Shore Restoration Project Monitoring and Adaptive Management Plan Data Report

Middle Waterway Post-Construction (Year 5)

Prepared for

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EXECUTIVE SUMMARY

Under the St. Paul Waterway Natural Resource Damage (NRD) settlement agreement, Simpson Tacoma Kraft Company (Simpson) and Champion International Corporation[1] (Champion) funded the completion the Middle Waterway Shore Restoration Project. 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).

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.

Monitoring at the site began prior to construction at the site (1994) and continued through 2000. Henceforth, the Trustees will take over any additional monitoring at the site. Results of monitoring through 2000 have included documentation that sediment grain-size distributions were dominated by sand/gravel and sediments containing the greatest silt and clay fraction were in mud flat areas at the lowest site elevations. Percent sand and gravel and porewater salinity tend to increase with elevation.

After pre-construction monitoring, none of the sediment chemistry samples exceeded the Washington State Sediment Quality Standards. Concentrations of all chemicals tested dropped dramatically between Year 0 preconstruction and Year 1 post construction monitoring and since Year 1 have continued to drop or have remained relatively steady.

Benthic invertebrates were collected in early spring of 1994 and 2000 to sample organisms that would be available to outmigrating juvenile salmon. Several species that are known to be prey for juvenile salmon and flat fish were found at the site. Although abundances of these species were not great, this is likely due to the fact that a large sieve size was used to screen the samples and that samples were taken from higher elevations than salmonid prey are generally found.

In all years that vegetation sampling was conducted, most of the low and high salt marsh communities lacked vegetation or had extremely low cover by vascular plants. In some of the higher-elevation, buffer areas, some drought resistant vascular plants that were planted in 1995 are surviving. Lower elevation plots are in functioning mudflat habitats with patchy but extensive cover of microalgae and a colonizing vascular plant species. These species generate organic matter and detritus that are consumed by bacteria and primary consumers, which, in turn, provide food for secondary consumers and juvenile salmon. Although the elevation of these lower, mudflat areas may be too low for larger, vascular plants to survive, they remain the most productive portions of the site.

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[1] Champion's role in the project has since been taken over by International Paper Corporation.

1. INTRODUCTION

1.1 PROJECT DESCRIPTION

Under the St. Paul Waterway Natural Resource Damage (NRD) settlement agreement, Simpson Tacoma Kraft Company (Simpson) and Champion International Corporation[2] (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:

- Convert 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.

Restoration at the Project site enhances and supports the continued existence of the remnant tide flats in a highly industrialized area at the head of the Middle Waterway (Appendix D, Figure 1). 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.

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[2] Champion's role in the project has since been taken over by International Paper Corporation.

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 report provides an overview of the objectives and methodology used to monitor the Project, a summary of the 2000 monitoring data, and a synopsis of the data previously reported during pre- and post-construction monitoring.

1.2 HISTORY OF 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 were 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"[3] 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.

The monitoring plan included several descriptive studies designed to 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 included the following studies:

- Document the general development of estuarine habitat on the project site through aerial photographs (annually through Year 5) and elevation mapping;

- Document the general development of new intertidal and salt marsh substrates through grain size analyses (Years 0-1, 3, and 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 grain size analyses (Years 1, 3, and 5) and benthic surveys (1994 and Year 5);

- Evaluate predictions about elevations and salt marsh establishment through vegetation analyses (annually through Year 5) and periodic measurement of elevations (Years 0, 2, and 5); and

- Document the general use of intertidal, salt marsh, and riparian habitats by wildlife through general qualitative observations (periodically conducted through volunteer effort).

A record of the monitoring activities that were conducted at the site is provided in Table 1.[4] 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

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

[4] The original Monitoring Plan of 1995 was revised in 1997 through consultation with representatives from Champion, Simpson, and the Trustees. Revisions approved at that time are specified in a memorandum that can be found in the Year 2 report (Parametrix 1997a).

been completed in early 1995, followed immediately by Year 0 monitoring for physical and soil characteristics. Vegetation and sediment chemistry monitoring were 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)* (Parametrix 1996). In 1997 (Year 2), vegetation and porewater salinity were monitored and results were presented in *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan Data Report—Post-Construction – Year 2* (Parametrix 1997a). In 1998 (Year 3), sediment, vegetation, and porewater salinity were monitored and the results reported in *Middle Waterway Shore Restoration Project Monitoring and Adaptive Management Plan Data Report—Post-Construction – Year 3* (Parametrix 1998).

This data report contains the sampling methods, data, analytical results, and other related information collected during the final year, Year 5, 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 are included in the appendices.

Table 1. Middle Waterway Shore Restoration Project Schedule of Monitoring Activities[a]

Activity	Pre-construction	1996 (Year 0-1)[a]	1997 (Year 2)	1998 (Year 3)	2000 (Year 5)
Physical Surveys					
Transects			X		X
Topographic Mapping	1995		X		
Sediment Surveys					
Grain Size		X		X	X
Biological	1994				X
Chemical	1993	X		X	X
Vegetation Surveys					
Transplant/Colonization		X	X	X	X
Plant Protection		X	X	X	X
Soil Salinity		X	X	X	X
Wildlife Surveys		X	X	X	
Aerial Photo		X	X	X	X

[a] Year 0-1 = period of construction, planting, and first annual surveys.

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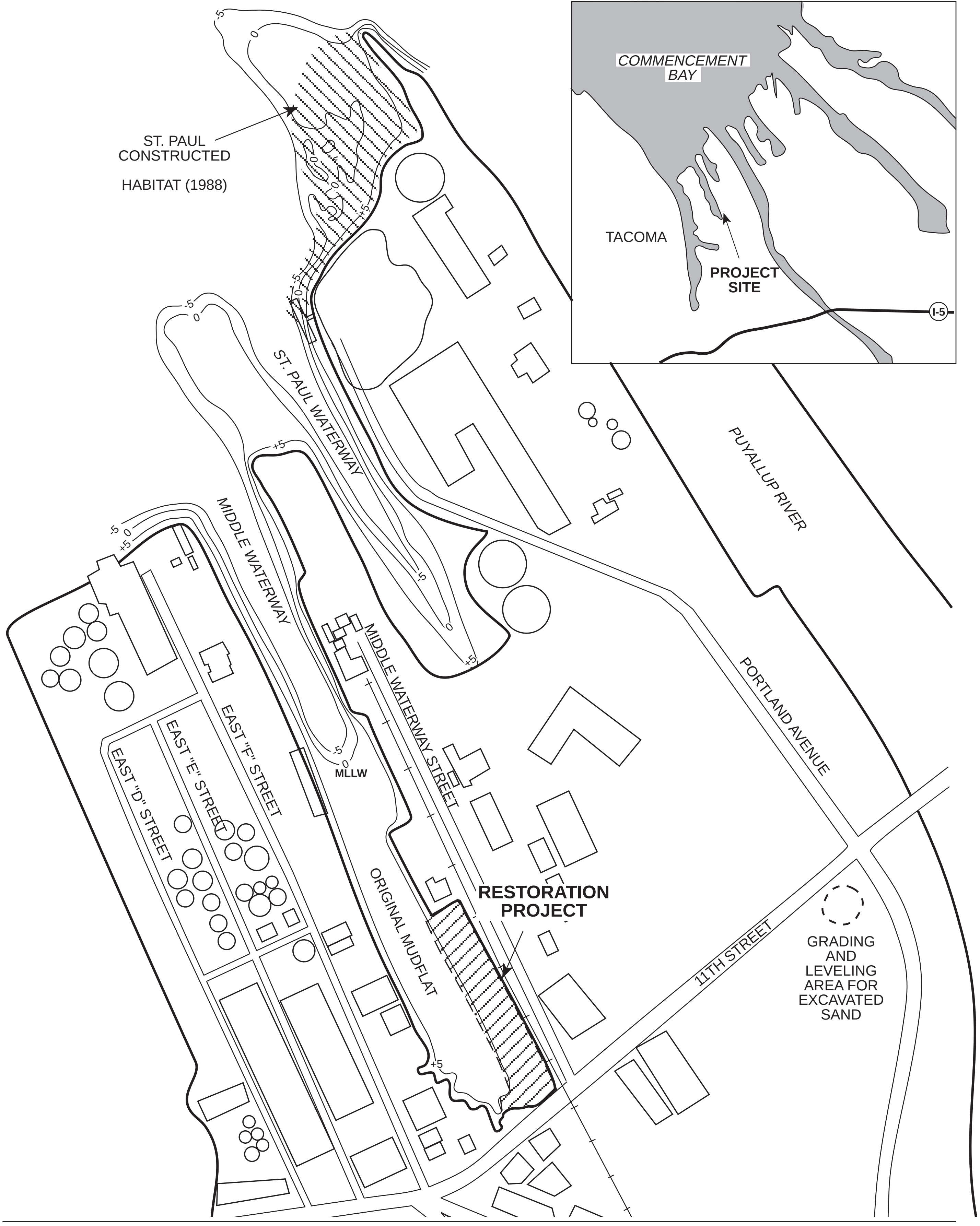

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SCALE IN FEET

0 300 600

N

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

2. METHODS AND RESULTS

2.1 SEDIMENT MONITORING

Year 5 sediment samples were collected on March 28, 2000 from 18 locations within the Project boundaries and at one location at the Hylebos reference site. AmTest, Inc. (Redmond, Washington) processed grain-size and sediment-chemistry samples. Allan Fukayama (Edmonds, WA) conducted taxonomic identification of benthic samples.

2.1.1 Sediment Physical Characteristics

In 2000, sediment samples were collected from 18 sampling stations (Table 2, Figure 2) including a sample from a previously eliminated station (GS-4), an additional station (HYL) from the reference location on the Hylebos waterway, and the five sediment chemistry sampling locations. Surveyors located sampling stations and placed stakes to mark their locations. Sampling methods and analyses for sediment grain size were consistent with the methods specified in the original monitoring plan (Parametrix 1994b)[5]. A field duplicate sample was also collected at station MW-1.

Grain-size samples were collected from the upper 2 cm of sediment using pre-cleaned stainless steel spoons and mixed in stainless steel bowls. Approximately 200 mL of sediments were placed in glass jars, labeled, and stored with ice packs in a cooler. Samples, along with corresponding chain-of-custody forms, were transported to the analytical laboratory (AmTest, Inc., Redmond, WA) for grain size determination within 24 hours. Samples were processed according to Puget Sound Estuarine Program (PSEP) protocols. (Hard copies of the analytical data sheets sent to Trustees as part of Appendix A.)

In general, sediment grain-size distributions were dominated by sand/gravel (i.e., fractions coarser than phi size +4) (Table 3) and there tended to be a positive relationship between elevation and percent sand/gravel in the sediments (Appendix A, Figure 1). Sediments from 9 stations in the project area (MW-1, MW-C, MW-1D, GS-1, GS-2, GS-6, GS-7, GS-8, and GS-14) contained greater than 90% sand/gravel. These stations were located primarily in the high to mid-intertidal areas (i.e., between 8 - 16 feet) (Table 3). Sediments containing the greatest silt and clay fraction (45.6%) were collected from station HC-2, located in the mud flat area and at one of the lowest site elevations (i.e., between 8 - 10 feet). Sediments from station MW-A also had a relatively high silt/clay fraction (23.2%) and this site was also located in a mud flat area with a low site elevation (i.e., between 8 - 10 feet). It appears that the percentage of sand in the sediments is increasing and the percentage of silt and clay is decreasing at the site except at station GS-13 (Table 4). This could be due to the dispersal of sands from the berm around GS-13 to other parts of the site or to erosion of fine sediments from the site. The sediments at the site were reworked after they were sampled in 2000 during a volunteer planting effort.

2.1.2 Sediment Chemical Characteristics

Sediment chemistry samples were collected from five stations (Table 2, Figure 2) and analyzed for mercury, semi-volatile organic compounds (low- and high-density polynuclear aromatic hydrocarbons [L/HPAHs]), and conventional parameters (i.e., total solids, total volatile solids, acid volatile sulfides, and total organic carbon) (Table 5). Sampling and analysis methods adhered to methods specified in the

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[5] In 1997, Champion, Simpson and the trustees agreed to minor changes in the sampling locations for collection of grain size sediments. Sampling at five stations (GS-3, GS-4, GS-9, GS-11, and GS-15) was discontinued (Parametrix 1997b).

Table 2. State Plane Coordinates and Evaluations (Ft MLLW) for 2000 Middle Waterway Shore Restoration Project Sediment Sampling Stations

Station	North	East	Elevation [a]	Descriptor
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
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-4	707175.1	1521851.4	9.8	Sediment-Grain Size #4
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

[a] City of Tacoma data.

monitoring plan (Parametrix 1994b). Sediment chemistry sampling stations were the same as the benthic community sampling stations. 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 decontaminated glass jar (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 decontaminated glass jars. All jars were stored on ice in a cooler. Sediment chemistry samples, along with corresponding chain-of-custody forms, were delivered to the analytical laboratory (AmTest, Inc., Redmond, WA) within 24 hours. (Hard copies of the analytical data sheets sent to Trustees as part of Appendix B.)

