YEAR 2 MONITORING REPORT

INTERIM REMEDIAL ACTION
LOG POND CLEANUP/HABITAT RESTORATION PROJECT
BELLINGHAM, WASHINGTON

Prepared for

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EXECUTIVE SUMMARY

In early 2001, Georgia-Pacific West, Inc. (G-P) completed construction of a combined sediment cleanup/habitat restoration action at the G-P Log Pond in Bellingham Bay. The project converted subtidal mudflat/debris and low intertidal riprap, all of which previously exceeded Washington State sediment quality standards (SQS), into clean intertidal and shallow subtidal silt and sand habitat. The integrated remediation and habitat restoration project was performed as an Interim Remedial Action under the authorities of the State Model Toxics Control Act, as set forth in an Agreed Order for this action between G-P and the Washington Department of Ecology (Ecology). The project was also authorized under a Clean Water Act Permit administered by the U.S. Army Corps of Engineers.

Beginning shortly after construction, G-P performed the first year of post-construction monitoring within the Log Pond to verify the integrity and performance of the cap, and to document the development of habitat functions within the Log Pond. The first year monitoring, completed seven months following construction, documented successful placement of the cap, development of required cap strength to generally resist erosion, and initial colonization and utilization of the new habitat by a range of endemic species.

To further evaluate cap stability and chemical integrity, and to document the continued development of habitat functions within the Log Pond, G-P conducted a second year of post-construction monitoring beginning in spring 2002 (Year 2 post-construction). This report presents data collected during the Year 2 monitoring, with results as summarized below:

- Bathymetric monitoring verified the continued physical stability and integrity of the cap/habitat surface, and documented net accretion on the cap from regional sediment deposition. Localized zones of intertidal erosion (greater than 1 foot loss of elevation relative to Year 0 conditions) were observed along portions of the Log Pond shoreline, but were limited to relatively small areas immediately adjacent to steep riprap banks. Overall, the cap thickness documented during the Year 2 monitoring is consistent with objectives set forth in the remedial design for this project. However, to limit further embankment erosion, G-P is currently evaluating an integrated shoreline stabilization/habitat enhancement for appropriate sections of the Log Pond. These enhancements, which might include further development of existing habitat functions within the Log Pond by softening the existing shoreline, will be developed in

coordination with the cleanup/redevelopment study of the adjacent former Chlor-Alkali Facility uplands, currently being performed under a separate Agreed Order between G-P and Ecology.

- Well point sampling at the margins of the Log Pond cap documented continued attainment of surface water and sediment quality protection objectives within the nearshore seepage zone of the cap. These data also verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.
- All chemical concentrations in surface sediments of the cap/habitat layer were well below SQS chemical criteria. These data indicate chemicals are not migrating into the cap/habitat layer at levels of potential concern.
- Consistent with the water and sediment quality data, juvenile Dungeness crab whole-body total mercury concentrations in the Log Pond area remain low and are within the low end of the range of values detected in the Bellingham Bay regional reference area near Portage Island.
- Epibenthic and benthic monitoring data indicate that the macroinvertebrate community is now well established in the Log Pond and continues to develop towards a community structure similar to that found in the Chuckanut Bay reference area.
- Fish sampling in the Log Pond documented utilization by juvenile salmonids during their spring outmigration. Five salmonid species (chinook, coho, chum, pink, and steelhead) and three forage fish species were collected in the Log Pond during fish sampling activities.
- Native eelgrass (*Zostera marina*) was observed colonizing the shallow subtidal elevations of the cap/habitat layer. Eelgrass colonization is an unexpected additional benefit of the habitat restoration action.

The Year 2 monitoring data document the continued success of the integrated cleanup and habitat restoration action. Physical, chemical, and biological monitoring of the Log Pond will continue during Years 5 and 10 to document the long-term effectiveness of the remedial/habitat restoration action.

1 INTRODUCTION

In late 2000 and early 2001, Georgia-Pacific West, Inc. (G-P) implemented a combined sediment cleanup/habitat restoration action at the G-P Log Pond, part of the Whatcom Waterway Site located in inner Bellingham Bay, Washington (Figures 1 and 2). The integrated remediation and habitat restoration project was performed as an Interim Remedial Action under the authorities of the State Model Toxics Control Act (MTCA; Chapter 173-340 WAC; RCW 70.105D), as set forth in an Agreed Order for this action between G-P and the Washington Department of Ecology (Ecology). The project was also authorized under Clean Water Act Permit No. 2000-2-00424 administered by the U.S. Army Corps of Engineers (Corps).

