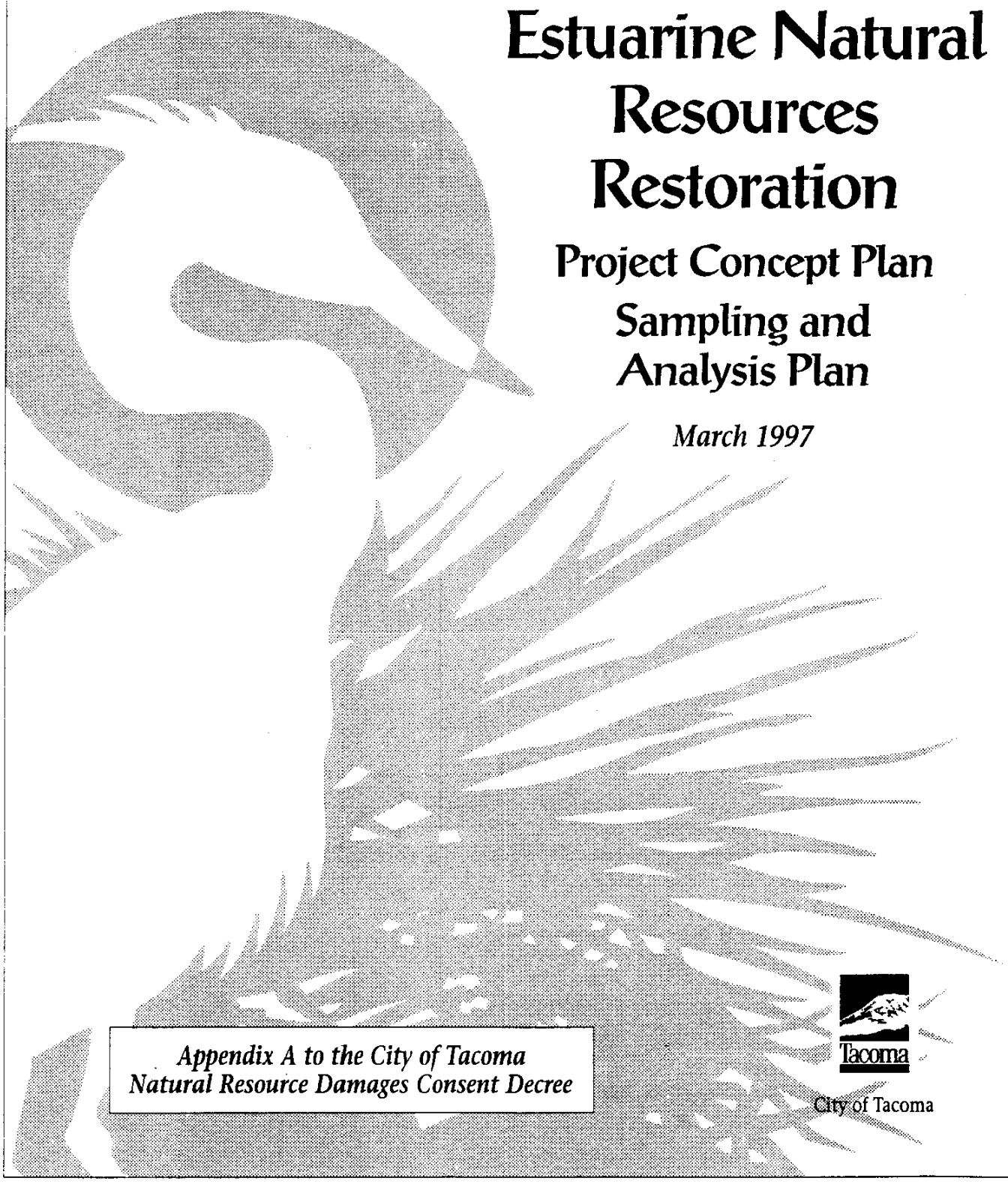
Middle Waterway Estuarine Natural Resources Restoration

Project Concept Plan
Sampling and Analysis Plan

March 1997



Appendix A to the City of Tacoma
Natural Resource Damages Consent Decree

Tacoma

City of Tacoma

This document is a reprint of the October 1996 document of the same title. This document and the October 1996 document differ in the following manner:

1. ***The date on the initial title pages has been corrected (updated);***
2. ***Selected graphics have been reproduced (but not changed) to enhance readability;***
3. ***The project schedule has been modified to reflect the passage of time.***

This document was prepared by the staff of the City of Tacoma Public Works Department, Utility Services Engineering Division, and Utility Services Laboratory. Questions concerning the information presented can be directed to Greg Zentner of Utility Services Engineering at the following address and phone number.

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MIDDLE WATERWAY ESTUARINE NATURAL RESOURCES RESTORATION

PROJECT CONCEPT PLAN
SAMPLING AND ANALYSIS PLAN

CITY OF TACOMA
MARCH 1997

CITY OF TACOMA
MIDDLE WATERWAY ESTUARINE NATURAL RESOURCES RESTORATION PROJECT
MARCH 1997

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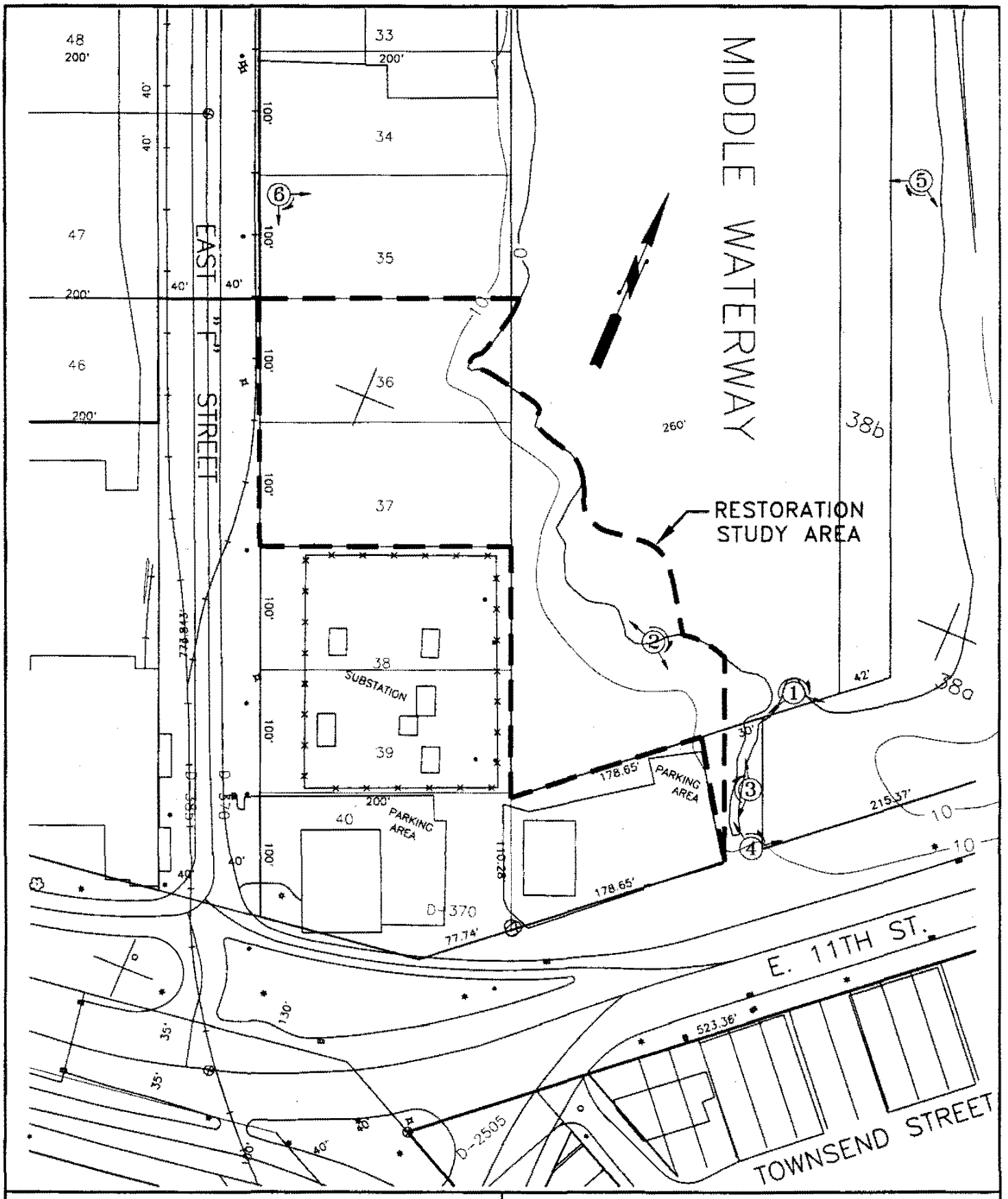

City of Tacoma
Middle Waterway
Restoration Study Area

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City of Tacoma Middle Waterway
Estuarine Natural Resources
Restoration Project Proposal

Preface to the 1996 Reprint

The *City of Tacoma Middle Waterway Estuarine Natural Resources Restoration Project Proposal*, the document you are now reading, describes actions the City of Tacoma will undertake to restore estuarine marsh habitat in Middle Waterway in the City of Tacoma, Washington State. The City had originally planned to develop the project in 1995 but circumstances have resulted in a different course of action. As a result, the City revised its project schedule and re-issued the document with this preface.

The need for the project schedule revision is the result of discussions aimed at expanding the City's effort from a single restoration project to a series of such projects in the Commencement Bay area. These discussions stemmed in part from the positive response the original Middle Waterway project proposal received from agency staff upon its original (draft) publication in September, 1994. The City's discussions with the Natural Resource Trustees[1] were initiated in early 1995 with the thought that such projects could be used to satisfy a presumed natural resources damages liability. After a period of negotiation, the expanded proposal was accepted in concept and the Middle Waterway project will go forward as part of a series of projects, with the following project clarifications:

1. The project area includes 1.85 acres of City and State lands, as depicted in Figure MW-2.

2. The City will develop 1.05 acres of salt marsh habitat, 50% of which will be planted with native marsh vegetation appropriate to the site. The City may propose during project permitting, if federal, state and tribal resource staff agree, that an additional area or areas of salt marsh be re-established through natural re-colonization in order to investigate the efficacy of natural re-colonization in this shoreline or if a higher value of habitat can be achieved through an alternative expenditure.

   Material at the new intertidal interface and immediately below will be demonstrably suitable for use in the intertidal environment. Where subsurface exploration or

[1] National Oceanic and Atmospheric Administration (NOAA); U.S. Fish and Wildlife Service (USFWS); Muckleshoot Indian Tribe; Puyallup Indian Tribe, Washington State Department of Ecology (acting as State lead), and the Washington State Departments of Fish & Wildlife; and Natural Resources.

project excavation reveals fill at the proposed wetland surface, such fill shall be excavated to a depth of 3 feet or to a depth where wood or other unsuitable fill material is not evident, whichever is less, and suitable material shall be placed in its stead. Where subsurface exploration reveals native material at the proposed intertidal surface and to a depth of two feet below that surface, the proposed surface would be considered suitable.

3. The City will develop 0.60 acres of riparian habitat, less any amount developed for public access from East F. St., existing utility tie-downs, or source control facilities agreed to by the City and the parties. 100% of the riparian area will be planted with native vegetation appropriate to the site.

   The City will utilize soil amendments in the riparian area in a manner suitable for shoreline environments.

   Irrigation will be provided for all shrub and tree riparian plantings.

4. The City will restore 0.20 acres of mudflat to provide transition from existing mudflat to the restored salt marsh.

5. A planting plan will be developed for the restoration site during project permitting and would be subject to the review, comment and approval of resource and permitting agencies prior to the issuance of project permits. Proposed plantings will be based upon a review of similar projects in the Commencement Bay Area.

6. The City will develop public access from either 11th St. (Figure MW-4) to an overlook on State or private property, or from East F. St. to an overlook on city property. In general, access from 11th St. is preferred in order to connect to a bicycle lane on that street. However, the 11th Street access route crosses private property and is contingent on reaching an agreement with the private landowner.

7. The project will result in the removal of the contaminants from City and State property identified as sources of contamination to the Middle Waterway by the Washington State Department of Ecology.[2] The properties were sampled by the City of Tacoma in July and August of last year as described in the June 1995 Sampling and Analysis Plan reproduced here. The issuance of the site characterization report will be the first step toward obtaining project permits and eventual project construction. Initial data has been provided to the United States Environmental Protection Agency and the Washington State Department of Ecology.

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[2] Washington State Department of Ecology. 1994. *Commencement Bay Nearshore/Tideflats Middle Waterway Source Control Status Report: Milestone 1. January, 1994.*

8. The City has included in the project budget funds sufficient for monitoring and maintenance of the project over a five year period. Funds have been budgeted for maintenance and the implementation of recommendations developed through project monitoring at an amount equal to 25% of the expected construction cost, or 5% per annum for five years. Additional funds are available for the monitoring of site conditions annually for five years. If funds are not utilized as part of the monitoring and maintenance program, they will be available for the implementation of project elements arising outside of the formal monitoring program or for restoration actions elsewhere in Commencement Bay at the discretion of the trustee agencies.

A note on the value of this type of habitat restoration project, located in this part of the Puyallup River/ Commencement Bay, may also be warranted and is provided below.

Estuarine marshes are one of the primary sources of carbon that drive the estuarine food web. Carbon, and the chemical energy associated with carbon molecules, comes into the estuarine system via primary production (i.e. is produced within the estuary by plants) and via import from the adjacent river and shoreline environments. The largest source of carbon to the estuary is the river. However, each source of carbon is important as each enters the estuary at different rates at different times of the year and each supports a different type of vertebrate or invertebrate organism. The organic matter that is exported as detritus from estuarine marshes to mudflats supports, for example, an assemblage of macro-invertebrates which are a primary prey organism of juvenile salmon (Simenstad, 1983). Estuarine marshes as a result provide indirect and perhaps indispensable support for a commercial, sport, subsistence and ceremonial fishery that remains central to life in the Pacific Northwest. Estuarine marshes also provide feeding opportunities for terrestrial mammals and wintering waterfowl. Mallard, pintail, and American widgeon, among others, feed directly on the seed of estuarine marsh grasses, and the northern harrier hunts deer mice and shrews in the marsh (Schultz, 1990). The restoration of estuarine marsh habitat was one of six recommendations put forth by researchers investigating historic changes in populations of fish and shellfish in Commencement Bay (Wampler, 1991).

A number of approaches have been attempted to define the value of such habitats. Mitsch and Gosselink (1986) review the difficulties inherent in such a valuation, i.e., wetlands are multiple value systems; their most valuable products are public amenities with limited value to a private landowner; and that as wetland area decreases, the marginal value increases. The increasing value of a diminishing resource is particularly relevant in Commencement Bay, where 240 of the original 6000 acres exist today, the remainder having been converted to upland uses or otherwise "lost" (USACOE, et. al., 1993). Although Commencement Bay wetland habitats have not been reduced to their last acre,

clearly there have been reductions in extent and function.[3] Consultants to federal agencies have concluded that "restoration of nearshore wetland habitat would benefit natural resources in this area and enhance fish and wildlife populations."

The desirability of restoring habitat in Middle Waterway was addressed by the Commencement Bay Cleanup Action Committee (CBCAC) in 1993. The CBCAC publication *A Vision for Commencement Bay* states that, "One of the most substantial contributions to the restoration of habitat and natural resources could be the preservation of the 18 acre Middle Waterway mudflats and the restoration of its shoreline...(which)..represents the largest original tideflat west of the Puyallup Delta." Restoration in this area would satisfy restoration planning goals and also be consistent with local economic development initiatives.

References

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Mitsch, W.J. and J.G. Gosselink. 1986. *Wetlands*. Van Nostrand Reinhold.

Schultz. S.T. 1990. *The Northwest Coast*. Timber Press, Portland, OR.

Simenstad, C.A. 1983. *The Ecology of Estuarine Channels of the Pacific Northwest Coast: A Community Profile*. United States Fish and Wildlife Service,. FWS/OBS-83-05. 181 pp.

United States Army Corps of Engineers, US Fish and Wildlife Service, National Oceanic and Atmospheric Administration, US Environmental Protection Agency. 1993. *Commencement Bay Cumulative Impact Study. Vol. 1, Assessment of Impacts*. United States Army Corps of Engineers, Seattle District Office, Seattle, WA.

Wampler, P.L. 1991. Changes in Populations and Distributions of Anadromous Fish, Demersal Fish, and Shellfish Utilizing nearshore Habitat in Commencement Bay, 1850-1988, in, *Commencement Bay Cumulative Impact Study. Vol. 1, Assessment of Impacts*. United States Army Corps of Engineers, Seattle District Office, Seattle, WA.

[3] The United States Fish and Wildlife Service offers a somewhat more forceful assessment: "(N)early total loss of habitat resulted in nearly total loss of many species endemic to the bay during the 138 years prior to 1988." (Wampler, 1991)

Foreword

The Project Concept and Sampling and Analysis Plan presented here for the restoration of estuarine habitat in Middle Waterway were prepared under the direction of staff at the City of Tacoma Public Works Department (Utility Services Engineering and Laboratory). In preparing this plan, City staff utilized the *Sampling and Analysis Plan for the Middle Waterway Shore Restoration Project*, prepared by Parametrix, Inc. for Simpson Tacoma Kraft Company and the Natural Resources Trustees, as a guide.[4] This City project, adjoining in locale and similar in habitat objectives to the Simpson/Trustee project, is in many ways a mirror to that project; the Sampling and Analysis Plan approved for that project therefore seemed a logical point of departure.

A factor which differentiates the City project (west side) from the Simpson/Trustee Project (east side) is the status of the west side properties with respect to the Middle Waterway Superfund Area. Properties on the west side within the restoration study area have been identified as sources (minor) of contamination to the waterway due to the chemical composition of material found on the banks. This sampling plan, and restoration concepts to be finalized after data collection, will by necessity address a contamination issue somewhat different from that addressed under restoration efforts on the east side.

Restoration planning would begin with completion of an environmental site characterization; the City sampled in the restoration study area in June of last year (1995). The results of sampling will be used to develop a conceptual or preliminary restoration design, consistent with site conditions and 404 permitting policies, during the following months. Substantial completion of preliminary design will allow the City to develop and circulate a more complete project description and begin the local permitting process. Completion of local permitting in turn triggers the state and federal permitting process, which would presumably be followed by construction in the summer of 1997. A more complete restoration project schedule is presented in Table MW-1 of this report.

A Note on Datums

Topographical data in Figures 2, 5 and 6 of this report describe existing conditions based upon the National Geodetic Vertical Datum, 1929 (NGVD29). This data is based upon aerial photogrammetric data collected by the City in 1990. NGVD29 is the datum appropriate for engineering and land surveying uses, where precision and accuracy with respect to elevations requires the use of an exact standard. For this reason, the City's Geographical Information

[4]The City also utilized the Quality Assurance Project Plans (QAPPs) prepared for recent Hylebos and Thea Foss Waterway biological and sediment testing, respectively, to prepare the QAPP included as an appendix to this document. The Hylebos QAPP was made available with the permission of Hylebos Cleanup Committee and their consultant team. The Foss QAPP was prepared by consultants to the City.

Systems City-Wide Base Map Data Base, which was used to produce these figures, utilizes NGVD29.

Topographical data depicted in habitat concept plans is reported relative to MLLW. This datum is utilized in Figures 3, 4, 7, 8 and 9. MLLW is the generally accepted and appropriate datum for biological investigations and restoration planning. In the intertidal environment, elevation with respect to a base hydraulic condition is a meaningful descriptor allowing comparison of flora and fauna between sites, while elevation relative to an arbitrary land based system may hamper the comparison of information between sites. The use of two datums in this report is unfortunate and at times confusing; as an aide to the reader, we have periodically presented in the text the NGVD29 elevation in parentheses following elevations presented relative to MLLW.[5]

Acknowledgment

City staff acknowledge the staff of the Simpson Tacoma Kraft Company and the Natural Resources Trustees (NOAA, USFWS, Dept. of Ecology, and the Puyallup and Muckleshoot Indian Tribes) for their pioneering habitat restoration efforts in Middle Waterway.

[5]In Commencement Bay using the NGVD29 datum, MHHW is located (approximately) at elevation 5.5 feet, and MLLW is located (approximately) at elevation -6.3 feet. An elevation relative to NGVD29 is converted to a MLLW elevation by adding 6.3 feet to the NGVD29 valur.

PROJECT CONCEPT PLAN
October 1996

1.0 INTRODUCTION

The City of Tacoma is proposing to develop an estuarine shoreline wetland restoration project on Middle Waterway within the City of Tacoma and Commencement Bay (Figures MW-1 & 2). Excavation or re-grading of the 1.85 acre vacant upland property, located adjacent to and within the southwest shore of the Waterway, would result in the establishment of intertidal marsh and riparian buffer bordering one of the few remaining original mudflats within Commencement Bay. The project would create new habitat, enhance existing habitat, buffer both new and existing habitat, and provide public access for education and passive recreation.

The project has been designed for the specific and single purpose of enhancing and expanding estuarine wetland habitat. Project goals are to:

1. Demonstrate the viability of reclaiming former industrial shorelines for estuarine intertidal habitat.

2. Restore and enhance estuarine habitat for juvenile salmonids, particularly Chinook (*Oncorynchus tshawytscha*), pink (*Oncorynchus gorbuscha*), and chum salmon (*Oncorynchus keta*), originating in the Puyallup River System.

3. Provide increased emergent, intertidal wetland habitat for wetland dependent species in the lower Puyallup River estuary.

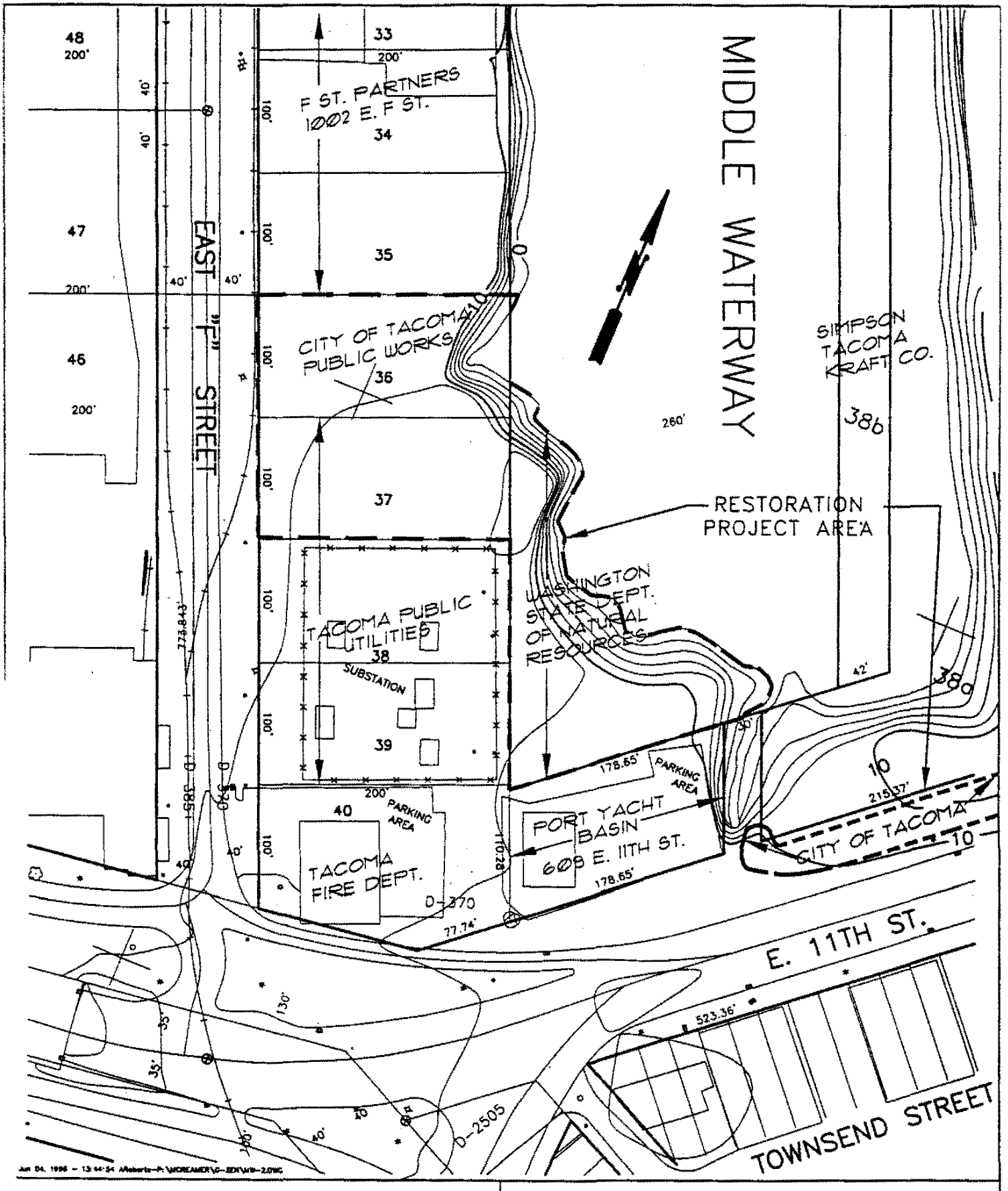
4. Provide habitat linkages to and between nearby estuarine intertidal mudflat and marsh habitats.

5. Increase awareness of the desirability of additional habitat restoration efforts within Middle Waterway, one of the largest tracts of intertidal mudflat remaining in Commencement Bay.

6. Complement and protect the Natural Resources Trustee/Simpson Middle Waterway restoration project and existing tideflats through the conversion of industrial shoreline property to habitat.

7. Provide an opportunity to investigate the viability of habitat in an urban estuarine environment.

8. Provide a non-intrusive environmental education/public access opportunity in close proximity to the city center to increase public awareness of the importance of this type of habitat within the Commencement Bay ecosystem.



City of Tacoma
Middle Waterway
Restoration Study Area

Figure MW-2
Southwest Shore and
Property Ownerships

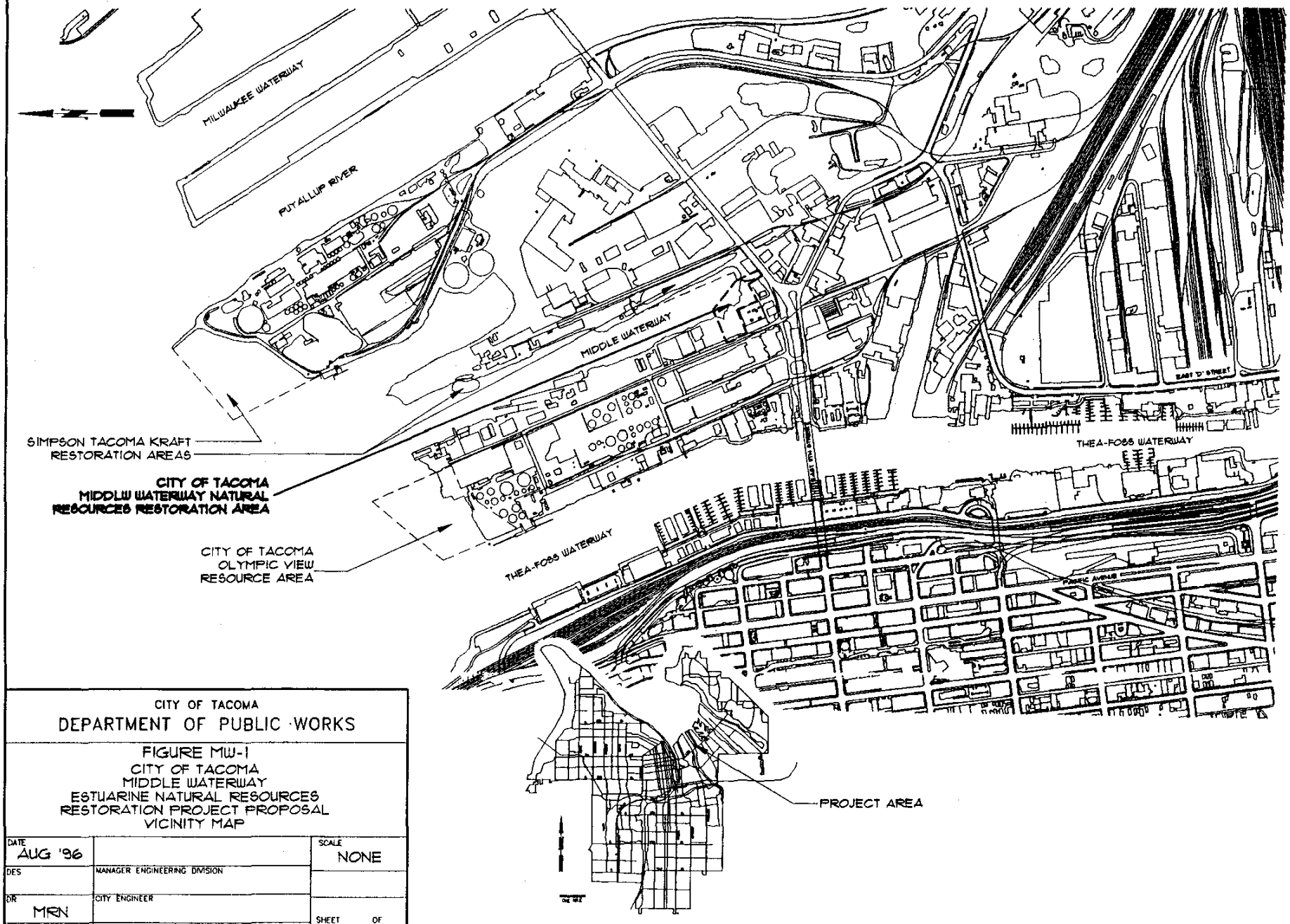
1.1 PROJECT PROPOSAL

The City is proposing a project to restore estuarine intertidal habitat on 1.85 acres of vacant property adjacent to Middle Waterway. Restoration activity would include the excavation and re-grading of vacant upland property adjacent to and possibly within the southwest shore of the Waterway. Intertidal wetland and riparian habitat would be constructed along the shore of the waterway and debris and other anthropogenic material would be removed from the surface of the existing shoreline. Limited public access for education and passive enjoyment would be permitted on the upland portions of the site.

As part of the restoration effort, the City would remove fill material from the project site and the head of Middle Waterway along the western shore. The City would re-grade the elevation of much of the project area to a level of +10 ft to +11 ft MLLW (4-5 ft. NGVD29, approximately), the elevation at which *Salicornia* and *Carex* (Lyngby's Sedge) is found in Middle Waterway and elsewhere in the estuary. If suitable, the excavated material would be used as fill in other areas of the project. One project concept would utilize a portion of this material in existing intertidal areas to create additional habitat for *Salicornia* and *Carex*. Re-establishment of intertidal vegetation would be by natural colonization (as evident in the southern area of the waterway) or by planting efforts. Schematic drawings of two project concepts are depicted in Figures MW-3 and MW-4, but final project plans, which would include the limits of excavation, over-excavation, fill and backfill and the extent of vegetative plantings would be based upon discussions with the regulating and resource agencies.

Restoration at this site presents both unique challenges as well as opportunities. The intertidal sediments adjacent to the project site are within the Middle Waterway Superfund Problem Area, although they are not identified for active remediation under the EPA Commencement Bay Record of Decision (ROD). The sediments on the banks of certain properties, however, are described as a minor source of contaminants to the Waterway by the Department of Ecology (Department of Ecology, 1994). The restoration project would result in the removal of this reported source of contamination to the waterway. Likewise, seeps to the waterway, although small, contain concentrations of copper in excess of state standards. The removal of subsurface material would presumably remove the source of seep contamination. Construction debris, a substrate largely unsuitable as habitat, would also be removed under a general plan of site grading.

