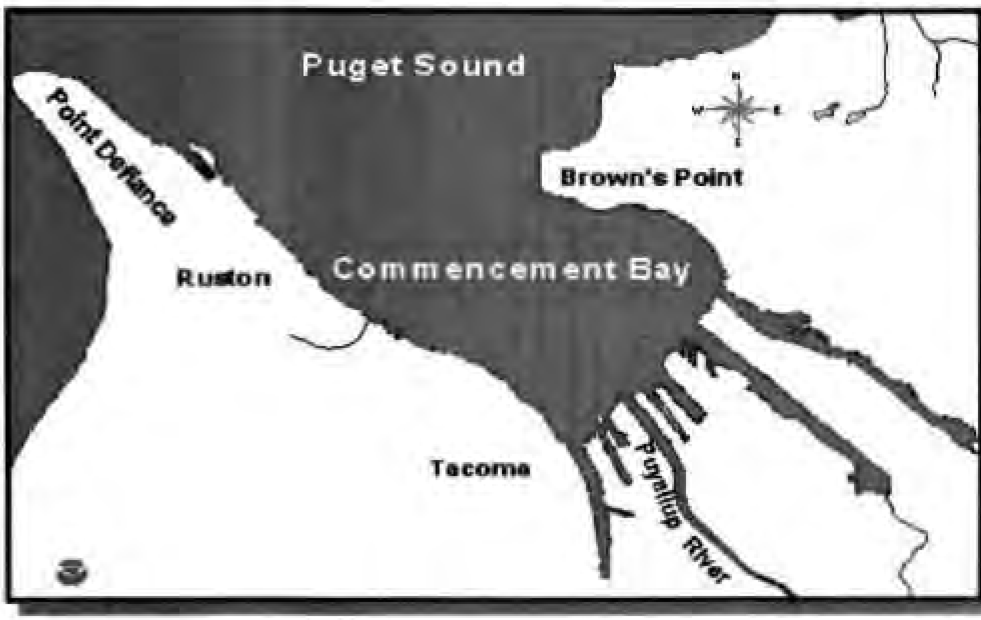
COMMENCEMENT BAY
NATURAL RESOURCE DAMAGE ASSESSMENT
(CB/NRDA)

RESTORATION MONITORING PROGRAM



MARCH 2001

FACT SHEET

COMMENCEMENT BAY NATURAL RESOURCE DAMAGE ASSESSMENT (CB/NRDA) RESTORATION MONITORING PLAN

CB/NRDA TRUSTEES: National Oceanic and Atmospheric Administration (NOAA) U.S. Department of the Interior (DOI): U.S. Fish and Wildlife Service (USFWS), Bureau of Indian Affairs (BIA) Puyallup Tribe of Indians, Muckleshoot Indian Tribe, State of Washington: Departments of Ecology (lead state trustee), Fish and Wildlife, and Natural Resources

ABSTRACT: The CB/NRDA Trustees are engaged in conducting a natural resource damage assessment for Commencement Bay. A Restoration Plan (Plan) was prepared to set out the restoration goals and objectives and the Trustees' framework for conducting restoration in the Bay. As part of the implementation of the Plan, the Trustees are initiating a Monitoring Program (Program) to evaluate all of the NRDA restoration projects in Commencement Bay (*see* Figure 1).

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ACRONYMS

BSC	Biological success criteria
CSL	Cleanup Screening Level
cm	centimeter
Corps	U.S. Army Corps of Engineers
CSC	Chemical success criteria
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
GPS	global position system
HPA	Hydraulic Project Approval
LIDAR	Laser Infrared Detection and Ranging
m	meter
mm	millimeter
MLLW	mean lower low water
NGVD	national geodetic vertical datum
NOAA	National Oceanic and Atmospheric Administration
NRDA	natural resource damage assessment
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorobiphenyls
Plan	NRDA Restoration Plan (Commencement Bay)
ppb	parts per billion
ppt	parts per thousand
Program	NRDA Restoration Monitoring Program (Commencement Bay)
PSC	Physical Success Criteria
PSEP	Puget Sound Estuarine Protocols
RP/EIS	Restoration Plan/Programmatic Environmental Impact Statement (Commencement Bay)
SQO	Sediment Quality Objectives (State of Washington)
SQS	Sediment Quality Standards (State of Washington)
TBT	*tributyltin*
USFWS	U.S. Fish and Wildlife Service

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1.0 INTRODUCTION

The Commencement Bay Natural Resource Trustees (Trustees) (the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, the U.S. Department of the Interior, including the U.S. Fish and Wildlife Service and the Bureau of Indian Affairs, the Puyallup Tribe of Indians, the Muckleshoot Indian Tribe, the Washington Department of Ecology (lead state trustee), the Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources) are engaged in conducting a natural resource damage assessment (NRDA) for Commencement Bay. To guide decision-making regarding the implementation of natural resource restoration activities, the Trustees prepared a NRDA Restoration Plan/Programmatic Environmental Impact Statement (RP/EIS), built in part upon the Commencement Bay Cumulative Impact Study (May/June 1993), a multi-agency cooperative project to study the natural habitat in the Commencement Bay environment. The Restoration Plan (Plan) sets out the restoration goals and objectives and the Trustees' framework for conducting restoration in the Bay.

As part of the implementation of the Plan, the Trustees are initiating a Monitoring Program (Program) to evaluate all of the NRDA restoration projects in Commencement Bay (*see* Figure 1). The Trustees believe that regional monitoring programs should be developed that use similar assumptions and protocols to ensure consistency and a correspondence in measurements of the physical, biological and chemical attributes among restoration projects in the Puget Sound region. For this reason, the Commencement Bay Trustees have incorporated many of the criteria and discussions from the Elliott Bay/Duwamish Restoration Program, the monitoring plan from the Trustees' pilot project at the Middle Waterway, and other monitoring protocols. Appendix F provides a brief review of a few of those documents.

1.1 PURPOSE AND NEED FOR THE PROGRAM

The Program is designed to generate practical information for evaluating the trajectory of project development, identifying successful and unsuccessful techniques or restoration strategies, and implementing mid-course corrections when necessary. It is intended to fulfill several important purposes:

1. To measure success. This plan describes the reference sites and criteria against which performance and success can be measured. This purpose responds to two basic monitoring questions: 1) Is a project performing as planned? 2) How is the project contributing to the overall intent of the program and each round of questions regarding success?

2. To identify adaptive management activities ("contingency planning") that will define a range of mid-course correction actions that could be implemented if the projects fail to perform.

3. To address the monitoring requirements under various permitting authorities. A detailed site-specific monitoring plan is a standard requirement for compliance with state and federal permits, *e.g.*, section 404 of the Clean Water Act and the State of Washington's Hydraulic Project Approval (HPA) process.

4. To ensure inter-project monitoring consistency within the CB/NRDA Restoration Program. This consistency allows for the comparison of NRDA and non-NDRA projects as well as assessing the overall function of the program to meet its objectives.

5. To serve as an outreach tool to provide information to interested parties regarding the progress of the projects and the program.

1.2 GOALS AND OBJECTIVES OF THE PROGRAM

This Program has been developed for use in evaluating and managing all NRDA restoration projects. The goals and objectives of restoration monitoring are to quantitatively measure these parameters:

Program Goals	Program Objectives
Assess the performance (success) of restoration projects.	*Compare similar sites with eachother, to site criteria and area reference sites.*
Determine reasons for projects not attaining goals.	*Compare the development and characteristics of the project to the Program's physical, biological, and chemical success criteria.*
Establish recommendations to improve the project (adaptive management).	*Select appropriate contingency measure(s).*
Compliance with permit conditions.	*Compare with regulatory requirements.*
Create databases for future restoration planning efforts and to prepare project reports.	*Document the development of the physical, chemical, and biological characteristics. Provide information for use in the design of future restoration projects.*
Provide information to interested parties.	*Provide education and outreach tools.*

The Program serves as the foundation upon which project-specific monitoring plans are based. This plan sets forth a wide suite of sampling protocols from which each site-specific project plan is developed. The purpose of developing these protocols is to enable each plan to target specific parameters and develop for each site a specific combination of measurements, sampling types, and tools tailored to the specific objectives of that project. Should a project fail to meet its objectives, additional protocols may be selected from the Program to aid in establishing the reason(s) for the failure and to suggest alternative adaptive management activities. The project-specific monitoring protocols are set out in Appendix G.

2.0 MANAGEMENT METHODS AND MONITORING CRITERIA

The intent of the Program is to implement the NRDA Restoration Plan by creating an overall structure to coordinate and streamline the field sampling, data processing, interpretation and report preparation thereby minimizing costs and oversight for project-specific monitoring plans. For example, most of the monitoring protocols are consistent among projects so a field team can conduct the monitoring for several projects within one sampling period.

2.1 MONITORING OF PHYSICAL ATTRIBUTES

To successfully restore a habitat, it is necessary to construct the physical site conditions (*e.g.*, hydrology, slope, substrate, vegetation) that will facilitate habitat development and use. The following success criteria provide guidance for monitoring whether or not post-construction site characteristics meet these criteria. Evaluating project performance against each criterion is intended to be an ongoing process that will take place for a number of years. At a minimum, five years of sampling will meet permit requirements although some monitoring efforts should extend to 10 years or beyond. Monitoring may continue for longer periods depending on project objectives and funding availability. The individual Physical Success Criteria (PSC) sampling sheets are located at Appendix A.

2.2 MONITORING BIOLOGICAL ATTRIBUTES

Biological success criteria (BSC) identified in this Program fall into two broad categories. There are those criteria that provide evidence that "attributes" of functioning intertidal habitat are developing within the project. For example, are the prey resources, an essential foraging function for juvenile chinook salmon, present in sufficient numbers and sizes to indicate the habitat is functioning properly? In addition, are there criteria that directly evaluate fish and wildlife presence within the project? While it may seem that this second set of criteria are sufficient to determine the success of the project, this is not always the case. Presence or absence of a target species fails to quantify the value of the habitat for the species. Failure to observe the target species within the project does not always mean that it has not, or will not, use the area.

This Program relies on the evaluation of habitat attributes such as vegetation and prey resources to evaluate project success. This data may be supplemented with some direct measurement of target species, including juvenile salmonids and other estuarine fish, as well as bird use of the restoration project sites. The individual BSC sampling sheets are located at Appendix B; Table 2 lists native species of intertidal plants observed in the Bay.

2.3 MONITORING OF CHEMICAL ATTRIBUTES

Monitoring of chemical attributes is especially important when evaluating a project that has not met the physical and biological success criteria. In general, chemical monitoring will only be implemented when there is a specific (*e.g.*, permit) and/or scientifically-based need. Chemical success criteria (CSC) sampling sheets are located at Appendix C.

2.4 SUMMARY

The Trustees recognize that most assessment and monitoring programs are constrained by funding and by the availability of personnel who are qualified to sample for such things as nitrogen fixation. Since the main purpose of monitoring is to characterize the structure and functioning of the habitat, the sampling program must be able to withstand the review of field ecologists. A monitoring program must identify the habitats being characterized, it should have replicate sampling stations within each habitat, and it should provide data that document ecologically meaningful changes when they occur. General analyses of the data should indicate that the sampling program is encountering the bulk of the species present, and that variances among replicate sampling stations are not excessively high.

This monitoring plan can be expanded or reduced in different ways, *e.g.*, by varying the number of attributes examined, the frequency of the examination, and the number of sampling stations. Additional modifications could include the level of detail of examination in the field within sampling stations (*e.g.*, depths at which soil salinity is measured) and at the laboratory (*e.g.*, determination of invertebrates to family or to species, chemical analysis is pooled or individual soil samples from each sampling station).

Priority attributes. The attributes can be prioritized based upon what we need to know and how much information is provided by the data (priority 1 = most needed; 2 = desirable; 3 = worthwhile). It should be noted that these priority designations are tentative. As the Trustees understand more about wetland ecosystem functioning, they will be better able to select the appropriate and more specific indicators of function.

Sampling frequency. Daily fluctuations occur in migratory bird attendance and colonization of sites. In contrast, plant invasions or local extinctions usually become obvious only after a year or two. Some attributes may be measured as often as weekly, others seasonally or annually, and some only after major events are noted.

Not all habitat types have the same temporal variability so it is difficult to suggest a simple program that can fit all systems. Monitoring programs must be tailored to fit the needs of the system being monitored, beginning with frequent measurements and reducing sampling if experience suggests that reducing the frequency will not significantly reduce information about the system. Monitors should be prepared to increase sampling frequency in response to events such as floods, wastewater spills, algal blooms, inlet closure, or project failure.

