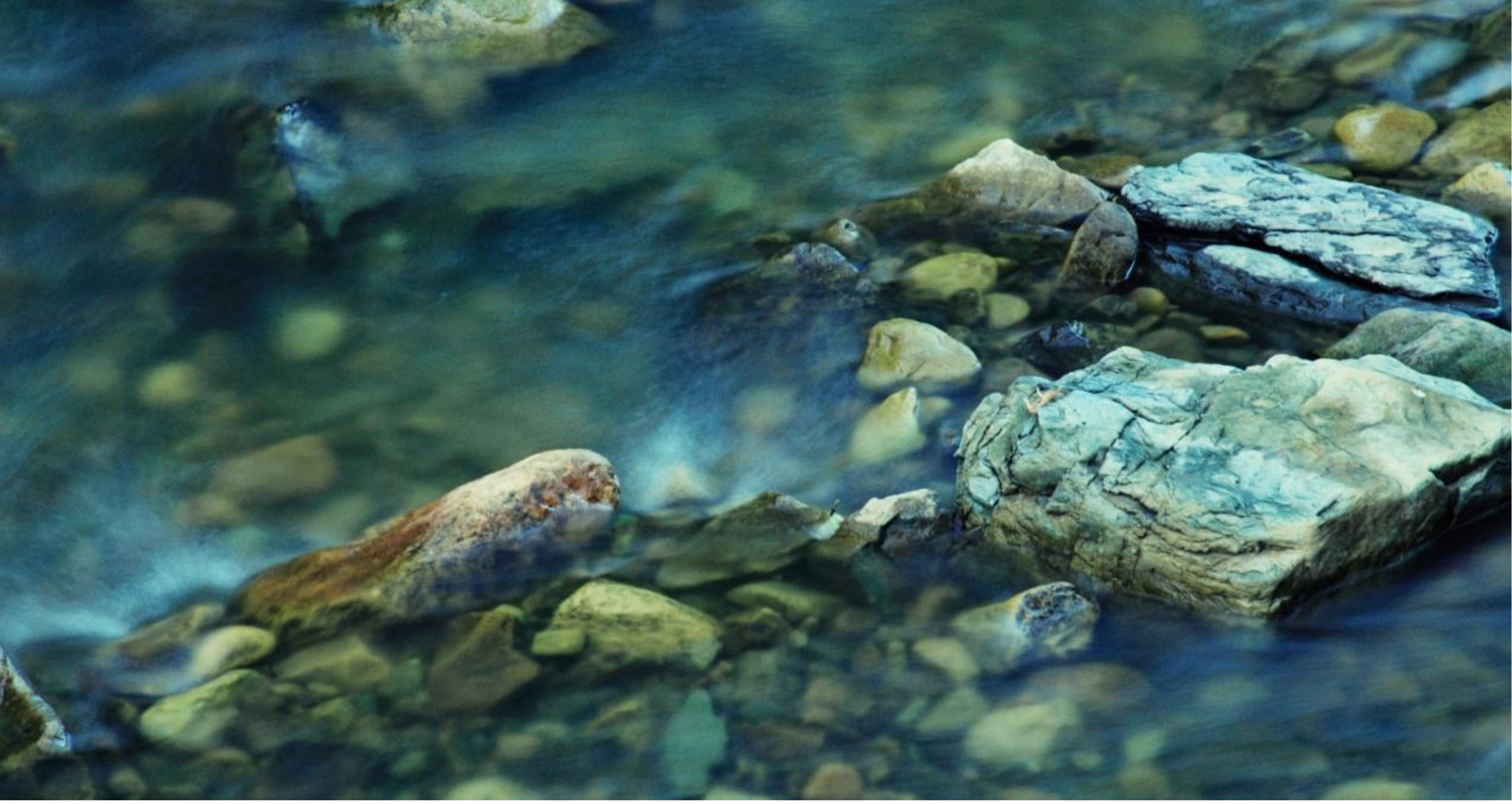

April 2019
Whatcom Waterway Cleanup in Phase 1 Site Areas

Year 1 Compliance Monitoring Report

Prepared for Port of Bellingham

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Whatcom Waterway Cleanup in Phase 1 Site Areas

Year 1 Compliance Monitoring Report

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ABBREVIATIONS

µg	microgram
ASB	Aerated Stabilization Basin
BSL	Bioaccumulation Screening Level
BST	Bellingham Shipping Terminal
cm	centimeter
D/F	dioxins/furans
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
GP West	Georgia-Pacific West, Inc.
L	liter
mg/kg	milligram per kilogram
MIG	mean individual growth rate
mL	milliliter
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
ng/kg	nanogram per kilogram
NMDS	nylon mesh diffusion sampler
Port	Port of Bellingham
Project	Whatcom Waterway Cleanup in Phase 1 Site Areas Project
PSEP	Puget Sound Estuary Program
RAU	remedial action unit
Report	Whatcom Waterway Year 1 Compliance Monitoring Report
RI/FS	Remedial Investigation and Feasibility Study
Site	Whatcom Waterway Site
SMS	Sediment Management Standards
SQAPP	Sampling and Quality Assurance Project Plan for Compliance Monitoring
SQS	sediment quality standards
TEQ	toxic equivalency quotient
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

GLOSSARY

Whatcom Waterway Site (Site)	The overall Model Toxics Control Act (MTCA) cleanup site addressed by the Whatcom Waterway Consent Decree. This area includes both Whatcom Waterway and adjacent aquatic lands impacted by historic mercury discharges from the former Georgia-Pacific chlor-alkali plant wastewater discharges. The Site includes both Phase 1 and Phase 2 cleanup areas and additional areas being addressed by monitored natural recovery.
Whatcom Waterway	The physical waterway extending from Roeder Avenue to deep water. Whatcom Waterway includes both the Inner Waterway and Outer Waterway areas.
Inner Waterway	The inner portion of Whatcom Waterway, extending from Roeder Avenue to the beginning of the federal navigation channel at Waterway Station 29+00. The Inner Waterway includes Site Units 2 and 3 of the Whatcom Waterway Site.
Outer Waterway	The outer portion of Whatcom Waterway, extending from Station 29+00 into deep water. The Outer Waterway includes Site Units 1A, 1B, and 1C of the Whatcom Waterway Site. The federal navigation channel that was updated in 2007 is located within the Outer Waterway.
Federal Navigation Channel	The Whatcom Waterway federal navigation project as currently authorized in existing Water Resources Development Act legislation. The authorized project includes a 30-foot deep navigation channel (plus applicable over-dredge allowances) extending from Station 29+00 of Whatcom Waterway into deep water. The Federal Navigation Channel is maintained by coordinated actions of the U.S. Army Corps of Engineers and the Port of Bellingham as the local sponsor.
Central Waterfront Site	The MTCA site located on certain properties between Whatcom Waterway and I&J Waterway. A Remedial Investigation and Feasibility Study (RI/FS) report for the Central Waterfront site has been completed under a MTCA Agreed Order.

