OPI Project File #: CSRP: N.000159.03 – F/GOP: N.000159.02

Base File #: 0103E 1262-1 (RDIMS #217827)

DGIEGPS EED File #:2016-21-005264

Department of National Defence (DND)

Environmental Effects Determination (EED) Report

Project: F/G Jetty Optimization Project and Colwood South Remediation Project

Prepared by: Golder Associates Ltd.

Date: July 7, 2016

Version: Final

Golder Reference No: 1657898-006-R-Rev0

OPI Project File #: CSRP: N.000159.03 – F/GOP: N.000159.02

Base File #: 0103E 1262-1 (RDIMS #217827)

DGIEGPS EED File #:2016-21-005264

Executive Summary

On behalf of Public Works and Government Services Canada (PWGSC) and Department of Defence (DND), Golder Associates Ltd. (Golder) prepared this Environmental Effects Determination (EED) Report for the Colwood South Remediation Project (CSRP) and the F/G Jetty Optimization Project (FGOP) located within the DND and CFB Esquimalt Waterlots in Esquimalt Harbour, BC. The EED report consists of a review of the potential environmental effects for the CSRP and FGOP, pursuant to Section 67 of the *Canadian Environmental Assessment Act, 2012*.

The objective of the two projects is to remediate historically contaminated sediments around existing infrastructure. The projects consist of the following components:

- Mobilization and demobilization;
- Structure removal, relocation and reinstatement;
- Dredging and residuals management;
- Barge dewatering;
- In-water transportation;
- Offloading, stockpiling, processing and potential treatment of contaminated sediment;
- Upland transportation and disposal; and
- Backfill and material placement.

Potential environmental effects of the projects on valued ecosystem components (VECs) were assessed and mitigation measures have been identified to minimize or eliminate these effects. Mitigation measures developed for the projects include:

- Preparation and implementation of an Environmental Management Plan (EMP), including a Water Quality Monitoring Plan (WQMP), outlining environmental construction requirements and providing guidelines for protection of VECs during the projects.
- Development of an Environmental Protection Plan (EPP) by the Contractor outlining measures to achieve environmental protection objectives identified in the EMP.
- Environmental monitoring by a qualified environmental monitor (EM) to oversee and report on the effectiveness of mitigation measures identified in this EED and to perform the following monitoring tasks:
    - Monitoring of water quality parameters (e.g. turbidity) as required to document compliance with regulatory requirements and mitigation measures outlined in the WQMP;
    - Monitoring of osprey and marine mammals, and other environmental monitoring (e.g., H_2S monitoring), if or as required to reduce potential adverse effects from project activities; and
    - Providing recommendations to the Departmental Representative if project activities contravene mitigation measures recommended in this EED, the terms and conditions of environmental permits and approvals, and/or existing legislative and regulatory requirements.
- Mitigation measures outlined in the archaeological overview assessment (AOA) at D Jetty and F/G Jetty and the subsequent archaeological impact assessment (AIA) at F/G Jetty will be implemented. If suspected archaeological deposits are discovered, project activities will be halted until further review can be conducted.

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There are several Aboriginal groups with interests that extend into the CSRP and FGOP areas, including from the Esquimalt Nation and Songhees Nation whose Reserve lands are located along the east shore of Esquimalt Harbour. Other Aboriginal groups with potential interests include member First Nations of the Te'mexw Treaty Association and the Hul'qumi'num Treaty Group, as well as the Métis Nation British Columbia and the Métis Nation of Greater Victoria. The DND has engaged with the Esquimalt Nation and Songhees Nation, making separate presentations on Esquimalt Harbour projects including the CSRP and FGOP to both Chief and Councils. First Nations have expressed considerable support for the Project, however, principal concerns raised by these First Nations include the implications of Health Canada's Seafood Consumption Advisory for the consumption of traditional foodstuffs; continuing access to the Esquimalt Harbour to harvest traditional resources and conduct other traditional activities; protection of archaeological sites; effects of proposed remediation activities on uncontaminated areas elsewhere in the Esquimalt Harbour; and economic opportunities for the First Nation and Aboriginal businesses from this Project.

On the basis of this EED report, it has been determined that the project is not likely to cause significant adverse environmental effects with application of mitigation measures specified in this report.

OPI Project File #: CSRP: N.000159.03 – F/GOP: N.000159.02

Base File #: 0103E 1262-1 (RDIMS #217827)

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List of Acronyms and Abbreviations

AIA .... archeological impact assessment
AOA .... archeological overview assessment
Anchor .... Anchor QEA L.L.C
CCME .... Canadian Council of Ministers of the Environment
CD .... chart datum
CDC .... British Columbia Conservation Data Centre
CEAA, 2012 .... *Canadian Environmental Assessment Act, 2012*
CFB .... Canadian Forces Base
COPC .... contaminant of potential concern
COSEWIC .... Committee on the Status of Endangered Wildlife in Canada
CRD .... Capital Regional District
CRIS .... Coastal Resources Information System
CSRP .... Colwood South Remediation Project
DCC .... Defence Construction Canada
DCPD .... Directorate of Construction Project Delivery
DFO .... Fisheries and Oceans Canada
DND .... Department of National Defence
EED .... environmental effects determination
EGD .... Esquimalt Graving Dock
EHRP .... Esquimalt Harbour Remediation Program

FGOP.. F/G Jetty Optimization Project
HCA ....*Heritage Conservation Act*
HHW .... higher high water
HHRA.. human health risk assessment
LLW.. lower low water
PAH.. polycyclic aromatic hydrocarbons
PCBs..polychlorinated biphenyls
PEL .... probable effects level
PWGSC ....Public Works and Government Services Canada
QHM..Queen’s Harbour Master
SARA ....*Species at Risk Act*
SQG ....sediment quality guideline
SL...shell length
SLR .... Consulting Ltd.
SMA .... sediment management area
TBT ....tributyltin
TEK .... traditional ecological knowledge
TSS .... total suspended solids
VEC.. valued ecosystem component
WQG .... water quality guideline

List of Units

°C .... degrees Celsius
km .... kilometre
m .... metres
m^2..metres squared
NTU.. nephelometric turbidity units

OPI Project File #: CSRP: N.000159.03 – F/GOP: N.000159.02

Base File #: 0103E 1262-1 (RDIMS #217827)

DGIEGPS EED File #:2016-21-005264

Part 1. Project Information

1.1 Title of Proposed Project

F/G Jetty Optimization Project (FGOP) and Colwood South Remediation Project (CSRP) - Project No. R.079731.001, CFB Esquimalt, British Columbia (BC)

1.2 Originating Directorate, Base, or Unit

Formation Safety and Environment (FSE)
Department of National Defence (DND)
Canadian Forces Base (CFB) Esquimalt

1.3 Location of Proposed Project

The proposed projects are located on the west shore of Esquimalt Harbour at DND Colwood (Figure 1). The CSRP is located at approximately 48°26’22”N, 123°26'50"W. The FGOP is located between F Jetty and G Jetty at approximately 48°26'34"N, 123°27'1"W.

An offloading area for the dredged sediment has not been determined at this point. Five potential offloading sites include Plumper Bay in Esquimalt Harbour, Victoria Harbour, Beecher Bay (near Sooke, BC) and Sumas (near Abbotsford, BC) in Canada as well as an offloading site in Seattle, Washington in the United States.

KEY MAP

LEGEND

REMEDIATION FOOTPRINT

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING: DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

0 250 500

1:10,000 METRES

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	J. SHERRIN
PREPARED	S. BIRDSELL
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
KEY PLAN

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	1

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1.4 Project Summary

DND, which administers Esquimalt Harbour, is implementing a remediation and risk management program in Esquimalt Harbour as part of a long-term strategy to address sediments that have been contaminated by historical industrial activities in the harbour. As a result of historical activities in Esquimalt Harbour, areas of sediment contamination exceeding the Canadian Council of Ministers of the Environment (CCME) probable effects level (PEL) sediment quality guidelines (SQGs) are present within the D Jetty and F/G Jetty Project Areas (CCME 1999). The primary contaminants of potential concern (COPCs) resulting from historical activities in the harbour include arsenic, copper, lead, zinc, mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, furans and organochlorine pesticides. Tributyl tin (TBT) may also be present; however, it is not a driver for the remediation.

A Fisheries Notice (FN0807) Consumption Advisory for Esquimalt Harbour (Area 19), dated October 9, 2009, recommended limiting consumption of Dungeness crab (*Metacarcinus magister*), red rock crab (*Cancer productus*), sea urchin (*Strongylocentrotus* spp.) roe and rockfish (*Sebastes* spp.) harvested from Esquimalt Harbour by sports fishers and subsistence populations, due to the presence of contaminants in marine sediments. A draft Human Health Risk Assessment (HHRA) for Esquimalt Harbour also identified a potential risk to Esquimalt Nation and Songhees Nation individuals from consumption of clams (class Bivalvia), mussels (*Mytilus* spp.) and shrimp (infraorder Caridae) (SLR 2010). DFO has enacted a permanent prohibited area (no harvesting for any purpose) on the basis of a sanitary closure, for any and all bivalve fishing within DFO *management subarea 19-2 – Esquimalt Harbour* (DFO 2016d).

Public Works and Government Services Canada (PWGSC) and DND are proceeding with remedial activities in the vicinity of F/G Jetty as part of the F/G Jetty Optimization Project (FGOP), and in the vicinity of D Jetty as part of the Colwood South Remediation Project (CSRP). The FGOP and CSRP are being tendered together in a combined tender package but are considered as two separate projects for the purposes of this EED. Remediation activities are also proposed for other areas of Esquimalt Harbour including areas around A and B Jetties (A/B Jetty), C Jetty, ML Floats, Y Jetty, and Lang Cove. Environmental effects determinations for these locations are being prepared separately from the FGOP and CSRP.

Preliminary target areas for remedial dredging were developed by Anchor QEA L.L.C (Anchor) based on the implementation of remediation and risk management of sediment contamination at five remediation sites (Anchor 2013). F/G Jetty (F/G Jetty Optimization Project (FGOP)) and D Jetty (Colwood South Remediation Project (CSRP)) represent two of the five sites identified by Anchor.

The remediation and risk management of sediment contamination for the CSRP and FGOP are the focus of this EED. Sources of historical contamination in the general vicinity of the CSRP and FGOP include (Anchor 2016a):

- On-land storage and transmission of fuels to F Jetty;
- Major leaks from pipelines, including a discharge from F Jetty into the harbour (1988 – 1990);
- Transmission of oily water from F Jetty, and subsequent on-land storage and treatment of wastewater;
- Ship fueling activities at F Jetty and at old Gas Float between F Jetty and G Jetty, which may have impacted the marine environment;

- Sand blasting activities at D Jetty and disposal of sand blast residues both on land and to the marine environment; and
- Typical vessel cleaning and berthing activities at D Jetty, including vessel cleaning and material jettisoned into the harbour.

The remediation of this historical contamination will be achieved through a combination of dredging and backfill and material placement to manage residual sources.

1.5 Project Alternatives

No alternatives to the projects are being considered at this stage of the design process.

1.6 Applicability of *CEAA, 2012*

Subsection 4(2) of the *Canadian Environmental Assessment Act, 2012* (S.C. 2012; *CEAA 2012*) states that “The Government of Canada, the Minister or Agency, federal authorities and responsible authorities, in the administration of this *Act*, must exercise their powers in a manner that protects the environment and human health and applies the precautionary principal.” A “project” defined under section 66 of *CEAA, 2012* that is carried out on federal lands or outside Canada or to be carried out or financially supported by a federal authority is considered in a careful and precautionary manner to avoid significant adverse environmental effects.

The remedial activities described in this report are physical activities to be carried out in Canada on federal lands and meets the definition of a project under Section 66 of the *CEAA, 2012.* Therefore, this EED fulfills a federal requirement under Section 67/68 in determining whether carrying out the projects are not likely to cause significant adverse effects before the projects can proceed.

1.7 EED Start Date

The EED for this Project commenced on May 30, 2016.

1.8 DGIEGPS EED number

2016-21-005264

1.9 Provincial and Municipal Government Involvement

The Projects are within the Federal harbour limits of Esquimalt Harbour and therefore neither Provincial nor Municipal government involvement is required for the actual dredging activity.

Provincial requirements under the *Environmental Management Act* may apply to the handling, treatment and disposal of contaminated dredged material transported outside of Esquimalt Harbour.

Municipal noise and nuisance bylaws may be applicable at the boundary between CFB Esquimalt and applicable municipalities (Township of Esquimalt, City of Colwood and Town of View Royal), for example:

- The Bylaw to Regulate Noise within the City of Colwood (Bylaw No. 38) (2001).
- The Township of Esquimalt (ToE) Property, Unsightly Properties and Nuisance Bylaw No. 2826 (2014).
- The City of Colwood Nuisance Controlled Substance Bylaw No. 851 (2006).
- The Town of View Royal Noise Bylaw No. 523 (2003).

Street and traffic regulation bylaws may also apply if dredged material is transported overland by truck to the disposal location, for example:

- City of Colwood Traffic and Highway Regulation Bylaw No. 1134.
- Township of Esquimalt Streets and Traffic Regulation Bylaw No. 2607 (2005).

1.10 Other Federal Departments

A Request for Review will be sent to Fisheries and Oceans Canada for their review of the potential for serious harm to fish to occur, pursuant the *Fisheries Act*.

A Notice of Works under the *Navigation Protection Act* will be submitted to Transport Canada.

1.11 Contacts

1.11.1 EED Point of Contact

a) Name, Rank, and Title: Tracy Cornforth – Environment Officer
b) E-mail Address: Tracy.Cornforth@forces.gc.ca

1.11.2 Project OPI

a) Name, Rank, and Title: Duane Freeman, Formation Environment Officer
b) E-mail Address: Duane.Freeman@forces.gc.ca

Part 2. Environmental Effects Discussion

2.1 Description of Project Components and Project Sites

The following project components are proposed for both the CSRP and FGOP:

- Mobilization and demobilization;
- Structure removal, relocation and reinstatement;
- Dredging and residuals management;
- Barge dewatering;
- In-water transportation;
- Offloading, stockpiling, processing and potential treatment of contaminated sediment;
- Upland transportation and disposal; and
- Backfill and material placement.

Specific details for each of the project components based on the Anchor QEA L.L.C. (Anchor) draft 100% design specifications (Anchor 2016a) are outlined in Table 1 below.

Table 1. Description of Project Components for the CSRP and FGOP

Project Component	CSRP	FGOP
Mobilization and demobilization	• Establishment of site offices, storage and other temporary facilities at on-site upland staging areas for both the CSRP and FGOP. The on-site upland staging areas made available to the contractor are to be used for parking, office space, equipment staging, and loading/unloading purposes only. No stockpiling or storage of dredged sediment or debris will occur at the on-site upland staging areas without written approval from the Departmental Representative. • Preparation of an off-site upland offload facility which will be identified by the contractor. • Dismantling and removal of all temporary facilities, and the cleanup of the on-site upland staging areas and the contractor off-site offload facility.	
Structure removal, relocation and reinstatement	• Removal and relocation of timber fender piles and corner dolphin piles will occur along the north berth of D Jetty. The site for temporary relocation of structures to be removed is to be determined. • Timber fender piles will be removed using vibratory methods. If vibratory methods are not used, an alternative similar method will be submitted to the Departmental Representative for review. • After extraction, sediment, marine invertebrates and other objects that are attached to the surface of the piles will be cleaned off inside of a silt curtain in the footprint of the dredge unit prior to dredging. • All structures will be reinstated in their existing locations and conditions unless the timber piling is damaged upon removal, in which case new treated timber replacement piles (or similar) will be installed. • Pile driving will be carried out using marine-based floating equipment. Vibratory pile driving is the proposed method for pile driving, if vibratory pile driving is not used, an alternative equivalent method will be submitted to the Departmental Representative for review.	• Removal and relocation of gas float and pivot ramp will occur to allow for dredging within its footprint. Temporary relocation site is to be determined. • Demolishing and disposal off site, or salvaging, storing, recycling, and/or re-use in the work for the miscellaneous designated jetty attachments and electrical utilities will occur as part of this work. • Demolition of existing gas float structures, timber pilings, and the disposal of debris arising from such demolition will occur as part of this work if materials were not suitable for reuse. • Timber piles will be removed using vibratory methods. If vibratory methods are not used, an alternative equivalent method will be submitted to the Departmental Representative for review. • After extraction, sediment, attached biota and other objects that are attached to the surface of the piles will be cleaned off inside of a silt curtain in the footprint of the dredge unit prior to dredging. • All structures will be reinstated in their existing locations and conditions unless the timber piling is damaged upon removal at which point new treated timber replacement piles (or equivalent) will be installed. • An estimate of up to four of eight piles may require replacement due to damage during extraction and/or excessive degradation observed upon removal. The piling will be stored at the Off-Site Offload Facility, on a barge at an Owner-approved location, or at an alternative location. • Pile driving will be carried out using marine-based floating equipment. Vibratory pile driving is the proposed method for pile installation, if vibratory pile driving is not used, an alternative equivalent method will be submitted to the Departmental Representative for review.
Dredging and residuals management	• Approximately 7,700 m^2 of sediment with a volume of 14,300 m^3 is proposed to be dredged around D Jetty. • Dredging will occur to remove contaminated sediments and potential re-dredging may occur to remove residuals or missed contaminated materials. • No dredging will occur under D Jetty, and a dredge offset area around the jetty will be established. • Mechanical dredging will be undertaken using a bucket type and size of the Contractor’s choosing (provided that water quality requirements of the EMP and permit conditions are met). • Dredged material and debris will be placed on a barge for transport. • A silt curtain will be used around the dredge area.	• Approximately 5,600 m^2 of sediment with a volume of 10,100 m^3 is proposed to be dredged between F and G Jetties. • Dredging will occur to remove contaminated sediments and potential re-dredging may occur to remove residuals or missed contaminated materials. • Mechanical dredging will be undertaken using a bucket type and size of the Contractor’s choosing (provided that water quality requirements of the EMP are met). • Dredged material and debris will be placed on a barge for transport. • A silt curtain will be used around the dredge area.

<table>
<tr><th>Project Component</th><th>CSRP</th><th>FGOP</th></tr>
<tr><td rowspan="2">Barge dewatering</td><td>• Passive dewatering of dredged sediment on the material barge will not be allowed for sediment from Dredge Units 4 and 5 on the north side of D Jetty.
• Passive dewatering of dredged sediment on the material barge at the Work Site will occur for the remaining parts of D Jetty, using filter media (such as filter fabric) to remove suspended solids from any barge effluent discharge, in a manner that is compliant with the water quality performance objectives presented in the Specifications and EMP.</td><td>• Passive dewatering of dredged sediment on the material barge at the Work Site will occur at F/G Jetty, using filter media (such as filter fabric) to remove suspended solids from any barge effluent discharge, in a manner that is compliant with the water quality performance objectives presented in the Specifications and EMP.</td></tr>
<tr><td colspan="2">• Passive dewatering of dredged sediment on the material barge at the Work Site will occur at F/G Jetty and parts of D Jetty, using filter media (such as filter fabric) to remove suspended solids from any barge effluent discharge, in a manner that is compliant with the water quality performance objectives presented in the Specifications and EMP.
• Barge dewatering will not be not allowed during in-water barge transportation of dredged sediment and debris from the D Jetty and F/G Jetty Work Sites to the Contractor Off-Site Offload Facility.
• The Contractor will collect, store, treat as necessary, and discharge or dispose of effluent from barges in such a manner that meets the water quality performance objectives described in the design specifications and all requirements of the EMP.
• The Contractor may propose to mix additives with the waste to bind available water during offloading, stockpiling, or dewatering activities; however, the Contractor is responsible for determining whether additives will be used and whether the Disposal Facility will accept the contaminated sediment with additives for disposal.</td></tr>
<tr><td>In-water transportation</td><td colspan="2">• All contaminated materials will be transported from dredge areas using waterborne equipment (i.e. barges). No passive barge dewatering is allowed during in-water transportation; therefore, the haul barge must be made watertight prior to in-water transportation to the contractor's off-site offload facility.</td></tr>
<tr><td>Offloading, stockpiling, processing and potential treatment of contaminated sediment</td><td colspan="2">• Dredged sediments and debris will be offloaded at an off-site offload facility determined by the contractor. As per the design specifications, the contractor off-site offload facility will be operated in compliance with all laws and regulations and have in place all necessary federal, provincial or state, and local permits and approvals for work activities anticipated to occur at the facility.
• It is expected that the offloading will occur directly from the material barge onto a staging area within the contractor off-site offload facility, where material will be processed.
• Dredged sediment will be processed at a processing facility at the contractor off-site offload facility to segregate suspected explosive items and explosives of concern and to monitor for antiquities.
• Processed sediment has the potential to be reloaded onto a barge and be shipped to a different upland area for disposal.
• Upland equipment decontamination primarily applies to activities that will be completed at the contractor off-site offload facility. Decontamination of equipment will occur after working in potentially contaminated work areas and prior to subsequent work or travel on clean areas.</td></tr>
<tr><td>Upland transportation and disposal</td><td colspan="2">• Upland transportation will either be by truck or rail for disposal.
• The location of the off-site disposal facility is to be determined.</td></tr>
<tr><td>Backfill and material placement</td><td>• Following completion of all dredging, the Contractor will place backfill and cover material.
• Structural Backfill Type A (well-graded base course 75 mm) will be placed along the north berth of D Jetty. Structural Backfill Type A will be placed prior to reinstatement of the fender system.
• Structural Backfill Type B (blend of open grade base 75 mm and quarry spalls) will be placed along the east berth of D Jetty.
• Underpier Cover (well-graded base course 75 mm) will be placed in underpier areas along the north berth of D Jetty.
• Residuals Management Cover (clean, fine-grained material as similar in nature to the native sediment) will be placed at D Jetty as directed by the Departmental Representative based on the results of the post-dredge confirmatory sampling.
• Chemical testing of backfill material is required per Anchor's specifications.to assess the ARD/ML potential of the materials as this can negatively affect water quality</td><td>• Following completion of all dredging activities, the Contractor will place backfill material.
• Structural Backfill Type A (well-graded base course 75 mm) will be placed at the gas float structure area. Structural Backfill Type A will be placed prior to reinstatement of the gas float structures.
• General Backfill (granular sub-base) will be placed in a portion of the F/G Jetty dredge area.
• Residuals Management Cover (clean, fine-grained material as similar in nature to the native sediment) will be placed in the F/G Jetty dredge area.
• Backfill will be placed in areas to restore the seabed elevation to the pre-dredge condition bed elevations.
• Chemical testing of backfill material is required to assess the ARD/ML potential of the materials as this can negatively affect water quality as per Anchor's specifications.</td></tr>
</table>

Notes: ARD/ML – acid rock drainage/metal leaching; CSRP – Colwood South Remediation Project; EMP – environmental management plan; FGOP – F/G Jetty Optimization Project.

Upland on-site staging areas, dredge areas and backfill and material placement areas for the CSRP and FGOP are depicted in Figure 2. The location/route of several components are to be determined including:

- Structure relocation area(s);
- In-water transportation route;
- Offloading, stockpiling, and potential treatment facility locations;
- Upland transportation route; and
- Disposal facility location.

Five potential offloading sites include Plumper Bay in Esquimalt Harbour, Victoria Harbour, Beecher Bay (near Sooke, BC) and Sumas (near Abbotsford, BC) in Canada as well as an offloading site in Seattle, Washington in the United States.

LEGEND

REMEDIATION FOOTPRINT

ON-SITE UPLAND STAGING AREA

NOTE(S)

1. SURFACE CONTOURS SHOWN IN 1 m (MINOR) AND 5 m (MAJOR) INTERVALS. ELEVATIONS SHOWN RELATIVE TO CHART DATUM.

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING "DFG Remediation Areas_20160630.dwg."
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
3. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE. ACCESSED 2016-03-03.
   3.1. BATHYMETRY: FILENAME: "COLWOOD_15031.TIF". THE SURFACE WAS USED AS-IS.
   3.2. UPLAND: FILENAME: "COL_ENV.DWG" SURFACE CONTOURS ADJUSTED TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.

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1:500 METRES

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	J. SHERRIN
PREPARED	S. BIRDSELL
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
SITE PLAN

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	2

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25 mm

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2.1.2 Project Schedule

The CSRP and FGOP will be carried out at the same time by the same contractor. The projects are proposed to start in mid-November 2016 and be substantially completed by March 31, 2017. Some work may need to be done between March 31 and May 1, 2017. A 12-hour work day and a six-day work week is proposed.

2.1.3 Timing Windows

The Project Areas are located in DFO *Management Subarea 19-2 – Esquimalt Harbour*, for which the marine/estuarine timing windows are as follows (DFO 2014):

- Summer Window: July 1 – October 1.
- Winter Window: December 1 – February 15.

Work windows are intended to provide windows of least risk to sensitive fisheries resources that may use the area. For example, salmon migrating to spawning areas may be present in October and November and spawning herring may be present from the end of February to June.

All in-water work including sediment dredging, structure removal and reinstatement, and backfill and material placement are planned to occur both inside and outside of the timing window with the application of appropriate mitigation measures, with the exception of impact pile driving of steel piles should it occur. Impact pile driving of steel piles, if it occurs, will not take place between April 1 and May 31 due to potential effects from underwater noise on fisheries resources in Esquimalt Harbour. The April 1 to May 31 time period is particularly sensitive due to the potential for herring spawning and out-migration of juvenile salmon in Esquimalt Harbour. Vibratory pile driving will still occur outside the window.

2.1 Identification of Valued Ecosystem Components (VECs)

This EED considers changes to the biophysical environment caused by the Project, as well as resultant effects on the socio-economic environment by scoping for appropriate Valued Ecosystem Components (VECs) (Table 2). For this Project, the criteria used to select VECs were based on ecological importance and/or value to the existing environment, the relative sensitivity of environmental components to Project influences and their relative social, cultural, or economic importance. Also included are components of the socio economic environment that may be affected by a change in the environment as a result of the Project. VECs for this project were chosen using the checklist below. Consideration was made for all aspects of the Project life cycle identified in the Scope of Project.

Table 2. Environmental Effects Matrix

PROJECT COMPONENTS	VALUED ECOSYSTEM COMPONENTS (VEC)															
	PHYSICAL			BIOLOGICAL						SOCIAL AND CULTURAL						
	Atmosphere	Surface Water	Substrate	Marine Vegetation	Marine Invertebrates	Fish/Fish Habitat	Aquatic Mammals	Birds	Species at Risk	Transportation	Navigation	Commercial, Recreational and First Nations Fisheries	Land and Marine Based Non-consumptive Recreation	First Nations Traditional Lands/Resources	In-Air Noise and Light and Odour	Archaeology
Mobilization and demobilization	x	x				x		x			x			x	x	
Structure removal, relocation and reinstatement	x	x	x	x	x	x	x	x	x		x	x		x	x	x
Dredging and residuals management	x	x	x	x	x	x	x	x	x		x	x		x	x	x
Barge dewatering	x	x		x	x	x		x			x			x	x	
In-water transportation	x	x				x					x			x	x	
Offloading, stockpiling, processing and potential treatment of contaminated sediment	x	x				x					x			x	x	
Upland transportation and disposal	x									x				x	x	
Backfill and material placement	x	x	x	x	x	x	x	x	x		x	x		x	x	x

Legend: [*Blank*] = No Effect **|** [X] = Potential Significant Adverse Effect

2.2 Description of Valued Ecosystem Components

Esquimalt Harbour is a sheltered body of water that covers a total area of 3.38 km^2 and occupies approximately 15 km of linear shoreline. The harbour entrance, Royal Roads passage, connects to the Strait of Juan de Fuca. The main body of Esquimalt Harbour has an average depth of 10 m below CD in open-water areas, and is deepest near the mouth of the harbour and shallowest towards Price Bay at the northern extent of the harbour. The mouth of Millstream Creek, at the northwest end of Esquimalt Harbour, is a productive estuary and mud flat, with tidal influence present for several hundred metres upstream of the shoreline of the harbour.

2.3.1 Physical Components

2.3.1.1 Atmosphere

Esquimalt Harbour lies in the Coastal Douglas Fir Biogeoclimatic Zone which experiences warm dry summers and mild wet winters (Nuszdorfer *et. al.* 1991). The daily average temperature in Victoria (Victoria Marine Station # 1018642) ranges from 4.4 to 14.3°C, while average monthly precipitation ranges from 23.2 mm in summer months to 228.4 mm in winter months (EC 2010a).

2.3.1.2 Surface Water

Surface water in Esquimalt Harbour exchanges with waters of the Strait of Juan de Fuca through the harbour entrance, Royal Roads passage, which is approximately 750 m across. The relatively wide entrance of the harbour allows the tidal regime of the harbour to match surrounding areas outside the harbour.

2.3.1.2.1 Tides/Currents

Based on Canadian Tide and Current Tables, Esquimalt Harbour’s mean tide is 1.8 m CD with a reported large tide of 3.1 m. The mean tide Higher High Water (HHW) is 2.5 m, and the large tide HHW is 3.4 m. The mean Lower Low Water (LLW) is 0.7 m, and the large tide LLW is 0.1 m (DFO 2016a).

An investigation of currents and tidal effects in the harbour was conducted in 2010 (Golder 2011a). A vessel mounted acoustic doppler current profiler was towed along five survey lines to determine current speeds and direction over an entire tidal cycle. Exchange of water through the mouth of the harbour during peak flood and ebb tidal periods resulted in depth-averaged current speeds in excess of 1 m/s near the mouth of the harbour. For most of the harbour, including the Project Areas, the measured currents were shown to be typically weak and variable in direction (Golder 2011a).

2.3.1.2.2 Water Quality

Total suspended solids (TSS) and turbidity measurements collected in Esquimalt Harbour over a two month period (October to December 2010) indicate that Esquimalt is relatively clear (i.e. turbidity was less than 6.4 NTU for 95% of the measurements collected), although turbidity spikes of up to 400 NTU may occur possibly related to vessel prop-wash and wind and wave events (Golder 2011b).

Water quality data for Esquimalt Harbour are available from surface water samples collected during multiple separate investigations between 2005 and 2014. Dissolved concentrations of mercury (SLR 2008) and tributyltin (Golder 2006a,b) exceeded CCME water quality guidelines (WQG) for the protection of aquatic life in a small number of the samples collected.

2.3.1.3 Substrate

Sub-seabed investigations were conducted around A and B Jetty as part of geotechnical and geophysical investigations for B Jetty in 2009 (Golder 2009). Based on these investigations, as well as investigation of stratigraphic sequences on the Esquimalt Graving Dock (EGD) property (Golder 2011c), it is anticipated that surficial sediments (upper 1 to 2 m) around the harbour are likely to consist mainly of surficial silt to clayey silt, typically underlain by various mixtures of sandy silt, silty sand, sand and gravelly sand. Below 1 to 2 m, sediments have been shown to consist mainly of dark grey organic silts, clayey silts, silty clays and clays, intercalated in some places with sands and gravels. Bedrock formations around the harbour undulate steeply over short distances, especially near shorelines.

There are limited sediment inputs to Esquimalt Harbour from upland areas, such as creeks and stormwater runoff; therefore, there is a low natural sediment deposition rate in Esquimalt Harbour. Migration of contaminated sediment in the harbour is primarily driven by propeller-induced re-suspension of seabed sediments resulting from vessels moving around the harbour. Once suspended in the water column, tidal and wave-driven currents cause these suspended sediments to drift within the surrounding harbour. Site-specific sediment transport studies have not been conducted in the areas being dredged; however, recontamination of remediated areas as a result of sediment suspension and migration can be a concern over the long term and is being considered as part of the remedial planning.

Detailed habitat surveys conducted by Golder in January and February 2016 collected data on intertidal and subtidal substrates within the Project Areas (Golder 2016a [Annex A]). Intertidal and subtidal substrate characteristics determined through analysis of the survey data are summarized in Table 3 and described in detail for each Project Area below. Representative photos of intertidal and subtidal substrates and associated marine organisms are provided in Appendix D (Photograph Log) of Annex A.

Table 3: Overview of Substrates within the Project Areas.

Area	Intertidal	Subtidal
D Jetty	Occupied by a man-made jetty structure.	Predominantly soft sediments with patches of mixed cobble/gravel substrate in two offshore areas. One area of boulder and riprap was identified adjacent to the D Jetty Project Area beneath the east side of the jetty.
F/G Jetty	Predominantly boulder/bedrock substrate along the southern shoreline with cobble/gravel substrate and a rocky reef at the northern extent of the survey area.	Predominantly soft sediments with nearshore areas of primarily gravel substrate. The rock wall to the south of the gasoline float extends into the subtidal zone. A subtidal boulder outcropping was identified within the northeast corner of the survey area.

Source: Balanced (2012a,b), Golder (2015; 2016a [Annex A])

F/G Jetty

Subtidal habitat within the F/G Jetty area contained a mix of soft sediment, mixed substrate and boulder/bedrock (Annex A – Figure 3). The nearshore portion of the proposed dredge boundary was characterized by intertidal bedrock, boulder and riprap substrate with three pockets of intertidal cobble, gravel and sand substrate. The intertidal area transitioned to either subtidal cobble, gravel and sand or sand, silt and mud substrate. At the northern portion of the proposed dredge boundary, subtidal sand, silt and mud substrate transitioned to cobble, gravel and sand substrate and bedrock, boulder and riprap substrate. Boulder substrate was documented nearshore, within the proposed Project Area and a rocky reef was documented near the northern extent of the F/G Project Area (Annex A – Figure 4). Shell and wood debris was observed in nearshore areas, primarily in the area of the gasoline float and approach structure (Balanced 2012a; Golder 2016a).

D Jetty

Subtidal habitat within the D Jetty area consisted of soft sediment with areas of mixed coarse substrate (Anchor 2016b, Anchor 2016c, Klohn Crippen Berger 2016; Golder 2016a); boulder substrate was observed outside but adjacent to the D Jetty Project Area along the D Jetty wall (Annex A – Figure 3). The area under the jetty was primarily composed of subtidal cobble, gravel and sand substrate which continued from the jetty in some patches and transitioned to subtidal sand, silt and mud substrate further offshore. Shell and wood debris were abundant in a few small patches (<5 m^2) throughout the survey area. Anthropogenic debris (e.g. metal, rope) was observed near the jetty within the survey area (Golder 2016a).

2.3.2 Biological Components

2.3.2.1 Marine Vegetation (Macroalgae and Eelgrass)

Habitat surveys conducted by Golder in January and February 2016 identified an overall low abundance and diversity of macroalgae throughout the F/G Jetty and D Jetty Project Areas (Annex A – Figure 3). The greatest abundance and diversity of macroalgae was typically observed on hard substrates (boulder/bedrock/riprap) with lower diversity and abundance on soft (sand/shell/mud) and mixed (cobble/gravel/sand) substrates (Golder 2016a [Annex A]). Macroalgae are generally more productive during the spring and summer seasons than during the winter and these surveys may not have captured the full extent of macroalgae abundance and distribution. Habitat surveys conducted by Balanced (2012a,b) in October 2012 observed a similar pattern of macroalgae distribution, with greater diversity of macroalgae on hard substrates than on soft substrates; however the surveys were qualitative in nature and did not estimate the abundance of macroalgae. Surveys conducted by Archipelago (2004) in March, May and June of 2000 estimated less than 10% of Esquimalt Harbour contained moderate or dense marine vegetation with many of these areas located near the entrance to Esquimalt Harbour.

Sensitive marine vegetation habitats with the potential to occur within the Project Areas include bull kelp (*Nereocystis luetkeana*) and eelgrass (*Zostera marina*). Bull kelp plays an important role in the life histories of fish and other marine species and has been documented in the vicinity of the Project Areas to the south of D Jetty and to the east of F/G Jetty (CRD 2010). Eelgrass (*Zostera marina*) is considered a valued and sensitive ecosystem component as eelgrass beds provide shelter and rearing habitat for important coastal fish and invertebrate species such as salmon (*Oncorhynchus* spp.), Dungeness crab, and Pacific herring (*Clupea pallasii*).

Eelgrass beds are particularly sensitive to development activities which result in increased levels of shading and sedimentation. Eelgrass has been previously documented approximately 500 m to the north of F/G Jetty (CRD 2010) and to the west of Grant Knoll which lies adjacent to the southwest corner of A Jetty, approximately 1 km to the southeast of D Jetty (Archipelago 2010).

A summary of the abundance and distribution of macroalgae observed within each Project Area during habitat surveys in 2016 is provided below; greater detail is provided in Annex A. In general, observations of macroalgae during the habitat surveys in 2016 align with information previously reported in the CRD Harbours Atlas (2010).

F/G Jetty

Branched, foliose and filamentous red algae were the dominant taxa (0 to 25% areal cover) on hard substrates at F/G Jetty. Other macroalgae observed at relatively low density included Japanese weed (*Sargassum* sp.), sea lettuce (*Ulva* sp.) and encrusting coralline algae (Golder 2016a [Annex A]). The dominant taxa within the intertidal zone at F/G Jetty is rockweed (*Fucus* sp.) which occurs at 25 to 50% areal cover (Golder 2016a [Annex A]). Other taxa documented included red branched algae, rusty rock (*Hildenbrandia* sp.) and sea lettuce.

The dominant macroalgae taxon observed on mixed and soft sediment substrates at F/G Jetty was brown bladed kelp (*Laminaria* sp.) with low cover (0 to 5% areal cover). Other algae species were not observed on mixed and soft sediment substrates within the F/G Jetty area (Golder 2016a [Annex A]).

No evidence of canopy-forming kelps (e.g. bull kelp) or eelgrass was found within the F/G Jetty Project Area during the habitat surveys in February 2016 (Golder 2016a [Annex A]) or October 2012 (Balanced 2012a). It is unlikely that kelp and eelgrass documented outside the F/G Jetty Project Area will be negatively affected by Project activities.

D Jetty

Red filamentous algae (*Gracilaria* sp.) was the dominant taxa (0 to 25% areal cover) occurring in patches in mixed substrate and soft sediment habitats at D Jetty (Golder 2016a [Annex A]). A few small patches of filamentous brown algae were also documented. Other algae species were not observed in mixed substrate and soft sediment habitats within the D Jetty area (Golder 2016a [Annex A]). Encrusting coralline (*Lithothamnion* sp.) algae was observed (75 to 100%) in the boulder habitat adjacent to the D Jetty Project Area during Phase 1 abalone reconnaissance surveys (Golder 2016a [Annex A]).

No evidence of canopy-forming kelps (e.g. bull kelp) or eelgrass was found within the D Jetty Project Area during habitat surveys in February 2016 (Golder 2016a [Annex A]) or October 2012 (Balanced 2012b). It is unlikely that kelp and eelgrass documented outside the D Jetty Project Area will be negatively affected by Project activities.

2.3.2.2 Marine Invertebrates

In general, hard substrates (boulder/bedrock/riprap) contained the greatest abundance and diversity of invertebrate species compared to mixed and soft sediment substrates (Balanced 2012a,b; Golder 2016a [Annex A]). Motile invertebrates were generally more abundant on mixed and soft sediment substrates while sessile invertebrates were more abundant on hard substrates.

Sensitive marine invertebrate habitats with the potential to occur within the Project Areas include habitats for northern abalone (*Haliotis kamtschatkana*) and for the native Olympia oyster (*Ostrea conchaphila*). Northern abalone is a federally threatened and provincially red-listed gastropod which is found typically on bedrock or boulder substrate containing encrusting coralline algae (*Lithothamnion* sp.) with presence of brown bladed kelp (e.g. bull kelp *Nereocystis luetkeana,* tangle kelp *Laminaria sp.,* walking stick kelp *Pterygophora californica*) (Breen and Adkins 1979). Olympia oyster is a federal species of concern and a provincial blue-listed species and is found primarily in the Gorge Waterway and Portage Inlet; there are no known occurrences of Olympia oysters within Esquimalt Harbour (CRD 2010). This oyster grows on hard substrate (e.g. rock, man-made debris) in the Gorge Waterway but is found growing on clumped oyster shells in Portage Inlet where the substrate is silty sand.

F/G Jetty

Hard substrates in the F/G Jetty Project Area generally supported a higher abundance and diversity of marine invertebrates (Balanced 2012a; Golder 2016a [Annex A]). Several species of bivalve were identified on hard substrates including rock scallop (*Crassadoma* sp.), blue mussel (*Mytilus sp.*) and swimming scallop (*Chlamys rubida*). Barnacles (*Semibalanus* spp. and *Balanus sp.*) were ubiquitous throughout the F/G Jetty Project Area. Other commonly observed taxa included plumose anemones (*Metridium senile, M. farcimen*), Dungeness crabs (*M. magister*), and coonstripe shrimp (*Pandalus danae*). Other species observed on riprap and boulder/bedrock habitat included mossy chiton (*Mopalia muscosa*), plate limpet (*Tectura scutum*), California sea cucumber (*Parastichopus californicus*), burrowing sea cucumber (*Cucumaria miniata*), bread of crumb sponge (*Halichondria panacea*), shiny orange tunicate (*Cnemidocarpa finmarkiensis*), transparent tunicate (*Corella willmeriana*), and calcareous tubeworm (*Serpula vermiuclaris*) (Balanced 2012a; Golder 2016a [Annex A]).

Several other invertebrate species were observed on soft sediments and mixed substrates within the F/G Jetty Project Area, though density of invertebrates was generally lower compared to hard substrates (Balanced 2012a; Golder 2016a [Annex A]). Dungeness crabs and red rock crabs (*C. productus*) were most commonly observed on soft sediments (Golder 2016a [Annex A]). Other crab species observed during habitat surveys in 2012 included shore crab (*Hemigrapsus* sp.) purple shore crab (*Hemigrapsus nudus*), graceful crab (*Cancer gracilis*), hermit crab (*Pagurus* sp.), kelp crab (*Pugettia producta*), and helmet crab (*Telmessus cheiragonus*) (Balanced 2012a). Several species of shrimp were observed on subtidal sediments; the most commonly observed species was coonstripe shrimp, while several other unidentified shrimp were also observed. Four species of nudibranch were observed within the F/G Jetty Project Area including hooded nudibranch (*Melibe leonine*), clown nudibranch (*Triopha catalinae*), white-rimmed nudibranch (*Aldisa albomarginata*), and sea lemon (*Anisodoris nobilis*) (Balanced 2012a; Golder 2016a [Annex A]). Mottled sea star (*Evasterias troschelii*) and sunflower star (*Pycnopodia helianthoides*) were also observed in the F/G Jetty Project Area in 2012 (Balanced 2012a).

Phase 1 abalone surveys conducted in the F/G Jetty Project Area found no evidence of abalone presence or suitable abalone habitat (Golder 2016a [Annex A]).

A survey for Olympia oyster was conducted concurrently with surveys for northern abalone and no Olympia oysters were found within the F/G Jetty Project Area (Golder 2016a [Annex A]).

D Jetty

Several invertebrate species were observed on soft sediments and mixed substrates within the D Jetty Project Area. Coonstripe shrimp (*Pandalus danae*) and several other unidentified shrimp species were the most commonly observed invertebrates (Golder 2016a [Annex A]). Aggregations of plumose anemones were observed in association with anthropogenic debris such as concrete, pipes, logs and tires. False jingle (*Pododesmus macrochisma*) was the only bivalve observed within the D Jetty Project Area (Golder 2016a, [Annex A]). Several crab species were observed including Dungeness crab, red rock crab, sharpnose crab (*Scyra acutifrons*), shore crab (*Hemigrapsus* sp.) and slender crab (*Cancer gracilis*) in 2016, and graceful crabs (*Cancer gracilis*), hermit crabs (*Pagurus* sp.), and kelp crabs (*Pugettia producta*) in 2012 (Balanced 2012b; Golder 2016a [Annex A]). A total of four species of nudibranch were observed in the D Jetty Project Area in 2016 including barnacle nudibranch (*Onchidoris bilamellata*), shaggy mouse nudibranch (*Aeolidia papillosa*), leopard nudibranch (*Diaulula sandiegensis*) and black-tip dendronotid (*Acanthodoris pilosa*) (Golder 2016a [Annex A]). Winged sea slugs (*Gastropteron pacificum*) were observed around D Jetty in 2012 (Balanced 2012b). Four species of sea star were observed during 2012 habitat surveys, mostly on soft sediments, including sunflower star (*Pycnopodia helianthoides*), mottled sea star (*Evasterias troschelii*), blood sea star (*Henricia leviuscula*) and ochre sea star (*Pisaster ochraceus*) (Balanced 2012b).

Phase 1 abalone surveys conducted in February 2016 identified the presence of four northern abalone, a gastropod listed federally as threatened and provincially as red-listed, adjacent to the D Jetty Project Area (Golder 2016a [Annex A]). The abalone were observed within boulder habitat in the under-pier area at the east side of D Jetty which is outside of the proposed Project footprint (Figure 3). Abalone were observed in the shallow subtidal zone ranging from 1.0 to 2.5 m below chart datum (Annex A – Figure 4) and ranged in size from 33 to 133 mm in shell length (SL). Suitable abalone habitat adjacent to the D Jetty Project Area was mapped at approximately 43 m in length parallel to the east side of D Jetty, and consisted primarily of boulder habitat covering a total estimated area of 241 m^2 (Annex A – Figure 4). Abalone predators were not observed within either area nor were abalone observed in association with urchins. A green sea urchin (*Strongylocentrotus droebachiensis*) and a red rock crab were also observed in the boulder area during the abalone survey.

A survey for Olympia oyster was conducted concurrently with surveys for northern abalone and no Olympia oysters were found within the D Jetty Project Area (Golder 2016a [Annex A]).

The CRD Harbours Atlas reported the presence of plumose anemones throughout the Project Area and burrowing sea cucumbers (*Cucumaria miniata*) in the F/G Jetty area (CRD 2010). The CRD Harbours Atlas indicated no presence of native oysters (*Ostrea lurida*) or piddock clams within the Project Area and no clam beds were identified within the D Jetty or F/G Jetty areas during habitat mapping surveys in 2016 (Golder 2016a [Annex A]).

Path: \\golder.gds\gal\Victoria\CAD-GIS\Client\PWGSC\esquimalt_harbour\99_projects\1545562_marinehabitat\02_PRODUCTION\3000_EnvEffectsDet\DWG\ | File Name: 1657898-1000-RB-55.dwg

LEGEND

REMEDIATION FOOTPRINT

ON-SITE STAGING AREA

BOULDER/BEDROCK/RIPRAP

BOULDER

MAPPED HABITAT:

ABALONE

OSPREY NEST

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

0 50 100

1:3,000 METRES

CLIENT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT

F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	V. LAWRENCE
PREPARED	R. WIGGINS
REVIEWED	V. LAWRENCE
APPROVED	B. WERNICK

TITLE

ENVIRONMENTAL FEATURES

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

2.3.2.3 Fish and Fish Habitat

This section refers to the taxonomic fish groups Agnatha (jawless fish), Chrondrichthyes (cartilaginous fish) and Osteichthyes (bony fish).

Fish observations were taken from towed video and diver survey data collected by Golder (2016a [Annex A]), and from video taken from marine habitat surveys at D Jetty and F/G Jetty (Balanced 2010a,b). Several species of fish were observed during towed video surveys in January 2016, primarily within boulder/bedrock and soft sediment habitats in areas with macroalgae cover (Golder 2016a [Annex A]). Few fish were observed at D Jetty and F/G Jetty; fish observed included a single snake prickleback at D Jetty and an unidentified flatfish at F/G Jetty. Many of the fish species identified during towed video surveys were also present during dive surveys in February 2016. Additional species observed during dive surveys included a juvenile rockfish (*Sebastes* sp.) within the F/G Jetty area (Golder 2016a [Annex A]). Several other fish species were observed during underwater dive surveys in 2012. A group of juvenile Pacific herring (*Clupea pallasi*), along with longfin sculpin (*Jordania zonope*), mosshead scuplin (*Clinocottus globiceps*) and pile perch were observed in the area around D Jetty during surveys in 2012 (Balanced 2012b). Surveys around F/G Jetty revealed copper rockfish (*Sebastes caurinus*), rock prickleback (*Xiphister mucosus*), kelp greenling, pile perch, rock sole, and several unidentified scuplins (Balanced 2012a).

Records of fish trapped in the EGD, which lies to the north of Constance Cove across Esquimalt Harbour from the Project Areas, indicate that Pacific herring, chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), several unidentified salmon species (*Oncorhynchus sp.*), starry flounder, lingcod and perch (genus/species unknown) have been recorded in the dry dock[1] area. The number of herring trapped during a single event ranged from ~500 to >1,000 individuals, and the number of salmon trapped ranged from 1 to 4 individuals[2].

The Habitat Wizard (MOE 2016a) was used to search for streams that flow into Esquimalt Harbour which are known to support anadromous fish. One such stream was identified: Millstream Creek (Watershed code 920-047500). Millstream Creek flows into the northwest portion of Esquimalt Harbour and is known to have contained the following anadromous species: coho salmon, anadromous coastal cutthroat trout (*O. clarkii clarkii*) and steelhead (anadromous rainbow trout) (*O. mykiss*). Mapster salmon escapement data indicated coho salmon were present in 2007 when the stream was last inspected (DFO 2016b). The last record for anadromous cutthroat trout was in 1977 and the last record for steelhead was in 1994 (MOE 2016a); therefore, it is unknown if these species still exist in Millstream Creek.

If anadromous cutthroat trout still exist in Millstream, adults and juveniles may reside in or migrate through Esquimalt Harbour and the CSRP and FGOP in-water work areas. If coho salmon and steelhead still exist in Millstream Creek, adults may migrate through the CSRP and FGOP in-water work areas to Millstream to spawn and juveniles may migrate through the CSPR and FGOP in-water work areas on their way to feeding grounds.

1 The EGD maintains a database of fish and other marine organisms trapped in the graving dock. The database is continually maintained and contains information dating back to June 6, 2004.

2 A bubble curtain, installed at the entrance of the graving dock in 2003, has reduced the amount of fish trapped (K. Ritchot, pers. comm. January. 4, 2011).

Pacific herring may also migrate through, spawn, incubate and rear in the CSRP and FGOP in-water work areas. DFO's herring spawning map for Section 193 indicate that herring have spawned in Esquimalt Harbour and in the vicinity of the CSRP and FGOP in-water work areas (Annex C) (DFO 2015). Cumulative spawning in the vicinity of the CSRP and FGOP in-water work areas is classified as a 'low' (DFO 2015). The last spawning event in the vicinity of the CSRP and FGOP in-water work areas was recorded in 1993 according to the text version of the spawning records (DFO 2015).

2.3.2.4 Aquatic Mammals

Harbour seals (*Phoca vitulina richardsi*) are considered resident within the coastal waters of BC (SARA 2010) and considered common inhabitants of Esquimalt Harbour (CRD 2011a; CRD 2011b). Harbour seals were observed on several occasions within the Project Areas during habitat surveys in 2016 (Golder 2016a [Annex A]). Harbour seals are not listed under the federal *Species at Risk Act* (SARA).

The northern river otter (*Lontra canadensis*) is relatively common in Victoria Harbour and in less disturbed areas of Esquimalt Harbour and Esquimalt Lagoon (CRD 2011c). Although not considered marine mammals under the Marine Mammal Regulations, northern river otters inhabit the intertidal and near-shore environment of marine ecosystems where they play an important ecological role (Melquist and Dronkert 1987). Engelstoft and Mogensen (2005) stated that northern river otters were considered relatively abundant in their study area, which included Esquimalt Harbour; however, the exact population size and density of northern river otters along the Vancouver Island coast from Port Renfrew to Victoria is unknown.

California sea lions (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) have been observed in Esquimalt Harbour, although their occurrence in these waters is considered rare. The Coastal Resources Information System (CRIS) database identifies a winter haul-out site (non-breeding assemblage) for both species at Race Rocks Ecological Reserve located in the Strait of Juan de Fuca, approximately 20 km from Esquimalt Harbour (BC Government 2010; DFO 2010). Steller sea lions were observed within Esquimalt Harbour/Constance Cove during dive surveys conducted along the North Landing Wharf in February of 2010 (Golder 2010). A sea lion (unknown species) is also listed in EGD's database of organisms that have been trapped within the dry dock. Steller sea lions are listed under SARA as special concern. California sea lions are not listed under SARA.

Killer whales (*Orcinus orca*) been observed in Esquimalt Harbour but only infrequently. Known geographical ranges, documented sightings and proposed critical habitat of the northern and southern resident killer whales include most coastal regions of Vancouver Island including the Strait of Juan de Fuca, Haro Strait, Boundary Pass, and the Strait of Georgia. However, Esquimalt Harbour and Victoria Harbour are not considered critical killer whale habitat (DFO 2006; DFO 2011). No killer whales were observed in Esquimalt Harbour during Golder field surveys in 2016; however, pods of two to three killer whales were observed within Esquimalt Harbour by Queen's Harbour Master staff in January 2014 and September 2013 (QHM pers. comm. with DND, 2014; Golder 2016a [Annex A]). Southern resident killer whales are listed under SARA as endangered. Transient killer whales are listed under SARA as threatened.

