APPENDIX C

FINAL OPERATION, MAINTENANCE, AND MONITORING PLANS

APPENDIX C
OPERATIONS, MAINTENANCE AND MONITORING PLAN
INTERIM REMEDIAL ACTION
LOG POND CLEANUP/HABITAT RESTORATION

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1 PURPOSE

This Operations, Maintenance, and Monitoring Plan (OMMP) describes how the Log Pond cleanup/habitat restoration project will be implemented to comply with requirements described in the Log Pond Interim Remedial Action Statement of Work (SOW). This OMMP also satisfies certain requirements of Clean Water Act Permit No. 2000-2-00424. The project sponsor/proponent for this work is Georgia-Pacific West, Inc. (G-P), who will oversee operations, maintenance, and monitoring at the site. Anchor Environmental, LLC and/or other consultants will assist G-P in these activities as necessary.

The purpose of this document is to describe and explain environmental monitoring activities and the rationale used to develop these activities for the Log Pond project. The specific objectives of the OMMP are to confirm that the cleanup remedy achieves and maintains performance standards as specified in the SOW, including protection of surface water and sediment quality, and restoration of aquatic habitat.

To meet these objectives, the general monitoring activities of the OMMP are as follows:

- Long-term monitoring of seepage quality at the margins of the Log Pond cap, to demonstrate protection of surface water;
- Sediment monitoring following completion of capping and habitat restoration activities within the Log Pond, to demonstrate compliance with State Sediment Quality Standards (SQS); and
- Biological monitoring within the Log Pond area, to demonstrate the protectiveness of the cap in controlling bioaccumulation exposures and restoration of aquatic habitat.

All remedial and restoration actions implemented within the Log Pond utilized demonstrated technologies with a 15 to 20-year record of successful performance. Additional research is not necessary to demonstrate the effectiveness of the technologies. Accordingly, long-term monitoring is appropriately focused in this OMMP toward routine maintenance objectives and verification that the cleanup and restoration action is achieving its intended goals.

This OMMP is intended to meet post-construction monitoring requirements of two different regulatory programs:

1) Sediment Management Standards/Model Toxics Control Act (SMS/MTCA) requirements administered by the Washington Department of Ecology (Ecology); and

2) Clean Water Act requirements of Permit No. 2000-2-00424 administered by the U.S. Army Corps of Engineers (Corps).

The OMMP is intended to integrate SMS/MTCA, Corps permit, and additional habitat restoration monitoring objectives into a single plan. The document identifies for Ecology, the Corps, and other stakeholders the quality assurance/quality control (QA/QC) steps to be used to perform initial baseline sampling and long-term operation, maintenance, and monitoring of the Log Pond cap/habitat restoration. The OMMP includes monitoring actions and reporting mechanisms, and identifies specific objectives, rationale, and methods to assess the long-term performance of the cleanup remedy and to evaluate the success of habitat restoration. The document describes how environmental monitoring will be performed and how response actions will be directed, as necessary, based on the monitoring results. Further, it delineates the quality assurance methods and protocols for project personnel to ensure that all have a complete understanding of monitoring, feedback, and adjustment mechanisms. The sections below describe the monitoring data quality objectives including the type, number, and location of samples to be collected; the frequency of sample collection; the sampling methods to be used; the analyses to be performed; and the procedures and schedule for reporting. The OMMP also includes a description of threshold or triggering criteria, and a description and schedule of corrective actions to be implemented in the event that these criteria are exceeded.

The OMMP is organized into three broad monitoring and maintenance categories as follows:

- **Water Quality.** Monitoring of seepage discharges from the adjacent upland area will be performed to document attainment and maintenance of surface water quality protection objectives within the nearshore seepage zone of the cap. Baseline sampling was performed during remedial design (see Appendix D of the Log Pond Engineering Design Report).

- **Sediment Stability and Quality.** Physical and chemical monitoring of the cap surface will be performed, including confirmatory biological monitoring as necessary, to verify that the habitat is not substantially eroded by propeller wash or storm wave forces, and to verify that the sediment cap is maintained below the SQS criteria. Baseline sampling was performed during the Whatcom Waterway RI/FS (Anchor Environmental and Hart Crowser 2000) and during remedial design (see Appendix D of the Log Pond Engineering Design Report).
- **Habitat Performance.** Monitoring of the performance of the mudflat restoration will be performed to document the rate of epibenthic and benthic infauna recolonization and utilization by juvenile salmonids, to verify that the cap is effective in controlling bioaccumulation exposures, and to ensure that productive biological communities become established in the Log Pond area. Baseline biological sampling was performed immediately prior to construction (see Section 5.2).

Site-Wide Tissue Monitoring

It should be noted that tissue quality monitoring is also being planned as part of the larger Whatcom Waterway Site cleanup action. As discussed in the Whatcom Waterway Remedial Investigation/Feasibility Study (RI/FS; Anchor Environmental and Hart Crowser 2000), mercury has been observed to bioaccumulate in certain Site fish and shellfish populations, particularly Dungeness crab. However, even the maximum tissue concentrations reported in this area are below conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood.

Fish and shellfish tissue concentrations of mercury are expected to decline as a result of implementation of the larger Whatcom Waterway Site cleanup action (Anchor Environmental and Hart Crowser 2000). Because of the home ranges of adult Dungeness crab and other target species such as English sole (averaging approximately 10 km^2; approximated as a circle with a radius of 1 mile), tissue concentrations are expected to decline in proportion to site-wide cleanup actions. Given the limited size of the Log Pond (representing less than 10 percent of the Whatcom Waterway Site that currently exceeds SQS criteria),

cleanup actions within this area are not expected to result in detectable reductions in edible tissue concentrations. Nevertheless, long-term tissue monitoring is planned as part of the larger Whatcom Waterway Site cleanup action and overall Bellingham Bay Comprehensive Strategy (Ecology 2000), utilizing baseline monitoring data as a basis for comparison. Such long-term tissue monitoring activities will be included as part of implementation of the separate Whatcom Waterway Site Cleanup Action Plan, expected to be issued in spring 2001, with tissue sampling potentially beginning as early as spring 2002.

2 PROJECT ROLES AND RESPONSIBILITIES

2.1 General

The roles and responsibilities of the parties involved in the remediation action are delineated in the Agreed Order for this Interim Remedial Action, as executed by G-P and Ecology.

As discussed above, this OMMP is intended to meet post-construction monitoring requirements of two different regulatory programs: 1) SMS/MTCA requirements administered by Ecology; and 2) Clean Water Act requirements of Permit No. 2000-2-00424 administered by the Corps. In the spirit of helping to achieve the habitat restoration objectives of the Bellingham Bay Comprehensive Strategy, G-P has agreed to place additional capping material in the Log Pond, over and above that required for cleanup alone, in order to restore historically lost intertidal habitat to this area. This OMMP is intended to integrate SMS/MTCA, Corps permit, and additional habitat restoration monitoring objectives into a single plan.

2.2 Washington State Department of Ecology

Ecology is the regulatory authority and responsible agency for overseeing and authorizing the remedial action. In this capacity, Ecology reviews monitoring plans during the remedial design phase and will review information described in this OMMP to ensure that the project is constructed and maintained in a manner consistent with the remedial design. An environmental monitor will be designated to exercise project oversight for the agency and to coordinate with G-P. Ecology will make final decisions to resolve unforeseen problems, which may change the project components, or the manner in which the OMMP is undertaken.

2.3 U.S. Army Corps of Engineers

Under the requirements of Clean Water Act Permit No. 2000-2-00424, the Corps' Seattle District has responsibility to review the G-P Log Pond monitoring plans and results relative to the proposed combined sediment remediation and habitat restoration remedy. As discussed above, this integrated OMMP has been designed to meet both cleanup and habitat restoration objectives. In matters of interpretation of state SMS and MTCA

requirements, the Corps expects that Ecology will consult with the Corps and other agencies consistent with the Bellingham Bay cooperative agreement, but the Corps will defer to Ecology's final regulatory authority for these state programs (see Corps letter to G-P dated November 7, 2000). The Corps will continue to provide oversight of the Log Pond remedy through its review of environmental monitoring data, collected for a minimum of 10 years following construction, in order to evaluate the effectiveness of the action as a final remediation remedy for the Log Pond site.

2.4 Georgia-Pacific West, Inc.

The operation, maintenance, and monitoring work on this project will be managed by G-P and executed by G-P or by one or more consultants specializing in this work. G-P has responsibility for management and contract administration, and may also perform the maintenance and monitoring as appropriate. G-P will also be responsible for implementation of the OMMP, including required monitoring, sampling, testing, and reporting. Included within this responsibility will be the monitoring of quality control activities to ensure that activities described in this OMMP are conducted in accordance with the requirements described herein. These activities may also be assigned to consultants with the requisite expertise and experience.

2.5 Consultants

During the course of construction, consultants may be utilized to ensure that the design objectives are realized and that the OMMP is implemented in accordance with the remedial design documents. Specialty consultants may include Anchor Environmental, LLC, Huxley College, Nooksack Tribe, and physical, chemical, and biological monitoring/analysis firms. All personnel utilized in this work will have the expertise, experience, and capability to satisfactorily execute the work. All personnel will be required to have applicable training.

3 WELL POINT WATER QUALITY MONITORING

Tasks associated with the well point water quality monitoring are described in detail in this section. A description of the rationale and summary of existing data is followed by the objectives, a description of the sampling equipment, sampling units and locations, sampling schedule, sample collection methods, and contingencies.

3.1 Rationale and Summary of Existing Data

During remedial design, primary seepage pathways to the Log Pond shoreline were sampled using temporary well points (see Appendix D of the Log Pond Engineering Design Report). A total of two (2) well point samples were collected within discernable seepage zones (WP-1 and -2), as depicted on Figure C-1; other locations evaluated did not produce sufficient sample volumes for chemical analyses. The well points consisted of a 1-foot-long screen section positioned below the sediment surface, within the zone of saturation encountered at low tide. Sampling of the well points occurred near the end of an outgoing (ebb) tide cycle to characterize minimum tidal dilution conditions. The remedial design sampling data, summarized in Table 4 of the Log Pond Engineering Design Report, were used to design the cap section to provide water and sediment quality protection.

As discussed in Section 4.1.3 of the Engineering Design Report, the sediment porewater concentration expected to be discharged through the surface layer of the Log Pond cap following cap construction is approximately 0.002 ug/L, well below the 0.025 ug/L marine water quality (chronic) criterion. These model estimates are conservative in that they do not directly address either the effects of tidal-induced dispersion or chemical precipitation. Thus, cap systems at the Log Pond site will likely be protective and consistent with the long-term maintenance of water quality.

The Model Toxics Control Act Cleanup Standards Regulation (Chapter 173-340 WAC) and State Surface Water Quality Standards (Chapter 173-201A WAC) specify that surface water quality standards are applicable at the point of discharge into surface waters. Well point sampling devices will be used to evaluate compliance with this criterion. Applicable surface water quality standards are listed in Table 2 of the Engineering Design Report.

Both total and dissolved low-level mercury as well as routine field parameters (see below) will be monitored at the well points.

Under the terms of an Agreed Order with Ecology, G-P is currently performing a supplemental remedial investigation/feasibility study (RI/FS) of the former G-P chlor-alkali facility located adjacent to the Log Pond. The supplemental RI/FS is intended to provide data, analyses, and engineering evaluations to develop and evaluate a set of feasible remediation alternatives for the chlor-alkali facility uplands (including groundwater) that will meet environmental standards set forth in MTCA, including protection of the Log Pond, and support site redevelopment plans. This work may lead to additional upland source controls, such as reduction of infiltration through paving, to further reduce mercury loading and provide additional protection of the Log Pond. Ecology's review may lead to revisions to the work outlined below; such revisions will be incorporated into the final OMMP.

3.2 Objectives

The objectives of long-term well point water quality monitoring at the Log Pond are as follows:

- To verify compliance of seepage discharges with State Surface Water Quality Standards (Chapter 173-201A WAC); and
- To verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.

Well point sampling will be performed concurrent with salmonid monitoring (see Section 5 below).

3.3 Sampling Units and Locations

G-P will perform water quality monitoring at the two (2) well point locations (WP-1 and -2) depicted in Figure C-1. These well point locations are consistent with the well points sampled during the remedial design phase.

3.4 Monitoring Schedule

Monitoring during Years 1, 2, 5, and 10 following completion of the capping action, when compared with baseline measurements collected during

remedial design, should be sufficient to document attainment and maintenance of surface water quality protection objectives within the nearshore seepage zone of the cap. The well points will be sampled during the month of April, corresponding to typical maximum seasonal groundwater discharge conditions. Sampling will continue for a period of 10 years at the above mentioned frequency. After receipt of each round of monitoring data, the information will be evaluated to determine whether adjustments to the scope of future monitoring are appropriate. After the 5-year and 10-year monitoring periods, the data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5 year MTCA remedial action review. This review will determine the need for and/or scope of future monitoring that may be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

3.5 Sampling Equipment

The sampling equipment used for the collection of groundwater seep samples along the shoreline are called well point samplers. Well point samplers consist of a pre-cleaned stainless steel or PVC tapered tube approximately 3-feet long and 1-inch in diameter with a 1-foot screened bottom section.

