Appendix A— Monitoring and Adaptive Management Plan

APPENDIX A
MONITORING AND ADAPTIVE MANAGEMENT PLAN

INTRODUCTION

This monitoring and adaptive management plan has been developed to monitor and ensure the success of the Swan Creek and Haire Wetland Restoration project. The plan is composed of two major elements: monitoring and adaptive management. For the first element, the plan includes qualitative and quantitative sampling methods that will be used to monitor and measure the ecological success of the project. Qualitative monitoring measures will include evaluation of the health and vigor of planted and naturally colonizing species, placement and function of large woody debris structures (LWD), and establishment of permanent photo points. Quantitative monitoring measures for the vegetated areas will include long-term, random sampling of vegetation and sediment along transects traversing the different enhancement areas in Communities A, C, D, F, and G. This monitoring data will be compared to establish performance standards (goals and objectives) for plant cover, species composition, and diversity to evaluate ecological success. Quantitative monitoring measures for the fish habitat created will include an assessment of the fish habitat created. Additionally, each LWD structure will be evaluated to determine if it is functioning as intended.

The adaptive management portion of the plan is an interactive decision-making, feedback loop that specifies contingency measures or corrective actions to be implemented if monitoring data suggest the restoration may not meet performance standards. Contingency measures may include modification of the physical configuration of the site, supplemental plantings, modification of LWD structures, addition of LWD structures or pieces, substrate amendments, and/or modification of project goals and objectives.

PERFORMANCE STANDARDS (GOALS AND OBJECTIVES)

The overall objectives of the project are as follows:

- Create side-channel rearing habitat for juvenile salmonids and other aquatic biota and amphibians.
- Create potential spawning habitat in a 530-ft channel connecting Swan Creek to the Haire Wetland.
- Restore and enhance the areal extent and associated functions of the Haire Wetland, Swan Creek, and associated riparian and upland forest habitats that have been greatly diminished or lost since the beginning of the industrial revolution.

Because aquatic environments are dynamic, restoring them is a challenge and requires application of an adaptive management strategy. Performance standards for areal coverage of native and invasive plants in each vegetation zone have been established to evaluate whether these goals and objectives are being met during the monitoring period. Performance standards for fish habitat created are based on habitat requirements of salmonids reported in the literature. In the event that standards for vegetation cover, species diversity or fish habitat are not being met, appropriate contingency measures will be implemented as part of the adaptive management process. The intent of this process is to use monitoring data and professional judgment to make appropriate decisions that will reasonably ensure the long-term success of the project.

MONITORING METHODS

A combination of qualitative and quantitative monitoring methods will be employed to measure the ecological success of the proposed restoration. Qualified professionals will implement all monitoring methods. Proposed monitoring methods may be changed in the future as part of the adaptive management process. Before implementing any proposed changes, they will be discussed with and agreed to by the Natural Resource Trustees and the City of Tacoma,.

Following adoption of any such changes through mutual consent, they will be carefully documented in subsequent monitoring reports.

QUALITATIVE METHODS

Vegetation

Professionals conducting this monitoring will make a number of qualitative observations on vegetation and wildlife as they collect quantitative data. To ensure the same observations are made each year of monitoring, the data form shown in Tables A-1 and A-2 will be used. Qualitative data will be collected within each enhancement and restoration area on plant cover, density, height, and survival; erosion and sedimentation; organic matter accumulation (e.g., leaf litter); naturally colonizing plants; and large organic debris. In addition, observations of wildlife use, including avifauna, amphibians, reptiles, small mammals, fish, and macroinvertebrates, will be recorded during each monitoring event.

To supplement these qualitative data, up to 10 permanent photo points will be established as shown in Figure A-1. Photo points will be established to coincide with different enhancement zones and be located at topographic vantage points that afford the most complete views of the different enhancement and restoration zones. Photos will be taken looking in the directions shown at each photo point. These will document relative changes in plant cover, density, and height, as well as changes in topography resulting from erosion and sedimentation processes. Permanent markers will be established at each photo point (either PVC, wood lathe, or a combination of PVC and rebar).

QUANTITATIVE METHODS

Vegetation

A stratified random sampling design will use transects and quadrats to monitor plant cover, survival of transplanted native plants, natural colonization, and successional patterns of native and invasive plant species. Six transects will be established within the different vegetation zones (Figure A-1).