Following monitoring plan protocols, sediment chemistry results are presented with Washington Sediment Quality Standards (SQS) for comparison. In accordance with Washington Department of Ecology guidelines, all analytical results for sediments with greater than 0.5% organic carbon content were organic carbon normalized. Organic carbon content of all sediment samples from Year 5 was greater than 0.5%.[6]

In 2000, none of the sediment chemistry samples exceeded the Washington State Sediment Quality Standards. In Year 0, MW-1, MW-A, and HC-2 exceeded the SQS for Mercury. Concentrations of mercury and all other chemicals tested dropped dramatically between Year 0 and Year 1 and since Year 1 have continued to drop or have remained relatively steady (Table 6). Concentrations of a few chemicals have fluctuated within ranges that might be expected due to analytical error, changes in detection limits, or slight changes in water–sediment partitioning coefficients.

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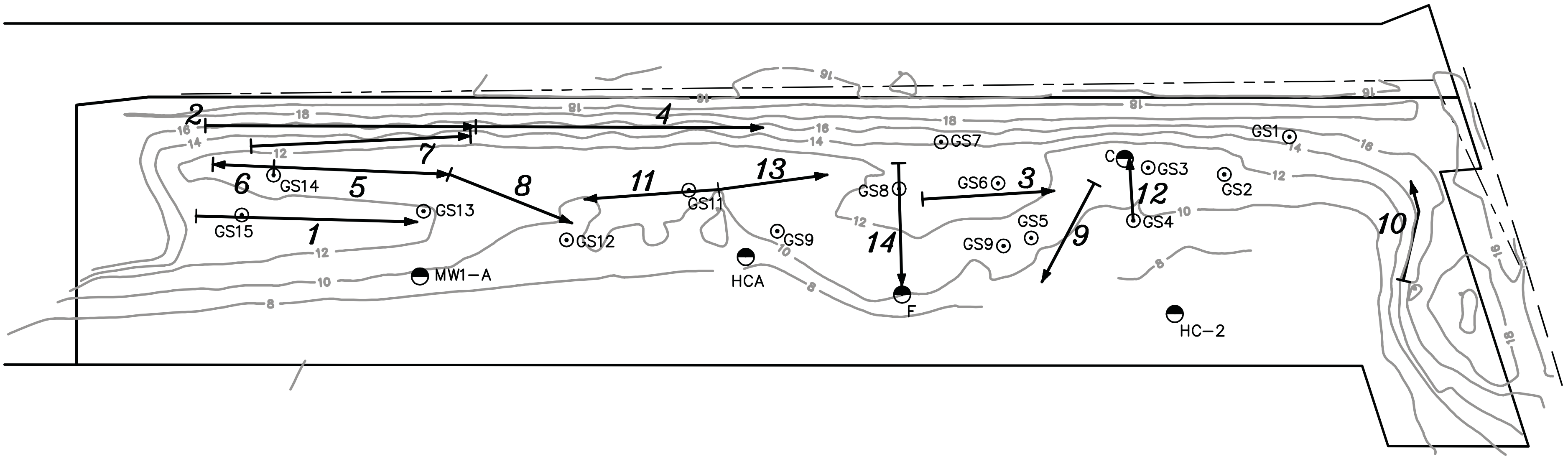
[6] Pre-construction chemistry data for Station F that was incorrectly reported in Parametrix 1994d has been corrected in Table 6. (Data validation memoranda in Appendix B.)



LEGEND:

4 ⟼ VEGETATION SAMPLING TRANSECT & DIRECTION SAMPLED

⊙ GRAINSIZE ONLY

◓ GRAINSIZE, BENTHOS, SEDIMENT CHEMISTRY

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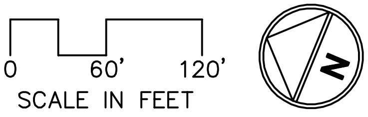

Figure 2
Sediment Sampling Locations and Vegetation Monitoring Transects at Middle Waterway Shore Restoration Project

Table 3. Sediment Grain Size Distribution for Middle Waterway Shore Restoration Project (2000)

	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**	**<0.001**	**%Sand/ Gravel**	**%Silt/ Clay**	**%Total Solids**
Finer than Phi			**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**	**+5**	**+6**	**+7**	**+8**	**+9**	**+10**	**>+10**			
Location[1]	**Elevation**[4]	**Relative Percent Sediment Retained With Each Mesh Size**																	
GS-1	14.9	0.60	<0.1	1.70	5.30	28.5	42.7	11.7	3.60	<0.1	0.50	<0.1	0.90	0.10	<0.1	4.30	94.3	6.00	95.0
GS-2	11.6	0.20	0.10	0.10	1.40	10.4	33.9	29.0	13.8	4.50	1.00	1.20	1.60	0.20	<0.1	2.50	93.4	6.60	81.0
GS-4	9.8	1.20	0.10	1.50	5.30	20.9	29.9	13.6	9.20	3.50	3.40	3.30	3.10	0.30	<0.1	4.80	85.2	15.0	72.0
GS-5	11.1	6.80	0.40	1.30	2.70	20.8	31.7	16.6	7.80	1.20	2.10	1.80	1.50	0.20	<0.1	5.10	89.3	10.8	77.0
GS-6	12.4	2.60	0.10	0.70	4.40	30.1	37.5	14.8	3.80	0.70	1.10	0.50	1.20	0.10	<0.1	2.30	94.7	5.30	85.0
GS-7	14.2	0.20	<0.1	1.50	2.00	21.5	50.6	15.8	4.10	0.70	0.40	0.60	0.90	0.10	<0.1	1.50	96.5	3.60	95.0
GS-8	12.3	1.40	<0.1	1.60	2.60	35.9	36.9	13.3	3.70	0.60	0.50	0.10	1.00	0.10	<0.1	2.30	96.1	4.10	84.0
GS-10	11.1	2.90	0.90	3.80	4.60	10.6	18.6	11.7	9.00	26.9	2.90	1.80	2.90	0.30	<0.1	3.00	89.0	11.0	64.0
GS-12	9.8	0.10	0.10	0.70	2.70	10.3	24.4	21.8	17.1	8.60	3.10	2.20	2.40	0.30	<0.1	6.00	85.8	14.1	66.0
GS-13	12.2	6.60	2.30	4.20	3.90	15.3	22.4	14.3	7.20	3.80	4.10	3.40	3.60	1.70	0.80	6.40	80.0	20.0	88.0
GS-14	10.3	0.40	<0.1	0.10	2.20	18.5	40.3	17.1	4.60	7.90	4.70	1.40	1.50	0.10	<0.1	1.30	91.2	9.10	71.0
HYL[3]		0.70	<0.1	0.30	0.80	4.70	44.0	34.1	7.20	2.90	0.40	1.20	2.10	0.20	<0.1	1.40	94.8	5.40	70.0
MW-1[2]	9.4	1.00	<0.1	1.30	3.00	18.3	38.8	22.3	6.00	2.80	1.50	<0.1	1.10	0.20	<0.1	3.80	93.6	6.80	83.7
MW-1D[2]		1.50	1.00	2.10	4.00	20.9	38.8	19.5	5.40	2.00	0.90	0.10	0.50	0.10	<0.1	3.10	95.2	4.80	79.5
MW-A[2]	8.6	4.80	0.20	1.40	3.90	13.9	22.8	10.9	10.4	8.40	7.70	2.90	1.80	0.90	0.40	9.50	76.7	23.2	59.3
MW-C[2]	10	0.10	0.10	0.30	2.60	24.1	36.5	18.6	6.30	4.60	2.10	0.80	1.10	0.20	<0.1	2.60	93.2	6.90	73.7
HC-2[2]	7.1	1.20	0.20	1.70	2.10	4.50	7.40	6.20	14.7	16.4	16.4	9.00	4.50	0.20	<0.1	15.4	54.4	45.6	41.4
MW-F[2]	10.1	7.40	<0.1	2.20	2.50	15.2	28.1	10.7	6.40	15.2	4.30	0.40	0.60	0.70	0.40	6.00	87.8	12.4	68.1

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[1] Sample locations GS-3, GS-4, GS-9, GS-11, and GS-15 were discontinued in 1997 (Parametrix 1997), although GS-4 was inadvertently included in 2000.

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

[3] Station HYL is a reference location in the Hylebos waterway.

[4] ft rel (MLLW).

Table 4. Summary of Percent Silt/Clay at Sediment Sampling Locations at Middle Waterway Shore Restoration Project

	Percentage of Sample Composed of Silt/Clay		
Station[1]	1996 (Year 0-1)	1998 (Year 3)	2000 (Year 5)
GS-1	6.30	5.70	6.00
GS-2	17.8	10.7	6.60
GS-3	18.4	--	--
GS-4	22.4	--	15.0
GS-5	22.5	13.2	10.8
GS-6	18.4	13.5	5.30
GS-7	7.10	3.70	3.60
GS-7(dup)	5.8	--	--
GS-8	19.7	14.2	4.10
GS-9	15.3	--	--
GS-10	24.9	34.4	11.0
GS-11	27.9	--	--
GS-12	40.8	18.1	14.1
GS-13	19.6	11.3	20.0
GS-14	8.10	22.5	9.10
GS-15	16.2	--	--
HYL[3]	--	--	5.40
MW-1[2]	--	12.8	6.80
MW-1D[2]	--	18.1	4.80
MW-A[2]	--	45.4	23.2
MW-C[2]	--	16.0	6.90
HC-2[2]	--	69.4	45.6
MW-F[2]	--	42.1	12.4

[1] Sample locations GS-3, GS-4, GS-9, GS-11, and GS-15 were discontinued in 1997 (Parametrix 1997), although GS-4 was inadvertently included in 2000.

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

[3] Station HYL is a reference location in the Hylebos waterway.

-- Not sampled.

Table 5. Sediment Chemistry Results for Middle Waterway Shore Restoration Project (2000)

Chemical	SQS*	MW-1		MW-1 (dup)		A		HC-2		C		F	
Metals (mg/kg dry wt)													
Mercury	0.41	0.13		0.13		0.25		0.24		0.05		0.04	
Organics (mg/kg OC)													
LPAH													
Acenaphthylene	66	1.4	U	2.0	U	0.4	U	0.8	U	2.7	U	0.5	U
Acenaphthene	16	1.4	U	2.0	U	0.4	U	2.0		2.7	U	0.5	U
Anthracene	220	1.4	U	2.0	U	0.4		4.6		2.7	U	0.7	
Fluorene	23	1.4	U	2.0	U	0.4	U	1.5		2.7	U	0.5	U
Naphthalene	99	1.4	U	2.0	U	0.4	U	0.8	U	2.7	U	0.5	U
Phenanthrene	100	3.7		4.8		1.2		18.1		2.9		2.3	
2-Methylnaphthalene	38	1.4	U	2.0	U	0.4	U	0.8	U	2.7	U	0.5	U
Total LPAHs**	370	4		5		2		26		3		3	
HPAH													
Benzo(*a*)anthracene	110	3.3		4.2		1.8		13.4		3.0		7.4	
Benzo(*a*)pyrene	99	3.8		5.5		2.5		14.4		3.3		7.4	
Benzo(*b*)fluoranthene	--	3.5		5.1		2.8		11.2		3.1		10.0	
Benzo(*k*)fluoranthene	--	4.2		5.7		2.7		12.4		3.3		9.3	
Total Benzofluoranthenes	230	7.7		10.8		5.5		23.7		6.4		19.3	
Benzo(*g,h,i*)perylene	31	2.2		3.9		1.2		6.6		2.7	U	3.0	
Chrysene	110	5.3		7.6		4.2		19.5		5.0		18.6	
Dibenzo(*a,h*)anthracene	12	1.4	U	2.0	U	0.4	U	1.3		2.7	U	0.7	
Fluoranthene	160	7.5		7.1		5.8		20.2		5.7		17.2	
Indeno(*1,2,3,-c,d*)pyrene	34	2.3		3.2		1.3		6.8		2.7	U	3.3	
Pyrene	1,000	8.3		9.7		5.7		29.3		6.1		11.2	
Total HPAHs**	960	40		52		28		135		30		88	
Conventionals													
Total solids (%)	--	83.7		79.5		59.3		41.4		73.7		68.1	
Total volatile solids (%)	--	1.8		2.2		7.9		13.0		1.5		6.6	
Total organic carbon (%)	--	1.2		0.9		6.0		4.1		0.7		4.3	
Acid volatile sulfides (mg/kg)	--	8.7	U	5.5	U	16.0		45.0		240		30.0	

Data qualifiers:

-- = No data available.

U = Value below stated detection limit.

Notes:

mg/kg OC = mg/kg, organic carbon-normalized.

* = Washington Sediment Quality Standards.

