MIDDLE WATERWAY SHORE RESTORATION PROJECT MONITORING AND ADAPTIVE MANAGEMENT PLAN DATA REPORT

POST-CONSTRUCTION (YEAR 3)

Prepared for

SIMPSON TACOMA KRAFT COMPANY
P.O. Box 2133
Tacoma, Washington 98421

and

CHAMPION INTERNATIONAL
One Champion Plaza
Stamford, Connecticut 06921

Prepared by

PARAMETRIX, INC.
5808 Lake Washington Blvd. N.E.
Kirkland, Washington 98033

November 1998

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

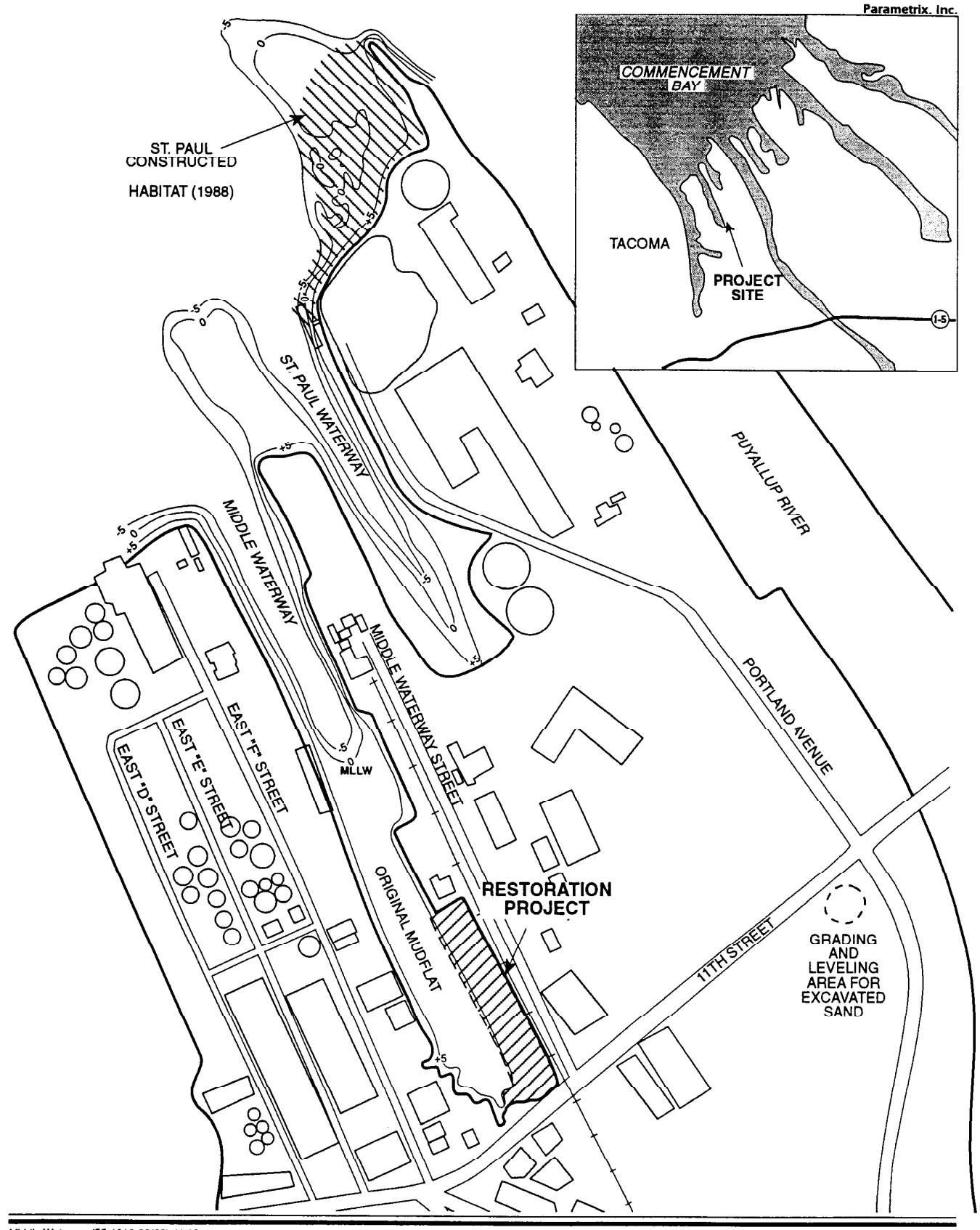
PROJECT DESCRIPTION

Under the St. Paul Waterway Natural Resource Damage (NRD) settlement agreement, Simpson Tacoma Kraft Company (Simpson) and Champion International Corporation (Champion) funded the completion of an additional restoration project to provide habitat value in Commencement Bay. The Middle Waterway Shore Restoration Project (the Project) is located on property owned by Simpson along the southeastern shore of the Middle Waterway in Commencement Bay. The project is located in close proximity, and functionally related to, the intertidal habitat constructed in 1988 as part of the St. Paul Waterway Area Remedial Action and Habitat Restoration Project conducted by Simpson and Champion at the north end of the Tacoma Kraft mill, as well as other intertidal and subtidal areas near the Puyallup River delta (Parametrix 1993) (Figure 1).

The Project was developed in cooperation with Champion and the Natural Resource Trustees for Commencement Bay (the Trustees), and other cooperating agencies. The Trustees include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish & Wildlife Service (USFWS), the Washington Department of Ecology (Ecology), the Muckleshoot Indian Tribe, and the Puyallup Tribe of Indians. Cooperating agencies include the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (the Corps), the Washington Department of Natural Resources (DNR), and the Washington Department of Fish and Wildlife (WDFW). Together, these organizations and agencies comprise the Restoration Project Planning Group.

The Project has dual goals of providing long-term environmental restoration and study value. The primary objective of the Project is to provide valuable estuarine habitat, in perpetuity, that is adjacent to one of the largest remaining areas of original Commencement Bay intertidal mud flat (nearly 20 acres) and functionally related to the intertidal habitat constructed at the north shore of the Tacoma Kraft Mill in 1988, the Puyallup delta, and other nearby intertidal and shallow subtidal habitats. Other environmental restoration objectives of the Project include the following:

- Conversion of approximately 1.5 upland acres from existing industrial use to estuarine intertidal wetland;
- Increase the length of natural shoreline along the +9 to +13 foot contour from 840 to 960 feet;
- Establish approximately 1.2 acres of habitat at known high and low salt marsh elevations;
- Provide a riparian buffer and transition zone between the tide flat and the upland area to screen, protect, and support the integrity of the remaining original Middle Waterway mud flat and the diverse species that use this biologically productive area of the estuary; and
- Restore a minimum of 0.23 acres of estuarine intertidal mud/sand habitat as mitigation for placing fill on a like acreage of intertidal mud/sand habitat at similar elevations.



Middle Waterway/55-1616-09(02) 11/96

SCALE IN FEET

0 300 600

N

Figure 1.
Vicinity Map,
Middle Waterway Shore Restoration,
Commencement Bay

Restoration at the Project site enhances and supports the continued existence of the remnant tide flats at the head of the Middle Waterway. The Natural Resource Trustees for Commencement Bay, together with Simpson and Champion, could not identify another location that would meet the Project's environmental restoration objective while also providing the additional benefit of protecting original Commencement Bay tide flats.

