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Final Report

PUGET SOUND AMBIENT MONITORING PROGRAM
MARINE SEDIMENT QUALITY IMPLEMENTATION PLAN

Prepared for

Washington Department of Ecology
Water Quality Programs Section

and

Puget Sound Water Quality Authority

by

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November 1988

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ACKNOWLEDGEMENTS

This implementation plan was prepared by Mr. Peter Striplin of the Department of Ecology's Ambient Monitoring Section. Assistance on technical issues was provided by Mr. John Bernhardt, Dr. Cliff Kirchmer, Mr. Bill Yake, Mr. Roy Araki and Mr. Dave Smith (Department of Ecology); Mr. Bruce Woods and Mr. Joe Blazevich (Region X Environmental Protection Agency); and Dr. Andrea Copping and Ms. Roberta Fines (Puget Sound Water Quality Authority); Dr. Raleigh Farlow (Jacobs Engineering Group); and Dr. Tom Ginn, Dr. Harry Beller, and Dr. Chip Hogue (PTI Environmental Services).

Editorial comments was provided by all the above-mentioned people and by Dr. John Armstrong (Region X Environmental Protection Agency); Ms. Mary Lou Mills and Ms. Cyreis Schmitt (Department of Fisheries); Dr. Jacques Faigenblum (Department of Social and Health Services); Mr. Gary Mauseth (Beak Consultants, Inc.); and Mr. Jeffrey Stern (Marine Dynamics).

Special thanks goes to Ms. Carol Perez and Ms. Sonya Kirkendall for their expertise and patience during the preparation of this document.

INTRODUCTION

The Ambient Monitoring Section of the Department of Ecology was assigned to implement the marine sediment quality task of the Puget Sound Ambient Monitoring Program (PSAMP, MMC, 1988). To this end, sediments will be examined using the triad approach. This approach consists of (1) benthic macroinvertebrate community analysis, (2) analysis of sediment for contamination by organic compounds and metals, and (3) a measure of sediment toxicity to experimental organisms (bioassays).

Sediment monitoring is one task of the Puget Sound Comprehensive Monitoring Program. Integration of data from all tasks in the program (sediments, water, fish, etc.) will enable the resource agencies to form a complete picture of the environmental health of the Sound. For example, the station locations selected for the sediment program will also be sampled for fin fish by the Department of Fisheries. An effort will be made to correlate sediment and Fisheries data. The stations may also be adjacent to Department of Natural Resources nearshore habitat monitoring stations or Department of Social and Health Services intertidal shellfish stations. The sediment monitoring task, as the first to be implemented, is the prototype for the programs to follow.

The purpose of this implementation plan is to provide a single interpretative document that will inform the Puget Sound Water Quality Authority (PSWQA), the Environmental Protection Agency (EPA), and the other state implementing agencies of the courses of action to be taken by Ecology in conducting the sediment monitoring task. The document serves as an expanded QAPP describing in detail the field sampling, laboratory procedures, analytical methods, quality assurance/control measures and data management needs of the sediment program. Finally, it will serve as the reference document for Ecology personnel when sediment monitoring is carried out by this agency.

This implementation plan describes, in detail, the considerations and needs of the study as we see it. A clear understanding of the scope of the task is a prerequisite to either overseeing contracted work or carrying out such a program internally.

Based on the information in this plan, it is anticipated that Ecology will develop a request for proposal (RFP) and hire a consultant for the first year of the task. The major focus during the first year will be to train Ecology personnel who will assume full responsibility the second year.

OBJECTIVES

This implementation plan differs from most services contracted in one important respect. The plan details logistics, sampling procedures, laboratory requirements, and other aspects of the program designed to ensure comparability of data. Thus the major thrust for the contractor is not development of a program, but implementation of the program as designed. This implementation plan conforms to the approach used by the

United States Environmental Protection Agency (U.S. EPA) for quality assurance project plans (U.S. EPA, 1980).

General Purpose

1. To provide a record of the condition of Puget Sound sediments.

2. To aid in the identification of reference sites/values.

3. To provide data for use by researchers concerned with sediment quality.

Specific Objectives

1. Collect baseline and long-term data on Puget Sound sediments and macroinvertebrate communities in uncontaminated and contaminated areas.

2. Identify areas of Puget Sound that are accumulating toxic chemicals.

3. Assess the potential sediment toxicity resulting from accumulating toxic chemicals.

4. Evaluate the condition of Puget Sound benthic macroinvertebrate communities in relation to the concentration of toxic chemicals in the sediments.

5. Document both natural and anthropogenic changes to sediment quality.

EXPERIMENTAL DESIGN

The experimental design of the marine sediment quality monitoring task is an integrated effort that includes the study of benthic macroinvertebrate community structure, the study of toxicity of the sediments to bioassay organisms, and an examination of the sediments to determine the presence or absence of chemical contaminants. The relationship between these components will be examined using an approach similar to the "sediment quality triad" approach (Chapman and Long, 1983).

A total of 119 stations were identified by the Monitoring Management Committee (MMC) for annual sampling. The majority of the stations were located along the 20 meter depth contour. Historical data show this depth to be the most productive in terms of the abundance and diversity of benthic organisms (Word et al., 1985). Additionally, the sediments at this depth are an important feeding habitat for salmonid and demersal fishes (Stober and Chew, 1985; Becker, 1984). Six of the 119 stations will be located at the centers of the Puget Sound basins at water depths exceeding 150 meters. Nichols (1985) showed that these basins, even though located away from anthropogenic activity, experienced major changes in benthic community structure. Whether these changes are related to anthropogenic activity or to long-term natural variation is unknown. The rationale for the station locations is discussed in detail in the MMC final report (MMC, 1988).

Fifty of the 199 stations were chosen at fixed locations, with 17 additional stations sampled in north Puget Sound in the first year, to central Puget Sound the second year, and south Puget Sound in the third year. In the fourth year the rotation would be reinitiated in northern Puget Sound. Thus these 51 stations would be resampled once every three years. Six additional stations were designated as floating stations to be moved from region to region each year at the discretion of the implementing agency.

Due to funding limitations, the goal is to sample only the 50 fixed stations in fiscal year 1988-1989. Once full program funding is achieved, the additional stations will be sampled.

DESCRIPTION OF STUDY AREA

The main body of Puget Sound was formed during the Pleistocene epoch by glaciers estimated to have extended 4000 feet above sea level. The rapidly sloping bottom topography, relatively wide basins, compact glacially formed clay layers, and relict glacial tills are the legacy of this relatively recent geological activity (Crandel et al., 1965).

Puget Sound encompasses an area of about 5000 square kilometers, including numerous urban bays (i.e., Bellingham Bay, Port Angeles, Port Gardner, Elliott Bay, Sinclair Inlet, Commencement Bay, and Budd Inlet), and areas relatively untouched by human activity (i.e., Strait of Georgia, San Juan Islands, and areas in Hood Canal. The evaluation of ambient conditions in Puget Sound will be carried out in unimpacted areas and in rural and urban embayments. The study area extends from Semiahmoo Bay and the Straits of Georgia in northern Puget Sound to Port Angeles in the Strait of Juan de Fuca; through, Hood Canal, the main basin of Puget Sound, and in southern Puget Sound (Figure 1).

SAMPLING PLAN

Station Locations

Using the rationale and criteria identified by the Monitoring Management Committee in their final report (MMC, 1988), Department of Ecology personnel recommend the station locations presented in Figure 1 and Table 1.

Sample Collection Schedule

Sampling is scheduled to commence in the first week of March 1989, and is anticipated to last about four weeks. The study area has been divided into six regions principally because of the location of emergency services. The location of the regions are listed in Table 2 along with the number of stations per region and the estimated number of days to complete the sampling in each region. The number of days estimated to complete the sampling is based on ten-hour work days.

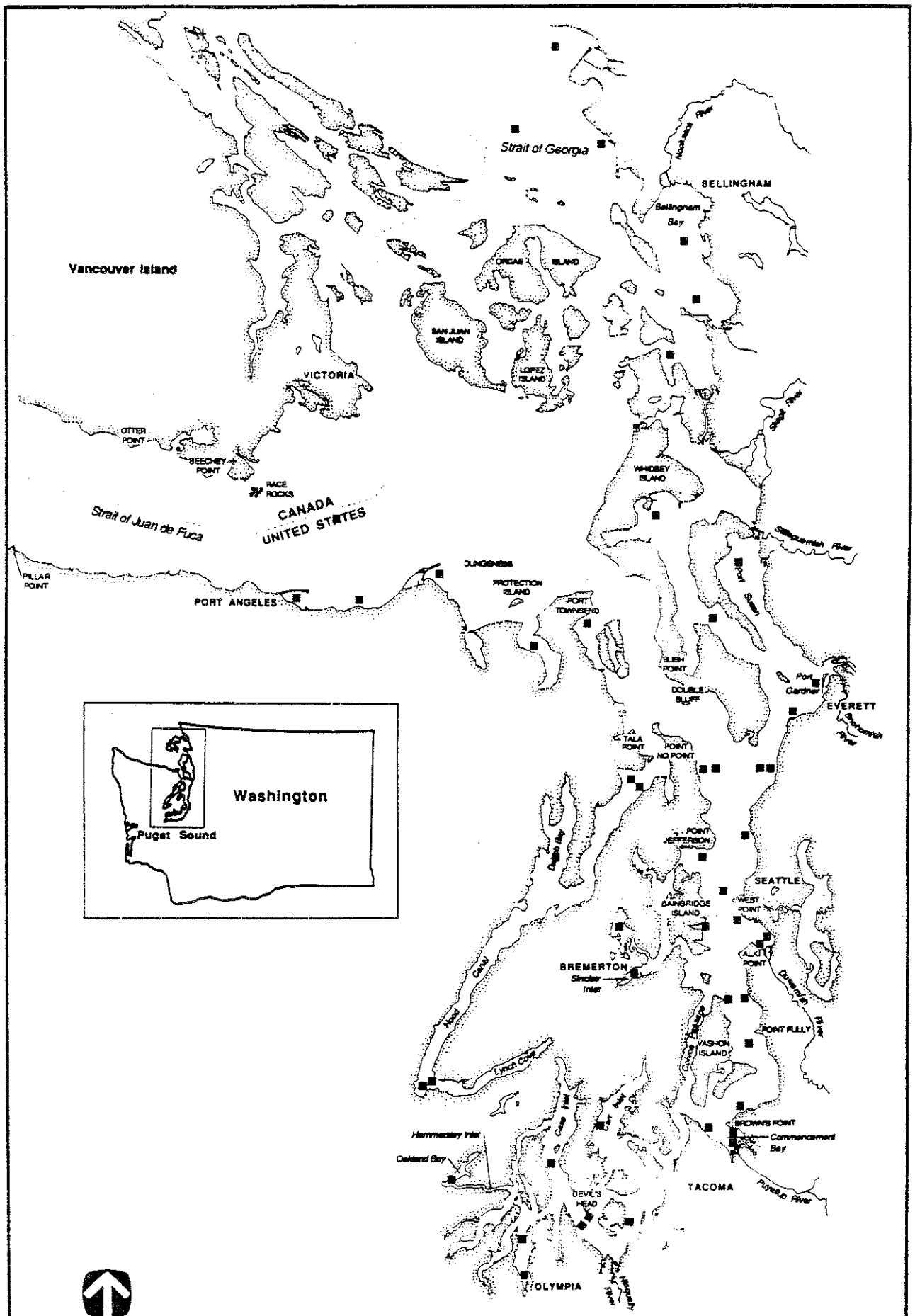

Figure 1. Location of fixed sampling stations. (Base map from Tetra Tech, 1988)

Table 1. Station coordinates for the 50 fixed stations.

