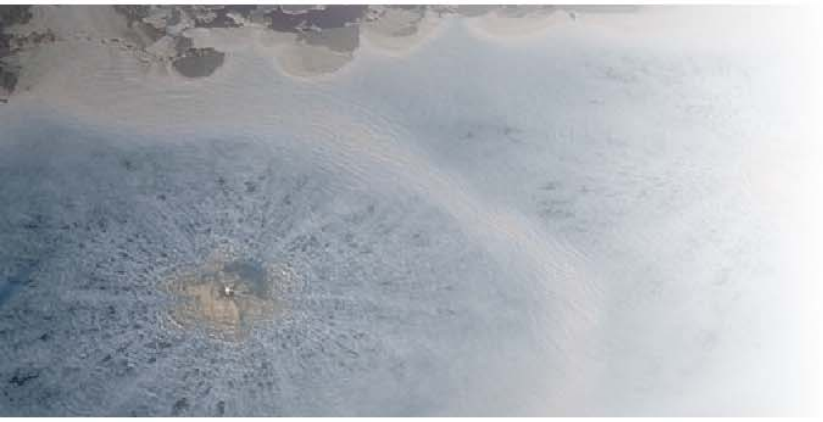

Year 2 (2006) Monitoring Report
Middle Waterway Problem Area C
Sediment Management Units 51a and 51b
Commencement Bay Nearshore/ Tideflats Superfund Site
Tacoma, Washington

Prepared for
Washington Department of Natural Resources

June 20, 2007
7946-02

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HABITAT MONITORING REPORT – YEAR 2
MANAGEMENT OF ENVIRONMENTAL RESOURCES, INC.

YEAR 2 (2006) MONITORING REPORT
MIDDLE WATERWAY PROBLEM AREA C
SEDIMENT MANAGEMENT UNITS 51a AND 51b
COMMENCEMENT BAY NEARSHORE/TIDEFLATS SUPERFUND SITE
TACOMA, WASHINGTON

1.0 INTRODUCTION

This report presents results of Year 2 (2006) post-construction monitoring for the Remedial Action completed at Middle Waterway Area C. A Vicinity Map and Site Plan for the Middle Waterway Area C are presented on Figures 1 and 2, respectively. The Remedial Action for Area C was completed between July and October 2004 by the Washington Department of Natural Resources (DNR). The Remedial Action removed and backfill and capped contaminated intertidal sediment near the head of the waterway. Post-construction monitoring is being completed to assess the performance of sediment backfilling and capping, and to ensure that long-term performance objectives are met. Monitoring activities for the Year 2 event were completed in accordance with the project Operations, Maintenance, and Monitoring Plan (OMMP, Hart Crowser 2005b). The Year 2 monitoring activities focused on observing the physical condition of the project area, evaluating erosion features, collecting samples for physical testing, and assessing upland and tideflat habitat conditions. Additional sediment sampling and chemical testing is planned during the upcoming Year 3 monitoring in 2007.

The Year 2 monitoring complies with the conditions and requirements of the Remedial Design/Remedial Action (RD/RA) Consent Decree (Civil Action No. CO3-5331 (RJB) FDB), dated August 14, 2003, U.S. Environmental Protection Agency (EPA 2003b). The Consent Decree was issued by the EPA to the DNR, City of Tacoma (City), and other parties. The Year 2 monitoring also addresses the requirements of EPA's Statement of Work (SOW)-Remedial Design, Remedial Action, and Long-Term Monitoring, dated April 10, 2003 (EPA 2003a).

1.1 Remedial Action and Monitoring Summary

The Remedial Action included sediment management units (SMUs) 51a and 51b of Middle Waterway Problem Area C (Figure 2). These SMUs were contaminated with metals and heavy-end organic constituents from historical waste disposal and industrial activities. Remedial activities involved excavation of more than 3,125 cubic yards of contaminated sediment from SMU 51a and backfilling of the SMU 51a excavation areas. In SMU 51b, a thin-layer cap was placed as a measure to enhance natural attenuation. In addition to removing and capping a substantial volume of contaminated sediments, the Remedial

Action restored intertidal habitat to restore one of the last original tideflats in Commencement Bay. Additional project details are described in the Remedial Action Construction Report (RACR, Hart Crowser 2005a).

Previous monitoring was completed in 2004 for the Year 0 post-construction baseline (Hart Crowser, 2006a), and in 2005 for Year 1 (Hart Crowser, 2006b). Monitoring results indicated that the post-construction objectives for the Remedial Action listed in the Consent Decree, SOW, and OMMP are being achieved. Additional details, and discussion of conditions related to the upland and tideflat habitat restoration, are presented in the Year 0 and Year 1 monitoring reports.

1.2 Monitoring Objectives and Scope

The overall objective of post-construction monitoring is to confirm that the Remedial Action is achieving the project performance objectives listed in the Consent Decree and SOW. These objectives include confirmation that:

- Performance standards are achieved throughout the area of the Remedial Action;
- Exposure of potential contaminants has not occurred through physical processes; and
- Natural recovery in SMU 51b has occurred within 10 years following completion of construction for the Remedial Action.

Monitoring is targeted for a minimum of 5 years following completion of construction in 2004. The need for potential additional monitoring will be evaluated following the Year 5 (2009) monitoring event, with revisions made to the monitoring strategy, as necessary. The frequency and years for long-term monitoring coincide with additional monitoring for Middle Waterway Area A and Area B being conducted by others.

1.3 Year 2 Monitoring Activities

Monitoring for Year 2 included:

- Sampling and grain size and water content testing of select surface sediment locations in SMU 51a and SMU 51b;

- Documentation of the physical characteristics of the restored tideflat to evaluate potential erosion, sediment deposition, and the extent of intermixing with underlying sediments; and

- Ensuring that the backfill function and thickness are not compromised where minor residual contamination remains at the base of the backfilled excavation in the central portion of SMU 51a.

Monitoring also included documentation of upland and tideflat habitat conditions following restoration efforts completed in 2004 and 2005. These activities are conducted separately from the CERCLA requirements for the project, but are included in Appendix B of this monitoring report for documentation purposes, and to provide continuity with other monitoring activities. Recolonization and recruitment of benthic organisms on the restored tideflat surface demonstrate the overall success of capping and backfilling as a key objective of the SOW. It should be noted that EPA's review and approval of this Year 2 Baseline Monitoring Report does not include the habitat restoration component.

1.4 Performance Standards

Performance standards for physical monitoring are described in the OMMP. Although physical performance standards are only applicable to areas of SMU 51a where sand backfill overlies residual contamination, an assessment was completed for both SMU 51a and SMU 51b. Applicable performance standards for Year 2 monitoring activities are presented in text discussions below.

1.5 Elements of the Year 2 Monitoring Report

The remainder of this report contains the following sections:

- Section 2.0 Results of Physical Monitoring;
- Section 3.0 Physical Characteristics Assessment;
- Section 4.0 References.

Appendix A presents photographs from the Year 2 field activities. Results of habitat monitoring for Year 2 are presented in Appendix B. For reference purposes, sediment sampling grids are identified on Figures 3, 4, 5, and 7. These grids were established to identify general locations where previous and future planned sediment samples collected were/will be collected for chemical testing. The grids are also referenced in the current monitoring report to describe tideflat conditions, sediment sample locations for physical testing, and site photograph locations.

2.0 RESULTS OF PHYSICAL MONITORING

Physical monitoring for Year 2 was completed between August 22 and September 20, 2006. In addition to the visual monitoring described in the OMMP, four sediment samples were collected from selected areas of the cap and analyzed for grain size distribution and water content to evaluate "soft" conditions noted in central portion of SMU 51a (see Section 3.0). Hart Crowser collected twenty-one additional samples during a second site visit on September 20, 2006 for additional grain-size testing. Sample locations are presented on Figures 4 and 5. Physical monitoring included visual inspections and elevation surveys as described below. Monitoring was conducted during low tide periods when the tideflat was exposed. Locations of referenced photographs are identified on Figure 7.

2.1 Visual Inspection

Visual inspection included observations of the physical appearance and integrity of the restored tideflat surface in SMU 51a and SMU 51b. Additional specific observations were made at locations where sediment samples were previously collected for laboratory chemical testing.

General Appearance

The near-surface backfill in SMU 51a and capping material in SMU 51b form a relatively even surface with the original tideflat. No seams, variations, or other discontinuities were seen between these areas and the adjacent tideflat (Photograph 1).

As expected, small, localized depression pockets (less than about 6 inches deep) persist throughout SMUs 51a and 51b. As described in Appendix B, these depressions are where the most recolonization and biological recruitment activity are observed. Previous monitoring reports identified a shallow depression of approximately 1,000 square feet also formed following capping in the southern part of SMU 51b. This depression formed during placement and/or settling of the surficial backfill in a low-relief part of the tideflat. This low-relief area was present prior to conducting the Remedial Action and may have promoted formation of the shallow depression and associated ponding on the post-backfill surface. These three sections have few direct drainage pathways to reduce the amount of ponded water present during low tide and are less consolidated than other areas.