A detailed description of the Project and its objectives can be found in *Project Analysis: Middle Waterway Shore Restoration Project* (Parametrix 1993) and *Project Supplemental Information Summary: Middle Waterway Shore Restoration Project* (Parametrix 1994a). The following provides an overview of the objectives and methodology used to monitor the Project and a summary of the 1998 monitoring data.

PROJECT MONITORING

The Middle Waterway Shore Restoration Project consists of an approximately 3.3-acre nearshore site in Commencement Bay that is in the process of being restored to functional estuarine habitat. In early 1995, approximately 1.5 acres of an industrial fill area was converted into estuarine wetland. In addition, the adjacent lower intertidal area was re-graded into a more structurally diverse intertidal area. The site presently comprises a low-elevation mud flat, low salt marsh, high salt marsh, and upland riparian buffer. On October 21, 1995, the riparian buffer was planted with upland vegetation and a small area of low salt marsh was planted with "sods"[1] of saltgrass (*Distichlis spicata*). On October 16 and 23, 1995, groundcover and trees were planted. On May 22, 1996, additional areas were planted with a variety of high and low salt marsh vegetation. Post-construction site monitoring began in April 1996.

Several descriptive and experimental studies were proposed as elements of the monitoring plan to collect data that would help determine the success and health of the restoration site over time and assist in developing future restoration projects in Commencement Bay. The Project monitoring program includes the following descriptive studies:

- Document the general development of estuarine habitat on the project site [through aerial photographs (through Year 5) and photogrammetric elevation mapping (when necessary)];
- Document the general development of new intertidal and salt marsh substrates [through grain size analyses (through Year 5)];
- Document trends in sediment chemistry, including potential contaminant transport from adjacent mud flats [through sediment chemistry analyses (Years 0, 1, 3, and 5)];
- Document trends in benthic infauna that correspond to changes in sediment grain size and chemistry [through sediment analyses (Years 1, 3, and 5) and benthic analysis in Year 5];

[1] Sods refer to clumps of vegetation with the root mass surrounded by attached soil.

- Evaluate predictions about elevations and salt marsh establishment, using vegetation established on-site [through vegetation analyses (Years 0, 1, 2, and 3) and periodic measurement of elevations (when necessary)]; and
- Document the general use of intertidal, salt marsh, and riparian habitats by wildlife [through general qualitative observations (periodically, through volunteer effort)].

A schedule of annual monitoring activities is provided in Table 1. As originally envisioned in the *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan* (the Monitoring Plan) (Parametrix 1994b), site construction and vegetation planting were to have been completed in early 1995, followed immediately by Year 0 monitoring for physical and soil characteristics. Vegetation and sediment chemistry monitoring was to begin the second year after construction. Because nearly a year elapsed between the site construction in 1995 and the final vegetation planting efforts in 1996, the first year of post-construction monitoring combined some Year 0 and Year 1 activities. That report was referred to as Year 0-1, in the *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan Data Report—Post-Construction (Year 0-1)* (the 1996 Data Report) (Parametrix 1996). In 1997 (Year 2), the site was monitored and results were presented in *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan Data Report—Post-Construction – Year 2* (Parametrix 1997a). This report summarizes findings from the third full year of monitoring in 1998. This report is referred to as Year 3.

Table 1. Middle Waterway Shore Restoration post-construction monitoring schedule.

Activity	Frequency	Activities Conducted 1996 (Year 0-1)	1997 (Year 2)	1998 (Year 3)
Physical Surveys				
Transects	Annually (years 0-1 and 2)		X	
Topographic Mapping	Years 0-1 and 2 (only if necessary thereafter)	X	X	
Sediment Surveys				
Grain Size	Annually (years 0-1, 3, and 5)	X		X
Biological	Annually (year 5)			
Chemical	Annually (years 0-1, 3, and 5)	X		X
Vegetation Surveys				
Transplant/Colonization	Semi-annually (year 0-1), annually (years 2 and 3)	X	X	X
Plant Protection	Semi-annually (year 0-1); (as needed thereafter)	X	X	X
Soil Salinity	Annually (years 0-1, 3, and 5)	X		X
Wildlife Surveys	Periodically per volunteer effort	X	X	X
Aerial Photo	Annually (years 0-1, 2, 3, 4, 5)	X	X	X

Year 0-1 = period of construction, planting, and first annual surveys

This data report contains the sampling methods, data, analytical results, and other related information collected during the third year of post-construction monitoring. In keeping with the Project understanding between Simpson, Champion, and the Trustees, limited data interpretation

was provided, other than discussions of how sampling methods may have affected or influenced the data. Copies of field survey data forms and analytical data can be found in the Data Appendix. Monitoring Plan revisions previously discussed and approved by representatives from Champion, Simpson, and the Trustees in 1997 are specified in a memorandum that can also be found in the Data Appendix.

The two primary survey elements comprising the third year of monitoring included physical and chemical characterization of sediments, and vegetation surveys of species and substrates present in planted and unplanted areas. Wildlife observations were reported separately by an independent observer.

METHODS AND RESULTS

SEDIMENT MONITORING

Surface sediments were last monitored in 1996. In 1998 sediments were collected from the Site for chemical analysis, grain size distribution, and total organic carbon. Sediment sampling was conducted in August 1998. All samples were analyzed by AmTest, in Redmond Washington.

Sediment Physical Characteristics

Surface sediments on the restored habitat were monitored to assess physical characteristics (i.e., grain size). Sampling methods and analyses adhered to the methods specified in the original monitoring plan (Parametrix 1994b). In 1997 Champion, Simpson and the trustees agreed to minor changes to the sampling locations for collection of sediments to be analyzed for grain size distribution (Parametrix 1997b). In 1998, sediment samples to be analyzed for grain size distribution were collected from 15 locations. Five stations (i.e., GS-3[2], GS-4, GS-9, GS-11 and GS-15) previously sampled were eliminated from the 1998 sampling event. Samples for grain size distribution were also collected at the sediment chemistry sampling locations. Figure 2 presents the grain size sample locations monitored in 1998.

Grain size samples were collected on August 25, 1998 at fifteen stations (Figure 2). Station coordinates are provided in Table 2. A field duplicate sample was collected at station MW-1. Station locations were based on locations indicated in the monitoring plan (Parametrix 1994b). Surveyors located these areas and placed stakes at the 15 sample locations.

Table 2. State plane coordinates and evaluations (ft MLLW) for 1998 Middle Waterway Shore Restoration sediment sampling stations.

Station	North	East	Elevation [a]	Descriptor
GS-1	707091.2	1521953.9	14.9	Sediment-Grain Size #1
GS-2	707125.5	1521909.3	11.6	Sediment-Grain Size #2
GS-5	707240.7	1521810.2	11.1	Sediment-Grain Size #5
GS-6	707279.4	1521838.6	12.4	Sediment-Grain Size #6
GS-7	707330.2	1521851.0	14.2	Sediment-Grain Size #7
GS-8	707345.9	1521806.6	12.3	Sediment-Grain Size #8
GS-10	707418.1	1521742.1	11.1	Sediment-Grain Size #10
GS-12	707561.1	1521676.1	9.8	Sediment-Grain Size #12
GS-13	707668.2	1521655.3	12.2	Sediment-Grain Size #13
GS-14	707767.9	1521642.7	10.3	Sediment-Grain Size #14
GS-15	707792.5	1521600.4	12.8	Sediment-Grain Size #15
HC-2	707120.0	1521797.0	7.1	Sediment-Chemistry
C	707198.8	1521891.3	10.0	Sediment-Chemistry
A	707432.5	1521715.0	8.6	Sediment-Chemistry
F	707315.0	1521733.0	10.1	Sediment-Chemistry
MW-1	707652.0	1521609.0	9.4	Sediment-Chemistry

[a] City of Tacoma datum

[2] Location GS-3 is the same as sediment chemistry sample location C.