3.6 Sampling Methods

G-P will perform water quality monitoring at the two (2) well point locations (WP-1 and -2; Figure C-1) sampled during the remedial design phase. A permanent stake will be driven near WP-1 and WP-2 to facilitate their location by sampling personnel, and to serve as a local reference to determine water level elevations within the well points.

Well points will be constructed within 3-inch diameter hand-auger borings advanced up to 2 feet into the shoreline. The hand-auger equipment will be backed out of the boring, leaving a 3-inch-diameter hole. The boring cuttings will be left next to the boring and backfilled into the hole after the well points are removed. The well point, consisting of a 1-inch-diameter pre-cleaned stainless steel or PVC assembly with a 1-foot-long screen section, will be lowered into the hole and placed within the upper zone of saturation

encountered at low tide. The outer annulus of the screen will be backfilled with 10/20 sand pack. Prior to sampling, each well point will be developed by purging slowly with a peristaltic pump to improve hydraulic connection and minimize turbidity. Following water quality sampling, the well points will be extracted and the cuttings backfilled.

At the time of sampling, a peristaltic pump and pre-cleaned (for low-level mercury analysis) tubing assembly will be installed in each well point, and water withdrawn at a relatively low rate (determined in the field) to reduce turbidity. At least three pore volumes from the well points will be removed using a peristaltic pump prior to sampling. All purge water obtained from the well points will be contained in PVC drums and properly disposed within the G-P wastewater treatment plant. Sampling of well points will occur near the end of the outgoing (ebb) tide cycle to characterize minimum tidal dilution conditions.

Water samples will be collected from the peristaltic pump/tubing assembly, and placed into certified, pre-cleaned, sample containers provided by the laboratory. Samples will be immediately placed in an iced cooler. All samples designated for dissolved metals analysis will be filtered in the field through a 0.45-micron membrane filter. Field measurements will be performed near the end of the sampling period and will include determinations of temperature, pH, redox potential, specific conductance, turbidity, and dissolved oxygen.

3.7 Sample Analysis

All water samples, plus QA/QC samples, will be analyzed for the following parameters:

- Total and dissolved mercury (low-level EPA Method 1631 or equivalent);
- Total suspended solids (Standard Method 2540-D or equivalent); and
- Salinity (University of Washington salinometer method or equivalent).

Data quality objectives for the well point sampling are summarized in Table C-1. Data packages received from the laboratories will be checked for completeness to ensure that data and QA/QC information requested are present. Data quality will be assessed using current U.S. EPA and Ecology protocols by considering the following:

- Holding times;
- Surrogate spike results;
- MS/MSD or MS/Duplicate results;
- Standard reference material results;
- Method blanks; and
- Detection limits.

Validated data will be compiled into a data report, including a narrative of quality assurance results. The data reports will be provided to Ecology and the Corps after receipt of the validated laboratory data. Estimated dates for submittal of the Year 1, 2, 5, and 10 water quality data reports are fall 2001, fall 2002, fall 2005, and fall 2010, respectively. The water quality data reports will be combined with sediment and habitat monitoring data reports (see Sections 4 and 5 below).

3.8 Contingencies

After the 5-year and 10-year monitoring periods, the data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5-year MTCA remedial action review. In the event that Year 5 total or dissolved mercury concentrations in WP-1 or WP-2 exceed Table 2 (Engineering Design Report) water quality criteria, the monitoring schedule beyond Year 5 may need to be adjusted. Similarly, in the event that Year 10 total or dissolved mercury concentrations in WP-1 or WP-2 exceed Table 2 water quality criteria, monitoring may need to continue beyond Year 10, as outlined below. In either event, the water quality data will be reviewed relative to the following evaluation criteria:

- Are mercury concentrations exhibiting statistically significant ($P<.05$; t-test or regression) declines over the monitoring period such that future compliance with the Table 2 criteria is anticipated?
- Do the mercury concentrations only exceed longer-term chronic aquatic life exposure criteria (i.e., the 0.025 ug/L mercury criterion applicable to a 4-day average concentration; WAC 173-201A-040[3])? Are mercury concentrations below shorter-term (i.e., 1-hour) acute exposure criteria?

In this event, further evaluation may be appropriate to address the effects of tidal dispersion near the seeps, and to assess compliance with water quality criteria set forth in Chapter 173-201A WAC.

If the 5-year or 10-year water quality monitoring report, as approved by Ecology (in consultation with the Corps and other agencies), determines that water quality criteria are exceeded in the well points but that the answer to either of the above questions is "yes", then future monitoring will continue at an agreed-upon schedule. However, in the unlikely event that the answer to both questions listed above is "no", G-P will prepare recommendations for a supplemental response plan for Ecology and Corps review. The plan will describe additional source evaluation, monitoring, and/or response actions to be undertaken to ensure the successful performance of the remedial action. These additional actions may be integrated with related work associated with the adjacent remediation of the former G-P chlor-alkali facility.

4 SEDIMENT MONITORING

Tasks associated with the sediment monitoring are described in detail in this section. A description of the rationale and summary of existing data is followed by the objectives, a description of the sampling equipment, sampling units and locations, sampling schedule, sample collection methods, and contingencies.

4.1 Rationale and Summary of Existing Data

As part of the Whatcom Waterway RI/FS (Anchor Environmental and Hart Crowser 2000), surface sediment samples were collected at four (4) locations within the Log Pond (SS-40, SS-74, SS-75, and SS-76; see Figure C-1). The Whatcom Waterway RI/FS investigation found that the Log Pond contained the highest mercury levels at the Site, with surface sediment concentrations ranging from 1 to 12 mg/kg (dry weight) as well as elevated phenol concentrations (to 1.8 mg/kg dry weight) and greater than 50 percent wood material by volume. Biological testing performed in the Log Pond vicinity confirmed that the toxicity of such sediments may have adversely affected the production of benthic infauna. Mercury present in surface sediments in the Log Pond also had the potential to bioaccumulate in fish and shellfish tissues.

A clean sediment cap was constructed in the Log Pond in late 2000 / early 2001. The bottom (Phase I) layer of the cap was constructed with sand, and was placed in a manner that minimized the potential for mixing of the cap with underlying sediments. Finer-grained native silt material was used for the final (Phase II) cap surface, providing a base seeding of endemic Bellingham Bay benthic fauna, facilitating rapid colonization of the mudflat. Shoreline sections of the cap (i.e., near WP-1 and WP-2) were also designed and constructed to mitigate possible mercury seepage discharges associated with adjacent upland sources (see Section 4.1.3 of the Engineering Design Report).

The SMS (Chapter 173-204 WAC) specify that sediment quality criteria are applicable within the upper biologically mixed layer of sediments, which has been generally defined in Bellingham Bay as the top 12 cm of sediment (Anchor Environmental and Hart Crowser 2000). Resampling of surface sediments at the four (4) Whatcom Waterway RI/FS locations, along with surface sediments in shoreline seepage zones (near WP-1 and WP-2) will be

used to evaluate compliance with SMS criteria. Applicable sediment quality standards are listed in Table 1 of the accompanying Log Pond Engineering Design Report. Mercury, phenolic compounds and conventional parameters (see below) will be monitored at each of the six (6) sampling locations.

In addition to surface sediment monitoring, sediment coring will be accomplished during Years 1, 5, and 10 at four representative locations (SS-40, SS-74, SS-76, and SS-301). Sediment coring will be performed to verify the predicted lack of upward migration of mercury through the cap.

As described in Sections 4.6.1 and 4.6.2 of the Engineering Design Report, erosional forces that may be generated by vessel operations and relatively large storm waves were assessed during remedial design to develop specifications of cap material gradation and thickness, and setback distances to prevent cap scour. Specifying the grain size of the capping material that will resist movement by such forces is one way of ensuring long-term stability of the cap/habitat system. Material meeting these specifications was available within the Swinomish Channel (Phase I capping source). The primary areas of potential erosion concern are located near the Whatcom Waterway edge of the Log Pond. A relatively coarse (Type A) capping material was specified and constructed in these areas to ensure cap stability (see Figure C-1).

Immediately following construction, the Log Pond mudflat surface may not have achieved sufficient strength to resist erosion from ambient waves. Accordingly, the design includes retention of a log boom near the offshore boundary of the cap to attenuate incoming waves and wakes and to facilitate rapid stabilization of the mudflat surface. Once the mudflat surface has developed sufficient strength to resist such forces, as determined from periodic post-construction shear strength monitoring (see below), the log boom will no longer be necessary for wave and wake protection. Typically, strength in this case is achieved within a period of 1-year following construction. As the log boom would provide an effective deterrent to recreational vessels, it will be retained until provisions for its removal, to be identified on the OMMP for the entire Whatcom Waterway site, are met.

Based on the analyses presented in the Engineering Design Report, the surface of the Log Pond will be maintained at elevations very similar to the constructed condition, even following major storm events. Nevertheless, periodic disturbances of the surface from variable storm conditions,

resulting in dynamic beach equilibrium processes typical of relatively flat (typical 20H:1V) mudflat slopes, are expected to result in periodic disturbances of the mudflat surface, leading to localized areas of accretion and erosion. However, these changes, which are characteristic of such normally dynamic natural systems, are predicted to be relatively minor and are unlikely to result in significant adverse effects on cap or habitat functions.

4.2 Objectives

The objectives of long-term sediment quality monitoring at the Log Pond are as follows:

- To verify that capping materials placed at the Log Pond are not eroded by vessel propeller wash or storm wave forces;
- To verify that the sediment surface (nominally 0 to 12-cm) is not recontaminated above the current SQS chemical criterion for mercury of 0.41 milligrams per kilogram (mg/kg), or contingent confirmatory biological criteria, following completion of the interim remedial action;
- To verify that mercury capped at the Log Pond is not migrating upward through the cap; and
- To generally document that the sediment surface provides a suitable surface for colonization of epibenthic and benthic macroinvertebrates (this objective is discussed in more detail in Section 5 below).

Sediment sampling will be performed concurrent with benthic macroinvertebrate monitoring (see Section 5 below).

4.3 Sampling Units and Locations

G-P will collect four (4) surface and subsurface sediment samples at stations SS-40, SS-75, SS-76, and SS-301. Two (2) additional surface sediment samples will be collected at the well point monitoring locations, WP-1 and WP-2. Locations of the OMMP surface and subsurface sampling stations are depicted on Figure C-1.

4.4 Monitoring Schedule

An initial post-construction survey of the Log Pond cap/habitat embankment occurred in mid- January 2001, immediately following completion of the Phase I capping action. This survey documented the baseline (Year 0) extent of the Phase I cap. An additional post-construction survey was performed in late February 2001, following completion of the Phase II habitat layer. The results of these surveys are presented in the accompanying Completion Report. The data collected during these surveys provide a basis to assess long-term stability of the overall cap system. Bathymetric surveys will also be completed during Years 1, 2, 5, and 10.

In order to document the development of shear strength on the Log Pond surface, field vane shear tests (ASTM D 2573-94) and Atterberg Limit determinations (ASTM D 4318-84) will be performed during Years 1 and 2 following Phase I cap construction. Year 1 sampling will occur in summer 2001. Depending on the results of the Year 1 and 2 sampling, there may be a need to perform additional Year 5 monitoring (see below).

Sediment monitoring during Years 1, 2, 5 and 10 following completion of the Phase I cap, particularly when compared with baseline measurements collected during the Whatcom Waterway RI/FS, should be sufficient to document the effectiveness of the action in achieving and maintaining SMS criteria. Sampling will be coordinated with benthic macroinvertebrate sampling activities (i.e., summer sampling). As described above, in addition to surface sediment quality monitoring, during Years 1, 5, and 10 sediment cores will be collected at four representative locations within the Log Pond to verify the predicted lack of upward migration of mercury through the cap.

After the 5-year and 10-year monitoring periods, the data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5-year MTCA remedial action review. This review will determine the need for and/or scope of future monitoring that may be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

4.5 Bathymetric Surveys

Bathymetric surveys will be performed over the full extent of the capping area as depicted on Figure C-1. The surveys will be completed in general conformance with a Corps of Engineers Class I survey (EM 110-2-1003) with the following modifications:

- Track lines will be placed on 25-foot centers (versus 100-foot centers as specified in EM 110-2-1003); and
- The reported elevation datum will be mean lower low water (MLLW).

Survey methods and transect locations will be similar between the annual surveys to allow detailed comparisons. Changes in bathymetry will be evaluated to identify areas of net erosion or deposition relative to post-construction conditions. A moderate concern will be assigned when an area of potentially significant erosion is observed that approaches the minimum capping thickness specified by Ecology in the final SMS/MTCA Cleanup Action Plan (CAP) for the site. A high concern will be assigned when an area of potentially significant erosion is observed that does not comply with the minimum capping thickness specified by Ecology in the final CAP. A moderate concern exceedance may trigger additional bathymetric monitoring to further assess erosion, whereas a high concern exceedance would trigger contingency evaluations (e.g., adding additional capping material, see below).

4.6 Shear Strength

For the purposes of vane shear strength, Atterberg Limit determinations, and sediment quality monitoring, G-P will sample surface sediments at stations SS-40, SS-75, SS-76, SS-301, WP-1 and WP-2. Locations of the six OMMP sampling stations are depicted on Figure C-1.