Other areas of SMU 51a and SMU 51b have continued to smooth and form even surfaces transitional to the mudflat tidal channels. The brown algal layer

noted in the fall of 2004, and spring, summer and fall of 2005 remained, but was curling upward in some locations. Fine, hair-like structures were also prevalent in the algal mat. These algae tended to form thin mats that trap fine silts. As during previous monitoring events, this algal material is underlain by a thin layer of fine black silt and sand demarking an anoxic zone just above the brown backfill or cap (Photograph 2). A sulfide-like odor was also observed in sediments below the algae in Sampling Grids B-2 and M.

An abundance of small holes up to several millimeters in diameter were also present throughout the SMU 51a backfill and SMU 51b thin-layer cap as a result of burrows from near-surface biological recruitment, as illustrated in Photographs 3 and 4 and described further in the Appendix B habitat monitoring report. Larger burrows up to about 2 to 3 centimeters in diameter were also present in many areas and may be indicative of the presence of Ghost Shrimp (see Figure B-1 of Appendix B).

Lager holes ranging in diameter from 18 to 24 inches were also observed in areas O and N of SMU 51b. Based on their size and appearance, these holes appear to be human-made and could possibly have been used to search for and/or harvest clams (Photograph 5).

Response: The burrow features noted are not expected to affect the performance of the backfill in SMU 51a or thin-layer cap in SMU 51b. These features will continue to be visually monitored. Chemical testing of supplemental sediment samples collected from selected burrow areas is also planned during Year 3 (2007) and Year 5 (2009) monitoring.

Surficial Sediment Thickness and Composition

Material placed for surficial backfill in SMU 51a and thin-layer capping in SMU 51b consisted of brown, silty sand and sandy silt. During Year 2 monitoring, the depth to the interface with underlying backfill in SMU 51a and native sediments in SMU 51b mainly varied from about 6 to 12 inches, with localized areas of up to 14 inches observed. The observed cap thicknesses were consistent with those observed during the original cap placement. There was no indication that the surficial backfilling or capping layers had been compromised by erosion or subsidence.

Many areas of the cap appeared to be moderately to highly consolidated, with the exception of the soft (low-consolidation) area in the central portion of SMU 51a described in Section 3.0. The soft backfill of SMU 51a exhibited limited consolidation and was difficult to walk through compared with adjacent areas. However, with the exception of the soft area in SMU 51a, locations with small

areas of ponded water generally tended to appear more consolidated than dry areas.

A distinct, sharp interface remains between the surficial backfill of SMU 51a and capping material of SMU 51b and the underlying sediments. Turbation from benthic organisms into the deeper backfill of SMU 51a and sediments of SMU 51b was not observed. However, worm tubes and other burrows appear even more abundant in near-surface material than during the previous monitoring events. This includes the areas of suspected Ghost Shrimp burrows described in Appendix B and identified on Figure B-1. Biological features are described in more detail in the Appendix B habitat monitoring report.

Erosion Features

As noted in the Year 1 monitoring report, minor erosion features that were noted following construction and in the winter and spring of 2005 have stabilized, with no indication of continued down cutting or back cutting. These features were generally limited to:

- Upland bank erosion at the southeastern edge of SMU 51a from wave undercutting;
- Gullying near Outfall No. 200; and
- Very minor sideslope erosion previously noted on the eastern bank of the upper portion of the outfall discharge channel.

Present conditions of areas where these features were identified are shown in Photographs 6, 7, and 8. Little erosion has been observed throughout the remaining tideflat areas of SMUs 51a and 51b, with the exception of minor bank undercutting adjacent to SMU 51a Grid G (Photographs 9 and 10). The Grid G erosion has occurred since 2005.

In addition, minor realignment of the lowermost 50 feet of discharge channel for Outfall No. 200 was noted during September 2005 and is described in the Year 1 monitoring report. The area of minor channel realignment is shown on Figure 6. No additional channel migration or erosion was noted during Year 2 monitoring. Channel realignment has caused slight re-entrenchment of the shallow discharge pathway within this channel segment. The channel banks have also been widened by up to about 4 feet along a portion of this segment. Realignment is occurring where the channel merges with other off-site tideflat drainage channels to the southeast (Figure 6), and is not adversely affecting the thin-layer cap in SMU 51b. No headcutting or other impacts to the SMU 51a

backfill were noted. The observed channel realignment is not unexpected as the restored tideflat surface adjusts following placement of the sediment capping and cover material.

Response. The Grid G bank area will continue to be visually observed for continued erosion in the spring of 2007 and during subsequent monitoring events.

It should be stressed that no erosion was noted in capped areas of SMU 51b or where minor residual contamination remains in and adjacent to SMU 51a, as described in the RACR (Hart Crowser 2005a), previous monitoring reports, and in Section 3.1, below.

Realignment of the Outfall No. 200 discharge channel will continue to be visually monitored and compared with the previous channel location to evaluate and document readjustment of the tideflat surface over time. The comparative early warning and potential response action levels for channel widening are 2 and 4 feet, respectively. As noted in the Year 1 report, no additional actions other than visual inspections are considered to be necessary to address channel realignment; given the overall stability of the channel and absence of apparent downcutting.

SMU 51a Baseline Grade Stake Survey

Grade stakes were established at the SMU 51a locations identified on Figure 6 following construction. An elevation survey for grade stakes was completed in September 2006 to compare with baseline readings obtained in October 2004 and September 2005. Results are presented in Table 1.

The maximum change between 2004 and 2006 was 0.63-foot loss at grade stake GS-4, compared the maximum change between 2004 and 2005, which was a 0.13-foot loss at GS-3. Elevation losses at the other grade stake locations ranged from 0.46 to 0.51 foot. By comparison, grade stake elevation differences between 2004 and 2005 ranged from 0.01 to 0.13 feet, indicating additional subsidence and/or possible (although unlikely) erosion since the 2005 (Year 1) monitoring event. We suspect that the current elevation difference is indicative of general subsidence of the SMU 51a backfill material, given the relatively consistent grade stake elevation differences from the 2004 (Year 0) baseline survey. There is also no indication of wholesale thinning of the near-surface backfill near the grade stakes, and the subsidence is likely occurring uniformly through the underlying backfill section.

Response. Although the grade stake elevation differences are within the performance criteria of 1.0 foot as an early warning and potential response action level, these elevations will continue to be observed closely during annual monitoring events.

Debris

Site visits in September 2006 noted that wood debris, mainly bark, and a small amount of litter washed up near the head of SMU 51a and bank areas. However, the outfall is unobstructed and free of debris. Abundant bark debris has accumulated on the upper tideflat area of SMU 51a (Photograph 11). Most of the goose exclusion netting is buried, but the remaining structure appears to trap debris at low tide and promote accumulation.

Response. Although the debris appears to have no adverse impacts on the channel, outfall, or backfill materials in SMU 51a, the goose exclusion barrier should be removed. Intertidal plantings in this area were not successful, negating the need for the barrier. As noted in the 2005 report, establishing additional protection from floating logs and debris would be difficult. Log structures anchored parallel to the beach face near 9 feet elevation might provide some additional protection from larger debris, but bark and smaller floating material could still be transported into the upper intertidal zone at high tide. Floating boom-type barriers might also be effective but would require further evaluation regarding anchorage and installation, maintenance, potential effects to habitat, and related land-use issues.

3.0 PHYSICAL CHARACTERISTICS ASSESSMENT

Hart Crowser completed physical characteristics assessment s of the SMU 51a backfill and SMU 51b cap to evaluate performance and integrity. Physical characteristics of the in situ sediments were observed at representative locations in SMU 51a and SMU 51b. As noted above, limited consolidation of the sandy backfill was noted in the central portion of SMU 51a near Grids HIJ, G, and EF (Figure 4). Compared with previous monitoring events, the degree of consolidation appeared to have decreased, making walking more difficult. Based on these observations, Hart Crowser collected samples of the surface and subsurface backfill sediments for grain size and water content analysis.

3.1 Physical Characteristic Assessment Sampling and Testing

Sampling of the backfill material in the low-consolidation area of SMU 51a Grids HIJ, G, and EF was conducted in September 2006. Sampling locations are

shown on Figures 4 and 5. Sampling also included locations outside of the low-consolidation area for comparison. The samples of the SMU 51a backfill section were collected at 3 depths via coring – near the surface (upper third, or "a" samples), near mid-depth of the backfill section ("b" samples), and at the bottom (lower third, or "c" samples). A total of 25 discrete samples were collected and analyzed by Hart Crowser's laboratory for grain size and water content analysis to assess the backfill's physical characteristics. Testing results are presented in Table 2.

Backfill material throughout SMU 51a (including both the low-consolidation area and elsewhere) generally consists of relatively uniform slightly gravelly, very silty sand. Water contents range from 16 to 27 percent. The overall average percentages of gravel, sand, and fines in the SMU 51a backfill are 8.1, 57.3, and 34.7 percent, respectively. In the near-surface silty sand backfill of SMU 51a to about 12 inches depth, the fines content ranged from 31.1 to 41.6 percent. This range is generally comparable to the upper limit of 35 percent fines allowed in the project specifications. The fines content of the deeper sandy backfill in SMU 51a was similar, ranging from 15 to 38.1 percent . With the exception of samples G2c (25.0 percent) and S (15.0 percent), the minimum fines content was 33.5 percent. These fines contents were in excess of the maximum 5 percent allowed by the project specifications. Although grain size analyses of the import backfill materials were conducted to verify conformance with the specifications, we suspect that subsequent deliveries contained excess fines. Visual examination of the backfill materials during placement did not identify this problem.

