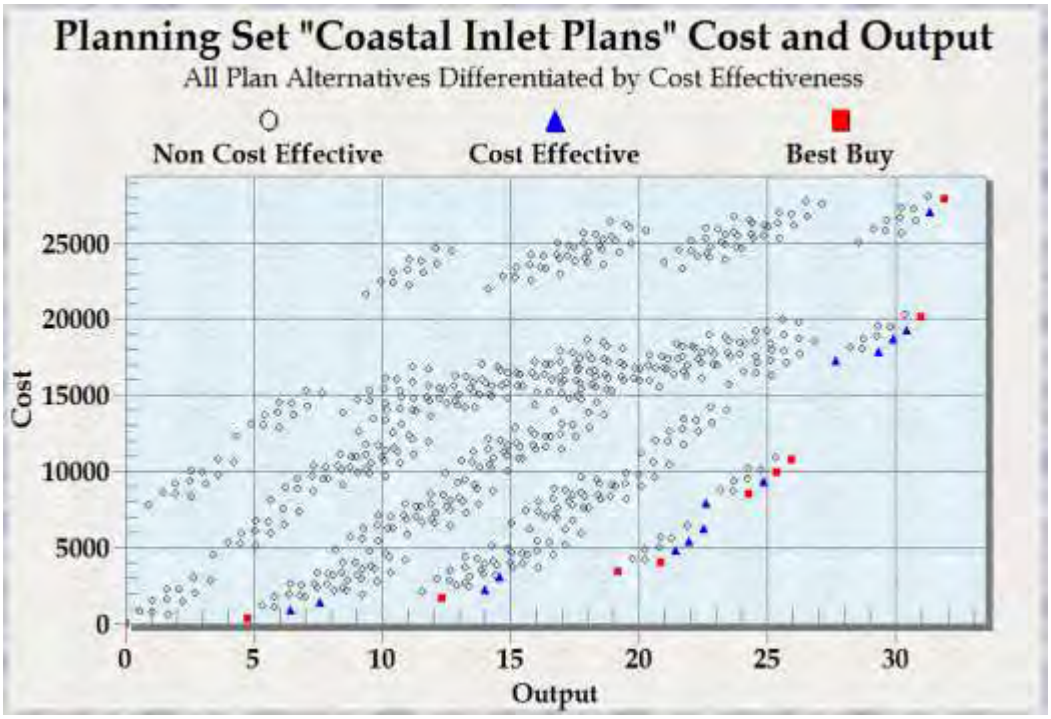

Figure 4-7. Coastal Inlet Strategy – Plot of Possible Plan Combinations

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 and Tahuya Causeway Full	$1,657	12.4	$134	$1,346	7.6	$177
Deer Harbor Full , Tahuya Causeway Full, Snow Salmon Partial,	$3,417	19.2	$178	$1,760	6.8	$259
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, and Harper Full	$3,986	20.9	$191	$569	1.7	$335
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, and Chambers Bay Partial	$5,411	22	$246	$1,425	1.1	$1,295
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, and Chambers Bay Partial, Lilliwaup Partial	$9,913	25.4	$390	$4,502	3.4	$1,324
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Chambers Bay Partial, Lilliwaup Partial, and Washington Harbor Partial	$10,735	26	$413	$822	0.6	$1,370
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Lilliwaup Partial, Washington Harbor Partial, and Chambers Bay Full	$24,143	34.5	$700	$13,408	8.5	$1,577
Deer Harbor Full, Tahuya Causeway, Snow Salmon Partial, Harper Full, Lilliwaup Partial, Washington Harbor Partial, Chambers Bay Full, and Sequalitchew Full	$31,886	35.4	$901	$7,743	0.9	$8,603

Note: Pink highlighted plan advanced.