Along each transect, between 5 and 10 sample plots (i.e., quadrats) will be established to measure the cover and distribution of native, non-native, and invasive plants. To eliminate potential bias, sample plot locations will be established using a random-number generator. Quadrat sample size will vary between the different enhancement and restoration zones to reflect the patch size and variation of vegetation communities and different life forms of plants within these areas. For shrubs, quadrat size will be at least 7 m^2 (3-m-diameter circular plot) and trees 64 m^2 (9-m-diameter circular plot)

Table A-1 SWAN CREEK RESTORATION VEGETATION SAMPLING

DATE: _____ LOCATION: _____ TRANSECT: _____

WEATHER: _____ PHOTOS: _____

QUAD NO.	1	2	3	4	5	6	7	8	9	10
Random Meter No.										

TAXA	% Plant Cover per 7m² (shrubs) and 29 m² (trees)									
Trees:										
Abies grandis										
Acer macrophyllum										
Alnus rubra										
Arbutus menziesii										
Cornus nuttallii										
Fraxinus latifolia										
Picea sitchensis										
Populus balsamifera ssp. trichocarpa										
Prunus emarginata										
Pseudotsuga menziesii										
Salix lucida ssp. lasiandra										
Thuja plicata										
Tsuga heterophylla										
Shrubs:										
Acer circinatum										
Cornus sericea										
Corylus cornuta										
Crataegus douglasii										
Gaultheria shallon										
Holodiscus discolor										
Lonicera involucrata										
Mahonia aquifolium										

Notes:

Table A-1 SWAN CREEK RESTORATION VEGETATION SAMPLING

DATE: _____ LOCATION: _____ TRANSECT: _____

WEATHER: _____ PHOTOS: _____

QUAD NO.	1	2	3	4	5	6	7	8	9	10
Random Meter No.										

TAXA	% Plant Cover per 7m² (shrubs) and 29 m² (trees)									
Shrubs (continued):										
Malus fusca										
Physocarpus capitatus										
Ribes sanguineum										
Rosa nutkana										
Salix hookeriana										
Salix scouleriana										
Salix sitchensis										
Sambucus racemosa										
Symphoricarpos albus										
Vaccinium ovatum										
Herbs:										
Polystichum munitum										

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Notes:

Table A-2

Line Intercept Method Data Form

Site: Swan Creek Restoration **Investigator:** _____

Transect: **Date:** _____

Transect Length:

Plant Number	Plant Species												Plant Survival			
	Intercept (ft.)	dbh (in.)	ht. (ft.)	Intercept (ft.)	dbh (in.)	ht (ft.)	Intercept (ft.)	dbh (in.)	ht. (ft.)	Intercept (ft.)	dbh (in.)	ht. (ft.)	Int. Loc'n	Species	L or D	ht. (ft.)
1																
2																
3																
4																
5																
6																
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26																
27																
28																
29																
30																
Total Int. Length																
% Cover																

Table A-2 (continued).

Line Intercept Method Data Form

Notes: Int. = the length of the transect intercepted by each plant in feet; it is measured by drawing an imaginary line from the edge of the plant canopy to the tape measure (e.g., 62 - 65 = 3 ft.)
dbh = estimated diameter at breast height; for shrubs with multiple stems cite a range.
ht. = estimated height of each tree or shrub
Plant Survival is measured within a belt transect that extends one meter to the east and west of the line intercept transect; it is calculated by adding the total number of living plants (L) and dead plants (D) together (including those in the intercept column for each species)
Int. Loc'n = the location of each species within the belt transect is recorded, including the intercept point and side of the transect (E for east and W for west) for each plant.

Herbaceous plant communities will be sampled with a circular, 1.5-m-diameter quadrat. Quadrats will be divided into subsections of known percent area to aid in estimation of percent cover. Trees and shrubs within the different zones will be sampled with circular, quadrats as noted above. In addition, line intercept methods (Barbour et al. 1980) will be used to estimate cover of trees and shrubs along each transect. Along each transect, the line-intercept method will be used to measure the cover of trees and shrubs within the different planting zones. The percent cover of each tree and shrub species is measured by extending a fiber-glass tape measure between the permanent transect endpoints of each transect, which will be marked with rebar and PVC pipe or other permanent markers. Percent cover for each species is the total amount of linear area of the tape intercepted by tree or shrub foliage divided by the total length of the transect. In addition to measuring cover for each species, total percent cover also will be calculated. Total percent cover is the sum of all individual species cover data for the entire transect. The total percent cover of all native species (trees, shrubs, and herbs) will be used to evaluate the performance standard for cover of native species.