Little physical variability exists between the backfill materials within the zone of low consolidation in Grids HIJ, G, and EF, and adjacent portions of SMU 51a. However, the low consolidation area closely matches locations where the depth of sediment excavation was deepest. The backfill thickness approached 4 to 5 feet in this area, and tidal groundwater seepage was more prevalent during construction. Low consolidation of the backfill in this area is likely a result of the increased fines content relative to the target specification, and significant groundwater flux through the backfill section.

Response. Despite the low consolidation condition noted in SMU 51a, the backfill function and integrity remains consistent with the performance objectives of the Remedial Action. There is no indication that backfill is being winnowed away or otherwise eroded through a preferential pathway. In addition, the fines fraction of the backfill more closely matches the preexisting tideflat condition (i.e., fines contents typically in excess of 50 percent) and is not expected to adversely impact the function of the backfill. The extent of the low-

consolidation area will continue to be monitored during subsequent events, but no additional actions are currently viewed as necessary.

4.0 REFERENCES

EPA 1999. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. October 1999.

EPA 2003a. Statement of Work – Remedial Design, Remedial Action, and Long-Term Monitoring, Middle Waterway Problem Area – Area C, Commencement Bay Nearshore/Tideflats Superfund Site. April 10, 2003.

EPA 2003b. Remedial Design/Remedial Action (RD/RA) Consent Decree for the Remedial Design and Remedial Action at the Middle Waterway Problem Area of the Commencement Bay Nearshore Tideflats Superfund Site (Consent Decree). August 14, 2003.

EPA 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. October 2004.

Foster Wheeler 1998a. Sampling and Analysis Plan. Prepared by Foster Wheeler Environmental Corporation for the Middle Waterway Action Committee. April 13, 1998.

Foster Wheeler 1998b. Quality Assurance Project Plan. Prepared by Foster Wheeler Environmental Corporation for the Middle Waterway Action Committee. April 13, 1998.

Hart Crowser 2005a. Remedial Action Construction Report, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-01, April 7, 2005.

Hart Crowser 2005b. Operations, Monitoring, and Maintenance Plan, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-01, April 27, 2005.

Hart Crowser 2006a. Year 0 (2004) Baseline Monitoring Report, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-01, December 11, 2006.

Hart Crowser 2006b. Year 1 (2005) Monitoring Report, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-02, December 12, 2006.

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Table 1 - Grade Stake Survey Elevation Data

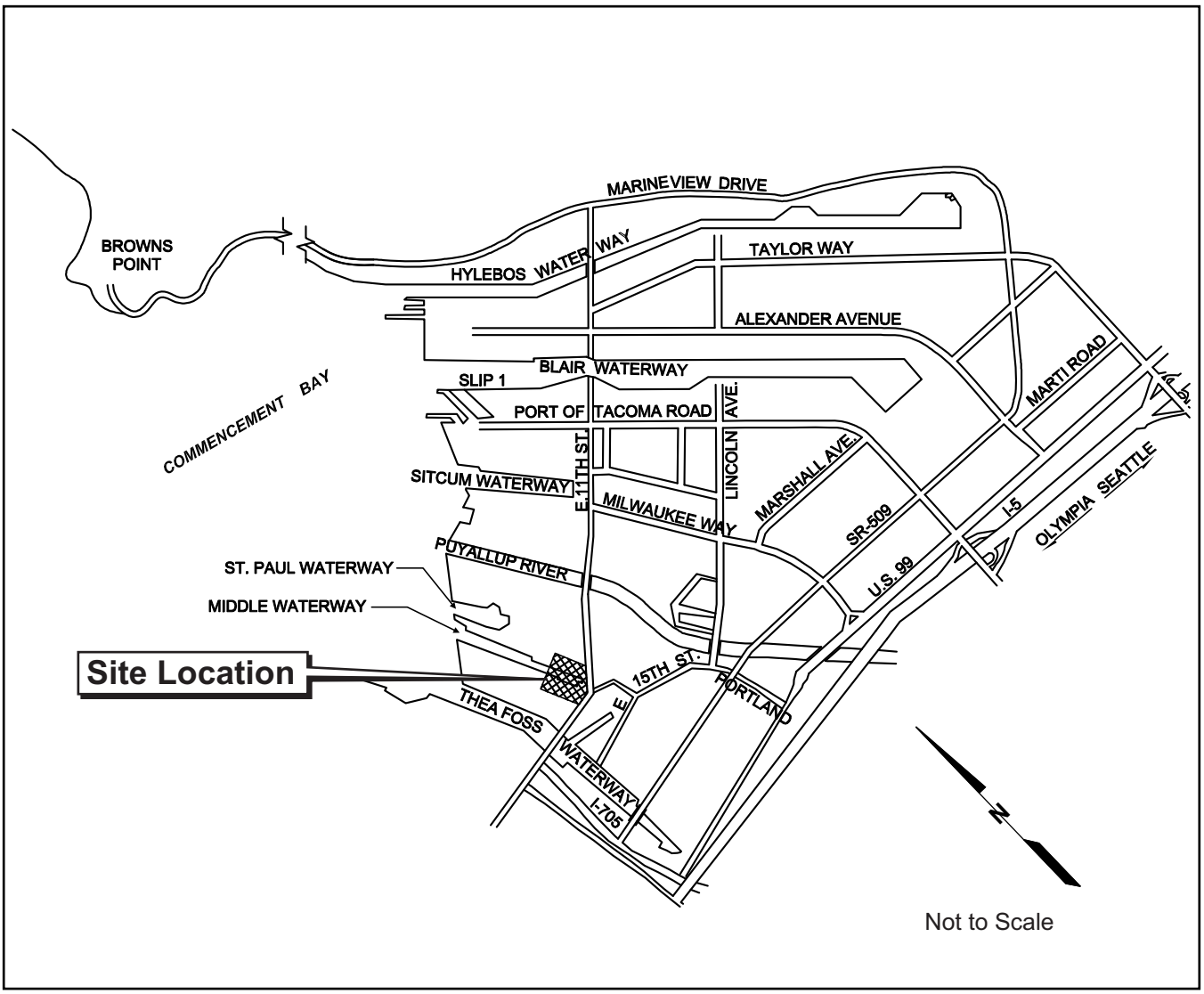
Grade Stake Survey No.	Post-Construction Elevation in Feet (October 2004)	Year 1 Elevation in Feet (September 2005)	Year 2 Elevation in Feet (September 2006)	Year 1 - Year 0 Elevation Difference in Feet	Year 2 - Year 0 Elevation Difference in Feet
GS-1	12.15	12.14	11.66	-0.01	-0.49
GS-2	10.18	10.15	9.72	-0.03	-0.46
GS-3	10.50	10.37	9.99	-0.13	-0.51
GS-4	10.39	10.32	9.76	-0.07	-0.63

Table 2 - Water Content and Grain Size Sample Results

Sample Name	Water Content	% Gravel	% Sand	% Fines
CDa	21%	9.0%	53.9%	37.1%
CDb	22%	11.5%	52.7%	35.8%
CDc	25%	16.2%	51.1%	32.7%
Ea	23%	5.8%	56.0%	38.2%
Eb	22%	10.1%	52.9%	37.0%
Ec	19%	7.1%	57.2%	35.7%
Fa	22%	8.6%	57.0%	34.4%
Fb	19%	10.2%	55.7%	34.1%
Fc	21%	7.5%	59.0%	33.5%
G1a	24%	14.7%	54.2%	31.1%
G1b	21%	9.7%	56.4%	33.9%
G1c	21%	4.9%	59.2%	35.9%
G2a	25%	8.3%	55.8%	35.9%
G2b	19%	8.2%	56.0%	35.8%
G2c	17%	7.0%	68.0%	25.0%
G3a	26%	5.9%	54.8%	39.3%
G3b	21%	4.9%	57.0%	38.1%
G3c	20%	7.2%	57.8%	35.0%
G4a	27%	5.2%	55.4%	39.4%
G4b	19%	6.9%	59.1%	34.0%
G4c	19%	5.8%	59.8%	34.4%
K	16%	11.0%	53.7%	35.3%
G, Upper	23%	7.6%	50.8%	41.6%
G, Lower	16%	8.9%	53.0%	38.1%
S	19%	0.0%	85.0%	15.0%
Median	**21.0%**	**7.6%**	**56.0%**	**35.7%**
AVERAGE	**21.1%**	**8.1%**	**57.3%**	**34.7%**
Std. Dev.	**2.1%**	**2.6%**	**10.9%**	**6.5%**

Notes:
"a" indicates upper (shallowest) part of core
"b" indicates middle part of core
"c" indicates lowest (deepest) part of core

Vicinity Map
Middle Waterway Problem Area C



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Note: Base map prepared from Microsoft Streets and Trips 2002.