Station	Location	Depth	Historical Station Name	Coordinates	
F1	Strait Georgia	(22)	NA	48 59.50	122 51.35
F2	Strait Georgia	(22)	NA	48 50.32	122 44.31
F3	Strait Georgia	(221)	NA	48 52.26	122 58.35
F4	Bellingham Bay	(22)	NA	48 41.00	122 32.50
F5	Samish Bay	(20)	NA	48 35.83	122 31.70
F6	Fidalgo Bay	(22)	NA	48 30.90	122 34.90
F7	St Juan de Fuca	(108)	NA	48 15.55	122 20.00
F8	Port Angeles	(21)	NA	48 08.00	123 26.80
F9	St Juan de Fuca	(21)	NA	48 08.24	123 17.10
F10	St Juan de Fuca	(20)	NA	48 10.00	123 05.80
F11	Discovery Bay	(22)	NA	48 03.08	122 52.82
F12	Port Townsend	(20)	NA	48 04.97	122 46.60
F13	Hood Canal, N	(20)	NA	47 50.30	122 37.43
F14	Hood Canal, N	(77)	NA	47 51.27	122 38.30
F15	Dabob Bay	(20)	NA	47 44.10	122 48.62
F16	Hood Canal, S	(22)	NA	47 22.45	123 06.80
F17	Hood Canal, S	(78)	NA	47 22.15	123 07.60
F18	Crescent Harbor	(20)	NA	48 15.40	122 37.15
F19	Saratoga Pass.	(124)	SP IIIF-402	48 05.95	122 28.25
F20	Port Susan	(22)	PS-1 (2)	48 09.83	122 27.40
F21	Port Gardner	(20)	PG IIIB (1)	47 59.08	122 14.60
F22	Port Gardner	(20)	NA	47 57.55	122 18.15
F23	Whidbey Basin	(20)	NA	47 51.78	122 20.30
F24	Whidbey Basin	(181)	NA	47 51.82	122 21.82
F25	Whidbey Basin	(231)	NA	47 51.34	122 30.20
F26	Whidbey Basin	(20)	NA	47 51.41	122 27.45
F27	Central Basin	(20)	NA	47 45.60	122 23.13
F28	Port Madison	(20)	NA	47 44.00	122 29.30
F29	Central Basin	(197)	Nich-2 (3)	47 41.90	122 27.20
F30	Eagle Harbor	(16)	NA	47 37.20	122 30.00
F31	Elliott Bay, N	(20)	NA	47 39.00	122 26.10
F32	Elliott Bay, M	(20)	NA	47 37.90	122 24.50
F33	Elliott Bay, S	(20)	NA	47 35.32	122 22.50
F34	Sinclair Inlet	(11)	BREM (5)	47 33.00	122 39.14
F35	Dyes Inlet	(15)	Dyes 4 (7)	47 36.87	122 41.71
F36	Central Basin	(15)	B-50E (6)	47 30.87	122 23.80
F37	Central Basin	(23)	B-75W (6)	47 30.20	122 26.65
F38	Central Basin	(197)	Nich-3 (3)	47 25.72	122 23.60
			H-640 (6)	"	"
F39	Central Basin	(15)	K.5-50E (6)	47 19.52	122 24.88
F40	Commencement Bay	(S)	NA	47 17.75	122 25.28
F41	Commencement Bay	(S)	NA	47 16.55	122 25.18
F42	Commencement Bay	(S)	RS-20	47 18.20	122 30.01
F43	Carr Inlet	(22)	NA	47 17.94	122 44.40
F44	South Sound	(15)	NDL-10W (1)	47 09.35	122 40.33
F45	South Sound	(46)	NRB-1E (1)	47 09.73	122 45.12
F46	South Sound	(22)	NRB-6W (1)	47 08.90	122 47.07
F47	Case Inlet	(20)	NA	47 14.00	122 51.09
F48	Budd Inlet	(18)	NA	47 07.50	122 55.05
F49	Budd Inlet	(6)	NA	47 04.90	122 54.70
F50	Oakland Bay	(7)	NA	47 13.10	122 04.30

Table 2. Regions in Puget Sound with the number of stations and estimated number of days to complete field sampling.

Region	Location	Number of Stations	Days
1	Strait of Georgia to Padilla Bay	8	4
2	Port Angeles to Admiralty Inlet	6	2
3	Hood Canal	5	3
4	Port Susan to West Point	9	3
5	Eagle Harbor/Sinclair Inlet to Commencement Bay	14	5
6	Tacoma Narrows through South Sound	8	3

Sampling Vessels

There are a number of vessels that are suitably equipped to carry out this sampling program. Four vessels commonly in use include the RV Kittywake, the RV Streeter, the MV Discovery and the RV Snow Goose. A brief description of each vessel is provided below. The discussion of these vessels in this implementation plan is not an endorsement for their use. They serve as examples of the types of vessels currently in use in Puget Sound.

The RV Kittywake is privately owned and operated by Mr. Charles Eaton of Seattle. Mr. Eaton has a M.S. in Marine Biology and has his Master of Inland Waters vessel license. The Kittywake is 42 feet in length, has a beam of 11 feet, and a draft of 5.5 feet. Her maximum speed is approximately nine knots. The electronics equipment includes ship to shore radios, LORAN C, RADAR with a variable range marker, and a chart recording fathometer. In the past five years the Kittywake has been used in most of the environmental studies in Puget Sound. Past projects include the Seahurst Baseline study, Duwamish Head Baseline study, the Commencement Bay Superfund study, the Elliott Bay and Everett Harbor Action Program studies, Ecology's Eagle Harbor study, and all field studies to identify the PSDDA phase I and II dredge disposal sites. Mr. Charles Eaton can be reached at (206) 282-4945.

The RV Streeter is owned by the National Oceanic and Atmospheric Administration (NOAA) and is used principally by the National Marine Fisheries Service (NMFS). The pilot of the vessel for biological studies is Mr. Paul Plesha. Mr. Plesha has a M.S. degree in Marine Biology and has a Master of Inland Water vessel license. The Streeter is 45 feet long, 12 feet wide and has a 4 foot draft. The vessel's maximum speed is about nine knots. The electronics equipment on board includes a ship to shore radio, LORAN C, RADAR with a variable range marker, and a chart recording fathometer. In the past five years the RV Streeter has been involved in the quarterly collection of sediment samples for the ongoing NMFS Bioindicater program. The vessel is being used to collect flatfishes for the OAD Reproductive study, and was recently used by the EPA Region X to collect sediment and fish samples that will be used for the Puget Sound Ambient Monitoring Program. The NMFS contact is Mr. Paul Plesha (206 743-3307).

The MV Discovery is owned and operated by Sea-Lease, Inc. Sea-Lease has on staff two qualified pilots, both with Master of Inland Water vessel licenses. The vessel is 54 feet long, 14 feet wide, and and has a draft of seven 7 feet. The maximum speed is about seven knots. On-board electronics equipment includes ship-to-shore radios, LORAN C, RADAR with a variable range marker, and a chart recording fathometer. The Discovery is currently being used by the U.S. Navy as a multi-task vessel in the Homeport monitoring program in Everett Harbor. Mr. Ted Huntley is the contact person at (206) 842-6423.

The RV Snow Goose is owned and operated by Anchor Excursions of Seattle. The Vessel has a two person crew including the pilot Mr. Robert Bacon who has his Master of Inland Water vessel license. The Snow Goose is 65 feet long, 18 feet wide, and has a draft of seven feet. The maximum speed is approximately nine knots. The electronics equipment includes ship-to-shore radios, RADAR, and a chart recording fathometer. The Snow Goose is used by the Seattle Aquarium to collect specimens for their Puget Sound displays. It is also used by various schools for their marine science programs, and by the Occupational Skill Center at Highland Park. The contact person is Ms. Pat Hamilton, (206) 282-8368.

Scientific Party

The scientific party will consist of four individuals: the chief scientist, the cruise leader, and two field technicians.

The chief scientist will be responsible for overseeing all aspects of the field sampling plan. His responsibilities include: assuring adherence to the quality assurance/quality control plan, and being responsible for decisions on plan changes during actual sampling. He is the designated safety officer and will also participate in the collection of sediment samples.

The cruise leader is responsible for cruise preparation which includes the selection of field personnel, and mobilization of equipment and supplies. The cruise leader is the designated sample custodian thus will be responsible for chain-of-custody.

The cruise leader is also responsible for carrying out the duties of the chief scientist in his absence except that he cannot authorize or carry out major plan changes without prior approval of the chief scientist.

The field technicians will assist in sample collection, handling, and storage. They will maintain the field sampling logs and notebooks, and will be responsible for writing sample tags and labeling containers for storage of macroinvertebrate, chemistry, and bioassay samples.

Sample Types

Five replicate sediment samples will be collected at each station to identify the structural and functional characteristics of the benthic macroinvertebrate community. For chemical and bioassay analysis, sediment from the upper two centimeters of an additional three grab samples will be composited. This material will be thoroughly homogenized

and divided into individual containers for analysis of acid and base/neutral semivolatile organic compounds, PCB and pesticides, metals, total organic carbon (TOC), sulfides, grain size, and the salinity of the pore water. Samples for volatile organics analysis (VOA) will be collected from the upper two centimeters of sediment from grab samples at selected stations. The sediment will be removed from the sampler prior to compositing and homogenizing. The redox potential will be qualitatively measured at each station by visually measuring the depth of aerobic layer in each grab sample. To obtain a measure of the environmental variability in sediment chemistry, field replicates samples will be collected at ten percent of the stations. Since the sediment types at the 119 stations will range from silt in the embayments and deep basins to sand along the open passages, stations for replicate analysis will be selected by stratified random sampling. Stratification will be based on a qualitative measure of grain size as determined at the time of sampling. This will ensure that the environmental variability around all sediments types will be examined.

Equipment and Supplies

The required equipment and supplies are presented below by sample type (Table 3). This list will also serve as a checklist prior to the sampling cruise. The amounts/volumes given for the various chemical supplies are estimates only.

Field Log and Notebook

Certain parameters and qualitative environmental observations will be measured at each station and recorded in the field log. The following physical characteristics of the sediment will be described and recorded in the field forms (Figure 2): sediment texture; sediment color; presence, type, and strength of odors; grab penetration depth (nearest 0.5 cm); degree of leakage or sediment surface disturbance; and any obvious abnormalities such as wood/shell fragments or large animals.

The field notebook is a bound record in narrative form of the day's activities. In this notebook will be recorded brief description of the proposed sampling effort, the vessel crew, types of samples to be collected, and the names and organization of visiting personnel. Other types of information that can be included in the notebook includes the daily starting and stopping time, problems encountered during the day, and any qualitative observations that may have been made. Examples of observations that will be recorded include the presence of surface slicks, siting of marine mammals, or other unusual animals.

Sample Collection Checklist

The sample collection checklist is a list of the stations and all parameters to be measured at the stations (Figure 3). The field crew simply enters the station name, date, and laboratory number, and checks off the samples as they are stored in the buckets or ice chests.

Table 3. Supplies and equipment needed for the collection of sediment samples. The number of sample containers is based on collecting samples at 73 stations per year.

Equipment	Number	Location of Backup Equipment
General equipment		
Modified van Veen sampler	2	Tetra Tech Inc., METRO
Sieving stand	1	Metro, RV Kittiwake
Meter block	1	Univ. of Washington
Swivel	1	Univ. of Washington
Indelible ink pens	12	Not applicable
Rubber bands (large)	1000	Not applicable
Pencils	20	Not applicable
Ice chests	10	Not applicable
Buckets w/ lids 5 gal	25	Not applicable
First Aid kit	1	Not applicable
Benthic macroinvertebrates sampling		
1.0 mm sieving screens	2	Tetra Tech, Inc., METRO, Beak Inc.
Sample containers	500	Not applicable
Formaldehyde	25 gal	Not applicable
Sodium borate buffer	8 pt	Not applicable
Internal labels	500	Not applicable
Brushes	2	Not applicable
Forceps	4 pr	Not applicable
Sediment chemistry/Bioassay sampling		
Stainless steel cookie cutters	5	Not applicable
Stainless steel spatulas	5	Not applicable
Stainless steel bowl	2	Not applicable
Stainless steel spoons	5	Not applicable
Sediment sample containers		
Volatiles, VOA vials	25	Not applicable
Semivolatiles 16 oz	100	Not applicable
Metals 16 oz	100	Not applicable
Sulfides 8 oz	100	Not applicable
TOC 16 oz	100	Not applicable
Grain size 16 oz	100	Not applicable
Bioassay (all) 1 gal	100	Not applicable
Methylene chloride	5 gal	Not applicable

SURVEY_____ DATE_____

STATION_____ CREW_____

WEATHER_____

SAMPLE NO: TIME: LORAN COORDINATES:

RADAR COORDINATES:

BIO/CHEM: BOTTOM DEPTH: PENETRATION DEPTH:

SEDIMENT TYPE: COBBLE GRAVEL SAND C M F SILT CLAY
WOOD/SHELL FRAGMENTS

SEDIMENT COLOR: D.O. GRAY BLACK BROWN BROWN SURFACE

SEDIMENT ODOR: H2S PETROLEUM NONE
SLIGHT MODERATE STRONG OVERWHELMING

COMMENTS:

SAMPLE NO: TIME: LORAN COORDINATES:

RADAR COORDINATES:

BIO/CHEM: BOTTOM DEPTH: PENETRATION DEPTH:

SEDIMENT TYPE: COBBLE GRAVEL SAND C M F SILT CLAY
WOOD/SHELL FRAGMENTS

SEDIMENT COLOR: D.O. GRAY BLACK BROWN BROWN SURFACE

SEDIMENT ODOR: H2S PETROLEUM NONE
SLIGHT MODERATE STRONG OVERWHELMING

COMMENTS:

REPLICATE NO: TIME: LORAN COORDINATES:

RADAR COORDINATES:

BIO/CHEM: BOTTOM DEPTH: PENETRATION DEPTH:

SEDIMENT TYPE: COBBLE GRAVEL SAND C M F SILT CLAY
WOOD/SHELL FRAGMENTS

SEDIMENT COLOR: D.O. GRAY BLACK BROWN BROWN SURFACE

SEDIMENT ODOR: H2S PETROLEUM NONE
SLIGHT MODERATE STRONG OVERWHELMING

COMMENTS:

Figure 2. Example of a field form.