GP West Site	The MTCA site located on upland property on the south side of Whatcom Waterway. The Georgia-Pacific West, Inc. (GP West) Site is divided into two remedial action units (RAUs), the Pulp and Tissue Mill RAU and the Chlor-Alkali RAU. The RAUs are in different stages of the cleanup process under MTCA.
Log Pond	Site Unit 4 of the Whatcom Waterway Site. The Log Pond is located between Whatcom Waterway and the GP West Site. The Log Pond was capped in 2001 as part of an Interim Action. Additional capping was completed as part of the Whatcom Waterway Phase 1 cleanup work.
Chlor-Alkali Remedial Action Unit	The Chlor-Alkali Remedial Action Unit comprises the western portion of the GP West Site adjacent to the Log Pond and Cornwall Avenue.
Pulp and Tissue Mill Remedial Action Unit	The Pulp and Tissue Mill Remedial Action Unit comprises the eastern portion of the GP West Site adjacent to Whatcom Waterway and Roeder Avenue.
Whatcom Waterway Cleanup in Phase 1 Site Areas (Project)	The construction and monitoring activities completed to implement the final cleanup of Phase 1 Areas of the Whatcom Waterway Site.
Phase 1 Site Areas	Whatcom Waterway Site Units 3B, 2A, 4, and portions of Units 1C and 2C. Cleanup of these units has been completed.
Phase 2 Site Areas	Whatcom Waterway Site Units 1A, 1B, 2B, and 8, and portions of Units 1C, 2C, 5B, 6B, and 6C. These areas will be cleaned up as part of a future phase of construction, consistent with the requirements of the First Amendment to the Whatcom Waterway Consent Decree.
Monitored Natural Recovery Areas (MNR Areas)	Whatcom Waterway Site Units 3A, 5A, 5C, 6A, 7, and 9, and portions of Units 5B, 6B, and 6C. Clean sediment is naturally accumulating in these areas and they are subject to long-term compliance monitoring requirements.

Central Waterfront Shoreline	The upland properties located between Whatcom Waterway and I&J Waterway and between Roeder Avenue and the aerated stabilization basin (wastewater treatment lagoon). The Central Waterfront Shoreline includes the properties within and outside of the Central Waterfront Site.
South Shoreline	The length of shoreline located along the GP West Site from the former GP West dock to the west end of the Central Avenue pier.

1 Introduction

This Compliance Monitoring Report (Report) summarizes Year 1 compliance monitoring activities performed by the Port of Bellingham (Port) as part of long-term monitoring for the Whatcom Waterway Cleanup in Phase 1 Site Areas (Project). Year 1 monitoring activities were performed between June 2017 and August 2017 in accordance with the Sampling and Quality Assurance Project Plan (SQAPP; Anchor QEA 2016) approved by the Washington State Department of Ecology (Ecology).

The Whatcom Waterway Site (Site) location and vicinity are shown in Figure 1. The Site includes sediments that have been impacted by mercury discharges from the former Georgia-Pacific West, Inc. (GP West) chlor-alkali plant. The Site boundary shown in Figure 1 was determined based on the extent of potentially significant surface and subsurface mercury contamination in sediments as determined during the Remedial Investigation and Feasibility Study (RI/FS; Anchor Environmental and Hart Crowser 2000) process and during subsequent pre-remedial design investigations conducted during 2008 (Anchor QEA 2010).

Other site-associated contaminants include wood waste and degradation products from historical log rafting activities and phenolic compounds from pulp mill wastewater discharges.

The Project included cleanup construction in the Inner Waterway area, the Log Pond, and the Bellingham Shipping Terminal (BST) area (Phase 1 site areas; Figure 2). Major activities included remedial dredging, engineered capping, containment wall installation, structure removal, structure replacement, and ancillary nearshore habitat improvements.

Project construction was completed in 2016 in accordance with requirements of the Ecology-approved Engineering Design Report (EDR; Anchor QEA 2015) and applicable permits and approvals. Details on completed construction activities and associated monitoring during the Project are documented in the As-built Report (Anchor QEA 2018). That report has been reviewed and approved by Ecology.

This cleanup action was performed in compliance with the requirements of the Model Toxics Control Act (MTCA) and Sediment Management Standards (SMS) regulations. Compliance monitoring requirements include monitoring during and after the cleanup action in Phase 1 site areas. The SQAPP (Anchor QEA 2016) describes the sampling and analysis plan for compliance monitoring conducted during and immediately following cleanup construction actions (performance monitoring) as well as long-term (compliance) monitoring at the Site. Compliance monitoring will be conducted in Years 1, 3, 5, 10, 20, and 30.

Results of Year 1 monitoring activities are described in this Report. The Year 1 monitoring activities included the following:

- Bathymetric surveys in cap areas
- Shoreline visual surveys in cap and containment wall areas
- Surface sediment monitoring within cap and natural recovery areas
- Subsurface sediment testing in natural recovery areas
- Monitoring of mercury in adult crab and juvenile crab tissue
- Monitoring of mercury in caged clams and testing of mercury in co-located porewater and sediments

2 Methods

Sample collection and processing for each program was conducted in according to field, laboratory, and quality assurance and quality control methods detailed in the SQAPP (Anchor QEA 2016). Site environmental monitoring stations are shown in Figure 3, and reference monitoring stations are shown in Figure 4.