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Figure 1

Site Plan
Middle Waterway Problem Area C

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51b SMU Number

SMU Boundary (Within Area C)

Northern Extent of Area C

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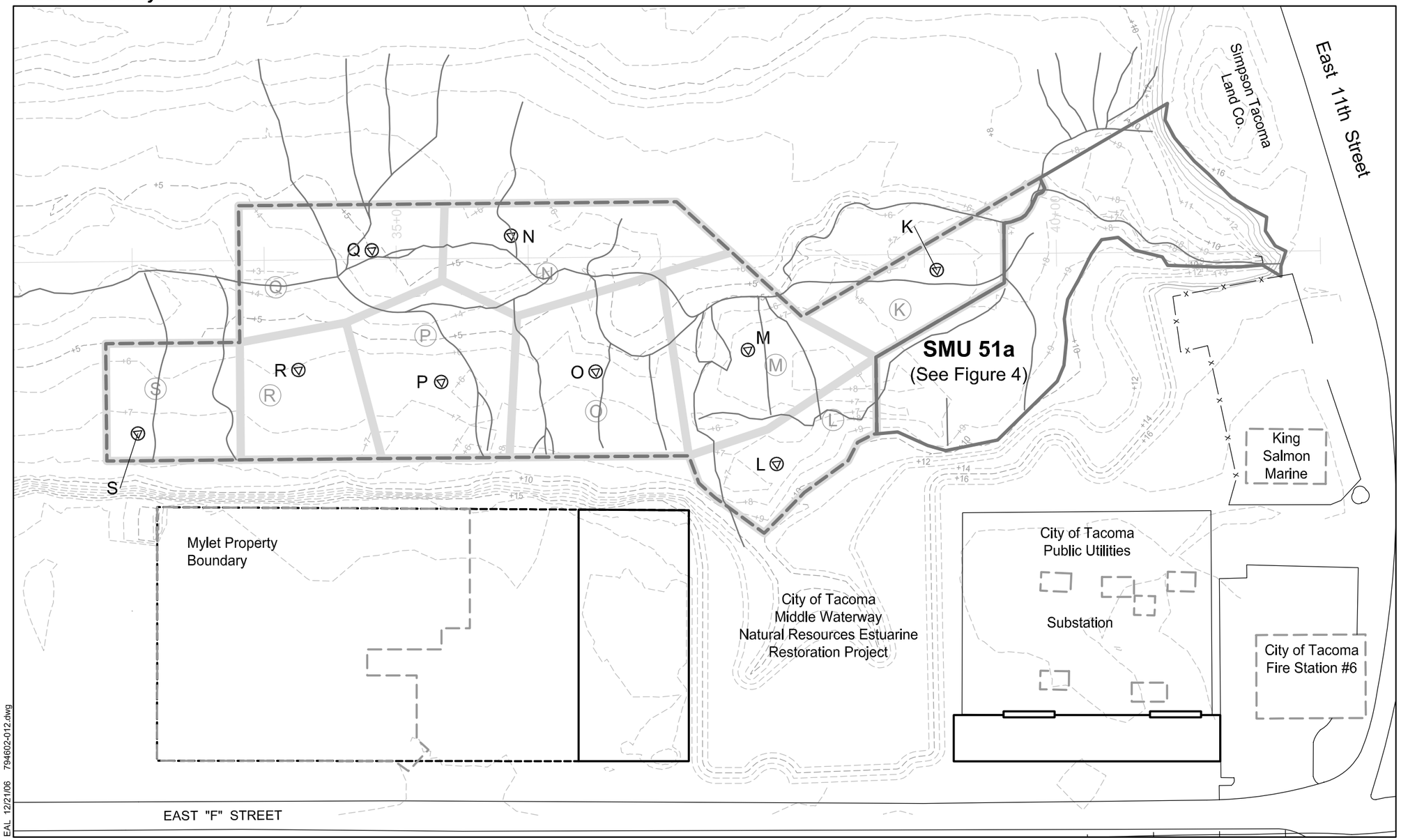
Figure 2

Year 2 Channel Location Plan
Middle Waterway Problem Area C



SMU 51a Boundary

SMU 51b Boundary

Channel Location

K Year 2 Cap Assessment/Observation Location and Number

K Sediment Sampling Grid and Designation

Notes:
1. Elevation contours outside SMU 51a and SMU 51b from Foster Wheeler and Blue Water Engineering Survey, 1998.
2. Elevation contours within SMU 51a and SMU 51b from Baseline Engineering Survey, October 2004.

Vertical Datum:
Datum: Corps of Engineers mean lower low water based on benchmark: BME406 1965 monument located on the south side of the east end of the East 11th Street bridge elevation: 24.09'

Basis of Bearings:
Washington State Plane coordinate system south zone, NAD83/1991

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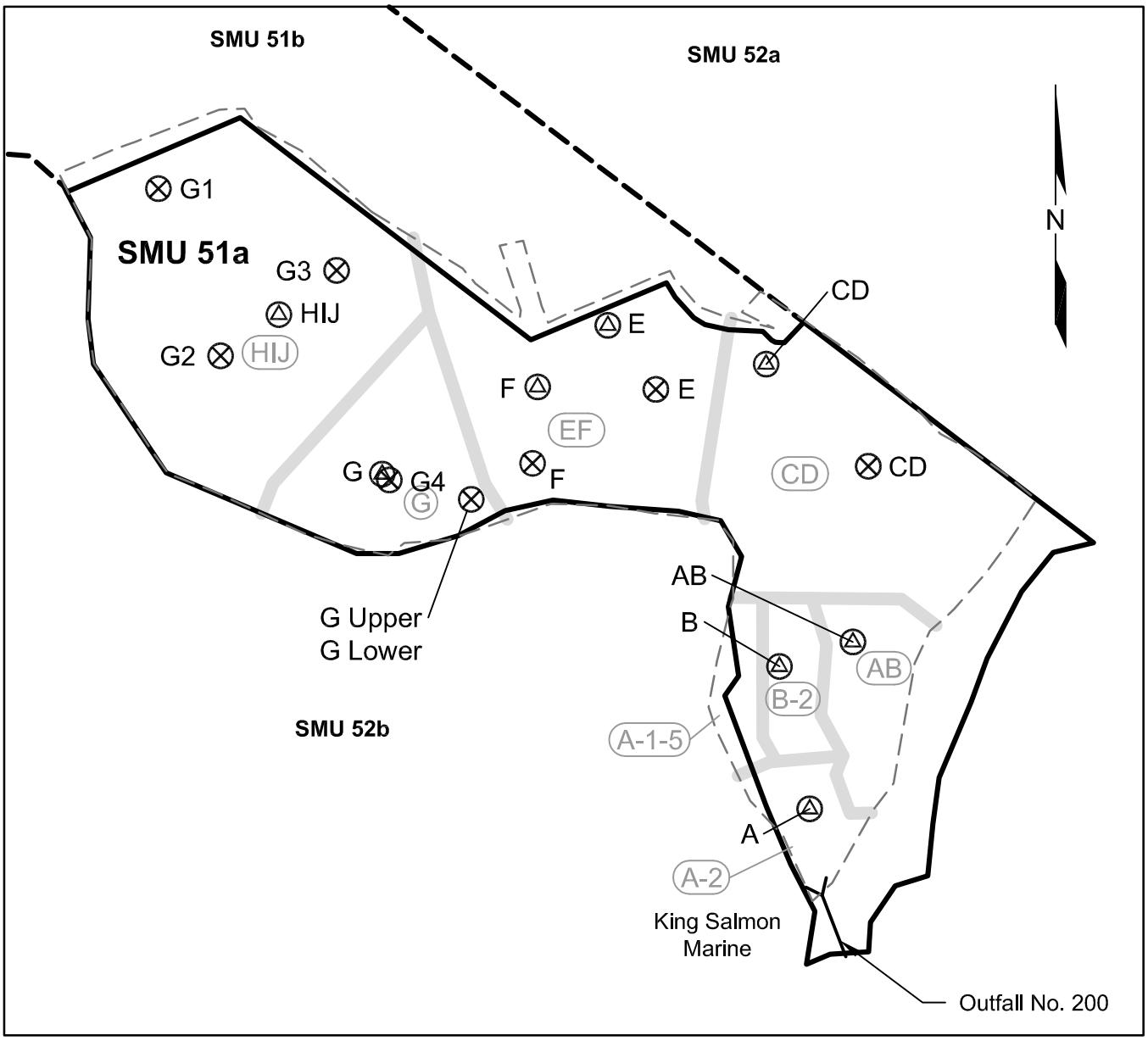
Figure 3

Year 2 Thin-Layer Cap and Backfill Assessment Locations
Middle Waterway Problem Area C SMU 51a