Numbers of sampling stations. Field monitoring programs should provide an adequate sample of the area. Adequacy in this case relates to the ability of the sampling effort to evaluate whether the management objective has been achieved. Experienced field ecologists usually can visit a site and easily define habitat areas that are "relatively homogeneous." Aerial photographs can provide additional identification tools. Within each habitat area, replicate samples are taken at a minimum of three stations. Initial sampling will provide estimates of heterogeneity (variance of each attribute measures). If initial replicate stations give high variance (*e.g.*, if the standard error exceeds 10% of the mean), additional replicate samples are needed to adequately characterize the attribute. Because the system's variability dictates the number of replicate samples needed, the exact number samples at each site cannot yet be predicted. It is, however, prudent to plan for a large number of replicate stations and cut back if variances are low. Results can be summarized to test for differences between different locations (*e.g.*, restored and natural wetlands) or differences with time (*e.g.*, year-to-year changes). Further information on the number of replicate samples needed to provide ecologically meaningful data can be found in Krebs (1989).

An alternative approach to replicate sampling within a study area is appropriate where gradients of environmental conditions are present. For estuarine channels that range from a high to low salinity, it is more useful to position sampling stations along the gradient and to plot water quality characteristics against distance. Instead of clumping stations within a homogeneous area, one would distribute the station intervals proceeding upstream from the saltwater inlet. Conversely, stations should be closer together where environmental changes are likely to be present. Results can be summarized as graphs of each attribute against distance from the inlet, looking for spatial trends and evidence of shifts through time.

In addition, a prefered alternative to determine the number of sampling stations needed is to conduct a small pilot study in order to determine the sample size needed to achieve the sampling objective. From pilot sampling, we can estimate the population mean and standard variation and use those numbers to calculate a coefficient of variation. We then use coefficient of variation to compare different sampling schemes - the smaller the coefficient of variation, the more efficient (e.g., fewer samples equals greater statistical power) is the sample design.

Here is one example of how to determine the number of samples needed:

1. Prior to pilot sampling, determine what the target goals are for restoration (e.g., restore population of species X to at least 30 plants per quadrat by year Y). These goals should be determined in part from sampling at appropriate reference sites.

The initial sample size should depend on the relative amount of variation in the data, start with few samples (e.g., 10) if there is little variation among quadrats and more samples (e.g., >15) if the number of plants of a given species varies from quadrat to quadrat.

3. Calculate the mean and standard deviation of species X from the quadrat measures. Determine acceptable levels of type I (á) and type II (â, also know as the precision level or power level) error. The reason for determining these error rates is to ensure that your monitoring program detects the biologically important changes that it has been designed to track.

4. Calculate an initial, uncorrected sample size using the following equation (Elzinga et al. 1998):

$$n = [(Z_\alpha)^2(s)^2]/(\beta)^2$$

where n = uncorrected sample size estimate
Z_α = standard normal coefficient (see Table 1 below). This value corresponds to your acceptable level of type I error, which is usually expressed as a confidence interval (e.g., 90% confidence interval equals 10% type 1 error rate or á = 0.10).
s = standard deviation
β = desired precision level. This value needs to be expressed in absolute terms instead of as a percentage. For example, if you wanted the sample mean estimate to be within 10 percent of the true population mean and the sample mean is 10 plants per quadrat, then
β = (0.10 * 10) = 1.

Table 1. Standard Normal Deviates (Z_α) for Various Confidence Levels.

Confidence Level	Type I (or Alpha) Error Rate	Z_α
80 %	0.20	1.28
90%	0.10	1.64
95%	0.05	1.96
99%	0.01	2.58

5. To obtain an adjusted sample size estimate (n*), correct n using Table 2. This table provides correction values for single parameter estimates. It was created by Elzinga et al. (1998) using an algorithm reported by Kupper and Hafner (1989).

Example (Elzinga et al. 1998):

Management objective: Restore the population of species X in population Y to a density of at least 40 plants per quadrat by the year 2005.

Sampling objective: Obtain estimates of the mean density and population size with 90% confidence that they are within 20% of the true population mean. [Type I error rate (á) = 0.10 and type II error rate (â) = 0.20.]

Results of pilot study: Mean density = 14 plants/quadrat Standard deviation = 5.12 plants

Sample size equation:
$\beta = (0.20*14) = 2.8$ $N = (1.64)^2(5.12)^2/(2.8)^2 =$ 8.9, which is rounded up to 9 samples for the unadjusted sample size.

Go to Table 2 to adjust this preliminary estimate and find n = 9 and the corresponding n* value in the 90% confidence level column of the table. For n = 9, the corrected sample size is 16.

Thus, the corrected estimated sample size needed to be 90% confidence that the estimate of the population mean is within 20% of the true mean is 16 quadrats.

Determining Quadrat Size. Quadrat size and shape should be determined during the pilot study. In general, the quadrat size should be determined by the project area and the spatial distribution of the plants you are sampling (e.g., clumped, uniform). You should avoid a quadrat size that is small enough to render many zero measurements, meaning that no plants are encountered in the quadrat, and that is so large that hundreds of plants have to be measured in each quadrat. To determine an appropriate quadrat size and shape, first wander around the project site to get a feel for the spatial distribution of plants at the site, and then ask and answer the following questions (Elzinga et al. 1998): At what scale can you detect clumping? How large are the clumps and what are the distances between the clumps? How long will quadrats need to be to avoid having many quadrats with zero plants in them? How narrow will quadrats need to be to avoid counting hundreds of plants whenever the quadrat intersects a dense clump? How wide an area can be efficiently searched from one edge of a quadrat? Efficient sampling using quadrats of appropriate size and shape can greatly reduce the number of samples needed to be measured and, thus, reduce the overall time and resources needed for monitoring.

Reference: Elzinga, C.L., D.W. Salzer, J.W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. BLM Technical Reference 1730-1. Bureau of Land Management, Denver, Colorado.

Table 2. Sample size correction table for single parameters.

80% Confidence Level						90% Confidence Level					
n	n*	n	n*	n	n*	n	n*	n	n*	n	n*
1	5	51	65	101	120	1	5	51	65	101	120
2	6	52	66	102	121	2	6	52	66	102	122
3	7	53	67	103	122	3	8	53	67	103	123
4	9	54	68	104	123	4	9	54	69	104	124
5	10	55	69	105	124	5	11	55	70	105	125
6	11	56	70	106	125	6	12	56	71	106	126
7	13	57	71	107	126	7	13	57	72	107	127
8	14	58	73	108	128	8	15	58	73	108	128
9	15	59	74	109	129	9	16	59	74	109	129
10	17	60	75	110	130	10	17	60	75	110	130
11	18	61	76	111	131	11	18	61	76	111	131
12	19	62	77	112	132	12	20	62	78	112	132
13	20	63	78	113	133	13	21	63	79	113	134
14	22	64	79	114	134	14	22	64	80	114	135
15	23	65	80	115	135	15	23	65	81	115	136
16	24	66	82	116	136	16	25	66	82	116	137
17	25	67	83	117	137	17	26	67	83	117	138
18	27	68	84	118	138	18	27	68	84	118	139
19	28	69	85	119	140	19	28	69	85	119	140
20	29	70	86	120	141	20	29	70	86	120	141
21	30	71	87	121	142	21	31	71	88	121	142
22	31	72	88	122	143	22	32	72	89	122	143
23	33	73	89	123	144	23	33	73	90	123	144
24	34	74	90	124	145	24	34	74	91	124	145
25	35	75	91	125	146	25	35	75	92	125	147
26	36	76	93	126	147	26	37	76	93	126	148
27	37	77	94	127	148	27	38	77	94	127	149
28	38	78	95	128	149	28	39	78	95	128	150
29	40	79	96	129	150	29	40	79	96	129	151
30	41	80	97	130	151	30	41	80	97	130	152
31	42	81	98	131	152	31	42	81	99	131	153
32	43	82	99	132	154	32	44	82	100	132	154
33	44	83	100	133	155	33	45	83	101	133	155
34	45	84	101	134	156	34	46	84	102	134	156
35	47	85	102	135	157	35	47	85	103	135	157
36	48	86	104	136	158	36	48	86	104	136	158
37	49	87	105	137	159	37	49	87	105	137	159
38	50	88	106	138	160	38	50	88	106	138	161
39	51	89	107	139	161	39	52	89	107	139	162
40	52	90	108	140	162	40	53	90	108	140	163
41	53	91	109	141	163	41	54	91	110	141	164
42	55	92	110	142	164	42	55	92	111	142	165
43	56	93	111	143	165	43	56	93	112	143	166
44	57	94	112	144	166	44	57	94	113	144	167
45	58	95	113	145	168	45	58	95	114	145	168
46	59	96	115	146	169	46	60	96	115	146	169
47	60	97	116	147	170	47	61	97	116	147	170
48	61	98	117	148	171	48	62	98	117	148	171
49	62	99	118	149	172	49	63	99	118	149	172
50	64	100	119	150	173	50	64	100	119	150	173

Table 2. (cont.)

95% Confidence Level						99% Confidence Level					
n	n*	n	n*	n	n*	n	n*	n	n*	n	n*
1	5	51	66	101	121	1	6	51	67	101	122
2	7	52	67	102	122	2	8	52	68	102	123
3	8	53	68	103	123	3	9	53	69	103	124
4	10	54	69	104	124	4	11	54	70	104	126
5	11	55	70	105	125	5	12	55	72	105	127
6	12	56	71	106	126	6	14	56	73	106	128
7	14	57	72	107	128	7	15	57	74	107	129
8	15	58	74	108	129	8	16	58	75	108	130
9	16	59	75	109	130	9	18	59	76	109	131
10	18	60	76	110	131	10	19	60	77	110	132
11	19	61	77	111	132	11	20	61	78	111	133
12	20	62	78	112	133	12	21	62	79	112	134
13	21	63	79	113	134	13	23	63	80	113	135
14	23	64	80	114	135	14	24	64	82	114	136
15	24	65	81	115	136	15	25	65	83	115	138
16	25	66	83	116	137	16	26	66	84	116	139
17	26	67	84	117	138	17	28	67	85	117	140
18	28	68	85	118	139	18	29	68	86	118	141
19	29	69	86	119	141	19	30	69	87	119	142
20	30	70	87	120	142	20	31	70	88	120	143
21	31	71	88	121	143	21	32	71	89	121	144
22	32	72	89	122	144	22	34	72	90	122	145
23	34	73	90	123	145	23	35	73	92	123	146
24	35	74	91	124	146	24	36	74	93	124	147
25	36	75	92	125	147	25	37	75	94	125	148
26	37	76	94	126	148	26	38	76	95	126	149
27	38	77	95	127	149	27	39	77	96	127	150
28	39	78	96	128	150	28	41	78	97	128	152
29	41	79	97	129	151	29	42	79	98	129	153
30	42	80	98	130	152	30	43	80	99	130	154
31	43	81	99	131	154	31	44	81	100	131	155
32	44	82	100	132	155	32	45	82	101	132	156
33	45	83	101	133	156	33	46	83	103	133	157
34	46	84	102	134	157	34	48	84	104	134	158
35	48	85	103	135	158	35	49	85	105	135	159
36	49	86	105	136	159	36	50	86	106	136	160
37	50	87	106	137	160	37	51	87	107	137	161
38	51	88	107	138	161	38	52	88	108	138	162
39	52	89	108	139	162	39	53	89	109	139	163
40	53	90	109	140	163	40	55	90	110	140	165
41	54	91	110	141	164	41	56	91	111	141	166
42	56	92	111	142	165	42	57	92	112	142	167
43	57	93	112	143	166	43	58	93	114	143	168
44	58	94	113	144	168	44	59	94	115	144	169
45	59	95	114	145	169	45	60	95	116	145	170
46	60	96	116	146	170	46	61	96	117	146	171
47	61	97	117	147	171	47	62	97	118	147	172
48	62	98	118	148	172	48	64	98	119	148	173
49	63	99	119	149	173	49	65	99	120	149	174
50	65	100	120	150	174	50	66	100	121	150	175

How long to monitor. From the standpoint of the biota, a 20-year monitoring period is not unreasonable. It may take longer for the restored marsh to fully develop its potential as habitat for rare species such as endangered birds or for the soil organic matter to increase to natural levels. It may take even longer for herbivory problems to become controlled by native predators. Long-term monitoring allows one to distinguish between short-term shifts (*e.g.*, annual variability in shorebird use) and long-term directional changes (*e.g.*, expansion of marsh, declines of endangered bird populations).

This Program is intended to be implemented over a 10-year period, however, it is designed to be implemented for five years at which time a decision point to continue for the remaining five years will be addressed. A summary of the physical, biological and chemical monitoring, along with schedules and contingencies, can be found in Table 1 (Appendix E).

3.0 REFERENCE SITES

The criteria for reference sites are based upon a restoration project's similarity or intended similarity to another restored or natural site. Simply stated, if a constructed marsh is intended to develop into a habitat like the Nisqually River delta, then it will be compared to the Nisqually system. If a cobble shoreline is being preserved and intended to perform the same functions as the Dumas Bay shoreline, it will be compared to the Dumas Bay shoreline using the criterion described previously in Section 2. For example, physical features, such as substrate type and slope (*e.g.*, the fine sediments and gentle slopes of the Nisqually delta), will be contrasted with comparable physical features at the restored project sites in Commencement Bay. The specific monitoring to be undertaken at the reference sites will be determined by the project specific monitoring plans.