Once sampling locations have been determined, the percent cover of each plant species present within each quadrat will be visually estimated along with the percent of bare ground (all viewed from the vertical). Individual species' cover values will be summed to determine the total areal coverage in each quadrat. Daubenmire cover classes (0-5%, 5-15%, 15-25%, 25-50%, 50-75%, 75-95%, and 95-100%) and cover class midpoint values (2.5%, 12.5%, 35%, 65%, 85%, and 97.5%) for each species also will be recorded. Average total areal cover for all quadrats within each zone will be calculated using the estimated cover and cover class midpoint values. To ensure that the same locations are monitored each year and to minimize bias and sampler error, transects and sample plot locations will be clearly marked with PVC or wood lathe. A map of the vegetation zones, transects, sampling locations, and property boundaries will be created in AutoCAD®.

Fish Habitat

Professionals conducting this monitoring will assess fish habitat along the entire length of each of the three newly constructed channels. Fish habitat will also be assessed along the 100-ft reach of Swan Creek where bioengineered structures will be placed. Fish habitat conditions will be determined using the same methods described in the Field Investigation Fish Habitat Methods section of the design report, which is a habitat unit survey method similar to that described by

Hankin and Reeves (1988). The location of any barriers that could prevent movement of adult or juvenile salmonids will also be identified during the survey. The following habitat elements will be examined: number of spawning sites, embeddedness (percentage fine sediment composition) of spawning gravel, percentage pool area, pool depth and cover class, dominant and subdominant substrate, and large woody debris (LWD). Tables A-3 and A-4 will be used to record the fish habitat assessment data.

Hydraulic performance of the 6 weirs will also be assessed during monitoring to ensure that they are functioning as designed. The amount of water flowing through Swan Creek will be assessed as well as the height of the weir to ensure they are not fish barriers. Adjustments in weir height will be made as needed.

Stream channel type, as defined by Montgomery and Buffington (1993), includes the following: pool-riffle, forced pool-riffle, plane-bed, step-pool, braided, and regime will be assessed for each of the newly created channels.

DURATION, FREQUENCY, AND TIMING

Monitoring of as-built conditions will be conducted in Year 0. Subsequently, monitoring will be conducted annually in Years 1, 2, and 5. Based on this proposed schedule of monitoring, a total of four monitoring events would be conducted over a 5-year period. Monitoring will be conducted in mid- to-late summer (late in the growing season), when vegetation is more or less fully developed for the current growing season and fish eggs have hatched. This schedule is expected to provide the most meaningful comparison for evaluating changes in the distribution and extent of plants in both time and space. Following the monitoring event after the fifth year, the City of Tacoma and the Natural Resource Trustees will meet to evaluate the monitoring data and will discuss the need and resources available for further management.

REPORTING

Reports documenting monitoring results will be completed within 6 weeks of each monitoring event. Copies of each report will be submitted to the Natural Resource Trustees. If necessary, follow-up meetings will be held between the City and the Natural Resource Trustees to discuss the monitoring results and any adaptive management recommendations included in the reports.

Table A-3 Fish Habitat Conditions - Field Inventory Sheet for Watershed Analysis

Stream _____ **Date** _____ **Crew** _____
Segment No./Location _____
Gradient _____ **Bankful Width** _____ **Wetted width** _____ **Channel Morphology** _____
Confinement _____ **Water Temperature** _____ **Time** _____ **Flow** _____

ENDING DIST, (Meters)	HAB. TYPE Pool Riffle Cascade	---POOLS ONLY---						HAB FORM W - Wood B - Boulder R-Rootwad	SUBSTRATE Sand, Gravel, Cobble, Bolder		
		RESDP (cm)					% Wood Cover		DOM	SDOM	SPGRV > 30% Emb. Y/N
		0 - 15	15 - 30	30 - 60	60 - 100	> 100					