The project schedule is included in this document as Table MW-1. The City initiated the environmental characterization upon publication and approval of the Sampling and Analysis Plan in 1995. Upon completion of the site characterization report, the City will initiate the shoreline substantial development permit application process, the first in a series of state and federal permits. The City Storm Utility, the project proponent, would work with the agencies and City regulators (Building and Land Use Services) through out the fall months to ensure that both cleanup and habitat considerations are addressed in a manner consistent with applicable local, state and federal regulations. Presumably, when the local, state and federal permits are issued in



CITY OF TACOMA

DEPARTMENT OF PUBLIC WORKS

FIGURE MW-1

CITY OF TACOMA
MIDDLE WATERWAY
ESTUARINE NATURAL RESOURCES
RESTORATION PROJECT PROPOSAL
VICINITY MAP

DATE AUG '96		SCALE NONE
DES	MANAGER ENGINEERING DIVISION	
DR MRN	CITY ENGINEER	SHEET OF
CK	DIRECTOR OF PUBLIC WORKS	DWG NAME

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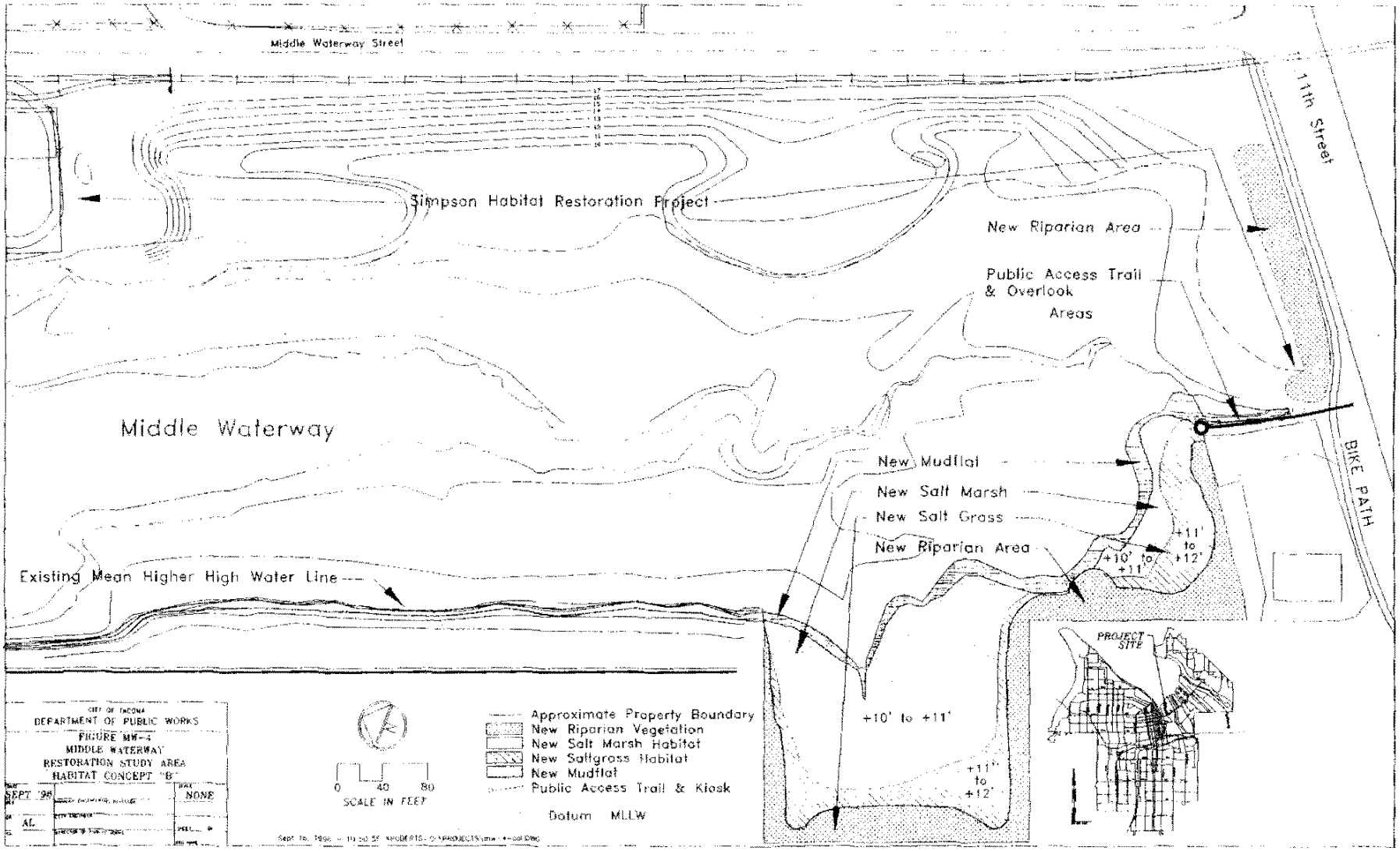
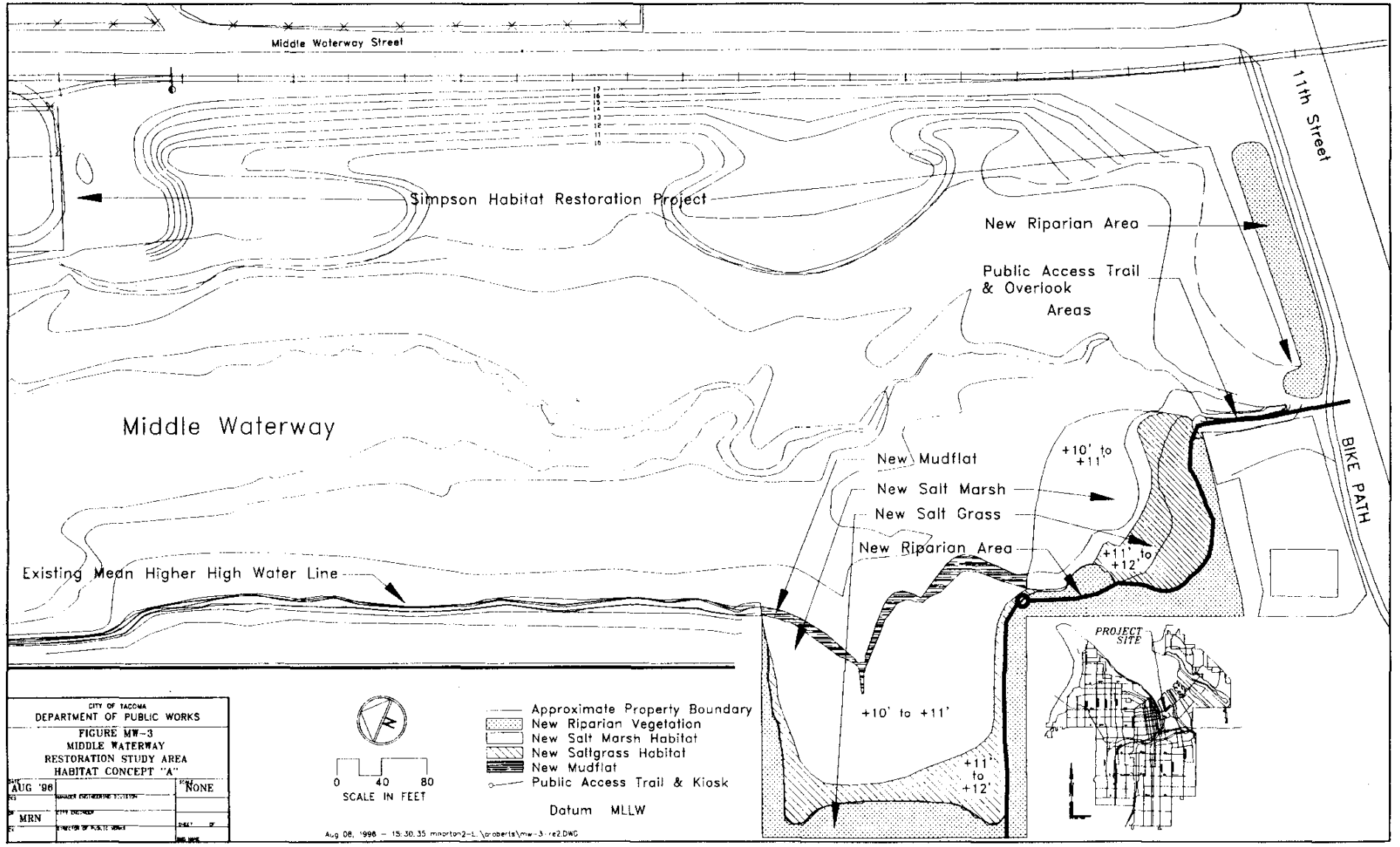

Middle Waterway Street
11th Street
Simpson Habitat Restoration Project
New Riparian Area
Public Access Trail & Overlook Areas
Middle Waterway
New Mudflat
New Salt Marsh
New Salt Grass
New Riparian Area
+11' to +12'
+10' to +11'
BIKE PATH
Existing Mean Higher High Water Line
PROJECT SITE
+10' to +11'
+11' to +12'
CITY OF TACOMA
DEPARTMENT OF PUBLIC WORKS
FIGURE MM-5
MIDDLE WATERWAY
RESTORATION STUDY AREA
HABITAT CONCEPT "B"
SEPT '98
AL
NONE
0 40 80
SCALE IN FEET
Approximate Property Boundary
New Riparian Vegetation
New Salt Marsh Habitat
New Saltgrass Habitat
New Mudflat
Public Access Trail & Kiosk
Datum MLLW


Middle Waterway Street
11th Street
Simpson Habitat Restoration Project
New Riparian Area
Public Access Trail
& Overlook
Areas
Middle Waterway
New Mudflat
New Salt Marsh
New Salt Grass
New Riparian Area
+10' to
+11'
+11' to
+12'
BIKE PATH
Existing Mean Higher High Water Line
+10' to +11'
+11'
to
+12'
PROJECT
SITE
CITY OF TACOMA
DEPARTMENT OF PUBLIC WORKS
FIGURE MW-3
MIDDLE WATERWAY
RESTORATION STUDY AREA
HABITAT CONCEPT "A"
DATE
AUG '96
SCALE
NONE
DES
MANAGER ENGINEERING DIVISION
DR
MRN
CITY ENGINEER
CK
DIRECTOR OF PUBLIC WORKS
SHEET OF
JOB NO.
0
40
80
SCALE IN FEET
Approximate Property Boundary
New Riparian Vegetation
New Salt Marsh Habitat
New Saltgrass Habitat
New Mudflat
Public Access Trail & Kiosk
Datum MLLW
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the latter part of 1996, such permits would reflect a cleanup and restoration plan that is consistent with state and federal regulatory program requirements.

As part of project planning and design, the City conducted a sediment characterization of properties within the restoration study area, with a primary objective of characterizing sediments at elevations that correspond to the proposed new grade (i.e. at proposed future intertidal elevations). Sampling was conducted in accordance with EPA Contract Laboratory Procedures (EPA CLPs) for chemical analysis and Puget Sound Estuary Program Protocols (PSEP Protocols) for biological analysis.

The objectives of the sampling program are:

1. Characterize the sediment quality of the proposed future intertidal surface to ascertain the feasibility of establishing intertidal habitat on the property.

2. Characterize the sediment quality in intertidal mudflats immediately adjacent to the project site to provide a description of the baseline environmental conditions in the immediate vicinity.

3. Characterize more completely sediment quality of the bank area on the project site.

4. Characterize sediment quality in material that may be utilized as fill in intertidal areas.

The sampling plan was similar to that proposed and executed by Simpson Tacoma Kraft and the Natural Resources Trustees in that:

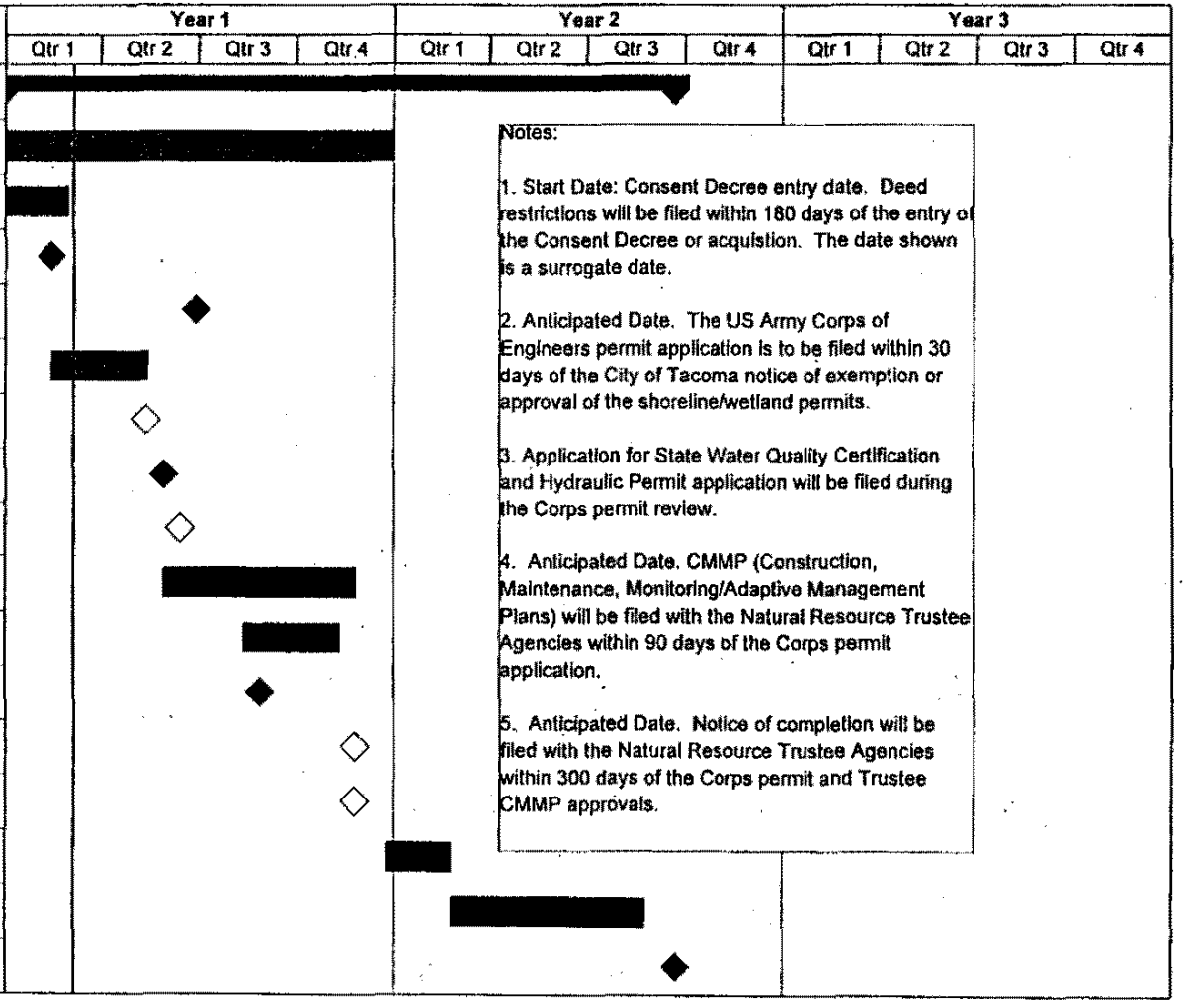
- The project involved the characterization of surface sediments and subsurface saturated fill material (materials occurring below +11.8 ft). The chemical characterization of the overlaying soils was not within the scope of this plan.

- The sampling of deeper strata in upland areas was by backhoe at low tide.

- Sediment in the mudflat adjacent to the project area was sampled at a depth of 0-10 cm depth for chemical and biological analysis and at depths of 1-2 feet and 2-3 feet for sediment quality analysis. All sediments were analyzed for acid-base/neutral compounds, total and acid volatile sulfides, mercury, and conventional parameters (grain size, total organic carbon, ammonia and total sulfide). Samples at 0-10 cm were also subject to biological characterization utilizing the amphipod *Rhepoxynius abronius*; echinoderm larval (*Dendraster excentricus*), juvenile polychaete (*Neanthes*), benthic community structure, and Microtox tests under PSEP protocols. Benthic population will be enumerated to the lowest practical taxonomic level.

CITY OF TACOMA
MIDDLE WATERWAY ESTUARINE RESTORATION
PROJECT SCHEDULE

ID	Task Name	Start Day	Finish Day
1	Middle Waterway Estuarine Restoration	1	630
2	Baseline Habitat Data Collection	0	365
3	Preliminary Design	0	60
4	Shoreline/Wetland Permit Applications	45	45
5	Deed Restrictions Filed (1)	180	180
6	Shoreline/Wetland Permit Review	45	135
7	City Shoreline/Wetland Permit Approval	135	135
8	Corps Of Engineers Permit Application (2)	150	150
9	State Shoreline Permit Approval	165	165
10	Corps Of Engineers Permit Review (3)	150	330
11	Final Design	225	315
12	CMMP Submittal (4)	240	240
13	Corps Of Engineers Permit Approval	330	330
14	CMMP Approval	330	330
15	Bid and Contract	360	420
16	Construction (5)	420	600
17	Notice of Completion (6)	630	630



Notes:

1. Start Date: Consent Decree entry date. Deed restrictions will be filed within 180 days of the entry of the Consent Decree or acquistion. The date shown is a surrogate date.

2. Anticipated Date. The US Army Corps of Engineers permit application is to be filed within 30 days of the City of Tacoma notice of exemption or approval of the shoreline/wetland permits.

3. Application for State Water Quality Certification and Hydraulic Permit application will be filed during the Corps permit review.

4. Anticipated Date. CMMP (Construction, Maintenance, Monitoring/Adaptive Management Plans) will be filed with the Natural Resource Trustee Agencies within 90 days of the Corps permit application.

5. Anticipated Date. Notice of completion will be filed with the Natural Resource Trustee Agencies within 300 days of the Corps permit and Trustee CMMP approvals.

Project: Middle Waterway
Date: Mar 6 '97

Task ■ Summary ■ Date ◇
Milestone Date ◆ Multiple Dates ▥

The second part of the document, the *Sampling and Analysis Plan*, outlines sampling and analysis procedures that were followed during the sediment characterization of the Middle Waterway project site. The plan was developed in accordance with the protocols and quality assurance/quality control (QA/QC) objectives set forth in EPA Contract Laboratory Procedures for chemical analysis and *Puget Sound Estuary Protocols Recommended Guidelines for Measuring Selected Environmental Variables in Puget Sound* (USEPA,1991) for biological analysis.

1.2 SITE HISTORY

Prior to the 1880s, the area now occupied by Middle Waterway existed without improvements as part of a larger tract of open water, mudflat and emergent marsh below the two main distributary channels of the Puyallup River. The transformation of the area began in 1888, when the St. Paul and Tacoma Lumber Company established what became the region's pre-eminent mill on marsh land situated between the mouths of the two distributary channels of the river, an area known as "the Boot", directly south of present day Middle Waterway. Until that time, the Puyallup River's main channel divided into two near present-day Interstate 5 and the western channel of the river met Commencement Bay in the embayment at the base of a forested bluff. Between 1888 and 1891, this embayment was dredged and a cut-off wall constructed at the head of the west channel, diverting the flow of the entire river through the eastern channel. The former west river channel, cut off from the flow of the river, became the Wheeler-Osgood Waterway, and the embayment the Thea Foss (City) Waterway. Twenty years later, construction of the Auburn Wall diverted the entire flow of the White River out of the Green-Duwamish basin and into the Puyallup River, where it remains to this day, doubling the flow rate in the Puyallup. (Morgan 1979, 1982; Magden and Martinson, 1982; Pierce County, 1992; USACOE, et. al., 1993).

Shortly after the St. Paul and Tacoma Mill became operational, the company constructed a pier extending from the mill south of East 11th Street into the deeper harbor area (Morgan 1979). In 1896, bulkheads were constructed about 600 ft north of East 11th Street and filled with mill debris and sawdust wastes (Sanborn 1896). Eventually, a piling wharf was extended beyond the fill to the Harbor line and schooner loading facilities. Between 1907 and 1913, the Middle Waterway, newly created by fill on either side, was dredged for navigation.

Major growth and expansion near and adjacent to the head of the Middle Waterway occurred in the 1920s and 1930s. Tennent Steel (later the Western Steel Casting Co.) built a foundry and mill in 1923 near the head of the waterway. The mill site apparently abutted the waterway on the southwest side. Berkhiemer Manufacturing (roofing products) preceded Tennent Steel, apparently on the same or an adjacent property . A series of small brass, aluminum, and steel foundries also operated on both sides of East 11th Street at the head of the waterway (Hart Crowser, 1991).

Since it's original dredging, the waterway's use for navigational commerce peaked at some unknown time and then declined. Four wharves were utilized in the Waterway for lumber and berthing (USACOE, et. al., 1993) between 1927 and 1941; however, by this latter date, shoaling had established tideflat habitat in the lower half of the waterway. Tideflats are at this writing exposed in much of the waterway at low tides, and in most of the waterway at extreme low tides.

1.3 RESTORATION STUDY AREA SITE CONDITIONS

The Restoration Site Study Area (the project site and adjacent tideflats) is comprised of vacant uplands, steep banks and tideflats. Data describing qualitatively the physical, chemical, and biological conditions of the study area was collected as part of a site characterization and will be published as a site characterization report prior to project permitting. A general discussion of site characteristics and previous sampling and analysis - which guided preparation of the sampling and analysis plan (Section 2.0) for the site characterization - is provided below.

1.3.1 City of Tacoma/Public Works Property

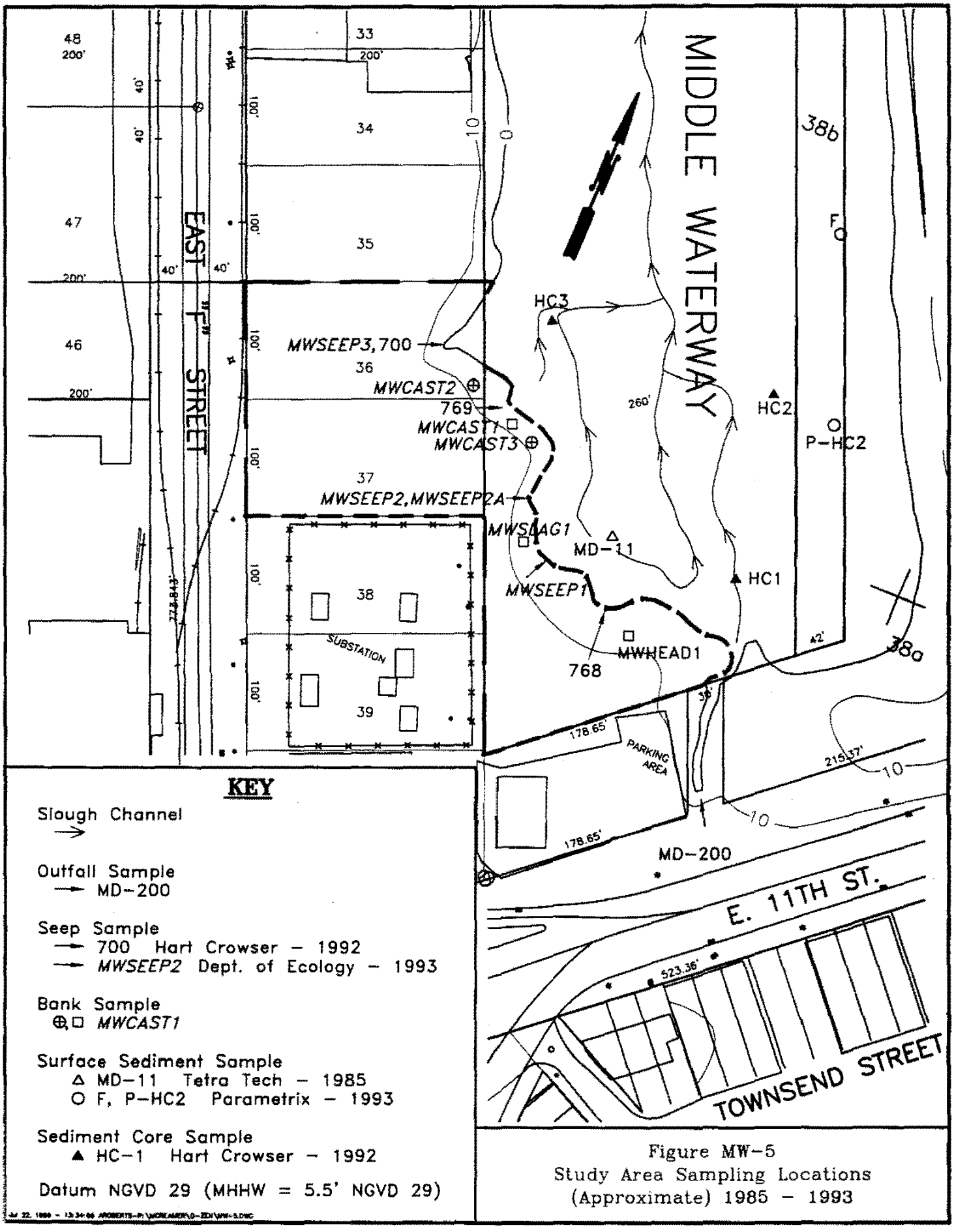
The City of Tacoma Public Works property is a 100' x 200' (0.45 acres) parcel that is presently vacant. The property is for the most part graded flat and partially graveled, except for the eastern quarter which slopes sharply to the intertidal mudflats of Middle Waterway. Property elevations range from approximately 10 ft NGVD29 on the western three fourths of the property to 0 feet in the tideflat area (i.e. 16 feet to 6 feet MLLW) on the eastern property boundary (Figure MW-2).

The property is dominated by an expanse of Himalayan blackberry (*Rubus discolor*) which extends from the central portion of the property to the property boundaries on the north and south and to the top of the slope on the east. Bank slopes are approximately 1:1 and are unvegetated to the intertidal mudflat.

Ecology staff (UBAT, 1993) sampled the seep and the bank area on this property (Figure MW-5 and Tables MW-2 & 4). Bank sediment samples were analyzed for priority organics (mwcast2), although analysis for total organic carbon was not undertaken. A number of exceedences of EPA SQOs were noted for the single sample analyzed for organics; as organic carbon data is not available, a comparison can not be made to state standards.

An undiluted seep sample (mwseep3) exceeded marine water quality criteria for copper and zinc.[6] Flow rate data was not obtained. Hart Crowser (Hart Crowser, 1992) had previously sampled this same seep (Seep No. 700) and analyzed the sample for arsenic, copper, lead and zinc. The undiluted sample exceeded the marine water quality standards for copper; the measured seep flow rate was approximately 0.0002 cfs.

[6] 40 CFR 131.36 (National Toxics Rule)



KEY

Slough Channel
→

Outfall Sample
→ MD-200

Seep Sample
→ 700 Hart Crowser – 1992
→ *MWSEEP2* Dept. of Ecology – 1993

Bank Sample
⊕,□ *MWCAST1*

Surface Sediment Sample
△ MD-11 Tetra Tech – 1985
○ F, P-HC2 Parametrix – 1993

Sediment Core Sample
▲ HC-1 Hart Crowser – 1992

Datum NGVD 29 (MHHW = 5.5' NGVD 29)

Figure MW-5
Study Area Sampling Locations
(Approximate) 1985 – 1993

TABLE MW-2
MIDDLE WATERWAY SEEP AND STORM DRAIN WATER QUALITY

Study / Station Name	Marine CMC	Marine CCC	Marine Consmp.	Department of Ecology - 1993 MW200	MWSEEP1	MWSEEP2	MWSEEP2A	MWSEEP3	Hart-Crowser - 1992 MW-200	768	769	700
Metals (mg/kg)												
Antimony				30 U		30 U		30 U				
Arsenic	69	36	0.14	12	3.0 U	3 U		3 U	30	50 U	50 U	50 U
Cadmium	43	9.3	narrative	2 U	2.0 U	3.O U		2.8 U				
Chromium	1100	50	narrative	6.5 U	30 U	35 U		21 U				
Copper	2.9	2.9		20	125	70 U		34	51	34	3	5
Lead	220	8.5	narrative	3.6 J	2.5 J	5 N		5.1 U	24 U	5 U	5 U	5 U
Mercury	2.1	0.025		0.1 U	0.25 U	0.1 U		1 U	1 U	1 U	1 U	
Nickel	75	8.3	4600	10 U	10 U	10 U						
Silver	2.3			3 U	3.0 U	3 U			10 U	50 U	50 U	50 U
Zinc	95	86		30 UJ	84	30 U		200	14 U	14 U	16 U	
Berylium			narrative	1 U	1.0 U	1 U						
Selenium	300	71	narrative	4 U	4.0 U	4 U						
Thallium			6.3	5 N	5.0 N	5 N						
Organics (ug/kg dry wt. except state standards are mg/kg total organic carbon)												
LPAH												
Naphthalene									1.5 U	1.1 U	1.1 U	1.5 U
Acenaphthylene							1.0 U		3.1 U	2.4 U	2.4 U	3.1 U
Acenaphthene							1.0 U		2.3 U	1.7 U	1.7 U	2.3 U
Fluorene							1.0 U		0.07 J	0.15 U	0.06 J	0.09 U
Phenanthrene							1.0 U		0.17	0.1 U	0.1 U	0.13 U
Anthracene							1.0 U		0.03 J	0.05 U	0.05 U	0.07 U
2-Methylnapthalene							1.0 U					
Total LPAH												
HPAH												
Flouranthene							1.0 U		0.33	0.2 U	0.2 U	0.12 J
Pyrene							1.0 U		1.4	0.35 U	0.16 J	0.47 U
Benzo(a)anthracene							1.0 U		0.49	0.25 U	0.25 J	0.33 U
Benzo(a)pyrene							1.0 U		0.27 U	0.2 U	0.2 U	0.05 J
Chrysene							1.0 U		0.06 J	0.1 U	0.02 J	0.05 J
Benzo(b)fluoranthene							1.0 U					
Benzo(k)fluoranthene							1.0 U					
Total Benzofluoranthenes									0.33 U	0.25 U	0.16 J	0.24 J
Indeno(1,2,3,c-d-)pyrene							1.0 U		0.11	0.05 U	0.02 J	0.05 J
Dibenzo(a,h)anthracene							1.0 U		0.4 U	0.3 U	0.3 U	0.4 U
Benzo(g,h,i)perylene							1.0 U		0.18 J	0.25 U	0.25 U	0.33 U
Total HPAH												

TABLE MW-2
MIDDLE WATERWAY SEEP AND STORM DRAIN WATER QUALITY

Study	Marine	Marine	Marine	Department of Ecology - 1993					Hart-Crowser - 1992			
Station Name	CMC	CCC	Consmp.	MW200	MWSEEP1	MWSEEP2	MWSEEP2A	MWSEEP3	MW-200	768	769	700
PCBs												
Total PCBs												
Chlorinated Hydrocarbons												
1,3-Dichlorobenzene								1.0 U				
1,4-Dichlorobenzene								1.0 U				
1,2-Dichlorobenzene								1.0 U				
1,2,4-Trichlorobenzene								1.0 U				
Hexachlorobenzene								1.0 U				
Phthalates												
Dimehtyl phthalate								1.0 U				
Diethyl phthalate								0.25 J				
Di-n-Butyl phthalate								0.1 J				
Butylbenzyl phthalate								1.0 U				
bis(2-Ethylhexyl) phthalate								1.0 U				
Di-n-Octyl phthalate								1.0 U				
Phenols												
Phenol								6.4				
2-Methylphenol								1.0 U				
4-Methylphenol								1.0 U				
2,4-Dimethylphenol								1.0 U				
Pentachlorphenol								5.1 U				
Volatile Organics												
Trichlorethene												
Tetrachloethene												
Ethyl Benzene												
Xylenes												
Miscellaneous Compounds												
2-Nitrophenol								2.5 U				
2-Chlorophenol								1.0 U				
2,4-Dinitrophenol								10.1 U				
2,4,5-Trichlorophenol								1.0 U				
2,4,6-Trichlorophenol								1.0 U				
4-Bromophenyl-phenylether												
4-Nitrophenol								1.0 U				
4-Chloro-3-Methylphenol								1.0 U				

TABLE MW-2
MIDDLE WATERWAY SEEP AND STORM DRAIN WATER QUALITY

Study / Station Name	Marine CMC	Marine CCC	Marine Consmp.	Department of Ecology - 1993 MW200	MWSEEP1	MWSEEP2	MWSEEP2A	MWSEEP3	Hart-Crowser - 1992 MW-200	768	769	700
4-6-Dinitro-2-Methylphenol												
Conventionals												
Discharge (cubic feet/sec)									0.0050	0.0001	0.01	0.0002
Dissolved Oxygen (mg/l)									6.2	5.7	6.1	7
Temperature (Degrees C)									19	20	17	19
pH									6.9	6.8	7.2	7
TDS (ppt)									1.1	27	24	28
TSS (mg/l)									61	100	97	110

Exceeds Water Quality CMC or CMC standard (established for the protection of aquatic life)
Exceeds Water Quality Standard for Organism Consumption (human health-based standard)
CMC = Criterion Maximum Concentration as per 40CFR 131.36
CMC = Criterion Continuous Concentration as per 40CFR 131.36

U =The analyte was not detected at or above the reported value.
J = The associated numerical result is an estimated quantity.
UJ = The analyte was not detected at or above the estimated value.
N = There is evidence that the analyte is present.
NJ or JN = There is evidence that the analyte is present. The associated numeric value is an estimate.
P = The analyte was detected above the instrument detection limit but below the established minimum quantification limit.