The data gathered at the reference sites will be used to formulate hypotheses regarding habitats:

- Function;
- Climate and hydrology;
- Influences of human access and economic activities;
- Size, morphology, water depth, wetland zones, and their proportion;
- General vegetation types and requirements;
- Soils and non-soil substrates; and
- Access and use by fish and wildlife.

4.0 ADAPTIVE MANAGEMENT (CONTINGENCY PLANNING)

The criteria established in the Program are defined by the Trustees' restoration goals and objectives and serve as a means of determining the triggers for mid-course corrections. The contingency measures are based upon scientific principles, best professional judgment, local knowledge, and an evolving understanding of natural processes in the Commencement Bay environment. A mid-course correction would involve going from a less intrusive to a more intensive solution depending upon the nature and type of problem. For example, if the Trustees believe, based upon monitoring results, that there is a slope stability issue at a particular site then their first steps would include adjustments using non-engineered controls such as planting different species and the placement of erosion control mats. If the problem is not mitigated through such actions, more engineered methods such as wave action controls (*e.g.*, booms) might be installed. In severe cases, fish-rock might be placed in problem areas.

5.0 VOLUNTEER / STEWARDSHIP PARTICIPATION

The Trustees strongly believe that a successful restoration project depends on the interest and investment of the community in which it resides and grows. For this reason, the Trustees will be identifying particular activities that could be successfully conducted in cooperation with area volunteer groups. This may include, but is not limited to, such actions as planting native vegetation, destroying or weeding of invasive species, vegetation sampling, and bird monitoring. Each project's specific monitoring plan will outline potential activities and education opportunities for volunteers and site stewards.

6.0 BUDGET

The budget for the Program is dependent upon the complexity of the individual restoration projects, the number and type of criteria which will be used to evaluate the project, and the number of sites being monitored. There is an economy of scale and each additional site may not have an equal increase in the cost. Detailed budgets will be prepared for individual plans once the Trustees determine the final level of sampling effort. These individual plans will be attached to this document at Appendix G.

7.0 REPORTING/DATABASES

Databases and reports will be developed in order for the Trustees to analyze and interpret the physical, biological, and if triggered, the chemical trends, occurring at the restored areas in contrast with the selected reference sites. Monitoring reports will be produced in Years 1, 2, 3, 5, and Years 7 and 10 if funding is available. Each report will take into consideration all previous monitoring years and findings. At a minimum, the reports will summarize:

- Monitoring tasks completed (methods, sampling locations, dates),
- Data and monitoring results,
- Status of projects sites,
- Trends in data for both individual sites and the overall program in relation to goals and objectives,
- "Triggers" indicating the need for contingencies and adaptive management,
- External conditions which may be influencing results,
- Recommendations and alternatives for action,

- Recommendations for future planning,
- An overall comparison of how each site is developing, and
- *Lessons learned for the individual projects and the Program.*

A draft report will be submitted to the Commencement Bay Natural Resource Trustee Council for review and comment within three months of completion of an annual sampling period. The Trustee Council may request an oral presentation of the results. Adaptive management/contingency planning will be initiated and approved by the Trustee Council. The Final Monitoring Report will incorporate Trustee comments and any planned adaptive management activities.

8.0 CONCLUSION

The Trustees are initiating this CB/NRDA Monitoring Program to evaluate all of their restoration projects in Commencement Bay. The Trustees believe that this plan could serve, in part, as the basis for an intertidal monitoring regime under a regional monitoring program. The Trustees believe that monitoring programs should be developed that use similar assumptions and protocols to ensure consistency and a correspondence in measurements of the physical, biological and chemical attributes among restoration projects in the Puget Sound region.

This Program will be updated to reflect improvements in technology and our continually evolving knowledge and understanding about natural and modified environments. The intent in the Program is to evaluate the success of the goals and objectives of the NRDA restoration projects. The Program will be periodically reviewed to ensure that it is producing the type of data necessary to achieve its overall goals and maintain its usefulness.

The following sections define the criteria, methodologies, success criteria, contingency measures and sampling schedules for the selected reference sites and the NRDA restoration project sites covered under this Program. A summary table (Table 1 in Appendix E) contains the components of the program in tabular format.

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APPENDIX A

PHYSICAL SUCCESS CRITERIA (PSC1-7)

PHYSICAL SUCCESS CRITERION 1
INTERTIDAL AREAL COVERAGE

INTERTIDAL AREAL COVERAGE: *The total restored area between an elevation of +12 ft NOS MLLW and -2 ft MLLW will be at least 90% of the target intertidal elevation.*

Monitoring Tasks:

- Using standard areal calculation techniques, such as geo-referenced aerial photography, LIDAR, GPS or other field survey techniques, estimate the total intertidal acreage (below +12 ft MLLW) of the project.

- "As-built" plan drawing(s) will be provided in the same format or appearance and on the same scale as the construction drawings. These will typically be provided by a contractor as part of project completion.

- Visual inspection(s) should be conducted following extreme episodic flood events (*e.g.*, 100-year flood conditions) to determine any erosional impacts.

Schedule:

- The "as-built" plan(s) will be prepared within two months of completion of construction. Year "0" is the year of construction; subsequent years will be the next growing season. This means Year "1" might be from 6 to15 months after completion of construction. For example, if a project is completed by September 30, 2000, Year 1 monitoring would start during September 2002.

- Areal calculations of intertidal habitat will be completed in Monitoring Years 1 and 5, and if funding is available, Years 7 and 10.

Contingency Measures:

- None, unless gross deviations -- indicated by filling or bank erosion of the intertidal area – exceed the criterion.

Discussion:

The elevation bands may be further subdivided, when needed. Certain minimum expectations for project size is a legitimate success criterion for an increase in area of intertidal habitat and in the softening or laying back of shoreline banks.

PHYSICAL SUCCESS CRITERION 2
INTERTIDAL STABILITY

INTERTIDAL STABILITY. *The as-designed contour elevations, especially for intertidal plant introductions, will be +/- 0.5 ft of the elevations specified in the construction plan. 75% of the target elevations will be maintained through Year 5.*

Monitoring Tasks:

- An "as-built" plan drawing(s) will be provided in the same format or appearance and on the same scale and contours as the construction drawings.
- Using standard areal calculation techniques, such as geo-referenced aerial photography, LIDAR, GPS or other field survey techniques, estimate any changes in surface topography of the project site. Profiles of the project can be taken from the transects employed for the Biological Monitoring criteria.

Schedule:

- The "as-built" plan(s) will be prepared within two months of completion of construction.
- Profiles on transects through the intertidal habitat will be completed in Monitoring Years 1, 2, and 5, and if funding is available, Years 7 and 10.

Contingency Measures:

- None, unless gross deviations – *e.g.*, 75% of the target elevations (+/- 0.5 ft) are not maintained through Year 5 – exceed the criterion. Project-specific elevation change will be evaluated that may modify this measure.

Discussion:

The hydrologic condition of intertidal sites are determined by measuring elevations relative to NOAA datums. Distribution of salt marsh plants often are referenced to these standard datum. High precision is necessary in elevation surveys. Salt marsh vegetation is extremely sensitive to slight differences in tidal inundation and plants that thrive at one elevation may yield to another species if the topography is six inches too high or too low.

This criterion differs from physical criterion # 4 in that physical criterion # 2 looks at the overall percentage of elevations maintained at a project site, it quantifies aerial extent of intertidal habitat. In contrast, physical criterion # 4 is designed to focus on the development of stream-channels within a project site. Criterion 4 is designed to help discern the occurences and distribution of hydrologic elements and how they change over time.

PHYSICAL SUCCESS CRITERION 3
TIDAL CIRCULATION

TIDAL CIRCULATION. *The tidal amplitude, as determined by both timing and elevation of high and low tide events, is equivalent inside and outside of the project area.*

Monitoring Tasks:

- Periodic visual inspections of the project area to see if tidal flows are unimpeded and there are no undrained basins which might strand fish during periods of low water. Tidal staffs can be placed both inside and outside the project if specific tidal heights are desired for an instantaneous reading. Recording tidal gauges (data loggers) may be used for longer-term determination, where justified.

Schedule:

- Periodic and during post-construction Years 1, 2 and 5. "Periodic" means opportunistic times other than during defined sampling events specific by the Monitoring Plan.

Contingency Measures:

- Failures at any site to show tidal circulation and tidal inundation consistent with the objectives of the individual projects will trigger discussion on the need to increase the size of the tidal connection between the project location and inundation water source (*i.e.*, Commencement Bay, the Waterways or Puyallup River).

- Attempt to drain any pools which might strand fish using low technology means (hand tools); failing this, discussions would be needed to develop more permanent solutions (*i.e.*, filling, determining current patterns).

Discussion:

The development of adequate tidal connections between the project sites and the rest of Commencement Bay and its tributaries is essential. Inadequate connection would lead to a dampened tidal hydrology which could favor invasive plant species over desired native plant communities. Other consequences could include reduction in fish access to and use of the project sites, reduced export of organic material from the site and associated food web support for the estuaries, excessive current velocities within the channels and openings that provide the connections, and associated problems with erosion. Where shallow pooling or ponding occurs within a project that traps water during periods of low tide, fish can become stranded and stressed through increased temperature, decreased oxygen, and increased bird predation. Additionally, ponding and resulting evaporation can result in hyper-saline conditions not healthy for plants or fish. Tidal circulation measurements will help to establish nutrient and organic carbon import and export.

PHYSICAL SUCCESS CRITERION 4
ELEVATION AND CHANNEL MORPHOLOGY

ELEVATION AND CHANNEL MORPHOLOGY. *No evidence of erosion that threatens restoration project goals, property, infrastructure, or is otherwise unacceptable is observed after a period of initial site stabilization.*

Monitoring Tasks:

- Periodic visual inspections of the project for signs of excessive erosion will be completed. Areas of concern may be photographed from a stable photo point periodically so the rate and severity of erosion can be judged.

- "As built" site surveys will be used to monitor and quantify changes in site geomorphology, especially where similar surveys are repeated on a periodic basis.

- Cross-section elevation data collected across permanent transects through the project will provide another way of evaluating how the project morphology is changing.

- In addition to visual inspections specific to this criterion, analysis of any available aerial photographs and elevation cross-section survey data to be obtained under PSC1 tasks will assist in quantifying the extent of erosion.

Schedule:

- Visual inspections and written comments regarding erosion should be made during all monitoring events at the project; observations will be recorded during monitoring of PSC2 (Intertidal Stability) in Years 1, 2, 5 and in Years 7 and 10 if funding is available.

Contingency Measures:

- The primary defense against excessive erosion should be non-structural, such as vegetation, fiber mats, low-tech drainage swales, or other "soft" approaches. Engineered approaches such as riprap or other shoreline "hardening" (*e.g.*, logs, root wads, post-construction) should be used as a last resort and in cases where the property owner, the NRDA Trustees, and relevant permitting authorities agree that a hazardous condition to the property exists or the need to preserve function and integrity of the project warrants corrective action.

Discussion:

Please refer to the disussion under PSC#2.

This criterion differs from physical criterion #2. Criterion # 2 looks at the overall percentage of elevations maintained at a project site, it quantifies aerial extent of intertidal habitat. In contrast physical criterion 4 is designed to focus on the development of stream-channels within a project site. Criterion 4 is designed to help discern the occurences and distribution of hydrologic elements and how they change over time.

PHYSICAL SUCCESS CRITERION 5
SEDIMENT STRUCTURE

SEDIMENT STRUCTURE. *Over time, intertidal sites may accumulate fine-grained materials and organic matter. This would be evidenced by a decrease in mean grain size and an increase in organic carbon in the surface sediments.*

Monitoring Tasks:

- Sediment grain size samples should be collected at each site in areas that will be also be sampled for benthic invertebrates (BSC8). Where appropriate, consideration will be given to stratifying the project sites into two bands: vegetated (+10 feet MLLW and above) and unvegetated (below +10 feet MLLW). Core samples in a project-defined sampling grid will be processed for grain size distribution and organic carbon by standard methods (*see*, CSC1). The results will be compared to reference sites and to comparable data from the same site in previous years.

Schedule:

- This monitoring task will be completed in all years where benthic invertebrates are sampled. The recommended schedule for sampling is post construction Years 1, 3, 5 and Years 7 and 10 if funding is available.

Contingency measures:

- Generally few modifications could be made. If the intertidal sediments do not support the biological production anticipated, analyses could be made to determine if adequate soil nutrients are present. Soil amendments could be considered if deemed appropriate by the technical staff.

Discussion:

Several intertidal habitat functions are associated with depositional environments. Specifically, the accumulation of fine grained sediment is indicative of environments that support the accumulation of organic matter and a detritus- based food web. Soft sediments and organic rich areas support benthic invertebrate prey resources, especially for juvenile fish, like salmonids, and shorebirds.

