JSS LOAD–OUT GRAVEL BED AND EAST INFILL PROJECT

VANCOUVER FRASER PORT AUTHORITY, PROJECT AND ENVIRONMENTAL REVIEW APPLICATION

SUPPLEMENTAL REPORT

JUNE 2020

Hatfield

Prepared for:

Seaspan ULC

North Vancouver, British Columbia

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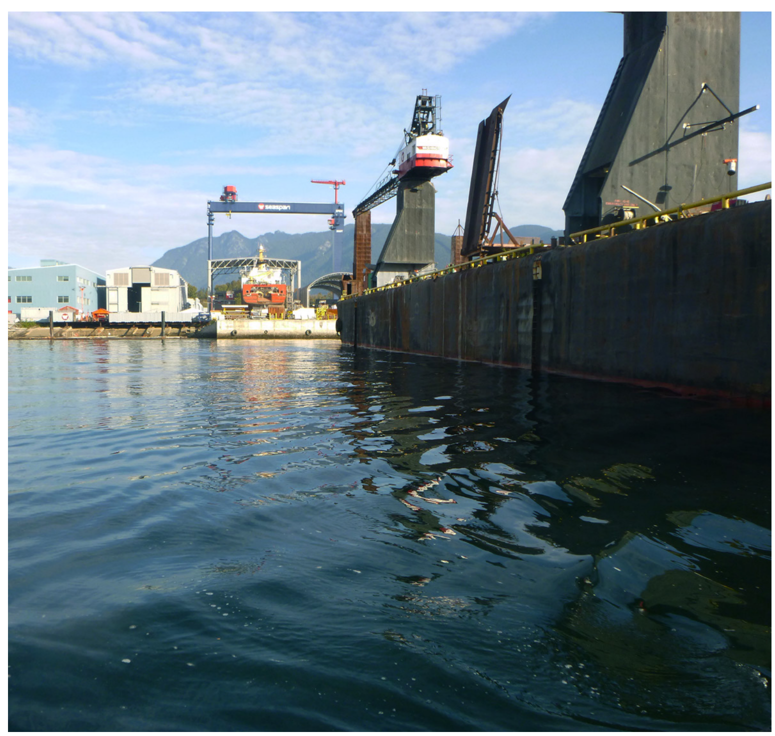

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Prepared for:

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BC	British Columbia
CCME	Canadian Council of Ministers of the Environment
CEMP	Construction Environmental Management Plan
CD	Chart Datum
ISQG	City of North Vancouver
DAS	Disposal at Sea
DFO	Fisheries and Oceans Canada
DNV	District of North Vancouver
HADD	Harmful Alteration, Disruption or Destruction (of fish habitat)
ISQG	Interim Sediment Quality Guidelines
JSS	Joint Support Ships
PAH	Polycyclic Aromatic Hydrocarbons
PEL	Probable Effects Level
PER	Project and Environmental Review
RFR	Request for Review
TSS	Total Suspended Solids
VFPA	Vancouver Fraser Port Authority

1.0 INTRODUCTION

Seaspan ULC. (Seaspan) is requesting a permit from Vancouver Fraser Port Authority (VFPA) under the Project and Environmental Review (PER) process for two upgrades at their Vancouver Shipyard (the Shipyard), at 10 Pemberton Avenue, North Vancouver, British Columbia (BC), as a result of the Joint Support Ships (JSS) program.

The upgrades comprise the construction of a gravel bed for the offloading of JSS vessels from the load-out pier (the Gravel Bed) and the infill of an area of the East Spit (the East Infill). These upgrades are collectively and henceforth referred to as the Project.

The Project is sited within the north-east corner of the Shipyard basin adjacent to the existing load-out pier (the Site).

The Gravel Bed falls within VFPA managed federal lands and waters and was the subject of a preliminary project enquiry (PER No. 17-407). The East Infill is largely outside of VFPA jurisdiction, being an area that was previously land. It is within the District of North Vancouver (DNV) jurisdiction. Only the rip-rap slope of the East Infill is within VFPA jurisdiction.

The two upgrades are in the same area of the Shipyard and the slope of the East Infill may overlap with the Gravel Bed. Therefore, the two upgrades are being engineered and will likely be constructed under the same contract.

Information relating to the East Infill is included to allow for the review of the rip-rap slope within VFPA managed federal lands and to provide context, within the PER permitting process.

Habitat offsetting (Offsetting) will be required under the *Fisheries Act.* An Offsetting plan, including engineering design have been prepared. The proposed Offsetting location is to the east of the Shipyard partly within VFPA managed federal waters. The Offsetting is expected to be constructed under the same contract and therefore, is considered part of the Project, and included in this PER application. The area of the proposed Offsetting outside of VFPA managed federal waters is within City of North Vancouver (CNV) jurisdiction.

A Site Plan (1:5000) is provided in Figure 1.

The purpose of this report is to provide:

- supplemental information that fulfills the requirements outlined in the PER checklist that are not covered within other documents;
- a review of potential environmental effects of the Project; and
- a concordance table that acts as a guide to where the PER checklist requirements are covered, and information can be found.

Figure 1 Project Overview.

Data Sources:
a) East Infill, JSS Load-out Gravel Bed, and Offsetting, Westmar, 2019.
b) Municipal Boundaries, District of North Vancouver, 1997.
c) VFPA federal waters, Port of Vancouver 2018.
d) Base image - Bing Maps

Hatfield

CEMP

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2.0 APPLICATION CONCORDANCE

The requirements defined in the PER checklist for the Gravel Bed have been copied into Table 1 for reference. The concordance of the application with these requirements is also provided.

A Construction Environmental Management Plan (CEMP) has been prepared for the Project as required under the PER checklist. The CEMP is the primary document to guide overall environmental management and protection practices to be implemented for the duration of Project construction and fulfills most of the PER requirements. The CEMP follows the VFPA PER CEMP Guidelines (VFPA 2018) and will be provided to the construction contractor as the basis for developing work plans and associated Environmental Protection Plans.

Table 1 PER requirements.

Study/Report	Requirement	Concordance
General Scope	Description of the Project, including the purpose, use, and Project rationale. Description of the Project setting, including proximity to sensitive receptors such as schools or parks. Description of potential impacts to land, water, air, land and adjacent community and businesses, as a result of the Project. List all studies that have been completed in support of the Project. Provide an updated scope of work including application methods and volume of gravel or dredge material to be installed or removed. Removal of the gravel bed should be considered as part of the scope of this Project. If the gravel bed is to remain in place permanently, provide information on maintenance of the gravel bed in consideration of habitat and aquatic life colonization (e.g., is it anticipated vessels will continue to ground on the gravel bed).	Section 3.0 of this supplementary information report.
Operations	Description of the hours of operation of the terminal, both current and proposed, and any changes to employment expected. Description of any potential environmental and community impacts and proposed mitigation strategies.	Terminal operations, including hours and employment, will not change due to the Project.
Construction and/ or Demolition	Proposed construction period (start and finish), hours, and method of construction and/ demolition. Describe any anticipated need for off-hours construction activities. Description of construction staging activities (on and offsite).	Section 3.0 of this supplementary information report, with further detail in Section 2.6 of the CEMP.
Location and Site Plans	Plan showing the relationship of the Project to surrounding area at a 1:5000 scale. Lease and property boundaries, easements and rights-of-way. Legal high-water mark where applicable. Location and dimensions of all existing and proposed buildings, structures, equipment, and marine structures. Access points including roadways, driveways, parking areas, walkways, berths, gangways, docks. Area of demolition or construction staging/laydown area.	Figure 1 and Engineering Drawings – Appendix A1.

Table 1 (Cont'd.)

Study/Report	Requirement	Concordance
Marine Structures	Site plan specific to proposed marine works only. Identify existing marine structures and those intended to be removed, relocated or will be impacted (e.g., stormwater outfall impacted by rip-rap placement). Dimensions, and cross-sections of front, rear and two sides of proposed marine structures including dolphins, piles, docks, piers, gangways, floats, fenders, bollards, rip rap, navigational lighting, navigation aids, ranges, dredging channels, dams, and areas to be filled, etc. Dimensions and characteristics of proposed materials. Structures in relation to the tidal Higher High Water and Lower Low Water lines including water depth. Plan of proposed dock facility to include location of mooring securing points. Confirm the design vessel (maximum size that can be accommodated) at the berths on the plans.	Engineering Drawings – Appendix A1.
Geotechnical Report	Description of site seismic and geologic hazards. Description of construction measures, precautions and corrective actions recommended for preventing structural damage and reducing the risk of terrestrial, marine and riparian geotechnical hazards to acceptable levels.	Geotechnical Technical Memo – Appendix A2.
Traffic Impact Study	An assessment of current site traffic as well as truck and/ rail traffic volumes anticipated, on-site circulation, traffic distribution throughout the day and impacts to adjacent and nearby roads, access/egress and storage analysis for vehicles and/rail cars accessing site as well as parking requirements. Include proposed hours of operation and staffing number and dimensioned site plan, showing circulation, buildings, new line painting, proposed rail tracks and any other proposed features.	Section 5.4 of this supplementary information report.
Dredging	Diagram of the proposed dredge area and Sediment Analysis. Description of the proposed dredge volume, method, and anticipated disposal method. Timing of proposed dredging in relation to the fisheries sensitive periods. Anticipated timeframe for the duration of works and hours of operation expected for the equipment. Mitigation measures proposed to reduce induced turbidity.	Dredging is not required for the Project.
Construction Environmental Management Plan (CEMP)	Description of how the Site will be managed during construction that does not result in adverse impacts to the environment, heritage resources, public (municipal, stakeholders, community), Indigenous groups and includes potential effects from limiting noise, vibration, light, dust emissions, and odour.	The CEMP submitted as part of this application.
Soil Management Plan	Outline how the proponent will test for, appropriately handle, limit migration/run-off and dispose of contaminated soils. Required when dealing with properties with known or suspected contamination in the soil.	Section 4.5 of the CEMP.
Biophysical Survey Report	An assessment of species and habitats that will be affected by Project activities such as infilling, vegetation removal, or shoreline modification. For further information, please review the VFPA Habitat Assessment Guidelines.	Habitat Assessment Report – Appendix A3.

Table 1 (Cont'd.)

Study/Report	Requirement	Concordance
Species-at-Risk Assessment	Identification of all federal and provincial listed species-at-risk associated with the proposed Project. Include a description of potential impacts and proposed mitigation strategies.	Habitat Assessment Report – Appendix A3.
Spill Prevention and Emergency Response Plan (on land and water)	Emergency Response Plan as it relates to reportable spills. Inventory of hazardous materials anticipated to be handled or stored on-site during normal operations. A description of spill prevention, containment and clean-up plan for hydrocarbon products (including fuel, oil and hydraulic fluid) and any other deleterious substances using standards, practices, methods and procedures to a good commercial standard, conforming to applicable laws. Description of proposed employee training, emergency response communication plan, emergency procedures, spill tracking and reporting, records of facilities inspections. Reference to appropriate spill containment and clean-up supplies available on-site at all times and that all personnel working on the Project are familiar with the spill prevention, containment and clean-up plan. May be provided as a component of the CEMP.	Section 7.3 of the CEMP.
Port Community Liaison Committees	The proposed Project will require a presentation to the following Port Community Liaison Committees: ▪ North Shore Waterfront Liaison Committee Submit draft presentation materials (i.e., presentation, brochures).	Presentation timing and materials to be agreed between Seaspan and VFPA
Existing Contamination	The proposed Project would potentially disturb and/or bury (cap) existing contaminated surficial and deeper sediment in the channel. ▪ Provide a memorandum describing the potential risks and benefits associated with burial of these contaminated sediment for consideration as part of the review.	Section 5.3 of this supplementary information report
Fisheries and Oceans Canada (DFO) Review and Offsetting	The Applicant shall review DFO's Projects Near Water website. ▪ As the proposed Project involves the permanent loss of habitat below the High-Water-Mark, VFPA requires a copy of the submitted DFO Request for Review. ▪ When issued, provide VFPA with a copy of the *Fisheries Act* authorization or Letter of Advice from DFO. ▪ If offsetting is required or anticipated, VFPA requires a conceptual plan prior to completing the Project and Environmental Review (PER). Note that any works associated with offsetting in VFPA jurisdiction will need to be included in the scope of the proposed Project and reviewed as part of the PER.	*Fisheries Act* Authorization Application – Appendix A4.
Hydraulic Impact Assessment	Provide a Hydraulic Impact Assessment that will assess effects of the gravel bed infill in relation to marine currents, silting, the accumulation of material, or other factors that may reduce the depth of the waters of the Port.	Section 5.5 of this supplementary information report.

3.0 PROJECT OVERVIEW

Seaspan has been competitively selected as the non-combat shipbuilder for the Government of Canada under the National Shipbuilding Strategy. The Government of Canada and Seaspan have entered into a long-term strategic relationship to build vessels for the Canadian Coast Guard and the Royal Canadian Navy.

Seaspan plans to undertake two upgrades to the Shipyard in support of this program. These upgrades are both planned for the eastern area of the Shipyard in proximity and are therefore covered by a single PER application.

In the Functional Design Phase, Seaspan retained Grand Marine Ltd. to investigate safe methods of launching JSS vessels from the load-out pier, that was constructed in 2014. The extensive launch study determined only one practical low-risk option; to launch the vessels using the dry-dock Seaspan Careen (Careen) grounded on a submarine gravel bed to ground during vessel launch operations. In the summer of 2019, the Project was temporarily put on hold, while Seaspan again reviewed the options for launching the vessels. This additional study confirmed the complexity of launching vessels at the Shipyard because of shallow water within the basin and that the alternatives to the gravel bed were very limited. The only other option that Seaspan identified that warranted more detailed review was dredging to provide sufficient water depth for the Careen to float throughout launching. However, through further engineering review it was determined that even with dredging there would still be unacceptable risk during some tidal conditions, due to the pumping capacity of the Careen to control ballast and therefore stability.

Seaspan met with the VFPA in early 2018 to advise of their intent to construct the gravel bed in support of the JSS.

Construction of the Gravel Bed will reduce access to the eastern basin and require changes to Seaspan's operations. Seaspan also has insufficient storage space and laydown area within the Shipyard. Therefore, it is proposed that the east basin be infilled to return the East Spit to its original configuration. This upgrade is named East Infill.

From an administrative and funding perspective these two upgrades are managed separately within Seaspan. However, they are in the same area of the Shipyard, have overlapping footprints and similar construction methods and therefore potential environmental effects. As a result, they will likely be constructed under the same construction contract.

The Gravel Bed will be approximately 7,500 m^2 in size. The bed will be -1 m Chart Datum (CD) to allow the Careen to be level with the load-out pier when grounded. The estimated volume of gravel fill is 24,000 m^3. Angular gravel of 25 to 50 mm mesh (1 to 2-inch mesh), is proposed. Slopes of the Gravel Bed will be lined with larger grade rock (large cobble – 260 mm minus filter stone) to protect against propeller wash. A total of approximately 3,000 m^3 of rock will be required.

The Gravel Bed is required for a minimum of 5 to 10 years for the JSS program. The Gravel Bed may be used at other times and may either be removed or remain in place once the JSS program is complete depending on ongoing shipbuilding activities at Seaspan at that time. The following specific requirements have already been defined for its use:

- Test fit Careen grounded for 5 to 7 days in 2021 or 2022.
- JSS 1 launch Careen grounded for approximately 7 days in 2022.
- JSS 2 launch Careen grounded for approximately 7 days in 2023.
- Polar Ice Breaker launch and associated Careen grounding yet to be scheduled.

The Careen will be grounded intermittently while the Gravel Bed will be exposed for most of the time.

The East Infill will be filled to the existing grade of the East Spit at 6.65 m above CD and be paved. Permanent buildings are not planned for this area. The footprint of the East Infill is approximately 8,400 m^2, of which only the lower 20 m or approximately 1,500 m^2 of the rip-rap slope falls within VFPA managed federal lands.

The first stage of the East Infill will be the construction of the berm to allow for the infill. The berm will be protected by rip-rap. The basin will then be filled with sand and gravel. There may be a requirement for ground improvements, for example the installation of stone columns or densification or removal of a layer of soft sediment. Ground improvements will occur after berm construction and therefore will be isolated from marine waters and will be outside of VFPA managed federal lands.

Hours of construction are expected to be restricted to 7 am to 8 pm Monday to Saturday as per VFPA standard work hours and the DNV Noise Restriction Bylaw (DNV 2000). This is discussed further in the CEMP (Section 4.4).

4.0 HABITAT OFFSETTING

As per the Letter of Advice from DFO (see Appendix A5), a *Fisheries Act* Authorization and Offsetting are required. An Offsetting plan has been prepared as part of the *Fisheries Act* Authorization application (see Appendix A4). Following a detailed review of offsetting options, a location on the eastern shoreline of the East Spit is proposed for Offsetting. The Offsetting design is provided in the Engineering Drawings in Appendix A1. The Offsetting involves enhancement of an area of approximately 7,000 m^2 of intertidal, and subtidal habitat, primarily to support juvenile salmon. The subtidal components of the Offsetting fall within VFPA managed federal waters. The intertidal area is within CNV jurisdiction..

The Offsetting involves the regrading of an area of the shoreline of the East Spit. The Offsetting design stretches from the high-water mark (approximately 5 m CD) to the subtidal basin (-4 m CD). The aim of the Offsetting is to naturalize the shoreline and to increase kelp and other marine vegetation abundance and spatial coverage, as fish habitat, with a focus on juvenile salmon. The design follows Green Shores principles that encourage the replacement of hard or armoured shores in favour of nature-based sustainable development of shoreline ecosystems.

