ESQUIMALT GRAVING DOCK

Phase 2 South Jetty Under-Pier Sediment Remediation Project

Water Quality Monitoring Plan

Final

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Limitations & Use of Report

This report was prepared for Public Works Government Services Canada and was prepared in accordance with the terms and conditions of the G3 Consulting Ltd.'s Task Authorization E0276-132639/001/VAN and workplans submitted to PWGSC for the preparation of this Water Quality Monitoring Plan.

Inferences concerning the Site conditions contained in this report are based on existing information, historical data and Phase 1 Project reports completed by Golder Associates. Information was also obtained from Public Works Government Services Canada *Esquimalt Graving Dock Waterlot Phase 2 South Jetty Under-Pier Sediment Remediation Project Demo-Remediation Specification*, Esquimalt Graving Dock Best Management Practices, discussions held with Public Works Government Services Canada and other Project Team members (PWGSC, 2010, 2014).

In evaluating the subject Site, G3 Consulting has relied in good faith on information provided. G3 accepts no responsibility for any deficiency or inaccuracy contained in this report as a result of our reliance on the aforementioned information.

The findings, conclusions and recommendations in this report have been prepared for the specific application to this project and were developed in a manner consistent with that level of care normally exercised by environmental professionals currently practising under similar conditions in the jurisdiction.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, and should be reviewed by those implementing recommendations made in this report.

If new information is discovered during future work, G3 should be requested to re-evaluate the conclusions of this report and to provide amendments, as required, prior to any reliance upon the information or recommendations presented herein.

Correct Citation:

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ABBREVIATIONS

ATM	Automated Turbidity Monitor
AZ	Activity Zone
BCMOE	British Columbia Ministry of Environment
BCMWLAP	British Columbia Ministry of Water, Land and Air Protection
CALA	Canadian Association for Laboratory Accreditation
CAZ	Controlled Access Zones
CCME	Canadian Council of Ministers of the Environment
CD	Chart Datum
CMA	*Canada Marine Act*
CP	Compliance Point
CRM	Certified Reference Materials
CSR	*Contaminated Sites Regulation*
DFO	Fisheries and Oceans Canada
DGPS	Differential Global Positioning System
DND	Department of National Defence
DO	Dissolved Oxygen
DPM	Deputy Project Manager
DQO	Data Quality Objective
DR	Department Representative from Public Works and Government Services Canada
DU	Dredge Unit
DZCP	Dilution Zone Compliance Point
EAP	Exterior Assessment Point
EC	Environment Canada
ECP	Exterior Compliance Point
EEE	Environmental Effects Evaluation
EGD	Esquimalt Graving Dock
EM	Environmental Monitor
EMIP	Environmental Monitoring Implementation Plan
EMP	Environmental Management Plan
EPP	Environmental Protection Plan
EWP	Early Warning Point
FFR	Far-Field Reference
HHWLT	Higher High Water Large Tide
HHWMT	Higher High Water Mean Tide
IAP	Interior Assessment Point
LC50	Lethal Concentration (mortality of 50% of sample population)
LLWLT	Lower Low Water Large Tide
LLWMT	Lower Low Water Mean Tide
MDL	Method Detection Limit
NFR	Near-field Reference
NMHR	Natural and Man Made Harbour Regulations
NOAA	National Ocean and Atmospheric Administration
NOEL	No Observed Effects Level
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
PCO	Project Coordination Officer
POD	Point of Discharge
POP	Persistent Organic Pollutant
PWGSC	Public Works and Government Services Canada
QA/QC	Quality Assurance/Quality Control
QEP	Qualified Environmental Professional
QHM	Queen’s Harbour Master

QSAR	Quantitative Structure-Activity Relationship
RAO	Remedial Action Objective
RMC	Residuals Management Cover
RPD	Relative Percent Difference
SedQCTCS	Sediment Quality Criteria For Typical Contaminated Sites (*Contaminated Sites Regulation* Schedule 9)
SMA	Sediment Management Area
SPL	Sound Pressure Level
SPM-O	Senior Project Manager - Operational
SPM-T	Senior Project Manager - Technical
SPW	Sheet Pile Wall
TAT	Turnaround Time
TBT	Tributyltin
TCDD	Dioxins
TCDF	Furans
TRB	Temporary Re-suspension Barrier
TRBCA	Temporary Re-suspension Barrier Containment Area
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency
WAAS	Wide Area Augmentation System
WQG	Water Quality Guideline
WQMA	Water Quality Management Area
WQMP	Water Quality Monitoring Plan

Units

h	hour
km	kilometre
kPa	kilopascal
m	metre
m/s	metres per second
mg/L	milligram per litre
NTU	nephelometric turbidity units
µg/L	micrograms per litre

1.0 INTRODUCTION

G3 Consulting Ltd. (G3) was retained by Public Works and Government Services Canada (PWGSC) to develop the following Water Quality Monitoring Plan (WQMP), to be implemented during the Esquimalt Graving Dock Waterlot Phase 2 South Jetty Under-Pier Sediment Remediation Project to provide water quality criteria for Project activities. The Project activities include: dredging, barge dewatering, contingency re-dredging, engineered capping placement, residuals management cover placement, operational activities associated with the opening and closing the Temporary Re-suspension Barrier (TRB) and demolition of the timber pile portion of the existing South Jetty. The WQMP also includes decision frameworks for the implementation of management actions if necessary based on water quality monitoring.

1.1 Background

PWGSC is in the process of remediating contaminated sediment in the Esquimalt Graving Dock (EGD) Waterlot and adjacent "buffer" areas (Appendix 1, Figure A1). Remediation involves removal of sediments that are contaminated above numeric remedial action objectives (RAOs) based on the remedial options analysis described in Anchor QEA (2009). Project numeric RAOs for contaminants of potential concern are defined as the most conservative of the applicable Canadian Council of Ministers of the Environment (CCME) *Canadian Environmental Quality Guidelines (for water)* (CCME, 2014) and British Columbia Ministry of Environment (BCMOE) *Contaminated Sites Regulation* (*CSR*) standards for marine sediment (typical contaminated sites [SedQCTCS]; BCMOE, 1996). Work is being undertaken in two main phases, of which Phase 1 (which includes Phase 1A, 1B and 1C) has now been completed (Appendix 1, Figure A2):

- Phase 1A consisted of the installation of a temporary sheet pile wall (SPW) around the South Jetty structure to minimize erosion and re-suspension of contaminated under-jetty sediments into areas of the Waterlot and adjacent buffer zones that were remediated as part of Phase 1B of the Project;
- Phase 1B involved dredging and excavation of contaminated sediments in an open-water work area outside the South Jetty and Munroe Head intertidal zone. Phase 1B also involved placement of sand and armour rock as part of the management of residual contamination following dredging, and to provide erosion protection and stability of existing structures. Set-backs from sensitive infrastructure were implemented in some areas with residual contamination managed using engineered capping;
- Phase 1C consisted of the construction of a compensation area at Dunn's Nook (as required as per the Phase 1 *Fisheries Act* Authorization [No.11 HPAC PA3 00016]) and described in the Phase 1 *Environmental Management Plan* (EMP; Golder, 2012a); and,
- Phase 2 of the Project (anticipated to commence in 2015), will consist of:
  1. re-driving of the sheet pile wall to zero (0) chart datum (CD);
  2. installation of a TRB and any associated support structures;
  3. deconstruction of the timber pile portion of the South Jetty;
  4. removal and remediation of sediments beneath the South Jetty;
  5. installation of sand and rock armor to manage missed inventory and/or residual contamination; and,
  6. removal and decontamination of the SPW and TRB.

This WQMP, as a part of the larger *Environmental Management Plan* (EMP; G3, 2014a), outlines the scope of monitoring to be undertaken during project activities and identifies appropriate parameters and assessment criteria. An *Environmental Effects Evaluation* (EEE) outlines potential effects of the project (G3, 2014b) and the *Environmental Monitoring Implementation Plan* (EMIP) describes specific methods to monitor the effects.

1.2 Objectives

The objectives of this WQMP are to:

- confirm that the Contractor is meeting discharge quality requirements and that activities will not result in the deposition of deleterious substance(s) outside of the enclosed Phase 2 Work Area;
- ensure that there is no "work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery" (*Fisheries Act*) taking place;
- provide data to support implementation of the Contractor's Environmental Protection Plan (EPP) through field-acquired data that may be used to revise work practices (e.g., decreases or increases in dredge cycle time, control of discharge water);
- support environmental reporting requirements that may be specified by environmental agencies; and,
- provide a basis to enable the Contractor to verify their work is conducted in accordance with regulatory and contractual obligations.

1.3 Report Format

This WQMP was written for Phase 2 activities only and includes the following components:

- a description of baseline water quality conditions in Esquimalt Harbour, including an evaluation of implications for the Project (Section 2.0);
- roles and responsibilities of PWGSC, Environmental Monitor (EM) and Contractor for implementing environmental management and mitigation measures (Section 3.0);
- parameters to be monitored and threshold limits that, if exceeded, would trigger Management Actions and methodology for *in situ* water quality monitoring for real-time assessment (Sections 4.0);
- Quality Assurance/Quality Control (QA/QC) procedures to be undertaken to verify data precision and accuracy (Section 5.1);
- handling and data management procedures for monitoring results (Section 5.2); and,
- requirements for Contractors and Environmental Monitors (EMs) to collect and report monitoring results (Section 6.0).

This WQMP is intended to be read in conjunction with the EMP (G3, 2014a), EEE (G3, 2014b), EMIP and any environmental requirements for the Project. Electronic copies of these documents may be obtained by an approved Contractor from the Departmental Representative (DR).

A summary of applicable federal and provincial legislation is provided in the EMP (G3, 2014a) and EMIP for this Project. The intent of this WQMP is to provide direction to PWGSC, Environmental Monitor (EM) and Contractor that is consistent with the provisions for environmental protection contained in legislation; however, it is the responsibility of the Contractor to be aware of all legislation and regulations associated with their activities. Should further clarification of any environmental issue be required, the appropriate regulation or legislative document should be consulted or advice sought from PWGSC.

2.0 PROJECT LOCATION & EXISTING CONDITIONS

The Esquimalt Graving Dock (EGD) facility is located on the north shore of Constance Cove, in Esquimalt Harbour on the southern tip of Vancouver Island, British Columbia. The Project is located within the Coastal Douglas Fir Biogeoclimatic Zone. Constance Cove is approximately 0.5 km wide at its entrance, sheltered and subject to the marine tidal regime of Esquimalt Harbour, BC (Appendix 1, Figure A1). Water depth within the Work Area ranges from 3 m above chart datum (CD) and 9 m below CD.

The mean tide in Esquimalt Harbour is 1.9 m (relative to CD). The higher high water mean tide (HHWMT) is 2.5 m and higher high water large tide (HHWLT) is 3.4 m. The lower low water mean tide (LLWMT) is 0.7 m and the lower low water large tide (LLWLT) is 0.1 m (Golder, 2012d).

Tides and wind-waves generate currents within Constance Cove, which are typically low during the ebb and flood phases of the tide and are variable in direction. There is a net drift of water out of Constance Cove from east to west (away from the project site) across the area of the EGD Waterlot. In Constance Cove measured maximum currents are 0.12 m/s and average 0.05 m/s with slower average currents beneath the South Jetty (0.04 m/s on average and less than 0.06 m/s 90% of the time; Golder, 2011).

Project effects are described in the *Environmental Effects Evaluation* (EEE; G3, 2014b)

2.1 Surface Water Quality

Existing surface water quality and water quality during Phase 1B activities is relevant to the Project water quality monitoring given that:

- it provides a characterization of pre-project water quality conditions;
- it provides existing conditions against which monitoring data will be compared, such that interpretation (by a Qualified Environmental Professional [QEP]) of water quality monitoring results is better supported;
- activity within the harbour surrounding the Phase 2 Work Area has the potential to increase turbidity and, as such, a need to establish accurate ambient values; and,
- activities similar to those during Phase 1B will be occurring during Phase 2.

For the purposes of this WQMP, and within the context of monitoring during activities, the term ‘ambient’ should be taken to mean conditions considerate of specific local conditions within and specific to Constance Cove (to account for localized influences such as prop-wash, vessel activity, blowing ballast tanks, etc.). For the purpose of this report, the term ‘background’ should be taken to mean levels reflective of the greater Esquimalt Harbour accounting for influences that affect the entire harbour (e.g., seasonality).

A brief overview of existing contaminant data is provided below with additional information on turbidity data as this parameter is a substantial aspect of the water quality monitoring program. In the event that further interpretation is required refer to the original reports referenced below. Prior to Phase 1 several surface water samples at varying depths were collected in 2005 by Golder (Golder, 2006a, b) and SLR Consulting Inc. (SLR, 2009). Metals were generally found to be below or at federal (CCME, 2014) and provincial (BCMOE, 2014) water quality guidelines (WQGs) except some samples collected near Outfall D (Appendix 1, Figure A2) in 2005. Concentrations of tributyltin (TBT) were 2 to 10 times the federal WQG in some samples collected near the outfall in 2005 (Golder, 2006a, b); however, not in 2008 (SLR, 2009). The dataset is limited and conditions should not be taken to necessarily be a representation of ambient or background concentrations at the time of Project implementation.

During Phase 1B water samples were collected surrounding Project activities and within Constance Cove and Esquimalt Harbour. Metals were generally found to be within CCME (2014) and BCMOE (2014) guidelines with 4.9% of analyzed samples (58 of 1,178 samples) exceeding guidelines (SLR, 2014). Of the 58 exceedances 12 occurred in background and ambient samples and 46 were down current from Project activities (e.g., dredging). Not all exceedances down current from Project activities were associated with increased total suspended solids (TSS)/turbidity. The majority of the exceedances were for copper (52 of 58 metal exceedances).

There were no exceedances of polycyclic aromatic hydrocarbons (PAH) guidelines (guidelines are found in the Phase 1 EMP; Golder, 2012c) in any of the 1,240 samples analyzed for total and/or dissolved PAHs (SLR, 2014). At the outset of Phase 1B, in areas of known high polychlorinated biphenyl (PCB) concentrations, water samples were collected during dredging. Of the eight samples collected, all indicated values were below detection limits for PCBs (SLR, 2014).

It is noted that available water quality data does not include conditions after the completion of Phase 1B (i.e., dredging and placement of engineered capping materials) to provide current or post-remediation conditions prior to starting of Phase 2.

All of Esquimalt Harbour is contained within Fisheries and Oceans Canada (DFO) Sanitary Shellfish Closure 19.1 which reduces the potential for risks to human health through consumption.

2.1.1 Turbidity

Turbidity is a measure of light reflectance within a sample of water and is reported in Nephelometric Turbidity Units (NTU). For the purposes of Phase 2, turbidity will be used as a real-time proxy estimate measurement of TSS. TSS is measured in the laboratory and is determined through centrifugation of samples and provides the actual weight of the particulate material in the sample. TSS and turbidity are not analogous in all situations, and the relationship must be calibrated independently for each sediment type. In addition, the relationship between turbidity and TSS varies temporally due to naturally-occurring variations in local conditions.

Turbidity monitoring program was conducted between October 18 and December 15, 2010 using automated turbidity monitors (ATMs), to determine ambient turbidity at designated monitoring locations in Constance Cove and at a reference site at the entrance of Esquimalt Harbour prior to the commencement of the remedial dredging program. On average, background turbidity in Esquimalt Harbour was low, with mean values typically being less than 5 NTU at most stations and median turbidity being <1 NTU.

Turbidity values ranged between 0 – 817 nephelometric turbidity units (NTU), with peaks of up to approximately 400 NTU for short periods (Appendix 2, Table B1). The 99th percentile of all NTU values observed in the field was 6.4 NTU. The short duration peaks in turbidity observed may have been due to sensor obstruction, sediment re-suspension caused by operational activities including boat/tug activity, propwash, or by natural re-suspension of sediments caused by wind-waves and tidal currents.

Monitoring of turbidity was conducted during Phase 1B in areas surrounding Project activities and at reference sites within Constance Cove and Esquimalt Harbour. The turbidity measurements from all monitoring locations ranged from 0.07 NTU to 115.39 NTU (SLR, 2014). Out of the 11,310 turbidity measurements collected during Phase 1B, 1.45% (164 samples) exceeded Project specific or ambient water quality guidelines (SLR, 2014). The ATMs installed in Constance Cove and Esquimalt Harbour generated a larger range of turbidity values within the harbour, 0.001 NTU to 1,225 NTU. High levels were likely associated with intermittent sensor obstruction (SLR, 2014). Highest turbidity levels and prolonged exceedances were most often recorded in areas in close proximity to the sheet pile wall (SPW) surrounding the South Jetty as the SPW acted as a barrier to current flow, effectively slowing dissipation of suspended materials.

Short duration transient events (i.e., propwash from ship passage) have been recorded as influencing turbidity readings by as much as two (2) orders of magnitude. For this reason, turbidity performance criteria for all activities (and associated TSS performance criteria) must be represented as increases over current ambient levels. Appropriate and ongoing measurements of ambient conditions are critical to Phase 2 works as they aid in assessing if turbidity measurements indicate a potential release of materials from the Phase 2 TRB containment area (TRBCA); or if, turbidity measurements are a result of normal transient events associated with existing conditions at the EGD facility.

As Phase 2 will be enclosed and all areas will be in proximity to the SPW and/or TRB complete dissipation of suspended materials may not always occur and, therefore, higher turbidity values could be expected within the TRBCA.

The following two WQMP considerations are raised by these observations:

- based on visual observations and *in situ* turbidity data collected during operations, the EM may recommend a greater number of reference stations and/or samples than recommended here to the DR to account for shifts in ambient turbidity unrelated to Project activities; and,
- given the characteristics of ambient and background turbidity (short duration, relatively high magnitude transient events), an appropriate response to a single high turbidity value is to resample and identify and document reasons for that increase. The Decision Management Frameworks (Appendix 1, Figures A4 to A5) outline the process of resampling prior to implementing more stringent operational controls or stop-work orders.

2.2 Navigation Resources

Esquimalt Harbour is administered by Department of National Defence (DND) and governed by the *Canada Marine Act* (*CMA*; 1998), the *Natural and Man Made Harbour Regulations* (*NMHR*; pursuant to the *Canada Marine Act*), and local Practices and Procedures (Government of Canada, 2014). The harbour is open to the public within the limitations set out in an Order in Council regarding Controlled Access Zones (CAZ) that provide for security around warships berthed or moving in the harbour. Vessels entering or departing Esquimalt Harbour are requested to contact the Queen's Harbour Master (QHM) of Operations (Government of Canada, 2014). Ship repair work at EGD may take place 24-hours-a-day, seven-days-a-week, 365-days-a-year (PWGSC, 2014a). Given that ship repair may take place at all times, ships frequently navigate in and out of the Project Area, and emergency docking of ships at the graving dock may need to occur during the Project.

3.0 ROLES & RESPONSIBILITIES

This section describes the roles and responsibilities of Public Works and Government Services Canada (PWGSC), Esquimalt Graving Dock (EGD) staff, PWGSC's designated Environmental Monitor (EM), and Contractor implementing, inspecting and reporting on the effectiveness of the environmental protection and mitigation measures. This is illustrated in the following diagram (Figure 3-1) with each group identified and defined in Table 3-1.

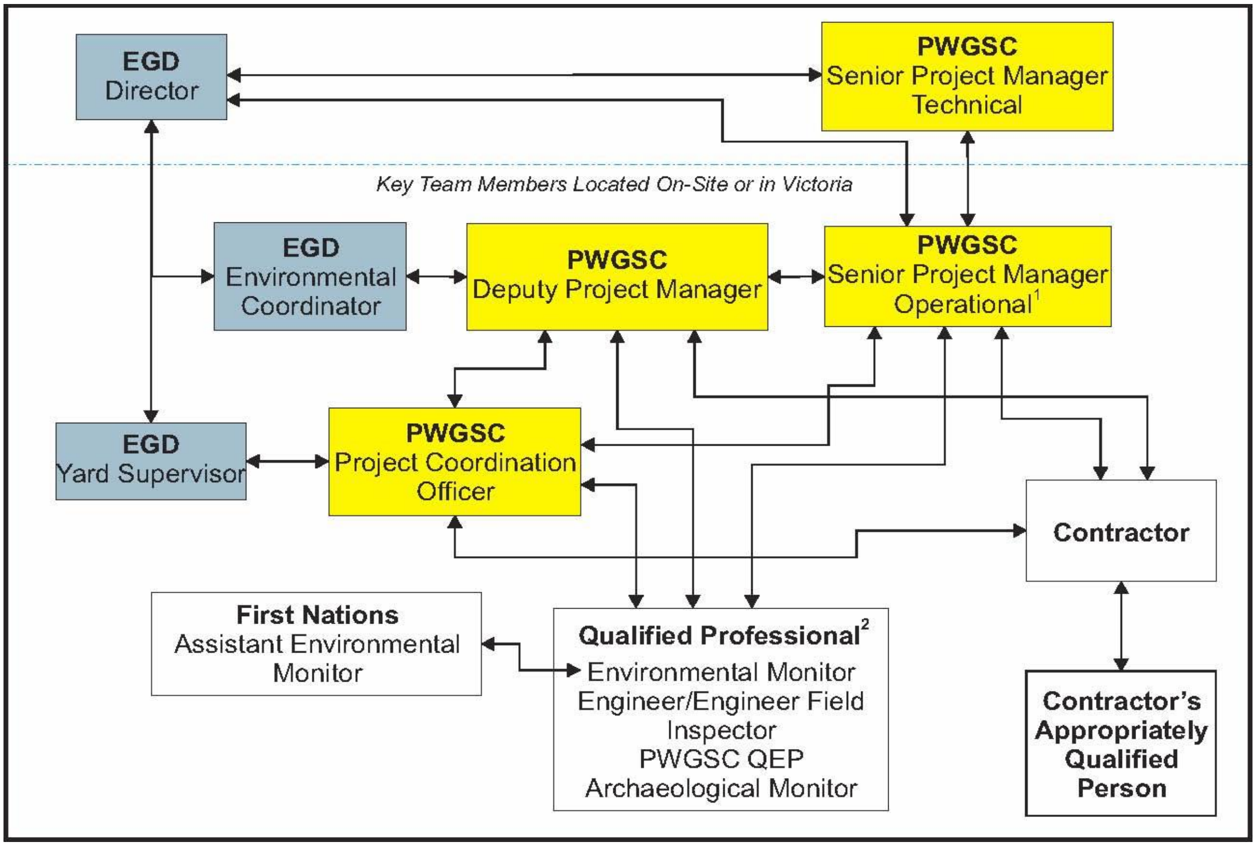

Figure 3-1: Communication Diagram

EGD – Esquimalt Graving Dock; PWGSC – Public Works and Government Services Canada; QEP – Qualified Environmental Professional

Note: This communication diagram focusses on communication regarding environmental management; additional communication may exist for other purposes.

[1] The PWGSC Senior Project Manager – Operational is also the Departmental Representative (DR).

[2] Qualified Professionals may communicate with each other as necessary.

3.1 Public Works & Government Services Canada

As the proponent of the Project, PWGSC has overall responsibility for the Project and the following obligations:

- administration of contracts;
- construction management and confirmation of Contractor compliance with plans and contract requirements, including those related to environmental protection;
- verifying compliance with terms and conditions of regulatory permits, approvals, and Authorizations, as mandated under federal and provincial legislation;
- managing communications and relations with EGD Operations and tenants, public stakeholders, regulatory agencies and First Nations; and,
- coordinating review of the Contractor's Environmental Protection Plan (EPP).

Specific roles of PWGSC are summarized in Table 3-1.

Table 3-1: Summary of PWGSC Roles & Responsibilities for Environmental Management

Role	Responsibility
Senior Project Manager – Technical (SPM-T)	PWGSC staff member responsible for coordinating the delivery of the entire project, who will: • interface with the senior management of PWGSC and participating departments (e.g., DND) and serve as senior PWGSC Environmental Specialist spokesperson for the project; • with other senior managers establish an appropriate organizational structure, and assign and detail roles and responsibilities to the project team; • be responsible for maintaining consistency between project implementation and previously defined objectives and decisions; • act as the senior project representative in meetings with First Nations or public; • attend project meetings as required; and, • be responsible for verifying that lessons learned are documented.
Senior Project Manager – Operational (SPM-O)	PWGSC staff member responsible for delivery of all project components, who will: • act as the primary on-site contact (**Departmental Representative [DR]**) for the Contractors, consultants, and EGD staff; • identify and resolve technical issues arising during the Project; • be responsible for project delivery and results meeting management objectives; • be responsible for verifying that all legislative and regulatory requirements are met and approvals obtained; • chair project meetings such as pre-construction/start-up meetings; and, • document lessons learned on a continuous basis.
Deputy Project Manager (DPM)	PWGSC staff member responsible for on-site delivery of project components, including construction of compensatory habitat, who will: • manage day-to-day implementation of project work on-site; • monitor progress of the Project; • liaise with Project Coordination Officer to coordinate work on-site; • attend and/or chair project meetings such as pre-construction/start-up meetings; • with Project Manager act as the primary authority to direct the Contractors and consultants carrying out the work; • be responsible for on-site liaison and coordination between client, design consultants and Contractors; • monitor and resolve issues related to on-site work; • be responsible for verifying that construction monitoring/quality assurance inspections (design consultants) and health and safety inspections are conducted and documented; • be responsible for verifying that environmental monitoring is conducted (environmental monitoring consultant); • conduct additional inspections as required to verify design consultant and environmental monitoring consultant reports; and, • document lessons learned on a continuous basis.
Project Coordination Officer (PCO)	PWGSC staff member responsible for on-site project coordination for all project work, who will: • liaise with the Deputy Project Manager and EGD Yard Supervisor. • make bookings and coordinate support for on-site project meetings, and attend project/construction meetings; • facilitate site access and egress for Contractor and consultants; • notify EGD Operations, tenants, and users of planned/on-going project work; • notify DND of planned/on-going project work in Esquimalt Harbour or work that may affect DND operations; • generally monitor on-site work; • prepare daily inspection/progress reports and photo logs of all work; • review Environmental Protection Plans prior to start of work; and, • monitor Contractor and consultant general compliance with EGD policies and procedures.

Con'd…

Table 3-1: Summary of PWGSC Roles & Responsibilities for Environmental Management (con'd)

Role	Responsibility

EGD Director	Primary EGD Operations representative, who will:
	• provide site-specific operational input, including specific site requirements or project restrictions, to project team as required;
	• identify other projects or operations and maintenance that may conflict with Project work;
	• delegate specific duties to the EGD Environmental Coordinator to facilitate implementation of the Project within site operational environment; and,
	• be the:
	  ◦ primary authority for design criteria and project decisions related to operational impacts;
	  ◦ senior liaison with EGD personnel, tenants and users;
	  ◦ primary contact for public questions/questions through the EGD hotline phone messaging centre.

EGD Yard Supervisor	Secondary EGD Operations project representative, who will: • be the primary contact for day-to-day coordination with EGD Operations, site tenants, and users; • have primary responsibility for managing tenant / user issues and / or conflicts, including vessel movement; • liaise with the EGD Environmental Coordinator, PCO, and DPM; • notify PCO of emergency dockings or other emergencies that may require changes to project work; • in coordination with PCO direct changes to site operations to avoid or minimize conflict with project work, or identify required changes to project work or schedule; and, • attend project meetings as required.
EGD Environmental Coordinator	EGD senior project representative to EGD Operations, tenants, users, and clients, who will: • provide assistance to the EGD Director for project-related responsibilities; • identify capital projects, operations and maintenance activities or client/user activities that may conflict with project work; and, • assist DPM with resolution of major project coordination issues

DND – Department of National Defence; EGD – Esquimalt Graving Dock; PWGSC – Public Works and Government Services Canada
Note: Roles and responsibilities as identified by PWGSC (2013).

3.2 Contractors

The Contractor will be responsible for the actions of their agents, employees and sub-contractors and will undertake all reasonable actions to have environmental protection measures in place and working effectively throughout the Phase 2 Work Area (Appendix 1, Figure A2). The Contractor is responsible for:

1. adhering to requirements set forth in any regulatory document (e.g., legislation), and all contract requirements, including this Water Quality Monitoring Plan (WQMP);
2. undertaking effective communication with work crews and sub-contractor such that environmental responsibilities and requirements are understood prior to the commencement of work, and are implemented during the work. This will include disseminating information from orientation and other meetings to personnel not in attendance at those meetings;
3. retaining an appropriately qualified person to prepare the EPP and evaluate performance against the requirements outlined in regulatory documents and Best Management Practices, as well as environmental protection goals provided in the *Environmental Management Plan* (EMP) and contract requirements;
4. implementing and conducting work activities in a manner that adheres to the water quality criteria detailed in this WQMP;
5. using equipment and implementing work procedures and controls to prevent and/or reduce work-related disturbance to environmental, social, heritage, archaeological and cultural resources;
6. implementing preventative and corrective measures in response to non-conformance with stated criteria (i.e., EMP), regulatory documents and the contract requirements including this WQMP;

7. responding immediately to emergencies and incidents;
8. quality assurance sampling; and,
9. reporting all water quality data collected (e.g., quality assurance, interior assessment point samples for modelling, barge dewatering, TRB function) in weekly reports to PWGSC.

3.3 Anchor QEA

Anchor QEA (Anchor), the lead consultant and project engineer for remediation, is responsible for:

- technical review of Contractor submittals;
- field inspection to monitor compliance with Contract requirements, ensuring that all work is completed in compliance with the *Phase 2 Demo-Remediation Specification* and contract;
- liaising with the PWGSC SPM-O during the Project; and,
- routine coordination with the EM in support of environmental monitoring and post-dredge confirmatory sampling.

3.4 Environmental Monitors (EM)

In addition to the Contractor's appropriately qualified person, PWGSC will retain an EM to confirm that environmental management measures and controls are implemented in accordance with regulatory documents, environmental components of the contract requirements, including the EMP and this WQMP as well as the EPP prepared by the Contractor. Environmental monitoring tasks are to be conducted by, or under, the supervision of a Qualified Environmental Professional (QEP) following procedures outlined in the EMIP. For the purposes of this WQMP, a QEP is defined as an applied scientist specializing in the area of biology, who:

- is registered in British Columbia and in good standing with an appropriate professional organization; and,
- through suitable education, experience, accreditation and knowledge, may reasonably be relied upon to provide advice regarding environmental management of the Project.

It is anticipated that various personnel will be necessary to undertake different monitoring components for the Project (e.g., water quality, aquatic mammals, etc.) and the experience of the personnel used should reflect those needs.

The EM will:

1. prepare an Environmental Monitoring Implementation Plan (EMIP) that outlines the type and frequency of observations and data collection that will be made (including quality control sampling);
2. prepare and deliver environmental orientation sessions to work crews;
3. document work activities and evaluate them against regulatory documents, environmental components of all contract documents, EMP and this WQMP;
4. the EM will advise PWGSC DR when work practices may need to be modified or improved to achieve the established environmental protection goals of the Project;
5. compile and maintain environmental monitoring data and related documentation (including environmental monitoring reports); and,
6. assist in responding to emergencies and environmental incidents.

Different roles and types of monitoring personnel are defined in the EMIP.

4.0 WATER QUALITY MONITORING

4.1 Sources of Decreased Water Quality

This section describes components of the water quality monitoring program that are used to verify that environmental controls put in place for this project are adequate to protect the receiving environment and provide environmental management data used to identify when additional controls or management actions may be necessary, including temporary cessation of Project activities as deemed appropriate by the DR. See Figure A3 (Appendix 1) for a summary of the Phase 2 monitoring plan for water quality.

Water quality in and adjacent to the Phase 2 Work Area may be affected by Project activities through:

- induced suspension of solids/turbidity (e.g., during dredging, placement of engineered capping/residuals management cover (RMC) and intertidal excavation);
- release of contaminants from re-suspension of contaminated sediments during dredging under the South Jetty;
- release of re-suspended solids and potential contaminants during opening and closing of the TRB;
- release of re-suspended solids and potential contaminants in the event of poor functioning or failure of the TRB;
- release of re-suspended solids during TRB/sheet pile wall removal/relocation;
- release of cementitious (alkaline) material from concrete works near watercourse;
- release of creosote from South Jetty pilings during removal and storage (before disposal); and,
- introduction of debris, air emissions, runoff, dewatering and other potential vectors.

Anchor (2011) used a modelling program called DREDGE (Hayes and Je, 2000) to assess the potential for sediment re-suspension and dispersion of contaminants during active dredging for a number of scenarios with various assumptions regarding particle size and density, dredge bucket size and cycle time. For Phase 2 work, Anchor updated the model to reflect the concentrations of contaminants known to be present in Phase 2 sediments (Appendix 4; Anchor, 2014). The model predicted that contamination associated with TSS would be at or below the performance criteria when TSS was below 68 mg/L and turbidity was less than 34 NTU. Performance criteria used for modelling were based on federal (CCME, 2014) and provincial (BCMOE, 2014) water quality guidelines (WQGs) and published studies.

To prevent recontamination of areas remediated as a part of Phase 1 works, the Phase 2 Project Area (South Jetty under-pier area) was enclosed by a sheet pile wall during Phase 1A. At the beginning of Phase 2 the SPW will be re-driven (or cut in designated areas) to 0 m chart datum (CD). An impermeable TRB will be installed above, and overlapping with, the re-driven SPW and extending to the shoreline at the east end of the South Jetty to enclose the work area. The TRB will be designed to minimize the potential for re-contamination of previously dredged areas outside the sheet pile wall. TRB design shall account for potential re-contamination outside the Phase 2 Work Area during opening and closing of the TRB (for the purpose of equipment and vessel movement inside and outside the TRB work area). Within the Phase 2 Project Area there is an area which has been identified as hazardous waste quality material. Dredging of the Hazardous Waste Area shall be sequenced and completed such that no recontamination of previously dredged areas occurs.

Specific water quality measurements within the TRBCA related to the handling of creosote-treated timber are not planned, as relevant analyses cannot be conducted in a timely manner to facilitate management of Project activities. Monitoring of pile removal activities within the TRBCA will rely on visual inspections by the Contractor and PWGSC designated EM as required and detailed in the EMP as well as monitoring outside the TRBCA. Monitoring of TRB/SPW and associated pile removal will follow the framework and criteria in Sections 4.6.9 and 4.7.

4.2 Monitoring Locations

Regulatory compliance is typically evaluated at the point at which an operator is no longer able to exercise control over a discharge; in the case of this project, the point at which the Contractor no longer exercises control is dependent on the activity and locations and for Phase 2, those locations are (Appendix 1, Figures A6 through A9):

1. dredging and/or dewatering inside the TRBCA: the outer face of the TRB;
2. opening and closing the TRB: Interior Assessment Point;
3. dewatering outside TRBCA: end of pipe (treatment barge only);
4. contingency re-dredging or placement of residuals management cover materials outside the TRBCA: centre of the dredge or equipment placing materials;
5. removal of TRB/SPW: the line of the removed structure; and,
6. offloading of material at Contractor's Off-Site Offloading Facility: point of deposit/discharge.

Monitoring procedures are described briefly in Section 4.2.1 (for summary see tables 4-1 to 4-3) and in detail in the EMIP. The parameters measured and location specific performance criteria are outlined in Tables 4-4 to 4-9. Monitoring will be conducted by the PWGSC designated EM (unless otherwise noted) at the following locations:

1. Early Warning Point(s) (EWP): All points located 25 m from the outer face of the TRB and no closer than 25 m from any active equipment. Assessed daily, during peak activity (Appendix 1, Figures A6 and A7);
2. Compliance Point(s) (CP): All points located 100 m from the outer face of the TRB (Appendix 1, Figures A6 and A7);
3. Interior Assessment Point (IAP): Point inside the TRB closest to any proposed opening. Assessed by the Contractor's appropriately qualified person prior to opening the TRB (Appendix 1, Figure A8);
4. Exterior Assessment Point (EAP_{25}): Point 25 m outside the TRB opening used to monitor potential releases of suspended sediment and contaminant laden waters from inside the TRB upon opening (Appendix 1, Figure A8);
5. Exterior Compliance Point (ECP): Point 100 m from the opening of the TRB (direction based on flow). Used to assess compliance with water quality performance criteria (Figure A8, Appendix 1);
6. Whole Effluent: prior to discharge (final, treated effluent) from a dewatering barge if dewatering at the Work Site (Appendix 1, Figure A9). EM shall have access to whole effluent (after treatment, prior to discharge) for required barge dewatering monitoring;
7. Dilution Zone Compliance Point (DZCP): 100 m from the dewatering barge point of discharge (POD) if dewatering at the Work Site (Appendix 1, Figure A9);
8. Near-Field Reference Point (NFR): Reference stations situated within Constance Cove (Appendix 1, Figures A6 to A8), further than 100 m from active operations and within the Discretionary Cetacean Zone (Appendix 1, Figure A10). This is a reference point for 'ambient' conditions (i.e., conditions specifically within Constance Cove) and should be in an open area that is not visibly different from surrounding areas (e.g., removed from obvious plumes, freshwater inputs, confounding sources, etc.) and is not in close proximity to areas of high activity (e.g., active dock, vessel undergoing ballast activity) at the discretion of the EM; and,
9. Far-Field Reference Point (FFR): Reference station situated within Esquimalt Harbour, not including Constance Cove (Appendix 1, Figures A6 to A8), and outside of the Discretionary Cetacean Zone (Appendix 1, Figure A10). This is a reference point for 'background' conditions (i.e., within Esquimalt Harbour yet outside of Constance Cove) and should be in an open area that is not visibly different from surrounding areas (e.g., removed from obvious plumes, freshwater inputs, confounding sources, etc.) and is not in close proximity to areas of high activity (e.g., active dock, vessel undergoing ballast activity) at the discretion of the EM.

At each monitoring location samples will be taken at three (3) depths unless otherwise specified. The depths for sampling are:

1. surface of the water column: 1 m below the surface;
2. bottom of the water column: 2 m above the seabed;
3. mid-water column: approximately half-way between surface and bottom of water column when not stratified or just below density barrier (i.e., thermocline or halocline) when/if stratified. If a visible plume is present (e.g., barge dewatering, TRB opening) the mid-water sample should be collected from the centre of the plume, where possible.

Sampling locations will be adjusted throughout the Project depending on the location of dredging activity, TRB opening and/or tides and prevailing currents at the time of sampling, etc. Sampling locations will be documented using wide area augmentation system (WAAS) corrected Differential Global Positioning System (DGPS) receivers. Selection of specific monitoring locations will be refined on the basis of the final dredging plan, local and site-specific conditions and ongoing assessment of monitoring results. A conceptual layout of sampling locations are provided in Figures A6 and A7 (Appendix 1) for dredging, Figure A8 (Appendix 1) for TRB opening and Figure A9 (Appendix 1) for barge dewatering. Conceptual layout of sampling locations for dredging activities can be applied during monitoring of other Project activities (e.g., debris removal, sheet-pile wall installation, contingency re-dredging and cover materials placement).

4.2.1 Water Quality Sampling

Water quality will be monitored at specific locations within the Phase 2 Project Area, ambient sites and background sites using a combination of *in situ* profiling and water collections for analytical testing.

4.2.1.1 In Situ Monitoring

In situ monitoring of water quality will be conducted daily at each compliance and reference point location (described in Section 4.3). Water quality monitoring will be conducted using a YSI EXO-2 Sonde (or similar) to collect continuous depth profiles (minimum one measurement per metre depth) for temperature, dissolved oxygen (DO), pH, conductivity, salinity, resistivity and turbidity at each station. Data will be stored in flash memory on the device and backed up on conventional media (e.g., external hard drive) each evening. Each probe must be calibrated daily or as necessary. *In situ* monitoring will occur concurrent with collection of water samples for laboratory analysis to facilitate direct comparisons and from which to generate calibration curves.

During daily *in situ* and all other monitoring the EM will be visually inspecting the TRB and water surrounding the TRBCA outside of the TRB for any obvious water perturbations or other evidence of TRB failure.

4.2.1.2 Laboratory Water Quality Monitoring

Water samples will be collected for laboratory analysis of turbidity, pH, TSS, total metals and total PAHs. Samples should be collected using a Beta-type Niskin Sampler (or similar sampler appropriate for organic testing and solvent rinsing). Total metals and total PAH analysis will be conducted only on a subset (approximately 50%) of samples as specified in Tables 4-1 to 4-3. Specific sampling methodology is provided in the EMIP.

For laboratory testing of final whole effluent from the dewatering treatment barge TSS, turbidity, pH and total metals and total PAH analysis must be performed regularly (Table 4-3) while the barge is actively discharging to ensure compliance with Water Quality Performance Criteria (Table 4-6).

The laboratory will archive samples for the duration of their appropriate hold times for potential additional PAH and metals testing, as required, as per Tables 4-1 to 4-3.

4.3 Monitoring Parameters

This WQMP includes measurement of various parameters that provide information to manage potential effects associated with Project activities. The Contractor is responsible for submitting all water quality data collected by the Contractor or their appropriately qualified person for any purpose in weekly reports to PWGSC. Background information on these various parameters is provided below.

4.3.1 Total Suspended Solids (TSS)

TSS encompasses both inorganic solids (such as clay, silt and sand) and organic solids (such as algae and detritus) and is a gravimetric measurement of the dry weight of suspended particulate material (solids) per unit volume of water. Suspended particles may damage fish gill structures and contain contaminants that may be up-taken by fish, benthic invertebrates and predators which depend on these organisms (i.e., aves and mammalia).

The measurement of TSS requires the collection and submission of sample to a laboratory. Analysis is done by filtering the sample onto a glass fibre filter and drying the sample at a specified temperature. Data from this analysis can be available on a 24 h ‘rush’ turnaround. TSS will also be estimated using *in situ* turbidity data as derived using a relationship calculated based on Phase 1B data (Appendix 4) which is to be updated as Phase 2 TSS/turbidity data becomes available.

Results of modelling studies must be confirmed with laboratory results for metals and PAHs for *in situ* conditions. Given that the relationships between TSS, turbidity, metal and PAH concentrations are complex, performance criteria should be evaluated and adjusted based on a weight of evidence approach considerate of both historical and current data in conjunction with the DR.

TSS/turbidity performance criteria have been designed to detect and prevent the release of contaminants from the Phase 2 Work Area. Due to variable ambient conditions, measurement of TSS and turbidity may not be adequate to detect project impacts in all ambient conditions.

The Contractor’s appropriately qualified person is responsible for determining TSS/turbidity criteria within the TRBCA that will ensure adherence to all performance criteria.

The EM will monitor at designated locations (Appendix 1, Figures A6 to A9) for a variety of parameters (Tables 4-4 to 4-9). Contractor’s adherence to performance criteria measurable *in situ* (i.e., turbidity) does not preclude their responsibility to ensure compliance with performance criteria requiring laboratory analysis.

4.3.1.1 Monitoring during Construction Activities (TRB Closed)

Phase 2 TSS performance criteria are based on CCME (2014) and BCMOE (2014) water quality guidelines (WQGs) for the protection of aquatic life from the physical effects of particulates. Monitoring criteria are applied at both the early detection level (EWP; 25 m from the TRB) and regulatory compliance level (CP; 100 m from the TRB). A stop work order, at the discretion of the Departmental Representative (DR), may occur if concentrations at 100 m are in exceedance of designated performance criteria.