PHYSICAL SUCCESS CRITERION 6
SOIL SALINITY

SOIL SALINITY. *Suitable salinity for emergent plant propagation, colonization and growth. Soil salinity affects seed germination and plant establishment.*

Monitoring Tasks:

- Soil salinity will be determined at multiple locations on the intertidal plant surface (and potentially core) samples using standard sampling methods and analysis using an accredited soils testing laboratory. In addition, soil salinity may be discerned through observation. Monitoring staff should keep detailed notes on patchy areas of vegetation, especially those in near seeps.

Schedule:

- Periodic and as appropriate as defined by the site-specific monitoring plans.

Contingency Measures:

- If, through sampling and analysis, it is determined that soil salinity is a limiting factor to plant growth and propagation at a restoration project site additional (different, more salt tolerant), plantings and plant species should be considered.

Discussion:

Soil salinities control seed germination and seedling establishment in coastal wetlands (Zedler and Beare, 1986). Soluble salts commonly associated with soil salinity affect plant growth in two ways. Firstly, they attract water, raising the suction (osmotic potential) of water held in the soil, thereby reducing a plant's ability to attract water from the soil. This limits plant vigor and growth. Secondly, soluble salts contain ions such as sodium, chloride and borates that are often toxic to plants. These ions are often responsible for raising soil pH. Indirectly, this results in nutrients such as iron, phosphate, zinc and manganese becoming unavailable for plant growth. As soil becomes increasingly sodic it is subject to dispersion and so is unstable and easily eroded. Other associated potential impacts include (but are not limited to) water-quality deterioration, loss of native aquatic habitat and death of vegetation.

If marsh vegetation does not reach full function as defined by the project goals, this success criteria and monitoring activity will be implemented.

PHYSICAL SUCCESS CRITERION 7
LIGHT ATTENUATION

LIGHT ATTENUATION. *Suitable light as compared to reference areas. This criterion is especially important if working in the shallow subtidal areas and with eelgrass enhancement creation. For plant propagation, colonization and growth results should be comparable to reference sites within two years.*

Monitoring Tasks:

- Compare restoration project areas to reference area using readings obtained using a submersible light refractometer which may be used in combination with a data logger.

Schedule:

- Periodic and during post-construction Years 1, 2, and 5 .

Contingency Measures:

- If plant communities do not develop, sediment control measures and/or turbidity controls should be considered in project areas not directly affected by the turbidity of the Puyallup River and its load of glacial four. It is noted that the Puyallup River system carries a significant sediment load into Commencement Bay. When planning a restoration effort that could require significant control of turbidity, the location of a project in relation to the Puyallup River must be considered carefully.

Discussion:

Several factors discussed above - such as nutrient concentration, light attenuation, dissolved oxygen, salinity and temperature should be recorded to overall assess water quality. Sampling before, during, and after restoration measures take place is important to determine the changes in ecosystem condition.

APPENDIX B

BIOLOGICAL SUCCESS CRITERIA (BSC1-12)

BIOLOGICAL SUCCESS CRITERION 1
MARSH DEVELOPMENT / AREAL COVERAGE

MARSH DEVELOPMENT. _Marsh Vegetation and Areal Coverage:_ *The areal extent (percent cover) of vegetation should be stable or increasing within portions of the project within elevations suitable to marsh establishment.*

Monitoring Tasks:

- An as-planted survey will be mapped following initial planting(s). Areal extent of vegetation will be measured from aerial photographs, if available. Alternatively and complementary, given the anticipated size of vegetation patches or bands, use GPS or traditional survey techniques to map the patch perimeter. Permanent photo points will be established and color photographs to adequately cover the site will be collected each sampling period.

Schedule:

- Monitoring tasks should be completed in Years 1, 2, 3, and 5, and in Years 7 and 10, if deemed appropriate and funding is available.

Contingency Measures:

- Evidence of plant failure, or if natural recruitment rates fail to meet expectations should trigger consideration of contingency measures. Depending on the hypothesized reason for failure, responses could include additional planting, soil amendments, herbivore exclusions, and/or focused stewardship efforts. Assumptions about appropriate plant species, elevation, salinity, and other design factors should be reexamined and the project goals readjusted if new information suggests this path.

Discussion:

The establishment of marsh vegetation is one of the primary objectives of the NRDA Trustees. Wetland vegetation is one of the most obvious and straight-forward indicators of habitat condition. Vegetation provides habitat structure for aquatic and terrestrial organisms, facilitates sediment accretion and build up of marsh substrate, and serves as a source of organic material to support detritus-based food webs. Changes in vascular plant populations often lag behind environmental changes, because most species are limited in their ability to become established even when the habitat structure is appropriate. Periodic examination of the vegetation will assist in the identification of potential problems, such as colonization by invasive species, excessive herbivory, or trampling by humans. Useful measures of vegetation community condition include plant distribution, species composition, and plant vigor.

BIOLOGICAL SUCCESS CRITERION 2
MARSH DEVELOPMENT / SPECIES COMPOSITION

MARSH DEVELOPMENT. *Marsh Vegetation and Species Composition: Species composition of native wetland/emergent plant species should be comparable to that of appropriate reference or comparison sites. If planted, survival should reach or show a trend toward 50% by Year 3. The project should not contain more than 5% cover by area of non-native or invasive plant species. Invasive plant species of special concern include, but are not limited to, Spartina spp.(cordgrass), Lythrum salicaria (purple loosestrife), Phalaris arundinacea (reed canarygrass), and Phragmities communis (common reed).*

Monitoring Tasks:

- Several permanent statistically-based transects will be established relative to the shoreline; the number of transects will be based on habitat area and shape to adequately define the entire project. The transects will encompass portions of the project area suitable for intertidal vegetation establishment. In addition, data analysis will include an estimate of areal extent of marsh vegetation cover and any observations in changes over time.

- Comparable transects will be established at suitable reference or comparison sites. During the height of the growing season (mid-summer), the transects will be surveyed to determine species composition and to estimate percent cover. Quadrats (number depending on length of transect) of 0.25 x 0.25 m will be randomly distributed along each transect line.

- A quantitative sampling for vascular plant species composition records species presence (for frequency of occurrence data), visual cover estimates for all species, and possibly a more intensive analysis for pickleweed (Salicornia sp.) or Carex spp., which are often target restoration species. The most important feature for measuring occurrence data is comparable quadrat size. To determine species composition and cover, permanent sampling locations (quadrats along transects) will be established and marked for elevation. Species composition of marsh vegetation and the occurrence of invasive species that exceeds 1% will be reported.
  Table 2 provides a listing of the plants that have been observed in Commencement Bay.

Schedule:

- Monitoring tasks should be completed in Years 1, 2, 3, and 5 and in Years 7 and 10, if deemed appropriate and funding is available.

Contingency Measures:

- Any occurrence of invasive species that exceeds the threshold of 1% should be controlled primarily by physical means (pulling, mowing, burning). Physical removal should occur as soon as invasive plants are identified and definetly prior to seed set. Chemical treatment (herbicides) should only be considered if physical removal fails. Control of invasive species can be very expensive and cost must be taken into consideration when determining the intensity of contingency measures.

- *Evidence of plant failure, or if natural recruitment rates fail to meet expectations,* should trigger consideration of contingency measures. Depending on the hypothesized reason for failure, responses could include additional planting, soil amendments, herbivore exclusions, and/or focused stewardship efforts. Assumptions about appropriate plant species, elevation, salinity, and other design factors should be reexamined and the project goals readjusted if new information suggests this path.

Discussion:

The establishment of marsh vegetation is one of the primary objectives of the NRDA Trustees. *Wetland vegetation is one of the most obvious and straight-forward indicators* of habitat condition. Vegetation provides habitat structure for aquatic and terrestrial organisms, facilitates sediment accretion and build up of marsh substrate, and serves as a source of organic material to support detritus-based food webs. Changes in vascular plant populations often lag behind environmental changes because most species are limited in their ability to become established even when the habitat structure is appropriate. Periodic examination of the vegetation will assist in the identification of potential problems, such as colonization by invasive species, excessive herbivory, or trampling by humans. Useful measures of vegetation community condition include plant distribution, species composition, and plant vigor.

BIOLOGICAL SUCCESS CRITERION 3
MARSH DEVELOPMENT / PLANT VIGOR

MARSH DEVELOPMENT. *<u>Plant vigor</u>, as measured by stem height and shoot density, should be comparable (greater than 80% by Year 3) to that of appropriate reference sites and/or improving over time.*

Monitoring Tasks:

- An as-planted survey will be compiled into a map following initial planting(s).
- Several permanent statistically-based transects will be established relative to the shoreline; the number of transects will be based on habitat area and shape to adequately define the entire project. The transects will encompass portions of the project area suitable for intertidal vegetation establishment.
- Comparable transects will be established at suitable reference or comparison sites. During the height of the growing season (mid-summer), the transects will be surveyed to determine species composition and to determine plant vigor. Quadrats (number depending on length of transect) of 0.25 x 0.25 m will be randomly distributed along each transect line.
- Plant vigor will be assessed by counting shoots of the "target" vegetation species within the quadrats. The height of (a minimum of) the three tallest shoots for each represented target species in a quadrat will be measured to the nearest centimeter (cm). Similarly, total number of shoots of target species, stem height, flowering condition and trends in mean shoot density (number of shoots per meters squared) and mean maximum shoot height will be tabulated.

Schedule:

- Monitoring tasks should be completed in Years 1, 2, 3, and 5 and in Years 7 and 10, if deemed appropriate and funding is available.

Contingency Measures:

- Evidence that planted vegetation is not thriving, should trigger consideration of contingency measures. Depending on the hypothesized reason for failure, responses could include additional planting, soil amendments, herbivore exclusions, and/or focused stewardship efforts. Assumptions about appropriate plant species, elevation, salinity, and other design factors should be reexamined and the project goals readjusted if new information suggests this path.

Discussion:

The establishment of marsh vegetation is one of the primary objectives of the NRDA Trustees. Wetland vegetation is one of the most obvious and straight-forward indicators of habitat condition. Vegetation provides habitat structure for aquatic and terrestrial organisms, facilitates sediment accretion and build up of marsh substrate, and serves as a source of organic material to support detritus-based food webs. Changes in vascular plant populations often lag behind environmental changes, because most species are limited in their ability to become established even when the habitat structure is appropriate. Periodic examination of the vegetation will assist in the identification of potential problems, such as colonization by invasive species, excessive herbivory, or trampling by humans. Useful measures of vegetation community condition include plant distribution, species composition, and plant vigor.

BIOLOGICAL SUCCESS CRITERION 4
MARSH VEGETATION HERBIVORY AVOIDANCE

MARSH VEGETATION HERBIVORY AVOIDANCE. *Confirm the success of stopping physical herbivory by Canada geese using physical barriers of wire, rope, rebar, posts, string, or netting.*

Monitoring Tasks:

- Periodic, and initially frequent, visual inspections of herbivore exclusion systems and immediate repair to reduce herbivory until the plant root systems have established themselves during two growing seasons.

Schedule:

- Installation of devices must take place before or simultaneous with planting of intertidal vegetation. Devices must be maintained for the first three years of the project. Periodic monitoring should confirm adequate site maintenance of devices. Observations should be logged for Years 1, 2 and 3.

Contingency Measures:

- Immediately repair of any damage to the herbivore exclusion devices caused by logs, trampling, or geese.

Discussion:

Canada geese can destroy newly planted restoration project sites in a matter of hours. There are several exclusion device designs that have proven successful in studies conducted in the Duwamish River and Commencement Bay. Such a design will be employed and monitored at all newly planted NRDA restoration project sites in Commencement Bay.

BIOLOGICAL SUCCESS CRITERION 5
RIPARIAN VEGETATION SURVIVAL

RIPARIAN VEGETATION SURVIVAL. *Riparian vegetation plantings should maintain not less than 75% survival over the first three years following initial planting.*

Monitoring Tasks:

- "As planted" surveys should be generated immediately following planting and serve as the baseline from which to measure survival.

- Establish vegetation transects through the riparian zone to the edges of the project. Use visual survey techniques such as point line intercept or quadrats to estimate plant survival along a transect line. Data should be provided as percent survival for each of the herb, shrub, and tree components preferably by species.

Schedule:

- Monitoring is to be conducted in Years 1, 2, 3.

Contingency Measures:

- Excessive failure rates (> 25% loss annually) for plant survival will be addressed with contingency measures. A secondary planting may be initiated if it appears a new planting would be successful.

- Potential failures include improper installation, poor soil structure and/or organic content, inadequate watering, herbivory, trampling, or competition. Improved site stewardship may address many of these problems, but replanting with improved soil preparation may also be necessary.

- Failure to meet numeric criteria should not trigger an automatic response that might prove damaging to the project; attempts to determine the cause of the failure should be made.

Discussion:

The establishment of healthy riparian plant communities is an essential project element. Native trees, shrubs, and herbs provide a buffer to adjacent urban and industrial lands and a habitat structure for wildlife. Insects growing on riparian vegetation that are deposited in the water can provide an important prey resource for fish. Leaf litter enhances detritus food webs when transported into adjacent intertidal areas. Large organic debris is also important for habitat structure.