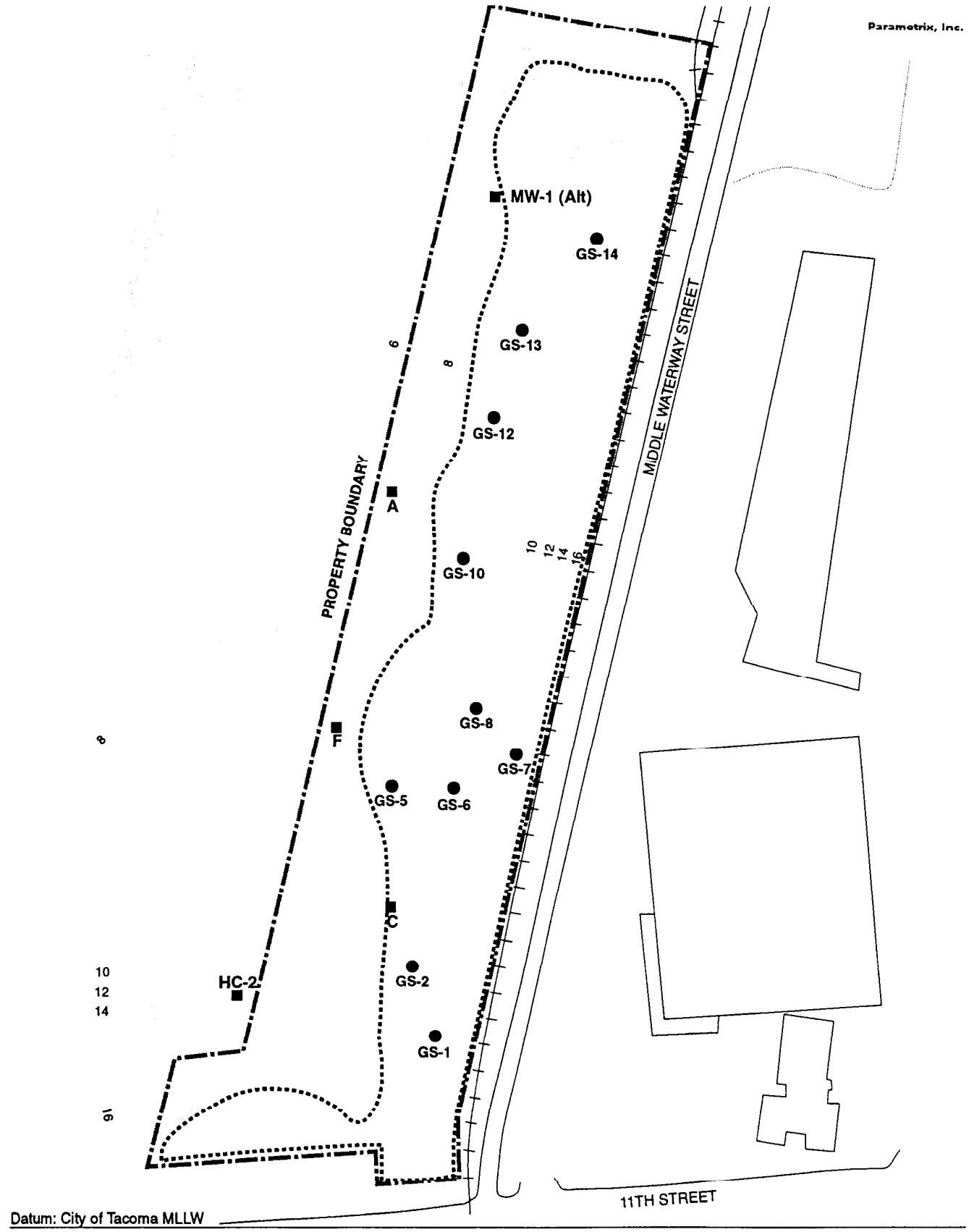


Figure 2. Sediment Sampling Locations

All sediment samples were collected by hand, using pre-cleaned stainless steel spoons, from the upper 2 cm of the sediment. In years when benthic infauna are collected (i.e., years 0 and 5), a sediment core of the upper 5 cm is collected for grain size to characterize the biologically active zone. This year, only shallow (0-2 cm) surface sediments were examined to evaluate if post-construction sedimentation had taken place.

Sediments collected for grain size distribution analysis (approximately 200 ml) were placed in clean ziplock plastic bags, labeled, and stored on ice in a cooler. Sediment samples were transported to the analytical laboratory (i.e., AmTest, Inc., Redmond, WA) for analysis.

Laboratory analysis followed the Puget Sound Estuarine Program (PSEP) protocols and were analyzed within the PSEP-specified holding time. A copy of the complete laboratory data package, including quality assurance/quality control (QA/QC) procedures can be found in the Data Appendix. As an additional data validation measure, Relative Percent Difference (RPD) was calculated for all particle sizes (i.e., Wentworth scale in phi units) for the sample, the laboratory duplicate, and the laboratory replicate analyses at stations MW-A and GS-10. All RPD results were within an acceptable range of ± 20% (see Data Appendix). Results of the sediment grain size analysis are summarized in Table 3.

In general, sediment grain size distribution at all stations was relatively similar, and dominated by sand (i.e., coarser than phi size +4). Sediments from stations C, MW-1, GS-1, GS-2, GS-5, GS-6, GS-7, GS-8, GS-12, and GS-13 contained greater than 80% sand. These stations were located primarily in the high to mid-intertidal areas (i.e., between 8 - 16 feet). Sediments containing the greatest silt fraction (69.4%) were collected from station HC-2, located in the mud flat area and at one of the lowest elevations (i.e., between 8 - 10 feet) at the site. Sediments from stations F and A also had relatively high (> 40%) silt fractions, these sites were also located in the mud flat areas in low elevation areas (i.e., between 8 - 12 feet). The dominance of coarse sand or fine silt/clay substrates in the grain size data corresponded to site observations and vegetation substrate data.

Sediment Chemical Characteristics

Sediment samples were collected to monitor chemical concentrations in project site sediments. Sediment samples were analyzed for mercury, semi-volatile organic compounds (low- and high-density polynuclear aromatic hydrocarbons [PAHs]), and conventional parameters (i.e., total solids, total volatile solids, acid volatile sulfide, and total organic carbon). Sampling methods and analyses adhered to the methods specified in the monitoring plan (Parametrix 1994b).

Table 3. Sediment grain size distribution for Middle Waterway Shore Restoration Project, 1998.