8/8/94
MWWSEEP.XLS

TABLE MW-3
MIDDLE WATERWAY STORM DRAIN SEDIMENT QUALITY

Study Station Name	EPA SQO	Wash. SQS	Wash MCUL/CSL	Dept. of Ecology MW200SS-1993*	
Metals (mg/kg)					
Antimony	150			3	UJ
Arsenic	57	57	93	20.5	
Cadmium	5.1	5.1	6.7	1.2	P
Chromium		260	270	36.4	E
Copper	390	390	390	323	
Lead	450	450	530	201	E
Mercury	0.59	0.41	0.59	0.165	
Nickel	140			25.6	
Silver	6.1	6.1	6.1	0.7	PJ
Zinc	410	410	960	3	UJ
Berylium				0.21	P
Selenium				0.4	U
Thallium				0.5	UJ
Organics (ug/kg dry wt.)	***Italicized state standards are mg/kg TOC***				
LPAH					
Naphthalene	2100	*99*	*170*	800	U
Acenaphthylene	1300	*66*	*66*	800	U
Acenaphthene	500	*16*	*57*	800	U
Fluorene	540	*23*	*79*	800	U
Phenanthrene	1500	*100*	*480*	250	J
Anthracene	960	*220*	*1200*	800	U
2-Methylnapthalene	670	*64*	*38*	800	U
Total LPAH	5200	*370*	*780*		
HPAH					
Flouranthene	2500	*160*	*1200*	620	J
Pyrene	3300	*1000*	*1400*	510	J
Benzo(a)anthracene	1600	*110*	*270*	250	J
Benzo(a)pyrene	2800	*99*	*210*	130	J
Chrysene		*110*	*460*	270	J
Benzo(b)fluoranthene				340	J
Benzo(k)fluoranthene	3600			800	U
Total Benzofluoranthenes	1600				
Indeno(1,2,3,c-d-)pyrene	690	*34*	*88*	120	J
Dibenzo(a,h)anthracene	230	*12*	*33*	800	U
Benzo(g,h,i)perylene	720	*31*	*78*	120	J
Total HPAH	17000	*960*	*530*		
PCBs					
Total PCBs	150	*12*	*65*		
Chlorinated Hydrocarbons					
1,3-Dichlorobenzene	170			800	U
1,4-Dichlorobenzene	110	*9*	*3.1*	800	U
1,2-Dichlorobenzene	50	*2.3*	*2.3*	800	U
1,2,4-Trichlorobenzene	51	*0.81*	*1.8*	800	U
Hexachlorobenzene	22	*0.38*	*2.3*	800	U
Phthalates					
Dimehtyl phthalate	160	*53*	*53*		
Diethyl phthalate	200	*61*	*110*	800	U
Di-n-Butyl phthalate	1400	*220*	*1700*	800	U
Butylbenzyl phthalate	900	*4.9*	*64*	800	U
bis(2-Ethylhexyl) phthalate	1300	*47*	*78*	3200	
Di-n-Octyl phthalate	6200	*58*	*4500*	800	U
Phenols					
Phenol	420	420	1200	800	U
2-Methylphenol	63	63	63	800	U
4-Methylphenol	670	670	670	800	U
2,4-Dimethylphenol	29	29	29	800	U

TABLE MW-3
MIDDLE WATERWAY STORM DRAIN SEDIMENT QUALITY

Study Station Name	EPA SQO	Wash. SQS	Wash MCUL/CSL	Dept. of Ecology MW200SS-1993*	
Pentachlorphenol	360	360	690	1900	U
Volatile Organics					
Trichlorethene					
Tetrachloethene	57				
Ethyl Benzene	10				
Xylenes	40				
Miscellaneous Compounds					
Benzyl Alcohol	73	57	73		
Benzoic Acid	650	650	650		
Dibenzonfuran	540	*15*	*58*	800	U
Hexachlorobutadiene		*3.9*	*6.2*	800	U
N-Nitrosodiphenylamine	11	*11*	*11*	800	U
Benzidine	28				
bis(2-chloroethyl) Ether				800	U
bis(2-chloroethoxy) Methane				800	U
Dimethyl-Nitrosomine					
Hexachlorobenzene					
Hexachlorcyclopentadiene				800	UJ
Isophorone				800	U
Hexachloroethane				800	U
N-Nitrosodi-n-propylamine				800	U
Nitrobenzene				800	U
Phenanthrene					
1-Methlynapthelene					
2-Chloronapthelene				800	U
2-Methlynapthelene				800	U
2-Nitroaniline				1900	U
2,4-Dinitrotoluene				800	U
2,6-Dinitrotoluene					
3-Nitroaniline				1900	U
3,3'-Dichlorobenzidine				800	U
4-Chloroaniline				800	U
4-Chlorphenyl-phenylether				800	U
4-Nitroanaline				1900	U
2-Nitrophenol					
2-Chlorophenol				800	U
2,4-Dinitrophenol				1900	U
2,4,5-Trichlorophenol				800	U
2,4,6-Trichlorophenol				1900	U
4-Bromophenyl-phenylether				800	U
4-Nitrophenol				1900	U
4-Chloro-3-Methylphenol				800	U
4-6-Dinitro-2-Methylphenol				1900	U
Pesticides					
Carbazole				800	U

Exceeds EPA SQO or Washington State SQS
MCUL = Minimum Cleanup Standard
CSL = Cleanup Screening Level

U =The analyte was not detected at or above the reported value.
J = The associated numerical result is an estimated quantity.
UJ = The analyte was not detected at or above the estimated value.
N = There is evidence that the analyte is present.
NJ or JN = There is evidence that the analyte is present. The associated numeric value is an estimate.
P = The analyte was detected above the instrument detection limit but below the established minimum quantification limit.

* Total Organic Carbon was not analyzed; a review of TOC data in Foss storm drains (twin 96ers) show mean and median TOC values of 6-12% (drain 237A) and 2-6% (drain 237B). TOC data for discharges to Foss Waterway are not necessarily applicable to Middle Waterway and have not been used to normalize Middle Waterway dry wt.data.

TABLE MW-4
MIDDLE WATERWAY BANK SEDIMENT CHEMISTRY

Study / Station Name	EPA SQO	Wash. SQS	Wash MCUL/CSL	Department of Ecology - 1993 MWHEAD1	MWSLAG1	MWCAST1	MWCAST2 *	MWCAST3 *
Metals (mg/kg)								
Antimony	150			15 UJ	46 PJ	3 UJ		
Arsenic	57	57	93	195 J	179 J	29.6 J		
Cadmium	5.1	5.1	6.7	5.7 PJ	2.5 PJ	1.0 UJ		
Chromium		260	270	110	355	18.2		
Copper	390	390	390	2440	3580	89.7		
Lead	450	450	530	415 J	1010 J	245 J		
Mercury	0.59	0.41	0.59	0.312 P	0.047 P	0.0757		
Nickel	140			121	315 J	23 J		
Silver	6.1	6.1	6.1	1.5 UJ	3.4 P	0.64 P		
Zinc	410	410	960	15 UJ	46 PJ	3 UJ		
Berylium				0.5 U	0.5 U	0.16 P		
Selenium				0.68 J	0.4 U	0.4 N		
Thallium				0.5 U	0.5 U	0.5 U		
Organics (ug/kg dry wt.)	***Italicized state standards are mg/kg TOC***							
LPAH								
Naphthalene	2100	*99*	*170*				184 U	143 J
Acenaphthylene	1300	*66*	*66*				184 U	51.9 J
Acenaphthene	500	*16*	*57*				11 J	74 J
Fluorene	540	*23*	*79*				196	781
Phenanthrene	1500	*100*	*480*				18 J	174 J
Anthracene	960	*220*	*1200*				27.8	55.9 J
2-Methylnapthalene	670	*38*	*64*					
Total LPAH	5200	*370*	*780*					
HPAH								
Flouranthene	2500	*160*	*1200*				731	1110
Pyrene	3300	*1000*	*1400*				749	819
Benzo(a)anthracene	1600	*110*	*270*				1140	767
Benzo(a)pyrene	1600	*99*	*210*				1800	358
Chrysene	2800	*110*	*460*				2360	1080
Benzo(b)fluoranthene							5150	1170
Benzo(k)fluoranthene							1340	431
Total Benzofluoranthenes	3600	*230*					6490	1601
Indeno(1,2,3,c-d-)pyrene	690	*34*	*88*				2990	331
Dibenzo(a,h)anthracene	230	*12*	*33*				928	198 J
Benzo(g,h,i)perylene	720	*31*	*78*				2630	215 U
Total HPAH	17000	*960*	*530*				19818	6479
PCBs								
Total PCBs	150	*12*	*65*					
Chlorinated Hydrocarbons								
1,3-Dichlorobenzene	170						184 U	215 U
1,4-Dichlorobenzene	110	*9*	*3.1*				184 U	215 U
1,2-Dichlorobenzene	50	*2.3*	*2.3*				184 U	215 U
1,2,4-Trichlorobenzene	51	*0.81*	*1.8*				184 U	215 U
Hexachlorobenzene	22	*0.38*	*2.3*					
Phthalates								
Dimehtyl phthalate	160	*53*	*53*				461 U	537 U
Diethyl phthalate	200	*61*	*110*				184 U	215 U
Di-n-Butyl phthalate	1400	*220*	*1700*				184 U	215 U
Butylbenzyl phthalate	900	*4.9*	*64*				45.2 J	66.7 J
bis(2-Ethylhexyl) phthalate	1300	*47*	*78*				184 UJ	1430 UJ
Di-n-Octyl phthalate	6200	*58*	*4500*				184 U	215 U
Phenols								
Phenol	420	420	420				284 U	215 U

TABLE MW-4
MIDDLE WATERWAY BANK SEDIMENT CHEMISTRY

Study / Station Name	EPA SQO	Wash. SQS	Wash MCUL/CSL	Department of Ecology - 1993 MWHEAD1	MWSLAG1	MWCAST1	MWCAST2 *	MWCAST3 *
2-Methylphenol	63	63	63				461 U	537 U
4-Methylphenol	670	670	670				184 U	215 U
2,4-Dimethylphenol	29	29	29				184 U	215 U
Pentachlorphenol	360	360	690				923 U	1070 U
Volatile Organics								
Trichlorethene								
Tetrachloethene	57							
Ethyl Benzene	10							
Xylenes	40							
Miscellaneous Compounds								
Benzyl Alcohol	73	57	73				184 U	
Benzoic Acid	650	650	650				923 U	
Dibenzonfuran	540	*15*	*58*				33.4 J	60.9 J
Hexachlorobutadiene	11	*3.9*	*6.2*				184 U	215 U
N-Nitrosodiphenylamine	28	*11*	*11*				184 U	
Benzidine							231 U	
bis(2-chloroethyl) Ether							184 U	215 U
bis(2-chloroethoxy) Methane							184 U	215 U
Dimethyl-Nitrosomine							184 U	
Hexachlorobenzene							184 U	215 U
Hexachlorcyclopentadiene							1840 U	
Isophorone							184 U	
Hexachloroethane							184 U	
N-Nitrosodi-n-propylamine								
Nitrobenzene							184 U	
Phenanthrene							196	
1-Methlynaptheiene							18.1 J	52.3 J
2-Chloronapthelene							184 U	215 U
2-Methlynapthelene								
2-Nitroaniline							461 U	
2,4-Dinitrotoluene							461 U	
2,6-Dinitrotoluene								
3-Nitroaniline							184 U	
3,3'-Dichlorobenzidine							231 U	
4-Chloroaniline							184 U	
4-Chlorphenyl-phenylether								
4-Nitroanaline							184 U	
2-Nitrophenol							461 U	
2-Chlorophenol								
2,4-Dinitrophenol							1840 U	2150 U
2,4,5-Trichlorophenol							184 U	215 U
2,4,6-Trichlorophenol							184 U	215 U
4-Bromophenyl-phenylether								
4-Nitrophenol							461 U	537 U
4-Chloro-3-Methylphenol							184 U	215 U
4-6-Dinitro-2-Methylphenol								
Pesticides								
Carbazole							184 U	527 J

Exceeds EPA SQO or Washington State SQS

MCUL = Minimum Cleanup Standard
CSL = Cleanup Screening Level
SQS = Sediment Quality Standard
SQO = Sediment Quality Objective
U = The analyte was not detected at or above the reported value.
J = The associated numerical result is an estimated quantity.
UJ = The analyte was not detected at or above the estimated value.
N = There is evidence that the analyte is present.
NJ or JN = There is evidence that the analyte is present. The associated numeric value is an estimate.
P = The analyte was detected above the instrument detection limit but below the established minimum quantification limit.
* Not analyzed for Total Organic Carbon

9/2/94

1.3.2 City of Tacoma/Public Utilities Property

This property within the study area is composed of a 100 x 200' upland adjacent to a utility substation (Figure MW-2). The lot is similar to the Public Works property in physical and biological characteristics (i.e., dominated by blackberry and otherwise graded flat and partially graveled), with the exception that the property is entirely upland. Environmental data on this property is lacking.

1.3.3 Department of Natural Resources Property

This property, approximately 0.8 acres in size, is located east of the City property and north of the Port Yacht Basin (Figure MW-2). The property is comprised of upland, intertidal bank and intertidal tideflat. The upland area, approximately 0.55 acres in size, is graded flat, partially graveled and largely devoid of vegetation except for the area adjacent to the top of the slope, where blackberries, grasses, shrubs and an apple tree are found. Slag or foundry waste, concrete and asphalt debris are evident in the bank areas. Bank slopes range from steep (1:1) to moderate (2:1 and grading to 5:1). *Salicornia virginica* and *Plantago maritima* are present in intertidal areas where natural sediments exist.

Ecology staff (UBAT, 1993) sampled the seeps and the bank area on this property (Table MW-2 and 4 and Figure MW- 5). Three sediment samples were analyzed for priority metals (mwhead1, mwslag1, mwcast1) and a third for organics (mwcast3). Two of the samples analyzed for metals exceeded EPA Sediment Quality Objectives (SQOs) or Washington State Sediment Quality Standards (SQSs) - arsenic, cadmium and copper in mwhead1 and arsenic, chromium, copper, lead and nickel in mwslag1. The sample analyzed for organic compounds (mwcast3) did not exceed EPA SQOs; as organic carbon data was not obtained, a comparison against state standards cannot be made.

Three samples were also collected from seeps (mwseep1, mwseep2, mwseep2a) on the property. Undiluted samples exceeded marine water quality standards for copper in the two samples that were analyzed for metals (mwseep1 and mwseep2). Organic compounds were generally not detected in the third sample, analyzed for organics only, except for phenol (6.4 ppb) and two phthalate compounds estimated to be in the sample at 0.6 and 0.1 ppb. Water quality standards for these three compounds have not been adopted by the state or by the federal government for the state.[7]

[7]Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington); Chapter 173-340 (Model Toxics Control Act Cleanup Regulation); and 40 CFR 131.36 (National Toxics Rule).

1.3.4 Port (Pacific) Yacht Basin

Only the most eastern ten to twenty feet of this property is within the study area; this portion of the property slopes steeply from the fence line to tideflat below. The bank/intertidal area is characterized by fill, concrete rubble, grasses, shrubs, *Salicornia virginica* and *Plantago maritima.*

This 0.75 acre property above the portion within the study area is covered by a concrete slab. A building which houses a small marine engine repair shop is situated on the west side of the property and power boats are stored within a fenced area on the east side of the property.

A City of Tacoma storm drain discharges to the waterway immediately adjacent to this property. The existing water and sediment quality data for this drain is presented in Tables MW-2 and MW-3.

1.3.5 Adjacent Tideflats

The tideflat adjacent to and within the study area is one of the largest contiguous tracts of mudflat habitat in the Commencement Bay/Puyallup River Estuary. The waterway is approximately 27 acres in extent, most of which is intertidal mudflat. As there is less than 200 acres of this habitat remaining in the estuary, out of approximately 2000 original mudflat acres, the tract in Middle Waterway is significant. Tideflats in the vicinity are generally sandy with typically 54% fine-grained material, and include a clay content of approximately 12% (David Evans and Associates 1993).

Past sampling in the waterway near the project site has shown metals and organic chemicals, principally mercury and PAHs, present in tideflat surface sediments (Parametrix 1988a, 1993a,b; US EPA 1989; Hart Crowser, 1992). Organic chemical concentrations are lower in the top 0-1 ft than in deeper sediments (1-3 ft), suggesting that the PAH contamination is primarily the result of historical activities (Hart Crowser, 1992).

Figure MW-5 depicts approximate sampling locations of prior studies and Table MW-5 presents a summary of the data. Data is presented on a dry weight basis and normalized to total organic carbon where carbon data is available. Organic carbon data utilized in the normalization may be outside of the range of organic carbon values utilized in the Department of Ecology's normalized Sediment Quality Data Base. (McMillan, Dept. of Ecology).

Tetra Tech 1985/1988

Tetra Tech, as part of the Commencement Bay Nearshore Tide/Flats Remedial Investigation (Tetra Tech 1985), conducted a preliminary and a final survey. During the preliminary study, sediment was sampled at one station, MD01, located in the middle of the waterway, at which elevated levels of mercury were detected. Aromatic hydrocarbons were also detected, although at lower concentrations than observed in later studies, during which samples were taken closer to

TABLE MW-5

MIDDLE WATERWAY TIDEFLAT SEDIMENT CHEMISTRY

Study	EPA	State	State	Parametrix 1993				Hart Crowser 1992									Parametix 1988		RI -1985
Station Name	SQO	SQS	MCUL/CSL	MW-1	F	P-HC-2	Reference	HC-1/S-1	HC-1/S-2	HC-1/S-3	HC-2/S-1	HC-2/S-2	HC-2/S-3	HC-3/S-1	HC-3/S-2	HC-3/S-3	MW-1	MW-1	MD-11
(Depth - cm/ft)				0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	
Metals (mg/kg)																			
Antimony	150																		0.9
Arsenic	57	57	93					16	7.9	6.7	38	3	2.4	12	4.4	5.3	13.6	6.3	15
Cadmium	5.1	5.1	6.7																3.4
Copper	390	390	390					170	52	39	200	25	37	90	33	22	165	70.0	176
Lead	450	450	530					240	86	38	240	7	7	100	20	7	127	46	188
Mercury	0.59	0.41	0.59	0.31	0.59	1.18	0.21	1.1	0.5	0.2	1.2	0.1	0.1 U	0.4	0.2	0.1 U	2.42	0.61	0.18
Nickel	140																		13
Silver	6.1	6.1	6.1					1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U			0.22
Zinc	410	410	960					300	120	94	380	40	44	120	51	32	145	102	178
Organics (ug/kg dry wt.)																			
LPAH																			
Naphthalene	2100			27	37	150	20 U	1800 DJ	88000 D	190000 D	930 DJ	540 DJ	89 J	220 J	290	65 J	240	590	2900
Acenaphthylene	1300			14	41	94	26	1200 DJ	35000 U	34000 U	4500 U	2900 U	320 U	98 J	130 J	300 U	130	540	530
Acenaphthene	500			12 U	35	340	20 U	2300 D	250000 D	540000 D	1300 U	820 U	91 U	98 U	190	32 J	74	130	350
Fluorene	540			13	30	250	29	1100 D	54000 D	94000 D	350 D	300 D	120	99	160	12 J	63	280	410
Phenanthrene	1500			120	300	4000 K	220	4100 D	180000 D	290000 D	2400 D	1700 D	480 D	670 D	790 D	71	930	2000	2100
Anthracene	960			23	75	470	85	1300 D	49000 D	83000 D	380 D	530 D	180	190	310	16	210	750	440
2-Methylnapthalene	670			12 U	19	83	20 U										42	10	910
Total LPAH	5200			221	537	5387	420	11800	656000	1E+06	9860	6790	1280	1375	1870	496	1689	4300	7640
HPAH																			
Flouranthene	2500			260	3000 K	3200 K	2000	4100 D	55000 D	96000 D	2800 D	2300 D	590	1200 D	1100 D	61	1300	3800	2600
Pyrene	3300			170	1700 K	4800 K	690	16000 D	370000 D	620000 D	8300 D	7800 D	1800 D	3500 D	3700 D	430	1800	6000	2900
Benzo(a)anthracene	1600			120	970	1800 K	510	4300 D	49000 D	88000 D	2700 D	2400 D	600 D	1300 D	1300 D	110	810	2400	1200
Chrysene	2800			180	1500 K	2400 K	1100	3200 D	16000 D	31000 D	2200 D	1700 D	140	860 D	890 D	17	900	2600	1500
Benzo(b)fluoranthenes				100	850 K	1200 K	720												
Benzo(k)fluoranthenes				200	800	800	830										1100		
Benzofluoranthenes	3600			300	1650	2000	1550	4390 D	35980 D	65100 D	2810 D	2120 D	1101 D	1410 D	1143 D	5 U	970	4700	
Benzo(a)pyrene	1600			120	940	1800 K	370	2400 D	24000 D	44000 D	1500 D	1200 D	220	750 D	650 D	26	710	4100	1600
Indeno(...)pyrene	690			67	320	430	160	1300 D	10000 D	15000 D	970 D	740 D	94	480 D	380 D	58	210	2900	710
Dibenzo(a,h)anthracene	230			24	140	190	55	68 U	680 U	660 U	580 D	360 D	6 U	7 U	6 U	6 U	130	780	140
Benzo(g,h,i)perylene	720			62	280	400	140	1200 D	6600 D	9900 D	820 D	730 D	110	390	300	7 U		3400	740
Total HPAH	17,000			1303	10500	17020	6575	36958	567260	969660	22680	19350	4661	9997	9469	720	6830	30680	
PCBs																			
Total PCBs	150																		29
Chlorinated Hydrocarbons																			
1,3-Dichlorobenzene	170																		5 U
1,4-Dichlorobenzene	110																		180
1,2-Dichlorobenzene	50																		97
1,2,4-Trichlorobenzene	51																		16
Hexachlorobenzene	22																		10 U

TABLE MW-5

MIDDLE WATERWAY TIDEFLAT SEDIMENT CHEMISTRY

Study	EPA	State	State	Parametrix 1993				Hart Crowser 1992									Parametrix 1988		RI -1985
Station Name	SQO	SQS	MCUL/CSL	MW-1	F	P-HC-2	Reference	HC-1/S-1	HC-1/S-2	HC-1/S-3	HC-2/S-1	HC-2/S-2	HC-2/S-3	HC-3/S-1	HC-3/S-2	HC-3/S-3	MW-1	MW-1	MD-11
(Depth - cm/ft)				0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	
Phthalates																			
Dimehtyl phthalate	160																		50 U
Diethyl phthalate	200																		10 U
Di-n-Butyl phthalate	1400																		1702
Butylbenzyl phthalate	900																		25 U
bis(2-Ethylhexyl) phthalate	1300																100	100	1200
Di-n-Octyl phthalate	6200																		25 U
Phenols																			
Phenol	420	420	1200																850
2-Methylphenol	63	63	63																68
4-Methylphenol	670	670	670														90	100	620
2,4-Dimethylphenol	29	29	29																10 U
Pentachlorphenol	360	360	690																620
Volatile Organics																			
Trichlorethene																			
Tetrachloethene	57																		
Ethyl Benzene	10																		
Xylenes	40																		
Miscellaneous Compounds																			
Benzyl Alcohol	73	57	73																47
Benzoic Acid	650	650	650																25 U
Dibenzonfuran	540																74	130	440
Hexachlorobutadiene	11																		25 U
N-Nitrisodiphenylamine	28																		
Hexachloroethane																			50 U
Pesticides																			
Total DDT																			
DDD	16																		50 U
DDE	9																		50 U
DDT	34																		50 U
Aldrin																			50 U
Chlodane																			50 U
Dieldrin																			50 U
Heptachlor																			50 U
Lindane																			50 U
Conventionals																			
Total solids (%)				66.59	41.58	39.17	39.5												
Total Vol. Solids (%)																			
TOC. (% dry wt.)				2.25	2.47	4.12	4.29	7.5	6.4	4	9.9	3.5	3.1	5.6	2.6	3.7			
Ammonia (mg/kg)				348	158	2.33 U	64.9												
Total Sulfides																			
Fines (%)				15	46	65	54												

TABLE MW-5

MIDDLE WATERWAY TIDEFLAT SEDIMENT CHEMISTRY

Study	EPA	State	State	Parametrix 1993				Hart Crowser 1992									Parametrix 1988		RI -1985
Station Name	SQO	SQS	MCUL/CSL	MW-1	F	P-HC-2	Reference	HC-1/S-1	HC-1/S-2	HC-1/S-3	HC-2/S-1	HC-2/S-2	HC-2/S-3	HC-3/S-1	HC-3/S-2	HC-3/S-3	MW-1	MW-1	MD-11
(Depth - cm/ft)				0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	2-3 ft.	0-1 ft.	1-2 ft.	
Organics (mg/kg total organic carbon)																			
LPAH																			
Naphthalene	99	170	1.2	1.5	3.6	0.5 U	24 DJ	1375 D	4750 D	9.4 DJ	15.4 DJ	2.9 J	3.9 J	11.2	1.8 J				
Acenaphthylene	66	66	0.6	1.7	2.3	0.6	16 DJ	546.88 U	850 U	45.5 U	82.9 U	10.3 U	1.8 J	5.0 J	8.1 U				
Acenaphthene	16	57	0.5 U	1.4	8.3	0.5 U	31 D	3906.3 D	13500 D	13.1 U	23.4 U	2.9 U	1.8 U	7.3	0.9 J				
Fluorene	23	79	0.6	1.2	6.1	0.7	15 D	843.75 D	2350 D	3.5 D	8.6 D	3.9	1.8	6.2	0.3 J				
Phenanthrene	100	480	5.3	12.1	97.1 K	5.1	55 D	2812.5 D	7250 D	24.2 D	48.6 D	15.5 D	12.9 D	30.4 D	1.9				
Anthracene	220	1200	1.0	3.0	11.4	2.0	17 D	765.63 D	2075 D	3.8 D	15.1 D	5.8	3.4	11.9	0.4				
2-Methylnapthalene	38	64	0.5 U	0.8	2.0	0.5 U													
Total LPAH	370	780	10	21.7	130.8	9.8	157.3	10250	30775	99.6	194.0	41.3	24.6	71.9	13.4				
HPAH																			
Flouranthene	160	1200	11.6	121.5 K	77.7 K	46.6	55 D	859.38 D	2400 D	28.3 D	65.7 D	19.0	21.4 D	42.3 D	1.6				
Pyrene	1000	1400	7.6	68.8 K	116.5 K	16.1	213 D	5781.3 D	15500 D	83.8 D	222.9 D	58.1 D	62.5 D	142.3 D	11.6				
Benzo(a)anthracene	110	270	5.3	39.3	43.7 K	11.9	57 D	765.63 D	2200 D	27.3 D	68.6 D	19.4 D	23.2 D	50.0 D	3.0				
Chrysene	110	460	8.0	60.7 K	58.3 K	25.6	43 D	250 D	775 D	22.2 D	48.6 D	4.5	17.1 D	34.2 D	0.5				
Benzo(b)fluoranthenes			4.4	34.4 K	29.1 K	16.8													
Benzo(k)fluoranthenes			8.9	32.4	19.4	19.3													
Benzofluoranthenes	230	450	13.3	66.8	48.5	36.1	59 D	562.19 D	1627.5 D	28.4 D	60.6 D	35.5 D	25.2 D	44.0 D	0.1 U				
Benzo(a)pyrene	99	210	5.3	38.1	43.7 K	8.6	32 D	375 D	1100 D	15.2 D	34.3 D	7.1	13.4 D	25.0 D	0.7				
Indeno(...)pyrene	34	88	3.0	13.0	10.4	3.7	17 D	156.25 D	375 D	9.8 D	21.1 D	3.0	8.6 D	14.6 D	1.6				
Dibenzo(a,h)anthracene	12	33	1.1	5.7	4.6	1.3	1 U	11 U	16.5 U	5.9 D	10.3 D	0.2 U	0.1 U	0.2 U	0.2 U				
Benzo(g,h,i)perylene	31	78	2.8	11.3	9.7	3.3	16 D	103.13 D	247.5 D	8.3 D	20.9 D	3.5	7.0	11.5	0.2 U				
Total HPAH	960	5300	57.9	425.1	##	153	493	8863.4	24242	229	553	150	179	364	19				

Exceeds applicable EPA Sediment Quality Objective or State Sediment Quality Standard

Not detected at a level above applicable EPA Sediment Quality Objective or State Sediment Quality Standard

U = The analyte was not detected at or above the reported value.

J = The associated numerical result is an estimated quantity.

UJ = The analyte was not detected at or above the estimated value.

N = There is evidence that the analyte is present.

NJ or JN = There is evidence that the analyte is present. The associated numeric value is an estimate.

P = The analyte was detected above the instrument detection limit but below the established minimum quantification limit.

K = Quantitative Value above calibration curve. Sample was diluted, resulting values are reported.

D = Sample Dilution Required

RI: 1985 Remedial Investigation, Tetra Tech, Inc. for EPA

the project site. Total PCBs were detected at 3 ppb and pesticides were not detected above 10 ppb (Parametrix, 1994).