Describe Conditions for: Off-Channel Rearing, Holding Pools, Redd Scour Potential, and Migrant Access Problems

Table A-4 Stream Survey **Large Woody Debris Inventory**

Stream Name_____ **Date** _____ **Recorder** _____
Stream Code _____ **Reach No.** _____ **Page**_____

Segment		Zone	Tally by log diameter group			No. in decay class		No. by recruit process		Function	
Start	End		10 - 30 cm	30 - 60 cm	> 60 cm	green	twigs	rootwad	blowdown	dom	sdom

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ADAPTIVE MANAGEMENT PLAN

Ecological success of the project will be measured and evaluated based on monitoring and performance standards established by the Adaptive Management Team, which consists of the Natural Resource Trustees, the City of Tacoma, and qualified professionals selected to monitor the project. Following each monitoring event, the Adaptive Management Team will discuss the monitoring data and any recommended contingency measures identified by the monitoring team, and strategies for implementing appropriate contingency measures. Implementation of this adaptive management process will be an essential element to project success.

PERFORMANCE STANDARDS

Vegetation

Plant Cover, Survival, and Invasive Species

Specific and general performance standards will be used to evaluate the successful establishment of the constructed channel, riparian, and upland forest habitats. Specific performance standards will include total areal cover and percent survival of plantings. Average percent cover will be used to evaluate differences between different years of monitoring. Because much of the energy during the first few years of growth is spent on root development, and unusual or unexpected environmental fluctuations can be detrimental to the successful establishment and survival of transplants, the performance standards for the first 2 years should be relatively modest; measurable gains should be expected by the fifth year. Total areal cover of invasive species, particularly reed canarygrass, Himalayan blackberry, and Scot's broom, are other metrics of ecological success.

Specific Performance Standards

Specific performance standards for total areal percent cover of native plants, percent survival of installed plant materials, and total area percent cover of invasive species for each of the enhancement and restoration areas are identified in Tables A-5 through A-8.

Table A-5 Performance standards for Community A enhancement areas (Zones 1, 2, 3, and 6).

Criterion	Year 0	Year 1	Year 2	Year 5
Total areal cover of native plants (%)	10-20	20-30	30-40	60-80
Survival of installed plants (%)	80	80	80	80
Total areal cover of invasive species (%)	0-5	5-15	5-15	5-10

Table A-6 Performance standards for reforestation areas in Communities C and D (Zones 4 and 5).

Criterion	Year 0	Year 1	Year 2	Year 5
Total areal cover of native plants (%)	30-45	30-50	35-60	60-85
Survival of installed plants (%)	80	80	80	80
Total areal cover of invasive species (%)	0-5	5-15	5-15	5-10

Table A-7 Performance standards for reed canarygrass control areas in Communities E and G (Zone 7).

Criterion	Year 0	Year 1	Year 2	Year 5
Total areal cover of native plants (%)	10-20[a]	20-30	30-40	60-80
Survival of installed plants (%)	80	80	80	80
Total areal cover of invasive species (%)	0-5	5-25	5-25	5-15

a Cover criterion assumes that plantings will be installed in the spring and cover estimated in the late summer of Year 0.

General Performance Standards

In addition to the specific performance standards, there are general performance standards for total area percent cover of native and invasive plants, as noted below.

Average Total Percent Areal Cover of Native Plants

- Year 0 – Average total areal cover of native or naturalized non-native plants for all of the enhancement areas (Communities A, C, D, E, and G), based on line intercept and quadrat data, shall be between 20 and 40 percent, which is equivalent to between 1.4 and 2.8 acres.

- Year 1 – Average total areal cover of native or naturalized non-native plants shall be for all of the enhancement areas (Communities A, C, D, E, and G) based on line intercept and quadrat data, shall be between 25 and 50 percent, which is equivalent to between about 1.8 and 3.5 acres.

- Year 5 – Total areal cover of native or naturalized non-native plants for all of the enhancement areas (Communities A, C, D, E, and G), based on line intercept and quadrat data, shall be greater than 60 percent, which is equivalent to more than about 4.2 acres.