SMU 51a Boundary

SMU 51b Boundary

SMU 51a Excavation Limit

(AB) Sediment Verification Sampling Grid and Designation

A Year 2 Thin-Layer Cap and Backfill Location and Number

F Backfill Sample Collection Location and Number

0 50 100
Scale in Feet

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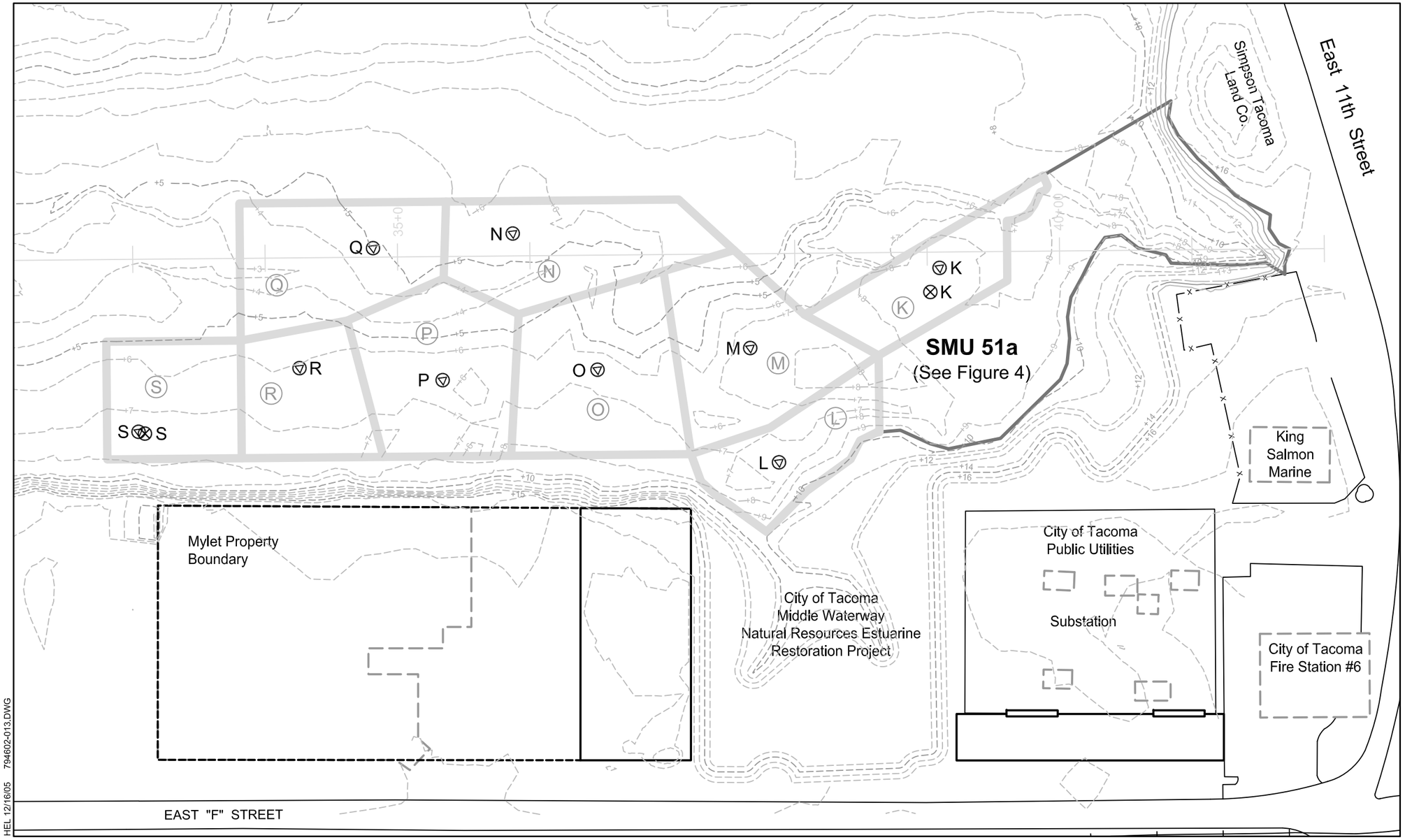
Figure 4

Year 2 Thin-Layer Cap Assessment Locations
Middle Waterway Problem Area C



SMU 51a Boundary

SMU 51b Boundary

K Year 2 Cap Assessment Location and Number

K Sediment Sampling Grid and Designation

K Thin-Layer Cap Sample Collection Location and Number

Notes:
1. Elevation contours outside SMU 51a and SMU 51b from Foster Wheeler and Blue Water Engineering Survey, 1998.
2. Elevation contours within SMU 51a and SMU 51b from Baseline Engineering Survey, October 2004.

Vertical Datum:
Datum: Corps of Engineers mean lower low water based on benchmark: BME406 1965 monument located on the south side of the east end of the East 11th Street bridge elevation: 24.09'

Basis of Bearings:
Washington State Plane coordinate system south zone, NAD83/1991

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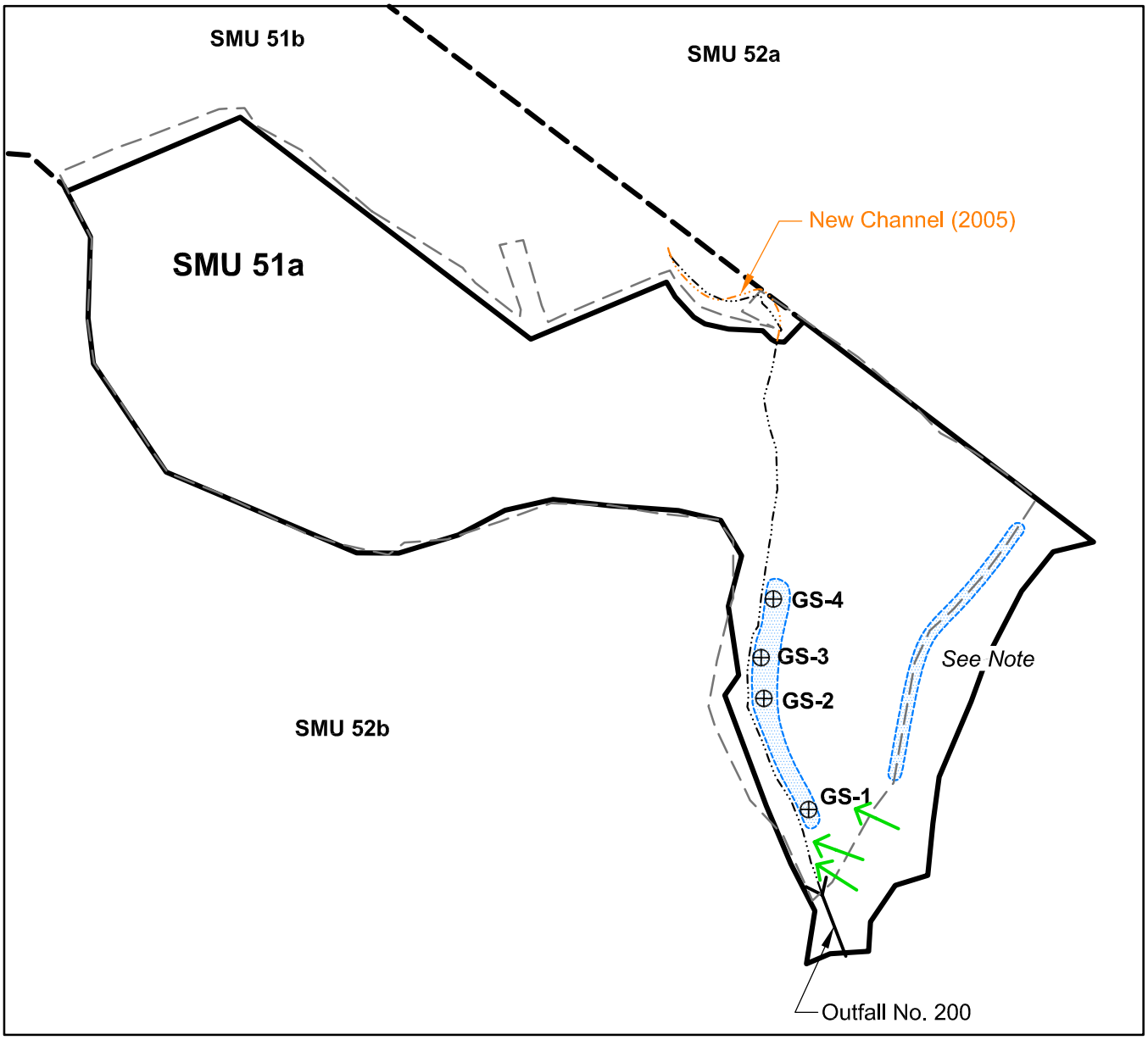
Figure 5

Long-Term Grade Monitoring Location Plan and Stabilized Erosion Areas (SMU 51a)

Middle Waterway Problem Area C



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Note: Jute mats placed along stabilized bank area in May 2005.