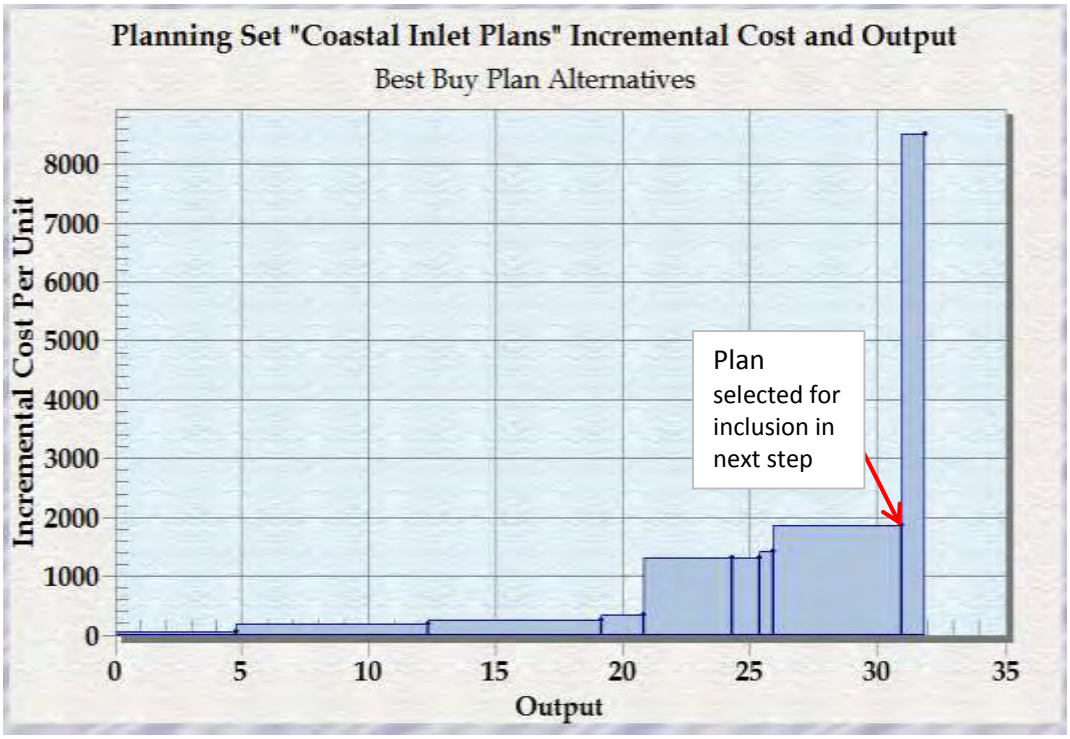

Figure 4-8. Coastal Inlet Strategy – Best Buy Plans

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. The best buy plan for the coastal inlet strategy was selected because there is a significant increase in incremental cost per output compared to the next larger best buy plan ($1,577,000 to $8,603,000) which would include the Sequalitchew site, with an incremental cost of $7,743,000 for 0.9 AAHU's.

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

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 whales[4], and bull trout.

[4] Federal ESA-listed species

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).

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	Milltown Island Partial	64	$198	$3.1	64	$198	$3.1
3	plus Deepwater Slough	154.2	$508	$3.3	90.2	$310	$3.4
4	plus Spencer Island Partial	290.2	$1,295	$4.5	136	$787	$5.8
5	plus Livingston Bay	330.7	$1,856	$5.6	40.5	$561	$13.9
6	plus Dugualla Bay	493.3	$5,221	$10.6	162.6	$3,365	$20.7
7	plus Nooksack Delta Partial	1143.8	$19,353	$16.9	650.5	$14,132	$21.7
8	plus Telegraph Slough Full	1397.7	$28,132	$20.1	253.9	$8,779	$34.6
9	plus Everett Marshland Full	1747	$44,776	$25.6	349.3	$16,644	$47.6
10	plus N. Fork Skagit River	1800.7	$47,774	$26.5	53.7	$2,998	$55.8
11	plus Deer Harbor Estuary	1805.5	$48,085	$26.6	4.8	$311	$64.8
12	plus Beaconsfield Bluff	1806.8	$48,226	$26.7	1.3	$141	$108.5
13	plus Tahuya River Estuary	1814.4	$49,572	$27.3	7.6	$1,346	$177.1
14	plus Big Beef Creek Estuary	1822.3	$51,091	$28.0	7.9	$1,519	$192.3
15	plus Duckabush Delta	1834.6	$53,810	$29.3	12.3	$2,719	$221.1
16	plus Point Whitney Lagoon	1836.6	$54,253	$29.5	2	$443	$221.5
17	plus Snow/SalmonCreek	1843.4	$56,013	$30.4	6.8	$1,760	$258.8
18	plus Harper Estuary Full	1845.1	$56,582	$30.7	1.7	$569	$334.7
19	plus WDNR Budd Inlet	1846.2	$57,028	$30.9	1.1	$446	$405.5
20	plusTwin Rivers Partial	1846.4	$57,286	$31.0	0.2	$258	$1,290.0
21	plus Lilliwaup Partial	1847.5	$58,711	$31.8	1.1	$1,425	$1,295.5
22	plus Washington Harbor	1848.1	$59,533	$32.2	0.6	$822	$1,370.0
23	plus Chambers Bay Full	1856.6	$72,941	$39.3	8.5	$13,408	$1,577.4