Measured turbidity and associated estimated and measured TSS values are to be correlated to measured levels of metals and PAH concentrations and applied to the day-to-day management of dredging and associated Phase 2 activities by the EM and Contractor’s appropriately qualified person independently. Specified TSS/turbidity limits within the TRBCA (measured *in situ* as turbidity outside the TRBCA at the CP and EWP) apply to all activities occurring within the TRBCA including management of dredging, jetty demolition, pile driving, SPW re-drive, TRB/SPW and associated pile removal, intertidal excavation under the South Jetty and engineered capping placement (Section 4.6.1 and Table 4-4).

4.3.1.2 Temporary Re-suspension Barrier Opening

The TRB shall not be opened until the Contractor’s appropriately qualified person has verified and demonstrated to the DR and EM that the criteria for opening the TRB have been met at the IAP. The Contractor’s qualified person is responsible for determining the appropriate turbidity threshold value necessary at the IAP to ensure criteria defined in Table 4-5 are not exceeded at EAP_{25} and ECP.

Performance criteria assessed by the EM at EAP_{25} and ECP following TRB opening are based on results of modelling conducted by Anchor (2014; Appendix 4) using data collected from Phase 2 sediments and established toxicity benchmarks (Golder, 2012b). Contaminant concentrations in under-pier sediment samples were used to estimate corresponding water column concentrations and determine corresponding TSS levels where waters would meet the performance criteria for release from the TRB (Appendix 4; Anchor, 2014).

4.3.1.3 Barge Dewatering

Phase 1B TSS performance criteria, developed by Golder (2012b), were based on a risk-based assessment of potential contaminants (e.g., metals and PAHs) that would desorb from suspended particles after suspension in a barge dewatering modelling assessment (Appendix 5). Phase 1 performance criteria were based on the Phase 1B Project Area and did not include the South Jetty under-pier area. The results of the modelling report for the Phase 2 Work Area (i.e., Sediment Management Area 6 [SMA-6], Dredge Units [DU] 34, 39 and 44 as sampled by Golder based on the 30% design specification DU numbering) indicated that there is no TSS value in barge dewatering effluent at which concentrations of potential contaminants would not pose a risk of acute lethality to fish and other marine life. For this reason, there can be no discharge of dewatered effluent from dredging within the TRBCA outside the TRBCA without treatment. Treated dewatering barge effluent from dredging within the TRBCA may be discharged outside of the TRBCA provided that all barge dewatering performance criteria have been met (Table 4-6).

Notwithstanding the above, passive barge dewatering may occur within the TRBCA provided that performance criteria are maintained outside the TRBCA (Table 4-4). There is to be no passive dewatering from the Hazardous Waste Area and all barge effluent must pass through a filter to decrease TSS prior to release, regardless of the location of discharge.

For contingency re-dredging, dewatering outside of the TRBCA must follow the criteria established for Phase 1B (Appendix 3). Barge dewatering effluent from contingency re-dredging may be discharged within the TRBCA in which case the criteria for dewatering within the TRBCA would apply.

In the event that additives are used to facilitate dewatering of the dredged material, this decanted water must be tested prior to discharge to verify that the added constituents will not be harmful to the receiving environment.

4.3.2 Dissolved Oxygen (DO)

DO analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Oxygen dissolves into water by diffusion from the surrounding air, by aeration (rapid movement) and as a product of photosynthesis (Poppe, 1988). DO is an important component of water that facilitates self-purification and maintenance of aquatic organisms utilizing aerobic respiration. DO levels <5 mg/L can stress organisms while sustained DO levels of <3 mg/L can result in fish kills (USEPA, 2000). Hypoxia (i.e., DO<2 mg/L) increases stress from other factors (e.g., contaminants) on marine organisms, whereas anoxic conditions (i.e., DO<0.1 mg/L) produce toxic hydrogen sulphide (H_2S) which may be lethal to marine biota. In Esquimalt Harbour, DO concentrations ranged from 6.23 mg/L to 7.98 mg/L during fall 2010 assessments. Concentrations were variable between locations and were lower at depth than at the surface (Appendix 2, Table B2; Golder, 2012d).

Dredging of marine sediments may re-suspend sediments with high oxygen demand (e.g., biological or chemical) which can reduce DO concentrations in the water column to harmful levels. The content of DO in water can also be affected by natural processes such as photosynthesis by algal blooms.

DO will be measured *in situ* by the EM (described in EMIP). Real-time data will be used to manage day to day operations and assist in interpreting whether changes in DO are project-related or related to natural processes.

4.3.3 pH

pH is a measure of the hydrogen ion concentration (or acidity) in water reported on a scale from 1 to 14. A pH of 7 is considered neutral. Values lower than 7 are considered acidic, while values higher than 7 are basic (alkaline). Many important chemical and biological reactions are strongly affected by pH. In turn, chemical reactions and biological processes (e.g., photosynthesis and respiration) may also influence pH. When water becomes either too alkaline or acidic, it can become inhospitable to many species of aquatic life. Typical pH values in seawater tend to be slightly alkaline. In fall 2010, pH values of 7.86 to 8.17 pH units were measured in Esquimalt Harbour (Appendix 2, Table B2; Golder, 2012d). Seawater chemistry has the ability to buffer minor changes in hydrogen ion concentration; however, this buffering ability can be overcome when such changes are substantial. pH can also be influenced by natural processes such as photosynthesis during algal blooms, which can result in elevated pH (i.e., > 9.0 pH units).

Contact of water with curing concrete can result in harmful pH levels (i.e., >9.0 pH units); whereas, dredging alone is not likely to result in harmful changes in pH. In addition to direct effects from higher or lower pH. pH changes can also affect the toxicity of other substances (e.g., nutrients).

pH will be measured *in situ* and results will be available daily. Monitoring of pH will be conducted concurrently with construction activities by both the Contractor’s appropriately qualified person (near activities) and EM (at safety perimeter [25 m], ambient and background environment; as described in the EMIP).

4.3.4 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a broad group of compounds present in hydrocarbon products, vessel exhaust and creosote used to treat timber for marine construction (EC, 1994). PAHs may be adsorbed onto sediments and released from those sediments during dredging. Water quality performance criteria for PAHs were established by Golder (2012c) for Phase 1B and were based on lowest available toxicity values for effluents (where applicable) and $1/10^{th}$ of the lowest available toxicity values for ambient conditions. Modelling results indicated the presence of PAH concentrations exceeding established toxicity values for Anthracene, Benz(a)anthracene, Naphthalene and Pyrene (Golder, 2012c); however, during Phase 1B monitoring no PAH exceedances were measured (SLR, 2014).

More recent modelling conducted by Anchor (2014) determined that PAH toxicity levels would be reached at 64 mg/L TSS (34 NTU); however, these values are subject to change based on Phase 2 data.

Water samples are to be collected as indicated in Section 4.3.1 and Tables 4-1 to 4-3 for submission to an analytical laboratory. Analytical sampling by the Contractor’s appropriately qualified person is to be conducted with the objective to establish an appropriate *in situ* relationship between TSS and/or turbidity and PAH concentrations in the enclosed Phase 2 Work Area. PAH analysis can be conducted with a minimum ‘rush’ 24 hour turnaround time (TAT) and will initially be sampled in higher volumes and frequency to establish concentration calibration curves associated with TSS with a concomitant reduction in frequency as reliability increases. Ongoing laboratory results for PAH will be used to provide feedback to dredge and other operations.

Performance criteria for the discharge of metals and PAHs were developed based on research conducted by Golder (2012c). Release criteria were based on the lowest available toxicity endpoints, using LC_{50} concentrations for salmonids, where available. Many of the PAHs listed are not well studied and levels were therefore based on no observed effects levels (NOELs) for the most relevant organisms for which data was available. Ambient criteria were taken from published WQGs (CCME, 2014; BCMOE, 2014) and include a safety factor of 10x. This safety factor was removed to establish meaningful release criteria that if maintained would not constitute the release of a deleterious substance.

4.3.5 Metals

Marine biota require varying amounts of metals (such as copper and zinc) as trace dietary minerals for proper enzyme functionality and cellular respiration. Molluscs and crustaceans use copper to bind oxygen in their blood pigment hemocyanin. Zinc is an essential mineral to all life and has an important role in RNA transcription. Zinc is also a Lewis acid and has an important role in enzyme reactions and carbon dioxide regulation as a catalyst. While at low concentrations these and other metals can be advantageous, high concentrations are toxic due to accumulations in filtration structures.

Marine sediments in the Phase 2 Project Area are expected to be high in copper and zinc (Golder 2012d) and there were exceedances of both copper and zinc during Phase 1B (SLR, 2014). Water samples will be collected by the EM as per Tables 4-1 through 4-3 and submitted to an analytical laboratory for total metals as indicated in Tables 4-1 to 4-3. Metal analysis requires a maximum 24 hour turnaround time and would be used to provide ongoing feedback to the efficient management of dredge operations and water quality performance criteria. Measured concentrations would be related to turbidity and TSS measurements (*in situ* and laboratory) to assess whether performance criteria continue to be protective of marine life and compliance with water quality criteria.

4.3.6 PCBs, TBT & Other Organochlorides

Prior to 1979, polychlorinated biphenyls (PCBs) were manufactured and distributed to a wide market. PCBs were never manufactured in Canada but were widely used until their import, manufacture or sale was banned in 1977. PCB pollution continued in Canada until their release to the environment was banned in 1985. PCBs are classified as persistent organic pollutants (POPs) and are readily absorbed by marine life and bioaccumulate in larger organisms.

Tributyltin (TBT) is a POP that was widely used in marine antifouling paint. TBT has been linked to imposex (development of male genitalia in female organisms) in some gastropods and other molluscs.

Dioxins (TCDDs) and furans (TCDFs) are colourless crystalline solids that are formed as a by-product of herbicide manufacturing, certain bleaching processes previously used in the pulp and paper industry and by-products of combustion. Dioxins and furans can be associated with creosote timber treatment processes and are likely to be found in sediments beneath the South Jetty and released during extraction and dredging. Dioxins and furans are sequestered and accumulate in fatty tissues of animals and are taken up when consuming contaminated food sources (Health Canada, 2005; USEPA, 2011). Dioxins and furans are human carcinogens, they disrupt hormones in humans and animals and exposure at high doses may result in chloracne (Health Canada, 2005; USEPA, 2011).

Given potential concentrations of PCBs, TBT, TCDDs TCDFs in Phase 2 sediments and predictions based on modelling conducted by Anchor for Phase 2 (2014), environmental and project operations should be considerate of the potential for Phase 2 works to liberate and disperse these contaminants. PCBs, TBT, TCDDs and TCDFs are not proposed for regular monitoring, as laboratory assessments of these compounds typically have prolonged turnaround times (relative to metals and PAHs) and are costly. It is expected that these contaminants will co-occur with metals and PAHs within the Project Area and monitoring of metals and PAHs will provide sufficient information regarding potential contaminants for the purposes of day-to-day monitoring.

4.3.7 Underwater Noise

Sound travels through water as pressure waves. Elevated sound pressure levels (SPLs) may cause marine mammals to avoid an area, disrupt echolocation, cause habitat abandonment, mask predators and conspecifics, cause aggression, pup/calf abandonment hearing loss and tissue damage (Vagle, 2003). In a review by the National Ocean and Atmospheric Administration (NOAA, 2013) dual acoustic threshold levels for groups of cetaceans and pinnipeds were proposed based on the behaviour of the source of the sound. Sound sources were defined as impulsive (e.g., impact pile driving and explosions) and non-impulsive (e.g., octave band noise and sonar) as they can result in differing results in the receiving animal. The BC Marine and Pile Driving Contractors Association developed sound specific BMPs for pile driving and related operations.

BMPs for underwater noise are outlined in the EMP (G3, 2014a) and monitoring procedures to ensure compliance with established BMPs are outlined in the EMIP. Based on these BMPs, pressure from underwater noise during pile driving, extraction and related activities should not exceed 30 kPa at a distance of <2 m from the activity or <2 m from the TRB (30 kPa is typically specified in authorizations issued by DFO). The Contractor will monitor sound within 2 m of the activity generating the noise and PWGSC's EM will monitor outside the TRBCA at the safest point closest to the noise generating activity (no closer than 25 m to an active area) with hydrophones as appropriate. Exceedances may require the contractor to implement additional mitigation techniques, as outlined in the EMP (including modification to activities; G3, 2014a).

4.4 Phase 2 Monitoring Schedule

The PWGSC designated EM will collect samples and conduct *in* situ profiling as outlined in Tables 4-1 to 4-3. Analytical results will be used by the EM to validate the modelled TSS/turbidity relationship and modelled metal and PAH toxicity correlations to TSS (Appendix 4).

A higher frequency of monitoring (Tables 4-1 to 4-3) will occur at the beginning of each operation (e.g., structure demolition, dredging, initial TRB opening, placement of engineered capping materials, contingency re-dredging/residuals management cover placement). Monitoring frequency may be progressively reduced over the first few weeks if water quality performance criteria are consistently met. If an exceedance is observed during any stage of the Project, the frequency of laboratory sample submission may increase (in accordance with Tables 4-1 to 4-9) until the issue has been addressed and results indicate compliance with water quality criteria. The management of day-to-day Project activities will rely on both *in situ* monitoring and analytical results.

In addition to activity specific monitoring, NFR (i.e., ambient) and FFR (i.e., background) samples will be collected outside of the area of project influence to obtain appropriate comparative reference measurements. Non-project related activities with potential to directly affect monitoring results need to be identified and accounted for in Project monitoring results (e.g., harbour activity, hydrological conditions, vessels berthing at EGD, etc.). The EM will adjust sampling plans, as required, to ensure that current ambient conditions are accurately considered when water quality performance criteria are assessed.

The Contractor and their appropriately qualified person are responsible for any quality assurance sampling which may be required and the EM is responsible for quality control sampling. The Contractor must report all data (for any purpose) to PWGSC in weekly reports.

4.5 Pre- & Post- Monitoring

Ambient (i.e., within the Constance Cove Discretionary Cetacean Safety Zone, no closer than 100 m to the TRB) and background (i.e., within Esquimalt Harbour, outside of Constance Cove) monitoring of POPs should be conducted as part of Phase 2 works. Baseline conditions should be established prior to commencement of in-water works and again following completion of Phase 2 works to establish baseline POP levels in the area prior to Project works occurring and to verify that POPs did not transit from the Phase 2 Project Area to surrounding areas.

Pre/post monitoring should be undertaken as a due diligence measure to evaluate potential releases of contamination through the course of regular dredging, TRB opening, potential reduced TRB function or failure and removal of the TRB and SPW at the end of the project. Monitoring should continue until concentrations have been demonstrated to be consistent with ambient conditions.

Table 4-1: Sampling Frequency for Regular Monitoring

Monitoring Station	Location of Sample	Resp Party [4]	Sample Collection	Initial Sampling Frequency (Week 1) [1]	Reduced Sampling Frequency (Weeks 2-3) [1, 2]	Further Reduced Sampling Frequency (Weeks 4 +) [2]
Early Warning Point (EWP)	One (1) location As close to the active dredge as possible, on the outside of the TRB, not within 25 m of any active equipment or the TRB	EM	*In situ* water column profiling Grab samples collected from three (3) depths[3] and coinciding with periods of peak dredge activity	*In situ* monitoring daily and at time of sample collection All samples collected and submitted daily for 'RUSH' analysis for TSS, turbidity, pH, metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection All samples collected daily. Submitted for analysis for TSS, turbidity, pH, metals and PAHs (total) once every three (3) days with remaining samples archived and tested in the event of an exceedance	*In situ* monitoring daily and at time of sample collection All samples collected for three (3) consecutive days each week. Submitted for analysis for TSS, turbidity, pH, metals and PAHs (total) once per week with remaining samples archived and tested in the event of an exceedance
Compliance Point(s) (CP)	Three (3) locations 100 m from the outer edge of the TRB [7]	EM	*In situ* water column profiling Grab samples collected from three (3) depths[3] at each CP	*In situ* monitoring daily and at time of sample collection All samples collected daily. Submitted daily for 'RUSH' analysis of TSS, turbidity and pH, 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection All samples collected once every three (3) days. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection All samples collected once per week. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)
Near Field Reference (Ambient) (NFR)	Two (2) locations Constance Cove Ambient Conditions >100 m from the outer edge of the TRB within the 500 m Discretionary Cetacean Zone	EM	*In situ* water column profiling Grab samples collected from three (3) depths[3]	*In situ* monitoring daily and at time of sample collection Samples collected three (3) days per week. Submitted daily for 'RUSH' analysis of TSS, turbidity and pH, 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection Samples collected once every three (3) days. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection Samples collected once per week. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)
Far Field Reference (Background) [5] (FFR)	One (1) location Esquimalt Harbour background conditions beyond the 500 m Discretionary Cetacean Zone	EM	*In situ* water column profiling Grab samples collected from three (3) depths[3]	*In situ* monitoring daily and at time of sample collection Samples collected three (3) days per week. Submitted daily for 'RUSH' analysis of TSS, turbidity and pH, 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection Samples collected once every three (3) days. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)	*In situ* monitoring daily and at time of sample collection Samples collected once per week. Submitted for TSS, turbidity and pH (standard TAT), 50% of samples tested for metals and PAHs (total)
Discretionary Sampling [6]	Additional sampling conducted if a visual plume of turbidity is observed	EM	Discretionary	Discretionary	Discretionary	Discretionary

CP – Compliance Point; EM – Environmental Monitor; EWP – Early Warning Point; FFR – Far-Field Reference; NA – not applicable; NFR – Near-Field Reference; PAH – Polycyclic Aromatic Hydrocarbon; TAT – Turnaround Time; TRB – Temporary Re-suspension Barrier; TSS – Total Suspended Solids

Notes:

(1) Sampling frequency may be reduced if site has been active for at least one (1) week and compliance point water quality performance criteria have been met for the three most recent samplings or with agreement of DR. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 5) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.

(2) Sampling frequency may increase to daily if water quality performance criteria are not met or with agreement of DR. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 5) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.

(3) Water samples collected at 1 m below surface (depth "A"), mid-water column (depth "B") and 2 m above seafloor (depth "C").

(4) PWGSC Designated Environmental Monitor (EM) is responsible for Quality Control sampling. Any Quality Assurance sampling which may be required is the responsibility of the Contractor and their retained appropriately qualified person.

(5) FFR (background) is to be used in comparison if/when NFR (ambient) conditions are confounded by vessel activity.

(6) DR must be notified of discretionary sampling prior to it occurring.

(7) The first CP should be located perpendicular to the activity occurring within the TRBCA with the second CP between 25 m and 100 m (at discretion of EM based on depth of entrainment) upcurrent from the first CP (still 100 m away from the TRB) and the third CP 25 m to 100 m (at discretion of EM based on depth of entrainment) downcurrent from the first CP (still 100 m away from the TRB). See Appendix 1, Figures A6 and A7 for conceptual layouts.

Table 4-2: TRB Opening Water Quality Criteria Compliance Sampling

Monitoring Station	Location of Sample	Responsible Party	Sample Collection	Initial Laboratory TAT (Week 1-3) [1]	Reduced Laboratory TAT (Weeks 4 +) [1, 2]
Interior Assessment Point (IAP)	At least one (1) location Point inside the TRB closest to the opening	Contractor's appropriately qualified person [5]	To be determined by Contractor's appropriately qualified person	To be determined by Contractor's appropriately qualified person	To be determined by Contractor's appropriately qualified person
Exterior Assessment Point (25 m; EAP_{25})	One (1) location Point 25 m from the opening of the TRB down gradient of prevailing current	EM	*In situ* water column profiling Grab samples collected from three (3) depths [4]	All samples collected and submitted following each opening [3, 8] of the TRB for RUSH analysis for TSS, turbidity, pH, metals and PAHs (total)	All samples collected and submitted following each opening [3, 8] of the TRB for standard TAT analysis for TSS, turbidity, pH, metals and PAHs (total)
Exterior Compliance Point (ECP)	One (1) location Point 100 m from the opening of the TRB down gradient of prevailing current	EM	*In situ* water column profiling Grab samples collected from three (3) depths [4]	All samples collected and submitted following each opening [3, 8] of the TRB for RUSH analysis for TSS, turbidity, pH, metals and PAHs (total)	All samples collected and submitted following each opening [3, 8] of the TRB for standard TAT analysis for TSS, turbidity, pH, metals and PAHs (total)
Near Field Reference (Ambient) (NFR)	Two (2) locations Constance Cove Ambient Conditions >100 m from the outer edge of the TRB within the 500 m Discretionary Cetacean Zone	EM	Sample collection conducted during regular monitoring. No additional collections proposed	NA	NA
Far Field Reference (Background) [6] (FFR)	One (1) location Esquimalt Harbour background conditions beyond the 500m Discretionary Cetacean Zone	EM	Sample collection conducted during regular monitoring. No additional collections proposed	NA	NA
Discretionary Sampling [7]	Additional discretionary sampling will be conducted if a visual plume of turbidity observed. Samples will only be collected beyond 25 m from the TRB to assist in contaminant tracking.	EM	Discretionary	Discretionary	Discretionary

EAP_{25} – Exterior Assessment Point (25 m from opening); ECP – Exterior Compliance Point; EM – Environmental Monitor; FFR – Far-Field Reference; IAP – Interior Assessment Point; NA – not applicable; NFR – Near-Field Reference; PAH – Polycyclic Aromatic Hydrocarbon; POD – Point of Discharge; TAT – Turnaround Time; TRB – Temporary Re-suspension Barrier; TSS – Total Suspended Solids

Notes:

- Opening of the TRB for new activities (e.g., demolition, dredging) restarts the Laboratory Turnaround Time.

(1) Sampling TAT may be reduced if all Exterior Assessment Point and Exterior Compliance Point Water Quality Performance Criteria are met for three (3) consecutive weeks or three (3) consecutive measurements. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 6) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.

(2) Sampling frequency may need to be increased if Exterior Assessment Point and Exterior Compliance Point Water Quality Performance Criteria are not met. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 6) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.

(3) Multiple TRB openings within a short period of time (e.g., one hour) would constitute a single event

(4) Water samples shall be collected at a 1 m below surface (depth "A"), mid-water column (depth "B"), and 2 m above seafloor (depth "C").

(5) PWGSC Designated Environmental Monitor (EM) is responsible for Quality Control sampling; Contractor to collect samples for submission to EM for Quality Control testing. Any other Quality Assurance sampling which may be required is the responsibility of the Contractor and their retained appropriately qualified person.

(6) FFR (background) is to be used in comparison if/when NFR (ambient) conditions are confounded by vessel activity.
(7) DR must be notified of discretionary sampling prior to it occurring.
(8) TRB is to be opened and closed as soon as possible to enable vessel transit in or out of the TRBCA to minimize the discharge of potential contaminants out of the TRBCA. If TRB is to be opened for extended periods of time sampling will occur while the TRB is open (sampling frequency to be based on length of time the TRB will be open) in addition to after it has been closed.

Table 4-3: Barge Dewatering Effluent Compliance Monitoring

Monitoring Station	Location of Sample	Resp [5] Party	Sample Collection	Initial Sampling Frequency (Week 1) [1]	Reduced Sampling Frequency (Weeks 2-3) [1, 2]	Further Reduced Sampling Frequency (Weeks 4 +) [2]
Final Whole Effluent	One (1) location Treatment Barge	EM	Grab whole final effluent immediately prior to discharge [3]	All samples collected and submitted daily for 'RUSH' analysis for TSS, turbidity, pH, metals and PAHs (total)	All samples collected daily. Submitted for analysis for TSS, turbidity, pH, metals and PAHs (total) once every three (3) days with remaining samples archived and tested in the event of an exceedance.	All samples collected for three (3) consecutive days each week. Submitted for analysis for TSS, turbidity, pH, metals and PAHs (total) once per week with remaining samples archived and tested in the event of an exceedance.
Dilution Zone Compliance Point (DZCP)	Three (3) locations 100 m from the point of discharge (POD)	EM	*In situ* water column profiling Samples collected from three (3) depths[4] at each CP	*In situ* profiling at time of sample collection. All samples collected daily. Submitted for TSS, turbidity and pH at RUSH, 50%of samples tested for metals and PAHs (total)	*In situ* profiling at time of sample collection. All samples collected once every three (3) days. Submitted for TSS, turbidity and pH (standard TAT), 50%of samples tested for metals and PAHs (total)	*In situ* profiling at time of sample collection. All samples collected once per week. Submitted for TSS, turbidity and pH (standard TAT), 50%of samples tested for metals and PAHs (total)
Near Field Reference (Ambient) (NFR)	Two (2) locations Constance Cove Ambient Conditions >100 m from the outer edge of the TRB within the Discretionary Cetacean Zone	EM	Sample collection conducted during regular monitoring. No additional collections proposed.	NA	NA	NA
Far Field Reference (Background) [6] (FFR)	One (1) location Esquimalt Harbour background conditions beyond the Discretionary Cetacean Zone	EM	Sample collection conducted during regular monitoring. No additional collections proposed.	NA	NA	NA
Discretionary Sampling [7]	Additional discretionary sampling will be conducted if a visual plume of turbidity observed	EM	Discretionary	Discretionary	Discretionary	Discretionary

DZCP – Dilution Zone Compliance Point; FFR – Far-Field Reference; NA – not applicable; NFR – Near-Field Reference; POD – Point of Discharge; TAT – Turnaround Time; TRB – Temporary Re-suspension Barrier; TSS – Total Suspended Solids

Notes:

(1) Sampling frequency may be reduced if all DZCP water quality performance criteria are met for two (2) consecutive weeks or three (3) consecutive measurements. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 6) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.
(2) Sampling frequency may be increased if DZCP water quality performance criteria are not met. If criteria for a parameter is exceeded at NFR (ambient; or FFR [background], see note 6) and the exceedance is unrelated to project operations, as assessed by the EM or DR, it may be omitted from evaluation of results for decreasing the sampling frequency at the discretion of the DR and EM.
(3) There is to be no discharge without treatment outside of the TRBCA. Passive dewatering may occur within the TRBCA if water quality performance criteria outside the TRBCA are maintained (Table 4-4).
(4) Water samples shall be collected at 1 m below surface (depth "A"), mid-water column (depth "B"), and 2 m above seafloor (depth "C").
(5) PWGSC Designated Environmental Monitor (EM) is responsible for Quality Control sampling. Any Quality Assurance sampling which may be required is the responsibility of the Contractor and their retained appropriately qualified person.
(6) FFR (background) is to be used in comparison if/when NFR (ambient) conditions are confounded by vessel activity.
(7) DR must be notified of discretionary sampling prior to it occurring.

4.6 Decision Frameworks

Specific parameters and points of compliance are generally determined by agreement at the project level through the process of environmental review and consultation with responsible regulatory agencies to meet the general provisions of the environmental statutes. The decision criteria and management actions provided in this section have been designed to provide continuous feedback for day-to-day management of project works and are based on conservative endpoint values measured at appropriate distances from Phase 2 Work Area activities.

For the purposes of Phase 2 of the Project, site-specific performance criteria for select parameters were designated to protect aquatic systems and guide management actions as deemed appropriate. Exceedances of performance criteria at the following stations may result in management actions (e.g., modified dredge frequency, modified performance criteria, TRB inspection/maintenance, re-evaluation of performance criteria and other actions determined by the DR with input from the EM and Contractor):

- Early Warning Point (EWP) for general and dredging activities;
- Exterior Assessment Point (EAP_{25}) for the TRB opening activities;
- Interior Assessment Point (IAP) to assess if the TRB can be opened under current conditions; and,
- Dewatering barge whole effluent to assess suitability prior to discharge.

Sites at 100 m from project activities were established to monitor for exceedances that will result in management actions, including temporary work stoppage, modification of activities or modification to timing of activities, to reduce the risk of Project activities generating potentially harmful conditions in the receiving environment:

- Compliance Point (CP) 100 m from the edge of the TRB for general and dredging activities;
- Exterior Compliance Point at 100 m (ECP) for TRB opening activities; and,
- Dilution Zone Compliance Point (DZCP) for barge dewatering final effluent discharge.

Day-to-day activities will be managed on the basis of *in situ* and laboratory results. The TSS/turbidity relationship and corresponding turbidity performance criteria are subject to change, at any time, based on field and laboratory results. Phase 1 design work conducted by Golder (2012d) determined that Water Quality Management Area A (WQMA-A; the area that contains the Phase 2 Work Site), and more specifically Sediment Management Area 6 (SMA-6; the area of focus in Phase 2) was high in metals and/or PAH concentrations relative to the majority of other areas in Phase 1.

Water quality performance criteria for activities in Phase 2 are provided in Tables 4-4 through 4-9. In all cases where water quality is assessed relative to ambient conditions, ambient is defined as the surrounding area of Constance Cove (measured at the Near-Field Reference location [NFR]).

4.6.1 Decision Framework for Activities Enclosed within the Temporary Re-suspension Barrier Containment Area (TRBCA)

The decision framework for implementing management actions during activities within the TRBCA (e.g., dredging) was designed to allow for adaptive management procedures responsive to environmental protection goals without unnecessary disruption to operational needs of the Project. Enclosed activities have four (4) sampling locations used to assess TRB performance and adherence to the water quality performance criteria: the Early Warning Point (EWP); and, three Compliance Points (CPs). These monitoring locations are compared to ambient (Constance Cove specific Near-Field Reference; NFR) and background (Esquimalt Harbour, general Far-Field Reference; FFR) reference points (Table 4-4 and Appendix 1, Figures A6 and A7). Far-field reference is to be used in comparison if/when NFR (ambient) conditions are confounded (e.g., vessel activity) and identify system-wide events that may not be related to specific activities within Constance Cove. Performance criteria were selected to enable early detection of defects or reduced/ineffective operation of the TRB or sheet pile wall.

The daily decision making framework for activities occurring within the TRBCA is illustrated in Figure A4 (Appendix 1). The steps are as follows:

1. through the course of regular monitoring the PWGSC EM will collect water samples and assess turbidity and other *in situ* water quality measurements using a multi-parameter *in situ* meter (Sonde) at each monitoring location (i.e., EWP, CPs [3], NFR [2] and FFR);
2. EM will estimate TSS concentration (mg/L) from *in situ* turbidity using a calibrated model specific to Phase 2 (initially following the model developed by Anchor, 2014 [Appendix 4]) to assess if suspended sediments from within the TRBCA may be exiting the worksite and determine if induced TSS is influenced by Project conditions relative to ambient water quality;
3. in the event that any water quality parameter exceeds the water quality criteria at any monitoring location (i.e., EWP, CPs; Table 4-4), then the EM is to:
   a) notify DR of exceedance;
   b) for *in situ* monitoring, immediately re-take measurement to ensure exceedance was not related to instrumentation error;
   c) proceed with confirmatory sampling as soon as possible. For *in situ* measurements the instrument should be re-calibrated and the site re-tested; this may take up to 3 hours as all sites would require additional *in situ* measurements. Confirmatory measurements will be made and/or samples collected at three (3) depths at the NFR and monitoring station(s) where the exceedance(s) was noted;
4. following confirmatory sampling, if the exceedance is confirmed, the EM will notify the DR and assess if the exceedance is a result of EGD or DND activity (e.g., propwash). The need for management action(s) will be evaluated and courses of action discussed;
5. management actions (e.g., changes to dredge operations, adjustment/repair of TRB) must then be implemented by the Contractor as required;
6. following management actions (and an appropriate passage of time as assessed by the EM based on the incident and activities involved), applicable water quality stations will be re-assessed to determine if the issue has been resolved;
7. if no further exceedances are detected, monitoring will revert to the regular monitoring schedule; however, if:
   a) the original issue has been detected at EWP and has spread further to CP, the EM will confirm the finding then notify the DR and proceed with the appropriate pathway as per Step 4;
   b) the original issue detected at the EWP remains an issue after confirmatory sampling and has not spread to CP the EM will notify the DR and proceed with appropriate pathway as per Step 4; and/or,
   c) the issue as previously detected at CP remains an issue after confirmatory testing, despite management actions, the EM must notify the DR and further management actions including a stop work order and/or change in activity(s) will be implemented until the problem is resolved through corrective actions;

8. if a stop work order is issued, following the cessation of activity, the Contractor shall implement any corrective actions determined to be necessary by the EM and/or DR. Once in place these actions must be inspected and approved by the DR and EM (if applicable). Work may resume once the water quality performance criteria have been met at the CP(s) with increased monitoring frequency (per Table 4-1).

4.6.2 Decision Framework for TRB Opening

Specific performance criteria for opening the TRB to permit vessel and equipment to transit was modelled by Anchor (2014; Appendix 4) based on concentrations of metals and PAHs that would meet or exceed established water quality guidelines (Table 4-5) within 100 m of the TRB opening and not result in serious harm to organisms at any point outside of the TRB.

Opening of the TRB will be at the discretion of the Contractor, based on turbidity monitoring conducted by the Contractor's appropriately qualified person at the Interior Assessment Point (IAP). The Contractor must provide evidence to the DR and EM that TRB opening criteria have been appropriately calculated and that the criteria are met at the IAP prior to opening the TRB.

The decision framework for opening the TRB includes frequent feedback processes to enable adaptive management of activities responsive to environmental protection goals without unnecessary disruption to the operational needs of the Project and is summarized in Figure A-5 (Appendix 1).

For TRB opening, water quality performance criteria would be evaluated at three (3) points:

1. Interior Assessment Point (IAP): monitoring conducted by Contractor's appointed appropriately qualified person prior to opening the TRB based on the methodology and criteria the developed by the appropriately qualified person;
2. Exterior Assessment Point (EAP_{25}): monitoring conducted by PWGSC's designated EM prior to and following each opening of the TRB; and,
3. Exterior Compliance Point (ECP): monitoring conducted by PWGSC's designated EM prior to and following each opening of the TRB.

The framework for TRB opening activities is illustrated in Figure A5 (Appendix 1). The steps are as follows:

1. Contractor will notify the EM by 14:00 h the day before of their intention open the TRB such that the EM can ensure that monitoring personnel and supplies are in place. If opening is to be daily or routine, this should be scheduled with the DR and EM;
2. EM will assess conditions at NFR to establish ambient TSS/turbidity concentrations (if not already available as part of other Project monitoring), collect water samples at the EAP_{25} and ECP and notify the DR (to relay to the Contractor) if any adjustments to the TSS/turbidity criteria are necessary based on exterior turbidity;
3. Contractor's appropriately qualified person, using their IAP criteria, will assess conditions at the IAP and notify the DR and EM if the IAP is compliant;
4. Contractor is to notify the EM and DR of their intent to open the TRB and will establish an appropriate Activity Zone (AZ) around the TRB opening and ensure that all non-Contractor personnel have exited the AZ prior to opening the TRB and related vessel activity. As soon as practical, the Contractor will close the TRB;
5. Contractor will ensure that the EGD Work Site outside of the TRB opening is safe for the EM to enter and conduct sampling and notify the EM when it is safe to conduct compliance monitoring;
6. EM will assess *in situ* water quality after the TRB has been re-closed at the EAP_{25}, ECP and NFR and collect samples at three (3) depths at each station (Tables 4-8);
7. EM will review the data when available to determine if contaminants had been released in quantities above the modelled scenario at 25 m and/or exceeded water quality criteria at 100 m and provide the results in a data summary report to the DR;

8. if criteria are exceeded at ECP the DR must be notified and management actions taken to prevent exceedances at the next TRB opening. If criteria are exceeded at EAP_{25} no management actions are necessary; however, the EM must still notify the DR of the exceedance (who will notify the Contractor);
9. the criteria for TRB opening must be re-assessed by the EM, DR and Contractor after an exceedance at any location; and,
10. prior to next TRB opening the Contractor or Contractor's appropriately qualified person must demonstrate to the DR and EM that actions have been taken to prevent another exceedance.

Note: The TRB is to be opened and closed as soon as possible to facilitate vessel passage in or out of the TRBCA to minimize any discharge of potential contaminants out of the TRBCA. If TRB is to be opened for extended periods of time sampling will occur while the TRB is open (sampling frequency to be based on length of time the TRB will be open) in addition to after it has been closed.

4.6.3 Decision Framework for Barge Dewatering

Passive (direct) dewatering of sediment, dredged within or outside (contingency re-dredging) the TRBCA, may occur only within the TRBCA and only if water quality performance criteria can be maintained outside the TRBCA (Table 4-4). At no time is there to be passive dewatering from the Hazardous Waste Area. All effluent from the Hazardous Waste Area must be treated and may only be released if water quality criteria for barge dewatering are met and demonstrated to the DR and EM.

No direct discharge from a barge loaded with sediments collected from the Phase 2 Work Area will occur outside the TRBCA without treatment and only if the effluent meets the criteria outlined in Table 4-6. Effluent does not have to be held for laboratory results if capabilities of the treatment barge are demonstrated to the DR and EM to meet the dewatering performance criteria by design.

To demonstrate compliance of barge discharge to water quality criteria, whole effluent will be collected prior to discharge and a sample collected at a point 100 m down gradient from the point of discharge (POD; defined as the end of pipe of the dewatering barge). If dewatered barge effluent does not meet the performance criteria within 100 m of the point of discharge, the EM will notify the DR. Management actions will be considered, including decreasing the performance criteria for discharge and ceasing discharge.

During contingency re-dredging within the TRBCA passive dewatering may occur within the TRBCA if effluent meets criteria specified for outside the TRBCA (Table 4-4) as most of the area would be considered remediated.

During contingency re-dredging outside the TRBCA dewatering outside the TRBCA may occur if effluent meets all Phase 1B water quality performance criteria for discharge of barge effluent (Appendix 3). If water quality performance criteria cannot be met effluent is to be treated to meet criteria or collected and stored for off-site treatment and/or disposal.

Water quality criteria established for work within the TRBCA (Section 4.6.1) are based on BCMOE (2014) criteria using ambient levels outside the TRBCA whereas contingency re-dredging (Section 4.6.6), associated de-watering and residuals management cover (RMC) placement (Section 4.6.5) outside the TRBCA are subject to criteria developed during Phase 1B operations. The two sets of criteria are based on the potential risk associated with each activity. Criteria for work occurring within the TRBCA are conservative and designed to assess and ensure the effectiveness of the TRB and SPW as potentially high levels of contamination could occur within the TRBCA. The BCMOE (2014) criteria account for conditions in the surrounding ambient environment (near-field reference) at the time of monitoring and were adopted for this situation as confounding ambient conditions may limit the ability to detect materials escaping from within the TRBCA.

Conditions under which contingency re-dredging and RMC placement outside of the TRBCA would be occurring have lower risk as area was previously remediated during Phase 1B. As this is an open water area, containment of suspended material is more challenging. Based on the findings from Phase 1B, TSS and turbidity levels in the open water area are likely to be greater than what can be expected for outside the TRBCA during the enclosed Phase 2 work.

There is to be no dewatering during transport.

4.6.4 Decision Framework for Demolition

During the demolition of the South Jetty the EM will conduct inspections of any activities and/or equipment specified in the EMP to ensure BMPs are being followed and conduct visual observations to determine if materials generated from the demolition activities have the potential to enter surrounding waters either directly or indirectly. Contractor operations should not permit any materials generated from demolition to enter any waterway outside the criteria stipulated in this WQMP and the EMP. If inspections by the EM indicate that materials are being deposited in a watercourse, the EM will communicate with the DR and the Contractor may be required to develop mitigation measures or actions to prevent further deposition of materials. Any agreed upon mitigation measures or decisions will be provided to the DR in writing by the EM or Contractor.

During demolition and any in-water activities, the EM will conduct underwater acoustic monitoring to ensure that sound pressure levels resulting from pile driving and other demolition activities are within the criteria outlined in the EMP (G3, 2014a). If inspections, conducted by the EM indicate that sound pressure levels exceed the required maximums the EM will notify the DR and management actions will be implemented. Any agreed upon mitigation measures or decisions will be provided to the DR in writing by the EM or Contractor.

4.6.5 Decision Framework for Material Placement

During placement of engineered capping materials within the TRBCA, the EM will conduct “regular monitoring” at the EWP and CPs, as described in Section 4.2.1 and Figures A6 or A7 (Appendix 1) based on barge location. The decision framework for *in situ* monitoring will be followed during placement of engineered capping materials (Appendix 1, Figure A4).

For placement of residuals management cover outside of the TRBCA, the monitoring framework and criteria for Phase 1B (Section 4.2.4 and Decision Framework 3.2.1 in the Phase 1B WQMP [Golder, 2012c], provided in Appendix 3) must be followed. At the DR’s discretion, performance criteria may be re-evaluated to account for differential toxicity of suspended sediments associated with clean capping material relative to removed contaminated sediments.

4.6.6 Decision Framework for Contingency Re-dredging

Contingency re-dredging may be required within the TRBCA or in open-water areas recontaminated by TRB failure, TRB opening or TRB/SPW removal. During contingency re-dredging inside the TRBCA, the decision framework for *in situ* monitoring (Section 4.6.1; Appendix 1, Figure A4), monitoring locations (Appendix 1, Figures A6 or A7 based on the location of the barge) and performance criteria (Table 4-4) should be followed. Barge dewatering for contingency re-dredging within the TRBCA must follow the framework outlined in Section 4.6.3.

For contingency re-dredging outside the TRBCA, the open-water dredging decision framework and criteria and barge dewatering criteria, outlined in the Phase 1B Water Quality Monitoring Plan, should be followed (Appendix 3; Golder 2012c).

4.6.7 Decision Framework for Concrete Works

Whenever concrete work is occurring near an aquatic environment there is potential for changes to the pH of surrounding waters. The normal range of pH in the marine environment is 7.0 to 8.7 pH units (BCMOE, 2014).

During concrete works, the Contractor will monitor the pH of waters immediately adjacent to the wet or curing concrete with a calibrated, submersible pH probe. To prevent unnecessary work stoppages, the probe should be able to report to two decimals places. Monitoring should be conducted:

- continuously while concrete is being poured;
- one hour after pouring has completed;
- four hours after pouring has completed; and,
- twice daily thereafter, for 72 hours or until concrete has cured.

Probes should be calibrated once every 12 hours, or as necessary, to ensure accuracy and prevent unnecessary work stoppages. The PWGSC designated EM will monitor *in situ* water quality at a safe distance (i.e., approximately 25 m) from active equipment, as deemed necessary and appropriate.

If pH in adjacent waters is found to exceed 8.7 or at any point >0.5 pH units above measured ambient conditions the Contractor will immediately notify the DR and undertake mitigation measures to prevent further release of concrete and implement mitigation measures until pH is within the acceptable range. Appropriate management actions will then be taken for source control (i.e., proper sealing of pipe or delivery system, plugging of catch basins, collection of wash water, etc.).

4.6.8 Decision Framework for Storm Sewer & Wastewater Discharge at the EGD Work Site

Storm sewers should be protected from deleterious materials including concrete containing wash water, chemical spills, sediment-laden water and other potentially deleterious materials. The EM will inspect erosion and sediment control BMPs prescribed by the EMP and Contractor's EPP.