Average Total Percent Areal Cover of Invasive Plants

Areal coverage and extent of non-native or invasive species, which are undesirable, is another way to evaluate the success of the project. As native vegetation matures, it is generally expected to outcompete or prevent the establishment of undesirable species. So, following relatively high values for the first 2 years because of the presence of invasive species, the presence of undesirable species should be declining or at least not increasing rapidly by Year 5.

- Year 0 – Average total areal cover of invasive plants for all of the enhancement areas (Communities A, C, D, E, and G), based on line intercept and quadrat data, shall be between 0 and 15 percent, which is equivalent to between 0 to 1.1 acres.

- Year 1 – Average total areal cover of invasive plants for all of the enhancement areas (Communities A, C, D, E, and G), based on line intercept and quadrat data, shall be between 0 and 20 percent, which is equivalent to between about 0 and 1.4 acres.

- Year 5 – Total areal cover of invasive plants for all of the enhancement areas (Communities A, C, D, E, and G) based on line intercept and quadrat data, shall be less than or equal to 15 percent, which is equivalent to no more than about 1.1 acres.

Diversity

Species diversity is another measure of evaluating the ecological success of the project. The long-term goal for species diversity within the created habitats is to have comparable diversity to intact or reference areas in the vicinity. Many riparian plants may recolonize the site as a result of animal and wind dispersal of seeds. The diversity values provided are targets only and not criteria by which success or failure will be judged.

- Year 1 – At least 35 species of native shrubs and trees shall be present and abundant; species will be considered abundant if they occur in 50 to 60 percent of the quadrats.
- Year 2 – Between 35 and 45 species of native or naturalized non-native herbs, shrubs, and trees shall be present and abundant (as defined under Year 1).
- Year 5 – Between 40 and 50 species of native or naturalized non-native herbs, shrubs, and trees shall be present and abundant (as defined under Year 1).

Fish Habitat

Performance standards for the fish habitat created will be based on criteria set forth by Raleigh et al 1984 and Anonymous 1996) shown in Table A-8.

Table A-8 Criteria for rating fish habitat quality.

Parameter (source)	Habitat Quality Rating		
	Poor	Fair	Good
Spawning habitat			
Embeddedness (Anonymous 1996)	> 60 percent of sites with embeddedness > 30 percent	> 60 of sites with embeddedness < 30 percent	> 60 percent of sites with embeddedness < 5 percent
Rearing habitat			
Percentage pool area (Raleigh et al. 1984)	< 20 percent or > 70 percent	20 - 30 percent	30 - 70 percent
Pool depth and cover class (similar to Raleigh et al. 1984)	> 30 percent are < 7" deep and < 30 percent are LWD-formed	> 30 percent are > 7" deep and 30 - 60 percent are LWD-formed	> 60 percent are > 28" deep and > 60 percent are LWD-formed
Dominant substrate for food production (Raleigh et al. 1984)	Gravel-dominant and sand-subdominant or boulder-dominant	Gravel-dominant and cobble-subdominant or cobble-dominant and boulder-subdominant	Cobble-dominant and gravel-subdominant
LWD (Anonymous 1996)	< 1 pieces/channel width	1 - 2 pieces/ channel width	> 2 pieces/ channel width

Performance standards for the weirs will be based on the water levels in Swan Creek, in Channels A and B, and in the Haire Wetland.

CONTINGENCY MEASURES

If identified performance standards are not met at any time, the nonconformance will be identified and described in the monitoring report. In addition, recommended contingency measures or adaptive management actions will be developed by the Adaptive Management Team to increase the long-term probability that successful habitat restoration will be achieved. These recommended strategies will be communicated to the Adaptive Management Team for discussion and approval.

Plant Cover and Species Diversity

A number of factors could influence plant establishment and natural recolonization in the different vegetation zones and result in failure to meet plant cover and species diversity performance standards. Through the process of monitoring the restoration project, knowledge and understanding of site conditions affecting plant survival and growth should increase. As this body of knowledge increases, it may become clear that there are some potentially beneficial or adaptive management strategies or contingencies that may be employed to increase the probability of successfully meeting these standards or accelerating the successful restoration of aquatic habitats on site. These strategies could include some combination of the following actions:

- Control herbivory.
- Supplemental plantings.
- Substitute plants with higher survival rates for those with lower survival rates.
- Amend soil.
- Modify the performance standard or goal.