Data collected during the final survey detected a number of chemicals of concern at station MD-11, located adjacent to the project site. Contaminants or groups of contaminants exceeding EPA's Sediment Quality Objectives (EPA SQOs) include aromatic hydrocarbons, phenols, chlorinated hydrocarbons and di-n-butyl phthalate (Table MW-5). Pesticides were not detected, although detection limits were above Sediment Quality Objectives.

Parametrix 1988/1993

Parametrix conducted several studies for Simpson Tacoma Kraft on the east side of the waterway beginning with environmental assessment work related to purchase of property adjacent to the waterway in 1988 and culminating with habitat pre-construction data collected as part of Corps of Engineers Section 10/404 permitting requirements. Mercury and aromatic hydrocarbon values exceeded EPA SQOs and State Standards. When normalized to carbon, organics generally do not exceed State Sediment Quality Standards. Two of four samples have organic carbon values within the range of carbon values utilized to develop state standards; the third and fourth values, at stations P-HC-2[8] and the reference station, are at the outer limit of the range of carbon values used in the Ecology AET data base.

Samples at the three Parametrix stations established in 1993 (MW-1, F and P-HC-2) were analyzed using standard sediment bioassay procedures. The sediments at all three stations passed the acute amphipod and the chronic *Neanthes* biomass tests, but did not pass an acute sediment larval bioassay using the Pacific oyster (*Crassostrea gigas*). The reference sediment used for the bioassay work was obtained from the Hylebos Waterway just north of 11th Street. (Figure MW-6).

Hart Crowser 1991, 1992

Hart Crowser investigated historical contamination and potential sources in Middle Waterway under contract to Foss Maritime and Simpson Tacoma Kraft Co. in 1991, and conducted additional investigatory work the following year, 1992. Three stations established in that study are in the head of the waterway near the restoration study area. Stations HC-1, 2 & 3 were sampled by Hart Crowser to a depth of three feet using hand-driven impact cores (Figure MW-5).

[8]This station is immediately adjacent to station HC-2, a station established by Hart-Crowser. Parametrix's station HC-2 is here referred to as P-HC-2 in order to differentiate it from the original station.

No exceedences of EPA SQOs or State Standards for metals were noted except for a single exceedence for mercury at HC-1, on the east side of the waterway. Samples at that station also exceeded EPA SQOs for PAHs, and State SQS in samples taken at the one-two and two-three foot intervals. The upper most foot did not exceed State SQSs, but the total organic compound concentration (7.5%) is apparently outside of the range used to develop state standards. Sample HC-3, in the vicinity of the north end of the study area, did not exceed state or EPA standards for metal or organics. Sample HC-2, furthest from the study area of the three Hart Crowser samples, exceeded EPA SQOs for organics in the two upper most feet of depth but did not exceed State Standards. Organic carbon values are roughly in the range of that utilized in standard development, although the upper most foot is slightly enriched. Hart Crowser concluded that contamination generally increased with depth and was apparently the result of historical activities.

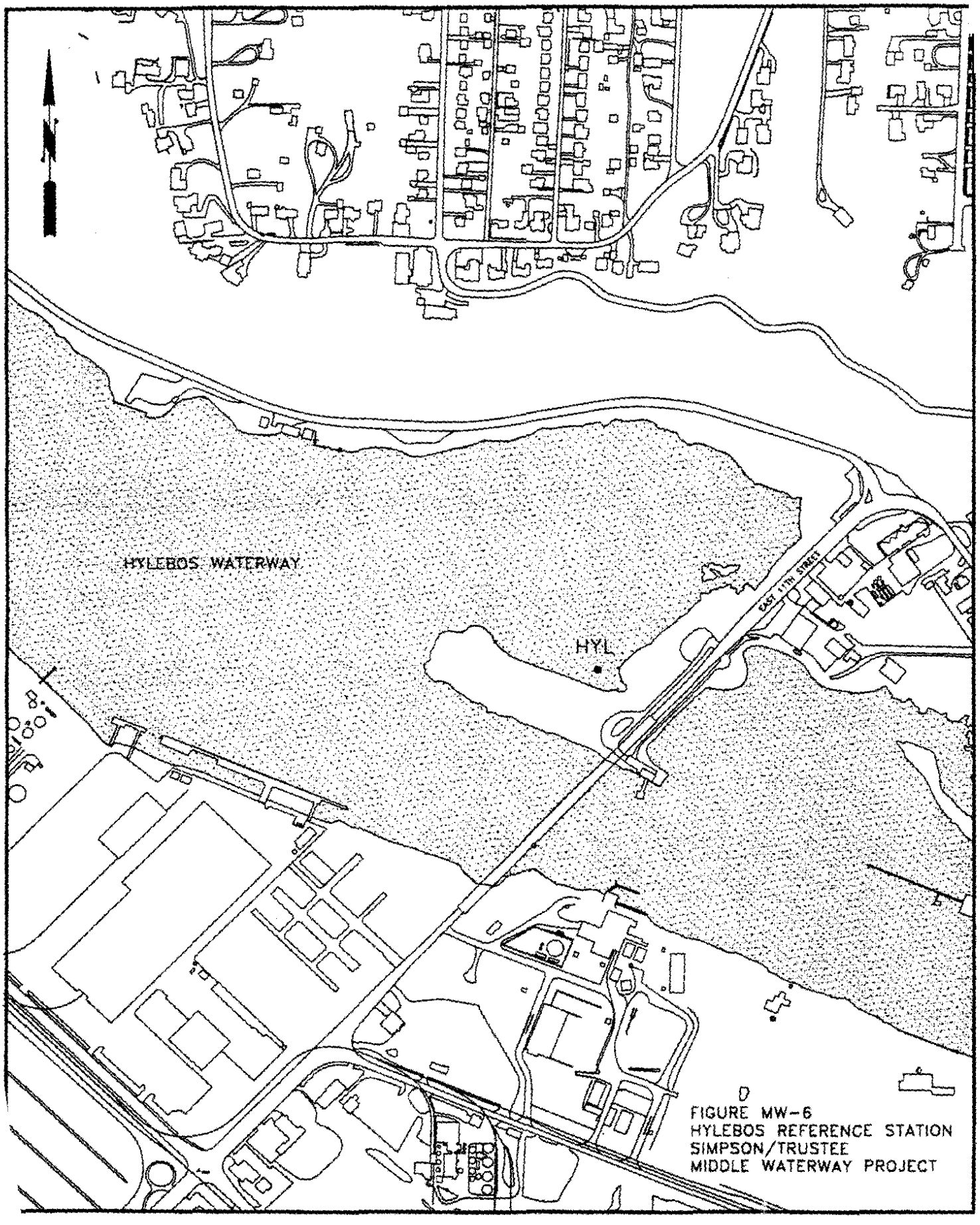


FIGURE MW-6
HYLEBOS REFERENCE STATION
SIMPSON/TRUSTEE
MIDDLE WATERWAY PROJECT

SAMPLING AND ANALYSIS PLAN
(June 1995 reprint)

2.0 OVERVIEW

The objective of this Sampling and Analysis Plan (SAP) is to determine the suitability of properties within the study area for intertidal habitat restoration and enhancement under Commencement Bay EPA Sediment Quality Objectives, 404(b)(1) guidelines, 401 WQC review, and WAC 173-204 (Washington State Sediment Management Standards). After review of regulatory guidelines, tasks were identified to characterize the restoration project site based upon generalized restoration plans involving the removal of material to a depth of approximately 10 or 11 feet MLLW and, possibly, filling for habitat enhancement in existing intertidal areas. Tasks include the following:

- Develop a sampling and analysis plan (SAP) that is consistent with EPA Contract Laboratory and PSEP protocols and state and federal programmatic requirements.

- Coordinate with the Department of Ecology, EPA, the Corps of Engineers and other resource agencies to select appropriate reference sediments for biological testing.

- Conduct field operations at Middle Waterway and collect sediment samples as specified in this SAP.

- Submit the composite representative sediment samples to the City Laboratory. Grain size and conventional analyses will be analyzed within seven days and other analyses will be completed within 28 days. Information from the grain size and conventional analyses are needed before bioassay testing can begin.

- Submit the composite representative sediment samples for biological testing to a laboratory experienced in the performance of biological testing as defined by Puget Sound Estuary Program (PSEP) Protocols.

- Review the analytical data for consistency with Department of Ecology Sediment Management Standards (SMS) requirements and to assure data quality. After QA/QC, identify sediment analyte levels above the Sediment Quality Standards (SQS, MCULs, CSLs).

- Review analytical results and determine, in consultation with regulating agencies, if any additional samples will be submitted for biological testing.

- Review biological data to assure data quality, and interpret the results in accordance with Department of Ecology interpretive criteria.

- o Manage the field, analytical, and biological data in a manner consistent with EPA CLPs and PSEP protocols and Department of Ecology requirements.

- o Deliver a report to the Department of Ecology, EPA, the US Corps of Engineers and the Natural Resource Trustee agencies that is consistent with the various sediment management program requirements pertaining to the collection and reporting of the field, analytical, and biological data.

2.1 SUMMARY OF PROPOSED SAMPLING AND ANALYSIS

The City is proposing to sample at a fourteen locations in the study area (Figure MW-7) . The City would sample for physical/chemical analysis:

1. Six test pits in upland areas, including two on DNR property and four on City property. Test pit sampling is designed to characterize material in the horizons (8-10 ft MLLW and 10-12 ft. MLLW) bracketing the future intertidal surface in order to ascertain the suitability of the materail in this horizon for conversion, via removal of overburden, to intertidal habitat. Two samples will be obtained from each test pit on DNR property in two foot vertical sections ("lifts") immediately above and below the expected future intertidal grade (Figure MW-8). Two samples will similarly be obtained from each test pit on City property. Samples from adjoining test pits at equal elevations on City property will be combined to create a total of four composite samples. The resulting four discrete samples (DNR) and four composite samples (City) will be submitted to the City laboratory for physical-chemical analysis (Table MW-6).

2. Five trenches in upland areas; trench sampling will be used to characterize soils in the 12-18 ft. MLLW horizon. This overburden material will be excavated and removed during project construction and data collected by the City will be used to define soil disposal options. A composite sample will be obtained from each trench in order to characterize soils for disposal during project construction. The five composite samples will be submitted to the City laboratory for physical-chemical analysis.

3. Bank areas. Bank sampling will be used to characterize the material evident in the bank, in strata that is obviously contaminated and in strata below the contaminated material in which contamination is not evident. Sampling of these two bank strata will be used, in conjunction with pit and trench sampling, to characterize the extent of on site contamination. One composite sample will be taken from each of four 150 foot sections of bank area in obviously contaminated strata. One composite sample will also be taken from each of four 150 foot sections of bank in the apparently uncontaminated material below the contaminated strata. The resulting eight composite samples will be submitted to the City laboratory for physical-chemical analysis.

4. Tideflat samples. Two cores will be taken, and samples will be obtained from each core at 0-10 cm, 1-2 foot and 2-3 foot depths. Two additional surface samples will also be obtained. The resulting eight discrete samples will be submitted to the City laboratory for physical-chemical analysis. The City would also collect sufficient surface sediment at each tideflat station to

undertake biological analysis of tideflat sediment samples. Analysis will consist of benthic community structure evaluation and performance of a standard suite of sediment bioassays as outlined in state sediment management guidance (Microtox, amphipod, sediment larvae - echinoderm embryo) plus a second chronic test (juvenile polychaete) in order to provide a more complete biological assessment of tideflats in the vicinity of the project. Core and grab samples in the tideflats will be used to better define the nature of the surrounding aquatic environment. These samples in essence provide context for restoration planning at the project site.

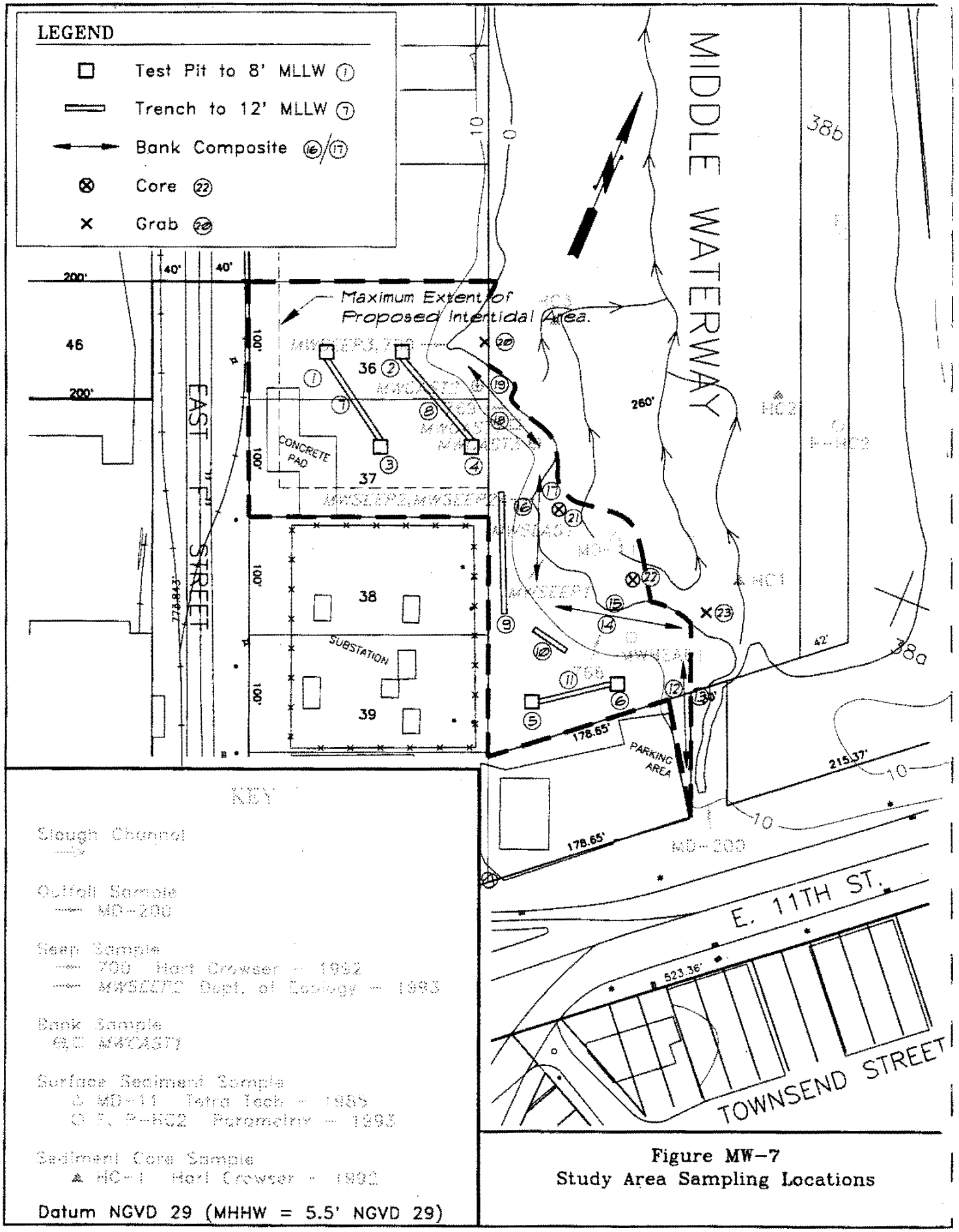


Figure MW-7
Study Area Sampling Locations

MIDDLE WATERWAY
PROPOSED SAMPLING STATIONS
CROSS SECTION

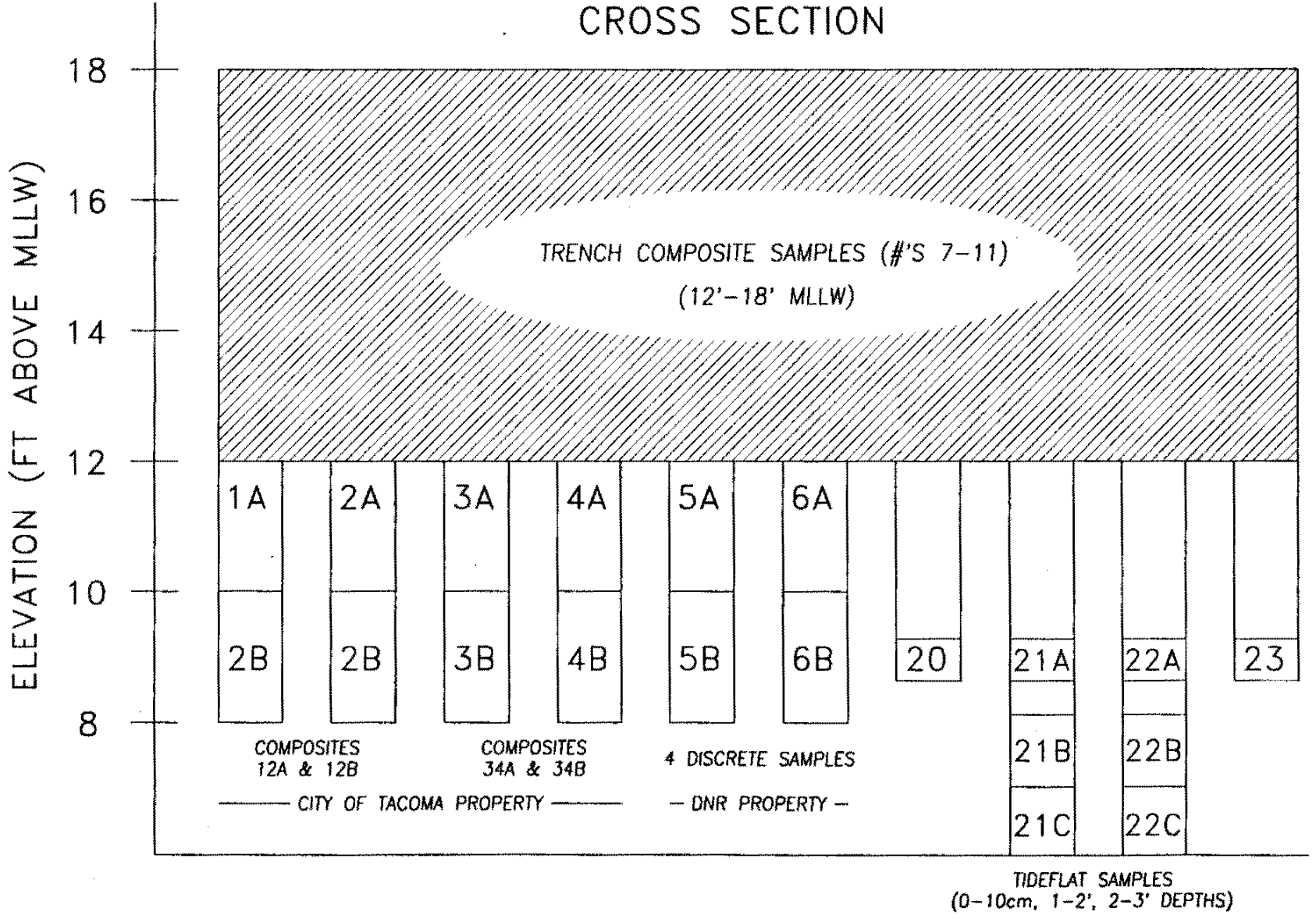


FIGURE MW-8

Jun 19, 1995 -- L:\MCREAMER\G-ZEN\MW-8.DWG

3.0 PROJECT TEAM AND RESPONSIBILITIES

Successful completion of the sampling and analysis requires coordination and adherence to the SAP and QA/QC procedures. Staffing and responsibilities are outlined below. Project personnel will consult with the regulating agencies should any of items described in Appendix A (Issues of Concern) be encountered during of the study.

3.1 PROJECT PLANNING AND COORDINATION

Project coordination is the responsibility of Greg Zentner of the Utility Services Engineering Division, Public Works Department and Chris Getchell of the City Of Tacoma Laboratory. Mr. Zentner is is the primary project contact. The sampling and analysis program (SAP) was developed by City staff in consultation with Dr. Donald Weitkamp and staff at Parametix.

3.2 FIELD SAMPLE COLLECTION

City personnel will be responsible for the collection of the sediment samples. The field team will consist of Mr. John O'Loughlin (City Laboratory) and Mr. Zentner and other personnel under their direction, with assistance provided by professional staff of Parametrix for the geologic mapping of on-site conditions. Mr. O'Loughlin will work closely with Mr. Getchell to ensure consistency with all QA/QC items listed in Section 4.0. City staff will collect the samples and record the necessary data on those samples. They will composite and homogenize the subsamples into samples as described in Section 4.0, and prepare the samples for shipment to the appropriate bioogical laboratory.

3.3 PHYSICAL/CHEMICAL ANALYSES

The composite sediment samples will be submitted to the City of Tacoma Laboratory. Mr. Christopher Getchell will provide oversight of the analytical laboratories, ensuring strict adherence to the procedures and detection limits defined in the this SAP. Ms. Judith Murray of the City Laboratory will perform the QA/QC analysis of the data. The data will be assembled into tabular format, and compared to appropriate regulatory standards. The results of the analyses will be included as part of the final data report. A list of parameters to be analyzed and analytical methods is included in this report as Table MW-6.

3.4 BIOLOGICAL ANALYSES

Biological testing will occur under the direction of Mr. Getchell at an outside laboratory in accordance with PSEP protocols. Reference sample collection will be coordinated with the regulatory agencies. The results of the analyses will be included as part of the final data report.

3.5 QA/QC MANAGEMENT

Mr. Getchell will provide a final QA review for the sediment characterization project. This includes the review of the analytical and biological data for accuracy and omissions, review of the field data and collection procedures for adherence to the sampling plan, and a review of the final report for accuracy of interpretation.

3.6 FINAL DATA REPORT

Mr. Zentnerwill be responsible for assembling the final sediment characterization report describing sample locations and depths; sampling, handling, and analytical methods; QA/QC; and data results. He will be assisted by Mr.Getchell.

4.0 SAMPLE COLLECTION AND HANDLING PROCEDURES

4.1 SAMPLING AND COMPOSITING OVERVIEW

Samples will be collected from six test pits and five trenches in upland areas, four reaches of bank in the intertidal, ands, two cores and two grab stations the tideflat area. Sampling stations at the proposed restoration project site are shown in Figures MW- 7. A cross section of the upland stations is shown in Figure MW-8. Samples taken at various elevations throughout the study area in test pits, trenches, banks and tideflat sediments are designed to provide a specific type of information, described below.

Sample Type	Sample Purpose
Test pit sampling	Characterize material in the horizons (8-10 ft MLLW and 10-12 ft. MLLW) bracketing the future intertidal surface in order to ascertain the suitability of the material in this horizon for conversion, via removal of overburden, to intertidal habitat. Samples taken from adjoining test pits on City property at the same elevations will be combined to create composite samples. Discrete sampling will be utilized on DNR property.
Trench sampling	Characterize soils in the 12-18 ft. MLLW horizon. Much of this overburden material will be excavated and removed during project construction; data collected by the City will be used to define soil disposal or use options. Samples taken from trenches will be composite samples obtained from representative material over the length and depth of any trench.
Bank sampling	Characterize the material evident in the bank, in strata that is obviously contaminated and in strata below the contaminated material in which contamination is not evident. Sampling of these two bank strata will be used, in conjunction with pit and trench sampling, to characterize the extent of on site contamination. Banks samples will be composite samples obtained from representative material within each strata and reach.
Core and Grab Samples (Tideflats)	Define the nature of the surrounding aquatic environment. These latter samples in essence provide context for restoration planning at the project site. These samples will be discrete samples.

The removal and re-use of material in alternative locations on site may be proposed if the material is physically and chemically suitable for the proposed use. Material will not be left on site or utilized on site if such use results in the maintenance or creation of a potential source of

contaminants to the waterway. Likewise, the ultimate removal of material from the property will be managed in a manner that prevents contamination from reaching the waterway

4.2 SAMPLING STATION LOCATION METHODS

Each location will be plotted on an appropriate blueprint drawing to determine the Washington State plane coordinates (MLLW datum). The position of each sampling location will be measured from existing city monuments or two known points previously surveyed and marked with a rebar and cap on City property. Station positioning will be achieved by measuring from the monuments or the surveyed positions to the sampling location. These coordinates will then be converted to latitude and longitude coordinates using Wildsoft Survey Software (Leica 1990), or equivalent, and reported to the nearest 0.1 second. The measurements to each location and the state plane coordinates will be provided with the final report. Locations are contained in Figure MW-7. .

4.3 PRE-SAMPLING PREPARATION

A backhoe will be scheduled well in advance of the sampling date, and other necessary equipment, such as core tubes, compositing bowls, and appropriate sample containers, will be obtained. The analytical and bioassay laboratories will be advised to expect the arrival of samples.

The stainless steel spoons and bowls, or other materials anticipated to come into contact with the samples, will be cleaned and decontaminated as follows: a thorough Alconox® wash; hot water rinse; a thorough rinse with deionized water (DI); rinse with methanol to remove residual organic mater; a final thorough rinse with DI. Once cleaned in the laboratory, the equipment will be wrapped in aluminum foil to prevent contamination. Prior to sampling, the samples will be labeled with station identification number, date, and time of collection.

4.4 SAMPLE COLLECTION AND FIELD PROCESSING

4.4.1 Sample Collection and Compositing

Test Pits

The upland sampling points have a current surface elevation of approximately 18 MLLW. Therefore, 6 ft of overlaying soil will be removed using a backhoe in order to access the underlying material proposed for excavation. (These elevations and depths will be confirmed by field surveys prior to sampling). Upon reaching the +12 ft MLLW elevation, the backhoe bucket will be de-contaminated and a sample will be taken to not deeper than +10 feet MLLW. Subsequently, upon reaching +10 ft MLLW, the backhoe bucket will be de-contaminated again and a sample taken to not deeper than +8 ft MLLW.

Samples taken from test pits on City property will be combined to create four composite samples. One composite will be created from material taken from test pits 1 and 2 at the 10-12 ft MLLW horizon to create composite sample 12A. A second composite will be created from material taken from test pits 1 and 2 at the 8-10 ft MLLW horizon to create composite sample 12B. Composite samples 34A and 34B will be similarly developed from test pits 3 and 4. Samples obtained from test pits 5 and 6 at 8-10 and 10-12 ft. MLLW on DNR property will be transported to the lab as four discrete samples. These samples will represent material that may be exposed as a new intertidal surface or used to raise elevations in order to create high marsh areas. The elevation of the new intertidal surface will vary slightly, but will generally occur at about +10 ft MLLW.

Trenches
Trenches will be sampled in 100 foot lengths, with one random sample of representative material obtained from every set of ten backhoe buckets. General observations of the physical composition of the excavated material will be recorded during trench excavation (see Section 4.4.2, Field Measurements and Miscellaneous Data). Non-representative material, such as obvious strata of contamination, will genrally not be sampled unless requested by on-oste agency personel or their consultants but will be noted in the geologic log.[6]

Banks
Bank composite samples will be developed by sampling a) equal volumes at up to five locations of the typical contaminant in each 150 reach of contaminated bank strata and b) equal volumes of material at 30 foot intervals within the assumed uncontaminated strata within every 150 foot reach. If more than one type of contaminant is evident in any reach, samples sufficient to describe each contaminant separately will be obtained and analyzed.

Cores
Core samples will be obtained at 0-10 cm, 1-2 foot, and 2-3 foot depths using hand-driven shelby tubes. Samples will be analyzed as discrete samples.

Grabs.
Grab samples will be obtained at a depth of 0-10 cm using hand-trowels after removal of any overlying soil sloughage. Samples will be analyzed as discrete samples.

General
Sample material will generally be placed in a stainless steel bowl for homogenization prior to transfer to sample containers. Sample material to be analyzed for volatile compounds, however, will be placed directly into sample containers without homogenization. For composite test pit samples, the stainless steel bowls containing material for samples will be covered and stored on ice until samples from all appropriate locations have been collected. The sample observations described in Section 4.4.2 will then be made, the samples composited, and the bowls de-contaminated. Trench and bank composite samples will be placed directly into stainless steel bowls and sample observations will be logged as sampling proceeds. Shelby tubes will be

[6] Additional glassware will be available in the field for agency-requested samples beyond those described in this SAP.

wrapped in aluminum foil and placed on ice for transport to the lab where material will be removed and placed in sample containers. Equal volumes of material will be composited from each sampling position to generate the composite sample. The spoon will be de-contaminated between samples One homogenized sample, determined to have an adequate volume, will be split to provide a blind duplicate. The duplicate will be labeled A99. All sampling devices touching the sample material will be previously decontaminated. Full QA/QC requirements are detailed in Appendix B.

Samples for analysis of sulfides and volatile organic compounds will be taken directly from the representative scoop of material prior to any subsampling for other analyses, immediately after sample collection and prior to compositing. Samples for sulfide analysis will be placed in 125 ml glass jars without mixing the material. Using a pipet, 40 ml of zinc acetate will be placed on top of the sample in the jar. For volatile organics, two separate 40 ml glass containers will be completely filled with sediment. No headspace will remain in these containers. Two samples will be collected to ensure that an acceptable sample without headspace is submitted to the laboratory for analysis. If there is adequate water in these sediments the containers will be filled to overflowing so that a convex meniscus forms at the top. Once sealed the bottle will be inverted to verify the seal by demonstrating the absence of air bubbles. If there is little or no water in the sediment, the jars will be filled and sealed as tightly as possible, eliminating obvious air pockets. Each sample will be stored at appropriate temperature until analyzed, and sediment samples collected for analysis of volatile compounds will not be frozen. Sample container and storage requirements are presented as a table in Appendix B, the QAPP. Each sample reserved for bioassays will be stored at 4°C in the dark, and with nitrogen gas in the container headspace, for up to 56 days pending initiation of any required biological testing.

Glassware and containers for collecting sample material will be provided by the City Lab and the contract biological lab. Containers will be pre-cleaned according to EPA CLP or PSEP protocols. A solvent rinse will not be used on the containers for analysis for volatile organics. Additional jars will be available to allow for breakage. Each sample container, as detailed in Appendix B, will be clearly labeled with the project name, sample/composite identification, date and time, initials of person(s) preparing the sample, analysis specifications, any pertinent comments such as preservatives present in the sample. Each sample will be referenced by entry onto the field log sheets.

4.4.2 Field Measurements and Miscellaneous Data

In addition to physical collection of the sediment samples, specific field information will be recorded. A field data log will be used to note the date, time, and location of sampling stations, as well as additional auxiliary parameters recorded in the field. The following data will be included on the data log:

- General field observations including, but not limited to, weather conditions, presence of shipping or other activities in the area, and any factors which may effect the quality data.

- o Depth of each subsurface station sampled relative to existing grade. Depth will be measured by using a tape measure from a previous surveyed elevation.
- o Date and time of collection of each sample.
- o Names of field coordinators and person(s) collecting and logging in the samples.
- o Qualitative notation of apparent resistance of sediment column to digging.
- o Observations made during sample collection.
- o Observations of sampling pits during excavation including water level and strata.

Sediment description of each sample will be recorded on the data log for the following parameters as appropriate:

- o Sample recovery (for cored)
- o Depth of sediment
- o Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency, color)
- o Odor
- o Debris
- o Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organism
- o Presence of oil sheen
- o Any other distinguishing characteristics or features, such as the presence or absence of slag.

4.5 SAMPLE TRANSPORT AND CHAIN-OF-CUSTODY PROCEDURES

Chain-of-custody (COC) forms will be completed immediately after sample processing. All sample containers will be carefully packed in containers to prevent breakage and transported in an upright position, on ice, to the City laboratory on the day of sample collection. Upon delivery of the samples to lab, representatives of lab will verify that sample descriptions on the COC are consistent with actual delivered samples. The COC will then be signed with the date and time

included in the appropriate spaces. Representatives of both companies will retain a copy of the COC. A sample chain of custody form is included in this report in the appendix.

