Combined work quality assurance project plan (CW/QAPP) for benthic monitoring: 1998-2001 Revision 1

Massachusetts Water Resources Authority

Environmental Quality Department
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COMBINED WORK QUALITY ASSURANCE PROJECT PLAN FOR BENTHIC MONITORING REVISION 1

for

Benthic Monitoring: 1998 - 2001

Tasks 17-20

MWRA Harbor and Outfall Monitoring Project
Contract No. S274

Submitted to

Massachusetts Water Resources Authority
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Report No. ms-050 Revision 1

COMBINED WORK QUALITY ASSURANCE PROJECT PLAN
(CW/QAPP)

Revision 1

for

BENTHIC MONITORING: 1998-2001

Tasks 17-20
MWRA Harbor and Outfall Monitoring Project

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1.0 PROJECT NAME

MWRA Harbor and Outfall Monitoring Project
Tasks 17–20
Benthic (Sea-Floor) Monitoring, 1998–2001

2.0 PROJECT REQUESTED BY

Massachusetts Water Resources Authority

3.0 DATE OF REQUEST

November 5, 1997

4.0 DATE OF PROJECT INITIATION

November 5, 1997

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7.0 PROJECT DESCRIPTION

The Benthic (Sea-Floor) Monitoring component of the MWRA Harbor and Outfall Monitoring (HOM) program addresses three main concerns: eutrophication, contaminants, and particulate inputs. Eutrophication, which may occur from the transfer of nutrient loads to the Massachusetts Bay outfall, may depress oxygen levels in benthic habitats. Such hypoxia could have profound impacts on the benthos (Diaz and Rosenberg, 1995). Toxic contaminants introduced into the environment may accumulate in depositional areas. Sediments not only represent a long-term sink for chemical contaminants, but are also sources of nutrients, toxic chemicals, and pathogenic microbes to the overlying water column (Salomons *et al.*, 1987; Brown and Neff, 1993). Excess sediment and organic particles discharged from an outfall, which is not expected from the MWRA outfall, could smother benthic habitats under certain circumstances. Such disturbances to benthic sediments frequently result in characteristic and well-documented changes in the communities that inhabit them (Pearson and Rosenberg, 1978). Therefore, benthic community structure and function can be used to indicate the overall condition of the receiving water environment. Moreover, analysis of synoptic sediment samples for benthic community parameters and for concentrations of chemical contaminants, nutrients, and organic matter, often make it possible to attribute changes in benthic faunal community characteristics to particular chemical constituents of the effluent or, in some cases, to other sources of disturbance (NRC, 1990).

The benthic monitoring tasks of the Harbor and Outfall Monitoring Project will collect data on the benthic macrofauna and flora, and the physical properties and levels of organic matter, nutrients, sewage indicators, and potentially toxic contaminants in the sediments in which the macrofauna reside. These measurements are made over a wide geographic area influenced by many natural and anthropogenic factors including past, current, or proposed effluents from MWRA wastewater outfall. These benthic monitoring studies provide valuable information on the temporal responses of Boston Harbor benthic communities to changes in MWRA wastewater treatment practices and are expected to provide evidence of response at the new outfall. Certain of these measurements have been developed into monitoring thresholds designed to provide evidence of important changes in the benthic environment that may be related to the discharge from the outfall.

7.1 Objective and Scope

Under this technical area, continued recovery of Harbor sediments is monitored, and baseline and post-commissioning data in the Bays prior to and in the years immediately following the discharge of effluent at the Massachusetts Bay outfall are to be obtained.

The principal aim of the Harbor studies is documentation of continuing recovery of benthic communities in areas of Boston Harbor as improvements are made to the quality of wastewater discharges. Recent reports have indicated that some infaunal community changes are consistent with those expected with habitat improvements (Kropp and Diaz, 1995; Hilbig *et al.*, 1996). The Harbor recovery monitoring includes evaluation of local and area-wide changes in the Boston Harbor system that have resulted from: (1) improvements in wastewater treatment practices (*e.g.*, cessation of sludge discharge and conversion from primary to full secondary treatment), (2) diversion of effluent to the new ocean outfall, and (3) improvements to combined sewer overflow (CSO) control systems.

The Harbor studies also include monitoring the response of benthic communities in Massachusetts and Cape Cod Bays to effluent discharge that began in late 1998. This monitoring focuses most intensely on Nearfield sites in western Massachusetts Bay (0–8 km from the outfall), where changes in water and sediment quality have been predicted following initiation of the discharge. The Bays monitoring also

examines Farfield areas (>8 km from the outfall), that serve primarily as reference areas for the Nearfield or as monitoring stations if the discharge affects sites distant from the diffuser.

The objectives of the benthic monitoring program are addressed in four tasks that involve sampling in the Harbor and Massachusetts Bay. Included are sediment sampling in the Harbor and Bays, hardbottom sampling near the outfall, and the analysis of sedimentary physical characteristics, organic matter content, nutrient loads, sewage tracer levels, chemical contaminant loads, and soft- and hardbottom benthic community structure. The present status and variability of the benthic environmental quality within the Harbor and Massachusetts Bays system will be evaluated by examination of the interrelationships among these parameters. Particular importance will be placed on the rapid evaluation of benthic data with respect to monitoring thresholds described in the Contingency and Outfall Monitoring Plans (MWRA, 1997a; b) and the Procedures for Calculation and Testing of Contingency Plan thresholds (MWRA in prep).

Task 17. Harbor Benthic Surveys — include traditional sediment grab-sampling to collect samples for characterization of the physical, chemical, and biological status of surficial sediments at eight stations throughout Boston Harbor (Kropp and Peven, 1993; Blake and Hilbig, 1995); an extensive reconnaissance survey using sediment profile images (SPI); and a focused survey to detect effects of CSOs on local sediment quality.

Task 18. Outfall Benthic Surveys — include Nearfield and Farfield soft-bottom surveys using traditional grab-sampling methods; SPI sampling designed to provide a rapid evaluation of those sedimentary habitats; and a Nearfield benthic ROV (remotely operated vehicle) survey to provide semiquantitative data about hardbottom community responses in the vicinity of the outfall. A special study will gather high-resolution data on Nearfield sediment contaminant loads to identify hypothesized rapid changes in organic carbon, sewage tracers, or contaminants in depositional areas soon after discharge begins. These outfall benthic data will be evaluated for apparent triggering of monitoring thresholds.

Task 19. Chemical Analysis of Sediments — includes the use of advanced analytical methods to determine potentially toxic metal and organic chemical contaminants of major concern in the sediments in Boston Harbor and the Bays. Sewage tracers, total organic matter, and grain size for the sediment samples collected under Tasks 17 and 18 are analyzed.

Task 20. Analysis of Benthic Fauna — includes the determination of the benthic soft- and hardbottom community structure and function. Benthic fauna recovered from sediment grab samples collected under Tasks 17 and 18 are identified and counted. Results are evaluated statistically to characterize benthic community structure and function, and to make temporal and spatial comparisons of community parameters within the Harbor and Bays ecosystems. Soft-bottom habitats are examined through the analysis of SPI photographs. Hardbottom communities (faunal and floral) are evaluated for possible responses to the initiation of effluent flow from the outfall. A reference collection of all soft-bottom taxa (identified and unidentified specimens) collected is stored, maintained, and compiled throughout the project.

7.2 Data Usage

The benthic monitoring provides data that will be used to:

- Continue to develop an understanding of the dynamics and status of the ecosystems
- Continue to quantify baseline conditions prior to effluent diversion to Massachusetts Bay
- Determine ecologically meaningful changes with statistical rigor and evaluate these changes as possible responses of benthic communities to initiation of treated wastewater discharges through the new diffuser
- Rapidly evaluate critical contaminant and biological variables with respect to apparent triggering of monitoring threshold levels
- Correlate changes in benthic community parameters to changes in sediment concentrations of organic matter, sewage tracers, and potentially toxic chemical contaminants.

Critical to this component of the monitoring program is the identification and use of statistical and numerical methods that can be used to evaluate benthic habitat and community changes and that can separate likely causes.

7.3 Technical Approach

7.3.1 Boston Harbor Studies

The Harbor Benthic Surveys provide the benthic samples and other data required to document long-term improvement of sediment quality and resulting recovery of the benthic communities in Boston Harbor following the cessation of sludge and effluent discharge into the Harbor. Data from an extensive reconnaissance survey using SPI supplements and extends traditional infaunal data to provide a large-scale picture of benthic conditions in the Harbor. This expanded coverage is particularly important because conditions are expected to improve over a broader expanse of the Harbor as secondary treatment is implemented and effluent discharge is diverted to the new outfall. Harbor surveys also provide the samples necessary for monitoring contamination of sediments near CSO discharges in support of MWRA's CSO monitoring study.

During the Harbor traditional surveys (Task 17.1), conducted in April and August, soft-sediment grab samples will be collected from eight sampling locations (Table 1, Figure 1). These "traditional" stations were selected after consideration of historic sampling sites and Harbor circulation patterns (Kelly and Kropp, 1992). Samples from these traditional stations will be collected for analysis of selected physical sediment parameters and sewage tracers (Task 19), and for benthic infaunal community parameters (Task 20).

To provide for greater geographic coverage of benthic community recovery, a Harbor reconnaissance survey (Task 17.2) will be conducted during August of each year. Sediment profile images (SPI) will be obtained at 60 "reconnaissance" stations (Table 1, Figure 1).

Table 1. Target Locations for Harbor Traditional And Reconnaissance Survey Stations.

Station	Latitude	Longitude	Depth (m)
Traditional Stations			
T01	42°20.95′N	70°57.81′W	4.0
T02	42°20.57′N	71°00.12′W	6.0
T03	42°19.81′N	70°57.72′W	9.0
T04	42°18.60′N	71°02.49′W	3.5
T05A	42°20.38′N	70°57.64′W	18.0
T06	42°17.61′N	70°56.66′W	6.0
T07	42°17.36′N	70°58.71′W	7.0
T08	42°17.12′N	70°54.75′W	11.0
Reconnaissance Stations			
R02	42°20.66′N	70°57.69′W	12.0
R03	42°21.18′N	70°58.37′W	5.5
R04	42°21.52′N	70°58.78′W	8.5
R05	42°21.38′N	70°58.68′W	7.1
R06	42°19.91′N	70°57.12′W	6.8
R07	42°20.85′N	70°58.53′W	5.9
R08	42°20.66′N	70°59.50′W	2.8
R09	42°20.80′N	71°00.98′W	11.8
R10	42°21.32′N	71°02.20′W	13.5
R11	42°19.28′N	70°58.48′W	7.0
R12	42°19.10′N	70°58.47′W	6.3
R13	42°19.03′N	70°58.84′W	7.2
R14	42°19.25′N	71°00.77′W	7.9
R15	42°18.92′N	71°01.15′W	3.6
R16	42°18.95′N	70°57.68′W	6.9
R17	42°18.29′N	70°58.63′W	8.2
R18	42°17.33′N	70°57.67′W	7.9
R19	42°16.92′N	70°56.27′W	9.7
R20	42°19.49′N	70°56.10′W	9.7
R21	42°18.53′N	70°56.78′W	7.0
R22	42°18.02′N	70°56.37′W	8.3
R23	42°17.63′N	70°57.00′W	10.5
R24	42°17.78′N	70°57.51′W	8.3
R25	42°17.48′N	70°55.72′W	6.8
R26	42°16.13′N	70°55.80′W	5.8
R27	42°16.83′N	70°54.98′W	3.7

Table 1. (continued)

Station	Latitude	Longitude	Depth (m)
R28	42°16.90′N	70°54.52′W	8.2
R29	42°17.38′N	70°55.25′W	8.8
R30	42°17.43′N	70°54.25′W	5.2
R31	42°18.05′N	70°55.03′W	9.8
R32	42°17.68′N	70°53.82′W	5.5
R33	42°17.65′N	70°59.67′W	4.0
R34	42°17.33′N	71°00.42′W	3.4
R35	42°17.05′N	70°59.28′W	4.3
R36	42°16.53′N	70°59.20′W	2.7
R37	42°17.93′N	70°59.08′W	4.0
R38	42°17.08′N	70°57.83′W	4.6
R39	42°17.73′N	70°58.22′W	6.4
R40	42°19.73′N	71°01.45′W	4.6
R41	42°18.67′N	71°01.50′W	5.5
R42	42°19.18′N	71°01.50′W	3.7
R43	42°18.40′N	71°00.13′W	4.0
R44	42°20.62′N	71°00.13′W	6.1
R45	42°19.70′N	70°58.05′W	6.7
R46	42°17.46′N	70°55.33′W	9.5
R47	42°20.67′N	70°58.72′W	8.3
R48	42°17.61′N	70°59.27′W	3.1
R49	42°16.39′N	70°54.49′W	8.4
R50	42°16.50′N	70°53.92′W	7.6
R51	42°15.80′N	70°56.53 ′W	2.4
R52	42°15.71′N	70°56.09′W	2.1
R53	42°16.15′N	70°56.27′W	3.0

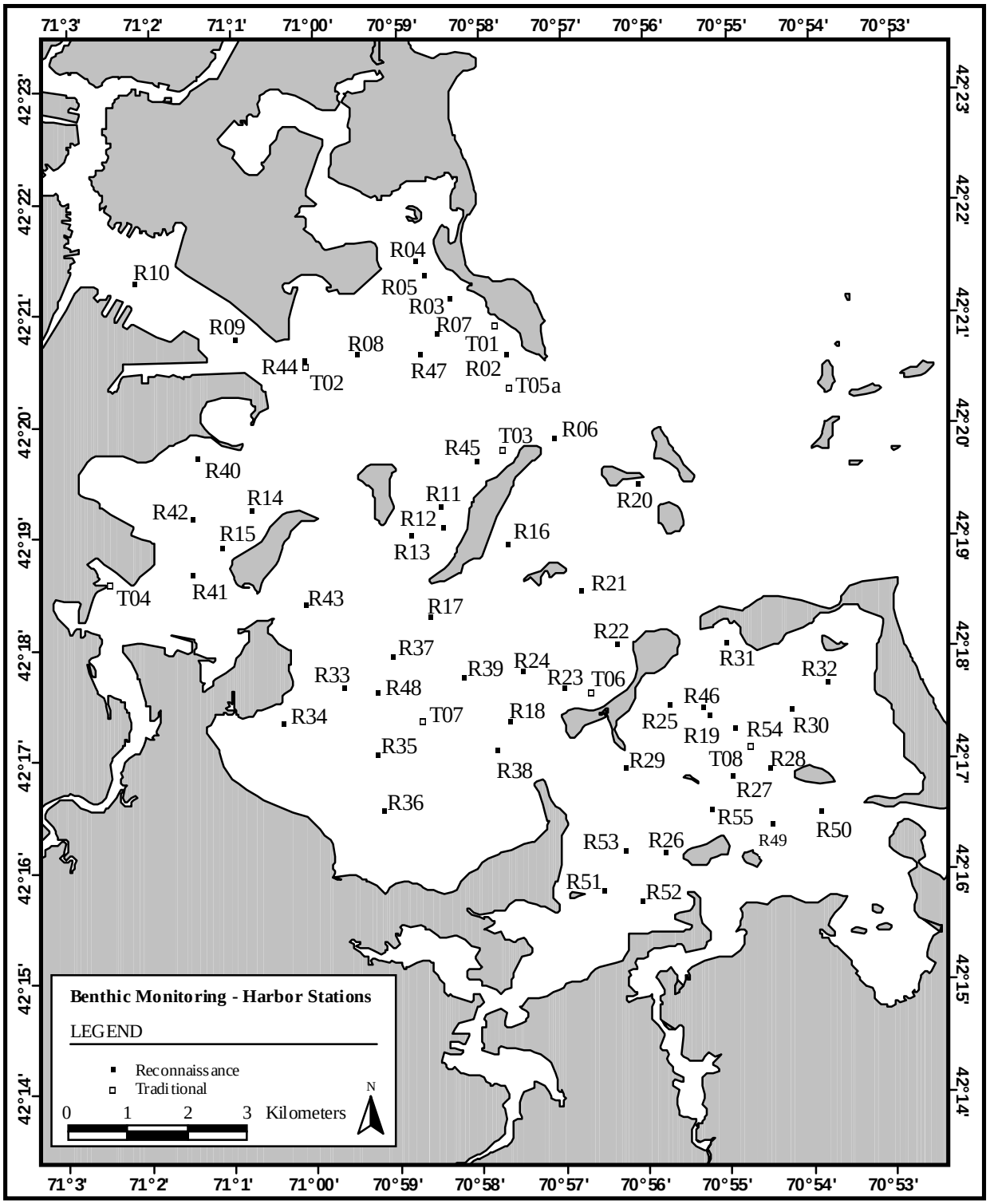


Figure 1. Locations of Boston Harbor Traditional and Reconnaissance Stations.

The CSO study, conducted in August 1998 (task 17.3), was a continuation of the MWRA's CSO studies conducted in 1990 and 1994. The CSO sediment studies are meant to provide information on improvements in sediment quality in the harbor after CSO upgrades. Sediments were collected from 14 sites in Boston Harbor and analyzed for selected contaminants. The results were compared to the results from the 1990 and 1994 studies and a synthesis report was submitted to MWRA in January, 2000.

Details of the field sampling and laboratory methods to be used in the Harbor benthic studies (including the CSO studies) are provided in Section 12.0.

7.3.2 Outfall Studies

The Outfall Benthic Surveys provide quantitative measurements of benthic community structure and patterns of contaminant concentrations within sediments of Massachusetts and Cape Cod Bays. Baseline data was collected yearly until the outfall went online (August 2000). After effluent discharge into the Bay began, the focus of the program changed from the collection of baseline data to an evaluation of the effects of the discharge on the Bay ecosystems. Outfall surveys conducted after the outfall goes online will provide the data required for a quantitative assessment of the effects of discharged effluent on sediment chemistry (Task 19) and benthic infauna communities (Task 20). The objectives of monitoring program in the post-discharge phase are (1) to monitor versus NPDES permit requirements, (2) to test whether or not the discharge-related impacts are within the limits predicted by the SEIS, and (3) to determine if changes in the system exceed Contingency Plan thresholds (MWRA, 1997a and MWRA, in prep).

Technical Overview — The Nearfield benthic surveys, conducted in August of each year (Task 18.1), are designed to provide spatial coverage and local detail of faunal communities inhabiting depositional environments within about 8 km of the diffuser. Samples for sediment chemistry and benthic infauna will be collected at the 20 Nearfield stations and three Farfield stations (Table 2; Figure 2). Inclusion of the three Farfield stations here allows faunal analysis of samples from them to be accelerated during laboratory activities conducted under Task 20.

The Nearfield Contaminant Special Study Surveys (Task 18.2) examine the possible short-term impacts of the outfall discharge on sediment contaminant concentrations and their relationship with possible sediment organic carbon changes in depositional environments near the outfall. Four nearfield depositional sites were selected for this study after consideration of grain size composition, (>50% sand/silt), stability of grain size composition over the period monitored, and historical high TOC relative to other stations nearby (>1% TOC). The Nearfield Contaminant Special Study was conducted once in 1998, to provide baseline data, and will continue to occur three times per year, following the August 2000 start of the outfall.

Nearfield sediment profile image surveys, conducted in August each year at 20 Nearfield and 3 Farfield stations (Task 18.3), give an area-wide, qualitative/ semiquantitative assessment of sediment quality and benthic community status that can be integrated with the results of the more localized, quantitative surveys to determine sedimentary conditions near the outfall. Furthermore, these surveys provide rapid comparison of benthic conditions to the benthic triggering thresholds. Traditional sediment profile imagery (35-mm slides) allows a faster evaluation of the benthos to be made than can be accomplished through traditional faunal analyses. A more rapid analysis of the SPI data will be accomplished by fitting the profile camera prism with a digital video camera arranged to view the same sediment profile as the 35-mm film camera.

Table 2. Target Locations for Outfall Survey Stations.

Station	Latitude	Longitude	Depth (m)
Nearfield Stations			
NF02	42°20.31′N	70°49.69′W	30
NF04	42°24.93′N	70°48.39′W	36
NF05	42°25.62′N	70°50.03′W	36
NF07	42°24.60′N	70°48.89′W	33
NF08	42°24.00′N	70°51.81′W	32
NF09	42°23.99′N	70°50.69′W	29
NF10	42°23.57′N	70°50.29′W	35
NF12	42°23.40′N	70°49.83′W	34
NF13	42°23.40′N	70°49.35′W	33
NF14	42°23.20′N	70°49.36′W	33
NF15	42°22.93′N	70°49.67′W	32
NF16	42°22.70′N	70°50.26′W	29
NF17	42°22.88′N	70°48.89′W	29
NF18	42°23.80′N	70°49.31′W	35
NF19	42°22.30′N	70°48.30′W	32
NF20	42°22.69′N	70°50.69′W	28
NF21	42°24.16′N	70°50.19′W	33
NF22	42°20.87′N	70°48.90′W	36
NF23	42°23.86′N	70°48.10′W	36
NF24	42°22.83′N	70°48.10′W	37
Farfield Stations			
FF01A	42°33.84′N	70°40.55′W	32
FF04	42°17.30′N	70°25.50′W	87
FF05	42°08.00′N	70°25.35′W	61
FF06	41°53.90′N	70°24.20′W	33
FF07	41°57.50′N	70°16.00′W	37
FF09	42°18.75′N	70°39.40′W	49
FF10*	42°24.84′N	70°52.72′W	27
FF11	42°39.50′N	70°30.00′W	87
FF12*	42°23.40′N	70°53.98′W	22
FF13*	42°19.19′N	70°49.38′W	19
FF14	42°25.00′N	70°39.29′W	77

*Farfield Stations FF10, FF12, and FF13 are sampled with the Nearfield stations.

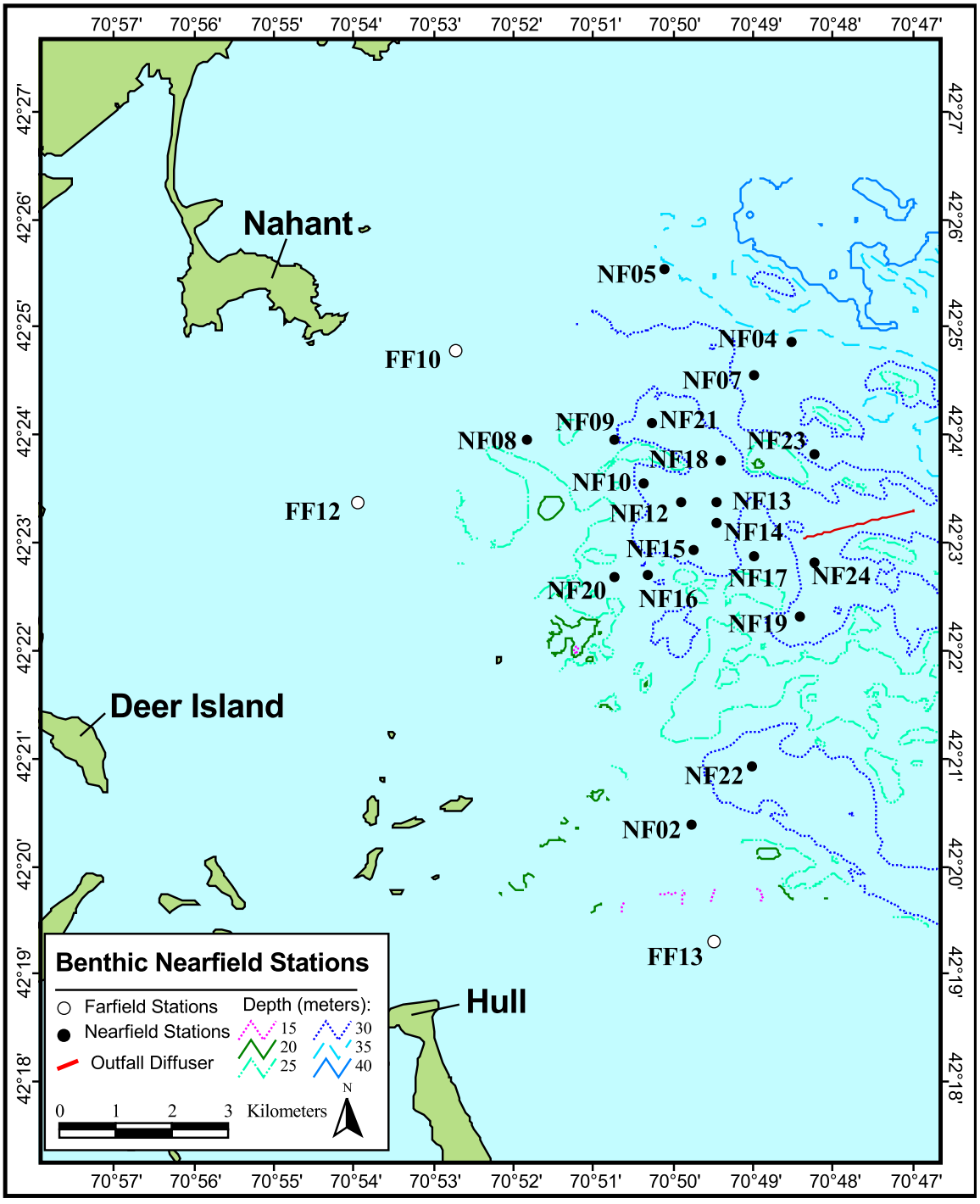


Figure 2. Locations of Nearfield Benthic Stations (including FF10, FF12 and FF13).

Because of the relative rarity of depositional habitats in the Nearfield and in the vicinity of the diffusers, a continuing study of hardbottom habitats has been implemented to supplement the soft-bottom studies. The Nearfield hardbottom surveys (Task 18.4) will be conducted in June each year. Video tape footage and 35-mm slides will be taken at waypoints along eight transects, two waypoints, and at Diffuser #44 (Table 3).

Farfield benthic surveys, conducted in August each year (Task 18.5), contribute reference and early-warning data on soft-bottom habitats in Massachusetts and Cape Cod Bays. Grab samples will be collected at eight stations (Table 2, Figure 3) for infaunal and chemical analyses. Some sampling within the Stellwagen Bank National Marine Sanctuary is required. Appropriate permits will be obtained.

Details of the field sampling and laboratory methods to be used in the Outfall studies are provided in Section 12.0.

Contingency Plan Thresholds — The MWRA (1997a) developed a Contingency Plan that specifies numerical or qualitative thresholds that may suggest that environmental conditions in the Bay may be changing or might be likely to change. The Plan provides a mechanism to confirm that a threshold has been exceeded, to determine the causes and significance of the event, and to identify the action necessary to return the trigger parameter to a level below the threshold (if the change resulted from effluent discharge). Sediment thresholds have been established for sediment RPD, sediment contaminant concentrations, benthic community diversity and relative abundance of opportunistic species (MWRA, 1997a and MWRA, in prep).

7.4 Monitoring Parameters and Collection Frequency

A summary of the numbers of stations to be visited and the types and numbers of field samples to be collected in Boston Harbor and in Massachusetts and Cape Cod Bays during this project is given in Table 5. The numbers of samples are listed per survey and for all benthic surveys of this project combined.

The parameters to be measured during the various Benthic (Sea-Floor) Monitoring tasks can be characterized as macrobiological, sedimentological (habitat properties and contaminant levels), and microbiological. Macrobiological parameters, based primarily on the species-level identifications, include community measures such as abundance (or percent cover), numbers of species, and diversity. Some sediment habitat properties are measured during the SPI studies (Table 6) and include information about sediment geophysical properties and the general nature of the infaunal community. Sediment grain-size distribution is determined visually during the SPI analyses and through the laboratory analysis of subsamples taken from grab samples. Sediment contaminant parameters include several types of organic contaminants (PAHs, PCBs, and pesticides) and metals. Microbiological parameters focus on sewage tracer organisms including *Clostridium perfringens*, fecal coliform bacteria, and *Enterococcus*. The latter two microbiological metrics were determined only for CSO study samples. A detailed presentation of the parameters to be collected is presented in the text and tables comprising Section 12.0.

Table 3. Target Locations for Hardbottom Survey Transects.