Upper (mm)	Mesh Size	4.75	4.00	2.00	1.00	0.50	0.25	0.125	0.063	0.032	0.016	0.008	0.004	0.002	0.001		%Sand/	%Silt/	%Total
Lower (mm)	Mesh Size	4.00	2.00	1.00	0.50	0.25	0.125	0.063	0.032	0.016	0.008	0.004	0.002	0.001	<0.001	<0.001	Gravel	Clay	Solids
Finer than Phi			-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	>+10			
Location[1]	Relative Percent Sediment Present in Each Mesh Size																		
A[2]		2.40	0.30	0.70	2.40	15.8	19.1	13.9	3.50	7.70	13.6	6.50	4.80	1.80	0.90	6.60	54.6	45.4	57.7
C[2]		1.20	0.30	0.30	1.60	26.4	37.1	17.2	6.30	0.90	1.30	1.60	1.60	0.20	<0.1	4.00	84.1	16.0	75.7
F[2]		1.30	0.30	1.60	2.90	15.7	24.6	11.7	19.9	9.70	1.50	2.90	2.10	0.20	<0.1	5.70	58.1	42.1	70.0
MW-1[2]		2.20	0.90	1.90	4.20	21.1	24.9	20.6	11.6	0.90	2.80	0.90	3.10	0.50	<0.1	4.50	87.4	12.8	67.4
MW-1(D)[2]		2.20	0.60	1.70	3.60	15.8	29.0	18.9	10.10	7.60	0.50	2.40	2.30	0.30	<0.1	4.90	81.9	18.1	72.0
HC-2[2]		2.80	0.50	1.40	2.10	3.90	6.70	6.70	6.90	29.9	12.0	7.9	6.8	1.2	<0.1	11.5	31.0	69.4	43.5
GS-1		1.70	<0.1	2.20	4.30	26.2	42.8	12.8	4.40	1.70	1.80	0.10	0.40	0.10	<0.1	1.50	94.5	5.7	100.0
GS-2		<0.1	0.10	0.20	1.30	13.3	40.4	24.9	9.10	3.90	1.70	0.20	1.00	0.20	<0.1	3.60	89.4	10.7	82.7
GS-5		1.80	0.20	1.20	3.20	25.1	30.3	16.6	8.40	5.30	2.30	0.50	1.10	0.20	<0.1	3.70	86.8	13.2	81.2
GS-6		1.00	0.10	1.50	4.40	26.5	34.2	14.2	5.00	5.30	<0.1	<0.1	0.90	0.20	<0.1	6.80	86.9	13.5	88.8
GS-7		1.00	<0.1	2.20	7.80	34.3	38.4	10.1	2.70	1.40	<0.1	<0.1	0.40	0.10	<0.1	1.50	96.7	3.7	99.6
GS-8		1.20	0.40	1.70	3.80	23.9	29.3	17.2	8.30	4.70	1.10	1.90	1.00	0.50	0.30	4.70	85.8	14.2	83.2
GS-10		3.60	<0.1	1.40	2.80	12.6	23.3	12.7	9.10	19.8	2.90	2.80	3.40	1.00	0.30	4.20	65.6	34.4	69
GS-12		0.90	0.10	0.60	1.60	8.60	23.3	31.1	15.6	2.90	4.80	2.60	2.40	0.80	0.40	4.2	81.1	18.1	68.6
GS-13		<0.1	0.10	0.40	1.70	13.9	34.9	27.4	10.3	4.30	1.50	0.80	1.00	0.20	<0.1	3.40	88.8	11.3	89.0
GS-14		0.60	0.10	0.60	2.70	25.3	28.0	14.9	5.50	10.6	3.70	1.60	1.80	0.20	<0.1	4.50	77.7	22.5	67.2

D - Duplicate Sample

[1] Sample locations GS-3, GS-4, GS-9, GS-11, and GS-15 were discontinued in 1997 (Parametrix 1997)

[2] These samples correlate with sediment chemistry sample locations.

Sediment samples for chemical analysis were collected on August 25, 1998, at five stations (Figure 2). These stations correspond to the benthic infauna stations that will be monitored in year 5 (year 2000). A field duplicate sample was collected from station MW-1. Samples were collected from the upper 2 cm of sediment using a decontaminated stainless steel spoon, and placed either directly into a laboratory container (for acid-volatile sulfide (AVS) analysis) or into a decontaminated stainless steel mixing bowl (for all other analyses). Sediment samples placed in mixing bowls were completely homogenized prior to transfer into laboratory containers. All containers were stored on ice in a cooler.

Sediment chemistry samples were transported, along with a chain-of-custody form, and delivered to the analytical laboratory (AmTest, Inc., Redmond, WA). Sediment samples were analyzed for the compounds listed in Table 4, using analytical methods specified in the monitoring plan (Parametrix 1994b). For comparison, sediment chemistry results from the 1993 pre-construction and 1996 post construction monitoring are included (Parametrix 1994b). The pre-construction chemistry results were taken from two reports (Parametrix 1994c, d). Pre-construction chemistry data for Station F that was incorrectly entered in Parametrix 1994d has been corrected for Table 4. The post construction data were taken from Parametrix (1997a). Following monitoring plan protocols, sediment chemistry results are presented with Washington Sediment Quality Standards (SQS) for comparison. Following Washington Department of Ecology guidelines, all sediments with greater than 0.5% organic carbon content were organic carbon normalized (organic carbon content of all sediments was greater than 0.5%).

Sediment mercury concentrations ranged from 0.076 mg/kg (dry wt.) at station C to 0.417 mg/kg (dry wt) at station MW-1. In general, 1998 sediment mercury concentrations were similar to those found in 1996. Duplicate sediment samples were collected at MW-1, where mercury in one sample was 0.207 mg/kg (dry wt.), below the mercury SQS of 0.41 mg/kg, and 0.41 mg/kg in the second sample. Sample location MW-1 is located in the Middle Waterway mudflats outside of the Project boundary where physical restoration activities were implemented and near the Site property boundary. Sediment mercury levels in all of the other sediment samples were below the mercury SQS, and of similar magnitude to concentrations found in 1996.

Concentrations of organic chemicals in all sediment samples were well below their corresponding SQS values. Concentrations of total low molecular weight polycyclic aromatic hydrocarbons (LPAH) were low at all stations and ranged from 5.0 mg/kg organic carbon (OC) at station MW-1 (duplicate) to 29.17 mg/kg OC at station C, 12 to 75 times below the LPAH SQS. A number of individual LPAHs were not detected above their respective detection limits at some or all sampling locations. In 1998 sediment LPAHs concentrations at stations MW-1, A, and HC-2 were lower than levels identified in 1996, and at stations C and F sediment LPAH levels in 1998 were similar to those found in 1996.

Table 4. Sediment chemistry results for Middle Waterway Shore Restoration Project, 1998.