Harbour porpoise (*Phocoena phocoena*) are known to occur in Esquimalt Harbour and Dall's porpoise (*Phocoenoides dalli*) have the potential to occur. The general distribution of both species includes the inlets and bays around Vancouver Island (CWS 2004). Harbour porpoises have been observed within Esquimalt Harbour and in the region surrounding the harbor on several occasions (QHM pers. comm. with DND, 2014; Baird and Geunther 1995; Hall 2004). Harbour porpoise are listed under SARA as special concern. Dall's porpoise remain unlisted under SARA.

2.3.2.5 Birds

Various bird species may occur in and adjacent to the Project Areas. Thirty-one bird species were observed in Esquimalt Harbour in surveys conducted in 2000-2001 and 2004-2005 as part of the BC Coastal Waterbird Surveys (Annex C) (Bird Studies Canada 2016). Birds observed included geese, swans, ducks, loons, cormorants, great blue heron (*Ardea herodias fannini)*, bald eagle (*Haliaeetus leucocephalus)*, peregrine falcon (*Falco peregrinus anatum* or *Falco peregrinus pealei*), gulls and kingfishers among others. Birds observed in and adjacent to Esquimalt Harbour during annual Christmas bird counts included loons, grebes, cormorants, herons, swans, geese, ducks, gulls and passerines (VNHS 2009). These birds may traverse and forage in the Project Areas; however, most are unlikely to nest due to limited nesting habitat in the Project Areas.

Osprey (*Pandion haliaetus*) nests are known to occur adjacent to the Project Areas. Two osprey nests have been documented at DND Colwood within 100 m of the Project Areas: one adjacent to D Jetty and one near the F/G Jetty project area (pers. comm. Tracy Cornforth, June 21, 2016). The locations of these nests are displayed on Figure 3. The nest near D Jetty was occupied in 2014, but the one near the F/G Jetty project area was a relocated nest and has never been occupied (pers. comm. Tracy Cornforth June 21, 2016).

Passerines, great blue herons and bald eagles may nest adjacent to the Project Areas. The Wildlife Tree Stewardship Atlas (WiTS 2016) was searched to determine if there are any mapped bald eagle nests adjacent to the Project Areas. The closest recorded bald eagle (*Haliaeetus leucocephalus*) nest is approximately 800 m away from the Project Areas to the north of F/G Jetty (WiTS 2016). The nest was last observed in 2010 and was considered occupied territory based on enough sightings of adult eagles around the nesting site.

Barn swallows (*Hirundo rustica*), a provincially blue-listed species, may nest under jetties within the Project Areas.

Esquimalt Lagoon is situated approximately 500 m south of D Jetty outside of the Project Areas. This area is classified as a Federal Migratory Bird Sanctuary (CRD 2011d; EC 2010b). Large numbers of seabirds, shorebirds, and waterfowl nest and feed in the lagoon year-round, particularly around gravel bars at the northeast end. Some species are migratory and use the lagoon as a feeding area during certain parts of the year. Birds which inhabit Esquimalt Lagoon may at times be found feeding within the Project Areas; however, federally protected habitat within the lagoon itself will not be affected by the Project.

2.3.2.6 Species at Risk (Provincial and Federal)

2.3.2.6.1 Species at Risk Designations

The Provincial government assigns a rank or listing of 'red' or 'blue' to a species based on its status within BC. The rankings of Provincial listing categories described below highlight species as well as natural plant communities that require special attention (MOE 2007):

- Red – Any indigenous species, subspecies or plant community that is extirpated, endangered, or threatened in BC;
- Blue – Any indigenous species, subspecies or community considered to be vulnerable (special concern) in BC; and
- Yellow – Any indigenous species or subspecies (taxa) which is not at risk in BC.

No legal protection or designation is associated with provincial species at risk rankings. Rather, the designations help guide provincial conservation, land use planning, management and protection activities (MOE 2007).

Committee on the Status of Endangered Wildlife in Canada

Federally, species ranking is conducted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), established under Section 14 of the *Species at Risk Act* (SARA). COSEWIC is a committee of experts that assesses and designates, under Sections 15 to 21 of SARA, which wild species of animal, plant or other organisms are in danger of disappearing from Canada (Government of Canada 2010). The status categories used by COSEWIC to rank or list a species are as follows:

- Extinct (XX) – a species that no longer exists;
- Extirpated (XT) – a species no longer existing in the wild in Canada, but occurring elsewhere;
- Endangered (E) – a species facing imminent extirpation or extinction;
- Threatened (T) – a species likely to become endangered if limiting factors are not reversed;
- Special Concern (SC) – a species that is particularly sensitive to human activities or natural events, but is not an endangered or threatened species;
- Data Deficient (DD) – a species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction; and
- Not at Risk (NAR) – a species that has been evaluated and found to be not at risk.

Species at Risk Act

SARA contains general prohibitions that make it an offence to:

- Kill, harm, harass, capture, or take an individual of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated;
- Possess, collect, buy, sell or trade an individual of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated; or
- Damage or destroy the residence (e.g. nest or den) of one or more individuals of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated, if a recovery strategy has recommended the reintroduction of that extirpated species.

Schedule 1 is the official list of wildlife species at risk receiving legal protection under SARA. Although Schedule 1 lists other designations in addition to endangered, threatened and extirpated, the prohibitions of the Act do not apply to these species (Government of Canada 2010). In some circumstances, the federal prohibitions could be applied to other species on private or provincial Crown land if it is deemed that provincial or voluntary measures do not adequately protect a species and its residence (Government of Canada 2010).

2.3.2.6.2 Species at Risk Occurring in and Adjacent to the Project Areas

No “non-sensitive”[3] species at risk have been recorded in the Project Areas by the BC Conservation Data Centre (CDC) (MOE 2016b). The closest non-sensitive occurrence is that of a purple martin (*Progne subis*). Purple martins nested in nest boxes at the Diving Unit dock (BC CDC 2014) which is approximately 150 m northeast of F/G Jetty dredge area. The purple martin nest box colony on the dive unit dock was removed in the spring of 2016 due to a few years of nest failure/abandonment (Tracy Cornforth, pers. comm. June 21, 2016). More information about the purple martin is provided in Table 4.

2.3.2.6.3 Species at Risk Potentially Occurring in and Adjacent to the Project Areas

The BC Species and Ecosystem Explorer database indicates the presence of 18 marine or estuarine species at risk in the CRD (not including shoreline plants and insects species) (MOE 2016c), and the BC Species at Risk website indicates there are 25 species at risk in the inshore areas of the CRD (Pearson and Healey 2012) (refer to Annex C for list of species). Species from both databases were combined resulting in a total of 33 species that may occur in the Project Areas, including 17 birds, six marine mammals, seven fish, one turtle, one marine gastropod and one bivalve. Habitat preferences and ranges of each species were compared to the location of and habitat present in the Project Areas to determine which species are likely to occur; 15 species have the potential to occur. Table 4 outlines these species along with their likelihood of occurring in the Project Areas.

[3] The CDC considers some species at risk occurrences as “sensitive” and masks their exact location to help protect the occurrence. All other occurrences are considered “non-sensitive” and exact locations are available to the public (MOE 2016a).

Table 4: Listed Species with the Potential to Occur in the Project Areas

Name	COSEWIC	SARA	BC	Habitat and Range Description	Comments
Birds					
Barn Swallow (*Hirundo rustica*)	T	N/A	Blue	Nests in barns or other buildings, under bridges, wharves, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Flies over open land and water and forages on insects. Usually forages within a few hundred meters of nest when breeding.	May nest under wharves in the Project Areas.
Brandt's Cormorant (*Phalacrocorax penicillatus*)	N/A	N/A	Red	Mainly inshore coastal zone, especially in areas having kelp beds; also around some offshore islands; less commonly, inshore on brackish bays; in winter, mostly around sheltered inlets and other quiet waters. Typically nests on flat or gently sloping surfaces on tops of rocky islands along coast.	May temporarily occur in the Project Areas but would likely not nest.
Caspian Tern (*Hydroprogne caspia*)	NAR	N/A	Blue	Seacoasts, bays, estuaries, lakes, marshes, and rivers. Nests on sandy or gravely beaches and shell banks along coasts or large inland lakes; sometimes with other water birds. Seasonal resident and probably breeds on Vancouver Island. Does not overwinter on Vancouver Island.	May temporarily occur in the Project Areas but would not nest.
Common Murre (*Uria aalge*)	N/A	N/A	Red	Non-breeding: pelagic and along rocky seacoasts. Nests in the open or in crevices on broad and narrow cliff ledges, on stack (cliff) tops, and on flat, rocky, low-lying islands. Breeds on the northern tip of Vancouver Island and overwinters around Vancouver Island.	May temporarily occur in the Project Areas but would not nest.
Double-Crested Cormorant (*Phalacrocorax auritus*)	NAR	N/A	Blue	Forage in all coastal areas of BC, utilising marine habitats such as bays, estuaries, and inlets and occasionally freshwater habitats such as lakes close to coastal areas and large rivers such as the Fraser River. Bare, rocky islands with sparse vegetation are the preferred nesting habitats.	May temporarily occur in the Project Areas but would not nest.
Great Blue Heron (*Ardea herodias fannini*)	SC	1-SC	Blue	Nest in a wide variety of tree species; the Pacific population nests in quiet woodlots within 8 km (most within 3 km) of foraging habitats such as large eelgrass meadows, along rivers, and in estuarine and freshwater marshes.	No nests known to occur within or adjacent to Project Areas. May temporarily occur in the Project Areas.
Marbled Murrelet (*Brachyramphus marmoratus*)	T	1-T	Red	Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g. Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth.	May temporarily occur in the Project Areas but would not nest.
Purple Martin (*Progne subis*)	N/A	N/A	Blue	Breeds but does not overwinter on Vancouver Island. Nest in natural cavities and woodpecker holes in trees and snags, and in holes in buildings. In recent years they have been almost entirely restricted to nest boxes and artificial holes in pilings in estuaries, bays, and harbours. Birds presumably forage over areas immediately surrounding nest site, although no information on typical travel distance while foraging.	May still occur in Esquimalt Harbour. Not known to nest in the Project Areas, but may forage over the Project Areas.
Peregrine Falcon (*Falco peregrinus anatum / tundrius*)	SC	1-SC	Blue	Nests on cliff ledges, crevices, and sometime on tall buildings or bridges, preferably between 50-200 m in height. Suitable nesting sites are often dispersed and can be either natural or on structures built by humans. Forages on small birds, bats, rodents and mammals. Often returns to use the same nesting sites for decades.	May temporarily occur in the Project Areas but would likely not nest.
Fish					
Canary Rockfish (*Sebastes pinniger*)	T	N/A	N/A	Juveniles occupy shallow inshore waters. Larvae and pelagic juvenile canary rockfish occupy the top 100 m for up to 3 to 4 months after live-birth (parturition) and then settle to a benthic habitat. Adults typically inhabit rocky bottom in 70 to 270 m depth on the continental shelf. Canary rockfish are widely distributed throughout BC coastal waters. The prevalence of this species in recreational fishing in the Strait of Georgia indicates that they are probably well distributed in enclosed waters and inlets.	Some potential for juveniles to occur in the Project Areas; however, none have been identified to date.
Cutthroat Trout, *clarkii* subspecies (*Oncorhynchus clarkii clarkii)*	N/A	N/A	Blue	Requires small, low gradient coastal streams and estuarine habitats. Some may spend entire life in freshwater, but most are anadromous. In marine habitats, generally remains close to the coast, usually remaining within estuary. Eelgrass and kelp beds provide habitat for cutthroat trout, as they host a wide variety of prey species, and provide shelter (CRD 2011e).	Cutthroat trout may migrate or forage in the Project Areas; however, none have been identified in the Project Areas to date.

Name	COSEWIC	SARA	BC	Habitat and Range Description	Comments
Invertebrates					
Northern Abalone (*Haliotis kamtschatkana)*	T	1-T	Red	Suitable abalone habitat is typically characterized as bedrock or boulder substrate containing encrusting coralline algae (*Lithothamnion* sp.) with presence of brown bladed kelp (e.g. bull kelp *Nereocystis luetkeana,* tangle kelp *Laminaria sp.,* walking stick kelp *Pterygophora californica*, etc.) (Breen and Adkins 1979). Abalone occur in sheltered bays to exposed coastlines and typically range from low intertidal to 30 feet depth.	Abalone were observed adjacent to the D Jetty Project Area. No suitable abalone habitat was observed within the D Jetty or F/G Jetty Project Areas.
Olympia Oyster (*Ostrea conchaphila)*	SC	1-SC	Blue	Mainly found in the lower intertidal and shallow subtidal zones of saltwater lagoons and estuaries. They have also been found on tidal flats, tidal channels, bays and sounds, in splash pools, near freshwater seepage, or attached to pilings or the undersides of floats. On the outer coast, this oyster species is only found in protected locations. Within suitable habitat, Olympia oysters need hard substrate for settlement.	No known occurrences of Olympia oysters within the Project Areas.
Marine Mammals					
Steller Sea Lion (*Eumetopias jubatus*)	SC	1-SC	Blue	Marine habitats include coastal waters near shore and over the continental slope; sometimes rivers are ascended in pursuit of prey. When not on land, the sea lions may congregate at nearshore traditional rafting sites, or move out to the edge of the continental shelf.	Steller sea lions have been observed in Esquimalt Harbour; however, the Project Areas are not considered important habitat for the Steller sea lion.
Harbour Porpoise (*Phocoena phocoena*)	SC	1-SC	Blue	Coastal waters and adjacent offshore shallows; also inhabits inshore areas such as bays, channels, and rivers. Mothers and young tend to move into sheltered coves and similar sites soon after parturition.	Harbour porpoises have been observed in Esquimalt Harbour; however, the Project Areas are not considered important habitat for this porpoise.
Killer Whale (Northeast Pacific southern resident population) *Orcinus orca pop. 5*	E	1-T	Red	The range during spring, summer, and fall includes the waterways of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait. Little is known about winter movements and range.	The Project Areas are not considered important habitat for this whale. Killer whales frequent nearshore waters of Juan de Fuca; however, they are not known to frequent the active harbours of Esquimalt and Victoria. It is considered unlikely that killer whales would enter within or adjacent to the Project Areas during the planned work.

Notes: E = endangered; N/A=Not applicable; NAR= Not at Risk; SC=Special Concern; T=Threatened, 1=Listed under Schedule 1 of the *Species at Risk Act*.

2.3.3 Socio-Economic Components

Esquimalt Harbour is surrounded by three Municipalities, the City of Colwood (Colwood), the Town of View Royal (View Royal), and the Township of Esquimalt (Esquimalt). Remediation sites are located adjacent to Colwood and across the Harbour from Esquimalt which is on the east side of Esquimalt Harbour. View Royal is located in the north western section of Esquimalt Harbour but none of the proposed remediation sites are adjacent to View Royal (Figure 3).

The Esquimalt and Songhees First Nations have reserves in Esquimalt Harbour. New Songhees 1A and the Esquimalt reserve are located on the east side of Esquimalt Harbour and are home to a number of Songhees and Esquimalt members. The reserves are approximately 900 m east of D Jetty (Figure 3). As of 2016, there were 565 registered members of the Songhees First Nation, including 338 living on reserve (INAC 2016a). There were 309 registered members of the Esquimalt First Nation as of February 2016, 174 of whom live on the Esquimalt reserve in Esquimalt Harbour (INAC 2016b).

Table 5 shows the 2011 population and total number of private dwellings in Esquimalt and Colwood and identifies the remediation sites adjacent to each community.

Table 5: Municipal Population by Remediation Site

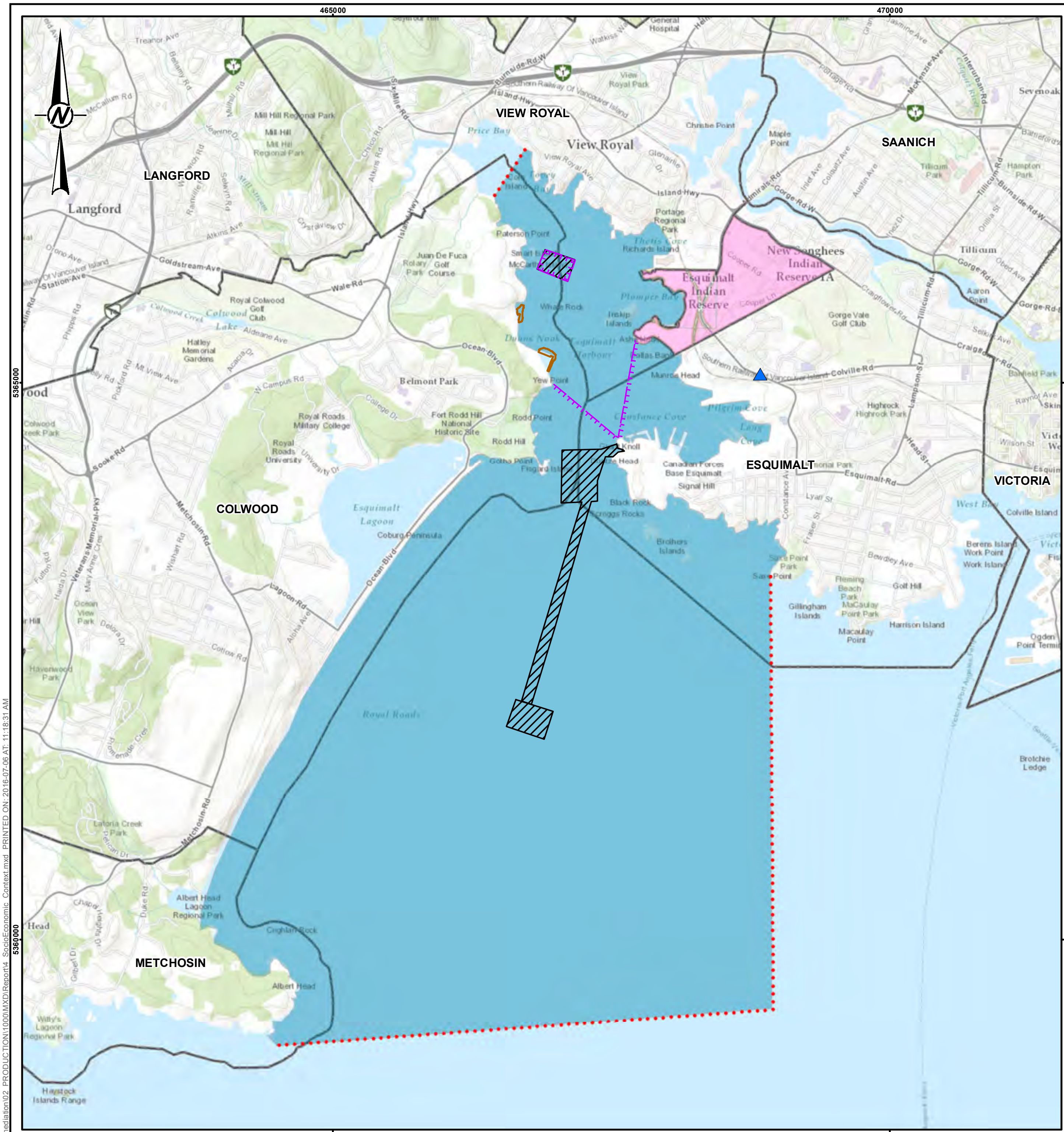
Municipality	Proximity to Project Areas	2011 Census Population	Total Private Dwellings
Township of Esquimalt	Across Esquimalt Harbour from the Project Areas	16,209	8,638
City of Colwood	Adjacent to the D Jetty and F/G Jetty Project Areas	16,093	6,395

Source: Statistics Canada, 2012

The remediation sites are located at existing developments in Esquimalt Harbour. The remediation sites are currently used for the following purposes.

- D Jetty is the berth for military vessels;
- F Jetty is the principle fueling station for the West Coast Naval fleet; and
- G Jetty is currently not in use as it is condemned and due for replacement (QHM, pers. comm., 2016).

The remediation sites are located adjacent to DND facilities on CFB Esquimalt and DND property and the zoning for each remediation site matches the current use. D Jetty and F/G Jetty are on land zoned by Colwood as P4, parks and open space, but are designated as “business/light industrial”, which is the designation given to the CFB Esquimalt Lands in the City of Colwood Official Community Plan, Bylaw 999 (2008).



LEGEND

- ESQUIMALT GRAVING DOCK
- ANCHORAGE PROHIBITED
- REMEDIATION FOOTPRINT
- CONTROLLED ACCESS ZONE / COMMERICAL WATER LEASE AREA
- FIRST NATIONS RESERVE
- MUNICIPAL BOUNDARY
- NO FISHING

0 1000 2000

1:50000 METRES

REFERENCE(S)

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DATUM: NAD 83 PROJECTION: UTM ZONE 10N

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT
F/G JETTY OPTIMIZATION PROJECT AND COLWOOD SOUTH REMEDIATION PROJECT ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
SOCIO-ECONOMIC CONTEXT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	AT
PREPARED	MH
REVIEWED	JS
APPROVED	BW

PROJECT NO.	CONTROL	REV.	FIGURE
1657898	1000	A	4

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

25mm

2.3.3.1 Transportation

The Township of Colwood's road system serves a variety of purposes and users. In addition to allowing residents to move between their homes, places of work, shopping and recreational facilities, it is also part of a larger regional network, which provides for the movement of private and commercial vehicles, as well as DND traffic.

2.3.3.2 Navigation

Esquimalt Harbour is administered by DND and is governed by the *Canada Marine Act,* the Natural and Man-Made Harbour Regulations (pursuant to the *Canada Marine Act*), and the Esquimalt Harbour Practices and Procedures (pursuant to the *Canada Marine Act*). The Queens Harbour Master (QHM) is the Transport Canada designated Harbour Authority for Esquimalt Harbour. All vessels entering or departing Esquimalt Harbour must contact the QHM Operations on marine VHF channel 10 or by telephone at (250) 363-2160.

The QHM is responsible for naval ship control within Esquimalt Harbour to ensure incoming vessels are berthed with due consideration to operational priority, repair and maintenance schedules, as well as international courtesy. The QHM has responsibility for all logistic requirements of Canadian and visiting warships in port. The Esquimalt Harbour Practices and Procedures, pursuant to Section 106 of the *Canada Marine Act*, promote safe and effective use, navigation, and environmental stewardship of the harbour and must be followed by all harbour users, including ships entering, berthing, departing, manoeuvring, or anchoring in the harbour (DND 2016).

Esquimalt Harbour is open to the public within the limitations regarding Controlled Access Zones that provide for security zones around warships berthed or moving in and out of the harbour. These zones include the harbour proper, and its approaches, bound to the south by Albert Head and the east by Saxe Point, as well as waters within 200 m (in any and all directions) from naval ships and DND Jetties, 500 m surrounding ships at anchor and 200 m around any vessels maneuvering within Esquimalt Harbour and approaches (Royal Canadian Navy 2016). The speed limit in Esquimalt Harbour is 7 knots.

Four types of vessels enter and exit Esquimalt Harbour, including naval ships accessing DND Jetties, commercial traffic accessing the Esquimalt Graving Dock, pleasure craft of all sizes, and recreational and commercial crab harvesting vessels (QHM, pers comm. 2016). Naval traffic generally includes DND vessels moving between jetties for fueling or maintenance purposes, or DND vessels arriving to and departing from berthing stations at DND Jetties. F Jetty is the principal fueling station for DND vessels, and tugs are often used to tow warships to and from Constance Cove for fueling. G Jetty is currently not in use as it is condemned and due for replacement (QHM, pers. comm, 2016). Commercial traffic generally consist of vessels accessing the Esquimalt Graving Dock. The Esquimalt Graving Dock is the largest solid-bottom commercial drydock on the west coast of the Americas and frequented by vessels of all sizes including fishing vessels and freighters.

Crab harvesting is only allowed outside of the controlled access zones and water lease areas. Fishing is not permitted in the harbour (QHM, pers comm. 2016). Anchoring is prohibited anywhere in the harbour except in the northern most part of the Inner Harbour. Ships at anchor must register with QHM Operations and cannot remain at anchor for longer than two weeks.

In addition to the designated harbour regulations, general regulatory measures to promote safe navigation of vessels apply within the harbour, including legislation under the *Canada Shipping Act, 2001* and directives in regard to vessel traffic management systems, pilotage, navigational aids, precautionary areas, and special operating instructions. Specific measures that are part of the general vessel traffic management systems to facilitate navigation include use of ship radar, carriage of an automated information system for larger vessels, and use of loudhailers on bridges of large ships to communicate with smaller vessels.

2.3.3.3 Commercial, Recreational and First Nations Fisheries

2.3.3.3.1 Commercial Crab Harvesting

As per the Esquimalt Harbour Practices and Procedures and the Canadian Hydrographic Service Chart 3419, fishing and crab harvesting is prohibited at the entrance to Esquimalt Harbour (Royal Canadian Navy 2016). Finfish harvesting is also prohibited within the Harbour. Crab harvesting is allowed in areas that minimize effects on marine traffic and harbour use. As the remediation sites are all located in areas subject to the controlled access zones under the Esquimalt Harbour Practices and Procedures, fishing and crab harvesting should not occur within the 200 m buffer around the jetties.

The Pacific Region crab-by-trap fisheries includes commercial, recreational and First Nations fisheries. According to the QHM, commercial crab fishery activities occur in Esquimalt Harbour (QHM, pers comm. 2016). DFO manages commercial crab harvesting on an area basis, and specifies limits on the harvest season, traps per vessel and management area, trap hauls, and sex and size of crabs. Crab is harvested over approximately two months at the start of the DFO-regulated opening in mid-June. Licences are based on vessel and management area. Crab Management Area H (within which Esquimalt Harbour is located) currently has 60 commercial crab licenses. Representatives of the QHM estimate that fewer than six harvesters harvest crab in Esquimalt Harbour (QHM, pers comm. 2016).

2.3.3.3.2 Recreational Crab Harvesting

Although recreational crab harvesting is permitted in parts of Esquimalt Harbour, a shellfish consumption advisory is in place for Esquimalt Harbour. This notice provides the recommended maximum weekly intake, in accordance with Health Canada (HC) recommendations for adults and toddlers, of Dungeness crab hepatopancreas and muscle, red rock crab hepatopancreas and muscle, sea urchin roe, and rockfish muscle (DFO 2016c). Bivalve fishing is not permitted due to a biotoxin and sanitary contamination closure DFO 2016d).

2.3.3.3.3 First Nations Fisheries

Under the Douglas Treaty, the Esquimalt and Songhees Nations have fishing and hunting rights which are practiced in Esquimalt Harbour. In meetings with DND, First Nations representatives have indicated that they have ongoing subsistence and cultural uses in the harbour. Both the Esquimalt and Songhees Nations assert aboriginal rights and interests within the harbour area.

2.3.3.4 Land and Non-consumptive Marine Based Recreation

No national or provincial parks are located adjacent to any of the remediation sites, but there are a number of waterfront parks in Esquimalt Harbour, including two National Historic Sites. Fort Rodd Hill and Fisgard Lighthouse National Historic Site is located on the west side of the entrance to the harbour. Another National Historic Site, Cole Island, is located at the north end of the harbour. Both sites are open to the public for day use recreation.

In addition to recreational fish and seafood harvesting, other water based recreation in Esquimalt Harbour includes recreational boating and kayaking and shoreline usage. Pleasure craft use the harbour year round (QHM, pers comm. 2016). The Pacific Fleet Kayak Club and Canadian Forces Sailing Association are based in Esquimalt Harbour with members of each organization using the harbour year round. In the summer, there is a youth sailing regatta, with up to 50 boats competing in the harbour. Recreational fishing is limited in the harbour and all visitors must report to the QHM upon arrival (QHM, pers comm. 2016). There are strict rules regarding anchoring, with a number of sections in the harbour off limits to anchoring (Figure 3).

2.3.3.5 In-Air Noise, Light and Odour

Specific information regarding ambient noise, light and odour levels within CFB Esquimalt and DND lands is not available. However, the remediation sites are located in an active, working harbour with other marine maintenance, repair, and construction related business and military facility sites associated with CFB Esquimalt and the nearby Esquimalt Graving Dock, all contributing to an existing level of noise pollution, light trespass, nighttime sky glow and odour.

While the remediation sites are all within existing DND facilities, residences are located approximately 1 km from the Project Areas and most of the distance between the homes and the jetty sites is forested. Other neighbourhoods bordering Esquimalt Harbour and temporary human receptors in proximity of CFB Esquimalt and DND lands could experience noise and light effects from the existing working harbour activities, and Project activities, include nearby marine based and shore-based recreational users.

Noise bylaws for adjacent municipalities are available for the Township of Esquimalt, the City of Colwood and the Town of View Royal. The Township of Esquimalt Maintenance of Property Bylaw No. 2826, 2014 regulates the maintenance of property, unsightly property, and nuisance, including noise. The nuisance section of bylaw includes specific provisions regarding noise:

- Generally, no person shall make noise, cause, allow, or permit a noise or sound in the street, park, plaza, or similar place which disturbs or tends to disturb the quiet, peace, rest, enjoyment, comfort, or convenience of persons in the neighbourhood or vicinity. For greater certainty, these activities are prohibited, between the hours of 10:00pm and 7:00am on Monday to Friday and between the hours of 10:00pm and 9:00am on Saturday, Sunday, or Holidays.

The Bylaw to Regulate Noise within the City of Colwood (Bylaw No. 38) stipulates the following construction hours:

- Monday to Saturday before 07:00 or after 19:00 h, no person shall construct, erect, reconstruct, alter, repair, or demolish any building, structure, or thing or excavate or fill in any manner which disturbs the quiet, peace, rest, enjoyment, comfort or convenience of the neighbourhood or of persons in the vicinity. Such work is prohibited on Sundays and statutory holidays.

- No person shall, on any day, before 8:00h or after 17:00 h operate, or cause to be operated, any drills and or compressors for blasting. All operations of drills or compressors are prohibited on Sundays and statutory holidays.

The Town of View Royal Noise Bylaw (Bylaw No. 523) stipulates the following with regards to disturbance from noise:

- No person shall make or cause to be made any noise or sound in or on a highway or elsewhere in the Town which disturb, or tend to disturb the quiet, peace, rest, enjoyment, comfort, or convenience of the neighbourhood, or of persons in the vicinity, or which the Council believes are objectionable or liable to disturb the quiet, peace, rest, enjoyment, comfort or convenience of individuals or the public.

2.3.3.6 First Nation Traditional Lands/Resources

The Project Areas are located within the asserted traditional territories of the Songhees Nation and the Esquimalt Nation. Consultation with the Songhees and Esquimalt Nations has been ongoing since 2006. Between 2006 and 2007, a First Nation Involvement Plan, including a traditional use and knowledge study, was undertaken as part of the Esquimalt Harbour Sediment Quality Project. The following provides a summary of work conducted between 2006 and 2007:

- Planning (August 2006): First Nations with potential interests in Esquimalt Harbour were identified and contacted based on background research and discussions with DND and PWGSC.
- Data Collection (September to October 2006): The team worked with local First Nations to understand how and where people currently use the harbour, as well as how and where the harbour was used in the past and how and where First Nations anticipate using the harbour in the future. Data collection methods included formalized interviews with community Elders and expert knowledge holders that documented and mapped traditional use sites, as well as Traditional Ecological Knowledge (TEK), from the harbour. Collected information was entered into a GIS database and the results summarized into a confidential report to PWGSC, DND and the Esquimalt and Songhees Nations.
- Communication (September 2006 to February 2007): The results of the TEK were provided to the community for additional comment, and protocols were put in place for protecting confidential information. In addition, the results of the environmental studies for the Harbour were shared with First Nations. Support to First Nations in the review of the technical environmental studies and the participation in the overall engagement process was offered.
- Evaluation (February to March 2007): The team committed to working with First Nations to monitor the effectiveness of the engagement process and to track relationships as they developed. Progress against the following goals were measured: increased awareness of the harbour environment; increased ability of First Nations to be involved in harbour management; and, improved communication between DND and First Nations.

Since 2006, engagement for the project has been ongoing with the most recent meeting held in April 2016. See Section 2.1.3 for further information about Project related engagement activities.

The confidential TEK identified a wide range of traditional and recreational use in Esquimalt Harbour as well as concerns regarding contamination and deterioration of the harbour environment and loss of access due to other activities in the harbour. While the TEK report is now almost 10 years old, concerns highlighted at recent consultations sessions echo the contamination issues highlighted in the TEK.

2.3.3.7 Archaeology

The proposed Project Areas are situated on federally owned land. Federal legislation applies to all properties that fall under federal jurisdiction, including lands belonging to federal departments such as DND, or locations where the federal government has some regulatory control. There is no comprehensive federal statute directing how (or whether) a given department is supposed to treat archaeological issues on its lands. However, *CEAA 2012* states that one of the purposes of the Act is "to ensure that projects…are considered in a careful and precautionary manner before federal authorities take action in connection with them, in order to ensure that such projects do not cause significant adverse environmental effects" (Section 4(1)(b)). Under CEAA 2012, environmental effects include "any structure, site or thing that is of historical, archaeological, paleontological or architectural significance" (Section 5(1)(c)) and the current use of lands and resources for traditional purposes by Aboriginal persons (i.e. traditional use sites). Ship and airplane wreck sites may also be protected under federal statute if it is determined that they possess characteristics of national historic significance (Historic Sites and Monuments Board of Canada 2000).

The shortcoming of the protection of heritage sites offered under the *CEAA, 2012* is the absence of statutory directives with respect to how these resources and features are to be 'considered' (i.e. managed). Given the absence of a federal regulations outlining how archaeological assessments are to be undertaken on federal lands, an archaeological overview assessment (AOA) (Golder 2015) and an archaeological impact assessment (AIA) (Golder 2016b) of portions of the Project Areas was conducted in general accordance with provincial regulations as described in the *Archaeological Impact Assessment Guidelines* (1998) developed by the British Columbia Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations. Under the terms of the British Columbia *Heritage Conservation Act* (*HCA*), all archaeological sites that predate AD 1846 are automatically protected. Heritage wrecks, consisting of the remains of vessels or aircraft after two or more years have passed since they sank, crashed, or were abandoned, are also protected under the *HCA*.

Esquimalt Harbour is a protected harbour setting with many previously registered archaeological sites representing a wide variety of site types, including precontact village sites with intact cultural deposits, as well as precontact shell midden sites, lithic scatters, subsistence features (i.e. roasting pits), wet sites (archaeological sites found below water table and in the intertidal zone) and associated human burials. Previous research has contributed to the development of a regional chronology that spans over 8,500 years for Vancouver Island and the Lower Mainland. There are also several important historical sites along Esquimalt Harbour, including the original location for the town of Esquimalt.

The registered archaeological site DcRu-136 is located adjacent to the Project Area. The site is located primarily on the bluffs north of Dunn's Nook; however, part of the site extends down to the shore adjacent to the F/G Jetty Project Area (Figure 5). DcRu-136 includes a precontact village site with associated human remains, shell midden deposits and numerous artifacts and features. In addition, there is a historical component associated with 19th and 20th Century industrial use of the area.

DcRu-136 was initially recorded by McMurdo and Hutchcroft in 1978 (Powel 1978); several additional archaeological investigations have occurred at the site in the last 20 years (Golder 1999, 2008, 2016; Matthews 2004; Millennia 2001, 2004, 2012a, 2012b). Archaeological monitoring (personal communication, D'Ann Owens, Millennia Research, March 2013) and AIA (Golder 2016b) in the intertidal and subtidal zones at and adjacent to the site have not identified any precontact archaeological deposits, likely the result of impacts from historical industrial activities that occurred along the shoreline of the Project area.

LEGEND

- REMEDIATION FOOTPRINT (JUNE, 2016)
- DREDGE UNITS (JUNE, 2016)
- FORMER REMEDIATION FOOTPRINT
- ARCHAEOLOGICAL SITE DcRu-136
- AREA OF ARCHAEOLOGICAL POTENTIAL

NOTE(S)

1. SURFACE CONTOURS SHOWN IN 1 m (MINOR) AND 5 m (MAJOR) INTERVALS. ELEVATIONS SHOWN RELATIVE TO CHART DATUM.

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING "DFG Remediation Areas_20160630.dwg."
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
3. FORMER PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA: DRAWING EH_DUs_20140110.DWG.
4. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE. ACCESSED 2016-03-03.
   - 4.1. BATHYMETRY: FILENAME: "COLWOOD_15031.TIF". THE SURFACE WAS USED AS-IS.
   - 4.2. UPLAND: FILENAME: "COL_ENV.DWG" SURFACE CONTOURS ADJUSTED TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.
5. DcRu-136 SITE BOUNDARY OBTAINED FROM REMOTE ACCESS TO ARCHAEOLOGICAL DATA (RAAD).
6. AOA REPORT: GOLDER. 2015. ARCHAEOLOGICAL OVERVIEW ASSESSMENT OF SIX PROPOSED REMEDIAL DREDGING AREAS IN ESQUIMALT HARBOUR, CFB ESQUIMALT, ESQUIMALT, BC. FINAL REPORT PREPARED FOR DCC, MARCH 31, 2015.

0 25 50
1:750 METRES

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	C. MOORE
PREPARED	R. WIGGINS
REVIEWED	C. MOORE
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
ENVIRONMENTAL EFFECTS DETERMINATION

TITLE
ARCHAEOLOGICAL POTENTIAL

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	5

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

DcRu-136 measures approximately 200 m by 130 m. The site has been subject to extensive land alterations due to industrial use, and is considered to be less than 50% intact. Previous archaeological investigations have identified a wide range of precontact cultural activities. The precontact deposits have been radiocarbon dated to approximately 1,400 BP[4], although an older component may be present.

Modern historical refuse was observed throughout the intertidal and subtidal areas during the AIA, the result of the industrial use of the area which included DND construction and use of the F/G Jetty, as well as the Johnson Wilfert lumber mill and a kiln operated by the Rosebank Lime Company (Figure 7). Observed historical materials included significant quantities of bottle and window glass, milled wood and wood debris, metal and rip rap.

The Project is located within the traditional territories of the Songhees Nation and Esquimalt Nation. Both First Nations are concerned with the treatment of archaeological resources in the region, including ancestral remains which are often present in archaeological sites in this area.

An AOA and associated pedestrian field reconnaissance (PFR) was conducted for the Esquimalt Harbour Remediation Project that included a review of the D Jetty and F/G Jetty (Golder 2015). There are no registered precontact archaeological sites located within these Project Areas; however, the precontact archaeological site DcRu-136 is located adjacent to the F/G Jetty Project Area (Figure 5). In addition, the archaeological overview assessment determined that there were locations with potential to contain undocumented precontact archaeological sites within the F/G Jetty Project Area, including along formerly exposed surfaces of seabed which have been inundated by post-glacial sea-level change (Figure 5). The D Jetty Project Area is considered to be in a location of low archaeological potential.

Considering the results of the AOA, Golder (2016b) undertook an AIA in the vicinity of F/G Jetty. No precontact archaeological materials were encountered within the F/G Jetty Project Area as a result of this assessment.

Historical materials, including historical artifacts and culturally modified faunal specimens, have been identified in intertidal and subtidal sediments in the Project Area. It is expected that additional historical materials will be observed in the Project Area during the development.

Based on the results of the AOA of the D Jetty and F/G Jetty and the AIA at F/G Jetty, the following has been recommended:

- Avoidance of archaeological site DcRu-136.
- If avoidance is not possible, the following mitigation procedures are recommended at archaeological site DcRu-136:
  - Archaeological monitoring during dredging activities conducted within the registered site boundary.
- Archaeological inspection of dredgeate from the Project Area at the Processing/Sorting Facility.
- When an archaeological monitor is not present, Project works should be conducted following guidelines for Archaeological Chance Find Management.

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[4] A dating convention usually associated with radiocarbon dating. BP stands for Before Present, with present being accepted as AD 1950 by convention.

No further archaeological work is recommended within the remainder of Project area unless the proposed remediation activities expand significantly beyond those areas reviewed in the AOA (Golder 2015) and subsequently sampled in the course of the AIA (Golder 2016b).

2.4 Project Effects and Associated Mitigation Measures

This section outlines the effects assessment undertaken for the Project. The effects assessment includes effects likely to occur on VECs from Project components, significance of those effects, recommended measures to mitigate effects, and significance of potential residual adverse effects which may occur after mitigation measures have been applied.

Table 6 outlines the criteria that were used to assist in the determination of significance of effects on VECs.

Table 6: Criteria for Significance of Effects

Criterion	Not Significant	Potentially Significant	Significant
Magnitude (of the effect)	**Low -** Effect is evident only at or nominally above baseline conditions.	**Moderate** - Effect exceeds regulatory criteria or published guideline values but is less than that shown to cause a harmful effect.	**High -** Effect exceeds values documented to cause a harmful effect.
Spatial Extent (of the effect)	**Low -** Effect is limited to the immediate project site/footprint.	**Moderate** - Effect extends into local areas beyond the project site/footprint boundary.	**High -** Effect will occur on a regional scale.
Duration (of the effect)	**Low** - Effect is evident only in the short term (i.e. during dredging).	**Moderate** - Effect is evident for up to a year following dredging	**High** - Effects will be evident for more than a year after dredging
Reversibility (of effect)	**High** - Effect is readily reversible (i.e. within days or weeks following dredging).	**Moderate** - Effect is reversible after dredging is finished (i.e. one growing season following dredging)	**Low -** Effect is permanent.

To describe the significance of residual effects for the analysis of potential environmental effects, the following rankings were used:

- “No” indicates that residual adverse effects are not likely to be significant because:
  - Potential residual effect(s) may result in only a slight decline, if any, in resource in study area during the life of the project. Research, monitoring and/or recovery initiatives would not normally be required; or
  - Potential residual effect(s) may result in only a slight decline, if any, in resource in study area during construction phase, but the resource should return to baseline levels.
- “Yes” indicates that residual adverse effects are likely to be significant since:
  - Potential effect(s) could affect long-term sustainability of the VEC and should be considered a management concern. Research, monitoring and/or recovery initiatives should be considered; or

- Potential effect(s) could result in a decline in the VEC to lower-than-baseline but stable levels in the study area after project closure and into the foreseeable future. Regional management actions such as research, monitoring and/or recovery initiatives may be required.

The effects assessment, including affected VECs, description of effects, mitigation measures, and significance of residual effects, is contained in Table 7.

Table 7: Potential effects of the project on each Valued Ecosystem Component (VEC) with mitigation measures

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
Atmosphere	All Project Components	A reduction in air quality in and adjacent to the Project Areas may occur as a result of: • Exhaust emissions from machinery and vehicles. • Potential generation of dust from barge transportation, material stockpiling and demolition work. • Release of hydrogen sulphide (H_2S) from the dredged material as it is placed on the barge. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• A qualified environmental monitor will be on-site during Project activities as outlined in the EMP. • The Contractor will prepare a Dust and Emissions Control Plan as part of the Environmental Protection Plan. • Implement dust control measures (such as the use of water as a dust suppressant) as outlined in the design specification. • Vessels and equipment will be well maintained and in good working order. • Efforts will be made to minimize exhaust emissions. Vessels and equipment will use low sulphur fuels. Idling of vessels and equipment will be minimized. • Hydrogen sulphide (H_2S) monitoring will be undertaken in and around the work area during dredging of subtidal sediment and the contractor will be responsible for preparing a Health and Safety plan detailing appropriate personal protective equipment, training and safe work practices for H_2S. The Occupational Health and Safety Regulation includes an air quality guideline of 10 parts per million for H_2S (ceiling short-term exposure level; Table of Exposure Limits for Chemical and Biological Substances (updated September 15, 2011), Guidelines Part 5 pursuant to the Occupational Health and Safety Regulation.)	No Potential residual effects may result in a slight decrease in air quality during the Project, but these effects are expected to be temporary and not significant.
Surface Water	Mobilization and demobilization Structure removal, relocation and reinstallation Dredging and residuals management Barge dewatering In-water transportation Offloading, stockpiling, processing and potential treatment of contaminated sediment Backfill and material placement	Water quality in and adjacent to the Project Areas may be negatively affected by Project activities through: • Deposit of deleterious substances in water from spills of fuel/oils during all indicated components. • Suspension of solids from: - Structure removal, relocation and reinstatement - Dredging of material/encountered debris and residuals management - Dewatering of dredged material and treatment of effluent - In-water transportation - Offloading, stockpiling, processing and potential treatment of contaminated sediment - Backfill and material placement • Release of contaminants from: - Creosote-treated pilings or old dock structures during removal, cleaning and reinstatement - Re-suspension of contaminated sediments during dredging	For all indicated Project components, the following mitigation measures will be followed for: • A qualified environmental monitor will be on-site during Project activities as outlined in the EMP. • A Water Quality Monitoring Plan (WQMP) has been developed for the Project that outlines performance objectives to be met and water quality monitoring requirements. • The Contractor will prepare a Spill Prevention and Response Plan as part of the Environmental Protection Plan (EPP). • The Contractor will indicate in the EPP the procedures that the Contractor will undertake to meet the water quality performance objectives presented in the WQMP. The WQMP provides water quality performance objectives for dredging and barge dewatering activities: • No passive dewatering will be allowed during dredging of sediments from Dredge Units 4 and 5 on the north side of D-Jetty. Based on the water quality modelling results, a TSS level of 40 mg/L was adopted in the WQMP for day-to-day management of TSS during dredging of DUs 4 and 5 (north). • A TSS limit of 75 mg/L is recommended for barge dewatering at F/G Jetty and remaining DUs of D Jetty (i.e. outside DU 4 and the northern section of 5) to manage physical rather than chemical impacts associated with suspended sediments (DFO and MELP 1992). This TSS level is also adopted in the WQMP for day-to-day management of TSS during dredging. The WQMP presents a TSS-turbidity relationship and a decision framework using real-time turbidity measurements for triggering changes to the dredging activity when the above performance objectives are not being met.	No Potential residual effects may result in a slight decrease in water quality during the Project, but these effects are expected to be temporary and not significant.