Transect	Waypoint/ Station	Latitude	Longitude	Depth (m)
T1	1	42°23.606'N	70°48.201'W	25
T1	2	42°23.625'N	70°48.324'W	24
T1	3	42°23.741'N	70°48.532'W	22
T1	4	42°23.815'N	70°48.743'W	20
T1	5	42°23.869'N	70°48.978'W	27
T2	1	42°23.634'N	70°47.833'W	26
T2	2	42°23.570'N	70°47.688'W	27
T2	3	42°23.525'N	70°47.410'W	26
T2	4	42°23.457'N	70°47.265'W	32
T2	5	42°23.331'N	70°46.807'W	34
T4	1	42°23.046'N	70°46.502'W	31
T4	2	42°23.012'N	70°46.960'W	29
T4	3	42°22.877'N	70°47.580'W	30
T4+6	4	42°22.948'N	70°47.220'W	23
T6	1	42°22.993'N	70°47.712'W	30
T6	2	42°22.855'N	70°47.082'W	27
T7	1	42°24.565'N	70°47.015'W	23
T7	2	42°24.570'N	70°46.920'W	24
T8	1	42°21.602'N	70°48.920'W	23
T8	2	42°21.823'N	70°48.465'W	23
T9	1	42°24.170'N	70°47.768'W	24
T10	1	42°22.680'N	70°48.852'W	26
Diffuser # 44		42°23.116'N	70°47.931'W	33

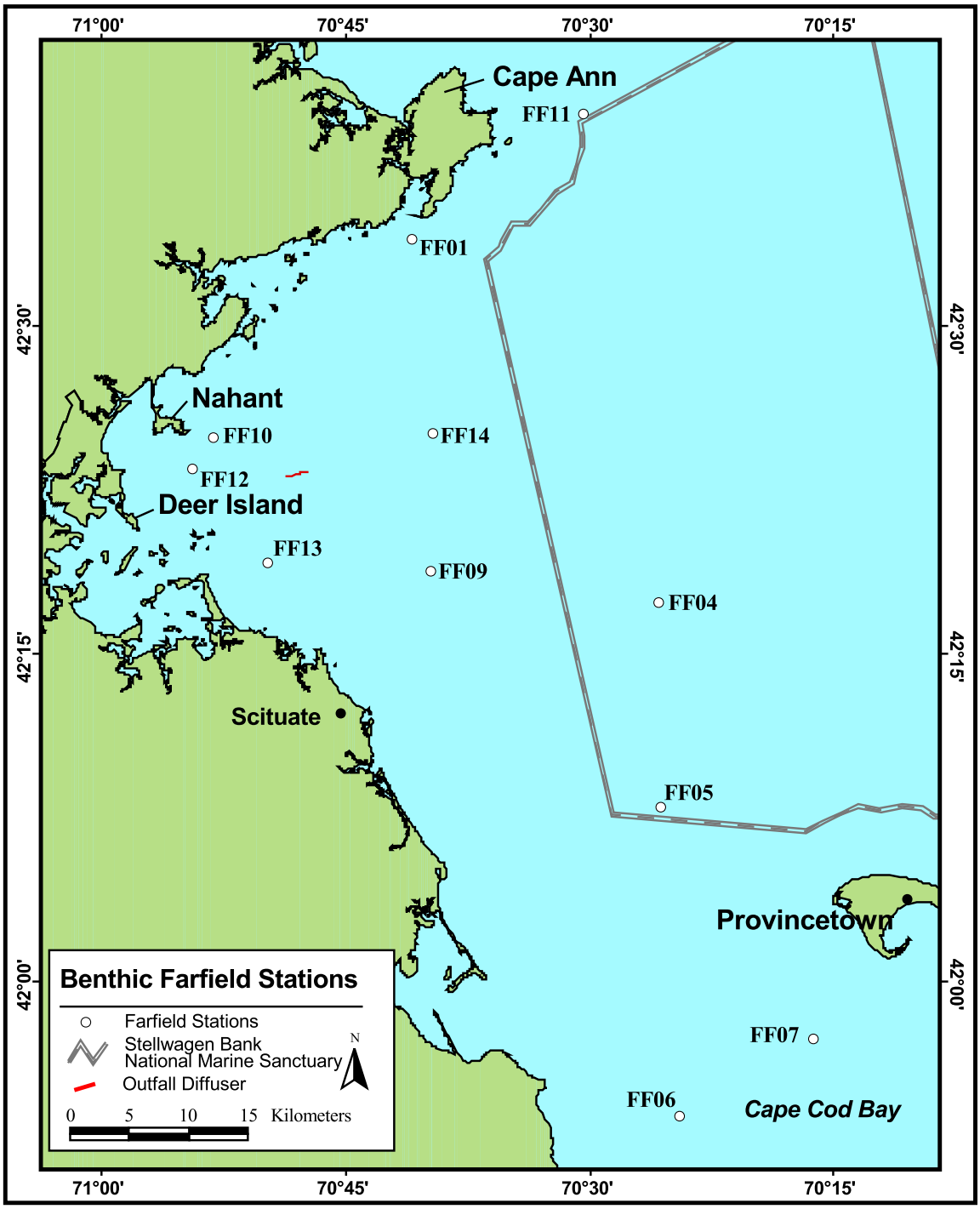


Figure 3. Locations of Farfield Benthic Stations (FF10, FF12, and FF13 will be sampled on the nearfield survey).

Table 4. (This table intentionally omitted in Revision 1 of this document.)

Table 5. Samples Collected for Tasks 17 and 18.

	Task 17 Harbor Surveys					Task 18 Outfall Surveys									
	17.1		17.2		17.3	18.1*		18.2		18.3		18.4		18.5	
	Survey	*Total*	*Survey*	*Total*	*Total*	*Survey*	*Total*	*Survey*	*Total*	*Survey*	*Total*	*Survey*	*Total*	*Survey*	*Total*
Infauna	24	192	___	___	___	35	140	—	—	___	___	___	___	24	96
Sediment Chemistry PAHs PCBs LABs Metals Coprostanol	___	___	___	___	42	29[1]	82	12	84	___	___	___	___	16[2]	44
Ancillary Parameters TOC Grain Size *C. perfringens*	8	64	___	___	42	29	116	12	84	___	___	___	___	16	64
Enterococcus	___	___	___	___	42	___	___	___	___	___	___	___	___	___	___
Fecal Coliform	___	___	___	___	42	___	___	___	___	___	___	___	___	___	___
SPI	___	___	180	720	___	___	___	___	___	69	276	___	___	___	___
Hardbottom Slides Video (min)	___	___	___	___	___	___	___	___	___	___	___	828 460	3312 1840	___	___

* Nearfield surveys include FF10, FF12, and FF13.

[1] Number of chemistry samples per survey was reduced to 12 in 2000.
[2] Number of chemistry samples per survey was reduced to 6 in 2000.

Table 6. Parameters Measured from Sediment Profile Images.

Parameter	Units	Method	Description
Sediment Grain Size	Modal phi interval	V	Estimate of type of sediments present. Determined from comparison of image to images of known grain size
Prism Penetration	cm	CA	A geotechnical estimate of sediment compaction. Average of maximum and minimum distance from sediment surface to bottom of prism window
Sediment Surface Relief	cm	CA	An estimate of small-scale bed roughness. Maximum depth of penetration minus minimum
Apparent Reduction-oxidation Potential Discontinuity Depth (from color change in sediment)	cm	CA	Estimate of depth to which sediments are oxidized. Area of aerobic sediment divided by width of digitized image
Thickness of Sediment Layers	cm, cm^2	CA	Measure thickness above original sediment surface and delineate area
Methane/Nitrogen Gas Voids	#, cm, cm^2	V, CA	Count, measure depth from sediment surface, delineate area
Epifaunal Occurrence	#	V	Count, identify
Tube Density	#/cm^2	V, CA	Count
Tube Type Burrow Structures Pelletal Layer Bacterial Mats	 — cm, cm^2 —	 V, CA V, CA V,	 Identify Measure thickness, area Determine presence and color
Infaunal Occurrence Feeding Voids Apparent Successional Stage	# #, cm, cm^2 —	V, CA	Count, identify Measure thickness, area
Organism Sediment Index	—	CA	Derived from RPD, Successional Stage, Voids (Rhoads and Germano, 1986)

V: Visual measurement or estimate
CA: Computer analysis

Under the sampling/analysis protocols specified by NOAA for the National Status & Trends Mussel Watch Project, no sediment holding times are specified. The U.S. EPA has suggested some holding times by reference to water sample holding times, for example, the interim final Monitoring Guidance for the National Estuary Program (EPA document #503/8-91-002). Sediment chemistry samples will be frozen as soon as possible after sampling and they will remain frozen until sample processing begins. It is assumed that if the samples are properly handled and remain frozen, their integrity will not be compromised prior to processing. Furthermore, project requirements for submission of data reports preclude the possibility of violation of the above mentioned holding times suggested by the EPA.

8.0 PROJECT FISCAL INFORMATION

This project is being carried out under the terms of Harbor and Outfall Monitoring Contract S274 between the MWRA and Battelle Duxbury Operations.

9.0 SCHEDULE OF ACTIVITIES AND DELIVERABLES

Benthic (Sea-Floor) Monitoring activities will span the period from the date of project initiation (November 5, 1997) until July 2002, when the last annual synthesis report is due. Activities include field sampling and laboratory analyses, with deliverables consisting of associated survey plans, survey reports, data reports, and synthesis reports (prepared under Task 33). A schedule for these activities and deliverables is outlined in Tables 7 and 8.

10.0 PROJECT ORGANIZATION

Benthic (Sea-Floor) Monitoring tasks will be accomplished through the coordinated efforts of several organizations and individuals (Figure 4). Dr. Michael Mickelson is the MWRA Project Manager. Mr. Ken Keay is the MWRA Deputy Project Manager and is the Project Area Manager for the Benthic (Sea-Floor) Monitoring. Ms. Wendy Leo is the MWRA EM & MS Manager.

Dr. Carlton Hunt is the Battelle Project Manager responsible for the overall performance of this project. Ms. Jeanine Boyle is the Deputy Project Manager. Ms. Boyle will aid Dr. Hunt in the management of program personnel and information for fulfillment of contract obligations. She will also be responsible for tracking deliverables and CW/QAPP changes. Battelle Quality Assurance Officer for the project is Ms. Rosanna Buhl. Ms. Buhl is responsible for auditing data generated at Battelle and for reviewing data reports and QA statements submitted by the members of the Benthic (Sea-Floor) Monitoring team for completeness and adherence to the CW/QAPP. Also, she is responsible for reviewing the data reports for accuracy and completeness. Mr. Wayne Trulli is the Battelle Field Manager responsible for all Battelle field collection activities. Ms. Deirdre Dahlen is the Battelle Laboratory Manager responsible for oversight of all laboratory activities performed under the contract. Ms. Ellie Baptiste-Carpenter is Battelle's Database Manager.

Technical oversight for the Benthic (Sea-Floor) Monitoring will be provided by several Senior Scientists: Benthic Ecology—Dr. Roy K. Kropp (Battelle) and Dr. Robert Diaz (Diaz and Daughters); Sediment Chemistry—Dr. Carlton Hunt (Battelle) Ms. Lisa Lefkovitz and Ms. Deirdre Dahlen (Battelle); SPI—Dr. Robert Diaz (Diaz & Daughters); and Hardbottom—Barbara Hecker (CR Environmental). The contacts for the supporting laboratories are shown in Figure 4.

Table 7. Overview of Harbor and Outfall Surveys and Associated Deliverables.

Survey Date	Survey	Survey Plan	Due Date Summary Report	Draft Survey Report *
April 1998	Harbor Traditional (Task 17.1)	March 1998		May 1998
June 1998	Nearfield Hardbottom Survey (Task 18.4)	May 1998		July 1998
August 1998	Harbor Traditional/Reconnaissance and Soft-Bottom Outfall Survey (Tasks 17.1,17.2,18.1,18.5)	July 1998	August 1998 (Task 18.1 only)	September 1998
	CSO Sediment Survey (Task 17.3)	July 1998		September 1998
	Nearfield Sediment Image Profile Survey (Task 18.3)	July 1998	August 1998	September 1998
October 1998	Nearfield Contaminant Special Study (Task 18.2)	September 1998		November 1998
February 1999	Nearfield Contaminant Special Study (Task 18.2)	January 1999		March 1999
April 1999	Harbor Traditional Survey (Task 17.1)	March 1999		May 1999
June 1999	Nearfield Hardbottom Survey (Task 18.4)	May 1999		July 1999
July 1999	Nearfield Contaminant Special Study (Task 18.2)	June 1999		August 1999
August 1999	Harbor Traditional/Reconnaissance and Soft-Bottom Outfall Survey (Tasks 17.1,17.2,18.1,18.5)	July 1999	August 1999 (Task 18.1 only)	September 1999
	Nearfield Sediment Profile Image Survey (Task 18.3)	July 1999	August 1999	September 1999
October 1999	Nearfield Contaminant Special Study (Task 18.2)	September 1999		November 1999

Table 7. (continued)

Survey Date	Survey	Survey Plan	Due Date Summary Report	Draft Survey Report *
February 2000	Nearfield Contaminant Special Study (Task 18.2)	January 2000		March 2000
April 2000	Harbor Traditional Survey (Task 17.1)	March 2000		May 2000
June 2000	Nearfield Hardbottom Survey (Task 18.4)	May 2000		July 2000
July 2000	Nearfield Contaminant Special Study (Task 18.2)	June 2000		August 2000
August 2000	Harbor Traditional/Reconnaissance and Soft-Bottom Outfall Survey (Tasks 17.1,17.2,18.1,18.5)	July 2000	August 2000 (Task 18.1 only)	September 2000
	Nearfield Sediment Profile Image Survey (Task 18.3)	July 2000	August 2000	September 2000
October 2000	Nearfield Contaminant Special Study (Task 18.2)	September 2000		November 2000
February 2001	Nearfield Contaminant Special Study (Task 18.2)	January 2001		March 2001
April 2001	Harbor Traditional Survey (Task 17.1)	March 2001		May 2001
June 2001	Nearfield Hardbottom Survey (Task 18.4)	May 2001		July 2001
August 2001	Harbor Traditional/Reconnaissance/ Nearfield Contaminant Special Study and Soft-Bottom Outfall Survey (Tasks 17.1,17.2,18.1,18.2,18.5)	July 2001	August 2001 (Task 18.1 only)	September 2001
	Nearfield Sediment Profile Image Survey (Task 18.3)	July 2001	August 2001	September 2001
October 2001	Nearfield Contaminant Special Study (Task 18.2)	September 2001		November 2001

* Final Survey Reports due 2 weeks from receipt of MWRA's comments on the draft report.

Table 8. Overview of Data and Synthesis Reports.

Survey Date	Deliverable	Draft Report Due Date
April 1998	Harbor Sediment Chemistry Data Report (Task 19.1)	July 1998
	April Harbor Faunal Sorting Completion Letter Report (Task 20.2)	June 1998
	April Harbor Faunal Data Report (Task 20.2)	August 1998
June 1998	Nearfield Hardbottom Reconnaissance Data Report (Task 20.8)	November 1998
August 1998	August Harbor Faunal Sorting Completion Letter Report (Task 20.2)	November 1998
	August Harbor Faunal Data Report (Task 20.2)	February 1999
	August Nearfield Faunal Sorting Completion Letter Report (Task 20.3)	45 days after completion of the survey
	Nearfield Faunal Data Report (Task 20.3)	October 1998
	August Farfield Faunal Sorting Completion Letter Report (Task 20.4)	November 1998
	Farfield Faunal Data Report (Task 20.4)	December 1998
	Harbor Sediment Chemistry Data Report (Task 19.1)	November 1998
	Nearfield/Farfield Sediment Chemistry Data Reports (Tasks 19.3, 19.5)	November 1998
	CSO Sediment Survey Data Report (Task 19.2)	90 d after survey completion
	Harbor Sediment Profile Imaging Survey Data Report (Task 20.6)	December 1998
	Nearfield Sediment Profile Imaging Survey Data Report (Task 20.7)	December 1998
October 1998	Nearfield Contaminant Special Study Data Report (Task 19.4)	January 1999
February 1999	Nearfield Contaminant Special Study Data Report (Task 19.4)	May 1999
1998 Annual	Outfall Benthic Synthesis Report (Task 33.5)	May 1999
	Reference Collection Status Report (Task 20.1)	June 1999
	Harbor Benthic Synthesis Report (Task 33.6)	July 1999
	CSO Sediment Synthesis Report (Task 33.7)	July 1999
April 1999	Harbor Sediment Chemistry Data Report (Task 19.1)	July 1999
	April Harbor Faunal Sorting Completion Letter Report (Task 20.2)	June 1999
	April Harbor Faunal Data Report (Task 20.2)	August 1999

Table 8. (continued)

Survey Date	Deliverable	Draft Report Due Date
June 1999	Nearfield Hardbottom Reconnaissance Data Report (Task 20.8)	November 1999
July 1999	Nearfield Contaminant Special Study Data Report (Task 19.4)	October 1999
August 1999	August Harbor Faunal Sorting Completion Letter Report (Task 20.2)	November 1999
	August Harbor Faunal Data Report (Task 20.2)	February 2000
	August Nearfield Faunal Sorting Completion Letter Report (Task 20.3)	45 days after the completion of the survey
	Nearfield Faunal Data Report (Task 20.3)	November 1999
	August Farfield Faunal Sorting Completion Letter Report (Task 20.4)	October 1999
	Farfield Faunal Data Report (Task 20.4)	December 1999
	Harbor Sediment Chemistry Data Report (Task 19.1)	November 1998
	Nearfield/Farfield Sediment Chemistry Data Reports (Tasks 19.3, 19.5)	November 1998
	Harbor Sediment Profile Imaging Survey Data Report (Task 20.6)	December 1999
	Nearfield Sediment Profile Imaging Survey Data Report (Task 20.7)	December 1999
October 1999	Nearfield Contaminant Special Study Data Report (Task 19.4)	January 2000
February 2000	Nearfield Contaminant Special Study Data Report (Task 19.4)	May 2000
1999 Annual	Outfall Benthic Synthesis Report (Task 33.5)	May 2000
	Reference Collection Status Report (Task 20.1)	June 2000
	Harbor Benthic Synthesis Report (Task 33.6)	July 2000
April 2000	April Harbor Faunal Sorting Completion Letter Report (Task 20.2)	June 2000
	Harbor Sediment Chemistry Data Report (Task 19.1)	July 2000
	April Harbor Faunal Data Report (Task 20.2)	August 2000
June 2000	Nearfield Hardbottom Reconnaissance Data Report (Task 20.8)	November 2000
July 2000	Nearfield Contaminant Special Study Data Report (Task 19.4)	October 2000

Table 8. (continued)

Survey Date	Deliverable	Draft Report Due Date
August 2000	August Harbor Faunal Sorting Completion Letter Report (Task 20.2)	November 2000
	August Harbor Faunal Data Report (Task 20.2)	February 2001
	August Nearfield Faunal Sorting Completion Letter Report (Task 20.3)	45 days after completion of the survey
	Nearfield Faunal Data Report (Task 20.3)	November 2000
	August Farfield Faunal Sorting Completion Letter Report (Task 20.4)	October 2000
	Farfield Faunal Data Report (Task 20.4)	December 2000
	Harbor Sediment Chemistry Data Report (Task 19.1)	November 2000
	Nearfield/Farfield Sediment Chemistry Data Reports (Tasks 19.3, 19.5)	November 2000
	Harbor Sediment Profile Imaging Survey Data Report (Task 20.6)	September 2000
	Nearfield Sediment Profile Imaging Survey Data Report (Task 20.7)	September 2000
October 2000	Nearfield Contaminant Special Study Data Report (Task 19.4)	January 2001
February 2001	Nearfield Contaminated Special Study Data Report (Task 19.4)	May 2001
2000 Annual	Outfall Benthic Synthesis Report (Task 33.5)	May 2001
	Reference Collection Status Report (Task 20.1)	June 2001
	Harbor Benthic Synthesis Report (Task 33.6)	July 2001
April 2001	April Harbor Faunal Sorting Completion Letter Report (Task 20.2)	June 2001
	Harbor Sediment Chemistry Data Report (Task 19.1)	July 2001
	April Harbor Faunal Data Report (Task 20.2)	August 2001
June 2001	Nearfield Hardbottom Reconnaissance Data Report (Task 20.8)	November 2001
August 2001	Nearfield Contaminant Special Study Data Report (Task 19.4)	November 2001
	August Harbor Faunal Sorting Completion Letter Report (Task 20.2)	November 2001
	August Harbor Faunal Data Report (Task 20.2)	February 2002
	August Nearfield Faunal Sorting Completion Letter Report (Task 20.3)	45 days after completion of the survey
	Nearfield Faunal Data Report (Task 20.3)	November 2001
	August Farfield Faunal Sorting Completion Letter Report (Task 20.4)	October 2001
	Farfield Faunal Data Report (Task 20.4)	December 2001

Table 8. (continued)

Survey Date	Deliverable	Draft Report Due Date
	Harbor Sediment Chemistry Data Report (Task 19.1)	November 2001
	Nearfield/Farfield Sediment Chemistry Data Reports (Tasks 19.3, 19.5)	November 2001
	Harbor Sediment Profile Imaging Survey Data Report (Task 20.6)	September 2001
	Nearfield Sediment Profile Imaging Survey Data Report (Task 20.7)	September 2001
October 2001	Nearfield Contaminant Special Study Data Report (Task 19.4)	January 2002
2001 Annual	Outfall Benthic Synthesis Report (Task 33.5)	May 2002
	Reference Collection Status Report (Task 20.1)	June 2002
	Harbor Benthic Synthesis Report (Task 33.6)	July 2002

* Final Reports due 2 weeks after receipt of MWRA's comments on the draft report.

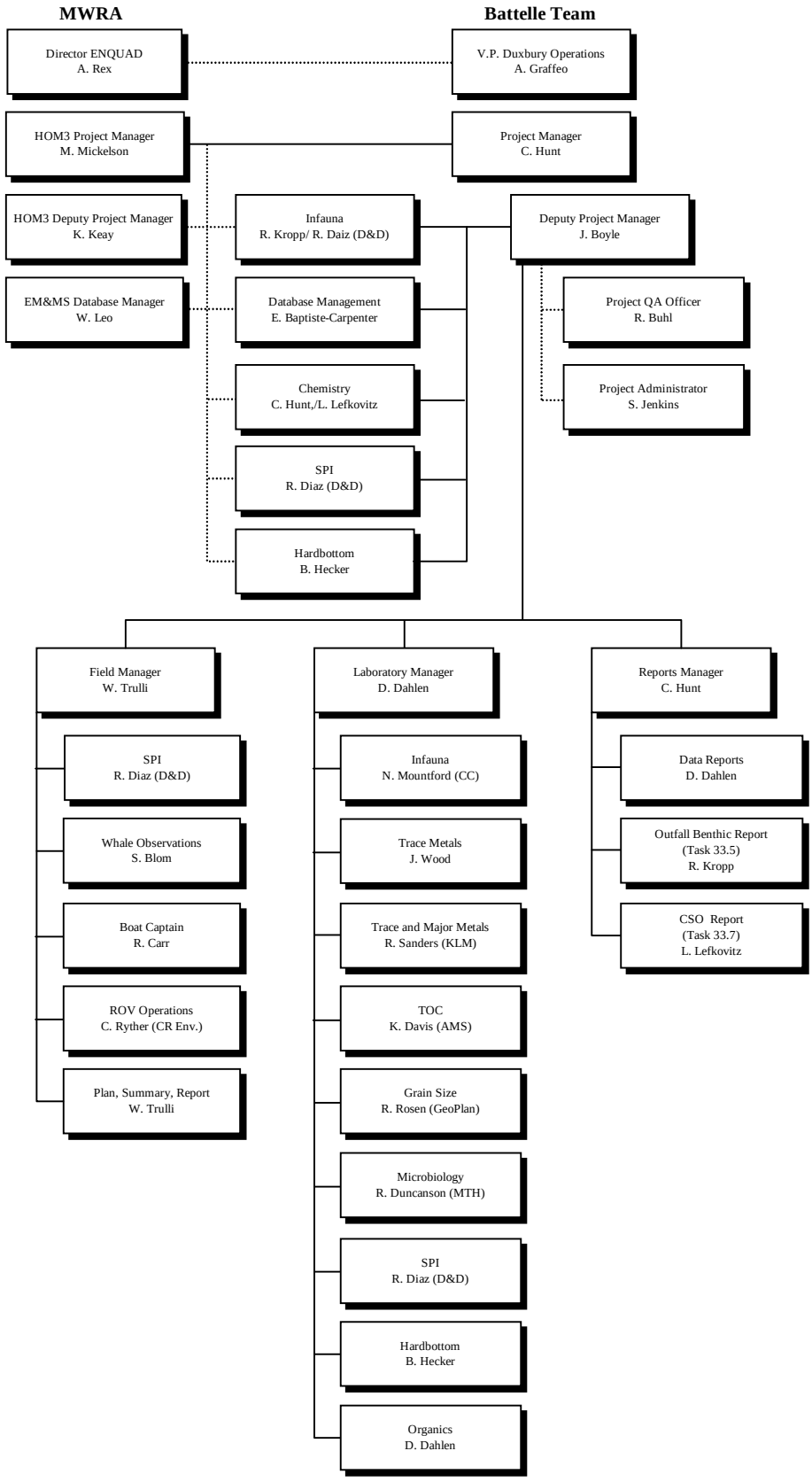


Figure 4. Benthic Monitoring Organization and Analyses.

11.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

Requirements for ensuring that the data are fit for their intended use (that is, are of suitable quality) include accuracy, precision, representativeness, comparability, and completeness. When these requirements are met, the final data product is technically defensible. Data elements for this project are discussed in terms of the appropriate characteristics, defined as:

Accuracy: The extent of agreement between a measured value and the true value of interest.
Precision: The extent of mutual agreement among independent, similar, or related measurements.
Representativeness: The extent to which measurements represent true systems.
Comparability: The extent to which data from one study can be compared directly to similar studies.
Completeness: The measure of the amount of data acquired versus the amount of data required to fulfill the statistical criteria for the intended use of the data.

The representativeness and comparability of all the data generated under this CW/QAPP depend to some extent upon the selection of the sampling sites. With the exception of 4 depositional sites for Task 18.2, the Nearfield Special Contaminant Study, and 14 sites for the CSO Sediment Study, Task 17.3, all soft-bottom stations to be visited during this program will be the same as those listed in Blake and Hilbig (1995). Hardbottom survey sites will be the same as listed in Hilbig (1997).

Details of how these criteria are met for each component of the Benthic (Sea-Floor) Monitoring tasks are presented in the following sections.

11.1 Field Activities

11.1.1 Navigation

The data quality requirements and assessments for navigational data are described in the water column monitoring CW/QAPP (Albro *et al.*, 1998). At each sampling station, the vessel is positioned as close to target coordinates as possible. The NAVSAM navigation and sampling software collects and stores navigation data, time, and station depth every 2 seconds throughout the sampling event, and assigns a unique ID to each sample when the sampling instrument hits bottom. The display on the BOSS computer screen is set to show a radius of 30 m around the target station coordinates (6, 5-m rings) for all benthic surveys. A station radius of up to 30 m is considered acceptable for benthic sediment sampling.

11.1.2 Grab Sampling

Samples for all benthic sediment infaunal analysis will be collected with a 0.04 m^2 Young-modified van Veen grab sampler. On surveys where contaminant sample collection is not required, the 0.04 m^2 grab sampler may also be used to collect sediment for grain size, Total Organic Carbon (TOC) and microbiology. Sediment samples for chemical analyses (organic and inorganic) will be collected with a Kyner-coated 0.1 m^2 Young-modified van Veen grab sampler. Undisturbed samples will be achieved by careful attention to established deployment and recovery procedures. Battelle's procedures cover the following aspects of deployment and recovery:

- thorough wash-down of the grab before each deployment;
- control of penetration by adding or removing weights to the frame and adjusting the rate of fall;
- slow recovery until grab is free of the bottom;
- inspection for signs of leakage; and

- securing the grab on deck.

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample.

- Sampler is not overfilled with sediment; the jaws must be fully closed and the top of the sediment below the level of the opening doors.
- Overlying water is present and not excessively turbid.
- Sampler is at least half full, indicating that the desired penetration was achieved.