Chemical	SQS*	Pre-Construction – 1993					Post-Construction – 1996					Post-Construction - 1998					
		MW-1 (a)**	A***	HC-2**	C***	F**	MW-1 (a)	A	HC-2	C	F	MW-1 (a)	MW-1 (dup)	A	HC-2	C	F
Metals (mg/kg dry wt)																	
Mercury	0.41	0.31	0.49	1.18	0.04	0.59	0.198	0.175	0.352 U	0.031	0.129	0.417	0.207	0260	0.359	0.076	0.160
Organics (mg/kg OC)																	
LPAH																	
Acenaphthylene	66	0.6	3.4	2.3	7.5[d] U	3.0	2.5 U	0.8 U	1.4	4.9 U	0.5 U	0.91 U	0.57 U	0.42 U	0.8	3.2 U	0.67
Acenaphthene	16	0.5 U	2.6	8.3	7.5[d] U	2.9	2.5 U	0.8 U	1.3	4.9 U	0.6	0.91 U	0.57 U	0.42 U	0.8	3.2 U	0.64 U
Anthracene	220	1.0	5.4	11.4	7.5[d] U	5.8	2.5 U	1.6	7.8	4.9 U	1.3	0.91 U	0.57 U	1.3	4.4	3.2 U	1.8
Fluorene	23	0.6	4.0	6.1	7.5[d] U	3.9	2.5 U	0.8	2.4	4.9 U	0.7	0.91 U	0.57 U	0.42 U	1.0	3.2 U	0.64 U
Naphthalene	99	1.2	7.7	3.6	7.5[d] U	10.0	2.5 U	0.8 U	2.4	4.9 U	0.7	0.91 U	0.57 U	0.42 U	0.7	3.2 U	0.64
Phenanthrene	100	5.3	23.0	97.1 D	7.5[d] U	20.0	4.5	6.5	17.3	4.9 U	6.7	2.09	1.57	4.4	100	10.2	7.6
2-Methylnaphthalene	38	0.5 U	2.8	2.0	8.8[d] U	3.6	2.5 U	0.8 U	1.2 U	4.9 U	0.5 U	0.91 U	0.57 U	0.42 U	0.5	3.2 U	0.63 U
Total LPAH's	370	9.8	48.9	130.8	53.8[d] U	49.2	19.4	12.1	33.7	34.1	10.9	7.6	5.0	7.7	183	29.2	12.6
HPAH																	
Benzo(a)anthracene	110	5.3	26.0	43.7 D	7.5[d] U	20.0	6.5	7.7	17.8	4.9 U	6.9	2.3	2.1	8.4	115	11.2	9.7
Benzo(a)pyrene	99	5.3	34.0	43.7 D	17[d]	29.0	8.2	8.7	18.2	4.9 U	8.6	2.9	2.7	8.4	117	10.3	11.2
Benzo(b)fluoranthene	--	4.4	43.0	29.1 D	23[d]	39.0 D	10.6	10.3	15.6	4.9 U	8.3	3.0	2.8	10.7	119	9.0	11.5
Benzo(k)fluoranthene	--	8.9	14.0	19.4	7.5[d] U	11.0	8.6	8.1	15.8	4.9 U	6.9	2.1	2.0	8.5	8.3	8.2	7.3
Total Benzofluoantenes	230	13.3	57.0	48.5	30.5[d]	50.0	19.2	18.4	31.5	9.7 U	15.3	5.1	4.8	19.3	202	34.3	18.8
Benzo(g,h,i)perylene	31	2.8	22.0	9.7	27[d]	14.0	6.4	5.5	9.5	4.9 U	5.8	1.5	1.7	4.7	7.2	11.0	6.7
Chrysene	110	8.0	26.0	58.3 D	11[d]	23.0	12.7	11.6	25.5	4.9 U	9.4	3.1	3.4	13.3	178	29.0	13.0
Dibenzo(a,h)anthracene	12	1.1	4.9	4.6	7.5[d] U	3.0	2.5 U	0.8 U	1.2 U	4.9 U	0.5 U	0.91 U	0.57 U	1.4	2.4	3.2 U	2.3
Fluoranthene	160	11.6	26.0	77.7 D	13[d]	22.0	11.7	14.2	32.7	6.2	10.8	4.5	3.7	11.8	185	18.3	14.5
Indeno(1,2,3,-c,d)pyrene	34	3.0	23.0	10.4	21[d]	15.0	6.2	5.8	1.2 U	4.9 U	5.8	2.2	2.0	6.2	8.2	6.8	8.5
Pyrene	,000	7.6	34.0	116.5 D	17[d]	48.0 D	10.3	13.5	32.7	7.2	10.0	4.5	4.0	12.2	185	20.0	16.4
Total HPAH's	960	57.9	252.9	413.1	151.5[d]	224.0	83.6	86.3	170.2	52.3	73.3	27.1	25.0	85.5	115.9	107.0	101.1
Conventionals																	
Total solids (%)	--	66.59	55.7	39.17	82.6	57.4	77.8	59	45.5	76.9	81.5	67.4	72.0	57.7	435	75.7	70.0
Total volatile solids (%)	--	--	11.5	--	1.40	13.4	1.9	5.4	12.1	1.3	3.6	3.3	2.7	6.7	14	2.8	6.2
Total organic carbon (%)	--	2.25	3.5	4.12	0.24 d	3.3	0.77	3.1	5.5	0.39 D	3.6	2.2	3.5	5.0	5.4	0.6	3.3
Acid volatile sulfides (mg/kg)	--	348	--	2.33 U	--	--	90 b, j	5,500 b,j	1,300 b,j	780 b, j	100 b,j	81	290	210	290	210	12 U

Data qualifiers:
-- = No Data
D = Dilution required.
U = Value below stated detection limit.
b = The associated value was detected in the method blank analysis, possible blank contamination.
d = Per Ecology guidelines, samples with <0.5%OC should not be compared to organic carbon-based criteria.
j = The associated value is an estimate.

Notes:
mg/kg OC = Mg/kg of Organic Carbon
* = Washington Sediment Quality Standard
** = Data from Parametrix 1994c
*** = Data corrected from Parametrix 1994d

Sediment concentrations of total high molecular weight polycyclic aromatic hydrocarbons (HPAH) were also low and ranged from 25.0 mg/kg OC at MW-1 (duplicate) to 115.9 mg/kg at HC-2, or 8 to 38 time below the HPAH SQS. With the exception of dibenzo(a,h)anthracene, all of the individual HPAHs evaluated were detected in all sediment samples. In 1998 sediment HPAH concentrations at stations MW-1 and HC-2 were lower than levels identified in 1996, and HPAH concentrations at stations C and F were higher than 1996 levels. At station A, 1998 HPAH concentrations were similar to those found in 1996.

Total sediment organic carbon content (TOC) levels in 1998 were similar to those identified in both 1993 and 1996. The highest TOC levels continue to be found at station A, while the lowest levels are found at station C. These data suggest that the restoration efforts have not resulted in a significant increase in the production of organic matter (e.g., through plant productivity, or sedimentation of fine grained materials).

Concentrations of acid volatile sulfides (AVS) were lower in 1998 than in 1996. It should be noted, however, that problems were encountered with the AVS analyses in 1996, and these data may have been biased high due to possible blank contamination.

Validation of laboratory data was conducted according to EPA functional guidelines for evaluating organics and inorganics (U.S. EPA 1994a, b). Because the data were reported in the laboratory standard reporting format, the following items were included in the data review performed:

- holding times
- blanks
- surrogate recovery
- internal standards recoveries
- matrix spike and matrix spike duplicate
- system performance and overall data assessment
- standard reference sample
- laboratory duplicate analysis

Some of these categories are only applicable to select analyses.

All summary tables generated from the laboratory data were checked for transcription errors. Copies of raw data, data validation checklists, and a data validation summary memorandum are provided in the Data Appendix.

Briefly, all laboratory and field quality assurance (QA) and quality control (QC) results associated with these sediment samples were within acceptable ranges.

VEGETATION SAMPLING

The Middle Waterway Shore Restoration site was planted with high and low salt marsh vegetation on May 22, 1996. Vegetation monitoring was designed and conducted to assess the post-construction presence, species composition, and distribution of planted and colonizing vegetation. As part of the Project Monitoring Program, both vascular (e.g., salt marsh plants) and non-vascular (e.g., seaweeds) macrophytes were surveyed. An aerial photograph was used to delineate plants on a site-wide basis for mapping.

Aerial Photo Mapping

An aerial photo of the Middle Waterway has been taken in July of 1996, 1997, and 1998. In 1998, the photograph was taken on August 9. As in previous years, photographic conditions were good, so the aerial photo provides clear images of the waterway, including upland buildings, the re-constructed shore, salt marsh and mudflat areas, vegetation, transplant enclosures, logs and debris. The aerial photo can be used in conjunction with the vegetation monitoring report to evaluate the extent of intertidal vegetation at the Project site and to identify any processes within the waterway that may be affecting the Project site.