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 $406 per output. A significant increase in cost per output occurs between plans 19 and 20 where the incremental cost per output increases from $406 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

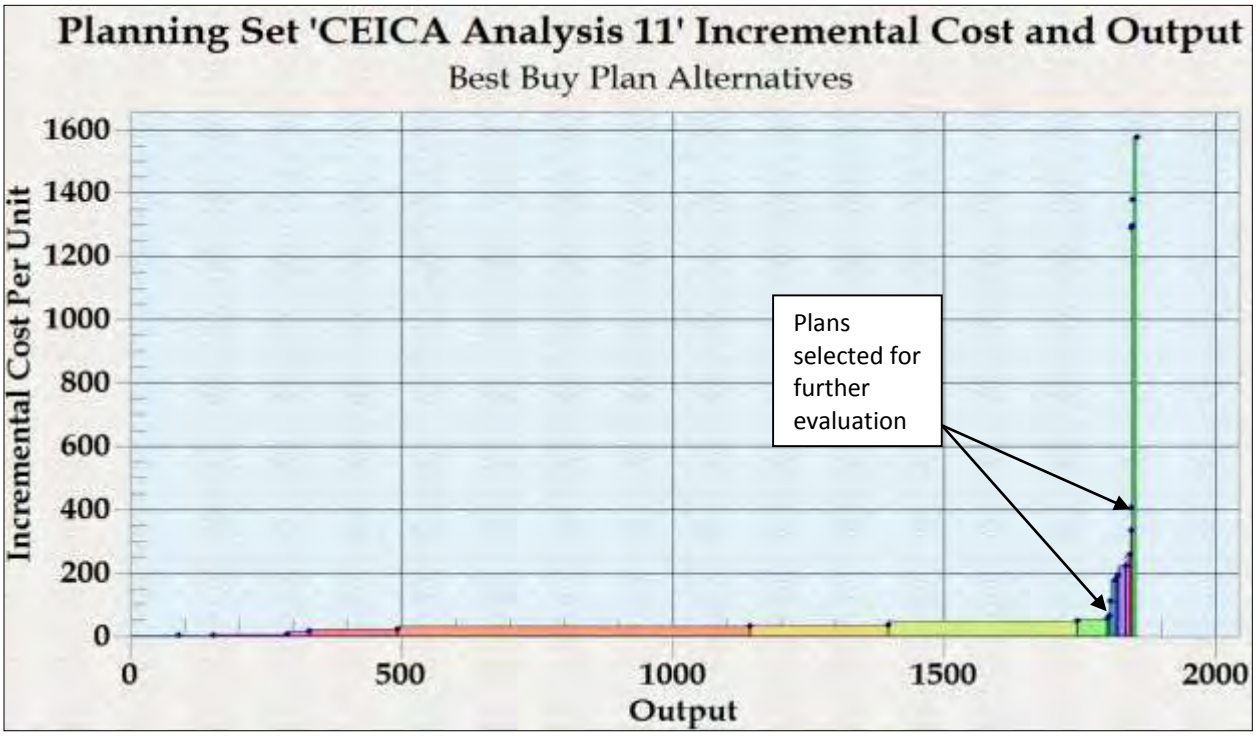

Figure 5-2. Incremental Cost Analysis for Combined Strategies

6 FINAL ARRAY OF ALTERNATIVES

After reviewing the analyses described above, the PDT identified a final array of three best buy alternatives and one non-best buy alternative to be carried forward for final evaluation, comparison, and selection of the TSP. 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. A fourth alternative not included in the CE/ICA analysis was also carried forward based on the results of implementation master plan development described in Section 4.3 of the main report. Following is a summary of the master plan development and criteria applied to arrive at the fourth alternative.