Wastewater is defined as waters produced from construction activities and personal hygiene and decontamination facilities on-site and excludes barge dewatering effluent. Wastewater from personal hygiene/decontamination facilities is not to be discharged on-site and it must be disposed of off-site at a permitted Wastewater Treatment/Disposal Facility. Wastewater produced at the Work Site (e.g., equipment decontamination wastewater) must be collected and tested prior to release to ensure water quality criteria will be met based on discharge location. If criteria cannot be met water is to be transported to an approved Wastewater Treatment Facility.

The EM will monitor storm sewer and wastewater discharge points within the Work Site to the receiving environment, where accessible (i.e., not discharging within the TRBCA) to ensure that water quality performance criteria (Table 4-4) are being met. For discharge within the TRBCA it must be ensured that water quality performance criteria outside the TRBCA are maintained (Table 4-4). After dredging within the TRBCA is completed and approved by the DR any discharge into the TRBCA must meet the criteria specified for outside the TRBCA (Table 4-4) as the area would be considered remediated. Any deficiencies will be included in the inspection report and submitted in writing to the DR and Contractor.

In the event of any exceedances or there is a visible sheen, the EM will immediately notify the DR and perform confirmatory sampling, including water entering storm sewers. The EM, DR and Contractor will assess the source and area of exceedance and determine if management actions (e.g., barriers around storm sewers, containment of contaminant source such as concrete run-off) or emergency spill response is required. Specific field forms associated with spill response and reporting are provided in the EMIP.

4.6.9 Decision Framework for TRB/SPW Removal and/or Relocation

The Contractor will notify the EM of their intention to remove or relocate the TRB and/or SPW in advance of planned activities. The Contractor will establish a safe working area within the TRBCA for the EM to conduct water sampling (can occur concurrently with PWGSC sampling activities to ensure completion of work). The EM will assess interior water quality *in situ* and collect 4 to 6 samples which will be submitted to the laboratory for analysis ('rush' turnaround time) and compared to criteria stipulated in Table 4-7. Based on laboratory results, the EM will notify the DR if interior water quality is sufficient for removal of the TRB and/or SPW. Criteria were established to ensure that water quality conditions within the TRBCA are comparable to those outside the TRBCA and within Constance Cove prior to TRB/SPW removal.

During TRB/SPW and support pile removal, the EM will conduct underwater acoustic monitoring to ensure that sound pressure levels resulting from pile removal and other underwater activities are within the criteria outlined in the EMP (G3, 2014a). If inspections, conducted by the EM indicate that sound pressure levels exceed the required maximums the EM will notify the DR and management actions will be implemented. Any agreed upon mitigation measures or decisions will be provided to the DR in writing by the EM or Contractor.

For removing the TRB/SPW and support piles the water quality criteria that apply are the same as those for activities occurring within the TRBCA (Table 4-4) and the Decision Framework for Activities within the TRBCA would be followed (Section 4.6.1), with monitoring locations being 25 m (EAP_{25}) and 100 m (ECP) from the activity that is occurring rather than the TRB or barge.

4.7 Water Quality Performance Criteria

Table 4-4: Water Quality Performance Criteria Activities within the TRBCA[1]

Parameter	Early Warning Point (EWP) (25 m outside of TRB)	Compliance Point (CP) (100 m from TRB)
Total Suspended Solids (mg/L)	<5 mg/L over NFR when NFR is between 0-25 mg/L [2,3] <10 mg/L over NFR when NFR is ≤100 mg/L [2,3] Increase of <10% over NFR when NFR is >100 mg/L [2,3] TSS exceedances at the EWP correlated with Project activities within the TRBCA may result in management actions to better contain silt.	<5 mg/L over NFR when NFR is between 0-25 mg/L [2,3] <10 mg/L over NFR when NFR is ≤100 mg/L [2,3] Increase of <10% over NFR when NFR is >100 mg/L [2,3] TSS exceedances at the CP correlated with Project activities within the TRBCA may result in work stoppage until the problem has been addressed.
Turbidity [4] (NTU)	Maximum increase of 8 NTU over NFR [4] for a short-term exposure (e.g. <24 hours) and 2 NTU for longer term exposure (e.g. 30 day) when NFR turbidity is <8 NTU Maximum increase of the greater of 8 NTU or 10% over NFR when NFR Turbidity is >8 NTU	Maximum increase of 8 NTU over NFR [4] for a short-term exposure (e.g. 24 hours) and 2 NTU for longer term exposure (e.g. 30 day) when NFR turbidity is <8 NTU Maximum increase of the greater of 8 NTU or 10% over NFR when NFR turbidity is >8 NTU
Dissolved Oxygen (mg/L) [5]	Instantaneous minimum (acute): 5 mg/L Mean concentration (chronic): 8 mg/L	Instantaneous minimum (acute): 5 mg/L Mean concentration (chronic): 8 mg/L
pH [2,6]	7.0-8.7 pH exceedances at the EWP correlated with Project activities would require corrective actions by the contractor	7.0-8.7 pH exceedances at the CP correlated with Project activities would require corrective actions by the contractor
Metals – various (mg/L)	See 'Release Criteria' in Table 4-8	See 'Compliance Criteria' in Table 4-8
PAHs – various (µg/L)	See 'Release Criteria' in Table 4-9	See 'Compliance Criteria' in Table 4-9

CP – Compliance Point; mg/L – milligrams per litre; µg/L – micrograms per litre; NFR – Near-Field Reference; NTU – nephelometric turbidity units; EWP – Early Warning Point; TRB – Temporary Re-suspension Barrier; TSS – Total Suspended Solids.

Notes:

- Refer to Figure A4 (Appendix 1) for decision-making framework for exceedances of water quality performance criteria for *in situ* monitoring.

(1) Includes sheet pile wall re-drive and removal, TRB removal, TRB support pile installation and removal.
(2) Based on *Canadian Environmental Quality Guidelines Water Quality for the Protection of Aquatic Life Marine* (CCME, 2014).
(3) Based on BCMOE *Ambient Water Quality Guidelines for Marine Turbidity, Benthic and Suspended Sediments* (BCMOE, 2014).
(4) Turbidity is to be used as an *in situ* approximation of TSS. The TSS/turbidity relationship will be evaluated and adjusted as necessary based on samples collected in the field. The interim values presented in this table should be used unless values are adjusted from field data. The baseline monitoring program indicated that ambient turbidity in Esquimalt Harbour is relatively low (mean = 3.8 NTU; Golder, 2012c); however, intermittent increases to 400 NTU were observed related to vessel operations and storm events. Turbidity will be evaluated for the Project as induced turbidity above ambient as measured at the time of sampling per Golder (2012c) and SLR (2013).
(5) Based on BCMOE *Ambient Water Quality Guidelines for Marine Dissolved Oxygen* (BCMOE, 2014).
(6) The range of pH specified for protection of marine waters is 7.0 – 8.7 unless it can be demonstrated that existing pH levels are the result of natural processes (BCMOE, 2014; CCME, 2014).

**Table 4-5: Water Quality Performance Criteria
Opening of the Temporary Re-Suspension Barrier**

Parameter	Interior Assessment Point [1] (IAP) (prior to opening TRB)	Receiving Environment After TRB closed [11] Distance from TRB	
		25 m (EAP_{25}) [3]	100 m (ECP) [12]
Total Suspended Solids[2] (mg/L)	To be determined by Contractor. TSS criteria to open TRB to be based on modelling of expected metal and PAH concentrations. Must not be acutely lethal.	68 mg/L	<5 mg/L over NFR when NFR is between 0-25 mg/L[2,4] <10 mg/L over NFR when NFR is ≤100 mg/L[2,4] Increase of <10% over NFR when NFR is >100 mg/L[2,4]
Turbidity [6] (NTU)	To be determined by Contractor. Turbidity criteria to open TRB to be based on modelling of expected metal and PAH concentrations. Must not be acutely lethal.	34 NTU	Maximum increase of 8 NTU over NFR[5] for a short-term exposure (e.g. 24 hours) and 2 NTU for longer term exposure (e.g. 30 day) when NFR turbidity is <8 NTU Maximum increase of the greater of 8 NTU or 10% over NFR when NFR turbidity is >8 NTU
Dissolved Oxygen[7] (mg/L)	≥5 mg/L	≥5 mg/L	≥5 mg/L
pH [8,9]	7.0-8.7	7.0-8.7	7.0-8.7
Metals – various (mg/L)	See 'Release Criteria' in Table 4-8 [10]	See 'Release Criteria' in Table 4-8	See 'Compliance Criteria' in Table 4-8
PAHs – various (µg/L)	See 'Release Criteria' in Table 4-9 [10]	See 'Release Criteria' in Table 4-9	See 'Compliance Criteria' in Table 4-9

EAP_{25} – Exterior Assessment Point, 25 m; ECP – Exterior Compliance Point; IAP – Interior Assessment Point; mg/L – milligrams per litre; µg/L – micrograms per litre; NFR – Near-Field Reference; NTU – nephelometric turbidity units; PAH – Polycyclic Aromatic Hydrocarbon; TRB – Temporary Re-suspension Barrier; TSS – Total Suspended Solids.

Notes:

- Refer to Figure A5 (Appendix 1) for decision-making framework for exceedances of water quality performance criteria for opening the TRB.

(1) Turbidity, dissolved oxygen and pH assessments to be made using *in situ* methods; *in situ* PAH and metals determination may be used if desired. Laboratory tests will be used to provide feedback after the fact for future TRB openings.
(2) TSS values may need to be revised in the field to account for other Water Quality Parameters.
(3) Exceedances at EAP_{25} to be modelled to 100 m to calculate likelihood of exceeding ECP performance criteria and recommend management actions, if required.
(4) Based on *Canadian Environmental Quality Guidelines Water Quality for the Protection of Aquatic Life* Marine (CCME, 2014).
(5) Based on BCMOE *Ambient Water Quality Guidelines for Turbidity, Benthic and Suspended Sediments* (BCMOE, 2014).
(6) The baseline monitoring program indicated that ambient turbidity in Esquimalt Harbour is relatively low (mean = 3.8 NTU; Golder, 2012c); however, intermittent increases to 400 NTU were observed related to vessel operations and storm events. Turbidity will be evaluated for the Project as induced turbidity above ambient as measured at the time of sampling per Golder (2012c) and SLR (2013). Turbidity is to be used as an *in situ* approximation of TSS. The TSS/turbidity relationship will be verified and adjusted as necessary based on laboratory data. These values should be used until field verification is possible.
(7) Based on BCMOE *Ambient Water Quality Guidelines For Dissolved Oxygen* (BCMOE, 2014).
(8) Based on *Canadian Environmental Quality Guidelines Water Quality for the Protection of Aquatic Life* Marine (CCME, 2014).
(9) The range of pH specified for protection of marine waters is 7.0 – 8.7, unless it can be demonstrated that such pH is a result of natural processes (BCMOE, 2014; CCME, 2014).
(10) Contractor must demonstrate that IAP water meets criteria established by the Contractor's appropriately qualified person prior to TRB opening.
(11) TRB is to be closed as soon as possible after vessel passage to minimize the discharge of potential contaminants out of the TRBCA. If TRB is to be opened for extended periods of time sampling will occur while the TRB is open (sampling frequency to be based on length of time the TRB will be open) in addition to after it has been closed.
(12) ECP TSS and turbidity modelled based on 10x safety factor of acute toxicity levels.

Table 4-6: Water Quality Performance Criteria
Dewatering Barge Effluent Outside TRBCA from Dredged Material within TRBCA

Parameter	Barge Effluent[1]	Dilution Zone Compliance Point (DZCP) 100 m from Point of Discharge
Total Suspended Solids	TSS values as compliance limits for discharge are not commonly specified [2]	5 mg/L over NFR when NFR is between 0-25 mg/L[3, 4] <10 mg/L over NFR when NFR is 26 to ≤100 mg/L[3, 4] Increase of <10% over NFR when NFR is >100 mg/L [3, 4]
Turbidity [5]	Turbidity values as compliance limits for discharge are not commonly specified [2]	Maximum increase of 2 NTU over NFR when NFR turbidity is <8 NTU Maximum increase of the greater of 8 NTU or 10% over NFR when NFR turbidity is >8 NTU
Dissolved Oxygen	≥5 mg/L [6]	≥ 5mg/L
pH	7.0-8.7 [7, 8]	7.0-8.7 [7, 8]
Metals – various	See ‘Release Criteria’ in Table 4-8 [9]	See ‘Compliance Criteria’ in Table 4-8 [10]
PAHs – various	See ‘Release Criteria’ in Table 4-9 [9]	See ‘Compliance Criteria’ in Table 4-9 [10]

DZCP – Dilution Zone Compliance Point; mg/L – milligrams per litre; µg/L – micrograms per litre; NFR – Near-Field Reference; NTU – nephelometric turbidity units; PAH – Polycyclic Aromatic Hydrocarbon; TRBCA – Temporary Re-suspension Barrier Containment Area; TSS – Total Suspended Solids

Notes:

- Refer to Figure A4 (Appendix 1) for decision-making framework for exceedances of water quality performance criteria for *in situ* monitoring.

(1) There is to be no discharge without treatment outside of the TRBCA. Passive dewatering may occur within the TRBCA if water performance criteria outside the TRBCA are maintained (Table 4-4).
(2) Discharge not subject to turbidity or TSS criteria; however, may not influence TSS or turbidity at any nearby monitoring locations (i.e., those within 100 m of discharge).
(3) Based on *Canadian Environmental Quality Guidelines Water Quality for the Protection of Aquatic Life* Marine (CCME, 2014).
(4) Based on BCMOE *Ambient Water Quality Guidelines for Turbidity, Benthic and Suspended Sediments* (BCMOE, 2014).
(5) The baseline monitoring program indicated that ambient turbidity in Esquimalt Harbour is relatively low (mean = 3.8 NTU; Golder, 2012c); however, intermittent increases to 400 NTU were observed related to vessel operations and storm events. Turbidity will be evaluated for the Project as induced turbidity above ambient as measured at the time of sampling per Golder (2012c) and SLR (2013).
(6) Based on BCMOE *Ambient Water Quality Guidelines For Dissolved Oxygen* (BCMOE, 2014).
(7) Based on BCMOE *Ambient Water Quality Guidelines For Dissolved pH* (BCMOE, 2014).
(8) The range of pH specified for protection of marine waters is 7.0 – 8.7, unless it can be demonstrated that such pH is a result of natural processes (BCMOE, 2014; CCME, 2014).
(9) Effluent exceeding these criteria may not be discharged.
(10) Exceedances of these criteria will result in stoppage of discharge and management actions to prevent further releases.

Table 4-7: Water Quality Performance Criteria Prior to Decommissioning Temporary Re-Suspension Barrier & Sheet Pile Wall (within TRBCA)[1]

Parameter	Inside TRBCA
Total Suspended Solids (mg/L)	<5 mg/L over NFR when NFR is between 0-25 mg/L [1, 2] <10 mg/L over NFR when NFR is ≤100 mg/L [1, 2] Increase of <10% over NFR when NFR is >100 mg/L [1, 2] TSS exceedances at the CP correlated with Project activities within the TRBCA may result in work stoppage until the problem has been addressed
Turbidity [3] (NTU)	Maximum increase of 8 NTU over NFR [3] for a short-term exposure (e.g. 24 hours) when NFR turbidity is <8 NTU Maximum increase of the greater of 8 NTU or 10% over NFR when NFR turbidity is >8 NTU
Dissolved Oxygen (mg/L)	minimum: 5 mg/L[4]
pH	7.0-8.7 [2, 5]
Metals – various (mg/L)	See 'Compliance Criteria' in Table 4-8 Results to be confirmed analytically
PAHs – various (µg/L)	See 'Compliance Criteria' in Table 4-9 Results to be confirmed analytically

mg/L – milligrams per litre; µg/L – micrograms per litre; NFR – Near-Field Reference; NTU – nephelometric turbidity units; PAH – Polycyclic Aromatic Hydrocarbon; SPW – Sheet Pile Wall; TRB – Temporary Re-suspension Barrier; TRBCA – Temporary Re-suspension Barrier Containment Area

Notes:

(1) The TRB and/or SPW will not be decommissioned until these criteria are met within the TRBCA and can be demonstrated to the DR and EM.
(2) Based on *Canadian Environmental Quality Guidelines Water Quality for the Protection of Aquatic Life Marine* (CCME, 2014).
(3) The baseline monitoring program indicated that ambient turbidity in Esquimalt Harbour is relatively low (mean = 3.8 NTU; Golder, 2012c); however, intermittent increases to 400 NTU were observed related to vessel operations and storm events. Turbidity will be evaluated for the Project as induced turbidity above ambient as measured at the time of sampling per Golder (2012c) and SLR (2013).
(4) Based on BCMOE *Ambient Water Quality Guidelines for Marine Dissolved Oxygen* (BCMOE, 2014).
(5) The range of pH specified for protection of marine waters is 7.0 – 8.7 unless it can be demonstrated that existing pH levels are the result of natural processes (BCMOE, 2014; CCME, 2014).

Table 4-8: Water Quality Performance Criteria
Total Metals

Parameter (as total) [1]	Release Criteria [2, 3] (25 m from point of release)	Compliance Criteria [4, 5] (100 m from point of release)
Arsenic (µg/L)	125	12.5
Copper (µg/L)	30	3
Zinc (µg/L)	100	10

CP – Compliance Point; EAP_{25} – Exterior Assessment Point, 25 m; ECP – Exterior Compliance Point; EWP – Early Warning Point; IAP – Interior Assessment Point; µg/L – micrograms per litre; TRB – Temporary Re-suspension Barrier.

Notes:

(1) The selection of this subset of metals is discussed in Golder (2012c).
(2) The performance criteria for release are based on 10x ambient water quality guidelines.
(3) At EWP or EAP_{25} based on if the TRB is opened or closed at time of measurement.
(4) Compliance performance criteria are based on ambient water quality guidelines (BCMOE, 2014).
(5) At CP or ECP based on if the TRB is opened or closed at time of measurement.

Table 4-9: Water Quality Performance Criteria
Total Polycyclic Aromatic Hydrocarbons

PAH Congeners [1]	Release Criteria [2, 3] (25 m from point of release)	Compliance Criteria [4, 5] (100 m from point of release)
Acenaphthene (µg/L)	510	51
Anthracene (µg/L)	5	0.5
Benzo(a)anthracene (µg/L)	1.8	0.18
Benzo(b)fluoranthene (µg/L)	8.6	0.86
Benzo(a)pyrene (µg/L)	5.6	0.56
Benzo(g,h,i)perylene (µg/L)	1	0.1
Chrysene (µg/L)	8.6	0.86
2-Methylnaphthalene (µg/L)	58	5.8
Naphthalene (µg/L)	100	10
Phenanthrene (µg/L)	40	4
Pyrene (µg/L)	12.8	1.28

CP – Compliance Point; EAP_{25} – Exterior Assessment Point, 25 m; ECP – Exterior Compliance Point; EWP – Early Warning Point; IAP – Interior Assessment Point; µg/L – micrograms per litre; TRB – Temporary Re-suspension Barrier.

Notes:

(1) The selection of this subset of PAHs is discussed in Golder (2012c).
(2) The values are based on a combination of literature review and quantitative structure-activity relationship (QSAR) as described in Golder (2012b).
(3) At EWP or EAP_{25} based on if the TRB is opened or closed at time of measurement.
(4) Compliance Criteria are based on the Release Criteria with a 10-fold safety factor applied.
(5) At CP or ECP based on if the TRB is opened or closed at time of measurement.

4.8 Management Actions

Management actions are additional mitigation measures agreed upon by the EM, DR and Contractor which may allow work to proceed following initial exceedances of performance criteria. Management actions may include checking the TRB functionality, slowing the dredging cycle, repairing the TRB or SPW, changing the dredge bucket or other mitigation techniques deemed appropriate. Performance criteria measured at sites proximal to the TRB (i.e., 25 m) are designed to provide early detection of potential issues to prevent any work stoppages from occurring when performance criteria are exceeded at the 100 m monitoring locations. Any agreed upon Management Actions will be documented and submitted to the DR.

4.9 TSS/Turbidity Relationship

The TSS/turbidity relationship, upon which the decision framework for management actions during Phase 2 activities is based, was generated using site specific TSS/turbidity sample data. This relationship will be further examined during the first few weeks of Phase 2 work.

Throughout the program samples will be analyzed in the laboratory for metals, PAHs and TSS and results paired with *in situ* field measurements. Results will be used to generate correlations between multiple parameters and assess the relationships as modelled.

The turbidity and TSS values used in the decision framework (Section 4.6) and Tables 4-4 through 4-7 may need to be adjusted if the results obtained during the work differ significantly from the model predicted analyses (Appendix 4; Anchor, 2014). A modified set of criteria for opening the TRB may be required if Phase 2 analytical results do not support the modelled data.

5.0 QA/QC & DATA MANAGEMENT

5.1 Quality Assurance / Quality Control (QA/QC)

Quality assurance (QA) is the process or set of processes used to measure and assure the quality of a product or service while quality control (QC) is the process of meeting products and services to consumer expectations. Field sampling and QA/QC procedures are summarized below and described in detail in the Phase 2 EMIP.

5.1.1 Field

The following general guidelines will apply to field sampling activities:

- sampling equipment will be prepared as detailed in the EMIP between sampling periods and stations where applicable (i.e., sampling for analysis of contaminants);
- samples will be collected in such a way as to minimize the introduction of contamination to the sample and loss of sample prior to analysis;
- sample media will be collected in pre-treated laboratory supplied containers and preserved as necessary with supplies and instructions for each analysis provided by the analytical laboratory;
- all samples will be placed in darkness, kept cold (4°C) and handled according to established chain-of-custody, transfer and storage protocols. Samples will be analyzed upon receipt at the lab, according to EM instructions;
- field meters will be calibrated according to manufacturers' instructions and calibrations will be verified with applicable commercially-formulated calibration standard solutions. Calibration records will be kept and submitted with data reports;
- chain-of-custody documentation will be maintained to document holding times, storage conditions, sample continuity, shipping and sample arrival/integrity;
- field duplicates, equipment rinsates, travel blanks and spiked samples will constitute 10% to 15% of samples submitted; and,
- relative percent difference (RPD) will be calculated for field duplicates to provide a measure of method precision:

$$RPD = \frac{|Sample - Duplicate|}{\left((Sample + Duplicate)/2\right)} * 100\%$$

In accordance with the *BC Field Sampling Manual* (BCMWLAP, 2003), an RPD value of ± 20% for values ≥ 5 times the method detection limit (MDL) will be used to identify notable differences between original and duplicate samples. RPDs are not calculated for values < 5 times the MDL due to increased variability near analytical detection limits.

Paired sampling of TSS/turbidity will be undertaken to validate the established TSS/turbidity relationship throughout the Project (Section 4.9).

5.1.2 Laboratory

Chemical analyses will be conducted in accordance with well-established, published laboratory protocols by a Canadian Association for Laboratory Accreditation (CALA) accredited laboratory. QA/QC procedures would include method blanks, laboratory samples, analysis of commercially prepared standards, field blanks (equipment rinsates) and travel blanks to check for sources of potential contamination, sample handling/storage issues and to assess variability. Approximately 10%-15% of samples submitted to the lab will be duplicated and/or replicated. Rigorous QA/QC procedures will be applied to avoid contamination during handling, storage and shipping of samples and to ensure samples are properly identified.

Field duplicates will be submitted blind to the laboratory to assess laboratory and subsample variability. Laboratory duplicates (minimum of 10% of samples collected) would also be analyzed in accordance with laboratory QA/QC protocols.

Prior to entry into the data management system (Section 3.6), laboratory data will be reviewed to verify that results are reliable and analyses were conducted and reported according to established protocols. For example, this review may include checking the following:

- each sample has a unique sample reference indicating date, time and location the sample was collected;
- sample control numbers from the chain of custody sheets and laboratory reports match;
- results are provided for samples submitted and analyses requested;
- method blanks are below method detection limits;
- results of duplicate samples and certified reference materials (CRMs) are within an acceptable range;
- hold times are not exceeded;
- no transcription errors are observed;
- preservatives are added;
- samples are stored, transferred and tested at appropriate temperature; and,
- appropriate units of measurement are reported.

5.2 Data Management

An electronic data management system will be required given the large amount of data that will be collected during the remediation project and the need for timely reporting of analytical results and statistical data following laboratory analyses and processing of the field data. The EM in consultation with the DR for PWGSC will decide best how to capture, store, report and make this data available.

Data (laboratory chemistry and field measurements) will be entered into the data management system following confirmation that laboratory and field data quality objectives (DQOs) were met. A number of different platforms are available for data management. The specific platform for data management will be selected by the EM in consultation with PWGSC and considerate of the system and protocols used in Phase 1.

6.0 REPORTING

6.1 General

Reporting will involve submission of daily and weekly environmental monitoring reports of a quality suitable for submission to regulatory agencies, First Nations and public stakeholders, submitted to the DR for distribution as appropriate. Monitoring reports are to be prepared by the EM and include, at a minimum, the following information requirements (templates for Environmental Monitoring reports are provided in Appendix 5 of the EMP; G3, 2014a):

1. a description of construction activities undertaken during the reporting period;
2. a description of environmental issues and corresponding mitigation measures implemented;
3. tracking of emerging and outstanding environmental issues;
4. results of monitoring and testing (e.g., water quality data, noise data, observations of aquatic mammals);
5. compliance assessments of the TRB;
6. compliance assessments and ongoing data summary of TRB opening activities and procedures; and,
7. photos documenting construction activities, environmental issues, corresponding mitigation measures and any adopted lessons learned.

Laboratory data will be reported in the next applicable monitoring report following receipt of the Certificate of Analysis from the analytical laboratory.

Detailed field notes will be collected and maintained in project specific notebooks and field forms. Notes will include site locations, date and time of sampling, names of field crews, descriptions of habitat parameters, (i.e., biota, substrates, water), ambient weather conditions and any notable observations (e.g., turbidity generating activities, etc.). Sampling methods and QA/QC procedures applied (i.e., field duplicates and/or travel blanks) would be recorded, in duplicate, by all field staff.

Field and laboratory data will be reported in tabular format. Raw data would be summarized with mean, maximum and minimum values with range, standard deviation and 95% confidence intervals reported as measures of variance.

Data will be graphed, where appropriate, and applicable test statistics tabularized for comparison within and between stations and to assess if the data is normalized. Reports would include a summary of adherence to data quality objectives, standard operating procedures and identification of any QA/QC issues (i.e., method detection limits, hold times, duplicate analysis, etc.).

The EM will also prepare an Environmental Completion Report one month following completion of the work. The report prepared following completion of Phase 2 work will provide an overall summary of the Project including, representative site photographs, a summary of monitoring data collected, a summary of construction activities, environmental management and issues during construction, how these issues were managed, mitigation measures and additive measures in response to lessons learned and recommendations.

6.2 Exceedances

The Environmental Monitor (EM) undertaking the monitoring as outlined in this WQMP will report exceedances and other non-compliance events to the DR as soon as possible. The DR may request corrective actions by the Contractor to address issue(s) as deemed necessary. Based on the severity of the event, the DR may be required to report exceedances to regulatory agencies (e.g., DFO) or other parties, based on regulatory obligations.

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APPENDICES

Appendix 1

Figures

Figure A1: Esquimalt Graving Dock Waterlot Sediment Remediation Project Area Map
Date: June 20, 2014
Coordinate System: NAD83 UTM Zone 10
Adapted from Golder, 2012a; Reference Department of natural Resources.

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Adapted From:

PROJECT PUBLIC WORKS GOVERNMENT SERVICES CANADA
EGD WATERLOT SEDIMENT REMEDIATION PROJECT
ENIVORNMENTAL ASSESSMENT
ESQUIMALT, B.C.

Golder Associates
Victoria, BC

PROJECT		10-1475-0002	FILE No. 1014750002-000-10-01	
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CADD	AW	9 MAR 11		
CHECK	VC	23 AUG 12		
REVIEW	TM	23 AUG 12		

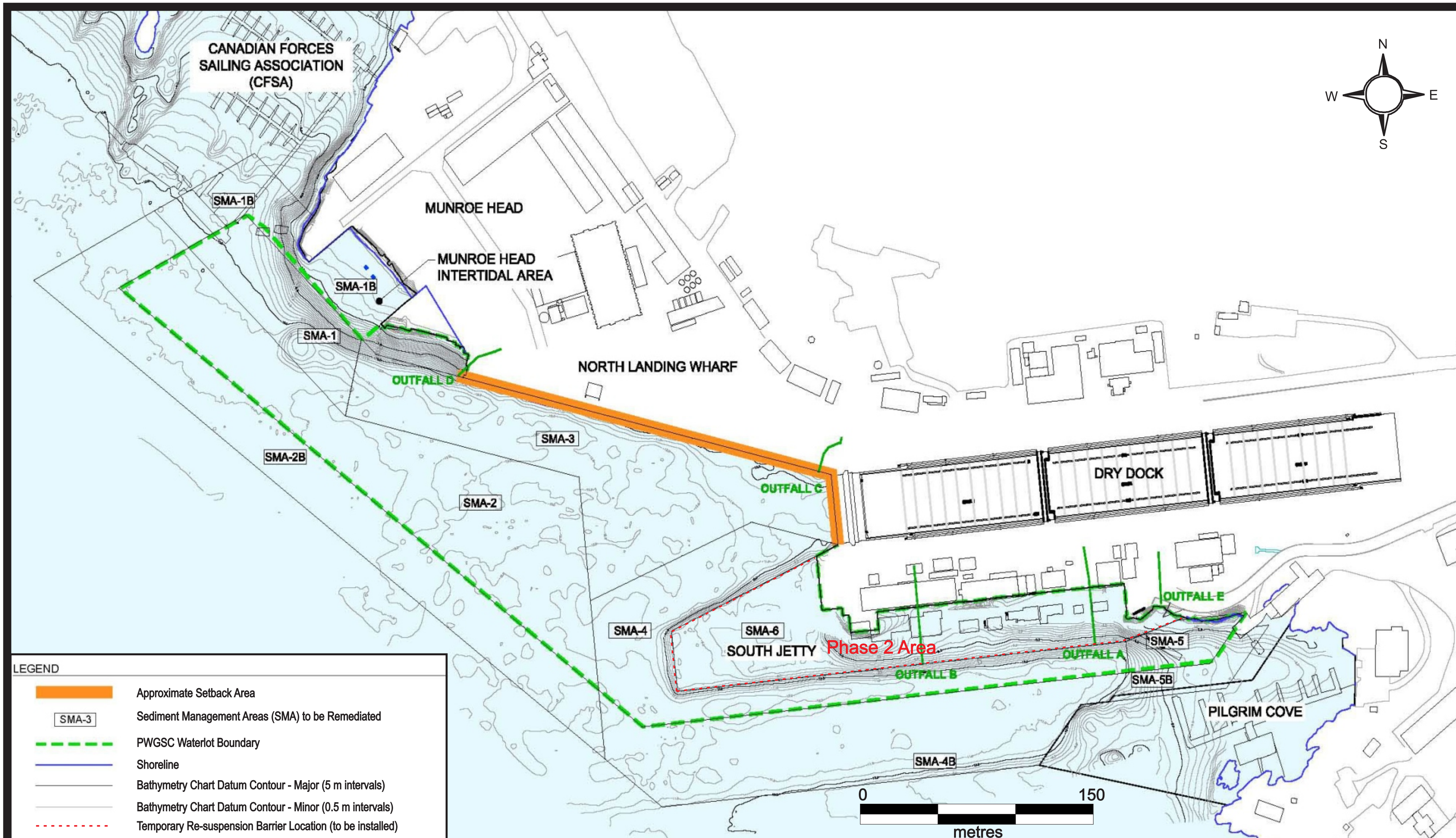

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Figure A2: Site Boundaries and Adjacent Properties

Bathymetry contours supplied by CRA Surveys 2010, shown in chart datum.
Coordinate System: NAD83 UTM Zone 10
Adapted from AQ/KCB/Golder/PWGSC, South Jetty Wharf Development Project R.026729.002/R.018400.002 Plan Sheets C3, C9 and C21.
Basemap adapted from Golder/PWGSC (PAC-#269014-v1-PWGSC-EGD-FINAL-BASE_MAP-ACAD-10-11-GOLDER-20110726).

Adapted from:

SITE BOUNDARIES AND ADJACENT PROPERTIES

Golder Associates

FIGURE 2

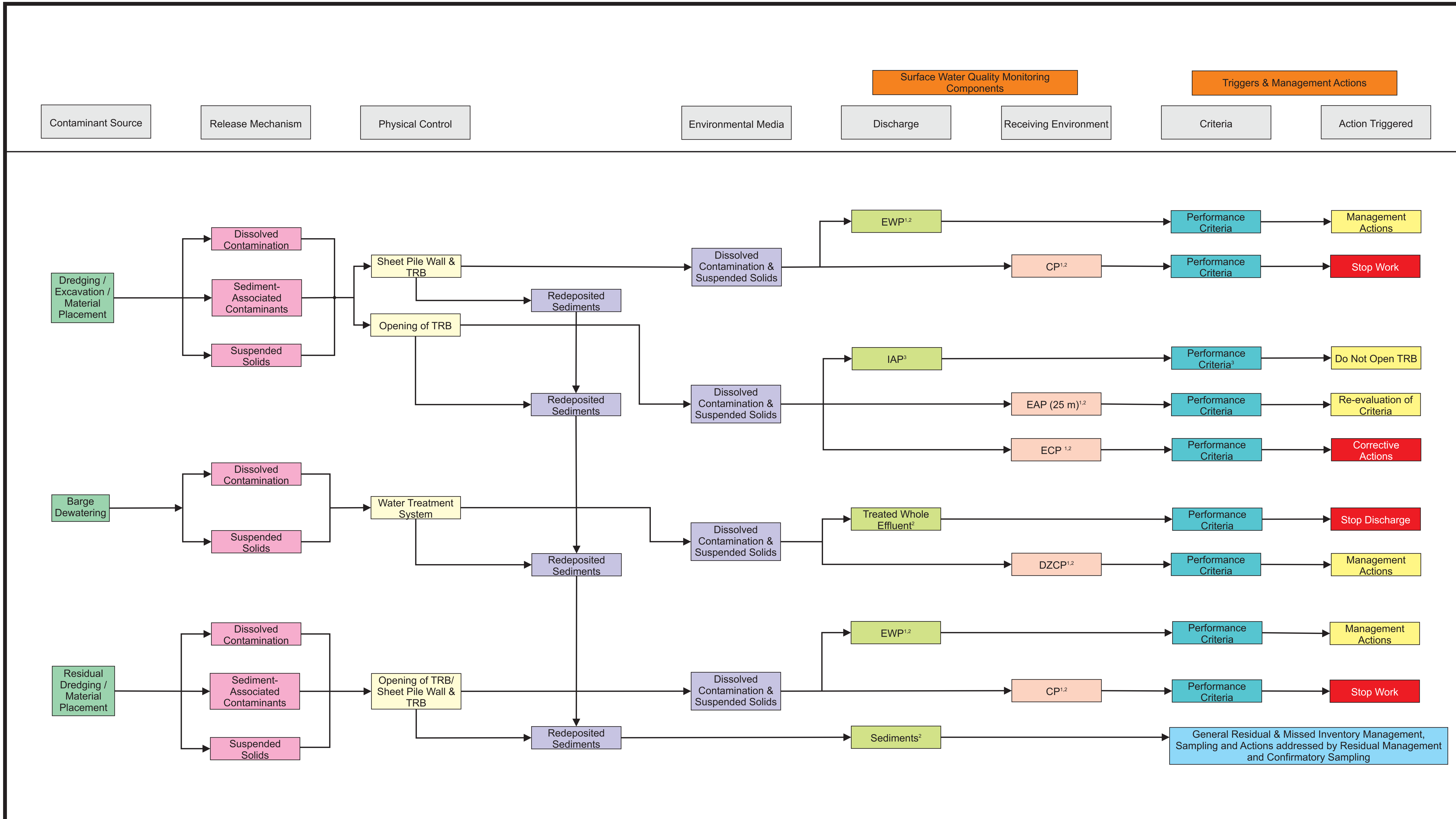

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Figure A3: Elements of the Water Quality Monitoring Plan for the Esquimalt Graving Dock Waterlot Remediation Project
An overview of the sources, release mechanisms, physical controls, environmental media, surface water quality monitoring components and triggers and response actions.

Notes:
1. *In situ* field assessment
2. Laboratory analyses
3. To be determined and measured by Contractor's appropriately qualified person
CP - Compliance Point; DZCP - Dilution Zone Compliance Point; EAP_{25} - Exterior Assessment Point (25 m); ECP - Exterior Compliance Point; IAP - Interior Assessment Point; EWP - Early Warning Point; TRB - Temporary Re-suspension Barrier

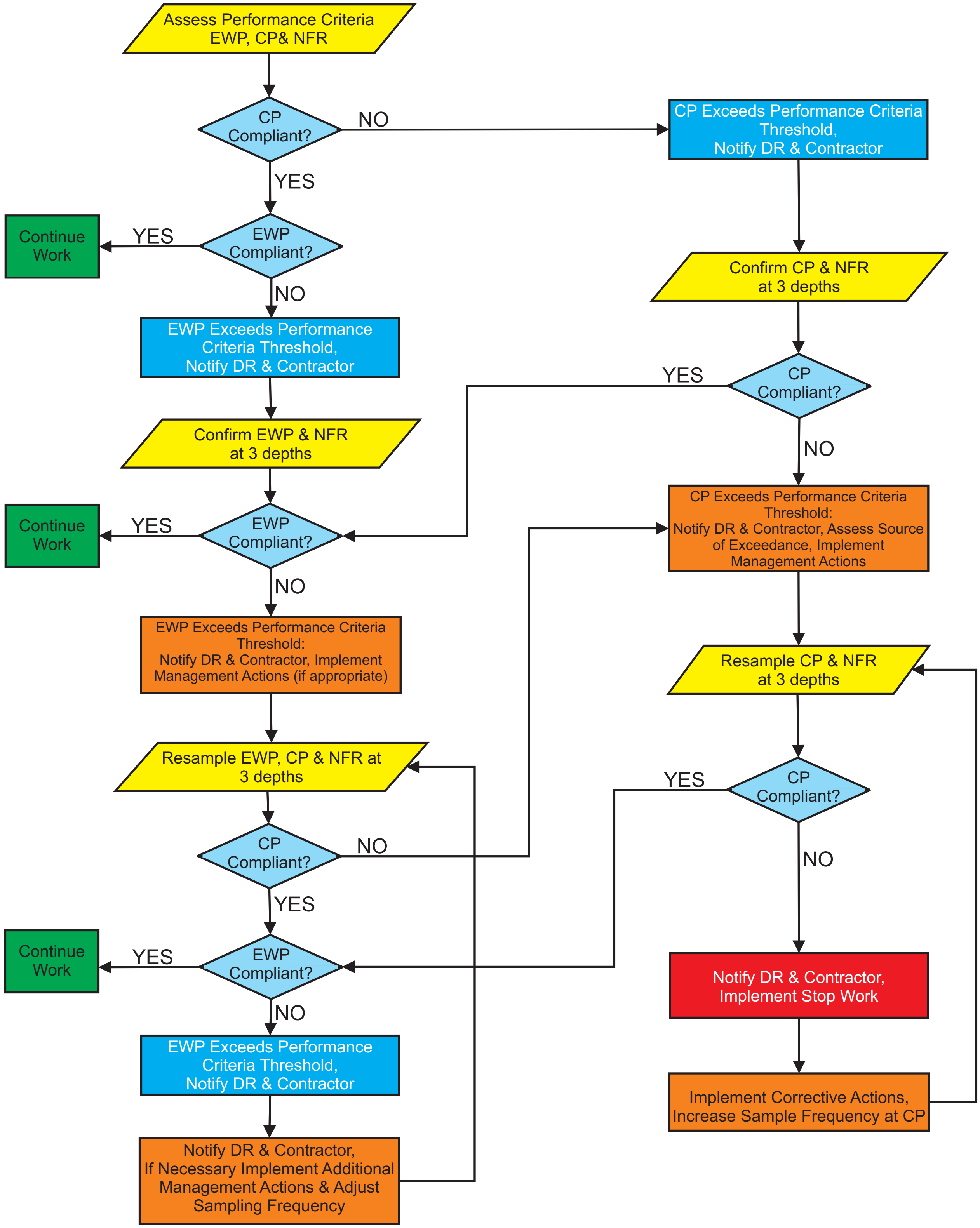

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Figure A4: Decision Framework for Monitoring during Activities Enclosed within the TRBCA

The steps and measures to be followed for normal *in situ* water quality monitoring outside of Temporary Re-suspension Barrier Containment Area (TRBCA) during Project activities (e.g., dredging, placement on engineered capping material) within TRBCA.

CP - Compliance Point; DR - Departmental Representative; EWP - Early Warning Point; NFR - Near-Field Reference

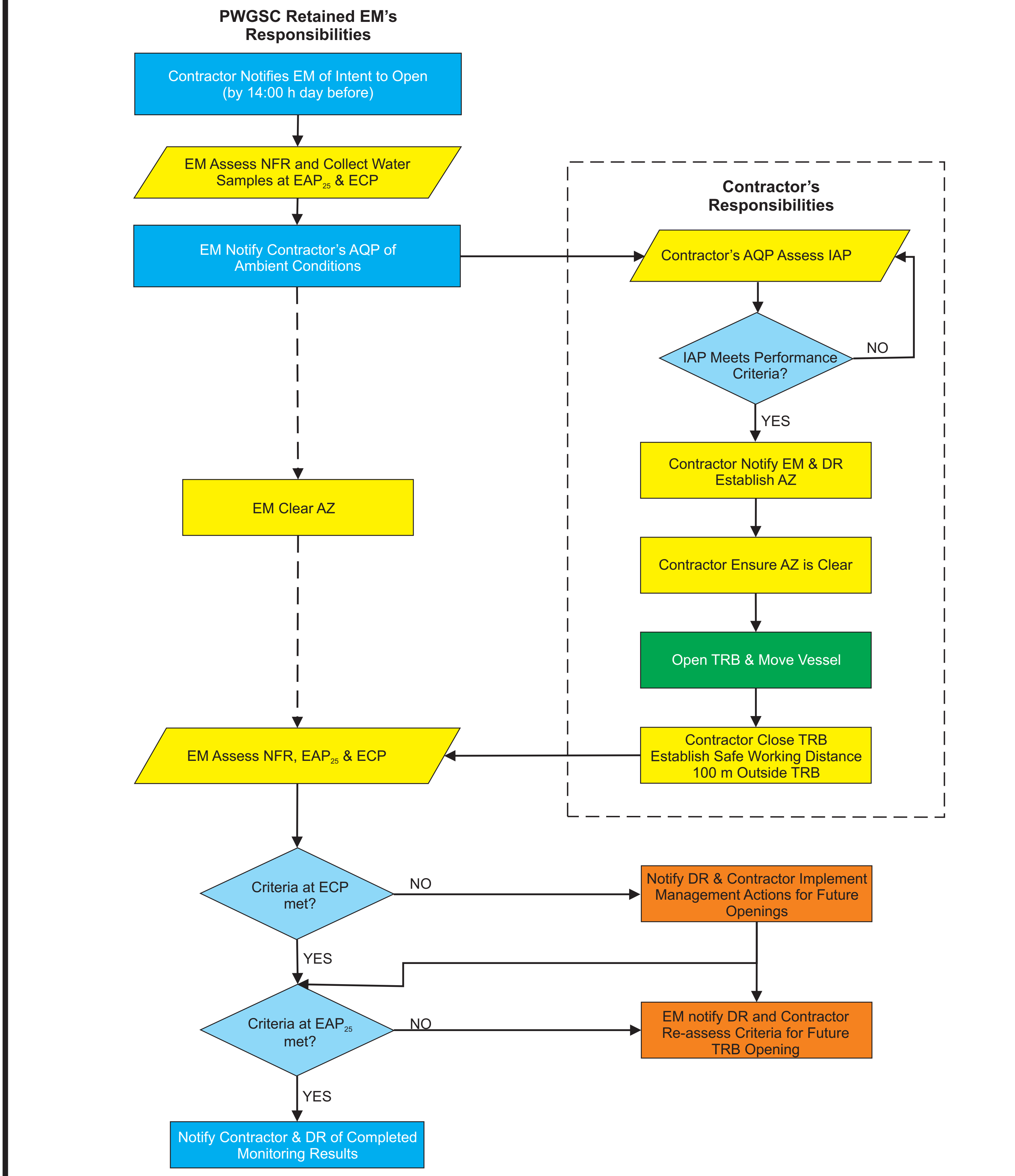

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Figure A5: Decision Framework for TRB Opening Monitoring

The steps and measures to be followed to monitor water quality during the opening of the Temporary Re-Suspension Barrier (TRB).