SMU 51a Boundary

SMU 51b Boundary

SMU 51a Excavation Limit

Outfall No. 200 Drainage Channel Centerline (See Table 1 elevation survey data)

GS-1 ⊕ Elevation Monitoring Grade Stake Location and Number (Established October, 2004)

Minor Bank Gully Features (Stabilized)

Stabilized Bank and Outfall Discharge Channel Erosion Areas

N

0 50 100

Scale in Feet

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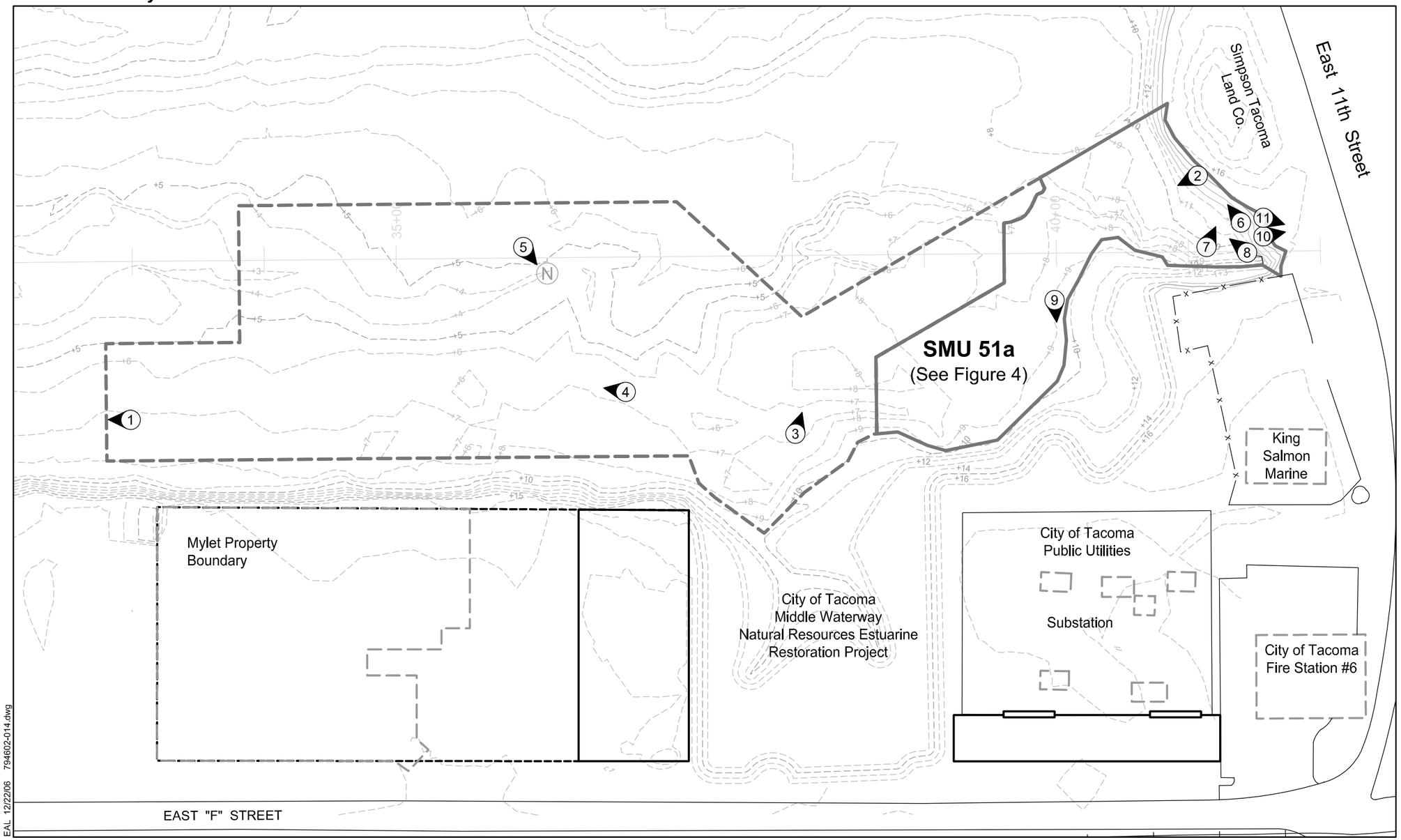
Figure 6

Year 2 Photograph Location Plan
Middle Waterway Problem Area C



SMU 51a Boundary

SMU 51b Boundary

(1) Photograph Location, Number, Direction and Month/Year

Notes:
1. Elevation contours outside SMU 51a and SMU 51b from Foster Wheeler and Blue Water Engineering Survey, 1998.
2. Elevation contours within SMU 51a and SMU 51b from Baseline Engineering Survey, October 2004.

Vertical Datum:
Datum: Corps of Engineers mean lower low water based on benchmark: BME406 1965 monument located on the south side of the east end of the East 11th Street bridge elevation: 24.09'

Basis of Bearings:
Washington State Plane coordinate system south zone, NAD83/1991

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Figure 7

APPENDIX A
YEAR 2 PHOTOGRAPHS

Photograph 1 - Example of SMU 51b thin-layer cap and adjacent tideflat continuity.

Photograph 2 - Algal growth.

Photograph 3 - Burrows resulting from benthic organism activity.

Photograph 4 - Close-up of benthic organism burrows.

Photograph 5 - Example of potential human-made clam digging holes.

Photograph 6 - Restoration of previous upland bank erosion at the southeastern edge of SMU 51a.

Photograph 7 - Restoration of previous gullying near Outfall No. 200.

Photograph 8 - Area of previous minor sideslope erosion near Outfall No. 200.

Photograph 9 - Minor bank undercutting at SMU 51a Grid G.

Photograph 10 - Minor bank undercutting at SMU 51a Grid G.

Photograph 11 - Bark accumulation and goose exclusion netting in upland area.

APPENDIX B
HABITAT MONITORING REPORT – YEAR 2
MANAGEMENT OF ENVIRONMENTAL RESOURCES, INC.

APPENDIX B

HABITAT MONITORING REPORT—YEAR 2

MIDDLE WATERWAY RESTORATION SITE
DEPARTMENT OF NATURAL RESOURCES PARCEL
COMMENCEMENT BAY, TACOMA, WASHINGTON

Prepared for: **Hart Crowser**
Seattle, Washington

Prepared by: **Management of Environmental Resources, Inc.**
Seattle, Washington

June 2007

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1.0 INTRODUCTION

This report presents the results of the second year of habitat monitoring following the sediment remedial action and restoration of associated riparian/upland habitats near the head of Middle Waterway (Commencement Bay, Tacoma, Washington). A Vicinity Map and Site Plan are provided on Figures 1 and 2 of the Year 2 (2006) Monitoring Report (Hart Crowser 2007). Habitat monitoring is being conducted by the Washington State Department of Natural Resources (DNR) to document the performance of restoration activities implemented in conjunction with the remediation of Sediment Management Units (SMUs) 51a and 51b in Middle Waterway Problem Area C. The remedial action was conducted according to the Consent Decree between the U.S. Environmental Protection Agency (EPA), DNR, City of Tacoma (City) and other parties, as referenced in the 2005 Monitoring Report (Hart Crowser 2005c).

Sediment remediation occurred in 2004 and consisted of excavation of contaminated sediments and backfilling with clean fine-grained sediment in SMU 51a and placement of a thin-layer cap of clean sediment in SMU 51b to enhance natural recovery of this area. In addition, the drainage channel leading from City outfall No. 200 that discharges at the head of the waterway to SMU 51a was armored to prevent erosion of backfill materials. Figures depicting excavation, backfilling, and thin-layer capping are presented in the Remedial Action Completion Report (Hart Crowser 2005a).

The upland parcel located south of SMU 51a was restored by planting various lowland trees and shrubs in November of 2004, following its use as a staging area for sediment remediation. Several perennial grasses were planted in a transition riparian zone (a low bank) between the high intertidal area and the upland. Due to loss of bank materials during the winter of 2004/2005, erosion control material (jute mats) was added to a portion of the SMU 51a bank slope in March of 2004. Trees and shrubs near the bank edge were moved and replanted higher on the bank. The high intertidal area at the head of the waterway (9.9 to 13. 4 feet elevation, U.S. Army Corps of Engineers datum) was planted with several saltmarsh plant species in the spring of 2005. Goose exclusion fencing was installed at the saltmarsh planting elevation to help these species establish.

1.1. Performance Criteria

The DNR is conducting habitat monitoring following completion of the remedial action, in conjunction with sediment chemical quality monitoring and physical monitoring described in the project Operations, Maintenance, and Monitoring Plan (OMMP) (Hart Crowser, 2005b) to assess the long-term performance of the action. The OMMP describes performance criteria for chemical quality and physical monitoring of the backfill and thin-layer cap. Performance criteria are primarily based on the physical stability and chemical quality of the surface sediments relative to the Sediment Management Standards in the two SMUs. The SMUs are also subject to annual visual inspections that document the

condition and character (both biological and physical) of the surface sediment at the sampling locations.

Performance objectives for visually monitoring of the restored tideflat environment of SMU 51a and SMU 51b focus on qualitatively assessing benthic habitat quality and function. This assessment is based on observation of the presence or absence of infaunal and epifaunal organisms or communities at the locations where surface sediment quality samples were collected (see Figure 4 and Figure 5 in the 2007 Monitoring Report).

For the purpose of assessing the ecological functions provided by saltmarsh or riparian/upland habitat areas, survival and areal coverage of the introduced plantings are used as the metrics of performance.

1.2. Objectives

The overall objective of the habitat monitoring is to document the condition of the restored habitats with respect to their physical stability and ecological function. A corollary objective for the second year is to determine if conditions observed during the first year's monitoring had changed. A second objective is to determine if any corrective actions are needed to ensure the long-term success of the restoration project.

2.0 APPROACH

Assessment of habitat condition and function relied upon qualitative measures for both the in-water and upland habitats. Specifically, observations of erosion, channelization, presence/absence of aquatic plants, presence or absence of infaunal and epifaunal communities and distribution of burrowing shrimp activity formed the basis of the Year 2 assessment for the mudflat habitat. In 2005, significant loss of transplanted saltmarsh and riparian plants was observed, along with extensive plant stress and apparent mortality in the upland plantings. These habitats were revisited in 2006 to determine if any recovery or regrowth of material had occurred. No measures were performed relative to upland plant areal coverage because of the continued loss of transplanted plant material.