SAMPLE COLLECTION CHECKLIST

SURVEY__________________________ SAMPLING DEVICE________________

STATION	DATE	FIELD NO.	LAB NO.	SAMPLES COLLECTED							
				Ben	BA	VOA	Org	Met	TOC	Sulf	GS

RECORDER____________________ DATE________________

Ben = Benthic macroinvertebrates, BA = Bioassay sample,
VOA = Volatile organics, Org = Semivolatile organics,
Met = Metals, TOC = Total organic carbon, Sulf = Sulfides,
GS = Sediment grain size.

Figure 3. Example of a sample collection checklist

Field Sampling Methods

Field sampling methods for the collection of sediment samples for benthic macroinvertebrate, chemical, and toxicity analysis are described below. These methods will follow those outlined in the Puget Sound Protocols (Tetra Tech, 1986a-c). Where deviations from these protocols occur the reasoning behind the deviation is explained.

Navigation

The Puget Sound Protocols identify a number of navigational systems and methods suitable for use in Puget Sound (Tetra Tech, 1986). These methods include the use of a number of high- and low- accuracy systems. The high-accuracy methods range from the traditional Theodolite systems to satellite navigation systems, while the low-accuracy methods include LORAN C, RADAR, and visual fixes using a sextant. The decision on which method to use depends on the design and objectives of the program. One method frequently used in Puget Sound involves establishing a series of microwave transponder stations around the study area. This system allows the occupation and reoccupation of stations with a high degree of accuracy and precision. The experimental design of the sediment monitoring task precludes the use of this system because the transponder would have to be moved after sampling is completed at each station. The timing, number of personnel required to move the transponders, and the estimated cost to establish and maintain such a system proved to be prohibitive. By agreement among the U.S. EPA Region X, the Washington Department of Ecology, and the PSAMP Monitoring Management Committee (MMC), the sediment task of the Ambient Monitoring Program will deviate from the Puget Sound Protocols and use a combination of the low-accuracy methods to achieve a higher degree of accuracy. These methods will include LORAN C, variable range RADAR, visual fixes when appropriate, and the water depth.

Quality control for station positioning -- Accurate location and relocation of stations are two of the most critical aspects of any benthic sampling program. The primary navigational system for this program is LORAN C. LORAN C repositioning is accurate within a circular diameter of approximately 20 meters if the coordinates on each line of positioning (LOP) are identical with the previous coordinates to 0.1 microsecond. For each station the LORAN C reading will be completely accurate on one LOP and within 0.1 microsecond reading on the other LOP.

Radars with variable range markers are generally accurate to within 18.5 meters. Targets for RADAR will be made on identifiable permanent objects in the water or on the shoreline not influenced by tidal height. Examples of these radar targets include: public fishing piers, fixed channel markers, or other USGS targets.

The water depth of a station when reoccupied should remain constant once depth differences due to tidal fluctuations are removed. The criteria for acceptable depth variation is 10 percent of the water depth or 20 feet, which ever is less. Depth will be measured with a digital readout fathometer and permanently recorded on a chart recording fathometer.

Where possible and appropriate, visual ranges will be taken in addition to LORAN C and RADAR fixes.

The combination of these positioning measurements will ensure that station relocation during subsequent sampling cruises will be more than adequate for the program purposes.

Sediment Sample Collection

Sediment samples will be collected in a consistent, repeatable manner with a stainless steel modified 0.1 m^2 double van Veen grab sampler. The sampling device will be attached to the hydraulic winch cable with a ball bearing swivel to prevent twisting movements on the sampler during deployment. The device will be raised and lowered through the water column by the vessel's hydraulic winch at a rate no greater than 20 meters per minute. This will ensure that the sampler doesn't flip over on decent and will prevent disturbance of the sediment surface on retrieval. Once the sampler is brought on board, it will be placed on the sieving stand. Access doors on the top of the sampler will allow visual characterization of the sediment surface in order to assess sample acceptability. Prior to characterization the overlying water in the sampler will be removed and passed through a 1.0 mm sieve using a vacuum suction device attached to the seawater system on the vessel.

Sediment acceptability criteria--For a sample to be acceptable certain criteria must be met. A detailed discussion of acceptability criteria is presented in the Puget Sound Protocols (Tetra Tech, 1986b). The criteria used in this program are consistent with them:

1. Sediment is not to extrude from the upper surface of the sampler.

2. No water leakage from the sampler is allowed.

3. The sediment surface is relatively flat.

4. For biological and chemical replicates the difference in penetration depth between replicates within a station can be no more than 10 percent. If the criteria are not met, sampling will continue until they are met. The following are minimum penetration depths.

Medium-coarse sand	4-5 cm
Fine sand	6-7 cm
Silt/clay	10 cm

Biological Sample Handling

When characterization is complete and recorded in the field log book, the sampler will be opened and the sediment released into the top section of the sieving stand. The sampler will be carefully washed of sediment adhering to the inside and prepared for its next descent. The sediment will be broken up with a gentle spray of seawater and rinsed into the lower section of the sieving stand where the 1.0mm mesh sieve screens are located. Once the sieving is complete, the remaining material will be rinsed into thick plastic bags or plastic jars for preservation.

The samples will be preserved with a formaldehyde solution buffered with sodium borate. The formaldehyde is further buffered with seawater to a concentration of 15 percent. Samples containing large volumes of fine grained sand or wood fragments will require a higher concentration of formaldehyde. Caution will be exercised when handling formaldehyde mixtures because it is toxic and carcinogenic (Kitchens et al., 1976). The sample bags or jars will be labeled using indelible ink on water resistant paper. Both internal and external labels will be used. The sample containers will be inventoried and placed in labeled buckets or boxes for return to the laboratory. The sample will be entered on chain-of-custody form at this time.

Chemical Sample Handling

Since an undisturbed sediment surface is necessary for chemical sampling, the physical characterization of the sediment in the grab sample will be delayed until after the chemical samples have been taken. Sample containers for organics and metals analysis will be cleaned in the appropriate manner using the standard U.S. EPA Contract Laboratory Program (U.S. EPA/CLP) procedures and those described in the Puget Sound Protocols. All sediment handling devices will be solvent rinsed with methylene chloride and allowed to air dry prior to use at each station. Sediment for chemical and bioassay analyses will be taken from the upper two centimeters using a stainless steel cookie cutter in the following manner. The cookie cutter, an inverted stainless steel pan, is placed on the sediment surface, gently pushed into the sediment, and a stainless steel spatula slid underneath the device. The sediment in the cutter will be placed into a stainless steel mixing bowl for homogenization. Sediment from the upper two centimeters of three grab samples will be composited and homogenized prior to being placed in containers for analysis.

Since the compositing and homogenizing process will drive off the volatile organic compounds (VOA), the sediment for volatile organics analysis will be taken from the upper two centimeters of the sediment prior to removal from the sampler for homogenization. One-third of each of the VOA containers will be filled from each grab sample to ensure some comparability to the other chemical measures.

The volumes of sediment needed to perform the various analyses are as established for EPA/CLP and listed in Puget Sound Protocols (Tetra Tech, 1986c). The container sizes needed to ensure that enough sediment is provided for analysis and reanalysis are given in Table 4.

Table 4. List of container sizes for storage of sediment samples.

Parameter	Minimum Sample Size	Container Size	Number/Station
Volatile organics	40 ml	8 dram VOA vials	2
Semivolatile organics	150 g	16 oz. glass jar	1
Metals	50 g	16 oz. glass jar	1
Total organic carbon	25 g	16 oz. glass jar	1
Sulfides	50 g	8 oz. glass jar	1
Grain size	100-200 g	16 oz. glass jar	1
Bioassays (All)	3.0 L	1 gal. glass jar	1

All sample containers will be labeled on the outside with indelible ink with the laboratory ID number, date collected, and analysis to be performed.

Sediment samples for grain size will be kept in a cool place, while samples for organics, metals, TOC, sulfides, and bioassay analysis will be stored on ice until returned to the laboratory for analysis.

The redox potential and the salinity of the pore water will be measured in the field, and no samples will be returned to the laboratory for analysis.

The sample collection checklist and the chain-of-custody log will be completed immediately following sample collection.

Chain-of-Custody Procedure

The cruise leader, as the designated sample custodian, is responsible for all sample tracking and chain-of-custody procedures for samples in the field. Each laboratory will also designate a sample custodian who will be responsible for the samples while they are in the laboratory. Each custodian will ensure that the chain-of-custody and sample tracking forms are properly completed, signed, and initialed on transfer of the samples. Examples of suitable chain-of-custody, and sample tracking forms are found in the Puget Sound Protocols.

LABORATORY ANALYSIS PLAN

The procedures outlined below are generally consistent with Puget Sound Protocols (Tetra Tech, 1986a-b). Deviations from the protocols are discussed.

Benthic Macroinvertebrate

Rescreening procedure -- Samples will be kept in the formaldehyde-seawater mixture for a minimum period of 24 hours and a maximum of 14 days to allow for the proper fixation of animal tissue. Caution needs to be exercised when handling formaldehyde mixtures because it is toxic and carcinogenic (Kitchens et al., 1976). Proper safety precautions described in the safety plan will be followed to minimize exposure.

When rinsing formaldehyde from the sample, a screen one screen size smaller than used in the field will be used (i.e., a 1.0 mm in the field and a 0.5 mm sieve in the laboratory). This will ensure that any material obtained during field sampling will be retained, regardless of shrinkage or breakage of organisms resulting from preservation. Since formaldehyde is toxic and carcinogenic, its safe disposal is an absolute necessity in any benthic sampling program. The Puget Sound Protocols do not describe handling procedures for residual formaldehyde (Tetra Tech, 1986b). The following method will be used in this program: Formaldehyde in the sample container is carefully decanted through a 0.5 mm mesh screen into a five gallon bucket. The sample is then transferred to sieve and washed with water in the manner described in the

Puget Sound Protocols (Tetra Tech, 1986b). The formaldehyde mixture in the bucket is then transferred into a 55-gallon drum. This procedure is followed with every sample until all samples have been rinsed. The 55-gallon drum of formaldehyde/seawater mix is disposed of in the proper manner for a hazardous chemical.

The sample will then be transferred to a glass or plastic jar and the jar filled with 70 percent ethanol. Isopropyl alcohol at a concentration of 70 percent is suitable; however, some people may have an adverse reaction to its vapor. Each jar will have two external and one internal label. The internal label will be written with indelible ink pen on waterproof 100 percent rag paper. The two external labels will be preprinted using an indelible ink pen. One label will be attached to the side of the jar and the second to the lid jar. The sample rescreening log must be completed at the time of transfer. An example of a rescreening log is presented in Figure 4.

Sample sorting -- The standard technique for sorting samples involves placing a teaspoon of the sample in a petri dish and, while viewing the sample through a 10 power dissecting microscope, removing each organism or fragment. Each petri dish will be sorted twice to be sure that all organisms are removed. The organisms will be sorted into the following taxonomic groups: annelida, arthropoda, mollusca, ophiuroidea, other echinodermata, and other phyla. All organisms will be stored in 70 percent ethanol solution except for the ophiuroidea which require air drying for identification. Each vial will have an internal data tag with the survey name, station designation, water depth, date sampled, and field screen size. All pertinent information will be recorded on the sample sorting form (Figure 5).

Identification of organisms -- Identification and enumeration of sorted organisms will be to the lowest taxonomic level possible, generally the species. The identifications will be done using 10 power dissecting microscopes and a compound microscope with 10, 40, and 90 power lenses. At least two different pieces of literature will be used for each species identification, one of which should be the original description. All identification will be checked against reference specimens from the Puget Sound Voucher Collection currently archived at Tetra Tech Inc.

Each taxonomist will initially record identifications in a bound, hardcover notebook which includes notes and comments on the organisms in each sample. On completion of the sample the data will be transferred to data sheets. Notebooks will be kept in the laboratory at all times so the laboratory supervisor can check questionable identifications as well as follow sample progress. The taxonomist initials the sample sorting form, indicating that the sample has been completed.

Quality control -- The quality control procedures to be used in this program have been abstracted from the Puget Sound Protocols.

Sample sorting -- Twenty percent of each sample will be re-sorted to determine sorting efficiency. The sample will be thoroughly homogenized to ensure that the re-sorted aliqout is representative of the entire sample. A sample is considered to have passed Quality Control (QC) if

RESCREENING LOG

SURVEY_____

STATION AND REP. NO.	AREA	DATE COLLECTED	NO. BAGS JARS	DATE RINSED	NO. JARS/ SAMPLE	INITIALS

Figure 4. Example of a rescreening log.