AQP - Contractor's Appropriately Qualified Person; AZ - Activity Zone; DR - Department Representative; EAP$_{25}$ - Exterior Assessment Point (25 m); ECP - Exterior Compliance Point; EM - Environmental Monitor; IAP - Interior Assessment Point; NFR - Near-Field Reference

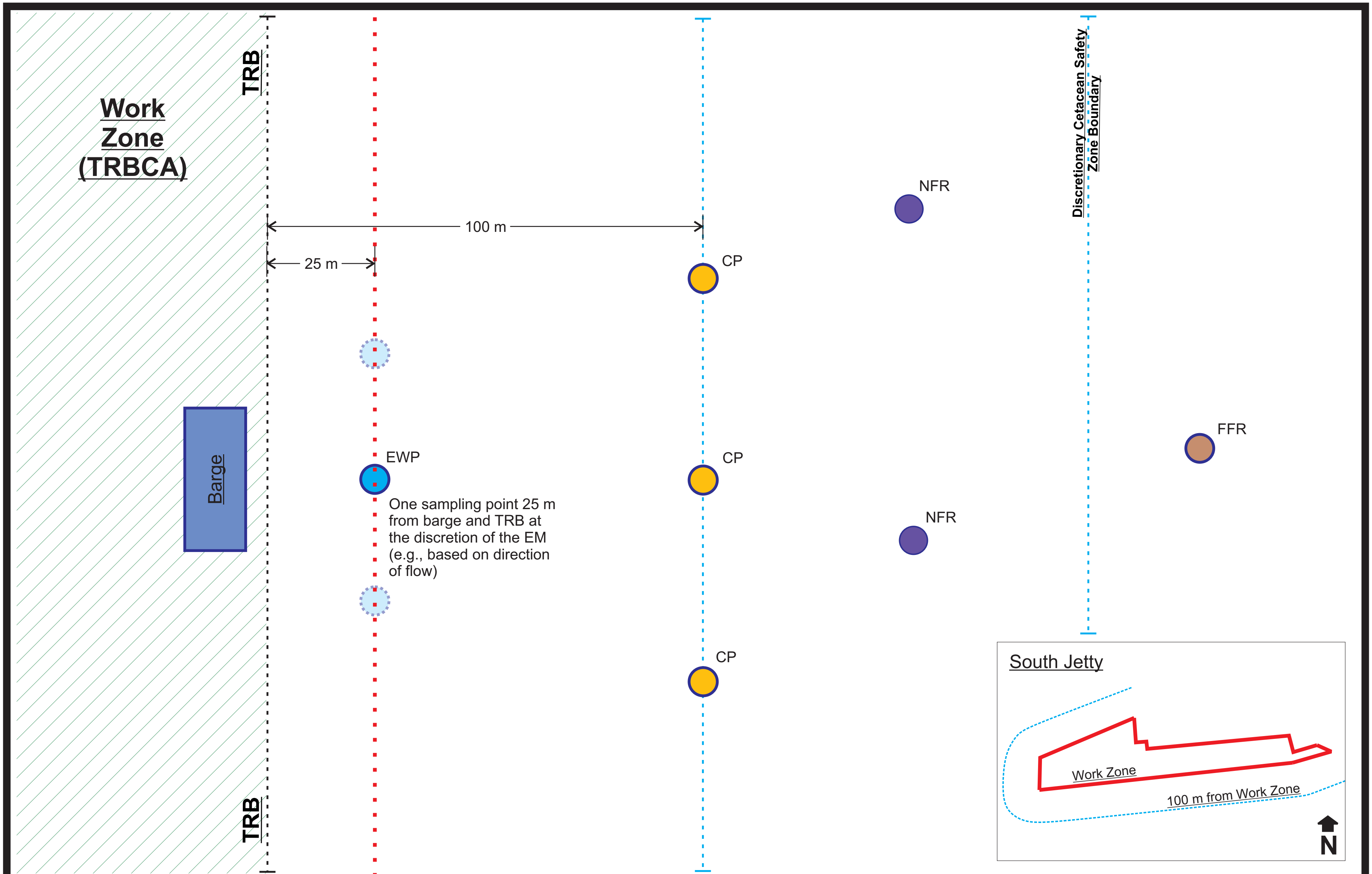

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Figure A6: Conceptual Layout of Monitoring Locations for Activity Inside the Temporary Re-Suspension Barrier Containment Area (TRBCA)
Inset: 100 m monitoring perimeter surrounding the South Jetty Work Zone.
CP - Compliance Point; EWP - Early Warning Point (Potential Location); FFR - Far-Field Reference Point (background, Esquimalt Harbour); NFR - Near-Field Reference Point (ambient, Constance Cove); TRB - Temporary Re-Suspension Barrier; TRBCA - Temporary Re-Suspension Barrier Containment Area

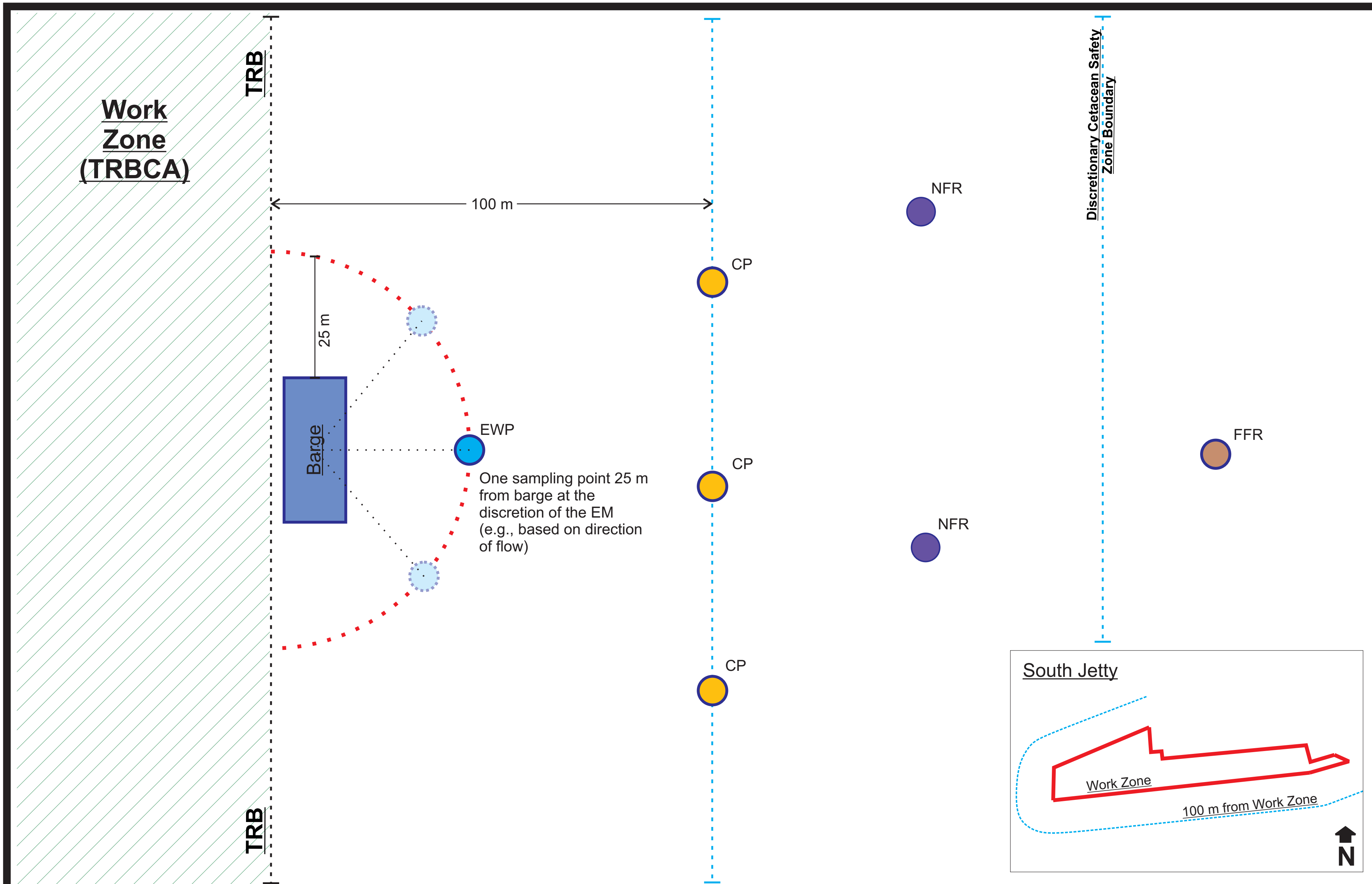

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Figure A7: Conceptual Layout of Monitoring Locations for Activity Inside the Temporary Re-Suspension Barrier Containment Area (TRBCA) When Additional Activities Occurring Outside

Inset: 100 m monitoring perimeter surrounding the South Jetty Work Zone.
CP - Compliance Point; EWP - Early Warning Point (Potential Location); FFR - Far-Field Reference Point (background, Esquimalt Harbour); NFR - Near-Field Reference Point (ambient, Constance Cove); TRB - Temporary Re-Suspension Barrier; TRBCA - Temporary Re-Suspension Barrier Containment Area

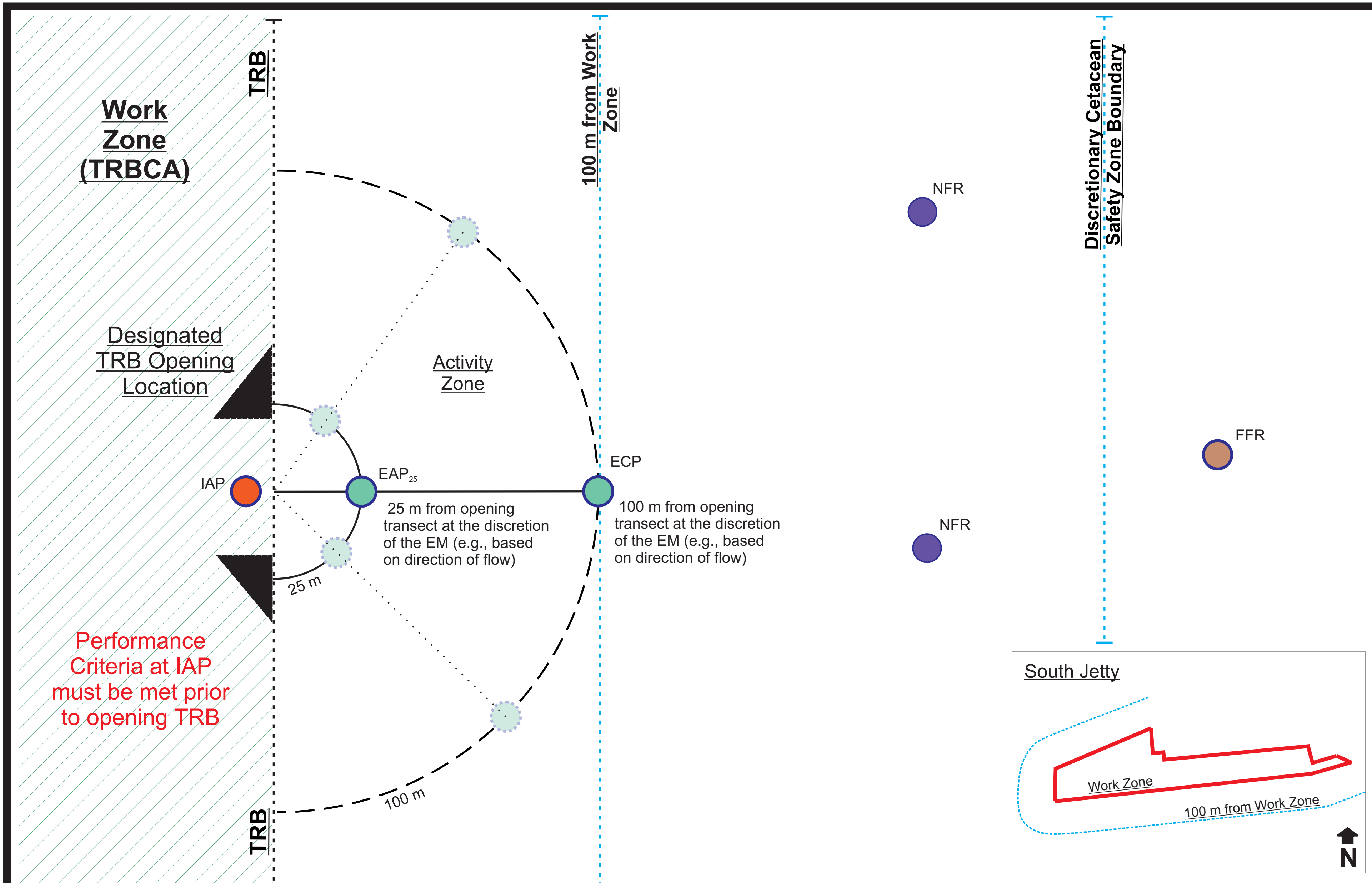

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Figure A8: Conceptual Layout of Monitoring Locations for Opening the Temporary Re-Suspension Barrier Containment Area (TRBCA)
Inset: 100 m monitoring perimeter surrounding the South Jetty Work Zone.
EAP - Exterior Assessment Point; ECP - Exterior Compliance Point; FFR - Far-Field Reference Point (background, Esquimalt Harbour); IAP - Interior Assessment Point; NFR - Near-Field Reference Point (ambient, Constance Cove); TRB - Temporary Re-Suspension Barrier

EAP_{25} sample collected 25 m from opening and assessed for compliance with water quality guidelines; ECP sample collected 100 m from opening and assessed for compliance with water quality guidelines.

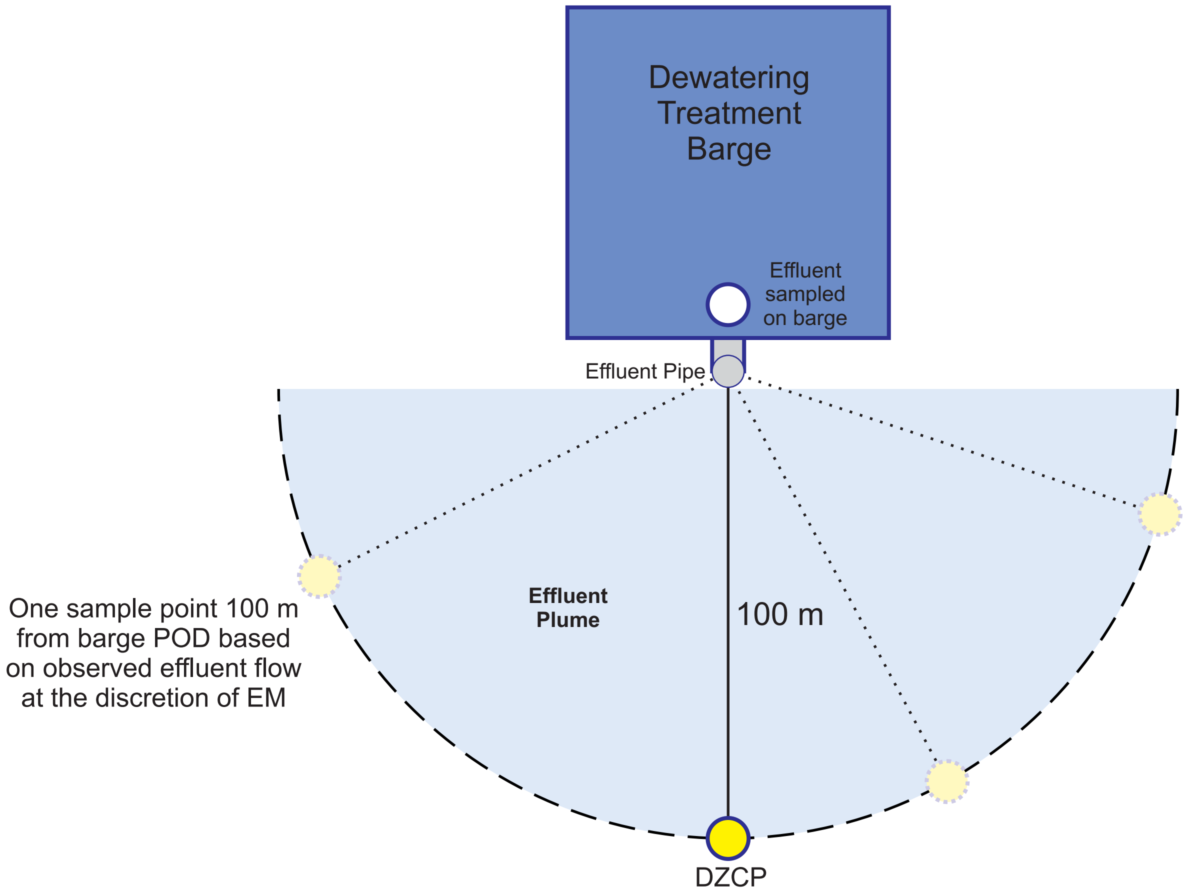

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Figure A9: Conceptual Layout of Dewatering Treatment Barge Effluent Sampling

DZCP - Dilution Zone Compliance Point; POD - Point of Discharge.

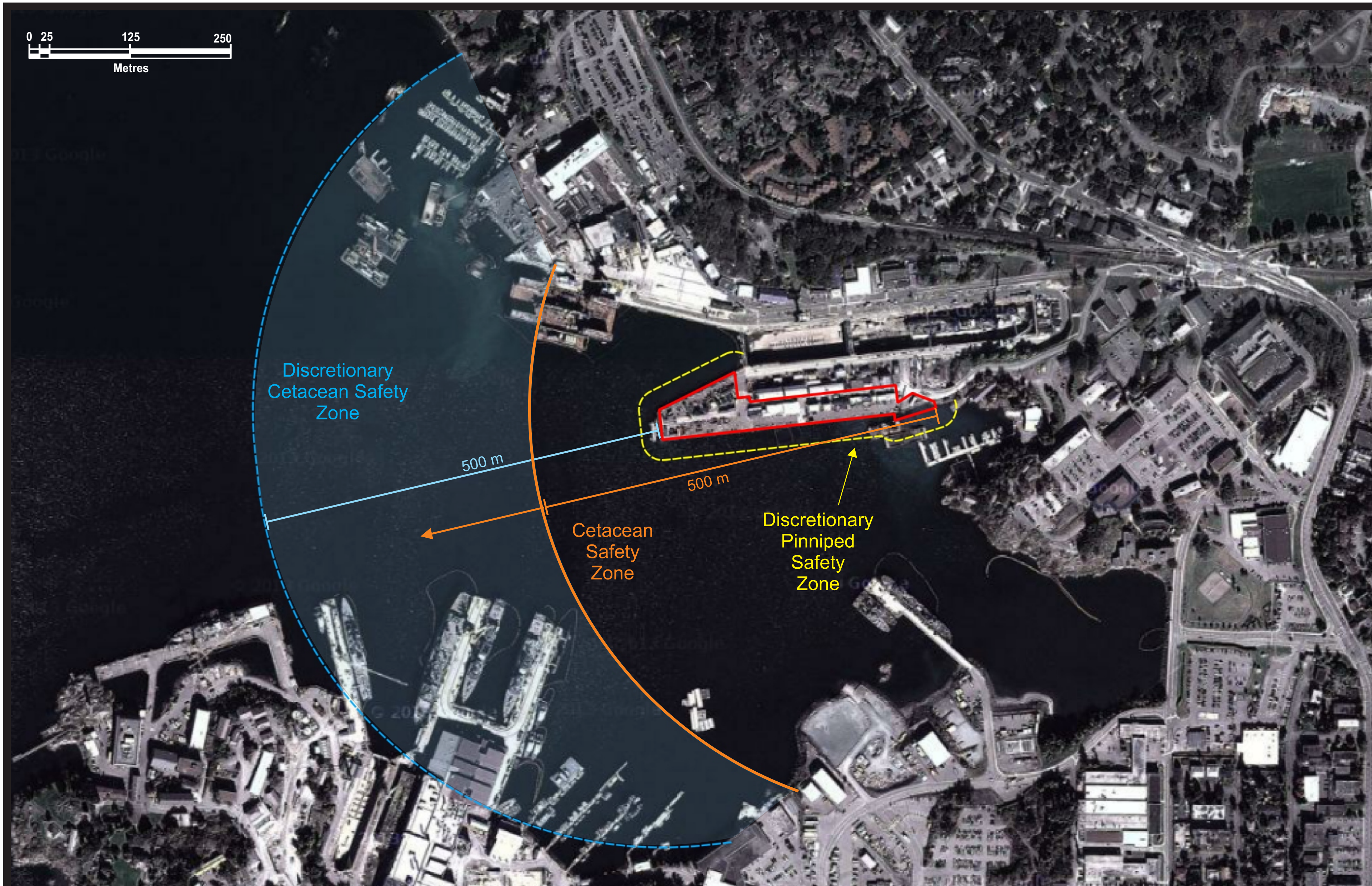

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Figure A10: Marine Mammal Safety Zones
Project Boundary Source: PWGSC Real Property Services
South Jetty Wharf Development Dredging Work Sequence Plan
Project R.026729.002/R.018400.002 Sheet C9.
Imagery Source: DigitalGlobe, Google, Parks Canada 2014.
Date: March 9, 2015.
Coordinate System: WGS84 Web Mercator.

- Project Boundary
- Discretionary Pinniped Safety Zone (25 m)
- Discretionary Cetacean Safety Zone (500 m from edge of Project Boundary)
- Cetacean Safety Zone (500 m from in-water activities)

N W E S

Appendix 2

Tables

Table B1: Summary Statistics for Turbidity Data Collected by Automated Data Loggers in Esquimalt Harbour – October/November 2010 (adapted from Golder, 2012c)

Table B2: Vertical Profile Data (Collected Manually) for Turbidity, Temperature, Dissolved Oxygen, Chlorophyll a, and pH – October/November 2010 (adapted from Golder, 2012c)

Table B1: Summary Statistics for Turbidity Data Collected by Automated Data Loggers in Esquimalt Harbour – October/November 2010 (adapted from Golder, 2012c)

Parameter	Turbidity Values (NTU)						
	Combined Data	TB01	TB02	TB03	TB04	TB05	TB06 (ref)
Mean	3.8	4.6	2.5	0.1	11.6	2.4	1.6
Median	0	0.10	0	0.04	0.1	0	0
Range	0 – 817	0 - 388	0 - 513	0 - 12	0 - 665	0 - 817	0 - 165
95th Percentile	6.4	3.9	0	0.4	32	15	9
No. samples (n)	59,352	7,608	10,244	10,352	9,869	10,803	10,471

Table B2: Vertical Profile Data (Collected Manually) for Turbidity, Temperature, Dissolved Oxygen, Chlorophyll a, and pH – October/November 2010 (adapted from Golder, 2012c)											
Parameter	**Depth**	**Mean Values**									
		TB01	**TB02**	**TB03**	**TB04**	**TB05**	**TB06 (ref.)**	**TB07**	**TB08**	**TB09**	**TB10**
Turbidity (NTU)	Shallow (0-4 m)	0.26	0.26	0.76	0.53	0.51	0.50	0.57	0.16	0.29	0.32
	Mid-water (4-8 m)	0.39	0.44	0.57	0.63	0.48	0.43	0.45	0.30	0.30	0.38
	Deep (8 m+)	0.57	0.56	0.59	-	0.60	0.54	0.68	-	0.36	0.52
	Overall	*0.36*	*0.40*	*0.64*	*0.55*	*0.54*	*0.49*	*0.59*	*0.17*	*0.32*	*0.40*
Temp. (°C)	Shallow (0-4 m)	8.58	8.38	7.78	8.51	7.88	7.53	8.68	9.42	9.45	9.42
	Mid-water (4-8 m)	8.71	8.19	7.70	8.00	7.94	8.54	8.85	9.33	9.35	9.40
	Deep (8 m+)	8.89	8.63	7.51	-	7.79	8.44	8.63	-	9.34	9.36
	Overall	*8.68*	*8.35*	*7.69*	*8.42*	*7.86*	*8.08*	*8.71*	*9.41*	*9.38*	*9.39*
Dissolved Oxygen (mg/L)	Shallow (0-4 m)	7.21	7.33	7.53	7.27	7.59	7.98	7.78	7.04	6.87	6.83
	Mid-water (4-8 m)	7.02	7.27	7.31	7.25	7.36	7.14	7.32	7.02	6.74	6.65
	Deep (8 m+)	6.82	7.05	7.37	-	7.38	6.99	7.21	-	6.47	6.23
	Overall	*7.07*	*7.24*	*7.40*	*7.27*	*7.45*	*7.44*	*7.41*	*7.03*	*6.68*	*6.58*
Chlorophyll *a* (µg/L)	Shallow (0-4 m)	1.04	1.03	1.00	1.24	1.08	0.74	0.94	0.73	1.22	1.38
	Mid-water (4-8 m)	0.68	0.80	1.08	0.65	0.91	1.06	0.87	1.42	2.10	1.50
	Deep (8 m+)	0.79	1.11	0.74	-	1.01	1.05	0.71	-	0.75	0.88
	Overall	*0.86*	*0.95*	*0.98*	*1.13*	*1.00*	*0.92*	*0.82*	*0.79*	*1.27*	*1.26*
pH	Shallow (0-4 m)	8.05	8.09	7.93	8.07	8.14	8.14	8.11	7.97	7.90	7.90
	Mid-water (4-8 m)	8.05	8.13	8.03	8.15	8.13	8.06	8.11	7.95	7.90	7.89
	Deep (8 m+)	8.03	8.09	8.07	-	8.17	8.08	8.11	-	7.89	7.86
	Overall	*8.04*	*8.11*	*8.00*	*8.08*	*8.15*	*8.10*	*8.11*	*7.97*	*7.90*	*7.88*

Notes:
°C – degrees Celsius; m – metre; mg/L – milligrams per litre; µg/L – micrograms per litre; NTU – nephelometric turbidity units

Appendix 3

Phase 1 Open-water Dredging & Barge Dewatering Decision Framework (adapted from Golder, 2012c)

3.2 Decision Criteria and Management Actions

There are presently no sector-specific regulations pertaining to discharge from dredging projects, nor are there provincial discharge standards applicable to the point of discharge from a dredging project. The specific parameters and points of compliance are generally determined by agreement at the project level through the process of environmental review and consultation with the responsible regulatory agencies such to meet the general provisions of the environmental statutes.

Regulatory compliance is typically evaluated at the point at which an operator no longer exercises control over a discharge, often called the "end of pipe"[8]. In a dredging operation, there is no pipe terminus and control ends at the point at which turbidity is no longer controlled. In the case of this project, that is the edge of the silt curtain for the dredging (Figure 5) and intertidal excavation (Figure 6) components, and at the point of discharge (POD) for the dewatering barge (Figure 7). In order to evaluate the controls over the dredging project, the Project must meet pre-specified criteria at the POD. For safety reasons, however, if the silt curtain is configured adjacent to/around the dredge bucket, the operational compliance point for dredging may be 25 m from the edge of the silt curtain.

If a different silt curtain configuration is used, the location of the compliance point may need to be re-evaluated.

To verify that these controls are sufficient to protect the surrounding environmental values, additional assessment is carried out approximately 100 m away (assessment point) where water quality should meet ambient WQGs or a pre-specified change from ambient conditions.

---

[8] This reasonable operational concept is adapted from the *Metal Mining Effluent Regulation* (MMER), a regulation made pursuant to the *Fisheries Act*. Although the remedial dredging project is obviously not a metal mine and the regulations do therefore not apply, the definition of a discharge point contained in the MMER is a contemporary workable definition for the present purpose and one intended to have conformity with the parent legislation, the *Fisheries Act*. The MMER defines a discharge point as being the point at which the operator ceases to have control over the effluent. This definition provides a workable parallel to prevailing environmental statutes and enables an assessment of ecological risks within the context of federal and provincial regulatory requirements.

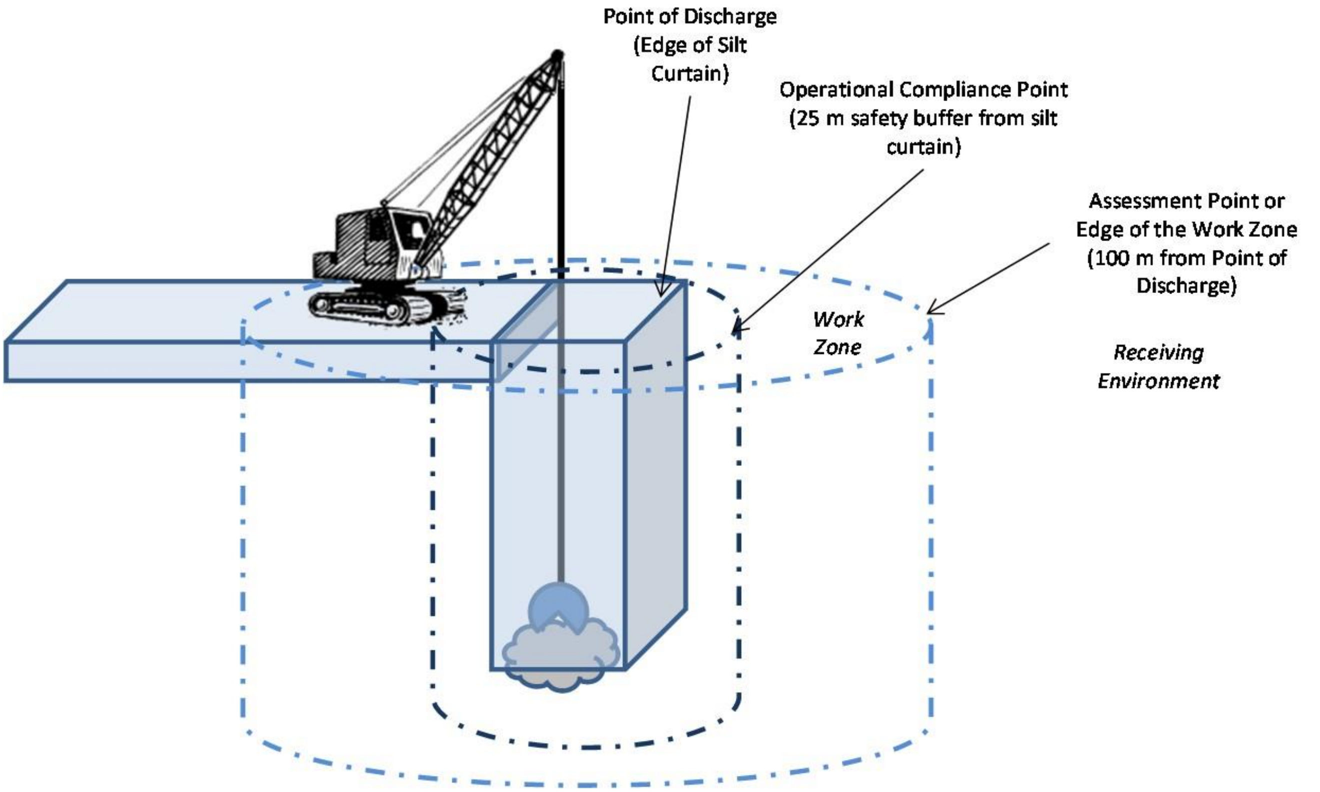

Figure 5: Schematic diagram showing the point of discharge, operational compliance point, and assessment point for a remedial dredging operation.

For the purposes of the EGD Waterlot project, site-specific benchmarks were developed for select parameters. The objective of the development and application of these benchmarks was two-fold:

- That lethal conditions (to fish) do not exist at the POD or the immediately surrounding work zone. The potential for acute lethality was evaluated against the proposed benchmarks.
- That chronic sub-lethal conditions (to fish) do not exist outside the work zone, which has been defined as 100 m away from the point of discharge (also called the assessment point). Ambient WQG or the proposed benchmark divided by 10, depending on how the WQG is derived, will be used to screen data from the edge of the work zone.

Decision criteria in Table 3 are provided for both the POD (*e.g.*, the operational compliance point is considered to be 25 m from the edge of silt curtain for dredging and intertidal excavation) and the assessment point as represented by the outer boundary of the work zone. Parameter limits for TSS for the POD are provided for three portions of the Project Area (shown in Figure 3):

- **WQMA-A** – This management area has been identified in the barge dewatering assessment to have sufficiently high metals and/or PAH concentrations to warrant more conservative mitigation to protect against acute effects from contaminants associated with the sediments being remediated. Direct barge dewatering may not be suitable without treatment, and dredging will need to be conducted to minimize re-suspension of seabed sediments. A TSS value of 40 mg/L (or 20 NTU as described in Section 3.1.2 will be used to manage dredging activities in WQMA-A.[9]

- **WQMA-C** – The metals and PAH concentrations in seabed sediments in the remainder of the Project Area are sufficiently low that they are not predicted to result in potentially acute effects at TSS values of 75 mg/L (or a turbidity of 25 NTU as described in Section 3.1.2). The management consideration for this area, WQMA-C, is related to the control of particulates.

Water quality parameters listed in Tables 3 to 5 are based on previously accepted[10] limits for remedial dredging projects as well as the assessment of barge dewatering effluent quality (Golder 2012b). It is proposed that the day-to-day dredging activities be managed on the basis of real-time turbidity measurements (Figure 8). *In situ* measurements will also include dissolved oxygen, temperature, pH and salinity, and samples will be collected for laboratory analysis of TSS, metals, and PAHs on a specified schedule or as necessary in the event of exceedance of turbidity criteria.

---

9 The suitability of barge dewatering in the under jetty area of WQMA-A will be re-assessed for Phase 2 when the engineering design of this component of the project is further advanced.

10 By federal regulators for remedial dredging projects in Vancouver Harbour.

Table 3: General Water Quality Requirements for the Project

Parameter	Point of Discharge[1]			Receiving Environment at Edge of Work Zone[2]
Total Suspended Solids	*Barge Dewatering*	WQMA-A: No discharge without treatment	WQMA-C: 75 mg/L[4]	<10 mg/L over ambient[5] at any given time (<24 h duration) when ambient[5] is <100 mg/L; <10% of ambient[5] when ambient[5] is >100 mg/L
	Open-water Dredging	WQMA-A: 40 mg/L[3]	WQMA-C: 75 mg/L[4]	
Turbidity[6]	Turbidity values as compliance limits for the discharge are not commonly specified for effluents. For the purposes of day-to-day management of dredging activities, turbidity value based on the TSS/turbidity relationship derived using sediment and sea water from the EGD Waterlot will be used (Section 3.1; APPENDIX A). The TSS/turbidity relationship will be verified and re-calibrated as necessary based on real-time data collected during the Project			< 5 NTU over ambient[5] when ambient[5] is <50 NTU; < 10% of ambient[5] when ambient[5] is > 50 NTU
Dissolved Oxygen	≥ 5 mg/L[7]			≥ 8 mg/L
pH	6.5 to 9.0 [8]			7.0-8.7
Metals – various	See Table 4			See Table 4
PAHs – various	See Table 5			See Table 5
Toxicity [10]	*Barge dewatering*: 96h LC_{50} ≥ 100%			n/a

Notes:

[1] Point of Discharge (POD) taken to be the established set-back or safe working distance from active dredging operations (*e.g.*, 25 m from the edge of the silt curtain). For the dewatering barge, the POD is considered to be the discharge from the barge.

[2] Receiving environment taken to be the edge of the work zone or assessment point (*i.e.*, 100 m from the edge of the silt curtain).

[3] Based barge dewatering assessment (Golder 2012b).

[4] Originates from DFO and MELP (1992) and is based on freshwater systems during wet weather; however, this number is frequently applied to marine discharges as well. This concentration is based on the release of clean suspended particulate matter, such as may occur during the dredging of uncontaminated materials.

[5] Ambient is defined as the conditions within Constance Cove.

[6] The baseline monitoring program indicated that turbidity in Esquimalt Harbour is relatively low (mean = 3.8 NTU). However, intermittent increases to 400 NTU have been observed in related to vessel operations at the EGD and storm events. Therefore, turbidity will be evaluated for the Project as induced turbidity above ambient measured at the time of sampling.

[7] Based on MOE ambient water quality guidelines for dissolved oxygen (MOE 1997).

[8] The range of pH specified for protection of marine waters is 7.0 – 8.7 to protect mollusk embryo development, based on MOE ambient water quality guidelines for pH (MOE 1991). However, for the purposes of concrete work, DFO has typically specified the same range as for freshwater (6.5 to 9.0), recognizing that these pH differences are small, short-term in nature, are not harmful, and with marine water buffering, the pH water quality guidelines will be met very quickly. Transient pH excursions to less than 7 or greater than 8.7 units are common natural occurrences in coastal environments.

[9] Based on MOE ambient water quality guidelines for pH (MOE 1991).

[10] Based on a test using a salt-water acclimated salmonid. All dewatering effluents are expected to be non-acutely lethal at the point of discharge; see Section 3.2.3 for discussion of when toxicity testing is to be conducted.

h – hour; mg/L – millgrams per litre; NTU – nephelometric turbidity units; POD – point of discharge; TSS – total suspended solids; WQMA-Water Quality Management Area (see Figure 3).

Table 4: Proposed Discharge Criteria for Metals

Parameter (as total)	Monitoring Criteria (µg/L) [1]	
	Point of Discharge [2]	Receiving Environment at Edge of Work Zone [3]
Arsenic	125	12.5
Copper	30	3
Zinc	100	10

Notes:

[1] The selection of this subset of metals is discussed in Golder (2012b).

[2] Compliance for the Point of discharge (POD) will be at an established set-back or safe working distance from active dredging/excavation operations (*e.g.*, 25 m from the edge of the silt curtain). For the dewatering barge, the POD is considered to be the discharge from the barge. These values apply to all Water Quality Management Areas (see Figure 3). The values are based on 10 x ambient WQG.

[3] Receiving environment taken to be the edge of the work zone (*i.e.*, 100 m from the POD). Values are based on ambient WQG (CCME 1999c; Singleton 1987; Nagpal 1999)

Table 5: Proposed Discharge Criteria for Polycyclic Aromatic Hydrocarbons

Parameter	Monitoring Criteria (µg/L) [1]	
	Point of Discharge[2]	Receiving Environment at Edge of Work Zone[3]
Acenaphthene	510	51
Anthracene	5.0	0.5
Benzo(a)anthracene	1.8	0.18
Benzo(b)fluoranthene	8.6	0.86
Benzo(a)pyrene	5.6	0.56
Benzo(g,h,i)perylene	1	0.1
Chrysene	8.6	0.86
2-Methylnaphthalene	58	5.8
Naphthalene	100	10
Phenanthrene	40	4.0
Pyrene	12.8	1.28

Notes:

[1] The selection of this subset of PAHs is discussed in Golder (2012b).

[2] Point of discharge (POD) taken to be the established set-back or safe working distance from active dredging/excavation activities (*e.g.*, 25 m from the edge of the silt curtain). For the dewatering barge, the POD is considered to be the discharge from the barge. These values apply to all Water Quality Management Areas (see Figure 3). The values are based on a combination of literature review and quantitative structure-activity (QSAR) relationship evaluations as described in Golder (2012b).

[3] Receiving environment taken to be the edge of the work zone (*i.e.*, 100 m from the POD). The values are based on the POD values with a 10-fold safety factor applied.

3.2.1 Decision Framework for Open-water Dredging

The decision framework for implementing management actions during **open-water dredging** is comprised of a series of steps to allow for adaptive management of dredging that will be responsive to environmental protection goals without unnecessary disruption to the operational needs of the Project. The framework for dredging in WQMA-A is illustrated in Figure 8. The steps are as follows (turbidity values for WQMA-A are used in this example; for dredging in WQMA-C, the applicable turbidity values should replace the ones below):

1) Regular monitoring (Section 3.3) is undertaken to evaluate potential for induced turbidity (*i.e.*, the change in turbidity greater than ambient) at the edge of the work zone (*i.e.*, the assessment point) during dredging (Figure 5).

2) If turbidity is observed to be less than the ambient WQG (*i.e.*, <5 NTU above ambient), regular monitoring of turbidity continues, with no application of management actions. In the event that turbidity is greater than the ambient WQG, the level of exceedance determines whether:

   a) Confirmatory sampling will be conducted (*i.e.*, when induced turbidity is between 5 and 20 NTU above ambient for dredging in WQMA-A). Confirmatory turbidity measurements will be made at three locations along the assessment point (100 m from the silt curtain) at three depths (1 m below surface, mid-water column, and 2 m above the seabed).

   b) Implementation of management actions is warranted (when induced turbidity at the assessment point is >20 NTU above ambient for dredging in WQMA-A), followed by confirmatory sampling at the assessment point as described in Step 2a to evaluate the effectiveness of the management action.

3) Step 2 is repeated. If the ambient WQG is met at the assessment point, regular monitoring is continued and the process returns to Step 1. If the ambient WQG is exceeded, the level of exceedance determines whether confirmatory sampling should be conducted or management actions are implemented.

4) If, after Steps 2 and 3, induced turbidity continues to exceed the ambient WQG at the assessment point:

   a) Management actions will be implemented if induced turbidity is >5 and <20 NTU (in WQMA-A) and confirmatory sampling will include collection of turbidity measurements at 3 depths and 5 locations along the compliance point (25 m from the silt curtain or closer depending on configuration of the silt curtain relative to the dredge head) as well as at the assessment point (100 m from the silt curtain). The purpose of the additional monitoring locations is to collect information about the behavior of the turbidity plume that can be used by a Qualified Registered Professional to evaluate the potential for environmental effects (which is determined in part by a combination of duration and magnitude). The QRP will need to take into account ambient (within Constance Cove) and background (within Esquimalt Harbour, outside of Constance Cove) conditions, visual observations, and level of accuracy of field instrumentation when assessing which course of action should be taken.

   b) Dredging will be stopped if induced turbidity is >20 NTU (in WQMA-A). After corrective actions are implemented, dredging may re-commence as will regular turbidity monitoring.