2.1 Work Performed

The environmental monitoring data described in this report were collected between June 2017 and August 2017 in accordance with the SQAPP (Anchor QEA 2016) as approved by Ecology.

The sections of this report present the data collected during the following monitoring activities:

- Bathymetric surveys to evaluate the in-water extents of the engineered cap in Units 2A, 3B, and 4, and the capped transition area between Units 1C and 2C, and to document conditions in the natural recovery area at the head of Whatcom Waterway (Unit 3A)
- Visual surveys to document physical condition of the above-water portions of engineered sediment caps, and exposed portions of the Central Waterfront containment walls and Maple Street Bulkhead
- Collection and analysis of surface sediment at 11 locations within Phase 1 remediation areas and 11 monitored natural recovery (MNR) locations to document effectiveness of remediation
- Collection and analysis of subsurface mercury concentrations in sediment at 5 MNR locations to assess changes in thickness of clean sediment cover
- Testing of tissue mercury levels in adult Dungeness crabs (*Metacarcinus magister*) collected from the Site and from the Samish Bay clean reference area to evaluate changes over time
- Testing of tissue mercury levels in juvenile Dungeness crabs collected from the Log Pond and from a clean reference area to provide information on potential short-term impacts to the aquatic food chain from source control and dredging activities
- Testing of tissue mercury levels in caged clams, sediment, and porewater from locations within the Site and collection of corresponding data from the Samish Bay reference area to assess mercury bioavailability following
- Porewater monitoring in Unit 4 (Log Pond) to assess groundwater as a source of potential recontamination and evaluate protectiveness of marine aquatic species

2.2 Deviations from SQAPP

All activities and methods were performed as indicated in the SQAPP with the following deviations:

2.2.1 Juvenile Crab Tissue Monitoring

Juvenile crab tissue monitoring was added to Year 1 Monitoring based on conversations with Ecology. The goal of the additional testing was to determine if juvenile crab tissue mercury concentrations had recovered to background levels following completion of contingent source control actions in the Log Pond.

2.2.2 Clam Tissue Testing Duration

In situ clam tissue monitoring was conducted in accordance with the SQAPP and ASTM Method E2122 02. The target test duration was 30 days. The test duration was adjusted slightly to address logistical constraints. Reference site samples were retrieved in 27 or 28 days, and Site and MNR samples were retrieved in 28, 29, or 30 days.

3 Surveys

This section describes the results of bathymetric and visual surveys conducted in Phase 1 capping areas.

Several different cap types were constructed during the Project using varying combinations and thicknesses of sand, filter, and stone or cobble armoring materials. Engineered sediment caps were constructed both on dredged surfaces and on existing grade where no dredging occurred. Therefore, varying rates of consolidation of the engineered capping materials and settlement of underlying materials were anticipated at time of design and construction. The Year 1 physical surveys were conducted to monitor these different processes and evaluate the amount of settlement that has occurred since the Year-0 post-construction conditions. Bathymetric and visual surveys were conducted in parallel to monitor in-water and intertidal capping areas, respectively.

3.1 Bathymetric Survey

A multi-beam bathymetric survey was conducted to evaluate the in-water extent of the engineered cap in Units 2A, 3B, and 4, and the capped transition area between Units 1C and 2C. Collection of survey data was performed on August 10, 2017, by Northwest Hydro Inc. during high tide conditions to maximize survey coverage area.

Bathymetric survey activities were performed in accordance with the SQAPP (Anchor QEA 2016). After collection, survey data were then compared with post-construction survey data to verify physical integrity of capped areas. The 2017 Year 1 monitoring bathymetric survey data are described in detail in the following sections for the BST, Log Pond, and Inner Waterway areas.

3.1.1 Bellingham Shipping Terminal (Unit 1C)

An engineered sediment cap consisting of stone armor was constructed in the BST at the transition between Unit 1C and Unit 2C, as shown on Figure 5a. The cap is built mainly on dredged surface but was tied into the undredged portion of the channel located toward the head of Whatcom Waterway from the BST. Upon comparison with post-construction data, the current mudline in the majority of the engineered cap placement is not significantly different (from 0.5 foot higher to 0.5 foot lower) from the post-construction surface (Figure 5b).

Areas where the present-day mudline is between 0.5 foot and 1.0 foot lower than the post-construction mudline are indicative of consolidation of the underlying sediments due to the load from the engineering cap materials. Consolidation/settlement analyses were performed as part of the Whatcom Waterway Final EDR (Anchor QEA 2015). The observed values are consistent with estimated cap consolidation in other areas of the waterway.

3.1.2 Log Pond (Unit 4)

Engineered sediment caps were constructed in the Log Pond area to meet remediation goals. The Log Pond cap placed in 2001 encompasses the majority of Unit 4, as shown on Figure 6a. The stone armored cap was constructed on the existing surface (i.e., no dredging took place), and placed at varying thicknesses based on existing bathymetry.

Most of the bathymetric data collected in the Log Pond area is outside the extent of the caps placed as part of the Project, as shown in Figure 6b. The data that does lie within the cap placement boundary generally varies from 0.5 foot higher to 1.5 foot lower than the post-construction mudline, which is consistent with the values estimated in the EDR. Some larger elevation differences observed near the limits of the survey appear to be artifacts. These can be attributed to a lower density of data points leading to jumps in the survey surface. These areas, along with areas too shallow for completion of an in-water bathymetric survey, were addressed with the intertidal visual survey as described in Section 3.2.

The bathymetric survey coverage area covers a section of Unit 4 that was not capped as part of the Project but was capped during an interim action completed in 2001. The bathymetric data in this area show that, although there are some active dynamics causing small changes to the cap, no major scour or other disturbances have taken place between the Year 0 and Year 1 monitoring events.

During this timeframe, the weather station at the Bellingham International Airport recorded several significant wind events with peak wind gusts (5-second gusts) up to 63 miles per hour and sustained (reported as daily averages) winds up to 26 miles per hour. Rainfall during the period of October 2016 to April 2017 was reported as the tenth rainiest rainy season in 60 years at Bellingham International Airport, with 33.67 inches of precipitation including a significant snow event in early February 2017 (Mittendorf 2017a, 2017b).