SURVEY: _____

STATION	REP	# JARS	VOL	# HOURS	SORTED BY	IDENTIFIERS INITIALS					
						POLY	ARTH	MOLL	OPH	ECH	MISC

Figure 5. Example of a sample sorting form

the number of organisms found in the re-sort does not deviate by more than 5 percent from the original count. The re-sort will be carried out using a 25X dissecting microscope by someone other than the original sorter. A quality assurance/quality control form is used to record the appropriate information (Figure 6).

Identification of organisms -- The QC procedures for the identification of macroinvertebrate samples are fully described in the Puget Sound Protocols and abstracted here. The consistency of identification between taxonomists and between sampling programs is crucial to maintaining a good Puget Sound database. Internal consistency within a laboratory will be maintained by the constant informal interaction among taxonomists. Internal quality control will be maintained by checking the identification against a verified voucher collection. External verification and quality control will be maintained by having 5 percent of all samples reidentified by another equally qualified taxonomist

Archival procedure -- Archival procedures vary from laboratory to laboratory and there are no specified procedures in the Puget Sound Protocols. The following procedures will be followed in the sediment task.

Sorted debris -- Upon completion of all quality control (QC) procedures, the remaining sediment residue will be characterized and a portion set aside for archival purposes. The characterization includes a description of the major sediment components and the volume of the material. An eight dram (1 fluid ounce) screw cap vial will be filled 3/4 full with a representative portion of the sediment. The vial will be topped off with 70 percent ethanol and the original label placed in the vial. All vials will be tightly closed and placed together in another container which will be filled with 70 percent ethanol and tightly sealed. Plastic tape will be tightly wrapped in a clockwise direction around the lid of the container to improve the seal and to ensure that the alcohol will not evaporate.

Identified samples -- Upon completion of all identifications and QC, the vials containing the major taxonomic groups will be topped off with 70 percent ethanol and the lids tightly sealed. Plastic tape will be wrapped around the vial to prevent evaporation. All vials from each replicate sample and station will be tied together. All samples from the survey will be placed into plastic buckets, the lid tightly sealed and wrapped with plastic tape. Each bucket will be clearly labeled with the survey name, date, and the number and type of samples in it.

Maintenance of a verified voucher collection -- A verified voucher collection of the organisms found during the monitoring program will be created. The collection will consist of from one to five individuals of each species found in the monitoring program. Each vial will contain organisms from only one station. A computer listing of each species name, the taxonomist who made the identification, and the name of the taxonomist who verified the identification will be recorded. The computer listing should also show when the specimen was verified, the location of the specimen in the voucher collection, the status of the specimen if it was loaned to outside experts, and references to pertinent literature. These specimens will complement the existing Puget Sound Voucher

SORTING QUALITY CONTROL DATA SHEET

SURVEY_____ Page___of _____

STATION NAME _____ REP NO. _____

APPROXIMATE SAMPLE VOLUME_____ SORT QC VOLUME_____

SORTED BY/ DATE_____ QC SORTED BY/DATE_____

IDENTIFICATION OF QC BY/ DATE_____

INDIVIDUALS FOUND IN THE QC SORT

TAXON NAME	TAXON CODE	COUNT		COMMENTS
		QC	FINAL	

RESORT INDICATED _____ YES _____ NO BY:_____

Figure 6. Example of a Quality Assurance/Quality Control form for sample sorting.

Collection. The Monitoring Program collection will be maintained at the Department of Ecology's Ambient Monitoring Section.

Data reporting requirements -- The following data will be reported by the benthic laboratory:

1. Data forms listing the abundance of all taxa by sample
2. Sorting quality control data sheets
3. Results from the external taxonomic quality control
4. Any problems that may have influenced data quality

Laboratory schedule--The completion dates in following laboratory schedule are tentative and based on sampling beginning on March 1, 1989 (Table 5). The count for number of days begins at initiation of field work. It is expected that many of these tasks will be co-occurring.

Table 5. Schedule for benthic macroinvertebrate sampling and laboratory analysis.

TASK	NO. DAYS
Begin field sampling	0
All samples to lab	30
Rescreening	39
Sorting	161
QC sorting	178
Identifications	221
QC identifications	253
Data entry	253
Data verification	268
Data report	298

Sediment Chemistry

The data quality objectives (DQO) of the sediment portion of the ambient monitoring program are implicitly stated in the general purpose and specific objectives of this implementation plan. The majority of stations have been located away from point sources of anthropogenic activity. However, stations in impacted and unimpacted embayments have been included. Care must be taken to ensure that the accuracy and precision of the data will enable detection of chemical concentrations above those found in the naturally variable environment. To ensure that these data are sufficient to meet the DQOs, full U.S. EPA/Contract Laboratory Program (CLP) procedures will be followed and CLP data packages will be required as deliverables (U.S. EPA, 1986a, b). These data packages will be reviewed by an independent contractor approved by Ecology.

Analytical methods -- The chemicals of concern that have been identified in Puget Sound sediments are presented in Table 6 (MMC, 1988). The analytical methods necessary to measure the target compounds are described in the EPA/CLP statement of work and in the Puget Sound Protocols. Methods for the analysis of the volatile and semivolatile organic compounds

Table 6. List of target chemicals for ambient sediment analysis.

METALS

Antimony	Nickel
Arsenic	Silver
Cadmium	Zinc
Chromium	Aluminum
Copper	Iron (a)
Lead	Manganese
Mercury	

VOLATILE ORGANICS

Halogenated Alkanes (neutrals)
- Chloromethane
- Bromomethane
- Chloroethane (e)
- Dichloromethane (Methylene chloride)
- 1,1'-dichloroethane
- chloroform
- 1,2-dichloroethane (e)
- 1,1,1-trichloroethane (e)
- Carbon tetrachloride (e)
- Bromodichloromethane (e)
- 1,2-dichloropropane
- Chlorodibromomethane (e)
- 1,1,2-trichloroethane (e)
- Bromoform (e)
- 1,1,2,2-tetrachloroethane (e)

Halogenated Alkenes (neutrals)
- Vinyl chloride
- 1,1'-dichloroethene
- Trans-1,2-dichloroethene

Cis-1,3-dichloropropene
- Trans-1,3-dichloropropene
- Trichloroethene
- Tetrachloroethene

Aromatic & Chlorinated Aromatic Hydrocarbons (neutrals)
- Benzene
- Toluene
- Ethylbenzene
- Styrene (ethenylbenzene)
- Total Xylenes
- Chlorobenzene

Table 6. (continued)

ACID EXTRACTABLES

Phenols
(organic acids)
- Phenol
- 2-methylphenol
- 4-methylphenol
- 2,4-dimethylphenol

Substituted Phenols
- 2-chlorophenol
- 2,4-dichlorophenol
- 4-chloro-3-methylphenol
- 2,4,6-trichlorophenol
- 2,4,5-trichlorophenol
- Pentachlorophenol
- 2-nitrophenol
- 2,4-dinitrophenol
- 4,6-dinitro-o-cresol

Miscellaneous Organic Acids (selected samples only)
- 2-methoxyphenol (b)
- 3,4,5-trichloroguaiacol (b)
- 4,5,6-trichloroguaiacol (b)
- Tetrachloroguaiacol (b)
- Mono-chlorodehydroabietic acid (b)
- di-chlorodehydroabietic acid (b)

BASE/NEUTRALS

LPAH (neutrals)
- Naphthalene
- Acenaphthylene
- Acenaphthene
- Fluorene
- Phenanthrene
- Anthracene

HPAH (neutrals)
- Fluoranthene
- Pyrene
- Benzo(a)anthracene
- Chrysene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Ideno(1,2,3-c,d)pyrene
- Dibenzo(a,h)anthracene
- Benzo(g,h,i)perylene

Table 6. (continued)

Chlorinated Aromatic Hydrocarbons (neutrals)
- 1,3-dichlorobenzene
- 1,4-dichlorobenzene
- 1,2-dichlorobenzene
- 2,4-trichlorobenzene
- 2-chloronaphthalene
- Hexachlorobenzene (HCB)
- Total PCB (mono - deca)

Chlorinated Aliphatic Hydrocarbons (neytrals)
- Hexachloroethene
- Trichlorobutadiene isomers (c)
- Tetrachlorobutadiene isomers (c)
- Pentachlorobutadiene isomers (c)
- Hexachlorobutadiene

Phthalate Esters (neutrals)
- dimethyl phthalate
- diethyl phthalate
- di-n-butyl phthalate
- Butly benzyl phthalate
- Bis(2-ethylhexyl) phthalate
- di-n-octyl phthalate

Misc oxygenated compounds (neutrals)
- Isophorone
- Benzyl alcohol
- Benzoic acid
- dibenzofuran
- Polychlorodibenzofuran (d)
- Polychlorodibenzodioxins (d)
- Coprostanol (a)

Organonitrogen Compounds (bases & neutrals)
- N-nitrosodiphenylamine
- 9(H)-carbazole

Pesticides
- p,p'-DDE
- p,p'-DDD
- p,p'-DDT
- Aldrin
- Dieldrin
- Alpha-chlordane
- Alpha-endosulfan (e)
- Beta-endosulfan (e)
- Endosulfan sulfate (e)
- Endrin
- Endrin aldehyde (e)
- Heptachlor
- Heptachlor epoxide (e)
- Alpha-HCH
- Beta-HCH
- Delta-HCH
- Gamma-HCH (Lindane)

(Table 6 continued)

a. Not of concern as pollutants, but to be analyzed as ancillary variables used in interpretation of data.

b. Recommended for analysis only near pulp mill facilities (chlorinated guaiacols are only of concern near kraft mills.

c. Recommended for analysis only where chlorinated butadienes are suspected to have a major source.

d. Chlorinated dibenzofurans and dioxins are recommended as special analyses only, as determined by specific project goals.

e. Compound is seldom or not reported, but can be easily analyzed for with other recommended analytes.

listed in Table 6 will follow the U.S. EPA/CLP protocols with modifications to obtain the recommended detection limits found in the protocols (U.S. EPA, 1986a). These modifications include the use of a larger sample size (approximately 150 grams), a smaller extract volume for GCMS analysis (5-10 mL), gel permeation chromatography, and elemental sulfur cleanup to reduce interferences and attain the detection limits recommended under the Protocols. The acid extractable, base/neutral fractions will be analyzed by Gas Chromatography/Mass Spectrosopy (GC-MS). The pesticide and PCB fraction will be cleaned up by alumina column chromatography followed by GC-ECD analysis. Quantification of pesticides and PCBs can be either by packed column or by silica capillary column, but confirmation must be by the latter.

A central issue in the analysis of environmental samples are the calibration procedures used in the analysis. A detailed discussion of calibration procedures is given in the Protocols for Measuring Organic Compounds in Puget Sound Sediments and Tissue samples (Tetra Tech, 1986c). For GC-MS analysis of organic compounds, internal standard calibration is nearly always used. The classical internal standard calibration procedure is used in the EPA Contract Laboratory Program methods and in the hazardous waste program methods (EPA 8000 series). A variation of the internal standard procedure, stable isotope dilution, has recently been developed and has some advantages over the classical procedure. The EPA 1624C and 1625C methods use stable isotope dilution calibration and analyses for sediments. The isotope dilution method involves spiking sediment samples with isotopically labeled analogs of the target compounds. There are primarily two groups of labeled compounds. One group are compounds whose carbon-12 atoms atoms have been replaced with carbon-13 atoms. The second group are compounds whose hydrogen atoms have been replaced with deuterium atoms (hydrogen atoms containing one more neutron than the normal hydrogen atom). The samples are spiked with the labeled compound prior to extraction, and losses due to sample extraction can theoretically be corrected for. A comparison of the classical internal standard procedure and the stable isotope dilution procedure is presented below.

	Classical Internal Procedure	Isotope dilution Internal standard Procedure
Availability	Commonly used in GC-MS labs	Only a few labs have capability
Cost/sample	~$425	~$750
Calibration bias	Averages ~-25% (Phenols ~50%)	Small
Precision	Averages ~35%	Some improved precision has been reported
Sensitivity	Comparable to isotope dilution for clean samples	Claimed to be slightly better for dirty samples
Ability to detect tentatively identified compounds	Good	Good if laboratory is experienced using method
Set up time	Most GC-MS labs already set up	~2 man-months needed to set up GC-MS data system
Routine analysis	Comparable	Comparable time

The stable isotope dilution procedure, while showing some advantages for the analysis of semivolatile organic compounds is not as advantageous for the analysis of volatile organics. For volatile compounds the improvement in calibration bias is generally negligible for both the isotope dilution and classical internal standard procedures. Since the isotope dilution method is selected to reduce calibration bias, the argument in favor of using it for volatile analysis is not very strong. While precision for isotope dilution may be slightly better, similar precision can also be achieved for the classical internal standard procedure by conducting replicate analyses. For pesticide and PCB analyses, the instrument used is a gas chromatograph - electron capture detector (GC-ECD). This instrument cannot measure the isotopically labeled compounds, but is used because it is able to detect smaller concentrations of compounds than does the GC-MS instrument.