BIOLOGICAL SUCCESS CRITERION 6
RIPARIAN VEGETATION AERIAL COVERAGE

RIPARIAN VEGETATION AERIAL COVERAGE. *Areal extent of native trees, shrubs, herbs and other riparian vegetation should be stable or increasing over time, and cover not less than 90% of the upland vegetated area of a project after 10 years. Invasive plant coverage should be minimal; species of special concern include Rubus procerus (Himalayan blackberry), Cytisus scoparius (Scot's broom), and Polygonum cuspidatum (Japanese knotweed). Minimum percent coverage of vegetation layers should be as shown in the table below.*

VEGETATION	YEAR 3 COVERAGE	YEAR 5 COVERAGE	YEAR 10 COVERAGE
Herbs	>70%	Percentage may decline as other layers mature, provided not >10% bare ground	Percentage may decline as other layers mature, provided not >10% bare ground
Shrubs	>30%	>50%	>80%
Trees	>25%	>40%	>70%
Non-Native Invasive Vegetation	<2%	<5%	<5%

Monitoring Tasks:

- As-built surveys should be generated following initial planting to serve as baseline data. Where aerial photographs are available, map the portions of the riparian area by the various cover classes.

- Establish vegetation transects through the riparian zone to the edges of the project. Use visual survey techniques such as point line intercept or quadrats to estimate the cover class and plant survival along a transect line. Data should be provided as percent coverage of riparian vegetation and percent survival for each of the herb, shrub, and tree components preferably by species.

Schedule:

- Monitoring tasks are to be completed in Years 1, 2, 3, and 5 and Years 7 and 10, depending upon funding availability and appropriateness.

Contingency Measures:

- Refer to BSC5 for contingency measures.

Discussion:

Refer to BSC5 for additional discussion regarding riparian vegetation.

BIOLOGICAL SUCCESS CRITERION 7
FISH ACCESS / PRESENCE

FISH ACCESS / PRESENCE. *Estuarine fish will access the project, with increasing utilization and colonization by resident species. Juvenile salmonid presence within the project should be comparable to that of appropriate reference sites at the end of 10 years.*

Monitoring Tasks:

- Fish access at sites with a single entrance will be monitored with a fyke net or block seine which is set just before a high tide and monitored during the subsequent ebb.

- Blocking nets prevent fish from escaping the sampling area. Standard mesh size allows comparisons among seining efforts. Adults and juvenile fishes should be collected using 3-mm mesh blocking nets and bag seine. The 3-mm mesh will ensure the capture of small yet ecologically important species. A linear distance (*e.g.*, 10-15 m) parallel to the tidal creek or channel sampled should be measured and the channel nets deployed to confine all fishes within the two nets. The bag seine is then drawn in a circle within the blocking nets and pulled to shore.

- At broad intertidal beach sites, a beach seine will be set, preferable on a flood tide.

- At all sites, captured fish may be briefly anesthetized, identified as to species, source (hatchery or wild) and counted. Fork length measurements will be taken from all salmonids. All fish will be released unharmed, unless stomach contents analysis on a subset of captured fish is determined necessary. Consideration will be given to marking a subset of the captured salmonids to determine residence time.

- Given the importance placed upon juvenile salmonids, the sampling will occur on a bi-weekly basis during the period of juvenile out- migration, *i.e.*, from early March through early- or mid-June. If resources permit, consideration should be given to undertaking fish access monitoring for a longer period, perhaps throughout the year.

Schedule:

- Monitoring tasks are to be conducted in Years 1, 2, 3, and 5 (Years 7 and 10 if resources are available).

Contingency Measures:

- Failure to meet fish access criteria would indicate that fundamental NRDA Trustee goals are not being met, especially if similar nearby reference or comparison sites have fish present. An examination of the project design, implementation, and site management would be warranted. Consultation with local fishery scientists and managers would be considered and outside expert assistance may be obtained in evaluating the monitoring data and the project performance.

Discussion:
Fishes are valuable indicators of ecosystem health. Generally, the presence of few species (low species richness) may indicate stressful environmental conditions. Fishes are additionally valued as food for birds that use an estuary. A few species are of subsistence, recreational and commercial interest (*e.g.,* salmon).

Of particular importance to the NRDA Trustees is a lack of high quality intertidal habitat, historically available to Puyallup River stocks, to support estuarine-dependent fish species, especially threatened juvenile salmonid stocks in Commencement Bay. Evaluation of this program goal will rely upon measuring both fish access and the provision of prey resources, including fallout insects and benthic invertebrates, important to juvenile salmonids.

Recommended protocols used under this criterion are described by Cordell *et al.* (1997, 1999) and Warner and Fritz (1995).

BIOLOGICAL SUCCESS CRITERION 8
INVERTEBRATE PREY RESOURCE PRODUCTION

INVERTEBRATE PREY RESOURCE PRODUCTION. *Production of invertebrate prey taxa known to be important to juvenile salmonids should be comparable to that of appropriate reference or comparison sites at the end of 10 years*

Monitoring Tasks:

- Benthic invertebrates are sampled with cores taken to a depth of 10 cm. Ten replicates are recommended in protocols by Cordell *et al,* (1994,1999). However, six replicates in each "stratum" will be the minimum acceptable in the interest of cost savings. Strata include mud or sand flats and areas of marsh vegetation. Taxa known to be important to juvenile salmonids are identified to species and enumerated; the remainder are identified to order level.

- Fallout insects are sampled using floating plastic bins distributed throughout the site.

- Benthic macroinvertebrate sampling stations are best located near fish sampling sites (BSC7) where channel morphology (width, depth, substrate and bank characteristics) is well-defined.

- If PSC5 is not implemented, in order to reduce cost, observational data on sediment structure should be noted.

Schedule:

- Monitoring tasks are to be conducted in Years 1, 3, and 5 and in Years 7 and 10 if resources are available.

Contingency Measures:

- Failure of the invertebrate prey taxa criterion would indicate that fundamental NRDA Trustees' goals are not being met. If the benthic community does not appear to be healthy, sediment sampling may be initiated to determine if contamination is responsible for the problem. The composition of the benthic organism community can be analyzed to determine if pollution-tolerant species are present in abundance. Lack of productive benthic community could also indicate inadequate physical conditions on the site such as unsuitable sediment grain size or excessive wave energy and scouring.

- No adaptive management activities are planned specifically for this criterion. Many important aquatic invertebrates in Commencement Bay appear to be eager colonizers.

Discussion:

Sampling protocols for fallout insects (insects produced on riparian and marsh vegetation that fall or drift into the water column) and benthic invertebrates are well described by Cordell *et al.* (1994,1999).

BIOLOGICAL SUCCESS CRITERION 9
BIRD USE

BIRD USE. *Use of project sites including an area beyond 50 meters of the site boundaries by indigenous/native bird species should be comparable to reference/comparison sites.*

Monitoring Task:

- Describe bird use of the project area compared to the reference sites. Data will be presented as species observed, mean abundance (by category), and species richness of indigenous/native bird species.

Schedule:

- This monitoring task is to be conducted in Years 1, 2, 3, and 5, plus Years 7 and 10 where appropriate and funded.

Contingency Measures:

- Low bird use of restored sites, relative to appropriate reference sites, could indicate human disturbance but may also indicate possible predation or lack of prey organisms. If data indicate that indigenous/native bird species are absent or present infrequently or in low numbers, public access and other management activities at the site should be examined for potential impacts to wildlife.

Discussion:

Use of sites by birds could be a good indication of improved habitat conditions. An assessment of bird diversity, abundance, and species lists for Commencement Bay appear in Appendix A to the RP/EIS.

Cordell et al. (1999) describes more elaborate protocols and categories (*i.e.*, passerine, raptors, shorebirds/waders, waterfowl, seabirds, introduced, and native but human-associated)

Cooperation with local volunteers will facilitate bird-use monitoring.

BIOLOGICAL SUCCESS CRITERION 10
PRIMARY PRODUCTION

PRIMARY PRODUCTION. *Exposed tidal surfaces below +12 MLLW should exhibit primary production in the form of microalgae (algal mats) comparable with appropriate reference or comparison sites.*

Monitoring Task:
- Areal extent of algal mats will be estimated visually or from aerial photographs, if available.

Schedule:
- This monitoring task is to be conducted in Years 1, 2, 3, and 5, and Years 7 and 10 where appropriate and funded.

Contingency Measures:
- None listed at this time.

Discussion:
Algae are the base of the food chain in aquatic ecosystems. While measurement of algal populations are not typically the best estimators of primary productivity, they are useful indicators of eutrophication and tidal flushing. While phytoplankton accumulate to bloom proportion, anaerobic conditions can develop at the channel bottom during the night. In tidal channels the highest algal biomass would be measurable at low tide at the end of a neap tide series when channels would not have been greatly diluted with salt water. Visual estimates of: (1) the percent of the water or sediment surface covered by macroalgae, and (2) genus present should be noted.

Although overall primary productivity is a basic ecosystem function, there are major problems and errors in measuring productivity rates and calculating the contributions of different producer components for different wetland areas are great. A further concern is the destructiveness of the habitat as a result of the sampling. It is recommended that productivity studies not be included in the Program.

BIOLOGICAL SUCCESS CRITERION 11
INSECT PRODUCTION

INSECT PRODUCTION. *Production of fallout insects known to be important to juvenile salmonids should be comparable to that of appropriate reference or comparison sites at the end of five years.*

Monitoring Tasks:

- Fallout insects are sampled using floating plastic bins distributed throughout a project site.

- Taxa known to be important to juvenile salmonids are identified to species and enumerated, the remainder are identified to order level.

Schedule:

- The monitoring tasks are to be completed in Years 1, 2, 3, and 5 and Years 7 and 10 will be added if funding is available.

Contingency Measures:

- Lack of fallout insects could indicate problems with riparian or marsh vegetation which may already be obvious through monitoring for other biological criteria. No adaptive management actions are anticipated based solely upon insect count results.

Discussion:

Insects are responsible for several marsh functions, including pollination, seed dispersal, aerating soils, controlling herbivorous insects, and providing food for birds, small mammals and other carnivores. While many plants are wind pollinated, there are several species that rely on insects for pollination and seed production. Pollinators link the upper salt marsh to the adjacent coastal scrub-dominated upland, where alternative nectar producing plants are found. A fully-functional marsh should have nearby transitional and upland habitats to support an abundance of pollinators.

Species identification is the biggest problem with characterizing the insect community, and it may not be possible to identify many taxa beyond the family level. However, this is often very useful for examining functional groups. Even general information on size and habit (flying or crawling) will be helpful in characterizing insects as potential food for consumers such as salmonids or birds.

Intensive sampling protocols for fallout insects (insects produced on riparian and marsh vegetation that fall or drift into the water column) are well described by Cordell et al. (1994, 1999).

This criterion, primarily designed for use in riparian areas is useful when criterion # 8 is not employed.

BIOLOGICAL SUCCESS CRITERION 12
PLANKTON PRESENCE

PLANTON PRODUCTION. *Presence of zooplankton and icthyoplankton are comparable to reference or comparison sites.*

Monitoring Tasks:

- Plankton can be measured at the same stations as the fish and invertebrates (BSC7 and BSC8), although prior to or on a different day, because seining can resuspend *benthic particles, thereby obscuring samples. These communities* should be sampled during a high tide and all of the habitat types can be included.

- Sampling should occur during high tide and in all of the habitat structural types (channels, beaches, marshes).

- Plankton nets with a mesh size of 35 microns are appropriate for collection of zooplankton samples. Most of the habitats to be sampled are relatively shallow (intertidal). A small boat should be used to perform a shallow tow from the bottom to the surface and running parallel to the shoreline. Samples should be fixed in the field with formalin, and quantified microscopically using Sedgwick-Rafter counting chambers. Zooplankton densities and community composition can be assessed spatially and temporally. Sampling of plankton should be done seasonally under the same tidal condition (*e.g.*, end of a neap tide series) in order to reduce the effect of saltwater dilution.

Schedule:

- Plankton sampling can be done at the same stations as the fish (BSC7) in Years 1, 2, 3 and 5 and Years 7 and 10 if funding is available.

- *Two periods have been recommended for sampling* ichthyoplankton -- sampling in March to capture nearshore species that move into the estuary with tidal waters, and sampling in April to assess availability of larvae of resident species. The sampling should coincide with juvenile salmonid outmigration.

Contingency Measures:

- None, lack of zooplankton or icthyoplankton at the project site compared to reference or comparison sites suggests that fundamental NRDA Trustees' goals are not being met.

Discussion:

If juvenile or adult fishes are not found using seines, the habitat might still be suitable but larvae may not be available for settling. In this case, ichthyoplankton sampling should be considered to determine if young are available for colonization. A lack of ichthyoplankton would indicate that a basic ecosystem function is missing.