An additional COC will be filled out for transfer of material to the bioassay laboratory from the City laboratory, if necessary. The material for bioassay testing will be held at 4°C until test initiation, if required. Maximum holding times are noted in the appendix..

5.0 PHYSICAL/CHEMICAL SEDIMENT ANALYSES

5.1 LABORATORY ANALYSES PROTOCOLS

As discussed previously, to meet QA/QC requirements, a blind duplicate sample will be analyzed for all conventional parameters, the chemical constituents for which the state has adopted sediment standards, and additional parameters as noted in Table MW-6. The composite samples will be identified as discussed in Section 4.4.1. The laboratory will be instructed to prioritize the conventional and grain size analyses, as those parameters are necessary for the selection of reference sediment(s) and appropriate bioassay testing procedures.

A COC record for the samples will be maintained throughout all sampling activities and will accompany samples during shipment to the laboratory. Custody of samples in the laboratory are controlled by keeping all samples in storage with locks that have a controlled number of keys.

Laboratory testing procedures will be conducted in accordance with the *Puget Sound Estuary Program Recommended Protocols*. Several details of these procedures are discussed below and in the project QAPP (Appendix B).

5.1.1 Conventional Parameters

The following conventional parameters must be run on each sample within the holding times specified below:

Total volatile solids	14 days at 4°C
Total organic carbon	14 days at 4°C
Percent solids	14 days at 4°C
Total sulfides	14 days at 4°C
Ammonia	7 days at 4°C
Grain size distribution	6 months at 4°C

Particle grain size distribution for each composite sample will be determined in accordance with EPA (1991). Wet sieve analysis will be used for the sieve sizes US No. 4, 10, 20, 40, 60, 140, 200, and 230. Pipette/hydrometer analysis will be used for particle sizes finer than the 230 mesh (as per ASTM 422. Water content will be determined using ASTM D2216. Sediment classification designation will be made in accordance with US Soil Classification System (ASTM D2487).

As mentioned above, the laboratory will be instructed to prioritize the grain size distribution, ammonia, and sulfide measurements, as those data are necessary for decisions related to biological tests (e.g., reference sediment selection, aeration of larval tests).

Table MW-6
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments Reference	Method	
CONVENTIONALS & MISC.					
Total Solids		1 %	SM	2540 G	
Total Vol Solids		1 %	SM	2540 E	
Total Organic Carbon		0.1 %	SW 846	9060 with I.R.	
Ammonia		50 ppm	MCAWW	350	
pH		NA	SW 846	9045	
Sulfide		NA	PSEP	NA	
Grain Size		NA	ASTM	D-422	
METALS in mg/kg (ppm)					
Antimony	150	100	CLP	SOW ILM03.0	(11)
Arsenic	57	1	CLP	SOW ILM03.0	(1)
Chromium		1.2	CLP	SOW ILM03.0	(1)
Mercury	0.59	0.1	CLP	SOW ILM03.0	
Silver	6.1	1	CLP	SOW ILM03.0	(1)
Copper	390	2.5	CLP	SOW ILM03.0	(1)
Nickel	140	4	CLP	SOW ILM03.0	(1)
Cadmium	5.1	1	CLP	SOW ILM03.0	(1)
Lead	450	0.6	CLP	SOW ILM03.0	(1)
Zinc	410	2	CLP	SOW ILM03.0	(1)
Tributyltin (as Tin) in µg/kg (ppb)		30	Laucks SOP	3550/8270	(7)
PHENOLS & SUB PHENOLS in µg/kg (ppb)					
Phenol	420	100	CLP	SOW OLM01.8	(2)
2-Methylphenol	63	55	CLP	SOW OLM01.8	(2)
4-Methylphenol	670	100	CLP	SOW OLM01.8	(2)
2,4-Dimethylphenol	29	29	CLP	SOW OLM01.8	(2,9)
Pentachlorophenol	360	200	CLP	SOW OLM01.8	(2)
LPAHs in µg/kg (ppb)					
Naphthalene	2100	100	CLP	SOW OLM01.8	(2)
2-Methylnaphthalene	670	100	CLP	SOW OLM01.8	(2)
Acenaphthylene	1300	100	CLP	SOW OLM01.8	(2)
Acenaphthene	500	100	CLP	SOW OLM01.8	(2)
Fluorene	540	100	CLP	SOW OLM01.8	(2)
Phenanthrene	1500	100	CLP	SOW OLM01.8	(2)
Anthracene	960	100	CLP	SOW OLM01.8	(2)
HPAHs in µg/kg (ppb)					
Fluoranthene	2500	100	CLP	SOW OLM01.8	(2)
Pyrene	3300	100	CLP	SOW OLM01.8	(2)
Benzo(a)anthracene	1600	100	CLP	SOW OLM01.8	(2)
Chrysene	2800	100	CLP	SOW OLM01.8	(2)
Total Benzofluoranthene (10)	3600	100	CLP	SOW OLM01.8	(2)
Benzo(a)pyrene	1600	100	CLP	SOW OLM01.8	(2)
Indeno(1,2,3-cd)pyrene	690	100	CLP	SOW OLM01.8	(2)
Dibenzo(a,h)anthracene	230	100	CLP	SOW OLM01.8	(2)
Benzo(g,h,i)perylene	720	100	CLP	SOW OLM01.8	(2)

Table MW-6
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments		
			Reference	Method	
PESTICIDES/PCBs in ug/kg (ppb)					
Total PCBs	150	80	CLP	SOW OLM01.8	(5,6)
4,4'-DDE	9	8	CLP	SOW OLM01.8	(6)
4,4'-DDD	16	8	CLP	SOW OLM01.8	(6)
4,4'-DDT	34	8	CLP	SOW OLM01.8	(6)
Chlordane (alpha, gamma)		8	CLP	SOW OLM01.8	(6)
Aldrin		8	CLP	SOW OLM01.8	(6)
Dieldrin		8	CLP	SOW OLM01.8	(6)
Heptachlor		8	CLP	SOW OLM01.8	(6)
Lindane		8	CLP	SOW OLM01.8	(6)

Notes:
(1) CLP digestion is 1gm/200 ml. Our digestion would be 1 gm/100 ml.
(2) Target analytes detected below the established linear range of the instrument but meeting the mass spectral identification criteria will be J-flagged as estimate values.
(3) Determined in the ABNs analysis.
(4) Determined in the pesticide fraction.
(5) Total values are calculated by summing concentrations above detection limits. Concentrations not detected at the detection limit value will not be included.
(6) Modified as necessary for the limited target anlayte list and including any or all of the following cleanups: florisil cleanup; SW 846 Method 3620; sulfite sulfur cleanup; or elemental mercury cleanup for sulfur.
(7) Based on Krone et al., 1989 (NOAA) A method for analysis of Butyltin species and measurement of butyltins in sediment and English Sole Livers from Puget Sound. Modified to achieve required DLG (SOP).
(8) Based on dry weight with assumption of sediment moisture content <50%.
(9) Detection limit goal is below anlayte's method detection limit. Samples with no semivolatile target analytes detected above the SQO value(s) will be reanalyzed, subsequent to further concentration of the sample extract, as a means to achieve detection limit goals. Please note that detection limits are highly matrix dependent, and may not always be achievable.
(10) Sum of benzo(b)fluoranthene and benzo(k)fluoranthene.
(11) Antimony will be analyzed along with other metals; however, QC criteria will not be enforced to reanalyze the sample.

SM	Standard Methods, 18th Edition
DLG	Detection Limit Goals
CLP	Contract Laboratory Program
MCAWW	Methods for the Chemical Analysis of Water and Waste
PSEP	Puget Sound Estuary Program

Actual Sample Detection Limits may vary from Method Detection Limits depending on the influences of limited sample volume, matrix interferences, blank contamination, and moisture content of sediments.

Table MW-6
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments		
			Reference	Method	
CHLOR. AROMATICS in µg/kg (ppb)					
1,3-Dichlorobenzene	170	100	CLP	SOW OLM01.8	(2,3)
1,4-Dichlorobenzene	110	100	CLP	SOW OLM01.8	(2,3)
1,2-Dichlorobenzene	50	45	CLP	SOW OLM01.8	(2,3)
1,2,4-Trichlorobenzene	51	30	CLP	SOW OLM01.8	(2,3)
Hexachlorobenzene	22	8	CLP	SOW OLM01.8	(4,6)
CHLOR. ALIPHATICS in µg/kg (ppb)					
Hexachlorobutadiene	11	8	CLP	SOW OLM01.8	(4,6)
PHTHALATE ESTERS in µg/kg (ppb)					
Dimethyl phthalate	160	100	CLP	SOW OLM01.8	(2)
Diethyl phthalate	200	100	CLP	SOW OLM01.8	(2)
Di-n-butyl phthalate	1400	100	CLP	SOW OLM01.8	(2)
Butylbenzylphthalate	900	100	CLP	SOW OLM01.8	(2)
Bis(2-ethylhexyl)phthalate	1300	100	CLP	SOW OLM01.8	(2)
Di-n-octyl phthalate	6200	100	CLP	SOW OLM01.8	(2)
MISC. OXY. COMPOUNDS in µg/kg (ppb)					
Benzyl alcohol	73	50	CLP	SOW OLM01.8	(2)
Benzoic acid	650	500	CLP	SOW OLM01.8	(2)
Dibenzofuran	540	100	CLP	SOW OLM01.8	(2)
N-nitrosodiphenylamine	28	28	CLP	SOW OLM01.8	(2,9)
VOLATILE ORGANICS in µg/kg (ppb)					
Tetrachloroethene	57	20	CLP	SOW OLM01.8	(2)
Trichloroethene		20	CLP	SOW OLM01.8	(2)
Ethylbenzene	10	10	CLP	SOW OLM01.8	(2)
Total xylenes	40	20	CLP	SOW OLM01.8	(2)

5.1.2 Chemical Analysis

Sediments, subsurface soils and bank material will be analyzed for the chemicals listed in Table MW-6. This table also lists the preparation and analysis method, sediment method detection limit, and sediment standards (EPA and State Department of Ecology). Every effort will be made to achieve detection limits below the Sediment Quality Standards (SQS), and the testing laboratory will be specifically notified of importance of the SQS detection limit requirements.

5.1.3 Quality Assurance/Quality Control Requirements

Complete QA/QC requirements are presented in the Quality Assurance Project Plan (Appendix B).

5.2 LABORATORY WRITTEN REPORT

A written report will be prepared by the analytical laboratories documenting all the activities associated with the sample analyses. At a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results
- All protocols used during analyses and explanation of any deviations from the sampling plan protocols
- Chain-of-custody procedures, including explanation of any deviation from those identified in this plan
- Location and availability of data.

As appropriate, this sampling plan may be referenced in describing protocols. Further reporting that will be completed by the City is detailed in Section 6.0.

5.3 GEOLOGIC MAPPING

Test pits, trenchs and bank areas will be field-logged during sample collection and a stratigraphic map prepared inorder to guide eventual project construction. Field logging will be conducted by qualified staff from Parametrix.

6.0 BIOLOGICAL TESTING

The City plans will conduct biological analysis on three samples collected in the tideflat area in conjunction with chemical analysis of those samples. In upland areas, a tiered approach will be utilized. Coordination between agency and local government staffs will be maintained throughout the analytical and biological testing process, described below.

6.1 BIOASSAY LABORATORY PROTOCOLS

Samples will be collected at three tideflat stations for biological analysis; in upland areas, a tiered testing approach will be used. Biological testing, and associated chemical re-testing, will be undertaken on any upland sample which has one or more chemicals above Minimum Cleanup Levels (MCULs). For samples in which one or more parameters exceed Sediment Quality Standards but not MCULs, the need for bioassay testing will be evaluated on an individual basis in consultation with the agencies. Testing will include the standard Ecology sediment suite of bioassays. To the maximum extent practicable, chemical results will be provided for bioassay decisions within 28 days of the first sample collection. The remaining 28-day period will allow for bioassay preparation as well as re-tests, if necessary.

Bioassay testing requires that test sediments be matched and run with an appropriate reference sediment to factor out sediment grain-size effects on bioassay organisms. The approach to selecting reference sediment samples is outlined below:

> Highest priority for testing will be the conventional parameters, specifically, the sieve-analysis portion of grain size determination. These early results are used to support the selection of the reference sediment(s).
>
> The laboratory performing the biological analysis will collect the identified reference sediments as soon as the location is selected. The guidance received by the regulating agencies will assist the City in locating a suitably matched reference sediment. Wet-sieving in the field, however, is essential in finding an adequate match. The location of the reference sediment sampling station will be recorded to the nearest 0.1 second.

All sediment samples for potential bioassays will be stored at 4°C, with headspace purged with nitrogen. pending initiation of bioassay testing. All bioassay analyses, including re-tests, will commence within 56 days after collection of the first core section in the sediment composite to be analyzed. Chain-of-custody procedures will be maintained by the laboratory throughout biological testing.

Bioassay testing will be pre-planned to initiate appropriate testing as soon as possible after the analytical results have been received. This includes obtaining test organisms and control and reference sediments in a timely manner. This approach will support the opportunity for any re-testing to occur within the 56-day holding period, if necessary. As initial chemistry data becomes

available, the project manager and the bioassay laboratory representative will coordinate closely with Ecology to expedite biological testing decisions.

The acute toxicity bioassays prescribed by Ecology (amphipod, echinoderm embryo, saline extract Microtox) and juvenile Neanthes will be conducted on each sample identified for biological testing. All biological testing will be in compliance with Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments (USEPA, Region 10), with appropriate modifications as specified by the agencies. General biological testing procedures and specific procedures for each sediment bioassay are summarized below.

6.2 GENERAL BIOLOGICAL TESTING PROCEDURES

6.2.1 Negative Controls

Negative control sediments are used in the amphipod and Neanthes bioassays to check laboratory performance. Negative control sediments are clean sediments in which the test organism normally lives, and exposure to which is likely to incur low mortality.

The sediment larval testy will utilize a negative seawater control rather than a control sediment.

The Microtox test has a blank incorporated in the test as a negative control and does not use a negative sediment or seawater control.

The amphipod, sediment larval, and Neanthes tests all have performance standards for negative controls, which are identified in Section 6.3.

6.2.2 Reference Sediment

For test comparison, bioassay reference sediments are used which closely match the grain size characteristics of the test sediments. The reference sediment data are used to statistically block physical effects of the test sediment. The City, upon the advise of Corps of Engineer dredge disposal staff, expect to utilize a station in Carr Inlet for reference sediment collection.

All reference sediments will be analyzed for conventional parameters, which include: total solids, total volatile solids, total organic carbon, ammonia, total sulfides, and grain size.

All bioassays have performance standards for reference sediments (see Section 6.3). The decision to re-test will be made in consultation with the agencies.

6.2.3 Replication

Five laboratory replicates of test sediments, reference sediments, and negative controls will be run for each bioassay. The Microtox test includes a dilution series with five replicates at the highest concentration as per the PSEP guidelines.

6.2.4 Positive Controls

A positive control will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism. These provide an indication of the sensitivity of the particular organisms used in a bioassay. Cadmium chloride will be used for the amphipod, Neanthes, and sediment larval bioassays. Phenol will be used for the Microtox test.

6.2.5 Monitoring of Sediment and Water Quality Parameters

Water quality monitoring will be conducted daily for the amphipod and sediment larval tests, and every other day for the Neanthes biomass bioassay. Parameters measured will be salinity, temperature, pH, and dissolved oxygen. Monitoring will be conducted for all test sediments, reference sediments, and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay. One replicate test vessel representing each station will be monitored for water quality parameters. Ammonia and sulfides will be determined at test initiation and termination. Initial ammonia and sulfide measurements for each treatment will be taken from a separate chemistry beaker set up to be identical to the other replicates within the treatment group, but without test organisms. Final aqueous ammonia and sulfide measurements will be taken at the end of the test from the beakers used for monitoring the other water quality parameters. If any of these parameters are outside the levels recommended in the protocol, the Department of Ecology will be contacted.

Prior to initiation and immediately following termination of the bioassays the redox potential of test sediments from each station will be measured, and the values recorded.

6.3 BIOASSAY-SPECIFIC PROCEDURES

6.3.1 Amphipod Bioassay

This test involves exposing the amphipod *Rhepoxynius abronius* to test sediment for ten (10) days and counting the number of surviving amphipods at the end of the exposure period. Daily emergence data and the number of amphipods failing to re-bury at the end of the test will also be recorded. Test validity will be ensured by performance standards.

The Sediment Quality Standard (passing) is defined by a maximum of 25% percent mortality and mortality levels statistically different (higher) than reference sediments. The reference sediments have a performance standard of 25 percent mortality and the control sediments have a performance standard of 10 percent mortality.

Sediment and water quality parameters will be measured as outlined in Section 6.2.5. The agencies will be consulted immediately if any abnormal observations are made.

6.3.2 Sediment Larval Bioassay

This test monitors larval development of a suitable echinoderm species (*either Strongylocentrotus purpuratus* or *Dendraster excentricus*) in the presence of test sediment. The test is run until the appropriate stage of development is achieved in a sacrificial seawater control . At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and survival.

The sediment larval bioassay has a variable endpoint (48-96 hours) which is determined by the developmental stage of organisms in a sacrificial seawater control. Initial counts will be made for a minimum of five 10-ml aliquots. Final counts for seawater control, and reference and test sediments will be made on two 10-ml aliquots from each replicate.

The state standard (passing) is defined by statistical significance from reference sediments and less than 15% of the mean mortality/abnormality observed in reference sediments. The seawater control has a performance standard of 50 percent combined mortality and abnormality.

Sediment and water quality parameters will be monitored as outlined in Section 6.2.5. In the event any abnormal observations are made, the agencies will be contacted immediately.

6.3.3 Microtox Bioassay

The Microtox bioassay will test the bioluminescence of the bacterium *Photobacterium phosphoreum* following a 15-minute exposure to a saline extract of test sediment. All five replicates at the highest dilution will be run simultaneously with the dilution series.

The state standard (passing) is defined by significant difference from reference and mean luminescence greater than 80% of reference.

6.3.4 Juvenile Infaunal Species Bioassay

Juvenile polychaetes *(Neanthes arenaceiodentata*) are used to assess the effect of the test sediment on growth. This bioassay determines the relative change in polychaete biomass following 20 days of exposure to test, reference, and control sediments. There are five organisms per test vessel, with the exception of the positive control, which has 10 organisms per test vessel.

The state standard (passing) is defined by significant difference from reference and mean rate of biomass growth greater than 70% of reference. The control sediment has a performance standard of 10 percent mortality. The reference sediment has a performance standard of 80 percent of the mean biomass growth rate of that observed in the control.

Sediment and water quality parameters will be monitored as outlined in Section 6.2.5. In the event any abnormal observations occur, the agencies will be contacted immediately.

6.4 Interpretation

Test interpretations consist of endpoint comparisons to control and reference sediments on an absolute or relative percentage basis, as well as statistical comparison to the reference sediment. Bioassay results will be interpreted based upon criteria outlined below..

Test	Criteria	Reference Area/Control Performance Standards
Amphipod	Test mean mortality < 25% and significantly different from reference ($P<0.05$)	Control Sediment < 10% mortality; Reference sediment , 25% mortality
Echinoderm Embryo	Test mean abnormality and mortality >15% of mean reference response and significantly different from reference ($P<0.05$)	Seawater control < 50% combined abnormality and mortality
Neanthes Growth	Mean biomass < 70 % of mean reference biomass and significantly different from reference.	Control sediment < 10% mortality; Reference sediment biomass > 80% control biomass.
Benthic Major Taxa	Mean abundance of any one group < 50% of reference and significantly different from reference ($P< 0.05$)	Assemblage representative of unimpacted areas of Puget Sound; richness and abundance within normal range of natural variability; pollution-sensitive taxa present; pollution tolerant taxa not numerically dominant.
Benthic Richness & Abundance	Mean index less than and significantly different from reference ($P < 0.05$)	Assemblage representative of unimpacted areas of Puget Sound; richness and abundance within normal range of natural variability; pollution-sensitive taxa present; pollution tolerant taxa not numerically dominant.

6.5 Bioassay Re-test

Any bioassay re-test will be fully coordinated with, and approved by, the regulating agencies.

6.6 LABORATORY WRITTEN REPORT

A written report will be prepared by the laboratory, documenting all the activities associated with sample analyses. At a minimum, the following will be included in the report:

- Results of the laboratory bioassay analyses, including control charts for each bioassay and $_{EC}50$ calculations, and QA/QC results, reported both in hard copy and in the Corps' DAIS data format, if requested. Raw data will be legible or typed. Illegible data may result in the need for a re-test if the agencies cannot interpret the data.

- All protocols used during analyses, including explanation of any deviation from the EPA CLP or PSEP Protocols and the approved sampling plan.

- Chain-of-custody procedures and copies of completed forms, including explanation of any deviation from the identified protocols.

As appropriate, this sampling plan may be referenced in describing protocols.

7.0 REPORTING

7.1 QA REPORT

The project QA representatives will prepare a QA report based on field sampling techniques and review of the laboratory analytical data. The laboratory QA/QC reports will be incorporated by reference. This report will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols. It will make a statement regarding the overall validity of the data collected. The QA/QC report will be incorporated into the final report.

7.2 FINAL REPORT

A written report shall be prepared and submitted by the City, documenting all activities associated with collection, compositing, and transportation of samples as well as chemical and biological analysis of samples. The chemical and biological reports will be included as appendices. At a minimum, the following will be included in the final report:

- Type of sampling equipment used.
- Protocols used during sampling and testing, and an explanation of any deviations from the sampling plan protocols.
- Descriptions of each sample adequate to provide a visual representation of the sediment
- Methods used to locate the sampling positions.
- Locations where the sediment samples were collected. Locations will be reported in latitude and longitude, to the nearest tenth of a second.
- Chain-of-custody procedures used, and explanation of any deviations from the sampling plan procedures.
- Description of sampling and compositing procedures.
- Final QA report as described in Section 7. l, above.
- QA data required by Ecology for data validation prior to entering data into their Sediment Quality database. These data are listed in Appendix B.
- All raw data required for DAIS as identified in Appendix B.
- Sampling and analysis cost data will be submitted upon project completion on forms provided by the agencies.

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APPENDIX A

PHOTO LOG

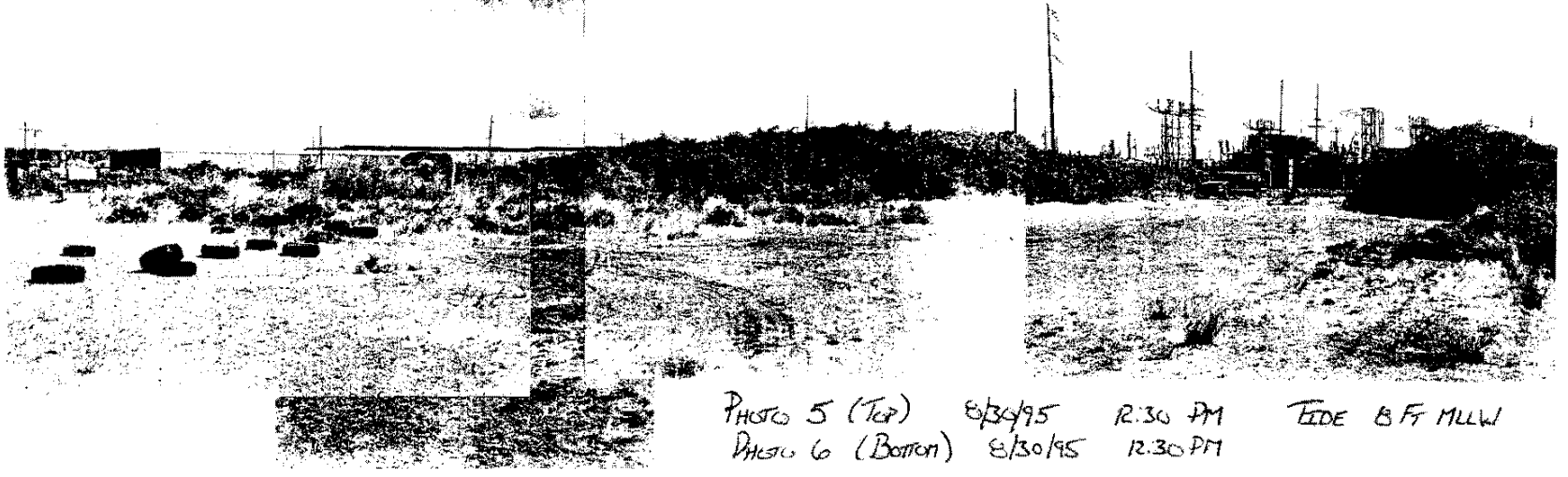

PHOTO 5 (Top) 8/30/95 12:30 PM TIDE 8 FT MLLW
PHOTO 6 (Bottom) 8/30/95 12:30 PM

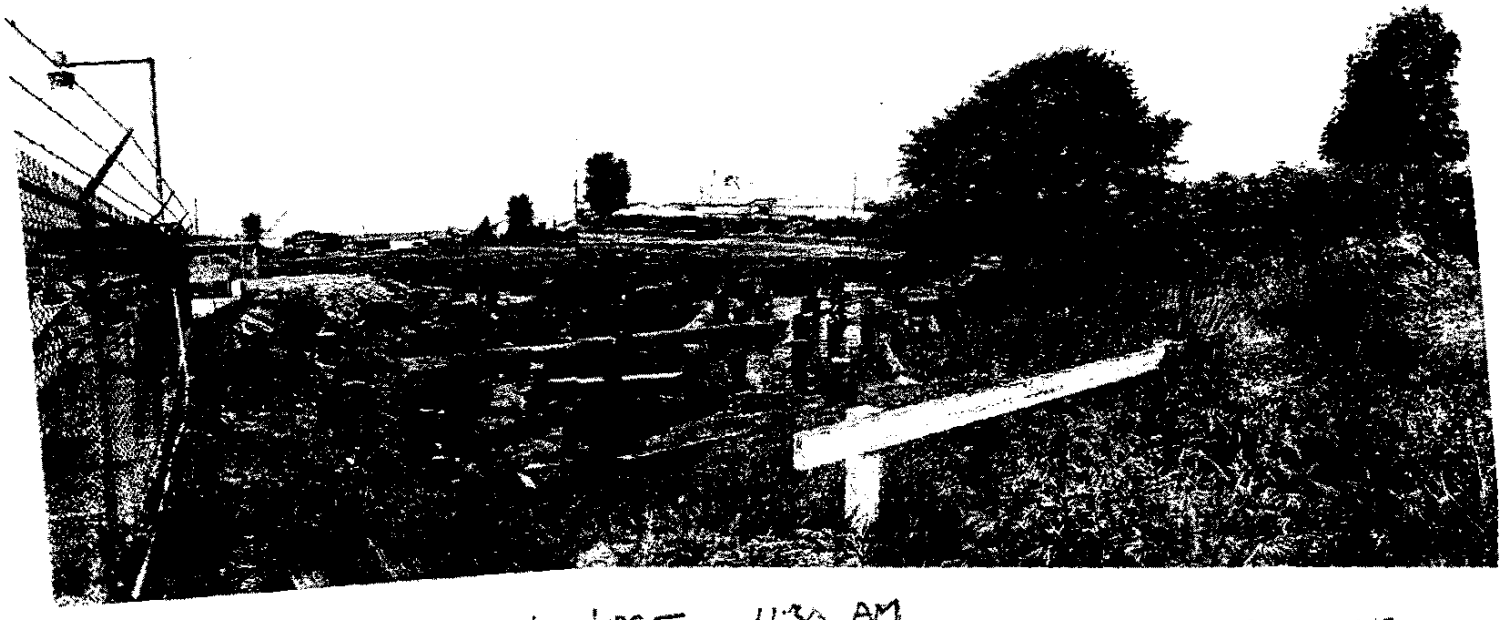

PHOTO 3 (TOP) 5/25/1995 11:30 AM
TIDE: -3.6' MLLW

PHOTOS: GSZ

PHOTO 4 (BOTTOM) 5/25/1995 11:30 AM TIDE -3.6' MLLW

PHOTO 1 (TOP) 5/25/95 11:30 AM TIDE -3.6' MLLW

PHOTO 2 (BOTTOM) 5/25/95 11:30 AM TIDE -3.6' MLLW

APPENDIX B

POTENTIAL ISSUES OF CONCERN

POTENTAL ISSUES OF CONCERN

Sampling:

- o Deviations from the sampling and analysis plan
- o Very poor recovery (<50%)
- o Survey errors
- o Equipment changes
- o Positioning problems
- o Sampling station access problems
- o Lost coolers/samples
- o Inability to locate reference sediment with a proper grain size match based on wet-sieving results (reference sediment must not be significantly finer than test sediments).

Chemical Testing:

- o Deviations from the Sampling and Analysis Plan
- o Poor QA/QC results
- o Detection limit problems.

Biological Testing:

- o Deviations from the Sampling and Analysis Plan
- o High ammonia or sulfides (prior to bioassay)
- o Reference sediment performance failure
- o Control sediment or seawater control performance failure
- o Significant water quality deviations
- o Significant deviations of LC50/EC50 from expected range
- o Obvious adverse conditions or unusual organism mortality
- o Predation
- o Indigenous population of test species in test, reference or control sediments
- o Any retests.

APPENDIX C

QUALITY ASSURANCE PROJECT PLAN

1.0 LABORATORY METHODS, QUALITY ASSURANCE, AND QUALITY CONTROL FOR SEDIMENT QUALITY ANALYSIS - CHEMISTRY

1.1 Introduction

The purpose of the Quality Assurance Project Plan (QAPP) presented herein is to give, in specific terms, the objectives, organization, and functional activities, associated with the sampling and analysis activities as set forth in the Sampling and Analysis Plan for the Middle Waterway Estuarine Natural Resources Restoration Project. This QAPP covers the sampling and analysis of upland (trenches and test pits), bank, intertidal surficial (0 to 10 cm) and intertidal core sediment samples for this project.

This document is based upon the QAPP prepared for recent Foss Waterway sediment predesign sampling and analysis. A number of EPA documents were used as aids in preparing the Foss document, including a specific set of EPA guidelines. This document, by extension, is designed to be consistent with and to meet the intent of EPA requirements.

Field activities, including sample collection and station surveys, will be conducted by City personnel with the aid of professional staff of Parametrix, Inc. for field logging of upland material. Chemical analyses of samples will be for TOC, tributyltin, semivolatiles, pesticides, PCB compounds, and other parameters as listed in Table 1-2. Table 1-6 summarizes samples by type (e.g. upland test pit, field duplicate). Laboratory analysis will be conducted by the City of Tacoma Laboratory, except for tributyltin, TOC and grain size; an outside laboratory will be utilized for these analyses.

The City Lab is in the process of Washington state accreditation for sediment analysis; however, EPA has indicated that in general the use of the City Laboratory is acceptable for sediment quality analysis in Commencement Bay, based upon results of Foss Waterway sampling and analysis results The City Laboratory Quality Assurance Manuals and standard operating procedures (SOP) have previously been submitted to EPA.

1.2 Project Organization and Responsibility

Quality assurance responsibilities of project personnel are summarized in Table 1-1.

1.3 Quality Assurance Objectives for Measurement of Data in Terms of Precision, Accuracy, Representativeness, Completeness, and Comparability

The primary quality assurance objective of this project is to ensure the collection of data of known and acceptable quality that are useful for achieving the goals of the City of Tacoma Middle Waterway Estuarine Natural Resources Habitat Restoration Project.

The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable quality control procedures are given below.