G-P prepared a Completion Report for the Log Pond project in May 2001 (Anchor 2001a). The Completion Report described the placement of approximately 43,000 cubic yards (cy) of clean cap/habitat restoration material from regional maintenance dredging projects into the Log Pond. Relatively fine-grained Squalicum Waterway dredge materials were used to construct the final Log Pond surface. The total placed thickness ranged from approximately 0.5 feet along the cap perimeter (e.g., adjacent to structures) to 10 feet within the interior of the project area. Nearly all of the Log Pond received more than 3 feet of cap/habitat restoration material, tapering to less than 0.5-foot-thick along the perimeter, consistent with the Agreed Order and associated remedial design (Anchor 2000).

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 low intertidal riprap, all of which previously exceeded MTCA/Sediment Management Standards (SMS) cleanup criteria, into 2.7 acres of shallow subtidal and 2.9 acres of low intertidal clean silt and sand habitat. The construction project achieved its intended goal of restoring shallow subtidal and low intertidal habitat to the Log Pond (Anchor 2001a).

Consistent with the requirements of the Agreed Order and Corps permit, G-P performed Year 1 post-construction monitoring within the Log Pond beginning shortly after completion of in-water construction activities. As set forth in the final Operations, Maintenance, and Monitoring Plan (OMMP) for the project (included as Appendix C of the Completion Report; Anchor 2001a), monitoring is being performed by G-P to verify the integrity and performance of the cap, and to document the development of habitat functions within the Log Pond. The Year 1

Monitoring Report (Anchor 2001b) presented data collected during the first year of post-construction monitoring. The results of Year 1 monitoring are summarized below:

- Surface sediment physical monitoring within the Log Pond verified that the cap/habitat surface maintained its integrity following construction, and had developed suitable strength to generally resist further erosion.
- Sampling at the margins of the Log Pond cap documented continued attainment of surface water and sediment quality protection objectives within the nearshore seepage zone of the cap. These data also verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.
- All chemical concentrations in both surface and subsurface zones of the cap/habitat layer were well below SMS Sediment Quality Standards (SQS) chemical criteria. Moreover, samples collected 1.0 to 1.5 feet above the bottom of the cap were also below SQS chemical criteria, indicating that the capping method used by G-P successfully minimized mixing of underlying contaminated sediments into the bottom of the clean cap. These data also verify that chemicals are not migrating vertically into the cap/habitat layer.
- Biological monitoring data revealed that within several months of construction, epibenthic and benthic biomass, species richness, diversity and evenness within the Log Pond recovered to Chuckanut Bay reference values, consistent with remedial design predictions of rapid re-colonization.

This monitoring report presents data collected to satisfy the Year 2 monitoring requirements of the OMMP. Monitoring activities during Year 2 included:

- A detailed bathymetry survey (using methods equivalent to those employed during the Year 0 and Year 1 monitoring) to document areas of net accretion and/or erosion on the Log Pond surface, and to generally assess cap stability.
- Surface sediment chemical monitoring throughout the Log Pond to evaluate whether surface sediments within the Log Pond continue to be maintained below SQS chemical criteria.
- Sampling of seepage quality along the Log Pond embankment to evaluate whether surface water quality protection objectives continue to be met within the nearshore seepage zone of the cap.

- Biological monitoring within the Log Pond area, to document the rate of epibenthic and benthic infauna re-colonization, as well as juvenile salmonid utilization of the restored habitat.
- Bioaccumulation sampling within the Log Pond and in a regional reference area (near Portage Island), to demonstrate the protectiveness of the cap in controlling bioaccumulation exposures and restoration of aquatic habitat.

Results of the Year 2 monitoring are presented in the following sections of this report.

2 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 3 – Cap Integrity
- Section 4 – Upland Source Control Monitoring – Well Point Water Quality
- Section 5 – Cap Sediment Quality Monitoring
- Section 6 – Biological Monitoring
- Section 7 – References

Figures and Tables summarizing each monitoring element are presented at the end of the report text.

Appendices provide supporting project documentation and are organized as follows:

- Appendix A – Well Point Field Logs
- Appendix B – Laboratory Report – Well Point Chemistry
- Appendix C – Data Validation Reports for Well Point and Sediment Chemistry
- Appendix D – Surface Sediment Field Logs
- Appendix E – Bingham et al. (2002), Huxley College Report – The Log Pond Restoration Project: Structure and Function of the Benthic Community – Year 2 Report
- Appendix F – Laboratory Report – Juvenile Crab Tissue Bioaccumulation Report

3 CAP INTEGRITY

In late February 2001, shortly after completion of in-water construction, G-P performed a detailed bathymetric survey of the Log Pond. These data, presented in the Completion Report (Anchor 2001a), provided post-construction baseline information to assess the long-term stability of the cap/habitat system.