Disadvantages of the isotope dilution procedure include the fact that isotopically labeled analogs for all the target compounds are not available. The compounds for which analogs do not exist must be done by the classical method. Due to the complexity of the stable isotope dilution procedure it is absolutely necessary for the laboratory to have extensive experience in the methodology to assure accurate results.

The decision whether or not to use the stable isotope dilution methods depend on the objectives of the study. Questions that should be asked before making the decision may include:

- What are the target compounds. Isotopically labeled analogs for all target compounds are not commercially available.

- What are the accuracy (precision and bias) requirements

- What deletion limits are needed

- What are the project qualitative and quantitative objectives

For the PSAMP sediment task, there are 106 organic and inorganic compounds on the target list. Of the organic compounds, 90 percent have isotopically labeled analogs commercially available. Thus there are enough labeled compounds available. However, the quantitative and qualitative objectives of the program are not regulatory in nature, in that there are no action levels that will automatically trigger remedial investigations. Nor is the program designed to conduct mass balance exercises, meaning it is not designed to measure the input and output of contaminants to the environment. For example, the program is not monitoring dredge disposal sites where we would need to know precisely and accurately whether the concentration of a given chemical is above some action level, nor whether the concentration of contaminants in the disposal site are approaching a level that would close the site. The program was designed to identify the ambient condition of Puget Sound sediment with a reasonable degree of accuracy and precision.

For the above reasons, we are recommending the use of the EPA CLP methods for sample analysis. All associated CLP QA/QC procedures and samples will be required deliverables during this program.

Analytical requirements -- Table 7 gives a brief overview of the analytical requirements to be followed in this program. These requirements are EPA/CLP approved and, with the exception of the holding times for semi-volatile organic compounds, agree with the Puget Sound Protocols.

Number of samples -- The number of samples analyzed are listed in Table 8 along with the number of matrix spikes, matrix spike duplicates, and standard reference material (SRM) samples. A total of 22 sediment samples for volatile organics and 131 sediment samples for the remaining chemical parameters will be sent to the laboratory for analysis. Ten percent of the samples will be field replicates. All samples will be taken from composites of three grab samples. Conventions for naming replicate samples were decided upon by the PSAMP Monitoring Management Committee and are presented below.

Field replicates -- Several different environmental samples may be taken at the same station, and each sample analyzed separately. For example, five separate benthic replicates will be taken at each sampling station in order to enable statistical analysis of differences in community structure among stations. Environmental replicates for sediment chemistry analysis will be taken at ten percent of sediment stations. The purpose of these samples is to measure natural variability in the environment.

Table 7. Laboratory analysis parameter table for target compounds indentifed for analysis.

PARAMETER	MATRIX	UNITS	DETECTION LIMITS	METHODS	HOLDING TIMES	PRESERVATION
ORGANIC COMPOUNDS						
Volatiles	Sediment	ug/kg DW	10-20 ug/kg DW	Purge & Trap,GCMS	14 days	Cool, 4 C
A,B/N	Sediment	ug/kg DW	20-100 ug/kg DW	Extraction,GCMS	7 days (sed) 40 days (ext)	Cool, 4 C
Pest/PCB	Sediment	ug/kg DW	50-100 ug/kg DW	Extraction,GC/ECD	7 days (sed) 40 days (ext)	Cool, 4 C
METALS & METALOIDS		(Strong acid digestion)				
Cr	Sediment	mg/kg DW	1.0 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Pb	Sediment	mg/kg DW	.1-.5 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Ag	Sediment	mg/kg DW	.06-0.1 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Cu	Sediment	mg/kg DW	.1-0.5 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Ni	Sediment	mg/kg DW	.1-0.5 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Zn	Sediment	mg/kg DW	.2 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Cd	Sediment	mg/kg DW	.05-0.1 mg/kg DW	GFAA	6 Mo	Cool, 4 C
Al	Sediment	mg/kg DW	10 mg/kg DW	GFAA, DFAA		
As	Sediment	mg/kg DW	0.1 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Fe	Sediment	mg/kg DW	0.7-1.0 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Sb	Sediment	mg/kg DW	0.1-0.3 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Mn	Sediment	mg/kg DW	1.0-2.0 mg/kg DW	GFAA, DFAA	6 Mo	Cool, 4 C
Hg	Sediment	mg/kg DW	0.005-0.01 mg/kg DW	CVAA	6 Mo	Cool, 4 C
CONVENTIONALS						
TOC	Sediment	% DW	NA	PSEP	6 Mo	Freeze
Sulfides	Sediment	mg/kg DW	NA	PSEP	7 Days	Cool, 4 C
GS	Sediment	% by phi class		PSEP	6 Mo	Cool, 4 C

Table 8. The number of sediment samples to be analyzed.

ANALYSIS	NUMBER OF SAMPLES (Actual number)	
Volatile organics	20 Sediments	(20)
	2 Field replicates	(2)
	2 Blind lab replicates	(2)
	2 Matrix spikes	(2)
	2 Matrix spike duplicates	(2)
	2 Analytical lab triplicates	(4)
	3 SRM	
Semivolatile organics	119 Sediments	(119)
	12 Field replicates	(12)
	12 Blind lab replicates	(12)
	12 Matrix spikes	(12)
	12 Matrix spike duplicates	(12)
	12 Analytical lab triplicates	(24)
	3 SRM	
Metals (Strong acid digestion)	119 Sediments	(119)
	12 Field replicates	(12)
	12 Blind lab replicates	(12)
	12 Matrix spikes	(12)
	12 Matrix spike duplicates	(12)
	12 Analytical lab triplicates	(24)
	3 SRM	
Total organic carbon	119 Sediments	(119)
	12 Blind lab replicates	(12)
	5 Triplicates	(10)
	3 Method blanks	(3)
Sulfides	119 Sediments	(119)
	12 Blind lab replicates	(12)
	5 Analytical lab triplicates	(10)
Grain size	119 Sediments	(119)
	12 Blind lab replicates	(12)
	5 Analytical lab triplicates	(10)

"Blind" lab replicates -- "Blind" lab replicates are separate bottles of material gathered from the same environmental sample (e.g., well-mixed sediment grab sample, or tissue composite). These replicates are usually created in the field and labeled to hide their identity from the lab (hence "blind" replicates). These replicates measure variability in both sample handling and lab analysis.

Analytical lab replicates -- Laboratories routinely conduct duplicate or triplicate analyses on a single sample, at a frequency determined by project quality assurance procedures. These analytical replicates are designed to measure variability in the laboratory analytical procedures.

Quality control requirements -- Quality control procedures are an integral part of chemistry analytical methods (EPA/OWRS, 1984; Werme, C., 1985). The data quality parameters to be discussed in this section are precision, accuracy (bias), representativeness, comparability, and completeness (PARCC).

Precision can be defined as the degree of mutual agreement between or among independent, similar, or repeated measures. While true precision cannot be measured, it can be expressed in terms of analytical variability. In this program analytical variability will be measured as the percent relative standard deviation or coefficient of variation of analytical lab replicates and the matrix spikes and matrix spike duplicates.

Accuracy is the amount of agreement between a measured value and the true value. It will be measured as the percent recovery of matrix spikes, matrix spike duplicates, and percent recovery of standard reference materials. Spiked method blanks can be used as performance indicators to judge whether matrix interferences are present in samples.

Representativeness is the degree to which sample results represent the true system. This component is generally considered during the design phase of a program. This program will use the results of all analyses to evaluate the data in terms of its intended use. Bias built into the experimental design includes the use of a single station to characterize the site (i.e.,. one station in an embayment). The collection of field replicates at ten percent of the stations will reduce this biasss somewhat, but not eliminate it completely.

Comparability is defined as the degree to which data from one study can be compared to other, similar studies. The results from this monitoring study will be comparable to other studies ongoing in Puget Sound. Ongoing studies with comparable methods and quality control requirements are the baseline study for the U.S. Navy Homeport Project and the Puget Sound Dredge Disposal Analysis (PSDDA) Baseline Study. Past Puget Sound studies using comparable methodologies include the Elliott Bay and Everett Harbor Action Program studies, and the Commencement Bay Remedial Investigation/Feasibility Study and the EPA Region X, 1988 Reconnaissance Survey. The PSDDA disposal site monitoring program is also somewhat comparable. The PSDDA program will analyze composited samples from the upper 5 cm of the sediment inside the deposition zone and the upper 2 cm off-site. The PSAMP sediment task will sample the upper 2 cm of sediment.

Completeness is the amount of data obtained during a project compared to the amount of data expected. Since the amount of sediment collected to measure each parameter exceeds that required for the analysis we expect 100 percent completeness. The volume of sediment to be collected will be sufficient to reanalyze the sample should the results not meet QC requirements. If completeness for any station is less than 90 percent the station will be resampled at contractor expense. Should a sample be lost or destroyed during analysis, Ecology will be immediately notified.

Quality control samples required for this project are presented below along with the requisite warning and control limits (Table 9). A full discussion of these variables, along with the volatile, acid and base/neutral semivolatile and pesticide/PCB compounds suitable for use, can be found in the Puget Sound Protocols and in the U.S. EPA/CLP procedures (Tetra Tech, 1986c; U.S. EPA, 1986a). The quality control samples include but are not limited to the following:

1. Surrogate spike compounds
2. Calibration standards
3. Method blanks
4. Standard reference materials
5. Matrix spikes
6. Analytical replicates
7. Field replicates
8. Initial and ongoing calibrations

For metals analysis, the strong acid digestion technique as opposed to the total acid digestion technique will be used. The strong acid digestion technique was selected because the sediment task is analyzing for metals bound to the sediment grains and not metals bound inside the crystalline matrix of the grains. Table 7 lists the instrumental methods and the required detection limits. The detection limits are expressed as a range around those found in the Puget Sound Protocols, using the Protocol value as either the low or high limit. No detection limits for chromium and aluminum are provided for in the Puget Sound Protocols because they are not considered to be chemicals of concern. The listed detection limits were based on information provided by the Ecology's Manchester Laboratory.

The QA/QC measures needed to ensure the DQOs will be met for metals analysis are discussed in detail in the Puget Sound Protocols and the U.S. EPA/CLP procedures. The instrumental QA/QC checks necessary for this project include:

1. Initial calibration
2. Continuing calibration verification (check standards)
3. U.S. EPA standard reference samples

The method quality control checks recommended in the Puget Sound Protocols will be required for this project. Method checks include:

1. Preparation blanks
2. Matrix spike analysis
3. Duplicate sample analysis

Table 9. Summary table of action and warning limits for quality control samples.

ANALYSIS TYPE	ACTION LIMIT	WARNING LIMIT
Surrogate spike	10% Recovery	50% recovery
Method Blank[a]		
Phthalate, acetone	30% of the analyte	5 ug total or 50% of the analyte
Other organic compounds	1 ug total or 5% of the analyte	2.5 ug total or 5% of the analyte
Standard Reference Materials	95% confidence interval	95% confidence interval for a certified reference material
Matrix spikes & matrix spike duplicates	50 - 65% recovery[b]	50% recovery
Spiked method blanks	50 - 65% recovery[b]	50% recovery
Analytical lab replicates		+/- 100% coefficient of variation
Field replicates		
Ongoing calibration		25% of initial calibration

[a] Irregardless of the warning and control limits should the method blanks show concentrations greater than the contract required quantitation limits, the analysis must be halted until the laboratory takes appropriate steps to identify the source of contamination and eliminate or reduce it.

[b] All samples for chemical analysis will be spiked with all of the target analytes, however, the recovery of the matrix spike and matrix spike duplicates (MS/MSD) for control limits uses only the U.S. EPA/CLP MS/MSD compounds at 50% in order effect corrective action.

4. GFAA method of standard addition (if necessary)
5. Laboratory control sample analysis (Standard Reference Manual)

The control limits for metals analysis can be found in the Puget Sound Protocols and U.S. EPA/CLP procedures (Tetra Tech, 1986; U.S. EPA, 1986b). These are listed below (Table 10).

Table 10. Warning and control limits for metals analysis. Limits are taken from the Puget Sound Protocols and U.S. EPA/CLP procedures (Tetra Tech, 1986b; U.S. EPA, 1986b).

PARAMETER	LIMITS	REFERENCE
Initial & ongoing calibration		
Atomic absorption	90 - 110 %	U.S. EPA/CLP
Cold vapor atomic absorption	80 - 120 %	U.S. EPA/CLP
Standard reference material	80 - 120 %	Puget Sound Protocols
Spikes	75 - 125 %	Puget Sound Protocols
Duplicate sample analysis	+/- 20 % RPD	Puget Sound Protocols

Data reporting requirements, backup documentation, and data qualifiers will follow guidelines established for the U.S. EPA/CLP and reiterated in the Puget Sound Protocols.