APPENDIX C

CHEMICAL SUCCESS CRITERIA (CSC1-2)

CHEMICAL SUCCESS CRITERION 1
SEDIMENT / SOIL QUALITY

SEDIMENT / SOIL QUALITY. *The organic content and nutrient content of the sediments and riparian soils should be comparable to reference or comparison sites.*

Monitoring Tasks:

- If plantings do not satisfy BSC1, 2, and 3 above an investigation of soil conditions, such as testing organic and nutrient content of sediments and soils.

- All soil sampling will be done randomly among predetermined 10 -12 meter transects, including 4-6 cores. The transects will be along selected elevations so replicate samples are under a similar tidal regime. Samples subject to seasonal variation may be taken quarterly. Particle size (conducted under PSC5) of marsh soils will be addressed through traditional ecological methods (hydrometer and sieve) to identify sand, silt and clay percentages.

- A measure of total nitrogen in the soil will not differentiate between the organic and inorganic forms of nitrogen yet it will provide valuable information. Nitrogen is either measured as NH_4^+ after Kjeldahl digestion (APHA 1986) or directly with a CNH analyzer.

Schedule:

- Depending on failure to reach BSC1, 2, and 3 above, as needed.

Contingency Measures:

- If the sediments do not reflect the necessary anticipated increase in fines or organic material, or if the soils do not have adequate nutrient levels to support target vegetation, soil amendments will be considered.

Discussion:

Soil conditions have a major influence on vegetation growth and on organisms that inhabit the rhizosphere of plants (*e.g.*, amphipods, nematodes, microbes). Four variables are especially helpful and may be implemented in predicting the ability of a site to support a functional salt marsh: soil salinity, nitrogen dynamics, organic matter concentration, and redox potential. Nutrient dynamics, organic matter, and redox conditions all interact to control growth rates, which in turn affect the consumers that live among the plant roots. Soils with low organic matter will have low nitrogen-fixation rates and low supplies of the main nutrient that limits plant growth. Soils with high organic matter will develop very negative redox potential, which may restrict the growth of some marsh plants. For example, Cantilli (1989) showed that low redox affected the growth of picklweed. The patterns of salinity, nitrogen dynamics, organic matter accumulation, and redox potential vary. Wetland hydrology determines the chemical and physical nature of salt marsh substrate to a great extent (Mitsch and Gosselink 1986).

CHEMICAL SUCCESS CRITERION 2
WATER QUALITY

WATER QUALITY. *In areas where a low salinity marsh is the goal, freshwater quantity needs to be sufficient to provide a surface water salinity regime (<12 parts per thousand) to support emergent intertidal plant species over the entire year. Water quality needs to be high enough to support a healthy growing plant and animal community. Water temperature should not exceed 65 degrees Fahrenheit to support fishery resources.*

Monitoring Tasks:

- Surface water salinity should be determined at multiple locations on the intertidal plant surface using a hand-held salinity meter and probe or a hand-held salinity refractometer (to the nearest ppt). In addition, a data logger may be used to provide a greater range of information, including water temperature, over a period of time.
- Dissolved oxygen may be measured as deemed appropriate.

Schedule:

- Periodic and during post-construction Years 1, 2 and 5, especially during spring growth seasons for emergent intertidal marsh plants and, if funding is available, Years 7 and 10.

Contingency Measures:

- If emergent intertidal marsh vegetation does not flourish and begin to spread, additional monitoring of quantity and quality of the water needs to be initiated as part of an adaptive management effort. If adequate quality (or in the case of a lower salinity marsh - freshwater quantity) cannot be delivered over the long term then emergent marsh development may need to modified to match the prevailing hydrological conditions.

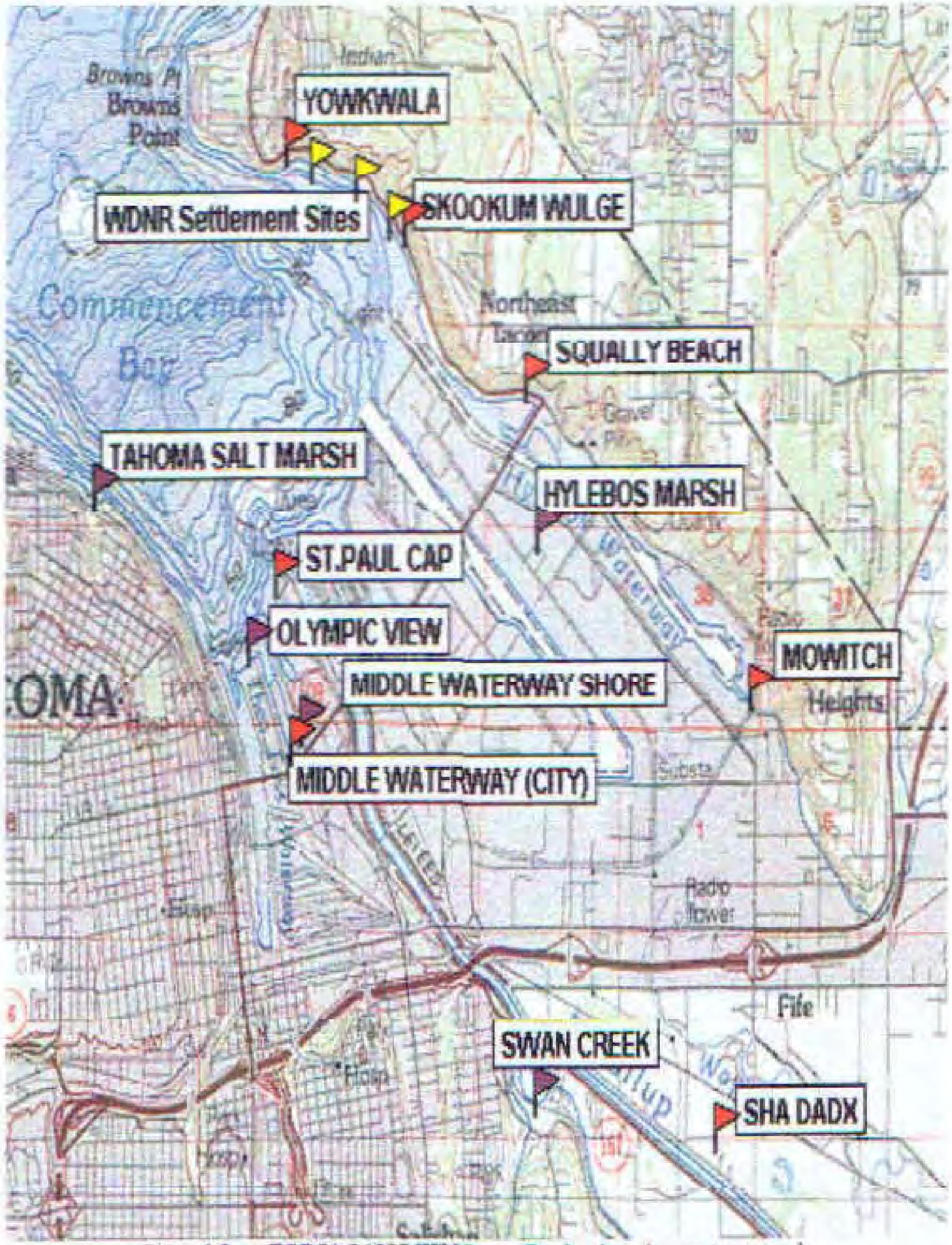
Discussion:

The interface between the high salinity (>25 ppt) marine waters of central Commencement Bay and the fresh water of the Puyallup River and the various shoreline streams, creeks, and seeps provides conditions of intermediate to high salinity where emergent plant communities survive. Historically, extensive marshes edged the Puyallup River delta providing organic debris input to the food chain, habitats for invertebrates, mammals, and birds, and refuges for small invertebrates and juvenile fishes.

APPENDIX D

FIGURES

FIGURE 1. NRDA RESTORATION PROJECT SITES



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APPENDIX E

TABLES

Physical Monitoring Criteria	Attribute & Measure	Rationale	Success Criterion	Methodology	Sampling Schedule-Post Construction Years	Adaptive Management/Contingency Measures
1	Intertidal Areal Coverage	*Surveys are necessary to document the success of plant growth and assess the site's potential for supporting animal populations.*	90% of designed area +12ft to -2ft MLLW	As-Built Drawings, Topographic Surveys, Aerial Photographs, LIDAR, Visual Inspection Photopoints	1,5 (7,10)	None, Unless gross deviations which could result in some active reshaping or restucturing of the site.
2	Intertidal Stability	*Influences hydrologic gradient, plant establishment, animal access and characterisiics of wetted edge.*	Countours remain wthin +/ 0.50' of design, 75% of contours maintained through year 5	As-Built Drawings, Topographic Surveys, Transects and Profiles	1,2,5 (7,10)	None, unless gross deviations, in which case re-contouring may be considered.
3	Tidal Circulation	*Influences plant establishment, substrate stability and chemistry.*	Tidal amplitude equivalent inside and outside site	Data Logger/Tide Guage or Tidal Staff and Visual Observation	1,2,5 (7,10 and/or periodic)	Drain pools to avoid fish stranding
4	Elevation & Channel Morphology	*Influences hydrologic gradient, plant establishment, animal access and characteristics of wetted edge.*	Erosion does not threaten the property, infrastructure, project/permit goals	Site Survey & Aerial Photographs, LIDAR	periodic observation and examination of data gathered to monitor contour stability in years1,2,5 (7 &10)	Non-stuctural controls first (plantings, erosion control mats) followed by more engineered controls shoreline reinforement, wave-action controls, etc.,) if necessary.
5	Sediment Structure	*Influences habitat value for fish and benthic organisms. Indicator of sedimentaton and/or erosion, stability indiactor.*	Accumulating fine grained materials to support biological production.	Grain Size Analysis, Organic Carbon Content	1,3,5 (7,10)	Soil amendments will be considered.
6	Soil Salinity	*Control seed germination and seedling establishment.*	Comparable with refernce sites.	Soil core sampling and laboratory analysis	Contingent upon adaptive management	Soil amendments will be considered.
7	Light Attenuation	*Influences plant development, especialy of concern if attempting to restore eelgrass beds.*	Comparable with refernce sites.	submersible light meter	1,2,5	Develop sediment/turbidity control measures

MONITORING PROGRAM SUMNARY TABLE

Biological Monitoring Criteria	Attribute & Measure	Rationale	Success Criterion	Methodology	Sampling Schedule-Post Construction Years	Adaptive Management/Contingency Measures
1	Marsh Development Areal Coverage	*Plant surveys are necessary to document the success of plant growth and assess the site's potential for supporting animal populations.*	Stable or increasing over time.	Aerial Photographs, Vegetation Surveys, Photo Points.	1,2,3,5 (7,10)	Soils amendments, additional plantings, consideration of a change in elevation of plant species, if warranted.
2	Marsh Development Species Composition	*same as above*	50% overall plant survival by year 3, <1% non-native, invasive species present.	Transect and Quadrat samping, Photo Points	1,2,3,5 (7,10)	Physical removal of non-native/invasive plants.
3	Marsh Development Plant Vigor	*same as above*	Stem height and shoot density 80% of that of the refernce by year 3.	Transect and Quadrat samping, Stem height/ Shoot density measures & Photo Points.	1,2,3,5 (7,10)	Soil amendments including nutrient content will be considered.
4	Marsh Vegetation Herbivory Avoidance	*Plants, especially young intertidal plants are suceptible to predation by Canada geese.*	Control herbivory by Canada geese.	Installation and maintenance of Goose exclusion devices/physical barriers.	Installation no later than along with initial plantings. Devices must be maintained for the first 3 years of the project. Therefore periodic monitoring is necessary.	Repair, reinstall exclusion devices.
5	Riparian Vegetation Survival	*same as above*	75% survival in 3 years	Aerial Photographs, Quadrats/Transects Point-line Intercepts	1,2,3	Replacement plantings, Soil amendments, Stewardship
6	Riparian Vegetation Areal Coverage	*Plant surveys are necessary to document the success of plant growth and assess the site's potential for supporting animal populations.*	70% coverage in 5 years, 90% coverage in 10 years.	Aerial Photographs, Quadrats/Transects, LIDAR Point-line Intercepts	1,2,3,5 (7,10)	Additional plantings, Soil amendments, Stewardship
7	Fish Access / Presence	*Fishes are good indicators of ecosystem health. Generally, the presence of a few species (low species richness) may indicate stressful environmental conditions.*	Comparable to reference areas in 10 years.	Fyke Nets, Beach Seine, Stomach Contents	1,2,3,5 (7,10)	Re-examine project design & goals - retain outside consultation.