Within the VFPA managed federal waters (subtidal), a rock sill will be constructed. Fill material will be placed behind the sill to create a continuous gradual slope between approximately 0 to -3 m CD over a distance of 25 m. Cobbles and small boulders will be placed on the surface to facilitate kelp recruitment. Large rock will also be placed seaward of the berm, creating a continuous subtidal rock sill ranging from -2 m to -4 m CD.

Within CNV jurisdiction, the beach will be elevated using sand and gravel that will stretch from 1.5 to 4 m CD. A rock sill will be constructed to protect the beach, using the existing large intertidal boulders, with additional rock used to supplement as required. Boulder clusters will be placed within the planned sandy beach to increase the stability of the beach and provide hard substrate for marine vegetation growth. Stepped habitat benches are proposed for the transition between the riparian and beach to provide additional vegetation, including salt marsh species.

The Offsetting is described in detail in the *Fisheries Act* Authorization application, including the offsetting objectives, habitat equivalency, uncertainties, and monitoring, as per DFO's guidance (DFO 2019a).

The construction methods for the Offsetting are very similar to those for the Gravel Bed and East Infill and therefore it is planned to be under the same construction contract. As such, the CEMP scope includes the Offsetting.

As described in the *Fisheries Act* Authorization application, , the Project was redesigned following the Habitat Assessment (Hatfield 2018) to reduce the, already small, area of moderate habitat affected and in turn reduce the Offsetting required.

5.0 POTENTIAL ENVIRONMENTAL EFFECTS

To support the preparation of the CEMP and specifically, to determine mitigation and monitoring requirements, potential environmental effects of the Project were assessed.

Construction will be marine-based and therefore the potential effects primarily relate to:

- Fish and fish habitat; and
- Marine mammals.

In addition, the following issues were specifically raised in the PER checklist:

- Contamination;
- Traffic impact; and
- Hydraulic impacts.

5.1 FISH AND FISH HABITAT

Potential effects to fish and fish habitat include:

- Increased turbidity and reduced water quality through sediment resuspension;
- Burial or isolation of marine fauna;
- Alteration and destruction of habitat; and/or
- Scour and direct effects on fish during ballasting.

5.1.1 Turbidity and Water Quality

Dredging is not required. There is potential for minor sediment resuspension during excavation and rock placement. Mitigation measures are included within the CEMP to manage suspended sediment to avoid exceedances of Council of Canadian Ministers of the Environment (CCME) Water Quality Guidelines for Total Suspended Solids (TSS) and turbidity outside of the immediate work area (within 30 m of construction activity). There are also commitments to environmental monitoring and adaptive management if turbidity levels exceed the criteria defined in the CEMP.

5.1.2 Burial or Isolation of Marine Fauna

There is potential for burial of marine fauna when the Gravel Bed is constructed and during the infill of the basin on the East Spit.

Sessile organisms would be buried. However, as per the Habitat Assessment (Appendix A3), the abundance of benthic species is low. Areas of moderate habitat that supports species such as sea stars has also largely been avoided.

The East Infill will be isolated from Burrard Inlet by the constructed berm during infilling and therefore there is potential for motile species to be trapped. The Gravel Bed will not be isolated and therefore motile species will be able to move from the Gravel Bed area during gravel placement. A crab salvage is proposed prior to construction, as per the CEMP, to reduce the likelihood of burial. In addition, during and after construction of the berm the East Infill will be monitored and a fish salvage completed, if fish have been isolated by its construction.

5.1.3 Alteration and Destruction of Habitat

The Habitat Assessment (Hatfield, 2018), which was based on a literature review and underwater video survey, found that the majority of the habitat was low value comprising predominantly sand substrate with some gravel and silt fractions. There were some small areas of moderate value habitat identified consisting of rip-rap, supporting macroalgae and a range of fish species.

A Request for Review (RFR) was submitted to DFO in late 2018. The corresponding Letter of Advice (see Appendix A5) explained that DFO determined that there would be Serious Harm to fish habitat requiring an authorization and Offsetting for the Project. In August 2019, the revised *Fisheries Act* came into force that reverted from Serious Harm back to Harmful, Alteration, Disruption or Destruction (HADD) of fish habitat and death of fish.

Since the time of the RFR, the footprint of the Project has also been reduced and steps have been taken to avoid the moderate value rip-rap habitat.

The footprint of the upgrades within VFPA jurisdiction is approximately 9,000 m^2. This is all permanent alteration rather than destruction of habitat and based on the Habitat Assessment (Hatfield 2018) and the designs of the upgrades, overall habitat value within VFPA jurisdiction is expected to increase due to the larger area of hard substrate available and the increase in refuge habitat through the placement of rock. However, Offsetting is required for the permanent alteration within the area of gravel placement that makes up approximately 5,000 m^2 of the Gravel Bed footprint.

There is destruction of fish habitat outside of VFPA jurisdiction.

HADD of fish habitat is not expected outside of the footprint of the Gravel Bed and East Infill.

Offsetting is discussed further in Section 4.0 and the HADD and Offsetting are described in detail in the *Fisheries Act* Authorization application (Appendix A4) that was submitted to DFO.

5.1.4 Ballasting

Ballast water discharge and intake will be required on the Careen throughout the loadout process. There are four intakes on the Careen that are currently situated on the bottom of the vessel. Two options are under consideration to allow for ballasting while the Careen is on or over the Gravel Bed. Option 1 involves adapting the Careen so that the intakes are on the sides of the vessel. This will allow the Careen to sit on the bed and discharge. Option 2 involves the placement of two concrete channels within the Gravel Bed that will allow for intake and discharge. These channels are shown in the Drawing in Appendix A1.

Although these two options will result in slightly different depths for intake and discharge, the potential effects are broadly the same. Both intake and discharge will result in strong localized currents. These have been factored into the design and these locations will be protected by rip-rap to avoid scour. Given the height of the discharge and intake above the seabed there is not expected to be scour beyond the Gravel Bed where the soft sediments remain exposed.

Intakes will be screened as per the related DFO Code of Practice (DFO 2019b) to avoid death of fish.

5.2 MARINE MAMMALS

There is no pile driving or blasting required and therefore underwater noise levels will be below auditory thresholds for marine mammals and no exclusion zone will be required. Mitigation measures are provided in the CEMP.

5.3 EXISTING CONTAMINATION

Sediment characterization within the basin has taken place over many years. Sediment sampling was also undertaken as part of the Project. Eleven samples were collected in total, seven of which were within VFPA jurisdiction, on October 18, 2018. This builds upon historic sediment chemistry data collected at the Site between 1990 and 2011.

Sediment samples were collected from the seabed for chemical analysis to better understand potential contamination in the surface layer. The results were compared to the CCME guidelines for Sediment Quality for the Protection of Aquatic Life, Marine, Interim Sediment Quality Guidelines (ISQG) and Probable Effects Level (PEL) and the Disposal at Sea (DAS) Regulations criteria. The sample concentrations at two locations within VFPA jurisdiction exceeded the DAS criteria for total PAH (Polycyclic Aromatic Hydrocarbons) and cadmium. All other DAS criteria were met. The CCME PEL was exceeded for arsenic at locations within VFPA jurisdiction and zinc at one location. All other sample results were within the PEL at these sample locations. The ISQG for arsenic, cadmium, copper, zinc, and a number of individual PAHs were exceeded at multiple sampling locations within VFPA jurisdiction.

Further information, including all sampling results is provided in Section 6.8 of the Habitat Assessment (Appendix A3).

There is no dredging required and therefore no management of contaminated soils or sediments. There is also no requirement to manage potentially contaminated groundwater. The potential for resuspension of sediments is low. Gravel will be placed and effectively cap any sediments within the footprint of the JSS Gravel Load-Out Bed. The area within the East Infill will also effectively be capped during the infill but this is outside of VFPA jurisdiction.

Mitigations are included within the CEMP to minimize and manage the resuspension of sediments during construction and monitoring requirements for turbidity are stipulated.

5.4 TRAFFIC IMPACT STUDY

The Project work will be constructed using marine-based equipment. The equipment will be mobilized by the marine contractor and arrive by sea. There will be no land-based equipment requiring trucking for the Gravel Bed.

The only land-based construction activity expected is the finishing of the East Infill, which will include drainage, paving and riparian planting all outside of VFPA jurisdiction.

As a result, the number of trucks or other vehicles required will be very small and insignificant in terms of Seaspan's general operations. There are no plans for additional controls for traffic and a traffic impact study is not required. Mitigations relating to traffic are provided in the CEMP.

5.5 HYDRAULIC IMPACT ASSESSMENT

No impacts to marine currents, silting, the accumulation of material, or other factors that may reduce the depth of the waters of Burrard Inlet are expected. Locally, the marine currents may be affected by the East Infill and the JSS Gravel Load-Out Bed. The East Infill will reduce the tidal volume of the Shipyard basin and therefore may slightly reduce the tidal currents locally. By decreasing the depth of water, the JSS Gravel Load-Out Bed may increase currents locally over the gravel bed. The gravel has been sized to remain stable under these potential tidal currents The Gravel Bed will also be protected by rip-rap around the perimeter. Tidal currents beyond the Gravel Bed are not expected to change and therefore a more detailed analysis (e.g., marine modelling), is not necessary.

The largest currents within the Shipyard basin are produced by propeller wash, which has been observed to resuspend seabed sediments (Hatfield *pers. observation*). There will be reduction in vessel activity in the area due to removal of the floating repair facility and the access restriction due to the Gravel Bed, but this is not expected to have any effect on sediment accumulation within the Shipyard basin.

The Gravel Bed and the East Infill have been designed to avoid pooling or channeling of water that could increase scour or deposition of sediment locally. Any areas where this could take place are within the footprint of the Gravel Bed or East Infill slope and therefore are protected by rip-rap.

Since MacKay Creek was diverted out of the East Basin there are no sources of sediment into the Shipyard basin that could lead to the accumulation of sediment.

The Shipyard basin is well protected from waves and only experiences vessel wake. There will be no change in the wave climate that could result in the accumulation of sediment or erosion of the seabed.

5.6 NAVIGATION AND MARINE USE

There is no marine use or navigation within the Shipyard basin other than Seaspan operations and therefore no potential interference with navigation under the *Canadian Navigable Waters Act* due to the Gravel Bed or East Infill. The Offsetting location is outside of Seaspan's leased water lot. There are several mooring buoys in the area that are used for temporary mooring of barges. One of these is owned and operated by Seaspan and the others are owned by the Council of Marine Carriers and can be rented for short periods of time. The closest buoy is approximately 250 m from the proposed Offsetting location. Seaspan is the primary user of the mooring buoy and does not have concerns about the Offsetting interfering with navigation. The Offsetting is subtidal and the berm will be approximately -1 m CD. It is close to the shoreline and there is no reason for vessels to transit through this area. No traditional or current marine use by Indigenous groups at the Offsetting location has been identified that would be affected by the Offsetting.

Following the PER process, which will consider navigation and marine use, Seaspan will submit a Notice of Works to Transport Canada for review under the *Canadian Navigable Waters Act.* The Project is not expected to require an approval.

6.0 REFERENCES

DFO. 2019a. Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the Fisheries Act. Fish and Fish Habitat Protection Program Fisheries and Oceans Canada Ottawa (Ontario). November 2019.

DFO. 2019b. Interim code of practice: End-of-pipe fish protection screens for small water intakes in freshwater. Fisheries and Oceans Canada. Modified August 28, 2019. https://www.dfo-mpo.gc.ca/pnw-ppe/codes/screen-ecran-eng.html.

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Westmar. 2019. Boat Basin North East Infill and JSS Load-Out – Seismic Considerations. Technical Memo Ref: 1190039-00-MEM-001_R2. Westmar Advisors. October 22, 2019.

APPENDICES

Appendix A1

Engineering Drawings

SEASPAN VANCOUVER SHIPYARD WATERFRONT INFILL PROJECT

DRAWING LIST

DRAWING NO.	DESCRIPTION
1190039-00-0100	COVER SHEET AND DRAWING LIST
1190039-00-0102	EXISTING SITE PLAN
1190039-00-0103	DEMOLITION PLAN
1190039-00-0104	GENERAL ARRANGEMENT – NORTH EAST INFILL
1190039-00-0105	GENERAL ARRANGEMENT – JSS LOAD OUT BED
1190039-00-0110	SECTIONS – SHEET 1
1190039-00-0111	SECTIONS – SHEET 2
1190039-00-0115	HABITAT COMPENSATION

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Last Saved: Dec. 13/19 2:26pm Plotted: Dec. 13/19

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D
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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

MGR

CLIENT: seaspan

PROJECT: SEASPAN VANCOUVER SHIPYARD WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE: COVER SHEET AND DRAWING LIST

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
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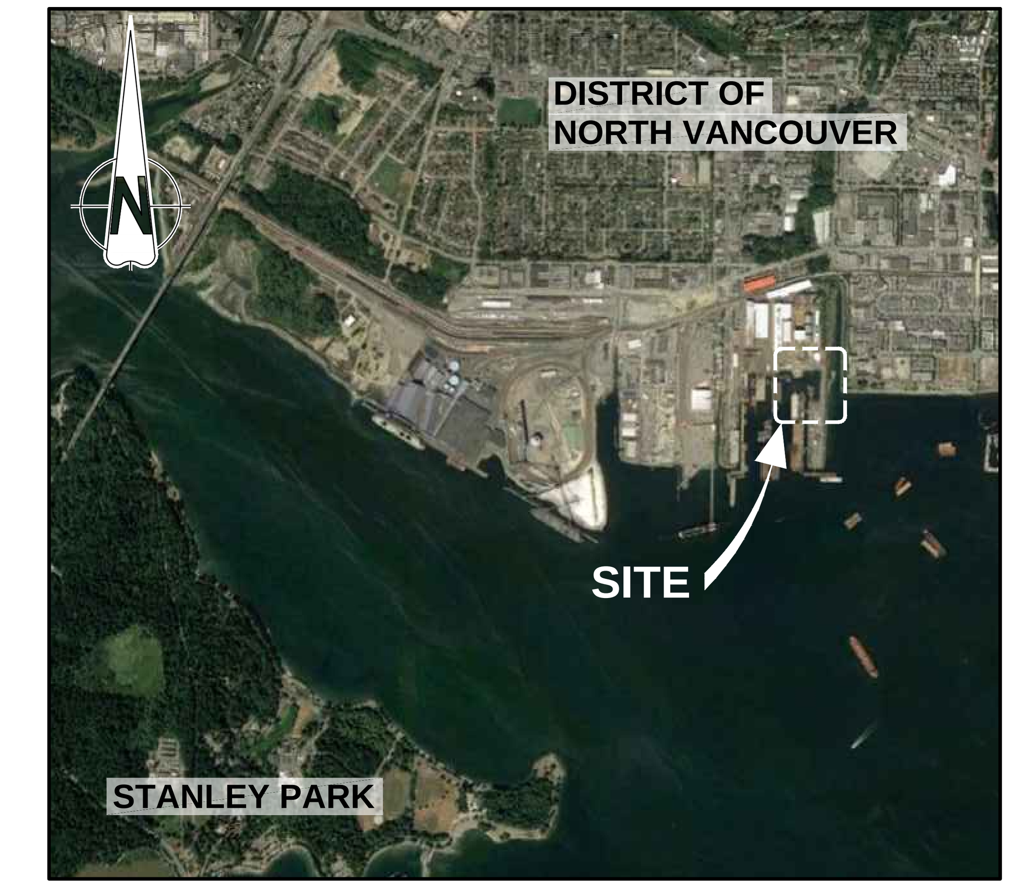
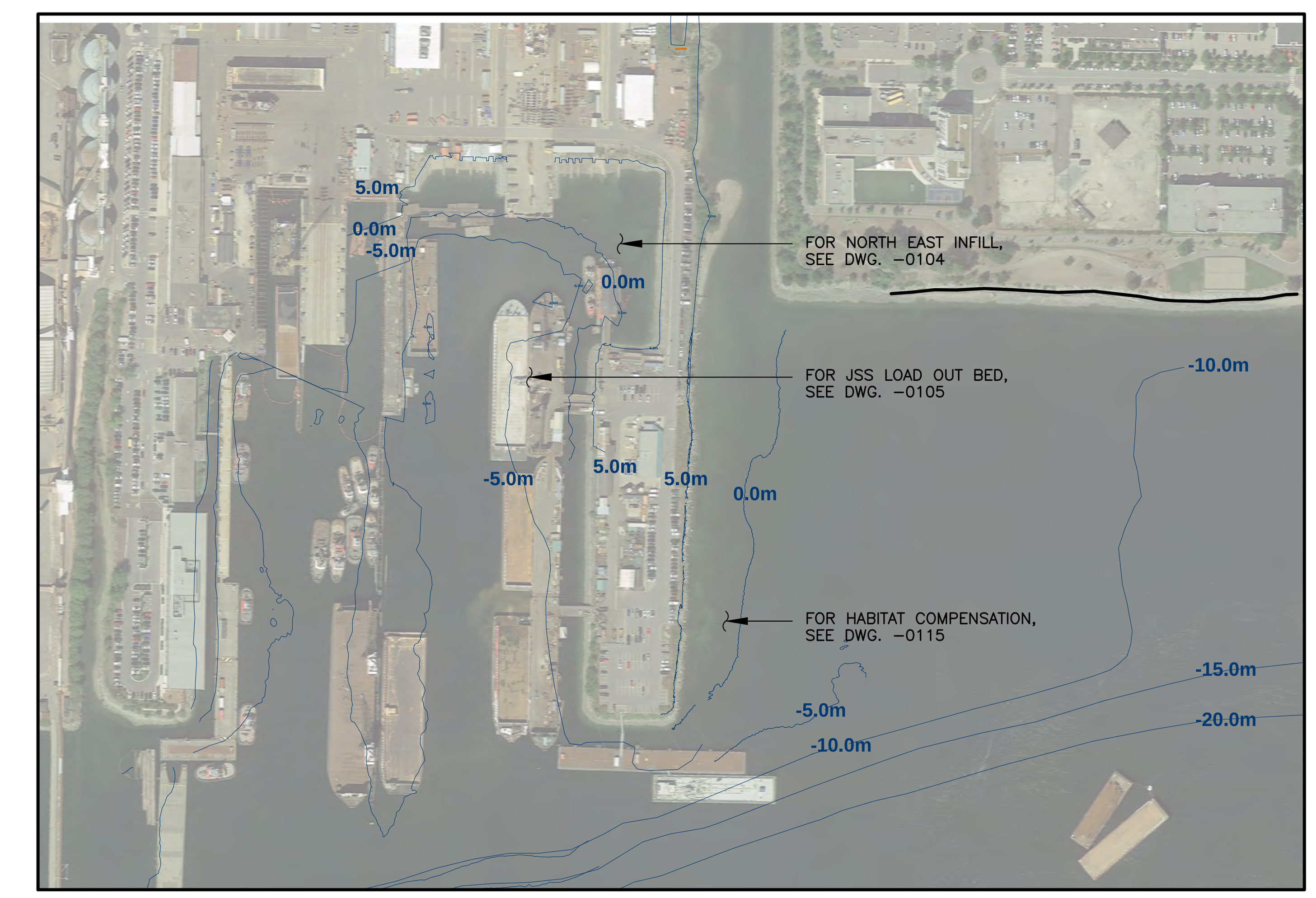


0 KM 1.0 KM

KEY PLAN



LOCATION PLAN
1:4000

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1:750

NOTES:

1. ALL ELEVATIONS ARE TO CHART DATUM.
2. BASE PLAN IS DERIVED FROM VPC-33 DATED APRIL 17, 1991 AND VPD_02305-1-5_R7.
3. CONTRACTOR TO FIELD VERIFY SITE INFORMATION PRIOR TO CONSTRUCTION.