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		- Effluent during dewatering of dredged material - Water and/or sediment accidentally discharged during in-water transportation of dredged material - Water and/or sediment accidentally discharged during offloading and stockpiling (including upland equipment decontamination) of dredged material directly into marine waters, overland or through stormwater system Induce turbidity and/or total suspended sediment (TSS) concentrations in the water column may result in a disruption of feeding by visual predators such as juvenile salmon (Berg and Northcote 1985), cause gill abrasions (Birtwell (1999), Servizi and Martens (1987)) and respiratory distress in fish (Berg and Northcote 1985), and temporarily affect photosynthesis by algae (Bilotta and Brazier 2008; CCME 1999). The re-suspension of sediments during dredging and barge de-water also has the potential to release COPCs to the water column. An assessment of the potential for effects related to the contaminants associated with dredged sediment is provided in Annex D. Under the assumptions used in predicting water quality during barge dewatering, and based on the available sediment chemistry data within the areas to be dredged that were modelled, 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. On the north side of D-Jetty, the predicted concentrations of copper and zinc in the discharge water exceed the screening values, including at relatively low TSS concentrations. Dewatering effluent from these areas is expected to be unsuitable for discharge to the marine environment, unless treated prior to disposal.	For structure removal, relocation and reinstallation, the following additional mitigation measures will be followed: • A reasonable attempt will be made to remove the entire creosote-treated pile. • Piles will be removed in a manner that minimises disturbance of seafloor habitats (e.g. using vibratory methods) and to avoid bringing creosote-contaminated sediments to the surface. If the pile breaks off below the biologically-active zone in the sediment, it may not be advisable to dredge the remainder out, depending on the sensitivity of the habitat at the site. • Used/decommissioned piles will be disposed of on land in an appropriate waste management facility (Hutton and Samis 2000). • Work will follow procedures outlined in DFO's 'Guidelines to Protect Fish and Fish Habitat from Treated Wood Used in Aquatic Environments in the Pacific Region (Hutton and Samis 2000). • Cleaning of pilings will, if necessary, will be conducted within the dredge area prior to dredging such that material (e.g. attached biological growth and sediment) is ultimately removed during dredging. • Booms or other measures will be implemented to contain floating debris from pile removal and cleaning. For dredging and residuals management, the following additional mitigation measures will be followed: • Prior to dredging, the perimeter of the dredge area will be delineated using GPS chart plotting software, so that work occurs within the confines of the Project Areas. • A clean silt curtain (i.e. free of sediment) will be used during dredging as outlined in the EMP. The silt curtain will be a minimum of 5 m deep. A Silt Curtain Control Plan will be developed by the Contractor to describe how the silt curtain will be installed and maintained. • The dredge material barge will not be overloaded beyond the top of the side rails, to minimize loss of dredged material and to prevent barge listing or instability. • The contract specifications will include operational controls to minimize disturbance of substrates (for example: controlling the rate of ascent and descent of the bucket; making additional dredge passes rather than dragging bucket or beam to level underwater surfaces; not stockpiling material underwater). • Implementation of monitoring procedures outlined in the WQMP for water quality to verify that water quality guidelines are being met and enable management decisions to be made in the event that they are not met. For barge dewatering, the following additional measures will be employed: • Implementation of monitoring procedures outlined in the EMP and WQMP to verify that the performance objectives are being met and enable management decisions to be made in the event that the performance objectives are not met. • In the event that additives are used to facilitate dewatering of the dredged material, the decant water will be tested prior to discharge to verify that the added constituents will not be harmful to the receiving environment. For in-water transport, the following additional mitigation measures will be employed:	

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• Transport of dredge material and debris will be performed using a barge/vessel with sidewalls of sufficient height to fully contain the dredge material, water, and debris. • Watertight barges will be used if necessary (e.g. where direct dewatering discharges are not considered suitable). Where a watertight barge is not necessary, barge dewatering will be managed to meet dredge performance objectives outlined in the EMP such as through the use of filter fabric to cover drainage features (e.g. scuppers). • The contractor will be required to provide certification of seaworthiness from an independent Marine Surveyor for each haul barge that will be used on the Project. In the event that a barge is damaged during project activities and requires repair, a new certification of seaworthiness will be required. In addition, material transportation by barge will require the contractor to obtain authorization from the Queen's Harbour Master pursuant to the Canada Marine Act and from DND. For offloading, stockpiling, processing and potential treatment of contaminated sediment, the following additional measures will be employed: • The Contractor will prepare a Stormwater Pollution Prevention Plan as a subcomponent of an Environmental Protection Plan. • Contingency stockpiling of dredged material may be necessary if contamination is encountered and additional testing is necessary to evaluate disposal options. In the event that stockpiling is necessary, stockpiles, where practical and feasible, will be located 30 m or greater away from watercourses (space is limited and constrained by operational requirements). • Additional mitigation measures that may be applied to control water quality (in particular where a 30 m buffer is not available) may include: - Construction of stockpile areas using berms or other barrier devices to prevent uncontrolled spreading of debris and/or contaminated sediment - Covering stockpiles to prevent erosion during periods of rain and/or wind • The contractor will construct, operate, and maintain the off-site offloading and stockpile area such that all effluent drainage water, stormwater, or other form of discharges from stockpiled sediment and debris are collected for treatment and proper disposal. - No direct discharge of untreated effluent from the off-site offloading and stockpile area to the receiving waters is allowed - All effluent from the off-site offloading and stockpile area will be collected, treated, and discharged to federal, provincial, and local laws and regulations. Discharge of water from off-site offloading and stockpile area may need a permit or temporary authorization from the Ministry of Environment. To obtain applicable permissions, a Qualified Professional (registered professional scientist or technologist with appropriate training and experience) would need to provide an opinion on whether or not the effluent is deleterious (vis-a-vis the *Fisheries Act*) or has the potential to cause pollution (vis-a-vis the BC *Environmental Management Act*) For backfill and material placement, the following additional measures will be employed: • A clean silt curtain (i.e. free of sediment) will be used during backfill and material placement as outlined in the EMP. The silt curtain will be a minimum of 5 m deep. A	

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
			Silt Curtain Control Plan will be developed by the Contractor to describe how the silt curtain will be installed and maintained. • Chemical testing of Backfill Material is required to assess the acid rock drainage (ARD) and metal leaching (ML) potential of the materials as this can negatively affect water quality. The following laboratory tests will be performed by an independent, certified testing laboratory, hired by the Contractor: - ARD Potential: Acid Base Accounting (ABA) testing - ML Potential: Multi-Element Analysis (ICP-MS) - Shake Flask Extraction (SFE) testing • Guidelines for ARD/ML have been developed for mine sites in Canada and can be used as general guidance in assessing ARD and ML potential for non-mining projects. • Results of laboratory testing of metal leaching will be compared, as a screening benchmark, with provincial and federal ambient water quality guidelines for the protection of aquatic life (a Qualified Professional will determine which guidelines are applicable). If tests results do not meet ambient guidelines, then the Contractor will submit a letter of professional opinion regarding suitability recommendation for use in the Project Areas. • One sample for every one thousand (1,000) m^3 (with an absolute minimum of one sample) of backfill material imported to the F/G Jetty and D Jetty Work Sites will be collected and analyzed per the above tests. The frequency of testing may be increased or decreased by the Owner's Representative if considered appropriate based on the results of testing or visual assessment of imported material. A minimum of one sample will be collected and analyzed for each backfill type if regardless of the volume. • The laboratory utilized by the Contractor must have the appropriate certification in accordance with ISO/IEC Standard 17025. The Contractor will submit documentation showing that the proposed laboratory is certified for the specific parameters of concern and proposed analytical methods. • The Contractor will employ placement means and methods that will avoid re-suspending sea bed sediment during placement activities, and prevent excessive mixing of the placed materials with the sea bed sediment. • The Contractor will not place substrate by rapid dumping of a barge load.	
Substrate	Dredging and residuals management	Dredging may cause slope instability, resulting in physical alterations of the seafloor, if not conducted as per the design specifications. Physical disruption of substrates as it relates to fish and fish habitat is addressed in the Fish and Fish Habitat VEC. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• The Contractor will prevent excessive dredging, the removal of material outside of the dredge prism or below the payable over-dredge allowance, to avoid potentially adversely affecting slope and/or structural stability. • Backfilling will be conducted to replace dredged substrate with substrate resembling the existing conditions and to the existing depth profile	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
Marine Vegetation	Structure removal, relocation and reinstatement Dredging and residuals management Barge dewatering Backfill and material placement	Removal and damage of marine vegetation: Dredging is not proposed to occur on rocky substrate; however, dredging could accidentally occur in these areas if not properly delineated which could remove marine vegetation. Grounding of barges on rocky areas could also damage marine vegetation. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• "No dredge zones" where rocky substrate and associated marine life is present, identified during Golder's habitat surveys in 2016 (Golder 2016a [Annex A]), will be delineated using GPS chart plotting software before dredging and backfill and material placement begins in order to avoid accidental dredging of and placement of substrate vegetated areas. • The barge will not come to rest on the seafloor (no grounding).	No
Marine Vegetation	Structure removal, relocation and reinstatement Dredging and residuals management Barge dewatering Backfill and material placement	Shading of Marine Vegetation: Structure removal/relocation/replacement, dredging, dewatering and backfill and material placement may result in a temporary increase in turbidity within the water column which may shade marine vegetation and temporarily affect photosynthesis by algae (Bilotta and Brazier 2008; CCME 1999). Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	Follow mitigation measures outlined in the Surface Water VEC section above.	No
Marine Invertebrates	Structure removal relocation and reinstatement Dredging and residuals management Barge dewatering Backfill and material placement	Marine invertebrates that occur in the Project Areas may be destroyed through removal of individuals in the benthic sediments, smothered or buried from resettling of suspended sediments, or may be physically damaged by the dredging equipment. Removal of existing piles and structures will result in a temporary loss of habitat for attached biota within the Project Areas. Dredging, dewatering and backfill and material placement may also cause increased turbidity if not mitigated.	Follow mitigation measures outlined in the Surface Water VEC section above. Follow mitigation measures outlined for the Fish and Fish Habitat VEC below.	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		Benthic communities are expected to recover from disturbance related to dredging. Soft sediments even where material is not replaced are expected to recolonize relatively rapidly (Guerra-Garcia et al. 2003; Korhonen et al. 2010). Losses of marine invertebrates attached to structures that are removed are expected to be temporary. Recolonization after structure replacement is anticipated to be sufficient to mitigate losses of marine invertebrates incurred during structure removal. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High		
Fish and Fish Habitat	Mobilization and demobilization Structure removal, relocation and reinstatement Dredging and residuals management Barge dewatering In-water transportation Offloading, stockpiling, processing and potential treatment of contaminated sediment Backfill and material placement	Change to Water Quality: Addressed in the Surface Water VEC. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No
	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	The indicated project components have the potential to physically harm herring eggs and emergent larvae if herring spawn in the in-water work areas. Herring may spawn, incubate and rear in the in-water work areas from late February to late June. Magnitude: Moderate Spatial extent: Low Duration: Moderate Reversibility: High	• Work with potential to affect herring egg masses or emergent larvae will be stopped for 10 to 14 working days if herring spawn is observed within in-water work areas. Work will also be stopped if herring eggs are found on equipment and will not resume until after eggs have hatched.	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Disturbance of Physical Habitat (Substrate): Soft substrate fish habitat will be temporarily disturbed during dredging. Magnitude: Moderate Spatial extent: Low Duration: Moderate Reversibility: High	• Prior to dredging, the perimeter of the dredge area will be delineated using GPS chart plotting software, so that work occurs within the confines of the Project Areas. • The contract specifications will include operational controls to minimize disturbance of substrates during dredging (for example: controlling the rate of ascent and descent of the bucket; making additional dredge passes rather than dragging bucket or beam to level underwater surfaces; not stockpiling material underwater). • Follow additional mitigation measures outlined in the Surface Water VEC section above.	No
	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Disturbance from Underwater Noise: Assessment of the potential effects of underwater anthropogenic noise on fish requires acoustic impact thresholds for which to compare emitted sound levels and establish potential for injury. Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for injury to fish from underwater noise is typically based on 'best available evidence', as documented in the scientific literature and/or established by other government agencies. The U.S. National Marine Fisheries Service (NMFS) have adopted interim acoustic threshold criteria specific to impact pile driving that are based on sounds pressure levels (SPLs) that are known to potentially result in physical effects in fish (Stadler and Woodbury 2009). The current NMFS interim threshold for potential injury to fish is 206 dB re 1 uPa SPL_{peak} (Stadler and Woodbury 2009; FHWG 2008). Underwater noise generated from dredging, structure removal, relocation and reinstatement (which includes pile driving), and backfill and material placement may affect fish behaviour. Impact pile driving also has the potential to exceed injury thresholds for fish (Caltrans 2001; Vagle 2003). Specific, systematic studies regarding the effects of underwater noise and vibrations of fish are limited and in some cases. Popper and Hastings (2009) reviewed the available studies, which addressed the following potential effects mechanisms: behavioural responses; stress and other physiological responses; hearing loss and	• Impact pile driving of steel piles, should it occur, will not take place between April 1 and May 31 due to potential effects from underwater noise on fisheries resources in Esquimalt Harbour. The April 1 to May 31 time period is particularly sensitive due to the potential for herring spawning and out-migration of juvenile salmon in Esquimalt Harbour. • A qualified environmental monitor will be on-site during Project activities as outlined in the EMP. • Monitoring of underwater noise using a hydrophone will be undertaken during impact pile driving, should it occur, to ground-truth the assessment predictions and determine if injury thresholds are being exceeded. • Monitoring for signs of dead fish will be undertaken by the environmental monitor. • The following mitigation measures may be employed if underwater noise monitoring determines that injury thresholds of fish are exceeded or if dead fish are observed: - Work will be suspended and DFO consulted on the course of action to take to reduce underwater sound levels to below injury thresholds. - Measures to reduce sound transmission (e.g., bubble curtains, isolation casing, coffer dams, cushion blocks). - Measures to reduce sound generated by the pile (e.g., design specifications, pile-driving equipment used).	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		damage to auditory tissues; structural and cellular damage on non-auditory tissues; and mortality. Depending on the species of fish and the nature of the noise exposure (e.g. duration, peak pressure, rise times, accumulation of energy with time), underwater noise may result in: • Startle responses or migration out of areas (behavioural response). • Increased levels of corticosteroid levels, which is an indicator of stress. Stress may impair a fish's ability to avoid predation. • Hearing loss. Inability to hear may affect a fish's ability to respond to other noise cues and thus be more susceptible to predation or less able to find food items. • Tears or rupture of the swim bladder or other tissues, which may affect buoyancy or cause internal bleeding and ultimately mortality. **Dredging** Clamshell dredging produces continuous, non-pulsive underwater noise and produces in-water SPLs ranging from 150 to 162 dB (re to 1 μPa) at 1 m from the source (Richardson et al. 1995). This is below the injury threshold for fish (206 dB SPL_{peak} re 1 μPa) (Richardson et al. 1995; Stadler and Woodbury 2009; FHWG 2008); therefore injury to fish is not expected. Potential effects related to underwater noise from clamshell dredging will likely be restricted to behavioural disturbance. **Pile Driving** Vibratory pile driving of timber piles is expected to be used during this Project. Vibratory pile driving produces continuous, non-impulsive underwater noise. In-water SPLs for vibratory pile driving have been recorded in the range of 165 dB (re 1 μPa; Caltrans 2015) and are not expected to exceed the injury threshold for fish (206 dB SPL_{peak} re 1 [μPa]) (Stadler and Woodbury 2009; FHWG 2008). Vibratory pile		

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		driving noise may cause changes to fish behaviour (Caltrans 2015). Should impact pile driving of steel piles occur, it would have the potential to create sound pressure levels which could exceed 206 dB SPL_{peak} re 1 (μPa) and may adversely affect fish through direct mortality, sublethal injuries, or behavioural changes (Caltrans 2015; FHWG 2008; SLR 2014). Impact pile driving (by hammer) is typically louder than clamshell dredging or vibratory pile driving. In-water SPLs ranging from 131 to 135 dB (re 1 μPa) have been measured 1,000 m from the source and up to 200+ dB (re 1 μPa) at 1 m from the source (Richardson et al. 1995). Based on reported SPLs for steel piles of equivalent dimensions as the timber piles proposed for the Projects, and standard noise attenuation losses in water (assuming simple spherical spreading), fish would not be expected to experience physical injury from sound pressures generated by impact pile-diving of steel piles unless they were <4 m from the source (Annex E). Impact pile driving noise will also likely cause changes to fish behaviour. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High		
Aquatic Mammals	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Disturbance from Underwater Noise: The potential effects of underwater noise on marine mammals depends, to a degree, on the type of marine mammal involved as well as the characteristics of the sound emitted including the received sound level and the frequency content of the received sound signal relative to the hearing abilities of the animal. The potential zone of effect of anthropogenic sound is also influenced strongly by the properties of natural background (ambient) sound present in the area of exposure (Richardson et al. 1995) and local sound transmission properties which are	• A qualified environmental monitor will be on-site during Project activities as outlined in the EMP. Aquatic mammal monitoring will be implemented during all in-water Project activities as a component of the environmental monitoring, with presence/ absence communicated to the contractor. • Should impact pile driving of steel piles be required for pile installation, the following mitigation measures will be implemented by the EM who will also be a certified Marine Mammal Observer (MMO) with relevant marine mammal monitoring experience: - A marine safety perimeter of 100 m will be visually monitored during impact pile driving activities should they occur. If an aquatic mammal enters the marine safety perimeter during impact pile driving, these activities will be suspended until such time as the aquatic mammal departs outside the marine safety perimeter. Activities will not resume until it is visually confirmed that the aquatic mammal is	No With the implementation of marine safety perimeters, no injury to marine aquatic mammals is anticipated from underwater noise associated with Project activities. Potential effects will likely be limited to behavioural disturbance to a few individuals during

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		determined by site-specific environmental factors such as seafloor bathymetry, substrate composition and water column characteristics. The potential for the Project to affect aquatic mammals is related to underwater noise generated from clamshell dredging and the installation of piles in the marine environment. Potential effects range from subtle changes in behaviour (i.e. avoidance) at low received levels to strong disturbance effects or temporary/ permanent hearing impairment at high received levels. There are currently no applicable underwater noise criteria for physical injury or behavioural disturbance in Canadian legislation (*Fisheries Act* or other). In absence of specific legislated underwater noise criteria in Canada, DFO bases its assessment of potential 'serious harm' to aquatic mammals on the best currently-available science. It also relies on the United States standards employed by the National Marine Fisheries Service (NMFS) (NOAA 2016; see Appendix E). For the assessment, the following NMFS thresholds for aquatic mammal injury and behavioural disturbance from impulsive and non-pulsive sounds (NOAA 2016) were applied: • Injury Thresholds: 190 dB re 1 μPa SPL_{rms} for pinnipeds, and 180 dB re 1 μPa SPL_{rms} for cetaceans. • Disturbance Threshold: 160 dB re 1 μPa SPL_{rms} for all aquatic mammals. Clamshell dredging produces in-water SPLs ranging from 150 to 162 dB (re to 1 μPa) at 1 m from the source (Richardson et al. 1995). These sounds are below the injury threshold for aquatic mammals. Vibratory pile driving of timber piles is expected to be used during this Project. Vibratory pile driving produces continuous, non-impulsive underwater noise. In-water SPLs for vibratory pile driving are not expected to exceed the injury threshold for aquatic mammals (190 dB re 1 μPa SPL_{rms} for pinnipeds; 180 dB re 1 μPa	outside the marine safety perimeter, or if a minimum of 10 minutes has elapsed since the animal was last sighted within the safety perimeter. - Concurrent multiple underwater noise generating activities will be minimized where practicable (e.g. avoiding multiple pile driving activities at the same time). Where multiple underwater noise generating activities are planned they will be sequenced where possible to minimize cumulative underwater noise effects. - Additional mitigation measures outlined in the Fish and Fish Habitat VEC section above will be followed for pile driving that may result in sound levels which exceed the injury thresholds for pinnipeds and/or cetaceans.	specific in-water work activities. No effect at the population level is anticipated and behavioural disturbance, should it occur, will likely be confined to a small number of individuals due to the overall low density of aquatic mammals present in the harbour at any given time.

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		SPL_{rms} for cetaceans) (NOAA 2016; Caltrans 2015). Vibratory pile driving noise may cause changes to aquatic mammal behaviour. Should impact pile driving of steel piles occur, it would have the potential to create sound pressure levels which could exceed the injury thresholds for aquatic mammals (Southall et al. 2007). The underwater sound pressure levels caused by pile driving can be harmful to marine animals (Casper et al. 2012; Halvorsen et al. 2011; Halvorsen et al. 2012). The generation of underwater noise during pile driving and the probability of impact are dependent on the type of pile being driven, the type of hammer, substrate type, water depth and the species auditory capabilities (ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009). Impact pile driving (by hammer) is typically louder than clamshell dredging or vibratory pile driving. In-water SPLs ranging from 131 to 135 dB (re 1 μPa) have been measured 1,000 m from the source and up to 200+ dB (re 1 μPa) at 1 m from the source (Richardson et al. 1995). Based on these reported values and standard noise attenuation losses in water (assuming simple spherical spreading), aquatic mammals would not be expected to experience physical injury/hearing impairment from sound pressures generated by pile-diving unless they were <18 m from the source (Annex E). Behavioural disturbances of aquatic mammals are expected to be experienced up to 400 m from the pile should impact pile driving of steel piles occur, but only up to 2 m if vibratory methods are used. Magnitude: Low Spatial extent: Moderate Duration: Low Reversibility: High		
Birds	Mobilization and demobilization Structure removal, relocation and reinstatement	Effects to nests and nesting birds: Several osprey nests are located adjacent to the Project Areas. Osprey nests may be occupied by adults, eggs and young from March 21 to September 5 according to "Guidelines for Raptor	• A qualified environmental monitor will be on-site during Project activities as outlined in the EMP. • During Project works within the buffer area between March 21 and September 5, monitoring will be undertaken by a qualified professional to monitor for nesting and	No No residual effects are expected to ospreys

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
	Dredging and residuals management Backfill and material placement	Conservation during Urban and Rural Land Development in British Columbia" (Government of BC 2013). Loud noises from equipment may be considered 'molestation' if this causes the birds to abandon active nests. MOE (2014) recommends a quiet buffer of 200 m for raptor nests (such as osprey nests) during the breeding season in urban areas. Some project components are within this 200 m buffer. Refer to the Species at Risk section for effects relating to barn swallow. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: Moderate	for bird behaviour if nesting. If disturbance is observed, Project works may need to be modified or stopped until nesting is complete or reduced to a level which does not disturb the nesting ospreys.	that nest adjacent to the Project Areas. Ospreys may avoid the area during the Project, but may return to nest in the area after the Project is complete.
Birds	Mobilization and demobilization Structure removal, relocation and reinstatement Dredging and residuals management Barge dewatering In-water transportation Backfill and material placement	Migratory birds may forage or temporarily occur in surface waters in and adjacent to the Project Areas, and could be negatively affected if a harmful substance is deposited into surface waters. Section 5 of the federal *Migratory Birds Convention Act* prohibits the deposit of substances harmful to migratory birds into waters or areas frequented by migratory birds. Magnitude: Moderate Spatial extent: Moderate Duration: Low Reversibility: High	• Follow mitigation measures outlined in the Surface Water VEC section above.	No
Species at Risk – Birds	Structure removal, relocation and reinstatement	Barn swallows, listed under COSEWIC but not SARA, have potential to nest under the structures proposed to be removed. Section 34 of the provincial *Wildlife Act* prohibits the injury, molestation, or destruction of birds, bird eggs, nests of eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl, and nests occupied by a bird or its eggs. Therefore, if a barn swallow nest is removed when the nest	• Structures should be removed outside of the breeding season. The breeding season is considered to be March 1 to August 31 for passerines, including barn swallows, according to MOE (2014) which also encompasses the regional nesting period for the area (Region A1) as indicated by Environment Canada and Climate Change (2016b). Prior to removal, surveys for old nests should be undertaken. If old nests are found on structures to be removed, Environment Canada and the Ministry of Environment should be consulted first before removal. • If structures are to be removed during the breeding season, non-intrusive surveys should be conducted to determine the presence of active nests immediately before structures are to be removed. If fully formed nests containing eggs or young are encountered, removal of the structures will be halted and the Contractor or	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
		is occupied by a bird or its egg, it would be considered an offence under the *Wildlife Act*. Section 6 of the Migratory Birds Regulations under the federal *Migratory Birds Convention Act* prohibits disturbing or destroying a migratory bird or its eggs except when authorized. The barn swallow is protected under this *Act* (Environment and Climate Change Canada 2016). Permits are only issued for certain activities such as for hunting and scientific purposes. Permits are not issued for nest disturbance or destruction during construction activities which is considered incidental take. Instead, best management practices are to be employed. Magnitude: Moderate Spatial extent: Low Duration: Low Reversibility: High	Environmental Monitor will inform the Departmental Representative to determine whether a permit from the Canadian Wildlife Service is required to remove the nest.	
Species at Risk – Fish	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Two listed fish species have potential to occur in the Project Areas (canary rockfish and cutthroat trout); however, none have been observed in the Project Areas. Effects to these fish species would be similar to the effects to fish. Refer to effects in the Fish and Fish Habitat section above. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• To mitigate effects to these species, mitigation measures outlined in the Surface Water and Fish and Fish Habitat VEC sections will be followed.	No
Species at Risk – Abalone	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Abalone, a SARA Schedule 1 threatened species, are present within boulder habitat beneath D Jetty adjacent to the D Jetty Project Area and could be affected by sediment mobilization during dredging, structure removal, relocation and reinstatement, and backfill and material placement. Magnitude: High Spatial extent: Low Duration: Low Reversibility: High	• A clean (i.e., free of sediment) silt curtain will be installed adjacent to the D Jetty Project Area to mitigate potential changes in water quality from affecting potential abalone habitat identified adjacent to the Project Area during all in water works. The silt curtain will be a minimum of 5 m deep. • A Silt Curtain Control Plan will be developed by the Contractor to describe how the silt curtain will be installed and maintained. • An abalone field assessment will be conducted in accordance with DFO survey protocol guidance (e.g. conducted during nighttime) to survey for potential abalone presence in areas previously identified as potentially suitable abalone habitat and to delineate their habitat for implementation of a silt curtain.	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
Species at Risk – Aquatic Mammals	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Three SARA-listed marine mammal species have some potential to occur in the Project Areas including Steller sea lions, harbour porpoise and killer whales. Steller sea lions, killer whales and harbor porpoise have been observed in Esquimalt Harbour; however, Esquimalt Harbour is not considered important habitat for these species. Magnitude: Low Spatial extent: Moderate Duration: Low Reversibility: High	• Mitigation measures outlined for the Aquatic Mammals VEC will be implemented to mitigate effects to these marine mammals.	No
Transportation	Upland transportation and disposal	At the current stage of project development, potential project use of public roads to remove dredged material is unknown.	• Should the Contractor choose to transport dredged material and debris for disposal using public roads, a Traffic Management Plan will be developed as part of the EPP.	No Residual effects are expected to be low and not significant as a result of an incremental increase in truck traffic associated with delivery of materials to the Project Areas.
Navigation	Mobilization and demobilization Structure removal, relocation and reinstatement Dredging and residuals management Barge dewatering In-water transportation Offloading, stockpiling, processing and potential treatment of contaminated sediment Backfill and material placement	Potential temporary changes to no access zones during remedial dredging activity; and Incremental vessel transit associated with disposal of dredged material and marine transportation of equipment and supplies to the remediation site to support dredging work. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Follow the QHM Operations Protocols starting with informing QHM on marine VHF channel 10 or by telephone at (250) 363-2160 forty-eight hours before any Project related vessels are expected to enter the harbour. • When possible, work with QHM to schedule work to minimize disruptions. • Develop an emergency docking plan that includes planning for the relocation of damaged Project equipment, so that in this event, vessels or equipment know where they should go, and can do so quickly. • A Notice of Works under the *Navigation Protection Act* will be submitted to Transport Canada. • A navigation management plan will be developed as part of a larger dredge management plan to address potential navigation concerns for barging of dredge materials to be disposed of at the offloading site.	No Residual effects are expected to be low and not significant as a result of an incremental increase in vessel traffic during the Project.
Commercial, Recreational,	Structure removal, relocation and reinstatement	Changes in biophysical conditions for fish and seafood, and effect on availability of fish and seafood resources for harvest.	• Implement mitigation measures outlined in Surface Water Quality and Fish and Fish Habitat VECs to mitigate any changes to biophysical conditions that may influence resource availability.	No

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
and Aboriginal Fisheries	Dredging and residuals management Backfill and material placement	Change in seafood harvest area, and access including navigation, due to potential temporary changes to no access zones, and/or movement of project associated marine vessels. Effects on commercial crab harvesting are not anticipated as fishing and crab harvesting should not occur within the 200 m buffer around the jetties. Temporary change in noise conditions, and effect on outdoor recreational environmental setting. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Implement mitigation measures outlined in Navigation VEC to mitigate changes in access. • Implement mitigation measures outlined in Noise VEC to mitigate changes in environmental setting.	
Land and Marine Based Non-consumptive Recreation	None	No change in Land and Marine Based Recreation is anticipated because the Project is located at existing jetty sites that are currently used by DND vessels and personnel and Project activities are consistent with the current land uses and designations at the remediation sites.	N/A	N/A
In-Air Noise, Light and Odour	All Project Components	Temporary changes in noise, light and odour levels is anticipated from all Project components. Noise generated during Project activities may disturb the peace, rest, comfort or enjoyment of a person in the vicinity of the Project Areas. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• Maintain equipment in good working order and switch it off when not in use. • Implement best practices for construction such as installation mufflers on machinery for noise control. • Workers should wear appropriate personal protective hearing equipment. • Equipment and machinery will be operated to be in compliance with the Bylaw to Regulate Noise within the City of Colwood (Bylaw No. 38) (2001), the Township of Esquimalt (ToE) Property, Unsightly Properties and Nuisance Bylaw No. 2826 (2014), and the Town of View Royal Noise Bylaw No. 523 (2003). • Pile installation methods which produce less noise (i.e. vibratory hammers) than impact hammers will be used where practical. • Undertake noisier work during daytime, weekday hours and modify activities based on resident feedback. • Spotlights will be directed away from residential areas or lights will be fitted with shrouds to direct light to the immediate work area. • Contractor to meet the limits within the Township of Esquimalt's Nuisance bylaw and the City of Colwood's Nuisance Controlled Substance bylaw with respect to odour and disturbances.	No Residual effects are expected to be low and not significant as a result of a slight increase in noise, light and odour in the Project Areas during Project activities. These effects are expected to be temporary and last only for the duration of the Project.

VEC(s) Affected	Project Component(s)	Description of Effects	Mitigation Measures	Residual significant adverse effects
First Nations Traditional Activities	All Project Components	Projects take place in the traditional territory of the Esquimalt and Songhees First Nations. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: High	• DND will continue to engage with the Songhees and Esquimalt First Nations regarding the project, including continued implementation of the First Nations Involvement Plan. • When possible, work with the Songhees and Esquimalt First Nations to schedule work to minimize disruptions. • Develop and implement a Project communications plan with the Songhees and Esquimalt First Nations outlining project notification procedures and processes for receiving input on work schedule.	No
Archaeology	Structure removal, relocation and reinstatement Dredging and residuals management Backfill and material placement	Proposed project-related activities, notably dredging, have the potential to impact archaeological materials or other heritage resources located in the surface and sub-surface areas of the seabed within the Project Areas by disturbing or destroying cultural deposits and features, damaging artifacts, and destroying contextual information that is essential for interpreting site function and age. Magnitude: Low Spatial extent: Low Duration: Low Reversibility: Low	• Per the results of an AOA of the Project Area and an AIA at F/G Jetty, Project activities will not impact registered archaeological sites in the vicinity of the Project Area. Mitigation measures for the protection of archaeological resources may consist of: - Avoidance of archaeological sites and areas of archaeological potential - Conducting additional AIA as necessary and/or monitoring during Project activities (i.e. dredging or geo-environmental testing) causing sub-surface impacts to archaeological site DcRu-136 and in those areas identified as having archaeological potential - When an archaeological monitor is not present, conducting Project works following guidelines for Archaeological Chance Find Management - Archaeological inspection of dredgeate from the Project Area at the Processing/Sorting Facility	No

2.5 Residual Effects

No significant adverse residual effects are expected for the Projects. With the implementation of mitigation measures outlined in this EED report and application of the EMP, WQMP, and EPP, it is anticipated that potential adverse effects to VECs will be mitigated. The Project OPI is responsible for the implementation of all mitigation measures. Overall, the Projects are expected to result in a net benefit to the environment based on the removal of historical contamination.

The Projects will be submitted to DFO for review to confirm that no serious harm will occur after mitigation.

2.6 Habitat Offsetting

Habitat offsetting requirements are limited to those Project activities that are likely to cause residual serious harm to fish and fish habitat. Based on our understanding of the proposed project activities as described in Anchor (2016a), Project activities such as structure removal, relocation and reinstatement, dredging and residuals management, and backfill and material placement have the potential to cause harm to fish and fish habitat. After avoidance and mitigation measures are applied, the proposed project activities for the FGOP and CSRP are not anticipated to cause residual serious harm to fish. As such, habitat offsets will not be required for the project. Further details are included within the Habitat Offsetting Review and Update which has been developed for the Project and is included in Annex B (Golder 2016c).

2.7 Environmental Monitoring

Environmental monitoring will be conducted during Project activities to oversee, evaluate, and report on the effectiveness of the above-referenced mitigation measures. A qualified environmental monitor(s) will be retained for the Project and will be on-site during Project activities to conduct environmental monitoring if or as required. Specific details regarding water quality monitoring required for the project will be outlined within the WQMP. All other types of environmental monitoring (e.g., marine mammal monitoring) as required will be outlined in detail within the EMP.

2.8 Environmental Management Plan (EMP)

An EMP will be prepared and implemented for these Projects. The purpose of an EMP is to provide guidance to the contractor with a comprehensive set of guidelines for protecting VECs during the Project by avoiding, where possible, and mitigating potential adverse effects. The EMP includes sections on applicable environmental legislation and regulations, environmental monitoring responsibilities, and environmental construction requirements (including performance objectives for managing water quality). The contractor will be required to provide the PWGSC Project Manager with an EPP to detail how the environment will be protected as laid out in the EMP.

2.9 Public Participation

The Projects will be conducted on DND administered lands within CFB Esquimalt. DND has conducted stakeholder consultations in advance of Project initiation and consulted with groups such as the Esquimalt Harbour Advisory Committee to identify and address public and other stakeholder concerns. A Public Communications Plan (Golder 2014b) has been prepared for the A/B Jetty Recapitalization Project by Golder on behalf of DCC and DND. This plan outlines the proposed process for keeping the public informed of key components of harbor-wide projects including the CSRP and FGOP.

The objectives of this Public Communications Plan include the following:

- Clearly communicate the potential effects and benefits of the Project on Esquimalt Harbour and on stakeholders. This will include temporary alteration of the viewscape for residents of View Royal.
- Establish realistic expectations for what this Project will achieve in the short term and the long term.
- Build on the relationships, past communications, and public involvement work conducted by DND, DCC, and PWGSC.
- Fulfill the requirements set by Federal agencies, including DND, DCC, PWGSC and DFO, in support of regulatory approval for the Project.

The Public Communications Plan identifies stakeholders that are anticipated to be engaged for the Projects. Through a review of past federal Projects within the Esquimalt Harbour, individuals and organizations have been identified who may have an interest in the Project, including the following four key audiences: regulatory agencies; adjacent businesses and residents; local governments and other government agencies; and Esquimalt Harbour users.

A review of key issues raised in previous federal public communication activities for the Esquimalt Harbour has been conducted. The review has identified anticipated concerns about the proposed Project activities that may affect these key audiences. Information packages have been designed to communicate important facts about the Projects, and include information on what steps have already occurred, what these Projects will involve, why it is taking place, how potential effects will be mitigated, and how the Projects fit with other initiatives occurring in the Esquimalt Harbour. Communication channels have been developed to engage stakeholders and the public and include face-to-face meetings, print communications, public information sessions, a Project website and press releases. The goal of these communications are to reach target audiences and to communicate the Project's planned remediation activities to stakeholders and members of the public in a relevant and timely manner.

The plan details proposed public communications activities to support necessary permitting for the Projects to proceed, and provides an outline of recommended activities through the implementation period to anticipated close-out to monitor and respond to emerging issues or concerns once work is underway. The plan is designed as a flexible document that can be adjusted to meet emerging Project needs (Golder 2014b).

A Public Information Session (PIS) was held on March 25, 2015 at the Songhees Nation Wellness Centre in Esquimalt, BC. Prior to the event, the PIS was advertised in local newspapers, and a mail out was sent to local mayors, councils and residents inviting their participation. The PIS was facilitated by the Base Commander and key senior staff from Formation Safety and Environment at CFB Esquimalt and Golder public engagement staff. Poster boards and information handouts were prepared that summarized the planned remediation activities to stakeholders and members of the public. Further PIS and First Nations engagement meetings are planned for fall 2016.

2.10 Aboriginal Community Engagement

This section summarizes collected background information on the Aboriginal groups that may be affected by the DND Project. Included is a description of how DND determined which Aboriginal groups needed to be engaged. The Aboriginal groups that will be potentially affected are identified based on guidance from DND and publically available information from the Province of British Columbia. Based on this information, DND concluded that the following groups and organizations have Aboriginal interests in the Project Areas:

- Esquimalt Nation
- Songhees Nation
- Te'mexw Treaty Association, representing the Malahat Nation, Scia'new (Beecher Bay) First Nation, Snaw-naw-as (Nanoose) First Nation, Songhees Nation, and the T'Sou-ke (Sooke) Nation
- Hul'qumi'num Treaty Group, representing the Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus (Chemainus) First Nation
- Métis Nation British Columbia
- Métis Nation of Greater Victoria

There are two First Nations communities with Indian Reserves (IRs) on Esquimalt Harbour and thus considered local to the Project Areas: the Esquimalt Nation on the Esquimalt IR) and the Songhees Nation on New Songhees IR 1A. These IRs are located on Plumper Bay on the east shore of the harbour, adjacent to the Esquimalt Graving Dock and approximately 700 m north of CFB Esquimalt.

The Esquimalt and Songhees Nations are Douglas Treaty Nations. The Douglas Treaties include a series of treaties signed in the 1850's by the Crown and Vancouver Island First Nations, including what are now the Esquimalt and Songhees Nations. Use of Esquimalt Harbour for the exercise of treaty rights or for other traditional purposes by the Esquimalt Nation and Songhees Nation has decreased since approximately 1960. Current use is related to non-harvesting activities; however, the Esquimalt Nation and Songhees Nation have indicated to DND that this current use does not reflect their past use or desired future use of the harbour for their "food basket," made up in part by seafood (i.e. ling cod, rockfish or rock cod, clams, mussels, sea urchin, crab, shrimp, and prawns) and waterfowl (i.e. duck and geese).

As part of the Te'mexw Treaty Association (TTA), the Songhees Nation is negotiating a final agreement with Canada and British Columbia through the British Columbia Treaty Commission (BCTC) process. There are five member First Nation that form the TTA: Malahat Nation, Scia'new (Beecher Bay) First Nation, Snaw-naw-as (Nanoose) First Nation, Songhees Nation, and the T'Sou-ke (Sooke) Nation. All of these First Nations have IRs located within the Capital Regional District, except for the Snaw-naw-as First Nation who have an IR situated on Nanoose Bay in the Regional District of Nanaimo.

The Esquimalt Nation is not participating in the BCTC process.

In addition to the Esquimalt Nation, Songhees Nation and the TTA, the First Nations Consultative Areas Database (accessed online March 1, 2016) maintained by the Province of British Columbia identifies Hul'qumi'num Treaty Group (HTG) member First Nations as having potential interests in Esquimalt Harbour, based on a large asserted marine (non-core) territory.

Like the TTA, the First Nations of the HTG are collectively negotiating a final agreement with Canada and British Columbia through the BCTC process; the HTG are currently at Stage 4 of the six-stage BCTC process. The six member groups of the HTG are Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, Penelakut Tribe, and Stz'uminus (Chemainus) First Nation. The closest HTG community to Esquimalt Harbour is located approximately 45 km to the north by the City of Duncan, BC. The HTG have indicated previously to DND that Esquimalt Harbour is a "lower priority" in relation to their interests, but have recommended that HTG member communities be notified about DND activities by letter.

It is not known if the Métis use Esquimalt Harbour, including the Project Areas, for harvesting purposes. Métis Nation British Columbia (MNBC) is an Aboriginal organization routinely identified by the Canadian Environmental Assessment Agency for BC-based Projects subject to review under the *Canadian Environmental Assessment Act, 2012*. MNBC represents 34 chartered communities in BC, including the Métis Nation of Greater Victoria (MNGV); MNGV is the Métis local for the Capital Regional District, which includes Esquimalt Harbour. There have been no previous communications between DND and MNBC or other Métis representative groups.

2.10.1 First Nations Communications for the Project

This section describes the approach, methods and actions that DND undertook to engage Aboriginal Groups prior to and during the environmental assessment process. The comments and concerns of Aboriginal groups, and the process for addressing these comments and concerns are summarized.

DND recognizes the importance of effectively engaging Aboriginal groups with Aboriginal interests in the Project Areas. The objective was to support positive, productive and long lasting relationships with affected Aboriginal communities that properly addressed applicable legal and regulatory requirements. DND has committed to providing Aboriginal groups opportunities where appropriate to engage in the project and to provide meaningful input for consideration.

A First Nations Communications Plan (Golder 2014a) was prepared for the Project that provided for a communications stream between DND and First Nations that is separate from the Public Communications Plan (Golder 2014b). This plan details communication activities with First Nations from Fall 2014 through to Project implementation (Fall 2016) to support the preliminary draft EED and the necessary permitting for the Project to proceed, and provides an outline of recommended activities through to implementation close out (December 2022) to monitor for emerging issues or concerns once the Project work is underway. The Plan is intended as a living document that can be adjusted as the Project and DND communications with First Nations evolve.

Through a combination of formal correspondence, face-to-face meetings, and telephone / e-mail communications, the plan (and amendments, as necessary) accomplished the following measurable and tangible outcomes as a result of its implementation:

- Obtained and demonstrated the incorporation of meaningful First Nations feedback on the preliminary draft EED report for the Project, including mitigation measures, habitat offsetting, and environmental / archaeological management plans;
- Produced appropriate documentation of communications activities, First Nations interests and concerns, DND responses, and key outcomes;

- Met First Nations communications requirements and expectations of applicable federal / provincial agencies, such as DFO; and
- Fostered First Nations support for the Project.

The plan anticipates that the HTG member First Nations and MNBC / MNGV will be formally notified of the Project, but that the focus of ongoing communications activities are with the Esquimalt Nation and Songhees Nation, in recognition of their unique history, interests, and concerns relative to Esquimalt Harbour (Golder, 2014a, 2014d). Meetings with the Chief of the Esquimalt Nation were held on September 25 and November 13, 2014. A presentation on the Esquimalt Harbour Remediation Program (EHRP), including D Jetty and F/G Jetty, was made to the Chief and Council of the Esquimalt Nation on March 7, 2016. A meeting with the Chief of the Songhees Nation was held on January 8, 2015. Presentations on the EHRP, including D Jetty and F/G Jetty, for the Songhees Nation Chief and Council were conducted on February 4, 2015 and May 4, 2016.

2.10.2 Aboriginal Activities

Use of Esquimalt Harbour for the exercise of treaty rights or for other traditional purposes by the Esquimalt Nation and Songhees Nation has decreased since approximately 1960. Current use is related to non-harvesting activities; however, the Esquimalt Nation and Songhees Nation have indicated to DND that this current use does not reflect their past use or desired future use of the harbour for their “food basket,” made up in part by seafood (i.e. ling cod, rockfish or rock cod, clams, mussels, sea urchin, crab, shrimp, and prawns), as well as waterfowl such as ducks and geese.

2.10.3 Communication Results

Leadership from the Esquimalt Nation and Songhees Nation have been provided Project-related information for their review and comment, including mapping of the six remediation areas. Separate face-to-face meetings on the Project were conducted with Chief and Council from the Esquimalt Nation and Songhees Nation. Draft environmental assessment documents were also provided to the Esquimalt Nation and Songhees Nation for their review and comment. DND has a standing offer with the Chief and Council from both the Esquimalt and Songhees Nations to conduct a site visit to the proposed Project Areas. Comments provided by the First Nations from these communications are summarized below.

First Nations expressed considerable support for the Project. Specific concerns regarding proposed Project activities include how and where the dredged sediments from the Project will be disposed of and whether dredging and shipping activities associated with CFB Esquimalt and Esquimalt Graving Dock will further disturb contaminated sediments, possibly contaminating other locations in the Esquimalt Harbour. DND has committed to sending the contaminated sediments from the remediation areas to a permitted off-site facility for disposal. DND acknowledged that preliminary studies suggests contaminants can move limited distances over time. However, it is unlikely that that the sediments from the EHRP will contaminate other areas of Esquimalt Harbour over the next 50 years.

Both the Esquimalt and Songhees Nations expressed interest in the potential economic opportunities for their First Nations from this Project, including employment and training opportunities. The Esquimalt and Songhees Nation’s majority owned Salish Sea Industrial

Services Ltd. (Salish Sea) has experience in conducting dredging activities. In addition, Salish Sea is currently constructing on the Esquimalt and Songhees Nations IR a ‘Sediment Separator Facility’ to clean water and sediments of contaminants.

DND has indicated that Defence Construction Canada (DCC) has contracting opportunities for the EHRP as a whole, including potential Aboriginal set-asides. DND will make DCC aware of the First Nation’s interest and as new contracting opportunities present themselves, DND will alert the Esquimalt and Songhees Nations. DND has also at the Esquimalt Nation’s request conducted a tour of Salish Sea’s Sediment Separator Facility located adjacent to the Esquimalt Harbour in Esquimalt.

Both the Esquimalt and Songhees Nations expressed considerable concern with the implications of Health Canada’s Seafood Consumption Advisory for the Esquimalt Harbour, especially as it relates to the consumption of their traditional foods from the harbour. These foods are an important part of the community member’s diet, and have a critical role in their traditional ceremonies. Traditional foods include not only those listed in the Seafood Consumption Advisory, but also waterfowl, clams and mussel, as well as several species of fish. There were also concern that the Project may interfere with fishing at the entrance to the Esquimalt Harbour.

DND acknowledges these concerns and indicated that this is one of the principal reasons for proceeding with the Project. While the Esquimalt Harbour will never be as it once was before industrialization, there should be significant improvements as a result of the Project that include the remediation of six highly contaminated locations within the Esquimalt Harbour, as well as construction of additional habitat for marine life in the Esquimalt Harbour. At their request, DND has also presented the First Nations with a draft poster board on the Seafood Consumption Advisory established by Health Canada. DND has also committed to investigating how to best accommodate fishing activities in Esquimalt Harbour, respecting the fact that there are security requirements that will not allow private vessels to come too close to the Jetties; DND will raise this concern with the Queen’s Harbour Master at CFB Esquimalt.

Songhees Nations has community events that include activities on the Esquimalt Harbour. For instance, there is an annual canoe race from their IR through the entrance to Esquimalt Harbour. DND has indicated that they can accommodate this race if provided with proper notice; DND has alerted the Queen’s Harbour Master at CFB Esquimalt of this issue.

First Nations expressed a concern about the potential for previously unidentified archaeological sites to be affected by the remediation activities in the Project Areas. DND has completed an archaeological overview assessment (Golder 2015) of the three proposed remediation areas in Esquimalt Harbour for the Project. Subsequently, an AIA was completed at F/G Jetty in 2015 (Golder 2016b).

First Nations have been engaged with details of the Project. DND has committed continuing to work with Aboriginal groups to identify potential adverse effects of the Project on Aboriginal interests. The future involvement of identified First Nations will be incorporated into the Project based on the results of the communication process.

2.11 Conclusion

This EED report identifies potential effects to physical, biological and socio-economic VECs in the Project Areas and mitigation measures to minimize or eliminate these effects. Mitigation measures outlined in this EED report will be developed further within the Environmental Management Plan (EMP) and Water Quality Monitoring Plan (WQMP), which will be developed for the Project to provide guidance for the development of an Environmental Protection Plan (EPP) by the Contractor. Environmental monitoring will be conducted by a qualified environmental monitor to oversee and report on the effectiveness of mitigation measures identified in this EED report. Mitigation measures outlined in the archaeological overview assessment (AOA) at D Jetty and F/G Jetty and subsequent archaeological impact assessment (AIA) F/G Jetty will also be implemented.

It is anticipated the Project is not likely to cause significant adverse environmental effects after mitigation measures have been applied.

2.12 References

The references listed below were used during the preparation of this EED report.

2.12.1 Acts, Regulations and Policies

- *Archaeological Impact Assessment Guidelines* (1998)
- BC *Wildlife Act*, 1996
- BC *Environmental Management Act* (2004)
- BC Hazardous Waste Regulation
- BC Workers Compensation Act (1996)
- *Canadian Environmental Assessment Act,* 2012
- *Canadian Environmental Protection Act,* 1999
- *Fisheries Act*, 1985
- *Heritage Conservation Act*, 1996
- *Migratory Birds Convention Act,* 1994
- *Navigation Protection Act,* 2014
- *Species at Risk Act*, 2003
- Occupational Health and Safety Administration (OSHA) Occupational Health and Safety Standards
- The Bylaw to Regulate Noise within the City of Colwood (Bylaw No. 38) (2001).
- The Township of Esquimalt (ToE) Property, Unsightly Properties and Nuisance Bylaw No. 2826 (2014)
- The Town of View Royal Noise Bylaw No. 523 (2003).
- The City of Colwood Nuisance Controlled Substance Bylaw No. 851 (2006)
- The City of Colwood Traffic and Highway Regulation Bylaw No. 1134
- The City of Colwood Official Community Plan, Bylaw 999 (2008)
- Township of Esquimalt Streets and Traffic Regulation Bylaw No. 2607 (2005)

2.12.2 Other References

Anchor (Anchor QEA LLC). 2016a. Draft 100% Design Report: Colwood Jetties Remediation Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. June 2016.

Anchor. 2016b. Esquimalt Harbour Remediation Project – D Jetty Debris Survey Summary. Memorandum prepared for Public Works and Government Services Canada. March 29, 2016.

Anchor. 2016c. Esquimalt Harbour Remediation Project – D Jetty Underpier Sediment Sampling Data Summary. Memorandum prepared for Public Works and Government Services Canada. March 24, 2016.

Anchor (Anchor QEA, LLC). 2013. Draft Preliminary Alternative Basis of Design Report Esquimalt Harbour Remediation Project. Report prepared for Public Works and Government Services Canada, Department of National Defence, Defence Construction Canada. Submitted July 2013.

Archaeology Branch. Ministry of Forests, Lands, and Natural Resource Operations. 1998. *British Columbia Archaeological Impact Assessment Guidelines.* Available at: http://www.tca.gov.bc.ca/archaeology/docs/impact_assessment_guidelines/assessment_and_review_process_part2.htm#3.4_overview.

Archipelago (Archipelago Marine Research Ltd.). 2004. Subtidal Survey of Physical and Biological Features of Esquimalt Harbour Report and Map Folio. Revised and Updated February 2004.

Archipelago. 2010. A-Jetty Marine Habitat Survey (Rev B-Final). March 31, 2010.

Baird, R.W. and T.J. Geunther. 1995. Account of Harbour Porpoise (*Phocoena phocoena*) Strandings and Bycatches along the Coast of British Columbia. Rep. Int. Whal. Commn. (Special Issue 16).

Balanced. 2012a. Qualitative Presence/Absence Survey for Marine Species, Esquimalt Harbour Remediation Project, F and G-Jetty Remediation Area. November 19, 2012.

Balanced. 2012b. Qualitative Presence/Absence Survey for Marine Species, Esquimalt Harbour Remediation Project, D Jetty Remediation Area. November 19, 2012.

BC CDC. 2014. Occurrence Report Summary, Shape ID: 10983, Purple Martin. B.C. Ministry of Environment. Available at: http://delivery.maps.gov.bc.ca/ess/sv/cdc. Accessed on: Jun 28, 2016.

BC Government. 2010. Coastal Resource Information System (CRIS) database. Available at: http://webmaps.gov.bc.ca/imf5/imf.jsp?site=dss_coastal. Accessed on March 16, 2010 and March, 2016.

Berg, L. and T. Northcote. 1985. Changes in territorial, gill-flaring and feeding behaviour in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Can. J. Fish Aquat. Sci. 42: 1410-1417.

Bilotta, G.S. and R.E. Brazier. 2008. Understanding the influence of suspended solids on water quality and aquatic biota. Wat. Res. 42: 2849-2861.

Bird Studies Canada. 2016. BC Coastal Waterbird Survey. Available at: http://www.birdscanada.org/volunteer/bccws/index.jsp?targetpg=index. Accessed on: June 7, 2016.

Birtwell I. 1999. The effects of sediment on fish and their habitat, Fisheries and Oceans Canada, Science Branch, Marine Environment and Habitat Sciences Division, West Vancouver, BC

Breen, P.A., and B.E. Adkins. 1979. A Survey of Abalone Populations on the East Coast of the Queen Charlotte Islands, August 1978. Fisheries and Marine Services, Manuscript Report 1490:125 pp.

Caltrans (California Department of Transportation). 2001. Pile installation demonstration project, fisheries impact assessment. PIDP EA 012081. San Francisco–Oakland Bay Bridge East Span Seismic Safety Project. Caltrans Contract 04A0148 San Francisco, CA: Caltran.

Caltrans. 2015. Technical Guidance for the Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Califronia Department of Transportation: Division of Environmental Analysis. Available at: http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf. Accessed June 13, 2016.

CCME (Canadian Council of Ministers of the Environment). 1999 (updated to 2007). Canadian environmental quality guidelines (for sediment and water). Canadian Council of Ministers of the Environment, Winnipeg.

CRD (Capital Regional District). 2010. Harbours Atlas. Available at: http://www.crd.bc.ca/maps/harbours/launch.htm. Accessed on March, 2016.

CRD. 2011a. Wildlife and Plants: Seals. Internet Source. Available at: http://www.crd.bc.ca/watersheds/protection/wildlife-plants/seals.htm. Accessed, March, 2016.

CRD. 2011b. Wildlife and Plants: Rocky Shorelines. Internet Source. Available at: http://www.crd.bc.ca/watersheds/ecosystems/coastalmarinerock.htm. Accessed, March, 2016.

CRD. 2011c. Wildlife and Plants: Otters. Internet Source. Available at: http://www.crd.bc.ca/watersheds/protection/wildlife-plants/otters.htm. Accessed, March, 2016.

CRD. 2011d. Esquimalt Harbour: Wildlife and Plants. Internet Source. Available at: http://www.crd.bc.ca/watersheds/protection/esquimaltlagoon/wildlife.htm. Accessed, March, 2016.

CRD. 2011e. Wildlife and Plants: Cutthroat Trout. Available at: http://www.crd.bc.ca/watersheds/protection/wildlife-plants/cutthroat-trout.htm.

CWS (Canadian Wildlife Services). 2004. Canadian Distribution of the Harbour Porpoise, Pacific Ocean population. Available at: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=493. Accessed, March, 2016.

DFO (Fisheries and Oceans Canada). 2006. An Assessment of Critical Habitats of Resident Killer Whales in Waters off the Pacific Coast of Canada. Canadian Science Advisory Secretariat. Research Document 2006/072.

DFO. 2010. Management Plan for the Steller Sea Lion (*Eumetopias jubatus*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. vi + 69 pp

DFO. 2011. Recovery Strategy for Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. Final – Amended. 99 pp

DFO. 2014. British Columbia Marine/Estuarine Timing Windows for the Protection of Fish and Fish Habitat - South Coast and Lower Fraser Areas. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/bc-s-eng.html#area-19.

DFO. 2015. Herring Spawn and Catch Records. Available at: http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default5_e.htm. Accessed on March 8, 2016.

DFO. 2016a. Canadian Tide and Current Tables: Volume 5. Canadian Hydrographic Service, Ottawa, ON.

DFO. 2016b. Mapster. Available at: http://www-heb.pac.dfo-mpo.gc.ca/maps/maps-data_e.htm. Accessed on March 8, 2016.

DFO. 2016c. Area 19 (Sidney/Victoria). Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s19-eng.html. Accessed March 2016.

DFO. 2016d. Biotoxin (Paralytic Shellfish Poisoning, Domoic Acid Poisoning, Diarrhetic Shellfish Poisoning and Vibrio Parahaemolyticus (Vp) Gastrointestinal Illness) and Sanitary (Emergency, Seasonal, Annual) Contamination Closures - Pacific Region. Available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/contamination/biotox/index-eng.html. Accessed March 2016.

DFO and MELP (Department of Fisheries and Oceans and Ministry of Environment, Lands and Parks). (1992). Land development guidelines for the protection of aquatic habitat. Available at: http://www.dfo-mpo.gc.ca/Library/165353.pdf.

DND (Department of National Defence). 2016. Esquimalt Harbour: practices and Procedures. Available at: http://www.navy-marine.forces.gc.ca/en/about/structure-marpac-poesb-practices-procedures.page. Accessed on June 13, 2016.

Engelstoft, C. and F. Mogensen. 2005. Marine-living Northern River Otter Health and Their Feasibility as a Sentinel Species Along the Coast of Southern Vancouver Island. Prepared for Dr. Helen Schwantje Biodiversity Branch, Ministry of Environment, Victoria, BC.

EC (Environment Canada). 2010a. Canadian Climate Normals 1971-2000: Victoria Marine Station # 1018642. Available at: http://www.climate.weatheroffice.gc.ca/climate_normals/results_e.html?Province=ALL and StationName=Victoria and SearchType=BeginsWith and LocateBy=Province and Proximity=25 and ProximityFrom=City and StationNumber= and IDType=MSC and CityName= and ParkName= and LatitudeDegrees= and LatitudeMinutes= and LongitudeDegrees= and LongitudeMinutes= and NormalsClass=A and SelNormals= and StnId=121 and . Accessed on March 3, 2016.

EC. 2010b. British Columbia Migratory Bird Sanctuary Facts. Available at: http://www.ec.gc.ca/ap-pa/default.asp?lang=en and n=04AEF3A2-1. Accessed on March 3, 2016.

Environment Canada and Climate Change. 2010b. British Columbia Migratory Bird Sanctuary Facts. Available at: https://ec.gc.ca/ap-pa/default.asp?lang=En&n=0D0A02C4-1. Accessed on June 19, 2016.

Engelstoft, C. and F. Mogensen. 2005. Marine-living Northern River Otter Health and Their Feasibility as a Sentinel Species Along the Coast of Southern Vancouver Island. Prepared for Dr. Helen Schwantje Biodiversity Branch, Ministry of Environment, Victoria, BC.

Environment and Climate Change Canada. 2016. List of Migratory Birds protected in Canada under the Migratory Birds Convention Act, 1994. Available at: https://www.ec.gc.ca/nature/default.asp?lang=En&n=421B7A9D-1

FHWG (Fisheries Hydroacoustic Working Group). 2008. Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities. June 12, 2008 edition. Available at: http://www.dot.ca.gov/hq/env/bio/files/fhwgcriteria_agree.pdf. Accessed June 24, 2016.

Golder (Golder Associates Ltd.). 1999. Archaeological Inventory at Select Department of National Defence Properties CFB Esquimalt. Report on file with the Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC.

Golder. 2006a. Interim Data Report Supplemental Field Investigation. Esquimalt Graving Dock Waterlot. Prepared for PWGSC.Golder, 2007. Draft Report on Problem Formulation and Detailed Quantitative Risk Assessment for Esquimalt Harbour (2006/07 Status Update). March 30, 2007.

Golder. 2006b. Detailed Quantitative Ecological and Human Health Risk Assessment and Updated Risk Management Plan, PWGSC Graving Dock Waterlot. August 2006.