5) If, after Step 4a, induced turbidity continues to exceed the ambient WQG at the assessment point (*i.e.,* is >5 and <20 NTU for WQMA-A) or is >20 NTU at the compliance point (for WQMA-A), dredging will be stopped and corrective actions will be implemented. Dredging and regular turbidity monitoring may then resume.

The same process will be followed for dredging in WQMA-C; however, a different turbidity trigger value will be used (*i.e.*, 25 NTU rather than 20 NTU).

In the event that validation of the TSS-turbidity relationship indicates that a different turbidity is associated with the TSS values applied as limits, the turbidity trigger values may be modified accordingly.

3.2.3 Decision Framework for Barge Dewatering

For **barge dewatering** the compliance point is the point of discharge from the barge, and the assessment point is 100 m from the barge outlet (Figure 7). Both points will be monitored regularly, and if the dewatering discharge is found to contain a TSS concentration >40 mg/L in WQMA-B or >75 mg/L in WQMA-C, management actions (*e.g.*, cease loading of dredged material on the barge) will be implemented and confirmatory monitoring conducted on the water in the barge (*e.g.*, toxicity testing) and at the assessment point to evaluate the potential for environmental impacts. No direct discharge from the barge will occur without treatment or other mitigation in WQMA-A unless testing indicates that it is suitable for discharge (*i.e.*, is not acutely lethal using a salt-water acclimated salmonid).

3.2.4 Decision Framework for Placement of Material

During **placement of sand and armour rock material**, turbidity measurements will be taken at three depths in the water column down-current at a suitable safety distance (25 m) from the activity (the compliance point), as well as 100 m from the activity (the assessment point), and the decision framework for WQMA-C outlined in Section 3.2.1 generally be followed.

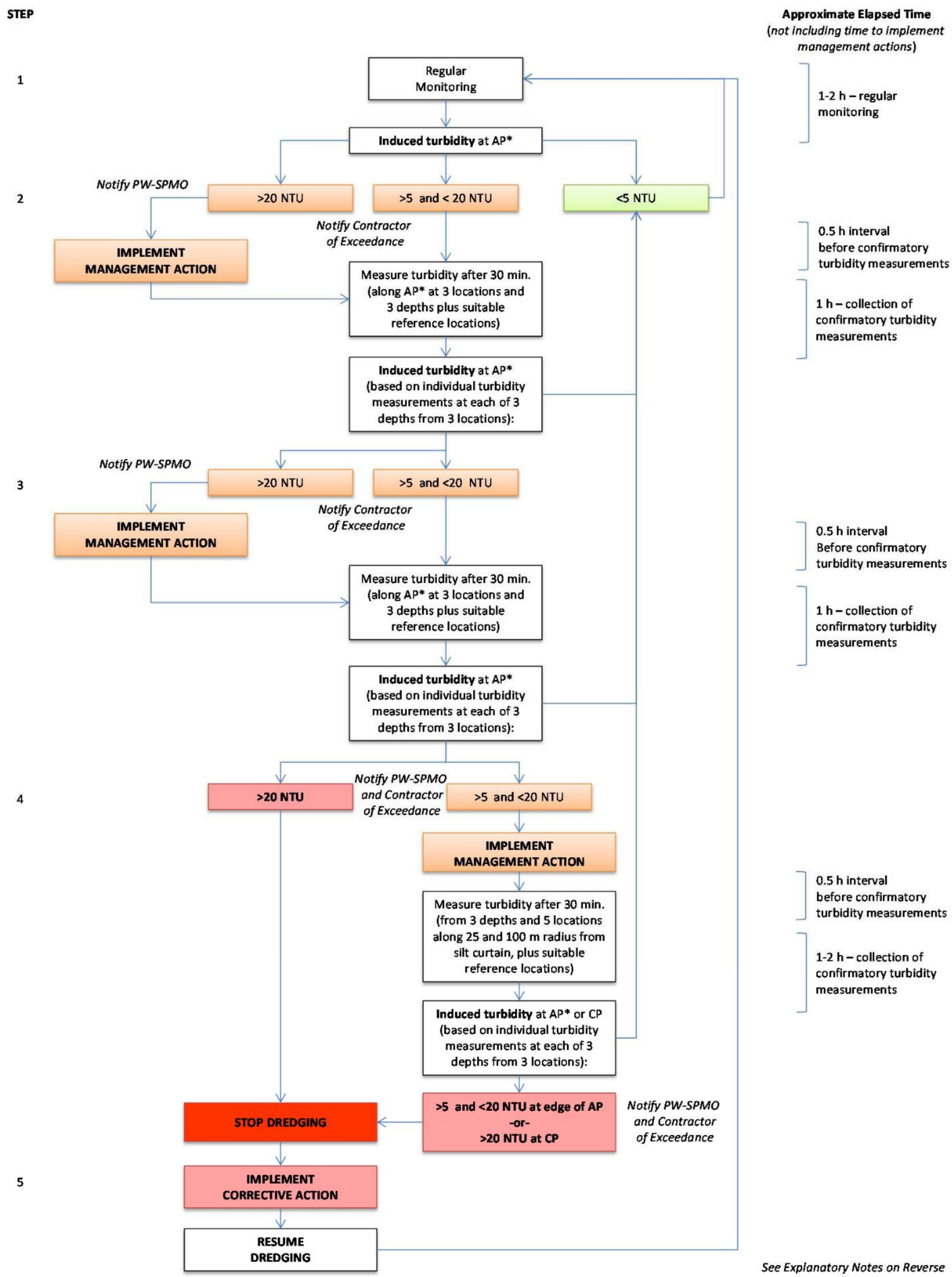

Figure 8: Decision Framework for implementing management actions during open-water dredging of water quality management areas a and b based on real-time monitoring of turbidity.

Notes for Figure 8:

IMPLEMENT MANAGEMENT ACTION – this may include: checking the silt curtain; slowing dredge cycle; changing bucket.

STOP DREDGING – Re-assess dredging to determine cause and define corrective actions prior to re-commencing dredging.

Induced turbidity is the level of change in turbidity greater than ambient. The value used for triggering management actions is dependent on the WQMA in which the work is being conducted. For dredging in WQMA-A, the turbidity limit is 20 NTU, and for dredging in WQMA-C, the turbidity limit is 25 NTU.

Ambient conditions – the conditions within Constance Cove.

Turbidity values triggering confirmatory sampling and/or implementation of management actions may change as the TSS-turbidity relationship is verified and recalibrated based on data collected during dredging.

A Qualified Registered Professional will evaluate potential for exceedances of performance objectives to cause environmental impact.

* Measurements based on real-time monitoring (collection of discrete samples in three locations in the water column). Additional sampling for metals and PAHs may need to be conducted in the event of exceedances of these induced turbidity values.

** Measurements made at 25 m from the silt curtain (or closer based on the configuration of the silt curtain relative to the dredge head) will be used to evaluate plume behaviour and potential for effects from exceedance of performance objectives.

Abbreviations:

AP – assessment point (100 m from POD; also called the edge of the work zone).
CP – compliance point (25 m safety buffer from silt curtain assuming that it is relatively close to the dredge bucket – the location of the compliance point will be re-evaluated based on the configuration of the silt curtain relative to the dredge head and may be at the edge of the silt curtain or at some distance within 25 m from the silt curtain).
m – metres.
min. – minutes.
NTU – nephelometric turbidity units.
PAH – polycyclic aromatic hydrocarbon.
PW-SPMO – Public Works Senior Project Manager (Operations).
TSS – total suspended solids.

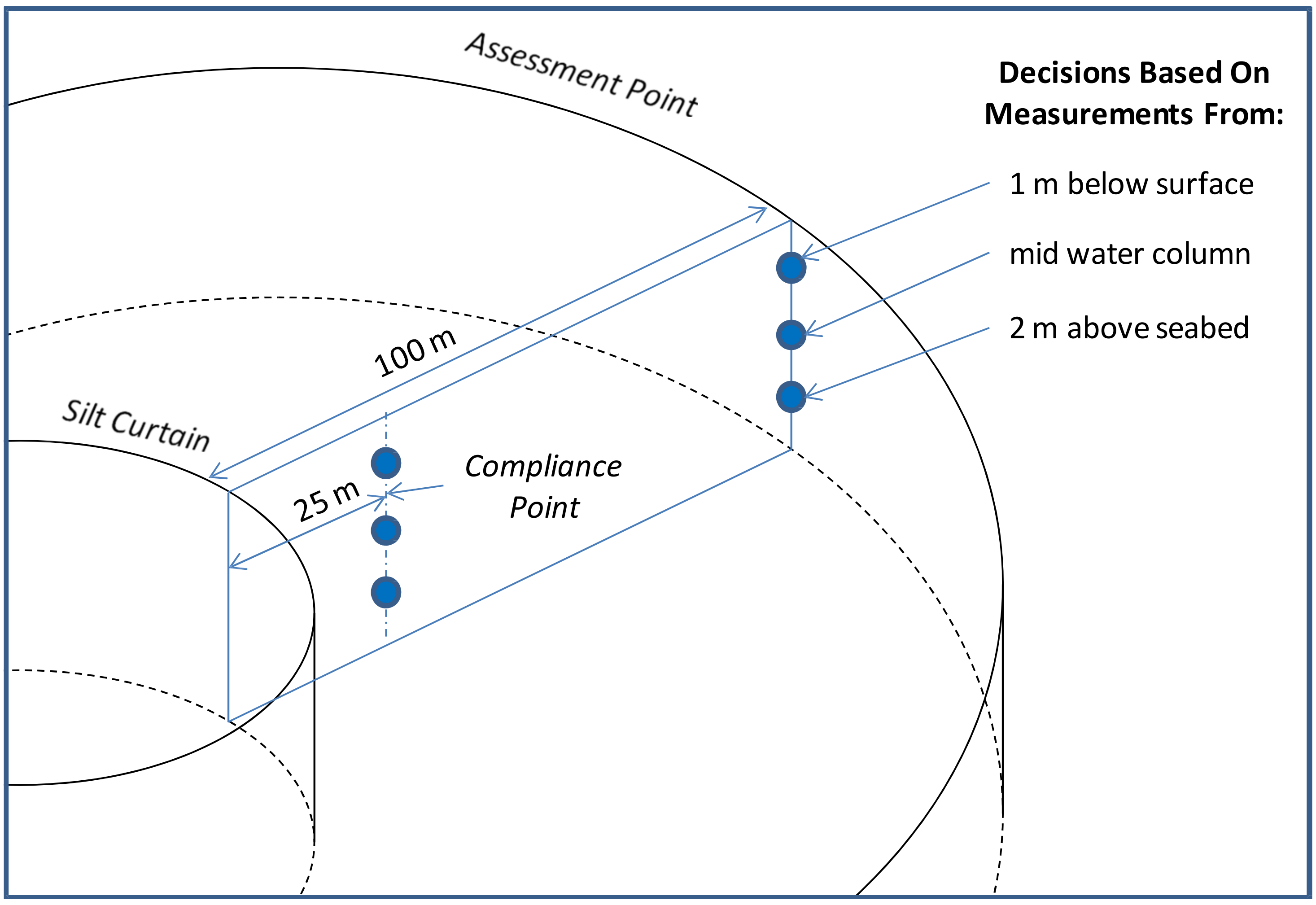

Figure 9: Conceptual layout of location of turbidity measurements in the water column.

3.3 Manual ("Real-time") Water Quality Monitoring

3.3.1 Monitoring Locations

The focus of the manual water quality monitoring program will be turbidity measurements, although *in situ* measurements of pH and dissolved oxygen will also be made occasionally to evaluate the effect of the Project activities on these parameters. The assumed number of sampling locations is described below and summarized in Table 6; however, a greater or lesser number of measurements may be made depending on the conditions at the time (*e.g.*, presence of confounding sources of turbidity or additional monitoring triggered per the decision framework for implementing management actions [Figure 8]). Water samples will also be collected for chemical analysis; samples for analysis of TSS will be collected as noted in Table 6, whereas metals and PAH analysis (for both total and dissolved[11] fractions for both sets of parameters) will be conducted only on a subset (approximately 50%) of samples to be determined at the time of sampling, at least initially. Samples for analysis of TSS will be relatively high initially to facilitate validation of the TSS-turbidity relationship (see also Section 3.5). If the environmental management measures for the Project are demonstrated to be consistently effective at the start of dredging, the frequency of collection of samples for laboratory analysis may be reduced (frequency is discussed further in Section 3.3.2).

Sampling stations will be located both up-current and down-current of the works, and will be adjusted throughout the event depending on the location of the dredging activity and the direction of prevailing current at the time of sampling (as noted in Section 2.0, currents in Esquimalt Harbour are variable). The sampling locations will be documented using hand-held GPS and laser rangefinder units. The selection of specific monitoring locations will be refined on the basis of the final dredging plan and site-specific conditions. A conceptual layout of the sampling locations is provided in Figure 10 for dredging, in Figure 11 for excavation activities at Munroe Head, and Figure 12 for barge dewatering, and described below. The conceptual layout of sampling locations for dredging activities can be applied to turbidity measurements during monitoring of other Project activities (*e.g.*, debris removal, sheet-pile wall installation, and sand cover placement).

- **Compliance Samples**
  - **Dredging location, 25 m from the edge of the silt curtain[12]** – this will consist of measurements collected down-current from the dredging in the water column outside the silt curtain as safety permits. Turbidity measurements will be collected from multiple depths:
    - At the surface of the water column: 1 m below the surface.
    - At the bottom of the water column 2 m above the sea bed (the grab sampler should be fitted with a weighted lead to help prevent the sampler itself from hitting the seabed and causing re-suspension of solids that may become entrained in the sample).

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[11] Samples for analysis of dissolved metals will be filtered through a 0.45 µm filter, and samples for dissolved PAH analysis will be prepared by centrifugation. Dissolved PAH analysis will only be conducted initially to evaluate the potential for presence of the soluble fraction).

[12] The safety distance assumes that the silt curtain will be placed relatively close to the dredge bucket. The distance of the CP from the silt curtain may need to be re-evaluated if a different silt curtain configuration is used.

- <u>Mid-water column.</u> This can be approximately half-way between the surface and bottom of the water column when it is not stratified, or just below the density barrier (*i.e.*, thermocline or halocline) when/if stratification is occurring.

■ **Assessment Samples –** samples will be collected at a distance of 100 m from the point at which the operator no longer exercises control over the discharge material (*e.g.*, from the edge of the silt curtain). It is proposed that turbidity measurements will be made at three locations along this radius with discrete measurements at three depths, as noted above. In the event that confirmatory sampling is triggered, two additional locations may also be sampled at this distance, for a total of five.

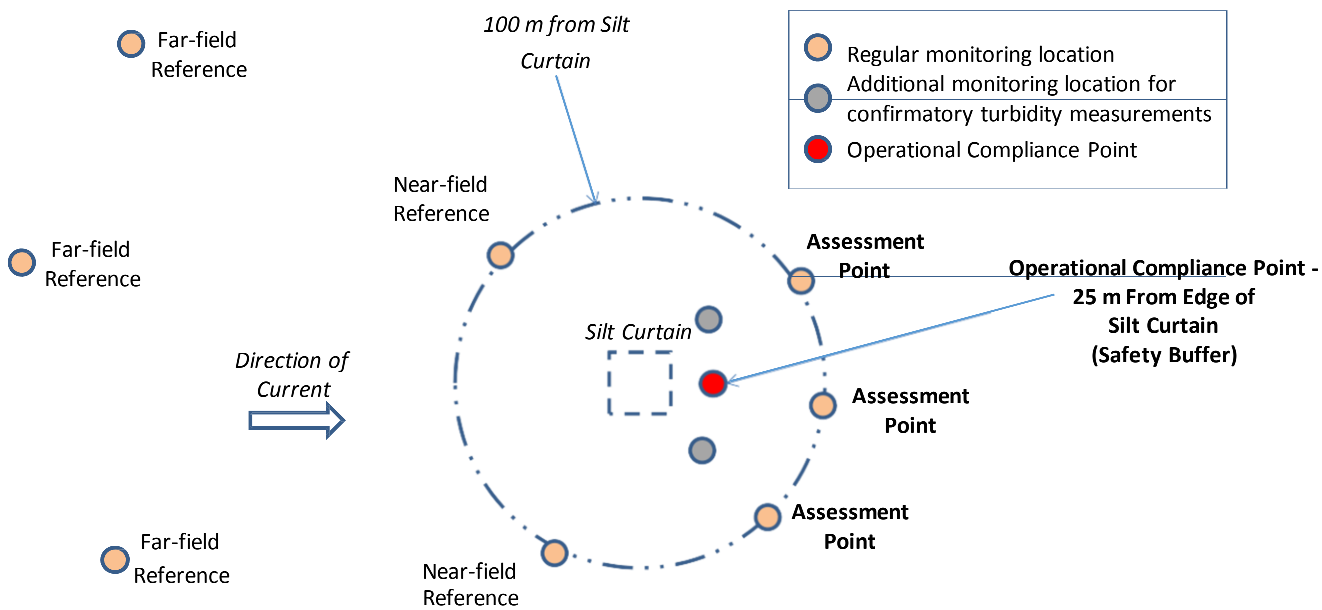

Figure 10: Conceptual layout of monitoring locations for dredging activities

Appendix 4

Water Quality Modelling Results

(Anchor, 2014)

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MEMORANDUM

To:	Andrew Mylly, Public Works and Government Services Canada	**Date:**	July 30, 2014
From:	Greg Brunkhorst and Dan Berlin, Anchor QEA	**Project:**	120553-02.24
Cc:	Greg Thomas, G3 Consulting Ltd.		
Re:	DRAFT - Anticipated Relationship between Contaminant Concentrations, Total Suspended Solids, and Turbidity During Phase 2 Dredging of Esquimalt Graving Dock		

PURPOSE

This memorandum summarizes available data and calculations used to estimate the relationship between contaminant concentrations in water, total suspended solids (TSS), and turbidity in support of development of water quality criteria for the Esquimalt Graving Dock (EGD) Phase 2 remediation activities. This is intended as an attachment to the Phase 2 Water Quality Monitoring Plan developed by G3 Consulting Ltd. (G3 Consulting), which describes chemical water quality, TSS, and turbidity criteria that are intended to prevent adverse impact to the environment during remediation activities, including the opening and closing of the temporary resuspension barrier (TRB).

WATER QUALITY CRITERIA

Table 1 presents the water quality criteria for a subset of contaminants that are representative of all contaminants present in sediment to be dredged during Phase 2 remediation. These 11 polycyclic aromatic hydrocarbons (PAHs) and three metals also have the highest concentrations in sediment relative to the cleanup criteria. As described in the Water Quality Monitoring Plan, the water quality criteria were developed for monitoring locations 25 meters (m) and 100 m from the project site. The criteria at the 25-m monitoring point are 10x the criteria at the 100-m monitoring point.[1] The water quality criteria were

[1] The main text of the Phase 2 Water Quality Monitoring Plan (G3 Consulting 2014) has several different designations for the 25- and 100-m monitoring points depending on the purpose of monitoring (e.g., monitoring during standard operations versus monitoring during TRB openings). For clarity, this memorandum refers to these monitoring points simply as the “25-m monitoring point” and the “100-m monitoring point.”

generally based on no observed effects levels (NOELs) associated with chronic exposures over time (e.g., 48- or 72-hour tests of sublethal and/or lethal effects).

Table 1 also presents average background concentrations from 280 measurements collected as part of the Phase 1B EGD remediation project between June 2013 and March 2014 from Esquimalt Harbour (SLR 2014). Results were non-detect for nearly all PAH samples, and 1/2 the detection limit was used to calculate the average background concentration. Copper had the highest background concentrations relative to water quality criteria, with an average of 1.1 micrograms per liter (μg/L) compared to the criterion of 3.0 μg/L. Copper exceeded the criterion in 7 of 280 background measurements (2.5% of samples).

TOTAL SUSPENDED SOLIDS TO ACHIEVE WATER QUALITY CRITERIA

The maximum TSS concentrations that achieve water quality criteria were estimated assuming that suspended solids have the same contaminant concentrations in bulk sediment from the Phase 2 remediation area targeted for dredging. The contaminant concentrations in sediment being dredged were estimated based on the average of all samples in the dredge prism (Table 1). Use of the average concentration of all sediment targeted for dredging is appropriate considering that sediment will be resuspended and mixed in the water column as the dredging is conducted within the Phase 2 area. Any suspended sediment released when the TRB is opened will be a mixture of previously dredged sediment.

This exercise uses a conservative approach to estimate the concentration sorbed to suspended sediment particles. Partitioning of contamination into the dissolved phase is not explicitly calculated; however, the total mass of contamination is accounted for in the calculations and assumes that dissolved phase contamination would move with suspended solids through the water column. This approach is reasonable for this analysis because the modeled contaminants have high partitioning coefficients and therefore tend to remain in the particulate phase. Settling is not incorporated into this analysis, which provides an additional layer of conservatism to the evaluation that may serve to reduce concentrations remaining in the water column.

The maximum TSS concentrations that achieve water quality criteria were calculated using the following formula:

$$TSS = \frac{WQC - B}{CS} \qquad (1)$$

where:

TSS	=	total suspended solids
WQC	=	water quality criterion
B	=	background
CS	=	average concentration in sediment

As shown by the formula, the calculation accounts for average background concentrations when evaluating potential exceedances. As noted above, background conditions alone can periodically result in water quality exceedances in Esquimalt Harbour, therefore, these calculations would apply to average conditions.

Based on these calculations, the lowest TSS concentration that would exceed water quality criterion is for copper, which is 68 milligrams per liter (mg/L) at the monitoring point of 25 m and 4.4 mg/L at the monitoring point of 100 m.

TURBIDITY – TSS RELATIONSHIP

Turbidity is commonly used to provide real-time measurements of water quality impacts during construction. TSS and chemical analyses can take several days, which does not support real-time modification of work activities for compliance with water quality criteria. For this analysis, the TSS and turbidity data from the Phase 1B EGD remediation project was used to predict the relationship between turbidity and TSS likely to be observed in the field. A relationship was also considered that was previously developed by Golder Associates Ltd. using sediment from the Phase 1B area during bench-scale testing (Golder 2012; see Figure 1). However, the Phase 1B field monitoring results were determined to be more representative of conditions expected to be observed during Phase 2 remediation activities.

Figure 1 shows a scatter-plot of 2,548 samples where TSS and turbidity were measured in paired samples. Two aberrant data points were removed as outliers. The figure indicates a relatively wide scattering of results, particularly at low levels of TSS (e.g., less than 20 mg/L) and turbidity (e.g., less than 10 Nephelometric Turbidity Units [NTU]). At higher levels of TSS and turbidity, most of the data points fall within a range of the following linear relationships:

$$\text{turbidity (NTU)} = 1.0 \times \text{TSS (mg/L)} \tag{2}$$ [2]

$$\text{turbidity (NTU)} = 0.25 \times \text{TSS (mg/L)} \tag{3}$$ [3]

The central tendency of all data can be described using the following regression equation using a least squares curve fit:

$$y = 0.48 \times x - 0.97 \tag{4}$$

where:

y	=	turbidity (NTU)
x	=	TSS (mg/L)

Based on the distribution of points, the coefficient of determination for the least squares curve fit (R^2) is 0.55. This regression equation can be generally described using the following equation:

$$y = 0.5 \times x \tag{5}$$

where:

y	=	turbidity (NTU)
x	=	TSS (mg/L)

The latter relationship was used to estimate turbidity values for specific Phase 2 TSS thresholds presented in Table 1.

This relationship between TSS and turbidity from the Phase 1B EGD remediation project dredging is generally consistent with observed TSS and turbidity measurements from other

[2] Shown as y = x on Figure 1.
[3] Shown as y = 0.25x on Figure 1.

dredging sites. Use of turbidity during the Phase 1B EGD remediation project was effective as a real-time warning for potential water quality exceedances. However, turbidity measurements should be further evaluated alongside other laboratory measurements (TSS and chemical concentrations) to confirm that the TSS/turbidity relationship provided in this memorandum is appropriate to estimate when potential environmental impacts may occur. In addition, the TSS-turbidity relationship should only be re-evaluated with a large number of data points.

REFERENCES

SLR (SLR Consulting (Canada) Ltd.), 2014. Draft Phase 1B Environmental Monitoring Completion Report. Prepared for PWGSC. April.

Golder (Golder Associates Ltd.), 2012. Final Water Quality Monitoring Plan – Appendix A: Total Suspended Solids/Turbidity Relationship. Esquimalt Graving Dock Waterlot Remediation Project. Prepared for PWGSC. December 6, 2012.

G3 Consulting (G3 Consulting Ltd.), 2014. Phase 2: Water Quality Monitoring Plan for the Esquimalt Graving Dock South Jetty Redevelopment/Waterlot Under-pier Phase 2 Remediation Project. Draft. Prepared for PWGSC. March 31, 2014.

ATTACHMENTS

Table 1
Approximate Total Suspended Solids and Estimated Turbidity to Achieve Monitoring Water Quality Criteria

Analyte	Monitoring Water Quality Criteria (µg/L)			Average of all Samples in Dredge Prism: Sediment Concentration (mg/kg dw)	Approximate TSS Concentration to Achieve Monitoring Criteria (mg/L)		Approximate Turbidity Measurement to Achieve Monitoring Criteria (NTU)[1]	
	100 m	25 m	Background	Average	TSS at 100 m	TSS at 25 m	Turbidity at 100 m	Turbidity at 25 m
Acenaphthene	51	510	0.025	8.6	5,900	59,000	3,000	30,000
Anthracene	0.50	5.0	0.0050	12	41	420	21	210
Benzo(a)anthracene	0.18	1.8	0.0050	19	9.2	95	4.6	47
Benzo(a)pyrene	0.56	5.6	0.0045	18	31	310	15	160
Benzo(b)fluoranthene	0.86	8.6	0.025	23	37	380	18	190
Benzo(g,h,i)perylene	0.10	1.0	0.025	11	7	89	3	45
Chrysene	0.86	8.6	0.025	8	100	1,100	52	530
2-Methylnapthalene	5.8	58	0.050	3.6	1,600	16,000	800	8,100
Naphthalene	10	100	0.051	10	970	9,800	490	4,900
Phenanthrene	4.0	40	0.026	58	69	690	34	350
Pyrene	1.28	12.8	0.011	51	25	250	12	130
Arsenic	12.5	125	1.98	82	130	1,500	64	750
Copper	3.0	30	1.12	425	4.4	68	2.2	34
Zinc	10	100	2.15	570	14	170	7	86

Notes:

1. For the calculation above, the turbidity - TSS relationship of turbidity (NTU) = 0.5*TSS (mg/L) was used. This equation is accurate to approximately +100% and -50%.

Highlighted cells represent the lowest measurements that would result in an exceedance.

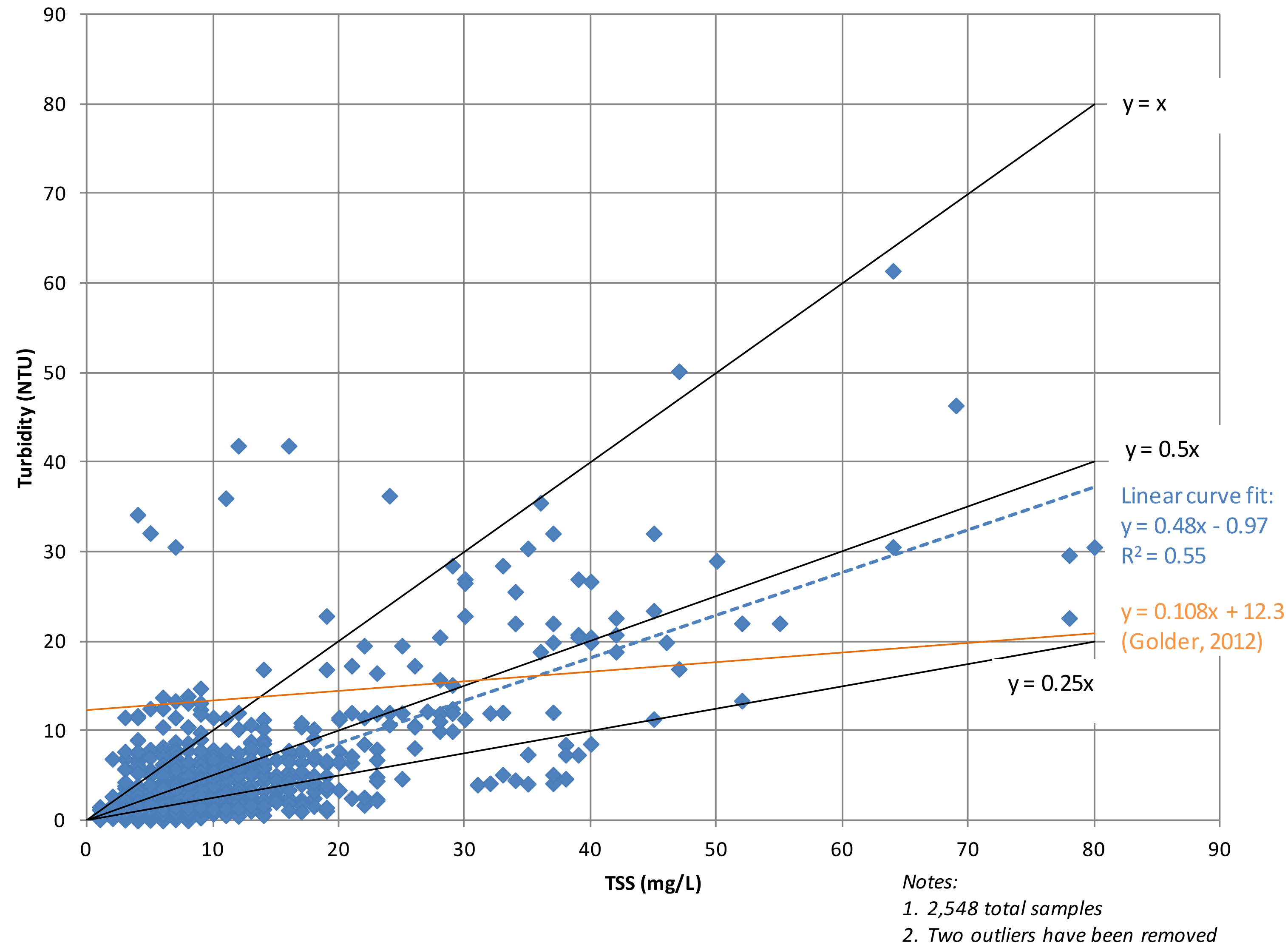

Figure 1
Turbidity - TSS Relationship for 2013-2014 Phase 1B EGD Dredging
Memorandum: Anticipated Relationship between Total Suspended Solids and Turbidity During Phase 2 Dredging
Esquimalt Graving Dock

ANCHOR QEA

Appendix 5

Phase 1 Barge Dewatering Assessment (Golder, 2012b)

APPENDIX E

Barge Dewatering Assessment

March 21, 2012 (FINAL DRAFT)

Project No. 10-1475-0002/10000/2000
E/12/0311

Mr. Andrew Mylly
Public Works and Government Services Canada
641 - 800 Burrard Street
Vancouver, BC
V6Z 2V8

ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT: ASSESSMENT OF PREDICTED QUALITY OF DISCHARGE WATER DURING BARGE DEWATERING

Dear Mr. Mylly,

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Public Works and Government Services Canada (PWGSC) to provide engineering and site assessment support for the Esquimalt Graving Dock Waterlot Remediation Project. The proposed remediation project involves the removal of contaminated sediments within the EGD Waterlot and adjacent “buffer” zones (herein referred to as the Project Area), that exceed numeric Remedial Action Objectives (RAOs) for the Project[1].

The design team for the remedial dredging includes Anchor QEA LLC (Anchor) of Seattle, Washington and Golder. The objective for the remediation is to reduce financial liability for PWGSC associated with historical contamination.

The remedial action plan, proposes the dredging of contaminated sediments within the Project Area primarily by clamshell dredging methods, with smaller areas adjacent to sensitive facility infrastructure targeted for suction dredging (potentially diver assisted). Dredged sediment will then be placed on a hopper barge for transportation to an off-loading facility prior to transportation overland to a permitted uplands disposal site.

Dredged material will require dewatering prior to overland transport, to enable appropriate handling and transportation. To support the assessment of dewatering requirements for the dredged material, this letter provides an assessment of the potential viability of discharge of water from dredged sediments to the marine environment during barge dewatering activities.

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1 Project numeric RAOs for contaminants of potential concern defined as the most conservative of the applicable Canadian Council of Ministers of the Environment (CCME) Probable Effects Level (PEL) guidelines (CCME, 1999) and British Columbia Ministry of Environment (BC MoE) Contaminated Sites Regulation (CSR) Generic Numerical Sediment Criteria for marine sediment (typical sites [$SedQC_{TS}$]) (BC MoE, 1996. With updates to 2010).

2.0 BACKGROUND AND OBJECTIVES

Discharges posing a potentially unacceptable risk could trigger a shutdown of dredging operations by regulatory agencies and it is therefore desirable to identify potential controls to be employed during the dredging as part of project planning and then develop additional controls as needed, before dredging begins.

The assessment provided below will assist the design team in identifying if specification of (for example) sealed barges for the project is required, resulting in the need for appropriate collection and treatment of the dewatering effluent prior to disposal. Alternatively, if discharge to the marine environment is acceptable, appropriate controls will need to be implemented to manage concentrations of total suspended solids (TSS) in the discharge water.

Golder will use the results of this assessment to support the development of the Water Quality Monitoring Plan for the Project, which will include proposed environmental performance monitoring and assessment criteria during remediation activities.

In accordance with Golder's final workplan *"Esquimalt Graving Dock Waterlot Sediment Remediation Project: Fiscal Year 2010-2011 Input to Dredge Effects Assessment"* dated November 18, 2010 (Golder, 2010a), Golder undertook an analysis of the potential for release of chemical substances in bedded sediment from the dewatering of the dredged material placed on a barge, to provide planning-level estimates of the potential water chemistry (total and dissolved) and an understanding of how concentrations of TSS affect the associated potential water quality impacts.

The assessment is based on the current understanding of the relevant chemical fate processes and sediment chemistry data available for the Project Area.

3.0 MODELLING OVERVIEW

The model used in the present analysis estimated the potential release of sediment-associated substances during dewatering of dredged material. The model evaluated a scenario of re-suspension of sediment particles into overlying seawater on the dredging barge, and desorption of organic substances from the particulate-associated phase into the dissolved phase prior to discharge from the barge.

The output of the model consists of predicted chemical concentrations in dewatering effluent (including both particulate and dissolved phases) at the time of discharge.

4.0 MODEL THEORY AND FRAMEWORK: ORGANICS

Organic chemicals in sediment typically undergo some degree of desorption following sediment re-suspension. The dynamics of desorption of organic chemicals from sediment is generally well described, and has been shown by many investigators to be biphasic, with a portion occurring as "rapid phase" desorption and the remainder, often a substantial portion, occurring as "slow phase" desorption (*e.g.*, Karickhoff 1980; Kan et al. 1998; Alexander 2000). "Slow phase" desorption is thought to be due to long-term physical or chemical changes in the conformation of sediment organic matter, resulting in entrapment of a portion of sorbed chemicals (Chen et al. 2000). The extent of entrapment is related to the residence time of the chemicals in the sediment, and historically-contaminated sediments often exhibit very low rates of chemical desorption (Chen et al. 1999).

The potential release of organic chemicals from historically-contaminated sediment is therefore best modelled as a function of chemical concentrations in the sediment, the amount of sediment released, and the duration of contact between re-suspended sediment and the water column (Sanchez et al. 2002; Thibodeaux 2005a, Thibodeaux et al. 2005b).

For this analysis, we constructed a dynamic, time-dependent, multimedia model of organic chemical release during a re-suspension event (Thibodeaux et al. 2005b). This type of model gives a more accurate prediction of the short-term fate of sediment-associated chemicals than do equilibrium models. The model was specified to include two sediment-associated chemical compartments (rapid-desorbing and slowly-desorbing) and a dissolved compartment. For each time step, the model calculated the exchange of chemical between suspended sediment and water, according to the following set of mass-balance equations:

$$\Delta X_R / \Delta t = D_R f_W - D_R f_R \tag{1}$$

$$\Delta X_S / \Delta t = D_S f_W - D_S f_S \tag{2}$$

$$\Delta X_W / \Delta t = D_S f_S + D_R f_R - (D_S + D_R) f_W \tag{3}$$

Where:

X is the mass of chemical in a compartment,

D is a transport parameter for solid-water exchange, and

f is the fugacity of chemical in the compartment; subscripts denote the rapidly-desorbing sediment fraction (R), slowly-desorbing sediment fraction (S), and water (W).

This model is specified in fugacity format, to take into account the relative capacities of resuspended sediment and water to adsorb contaminants. Fugacity is calculated as the chemical concentration in a compartment normalized to the compartment's sorptive capacity for that chemical. Sorptive capacity of resuspended sediment is calculated as a function of the material's organic carbon content. Sorptive capacity of water is a function of the chemical's Henry's Law Constant.

The model was run through a number of time steps to represent the period of sediment suspension prior to discharge of water from dredged sediments placed on a barge. The model therefore evaluated the redistribution of chemicals from the bedded sediment following re-suspension of the dredged material on the barge, constrained by the duration of time actually available for this redistribution to take place (on the barge).

Model predictions were generated for a range of assumed suspended sediment concentrations (5 to 75 mg/L).

5.0 MODEL THEORY AND FRAMEWORK: METALS

Release of metals from sediment following re-suspension is generally much lower than that observed for organic substances, and the release of metals is governed by much more complex and less-well understood processes than those involved in desorption of organic contaminants (Eggleton and Thomas 2004).

A change in the chemical properties of the sediment–metal complexes during dredging can cause mobilization of metals, principally from sulphide-bound complexes (Calmano et al. 1993). However, in situations where sediment redox potential and pH do not change dramatically (*i.e.*, in partially oxidized sediments such as those present in Esquimalt Harbour), the release of metals is generally negligible (Forstner et al. 1989; Reible et al. 2002). For example, Pieters et al. (2002) observed low metal mobilisation during dredging, although metal mobility differed between dredging techniques and was different for every metal examined. Van den Berg et al. (2001) and De Groote et al. (1998) also observed low mobilisation of metal contaminants into the dissolved phase during dredging, which was thought to be due to the rapid scavenging of sulphide liberated metals by newly formed iron and manganese oxides/hydroxides.

This is in agreement with simulated dredging studies, where low or no metal contaminants were released and concentrations returned to background levels within hours (Bonnet et al. 2000). It is also in agreement with the results of dredging elutriate testing (DRET) of sediment samples from the EGD Waterlot (Golder 2010b), in which metals concentrations in filtered samples were generally observed to be lower than concentrations in unfiltered samples (*e.g.*, copper concentrations in filtered samples were on average 4.2% of those in unfiltered samples).

For this model, release of metals from the solid phase into the dissolved phase during dredge dewatering was assumed to be negligible relative to the contribution of particulate-phase metals to total metals concentrations. Concentrations of chemical substances in the discharged water were therefore calculated from reported chemical concentrations in sediment (normalized to percent fines) and assumed concentrations of suspended sediment in the discharged water (ranging from 5 to 75 mg/L TSS).

When predicted total metals concentrations exceeded screening values, a further analysis was undertaken to evaluate dissolved metals concentrations. The rationale for this further analysis was that water quality guidelines are generally based on toxicity testing with soluble metal salts, and therefore the screening values derived from these water quality guidelines are most relevant to the evaluation of dissolved metals concentrations.

The results of DRET testing (Golder 2010b) were used to estimate the fraction of sediment metals expected to be in the dissolved phase following discharge. The dissolved fraction from DRET results was used to calculate a dissolved-phase concentration, which was then evaluated relative to the selected screening values.

6.0 MODEL ASSUMPTIONS

For the purposes of this modelling analysis, the following assumptions were made:

- The available sediment chemistry data were assumed to provide an accurate characterization of the sediment to be dredged;
- Depth-weighted average contaminant concentrations for each dredge unit (DU) provided by Anchor[2] were assumed to be representative of sediment contaminant conditions on a barge during dredging of that DU;
- Measured organic chemicals were assumed to be in dissolved or particulate-associated phases, *i.e.*, the volume of sediment to be dredged contains no non-aqueous phase liquid (NAPL);
- Measured organic chemicals were assumed to have the potential for release into the dissolved phase, *i.e.*, none is associated with non-desorbing (permanently sequestered) phases;
- Pre-dredging concentrations of substances in overlying seawater were assumed to be negligible;

2 Depth-weighted average concentrations provided by Anchor for sediment dredge units by email dated January 12, 2011.

- The time available for desorption to occur (*i.e.*, between the time of placement of material on the barge and the time of discharge of the overlying water) was assumed to be 1 hour;
- The mean suspended sediment concentration of the dredged material suspension (sediment and entrained seawater) during the desorption period was assumed to be 500 mg/L;
- As noted above, release of metals from the solid phase into the dissolved phase prior to effluent discharge was assumed to be negligible; and,
- Metals and PAHs were assumed to be associated with the fines (< 0.075 mm) fraction of the sediment (*i.e.*, measured concentrations in sediment were normalized to percent fines), and the TSS in dredge discharge water was assumed to be entirely composed of this fines fraction.

7.0 WATER QUALITY SCREENING

Predicted total concentrations of select[3] chemical substances in the discharged water were screened against numerical values representative of concentrations that would, in our opinion, ordinarily be considered acceptable for discharge into the marine environment, summarized in Table 1.

The benchmarks for evaluating PAHs have previously been accepted in Vancouver Harbour for other dredging projects. For convenience, the rationale for the selected concentrations are provided in the summary table. Predicted concentrations of metals were screened against benchmarks selected in the following order of priority:

- 10× CCME marine water quality guidelines[4].
- 10× BC marine water quality guidelines[5].
- 10× CCME freshwater quality guidelines[4].
- 10× BC freshwater quality guidelines[5].
- 10× US EPA acute marine water quality criteria[6].

Where available, acute guidelines were selected over chronic guidelines.

WQG are not intended to be effluent limits, particularly for larger bodies of water such as Esquimalt Habour, for several reasons, such as:

- WQG are often derived from conservative endpoints (*e.g.*, lowest observed effects concentrations or LOECs), and the most sensitive species for which toxicity test data are available, and
- Safety factors, often 10 times, are often applied to add conservatism.

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3 Based on a preliminary screening exercise using the highest maximum sediment concentrations observed by sediment management areas, a subset of parameters was selected for more detailed analysis on the basis of smaller dredge units.

4 Canadian Council of Ministers of the Environment (CCME), "Canadian Water Quality Guidelines for the Protection of Aquatic Life", updated 2007 (CCME 1999).

5 BC Ministry of Environment, “A Compendium of Working Water Quality Guidelines for British Columbia”, updated August 2006; and BC Ministry of Environment, “British Columbia Approved Water Quality Guidelines”, updated January 2010 (BC MoE 2010).

6 U.S. Environmental Protection Agency, “National Recommended Water Quality Criteria”, updated 2011 (US EPA, 2011). Accessed online at: http://water.epa.gov/scitech/swguidance/standards/current/index.cfm

A common approach to defining effluent limits, therefore, is to multiply a given WQG by ten.