The Log Pond cap/habitat restoration action was designed to be maintained at elevations very similar to the initial constructed condition, even following major storm events (Anchor 2000). Nevertheless, disturbances of the surface from variable storm conditions, resulting in dynamic beach equilibrium processes typical of mudflats, are expected to result in periodic disturbances of the cap/habitat surface, leading to localized areas of accretion and erosion. These changes, which are characteristic of such normally dynamic systems, were predicted during remedial design to be relatively minor (Anchor 2000). Based on previous habitat restoration experience in Puget Sound (e.g., Simpson and Champion 1999), the most pronounced changes are expected within the first two years following construction, as the sediment redistributes to achieve its new equilibrium condition.

Monitoring conducted in Year 1, seven months after construction, verified that capping materials placed at the Log Pond had not been eroded significantly by vessel propeller wash or storm wave forces. A comparison of the February 2001 baseline bathymetry (Year 0) with the October 2001 survey (Year 1) is presented in Figure 3. Overall, the surface of the cap/habitat appeared to consolidate and/or settle by several inches during the initial 7-month period, consistent with design estimates (Anchor 2000). Excluding such consolidation/settlement, more than 95 percent of the cap/habitat surface did not exhibit any discernable change in elevation over the 7-month period (Anchor 2001b). However, localized erosional areas were noted near both the center and margin of the cap/habitat surface, consistent with the expected redistribution/equilibration of the new sediment surface. Localized areas of erosion appeared to be most pronounced adjacent to relatively steep shoreline riprap slopes. The extent of erosion observed in these localized areas typically varied between 0.5 and 1.0 feet. Corresponding areas of sediment accretion were noted near the northeast end of the Log Pond cap. The Year 1 thickness of the Log Pond cap/habitat was consistent with objectives set forth in the Agreed Order and associated remedial design (Anchor 2000). Year 1 data also verified remedial design predictions that the surface of the Log Pond cap/habitat had developed suitable strength to generally resist further erosion.

In accordance with methods specified in the OMMP (Anchor 2001a), a bathymetric survey of the Log Pond was again conducted in Year 2 to document areas of net accretion and/or erosion on the Log Pond surface, and to generally assess cap stability. The bathymetric survey was performed on October 1, 2002, over the full extent of the capping area, approximately 19 months after completion of construction. In order to support detailed comparisons, survey methods and transect locations were equivalent to methods used during the initial February 2001 (Year 0) survey and Year 1 monitoring in October 2001.

A comparison of the Year 0 baseline bathymetry with the October 2002 survey is presented in Figure 4. Consistent with the Year 1 monitoring, more than 95 percent of the cap/habitat surface exhibited either no discernable change in elevation, or significant net accretion (greater than 0.5 feet accumulation) over the 19-month period. The area-weighted average elevation of the Year 2 cap/habitat surface was slightly higher (net accretion) relative to Year 1 conditions, likely as a result of continued deposition of regional sediments within the Log Pond areas.

Localized erosional areas were noted along the inshore margin of the cap/habitat surface immediately adjacent to relatively steep riprap embankments. These findings are consistent with the expected redistribution and equilibration of the new sediment surface predicted during Remedial Design (Anchor 2000). The areal extent of shoreline erosion expanded somewhat from the Year 1 monitoring, and typically varied between 0.5 and 2.0 feet. Localized areas of erosion previously identified in the center of the cap/habitat surface during Year 1 monitoring now exhibit no discernable change from the baseline post-construction data, indicating sediment redistribution in the center between Years 1 and 2.

Based on the October 2002 bathymetric survey, the majority of the former Log Pond sediment surface is presently covered by more than 3 feet of cap/habitat restoration material within the target capping area, tapering to zero along the perimeter, consistent with the Agreed Order and associated remedial design (Anchor 2000). The cap/habitat layer is up to 10 feet thick within the interior of the project area (Figure 5).

The Year 2 bathymetric survey data collected at the Log Pond verify that the majority of capping materials placed at the Log Pond have not been eroded significantly by vessel propeller wash or storm wave forces. Moreover, the Year 2 thickness of the entire Log Pond cap/habitat is consistent with objectives set forth in the Agreed Order and associated remedial design (Anchor 2000). Periodic disturbances of the cap/habitat surface from variable storm conditions, resulting in dynamic beach equilibrium, are expected to continue to result in disturbances of the mudflat surface. These changes, which are characteristic of such normally dynamic systems, are predicted to be relatively minor, and will be monitored by performing bathymetric surveys during Years 5 and 10, as set forth in the OMMP.

In part to further stabilize the existing embankment and minimize future erosion, G-P is currently evaluating an integrated shoreline stabilization/habitat enhancement for appropriate sections of the Log Pond. These enhancements, which might include further development of existing habitat functions within the Log Pond by softening the existing shoreline, will be developed in coordination with the cleanup/redevelopment study of the adjacent former Chlor-Alkali Facility uplands, currently being performed under a separate Agreed Order between G-P and Ecology (see Section 4).