Golder. 2008. Archaeological Impact Assessment of the Canadian Forces Sailing Association Site in Esquimalt, BC. Report on file with the Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC.

Golder. 2009. Replace B Jetty CFB Esquimalt: Offshore Geophysics Results, Technical Memo. December 19, 2009.

Golder. 2010. Preliminary scoping study for habitat compensation options within Esquimalt Harbour for the PWGSC Esquimalt Graving Dock Waterlot Remedial Action Plan and Risk Management Plan. Unpublished technical memorandum prepared for Public Works and Government Services Canada. March, 2010.

Golder. 2011a. Results of Current Surveys in Esquimalt Harbour. January 28, 2011.

Golder. 2011b. Baseline Turbidity and Current Monitoring in Esquimalt Harbour – Preliminary Data Report. February, 2011.

Golder. 2011c. Draft Esquimalt Graving Dock Waterlot Detailed Site Investigation, prepared for PWGSC. February 10, 2012.

Golder. 2014a. A and B Jetty Project First Nations Communications Plan. December 22, 2014.

Golder. 2014b. A and B Jetty Project Public Communications Plan. December 1, 2014.

Golder. 2014c Sampling and Analysis Plan for South Jetty AIA, Esquimalt, BC. Final document prepared for PWGSC (Esquimalt Graving Dock Waterlot Remediation Project, Esquimalt, BC), December 2, 2014.

Golder. 2014d Guidelines for Archaeological Chance Find Management. Final document prepared for PWGSC (Esquimalt Graving Dock Waterlot Remediation Project, Esquimalt, BC), December 4, 2014.

Golder. 2015. Archaeological Overview Assessment of Six Proposed Remedial Dredging Areas in Esquimalt Harbour, CFB Esquimalt, Esquimalt, BC. Final report prepared for DCC, March 31, 2015.

Golder. 2016a. Final Marine Habitat Assessment: F/G Jetty Optimization Project and Colwood South Remediation Project. July 7, 2016.

Golder. 2016b. Archaeological Impact Assessment of Remedial Dredging Areas at Lang Cove and F & G Jetty in Esquimalt Harbour, Esquimalt, B.C. (Non-Permit Report) . Final Report prepared for PWGSC and DCC, March 31, 2016.

Golder. 2016c. Final Habitat Offsetting Review and Update for F/G Jetty and D Jetty: F/G Jetty Optimization Project and Colwood South Remediation Project. July 7, 2016.

Government of BC. 2013. Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia. Available at: http://www.env.gov.bc.ca/wld/documents/bmp/raptor_conservation_guidelines_2013.pdf

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. Simmonds, R. Swift and D. Thompson. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technological Society Journal 37:41–53.

Government of Canada. 2010. Species at Risk Public Registry. Available at: http://www.sararegistry.gc.ca/default_e.cfm.

Guerra-Garcia, J., Corzo, J. and J. Garcia-Gomez. 2003. Short-Term Benthic Recolonization after Dredging in the Harbour of Ceuta, North Africa. Marine Ecology. 24 (3): 217-229.

Hall, A.M. 2004. Seasonal Abundance, Distribution and Prey Species of Harbour Porpoise (*Phocoena phocoena*) in Southern Vancouver Island Waters. Masters Thesis at the University of Victoria, Faculty of Graduate Studies, Department of Zoology.

Historic Sites and Monuments Board of Canada. 2000. Guidelines for Evaluating Shipwrecks of National Historic Significance in Canada. On-line resource at http://www.pc.gc.ca/eng/docs/pc/guide/res/arch4_a.aspx#4a f, accessed November 28, 2010.

Hutton, K. E. and S. C. Samis. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 2314: vi + 34 p.

INAC (Indigenous Affairs and Northern Development Canada). 2016a. Registered Population: Songhees First Nation. Available at: http://pse5-esd5.aadnc-aandc.gc.ca/fnp/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=656&lang=eng. Accessed March 2016.

INAC. 2016b. Registered Population: Esquimalt First Nation. Available at: http://pse5-esd5.aadnc-aandc.gc.ca/fnp/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=644&lang=eng. Accessed March 2016.

Klohn Crippen Berger. 2016. D Jetty and Jetty 11 Structural Reconnaissance. Memorandum submitted to SNC-Lavalin Inc., Environment Division, Victoria, BC. March 31, 2016.

Korhonen, J., Soininen, J. and H. Hillebrand. 2010. A quantitative analysis of temporal turnover in aquatic species assemblages across ecosystems. Ecology, 91(2): 508-517.

Lessard, J., A. Campbell, Z. Zhang, L. MacDougall, and S. Hankewich. 2007. Recovery Potential Assessment for the northern abalone, *Haliotis kamtschatkana*, in Canada. Canadian Science Advice Secretariat Research Document 2007/061:107 pp.

Matthews, D. 2004. Deconstruction of the F-Jetty Pipeline, Canadian Forces Base Esquimalt, Colwood Property. Report on file with Public Works and Government Services Canada, Victoria, BC.

Melquist, W.E. and A.E. Dronkert. 1987. Northern River Otter. Page 1150 in M. Novak, J.A. Baker, M.E. Obbard, and B. Mallock, eds. Wild furbearer management and conservation in North America. Ontario Minist. Natural Resources, Toronto, ON. in: Engelstoft, C. and F. Mogensen. 2005. Marine-living Northern River Otter Health and Their Feasibility as a Sentinel Species Along the Coast of Southern Vancouver Island. Prepared for Dr. Helen Schwantje Biodiversity Branch, Ministry of Environment, Victoria, BC.

Millennia Research Ltd. 2001. Final Report Colwood Fuel Supply Depot, F-Jetty: Mitigative Archaeological Excavation, Pipeline Installation, DcRu-136. On file with CFB Esquimalt, Department of National Defence.

Millennia. 2004. Esquimalt Graving Dock: Archaeological Inventory. Non-permit report on file with the Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations, Victoria.

Millennia Research Ltd. 2012a. Archaeological Monitoring of Environmental Remediation Excavations at Col 20,

CFB Esquimalt, Colwood, BC.

Millennia Research Ltd. 2012b Archaeological Monitoring CFB Esquimalt, Col 43, Colwood BC Letter Report

MOE (Ministry of Environment). 2007. Endangered Species and Ecosystems: Provincial Red and Blue Lists. Available at: http://www.env.gov.bc.ca/atrisk/red-blue.htm.

MOE. 2014. Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Available at: http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare/#Main

MOE. 2016a. Habitat Wizard. Available at: http://webmaps.gov.bc.ca/imf5/imf.jsp?site=moe_habwiz. Accessed on March 4, 2016.

MOE. 2016b. CDC Internet Mapping Application. Available at: http://maps.gov.bc.ca/ess/sv/cdc/. Accessed February 2016.

MOE. 2016c. CDC BC Species and Ecosystem Explorer. Available at: http://a100.gov.bc.ca/pub/eswp/. Accessed on March 3, 2016.

NOAA (National Ocean and Air Administration). 2016.; NOAA Fisheries, West Coast Region. Interim Sound Threshold Guidance. Available at: http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html. Accessed June 14, 2016.

Nuszdorfer, F.C., K. Klinka, and D.A. Demarchi. 1991. Ecosystems of BC: Chapter 5: Coastal Douglas-fir Zone. Available at: http://www.for.gov.bc.ca/hfd/pubs/docs/Srs/Srs06/chap5.pdf

Pearson, Mike and Healey, M.C.2012. Species at Risk and Local Government: a Primer for BC. Stewardship Centre of British Columbia, Courtenay BC.

Popper, A.N. and Hastings, M.C. 2009. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology. 75:455-489.

QHM (Queen's Harbour Master). 2016. Personal Communication between representatives of the Queen's Harbour Master and Golder Associates Ltd. March 16. 2016.

Richardson, J., C.R. Greene Jr., C. Malme and D. Thomson. 1995. Marine Mammals and Noise. Academic Press. San Diego, CA.

Royal Canadian Navy. 2016. Esquimalt Harbour Practices and Procedures. Available at: http://www.navy-marine.forces.gc.ca/en/about/structure-marpac-poesb-practices-procedures.page. Accessed March 2016.

Servizi J, Martens D. 1987. Some effects of suspended Fraser River sediments on sockeye salmon (*Oncorhynchus nerka*). Can Spec Pub Fish Aquat Sci 96: 254-64

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. 2007. *Marine mammal noise exposure criteria: initial scientific recommendations*. Aquatic Mammals. 33:411–521.

Species at Risk Act (SARA). 2010. Internet Source. Available at: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=612#docs. Accessed, March 3, 2016.

SLR (SLR Consulting Ltd.) 2008. Esquimalt Harbour Sediment Management Esquimalt, BC. 2007/2008 Supplemental Site Investigation.

SLR. 2010. Draft: Human Health Risk Assessment, Esquimalt Harbour: Esquimalt Harbour Sediment Management (FY 2009/2010). Prepared for PWGSC and DND. February 4, 2010.

SLR Consulting (Canada) Ltd. (2014). A and B Jetty Construction Underwater Noise Impact Assessment. November 2014.

Stadler, J.H. and D.P. Woodbury. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. National Marine Fisheries Service. Available at: http://golderportal/Technical/GroupGlobalMarineServicesNetwork/Documents/Reference/Pile%20Driving%20%20Overpressure/Stadler_and_Woodbury_2009.pdf. Accessed June 13, 2016.

Statistics Canada. 2012. 2011 Census Profile. Online database. Available at: https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E. Accessed March 2016.

Vagle, S. 2003. On the Impact of Underwater Pile-Driving Noise on Marine Life. Ocean Science and Productivity Division. Institute of Ocean Sciences. DFO/Pacific.

Victoria Natural History Society (VNHS). 2009. Victoria Christmas Bird Count Maps and Lists: Area 8 - Esquimalt Harbour. Available at: http://www.vicnhs.bc.ca/cbc/HistoryArea8.mht. Accessed on: June 13, 2016.

Wildlife Tree Stewardship Program (WiTS). 2016. Nest Tree Report. The Community Mapping Network. Available: http://www.cmnmaps.ca/wits/ Accessed May 26, 2016.

2.13 Closure

This EED report has been prepared by Golder Associates Ltd. in accordance with the scope of work submitted to Public Works and Government Services Canada on May 26, 2016. The report was prepared with the information available in the draft 100% design specifications for the CSRP and FGOP (Anchor 2016a).

OPI Project File #: CSRP: N.000159.03 – F/GOP: N.000159.02

Base File #: 0103E 1262-1 (RDIMS #217827)

DGIEGPS EED File #:2016-21-005264

Part 3. Environmental Effects Determination

On the basis of this DND EED Report, it has been determined that the impact of this project on the environment is as follows:

☒ Project is not likely to cause significant adverse environmental effects. The project **can** proceed with application of the mitigation measures specified in the interaction tables in this report.

☐ The project is likely to cause significant adverse environmental effects that cannot be mitigated. The project **cannot** proceed without Governor in Council approval.

☐ Refer the project, through the chain of command and **only on the recommendation of Environmental Command and DGIEGPS**, to Governor in Council for a decision on whether the project is justified to proceed.

DND EED Report Prepared by:

John Sherrin, MSc, BSc
Marine Biologist, Golder Associates Ltd.

07-07-2016
Date (dd-mm-yyyy)

DND EED Report Reviewed by:

COLLEGE OF APPLIED BIOLOGY
Barbara Wernick
BW 7 Jul 16
R.P. Bio
#1171
CAB

Barbara Wernick, MSc, RPBio
Principal, Senior Environmental Scientist, Golder Associates Ltd.

07-07-2016
Date (dd-mm-yyyy)

DND EED Report Reviewed by:

Tracy Cornforth, Environmental Officer
Formation Safety and Environment, tracey.cornforth@forces.gc.ca

Date (dd-mm-yyyy)

DND EED Report Accepted and Approved by:

The undersigned accepts the determination and recommendations of this environmental effects determination report. The undersigned also accepts the responsibility to incorporate the recommendations of the report into the project design and implementation.

Duane Freeman, Formation Officer
Formation Safety and Environment, duane.freeman@forces.gc.ca

Date (dd-mm-yyyy)

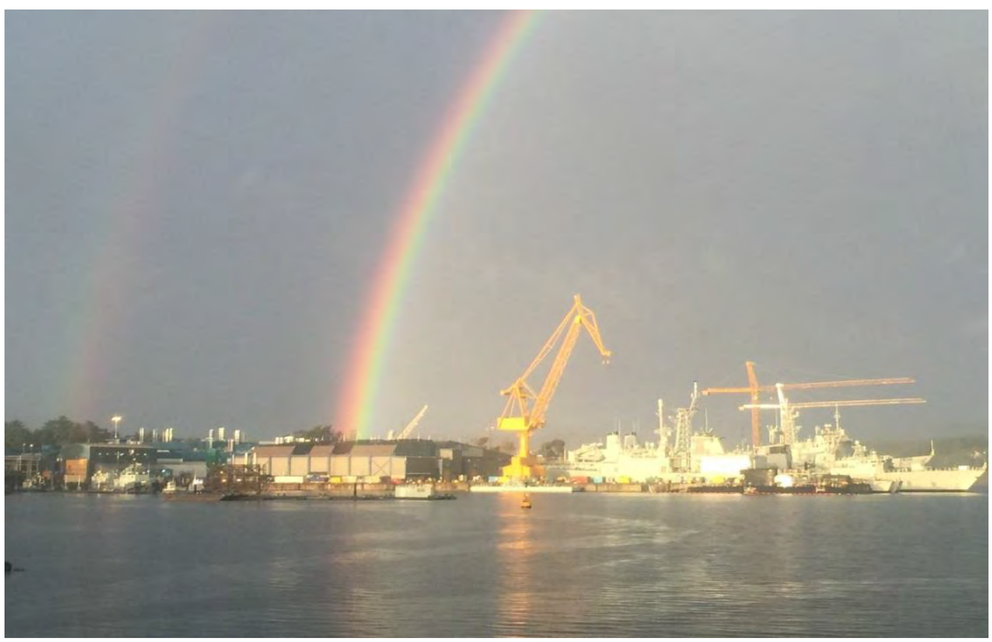
Annex A. Marine Habitat Assessment Report

7 July 2016

F/G JETTY OPTIMIZATION PROJECT AND COLWOOD SOUTH REMEDIATION PROJECT

Marine Habitat Assessment for F/G Jetty and D Jetty

Submitted to:
Mr. Andrew Smith
Public Works and Government Services Canada
Environmental Services, Pacific Region
401-1230 Government Street
Victoria, BC
V8W 3X4



Report Number: 1657898-004-R-Rev0-1000

Distribution:

2 copies - Public Works and Government Services Canada
1 copy - Golder Associates Ltd.

REPORT

Golder Associates

Notice to Readers

This report was prepared for Public Works and Government Services Canada in accordance with the terms and conditions outlined in the PWGSC Marine Sediment Task Authorization (reference EZ899-150978/002/PWY).

The inferences concerning the Site conditions contained in this report are based on information obtained during the assessment conducted by Golder personnel, and are based solely on the condition of the property at the time of the field surveys, and supplemented by historical information obtained by Golder, as described in this report.

This report was prepared, based in part, on information obtained from historic information sources. In evaluating the subject Site, Golder has relied in good faith on information provided.

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.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, and should be reviewed.

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TABLES

FIGURES

APPENDICES

Abbreviations

CD .... chart datum
CSRP .... Colwood South Remediation Project
DFO .... Fisheries and Oceans Canada
DND .... Department of National Defence
EHRP .... Esquimalt Harbour Remediation Project
FGOP .... F/G – Jetty Optimization Project
GPS .... Global Positioning System
HaSEP .... health and safety environment plan
LPL .... lowest practical taxonomic level
MFEAP .... Marine Foreshore Environmental Assessment Procedure
PWGSC .... Public Works and Government Services Canada
QA/QC .... quality assurance/quality control
WAAS .... Wide Area Augmentation System

UNITS

cm .... centimetre
hr .... hour
individuals/m^2 .... individuals per square metre
m .... metre
m^2 .... square metre
% .... percent

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) under the Marine Sediment Task Authorization (reference EZ899-150978/002/PWY) to conduct habitat surveys in proposed remedial areas at F/G Jetty and D Jetty in Esquimalt Harbour, British Columbia (Figure 1). The scope of work for the habitat surveys (Task O-1 Habitat Survey) was outlined in Golder's proposal titled "*Work Plan and Cost Estimate to Provide Support for DND CFB Esquimalt, Esquimalt Harbour Remediation Project Definition Phase for Fiscal Year 2015-16 - Environmental Assessment*", dated January 19, 2016.

A draft habitat assessment report, *Esquimalt Harbour Remediation Project: Marine Habitat Assessment*, Report Number: 1545562-008-R-RevA-3000 (Golder 2016a), was issued to PWGSC on March 23, 2016. PWGSC and the Department of National Defence (DND) are proceeding with remedial activities in the vicinity of F/G Jetty as part of the F/G Jetty Optimization Project (FGOP), and in the vicinity of D Jetty as part of the Colwood South Remediation Project (CSRP). The FGOP and CSRP are being tendered together in a combined tender package but are considered as two separate projects for the purposes of this habitat assessment. This habitat assessment report was based on the Anchor QEA LLC (Anchor) draft 100% design specifications (Anchor 2016) and includes habitat information relevant to project activities proposed for F/G Jetty and D Jetty at the time of the surveys.

1.1 Background

Golder understands that the DND has undertaken an investigation and risk assessment of sediment quality in Esquimalt Harbour. These tasks were conducted as part of the EHRP to assess sediment contamination associated with historical activities and DND plans to conduct sediment remediation of select areas identified. Some of the remediation tasks will be undertaken in part as projected capital improvement of jetties. The DND and PWGSC project team is currently considering remediation of several locations within the Federal Harbour limits of Esquimalt Harbour including areas on the west shore of Esquimalt Harbour, between F and G Jetty (F/G Jetty) and around D Jetty (the Project Area). Proposed project activities in Esquimalt Harbour including areas around A/B Jetty, C Jetty, ML Floats, Y Jetty, and Lang Cove are being evaluated separately from the FGOP and CSRP. The remediation is proposed to be undertaken in two phases; the first phase involves active remediation (e.g. dredging and substrate placement) and the second phase involves risk assessment and risk management of contaminated sediments. The proposed activities include dredging contaminated sediment and substrate placement, which have the potential to cause "serious harm to fish" as defined by the *Fisheries Act* (1985) and fisheries protection policy (Fisheries and Oceans Canada (DFO) 2013).

1.2 Objective

The objective of this work was to document marine communities in the Project Area (Figure 1) to support environmental permitting and potential habitat offsetting requirements for the proposed remediation activities. The survey design was based on Golder's understanding of the project description at the time of the survey, which was described in Anchor (2013). The proposed project activities and dredge areas identified in Anchor's 2013 preliminary alternative basis of design report were the most up to date project specifications available at the time of the survey.

KEY MAP

LEGEND

REMEDIATION FOOTPRINT

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING: DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

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CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	K. WESTMAN
PREPARED	R. WIGGINS
REVIEWED	J. SHERRIN
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT ASSESSMENT SURVEY

TITLE
KEY PLAN

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	1

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2.0 METHODS

2.1 Health and Safety

Golder prepared and implemented a Health, Safety and Environment Plan (HaSEP) to address potential health and safety issues identified for the field work programs, with a specific focus on working over water, vessel operation and dive surveys including lockout procedures for work near vessels. The HaSEP outlined mitigation measures adopted during the course of the works to manage and minimize hazards associated with the identified risks.

A PWGSC Job Hazard Analysis checklist addressing specific job-related hazards was also reviewed in conjunction with the HaSEP prior to conducting the various site activities.

The HaSEP was submitted to PWGSC for comment prior to commencement of the work, and Golder field supervisor conducted daily health and safety meetings with field personnel on Site. Field personnel involved with the works were required to review and sign the relevant HaSEP to confirm their understanding of the potential health and safety hazards and safe work procedures.

The three-person biologist dive team conducting the dive surveys were certified in accordance with Canadian Standard Association Z275:4-97 and WorkSafe BC Regulations Part 24. A Notice of Project for planned dive survey work was submitted electronically to Work Safe BC in accordance with the BC Occupational Health and Safety Regulations (B.C. Regulation 296/97 s.24.9[1], last amended August 4, 2015).

2.2 Overview of the Habitat Assessment

Field surveys were conducted during the winter season and targeted the proposed Project Area. Towed video surveys were conducted over five days from January 26 to 30, 2016 and dive surveys were conducted over 12 days from February 1 to 19, 2016. The assessment was based on surveys conducted within the proposed Project Area that are identified in Anchor (2013) and illustrated on Figure 2. Field data were collected by a three-person Golder team and were staged from the Pacific GAL, an 8.3 m aluminum skiff powered by a 150 horsepower engine.

Field surveys included the following components (Figure 2):

- Towed video surveys to identify sensitive habitats, characterize substrate features and assess presence/ absence of marine communities;
- Subtidal biophysical transect and quadrat sampling (DJ1 to DJ3, FG1 to FG3);
- Subtidal habitat reconnaissance surveys at identified boulder habitat documented at F/G Jetty;
- Abalone (*Haliotis kamtschatkana*) habitat mapping along the eastern side of D Jetty; and
- DFO Phase 2 abalone transect survey in the eastern side of D Jetty.

2.3 Towed Video Survey

The main objectives of the underwater towed video survey were to provide a general characterization of the subtidal benthic environment and to identify presence/absence of potentially sensitive habitat with a particular emphasis on eelgrass beds, macroalgae/kelp beds, and clam beds. Areas identified for further characterization including suitable abalone habitat were assessed and mapped in greater detail during subsequent dive surveys (Section 2.4). The towed video survey area included the proposed dredge footprint at D Jetty and F/G Jetty (Figure 2) as noted by Anchor (2013) and was conducted using both shore parallel and shore perpendicular transects.

The underwater towed video system used for the surveys included a high-resolution video camera mounted on a towfish frame with high-powered LED lights and an integrated Wide Area Augmentation System (WAAS) -enabled Global Positioning System (GPS; accurate to ± 3 m) video overlay. The system was deployed from the Pacific GAL, an 8.3 m aluminum skiff powered by a Yamaha 150 horsepower engine, and was remotely operated topside by trained Golder personnel. Video footage was viewed real-time on a topside monitor set-up onboard the deck of the vessel. Vessel positioning during the towed video survey was monitored and recorded using on-board Nobeltec™ navigational software.

The underwater video footage was post-processed by a Golder marine biologist in Golder's Victoria office. The analysis included substrate classification and identification of macroalgae, sessile and motile invertebrates, and fish taxa to the lowest practical taxonomic level (LPL). Species identified during video processing are listed in Table 2 and Appendix B. Enumeration of species observed during towed video surveys is not provided in this report. Quantification of benthic invertebrate species was only performed from dive survey video as outlined in Section 2.4 as the dive surveys collected higher resolution imagery for species identification and enumeration and utilized methods for calculation of the area of seafloor surveyed (e.g. measured distance transects, quadrats). The underwater video survey footage was recorded in a digital format and will be provided with the final version of this report.

LEGEND

- REMEDIATION FOOTPRINT (2016)
- FORMER REMEDIATION FOOTPRINT

SURVEY METHODS:

- ABALONE DIVE TRANSECT
- BIOPHYSICAL DIVE TRANSECT
- TOWED VIDEO SURVEY

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING: DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

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CONSULTANT

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YYYY-MM-DD	2016-07-07
DESIGNED	K. WESTMAN
PREPARED	R. WIGGINS
REVIEWED	J. SHERRIN
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT ASSESSMENT SURVEY

TITLE
HABITAT ASSESSMENT METHODS

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	2

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2.4 Dive Surveys

2.4.1 Biophysical Transect Survey

To quantify and characterize substrate and marine biota within each survey area, dive surveys were conducted in general accordance with DFO's Marine Foreshore Environmental Assessment Procedure (MFEAP) (Appendix A). The dive transects were positioned to achieve spatial coverage of proposed dredge areas and to target habitat features identified in the towed video surveys that required additional characterization (Figure 2). Transects were oriented perpendicular to shore at F/G Jetty and oriented parallel along D Jetty, and habitat observations were recorded along the extent of each transect. Quadrat sampling, using a 1-m^2 quadrat, was conducted along each transect at regular intervals (10 or 20 m). For homogeneous habitats, divers sampled every 20 m interval to cover a larger area. For each quadrat, the following information was recorded:

- Substrate type was visually estimated generally according to the size ranges provided in the DFO's MFEAP (i.e. bedrock; boulder [>256 mm diameter]; cobble [634 to 256 mm]; gravel [2 to 64 mm]; sand [0.0625 to 2 mm]; silt/mud [<0.0625 mm]) and relative composition (i.e. as a percentage);
- Marine vegetation, identified to the LPL and areal coverage by the MFEAP coverage categories (i.e. <1%, 1 to 5%; 5 to 25%; 25 to 50%; 50 to 75%; and 75 to 100%). Measurement of standing biomass (e.g. weight of blades) requires destructive sampling, and was therefore not conducted;
- Sessile invertebrates (e.g. barnacles, mussels, anemones), identified to LPL and areal coverage category (as above); and
- Motile invertebrates (e.g. abalone, crabs, snails) and fish, identified to LPL and enumerated. Abundance was visually estimated if a relatively large number of motile species were present.

Transect locations were geo-referenced and recorded for subsequent mapping. Survey data was recorded on Project-specific field data forms.

2.4.2 Habitat Mapping

Habitat features identified during the towed video survey such as boulder/bedrock habitat, kelp beds and potentially suitable abalone habitat were further characterized and mapped by divers using Golder's Aquatic Mapping System (AMS). The AMS is an integrated geo-referencing system that includes a float supported WAAS-enabled GPS that was designed to document subtidal features. Using this system, divers swam the perimeter of the habitat feature towing the GPS-equipped float. The float line was taught throughout the survey and the float remained directly above the diver. The GPS unit was programmed to record diver position at 5-second intervals. Positional data was subsequently plotted on a base map identifying boundaries of habitat features.

Analysis- Habitat Mapping Zones

Data collected for this assessment will support habitat offsetting, if required, for the remedial dredging in the Project Area. Previous habitat characterization and offsetting efforts in Esquimalt Harbour for A/B Jetty remediation followed the SLR (2015) habitat type classification identified in Table 1. Classification was based on substrate type and tidal range/zone (m chart datum [CD]). For the purpose of the present assessment, habitat types were combined into general categories to estimate taxonomic richness as a measure of diversity of biological communities on a broader scale. Using quadrat data collected during the subtidal transect surveys, mean taxonomic richness was calculated to provide a measure of the number of taxa observed for each combined habitat type. A range (lowest and highest taxa observed per quadrat) by habitat type was also included.

Table 1: Habitat Categories by Tidal Range/Zone

Habitat Type[1]	Combined Habitat Type	Tidal Range/Zone (m CD)[2]
1 - Upper Intertidal Bedrock, Boulder, and Riprap (3.1 to 2.6 m CD)	Intertidal Bedrock, Boulder, and Riprap (Int- BBR)	3.1 to 0.1
2 - Upper Intertidal Cobble, Gravel, and Sand (3.1 to 2.6 m CD)		
3 - Mid Intertidal Bedrock, Boulder, and Riprap (< 2.6 to 1.6 m CD)		
4 - Mid Intertidal Cobble, Gravel, and Sand (< 2.6 to 1.6 m CD)	Intertidal Cobble, Gravel, and Sand (Int- CGS)	3.1 to 0.1
5 - Low Intertidal Bedrock, Boulder, and Riprap (< 1.6 to 0.1 m CD)		
6 - Low Intertidal Cobble, Gravel, and Sand (< 1.6 to 0.1 m CD)		
7 - Subtidal Bedrock, Boulder, and Riprap (< 0.1 m CD)	Subtidal Bedrock, Boulder, and Riprap (Sub-BBR)	<0.1
8 - Subtidal Sand, Silt, and Mud (< 0.1 m CD)	Subtidal Sand, Silt, and Mud (Sub- SSM)	<0.1
9 - Subtidal Cobble, Gravel, and Sand (< 0.1 m CD)	Subtidal Cobble, Gravel, and Sand (Sub- CGS)	<0.1

Notes:

Hard substrates identified adjacent to D Jetty during the dive survey are outside the D Jetty Project Area and are therefore not included in Table 1.

[1] Habitat Type 1 to 8 following SLR (2015)

[2] GPS coordinates at Esquimalt Harbour were converted from Geodetic (CGVD28) to chart datum (CD) with a conversion value of 1.885 m

2.4.3 Abalone Survey

2.4.3.1 Initial Abalone Habitat Reconnaissance Survey (Phase 1)

Towed video was considered as a suitable method for identifying abalone habitat features, but was not considered a suitable method for identifying individual abalone due to their cryptic nature and tendency to inhabit crevices and overhangs, which are not detectable using towed video. Suitable abalone habitat is typically characterized as bedrock or boulder substrate containing encrusting coralline algae (*Lithothamnion* sp.) with presence of brown bladed kelp (e.g., bull kelp *Nereocystis luetkeana,* tangle kelp *Laminaria sp.,* walking stick kelp *Pterygophora californica*) (Breen and Adkins 1979).

For boulder and bedrock substrates identified during the towed video and biophysical surveys, a Phase 1 Initial Survey based on DFO's Impact Assessment Protocol for Works and Developments Potentially Affecting Abalone and their Habitat (Appendix 2 in DFO 2007) was conducted to establish and delineate potential abalone habitat.

Several physical (e.g. salinity, depth) and biological (e.g. presence of coralline algae, sea urchins) indicators of potential abalone habitat were only identified within boulder substrate under the D Jetty adjacent to the Project Area. Factors of potential abalone habitat were not observed within the boulder/cobble substrate in the north part of the F/G Jetty Project Area; however, since factors (e.g. depth, presence of coralline algae) observed were similar to those observed at D Jetty where abalone were identified, a precautionary approach was used to conduct a Phase 1 survey of the boulder and bedrock habitats observed in the F/G Jetty Project Area. The Phase 1 surveys were carried out by dive biologists that are approved by DFO Science Branch as biological monitors (3rd party abalone biologist). The specific approach used for this survey is summarized below:

- Divers swam at select depth contours based on site characteristics (e.g. water depth at time of survey to a maximum depth of -10 m CD) parallel to the shoreline along the boulder substrate, ascending 2 m at the end of each sweep (survey contours are identified in Appendix B);
- Divers were spaced 1 m apart and were able to survey a 2 m swath, creating an overlap that provided redundancy in search efforts; and
- Abalone observed during the survey were photographed against their substrate, measured with calipers, and general observations were recorded including time, depth, macroalgae species and percent cover, substrate and abalone predators.

Reconnaissance surveys were conducted during daylight hours. Nighttime surveys will be conducted prior to the commencement of in-water Project activities.

2.4.3.2 Abalone Habitat Mapping and Transect Survey (Phase 2)

Where abalone were observed during the biophysical transect or Phase 1 abalone habitat reconnaissance survey, the extent of the abalone habitat was mapped using Golder's AMS and a Phase 2 Transect Survey (Appendix 2 in DFO 2007) was used to estimate abalone density and distribution within the delineated habitat. The number of transects conducted within the mapped abalone habitat was chosen based on the width of the habitat. If the area of suitable habitat was less than 300 m wide, a lesser number of transects were conducted. Transect locations were randomly chosen through an on-line random number generator application (random.org). Transects were oriented perpendicular to shore and extended from shore to 10 m below chart datum (CD). Along each transect, divers placed a 1 m^2 quadrat 1 m away from the transect line to avoid potentially disturbed substrate and the quadrat was flipped parallel to the transect line. For each quadrat, the divers recorded the following on waterproof data sheets:

- Abalone shell length (standard length [SL] in mm);
- Depth and time;
- Substrate type and percent cover;
- Urchin species and counts (e.g. red sea urchin (*Strongylocentrotus franciscanus*), green sea urchin (*Strongylocentrotus droebachiensis*));

- Abalone predators and counts (e.g. sunflower sea star (*Pycnopodia helianthoides*), red rock crab (*Cancer productus*), Dungeness crab (*Metacarcinus magister*)); and
- Percent (%) cover of encrusting coralline algae and macroalgae taxa present.

2.5 Quality Assurance / Quality Control

Quality assurance (QA) and quality control (QC) measures for quantitative and qualitative data collected during transect and quadrat surveys included:

- Towed video survey data, GIS tracks and waypoints were saved to a Toughbook laptop computer and external hard drive at the end of each field day;
- Dive survey photographs and video were saved to an external hard drive at the end of each field day;
- Field survey data sheets were checked and validated before leaving the site;
- Data were entered into a Microsoft Excel® database and screened for transcription errors; and
- Internal peer review was conducted for statistical analysis and calculated summary metrics.

3.0 RESULTS

3.1 Towed Video Survey

Subtidal habitats throughout the survey area were composed primarily of unconsolidated soft sediments containing a mixture of silt, sand, mud, gravel, woody debris and organic debris. Small patches of hard substrate (bedrock/boulder) were present in nearshore areas and in a few offshore areas (e.g., boulder patches). Anthropogenic metal and wood debris were distributed throughout the survey area and were observed to be primarily concentrated around existing man-made structures such as boat floats and jetties. In all locations, existing concrete and wood structures extend out into the subtidal habitat and act as substrate for sessile marine organism attachment and growth.

To aid in habitat characterization, subtidal habitats were categorized into three habitat types based on the dominant substrate observed during video analysis and specifications identified in Table 1:

- Boulder/Bedrock (Sub-BBR): >50% boulder, bedrock or riprap, generally with some silt/sand and gravel/cobble intermixed;
- Mixed Substrate (Sub-CGS): >50% cobble and/or gravel, generally with some silt/sand and boulders intermixed; and
- Soft Sediment (Sub-SSM): >50% unconsolidated soft sediments (silt/sand/mud or clay).

Motile invertebrates were generally more abundant in soft sediment and mixed substrate habitat types with sessile invertebrates more abundant in boulder/bedrock habitat. Most species of macroalgae were identified within several different habitat types, though distribution was restricted by depth and minor differences in community composition were apparent between habitat types. Several sensitive habitats were identified within the survey including potential abalone habitat. A general description of habitat types, presence/absence of macroalgae, invertebrates, fish and potential sensitive habitats within each survey area documented during towed video surveys is provided in the following sections and summarized in Table 2. A more detailed analysis of sensitive habitats identified during the towed video survey and targeted during the subsequent dive survey program is provided within Section 2.4.

Table 2: Summary of Species Observed During Towed Video Surveys by Habitat Type

Area	Habitat Type[1]	Macroalgae	Invertebrates and Fish[2]
D Jetty	Boulder/ Bedrock	none[3]	none
	Mixed Substrate	none	shrimp, Dungeness crab, anemone, feather duster worm (*Eudistylia vancouveri)*, unidentified sculpin
	Soft Sediment	filamentous brown algae, red spaghetti (*Gracilaria* sp.)	shrimp, Dungeness crab, red rock crab, plumose anemone (*Metridium senile*), anemone, feather duster worm, rose star (*Crossaster papposus*), mottled star (*Evasterias troschelii*), snake prickleback (*Lumpenus sagitta*)
F/G Jetty	Boulder/ Bedrock	bladed brown kelp, red branched algae	sea lemon nudibranch (*Anisodoris nobilis*)
	Mixed Substrate	Japanese weed (*Sargassum* sp.)	red rock crab, plumose anemone
	Soft Sediment	bladed brown kelp	shrimp, Dungeness crab, red rock crab, plumose anemone, rock scallop (*Crassadoma gigantean*), unidentified flatfish

Notes:

[1] Habitat types were determined using the following criteria: Boulder/ Bedrock= >50% Boulder/Bedrock or Riprap; Mixed= >50% gravel and/or cobble; Soft Sediment= >50% soft sediments (silt/sand/clay).

[2] Organisms observed during the towed video survey were not enumerated. A list of species with common and scientific names is provided in Appendix C.

[3] Observations of boulder /bedrock habitat at D Jetty were limited due to the inability to survey under the jetty structures using towed video equipment.

D Jetty

Subtidal habitat within the D Jetty area consisted of soft sediment with areas of mixed coarse substrate (Figure 3). Shell and wood debris were abundant in a few small patches (<5 m^2) throughout the survey area. Anthropogenic debris (e.g. metal, rope) was observed near the jetty within the survey area.

Macroalgae cover was generally low throughout the D Jetty survey area (Table 2). Two areas were identified as consisting of patchy red algae (red spaghetti) beds that were observed towards the southeast extent of the survey area and a few small patches of filamentous brown algae were also observed. Macroalgae are generally more productive during the spring and summer seasons than during the winter and these surveys may not have captured the full extent of macroalgae abundance and distribution.

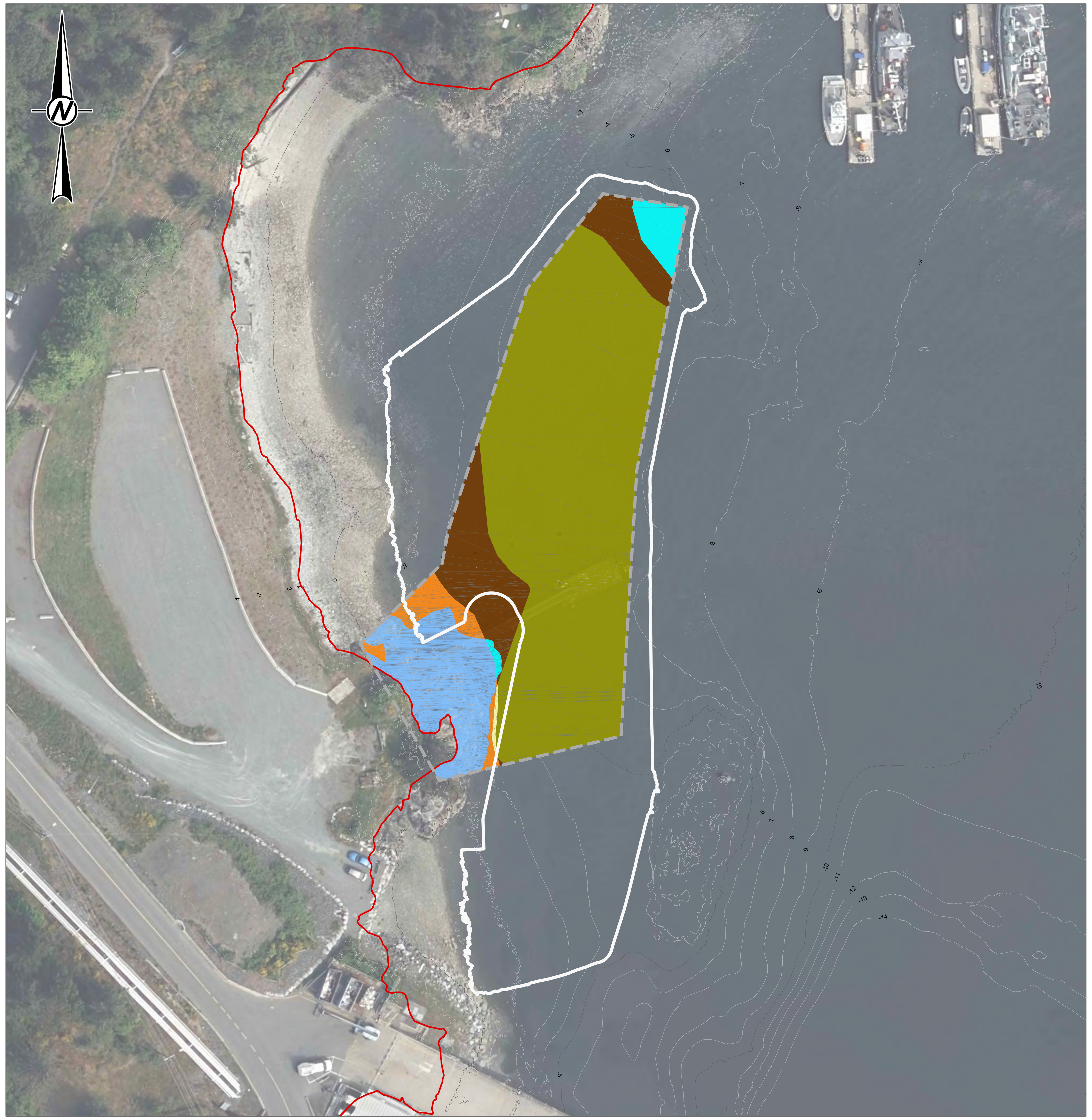
Motile invertebrate species were abundant throughout soft sediment and mixed substrate habitats within the survey area. Species observed included shrimp and Dungeness crabs throughout the survey area, and red rock crabs on areas of soft sediment only. Other invertebrate species observed included feather duster worms, plumose anemones, rose stars and mottled stars. A single unidentified sculpin (Family Cottidae) was observed in nearshore mixed substrate habitat and a single snake prickleback was observed further offshore in soft sediment habitat.

F/G Jetty

Subtidal habitat within the F/G Jetty area contained a mix of soft sediment, mixed substrate and boulder/bedrock (Figure 3). The shoreline to the north of the existing gasoline float and approach structure contained a mix of boulder and cobble/gravel substrate which transitioned into soft sediment habitat further offshore. To the south of the gasoline float, boulder/bedrock substrate extended along the shoreline. The northeast area of the survey area contained a boulder outcropping, no bedrock was observed in this area. Shell and wood debris was observed in nearshore areas, primarily in the area of the gasoline float and approach structure.

Bladed brown kelp was the dominant macroalgae within the F/G Jetty survey area (Table 2). The bladed brown kelp was observed in patchy distribution on mixed substrate and boulder/bedrock habitat within the northern nearshore portion of the survey area. Presence of red branched algae was observed along the boulder/bedrock shore to the south of the gasoline float. Japanese wireweed, was observed along nearshore margins below CD within mixed substrate habitat to the north of the gasoline float. As with habitat surveys conducted at D Jetty, habitat surveys conducted at F/G Jetty were conducted during the winter and may underestimate the abundance and distribution of macroalgae within the F/G Jetty Project Area.

Shrimp were moderately abundant throughout soft sediments. Other species commonly observed included Dungeness crabs, which were observed on soft sediments, and red rock crabs observed on soft sediment and mixed coarse substrate. Other invertebrate species observed included rock scallops, plumose anemones, and several species of nudibranch. A single unidentified flatfish was observed in soft sediment habitat; no other fish were observed within the survey area.



LEGEND

REMEDIATION FOOTPRINT

FORMER REMEDIATION FOOTPRINT

LIMITS OF AVAILABLE ELEVATION DATA

INTERTIDAL (TO 3.1 m CD, OR AREAS WITHOUT ELEVATION DATA):

HIGH HIGH WATER LEVEL

SAND, SILT AND MUD

COBBLE, GRAVEL AND SAND

BEDROCK, BOULDER AND RIPRAP

SUBTIDAL (AREAS WITH BATHYMETRIC ELEVATION DATA, MAXIMUM ELEVATION VARIES FROM -0.8 m TO -2.0 m):

SAND, SILT AND MUD

COBBLE, GRAVEL AND SAND

BOULDER

NOTE(S)

1. SURFACE CONTOURS SHOWN IN 1 m (MINOR) AND 5 m (MAJOR) INTERVALS. ELEVATIONS SHOWN RELATIVE TO CHART DATUM.

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING: DFG REMEDIATION AREAS_20160630.DWG.
2. IMAGE DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
3. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE. ACCESSED 2016-03-03.
   3.1. BATHYMETRY: FILENAME: "COLWOOD_15031.TIF". THE SURFACE WAS USED AS-IS.
   3.2. UPLAND: FILENAME: "COL_ENV.DWG" SURFACE CONTOURS ADJUSTED TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.

0 20 40

1:600 METRES

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	K. WESTMAN
PREPARED	R. WIGGINS
REVIEWED	J. SHERRIN
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT ASSESSMENT SURVEY

TITLE
HABITAT CHARACTERIZATION

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	3

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3.2 Dive Surveys

Subtidal data was tabulated by survey area and type and includes physical and biological characteristics that are provided in Appendix B. A species list with common and scientific names is provided in Appendix C. Representative photographs taken during the survey are provided in Appendix D. Underwater video footage for surveys will be provided with the final version of this report.

3.2.1 Biophysical Transect Survey

The transect locations for the biophysical transect survey were chosen based on review of the towed video survey video in an effort to characterize major biophysical features and habitats in the Project Area.

D Jetty

Substrate in the D Jetty survey area was either soft sediment or mixed coarse substrate with wood and shell debris (Table 3; Figure 3). Hard substrates identified as potential abalone habitat were observed adjacent to the D Jetty Project Area and are not located within the 100% design specifications Project footprint (Anchor 2016); therefore, these substrates have not been included in Table 3. Overall, diversity of macroalgae, sessile and motile invertebrates was low (none to three species; Table 3). The dominant macroalgae taxonomic group, red filamentous algae (0 to 25% areal cover), was observed in two of the 21 quadrats surveyed. Plumose anemones were observed on both soft sediment and mixed coarse substrate. Coonstripe shrimp (*Pandalus danae*) were observed throughout the survey area with up to 22 individuals/m^2. Other motile invertebrate taxa observed were Dungeness crab and nudibranchs, specifically black-tip dendronotid (*Acanthodoris pilosa*), shaggy mouse nudibranch (*Aeolidia papillosa*), and one unidentified species. Fish observed included tidepool sculpin (*Oligocottus maculosus*) and blackeye goby (*Coryphopterus nicholsi*). Other fish species documented were pile perch (*Rhacochilus vacca*), northern ronquil (*Ronquilus jordani*) and tubesnout (*Aulorhynchus flavidus*).

Table 3: Summary of Macroalgae and Invertebrate Community Species Richness at D Jetty

Habitat Type	Macroalgae		Sessile Invertebrates		Motile Invertebrates	
	Richness mean (range)	Dominant Taxa	Richness mean (range)	Dominant Taxa	Richness mean (range)	Dominant Taxa
Sub-SSM	0.2 (0 to 1)	red filamentous algae	0.6 (0 to 2)	plumose anemone	1.2 (0 to 3)	coonstripe shrimp
Sub-CGS	0.3 (0 to 2)	red filamentous algae	1.0 (0 to 3)	plumose anemone	0.6 (0 to 1)	coonstripe shrimp

[1]Habitat type: Sub-SSM= subtidal sand, shell, mud substrate; Sub-CGS= subtidal cobble, gravel, sand substrate

F/G Jetty

F/G Jetty survey area contained boulder/bedrock substrate along the southern shoreline as well as a rocky reef on the western edge of the proposed dredge footprint and some patchy boulder substrate in the northeast corner of the survey area (Figure 3). The substrate in the remainder of the survey area was either soft sediment with wood debris or mixed coarse substrate. The intertidal and subtidal boulder/ bedrock substrate had the highest diversity of macroalgae (Table 4). The dominant taxon observed on the intertidal boulder/ bedrock habitat was rockweed (*Fucus* sp.) at 25 to 50% areal cover. Other taxa documented were red branched algae, rusty rock (*Hildenbrandia* sp.) and sea lettuce (*Ulva* sp.). Observed on the subtidal boulder/ bedrock habitat were a variety of red algae taxa, including branched, foliose and filamentous, ranging from 0 to 25% areal cover. Other macroalgae observed at relatively low density included Japanese weed, sea lettuce and encrusting coralline algae. Species richness was greater in the subtidal boulder/bedrock habitat for both sessile and motile invertebrates. Barnacles (*Semibalanus cariosus/Balanus* spp.) were the dominant taxon observed on both intertidal boulder/bedrock (75% cover) and subtidal boulder/bedrock (5 to 50% cover) habitat. Other invertebrate taxa quantified in the intertidal boulder/bedrock substrate were mussels and littorine snails (*Littorina* spp.). Sessile taxa quantified in the subtidal boulder/bedrock habitat were false jingle (*Pododesmus macrochisma*) and a variety of tunicates, specifically Monterey stalked squirt (*Styela montereyensis*), compound tunicate (class Ascidiacea) and mushroom compound tunicate (*Distaplia occidentalis*). Coonstripe shrimp was the dominant motile taxon observed. Other taxa quantified at low abundance were swimming scallop (*Chlamys rubida*), white-rimmed nudibranch (*Aldisa albomarginata*) and lined chiton (*Tonicella lineata*). A juvenile rockfish (*Sebastes* sp.) was observed on subtidal boulder substrate.

The dominant macroalgae taxon observed on the soft and mixed substrate was brown bladed kelp (i.e. *Laminaria* sp.) with low cover (0 to 5% areal cover). The dominant sessile taxon were barnacles with low cover (0 to 5%). No other sessile or motile taxa were observed on the soft or mixed substrate.

Table 4: Summary of Macroalgae and Invertebrate Community Species Richness at F/G Jetty

Habitat Type	Macroalgae		Sessile Invertebrates		Motile Invertebrates	
	Richness mean (range)	Dominant Taxa	Richness mean (range)	Dominant Taxa	Richness mean (range)	Dominant Taxa
Int-BBR	4.0 (4)	rockweed	2.0 (2)	barnacles	1.0 (1)	littorine snails
Sub-SSM	0.3 (0 to 2)	bladed brown kelp	0.1 (0 to 1)	barnacles	0	-
Sub-CGS	0.3 (0 to 1)	bladed brown kelp	0.7 (0 to 1)	barnacles	0	-
Sub-BBR	4.0 (3 to 5)	red branched/ foliose/ filamentous algae	3.3 (2 to 5)	barnacles	1.7 (1 to 2)	coonstripe shrimp

Notes:

Species observed during towed video analysis are listed in the Species List in Appendix B. Table 3 and Table 4 summarize observations made during dive surveys only.

[1]Habitat type: Int-BBR= intertidal boulder, bedrock, rip rap substrate; Sub-SSM= subtidal sand, shell, mud substrate; Sub-CGS= subtidal cobble, gravel, sand substrate; Sub-BBR= subtidal boulder, bedrock, rip rap substrate.

3.2.2 Habitat Mapping

D Jetty

The area under the jetty was composed of subtidal cobble, gravel and sand substrate and continued from the jetty or transitioned to subtidal sand, silt and mud substrate (Figure 3). Sensitive habitats mapped in the vicinity to D Jetty include known abalone habitat as illustrated on Figure 4.

F/G Jetty

Elevation data for the nearshore portion of the proposed dredge boundary was unavailable at the time of the habitat assessment (Figure 3); therefore, the intertidal area in the southwest portion of the proposed dredge boundary was combined (0.1 to 3.1 m CD). This area was characterized by intertidal bedrock, boulder and riprap substrate with three pockets of intertidal cobble, gravel and sand substrate. The intertidal area transitioned to either subtidal cobble, gravel and sand or sand, silt and mud substrate. At the northern portion of the proposed dredge boundary, subtidal sand, silt and mud substrate transitioned to cobble, gravel and sand substrate and a small patch of boulder substrate. Boulder substrate was documented nearshore and within the northern extent of the F/G Project Area (Figure 4). Habitat characteristics for these areas are summarized in Table 5 below.

LEGEND

REMEDIATION FOOTPRINT (2016)
FORMER REMEDIATION FOOTPRINT
ABALONE LOCATION
BOULDER/BEDROCK/RIPRAP
BOULDER
MAPPED HABITAT:
ABALONE

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING: DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

0 25 50
1:1,000 METRES

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-07-07
DESIGNED	K. WESTMAN
PREPARED	R. WIGGINS
REVIEWED	J. SHERRIN
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT ASSESSMENT SURVEY

TITLE
MAPPED SENSITIVE HABITATS

PROJECT NO.	PHASE	REV.	FIGURE
1657898	1000	0	4

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3.2.3 Abalone Survey

Initial Abalone Habitat Reconnaissance Survey (Phase 1)

During the Phase 1 survey, four abalone were observed along the D Jetty wall in the shallow subtidal zone ranging from 1.0 to 2.5 m below CD of boulder (100%) habitat with a high cover of encrusting coralline algae (75 to 100%) (Table 5). Abalone ranged in size from 33 to 133 mm SL. Abalone predators were not observed nor were abalone observed in association with urchins. Macroalgae was observed with a low cover (<1 to 5%) along the boulder habitat including five rib kelp (*Costaria costata*), Japanese weed, sea lettuce and red algae.

No abalone were observed during the Phase 1 surveys conducted at F/G Jetty. In addition, many factors that indicate potential abalone habitat were not observed in the F/G Jetty area; specifically, coverage by brown bladed kelps and other macroalgae was low (<5%) or absent and the density of boulder substrate in the northern part of the F/G Jetty Project Area was determined to be low (50-60% boulder; 25-50% cobble) over a relatively small area of seafloor (187 m^2). As a result, this habitat was considered not suitable for abalone due to the overall substrate composition and a lack of factors indicative of potential abalone habitat (e.g., low coverage of kelp and other macroalgae). The mapped boundary of the F/G Jetty boulder and bedrock substrate is illustrated on Figure 4; abalone habitat mapping surveys (Phase 2) were not conducted in this area.