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Last Saved: Dec. 13/19 2:48pm Plotted: Dec. 13/19

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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

MGR

CLIENT
seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
EXISTING SITE PLAN

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
SHOWN	1190039	00-0102	P3

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Last Saved: Jun. 17/20 8:37am Plotted: Jun. 17/20

DEMOLITION PLAN
1:750

0 KM 1.0 KM

KEY PLAN

m 0 10 20 30 40 m
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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

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CLIENT
seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
DEMOLITION PLAN

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
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PLAN – NORTH EAST INFILL
1:500

m 0 5 10 15 20 25 m
1:500

NOTES:

1. ALL ELEVATIONS ARE TO CHART DATUM.

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D
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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

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seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
GENERAL ARRANGEMENT
NORTH EAST INFILL

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
SHOWN	1190039	00–0104	P3

PLAN – JSS LOAD OUT BED

1:500

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1:500

NOTES:

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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

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CLIENT

seaspan

PROJECT

SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE

GENERAL ARRANGEMENT
JSS LOAD OUT BED

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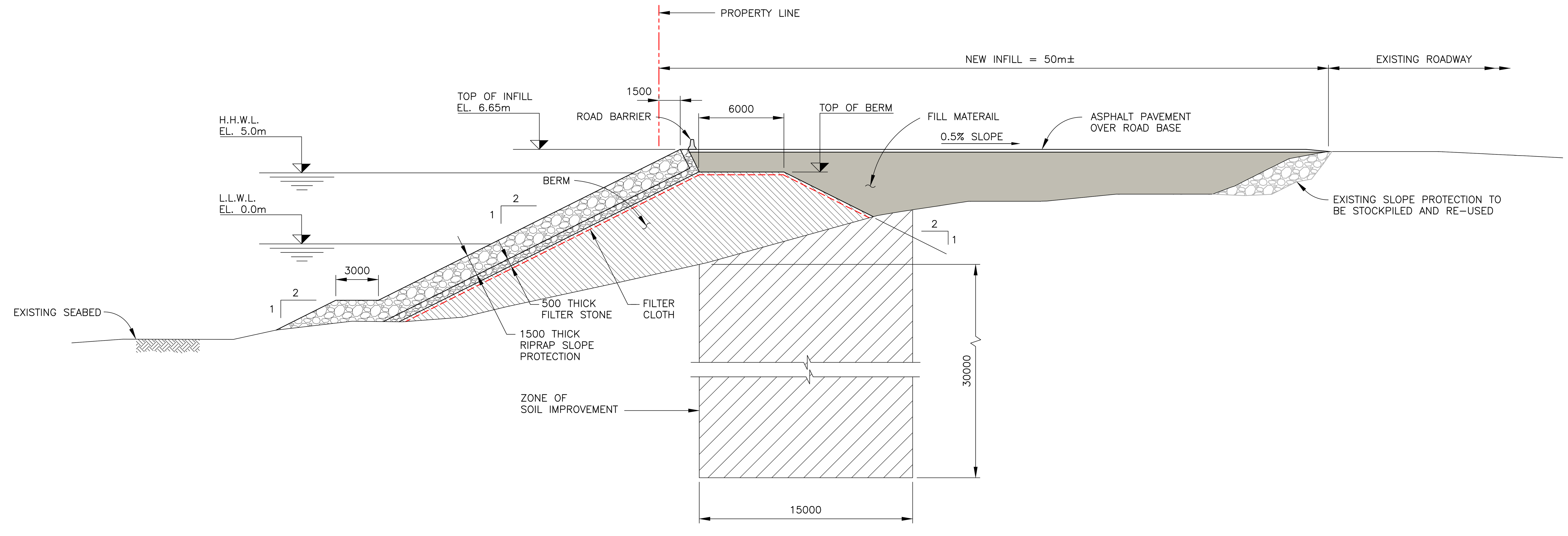

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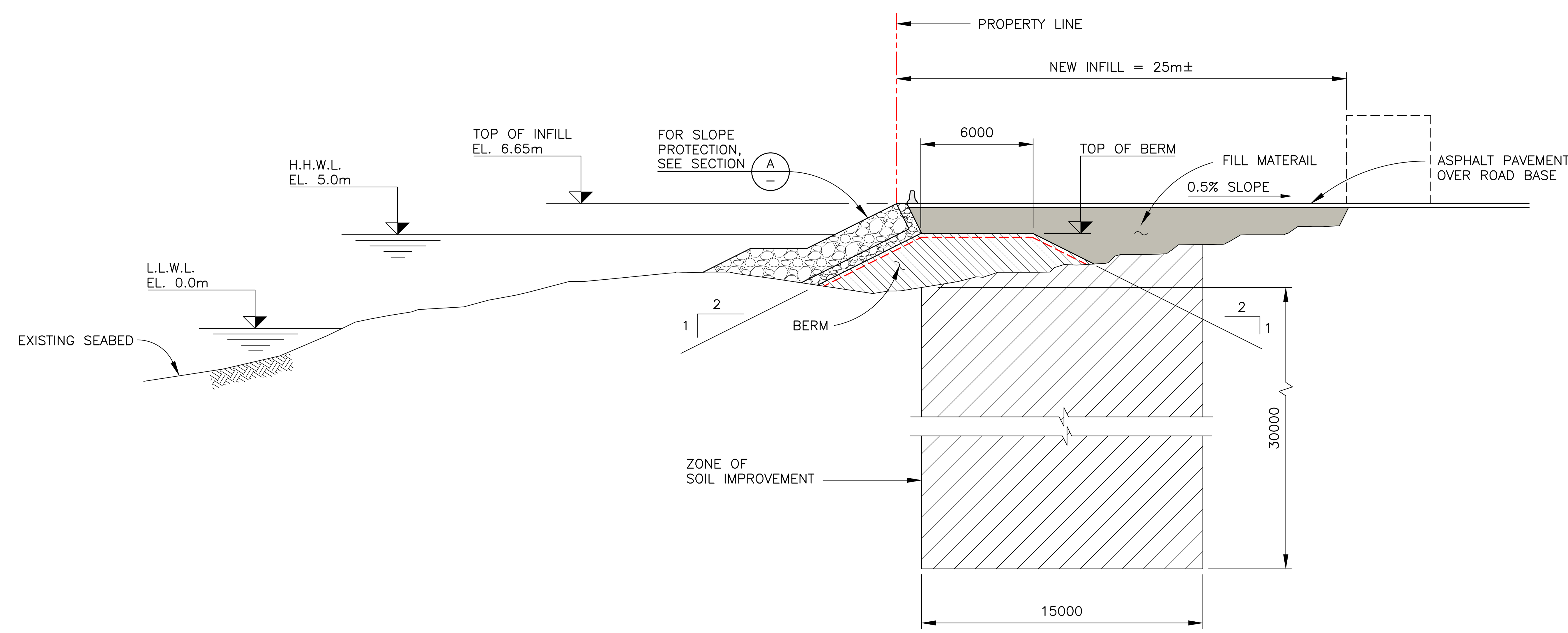
1:200
0104



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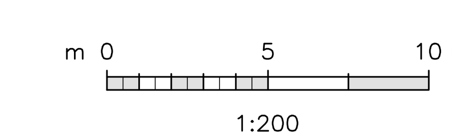

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No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

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CLIENT
seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
SECTIONS
SHEET 1

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
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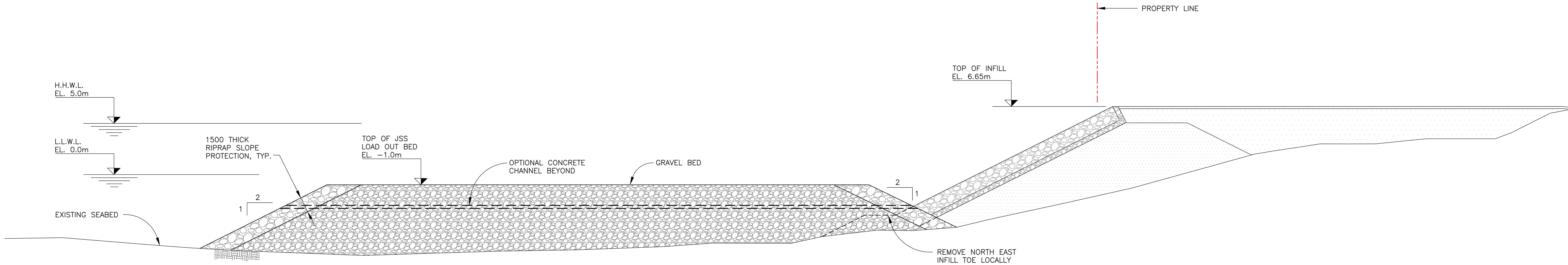

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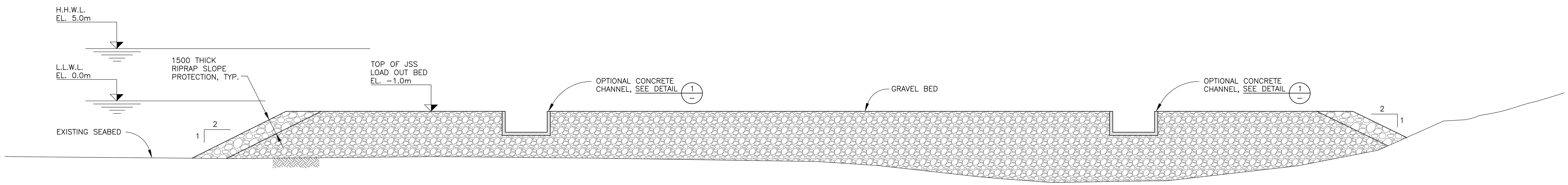

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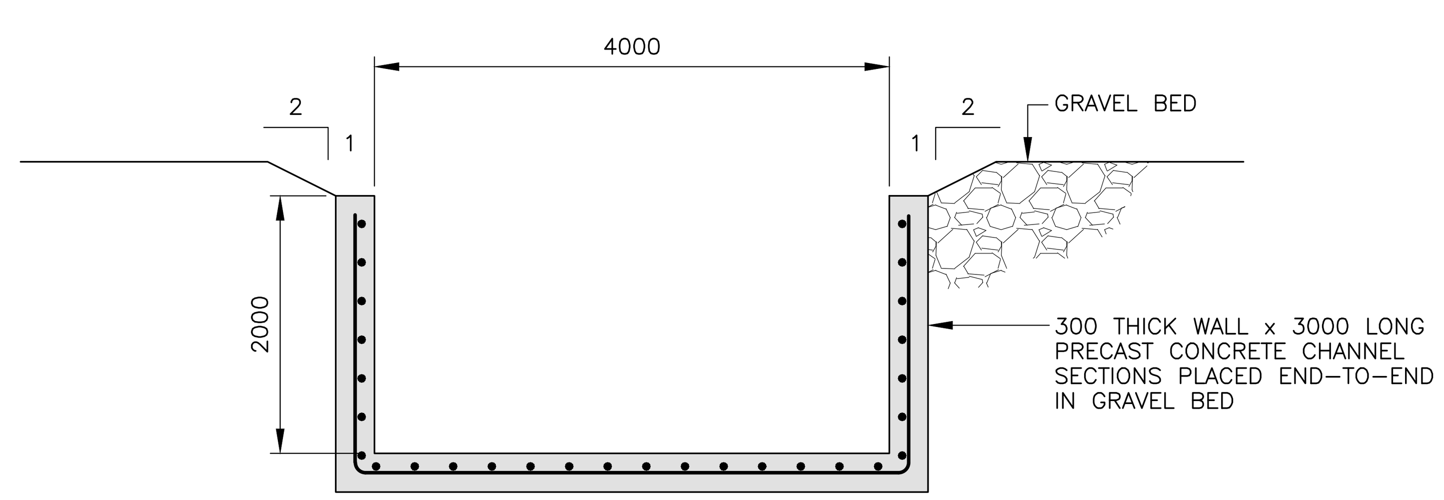

DETAIL 1
1:50 –

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1:200

NOTES:

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P2	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P1	MAY02/19	ISSUED FOR CLIENT REVIEW	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

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seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
SECTIONS
SHEET 2