2.1. Mudflat Habitat

Habitat monitoring took place on August 22 and 23, 2006 during low tides. The 2005 sediment sampling points were revisited by returning to the GPS coordinates recorded for each point. Sampling station descriptions on the sediment backfill and thin-layer cap are presented in the Year 1 Report. The general condition of the top few centimeters of sediments at each location was noted along with any evidence of aquatic vegetation or infaunal/epifaunal organisms (e.g., tubes, fecal castings, siphon holes). The subsurface layer was evaluated at several locations to examine the depth of burrowing activity. Photographic documentation of the habitat areas is provided in Attachment 1 to this report. Hart Crowser took concurrent sediment samples at four other

locations for the purpose of evaluating grain size of the backfill (see 2007 Monitoring Report for results).

2.2. Shoreline/Upland Habitat

The general habitat condition of the saltmarsh and adjacent riparian/upland habitat was revisited to evaluate survival from the prior year. Only plant survival and condition observations were recorded; percent cover was not documented due to the low survival or recovery of the transplanted material.

Photographic documentation was conducted as part of the habitat monitoring for Year 2, with selected photographs provided in Attachment 1.

3.0 RESULTS

3.1. Mudflat Habitat

Observations were made at 17 of the 19 (J and F-2 were not revisited) sediment sampling locations in SMU 51a and SMU 51b on August 22, as identified on Figure 4 and Figure 5 of the 2007 Monitoring Report. Sediment characteristics ranged from consolidated sand and pea gravel to unconsolidated silts and fine sand. Most sediment characteristics appeared to be similar to those found in 2005, with the exception of the area around Station M and the area associated with the SMU 51a remedial excavation (G, H/I and J, in part). In Area M of SMU 51b, the sediments seemed very consolidated with a high gravel content (pea gravel was present at the surface) relative to 2005 observations. Subsequent grain size analysis indicated that that the gravel, sand and silt content was typical for thin-layer capping materials in SMU 51b, although more of the pea gravel material was exposed in the upper-most sediment. In contrast, the backfill material within the central excavation area of SMU 51a appeared very unconsolidated and watery. Although, this area was very soft when observed in 2005, the material seemed more so during the 2006 observations. A thin crust (several inches) of slightly firmer material was present on top, with soupier material underneath. The surface crust supported filamentous algal growth and small invertebrates (no large burrows or clam show were evident). It is unclear to what extent the sediment consistency in this area will affect development of later successional stages of the benthic community (which typically includes larger, long-lived, burrowing invertebrates). Hart Crowser discusses the physical properties relative to the design specifications for the backfill materials in the 2007 Monitoring Report.

In general, the sediment surface on the mudflat was covered with a fine, hair-like algae (likely *Vaucheria* sp. or *Enteromorpha* spp.) that tended to form thin mats, similar to conditions observed in 2005 (Photo 1). There was evidence of extensive invertebrate activity associated with the top few centimeters of sediment (tubes, burrow openings, fecal pellets, etc.). Infaunal and epifaunal organisms, while tiny, seemed to be very abundant in most areas, particularly

areas covered with algae or diatoms. Amphipods (including *Corophium* sp.), tube-dwelling or burrowing polychaetes (including many spionids) and small clams were present.

Throughout the mudflat in channelized areas or on the shoulders of raised area, there was evidence of extensive burrowing of larger organisms (Photo 2). The approximate location of the burrows is provided in Figure B-1. While no organisms were captured, it is likely that these burrows are associated with a shrimp [either *Neotrypaea* (formerly Callianassa) sp. or *Upogebia* sp.]. Figures B-2 and B-3 show examples of ghost shrimp burrows from a mudflat in California (from Anderson 2003). Similar features are found throughout the Middle Waterway mudflat (Photos 2 and 3). Shrimp burrows extended 1 to 2 feet below the sediment surface (in some cases may have been deeper) with a number of lateral branches. The entrance to the burrows were asymmetrical and often contain a small shore crab. The subsurface portion of the burrows were more tubular (up to about an inch across), with smooth walls.

There was evidence of clam digging on the mudflat in the vicinity of Stations O and P in front of the Mylet property (Photo 4). Large holes had been dug and left unfilled. Other areas also appeared to be disturbed from extensive debris or erosion. Shoreline areas near the City restoration site and at the head of the waterway were littered with bark, plastic and other debris (Photo 5). These areas are adjacent to SMU 51a and SMU 51b and are not part of the current Remedial Action. In addition, it appears that the goose exclusion fencing in the saltmarsh restoration area in SMU 51a traps debris, where it has not been physically damaged by debris. The City outfall channel seems to be maintaining its alignment and no additional channelization or erosion appears to be occurring in the vicinity of the outfall. However, the low bank areas along the City restoration site north of the outfall show evidence of undercutting (Photo 6) in several areas, including the upper edge of SMU 51a. Some erosion channels appear to be forming in the southeast corner of the waterway (outside of SMU 51a) and lead down to the mudflat in front of the upland restoration (Photo 7). Channel erosion does not appear to be adversely affecting SMU 51a. A channel leading from the Mylet parking/roof drains appears to be eroding the mudflat at a location just west of SMU 51b (Photo 8). The channel depth and width is comparable to the 2005 configuration, and adjacent erosion does not appear to be adversely affecting SMU 51b.

Additional field observations of intertidal habitat characteristics at SMU 51a and SMU 51b sediment sampling locations are provided in Attachment 2.

3.2. Shoreline/Upland Habitat

In 2005, the transplanted material in the high intertidal area at the head of the waterway was mostly absent. While the area continues to be impacted with debris, there is evidence of recolonization by pickleweed (Photo 9), particularly along the eastern portion of the saltmarsh. The riparian habitat (with the

exception of plantings between the outfall channel and the King Salmon Marine eastern fence line) is either absent (the bank is unvegetated) or invasive species are colonizing.

Habitat	Plant Species	Quantity Planted	Surviving in 2005	Surviving in 2006
Saltmarsh (Planted May, 2005)	Brass buttons	500	0	0
	Pickleweed	500	~5	Significant recolonization
Transition zone (Planted May 2005)	Tufted hairgrass	216	0	0
	Salt grass	216	0	0
Upland (Planted December 2004)	Big leaf maple	18	~2	~3 (appears to have been minor recovery from 2005)
	Red alder	18	~14	~6
	Madrone	18	~16	~14
	Shore pine	18	~17	~15
	Hooker's willow	49	~33	~24
	Nootka rose	49	~30	~24
	Oceanspray	49	~15	~8

In the upland area, estimates were made of what living plant material remained from the 2005 observations. There was evidence that some of the stressed plants from 2005 may have recovered over the course of the 2005/2006 rainy season into the spring, but had been stressed again during the 2006 dry season (plants had formed new branches that had leafed out, but were wilted or were dry and brittle when observed in August 2006). In addition to the survivors listed in Table 1, there were additional plants that appears stressed that may or may not survive including 3 big leaf maple, 2 madrone, 2 pine, 3 willow, 1 Nootka rose, and 3 oceanspray. If they survive, they would add to the 2006 survival counts.

The hydraulic dredge pipe from the Thea Foss Waterway to the St. Paul Waterway placed along the East 11th Street boundary had been removed; however, none of the planting covered by the pipe had been replaced.

Weeds (dandelion, vetch, pineapple plant, horsetail, dock, etc.) and invasive plants (butterfly bush, tansy, Scots broom, thistle, and blackberry) had further established themselves in the upland area. There was evidence (large piles of weeds and debris) that someone had attempted some weed control in the area along the shoreline adjacent to the Simpson restoration area; however, grasses and other annual weeds were still prevalent.

Table 1. Surviving Plant Material

4.0 SUMMARY

Overall, near-surface sediments comprising the SMU 51a backfill and SMU 51b thin-layer cap appear to be in a similar stage of recolonization observed in 2005. Infaunal and epifaunal communities that are adapted to disturbed or newly created habitat appear to be thriving. Burrowing shrimp appear to be abundant; burrows were aggregated along the slope of the tidal channels that have formed. It is unknown if larger infaunal organisms are beginning to colonize (e.g., clams), but this organisms would be anticipated as part of a later successional infaunal community. Diatoms and small filamentous algae are well developed on the sediment surface and appear to contribute significantly to the productivity of the mudflat surface.

The saltmarsh plant community appears to be re-establishing itself along the beach; however, smothering by debris (particularly bark) continues to hinder development of this habitat. The upland area continues to be neglected, as evidenced by further plant mortality and replacement by grasses, herbs and invasive weeds. There was no evidence that plant material had been replaced or that water had been provided during the dry season.

Several areas of erosion were noted include the storm drain channel that has formed from the Mylet property and the shoreline along the City restoration project, where the bank is being undercut.

5.0 RECOMMENDATIONS

The following recommendations are provided as potential corrective actions that may contribute to the long-term success of the mudflat, saltmarsh and riparian/upland habitats.