The master plan identifies various approaches for implementation of the 36 projects: General Investigation (GI) projects to be recommended for construction, GI projects recommended for additional study, projects to be completed under existing Corps construction authorities (Continuing Authorities Program (CAP) or Puget Sound and Adjacent Waters Program (PSAW)), and projects to be completed by others. A number of qualitative criteria were identified to categorize sites into the various implementation approaches described above.

Key criteria are summarized below:

- Estimated project costs: Smaller sites (i.e., estimated costs less than $20 million) were generally identified as implementable under CAP or PSAW, while sites with estimated costs greater than $20 million were identified as more appropriate to carry forward under the GI program or be implemented by others. For example, the estimated project cost for WDNR Budd Inlet Beach is approximately $10 million, leading the team to recommend this site for implementation under CAP.

- Restoration potential: Sites were evaluated based on restoration benefits (Ecosystem output, score, type of habitat restored, and location of restoration) and overall restoration potential. For example, restoration of the Nooksack River Delta would provide 25 percent of the Puget Sound Action Agenda's 2020 estuarine habitat recovery goal in a single project. This significant restoration potential led the team to identify this site to be carried forward with a recommendation for construction in a Chief's Report.

- Lands and real estate considerations: Sites were evaluated based on availability of lands as well as amount of lands, easements, rights of way, or relocations required for the project. Evaluation of this criteria included an assessment of whether sites have land already in public ownership or whether sites have large relocation requirements. For example, lands in the project footprint of the Duckabush River Estuary are primarily in public ownership, leading the team to carry this site forward as a GI project to be recommended for construction in a Chief's Report. On the other hand, a lack of landowner willingness at the Beaconsfield Feeder Bluff site led the study team to recommend this project be completed by others.

- Overall readiness to proceed: Considerations of community endorsement, broader regional endorsement, and tribal support assisted the team in determining whether sites were suitable to move forward in the near-term or require additional coordination before site-specific analysis occurs. For example, a number of public comments related to proposed restoration at Everett Marshland led the team to recommend this site for further study under the GI program, allowing for additional coordination with local landowners and community stakeholders.

- Corps policy considerations: Some sites were identified as having outstanding policy concerns that will require additional coordination and analysis before being recommended for construction.

- Finally, 12 sites were identified where restoration work is complete, underway, or will soon be underway by others. These sites were categorized under the "projects to be completed by others" category in the master plan. For example, restoration at Deer Harbor is being carried forward by a local project proponent, leading the team to identify this as a site to be completed by others.

Based on the qualitative evaluation summarized above, the team identified a master plan for strategic implementation of 36 sites across the Puget Sound. Of the 36 sites, three are being recommended for construction authorization under the existing Corps feasibility study and are presented as the recommended plan for this study and is referenced as Alternative 4. There are 9 additional sites that are recommended for additional study, 12 sites that will be completed under the CAP or PSAW; and 12 sites that will be completed without Corps involvement.

Plans 2 through 11 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 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. As described in Section 4.5, 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.

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 $406/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, one additional beach site, and one additional river delta site.

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.

Finally, one additional alternative was carried forward in the final array. As described in Section 4.3 of the feasibility report, three sites are being recommended for construction authorization in a Chief's Report as part of the Puget Sound Nearshore implementation

masterplan. While this 3-site alternative was not traditionally evaluated using the CE/ICA process summarized in previous sections of this report, it will be carried forward in the final array of alternatives for additional evaluation, comparison, and trade-off analysis.

A summary of the final array of three alternatives is included below. Formal evaluation and comparison of these alternatives is presented in Sections 4.6 and 4.7 of the feasibility 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 6-1).