The speciation of chromium in dredge discharge water is not known, and chromium was therefore evaluated relative to benchmarks based on the CCME water quality guidelines for both Cr (VI) and Cr (III). Tributyltin was not screened because only a chronic effects benchmark was available, which is not an appropriate basis for assessing potential effects of an acute exposure for this substance.

8.0 MODEL INPUTS

A preliminary series of model analyses was conducted to focus the investigation on substances with the potential to result in unacceptable discharge water quality. These analyses were based on the maximum fines-normalized concentration of each substance across SMAs, to provide a conservative evaluation of worst-case conditions across the proposed dredging area. This scenario estimated the discharge water quality that would result if the holding vessel contained suspended solids only from the area in which the highest concentration of a particular parameter was reported. This is not necessarily a realistic estimate of conditions that will result if a larger area is dredged (*i.e.*, containing some sediment with lower parameter concentrations), but was undertaken to give a high-level screening assessment of each parameter. If this evaluation resulted in predicted discharge water concentrations of a parameter that did not exceed the selected assessment benchmarks, this indicated that discharge water quality would be acceptable for that parameter for any portion of the dredging area.

Subsequent model analyses were based on average concentrations of substances in sediment within each Dredge Unit (DU) designated by Anchor as part of the remedial dredge plan. Estimated depth-weighted average sediment concentrations of arsenic, copper, zinc, and total PAHs in each DU were provided by Anchor. Concentrations of 10 individual PAHs were estimated by multiplying the total PAH concentration for each DU by the average fraction of total PAHs that each individual PAH represented in the sediment (based on reference to chemistry screening tables prepared by Golder as part of the Detailed Site Investigation for the Project). Individual PAH fractions were calculated for each SMA and applied to all DUs within that SMA.

Grain size and average total organic carbon were calculated by querying data available for the Project Area from the Esquimalt Harbour Access Database managed by SLR. Average total organic carbon and percent fines were calculated for each SMA and applied to all DUs within that SMA.

9.0 RESULTS

The modelling evaluation based on maximum fines-normalized concentrations across the SMAs resulted in predicted discharge water concentrations exceeding the screening values for arsenic, copper, zinc, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(ghi)perylene, chrysene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene. Predicted maximum discharge water concentrations of chromium exceeded the screening value for chromium (VI), but not for chromium (III). Given the absence of information about chromium speciation in dewatering effluent, and given that chromium concentrations in all but three sediment samples were less than the PEL, it was assumed that modelling the remaining substances would provide an appropriately conservative evaluation of effluent water quality. The remaining substances were evaluated further by modelling discharge water quality for each DU.

Predicted total concentrations of the modelled substances in discharge water for each DU are presented in Table 2a-n. Predicted concentrations exceeding the screening value are highlighted. The following substances exhibited one or more predicted total concentrations in excess of the screening value:

- Copper: Predicted total copper concentrations in discharge water exceeded the screening value at one or more TSS concentrations for 26 DUs. However, the majority of discharged copper is expected to be in the particulate phase, and therefore these predicted total copper concentrations do not necessarily represent a potential for adverse effects to marine life. Based on the results of DRET testing (Golder 2010b), the dissolved fraction of total copper was on average 4.2% (minimum 0.2%; maximum 16%; n = 41). Conservatively assuming the maximum fraction dissolved that was observed in DRET testing (*i.e.*, 16%), predicted dissolved copper exceeded the screening value only in DU19B (at TSS > 20 mg/L), DU20B (at TSS > 30 mg/L), and DU21 and DU49 (at TSS > 40 mg/L). DUs 19B, 20B, and 49 are along the eastern-most project boundary in Pilgrim Cove, and DU21 is along the North Landing Wharf (NLW; Figure 1). Assuming the average fraction dissolved observed in DRET testing (*i.e.*, 4.2%), predicted dissolved copper did not exceed the screening value in any of the DUs.

- Zinc: Predicted total zinc concentrations in discharge water exceeded the screening value at one or more TSS concentrations for 10 DUs. However, a fraction of discharged zinc is expected to be in the particulate phase, and therefore these predicted total zinc concentrations do not necessarily represent a potential for adverse effects to marine life. Based on the results of DRET testing (Golder 2010b), the dissolved fraction of total zinc was on average 14% (minimum 1%; maximum 58%; n = 41). Conservatively assuming the maximum fraction dissolved that was observed in DRET testing (*i.e.*, 58%), predicted dissolved zinc exceeded the screening value only in DU19B and DU20B (at TSS > 20 mg/L), DU49 (at TSS > 30 mg/L), DU21 (at TSS > 40 mg/L) and DU22 (at TSS > 70 mg/L). DUs 19B , 20B and 49 are along the eastern-most project boundary in Pilgrim Cove, and DUs 21 and 22 are along the NLW (Figure 1). Assuming the average fraction dissolved observed in DRET testing (*i.e.*, 14%), predicted dissolved zinc did not exceed the screening value in any DU.

- PAHs: Predicted concentrations in discharge water of one or more individual PAHs exceeded their respective screening values at one or more TSS concentrations for 9 DUs (DUs 18B, 19B, 20B, 32, 34, 39, 44, 48, and 49) (Figure 1). The DUs exhibiting predicted exceedances of screening values were those in SMA-5 and 5B (DUs 18B, 19B, 20B, 48, and 49 at the east end of the South Jetty), SMA-6 (DUs 34, 39, and 44 in the South Jetty under pier area), and SMA-3 (at the mouth of the Graving Dock; DU32 only). Predicted concentrations of anthracene exceeded the screening value at all modelled TSS concentrations in all nine of these DUs. Other PAHs exhibiting one or more predicted exceedances of screening values were naphthalene, benzo(a)anthracene, pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, phenanthrene, pyrene, benzo(a)pyrene, chrysene, and 2-methylnaphthalene.

10.0 INTERPRETATION

Under the assumptions of the model stated above, and based on the available sediment chemistry data, the modelling analysis predicted that discharge water from dewatering of dredged sediment on the barges in the majority of the site would likely be considered acceptable for discharge to the marine environment, subject to suitable control of TSS.

The following portions of the site were identified as requiring mitigation to avoid potential adverse effects to marine life:

- Nearshore areas adjacent to the South Jetty (SMA-5, -5B, -6 and -3): Predicted concentrations of one or more individual PAHs in discharge water exceeded screening values for most of the DUs within SMA-5 and -5B (DUs 18B, 19B, 20B, and 21B) and -6 (DUs 34, 39, and 44), and for DU32 in SMA-3. For several individual PAHs, predicted dissolved concentrations exceeded screening values, indicating that even strict TSS control may not be sufficient to prevent adverse effects. In addition, predicted concentrations of dissolved copper and dissolved zinc in discharge water exceed the screening values in several DUs within SMA-5 and -5B when the assumed TSS in discharge water was greater than 20 mg/L. The predicted concentrations of PAHs and dissolved metals indicate a potential for acute toxicity to marine life under the evaluated conditions. Dewatering effluent from these areas is likely to be unsuitable for discharge to the marine environment, therefore potentially requiring additional treatment and/or management methods prior to disposal.

- Nearshore areas adjacent to the North Landing Wharf (SMA-3): Predicted concentrations of dissolved copper and dissolved zinc in discharge water exceeded the screening values in DU21 and DU22 when the assumed TSS in discharge water was greater than 40 mg/L. Dewatering effluent from these areas is likely to be suitable for discharge to the marine environment with commonly applied controls (*e.g.*, settling, filtration through fabric) to reduce TSS.

- Some additional DUs had total copper concentrations exceeding the screening value at one or more TSS concentrations. These areas were in SMA-3, -4 and -4B, and tended to be adjacent to the areas identified above. Given the results of DRET testing, dissolved copper concentrations in dewatering effluent from these DUs are not expected to exceed the screening value, and therefore it is unlikely that adverse effects to marine life will result. However, actual dissolved copper concentrations in dewatering effluent will not be known until dredging is underway. Monitoring of dredge dewatering effluent quality will be required to confirm these modelling results.

11.0 LIMITATIONS

This report was prepared for PWGSC, and is intended to provide an evaluation of potential discharge water quality during dredging. The findings and conclusions documented in this report have been prepared for the specific application to this project and have been developed in a manner consistent with that level of care normally exercised by environmental professionals currently practising under similar conditions in the jurisdiction. Golder makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

If new information is discovered during future work it is recommended that Golder be requested to re-evaluate the conclusions of this report and to provide amendments as required prior to any reliance upon the information presented herein.

12.0 CLOSURE

This assessment has been undertaken to support the identification of environmental mitigation measures for the Project and development of the Water Quality Monitoring plan for implementation during the dredging. We look forward to discussing the results further with the Project Team next fiscal year. Please contact the undersigned at your convenience should you have questions or comments.

Yours very truly,

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Attachments: Table 1 - Summary of Proposed Screening Benchmarks for Dredged Material Dewatering
Table 2 - Predicted Discharge Water Quality Results
Figure 1 – Location of Sediment Management Areas and Dredge Units in the Esquimalt Graving Dock Waterlot and Buffer Areas

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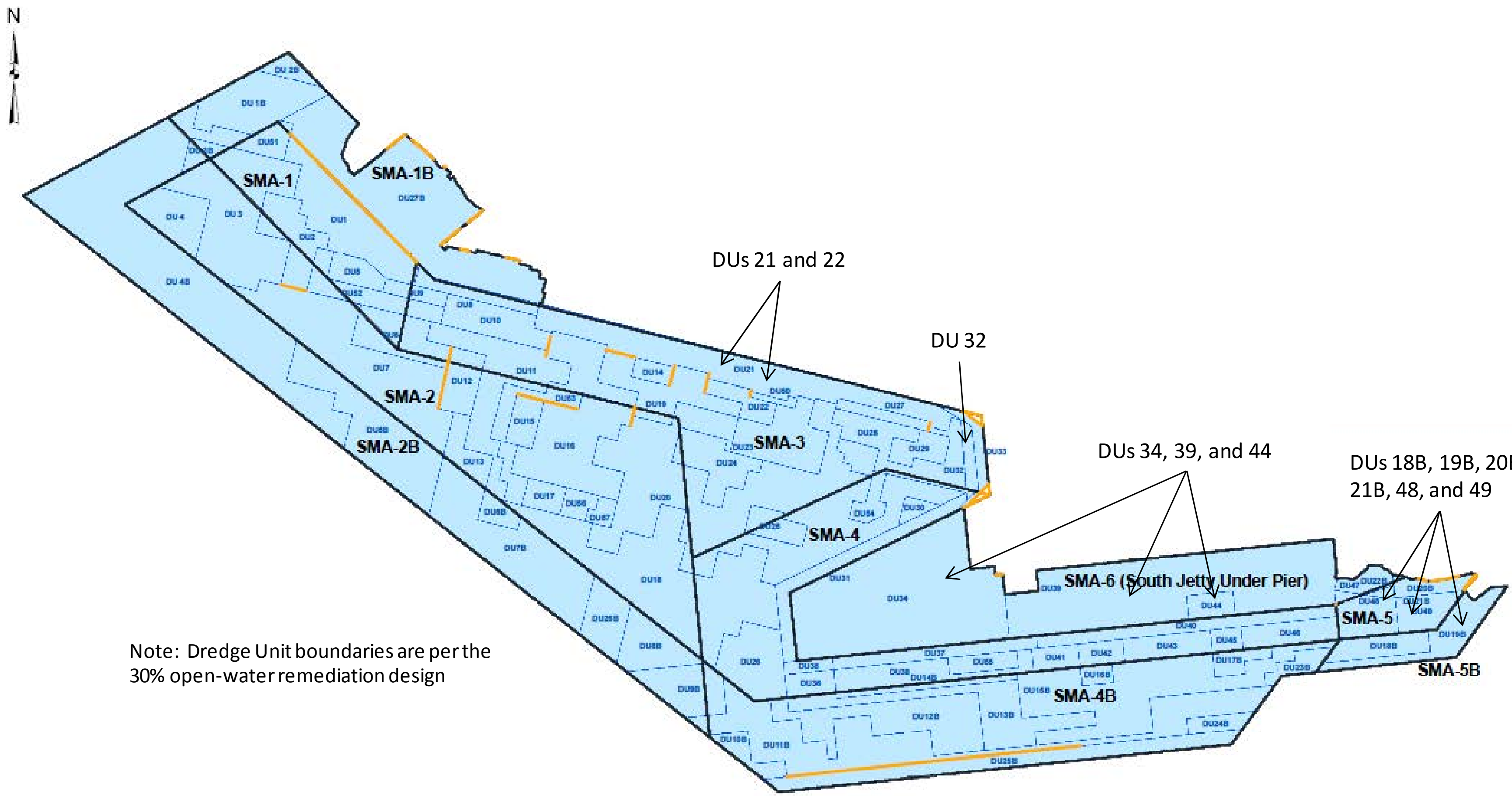

Figure 1: Location of Sediment Management Areas and Dredge Units in the Esquimalt Graving Dock Waterlot and Buffer Areas

Table 1: Summary of Proposed Dredge Discharge Benchmarks for Select Parameters

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Polycyclic Aromatic Hydrocarbons			
Anthracene	5.0	Literature review*	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(a)anthracene	1.8	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level.
Benzo(b)fluoranthene	8.6	QSAR **	Based on methods of DiToro et al. (2000).
Benzo(a)pyrene	5.6	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) without a safety factor because the data point represents a no-effect level. Further weight of evidence assessment of available toxicity data indicated that the value is similar to the results of guppy and Japanese medaka tested in a 6-h acute toxicity test and thus would be protective of shorter term discharges. Other endpoints were determined not to apply.
Benzo(g,h,i)perylene	1	QSAR	Based on methods of DiToro et al. (2000).
Chrysene	8.6	QSAR	Based on methods of DiToro et al. (2000).
2-Methylnaphthalene	58	Literature review	The lowest available toxicity data point (a 96-h LC_{27} for cod embryos; Saethre et al. 1984) with a 10-fold safety factor. The safety factor was applied to address uncertainty introduced by the number of studies available and species assessed.
Naphthalene	100	Literature review	The lower 95% CL of the lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983, cited in CCME 1999) without a safety factor. A safety factor was not applied because the results of 24-h LC_{50} tests were greater than the selected benchmark, suggesting that acute toxicity to site-specific fin-fish at the point of discharge would be unlikely.
Phenanthrene	40	Literature review	The lower 95% CL of the second lowest available toxicity data point (a 96-h LC_{50} for rainbow trout embryos; Black et al. 1983; cited in CCME 1999) without a safety factor. The lowest available toxicity data point was not used because it was not considered to be directly applicable (*i.e.*, it was for a 27-d rainbow trout embryo LC_{50}).
Pyrene	12.8	Literature review	The lowest available toxicity data point (a 96-h LC_0 for fathead minnow fry; Oris and Giesy 1987, cited in CCME 1999) with a 2-fold safety factor. Although the selected data point represented a no-effect level, the 2-fold safety factor was considered necessary because only one data point was available.

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Metals			
Arsenic	125	CCME marine WQG, X by 10	The WQG was derived based on the application of a 10-times safety factor to the LOEC of the most sensitive species for which toxicity data were available (a marine diatom, *Skeletonema costatum*). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 500 µg/L).
Copper	30	BC marine maximum WQG X by 10	The WQG was derived based on acute toxicity to oyster and mussel larvae (96-h LC_{50} = 5.3-5.8 µg/L) (Singleton 1987). Adult stages of invertebrates are less sensitive to copper, as are fish. The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 300 µg/L).
Zinc	100	BC marine maximum WQG X by 10	The WQG was derived based on the application of a 5-times safety factor applied to chronic toxicity to two marine diatoms (Nagpal 1999). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharges from metal mines (*i.e.*, 500 µg/L).

Notes:

* The literature review included a search of available electronic databases (*e.g.*, BIOSIS), on-line toxicological databases (*e.g.*, USEPA ECOTOX) and data compilations used for regulatory purposes (*e.g.*, CCME 1999, Nagpal 1993). Lethal concentration values resulting in 50% mortality (LC_{50}) were obtained for both freshwater and marine fish species as the expectation of the *Fisheries Act* is that at the point of discharge, the dewatering effluent with non-acutely lethal, operationally defined by Environment Canada and MOE as 96-h $LC_{50} \geq 100\%$ for rainbow trout. Invertebrates were excluded from the literature search because by nature dredging will be removed by the physical activity of the dredging.

** The Target Lipid approach is based on a QSAR for PAH compounds developed by DiToro et al. (2000). The underlying principle of the Target Lipid approach is that the target lipid is the site of PAH action in the organism and that the target lipid has the same lipid-octanol linear free energy relationship irrespective of species. DiToro et al. (2000) derived a method for developing water quality criteria for narcotic chemicals (Type 1) and specifically for PAHs, based on using a single universal slope for the log LC_{50} versus log K_{ow} (octanol-water partitioning coefficient) QSAR for all species.

CCME – Canadian Council of Ministers of the Environment; CL – confidence limit; LOEC – lowest observed effects concentration; MMER – Metal Mining Effluent Regulation; QSAR – Quantitative Structure-Activity Relationship; WQG – water quality guideline.

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Anthracene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.806	0.808	0.811	0.814	0.817	0.82	0.823	0.827	0.828
2	0.144	0.145	0.145	0.146	0.146	0.147	0.148	0.148	0.148
3	0.522	0.523	0.525	0.527	0.529	0.531	0.532	0.534	0.535
4	0.0988	0.099	0.0993	0.0997	0.100	0.100	0.101	0.101	0.101
5	1.19	1.19	1.2	1.2	1.21	1.21	1.22	1.22	1.22
6	1.09	1.09	1.10	1.10	1.11	1.11	1.12	1.12	1.13
7	0.115	0.115	0.115	0.116	0.116	0.117	0.117	0.117	0.118
8	0.573	0.574	0.577	0.58	0.582	0.585	0.588	0.591	0.592
9	1.92	1.93	1.94	1.94	1.95	1.96	1.97	1.98	1.99
10	0.123	0.123	0.124	0.125	0.125	0.126	0.126	0.127	0.127
11	0.151	0.152	0.152	0.153	0.154	0.154	0.155	0.156	0.156
12	0.116	0.116	0.116	0.117	0.117	0.118	0.118	0.118	0.119
13	0.0707	0.0708	0.0711	0.0713	0.0716	0.0718	0.0721	0.0724	0.0725
14	0.659	0.66	0.663	0.667	0.67	0.673	0.676	0.679	0.681
15	0.121	0.121	0.122	0.122	0.123	0.123	0.124	0.124	0.124
16	0.141	0.141	0.142	0.142	0.143	0.143	0.144	0.144	0.145
17	0.0903	0.0904	0.0908	0.0911	0.0914	0.0917	0.0921	0.0924	0.0925
18	0.0865	0.0867	0.087	0.0873	0.0876	0.0879	0.0883	0.0886	0.0887
19	0.528	0.529	0.531	0.534	0.536	0.539	0.542	0.544	0.545
20	0.301	0.302	0.304	0.305	0.307	0.308	0.309	0.311	0.312
21	1.03	1.03	1.03	1.04	1.04	1.05	1.05	1.06	1.06
22	0.358	0.359	0.361	0.363	0.365	0.366	0.368	0.37	0.371
23	0.221	0.222	0.223	0.224	0.225	0.226	0.227	0.228	0.229
24	0.0895	0.0897	0.0902	0.0906	0.091	0.0914	0.0919	0.0923	0.0925
25	0.106	0.106	0.107	0.107	0.108	0.108	0.109	0.11	0.11
26	0.107	0.107	0.108	0.109	0.109	0.11	0.11	0.111	0.111
27	0.279	0.28	0.281	0.282	0.284	0.285	0.286	0.288	0.288
28	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.10
29	1.57	1.57	1.58	1.59	1.60	1.60	1.61	1.62	1.62
30	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.9	1.9
31	0.933	0.935	0.94	0.946	0.951	0.956	0.961	0.966	0.969
32	5.23	5.24	5.26	5.29	5.31	5.34	5.36	5.39	5.4
34	12.2	12.3	12.3	12.4	12.5	12.5	12.6	12.7	12.7
35	0.254	0.255	0.256	0.258	0.259	0.26	0.262	0.263	0.264
36	0.251	0.252	0.253	0.255	0.256	0.258	0.259	0.26	0.261
38	1.77	1.77	1.78	1.79	1.8	1.81	1.82	1.83	1.84
39	16.5	16.6	16.7	16.8	16.9	17	17.1	17.2	17.2
40	1.29	1.29	1.3	1.31	1.31	1.32	1.33	1.33	1.34
41	0.857	0.86	0.864	0.869	0.874	0.879	0.883	0.888	0.891
42	0.0784	0.0786	0.0791	0.0795	0.0799	0.0804	0.0808	0.0812	0.0815
43	1.69	1.69	1.7	1.71	1.72	1.73	1.74	1.75	1.76
44	7.88	7.91	7.95	8	8.05	8.1	8.14	8.19	8.21
45	1.22	1.22	1.23	1.23	1.24	1.25	1.25	1.26	1.26
46	0.339	0.339	0.341	0.343	0.345	0.347	0.349	0.351	0.352
48	36.6	36.7	36.8	36.9	37	37.1	37.2	37.3	37.4
49	42	42.1	42.2	42.4	42.5	42.6	42.8	42.9	42.9
50	0.724	0.726	0.73	0.733	0.737	0.74	0.744	0.747	0.749
51	0.13	0.13	0.131	0.131	0.132	0.132	0.133	0.133	0.133
52	0.972	0.974	0.978	0.981	0.985	0.989	0.993	0.996	0.998
53	0.497	0.498	0.501	0.503	0.506	0.508	0.51	0.513	0.514
54	1.35	1.36	1.36	1.37	1.38	1.39	1.39	1.4	1.4
55	2.9	2.91	2.92	2.94	2.96	2.97	2.99	3	3.01
56	0.0903	0.0904	0.0908	0.0911	0.0914	0.0917	0.0921	0.0924	0.0925
57	0.0903	0.0904	0.0908	0.0911	0.0914	0.0917	0.0921	0.0924	0.0925
1B	1.69	1.69	1.7	1.7	1.71	1.72	1.72	1.73	1.73
2B	1.89	1.89	1.9	1.91	1.91	1.92	1.93	1.94	1.94
3B	0.0712	0.0714	0.0718	0.0722	0.0726	0.073	0.0734	0.0738	0.074
4B	0.0955	0.0957	0.0963	0.0968	0.0973	0.0978	0.0984	0.0989	0.0992
5B	0.0459	0.0461	0.0463	0.0466	0.0468	0.0471	0.0473	0.0476	0.0477
6B	0.0385	0.0386	0.0388	0.039	0.0392	0.0394	0.0397	0.0399	0.04
7B	0.046	0.0461	0.0463	0.0466	0.0469	0.0471	0.0474	0.0476	0.0477
8B	0.34	0.341	0.343	0.345	0.347	0.349	0.351	0.352	0.353
9B	0.349	0.35	0.352	0.354	0.356	0.358	0.36	0.362	0.363
10B	0.0137	0.0137	0.0138	0.0138	0.0139	0.014	0.0141	0.0141	0.0142
11B	0.0956	0.0959	0.0964	0.0969	0.0973	0.0978	0.0983	0.0988	0.099
12B	0.342	0.343	0.345	0.346	0.348	0.35	0.351	0.353	0.354
13B	0.43	0.431	0.433	0.435	0.437	0.44	0.442	0.444	0.445
14B	0.976	0.979	0.984	0.989	0.994	0.998	1	1.01	1.01
15B	0.435	0.436	0.438	0.44	0.443	0.445	0.447	0.449	0.45
16B	0.0809	0.0811	0.0815	0.0819	0.0824	0.0828	0.0832	0.0836	0.0838
17B	0.0342	0.0343	0.0344	0.0346	0.0348	0.0349	0.0351	0.0353	0.0354
18B	7.21	7.23	7.27	7.31	7.35	7.39	7.43	7.48	7.5
19B	8.14	8.16	8.21	8.26	8.31	8.35	8.4	8.45	8.47
20B	39.2	39.3	39.4	39.5	39.7	39.8	39.9	40	40.1
23B	0.298	0.299	0.301	0.302	0.304	0.305	0.307	0.308	0.309
24B	0.0149	0.0149	0.015	0.0151	0.0152	0.0152	0.0153	0.0154	0.0154
25B	0.164	0.164	0.165	0.166	0.167	0.167	0.168	0.169	0.17
26B	0.526	0.527	0.53	0.533	0.536	0.539	0.542	0.545	0.546
27B	1.76	1.76	1.77	1.77	1.78	1.79	1.79	1.8	1.8

Screening benchmark = 5 µg/L

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo(a)anthracene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.0804	0.0838	0.0908	0.0977	0.105	0.112	0.118	0.125	0.129
2	0.0144	0.015	0.0163	0.0175	0.0187	0.02	0.0212	0.0225	0.0231
3	0.0466	0.0485	0.0523	0.056	0.0598	0.0636	0.0674	0.0711	0.073
4	0.00882	0.00917	0.00989	0.0106	0.0113	0.012	0.0127	0.0135	0.0138
5	0.119	0.124	0.134	0.144	0.154	0.165	0.175	0.185	0.19
6	0.106	0.112	0.123	0.134	0.145	0.157	0.168	0.179	0.185
7	0.0102	0.0107	0.0115	0.0123	0.0131	0.014	0.0148	0.0156	0.0161
8	0.0556	0.0586	0.0646	0.0705	0.0764	0.0824	0.0883	0.0942	0.0972
9	0.187	0.197	0.217	0.236	0.256	0.276	0.296	0.316	0.326
10	0.012	0.0126	0.0139	0.0151	0.0164	0.0177	0.019	0.0202	0.0209
11	0.0147	0.0155	0.017	0.0186	0.0202	0.0217	0.0233	0.0249	0.0257
12	0.0103	0.0107	0.0116	0.0124	0.0133	0.0141	0.0149	0.0158	0.0162
13	0.00631	0.00656	0.00708	0.00759	0.0081	0.00861	0.00912	0.00964	0.00989
14	0.064	0.0674	0.0742	0.0811	0.0879	0.0947	0.102	0.108	0.112
15	0.0108	0.0113	0.0121	0.013	0.0139	0.0148	0.0156	0.0165	0.017
16	0.0126	0.0131	0.0141	0.0151	0.0162	0.0172	0.0182	0.0192	0.0197
17	0.00805	0.00838	0.00904	0.00969	0.0103	0.011	0.0116	0.0123	0.0126
18	0.00772	0.00804	0.00866	0.00929	0.00992	0.0105	0.0112	0.0118	0.0121
19	0.0513	0.054	0.0595	0.0649	0.0704	0.0759	0.0813	0.0868	0.0896
20	0.0293	0.0309	0.034	0.0371	0.0402	0.0434	0.0465	0.0496	0.0512
21	0.0998	0.105	0.116	0.126	0.137	0.148	0.158	0.169	0.174
22	0.0348	0.0367	0.0404	0.0441	0.0478	0.0516	0.0553	0.059	0.0608
23	0.0215	0.0226	0.0249	0.0272	0.0295	0.0318	0.0341	0.0364	0.0375
24	0.0087	0.00916	0.0101	0.011	0.0119	0.0129	0.0138	0.0147	0.0152
25	0.00847	0.00899	0.01	0.011	0.0121	0.0131	0.0141	0.0152	0.0157
26	0.00858	0.0091	0.0101	0.0112	0.0122	0.0133	0.0143	0.0154	0.0159
27	0.0271	0.0286	0.0314	0.0343	0.0372	0.0401	0.043	0.0459	0.0474
28	0.197	0.208	0.229	0.25	0.271	0.292	0.313	0.334	0.345
29	0.153	0.161	0.177	0.193	0.209	0.226	0.242	0.258	0.266
30	0.147	0.156	0.173	0.191	0.209	0.227	0.245	0.263	0.272
31	0.0747	0.0792	0.0883	0.0974	0.107	0.116	0.125	0.134	0.138
32	0.508	0.535	0.589	0.643	0.697	0.751	0.806	0.86	0.887
34	0.845	0.9	1.01	1.12	1.23	1.35	1.46	1.57	1.62
35	0.0203	0.0216	0.0241	0.0265	0.029	0.0315	0.034	0.0364	0.0377
36	0.0201	0.0214	0.0238	0.0263	0.0287	0.0312	0.0336	0.0361	0.0373
38	0.142	0.15	0.168	0.185	0.202	0.219	0.237	0.254	0.262
39	1.14	1.22	1.37	1.52	1.67	1.82	1.97	2.12	2.2
40	0.103	0.109	0.122	0.135	0.147	0.16	0.172	0.185	0.191
41	0.0686	0.0728	0.0812	0.0895	0.0979	0.106	0.115	0.123	0.127
42	0.00628	0.00666	0.00743	0.00819	0.00895	0.00972	0.0105	0.0112	0.0116
43	0.135	0.144	0.16	0.177	0.193	0.209	0.226	0.242	0.251
44	0.545	0.581	0.653	0.725	0.796	0.868	0.94	1.01	1.05
45	0.0973	0.103	0.115	0.127	0.139	0.151	0.162	0.174	0.18
46	0.0271	0.0288	0.0321	0.0354	0.0387	0.042	0.0453	0.0486	0.0502
48	3.34	3.45	3.69	3.92	4.16	4.4	4.63	4.87	4.99
49	3.83	3.96	4.24	4.51	4.78	5.05	5.32	5.59	5.72
50	0.0704	0.0741	0.0816	0.0892	0.0967	0.104	0.112	0.119	0.123
51	0.0129	0.0135	0.0146	0.0157	0.0169	0.018	0.0191	0.0202	0.0208
52	0.0969	0.101	0.109	0.118	0.126	0.134	0.143	0.151	0.155
53	0.0483	0.0509	0.056	0.0612	0.0663	0.0715	0.0767	0.0818	0.0844
54	0.108	0.115	0.128	0.141	0.154	0.168	0.181	0.194	0.2
55	0.232	0.246	0.275	0.303	0.331	0.359	0.388	0.416	0.43
56	0.00805	0.00838	0.00904	0.00969	0.0103	0.011	0.0116	0.0123	0.0126
57	0.00805	0.00838	0.00904	0.00969	0.0103	0.011	0.0116	0.0123	0.0126
1B	0.118	0.123	0.134	0.144	0.154	0.164	0.175	0.185	0.19
2B	0.132	0.138	0.15	0.161	0.172	0.184	0.195	0.207	0.212
3B	0.0081	0.00859	0.00958	0.0106	0.0116	0.0125	0.0135	0.0145	0.015
4B	0.0109	0.0115	0.0128	0.0142	0.0155	0.0168	0.0181	0.0194	0.0201
5B	0.00522	0.00554	0.00618	0.00681	0.00745	0.00808	0.00872	0.00936	0.00967
6B	0.00438	0.00464	0.00517	0.00571	0.00624	0.00677	0.0073	0.00784	0.0081
7B	0.00523	0.00554	0.00618	0.00682	0.00745	0.00809	0.00872	0.00936	0.00968
8B	0.0387	0.041	0.0457	0.0504	0.0551	0.0599	0.0646	0.0693	0.0716
9B	0.0397	0.0421	0.047	0.0518	0.0566	0.0615	0.0663	0.0711	0.0736
10B	0.00131	0.00139	0.00153	0.00168	0.00183	0.00197	0.00212	0.00227	0.00234
11B	0.00919	0.0097	0.0107	0.0118	0.0128	0.0138	0.0148	0.0159	0.0164
12B	0.0329	0.0347	0.0384	0.042	0.0457	0.0494	0.053	0.0567	0.0586
13B	0.0413	0.0436	0.0482	0.0528	0.0575	0.0621	0.0667	0.0713	0.0736
14B	0.0938	0.099	0.11	0.12	0.13	0.141	0.151	0.162	0.167
15B	0.0418	0.0441	0.0488	0.0535	0.0581	0.0628	0.0675	0.0721	0.0745
16B	0.00777	0.00821	0.00908	0.00995	0.0108	0.0117	0.0126	0.0134	0.0139
17B	0.00328	0.00347	0.00383	0.0042	0.00457	0.00493	0.0053	0.00567	0.00585
18B	0.7	0.744	0.833	0.921	1.01	1.1	1.19	1.28	1.32
19B	0.79	0.84	0.941	1.04	1.14	1.24	1.34	1.44	1.49
20B	3.57	3.7	3.95	4.21	4.46	4.71	4.96	5.22	5.34
23B	0.0287	0.0303	0.0335	0.0367	0.0399	0.0431	0.0463	0.0495	0.0511
24B	0.00143	0.00151	0.00167	0.00183	0.00199	0.00215	0.00231	0.00247	0.00255
25B	0.0157	0.0166	0.0184	0.0201	0.0219	0.0236	0.0254	0.0272	0.028
26B	0.0598	0.0634	0.0707	0.078	0.0853	0.0925	0.0998	0.107	0.111
27B	0.123	0.128	0.139	0.15	0.16	0.171	0.182	0.192	0.198

Screening benchmark = 1.8 µg/L

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo[a]pyrene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.0704	0.0744	0.0825	0.0905	0.0986	0.107	0.115	0.123	0.127
2	0.0126	0.0133	0.0148	0.0162	0.0177	0.0191	0.0206	0.022	0.0227
3	0.0354	0.0373	0.0411	0.0449	0.0487	0.0526	0.0564	0.0602	0.0621
4	0.00669	0.00706	0.00778	0.0085	0.00922	0.00995	0.0107	0.0114	0.0118
5	0.104	0.11	0.122	0.134	0.146	0.157	0.169	0.181	0.187
6	0.1	0.107	0.122	0.136	0.15	0.164	0.178	0.193	0.2
7	0.00777	0.00819	0.00903	0.00987	0.0107	0.0115	0.0124	0.0132	0.0136
8	0.0528	0.0565	0.064	0.0714	0.0789	0.0863	0.0938	0.101	0.105
9	0.177	0.19	0.215	0.24	0.265	0.29	0.315	0.34	0.352
10	0.0113	0.0121	0.0137	0.0153	0.0169	0.0185	0.0201	0.0217	0.0225
11	0.0139	0.0149	0.0169	0.0188	0.0208	0.0228	0.0248	0.0267	0.0277
12	0.00784	0.00826	0.00911	0.00996	0.0108	0.0116	0.0125	0.0133	0.0138
13	0.00479	0.00505	0.00557	0.00608	0.0066	0.00712	0.00763	0.00815	0.00841
14	0.0607	0.065	0.0736	0.0821	0.0907	0.0993	0.108	0.116	0.121
15	0.00821	0.00866	0.00954	0.0104	0.0113	0.0122	0.0131	0.014	0.0144
16	0.00956	0.0101	0.0111	0.0121	0.0132	0.0142	0.0152	0.0163	0.0168
17	0.00612	0.00645	0.00711	0.00777	0.00843	0.00909	0.00975	0.0104	0.0107
18	0.00587	0.00618	0.00681	0.00745	0.00808	0.00871	0.00935	0.00998	0.0103
19	0.0486	0.052	0.0589	0.0658	0.0727	0.0795	0.0864	0.0933	0.0967
20	0.0278	0.0297	0.0337	0.0376	0.0415	0.0454	0.0494	0.0533	0.0553
21	0.0947	0.101	0.115	0.128	0.141	0.155	0.168	0.182	0.188
22	0.033	0.0354	0.04	0.0447	0.0494	0.054	0.0587	0.0634	0.0657
23	0.0204	0.0218	0.0247	0.0276	0.0305	0.0333	0.0362	0.0391	0.0405
24	0.00825	0.00883	0.01	0.0112	0.0123	0.0135	0.0147	0.0158	0.0164
25	0.00857	0.00926	0.0106	0.012	0.0134	0.0148	0.0162	0.0175	0.0182
26	0.00868	0.00938	0.0108	0.0122	0.0136	0.015	0.0164	0.0178	0.0185
27	0.0257	0.0275	0.0312	0.0348	0.0384	0.0421	0.0457	0.0493	0.0511
28	0.187	0.2	0.227	0.253	0.28	0.306	0.333	0.359	0.372
29	0.145	0.155	0.175	0.196	0.216	0.237	0.257	0.277	0.288
30	0.148	0.16	0.184	0.208	0.232	0.256	0.28	0.303	0.315
31	0.0756	0.0817	0.0938	0.106	0.118	0.13	0.142	0.155	0.161
32	0.481	0.515	0.583	0.652	0.72	0.788	0.856	0.924	0.958
34	0.622	0.676	0.783	0.891	0.999	1.11	1.21	1.32	1.38
35	0.0206	0.0222	0.0256	0.0289	0.0322	0.0355	0.0388	0.0421	0.0438
36	0.0204	0.022	0.0253	0.0286	0.0318	0.0351	0.0384	0.0417	0.0433
38	0.143	0.155	0.178	0.201	0.224	0.247	0.27	0.293	0.305
39	0.841	0.914	1.06	1.21	1.35	1.5	1.64	1.79	1.86
40	0.104	0.113	0.13	0.146	0.163	0.18	0.197	0.214	0.222
41	0.0695	0.0751	0.0862	0.0974	0.109	0.12	0.131	0.142	0.148
42	0.00636	0.00687	0.00789	0.00891	0.00993	0.011	0.012	0.013	0.0135
43	0.137	0.148	0.17	0.192	0.214	0.236	0.258	0.28	0.291
44	0.401	0.436	0.506	0.575	0.645	0.714	0.784	0.854	0.889
45	0.0985	0.106	0.122	0.138	0.154	0.17	0.186	0.201	0.209
46	0.0274	0.0296	0.034	0.0385	0.0429	0.0473	0.0517	0.0561	0.0583
48	3.01	3.15	3.44	3.72	4	4.29	4.57	4.85	5
49	3.46	3.62	3.95	4.27	4.6	4.92	5.25	5.57	5.74
50	0.0667	0.0715	0.0809	0.0903	0.0997	0.109	0.119	0.128	0.133
51	0.0113	0.012	0.0133	0.0146	0.0159	0.0172	0.0185	0.0198	0.0204
52	0.0848	0.0897	0.0994	0.109	0.119	0.129	0.138	0.148	0.153
53	0.0458	0.049	0.0555	0.062	0.0685	0.0749	0.0814	0.0879	0.0911
54	0.11	0.118	0.136	0.154	0.171	0.189	0.206	0.224	0.233
55	0.235	0.254	0.292	0.329	0.367	0.405	0.443	0.481	0.5
56	0.00612	0.00645	0.00711	0.00777	0.00843	0.00909	0.00975	0.0104	0.0107
57	0.00612	0.00645	0.00711	0.00777	0.00843	0.00909	0.00975	0.0104	0.0107
1B	0.0924	0.0977	0.108	0.119	0.129	0.14	0.151	0.161	0.167
2B	0.103	0.109	0.121	0.133	0.145	0.157	0.169	0.18	0.186
3B	0.0075	0.0081	0.00931	0.0105	0.0117	0.0129	0.0141	0.0153	0.0159
4B	0.01	0.0109	0.0125	0.0141	0.0157	0.0173	0.0189	0.0206	0.0214
5B	0.00484	0.00523	0.006	0.00678	0.00756	0.00834	0.00911	0.00989	0.0103
6B	0.00405	0.00438	0.00503	0.00568	0.00633	0.00698	0.00763	0.00829	0.00861
7B	0.00484	0.00523	0.00601	0.00678	0.00756	0.00834	0.00912	0.0099	0.0103
8B	0.0358	0.0387	0.0444	0.0502	0.056	0.0617	0.0675	0.0732	0.0761
9B	0.0368	0.0397	0.0456	0.0516	0.0575	0.0634	0.0693	0.0752	0.0782
10B	0.0013	0.0014	0.00159	0.00178	0.00198	0.00217	0.00236	0.00256	0.00265
11B	0.00912	0.00979	0.0111	0.0125	0.0138	0.0152	0.0165	0.0179	0.0186
12B	0.0326	0.035	0.0398	0.0447	0.0495	0.0543	0.0591	0.0639	0.0663
13B	0.041	0.044	0.0501	0.0561	0.0622	0.0682	0.0743	0.0804	0.0834
14B	0.0931	0.0999	0.114	0.127	0.141	0.155	0.169	0.183	0.189
15B	0.0415	0.0445	0.0507	0.0568	0.0629	0.069	0.0752	0.0813	0.0844
16B	0.00771	0.00828	0.00942	0.0106	0.0117	0.0128	0.014	0.0151	0.0157
17B	0.00326	0.0035	0.00398	0.00446	0.00494	0.00542	0.00591	0.00639	0.00663
18B	0.797	0.864	0.997	1.13	1.26	1.4	1.53	1.66	1.73
19B	0.9	0.976	1.13	1.28	1.43	1.58	1.73	1.88	1.95
20B	3.23	3.38	3.68	3.99	4.29	4.59	4.9	5.2	5.35
23B	0.0284	0.0305	0.0348	0.039	0.0432	0.0474	0.0516	0.0558	0.0579
24B	0.00142	0.00152	0.00173	0.00194	0.00215	0.00236	0.00257	0.00278	0.00289
25B	0.0156	0.0168	0.0191	0.0214	0.0237	0.026	0.0283	0.0306	0.0318
26B	0.0554	0.0598	0.0687	0.0776	0.0865	0.0954	0.104	0.113	0.118
27B	0.0961	0.102	0.113	0.124	0.135	0.146	0.157	0.168	0.173