** = Totals summed per Washington State Sediment Management Standards.

Table 6. Sediment Chemistry Result Trends, by Sampling Site, for the Middle Waterway Shore Restoration Project

		MW-1								MW-A								HC-2							
Chemical	**SQS***	**Year 0****		**Year 1**		**Year 3**		**Year 5**		**Year 0*****		**Year 1**		**Year 3**		**Year 5**		**Year 0****		**Year 1**		**Year 3**		**Year 5**	
Metals (mg/kg dry wt)																									
Mercury	0.41	0.31		0.20		0.42		0.13		0.49		0.18		0.26		0.25		1.18		0.35		0.36		0.24	
Organics (mg/kg OC)																									
<u>LPAH</u>																									
Acenaphthylene	66	0.6		2.5	U	0.9	U	1.4	U	3.4		0.8	U	0.5	U	0.4	U	2.3		1.4		0.8		0.8	U
Acenaphthene	16	0.5	U	2.5	U	0.9	U	1.4	U	2.6		0.8	U	0.5	U	0.4	U	8.3		1.3		0.8		2.0	
Anthracene	220	1.0		2.5	U	0.9	U	1.4	U	5.4		1.6		1.4		0.4		11.4		7.8		4.4		4.6	
Fluorene	23	0.6		2.5	U	0.9	U	1.4	U	4.0		0.8		0.5	U	0.4	U	6.1		2.4		1.0		1.5	
Naphthalene	99	1.2		2.5	U	0.9	U	1.4	U	7.7		0.8	U	0.5	U	0.4	U	3.6		2.4		0.7		0.8	U
Phenanthrene	100	5.3		4.5		2.1		3.7		23.4		6.5		4.8		1.2		97.1	D	17.3		10.0		18.1	
2-Methylnaphthalene	38	0.5	U	2.5	U	0.9	U	1.4	U	2.8		0.8	U	0.5	U	0.4	U	2.0		1.2	U	0.6	U	0.8	U
Total LPAHs****	370	9		5		2		4		49		9		6		2		34		33		18		26	
<u>HPAH</u>																									
Benzo(*a*)anthracene	110	5.3		6.5		2.3		3.3		26.3		7.7		9.2		1.8		43.7	D	17.8		11.5		13.4	
Benzo(*a*)pyrene	99	5.3		8.2		2.9		3.8		34.3	D	8.7		9.2		2.5		43.7	D	18.2		11.7		14.4	
Benzo(*b*)fluoranthene	--	4.4		10.6		3.0		3.5		42.9	D	10.3		12.0		2.8		29.1	D	15.6		11.9		11.2	
Benzo(*k*)fluoranthene	--	8.9		8.6		2.1		4.2		14.3		8.1		9.4		2.7		19.4		15.8		8.3		12.4	
Total Benzofluoranthenes	230	13.3		19.2		5.1		7.7		57.2		18.4		21.4		5.5		48.5		31.4		20.2		23.7	
Benzo(*g,h,i*)perylene	31	2.8		6.4		1.5		2.2		22.3		5.5		5.2		1.2		9.7		9.5		7.2		6.6	
Chrysene	110	8.0		12.7		3.3		5.3		25.7		11.6		14.6		4.2		58.3	D	25.5		17.8		19.5	
Dibenzo(*a,h*)anthracene	12	1.1		2.5	U	0.9	U	1.4	U	4.9		0.8	U	1.5		0.4	U	4.6		1.2	U	2.4		1.3	
Fluoranthene	160	11.6		11.7		4.5		7.5		26.0		14.2		13.0		5.8		77.7	D	32.7		18.5		20.2	
Indeno(*1,2,3,-c,d*)pyrene	34	3.0		6.2		2.2		2.3		23.1		5.8		6.8		1.3		10.4		1.2	U	8.2		6.8	
Pyrene	1,000	7.6		10.3		4.5		8.3		34.3		13.5		13.4		5.7		117	D	32.7		18.5		29.3	
Total HPAHs****	960	58		81		26		40		254		85		94		28		413		168		116		135	
Conventionals																									
Total solids (%)	--	66.6		77.8		67.4		83.7		55.7		59.0		57.7		59.3		39.2		45.5		43.5		41.4	
Total volatile solids (%)	--	--		1.9		3.3		1.8		11.5		5.4		6.7		7.9		--		12.1		14.0		13.0	
Total organic carbon (%)	--	2.3		0.8		2.2		1.2		3.5		3.1		5.0		6.0		4.1		5.5		5.4		4.1	
Acid volatile sulfides (mg/kg)	--	348		90.0	b,j	81.0		8.7	U	--		5500	b,j	210		16.0		2.3	U	1300	b,j	290		45.0	

Table 6. Sediment Chemistry Result Trends, By Sampling Site, for the Middle Waterway Shore Restoration Project (Continued)

		MW-C								F							
Chemical	**SQS***	**Year 0*****		**Year 1**		**Year 3**		**Year 5**		**Year 0****		**Year 1**		**Year 3**		**Year 5**	
Metals (mg/kg dry wt)																	
Mercury	0.41	0.04		0.03		0.08		0.05		0.59		0.13		0.16		0.04	
Organics (mg/kg OC)																	
<u>LPAH</u>																	
Acenaphthylene	66	7.5	U,d	4.9	U,d	3.2	U	2.7	U	3.0		0.5	U	0.7		0.5	U
Acenaphthene	16	7.5	U,d	4.9	U,d	3.2	U	2.7	U	2.9		0.6		0.6	U	0.5	U
Anthracene	220	7.5	U,d	4.9	U,d	3.2	U	2.7	U	5.8		1.3		1.8		0.7	
Fluorene	23	7.5	U,d	4.9	U,d	3.2	U	2.7	U	3.9		0.7		0.6	U	0.5	U
Naphthalene	99	7.5	U,d	4.9	U,d	3.2	U	2.7	U	10.0		0.7		0.6		0.5	U
Phenanthrene	100	8.8	d	4.9	U,d	10.2		2.9		20.3		6.7		7.6		2.3	
2-Methylnaphthalene	38	7.5	U,d	4.9	U,d	3.2	U	2.7	U	3.6		0.5	U	0.6	U	0.5	U
Total LPAHs****	370	9	d	5	U,d	10		3		50		10		11		3	
<u>HPAH</u>																	
Benzo(*a*)anthracene	110	7.5	U,d	4.9	U,d	11.2		3.0		19.7		6.9		9.7		7.4	
Benzo(*a*)pyrene	99	17.0	d	4.9	U,d	10.3		3.3		29.4		8.6		11.2		7.4	
Benzo(*b*)fluoranthene	--	22.9	d	4.9	U,d	9.0		3.1		39.4	D	8.3		11.5		10.0	
Benzo(*k*)fluoranthene	--	7.5	U,d	4.9	U,d	8.2		3.3		10.9		6.9		7.3		9.3	
Total Benzofluoranthenes	230	22.9	d	4.9	U,d	17.2		6.4		50.3		15.2		18.8		19.3	
Benzo(*g,h,i*)perylene	31	26.7	d	4.9	U,d	5.5		2.7	U	14.2		5.8		6.7		3.0	
Chrysene	110	11.3	d	4.9	U,d	14.5		5.0		23.3		9.4		13.0		18.6	
Dibenzo(*a,h*)anthracene	12	7.5	U,d	4.9	U,d	3.2	U	2.7	U	3.0		0.5	U	2.3		0.7	
Fluoranthene	160	12.9	d	6.2	d	18.3		5.7		21.5		10.8		14.5		17.2	
Indeno(*1,2,3,-c,d*)pyrene	34	21.3	d	4.9	U,d	6.8		2.7	U	14.5		5.8		8.5		3.3	
Pyrene	1,000	16.7	d	7.2	d	20.0		6.1		48.5	D	10.0		16.4		11.2	
Total HPAHs****	960	129	d	13	d	104		30		224		73		101		88	
Conventionals																	
Total solids (%)	--	82.6		76.9		75.7		73.7		57.4		81.5		70.0		68.1	
Total volatile solids (%)	--	1.4		1.3		2.8		1.5		13.4		3.6		6.2		6.6	
Total organic carbon (%)	--	0.2	d	0.4	d	0.6		0.7		3.3		3.6		3.3		4.3	
Acid volatile sulfides (mg/kg)	--	--		780	b,j	210		240		--		100	b,j	12.0	U	30.0	

Data qualifiers:

-- = No data available.
D = Dilution was required.
U =Analyte value was below stated detection limit.
b = Associated value was detected in the method blank, possible blank contamination.
d = Samples with < 0.5% TOC; Ecology guidelines state that result should not be compared with OC normalized criteria.
j = The associated value is considered estimated.

Notes:

mg/kg OC = mg/kg, organic carbon-normalized.
* = Washington State Sediment Quality Standards.
** = Data from Parametrix 1994c.
*** = Data corrected from Parametrix 1994d.
**** = Totals summed per Washington State Sediment Management Standards.

In Year 5, sediment mercury concentrations ranged from 0.04 mg/kg (dry wt) at station F to 0.25 mg/kg (dry wt) at station MW-1. In general, sediment mercury concentrations in 2000 were similar, if not slightly lower, than those found in 1998. Sediment mercury levels in all of the sediment samples collected in Year 5 were below the mercury SQS of 0.41 mg/kg.

Concentrations of organic chemicals in all sediment samples were well below their corresponding SQS values. Concentrations of total LPAH were low at all stations, ranging from 4.0 mg/kg organic carbon (OC) at station A to 29.0 mg/kg OC at station HC-2 (13 to 93 times less than the total LPAH SQS of 370 mg/kg). A majority of individual LPAHs were not detected above their respective detection limits at some, or all, sampling locations. Phenanthrene was the only LPAH detected at all stations. In 2000, sediment LPAH concentrations at stations C and F were lower than levels identified in 1998, and at stations MW-1, A, and HC-2, sediment LPAH levels were similar to (or slightly higher than) those found in 1998.

Sediment concentrations of total HPAH were also low, ranging from 28.0 mg/kg OC at station A to 135 mg/kg at station HC-2 (7 to 34 times less than the total HPAH SQS of 960 mg/kg). With the exception of dibenzo(a,h)anthracene (at stations MW-1, A, and C), benzo(g,h,i)perylene (at station C), and indeno(1,2,3-cd)pyrene (at station C), all of the individual HPAHs of interest were detected in all sediment samples. In 2000, sediment HPAH concentrations at stations A and C were lower than levels identified in 1998, and HPAH concentrations at stations MW-1 and HC-2 were higher than 1998 levels. At station F, HPAH concentrations in 2000 were similar to those detected in 1998.

Sediment total organic carbon content (TOC) and acid volatile sulfide (AVS) levels in 2000 were similar to those identified in 1993, 1996, and 1998. The highest TOC levels continue to be found at station A, while the lowest levels are seen 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). AVS results for stations MW-1, A, and HC-2 were lower in 2000 than in 1998, while stations C and F showed slightly higher levels. Stations MW-1 and A have shown a continuing trend of decreasing AVS levels, while concentrations at stations C, F, and HC-2 have varied year to year.

Validation of laboratory data was conducted according to the EPA functional guidelines for evaluating inorganic and organic data (USEPA 1994a,b). Because the data were reported in the laboratory standard reporting format, the following items[7] were included in the data review:

- holding times
- laboratory method blanks
- surrogate recovery
- analytical or spike replicates
- matrix spike recoveries
- standard reference material recoveries
- system performance and overall data assessment

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

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[7] Some of these categories are only applicable to certain analyses.

2.1.3 Sediment Biological Characteristics

Benthic infauna were sampled on March 28, 2000, using the same protocols that were used during a preconstruction study in 1994 (Parametrix, 1994e). As in 1994, 10 replicate cores were collected near stations HC-2, MW-1a, F, and HYL (reference site on Hylebos). Cores were 2.5 cm diameter and were pushed into the sediments to collect the upper 6 cm of sediment. Samples were placed in plastic jars and preserved with a 10% formalin solution. The preserved samples were sent to Alan Fukuyama (Everett, WA) who screened the samples through a 1-mm sieve. Sorting and taxonomy were conducted according to procedures outlined in the PSEP guidelines (US EPA, 1990).

Samples were collected during the early spring in order to sample benthic organisms that would be available to outmigrating juvenile salmon. In general, juvenile salmon would be consuming smaller organisms than the organisms that were enumerated in this study, but it was determined that screening the samples using the same mesh size employed during the preconstruction study was preferable to changing protocols.

Several species that are known to be prey for juvenile salmon and flat fish were found at the site (Appendix C, Table 1). For example, *Corophium insidiosum*, *C. salmonis*, *Eogammarus confervicolus*, *Grandidierella japonica*, *Cumella vulgaris*, *Nippoleucon himumenisi*, *Harpacticus* sp., and some insect larvae were noted in one or both of the years sampled. Abundances of these species were not great (Appendix C, Table 2), but this is likely due to the fact that a large sieve size was used to screen the samples and that most of these species would be best retained with a 0.5 mm or smaller sieve size that is commonly used for epibenthic studies (Cordell 2001 personal communication).