In certain locations, however, slight over-penetration may be accepted at the discretion of the chief scientist. Mild over-penetration may be accepted according to the following standards:

- the sediment surface is intact on at least one side of the grab and
- there is little or no evidence that the surface sediment has pushed through the grid surface of the grab, i.e. no visable imprint from the screening outside of that grid
- No evidence that sediment has squirted out through the hinge or the edges.

Given the difficulty of obtaining undisturbed sediment in areas with exceptionally thick, anoxic mud, these standards may have to be relaxed further. The chief scientist will make the final decision regarding acceptability of all grabs, and the overall condition of the grab (i.e. "slight overpenetration on one side") will be documented on the station log.

11.1.2.1 Benthic Infauna

Accuracy, Precision, and Representativeness
Because no subsampling will be performed, the accuracy, precision, and representativeness of the sampling will depend upon the factors discussed above under Section 11.1.2.

Comparability
Procedures for washing, sieving, and preserving the samples will be consistent with methods used in previous studies. The use of 300-μm sieves only, rather than stacked 500-μm and 300-μm sieves as in 1993 and 1994, will have no impact on the comparability of the samples because the faunal abundances will be compared with the total abundances (300-μm and 500-μm fractions summed) reported through the 1997 study. In addition, samples will be collected only by trained staff under the supervision of a chief scientist with experience in the collection of benthic infaunal samples.

Completeness
All required samples will be collected at all of the stations required for each survey. The entire sample will be sieved, and all material retained on the 300-μm screen will be fixed for analysis.

11.1.2.2 Sediment

Accuracy, Precision, and Representativeness
These qualities will be assured by the sampling design factors discussed under Grab Sampling (above) and by ensuring that samples are well-homogenized, subsampled according to methods detailed in Section 12.0, and preserved.

Comparability
Procedures for sampling and subsampling will be comparable to those used on previous MWRA surveys and other investigations in Boston Harbor and Massachusetts Bay.

Completeness
All required samples will be collected at all of the stations required for each survey.

11.1.3 Sediment Profile Imagery

The data quality objectives for the field collection of the SPI will be met by following several procedures. Proper assembly and operation of the video/SPI system will ensure that the tape and 35-mm images obtained are clear and of high quality. Real-time monitoring of the video system will permit some degree of evaluation of the potential quality of the 35-mm photographs because the two cameras occupy the same housing and share similar views of the sediment profile. Prior to every field deployment, all video/SPI components are collected and tested for proper operation. Once the video/SPI system is assembled on board the research vessel a system check is initiated that includes all features of the video/SPI system from tightening all bolts and video cable connectors to testing the video camera and deck video monitor and recorder. Proper system functioning (penetration of prism, flash from film SPI camera) will be monitored in real time on deck via the video monitor. Any miss-fires or improper film camera operation can then be corrected while on station.

Representativeness will be ensured by sampling at previously sampled locations that were chosen based on similarity of habitat or to allow for wide geographic coverage. Use of a differential global positioning system (DGPS) for navigation will allow re-occupation of previously sampled sites.

The methods used to collect the sediment profile images will be consistent with those used previously on the program. These documented methods will be followed consistently by trained staff members throughout the program.

To ensure that all required images will be collected, after every station or replicate deployment the film counter will be checked to confirm that the system was functioning properly. Any miss-fires or improper camera operation can then be corrected while on station. Almost any electronic or mechanical failure of the profile camera can be repaired in the field. Spare parts and a complete back-up camera will be carried on each SPI survey. Images will be collected at all required stations.

11.1.4 Hardbottom ROV Survey

Accuracy and Precision
The data quality objectives for the field collection of the SPI will be met by following several procedures. The real-time viewing of videotapes during the surveys will ensure that the tapes will be of sufficient quality to achieve the objectives of the survey. Only EHG (extra high grade) magnetic videotapes will be used for this project. All equipment will be cleaned and checked thoroughly before deployment.

Hardbottom transects and waypoints to be taped and photographed are those that were selected by MWRA to be representative of the hardbottom habitats in the vicinity of the outfall.

The field methods used will be similar to those followed previously. The hardbottom surveys will follow the same transects as those listed in Hilbig (1997) to ensure that video and photographic data will be comparable. All transects will be occupied in such a manner that the nature of the epifauna and sedimentary environment in the hard bottom area can be compared to the previous surveys.

All of the requisite transects (and their waypoints) will be video taped and photographed. Approximately 20 minutes of video and images from a full roll of film (36 exposure) will be collected at each waypoint. ROV operations will be monitored by real-time viewing of the video during the survey. The videotapes will be checked in the field to ensure the video images are recorded. The still photographs will be developed in the field as they are collected to ensure proper photographic quality and camera functions.

11.2 Laboratory Activities

11.2.1 Infaunal Analysis

Accuracy
Benthic infauna will be identified by experienced taxonomists at Cove Corporation (Lusby, MD) and Ocean's Taxonomic Services (Plymouth, MA). In the case of questions about organisms in specific taxonomic groups, specimens may be sent to recognized experts for a second opinion on the identification. Standard taxonomic references will be used, and selected specimens of newly found species will be retained as part of an already existing voucher collection.

Precision
Sorting technicians will remove all organisms from the samples and separate them into major taxonomic groups. All residual material will be labeled and stored for QC analysis. Samples will be divided into batches of approximately 10 samples. All samples will be pre-sorted by a junior technician and then 100% re-sorted by an experienced technician. Approximately 10% of the samples from each batch will then be randomly chosen as an independant QC check. If more than 5% of the total organisms in the QC sample have been missed, all remaining samples from that batch will be re-sorted.

Representativeness
Because all of the sample will be analyzed, representativeness will be determined by sampling factors.

Completeness
All samples collected are scheduled for analysis. Because three replicates will be collected at most stations, loss of a sample from a replicated station would still permit data to be obtained for that station. One hundred percent completeness is expected.

Comparability
Methods of analysis will be comparable to those used in previous benthic investigations in Boston Harbor and Massachusetts Bay. Comparability of the identifications will be ensured through the use of standard taxonomic references and by comparison of specimens to a voucher collection provided by the Authority. This voucher collection will be maintained and, if new species are identified, expanded by Cove Corporation and turned over to the Authority, or the Authority's designee, at the end of the project.

11.2.2 Sediment Chemistry

Data Quality Objectives for the laboratory program are presented in Table 9 and detailed in the following sections.

Accuracy

Organic Contaminants: Analytical accuracy for organic analyses will be evaluated based on percent recoveries of analytes in National Institute of Standards and Technology (NIST) standard reference materials (SRM), matrix spike samples, and the surrogate internal standards (SIS) that are added to every sample. In addition, results of procedural blanks will be monitored with each analytical run.

One SRM will be analyzed with each batch of up to 20 samples. The data quality objective for recovery of analytes in SRM samples is ±35 percent difference from the certified value and/or the certified range (see Table 9). The percent difference is calculated as follows:

$$\text{Percent Difference} = [(\text{Certified value} - \text{SRM sample result}) \div \text{Certified value})] \times 100$$

One set of MS/MSD samples with be analyzed with each batch of up to 20 sediment samples. The data quality objective for MS and MSD recovery is 50–150%. The percent recovery of analytes in matrix spike and matrix spike duplicate samples is calculated by the following equation:

$$\text{Percent Recovery} = ([\text{spiked sample result} - \text{unspiked sample result}] \div \text{spike amount}) \times 100$$

One procedural blank will be analyzed with each batch of up to 20 samples. Procedural blanks will be acceptable if the concentrations of any target analyte is less than five times the method detection limit (MDL).

All sediment samples and associated QC samples processed for organic analysis will be spiked with the appropriate SIS before extraction. Quantification of the SIS will be based on the recovery internal standards (RIS) added to the final extract just before instrumental analysis. The acceptable SIS recovery range is 50–150%; one of the PAH surrogate internal standards can be outside this range as long as the others are within the acceptable range. Because samples are quantified relative to the recovery of the SIS which is added before extraction, any loss of analytes during processing is corrected by a comparable loss of the SIS. Therefore, recoveries of less than 50% may be considered acceptable. Each sample showing low recoveries will be individually examined by the laboratory manager and/or task leader to determine the necessity of reextraction or reanalysis.

Metals Analyses: The accuracy of the metals analysis (Ag, Cd, Hg) will be evaluated by analyzing an SRM with each batch of up to 20 samples. In addition, a matrix spike sample and a procedural blank will be run with each batch of up to 20 samples. The goals for blank analyses will be $< 5 \times$ MDL. The goal for the percent recovery of matrix spike samples will be 70–130%. The goal for the recovery of the SRM will be ± 20% of the true value.

The accuracy of the remaining trace and major metals analyses (Al, Fe, Cr, Ni, Pb, Zn, Cu) will be evaluated by analyzing the same USGS or NIST traceable matrix standard at the start and end of each analytical run.

Table 9. Data Quality Objectives for Sediment Chemistry.

QC Type	Acceptance Criteria	Corrective Action
Procedural Blanks		
Organics Metals (Hg, Cd, Ag) Metals (Al, Fe, Cr, Ni, Pb, Zn, Cu) TOC Grain Size Microbiology: *C. perfringens* Fecal Coliform *Enterococci*	< 5X MDL <5X MDL NA <0.1 of the lowest sample concentration (total carbon) NA No growth of target or non-target organisms	Results examined by project manager, task leader, or subcontractor lab manager. Reextraction, reanalysis, or justification documented.
Accuracy		
Matrix Spike Organics Metals (Hg, Cd, Ag) Metals (Al, Fe, Cr, Ni, Pb, Zn, Cu) TOC Grain Size Microbiology	 50–150% recovery 70–130% recovery NA NA NA NA	Document, justify deviations
SIS Organics only	 50-150%	Document, justify deviations
SRMs Organics Metals (Hg, Cd, Ag) Metals (Al, Fe, Cr, Ni, Pb, Zn, Cu) TOC Grain Size Microbiology	 PD ±35% vs SRM range[a] PD ±20% vs SRM values PD ±20% vs SRM values ±5% of certified value NA NA	Results examined by project manager, task leader, or subcontractor lab manager. Reextraction, reanalysis, or justification documented.
Precision		
Duplicates Organics (MS/MSD) Metals (Hg, Cd, Ag) (Lab Duplicates) Metals (Al, Fe, Cr, Ni, Pb, Zn, Cu) TOC Grain Size Microbiology (Duplicate Counts of 10% of samples by different analysts) **Triplicates** Grain Size	 ≤30 R%D CV=±25% if value is 5∗MDL CV=±25% if value is 5∗MDL ≤25 R%D See triplicates ≤10% difference between counts CV=<20% if the component is >5% of the sample	 Document, justify deviations Recount to reach consensus Document, justify deviations

[a]For organics SRM: If the detected value falls within the SRM certified range, then PD = 0. If the detected value falls outside the SRM certified range, then the PD is determined against either the upper or lower limit of the range.

Precision

Organic Contaminants: Analytical precision for organic analyses will be determined using the concentrations of matrix spike (MS) and matrix spike duplicate (MSD) samples, with the relative percent difference (R%D) between duplicate analyses serving as the measure of precision. The R%D goal for MS/MSD samples is 30%. The R%D is calculated by

$$R\%D = [\ 2\ (D_1 - D_2) \div (D_1 + D_2)] \times 100$$

where D_1 = concentration of the first duplicate sample and
D_2 = concentration of the second duplicate sample.

Metals (Ag, Cd, Hg): Laboratory duplicates for metals analyses will be performed at a frequency of not fewer than one per 20 samples. The coefficient of variation (CV) goal for these analyses will be $\pm$ 25% if the element is greater than 5 times the MDL.

Metals (Al, Fe, Cr, Ni, Pb, Zn, Cu): One sample duplicate will be analyzed with each sample loading.

Representativeness

Representativeness has been addressed primarily in the sample collection design through sampling locations, number of grab samples, and collection of grab samples. Representativeness will also be ensured by proper handling, storage, and analysis of samples, using accepted procedures so that the material analyzed reflects the material collected as accurately as possible.

Completeness

The completeness of analyses will be ensured by comparing the samples received by the laboratory with the samples analyzed. All samples will be analyzed for the parameters listed in Table 10. These analyses will be documented in the laboratory project files. The data quality objective is 95% completion. Completeness will be calculated as:

$$\text{Completeness} = ([\text{Valid data obtained}] \div [\text{Total data planned}]) \times 100$$

Comparability

All data developed for this project will be comparable to previous data generated for the MWRA program. To accomplish this goal, field samplers and subcontractor laboratories will employ modifications of EPA methods and other procedures that are comparable to those used on previous sediment characterization studies (e.g., NOAA, 1993; Shea, 1993; 1994; Blake and Hilbig, 1995). In addition, these methods are comparable to those being used in other similar sediment studies [e.g., for the MWRA, Massachusetts Bays Program, and NOAA NS&T Program]. Furthermore, Battelle participates in intercomparison exercises for analysis of PAHs, PCBs, and pesticides in sediment using methods that are similar to those proposed for this task.

Trace metal data generated during HOM3 will be comparable to those generated previously. The EDXRF methods that will be used during HOM3 also were used during HOM1. EDXRF methodology is comparable the methods used under HOM2. Although direct methodological comparisons have not been performed, interlaboratory comparisons conducted by NOAA and the National Research Council of Canada have shown that laboratories that employ EDXRF methods perform as well as, or better than, most laboratories that use other methods (Willie, 1997). This intercomparison showed that the data generated by EDXRF methods for each trace metal tested met the same acceptability criteria as those generated by other methods.

11.2.3 Physicochemical and Microbiological Parameters

Accuracy

Total Organic Carbon: Accuracy of TOC analysis will be evaluated by blanks and SRMs. An acceptable procedural blank must be less than 1/10 of the lowest sample signal (S:N = 10:1)for the batch. SRMs will be analyzed with each batch of samples and must be within 5% of the true value.

Grain Size: Direct measures of accuracy in grain size determination are not possible because there are no standards. Accuracy of laboratory balances at GeoPlan will be maintained by monthly calibration with S class (or equivalent) weights.

Microbiology: The accuracy of measurement of microbiological parameters in sediment samples is not easily quantified, as no standards exist. One procedural blank will be analyzed with each batch of approximately 4–6 samples (8–12 individual assays). The procedural blank will consist of sterile, deionized water and all reagents used during extraction. It will be processed concurrently with a batch of samples. In addition, a filtration blank, consisting of an aliquot of sterile buffered dilution water will be processed through the membrane filtration procedure with each batch of samples. Blanks should have no growth of target or non-target organisms following incubation. Corrective action, such as reextraction and reanalysis will be taken as necessary, and all corrective actions will be documented.

Precision

Total Organic Carbon: The precision of TOC analysis will be measured by laboratory duplicates run at a frequency of 1 per batch of 20 samples. The R%D objective for duplicate analysis is $\leq$25%. The R%D will be calculated as described above from MS/MSD samples.

Grain Size: The precision of grain size analysis will be evaluated using laboratory triplicates. Triplicate analysis will be run at a frequency of 5%. The goal for these analyses will be a relative standard deviation (CV) of $\leq$20% for the individual fractions of sand, silt, and clay, if the component is >5% of the sample.

Microbiology: All samples will be extracted and analyzed in duplicate to increase the accuracy of the analytical result. To increase the precision of the number obtained by membrane filtration procedure, each dilution will be filtered in triplicate. For 10% of the assays performed, duplicate counts of the colonies will be conducted by two different analysts with a goal of $\leq$10% difference between counts.

Completeness

Completeness in the lab is assured as described in section 11.2.2 for sediment chemistry .

Comparability

Comparability of microbiological and physicochemical determinations will be ensured by using the same methods used previously in MWRA effluent and sludge samples, sediment samples from Boston Harbor and Massachusetts Bay, and on samples for other sewage disposal studies.

Representativeness

Sample integrity and representativeness can be ensured through proper sample collection and handling procedures and careful maintenance of acceptable sample storage conditions. In addition, thorough sample homogenization and filtration techniques will be employed, using acceptable methods to ensure that the material analyzed reflect the material collected as accurately as possible.

Table 10. Sediment Chemistry Analytes and Target Method Detection Limits (MDL).

Analyte	MDL[1]
Physical Sediment Parameters	
Total organic carbon	.01%
Grain size	--
Sewage Tracers	
Clostridium perfringens	--
Coprostanol	--[2]
Fecal Coliform, *Enterococcus*	--
Linear alkyl benzenes[3]	
phenol decane	5
phenyl undecane	5
phenyl dodecane	5
phenyl tridecane	5
phenyl tetradecane	5
Metals	
Al Aluminum	2300
Fe Iron	6
Ag Silver	0.063
Cd Cadmium	0.058
Cr Chromium	9
Cu Copper	2
Hg Mercury	0.028
Ni Nickel	2
Pb Lead	2
Zn Zinc	2
Polychlorinated biphenyls[4]	
2,4-Cl_2(8)	0.075
2,2',5-Cl_3(18)	0.036
2,4,4'-Cl_3(28)	0.052
2,2',3,5'-Cl_4(44)	0.046
2,2',5,5'-Cl_4(52)	0.049
2,3',4,4'-Cl_4(66)	0.054
3,3',4,4'-Cl_4(77)	0.076
2,2'4,5,5'-Cl_5(101)	0.047
2,3,3',4,4'-Cl_5(105)	0.041
2,3',4,4'5-Cl_5(118)	0.053
3,3',4,4',5-Cl_5(126)	0.066
2,2',3,3,4,4'-Cl_6(128)	0.087
2,2',3,4,4',5-Cl_6(138)	0.044
2,2'4,4',5,5'-Cl_6(153)	0.066
2,2'3,3,4,4',5-Cl_7(170)	0.044
2,2',3,4,4',5,5'-Cl_7(180)	0.047
2,2',3,4,5,5',6-Cl_7(187)	0.043
2,2',3,3',4,4',5,6-Cl_8(195)	0.040
2,2',3,3'4,4',5,5',6-Cl_9(206)	0.040
Decachlorobiphenyl-Cl_{10}(209)	0.043
Polynuclear Aromatic Hydrocarbons[4] (PAH)	
naphthalene	3.14
C_1-naphthalenes	3.14
C_2-naphthalenes	3.14
C_3-naphthalenes	3.14
acenaphthylene	0.020
acenaphthene	0.025
fluorene	0.015
C_1-fluorenes	0.015
C_2-fluorenes	0.015
C_3-fluorenes	0.015
anthracene	0.019
phenanthrene	0.022
C_1-phenanthrenes/anthracene	0.022
PAH[4] (Continued)	
C_2-phenanthrenes/anthracene	0.022
C_3-phenanthrenes/anthracene	0.022
C_4-phenanthrenes/anthracene	0.022
dibenzothiophene	0.005
C_1-dibenzothiophenes	0.005
C_2-dibenzothiophenes	0.005
C_3-dibenzothiophenes	0.005
fluoranthene	0.019
pyrene	0.021
C_1-fluoranthenes/pyrenes	0.021
benzo(a)anthracene	0.021
chrysene	0.011
C_1-chrysene	0.011
C_2-chrysene	0.011
C_3-chrysene	0.011
C_4-chrysene	0.011
benzo(b)fluoranthene	0.030
benzo(k)fluoranthene	0.023
benzo(a)pyrene	0.029
dibenzo(a,h)anthracene	0.023
benzo(g,h,i)perylene	0.019
indeno(1,2,3-c,d)pyrene	0.013
perylene	0.020
biphenyl	0.030
benzo(e)pyrene	0.011
dibenzofuran	0.083
benzothiazole[3]	1.25
Pesticides[4]	
Hexachlorobenzene	0.041
Lindane	0.023
Heptachlor	0.057
Aldrin	0.029
Heptachlorepoxide	0.035
alpha-chlordane	0.033
trans-Nonachlor	0.037
Dieldrin	0.044
Endrin	0.046
Mirex	0.037
2,4'-DDD	0.049
4,4'-DDD	0.045
2,4'-DDE	0.061
4,4'-DDE	0.041
2,4-DDT	0.057
4,4'-DDT	0.042
DDMU	0.049

[1] μg/g dry weight for metals; ng/g dry weight for organic analytes (PCBs, PAHs, LABs, pesticides)
[2]Reporting limit to be determined
[3]Detection limits are reporting limits (RL) calculated from the low calibration standard and adjusted for sample processing factors. RL = (conc. in low std × final extract volume × dilution factor) ÷ (sample dry weight). Actual RLs will vary depending upon sample processing factors (*e.g.*, moisture content). Actual RLs will be reported with the data.
[4]MDL concentrations for PAHs, PCBs and Pesticides are based on surrogate corrected data. These MDLs are representative of year 2000 MDL study results. MDLs are updated annually, and are available on request. Batch-specific achieved MDLs will be reported with the data.

11.2.4 Sediment Profile Image Analysis

Accuracy
Control of the computer image analysis includes system preparation, actual image analysis, and data reduction. A set of standard instructions is followed in setting-up the image processor. These instructions include system warm-up time, video camera to slide distance, light table color check, and cleaning of lens and color filters. Once the system is on and functioning, a standardized scale slide is measured to insure the linear measurements made on the profile images are accurate.

Precision
Even with the most careful control on development there may be variation in either the film lots or processing that causes subtle color differences among slides. To correct for this problem, the first and last picture taken each field-day is of a standard color card (Macbeth Colorchecker™) with red, green, blue, white, and neutral gray densities. Examination of these color card images allows determination of any variation in color from day to day or film to film. Color variations then can be accounted for during the computer image analysis.

Completeness
Only established and reputable film processing laboratories will be used to develop film. All images will be analyzed.

Comparability
The comparability of the SPI analyses will be ensured by consistent application of QC procedures and by using the same analysts throughout the project whenever possible. The analyses will be comparable to those previously obtained for the MWRA program.

Representativeness
Not applicable.

11.2.5 Hardbottom Video and 35-mm Slide Analysis

Accuracy and Precision
Each slide will be projected and analyzed by Dr. Barbara Hecker. Data to be collected for each slide includes: primary and secondary substrate type, degree of sediment drape, estimated percent cover of crustose pink algae, estimated relative abundance of hydroids, spirorbid/barnacle complex, *Asparagopsis hamifera* and dulse, and counted abundance of other identifiable biota. Organisms will be identified to the lowest possible taxonomic level with the aid of pictoral keys. Taxa that can not be assigned to a species category will be assigned to general catagories (ie. anemone, fish).

Videotapes will be viewed for the range of substate characteristics, sediment drape, and habitat relief, and the occurrence of large identifiable taxa, at each waypoint. Encrusting, cryptic, or very abundant taxa will not be counted from the videotapes because of reduced visual resolution and time constraints.

Completeness
All still photographs and video images will be analyzed.

Comparability
The methods of collection and analysis of the still and video images are sufficiently similar to previous MWRA hardbottom studies to allow comparisons between the previously collected baseline data and the monitoring data to be collected. The method of analysis of the still photographs is identical to that used in previous MWRA hardbottom studies and will allow for direct comparisons. The method of analysis

for the video images is sufficiently similar to previous studies to allow qualitative comparisons.

Representativeness

Hardbottom biological assemblages are routinely documented using video and still photographs. For true representativeness the video footage and still photographs should be randomly located within waypoints to allow for unbiased extrapolation of the data for the area being sampled. Due to various technical constraints of working with an ROV, true randomness is rarely ever accomplished in hardbottom studies. The location of the photographic coverage is usually constrained by: strength of tidal currents determining the direction in which the ROV can maintain a heading, mobility of the ship during station occupation due to surface currents and wind, bottom visibility (moving in a down current direction frequently causes reduced visibility due to sediment clouds), bottom topography (going over every boulder could keep the ROV too far off bottom), tether length (the ROV could be at the end of the tether before the requisite footage has been collected), and the ROV needing to be a certain distance from the bottom to obtain usable still photographs. Within these constraints we will try to obtain representative visual images of each area.

The still photographs will be taken as randomly as possible within each video transect to assure that they are representative of the area surveyed. The still photographs will be the primary sample type, and the video footage will be used to supplement them. Due to the more 3-dimensional nature of the video footage, qualitative characterization of habitat relief and habitat and biotic heterogeneity is usually easier from the video footage. Additionally, the video footage covers more area and is thus used to document the occurrence of larger, more sparsely distributed fauna.

12.0 SAMPLING AND ANALYTICAL PROCEDURES

12.1 Navigation

Refer to the Water Column CW/QAPP (Albro *et al*., 1998) for a complete description of navigation procedures. Station logs used for this task are shown in Appendix A. Navigation data from NAVSAM™ will be used for reporting purposes.

During the hardbottom reconnaissance surveys, a DGPS and an ORE International LXT Underwater Positioning System will be used for positioning the vessel and the ROV. The Windows™-based software, HYPACK, will be used to integrate these positioning data and provide real-time navigation, including the position and heading of the vessel and the position of the ROV relative to the vessel.

12.2 Benthic Sample Collection/Shipboard Processing

Field samples collected and analytical methods are summarized in Tables 5 and 11, respectively. The numbers of field samples and the shipboard processing and storage requirements for all samples collected for the Benthic (Sea-Floor) Monitoring tasks are listed in Tables 12 (Harbor benthic surveys) and 13 (Outfall benthic surveys). At all stations, the station coordinates, time, sea state and other weather conditions, and water depth will be recorded by hand onto a field log. Any incidental observations of marine mammals also will be recorded on the log.

12.2.1 Grab Sample Collection

A 0.04 m^2, Young-modified van Veen grab sampler will be used to collect soft-bottom sediment samples for infaunal analysis. The 0.04-m^2 grab may also be used to collect samples for TOC, grain size and microbiology, provided that sufficient sample volumes can be obtained. A Kynar-coated 0.1 m^2 Young-modified van Veen grab sampler will be used to collect all soft-bottom sediment samples for chemical analyses (organic and inorganic).

Once the survey vessel is on station and coordinates have been verified, the sediment grab will be deployed. When slack in the winch wire indicates the grab is on the bottom, the grab and included sample will be brought back to the surface. Upon retrieval of the grab, the sample will be inspected for acceptability (see Section 11.1.2). If the sample is unacceptable, the grab will be emptied, rinsed, and redeployed.

If the sample is acceptable, the penetration depth, sediment volume, sediment texture, and depth of the apparent redox potential discontinuity will be visually estimated. The depth of the redox potential discontinuity will be estimated by using a syringe to withdraw a small core from the sample and measuring the depth (cm) of the uppermost portion of the black subsurface sediments. The material from the syringe will be returned to the grab for processing with the remainder of the sediment. The volume of the grab will be estimated by comparing the measured penetration depth with a prepared chart of penetration depths versus grab volumes (see box). These data will be recorded onto the field log.

Chart used to convert grab penetration depth to sediment volume.
0.04m^2 Van Veen Grab Sampler

Grab Penetration Depth (cm)	Sediment Volume (L)
3.5–4.0	1.0
5.0	1.5
6.0–6.5	2.0
7.0	2.25
7.5	2.5
8.0	2.75
8.5–9.0	3.0
> 9.5 (over penetration)	3.25

For the infaunal samples only, after these measurements are taken, the grab will be placed over a bucket, the jaws will be opened, and the sample emptied into the bucket. Filtered seawater will be used to gently wash the grab sampler into the bucket. Once thoroughly washed (if necessary), the grab will be redeployed until the required number of acceptable samples have been obtained for infaunal and/or chemical analysis.

Precautions will be taken during the deployment and retrieval of the grab sampler to prevent contamination of samples between stations. Sampling for infaunal, TOC and grain size determinations require the grab and associated sampling equipment to be washed and rinsed with soap and water. Samples taken for *C. perfringens,* fecal coliform and *Enterococcus* analysis require an addition rising with ethanol. To remove organic contaminants for samples collected for chemical analyses, the grab and associated sampling equipment must be cleaned with soap and water, and then rinsed with acetone, and methylene chloride. Liquid wastes resulting from the latter two rinses will be collected in appropriate containers and returned to the laboratory for proper disposal. Before the grab is retrieved, the vessel must be positioned so that the engine exhaust will not contaminate the sample when it has been brought on deck. The numbers of grab samples to be collected at each station for macrofaunal and/or chemical analyses are listed in Tables 12 and 13.