Table 5: Summary of Phase 1 Habitat and Abalone Reconnaissance Surveys

Area	Substrate (%)	Encrusting coralline (% Cover)	Macroalgae (% Cover)[1]	Abalone Shell Length (mm)[2]	Comments/ Observations
D Jetty, boulder along Jetty	Boulder 100%	75 to 100%	Five rib kelp (1 to 5%), Japanese wireweed (1 to 5%), sea lettuce (<1%), RF (<1%), RB (<1%), RH (<1%)	133	Suitable abalone habitat. No predators or urchins observed.
				52	
				112	
				33	
F/G Jetty, offshore boulder	Boulder (50 to 60%), Cobble (25 to 50%)	5 to 25%	Bladed brown kelp (<1%), RF (5 to 25%), RB (<1%), RH (1-5%)	No abalone observed	Not suitable abalone habitat.
F/G Jetty, nearshore boulder	Boulder 100%	5 to 25%	Japanese wireweed (1 to 5%), sea lettuce (5 to 25%), bladed brown kelp (<1%), RF (1-5%), RB (<1%)	No abalone observed	Not suitable abalone habitat. Red rock crab, Dungeness crab observed.

[1] Macroalgae codes: RF- red foliose, RB- red branched, RH- red filamentous, Brown bladed kelp includes five rib kelp and *Laminaria* sp.
[2] Abalone presence: mm SL- shell length in millimetres, abalone was measured using calipers

Abalone Habitat Mapping and Transect Survey (Phase 2)

Suitable abalone habitat identified during the Phase 1 survey was mapped in more detail along the east wall under the D Jetty (Figure 4). Abalone habitat extended approximately 43 m in length parallel to the boulder habitat and was estimated to be 241 m^2. Three transects were surveyed (see Figure 2) with three to seven quadrats sampled per transect. Abalone were not observed during the transect survey (Table 6).

Although the important factors that indicate abalone habitat were not observed in the boulder habitat at the north end of the F/G Jetty Project Area, as a precautionary measure, Phase 2 transect surveys were conducted as well. Abalone were not observed during transect surveys.

Table 6: Summary of Phase 2 Abalone Transect Survey

Area	# of Quadrats	Max Depth (m CD)	# of abalone (mm SL)[1]	Dominant Substrate (%)	Habitat Characteristics		
					Macroalgae (% cover)[3]	Urchin Presence	Predator Presence
D Jetty, boulder along Jetty	16	-3.5	0	EN[2] 10 to 95	RF/RB/RH (<1 to 5%)	Green urchin	Red rock crab

[1] mm SL- millimetres shell length of abalone measured with calipers

[2] EN- encrusting coralline algae

[3] Macroalgae codes: RF- red foliose, RB- red branched, RH- red filamentous

4.0 SUMMARY

This habitat assessment report was based on Anchor's 2013 design (Anchor 2013) and includes habitat information relevant to project activities proposed for F/G and D Jetty at the time of the surveys. Survey results indicate that subtidal habitats throughout the Project Area were composed primarily of boulder or bedrock substrate in nearshore areas and in a few offshore areas with a transition of gravel/cobble substrate and soft sediments in offshore areas. Anthropogenic debris, such as metal was distributed throughout the survey area and were primarily observed around existing man-made structures such as boat floats and jetties. In both locations, existing concrete and wood structures that extended into intertidal and subtidal zones offered a hard substrate for sessile marine organism attachment and growth. Hard substrates within the D Jetty survey area are outside of the D Jetty Project Area as defined within the draft 100% design specifications (Anchor 2016).

Subtidal and intertidal boulder/bedrock habitat had higher species richness and diversity of macroalgae and invertebrate taxa compared to mixed and soft sediment habitats. Sensitive habitats including suitable abalone habitat were identified and delineated within the D Jetty Project Area. Macroalgae abundance and distribution within the Project Areas may not have been fully captured during the habitat surveys as the surveys were conducted during the winter and macroalgae are generally more productive during the spring and summer seasons.

Abalone, a gastropod listed federally as threatened and provincially as red-listed, was present at low density in the boulder substrate observed along the east jetty wall of D Jetty adjacent to, and outside of, the D Jetty Project Area. Additional abalone surveys will be conducted in accordance with DFO survey protocol guidance (e.g. survey conducted during nighttime) prior to the commencement of Project activities to delineate adjacent abalone and their habitat.

Invertebrate species that were ubiquitous within the Project Area included Dungeness crab and red rock crab. Other species that were substrate specific were rock scallop and blue mussel on boulder/bedrock substrate.

5.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any questions regarding this report, please do not hesitate to contact the undersigned at 250-881-7372.

GOLDER ASSOCIATES LTD.

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EG/MS/BGW/syd

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6.0 REFERENCES

Anchor (Anchor QEA LLC). 2016. Draft 100% Design Report: Colwood Jetties Remediation Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. June 2016.

Anchor (Anchor QEA, LLC). 2013. Draft Preliminary Alternative Basis of Design Report Esquimalt Harbour Remediation Project. Report prepared for Public Works and Government Services Canada, Department of National Defence, Defence Construction Canada. Submitted July 2013.

Breen, P.A., and B.E. Adkins. 1979. A Survey of Abalone Populations on the East Coast of the Queen Charlotte Islands, August 1978. Fisheries and Marine Services, Manuscript Report 1490:125 pp.

Fisheries and Oceans Canada (DFO). 2007. Recovery Strategy for the Northern Abalone (*Haliotis kamtschatkana*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver. vi + 31 pp.

DFO. 2013. Fisheries Productivity Investment Policy: A Proponents Guide to Offsetting. November 2013.

Golder (Golder Associates Ltd.). 2016a. Esquimalt Harbour Remediation Project: Marine Habitat. Report prepared for Public Works and Government Services Canada. Submitted March 23, 2016. Reference no: 1545562-008-R-RevA-3000

Golder. 2016b. Esquimalt Harbour Remediation Project: Marine Habitat Assessment for C Jetty, ML Floats, Y Jetty and Lang Cove. Report prepared for Public Works and Government Services Canada. Reference no: 1545562-008-R-Rev0-3000

SLR. 2015. A/B Jetty Recapitalization Project, CFB Esquimalt, Victoria, BC. A/B Jetty Habitat Offsetting Plan. Report prepared for Defence Construction Canada. Submitted July 2015.

APPENDIX A

DFO's Marine Foreshore Environmental Assessment Procedure

Marine Foreshore Environmental Assessment Procedure

1.0 INTRODUCTION

Marine foreshore projects have the potential to effect fish[1] and fish habitat[2]. Fisheries and Oceans Canada (DFO) is responsible for the protection and management of fish habitat under the authority of the Fisheries Act and may request plans, specifications and environmental assessments specific to such projects where more detailed information is required. Presented below are standardized, transect-based assessment procedures intended to provide DFO with the basic information required to determine the potential effects of proposed developments on fish habitat.

2.0 METHODS

2.1 Assessment Area

The assessment area should include the proposed tenure area, as well as the adjacent foreshore, for comparative purposes. This will provide a context for the project and may provide data about cumulative effects, if similar developments already occur on or adjacent to the site. A large scale site plan, preferably an enlargement of the hydrographic chart, with a small scale insert of the general geographic location will serve as a base map of the study area.

2.2 Transects

Transects should be established perpendicular to the shoreline at regular intervals, in order to assess a representative sample of the fish habitats across the site. The number of transects will vary depending on the size of the proposed tenure and the variability of fish habitats sustained by the site. Transects should begin at the HHWM (highest high water mark) and extend to the –20m depth at a minimum (-30m, if development has the potential to effect deeper benthic habitats). Intertidal projects will only require intertidal transects, but care must be taken to ensure that a representative sample across the proposed development area is collected (intertidal clam or benthic invertebrate sampling may be recommended; sampling manuals for these assessments are available from DFO). It is recommended that a reconnaissance swim or walk be undertaken prior to establishing transects in order to determine site variability.

To ensure that marine plants and animals in the photic zone will be assessed completely, deeper transects may be necessary. Deeper transects may also be required to determine distribution of sunken debris or woodwaste accumulations resulting from existing or former developments. Transect lengths will normally extend from the HHWM to a point extending approximately 25 m beyond the tenure boundary and spaced approximately 25 m apart. The number of transects required will depend on the nature of the proposed

---

[1] shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;

[2] spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes;

activity, the anticipated affects of the development and the local site conditions (tides and currents, habitat variability, geography, fetch, geology, etc.). Transects should be individually numbered and indicated on the site plan, with the commencement point of the transects referenced to benchmarks, where possible.

2.3 Habitat Observations

Habitat inventories should be conducted during more productive spring/summer periods. Seaweeds and saltmarsh species are more readily identifiable

Habitat observations are to be recorded every 5 m along the transect or at significant changes in habitat type. Observations should include substrate type and composition, marine plants, sessile and motile marine animals and other features (i.e. debris). The information should be compiled in tabular form, by transect. Common names of observed animals and plants are acceptable for the data table, however, a species list with scientific names should be included as an appendix to the report. An example data table is attached for reference. Observations of substrate type, presence and relative abundance of marine animals and plants and other features should be correlated with tidal height or water depth and their position along the transect.

2.3.1 Substrate

Substrate type and relative composition are recorded along the transect. Substrate types are to be subdivided into the following size class categories:

- Bedrock
- Boulder (>256 mm diameter)
- Cobble (64-256 mm diameter)
- Gravel (2-64 mm diameter)
- Sand (0.0625-2 mm diameter)
- Silt/Mud/Clay (<0.0625 mm diameter)

Substrate types are cumulative and recorded as percentages out of a total of 100.

E.g. Boulder 5%; Cobble 15%; Gravel 60%, Sand 20%

2.3.2 Marine Plants

Marine plants include rooted vascular vegetation (eelgrass, saltmarsh vegetation) and marine algae (seaweed/kelp). Marine plant observations are recorded as percent areal coverage estimates per 5 m X 1 m transect segment. Observations can be recorded as percentages (5%, 10%, 15% etc.) or by utilizing the following areal coverage classes:

+	<5%
1	5-25%

2	>25-50%
3	>50-75%
4	>75-100%

2.3.3 Sessile Animals

Many marine animals become permanently attached to substrates as part of their life history. These animals also function as habitats that are important to fish. Barnacles and mussels are examples of animals that function as fish habitat in the marine environment. Sessile animals are recorded as percent areal coverage along the transect line. Observations can be recorded as percentages (5%, 10%, 15% etc.) or by utilizing the areal coverage classes presented above.

2.3.4 Motile Animals

Motile animals include fish and marine invertebrates such as crabs and snails. These can be counted along the transect line, or, in cases where they are too numerous, estimates of their numbers can be recorded. Estimates will most likely be applied to species such as herring or mysid shrimp that occur in large numbers.

3.0 HABITAT MAPPING

General marine plant categories (i.e.: rockweed, eelgrass, bull kelp, saltmarsh etc) and any other notable features should be sketched to scale directly on a copy of the site plan, drawings or photographs of the site. A site profile should be prepared for each transect showing the slope of the foreshore, with the location of indicator marine plants or invertebrates marked directly on the profile. A sketch of proposed tenure works (long line locations, anchor locations, seed holding areas, areas with predator netting etc.) should be superimposed over the site plan, so that the effect of the project on fish habitat characteristics, is clear. Maps should be presented at no greater than 1:1000 scale for ease of interpretation.

Tidal Height/Water Depth

The lowest normal tide (0.0m), or chart datum, will be used as the reference point for the measurement of tidal height and water depth to accompany the assessment. Tidal height is recorded as positive relative to chart datum, while water depth below chart datum will be recorded as a negative value (i.e.: if the assessment is made when the tide is at 2.0m, and a record is taken at a water depth of 8.0m, then the depth will be recorded as –6m). Tidal height will be corrected using the closest secondary port to the reference port found in the Canadian Tide and Current Tables, with further correction made for daylight savings time as required.

4.0 VIDEO AND STILL PHOTOGRAPHY

Video and photographs provide a real-time record of the fish habitat characteristics of the site and can be used to assess future impacts based on site monitoring.

An unedited, labelled copy of video transects should be submitted with the report. The video footage should be referenced with additional information (time, date, depth, heading etc.) for later analysis. A written or recorded interpretation should accompany the video.

For best results, photographic records should be collected during the more productive spring/summer seasons. If timing is critical, interpretation of the results should include references to data collected during the most productive seasons in the year (ie: although rockfish may not be observed in rocky reef habitats during the winter, they will likely be present during the spring and summer). Seaweeds and saltmarsh species are more readily identifiable during the spring and summer and a better impression of the productive capacity of the site can be made. Visibility may, however, be a problem, and appropriate tidal levels and midday lighting conditions are recommended.

Aerial photos are often useful as well, and these should preferably be taken at low tide. Such photographs will help the assessor to put the site into context with the surrounding area, and verify information provided from other sources.

5.0 SUMMARY OF INFORMATION TO BE SUBMITTED

1. Basemap showing tenure area boundaries, surrounding area, transect locations and sampling stations.
2. Shoreline video/photographs of intertidal zone.
3. Underwater video/photographs of transects
4. Tabular data for each transect.
5. Habitat map showing location of different substrate types, plants, animals and operational infrastructure.
6. Profile diagrams of each transect showing slope, sediment types and the major marine plants or animals observed.
7. Photographs of the site (if applicable)

APPENDIX B

Survey Data

Site Details									Substrate (% Cover)							Other (% Cover)						Macroalgae (% Cover)									
																						Red Algae (Rhodophyta)						Brown Algae (Phaeophyta)			Green Algae (Chlorophyta)
Date	Location	Transect Number	Time	Quadrat/ Distance Location along Transect (m)	Max Depth (ft)	Max Depth (m)	Approximate Tide (m)	Depth (m below CD)	Bedrock - crevice	Bedrock - Smooth	Boulder (>25 cm)	Cobble (6.5 to 25 cm)	Gravel (0.2 to 6.5 cm)	Silt / mud / clay (<0.06 sm)	Shell (crushed and whole)	Detrital Algae	Diatoms	Wood piling	Wood debris	Metal debris	Bacterial mat	Red foliose	Red filamentous	Red branched	Red spaghetti *Gracilaria* sp.	Rusty rock *Hildenbrandia* sp.	Encrusting coralline *Lithothamnion* sp.	Bladed kelp *Laminaria* sp.	Rockweed *Fucus* sp.	Japanese weed *Sargassum* sp.	Sea lettuce *Ulva* sp.
3-Feb-16	D Jetty	DJ1	10:39	0	25.6	7.8	2.50	-5.3					2	83	5				10												
3-Feb-16	D Jetty	DJ1	10:44	10	26.9	8.2	2.50	-5.7					40	30	20	<1			10												
3-Feb-16	D Jetty	DJ1	10:47	20	28.5	8.7	2.50	-6.2						55	10	<1			35												
3-Feb-16	D Jetty	DJ1	10:52	30	28.2	8.6	2.50	-6.1						30	10	<1			60												
3-Feb-16	D Jetty	DJ1	10:58	40	28.9	8.8	2.50	-6.3					5	30	15				50			<1	1-5								
3-Feb-16	D Jetty	DJ1	11:02	50	28.9	8.8	2.50	-6.3						40	10	<1			50				5-25								
3-Feb-16	D Jetty	DJ1	11:09	60	28.9	8.8	2.48	-6.3				15	5	55	10	1-5			15												
3-Feb-16	D Jetty	DJ1	11:15	70	29.5	9.0	2.44	-6.6				5		45	25	1			25												
3-Feb-16	D Jetty	DJ1	11:20	80	32.5	9.9	2.44	-7.5				20		65	10				5								1-5				
3-Feb-16	D Jetty	DJ1	11:22	90	35.1	10.7	2.42	-8.3				20		65	10				5												
3-Feb-16	D Jetty	DJ1	11:29	100	42.0	12.8	2.40	-10.4				15		60	15				10												
3-Feb-16	D Jetty	DJ1	11:32	110	43.3	13.2	2.40	-10.8						75	15				10												
3-Feb-16	D Jetty	DJ2	13:40	0	21.3	6.5	2.38	-4.1				30	30	30	10																
3-Feb-16	D Jetty	DJ2	13:49	20	21.6	6.6	2.34	-4.3				24	50	25	1																
3-Feb-16	D Jetty	DJ2	13:56	40	21.6	6.6	2.30	-4.3				20	30	45	5																
3-Feb-16	D Jetty	DJ2	14:01	60	20.3	6.2	1.90	-4.3				15	40	40	5																
3-Feb-16	D Jetty	DJ2	14:14	80	30.8	9.4	1.84	-7.6				20	25	40	10				5												
3-Feb-16	D Jetty	DJ3	15:29	0	33.8	10.3	1.70	-8.6					5	85	5				5												
3-Feb-16	D Jetty	DJ3	15:38	20	32.1	9.8	1.68	-8.1						60					40												
3-Feb-16	D Jetty	DJ3	15:42	40	31.8	9.7	1.68	-8.0				10		70	5					15											
3-Feb-16	D Jetty	DJ3	15:55	60	33.1	10.1	1.54	-8.6				15		50	15					20											
9-Feb-16	F/G Jetty	FG1	10:15	0	14.8	4.5	2.15	-2.4					5	90	5										<1			<1			
9-Feb-16	F/G Jetty	FG1	10:19	5	16.4	5.0	2.16	-2.8				20	5	65	10																
9-Feb-16	F/G Jetty	FG1	10:23	10	16.4	5.0	2.18	-2.8				75	5	8	2													<1			
9-Feb-16	F/G Jetty	FG1	10:30	15	13.8	4.2	2.20	-2.0			60	20	10	8	2							<1	5-25	<1				1-5			
9-Feb-16	F/G Jetty	FG1	10:38	20	14.8	4.5	2.23	-2.3			50	25	10	13	2							1-5	5-25	<1							
9-Feb-16	F/G Jetty	FG1	10:42	25	19.0	5.8	2.24	-3.6			30	30	8	30	2																
9-Feb-16	F/G Jetty	FG2	11:02	0	14.4	4.4	2.30	-2.1					8	90	2																
9-Feb-16	F/G Jetty	FG2	11:04	5	16.4	5.0	2.30	-2.7						90	<1				10		1-5										
9-Feb-16	F/G Jetty	FG2	11:07	10	17.7	5.4	2.31	-3.1						90	<1		P		10												
9-Feb-16	F/G Jetty	FG2	11:13	15	20.3	6.2	2.31	-3.9						90			P		10												
9-Feb-16	F/G Jetty	FG2	11:15	20	21.3	6.5	2.32	-4.2						90	<1	<1	P		10												
9-Feb-16	F/G Jetty	FG2	11:16	25	23.3	7.1	2.32	-4.8						100			P														
9-Feb-16	F/G Jetty	FG3	12:46	0	2.0	0.6	2.48	1.9		100														5-25		1-5			25-50		<1
9-Feb-16	F/G Jetty	FG3	12:54	5	9.5	2.9	2.49	-0.4			95			5								1-5			1-5		5-25			5-25	1-5
9-Feb-16	F/G Jetty	FG3	13:02	10	13.4	4.1	2.50	-1.6						95	5		P														
9-Feb-16	F/G Jetty	FG3	13:06	15	15.7	4.8	2.50	-2.3						95	5	1-5	P														
9-Feb-16	F/G Jetty	FG3	13:10	20	17.4	5.3	2.51	-2.8						90	<1		P		10												
9-Feb-16	F/G Jetty	FG3	13:14	25	18.7	5.7	2.52	-3.2						70	2	<1	P		28								2	1-5			
9-Feb-16	F/G Jetty	FG3	13:23	30	20.7	6.3	2.53	-3.8						35	3	<1	P	25	37												

Notes:
* Sessile invertebrate cover was estimated based on the total area surveyed using the following categories: <1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-100%
* P for diatoms refers to presence
* Approximate tidal height was based on information for Esquimalt Harbour, BC (DFO station ID #7109).
* Metres chart datum (m CD) refers to the depth of transect observations at lowest low water.

APPENDIX B
Habitat Survey Data

Site Details									Invertebrates (% Cover or Counts by species)																							Fish		Comments
									Crustaceans (Counts)					Echinoderms (Counts)	Mollusca (Counts)									Cnidaria (Counts / %		Worms (Counts)					Sponge (% Cover)			
Date	Location	Transect Number	Time	Quadrat/ Distance Location along Transect (m)	Max Depth (ft)	Max Depth (m)	Approximate Tide (m)	Depth (m below CD)	Barnacles *Semibalanus cariosus/ Balanus* spp. (% cover)	Coon-stripe shrimp *Pandalus danae*	Dungeness crab *Metacarcinus magister*	Red rock crab *Cancer productus*	Slender crab *Cancer gracilis*	Mottled star *Evasterias troschelii*	Lined chiton *Tonicella lineata*	Swimming scallop *Chlamys rubida*	Blue mussel *Mytilus edulus* (% cover)	False jingle *Pododesmus macrochisma*	Littorine snails *Littorina* spp.	Unidentified nudibranch Order Nudibranchia	White rimmed nudibranch *Aldisa albomarginata*	Black tip dendronotid *Acanthodoris pilosa*	Shaggy mouse nudibranch *Aeolidia papillosa*	Plumose anemone *Metridium senile* (counts)	Hydroid Class Hydrozoa	Calcareous tube worms Family Serpulidae	Monterey stalked squirt *Styela montereyensis*	Compound tunicate Class Ascidiacea	Mushroom compound tunicate *Distaplia occidentalis*	Unidentified encrusting tunicate	Sponge Class Demospongiae	Blackeye goby *Coryphopterus nicholsi*	Tidepool sculpin *Oligocottus maculosus*	
3-Feb-16	D Jetty	DJ1	10:39	0	25.6	7.8	2.50	-5.3																										
3-Feb-16	D Jetty	DJ1	10:44	10	26.9	8.2	2.50	-5.7														1		5										
3-Feb-16	D Jetty	DJ1	10:47	20	28.5	8.7	2.50	-6.2																							<1			
3-Feb-16	D Jetty	DJ1	10:52	30	28.2	8.6	2.50	-6.1																1							<1			
3-Feb-16	D Jetty	DJ1	10:58	40	28.9	8.8	2.50	-6.3																										Feather duster castings observed.
3-Feb-16	D Jetty	DJ1	11:02	50	28.9	8.8	2.50	-6.3		10																								Feather duster castings observed.
3-Feb-16	D Jetty	DJ1	11:09	60	28.9	8.8	2.48	-6.3		22																								Feather duster castings observed.
3-Feb-16	D Jetty	DJ1	11:15	70	29.5	9.0	2.44	-6.6		18	2													4										Wire debris
3-Feb-16	D Jetty	DJ1	11:20	80	32.5	9.9	2.44	-7.5			1							1						1										
3-Feb-16	D Jetty	DJ1	11:22	90	35.1	10.7	2.42	-8.3		6																								Feather duster castings observed
3-Feb-16	D Jetty	DJ1	11:29	100	42.0	12.8	2.40	-10.4		3																								Feather duster castings observed, dark sediment.
3-Feb-16	D Jetty	DJ1	11:32	110	43.3	13.2	2.40	-10.8		9														1										Feather duster castings observed
3-Feb-16	D Jetty	DJ2	13:40	0	21.3	6.5	2.38	-4.1		5																								
3-Feb-16	D Jetty	DJ2	13:49	20	21.6	6.6	2.34	-4.3		6								1						1								1		
3-Feb-16	D Jetty	DJ2	13:56	40	21.6	6.6	2.30	-4.3		6															<1									
3-Feb-16	D Jetty	DJ2	14:01	60	20.3	6.2	1.90	-4.3										1															1	
3-Feb-16	D Jetty	DJ2	14:14	80	30.8	9.4	1.84	-7.6												1														
3-Feb-16	D Jetty	DJ3	15:29	0	33.8	10.3	1.70	-8.6		6	1		1																					Glass bottle debris
3-Feb-16	D Jetty	DJ3	15:38	20	32.1	9.8	1.68	-8.1		8		1																						Ceramic debris
3-Feb-16	D Jetty	DJ3	15:42	40	31.8	9.7	1.68	-8.0		14														2										Fabric debris, snail eggs on fabric, chain debris.
3-Feb-16	D Jetty	DJ3	15:55	60	33.1	10.1	1.54	-8.6			1												1	4										
9-Feb-16	F/G Jetty	FG1	10:15	0	14.8	4.5	2.15	-2.4																										
9-Feb-16	F/G Jetty	FG1	10:19	5	16.4	5.0	2.16	-2.8	<1																									
9-Feb-16	F/G Jetty	FG1	10:23	10	16.4	5.0	2.18	-2.8	5																									
9-Feb-16	F/G Jetty	FG1	10:30	15	13.8	4.2	2.20	-2.0	50	11											2						<1	<1		<1				
9-Feb-16	F/G Jetty	FG1	10:38	20	14.8	4.5	2.23	-2.3	40					1		1										<1								
9-Feb-16	F/G Jetty	FG1	10:42	25	19.0	5.8	2.24	-3.6	5																									Detrital *Laminaria* sp. (<1)
9-Feb-16	F/G Jetty	FG2	11:02	0	14.4	4.4	2.30	-2.1																										
9-Feb-16	F/G Jetty	FG2	11:04	5	16.4	5.0	2.30	-2.7																										Organic debris on sediment surface
9-Feb-16	F/G Jetty	FG2	11:07	10	17.7	5.4	2.31	-3.1																										Piece of wood with nudibranch egg ribbon and detrital *Sargassum* sp.
9-Feb-16	F/G Jetty	FG2	11:13	15	20.3	6.2	2.31	-3.9																										
9-Feb-16	F/G Jetty	FG2	11:15	20	21.3	6.5	2.32	-4.2																										
9-Feb-16	F/G Jetty	FG2	11:16	25	23.3	7.1	2.32	-4.8																										
9-Feb-16	F/G Jetty	FG3	12:46	0	2.0	0.6	2.48	1.9	75								5-25		200															
9-Feb-16	F/G Jetty	FG3	12:54	5	9.5	2.9	2.49	-0.4	5						1			3						2			<1		<1					Barnacles present were mainly empty tests.
9-Feb-16	F/G Jetty	FG3	13:02	10	13.4	4.1	2.50	-1.6																										
9-Feb-16	F/G Jetty	FG3	13:06	15	15.7	4.8	2.50	-2.3																										
9-Feb-16	F/G Jetty	FG3	13:10	20	17.4	5.3	2.51	-2.8																										Decapoda claw was observed.
9-Feb-16	F/G Jetty	FG3	13:14	25	18.7	5.7	2.52	-3.2																										*Laminaria* sp. on wood debris
9-Feb-16	F/G Jetty	FG3	13:23	30	20.7	6.3	2.53	-3.8																										

Notes:
* Sessile invertebrate cover was estimated based on the total area surveyed using the following categories: <1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-100%
* P for diatoms refers to presence
* Approximate tidal height was based on information for Esquimalt Harbour, BC (DFO station ID #7109).
* Metres chart datum (m CD) refers to the depth of transect observations at lowest low water.

APPENDIX B
Habitat Reconnaissance Survey

Area	Location	Max Depth Range (m below CD)	Substrate (%)	Macroalgae (% Cover)	Species Observed	Comments/ Observations
D Jetty	Boulder/ Bedrock/ Rip Rap	0 to -4.0	Shallow depths (0 to 2.5 m): Boulder (25-100%), Cobble (0-25%) and Metal debris (25-75%). Deeper depths (2.5 to 6.5 m): Cobble (10%) and Metal debris (90%)	Five rib kelp (1-5%), Japanese weed (1-5%), sea lettuce (<1%), encrusting coralline (1-5%), red foliose (<1%), red branched (<1%), red filamentous (<1%)	Barnacles, sharpnose crab, coon-stripe shrimp, shore crab, six ray star, green sea urchin, mossy chiton, black katy chiton, swimming scallop, mussels, keyhole limpet, barnacle nudibranch, anemones, pile perch, northern ronquil, blackeye goby, tubesnout	Abalone (length 12.2 cm) observed on 100% boulder substrate with 75-100% coverage by encrusting coralline (*Lithothamnion* sp.). Time of observation was 15:21 at a depth of 3.2 m. Lemon nudibranch egg ribbon observed. Sheet pile discarded and laying on boulder substrate.
F/G Jetty	Nearshore boulder/ bedrock	0.3 to 1.4	Boulder 100%	Japanese weed (1-5%), sea lettuce (5-25%), encrusting coralline (5-25%), bladed brown kelp (<1%), red folios (1-5%), red branched (<1%)	Red rock crab, Dungeness crab, kelp crab, white lined nudibranch	No abalone observed. Habitat not considered suitable abalone habitat based on observed characteristics
F/G Jetty	Boulder outcrop	-2.0 to -3.1	Boulder (50%), Cobble (25 to 50%)	Bladed brown kelp (<1%), encrusting coralline (5-25%), red folios (5 to 25%), red branched (<1%), red filamentous (1-5%)	Juvenile rockfish (unidentified species), sea lemon, rock scallop, California sea cucumber	No abalone observed. Not considered suitable abalone habitat.

Notes:
* Approximate tidal height was based on information for Esquimalt Harbour, BC (DFO station ID #7109).
* Metres chart datum (m CD) refers to the depth of transect observations at lowest low water

APPENDIX B
Reconnaissance Abalone Habitat Survey

Site Details								Substrate (%)	Encrusting coralline algae (% Cover)	Macroalgae (% Cover)	Abalone Shell Length (mm)	Observations
Date	Location	Time	Distance along Transect (m)	Max Depth (ft)	Max Depth (m)	Approximate Tide (m)	Depth (m below CD)					
18-Feb-16	D Jetty	15:21	20	8.2	2.5	1.55	-1.0	Boulder: 100	75 to 100	-	133	No predators or urchins observed
18-Feb-16	D Jetty	15:21	20	8.2	2.5	1.55	-1.0	Boulder: 100	75 to 100	-	52	No predators or urchins observed
18-Feb-16	D Jetty	15:25	21	13.1	4.0	1.53	-2.5	Boulder: 100	75 to 100	-	112	No predators or urchins observed
18-Feb-16	D Jetty	15:30	24.7	10.8	3.3	1.50	-1.8	Boulder: 100	75 to 100	-	33	No predators or urchins observed

Notes:
* Approximate tidal height was based on information for Esquimalt Harbour, BC (DFO station ID #7109).
* Metres chart datum (m CD) refers to the depth of transect observations at lowest low water.

APPENDIX B
Abalone Transect Survey Data

Site Details									Substrate Code	Macroalgae (% Cover)				Abalone Shell Length (mm)	Invertebrates (Counts)	
										Encrusting	Red Algae (Rhodophyta)				Urchin	Predator
Date	Location	Time	Distance along Transect (m)	Quadrat Number	Max Depth (ft)	Max Depth (m)	Approximate Tide (m)	Depth (m below CD)		Encrusting coralline *Lithothamnion* sp.	Red foliose	Red filamentous	Red branched	Northern abalone *Haliotis kamtschatkana*	Green sea urchin *Strongylocentrotus droebachiensis*	Red rock crab *Cancer productus*
18-Feb-16	D Jetty	15:28	12	1	5.9	1.8	1.52	-0.3	3	85	<1	1-5	<1			
18-Feb-16	D Jetty	15:31	12	2	5.2	1.6	1.50	-0.1	3/4	75		<1	<1			
18-Feb-16	D Jetty	15:33	12	3	3.3	1.0	1.48	0.5	3	15		<1				
18-Feb-16	D Jetty	15:38	22	1	14.1	4.3	1.46	-2.8	3/4	95			<1			
18-Feb-16	D Jetty	15:40	22	2	12.5	3.8	1.45	-2.4	3/4	90			<1			
18-Feb-16	D Jetty	15:42	22	3	10.5	3.2	1.43	-1.8	3/4/8	75			<1			
18-Feb-16	D Jetty	15:44	22	4	8.5	2.6	1.41	-1.2	3/8	80			<1			
18-Feb-16	D Jetty	15:47	22	5	4.9	1.5	1.37	-0.1	3/5	90						
18-Feb-16	D Jetty	15:49	22	6	3.9	1.2	1.36	0.2	3	80						
18-Feb-16	D Jetty	15:58	30	1	15.7	4.8	1.31	-3.5	3	90	<1					
18-Feb-16	D Jetty	16:00	30	2	15.1	4.6	1.30	-3.3	4	60					1	
18-Feb-16	D Jetty	16:02	30	3	12.5	3.8	1.29	-2.5	4	65						
18-Feb-16	D Jetty	16:04	30	4	10.2	3.1	1.27	-1.8	3/4	85						1
18-Feb-16	D Jetty	16:06	30	5	8.2	2.5	1.26	-1.2	3/4	85						
18-Feb-16	D Jetty	16:10	30	6	5.6	1.7	1.23	-0.5	3/4	45						
18-Feb-16	D Jetty	16:12	30	7	5.6	1.7	1.21	-0.5	3/4	30						

Notes:
* Sessile invertebrate cover was estimated based on the total area surveyed using the following categories: <1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-100%
* Approximate tidal height was based on information for Esquimalt Harbour, BC (DFO station ID #7109).
* Metres chart datum (m CD) refers to the depth of transect observations at lowest low water.
* Substrate codes: bedrock smooth (1), bedrock crevices (2), boulders (3), cobble (4), gravel (5), pea gravel (6), sand (7), shell (8), mud (9)

APPENDIX C

Species List

APPENDIX C
Survey Species List

Group	Common Name	Scientific Name
Fish	Blackeye goby	*Coryphopterus nicholsi*
Fish	Northern ronquil	*Ronquilus jordani*
Fish	Pile perch	*Rhacochilus vacca*
Fish	Snake prickleback	*Lumpenus sagitta*
Fish	Tidepool sculpin	*Oligocottus maculosus*
Fish	Tubesnout	*Aulorhynchus flavidus*
Fish	Unidentified flatfish	Order Pleuronectiformes
Invertebrate	Barnacles	*Semibalanus cariosus* /*Balanus* spp.
Invertebrate	Barnacle nudibranch	*Onchidoris bilamellata*
Invertebrate	Black katy chiton	*Katharina tunicata*
Invertebrate	Black tip dendronotid	*Acanthodoris pilosa*
Invertebrate	Blue mussel	*Mytilus edulis*
Invertebrate	Calcareous tube worms	Family Serpulidae
Invertebrate	Compound tunicate	Class Ascidiacea
Invertebrate	Coon stripe shrimp	*Pandalus danae*
Invertebrate	Dungeness crab	*Metacarcinus magister*
Invertebrate	False jingle	*Pododesmus macrochisma*
Invertebrate	Feather duster	*Eudistylia vancouveri*
Invertebrate	Green sea urchin	*Strongylocentrotus droebachiensis*
Invertebrate	Hydroid	Class Hydrozoa
Invertebrate	Keyhole limpet	*Diodoa aspera*
Invertebrate	Lined chiton	*Tonicella lineata*
Invertebrate	Littorine snails	*Littorina* spp.
Invertebrate	Monterey stalked squirt	*Styela montereyensis*
Invertebrate	Mossy chiton	*Mopalia mucosa*
Invertebrate	Mottled star	*Evasterias troschelii*
Invertebrate	Mushroom compound tunicate	*Distaplia occidentalis*
Invertebrate	Northern abalone	*Haliotis kamtschatkana*
Invertebrate	Plumose anemone	*Metridium senile*
Invertebrate	Red rock crab	*Cancer productus*
Invertebrate	Rock scallop	*Crassadoma gigantea*
Invertebrate	Rose star	*Crossaster papposus*
Invertebrate	Sea lemon	*Anisodoris nobilis*
Invertebrate	Shaggy mouse nudibranch	*Aeolidia papillosa*
Invertebrate	Sharpnose crab	*Scyra acutifrons*
Invertebrate	Shore crab	*Hemigrapsus* sp.
Invertebrate	Six ray star	*Leptasterias hexactis*
Invertebrate	Slender crab	*Cancer gracilis*
Invertebrate	Sponge	Class Demospongiae
Invertebrate	Swimming scallop	*Chlamys rubida*
Invertebrate	Unidentified anemone	*Urticina* sp.
Invertebrate	Unidentified encrusting tunicate	–
Invertebrate	Unidentified nudibranch	Order Nudibranchia
Invertebrate	Unidentified shrimp	Family Caridae
Invertebrate	White rimmed nudibranch	*Aldisa albomarginata*
Macroalgae	Bladed kelp	*Laminaria* sp.
Macroalgae	Encrusting coralline algae	*Lithothamnion* sp.
Macroalgae	Five rib kelp	*Costaria costata*
Macroalgae	Japanese weed	*Sargassum* sp.
Macroalgae	Red branched algae	–
Macroalgae	Red filamentous algae	–
Macroalgae	Red foliose algae	–
Macroalgae	Red spaghetti	*Gracilaria* sp.
Macroalgae	Rockweed	*Fucus* sp.
Macroalgae	Rusty rock	*Hildenbrandia* sp.
Macroalgae	Sea lettuce	*Ulva* sp.

References:

Druehl, L. 2000. Pacific Seaweeds. A guide to common seaweeds of the west coast. Harbour Publishing, Madeira Park, British Columbia, Canada.
Humann, P. 1996. Coastal Fish Identification. California to Alaska. New World Publications Inc., Jacksonville, Florida, USA.
Lamb, A, Edgell, P. 1986. Coastal Fishes Of The Pacific Northwest. Harbour Publishing, Madeira Park, British Columbia, Canada.
Lamb, A, Hanby, BP. 2005. Marine Life of the Pacific Northwest. A Photographic Encyclopedia of Invertebrates, Seaweeds and Selected Fishes.

APPENDIX D

Photograph Log

Photograph 1: Hooded mergansers near shoreline at F/G Jetty (looking west) – Feb 9, 2016

Photograph 4: Northern abalone at D Jetty (dive survey) – Feb 18, 2016

Photograph 2: Towed video camera during survey – Jan 26, 2016

Photograph 5: Scalyhead sculpin at D Jetty (dive survey) – Feb 18, 2016

Photograph 3: Northern abalone on encrusting coralline algae at D Jetty (dive survey) – Feb 18, 2016

Photograph 6: Measuring northern abalone at D Jetty (dive survey) – Feb 18, 2016

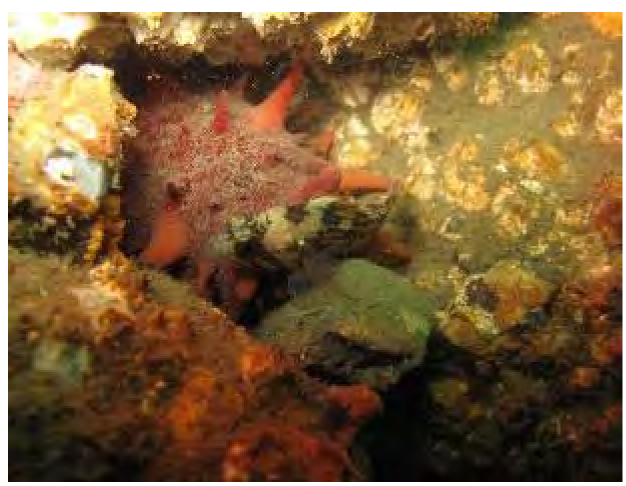
Photograph 7: Northern abalone at D Jetty (dive survey) – Feb 18, 2016

Photograph 8: Plumose anemones and mussels on piling at D Jetty (dive survey) – Feb 3, 2016

Photograph 9: Rock scallop on boulder and cobble substrate at F/G Jetty (dive survey) – Feb 9, 2016

Photograph 10: Sea lemon nudibranch on boulder substrate at F/G Jetty (dive survey) – Feb 9, 2016

Photograph 11: Red rock crab on boulder and cobble substrate at F/G Jetty (dive survey) – Feb 9, 2016



Photograph 12: Juvenile rockfish on California sea cucumber at F/G Jetty (dive survey) – Feb 9, 2016

Photograph 13: Kelp crab on boulder substrate at F/G Jetty (dive survey) – Feb 9, 2016

Photograph 14: White-rimmed nudibranch at F/G Jetty (dive survey) – Feb 9, 2016

Photograph 15: Unidentified flatfish at F/G Jetty (towed video survey) – Jan 27, 2016

Photograph 16: Japanese weed at F/G Jetty (towed video survey) – Jan 27, 2016

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Golder Associates

Annex B. Habitat Offsetting Review and Update

7 July 2016

F/G JETTY OPTIMIZATION PROJECT AND COLWOOD SOUTH REMEDIATION PROJECT

Assessment for Potential Serious Harm and Review of Habitat Offsetting Requirements at F/G Jetty and D Jetty

Submitted to:
Kristen Ritchot
Public Works and Government Services Canada
Environmental Services, Pacific Region
401-1230 Government St.
Victoria, BC
V8W3X4

REPORT

Report Number: 1657898-005-R-Rev0-2000

Distribution:

2 copies - Public Works and Government Services Canada
1 copy - Golder Associates Ltd.

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Notice to Readers

This report was prepared for Public Works and Government Services Canada in accordance with the terms and conditions outlined in the Public Works and Government Services Canada Marine Sediment Task Authorization (reference EZ899 150978/002/PWY).

The inferences concerning the Site conditions contained in this report are based on information obtained during the assessment conducted by Golder personnel, and are based solely on the condition of the property at the time of the field surveys, and supplemented by historical information obtained by Golder, as described in this report.

This report was prepared, based in part, on information obtained from historic information sources. In evaluating the subject Site, Golder has relied in good faith on information provided.

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.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, and should be reviewed.

Table of Contents

TABLES

FIGURES

Abbreviations and Acronyms

CCME .... Canadian Council of Ministers of the Environment
CD .... chart datum
CEAA .... *Canadian Environmental Assessment Act, 2012*
CFB .... Canadian Forces Base
CRD .... Capital Regional District
CSRP .... Colwood South Remediation Project
DFO .... Fisheries and Oceans Canada
DND .... Department of National Defence
EED .... environmental effects determination
EHRP .... Esquimalt Harbour Remediation Project
EMP .... Environmental Management Plan
EPP .... Environmental Protection Plan
FGOP .... F/G Jetty Optimization Project
PEL .... probable effect level
PWGSC .... Public Works and Government Services Canada
SARA .... *Species at Risk Act*
TSS .... total suspended solids

UNITS

m .... metres
m^2 .... metres squared
m^3 .... metres cubed
% .... percent

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) under the Marine Sediment Task Authorization (reference EZ899 150978/002/PWY) to assess for potential serious harm to fish and to review the habitat offsetting requirements for proposed remedial activities at F/G Jetty and D Jetty in Esquimalt Harbour, British Columbia (Figure 1). The scope of work for this report (Task 0-7 Habitat offsetting plan updates) was outlined in Golder's "Work-Plan and Cost Estimate to Provide Support for DND CFB Esquimalt F/G Jetty Optimization Project and Colwood South Remediation Project", dated May 26, 2016.

PWGSC and the Department of National Defence (DND) are proceeding with remedial activities in the vicinity of F/G Jetty as part of the F/G Jetty Optimization Project (FGOP), and in the vicinity of D Jetty as part of the Colwood South Remediation Project (CSRP). The FGOP and CSRP are being tendered together in a combined tender package but are considered as two separate projects for the purposes of this report. This assessment for potential serious harm and review of habitat offsetting requirements provides an update on the potential for serious harm and a review of the habitat offsetting requirements for the FGOP and CSRP based on the Anchor QEA L.L.C. (Anchor) draft 100% design specifications (Anchor 2016a). Remediation activities are proposed for other areas of Esquimalt Harbour including areas around A and B Jetties (A/B Jetty), C Jetty, ML Floats, Y Jetty, and Lang Cove. The potential for serious harm and habitat offsetting considerations for these locations are being evaluated separately from the FGOP and CSRP.

KEY MAP

LEGEND

REMEDIATION FOOTPRINT

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING "DFG Remediation Areas_20160630.dwg"
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.

0 250 500

1:10,000 METRES

CLIENT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

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YYYY-MM-DD	2016-07-07
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PROJECT

F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT OFFSETTING

TITLE

KEY PLAN

PROJECT NO.	PHASE	REV.	FIGURE
1657898	2000	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

Path: \\golder.gds\gal\Victoria\CAD-GIS\Client\PWGSC\esquimalt_harbour\99_projects\1545562_marinehabitat\02_PRODUCTION\3000_Offsetting\ | File Name: 1545562-3000-RB-44.dwg

1.1 Background

The DND and PWGSC project team is currently considering remediation within the Federal Harbour limits for Esquimalt Harbour as part of the FGOP and CSRP. Remediation activities are proposed to be undertaken in two phases. The first phase involves active remediation (e.g. dredging followed by backfill and material placement). The second phase involves risk assessment and risk management of contaminated sediments. Remediation activities have the potential to cause "serious harm to fish" as defined by the *Fisheries Act*. An assessment of the potential effects of the proposed activities on fish and fish habitat and an evaluation of potential offsetting is required. This offsetting evaluation followed a similar approach to the strategy used by SLR Consulting Ltd. (2015) to determine offset requirements for the proposed recapitalization project in the vicinity of A/B Jetty. The proposed project activities at A/B Jetty required a Paragraph 35(2)(b) *Fisheries Act* authorization (File 15-HPAC-00771 issued November 18, 2015) for serious harm to fish.

1.2 Objective

The objective of this report was to assess the potential for serious harm to fish and evaluate the amount of habitat offsetting required (if any) for current remediation plans and to determine if additional offsetting measures are required based on the balance in the DND habitat bank. Specifically, the objective of this review and update was to:

- Assess the potential for effects to fish habitat based on the draft 100% design specifications for the FGOP and CSRP (Anchor 2016a);
- Evaluate the potential serious harm to fish and offsetting requirements based on the approach used for the habitat assessment and offsetting for the A/B Jetty Recapitalization Project as required in the *Fisheries Act* authorization; and
- Determine the amount of offsetting credit available in the DND habitat bank and identify if sufficient habitat credits are available or if additional offsetting measures are required to offset the potential serious harm to fish.

This habitat offsetting review was based on data collected by Golder (2016a) for the F/G Jetty and D Jetty project footprint identified in Anchor (2013) and was supplemented with data from previous assessments to characterize the revised project footprints identified in the 100% Design Report (Anchor 2016a,b). The FGOP and CSRP will be implemented through a phased investigation approach and it is assumed that this review and update may require further revisions once project specifications are finalized.

2.0 DESCRIPTION OF THE PROPOSED FGOP AND CSRP

The habitat offsetting approach outlined in this review is based on Golder's understanding of the Project activities as described by Anchor (2016a). Proposed project activities for the FGOP and CSRP include:

- Mobilization and demobilization;
- Structure removal, relocation and reinstatement;
- Dredging and residuals management;
- Barge dewatering;
- In-water transportation;
- Offloading, stockpiling, processing and potential treatment of contaminated sediment;
- Upland transportation and disposal; and
- Backfill and material placement.

Project activities for the FGOP and CSRP are described in more detail below.

2.1 Description of Proposed Project Activities

Dredging is proposed for the FGOP and the CSRP and will involve removal of seafloor debris and contaminated sediments. Previous sediment investigations identified seafloor contaminants in exceedance of the Canadian Council of Ministers of the Environment (CCME) probable effects level (PEL) sediment quality guidelines (Anchor 2013). Temporary increases in turbidity and total suspended solids (TSS) are anticipated for project activities such as dredging, backfill and material placement and other in-water works. The measures to mitigate temporary increases in turbidity and TSS, along with other project specific mitigation measures are further described in a separate *Canadian Environmental Assessment Act, 2012* (CEAA, 2012) Section 67/68 Environmental Effects Determination (EED) report and project specific environmental management plan (EMP). Removal of contaminated sediment will result in an overall improvement to benthic habitat. The most current engineering design for dredging, available at the time of preparation of this assessment, is provided in the draft 100% design specification report developed by Anchor (2016a).

2.1.1 Mobilization and Demobilization

Mobilization activities proposed for the FGOP and CSRP include establishment of office facilities onsite and other temporary structures. Materials and equipment staging is proposed to be on-site, in an area such as the gravel parking area at the DND Colwood, at an upland location, or on barges within the F/G Jetty and D Jetty Project Areas. The staging area will be identified prior to project commencement and use will be limited to parking, office space, equipment staging and loading and unloading purposes only. No stockpiling or storage of dredged sediment or debris will occur at the staging area without written approval from the Departmental Representative. Demobilization activities include dismantling and removing all temporary facilities, clean-up of the F/G Jetty work site and any contractor off-site offload facility (Anchor 2016a).

Mobilization for the CSRP will be limited to the establishment of site offices, storage and other temporary facilities at the onsite staging area on D Jetty. Demobilization activities includes dismantling and removing all temporary facilities, clean-up of the D Jetty work site and if applicable, the contractor off-site offload facility (Anchor 2016a).

2.1.2 Structure Removal, Relocation and Reinstatement

Prior to dredging the utilities associated with the gas float and associated structures located within the F/G Jetty Project Area will be disconnected and the structures will be removed. Existing timber pilings will be removed using vibratory methods and after extraction, sediment and other objects attached to the surface of these piles will be cleaned off within the dredge area. Demolished structures will be disposed off-site or temporarily relocated to an identified area off-site (to be determined) until dredging is complete. Structures will be reinstalled in their existing locations and configurations. In the event the timber pilings are damaged upon removal, new timber pilings will be installed. It is expected that 50% of the pilings removed may require replacement due to damage from degradation and/or extraction. Pile driving and removal will be conducted using marine based floating equipment. Pile installation will occur using vibratory pile driving methods or an alternative equivalent method if submitted to the Departmental Representative for review (Anchor 2016a).

Structure removal proposed for the D Jetty Project Area includes removal of floating camel/tire fenders and attachments, wharf safety ladders and attachments, and miscellaneous jetty attachments and components. These structures will be removed prior to dredging and where possible will be salvaged, cleaned, stored off-site and replaced once dredging is complete. Structures that are deemed unsuitable for reinstatement will be disposed off-site. Removal of pilings associated with the fender system on the north side of D jetty is also proposed to facilitate dredging closer to the structure and backfill and material placement under the jetty. Pilings will be removed using vibratory methods. Where possible, pilings will be salvaged, cleaned, stored off site and reinstalled once dredging activities are complete. Pilings that are deemed unsuitable for reinstatement will be replaced with new timber piles of equivalent dimensions. Pile driving is proposed using marine/ barge-based floating equipment. Vibratory pile driving is the proposed method for pile driving, if vibratory pile driving is not used, an alternative equivalent method will be submitted to the Departmental Representative for review. (Anchor 2016a).

2.1.3 Dredging and Residuals Management

Dredging and re-dredging of targeted dredge pockets may be required to adequately remove contaminants and/or residuals from the F/G Project Area. The proposed dredge area for the FGOP includes 5,600 m^2 with a dredge volume of 10,100 m^3. The proposed F/G Jetty dredge area runs parallel to approximately 35 m of shoreline and extends offshore to a depth of -6.5 m chart datum (CD). Dredging rock outcrops is not considered feasible and is not required to meet remedial objectives. Dredging will be undertaken using mechanical dredging methods and dredged material and debris will be placed on a barge in preparation for disposal (Anchor 2016a).

A preliminary dredge area of 7,700 m^2 with a dredge volume of 14,300 m^3 has been identified for the CSRP and extends offshore to a depth of approximately -12 m chart datum. No dredging will occur under D Jetty, and a dredge offset area around the jetty will be established. Dredging will be undertaken using a bucket type and size of the Contractor's choosing provided that water quality requirements of the EMP and permit conditions are met (Anchor 2016a).

2.1.4 Barge Dewatering

No passive dewatering will be permitted in Dredge Units (DUs) 4 and 5 on the north side of D-Jetty based on water quality modelling undertaken for the Project (Golder 2016c). For the remainder of the DUs at D Jetty and at F/G Jetty, passive dewatering will occur. Dewatering will occur on the work site using filter media, such as filter fabric, to remove suspended solids from any barge effluent discharge with a discharge limit of 75 mg/L. The contractor shall collect, store, treat as necessary and discharge of effluent from barges in a manner that meets the water quality requirements of the EMP. Passive barge dewatering is proposed only within the remediation area boundaries (Anchor 2016a).

2.1.5 In-Water Transportation

Contaminated materials shall be transported from the worksite to the contractor's off-site offload facility using barges. Haul barges must be watertight to prevent passive dewatering of dredged sediment during in water transportation (Anchor 2016a).

2.1.6 Offloading, Stockpiling, Processing and Potential Treatment of Contaminated Sediment

Offloading of dredged sediments and debris is expected to occur at a staging area within the contractor's designated off-site offload facility. Dredged sediments and debris will be offloaded at an off-site offload facility determined by the contractor. It is expected that the offloading will occur directly from the material barge onto a staging area within the contractor off-site offload facility, where material will be processed (Anchor 2016a). Dredged sediment will be processed at a processing facility at the contractor off-site offload facility to segregate suspected explosive items and explosives of concern and to monitor for antiquities. Processed sediment has the potential to be reloaded onto a barge and shipped to a different upland area for disposal.

2.1.7 Upland Transportation and Disposal

Equipment used for activities occurring upland, at the contractor's off-site offload facility, will be decontaminated after working in potentially contaminated work areas and prior to subsequent work and will be transported by truck or rail for disposal. Wastewater generated from upland equipment decontamination activities will be contained, sampled and disposed of in accordance with federal, provincial and municipal regulations (Anchor 2016a).