Chemical Analyses

The applicable quality control procedures and quantitation limits are dictated by the specific analytical methods employed and the intended use of the data. For this project, the chemical data will be used to assess the nature and extent of contamination within the study area. Chemical analysis for the parameters in Table 1-2 will be performed on the sediment samples. This table presents a compilation of analytes of concern with their associated method of analysis, detection limit goals, and the SQOs for sediment samples. Tables 1-3 and 1-4 present the Project precision and accuracy objectives, which reflect necessary method modifications for achieving required detection limits. Table 1-5 presents the SRM/CRM results acceptance criteria. Table 1-6 is a field and QC sample summary.

Quality Assurance Objectives

Precision. Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Precision is generally evaluated using both MS/MSD results and field duplicate results. MS/MSD results provide information on laboratory (only) precision, while field duplicates provide information on field and lab precision combined.

Analytical precision is measured through matrix spike/matrix spike duplicate (MS/MSD) samples for organics analyses, MS/duplicate for metals, and through duplicate samples for other inorganic analyses. Analytical precision is quantitatively expressed as the relative percent difference (RPD) between the MS/MSD or duplicates. Analytical precision measurements will be carried out on intertidal sediment samples at a minimum frequency of one per batch of sediments (20 or fewer field samples per intertidal batch, which consists of one or more sample delivery groups) or one in 20 samples per matrix analyzed, whichever is more frequent. A quantitative definition of the RPD is given in Section 1.12. The quality assurance objectives are presented in Table 1-3.

Two field duplicates (homogenized samples, except VOA and sulfides) will be collected and analyzed for this project. Considering high variability of sediment matrix and uncertainties associated with the field sampling, and based on the data from previous similar sediment project, the precision acceptance criteria for field duplicates will be equal to or less than 50% RPD. The field replicate results will be evaluated to establish field variability of the sediments.

Accuracy. Accuracy measures the closeness of the measured value to the true value. The accuracy of chemical test results is assessed by analyzing standard reference materials or by "spiking" samples with known standards (surrogates and/or matrix spike) and measuring the percent recovery. A quantitative definition of percent recovery is given in Section 1.12.

Accuracy measurements for sediment samples will be carried out in accordance with CLP SOW requirements for organic and inorganic analyses and at a minimum frequency of one per batch or one in 20 samples per matrix analyzed, whichever is greater.

As additional laboratory internal QC check samples for this project, the laboratory will also analyze the applicable sediment standard reference materials (SRMs) or certified reference materials (CRMs) using the project specific methodologies (Table 1-2) (which may not be the same as the SRM/CRM employed) for limited selected samples. The availability of SRMs and CRMs are subject to change and specific catalog numbers may vary; hence, the associated certified values and acceptance ranges may change accordingly. The SRM/CRM accuracy requirements are presented in Table 1-5. The generated data will be evaluated based on the certified values and associated uncertainties provided in the "Certificate of Analysis" of the SRMs/CRMs, and the accuracy acceptance criteria are presented in Table 1-5. The SRM/CRM data are intended for use in evaluating the consistency of the analytical methods. Therefore, no data will be rejected or samples reanalyzed based on SRM results alone.

In the event that low recoveries of SRM ABN and pesticides/PCBs analytes are encountered, blank spikes may be concurrently analyzed with the SRM. Acceptable blank spike recoveries would indicate the analytical process was in control and support the validity of the data.

Representativeness. Representativeness measures how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the matrix sampled. The sampling plan design, sampling techniques, and sample handling protocols (e.g., storage, preservation, and transportation) have been developed to assure representative samples; these procedures are discussed in the Sampling and Analysis Plan (SAP). Field duplicates will be collected from the homogenized sample (except VOA and sulfide samples) to evaluate the precision (reproducibility) of the field procedures (sample collection, processing) and to assess laboratory method variation. The field duplicates for VOA and sulfide analyses will be collected first from the same grabs without mixing. For the composite samples, equal aliquots of subsamples will be layered in the sample containers. Sulfide composite samples will be mixed with ZnOAc preservative in the closed sample containers in the field. Laboratory method blanks will be run at a minimum of 5 percent frequency or one per batch, whichever is more frequent, to assess laboratory contamination.

Completeness. Completeness is defined as the percentage of measurements made which are judged to be valid measurements. The completeness of the data will be the number of acceptable data points over the total number of data points times 100. A target completeness goal for this work will be 90 percent. A quantitative definition of completeness is given in Section 1.12.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The use of standard techniques for both sample collection and laboratory analysis should make data collected from same sampling locations and depth comparable to both internal and other data generated.

1.4 Sediment Sampling Procedures

Sample site location and description and sampling procedures are detailed in the SAP. The plan outlines the data needs identified for this work and the specific procedures to be used to obtain representative samples to fulfill these data needs. The information provided within the QAPP outlines the data documentation procedures which will be followed to assure quality data. The documentation procedures include specific data forms for recording field observations and Sample Custody Records.

To control the quality of samples submitted for laboratory analysis, established preservation and storage measures will be followed. Table 1-7 provides information on holding times, sample containers, and sample preservation requirements for sediment samples. All sediment sample containers will be provided by the City or contract lab. The labs will either clean the sample containers and conduct the certification analyses or purchase precleaned and certified free of contamination sample containers from environmental sampling supply companies. The analytical results and the certifications will be kept in the laboratory project files.

The containers are precleaned by the laboratory or supplier(s) to one of three specifications, depending on the analytical purpose, as described below:

- **Procedure 1.** For extractable organics (acid/base/neutral compounds). The 16 ounce clear glass jars, teflon liners, and caps are washed in hot tap water using laboratory grade non-phosphate detergent. All are then rinsed three times with hot tap water. All are then rinsed once with 1:1 nitric acid (metals-grade HNO_3 and ASTM deionized water) and then rinsed three times with ASTM Type I deionized water. A final rinse is made using pesticide grade methylene chloride. The jars and teflon liners are oven-dried at 125°C, then allowed to cool to room temperature in an enclosed, contaminant-free environment before assembling.

- **Procedure 2.** For metals and miscellaneous inorganic constituents. The 16 ounce jars and caps are washed in hot tap water using laboratory grade non-phosphate detergent, then rinsed three times with hot tap water followed by one rinse with 1:1 nitric acid (metals-grade HNO_3 and ASTM deionized water). All are then rinsed three times with ASTM Type I deionized water, inverted and air-dried in a contaminant-free environment before assembling.

- **Procedure 3.** For volatile organics. The 2 ounce glass jars, screw caps, and teflon liner inserts are washed in hot tap water using laboratory grade non-phosphate detergent. The jars are then rinsed and dried in a dryer. The caps are rinsed and air dried in a wire basket. After the jars are dried they are heated in the VOA oven overnight at 100°C and then allowed to cool to room temperature. The jars are then capped for storage and labeled with a lot number that reflects the date of preparation.

1.5 Sample Custody

This section provides guidance on labeling and custody of samples.

Sample Labeling and Nomenclature

Sample labels will clearly indicate the sample number. Depth interval, date, sampler's initials, and any pertinent comments will also be included. The sample numbers will be cross-referenced with the sample locations in the field log book. Blind field duplicates, SRM samples, and rinseate blands will be labeled with a fictitious sample number. Labels will be partially pre-filled out and put on the sample containers in the City lab. Specific sampling information (such as sampling time and person, etc.) will be filled out at the time of sampling.

Sample Custody

Definition of Custody. After recovery, samples will be maintained in the Citys custody. For purposes of this work, custody will be defined as follows:

- In plain view of the field representatives;
- Inside a cooler which is in plain view of the field representative; or
- Inside any locked space such as a cooler, locker, car, or truck to which the field representative has the only immediately available key(s).

Custody Records. A chain of custody record will be initiated at the time of sampling for each sample collected. This record will be signed by the sampler and others who subsequently hold custody of the sample.

Sediment samples will be stored in coolers and transported to the laboratories for physical and chemical testing.

Custody Seal. Samples selected for chemical analyses along with their respective custody records will be transported to the chemical laboratory in coolers with custody seals affixed.

Laboratory Custody Procedures

Laboratory custody procedures ensure that each sample is uniquely identified and stored in a secure area. Access to the laboratory as a whole is restricted. Access to samples is restricted to authorized laboratory staff.

Specific lab custody procedures for this work are provided in the lab QA Manual.

Sample Receipt. Samples will be received at the laboratory under chain of custody, the chain of custody document having been initiated in the field. The Sample Custodian will observe and record the condition of custody seals present on ice chests. Before signing the chain of custody document, the samples will be inventoried to ensure that all containers are present.

Sample Log In. At log in, the samples will again be inventoried to ensure that identification on the sample containers and on the chain of custody are in agreement. Any discrepancies will be noted on the chain of custody record and will be communicated immediately to City field personnel.

Secure Sample Storage. Following log in, samples are removed to secure cold storage areas appropriate to the sample type. Volatile organics aliquots are stored at 4°C, under lock and key, in a refrigerator reserved for the purpose. They are stored separately from other sample types and from standards.

Recordkeeping. All documents created and received associated with the samples are retained in the case master file. All bench sheets, raw data, internal chain of custody documents, and other paperwork generated during storage, handling, and analysis of the samples come together at the completion of analysis, prior to reporting, and remain together filed underneath the laboratory work order number.

1.6 Calibration Procedures and Frequency

Laboratory Calibration Procedures

The laboratory calibration procedures are specified in the laboratory SOPs and EPA CLP SOWs for each parameter or the methods for non-CLP analyses. Lower concentration standards and extended calibration curves will be used for organic analysis to achieve linear range at the detection limit or below the SQOs, whenever possible.

- A 0.5 ppb standard will be incorporated into the VOA 5-point calibration curve to ensure accurate quantitation of hits at the detection limit.

- Benzyl alcohol and benzoic acid standards will be added to the semivolatile calibration.

- The laboratory will attempt to extend the linear range of the semivolatile method by running low level calibration standards at 5 ng/µl, 2 ng/µl, and 1 ng/µl in addition to the standard CLP 5-point concentration range (8-point calibration). The intent will be quantify analytes at DLG levels.

- Hexachlorobutadiene and hexachlorobenzene standards will be added to the pesticides/PCBs calibration, and these two compounds will be determined in pesticides/PCB analysis instead of in semivolatile analysis.

1.7 Sediment Analytical Procedures

Table 1-2 presents the target list of compounds to be analyzed.

In general, all organic and metal analyses for sediments will be performed in accordance to protocols specified on the Statement of Work (SOW) (ILM03.0 and OLM01.8) for the EPA CLP. Some analyses will be performed with SW 846 methods (Table 1-2). In some cases, detection limits lower than those in the SOW CLP protocols are required for particular analytes to provide sufficient data resolution for purposes of comparison with sediment cleanup objectives. In such cases modifications to established analytical methods will be necessary to achieve project data quality objectives. For instance, the sample size and final volume of the digestate or extract may have to be adjusted to achieve the required quantitation limits as described in more detail below.

Modifications to protocols for the analysis of organic substances specified in the CLP SOW OLM01.8 include the following:

Semivolatile Organics

- GC/MS semivolatile organic compound identifications will be made and concentrations will be reported as long as spectral confirmation can be made. However, the lab will report any concentrations detected below the established linear range of the instrument with "J" (estimated) qualifiers when mass spectra confirm the presence of compounds. "J" flags may also be assigned during data validation.

Pesticides (and Hexachlorobenzene and Hexachlorobutadiene)/PCBs

- To achieve the required quantitation limits, hexachlorobenzene and hexachlorobutadiene will be determined in the pesticide fraction analyses instead in the semivolatile analysis. The only method modification is to add these two compounds to the standard solution of the pesticides/PCBs method.

- In the event it is the analyst's judgement that the potential exists for petroleum hydrocarbon contamination in a sample, causing false PCB identification, a sulfuric aid cleanup and re-analysis will be performed to confirm the presence or absence of the aroclor (PCB).

- Concentrations outside the instrument linear calibration range will be qualified "J" (estimated).

VOAs

- GC/MS volatile organic compound identifications will be made and concentrations will be reported as long as spectral confirmation can be made. However, the lab will report any concentrations detected below the established linear range of the instrument with "J" (estimated) qualifiers when mass spectra confirm the presence of compounds. "J" flags may also be assigned during data validation.

Metals

Sediment samples for the analysis of metals may be digested by microwave or hot plate procedures as specified in the CLP SOW ILM03.0. Modifications to protocols for the analysis of metals specified in the CLP SOW ILM03.0 are:

- Hot plate sediment digest will be diluted to a final volume of 100 ml instead of 200 ml.

- Samples for lead analysis will be analyzed by graphite furnace or ICP.

Butyltin

- GC/MS organotin compound identifications will be made and concentrations will be reported as long as spectral confirmation can be made. However, the lab will report any concentrations detected below the established linear range of the instrument with "J" (estimated) qualifiers when mass spectra confirm the presence of compounds. "J" flags may also be assigned during data validation.

- To achieve the project required quantitation limits and meet the data quality objectives for tributyltin, the contract lab will extract two separate 20 gram aliquots of sediment via sonic horn technique and combine them prior to instrumental analysis, because lab R&D showed that analyzing sample size any larger yielded unacceptable recoveries. The tributyltin will be reported as tin.

- Three other organotin compounds (mono, di, and tetrabutyltin) will also be included in the calibration. The monobutyltin, dibutyltin, and tetrabutyltin results will be treated as TICs in the data validation.

Conventional analysis will be performed according to the lab SOPs and one of the following references: Methods for the Chemical Analyses of Water and Waste; Standard Methods, 18th edition, Puget Sound Estuary Program, or SW 846, as presented in Table 1-2, since no CLP protocols have been established for these parameters.

Other method modifications and/or alternatives may be necessary due to the saline matrix of sediment samples. In that case, EPA will be informed and the QAPP will be amended. All results for sediment sample analysis will be presented on dry weight basis.

1.8 Internal Quality Control Checks

The internal quality control procedures will consist of the following:

Instrument Calibration

Sediment. Instrument calibration and standards as defined in the EPA CLP SOWs for organic and inorganic analyses, the quality control specifications outlined in the laboratories' SOPs and analytical methods as described in Sections 1.6 and 1.7 will be followed.

Blanks

Method Blank. Laboratory method blank measurements at a minimum frequency of 5 percent or one per analytical batch, whichever is greater. An analytical batch contains a maximum of 20 field samples and consists of one or more SDGs.

Rinseate Blank. One rinseate blanks will be collected and analyzed for metals, semivolatiles, VOAs, pesticides and PCBs. Sampling equipment will be rinsed with deionized water and the rinseate will be placed in a sample container for analyses. Analyses of the rinseate blanks will be according to methods as specified in Table 1-2 with appropriate modifications to sample preparation for the water matrix. Rinseate blanks will be used to determine if any cross contamination has occurred during sampling.

Accuracy and Precision

Duplicates/Replicates. Two field duplicates will be collected and used to evaluate laboratory and field precision.

Matrix Spike/Matrix Spike Duplicates. MS/MSD or lab duplicate measurements will be performed at a minimum frequency of 5 percent or one per analytical batch. The acceptance criteria are presented in Tables 1-3 and 1-4. The estimated number of QC samples is presented in Table 1-6.

Reports

Data reports will include a Quality Control Data Review for each analytical batch. CLP documentation for each analysis, as described in the EPA SOWs for organic and inorganic analysis (EPA, 1991 and undated, respectively), or according to the laboratory QA/QC procedures described in previous sections when modifications to CLP procedures are used, will be provided at request of the EPA project coordinator. For non-CLP procedures, data reports will include necessary information and raw data (see Section 2.9) to allow reviewer to perform a QA/QC review equivalent to CLP review, unless the EPA project coordinator approves a modified data report.

All original data records will be maintained at the City laboratory for a period of at least five years from the time fo sampling.

1.9 Data Reduction, Validation, and Reporting

All data will undergo quality assurance/quality control evaluation. Data reduction, evaluation, and reporting at the laboratory will be carried out as described in the EPA CLP SOWs for organic and inorganic analysis (EPA, 1991 and undated, respectively) or based on the analytical laboratory in-house protocols when CLP procedures are not used or not defined. The laboratory protocols are presented in the laboratory SOPs.

Data Reduction, Validation, and Reporting

Sediment - Laboratory Data Validation. All analysts are required to complete a QC Non-Conformance Memo documenting that corrective action has been taken when quality control indicators fall outside of control limits. An in-control analysis requires no further action. A memo noting out-of-control circumstances must be reviewed and initialed by the Quality Control Officer (QCO). The QCO may concur with the corrective actions already initiated by the analyst, or may require that further action be taken. If reanalysis is required, the review process is repeated.

After the QC Non-Conformance Memo has been reviewed and accepted (which may occur after reanalysis), the report of test results, associated quality control results, raw data, and QC memos are transferred to the laboratory manager for review . The lab manager accepts the data, initialing it, or rejects the data based on criteria such as surrogate and MS/MSD recovery values, data package completeness, calibration, and correctly calculated sample results. If rejected, the data are returned to the analyst via the QCO and reanalysis may be performed. After the analyst, QCO and lab manager (if out of control events occurred) have accepted the data, the final report is prepared.

Laboratory data flags, or qualifiers, are applied following the lab SOPs and EPA CLP protocols for organic and inorganic analyses. These data flags may have different meanings than those commonly employed by non-laboratory data reviewers. The flags will be defined in the accompanying case narrative.

Detection Limits and Quantitation Limits

In general, detection limits will reflect the lowest levels of analyte that can be accurately and reproducibly detected by the analytical method employed. Data for each target compound generated in accordance with the EPA SOW for organics and inorganics analysis (EPA, 1992a and 1992b) will be reported with a sample quantitation limit (SQL) by the lab for this project. The SQL is defined as follows:

SQL = The lowest reproducible concentration at which a chemical can be accurately and reproducibly quantitated for a given sample. The SQL can vary from sample to sample depending on sample size, matrix interferences, moisture content, and other sample-specific conditions.

SQLs may be adjusted for a specific sample as a result of adjustments to the preparation or analytical method (i.e., sample dilution, sample matrix or variations in sample mass or volume extracted). Because SQLs take into account sample characteristics (i.e., matrix effects), sample preparation, and analytical adjustments, these values are the most relevant quantitation limit for evaluating non-detected chemicals.

Data Qualifiers

The data will be qualified by the laboratory in accordance with established control limits (lab SOPs and QC Manual) and with CLP laboratory data qualifier definitions for inorganic and organic chemical data (EPA, 1991 and undated). Additional laboratory data qualifiers may be defined and reported in order to more completely explain the laboratory's quality control concerns regarding a particular sample result. All additional data qualifiers will be defined in the laboratory's case narrative reports associated with each case.

1.10 Performance and System Audits

The Laboratory Manager and Project Coordinator will monitor the performance of the field and laboratory quality assurance program. This will be achieved through regular contact with the field and analytical QA officers.

Field Performance

Field performance will be monitored through review of sample collection documentation, sample handling records (chain of custody forms), field notebooks, and field measurements.

1.11 Preventative Maintenance

Field Preventative Maintenance

Preventative maintenance of field instruments and equipment will follow manufacturer's specifications. All routine maintenance will be recorded in instrument log books or directly on the instrument as appropriate.

Analytical Laboratory Preventative Maintenance

Preventative maintenance in the laboratory will be the responsibility of the laboratory personnel and analysts. This maintenance includes routine care and cleaning of instruments and inspection and monitoring of carrier gases, solvents, and glassware used in analyses.

Precision and accuracy data are examined for trends and excursions beyond control limits to determine evidence of instrument malfunction. Maintenance will be performed when an instrument begins to change as indicated by the degradation of peak resolution, shift in calibration curves, decrease in sensitivity, or failure to meet one or another of the quality control criteria. Details of the maintenance procedures for laboratories will be addressed in the laboratory Quality Control Manual(s).

1.12 Specific Routine Calculations to be Used to Assess Data Precision, Accuracy, and Completeness

Data assessment will be based on the data quality objectives. This will include data validation procedures described in this attachment. The quantitative definitions of precision, accuracy, and completeness are presented in this section.

Precision

The results from matrix spikes and matrix spike duplicate analyses will be used to determine the relative percent difference (RPD) between the pair of analyses. This is a measure of analytical precision and can be calculated as follows:

$$RPD = \frac{(C_1 - C_2)}{(C_1 + C_2)/2} \times 100$$

Where:

RPD	=	relative percent difference
C_1	=	larger of the two observed values
C_2	=	smaller of the two observed values

Accuracy

For spiked samples, the percent recovery (%R) can be used as the measure of accuracy as follows:

$$\%R = 100 \times (S-U) / C_{sa}$$

Where: %R = percent recovery
C_{sa} = actual concentration of spike added
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot

Completeness

Measurement of completeness (C) can be defined as the ratio of acceptable measurements obtained to the total number of planned measurements for an activity. Completeness can be defined as:

$$\%C = \frac{\text{(Number of acceptable data points)}}{\text{(Total Number of data points)}} \times 100$$

1.13 Corrective Action

If quality control audits result in detection of unacceptable conditions or data, the project quality assurance coordinator will be responsible for implementing corrective action and EPA will be notified immediately. Specific corrective actions are outlined in each respective EPA CLP SOW or method and include but are not limited to the following:

- Identifying the source of the violation;
- Re-analyzing or re-extracting samples if holding time criteria permit;
- Resampling;
- Evaluating and amending sampling and analytical procedures; and/or
- Accepting data and flagging to indicate the level of uncertainty.

Corrective actions may also be initiated as a result of other QA activities, including:

- Performance audits;
- System audits; and
- Laboratory/interfield comparison studies.

1.14 Quality Assurance Reports

After data have been received and evaluated by the City Laboratory Manager, a report summarizing the specific QC checks will be written. This summary will also include:

- Validated data;
- Assessment of measurement data precision, accuracy, and completeness;
- Results of system and performance audits; and
- Significant QA problems and recommended solutions.

This report will be submitted to the laboratory manager for final confirmation of the validity of the data. These reports will be included in the Data Report.

Table 1-2
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments Reference	Method	
CONVENTIONALS & MISC.					
Total Solids		1 %	SM	2540 G	
Total Vol Solids		1 %	SM	2540 E	
Total Organic Carbon		0.1 %	SW 846	9060 with I.R.	
Ammonia		50 ppm	MCAWW	350	
pH		NA	SW 846	9045	
Sulfide		NA	PSEP	NA	
Grain Size		NA	ASTM	D-422	
METALS in mg/kg (ppm)					
Antimony	150	100	CLP	SOW ILM03.0	(11)
Arsenic	57	1	CLP	SOW ILM03.0	(1)
Chromium		1.2	CLP	SOW ILM03.0	(1)
Mercury	0.59	0.1	CLP	SOW ILM03.0	
Silver	6.1	1	CLP	SOW ILM03.0	(1)
Copper	390	2.5	CLP	SOW ILM03.0	(1)
Nickel	140	4	CLP	SOW ILM03.0	(1)
Cadmium	5.1	1	CLP	SOW ILM03.0	(1)
Lead	450	0.6	CLP	SOW ILM03.0	(1)
Zinc	410	2	CLP	SOW ILM03.0	(1)
Tributyltin (as Tin) in µg/kg (ppb)		30	Laucks SOP	3550/8270	(7)
PHENOLS & SUB PHENOLS in µg/kg (ppb)					
Phenol	420	100	CLP	SOW OLM01.8	(2)
2-Methylphenol	63	55	CLP	SOW OLM01.8	(2)
4-Methylphenol	670	100	CLP	SOW OLM01.8	(2)
2,4-Dimethylphenol	29	29	CLP	SOW OLM01.8	(2,9)
Pentachlorophenol	360	200	CLP	SOW OLM01.8	(2)
LPAHs in µg/kg (ppb)					
Naphthalene	2100	100	CLP	SOW OLM01.8	(2)
2-Methylnaphthalene	670	100	CLP	SOW OLM01.8	(2)
Acenaphthylene	1300	100	CLP	SOW OLM01.8	(2)
Acenaphthene	500	100	CLP	SOW OLM01.8	(2)
Fluorene	540	100	CLP	SOW OLM01.8	(2)
Phenanthrene	1500	100	CLP	SOW OLM01.8	(2)
Anthracene	960	100	CLP	SOW OLM01.8	(2)
HPAHs in µg/kg (ppb)					
Fluoranthene	2500	100	CLP	SOW OLM01.8	(2)
Pyrene	3300	100	CLP	SOW OLM01.8	(2)
Benzo(a)anthracene	1600	100	CLP	SOW OLM01.8	(2)
Chrysene	2800	100	CLP	SOW OLM01.8	(2)
Total Benzofluoranthene (10)	3600	100	CLP	SOW OLM01.8	(2)
Benzo(a)pyrene	1600	100	CLP	SOW OLM01.8	(2)
Indeno(1,2,3-cd)pyrene	690	100	CLP	SOW OLM01.8	(2)
Dibenzo(a,h)anthracene	230	100	CLP	SOW OLM01.8	(2)
Benzo(g,h,i)perylene	720	100	CLP	SOW OLM01.8	(2)

Table 1-1
Personnel Responsible for Quality Assurance Activities

Personnel	Responsibilities
EPA Project Manager Mary Kay Voytilla	Oversee project performance and compliance with EPA objectiv
Analytical Laboratory Manager Christopher Getchell	Oversee laboratory analytical performance to ensure compliance. Implementnecessary action and adjustments to accomplish analytical project objectives.
Laboratory QA Officer Judy Murray	Ensure the use of proper analytical procedures; ensure all quality control indicators are within control limits specified; initiate corrective action.
City of Tacoma Project Coordinator Greg Zentner	Coordinate City activities to implement required work.

Table 1-2
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments		
			Reference	Method	
CHLOR. AROMATICS in µg/kg (ppb)					
1,3-Dichlorobenzene	170	100	CLP	SOW OLM01.8	(2,3)
1,4-Dichlorobenzene	110	100	CLP	SOW OLM01.8	(2,3)
1,2-Dichlorobenzene	50	45	CLP	SOW OLM01.8	(2,3)
1,2,4-Trichlorobenzene	51	30	CLP	SOW OLM01.8	(2,3)
Hexachlorobenzene	22	8	CLP	SOW OLM01.8	(4,6)
CHLOR. ALIPHATICS in µg/kg (ppb)					
Hexachlorobutadiene	11	8	CLP	SOW OLM01.8	(4,6)
PHTHALATE ESTERS in µg/kg (ppb)					
Dimethyl phthalate	160	100	CLP	SOW OLM01.8	(2)
Diethyl phthalate	200	100	CLP	SOW OLM01.8	(2)
Di-n-butyl phthalate	1400	100	CLP	SOW OLM01.8	(2)
Butylbenzylphthalate	900	100	CLP	SOW OLM01.8	(2)
Bis(2-ethylhexyl)phthalate	1300	100	CLP	SOW OLM01.8	(2)
Di-n-octyl phthalate	6200	100	CLP	SOW OLM01.8	(2)
MISC. OXY. COMPOUNDS in µg/kg (ppb)					
Benzyl alcohol	73	50	CLP	SOW OLM01.8	(2)
Benzoic acid	650	500	CLP	SOW OLM01.8	(2)
Dibenzofuran	540	100	CLP	SOW OLM01.8	(2)
N-nitrosodiphenylamine	28	28	CLP	SOW OLM01.8	(2,9)
VOLATILE ORGANICS in µg/kg (ppb)					
Tetrachloroethene	57	20	CLP	SOW OLM01.8	(2)
Trichloroethene		20	CLP	SOW OLM01.8	(2)
Ethylbenzene	10	10	CLP	SOW OLM01.8	(2)
Total xylenes	40	20	CLP	SOW OLM01.8	(2)

Table 1-2
Methods of Analysis and Detection Limit Goals

Analyte	SQO	Detection Limit Goals (8)	Test Methods Sediments		
			Reference	Method	
PESTICIDES/PCBs in µg/kg (ppb)					
Total PCBs	150	80	CLP	SOW OLM01.8	(5,6)
4,4'-DDE	9	8	CLP	SOW OLM01.8	(6)
4,4'-DDD	16	8	CLP	SOW OLM01.8	(6)
4,4'-DDT	34	8	CLP	SOW OLM01.8	(6)
Chlordane (alpha, gamma)		8	CLP	SOW OLM01.8	(6)
Aldrin		8	CLP	SOW OLM01.8	(6)
Dieldrin		8	CLP	SOW OLM01.8	(6)
Heptachlor		8	CLP	SOW OLM01.8	(6)
Lindane		8	CLP	SOW OLM01.8	(6)

Notes:

(1) CLP digestion is 1gm/200 ml. Our digestion would be 1 gm/100 ml.
(2) Target analytes detected below the established linear range of the instrument but meeting the mass spectral identification criteria will be J-flagged as estimate values.
(3) Determined in the ABNs analysis.
(4) Determined in the pesticide fraction.
(5) Total values are calculated by summing concentrations above detection limits. Concentrations not detected at the detection limit value will not be included.
(6) Modified as necessary for the limited target anlayte list and including any or all of the following cleanups: florisil cleanup; SW 846 Method 3620; sulfite sulfur cleanup; or elemental mercury cleanup for sulfur.
(7) Based on Krone et al., 1989 (NOAA) A method for analysis of Butyltin species and measurement of butyltins in sediment and English Sole Livers from Puget Sound. Modified to achieve required DLG (SOP).
(8) Based on dry weight with assumption of sediment moisture content <50%.
(9) Detection limit goal is below anlayte's method detection limit. Samples with no semivolatile target analytes detected above the SQO value(s) will be reanalyzed, subsequent to further concentration of the sample extract, as a means to achieve detection limit goals. Please note that detection limits are highly matrix dependent, and may not always be achievable.
(10) Sum of benzo(b)fluoranthene and benzo(k)fluoranthene.
(11) Antimony will be analyzed along with other metals; however, QC criteria will not be enforced to reanalyze the sample.

SM	Standard Methods, 18th Edition
DLG	Detection Limit Goals
CLP	Contract Laboratory Program
MCAWW	Methods for the Chemical Analysis of Water and Waste
PSEP	Puget Sound Estuary Program

Actual Sample Detection Limits may vary from Method Detection Limits depending on the influences of limited sample volume, matrix interferences, blank contamination, and moisture content of sediments.

Table 1-3
Quality Assurance Objectives
Accuracy and Precision of Matrix Spike,
Matrix Spike Duplicates, and Lab Duplicates for Sediments

Analyte	Acceptance Criteria Accuracy (% Recovery	Precision (RPD)
METALS		
Antimony	30 - 150	30
Arsenic	60 - 128	35
Chromium	25 - 125	20
Mercury	75 - 125	20
Silver	75 - 125	20
Copper	75 - 125	20
Nickel	75 - 125	20
Cadmium	75 - 125	20
Lead	75 - 125	20
Zinc	75 - 125	20
Tributyltin(1)	20 - 160	50
CONVENTIONALS		
Total Organic Carbon	50 - 150	20
Ammonia(2)	50 - 128	30
Sulfide(2)	50 - 150	30
Semi-Volatiles (ABNs) BY GC/MS		
1,2,4-Trichlorobenzene	38 - 107	23
1,4-Dichlorobenzene	28 - 104	27
Acenaphthene	31 - 137	19
Pentachlorophenol	17 - 109	47
Phenol	26 - 90	35
Pyrene	35 - 142	36
n-Nitroso-di-n-propylamin	41 - 126	38
2-Chlorophenol	25 - 102	50
4-Chloro-3-methylphenol	26 - 103	33
4-Nitrophenol	11 - 114	50
2,4-dinitrotoluene	28 - 89	47

Analyte	Acceptance Criteria Accuracy % Recovery	Precision (RPD)
PESTICIDES/PCBs		
4,4'-DDT	23 - 134	50
gamma-BHC (Lindan	46 - 127	50
Heptachlor	35 - 130	31
Aldrin	34 - 132	43
Dieldrin	31 - 134	38
Endrin	42 - 139	45
VOLATILE ORGANICS		
Trichloroethene	62 - 137	24
Benzene	66 - 142	21
Toluene	59 - 139	21
Chlorobenzene	69 - 133	21
1,1-Dichloroethane	59 - 172	22

Note:

* When an upper control limit has been statistically established as less than 100%, the analysis is considered in control up to a limit of 120%.

