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. *Plant vigor, 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.