2.1.8 Backfill and Material Placement

Following the completion of the dredging activities at F/G Jetty, backfill material will be placed to match pre-construction elevations and grades. Structural backfill will be placed for gas float structures prior to pile reinstatement. General backfill and surface backfill will be placed in areas to restore the seabed elevation to the pre-dredge bed elevation. Compaction of backfill after placement is not required (Anchor 2016a).

Once dredging activities at D Jetty are complete, backfill will be placed in the dredge prism footprint. Structural backfill for the fender system will be placed prior to reinstatement of the fender piling system. Substrate cover will be placed in underpier areas. A residuals management cover is proposed for the remainder of the dredge area (Anchor 2016a).

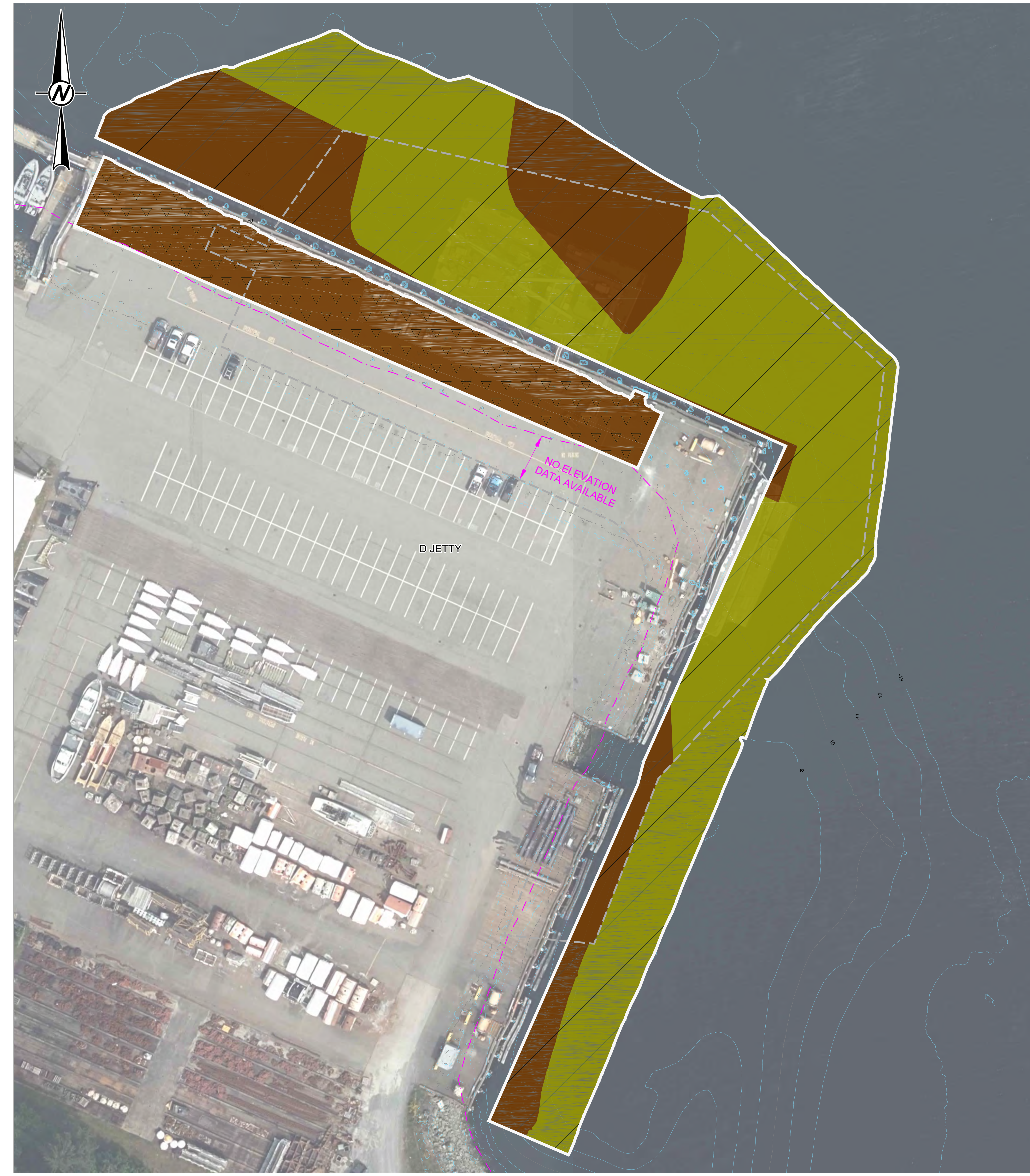
3.0 DESCRIPTION OF AQUATIC ENVIRONMENT

3.1 Existing Habitat within the Project Areas

Characterization of existing habitat within the Project Areas was based on data collected by Golder (2016a) and was supplemented with data from previous assessments conducted at F/G and D Jetties to characterize the revised project footprints identified in the 100% Design Report (Anchor 2016a). The preliminary project footprint (Anchor 2013) and the revised footprint (Anchor 2016a) are identified on Figure 2. Habitat information from the sources listed below was used to characterize existing habitat within the Project Areas:

- F/G - Jetty Optimization Project and Colwood South Remediation Project Marine Habitat Assessment for F/G Jetty and D Jetty (Golder 2016a);
- Esquimalt Harbour Remediation Project – D Jetty Debris Survey Summary (Anchor 2016b);
- Esquimalt Harbour Remediation Project – D Jetty Underpier Sediment Sampling Data Summary (Anchor 2016c);
- Qualitative Presence/Absence Survey for Marine Species. Esquimalt Harbour Remediation Project, F & G Jetty Remediation Area (Balanced Environmental Services Inc. [Balanced] 2012);
- Preliminary Marine Habitat Compensation Plan – Draft. Esquimalt Harbour Remediation Project, F & G Jetty Remediation Area (Balanced 2013);
- Archaeological Impact Assessment of Remedial Dredging Areas at Lang Cove and F & G Jetty in Esquimalt Harbour, Esquimalt, B.C. (Golder 2016b); and
- D Jetty and Jetty 11 Structural Reconnaissance (Klohn Crippen Berger 2016).

In general, the subtidal Project Areas to be dredged are composed of gravel/cobble substrate and mainly soft sediments. Nearshore areas were composed primarily of boulder/bedrock substrate and boulder patches were identified in a few offshore areas (Figure 2). Sensitive habitats including potential abalone habitat identified within the Project Areas are shown in Figure 3. Habitat characteristics specific to F/G Jetty and D Jetty are described in more detail below.



LEGEND

- REMEDIATION FOOTPRINT (JUNE, 2016)
- FORMER REMEDIATION FOOTPRINT
- LIMITS OF AVAILABLE ELEVATION DATA

INTERTIDAL (TO 3.1 m CD, OR AREAS WITHOUT ELEVATION DATA):

- HIGH HIGH WATER LEVEL
- SAND, SILT AND MUD
- COBBLE, GRAVEL AND SAND
- BEDROCK, BOULDER AND RIPRAP

SUBTIDAL (AREAS WITH BATHYMETRIC ELEVATION DATA, MAXIMUM ELEVATION VARIES FROM -0.8 m TO -2.0 m):

- SAND, SILT AND MUD
- COBBLE, GRAVEL AND SAND
- BOULDER

PROJECT COMPONENTS

- DREDGING FOOTPRINT
- UNDER-PIER BACKFILL AND MATERIAL PLACEMENT

0 20 40
1:500 METRES

NOTE(S)

1. SURFACE CONTOURS SHOWN IN 1 m (MINOR) AND 5 m (MAJOR) INTERVALS. ELEVATIONS SHOWN RELATIVE TO CHART DATUM.

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING "DFG Remediation Areas_20160630.dwg"
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
3. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE. ACCESSED 2016-03-03.
   3.1. BATHYMETRY: FILENAME: "14016_COLWOOD_25CMPIX.TIF". THE SURFACE WAS USED AS-IS.
   3.2. UPLAND: FILENAME: "COL_ENV.DWG" SURFACE CONTOURS ADJUSTED TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

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YYYY-MM-DD	2016-07-07
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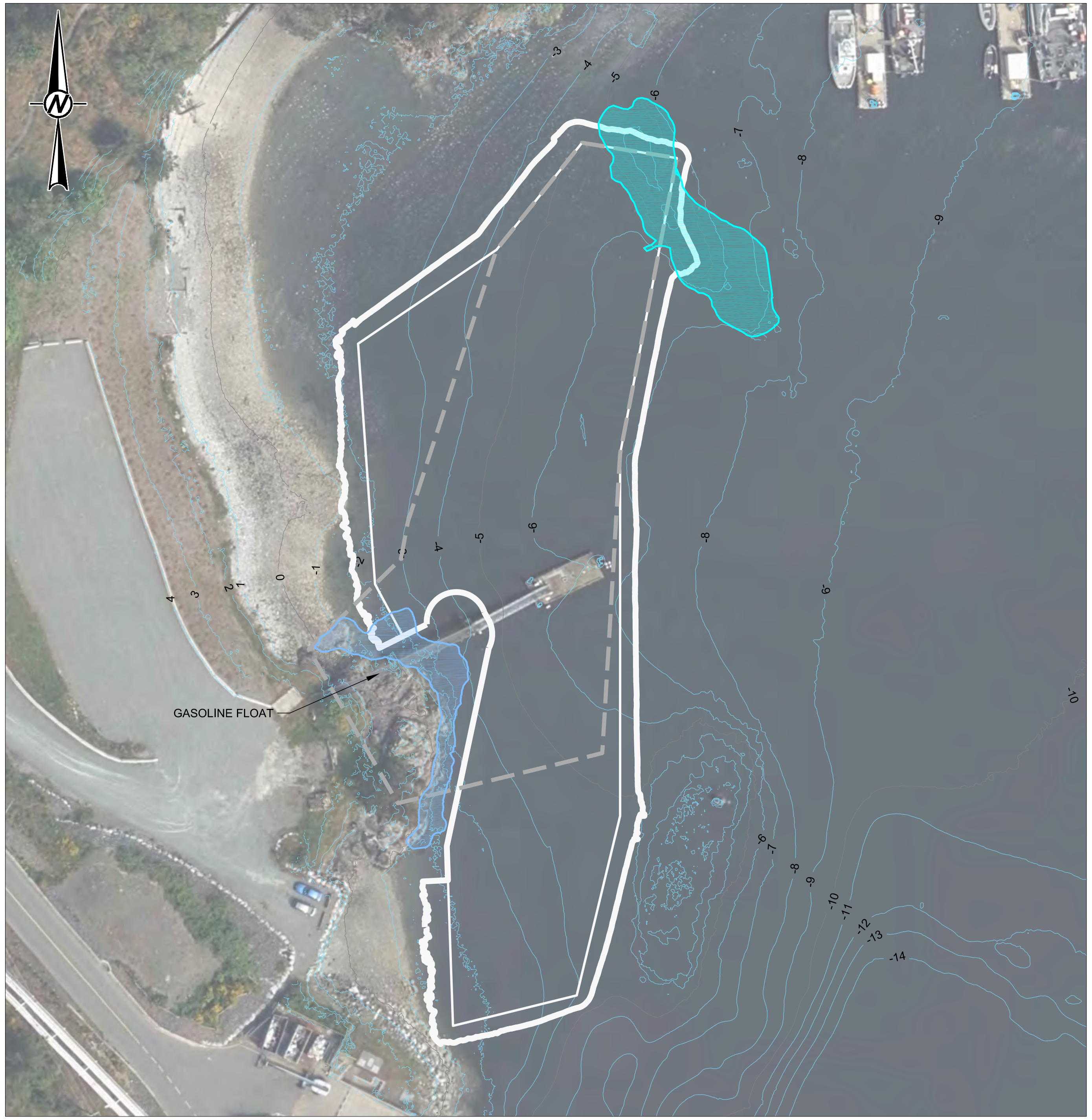
PREPARED	R. WIGGINS
REVIEWED	J. SHERRIN
APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT OFFSETTING

TITLE
HABITAT CHARACTERIZATION AND PROJECT COMPONENT F/G JETTY AND D JETTY

PROJECT NO.	PHASE	REV.	FIGURE
1657898	2000	0	2



LEGEND

- REMEDIATION FOOTPRINT (JUNE, 2016)
- DREDGE UNITS (JUNE, 2016)
- FORMER REMEDIATION FOOTPRINT
- BOULDER/BEDROCK/RIPRAP
- BOULDER

MAPPED HABITAT:

- ABALONE

0 25 50

1:1,000 METRES

REFERENCE(S)

1. PROJECT FOOTPRINT PROVIDED BY ANCHOR QEA; DRAWING DFG Remediation Areas_20160630.dwg.
2. IMAGERY DOWNLOADED FROM SLR CONSULTING EXAVAULT; ACCESSED 2016-02-03; 2015 AIR PHOTOS, 10 cm RESOLUTION.
3. SURFACE CONTOURS EXTRACTED FROM DIGITAL DATA DOWNLOADED FROM SLR CONSULTING'S EXAVAULT ESQUIMALT HARBOUR REMEDIATION PROJECT FTP SITE.
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   3.2 UPLAND: FILENAME: "COL_ENV.DWG". SURFACE CONTOURS ADJUSTED TO CHART DATUM USING A CONVERSION VALUE OF 1.885 m.

CLIENT
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

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YYYY-MM-DD	2016-07-07
DESIGNED	M. SPANI
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APPROVED	B. WERNICK

PROJECT
F/G JETTY OPTIMIZATION PROJECT
AND COLWOOD SOUTH REMEDIATION PROJECT
MARINE HABITAT OFFSETTING

TITLE
MAPPED SENSITIVE HABITATS

PROJECT NO.	PHASE	REV.	FIGURE
1657898	2000	0	3

3.1.1 F/G Jetty

Subtidal habitat within the F/G Jetty Project Area contained a mix of soft sediment, mixed substrate and boulder/bedrock habitat (Figure 2). The nearshore portion of the proposed dredge boundary was characterized by intertidal bedrock, boulder and riprap substrate with three pockets of intertidal cobble, gravel and sand substrate. The intertidal area transitioned to either subtidal cobble, gravel and sand or sand, silt and mud substrate. At the northern portion of the proposed dredge boundary, subtidal sand, silt and mud substrate transitioned to cobble, gravel and sand substrate and to patchy boulder substrate in the northeast corner of the survey area. Boulder substrate was documented nearshore and within the northern extent of the Project Area (Figure 3). Shell and wood debris was observed in nearshore areas, primarily in the area of the gasoline float and approach structure (Balanced 2012a, 2013; Golder 2016a,b).

The intertidal and subtidal boulder/ bedrock substrate had the highest diversity of macroalgae. The dominant taxon observed on the intertidal boulder/ bedrock habitat was rockweed (*Fucus* sp.) at 25 to 50% areal cover. Other taxa documented in association with the intertidal boulder/ bedrock substrate were red branched algae, rusty rock (*Hildenbrandia* sp.) and sea lettuce (*Ulva* sp.). A variety of red algae taxa, including branched, foliose and filamentous, ranging from 0 to 25% areal cover was observed on the subtidal boulder/bedrock habitat. Other macroalgae observed at relatively low density on the subtidal boulder/bedrock habitat included Japanese weed (*Sargassum* sp.), sea lettuce and encrusting coralline algae (*Lithothamnion* sp.). The dominant macroalgae taxon observed on the soft and mixed substrate was brown bladed kelp (*Laminaria* sp.) with low cover (0 to 5% areal cover). The dominant sessile taxon were barnacles with low cover ranging from 0 to 5% (Golder 2016a).

Species richness was greater in the subtidal boulder/bedrock habitat for both sessile and motile invertebrates. Barnacles were the dominant taxon observed on both intertidal boulder/bedrock (75% cover) and subtidal boulder/bedrock (5 to 50% cover) habitat. Other invertebrate taxa observed in the intertidal boulder/bedrock substrate were mussels and littorine snails (*Littorina* spp.). Sessile taxa identified in the subtidal boulder/bedrock habitat included false jingle (*Pododesmus macrochisma*) and a variety of tunicates, coonstripe shrimp (*Pandalus danae*), swimming scallop (*Chlamys rubida*), white-rimmed nudibranch (*Aldisa albomarginata*) and lined chiton (*Tonicella lineata*). Species observed throughout the F/G Jetty Project Area included shrimp and Dungeness crabs, which were observed on soft sediments, and red rock crabs observed on soft sediment and mixed coarse substrate. Other invertebrate species observed included rock scallops, plumose anemones, and a sea lemon nudibranch (*Anisodoris nobilis*) (Golder 2016a).

Surveys of the F/G Jetty Project Area in 2012 documented a juvenile rockfish (*Sebastes* sp.) on subtidal boulder substrate and a single unidentified flatfish was observed in soft sediment habitat (Golder 2016a). Copper rockfish (*Sebastes caurinus*), rock prickleback (*Xiphister mucosus*), kelp greenling, pile perch, rock sole, and several unidentified sculpins were observed in the F/G Jetty Project Area during surveys conducted in 2012 (Balanced 2012a).

No abalone were observed during the Phase 1 abalone surveys conducted at F/G Jetty. In addition, many indicators of potential abalone habitat based on DFO guidance (Appendix 2 in DFO 2007) were not observed in the F/G Jetty area, specifically coverage by brown bladed kelps and other macroalgae was low (<5%) or absent. The density of boulder substrate in the boulder habitat area in the northern part of the F/G Jetty Project Area was determined to be relatively low (50-60% boulder; 25-50% cobble) over a relatively small area of seafloor (187 m^2). As a result, this area was considered not suitable abalone habitat due to the overall substrate composition and a lack of indicators of potential abalone habitat (e.g., low coverage of kelp and other macroalgae). The mapped boundary of the F/G Jetty boulder area is illustrated on Figure 4; abalone habitat mapping surveys (Phase 2) were not conducted in this area.

3.1.2 D Jetty

Subtidal habitat within the D Jetty area consisted of soft sediment with areas of mixed coarse substrate. Boulder substrate was observed along the D Jetty wall (Figures 2 and 3; Anchor 2016b,c; Klohn Crippen Berger 2016; Golder 2016a). The area under the jetty was composed of subtidal cobble, gravel and sand substrate and continued from the jetty or transitioned to subtidal sand, silt and mud substrate offshore. Shell and wood debris were abundant in a few small patches (<5 m^2) throughout the survey area. Anthropogenic debris (e.g. metal, rope) was observed near the jetty within the survey area (Golder 2016a).

Macroalgae cover was generally low throughout the D Jetty survey area. Patchy red algae (*Gracilaria* sp.) beds were observed towards the southeast extent of the survey area and a few small patches of filamentous brown algae were also documented. Motile invertebrate species were abundant throughout soft sediment and mixed substrate habitats within the survey area. Invertebrate species observed included shrimp and Dungeness crabs (*Metacarcinus magister*) throughout the survey area, and red rock crabs (*Cancer productus*) on areas of soft sediment only. Other species observed included Northern abalone (*Haliotis kamtschatkana*), feather duster worms, plumose anemones, rose stars (*Crossaster papposus*) and mottled stars (*Evasterias troschelii*).

Fish observed during 2016 surveys included tidepool sculpin (*Oligocottus maculosus*), blackeye goby (*Coryphopterus nicholsi*), pile perch (*Rhacochilus vacca*), northern ronquil (*Ronquilus jordani*) and tubesnout (*Aulorhynchus flavidus*). A single unidentified sculpin (Family Cottidae) was observed in nearshore mixed substrate habitat and a single snake prickleback (*Lumpenus sagitta*) was observed further offshore in soft sediment habitat (Golder 2016a). Several other fish species were observed during underwater dive surveys in 2012 including juvenile Pacific herring (*Clupea pallasi*), longfin sculpin (*Jordania zonope*) and mosshead scuplin (*Clinocottus globiceps*) were observed in the area around D Jetty during surveys in 2012 (Balanced 2012b).

Four abalone were observed in association with boulder substrate along the D Jetty wall in the shallow subtidal zone ranging from 1.0 to 2.5 m below CD. Abalone ranged in size from 33 to 133 mm SL. Abalone predators were not observed nor were abalone observed in association with urchins. The area identified as suitable abalone habitat extended approximately 43 m in length and was parallel to the east side of D Jetty, along the boulder habitat, and was estimated to be 241 m^2 (Figure 3).

3.2 Habitat Adjacent to Project Areas

Subtidal substrates immediately beyond the remedial dredge areas were mapped during towed video surveys conducted by Golder (2016a) in January 2016. Additional habitat information for surrounding areas was incorporated from the following sources: habitat surveys conducted by Balanced (2012a-c) in 2012 and by Archipelago (2004; 2010), the Capital Regional District (CRD) harbours atlas (CRD 2010) and DFO herring spawn and catch records (DFO 2015). Sensitive habitats (e.g. abalone habitat, clam beds and kelp beds) generally were not mapped beyond the proposed dredge areas during targeted dive surveys conducted by Golder in February 2016 (Golder 2016a). A summary of the areas immediately surrounding each of the proposed dredge pockets is provided below:

- F/G Jetty – Soft sediments within the subtidal zone extend to the northwest and southwest of the dredge footprint. Boulder/bedrock substrate extends along the shoreline to the south of the footprint and to the northwest and southwest of the subtidal boulder area in the northern part of the survey area. A small gravel beach is located along the shoreline immediately adjacent to the Project Area. The patchy boulder habitat identified at the northern extent of the Project Area has not been considered suitable abalone habitat due to the lack of indicators of potential abalone habitat based on DFO guidance (Appendix 2 in DFO 2007), specifically coverage by brown bladed kelps and other macroalgae was low (<5%) or absent. The density of boulder substrate in the boulder habitat was also determined to be relatively low with a maximum of 60% boulder coverage over a relatively small area.

- D Jetty – Soft sediments extend beyond and are similar to substrates within the proposed dredge footprint as well as 1 to 5 m beyond the cobble, gravel and sand substrate identified in the southern extent of the footprint. Cobble, gravel and sand substrate in the northern part of the dredge footprint extends offshore to the north and northwest of the survey area.
- Bull kelp plays an important role in the life histories of fish and other marine species and has been documented in the vicinity of the Project Areas to the south of D Jetty and to the east of F/G Jetty (CRD 2010); however, no evidence of canopy-forming kelps (e.g. bull kelp (*Nereocystis luetkeana*)) were found within the Project Areas during the habitat surveys (Golder 2016a).
- Eelgrass (*Zostera marina*) is considered a valued and sensitive ecosystem component as eelgrass beds provide important refuge and rearing habitat for coastal fish and invertebrate species such as salmon (*Oncorhynchus spp.*), Dungeness crab, and Pacific herring (*Clupea pallasii*). Eelgrass beds are particularly sensitive to development activities that can cause increased levels of shading and sedimentation. No evidence of eelgrass was observed within the D Jetty and F/G Jetty areas (Golder 2016a). The nearest documented eelgrass observations are approximately 500 m to the north of F/G Jetty (CRD 2010) and to the west of Grant Knoll which lies adjacent to the southwest corner of A Jetty, approximately 1 km to the southeast of D Jetty (Archipelago 2010).
- Millstream Creek flows into the northwest portion of Esquimalt Harbour and is known to have supported the following anadromous species: coho salmon, anadromous coastal cutthroat trout (*Oncorhynchus clarkii clarkii*) and steelhead (anadromous rainbow trout) (*O. mykiss*). Mapster salmon escapement data indicated coho salmon (*O. kisutch*) were present in 2007 when the stream was last inspected (DFO 2016b). The last record for anadromous cutthroat trout was in 1977 and the last record for steelhead was in 1994 (MOE 2016a); therefore, it is unknown if these species still exist in Millstream Creek. Herring spawning has historically occurred in areas of Esquimalt Harbour including the shoreline around the Project Areas. DFO's cumulative herring spawn records, dating from 1928 to 2001, show that herring spawn was recorded (by surface observation) on March 25, 1993, within or close to the Project Areas and was classified as a 'minor' spawn and ranked within the bottom 25% of ranked shoreline km segments (DFO 2015).

4.0 IDENTIFICATION OF MITIGATION MEASURES

The CSRP and FGOP will be carried out concurrently by the same contractor. The projects are proposed to start in mid-November 2016 and be substantially completed by March 31, 2017. Some work may need to be done between March 31 and May 1, 2017. A 12-hour work day and a six-day work week is proposed.

The Project Areas are located in DFO *management subarea 19-2 – Esquimalt Harbour*, for which the marine/estuarine timing windows are as follows:

- Summer Window: July 1 – October 1.
- Winter Window: December 1 – February 15.

Work windows are intended to provide windows of least risk to sensitive fisheries resources that may use the area. For example, salmon migrating to spawning areas may be present in October and November and spawning herring may be present from the end of February to June.

In-water work including sediment dredging, structure removal and reinstatement, and backfill and material placement are planned to occur both inside and outside of the timing window with the application of appropriate mitigation measures, with the exception of impact pile driving of steel piles should it occur. Impact pile driving of steel piles, if it occurs, will not take place between April 1 and May 31 due to potential effects from underwater noise on fisheries resources in Esquimalt Harbour. The April 1 to May 31 time period is particularly sensitive due to the potential for herring spawning and out-migration of juvenile salmon in Esquimalt Harbour. Vibratory pile driving will still occur outside the window.

The environmental management plan (EMP), including a Water Quality Monitoring Plan, for the FGOP and CSRP outlines mitigation specific to the project activities proposed. With implementation of these measures and plans, harm from the Project and to habitat adjacent to the Project Areas can be avoided or reduced. Mitigation measures for project activities are described in the FGOP and CSRP EED report and the project specific EMP.

5.0 POTENTIAL EFFECTS OF THE PROPOSED PROJECT ON FISH

5.1 Potential Effects by Proposed Project Activities

Proposed project activities such as structure removal, relocation and reinstatement, dredging and residuals management and backfill and material placement have the potential to cause serious harm to fish and fish habitat. Changes in productivity associated with project activities were evaluated following a similar approach as described by SLR (2015). Temporary loss in productivity or serious harm to fish is not anticipated for project activities such as mobilization and demobilization, barge dewatering, in-water transportation, offloading and associated activities and upland transportation and disposal after the application of mitigation measure described in the FGOP and CSRP S.67/68 EED and EMP. Activities with potential to cause temporary alteration to fish and fish habitat are discussed below.

5.1.1 Structure Removal, Relocation and Reinstatement

Existing pilings and associated structures provide habitat for encrusting organisms. The proposed removal, relocation and replacement of structures and pilings at F/G Jetty and D Jetty is likely to result in a temporary disturbance to productivity. In addition, structure removal, relocation and replacement may result in temporary mobilization of contaminants into the water column. Where possible the reinstatement of existing structures after dredging is proposed for this project. For the purpose of this review, it was assumed that the size and extent of replacement pilings and structures will be equivalent to existing structures. Mitigation measures to avoid or reduce effects from structure removal, relocation and reinstatement are outlined within the EMP and EED developed for these Projects.

The removal, relocation and replacement of pilings and related structures are expected to result in a temporary disturbance. This activity will result in a temporary alteration to fish habitat, however, with the implementation of mitigation measures it is anticipated that harm to fish and fish habitat can be avoided.

5.1.2 Dredging, Residuals Management and Backfill and Material Placement

Dredging activities will result in the direct mortality of benthic organisms inhabiting the seafloor within the proposed dredge area resulting in temporary alteration to benthic habitats. Dredging of rock outcrops identified in Figures 2 and 3 is not anticipated to achieve remedial objectives at F/G Jetty and D Jetty Project Areas (Anchor 2016a). Anticipated replacement sediment grainsize for sub-tidal soft sediments after dredging is expected to remain consistent with current conditions; however, the application of a clean rock and sand residuals management cover to accelerate the natural remediation and recovery process in the biologically active zone may modify existing substrate particle distributions (SLR 2015). Over time this layer of substrate cover will mix with ambient sediments providing a substrate more similar to natural conditions. Benthic communities are expected to recover from disturbance related to dredging (Guerra-Garcia and Garcia Gomez 2006; Newell et al. 1998).

Many non-motile benthic species that will be affected by dredging have a high turnover rate (Korhonen et al. 2010; Guerra-Garcia et al. 2003) and can reproduce several times throughout the year. Results from Korhonen et al. (2010) suggest that the long-term temporal turnover rate is faster in large ecosystems and faster at high latitudes (e.g. temperate areas) in the marine environment compared to lower latitudes (e.g. the tropics). A comparison of a dredged (2.63 ha) and control site in a harbour in the Strait of Gibraltar showed that it took about six months for the disturbed area to re-establish a sediment structure and a macrobenthic community similar to the undisturbed area (Guerra-Garcia et al. 2003). Habitat adjacent to the Project Areas is similar in structure and function and species adjacent to the dredging are not likely to be affected by the Project, with implementation of mitigation measures. The depth of the dredge prism ranges from 0.5 to 3 m and it is therefore anticipated that dredging and subsequent substrate cover and placement will result in a temporary alteration of soft bottom habitat and will be recolonized with species from the adjacent soft bottom habitats. In areas where the crushed rock layer is within the photic zone, the hard surface will provide habitat for macroalgae to attach to and likely result in an overall increase in productivity. Contaminant removal will also provide a healthier benthos and as such, the long-term harm to fish and fish habitat can be avoided and reduced.

5.1.2.1 Dredging in Proximity to Abalone Habitat

Northern abalone, a gastropod listed federally as threatened and provincially as red-listed, was present in low density in the boulder substrate under the east side of D Jetty, adjacent to the Project Area. Abalone were not observed within the F/G Jetty Project Area and no areas within the F/G Jetty Project Area were identified as suitable abalone habitat (Golder 2016a). Dredging can alter abalone habitat and may result in loss of primary substrate, increased sedimentation and/or effects on water quality (DFO 2012). Dredging activities are proposed in the Project Areas to remove contaminated sediments; however, direct impacts to boulder and bedrock habitats considered suitable abalone habitats are not anticipated as dredging will not be conducted in these areas. Mitigation measures to avoid or reduce potential effects on abalone from increased sedimentation or changes in water quality during dredging, residuals management and from backfill and material placement are outlined within the EMP and EED developed for these Projects.

An abalone field assessment will be conducted in accordance with DFO survey protocol guidance (e.g. survey conducted during nighttime) prior to commencement of Project activities to survey for potential abalone presence in areas previously identified as potentially suitable abalone habitat. Where abalone have been identified adjacent to the project area (i.e. along D Jetty), a silt curtain will be installed to isolate them from potential effects that may occur during adjacent project activities. After implementation of the mitigation described above, serious harm and/or impacts to abalone are not anticipated.

6.0 DETERMINATION OF SERIOUS HARM

Prior to dredging, the existing gasoline float and approach structure at F/G Jetty will be removed. Structure removal proposed for the D Jetty Project Area include removal of floating camel/tire fenders and attachments, wharf safety ladders and attachments and miscellaneous jetty attachments and components. The proposed removal, relocation and replacement of structures and pilings at F/G Jetty and D Jetty is likely to result in a temporary disturbance to productivity. This activity will result in a temporary alteration to fish habitat and with the implementation of mitigation measures it is anticipated that serious harm to fish and fish habitat can be avoided.

It is anticipated that dredging and subsequent backfill and material placement proposed at F/G and D Jetties will result in a temporary alteration of soft bottom habitat and mortality of benthic invertebrates but will be recolonized with species from adjacent habitats. Backfill and material placement is proposed following dredging and, where possible, will be similar to pre-construction seafloor elevations and grades and as well as substrate type. The dredging and backfill and material placement at the F/G and D Jetties will result in a temporary disruption and alteration to fish and fish habitat; however, serious harm to fish and fish habitat is not anticipated.

Direct impacts to abalone habitat will be mitigated though project design (i.e. dredging will not occur in documented abalone habitat). In addition a silt curtain will be deployed to mitigate the potential for changes to water quality and habitat associated with sediment dispersion and re-deposition during dredging. Serious harm to abalone is not anticipated for proposed project activities at F/G and D Jetty.

Table 1: Determination of Serious Harm for Project Components Proposed for F/G Jetty and D Jetty

Project Area	Proposed Dredge Footprint[1] (m^2)	Project Component Description	Rationale/ Determination
F/G Jetty	5,600 m^2	Structure removal, relocation and reinstatement	Temporary alteration; serious harm is not anticipated
		Dredging and residuals management	
		Backfill and material placement	
D Jetty	7,700 m^2	Structure removal, relocation and reinstatement	Temporary alteration; serious harm is not anticipated
		Dredging and residuals management	
		Backfill and material placement	

[1] Proposed dredge footprints are based on Anchor 2016a.

7.0 HABITAT OFFSETTING REQUIREMENTS

On November 25, 2013, the fisheries protection provisions of the *Fisheries Act* came into force along with new fisheries protection regulations and policies. These amendments shifted the focus of the *Fisheries Act* to maintaining the sustainability and ongoing productivity of commercial, recreational and Aboriginal (CRA) fisheries.

The Fisheries Protection Policy Statement (DFO 2013) replaces the former Policy for the Management of Fish Habitat and introduces the *serious harm* provision that "no person shall carry out any work, undertaking or activity that results in serious harm to fish that are a part of a commercial, recreational or Aboriginal fishery or to fish that support such a fishery". The *serious harm* to fish is defined as the death of a fish or any permanent alteration to, or destruction of, fish habitat.

The proposed project activities for the FGOP and CSRP are not anticipated to cause residual *serious harm* to fish after avoidance and mitigation measures are applied and therefore, habitat offsets will not be required for the project.

8.0 SUMMARY AND RECOMMENDATIONS

- This aquatic effects assessment and habitat offsetting review was based on data collected by Golder (2016a) for the F/G Jetty and D Jetty project footprint identified in Anchor (2013) and was supplemented with data from previous assessments to characterize the revised project footprints identified in Anchor (2016a,b).
- Subtidal habitats throughout the Project Areas were composed primarily of bedrock/boulder substrate in nearshore areas and boulder in a few offshore areas with a transition of gravel/cobble substrate and soft sediments in offshore areas (Figure 2). Sensitive habitats (i.e. suitable abalone habitat) were not identified within the Project Areas.
- Northern abalone, a gastropod listed federally as threatened and provincially as red-listed, was present in low density in the boulder substrate along the east jetty wall of D Jetty (Golder 2016b) adjacent to the Project Area.
- An abalone field assessment will need to be conducted in accordance with DFO survey protocol guidance (e.g. conducted during nighttime) to survey for potential abalone presence in areas previously identified as potentially suitable abalone habitat and to delineate their habitat for implementation of a silt curtain.
- Invertebrate species that were ubiquitous within the Project Areas included Dungeness crab and red rock crab. Other species that were substrate specific were rock scallop and blue mussel on boulder/bedrock substrate. Fish were primarily observed along boulder/ bedrock habitat and in areas of mixed substrate including, pile perch tidepool sculpin, blackeye goby, northern ronquil, tubesnout and a rockfish (juvenile). Observations for each Project Area are described in detail in Golder (2016b).
- Structure removal, relocation and reinstatement, dredging and residuals management and backfill and material placement proposed for F/G and D Jetty will result in a temporary alteration of fish habitat. After the implementation of the proposed mitigations measures, it is anticipated that serious harm to fish and fish habitat can be avoided.
- This assessment for potential serious harm and review of habitat offsetting requirements was prepared based on our understanding of project activities as outlined in Anchor (2016a). Re-evaluation of project effects is recommended once remediation methods and planning is further defined.
- Once remediation methodology has been finalized the contractor will prepare an environmental protection plan (EPP). The EPP will outline measures to achieve environmental protection objectives identified in the EMP.

9.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any questions regarding this report, please do not hesitate to contact the undersigned at 250-881-7372.

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10.0 REFERENCES

Anchor (Anchor QEA LLC). 2016a. Draft 100% Design Report: Colwood Jetties Remediation Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. June 2016.

Ancho. 2016b. Esquimalt Harbour Remediation Project – D Jetty Debris Survey Summary. Memorandum prepared for Public Works and Government Services Canada. March 29, 2016.

Anchor. 2016c. Esquimalt Harbour Remediation Project – D Jetty Underpier Sediment Sampling Data Summary. Memorandum prepared for Public Works and Government Services Canada. March 24, 2016.

Anchor. 2013. Draft Preliminary Alternative Basis of Design Report: Esquimalt Harbour Remediation Project. Prepared for Public Works and Government Services Department of National Defence, Defence Construction Canada. July 2013.

Archipelago (Archipelago Marine Research Ltd.). 2004. Subtidal Survey of Physical and Biological Features of Esquimalt Harbour Report and Map Folio. Revised and Updated February 2004.

Archipelago. 2010. A-Jetty Marine Habitat Survey (Rev B-Final). March 31, 2010.

Balanced Environmental Services Inc. 2012a. Qualitative Presence/Absence Survey for Marine Species. Esquimalt Harbour Remediation Project, F& G Jetty Remediation Area, Canadian Forces Base Esquimalt, BC. Submitted to SNC-Lavalin Environment Division, Victoria, BC. November 19, 2012.

Balanced. 2012b. Qualitative Presence/Absence Survey for Marine Species, Esquimalt Harbour Remediation Project, D-Jetty Remediation Area. November 19, 2012

Balanced. 2012c. Qualitative Presence/Absence Survey for Marine Species, Esquimalt Harbour Remediation Project, F and G-Jetty Remediation Area. November 19, 2012.

Balanced Environmental Services Inc. 2013. Preliminary Marine Habitat Compensation Plan – Draft. Esquimalt Harbour Remediation Project, F& G Jetty Remediation Area, Canadian Forces Base Esquimalt, BC. Prepared for SNC-Lavalin Inc., Environment Division, Victoria, BC. March 8, 2013.

CRD (Capital Regional District). 2010. Harbours Atlas. Available at: http://www.crd.bc.ca/maps/harbours/launch.htm. Accessed on March, 2016.

DFO (Fisheries and Oceans Canada). 2012. Action Plan for the Northern Abalone (*Haliotis kamtschatkana*) in Canada Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. vii + 65 pp.

DFO. 2013. Fisheries Productivity Investment Policy: A Proponents Guide to Offsetting. November 2013.

DFO. 2015. Herring Spawn and Catch Records. Available at: http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default5_e.htm. Accessed on March 8, 2016.

Golder (Golder Associates Ltd.). 2016a. F/G Jetty Optimization Project and Colwood South Remediation Project Marine Habitat Assessment for C Jetty, ML Floats, Y Jetty and Lang Cove. Dated March 31, 2016. Reference no: 1657898-005-R-Rev0-2000

Golder. 2016b. Archaeological Impact Assessment of Remedial Dredging Areas at Lang Cove and F & G Jetty in Esquimalt Harbour, Esquimalt, B.C. (Non-Permit Report). Submitted to Public Works and Government Services Canada. March 22, 2016.

Golder. 2016c. Preliminary Modeling of Predicted Quality of Discharge Water during Barge Dewatering for The F/G Jetty Optimization Project and the Colwood South Remediation Project. Submitted to PWGSC. Reference No. 1657898-010-L-Rev0.

Guerra-Garcia, J., Corzo, J. and J. Garcia-Gomez. 2003. Short-Term Benthic Recolonization after Dredging in the Harbour of Ceuta, North Africa. Marine Ecology. 24 (3): 217-229.

Guerra-Garcia, J., Corzo, J. and J. Garcia-Gomez. 2006. Recolonization of defaunated sediments: fine versus gross sand and dredging versus experimental trays. Estuarine, Costal Shelf Science 68. 328-342.

Hutton, K. E. and S. C. Samis. 2000. Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 2314: vi + 34 p.

Klohn Crippen Berger. 2016. D Jetty and Jetty 11 Structural Reconnaissance. Memorandum submitted to SNC-Lavalin Inc., Environment Division, Victoria, BC. March 31, 2016.

Korhonen, J., Soininen, J. and H. Hillebrand. 2010. A quantitative analysis of temporal turnover in aquatic species assemblages across ecosystems. Ecology, 91(2): 508-517.

Newell, R.C., L.J. Seiderer and D.R. Hitchcock. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and Marine Biology: an Annual Review. 36:127-178.

SLR (SLR Consulting (Canada) Ltd.). 2015. A/B Jetty Habitat Offsetting Plan A/B Jetty Recapitalization Project CFB Esquimalt, Victoria, BC. Prepared for Defence Construction Canada, July 24, 2015.

Wernick, B.G., Nikl, L.H., Seguin, S.R., Sinnett., G. 2010. Britannia Mine remediation project – intergrating ecological monitoring with remedial activities. Australian Center for Geomechanics. ISBN 978-0-9806154-4-9.

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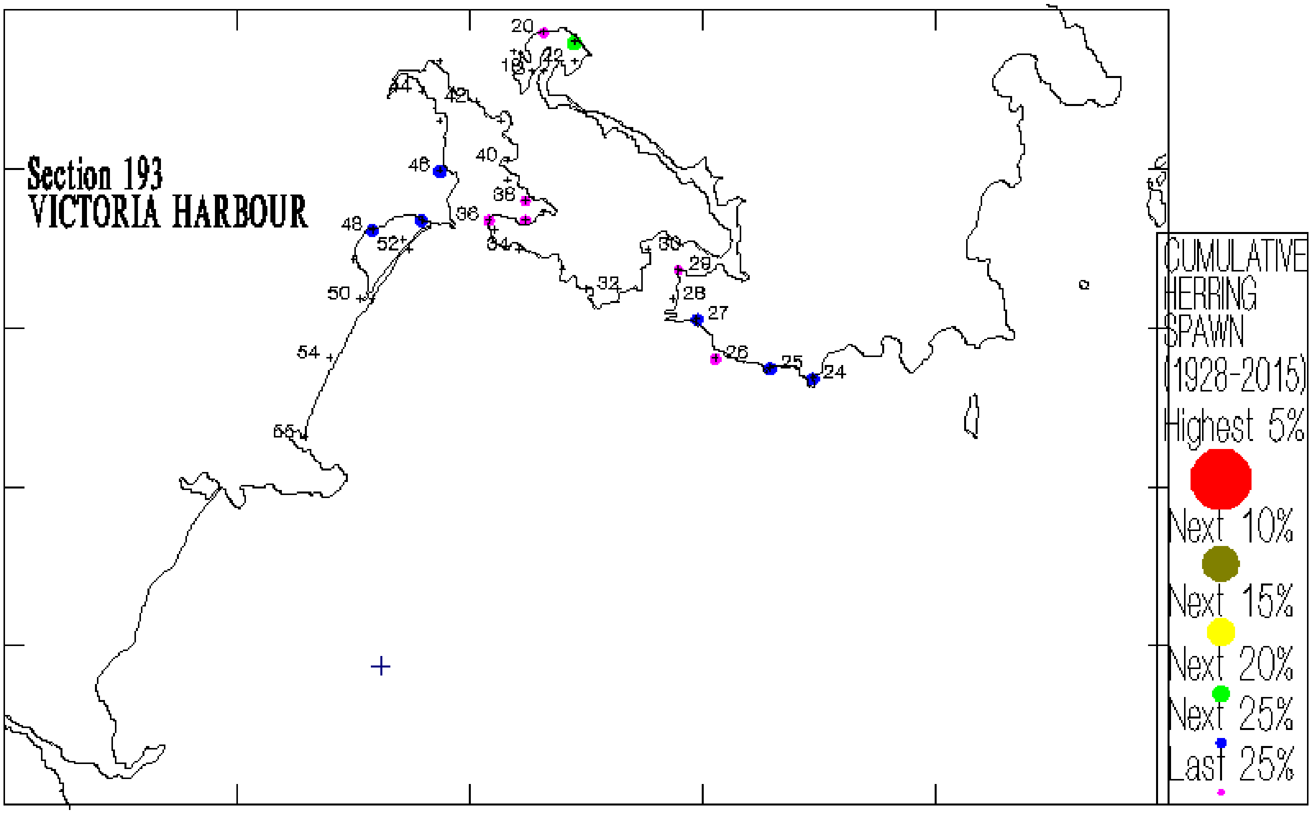
Annex C. Environmental Background Information


Section 193
VICTORIA HARBOUR
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(1928-2015)
Highest 5%
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Welcome to the B.C. Coastal Waterbird Survey
Data summary page

Please select what type of summary you would like to see
(only areas and regions with data are shown).

1) Select an Area: Vancouver Island ▼

2) Select a Region: Victoria (VIVI) ▼

3) Select a Site: 19. Esquimalt Harbour ▼

If you want to view only the data for a specific observer, please enter the observer code:

Monthly Abundance | Monthly Frequency

Annual Abundance | Annual Frequency

This table presents annual indices of abundance (mean number of birds per survey) in the following sites: **Area:** Vancouver Island **Region:** Victoria **Site:** Esquimalt Harbour

Species	2000	2001	2002	2003	2004	2005
Canada Goose						
Mute Swan						
American Wigeon						
Mallard						
Green-winged Teal						
Greater Scaup						
Surf Scoter						
Long-tailed Duck						
Bufflehead						
Common Goldeneye						
Barrow's Goldeneye						
Hooded Merganser						
Common Merganser						
Red-breasted Merganser						
Common Loon						
Double-crested Cormorant						
Pelagic Cormorant						
Great Blue Heron						
Bald Eagle						
Cooper's Hawk						
Peregrine Falcon						
Black Oystercatcher						
Black Turnstone						
Surfbird						
Heermann's Gull						
Mew Gull						
Thayer's Gull						
Glaucous-winged Gull						
Unidentified Gull						
Unidentified Alcid						
Belted Kingfisher						
Number of surveys	3	4	0	0	3	4

Table 1: Species that Occur in Marine and Estuary Environments in the CRD

Scientific Name	English Name	COSEWIC Status	BC CDC List	SARA Schedule-Status	Class	Habitat and Range	Potential to Occur
Botaurus lentiginosus	American Bittern		Blue		Bird	Nests primarily in inland freshwater wetlands, sometimes in tidal marshes or in sparsely vegetated wetlands or dry grassy uplands. Breeding occurs primarily in wetlands with tall emergent vegetation. Sparsely vegetated wetlands and dry grassy uplands are sometimes used, as are tidal marshes in some areas. It is rare year-round on southern Vancouver Island.	Unlikely to occur
Hirundo rustica	Barn Swallow	T (May 2011)	Blue		Bird	Nests in barns or other buildings, under bridges, wharves, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Flies over open land and water and forages on insects. Usually forages within a few hundred meters of nest when breeding.	Potential to occur
Phoebastria nigripes	Black-footed Albatross	SC (Apr 2007)	Blue	1-SC	Bird	Pelagic. Frequently follows ships. Nests in sand on oceanic islands. Does not breed in BC.	Unlikely to occur
Phalacrocorax penicillatus	Brandt's Cormorant		Red		Bird	Mainly inshore coastal zone, especially in areas having kelp beds; also around some offshore islands; less commonly, inshore on brackish bays; in winter, mostly around sheltered inlets and other quiet waters. Typically nests on flat or gently sloping surfaces on tops of rocky islands along coast.	Potential to occur
Hydroprogne caspia	Caspian Tern	NAR (May 1999)	Blue		Bird	Seacoasts, bays, estuaries, lakes, marshes, and rivers. Nests on sandy or gravelly beaches and shell banks along coasts or large inland lakes; sometimes with other water birds. Seasonal resident and probably breeds on Vancouver Island. Does not overwinter on Vancouver Island.	Potential to occur
Uria aalge	Common Murre		Red		Bird	Nonbreeding: pelagic and along rocky seacoasts. Nests in the open or in crevices on broad and narrow cliff ledges, on stack (cliff) tops, and on flat, rocky, low-lying islands. Breeds on the northern tip of Vancouver Island and overwinters around Vancouver Island.	Potential to occur
Phalacrocorax auritus	Double-crested Cormorant	NAR (May 1978)	Blue		Bird	Forage in all coastal areas of British Columbia, utilizing marine habitats such as bays, estuaries, and inlets and occasionally freshwater habitats such as lakes close to coastal areas and large rivers such as the Fraser River. Bare, rocky islands with sparse vegetation are the preferred nesting habitats.	Potential to occur
Ardea herodias fannini	Great Blue Heron, fannini subspecies	SC (Mar 2008)	Blue	1-SC	Bird	Nest in a wide variety of tree species; the Pacific population nests in quiet woodlots within 8 km (most within 3 km) of foraging habitats such as large eelgrass meadows, along rivers, and in estuarine and freshwater marshes.	Potential to occur
Butorides virescens	Green Heron		Blue		Bird	Feeds in swamps, riparian zones along creeks and streams, also marshes, human-made ditches, canals, ponds, lake edges, open floodplains , backwater oxbow ponds, sloughs and side channels, salt marshes, mangrove swamps, pastures, mudflats, ponds in parks, and harbors. Although clearly prefers thick vegetation throughout range, will feed in open when food is available. In salt marshes, tends to hug creek banks; avoids open flats frequented by longer-legged herons. Nests in forest and swamp patches; may nest in dry woods or orchards, but usually near water. Breeds but does not overwinter on Vancouver Island.	Unlikely to occur

Scientific Name	English Name	COSEWIC Status	BC CDC List	SARA Schedule-Status	Class	Habitat and Range	Potential to Occur
Brachyramphus marmoratus	Marbled Murrelet	T (Nov 2000)	Blue	1-T	Bird	Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g., Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth. Feeds in the nearshore marine environment throughout the year, rarely farther than 5 km from shore. It frequents areas of turbulence and upwellings such as tidal rips, shelf edges, underwater sills, fiords, and narrow passages. It also occurs in sheltered habitats such as harbours, bays lagoons, inlets, kelp beds, and coves and tends to prefer relatively shallow waters (usually <60 m deep).	Potential to occur
Falco peregrinus anatum	Peregrine Falcon, anatum subspecies	SC (Apr 2007)	Red	1-T	Bird	Typically nest on rock cliffs above lakes or river valleys where abundant prey is nearby. The anatum subspecies is the most common form to be found on the southern portion of the Coast Region (Fraser Lowlands as well as southern Vancouver Island and the Gulf Islands). Aeries described in BC are on the ledges of cliffs (6–260 m high) that overlook marine waters, large lakes and rivers. This falcon is also an urban adaptor and successful aeries have been established naturally or through reintroduction programs using building ledges or under high span bridges.	Unlikely to occur
Falco peregrinus pealei	Peregrine Falcon, pealei subspecies	SC (Apr 2007)	Blue	1-SC	Bird	Typically nests on ledges of rocky island cliffs, usually near seabird colonies. Occasionally, nests occur on mainland headland cliffs. A few nests occurred on grassy ledges on rock bluffs. In BC, Haida Gwaii forms the center of this subspecies population with ~200 active and historic aeries documented from northern Vancouver Island, the Central and North Coast and associated islands. Aeries described in BC are on the ledges of cliffs (6-260 m high) that overlook marine waters, large lakes and rivers. This falcon is also an urban adaptor and successful aeries have been established naturally or through reintroduction programs using building ledges or under high span bridges.	Unlikely to occur
Puffinus creatopus	Pink-footed Shearwater	T (May 2004)	Blue	1-T	Bird	Occurs off the coast of BC, with the north end of Vancouver Island likely representing the northern limits of where the species regularly occurs. Does not breed in BC.	Unlikely to occur
Progne subis	Purple Martin		Blue		Bird	Breeds but does not overwinter on Vancouver Island. Nest in natural cavities and woodpecker holes in trees and snags, and in holes in buildings. In recent years they have been almost entirely restricted to nest boxes and artificial holes in pilings in estuaries, bays, and harbours. Now restricted to six sites on southeast Vancouver Island (Victoria Harbour, Esquimalt Harbour, Cowichan River Estuary, Nanaimo River Estuary, Newcastle Island, and Ladysmith Harbour). Birds presumably forage over areas immediately surrounding nest site, although no information on typical travel distance while foraging	Potential to occur
Asio flammeus	Short-eared Owl	SC (Mar 2008)	Blue	3	Bird	Prefers open areas such as grasslands, meadows in early succession (some shrubs or trees), marshlands, sloughs, beaches, sedge fields and previously forested areas that have been cleared. Suitable winter habitat includes marine foreshores, grasslands, fallow fields, etc. with a sufficient prey base and adequate roost sites. Breeding and over-wintering for this species occurs between the BC interior and the Lower Mainland. Migration may be driven by prey availability. In particular, the Fraser Estuary, Deer Lake (Burnaby), Colony Farm Regional Park, Pitt River floodplain and the agricultural areas of the Fraser Lowlands provide the essential old-field habitat and estuarine/freshwater marshlands utilized by this species. Periodically individuals may overwinter on southern Vancouver Island.	Unlikely to occur
Phoebastria albatrus	Short-tailed Albatross	T (Nov 2003)	Red	1-T	Bird	A pelagic bird that often occurs in regions of high marine productivity. It nests on the ground on small oceanic islands. Only scarce sightings off the coast. Does not breed in BC.	Unlikely to occur

Scientific Name	English Name	COSEWIC Status	BC CDC List	SARA Schedule-Status	Class	Habitat and Range	Potential to Occur
Fratercula cirrhata	Tufted Puffin		Blue		Bird	Nonbreeding: primarily pelagic. Can be found well out to sea all year. Nests on offshore islands or along the coast. Nests on slopes in ground burrows, sometimes under boulders and piles of rocks, occasionally under dense vegetation. Breeds along west and south coast of Vancouver Island.	Unlikely to occur
Cetorhinus maximus	Basking Shark	E (Apr 2007)	No Status	1-E	Fish	Found in pelagic and inshore waters along temperate and boreal coastlines around the world. Usually, they are observed at the surface, filter feeding on concentrations of plankton. The current population is very small, with only six confirmed sightings since 1996.	Unlikely to occur
Sebastes paucispinis	Bocaccio	T (Nov 2002)	No Status		Fish	For the first few months of the year, young fish live near the surface. From late spring through the summer, they settle together in near-shore areas with bottom depths of 30 to 120 m. Adults are found over a variety of bottom types — most commonly over depths of 60 to 340 m — but are still considered semi-pelagic (tending to prefer the upper layers of the open sea). In Canada, it is present along the outer Pacific Coast, where it is caught by commercial trawlers fishing for other species. The inshore distribution of the Bocaccio is less well understood because most commercial groundfishing in BC is done on the outer Pacific Coast, near the edge of the continental shelf. It is known, however, to occur in some inlets and in the Strait of Georgia.	Unlikely to occur
Sebastes pinniger	Canary Rockfish	T (Nov 2007)	No Status		Fish	Juveniles occupy shallow inshore waters. Larvae and pelagic juvenile canary rockfish occupy the top 100 m for up to 3-4 months after live-birth (parturition) and then settle to a benthic habitat. Adults typically inhabit rocky bottom in 70-270 m depth on the continental shelf. Canary rockfish are widely distributed throughout B.C. coastal waters. The prevalence of this species in recreational fishing in the Strait of Georgia indicates that they are probably well distributed in enclosed waters and inlets.	Potential to occur
Oncorhynchus clarkii	Cutthroat Trout, clarkii subspecies		Blue		Fish	Requires small, low gradient coastal streams and estuarine habitats; well-shaded streams with water temperatures below 18°C are optimal. Some may spend entire life in freshwater (many of these live in lakes), but most are anadromous. In marine habitats, generally remains close to the coast, usually remaining within estuary.	Potential to occur
Salvelinus malma	Dolly Varden		Blue		Fish	Anadromous individuals occur in coastal seas (2-3 years) and in deep runs and pools of creeks and small to large rivers. Most dwarfed race populations seem to spend their lives in rivers and streams. Some landlocked populations inhabit lakes and tributary streams. Anadromous dolly varden spend time in the ocean as well as in rivers and streams; they do not seem to move out into the open ocean, but remain close to river mouths and the shore. Not known to occur in streams close to Project area.	Unlikely to occur
Sebastes aleutianus	Rougheye Rockfish	SC (Apr 2007)	No Status	1-SC	Fish	Found from southern California, around the Pacific rim to northern Japan usually around caves, crevices and steeply sloped boulder fields at depths ranging from 25 to over 1000 m. Juveniles occupy much shallower water than adults. In BC, they occur along the continental slope, and are typically found at depths between 170 and 660 m.	Unlikely to occur
Sebastes ruberrimus	Yelloweye Rockfish	SC (Nov 2008)	No Status	1-SC	Fish	Occur over rocky reefs, typically at depths below 50 m, from northern Baja California to the Gulf of Alaska. Fisheries primarily take Yelloweye Rockfish between 19 and 251 m depth (95% of observations). Yelloweye Rockfish have been observed from submersibles in depths from 30 to 232 m over substrates that are hard, complex and with some vertical relief, such as broken rock, rock reefs, ridges, overhangs, crevices, caves, cobble and boulder fields.	Unlikely to occur

Scientific Name	English Name	COSEWIC Status	BC CDC List	SARA Schedule-Status	Class	Habitat and Range	Potential to Occur
Eumetopias jubatus	Steller Sea Lion	SC (Nov 2003)	Blue	1-SC	Mammal	Marine habitats include coastal waters near shore and over the continental slope; sometimes rivers are ascended in pursuit of prey. When not on land, the sea lions may congregate at nearshore traditional rafting sites, or move out to the edge of the continental shelf.	Potential to occur
Phocoena	Harbour Porpoise	SC (Nov 2003)	Blue	1-SC	Mammal	Coastal waters and adjacent offshore shallows; also inhabits inshore areas such as bays, channels, and rivers. Mothers and young tend to move into sheltered coves and similar sites soon after parturition.	Potential to occur
Orcinus orca pop. 5	Killer Whale (Northeast Pacific southern resident population)	E (Nov 2008)	Red	1-E	Mammal	The range during spring, summer, and fall includes the inland waterways of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait. Little is known about winter movements and range.	Potential to occur
Orcinus orca pop. 3	Killer Whale (West Coast transient population)	T (Nov 2008)	Red	1-T	Mammal	They are found in all oceans, in water temperatures ranging from below 0°C to warm tropical waters. Transients tend to spend more time in water less than 5m deep, often foraging in inter-tidal areas at high tides	Unlikely to occur
Megaptera novaeangliae	Humpback Whale	SC (May 2011)	Blue	1-T	Mammal	Habitat includes open ocean and coastal waters, sometimes including inshore areas such as bays. Summer distribution is in temperate and subpolar waters. In winter, most humpbacks are in tropical/subtropical waters near islands or coasts.	Unlikely to occur
Callorhinus ursinus	Northern Fur Seal	T (Nov 2010)	Red		Mammal	Open ocean and coastal waters. Rocky shores during breeding season. Within Canada. The offshore waters of BC represent important habitat for northern fur seals, mostly for migrating and over-wintering.	Unlikely to occur
Dermochelys coriacea	Leatherback Turtle	E (May 2001)	Red	1-E	Turtle	Marine; open ocean, often near edge of continental shelf; also seas, gulfs, bays, and estuaries. Mainly pelagic, seldom approaching land except for nesting. Does not nest in BC.	Unlikely to occur
Haliotis kamtschatkana	Northern Abalone	T (May 2000)	Red	1-T	Gastropod	It occurs in a wide range of habitats from fairly sheltered bays to exposed coastlines but the populations with the highest densities are found in areas with the highest wave exposure. Habitat is predominantly kelp beds along outer well-exposed coasts; typically low intertidal to 30 feet depth, but ranges to 100 m depth.	Potential to occur
Ostrea conchaphila	Olympia Oyster	SC (May 2011)	Blue	1-SC	Bivalve	Mainly found in the lower intertidal and shallow subtidal zones of saltwater lagoons and estuaries. They have also been found on tidal flats, tidal channels, bays and sounds, in splash pools, near freshwater seepage, or attached to pilings or the undersides of floats. On the outer coast, this oyster species is only found in protected locations. Within suitable habitat, Olympia oysters need hard substrate for settlement.	Potential to occur

Annex D. Preliminary Modelling of Predicted Quality of Discharge Water During Barge Dewatering for the F/G Jetty Optimization Project and the Colwood South Remediation Project

7 July 2016 Reference No. 1657898-010-L-Rev0

Ms. Kristen Ritchot
Public Works and Government Services Canada
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Victoria, BC
V8W 3X4

PRELIMINARY MODELING OF PREDICTED QUALITY OF DISCHARGE WATER DURING BARGE DEWATERING FOR THE F/G JETTY OPTIMIZATION PROJECT AND THE COLWOOD SOUTH REMEDIATION PROJECT

Dear Ms. Ritchot:

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) to undertake an assessment of potential barge dewatering effluent quality to support environmental planning for the proposed F/G-Jetty Optimization Project (FGOP) and Colwood South Remediation Project (CSRP) (collectively referred to hereafter as 'the Project'). This letter report was prepared per the workplan submitted to PWGSC on May 26, 2016, and approved under Golder's Marine Sediment Task Authorization No. EZ899-150978/002/PWY dated February 16, 2015.