Vegetation Sampling

In 1996, the low salt marsh, high salt marsh, and mud flat areas of the site were divided into nine beds (Parametrix 1996). Selected beds in the high and low salt marsh areas were planted. Planted beds were associated with unplanted beds with similar elevation and substrate (planted, high marsh Beds 1,2 paired with unplanted Bed 3; planted, low marsh Beds 4,5 paired with Bed 6). Most planted beds were enclosed with string and flagging to exclude geese; one low salt marsh bed in the north was planted without an enclosure (Bed 4). Low and high mudflat areas (Beds 7-9) were not planted, and Beds 8 and 9 were top-dressed with salvaged soils that, it was hoped, would promote recruitment of vegetation.

Fourteen transects were established through the site. The ends of each transect were semi-permanently marked with rebar (Figure 3) and eighty random locations were selected along the transects. On September 9, 1988, transect endpoints were relocated and percent cover by individual species in 1-m^2 quadrats was visually estimated at the original eighty locations. Copies of vegetation monitoring data field sheets can be found in the Data Appendix.

As in 1996 and 1997, most of the low and high salt marsh communities lacked vegetation or had extremely low cover by vascular plants (Figure 4, Table 5). High salt marsh bed number 1, along Transect 1, was devoid of vegetation except for a few scattered recruits of *Atriplex patula* (salt weed) and exposed root masses of *Distichlis spicata* (saltgrass; remains from sods planted in 1996). This bed, a sandy berm in the northwest section of the site, had been planted with Carex lynbgyei and protected from predation by geese. In high-marsh Bed 2, along Transect 2, *Deschampsia caespitosa* is surviving and growing but has not completely filled in the area.

Table 5. Vegetation species, percent cover, and dominant substrate characteristics by transect, 1998.

Transect # (Bed #)	Endpoints	Species	% Cover (Range)[1]	Dominant Substrate (>50%)[2]
1 (1)	A, A1	*Atriplex patula*	0-7	sand, mud
		Distichlis spicata	0-2	
2 (2)	B, B1	*Atriplex patula*	0-25	Sand
		Deschampsia caespitosa	0-15	
		Distichlis spicata	0-5	
3 (3)	C, C1	No vegetation	--	Sand
4 (2,3)	D, D1	No vegetation	--	Sand
5 (4,5)	E, E1	Diatoms	0-100	Mud
		Vaucheria sp.	0-100	
		Eleocharis parvula	0-15	
6 (4)	F, F1	*Vaucheria* sp.	0-40	Mud
7 (5)	G, G1	*Distichlis spicata*	0-12	sand
		Atriplex patula	0-25	
8 (6)	H, H1	*Vaucheria* sp.	0-50	Mud
		Eleocharis parvula	trace	
9 (6)	I, I1	*Vaucheria* sp.	0-20	sand, mud
10 (2)	J, J1	*Deschampsia caespitosa*	0-65	sand
		Fragaria chiloensis	0-4	
		Distichlis spicata	0-15	
		Agrostis sp.	0-10	
		Agropyron repens	0-10	
		Bromus sp.	0-10	
		Atriplex patula	0-1	
		Scotch broom	0-45	
11 (7, 6)	K, K1	*Vaucheria sp.*	1-100	Mud
		Rhizoclonium sp.	0-100	
12 (7)	L, L1	*Vaucheria sp.*	0-40	mud, small pools
		Rhizoclonium sp.	0-65	
13 (8,9)	M, M1	Diatoms	0-100	Mud
		Rhizoclonium	0-100	
		Vaucheria sp.	0-1	
		Eleocharis parvula	0-75	
14 (9)	N, N1	*Vaucheria* sp.	0-95	sand, silt, cobble
		Rhizoclonium	0-10	
		Enteromorpha flexuosa	trace	

[1] Cover estimates comprise live plants; dead plants were included as litter under the substrate heading.
[2] Underlined substrate is dominant; other substrates were present.