As discussed in Section 4.6.2 of the Engineering Design Report, the surface of the Log Pond cap should exhibit a critical shear strength greater than 0.2 lb/ft^2. The experimental relationship described in Vanovi (1975) between the critical shear stress and vane shear strength and plasticity measurements will be used to evaluate whether sufficient strength has been developed on the cap/habitat surface to resist wave- and current-induced erosive forces. Field vane shear tests will be performed in general accordance with ASTM Method D 2573-94. Atterberg Limit determinations,

including liquid and plastic limits, will be determined in general accordance with ASTM D 4318-84.

4.7 Surface Sediment Sampling

4.7.1 Sampling Equipment

All surface sediment samples will be collected using a van Veen grab sampler or equivalent.

4.7.2 Sampling Methods

Surface sediment samples from the 0 to 12-cm biologically mixed surface layer at six (6) locations (see Figure C-1) will be collected for chemical, physical, and contingent biological testing using a van Veen grab sampler or equivalent in accordance with Puget Sound Estuary Program (PSEP) protocols (PSEP 1997a). Upon contact with sediments, the jaws will be drawn shut to collect the sample. Samples will be collected in the following manner in accordance with the PSEP protocols:

- Sediment sampling will be performed during high tide conditions. The sampling vessel will be positioned within 3 meters of the desired location. At the time of sampling, the geodetic horizontal position (i.e., latitude and longitude) of each sample location will be documented to the nearest 0.01 seconds in NAD27, Washington State North Zone Datum;
- Mudline elevation will be recorded at each sample location. Mudline elevations will be determined by leadline measurements, local tide gages, and published tide tables and referenced to the MLLW datum. Calculated mudline elevations at the sampling locations will be rounded to the nearest 1.0-foot;
- Jaw assembly will be decontaminated;
- Jaw assembly will be deployed;
- The cable to the jaw assembly will be drawn in taut and perpendicular;

- Location of the cable hoist will be measured and recorded by the location control personnel;
- The jaw assembly will be drawn shut to collect the sediment sample to a penetration depth of approximately 18-cm for a 0 to 12-cm grab;
- The sediment sample will be retrieved aboard the vessel and evaluated against the following PSEP acceptability criteria:

  · van Veen sampler is not overfilled (i.e., sediment surface against top of sampler);

  · Sediment surface is relatively flat, indicating minimal disturbance or winnowing;

  · Overlying water is present, indicating minimal leakage;

  · Overlying water has low turbidity, indicating minimal sample disturbance; and

  · Desired penetration depth is achieved.

- Overlying water will be siphoned off and a stainless steel trowel or similar device will be used to collect only the desired sediment fraction from inside the van Veen sampler, taking care not to collect sediment in contact with the sides of the sampler;
- The desired sediment fraction from the inside of the van Veen sampler will be placed in a high-density polyethylene (HDPE) bucket. Sediment from multiple grabs may be necessary to collect sufficient sample volumes for analysis. When sufficient sample volume has been collected into the HDPE bucket, the sediment will be homogenized using a variable speed drill fitted with a stainless steel paddle; and
- Homogenized sediment will be placed immediately into appropriate pre-labeled sample containers and placed immediately on ice for transport to the appropriate laboratory.

4.8 Subsurface Sediment Sampling

4.8.1 Sampling Equipment

Subsurface sediment samples will be collected using a vibracorer or equivalent coring device.

4.8.2 Sampling Methods

During the Year 1, 5, and 10 monitoring events, sediment cores will be collected at four representative locations within the Log Pond (Stations SS-40, SS-74, SS-76 and SS-301) to verify the predicted lack of upward migration of mercury through the cap. Sediment cores will be collected using a vibracorer. The vibracorer unit consists of two contra-rotating electric motors encased in an aluminum housing. An electric generator on the vessel via a submersible tether cable powers the vibracorer. When energized, the motors produce a high-frequency vibration capable of penetrating most unconsolidated strata.

The vibracorer will be deployed from the pontoon boat using the I-beam spud as a guide assembly for the core driving vibration head. A 3.75-in. inside diameter decontaminated aluminum pipe will be cut to the appropriate length based on the sampling depth at each location and clamped to the vibracorer. The vibracorer will be deployed and sent to the bottom, where the unit will then be energized and lowered to the appropriate depth. When that depth is reached, the vibracorer will be turned off and returned to the surface for sample processing. During the coring operation, the penetration of the core pipe is continuously monitored.

The minimum acceptable penetration depth for a successful core will be 2 or more feet below the bottom of the Phase I cap (e.g., 12.5 feet below the final mudline elevation at SS-301). If these acceptance criteria are met, the core will then be capped and delivered onshore for processing.

The following procedure will be used to decontaminate sample tubes prior to use:

- Rinse and pre-clean with potable water;

- Wash and scrub the tubes in a solution of laboratory grade non-phosphate based soap and potable water;
- Rinse with potable water;
- Rinse three times with distilled water; and
- Seal both ends of each core tube with aluminum foil.

The core tube caps will be removed immediately prior to placement into the coring device. Care will be taken during sampling to avoid contact of the sample tube with potentially contaminated surfaces. Extra sample tubes will be available during sample operations for uninterrupted sampling in the event of a potential core tube breakage or contamination. Core tubes suspected to have been accidentally contaminated will not be used. Logs and field notes of all core samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included in this log:

- Elevation of each boring station sampled as measured from MLLW. This will be accomplished using a fathometer or lead line to determine the depth at the sampling location;
- Location of each boring station as determined by DGPS;
- Date and time of collection of each sediment core sample;
- Names of field supervisor and person(s) collecting and logging in the sample;
- Observations made during sample collection including: weather conditions, complications, and other details associated with the sampling effort;
- The sample station number;
- Length and depth intervals of each core section and recovery for each sediment sample as measured from MLLW;
- Qualitative notation of apparent resistance of sediment column to coring; and

- Any deviation from this sampling plan.

When retrieved, each core will be inspected and a physical description of the material at the mouth of the core will be entered into the core log.

Core tubes longer than 4 feet will be cut in half to facilitate upright storage. The cut tubes will be individually labeled. Core orientation will also be marked on each tube. Labels identifying the core section will be securely attached to the outside of the casing and wrapped with transparent tape to prevent loss or damage of the label. The core sections will be stored upright in iced containers for transport to the core processing facility.

At the core processing facility, the cores will be cut open and a sediment description of each core sample will be recorded on the core log for the following parameters as appropriate and present:

- Sample recovery (depth in feet of penetration and sample compaction);
- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color), with particular focus on the delineation of Phase I and II capping layers;
- Odor (e.g., hydrogen sulfide);
- Wood material and other debris;
- Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms);
- Presence and depth of the redox potential discontinuity layer;
- Any other distinguishing characteristics or features

Sample intervals will be selected from the cores collected based on physical observations, particularly the delineation of Phase I and II capping layers. Target intervals for sediment quality analyses will be as

follows (surface sediments from these locations will be obtained from vanVeen samplers as described above):

- 0.4 to 1.0 feet below mudline;
- 1.0 to 1.5 feet below mudline;
- 1.0 to 1.5 feet above the Phase I/II cap interface (e.g., 5.5 to 6.0 feet below final mudline at SS-301);
- 1.0 to 1.5 feet above the bottom of the Phase I cap (e.g., 9.0 to 9.5 feet below final mudline at SS-301); and
- 1.0 to 1.5 feet below the bottom of the Phase I cap (e.g., 11.5 to 12.0 feet below final mudline at SS-301).

4.9 Sediment Subsampling and Analysis

To prevent sample contamination, all sampling equipment in contact with the sediment samples will undergo the following decontamination procedures prior to and between collection activities:

- Rinse with site water and wash with scrub brush until free of sediment;
- Wash with phosphate-free detergent and tap water;
- Rinse with tap water; and
- Rinse three times with distilled water.

Table C-2 provides the recommended containers, preservation techniques, and holding times for conventional, organic, and inorganic compounds necessary to meet the requirements specified in PSEP protocols (PSEP 1997a).

All on-site activities and field observations, including the visually estimated volumetric fraction of woody debris, will be documented in a site logbook. All containerized sediment samples will be shipped to the analytical laboratory after preparation is completed. Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the chain-of-custody

form. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the receiver will record the condition of the samples. Chain-of-custody forms will be used internally in the lab to track sample handling and final disposition.

All chemical/physical testing will adhere to the most recent PSEP quality assurance/quality control procedures (PSEP 1997b) and PSEP analysis protocols. Metals and organic compounds will be analyzed according to the guidelines provided in PSEP (1997c) and PSEP (1997d), respectively. Method 9060 (EPA 1986) will be used for the analysis of TOC because the analytical method for TOC in PSEP (1986) is now out of date (PTI 1995). The analytical methods and target detection limits are presented in Table C-3.

All sediment samples, plus QA/QC samples, will be analyzed for the following parameters:

- Percent solids;
- Grain size;
- Total organic carbon;
- Total mercury; and
- Miscellaneous extractable compounds.

Analysis methods and target detection limits are summarized in Table C-3. Surface sediment samples will also be submitted and archived for contingent bioassay testing.

Data quality objectives for the sediment sampling are summarized in Table C-4. Data packages received from the laboratories will be checked for completeness to ensure that data and QA/QC information requested are present. Data quality will be assessed using current U.S. EPA and Ecology protocols by considering the following:

- Holding times;
- Surrogate spike results;
- MS/MSD or MS/Duplicate results;
- Standard reference material results;

- Method blanks; and
- Detection limits.

Validated data will be compiled into a data report, including a narrative of quality assurance results. The data reports will be provided to Ecology and the Corps within 30 days of receipt of the validated laboratory data. Estimated dates for submittal of the Year 1, 2, 5, and 10 sediment data reports are fall 2001, fall 2002, fall 2005, and fall 2010, respectively. The sediment data reports will be combined with water quality and habitat monitoring data reports (see Sections 3 and 5).

4.10 Contingencies

Monitoring during Years 1, 2, 5 and 10 following completion of the remedial action, particularly when compared with baseline measurements collected during the Whatcom Waterway RI/FS, should be sufficient to document the effectiveness of the action in achieving and maintaining SMS criteria. Sampling will continue for a period of 10 years and will be coordinated with benthic macroinvertebrate sampling activities. The monitoring reports prepared following the Year 1, 2, 5, and 10 sampling events will summarize bathymetric monitoring data relative to baseline conditions, noting areas of moderate and high concern erosion as defined above. A moderate concern exceedance may trigger additional bathymetric monitoring to further assess erosion, whereas a high concern exceedance would trigger contingency evaluations. In the event that a high concern erosion area is identified, G-P will submit recommendations for further monitoring or corrective action for Ecology and Corps review. As appropriate, the response plan may include recommendations for sediment quality sampling within those erosion areas where there may be a concern for breaching of the cap.

In the event that surface (0 to 12 cm) concentrations of mercury or phenolic compounds detected at an individual sampling location exceed SQS chemical criteria, G-P will submit recommendations for further monitoring or corrective action for Ecology and Corps review. The supplemental response plan may include conducting confirmatory biological tests (in accordance with the SAP and QAPP used in the Whatcom Waterway RI/FS), if such testing is deemed necessary. The need for additional response actions (e.g., adding additional capping material) will also take into

consideration the results of sediment coring, bathymetric and well point sampling.

5 BIOLOGICAL MONITORING

5.1 Rationale

The Log Pond remedial/restoration project converted 1.8 acres of deep subtidal, 2.7 acres of shallow subtidal mudflat/debris, and 1.1 acres of intertidal riprap (along with sheet pile, bulkheads, and concrete debris), all of which previously exceeded SQS criteria, into 2.9 acres of clean, low intertidal, silt-sand and 2.7 acres of shallow subtidal habitat. Relatively fine-grained native silt material was used for most of the final (Phase II) cap surface, providing a base seeding of endemic Bellingham Bay benthic fauna, facilitating rapid colonization of the mudflat.

As a mechanism to characterize habitat changes in the Log Pond that result from this action, a preliminary habitat equivalency analysis (HEA) was performed using procedures outlined in NOAA (1996). The Log Pond project altered the current habitat; the purpose of the project was to improve the overall quality of habitat provided in this area (BBWG 1991; Ecology 2000). Significant long-term habitat functional benefits expected to be provided by the project include:

- Increased epibenthic production;
- Increased rearing area for juvenile salmonids and other resources; and
- Enhanced migratory corridor and habitat connectivity.

The preliminary HEA was used to evaluate interim habitat losses due to construction, as well as longer-term improvements in habitat functions, and provided an estimate of overall net benefits of the action (Anchor Environmental 2000). Consistent with monitoring data available from similar capping/mudflat restoration projects in Puget Sound, habitat functions are expected to develop rapidly within months of mudflat construction, with nearly full function provided within a period of approximately 3 to 4 years after construction (e.g., see Parametrix 1997). Use of the Squalicum "seeding" material should facilitate rapid colonization of the mudflat. An assumed 4-year (roughly logarithmic development) restoration time frame was incorporated into the preliminary HEA, along with estimated Phase I and II construction (interim loss) timelines.

The results of the preliminary HEA suggest that, beginning with the first juvenile salmon outmigration period, habitat functions provided by the Log Pond are expected to return to pre-construction conditions (Anchor Environmental 2000). Thus, the Log Pond project is unlikely to have any short-term adverse impacts on salmonid rearing or related productive capacity. Thereafter, habitat functions in the Log Pond are expected to continue to increase, approaching full functionality (roughly 4 times greater than existing conditions) within several years following construction.