Conventional sediment parameters -- The laboratory methods for analysis of total organic carbon (TOC), sulfides, and sediment grain size are fully documented in the Puget Sound Protocols.

Total organic carbon -- Total organic carbon will be analyzed using a combustion method at 950°C. The minimum sample size for TOC analyses is 25 g. Reporting units will be in percent dry weight with a precision of +/- 0.1 unit (Table 7). Analytical lab triplicates will be done on one sample in each batch of 20 samples (Table 8).

Sulfides -- Sulfides will be measured using the methods outlined in the the Puget Sound Protocols (Tetra Tech, 1986e). The method involves a distillation process and measuring color absorbance of the sample at 650 nm. The minimum sample size is 50 g and values are reported in mg/kg dry weight to the nearest 0.1 unit (Table 7). Analytical lab triplicates will be done on one sample in each batch of 20 samples (Table 8).

Pore water salinity -- The pore water salinity will be measured in the field at the time of sample collection by taking an aliquot of the sediment sample and centrifuging it to release the water. The salinity of this water can then be measured using conventional technique outlined in Standard Methods for the Analysis of Water and Waste Water (ASTM, 19__).

The pore water salinity will not be measured at all stations, but only where field replicates are taken.

Grain size -- The grain size distribution in the sediment sample will be measured using the methods found in the Puget Sound Protocols and in the PSDDA Depositional Analysis studies (Tetra Tech, 1986e; Striplin et al., 1986). This method measures the apparent grain size because the organic material is not stripped from the inorganic material prior to the analysis. The grain size will be determined by wet sieving up to 150 g of sediment followed by dry sieving the gravel and sand fraction. The silts and clays will be separated using the pipet technique. The minimum sample size can range from 20 g for muddy sediments to 150 g for sandy sediments. Results will be reported in percent by phi class (Table 7). Analytical lab triplicates will be done on one sample in each batch of 20 samples (Table 8).

Laboratory schedule -- The laboratory schedule for the organics, metals, and conventional parameter analysis will be consistent with the holding times for each specific analysis. The completion dates in the following schedule are tentative and based on sampling beginning on March 1, 1989 (Table 11). The count for number of days begins at initiation of field work.

Table 11. Schedule for volatile and semivolatile organics and metals sampling and laboratory analysis.

TASK	# DAYS
Begin field sampling	0
Last samples to lab	30
Volatile organics analysis	37
Semivolatile organics	
Last extraction	37
Last analysis	69
Metals analysis	69
Complete data package	84
Data verification	122
External QA/QC	150
Report completed	185

Sediment bioassay

The three sediment bioassays selected for this program have been used extensively in Puget Sound. The ten-day amphipod bioassay uses Rhepoxynius abronius to measure the acute lethality (survival and emergence) of the sediments (Swartz et al., 1985). The bivalve larvae test measures the survival and percent of abnormality (developmental success) in either the larvae of the oyster Crassostrea gigas or the mussel Mytilus edilus over a 48-hour period (Chapman and Morgan, 1983). The Microtox bioassay uses a photoluminescent bacteria Photobacterium phosphoreum to measure the sublethal effect of sediments on the physiological functions of light output (Bulich et al., 1988; Beckman Instruments, 1982). To eliminate possible bias in the analysis due to knowledge of conditions at particular station locations, all sediment samples will be labeled in a way as to mask their original location.

Amphipod bioassay -- Amphipods for use in this study will be collected from West Beach on Whidbey Island, Washington and the taxonomic identification confirmed by a qualified taxonomist. Five replicate tests will be conducted on each of the sediment samples. Positive and negative controls will be used to determine the validity of the tests. Twenty individual Rhepoxynius abronius will be used in each test chamber. Samples will be delivered to the laboratory in three batches. The laboratory specifications are presented in Table 12. Procedures for the collection of the organisms, control sediments, and detailed laboratory procedures can be found in the Puget Sound Protocols (Tetra Tech and EVS, 1986).

The response criteria to be examined in this bioassay are emergence and survival. The emergence data are used to behavioral responses, and survival data are the primary measure of toxicity.

The data reporting requirements as stated in the Puget Sound Protocols are listed below (Tetra Tech and EVS, 1986).

1. Water quality measurements

2. Daily emergence for each beaker and the 10 day mean and standard deviation for each treatment

3. Ten-day survival in each beaker and the mean and standard deviation for each treatment

4. Interstitial salinity values of the test sediments

5. 96-hour LC-50 values with reference toxicants

6. Any problems that may have influenced data quality

Bivalve larvae bioassay -- The specific bivalve larvae to be used in the PSAMP sediment task has not been selected. The March (spring) sampling coincides with increasing water temperature; thus, there should be an abundance of ripe oysters or mussels. The bioassay is a 48-hour test, and the response criteria are percent survival and percent abnormality. Five replicate test chambers will be set up for each of the sediment samples. In addition, both positive and negative control will be run concurrently with each sample series. Table 13 condenses the specifications and control limits found the Puget Sound Protocols (Tetra Tech and EVS, 1986).

The data reporting requirements are similar to those for the amphipod bioassay and have been abstracted from the Puget Sound Protocols (Tetra Tech and EVS, 1986) and are presented below.

1. Water quality measurements at the beginning and end of testing

2. Individual replicate and mean and standard deviation data for larval survival after 48 hours

3. Individual replicate and mean and standard deviation data for larval abnormalities after 48 hours

Table 12. Laboratory specifications for amphipod bioassays.

PARAMETER	SPECIFICATION
Duration	10 days
Number of analytical replicates	5 test chamber/sample
Number of organisms	20 per test chamber
Volume of sediment	0.25 L per chamber
Holding time	
Organisms	4 - 14 days
Sediment	14 days at 4 C in dark
Interstitial salinity	> 25 ppt
Negative controls	1 per series 90% survival
No. replicates	5 test chambers
Positive controls	96 h LC - 50
No. of toxicants	2 reference toxicants
Water quality	
Temperature	15 +/- .5 C Sampled daily
Salinity	28 +/- 1 C Sampled day 0 & 10
D.O.	>5 mg/L Sampled day 0 & 10
pH	8+/-1 Sampled daily

Table 13. Laboratory specifications for bivalve larvae bioassays.

PARAMETER	SPECIFICATION
Duration	48 hours
Number of analytical replicates	5 test chamber/sample
Volume of sediment	20 g per test chamber
Holding time	
Sediment	14 days at 4 C in dark
Interstitial salinity	> 10 ppt
Negative controls	1 per series
Sediment controls	70% survival
Seawater controls	and 90% without abnormalities
No. replicates	5 test chambers
Positive controls	48 h LC - 50
No. of toxicants	2 reference toxicants
Water quality	
Temperature	20 +/-1 C Sampled at start & stop
Salinity	28 +/- 1 ppt Sampled at start & stop
D.O.	>4 mg/L Sampled at start & stop
pH	8+/-1 Sampled at start & stop

4. 48 hour LC-50 and EC-50 values with reference toxicants

5. Any problems that may have influenced data quality

Microtox bioassay -- Two methods for conducting the microtox bioassay are currently used in Puget Sound. The organic extraction method uses organic solvents to extract toxic materials from the sediment. The Puget Sound Protocols stipulates two caveats for this method. The first is that the extraction procedure is specific for neutral, nonionic organic compounds. Contaminants such as metals, and highly acidic or basic organic compounds are not effectively extracted. The second is that naturally occurring toxic substances may be present. Thus occasionally toxicity may be noted in areas with no source of contamination. A second method using a saline extraction process is relatively untested in Puget Sound, but is currently being used in the Puget Sound Dredge Disposal Analysis Baseline Study (Williams et al., 1986). PSAMP should wait for the results of that study before making a final decision on the methodology to use. The general analytical procedures, controls, and reporting requirements are different for each method. The methods are discussed in detail in the Puget Sound Protocols (Tetra Tech and EVS, 1986) (Table 14). Five analytical lab replicates will be analyzed to determine the variability at each station.

Quality control -- Sediment samples will be delivered to the laboratory as blind samples to reduce analytical bias due to station location. The controls used to evaluate the organic extract method include the use of ethanol, sodium lauryl sulfate, or some similar compound to assess the daily bioassay performance and to determine the differences in response among bacterial lots. The bioassay repeatability is evaluated by duplicate testing of ten percent of the sediment extracts.

Data reporting requirements for the organic extract include:

1. Range-finding assay results

2. Raw light emission data for each test series

3. Fifteen-minute EC-50 data and the 95 percent confidence interval for each test series and for controls

4. Any problems that may have influenced data quality.

Controls for the saline extract method include the use of negative controls, conducted using clean reference sediments. Calibration curves are used to determine salinity-induced changes in bacterial luminescence. Sodium arsenate is used as a reference toxicant in the positive control to assess the day-to-day performance of the bioassay and to examine differences in bacterial lots. The final control factor is verification of a dose-response relationship between bacterial luminescence and extract concentration.

Table 14. Laboratory specifications for the Microtox bioassay

PARAMETER	ORGANICS EXTRACT	SALINE EXTRACT
Number of analytical replicates	5 replicates per sample 2 per serial dilution	5 replicates per sample 2 per serial dilution
Volume of sediment	500 g per sample	200 g per sample
Preextract volume	10 +/- 0.5 g (nearest .01 g)	30 g
Dry wt determination	10 g	
Holding time		
Sediment	6 mo at -20 C	14 days at 4 C
Bacteria	8 hrs at 4 C	5 hrs at 4 C
Required blanks	Extraction & reagent blanks	Reagent blank
Serial dilutions		
Primary dilution	5.0, 0.5, 0.05% extract	
Definitive assay	5.0, 2.5, 1.25, 0.625% extract	100, 50, 12.5, 0% of sediment supernatent
Negative controls	Incorporated into response determination	
Positive controls		
No. of toxicants	1	1

Reporting requirements for the saline extract method includes:

1. Percent decrease in luminescence for each concentration of supernatent tested.

2. Determination of a significant dose-response relationship between percent decrease in luminescence on the logarithm to sample dilution using least squares regression analysis.

3. Determination of EC-50 values and the 95 percent confidence interval for a reference toxicant.

4. Any problems that may have influenced data quality.

Laboratory schedule -- The laboratory schedule for all bioassays will be consistent with the holding times for a specific assay. The completion dates are tentative and based on sampling beginning on March 1, 1989 (Table 15). The days begin with initiation of field work. It is expected that these bioassays will be co-occurring.

Table 15. Schedule for sediment bioassay analysis.

TASK	NO. DAYS
Begin field sampling	0
Last samples to lab	30
Complete data package	84
Report completed	122

DATA MANAGEMENT

Sediment task data will be stored in a computerized database to facilitate user access, provide an interface with existing statistical analysis programs, and allow computer-enerated reports.

The Department of Ecology is in the process of evaluating database management systems for department use. The Ambient Monitoring Section (AMS) currently uses EPA STORET to store water quality data, t this system is inappropriate for sediment monitoring data. AMS, in cooperation with the PSAMP Monitoring Management staff, is designing a database management system for use in the sediment task. The system will be designed according to the formats identified by the Monitoring Management staff in their final report (MMC, 1988b).

AMS will store the sediment data on a Compaq 386-20 computer with two megabyte (MB) RAM (Random Access Memory). The computer will have a 130 MB hard drive, a 80387-20 math co-processor, and an Alloy FT-60 external tape backup. This computer has the potential to be a fileserver in a Local Area Network (LAN) to allow more users within Ecology to directly access data. Data will be transferred to the PSAMP central database which allows users to access many different types of Puget Sound data. The AMS data also will be transferred to the Department of Ecology

Sediment Management Unit (SMU) for updating the Puget Sound Dredged Disposal Analysis (PSDDA) database.

Data management plan

A data management plan is an integral part of an environmental study; and as such should be completed and ready for implementation when field operations commence. Data management for the sediment task of the Ambient Monitoring Program is diagramed in Figure 7 and described below.

Collection of data -- The first step is the collection of field data that can be immediately entered into a computerized database and the collection of samples for laboratory analysis. Field data that can be directly entered into a database includes: navigational information, numbers and types of samples collected, and the other qualitative information that describe the sediment samples. Data from laboratory analyses includes: chemical contaminants concentrations, toxicity to bioassay organisms, and the condition of the benthic macroinvertebrate community.

Quality assurance (QA) -- All laboratory data will undergo a quality assurance/quality control review. This is an extensive review of the data to determine whether it is acceptable for entry into the database. For data to be accepted, it will be examined to determine if the essentials of the quality assurance plan have been followed including a review of the data for completeness. The extent of the quality assurance process varies with the type of data. For example, sediment chemistry data must undergo formal and extensive data validation procedures similar to those outlined in the EPA Functional Guidelines for Evaluating Organics and Inorganics Analyses. (U.S. EPA Data Review Work Group, 1988).