Table 11. Benthic Survey Sample Analyses.

Parameter	Lab	Unit of Measurement	Method	Reference
Infaunal Analysis	**Cove Corporation and Ocean's Taxonomic**	**Count/species (# per grab)**	**ID and Enumeration**	**Section 12.3.1**
Organic Analyses				
Linear Alkylbenzenes (LAB)	**Battelle**	**ng/g**	**GC/MS**	**Battelle SOP 5-157**
Polycyclic Aromatic Hydrocarbons (PAH)	**Battelle**	**ng/g**	**GC/MS**	**Battelle SOP 5-157**
Polychlorinated Biphenyls (PCB)/ Pesticides	**Battelle**	**ng/g**	**GC/ECD**	**Battelle SOP 5-128**
Coprostanol	**Battelle**	**ng/g**	**GC/MS**	**Battelle SOP 5-157**
Metals Analyses				
Major Metals (Al, Fe)	KLM	% Dry Weight	EDXRF	KLM Tech. Procedure 7-40.48 (formerly PNL-ALO-266)
Trace Metals (Cr, Ni, Pb, Zn, Cu)	KLM	μg/g	EDXRF	KLM Tech. Procedure 7-40.48 (formerly PNL-ALO-266)
Trace Metals (Ag, Cd, and Hg)	Battelle (Feb-Aug 1998 only)	μg/g	GFAA (Ag,Cd) CVAA (Hg)	Battelle SOP 3-103 Battelle SOP 5-224
Trace Metals (Ag, Cd, and Hg)	Sequim (August 1998 - present)	μg/g	ICP-MS (Ag, Cd) CVAA (Hg)	MSL-I-022-02 MSL-I-016-02
Trace Metals (selected - except Hg)	Sequim	μg/g	GFAA	MSL-I-029-00
Ancillary Physicochemical and Microbiological Parameters				
Total Organic Carbon (TOC)	Applied Marine Science	%C by dry weight	Coulometric Carbon Analyzer	AMS- TOC94
Sediment Grain Size	GeoPlan	% by weight	Stacked sieves on Fritsch Analysette vibrating table and pipette/settling procedures	Folk (1974)
Microbiology: *C. perfringens* *Fecal Coliform* *Enterococcus*	MTH Environmental	#organisms/g of dry weight sediment	Membrane filtration	Emerson and Cabelli (1982) Saad (1992) Messer and Dufour (1998) EPA 600/4-85/076 Bisson and Cabelli (1979)
SPI	Diaz and Daughters	varies (see Table 6)	varies	See Section 12.3.4
Hardbottom	Hecker Environmental	varies	varies	See Section 12.3.5

Table 12. Field Samples, Processing, and Storage for Boston Harbor Benthic Surveys.

Activity	Task 17.1 Harbor Traditional Survey	Task 17.2 Harbor Reconnaissance Survey (SPI)	Task 17.3 CSO Sediment Survey
Stations	8; T01–T08 (Table 1)	60; T01–T08; R02–R53 (Table 1)	14; To be determined
Weather/sea state/ bottom depth	Record general conditions; record bottom depth (0.5 m)	As for Task 17.1	As for Task 17.1
Marine mammals	Note incidental observations	As for Task 17.1	As for Task 17.1
Sampling: Gear	0.04 m^2 Young-modified van Veen grab sampler	Sediment profile camera	(0.1 or 0.04 m^2) Kynar coated Young-modified van Veen grab sampler
Sampling: Measurements	Record penetration (0.5 cm) and sediment volume (0.5 L)	Record prism penetration (0.5 cm)	As for Task 17.1
Sampling: Sediment texture	Describe qualitatively	Not Applicable (NA)	As for Task 17.1
Sampling: RPD depth	Record (0.5 cm)	Visual estimate	As for Task 17.1
Faunal Samples: Number	3 each station	3 images at each station	NA
Faunal Samples: Processing	rinse over 300-µm sieve; fix in 10% buffered formalin	check counter	NA
Faunal Samples: Storage	clean, labeled jar	NA	NA
Chemistry/Microbiology Samples (All): Number	1 each station (Microbiology, TOC, GS only)	NA	3 each station (Chemistry, Microbiology, TOC, GS)
Chemistry Samples (Organics): Processing	NA	NA	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize, and collect ~200 mL subsample
Chemistry Samples (Organics): Storage	NA	NA	Clean, labeled glass jar with teflon-lined cap; freeze (−20° C)
Chemistry Samples (Metals): Processing	NA	NA	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize, and collect ~200 mL subsample

Table 12. (continued)

Activity	Task 17.1 Harbor Traditional Survey	Task 17.2 Harbor Reconnaissance Survey (SPI)	Task 17.3 CSO Sediment Survey
Chemistry Samples (Metals): Storage	NA	NA	Clean, labeled teflon bottle; freeze (−20° C)
Chemistry Samples (Ancillary): Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~75-100 mL subsample for TOC and grain size	NA	As for Task 17.1
Chemistry Samples (Ancillary): Storage	Clean, labeled glass jar (freeze TOC, grain size, refrigerate)	NA	As for Task 17.1
Microbiology Samples: Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~75 mL subsample	NA	As for Task 17.1
Microbiology Samples: Storage	Sterile specimen cup; refrigerate at 1–4°C[1]. Deliver fecal coliform and Enterococcus to MTH within 24 h	NA	As for Task 17.1

[1] Clostridium perfringens may be stored frozen, but then must not be thawed until analyses are performed.

Table 13. Field Samples, Processing, and Storage for Outfall Benthic Surveys.

Activity	Task 18.1 Nearfield Benthic Survey	Task 18.2 Nearfield Contaminant Special Study	Task 18.3 Nearfield SPI Survey	Task 18.4 Nearfield Hardbottom Survey	Task 18.5 Farfield Benthic Survey
Stations	20 Nearfield (Table 2); FF10, FF12, FF13	4; located in depositional sites, NF08, NF22, NF24, FF10	20 Nearfield (Table 2); FF10, FF12, FF13	23 waypoints on 6 transects; T1, T2, T4, T6, T7, T8, T9, T10; diffuser #44 (Table 2)	8;(Table 2, except FF10, FF12, FF13)
Weather/sea state/ bottom depth	Record general conditions; record bottom depth (0.5 m)	As for Task 18.1	As for Task 18.1	As for Task 18.1	As for Task 18.1
Marine mammals	Note incidental observations	As for Task 18.1	As for Task 18.1	As for Task 18.1	As for Task 18.1
Sampling: Gear	Young-modified van Veen grab sampler	Young-modified van Veen grab sampler	Digital video camera coupled to 35-mm sediment profile camera	ROV equipped with video and 35-mm cameras	Young-modified van Veen grab sampler
Sampling: Measurements	Record penetration (0.5 cm) and sediment volume (0.5 L)	As for Task 18.1	record prism penetration	record ROV position, depth, heading	As for Task 18.1
Sampling: Sediment texture	Describe qualitatively	As for Task 18.1	Estimate from images (see Section 12.2.3)	Not Applicable (NA)	As for Task 18.1
Sampling: RPD depth	Record (0.5 cm)	As for Task 18.1	Estimate from images (see Section 12.2.3)	NA	As for Task 18.1
Faunal Samples: Number	3 each at stations NF12, NF17, NF24, FF10, FF12, FF13, 1 each at remaining stations	NA	3 each station	20 min video tape, 36 still photos per waypoint	3 at each station
Faunal Samples: Processing	rinse over 300-µm sieve; fix in 10% buffered formalin	NA	check counter; preview images within 24 h (see Section 12.2.3)	NA	As for Task 18.1
Faunal Samples: Storage	clean, labeled jar Ambient temperature	NA	NA	NA	As for Task 18.1
Chemistry/Microbiology Samples (All): Number	2 each at stations NF12, NF17, NF24, FF10, FF12, FF13, 1 each at remaining stations	3 at each station	NA	NA	2 at each station
Chemistry Samples (Organics): Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~200 mL subsample	As for Task 18.1	NA	NA	As for Task 18.1

Table 13. (continued)

Activity	Task 18.1 Nearfield Benthic Survey	Task 18.2 Nearfield Contaminant Special Study	Task 18.3 Nearfield SPI Survey	Task 18.4 Nearfield Hardbottom Survey	Task 18.5 Farfield Benthic Survey
Chemistry Samples (Organics): Storage	Clean, labeled glass jar with teflon-lined cap; freeze (−20° C)	As for Task 18.1	NA	NA	As for Task 18.1
Chemistry Samples (Metals): Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~200 mL subsample	As for Task 18.1	NA	NA	As for Task 18.1
Chemistry Samples (Metals): Storage	Clean, labeled teflon bottle; freeze (−20° C)	As for Task 18.1	NA	NA	As for Task 18.1
Chemistry Samples (Ancillary): Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~150 mL subsample for TOC and grain size	As for Task 18.1	NA	NA	As for Task 18.1
Chemistry Samples (Ancillary): Storage	Clean, labeled glass jar (TOC and grain size); freeze (TOC) refrigerate grain size	As for Task 18.1	NA	NA	As for Task 18.1
Microbiology Samples: Processing	Use Kynar-coated scoop to collect upper 0–2 cm from grab, homogenize and collect ~75 mL subsample	As for Task 18.1	NA	NA	As for Task 18.1
Microbiology Samples: Storage	Sterile specimen cup; refrigerate at 1–4°C[1]. Deliver fecal coliform and Enterococcus to MTH within 24 h	As for Task 18.1	NA	NA	As for Task 18.1

[1] *Clostridium perfringens* may be stored frozen, but then must not be thawed until analyses are performed.

12.2.2 Shipboard Processing of Grab Samples

At Harbor traditional stations and at all outfall stations, grab samples for infaunal analyses will be rinsed with filtered seawater through 300-μm mesh sieves. The samples retained on the screens will be transferred to labeled jars and fixed in 10% buffered formalin. Sieves will be washed between samples. The samples will be transferred to 70–80% ethanol as soon as they are received by the sorting laboratory to ensure that mollusks and other organisms with calcareous structures are not damaged by the slightly acidic formalin.

If the grab sample to be used for chemical analyses meets the acceptability criteria, the water overlying the sample will be siphoned from the grab and the surface sediment (0–2 cm) will be collected with a Kynar-coated scoop and transferred to a clean (rinsed with filtered water, acetone, and methylene chloride) glass bowl. The sediment will be thoroughly homogenized before being transferred to appropriate storage containers. About 200 mL of sediment for organic compound analysis will be placed into a clean, wide-mouth glass jar (250 mL) with a teflon-lined screw cap. About 200 mL of sample for metals analysis will be placed into a clean, teflon container. Approximately 75-100 mL subsamples for TOC and Grain Size will be placed into separate 150 mL wide-mouth glass jars. A subsample to be used for *Clostridium perfringens* analysis will be placed into a sterile specimen cup (½ to 3/4 full), labeled and refrigerated or frozen until analysis. During the CSO survey, additional subsamples taken for fecal coliform and *Enterococcus* analyses will be placed in separate sterile specimen cups (½ to 3/4 full). These samples will be labeled, refrigerated at 1–4°C, and sent to MTH Environmental within 24 hours of collection.

12.2.3 Sediment Profile Image Collection

The sediment profile camera system consists of a camera enclosed in a pressure-resistant housing, a 45° prism, and a mirror that reflects an image of the sediment through the camera lens. A strobe mounted inside the prism is used to illuminate the sediment. Prior to every field deployment all essential items are gathered and tested for proper operation. The camera/prism system is mounted in a cradle that is secured to a larger frame that ensures that the prism penetrates the sediment at a 90° angle. A winch is used to lower the entire assembly (at a consistent rate) to the seafloor. When the system is on the seabed, the penetration rate of the camera/prism assembly into the sediment is controlled by a hydraulic piston. Contact with the seabed triggers the camera. To permit proper penetration of the sediment by the prism, a brief time delay occurs between contact with the seafloor and the first exposure. The delay ranges from 1 second in soft mud to 15 seconds in hard sand. After the required number of exposures, the camera assembly is returned to the ship and an estimate of the prism penetration depth is made by visually measuring the displacement of a moveable sleeve placed on the camera assembly. A more accurate estimate will be obtained during subsequent laboratory analysis of the images.

The profile camera prism will be fitted with a digital video camera so that video and 35-mm cameras have the same view of the sediment profile. The video signal will be sent to the surface via cable so that prism penetration can be monitored and an initial impression of benthic habitat type can be formed. The initial evaluation will be done on the boat in real-time or between stations by an experienced senior scientist (Dr. Robert Diaz). The video signal will be recorded for later detailed evaluation and review.

The real time video image will be monitored on deck and recorded onto Hi8-mm tape. To check for subtle color differences due to lighting variation (prism video lights and ambient light) a standard color card (Macbeth Colorchecker™) with red, green, blue, white, and neutral gray densities will be place in front of the prism and recorded for 5–10 seconds between stations. From these color card images, variation in color can be monitored. Color variations then can be accounted for during the computer image analysis. The images are used to complete initial assessment of habitat changes resulting from

outfall discharges.

The video will be used to provide a "quick look" analysis within 24 hours of completing the field work. Parameters that will be evaluated in the quick look analysis are

- sediment grain size,
- sediment layering, thickness, and type,
- surface and subsurface fauna and structures,
- approximate prism penetration,
- approximate surface relief,
- approximate color RPD,
- general benthic successional stage, and
- other major, readily discernable patterns.

The results of this rapid review then will be communicated within two business days to MWRA via an e-mail summary of the survey. The combination of video and slide film will ensure accurate and reliable collection of SPI data. The video contributes the real-time assessment component, whereas the 35-mm film provides high-resolution image detail for full image analysis in the laboratory. The 35-mm film also allows for direct comparisons with historic profile camera data.

12.2.4 Hardbottom Video Tapes and 35-mm Slides

The annual ROV survey of the Nearfield hard bottom environment will examine a series of waypoints along transects. A MiniRover MK II ROV equipped with a Benthos low-light, high-resolution video camera and a Benthos Model 3782 35-mm minicamera with strobe, 150 W halogen lamps, a compass, and a depth gauge will be deployed from the survey vessel to obtain the necessary video and slides. The ROV will travel as close to the bottom as possible so that the clarity of the video and photographs is as good as conditions will allow. Approximately 20 minutes of video footage will be recorded along randomly-selected headings. Along this route, still photographs will be taken as randomly as possible until an entire (36 exposure) roll of 35-mm film has been exposed. At waypoints including an outfall diffuser, approximately 50% of the effort will be devoted toward documenting the diffuser itself and 50% toward documenting the seafloor nearby. The date, time, and water depth will be recorded on the videotapes and will appear on the video monitor during the recording. The time, depth and description of any identifying characteristics will be recorded for each photograph taken at the waypoints. The occurrence of the video taping and 35-mm slide exposure will be recorded as "event" on the NAVSAM™ system. The time that is displayed on the video monitor (and recorded on the tape) will be synchronized with the NAVSAM™ clock. When a still photograph is taken, the event will be marked on the NAVSAM™ system and marked verbally on the video tape. The NAVSAM™ will produce labels that will be attached to each video cartridge. Each roll of film will be labeled immediately after processing and slides will be manually labeled after they are mounted.

The video footage is compared in real-time to a summary of each waypoint from the previous year. This assures that we are in the same location and would also rapidly highlight any dramatic changes. Any readily observable changes will be communicated to MWRA via e-mail immediately following the cruise. This video comparison component provides real-time qualitative assessment, while the 35-mm slides provide high-resolution for a more detailed analysis. The 35-mm slides also allow for direct comparisons with the historical hardbottom data.

12.3 Laboratory Processing

Data will be recorded on project-specific data sheets (Appendix A) and entered into the computer application provided by Battelle.

12.3.1 Macrofaunal Analysis

All grab samples obtained on the Harbor benthic (Task 17) and Outfall benthic (Task 18) surveys for benthic faunal analysis will be shipped to Cove Corporation in Lusby, Maryland for sorting and taxonomic identifications. All acceptable grab samples will be processed.

Samples will be rinsed over 300-μm mesh screens to remove any broken-up mud casts and transferred to 70–80% ethanol for sorting and storage. To facilitate the sorting process, all samples will be stained in a saturated alcoholic solution of Rose Bengal at least overnight, but no longer than 48 hours to avoid over staining. After rinsing with clean alcohol, small amounts of the sample will be placed in glass dishes, and all organisms, including anterior fragments of polychaetes, will be removed and sorted to major taxonomic categories such as polychaetes, arthropods, and mollusks.

After samples have been sorted, the organisms will be sent to taxonomists for identification and enumeration. Identifications will be made at the lowest practical taxonomic level, usually species. Primary taxonomic responsibilities are

- Nancy Mountford (Cove)—Mollusks and Polychaetes
- Tim Morris (Cove)—Crustaceans and Polychaetes
- Russ Winchell (Ocean's Taxonomic, services obtained through Cove)—Oligochaetes

Dr. Roy Kropp (Battelle) will provide general oversight of the taxonomy performed for the Benthic (Sea-Floor) Monitoring studies.

12.3.1.1 Reference Collection

MWRA has established a project-specific reference collection. The reference collection is a valuable resource that will be used by project taxonomists to ensure comparability of the taxonomic identifications performed under HOM3 with those made under previous contracts. This collection will be inspected regularly to ensure that it is stored properly to reduce the risk of alcohol evaporation and damage, and to ensure that labels are intact and legible. Vials in which the alcohol level is low will be filled with clean alcohol. Any labels showing signs of deterioration will be replaced.

Specimens of any taxon not previously identified during the program will be added to the collection. As part of the maintenance of the reference collection, taxonomists will review any possible inconsistencies between previous identifications and those made during this project. The taxonomic status of species in the collection will be evaluated as relevant systematic revisions appear in the scientific literature. If necessary, recommendations for changes in taxonomic usages will be made to MWRA. The reference collection will be returned to MWRA upon submission of the final reference collection status report in June 2002.

12.3.2 Sediment Chemistry

The physical parameters and chemical analytes of interest are listed in Table 10.

Organic Chemical Analyses: Sediment samples will be extracted for PAH, LAB, chlorinated pesticides, and PCB by following Battelle SOP 5-192. This modification of EPA Method 3550 incorporates methods developed by Battelle for NOAA's National Status & Trends Mussel Watch Project (Peven and Uhler, 1993). Briefly, approximately 30 g of sediment will be serially extracted with dichloromethane (DCM) and sodium sulfate using shaker table techniques. A 10-g aliquot of the original sample will also be taken for dry weight determination. The sample will be weighed into a Teflon extraction jar and spiked with surrogate internal standards, solvent will be added, the jar will be shaken for the appropriate amount of time, and the sample will be centrifuged. The extract will be decanted into an Erlenmeyer flask. After each extraction (total of three solvent additions) the filtered solvent will be combined in the flask. The combined extracts will be processed through a 2% deactivated alumina column, concentrated to 900 μL in a Kuderna-Danish apparatus and under nitrogen. The concentrated extract will be further cleaned using size-exclusion high-performance liquid chromatography (HPLC). This procedure will remove common contaminants which interfere with instrumental analysis, including elemental sulfur. The post-HPLC extract will be concentrated to approximately 1 mL under nitrogen and the recovery internal standards (RIS) will be added to quantify extraction efficiency. The final extract will be split for analysis, one half remaining in DCM for PAH and LAB analysis, and the other half solvent-exchanged with isooctane for PCB and pesticide analysis.

Sample extracts will be analyzed for PAH and LAB compounds by gas chromatography mass spectrometry (GC/MS) operating in the selected-ion-monitoring (SIM) mode using a 60-m DBS-MS column and a Hewlett Packard 5972 or 5973 detector (SOP 5-157). Concentrations of LAB compounds will be determined as five separate LAB groups (those with alkyl chains containing 10, 11, 12, 13, and 14 carbon atoms, primary ion-m/*z* 91). LABs will be quantified versus the surrogate internal standard 1-phenylnonane.

Pesticides and PCB congeners will be analyzed and quantified using gas chromatography/electron capture detection (GC/ECD) (Hewlett Packard 5890 Series 2 GC) using a 60-m DBS column and hydrogen as the carrier gas following Battelle SOP 5-128, including a second column for confirmation. Concentrations for all target analytes will be determined by the method of internal standard, using surrogate internal standards (SISs) for quantification.

All PAH, LAB, PCB and pesticide results will be reported in ng/g dry weight.

Trace Metals: Sediment samples analyzed for the trace metals Ag, Cd, and Hg will be digested using an aqua regia according to Battelle SOP MSL-I-006-00 *Aqua Regia Sediment and Tissue Digestion*. To prepare samples for metals analysis, samples are first freeze-dried and homogenized in a ball-mill. A 200- to 300-mg aliquot of each dried, homogeneous sample is combined with aqua regia (nitric and hydrochloric acids at a ratio of 5.0 mL:3.5 mL) in a Teflon bomb and heated in an oven at 130 ºC (±10 ºC) overnight. After heating and cooling, deionized water is added to the acid-digested sediment to achieve analysis volume and the digestates are submitted for analysis.

Alternatively, in cases where hydrochloric acid in the digestion procedure can be found to cause chloride interferences with certain metals during ICP-MS analysis, sediment samples may be processed using a nitric acid-only digestion procedure, Battelle SOP MSL-I-005-01 *Hot Nitric Acid Digestion of Sediments and Tissues*. An approximately 200-mg aliquot of each dried, homogeneous sediment sample and nitric acid are combined in a glass vial. The vials are loosely capped and heated on a hot plate at a temperature just high enough to boil the acid, without boiling over or evaporating the sample to dryness. After

heating and cooling, deionized water is added to the acid-digested sediment to achieve analysis volume and the digestates are submitted for analysis.

CVAA Analysis of Hg - Sample digestates will be analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016-02 *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*, which is based on EPA Method 245.5 *Determination of Mercury in Sediments by Cold Vapor Atomic Absorption Spectrometry* (EPA 1991a). The CVAA will be calibrated according to the SOP. Acceptance criteria for the calibration are listed in Table 14. Results are reported in units of µg/g on a dry-weight basis.

Table 14. Laboratory Instrument Calibration Procedures.

Parameter	Instrument Type[a]	Initial Calibration			Continuing Calibration		Corrective Action
		No. Stds	Acceptance Criteria	Frequency	Acceptance Criteria	Frequency	
PAH/LAB Coprostanol	GC/MS	≥5	RSD ≤25% mean RSD ≤15%	Prior to analytical run	PD from initial ≤25%; mean PD ≤15%	every 10 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
PCB/ Pesticide	GC/ECD	≥5	r ≥ 0.995	Prior to analytical run	PD from true value ≤25%; mean PD ≤15%	every 10 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
Metals	CVAA (Hg);	≥3 (5)	r ≥0.995	Prior to analytical run	PD ≤15% of initial	every 10 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
	ICP-MS (Ag, Cd)	≥3 (4)	r ≥0.995	Prior to analytical run	PD ≤15% of initial	every 10 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
	GFAA (as required)	≥3	r ≥0.995	Prior to analytical run	PD ≤15% of initial	every 10 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
	EDXRF	≥ 1	<10%	Prior to analytical run	PD ≤10%	every 16 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
TOC (Sediment)	Coulometric Carbon Analyzer	3	5% R%D from known value	weekly	5% R%D	every 20 samples	Remedial maintenance, new initial calibration, or reanalyze samples. Document and justify.
Grain Size	Analytical Balance, Thermometers	NA	Manufacturers specifications	Annually	NA	daily	Recalibrate
Microbiology: *C. perfringens* Fecal Coliform *Enterococcus*	Thermometers Incubators	NA	Manufacturers specifications	Annually Temperature checked daily	NA	daily	Recalibrate

NA: Not Available.
[a] Analytical procedures are described in Section 12.0 and listed in Table11.

ICP-MS Analysis of Ag and Cd - For analysis of multiple metals simultaneously, sample digestates will be analyzed for Ag and Cd using inductively coupled plasma - mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022-02 *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. This procedure is based on two methods modified and adapted for analysis of solid sample digestates, EPA Method 1638 *Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma - Mass Spectrometry* (EPA 1996) and EPA Method 1640 *Determination of Trace Elements in Water by Preconcentration and Inductively Coupled Plasma - Mass Spectrometry* (EPA 1997). The ICP-MS will be calibrated according to the SOP. Acceptance criteria for the calibration are listed in Table 14. Results are reported in units of µg/g on a dry-weight basis.

GFAA Analysis of Selected Metals - Sample digestates may also analyzed by graphite furnace atomic absorption (GFAA) when analysis of a single element (except Hg) is required. GFAA analysis will be conducted according to Battelle SOP MSL-I-029-00 *Determination of Metals in Aqueous and Digestate Samples by GFAA*. This procedure is based on EPA Method 200.9 *Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry* (EPA 1991b). The GFAA will be calibrated according to the SOP. Acceptance criteria for the calibration are listed in Table 14. Results are reported in units of µg/g on a dry-weight basis.

EDXRF - Laboratory analysis of major metals Al and Fe, and trace metals Cr, Ni, Pb, Zn and Cu will be performed by KLM Laboratories using acquisition and data reduction procedures described in, and in compliance with, KLM Technical Procedure KLM 7-40.48 (formerly PNL-ALO-266). The received sample will be transferred to Teflon beakers and dried at 105 °C for 24 hours. The total received sample then will be homogenized and approximately 500 mg of the resultant material will be ground to smaller than 300-μ mesh size for data acquisition. The samples probably will be presented to the analytical system as loose powders supported by para-film. Samples are prepared to fill the sensitive area viewed by the x-ray detector as to provide maximum count-rate. A USGS NIST matrix standard is placed in position 1 of 16. The remaining 15 positions generally are filled with at least one more NIST, USGS, or, NRCC standard and one field sample duplicate. The KEVEX 0810A and kevex-ray high voltage generator are set to computer control and the acquisition program is activated to acquire data on 17 samples. The standard mounted in position #1 is acquired at the start and end of each acquisition run. The spectral data from position 1, the inclusive standard, and duplicate field sample provide internal QA for the laboratory.

12.3.3 Physicochemical and Microbiological Parameters

Total Organic Carbon: Samples are processed and analyzed by AMS according to SOP AMS - TOC94. Sediment samples for TOC analysis will be removed from the refrigerator just prior to drying. A portion of the sample will be dried at 70°C for 24 to 36 hours and ground to a fine powder. The sample will be treated with 10% HCl to remove inorganic carbon and dried at 70° for 24 hours. Between 10 and 500 mg of dry, finely ground, and homogenized sample will be weighed to the nearest 0.1 mg and placed in a crucible that has been precombusted for 4 hours at 500°C.

The analyzer operates through the high-temperature conversion of all carbon in the treated sample to carbon dioxide in the presence of oxygen. The carbon dioxide is quantified by coulometric detection.

Sediment Grain Size: Samples will be analyzed for grain size by a sequence of wet sieving and dry sieving. Methodologies will follow Folk, 1974. Samples will be prepared by first splitting the individual sediment samples into the appropriate size for analysis. If sufficient sample material is available, optimal sample size will be 30 dry grams of mud and at least 70 dry grams of sand. The sample will be mixed by hand in 200 mL of a 5% solution of dispersant (sodium hexametaphosphate) to loosen clays. The mixture will be left for at least 12 hours and mixed by hand a second time. A 3% hydrogen peroxide

solution will be mixed and left at least 12 hours. This procedure will be repeated if necessary. The wash load, which contains the silt and clay fractions, will be transferred to a 1000-mL cylinder, topped to 1000 mL with deionized water, and covered. The material retained on the sieve is the sand and gravel fractions. This coarse load will be transferred to a 200-mL beaker, decanted, and dried overnight at 95°C.

The dried sand and gravel fraction will be mixed by hand to disaggregate the material, and then dry-sieved using the following six sieve sizes:

Millimeters	2	1	0.5	0.25	0.125	0.0635
Phi Units	–1.0	0.0	1.0	2.0	3.0	4.0
U.S. Standard Sieve Mesh #	10	18	35	60	120	230

Stacked sieves will be placed on a Fritsch Analysette vibrating table for 10 minutes. Material retained on the 0-, 1-, 2-, 3-, and 4-phi sieves will be considered the sand fraction. Particles smaller than 4 phi will be analyzed using the pipette method described below. Each size class will be weighed to the nearest 0.1 mg on a top-loading balance.