3.1.3 Inner Waterway (Unit 2A/3B and a Portion of Unit 2C)

The Inner Waterway was capped using two different caps, as shown on Figure 7a. In general, the waterway and offshore areas were capped with cobble armor, while the shoreline areas (South Shoreline and Central Waterfront Shoreline) were capped with stone armor. Caps were constructed in areas where dredging occurred and areas where no dredging occurred. The dredging that occurred varied greatly, from very thin to very thick cuts, to meet remedial objectives. Because of these different factors, a wide range of consolidation and settlement was expected.

Differences in cap surface elevation between Year 0 and Year 1 monitoring events are shown on Figure 7b. Some of the general trends observed in the comparison of the post-construction survey with the Year 1 monitoring survey include the following:

- Some accretion of material is observed at the head of the waterway and is consistent with historical accumulation of material in this area due to loading from Whatcom Creek.
- Minimal settlement/consolidation has occurred in the flat portion of the Inner Waterway where dredge cuts were thickest. The thick dredge cuts exposed materials less prone to consolidation. More settlement was observed in the flat portion of the waterway where only thin cuts or no dredging was performed and cap materials were placed on existing softer sediments.
- A moderate amount of settlement and consolidation was observed along the shoreline slopes. The stone armored engineered cap was placed in these areas (South Shoreline and Central Waterfront Shoreline). Placement of this heavier material reasonably has resulted in more consolidation of the underlying capping materials and subgrade.

3.2 Visual Survey (Intertidal Shoreline Inspection)

A visual survey was conducted within the intertidal shoreline areas of the Inner Waterway and the Log Pond during periods of optimal low tide to document physical condition of the engineered sediment caps, and exposed portions of the Central Waterfront containment walls and Maple Street Bulkhead.

Intertidal engineered sediment caps were visually inspected during periods of low tide over a three-day duration (July 18–20, 2017). Inspections took place both by boat and on foot depending on access to the cap area, as shown on Figures 8a and 8b. Photomaps and corresponding photographs showing the general conditions of the above-water engineered caps are included in Appendix B.

Continuous inspections were conducted in cap areas to look for indications of erosion/settlement, presence of potential contamination/debris, or other disturbances or signs of impact to the integrity and function of the cap. Inspections in containment wall areas were conducted to look for indications of corrosion, groundwater seepage, and other disturbances or signs of impact to the integrity and function of the remedial wall structure. Any disturbance found was documented (i.e., location, description, apparent cause if known) and photographed.

3.2.1 Engineered Caps

In general, the engineered sediment caps along the Central Waterfront, South Shoreline, and Log Pond shoreline were found to be in good condition:

- There was no evidence of significant erosion, settlement, or debris accumulation.

- There were no signs of contamination or significant groundwater seepage observed during the survey. Some growth of algae and colonization by marine organisms (e.g., barnacles) were noted.
- At some of the Log Pond stations (Stations 21+25 to 21+75), sand was visible on top of the stone armored cap, indicating some movement of capping materials from the thicker Log Pond cap and habitat restoration areas located offshore of the shoreline armoring. Some movement of this type was anticipated as part of the design.

3.2.2 Containment Walls

The Central Waterfront and Maple Street Bulkhead containment walls were inspected during the visual survey. This included a survey of the Central Waterfront containment wall on July 20, 2017, and surveys of the Maple Street Bulkhead containment wall on October 4 and November 29, 2017. The Maple Street Bulkhead containment wall surveys occurred on separate dates because barges blocked access.

Both containment walls were observed to be in good condition with no signs of corrosion or other disturbances.

In addition to a visual survey of the walls, Norton Corrosion performed an inspection of the Maple Street Bulkhead cathodic protection system. The inspection by Norton Corrosion confirmed that the Maple Street Bulkhead containment wall is receiving adequate protection, consistent with their design recommendations. No corrective actions were recommended.

During construction of the Maple Street Bulkhead containment wall, wall obstructions and hard-driving conditions were encountered. This resulted in damage to the joint sealant and groundwater seepage from portions of the wall. The damaged joints were repaired through diver-assisted welding and application of sealant to the exterior of the wall, and placement of sealant at tie-back locations. These repairs were performed both during construction and as part of a second welding/sealing event that was conducted during July 2017 in parallel with Year 1 monitoring. In follow-up surveys performed on October 4 and November 29, seeps from wall joints had been terminated, but several small areas of seepage were observed at tie-back penetrations of the wall. These seepage areas are to be addressed by the Port as described in Section 7.

4 Sediment Testing

This section describes surface and subsurface sediment testing conducted during Year 1 compliance monitoring activities. Sample locations described in this section are shown in Figure 3 (Site locations) and Figure 4 (reference area locations).

4.1 Surface Sediment Quality

Surface sediment monitoring included the following sample locations:

- 8 locations in Phase 1 capping areas
- 1 location in Log Pond areas previously capped
- 2 locations within Phase 1 dredging areas of the Outer Waterway
- 11 locations within MNR areas
- 5 reference locations in Samish Bay

4.1.1 Sediment Distribution in Cap Areas

Within the Phase 1 cap placement areas, insufficient sediment had deposited since construction to allow for chemical testing. Photographs of the material encountered at these sample stations are included in Appendix F.

Based on the absence of accumulated sediment, no chemical or biological testing was performed at these eight locations. Sediment testing will be performed at these locations in the future once sufficient sediment has accumulated to support that testing.

4.1.2 Surface Sediment Mercury Concentrations

Chemical testing was performed in compliance with the SQAPP at 14 stations at which sediment was available for testing. These samples were tested for a wide range of potential contaminants consistent with the SQAPP (Anchor QEA 2016).

Table 1 summarizes the chemical testing data. Other than mercury, there were no exceedances of the site cleanup levels at any locations tested.

Figure 9 illustrates the mercury concentrations detected in surface sediment:

- At all 14 testing stations, measured mercury concentrations were below the site cleanup level for protection of human health and ecological receptors (1.2 milligrams per kilogram [mg/kg]).
- At 10 of 14 testing stations, measured mercury concentrations were below the site cleanup level for protection of benthic organisms (0.41 mg/kg), with concentrations ranging from 0.04 to 0.38 mg/kg. These locations included the Phase 1 dredging areas and most of the MNR areas.