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
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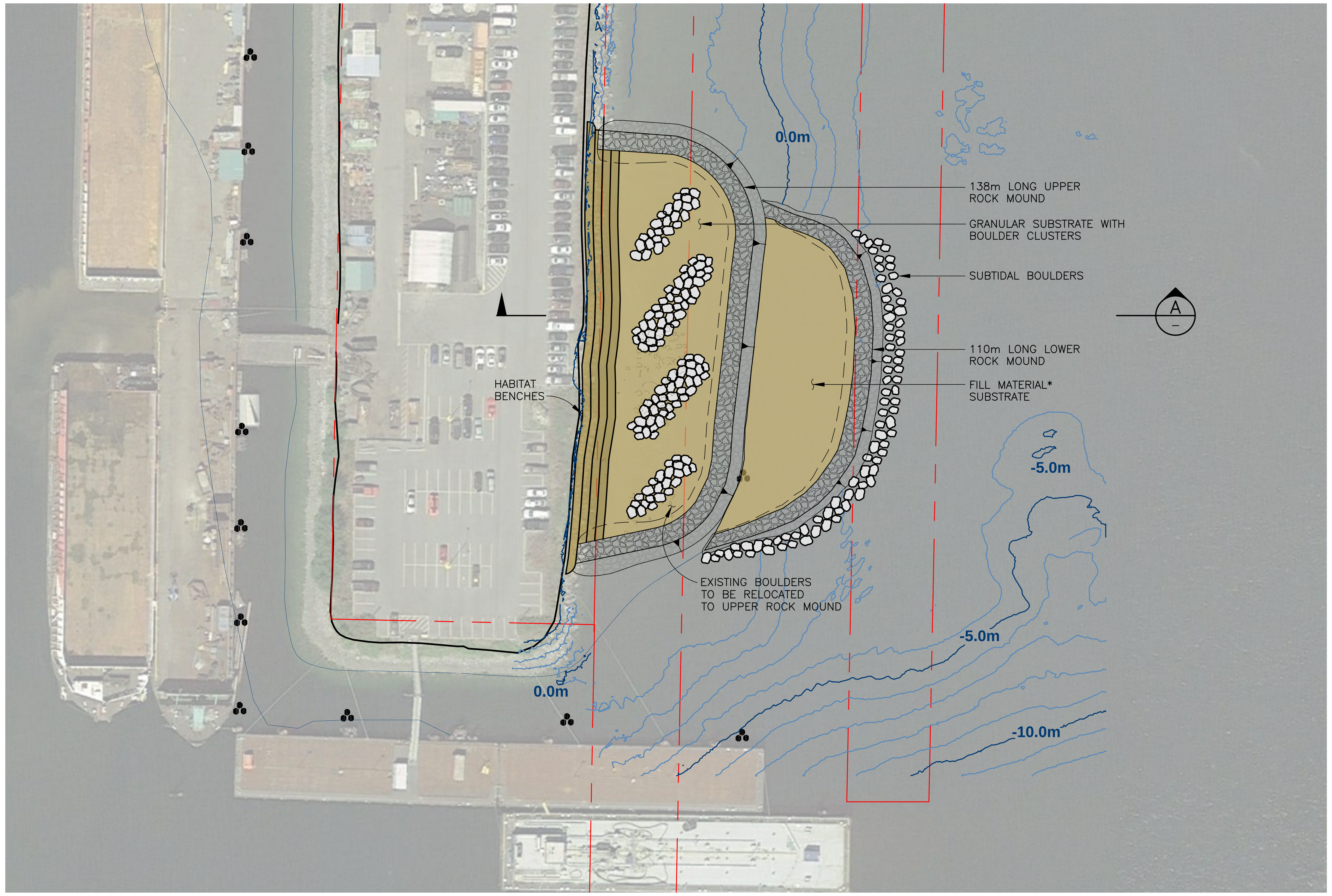
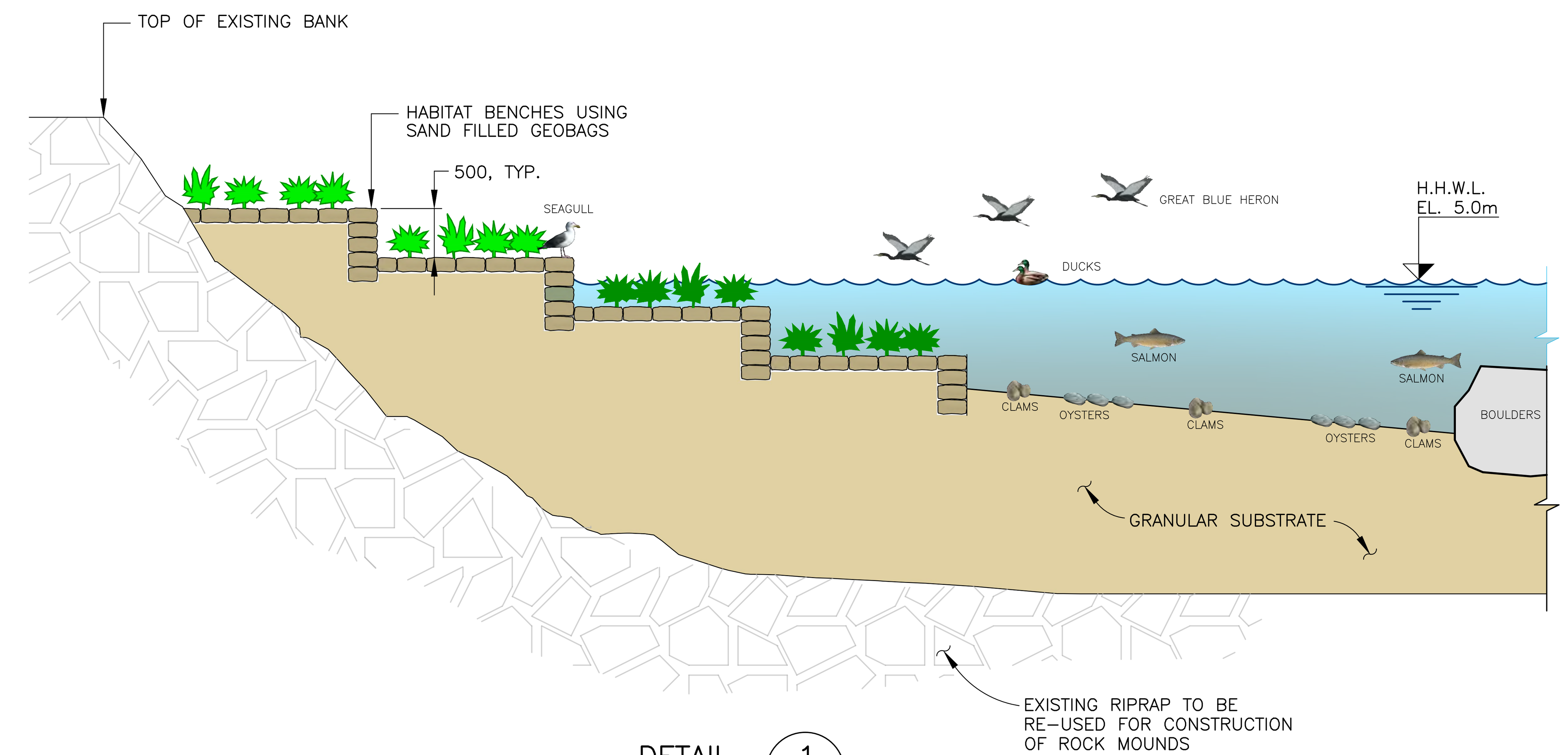


PLAN – HABITAT COMPENSATION
1:750
* FILL MATERIAL TO CONSIST OF COBBLES ON SURFACE. DETAILED GRADATION TO BE DETERMINED.



DETAIL 1
1:50

SECTION A
1:150

NOTES:

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Filename: G:\Jarelco Engineering\Westmar\2019\1190039-Seaspan\1190039-00-0115.dwg – 0115
Last Saved: May. 06/20 8:00pm Plotted: May. 6/20

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D
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P8	MAY05/20	ISSUED FOR CLIENT REVIEW	RM	–	VR	SW	DEL
P7	MAR27/20	ISSUED FOR CLIENT REVIEW	RM	–	VR	SW	DEL
P6	MAR26/20	ISSUED FOR CLIENT REVIEW	RM	–	VR	SW	DEL
P5	DEC16/19	ISSUED FOR PERMITTING	RM	–	VR	SW	DEL
P4	DEC02/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL
P3	JUN26/19	ISSUED FOR CLIENT REVIEW	RM	–	VR	DEL	DEL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

PRELIMINARY
DO NOT USE FOR CONSTRUCTION
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seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT

WESTMAR ADVISORS

TITLE
HABITAT COMPENSATION

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
SHOWN	1190039	00-0115	P9

Appendix A2

Geotechnical Technical Memo

WESTMAR ADVISORS

December 13, 2019

Project No.: 1190039
1190039-00-MEM-001_R3

Seaspan ULC
10 Pemberton Avenue,
North Vancouver BC V7P 2R1

Attention: George Geatros, Manager – Special Projects

Reference: Boat Basin North East Infill and JSS Load-Out – Seismic Considerations

Introduction

Seaspan ULC (Seaspan) is in the process of developing permit applications for the boat basin north east infill and the JSS load-out gravel bed projects. This memorandum describes the expected performance of the proposed infill and gravel bed under various levels of seismic events and recommendations on ground improvement to improve seismic performance.

Geotechnical Analysis

The following historical ground investigation data from Seaspan's Vancouver Shipyards site has been used in assessing the liquefaction potential of in-situ soils:

- Swan Wooster Drawing No. U-1584-08-203 Rev A " Vancouver Tug Boat Company Ltd: North Vancouver Development – Topography and Test Holes"
- Swan Wooster Drawing No. U-3141-01-102 Rev 2 " Vancouver Shipyards Ltd: North Vancouver, B.C, Shipbuilding Berth – Soils Information"
- Swan Wooster Drawing No. U-3141-01-103 Rev 2 " Vancouver Shipyards Ltd: North Vancouver, B.C, Shipbuilding Berth – Test Piles"
- Sandwell/MEG Consulting Limited – "07-250-13:Geotechnical Investigation Report for JSS Facilities" dated December 2007
- Stantec Consulting Ltd – "1145-01528: Marine Geotechnical Factual Report: Vancouver Shipyard Facility Modernization Project – Load Out Pier" dated 25 January 2013

- Thurber Engineering Ltd – " Vancouver Shipyard Modernization - Load Out Pier – Ground Improvement" dated 30 October 2013
- Geopacific Consultants Ltd – "Field Test Data – CPT and SCPT data for proposed Seaspan Buildings" dated April 9, 2014

It is noted that SPT values from historical data were found to be lower than values typically observed in similar soils and should a project specific ground investigation program be adopted, more accurate estimates on seismic performance and ground improvement requirements can be obtained.

Historical boreholes indicate that the site is underlain by loose sands that are prone to liquefaction and large displacements during earthquakes with return periods lesser than those recommended by current building codes:

- **1 in 100 years return period event:** The in-situ soil is generally stable during this level of seismic shaking, however there are zones of liquefaction that could cause lateral displacements in the order of 1m. Ground improvement of in-situ soils can reduce these displacements.
- **1 in 475 years and 1 in 2,475 years return period event:** Under these levels of seismic events, extensive liquefaction is expected to depths of 30m below seabed. Lateral movements in excess of several meters is expected, extending to more than 20m from the top of slope.

Lateral displacements can be reduced by ground improvement using vibro-replacement method. A densified perimeter 'dyke' about 15m wide by 30 m deep located near the toe of the slopes could be used to limit lateral displacements. A typical cross section showing the ground improvement scheme that could be adopted is presented in Appendix 1. It is noted that even after densification, sections of the infill and gravel bed located away from the densified 'dyke' could still be subjected to settlement in the order of 350 to 900 mm.

Seismic Design Philosophy

When subject to design seismic events, the performance objective of codes and standards is focused on life safety with the understanding that structures may sustain irreparable damage but will not collapse. The design event recommended by the British Columbia Building Code is an earthquake with a probability of exceedance of 2% during the life of the structure (return period of 1 in 2,475 years).

When constructing new structures to current seismic code requirements around existing structures that were not designed for seismic loads or were designed to previous seismic codes, it is possible that the existing structures may fail during an event that is of lower magnitude than the design seismic event. Based on discussions with Seaspan, it is Westmar's understanding that most existing facilities at the site are likely not designed to withstand kinematic loads and soil flow loads due to liquefaction of surrounding soil.

Seaspan has advised that the north east infill will be primarily used for material storage with personnel operating in the area only when material is to be moved. Based on Seaspan's intended use of the area and a project specific ground investigation program, Westmar recommends the adoption of a suitable ground improvement scheme that will limit displacements in the North East Infill such that code intent of life safety is met.

The gravel bed is expected to be used over a 12 to 24 hour period during vessel load outs at intervals of 1 to 2 years. Further, life safety would not be compromised in the event of failure of the gravel bed as all personnel would be onboard the Seaspan Careen or the load out pier during vessel load outs. Based on this, it is proposed that the no ground improvement be undertaken at the gravel bed location.

It is also noted that there is a business risk associated with failure of both the north east infill and the gravel bed during seismic events and this will have to be internally assessed by Seaspan.

Conclusion and Recommendations

Based on a review of historical ground investigation data, an assessment of the liquefaction potential of the in-situ soils has been carried out. The in-situ soils are expected to liquefy to varying degrees depending upon the intensity of the seismic event.

The North East Infill is intended to be used as a storage area and Seaspan's functional requirements for the area can accommodate relatively large displacements and settlement while meeting the code intent of life safety. Based on a project specific ground investigation program, a suitable ground improvement scheme may be considered.

The Gravel Infill will be used infrequently, over a 12 to 24 hour period at 1 to 2 year intervals. Further, during vessel load outs, all personnel using the facility will be either onboard the Seaspan Careen or on the load out pier. Based on this, the gravel infill proposes no life safety risk to users and hence, no ground improvement is proposed in this area.

We trust the above meets your immediate requirements. Please do not hesitate to contact us at 604-729-8125 or via email at vramadhas@westmaradvisors.com should you have any questions or require additional information or clarification.

Sincerely,

Vignesh Ramadhas

Vignesh Ramadhas, P.Eng.
Practice Lead, Infrastructure
Westmar Advisors Inc.

cc: Daniel Leonard, Vice-President, Westmar Advisors Inc.
Kai-Sing Hui, Manager, Geotechnical Discipline, EXP Services Inc.
Stewart Wright, Senior Manager, Hatfield Consultants Inc.

Appendix 1 – Proposed Ground Improvement Scheme

Appendix A3

Habitat Assessment

Hatfield
CONSULTANTS
Environmental Specialists Since 1974

JSS Load-out Gravel Bed and East Infill Project
Habitat Assessment

December 2018

Prepared for:
Seaspan ULC
North Vancouver, BC

#200 - 850 Harbourside Drive, North Vancouver, British Columbia, Canada V7P 0A3 • **Tel: 1.604.926.3261** • Fax: 1.604.926.5389 • **www.hatfieldgroup.com**

JSS LOAD-OUT GRAVEL BED AND EAST INFILL PROJECT: HABITAT ASSESSMENT

Prepared for:

SEASPAN ULC
10 PEMBERTON AVENUE
NORTH VANCOUVER
BC V7P 2R1

Prepared by:

HATFIELD CONSULTANTS
#200 – 850 HARBOURSIDE DRIVE
NORTH VANCOUVER, BC
CANADA V7P 0A3

DECEMBER 2018

SSPAN9409 & SSPAN9484

VERSION 2

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

BC	British Columbia
BEDS	Biological Effects Database for Sediments
CCME	Canadian Council of Ministers of the Environment Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Marine
CDC	BC Conversation Data Center
CSR SEDQ	British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water(Typical).
DFO	Department of Oceans and Fisheries
DLCI	Detection Limit Raised: Chromatographic Interference due to co-elution.
DSR	Disposal at Sea Regulation of the *Canadian Environmental Protection Act* 1999
HEPH	Heavy Extractable Petroleum Hydrocarbons
ISQG	Interim Sediment Quality Guideline
JSS	Joint Support Ships
LEPH	Light Extractable Petroleum Hydrocarbons
NSS	National Ship Building Strategy
PAH	Polycyclic Aromatic Hydrocarbon
PEL	Probable Effect Level
SHIM	Sensitive Habitat Information Mapping

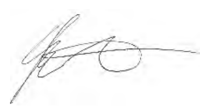
DISTRIBUTION LIST

The following individuals/firms have received this document:

Name	Firm	Email
George Geatros	Seaspan	✓
Daryl Lawes	Seaspan	✓
Cory Zachrisson	Seaspan	✓

AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Description	Date	Approved by	
1	First version of JSS Load-Out Gravel Bed and East Infill Projects Habitat Assessment	20181203	Stewart Wright, EP Project Environmental Director	Marek Holin, RPBio Project Environmental Manager
2	Revised version of JSS Load-Out Gravel Bed and East Infill Projects Habitat Assessment	20181214	 Stewart Wright, EP Project Environmental Director	 Marek Holin, RPBio Project Environmental Manager

1.0 INTRODUCTION

Seaspan ULC (Seaspan) has been competitively selected as the non-combat shipbuilder for the Government of Canada under the National Shipbuilding Strategy (NSS). The Government of Canada and Seaspan have entered into a long-term strategic relationship to build vessels for the Canadian Coast Guard and the Royal Canadian Navy.

Seaspan plans to undertake two additional upgrades to its Vancouver Shipyard on Pemberton Avenue in North Vancouver, British Columbia (BC) in support of this program. These upgrades are both planned for the eastern area of the shipyard in close proximity and are therefore covered by a single habitat assessment.

The Joint Support Ships (JSS) are a component of the NSS. Seaspan plans to construct a submarine gravel bed for grounding of the drydock Seaspan Careen to support the offloading of the vessels from the load-out pier. The load-out pier was constructed in 2014. This upgrade is named JSS Load-Out Gravel Bed. During the functional design phase, Seaspan investigated safe methods of launching JSS vessels. The launch study determined the JSS Load-Out Gravel Bed as the only practical low risk option.

Construction of the JSS Load-Out Gravel Bed will reduce access to the east basin and require changes to Seaspan's operations. Seaspan also has insufficient storage space and laydown area within the shipyard. Therefore, it is proposed that the east basin be infilled to return the eastern spit to its original configuration. This upgrade is named East Infill.

Collectively, both upgrades are referred to in this report as the Project.

This report provides a review of existing studies and environmental information for the area that will be affected by the Project, including results of an environmental field survey completed on October 18, 2018. The document summarizes baseline conditions and environmental considerations including potential environmental impacts.

2.0 SCOPE

The scope of this report includes an assessment of:

- Fish and fish habitat;
- Intertidal and subtidal vegetation; and
- Potential presence of species at risk.

3.0 STUDY AREA

The Project is in the District of North Vancouver, along the North Shore of Burrard Inlet within the Inner Harbour of Vancouver (Figure 3.1). The Seaspan Shipyard facility is situated immediately east, adjacent to the outlet of MacKay Creek and approximately 3 kilometers (km) west of the mouth of the Capilano River.

The Study Area for this report was selected based on the proposed Project development footprint (Figure 3.2). The Study Area is in the northeastern portion of the shipyard within the intertidal and subtidal zone. This Study Area is bordered by the JSS work site to the north, the access road to the Seaspan spit carpark, to the east, floating repair facility to the south and the syncro lift dock to the west. A permanently moored barge is located within the Study Area protruding from the southern boundary.

The western portion of the Study Area is within Vancouver Fraser Port Authority managed federal lands and waters and the eastern portion is within the District of North Vancouver lands. Seaspan retains leases for these areas of land and water and the lease and jurisdictional boundaries are provided in Figure 3.2.

Figure 3.1 Project location.