There may have been a slight reduction from 1994 in the total number of benthic species found during 2000 at Middle Waterway stations MW-1a and MW-F (Appendix C, Table 1, last row). At the site in general, no anemomes, isopods, bivalves, nemerteans (worms), or nereids (worms), and very few tanaaiids, were noted during 2000. No copepods or nematodes were noted in 1994. As in 1994, the most abundant amphipod was the species *Grandidierella japonica*. The most abundant polychaetes in both years were *Capitella capitata*, *Manayunkia aestuarina*, and *Pygospio elegans*. The genera *Polydora* and *Boccardia* were not found in 2000. In 2000, amphipods were the most abundant species at both the reference and the Middle Waterway stations. In 1994, oligochaetes and the *Capitella capitata* complex predominated at both sites. These and other differences between the two years in terms of species presence may have been caused by the difference between the seasons that were sampled (December 1994 vs. March 2000), differences between taxonomists, and the fact that several of the species were sparse and patchy (i.e., they may have been present in one or the other year but sampling was not adequate to detect them). It is not immediately apparent why station MW-F may have had fewer polychaetes than the other stations. Grain size and elevation at this station were both within the ranges found at the other stations that were sampled.

2.2 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 post-construction species composition and the spatial 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) were surveyed. Aerial photographs were taken to capture the distribution of habitats on a site-wide basis and elevation profiles were surveyed to track changes in elevation at the site.

2.2.1 Aerial Photo and Mapping

An aerial photo of the Middle Waterway has been taken during each year of monitoring. Each year, the photo was taken in late July or early August by Sound Aerial Surveys (Seattle). In 2000, 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 (Appendix D, Figure 1. Hard copy of full photo presented to Trustees).

As in 1995 and 1997, in 2000, elevation was measured along the five vertical transects at the site (Figure 3). Changes in the topography of the site have been subtle except along Transect E in the southern portion of the site (Appendix D, Figures 2, 3).

Photographs from different points in the site were also taken to provide a visual impression of conditions at the site (Appendix D, Table 1).

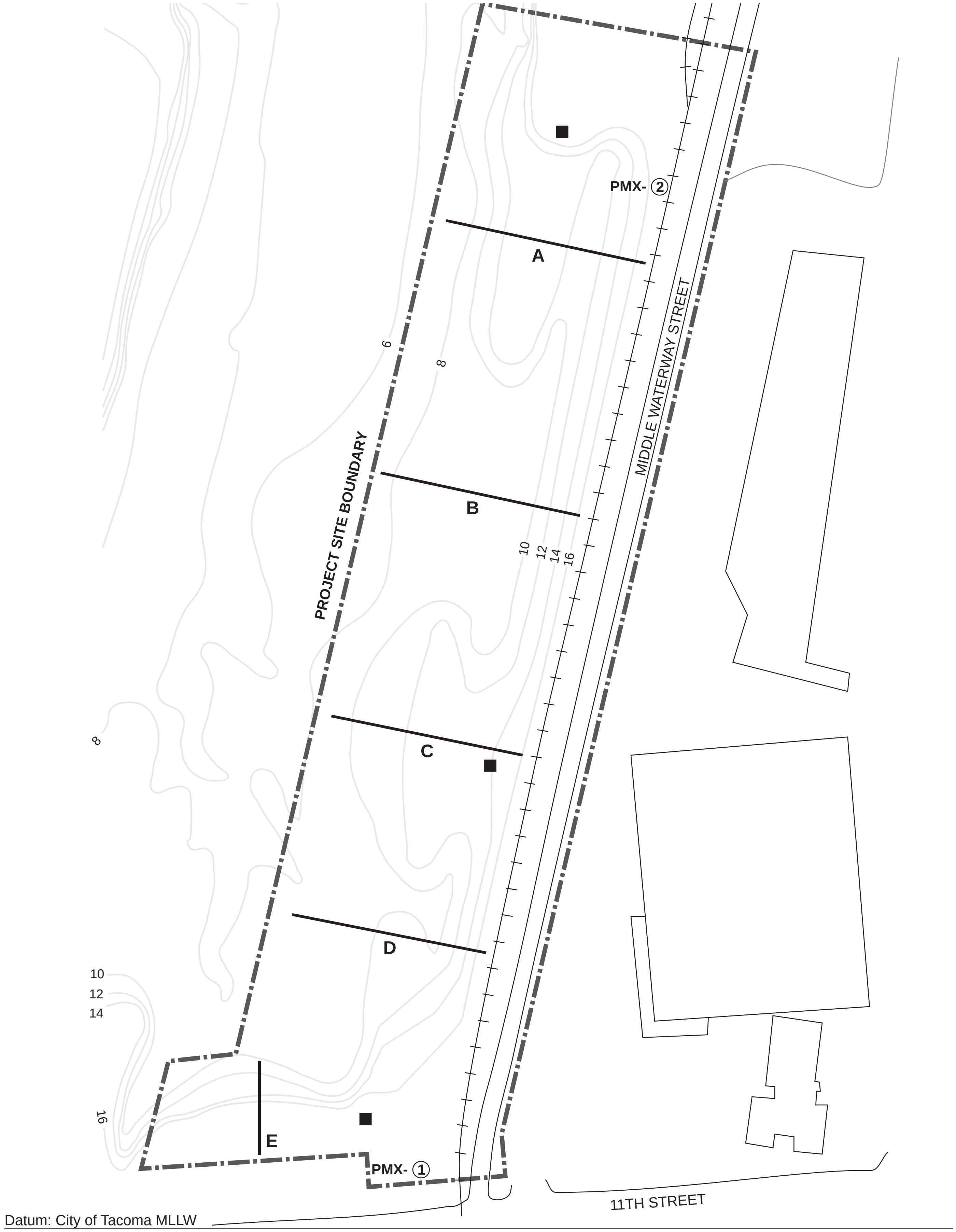
2.2.2 Vegetation Sampling

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 and planted beds were associated with unplanted beds with similar elevation and substrate. Most planted beds were enclosed with string and flagging to exclude geese; one low-marsh bed in the north was planted without an enclosure. Low and high mudflat areas were not planted, but two areas were top-dressed with salvaged soils that, it was hoped, would promote recruitment of vegetation.

Fourteen transects were established through the site (Figure 2). The ends of each transect were semi-permanently marked with rebar and eighty random locations were selected along the transects. Each year, 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 Data Appendix E.

In Year 5, as in Years 0-1, 2, and 3, most of the low and high salt marsh communities lacked vegetation or had extremely low cover by vascular plants (Tables 7, 8). In some of the higher-elevation, buffer areas, for example at the north end of the site along Transect 2 and the southern end of the site along Transect 10, vascular plants such as tufted hair grass (*Deschampsia caespitosa)* and wild strawberry (*Fragaria chiloensis)* that were planted in 1995 are surviving but have not completely filled in the area. Along Transect 10, some grasses and larger herbaceous species have recruited to the area and the sweet clover (*Melilotus alba*) that was abundant in previous years had disappeared in 2000. Upland buffer vegetation along the entire site would likely benefit from the addition of some organic matter, nutrients, and, perhaps, fresh water.

Some lower elevation plots that were originally designated as low marsh areas appear to be functioning as mudflat with patchy but extensive cover of the yellow-green alga *Vaucheria* sp., the green algae *Enteromorpha* sp. and *Rhizochlonium* sp., diatoms, and some smaller patches of the vascular spike rush *Eleocharis parvula*. Biomass from these species generates organic matter and detritus that are consumed by bacteria. Bacteria and microalgae such as diatoms are important food sources for secondary consumers (e.g., harpacticoid copepods) which, in turn, are consumed by tertiary consumers (e.g., juvenile salmon). Although the elevation of these lower, mudflat areas may be too low for larger, vascular plants to survive, they remain the most productive portions of the site.



Simp. Mon. Report/55-1650-42 7/97

Figure 3.
Locations of Elevation Transects, Middle Waterway Shore Restoration Project

Table 7. Vegetation Species, Percent Cover, and Dominant Substrate Characteristics by Transect for Middle Waterway Shore Restoration Project (2000)

Transect #	Species	% Cover (Range)[1]	Post-Construction Dominant Substrate (>50%)[2]
1	*Atriplex patula*	tr	sand, mud
	Vaucheria sp.	90	
	Rhizochlonium sp.		
2	*Atriplex patula*	tr	sand
	Deschampsia caespetosa	tr-5	
3	*Rhizochlonium* sp.	tr	sand
4	*Fragaria chiloensis*	tr	sand
	Deschampsia caespetosa	tr	
	Scirpus maritimus	tr	
5	Diatoms	25-100	mud
	Vaucheria sp.	tr-90	
	Eleocharis parvula	0-50	
	Rhizochlonium sp.	tr	
	Enteromorpha sp.	tr	
6	*Vaucheria sp.*	0-90	mud
	Rhizochlonium sp.	5-10	
	Salicornia virginica	tr	
7	*Distichlis spicata*	tr	sand
	Atriplex patula	10-15	
	Salicornia virginica	tr	
8	*Vaucheria* sp.	5-95	mud
	Eleocharis parvula	0-5	
	Rhizochlonium sp.	tr-95	
9	*Vaucheria* sp.	tr-50	sand, mud
	Rhizochlonium sp.	tr-100	
	Enteromorpha sp.	tr	
10	*Melilotus alba*	0-25	sand
	Deschampsia caespetosa	75-100	
	Vicchia sp.	tr	
	Fragaria chiloensis	tr	
	Atriplex patula	tr	
	Grass	tr	
11	*Vaucheria* sp.	tr-95	mud
	Eleocharis parvula	tr-5	
	Rhizoclonium sp.	50-99	
12	*Vaucheria* sp.	50-100	mud, small pools
	Rhizoclonium sp.	tr-100	
	Enteromorpha sp.	trace	
13	*Rhizoclonium* sp.	15-70	mud
	Vaucheria sp.	0-5	
14	*Vaucheria* sp.	tr-100	sand, silt, cobble
	Rhizoclonium sp.	tr-100	
	Enteromorpha sp.	tr-95	

[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.

Table 8. Species Present at Middle Waterway Shore Restoration Project over Monitoring Period

Transect	Vegetation	1996 (Year 0-1)	1997 (Year 2)	1998 (Year 3)	2000 (Year 5)
1	*Atriplex patula*			x	x
	Carex lyngbyei	x			
	Distichlis spicata			x	
	Rhizochlonium sp.				x
	Salicornia virginica		x		
	Vaucheria sp.		x		x
2	*Atriplex patula*	x		x	x
	Deschampsia caespitosa	x		x	x
	Distichlis spicata			x	
	Pinus contorta		x		
	Vaccinium sp.		x		
3	Diatoms		x		
	Rhizochlonium sp.				x
4	*Atriplex patula*	x			
	Deschampsia caespitosa				x
	Fragaria chiloensis				x
	Scirpus maritimus				x
5	Diatoms		x	x	x
	Eleocharis parvula		x	x	x
	Enteromorpha sp.	x	x		x
	Rhizochlonium sp.				x
	Salicornia virginica	x			
	Vaucheria sp.	x	x	x	x
6	*Atriplex patula*		x		
	Distichlis spicata	x			
	Enteromorpha sp.	x	x		
	Rhizochlonium sp.				x
	Salicornia virginica	x	x		x
	Scirpus maritimus	x			
	Vaucheria sp.	x	x	x	x
7	*Atriplex patula*	x	x	x	x
	Distichlis spicata	x	x	x	x
	Jaumea carnosa	x			
	Plantago maritima	x			
	Salicornia virginica	x	x		x
8	*Eleocharis parvula*			x	x
	Enteromorpha sp.	x			
	Rhizochlonium sp.				x
	Vaucheria sp.	x	x	x	x
9	Diatoms		x		
	Enteromorpha sp.	x			x
	Rhizochlonium sp.				x
	Vaucheria sp.	x	x	x	x

Table 8. Species Present at Middle Waterway Shore Restoration Project Over Monitoring Period (Continued)

Transect	Vegetation	1996 (Year 0-1)	1997 (Year 2)	1998 (Year 3)	2000 (Year 5)
10	*Agropyron repens*		x	x	
	Agrostis sp.		x	x	
	Aster subspicatus		x		
	Atriplex patula	x	x	x	x
	Bromus sp.		x	x	
	Deschampsia caespitosa	x	x	x	x
	Distichlis spicata		x	x	
	Fragaria chiloensis	x	x	x	x
	Grasses		x		x
	Herbs		x		
	Melilotus alba		x		x
	Rumex crispus		x		
	Scotch broom			x	
	Trifolium sp.		x		
	Vicchia sp.				x
11	Diatoms		x		
	Eleocharis parvula				x
	Enteromorpha sp.	x	x		
	Rhizoclonium sp.			x	x
	Vaucheria sp.	x	x	x	x
12	*Enteromorpha* sp.	x	x		x
	Rhizoclonium sp.			x	x
	Vaucheria sp.	x	x	x	x
13	Diatoms			x	
	Eleocharis parvula		x	x	
	Enteromorpha sp.	x	x		
	Rhizoclonium sp.			x	x
	Vaucheria sp.	x		x	x
14	*Enteromorpha flexuosa*	x	x	x	x
	Rhizoclonium sp.			x	x
	Vaucheria sp.		x	x	x

2.2.3 Interstitial Water Salinity Sampling

Interstitial water was sampled for salinity and temperature on October 11, 2000 at 14 stations (Figure 2). Interstitial water stations were co-located with sediment chemistry and/or grain size sample collection locations. Sampling was conducted on the first few hours of a daytime rising tide during a period with minimal rainfall. 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 thermometer and refractometer (Table 8). To collect interstitial water, a small hole was dug to a depth of about 25 cm (or until water appeared) and interstitial water was allowed to seep in. A clean pipette was used to transfer water to a refractometer; the thermometer was placed directly into the water. All equipment was rinsed with deionized water between stations.