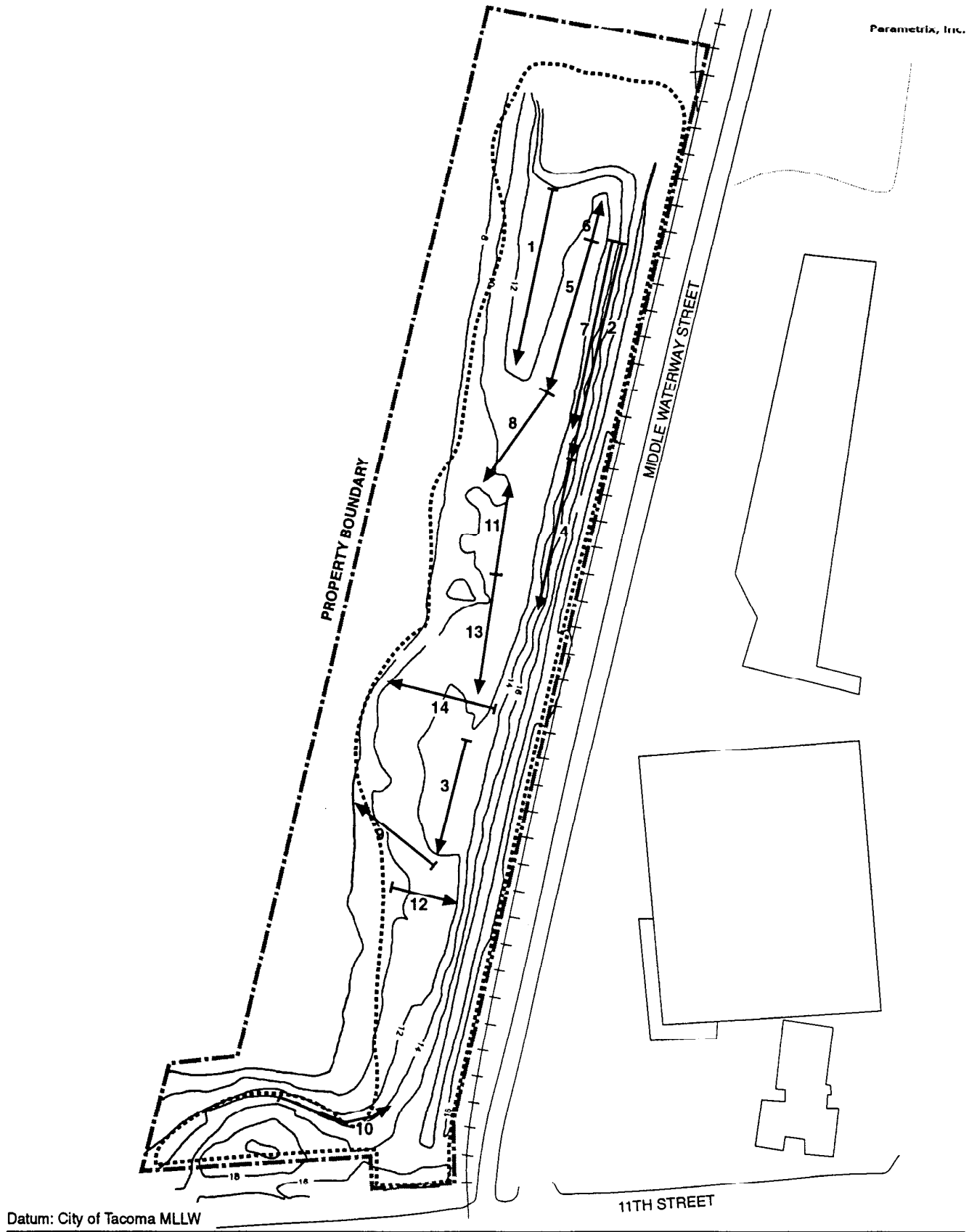


Figure 3.
Vegetation Monitoring Transects and Directions

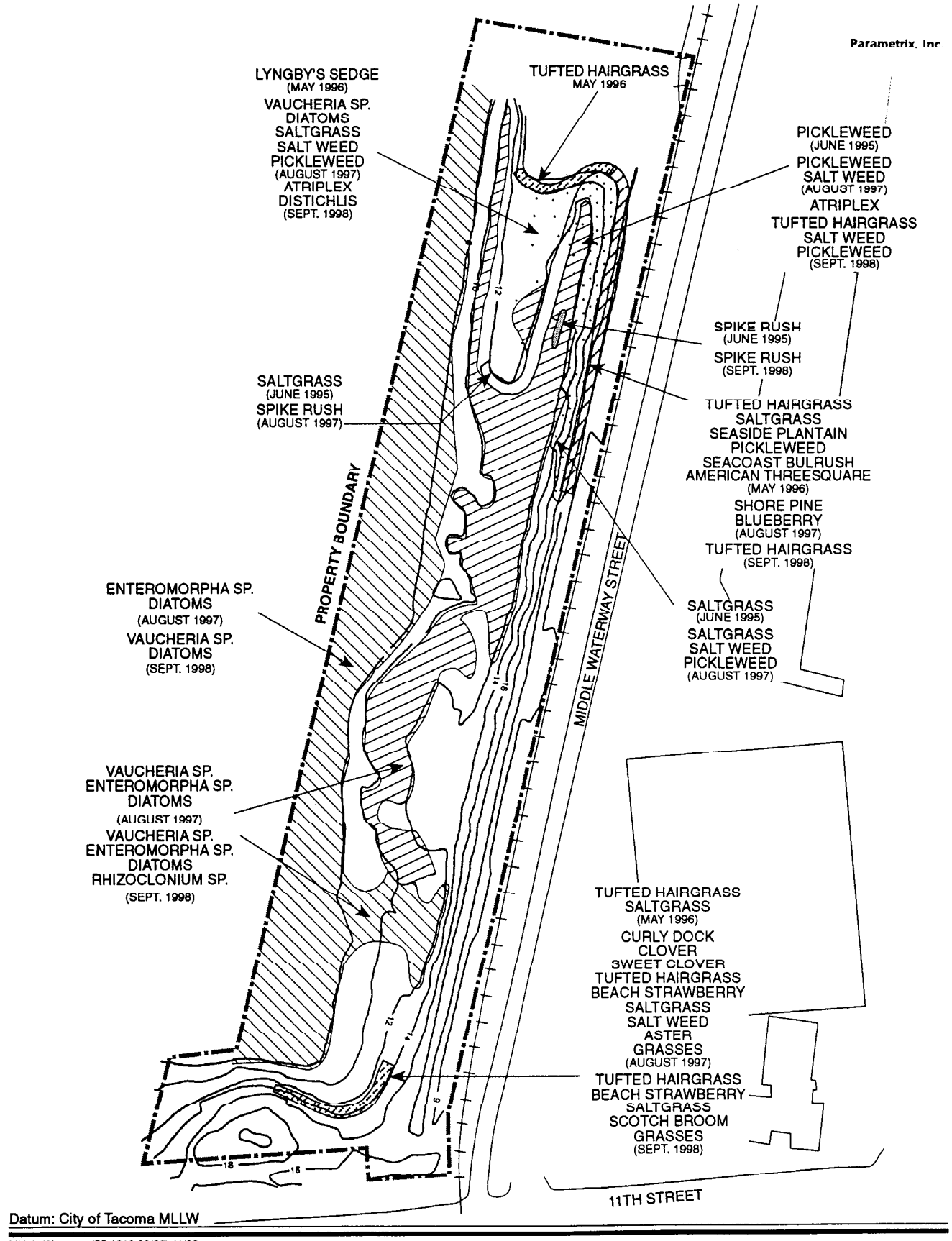


Figure 4.
Extent of Salt Marsh Vegetation 1998

In a portion of low-marsh Bed 4, at the head of the small channel west of the berm and north of Transect 7, some clumps of *Salicornia virginica* (pickleweed), *D. caespitosa* (tufted hair grass), *D. spicata*, and *A. patula* were growing outside of the exclosures. This 20-30 m^2 area contained the majority of the low marsh vegetation at the site. The shallow slope and protection from exposure to waves in this area may promote the retention of seeds and organic matter and reduce the exposure of established plants. It was not clear if the existing plants in the area were new recruits or growth from plantings in 1996.

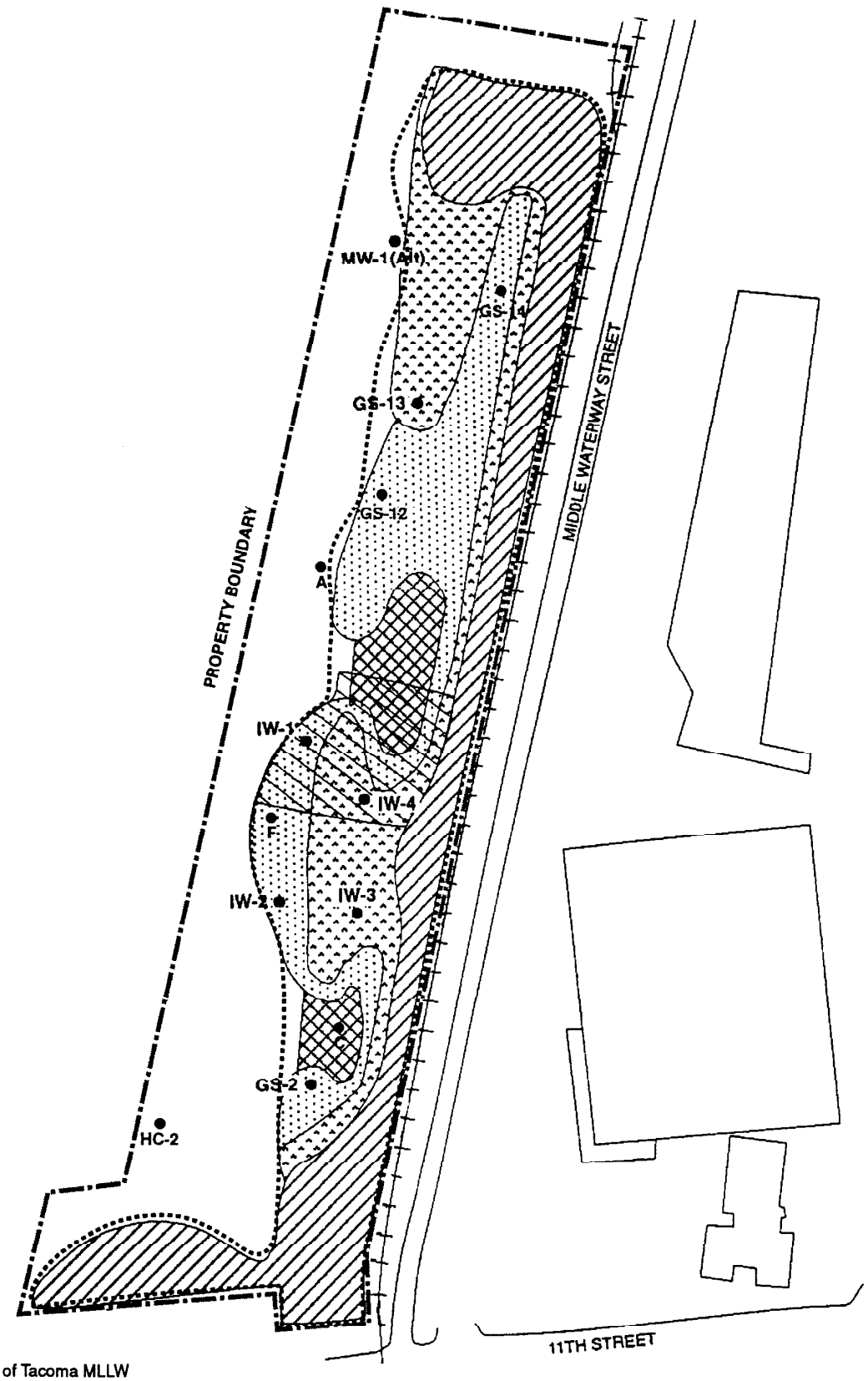
Other beds originally designated as low marsh, i.e., Beds 4, 5, and 6 (Transects 5, 6, 8), were functioning as mudflat. Most mudflat areas had very shallow slopes and were dominated by a mix of *Vaucheria* sp. (a yellow-green alga), *Rhizoclonium* sp. (a green alga), and diatoms. A few small patches of (vascular) *Eleocharis parvula* (spike rush) were found along Transects 5 and 8. These plants are common in protected mudflat areas around Puget Sound. Algal and vascular plant biomass may be consumed directly by some animals but, perhaps more importantly, it generates detritus which is consumed by bacteria. Bacteria and microalgae such as diatoms are important food sources for secondary consumers (e.g., harpacticoid copepods) that, in turn, are consumed by tertiary consumers (e.g., juvenile salmon).