Screening benchmark = 5.6 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo[b]fluoranthene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.179	0.185	0.197	0.209	0.221	0.233	0.245	0.257	0.263
2	0.032	0.0331	0.0352	0.0374	0.0396	0.0417	0.0439	0.0461	0.0471
3	0.0895	0.0923	0.098	0.104	0.109	0.115	0.121	0.126	0.129
4	0.0169	0.0175	0.0185	0.0196	0.0207	0.0218	0.0228	0.0239	0.0245
5	0.264	0.272	0.29	0.308	0.326	0.344	0.362	0.379	0.388
6	0.242	0.252	0.272	0.293	0.313	0.333	0.354	0.374	0.384
7	0.0197	0.0203	0.0215	0.0228	0.024	0.0253	0.0265	0.0278	0.0284
8	0.127	0.133	0.143	0.154	0.164	0.175	0.186	0.196	0.202
9	0.427	0.444	0.48	0.516	0.552	0.588	0.623	0.659	0.677
10	0.0273	0.0285	0.0308	0.033	0.0353	0.0376	0.0399	0.0422	0.0433
11	0.0336	0.035	0.0378	0.0406	0.0434	0.0462	0.049	0.0519	0.0533
12	0.0198	0.0205	0.0217	0.023	0.0242	0.0255	0.0268	0.028	0.0287
13	0.0121	0.0125	0.0133	0.014	0.0148	0.0156	0.0164	0.0171	0.0175
14	0.146	0.152	0.165	0.177	0.189	0.201	0.214	0.226	0.232
15	0.0208	0.0214	0.0228	0.0241	0.0254	0.0267	0.028	0.0294	0.03
16	0.0242	0.0249	0.0265	0.028	0.0295	0.0311	0.0326	0.0342	0.0349
17	0.0155	0.016	0.0169	0.0179	0.0189	0.0199	0.0209	0.0219	0.0224
18	0.0148	0.0153	0.0162	0.0172	0.0181	0.0191	0.02	0.021	0.0214
19	0.117	0.122	0.132	0.142	0.152	0.161	0.171	0.181	0.186
20	0.0669	0.0697	0.0754	0.081	0.0866	0.0922	0.0978	0.103	0.106
21	0.228	0.238	0.257	0.276	0.295	0.314	0.333	0.352	0.362
22	0.0796	0.0829	0.0896	0.0963	0.103	0.11	0.116	0.123	0.126
23	0.0491	0.0512	0.0553	0.0594	0.0635	0.0676	0.0718	0.0759	0.0779
24	0.0199	0.0207	0.0224	0.024	0.0257	0.0274	0.029	0.0307	0.0315
25	0.0222	0.0232	0.0253	0.0275	0.0296	0.0317	0.0338	0.036	0.037
26	0.0225	0.0235	0.0257	0.0278	0.03	0.0321	0.0343	0.0364	0.0375
27	0.062	0.0646	0.0698	0.0749	0.0801	0.0853	0.0905	0.0957	0.0983
28	0.451	0.47	0.508	0.546	0.584	0.622	0.659	0.697	0.716
29	0.349	0.363	0.392	0.422	0.451	0.48	0.509	0.538	0.553
30	0.384	0.402	0.439	0.476	0.512	0.549	0.586	0.623	0.641
31	0.195	0.205	0.223	0.242	0.261	0.28	0.298	0.317	0.326
32	1.16	1.21	1.31	1.4	1.5	1.6	1.7	1.79	1.84
34	1.62	1.71	1.88	2.04	2.21	2.38	2.55	2.72	2.8
35	0.0532	0.0558	0.0609	0.066	0.0711	0.0762	0.0813	0.0864	0.0889
36	0.0527	0.0552	0.0602	0.0653	0.0703	0.0754	0.0804	0.0855	0.088
38	0.371	0.388	0.424	0.459	0.495	0.53	0.566	0.601	0.619
39	2.2	2.31	2.54	2.77	3	3.22	3.45	3.68	3.79
40	0.27	0.283	0.309	0.335	0.36	0.386	0.412	0.438	0.451
41	0.18	0.188	0.205	0.223	0.24	0.257	0.274	0.291	0.3
42	0.0164	0.0172	0.0188	0.0204	0.0219	0.0235	0.0251	0.0267	0.0275
43	0.354	0.371	0.405	0.439	0.473	0.507	0.541	0.575	0.592
44	1.05	1.1	1.21	1.32	1.43	1.54	1.65	1.75	1.81
45	0.255	0.267	0.291	0.316	0.34	0.364	0.389	0.413	0.425
46	0.0709	0.0743	0.0811	0.0879	0.0947	0.102	0.108	0.115	0.118
48	10.1	10.3	10.9	11.4	12	12.6	13.1	13.7	14
49	11.5	11.9	12.5	13.1	13.8	14.4	15.1	15.7	16
50	0.161	0.168	0.181	0.195	0.208	0.222	0.235	0.248	0.255
51	0.0288	0.0298	0.0317	0.0336	0.0356	0.0375	0.0395	0.0414	0.0424
52	0.215	0.223	0.237	0.252	0.266	0.281	0.295	0.31	0.317
53	0.11	0.115	0.124	0.134	0.143	0.152	0.161	0.171	0.175
54	0.283	0.297	0.324	0.351	0.378	0.405	0.432	0.46	0.473
55	0.608	0.637	0.695	0.753	0.811	0.87	0.928	0.986	1.02
56	0.0155	0.016	0.0169	0.0179	0.0189	0.0199	0.0209	0.0219	0.0224
57	0.0155	0.016	0.0169	0.0179	0.0189	0.0199	0.0209	0.0219	0.0224
1B	0.209	0.216	0.23	0.245	0.259	0.273	0.287	0.301	0.308
2B	0.234	0.242	0.258	0.274	0.29	0.305	0.321	0.337	0.345
3B	0.0177	0.0186	0.0203	0.022	0.0237	0.0254	0.0271	0.0288	0.0296
4B	0.0237	0.0249	0.0272	0.0294	0.0317	0.034	0.0363	0.0385	0.0397
5B	0.0114	0.012	0.0131	0.0142	0.0153	0.0164	0.0174	0.0185	0.0191
6B	0.00957	0.01	0.0109	0.0119	0.0128	0.0137	0.0146	0.0155	0.016
7B	0.0114	0.012	0.0131	0.0142	0.0153	0.0164	0.0175	0.0185	0.0191
8B	0.0846	0.0886	0.0968	0.105	0.113	0.121	0.129	0.137	0.141
9B	0.0869	0.0911	0.0994	0.108	0.116	0.124	0.133	0.141	0.145
10B	0.00336	0.00351	0.0038	0.0041	0.00439	0.00469	0.00498	0.00528	0.00543
11B	0.0235	0.0245	0.0266	0.0287	0.0307	0.0328	0.0349	0.0369	0.038
12B	0.084	0.0877	0.0951	0.102	0.11	0.117	0.125	0.132	0.136
13B	0.106	0.11	0.12	0.129	0.138	0.147	0.157	0.166	0.171
14B	0.24	0.25	0.272	0.293	0.314	0.335	0.356	0.377	0.387
15B	0.107	0.112	0.121	0.13	0.14	0.149	0.159	0.168	0.173
16B	0.0199	0.0208	0.0225	0.0243	0.026	0.0277	0.0295	0.0312	0.0321
17B	0.0084	0.00877	0.0095	0.0102	0.011	0.0117	0.0125	0.0132	0.0136
18B	2.13	2.24	2.45	2.66	2.88	3.09	3.3	3.52	3.62
19B	2.41	2.53	2.77	3.01	3.25	3.49	3.73	3.97	4.09
20B	10.8	11.1	11.7	12.3	12.9	13.5	14.1	14.7	15
23B	0.0733	0.0766	0.083	0.0894	0.0959	0.102	0.109	0.115	0.118
24B	0.00366	0.00382	0.00414	0.00446	0.00478	0.0051	0.00543	0.00575	0.00591
25B	0.0402	0.042	0.0455	0.0491	0.0526	0.0561	0.0597	0.0632	0.065
26B	0.131	0.137	0.15	0.162	0.175	0.187	0.2	0.212	0.219
27B	0.218	0.225	0.24	0.255	0.269	0.284	0.299	0.313	0.321

Screening benchmark = 8.6 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Benzo[g,h,i]perylene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.0099	0.0124	0.0173	0.0223	0.0273	0.0322	0.0372	0.0422	0.0446
2	0.00177	0.00222	0.00311	0.004	0.00489	0.00577	0.00666	0.00755	0.008
3	0.00467	0.00579	0.00802	0.0102	0.0125	0.0147	0.0169	0.0192	0.0203
4	0.000884	0.0011	0.00152	0.00194	0.00236	0.00278	0.00321	0.00363	0.00384
5	0.0146	0.0183	0.0256	0.0329	0.0402	0.0476	0.0549	0.0622	0.0659
6	0.0138	0.0179	0.026	0.0342	0.0423	0.0505	0.0586	0.0668	0.0708
7	0.00103	0.00127	0.00176	0.00225	0.00274	0.00323	0.00372	0.00421	0.00446
8	0.00726	0.0094	0.0137	0.018	0.0222	0.0265	0.0308	0.0351	0.0372
9	0.0244	0.0315	0.0459	0.0603	0.0746	0.089	0.103	0.118	0.125
10	0.00156	0.00202	0.00294	0.00386	0.00478	0.0057	0.00662	0.00754	0.008
11	0.00192	0.00248	0.00361	0.00474	0.00587	0.007	0.00813	0.00926	0.00983
12	0.00104	0.00128	0.00178	0.00227	0.00277	0.00326	0.00375	0.00425	0.0045
13	0.000633	0.000784	0.00109	0.00139	0.00169	0.00199	0.00229	0.0026	0.00275
14	0.00835	0.0108	0.0157	0.0207	0.0256	0.0305	0.0354	0.0403	0.0428
15	0.00109	0.00134	0.00186	0.00238	0.0029	0.00342	0.00393	0.00445	0.00471
16	0.00126	0.00156	0.00217	0.00277	0.00337	0.00397	0.00458	0.00518	0.00548
17	0.000808	0.001	0.00139	0.00177	0.00216	0.00254	0.00293	0.00331	0.00351
18	0.000775	0.00096	0.00133	0.0017	0.00207	0.00244	0.00281	0.00318	0.00336
19	0.00669	0.00866	0.0126	0.0165	0.0205	0.0244	0.0284	0.0323	0.0343
20	0.00382	0.00495	0.0072	0.00946	0.0117	0.014	0.0162	0.0185	0.0196
21	0.013	0.0169	0.0245	0.0322	0.0399	0.0476	0.0553	0.0629	0.0668
22	0.00455	0.00589	0.00856	0.0112	0.0139	0.0166	0.0193	0.022	0.0233
23	0.0028	0.00363	0.00528	0.00694	0.00859	0.0102	0.0119	0.0135	0.0144
24	0.00114	0.00147	0.00214	0.00281	0.00348	0.00415	0.00481	0.00548	0.00582
25	0.00112	0.00148	0.00221	0.00293	0.00366	0.00439	0.00511	0.00584	0.0062
26	0.00113	0.0015	0.00224	0.00297	0.00371	0.00444	0.00518	0.00591	0.00628
27	0.00354	0.00458	0.00667	0.00875	0.0108	0.0129	0.015	0.0171	0.0181
28	0.0258	0.0334	0.0486	0.0637	0.0789	0.0941	0.109	0.124	0.132
29	0.0199	0.0258	0.0375	0.0492	0.061	0.0727	0.0844	0.0962	0.102
30	0.0194	0.0256	0.0382	0.0508	0.0634	0.0759	0.0885	0.101	0.107
31	0.00986	0.0131	0.0195	0.0259	0.0323	0.0387	0.0451	0.0515	0.0547
32	0.0663	0.0858	0.125	0.164	0.203	0.242	0.281	0.32	0.34
34	0.0835	0.112	0.169	0.227	0.284	0.341	0.398	0.456	0.484
35	0.00269	0.00356	0.0053	0.00705	0.00879	0.0105	0.0123	0.014	0.0149
36	0.00266	0.00352	0.00525	0.00697	0.0087	0.0104	0.0121	0.0139	0.0147
38	0.0187	0.0248	0.0369	0.0491	0.0612	0.0734	0.0855	0.0976	0.104
39	0.113	0.152	0.229	0.307	0.384	0.462	0.539	0.617	0.656
40	0.0136	0.018	0.0269	0.0357	0.0446	0.0534	0.0623	0.0711	0.0755
41	0.00907	0.012	0.0179	0.0238	0.0297	0.0355	0.0414	0.0473	0.0503
42	0.000829	0.0011	0.00164	0.00218	0.00271	0.00325	0.00379	0.00433	0.0046
43	0.0179	0.0237	0.0353	0.0469	0.0585	0.0701	0.0817	0.0933	0.0991
44	0.0539	0.0724	0.109	0.146	0.183	0.22	0.257	0.294	0.313
45	0.0128	0.017	0.0254	0.0337	0.042	0.0504	0.0587	0.0671	0.0712
46	0.00358	0.00474	0.00707	0.00939	0.0117	0.014	0.0164	0.0187	0.0198
48	0.474	0.575	0.778	0.98	1.18	1.38	1.59	1.79	1.89
49	0.544	0.66	0.893	1.13	1.36	1.59	1.82	2.06	2.17
50	0.00919	0.0119	0.0173	0.0227	0.0281	0.0335	0.039	0.0444	0.0471
51	0.0016	0.002	0.0028	0.00359	0.00439	0.00519	0.00599	0.00679	0.00719
52	0.0119	0.0149	0.0209	0.0269	0.0329	0.0389	0.0448	0.0508	0.0538
53	0.0063	0.00816	0.0119	0.0156	0.0193	0.023	0.0267	0.0305	0.0323
54	0.0143	0.0189	0.0282	0.0375	0.0468	0.056	0.0653	0.0746	0.0792
55	0.0307	0.0406	0.0605	0.0804	0.1	0.12	0.14	0.16	0.17
56	0.000808	0.001	0.00139	0.00177	0.00216	0.00254	0.00293	0.00331	0.00351
57	0.000808	0.001	0.00139	0.00177	0.00216	0.00254	0.00293	0.00331	0.00351
1B	0.0105	0.0131	0.0184	0.0237	0.0289	0.0342	0.0395	0.0447	0.0474
2B	0.0118	0.0147	0.0206	0.0265	0.0324	0.0383	0.0442	0.0501	0.053
3B	0.00127	0.00168	0.0025	0.00332	0.00414	0.00496	0.00578	0.0066	0.00701
4B	0.00169	0.00225	0.00335	0.00445	0.00555	0.00665	0.00775	0.00885	0.0094
5B	0.000816	0.00108	0.00161	0.00214	0.00267	0.0032	0.00373	0.00426	0.00452
6B	0.000683	0.000905	0.00135	0.00179	0.00224	0.00268	0.00312	0.00357	0.00379
7B	0.000816	0.00108	0.00161	0.00214	0.00267	0.0032	0.00373	0.00426	0.00452
8B	0.00604	0.008	0.0119	0.0158	0.0198	0.0237	0.0276	0.0315	0.0335
9B	0.0062	0.00822	0.0122	0.0163	0.0203	0.0243	0.0283	0.0324	0.0344
10B	0.000206	0.000269	0.000395	0.00052	0.000646	0.000772	0.000898	0.00102	0.00109
11B	0.00144	0.00188	0.00276	0.00364	0.00452	0.0054	0.00628	0.00716	0.0076
12B	0.00516	0.00673	0.00988	0.013	0.0162	0.0193	0.0225	0.0256	0.0272
13B	0.00648	0.00846	0.0124	0.0164	0.0203	0.0243	0.0282	0.0322	0.0342
14B	0.0147	0.0192	0.0282	0.0372	0.0462	0.0551	0.0641	0.0731	0.0776
15B	0.00656	0.00856	0.0126	0.0166	0.0206	0.0246	0.0286	0.0326	0.0346
16B	0.00122	0.00159	0.00234	0.00308	0.00383	0.00457	0.00531	0.00606	0.00643
17B	0.000515	0.000672	0.000987	0.0013	0.00162	0.00193	0.00224	0.00256	0.00271
18B	0.113	0.15	0.226	0.301	0.376	0.451	0.527	0.602	0.639
19B	0.127	0.17	0.255	0.34	0.425	0.51	0.595	0.68	0.722
20B	0.508	0.616	0.833	1.05	1.27	1.48	1.7	1.92	2.03
23B	0.0045	0.00587	0.00862	0.0114	0.0141	0.0169	0.0196	0.0223	0.0237
24B	0.000225	0.000293	0.00043	0.000567	0.000704	0.000841	0.000978	0.00111	0.00118
25B	0.00247	0.00322	0.00473	0.00623	0.00774	0.00925	0.0108	0.0123	0.013
26B	0.00934	0.0124	0.0184	0.0245	0.0305	0.0366	0.0427	0.0487	0.0518
27B	0.0109	0.0137	0.0192	0.0246	0.0301	0.0356	0.0411	0.0465	0.0493

Screening benchmark = 1 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Chrysene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.105	0.109	0.117	0.125	0.133	0.141	0.149	0.157	0.161
2	0.0188	0.0195	0.0209	0.0224	0.0238	0.0253	0.0267	0.0282	0.0289
3	0.0608	0.063	0.0674	0.0718	0.0762	0.0806	0.085	0.0894	0.0917
4	0.0115	0.0119	0.0128	0.0136	0.0144	0.0153	0.0161	0.0169	0.0173
5	0.154	0.16	0.172	0.184	0.196	0.208	0.22	0.232	0.238
6	0.14	0.146	0.16	0.173	0.186	0.2	0.213	0.226	0.233
7	0.0134	0.0138	0.0148	0.0158	0.0167	0.0177	0.0187	0.0197	0.0201
8	0.0734	0.0769	0.0839	0.0909	0.0979	0.105	0.112	0.119	0.122
9	0.246	0.258	0.281	0.305	0.328	0.352	0.376	0.399	0.411
10	0.0158	0.0165	0.018	0.0195	0.021	0.0225	0.024	0.0256	0.0263
11	0.0194	0.0203	0.0221	0.024	0.0258	0.0277	0.0295	0.0314	0.0323
12	0.0135	0.014	0.0149	0.0159	0.0169	0.0179	0.0188	0.0198	0.0203
13	0.00823	0.00853	0.00913	0.00972	0.0103	0.0109	0.0115	0.0121	0.0124
14	0.0844	0.0884	0.0965	0.105	0.113	0.121	0.129	0.137	0.141
15	0.0141	0.0146	0.0156	0.0167	0.0177	0.0187	0.0197	0.0208	0.0213
16	0.0164	0.017	0.0182	0.0194	0.0206	0.0218	0.023	0.0242	0.0248
17	0.0105	0.0109	0.0117	0.0124	0.0132	0.0139	0.0147	0.0155	0.0158
18	0.0101	0.0104	0.0112	0.0119	0.0126	0.0134	0.0141	0.0148	0.0152
19	0.0676	0.0708	0.0773	0.0837	0.0902	0.0967	0.103	0.11	0.113
20	0.0386	0.0405	0.0442	0.0478	0.0515	0.0552	0.0589	0.0626	0.0645
21	0.132	0.138	0.15	0.163	0.176	0.188	0.201	0.213	0.22
22	0.0459	0.0481	0.0525	0.0569	0.0613	0.0657	0.0701	0.0745	0.0767
23	0.0283	0.0297	0.0324	0.0351	0.0378	0.0405	0.0432	0.0459	0.0473
24	0.0115	0.012	0.0131	0.0142	0.0153	0.0164	0.0175	0.0186	0.0191
25	0.012	0.0127	0.014	0.0153	0.0166	0.0179	0.0192	0.0206	0.0212
26	0.0122	0.0128	0.0142	0.0155	0.0168	0.0182	0.0195	0.0208	0.0215
27	0.0357	0.0374	0.0409	0.0443	0.0477	0.0511	0.0545	0.058	0.0597
28	0.26	0.273	0.298	0.323	0.347	0.372	0.397	0.422	0.435
29	0.201	0.211	0.23	0.249	0.268	0.288	0.307	0.326	0.336
30	0.208	0.219	0.242	0.265	0.288	0.31	0.333	0.356	0.367
31	0.106	0.112	0.123	0.135	0.146	0.158	0.17	0.181	0.187
32	0.669	0.701	0.765	0.829	0.893	0.957	1.02	1.09	1.12
34	1.14	1.21	1.34	1.48	1.61	1.75	1.88	2.02	2.09
35	0.0289	0.0304	0.0336	0.0367	0.0399	0.043	0.0462	0.0494	0.0509
36	0.0286	0.0301	0.0332	0.0364	0.0395	0.0426	0.0457	0.0488	0.0504
38	0.201	0.212	0.234	0.256	0.278	0.3	0.322	0.344	0.355
39	1.55	1.64	1.82	2	2.19	2.37	2.55	2.73	2.82
40	0.146	0.154	0.17	0.186	0.202	0.218	0.234	0.25	0.258
41	0.0974	0.103	0.113	0.124	0.135	0.145	0.156	0.167	0.172
42	0.00891	0.0094	0.0104	0.0113	0.0123	0.0133	0.0143	0.0152	0.0157
43	0.192	0.203	0.224	0.244	0.265	0.286	0.307	0.328	0.339
44	0.737	0.78	0.867	0.955	1.04	1.13	1.22	1.3	1.35
45	0.138	0.146	0.161	0.176	0.191	0.206	0.221	0.236	0.244
46	0.0385	0.0406	0.0448	0.049	0.0532	0.0574	0.0616	0.0658	0.0679
48	5.67	5.85	6.21	6.56	6.92	7.28	7.64	8	8.18
49	6.51	6.71	7.13	7.54	7.95	8.36	8.77	9.18	9.39
50	0.0928	0.0972	0.106	0.115	0.124	0.133	0.142	0.15	0.155
51	0.0169	0.0175	0.0188	0.0201	0.0214	0.0227	0.024	0.0253	0.026
52	0.126	0.131	0.141	0.151	0.16	0.17	0.18	0.19	0.194
53	0.0637	0.0667	0.0728	0.0789	0.085	0.0911	0.0972	0.103	0.106
54	0.154	0.162	0.179	0.195	0.212	0.229	0.246	0.263	0.271
55	0.329	0.347	0.383	0.419	0.455	0.491	0.527	0.563	0.581
56	0.0105	0.0109	0.0117	0.0124	0.0132	0.0139	0.0147	0.0155	0.0158
57	0.0105	0.0109	0.0117	0.0124	0.0132	0.0139	0.0147	0.0155	0.0158
1B	0.155	0.161	0.173	0.184	0.196	0.208	0.22	0.232	0.238
2B	0.173	0.18	0.193	0.206	0.22	0.233	0.247	0.26	0.267
3B	0.0104	0.011	0.0121	0.0133	0.0144	0.0156	0.0167	0.0178	0.0184
4B	0.014	0.0147	0.0163	0.0178	0.0193	0.0208	0.0224	0.0239	0.0247
5B	0.00673	0.0071	0.00783	0.00857	0.0093	0.01	0.0108	0.0115	0.0119
6B	0.00564	0.00594	0.00656	0.00717	0.00779	0.00841	0.00902	0.00964	0.00994
7B	0.00673	0.0071	0.00783	0.00857	0.0093	0.01	0.0108	0.0115	0.0119
8B	0.0498	0.0525	0.058	0.0634	0.0689	0.0743	0.0797	0.0852	0.0879
9B	0.0512	0.054	0.0595	0.0651	0.0707	0.0763	0.0819	0.0875	0.0903
10B	0.0019	0.002	0.00219	0.00238	0.00257	0.00276	0.00295	0.00314	0.00323
11B	0.0133	0.014	0.0153	0.0166	0.018	0.0193	0.0206	0.022	0.0226
12B	0.0476	0.0499	0.0547	0.0595	0.0642	0.069	0.0738	0.0785	0.0809
13B	0.0598	0.0628	0.0688	0.0748	0.0808	0.0867	0.0927	0.0987	0.102
14B	0.136	0.143	0.156	0.17	0.183	0.197	0.211	0.224	0.231
15B	0.0605	0.0635	0.0696	0.0756	0.0817	0.0878	0.0938	0.0999	0.103
16B	0.0113	0.0118	0.0129	0.0141	0.0152	0.0163	0.0175	0.0186	0.0191
17B	0.00475	0.00499	0.00547	0.00594	0.00642	0.00689	0.00737	0.00785	0.00808
18B	1.06	1.12	1.24	1.36	1.48	1.6	1.72	1.85	1.91
19B	1.2	1.27	1.4	1.54	1.68	1.81	1.95	2.08	2.15
20B	6.07	6.27	6.65	7.03	7.42	7.8	8.19	8.57	8.76
23B	0.0415	0.0436	0.0477	0.0519	0.0561	0.0602	0.0644	0.0685	0.0706
24B	0.00207	0.00217	0.00238	0.00259	0.0028	0.003	0.00321	0.00342	0.00352
25B	0.0228	0.0239	0.0262	0.0285	0.0308	0.033	0.0353	0.0376	0.0387
26B	0.077	0.0812	0.0896	0.098	0.106	0.115	0.123	0.132	0.136
27B	0.161	0.167	0.179	0.192	0.204	0.217	0.229	0.242	0.248

Screening benchmark = 8.6 µg/L

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for 2-Methylnaphthalene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	2.15	2.15	2.15	2.16	2.16	2.16	2.16	2.16	2.16
2	0.385	0.386	0.386	0.386	0.386	0.387	0.387	0.387	0.388
3	1.71	1.71	1.71	1.71	1.71	1.72	1.72	1.72	1.72
4	0.323	0.324	0.324	0.324	0.324	0.325	0.325	0.325	0.325
5	3.17	3.18	3.18	3.18	3.18	3.19	3.19	3.19	3.19
6	1.94	1.94	1.94	1.94	1.94	1.95	1.95	1.95	1.95
7	0.376	0.376	0.376	0.376	0.377	0.377	0.377	0.378	0.378
8	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
9	3.41	3.42	3.42	3.42	3.43	3.43	3.43	3.44	3.44
10	0.219	0.219	0.219	0.219	0.219	0.22	0.22	0.22	0.22
11	0.269	0.269	0.269	0.269	0.27	0.27	0.27	0.27	0.271
12	0.379	0.379	0.379	0.38	0.38	0.38	0.38	0.381	0.381
13	0.231	0.232	0.232	0.232	0.232	0.232	0.232	0.233	0.233
14	1.17	1.17	1.17	1.17	1.17	1.18	1.18	1.18	1.18
15	0.397	0.397	0.397	0.398	0.398	0.398	0.399	0.399	0.399
16	0.462	0.462	0.462	0.463	0.463	0.463	0.464	0.464	0.464
17	0.296	0.296	0.296	0.296	0.296	0.297	0.297	0.297	0.297
18	0.283	0.283	0.284	0.284	0.284	0.284	0.285	0.285	0.285
19	0.937	0.938	0.939	0.94	0.941	0.942	0.943	0.944	0.944
20	0.536	0.536	0.536	0.537	0.538	0.538	0.539	0.539	0.54
21	1.83	1.83	1.83	1.83	1.83	1.83	1.84	1.84	1.84
22	0.637	0.637	0.638	0.639	0.639	0.64	0.641	0.641	0.642
23	0.393	0.393	0.394	0.394	0.394	0.395	0.395	0.396	0.396
24	0.159	0.159	0.159	0.159	0.16	0.16	0.16	0.16	0.16
25	0.109	0.109	0.109	0.109	0.11	0.11	0.11	0.11	0.11
26	0.11	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
27	0.496	0.496	0.497	0.497	0.498	0.498	0.499	0.499	0.499
28	3.61	3.61	3.62	3.62	3.62	3.63	3.63	3.64	3.64
29	2.79	2.79	2.79	2.8	2.8	2.8	2.8	2.81	2.81
30	1.89	1.89	1.89	1.89	1.9	1.9	1.9	1.9	1.9
31	0.962	0.962	0.963	0.965	0.966	0.967	0.968	0.969	0.97
32	9.28	9.29	9.3	9.31	9.32	9.33	9.34	9.35	9.35
34	26.2	26.2	26.2	26.2	26.3	26.3	26.3	26.4	26.4
35	0.262	0.262	0.262	0.263	0.263	0.263	0.264	0.264	0.264
36	0.259	0.259	0.26	0.26	0.26	0.261	0.261	0.261	0.261
38	1.82	1.83	1.83	1.83	1.83	1.83	1.84	1.84	1.84
39	35.4	35.4	35.5	35.5	35.6	35.6	35.7	35.7	35.7
40	1.33	1.33	1.33	1.33	1.33	1.34	1.34	1.34	1.34
41	0.884	0.885	0.886	0.887	0.888	0.889	0.89	0.891	0.891
42	0.0809	0.0809	0.081	0.0811	0.0812	0.0813	0.0814	0.0815	0.0815
43	1.74	1.74	1.75	1.75	1.75	1.75	1.75	1.76	1.76
44	16.9	16.9	16.9	16.9	17	17	17	17	17
45	1.25	1.25	1.26	1.26	1.26	1.26	1.26	1.26	1.26
46	0.349	0.349	0.35	0.35	0.35	0.351	0.351	0.352	0.352
48	57.4	57.4	57.4	57.5	57.5	57.6	57.6	57.6	57.7
49	65.9	65.9	65.9	66	66	66.1	66.1	66.2	66.2
50	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.3	1.3
51	0.347	0.347	0.347	0.347	0.348	0.348	0.348	0.349	0.349
52	2.59	2.59	2.6	2.6	2.6	2.6	2.6	2.61	2.61
53	0.883	0.884	0.885	0.886	0.887	0.888	0.888	0.889	0.89
54	1.39	1.39	1.4	1.4	1.4	1.4	1.4	1.4	1.41
55	2.99	2.99	3	3	3	3.01	3.01	3.01	3.01
56	0.296	0.296	0.296	0.296	0.296	0.297	0.297	0.297	0.297
57	0.296	0.296	0.296	0.296	0.296	0.297	0.297	0.297	0.297
1B	6.51	6.51	6.52	6.53	6.53	6.54	6.54	6.55	6.55
2B	7.29	7.29	7.3	7.3	7.31	7.31	7.32	7.33	7.33
3B	0.169	0.169	0.169	0.169	0.169	0.169	0.17	0.17	0.17
4B	0.226	0.226	0.226	0.226	0.227	0.227	0.227	0.228	0.228
5B	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.11	0.11
6B	0.091	0.0911	0.0912	0.0913	0.0914	0.0915	0.0916	0.0917	0.0918
7B	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.11	0.11
8B	0.805	0.805	0.806	0.807	0.808	0.809	0.81	0.811	0.811
9B	0.826	0.827	0.828	0.829	0.83	0.831	0.832	0.833	0.833
10B	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0105
11B	0.0726	0.0726	0.0727	0.0728	0.0729	0.0729	0.073	0.0731	0.0731
12B	0.26	0.26	0.26	0.26	0.261	0.261	0.261	0.261	0.262
13B	0.326	0.326	0.327	0.327	0.328	0.328	0.328	0.329	0.329
14B	0.741	0.741	0.742	0.743	0.744	0.745	0.745	0.746	0.747
15B	0.33	0.33	0.331	0.331	0.331	0.332	0.332	0.332	0.333
16B	0.0614	0.0615	0.0615	0.0616	0.0617	0.0617	0.0618	0.0619	0.0619
17B	0.0259	0.0259	0.026	0.026	0.026	0.0261	0.0261	0.0261	0.0261
18B	7.42	7.43	7.44	7.44	7.45	7.46	7.47	7.48	7.49
19B	8.38	8.39	8.4	8.41	8.42	8.43	8.44	8.45	8.46
20B	61.5	61.5	61.5	61.6	61.6	61.7	61.7	61.8	61.8
23B	0.226	0.227	0.227	0.227	0.227	0.228	0.228	0.228	0.228
24B	0.0113	0.0113	0.0113	0.0113	0.0113	0.0114	0.0114	0.0114	0.0114
25B	0.124	0.124	0.124	0.125	0.125	0.125	0.125	0.125	0.125
26B	1.24	1.24	1.25	1.25	1.25	1.25	1.25	1.25	1.25
27B	6.77	6.78	6.78	6.79	6.79	6.8	6.81	6.81	6.81

Screening benchmark = 58 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Naphthalene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	5.52	5.52	5.52	5.53	5.53	5.53	5.53	5.53	5.54
2	0.989	0.99	0.99	0.99	0.991	0.991	0.991	0.992	0.992
3	8.87	8.87	8.88	8.88	8.88	8.88	8.89	8.89	8.89
4	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
5	8.15	8.15	8.15	8.16	8.16	8.16	8.17	8.17	8.17
6	5.08	5.08	5.08	5.08	5.08	5.09	5.09	5.09	5.09
7	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
8	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.68
9	8.95	8.95	8.96	8.96	8.96	8.97	8.97	8.97	8.97
10	0.573	0.573	0.573	0.574	0.574	0.574	0.574	0.575	0.575
11	0.704	0.704	0.705	0.705	0.705	0.706	0.706	0.706	0.706
12	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
13	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
14	3.07	3.07	3.07	3.07	3.07	3.07	3.08	3.08	3.08
15	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06
16	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
17	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.54	1.54
18	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
19	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
20	1.4	1.4	1.41	1.41	1.41	1.41	1.41	1.41	1.41
21	4.79	4.79	4.79	4.79	4.79	4.79	4.8	4.8	4.8
22	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
23	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
24	0.417	0.417	0.417	0.417	0.418	0.418	0.418	0.418	0.418
25	1.14	1.14	1.14	1.14	1.14	1.15	1.15	1.15	1.15
26	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
27	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
28	9.47	9.47	9.47	9.48	9.48	9.48	9.49	9.49	9.49
29	7.31	7.31	7.32	7.32	7.32	7.33	7.33	7.33	7.33
30	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
31	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
32	24.3	24.3	24.4	24.4	24.4	24.4	24.4	24.4	24.4
34	224	224	224	224	224	225	225	225	225
35	2.74	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
36	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
38	19.1	19.1	19.1	19.1	19.1	19.2	19.2	19.2	19.2
39	303	303	304	304	304	304	304	304	304
40	13.9	13.9	13.9	13.9	13.9	13.9	14	14	14
41	9.26	9.26	9.27	9.27	9.28	9.28	9.28	9.29	9.29
42	0.847	0.847	0.848	0.848	0.849	0.849	0.849	0.85	0.85
43	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3
44	145	145	145	145	145	145	145	145	145
45	13.1	13.1	13.1	13.1	13.1	13.2	13.2	13.2	13.2
46	3.66	3.66	3.66	3.66	3.66	3.66	3.67	3.67	3.67
48	270	270	270	270	270	270	271	271	271
49	310	310	310	310	310	311	311	311	311
50	3.37	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
51	0.89	0.89	0.89	0.891	0.891	0.891	0.892	0.892	0.892
52	6.66	6.66	6.66	6.66	6.66	6.67	6.67	6.67	6.67
53	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
54	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
55	31.3	31.3	31.3	31.4	31.4	31.4	31.4	31.4	31.4
56	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.54	1.54
57	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.54	1.54
1B	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
2B	18.4	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
3B	0.513	0.513	0.514	0.514	0.514	0.514	0.514	0.515	0.515
4B	0.688	0.688	0.688	0.688	0.689	0.689	0.689	0.69	0.69
5B	0.331	0.331	0.331	0.331	0.331	0.332	0.332	0.332	0.332
6B	0.277	0.277	0.277	0.278	0.278	0.278	0.278	0.278	0.278
7B	0.331	0.331	0.331	0.331	0.332	0.332	0.332	0.332	0.332
8B	2.45	2.45	2.45	2.45	2.45	2.46	2.46	2.46	2.46
9B	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52
10B	0.0628	0.0629	0.0629	0.0629	0.0629	0.063	0.063	0.063	0.063
11B	0.44	0.44	0.44	0.44	0.44	0.441	0.441	0.441	0.441
12B	1.57	1.57	1.57	1.57	1.57	1.58	1.58	1.58	1.58
13B	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
14B	4.49	4.49	4.49	4.49	4.49	4.5	4.5	4.5	4.5
15B	2	2	2	2	2	2	2	2	2.01
16B	0.372	0.372	0.372	0.372	0.373	0.373	0.373	0.373	0.373
17B	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.158
18B	32.7	32.7	32.7	32.8	32.8	32.8	32.8	32.8	32.8
19B	37	37	37	37	37	37	37.1	37.1	37.1
20B	289	289	290	290	290	290	290	290	290
23B	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.38	1.38
24B	0.0684	0.0685	0.0685	0.0685	0.0685	0.0686	0.0686	0.0686	0.0686
25B	0.753	0.753	0.753	0.754	0.754	0.754	0.754	0.755	0.755
26B	3.79	3.79	3.79	3.79	3.79	3.8	3.8	3.8	3.8
27B	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2

Screening benchmark = 100 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Phenanthrene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	2.23	2.23	2.24	2.25	2.26	2.27	2.28	2.29	2.29
2	0.399	0.4	0.402	0.403	0.405	0.407	0.408	0.41	0.411
3	1.52	1.52	1.53	1.53	1.54	1.54	1.55	1.56	1.56
4	0.287	0.288	0.289	0.29	0.291	0.292	0.293	0.295	0.295
5	3.29	3.3	3.31	3.32	3.34	3.35	3.36	3.38	3.38
6	3.65	3.66	3.68	3.7	3.72	3.74	3.76	3.77	3.78
7	0.334	0.334	0.336	0.337	0.338	0.34	0.341	0.342	0.343
8	1.92	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99
9	6.44	6.46	6.49	6.52	6.56	6.59	6.62	6.65	6.67
10	0.412	0.413	0.416	0.418	0.42	0.422	0.424	0.426	0.427
11	0.507	0.508	0.511	0.513	0.516	0.518	0.521	0.524	0.525
12	0.337	0.337	0.339	0.34	0.341	0.342	0.344	0.345	0.346
13	0.206	0.206	0.207	0.208	0.208	0.209	0.21	0.211	0.211
14	2.21	2.21	2.22	2.24	2.25	2.26	2.27	2.28	2.29
15	0.353	0.353	0.355	0.356	0.357	0.359	0.36	0.361	0.362
16	0.41	0.411	0.413	0.414	0.416	0.417	0.419	0.421	0.421
17	0.263	0.263	0.264	0.265	0.266	0.267	0.268	0.269	0.27
18	0.252	0.252	0.253	0.254	0.255	0.256	0.257	0.258	0.259
19	1.77	1.77	1.78	1.79	1.8	1.81	1.82	1.83	1.83
20	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.05
21	3.44	3.45	3.47	3.49	3.51	3.52	3.54	3.56	3.57
22	1.2	1.2	1.21	1.22	1.22	1.23	1.24	1.24	1.24
23	0.741	0.743	0.747	0.751	0.755	0.759	0.762	0.766	0.768
24	0.3	0.301	0.302	0.304	0.305	0.307	0.308	0.31	0.311
25	0.214	0.215	0.216	0.218	0.219	0.22	0.221	0.223	0.223
26	0.217	0.218	0.219	0.22	0.222	0.223	0.224	0.226	0.226
27	0.935	0.938	0.942	0.947	0.952	0.957	0.962	0.967	0.969
28	6.81	6.83	6.86	6.9	6.93	6.97	7	7.04	7.06
29	5.26	5.27	5.3	5.33	5.36	5.38	5.41	5.44	5.45
30	3.71	3.72	3.74	3.77	3.79	3.81	3.83	3.85	3.87
31	1.89	1.9	1.91	1.92	1.93	1.94	1.95	1.96	1.97
32	17.5	17.6	17.6	17.7	17.8	17.9	18	18.1	18.1
34	22.8	22.9	23	23.2	23.3	23.5	23.6	23.8	23.8
35	0.515	0.516	0.519	0.523	0.526	0.529	0.532	0.535	0.536
36	0.509	0.511	0.514	0.517	0.52	0.523	0.526	0.529	0.531
38	3.59	3.6	3.62	3.64	3.66	3.68	3.7	3.72	3.73
39	30.9	31	31.2	31.4	31.6	31.8	32	32.2	32.3
40	2.61	2.62	2.63	2.65	2.67	2.68	2.7	2.71	2.72
41	1.74	1.74	1.75	1.76	1.77	1.78	1.79	1.8	1.81
42	0.159	0.159	0.16	0.161	0.162	0.163	0.164	0.165	0.166
43	3.43	3.44	3.46	3.48	3.5	3.52	3.54	3.56	3.57
44	14.7	14.8	14.9	14.9	15	15.1	15.2	15.3	15.4
45	2.46	2.47	2.48	2.5	2.51	2.53	2.54	2.56	2.56
46	0.686	0.688	0.692	0.696	0.7	0.704	0.708	0.713	0.715
48	91.6	91.8	92.1	92.4	92.7	93	93.3	93.6	93.8
49	105	105	106	106	106	107	107	108	108
50	2.43	2.43	2.45	2.46	2.47	2.48	2.5	2.51	2.52
51	0.359	0.36	0.361	0.363	0.364	0.366	0.367	0.369	0.37
52	2.69	2.69	2.7	2.71	2.73	2.74	2.75	2.76	2.76
53	1.67	1.67	1.68	1.69	1.7	1.71	1.71	1.72	1.73
54	2.74	2.75	2.76	2.78	2.8	2.81	2.83	2.84	2.85
55	5.88	5.9	5.93	5.96	6	6.03	6.07	6.1	6.12
56	0.263	0.263	0.264	0.265	0.266	0.267	0.268	0.269	0.27
57	0.263	0.263	0.264	0.265	0.266	0.267	0.268	0.269	0.27
1B	6.29	6.3	6.33	6.36	6.38	6.41	6.43	6.46	6.47
2B	7.04	7.06	7.08	7.11	7.14	7.17	7.2	7.23	7.24
3B	0.216	0.217	0.218	0.219	0.22	0.222	0.223	0.224	0.225
4B	0.289	0.29	0.292	0.294	0.295	0.297	0.299	0.301	0.301
5B	0.139	0.14	0.141	0.141	0.142	0.143	0.144	0.145	0.145
6B	0.117	0.117	0.118	0.118	0.119	0.12	0.12	0.121	0.122
7B	0.139	0.14	0.141	0.141	0.142	0.143	0.144	0.145	0.145
8B	1.03	1.03	1.04	1.05	1.05	1.06	1.06	1.07	1.07
9B	1.06	1.06	1.07	1.07	1.08	1.09	1.09	1.1	1.1
10B	0.0353	0.0354	0.0356	0.0358	0.0359	0.0361	0.0363	0.0365	0.0366
11B	0.247	0.248	0.249	0.25	0.252	0.253	0.254	0.256	0.256
12B	0.883	0.885	0.89	0.895	0.899	0.904	0.909	0.914	0.916
13B	1.11	1.11	1.12	1.12	1.13	1.14	1.14	1.15	1.15
14B	2.52	2.53	2.54	2.55	2.57	2.58	2.59	2.61	2.61
15B	1.12	1.13	1.13	1.14	1.14	1.15	1.16	1.16	1.16
16B	0.209	0.209	0.211	0.212	0.213	0.214	0.215	0.216	0.217
17B	0.0882	0.0884	0.0889	0.0894	0.0898	0.0903	0.0908	0.0913	0.0915
18B	21.1	21.2	21.3	21.5	21.6	21.7	21.8	22	22
19B	23.9	23.9	24.1	24.2	24.4	24.5	24.7	24.8	24.9
20B	98.2	98.4	98.7	99	99.3	99.7	100	100	100
23B	0.77	0.772	0.776	0.78	0.785	0.789	0.793	0.797	0.799
24B	0.0384	0.0385	0.0387	0.0389	0.0391	0.0394	0.0396	0.0398	0.0399
25B	0.423	0.424	0.426	0.428	0.431	0.433	0.435	0.437	0.439
26B	1.59	1.6	1.61	1.62	1.63	1.64	1.65	1.66	1.66
27B	6.55	6.56	6.59	6.61	6.64	6.67	6.69	6.72	6.73