Bioassay and macroinvertebrate community data undergo a less formal examination. At a minimum the following questions will be addressed prior to data acceptance. (Adapted from PTI, 1988).

Field sampling:

1. Were field sampling protocols followed?
2. Were the field log and notebook completed in full?
3. Was the sample collection checklist completed in full?
4. Were the chain-of-custody procedures followed?

Laboratory analyses:

Benthic macroinvertebrate:

1. Were the appropriate protocols followed?
2. Is there a sorting QC form for each sample?
3. Were samples that failed sorting QC re-sorted?
4. Was external verification of the identifications completed?
5. Was corrective action taken arising from the QC process?
6. Were all essential data/information available?

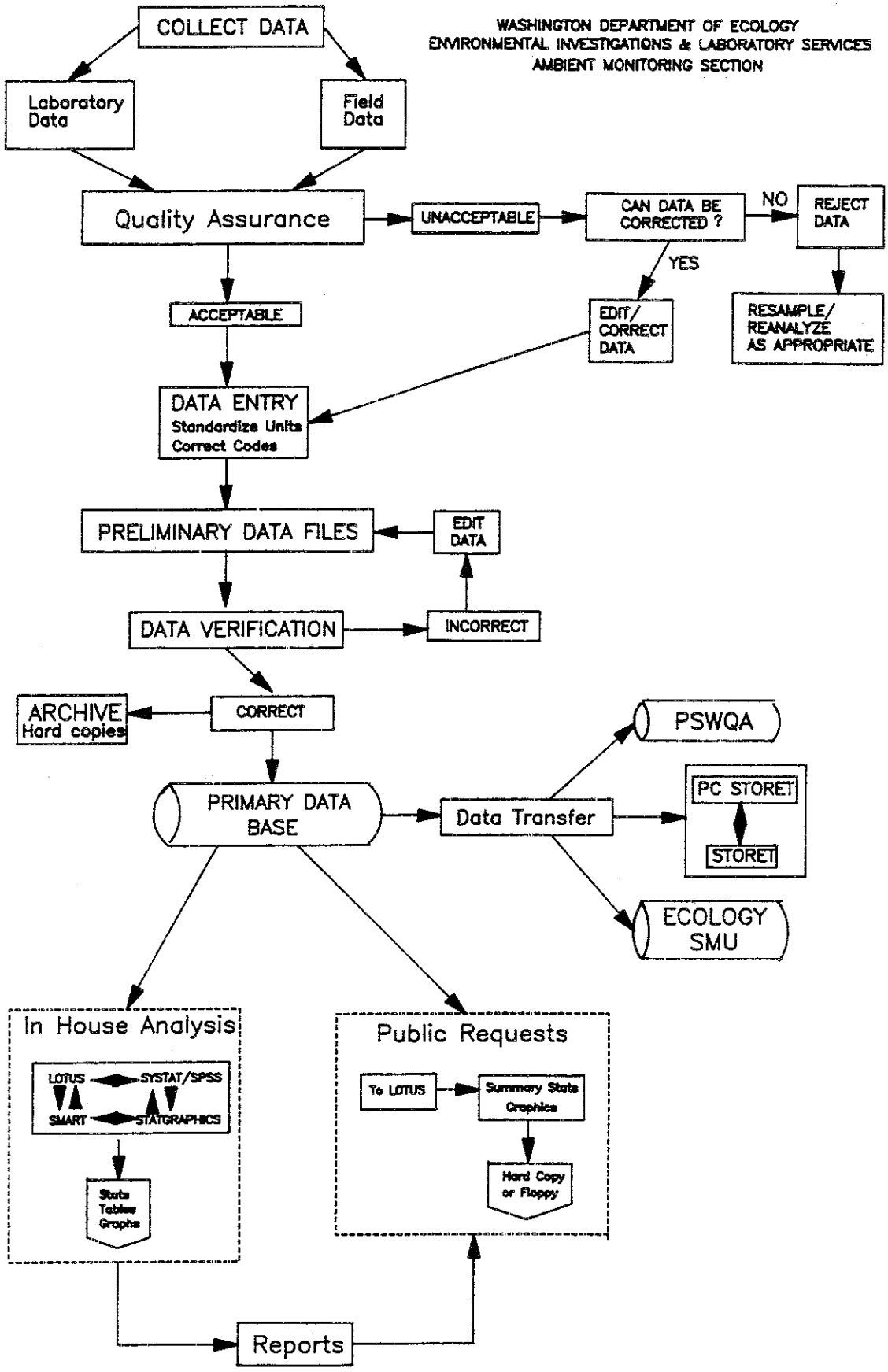

Figure 7. Data management flow chart for the ambient sediment monitoring task.

Sediment chemistry:

1. Were the appropriate protocols followed?
2. Were the samples analyzed within the proper holding time?
3. Were the contract-required detection limits met?
4. Was there method blank contamination?
5. Was recovery of the Standard Reference Material (SRM) samples within limits?
6. Were results from the analytical replicates within limits?
7. Were results from blind field replicates/duplicates within limits?
8. Were matrix spike recovery limits met (if appropriate)?
9. Was data supplied in the correct format?
10. What was the percentage completeness?

Sediment bioassay:

1. Were the appropriate protocols followed?
2. Were the samples analyzed within the proper holding time?
3. Were limits for the negative controls met?
4. Did the positive controls show the test organisms to be sensitive to the reference toxicants?
5. Were the appropriate number of analytical replicates run?
6. Were water quality parameters exceed?
7. Was data supplied in the correct format?
8. What was the percentage completeness?

Data judged unacceptable but correctable will be edited and entered. In certain cases the data may have to be qualified prior to entry. Qualifier codes to be used in the sediment quality task of PSAMP are presented below. These codes differ from the PSAMP transfer qualifier codes in that they include additional codes reporting quality assurance/quality control aspects of the data. The PSAMP central database contains enough information to inform researchers about the quality of the data and where to look for additional information should it be needed.

Data qualifiers -- Data qualifier codes to be used include:

No qualifier - data are usable without qualification

B - Value is blank corrected down to detection limit
C - Value is for the measured chemical in combination with unresolved substances
E - Value is an estimate
G - Value is a minimum estimate
K - Detected at less than detection limit shown
L - Value is less than the maximum shown
M - Value is a mean
O - Data value was lost or rejected
Q - Questionable value
T - Substance detected below quantification limit shown
U - Substance undetected at detection limit shown
X - Substance was measured in a sample where recovery was less than 10 percent
Z - Value has been blank corrected and is still above detection limit

If the data cannot be corrected then they will be rejected, and reanalysis or resampling will be required if appropriate.

Data entry -- Prior to entry, data will be checked to ensure that units are standardized, that correct codes have been used, that data modified due to the QA/QC procedures are corrected, and that all necessary data and information are available in a computer format. Once this is completed the data will be entered into the preliminary data files. These preliminary data files, in Puget Sound data transfer format, will be loaded into Ecology's primary database after verification. Alternative methods of data entry can be data files in ASCII format, as a file delimited by commas for numeric fields, commas and quotation marks for alphanumeric fields. Although extra steps would be required, data could also be entered through LOTUS 1-2-3 spreadsheet files. In both cases the measured parameters will be in columns and station/sample in rows.

Codes -- The AMS primary database management system will be fully compatible with the PSAMP central database system. Therefore the computer codes for the variables and the data will follow those identified in the Puget Sound data transfer formats.

Data verification -- Data entered into the preliminary data files will be verified by either double entry, or by visual verification of five percent of the data. Computer or visual verification by qualified technical staff will ensure the data have been entered in the correct units, number of significant digits, the correct codes, and correct format. Should a high error rate occur (>1 percent) the entire data set will be verified.

Project archive -- Archival of data in paper form is important for tracking purposes. When data verification is complete, a copy of all original field data sheets, QA/QC reports, and correspondence will be placed in three-ring binders arranged by subtask within each scientific discipline. These binders will be kept at AMS for five years, then moved to Ecology's archival facility for long-term storage. A tracking system will be developed relating data archived on paper to data stored on disk.

Primary database -- The Ambient Monitoring Section primary database will be based on and developed concurrently with the PSAMP central database. The primary difference between the two is that the sediment portion of the AMS database will contain all of the raw data while the sediment portion of the PSAMP central database will contain summarized data only. The file structure and database contents for the sediment monitoring task will follow that outlined in the PSAMP transfer formats. The PSAMP staff are currently evaluating software packages in which to write the databases. The Department of Ecology could most easily maintain a database written in Ashton-Tate dBase IV software. The types of data retrievals performed by the database will include the following:

- Retrieve all sediment chemistry data by station and replicate
- Retrieve all benthic macroinvertebrate data by station and replicate
- Retrieve all bioassay data by station and replicate

- Retrieve bioassay data by sample and replicate
- Summarize benthic macroinvertebrate, sediment chemistry, and bioassay data by station and replicate
- Rank chemicals at selected stations
- Rank stations by concentration of selected chemicals
- Calculate detection frequency for selected chemicals

Other modules or programs are being considered for development. These can be prioritized into essential and nonessential categories. Essential items for inclusion are a data entry module based on double keystroke entry, that prompts for all the required data, and performs some tests for format and completeness. In addition, routines are needed that would allow data retrievals by major taxa/chemical group (i.e., all HPAH from a station by chemical, all mollusks at a station by species). Programs to summarize data in the format needed by the PSAMP central database, and to produce data files in PSAMP data transfer format will be essential programs for development.

Nonessential but desirable programs include modules or specific designs of modules or programs that will perform the following functions prioritized below:

- Synonym library that would automatically inform the user that a chemical or species is listed in the database under a synonym

- Routines for transferring data from the AMS database to PC STORET

- Routines for performing simple statistics such as means, standard deviations, variance and coefficient of variation without needing other software (i.e., SYSTAT/SPSS)

The transfer of data from the preliminary data files to the primary database will be direct since both are in the same format. This format is outlined in the PSAMP data transfer formats. The file structure for data entry will be an ASCII file delimited by commas for numeric fields and commas and quotation marks for alphanumeric fields.

Data transfer -- There are three elements in the data transfer process. The first and most important are formats for transferring data from the AMS database to the PSAMP central database. Specific data transfer procedures and formats are outlined in the PSWQA Monitoring Management Committee draft report titled " Specifications for the transfer of data from the Puget Sound Ambient Monitoring Program" (MMC Staff, 1988).

The second element in the data transfer process is the exchange of sediment chemistry, bioassay, and macroinvertebrate community data with the Ecology, Sediment Management Unit (SMU).

This unit in Ecology has provisionally selected SEDQUAL for use as the primary database for their program. The SMU is responsible for developing and updating Washington State sediment quality criteria. Since AMS data will be used by SMU to update Washington State sediment quality criteria, data transfer formats between the AMS database and SEDQUAL will be necessary.

The third element is the transfer of data from the AMS database to PC STORET. This element would allow the comparison of water quality data currently stored in PC STORET to sediment quality data from the same location. At this time this element has a very low priority and is not expected to become operational in the near future.

Data analysis -- Analytical methods and techniques vary greatly depending on the experimental design, study objectives, and hypotheses to be tested. For the sediment monitoring task, the computerized data reports and the analytical procedures described below will enable Ecology to quantitatively ascertain the condition of Puget Sound sediments.

Data Reports -- Data reports may be defined as data listings or listings of analysis results by replicate and station. The types of computerized data reports needed to analyze the sediment task data will vary from year to year as data are added to the database. However, certain types of reports will be needed with each year's sampling. These reports some of which will be generated by the AMS database(*) will include:

Benthic macroinvertebrate community analyses

Species list with abundance by replicate sample*

- Number of taxa and abundance by replicate sample*
- Mean, standard deviation for number of taxa and abundance by station*
- Infaunal Trophic Index by replicate and mean by station*
- Shannon-Weiner diversity by replicate and mean by station
- Pielou's equitability measure (Pielou, 1966)
- Numerical dominance (expressed as complement of equitability)
- Abundance of pollution sensitive/pollution tolerant species
- Comparison with reference values/areas

Sediment chemistry analyses

- Listing of values by chemical by station, embayment, region*
- Listing of values summed into major chemical group (Table 6)*
- Listing of values normalized to TOC or percent fines*
- Mean concentration of chemicals by area, embayment, region*
- Comparison with reference values/areas

Sediment bioassay

- Percent mortality by replicate*
- Mean, standard deviation of percent mortality by station*
- Comparison with positive and negative controls
- Comparison with reference values/areas
- Comparison of sublethal responses with reference/controls

Complex data analysis and hypothesis testing will be done by the staff of the Ambient Monitoring Section starting in the second year of the sediment task. During the first year, initial analysis and report writing will be done by a contractor. Since the analysis and interpretation of the data collected is an important, integral part of any study, the database system will allow data to be easily transferred into

existing statistical analysis programs. Statistical analyses packages such as Systat, SPSSPC, SAS, and Statgraphics will be used for hypothesis testing as well as multivariate procedures and data displays. Examples of the types of analyses to be preformed include:

Analysis of variance
Analysis of covariance
Linear and curvilinear regression, and correlation analysis
Hierarchical cluster analysis: Bray-Curtis, Canberra metric
Discriminant, factor, canonical correlation or principal component analysis to relate biotic to abiotic parameters
Graphical display of data

Public requests -- All data generated by the sediment monitoring task will be made available to the public upon request on completion of the final report. Data reports will be made available in the form of LOTUS 123 files, ASCII files or as printouts.