In 2000, measured porewater salinities ranged from 25 to 33 ppt. Porewater salinities seem to be increasing at the site. This may be due to discontinuation of irrigation at the site.

Table 9. Interstitial Water Salinity Result Trends at Middle Waterway Shore Restoration Project

		Temp.(ºC)				Salinity (ppt)			
Station	**Elevation**	**1996**	**1997**	**1998**	**2000**	**1996**	**1997**	**1998**	**2000**
IW-1 (F)	10.1	14.4	11.5	18	12.8	28	19	25	30
IW-2 (GS-5)	11.1	14.9	11.5	20	--	30	29	25	--
IW-3 (GS-6)	12.4	15.3	12.5	21	--	20	13	15	--
IW-4 (GS-8)	12.3	15.7	12.5	21	14.8	19	9	14	32
MW-1(A)	9.4	--	12.5	18	12.2	--	8	25	29
GS-13	12.2	--	14.0	20	--	--	24	30	--
GS-2	11.6	--	11.3	--	13.7	--	21	--	33
HCA	8.6	--	--	17	12.3	--	--	25	25
GS-10	11.1	--	--	18	--	--	--	20	--
GS-12	9.8	--	--	18	12.3	--	--	25	27
GS-14	10.3	--	--	19	12.7	--	--	25	31
C	10.0	--	--	20	12.0	--	--	22	28
HC-2	7.1	--	--	18	13.3	--	--	25	28

-- Indicates not sampled or insufficient interstitial water was obtained for measurements.

2.3 WILDLIFE OBSERVATIONS

No wildlife observations were recorded on the Project site for Year 5.

3. REFERENCES

Cordell, J. 2001. Personal communication. University of Washington.

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

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USEPA. 1994a. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response. EPA-540/R-94-013. Washington, D.C. 42p.

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APPENDIX A

Relationship between Elevation and Grain Size and Analytical Laboratory Data Sheets – Sediment Grain Size

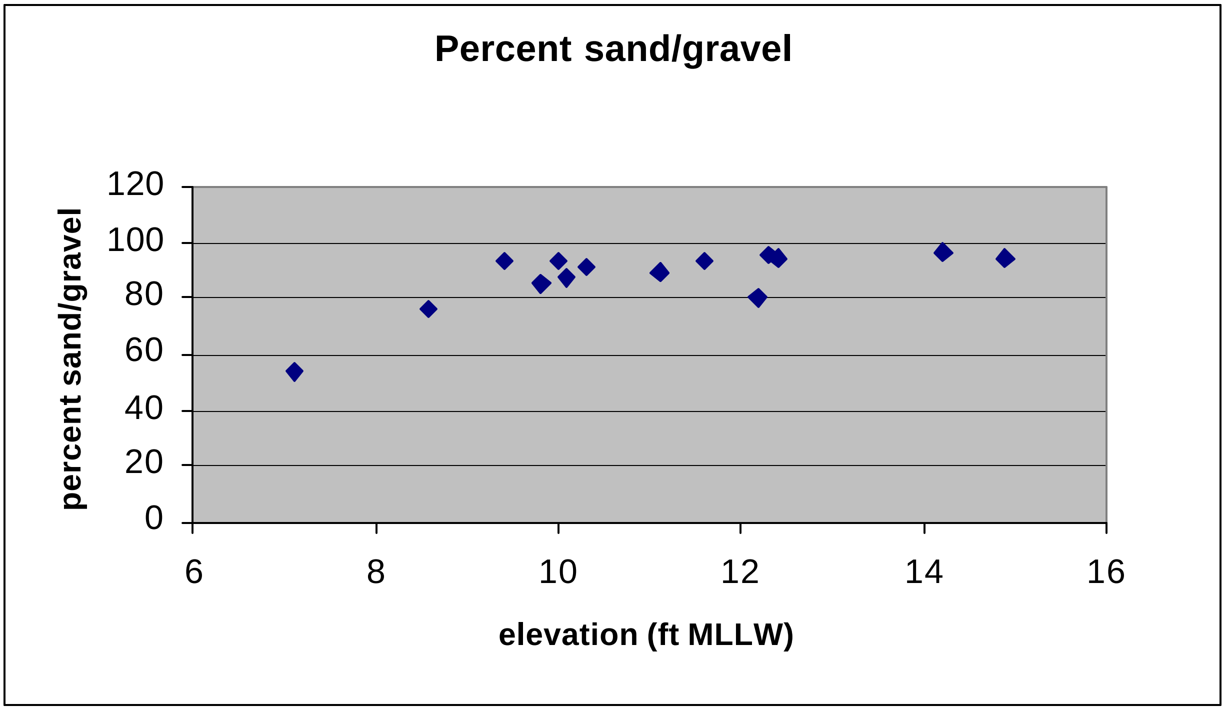

Figure A-1. **Relationship between Elevation and Percent Sand and Gravel in Sediments at Middle Waterway Shore Restoration Project (2000)**

APPENDIX B

Analytical Data Validation Memoranda and Analytical Laboratory Data Sheets – Sediment Chemistry

MEMORANDUM

Date: **September 13, 2000**

To: **Project File**

From: **Stuart Currie**

Subject: **Corrections to the sediment chemistry results table for the Middle Waterway Shore Restoration Project Year 5 report.**

cc: **Lucinda Tear, Michael Kluck**

Project Number: **555-1616-010**

Project Name: **Middle Waterway Shore Restoration Project**

This memorandum summarizes the corrections made to the sediment chemistry results table, previously identified as Table 4 in the 1998 Post-Construction Data Report (Year 3). As a result of QA/QC efforts during the initial stages of production of the 2000 Post-Construction Data Report (Year 5), several mistakes were found in the data reported in the sediment chemistry results table. In order to correct these mistakes, several changes were made to the table. These changes included:

- Reviewing the original laboratory reports and re-calculating the TOC-normalized concentrations reported in the table.

- Reviewing the original laboratory reports and flagging chemical data (previously reported as detected) as non-detected.

- Reviewing the original laboratory reports and reporting chemical data (previously flagged as non-detected) as detected.

- Flagging chemical data as being associated with TOC levels less than 0.5%.

- Recalculating the reported summed values for total LPAHs, total Benzofluoranthenes, and total HPAHs. Previous versions of the table had incorporated non-detected values by adding the reported detection limit to the summed total values. The Department of Ecology Sediment Management Standards (Chapter 173-204 WAC, 1995) state that the following methods are to be applied when summing individual compounds or isomers:

    1. Where chemical analyses identify an undetected value for every individual compound/isomer, then the single highest detection limit shall represent the sum of the respective compounds/isomers

    2. Where chemical analyses detect one or more individual compounds/isomers, only the detected concentrations will be added to represent the group sum.

MEMORANDUM

Date: **July 13, 2000**
To: **Project File____**
From: **Stuart Currie**
Subject: **Middle Waterway sediments - analytical data validation**
cc: **Michael Kluck**
Lucinda Tear

Project Number: **556-1616-010**
Project Name: **Champion-Tacoma/Middle Waterway Restoration Project**

QUALITY ASSURANCE REVIEW

This memorandum summarizes a Level 1 internal quality assurance/quality control review of sediment data for the Champion-Tacoma/Middle Waterway Restoration Project (Parametrix Project #556-1616-010). AmTest, Inc. in Redmond, WA performed the analyses in April 2000. Data were reviewed using the 1994 USEPA Contract Laboratory Program (CLP) National Functional Guidelines (NFG) for Inorganic and Organic Data Review (USEPA 1994a,b). Data were reviewed for a total of eighteen (18) sediment samples and the data review checklists are attached.

Analyses performed included:

- LPAH/HPAH by EPA 3550/8270
- Mercury by EPA 7471
- Total Solids, Total Volatile Solids, and Grain Size by PSEP methodology
- Total Organic Carbon by SM 5310B
- Acid Volatile Sulfides by DiToro, 1990 methodology

Data validation included evaluation of the following (as appropriate):

- Holding Times
- Laboratory Method Blanks
- Analytical or Spike Replicates and Relative Percent Difference (RPD) or Relative Standard Deviation (RSD)
- Matrix Spike Recoveries
- Standard Reference Materials

DATA QUALITY SUMMARY

The data package was found to be complete. The relevant sample collection, receipt, extraction, digestion, and analysis dates were included. All other necessary summary sample results, quality control (QC) results, and sample detection limits were provided. The laboratory also provided a narrative cover letter, which summarized the analyses performed, the analytical methods used, and any problems encountered during analysis.

Six (6) sediment samples were analyzed for all parameters requested (PAHs, mercury, and conventionals), while the remaining twelve (12) samples were analyzed for grain size only. The laboratory reported that there were no major problems with any of the analyses. All samples were analyzed within the method-specified holding times. Applicable laboratory method blanks were analyzed at the required frequency and no contamination was evident. Matrix spikes, matrix spike duplicates, analytical replicates, and reference material samples were all analyzed at the required frequency and their results were all within corresponding control limits. It was not necessary to qualify the analytical results of any of the samples collected for this project.

DATA VALIDATION

LPAH / HPAH

Sediment samples were analyzed for low molecular weight polycyclic aromatic hydrocarbon (LPAH) and high molecular weight polycyclic aromatic hydrocarbon (HPAH) compounds. Analysis was conducted by EPA Method 3550/8270, using a gas chromatograph with mass spectrometer detection (GC-MS).

All samples were extracted and analyzed within the method-specified holding times of 14 and 40 days, respectively. As noted by the laboratory, double the usual sample amount (i.e., two times 35 g, or 70 g) was extracted, in order to reach the lowest possible detection limits. A method blank was analyzed at the correct frequency (one per analytical batch), and no contamination was evident. A matrix spike and matrix spike duplicate were included in the extraction and analysis as required, and all recoveries were within the laboratory provided PSDDA control limits. The relative percent differences (RPDs) between the spike and spike duplicate compound results were also found to be in control (i.e., <50%).

Surrogate results for all analytical and QC samples were within control limits. A standard reference material sample (SRM) was analyzed and its recoveries were within the laboratory provided control limits. No samples were qualified as a result of the semivolatiles analyses.

Mercury

Mercury analysis was conducted on the sediment samples using cold vapor atomic absorption spectroscopy (CVAAS, EPA Method 7471). Samples were digested and analyzed within the specified holding time of 28 days. A method blank was analyzed along with the samples and no contamination was detected. A standard reference material, sample duplicates, and matrix spikes were analyzed at the required frequency (i.e., at least one per analytical batch) and all were within their respective control limits. No samples were qualified as a result of the mercury analyses.

Conventionals

Sediment samples were analyzed for Acid Volatile Sulfides (AVS), Total Solids (TS), Total Volatile Solids (TVS), Total Organic Carbon (TOC), and Grain Size by the appropriate methods. All samples were collected and analyzed within the respective required holding times. All applicable method blank concentrations were below the reporting limit. The TOC SRM (NBS 2704) was analyzed at the required frequency (one per analytical batch), and its recovery was within control limits. As no control limits were provided, limits of ±25% were used. Analytical replicates were performed at the required frequency (5%), and the chosen sample was analyzed in triplicate. The relative standard deviation (RSD) was within the assigned control limits of <20%. No samples were qualified as a result of the conventional analyses.