- Continue to monitor the distribution and density of burrowing shrimp.
- Continue to monitor the tidal channel from the Mylet drain and erosion area upstream of SMU 51b.
- Monitor consolidation in area F, G and H/I.
- Replace dead or severely compromised trees and shrubs in the upland area.
- Provide regular watering until the plants are well established (include at least one summer of regular watering)
- Coordinate invasive species control with adjacent restoration projects.
- Continue to monitor erosion-prone areas along the shoreline and consider more aggressive bank erosion control, if necessary based on subsequent observations.

- Remove goose exclusion fencing (it does not appear to enhance survival of pickleweed and acts as a trap for debris).

6.0 REFERENCES

Hart Crowser 2005a. Remedial Action Construction Report, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-01, April.

Hart Crowser 2005b. Operations, Monitoring, and Maintenance Plan, Middle Waterway Problem Area C, Sediment Management Units 51a and 51b, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma Washington. Prepared for the DNR, Contract No. AE 099, 7946-01, April.

Hart Crowser. 2005c. Year 1 (2005) Monitoring Report. Middle Waterway Problem Area C. Sediment Management Units 51A and 51B. Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma, Washington. Prepared for the DNR. December.

Hart Crowser. 2007. Year 2 (2006) Monitoring Report. Middle Waterway Problem Area C. Sediment Management Units 51A and 51B. Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma, Washington. Prepared for the DNR. June 20, 2007.

Anderson, Genevieve. 2003. Biological Sciences Department. Santa Barbara City College. http://www.biosbcc.net/ocean/marinesci/03ecology/mfunder.htm

ATTACHMENT 1: PHOTO LOG

Photo 1: Algal mats on sediment surface

Photo 2: Burrowing activity

Photo 3: Burrowing shrimp mound

Photo 2: Evidence of clam digging

Photo 5: Debris at the head of the waterway

Photo 6: Bank erosion in City restoration area

Photo 7: Erosion channels near saltmarsh habitat

Photo 8: Erosion channel from Mylet

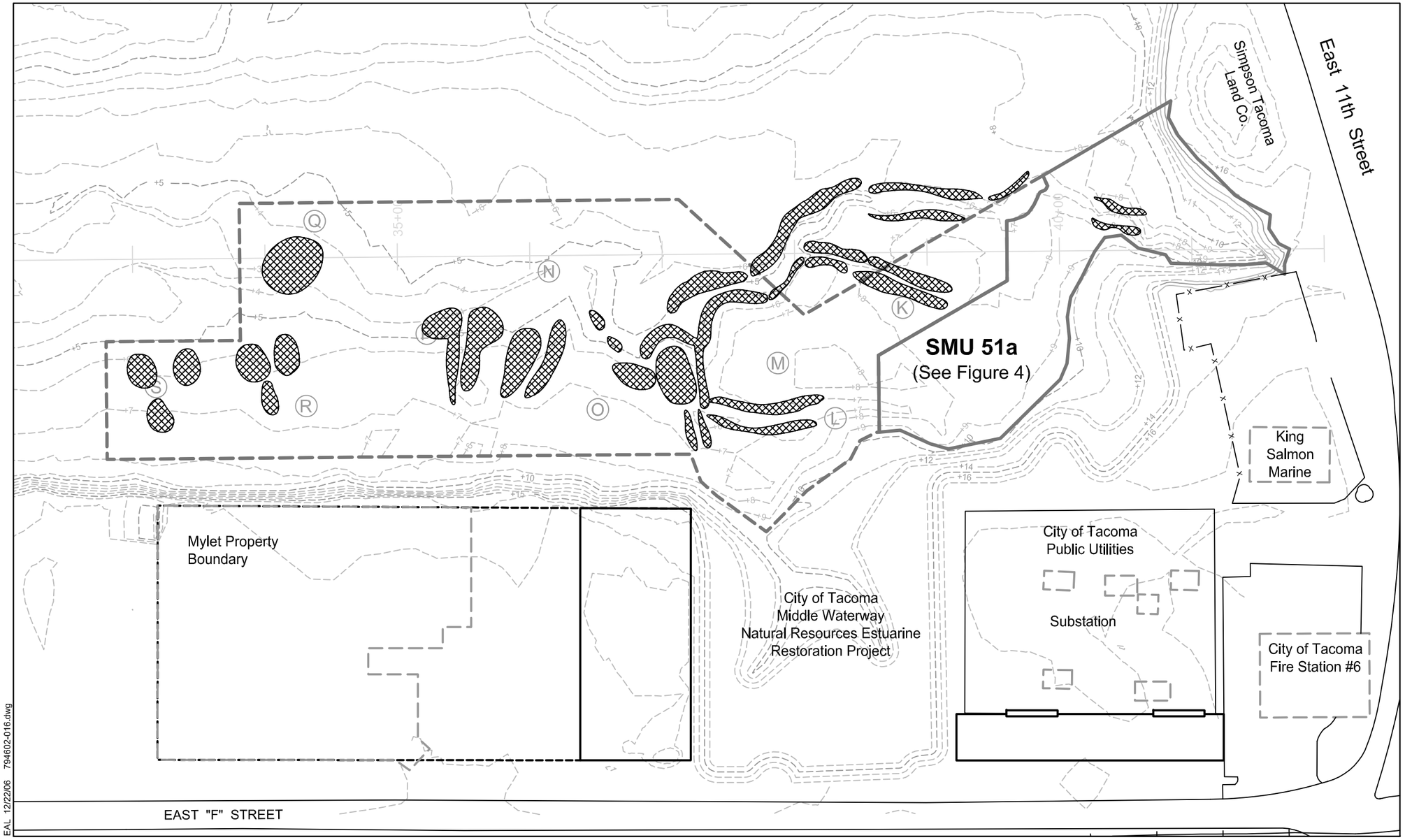
Photo 9: Pickleweed recolonization in saltmarsh

ATTACHMENT 2: INTERTIDAL HABITAT OBSERVATIONS

Station[a]	Observations
A-2	Highest elevation of all stations. Woody/plastic debris covering high percentage of surface. Pickleweed appears to be recolonizing.
AB	Silt layer at surface with anoxic layer beneath. Woody debris. Logs scattered along shoreline.
B-2	Silt underlain by very firm sediment. Some diatoms at surface,. Woody debris, leaf litter present on surface.
CD	Very soft sediments. Adjacent to channel. Surface appears bare. Still good evidence of burrows and other openings in sediment. Very thin anoxic layer below surface.
E	Adjacent to tidal channel. Sediments soft with underlying anoxic layer.
F-1/F-2	Soft sediment (to a least 1 ft depth).
G	Sediments extremely soft and watery relative to other SMU 51a backfill sediments. No evidence of invertebrate activity. Material may be too soupy.
HI	Sediments very soft. No evidence of invertebrate activity. Material may be too soupy.
J	Adjacent to backwater area. No evidence of trapped fish. Some bird loafing/foraging sign.
K	Among piling. Hair-like algae (*Enteromorpha or Vaucheria*?) present at surface. Some *Ulva* (algae) present.
L	Entrance to City mitigation site. Sediments unconsolidated, but less so compared to Year 1. Pickleweed appears to be recolonizing shoreline. Channel from back area appears deeper. The is some evidence of erosion along the restoration site banks.
M	Location very consolidated relative to prior year. Pea gravel evident on surface. Little sign of invertebrate activity.
N	*Ulva* (algae) present. Some sheen on sediment surface. No evidence of anoxic layer. Channel forming. Surface sediment has many openings.
O	Very thin silt layer with diatoms and hair-like algae matting surface with some *Ulva* spp. Clam or mud shrimp burrow openings evident. Some local channelization present in mudflat.
P	Sandy surface covered by hair-like algae. Storm drain off of east end of building is eroding a channel in the mudflat. Appears deeper than observed in Year 1. Ghost/mud shrimp burrows fairly dense along side of erosional channel and present where slight hummocks form on cap. Evidence of clam digging in area.
Q	Sandy, firm sediment at higher elevation on mudflat. Filamentous algae and *Ulva* spp. present.
R	Filamentous algae prevalent. Presence of small clams and invertebrate sign. Similar in characteristics to S sampling location.

S	Thin layer of filamentous algae (*Vaucheria*?) overlaying a thin anoxic layer. Limited clam sign along with very small invertebrates. Cap appears to be about 1 foot thick at this location and thins out towards the shoreline.
a: Habitat observations were made at stations where sediment was collected for chemical analysis as part of Year 1 backfill and thin-layer cap performance monitoring	

Year 2 Benthic Organism Burrow Location Plan
Middle Waterway Problem Area C



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SMU 51a Boundary

SMU 51b Boundary

(K) Sediment Sampling Grid and Designation

Burrow Area

Notes:
1. Elevation contours outside SMU 51a and SMU 51b from Foster Wheeler and Blue Water Engineering Survey, 1998.
2. Elevation contours within SMU 51a and SMU 51b from Baseline Engineering Survey, October 2004.

Vertical Datum:
Datum: Corps of Engineers mean lower low water based on benchmark: BME406 1965 monument located on the south side of the east end of the East 11th Street bridge elevation: 24.09'

Basis of Bearings:
Washington State Plane coordinate system south zone, NAD83/1991

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Figure B-1

Figure B-2. Example of ghost shrimp burrows on a mudflat from California

Figure B-3. Close up of Neotrypaea burrow opening