The habitat monitoring plan presented below will allow verification of preliminary HEA predictions, particularly relative to epibenthic and benthic infauna production and utilization/rearing by juvenile salmonids. Monitoring will focus on epibenthic, benthic infauna, and juvenile salmonid population assessments.

5.2 Summary of Existing Data

Pre-construction baseline biological sampling was conducted at the Log Pond Site during three events between July and September 2000. The July sampling event included beach seine sampling, a diver survey, crab tissue sampling, and benthic infauna sampling. Subsequent sampling in August and September focused on beach seine sampling to monitor pre-project utilization of the Log Pond area by juvenile salmonids. Each sampling event is summarized below. Baseline sampling and analysis data are provided in Attachment 1 to this OMMP.

5.2.1 Biological Sampling - July 27, 2000

Staff from Anchor Environmental and Lummi Natural Resources performed the initial baseline biological sampling of the Log Pond on July 27, 2000. The scope of fieldwork included the following tasks:

- Beach seine incoming and outgoing tides at three locations to evaluate the presence of juvenile salmonids;
- Diver survey of a representative transect running east to west across the Log Pond;
- Collection of juvenile crab tissue composites for total mercury analysis; and

- Collection of benthic macroinvertebrate samples for abundance and diversity analysis.

The following sections summarize the activities for each task.

5.2.1.1 *Juvenile Salmonid Sampling*

Juvenile salmonids in the Log Pond were sampled using a beach seine measuring approximately 100 ft long by 5 ft high made of 6-mm mesh. Beach seining was performed at representative locations within the Log Pond and over a range of tide levels to document the presence or absence of juvenile salmonids. The locations of the seining stations were distributed along the Log Pond shoreline, as depicted on Figure C-1.

Each of the seine sets fished effectively (i.e., the seine was set to maximize fishing area, lead line was kept along substrate, catches successfully captured for identification and documentation, catches included bottom-oriented and pelagic species). Some net snags occurred but these were cleared quickly, with minimal time with the lead line off the substrate.

Catches were identified to species. Counts of non-salmonid catches were recorded. Chinook salmon juveniles, the only salmonid species caught during the July sampling, were counted and fork length measured. Caudal fin clips were taken for DNA analysis on a subset of nine Chinook salmon juveniles representing the size range of all Chinook salmon juveniles caught. These fin clips were collected using methods employed by Lummi Natural Resources. Table C-6 summarizes the beach seine catches and provides forklength and DNA analysis code information. A total of 26 juvenile salmonids were collected during the July 27th sampling. Fork length of these individuals ranged from 8.1 to 16.2 centimeters (cm), averaging 12.8 cm.

5.2.1.2 *Diver Survey*

A trained biologist/diver observed and documented biological communities present along a representative transect within the Log Pond. The diver survey was conducted along a track line from

approximately Station SS-40 to WP-1 (see Figure C-1). The survey was conducted during a rising tide and over a range of depths from 7 to 22 ft MLLW. Organisms identified during the survey included three (3) Dungeness crabs (10 to 13 cm carapace length); one (1) red rock crab; one (1) cockle; and two (2) sea stars. No eelgrass or other attached vegetation was observed in the area. Additional diver surveys were not performed due to poor visibility (less than 2 feet).

5.2.1.3 *Juvenile Crab Bioaccumulation Sampling and Analysis*

Year-1 juvenile Dungeness crabs (carapace length 6 to 7 cm) were collected at three stations (SC-74, SC-75, and SC-76; see Figure C-1) using a shrimp pot baited with dead fish. Traps (shrimp pots) were set at low tide and fished for approximately 5-6 hours on the incoming tide. Traps were checked every two hours and crabs were placed into 5 gallon HDPE buckets until processing. No crabs were collected at the two shallower stations (SC-74 and SC-76) during low tide. Crabs were collected at Station SC-75, however, which was located in deeper water near the waterway channel. After three trap runs, sufficient crabs had been collected at all stations to meet a targeted composite size of 2 to 3 crabs per sample. In addition, duplicate juvenile Shiner perch samples collected during beach seining at nearby Station BS-1 (see Table C-6) were also provided for analysis.

Tissue processing consisted of placing the whole tissue samples into double-bagged, mercury-free, glass sample jars provided by Frontier GeoSciences. Additional samples were collected for quality control (e.g., field duplicates). The jars were then labeled and placed in a cooler on ice until delivery to the laboratory the next morning. Frontier GeoSciences received the tissue samples in good condition on July 28, 2000, where they were held frozen prior to analysis. Whole-body tissue samples were analyzed for total mercury using Frontier total mercury method FGS-011. Analytical results are summarized in Table C-7. Complete laboratory reports are provided in Attachment 1.

Whole-body total mercury concentrations in juvenile crab tissues (including carapace) ranged from approximately 0.005 to 0.027

mg/kg (wet weight basis), averaging 0.019 mg/kg throughout the Log Pond area. Juvenile Shiner perch whole-body tissue concentrations were somewhat lower, averaging 0.012 mg/kg. These values are significantly less than mercury concentrations previously measured in adult crabs within the Whatcom Waterway (0.10 to 0.21 mg/kg in adult muscle tissue), but are nevertheless consistent with age-dependent bioaccumulation of mercury (Anchor Environmental and Hart Crowser 2000). The juvenile tissue data document pre-project conditions within the Log Pond.

5.2.1.4 Benthic Invertebrate Sampling and Analysis

Benthic invertebrates within the Log Pond were sampled using a petite ponar grab sampler (0.023 m^2) in accordance with PSEP protocols (PSEP 1997a). One sample was collected at each of the three Log Pond sampling sites depicted on Figure C-1 (SC-74, SC-75, and SC-76). Surface sediment was sieved through a 0.5-mm brass sieve using seawater. All material retained on the sieve was placed into a 500 ml glass jar and fixed with 10% buffered formalin. The samples were then shipped to Marine Taxonomic Services for sorting, identification, enumeration, and gross biomass determinations. Each sample was sorted to the major taxonomic group level (i.e., crustacea, molluscs, polychaetes, echinoderms, and other), and the biomass of each group determined. Analytical results are summarized in Table C-8. Complete laboratory reports are provided in Attachment 1. The Log Pond baseline data will be used in future comparisons with post-construction biological data, as described in Section 5.4.3 below.

5.2.2 Juvenile Salmonid Sampling - August 22 and September 20, 2000

Staff from Anchor Environmental and Lummi Natural Resources performed follow-up beach seining at three stations (BS-2, BS-3, and BS-4) within the Log Pond on August 22 and again on September 20, 2000. Sampling equipment and methods are described above in Section 5.3.1. Each station was sampled twice (six sets total) over a rising tide and slack high tide. Caudal fin clips for DNA analysis were taken from all chinook salmon caught. Heavy (August 22nd) and light-to moderate (September 20th) catches of gelatinous organisms (i.e., ctenophores or jellyfish) were observed in the seine samples.

Summary tables of the August and September seining are provided in Tables C-9 and C-10, respectively. A total of eight (8) juvenile salmonids were collected during the August 22nd sampling. The fork length of these individuals ranged from 7.5 to 14.7 cm, averaging 11.0 cm (Table C-9). No juvenile salmonids were collected during the September 20th sampling (Table C-9).

5.3 Objectives

The objectives of habitat monitoring at the Log Pond are as follows:

- To document the rate of recolonization of epibenthic and benthic macroinvertebrates;
- To document utilization by juvenile salmonids;
- To verify that the cap is effective in controlling bioaccumulation exposures; and
- To ensure that productive biological communities become established in the Log Pond.

Habitat monitoring will be performed concurrent with water and sediment quality monitoring (see Sections 3 and 4 above).

5.4 Monitoring Locations

Following cap construction, epibenthic and benthic infauna macroinvertebrate community monitoring, juvenile crab bioaccumulation monitoring, and juvenile salmonid utilization sampling will be performed at the same Log Pond stations used for the baseline sampling described in Section 5.2. For evaluation purposes, data collected from these locations will be compared with baseline information (see Section 5.2), and/or with monitoring data collected at two (2) regional reference locations within Chuckanut Bay having similar depth and substrate characteristics (Figure C-2). Previous sediment quality data collected within Chuckanut Bay verify that this general area does not exceed SQS criteria (BBWG 1999b). The location of the reference area is depicted on Figure C-2; positioning of the two Chuckanut Bay stations will be determined in the field during the first sampling event, in order to ensure a good match of physical characteristics with the Log Pond.

5.5 Monitoring Schedule

As outlined above, habitat development within the Log Pond is expected to occur over a period of 3 to 4 years following construction. Baseline monitoring conducted immediately prior to cap construction (see Section 5.3 below) and during Years 1, 2, 5 and 10 following completion of the remedial action should be sufficient to document the effectiveness of the restoration action.

Following cap construction, sampling will begin during the first spring, several months following construction, and will continue for a period of approximately 10 years. Habitat monitoring will be coordinated with other water and sediment sampling activities. Juvenile salmonid monitoring will generally occur during the month of April to correspond with expected outmigration periods. Benthic macroinvertebrate and juvenile crab bioaccumulation monitoring will generally occur during late July/early August to allow for interannual comparisons, consistent with PSEP protocols (PSEP 1997a). After the 5-year and 10-year monitoring periods, the data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5 year MTCA remedial action review. This review will determine the need for and/or scope of future monitoring that may be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

5.6 Benthic Macroinvertebrates

5.6.1 Sampling Equipment

Benthic macroinvertebrate samples will be collected using a petite ponar grab sampler or equivalent sampling device as described in the following section.

5.6.2 Sampling Methods

Benthos on the restored habitat surface will be sampled using a petite ponar grab sampler or equivalent in accordance with PSEP protocols (PSEP 1997a; see Section 4.1 above). Three replicate samples will be collected at each of the three baseline sampling sites in the Log Pond

(SC-74, SC-75, and SC-76). Triplicate samples will also be collected at each of the two reference sites. Benthic sampling event will occur in late July/early August, to allow for interannual comparisons (PSEP 1997a), also coinciding with sediment sampling events. Samples will be processed through a sluice box and washed through a 0.5-mm sieve. Organisms, sediment, and debris retained on the sieve surface will be washed into a collection jar and preserved for sorting and taxonomic identification at a laboratory.

Each replicate sample will be sorted to the major taxonomic group level (i.e., crustacea, molluscs, polychaetes, echinoderms, and other), and the biomass of each group determined. The habitat function assessment will consist of comparing abundance, biomass, and diversity indices from the restoration area sample sites (likely pooled together) to the reference sites. Data from multiple years of sampling at the restoration site will allow a determination of the rate of productivity increase and biological development on the habitat surface, as well as longer-term comparisons of the function at the restoration site compared to reference sites.

Benthic macroinvertebrate sampling and analysis methods are described to more detail in Attachment 2 of this OMMP prepared by Huxley College.

5.7 Epibenthic Macroinvertebrates

5.7.1 Sampling Equipment

Epibenthic macroinvertebrates will be sampled using an epibenthic suction pump as described in the following section.

5.7.2 Sampling Methods

Epibenthos on the restored habitat surface will be sampled using an epibenthic suction pump, following methods outlined in the PSEP Estuarine Habitat Assessment Protocols (Simenstad et. al. 1991). A suction pump device that encompasses 0.1 m^2 of the bottom will be used to collect samples at each of the three study sites within the Log Pond and at the two reference sites. Samples will be collected during two discrete sampling events within the spring juvenile salmon outmigration period (extending from late March through early June). The sampler will be equipped with fine mesh (0.130 mm) screened ports to allow water to

be pulled through the sample area, but screening any organisms from outside the sampling quadrat to enter the sample itself. Approximately three volumes of water will be flushed through the system to ensure that all organisms encompassed within the sampler are captured in the sample. The pumped water and epibenthic organisms will be sieved through a 0.253-mm mesh sieve. All organisms/debris retained on the sieve will be washed into a sample jar, and preserved for later sorting and taxonomic identification at a laboratory. Three replicate samples will be collected at each sampling station to support statistical analyses of the data.

Each sample will be sorted to the lowest taxonomic level practical. The habitat function assessment will consist of comparing abundance and diversity indices from the restoration area sample sites (likely pooled together) to the reference sites. Data from multiple years of sampling at the restoration site will allow a determination of the rate of productivity increase and biological development on the habitat surface, as well as longer-term comparisons of the function at the restoration site compared to reference sites.

Epibenthic macroinvertebrate sampling and analysis methods are described in more detail in Attachment 2 of this OMMP prepared by Huxley College.

5.8 Bioaccumulation Monitoring

5.8.1 Sampling Equipment

Shrimp pots or other equivalent juvenile crab sampling gear will be used to collect juvenile crabs as described in the following section.

5.8.2 Sampling Methods

Shrimp pots or other equivalent juvenile crab sampling gear will be deployed to obtain representative Year-1 Dungeness crabs for bioaccumulation monitoring. Sampling will be performed at each of the three Log Pond baseline sampling sites stations (SC-74, SC-75, and SC-76; see Figure C-1), and also at two (2) representative reference sites in Chuckanut Bay (Figure C-2). Three replicate samples will be collected at each sampling station to support statistical analyses of the data.