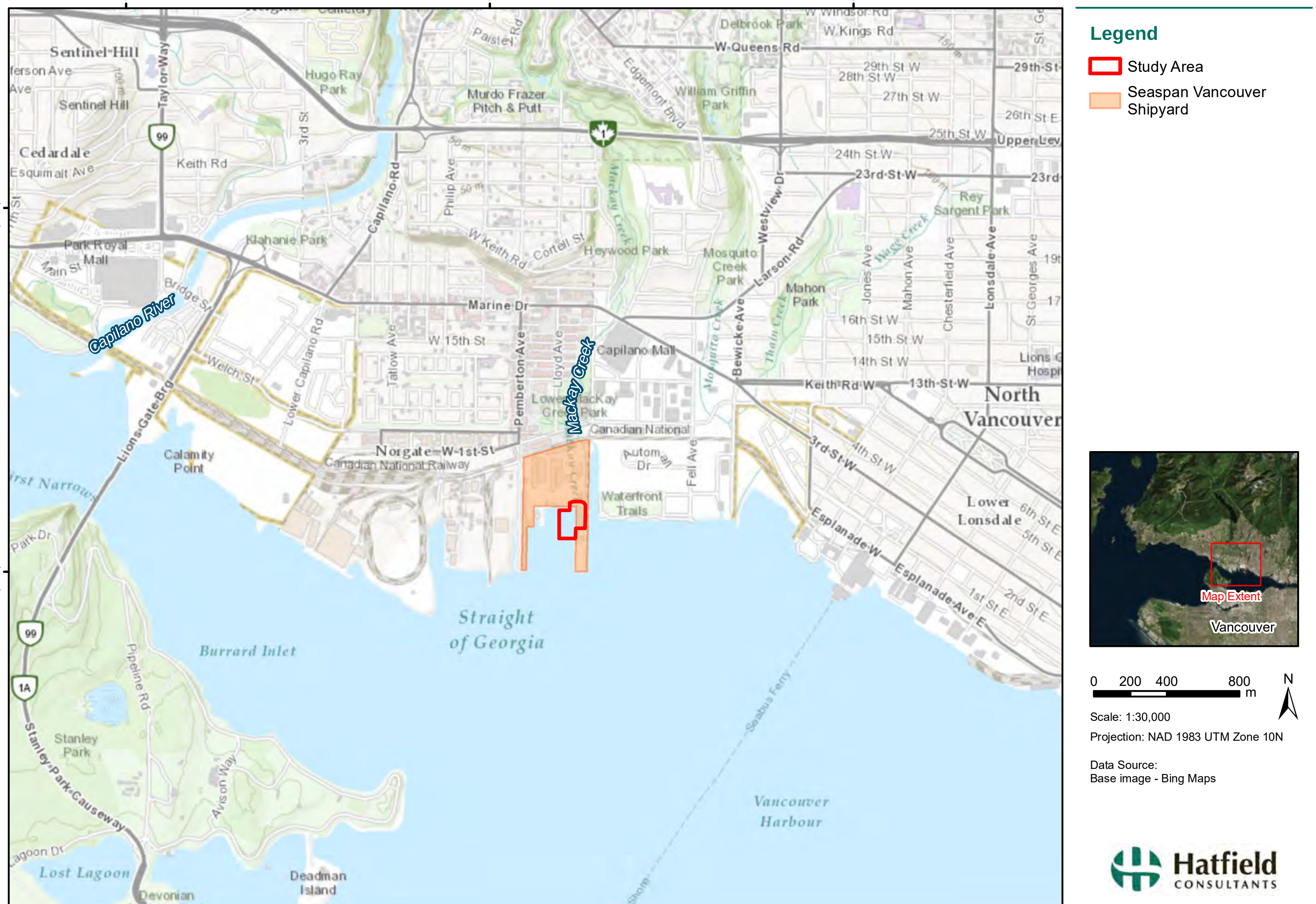


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Figure 3.2 Study Area.

K:\Data\Project\SSPAN9409\A_MXD\SSPAN9409_01_StudyArea_20181212_v0_7_SJ.mxd

4.0 PROJECT OVERVIEW

Two upgrades are proposed in the Study Area where the habitat assessment took place. The JSS-Load-Out Gravel Bed and the East Infill upgrades (the Project) are located adjacent to each other. They differ in purpose, character and permanence as described below. A brief history of the Seaspan Shipyard site is provided for context.

4.1 SITE HISTORY

The Seaspan Shipyards was established at 50 Pemberton Avenue in 1968. The 40 acre facility undertakes design, construction, maintenance and repair of all vessel types. Repair services are centered on a Synhro lift marine elevator of 1,200 tonnes capacity. The yard's facilities include a major steel forming, a large fabrication and assembly hall and a nearly 2,000 m^2, totally enclosed, environmentally controlled, paint facility where entire vessels are sheltered for preparation and painting. The yard also has the capability to drydock multiple vessels simultaneously.

Prior to 1968, land use in the area included logging and associated activities. Historical photos identified in City of North Vancouver Archives from 1917 and 1920 show the site to be cleared at the southern end of Pemberton Avenue with log booms predominant in the area. Log booming appeared to be common in these intertidal areas. One set of photos from 1917 show the area being dredged to construct logging booms at the end of Pemberton Avenue.

Natural intertidal foreshore was still present during this time. The foreshore was low in gradient slope with meandering channels flowing from MacKay Creek and other nearby drainages, indicating a low energy wave environment. Intertidal areas in these historical photos from 1918 appear sandy and sporadically covered in cobbles, devoid of intertidal vegetation.

Photos from 1926 show a timber mill located within the intertidal area at the end of Pemberton Avenue, named Capilano Timber Mill. The mill included a dump and was connected to a train line running north to south along Pemberton Avenue. Photos of the train line show it located amongst established marsh grasses on flat poorly drained ground. The mill and train line were located above the high tide mark on fill and constructed docks.

Industry continued to develop in the area throughout the 1920s. Photos of the foreshore in 1926 show a shingle mill and oil tank at the end of Pemberton Avenue as well as the established timber mill. A creosote plant, Vancouver Creosoting Co., was also established by this time adjacent to the mill. Photos show the creosote company in existence up until at least 1950.

The scale of industrialization in the Study Area is shown in an aerial photo taken in 1926. Nearly all of the intertidal and foreshore area is taken up by logging booms, the timber mill and creosote company. Natural habitat features appear to be highly limited in extent. By 1950 the Study Area appears to have established permanent infrastructure in place including the mill, now called Lions Gate Lumber Co., parking and demarked concrete docks as well as storage facilities. The creosote plant is also in existence as well as booming grounds.

Reclamation of the intertidal foreshore occurred around 1970 to allow for permanent infrastructure at the shipyard and the harbourside area to the east. The Eastern Spit was part of this reclamation (see Figure 4.1,

Figure 4.2 and Figure 4.3). The east basin that is now proposed for infill did not originally exist, as can be seen from the photograph, hence the area still to this day is in District of North Vancouver jurisdiction. The basin was excavated soon after to accommodate the side launch skids.

Figure 4.1 Vancouver Shipyard and Harbourside area before construction of Eastern Spit in 1969. Approximate location of the Study Area is shown in orange.

Figure 4.2 **Vancouver Shipyard and Harbourside area following construction of Eastern Spit in 1971. Approximate location of the Study Area is shown in orange.**

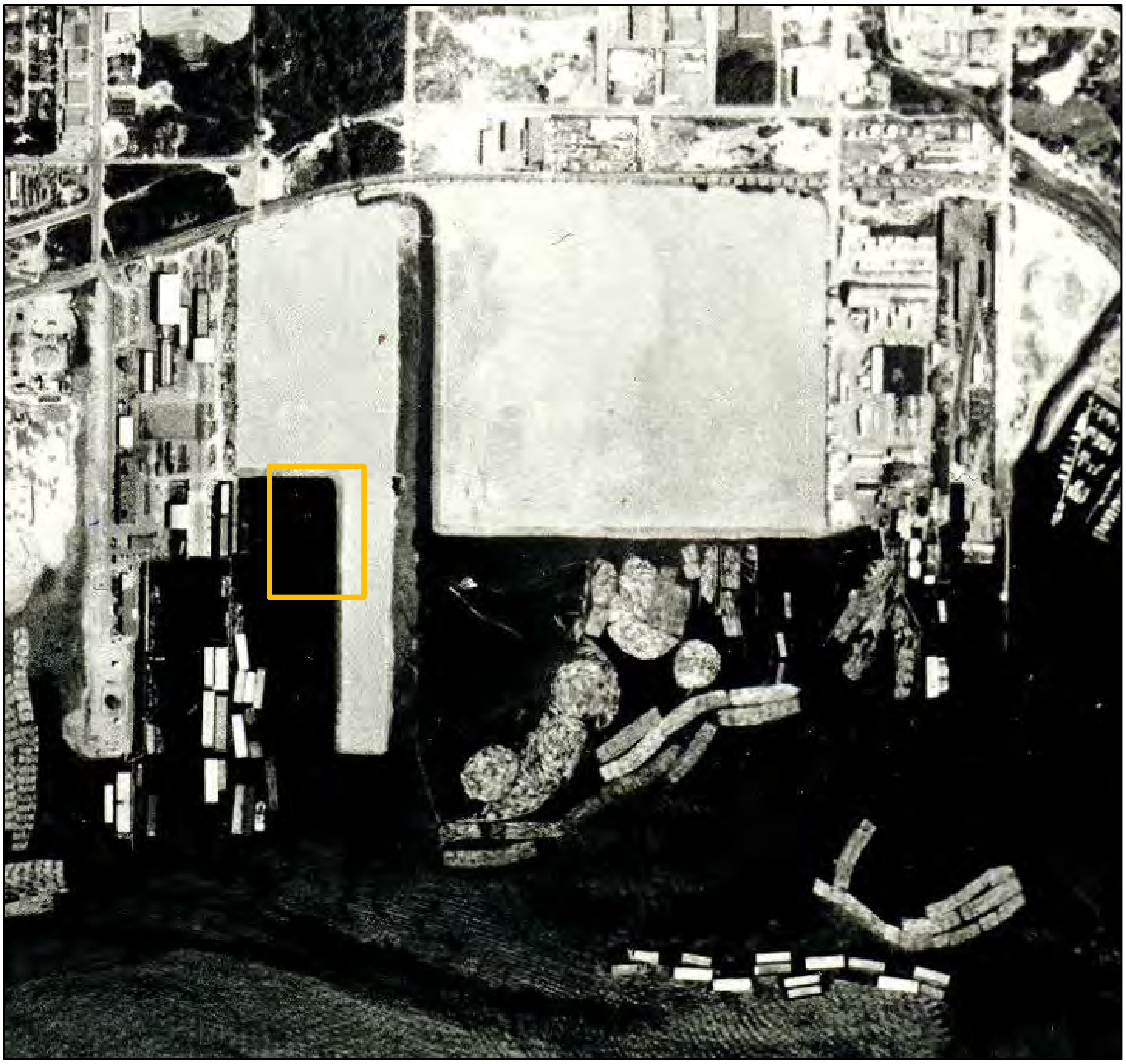
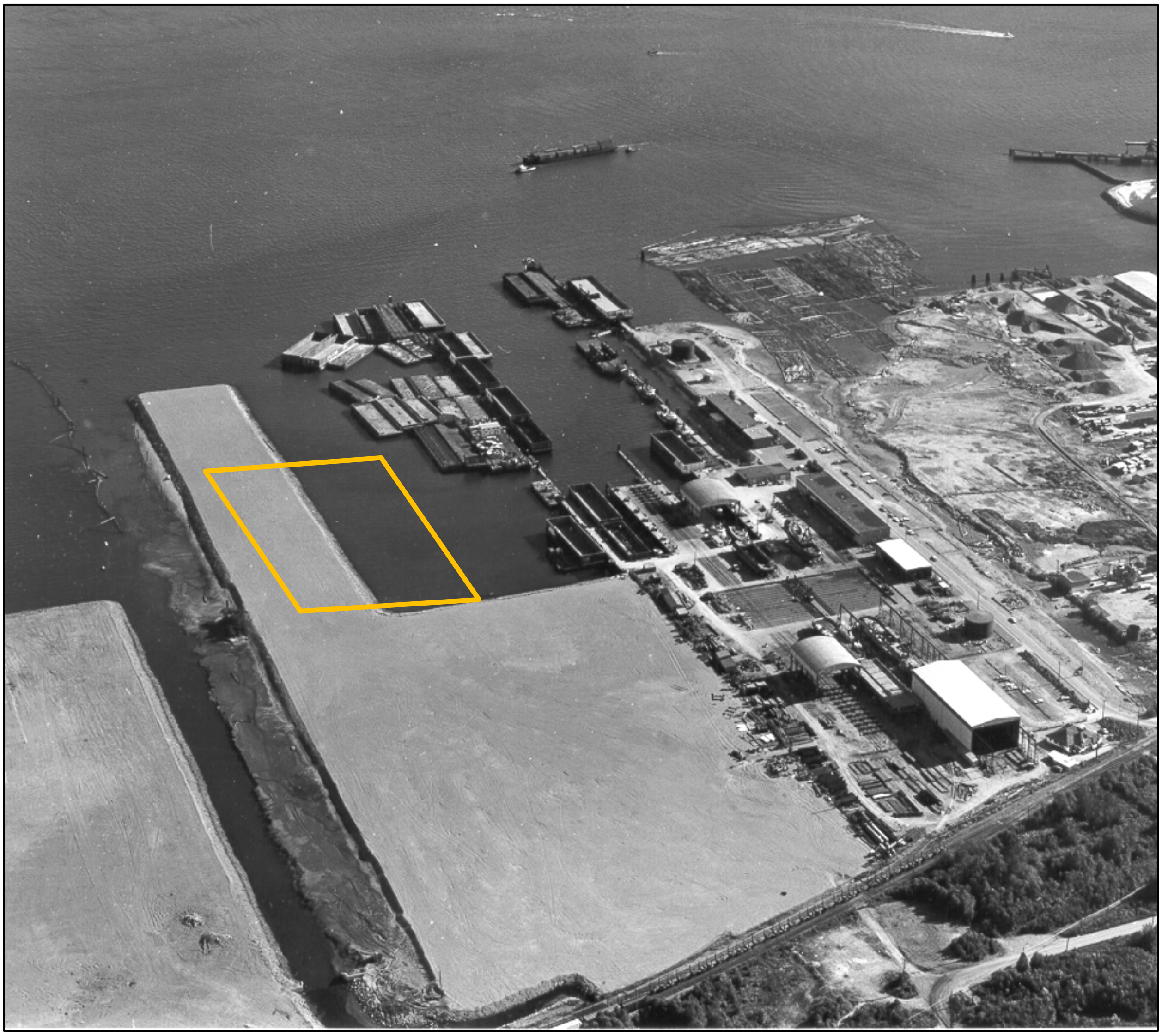


Figure 4.3 The Eastern Spit following construction in 1971. Approximate location of the Study Area is shown in orange.



Remnants of the structures still remain but the launch skids are no longer in use and were replaced by the load-out pier in 2014. MacKay Creek discharges to the Burrard Inlet to the east. A small side channel parallels the main MacKay Creek channel. This side channel used to discharge to the east basin through culverts in the access road to the Eastern Spit. The southern end of the side channel was infilled around 2006 and flows were diverted. There is no longer any discharge from MacKay Creek into the east basin.

The Study Area is currently used for docking barges, such as logging barges for repair, as well as providing a repair location for Seaspan vessels, primarily tug boats. There is a high level of large vessel traffic within a confined area.

4.2 JSS LOAD-OUT GRAVEL BED

The Project involves the building of a JSS Load-Out Gravel Bed to place the Seaspan Careen (Figure 4.4). The Careen will be used to offload sections of the JSS ship to support construction. The JSS Load-Out Gravel Bed will be approximately 6,700 m^2 in size. The bed will be approximately 1 m below chart datum to allow the Careen to be level with the load-out pier when grounded. The estimated volume of gravel that will be needed, including gravel for the slopes, is 36,522 m^3. Gravel of 25 mm to 50 mm mesh (i.e., 1" to 2" mesh), of angular type is proposed to be used. Slopes of the Load-Out Gravel Bed are expected to be lined with larger grade rock to protect against propeller wash.