MONITORING PROGRAM SUMMARY TABLE

8	Invertebrate Prey Resource Production	*Benthic macroinvertebrates are good indicators of ecosystem health. Tidal wetlands can easily, and often do, support a wide variety and number of benthic invertebrate species.*	Comparable to reference areas in 10 years.	Cores, Seives, Litterbags, and visual observation	1,3,5 (7,10)	Re-examine project design and goals, retain outside consultation.
9	Bird Use	*Increased bird use of the restored habitat will be used as an indication of improved habitat conditions.*	Use within 50 m. comparable to reference sites	Observational Surveys	1,2,3,5 (7,10)	Re-evaluation of human disturbace, installation of nest boxes and or other enhancement measures (decoys)
10	Primary Production	*Influences growth rate/food chain support.*	Algal mats comparable with reference sites.	Visual Inspection, Aerial Photographs	1,2,3,5 (7,10)	None
11	Insect Production	*Insects are responsible for pollunation, seed dispersal, aerating soils, controlling herbivorous insects and food chain support.*	Comparable with refernce sites.	Floating Pan Traps, Litter bags, Sweep Nets	1,2,3,5 (7,10)	None
12	Plankton Presence	*Primary production indicators.*	Comparable with refernce sites.	Plankton Nets	1,3,5 (7,10)	None
Chemical Monitoring	**Attribute & Measure**	***Rationale***	**Success Criterion**	**Methodology**	**Sampling Schedule-Post Construction Years**	**Adaptive Management/Contingency Measures**
1	Sediment/Soil Quality	*Influences habitat value for fish and benthic organisms. Influences growth rates. Indicator of sedimentation and/or erosion, stability indiactor.*	Comparable to reference sites.	Sediment samples, Standard methods, surficial and core samples as necessary.	As needed, as determined by physical and biological criteria above.	Soil Amendments
2	Water Quality/Quantity Temperature	*Influences plant development and is an idicator for tidal circulation.*	Suitable salinity for emergent plant propogation, colonization and growth. Suitable tempertures for fishery resources.	Data Logger, Salinometer or Refractometer	1,2,5 (7,10 and/or periodic)	Manipulate Freshwater flow as practicable and feasible, re-examine plant species selection.

MONITORING PROGRAM SUMMARY TABLE

ELEVATION

HIGH

SALINITY

LOW

TABLE 2	LOW	HIGH
MARINE	*Salicornia virginica* *Zostera marina* *Zostera japonica*	*Elymus mollis** *Frageria chiloensis*
ESTUARINE	*Atriplex patula [high estuary]* *Cuscuta salina [low brackish]* *Distichlis spicata* *Jaumea carnosa* *Lilaeopsis occidentalis* *Plantago maritima [high estuary]* *Salicornia virginica* *Triglochin maritimum* *Carex lyngbyei (along channels)* *Scirpus maritimus* *Scirpus americanus*	*Aster subspicatus* *Atriplex patula* *Carex lyngbyei* *Cuscuta salina [low brackish]* *Deschampsia caespitosa* *Distichlis spicata [low estuarine]* *Grindelia integrifolia* *Hordeum brachyantherum* *Jaumea carnosa [low estuarine]* *Juncus balticus* *Orthocarpus castillejoides** *Plantago maritima* *Potentilla anserina ssp. Pacifica* *Scirpus acutus [high tidal fresh]* *Scirpus maritimus [low estuarine]* *Trifolium wormskjoldii*
BRACKISH	*Carex lyngbyei* *Lilaeopsis occidentalis** *Scirpus americanus* *Triglochin maritimum [low esturine]* *Cuscuta salina** *Jaumea carnosa*	*[Agrostis alba]* *Eleocharis palustris** *Juncus balticus* *Scirpus americanus[low esturine]* *Trifolium wormskjoldii [high esturine]* *Pyrus fusca* *Picea sitchensis* *Salix hookeriana*
TIDAL FRESH	*Carex obnupta* *Typha latifolia** *Scirpus tabernaemontanii*	*Agrostis alba [high brackish]* *Carex obnupta* *Physocarpus capitatus* *Rosa nutkana* *Scirpus acutus* *Typha latifolia [low tidal fresh]* *Pyrus fusca* *Picea sitchensis* *Salix hookeriana* *Salix lucida var. lasiandra*

*Volunteer species, should not be widely planted.

Table 2. (cont.) Latin and Common Names for Commencement Bay Plant List

Latin Name	Common Name
Agrostis alba	Creeping bentgrass
Aster subspicatus	Douglas aster
Atriplex patula	Saltweed, orache, fat hen
Bidens cernua	Nodding beggar-tick
Carex lyngbyei	Lyngby's sedge
Carex obnupta	Slough sedge
Cuscuta salina	Saltmarsh dodder
Deschampsia caespitosa	Tufted hairgrass
Distichlis spicata	Seashore saltgrass
Eleocharis palustris	Creeping spikerush
Elymus mollis	American beachgrass
Frageria chiloensis	Beach strawberry
Grindelis integrifolia	Puget-Sound gumweed
Hordeum brachyantherum	Meadow barley
Jaumea carnosa	Fleshy jaumea
Juncus balticus	Baltic rush
Lilaeopsis occidentalis	Western lilaeopsis
Orthocarpus castillejoides	Paintbrush owl-clover
Physocarpus capitatus	Pacific ninebark
Picea sitchensis	Sitka spruce
Plantago maritima	Seaside plantain
Potentilla pacifica	Pacific silverweed
Pyrus fusca	Pacific crabapple
Rosa nutkana	Nootka rose
Salicornia virginica	Pickleweed
Salix hookeriana	Hooker's willow
Salix lucida var. lasiandra	Pacific willow
Scirpus acutus	Hardstem bulrush
Scirpus americanus	Three-square bulrush
Trifolium wormskjoldii	Springbank clover
Triglochin maritima	Seaside arrowgrass
Typha latifolia	Common cattail
Zostera japonica [delete]	Eelgrass, Grass-Wrack
Zostera marina	Dwarf Eelgrass, Narrow-Bladed Eelgrass

APPENDIX F

SURVEY OF MONITORING PROGRAMS

SURVEY OF MONITORING PROGRAMS

The following section is a summary of several publications describing monitoring programs. They are provided to show the variety of parameters available and the recommendations from recognized authorities and agencies. More detailed information regarding the methods and instructions for developing monitoring programs may be found in the Army Corps of Engineers IWR Report 96-R-23, published in 1996.

Example 1: Measurement Selection in Wetlands by Erwin (1990)

Erwin suggested that a quantitative wetland evaluation be implemented "when the construction technique is unproven, where the ability to successfully create or restore habitat is unproven, or when success criteria are related to obtaining specific thresholds of plant cover, diversity, and wildlife utilization." This quantitative wetland evaluation should include hydrological monitoring and vegetation analysis. Qualitative evaluations can be carried out in situations where there is more certainty of success, and where performance is not tied to specific quantitative criteria. As an example of qualitative evaluations used for wetlands, Erwin recommended:

- baseline vegetation surveys
- fixed point panoramic photographs
- rainfall and water level data
- plan view of sampling points
- wildlife use observations
- fish and macroinvertebrate data
- annual reporting for five years

Erwin stated that criteria for performance must be established before the evaluation effort and must be "fundamental to the existence, functions, and contributions of the wetland system and its surrounding landscape."

Example 2: Measurement Selection in Wetlands by the Natural Resource Council (NRC 1992)

The Natural Resource Council described a process that would have structural and functional attributes of a wetland form the basis for evaluating success of the restoration project. The NRC further suggested that two factors influence the success rating: (1) the specific criteria used, and (2) the reference data or sites used for comparison. The NRC recommended the following for a restoration monitoring program:

- assessment criteria should include structural and functional attributes
- criteria should be established before the assessment takes place
- criteria should be linked to objectives for the project
- several criteria should be used for evaluation
- criteria may need to be regionalized
- reasonable reference sites and long-term data set should be available for comparison
- measurements should take into account temporal and spatial heterogeneity
- there should be an a priori indication of similarity expected between the restored sites and the reference sites
- a time frame for monitoring should be established a priori
- criteria and methods should stand up to peer review.

The NRC developed a list of seven wetland functions that should be considered in assessing equivalency between natural and constructed wetland systems. These were based upon experiences in coastal salt marshes, but apply generally to all wetland systems. For each function, the NRC suggested measures that could be used for quantification.

The NRC (1995) reviewed wetland delineation methods and concluded that the use of three wetland indicators, hydrology, soils and wetland plants, were reliable and valid indicators of the presence of a wetland and commended the use of manuals already in place for delineating wetlands. For restoration projects, the 1989 Corps of Engineers method for wetland delineation may be adequate to evaluate wetland development and the area occupied by a wetland (FICWD 1989).

Example 3: Measurement Selection in Wetlands by the U.S. Army Corps of Engineers HGM Method

The U.S. Army Corps of Engineers (Corps) has a history assessing structure and function of wetlands and other habitats. One approach has been developed synthesizes much of the work that is relevant to wetland systems. Brinson (1993) developed an approach for classifying wetlands that is based upon hydrology and geomorphology - the hydrogeomophic method (HGM). This approach relies on water quality, hydrology, and soils as indicators of ecological conditions of a wetland. For example, northern, cold systems with a positive water balance and a low pH may favor *Sphagnum* peat development. So, by characterization of hydrological conditions, along with other aspects of the system, wetland type and ecological function (or significance)can be predicted. Additionally, the HGM approach uses a range of reference values rather than a single success criteria. This idea of developing a database for long-term use is necessary to obtain a more thorough understanding if natural wetland systems, their fluctuation in equilibrium and trends.

Example 4: Measurement Selection in Aquatic Systems the Index of Biological Integrity

The Index of Biological Integrity (IBI), developed by Karr (Karr and Dionne 1991; Karr 1993) is designed to provide a cost-effective method for evaluating the biological conditions in streams. The IBI focuses on attributes of fish communities to evaluate the effects of humans on streams and watersheds. An IBI is developed based upon sampling of these attributes in a disturbed stream, and ranking them according to their deviations from values expected at an undisturbed reference stream. When several attributes are combined and scaled, the sites can be graded as having an excellent, good, fair, or poor biological integrity. This method has been applied throughout much of the United States, and has been tested in estuarine systems in New England (Deegan et al. 1993).

Example 5: Measurement Selection in Wetlands by the EPA

The most specific guidance on selection of restored wetland monitoring parameters comes from the EPA (Kusler and Kentula 1990; Kentula et al. 1992). Kentula et al. (1992) presents a list of 26 wetland system variables, justification for selection, suggested uses, and general procedures. The variables are divided into categories of general information: morphology, hydrology, substrate, vegetation, fauna, water quality, and additional information. These variables are well justified in the scientific literature, and many have been investigated directly by the EPA Wetland Research Program.

The EPA, through its Environmental Monitoring and Assessment Program (EMAP; Hunsaker and Carpenter 1990), has been developing parameters to monitor the status and trends of the ecological conditions of the ecosystems of the United States. For wetlands and surface waters, EMAP has developed a list of 20 and 18 "candidate indicators' for surface waters and wetland ecosystems respectively. Each of these indicators is graded high, medium or low relative to 12 selection criteria. The selection criteria identify the following about an indicator:

- Can it be correlated with unmeasured ecosystem components?
- Is it applicable on a regional basis, is related unambiguously and monotonically to an environmental value or habitat value?
- Can it be easily sampled?
- Does it exhibit a low measurement error?
- Is it cost effective?

Although EMAP was not designed to monitor restoration sites, the analysis of ecosystem indicators is useful in selecting defensible and relevant parameters for this purpose.

Example 6: Measurement Selection in the U.S. Army Corps of Engineers Civil Works Program

Circular No. 1105-2-210 (Corps 1995) identified structural and functional characteristics of the ecosystem that are potential useful for measuring the progress of restoration projects.

The circular provided a discussion of the following characteristics:

Structural	Functional
water quality	water storage, recharge, supply
water quantity	floodwater and sediment retention
soil condition	transport of organisms, nutrients, etc.
geology	oxygen production
topography	biomass production, food web support
flora and fauna	nutrient cycling
concepts (patch size, edge, etc.,)	shelter detoxification of wastes
morphology	energy flow

Example 7 Measurement Selection in Water Quality Assessments by the EPA

The EPA (1991a, 1991b) has attempted to develop biological criteria for water quality assessments in a variety of system types. Biological criteria are not universally recognized in the United States because they have not been developed to a state that allows for broad application. Biological water quality criteria can be developed for local areas and used for monitoring changes in the conditions in a particular watershed or stream. These same criteria could also be used to assess the changes in water quality associated with restored systems.

Example 8: Regional Parameter Selection in Coastal Wetlands in Southern California

Based upon more than ten years of research on constructed wetlands in southern California's coastal zone, Pacific Estuarine Research Laboratory (PERL, 1990) considered the following functions and characteristics essential for the success of restoration projects in southern California coastal wetlands:

- provision of habitat for wetland dependent species
- support for food chains
- transformation of nutrients
- maintenance of plant populations
- resilience (ability to recover from disturbances)
- resistence to invasive species (plant or animal)
- resistence to herbivore outbreaks
- pollination
- maintenance of local gene pools
- access to refuges during high water
- accommodations of rising sea level

These functions are directly measurable and have been justified through research. Because this list was developed specifically for the region and system type, it can be used in the planning process to define the vision and goals for the project. The monitoring program can then develop performance criteria and measurable parameters with confidence that they will be highly relevant and sensitive indicators of the progress of the system.