- At four testing stations, measured mercury concentrations exceeded the numeric site cleanup level for protection of benthic organisms (0.41 mg/kg).
  - One location in the Log Pond near the former GP West dock had mercury concentrations of 0.6 mg/kg. The measured concentration was similar to results detected between 2001 and 2005.
  - Three locations in MNR areas located offshore of the Aerated Stabilization Basin (ASB) had mercury concentrations of 0.44, 0.69, and 1.18 mg/kg. These measured concentrations were similar to those reported during testing events in 2002.
- Sediment from these four testing stations was subject to confirmational bioassay testing consistent with the SQAPP (see Section 4.1.3 below). All samples passed biological testing.

Results demonstrate that mercury concentrations comply with site cleanup levels established in the Consent Decree for protection of benthic organisms and protection of human health and ecological receptors (Ecology 2011).

In addition to demonstrating compliance with the requirements of the Consent Decree, the monitoring data for surface sediment show that the site-wide concentrations of mercury continue to decrease and are approaching natural background levels. The natural background concentration for mercury in Puget Sound sediments has been established by Ecology as 0.20 mg/kg (Ecology 2017). Concentrations of mercury within the Site currently average 0.24 mg/kg (expressed as the surface weighted average concentration). Ongoing natural recovery processes and the future cleanup of Phase 2 areas of the Site will further reduce site-wide surface sediment concentrations of mercury.

4.1.3 Confirmational Bioassay Testing

Confirmational bioassay testing was performed on four surface sediment samples that contained mercury concentrations in excess of the 0.41 mg/kg site cleanup level. This testing was performed by Ramboll Environ in Port Gamble, Washington.

Testing included two acute toxicity tests (the 10-day amphipod survival test and the 96-hour larval echinoderm survival and development test) and one chronic toxicity test (20-day polychaete survival and growth test). The 20-day juvenile polychaete and the 96-hour echinoderm tests were initiated on August 25 and 30, 2017, respectively, within the 56-day holding time. The 10-day amphipod test was initiated on August 30, 2017; however, this test failed due to poor animal health observed in the control treatment. The test was re-run on September 15, 10 days outside of the recommended hold time, and met performance criteria. Given these results concur with the two other bioassay tests, and that all other performance criteria were met, results from the re-run test were determined to be suitable for making management decisions.

The four sediment samples were tested against clean reference samples collected by Ramboll Environ from Carr Inlet. Test methods followed guidance provided by the Puget Sound Estuary Program (PSEP 1995), the Sediment Cleanup User's Manual II (Ecology 2017), and the various updates presented during the Sediment Management Annual Review Meeting. The following describes the tests and species used, along with key observations from data validation.

- **10-day amphipod mortality (Eohaustorius estuaries)**

  Water quality conditions were maintained to ensure optimal health of the organisms and were within acceptable limits throughout the testing duration. Temperature, dissolved oxygen, salinity, and pH from one replicate per treatment were monitored daily. Additionally, ammonia and sulfide concentrations were measured in both porewater and overlying water at the beginning and termination of testing. Concentrations were below trigger values, indicating mortality due to ammonia and/or sulfide was unlikely. The test met the survival acceptability criteria specified in the test protocol with 9% mean mortality in the control and 12% and 14% mean mortality for reference samples CR-022 and CR-023, respectively. The reference toxicant test was conducted using total ammonia, resulting in median lethal concentration (LC50) of 46.2 milligrams per liter (mg/L), and was within the laboratory acceptability range of 13.8 to 88.1 mg/L. Despite the test re-run slightly outside of recommended hold time, it met performance criteria. No problems were found with the test organisms or the testing procedure, and it was concluded that the test developed fully acceptable data for use in management decisions.

- **96-hour benthic larval development (Dendraster excentricus)**

  The test organisms were collected by EcoAnalysts personnel along the northern Hood Canal in Washington State. Testing was initiated on August 30, 2017, within the appropriate holding time. Water quality conditions were maintained to ensure optimal health of the organisms and were within acceptable limits throughout the testing duration. Temperature, dissolved oxygen, salinity, and pH from one replicate per treatment were monitored daily. Water quality parameters were within protocol-specified ranges except for temperature, where the mean measurement for all treatments was 16.1, slightly above the 15 ± 1°C target temperature. Additionally, ammonia and sulfide concentrations were measured in overlying water at the beginning and termination of testing. Concentrations were below trigger values, indicating mortality due to ammonia and/or sulfide was unlikely. The test met the survival acceptability criteria specified in the test protocol with 84.0% and 88.4% normal survivorship in the seawater and sediment controls, respectively. Reference sediment also met acceptability criteria, with mean normal survival between 78.2% and 83.1%. The reference toxicant test was conducted using total ammonia, resulting in median lethal concentration (LC50) of 2.95 mg/L, and was within the laboratory acceptability range of 0.57 to 5.41 mg/L.

No problems were found with the test organisms or the testing procedure, and it was concluded that the test developed fully acceptable data for use in management decisions.

- **20-day juvenile polychaete survival and growth (Neanthes arenaceodentata)**

  The test organisms were obtained from Aquatic Toxicology Support, Bremerton, Washington. Testing was initiated on August 25, 2017, within the appropriate holding time. Water quality conditions were maintained to ensure optimal health of the organisms and were within acceptable limits throughout the testing duration. Temperature, dissolved oxygen, salinity, and pH, from one replicate per treatment were monitored daily. Additionally, ammonia and sulfide concentrations were measured in both porewater and overlying water at the beginning and termination of testing. Concentrations were below trigger values, indicating mortality due to ammonia and/or sulfide was unlikely. The test met the acceptability criteria specified in the test protocol. No mortality was observed in the control treatment, and mean individual growth rates (MIG) as dry weight and ash free dry weight were 0.660 and 0.404 mg/individual/day, respectively. Mean mortality in reference treatments were 0% for CR-022 and 8% for CR-023. MIGs as dry weight were 0.685 and 0.691 mg/individual/day, respectively, and MIGs as ash free dry weight were 0.532 and 0.498 mg/individual/day, respectively. The reference toxicant test was conducted using total ammonia, resulting in median lethal concentration (LC50) of 172.2 mg/L, and was within the laboratory acceptability range of 90.1 to 237.5 mg/L. No problems were found with the test organisms or the testing procedure, and it was concluded that the test developed fully acceptable data for use in management decisions. For additional details regarding bioassay testing, refer to Appendix E.