The Load-Out Gravel Bed will be used for the offloading of ships during manufacture. It is required for a minimum of 5 to 10 years for the JSS contract. The Load-Out Gravel Bed may be used at other times and may either be removed or remain in place once the JSS contract is complete depending on ongoing shipbuilding activities at Seaspan at that time. The following specific requirements have already been defined for its use:

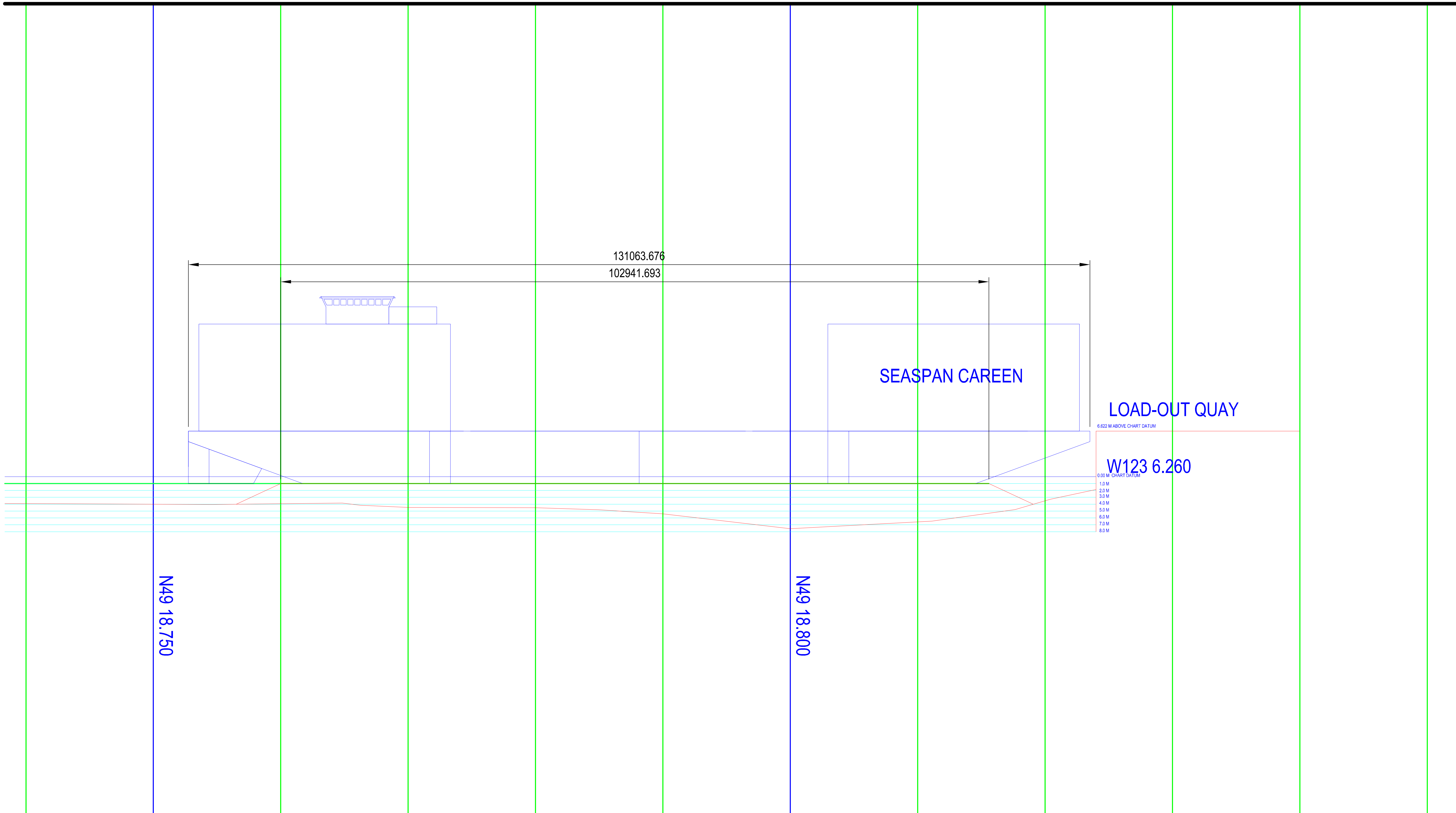
- Test fit Careen grounded for 5 to 7 days during 2021 or 2022;
- JSS 1 launch Careen grounded for approximately 7 days in 2022;
- JSS 2 launch Careen grounded for approximately 7 days in 2023; and
- Polar Ice Breaker launch and associated Careen grounding yet to be scheduled.

4.3 EAST INFILL

The JSS Load-Out Gravel Bed will impede access to the East Basin further reducing any potential use for the area. As discussed in Section 4.1, the area was excavated in the 1970s to install the side launch; the remnants of which remain on site and can be seen in Figure 3.2. Seaspan currently has insufficient space for equipment and materials storage. Therefore, Seaspan plans to infill the East Basin.

The East Infill is proposed to increase the area of land available to support general shipyard services (Figure 4.5). The East Infill will be filled to the existing grade of the Eastern Spit at approximately 6.2 m above chart datum. The area will be paved. No permanent buildings are planned for this area. The East Infill is a permanent upgrade. The East Infill will require construction of either a rip-rap berm or a sheetpile wall. The basin will then be filled with sand and gravel behind the berm or wall. At this stage there is no plan to excavate material from the basin before it is filled, but ground improvements may be required prior to paving, to avoid potential settlement issues.

The side launch skids within the East Infill will be removed. The floating repair facility will also be removed from the East Infill and this activity will take place elsewhere on the site outside of the Study Area.



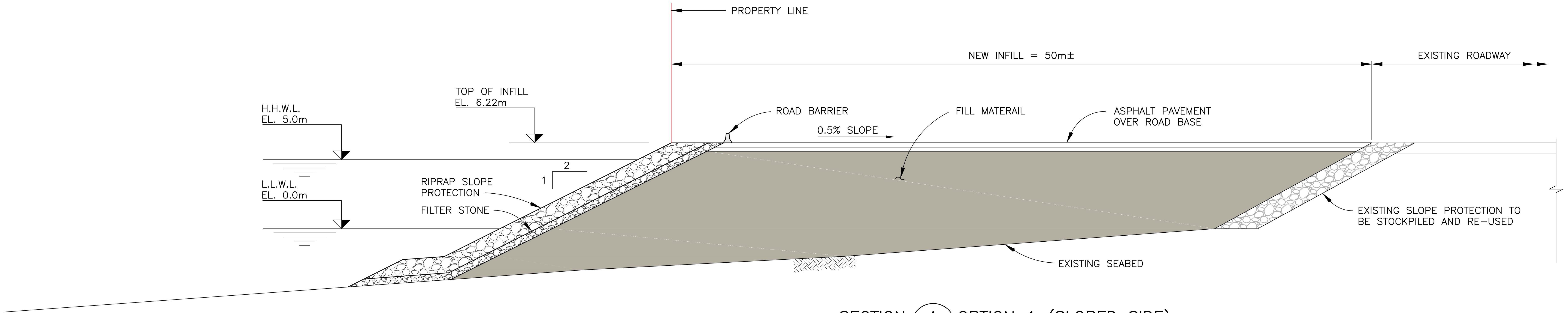
REV	DATE	DESCRIPTION	DRN	CHK	APP
3.0	18-DEC-17	SOUNDINGS & GRAVEL BED UPDATE	A&A	AGS	AMS
1.0	09-APR-17	INITIAL ISSUE	A&A	AGS	AMS

CLIENT:	VANCOUVER SHIPYARDS
PROJECT:	JSS GROUNDED LOAD-OUT
TITLE:	VSY BASIN N-S SECTION LOAD-OUT GRAVEL BED

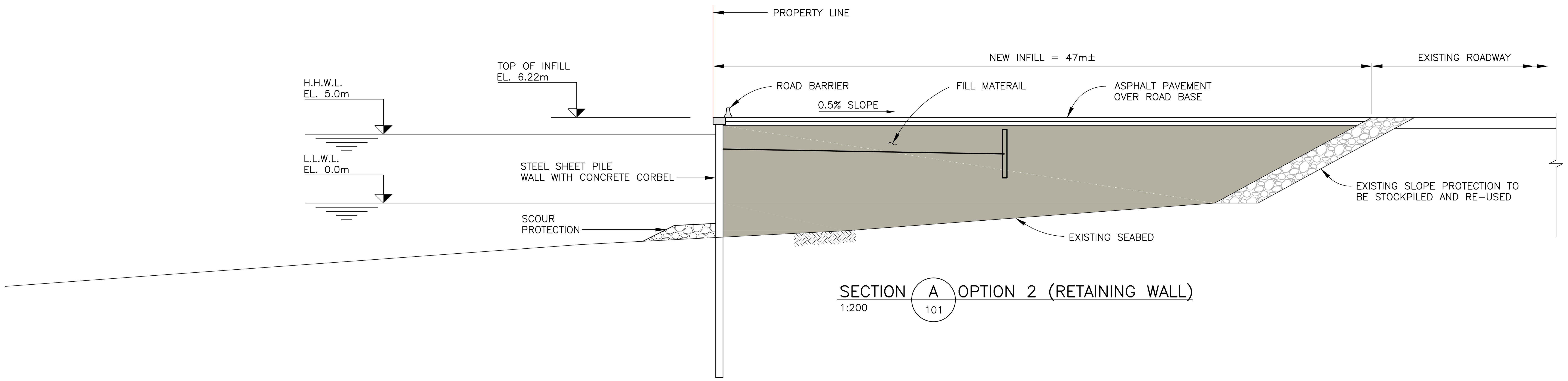
GRAND MARINE LTD

www.grandmarine.com info@grandmarine.com

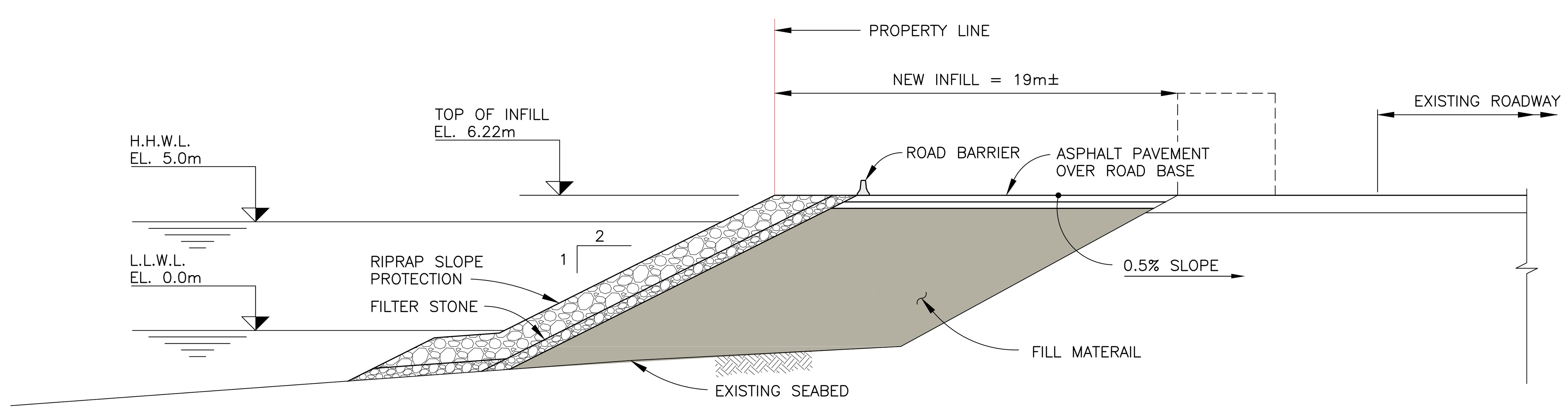
PROJ. NO.	DOCKING	SCALE	DWG NO.	SHEET	REV
A-17-43	.	1:500	A-17-43-111	1 OF 1	3.0



SECTION (A / 101) OPTION 1 (SLOPED SIDE)
1:200



SECTION (A / 101) OPTION 2 (RETAINING WALL)
1:200



SECTION (B / 101) OPTION 1 AND 2 (SLOPED SIDE)
1:200

m 0 5 10 m
1:200

NOTES:

1. ALL ELEVATIONS ARE TO CHART DATUM.
2. PROPERTY INFORMATION HAS BEEN PROVIDED BY SEASPAN.

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Last Saved: Nov. 30/18 11:19am Plotted: Nov. 30/18

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D
P1	NOV30/18	ISSUED FOR PERMITTING	RM	DL	DL		DL

ISSUE / REVISIONS

No.	DATE	DESCRIPTION	DRAWN	CHK'D	DESIGN	CHK'D	APP'D

ISSUE / REVISIONS

MGR

CLIENT
seaspan

PROJECT
SEASPAN VANCOUVER SHIPYARD
WATERFRONT INFILL PROJECT
PERMITTING APPLICATION

WESTMAR ADVISORS
Hatfield CONSULTANTS

TITLE
SECTIONS

DRAWING SCALE	PROJECT NUMBER	DRAWING NUMBER	REV.
SHOWN	1180030	00-102	P1

5.0 STUDY METHOD

A field study was undertaken to assess and characterize the marine environment potentially affected by the Project. The field study consisted of underwater video transects of the Study Area (Figure 3.2) and collection of sediment samples for laboratory analysis. The field study occurred on October 18, 2018 and was followed by a literature review of publicly available information to describe marine habitat and confirm results of the field study. The habitat assessment followed the Port of Vancouver Project and Environmental Review Guidelines for Habitat Assessment (2015).

5.1 HABITAT SURVEY

A subtidal and intertidal biophysical survey through videography documentation was undertaken by towed video camera along 5 transects extending vertically through the Study Area (Figure 5.1). The survey documented aquatic life and observations of substrate and intertidal habitat quality. Because of the highly disturbed nature of the intertidal area, that has involved previous dredging and industrial use (Section 4.1), documentation and sediment analysis was sufficient to characterize the area without the need for a quantitative intertidal habitat survey.

Videography transects were taken in a south to north direction around permanent infrastructure, including the floating repair facility and the permanently moored barge. The second barge depicted in Figure 5.1 parallel to the permanent barge was not present during the survey.

A GoPro in towed housing was suspended from the survey boat and guided along the sea bottom by an operator onboard along the pre-specified transect routes shown in Figure 5.1. Transects 3, 4 and 5 surveyed the area that will be affected by the JSS Load-Out Gravel Bed. Transect 1 and 2 surveyed the area that will be affected by the East Infill.

Survey transects were taken between 8:30 and 11:30 am on a diurnal low tide. A GPS was used to record the start and finish point of each transect. At times, reflected light from suspended solids decreased visibility. The cameraman had real time view access using virtual camera goggles and was able to adjust the position of the towed camera to maintain visibility of the seabed. Videos were reviewed following filming to identify and summate observed organisms, habitats and substrates.

Any areas that showed habitat value were surveyed in more detail. A sixth transect was undertaken for this reason, around the base of the load-out pier and eastern shoreline. The transect occurred in an east to west direction along rip-rap placed at the base of the load-out pier. The transect was taken along an area that is not expected to be affected by the Project.

Physical substrate characteristics observed are described according to the categories presented in Table 5.1.

Table 5.1 Substrate categories for the habitat field assessment.

Substrate	Definition	Size (mm)
Fines: Silt, clay, mud	Loose sedimentary deposit	<0.0625
Fines: Sand	Loose granular material	0.0625 – 2
Gravel	Loose fragments of rock	2 – 64
Cobble	Loose stone larger than gravel, smaller than a boulder	64 – 256
Boulder	Detached mass of rock	>256
Shell hash	Surface substrate layers are dominated by loose shell accumulations.	2 – 64

Source: DFO (1990)

5.2 SEDIMENT SAMPLING AND ANALYSIS

Sediment samples were collected from the seabed throughout the Study Area for chemical analysis to better understand potential contamination in the surface layer.

To comprehensively cover the Study Area, a grid layout was applied to define sediment sampling locations (Figure 5.1). Sampling procedures followed Hatfield Standard Operating Procedure 7 Sediment/Soil sampling procedures (Appendix A1). In total 11 samples were collected by an Ekman grab sampler 0.5 cm below the seabed. Because of coarse gravel substrate at sediment sampling Sites 6 and 7, it was not possible to collect a sufficient sediment for analysis using the grab sampler. Therefore, a total of 10 locations were sampled with one duplicate for Quality Assurance purposes. Sediment samples were prepared and sent to the laboratory for analysis of the following analyte concentrations:

- Metals (Soil);
- Hydrocarbons; and
- Polycyclic Aromatic Hydrocarbons (PAHs).

Results of analysis were measured against the Canadian Council of Ministers of the Environment (CCME) Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Marine, Interim Sediment Quality Guidelines (ISQGs) and the Probable Effect Level (PEL). Results were also compared to the criteria within *Disposal at Sea Regulations* of the *Canadian Environmental Protection Act 1999* (DSR) and the British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water (Typical). (CSR SEDQ).

5.3 LITERATURE REVIEW

Data sources reviewed and evaluated included:

- BC Ecosystem Explorer: which lists species status provincially and federally (COSEWIC and SARA). http://a100.gov.bc.ca/pub/eswp/
- Species at Risk Registry: The Public Registry for species at risk in Canada. http://www.sararegistry.gc.ca/sar/index/default_e.cfm
- Fisheries Information Summary System Habitat Wizard, https://cmnbc.ca/atlas_gallery/fisheries-information-summary-system-data-entry-tool
- Sensitive Habitat Information Mapping (SHIM) https://cmnbc.ca/atlas_gallery/shim-sensitive-habitat-inventory-and-mapping
- BC Conversation Data Center (CDC) https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre
- Electronic Atlas of the Flora of British Columbia: Algae identification http://ibis.geog.ubc.ca/biodiversity/eflora/algae.html
- Fisheries and Oceans Canada, Pacific Ocean Recreational Fisheries Information Page. http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.html
- Fisheries and Oceans Canada, Pacific Ocean, Aquatic Species at Risk Maps, British Columbia South West (Map 4 of 13) http://www.dfo-mpo.gc.ca/species-especes/fpp-ppp/bcsw-socb-4-eng.htm
- Fisheries and Oceans Canada, Pacific Ocean, Project Near Water, http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html.
- BC Parks Intertidal Information Sheet. http://www.env.gov.bc.ca/bcparks/conserve/lifeattheedge.pdf?v=1490572800040
- Mollusc Paver Species in Howe Sound, marine biodiversity information page Vancouver Aquarium http://www.vanaqua.org/marine-biodiversity/molluscs/mollusc-paver-species-in-howe-sound/

Figure 5.1 Study Area field work.

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6.0 BASELINE CONDITIONS

6.1 PHYSICAL CONDITIONS

Physical conditions and habitat vary depending on the shipyard infrastructure present within the Study Area and associated features. Table 6.1 summarizes observed results.

Table 6.1 Observed physical characteristics.