The mud (silt + clay) fraction will be analyzed using the pipette method. The procedure is based on Stokes Law, which computes sediment settling velocity. The sample in the cylinder will be mixed to fully and uniformly suspend the sediment in the cylinder. When the mixing stops, settling of mud will begin and the time will be recorded. Within the first 20 seconds of settling, a 25-mL aliquot will be removed by pipette from a depth of 20 cm and emptied into a pre-weighed (based on an average of at least three weighings) 50-mL beaker. Twenty-five milliliters of deionized water then will be drawn into the pipette and emptied into the beaker to wash out any sediment inside the pipette. This sample will represent the total mud fraction of the sample. The beaker will be dried overnight at 95°C and weighed to the nearest 0.1 mg. The total mud weight will be determined by subtracting the beaker weight and multiplying by 40 (25 mL × 40 = 1000 mL, total sample volume). A second withdrawal will be made at the time when all silt-sized (coarser than 8 phi) material has settled below the depth of the pipette. This withdrawal can be made at any depth, as long as the settling times are properly computed according to Stokes Law. According to calculations based on Stokes Law, at 10-cm depth this withdrawal time should occur at 2 hours, 3 minutes after mixing stops, and at 20-cm depth at about 4 hours, 5 minutes after mixing stops (Folk, 1974). Data will be presented in weight percent by size class. In addition, the gravel:sand:silt:clay ratio and a numerical approximation of mean size and sorting (standard deviation) will be calculated. A cumulative frequency curve of the data may be prepared using phi units.

*Microbiological Parameters: A*nalysis of sediment samples for *Clostridium perfringens*, Fecal Coliform, and *Enterococcus* will be performed by MTH Environmental Associates. Sediment extraction methods will follow methods developed by Emerson and Cabelli (1982) as modified by Saad (1992). Briefly, samples will be homogenized, and an aliquot of known weight transferred to a sterile 50-mL polypropylene centrifuge tube. Sterile sodium hexametaphosphate solution will be added to the sample, and the tube will be capped and mixed thoroughly for 10–15 seconds. Sterile deionized water will be added, the sample remixed, and allowed a to settle for 10 minutes. The supernatant will be removed from the tube with a sterile pipette and placed in a sterile test tube. The tubes will be stored on ice and analyzed within 30 minutes.

Analysis of the supernatant will be performed by membrane filtration. Enumeration of *C. perfringens* spores will follow the method of Bisson and Cabelli (1979). Enumeration of fecal coliform and

Enterococcus are described in the EPA method 600/4-85/076 (EPA, 1985) with the modification to the *Enterococcus* method discussed below. The extract will be filtered through a sterile, 0.45-μm pore size, gridded membrane filter that retains the bacteria. After filtration, the membrane containing the bacterial cells will be placed on a selective-differential medium and incubated.

The filters for enumeration of *C. perfringens* spores will be incubated anaerobically at 44.5 °C for 24 hours. Following incubation, the filter will be exposed to ammonium hydroxide for 15–30 seconds. Yellowish colonies that turn red to dark pink upon exposure will be counted as *C. perfringens*.

Filters to be enumerated for fecal coliform will be incubated at 35 °C for 2 hours, followed by incubation at 44.5 °C for 18–20 hours. Yellow colonies will be counted and recorded as fecal coliform.

Following filtration, filters for *Enterococcus* enumeration will be incubated for 24 hours at 41 °C following the procedure of Messer and Dufour (1998). This modification of the procedure described in EPA (1985) eliminates the need for the transfer of the filter to EIA agar and shortens the incubation time.

12.3.4 Sediment Profile Image Analysis

12.3.4.1 General Approach

Post field analysis will continue with a reanalysis of the video tapes previously examined in the field and the processing of the 35-mm film. After the film is processed (within 24 hours of completion of the field work), a visual analysis including the same parameters as estimated from the video SPI will be conducted. These data will be combined with the video data and the final rapid "quick look" analysis will be completed within 24 hours of film development.

After the film is developed, each slide will be labeled with station and replicate data. The first analytical step is accomplished visually by projecting the images and recording all observed features into a preformatted, standardized spread sheet file. The video tapes also are analyzed visually, with all observed features also recorded into a preformatted, standardized spreadsheet. The sediment profile images are digitized by a commercial processor into Kodak Photo CD format. Adobe Photoshop™ is used to preprocess the images (enhancements, color balance, etc.). Computer images will be analyzed by using a Power Macintosh microcomputer and NIH Image, the National Institutes of Health image analysis program. Computer analysis procedures for each image are standardized by executing a series of macro commands. Data from each image are saved sequentially to an ASCII file for later analysis and reduction via Microsoft Excel™.

The actual image analysis is done through a series of macro commands executed from a video screen menu. After every step the analyst is asked if the results are satisfactory and given the chance to redo any step. While the computer will always examine a slide the same way, the operators do not, which results in slight variation of image areas analyzed within and between slides. To control for operator error, 10% of all slides will be reanalyzed and compared to previous results.

During the image analysis session, two computer files are opened to receive that data from each image. One file includes all computer executed statements and the resultant data. This file is archived and can be accessed should any questions arise as to how the analysis of any particular slide was conducted. A second file that includes only the selected image data to be used in reports is generated at the same time. After computer analysis, all slides are put into the SPI photo archives for future reference.

12.3.4.2 Specific Parameter Analyses

The importance and usefulness of the data produced from analysis of profile images are described below. Further details about these analyses can be found in Kiley (1989) and in the standardized image analysis procedures of Viles and Diaz (1991).

Prism penetration provides a geotechnical estimate of sediment compaction, with the profile camera prism acting as a dead weight penetrometer. The further the prism enters into the sediment the softer the sediments, and likely the higher the water content. Penetration is measured simply as the distance the sediment moves up the 25-cm length of the face plate. If the weight of the camera frame is not changed during field image collection then the prism penetration provides a means for assessing the relative sediment compaction between stations or different habitat types. By taking two exposures, at 10 second intervals, per deployment the camera can record overlapping photographs of the sediment as the prism penetrates. Penetration as deep as 27 cm has been obtained (18 cm in the 4-second image and an additional 9 cm in the 14-second image) on other studies using this technique. Deep prism penetration is indicative of recent rapid sediment accumulation where sediments have not had the time to dewater.

Surface relief is measured as the difference between the maximum and minimum distance the prism penetrates. This parameter provides an estimate of small-scale bed roughness, on the order of the prism face plate width (15 cm). The causes of roughness often can be determined from a visual analysis of the images. In physically dominated sandy habitats, surface relief typically consists of small sand waves or bed forms. In muddy habitats, surface relief is typically irregular (being primarily derived from biological activity of benthic organisms, which form mounds or pit during feeding and burrowing) or smooth. Biological surface roughness can range from small fecal mounds and tubes to large colonies of hydroids or submerged aquatic vegetation (SAV). Surface relief provides qualitative and quantitative data on habitat characteristics, which can be used to evaluate recent and existing habitat quality.

Apparent color redox potential discontinuity (RPD) layer is an important estimator of benthic habitat quality. It is the depth to which sediments are oxidized. The term apparent is used in describing this parameter because no actual measurement is made of the redox potential. An assumption is made that, given the complexities of iron and sulfate reduction-oxidation chemistry, reddish-brown sediment color tones are indications that the sediments are oxic, or at least are not intensely reducing (Diaz and Schaffner, 1988). This is in accordance with the classical concept of RPD depth, which associates it with sediment color (Fenchel, 1969).

The depth of the apparent color RPD is defined as the area of all the pixels in the image discerned as being oxidized divided by the width of the digitized image. The area of the image with oxic sediment is obtained by digitally manipulating the image to enhance characteristics associated with oxic sediment (greenish-brown color tones). The enhanced area then is determined from a density slice of the image or, if image quality is poor, the area is delineated with the cursor.

The apparent color RPD is very useful in assessing the quality of a habitat for epifauna and infauna from physical and biological perspectives. Rhoads and Germano (1986), Day *et al.* (1988), and Diaz and Schaffner (1988) found the depth of the RPD from profile images to be directly correlated to the quality of the benthic habitat in polyhaline and mesohaline estuarine zones. Thin RPDs, on the order of a few millimeters, tend to be associated with some environmental stress, whereas areas with deep RPDs, deeper than 3 cm, usually were found to have flourishing epibenthic and infaunal communities.

Sediment grain size is a geotechnical feature of the sediments that is used to determine the type of sediments present. The nature of the physical forces acting on a habitat can be inferred from grain-size distribution of the sediments. The sediment type descriptors used follow the Wentworth classification as

described in Folk (1974) and represent the major modal class for each layer identified in an image. Grain size is determined by comparison of collected images with a set of standard images made of sediments for which mean grain size has been determined by laboratory analyses. Sediment grain sizes ranging from pebble/rock to gravel, to sand, to silt, and clay can be estimated accurately from the images.

Surface features include a variety of physical and biological features that can be seen at or on the sediment surface. These can range from SAV, worm tubes, fecal pellets, epibenthic organisms, bacterial mats, algal mats, shells, mud clasts, bed forms, to feeding pits and mounds. Each feature provides information on the type of habitat and its quality. Certain surface features are indicative of the overall nature of a habitat. For example, bedforms are always associated with physically dominated habitats, whereas worm tubes or feeding pits are indicative of a more biologically accommodated habitat (Rhoads and Germano, 1986; Diaz and Schaffner, 1988). Surface features are visually evaluated from each slide and compiled by type and frequency of occurrence.

Subsurface features include a variety of features such as burrows, water filled voids, SAV rhizomes , infaunal organisms, gas voids, shell debris, detrital layers, and sediment lenses of different grain size. Subsurface features also reveal a great deal about the physical-biological control occurring in a habitat. For example, the presence of gas voids with a mixture of nitrogen and methane from bacterial metabolism (Reineck and Singh, 1975) has been found to be an indication of anaerobic metabolism (Rhoads and Germano, 1986) and associated with high rates of bacterial activity. Muddy habitats with large amounts of methane gas are generally associated with areas of oxygen stress or high organic loading (Day *et al*., 1988). On the other hand, habitats with burrows, infaunal feeding voids, and/or visible infauna are generally more biologically accommodated and considered unstressed.

Successional stages of the fauna in a habitat can be estimated by using SPI data (Rhoads and Germano, 1986). Characteristics that are associated with pioneering or colonizing (**Stage I**) assemblages (in the sense of Odum, 1969), such as dense aggregations of small polychaete tubes at the surface and shallow apparent RPD layers, are easily seen in sediment profile images. Advanced or equilibrium (**Stage III**) assemblages also have characteristics that are easily seen in profile images, such as deep apparent RPD layers and subsurface feeding voids. **Stage II** is intermediate to Stages I and III, and has characteristics of both (Rhoads and Germano, 1986).

12.3.5 Hardbottom Video Tapes and 35-mm Slides

The 35-mm film will be mounted, labeled (cruise, date, roll number, frame number, and waypoint), and scanned onto CD immediately after the cruise. The slides will then be transferred to Dr. Barbara Hecker for analysis.

Each slide will be projected and analyzed for habitat characteristics and biota. These include:

- primary and secondary substrate
- degree of sediment drape
- estimated percent cover of crustose pink algae(previously identified as *Lithothamnion* spp.)
- relative abundance of hydroids, spirorbid/barnacle complex, *Asparagopsis* and dulse
- occurrence and abundance of all recognizable taxa.

Data collected from the slides are numerically coded and entered directly into a Macintosh computer using a customized FoxBase data entry form. At this point the data are stored in a condensed Foxbase database. At the end of analyzing the slides from each waypoint, the condensed database is proofread for

typographical errors. Once all of the slides have been analyzed the database is run through a series of customized programs to produce an expanded database in Microsoft Excel format. Summaries for each waypoint are then generated and again proofread. If errors are found, the slides from that waypoint are rechecked. The expanded database and summaries are then transferred to Battelle for data management and retained for data analysis.

The video footage from each waypoint is viewed immediately after the stills from that waypoint are analyzed. This allows for cross-referencing between the greater areal coverage of the video and the higher visual resolution of the stills. The video footage is initially viewed once for habitat characteristics and heterogeneity (substrate types, sediment drape, habitat relief) and then a second time for biotic components. The data from the video footage is collected on data sheets and then transferred into an Excel database.

13.0 SAMPLE CUSTODY

Sample custody will be maintained through station logs (Figure 5), laboratory record books, chain-of-custody (COC) forms for benthic samples (Figure 6) and SPI field data sheets (Appendix A). All original SPI field data sheets and associated film (video and 35 mm) will be generated by and remain in the custody of the senior scientist from Diaz and Daughters. Similarly, all data from the yearly ROV surveys will be generated and maintained by Barbara Hecker. The Field Sample Custodian (Chief Scientist) will maintain custody of all sediment chemistry and infaunal samples onboard the vessel. The Field Sample Custodian or his designate will record event information such as station, location, sampling time, water depth, and weather and sea conditions (wind direction, sea state, etc.) in the field log book.

A unique eight character *Sample ID* which is a concatenation of a five character *Event ID* and a three-character hexadecimal number (*Marker No*) will identify samples collected in the field. The *Sample ID* will identify the sediment collected from the grab during a particular station on the specified survey. The five character *Event ID* will be unique to each survey, such as BF982, with "BF" indicating that it is a Farfield benthic survey, "98" indicating the survey year, and "2" signifying the second survey of the year. The *Marker No* is a non-repeating number generated by the NAVSAM software during the closing of the grab.

Each portion of a sample separated for analytical purposes will be assigned a unique *Bottle ID*, composed of the eight–character *Sample ID* plus a 3–character suffix designating the sample type and replicate number. For example, "FA1" indicates that the subsample is the first replicate for "infauna" analyses (see Table 15 for the two letter codes). All data reporting will be keyed to Battelle's sample identification scheme. Note that for SPI data (analysis codes RS and SP) and hardbottom data (analysis codes BV and BP) there is no physical sample, so no sample or bottle records will be reported to MWRA.

During field collection, COC forms will be completed and labels will be affixed to the sample containers, thereby creating a link between the sample and data recorded on the COC form. The COC forms will have an identical label containing the same alphanumeric code as the corresponding label on the sample container, ensuring the tracking of sample location and status.

STATION LOG

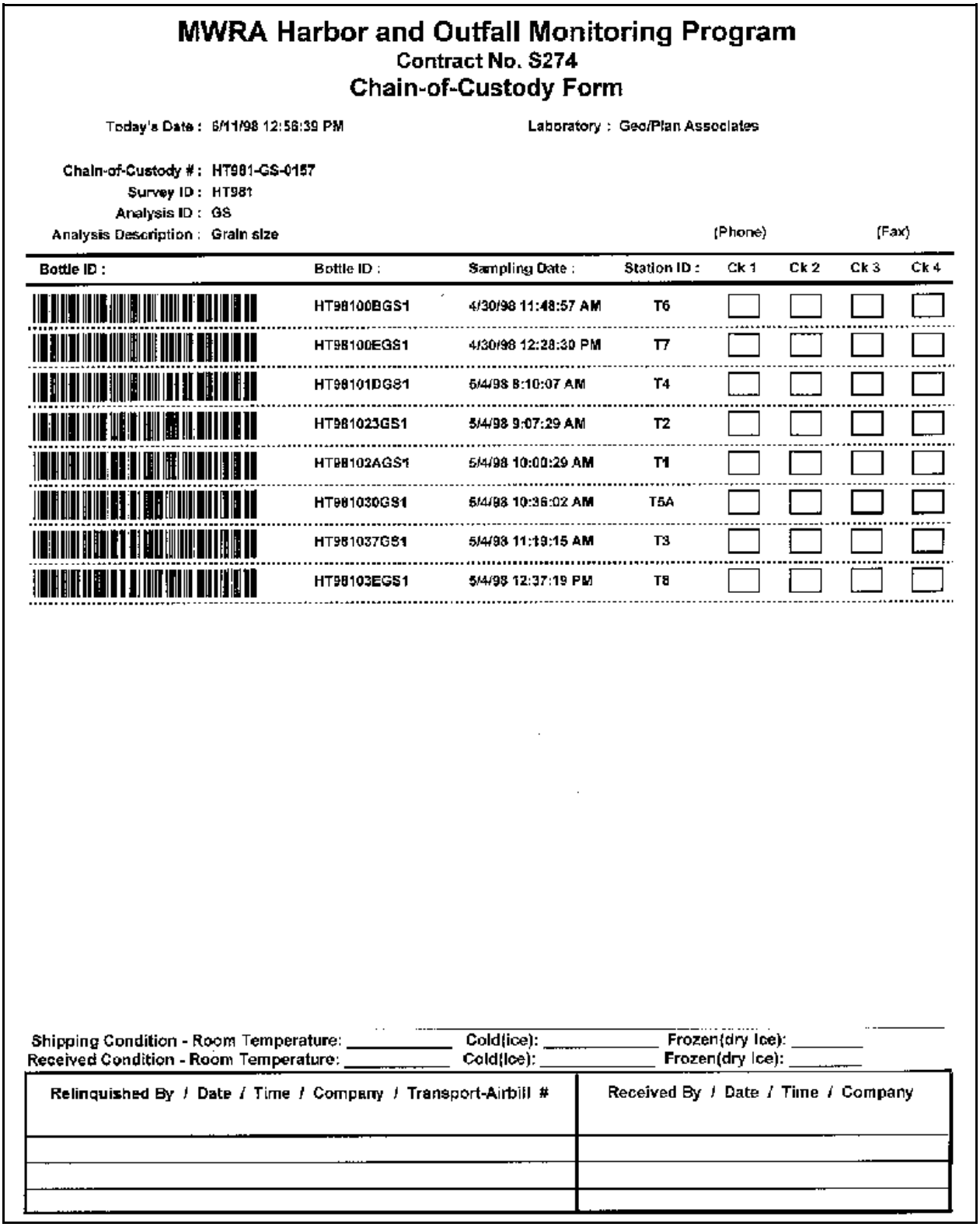
For Benthic Sediment Grab Samples

Project Name: Harbor and Outfall Monitoring — MWRA Contract No. S274

Survey: Harbor-Traditional Date: April 1998 Weather: Seas:	Comments: Recorded By:
Station: Date: Time:	Grab Penetration:
Grab No.: Depth:	Sediment Volume:
Event_ID:	Redox Depth:
Marker_No:	Comment:
Latitude:	
Longitude:	
Protocol: Lab: Sampled By:	
Station: Date: Time:	Grab Penetration:
Grab No.: Depth:	Sediment Volume:
Event_ID:	Redox Depth:
Marker_No:	Comment:
Latitude:	
Longitude:	
Protocol: Lab: Sampled By:	
Station: Date: Time:	Grab Penetration:
Grab No.: Depth:	Sediment Volume:
Event_ID:	Redox Depth:
Marker_No:	Comment:
Latitude:	
Longitude:	
Protocol: Lab: Sampled By:	
Station: Date: Time:	Grab Penetration:
Grab No.: Depth:	Sediment Volume:
Event_ID:	Redox Depth:
Marker_No:	Comment:
Latitude:	
Longitude:	
Protocol: Lab: Sampled By:	
Station: Date: Time:	Grab Penetration:
Grab No.: Depth:	Sediment Volume:
Event_ID:	Redox Depth:
Marker_No:	Comment:
Latitude:	
Longitude:	
Protocol: Lab: Sampled By:	

PLEASE RETURN THE ORIGINAL OF THIS COMPLETED STATION LOG FORM TO HEATHER TRULLI-BATTELLE

Figure 5. Example of a Station Log Form.



MWRA Harbor and Outfall Monitoring Program

Contract No. S274

Chain-of-Custody Form

Today's Date : 6/11/98 12:58:39 PM

Laboratory : Geo/Plan Associates

Chain-of-Custody # : HT981-GS-0157
Survey ID : HT981
Analysis ID : GS
Analysis Description : Grain size

(Phone) (Fax)

Bottle ID :	Bottle ID :	Sampling Date :	Station ID :	Ck 1	Ck 2	Ck 3	Ck 4
	HT98100BGS1	4/30/98 11:48:57 AM	T6				
	HT98100EGS1	4/30/98 12:28:30 PM	T7				
	HT98101DGS1	5/4/98 8:10:07 AM	T4				
	HT981023GS1	5/4/98 9:07:29 AM	T2				
	HT98102AGS1	5/4/98 10:00:29 AM	T1				
	HT981030GS1	5/4/98 10:36:02 AM	T5A				
	HT981037GS1	5/4/98 11:19:15 AM	T3				
	HT98103EGS1	5/4/98 12:37:19 PM	T8				

Shipping Condition - Room Temperature: _____ Cold(ice): _____ Frozen(dry Ice): _____
Received Condition - Room Temperature: _____ Cold(Ice): _____ Frozen(dry Ice): _____

Relinquished By / Date / Time / Company / Transport-Airbill #	Received By / Date / Time / Company

Figure 6. Example of a Chain-of-Custody Form.

Transfer of benthic chemistry and infaunal samples will be documented on the chain-of-custody forms. All samples will be distributed to the appropriate laboratory personnel by hand or by Federal Express. A copy of the COC will be retained by the field sample custodian in the Field Log. The original will accompany the samples to the laboratory for subsequent sample transfer. When samples arrive at each of the laboratories, custody will be relinquished to the Laboratory Custodian. Upon receipt of the samples at Battelle or its subcontractors, the Sample Custodian will examine the samples, verify that sample-specific information recorded on the COC is accurate and that the sample integrity is uncompromised, log the samples into the laboratory tracking system, complete the custody forms, and sign the COC form so that transfer of custody of the samples is complete. Any discrepancies between sample labels and transmittal forms, and unusual events or deviations from the project CW/QAPP will be documented in detail on the COC and the Task Leader and Project Manager notified. The receiving lab will return the signed original custody form along with the data report for those samples. Sample numbers that include the complete field ID number will be used to track the samples through the laboratory.

Field custody of electronic data will be the responsibility of the survey chief scientist. This person will be identified for each survey. The field custody of the electronic data consists of creating floppy-disk backups of all electronic data generated each day. Each floppy disk label will include a survey ID, date, name of person creating the backup files, and a disk number. When the equipment is returned to Battelle, a second complete backup labeled as “Set 2", will be generated on floppy disks. The backup will be in the custody of Mr. Trulli. The survey chief scientist maintains the original.

Table 15. Analysis Codes Used in *Bottle ID*.

Analysis Code	Description	Laboratory
RS	Rapid SPI Analysis	Diaz
TC	TOC	AMS
GR	Granulometry	GeoPlan
CL	Clostridium	MTH
LA	LAB	Battelle
MM	Major metals	KLM
TM	Trace metals	Battelle
PB	PCB	Battelle
PA	PAH	Battelle
PE	Pesticides	Battelle
CO	Coprostanol	Battelle
FE	Fecal coliform	MTH
EN	Enterococcus	MTH
FA	Infauna	Cove
SP	SPI Data	Diaz
BV	Benthic Hardbottom Video	Hecker
BP	Benthic Hardbottom Photos	Hecker

Battelle and several subcontractors will produce electronic data under this task. At Battelle, the electronic files for chemical data will remain in the custody of the analysts until all analyses are completed and data have gone through the Battelle Quality Assurance Unit. The data will be entered into a loading application that contains the data integrity checks for the EM&MS. Two copies of each type of electronic file will be made. Set 1 will remain in custody of the Senior Scientist in the Task notebook. Set 2 will be transferred to the HOM3 Database Manager for entry into the MWRA database. Data custody will follow the sample procedures at subcontractor laboratories, with the exception that a third set may be made and held by the subcontractor Senior Scientist.

14.0 CALIBRATION PROCEDURES AND PREVENTIVE MAINTENANCE

Maintenance of and repairs to instruments will be in accordance with manufacturers' manuals.

14.1 Navigation Equipment

Details of the calibration procedures and preventative maintenance for the navigation equipment can be found in the Water Column Monitoring CW/QAPP (Albro *et al.*, 1998).

14.2 Laboratory Equipment

Logs of maintenance, calibrations, and repairs made to instruments will be stored in laboratory files. All routine and non-routine repairs are documented in the maintenance section of the instrument logbook assigned to each analytical instrument. The information recorded includes analysts initials, date maintenance was performed, and a description of all activities, including information such as flow rates. Additionally, the reasons for and results of all service calls are recorded and maintained in the instrument logbook. All routine and non-routine maintenance are fully defined in the appropriate instrument operation SOPs (cited in the following sections).

14.2.1 Organic Analysis Equipment

14.2.1.1 GC/MS

Instrumental calibration, operation, maintenance, and QC procedures for the GC/MS analysis of samples for PAH will be performed according to Battelle SOPs 3-092 and 5-157, a modification of EPA Method 8270. The GC/MS will be tuned with perfluorotributylamine before the initiation of the sample sequence. Analytical instruments will be calibrated before sample analysis and response factors (RF) will be generated for each PAH target analyte (Table 10).

The GC/MS system calibrations will be verified using a mid-range calibration check. Using the mean RF of each analyte from the initial calibration, the percent difference between those mean values and the RFs from the midrange calibration checks will be calculated. If the percent difference between the RFs is greater than the acceptability criteria, remedial maintenance will be performed on the instrument, and a new calibration check standard analyzed. If the check standard then meets the acceptance criteria, the affected samples will be reanalyzed. If the check standard still does not meet the acceptance criteria then a new initial calibration will be performed, and the affected batch of samples will be reanalyzed, at the discretion of the Task Leader. Because GC/MS analysis is a multi-component analysis, it may not be necessary to reanalyze all bracketed samples if a mid-range calibration check standard does not meet the acceptability criteria. This decision will be based on a comparison of the analytes detected in the samples vs. the target analytes which did not meet the mid-check acceptability criteria. Reanalysis will only be necessary if RFs for the analytes that are detected in a sample did not meet the criteria.

Reanalyses will be performed at the discretion of the Task Leader. Deviations from calibration or data objectives will be documented in the project files.

Samples analyzed by GC/MS will be bracketed by two acceptable calibrations, initial or check. Analytes will be quantified by using the average RFs for that individual PAH analyte generated from the initial calibration following the method of internal standards, using surrogate internal standard (SIS) compounds.

Response factors (RF) will be generated for each target analyte using the following equation:

$$RF = \frac{A_x}{A_{IS}} \times \frac{C_{IS}}{C_x}$$

where:
- A_x = peak area of the analyte in the calibration standard
- A_{IS} = peak area of the appropriate internal standard in the calibration standard
- C_x = concentration of the analyte in the calibration standard
- C_{IS} = concentration of the appropriate internal standard in the calibration standard.

Using the mean RF of each analyte from the initial calibration, the percent difference between those mean values and the RFs from the midrange calibration checks will be calculated. The percent difference is calculated by:

$$\% \text{ Difference} = [(RF_i - RF_r) \div RF_i] \times 100$$

where
- RF_i = average response factor from the initial calibration, and
- RF_r = response factor from the midrange calibration check.

14.2.1.2 GC/ECD

Instrumental calibration, operation, maintenance, and QC procedures for gas chromatography with electron capture detection (GC/ECD) will be performed in accordance with Battelle SOPs 3-116 and 5-128, a modification of EPA method 8081. The data collected from the confirmatory analysis will be used to qualitatively confirm target analytes. Analytical instruments will be calibrated before sample analysis and a calibration curve using the quadratic equation method will be generated for each PCB and pesticide target analyte (Table 10).

A mid-level calibration check standard will be analyzed to verify the GC/ECD system calibration during analysis. This check standard will be quantified in the same manner as field and QC samples. If the percent difference between the detected and true concentrations of the target pesticides and PCB congeners is greater than the acceptability criteria, remedial maintenance will be performed on the instrument, and a new calibration check standard analyzed. If the check standard then meets the acceptance criteria, the affected samples will be reanalyzed. If the check standard still does not meet the acceptance criteria then a new initial calibration will be performed, and the affected batch of samples will be reanalyzed, at the discretion of the Task Leader. Because GC/ECD analysis is a multi-component analysis, it may not be necessary to reanalyze all bracketed samples if a mid-range calibration check standard does not meet the acceptability criteria. This decision will be based on a comparison of the analytes detected in the samples vs. the target analytes which did not meet the mid-check acceptability

criteria. Reanalysis will only be necessary if percent differences for the analytes that are detected in a sample did not meet the criteria. Reanalysis will be performed at the discretion of the Task Leader. Deviations from calibration or data objectives will be documented in the project files.