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 6-1). 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

Alternative 4

A total of 3 sites were selected for Alternative 4. These sites were selected based on the recommendations included in the implementation masterplan described in Section 4.3 of the feasibility report. Sites included in Alternative 4 include the following:

- Duckabush River Estuary
- Nooksack River Delta
- North Fork Skagit River Delta

For more detailed information on the site designs, see Appendix B (Engineering Appendix).

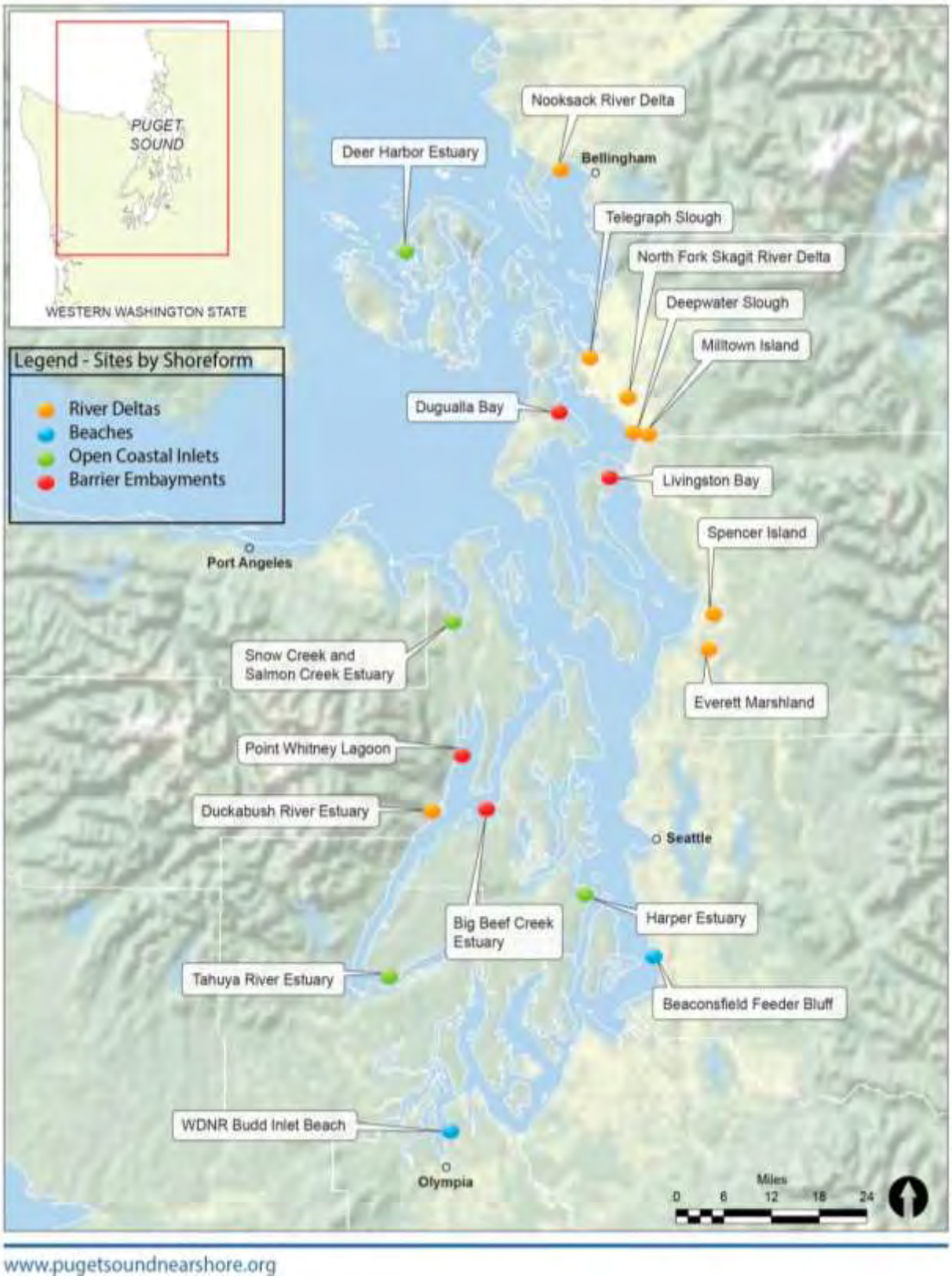

Figure 6-1. Geographic Locations of the Sites included in the Final Array of Alternatives

7 TENTATIVELY SELECTED PLAN AND RECOMMENDED PLAN

The information developed by the CE/ICA and evaluation, comparison, 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 is 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.