REPORTS

The Ambient Monitoring Section of Ecology will prepare reports describing all aspects of the sediment monitoring task. These reports will include a cruise report, monthly progress reports, and a draft and final report.

Cruise Report

The cruise report will provide a brief summary of all technical and observational information obtained during the cruise. Observational information from the field notebook will be presented in narrative form. The technical information will include in tabular form:

Station name, sample number if applicable
Actual station coordinates
Water depth
Date and time of each grab sample

The following qualitative information from the field log

Sediment type
Color
Presence and types of odors
Sampler penetration depth

Monthly Progress Report

The monthly progress report will be a brief report on the status of the sample analysis, data entry and interpretation, and report production. In addition, any problems or scheduling delays will be clearly stated.

Draft/Final Report

The Ambient Monitoring Section will prepare a draft and final report. This will be an in-depth report on the monitoring program. The report

will include sample collection, analysis, and interpretation methods, results and a discussion of Puget Sound sediment quality. The discussion will be an integration of benthic community, sediment chemistry, and sediment toxicity data.

SAFETY PLAN

The sediment monitoring program will be collecting sediments for benthic macroinvertebrates, chemistry, and for bioassays. While the procedures used to the collect the sediment are the same for each type of analysis, each has its own operating procedures for sample handling, and a unique set of hazards. The smooth, efficient execution of any field sampling program is dependent upon all personnel knowing the tasks they are performing and performing them in a professional manner. This starts with a safety plan that documents the potential hazards, identifies safe work practices, and contains emergency planning. The key person responsible for implementing this plan is the safety officer.

Safety Officer

The chief scientist is the designated safety officer for the sediment monitoring task. He/she will be responsible for all shipboard operations involving personnel, sample handling, and processing. The captain of the survey vessel and the safety officer have the authority to suspend sampling operations should working or sea conditions become, in their opinion, hazardous. In matters of vessel safety, the captain is the ultimate authority on board and has the authority to override the safety officer if they differ in opinion. The safety officer is also responsible for conducting a precruise briefing on the vessel with the vessels pilot, the cruise leader, and sampling technicians, to discuss the safety plan. The purpose of the meeting is to make sure that everyone knows the sampling procedures, is aware of potential physical and chemical hazards, and knows the location of and how to use all emergency equipment on board, including the ship-to-shore radio.

Sampling Hazards

When sampling at sea there are two categories of hazards which all personnel need to be aware of. The first are the physical hazards associated with being on board a vessel and in handling the sampling equipment, and the second are the chemical hazards associated with the preservation of samples and with the cleaning of sediment handling tools.

Physical hazards -- The physical hazards associated with the deployment and retrieval of the van Veen sampler are associated with its weight and method of closure. The van Veen weighs about 75 lbs when empty and about 100 lbs when full of sediment. In rough seas or in strong winds it can bounce around in the sieving stand. Therefore care should be taken when the sampler is being readied for deployment and retrieval.

All sampling in the marine environment entails the use of mooring lines to tie down sampling equipment, seawater hoses to rinse the samples, and

overhead steel cables that are attached to the vessel's hydraulic system for sample collection. The potential for accidentally slipping, tripping falling or bumping your head is great. All personnel should be aware of these hazard at all times.

Exposure and fatigue are two major causes of accidents on board ships. The sampling regime will include long work days, and during the March sampling period the weather can be unpredictable. Working in cold, rough seas can lead to sea sickness, fatigue, and exposure.

The weather during the March sampling period will be unpredictable, and some of the sampling stations will be in exposed waters (i.e., Straits of Georgia, and Juan de Fuca). The combination of rough seas and fatigue can easily lead to a man-overboard situation.

Chemical hazards -- The sediment task of the ambient program will for the most part, be sampling in rural embayments where little sediment contamination is expected. The exceptions are in portions of Elliott Bay where a test site for the disposal of sediments contaminated with PCBs was located ten years ago, in portions of Eagle Harbor where the sediments are contaminated with creosote, and Commencement Bay along that part of the Ruston shoreline near the Asarco plant. There are no stations planned in the immediate vicinity of these areas, but all field personnel need to be aware of the potential hazards of handling contaminated sediment without protective clothing.

Two potentially hazardous chemicals will be used in the field for sample processing: methylene chloride and formaldehyde. Methylene chloride will be used to clean sediment handling equipment between stations; formaldehyde will be used to preserve the benthic macroinvertebrate samples.

Safe Work Practices

The physical and chemical hazards can be easily dealt with by observing some simple precautions.

Physical hazards -- The van Veen sampler will always be handled by two people. When deploying the sampler the safety pin will be left in place until the sampler clears the transom. If for some reason the sampler needs to be brought back on board before the sample is collected, the safety pin will be put back in place before it clears the transom. At no time will anyone place their hands underneath the sampler for any reason. The probability that the sampler will accidentally close with the safety pin in place is very small, but not putting your hands in or under a cocked sampler is a good work habit. There will always be at least one person holding on to the sampler when it is out of the sieving stand. Upon retrieval one person will be watching over the stern of the vessel and will notify the winch operator when the sampler first comes in sight, and when it breaks the surface. No unnecessary personnel will be near these operations. At no time will anyone block the view of the winch operator when the sampler is being raised or lowered while near the surface.

To avoid injuries from deck gear, all personnel on deck will wear hard hats, and hard shoes with good traction. All unnecessary sample handling equipment, containers, deck lines, and water hoses will be kept clear of walkways and work areas until needed. Upon completion of sampling at every station, any sediment on the deck will be washed overboard to prevent slipping.

To prevent fatigue and overexposure in adverse weather conditions, the field personnel will rotate tasks so that each is periodically working inside the cabin. Extra clothing will be brought to accommodate changes in weather. Foul weather gear (rain gear) will be worn by sampling personnel when conditions warrant. The duration of field sampling will be three weeks. To reduce the consequences of prolonged time on the sampling vessel, the crew will be provided with sleeping accommodations during sampling in all regions.

When sampling during adverse weather conditions where there is a possibility of someone going overboard, all deck personnel will wear Coast Guard approved life vests/jackets. All new personnel and visitors will be briefed as to the location and operation of all emergency equipment prior to the beginning of the day's sampling. To facilitate communications between the vessel and shore installations, it is recommended that the vessel be equipped with a cellular telephone in addition to the vessel's ship-to-shore radios.

Chemical hazards -- The solvent methylene chloride has long been used to clean sampling equipment between stations during field operations. It is toxic and carcinogenic and can absorbed through the skin. Contact with skin and eyes will be avoided; rubber gloves will be worn when rinsing sampling equipment, and as much as possible, avoid breathing the fumes. Symptoms of exposure include light-headedness, dizziness, and irritation of the eyes, nose, and throat. If these symptoms occur, notify the safety officer immediately and move away from the area until symptoms cease.

Formalin is a 37 percent mixture of formaldehyde and water. It is commonly used in fixing tissue and macroinvertebrate samples. A 10-15 percent mixture is generally used to fix macroinvertebrate samples. It is toxic, carcinogenic, and can cause adverse reactions at concentrations of one part per million in sensitive individuals. Avoid contact with the skin, if contact occurs immediately flush with water. During the rescreening process, personnel should wear gloves, protective clothing, safety glasses, and use an organic vapor respirator when working in an enclosed area. Symptoms of exposure include headaches, dizziness, nausea, skin rashes, and irritation to the eyes, nose, and throat. If contact with skin or if a spill occurs on board, it should be thoroughly rinsed with water. Notify the safety officer immediately so that so that further action can be taken if warranted.

EMERGENCY PLANNING

The reactions of the field personnel in an emergency could be critical in saving the life of a crew member. The chief scientist is responsible for making decisions in emergency situations; should he be injured or not on board, the cruise leader will assume that responsibility. Responses in emergency situations should be discussed during the precruise briefing so that all personnel are aware of the appropriate actions to take. Because of the large geographic area being covered by this program the Sound has been divided into six regions. The emergency services available within each region are listed by city.

THE FOLLOWING NUMBERS ARE FOR EMERGENCY USE ONLY AND NOT FOR GENERAL INFORMATION.

Emergency air lift ambulance services

Air-Evac International	1- 800 854-2569
Airlift Northwest	1- 800 542-1646
EMS Helicopters	1- 206 733-3096

REGION 1

Bellingham Bay/Whatcom County

St. Luke's General Hospital 809 E. Chestnut St. Bellingham	734-8300
St. Joseph's Hospital 2901 Squalicum Pkwy Bellingham	734-5400

Emergency services and transportation

Whatcom County Sheriff	676-6650
Bellingham Police Dept.	911
Bellingham Fire Dept.	911
Hubbard Ambulance	676-9555
United States Coast Guard	1-800-592-9911

Anacortes/Skagit County

Island Hospital 24th and M Ave. Anacortes	293-3181

Emergency services and transportation

Skagit County Sheriff	336-3146
Island Hospital Ambulance Service	293-3181
Anacortes Fire Department	911
Paramedic Ambulance Service	911

REGION 2

Olympic Memorial Hospital 939 Caroline, Port Angeles	457-8513
Emergency services and transportation	
Clallam County Sheriff	911
Port Angeles Police Department	911
Port Angeles Fire Department	911
Olympic Ambulance Service	683-3347
Port Angeles Ambulance Service	452-2366
United States Coast Guard	457-4401

Port Townsend

Jefferson General Hospital 834 Sheridan Ave.	385-4622
Emergency services and transportation	
Jefferson County Sheriff	1-800-552-0750
Port Townsend Police Department	911
Port Townsend Fire Department	911
United States Coast Guard	385-3070

REGION 3

In north Hood Canal use emergency services from Port Townsend

Bremerton

Harrison Memorial Hospital 2520 Cherry Ave.	377-3911
Emergency services and transportation	
Kitsap County Sheriff	911
Bremerton Police Department	911
Bremerton Fire Department	911
Olympic Ambulance Service	377-7777

Shelton

Mason General Hospital 2100 Sherwoon Ln	426-2611
Emergency services and transportation	911
Mason County Sheriff	911
Shelton Police Department	911
Shelton Fire Department	911

REGION 4

Everett

Everett General Hospital (TRAUMA CENTER)	14th & Whitmore	258-6301
Providence Hospital	916 Pacific Ave.	258-7555

Emergency services and transportation

Everett Police Department	911
Everett Fire Department	911
Everett Ambulance	252-1234
Shepard Ambulance	258-1825
United States Coast Guard	252-5281

REGION 5

Seattle

Harborview Medical Cntr (TRAUMA CENTER) 325 9th St	223-3074
Virginia Mason Hospital 925 Seneca	624-1144
University Hospital, 1959 N.E. Pacific Ave	548-4000

Emergency services and transportation

King County Sheriff	911
Seattle Police Department	911
Seattle Fire Department	911
Shepard Ambulance Service	322-0330
United States Coast Guard	422-7070

South King County

Renton

Valley Medical Center, 400 S. 43rd St	251-5185
St. Francis Community Hospital 34515 9th Ave S.	927-9700

Tacoma

St Joseph's Hospital (TRAUMA CENTER) 1718 South I St.	591-6660
Tacoma General Hospital, 315 South K St.	594-1050

Emergency services and transportation

Pierce County Sheriff Department	911
Out of area	1-800-562-9800
City of Tacoma Emergency Services	591-5747
Pierce County Emergency Services	593-4797
Tacoma Police Department	593-4911
Washington State Patrol	593-2424
Tacoma Fire Department	627-0151
Shepard Ambulance Service	383-5416
Oliver Ambulance Service	572-3111
United States Coast Guard	858-9998

REGION 6

Gig Harbor	
Peninsula ambulance and Paramedic Service	851-2383
Olympia	
St. Peter's Hospital 413 N. Lilly Rd	456-7289
Black Hills Community Hospital 3900 Capitol Mall Dr S.W.	754-5858
Emergency services and transportation	
Thurston County Sheriff	911
Olympia Police Department	911
Olympia Fire Department	911
Olympic Ambulance and Cabulance	491-3200
United States Coast Guard	1-800-592-9114

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