Juvenile crab bioaccumulation monitoring will occur in late July/early August, to allow for comparisons with baseline data (PSEP 1997a), also coinciding with sediment and benthic macroinvertebrate sampling events. Total mercury analyses (triplicate samples comprised of single specimens) will be performed on selected tissue samples using Frontier total mercury method FGS-011 or equivalent.

5.9 Fisheries Monitoring

5.9.1 Sampling Equipment

Juvenile salmonids will be collected using a beach seine as described in the following section.

5.9.2 Sampling Methods

Juvenile salmonids in the Log Pond will be sampled using a beach seine measuring approximately 100 ft long by 5 ft high made of 6-mm mesh. Three seining sites will be used in the Log Pond (BS-2, BS-3, and BS-4), and two sites established at the reference location. Sites will be sampled three times throughout the juvenile salmonid outmigration period (e.g., early April, May, and June sampling). All salmonid fish captured during each beach seine set will be identified to species, enumerated, and released back into the water at their point of capture. No fish will be sacrificed for study purposes.

Trends in abundance and species composition at the Log Pond restoration site will be determined over the length of the outmigration period, and will be compared to the reference locations. Results of the seining efforts will be used to verify that juvenile salmon are migrating through the Log Pond area and using the restored habitat surface.

5.10 Contingencies

As discussed above, habitat development within the Log Pond is expected to occur over a period of years following construction. Monitoring during Years 1, 2, 5 and 10 following completion of the remedial action should be sufficient to document the effectiveness of the action in restoring habitat functions. Sampling will continue for a period of 10 years and will be coordinated with water and sediment sampling activities. After the 10-year

monitoring period, the data will be summarized and evaluated to determine the need for and/or scope of future monitoring.

6 REPORTING

Epibenthic, bioaccumulation, benthic infauna, and juvenile salmonid monitoring data will be compiled into a data report, including a narrative of quality assurance results. The data reports will be provided to Ecology and the Corps within 30 days of receipt of the validated laboratory data. Estimated dates for submittal of the Year 1, 2, 5, and 10 habitat monitoring data reports are Fall 2001, Fall 2002, Fall 2005, and Fall 2010, respectively. The habitat data reports will be combined with water and sediment quality monitoring data reports (see Sections 3 and 4).

7 SCHEDULE

The schedule for implementation of OMMP tasks is summarized in Figure C-3. Annual reports including water quality, sediment, and habitat monitoring data will be provided to Ecology and the Corps within 30 days of receipt of the validated laboratory data. Estimated dates for submittal of the Year 1, 2, 5, and 10 data reports are Fall 2001, Fall 2002, Fall 2005, and Fall 2010, respectively.

8 REFERENCES

Anchor Environmental, L.L.C. & Hart Crowser, Inc, 2000. Remedial Investigation/Feasibility Study, Whatcom Waterway Site, Bellingham, Washington, prepared for Georgia-Pacific West, Inc. July 25, 2000.

Anchor Environmental, L.L.C, 2000. Biological Assessment: Chinook salmon, Coho Salmon, Bull Trout, and Bald Eagles. Combined Remedial Action and Habitat Enhancement for the Georgia-Pacific Log Pond, Whatcom Waterway, Bellingham. Report prepared for Georgia-Pacific West, Inc. by Anchor Environmental, Seattle, WA March 20, 2000 (w/ addenda).

BBWG, 1999a. Habitat Restoration Documentation Report. Report prepared for Bellingham Bay Demonstration Pilot Project by Pacific International Engineering. PLLC and Anchor Environmental, LLC. February 15, 1999.

BBWG, 1999b. Sediment Site and Source Control Documentation Report. Report prepared for Bellingham Bay Demonstration Pilot Project by Anchor Environmental, LLC. July 30, 1999.

Ecology, 2000. Bellingham Bay Comprehensive Strategy: Final Environmental Impact Analysis. Washington Department of Ecology. October 2000.

EPA. 1986. Test procedures for solid waste. 3rd Edition. SW-846. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

National Oceanic and Atmospheric Administration, 1996. Habitat Equivalency Analysis: An Overview. Policy and Technical Paper Series, Number 95-1. Damage Assessment and Restoration Program, National Oceanic and Atmospheric Administration, Department of Commerce. June 12, 1996.

Parametrix, 1997. St. Paul Waterway Remedial Action and Habitat Restoration Project: 1997 Monitoring Report. Prepared for Simpson Tacoma Kraft Co., Tacoma, WA and Champion International, Stamford, CN by Parametrix, Inc., Kirkland, WA.

PSEP. 1986. Recommended protocols for measuring conventional sediment variables in Puget Sound. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

PSEP. 1997a. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, Washington.

PSEP. 1997b. Recommended quality assurance and quality control guidelines for the collection of environmental data in Puget Sound. Draft Report. Prepared for U.S. Environmental Protection Agency, Seattle, Washington.

PSEP. 1997c. Recommended guidelines for measuring metals in Puget Sound water, sediment and tissue samples. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, Washington.

PSEP. 1997d. Recommended guidelines for measuring organic compounds in Puget Sound water, sediment and tissue Samples. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, Washington.

PTI. 1995. Sediment sampling and analysis plan appendix- guidance on the development of sediment sampling and analysis plans meeting the requirements of the Sediment Management Standards (Chapter 173-204 WAC). Draft. Prepared for Washington State Department of Ecology.

Simenstad, C.S., C.D. Tanner, R.M. Thom, and L.L. Conquest, 1991. Estuarine Habitat Assessment Protocol. Report prepared for U.S. Environmental Protection Agency by Fisheries Research Institute and Center for Quantitative Science, University of Washington, Seattle, WA. EPA 910/9-91-037.

Vanovi, V.A., 1975. Sedimentation Engineering. American Society of Civil Engineering, Hydraulics Division, Sedimentation Committee. New York, N.Y.

Table C-1. Data Quality Objectives for Well Point Sampling

Parameter	Units	Reporting Limits	Precision	Accuracy	Completeness	Method	Container	Holding Time	Preservation
Water									
Total suspended solids	%	0.1	±20 RSD	NA	100%	Standard Method 2540-D	500-mL HDPE	7 days	dark/4degC
Salinity	psu	0.002	±5 RPD	±5 %D	100%	Salinometer	300-mL glass	90 days	dark/room temp
Total and dissolved mercury	ug/L	0.0001	±25 RPD	75 to 125 %R	100%	EPA Method 1631	2x250-mL HDPE	28 days	5 mL 1:1 HNO_3

Notes:
RSD - Relative standard deviation.
RPD - Relative percent difference.
%D - Percent difference.
%R - Percent recovery.
NA – Not applicable.

Table C-2. Containers, Preservation Techniques, Holding Times for Sediment Samples

Sample Type	Container Size and Type	Preservation Technique	Holding Time
Particle size	16-oz Glass	Cool/4°C	6 months
Total solids	4-oz Glass (combined)	Cool/4° C	14 days
Total organic carbon		Cool/4° C	14 days
Mercury		Cool/4° C	28 days
Miscellaneous Extractables	16-oz Glass	Cool/4° C	14 days
Bioassay (Surface Sediments Only)	2x2-gallon HDPE	Cool/4° C/dark nitrogen atmosphere	56 days

Note:
The holding time for bioassay samples is based on the Puget Sound Dredged Disposal Analysis (PSDDA) guidelines.

Table C-3. Chemical/Physical Analysis Methods and Target Detection Limits

Parameter	Target Detection Limits	Ecology SQS Criteria	Sample Preparation Method	Sample Cleanup Method	Analytical Method
Conventionals					
Percent solids in %	0.1	NA	---[a]	---	CLP ILM 03.0
Grain size in %	0.1	NA	---[a]	---	PSEP
Total organic carbon in %	0.1	NA	---[a]	---	EPA 9060
Metals in mg/kg dry					
Mercury	0.10	0.41	PSEP 1997c	---	EPA 7471
Miscellaneous Extractables in ug/kg dry					
Phenol	20	420	EPA 3540/3550	EPA 3640/3660	EPA 8270
2-Methylphenol	20	63	EPA 3540/3550	EPA 3640/3660	EPA 8270
4-Methylphenol	20	670	EPA 3540/3550	EPA 3640/3660	EPA 8270
2,4-Dimethylphenol	20	29	EPA 3540/3550	EPA 3640/3660	EPA 8270
Pentachlorophenol	50	360	EPA 3540/3550	EPA 3640/3660	EPA 8270
Benzyl alcohol	20	57	EPA 3540/3550	EPA 3640/3660	EPA 8270
Benzoic acid	200	650	EPA 3540/3550	EPA 3640/3660	EPA 8270

Table C-4. Data Quality Objectives for Sediment Sampling

Parameter	Units	Precision	Accuracy	Completeness
Grain size	%	±20 RSD[a]	NA	100%
Total solids	%	±10 RPD[b]	NA	100%
Total organic carbon	%	±20 RPD	65 – 135 %R[c]	100%
Mercury	mg/kg	±25 RPD	65 – 135 %R	100%
Miscellaneous Extractables	µg/kg	±40 RPD	50 – 135 %R	100%

Notes:
(a) Relative standard deviation.
(b) Relative percent difference.
(c) Percent recovery.
NA – Not applicable.

Table C-5. Habitat Restoration Acreages

Habitat Zone Elevations in feet MLLW	Pre-Capping Acres	Post-Capping Aces	Change in Acres
8 to 11	0.0	0.0	0.0
4 to 8	0.0	0.01	0.01
0 to 4	0.27	0.96	0.69
-4 to 0	0.78	1.89	1.11
-10 to –4	2.67	2.69	0.02 –
-20 to –10	2.21	0.4	-1.81
Deeper than -20	0.0	0.0	0.0

Table C-6. Log Pond Beach Seine Catch Summary, July 27, 2000

Set Number	1	2	3	4	5
Station	**BS-1**	**BS-2**	**BS-3**	**BS-2**	**BS-3**
Time	800	820	850	1430	1515
	Number Caught				
Pacific herring	0	0	0	287	0
Shiner perch	34	9	39	3	3
Chinook salmon	0	0	0	2	24
Shore crab	1	0	14	1	0
Sand lance	0	0	0	6	8
Staghorn sculpin	7	0	6	1	0
Unidentified shrimp (<3 cm long)	6	0	0	0	0
Starry flounder	0	0	2 (1 adult, 1 juvenile)	0	0
Saddleback gunnel	0	0	2	0	0
Threespine stickleback	0	0	0	2	0
Bay goby	0	0	1	0	0
	Chinook salmon fork length in cm (DNA sample code)				
				8.1 (GPLPn9)	9.2
				9.5 (GPLPn8)	9.8 (GPLPn3)
					10.0
					12.0 (GPLPn1)
					12.1 (GPLPn5)
					12.3
					12.9
					12.9
					13.0
					13.3
					13.3
					13.4
					13.5
					13.5
					13.5
					13.6 (GPLPn7)
					14.1 (GPLPn2)
					14.2
					14.2
					14.3
					14.4
					14.6 (GPLPn6)
					16.0 (GPLPn4)
					16.2

Table C-7. Tissue Mercury Results - G-P Log Pond Baseline Sampling

Sample Identification	Species	Number of Individuals Composited	Date Collected	Whole Body Total Mercury Concentration in mg/kg wet wt.
C-SC-74	Juvenile Dungeness crab	3	7/27/2000	0.027
C-SC-74 DUP	Juvenile Dungeness crab	3	7/27/2000	0.021
C-SC-75	Juvenile Dungeness crab	2	7/27/2000	0.022
C-SC-75 DUP	Juvenile Dungeness crab	2	7/27/2000	0.005
C-SC-76	Juvenile Dungeness crab	3	7/27/2000	0.017
C-SC-76 DUP	Juvenile Dungeness crab	3	7/27/2000	0.024
F-SC-BS-1	Juvenile Shiner perch	3	7/27/2000	0.013
F-SC-BS-1 DUP	Juvenile Shiner perch	3	7/27/2000	0.010

Table C-8. Benthic Infauna - G-P Log Pond Baseline Sampling

	Station		
	SC-74	SC-75	SC-76
Total Abundance	341	332	249
Taxa Richness	30	37	40
Major Taxa Abundance			
Polychaeta	64 (19%)	229 (69%)	144 (58%)
Crustacea	234 (69%)	45 (14%)	25 (10%)
Mollusca	28 (8%)	45 (14%)	76 (31%)
Miscellaneous	15 (4%)	13 (4%)	4 (2%)
Major Taxa Biomass (in grams wet wt)			
Polychaeta	0.078 (10%)	1.889 (64%)	0.597 (57%)
Crustacea	0.159 (21%)	0.026 (1%)	0.016 (2%)
Mollusca	0.535 (69%)	0.861 (29%)	0.239 (23%)
Miscellaneous	---	0.159 (5%)	0.191 (18%)