4.1.4 Surface Sediment Dioxin/Furan Concentrations

Dioxins/furans (D/F) are known to be present in surface and subsurface sediments throughout most of Bellingham Bay and other urban bays within Puget Sound. The full range of sources for these compounds in Bellingham Bay has not yet been determined but may include contributions from many sources throughout the bay, including former combustion sources, former GP pulp and paper mill operations, former wood-treating facilities, historic and ongoing stormwater and wastewater discharges, and atmospheric deposition.

Since execution of the First Amendment to the Consent Decree, Ecology conducted work to determine if regional background concentrations of certain bioaccumulative chemicals existed in Bellingham Bay (Ecology 2015). That work identified a regional background D/F concentration of 15 nanograms per kilogram toxic equivalency quotient (ng/kg TEQ).

Chemical testing for D/F was performed at seven locations. These included the following:

- Five MNR locations located offshore of the ASB and Outer Waterway areas

- One location within the Phase 1 dredging area of the Outer Waterway, adjacent to BST
- One MNR location located at the head of the Inner Waterway, adjacent to Roeder Avenue

Three locations within the Phase 1 capping areas had been designated in the SQAPP for D/F testing. However, insufficient sediment accumulation had occurred at these locations to support sediment chemical testing (see Section 4.1.1).

D/F concentrations within the five MNR areas and the Phase 1 dredging area were compared to the regional background concentration in Bellingham Bay, defined by the 2015 Ecology study of Bellingham Bay (Ecology 2015). Six samples were below the regional background concentration. A higher concentration was noted at MNR station WW-MNR-11, located in between the Phase 1 capping areas and Roeder Avenue. A specific source for the elevated D/F concentration at this location is not known. However, this location will continue to be evaluated as part of long-term monitoring.

An estimated surface weighted average concentration (SWAC) of D/F concentrations was developed based on Year 1 monitoring data and recent data collected as part of investigations at the I&J Waterway Site and the RG Haley site. That result was 9 ng/kg TEQ, which is well below the regional background concentration of 15 ng/kg TEQ.

Results of monitoring demonstrate that SWAC-based D/F concentrations are below regional background levels. Ongoing reductions are expected from natural recovery processes and implementation of planned cleanup actions at numerous waterfront contaminated sediment sites, including Phase 2 areas of the Whatcom Waterway site.

4.2 Subsurface Sediment

Subsurface sediment was collected and analyzed in MNR areas during the Year 1 monitoring event. That testing was intended to measure changes (accumulations) in the thickness of clean sediment cover overlying subsurface sediment buried safely at depth and containing elevated mercury concentrations.

Compliance monitoring included the collection of subsurface sediment cores at five stations. These stations were co-located with MNR surface sediment monitoring (Figure 3). Subsurface sediment monitoring included the following sample locations within the MNR areas:

- Four locations in Unit 9 (WW-MNR-02, WW-MNR-03, WW-MNR-04, and WW-MNR-08)
- One location in Unit 5a (WW-MNR-07)

Sediment was collected from the mudline to 3 feet below the sediment water interface, and subsampled in 0.5-foot sections. These subsamples were tested for mercury and total solids consistent with the SQAPP (Anchor QEA 2016). Estimated sedimentation rates in inner Bellingham

Bay indicate that mercury and other contaminants are subject to relatively rapid burial (expected average sediment accumulation rates of 16 centimeters (cm) over a 10-year period) and thus isolation from the overlying water column and marine organisms (Anchor Environmental and Hart Crowser 2000).

Figure 11 shows the results of subsurface sediment testing performed during the Year 1 monitoring event. Significant observations from that testing include the following:

- Stations WW-MNR-04 and WW-MNR-07 located on the shoulder of the ASB had the thinnest layer of cleaner sediments. Sediments exceeding the BSL are covered by at least 12 inches (30.5 cm) of cleaner sediments at these locations. However, this shows a significant accumulation of cleaner sediment accumulation in comparison to natural recovery cores tested in 1997. At that time, the natural recovery core located on the shoulder of the ASB (station HC-NR-101: Hart Crowser and Anchor 2000) contained exceedances of the BSL (1.2 mg/kg) in the surface intervals. Now those sediments are covered by over 30 cm of cleaner material.
- Station WW-MNR-08 located near the Cornwall Avenue Landfill had the thickest layer of cleaner sediments. Sediments exceeding the BSL are covered by 30 inches (76.2 cm) of cleaner sediment at this location. This is more than double the thickness of cleaner sediment that had been observed during 1997 natural recovery studies.
- Stations WW-MNR-02 and WW-MNR-03 located in outer Site areas had intermediate thicknesses of cleaner sediments. Sediment exceeding the BSL are covered by at least 18 inches (45.7 cm) of cleaner sediments at these locations. There were no directly comparable natural recovery cores analyzed in 1997 in these two Site areas.

Results demonstrate continued accumulation of clean sediments throughout the MNR areas, consistent with cleanup expectations and historically measured sedimentation rates and natural recovery modeling. Measured mercury concentrations were lower in surface intervals than in deeper subsurface intervals at all five testing locations.

Consistent with the SQAPP, additional subsurface sediment monitoring will be performed in future years to document ongoing natural recovery of Bellingham Bay sediments.

5 Seafood Tissue Monitoring

This section describes post-construction tissue monitoring performed in accordance with the SQAPP (Anchor QEA 2016). This monitoring was conducted during June and July 2017 and included the following activities:

- Testing of tissue mercury levels in adult Dungeness crabs (*Metacarcinus magister*) collected from the Site and from the Samish Bay clean reference area
- Testing of tissue mercury levels in juvenile Dungeness crabs collected from the Log Pond and from a clean reference area within Bellingham Bay
- Testing of tissue mercury levels in caged clams, sediment, and porewater from multiple locations within the Site, and collection of corresponding data from the Samish Bay reference area

Locations of samples described in this section are presented in Figure 3 (Site samples) and Figure 4 (reference area samples).