4 UPLAND SOURCE CONTROL MONITORING - WELL POINT WATER QUALITY

During remedial design, primary seepage pathways to the Log Pond shoreline were sampled using monitoring wells and shoreline well points (Anchor 2000). These sampling data were evaluated to ensure that water and sediment quality within the Log Pond would be protected following completion of the interim remedial action. Pre-project discharges to the Log Pond were found to be protective of water and sediment quality conditions.

Under the terms of a separate 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 providing data, analyses, and engineering evaluations to develop and evaluate a set of feasible remediation alternatives for the Chlor-Alkali Facility uplands (including soil and groundwater) that will meet environmental standards set forth in MTCA, including protection of the Log Pond, and support site redevelopment plans. This work led to the 2001 implementation of additional upland source controls, including reduction of infiltration through paving, to further reduce mercury loading and provide additional protection of the Log Pond. Further upland and shoreline remediation actions are being evaluated. Additional habitat restoration actions within the Log Pond shoreline area (e.g., near riprap and bulkhead structures) are also being developed.

The MTCA 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 were used during the Year 2 monitoring to evaluate compliance with this criterion. As summarized in the Agreed Order and associated remedial design (Anchor 2000), the applicable surface water quality standards for mercury are:

- Acute criterion (1-hour average concentration) – 1.8 ug/L
- Chronic criterion (48-hour average concentration) – 0.025 ug/L

The objectives of long-term well point water quality monitoring at the Log Pond were to verify compliance of seepage discharges with State Surface Water Quality Standards, and to verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.

Well point samples collected during Year 1 monitoring were similar to or lower than pre-construction baseline concentrations (Anchor 2001b). Year 1 water quality monitoring data collected at the Log Pond indicated compliance of seepage discharges with State Surface Water Quality Standards and also verified remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.

This section discusses the collection activities, sample analyses, data quality assessment, and results of the Year 2 well point monitoring.

4.1 Well Point Sampling Activities

Water quality monitoring was conducted on May 15, 2002, at two well point locations (WP-1 and WP-2) within the Log Pond, in accordance with the OMMP. Well point sampling locations are depicted in Figure 6 and station coordinates are provided in Table 1. Both of the well points were positioned at the margins of the cap. Water samples were collected with a 1-foot-long temporary screen placed within the cap section immediately above the pre-cap sediment surface. Well point field logs are presented in Appendix A.

The sampling event coincided with typical maximum seasonal groundwater discharge conditions, and also with a spring tide event characterized by a relatively large daily tidal variation. The well point samples were collected just before and after low tide (WP-1 and WP-2, respectively), in order to characterize minimum tidal dilution conditions. Tide levels were –1.7 feet and –1.9 feet mean lower low water (MLLW) at WP-1 and WP-2, respectively, at the time of sampling. Thus, water samples collected from the well points are generally representative of daily maximum seepage concentrations discharging into the Log Pond, comparable to the acute water quality criterion discussed above. Because of tidal dilution during flood tides, 48-hour average concentrations at the well point locations (comparable to a chronic exposure condition) are much lower (see below).

Sample collection necessitated two minor deviations from the OMMP:

- Well point station WP-2 was sampled in the same location as sampled in Year 1 (2001). This location is approximately 100 feet north of the location proposed in the OMMP. This adjustment was necessary because the original site did not exhibit discernable seepage. In Years 1 and 2, the WP-2 sample location was positioned within a visible seep, and is more representative of local discharges.

- As in Year 1, a hand-auger and sand pack were not needed for the installation of well points during Year 2 monitoring. Site conditions were suitable for direct installation of the well points. That is, the well points were pushed in by hand. Turbidity measurements indicated that water of suitably low turbidity (less than 50 nephelometric turbidity units) was withdrawn from the well points within a minute of the start of sampling/pumping activities.

4.2 Field Quality Assurance Sampling

One filter blank for dissolved mercury analysis was submitted to the laboratory with the well point samples. The purpose of the filter blank was to assess the degree to which dissolved mercury was added or removed during field operations such as equipment decontamination procedures. The equipment decontamination procedures were successful, as evidenced by an acceptably low dissolved mercury concentration (0.0015 ug/L) detected in the filter blank.

4.3 Well Point Chemical Analyses

Two well point samples, one each from WP-1 and WP-2, were submitted to Frontier Geosciences, Inc., for low-level total and dissolved mercury and total suspended solids in accordance with analytical methods identified in the OMMP. The overall data quality objectives for collection and chemical testing of well point samples were met, as set forth in the OMMP. All data for this project are considered acceptable for use; however, total suspended solid results are considered estimates because the holding time was exceeded by two days. Laboratory and data validation reports for well point chemical determinations are presented in Appendices B and C, respectively.