References

USEPA. 1994a. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response. EPA-540/R-94-013. Washington, D.C. 42p

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APPENDIX C

Benthic Invertebrate Data

Table C-1. Number of Samples Containing Benthic Organisms at Sampling Locations at Middle Waterway Shore Restoration Project and Hylebos Reference Site

				1994				2000			
Type	**Subgroup**	**Taxon**	**Juvenile fish prey**[a]	**HYL**	**MW-1a**	**MW-F**	**MW-HC-2**	**HYL**	**MW-1a**	**MW - F**	**MW-HC-2**
Acarina (mites)	Acarina	Acarina								1	
		Halacaridae		2							
Actiniaria (anemome)	Actiniaria	Nynantheae		6	9	8	9				
Crustacea	Amphipod	*Ampithoe* sp.			1	1					
		Corophium insidiosum	y			2				8	
		Corophium salmonis	y					2			
		Corophium sp.	y		1						
		Eogammarus confervicolus	y			2		1			
		Grandidierella japonica	y	1	11	11	2	10	10	10	6
	Cumacean	*Cumella vulgaris*	y				2			1	
		Nippoleucon hinumensis	y	4	9	8		2	1	5	
	Harpacticoid copepods	*Harpacticus* sp.	y					1	3		
		Heterolaophonte discophora								1	
		Huntemannia jadensis						1			
		Nitokra sp.						1			
		Schizopera knabeni						1			
	Isopod	*Limnoria lignorum*		1	11	11					
	Tanaaiid	*Sinelobus stanfordi*		10	10	10	4		1		
Insect	Ceratopogonidae	Ceratopogonidae	y							2	
	larvae	Chironomidae larvae	y					6	1	1	1
		Insect larval stages			10	1					
Mollusca	Bivalvia	*Macoma balthica*		2							
Nematoda	Nematoda	Nematoda						7		5	4
Nemertea	Nemertea	Nemertinea		6	2						
Nereid	Nereid	*Nereis virens*		2	2		2				
Oligochaeta	Oligochaeta	Oligochaeta		11	11	10	8	9	5	8	9

Table C-1. Number of Samples Containing Benthic Organisms at Sampling Locations at Middle Waterway Shore Restoration Project and Hylebos Reference Site (Continued)

				1994				2000			
Type	**Subgroup**	**Taxon**	**Juvenile fish prey[a]**	**HYL**	**MW-1a**	**MW-F**	**MW-HC-2**	**HYL**	**MW-1a**	**MW - F**	**MW- HC-2**
Polychaeta	Polychaeta	*Abarenicola* sp.						2			1
		Abarenicola sp. *Juv*.				2					
		Boccardia proboscidea		5	11	2	2				
		Capitella capitata complex		10	11	11	11	10	9		9
		Eteone californica									3
		Eteone longa			6	4	2				
		Eteone sp.									1
		Manayunkia aestaurina		10	10	2	2	9	9	1	10
		Polydora cornuta		2	5	9	11	1			3
		Polydora sp.					2				
		Pseudopolydora kempi		6	3	4		1			4
		Pygospio elegans		7	11	9	7	10	3		10
		Streblospio benedicti						1			
		Tharyx sp.						1			2
Species richness				**16**	**18**	**18**	**13**	**19**	**9**	**11**	**13**

[a] Source: Cordell 2001 personal communication.

Table C-2. Total Number of Organisms Found in Benthic Samples at Middle Waterway Shore Restoration Project Benthic Sampling Stations and Hylebos Reference Site

				1994				2000			
Type	**Subgroup**	**Taxon**	**Juvenile fish prey[a]**	**HYL**	**MW-1a**	**MW - F**	**MW-HC-2**	**HYL**	**MW-1a**	**MW - F**	**MW-HC-2**
Acarina (mites)	Acarina	Acarina								1	
		Halacaridae		2							
Actiniaria (anemome)	Actiniaria	Nynantheae		24	44	48	52				
Crustacea	Amphipod	*Ampithoe* sp.			1	1					
		Corophium insidiosum				2				39	
		Corophium salmonis						2			
		Corophium sp.			1						
		Eogammarus confervicolus				2		1			
		Grandidierella japonica		175	244	223	55	133	175	118	53
	Cumacean	*Cumella vulgaris*					2			2	
		Nippoleucon hinumensis		7	322	76		7	1	14	
	Harpacticoid copepods	*Harpacticus* sp.						2	3		
		Heterolaophonte discophora								1	
		Huntemannia jadensis						1			
		Nitokra sp.						1			
		Schizopera knabeni						1			
	Isopod	*Limnoria lignorum*		8	42	62					
	Tanaaiid	*Sinelobus stanfordi*		119	168	248	24		1		
Insect	Ceratopogonidae	Ceratopogonidae								19	
	larvae	Chironomidae larvae						10	1	1	2
		Insect larval stages			140	1					
Mollusca	Bivalvia	*Macoma balthica*		2							
Nematoda	Nematoda	Nematoda						18		9	10
Nemertea	Nemertea	Nemertinea		32	2						
Nereid	Nereid	*Nereis virens*		2	2		2				
Oligochaeta	Oligochaeta	Oligochaeta		1734	380	96	102	78	10	26	84

Table C-2. Total Number of Organisms Found in Benthic Samples at Middle Waterway Shore Restoration Project Benthic Sampling Stations and Hylebos Reference Site (Continued)

				1994				**2000**			
Type	**Subgroup**	**Taxon**	**Juvenile fish prey**[a]	**HYL**	**MW-1a**	**MW-F**	**MW-HC-2**	**HYL**	**MW-1a**	**MW - F**	**MW-HC-2**
Polychaeta	Polychaeta	*Abarenicola* sp.						4			1
		Abarenicola sp. *Juv*.				2					
		Boccardia proboscidea		42	358	2	2				
		Capitella capitata complex		288	324	422	270	85	42		48
		Eteone californica									4
		Eteone longa			16	8	2				
		Eteone sp.									1
		Manayunkia aestaurina		1286	102	2	2	52	61	1	352
		Polydora cornuta		2	34	72	194	1			3
		Polydora sp.					2				
		Pseudopolydora kempi		12	4	8		2			5
		Pygospio elegans		36	112	20	34	142	4		171
		Streblospio benedicti						1			
		Tharyx sp.						1			2

[a] Source: Cordell 2001 personal communication.

APPENDIX D

Vegetation Data

Parametrix, Inc. Middle Waterway/556-1616-010/01(07) 4/01 (K)

Figure D-1
Aerial View of Middle Waterway Shore Restoration Project and Surrounding Land Uses (2000)

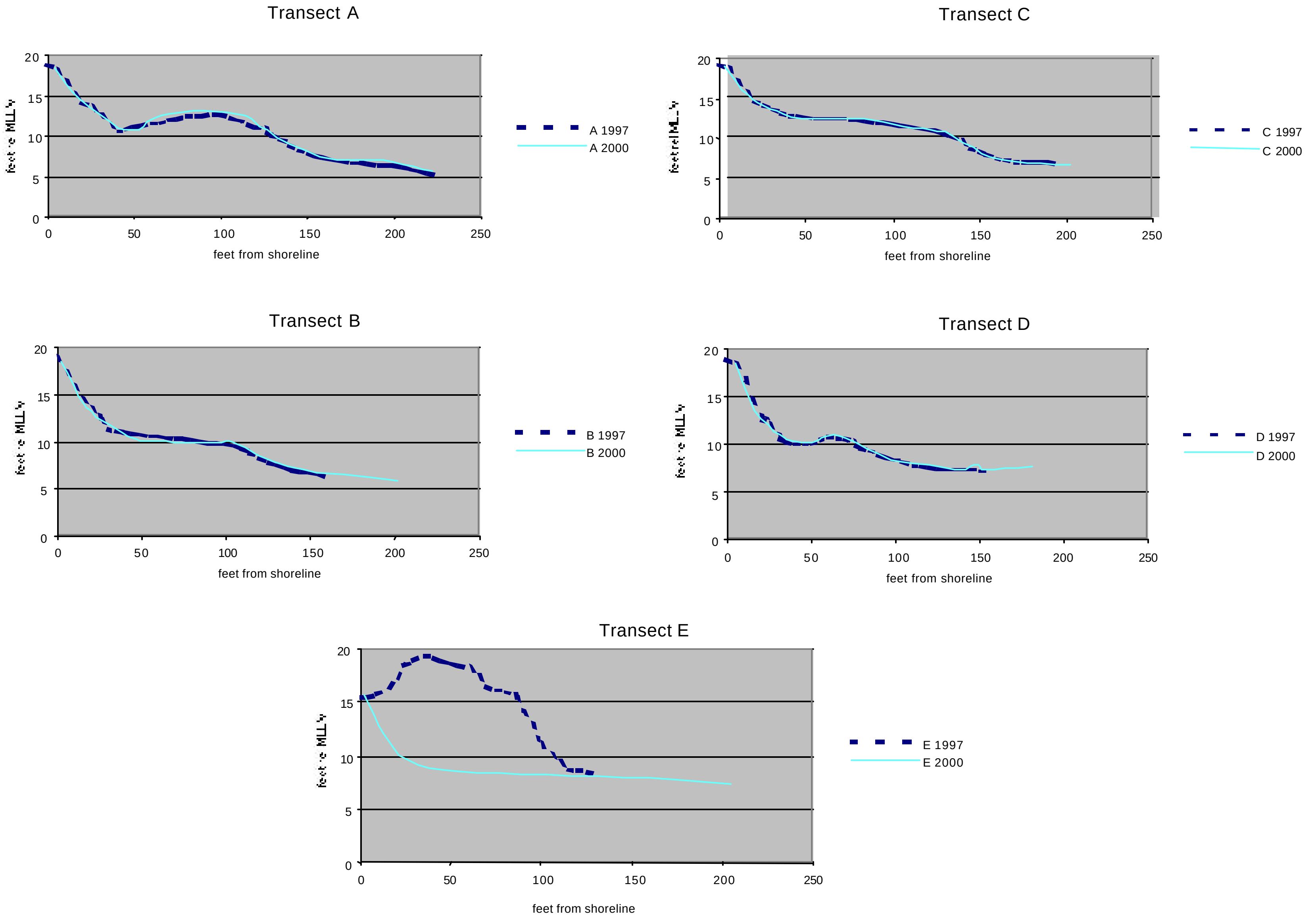


Figure D-2. Vertical Transect Elevations at Middle Waterway Restoration Site, 1997 and 2000. Transects are Ordered Alphabetically from North to South.