Samples analyzed by GC/ECD will be bracketed by two acceptable calibrations, initial and check. Analytes will be quantified using the calibration curve generated from the initial calibration following the method of internal standards, using surrogate internal standard (SIS) compounds.

14.2.2 Metals Analysis Equipment

The CVAA, ICP-MS, and GFAA instruments will be calibrated prior to each analytical run (Table 14).

14.2.2.1 CVAA

Instrument calibration, operation, and maintenance procedures for CVAA analysis of tissue samples for Hg will be conducted according to Battelle SOP MSL-I-016-02 *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The instrument is maintained by the analyst, with the assistance of service personnel from Thermo-Separation Products. The soda lime trap and reagents (stannous chloride, 3% nitric acid, and rinse water) are checked daily and changed weekly under constant use. The carbon trap and filters are checked weekly and changed bimonthly under constant use. The sample injection syringe, tubing, connectors, and lamp are checked weekly and changed as needed, and the autosampler arm should be cleaned and lubricated bimonthly.

14.2.2.2 ICP-MS

Instrument calibration, operation, and maintenance procedures for ICP-MS analysis of tissue samples for metals will be conducted according to Battelle SOP MSL-I-022-02 *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The instrument is maintained by the analyst, with the assistance of a service engineer from Perkin-Elmer, under a maintenance agreement. The argon supply pressure, base and operating vacuum, temperature of cooling chiller, and nebulizer flow are checked daily by the analyst. Instrument sensitivity and stability are checked each day of operation.

14.2.2.3 GFAA

Instrument calibration, operation, and maintenance procedures for GFAA analysis of tissue samples for metals will be conducted according to Battelle SOP MSL-I-029-00 *Determination of Metals in Aqueous and Digestate Samples by GFAA*. The instrument is maintained by the analyst, with the assistance of a service engineer from Perkin-Elmer on an as-needed basis. Argon supply pressure is checked by the analyst daily. Other daily maintenance includes inspection of the furnace tube, contact rings, and optical windows.

14.2.2.4 EDXRF

The EDXRF instrument calibration is checked prior to daily sample analysis through the analysis of certified reference materials. If the instrument is not within the certified range for these standards, the corrective action recommended by the manufacturer will be taken.

14.2.3 TOC Analysis Equipment

Instrument calibration, operation and maintenance of the UIC Model 5012 Carbon Dioxide Coulometer conform to the Applied Marine Science SOP AMS-TOC94 and manufacturer specifications. The performance of the coulometer is verified by the analysis of 4.8%, 12%, and 42.1% carbon standards. The standards are treated in the same manner as the samples. Because the coulometer measures total CO_2 evolved from a sample, a three-level calibration can be evaluated by using standards with different concentrations of carbon. Once the standards have been analyzed, the percent carbon measured will be compared with the known carbon value of the standard. The difference between the measured and known values for the standard must be within 5%. Initial calibration will be performed on a weekly basis. The 4.8% standard will be analyzed as a continuing calibration check following the analysis of 20 field and the associated QC samples. The continuing calibration check must be within 5% of the known carbon content for the preceding analysis to be acceptable.

14.2.4 Grain Size Analysis Equipment

The top loading balance is calibrated monthly with a 50-g standard weight using an internal calibration procedure. The analytical balance is calibrated daily using an internal calibration method with internal standard weights. These automatic calibration procedures are verified with Class S weights monthly.

14.2.5 Microbiological Parameters

The temperature of the incubators used for the growth of bacterial cultures will be monitored twice daily, for days on which the incubators are in use. A NIST traceable thermometer, accurate to 0.1 °C when immersed in water, will be used and the readings recorded.

14.3 Sediment Profile Image Analysis System

Prior to every field deployment, all video components are collected and tested for proper operation. Once the video SPI system is assembled on board the research vessel, a system check is initiated that includes all features of the video SPI system from tightening all bolts and video cable connectors to testing the video camera and deck video monitor and recorder.

Prior to and after every station deployment, a station card is place in front of the prism and recorded for 5–10 seconds. This records the station data on the video tape for later analysis. Proper system functioning (penetration of prism, flash from film SPI camera) will be monitored in real time on deck via the video monitor. Any miss-fires or improper film camera operation then can be corrected while on station. Almost any electronic or mechanical failure of the video camera can be repaired in the field. Spare parts and complete back-up video and 35-mm cameras will be carried on each survey.

14.4 Hardbottom ROV Video and 35-mm Cameras

The subcontractor, CR Environmental, is responsible for ensuring that all maintenance and calibrations of the still camera, video camera, and ROV are carried out prior to the survey, in accordance with the manufacturer's specifications.

15.0 DOCUMENTATION, DATA REDUCTION, AND REPORTING

15.1 Documentation

Initially, all data will be recorded either (1) electronically onto computer storage media from NAVSAM™ or other laboratory systems or (2) manually into bound laboratory notebooks or onto established data forms. All notes will be written in black ink. Corrections to hand-entered data will be initialed, dated, and justified. Corrections to electronically captured data (e.g., electronic "spikes") will be documented on a hard-copy plot of the data. Completed data forms or other types of hand-entered data will be signed and dated by the individual entering the data. Direct-entry and electronic data entries will indicate the person collecting or entering the data. It will be the responsibility of the laboratory managers to ensure that all data entries and hand calculations are verified in accordance with procedures described in Section 16 (below). Station logs associated with field and laboratory custody and tracking will be kept in survey notebook for each survey. These notebooks will be held in the custody of the Field Manager, Mr. Wayne Trulli.

For the SPI field program, data for every station sampled are logged into a plastic-paper field notebook. Data logged include station position, date, time, camera counter number, depth of prism penetration as determined from the deployment frame, water depth, and other parameters. This field notebook will be kept at Diaz & Daughters under the supervision of Dr. Robert Diaz.

Sample laboratory data recording forms are provided in the Appendix.

15.2 Data Reduction

Data reduction is the process of converting raw numbers (e.g., numbers of organisms per replicate) into data that can be displayed graphically, summarized in tables, or compared statistically for differences between mean values for sampling times or stations.

15.2.1 Infaunal Analysis

Data reduction for the detailed faunal analysis will focus on two major, but related goals: (1) to assess the patterns in community structure in Massachusetts Bay, and (2) to determine the nature of any changes in community structure through time and to evaluate whether these changes could be attributed to discharges from the MWRA outfall. These analyses will be performed by Dr. Roy Kropp. A general analysis plan is presented below.

15.2.1.1 Preliminary Data Treatment

Prior to analysis, the senior scientists will scan the data to see if preliminary modifications are warranted. Typically, certain taxa may be pooled. Usually this involves pooling data for a taxon identified to a level higher than species (*e.g.*, genus) with those data for a species within the higher taxon. Another potential modification would be the exclusion of selected (non-benthic) taxa. All such data modifications will be documented in the data reports.

Calculations of abundance will include all taxa occurring in each sample. Calculations based on species (diversity, evenness, number of species) will include only those taxa identified to species level. Prior to analyses, the data will be scanned and taxa identified to a taxonomic level other than species (*e.g.*, genus) may be chosen to be included in the species-level calculations if they are unique in some way.

15.2.1.2 Diversity Analysis

The software package BioDiversity Professional, Version 2 (© 1997 The Natural History Museum / Scottish Association for Marine Science) will be used to perform calculations of total species, log-series alpha, Shannon's Diversity Index (*H'*), the maximum *H'* (Hmax), and Pielou's Evenness (*J'*). BioDiversity Pro is available at http://www.nhm.ac.uk/zoology/bdpro. Magurran (1988) describes all of the diversity indices to be used here.

Shannon's *H'* will be calculated by using $\log_2$ because that is closest to Shannon's original intent. Pielou's (1966) *J'*, which is the observed *H'* divided by Hmax, is a measure of the evenness component of diversity. BioDiversity Pro also provides a calculation of abundance that includes only species-level taxa. This number will be compared to the abundance calculations based on all taxa to determine the proportion of infauna that are identifiable to species.

15.2.1.3 Cluster & Ordination

Cluster analyses will be preformed with the program COMPAH96 (available on E. Gallagher's web page, http://www.es.umb.edu/edgwebp.htm), originally developed at the Virginia Institute of Marine Science in the early 1970's. The station and species cluster groups will be generated using unweighted pair group mean average sorting (UPGMA) and chord normalized expected species shared (CNESS) to express similarity (Gallagher 1998).

Results of the station and species clusters will be compared by using nodal analysis, which examines the original data matrix rearranged into a two-way table based on the cluster defined groups. Constancy, a measure of the association of species with stations (Fager 1963), will be calculated from the nodal table based on the proportions of the number of occurrences of species in the station group to the total possible number of such occurrences (Boesch 1977):

$$C_{ij} = a_{ij} / (n_i \times n_j)$$

Where a_{ij} is the actual number of occurrences of members of species group i in station group j, n_i is the total number of species in group i, and n_j is the number of stations in group j. Constancy will range from 0.0 when none of the species in a species group occurred in a station group to 1.0 when all of the species in a species group occurred in all of the stations of a station group. Fidelity, a measure of the constancy of species in a station group compared to the constancy over all station groups (Fager 1963), will be used to indicate the degree to which species prefer station groups (Boesch 1977):

$$F_{ij} = (a_{ij} \text{å} n_j) / (n_j \text{å} a_{ij})$$

where a_{ij} and n_j are the same as defined for the constancy index. Fidelity is 1.0 when the constancy of a species group in a station group is equal to its overall constancy, > 1.0 when its constancy in a station group is greater than that overall, and < 1.0 when its constancy is less than its overall constancy. Values of F > 2.0 suggest strong preference of species for a station group and values < 0.7 suggest avoidance of these species from the station group in question (Boesch 1977).

For the nearfield/farfield data report, discriminant analysis will be used for predicting cluster group membership based on sediment, SPI, hydrocarbon, and heavy metal data. After subtraction of group means, variables highly correlated with other predictors in each of these four data sets will be eliminated from the analysis. Linear discriminant functions will be extracted using within group covariance and posterior probability of membership predicted using squared distance function (D^2). The smaller the D^2 the more likely the station belongs in the predicted group rather than the original cluster group.

15.2.1.4 Benthic Threshold Evaluation

Annual mean community diversity measurements will be considered for use in threshold evaluation. Those measurements include total species, log-series alpha, the Shannnon-Wiener H′, and Pielou's J′.

15.2.2 Sediment Chemistry Analyses

15.2.2.1 Organics and Metals

GC/MS data will be acquired and reduced on Hewlett-Packard PC-based chemstation minicomputers with dedicated chromatography software. GC/ECD data will be acquired and reduced by the Thermo Lab Systems XCHROME System. All GC/MS and GC/ECD data files will be transferred electronically to a PC so that the data can be incorporated into an electronic database or spreadsheets for final quantification and tabular results presentation. Data for metals analysis by GVAA, ICP-MS, and GFAA are collected and processed by the instruments' software systems. Processed data are electronically transferred to Excel™ spreadsheet format for report generation. Contaminant data for the Nearfield stations will be compared to the appropriate MWRA threshold levels. The final reduction of analytical chemistry data will account for the size of the processed sample and dilution factors. EDXRF data will be recorded in Excel™ spreadsheets.

15.2.2.2 TOC

Total organic carbon measurements are acquired on instrument software and downloaded onto spreadsheets. TOC results will be reported as percent total organic carbon on a dry weight basis.

15.2.2.3 Grain Size

Grain Size will be reported as percent of the total for each size fraction measured. Silt content is determined by subtracting the total clay content from the mud content, as described in section 12. Data are entered onto a spreadsheet to perform the calculation for silt content. In addition to weight percent by size class, the Gravel: Sand: Silt: Clay ratio and a numerical approximation of mean size and sorting (Standard deviation) is calculated. A cumulative frequency curve of the data may be prepared using phi data.

15.2.2.4 Microbiological Parameters

All final data will be reported in units of spores/g dry weight (*C. perfringens*) or colonies/g dry weight (fecal coliform and *Enterococcus*). All microbiological data will be hand entered.

15.2.3 SPI Analysis

After visual and computer image analyses are completed, a standard set of parameters (Table 5) taken from both analyses is combined and tabulated for reporting. If appropriate, statistical analyses can be done to test hypotheses by applying appropriate parametric (e.g., *t*-test, ANOVA) and/or nonparametric (e.g., Logistic regression, Log-linear Modeling, Friedman's test) techniques.

SPI data are used to summarize environmental conditions through the calculation of the Organism-Sediment Index (OSI). The OSI, as developed by Rhoads and Germano (1986), is an integrative estimate of the general ability of the benthic habitat to support fauna. The OSI is defined from SPI parameters and the indirect estimation of bottom dissolved oxygen levels. The lowest value of the OSI (–10) is given to habitats that have little or no dissolved oxygen, no apparent evidence of fauna (surface or subsurface data), and where methane gas is present (subsurface data). The highest value of the OSI (+11) is given to habitats that have high dissolved oxygen, a deep apparent RPD layer, evidence of fauna, and no methane gas. The index is calculated by using the RPD depth, the successional stage, the presence of methane voids, and visual indications of low oxygen concentrations in the water column. The formulation for the OSI and three hypothetical examples are shown in Table 16. For SPI data collected from the Nearfield, RPD values will be compared to the MWRA threshold levels.

15.2.4 Hardbottom Video Tape and 35-mm Slide Analyses

Data reduction and analysis will focus on several goals: (1) to obtain baseline spatial and temporal data on habitat characteristics at each waypoint, (2) to assess temporal stability of community structure at each of the waypoints, (3) to assess temporal variability in percent cover of *Crustose pink algae* at each of the waypoints, and (4) to evaluate if changes in biotic parameters could be attributed to discharges from the MWRA outfall.

Data analysis products will include descriptions of habitat characteristics, species lists, hierarchical classification analysis, and descriptive multi-year comparisons in map and table form. Pre- and post-discharge comparisons will be made for each waypoint in terms of: degree of sediment drape, benthic community characterization (from classification), percent cover of *Crustose pink algae*, and relative abundance (species counts normalized to mean number per slide) of some of the dominant benthic taxa.

15.3 Reporting

15.3.1 Navigation and Sample Collection Data

Details can be found in the Water Column Monitoring CW/QAPP (Albro *et al.*, 1998).

15.3.2 Analytical and Experimental Data

The data reporting for analytical and experimental data begins with the Battelle Data Management Team who will populate a loading application that is then sent to each laboratory for data entry. The data from field activities first will be delivered to the data manager as an Access database. Sample_ID numbers and analysis protocols will be extracted from this database and used to populate a database within the loading application. A separate loading application will be prepared for each data deliverable. When data

contributors open the database they will be presented with a form that already contains the Sample_ID numbers and an analyte list for the required data submittal. The laboratory will enter the results of the analyses and other supporting information such as data qualifier codes. All entries will be constrained by the rules of EM&MS. Errors will be caught on entry and fixed by the data contributor. Primary keys will be in place so duplication can not occur. Entry applications will be developed for each analytical laboratory. Laboratory staff will receive one day of training on the application prior to analysis of the lab's first set of samples. When data entry is complete, the database will be sent back to Battelle. Laboratories with existing data processing capability will be supplied with a loading application that can import the laboratory's final spreadsheet and then run the necessary quality control checks. The laboratory will have to meet its internal laboratory format for the data to load successfully.

The loading application will provide the laboratory with several function buttons. These include hard copy report, quality control checks, exception report, and analysis summary. The hard copy report will allow the laboratory to create a hard copy report to check for entry errors and to submit a final report to Battelle with the data deliverable. The quality control checks will be comprised of the applicable sections of EM&MS check script and will also perform checks for outliers. This report will provide the data contributor a chance to confirm the reasonableness of the data prior to its submission to Battelle. The exception report will check the data that was expected against the results that were loaded. The data contributor must account for any entries in the exception report. The analysis report will produce a report of the number of analyses by analyte. A copy of this report will be included with the data deliverable and with the invoice for the analyses. Within the loading application, the data entered by the laboratory will be translated into the correct codes and inserted into database tables with the same structure as the matching EM&MS table. Table 17 shows the analytical parameters and database codes for the analytes collected under this task. Table 19 describes the database codes to be used by the laboratories. The laboratories will have the ability to add additional codes to describe their results but the new qualifiers will be highlighted in the exception report. Battelle will notify MWRA concerning the new qualifier and will adjust the code table in the application to agree with any changes to the EM&MS code_list table. MWRA has the responsibility for maintaining the code list for the EM&MS.

The loading application for infaunal enumeration data will differ slightly from the chemistry applications. The users will not see a form populated with all the species names, instead they must choose the proper species code from a pull-down list (Figure 7). Selection of the proper code automatically enters the correct species name in the species field. The codes in the list will be those from the EM&MS code list table. These codes are a combination of NODC and MWRA codes. If the users do not find the proper species code for an identified taxon on the pull-down list (thus indicating that the species has not been found previously on an MWRA survey), they will be able to add a new one. These new codes will be flagged on the exceptions report. Battelle will request a new code from MWRA upon receipt of the data.

Table 16. Formulation of the Organism-Sediment Index.

SPI Parameter	Score	Three Hypothetical Examples		
		Station 1	Station 2	Station 3
RPD Depth (cm) (choose one value)				
0	0			
>0–0.75	1	X		
0.76–1.50	2			
1.51–2.25	3		X	
2.26–3.00	4			
3.01–3.75	5			X
>3.75	6			
Successional Stage (choose one value)				
Azoic	–4			
Stage I	1	X		
Stage I–II	2			
Stage II	3		X	
Stage II–III	4			
Stage III	5			X
Stage I on III	5			
Stage II on III	5			
Sediment/Near-bottom Gas (choose neither, one, or both as appropriate)				
Methane	–2	X	X	
No/Low DO	–4	X		
Calculated OSI		–4	+4	+10

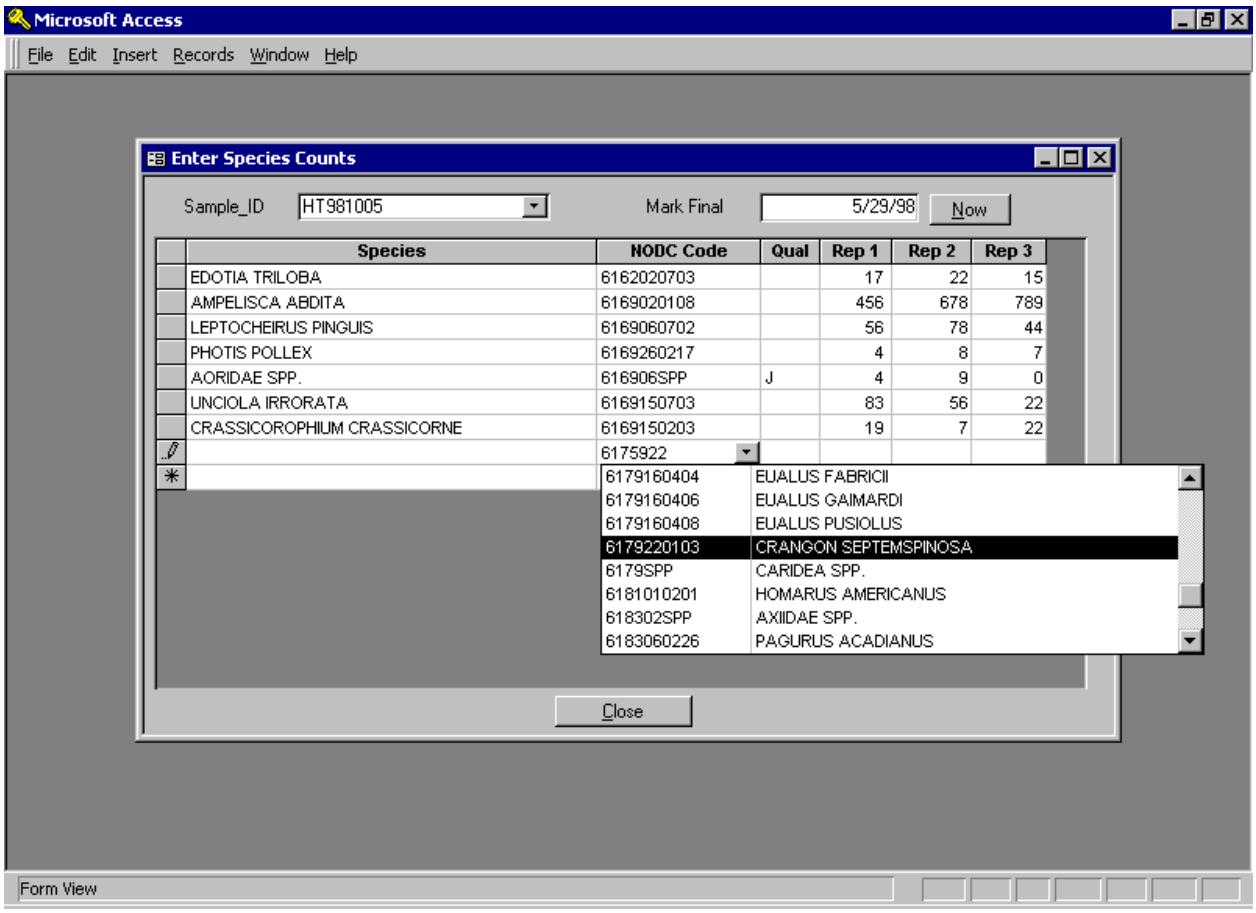


Figure 7. Example of the Data Loading Application for Infaunal Analyses.

Table 17. Parameters and Database Codes for Sediment Chemical / Physicochemical Analyses.

Parameter	Param_Code	Meth_Code	Unit_Code	Instr_Code
1-PHENYLNONANE (SURROGATE)	MWRA85	BSOP5-157	PCTREC	GCMS
2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL	40186-72-9	BSOP5-128DUAL	ng/g	GCECD
2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL	52663-78-2	BSOP5-128DUAL	ng/g	GCECD
2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL	35065-30-6	BSOP5-128DUAL	ng/g	GCECD
2,2',3,3',4,4'-HEXACHLOROBIPHENYL	38380-07-3	BSOP5-128DUAL	ng/g	GCECD
2,2',3,4',5,5',6-HEPTACHLOROBIPHENYL	52663-68-0	BSOP5-128DUAL	ng/g	GCECD
2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL	35065-29-3	BSOP5-128DUAL	ng/g	GCECD
2,2',3,4,4',5-HEXACHLOROBIPHENYL	35065-28-2	BSOP5-128DUAL	ng/g	GCECD
2,2',3,5'-TETRACHLOROBIPHENYL	41464-39-5	BSOP5-128DUAL	ng/g	GCECD
2,2',4,4',5,5'-HEXACHLOROBIPHENYL	35065-27-1	BSOP5-128DUAL	ng/g	GCECD
2,2',4,5,5'-PENTACHLOROBIPHENYL	37680-73-2	BSOP5-128DUAL	ng/g	GCECD
2,2',5,5'-TETRACHLOROBIPHENYL	35693-99-3	BSOP5-128DUAL	ng/g	GCECD
2,2',5-TRICHLOROBIPHENYL	37680-65-2	BSOP5-128DUAL	ng/g	GCECD
2,3',4,4',5-PENTACHLOROBIPHENYL	31508-00-6	BSOP5-128DUAL	ng/g	GCECD
2,3',4,4'-TETRACHLOROBIPHENYL	32598-10-0	BSOP5-128DUAL	ng/g	GCECD
2,3,3',4,4'-PENTACHLOROBIPHENYL	32598-14-4	BSOP5-128DUAL	ng/g	GCECD
2',3,5-TRICHLOROBIPHENYL	37680-68-5	BSOP5-128DUAL	PCTREC	GCECD
2,4'-DICHLOROBIPHENYL	34883-43-7	BSOP5-128DUAL	ng/g	GCECD
2,4,4'-TRICHLOROBIPHENYL	7012-37-5	BSOP5-128DUAL	ng/g	GCECD
3,3',4,4',5-PENTACHLOROBIPHENYL	57465-28-8	BSOP5-128DUAL	ng/g	GCECD
3,3',4,4'-TETRACHLOROBIPHENYL	32598-13-3	BSOP5-128DUAL	ng/g	GCECD
ACENAPHTHENE	83-32-9	BSOP5-157	ng/g	GCMS
4,4 DDD OLEFIN (DDMU)	1022-22-6	BSOP5-128DUAL	ng/g	GCECD
ACENAPHTHYLENE	208-96-8	BSOP5-157	ng/g	GCMS
ALDRIN	309-00-2	BSOP5-128DUAL	ng/g	GCECD
ALUMINUM	7429-90-5	PNL266	PCTDRYWT	EDXRF
ANTHRACENE	120-12-7	BSOP5-157	ng/g	GCMS
Androstanol	ANDROSTANOL	BSOP5-157	PCTREC	GCMS
BENZ(A)ANTHRACENE	56-55-3	BSOP5-157	ng/g	GCMS
BENZO(A)PYRENE	50-32-8	BSOP5-157	ng/g	GCMS
BENZO(B)FLUORANTHENE	205-99-2	BSOP5-157	ng/g	GCMS
BENZO(E)PYRENE	192-97-2	BSOP5-157	ng/g	GCMS
BENZO(G,H,I)PERYLENE	191-24-2	BSOP5-157	ng/g	GCMS
BENZO(K)FLUORANTHENE	207-08-9	BSOP5-157	ng/g	GCMS
BENZOTHIAZOLE	95-16-9	BSOP5-157	ng/g	GCMS
BIPHENYL	92-52-4	BSOP5-157	ng/g	GCMS
C1-CHRYSENES	MWRA70	BSOP5-157	ng/g	GCMS
C1-DIBENZOTHIOPHENES	MWRA68	BSOP5-157	ng/g	GCMS
C1-FLUORANTHENES/PYRENES	MWRA69	BSOP5-157	ng/g	GCMS
C1-FLUORENES	MWRA65	BSOP5-157	ng/g	GCMS
C1-NAPTHALENES	MWRA64	BSOP5-157	ng/g	GCMS
C1-PHENANTHRENE/ANTHRACENES	MWRA67	BSOP5-157	ng/g	GCMS
C2-CHRYSENES	MWRA4	BSOP5-157	ng/g	GCMS

Table 17. (continued)