4.4 Well Point Water Quality Results and Discussion

As discussed in the Engineering Design Report (Anchor 2000), dissolved mercury concentrations are more representative of mercury available for transport than total mercury concentrations. Year 2 dissolved mercury concentrations at WP-1 and WP-2 were 0.0721 ug/L and undetected at 0.0026 ug/L, respectively (Table 2). The Year 2 dissolved mercury concentrations at both stations were well below the acute (1.8 ug/L) water quality standards for mercury; however, the chronic water quality standard for mercury (0.025 ug/L) was exceeded at station WP-1. In Year 1, dissolved mercury concentrations at WP-1 and WP-2 were 0.0059 ug/L and 0.0074 ug/L, respectively (Anchor 2001b). Dissolved mercury concentrations at WP-1 increased from Year 1 to Year 2, but decreased at WP-2.

Total mercury concentrations detected at stations WP-1 and WP-2 were 0.1550 ug/L and 0.0313 ug/L, respectively. In Year 1, total mercury concentrations at WP-1 and WP-2 were 0.0579 ug/L and 0.0304 ug/L, respectively (Anchor 2001b). Thus, total mercury concentrations at WP-1 increased from Year 1 to Year 2, but remained relatively constant and low at station WP-2.

Although mercury concentrations detected at WP-1 and WP-2 remain somewhat greater than the 0.025 ug/L chronic (48-hour-average) water quality criterion, the well point data are representative of minimum tidal dilution conditions, and overestimate the average concentration that would be comparable to the chronic criterion, as outlined above. Based on screening-level tidal dilution modeling and tidal series monitoring performed at other similar shoreline sites within the Whatcom Waterway area (Anchor and Aspect 2001; ReTec 2001; Anchor 2002), 48-hour tidally-averaged seepage concentrations are expected to be at least six times lower than peak (i.e., low tide) seep discharge concentrations. Based on this comparison, compliance with water quality and sediment protection criteria set forth in the Engineering Design Report is indicated. However, as discussed above, G-P is currently evaluating further upland and shoreline remediation actions, along with concurrent habitat restoration actions within the Log Pond shoreline area (e.g., near riprap and bulkhead structures) as part of the ongoing RI/FS of the former G-P Chlor-Alkali Facility. These pending future actions will provide for further source controls and additional protection of the Log Pond shoreline area.

As set forth in the OMMP, well point monitoring will continue during Years 5 and 10 to document attainment and maintenance of surface water quality protection objectives within the nearshore seepage zone of the cap. As appropriate, the Year 5 monitoring report will include a statistical evaluation of mercury concentration trends, and a detailed evaluation of compliance with applicable water quality standards.

5 CAP SEDIMENT QUALITY MONITORING

As set forth in the OMMP, sampling of surface sediments at four Whatcom Waterway RI/FS locations and in two shoreline seepage zones (near WP-1 and WP-2) are used to determine compliance with SMS criteria. 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 centimeters (cm) of sediment (Anchor and Hart Crowser 2000). Applicable SQS chemical and optional confirmatory biological testing criteria for surface sediments are set forth in the Agreed Order and associated Engineering Design Report (Anchor 2000).

Year 1 sediment chemistry sampling verified that surface sediment chemical concentrations were well below SQS chemical criteria immediately following construction of the Log Pond cap/habitat restoration action. These data also indicated that the capping method successfully minimized mixing of underlying contaminated sediments into the bottom of the clean cap, and verified that chemicals were not migrating vertically into the cap/habitat layer. As set forth in the OMMP, no subsurface sediment sampling was necessary during the Year 2 monitoring.

This section discusses the collection activities, sample analyses, data quality assessment, and results associated with the Year 2 sediment samples collected as part of the OMMP. Sample collection logs for surface sediments are provided in Appendix D.

5.1 Surface Sediment Sampling Activities

Surface sediment samples from the 0 to 12-cm biologically mixed surface layer were collected at six locations within the G-P Log Pond on May 15, 2002, in accordance with the OMMP. Surface sediment sampling locations are depicted in Figure 6 and station coordinates are provided in Table 1.

5.2 Field Quality Assurance Sampling

One equipment rinsate blank and one field blank were submitted to the laboratory with the surface sediment samples for chemical analyses. The purpose of the equipment rinsate and field blanks was to assess the degree to which a parameter of interest was added or removed during field operations such as equipment decontamination procedures. The equipment rinsate blank was prepared by pouring distilled water over the decontaminated sampling and compositing equipment into an appropriate sample jar. The field blank was collected by pouring distilled water directly from its container into an appropriate sample jar. The rinsate and field blanks were analyzed for total mercury and extractable organic compounds. No compounds or analytes were detected in the equipment rinsate or field blanks; however, the equipment rinsate blank data were qualified as undetected with estimated reporting limits due to the extraction holding time having been exceeded (see Data Validation Report in Appendix C).