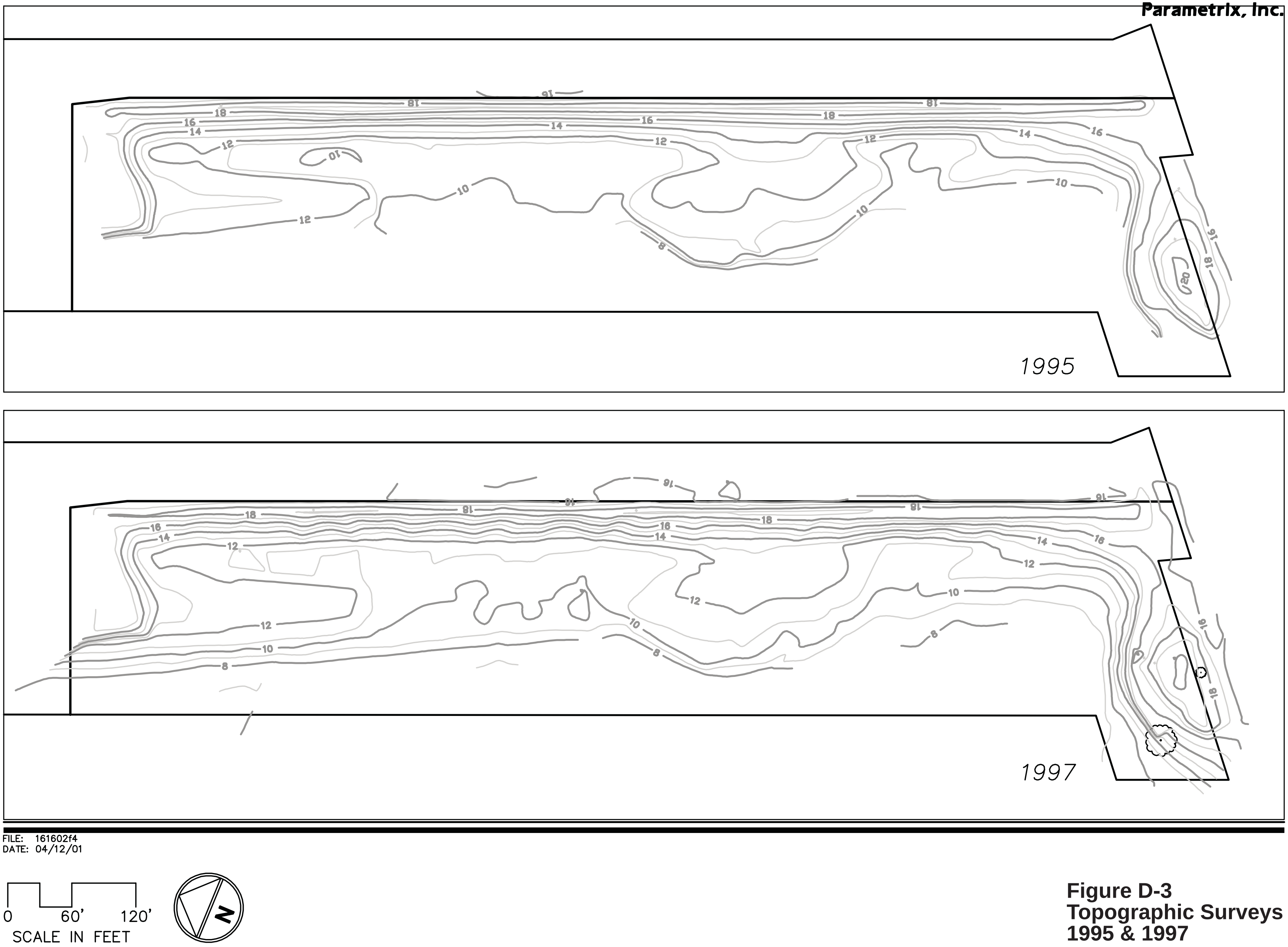
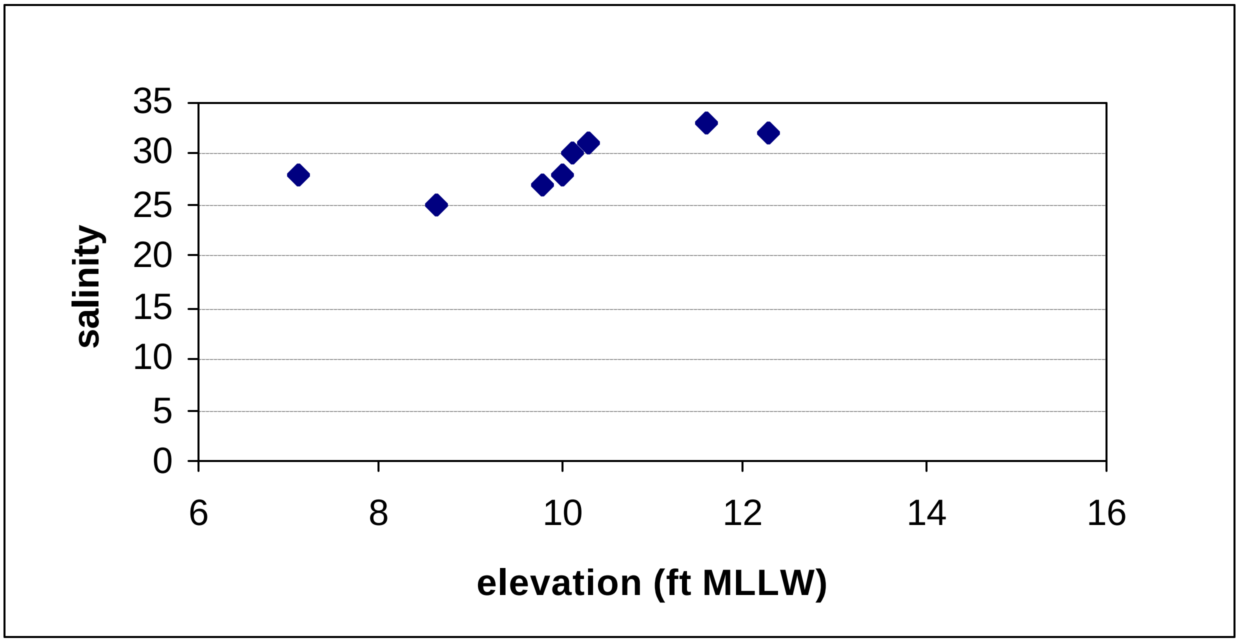


Figure D-3
Topographic Surveys
1995 & 1997



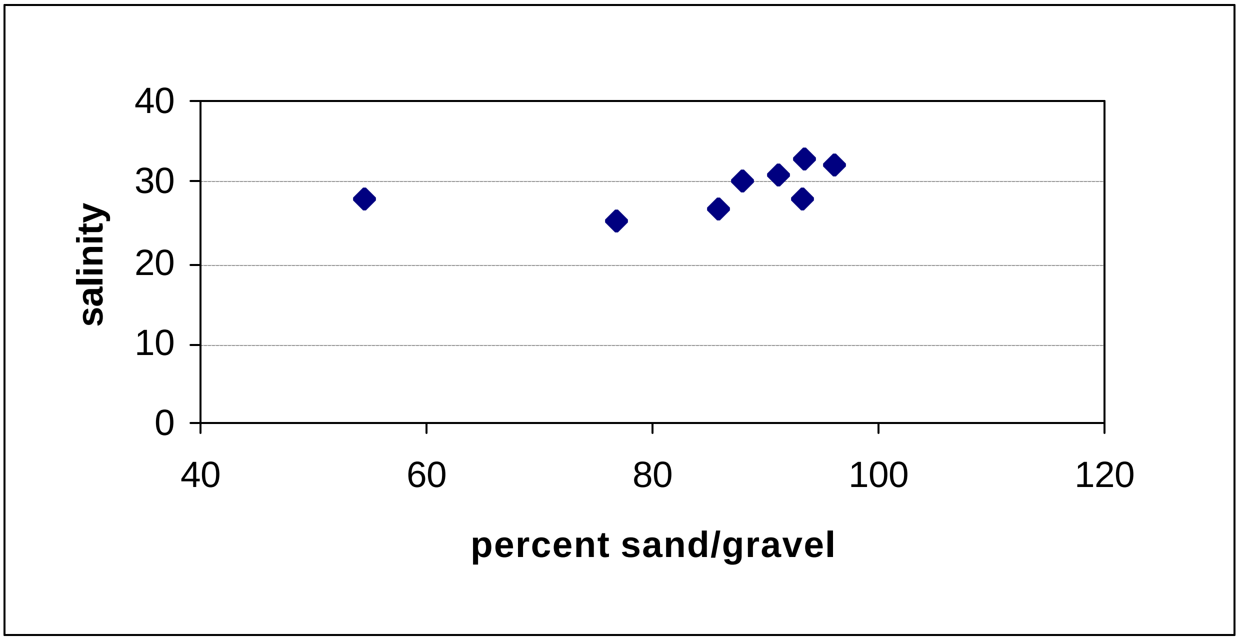


Figure D-4. Relationship between Porewater Salinity, Elevation, and Percent Sand/Gravel at Middle Waterway Shore Restoration Project (2000)

Table D-1. Locations, Elevation, Sediment Grain Size, and Porewater Salinity for Middle Waterway Shore Restoration Project (2000)

	Northing	Easting	Elevation	% Sand/Gravel	% Silt/Clay	Porewater Salinity
GS-1	707091.2	1521954	14.9	94.3	6	
GS-2	707125.5	1521909	11.6	93.4	6.6	33
GS-4	707175.1	1521851	9.8	85.2	15	
GS-5	707240.7	1521810	11.1	89.3	10.8	
GS-6	707279.4	1521839	12.4	94.7	5.3	
GS-7	707330.2	1521851	14.2	96.5	3.6	
GS-8	707345.9	1521807	12.3	96.1	4.1	32
GS-10	707418.1	1521742	11.1	89	11	
GS-12	707561.1	1521676	9.8	85.8	14.1	27
GS-13	707668.2	1521655	12.2	80	20	
GS-14	707767.9	1521643	10.3	91.2	9.1	31
HYL3				94.8	5.4	
MW-1	707652	1521609	9.4	93.6	6.8	
MW-1D2				95.2	4.8	
A	707432.5	1521715	8.6	76.7	23.2	25
C	707198.8	1521891	10	93.2	6.9	28
HC-2	707120	1521797	7.1	54.4	45.6	28
F	707315	1521733	10.1	87.8	12.4	30

Table D-2. Photographic Record - Middle Waterway Shore Restoration Project (2000)

Date: August 1, 2000 **Observer:** L. Tear, M. Kluck

Site and Location	Photo Numbers	Description/Remarks/Wildlife Observations
Outside site (East)	Dscf 0001.jpg	trial picture to see how camera works
by SGS14, transect 5	Dscf 0002.jpg	*Vaucheria* coverage
by SGS14, transect 5	Dscf 0003.jpg	*Eleocharis parvula* coverage
by SGS14, transect 5	Dscf 0004.jpg	*Eleocharis parvula* coverage; zoom in
east berm, transect 5	Dscf 0005.jpg	looking down transects 5 & 6
north berm, transect 6	Dscf 0006.jpg	planted vegetation and bird protection
south berm, transect 5	Dscf 0007.jpg	channel forming south of berm
start of transect 11/13	Dscf 0008.jpg	*Vaucheria* and *Rhizochlonium* mix
transect 12	Dscf 0009.jpg	dense *Rhizochlonium/Vaucheria* mix
transect 9	Dscf 0010.jpg	bright patch of *Rhizochlonium/Enteromorpha*
transect 14 - north	Dscf 0011.jpg	view north towards waterway inlet
transect 14	Dscf 0012.jpg	dried patches of *Rhizochlonium*
transect 14	Dscf 0013.jpg	view north towards waterway inlet
north of transect 10	Dscf 0014.jpg	view of project area
south of transect 10	Dscf 0015.jpg	view of shoreline coverage