Plants in the sandy upland buffer generally appeared healthy although bare areas between the plants still dominated the space. In the southern portion of the site, upland buffer coverage was slightly higher than in the northern areas and several grasses have recruited to the area. The *Melilotus alba* (sweet clover) that was very abundant last year was not seen this year.

Currently, the low mudflat areas, covered by nonvascular plants, are the most productive portions of the site. High and low marsh vegetation has been largely unsuccessful at the site, except for the small protected area at the northern end of the site. Upland buffer vegetation is surviving, but might benefit from the addition of some organic matter, nutrients, and, perhaps, fresh water. It appears that "treatments" used to promote growth and recruitment of vegetation, goose exclosures in salt marsh areas and top-dressing in mudflat areas, played a less important role in determining the distribution of plants at the site than other physical factors such as slope, exposure, and substrate.

Interstitial Water Salinity Sampling

Interstitial water was sampled for salinity and temperature on August 25, 1998 at 14 stations (Figure 5). Sampling was conducted on an ebb tide, on a day without rainfall (no rainfall for more than a month). Stations were selected to characterize salinity near the north, central, and south areas of the site. Temperature and salinity were measured *in situ* with a refractometer and mercury thermometer (Table 6). To collect interstitial water, a small hole was dug to a depth of about 30 cm and interstitial water was allowed to seep in. A clean pipette was used to transfer water to the refractometer; the thermometer was placed directly into the water. All equipment was rinsed with deionized water between stations.



Datum: City of Tacoma MLLW

Middle Waterway/55-1616-09(02) 11/98

SCALE IN FEET
0 50 100

N

High Salt Marsh
Low Salt Marsh
Mud Flat
Sediment Topdress
Upland Buffer
Sampling Station
Property Boundary
Project Activity Boundary

Figure 5.
Marsh Zones, Buffer, and Interstitial Water Stations

Interstitial water stations were co-located with either the sediment chemistry or grain size sample collection locations.

Table 6. Interstitial water salinity results.

Station	Time (PST)			Temp. (°C)			Salinity (ppt)		
	1997	1996	1998	1997	1996	1998	1997	1996	1998
IW-1	1650	1810	--	11.5	14.4	--	19	28	--
IW-2 (GS-5)	1655	1830	1430	11.5	14.9	20	29	30	25
IW-3 (GS-6)	1427	1710	1445	12.5	15.3	21	13	20	15
IW-4 (GS-8)	1420	1720	1100	12.5	15.7	21	9	19	14
MW-1(Alt)	1354	--	1245	12.5	--	18	8	--	25
GS-13	1410	--	1330	14.0	--	20	24	--	30
GS-2	1702	--	--	11.3	--	--	21	--	--
F	--	--	1130	--	--	18	--	--	25
A	--	--	1200	--	--	17	--	--	25
GS-10	--	--	1215	--	--	18	--	--	20
GS-12	--	--	1230	--	--	18	--	--	25
GS-14	--	--	1345	--	--	19	--	--	25
C	--	--	1450	--	--	20	--	--	22
HC-2	--	--	1500	--	--	18	--	--	25

-- not sampled

WILDLIFE OBSERVATIONS

Wildlife observations on the Project site were recorded by a local volunteer. Observations focused primarily on birds and small mammals.

REFERENCES

Parametrix, Inc. 1993. Project analysis: Middle Waterway shore restoration project. Prepared for Simpson Tacoma Kraft Company, Tacoma, Washington.

Parametrix, Inc. 1994a. Project Supplemental Information Summary: Middle Waterway Shore Restoration Project. Prepared for Simpson Tacoma Kraft Company, Tacoma, Washington.

Parametrix, Inc. 1994b. Middle Waterway shore restoration monitoring and adaptive management plan. Prepared by the Restoration Project Planning Group for Simpson Tacoma Kraft Company, Tacoma, Washington. 23 pp.+ Appendices.

Parametrix, Inc. 1994c. Middle Waterway Shore Restoration Project pre-construction sampling report. Prepared for Simpson Tacoma Kraft Company, Tacoma, Washington. 18 pp. + Appendices.

Parametrix, Inc. 1994d. Preliminary draft sampling report Puget Sound dredged disposal analysis for sediment characterization at Middle Waterway shore restoration project. Prepared for Simpson Tacoma Kraft Company, Tacoma, Washington. 47 pp.+ Appendices.

Parametrix, Inc. 1996. Middle Waterway Shore Restoration Project monitoring and adaptive management plan data report, post-construction (Year 0-1). Prepared for Simpson Tacoma Kraft Company, Tacoma, Washington and Champion International, Stamford, Connecticut. 26 pp. + Appendices.

Parametrix, Inc. 1997a. Middle Waterway Shore Restoration Project monitoring and adaptive management plan data report, post-construction (year 2). Prepared for Simpson Tacoma Kraft company, Tacoma, Washington and Champion International, Stanford, Connecticut. 19pp.+ Appendices.

Parametrix, Inc. 1997b. Changes to the Middle Waterway Shore Restoration Project monitoring and adaptive management plan. Memorandum from Allison Reak, Parametrix to Dave McEntee, Simpson Tacoma Kraft Company. November 2, 1997. 3p.

U.S. Environmental Protection Agency. 1994a. Contract Laboratory Program National Functional Guidelines for Organic Data Review. Office of Solid Waste and Emergency Response. 540/R-94-012.

U.S. Environmental Protection Agency. 1994b. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. Office of Solid Waste and Emergency Response. 540/R-94-013.