Parameter	Param_Code	Meth_Code	Unit_Code	Instr_Code
C2-DIBENZOTHIOPHENES	MWRA5	BSOP5-157	ng/g	GCMS
C2-FLUORENES	MWRA6	BSOP5-157	ng/g	GCMS
C2-NAPTHALENES	MWRA7	BSOP5-157	ng/g	GCMS
C2-PHENANTHRENE/ANTHRACENES	MWRA57	BSOP5-157	ng/g	GCMS
C3-CHRYSENES	MWRA71	BSOP5-157	ng/g	GCMS
C3-DIBENZOTHIOPHENES	MWRA9	BSOP5-157	ng/g	GCMS
C3-FLUORENES	MWRA66	BSOP5-157	ng/g	GCMS
C3-NAPTHALENES	MWRA10	BSOP5-157	ng/g	GCMS
C3-PHENANTHRENE/ANTHRACENES	MWRA52	BSOP5-157	ng/g	GCMS
C4-CHRYSENES	MWRA72	BSOP5-157	ng/g	GCMS
C4-PHENANTHRENE/ANTHRACENES	MWRA54	BSOP5-157	ng/g	GCMS
CADMIUM	7440-43-9	MSL-I-022	ug/g	ICPMS
CHROMIUM	7440-47-3	PNL266	ug/g	EDXRF
CHRYSENE	218-01-9	BSOP5-157	ng/g	GCMS
CHRYSENE-D12 (surrogate)	D12_218-01-9	BSOP5-157	PCTREC	GCMS
CIS-CHLORDANE	5103-71-9	BSOP5-128DUAL	ng/g	GCECD
CLAY	CLAY	FOLK74	PCTDRYWT	SVSET
CLOSTRIDIUM PERFRINGENS	CPERF	EC182	#/GDW	MICR
COPPER	7440-50-8	PNL266	ug/g	EDXRF
COPROSTANOL	360-68-9	BSOP5-157	ng/g	GCMS
DECACHLOROBIPHENYL	2051-24-3	BSOP5-128DUAL	ng/g	`GCECD
DIBENZO(A,H)ANTHRACENE	53-70-3	BSOP5-157	ng/g	GCMS
DIBENZOFURAN	132-64-9	BSOP5-157	ng/g	GCMS
DIBENZOTHIOPHENE	127330-66-9	BSOP5-157	ng/g	GCMS
DIELDRIN	60-57-1	BSOP5-128DUAL	ng/g	GCECD
ENDRIN	72-20-8	BSOP5-128DUAL	ng/g	GCECD
FLUORANTHENE	206-44-0	BSOP5-157	ng/g	GCMS
FLUORENE	86-73-7	BSOP5-157	ng/g	GCMS
GRAVEL	GRAVEL	FOLK74	PCTDRYWT	SVSET
HEPTACHLOR	MWRA25	BSOP5-128DUAL	ng/g	GCECD
HEPTACHLOREPOXIDE	MWRA24	BSOP5-128DUAL	ng/g	GCECD
HEXACHLOROBENZENE	118-74-1	BSOP5-128DUAL	ng/g	GCECD
INDENO(1,2,3-CD)PYRENE	193-39-5	BSOP5-157	ng/g	GCMS
IRON	7439-89-6	PNL266	PCTDRYWT	EDXRF
LEAD	7439-92-1	PNL266	ug/g	EDXRF
LINDANE	58-89-9	BSOP5-128DUAL	ng/g	GCECD
MERCURY	7439-97-6	MSL-I-016	ug/g	CVAA
MIREX	2385-85-5	BSOP5-128DUAL	ng/g	GCECD
NAPHTHALENE	91-20-3	BSOP5-157	ng/g	GCMS
NAPTHALENE-D8 (surrogate)	D8_91-20-3	BSOP5-157	PCTREC	GCMS

Table 17. (continued)

Parameter	Param_Code	Meth_Code	Unit_Code	Instr_Code
NICKEL	7440-02-0	PNL266	ug/g	EDXRF
O,P-DDD	MWRA33	BSOP5-128DUAL	ng/g	GCECD
O,P-DDE	MWRA34	BSOP5-128DUAL	ng/g	GCECD
O,P-DDT	789-02-6	BSOP5-128DUAL	ng/g	GCECD
P,P-DDD	72-54-8	BSOP5-128DUAL	ng/g	GCECD
P,P-DDE	75-55-9	BSOP5-128DUAL	ng/g	GCECD
P,P-DDT	50-29-3	BSOP5-128DUAL	ng/g	GCECD
Percent weight of the sample which is dry	PCTDRYWT	BSOP5-190	PCTDRYWT	BAL
Percent weight of the sample which is dry	PCTDRYWT	MSL-C-003	PCTDRYWT	BAL
PERYLENE	198-55-0	BSOP5-157	ng/g	GCMS
PHENANTHRENE	85-0108	BSOP5-157	ng/g	GCMS
PHENANTHRENE-D10	D10-85-0108	BSOP5-157	PCTREC	GCMS
PHENYL DECANES	MWRA39	BSOPS-157	ug/g	GCMS
PHENYL DODECANES	MWRA31	BSOPS-157	ug/g	GCMS
PHENYL TETRADECANES	MWRA30	BSOPS-157	ug/g	GCMS
PHENYL TRIDECANES	MWRA29	BSOPS-157	ug/g	GCMS
PHENYL UNDECANES	MWRA28	BSOPS-157	ug/g	GCMS
Phi Size -1 - 0	-1 - 0	FOLK74	PCTDRYWT	SVSET
Phi Size 0 - 1	0 - 1	FOLK74	PCTDRYWT	SVSET
Phi Size 1 - 2	1 - 2	FOLK74	PCTDRYWT	SVSET
Phi Size 2 - 3	2 - 3	FOLK74	PCTDRYWT	SVSET
Phi Size 3 - 4	3 - 4	FOLK74	PCTDRYWT	SVSET
Phi Size <-1	<-1	FOLK74	PCTDRYWT	SVSET
PYRENE	129-00-0	BSOP5-157	ng/g	GCMS
Redox potential discontinuity at the bottom of the bioturbation layer - where sediment is sulfidic	ARPD	KEL93	cm	RULER
r-squared of linear regression for estimation of parameter Chromium	7440-47-3_R2	PNL266		EDXRF
r-squared of linear regression for estimation of parameter Copper	7440-50-8_R2	PNL266		EDXRF
r-squared of linear regression for estimation of parameter Nickel	7440-02-0_R2	PNL266		EDXRF
r-squared of linear regression for estimation of parameter Zinc	7440-66-6_R2	PNL266		EDXRF
SAND	SAND	FOLK74	PCTDRYWT	SVSET
SILT	SILT	FOLK74	PCTDRYWT	SVSET
SILVER	7440-22-4	MSL-I-022	ug/g	ICPMS
SILVER	7440-22-4	MSL-I-029	ug/g	GFAA
TOTAL ORGANIC CARBON	TOC	NS-T_TOC	PCTDRYWT	COULC
TOTAL ORGANIC CARBON	TOC	NS-T_TOC	PCTDRYWT	PE24CHN
TRANS_NONACHLOR	24143-69-9	BSOP5-128DUAL	ng/g	GCECD
ZINC	7440-66-6	PNL266	ug/g	EDXRF

Table 18 lists the database codes used for the sediment profile imaging data. The hardbottom codes (LOC_DRUMLIN_CODE, PRIMARY_SUBS_CODE**,** SECONDARY_SUBS_CODE, and SED_DRAPE_CODE, and PARAM_CODE) are too numerous to list, as are the SPEC_CODEs found in the infaunal abundance data. The database tables CODE_LIST and SPECIES_CODES have been populatd with most of the codes used for these data. Additional codes are added by the MWRA DBA when requested by Battelle data management.

Table 18. Parameters and Database Codes for SPI Analysis.

Parameter	Param_code	Meth_ code	Unit_ code	Gear_code
Depth beneath sediment surface of anoxic voids, in cm	ANOXIC_VOID_DEPTH	KP93	cm	HMMSPCAM
Number of inactive water filled spaces in sediment	ANOXIC_VOID_NUM	KP93		HMMSPCAM
Average penetration	AVG_PEN	KP93	cm	HMMSPCAM
Average depth of redox potential discontinuity	AVG_RPD	KP93	cm	HMMSPCAM
Number of burrows	BURR_NO	KP93		HMMSPCAM
Type of burrow in sediments	BURR_TYPE	KP93		HMMSPCAM
Depth beneath sediment surface of sub-surface fauna, in	FAUNA_DEPTH	KP93	cm	HMMSPCAM
Depth beneath sediment surface of gas voids, in cm	GAS_VOID_DEPTH	KP93	cm	HMMSPCAM
Number of gas filled spaces in sediment resulting from	GAS_VOID_NUM	KP93		HMMSPCAM
Sediment grain size	GRN_SZ	KP93		HMMSPCAM
Presence of apparent low dissolved oxygen water	LOW_DO	KP93		HMMSPCAM
Median size class of amphipod tubes	MEDI_TUBE_SIZE	KP93		HMMSPCAM
Organism-Sediment Index	OSI	KP93		HMMSPCAM
Depth beneath sediment surface of oxic voids, in cm	OXIC_VOID_DEPTH	KP93	cm	HMMSPCAM
Num. of active, water-filled spaces in sed. resulting from	OXIC_VOID_NUM	KP93		HMMSPCAM
Maximum penetration depth of camera	PEN_MAX	KP93	cm	HMMSPCAM
Minimum penetration depth of camera	PEN_MIN	KP93	cm	HMMSPCAM
Maximum depth of Redox Penetration Depth layer	RPD_MAX	KP93	cm	HMMSPCAM
Minimum depth of Redox Penetration Depth layer	RPD_MIN	KP93	cm	HMMSPCAM
Sediment layer on rock substrate	SEDI_LAYER	KP93		HMMSPCAM
Surface Relief	SR	KP93	cm	HMMSPCAM
Infaunal worms counted	SUB_FAUNA_WORMS	KP93		HMMSPCAM
Infaunal successional stage	SUCC_STG	KP93		HMMSPCAM
General description of processes causing surface	SURF_ROUGH_TYPE	KP93		HMMSPCAM
Features on the sediment surface	SURFACE_FEATURES	KP93		HMMSPCAM
Amphipod tube	TUBE_AMPH	KP93		HMMSPCAM
Polychaete tube	TUBE_POLY	KP93		HMMSPCAM
Number of voids	VOID_NO	KP93		HMMSPCAM
Type of void in sediments	VOID_TYPE	KP93		HMMSPCAM

Table 19. Descriptions of other Database Codes.

Field Name	Code	Description*
ANAL_LAB_ID	AMS	Applied Marine Sciences
ANAL_LAB_ID	BOS	BATTELLE OCEAN SCIENCES
ANAL_LAB_ID	BSQM	Battelle Marine Sciences Laboratory
ANAL_LAB_ID	COV	COVE CORP.
ANAL_LAB_ID	GOP	GEOPLAN ASSOC
ANAL_LAB_ID	KLM	KLM Analytical - Ron Sanders
ANAL_LAB_ID	MTH	MTH ENVIR ASSOC
DEPTH_UNIT_CODE	m	Meters
DEPTH_UNIT_CODE	cm	Centimeters
GEAR_CODE	HMMSPCAM	HULCHER MODEL MINNIE SEDIMENT PROFILE CAMERA
GEAR_CODE	VV01	0.1-M2 Young-Modified Van Veen Grab
GEAR_CODE	VV04	0.04 m2 Young-modified Van Veen Grab
INSTR_CODE	BAL	Balance
INSTR_CODE	COULC	Coulometric carbon analyzer
INSTR_CODE	CVAA	COLD VAPOR ATOMIC ABSORPTION
INSTR_CODE	EDXRF	ENERGY DISPERSIVE XRAY FLUORESCENCE
INSTR_CODE	GCECD	GAS CHROMOTOGRAPH ELECTRON CAPTURE DETECTOR
INSTR_CODE	GCMS	GAS CHROMOTOGRAPH/MASS SPECTOMETER
INSTR_CODE	ICPMS	Inductively coupled plasma mass spec
INSTR_CODE	MICR	MICROSCOPE
INSTR_CODE	PE24CHN	Perkin-Elmer 2400 CHN Elemental Analyzer
INSTR_CODE	RULER	Ruler
INSTR_CODE	SVSET	Sieve/settling
MATRIX_CODE	SED	SEDIMENT
METH_CODE	BSOP5-128DUAL	Battelle Ocean Sciences SOP No. 5-128, PCB/pesticides by GCECD, dual column
METH_CODE	BSOP5-157	Battelle Ocean Sciences SOP No. 5-157, PAH by GCMS
METH_CODE	BSOP5-190	Battelle Ocean Sciences SOP No. 5-190, Lipids by gravimetric means
METH_CODE	EC182	Emerson D., V. Cabelli. 1982. Extr of C. perf. spores. Appl. Environ. Microbiol. 44:1144-49
METH_CODE	ENUM	Enumeration
METH_CODE	FOLK74	FOLK (1974)
METH_CODE	KEL93	Kelly et al 1993 Benthic nut flux QA plan
METH_CODE	KP93	Kelly and Kropp 1993 Soft-bottom QA Plan
METH_CODE	KP93PAH	Kelly and Kropp 1993 Soft-bottom QA Plan
METH_CODE	MSL-C-003	Percent dry weight
METH_CODE	MSL-I-016	Total mercury in tissues and sediments by CVAA
METH_CODE	MSL-I-022	Determination of elements in aqueous and digestate samples by ICP/MS
METH_CODE	MSL-I-029	Determination of metals in aqueous and digestate samples by graphite furnace atomic absorptn (GFAA)
METH_CODE	NS-T_TOC	NATIONAL STATUS & TRENDS METHOD FOR TOC (GERG)
METH_CODE	PNL266	PNL ALO-266 EDXRF method for metals analysis, cited in Kropp and Boyle 1998, Benthic CW/QAPP
SAMP_VOL_UNIT_CODE	cm3	Cubic centimeters
SAMP_VOL_UNIT_CODE	L	Liter
UNIT_CODE	#/GDW	Number of Colonies Per Gram Dry Weight
UNIT_CODE	0.04m2	Units associated with a VanVeen grab, gear_type of VV04
UNIT_CODE	cm	Centimeters
UNIT_CODE	ng/g	nanograms per gram
UNIT_CODE	PCT	PERCENT
UNIT_CODE	PCTDRYWT	Percent dry weight
UNIT_CODE	PCTREC	PERCENT RECOVERY
UNIT_CODE	ug/g	micrograms per gram
VAL_QUAL	A	Value above maximum detection limit, e.g. too numerous to count or beyond range of instrument
VAL_QUAL	As	VALUE ABOVE MAXIMUM DETECTION LIMIT AND SUSPECT/INVALID, NOT FIT FOR USE
VAL_QUAL	B	Blank corrected, blank >= 5xMDL
VAL_QUAL	Br	Blank corrected, blank >= 5xMDL, value reported < dectect limit
VAL_QUAL	D	surrogate recovery < 50% or > 150%
VAL_QUAL	Ds	surrogate recovery < 50% or > 150%, suspect/invalid, not fit for use
VAL_QUAL	E	CALIBRATION LEVEL EXCEEDED
VAL_QUAL	ELs	Calibration exceeded, concentration reported from dilution, suspect/invalid, not fit for use

Table 19. (continued)

Field Name	Code	Description*
VAL_QUAL	Es	Calibration exceeded, suspect/invalid, not fit for use
VAL_QUAL	F	Abundance recorded for a fraction or portion of the sample collected
VAL_QUAL	G	Co-eluting compound interferes with peak of interest
VAL_QUAL	Gs	Co-eluting compound, suspect/invalid, not fit for use
VAL_QUAL	H	thick mat
VAL_QUAL	I	INTERFERANT FROM STANDARD
VAL_QUAL	L	ANALYTICAL CONCENTRATION REPORTED FROM DILUTION
VAL_QUAL	LE	Analytical concentration reported from dilution, calibration level exceeded
VAL_QUAL	LT	Analytical concentration reported from dilution, holding time exceeded
VAL_QUAL	Ls	Analytical concentration reported from dilution, suspect/invalid, not fit for use
VAL_QUAL	P	Present but uncountable, value given is NULL
VAL_QUAL	S	not surrogate corrected
VAL_QUAL	T	holding time exceeded
VAL_QUAL	a	Not detected - value reported as negative or null
VAL_QUAL	aG	Not detected, value is null, co-eluting compound
VAL_QUAL	aGs	Not detected, value is null, co-eluting compound, suspect/invalid, not fit for use
VAL_QUAL	aGx	Not detected, value is null, co-eluting compound, matrix interference
VAL_QUAL	aL	Below MDL; value reported as negative or null, analytical conc. reported from dilution
VAL_QUAL	aLT	Not detected, analytical conc. reported from dilution, holding time exceeded
VAL_QUAL	aLs	Not detected, analytical conc. reported from dilution, suspect/invalid, not fit for use
VAL_QUAL	aT	Not detected - value reported as negative or null, and holding time exceeded
VAL_QUAL	as	Not detected - value reported as negative or null, and not fit for use
VAL_QUAL	asT	Not detected - value reported as negative or null, not fit for use, and holding time exceeding
VAL_QUAL	ax	not detected, value is null, matrix interference
VAL_QUAL	b	Not blank corrected, blank >= 5xMDL
VAL_QUAL	bs	Not blank corrected, blank >= 5xMDL, suspect/invalid, not fit for use
VAL_QUAL	e	Results not reported, value given is NULL. Explanation in COMMENTS field
VAL_QUAL	f	VALUE reported is below method detection limit
VAL_QUAL	fG	Reported value below mdl and co-eluting compound interferes with peak of interest
VAL_QUAL	fL	Value reported is between zero and MDL, analytical conc. reported from dilution
VAL_QUAL	fT	Reported value below MDL and holding time is exceeded
VAL_QUAL	fs	VALUE reported is below method detection limit, not fit for use
VAL_QUAL	fsT	Reported value is below MDL, suspect/invalid, not fit for use, and holding time is exceeded
VAL_QUAL	fx	Below method detect limit, matrix interference
VAL_QUAL	g	recovery outside data objectives
VAL_QUAL	h	BELOW THE STANDARD CURVE 0
VAL_QUAL	j	ESTIMATED VALUE
VAL_QUAL	jBS	estimated, Blank corrected, blank > mdl by factor of 5 or greater, not surrogate corrected
VAL_QUAL	jS	estimated, not surrogate corrected
VAL_QUAL	jp	estimated value and bottles mislabeled
VAL_QUAL	o	Value out of normal range judged fit for use by principal investigator
VAL_QUAL	p	Lab sample bottles mislabelled - caution data us
VAL_QUAL	q	Possibly suspect/invalid and not fit for use. Investigation pending.
VAL_QUAL	r	precision does not meet data quality objectives
VAL_QUAL	s	Suspect/Invalid. Not fit for use.
VAL_QUAL	sT	suspect/invalid, not fit for use and holding time is exceeded
VAL_QUAL	sv	Value is suspect/invalid and not fit for use, arithmetic mean of multiple results
VAL_QUAL	v	ARITHMETIC MEAN
VAL_QUAL	x	Matrix interference

15.3.2.1 Loading Analytical and Experimental Data into the Harbor Studies Database

Data submissions from the laboratory will consist of the final loading applications. The submissions will be logged in upon receipt and a copy of the log-in will be maintained on file under the login id. Data will be loaded into a temporary table by striking a button on the application. A transfer script will copy the data into the proper table in Battelle's copy of the EM&MS. Data from the laboratories will receive a quality assurance review by Battelle after the data have been synthesized into a data report. Any issues will be corrected in the database and the script output will be supplied to MWRA with the export of the database. The MWRA check script will be run on the database as a batch job each night. Any issues will be sent to the Data Manager via email. Any unresolvable issues in the database as a result of quality control checks (for example, stations more than specified distance from target) will also be submitted to MWRA with the data export.

15.3.2.2 Reporting Data to MWRA

The data contained in each hard copy data report will be submitted to MWRA as a database export. The supporting documentation files will be included with the data submission. Data deliverables will be combined only with permission from MWRA.

16.0 DATA VALIDATION

The data validation procedures for this project are defined in the HOM3 Quality Management Plan (Battelle, 1998). As a part of data validation, each laboratory will ensure that:

- All data that are hand-entered (i.e., typed) will be validated by 100% qualified personnel prior to use in calculations or entry into the database.

- All manual calculations will be performed by a second staff member to verify that calculations are accurate and appropriate.

- Calculations performed by software will be verified at a frequency sufficient to ensure that the formulas are correct, appropriate, and consistent, and that calculations are accurately reported. All modifications to data reduction algorithms will be verified prior to submission of data to the Authority.

Electronic submissions will be loaded to temporary files prior to incorporation into the database, and will be analyzed selectively using methods such as scatter plots, univariate and multivariate analyses, and range checks to identify suspect values. Routine system back-ups are performed daily.

Once data have been generated and compiled in the laboratory, Senior Scientists will review data to identify and make professional judgements about any suspicious values. All suspect data will be reported, but flagged with a qualifier. These data may not be used in calculations or data summaries without the review and approval of the appropriate Senior Scientist. No data measurements will be eliminated from the reported data or database and data gaps will never be filled with other existing data. The loss of samples during shipment or analysis will be documented in the data reports to the Authority and noted in the database.

17.0 PERFORMANCE AND SYSTEM AUDITS

The Battelle QA Officer for the Harbor and Outfall Monitoring Project is Ms. Rosanna Buhl. She will direct the conduct of at least one systems audit to ensure that Tasks 17–20 are carried out in accordance with this CW/QAPP. A systems audit will verify the implementation of the Quality Management Plan and this CW/QAPP for the work conducted in the Benthic monitoring.

Tabular data reported in deliverables, and associated raw data generated by Battelle will be audited under the direction of the Project QA Officer. Raw data will be reviewed for completeness and proper documentation. For electronically acquired data (e.g., navigational data), Ms. Buhl will verify that computer software used to process the data has been validated. Errors noted in data audits will be communicated to analysts and project management and corrected data will be verified.

Audits of the data collection procedures at subcontractor laboratories will be the responsibility of the Subcontractor. Each subcontractor is fully responsible for the QA of the data it submits. Data must be submitted in CW/QAPP-prescribed formats; no other will be acceptable. During the time work is in progress, an inspection will be conducted by the subcontractor QA Officer or their designee to evaluate the laboratory data-production process. All data must be reviewed by the subcontractor QA Officer prior to submission to the Battelle Database Manager and must be accompanied by a signed QA statement (a copy of the statement can be found in the Quality Management Plan; Battelle, 1998) that describes the types of audits and reviews conducted, the results, any outstanding issues that could affect data quality, and a QC narrative of activities.

Performance audits, procedures used to determine quantitatively the accuracy of the total measurement system or its components, will be the responsibility of the subcontractor laboratory and may include SRMs, internal performance evaluation samples, and participation in external certification programs.

18.0 CORRECTIVE ACTION

All technical personnel share responsibility for identifying and resolving problems encountered in the routine performance of their duties. Dr. Carlton Hunt, Battelle's Project Manager, will be accountable to MWRA and to Battelle management for overall conduct of the Harbor and Outfall Monitoring Project, including the schedule, costs, and technical performance. He is responsible for identifying and resolving problems that (1) have not been addressed timely or successfully at a lower level, (2) influence multiple components of the project, (3) necessitate changes in this CW/QAPP, or (4) require consultation with Battelle management or with MWRA.

Issues that affect schedule, cost, or performance of Task 26 will be reported to the Battelle Project Manager. They will be responsible for evaluating the overall impact of the problem on the project and for discussing corrective actions with the MWRA Project Manager.

Problems identified by the QA Officer will be reported and corrected as described in Section 17.0 and the Quality Management Plan (Battelle, 1998).

19.0 REPORTS

Documents that will be generated under the Benthic (Sea-Floor) Monitoring tasks are:

- Survey plans;
- Survey reports;
- Data reports; and
- Synthesis reports.

19.1 Survey Plans

Each survey plan will follow the new guidelines established by the U.S. Environmental Protection Agency for use on the *OSV Anderson* and will include the following information:

- Documentation of any deviations from this CW/QAPP
- Schedule of operations
- Specific location and coordinates of each station
- Survey/sampling methods
- Navigation and positioning control
- Vessel, equipment, and supplies
- Scientific party

Two bound copies (double-sided on three-hole punched paper) of the final survey plan will be submitted to MWRA at least one week prior to the start of the survey. No draft survey plans will be prepared.

19.2 Survey Reports

Survey reports will describe the survey conducted and will include a table that contains all information specific to each survey (including, but not limited to, survey date, sampling times, Survey_ID, sample types, etc.). The table will be derived from an electronic file that can be used to load the data into the MWRA database. In addition to the general survey information, any problems experienced and the corrective actions required will be noted. Any incidental observations of marine mammals will be included. Any deviations from this CW/QAPP, not known at the time of survey plan preparation, will also be incorporated into the survey reports.

A survey report is expected to include about 4-5 pages of text, with accompanying station maps and sample table. A tabular summary of stations occupied, station locations, and samples collected will be included in the survey reports. Two bound, double-sided copies of the draft survey report will be submitted to MWRA no later than four weeks after the completion of each survey. MWRA's comments will be due two weeks after receipt of the draft report. One unbound copy (double-sided on three-hole punched paper) of the final survey report, addressing MWRA's comments, will be due two weeks after receipt of the comments. If MWRA does not submit comments within the two-week period, the draft survey report will be considered final.

Within two business days of the completion of the Nearfield Benthic and Nearfield SPI surveys, a survey summary will be sent via e-mail to MWRA. The form of the summary will be similar to that shown on pages 56 of 164 of the Contract. In addition to highlighting anything noteworthy about the survey, the summary will report any monitoring thresholds that apparently have been exceeded, or conditions that may lead to a threshold being exceeded. In addition, the e-mail summary that follows each Nearfield SPI survey will contain the results of the rapid review of the images (see Section 12.2.3 for the parameters included in the rapid review).

19.3 Data Reports

Following each analytical subtask conducted under the Benthic (Sea-Floor) Monitoring program (except Task 20.1, which requires a Status Report), a data report will be prepared and delivered to MWRA. All data reports will be generated from the central MWRA database. Each report will include a brief introduction, brief written summary, and some preliminary summary descriptive statistics (as appropriate). The data table will include the sample ID, collection date, the station and replicate numbers, and the analytical results. Some of the specific reports produced under Task 20 have additional individual requirements. The sediment chemistry data reports (Tasks 19.1–19.5) will include the results of all quality control data (procedural/method blank results on a concentration basis using representative weight of analytical batch; SRM PD results; MS percent recoveries; SIS recoveries; sample replicate R%Ds or RSDs). The infaunal data reports (Tasks 20.2–20.5) also will include the NODC code, the taxon name, the number of individuals counted for each taxon, a three-letter major taxon abbreviation, and, where possible, the family name. The Hardbottom Survey data reports (Task 20.8) will be accompanied by copies of the videotapes and scanned photographic images taken during the survey.

The due dates for the various data reports are listed in Section 9.0.

19.4 Reference Collection Status Report

Once per year (June 1999–2002), a reference collection status report will be prepared after MWRA accepts all infaunal data reports from a year's sampling. The report, in letter format, will include

- a hierarchical taxonomic list of all taxa comprising the collection,
- the current species code for all taxa from the EM&MS database,
- the staff with custody of parts of the collection, any new taxa identified in the previous year's samples, and
- any taxonomic changes to previously identified taxa and a justification for the change.

19.5 Annual Synthesis Reports

Data collected under the Benthic (Sea-Floor) Monitoring program will be used to prepare annual synthesis reports (under Tasks 33.5–33.7). Each report will be reviewed by the Battelle Program Manager and scientists who are knowledgeable in the subject matter of the report. This will ensure that interpretations made in the reports are scientifically and technically valid and meet the MWRA's needs. To ensure readability and accuracy in use of scientific language, symbols, and format, each report will be reviewed by a technical editor and Battelle's QA Office. The names of the QA, technical, and editorial reviewers will be provided upon submission of the draft report. Any QA/QC issues recognized and corrected during the audit will be provided. Thirty days prior to the due date of the draft report, an outline will be delivered to MWRA. The due dates for the draft and final annual synthesis reports are listed in Section 9.0. The specific approach to each report is presented below.

Task 33.5 — Outfall Benthic Report. The 1998 Annual Outfall Benthic report will focus on the current status of benthic environmental quality in the Nearfield and Farfield. In subsequent years, reports will focus on evaluation of the baseline years' data versus the relevant infaunal, contaminant, and SPI (RPD in the sediments) monitoring thresholds. The outfall went online in August 2000. The prime consideration of the outfall benthic report will now be towards any parameters that violate thresholds (once they are established) and the extent to which these violations might have resulted from the MWRA discharge. The analytical approach will include a concise description of relevant benthic species composition and structure parameters at each station and a comparison of these parameters among stations. Of particular interest are Shannon diversity *(H'*), evenness (*J'*), and the log-series alpha diversity measure. Analyses will be planned to examine trends across the entire study area, including benthic organisms, sediment parameters, and contaminant levels. Graphics illustrating key area-wide trends will be prepared. To detect changes possibly related to outfall discharges, analyses of data from all baseline and post-discharge years will include a multivariate approach, which incorporates cluster and ordination analyses.

The technical content of each report will be presented in chapters that describe the results from the year's studies and provide comparisons to all previous MWRA studies. These chapters will be based on the physico-chemical analyses, traditional infaunal analysis, SPI analysis, and hardbottom analysis. Each chapter will discuss the data with respect to thresholds, and incorporate, as appropriate, results from other studies. Conclusions will also be presented.

Task 33.6 — Harbor Benthic Report. The purpose of the Annual Harbor Benthic Report is to present and interpret the data collected during the previous calendar year and to compare those data to results of the previous Harbor studies. Relevant benthic species composition and structure parameters will be described concisely for each station and compared among stations. Alpha and beta diversity estimates that will be described with log-series alpha diversity measurement and CNESS metrics will be particularly important. The spatial and temporal trends of change in the Harbor's benthic communities will be evaluated in the reports. To further analyze the Harbor data and to help clarify response that may be related to improvement in water and sediment quality in the Harbor, a multivariate approach incorporating clustering and ordination analyses will be performed.