5.3 Surface Sediment Chemical/Physical Analyses

Surface sediment samples were submitted to Analytical Resources, Inc. (ARI) for chemical and physical testing in accordance with Puget Sound Estuary Program (PSEP) protocols (PSEP 1997) as specified in the OMMP.

The overall data quality objectives for collection and chemical testing of sediment samples were met, as set forth in the OMMP. All data for this project are considered acceptable for use as qualified. The data validation report is presented in Appendix C of this report.

5.4 Sediment Quality Results and Discussion

In accordance with the OMMP, all sediment chemistry data were compared to the Washington State SQS chemical criteria. The sediment chemistry results along with SQS chemical criteria are provided in Table 3.

Total mercury and miscellaneous extractable organic chemical concentrations in all surface sediment samples collected within the cap/habitat layer were well below SQS chemical criteria. Consistent with the Year 1 monitoring results, no extractable organic chemicals were detected in the Year 2 surface sediment monitoring samples. Between Year 1 and Year 2, mercury concentrations increased marginally at five of the six surface sediment stations, consistent with the deposition of regional sediments (with slightly higher mercury concentrations) on the Log Pond surface (see Anchor 2000). However, mercury concentrations remain well below the SQS chemical criterion on the Log Pond surface.

As set forth in the OMMP, surface sediment monitoring within the Log Pond will continue during Years 5 and 10 to document the effectiveness of the cap/habitat restoration action in achieving and maintaining SMS criteria. Sampling will be coordinated with benthic macroinvertebrate sampling activities (see Section 6). In addition, during Years 5 and 10, sediment cores will be collected at representative locations within the Log Pond to verify the predicted lack of upward migration of mercury through the cap, verified by the results of both the Year 1 and Year 2 sediment monitoring.

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 could be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

6 BIOLOGICAL MONITORING

The integrated remediation and habitat restoration action at the Log Pond was designed to improve the overall quality and function of aquatic habitat in this area. Significant long-term habitat functional benefits anticipated by this action include:

- Increased epibenthic and benthic macroinvertebrate production
- Increased and enhanced rearing area for juvenile salmonids and other resources
- Enhanced migratory corridor and habitat connectivity

Although the MTCA process does not require evaluation of this habitat restoration action, biological monitoring has been incorporated in the OMMP because of the integrated nature of the project. The habitat monitoring plan described in the OMMP (Anchor 2000) was designed to allow verification of predicted habitat function improvements, particularly relative to epibenthic and benthic infauna production. Tissue monitoring was also performed 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. Year 2 biological monitoring was performed in accordance with the OMMP.

As discussed in the Whatcom Waterway Site RI/FS (Anchor and Hart Crowser 2000), mercury has been observed to bioaccumulate in certain site fish and shellfish populations, particularly Dungeness crab. As with other fish and shellfish species, mercury concentrations in Dungeness crab muscle tissue are highest in older crab individuals, consistent with age-dependent bioaccumulation of mercury. However, even the maximum adult tissue concentrations reported in this area were below conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood.

6.1 Epibenthic and Benthic Re-colonization

Using methods described in the OMMP, benthic and epibenthic re-colonization within the Log Pond was evaluated by Western Washington University's Huxley College of Environmental Studies. Huxley's benthic/epibenthic community report is included as Appendix E.

6.1.1 Epibenthic and Benthic Sampling Activities

Biological sampling included collection of triplicate epibenthic and benthic samples at three stations within the Log Pond (SS-74, SS-75, and SS-76; Figure 6), and two comparable reference stations in Chuckanut Bay (Bingham et al. 2002, attached as Appendix E). The Chuckanut Bay reference stations were selected to represent similar water depth, sediment grain size composition, sediment organic content, and exposure characteristics as the Log Pond stations; sampling data confirmed this match. Epibenthic and benthic sampling was conducted almost exactly one year after the Year 1 data were collected and therefore data can be directly compared between years without confounding seasonal effects. Year 2 epibenthic sampling occurred on May 14 and June 24, 2002. Benthic sampling was conducted on June 24, 2002.

6.1.2 Epibenthic and Benthic Sample Analysis

Benthic and epibenthic invertebrates were sorted and identified to the lowest taxonomic level. The dry weight biomass of each broad taxonomic group (e.g., nematodes, annelids, molluscs, crustaceans, and echinoderms) was also measured.

Statistical analyses of the macroinvertebrate samples included calculations of the total number of invertebrate species, the Shannon-Weiner diversity index, and Pielou's evenness index. Differences between the Log Pond and Chuckanut Bay data were evaluated using analysis of variance (ANOVA) and hierarchical cluster analyses. A p-value of 0.05 was used to evaluate statistical significance in all analyses.