5.1 Adult Dungeness Crab

Adult crab were collected using crab traps deployed at three locations within the Site (Figure 3) and at two locations within the Samish Bay reference areas (Figure 4). Three adult male Dungeness crabs with a carapace width of 16.5 cm or greater were collected at each station. Two replicate samples for each station were created by homogenizing sternal plate, leg, and claw muscle tissue, resulting in a total of six composite samples from the Site and six composite samples from the Samish Bay reference area.

Adult Dungeness crabs utilize a large home range (estimated at approximately 10 square kilometers, which is larger than the Site). Therefore, the adult Dungeness crab collected at any one station within the Site are representative of the overall Site, not the individual sampling station. Similarly, the adult crab collected at either of the Samish Bay reference areas are representative of the overall reference area and not the individual sampling station.

Table 5 and Figure 12 summarize the tissue monitoring data collected for adult crab for both the Site and the reference area stations.

- Tissue mercury levels detected in Site crab were well below those measured previously in 1991 and 1997 and were also lower than 2016 Compliance Monitoring concentrations.
- The tissue mercury concentrations from the Site remain well below the U.S. Environmental Protection Agency's (USEPA's) consumption guideline for seafood tissue (0.3 mg/kg wet weight), and they are more than 66% lower than the tissue concentration identified as protective of tribal seafood consumption (0.18 mg/kg wet weight) (Anchor Environmental and Hart Crowser 2000).

- Crab tissue mercury levels have been experiencing a steady decrease in concentrations, consistent with an exponential (first-order) rate of decrease. This is consistent with natural recovery modeling expectations.
- Tissue mercury concentrations remain slightly higher than those in crab collected from the Samish Bay reference area, with average mercury concentrations of 0.061 mg/kg wet weight compared to an average of 0.046 mg/kg wet weight at reference stations.

Because Site crab tissue mercury concentrations remain slightly higher than crab tissue collected from Samish Bay, adult crab tissue monitoring will continue as part of future monitoring events.

5.2 Juvenile Crab

Juvenile Dungeness crab were collected using crab traps deployed along the shoreline of the Log Pond (Figure 3) and at a reference site located near Brant and Portage Islands (Figure 4). Juvenile crab tissue from these locations was previously sampled for mercury concentrations during 2001, 2002, and 2005 after completion of the Log Pond Interim Action, as well as during Year 0 Monitoring (Anchor QEA 2018) immediately following implementation of the cleanup in Phase 1 Site areas.

At each location, crab were collected by baited ring traps. Five juvenile crabs were collected at each location and used to form two whole-body composite samples. Crab were collected using baited ring nets deployed from a vessel. Juvenile Dungeness crabs ranged in carapace length from 5 to 9 cm, indicating that the individuals were between 1 and 2 years old (Pauley, Armstrong, and Heun 1986).

Five replicate samples from each composite were submitted to the chemical testing laboratory for analysis of total solids, lipids, and mercury concentrations (Table 5). The reference area was created from whole-body composites prior to analysis at the laboratory. Three replicates from each area were run as the tissue became available, while two composites were placed on hold. Testing in the final two composites was initiated on July 20, 2017, slightly outside target hold times (refer to Appendix D for data validation information).

Mercury concentration data for the juvenile crab are summarized in Table 7 and Figure 13:

- Juvenile crab tissue mercury levels are lower than Year 0 concentrations.
- Tissue mercury concentrations remain slightly higher than crab collected from the reference area, with average mercury concentration of 0.025 mg/kg wet weight compared to an average of 0.018 mg/kg wet weight at the reference station. This average reference station concentration was slightly lower than in previous years.

Because juvenile crab tissue mercury concentrations remain slightly higher than comparable tissue collected from the reference location, juvenile crab tissue monitoring will be repeated during the Year 3 monitoring event.

5.3 Caged Clam Tissue and Associated Testing

Year 1 monitoring activities included an in situ bioaccumulation testing using caged clams. As part of this testing, clams were placed in situ at the following locations (see Figures 3 and 4):

- Two Phase 1 Site cleanup areas
- Three Site MNR areas
- Five clean reference areas located in Samish Bay

Co-located testing of mercury in porewater and sediment was performed in parallel with the clam tissue testing.

Divers deployed three cages of clams at each of the five Site and five reference test stations during July of 2017. Clams (*Venerupis japonica*) were purchased from Taylor Shellfish in Bow, Washington, and placed into predator-exclusion cages. Three replicate cages (each containing 30 clams) were deployed at every station. Cages were buried 10 cm into the sediment surface and left in situ in accordance with ASTM Method E2122 02.

Following retrieval, clams were depurated for at least 14 hours. Soft body tissue samples were then composited from each cage separately and then an overall station composite was created for analysis. An additional 'time zero' sample was analyzed to document the mercury concentrations in clam tissues prior to deployment.

A set of nylon mesh diffusion samplers (NMDS) were also deployed at each test location to measure porewater mercury concentrations:

- The NMDS deployment methodology was consistent with methods used by the U.S. Geological Survey and U.S. Environmental Protection Agency (USGS and USEPA 2003).
- Nylon mesh diffusion samplers were constructed using 250-milliliter (mL) polypropylene jars fitted with 120-micron mesh and screw-on lids.
- Samplers were buried 10 cm into the sediment and left in situ to equilibrate.
- Nylon mesh diffusion samplers were retrieved between 6 and 8 days.
- Upon retrieval, porewater was extracted using a 60-mL disposable syringe and shipped to the laboratory for analysis. Porewater samples were analyzed for total and dissolved mercury.
- During retrieval, elevated turbidity levels were noted in the unfiltered porewater samples. The turbidity was absent in the filtered samples. Based on the observations of elevated turbidity, the unfiltered samples are not considered fit for quantitative use and should only be used qualitatively.

Surface sediment samples were also collected at each deployment area. These samples were tested for total solids, total organic carbon, and total mercury. These data allow results of tissue and porewater mercury measurements to be compared to total mercury concentrations in sediments.