NOTE: Abundance and biomass data based on a sampling area of 0.023 m^2

Table C-9. August 22, 2000 Log Pond Beach Seine Catch Summary

Set Number **Station** Time	1 **BS-2** 1000	2 **BS-3** 1030	3 **BS-4** 1105	4 **BS-2** 1150	5 **BS-3** 1230	6 **BS-4** 1310
	Number Caught					
Pacific herring	1	0	0	207	0	0
Shiner perch	0	47	0	5	36	15
Chinook salmon	0	0	2	1	4	1
Threespine stickleback	0	0	0	0	3	1
Shore crab	0	0	0	1	0	3
Staghorn sculpin	0	2	0	0	1	0
Cutthroat trout	0	0	2	0	0	0
Sand lance	1	0	0	0	0	0
Surf smelt	0	0	0	0	1	0
	Chinook salmon fork length in cm (DNA sample code)					
			9.9 cm (GPLPN11) 11.5 cm (GPLPN10)	7.5 cm (GPLPN12)	10.8 cm (GPLPN14) 10.9 cm (GPLPN16) 12.7 cm (GPLPN15) 14.7 cm (GPLPN13)	10.2 cm (GPLPN17) —

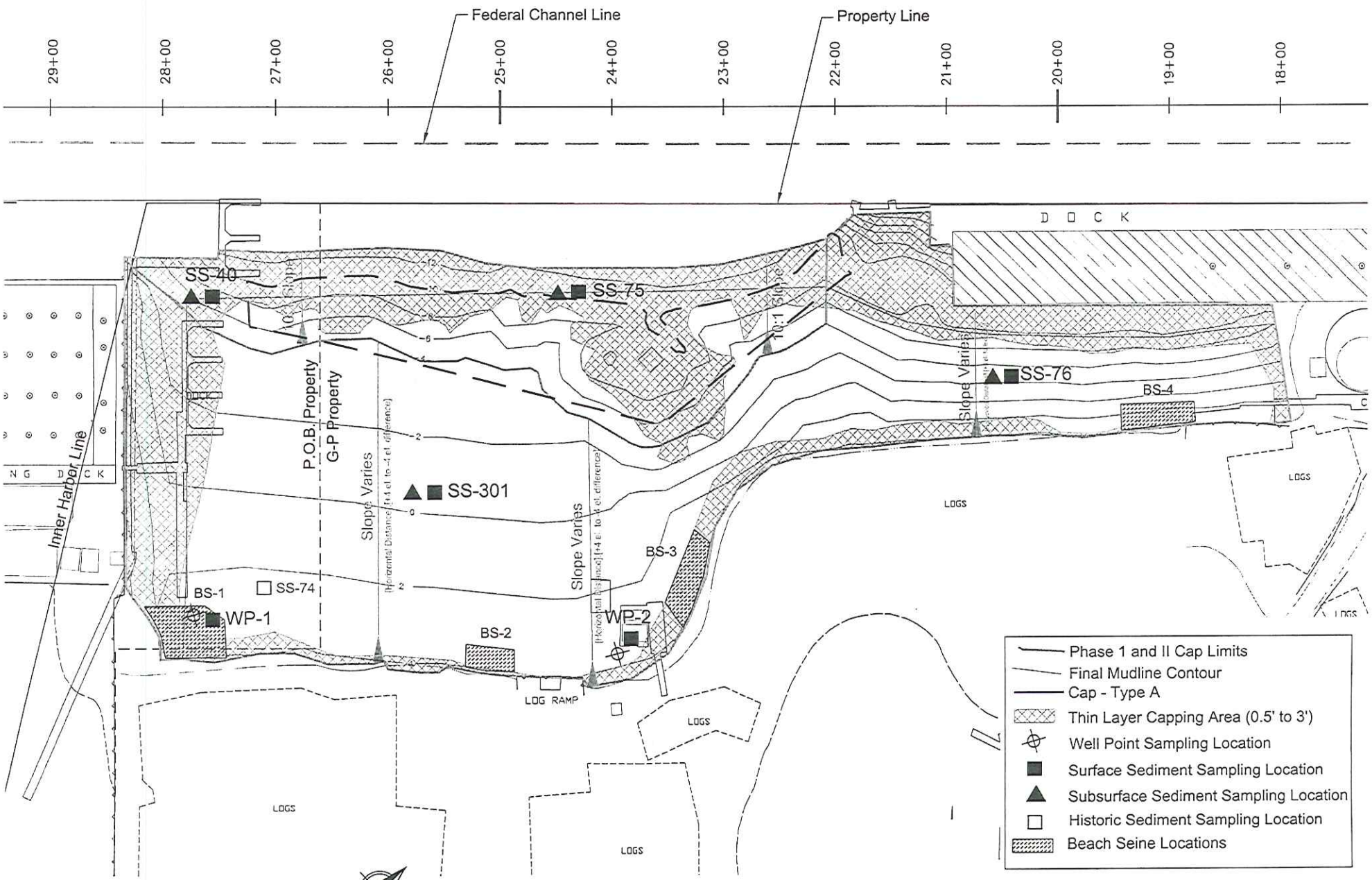
Table C-10. September 20, 2000 Log Pond Beach Seine Catch Summary

Set Number	1	2	3	4	5	6
Station	**BS-2**	**BS-3**	**BS-4c**	**BS-2**	**BS-3**	**BS-4**
Time	1007	1035	1058	1202	1222	1255
	Number Caught					
Shiner perch	4	20	3	7	35	1
Larval sand lance	27[a]	14	1	0	0	0
Threespine stickleback	0	14	1	0	0	0
Sand lance	8[b]	0	0	0	0	0
Sculpin spp.	0	0	0	2	0	0
Saddleback gunnel	0	0	1	0	0	0

NOTES:

(a) Three unidentified larval fish collected in the field were later identified by Mike MacKay as sand lance.

(b) Upon reloading the seine into boat for the next set, two live sand lance were found. It is likely these sand lance were among the original 8 captured and stayed in the area of the net after their release.



ANCHOR ENVIRONMENTAL, L.L.C.

5/29/01 GPB009-02.dwg 99-030-01

Figure C-1
Proposed Long-Term Monitoring Stations
Log Pond Interim Action

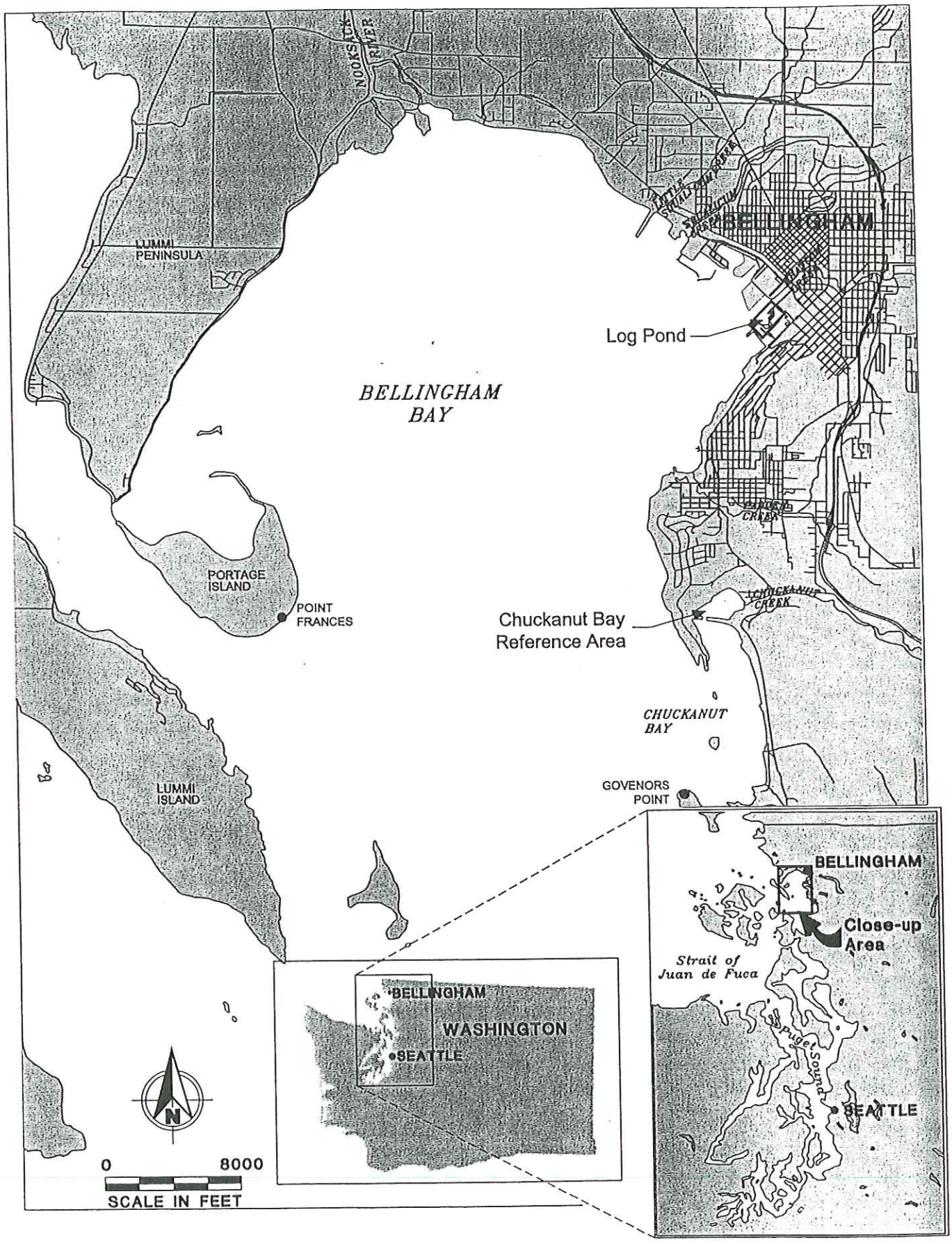


Figure C-2
Chuckanut Bay Reference Area

ANCHOR ENVIRONMENTAL, L.L.C.

06/06/00 GPB010-01.dwg 90-030-01

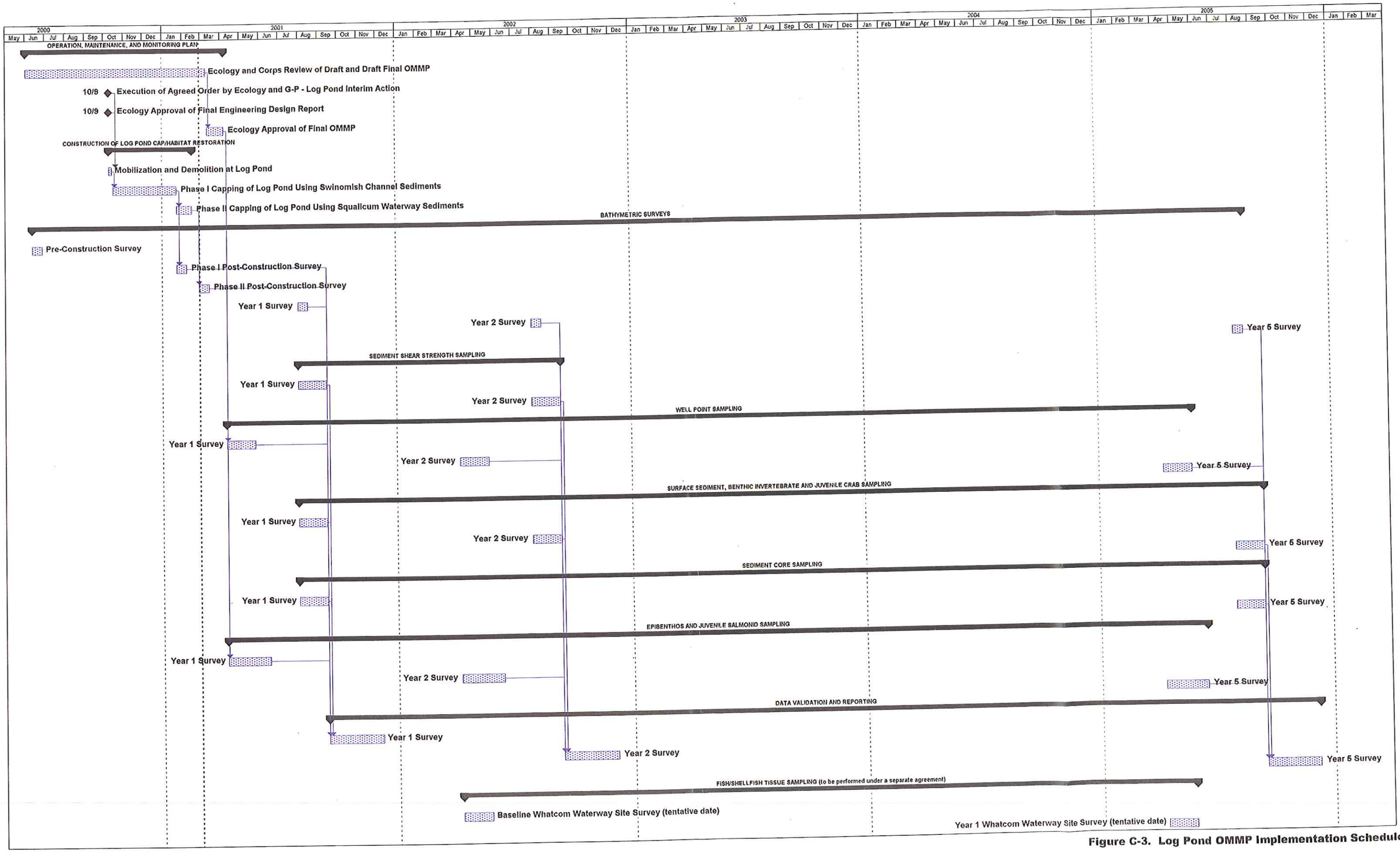


Figure C-3. Log Pond OMMP Implementation Schedule

ATTACHMENT 1

ANALYTICAL DATA REPORTS FOR TISSUE SAMPLES COLLECTED

JULY 27, 2000

Frontier
Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

August 15, 2000

Steve Cappellino
Anchor Environmental
1411 4th Avenue, Suite 1210
Seattle, WA 98101

Re: Total Hg in Tissues: G-P Log Pond

Dear Mr. Cappellino,

Enclosed are results for total mercury in crab and fish tissue samples colected on July 27, 2000. The samples were received in good condition on July 28. Following receipt, the samples were immediately placed in frozen storage until sample preparation could take place.