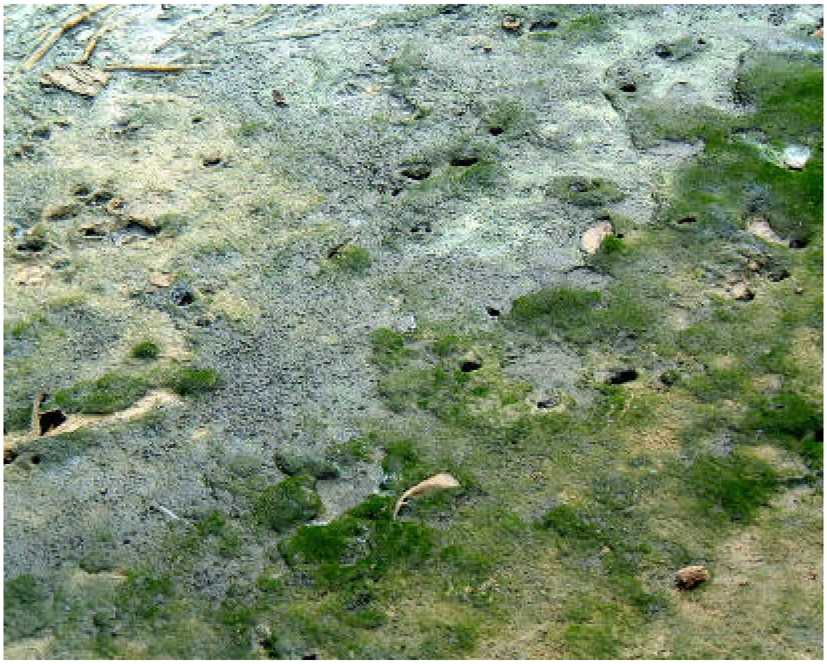


Figure D-5. *Vaucheria* **Coverage**

Figure D-6. *Eleocharis parvula* **Coverage**

Figure D-7. ***Eleocharis parvula*** **Coverage**

Figure D-8. Looking Down Transects 5 and 6

Figure D-9. Planted Vegetation and Bird Protection

Figure D-10. Channel Forming South of Berm

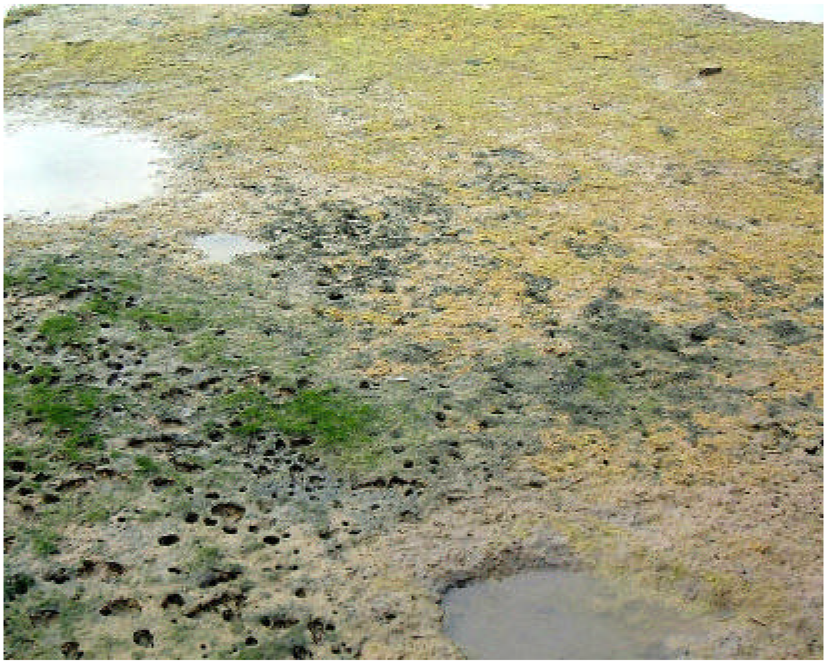


Figure D-11. ***Vaucheria*** **and** ***Rhizochlonium*** **Mix**

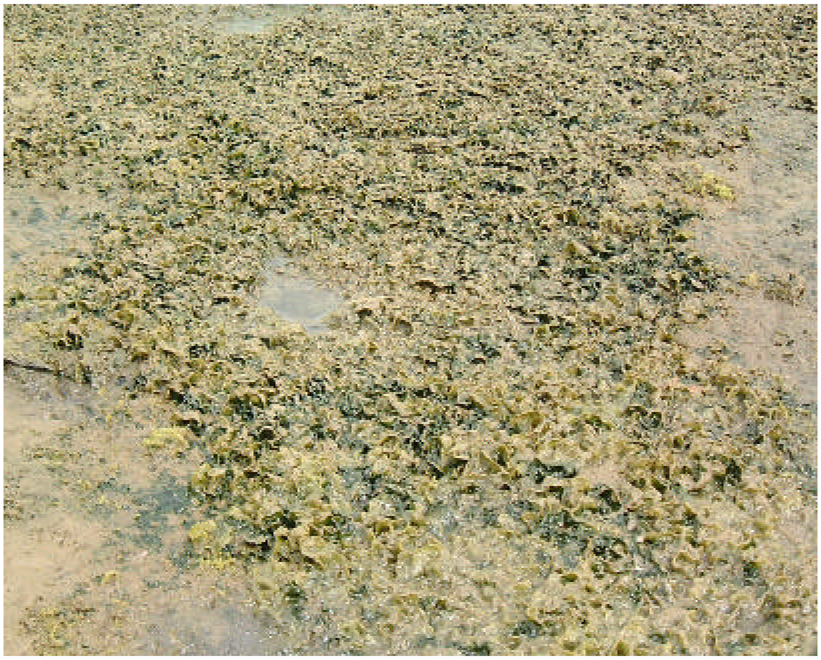


Figure D-12. Dense ***Rhizochlonium*** **/*Vaucheria*** **Mix**

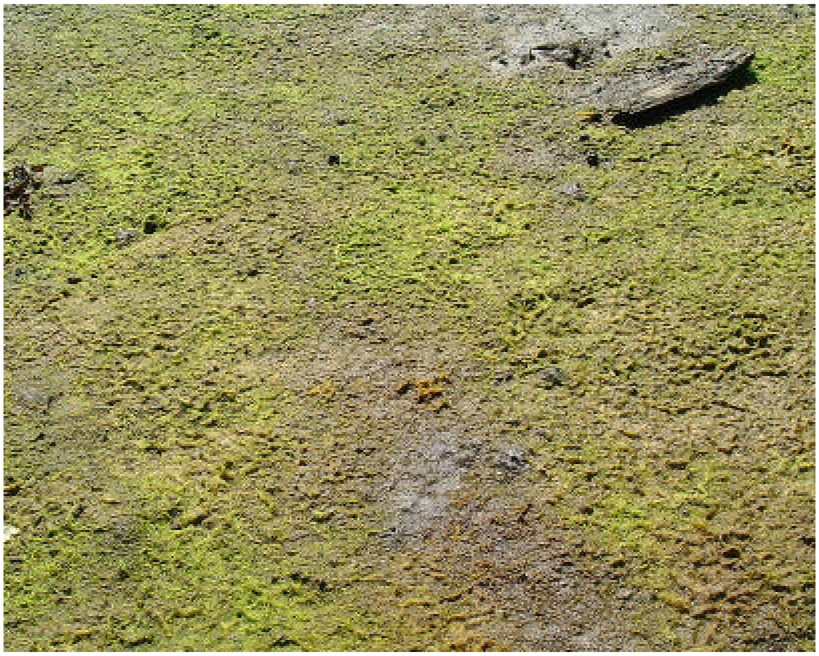


Figure D-13. Bright Patch of *Rhizochlonium/Enteromorpha*

Figure D-14. View North towards Waterway Inlet

Figure D-15. Dried Patches of *Rhizochlonium*

Figure D-16. View North towards Waterway Inlet

Figure D-17. View of Project Area

Figure D-18. View of Shoreline Coverage

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 5 **Observers:** L. Tear, M. Kluck

Macrophyte Bed: Low salt marsh, planted, mudflat **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.87	W	1.62	*Vaucheria* sp.	60	Thin
2	3.00	W	1.81	*Vaucheria* sp.	90	Medium
3	6.24	W	0.05	*Eleocharis parvula* *Vaucheria* sp. Diatoms *Rhizochlonium* sp.	10 trace 90 trace	
4	9.53	W	0.433	*Vaucheria* sp. Diatoms	75 25	
5	14.09	W	2.56	*Vaucheria* sp. *Rhizochlonium* sp.	70 trace	Diatoms
6	16.42	E	2.02	*Eleocharis parvula* Diatoms	40-50 100	Sheen and iron coloring
7	19.09	W	1.09	*Vaucheria* sp. Diatoms *Rhizochlonium* sp.	trace 90 trace	
8	24.02	E	1.5	*Eleocharis parvula*	2	Diatoms
9	25.1	E	3.68	Bare	0	sand
10	30.90	E	2.85	*Enteromorpha sp.*	2	Not at lowest elevations in channel.

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 12 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Mud #2 **Starting Point:** West @ GS-4

Plot #	Distance (m)			Species	% Cover	Remarks
1	1.1	S	0.61	*Rhizochlonium* sp.	100	Thick
				Enteromorpha sp.	trace	
2	5.07	N	2.61	*Vaucheria* sp.	100	Thin
				Enteromorpha sp.	trace	
				Rhizochlonium sp.	trace	
3	8.93	N	1.10	*Enteromorpha* sp.	trace	Thin
				Rhizochlonium sp.	50	
				Vaucheria sp.	50	
4	13.22	S	2.48	*Rhizochlonium* sp.	25	Pool
				Enteromorpha sp.	trace	
				Vaucheria sp.	75	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 13 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Mud Cap #1 **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	5.69	E	2.94	*Rhizochlonium* sp. *Rhizochlonium* sp.	40 50	Lush Thin
2	16.15	E	2.95	*Rhizochlonium* sp. *Rhizochlonium* sp.	30 70	Some water Thinner
3	24.29	E	1.63	*Rhizochlonium* sp. *Vaucheria* sp.	15 5	Diatom

MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 11 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Mud #1 **Starting Point:** South

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.16	E	3.78	*Eleocharis parvula* *Vaucheria* sp. Diatoms	5 90	
2	1.94	W	1.55	*Rhizochlonium* sp. *Vaucheria* sp.	99 trace	
3	7.09	E	4.78	*Vaucheria* sp. *Eleocharis parvula*	95 trace	Thick then thinning across area
4	10.75	W	0.89	*Rhizochlonium* sp. *Vaucheria* sp.	75 trace	Pool
5	16.46	E	3.78	*Rhizochlonium* sp. *Vaucheria* sp.	50 trace	Very green Very thin
6	22.27	W	0.21	*Rhizochlonium* sp. *Vaucheria* sp.	50 50	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 9 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Low salt marsh control, unplanted, somewhat sandy **Starting Point:** South

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.4	E	4.3	*Rhizochlonium* sp.	trace	
2	3.9	E	2.7	Bare	0	
3	10.6	W	0.19	*Rhizochlonium* sp.	100	Matted
4	16.7	E	3.2	*Vaucheria* sp. *Rhizochlonium* sp. *Enteromorpha* sp.	50 50 trace	Mixed w/ *Rhizochlonium* sp. Mixed w/ *Vaucheria* sp., small white worms
5	23.2	W	4.2	*Rhizochlonium* sp. *Enteromorpha* sp. *Vaucheria* sp.	95 trace trace	Dried clumps

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1,2000 **Transect:** 4 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: High salt marsh control **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	3.1	W	1.7	Bare	0	
2	10.4	W	2.4	Bare		
3	20.2	W	0.0	*Fragaria chiloensis*	trace	
4	30.6	W	2.2	Bare	0	
5	34.6	W	0.3	*Deschampsia caespitosa* *Scirpus maritimus*	trace trace	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1,2000 **Transect:** 8 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Low salt marsh control, unplanted, mud base **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.2	E	3.5	*Eleocharis parvula* *Vaucheria* sp.	5 10	Depression Iron colored
2	7.3	W	8.6	*Vaucheria* sp. *Rhizochlonium* sp.	95 trace	
3	14.2	E	3.7	*Rhizochlonium* sp. *Vaucheria* sp.	95 5	Standing water Lush
4	17.3	E	0.7	*Rhizochlonium* sp. *Vaucheria* sp.	60 30	
5	23.5	E	1.4	*Vaucheria* sp. *Rhizochlonium* sp.	20 5	Pool Sandy

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 6 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Mudflat **Starting Point:** South

Plot #	Distance (m)			Species	% Cover	Remarks
1	1.8	E	2.2	*Vaucheria* sp. *Rhizochlonium* sp.	50 5	Medium pieces of loose organic matter Small pool
2	4.4	E	0.1	*Vaucheria* sp. *Vaucheria* sp. *Salicornia virginica* *Rhizochlonium* sp.	90 10 trace 5-10	Thin Thick
3	11.1	W	2.0	*Salicornia virginica*	trace	Sandy, some gravel

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 1 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: High salt marsh, enclosure **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.8	E	1.0	Bare	0	
2	2.9	W	3.9	*Atriplex patula*	trace	
3	8.1	E	0.0	Bare	0	
4	11.3	E	4.7	Bare	0	
5	16.3	E	2.2	Bare	0	
6	22.4	W	4.8	Bare	0	
7	29.1	W	3.0	Bare	0	
8	33.6	E	4.5	*Vaucheria* sp. *Rhizochlonium* sp.	90 trace	Some thick, some thin
9	41.6	W	3.0	Bare	0	
10	46.7	E	1.4	*Vaucheria* sp.	90	Thin

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 7 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: Low salt marsh, planted, enclosure **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	0.7	W	0.2	*Atriplex patula* *Salicornia virginica* *Distichlis spicata*	10 trace trace	
2	4.7	W	0.9	*Atriplex patula*	15	Logs
3	17.4	W	0.6	Bare	0	
4	21.7	W	0.25	Bare	0	
5	25.8	W	0.7	Bare	0	
6	31.9	W	0.15	Bare	0	
7	42.8	W	0.55	Bare	0	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 2 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: High salt marsh, planted, enclosure **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	10.5	E	1.2	*Atriplex patula*	trace	
2	19.7	E	0.5	*Deschampsia caespetosa*	5	
3	23.5	E	0.4	*Deschampsia caespetosa*	5	
4	33.8	E	0.3	Bare	0	
5	49.0	E	1.3	Bare	0	
6	64.9	E	1.5	Bare	0	
7	79.7	E	1.9	*Atriplex patula* *Deschampsia caespetosa*	trace trace	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 3 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: high salt marsh, no top dress **Starting Point:** North

Plot #	Distance (m)			Species	% Cover	Remarks
1	1.0	W	5.7	Bare	0	
2	2.7	W	2.5	Bare	0	
3	4.5	E	7.3	Bare	0	Drift straw
4	11.8	E	1.3	Bare	0	
5	15.6	W	0.4	Bare	0	
6	21.8	W	1.8	Bare	0	
7	23.7	E	5.5	*Rhizochlonium* sp.	trace	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 10 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: High salt marsh, planted, enclosed, south end of site **Starting Point:** West

Plot #	Distance (m)			Species	% Cover	Remarks
1	11.5	N	0.6	*Melilotus alba*	25	
				Deschampsia caespetosa	75	
				Vicchia sp.	trace	
				Grass	trace	
2	19.0	N	0.5	*Melilotus alba*	25	
				Deschampsia caespetosa	75	
				Fragaria chiloensis	trace	
3	28.5	N	0.5	*Deschampsia caespetosa*	100	
				Atriplex patula	trace	

HERBACEOUS VEGETATION COVER DATA
MIDDLE WATERWAY SHORE RESTORATION
WETLAND MITIGATION MONITORING

Date: August 1, 2000 **Transect:** 14 **Observer:** L. Tear, M. Kluck

Macrophyte Bed: High to low salt marsh, topdressed (Mud Cap #2) **Starting Point:** East

Plot #	Distance (m)			Species	% Cover	Remarks
1	9.4	N	0.8	*Rhizochlonium* sp.	trace	Sand
2	12.7	N	0.6	*Vaucheria* sp. *Rhizochlonium* sp.	50 2	
3	16.7	S	1.4	*Vaucheria* sp.	100	Thick
4	19.9	S	0.6	*Rhizochlonium* sp. *Enteromorpha* sp.	95 trace	Dried clumps
5	22.0	N	2.2	*Rhizochlonium* sp. *Vaucheria* sp.	55 45	Dried clumps
6	23.7	N	0.3	*Rhizochlonium* sp.	100	Dried clumps
7	27.8	S	1.7	*Enteromorpha* sp. *Vaucheria* sp.	95 trace	Lower, very green, thick and thin varieties

APPENDIX E

Analytical Laboratory Data Sheets