Table 8 and Figures 14a, 14b, and 14c present the mercury concentrations reported in clam tissue, porewater, and sediment by area type and station:

- As indicated in Figure 14a, results of clam tissue testing showed no significant difference between any of the Site testing locations and the five reference locations.
  - Results demonstrate that the remediation in Phase 1 dredging and capping areas has been successful in preventing bioavailability to benthic organisms.
  - Likewise, results demonstrate that the mercury in monitored natural recovery areas is not bioavailable, despite differences in sediment total mercury concentrations (see Table 8).
- The lack of differences in clam tissue mercury concentrations is not surprising, given the absence of detectable dissolved mercury concentrations in sediment porewater at either the Site or reference area locations (see Figure 14b).
- The total mercury measurements (Figure 14c) are not suitable for quantitative use due to the presence of elevated turbidity in the unfiltered porewater samples. Qualitatively, some differences in total mercury concentrations were noted. But these differences were not reflected in either the dissolved mercury or the clam tissue concentrations.

6 Porewater Monitoring in Unit 4

Porewater monitoring was conducted at two nearshore stations in the Log Pond to assess groundwater as a source of potential sediment recontamination.

Porewater samples were collected from each of two sampling stations (see Figure 3). Samples were collected using NMDS samplers using the same methods as those used for co-located porewater during in situ clam bioaccumulation testing (Section 5.3):

- NMDS samplers were deployed using a 120-micron mesh size.
- Samplers were retrieved after 4 days of equilibration.
- Porewater samples were analyzed for total and dissolved mercury.
- Significant turbidity was observed in the unfiltered samples, indicating that unfiltered results are not suitable for quantitative use.

Results of Log Pond porewater testing are shown in Table 10.

- There were no detections of dissolved mercury in any of the samples, confirming that mercury concentrations in shoreline porewater are not bioavailable.
- Method reporting limits were well below the Log Pond interpretive framework value of 0.0594 micrograms per liter (µg/L) dissolved mercury. That value was established as part of remedial activities at the GP West Chlor-Alkali RAU, and set to be protective of sediment quality at the SQS (0.41 mg/kg).

Results demonstrate that shoreline groundwater is not an ongoing source of sediment recontamination.

During future porewater testing, the use of a finer (i.e., 20 µm) NMDS mesh size is recommended to limit the influence of the turbidity artifact on unfiltered total mercury analyses.

7 Summary and Recommendations

The results of Year 1 compliance monitoring are summarized as follows:

- Phase 1 capping areas are performing within expectations, with no areas of erosion or cap damage noted during Year 1 bathymetric and visual surveys. Observed ranges of sediment consolidation are within expectations.
- Sediment containment walls are in good condition, with no observations of corrosion or other damage. However, several small areas of seepage were observed at tie-back penetrations.
- Mercury levels in surface sediments are below levels protective of benthic organisms and human health and ecological receptors. Results confirm the performance of the remedy within both the Phase 1 capping and Site MNR areas.
- Site SWAC-based dioxin/furan concentrations are well below the regional background concentration for Bellingham Bay.
- The thickness of clean sediments depositing over sediments containing elevated mercury levels continues to increase. Accumulation of cleaner sediments has been significant in comparison to previous testing data collected during 1997. Sediments exceeding the mercury BSL are currently buried by between 30 and 76 cm of cleaner sediments. The results are generally consistent with previous natural recovery modeling.
- Mercury levels in adult crab tissue continue to decrease, following an exponential (first-order) rate toward reference concentrations.
- Mercury levels in juvenile Dungeness crab collected from the Log Pond have decreased between Year 0 and Year 1. However, concentrations are slightly above tissue collected from the reference station.
- Results of biological monitoring performed using in situ caged clam testing and co-located porewater mercury testing have demonstrated that mercury in Site sediments is no longer bioavailable. Mercury levels in clam tissues were not significantly different from clean reference areas ($p < 0.0486$), and dissolved mercury concentrations were below reporting limits in all of the test and reference samples.

Based on the results of Year 1 compliance monitoring, it is recommended that Year 3 monitoring be performed consistent with the SQAPP (Anchor QEA 2016), including the following adjustments:

- Discontinue clam tissue testing: Year 0 and Year 1 clam tissue mercury levels indicate that sediment mercury levels in Phase 1 remediation areas and in Site MNR areas are not bioavailable. Clam tissue mercury levels are not significantly different from tissue collected from clean reference areas located in Samish Bay. Consistent with the decision criteria defined in the SQAPP, no clam tissue testing will be performed.

- Update NMDS sampling methodology: Reduce the NMDS mesh size from 120 microns to 20 microns or less. At other MTCA cleanup sites, this adjustment has been shown to reduce the level of the turbidity artifact on unfiltered porewater measurements (GSI 2018).

In addition, the Port is developing a plan to further assess/address the localized groundwater seeps observed at some of the tie-backs along the face of the Maple Street Bulkhead. The plan will summarize actions taken to date to assess and address all containment wall seeps, and describe activities to further assess/address remaining seeps. The plan will also include a schedule for activities. The plan will be submitted to Ecology for review and approval prior to implementing the work. That plan and follow-up work will be conducted as part of ongoing activities at the Central Waterfront Site cleanup.

8 Year 3 Compliance Monitoring

Year 3 monitoring will be performed in 2019. Consistent with the SQAPP (Anchor QEA 2016) and recommendations based on Year 1 results (see Section 7), the scope of monitoring will include the following:

- Bathymetric surveys
- Visual surveys
- Surface sediment testing
- Seafood tissue monitoring for adult and juvenile Dungeness crab, and benthic fish
- Porewater monitoring in Unit 4

Fieldwork will be conducted in the months of June through August 2019. Field sampling for seafood tissue monitoring will be prioritized to occur before surveys and surface sediment sampling to comply with the timeframe specified in the SQAPP. Analytical results from chemical and biological testing and data validation is expected to be complete in November 2019. Preparation of the Year 3 Compliance Monitoring Report is anticipated to be completed by February 2020. Data will be submitted to EIM by March 1, 2020.

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Tables

Figures