Invasive Species

Controlling the spread and cover of invasive plants is an important goal. Adaptive management actions that may need to be implemented to achieve effective control may include the following:

- Prevent the spread of invasive species through physical removal.

- Develop an integrated pest management plan to control them.
- Implement control methods.
- Modify the areal coverage goal.

CONCLUSIONS

Habitat restoration is an inexact science. Successful achievement of the restoration goals identified in this plan will require careful construction control and transplanting, vigilant monitoring, and thoughtful consideration of monitoring data in conjunction with project goals. Implementation of an adaptive management strategy is also expected. This strategy includes identification and implementation of contingency measures based on postconstruction monitoring. Using this process, a high probability of success for the proposed habitat restoration and enhancements is expected.

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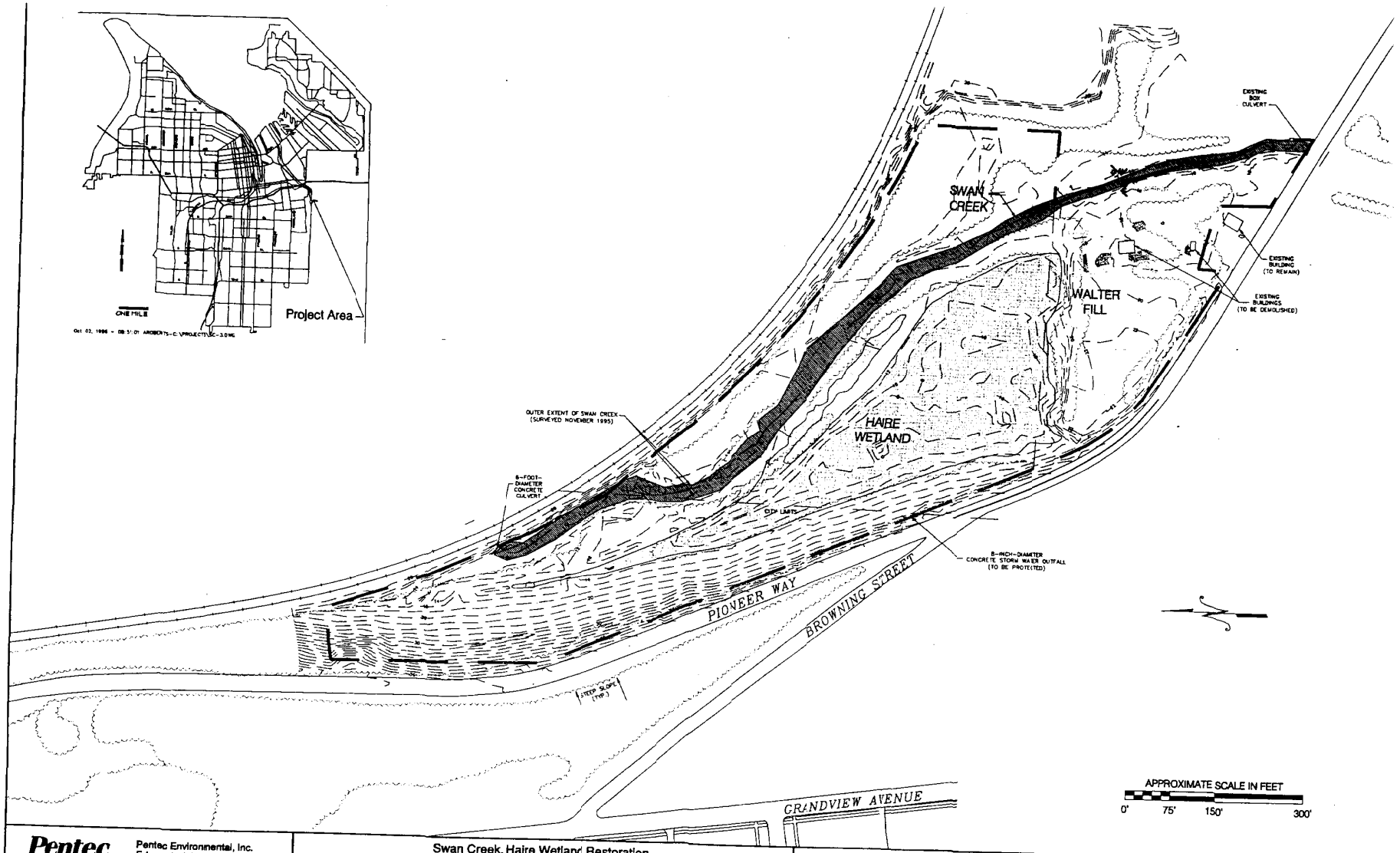

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Swan Creek, Haire Wetland Restoration
Tacoma, Washington
for City of Tacoma

Figure 2

Swan Creek existing conditions.