	TR 1			TR 2			TR 3			TR 4			TR 5			TR 6		
	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	West	Mid	East
SUBSTRATE (%)																		
Boulder	0	0	0	0	0	5	5	5	70	0	0	80	0	0	85	85	85	70
Cobbles	0	10	0	10	30	25	25	45	10	10	10	10	25	40	5	5	5	10
Gravel	10	30	30	60	40	50	25	30	10	50	50	5	50	35	0	0	0	10
Fines	80	50	60	30	30	30	45	20	10	40	40	5	25	25	10	10	10	10
Shell Hash	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Interspersed throughout the Study Area are anthropogenic debris in both subtidal nearshore and intertidal areas including rope, cables, scrap metal, tires, timber and metal pipe.

6.1.1 Physical Conditions of the East Infill

Except for the channel that allows tug boats to access the floating repair facility, the East Infill is intertidal, with depths of 0.0 to +5.0 m Chart Datum. The floating repair facility is the only infrastructure present within the proposed East Infill and is constructed of creosote timber piles. A small subtidal basin is present immediately east of the floating repair facility that does not drain during the outgoing tide. The basin appears to be poorly mixed and its substrate was found to be contaminated (see Section 6.8).

Transect 1 describes the substrate observed within the East Infill (Table 6.1). The substrate of the East Infill is predominantly low gradient sand tidal flats and shell hash interspersed with gravel. The upper intertidal slope is composed of cobble and sand. The East Infill foreshore is bordered by rip-rap that protects surrounding shipyard infrastructure. Six disused side launch skids protrude perpendicular to the shoreline into the Study Area.

6.1.2 Physical Conditions near the proposed JSS Load-Out Gravel Bed

The western portion of the Study Area that is proposed to contain the JSS Load-Out Gravel Bed is subtidal nearshore with depths of -0.8 m -and 8.1 m Chart Datum along the northwestern edge.

Shipyard infrastructure surrounding the proposed JSS Load-Out Gravel Bed includes the load-out pier that protrudes from the foreshore along northern boundary of the Study Area (Figure 5.1). The load-out pier is a concrete rectangular structure that protrudes 880 m^2 into the water. Rip-rap has been placed at its base to prevent scour. The rip-rap extends approximately 1-2 m into the seabed and is approximately -1.0 to -3.0 m Chart Datum in depth. Transects 3 to 6 show a high percentage of boulders along the northern portion of each survey, which reflects the presence of rip-rap (Table 6.1). Coarse materials including concrete debris, cobbles and a number of sawn-off wooden piles are located immediately south of the rip-rap.

What appears to be a dredged navigation channel is present south of the load-out pier (Figure 5.1). The channel extends in a dog-leg fashion west from the floating repair facility past the permanently moored log barge and veers south, running parallel to the log barge until the southern boundary of the Study Area. The channel is used by tug boats to gain access to the floating repair facility. Depths in the channel vary between -6.0 to -8.1 m Chart Datum but are generally uniform without large gradients. The seafloor along the dredged channel is predominantly fines and gravel with finer material such as silts and fine sand identified in the deeper portions of the channel. Transects 4 and 5 were taken along the channel depth and show a higher percentage of gravel and fines in the south and mid portion of the transects with minimal to no boulders present (Table 6.1).

The slopes of the dredge channel separate it from the intertidal area (Figure 5.1). The cut slope also separates the dredge channel from the load-out pier to the north of the Study Area and cuts into the intertidal area north of the floating repair facility. The cut slope is present underneath the length of the permanently moored logging barge. Cut slope depths increase from -6.0 m from the channel to 0 m Chart Datum and are characterized by predominantly gravel substrate, as seen in Transect 2 south portion (Table 6.1).

6.2 MARINE VEGETATION

Red, green and brown algal species were identified primarily around rocky substrates in the north of the Study Area including Sea lettuce (*Ulva)* and rockweed (*Fucus gardineri)*, sugar wrap kelp (*Saccharina latissima*), turkish washcloth (*Mastocarpus papillatus*) and splendid iridescent seaweed (*Mazzaella splendens)*. These algal species provide habitat and nursery environments for fish, invertebrates, and some other algae. Their biomass also provides primary productivity oxygen to nearshore food webs (Bates 2004). Table 6.2 provides a summary of transect observations, which are mapped in Figure 5.1. All marine algae observed were covered in fine sediments (Figure 6.1). Propeller wash from tug boats frequently passing through the Study Area likely resuspend seabed sediments leading to this deposition.

Figure 6.1 Marine algae covered in fine sediment.

Marine algae was primarily observed around rip-rap at the base of the load-out pier in established kelp beds, throughout Transect 6 and the northern portion of Transects 4 and 5 (Table 6.2). Marine algae were interspersed minimally throughout the remainder of the transects taken within the dredge channel and cut slope shown in Figure 5.1. Brown algae was observed in the southern portion of Transect 2 on the substrate around piers adjacent to the permanently moored logging barge and rip-rap lining the Eastern Spit. Boat traffic is minimal in this location because of the confined nature of the waterway between the barge and spit. The East Infill including the subtidal nearshore and intertidal area (Transect 1) had only trace marine vegetation present, along the northern portion of the transect. Otherwise the remainder of the transect was absent of marine vegetation. There is no eelgrass present in the Study Area.

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Table 6.2 Observed marine vegetation.

	TR 1			TR 2			TR 3			TR 4			TR 5			TR 6		
	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	West	Mid	East
VEGETATION																		
Brown Algae (Phaeophyta spp.)	-	-	-	Throughout	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Abundant*	Trace	Minimal	Abundant	Abundant	Abundant	Abundant
Red Algae (Rhodophyta spp.)	-	-	-	Trace	Trace	-	Trace	Trace	Minimal	-	-	Abundant*	-	-	Abundant	Abundant	Abundant	Abundant
Green Algae (Chlorophyta spp.)	-	-	Trace ulva	Throughout	Minimal	Throughout	Minimal	Minimal	Minimal	Minimal	Minimal	Abundant*	-	-	Abundant	Abundant	Abundant	Abundant
Other/notes	-	Trace	-	OM on bottom	OM on bottom	Ulva on rocks	-	Algae concentrated on rocks	Algae concentrated on rip-rap	-	-	* Algae on Rip-rap features	-	-	Rip-rap features	Rip-rap features	Rip-rap features	Rip-rap features

6.3 FISH

One lingcod (*Ophiodon elongatus*) and two kelp greenling (*Hexagrammos decagrammus*) (Figure 6.2) were observed during the video survey in Transects 5 and 6 (Table 6.3). The fish were identified among rip-rap lined along the base of the load-out pier along the north side of the Study Area. Other fish species identified in the same area included shiner surfperch (*Cymatogaster aggregate*) (Figure 6.3); 30 individuals were identified swimming in schools between and along the rip-rap at the base of the load-out pier (Table 6.3).

Figure 6.2 Kelp greenling, Transect 5.

Figure 6.3 Shiner surfperch.

A bay pipefish (*Sygnathus leptorhynchus*) was observed in the mid portion of Transect 2. A gunnel (*Pholis laeta*) and a three-spined stickleback (*Gasterosteus aculeatus*) were observed in the southern portion of Transect 3 and a sculpin (*Clinocottus acuticeps*) was observed in the mid portion of Transect 4. No other fish species were observed during the video survey. Appendix A3 provides photos of identified species and habitat.

Table 6.3 Observed fish.

	TR 1			TR 2			TR 3			TR 4			TR 5			TR 6		
	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	West	Mid	East
CRA FISHERY SPECIES																		
Rough fish																		
Lingcod (*Ophiodon elongatus*)																	1	
Kelp greenling (*Hexagrammos decagrammus*)															1		1	
OTHER FISH SPECIES																		
Shiner surfperch (*Cymatogaster aggregate*)												8			11	11		
Gunnels (*Pholis lata, Apodichtys flavidus, P. ornate)*							1											
Three-spined stickleback (*Gasterosteus aculeatus*)							1											
Sculpins (*Clinocottus acuticeps, Oligocottus maculosus*)											1							
Bay pipefish (*Sygnathus leptorhynchus*)					1													

Capilano River and MacKay Creek are both salmon bearing watercourses in vicinity of the Study Area. MacKay Creek is separated from the shipyard by the Eastern Spit. Chum (*Oncorhynchus keta*), Coho (*Oncorhynchus kisutch*) and Pink (*Oncorhynchus gorbuscha*) salmon use the creek and have been increasing in returns since the weir was removed in 2013, (Echo Ecological 2016). There is potential for salmonids to be present in the Study Area, however, there is no freshwater spawning habitat present or direct access to such habitat from the Study Area.

Potential nursery environments and food sources for other fish were present in the Study Area. Brown, green and red algae beds were present in the nearshore subtidal area around rip-rap placed at the base of the load-out pier. Various marine invertebrates including crustaceans and molluscs were also present throughout the Study Area.

The BC Ecosystem Explorer, BC Conversation Data Center (CDC), Fisheries Information Summary System Habitat Wizard, Sensitive Habitat Information Mapping, Fisheries and Oceans Canada (DFO), Pacific Ocean Recreational Fisheries Information Page and DFO aquatic species at risk maps were reviewed to identify other potential fish species that could potentially occur in the in the Study Area. Other fish species with potential to occur in the Study Area include, surf smelt (*Hypomesus pretiosus*), pile perch (*Rhacochilus vacca*), pacific herring (*Clupea pallasi*) and sand lance (*Ammodytes hexapterus*).

6.4 MARINE MAMMALS

No marine mammals were observed during the field study. Incidental observations of pacific harbor seals (*Phoca vitulina richardsi)* have been made within the Study Area by Hatfield during other work at the shipyard. Harbor seals diet consists primarily of species similar to those observed and with potential to occur in the area. Cetaceans are unlikely to occur in the Study Area. They are infrequent visitors to Burrard Inlet (Haggarty, 2001) and are unlikely to enter the Study Area because of the small size of the waterway and density of marine vessels and docks.

River otter (*Enhydra lutris*) observations have also been made incidentally just south of the Study Area in the vicinity of the permanently docked log barge (Marc Vandermeer, Hatfield *pers. observation*). River otter diet consist of species similar to those observed and with potential to occur in the area.

6.5 MARINE BIRDS

Glaucous-winged gulls (*Larus glaucescens*) and cormorants (*Phalacrocoracidae*) were the predominant marine birds observed in the Study Area and appear to congregate on pier structures and barges regularly, based on scat residue. Cormorants were also observed swimming in the Study Area. Cormorant diet consists primarily of fish species similar to those observed and with potential to occur in the area.

Habitat within the Study Area is not suitable for other marine birds as described in (FLNRO 1997). There is a lack of riparian vegetation (no mature tree stands and shrubs), tidal flats, marshes and grasses. An artificially constructed osprey nest site is located on the Eastern Spit that supports an active breeding pair (Figure 5.1). The nest is located just to the east of the Study Area and is not expected to be disturbed during Project construction.

6.6 MARINE INVERTEBRATES

A variety of marine invertebrates were observed within the Study Area. The most predominant was the Dungeness crab (*Metacarcinus magister*). Both adult and juvenile crabs were observed. The highest density of crabs was observed between the permanently moored logging barge and the Eastern Spit (Figure 6.4). Habitat in this area includes a steep rip-rap slope, subtidal nearshore water depth -1.5 m Chart Datum and pilings that support the access jetty to the permanently moored logging barge. Other crustaceans observed included red rock crab (*Cancer productus*) and a solitary coonstripe shrimp (*Pandalus danae).*

**Figure 6.4	Dungeness crab.**

Bay mussels (*Mytilus trossulus*), were observed on the underside of the permanently moored barge, anchor chains and access way pier pilons. No evidence of marine invertebrates was observed along the floating repair facility but similar colonisation was observed on the access jetty pier pilons. Acorn barnacles (*Balanus glandula*) were present throughout the Study Area on rock features and coarse substrates. No live bivalves were identified in the intertidal area within sediment during sediment sampling.

In addition to crustaceans and bivalves, purple starfish (*Pisaster ochraceus*) and jelly fish were observed primarily around the load-out pier and also around piers near the permanently moored logging barge. A polychaete worm was also identified within the intertidal area in samples collected for sediment analysis. Appendix A2 provides a list of invertebrates identified during the field survey. Appendix A3 provides photos of identified species and habitat.

Table 6.4 Observed marine invertebrates.

	TR 1			TR 2			TR 3			TR 4			TR 5			TR 6			Sediment Sampling
	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	West	Mid	East	Sediment Sampling site 8
Crustaceans																			
Red rock crab (*Cancer productus*)				3				1	1	4		1			3	1	1		
Dungeness crab (*Cancer magister*)	5			7	14	10	3	9	2	9	7	6	11	12	9	4	1	1	
Shrimp (*Pandalus spp.*)											1	1		1					
Bivalves (Bivalvia)																			
Bivalvia Spp.	21					5					1	2							
Invertebrates																			
Asteroidea				2		1		1	2			3			2		1		
Polychaeta																			1
Other aquatic species																			
Cnidaria Spp. (Jellyfish/anemone)										2	1	2	2	1					

6.7 POTENTIAL SPECIES AT RISK

The Species at Risk Public Registry, BC Ecosystem Explorer, CDC and DFO aquatic species at risk maps were reviewed to identify aquatic species at risk with a range that covers the Study Area. Based on habitat characteristics present in the Study Area and known ranges of various at-risk species, the yelloweye rockfish (*Sebastes ruberrimus),* northern abalone *(Haliotis kamtschatkana)* and stellar sea lions (*Eumetopias jubatus*) have the potential to be found in the Study Area. However, stellar sea lions are infrequent visitors to Burrard Inlet (Tsleil-Waututh 2017) and given the limited number of fish observed and high volume of vessels it is unlikely that stellar sea lions would be present in the Study Area. Suitable yelloweye rockfish habitat is limited at the Study Area, as the species is typically found at depths of 17 to 250 m, which does not occur within the Study Area. Northern abalone are extremely rare due to overharvesting and occur on exposed or semi-exposed rocky shorelines (COSEWIC 2009). Sediment, sand, gravel or shell are not suitable habitat and a source of macro-algae, particularly kelp is required as food. No abalone were identified during the field survey and the species is highly unlikely to be present within the Study Area.

6.8 SEDIMENT ASSESSMENT

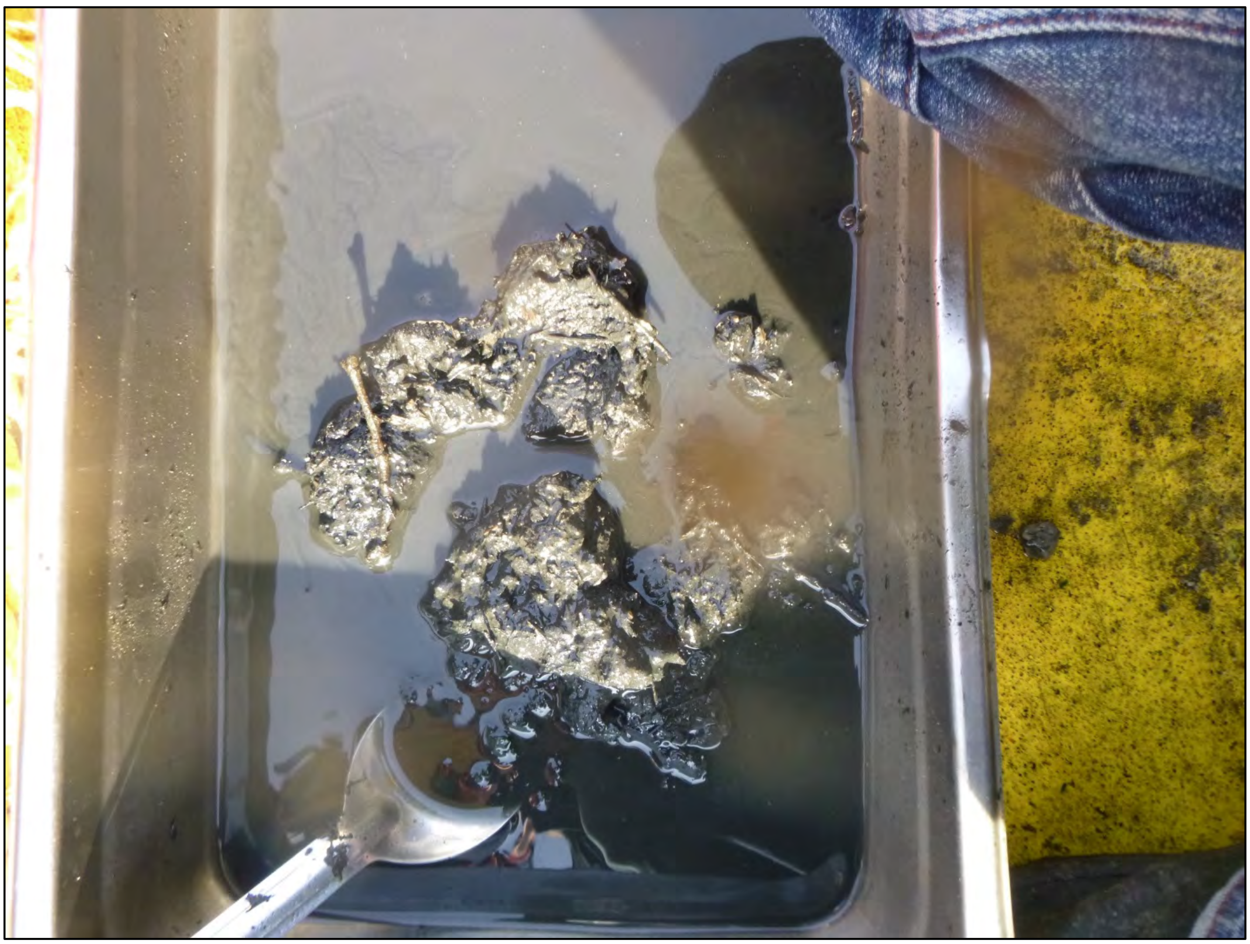
Sediment samples were collected during the field assessment to evaluate sediment quality. Eleven samples were collected throughout the Study Area as depicted in Figure 5.1. Sediment sample results were compared against CCME, DSR and CSR SEDQ guidelines. The following sections describe the results of these comparisons. CCME guidelines provide the most conservative thresholds and therefore a more detailed analysis is provided in Section 6.8.1.