Prior to digestion for total mercury, each sample was homogenized in a clean blender. Approximately one gram of each sample was digested with 10 ml of hot refluxing 70%HNO_3/30%H_2SO_4 for approximately two hours. The digests were then diluted to a final volume of 40 ml with a solution of 10% (v/v) 0.2N BrCl. Aliquots of each sample were analyzed by $SnCl_2$ reduction, dual gold amalgamation, and cold vapor atomic fluorescence (CVAFS) detection (EPA method 1631). No analytical difficulties were encountered. Please feel free to call me if you have any questions.

Best Wishes,

Eric J. von der Geest
Project Manager

206 622 6960
fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Steve Cappillino)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 10, 2000 (THG6-000810-1)

Sample Identification	Date Collected	Total Hg, ng/g*
C-SC-74-1	7/27/00	26.8
C-SC-74-2	7/27/00	20.5
C-SC-75-1	7/27/00	22.0
C-SC-75-2	7/27/00	4.54
C-SC-76-1	7/27/00	17.1
C-SC-76-2	7/27/00	23.6
F-SC-74-N	7/27/00	13.1
F-SC-74-S	7/27/00	10.2

*Blank corrected

Total Mercury in Tissues-GP Log Pond
(Anchor Environmental c/o Steve Cappillino)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 10, 2000 (THG6-000810-1)

Sample Identification	Date Collected	Total Hg, ng/g*
Method blanks		
Blank-1		0.71
Blank-2		0.13
Blank-3		0.11
Mean		**0.31**
Method MDL		**0.50**
Standard Reference Materials		
DORM-2		3,735
recovery		**80.5%**
reference value		4,640

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Steve Cappillino)

analyzed by:

Frontier Geosciences, Inc.

414 Pontius Avenue North, Suite B, Seattle, WA 98109

phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 10, 2000 (THG6-000810-1)

Sample Identification	Date Collected	Total Hg, ng/g*

Analytical Replicates

C-SC-74-1		26.77
C-SC-74-1 MD		26.49
Mean		**26.63**
RPD		**1.1%**

*Blank corrected

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Steve Cappillino)

analyzed by:

Frontier Geosciences, Inc.

414 Pontius Avenue North, Suite B, Seattle, WA 98109

phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 10, 2000 (THG6-000810-1)

Sample Identification	Date Collected	Total Hg, ng/g*
Matrix spikes		
C-SC-74-1 MS		87.69
spiking level		59.69
net		61.06
recovery		**102.3%**
C-SC-74-1 MSD		82.42
spiking level		59.22
net		55.79
recovery		**94.2%**

*Blank corrected

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North Seattle WA 98109
(206) 622-6960 fax (206) 622 -6870 Info@Frontier.WA.Com

Chain of Custody Record & Laboratory Analysis Request

Date: 7/27/00 Page: 1 of 1

Client Company: Anchor Environmental
Address: 1411 4th Ave., 1210
Seattle, WA. 98101

CONTACT: Steve Cappellino
Phone: 206-287-9130 Fax: 206-287-9131
Email: scappellino@anchorenv.com
Project Name: G-P Log Pond
Contract/PO #:

Frontier Project Manager: Vander Geist
Guaranteed Turnaround Time:
Confirmation of Sample Arrival at Frontier: ❑ YES ❑ NO
Quality Assurance Level: ❑ Standard ❑ High
Disposal*: ❑ FGS Dispose ❑ Return to Client ❑ Ship to 3rd Party**

*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.

**Please discuss this with the Frontier Project Manager.

Bottle #	Sample ID	Matrix	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
1	C-SC-74-1	Tissue	7/27/00	SC	None (ice)	Total Hg - Low Level
2	C-SC-74-2		7/27/00	SC		
3	C-SC-75-1		7/27/00	SC		
4	C-SC-75-2		7/27/00	SC		
5	C-SC-76-1		7/27/00	SC		
6	C-SC-76-2		7/27/00	SC		
7	F-SC-74-N		7/27/00	SC		
8	F-SC-74-S		7/27/00	SC		

Sample Receipt	Relinquished by:	Relinquished by:	Relinquished by:
C.O.C. Seal Intact? ❑ YES ❑ NO	Print name: Steve Cappellino	Print name:	Print name:
Cooler Temperature: 4.0 °C	Company: Anchor Environmental	Company:	Company:
Comments:	Date: 7/28/00 Time: 0800	Date: Time:	Date: Time:
	Received by:	Received by:	Received by:
	Print name:	Print name:	Print name:
	Company: FGS	Company:	Company:
	Date: 7/28/00 Time: 1150	Date: Time:	Date: Time:

MARINE TAXONOMIC SERVICES, LTD
5125 NW Crescent Valley Dr.
Corvallis, OR 97330

Phone: (541) 753-7609
Fax: (541) 753-0715

August 23, 2000

David Templeton
Anchor Environmental
1411 4th Ave., Suite 1210
Seattle, WA 98101

Dear David:

Enclosed you will find a hard copy of the data for the GP Log Pond Biological Sampling Project from Bellingham Bay. These include a species checklist, species data, a biomass table and voucher collection list. Also enclosed is a disk with the files in both QUATTRO PRO and EXCEL formats, as well as an invoice for this work. The voucher collection will be sent to you under separate cover.

If you have any questions, give us a call at (541) 753-7609. Thank you for calling on MTS.

Sincerely,

Howard R. Jones

Howard R. Jones
President

kj

BELLINGHAM BAY, WASHINGTON
INVERTEBRATE SPECIES CHECKLIST
For Anchor Environmental
By Marine Taxonomic Services, Ltd.
August, 2000

Phylum Cnidaria
- Class Anthozoa
  - Order Actiniaria
    - Nynantheae sp. Indeterminate

Phylum Nemertea
- Nemertea sp. Indeterminate

Phylum Annelida
- Class Polychaeta
  - Order Cossurida
    - Family Cossuridae
      - Cossura sp. Indeterminate
  - Order Spionida
    - Family Spionidae
      - Polydora sp. Indeterminate
      - Prionospio (Minuspio) lighti Maceolek, 1985
      - Prionospio (Prionospio) steenstrupi Malmgren, 1867
    - Family Cirratulidae
      - Aphelochaeta monilaris (Hartman, 1960)
      - Aphelochaeta sp. N-1
      - Cirratulidae sp. Indeterminate
      - Cirratulus spectabilis (Kinberg, 1866)
      - Cirratulus sp. Indeterminate
  - Order Capitellida
    - Family Capitellidae
      - Capitella capitata 'hyperspecies' (Fabricius, 1780)
      - Heteromastus filobranchus Berkeley & Berkeley, 1932
      - Mediomastus sp. Indeterminate
  - Order Opheliida
    - Family Opheliidae
      - Armandia brevis (Moore, 1906)
      - Opheliidae sp. Juvenile
  - Order Phyllodocida
    - Family Phyllodocidae
      - Eteone sp. Indeterminate
      - Phyllodoce sp. Juvenile
    - Family Polynoidae
      - Harmothoe imbricata (Linnaeus, 1767
    - Family Sigalionidae
      - Pholoe minuta (Fabricius, 1780)
    - Family Hesionidae
      - Podarke pugettensis Johnson, 1901
      - Podarkeopsis glabra (Hartmann-Schroder, 1959)
    - Family Nereidae
      - Platynereis bicanaliculata (Baird, 1863)
    - Family Goniadidae

Glycinde polygnatha Hartman, 1950
Glycinde sp. Juvenile
Family Nephtyidae
Nephtys caeca (Fabricius, 1780)
Nephtys caecoides Hartman, 1938
Nephtys cornuta Berkeley & Berkeley, 1945
Order Eunicida
Family Lumbrineridae
Lumbrineris limicola Hartman, 1944
Order Terebellida
Family Pectinariidae
Pectinaria californiensis Hartman, 1941
Pectinaria granulata (Linnaeus, 1767)
Family Trichobranchidae
Terebellides californica Williams, 1984
Class Oligochaeta
Oligochaeta sp. Indeterminate
Phylum Mollusca
Class Gastropoda
Order Mesogastropoda
Family Lacunidae
Lacuna vincta (Montagu, 1803)
Family Rissoidae
Alvania compacta (Carpenter, 1864)
Order Neogastropoda
Family Nassariidae
Nassarius mendicus (Gould, 1849)
Family Turridae
Oenopota sp. Juvenile
Subclass Opistobranchia
Family Pyramidellidae
Turbonilla sp. Indeterminate
Order Cephalaspidea
Family Aglajidae
Melanochlamys diomedea (Bergh, 1894)
Family Scaphandridae
Scaphander sp. Indeterminate
Class Bivalvia
Bivalvia sp. Juvenile
Order Mytiloida
Family Mytilidae
Mytilis sp. Indeterminate
Order Veneroida
Family Thyasiridae
Axinopsida serricata (Carpenter, 1864)
Superfamily Galeommatoidea
Family Lasaeidae
Rochefortia tumida (Carpenter, 1864)
Family Cardiidae
Clinocardium nuttalli (Conrad, 1837)
Clinocardium sp. Juvenile
Family Tellinidae
Macoma elimata Dunnill and Coan, 1968
Macoma inquinata (Deshayes, 1855)

Macoma nasuta (Conrad, 1837)
Macoma sp. Juvenile
Tellina modesta (Carpenter, 1864)
Order Myoida
Family Myidae
Cryptomya californica (Conrad, 1837)
Phylum Arthropoda
Subphylum Crustacea
Class Ostracoda
Order Myodocopida
Family Philomedidae
Euphilomedes carcharodonta (Smith, 1952)
Class Copepoda
Order Harpacticoida
Harpacticoida sp. Indeterminate
Class Malacostraca
Order Cumacea
Family Leuconidae
Eudoralla pacifica Hart, 1930
Leucon subnasica Given, 1962
Family Nannastacidae
Cumella vulgaris Hart, 1930
Order Tanaidacea
Family Paratanaidae
Leptochelia dubia (Kroyer, 1842)
Order Isopoda
Order Amphipoda
Amphipoda sp. Juvenile
Family Uristidae
Orchomene cf. pinguis (Boeck, 1861)
Family Aoroidae
Grandidierella japonica Stephensen, 1938
Family Corophiidae
Corophiidae sp. Indeterminate
Monocorophium acherusicum Costa, 1857
Order Decapoda - zoea
Decapoda sp. Juvenile
Phylum Phoronida
Family Phoronidae
Phoronida sp. Indeterminate
Phylum Echinodermata
Class Echinoidea
Order Clypeasteroida
Family Dendrasteridae
Dendraster excentricus (Eschscholtz, 1831)

BELLINGHAM BAY, WASHINGTON - BENTHIC WORK
SPECIES DATA
For Anchor Environmental
By Marine Taxonomic Services, Ltd.
August, 2000

STATION	SC-74	SC-75	SC-76
TAXON			
POLYCHAETA			
Aphelochaeta monilaris		3	1
Aphelochaeta sp. N-1		17	9
Armandia brevis	7		2
Capitella capitella 'hyperspecies'	20	3	12
Cirratulidae sp. indet.		86	12
Cirratulus spectabilis	1	2	1
Cirratulus sp. indet.			3
Cossura sp. indet.		17	2
Eteone sp. indet.	3	2	2
Galathowenia oculata	3	37	65
Glycinde polygnatha	2	4	2
Glycinde sp. juv.	7	7	1
Harmothoe imbricata		1	
Heteromastus filobranchus		1	
Lumbrineris limicola			1
Mediomastus sp. indet.	7		1
Nephtys caeca	1		
Nephtys cornuta		23	1
Oligochaeta sp. indet.	1		11
Opheliidae sp. juv.	9		
Pectinaria californiensis		1	
Pectinaria granulata		1	
Pholoe minuta		15	15
Phyllodoce sp. juv.	2		
Platynereis bicanaliculata			1
Podarke pugettensis		3	
Podarkeopsis glabra		1	1
Polydora sp. indet.	1		
Prionospio lighti		2	1
Prionospio steenstrupi		2	
Terebellides californica		1	
MOLLUSCA			
Alvania compacta	7	3	25
Axinopsida serricata		4	
Bivalvia sp. juv.			1
Clinocardium nuttalli			1
Clinocardium sp. juv.			1
Cryptomya californica	1		
Lacuna vincta	1		
Macoma elimata		1	
Macoma inquinata	2		
Macoma nasuta	3		5
Macoma sp. juv.			12
Melanochlamys diomedea			8
Mytilus sp. indet.		2	

BELLINGHAM BAY, WASHINGTON - BENTHIC WORK
SPECIES DATA
For Anchor Environmental
By Marine Taxonomic Services, Ltd.
August, 2000

STATION	SC-74	SC-75	SC-76
TAXON			
Nassarius mendicus	1	10	
Oenopota sp. juv.			2
Rochefortia tumida	12	19	18
Scaphander sp. indet.			1
Tellina modesta	1	4	2
Turbonilla sp. indet.		2	
CRUSTACEA			
Amphipoda sp. juv.	3		
Corophiidae sp. indet.	3	1	
Cumella vulgaris	63		1
Decapoda zoea			1
Eudorella pacifica		9	2
Euphilomedes carcharodonta			2
Grandidierella japonica	8	20	5
Harpacticoida sp. indet.	3		
Leptochelia dubia	1		
Leucon subnasica	80	4	10
Monocorophium acherusicum	73		4
Orchomene cf. pinguis		11	
MISCELLANEOUS			
Dendraster excentricus		10	3
Nemertinea sp. indet.	15	2	
Nynanthae sp. indet.			1
Phoronida sp. indet.		1	

BELLINGHAM BAY, WASHINGTON - BENTHIC WORK
BIOMASS IN GRAMS
For Anchor Environmental
By Marine Taxonomic Services, Ltd.
August, 2000

STATION	POLYCHAETA	MOLLUSCA	CRUSTACEA	MISCELLANEOUS
SC-74	0.078	0.535	0.159	------
SC-75	1.889	0.861	0.026	0.159
SC-76	0.597	0.239	0.016	0.191

BELLINGHAM BAY, WASHINGTON - BENTHIC WORK

VOUCHER COLLECTION

For Anchor Environmental

By Marine Taxonomic Services, Ltd.