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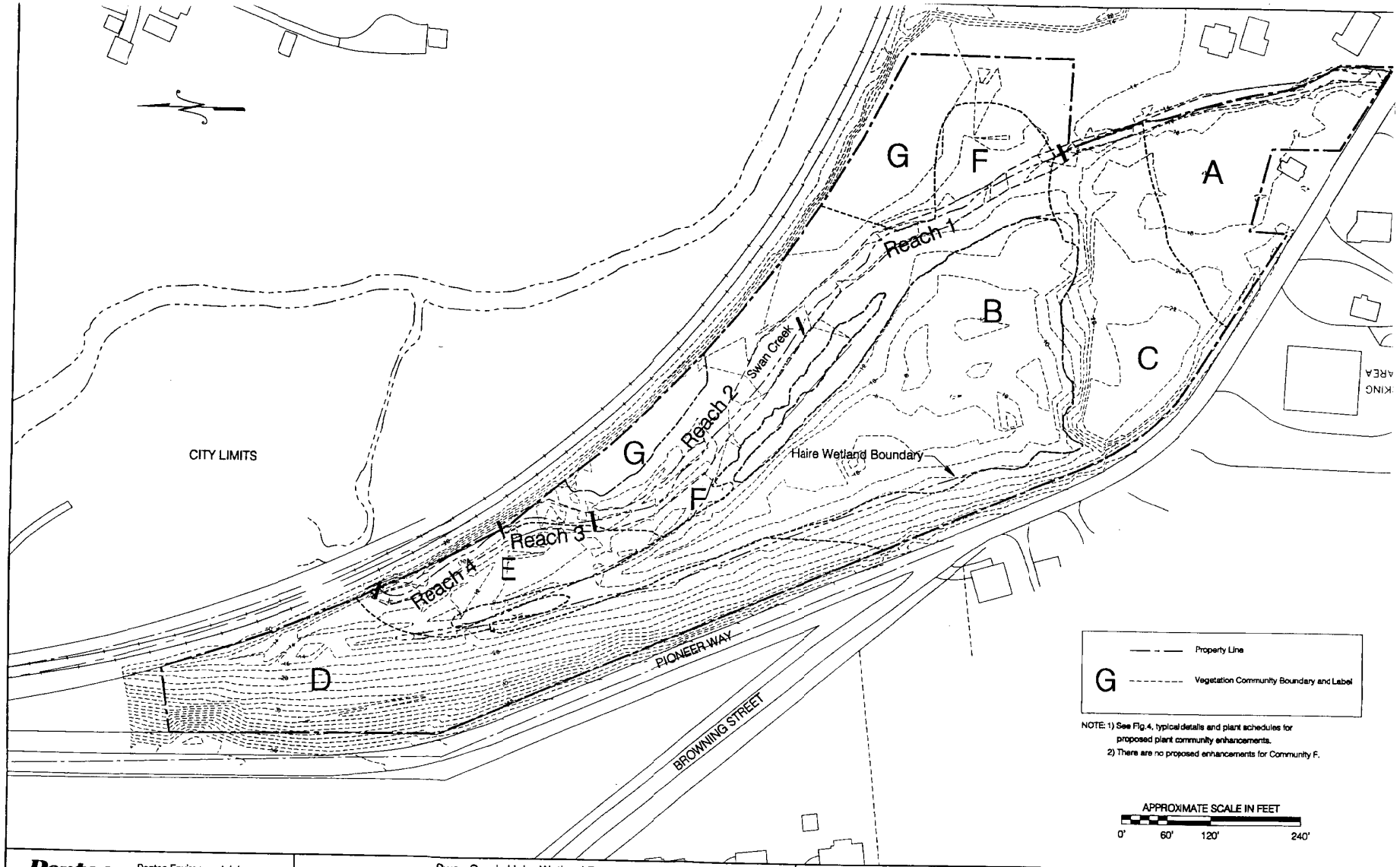

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Swan Creek Haire Wetland Restoration
Tacoma, Washington
for City of Tacoma

Figure 3
Existing plant communities and reach locations.