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 this Chapter, Alternative 2 was identified as the Tentatively Selected Plan. Alternative 2 was presented as the TSP in the Draft Feasibility Report/Environmental Impact Statement.

As described in Section 4.3 of the feasibility report, a tiered implementation approach was developed for all 36 sites identified across Puget Sound deemed critical to restore the connectivity and size of large river delta estuaries, restore the number and quality of coastal embayments, and restore the size and quality of beaches and bluffs. The tiered strategy allows for a more diversified scope of projects to be implemented under various restoration authorities and partners. This strategic masterplan was developed after the TSP was initially identified. As such, the study team revisited the original plan formulation and evaluation results, ultimately revising the TSP to be consistent with the strategic implementation masterplan. Of the 36 sites identified for implementation across Puget Sound, three are being recommended for construction authorization under this existing Corps feasibility study and are presented as the recommended plan. Alternative 4 is the recommended plan and Agency Preferred Alternative and includes the following sites:

- Duckabush River Estuary
- Nooksack River Delta
- North Fork Skagit River Delta

Sites included in the recommended plan range from 28 to 1,800 acres with costs ranging from $90.5 million to $262.1 million per site. The total area of the proposed sites is 2,101 acres, and the estimated cost of all these sites is approximately $452,286,000 at the March 2016 price level. There are no costs or features (local betterments) over the National Ecosystem Restoration (NER) Plan that has been identified for implementation.

Table 7-1 provides an economic summary of the recommended plan. Interest during construction was computed using estimated project costs at the March 2016 price level, anticipated construction durations for each of the 3 sites (they range from 2 to 6 years each), and the current Federal discount rate (3.125% for fiscal year 2016), bringing total investment costs to $528,918,000. Operations and maintenance expenses have been developed for each site. Annual costs were updated using the current cost estimate at the March 2016 price level. Total average annual cost is estimated at $21,910,000, with an average annual cost of $31,000 per AAHU (or net EO). Economic costs and benefits are also presented at the site-specific level in Chapter 6 of the feasibility report, as well as risks and uncertainties by site which are factored into cost contingencies. No significant risks were identified during feasibility phase which could impact computed environmental benefits. Table 7-2 presents site-specific costs and benefits of the recommended plan.

Table 7-1. Economic Summary of the Recommended Plan

	Cost and Benefit Summary of Recommended Plan (Mar 2016 price level)
Interest Rate (Fiscal Year 2016)	3.125%
Interest Rate, Monthly	0.26%
Construction Period, Months	120
Period of Analysis, Years	50
Estimated Cost	$452,286,000
Interest During Construction (IDC)	$76,632,000
Investment Cost	$528,918,000
Average Annual Cost	
Amortized Cost	$21,047,000
OMRR&R	$863,000
Total Annual Cost	$21,910,000
Average Annual Benefits	
Average Annual Habitat Units (AAHUs, or Net EO)	716.5
Average Annual Cost/AAHU	$31,000

Table 7-2. Site-Specific Costs and Benefits of the Recommended Plan (March 2016 price level, 3.125% discount rate)

Site	Total Project Cost	Construction Duration	Annual OMRR&R	Total Annual Cost (including IDC and OMRR&R)	Acres Restored	AAHU
Duckabush	$90,544,000	2 years	$122,000	$3,833,000	38.1	12.3
North Fork Skagit River Delta	$99,601,000	2 years	$36,000	$4,119,000	256.1	53.7
Nooksack River Delta	$262,141,000	6 years	$705,000	$12,147,000	1807	650.5
Total	$452,286,000	10 years	$863,000	$20,099,000	2101.2	716.5

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