(1) Tributyltin analysis control limits are in-house default limits due to inadequate number of data points for statistical determination (sonic horn technique).

(2) According to lab SOPs.

Table 1-4
Quality Assurance Objectives
Surrogate Recoveries for Sediments

Analyte	Acceptance Criteria (%Recovery)
TRIBUTYLTIN by GC/MS	
Tritropyltin	20 - 160
ABNs by GC/MS	
2-Fluorobiphenyl	30 - 115
2-Fluorophenol	25 - 121
2,4,6-Tribromophenol	19 - 122
dl4-p-Terphenyl	18 - 137
d5-Nitrobenzene	23 - 120
d5-Phenol	24 - 113
d4-2-Chlorophenol	20 - 130*
d4-1,2-Dichlorobenzene	20 - 130*
PESTICIDES/PCBs	
Tetrachloro-m-xylene	60 - 150*
Decachlorobiphenyl	60 - 150*
VOAs by GC/MS	
d8-Toluene	84 - 138
Bromofluorobenzene	59 - 113
d4-1,2-Dichloroethane	70 - 121

* Advisory

Table 1-5
SRM/CRM Recovery Acceptance Criteria

Analyte	Accuracy (1) (% Recovery or range in µg/kg)
Metals	MESS-2
Antimony	80-120%
Arsenic	80-120%
Cadmium	80-120%
Chromium	80-120%
Copper	80-120%
Lead	80-120%
Mercury	80-120%
Nickel	80-120%
Silver	80-120%
Zinc	80-120%
Base/Neutrals	ERA 327
Anthracene	2530 - 8490
Benzo(k)fluoranthene	2310 - 5700
4-Chlorophenyl-phenylether	3040 - 6390
Chyrsene	1270 - 3690
Di-n-octylphthalate	2580 - 11800
Dibenzofuran	2700 - 7790
1,2-Dichlorobenzene	1060 - 13800
2,4-Dinitrotoluene	2910 - 8970
bis(2-Ethylhexyl)phthalate	1450 - 3620
Fluorene	4070 - 11400
Naphthalene	787 - 3990
Phenanthrene	1810 - 5180
Pyrene	1900 - 5430
1,2,4-Trichlorobenzene	1230 - 6810
Acids	ERA 327
2-Chlorophenol	1650 - 5410
2,4-Dichlorophenol	5080 - 12300
2-Methylphenol	2150 - 13200
Pentachlorophenol	1980 - 10600
2,4,6-Trichlorophenol	2790 - 7650
Pesticides	ERA 327
Aldrin	191 - 402
beta-BHC	183 - 443
4,4'-DDD	133 - 334
4,4'-DDE	257 - 534
4,4'-DDT	161 - 471
Dieldrin	187 - 465
Endrin	113 - 274
Heptachlor	82.1 - 167
Heptachlor Epoxide	166 - 591

(1) Note: No sample will be reanalyzed and no data will be rejected based on SRM/CRM results alone.

Table 1-6
Summary of Field and QC Samples

	Field Samples							Lab Samples		
Parameter	Trench	Upland Test Pit	Bank	Intertidal Grab	Intertidal Core	Duplicate	Rinseate	Matrix Spike	CRM/ SRM	Total # Analytes
Grain Size	5	8	8	2	6	2				31
TS		8		2	6	2				18
pH		8		2	6	2				18
TOC		8		2	6	2				18
TVS		8		2	6	2				18
Sulfides		8		2	6	2	1	1	1	21
Ammonia		8		2	6	2	1	1	1	21
Metals	5	8	8	2	6	2	1	1	1	34
VOAs	5	8	8	2	6	2	1	1	1	34
Semi-VOA	5	8	8	2	6	2	1	1	1	34
Pest/PCB	5	8	8	2	6	2	1	1	1	34
TBT				2	6				1	9

Sample Type	**Sample Purpose**
Trench	Characterize soils in the 12-18 ft. MLLW horizon. Data will be used to define soil disposal or reuse options.
Test pit	Characterize material in the horizons (8-10 ft MLLW and 10-12 ft MLLW) bracketing the future intertidal surface.
Bank	Characterize the material evident in the bank, in strata that is obviously contaminated and in strata below that is not. Sampling of these two bank strata will be used, in conjunction with pit and trench sampling, to characterize the extent of on site contamination.
Core and Grab Samples (Tideflats)	Define the nature of the surrounding aquatic environment. These samples in essence provide context for restoration planning at the project sit.

2.0 LABORATORY METHODS, QUALITY ASSURANCE, AND QUALITY CONTROL FOR SEDIMENT QUALITY ANALYSIS - TOXICITY TESTS

Biological sediment characterizations (bioassays) will be conducted to test and evaluate the sediment samples relative to Washington State Sediment Management Standards (WAC 173-204) . The following sediment bioassays will be conducted on four test samples obtained from Middle Waterway at a depth of 0- 10 cm, and appropriate reference and control samples as described in WAC 173-204 or associated guidance.

- 10-day amphipod bedded sediment test using *Rhepoxynius abronius* or *Ampelisca abdita*
- 20-day polychaete growth test using *Neanthes arenaceodentata*
- The echinoderm larval sediment elutriate test using *Dendraster excentricus*
- The Microtox$^{\otimes}$ Saline-extract test.[1]

Procedures for testing, analysis, quality assurance and quality control are discussed below. Procedueres for sampling and handling of sediments are included in the Sampling and Analysis Plan; in general, stations shall be accessed from shore via foot. Grab samples will be obtained within 1 meter of the sampling station for bioassays by using stainless steel spoons and bowls and sample material will be transfered to 1 liter sampling jars for transportion to the testing laboratory.

2.1 Quality Assurance Procedures

To ensure the production of technically defensible biological data, a QA/QC program will be instituted as part of the biological characterization of test sediments. This program has included a competitive laboratory selection process for the contracting laboratory, and the utilization of quality assurance and quality control protocols developed for biological analysis by the contracting lab. The elements of this QA/QC program are discussed below.

2.1.1 Selection of Bioassay Laboratory

Parametrix, Inc. of Kirkland, Washington was selected to perform bioassays following the competitive selection process. Parametrix has an extensive record of performing bioassay tests required for biological assessment, dredge disposal and pre-remedial design.

2.1.2 Quality Assurance Program Plan and Test Protocols

The QAPP prepared by Parametrix and Northwest Aquatics (Newport, OR) for the analysis of test sediments in the Hylebos waterway are being utilized as the Quality Assurance Project Plans for this project, with appropriate modifications for project scale. This QAPP has not been reproduced here, but is instead summarized with deviations noted. Parametrix has a copy of the QAPP at their Kirkland facility.

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[1]Criteria established under PSDDA will be utilized for Microtox testing.

2.1.3 Quality Control

Quality control checklists will be used by the laboratory to ensure that all procedural and data elements of the tests will be followed and recorded. An example of these checklists is included here as an attachment; the checklists also include specific bench data sheets. These checklists have been recommended for use by the U.S. Army Corps of Engineers in the *QA/QC Guidance for Laboratory Dredged Material Bioassays* (USACOE WES 1993, Draft).

For each batch of bioassays, the lab will initiate these checklists. Lab staff are required to complete all elements of the checklists, and the original lists will be submitted as a deliverable in the final data package.

2.2 Test Procedures

General guidance for conducting biological testing in Puget Sound may be found in the revised Puget Sound Estuary Protocols (PSEP 1991), with applicable modifications identified under the PSDDA (1990) program. The following sections discuss both general and test-specific methods and performance criteria.

2.2.1 General

All general criteria defined by PSEP (1991) will be applied to this program. In addition, the following project-specific criteria will be used:

- All tests will be conducted within 8 weeks from the time of sediment collection. Holding conditions will be 4°C in the dark. Samples with any remaining head space will be stored under nitrogen.
- All physical/chemical measurements will be taken from a surrogate sixth replicate at the time of inoculation, and at the conclusion of the amphipod, *Neanthes,* and *D. excentricus* tests.
- The lab will incorporate a completely randomized design for replicate placement in water baths or growth chambers.
- Total ammonia and sulfides will be measured at the time of inoculation and at test termination for the amphipod, *Neanthes*, and *D. excentricus* tests.
- Positive control tests that exceed the UWL or UCL will be brought to the immediate attention of the City of Tacoma project coordinator.

2.2.2 Control and Reference Sediments

Control sediments for most bioassay testing will be collected from West Beach (Whidbey Island, WA). Control sediments for *Ampelisca abdita* will come from the test organisms' collection site. Control tests are used to assess the relative health of the test species. During late summer and early fall, West Beach control sediments may experience unusual test mortality. To reduce the chance of test failure, the West Beach control sediments may be gently washed to remove organic material. In past years, use of this procedure for the PSDDA program has reduced control mortality to levels typical of the rest of the year. In the event that test sediments are washed, a second set of unwashed control sediments will also be tested.

Reference sediments for bioassay testing will be collected from within Carr Inlet, based upon the recommendation of the Corps DMMO. Reference sediments will contain approximately the same sediment grain size (i.e., percent fines) as the test sediment. To ensure a reasonable grain size match, potential reference sediments will be wet sieved during collection. Results of wet-sieving that are within the range of percent fines ±10 percent will be considered acceptable. Reference sediments will be analyzed for grain size, total organize carbon, total sulfides, total solids, total volatile solids, and ammonia using methods provided in the Sampling and Analysis Plan. Additional sediment will be archived for potential chemical analysis. This sediment could be analyzed if unexplainable reference sediment failures were noted.

Performance criteria for control and reference sediments are provided in Tables 2-1 thorugh 2-4. If these criteria are exceeded, the contracting laboratory will notify the City project coordinator, who will in turn notify the EPA project coordinator in order to evaluate of the data. In past PSDDA projects, there have been occasions when control sediments have slightly exceeded the criteria but reference and test sediments have both passed. Based on best professional judgment, the PSDDA agencies accepted the data. In the event that similar situations arise during this analysis, best professional judgment will be applied, in consultation with EPA, the natural resources agencies and, as necessary, the DMMO, to determine whether the test results pass the corresponding criteria.

2.2.3 Ten-Day Amphipod Bedded Sediment Test

These tests will be conducted with either *Rheopoxynius abronius* or Ampelisca abdita, depending upon the physical conditions of the test sediments. *R. arbronius* is the preferred test species and will be used on all test sediments having a combined percent fines (silts + clays) of ≤ 60 percent. *A abdita* will be used for those sediments having percent fines > 60 percent. The decision criteria for determining test performance (i.e. pass/fail) will be applied uniformly to both species.

A summary of the test conditions and test acceptability criteria for the amphipod test are found in Table 2-1. Taxonomic verification of the test organisms will be conducted on specimens from at least one collection or shipment.

2.2.4 Echinoderm Larval Test

These bioassays will be conducted using larvae of the eastern Pacific sand dollar, *Dendraster excentricus*. Test conditions and acceptability criteria for this procedure are found in Table 2-2. Program-specific procedures and criteria for the *D. excentricus* are as follows:

- All seawater used in the larval test must be collected within 48 hours of use in the tests.
- For each control, reference, and test replicate, three 10-milliliter aliquots will be withdrawn and preserved at test termination. Two of those aliquots will be counted and the data submitted with the final report. The third aliquot will be archived by the City for a period of up to one year beyond the submittal of the final data package.

2.2.5 20-Day *Neanthes* Growth Test

N. arenaceodentata is the test organism for this bioassay. Test conditions and acceptability criteria for this procedure are found in Table 2-3. Particular attention will be given to ensuring that the specified initial age and weight of the test organisms are observed. There are no additional special conditions attached to this test.

2.2.6 Microtox Saline-Extract Test

Test conditions and acceptability criteria are found in Table 2-4. In conducting this analysis, a dilution series is run on the sediment extract, and a total of five replicates are required at the highest dilution concentration. Reference material is to be run with each batch, with a batch being defined as all tests conducted on a single lyophilized vial of test bacterium. Tests will be conducted within 6 hours of reconstituting the bacteria.

2.3 Data Reporting Requirements

Upon completion of all testing, the lab will submit a report that includes the data listed below. The report will be provided both in hard copy and magnetic media (DOS-compatible).

- Survival of test organisms in each test container expressed as the number of test organisms alive, number dead, number missing, and the proportion surviving.
- The mean percent survival, standard deviation, and variance for each test sediment.
- For the echinoderm test, number of normal and abnormal larvae recovered from each test vessel.
- For the *Neanthes* growth test, raw data including average weight of test organisms recovered in each test vessel.
- For the Microtox$^{\otimes}$ test, raw data including average weight of test organisms recovered in each test vessel.

- Water quality measurements, including ammonia and sulfides. Accompanying the ammonia and sulfide data, the lab will also supply the associated instrument calibration and results for seawater spikes.
- Interstitial water salinity values.
- 96-hour LC_{50} values with 95 percent confidence intervals for the reference toxicant. Method of calculating the LC_{50} will also be included.
- Results of any priority pollutant scan(s) conducted on the seawater used in the tests.
- Any problems or deviations from the protocols, SOPs, or the SAP that may influence test results or data quality.
- Copies of all lab QC checklists for bioassay.

2.4 Quality Assurance Review of Lab Data

All data developed by the laboratory will be subject to a quality assurance review. QA guidelines for bioassay data review procedures that will be followed in this program are adapted from Sturgis (199), PTI (1989),and WEST (draft, 1993). An example of the QA review checklist is included here as an attachment. At a minimum, the submitted data will be reviewed for the following.

- **Data Completeness**. Defined as the amount of data obtained versus the amount of data originally intended to be collected. For this program, 80 percent will be considered acceptable.
- **Data Quality Objectives**. Data will be reviewed for compliance with the acceptable parameters established in the specific test protocols. These may include, but are not limited to the following:
    - Test conducted within specified holding times
    - Test organism normalities/abnormalities exceeding performance criteria
    - Out-of-range water quality parameters
    - Lack of randomization
    - Lack of required reference, control, or reference toxicant exposures
    - Reference toxicant results outside of specified ranges.

2.5 Corrective Action for Unacceptable Data

Tests that do not meet completeness and DQO objectives will either be qualified or be rerun. The conditions under which data will be qualified or tests rerun are shown in Table 2-5.

Table 2-1. Summary of test conditions and test acceptability criteria for *Rhepoxynius abronius* and *Ampelisca abdita.*

Parameter	Description
1. Test Protocol	*R. abronius* PSEP, 1991 with PSDDA (1990) modifications
	A. abdita ASTM Method E1367, adapted to PSDDA modifications
2. Test Duration	10 days
3. Temperature	*R. abronius* 15° ± 1°C
	A. abdita 20° ± 1°C
4. Lighting	Continuous Ambient Lighting (50-80 foot-candles)
5. Test Chamber Size	1 L
6. Volume of Test Sediment	175 mL/replicate
7. Number of Replicates/Test	5
8. Number of Organisms/ Replicate	20
9. Aeration	≤ 100 bubbles/minute
10. Test Water	28 ppt ± 1 ppt
11. Dissolved Oxygen	≥ 5.0 mg/L
12. pH	>7, ≤ 9
13. Daily Observation	Temperature, salinity, dissolved oxygen, pH, and daily emergence.
	At time 0, every 24 hours thereafter, and test termination.
	Ammonia and sulfide at time 0, and test termination.
14. Reference Toxicant	Cadmium chloride
15. Endpoints	Recovered animals and reburial at test termination LC50
	Reference Toxicant
16. Test Acceptability	Control Mortality ≤ 10%
	Reference ≤ 25%.

Table 2-2. Summary of test conditions and test acceptability criteria for *Dendraster excentricus*.

Parameter	Description
1. Test Protocol	PSEP, 1991, with appropriate PSDDA (1990) modifications
2. Test Duration	4Variable. Test continues until development to the pluteus stage is achieved in 95% of the individuals in the sacrificial seawater control.
3. Physical Parameters	
Temperature	15 ± 1°C
Salinity	28 ± 1 ppt
Dissolved Oxygen	≥ 7.0, ≤ 9.0
pH	
4. Lighting	14 hr light, 10 hr dark using ambient light
5. Test Sediment Volume	20 gms/1 L seawater
6. Number of Replicates/Test	5
7. Test Water	Test water must be used within 8 hours of collection
8. Number of Organisms/ Replicate	20-30 embryos/mL
9. Settling Time	For *Dendraster*, 4 hr before inoculation, with gentle aeration
10. Water Quality Measurements	Temperature, salinity, pH, DO at times 0, 24 and 48 Ammonia and sulfide at least initiation and termination
11. Reference Toxicant	Cadmium chloride
12. Endpoints	Number of normal and abnormal larvae in Test Replicates. LC50 and EC50 on Reference Toxicant
13. Test Acceptability	Seawater Control Combined Mortality and Abnormality ≤ 50%

Table 2-3. Summary of test conditions and test acceptability criteria for *Neanthes arenaceodentata*.

Parameter	Description
1. Test Protocol	PSEP, 1991 with PSDDA modifications
2. Test Duration	20 days
3. Physical Parameters	
Temperature	20°C ± 1°C
Salinity	28 ± 2 ppt
Dissolved Oxygen	≥ > 7.0, ≤ 9.0
Aeration	150-300 ml/min
4. Lighting	Continuous Ambient Lighting (50-80 foot-candles)
5. Test Sediment Volume	175 mL/1 L/replicate
6. Number of Replicates/Test	5
7. Number of Organisms/ Replicate	5
8. Age of Test Organisms	2-3 weeks post-embryo, 0.5-1.0 mg dry weight
9. Measurement	Dry weights of 3 sets of 5 worms each Ammonia and sulfides from overlying water Salinity, temperature, dissolved oxygen, pH, interstitial salinity adjusted to 28 ppt
10. Test Water Renewal	Every third day, 1/3 volume of each replicate
11. Feeding Regime	Dried, powdered *Ulva* or *Enteromorpha*, or Tetramarin⊗ 8 mg/juvenile every other day
12. Water Quality Measurements	Test initiation, prior to renewal event (except ammonia and sulfides), and test termination
13. Reference Toxicant	Cadmium chloride
14. Endpoints	Mortality, final dry weights LC50 on Reference Toxicant
15. Test Acceptability	Control Mortality ≤ 10% Reference Biomass ≥ 80% of the Control Biomass

Table 2-4. Summary of test conditions and test acceptability criteria for saline-extract Microtox procedure.

Parameter	Description
1. Test Protocol	PSEP, 1991 with PSDDA modifications
2. Test Duration	15 minutes
3. Replication	5 at the highest concentration 2 at each subsequent dilutions
4. Reference Toxicant	Phenol or ethanol
5. Frequency of Reference Sediments	One per lot of bacterial (all vials shipped together) or one per every 20 samples, whichever is less
6. Centrifugate holding time	2 hr
7. Endpoints	Light readings and gamma calculations for all replicates. Calculation of EC50 for reference toxicant.
8. Test Acceptability	Confirmation of dose response in reference toxicant and calculated EC50 within 2 standard deviations of the lab's performance chart for Microtox. Reference sediment performance is $\leq$ 20% blank-corrected light reduction

Table 2-5. Summary of test deviations and suggested responses. (Adopted from USACE, 1993-DRAFT)

Deviation	Corrective Measures	
	Retesting Required	Retesting May Be Required[1]
Lack of test array randomization		√
Testing was not blind		√
Required references or controls were not tested	√	
Test chambers not identical		√
Test container(s) broken or misplaced		√
Test organism mortality in controls or reference exceeds acceptable limits	√	
Excessive test organism mortality in a single replicate of a control		√
Test organisms were not randomly assigned to test chambers		√
Test organisms were not from the same population		√
Text organisms were not all the same species (or species complex)	√	
Test organism holding times were exceeded		√
Water quality parameters consistently out of range	√	
Brief episodes of out-of-range water quality parameters		√
Test monitoring was not documented		√
Test monitoring was incomplete		√
Sediment holding times were exceeded	√	
Sediment storage conditions were out of acceptable ranges		√[2]

[1] If not retested, data may have to be qualified

[2] Unless evidence is provided to show that sediment quality) geochemistry and contaminated levels) have not been affected

EXAMPLE QUALITY CONTROL CHECKLIST FOR BIOASSAYS

PROJECT SCHEDULE

Sediment Collection and Expiration Dates

Date of First Sediment Collection _____

Date Sediment Delivered _____

Holding Time (check one) 2 weeks _____

8 weeks _____

Holding Time Expiration _____

Amphipod Collection and Handling Conditions

Date of Amphipod Collection: _____

Site of Amphipod Collection _____

Field Personnel _____

Collection site salinity _____

Collection site temperature _____

Field weather conditions _____

Time initiated - time completed _____

Time Arrive Lab: _____

Water Temperature at return _____

Storage Facility: _____

Storage Temp: _____

Buckets Aerated: _____

Field Notes: _____

_____

_____

_____

_____

Exposure Dates

Test Setup _____

Amphipod Innoculation _____

Test Breakdown _____

Reporting Requirements

Data available for report compilation _____

Draft Report completed _____

QA Review by: _____

Report Due to Client By: _____

mphipod Innoculation

Collect amphipods by sieving a small amount of sand through a 1.0 mm NITEX screen in seawater. Take screen out of water for just a moment, and then place back into the seawater. The amphipods will float, and are available for collection with a glass or plastic beaker.

Sort 10 sexually immature amphipods approximately 4mm into a plastic cup, with 1/4 in. of seawater and keep on ice. DO NOT collect obvious females with brood pouch, or sexually active males.

QC Amphipods with dissecting microscope. DO NOT use Stage Lighting System. _____

QA counts in cups prior to innoculation. _____

Monitor physical parameters (DO, pH, salinity) in all vesels prior to innoculation. _____

Combine Amphipods into groups of 20 placing the empty cup on the bottom of the full cup. Being careful not to leave any in the empty cups. _____

To seed Amphipods first remove all the watch glasses from one row of test vessels. Next seed the vessel farthest away, Check to see that all amphipods sink into water column nd are not retained in the medicine cup. replace the watch glass and place the empty medicine cup on top of it. Proceed to the next test vessel

Seed reference toxicant replicates _____

Allow Amphipods one hour to rebury in test sediment if they do not bury. _____

Remove them using a clean pippet and replace them with a healthy amphipod _____

Check to make sure Ref-Tox Amphipods are not trapped on surface _____

Take Ammonia and Sulfide samples. _____

Each label should contain date, time, organism, Sulfide or Ammonia, test name and number, sample name or number, and initials. _____

Check to make sure watch glasses are placed on ref-tox and amphipods are not trapped on surface _____

Refrigerate Ammonia and Sulfide sample bottles _____

Clean laboratory area _____

Initials of individual verifying completion of tasks _____

AMPHIPOD SETUP FORM

Project _____
Project Number _____
Date: _____

Test Organism _____
Page _____ of _____

Project Sample I.D. Number	Lab Replicate Number	Interstitial Salinity	Soil Type/Comments	Initials

AMPHIPOD SOLID PHASE BIOASSAY: DAILY OBSERVATION FORM

[illegible] ______________________ Test Start ______________

Project Number ______________________ Test End ______________ Page ________ of ________

Replicate	Amphipods Visible									
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

AMPHIPOD BREAKDOWN PROCEDURAL CHECKLIST

Conduct Final Replicate Physical Monitoring _____

Record Daily Observations _____

Take ammonia and sulfide samples _____
(Each label should contain date, time, organism,
Sulfide or Ammonia, test nameand number, sample name
or number, and initials.)

Store ammonia and sulfide samples at 4 degrees C _____

Screen sediments using .5mm screen _____

Collect amphipods using a pipet and place in labelled medicine cup _____

Make sure Amphipods are kept in an adequate supply of sea water. _____

Place West Beach sand in medicine cups and add Amphipods. placing
.npty Amphipod cup on the bottom. Leave for One Hour to rebury. _____

Record reburial data _____

Confirm all data is correctly entered, no blanks allowed. _____

File all raw data sheets with the project file, and copies with this notebook _____

Remove temperature record sheet and place in notebook _____

Clean laboratory after breakdown. _____

Schedule glass clean-up and decontamination _____

Initials of individual verifying completion of tasks _____

AMPHIPOD BREAKDOWN DATA SHEET

Project ____________ Date ________________________

Project Number ____________ Page ______ of ____________

			Found		
Replicate	Initials	Visible	Alive	Dead	Reburied

AMPHIPOD DAILY WATER QUALITY MONITORING

Project _____ Test Organism _____
Project Number _____ Test Day # _____
Page _____ of _____ Date _____

Instrument Serial Number _____

Replicate	Temperature (degrees-C)	pH	Salinity (o/oo)	D.O. (mg/L)

AMPHIPOD DAILY QC CHECKLIST

Project _____

Project Number _____

Conduct task, and initial after completion

Date:	Day 0	Day 1	Day 2	Day 3
Monitor	____	____	____	____
Emergence	____	____	____	____
Note observations	____	____	____	____
Monitor Ref-Tox	____	____	____	____
Check aeration	____	____	____	____
Restore water levels with D.I. water	____	____	____	____

Date:	Day 4	Day 5	Day 6	Day 7
Monitor	____	____	____	____
Emergence	____	____	____	____
Note observations	____	____	____	____
Monitor Ref-Tox	____			
Check aeration	____	____	____	____
Restore water levels with D.I. water	____	____	____	____
Replace Temp. Record Card				____
Ref Tox Breakdown	____			

Date:	Day 8	Day 9	Day 10
Monitor	____	____	____
Emergence	____	____	____
Note observations	____	____	____
Check aeration	____	____	____
Restore water levels with D.I. water	____	____	____
Remove Temp. Record	____	____	____

Amphipod Reference Toxicant Procedures

or use with ***Rhepoxynius abronius & Ampelisca abdita***

Reference toxicant should be prepared as follows:

Positive control: Cadmium Chloride. Express concentrations as Cd.
Stock Solution prepared at 10 mg/L
Stock Preparation Date:_____

Preparation of Reference Toxicant Replicates

Cd Concentation	ml Stock Solution	ml Seawater	Label Replicates
1.5mg/l	0.15	999.85	A - C
75mg/l	0.075	999.925	D - F
.25mg/l	0.025	999.975	G - I
0.0mg/l	0	1000	J - K

reserve 100 mL of Reference Toxicant at highest concentration for analysis _____

Reference Toxicant Replicates Prepared By: _____

AMPHIPOD SETUP PROCEDURAL CHECKLIST

.eawater Collection. Filtration. Preparation

Seawater Volume Required	_____
Approximate Volume Collected	_____
Date and Time of Collection	_____
Location of Source Water	_____
Collection Temperature	_____
Filter and Adjust Sea water	_____
Final Seawater Salinity (o/oo)	_____

Randomization Schedule

Randomization prepared by	_____
Place copy of schedule with this file	_____

Sediment Setup

Measure and record interstitial salinity	_____
Sieve control sediment and wash with clean sea water. Use .5mm screen.	_____
Verify temperature of water bath or E.C.	_____
Check to see that the light cycle is set for constant illumination.	_____
Use deconed stainless steel spoons and plasitc cups to dispense 175ml of sediment into each test vessel .	_____
Take ammonia and sulfide for each station	_____
Purge remaining sample containers with Nitrogen	_____
Add adjusted seawater to test vessel to 1000 mL	_____
Aerate all replicates @ < 100 bubbles/minute	_____
Put glass covers on all replicates	_____
Clean up the lab area	_____
Initials of individual verifying completion of tasks	_____

QUALITY CONTROL CHECKLIST FOR 10-DAY AMPHIPOD TEST

SPECIES: (check one)

Rhepoxynius abronius _____
Ampelisca abdita _____

PROJECT DATA

PROJECT NAME: _____

PROJECT NUMBER: _____

CLIENT: _____

CLIENT CONTACT: _____

ADRESS _____

_____

_____

_____

PHONE NUMBER _____

PROTOCOL

Project Testing Program (check one)

PSDDA _____
PSEP _____
Green Book _____
Other _____

Laboratory Protocol Number _____
Protocol Reviewed and Signed by Client? _____

PROJECT STAFF

Principal Investigator _____
Associate Investigator _____
Staff _____

_____

_____

QA Officer _____

Protocol Reviewed by all project staff? _____

DATA QUALITY ASSURANCE CHECKLIST FOR BIOASSAYS

AMHIPOD FINAL QUALITY ASSURANCE CHECK

TEST # **EXPER. #**

CONTROL % SURVIVAL THIS TEST: PASSED FAILED

Reference Test Experiment #: Control % Surviv.: LC 50:

List any problems associated with this test:

_____
_____
_____
_____
_____
_____

CHECK OF DATA INPUT PAGES

_____ Present: Method Summary sheet Randomization sheet (1-2 pg), Breakdown sheets (1-2 pg), 10 Daily Data sheets, Physical Data sheets (1-2), Field/Culture sheet Holding Time table

_____ Breakdown sheet: verify that vials were recounted.
_____ Breakdown sheet: verify that live animals found during repick were added to the total live pods.
_____ Breakdown sheet: verify that live animals found at 24, 48, 72 hr were added to total of live pods found.
_____ Breakdown sheet: verify that any tubes found at start were included in the total number of animals per rep.
_____ Breakdown sheet: check to see if the sum of the number dead during test and the number found live exceeds 20.
_____ Breakdown sheet: verify that reps in which no animals were found contained no tubes, molts, or animals dead durin
_____ Breakdown sheet: make sure that QA'd sheet was signed.
_____ From Holding Time sheet, verify that experiment numbers, sample numbers, collection dates, and Day 0 dates were and signed.
_____ From 10 day data sheets, verify the test day numbers on which the physical data were taken.

CHECK OF DATA OUTPUT PAGES

_____ Present: Data Entry Pages (1-2), Summary Data Pages (2), Data Base Pages (1-2) Project Summary Page Stat pages (1-2)

_____ RAND file: From randomization sheet: verify test and experiment number.
_____ RAND file: From randomization sheet: verify jar numbers.
_____ RAND file: From randomization sheet: verify sample numbers.
_____ RAND file: From holding time table: verify days hold.
_____ RAND file: Make sure experiment number appears in footer.

_____ SORT file: Verify that RAND file was QA'd and signed before it was converted to a SORT file.
_____ SORT file: Verifty that the filename has been changed to SORT.
_____ SORT file: From 10 day data sheets: Verify temperature range.
_____ SORT file: From breakdown sheet: verify that correct breakdown sheet was used.
_____ SORT file: From breakdown sheet: verify values for number alive (total live pods at end of test).
_____ SORT file: From breakdown sheet: verify values for the number of pods added to each jar (# per rep).
_____ SORT file: From physical data sheet: verif that corrrect physicl data sheet was used as a source of the pH, D.O., Sali
_____ SORT file: verify that the physical data were entered for the correct two replicate numbers.
_____ SORT file: verify pH values.
_____ SORT file: verify D.O. values.
_____ SORT file: verify salinity values.