Example 9: Regional Parameter Selection in Seagrass Systems

Seagrass systems occur in most coastal waters of the United States, where they form important habitats for a variety of fish and aquatic invertebrates. They are one of the most productive habitats but have suffered severe losses and are under constant pressure from coastal development (Thom 1990). Fonesca (1990) found that seagrass restoration has historically resulted in a net loss of habitat primarily because performance goals and criteria were inappropriate. He recommended the following goals for which criteria can be formulated:

- development of persistent cover
- generation of equivalent or increased area
- replacement with the same seagrass species that suffered impact
- restoration of faunal production.

These goals are applicable to seagrass systems throughout the United States.

Example 10: Regional Parameter Selection in Coastal Wetlands in Louisiana

The Coastal Wetlands Planning, Protection, and Restoration Act (CWPRA) was established to provide guidance and means to implement projects that stop further loss of Louisiana's coastal wetlands and that restore coastal wetlands in the region. As part of the effort under CWPRA, monitoring protocols were developed to provide guidance on minimum monitoring standards to assess performance of restored systems relative to goals, and to provide information for developing costs for restoration programs (Steyer and Stewart 1992).

Subgroups of technical experts developed protocols in seven categories: water quality, hydrology, soils and sediments, vegetative health, habitat mapping, wildlife and fisheries. Monitoring plans were developed for nine project types: freshwater introduction and diversions, sediment diversions, marsh management, hydrologic restoration, beneficial use of dredged material, shoreline protection, barrier island restoration, vegetative planting, and sediment nutrient trapping. Variables (i.e., measurable elements) are developed for each monitoring category and prioritized for each project type.

Priorities range from a primary objective (Priority 1) through lower priority-long term evaluation (Priority 4), with an additional priority, as needed, unique to a specific project (Priority N). Cost estimates are provided for instrumentation, analysis and related items. Methods are provided in varying degrees of detail for the variables.

Example 11: Regional Parameter Selection in Estuarine Habitats in the Pacific Northwest

Simenstad et al. (1991) developed the Estuarine Habitat Assessment Protocol (EHAP) to provide a standardized approach and sampling protocols for assessing the performance of restored or constructed estuarine systems in the Pacific Northwest. EHAP proposes characteristics (termed attributes) of estuarine habitats that promote fish and wildlife use and fitness. These attributes indicate the potential to provide a specific function, which can provide design criteria for habitat restoration. The attributes selected were based upon a comprehensive survey of approximately 200 estuarine scientists in the region and were supported by published information such as those listed above. A total of 105 "protocol" species" were identified, which included fish, invertebrates, birds and mammals. The occurrence of the species in each major habitat type is shown, and the reason for the occurrence (e.g., feeding, rearing, reproduction, resting) is provided. Finally, specific methods for sampling attributes of each habitat that are related to the occurrence of the protocol species are described. The EHAP further identifies three levels of sampling complexity: minimum, recommended, and prefered.

Discussion:

Consideration was many approaches to monitoring including, but not limited to those programs listed above. In general, most restoration and mitigation monitoring plans support an approach that assesses both the physical stability and habitat function of a created/enhanced wetland.

To insure the quantitative, comparable nature of data from this monitoring effort, the approach and methodologies prescribed by the EHAP (Simenstad et. al., 1991) will be used to the greatest extent possible while still considering the plans listed above such as the HGM Model. EHAP is a framework upon which this plan is based, it is considered the most applicable and employs the widest array of parameters and guidance in comparison with the other guidance provided by EPA, the U.S. Army Corps and others.

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APPENDIX G

SITE SPECIFIC MONITORING PLANS

MONITORING PLAN - MIDDLE WATERWAY (TRUSTEE/SIMPSON)

PROJECT:
Simpson Tacoma Kraft / NRDA
Middle Waterway Shore
Habitat Restoration Project

LOCATION:
Middle Waterway, Commencement Bay,
Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile
salmonid migration.
Establish marsh vegetation.
Protect the site for natural resources.

CRITERIA: PSC 1,2,4; BSC 1,2,4,6,7,8*,9
*BSC8 in monitoring years 1,5 and 10 if funding is available

SITE SUMMARY:
In the spring of 1995, Champion International Corporation, the former owner of the Simpson Tacoma Kraft Mill, and Simpson Tacoma Kraft Company, its current owner, in cooperation with the Trustees, created the Middle Waterway Shore Restoration Project on a five-acre site owned by Simpson on the northeast bank of the Middle Waterway. The project was developed in connection with a settlement approved in court on April 1, 1996, that resolved Bay-wide claims for natural resource damages against the two companies. The Middle Waterway project re-establishes over three acres of intertidal, salt marsh, and riparian habitat along the Middle Waterway, a high priority location for restoration in the Bay ecosystem. The waterway had one of the largest remaining areas of original intertidal mudflats in the Bay (about 20 acres). Formerly filled land has been excavated and contoured to create a natural shoreline with hummocks and other natural marsh features, increasing the complexity, diversity and habitat value of Middle Waterway for shore birds, salmonids and marine fish, river otters and other wildlife in the area. The project provides a partial buffer between the mudflats and adjacent upland industrial uses.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - MIDDLE WATERWAY (TRUSTEE/SIMPSON)

PROJECT:
Simpson Tacoma Kraft / NRDA
Middle Waterway Shore
Habitat Restoration Project

LOCATION:
Middle Waterway, Commencement Bay,
Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration
Establish marsh vegetation
Protect the site for natural resources.

CRITERIA: PSC 1,2,4; BSC 1,2,4,6,7,8*,9
*BSC8 in monitoring years 1,5 and 10 if funding is available

SITE SUMMARY:
In the spring of 1995, Champion International Corporation, the former owner of the Simpson Tacoma Kraft Mill, and Simpson Tacoma Kraft Company, its current owner, in cooperation with the Trustees, created the Middle Waterway Shore Restoration Project on a five-acre site owned by Simpson on the northeast bank of the Middle Waterway. The project was developed in connection with a settlement approved in court on April 1, 1996, that resolved Bay-wide claims for natural resource damages against the two companies. The Middle Waterway project re-establishes over three acres of intertidal, salt marsh, and riparian habitat along the Middle Waterway, a high priority location for restoration in the Bay ecosystem. The waterway had one of the largest remaining areas of original intertidal mudflats in the Bay (about 20 acres). Formerly filled land has been excavated and contoured to create a natural shoreline with hummocks and other natural marsh features, increasing the complexity, diversity and habitat value of Middle Waterway for shore birds, salmonids and marine fish, river otters and other wildlife in the area. The project provides a partial buffer between the mudflats and adjacent upland industrial uses.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - MIDDLE WATERWAY (TRUSTEE/CITY)

PROJECT:
City of Tacoma / NRDA
Middle Waterway
Estuarine Resources
Restoration Project

LOCATION:
Middle Waterway, Commencement Bay,
Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration.
Establish marsh vegetation.
Protect and preserve the site for natural resources.

CRITERIA: PSC 1, 2, 4; BSC 1,2,4,5,6,7,8*
*BSC8 in Years 1,5 & 10 if funding is available

SITE SUMMARY:
The City of Tacoma, in coordination with the Trustees, has developed an estuarine shoreline wetland restoration project on the Middle Waterway within the City of Tacoma and Commencement Bay. Excavation or re-grading of the 1.65 acres vacant upland property, located adjacent to and within the southwest shore of the Waterway should facilitate the establishment of intertidal marsh and riparian buffer bordering one of the few remaining original mudflats within Commencement Bay. The project is intended to create new habitat, enhance existing habitat, buffer both new and existing habitat, and provide public access for education and passive recreation. The project goal is to establish estuarine marsh habitat for an assemblage of wetland dependent marine, bird and plant species. The project is across the head of Middle Waterway from and complements the Middle Waterway Shoreline Restoration Project developed earlier by Simpson Tacoma Kraft Co. in cooperation with the Trustees.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - SQUALLY BEACH

PROJECT:
Squally Beach

LOCATION:
Inner Turning Basin, Hylebos Waterway,
Commencement Bay,
Tacoma, Washington

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration.
Create interstices for invertebrates.
Establish backwater ponds to increase intertidal saltmarsh area.
Protect and preserve the site for natural resources.

CRITERIA: PSC 1,2,4; BSC 1-9

SITE SUMMARY:
The project site is located waterward of Marine View Drive near the middle of the Hylebos Waterway on property owned by the Puyallup Tribe. The site is approximately 0.66 acres, and contained blackberry bushes, some hardwood trees, and a strip of intertidal marsh vegetation approximately three feet wide. The site supported a small fringe marsh and low-gradient mudflats that provide habitat for benthic, or bottom-dwelling organisms important to the food chain. These organisms are of particular importance to shorebirds and juvenile salmon. The project restores intertidal habitat by excavating about 2,000 cubic yards of material, grading an area north of the existing vegetation line, and planting intertidal vegetation. Runoff from the hillside on the north side of Marine View Drive, which forms the eastern project boundary, has been intercepted and routed through the project site in a dendritic channel pattern. Freshwater inputs would lower salinity and encourage growth of species that tolerate brackish conditions. Substrate enhancement is a component of the project depending on the nutrient availability of the existing materials.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - YOWKWALA

PROJECT:
Yowkwala

LOCATION:
Hylebos Waterway, Commencement Bay, Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration.
Demolish and remove two derelict barges and a drydock and associated debris.
Maintain and facilitate further development of marsh vegetation.
Protect and preserve the site for natural resources.

CRITERIA: BSC 1,2,7

SITE SUMMARY:
The project site, approximately 15 acres in size, is located between Browns Point and Tyee Marina. Two derelict barges, a dilapidated drydock and other debris have been removed from the cobble beach. The barges had provided a sheltered area for a small fringe marsh which is anticipated will remain and may be facilitated through further restoration activities.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - SKOOKUM WULGE

PROJECT:
Skookum Wulge

LOCATION:
Mouth of Hylebos Waterway,
Commencement Bay,
Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration.
Monitor marsh vegetation and erosion.
Protect and preserve the site for natural resources.

CRITERIA: PSC 1 - to be conducted in year 1 and once again if/when log booms are removed to observe beach effects.

SITE SUMMARY:
The Skookum Wulge Beach site consists of 1.19 acres of uplands and tidelands with 418 linear feet of waterfront immediately inshore from a subtidal Trustee restoration site, formerly the Meeker Log Storage Lease. The site is a natural fill of unconsolidated glacial till which slid off of the hillside above into Commencement Bay in 1938; the shape of the riparian point of land extending onto the beach is the result of this slide and subsequent wave erosion from the Bay. The site is partially protected from major winter storm effects from the northwest by the Foss Maritime log storage area immediately offshore. The Trustees have requested that the protective outline of this log storage area be somewhat reconfigured to move the inshore footprint to water deeper than -10 feet (MLLW). The Trustees will hold this site for future restoration activities and will continue to monitor changes in offshore activities as well as perform routine maintenance and cleanup of the intertidal area.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites; Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.

MONITORING PLAN - MOWITCH

PROJECT:
Mowitch

LOCATION:
Mouth of Hylebos Creek
at the head of Hylebos Waterway,
Commencement Bay,
Tacoma, Washington.

DESIGN OBJECTIVES:
Enhance intertidal area for juvenile salmonid migration.
Establish backwater sloughs.
Establish salt marsh vegetation and riparian plants.
Protect and preserve the site for natural resources.

CRITERIA: PSC 1,2,3(visual inspections),4; BSC 1-9

SITE SUMMARY:
The project site was filled to its pre-project elevation, channelized, and straightened in the early 1960's when the upper Hylebos Waterway Turning Basin was dredged to its current configuration. The character of the straight stream channel has been modified and diversity was added to the habitat. Three backwater pools with base elevations near Mean Low Water (MLW) were sculpted from the past upland. A secondary stream mouth was added in the area of the site that was an historical log ramp. The backwater will be flooded the majority of the year. The pools and adjacent terraces include large woody debris as habitat features. A minimum of 25 feet next to the fence is to remain vegetated. The planting designs are based upon plants native to Commencement Bay. The emergent plant species will be similar to those found elsewhere in Commencement Bay and will utilize the freshwater component from Hylebos Creek.

VOLUNTEER OPPORTUNITIES:
To be defined prior to conducting sampling activities.

REFERENCE / COMPARISON SITES: Based upon approval of the Trustee Council, appropriate reference sites will be selected for various sites and various criteria. For example: plant vigor **(BSC3)** would incorporate comparisson data from a site adjacent to Squally Beach along the inner Hylebos mudflat, Elliott Bay monitoring data and data reported for Coastal America sites. Fish **(BSC7)** sampling results could be compared to historical data gathered by the Puyallup Tribe of Indians in Commencement Bay and the Muckleshoot Indian Tribe in the Duwamish and data gathered at Coastal America sites. Invertebrates **(BSC8)** inhabitating restored areas could be compared to the Outer Hylebos mudflat - provided that grain size is appropriate. Bird usage **(BSC9)** could be compared across all sites and include the Duwamish Waterway restoration projects.