02/17/2000 fig_3.dwg

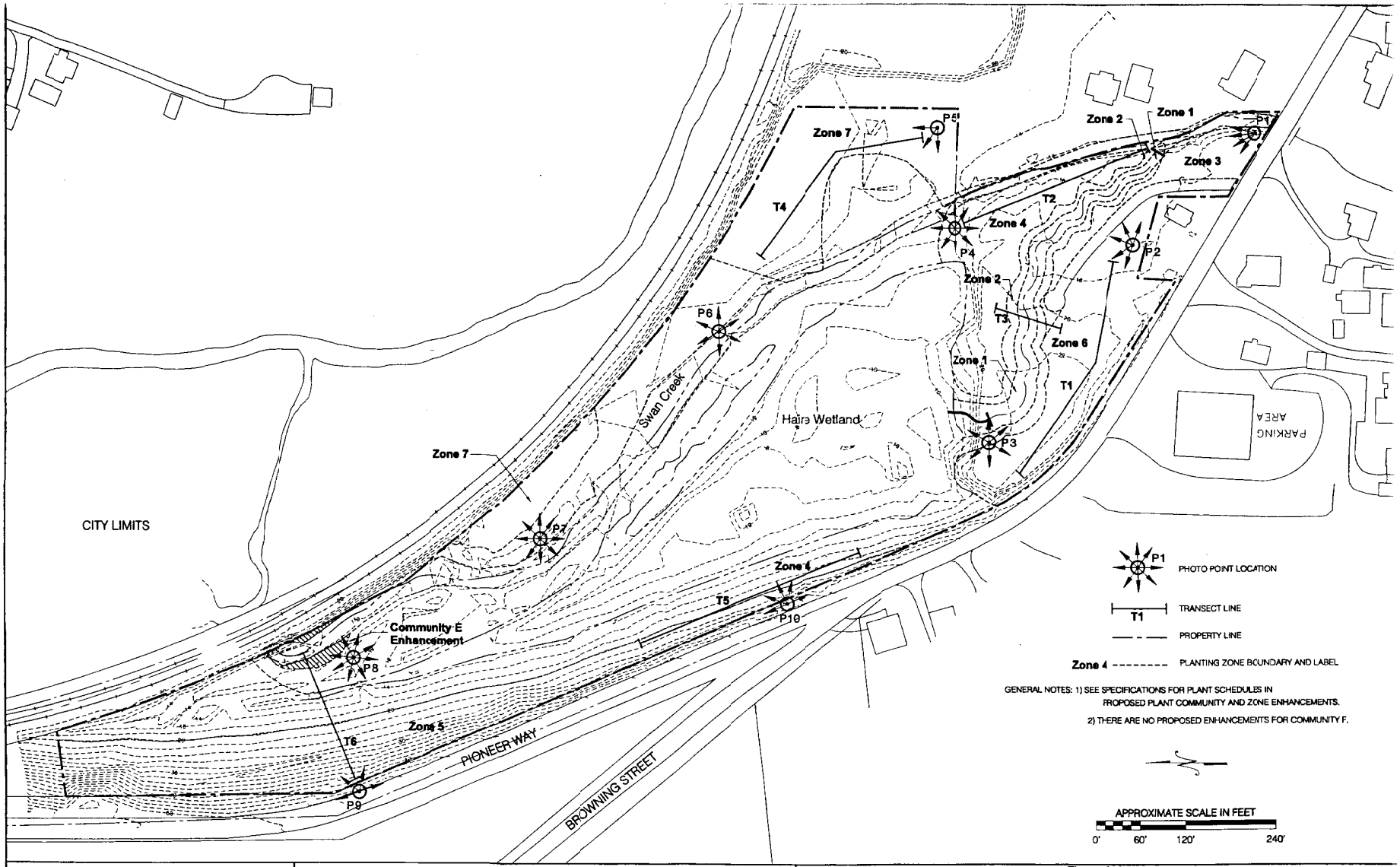

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Figure A-1
Proposed monitoring locations.

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