CHECKLIST FOR AMPHIPOD MORTALITY BIOASSAY

Project Name: _____ SAIC Project No: _____

Laboratory: _____ Lab Number _____ Batch _____

Responsible Technician _____ Reviewed By: _____

Amphipod species _____

Date Sampled _____ Received by Lab _____

Date Analysis Begun _____

Problems noted (e.g., deviations from prescribed methods, analytical problems)

_____

_____

_____

_____

COMPLETENESS AND HOLDING CONDITIONS

Samples Submitted _____ # Samples Analyzed _____

Holding conditions acceptable (Y/N) PSEP ; 4° C under nitrogen < 2 weeks _____
PSDDA; 4° C under nitrogen < 8 weeks _____

If no, identify samples _____

_____

FORMAT

Standard data report sheet (check off)

Number of amphipods reported for each replicate _____ Field samples _____
Percent Mortality reported for each replicate _____ Positive controls _____
Daily emergence taken for each replicate _____ Negative controls _____
Individual replicate, plus sample mean and standard deviations for mortality? _____

Analytical Replicates

Number per Sample _____
Any < 5 RPD? _____

Water Quality Variable Reported for each Replicate (check)

Interstitial salinity for each sample (initiation) _____ Salinity (daily) _____
Dissolved Oxygen (daily) _____ pH (daily) _____
Temperature (daily) _____ Sulfide (initiation and termination) _____
Ammonia (initiation and termination) _____

CHECKLIST FOR AMPHIPOD MORTALITY BIOASSAY

QA/QC SAMPLES

Negative Control

Control Sediment Collection Site _____
Water Source _____
Current priority pollutant scan available? _____
Mean Control Mortality (%) _____
Exceed PSEP QA Limit of 10%? _____

Reference Sediment

Collection Site _____
Total Number of Analyses _____
Mean Mortality _____
Mean mortality exceed PSEP QA limit of > 20% over control? (Y/N) _____

Positive Controls

Reference Toxicant _____
Exposure Concentrations _____
% mortality/exposure concentration _____
Organism Response (LC50) _____
Laboratory Performance Standards for Reference Toxicant _____
Did the test LC50 fall within lab standards (Y/N)? _____

WATER QUALITY

Samples with temperature <14 or > 16° C _____
Samples with salinity < 27 or > 30 ppt _____
Samples with pH < 7 or > 8 _____
Samples with DO < 5 mg/L _____

AMHIPOD FINAL QUALITY ASSURANCE CHECK

_____ CALC file: Verify that SORT file was QA'd and signed before it was posted into CALC file.

_____ CALC file: verify that reps for which there is no data have an empty cell under decimal mortality.
_____ CALC file: Stats page(s): verify that reps for which there is no data have been replaced by a period.
_____ CALC file: Database pages: Verify that reps for which there is no data have been cleared.
_____ From Breakdown sheet: verify that comments have been transferred to Summary Data Pages.
_____ From 10 Day Data Sheets: verify that comments hvae been transferred to Summary data sheets.
_____ From Physical Data Sheets: verify that comments have been transferred to the Summary Data Sheets.
_____ From the corresponding Reference Test: verify that any comments have been transferred to the

Table 3-1. Benthic laboratory rescreening log.

SURVEY _____

Station and Replicate Number	Area	Date Collected	No. of Bags or Jars	Date Rinsed	No. of Jars per Sample	Initials

Table 3-3. Benthic laboratory QC form for sorting.

SURVEY _____ Page ___ of _____

STATION NAME _____ REPLICATE NO. _____

APPROXIMATE SAMPLE VOLUME _____ SORT QC VOLUME _____

SORTED BY/DATE _____ QC SORTED BY/DATE _____

IDENTIFICATION OF QC BY/DATE _____

INDIVIDUALS FOUND IN THE QC SORT:

Taxon Name	Taxon Code	Count		Comments
		QC	Final	

RESORT INDICATED Yes No By: _____

Table 3-2. Benthic laboratory sorting form.

SURVEY _____

Station	Replicate	No. of Jars	Volume	No. of Hours	Sorted by	Taxonomist's Initials					
						Polychaetes	Arthropods	Mollusks	Ophiuroids	Echinoderms	Miscellaneous

STANDARD OPERATING PROCEDURES
AND
LABORATORY QUALITY ASSURANCE PROJECT PLANS:

BENTHIC INFAUNA ANALYSIS

Sampling, Analysis and QA/QC Procedure Manual

for Field and Laboratory Work-up of Benthic Infauna

for

Marine Taxonomic Services

Field Procedures--

The field and laboratory procedures followed by Marine Taxonomic Services (MTS) are designed to ensure the generation of high quality data. This objective is achieved through careful sample handling, sorting and identification procedures.

Field Procedures

Fixative Preparation--

The fixative most commonly used for benthic macroinvertebrate samples is formalin, an aqueous solution of formaldehyde gas. Under no circumstances is ethyl or isopropyl alcohol (i.e., preservatives) used in place of the formalin. Penetration of the alcohol into body tissues is too slow to prevent decomposition of the specimens.

MTS uses formalin solutions of 5-20 percent (v/v) strength for fixing marine organisms as recommended by Gosner 1971:Birkett and McIntyre 1971; Smith and Carlton 1975; Swartz 1978. Solutions of 10-15 percent are used most commonly.

The formalin solution is always buffered to reduce acidity. Failure to buffer this solution may result in decalcification of molluscs and echinoderms. Ideally, the pH should be at least 8.2, as calcium carbonate dissolves in more acidic solutions. Borax (sodium borate, Na2B4O7) should be used as the buffering agent because other buffering agents may hinder identification by leaving a precipitate on body tissues and setae.

A 10 percent buffered formalin solution is prepared by adding 4 oz of borax to each gallon of concentrated formalin (i.e., a 40 percent solution of formaldehyde in water). This amount will be in excess, so use the clear supernatant when making seawater dilutions. Dilute the concentrate to a ratio of one part concentrated formalin to nine parts seawater. Seawater will further buffer the solution. Seawater also makes the fixative isotonic with the tissues of the animals, thereby decreasing the potential for animal tissues to swell and break apart, as often happens with freshwater dilutions of formalin.

washed using a combination of these techniques. For all methods, it is imperative that the samples be washed gently to minimize specimen damage. A few minutes of extra care in the field can save hours of time for the taxonomist, and will result in a better data set.

For many surveys, it is easiest to wash the samples from above with a gentle spray, because efficient, easy-to-use gear may be constructed to hold the sampler and sieve boxes. MTS recommends the use of a high volume low pressure seawater pump to get filtered seawater for sieving purposes.

All wash water is to be filtered (using a cartridge-filter system) or screened through a mesh with openings less than one half the size of those used in the survey, so as not to introduce planktonic or bentho-pelagic organisms into the samples. Failure to screen in this way can result in increased sorting time. It can also compromise the quality of the resulting data, because it is impossible to distinguish bentho-pelagic organisms caught by the grab from those entrained in the wash water. Never use fresh water to wash marine samples as destruction of soft-bodied organisms will occur through the disparity in osmotic potentials.

Once sieving is completed, the screen box should be held at an angle and the remaining material gently washed into one corner. The sample may then be transferred to a container for relaxation, if desired, or for immediate fixation, using as little seawater as possible. A permanent internal sample label is placed in the container at this time. If more than one screen fraction is generated, be sure to keep them separate throughout all phases of field and laboratory processing. Be sure to check the screen for organisms trapped in (or wound around) the mesh wires. If they cannot be dislodged with gentle water pressure, use a pair of jewelers forceps to remove them. Be careful not to damage the wire mesh. After the screen has been checked for remaining animals and sample removal is complete, back-wash the screen with a high-pressure spray to dislodge any sediment grains that may be caught in the mesh.

As mentioned earlier, a 10-15 percent solution of borax-buffered formalin usually is sufficient to fix benthic organisms. However, samples containing large amounts of fine-grained sediments, peat, or woody plant material may require higher concentrations. The volume of fixative should be at least twice the volume occupied by the sample. The formalin solution should be added to the sample container until it is completely filled. This will minimize abrasion during shipping and handling. If the sample volume exceeds one half of the container volume, more than one container should be used. Use of multiple containers for single samples should be recorded on the log sheet.

MTS recommends that fresh fixative be prepared prior to each sampling excursion, as formalin will eventually consume all the buffering capacity of the borax. Formalin solution of any strength should not be exposed to freezing temperatures, because the formaldehyde polymers will degrade into paraformaldehyde and the solution will have to be discarded.

Rose Bengal Preparation--

If staining is to be used to aid in sorting, rose bengal may be added to the samples either as a powder or a solution. Both are effective. However, it is easier to use a solution. A rose bengal concentration of 4 g/L of concentrated formalin commonly is used (Eleftheriou and Holme 1984).

Sample containers--

Samples can be stored in a variety of containers including glass or plastic jars, and plastic or muslin bags. If jars are used, plastic lids are preferable to metal lids because formalin corrodes metal. If glass jars are used, extra care should be taken when handling, shipping, and storing them to prevent breakage. If plastic or muslin bags are used, extra care should be taken to prevent them from tearing. MTS prefers the use of plastic jars with plastic or plastic lined lids.

In general, a single 1 or 2 quart container is large enough to hold a sieved sample from a 0.1 m^2 sampler. However, more or larger containers may be required if large quantities of gravel, peat, wood chips, or other large items occur in the sample.

Labels--

MTS field and laboratory people use a complete label inside each sample container, as well as on the side of each container. An abbreviated label is placed on the caps of jars to identify them when in shipping or storage cases. All MTS labels are made of waterproof rag paper and the external labels are gummed. External labels may be filled out using waterproof ink, but internal labels must be filled out using only a #2 pencil.

Processing

MTS highly recommends that the entire sample be sieved for benthic infaunal analyses. If samples are needed for physical or chemical analyses, they should be taken from a separate sample.

After qualitative characteristics of the sample have been recorded, sediments are washed on the designated sieve(s). MTS recommends the use of a 0.5 mm sieve for macro benthic work. Sediment adhering to the outside of the sampler should not be mixed with the sample. When being sieved, sediments can be gently sprayed with water from above, gently agitated by hand in a washtub of water (in an up-and-down, not swirling, motion), or

Analytical Procedures

Transfer to Alcohol--

Samples are to remain in the formalin-seawater solution for a minimum of 24 hours to allow proper fixation (Fauchald 1977). A maximum fixation period of 10 days is recommended by MTS to reduce the risk of decalcifying molluscs and echinoderms. After fixation, the samples should be washed (i.e., rescreened) on a sieve with mesh openings of at least half the size of those used in the field. The smaller screen size ensures that the specimens collected in the field will be retained in the sample regardless of shrinkage or breakage resulting from contact with the formalin. MTS has found it desirable to wash the formalin from the samples as soon as possible after the initial 24 hours because the buffering capacity of the borax in the formalin solution decreases continually.

If the sample consists of multiple containers, all containers are located prior to rescreening and washed at the same time. The contents of each container are carefully poured onto the appropriately sized screen. The container should be rinsed to remove adhering organic material, sediment, or organisms. The screen is not to be filled more than half full to avoid spilling or splashing the sample.

There are several acceptable methods for rinsing formalin from a sample. The MTS recommended method is to gently flush the sample with large quantities of fresh water from a low-pressure faucet or hose, being careful not to splash any sample material. A second method is to partly immerse the sieve in a plastic tub filled with fresh water and wash the sample by moving the sieve in an up and down motion. Care must be taken not to let the water rise above the top level of the sieve. Allow the rinse water to completely drain from the sieve and lightly rinse the sample with a solution of 70 percent alcohol from a squirt bottle. Carefully wash the sample material into a sample jar filling it no more than three-quarters full. Rinse the last bit of material into the jar using the squirt bottle of alcohol. Fill the jar to the top with the 70 percent alcohol solution and screw the lid on tightly. Gently shake and invert the jar several times to ensure proper mixing.

Each jar should have one internal label and two external labels. The internal label should be made of waterproof, 100 percent rag paper and filled out using a #2 pencil. One label is attached to the side of the jar and the second should be attached to the lid of the jar. All three labels will include all information recorded on the field data tag, plus all other information needed to ensure proper identification of the sample.

After fixative has been added to a sample container, it is critical that the contents be mixed adequately. This usually can be accomplished by inverting the container several times. After mixing, sample containers are to be placed in protective containers for storage and transport to the laboratory. After being stored for approximately 1 h, samples should be inverted several times again to ensure adequate mixing.

On board ship, samples should be stored so as to minimize exposure to sunlight and temperature extremes. They should also be stored in a stable part of the ship to minimize agitation.

Laboratory Procedures

Equipment and Supplies--

The MTS laboratory is equipped with both Zeiss and Wild stereo dissection and Zeiss compound microscopes. Magnifying lamps are also available for sorting samples. Compound microscopes are capable of magnifications up to 1,000 power. The optics of these microscopes are of the highest quality. Other MTS laboratory supplies include jewelers forceps, fine scissors, small scalpels, fine needles, flat and depression microscope slides, cover slips, small dissection trays, immersion oil, glycerol alcohol (half glycerol and half 70 percent alcohol), numerical counters, fiberoptic light sources and miscellaneous glass and plastic ware.

Preservative Preparation--

After the specimens are fixed, alcohol is used as a long-term preservative. Either 70 percent ethanol (v/v) in water or 70 percent isopropanol (v/v) are used (Fauchald 1977). Specimens preserved in isopropanol are unsuitable for histological examination. If future studies of anatomy or reproductive biology are anticipated, ethanol will be used.

To prepare 1 L of a 70 percent solution of either alcohol, add 263 mL of distilled water to 737 mL of 95 percent alcohol solution.

Use of the 70 percent alcohol/30 percent water solution is adequate for the preservation of most infaunal organisms (Fauchald 1977; Eleftheriou and Holme 1984). For long-term storage of crustaceans, however, it is recommended that glycerine be substituted for some of the water. The glycerine helps keep the exoskeletons supple, thereby facilitating examination and manipulation. This is especially critical for crustaceans archived in the reference collection (see below). An appropriate alcohol-glycerine solution would be 70 percent alcohol, 25 percent water, and 5 percent glycerine (Eleftheriou and Holme 1984).

Each sample will be sorted by only one person. At a minimum, organisms should be sorted into the following major taxonomic groups: Annelida, Arthropoda, Mollusca, Echinodermata, and miscellaneous phyla (combined). All organisms will be placed in large vials containing a 70 percent alcohol solution. Each vial containing a major taxonomic group should have an internal label listing the survey name, station designation, water depth, date sampled, and field screen size. All vials from the same sample will be stored in a common container and immersed in the 70 percent alcohol solution. To reduce evaporation of alcohol, lids will be sealed with plastic electrical tape.

Biomass Determination--

MTS is equipped to to perform wet weight biomass. When required, biomass estimates for the major taxonomic groups will be made prior to identifying the organisms to the species level. It is recommended, however, that taxonomists examine the major taxonomic groups before biomass measurements are made, to ensure that sorters have correctly grouped all individuals and fragments and that the remains of dead organisms (e.g., empty mollusc shells) are not included. Biomass will be estimated to the nearest 0.1 g (wet weight). All specimens within a major group will be composited for biomass analyses: Annelida (principally polychaete worms), Mollusca (principally bivalves, gastropods and aplacophorans), Arthropoda (principally crustaceans), Echinodermata (principally asteroids, ophiuroids, echinoids, and holothuroids), and miscellaneous taxa (combined). These five categories generally are adequate to characterize the standing stocks of the major infaunal groups. They also are sufficiently distinct from each other to permit proper assignment of fragments to each of the groups. All fragments will be placed in their respective major taxonomic groups prior to weighing.

There are several major problems associated with the collection and interpretation of biomass information. Some taxa lose weight when immersed in preservative fluids, while others gain weight (Howmiller 1972; Lappalainen and Kangas 1975; Wiederholm and Eriksson 1977; Mills et al. 1982). For this reason, the most accurate biomass estimates are performed on live material. However, it is rarely practical to sort and weight live specimens. Accurate measurements of biomass may be compromised further by evaporation from the specimens while they are on the balance. Lastly, biomass measurements are only estimates of standing crop. They do not reflect estimates of production because all organisms are treated in the same manner whether they are large and long-lived, or small and short-lived. Because of these problems, biomass measurements should be interpreted carefully.

All jars of a given sample are kept together (if more than one), and all replicate samples from a given station are stored together. As the samples are shelved prior to sorting, each will be cross-referenced to the field log sheet. At this point the sample custodian will date and initial the rescreening section of the sample tracking form for each station. Washed samples are stored in an upright secure position at a cool temperature, and away from direct sunlight. Samples are periodically curated.

Sample Sorting--

MTS uses several techniques to sort organisms from sediment. The most common technique involves placing a small amount of the sample into a glass or plastic grided petri dish and using a pair of jewelers forceps to sort through the sample in a systematic manner, removing each organism. This entire process is done while viewing the sample through a 10 power dissecting microscope or a magnifying lamp. Care must be taken that enough liquid is present in the petri dish to completely cover the sample to avoid reflections from the sediment/liquid interface which will cause distortion in the field of view. Each petri dish of material should be sorted twice to be sure that all organisms are removed.

A second sorting technique is a flotation method, which was found to be particularly effective when the sediment residue is primarily coarse sediment grains containing small amounts of organic matter (e.g., wood fragments, leaf debris, sewage sludge). The sample is first washed with fresh water in a large flat tray. The less dense material that becomes suspended in the fresh water (organic material, arthropods, and most soft-bodied organisms) is carefully poured into a sieve, and is sorted using the standard technique described above. The remaining material is covered with liquid and sorted using a 5 power self-illuminated lens. Organisms remaining in this portion of the sample generally include molluscs and some tube-dwelling or encrusting organisms that are associated with sand grains. Because it is difficult to see extremely small organisms with the 5 power lens, the sorter must remove all molluscs and polychaete tube fragments for closer inspection. All material collected from this portion is then placed into a labeled sample jar and viewed under a 10 power dissecting microscope to remove organisms from tubes and to ensure that the molluscs were alive when captured.

Whichever technique is used, the sorter is exposed to alcohol fumes. Because these fumes can be irritating to some people, the sorting process can be done using fresh water. However, as each portion of the sample is sorted, it should be drained and returned to the alcohol solution immediately.

Each taxonomist will record the initial identifications and counts in a notebook, which should also include notes and comments on the organisms in each sample. Upon completion of the sample, the data will be transferred to the sample data sheets and double-checked. The taxonomist will then sign and date the sample data sheet. All notebooks will be kept in the laboratory at all times so the laboratory supervisor can check questionable identifications and follow the progress of each sample.

QA/QC Procedures

Calibration and Preventive Maintenance

To make taxonomic identifications consistent within a given laboratory, and with the identifications of other regional laboratories voucher and reference collections will be used where available. At least three individuals of each taxon should be sent for verification to recognized experts. The verified specimens should then be placed in a permanent reference collection. Continued collection of a verified species does not require additional expert verification, because the reference collection can be used to confirm the identification. Participation of the laboratory staff in a regional taxonomic standardization program (if available) is recommended, to ensure regional consistency and accuracy of identifications. All members of the MTS taxonomic team belong to the Southern California Association of Invertebrate Taxonomists, however, due to travel distance, personal participation is not practiced.

All specimens in the reference collection will be held in labeled vials that are segregated by species and sample number. More than one specimen may be placed in each vial. The labels placed in these vials will be the same as those used for specimens in the sample jars. It is important to complete these labels, because future workers may not be familiar with the survey, station locations, and other details of the work in progress. In addition, the reverse side of the label should contain information about the confirmation of the identification by experts in museums or other institutions (if appropriate). Such information would include the name and institution of the outside expert, and date of verification. All vials for a given species should be placed in a single jar filled with alcohol. To reduce evaporation of alcohol, the lids of the jars will be sealed with plastic electrical tape wrapped in a clockwise direction. Reference specimens will be archived alphabetically within major taxonomic groups. A listing of each species name, the name and affiliation of the person who verified the identification, the location of the individual specimen in the museum, the status of the sample if it has been loaned to outside experts, and references to pertinent literature will be maintained by the MTS laboratory taxonomists.

Several methods of measuring biomass are possible. One technique is to estimate the difference in weight of a tared beaker filled with preservative before and after organisms are placed in the beaker. The individual organisms are not blotted prior to weighing, and as few individuals as possible are transferred to the weighing container. These procedures minimize the transfer of fluids held within a pile of individuals. This technique can be used for preserved or live animals, and appears to introduce the least amount of variation into the weighing process.

A second technique for biomass determination consists of air-drying the organisms on absorbent paper for a specific length of time (e.g., 5 min). Because 70 percent ethanol is volatile, small variations in drying time may increase the errors associated with the weight measurements. A container open at one end and covered at the other end with a 0.25-mm mesh screen (maximum mesh opening) can be used to hold the organisms for weighing. After the tare weight of the container is measured, the animals are carefully placed into the container. The container with organisms is then placed on a paper towel and allowed to air dry for exactly 5 minutes prior to weighing. The weight of the organisms is obtained by subtracting the weight of the container with the organisms from the tare weight of the container. Extremely large organisms (e.g., large molluscs or asteroids) should be weighed individually.

Taxonomic Identification--

After biomass estimates are completed, identification and counting of the organisms may begin. Unless otherwise specified, identifications will be to the lowest taxonomic level possible, usually the species level. For incomplete specimens only the anterior end is counted. All identifications should be made using binocular dissecting or compound microscopes. If possible, at least two pieces of literature will be used for each species identification. Moreover, each species identification will be checked against a reference specimen from a verified reference collection if one exists (see QA/QC Procedures).

After completing taxonomic identifications, all organisms will be placed in vials containing 70 percent alcohol. All vials for a single sample will be stored in common jars and immersed in 70 percent alcohol. Each vial will contain an internal label with the following information: survey name, station number, replicate number, collection gear, water depth, and date of collection. Any specimens removed from the sample jar and placed in the reference collection will be so noted (species, number) on the sample identification sheet.

Corrective Action

Following QA/QC procedures discussed earlier, each 20 percent sample aliquot is checked for complete or nearly complete removal of organisms. Thus, each sample elicits a decision concerning a possible re-sort. When a sample is found that does not meet the recommended 95 percent removal criterion (see Data Quality and Reporting Requirements below), it will be re-sorted.

When a taxonomic error or inconsistency is found, it is MTS policy to trace all of the work of the taxonomist responsible for the error, so as to identify those samples into which the specific error or inconsistency may have been introduced. This process can be very time-consuming. However upon completion of all taxonomic work, few (if any) taxonomic errors or inconsistencies remain in the data set. Avoiding errors and inconsistencies through the constant interchange of information and ideas among taxonomists is the best way to minimize lost time due to faulty identification.

Data Quality and Reporting Requirements

At MTS a sample sorting efficiency of 95 percent of total number of individuals is considered acceptable. That is, no more than five percent of the organisms in a given sample are missed by the sorter. Similarly, species identifications by each taxonomist can reasonably be expected to be accurate for at least 95 percent of total number of species. Unless otherwise specified, all organisms will be identified to the lowest possible taxon; to species level whenever possible. In cases where the identity of a species is uncertain, a species number is used (e.g., Macoma sp. 1, Macoma sp. 2). Numerical designations must be consistent throughout each study. To facilitate comparability among different studies, the distinguishing characteristics of each unidentified species will be recorded. Data for each replicate sample is reported as numbers of individuals per sample for each species and as biomass (nearest 0.1 g wet weight per sample) for each major taxonomic group.

Reference specimens are invaluable, and will be retained in the MTS laboratory, in the offices of the funding agencies, or at a museum with long-term storage capabilities. In no instance should this portion of the collection be destroyed.

Quality Control Checks

MTS quality control procedure recommends that at least 20 percent of each sample be re-sorted for QA/QC purposes. Re-sorting is the examination of a sample that has been sorted once and is considered free of organisms. The 20 percent aliquot should be taken after the entire sample has been spread out in a pan or tray. It is critical that the aliquot be a representative subsample of the total sample. Care is taken to include any organisms that may be floating in the preservative. Re-sorting will be conducted using a dissection microscope capable of magnification to 25 power. A partial re-sorting of every sample will ensure that all gross sorting errors are detected. In addition, it will give added incentive to sorters to process every sample accurately. Re-sorting will be conducted by an individual other than the one who sorted the original sample.

In addition to efficient sample sorting, consistent identification of organisms among individuals and among sampling programs is critical to the collection of high quality data. Consistent identifications are achieved by implementing the procedures discussed below and by maintaining informal, but constant, interaction among the taxonomists working on each major group. One important procedure at MTS is to verify identifications by comparison with the reference collection specimens. To ensure that identifications are correct and consistent, 5 percent of all samples identified by one taxonomist should be re-identified by another taxonomist who is also qualified to identify organisms in that major taxonomic group. MTS uses the following specialists to verify identifications (see attached sheet). It is the duty of the senior MTS taxonomist to decide upon the proper identification(s). The senior taxonomist may also decide whether the taxonomic level to which a given organism is identified is appropriate. If it is not, the senior taxonomist may decide to drop back to a higher taxonomic level, or to further refine the taxonomy of that group through additional study.

When all identifications and QA/QC procedures are completed, the jars containing the vials of identified species are topped off with 5 percent glycerine/70 percent alcohol. The lids are then sealed tightly with black electrical tape to prevent evaporation. All sample jars are be placed in containers filled with 70 percent alcohol for long term storage. The containers are fitted with a tightly sealed lid, and electrical tape is again used to seal the joints. Each container is labeled clearly with the survey name, date, and number and type of samples within it.

APPENDIX D

RAW DATA REQUIREMENTS FOR DAIS

SPREADSHEET A

Header:

1. Survey (project) name
2. Tracking number (Corps will provide)
3. Section 10/404 Permit application number
4. Applicant name
5. Date spreadsheet prepared

Sampling Stations:

6. Station numbers
7. Latitudes and Longitudes (min. precision = 0.1")
8. Horizontal datum (NAD 1927 or 1983)
9. Water Depth in feet corrected to MLLW
10. Control/Reference Station Names

Lab Samples:

11. Lab Sample Codes
12. Sampling stations and depths comprising each sample
13. Earliest Sampling Date
14 .Subarea numbers and ranks.

SPREADSHEET B

Conventional Chemistry (Total Solids, Total Volatile Solids, Total Organic Carbon, Total Sulfides, and Ammonia):

1. Lab Names
2. Batch Composition
3. Preparation and analysis codes
4. Replicate numbers
5. Analyte Measurements and Qualifiers
6. Units and Method Blank Units (i.e. %, mg/kg...)
7. Method Blank results for TOC, Ammonia and Sulfides
8. Analysis Dates
9. TOC CRM 95% Confidence Interval
10. TOC CRM analysis results

Grain Size Analysis:

11. Fine-grain analysis method (pipette or hydrometer)

Grain Size Analysis:

11. Fine-grain analysis method (pipette or hydrometer)
12. Batch Composition

Replicate numbers

13. Analysis Dates
14. Grain Size intervals
15. Percent falling within each interval

SPREADSHEET C

Sample Preparation Data and Sample Weights:

1. Extraction/Preparation Group Names
2. Extract/Preparation Codes
3. Extraction/preparation dates
4. Method Blank start dates
5. Surrogates used for each chemical group
6. Lab names
7. Batch composition (including reference materials)
8. Replicate numbers
9. Sample Weights

*NOTE: It is critical for the sample weight to be recorded for each sample taken in the particular extraction/preparation group (including the CRMs, RMs, and matrix spikes). This is a key field in the DAIS database and will drive the automated input screen displays.

Analysis Data:

10. For each chemical-of-concern there is a common list of needed data:
    - -extract/prep group number
    - -analysis method code
    - -units (dry weight basis)
    - -blank units
11. Sample analysis information includes the following:
    - -replicate number
    - -analysis date
    - -concentration
    - -data qualifier (if necessary)

12. Analysis data are needed for the following:
    - -test sediments
    - -reference materials
    - -method blanks

-matrix
-spiked samples

13. Matrix spikes must be reported on a sample-specific dry-weight-normalized basis

Surrogate Recoveries:

14. Analysis method codes
15. Replicate numbers
16. Analysis dates
17. Recovery for test sediments, method blanks, reference materials and matrix-spiked samples.

SPREADSHEET D

Amphipod Mortality and Emergence:

1. Species name
2. NODC code
3. Exposure Time
4. Lab Name
5. Lab Sample Codes
6. Batch Composition
7. Start Dates
8. Daily Emergence Counts (for 10 days)
9. Number of Survivors
10. Number Failing To Reburow

Amphipod Bioassay Positive Control:

11. Toxicant used
12. Exposure Time
13. LC50 Method of calculation
14. Batch numbers
15. Start Dates
16. Toxicant concentrations
17. Percent survival at each concentration
18. LC50

Amphipod Bioassay Water Quality:

19. Methods used:
    -Dissolved Oxygen
    -Water Salinity

-Interstitial Water Salinity
-Ammonia
-Sulfide

20. Batch numbers
21. Daily Temperature
22. Daily pH
23. Daily DO (mg/L)
24. Daily Water Salinity (ppt)
25. Initial Interstitial Salinity (ppt)
26. Initial and Final Sulfide (mg/L)
27. Initial and Final Ammonia (mg/L)

Sediment Larvae Mortality and Abnormality:

28. Species Name
29. NODC Code
30. Lab Name
31. Inoculation Time (hrs.) = the length of time after the sediment is placed into the beaker and before the organisms are added.
32. Exposure Time (hrs.)
33. Test Beaker Volume (ml)
34. Stocking Density (eggs/ml) for each batch = concentration of eggs in the beaker from which all test beakers are stocked
35. Stocking Aliquot Size (ml) = the volume taken from the fertilization beaker to stock each of the test beakers.

Sediment Larval Test Results:

36. Batch composition
37. Start Dates

For initial counts, seawater controls, test and reference sediments:

38. Number of aliquots counted
39. Aliquot Size (ml)
40. Number of Normal per aliquot
41. Number of Abnormal per aliquot

Sediment Larval Bioassay Positive Control (% Survival):

42. Toxicant
43. Exposure Time (hrs)
44. LC50 Method of Calculation
45. Batch numbers

46. Start Dates
47. Toxicant Concentrations
48. % Survival for each concentration

Sediment Larval Bioassay Positive Control (% Abnormality):

49. Same as #42-48, except for 44. which should be - EC50 Method of Calculation

Sediment Larval Bioassay Water Quality:

50. See #19-27, exclude Interstitial Water Salinity

Juvenile Infaunal Species Bioassay Mortality and Growth

51. Species Name
52. NODC code
53. Lab name
54. Starting Age (in days post emergence)

20-day growth test only:

55. Food Type
56. Feeding Interval (hrs.) = the time between feedings
57. Feeding Quantity (mg dry weight/individual/feeding event)

Juvenile infaunal species
beginning biomass

58. Batch and Rep number
59. Analysis Date
60. Number of Organisms Weighed
61. Total Start Weight (mg/dry)
62. Organisms Depurated (yes or no)
63. Total End Weight of Survivors (mg dry)

Juvenile Infaunal Species Mortality:

64. Batch number and start date
65. Number of Organisms Beginning
66. Number of Survivors
    Initial weight of organisms
    Final weight of organisms

Juvenile Infaunal Species Bioassay Positive Control (% Survival):

67. See #42-48
68. LC50 mg/L

Juvenile Infaunal Species Bioassay Water Quality:

69. See # 19-27

Microtox Bioassay:

70. Lab Name
71. Batch Composition
72. Extraction Time
73. Extraction Date
74. Analysis Date
75. Analysis Time
76. Extract Dilutions
77. Initial and Final illumination values for rep 1 and rep 2 for each dilution (including the blank)
78. Initial and Final illumination values for five replicates at the highest concentration

Microtox Bioassay Positive Control:

79. Toxicant
80. EC50 Method of calculation
81. See #72-78
82. EC50 %