1.0 INTRODUCTION

Golder understands that the Department of National Defence (DND) is continuing its long-term program of remediation and risk management in Esquimalt Harbour to address sediment contamination associated with historical activities. This barge dewatering assessment addresses remediation at D, F and G Jetty, which will involve dredging and substrate placement.

The remedial action plan proposes the dredging of contaminated sediments within the Project Area by clamshell dredging methods. Dredged sediment will then be placed on a 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 facilitate 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. Discharges posing a potentially unacceptable risk could trigger a shutdown of dredging operations 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 discharge water. The results of this assessment will be used to support the environmental assessment for the Project.

2.0 REGULATORY CONTEXT

The primary statute applicable to the discharge of dewater effluent from the dredge barge is the federal *Fisheries Act* and the provincial *Environmental Management Act*. Section 36 of the *Fisheries Act* is concerned with the control of substances that are harmful to fish ("deleterious substances") by way of a general prohibition against the deposit of such substances. While certain sector-specific regulations (e.g., *Metal Mining Effluent Regulation*) define what a deleterious substance is for that sector, the properties defining a substance as being deleterious under the parent act are left to interpretation by experts. The 96-h LC_{50} rainbow trout toxicity test has been frequently applied by Environment Canada, who have the administrative lead role for Section 36, as a defining endpoint where 96-h $LC_{50} \geq 100\%$ is required to comply. The *Fisheries Act* applies to the point of discharge.

3.0 SITE INFORMATION

The assessment is based on current understanding of relevant chemical fate processes and sediment chemistry data available for the Project Area. Physico-chemical information for sediments in the proposed dredge areas were provided to Golder by PWGSC[1]. The available data are summarized in Table 1. For some dredge units, the number of samples is relatively small and grainsize distribution data are not available for all samples. Moreover, in some cases the vertical extent of contamination has not been identified (i.e., it is unbounded). The dredge design incorporates an approximately 1-m over-dredge from the bottom of the cores available; however, it is unknown at this time what the quality of material is in the additional 1 m of sediment profile, in particular against the north face of D-Jetty. As well, it is unknown what the source of contaminants, metals in particular, is and in what size fraction a majority of the contamination occurs. There is anecdotal information that sand blasting grit was disposed of into the marine environment at D-Jetty but this has not been validated with laboratory data.

The limited data set increases the level of uncertainty in the assessment and decreases the ability to understand the risk of either over- or under-predicting the potential for effects to water quality from discharge of decant water from the dredge barge. A standard practice of care in situations such as these is to increase the level of conservatism in the assessment to mitigate for that uncertainty.

4.0 MODELLING OVERVIEW

The model used in the present analysis was based on the model previously developed by Golder for use on similar projects, like the support of environmental management planning for the Esquimalt Graving Dock (EGD) Waterlot Sediment Remediation Project (Golder 2012a) and the preliminary water quality modeling dredging of A and B Jetty for DND (Golder 2014). The model evaluated a scenario of re-suspension of sediment particles into overlying seawater on the dredged material 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.

Monitoring data were obtained from the EGD Waterlot project to help with validation of the model; an assessment of the monitoring data is provided in Appendix A. No changes to the model were made as a result of this review.

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[1] Data provided by Anchor via PWGSC (e-mail dated May 25, 2016).

5.0 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. 1993).

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,b).

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,

f is the fugacity of chemical in the compartment, and

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 absorb 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 bedded sediment following re-suspension of 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 TSS concentrations (5 to 75 mg/L).

6.0 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 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. This further evaluation relied in part on DRET testing of sediments from the waterlot associated with D Jetty (data provided by Anchor)[2]. There is some uncertainty in using these data because the sample number is relatively small (n = 4), the samples were not collected from areas with a lower fines content, and the concentrations of several metals were at detection limits for both total and dissolved forms. The assumptions associated with using the DRET data and limitations are described further in Section 8.0.

2 Data provided by Anchor by e-mail dated February 12, 2014.

7.0 MODEL ASSUMPTIONS

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

- The available sediment chemistry data (as discussed in Section 2.0) were assumed to provide an accurate characterization of the sediment to be dredged;
- Contaminant concentrations for each DU (as discussed in Section 2.0) 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;
- 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 one 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 in Section 6.0, release of metals from the solid phase into the dissolved phase prior to effluent discharge was assumed to be negligible; and
- Metals and polycyclic aromatic hydrocarbons (PAHs) were assumed to be associated with the fines (< 0.063 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. Where normalization to fines resulted in substantially inflated concentrations because the samples had low fines content (i.e., <10 to 15%), additional calculations were made using non-normalized data to assess how the predictions may change.

8.0 PRELIMINARY 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 2. The benchmarks for evaluating PAHs have previously been accepted in Vancouver Harbour and in Esquimalt Harbour for other dredging projects. For convenience, the rationale for the selected PAH concentrations are provided in the summary table.

[3] Parameters for which the CCME probable effects level (PEL) sediment quality guidelines (SQGs) were exceeded by more than five times were selected for a more detailed analysis by dredge unit.

Table 2 also provides the rationale for screening benchmarks for metals which were 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]; and
- 10× US EPA acute marine water quality criteria[6].

Where available, acute (i.e., short-term exposure) guidelines were selected over chronic (i.e., long-term exposure) guidelines and data from toxicity testing with fish species were prioritized (vis-à-vis the requirements of Section 36 of the *Fisheries Act*).

Water quality guidelines (WQG) are not intended to be effluent limits, particularly for larger bodies of water such as Esquimalt Harbour, 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.

A common approach to defining effluent limits, therefore, is to multiply a given WQG by 10.

The speciation of chromium in dredge discharge water is not known. 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.

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 MOE (British Columbia Ministry of Environment). 2016. British Columbia approved water quality guidelines: aquatic life, wildlife & agriculture. Summary Report. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/waterqualityguidesobjs/approved-wat-qual-guides/final_approved_wqg_summary_march_2016.pdf

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

9.0 MODEL INPUTS

Sediment chemistry data provided by Anchor were summarized by preliminary DUs as delineated by Anchor (2016b). Specifically, DUs D-1, D-2, D-3, D-4, D-5N, and D-5E are located at D-Jetty. DU 5 was divided into two sub-units for this assessment because the sediment chemistry on the north side of the jetty (D-5N) is notably different than on the east side of the jetty (D-5E). DU FG is a single unit at F/G-Jetty. Data were available for surficial sediments and from depth; for this preliminary modeling exercise, the data were pooled and mean and maximum values calculated by DU (Table 1). Metals (arsenic, copper, lead, zinc) and PAHs (2-Methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene) with mean and/or maximum values greater than five times the probable effects level (PEL) sediment quality guideline (SQG; CCME 1999)[7] were retained for modelling, with the exception of acenaphthylene and dibenz(a,h)anthracene. These parameters do not have readily available water quality guidelines and there is limited information to develop alternate benchmarks. Because these contaminants without benchmarks are co-located with other parameters that were modelled and assessed in this letter report, it is expected that mitigation measures implemented for these other parameters will also control potential effects of parameters that were not modelled.

Mean and maximum total metals and PAH concentrations, and mean total organic carbon and percent fines, were calculated for each DU from data provided by Anchor.

10.0 RESULTS AND UNCERTAINTY

Predicted total concentrations of the modelled substances in discharge water for each DU are presented Table 4. Predicted concentrations exceeding the screening value are highlighted. The following substances exhibited one or more predicted total concentrations in excess of the screening value.

10.1 Metals

10.1.1 Arsenic

Predicted total arsenic concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment arsenic concentrations (D-4, -5N) and maximum arsenic concentrations (D-1, -3, -4, and 5N; Table 3A). However, this was in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data were lower and the only exceedances of the screening benchmark were observed at maximum sediment arsenic concentrations, specifically at TSS concentrations >50 mg/L. Only a fraction of discharged arsenic is expected to be in the particulate phase, therefore these predicted total arsenic concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

[7] Five times PEL was used to identify potential parameters of concern because this was the approach to identifying a remedial action objectives for the dredge design.

10.1.2 Copper

Predicted total copper concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment copper concentrations (D-1, -4, -5N) and maximum sediment copper concentrations (all DUs but FG and D-2; Table 3B). When non-normalized sediment concentrations were used, predicted copper concentrations exceeded the benchmark in two or more DUs at TSS concentrations of >20 mg/L.

Given that a fraction of discharged copper is expected to be in the particulate phase, these predicted total copper concentrations do not necessarily represent a potential for adverse effects to marine life. Based on the results of DRET testing (data provided by Anchor), dissolved copper was below detection limits. Conservatively assuming that the detection limits represent actual dissolved copper concentrations, the dissolved fraction of copper was on average 28% (n = 4).[8] Using this proportion to predict dissolved concentrations, predicted copper concentrations exceeding the screening benchmark in two DUs at mean sediment copper concentrations (D-4, -5N) and four DUs at maximum sediment concentrations (D-1, -3, 5N, 5E).

We note that several predicted concentrations were higher than 300 µg/L, which is the limit for total copper in the Metal Mining Effluent Regulations. Although this is not a mining project, this concentration provides an example of a federal regulation in which “deleteriousness” per the *Fisheries Act* is defined by a numerical limit.

10.1.3 Lead

Predicted total lead concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment lead concentrations (D-4, -5N) and maximum sediment lead concentrations (D-1, -3, -4, -5N; Table 3C). However, this is in part influenced by the relatively low fines content of several samples; predicted concentrations using non-normalized data are lower and the only exceedances of the screening benchmark were observed at maximum sediment lead concentrations, specifically and only at TSS concentrations >70 mg/L. Only a fraction of discharged lead is expected to be in the particulate phase, therefore these predicted total lead concentrations may not be bioavailable and do not necessarily represent a potential for adverse effects to marine life.

10.1.4 Zinc

Predicted total zinc concentrations in discharge water exceeded the screening value at one or more TSS concentrations for one or more DUs at mean sediment zinc concentrations (D-1, -3, -4, -5N) and maximum zinc concentrations (all but D-1 and FG; Table 3D). When non-normalized sediment concentrations are used, predicted zinc concentrations exceed the benchmark in two or more DUs for maximum sediment concentrations (D-3, -4, -5N, -5E) at TSS concentrations starting at 5 mg/L.

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. However, the available DRET data were not suitable for evaluating the proportion that may be in the dissolved fraction (i.e., the detection limits were at the screening benchmark of 100 µg/L).

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[8] Monitoring data from the EGD Waterlot project suggest that as TSS increases, copper, lead, and zinc tend to be present to a greater degree in particulate form (Appendix A).

Acid-volatile sulphide (AVS) and simultaneously extractable metals (SEM) data are available for a sediment sample in the D-5N and -4 area. The difference between AVS and SEM can be used as an indicator of the potential for a given divalent metal (e.g., copper, zinc) to be bioavailable because sulphides are one of the constituents in sediments that can bind metals (Hansen et al. 1996). If sufficient AVS is available (*i.e.*, AVS-SEM > 0), the select metals are unlikely to contribute to any observed acute toxicity in sediments (DiToro et al. 1992). Conversely, if the difference between AVS and SEM is less than zero, then toxicity due to SEM may or may not occur because other sediment constituents can also bind metals. For station EH-15-SED-02, AVS-SEM = -47.4, indicating that there was insufficient sulphide to bind the metals, particularly for zinc because it has a lower affinity for sulphide complexing than other divalent metals (e.g., copper and lead; Brumbaugh and Arms 1996). This is an additional indication of the potential for zinc to be of concern during dewatering of dredged sediments.

We also note that several predicted concentration are higher than 500 µg/L, which is the limit for total zinc in the Metal Mining Effluent Regulations.

10.2 PAHs

Predicted concentrations in discharge water did not exceed respective screening values for: acenaphthene; benzo(a)pyrene; chrysene (except for a minor exceedance at the highest sediment and TSS concentrations); fluorene; 2-methylnaphthalene; or naphthalene (Table 4).

For the remaining PAHs, predicted concentrations exceeded respective screening values for one or more TSS levels, primarily in D-1, D-5N, and FG. In D-1 and D-5N at D-Jetty, the sediment concentrations are either lower than or at 5xPEL, and normalized concentrations are influenced by the low proportion of fines in the sediments. Monitoring data from the EGD Waterlot project (Appendix A) suggest that at the Compliance Point, PAH concentrations did not reach predicted levels; moreover, the data also suggest that either partitioning into dissolved phase did not occur or that resorption occurred relatively quickly following disturbance of the bedded sediments. Therefore, the predicated PAH concentrations at D-Jetty are not expected to be of concern.

At F/G Jetty, the predicted PAH concentrations that exceeded screening values were influenced primarily by data from surficial samples from two sampling locations, one immediately adjacent to G-Jetty and one between G-Jetty and F-Jetty. When the mean sediment concentration (a reasonable proxy for the sediment on the barge which will consist of a greater volume of material than is represented by a single sampling location) is used, screening values are not exceeded.

10.3 Uncertainties

The assessment conducted here was an *a priori* exercise with the objective of identifying the potential viability of discharge of water from dredged sediments to the marine environment during barge dewatering activities. This assessment necessarily required the use of predictive tools such as desorption modelling. While these tools are useful and provide a reasonable estimate of likely conditions, it is important to identify major uncertainties and to consider the implications of these uncertainties on predictions made. Main uncertainties are summarized below:

- **Sediment chemistry** – Available sediment chemistry data were assumed to provide an accurate characterization of sediment to be dredged for this preliminary assessment. However, as noted in Section 3.0, the dataset available for this assessment was limited in showing the vertical and horizontal extent of contamination in some DUs.

- **DRET testing data** – DRET testing was based on a limited number of samples (*n* = 4) and it is possible that the sediment samples tested may not be representative of the greater bulk of sediment across the project area. Moreover, a number of results were below or near detection limits (analytical variability is relatively high within approximately five times the detection limit), and detection limits were at or near some screening values. This potential for elevated analytical variability limited the further interpretation of predicted dewatering concentrations, in particular for zinc.
- **Representativeness of modelled conditions –** Modelled conditions were necessarily based on a series of assumptions, as stated throughout the letter report. Due to factors such as the uncertainties identified above, conservative assumptions were made; however, the direction of uncertainty (i.e., whether the model over or under predicts contaminant concentrations) cannot be verified at this time.

11.0 INTERPRETATION

Under the assumptions of the model stated above, and based on the available sediment chemistry data within the areas to be dredged that were modelled, 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. Specifically, a TSS limit of 75 mg/L is recommended for managing physical rather than chemical impacts associated with suspended sediments (DFO and MELP 1992).

On the north side of D-Jetty (DUs D-4 and D-5N), the predicted concentrations of copper and zinc in the discharge water exceed the screening values, including at relatively low TSS concentrations. Dewatering effluent from these areas may be unsuitable for discharge to the marine environment, potentially requiring additional treatment or other management methods prior to disposal.

12.0 NOTICE TO READER

This report was prepared for Canada in accordance with terms and conditions of the task authorization contract #EZ899-150978/002/PWY, dated February 16, 2015.

The inferences concerning the Site conditions contained in this report are based on information obtained during the assessment conducted by Golder personnel, and are based solely on the condition of the property at the time of the Site reconnaissance, supplemented by historical and interview information obtained by Golder, as described in this report.

This report was prepared, based in part, on information obtained from historic information sources. In evaluating the subject Site, Golder has relied in good faith on information provided. We accept no responsibility for any deficiency or inaccuracy contained in this report as a result of our reliance on the aforementioned information.

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 practicing under similar conditions in the jurisdiction.

With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time, these should be reviewed.

If new information is discovered during future work, the conclusions of this report should be re-evaluated and the report amended, as required, prior to any reliance upon the information presented herein.

13.0 CLOSURE

We trust the information presented in this report is satisfactory for your current purposes. Should you have any questions or comments, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

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14.0 REFERENCES

Alexander M. (2000). "*Aging, bioavailability, and overestimation of risk from environmental pollutants*". Environ Sci Technol 34: 4259-4265.

Anchor (Anchor QEA LLC). (2016a). 90% Design Basis of Design Report: F/G Jetty Optimization Study Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. March 2016.

Anchor. (2016b). Draft D Jetty Preliminary Basis of Design Report: Colwood South Remediation Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. May 2016.

BC MOE (British Columbia Ministry of Environment). 2016. British Columbia approved water quality guidelines: aquatic life, wildlife & agriculture. Summary Report. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/waterqualityguidesobjs/approved-wat-qual-guides/final_approved_wqg_summary_march_2016.pdf

Black JA, Birge WJ, Westerman AG, Francis PC. (1983). "*Comparative toxicology of aromatic hydrocarbons.*" Fundam Appl Toxicol 3: 353-358. Cited in CCME 1999.

Bonnet C, Babut M, Ferard J-F, Martel L, Garric J. (2000). "*Assessing the potential toxicity of re-suspended sediment*". Environ Toxicol Chem 19: 1290-1296.

Brumbaugh, W.G., and J.W. Arms. 1996. Quality control considerations for the determination of acid-volatile sulfide and simultaneously extracted metals in sediment. Environ. Toxicol. Chem. 15: 282-285.

CCME (Canadian Council of Ministers of the Environment) (1999). Canadian Environmental Quality Guidelines (for sediment and water), updated to 2007. <http://st-ts.ccme.ca/>

Calmano W, Hong J, Forstner U. (1993). "*Binding and mobilisation of heavy metals in contaminated sediments affected by pH and redox potential*". Water Sci Technol 28:223-235.

Chen W, Kan AT, Fu G, Tomson M. (2000). "*Factors affecting the release of hydrophobic organic contaminants from natural sediments*". Environ Toxicol Chem 19: 2401-2408.

Chen W, Kan AT, Fu G, Vignona C, Tomson M. (1999). "*Adsorption-desorption behaviors of hydrophobic organic compounds in sediments of Lake Charles Louisiana, USA*". Environ Toxicol Chem 18: 1610-1616.

De Groote J, Dumon G, Vangheluwe M, Jansen C. (1998). "*Environmental monitoring of dredging operations in the Belgian nearshore zone*". Terra et Aqua 70: 21-25.

DFO and MELP (Department of Fisheries and Oceans and Ministry of Environment, Lands and Parks). (1992). Land development guidelines for the protection of aquatic habitat. Available at: http://www.dfo-mpo.gc.ca/Library/165353.pdf.

DiToro, D.M., J.D. Mahony, D.J.Hansen, K.J. Scott, A.R. Carlson, and G.T. Ankley. 1992. Acid volatile sulfide predicts the acute toxicity of cadmium and nickel in sediments. Environ. Sci. Tech. 26: 96-101.

DiToro DM, McGrath JA, Hansen DJ. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Environ Toxicol Chem 19(8): 1951-1970.

Eggleton J, Thomas KV. (2004). "*A review of factors affecting the release and bioavailability of contaminants during sediment disturbance events*". Environ Int 30: 973– 980.

Finger SE, Little EF, Henry MG, Fairchild FJ, Boyle TP. 1985. Comparison of laboratory and field assessment of fluorene. Part I. Effects of fluorene on the survival, growth, reproduction, and behavior of aquatic organisms in laboratory tests. In: Validation and predictability of laboratory methods for assessing the fate and effects of contaminants in aquatic ecosystems. ASTM STP 865. TP Boyle, ed. Philadelphia. Cited in CCME 1999.

Forstner U, Ahlf W, Calmano W. (1989). "*Studies on the transfer of heavy metals between sedimentary phases with a multi-chamber device: combined effects of salinity and redox potential*". Mar Chem 28: 145–158.

Golder (Golder Associates Ltd.) (2010a) Esquimalt Graving Dock Waterlot Sediment Remediation Project, Fiscal Year 2010-2011 Input to Dredge Effects Assessment, dated November 18, 2010.

Golder. (2010b) Draft Letter on Preliminary Screening of Dredging Elutriate Test Results, dated December 23, 2010.

Golder. (2012a). Letter on Esquimalt Graving Dock Waterlot Remediation Project: Assessment of Predicted Quality of Discharge Water During Barge Dewatering. Dated March 2012.

Golder. (2012b). Esquimalt Graving Dock Waterlot Sediment Remediation Project: Final Water Quality Monitoring Plan. PWGSC Project: R.018400.001/Golder submission: 20000_20001.

Golder. 2014. AB Jetty barge dewatering letter.

Hansen, D.J., W.J. Berry, J.D. Mahony, W.S. Boothman, D.M. DiToro, D.L. Robson, G.T. Ankley, D. Ma, Q. Yan, and C.E. Pesch. 1996. Predicting the toxicity of metal contaminated field sediments using interstitial concentrations of metals and acid-volatile sulfide normalizations. Environ. Toxicol. Chem. 15: 2080-2094.

Holcombe GW, Phipps GL, Fiandt JT. 1983. Toxicity of selected priority pollutants to various aquatic organisms. Ecotox Environ Saf. 7:400-409. Cited in CCME 1999.

Kagan J, Kagan ED, Kagan IA, Kagan PA, Quigley S. 1985. The phototoxicity of non-carcinogenic polycyclic aromatic hydrocarbons in aquatic organisms. Chemosphere 14:1829-1834. Cited in CCME 1999.

Kan AT, Fu G, Hunter M, Chen W, Ward CH, Tomson MB. (1998). "*Irreversible adsorption of neutral organic hydrocarbons-Experimental observations and model predictions*". Environ Sci Technol 32: 892-902.

Karickhoff SW. (1980). "*Sorption kinetics of hydrophobic pollutants in natural sediments. In: Baker R.A., ed. Contaminants and sediments*". Ann Arbor, MI: Ann Arbor Science Publ, pp. 193-205.

Nagpal NK. 1987. Water quality criteria for lead: technical appendix. Ministry of Environment and Parks, Province of British Columbia.

Nagpal NK. 1993. Ambient water quality criteria for polycyclic aromatic hydrocarbons (PAHs). Ministry of Environment, Lands and Parks, Province of British Columbia.

Nagpal NK. 1999. Ambient water quality criteria for zinc. Ministry of Environment, Lands and Parks, Province of British Columbia.

Oris, JT, Giesy JP. (1987). "*The photoinduced toxicity of polycyclic aromatic hydrocarbons*". Chemosphere 16: 1395-1404. Cited in CCME 1999.

Pieters A, Van Parys M, Dumon G, Speelers L. (2002). "*Chemical monitoring of maintenance dredging operations at Zeebrugge*". Terra et Aqua 86.

Reible DD, Fleeger JW, Pardue J, Tomson M, Kan A, Thibodeaux L. (2002). "*Contaminant release during removal and re-suspension*". http://www.hsrc.org/hsrc/html/ssw/ssw-contaminant.html.

Saethre LG, Falk-Petersen IB, Sydnes LK, Lonning S, Naley AM. 1984. "*Toxicity and chemical reactivity of naphthalene and methylnaphthalenes*". Aquat Toxicol 5: 291-306.

Sanchez FF, Thibodeaux LJ, Valsaraj KT, Reible DD. (2002). "*Multimedia chemical fate model for environmental dredging*". Pract Periodical Haz Toxic Radioactive Waste Mgmt 6: 120-128.

Singleton HJ. 1987. Water quality criteria for copper: technical appendix. Ministry of Environment and Parks, Province of British Columbia.

Thibodeaux LJ. (2005a). "*A Recent advances in our understanding of sediment-to-water contaminant fluxes-The soluble release fraction*". Aquat Ecosyst Health Mgmt 8: 1-9.

Thibodeaux LJ. Birdwell J, Reible DD. (2005b). "*Soluble contaminant release during bed sediment removal and resuspension-chemodynamic model predictions*". Platform Presentation, "*Society of Environmental Toxicology and Chemistry North America 26th Annual Meeting*", 13-17 November 2005, Baltimore, MD, USA.

USEPA (United States Environmental Protection Agency). 1985. Ambient water quality criteria for lead – 1984. EPA 440/5-84-027. Washington, DC. Cited in Nagpal (1987).

Van Den Berg GA, Meijers GGA, Van Der Heijdt LM, Zwolsman JJG. (2001). "*Dredging-related mobilisation of trace metals: A case study in the Netherlands*". Wat Res 35: 1979-1986.

Table 1: Summary of Physico-chemical Data Available for Sediment Samples Collected from the Proposed Remediation Areas for D Jetty and F/G Jetty

Parameter	CCME PEL	D-1				D-2				D-3				D-4				D-5N				D-5E				FG			
		n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Grainsize (%)																													
Clay - Fine (<2um /<0.002mm)		2	2.05	2.6	3.05	1	23	23	23					3	1.39	8.13	12					1	7.69	7.69	7.69	6	4.92	10	15
Clay (<4um/<0.004mm)						4	3.5	3.7	4.1	5	14	17.4	21					4	2	3.9	6.7	4	11	17	24	10	7.1	11	16.2
Gravel - All sizes (>2.00mm)		2	60.5	64.5	68.4	5	0.1	47.6	74	5	2	2.86	4.9	3	0.1	22	65.1	4	28	53.5	83	5	4.3	21.58	37	16	0.1	23	56
Sand - All sizes(0.053mm - 2.0mm)						5	15	32	56	5	15	30.4	56	2	71	72	73	4	14	37.8	56	4	13	24.5	37	11	26	46	65
Sand - Coarse (0.5mm - 1.0mm)		2	4.77	5.1	5.44									1	9.17	9.17	9.17					1	7.6	7.6	7.6	5	4.29	8.8	12
Sand - Fine (0.10mm - 0.25mm)		2	4.25	4.9	5.52									1	3.67	3.67	3.67					1	5.76	5.76	5.76	5	6.12	11.78	22.6
Sand - Medium (0.25mm - 0.5mm)		2	3.47	4.0	4.45									1	5.66	5.66	5.66					1	5.37	5.37	5.37	5	5.28	10	17
Sand - Very Coarse (1.0mm - 5.0mm)		2	6.35	6.9	7.48									1	9.79	9.79	9.79					1	7.92	7.92	7.92	5	5.05	11	21.7
Sand - Very Fine (0.053mm - 0.10mm)		2	2.75	3.5	4.34									1	1.17	1.17	1.17					1	6.88	6.88	6.88	5	5.46	8.7	10.8
Silt - All sizes (0.002mm - 0.063mm)		2	4.81	5.3	5.86	1	39	39	39					3	2.7	12	17					1	18.4	18.4	18.4	6	9.29	16.7	25
Silt - Coarse (0.02mm - 0.063mm)		2	3.11	3.3	3.4	4	5.4	6.6	8	5	29	50.4	66	1	1.36	1.36	1.36	4	2	5.35	9.7	5	11.8	33.16	55	15	6.5	14	31
Metals (mg/kg dw)																													
Aluminum		2	11400	11600	11800	5	10800	11800	12900	5	13300	15500	21300	5	9220	17484	21400	8	11700	15713	20400	3	14600	14933	15500	25	4420	9651	17200
Antimony		10	0.21	39	149	9	6.9	72	169	5	1.06	283	1310	12	0.13	325	1190	8	82.9	652	1920	9	1.32	65.1	266	62	0.1	1.2	10
Arsenic	41.6	10	3.81	67	266	9	24.1	141.6	320	5	7.59	527	2430	12	6.35	664	2070	8	221	1210	2510	9	9.67	155.3	669	62	2.25	11.2	33.4
Barium		10	19.9	36.4	65.5	9	29.1	46.0	67.5	5	33.4	111	322	12	30.8	155	386	8	89.3	222	534	9	35.3	61.6	126	62	12	36.3	80.5
Beryllium		10	0.16	0.25	0.4	9	0.17	0.33	0.4	5	0.4	0.5	0.96	12	0.29	0.57	1.51	8	0.4	0.9	1.94	9	0.25	0.3	0.55	62	0.11	0.3	1.08
Bismuth		2	0.16	0.20	0.23	5	0.1	0.3	0.7	5	0.1	1.05	4.52	5	0.31	4.52	7.37	8	1.35	4.2	13.8	3	0.1	0.9	1.33	25	0.1	0.1	0.14
Cadmium	4.2	10	0.16	1.21	2	9	0.29	1.47	2.48	6	0.0093	2.49	5.84	12	1.67	5	12.2	8	2.48	6.2	18.8	9	1.45	2.1	3.59	62	0.07	2.0	4.49
Calcium		2	14100	14300	14500	5	10200	24560	49800	5	7040	14218	23300	5	10000	20540	26400	8	15000	27813	42200	3	21500	31900	39000	25	10000	52824	149000
Chromium	160	10	13.3	23.0	32	9	17.7	26.6	34.9	5	25.9	42	80.3	12	21.1	50	104	8	33.5	77.4	149	9	30.5	40.3	57.1	62	2.7	19.4	35.6
Cobalt		10	5.07	8.6	16.5	9	5.52	11.7	20.3	5	5.23	27	106	12	5.23	33	88.9	8	13.5	52.9	126	9	6	12.2	32.9	62	1.23	4.4	10.2
Copper	108	10	15.7	79.0	305	9	23.7	120	226	6	0.34	257	1240	12	18.1	621	1930	8	354	985	2740	9	22.8	188.5	544	62	7.24	35.4	75.8
Iron		2	19800	20600	21400	5	16500	21200	25900	5	19400	39880	105000	5	19300	82460	126000	8	34200	71050	173000	3	22100	36700	44900	25	3490	16301	38100
Lead	112	10	2.3	58	212	9	15.3	114	254	6	0.12	340	1800	12	3.55	552	1680	8	225	1055	2220	9	5.21	166.4	557	62	1.16	30.6	87.8
Lithium		2	11	11.9	12.7	5	10.9	13.8	17.4	5	18.6	19.4	20.2	5	11.7	14.34	18.1	8	9.5	14.3	18.6	3	17.8	19.3	21.7	25	5	13.1	25.8
Magnesium		2	6620	6705	6790	5	5580	6234	6840	5	6560	7398	7900	5	5380	6406	6930	8	6350	7091	7740	3	6690	7257	7540	25	4410	27906	165000
Manganese		2	228	245	261	5	186	222	271	5	187	274	572	5	215	616	937	8	286	529	1490	3	207	293	368	25	86.8	184	339
Mercury	0.7	10	0.01	0.074	0.18	9	0.05	0.27	0.72	6	0.0003	0.31	0.75	12	0.02	0.08	0.27	8	0.05	0.2	0.38	9	0.05	0.3	0.46	62	0.01	0.2	0.87
Molybdenum		10	0.95	2.92	7.58	9	2.42	5.38	9.12	5	3.5	17.2	69.4	12	3.1	27.1	78.7	8	10.7	54.2	130	9	4.16	11.1	23.4	62	0.13	5.0	14.8
Nickel		10	12.4	16.0	18.9	9	13.6	17.67	20.6	6	0.12	21.3	42.2	12	14.4	24.5	38.7	8	17.1	29.9	43.6	9	19.4	23.5	27.4	62	3.74	13.9	29.5
Phosphorus		2	848	862	876	5	613	745.4	909	5	683	851	1010	5	682	749	836	8	524	751.5	968	3	836	913	973	25	322	1474	3440
Potassium		2	957	1114	1270	5	1030	1382	1790	5	1790	2674	4620	5	1120	3490	4740	8	1880	3226	6810	3	2090	2447	2780	25	784	1557	2590
Selenium		10	0.2	0.51	0.81	9	0.2	0.6	0.94	5	0.8	1.3	2.39	12	0.5	1.19	1.85	8	0.68	1.6	2.38	9	0.84	1.2	1.65	62	0.21	1.0	3
Silver		10	0.1	0.16	0.37	9	0.1	0.3	0.8	5	0.09	0.6	2.22	12	0.1	0.9	2.36	8	0.63	1.8	3.19	9	0.11	0.4	0.91	62	0.05	0.2	2
Sodium		2	3760	4355	4950	5	3280	6454	10200	5	7170	12174	16400	5	4670	6724	9060	8	5140	8546	14100	3	9380	10770	13300	25	2740	15335	31900
Strontium		2	57.9	64.9	71.9	5	72	155.6	358	5	56.4	104	175	5	57	133	176	8	87.9	183	311	3	139	200	232	25	88.6	505	1810
Thallium		10	0.05	0.22	0.34	9	0.13	0.4	0.58	5	0.27	0.51	1.27	12	0.24	0.55	1.12	8	0.43	0.8	1.33	9	0.17	0.3	0.61	62	0.05	0.4	1
Tin		10	2	7.4	26.6	9	1.83	12.4	28.5	5	0.56	51.29	212	12	2	66.3	189	8	18.5	109	249	9	0.72	14.3	40.7	62	0.19	8.7	170
Titanium		2	900	927	954	5	730	855.4	998	5	800	899	969	5	730	785	857	8	608	790	948	3	710	880	1050	25	156	592	1060
Total Solids		8	63.1	75	89	8	65.7	78.6	91.3	4	36.9	50.5	63.1	7	55.4	64.4	79.6	3	46.2	71	90.4	9	35.3	48.1	56.1	44	20.7	56.6	90
Uranium		10	0.66	1.01	1.71	9	0.61	1.2	1.96	5	1.18	2.2	5.13	12	1.01	3.5	9.44	8	2.23	5.2	19.5	9	1.74	2.6	3.29	59	0.57	2.9	7.84
Vanadium		10	43.8	47.9	52	9	40.1	47.2	54.2	5	44.2	51.0	67.9	12	39	58	83	8	47.8	61	115	9	49.4	57.9	66.6	62	11.7	39.1	60.1
Zinc	271	10	36.1	272.4	1020	9	105	556	1260	6	1.95	1547	8190	12	55.1	3374	11300	8	1610	6561	20500	9	78.5	764	2640	62	13.9	91.3	234
Zirconium		2	4.38	4.74	5.1	5	4.97	5.6	6.59	5	6.66	10.07	20.3	5	5.35	12.09	17.7	8	7.06	12	22.4	3	7.53	9.0	9.91	25	1.16	4.3	7.64

Parameter	CCME PEL	D-1				D-2				D-3				D-4				D-5N				D-5E				FG			
		n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max	n	Min	Mean	Max
Polycyclic Aromatic Hydrocarbons (mg/kg dw)																													
2-Methylnaphthalene	0.245	7	0.0043	0.0087	0.01	7	0.01	0.01	0.03	5	0.01	0.02	0.03	6	0.01	0.01	0.02	7	0.0081	0.041	0.11	6	0.01	0.04	0.09	42	0.0015	0.1603	1.35
Acenaphthene	0.693	7	0.0044	0.0378	0.23	7	0.005	0.009	0.02	5	0.005	0.023	0.03	6	0.005	0.008	0.01	7	0.0064	0.090	0.32	6	0.005	0.083	0.13	42	0.0005	0.5480	7.7
Acenaphthylene	0.763	7	0.005	0.0085	0.01	7	0.005	0.014	0.04	5	0.005	0.037	0.09	6	0.005	0.013	0.02	7	0.02	0.07	0.23	6	0.005	0.248	0.46	42	0.0005	0.1754	2
Anthracene	0.245	7	0.004	0.120	0.66	7	0.006	0.047	0.12	5	0.01	0.15	0.26	6	0.004	0.056	0.11	7	0.06	0.47	1.9	6	0.01	0.57	1	42	0.001	1.14	17.2
Benzo(a)anthracene	0.693	7	0.01	0.23	1.33	7	0.01	0.10	0.2	5	0.01	0.27	0.54	6	0.01	0.11	0.23	7	0.1	0.82	2.7	6	0.01	1.25	2.3	42	0.001	1.70	26.2
Benzo(a)pyrene	0.763	7	0.01	0.22	1.21	7	0.01	0.10	0.2	5	0.01	0.28	0.49	6	0.01	0.10	0.21	7	0.12	0.61	1.7	6	0.01	1.16	1.81	42	0.001	1.70	23.1
Benzo(b)fluoranthene		5	0.01	0.38	1.51	4	0.02	0.18	0.29					4	0.01	0.14	0.29					3	3.37	3.62	3.78	16	0.01	3.27	28.8
Benzo(b+j+k)fluoranthene		5	0.01	0.53	2.1	3	0.03	0.21	0.42					2	0.01	0.08	0.15					3	4.67	5.06	5.28	14	0.01	4.72	40.4
Benzo(g,h,i)perylene		7	0.01	0.13	0.75	7	0.01	0.06	0.13	5	0.02	0.14	0.24	6	0.01	0.06	0.11	7	0.04	0.22	0.54	6	0.02	0.42	0.69	42	0.002	0.920	12.5
Benzo(k)fluoranthene		7	0.01	0.12	0.58	7	0.01	0.07	0.13	5	0.01	0.18	0.31	6	0.01	0.06	0.13	7	0.07	0.38	1.1	6	0.01	0.94	1.54	42	0.001	1.074	11.6
Chrysene	0.846	7	0.01	0.26	1.34	7	0.01	0.16	0.37	5	0.01	0.44	0.76	6	0.01	0.16	0.36	7	0.21	1.35	4.5	6	0.01	2.15	3.3	42	0.002	2.772	37
Dibenz(a,h)anthracene	0.135	7	0.005	0.030	0.16	7	0.005	0.013	0.03	5	0.005	0.043	0.12	6	0.005	0.013	0.02	7	0.01	0.06	0.17	6	0.005	0.124	0.2	42	0.0005	0.2509	3.09
Fluoranthene	1.49	7	0.01	0.56	3.24	7	0.01	0.28	0.93	5	0.01	0.55	0.97	6	0.01	0.23	0.5	7	0.22	1.78	5	6	0.01	5.53	12.8	42	0.001	8.241	210
Fluorene	0.144	7	0.0068	0.033	0.18	7	0.01	0.01	0.03	5	0.01	0.04	0.06	6	0.01	0.02	0.02	7	0.01	0.14	0.38	6	0.01	0.18	0.39	42	0.001	0.716	12
Indeno(1,2,3-c,d)pyrene		7	0.01	0.14	0.8	7	0.01	0.06	0.11	5	0.02	0.14	0.28	6	0.01	0.05	0.1	7	0.04	0.23	0.56	6	0.02	0.51	0.9	42	0.002	1.03	15.2
Naphthalene	0.391	7	0.0041	0.0099	0.02	7	0.01	0.01	0.02	5	0.01	0.03	0.04	6	0.01	0.01	0.01	7	0.0067	0.052	0.24	6	0.01	0.04	0.08	42	0.001	0.439	3.84
Phenanthrene	0.544	7	0.01	0.27	1.7	7	0.01	0.07	0.17	5	0.01	0.22	0.33	6	0.01	0.07	0.15	7	0.06	0.80	2.1	6	0.01	2.30	6.7	42	0.0036	5.75	130
Pyrene	1.4	7	0.01	0.51	2.73	7	0.01	0.30	0.79	5	0.01	0.85	1.3	6	0.01	0.25	0.53	7	0.41	2.38	6.6	6	0.02	6.17	12.7	42	0.0015	7.15	140
Total PAH		2	0.71	0.84	0.97	4	0.01	1.40	2.7	4	0.01	2.43	4.2	4	0.25	1.39	2.2	7	1.8	8.84	25	3	0.02	15.14	36	28	0.0096	31.20	570

Notes:
Yellow-highlighted cells have concentrations that are >five times PEL

Table 2: Summary of Proposed Dredged Material Dewatering Discharge Benchmarks

Parameter	Proposed Benchmark (µg/L)	Approach	Rationale
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	510	Literature review*	The lower 95% confidence limit of the lowest available toxicity data point (a 96-h LC_{50} for brown trout; Holcombe et al. 1983, cited in CCME 1999) without a safety factor because the data point is lower than observed for other fish species, suggesting that acute toxicity to site-specific fin-fish would be unlikely.
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(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.
Chrysene	8.6	QSAR	Based on methods of DiToro et al. (2000).
Fluoranthene	20	Literature review	The lowest available toxicity data point (a 24-h LC_{50} for fathead minnow; Kagan et al 1985) with a 10-fold safety factor.
Fluorene	82	Literature review	The lowest available toxicity data point (a 96-h LC_{50} for rainbow trout; Finger et al. 1985, cited in CCME 1999) with a 10-fold safety factor.
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_{50} 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).
Lead	140	BC marine maximum WQG	The WQG was adopted from USEPA (1985) and is approximately half the lowest marine LC50 of 315 µg/L for mummichog (*Fundulus heroclitus*) (Nagpal 1987). The screening value is lower than the maximum authorized monthly mean concentration specified in the MMER for discharge from metal mines (*i.e.*, 200 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. Phototoxic effects were not considered because by nature the water will contain some turbidity which will reduce UV penetration.