6.1.3 Epibenthic and Benthic Re-colonization Results

No significant differences in either epibenthic or benthic biomass were observed between the Log Pond and the Chuckanut Bay reference area sites. However, a comparison of benthic biomass between stations revealed significantly higher biomass at Log Pond station SS-75 than all other sampling stations. A similar examination of epibenthic biomass data was not significant, although the data suggest that there may be a difference among Log Pond stations as SS-75 had higher biomass than the other two stations.

The examination of epibenthic community composition showed no clear site difference in the number of species between the Log Pond and Chuckanut Bay reference area samples, as many of the same species occurred at both sites. The data indicate significant increases in the number of species between the May and June sampling at both sites. Although these increases were observed at each station, the change in number of species between May and June was found to be significantly higher at the Chuckanut Bay reference area than the Log Pond.

In benthic sampling, there were no significant differences in the number of species between the Log Pond and Chuckanut Bay reference area. There were significant differences in diversity and evenness between sites, as both were slightly higher in the Chuckanut Bay reference area.

Cluster analysis results revealed that the structure of the epibenthic community was similar between the Log Pond and Chuckanut Bay. However, the epibenthic community at Log Pond station SS-76 appeared to be an outlier with exceptionally high numbers of nematodes and harpacticoid copepods. The structure of the benthic community was significantly different between the Log Pond and Chuckanut Bay reference area. The most striking pattern was the separation of SS-75 from all other stations due to the exceptionally high abundance of a polychaete (*Owenia fusiformis*) at the station. Observed differences between the Log Pond and Chuckanut Bay benthic communities were driven by differing abundances of polychaetes, crustaceans, and gastropods.

As described in more detail in Appendix E, the Year 2 benthic and epibenthic sampling data document the continuing development of a healthy invertebrate community within the Log Pond, consistent with early colonization documented during the Year 1 monitoring (Anchor 2001b). In accordance with the OMMP, benthic and epibenthic sampling will continue during Years 5 and 10 to provide information on long-term colonization of the macroinvertebrate communities in this area.

6.2 Bioaccumulation Monitoring

This section discusses the collection activities, sample analyses, data quality assessment, and results associated with the juvenile Dungeness crab bioaccumulation samples collected as part of the OMMP.

6.2.1 Juvenile Crab Sampling Activities

Juvenile Dungeness crab tissue mercury bioaccumulation sampling was conducted on July 22, 2002, at three locations (Stations SS-74, SS-75, and SS-76) within the Log Pond and two Chuckanut Bay reference stations in accordance with the OMMP. However, even after repeated attempts, no juvenile Dungeness crabs were retrieved in samplers deployed at the Chuckanut Bay reference area sampling. Following consultation with Pete Adolphson of Ecology and Mike MacKay of the Lummi Nation Natural Resources Department, alternate reference stations were established in west Bellingham Bay near Portage Island. These stations were sampled on August 21, 2002, resulting in the collection of three reference samples, which were then submitted to the testing laboratory. G-P Log Pond juvenile crab sampling locations are depicted in Figure 6 and station coordinates are provided in Table 1. Reference area locations are shown on Figure 1.

Sample collection and processing procedures for the juvenile crab sampling did not deviate from the OMMP except for the change in reference area location discussed above and the availability of three replicate samples from one reference station rather than two.

6.2.2 Juvenile Crab Sample Analysis

Three juvenile crab replicate samples from each of the three Log Pond sampling stations and the Portage Island reference area were submitted to Frontier Geosciences, Inc. for the analysis of total mercury. Each replicate was comprised of two to three juvenile crabs. The tissue samples were analyzed in accordance with the OMMP using Frontier's total mercury method FGS-011.

The overall data quality objectives for collection and chemical testing of the crab tissue samples were met, as set forth in the OMMP, except for the matrix duplicate relative percent difference for sample Ref-1 which was elevated at approximately 54 percent. The difference between the native sample and the sample duplicate is greater than can be explained by analytical variability and may indicate insufficient homogenization of the sample. Nevertheless, all data for this project are considered acceptable for use. The laboratory report for juvenile crab tissue bioaccumulation is provided in Appendix F.

6.2.3 Juvenile Crab Results

Juvenile Dungeness crabs ranging in carapace width (straight line distance across the carapace including the spines) from 60 to 83 millimeters (mm) were collected from the Portage Island reference area. Comparably-sized juvenile Dungeness crabs ranging in carapace width from 52 to 78 mm were collected from the Log Pond.