Screening benchmark = 40 µg/L

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Pyrene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	1.08	1.09	1.11	1.13	1.15	1.17	1.18	1.2	1.21
2	0.194	0.196	0.199	0.202	0.206	0.209	0.212	0.215	0.217
3	0.521	0.525	0.533	0.541	0.549	0.558	0.566	0.574	0.578
4	0.0986	0.0993	0.101	0.102	0.104	0.105	0.107	0.109	0.109
5	1.6	1.61	1.64	1.67	1.69	1.72	1.75	1.77	1.79
6	1.43	1.45	1.48	1.51	1.54	1.57	1.6	1.63	1.64
7	0.114	0.115	0.117	0.119	0.121	0.123	0.124	0.126	0.127
8	0.753	0.761	0.776	0.792	0.808	0.823	0.839	0.855	0.862
9	2.53	2.55	2.6	2.66	2.71	2.76	2.81	2.87	2.89
10	0.162	0.163	0.167	0.17	0.173	0.177	0.18	0.184	0.185
11	0.199	0.201	0.205	0.209	0.213	0.217	0.221	0.226	0.228
12	0.115	0.116	0.118	0.12	0.122	0.124	0.125	0.127	0.128
13	0.0705	0.0711	0.0722	0.0733	0.0744	0.0755	0.0766	0.0777	0.0783
14	0.866	0.875	0.893	0.911	0.929	0.947	0.965	0.983	0.992
15	0.121	0.122	0.124	0.126	0.128	0.129	0.131	0.133	0.134
16	0.141	0.142	0.144	0.146	0.148	0.151	0.153	0.155	0.156
17	0.0901	0.0908	0.0922	0.0936	0.095	0.0964	0.0978	0.0992	0.0999
18	0.0863	0.087	0.0884	0.0897	0.0911	0.0924	0.0938	0.0951	0.0958
19	0.694	0.701	0.715	0.73	0.744	0.758	0.773	0.787	0.794
20	0.396	0.4	0.409	0.417	0.425	0.433	0.442	0.45	0.454
21	1.35	1.36	1.39	1.42	1.45	1.48	1.5	1.53	1.55
22	0.471	0.476	0.486	0.496	0.506	0.515	0.525	0.535	0.54
23	0.291	0.294	0.3	0.306	0.312	0.318	0.324	0.33	0.333
24	0.118	0.119	0.121	0.124	0.126	0.129	0.131	0.134	0.135
25	0.129	0.13	0.133	0.136	0.139	0.142	0.146	0.149	0.15
26	0.13	0.132	0.135	0.138	0.141	0.144	0.147	0.151	0.152
27	0.367	0.371	0.378	0.386	0.393	0.401	0.409	0.416	0.42
28	2.67	2.7	2.75	2.81	2.87	2.92	2.98	3.03	3.06
29	2.06	2.08	2.13	2.17	2.21	2.26	2.3	2.34	2.36
30	2.23	2.25	2.31	2.36	2.41	2.47	2.52	2.57	2.6
31	1.13	1.15	1.17	1.2	1.23	1.26	1.28	1.31	1.32
32	6.87	6.94	7.08	7.23	7.37	7.51	7.65	7.8	7.87
34	9.75	9.88	10.1	10.4	10.6	10.9	11.1	11.4	11.5
35	0.309	0.313	0.32	0.327	0.335	0.342	0.349	0.357	0.361
36	0.306	0.309	0.317	0.324	0.331	0.338	0.346	0.353	0.357
38	2.15	2.18	2.23	2.28	2.33	2.38	2.43	2.49	2.51
39	13.2	13.4	13.7	14.1	14.4	14.7	15.1	15.4	15.6
40	1.57	1.59	1.62	1.66	1.7	1.73	1.77	1.81	1.83
41	1.04	1.06	1.08	1.1	1.13	1.15	1.18	1.2	1.22
42	0.0954	0.0965	0.0988	0.101	0.103	0.106	0.108	0.11	0.111
43	2.06	2.08	2.13	2.18	2.23	2.28	2.33	2.37	2.4
44	6.3	6.38	6.54	6.7	6.87	7.03	7.19	7.36	7.44
45	1.48	1.5	1.53	1.57	1.6	1.64	1.67	1.71	1.72
46	0.412	0.417	0.426	0.436	0.446	0.456	0.466	0.476	0.48
48	38.7	39	39.5	40.1	40.6	41.1	41.6	42.2	42.4
49	44.5	44.8	45.4	46	46.6	47.2	47.8	48.4	48.7
50	0.952	0.962	0.982	1	1.02	1.04	1.06	1.08	1.09
51	0.175	0.176	0.179	0.182	0.185	0.188	0.191	0.194	0.195
52	1.31	1.32	1.34	1.36	1.38	1.4	1.43	1.45	1.46
53	0.654	0.66	0.674	0.688	0.701	0.715	0.728	0.742	0.749
54	1.64	1.66	1.7	1.74	1.78	1.82	1.86	1.9	1.92
55	3.53	3.57	3.65	3.74	3.82	3.91	3.99	4.07	4.12
56	0.0901	0.0908	0.0922	0.0936	0.095	0.0964	0.0978	0.0992	0.0999
57	0.0901	0.0908	0.0922	0.0936	0.095	0.0964	0.0978	0.0992	0.0999
1B	1.32	1.33	1.35	1.38	1.4	1.42	1.44	1.47	1.48
2B	1.48	1.49	1.52	1.54	1.57	1.59	1.61	1.64	1.65
3B	0.0922	0.0933	0.0955	0.0977	0.0999	0.102	0.104	0.107	0.108
4B	0.124	0.125	0.128	0.131	0.134	0.137	0.14	0.143	0.144
5B	0.0595	0.0602	0.0616	0.063	0.0644	0.0659	0.0673	0.0687	0.0694
6B	0.0498	0.0504	0.0516	0.0528	0.054	0.0552	0.0564	0.0575	0.0581
7B	0.0595	0.0602	0.0616	0.063	0.0645	0.0659	0.0673	0.0687	0.0694
8B	0.44	0.446	0.456	0.467	0.477	0.488	0.498	0.509	0.514
9B	0.452	0.458	0.468	0.479	0.49	0.501	0.512	0.522	0.528
10B	0.0177	0.0179	0.0183	0.0187	0.0191	0.0195	0.0198	0.0202	0.0204
11B	0.124	0.125	0.128	0.131	0.133	0.136	0.139	0.142	0.143
12B	0.443	0.448	0.458	0.467	0.477	0.487	0.496	0.506	0.511
13B	0.557	0.563	0.575	0.588	0.6	0.612	0.624	0.636	0.642
14B	1.27	1.28	1.31	1.33	1.36	1.39	1.42	1.44	1.46
15B	0.564	0.57	0.582	0.594	0.607	0.619	0.631	0.644	0.65
16B	0.105	0.106	0.108	0.111	0.113	0.115	0.117	0.12	0.121
17B	0.0443	0.0448	0.0457	0.0467	0.0477	0.0486	0.0496	0.0506	0.051
18B	11.6	11.8	12.1	12.4	12.6	12.9	13.2	13.5	13.7
19B	13.1	13.3	13.6	14	14.3	14.6	14.9	15.3	15.4
20B	41.5	41.8	42.4	42.9	43.5	44.1	44.6	45.2	45.5
23B	0.387	0.391	0.399	0.408	0.416	0.425	0.433	0.442	0.446
24B	0.0193	0.0195	0.0199	0.0203	0.0208	0.0212	0.0216	0.022	0.0222
25B	0.212	0.215	0.219	0.224	0.228	0.233	0.238	0.242	0.245
26B	0.681	0.689	0.705	0.721	0.738	0.754	0.77	0.786	0.794
27B	1.38	1.39	1.41	1.43	1.46	1.48	1.5	1.52	1.54

Screening benchmark = 12.8 µg/L

Dredge Unit:	**Predicted Discharge Water Total Concentrations (µg/L) for Arsenic**								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.0603	0.121	0.241	0.362	0.482	0.603	0.723	0.844	0.904
2	0.0459	0.0917	0.183	0.275	0.367	0.459	0.55	0.642	0.688
3	0.0974	0.195	0.39	0.584	0.779	0.974	1.17	1.36	1.46
4	0.0193	0.0386	0.0771	0.116	0.154	0.193	0.231	0.27	0.289
5	0.0743	0.149	0.297	0.446	0.595	0.743	0.892	1.04	1.11
6	0.0777	0.155	0.311	0.466	0.621	0.777	0.932	1.09	1.17
7	0.0543	0.109	0.217	0.326	0.435	0.543	0.652	0.761	0.815
8	0.878	1.76	3.51	5.27	7.02	8.78	10.5	12.3	13.2
9	0.377	0.754	1.51	2.26	3.02	3.77	4.53	5.28	5.66
10	0.313	0.626	1.25	1.88	2.5	3.13	3.75	4.38	4.69
11	0.0996	0.199	0.398	0.597	0.797	0.996	1.19	1.39	1.49
12	0.0408	0.0815	0.163	0.245	0.326	0.408	0.489	0.571	0.612
13	0.0512	0.102	0.205	0.307	0.409	0.512	0.614	0.716	0.767
14	0.23	0.46	0.919	1.38	1.84	2.3	2.76	3.22	3.45
15	0.0411	0.0823	0.165	0.247	0.329	0.411	0.494	0.576	0.617
16	0.104	0.209	0.418	0.627	0.836	1.04	1.25	1.46	1.57
17	0.0377	0.0754	0.151	0.226	0.301	0.377	0.452	0.528	0.565
18	0.0776	0.155	0.311	0.466	0.621	0.776	0.932	1.09	1.16
19	1.73	3.47	6.94	10.4	13.9	17.3	20.8	24.3	26
20	0.143	0.286	0.571	0.857	1.14	1.43	1.71	2	2.14
21	6.12	12.2	24.5	36.7	49	61.2	73.5	85.7	91.8
22	4.17	8.33	16.7	25	33.3	41.7	50	58.3	62.5
23	0.167	0.333	0.666	0.999	1.33	1.67	2	2.33	2.5
24	0.0816	0.163	0.326	0.49	0.653	0.816	0.979	1.14	1.22
25	0.0756	0.151	0.302	0.454	0.605	0.756	0.907	1.06	1.13
26	0.131	0.263	0.526	0.789	1.05	1.31	1.58	1.84	1.97
27	0.431	0.862	1.72	2.59	3.45	4.31	5.17	6.04	6.47
28	0.44	0.88	1.76	2.64	3.52	4.4	5.28	6.16	6.6
29	1.33	2.65	5.31	7.96	10.6	13.3	15.9	18.6	19.9
30	0.165	0.331	0.661	0.992	1.32	1.65	1.98	2.32	2.48
31	0.16	0.32	0.641	0.961	1.28	1.6	1.92	2.24	2.4
32	0.18	0.361	0.721	1.08	1.44	1.8	2.16	2.52	2.7
34	0.834	1.67	3.34	5.01	6.67	8.34	10	11.7	12.5
35	0.133	0.266	0.532	0.798	1.06	1.33	1.6	1.86	2
36	0.0918	0.184	0.367	0.551	0.734	0.918	1.1	1.29	1.38
38	0.309	0.617	1.23	1.85	2.47	3.09	3.7	4.32	4.63
39	0.906	1.81	3.63	5.44	7.25	9.06	10.9	12.7	13.6
40	1.03	2.07	4.14	6.2	8.27	10.3	12.4	14.5	15.5
41	0.311	0.621	1.24	1.86	2.49	3.11	3.73	4.35	4.66
42	0.104	0.208	0.415	0.623	0.831	1.04	1.25	1.45	1.56
43	0.695	1.39	2.78	4.17	5.56	6.95	8.34	9.73	10.4
44	0.535	1.07	2.14	3.21	4.28	5.35	6.42	7.49	8.02
45	1.24	2.47	4.95	7.42	9.9	12.4	14.8	17.3	18.6
46	1.19	2.38	4.75	7.13	9.5	11.9	14.3	16.6	17.8
48	0.313	0.626	1.25	1.88	2.5	3.13	3.75	4.38	4.69
49	0.164	0.328	0.656	0.985	1.31	1.64	1.97	2.3	2.46
50	2.2	4.41	8.82	13.2	17.6	22	26.4	30.9	33.1
51	0.0762	0.152	0.305	0.457	0.609	0.762	0.914	1.07	1.14
52	0.0811	0.162	0.324	0.486	0.648	0.811	0.973	1.13	1.22
53	0.315	0.629	1.26	1.89	2.52	3.15	3.78	4.4	4.72
54	0.208	0.416	0.831	1.25	1.66	2.08	2.49	2.91	3.12
55	0.684	1.37	2.74	4.11	5.47	6.84	8.21	9.58	10.3
56	0.037	0.0739	0.148	0.222	0.296	0.37	0.443	0.517	0.554
57	0.034	0.0681	0.136	0.204	0.272	0.34	0.409	0.477	0.511
1B	0.0222	0.0445	0.0889	0.133	0.178	0.222	0.267	0.311	0.333
2B	0.0211	0.0422	0.0845	0.127	0.169	0.211	0.253	0.296	0.317
3B	0.0624	0.125	0.25	0.374	0.499	0.624	0.749	0.873	0.936
4B	0.0549	0.11	0.219	0.329	0.439	0.549	0.658	0.768	0.823
5B	0.0602	0.12	0.241	0.361	0.481	0.602	0.722	0.842	0.902
6B	0.0396	0.0792	0.158	0.238	0.317	0.396	0.475	0.554	0.594
7B	0.0439	0.0878	0.176	0.264	0.351	0.439	0.527	0.615	0.659
8B	0.0974	0.195	0.39	0.584	0.779	0.974	1.17	1.36	1.46
9B	0.0915	0.183	0.366	0.549	0.732	0.915	1.1	1.28	1.37
10B	0.0318	0.0637	0.127	0.191	0.255	0.318	0.382	0.446	0.478
11B	0.0714	0.143	0.286	0.429	0.571	0.714	0.857	1	1.07
12B	0.0544	0.109	0.218	0.327	0.436	0.544	0.653	0.762	0.817
13B	0.097	0.194	0.388	0.582	0.776	0.97	1.16	1.36	1.45
14B	0.183	0.365	0.731	1.1	1.46	1.83	2.19	2.56	2.74
15B	0.214	0.428	0.856	1.28	1.71	2.14	2.57	3	3.21
16B	0.067	0.134	0.268	0.402	0.536	0.67	0.803	0.937	1
17B	0.407	0.814	1.63	2.44	3.26	4.07	4.89	5.7	6.11
18B	0.165	0.329	0.659	0.988	1.32	1.65	1.98	2.31	2.47
19B	0.165	0.329	0.658	0.988	1.32	1.65	1.98	2.3	2.47
20B	0.189	0.377	0.754	1.13	1.51	1.89	2.26	2.64	2.83
23B	0.796	1.59	3.18	4.77	6.36	7.96	9.55	11.1	11.9
24B	0.0416	0.0832	0.166	0.25	0.333	0.416	0.499	0.583	0.624
25B	0.068	0.136	0.272	0.408	0.544	0.68	0.817	0.953	1.02
26B	0.108	0.216	0.432	0.648	0.864	1.08	1.3	1.51	1.62
27B	0.0931	0.186	0.372	0.559	0.745	0.931	1.12	1.3	1.4

Screening benchmark = 125 µg/L

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Copper								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.564	1.13	2.26	3.38	4.51	5.64	6.77	7.89	8.46
2	0.451	0.902	1.8	2.7	3.61	4.51	5.41	6.31	6.76
3	1.06	2.11	4.23	6.34	8.46	10.6	12.7	14.8	15.9
4	0.167	0.335	0.669	1	1.34	1.67	2.01	2.34	2.51
5	0.679	1.36	2.72	4.08	5.43	6.79	8.15	9.51	10.2
6	0.651	1.3	2.6	3.9	5.2	6.51	7.81	9.11	9.76
7	0.486	0.971	1.94	2.91	3.88	4.86	5.83	6.8	7.28
8	3.36	6.72	13.4	20.2	26.9	33.6	40.3	47.1	50.4
9	1.82	3.64	7.28	10.9	14.6	18.2	21.8	25.5	27.3
10	1.46	2.92	5.85	8.77	11.7	14.6	17.5	20.5	21.9
11	0.815	1.63	3.26	4.89	6.52	8.15	9.78	11.4	12.2
12	0.355	0.711	1.42	2.13	2.84	3.55	4.27	4.98	5.33
13	0.629	1.26	2.52	3.77	5.03	6.29	7.55	8.8	9.43
14	1.39	2.78	5.56	8.34	11.1	13.9	16.7	19.5	20.9
15	0.381	0.762	1.52	2.29	3.05	3.81	4.57	5.33	5.72
16	0.743	1.49	2.97	4.46	5.95	7.43	8.92	10.4	11.1
17	0.405	0.81	1.62	2.43	3.24	4.05	4.86	5.67	6.08
18	0.787	1.57	3.15	4.72	6.3	7.87	9.44	11	11.8
19	5.29	10.6	21.1	31.7	42.3	52.9	63.4	74	79.3
20	1.11	2.22	4.43	6.65	8.86	11.1	13.3	15.5	16.6
21	18.8	37.6	75.3	113	151	188	226	263	282
22	11.8	23.7	47.4	71.1	94.8	118	142	166	178
23	1.3	2.61	5.21	7.82	10.4	13	15.6	18.2	19.5
24	0.646	1.29	2.59	3.88	5.17	6.46	7.76	9.05	9.7
25	0.811	1.62	3.24	4.87	6.49	8.11	9.73	11.4	12.2
26	2.48	4.96	9.92	14.9	19.8	24.8	29.8	34.7	37.2
27	2.53	5.06	10.1	15.2	20.2	25.3	30.3	35.4	37.9
28	2.65	5.29	10.6	15.9	21.2	26.5	31.7	37	39.7
29	7.68	15.4	30.7	46.1	61.4	76.8	92.2	108	115
30	1.04	2.08	4.16	6.23	8.31	10.4	12.5	14.5	15.6
31	1.92	3.83	7.67	11.5	15.3	19.2	23	26.8	28.8
32	1.42	2.84	5.67	8.51	11.3	14.2	17	19.8	21.3
34	6.63	13.3	26.5	39.8	53.1	66.3	79.6	92.9	99.5
35	2.58	5.17	10.3	15.5	20.7	25.8	31	36.2	38.8
36	1.79	3.58	7.15	10.7	14.3	17.9	21.5	25	26.8
38	4.28	8.55	17.1	25.7	34.2	42.8	51.3	59.9	64.1
39	9.77	19.5	39.1	58.6	78.2	97.7	117	137	147
40	5.12	10.2	20.5	30.7	41	51.2	61.5	71.7	76.8
41	2.36	4.73	9.46	14.2	18.9	23.6	28.4	33.1	35.5
42	1.28	2.56	5.12	7.67	10.2	12.8	15.3	17.9	19.2
43	4.08	8.16	16.3	24.5	32.7	40.8	49	57.2	61.2
44	7.45	14.9	29.8	44.7	59.6	74.5	89.4	104	112
45	5.77	11.5	23.1	34.6	46.1	57.7	69.2	80.7	86.5
46	5.77	11.5	23.1	34.6	46.2	57.7	69.2	80.8	86.5
48	2.76	5.52	11	16.6	22.1	27.6	33.1	38.7	41.4
49	21.7	43.4	86.8	130	174	217	260	304	325
50	10.2	20.3	40.7	61	81.4	102	122	142	153
51	0.766	1.53	3.06	4.6	6.13	7.66	9.19	10.7	11.5
52	0.654	1.31	2.61	3.92	5.23	6.54	7.84	9.15	9.81
53	1.58	3.17	6.34	9.5	12.7	15.8	19	22.2	23.8
54	1.33	2.66	5.31	7.97	10.6	13.3	15.9	18.6	19.9
55	6.83	13.7	27.3	41	54.6	68.3	82	95.6	102
56	0.394	0.788	1.58	2.36	3.15	3.94	4.73	5.52	5.91
57	0.373	0.745	1.49	2.24	2.98	3.73	4.47	5.22	5.59
1B	0.166	0.332	0.664	0.996	1.33	1.66	1.99	2.32	2.49
2B	0.151	0.302	0.603	0.905	1.21	1.51	1.81	2.11	2.26
3B	0.62	1.24	2.48	3.72	4.96	6.2	7.44	8.68	9.3
4B	0.448	0.895	1.79	2.69	3.58	4.48	5.37	6.27	6.71
5B	0.49	0.98	1.96	2.94	3.92	4.9	5.88	6.86	7.35
6B	0.42	0.841	1.68	2.52	3.36	4.2	5.04	5.89	6.31
7B	0.446	0.892	1.78	2.68	3.57	4.46	5.35	6.24	6.69
8B	0.905	1.81	3.62	5.43	7.24	9.05	10.9	12.7	13.6
9B	0.932	1.86	3.73	5.59	7.46	9.32	11.2	13	14
10B	0.334	0.668	1.34	2	2.67	3.34	4.01	4.68	5.01
11B	0.681	1.36	2.72	4.09	5.45	6.81	8.17	9.53	10.2
12B	0.502	1	2.01	3.01	4.02	5.02	6.02	7.03	7.53
13B	1.04	2.08	4.16	6.24	8.32	10.4	12.5	14.6	15.6
14B	2.05	4.09	8.18	12.3	16.4	20.5	24.5	28.6	30.7
15B	1.81	3.62	7.23	10.9	14.5	18.1	21.7	25.3	27.1
16B	0.935	1.87	3.74	5.61	7.48	9.35	11.2	13.1	14
17B	2.04	4.09	8.17	12.3	16.3	20.4	24.5	28.6	30.7
18B	0.864	1.73	3.46	5.18	6.91	8.64	10.4	12.1	13
19B	34.5	69.1	138	207	276	345	414	484	518
20B	30.6	61.1	122	183	244	306	367	428	458
23B	3.72	7.45	14.9	22.3	29.8	37.2	44.7	52.1	55.8
24B	0.335	0.669	1.34	2.01	2.68	3.35	4.02	4.68	5.02
25B	0.671	1.34	2.68	4.03	5.37	6.71	8.05	9.4	10.1
26B	1.03	2.05	4.1	6.15	8.2	10.3	12.3	14.4	15.4
27B	0.418	0.837	1.67	2.51	3.35	4.18	5.02	5.86	6.28

Screening benchmark = 30 µg/L

Dredge Unit:	Predicted Discharge Water Dissolved Concentrations (µg/L) for Copper (based on maximum observed dissolved fraction - 16% - in DRET testing)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.090	0.181	0.362	0.541	0.722	0.902	1.08	1.26	1.35
2	0.072	0.144	0.288	0.432	0.578	0.722	0.866	1.01	1.08
3	0.170	0.338	0.677	1.01	1.35	1.70	2.03	2.37	2.54
4	0.027	0.054	0.107	0.160	0.214	0.267	0.322	0.374	0.402
5	0.109	0.218	0.435	0.653	0.869	1.09	1.30	1.52	1.63
6	0.104	0.208	0.416	0.624	0.832	1.04	1.25	1.46	1.56
7	0.078	0.155	0.310	0.466	0.621	0.778	0.933	1.09	1.16
8	0.538	1.08	2.14	3.23	4.30	5.38	6.45	7.54	8.06
9	0.291	0.582	1.16	1.74	2.34	2.91	3.49	4.08	4.37
10	0.234	0.467	0.936	1.40	1.87	2.34	2.80	3.28	3.50
11	0.130	0.261	0.522	0.782	1.04	1.30	1.56	1.82	1.95
12	0.057	0.114	0.227	0.341	0.454	0.568	0.683	0.797	0.853
13	0.101	0.202	0.403	0.603	0.805	1.006	1.21	1.41	1.51
14	0.222	0.445	0.890	1.33	1.78	2.224	2.67	3.12	3.34
15	0.061	0.122	0.243	0.366	0.488	0.610	0.731	0.853	0.915
16	0.119	0.238	0.475	0.714	0.952	1.189	1.43	1.66	1.78
17	0.065	0.130	0.259	0.389	0.518	0.648	0.778	0.907	0.973
18	0.126	0.251	0.504	0.755	1.01	1.26	1.51	1.76	1.89
19	0.846	1.70	3.38	5.07	6.77	8.46	10.1	11.8	12.7
20	0.178	0.355	0.709	1.06	1.42	1.78	2.13	2.48	2.66
21	3.01	6.016	12.0	18.1	24.2	30.1	36.2	42.1	45.1
22	1.89	3.79	7.58	11.4	15.2	18.9	22.7	26.6	28.5
23	0.208	0.418	0.834	1.25	1.66	2.08	2.50	2.91	3.12
24	0.103	0.206	0.414	0.621	0.827	1.03	1.24	1.45	1.55
25	0.130	0.259	0.518	0.779	1.04	1.30	1.56	1.82	1.95
26	0.397	0.794	1.59	2.38	3.17	3.97	4.77	5.55	5.95
27	0.405	0.810	1.62	2.43	3.23	4.05	4.85	5.66	6.06
28	0.424	0.846	1.70	2.54	3.39	4.24	5.07	5.92	6.35
29	1.23	2.46	4.91	7.38	9.82	12.3	14.8	17.3	18.4
30	0.166	0.333	0.666	0.997	1.33	1.66	2.00	2.32	2.50
31	0.307	0.613	1.227	1.840	2.45	3.07	3.68	4.29	4.61
32	0.227	0.454	0.907	1.362	1.81	2.27	2.72	3.17	3.41
34	1.06	2.13	4.24	6.37	8.50	10.6	12.7	14.9	15.9
35	0.413	0.827	1.65	2.48	3.31	4.13	4.96	5.79	6.21
36	0.286	0.573	1.14	1.71	2.29	2.86	3.44	4.00	4.29
38	0.685	1.37	2.74	4.11	5.47	6.85	8.21	9.58	10.3
39	1.56	3.12	6.26	9.38	12.5	15.6	18.7	21.9	23.5
40	0.819	1.63	3.28	4.91	6.56	8.19	9.84	11.5	12.3
41	0.378	0.757	1.51	2.27	3.02	3.78	4.54	5.30	5.68
42	0.205	0.410	0.819	1.23	1.63	2.05	2.45	2.86	3.07
43	0.653	1.31	2.61	3.92	5.23	6.53	7.84	9.15	9.79
44	1.19	2.38	4.77	7.15	9.54	11.9	14.3	16.6	17.9
45	0.923	1.84	3.70	5.54	7.38	9.23	11.1	12.9	13.8
46	0.923	1.84	3.70	5.54	7.39	9.23	11.1	12.9	13.8
48	0.442	0.883	1.76	2.66	3.54	4.42	5.30	6.19	6.62
49	3.47	6.94	13.9	20.8	27.8	34.7	41.6	48.6	52.0
50	1.63	3.25	6.51	9.76	13.0	16.3	19.5	22.7	24.5
51	0.123	0.245	0.490	0.736	0.981	1.23	1.47	1.71	1.84
52	0.105	0.210	0.418	0.627	0.837	1.05	1.25	1.46	1.57
53	0.253	0.507	1.01	1.52	2.03	2.53	3.04	3.55	3.81
54	0.213	0.426	0.850	1.28	1.70	2.13	2.54	2.98	3.18
55	1.09	2.19	4.37	6.56	8.74	10.9	13.1	15.3	16.3
56	0.063	0.126	0.253	0.378	0.504	0.630	0.757	0.883	0.946
57	0.060	0.119	0.238	0.358	0.477	0.597	0.715	0.835	0.894
1B	0.027	0.053	0.106	0.159	0.213	0.266	0.318	0.371	0.398
2B	0.024	0.048	0.096	0.145	0.194	0.242	0.290	0.338	0.362
3B	0.099	0.198	0.397	0.595	0.794	0.992	1.19	1.39	1.49
4B	0.072	0.143	0.286	0.430	0.573	0.717	0.859	1.00	1.07
5B	0.078	0.157	0.314	0.470	0.627	0.784	0.941	1.10	1.18
6B	0.067	0.135	0.269	0.403	0.538	0.672	0.806	0.942	1.010
7B	0.071	0.143	0.285	0.429	0.571	0.714	0.856	0.998	1.070
8B	0.145	0.290	0.579	0.869	1.16	1.45	1.74	2.03	2.18
9B	0.149	0.298	0.597	0.894	1.19	1.49	1.79	2.08	2.24
10B	0.053	0.107	0.214	0.320	0.427	0.534	0.642	0.749	0.802
11B	0.109	0.218	0.435	0.654	0.872	1.09	1.31	1.52	1.63
12B	0.080	0.160	0.322	0.482	0.643	0.803	0.963	1.12	1.20
13B	0.166	0.333	0.666	0.998	1.33	1.66	2.00	2.34	2.50
14B	0.328	0.654	1.31	1.97	2.62	3.28	3.92	4.58	4.91
15B	0.290	0.579	1.16	1.74	2.32	2.90	3.47	4.05	4.34
16B	0.150	0.299	0.598	0.898	1.20	1.50	1.79	2.10	2.24
17B	0.326	0.654	1.31	1.97	2.61	3.26	3.92	4.58	4.91
18B	0.138	0.277	0.554	0.83	1.11	1.38	1.66	1.94	2.08
19B	5.52	11.1	22.1	33.1	44.2	55.2	66.2	77.4	82.9
20B	4.90	9.78	19.5	29.3	39.0	49.0	58.7	68.5	73.3
23B	0.595	1.19	2.38	3.57	4.77	5.95	7.15	8.34	8.93
24B	0.054	0.107	0.214	0.322	0.429	0.536	0.643	0.749	0.803
25B	0.107	0.214	0.429	0.645	0.859	1.07	1.29	1.50	1.62
26B	0.165	0.328	0.656	0.984	1.31	1.65	1.97	2.30	2.46
27B	0.067	0.134	0.267	0.402	0.536	0.669	0.803	0.938	1.00

Screening benchmark = 30 µg/L

Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Zinc								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.564	1.13	2.26	3.38	4.51	5.64	6.77	7.89	8.46
2	0.451	0.902	1.8	2.7	3.61	4.51	5.41	6.31	6.76
3	1.06	2.11	4.23	6.34	8.46	10.6	12.7	14.8	15.9
4	0.167	0.335	0.669	1	1.34	1.67	2.01	2.34	2.51
5	0.679	1.36	2.72	4.08	5.43	6.79	8.15	9.51	10.2
6	0.651	1.3	2.6	3.9	5.2	6.51	7.81	9.11	9.76
7	0.486	0.971	1.94	2.91	3.88	4.86	5.83	6.8	7.28
8	3.36	6.72	13.4	20.2	26.9	33.6	40.3	47.1	50.4
9	1.82	3.64	7.28	10.9	14.6	18.2	21.8	25.5	27.3
10	1.46	2.92	5.85	8.77	11.7	14.6	17.5	20.5	21.9
11	0.815	1.63	3.26	4.89	6.52	8.15	9.78	11.4	12.2
12	0.355	0.711	1.42	2.13	2.84	3.55	4.27	4.98	5.33
13	0.629	1.26	2.52	3.77	5.03	6.29	7.55	8.8	9.43
14	1.39	2.78	5.56	8.34	11.1	13.9	16.7	19.5	20.9
15	0.381	0.762	1.52	2.29	3.05	3.81	4.57	5.33	5.72
16	0.743	1.49	2.97	4.46	5.95	7.43	8.92	10.4	11.1
17	0.405	0.81	1.62	2.43	3.24	4.05	4.86	5.67	6.08
18	0.787	1.57	3.15	4.72	6.3	7.87	9.44	11	11.8
19	5.29	10.6	21.1	31.7	42.3	52.9	63.4	74	79.3
20	1.11	2.22	4.43	6.65	8.86	11.1	13.3	15.5	16.6
21	18.8	37.6	75.3	113	151	188	226	263	282
22	11.8	23.7	47.4	71.1	94.8	118	142	166	178
23	1.3	2.61	5.21	7.82	10.4	13	15.6	18.2	19.5
24	0.646	1.29	2.59	3.88	5.17	6.46	7.76	9.05	9.7
25	0.811	1.62	3.24	4.87	6.49	8.11	9.73	11.4	12.2
26	2.48	4.96	9.92	14.9	19.8	24.8	29.8	34.7	37.2
27	2.53	5.06	10.1	15.2	20.2	25.3	30.3	35.4	37.9
28	2.65	5.29	10.6	15.9	21.2	26.5	31.7	37	39.7
29	7.68	15.4	30.7	46.1	61.4	76.8	92.2	108	115
30	1.04	2.08	4.16	6.23	8.31	10.4	12.5	14.5	15.6
31	1.92	3.83	7.67	11.5	15.3	19.2	23	26.8	28.8
32	1.42	2.84	5.67	8.51	11.3	14.2	17	19.8	21.3
34	6.63	13.3	26.5	39.8	53.1	66.3	79.6	92.9	99.5
35	2.58	5.17	10.3	15.5	20.7	25.8	31	36.2	38.8
36	1.79	3.58	7.15	10.7	14.3	17.9	21.5	25	26.8
38	4.28	8.55	17.1	25.7	34.2	42.8	51.3	59.9	64.1
39	9.77	19.5	39.1	58.6	78.2	97.7	117	137	147
40	5.12	10.2	20.5	30.7	41	51.2	61.5	71.7	76.8
41	2.36	4.73	9.46	14.2	18.9	23.6	28.4	33.1	35.5
42	1.28	2.56	5.12	7.67	10.2	12.8	15.3	17.9	19.2
43	4.08	8.16	16.3	24.5	32.7	40.8	49	57.2	61.2
44	7.45	14.9	29.8	44.7	59.6	74.5	89.4	104	112
45	5.77	11.5	23.1	34.6	46.1	57.7	69.2	80.7	86.5
46	5.77	11.5	23.1	34.6	46.2	57.7	69.2	80.8	86.5
48	2.76	5.52	11	16.6	22.1	27.6	33.1	38.7	41.4
49	21.7	43.4	86.8	130	174	217	260	304	325
50	10.2	20.3	40.7	61	81.4	102	122	142	153
51	0.766	1.53	3.06	4.6	6.13	7.66	9.19	10.7	11.5
52	0.654	1.31	2.61	3.92	5.23	6.54	7.84	9.15	9.81
53	1.58	3.17	6.34	9.5	12.7	15.8	19	22.2	23.8
54	1.33	2.66	5.31	7.97	10.6	13.3	15.9	18.6	19.9
55	6.83	13.7	27.3	41	54.6	68.3	82	95.6	102
56	0.394	0.788	1.58	2.36	3.15	3.94	4.73	5.52	5.91
57	0.373	0.745	1.49	2.24	2.98	3.73	4.47	5.22	5.59
1B	0.166	0.332	0.664	0.996	1.33	1.66	1.99	2.32	2.49
2B	0.151	0.302	0.603	0.905	1.21	1.51	1.81	2.11	2.26
3B	0.62	1.24	2.48	3.72	4.96	6.2	7.44	8.68	9.3
4B	0.448	0.895	1.79	2.69	3.58	4.48	5.37	6.27	6.71
5B	0.49	0.98	1.96	2.94	3.92	4.9	5.88	6.86	7.35
6B	0.42	0.841	1.68	2.52	3.36	4.2	5.04	5.89	6.31
7B	0.446	0.892	1.78	2.68	3.57	4.46	5.35	6.24	6.69
8B	0.905	1.81	3.62	5.43	7.24	9.05	10.9	12.7	13.6
9B	0.932	1.86	3.73	5.59	7.46	9.32	11.2	13	14
10B	0.334	0.668	1.34	2	2.67	3.34	4.01	4.68	5.01
11B	0.681	1.36	2.72	4.09	5.45	6.81	8.17	9.53	10.2
12B	0.502	1	2.01	3.01	4.02	5.02	6.02	7.03	7.53
13B	1.04	2.08	4.16	6.24	8.32	10.4	12.5	14.6	15.6
14B	2.05	4.09	8.18	12.3	16.4	20.5	24.5	28.6	30.7
15B	1.81	3.62	7.23	10.9	14.5	18.1	21.7	25.3	27.1
16B	0.935	1.87	3.74	5.61	7.48	9.35	11.2	13.1	14
17B	2.04	4.09	8.17	12.3	16.3	20.4	24.5	28.6	30.7
18B	0.864	1.73	3.46	5.18	6.91	8.64	10.4	12.1	13
19B	34.5	69.1	138	207	276	345	414	484	518
20B	30.6	61.1	122	183	244	306	367	428	458
23B	3.72	7.45	14.9	22.3	29.8	37.2	44.7	52.1	55.8
24B	0.335	0.669	1.34	2.01	2.68	3.35	4.02	4.68	5.02
25B	0.671	1.34	2.68	4.03	5.37	6.71	8.05	9.4	10.1
26B	1.03	2.05	4.1	6.15	8.2	10.3	12.3	14.4	15.4
27B	0.418	0.837	1.67	2.51	3.35	4.18	5.02	5.86	6.28

Screening benchmark = 100 µg/L

Table 2: Draft Predicted Discharge Water Quality Results
Esquimalt Graving Dock Waterlot Remediation Project

Dredge Unit:	Predicted Discharge Water Dissolved Concentrations (µg/L) for Zinc (based on maximum observed dissolved fraction - 58% - in DRET testing)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
1	0.327	0.655	1.31	1.96	2.62	3.27	3.93	4.58	4.91
2	0.262	0.523	1.04	1.57	2.09	2.62	3.14	3.66	3.92
3	0.615	1.22	2.45	3.68	4.91	6.15	7.37	8.58	9.22
4	0.097	0.194	0.388	0.580	0.777	0.969	1.17	1.36	1.46
5	0.394	0.789	1.58	2.37	3.15	3.94	4.73	5.52	5.92
6	0.378	0.754	1.51	2.26	3.02	3.78	4.53	5.28	5.66
7	0.282	0.563	1.13	1.69	2.25	2.82	3.38	3.94	4.22
8	1.95	3.90	7.77	11.7	15.6	19.5	23.4	27.3	29.2
9	1.06	2.11	4.22	6.32	8.47	10.6	12.6	14.8	15.8
10	0.847	1.69	3.39	5.09	6.79	8.47	10.2	11.9	12.7
11	0.473	0.945	1.89	2.84	3.78	4.73	5.67	6.61	7.08
12	0.206	0.412	0.824	1.24	1.65	2.06	2.48	2.89	3.09
13	0.365	0.731	1.46	2.19	2.92	3.65	4.38	5.10	5.47
14	0.806	1.61	3.22	4.84	6.44	8.06	9.69	11.3	12.1
15	0.221	0.442	0.882	1.33	1.77	2.21	2.65	3.09	3.32
16	0.431	0.864	1.72	2.59	3.45	4.31	5.17	6.03	6.44
17	0.235	0.470	0.940	1.41	1.88	2.35	2.82	3.29	3.53
18	0.456	0.911	1.83	2.74	3.65	4.56	5.48	6.38	6.84
19	3.07	6.15	12.2	18.4	24.5	30.7	36.8	42.9	46.0
20	0.644	1.29	2.57	3.86	5.14	6.44	7.71	8.99	9.63
21	10.9	21.8	43.7	65.5	87.6	109	131	153	164
22	6.84	13.7	27.5	41.2	55.0	68.4	82.4	96.3	103
23	0.754	1.51	3.02	4.54	6.03	7.54	9.05	10.6	11.3
24	0.375	0.748	1.50	2.25	3.00	3.75	4.50	5.25	5.63
25	0.470	0.940	1.88	2.82	3.76	4.70	5.64	6.61	7.08
26	1.44	2.88	5.75	8.64	11.5	14.4	17.3	20.1	21.6
27	1.47	2.93	5.86	8.82	11.7	14.7	17.6	20.5	22.0
28	1.54	3.07	6.15	9.22	12.3	15.4	18.4	21.5	23.0
29	4.45	8.93	17.8	26.7	35.6	44.5	53.5	62.6	66.7
30	0.603	1.206	2.41	3.61	4.82	6.03	7.25	8.41	9.05
31	1.11	2.22	4.45	6.67	8.87	11.1	13.3	15.5	16.7
32	0.824	1.65	3.29	4.94	6.55	8.24	9.86	11.5	12.4
34	3.85	7.71	15.4	23.1	30.8	38.5	46.2	53.9	57.7
35	1.50	3.00	5.97	8.99	12.0	15.0	18.0	21.0	22.5
36	1.04	2.08	4.15	6.21	8.29	10.4	12.5	14.5	15.5
38	2.48	4.96	9.92	14.9	19.8	24.8	29.8	34.7	37.2
39	5.67	11.3	22.7	34.0	45.4	56.7	67.9	79.5	85.3
40	2.97	5.92	11.9	17.8	23.8	29.7	35.7	41.6	44.5
41	1.37	2.74	5.49	8.24	11.0	13.7	16.5	19.2	20.6
42	0.742	1.48	2.97	4.45	5.92	7.42	8.87	10.4	11.1
43	2.37	4.73	9.45	14.2	19.0	23.7	28.4	33.2	35.5
44	4.32	8.64	17.3	25.9	34.6	43.2	51.9	60.3	65.0
45	3.35	6.67	13.4	20.1	26.7	33.5	40.1	46.8	50.2
46	3.35	6.67	13.4	20.1	26.8	33.5	40.1	46.9	50.2
48	1.60	3.20	6.38	9.63	12.8	16.0	19.2	22.4	24.0
49	12.6	25.2	50.3	75.4	101	126	151	176	189
50	5.92	11.8	23.6	35.4	47.2	59.2	70.8	82.4	88.7
51	0.444	0.887	1.77	2.67	3.56	4.44	5.33	6.21	6.67
52	0.379	0.760	1.51	2.27	3.03	3.79	4.55	5.31	5.69
53	0.916	1.84	3.68	5.51	7.37	9.16	11.0	12.9	13.8
54	0.771	1.54	3.08	4.62	6.15	7.71	9.22	10.8	11.5
55	3.96	7.95	15.8	23.8	31.7	39.6	47.6	55.4	59.2
56	0.229	0.457	0.916	1.37	1.83	2.29	2.74	3.20	3.43
57	0.216	0.432	0.864	1.30	1.73	2.16	2.59	3.03	3.24
1B	0.096	0.193	0.385	0.578	0.771	0.963	1.15	1.35	1.44
2B	0.088	0.175	0.350	0.525	0.702	0.876	1.05	1.22	1.31
3B	0.360	0.719	1.44	2.16	2.88	3.60	4.32	5.03	5.39
4B	0.260	0.519	1.04	1.56	2.08	2.60	3.11	3.64	3.89
5B	0.284	0.568	1.14	1.71	2.27	2.84	3.41	3.98	4.26
6B	0.244	0.488	0.974	1.46	1.95	2.44	2.92	3.42	3.66
7B	0.259	0.517	1.03	1.55	2.07	2.59	3.10	3.62	3.88
8B	0.525	1.05	2.10	3.15	4.20	5.25	6.32	7.37	7.89
9B	0.541	1.08	2.16	3.24	4.33	5.41	6.50	7.54	8.12
10B	0.194	0.387	0.777	1.16	1.55	1.94	2.33	2.71	2.91
11B	0.395	0.789	1.58	2.37	3.16	3.95	4.74	5.53	5.92
12B	0.291	0.580	1.17	1.75	2.33	2.91	3.49	4.08	4.37
13B	0.603	1.21	2.41	3.62	4.83	6.03	7.25	8.47	9.05
14B	1.19	2.37	4.74	7.13	9.51	11.9	14.2	16.6	17.8
15B	1.05	2.10	4.19	6.32	8.41	10.5	12.6	14.7	15.7
16B	0.542	1.08	2.17	3.25	4.34	5.42	6.50	7.60	8.12
17B	1.18	2.37	4.74	7.13	9.45	11.8	14.2	16.6	17.8
18B	0.501	1.00	2.01	3.00	4.01	5.01	6.03	7.02	7.54
19B	20.0	40.1	80.0	120	160	200	240	281	300
20B	17.7	35.4	70.8	106	142	177	213	248	266
23B	2.16	4.32	8.64	12.9	17.3	21.6	25.9	30.2	32.4
24B	0.194	0.388	0.777	1.17	1.55	1.94	2.33	2.71	2.91
25B	0.389	0.777	1.55	2.34	3.11	3.89	4.67	5.45	5.86
26B	0.597	1.19	2.38	3.57	4.76	5.97	7.13	8.35	8.93
27B	0.242	0.485	0.969	1.46	1.94	2.42	2.91	3.40	3.64

Screening benchmark = 100 µg/L