** 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.

Table 3: FGOP and CSRP Preliminary Predicted Discharge Water Concentrations For Metals

(A) Arsenic

Dredge Unit	**Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Fines Normalized Sediment Chemistry)**								
TSS (mg/L) =>	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**75**
Mean									
D-1	4	8	15	23	30	38	45	53	56
D-2	1	2	5	7	9	11	14	16	17
D-3	3	6	12	18	24	31	37	43	46
D-4	11	23	46	69	92	115	137	160	172
D-5N	37	74	148	221	295	369	443	516	553
D-5E	1	2	4	6	8	10	12	14	15
FG	0.1	0.2	0.5	1	1	1	1	2	2
Maximum									
D-1	15	30	60	90	119	149	179	209	224
D-2	3	5	10	15	21	26	31	36	39
D-3	14	28	57	85	113	141	170	198	212
D-4	36	71	143	214	286	357	428	500	535
D-5N	77	153	306	459	612	765	918	1071	1148
D-5E	4	9	18	26	35	44	53	62	66
FG	0.4	1	1	2	3	4	4	5	5

Highlighted cells exceed the screening benchmark of 125 µg/L

Dredge Unit	**Predicted Discharge Water Total Concentrations (µg/L) for Arsenic (Not Normalized to Fines)**								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	0.3	1	1	2	3	3	4	5	5
D-2	1	1	3	4	6	7	8	10	11
D-3	3	5	11	16	21	26	32	37	40
D-4	3	7	13	20	27	33	40	46	50
D-5N	6	12	24	36	48	61	73	85	91
D-5E	1	2	3	5	6	8	9	11	12
FG	0.1	0.1	0.2	0.3	0.4	1	1	1	1
Maximum									
D-1	1	3	5	8	11	13	16	19	20
D-2	2	3	6	10	13	16	19	22	24
D-3	12	24	49	73	97	122	146	170	182
D-4	10	21	41	62	83	104	124	145	155
D-5N	13	25	50	75	100	126	151	176	188
D-5E	3	7	13	20	27	33	40	47	50
FG	0.2	0.3	1	1	1	2	2	2	3

Highlighted cells exceed the screening benchmark of 125 µg/L

(B) Copper

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	4	9	18	27	35	44	53	62	66
D-2	1	2	4	6	8	10	12	14	14
D-3	1	3	6	9	12	15	18	21	22
D-4	11	21	43	64	86	107	129	150	161
D-5N	30	60	120	180	240	300	360	420	450
D-5E	1	2	5	7	10	12	15	17	19
FG	0.4	1	2	2	3	4	5	5	6
Maximum									
D-1	17	34	68	103	137	171	205	240	257
D-2	2	4	7	11	15	18	22	26	27
D-3	7	14	29	43	58	72	86	101	108
D-4	33	67	133	200	266	333	399	466	499
D-5N	84	167	334	501	668	835	1002	1169	1253
D-5E	4	7	14	21	29	36	43	50	54
FG	1	2	3	5	6	8	10	11	12

Highlighted cells exceed the screening benchmark of 30 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Fines Normalized Sediment Chemistry and Maximum Observed Dissolved Fraction - 28% - in DRET Testing)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	1	2	5	7	10	12	15	17	19
D-2	0.3	1	1	2	2	3	3	4	4
D-3	0	1	2	3	3	4	5	6	6
D-4	3	6	12	18	24	30	36	42	45
D-5N	8	17	34	50	67	84	101	118	126
D-5E	0.3	1	1	2	3	3	4	5	5
FG	0.1	0.2	0	1	1	1	1	1	2
Maximum									
D-1	5	10	19	29	38	48	58	67	72
D-2	1	1	2	3	4	5	6	7	8
D-3	2	4	8	12	16	20	24	28	30
D-4	9	19	37	56	75	93	112	130	140
D-5N	23	47	94	140	187	234	281	327	351
D-5E	1	2	4	6	8	10	12	14	15
FG	0.2	0	1	1	2	2	3	3	3

Highlighted cells exceed the screening benchmark of 30 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Copper (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	0.4	1	2	2	3	4	5	6	6
D-2	1	1	2	4	5	6	7	8	9
D-3	1	3	5	8	10	13	15	18	19
D-4	3	6	12	19	25	31	37	43	47
D-5N	5	10	20	30	39	49	59	69	74
D-5E	1	2	4	6	8	9	11	13	14
FG	0.2	0.4	1	1	1	2	2	2	3
Maximum									
D-1	2	3	6	9	12	15	18	21	23
D-2	1	2	5	7	9	11	14	16	17
D-3	6	12	25	37	50	62	74	87	93
D-4	10	19	39	58	77	97	116	135	145
D-5N	14	27	55	82	110	137	164	192	206
D-5E	3	5	11	16	22	27	33	38	41
FG	0.4	1	2	2	3	4	5	5	6

Highlighted cells exceed the screening benchmark of 30 µg/L

(C) Lead

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	3	7	13	20	26	33	39	46	49
D-2	1	2	4	6	7	9	11	13	14
D-3	2	4	8	12	16	20	24	28	30
D-4	10	19	38	57	76	95	114	133	143
D-5N	32	64	129	193	257	321	386	450	482
D-5E	1	2	4	7	9	11	13	15	16
FG	0.3	1	1	2	3	3	4	5	5
Maximum									
D-1	12	24	48	71	95	119	143	167	178
D-2	2	4	8	12	16	20	25	29	31
D-3	10	21	42	63	84	105	126	147	157
D-4	29	58	116	174	232	290	348	406	434
D-5N	68	135	271	406	541	677	812	948	1015
D-5E	4	7	15	22	29	37	44	51	55
FG	1	2	4	6	7	9	11	13	14

Highlighted cells exceed the screening benchmark of 140 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Lead (Non-Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	0.3	1	1	2	2	3	3	4	4
D-2	1	1	2	3	5	6	7	8	9
D-3	2	3	7	10	14	17	20	24	26
D-4	3	6	11	17	22	28	33	39	41
D-5N	5	11	21	32	42	53	63	74	79
D-5E	1	2	3	5	7	8	10	12	12
FG	0.2	0.3	1	1	1	2	2	2	2
Maximum									
D-1	1	2	4	6	8	11	13	15	16
D-2	1	2	5	7	10	12	15	17	18
D-3	9	18	36	54	72	90	108	126	135
D-4	8	17	34	50	67	84	101	118	126
D-5N	11	22	44	67	89	111	133	155	167
D-5E	3	6	11	17	22	28	33	39	42
FG	0.4	0.9	1.8	2.6	3.5	4.4	5	6	7

Highlighted cells exceed the screening benchmark of 140 µg/L

(D) Zinc

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Fines Normalized Sediment Chemistry)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	15	31	61	92	122	153	183	214	229
D-2	4	9	18	27	36	45	54	63	67
D-3	9	18	36	54	72	90	108	126	135
D-4	58	116	233	349	465	582	698	814	873
D-5N	200	400	800	1200	1600	2000	2400	2801	3001
D-5E	5	10	20	30	40	50	60	70	75
FG	1	2	4	6	8	10	12	14	15
Maximum									
D-1	6	11	23	34	46	57	69	80	86
D-2	10	20	41	61	81	102	122	142	152
D-3	48	95	190	286	381	476	571	667	714
D-4	195	390	779	1169	1559	1948	2338	2728	2922
D-5N	625	1250	2500	3750	5000	6250	7500	8750	9375
D-5E	17	35	69	104	139	174	208	243	260
FG	2	5	10	15	20	25	30	35	37

Highlighted cells exceed the screening benchmark of 100 µg/L

Dredge Unit	Predicted Discharge Water Total Concentrations (µg/L) for Zinc (Not Normalized to Fines)								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	1	3	5	8	11	14	16	19	20
D-2	3	6	11	17	22	28	33	39	42
D-3	8	15	31	46	62	77	93	108	116
D-4	2	3	7	10	13	17	20	24	25
D-5N	17	34	67	101	135	169	202	236	253
D-5E	4	8	15	23	31	38	46	53	57
FG	0.5	0.9	2	3	4	5	5	6	7
Maximum									
D-1	5	10	20	31	41	51	61	71	77
D-2	6	13	25	38	50	63	76	88	95
D-3	41	82	164	246	328	410	491	573	614
D-4	57	113	226	339	452	565	678	791	848
D-5N	103	205	410	615	820	1025	1230	1435	1538
D-5E	13	26	53	79	106	132	158	185	198
FG	1	2	5	7	9	12	14	16	18

Highlighted cells exceed the screening benchmark of 100 µg/L

Table 4: FGOP and CSRP Preliminary Predicted Discharge Water Concentrations For Polycyclic Aromatic Hydrocarbons

(A) Acenaphthene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Acenaphthene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	7.16	7.16	7.16	7.17	7.17	7.17	7.18	7.18	7.19
D-2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
D-3	4.36	4.36	4.36	4.37	4.37	4.37	4.37	4.38	4.38
D-4	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
D-5N	9.96	9.97	9.97	9.98	9.98	9.99	9.99	10.00	10.00
D-5E	0.52	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53
FG	3.81	3.82	3.83	3.84	3.85	3.86	3.88	3.89	3.89
Maximum									
D-1	43.5	43.5	43.5	43.6	43.6	43.6	43.6	43.7	43.7
D-2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
D-3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
D-4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
D-5N	35.2	35.2	35.3	35.3	35.3	35.3	35.3	35.4	35.4
D-5E	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
FG	53.6	53.6	53.8	54.0	54.1	54.3	54.4	54.6	54.7

Screening benchmark = 510 µg/L

(B) Anthracene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Anthracene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
D-2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
D-3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
D-4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
D-5N	14.0	14.0	14.0	14.1	14.1	14.1	14.2	14.2	14.2
D-5E	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FG	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	2.1
Maximum									
D-1	32.9	33.0	33.0	33.1	33.2	33.3	33.3	33.4	33.4
D-2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
D-3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
D-4	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9
D-5N	56.1	56.2	56.3	56.4	56.5	56.6	56.7	56.8	56.9
D-5E	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
FG	29.1	29.3	29.6	30.0	30.4	30.7	31.1	31.5	31.7

Screening benchmark = 5 µg/L

(C) Anthracene

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
Mean									
D-1	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
D-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D-3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-5N	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4
D-5E	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
FG	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
Maximum									
D-1	3.0	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.0
D-2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
D-4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
D-5N	3.5	3.6	3.8	4.0	4.1	4.3	4.4	4.6	4.7
D-5E	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
FG	2.2	2.4	3.0	3.6	4.1	4.7	5.2	5.8	6.1

Screening benchmark = 1.8 µg/L

(D) Benzo(a)pyrene

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
Mean									
D-1	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
D-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D-3	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-5N	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9
D-5E	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
FG	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4
Maximum									
D-1	2.0	2.1	2.2	2.3	2.5	2.6	2.8	2.9	3.0
D-2	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-4	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
D-5N	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
D-5E	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
FG	1.5	1.7	2.2	2.7	3.2	3.7	4.2	4.7	4.9

Screening benchmark = 5.6 µg/L

(E) Chrysene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Chrysene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
D-2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D-4	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
D-5N	2.0	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6
D-5E	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
FG	0.3	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7
Maximum									
D-1	3.3	3.4	3.6	3.7	3.9	4.0	4.2	4.3	4.4
D-2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
D-3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
D-4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
D-5N	6.6	6.7	7.0	7.3	7.6	7.8	8.1	8.4	8.5
D-5E	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6
FG	3.4	3.8	4.6	5.4	6.1	6.9	7.7	8.5	8.9

Screening benchmark = 8.6 µg/L

(F) Fluoranthene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluoranthene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	5.9	6.0	6.0	6.1	6.1	6.2	6.3	6.3	6.4
D-2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
D-3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
D-4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
D-5N	11.2	11.2	11.3	11.4	11.6	11.7	11.8	11.9	11.9
D-5E	1.8	1.9	1.9	2.0	2.1	2.2	2.2	2.3	2.3
FG	3.0	3.1	3.3	3.4	3.6	3.8	4.0	4.1	4.2
Maximum									
D-1	34.3	34.5	34.9	35.3	35.6	36.0	36.3	36.7	36.9
D-2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5
D-3	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
D-4	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9
D-5N	31.4	31.5	31.9	32.2	32.5	32.8	33.1	33.4	33.5
D-5E	4.2	4.3	4.5	4.6	4.8	5.0	5.1	5.3	5.4
FG	76.2	78.4	82.9	87.3	91.8	96.3	101	105	107

Screening benchmark = 20 µg/L

(G) Fluorene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Fluorene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.8	3.8
D-2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
D-3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
D-4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
D-5N	9.1	9.1	9.1	9.1	9.1	9.1	9.2	9.2	9.2
D-5E	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
FG	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9
Maximum									
D-1	20.1	20.1	20.1	20.1	20.1	20.1	20.2	20.2	20.2
D-2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
D-3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
D-4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
D-5N	25.0	25.0	25.0	25.0	25.0	25.1	25.1	25.1	25.1
D-5E	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
FG	46.2	46.3	46.6	46.8	47.1	47.3	47.6	47.8	48.0

Screening benchmark = 82 µg/L

(H) 2-methylnaphthalene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for 2-Methylnaphthalene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
D-2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
D-3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
D-4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
D-5N	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
D-5E	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
FG	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Maximum									
D-1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
D-2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
D-3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
D-4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
D-5N	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
D-5E	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
FG	10.8	10.8	10.8	10.8	10.9	10.9	10.9	10.9	11.0

Screening benchmark = 58 µg/L

(I) Naphthalene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Naphthalene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
D-2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
D-3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
D-4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
D-5N	12.1	12.1	12.2	12.2	12.2	12.2	12.2	12.2	12.2
D-5E	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FG	10.4	10.4	10.4	10.5	10.5	10.5	10.5	10.5	10.5
Maximum									
D-1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
D-2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
D-3	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
D-4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
D-5N	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.8
D-5E	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
FG	91.2	91.2	91.3	91.4	91.5	91.5	91.6	91.7	91.7

Screening benchmark = 100 µg/L

(J) Phenanthrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Phenanthrene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	12.8	12.8	12.8	12.9	12.9	12.9	13.0	13.0	13.0
D-2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
D-3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
D-4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
D-5N	22.0	22.1	22.1	22.2	22.2	22.2	22.3	22.3	22.4
D-5E	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	3.5
FG	9.1	9.1	9.3	9.4	9.5	9.6	9.8	9.9	9.9
Maximum									
D-1	79.2	79.3	79.5	79.7	79.9	80.1	80.3	80.5	80.6
D-2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
D-3	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6
D-4	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4
D-5N	57.9	58.0	58.1	58.3	58.4	58.5	58.6	58.8	58.8
D-5E	9.7	9.7	9.8	9.9	10.0	10.1	10.2	10.2	10.3
FG	205	207	210	212	215	218	221	223	225

Screening benchmark = 40 µg/L

(J) Pyrene

Dredge Unit:	Predicted Discharge Water Total Concentrations (µg/L) for Pyrene								
TSS (mg/L) =>	5	10	20	30	40	50	60	70	75
Mean									
D-1	5.9	6.0	6.0	6.1	6.1	6.2	6.2	6.3	6.3
D-2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
D-3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1
D-4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
D-5N	16.3	16.4	16.6	16.7	16.8	17.0	17.1	17.3	17.4
D-5E	2.2	2.3	2.3	2.4	2.5	2.6	2.7	2.8	2.8
FG	2.8	2.9	3.1	3.2	3.4	3.5	3.7	3.8	3.9
Maximum									
D-1	31.7	31.9	32.2	32.5	32.8	33.1	33.4	33.7	33.8
D-2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4
D-3	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
D-4	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2
D-5N	45.4	45.6	46.0	46.4	46.8	47.2	47.6	48.0	48.2
D-5E	4.6	4.7	4.8	5.0	5.2	5.3	5.5	5.7	5.8
FG	55.5	57.0	60.0	63.0	65.9	68.9	71.9	74.9	76.4

Screening benchmark = 12.8 µg/L

ATTACHMENT A

REVIEW OF ENVIRONMENTAL MONITORING DATA FROM THE ESQUIMALT GRAVING DOCK WATERLOT REMEDIATION PROJECT

1.0 BACKGROUND

Modelling of potential barge dewatering effluent quality was originally conducted for the Esquimalt Graving Dock (EGD) Waterlot Sediment Remediation Project.[1] As part of the environmental management for that project, water quality monitoring as undertaken to verify that the dredge performance objectives, which were based in part on the results from the barge dewatering modelling, were met. Monitoring data (chemistry, total suspended solids [TSS], and turbidity) from dredging activities conducted in 2013 were obtained from SLR Consulting (Canada) Ltd.[2] (SLR) and data (TSS and turbidity) data from dredging conducted in 2016 were obtained by Public Works and Government Services Canada (PWGSC) and actual measurements were compared with previous predictions. Monitoring data were not available for dredging activities currently being undertaken at A Jetty in Esquimalt Harbour. The purpose of this comparison was to evaluate whether or not the assumptions in the model are appropriate or need to be adjusted to reflect ambient conditions in Esquimalt Harbour.

2.0 SUMMARY OF MONITORING DATA

The original modelling undertaken for the EGD Waterlot project was predicated on an assumption that the dredged material on barges would be passively dewatered directly to Esquimalt Harbour. For the purposes of the EGD Waterlot project, a TSS concentration of 40 mg/L was conservatively estimated to be the value above which a potential for acute lethality from contaminants associated with the suspended solids in barge dewatering effluent may occur for areas with higher contaminant concentrations (Golder 2012).[3] In some areas, denoted as EGD Water Quality Monitoring Area A (EGD WQMA-A), no direct dewatering without additional treatment was recommended. In EGD WQMA-B, direct dewatering was allowable provided TSS remained below 40 mg/L. In the remainder of the Waterlot, denoted as EGD WQMA-C, a TSS limit of 75 mg/L was adopted from DFO and MELP (1992).[4] This higher TSS limit was recommended based on potential physical effects associated with induced turbidity and suspended solids (*i.e.*, contaminant concentrations in seabed sediments were sufficiently low that they were not predicted to result in water-borne contaminant concentrations with a potential to result in acute lethality).

In actuality, the contractor conducting the sediment remediation at the EGD Waterlot collected the decant water and treated it with an active process; however, the data from the barge dewatering were not available at the time this Appendix was prepared. Thus, this review focussed on receiving environment samples collected at the Compliance Point (CP) 25 m from the dredge bucket.

For the day-to-day management of the EGD Waterlot dredging itself, the TSS limits discussed above were used to derive turbidity limits applied at the CP and used in a decision framework for implementing management actions. This adaptation of the barge dewatering assessment to *in situ* dredging assumed that the conditions modelled were similar those experienced in the immediate vicinity of the dredge bucket (e.g., mean TSS levels, time for

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1 Golder. 2012. Letter on Esquimalt Graving Dock Waterlot Remediation Project: Assessment of Predicted Quality of Discharge Water During Barge Dewatering. Dated March 2012.

2 E-mail from J. Nyman (SLR) to E. von Krogh (Golder) dated January 28, 2014 (with attachments).

3 The proposed benchmarks were conservatively derived and acute lethality was not anticipated to occur at the TSS values proposed for day-to-day management of the dredging.

4 DFO and MELP (Department of Fisheries and Oceans and Ministry of Environment, Lands and Parks). (1992). Land development guidelines for the protection of aquatic habitat. Available at: http://www.dfo-mpo.gc.ca/Library/165353.pdf.

desorption). In reality, the conditions at the point of dredging are likely more dynamic and thus there was some uncertainty in the application of the modelling to the dredging scenario. Nonetheless, the monitoring data provide information about induced water chemistry at the CP, 25 m from the dredge bucket.

Table A1 summarizes laboratory-measured TSS and total and dissolved metals in samples from three depths in the water column (*i.e.*, surface, middle and bottom) collected during the dredging at the EGD Waterlot, Figure A1 illustrates the relationship of laboratory TSS with paired laboratory turbidity measurements and Figure A2 illustrates the relationship of copper and zinc concentrations to TSS. The highest TSS, turbidity and metals concentrations were measured in samples from the bottom of the water column. There were no exceedances of the discharge criteria for arsenic, copper or zinc. TSS did not exceed the discharge criteria except in one bottom sample (78 mg/L versus the discharge criterion of 75 mg/L for the given WQMA). Samples were also analysed for polycyclic aromatic hydrocarbons (PAH); results were below or near detection limits (data not shown).

3.0 IMPLICATIONS FOR THE F/G OPTIMIZATION AND COLWOOD SOUTH REMEDIATION PROJECTS

For the EGD Waterlot Project, turbidity in the surface and mid-points of the water column were consistently below or near the water quality guideline and TSS values associated with these measurements did not exceed the discharge criteria for either EGD WQMAs (Figure A1). Turbidity and TSS at the bottom of the water column were more variable and samples with differing TSS values shared a similar turbidity. However, only in a few instances did turbidity not link to a TSS concentration that would have triggered a response through the decision framework in the Water Quality Monitoring Plan.

Figure A3 illustrates total and dissolved copper concentrations versus TSS for the EGD WQMAs described in Section 2.0, for which different management actions were applied. In WQMAs A and B, none of the TSS measurements exceeded 40 mg/L (the applicable criterion) and none of the copper concentrations exceeded the discharge criterion of 30 µg/L. For EGD WQMA-C, one TSS measurement exceeded the applicable discharge criterion of 75 mg/L but none of the copper concentrations exceeded the 30 µg/L criterion. Moreover, as TSS increased, the occurrence of copper in dissolved form decreased notably. Although this tendency should not be relied on as a mitigation measure, it does provide confirmation that the metal is not likely to be present in a dissolved, bioavailable form (Golder 2012a).

Relating this information to the F/G Optimization Project (FGOP) and Colwood South Remediation Project (CSRP), the grainsize of the sediment in the current project areas, D-Jetty in particular, appears to be coarser in certain dredge units. Therefore, it is possible that the TSS-turbidity relationship derived for EGD Waterlot dredging may be either under- or over-conservative. For planning purposes it may be suitable to rely initially on the EGD relationship and as the monitoring data are acquired, the turbidity value for triggering management responses may be revised to something that is more reflective of the conditions at the site.

Table A1: Summary of EGD Waterlot Metals Concentrations in Receiving Environment Samples from the CP (25 m from dredging)

Parameter	All Data					Location in Water Column														
						Surface					Middle					Bottom				
	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n
TSS (mg/L)	78	1	10	6	171	9.0	3.0	5.5	5.0	27	17	2	6.6	6	49	78	1	14.2	7	86
Total																				
Aluminum	2250	<10	204	65	177	99	<10	31	24	27	384	<10	90	68	51	2250	<10	331	87	90
Antimony	1.2	<0.5	0.5	<0.5	177	<0.5	<0.5	-	-	27	<0.5	<0.5	-	-	51	1.2	<0.5	0.5	<0.5	90
Arsenic	5.7	1.6	2.1	2.0	177	2.35	1.73	2.02	2.02	27	2.7	1.6	2.0	2.0	51	5.7	1.6	2.2	2.1	90
Barium	70.3	5.2	11.4	9.7	177	17.7	5.2	9.4	9.4	27	11.9	7.9	9.7	9.5	51	70	8	13	10	90
Beryllium	<1	<1	-	-	177	<1	<1	-	-	27	<1	<1	-	-	51	<1	<1	-	-	90
Bismuth	<1	<1	-	-	177	<1	<1	-	-	27	<1	<1	-	-	51	<1	<1	-	-	90
Boron	5270	2700	3929	3860	177	4840	2700	3988	3980	27	4530	2770	3834	3810	51	4900	3350	3915	3860	90
Cadmium	0.2	0.1	0.1	0.1	177	0.16	0.07	0.12	0.12	27	0.17	0.09	0.13	0.13	51	0.23	0.09	0.13	0.12	90
Chromium	3.6	0.5	0.7	0.5	177	0.93	<0.5	0.56	<0.5	27	1.41	<0.5	0.56	<0.5	51	3.56	<0.5	0.87	0.54	90
Cobalt	1.0	<0.1	0.2	<0.1	177	<0.1	<0.1	-	-	27	0.3	<0.1	0.1	<0.1	51	1.0	<0.1	0.2	<0.1	90
Copper	15.3	0.5	2.3	1.5	177	10.6	0.7	2.2	1.6	27	5.3	<0.5	1.5	1.1	51	15.3	<0.5	2.8	1.5	90
Iron	2530	2.9	250	88	177	156.0	11.4	47.0	36.7	27	711	2.9	132	80.2	51	2530	4	391	127	90
Lead	9.0	0.1	0.8	0.3	177	0.91	<0.1	0.22	0.18	27	2.8	<0.1	0.4	0.3	51	9.0	<0.1	1.2	0.4	90
Lithium	228	86	170	168	177	228	86	175	177	27	210	89	166	166	51	205	146	169	169	90
Manganese	49.1	1.53	6.4	3.79	177	6.43	1.71	3.66	3.66	27	11.9	2.1	4.5	3.6	51	49.1	1.5	8.6	4.6	90
Mercury	0.04	<0.01	<0.01	<0.01	177	<0.01	<0.01	-	-	27	0.02	<0.01	0.01	<0.01	51	0.04	<0.01	0.01	<0.01	90
Molybdenum	15.6	9.3	11.6	11.5	177	15.6	10.0	11.5	11.2	27	14.6	10.4	11.7	11.5	51	15.3	9.3	11.6	11.6	90
Nickel	10.4	0.2	0.9	0.68	177	1.37	0.24	0.56	0.49	27	2.3	<0.2	0.8	0.6	51	10.4	<0.2	1.1	0.8	90
Selenium	<0.5	<0.5	-	-	177	<0.5	<0.5	-	-	27	<0.5	<0.5	-	-	51	<0.5	<0.5	-	-	90
Silver	0.07	0.05	0.1	0.05	177	0.07	<0.05	0.05	<0.05	27	0.06	<0.05	0.05	<0.05	51	0.07	<0.05	0.05	<0.05	90
Strontium	9970	6720	7778	7690	177	9660	6720	7824	7740	27	9970	7010	7815	7760	51	9880	6900	7747	7690	90
Thallium	0.16	0.1	0.1	0.1	177	<0.1	<0.1	-	-	27	<0.1	<0.1	-	-	51	0.2	<0.1	0.1	<0.1	90
Tin	5.6	<1	1	<1	177	<1	<1	-	-	27	<1	<1	-	-	51	5.6	<1	1.1	<1	90
Titanium	119	10	15.6	10	177	<10	<10	-	-	27	24	<10	11	<10	51	119	<10	21	<10	90
Uranium	3.72	2.4	2.9	2.83	177	3.5	2.4	2.8	2.8	27	3.5	2.5	2.9	2.8	51	3.7	2.5	2.9	2.8	90
Vanadium	<10	<10	-	-	177	<10	<10	-	-	27	<10	<10	-	-	51	<10	<10	-	-	90
Zinc	33	<1	2.9	2.1	177	11.2	<1	3.6	3.1	27	3.8	<1	1.9	1.7	51	33.0	<1	3.4	2.3	90

Parameter	All Data					Location in Water Column														
						Surface					Middle					Bottom				
	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n	Max	Min	Mean	Med	n
Dissolved																				
Aluminum	211	<10	13.9	10	184	26	<10	12	<10	27	26	<10	11	<10	54	211	<10	16	<10	94
Antimony	0.87	0.5	0.5	0.5	185	0.5	0.5	0.5	0.5	27	0.5	0.5	0.5	0.5	55	0.9	0.5	0.5	0.5	94
Arsenic	3.53	1.49	1.9	1.91	185	2.38	1.65	1.93	1.90	27	2.3	1.7	2.0	1.9	55	3.5	1.5	2.0	1.9	94
Barium	46.1	2.4	9.7	9.1	185	10.9	2.4	8.2	8.6	27	13.4	5.3	9.5	9.3	55	46.1	5.9	10.3	9.2	94
Beryllium	<1	<1	-	-	185	<1	<1	-	-	27	<1	<1	-	-	55	<1	<1	-	-	94
Bismuth	<1	<1	-	-	185	<1	<1	-	-	27	<1	<1	-	-	55	<1	<1	-	-	94
Boron	4900	2630	3839	3800	185	4630	2730	3898	3870	27	4670	2630	3772	3700	55	4900	3210	3826	3790	94
Cadmium	0.36	<0.05	0.12	0.12	185	0.36	0.08	0.13	0.12	27	0.19	0.08	0.13	0.12	55	0.35	0.05	0.11	0.11	94
Chromium	1.01	<0.5	0.5	<0.5	184	1.0	<0.5	0.5	<0.5	27	0.6	<0.5	0.5	<0.5	55	0.8	<0.5	0.5	<0.5	94
Cobalt	0.4	<0.1	0.1	<0.1	185	0.23	<0.1	0.11	<0.1	27	0.13	<0.1	0.10	<0.1	55	0.40	<0.1	0.11	<0.1	94
Copper	2.59	<0.5	0.9	0.74	185	2.59	0.67	1.51	1.69	27	2.40	<0.5	0.85	0.71	55	2.53	<0.5	0.85	0.63	94
Iron	165	<2	12	6	185	28	3	8	6	27	47	<2	6	5	55	165	<2	16	6	94
Lead	0.66	<0.1	0.1	<0.1	185	0.1	<0.1	0.1	<0.1	27	0.2	<0.1	0.1	<0.1	55	0.5	<0.1	0.1	<0.1	94
Lithium	216	86	165	165	185	192	92	167	174	27	216	86	165	165	55	199	136	165	164	94
Manganese	19.5	1.28	3.41	2.95	185	6.33	1.49	3.02	2.79	27	6.8	1.3	3.0	2.9	55	19.5	1.4	3.9	3.4	94
Mercury	<0.01	<0.01	-	-	185	<0.01	<0.01	-	-	27	<0.01	<0.01	-	-	55	<0.01	<0.01	-	-	94
Molybdenum	13.5	9.9	11.3	11.3	185	13.5	10.1	11.4	11.1	27	12.9	10.1	11.4	11.5	55	12.9	9.9	11.3	11.2	94
Nickel	2.51	0.2	0.7	0.61	185	1.0	0.4	0.7	0.7	27	2.0	<0.2	0.7	0.6	55	2.5	<0.2	0.7	0.6	94
Selenium	0.55	<0.5	0.5	<0.5	185	<0.5	<0.5	-	-	27	<0.5	<0.5	-	-	55	<0.5	<0.5	-	-	94
Silver	0.173	<0.05	0.05	<0.05	185	0.10	<0.05	0.06	<0.05	27	0.09	<0.05	0.05	<0.05	55	0.17	<0.05	0.05	<0.05	94
Strontium	8900	6720	7555	7510	185	8730	6720	7591	7440	27	8620	6810	7601	7600	55	8900	6770	7549	7495	94
Thallium	<0.1	<0.1	-	-	185	<0.1	<0.1	-	-	27	<0.1	<0.1	-	-	55	<0.1	<0.1	-	-	94
Tin	<1	<1	-	-	185	<1	<1	-	-	27	<1	<1	-	-	55	<1	<1	-	-	94
Titanium	<10	<10	-	-	185	<10	<10	-	-	27	<10	<10	-	-	55	<10	<10	-	-	94
Uranium	3.9	2.2	3	2.8	185	4.0	2.3	2.8	2.8	27	3.4	2.4	2.8	2.8	55	3.7	2.2	2.8	2.8	94
Vanadium	<10	<10	-	-	185	<10	<10	-	-	27	<10	<10	-	-	55	<10	<10	-	-	94
Zinc	12.9	<1	3.4	3.2	185	12.4	1.4	4.8	4.9	27	12.9	<1	3.7	3.5	55	9.4	<1	2.8	2.3	94

Notes:
'<' - less than detection limit; '-' – not calculated (all values less than detection limit); 'n' – number of analyses
Source: SLR (January 28, 2014 e-mail from J. Nyman)
Summarized data do not include duplicate samples.
Max = maximum; Min = minimum; Med = median

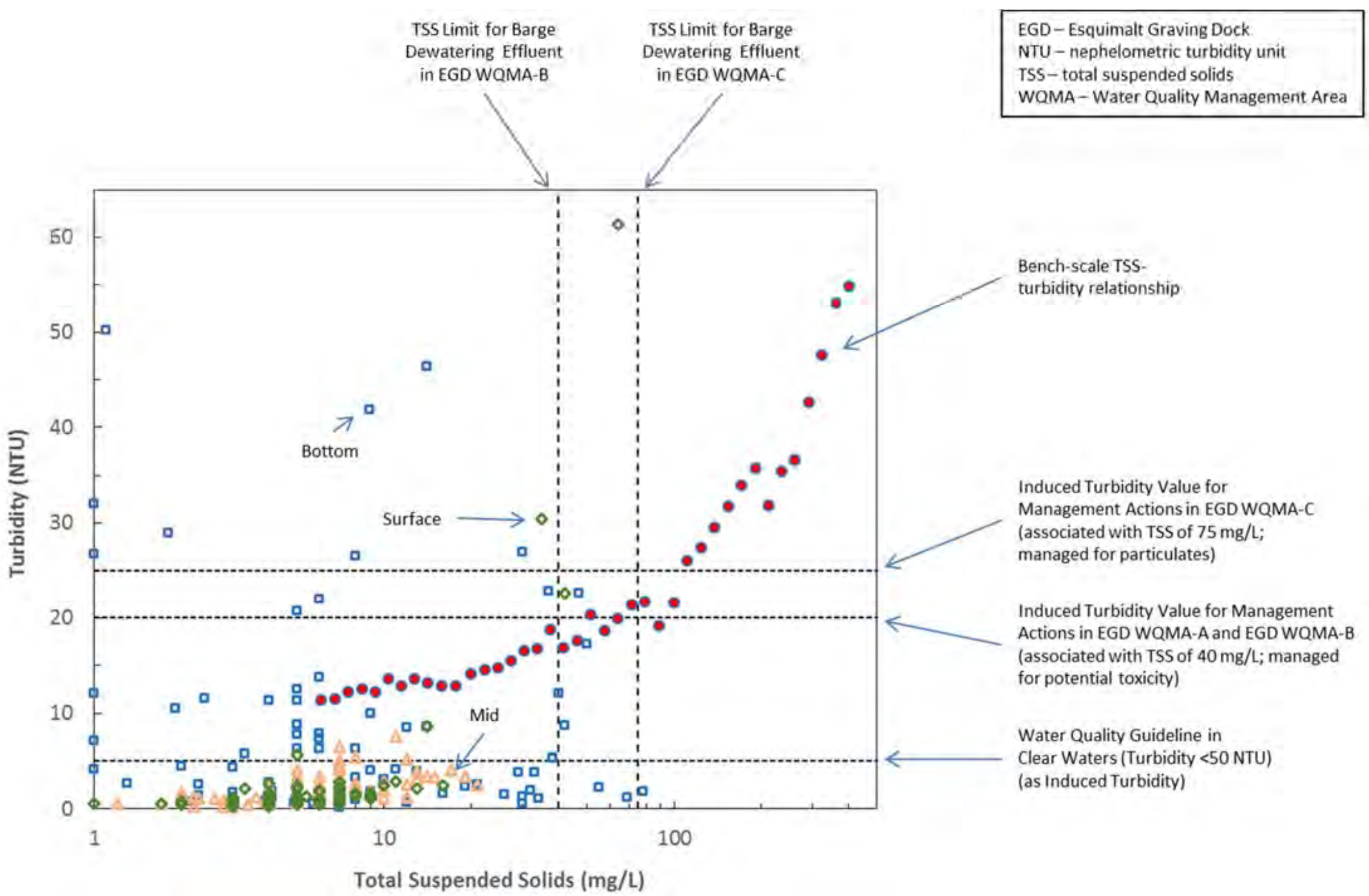


Figure A1: Relationship of Total Suspended Solids Concentrations to Turbidity Measurements in Receiving Environment Samples from Three Water Column Depths at the Compliance Point During the EGD Waterlot Sediment Remediation Project

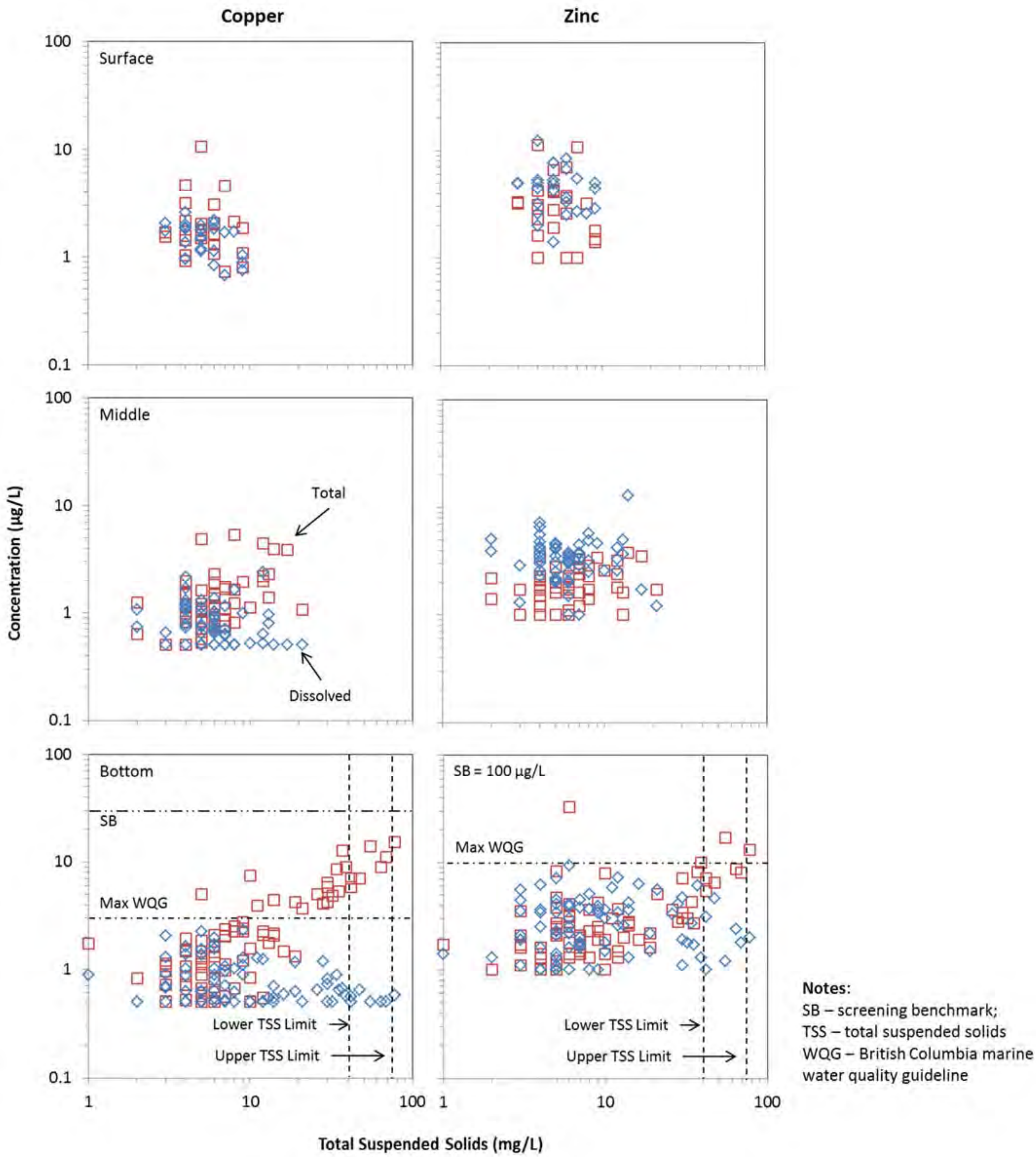
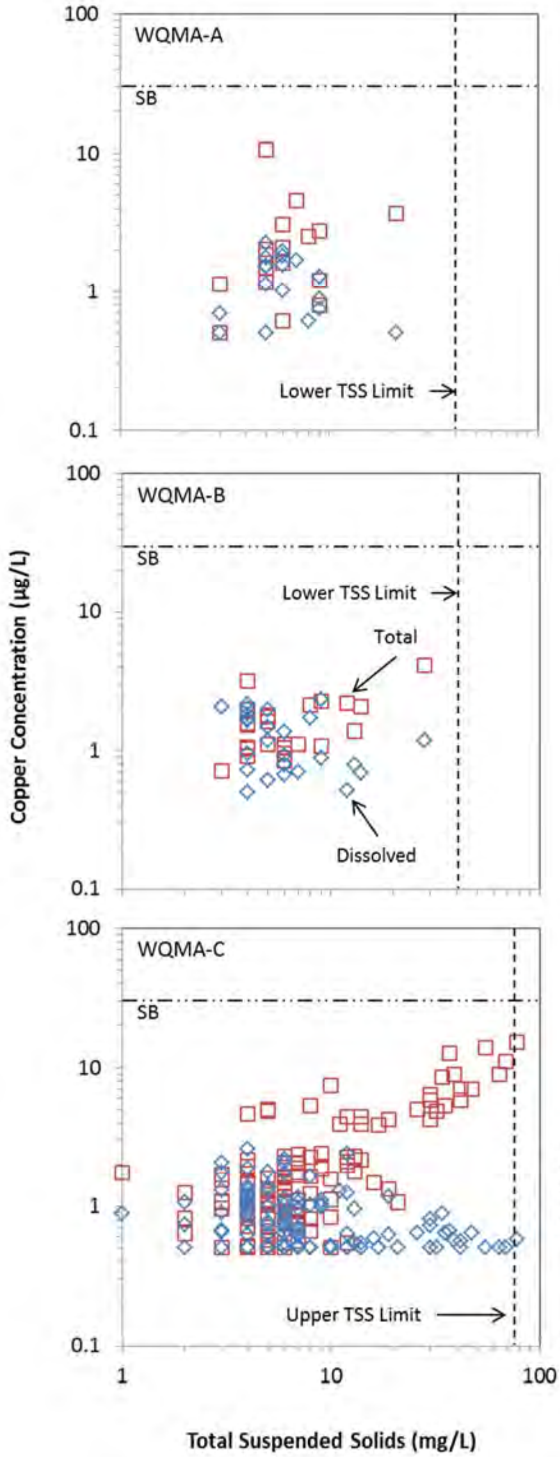


Figure A2: Relationship of Copper and Zinc Concentrations to Total Suspended Solids in Receiving Environment Samples from Three Water Column Depths at the Compliance Point During the EGD Waterlot Sediment Remediation Project



Notes:
SB – screening benchmark;
TSS – total suspended solids
WQMA – water quality management area*
A – area of no allowable direct barge dewatering
B – area of allowable direct barge dewatering with TSS limit of 40 mg/L
C – area of allowable direct barge dewatering with TSS limit of 75 mg/L
* Based on Golder (2012b)

Figure A3: Total and Dissolved Copper Concentrations Versus Total Suspended Solids at the Compliance Point (25 m from Dredging) By Water Quality Management Area for the EGD Waterlot Sediment Remediation Project

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Annex E. Underwater Noise Modelling

1.0 INTRODUCTION

Certain in-water work activities associated with the F/G Jetty Optimization Project (FGOP) and Colwood South Remediation Project (CSRP) (collectively referred to as the "Project") have the potential to cause underwater noise effects to fish and aquatic mammals. Depending on the level of underwater noise generated and how well the species can hear the sounds produced, potential effects could result in either acoustic injury or behavioural disturbance to fish and aquatic mammals. To assess the potential effects of Project generated underwater noise Project sound levels are modeled and then compared against acoustic impact (injury) and disturbance (behavioural) thresholds for aquatic mammals and fish.

Acoustic modeling was undertaken to determine the potential area of influence for Project generated underwater noise. Underwater noise sources considered in the model included vibratory driving of steel piles and impact driving of steel and timber piles.

The area of influence determined by the model informs the environmental effects determination (EED) regarding the assessment of potential injury and behavioural related effects to aquatic mammals and fish and the environmental management plan (EMP) regarding the establishment of marine safety perimeters for aquatic mammals.

2.0 UNDERWATER NOISE EXPOSURE CRITERIA

2.1 Marine Mammals

The potential for acoustic injury and behavioural disturbance in aquatic mammals depends on the level of underwater noise produced and how well the species can hear the sounds produced, although not all regulatory thresholds address species-dependent hearing acuity. Auditory thresholds from underwater noise are expressed using two common metrics: sound pressure level (SPL), measured in dB re: 1 µPa, and sound exposure level (SEL), a measure of energy in dB re: 1 uPa^{2}s. SPL is an instantaneous value represented as either root-mean-square (SPL_{rms}) or peak sound pressure level (SPL_{peak}), whereas SEL is the total noise energy to which an organism is exposed over a given time period, typically one second for pulse sources.

Currently, DFO has no defined standard acoustic thresholds for assessing acoustic injury or behavioural disturbance in aquatic mammals. In absence of specific legislated underwater noise criteria in Canada, DFO bases its assessment of potential 'serious harm' to aquatic mammals on the best currently-available science. It also relies on the United States standards employed by the National Marine Fisheries Service (NMFS) (NOAA 2016). The following section provides an overview of acoustics threshold criteria applicable to aquatic mammals.

For modelling, the following NMFS thresholds for aquatic mammal injury and behavioural disturbance from impulsive sounds (NOAA 2016) were applied:

- For injury: 190 dB re 1 µPa SPL_{rms} for pinnipeds, and 180 dB re 1 µPa SPL_{rms} for cetaceans.
- For behavioural disturbance: 160 dB re 1 µPa SPL_{rms} for all aquatic mammals.

Also considered in the modeling exercise were injury thresholds that account for acoustic intensity, duration, frequency content and number of impulse events, as recommended by an expert working group (Southall et al. 2007). These criteria include both SPL_{peak} and SEL metrics, and have been accepted by many regulatory agencies including DFO, as they consider frequency-dependence of hearing acuity for the following species groups:

- Low-frequency cetaceans (LFCs) – mysticetes (baleen whales).
- Mid-frequency cetaceans (MFCs) – some odontocetes (toothed whales).
- High-frequency cetaceans (HFCs) – odontocetes specialized for using high frequencies.
- Pinnipeds (PINN) - seals, sea lions, and walrus (in-water).

The Southall et al. (2007) injury criteria considered in this assessment include the following:

- Injury from single or multiple impulsive sound events over 24 hours: 186 dB re 1 μPa^2s SEL for pinnipeds, and 198 dB re 1 μPa^2s for cetaceans.
- Injury based on peak pressure (SPL_{peak}) of individual impulse events of 218 dB re 1 μPa for pinnipeds and 230 dB re 1 μPa for cetaceans.

It should be further noted that NMFS has recently proposed new draft criteria (NOAA 2015) that suggest using an assessment approach based on that of Southall et al. (2007), but with different weighting functions and thresholds. These criteria have not been considered in this assessment as they are currently in public review and are likely to be revised prior to being finalized. The current NMFS acoustic threshold levels, used for most sound sources, consist of the single SPL_{rms} threshold for cetaceans and the single SPL_{rms} threshold for pinnipeds regardless of sound source (i.e. they do not take into account of the hearing ability of different aquatic mammal groups or the differences among sound sources in terms of auditory impacts). The updated acoustic threshold levels will consist of several thresholds and when finalized will replace those currently in use by NMFS (NOAA 2016).

The most conservative aquatic mammal injury threshold was adopted in the model for each sound pressure metric for pinnipeds and cetaceans to determine the spatial limits of underwater noise effects and to determine an appropriate marine safety perimeter for aquatic mammals for the Project.

2.2 Marine Fish

Currently, there are no legislated underwater noise criteria in Canada for assessing injury in fish. In absence of specific legislated criteria, assessing potential for 'serious harm[1]' to fish from underwater noise is typically based on 'best available evidence', as documented in the scientific literature, available Best Management Practices (BMPs) and/or established by other government agencies.

The NMFS has adopted interim acoustic threshold criteria specific to impact pile driving that are based on SPL that are known to potentially result in physical effects in fish (FHWG 2008; Stadler and Woodbury 2009). The current NMFS interim SPL injury thresholds for fish are:

- SPL_{peak} for potential injury to fish is 206 dB re 1 uPa (FHWG 2008; Stadler and Woodbury 2009).

3.0 NOISE MODEL PARAMETERS

Noise modeling was conducting using a two-dimensional model designed by NMFS specifically for pile driving activities (WSDOT 2009). Underwater noise levels were calculated on the basis of data and methods described in WSDOT's Advanced Training Manual, Biological Assessment Preparation for Transportation Projects Version 02-2015 (WSDOT 2015).

In accordance with guidance from the NMFS, this analysis used the Practical Spreading Loss Model which is based on the following formula for geometric spreading:

$$\mathbf{TL = 15 \times Log\ (R1/R2) + \alpha R}$$

Where:

TL: is the transmission loss in dB.

R1: is range in meters of the sound pressure level.

R2: is the distance from the source of the initial measurement.

αR: linear absorption and scattering loss

Solving for TL will provide the underwater sound pressure level at a given distance. To determine at what distance or range a known sound pressure level will occur, the equation must be solved for R1:

$$R1 = (10(TL/15)) \bullet R2$$

The NMFS model was used to calculate the distance from the source Project generated sound levels would be expected to reach the injury and disturbance thresholds for aquatic mammals and fish. A default transmission loss constant of 15 was used, as indicated by the guidance, due to the lack of site-specific transmission loss information (WSDOT 2009). This is equivalent to a 4.5 dB attenuation rate per doubling of distance, which is within the range of attenuation rates recorded for several pile-driving projects in shallow waters (<10 m depth) in California (Caltrans 2015).

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[1] includes the destruction of fish habitat or an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes (*Fisheries Act* 1985)

4.0 PILE DRIVING NOISE

Certain piling activities are known to generate high intensity underwater noise that can adversely affect marine animals, particularly whales and seals which rely on underwater sound as a primary method of navigation, orientation, communication and foraging. Pile-driving sounds result from a rapid release of energy when two objects hit one another. The characteristics of impact sounds depend primarily on the physical properties of the impacting objects. When a pile-driving hammer strikes a pile, sound from the impact radiates into the air and a transient stress wave, or pulse, propagates down the length of the pile. The impact will also create flexural (or transverse) stress waves in the wall of the pile which couple with the surrounding fluids (air and water) to radiate sound into the water and additional sound into the air. Moreover, the pulse propagating down the length of the pile may couple to the substrate at the water bottom and cause waves to propagate outward through the bottom sediment.

Typically, noise generated by impact pile driving consists of pulsed sounds that occur at intervals of approximately 1 to 3 seconds depending on the equipment used. The repetitive nature of the pile driving sounds does not allow for receivers to fully recover from one pulse before the next pulse is produced. In order to assess this type of sound source, the NMFS noise model and impact criteria are based upon the sound pressure in peak (SPL_{peak}) and rms (SPL_{rms}), and the sound exposure level (SEL) which take into account the number of pulses generated per day.

The proposed construction approach involves removal of existing timber piles (300-mm Ø), re-installation of old timber piles where possible, and installation of new timber piles (300-mm Ø), by vibratory hammer (Anchor 2016). In general, vibratory hammers generate lower sound levels than impact hammers, and the driving of timber piles generate lower sound levels than steel piles. Source levels used in the model were derived from available literature (Caltrans 2015; Illinworth and Rodkin 2007; WSDOT 2009) for similar pile types (300 mm timber and steel piles) and driving techniques (vibratory hammer, impact hammer, and drop hammer), as outlined in Table 1.

Table 1: Reference Sound Source Levels for Various Pile Types (single-strike)

Pile type / hammer type	Underwater Sound Source Levels		
	SPL_{peak} (dB re 1 μPa)	SPL_{rms} (dB re 1 μPa)	SEL (dB re 1 μPa^{2}s)
Timber (300-mm Ø) / drop hammer	177	165	157
Cast-in-steel shell (CISS) (300-mm Ø) / drop hammer	177	165	152
CISS (300-mm Ø) / impact hammer	200	184	174
Steel H-Type (thick) (300-mm Ø) / impact hammer	190	175	160
Steel H-Type (thin) (300-mm Ø) / impact hammer	195	183	170
Steel H-Type (300-mm) vibratory	165	150	150

Note: Sound levels measured at 10 m from pile.

5.0 RESULTS

Underwater noise modeling results are presented in Table 2. The injury threshold for fish will not be exceeded at any distance from the pile when using timber or steel piles with drop or vibratory hammers, but will be exceeded within 1 to 4 m from the pile when using steel piles with an impact hammer (Table 2). The injury threshold for aquatic mammals is expected to be exceeded within 1 m from the pile when using timber piles, and up to 18 m when impact-driving steel piles. Based on these results when using timber piles with a drop hammer, potential injury effects are not expected for fish or aquatic mammals, unless an aquatic mammal is located within 1 m from the source during active pile driving. Potential injury effects are expected for aquatic mammals up to 18 m from the steel pile when installing steel piles with an impact hammer.

Underwater noise from pile driving will exceed the behavioural disturbance threshold (160 dB re 1 µPa SPL_{rms}) for aquatic mammals up to 22 m for timber and cast-in-shell steel piles using a drop hammer, and at distances ranging between 341 to 398 m for various other types of steel piles using an impact hammer. These results suggest that behavioral effects are likely to occur, although they would be limited to Esquimalt Harbour. With the implementation of noise-reduction measures (e.g. bubble curtains, avoiding concurrent noise activities), this zone of disturbance may be further reduced.

Table 2: Distances to Fish and Aquatic mammal AcousticThresholds for Various Pile Driving Methods

Pile type / hammer type	Distance (m) to Which Threshold Value Attenuates				
	Fish Threshold	Aquatic Mammal Thresholds			
	Injury	Injury			Behavioural
	206 SPL_{peak} (dB re 1 µPa)	218 SPL_{peak} (dB re 1 µPa)	180 SPL_{rms} (dB re 1 µPa)	186 SEL (dB re 1 mPa^{2}s)	160 SPL_{rms} (dB re 1 µPa)
Timber (300-mm Ø) / drop hammer	0	0	1	0	22
Cast-in-steel shell (CISS) (300-mm Ø) / drop hammer	0	0	1	0	22
CISS (300-mm Ø) / impact hammer	4	0	10	0	398
Steel H-Type (thick) (300-mm Ø) / impact hammer	1	1	18	2	100
Steel H-Type (thin) (300-mm Ø) / impact hammer	2	0	5	0	341
Steel H-Type (300-mm) vibratory	0	0	0	0	2

Marine Safety Perimeter

Marine safety perimeters are used to mitigate the potential effect of injury to aquatic mammals as a result of elevated underwater noise levels. Based on the model, sound levels generated by drop hammer driving of timber pile is below the injury thresholds for aquatic mammals, therefore no marine safety perimeter is required. The model predicts that the sound level from impact driving of steel piles will attenuate to the lowest injury threshold (180 SPL_{rms}) within 18 m from the pile. It is therefore recommended that a conservative 100 m marine safety perimeter be established during all impact driving of steel piles, should it occur for the project.

6.0 PREDICTION CONFIDENCE

Prediction confidence in the underwater noise model is considered to be moderate based on the following factors:

- Pile driving activities were modeled using conservative source level values from similar pile types (size and material) and driving techniques (impact, hammer).
- The NMFS model is designed specifically for pulsive noise sources such as pile driving.
- Quality control checks were undertaken on all model runs to verify that model input parameters were correct, model output was plotted correctly and any calculations were checked.
- There are limitations of using a two-dimensional model with respect to sound attenuation in a three-dimensional environment. The spreading loss model used for the underwater noise assessment only provides an approximation to the actual spreading loss in the marine environment. The model assumes that sound travels in a homogeneous environment. It does not take into account potential propagation effects related to absorption / reflection that may occur as a result of sound interacting with local marine topographical features, nor effects related to refraction that may occur as a result of boundary layer effects / water column stratification. For example, physical aspects of the receiving environment (e.g. freshwater surface lens, in-field gradients in temperature, bottom topography) could cause sound levels to attenuate at different rates than predicted by this geometric spreading-based model. Sophisticated sound field models do exist that that take into account the actual sound speed field in the ocean and the reflections from the sea surface and sea floor as the sound travels away from the source. However, these types of models require detailed site-specific inputs for the model with respect to existing oceanographic, bathymetric and substrate conditions, which were beyond the scope of the assessment. Nonetheless, the practical spreading loss model is commonly used to obtain an estimate of sound levels around a source when more complex models are not achievable.

7.0 REFERENCES

Anchor (Anchor QEA LLC). 2016a. Draft 100% Design Report: Colwood Jetties Remediation Project. Esquimalt Harbour, Esquimalt, BC. Prepared for PWGSC. June 2016.

California Department of Transportation (Caltrans), Division of Environmental Analysis. 2015. *Technical guidance for assessment and mitigation of the hydroacoustic effects of pile driving on fish*. Available at: http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf. Accessed June 2016.

Fisheries Act. (R.S.C., 1985, c.F-14). Current to March 4, 2013. Last amended on June 29, 2012. Available from: http://laws-lois.justice.gc.ca/eng/acts/F-14/. Accessed: July 2016.

Fisheries Hydroacoustic Working Group (FHWG). 2008. Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities. June 12, 2008 edition. http://www.dot.ca.gov/hq/env/bio/files/fhwgcriteria_agree.pdf.

Illinworth & Rodkin. 2007. Compendium of Pile Driving Sound Data. Prepared for the California Department of Transportation. Available at: http://www.dot.ca.gov/hq/env/bio/files/pile_driving_snd_comp9_27_07.pdf. Accessed June 2016.

National Oceanic and Atmospheric Administration (NOAA). 2016. *Marine Mammals: Interim Sound Threshold Guidance* (webpage). National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html Accessed June 2016.

National Oceanic and Atmospheric Administration (NOAA). 2015. *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts*. Available at: http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm. Accessed June 2016

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. 2007. *Marine mammal noise exposure criteria: initial scientific recommendations*. Aquatic Mammals. 33:411–521.

WSDOT (Washington State Department of Transportation). 2009. WSDOT Biological Assessment Guidance Website. NMFS calculator. Available at: http://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm#noise. Accessed June, 2016

WSDOT. 2015. Biological Assessment Preparation for Transportation Projects – Advanced Training Manual. Version 02-2015