Whole-body total mercury concentrations in juvenile crab tissues (including carapace) collected from the Portage Island reference area ranged from approximately 0.02 to 0.31 milligrams per kilogram (mg/kg; wet weight basis; Table 4). By comparison, Year 2 whole-body total mercury concentrations measured in individual juvenile crab tissues collected from the Log Pond (two to three composited individuals) were at the low end of the reference area range, varying from approximately 0.01 to 0.03 mg/kg, averaging 0.020 mg/kg throughout the Log Pond area (Table 4). The average whole-body total mercury concentrations in juvenile crab tissues detected in Year 2 were also similar to pre-construction baseline levels (0.019 mg/kg) and levels measured during the Year 1 sampling (0.023 mg/kg). Juvenile Dungeness crab whole-body total mercury concentrations remain more than 10 times lower than conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood (Anchor and Hart Crowser 2000).

The relatively low concentrations of mercury detected in juvenile Dungeness crab whole-body tissue, relative to both regional reference values and risk-based benchmarks, further demonstrate the protectiveness of the cap in controlling bioaccumulation exposures and restoration of aquatic habitat. As set forth in the OMMP, bioaccumulation sampling will continue during Years 5 and 10, to document the continued effectiveness of the action.

6.3 Fish Utilization

Using methods described in the OMMP, juvenile salmonid utilization of the Log Pond was evaluated during the spring outmigration period. Scientific collection permits from the National Marine Fisheries Service (NMFS permit 1319), U.S. Fish and Wildlife Service (USFWS permit TE040557-0), and the Washington Department of Fish and Wildlife (WDFW permit 02-202) were obtained for this investigation.

6.3.1 Fish Sampling Activities

Beach seine sampling was conducted to investigate fish utilization of the Log Pond. Sampling was conducted at three stations within the Log Pond and two comparable reference stations in Chuckanut Bay. The Chuckanut Bay reference stations were near those used for the epibenthic and benthic sampling activities. Beach seine sampling was conducted May 22, June 26, and July 18 to monitor utilization during the juvenile salmonid outmigration period. Sampling was conducted during rising and high tide slack conditions.

6.3.2 Fish Sampling Analysis

Beach seine catches were identified to species and enumerated. Juvenile salmonids captured in the beach seine were identified to species, enumerated, and measured for forklength. Other fishes were identified to a practical taxonomic level and enumerated. All fish were released back into the water at their point of capture. Note that visual identification of juvenile salmonids to species can often be uncertain due to morphological changes that occur during transition to the estuary and initial nearshore rearing. Key features used to identify salmonids in freshwater become less apparent during this transitional phase, and ocean phase distinguishing features are also not well established. In particular, juvenile chinook and coho salmon can be difficult to distinguish.

6.3.3 Fish Sampling Results

Five salmonid species (chinook, coho, chum, pink, and steelhead) were collected in the Log Pond during the first sampling event in May (Table 5). All five species were found at more than one station at the site. Coho and pink salmon were the most numerous salmonids in the May Log Pond sampling with 71 and 41 captured, respectively. Sixteen chinook salmon were captured in May. All three of the “forage fish” species were collected in the Log Pond also. Pacific herring, surf smelt, and sand lance are denoted by NMFS and WDFW as forage fish due to their importance in the diet of salmonids.

Few salmonids were captured in the Log Pond during June and July. In June, five chinook and three coho salmon were captured in the Log Pond.

Catches in the Chuckanut Bay reference stations were slightly lower than those in the Log Pond, but exhibited a similar pattern between sampling periods. In May, salmonid catches and species diversity was highest. Catches and the number of species decreased as spring and summer progressed.

The Year 2 monitoring documented utilization of the Log Pond by juvenile salmonids during their spring outmigration. In combination with the healthy invertebrate community shown in the epibenthic and benthic sampling (see Section 6.1), these results indicate that the Log Pond provides relatively high functioning habitat along the migration corridor of Bellingham Bay.

As set forth in the OMMP, juvenile salmonid utilization of the Log Pond will continue in Years 5 and 10, to document the continued effectiveness of the restoration action. After the 5-year and 10-year monitoring periods, the biological monitoring 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.

6.4 Eelgrass Colonization

To document initial colonization of the Log Pond cap/habitat restoration surface by native eelgrass (*Zostera marina*), a reconnaissance survey was performed of the shoreline during low tide conditions on July 22, 2002. Water visibility was relatively clear during this period, and the tide receded to –1.9 feet MLLW during a morning low tide event. The survey covered approximately three-quarters of the Log Pond shoreline. GPS locations were noted where eelgrass colonization was observed.

Eleven very small patches (between two and ten shoots) of *Z. marina* were identified, as well as 27 isolated shoots. The eelgrass was found scattered along much of the shoreline surveyed (Figure 6). No non-native eelgrass (*Z. japonica*) was observed in the Log Pond.

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