August, 2000

Vial #		COUNT		STATION
	POLYCHAETA			
1	Aphelochaeta monilaris	1		SC-76
2	Aphelochaeta sp. N-1	1		SC-76
3	Armandia brevis	1		SC-74
4	Capitella capitella 'hyperspecies'	1		SC-74
5	Cirratulus spectabilis	1		SC-74
6	Cossura sp. indet.	1		SC-76
7	Eteone sp. indet.	1		SC-74
8	Galathowenia oculata	1		SC-74
9	Glycinde polygnatha	1		SC-74
10	Glycinde sp. juv.	1		SC-74
11	Harmothoe imbricata	1		SC-75
12	Heteromastus filobranchus	1		SC-75
13	Mediomastus sp. indet.	1		SC-74
14	Nephtys caeca	1		SC-74
15	Nephtys cornuta	1		SC-76
16	Oligochaeta sp. indet.	1		SC-74
17	Pectinaria californiensis	1		SC-75
18	Pectinaria granulata	1		SC-75
19	Pholoe minuta	1		SC-74
20	Phyllodoce sp. juv.	1		SC-74
21	Platynereis bicanaliculata	1		SC-76
22	Podarke pugettensis	1		SC-75
23	Podarkeopsis glabra	1		SC-75
24	Polydora sp. indet.	1		SC-74
25	Prionospio lighti	1		SC-75
26	Terebellides californica	1		SC-75
	MOLLUSCA			
27	Alvania compacta	1		SC-76
28	Axinopsida serricata	1		SC-75
29	Clinocardium nuttalli	1		SC-76
30	Clinocardium sp. juv.	1		SC-76
31	Cryptomya californica	1		SC-74
32	Lacuna vincta	1		SC-74
33	Macoma elimata	1		SC-75
34	Macoma inquinata	1		SC-74
35	Macoma nasuta	1		SC-76
36	Macoma sp. juv.	1		SC-76
37	Melanochlamys diomedea	1		SC-76
38	Mytilus sp. indet.	1		SC-75
39	Nassarius mendicus	1		SC-75
40	Oenopota sp. juv.	1		SC-76
41	Rochefortia tumida	1		SC-76
42	Scaphander sp. indet.	1		SC-76
43	Tellina modesta	1		SC-76
44	Turbonilla sp. indet.	1		SC-75

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		COUNT		STATION
	CRUSTACEA			
45	Corophiidae sp. indet.	1		SC-74
46	Cumella vulgaris	1		SC-74
47	Decapoda zoea	1		SC-76
48	Eudorella pacifica	1		SC-75
49	Euphilomedes carcharodonta	1		SC-76
50	Grandidierella japonica	1		SC-74
51	Harpacticoida sp. indet.	1		SC-74
52	Leptochelia dubia	1		SC-74
53	Leucon subnasica	1		SC-74
54	Monocorophium acherusicum	1		SC-74
55	Orchomene cf. pinguis	1		SC-75
	MISCELLANEOUS			
56	Nemertinea sp. indet.	1		SC-75
57	Nynanthae sp. indet.	1		SC-75
58	Ophiuroidea sp. indet.	1		SC-76
59	Phoronida sp. indet.	1		SC-76

ATTACHMENT 2

BENTHIC MACROINVERTEBRATE AND EPIBENTHIC MACROINVERTEBRATE SAMPLING AND ANALYSIS PLAN

The Log Pond Restoration Project: Structure and Function of the Benthic Community

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The Log Pond Restoration Project: Structure and Function of the Benthic Community

Introduction

As part of the comprehensive plan to clean up sediments and restore habitat in Bellingham Bay, the Georgia Pacific Log Pond has been capped with clean sediment. The capping modified 1.5 acres of deep subtidal, 2.5 acres of shallow subtidal and 1.6 acres of intertidal riprap, providing 4.0 acres of low intertidal and 1.6 acres of shallow subtidal habitat (Anchor Environmental 2000).

The capping process occurred in 2 phases. Phase I involved covering existing sediments with a thick layer of clean sediment. In Phase II, a thinner layer of native silt material from Squalicum was placed over the capping material. This local material should already contain an established community of infaunal invertebrates. In addition, it should provide good settlement habitat for larvae from other regional invertebrate species.

The Log Pond restoration plan includes assessment of the new habitat performance. While capping the sediments in the pond should improve sediment quality, it is important to demonstrate that the sediment cap is controlling bioaccumulation exposures and that the habitat is functioning properly with a healthy, productive benthic community. This is important both for the inherent value of the benthic invertebrate community itself and for its role it plays in the broader Bellingham Bay and regional ecosystems (e.g., as food for juvenile salmonids).

It has been predicted that the Phase II sediments will be rapidly recolonized and that a fully functional benthic community will be established by 3 - 4 years after construction of the cap. Documenting the recovery will require regular sampling and monitoring of the infaunal and epibenthic invertebrate fauna. This should be continued until the benthic communities structure approaches that seen in reference sites that have not be impacted by historical commercial/industrial activities. Initial baseline sampling of the Log Pond was done immediately prior to construction and capping activities. We propose to continue sampling to document changes in the benthic community.

Objectives

Short-term

The short-term objective of this work is to characterize the invertebrate infaunal and epibenthic communities in the Log Pond. Our goal will be to follow a sampling procedure that provides solid data amenable to statistical analyses. The goal will be to document changes in the invertebrate community.

Long-term

In the long term, our data will allow us to evaluate recolonization rates of epibenthic and infaunal macroinvertebrates in the Log Pond cap materials. We will be looking for evidence that healthy, productive biological communities have been established in the log pond and that these communities are similar to those in unimpacted reference sites.

Methods

It will be important that post-construction data are comparable to the baseline data collected before the Log Pond was capped. To ensure that is the case, we will use the same methods as those used in the baseline survey. Those methods are outlined below.

Quantitative sampling of the epibenthos

In accordance with the Operations, Maintenance and Monitoring Plan for the Log Pond Project (OMMP), we will use an epibenthic suction pump (Simenstad et. al. 1991) to take three epibenthic samples at each of 3 fixed stations within the log pond. Sampling sites will be chosen to maximize the probability that samples are 1) unbiased and 2) representative of the Log Pond.

The suction pump will sample 0.1 m^2 of the bottom. After the sample has been collected, three volumes of water will be flushed through the system to ensure that all invertebrates have been flushed from the pump. The pump will have 0.130 mm screened ports that will retain the macroinvertebrates and allow the water to pass. The collected sample will be washed through a 0.253-mm mesh sieve, preserved, and sorted to the lowest possible taxonomic group. We will consult with taxonomic experts where necessary.

For comparison, two reference sites will be established in Chuckanut Bay. These sites will be chosen to duplicate the Log Pond as closely as possible (e.g., water depth, sediment composition, exposure). The sampling protocol will be identical to that described for the log pond. The reference sites will be sampled each time collections are made in the Log Pond.

Quantitative sampling of benthic invertebrates

Effectively sampling the epibenthic community requires a different sampling protocol. For consistency with pre-construction sampling, we will use a 0.023 m^2 petite ponar grab sampler (PSEP 1997a) to collect benthic invertebrates. On each sampling date, three grab samples will be taken from each of three sampling sites established in the baseline survey (SC-74, SC-75, SC-76). Three grab samples will also be taken at each of two reference sites in Chuckanut Bay. The log pond and reference sites will be sampled during the same periods so results can be compared.

All grab samples will be washed through a 0.5-mm brass sieve, put in 500 ml glass jars and fixed with 10% buffered formalin. They will later be sorted and identified to the lowest possible taxonomic group. Samples will be weighed to determine the biomass of each sample.

Because sediment composition can have a strong impact on benthic community structure and composition, it will be important to characterize the sediments from each sample location. We will do this by taking sediment from the grab sampler. The sediment will be partitioned, dried, and weighed to produce a measure of grain-size composition. A subsample will also be burned to produce a measure of sediment organic

content. These data will allow us to include sediment composition as a factor in analyses of benthic community structure.

Graduate thesis research

As part of the project, the graduate assistant will develop a thesis research project. The research will investigate some aspect of the biology/ecology of the benthic community we are studying and will contribute to our understanding of the way the habitat is functioning. The basic sampling of the epibenthos and benthos will follow the exact OMMP sampling guidelines. However, additional sampling may be done to support the graduate assistant's thesis research.

The graduate assistant will also participate in other aspects of the OMMP project. This participation will include 6 full days of field assistance in 2001 and 5 full days in 2002. The student will serve only as a field hand and will not be responsible for sample processing or data collection. The actual sampling dates will be planned to accommodate the student's academic schedule (e.g., classes, exams). The assistant will participate in the following specific tasks.

- Fish seining (one full day in April 2001, May 2001, June 2001, April 2002, May 2002 and June 2002).
- Juvenile crab and sediment sampling (one full day in July 2001 and July 2002).
- Well point sampling (one full day in April 2001 and April 2002).
- Sediment core sampling (one full day in July 2001).

Anticipated results

We anticipate that the sampling will give us some indication of changes in the benthic invertebrate community. Invertebrate diversity and abundance will be low initially but should come to resemble that seen in the reference community.

Schedule and reporting

Date	Scheduled activity
Year 1 (2001)	
Mid-April*	1st quantitative sampling of epibenthic invertebrates in the Log Pond and Chuckanut reference sites
Mid-June*	2nd quantitative sampling of epibenthic invertebrates in the Log Pond and Chuckanut reference sites
July	1st quantitative sampling of benthic invertebrates in the Log Pond and Chuckanut reference sites
August - September	Work up results of first year's samples
November	First year's sampling report
Year 2 (2002)	
Mid-April*	3rd quantitative sampling of epibenthic invertebrates in the Log Pond and Chuckanut reference sites
Mid-June*	4th quantitative sampling of epibenthic invertebrates in the Log Pond and Chuckanut reference sites
July	2nd quantitative sampling of benthic invertebrates in the Log Pond and Chuckanut reference sites
August - September	Work up results of second year's sampling
November	Summary report for the first 2 years of sampling

*Sampling dates for epibenthic invertebrates are intended to correspond with periods of peak utilization by juvenile salmonids. The actual sampling dates may be modified somewhat based on year-to-year variation.

Budget

	Year 1	Year 2	Project
Salaries and Wages			
Graduate assistant (12 months)	$12,648	$13,280	$25,928
Faculty (1 month)	$5,369	$5,637	$11,006
Project administration (1 hr/wk @ 16.5/hr)	$858	$901	$1,759
Total Salaries and Wages	$18,875	$19,818	$38,693
Fringe benefits	$3,219	$3,380	$6,598
Other Direct Costs			
Tuition (partial award if out of state)	$4,812	$5,053	$9,865
Materials and supplies	$2,000	$2,000	$4,000
Equipment	$500	$0	$500
Boat rental	$240	$240	$480
Travel	$240	$240	$480
Total Direct Costs	$29,886	$30,731	$60,616
Indirect Costs	$10,966	$11,514	$22,481
Total Project Costs	$40,852	$42,245	$83,097

Budget justification

Salaries, Wages, and Tuition

Primary salary support is requested for a graduate student research assistant. We are requesting a 12-month salary with part-time support through the summer. We also request partial tuition support for the student.

This project will include substantial faculty involvement. We request 1 month of summer salary for Brian Bingham who will be involved with the sample collection, sample processing and taxonomic work. One hour per week is also requested for administrative support (budget administration).

Fringe Benefits

Fringe benefits are calculated according to established Western Washington University guidelines. The required charges are 10% of student salaries, 30% of faculty salaries and 40% of staff salaries.