The technical content of the report will be presented in chapters that describe the results from the year's studies and provide comparisons to previous studies. These chapters will be based on the physico-chemical analyses, traditional infaunal analysis, SPI analysis, and rapid sorting analysis. Each chapter will discuss the data and incorporate, as appropriate, results from other studies.

Task 33.7 — CSO Report. The primary objectives of this report are to examine the potential effects of CSO discharges on sediments in receiving water areas and to assess temporal differences in sediment contaminant concentrations between the 1998 study and the previous CSO studies performed for MWRA in 1990 and 1994 (Durell *et al*., 1991; Durell, 1995). Data from CSO effluent studies conducted by MWRA will be used to compare CSO contaminant loadings with results from the sedimentary analyses. Other data also will be consulted and compared to MWRA CSO data.

In general, the analytical approach will involve graphical presentation and statistical comparisons of the 1998 data similar to those used by Durell (1995). An attempt will be made to describe the relative contributions of particular pollutant sources to sediment contamination, although this can be difficult. In Boston Harbor, CSO impacts are confounded by inputs from treatment plants, upstream river sources, boats, stormwater runoff, and atmospheric deposition. When appropriate, microbial indicators will be used to help discriminate among these sources at sites near to and far from CSOs. An attempt to relate toxic contaminants to pollutant sources will be made.

20.0 REFERENCES

Albro CS, Trulli HK, Boyle JD, Sauchuk SA, Oviatt CA, Keller AA, Zimmerman C, Turner JT, Borkman D, Tucker J. 1998. Combined work/quality assurance plan for baseline water quality monitoring: 1998-2000. Boston: Massachusetts Water Resources Authority. Report ENQUAD ms-048. 121 p.

Battelle. 1998. Quality management plan for Massachusetts Water Resources Authority Harbor and Outfall Monitoring Project (HOM) III. 28 pp.

Bisson, J.W. and V.J. Cabelli. 1979. Membrane filter enumeration method for *Clostridium perfringens*. *Applied Environmental Microbiology* 37:55-66.

Blake, J. and B. Hilbig. 1995. Combined work/quality assurance project plan for benthic monitoring: 1995-1997. MWRA Environmental Quality Technical Report Series No. MS-34. Massachusetts Water Resources Authority, Boston, MA. 68 pp.

Boesch DF. 1977. Application of numerical classification in ecological investigations of water pollution. Report prepared for US EPA Ecological Research Series (EPA-600/3-77-033). Available as PB269 604 from: National Technical Information Service. U.S. Department of Commerce. Springfield VA 22161.

Brown, B. and J. Neff. 1993. Bioavailability of sediment-bound contaminants to marine organisms. Report to the National Oceanic and Atmospheric Administration, National Ocean Pollution Program Office, Rockville, MD.

Coats, D.A. 1995. 1994 annual soft-bottom benthic monitoring: Massachusetts Bay outfall studies. MWRA Environmental Quality Technical Report Series No. 95-20. Massachusetts Water Resources Authority, Boston, MA. 184 pp.

Day, M. E., L. C. Schaffner, and R. J. Diaz. 1988. Long Island Sound sediment quality survey and analyses. Tetra Tech, Report to the National Oceanic and Atmospheric Administration, NOS, OMA, Rockville, MD. 113 pp.

Diaz, R.J. and R. Rosenberg. 1995. Marine benthic hypoxia: a review of its ecological effects and the behavioral responses of benthic macrofauna. *Oceanography and Marine Biology, An Annual Review* 33:245-303.

Diaz, R. J. and L. C. Schaffner. 1988. Comparison of sediment landscapes in the Chesapeake Bay as seen by surface and profile imaging. Pp. 222-240. In: M. P. Lynch and E. C. Krome, eds. *Understanding the Estuary; Advances in Chesapeake Bay Research*. Chesapeake Research Consortium Publication 129 CBP/TRS 24/88.

Durell, G.S. 1995. Concentrations of contaminants in Dorchester Bay and Boston Harbor sediments collected in the vicinity of CSO discharges and comparison to 1990 concentrations. MWRA Environmental Quality Technical Report Series No. 95-14. Massachusetts Water Resources Authority, Boston, MA. 128 pp.

Durell, G., L. Ginsburg, and D. Shea. 1991. CSO Effects on contamination of Boston Harbor sediment. MWRA Environmental Quality Technical Report Series No. 91-8. Massachusetts Water Resources Authority, Boston, MA, 146 pp.

Emerson, D.J. and V.J. Cabelli. 1982. Extraction of *Clostridium perfringens* spores from bottom sediment samples. *Applied Environmental Microbiology* 44:1144-1149.

EPA (U.S. Environmental Protection Agency). 1997. Method 1640: Determination of Trace Elements in Water by Preconcentration and Inductively Coupled Plasma - Mass Spectrometry. EPA Office of Water and Office of Science and Technology. Washington, DC.

EPA (U.S. Environmental Protection Agency). 1996. Method 1638: Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma - Mass Spectrometry. EPA Office of Water and Office of Science and Technology. Washington, DC.

EPA (U.S. Environmental Protection Agency). 1991a. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010. Method 245.5: Determination of Mercury in Sediments by Cold Vapor Atomic Absorption Spectrometry. Environmental Protection Agency, Environmental Services Division, Monitoring Management Branch. Cincinnati, Ohio.

EPA (U.S. Environmental Protection Agency). 1991b. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010. Method 200.9: Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry. Environmental Protection Agency, Environmental Services Division, Monitoring Management Branch. Cincinnati, Ohio.

EPA (U.S. Environmental Protection Agency). 1985. Test methods for *Escherichia coli* and Enterococci in water by the membrane filter procedure. EPA 600/4-85/076. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Fager EW. 1963. Communities of organisms. pp 415-433. In: M.N. Hill (ed.) The Sea. Wiley-Interscience, New York.

Fenchel, T. 1969. The ecology of marine microbenthos. IV. Structure and function of the benthic ecosystem, its chemical and physical factors and microfauna communities with special reference to the ciliated Protozoa. *Ophelia* 6:1-182.

Folk, R.L. 1974. *Petrology of Sedimentary Rocks.* Hemphill Publishing Company, Austin, TX. 184 pp.

Gallagher ED, Keay KK. 1998. Organism-sediment-contaminant interactions in Boston Harbor. Pp. 89-132. In: Stolzenbach KD, Adams EE, eds., Contaminated sediments in Boston Harbor. MIT Sea Grant Publication 98-1. 170p.

Hilbig, B. 1997. Draft Nearfield hardbottom survey report: June 1997 survey. Massachusetts Water Resources Authority, Boston, MA.

Hilbig, B., J.A. Blake, E. Butler, B. Hecker, D.C. Rhoads, G. Wallace, and I.P. Williams. 1996.

Massachusetts Bay outfall monitoring program: 1995 benthic biology and sedimentology. MWRA Environmental Quality Technical Report Series No. 96-5. Massachusetts Water Resources Authority, Boston, MA. 230 pp.

Kelly, J.R. and R.K. Kropp. 1992. Benthic recovery following sludge abatement in Boston Harbor: Part I Baseline survey 1991 and Part II Spring survey 1992. Technical report to MWRA Environmental Quality Department, November 1991. Massachusetts Water Resources Authority, Boston, MA. 45 + 29 pp.

Kiley, K. 1989. Report on the use of personal computer based image analysis software and hardware for dredge material disposal monitoring. Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Pt., VA. Report. to U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. 32 pp.

Kropp, R.K. and R.J. Diaz. 1995. Infaunal community changes in Boston Harbor, 1991-1994. MWRA Environmental Quality Technical Report Series No. 95-21. Massachusetts Water Resources Authority, Boston, MA, 94 pp.

Kropp, R. and C. Peven. 1993. Combined work/quality assurance plan for soft-bottom benthic monitoring: 1993-1994. MWRA Environmental Quality Technical Report Series No. ms-12. Massachusetts Water Resources Authority, Boston, MA. 64 pp.

Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton.

Messer, J.W. and A.P. Dufour. 1998. A rapid, specific membrane filtration method procedure for enumeration of Enterococci in recreational water. *Applied and Environmental Microbiology* Feb. 1998:678-680.

MWRA (in Prep) Procedures for calculation and testing of Contingency Plan thresholds. Boston: Massachusetts Water Resources Authority. Report ENQUAD ms-064.

MWRA 1997a. Contingency plan. Massachusetts Water Resources Authority, Boston, MA. 40 pp.

MWRA. 1997b. Massachusetts Water Resources Authority effluent outfall monitoring plan: Phase II post-discharge monitoring. MWRA Environmental Quality Department Miscellaneous Report No. ms-44 Massachusetts Water Resources Authority, Boston, MA. 61 pp.

NOAA. 1993. Comprehensive descriptions of trace organic analytical methods. Sampling and Analytical Methods of the National Status and Trends Program, National Benthic Surveillance and Mussel Watch Project, 1984 - 1992 (Volume IV). NOAA Technical Memorandum NOS/ORCA/CMBAD 71. 182 pp.

NRC. 1990. Managing troubled waters: The role of marine environmental monitoring. National Research Council (NRC). National Academy Press, Washington DC. 125 pp.

Odum, E. P. 1969. The strategy of ecosystem development. *Science* 164:262-270.

Parmenter, C.M. and M.H. Bothner. 1993. The distribution of *Clostridium perfringens*, a sewage indicator, in sediments of coastal Massachusetts. US Geological Survey Open File Report 93-8.

Pearson, T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology, An Annual Review* 16:229-311.

Peven, C.S. and A.D. Uhler. 1993. Analytical procedures for trace and major element analysis. In: Sampling and Analytical methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Project. Volume III. NOAA Technical Memorandum NOS ORCA 71. National Oceanic and Atmospheric Administration, Silver Spring, MD.

Reineck, E. and I. B. Singh. 1975. *Depositional Sedimentary Environments*. Springer-Verlag, New York.

Rhoads, D.C. and J.D. Germano. 1986. Interpreting long-term changes in benthic community structure: a new protocol. *Hydrobiologia* 142:291-308.

Saad, D.L. 1992. Simplified Method for Extraction of *Clostridium perfringens* spores and Indicator Bacteria from Marine Sediments. In: *Seasonal Disinfection with Respect to Marine Waters*. Ph.D. Dissertation, University of Rhode Island, Kingston, RI.

Salomons, W., N.M. de Rooij, H. Derdijk, and J. Bril. 1987. Sediments as a source for contaminants. *Hydrobiologia* 149:13-30.

Shea, D. 1993. Combined work/quality assurance plan for detailed effluent characterization: 1993-1994. Amended 3/24/94 by D. West and P. Doering. MWRA Environmental Quality Department Miscellaneous Report No. ms-13. Massachusetts Water Resources Authority, Boston, MA. 48 pp.

Shea, D. 1994. Quality assurance project plan for inventories and concentrations of organic contaminants in sediments of Massachusetts and Cape Cod Bays. Report to Massachusetts Bays Program, Boston, MA.

Viles, C. and R. J. Diaz. 1991. Bencore, an image analysis system for measuring sediment profile camera slides. Virginia Institute of Marine Science, Gloucester Pt. VA. 13 pp.

Willie, S. 1997. NOAA/11: Eleventh Round Intercomparison for Trace Metals in Marine Sediments and Biological Tissues. Final Report National Research Council of Canada. 51 pp.

APPENDIX A

Data Forms

Barbara Hecker/
Hecker Environmental

Roll #:		**Station:T - WP**	**Date**:
Frame #	Time	Depth (ft)	Comments
1			
2			
3			
4			
5			
6			
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8			
9			
10			
11			
12			
13			
14			
15			
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36			

GeoPlan Associates

GEO/PLAN Associates

Sediment Grain Size Analysis Summary

Client: XXXX

Project: MWRA Harbor and Outfall Monitoring

Project Number: 4501-XXXX-XXX

Date: XXX 19XX

SAMPLE	% Gravel	% Sand	% Silt	% Clay	PHI PERCENT						Mean	Std Dev
					<-1	0	1	2	3	4		

KLM Analytical

EXHIBIT 1

Analysis Request Form

Instructions:

1. Please submit completed form with samples, QC section must be specific.
2. Sample designation can be up to 25 characters.
3. Leave form with samples in the sample receiving area, or send form with samples to:

   R.W. Sanders
   KLM Analytical
   200 Logston Blvd.
   Richland, WA 99352

4. All prepared sample and residual sample material will be disposed of unless you specify otherwise under "special instructions" (e.g. return excess sample to client, or storage for XX time).

General Information:

Client Name:_____ Phone:_____
Address:_____
_____
_____
_____

Specific QC requirements:_____
_____
_____
_____

Date Results Needed:_____
Date samples Sent:_____
Date samples Received_____ (KLM use only)

Client Sample Identification:

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

Brief Description of sample Material:_____
_____
_____
_____
_____

Analyze these samples qualitatively/quantitatively (circle one) for the following elements:

XRFA:
AAS:

Special Instructions:

( ) Samples need refrigeration
( ) Other requirements
( ) Return residual sample material. Yes( ) No( )
To:_____

( ) Send prepared samples. Yes( ) No( )
To:_____

( ) Send _____analysis report(s).
( ) Other comments and/or instructions:

Author: _____ Date:_____

KLM Manager:_____ Date:_____

Discrepancy/Resolution:_____

X-RAY FLUORESCENCE ANALYSIS : EDXRF Final Report:															
SPONSOR:															
DATE OF WORK: 3/19/98															
WORK ORDER NUMBER:															
TYPE OF MATERIAL: SEDIMENTS															
SERIES NAMES ASSOCIATED WITH THIS SAMPLE SET:															
DESCRIPTION OF XRFA TECHNIQUES USED:															
The received samples were homogenized by grinding in an alumina M/P and 500mg of the material removed															
and ground to about 300 mesh. The material was processed as loose powder as described and in															
accordance with KLM test Procedure 7-40.48. Standards of 2704,1643 BCR-1, BHVO, W-1, and PCC-1															
were processed with the samples for control and test equipment check.															
ANALYST: RON SANDERS/ KLM Analytical															
PHONE: (509) 375-3268 EXT. 361															
SS UNITS	EL		SRM 2704 RUN1			SEM 1646			USGS BCR-1				USGS W-1		
ZR															
				+/-			+/-				+/-				+/-
%	AL		7.7	0.84	AL	5.99	0.93	AL		8.79	0.87	AL		8.76	0.84
%	SI		29.1	1.6	SI	29.5	1.7	SI		30.6	1.7	SI		28.5	1.6
%	P	<	0.31		P	< 0.3		P		0.47	0.18	P	<	0.35	
%	S		0.308	0.077	S	0.97	0.1	S		0.163	0.078	S	<	0.14	
%	CL	<	0.072		CL	1.289	0.087	CL	<	0.078		CL	<	0.066	
%	K		1.96	0.1	K	1.823	0.097	K		1.453	0.079	K		0.53	0.033
%	CA		2.58	0.13	CA	0.778	0.043	CA		4.69	0.24	CA		7.46	0.38
%	TI		0.458	0.024	TI	0.489	0.026	TI		1.441	0.073	TI		0.687	0.036
PPM	V		109	31	V	99	30	V		500	58	V		343	43
PPM	CR		157	18	CR	61	15	CR	<	43		CR		131	21
PPM	MN		584	34	MN	341	22	MN		1512	80	MN		1374	74
%	FE		4.06	0.2	FE	3.18	0.16	FE		9.5	0.48	FE		7.82	0.39
PPM	CO	<	51		CO	< 44		CO	<	85		CO	<	79	
PPM	**NI**		**44.6**	**3.8**	**NI**	**33.6**	**3**	**NI**	<	**19**		**NI**		**71.8**	**9.9**
PPM	CU		97.5	5.8	CU	18.8	2.1	CU		23.3	3.2	CU		111.8	7
PPM	ZN		433	22	ZN	123.8	6.8	ZN		127.4	7.3	ZN		84	5.2
PPM	GA		12.6	1.6	GA	13.7	1.5	GA		24	2.1	GA		19.5	2
PPM	HG	<	3.3		HG	< 2.9		HG	<	4.2		HG	<	4.1	
PPM	SE	<	1.6		SE	< 1.5		SE	<	1.8		SE		2.72	0.93
PPM	PB		177.1	9.6	PB	29.1	2.8	PB		17.6	2.8	PB	<	5.5	
PPM	AS		19.9	2.5	AS	11.5	1.5	AS		3.4	1.4	AS		3.3	1.3
PPM	BR		6.3	1	BR	124.3	6.5	BR	<	1.8		BR	<	2	
PPM	RB		113.9	5.9	RB	95.4	5	RB		55.2	3	RB		24.8	1.7
PPM	SR		128	8.2	SR	147.8	9	SR		355	19	SR		187	12

MTH Environmental Associates

MTH ENVIRONMENTAL ASSOCIATES
SEDIMENT CLOSTRIDIUM PERFRINGENS CALCULATIONS

Project:
Client:

Entered By:_____ Date:_____ Verified By:_____ Date:_____

Sample ID	Rep. No.	Run	Wet Wt. Used	Total Count	Total mls	T counts /T mls	X 35 mls	CFU/ gm wet wt.	Wet/ dry ratio	CFU/ gm dry wt.	Sum CFU/ gm dry wt.	Mean	SD	CV	CVx100

MTH ENVIRONMENTAL ASSOCIATES
WET/DRY CALCULATIONS

Project:______________________
Client:______________________

Entered By:______ Date:__________ Verified By:______________ Date:________

Pan No.	Sample No.	Rep. No.	Weight Pan Only (gm)	Wet Wt. Pan & Sed. (gm)	Wet Wt. Sed. Only (gm)	Dry Wt. 1 Pan & Sed. (gm)	Dry Wt. 2 Pan & Sed. (gm)	Dry Wt. 3 Pan & Sed. (gm)	Average Dry Wt. Pan & Sed. (gm)	Average Dry Wt. Sed. Only (gm)	Wet/Dry Ratio

Analytical Results: Clostridium perfringens
Date:
Contact: MTH Environmental Associates
Dr. Dale L. Saad
Dr. Robert A. Duncanson
(508) 420-0706

Sample ID	Rep	Bar Code No.	Param. Code	Anal. Date	Value	Unit Code	CV (%)	Comments
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		
			Clostridium			C. perfringens/gm dry wt.		

Notes:
1. Reported value based on duplicate analyses unless otherwise noted.
2. CV = coefficient of variation in percent.

Battelle

BATTELLE - DUXBURY OPERATIONS

DAILY SAMPLE TRACKING PAGE

Samples Relinquished by Custodian :	Date :	Time:
Location from which retrieved :	Date :	Time:
Samples received for sample prep by :	Date :	Time:
Storage until prep initiated :	Date :	Time:
Samples Returned to Custodian :	Date :	Time:
Location Stored :	Date :	Time:

Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:
Date Extracts Removed :	Initials:	Location removed from:
Date Extracts Returned :	Initials:	Storage Location:

Comments:

BATTELLE - DUXBURY OPERATIONS
SAMPLE WEIGHT FORM

Sample ID	Tare Wt (g)	Wet Wt (g)	Dry Wt #1 (g)	Dry Wt #2 (g)	Extraction Wet Wt (g)
Date/Initials					
Balance					
& Location					

BATTELLE - DUXBURY OPERATIONS
SURROGATE SPIKE FORM

Sample ID	Standard ID	Vial #	Volume Added (uL)	Date	Spiked By	Witn'd By

Extraction Started: **Date:**_____ **Initials:** _____ **TurboVap** ____ **C** ____ **psi**
Extraction Completed: **Date:** _____ **Initials:** _____ **K-D** _____ **C**
Comments:

BATTELLE - DUXBURY OPERATIONS
HPLC DILUTION DOCUMENTATION

Sample ID	Sample Volume	HPLC Inj Volume	HPLC Split

HPLC System ID: _____ Date/Initials: _____
Comments:

BATTELLE - DUXBURY OPERATIONS
INTERNAL STANDARD SPIKING FORM

Sample ID	Extract Volume (uL)	Standard ID and Vial #	Volume Added (uL)	Final Dilution*	Spiked By	Witn'd By	Date

Samples split after RIS added: Yes No

*Final Dilution is any PHLC splits, dilutions, or other sample manipulations

BATTELLE - DUXBURY OPERATIONS
SAMPLE DILUTION AND SPLIT PAGE

Sample ID	Initial Sample Volume (uL)	Volume Removed from Initial (uL)	Final Volume for Prep (uL)/ Analysis	Diluted Sample ID (e.g., -D)	Dilution of Amount	Date/ Initials

Dilution of Amount = [Initial Sample Volume {uL}/Volume Removed from Initial Volume (uL}]
Comments:

BATTELLE - DUXBURY OPERATIONS
CHAIN-OF-CUSTODY PAGE

GC/CD TRANSFER				
Relinquished by:	**Date:**	**Received by:**	**Date:**	**Refrig. ID/GC**

GC/MSD TRANSFER				
Relinquished by:	**Date:**	**Received by:**	**Date:**	**Refrig. ID/GC**

GC/FID TRANSFER				
Relinquished by:	**Date:**	**Received by:**	**Date:**	**Refrig. ID/GC**

GC/FPD (HPLC/UV) TRANSFER				
Relinquished by:	**Date:**	**Received by:**	**Date:**	**Refrig. ID/GC**

Cove Corporation

COVE CORPORATION SORTING QC SHEET

Client: _____ Study Site: _____ Sampling Date: _____

Trial Number: _____ Station Code: _____ Replicate Code: _____

Technician: _____ Sample Batch: _____

I. NUMBER OF ORGANISMS FOUND IN QC INSPECTION

Taxon	Count	Taxon	Count

II. EVALUATION OF QC SAMPLE

Number of organisms found in QC inspection: _____

Total number of organisms present in sample: _____

Percent error calculation: _____ Pass: ____ Fail: ____

Date and initials of sorter performing the QC resort: _____

Date and initials of taxonomist recording the number of organisms missed: _____

Has this batch previously failed a QC check? Yes ____ No ____

Was the sample residue properly labeled with internal and external labels? Yes ____ No ____

Were all specimen vials of the QC sample properly labeled? Yes ____ No ____

III. COMMENTS CONCERNING SAMPLE PROCESSING

(initialize & date all entries -- continue on back if necessary)

Necessary Remedial Action: _____

_____

_____

Comments: _____

SPECIES ABUNDANCE DATA SHEET Page 1 of ____

Client: Battelle Study Site: Boston Harbor - MWRA Sampling Date: APR98

Remarks: _____

Taxonomists:

Station: T		cc	cc	cc
Species	NODC code	rep. 1	rep. 2	rep. 3
Aricidea catherinae	5001410208			
Capitella capitata complex	5001600101			
Cirratulidae	5001500000			
Eteone longa	5001130205			
Exogone	50012307			
Mediomastus californiensis	5001600402			
Microphthalmus aberrans	5001210202			
Monticellina baptisteae	5001501101			
Nephtyidae	5001250000			
Nephtys caeca	5001250103			
Ninoe nigripes	5001310204			
Pholoe minuta	5001060101			
Phyllodoce mucosa	5001130104			
Polydora cornuta	5001430411			
Diolydora socialis	5001430402			
Polynoidae	5001020000			
Prionospio steenstrupi	5001430506			
Scoletoma hebes	5001310140			
Spio armata	5001430709			
Streblospio benedicti	5001431801			
Tharyx spp. complex	5001500300			
Nemertinea	4300000000			

SPECIES ABUNDANCE DATA SHEET

Client: Battelle Study Site: Boston Harbor - MWRA Sampling Date: APR98

Remarks: _____

Taxonomists:

Station: T		cc	cc	cc
Species	NODC code	rep. 1	rep. 2	rep. 3
Bivalvia spp.(indeterminate)	5500000000			
Lyonsia	55200502			
Mya arenaria	5517010201			
Mytilus edulis	5507010101			
Nassarius trivittatus	5105080103			
Nucula dephinodonta	5502020206			
Tellina agilis	5515310205			
Tellinidae	5515310000			
Ampelisca abdita	6169020108			
Corophium	61691502			
Dyopedos monacanthus	6169440104			
Leptocheirus pinguis	6169060702			
Photis pollex	6169260215			
Phoxocephalus holbolli	6169420702			
Unciola	61691507			
Edotea triloba	6162020703			

SPECIES ABUNDANCE DATA SHEET

Client: Battelle Study Site: Boston Harbor - MWRA Sampling Date: APR98

Remarks: ____

Taxonomists:

Station: T		cc	cc	cc

SPECIES ABUNDANCE DATA SHEET

Client: Battelle Study Site: Boston Harbor - MWRA Sampling Date: APR98

Remarks: Oligochaete identifications by Russ Winchell.

Taxonomists:

Station: T		cc	cc	cc
Species	NODC code	rep. 1	rep. 2	rep. 3

COVE CORPORATION IDENTIFICATION QC SHEET

Page _____ of _____

Client: _____ Study Site: _____ Sampling Date: _____

Trial Number: _____ Station Code: _____ Replicate Code: _____

Taxonomist: _____ Sample Batch: _____

I. TYPE I ERRORS (taxa incorrectly enumerated)

Taxon	QC Count	Original Count	Taxon	QC Count	Original Count
Total number of enumeration errors					

II. TYPE II ERRORS (taxa incorrectly identified)

Number Misid.	QC Id.	Original Id.	Number Misid.	QC Id.	Original Id.
Total number of identification errors					

III. TYPE III ERRORS (taxa not recorded or recorded on the wrong line of the data sheet)

Taxon	Number	Taxon	Number
Total number of recording errors			

IV. EVALUATION OF QC SAMPLE

Total number of organisms present in sample: _____ Total number of errors detected in QC audit: _____

Identification QC error: _____ Pass: _____ Fail: _____

Reidentified by: _____ Date Reidentified: _____

Necessary Remedial Action: _____

Comments: _____

CHAIN OF CUSTODY RECORD

Page ___ of ___

COVE CORPORATION, 10200 Breeden Road, Lusby, MD 20657
Tel: 410-326-4577 FAX 410-326-4767

Client: _____ Destination: _____

Project Name: _____ _____

Project Description: _____ _____

Station	Replicate	Serial Number	Sampling Date	Station	Replicate	Serial Number	Sampling Date

Relinquished by (Signature)	Date and Time	Method of Shipment	Received by (Signature)	Date and Time	Method of Shipment
Relinquished by (Signature)	Date and Time	Method of Shipment	Received by (Signature)	Date and Time	Method of Shipment

COVE CORPORATION SAMPLE BATCH LISTING SHEET

Client: _____ Study Site: _____

Technician: _____ Sampling Date: _____

I. BATCHES OF SAMPLES

Batch No.	Batch No.	Batch No.	Batch No.
1)	1)	1)	1)
2)	2)	2)	2)
3)	3)	3)	3)
4)	4)	4)	4)
5)	5)	5)	5)
6)	6)	6)	6)
7)	7)	7)	7)
8)	8)	8)	8)
9)	9)	9)	9)
10)	10)	10)	10)

II. QC EVALUATION

QC Results	Batch	Batch	Batch	Batch	Batch	Batch
QC Sample						
Serial Number						
QC Date						
QC Inspector						
Percent Error						

III. COMMENTS CONCERNING SAMPLE PROCESSING (initialize & date all entries -- continue on back if necessary)

Necessary Remedial Action: _____

_____

_____

Comments: _____

_____

_____

Study Site/Sampling Date: _____ Page _____ of _____
Cove Serial Number: _____
Station/Replicate Code: _____

I. TYPE I ERRORS (CONTINUED)

Taxon	QC Count	Original Count	Taxon	QC Count	Original Count
Total number of enumeration errors					

II. TYPE II ERRORS (CONTINUED)

Number Misid.	QC Id.	Original Id.	Number Misid.	QC Id.	Original Id.
Total number of identification errors					

III. TYPE III ERRORS (CONTINUED)

Taxon	Number	Taxon	Number
Total number of unrecorded errors			

Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129
(617) 242-6000
http://www.mwra.state.ma.us