In summary, Sample 12, located immediately east of the floating repair facility within the proposed East Infill, contained the highest concentration of metal and PAH analytes. Mercury concentrations at this location were up to an order of magnitude higher than at any other sampled sediment site. Benzo(a)pyrene was also up to an order of magnitude higher than at any other sampled sediment site.

Higher concentrations of PAH analytes were observed at Sample 3 and 4 located south of the load-out pier in comparison to other collected samples. Sample 11, located just to the north of Sample 12 contained the lowest concentration of PAH analytes out of all samples collected. This location was in an area of intertidal sands.

Results of hydrocarbon analysis were below detection limits for all samples, except for Sample 12. This sample had detectable concentrations of Highly Extractable Petroleum Hydrocarbons (HEPH) and EPH19-32.

Figure 6.5 Sediment Sample 12.



6.8.1 Canadian Council of Ministers of the Environment Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Marine, Interim Sediment Quality Guidelines

6.8.1.1 Interim Sediment Quality Guidelines

Analytical results as shown in Table 6.5 indicate that certain metals were detected at concentrations greater than CCME ISQG. Full comparison and laboratory analysis results are provided in Appendix A4. Sediment Sample 12, located immediately east of the floating repair facility, within the proposed East Infill had elevated concentrations of all metals except for chromium. Elevated levels of arsenic were also present in Sample 1 and 2 located west of the permanently moored logging barge, in Sample 3 located south of the load-out pier, and in Sample 11, located west of the eastern spit within the proposed East Infill. Elevated levels of cadmium were present in Sample 4 located south of the load-out pier. Elevated levels of copper were identified at all sediment sampling sites. Elevated levels of lead and zinc where present in Samples 1 and 2, located west of the permanently moored logging barge. Elevated levels of zinc were also in Samples 3 and 4, located south of the load-out pier, and in Sample 5, immediately east of the load-out pier.

Analytical results (Table 6.5) indicate that various PAHs were detected at concentrations greater than CCME ISQG for the majority of PAH analytes with the exception of Sample 11, located west of the Eastern Spit within the proposed East Infill and Sample 1, located west of the permanently moored logging barge. Sediment Sample 12, located immediately east of the floating repair facility had elevated concentrations of all PAHs. During laboratory analysis, detection limits were raised for Samples 5, 6, 8, 9 and 10 and therefore results were not available for PAH analytes colour coded yellow in Table 6.5.

Duplicate QA/QC samples were taken at the site of Sample 10, located west of the Eastern Spit within the proposed East Infill. These provided similar compliance results for metals, however, compliance results for PAHs varied for Anthracene, Benzo(a)pyrene and Chrysene with the duplicate sample identifying these analytes as being in exceedance CCME ISQG for PAHs. Six other PAH analytes were unable to provide results because detection limits were raised. Laboratory QA/QC did not identify any anomalies during laboratory analysis (Appendix A4).

Table 6.5 **Sediment sampling results measured against Canadian Council of Ministers of the Environment Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Marine, Interim Sediment Quality Guidelines.**

ALS	Units	Sample ID	CCME ISQGs	SS1	SS2	SS3	SS4	SS5	SS8	SS9	SS10	DUP	SS11	SS12
		LOR		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Moisture	%	0.25	-	16.1	20.2	24.4	51.7	30.6	29.3	33.2	30.9	28.8	21.9	71.2
pH (1:2 soil:water)	pH	0.1	-	8.42	8.29	8.11	7.98	8.03	7.96	8.07	7.97	7.93	7.94	7.44
Arsenic (As)	mg/kg	0.1	7.24	53.6	51.7	9.61	5.8	2.6	2.8	2.77	4.02	3.04	12.7	12
Cadmium (Cd)	mg/kg	0.02	0.7	0.434	0.296	0.685	1.01	0.612	0.358	0.307	0.318	0.275	0.094	2.06
Chromium (Cr)	mg/kg	0.5	52.3	17.8	27.7	14.5	19	10.7	9.63	8.81	15.9	21.6	24.4	27.3
Copper (Cu)	mg/kg	0.5	18.7	69.2	50.7	41.6	64.6	39.2	21.7	29.8	37.3	30.4	58	135
Lead (Pb)	mg/kg	0.5	30.2	33.2	34.1	14.2	18.8	12.7	8.76	9.95	11.5	9.59	10.1	43.1
Mercury (Hg)	mg/kg	0.05	0.13	<0.050	<0.050	<0.050	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.155
Zinc (Zn)	mg/kg	2	124	296	182	160	208	140	88	81.8	94.7	75.6	62.2	361
EPH10-19	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
EPH19-32	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	530
LEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
HEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	520
Acenaphthene	mg/kg	0.005	0.00671	0.0114	0.0437	0.369	0.308	0.0179	0.0206	0.0236	<0.017 DLCI	0.0724	<0.0050	0.293
Acenaphthylene	mg/kg	0.005	0.00587	<0.0050	<0.0050	0.021	0.0461	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.0129	<0.0050	0.134
Anthracene	mg/kg	0.004	0.0469	0.0368	0.0633	0.307	0.501	0.0387	0.0748	0.0987	0.0241	0.0823	0.0148	1.24
Benz(a)anthracene	mg/kg	0.01	0.0748	0.075	0.149	0.668	1.11	0.142	0.119	0.228	0.093	0.366	0.038	2.7
Benzo(a)pyrene	mg/kg	0.01	0.0888	0.042	0.092	0.274	0.647	0.137	0.093	0.185	0.081	0.407	0.03	1.54
Chrysene	mg/kg	0.01	0.108	0.079	0.175	0.621	1.02	0.163	0.204	0.256	0.104	0.526	0.054	2.54
Dibenz(a,h)anthracene	mg/kg	0.005	0.00622	0.0058	0.0135	0.0356	0.0866	0.0212	<0.020 DLCI	0.0271	<0.017 DLCI	0.0606	<0.0050	0.177
Fluoranthene	mg/kg	0.01	0.113	0.242	0.497	2.79	3.82	0.432	0.467	0.651	0.275	1.14	0.09	9.54
Fluorene	mg/kg	0.01	0.0212	0.013	0.035	0.335	0.291	0.02	0.031	0.034	<0.017 DLCI	0.073	<0.010	0.351
2-Methylnaphthalene	mg/kg	0.01	0.0202	<0.010	<0.010	0.049	0.088	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.02	<0.010	0.074
Naphthalene	mg/kg	0.01	0.0346	0.011	0.011	0.094	0.164	0.012	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.032	<0.010	0.135
Phenanthrene	mg/kg	0.01	0.0867	0.051	0.199	1.12	1.6	0.156	0.143	0.231	0.069	0.699	0.024	1.71
Pyrene	mg/kg	0.01	0.153	0.128	0.295	1.57	2.37	0.329	0.24	0.447	0.189	0.845	0.055	5.13

Color Key:	Within Guideline	Exceeds Guideline	Detection Limit Raised: Chromatographic Interference due to co-elution (DLCI).

6.8.1.2 Probable Effects Level

Synoptically collected chemical and biological data (co-occurrence data) are evaluated from numerous individual studies to establish an association between the concentration of each chemical measured in the sediment and any adverse biological effect observed (Canadian Environmental Quality Guidelines for the Protection of Aquatic Life, CCME, 2001). The co-occurrence data are compiled in a database referred to as the Biological Effects Database for Sediments (BEDS). The upper value, referred to as the probable effect level (PEL), defines the level above which adverse effects are expected to occur frequently.

Analytical results shown in Appendix A5 indicate that metals (i.e., zinc, copper, arsenic) were detected at concentrations greater than CCME PEL standards in three sediment samples. Sediment Sample 1, located west of the logging barge within the dredged channel had elevated concentrations of arsenic and zinc. Sediment Sample 2 had elevated concentrations of arsenic. Sediment Sample 12, located immediately east of the floating repair facility, had elevated concentrations of copper and zinc.

Analytical results shown in Appendix A5 indicate that various PAHs were detected at concentrations greater than CCME PEL standards in four of the sediment samples. Samples 3 and 4, located south of the load-out pier within the dredged channel, had elevated concentrations of 8 and 9 PAH analytes, respectively. Sediment Sample 12, located immediately east of the floating repair facility, had elevated concentrations of all 12 PAH analytes. The duplicate sediment sample obtained from the site of Sample 10 also had elevated concentrations of two PAH analytes (Chrysene and Phenanthrene), while Sample 10 did not exceed CCME PEL standards for these analytes. This indicates that concentrations are highly spatially variable. All other PAH analytes for sediment Sample 10 and its duplicate were within CCME PEL standards.

6.8.2 *Disposal at Sea Regulation* of the *Canadian Environmental Protection Act 1999*

Disposal at Sea Regulation (DSR) criteria are only applicable to cadmium and mercury. Analytical results, as shown in Appendix A6, indicate that sediment Samples 3, 4 and 5, located south and immediately west of the load-out pier, exceeded the criteria for cadmium. As well as Sample 12, located immediately east of the floating repair facility. Analytical results for mercury did not exceed DSR criteria.

PAHs were detected at concentrations greater than DSR criteria for Total PAH in Samples 3, 4, 9 and 12 (Appendix A6). The duplicate sediment sample obtained at the site of Sample 10 also had elevated concentrations of Total PAH, while sediment Sample 10 did not exceed DSR standards for Total PAH. This indicates that concentrations are highly spatially variable. (Appendix A6).

6.8.3 British Columbia Contaminated Sites Regulation Stage 10 Amendment (Nov 2017) ï Schedule 3.4 Sediment Standards Marine and Estuarine Water (Typical)

Analytical results as shown in Appendix A7 indicate that metals (zinc, copper, arsenic) were detected at concentrations greater than CSR SEDQ standards in three sediment samples. Sediment Samples 1 and 2, located west of the logging barge within the dredged channel had elevated concentrations of copper and arsenic. Sediment Sample 12, located immediately east of the floating repair facility, had elevated concentrations of copper and zinc.

Analytical results shown in Appendix A7 indicate that various PAHs were detected at concentrations greater than CSR SEDQ standards in three sediment samples. Sediment Samples 3 and 4, located south of the load-out pier within the dredged channel, had elevated concentrations of 5 and 8 PAH analytes, respectively. Sediment Sample 12, located immediately east of the floating repair facility, had elevated concentrations of 10 PAH analytes above the CSR standards. The duplicate sediment sample obtained at the site of Sample 10 also had elevated concentrations of the PAH analyte Phenanthrene, while sediment Sample 10 did not exceed CSR SEDQ PAH standards. This indicates that concentrations are highly spatially variable. All other PAH analytes for sediment Sample 10 and its duplicate were within CSR SEDQ standards.

7.0 HABITAT QUALITY SUMMARY

Natural habitat within the Study Area is highly disturbed and modified (Section 4.0) because of industrial use since the early 20th century. Infrastructure that has been put in place for Seaspan Shipyard activities determines the habitat quality present within the Study Area. Figure 7.1 illustrates the habitat quality based on the results of this habitat assessment.

A variety of marine organisms were observed during the field study; however, the distribution of organisms is primarily limited to two locations where habitat features are present, namely rip-rap and piles (Section 6.0). Rip-rap placed around the base of the load-out pier provides habitat for most of the marine organisms observed including fish, crustaceans and marine algae. The highest abundance of crustaceans was observed around piers and rip-rap between the permanently moored logging barge and the Eastern Spit, a location that is relatively undisturbed by boat traffic. These areas were assessed as moderate habitat quality.

The dredge channel and intertidal areas contained the least habitat value. Sporadic marine algae were observed growing in these locations, and marine organisms were limited to occasional sightings of crustaceans. The intertidal area contained very low numbers of bi-valves. These areas are exposed to significant prop wash from tugboats and historically from sediment discharge when the creek flowed into the east basin resulting in sediment deposition. These areas were assessed as low habitat quality.

The proposed JSS Load-Out Gravel Bed would affect a portion of moderate quality habitat between the permanently moored logging barge and the Eastern Spit (Figure 7.1). As well as a portion of low quality habitat present within the subtidal nearshore dredge channel and cut slope (Figure 5.1 and Figure 7.1). The East Infill would affect an area of moderate quality habitat around the load-out pier and south of where the floating repair facility is located (Figure 5.1 and Figure 7.1). As well as low quality subtidal habitat present within the nearshore cut slope and the intertidal area (Figure 5.1 and Figure 7.1).

Habitat quality in the Study Area has further been affected by the poor sediment quality in some locations, as discussed in Section 6.8. The area of the East Infill to the east of the floating repair facility (Sediment Sample 12) had the highest levels of contamination.

Figure 7.1 Habitat quality map.

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APPENDICES

Appendix A1

Hatfield SOP 7 Sediment/Soil

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1.0 SEDIMENT/SOIL QUALITY SURVEYS

Aquatic bottom sediment is collected for analysis of physical, chemical or toxicological characteristics in an effort to assess sediment quality. Sediment quality surveys are often conducted concurrently with water quality surveys and biological monitoring to determine if there is a relationship between environmental quality and the health of resident biota. In addition, sediment quality surveys are conducted to evaluate changes in environmental quality over time and/or space.

Soil surveys are conducted in areas that may contain contamination from toxic substances. These soils have the potential to affect water supplies and food resources.

2.0 PREPARATION FOR FIELD PROGRAMS

General tasks to be completed in preparation for conducting a sediment quality field survey are consistent with those outlined in SOP 1, General Information, and SOP 8, Water Quality, with the exception of needing specific sediment sample containers and sampling equipment (see Section 1.6).

3.0 DATA COLLECTION

Field notes and measurements should be recorded on the sample sediment quality data sheet (Figure 1) and/or in a waterproof field book. A detailed list of data that should be recorded at each site is provided in SOP 1, including supporting *in situ* field water quality data. The following supplemental information should also be recorded:

- Details pertaining to unusual events that might have occurred during the operation of the sampler (e.g., possible sample contamination, equipment failure, unusual appearance, control of vertical descent of the sampler, etc.);
- Any deviations from standard operating procedures or Field Work Instructions (FWIs);
- Sediment characteristics, such as texture, colour, biological components and structure (e.g., shells, tubes, macrophytes), debris (e.g., wood chips, plant fibers), presence of oily sheen and obvious odours;
- Characteristics of the vertical profile, including the presence and depth of distinct layers (more appropriate for core samplers); and
- Depth of penetration of the sediment sampler and/or fullness of sediment of grab.

Figure 1 Sample sediment quality data sheet.

EEM Benthos/Sediment/Water Collection **Project No.**

Station ID: **Name:**

Area (R,N,F)	Area-ID (01,02)	UTM Easting / Longitude	UTM Northing / Latitude
Date (yyyy/mm/dd)	Time (24 hr)	Weather	Crew
			NH MD DM NB
Photo Numbers	Disc Number(s)	Collection Method	Recorded by
		Van Veen Grab	

Near-Bottom Water Quality Comments:

Depth (m)	Dissolved Oxygen (mg/L)	Temp. (°C)	Salinity (ppt)
UTM Easting / Longitude	UTM Northing / Latitude	Equipment, Serial #	

Benthos Subsample 1	Benthos ID	TOC / Tot-N sample ID	Redox / Tot-SO_3 sample ID
UTM Easting / Longitude	UTM Northing / Latitude	Depth (m)	Subsample Area (cm^2)

Comments:

Benthos Subsample 2	Benthos ID	TOC / Tot-N sample ID	Redox / Tot-SO_3 sample ID
UTM Easting / Longitude	UTM Northing / Latitude	Depth (m)	Subsample Area (cm^2)

Comments:

Benthos Subsample 3	Benthos ID	TOC / Tot-N sample ID	Redox / Tot-SO_3 sample ID
UTM Easting / Longitude	UTM Northing / Latitude	Depth (m)	Subsample Area (cm^2)

Comments:

Sediment Grain Size Subsample 4	Sed Grain Size ID		
UTM Easting / Longitude	UTM Northing / Latitude	Depth (m)	Subsample Area (cm^2)
			composite of 1 full grab

Comments:

4.0 SAMPLE COLLECTION

Sediment sampling methods follow those used in the RAMP program (Golder 1998) or guidance prepared by federal and provincial agencies (Environment Canada 2002; 2005; BC WLAP 2003).

4.1 SAFETY

Sample and data collections are always determined by site conditions that might affect the safety of the field crew. When safety may be compromised due to site conditions, sampling must be relocated or postponed.

4.2 SEDIMENT SAMPLERS

Two types of sediment samplers are used for sediment surveys of lotic and lentic depositional habitats: a) grab samplers or dredges; and b) sediment core samplers. Grab samplers, such as an Ekman or Ponar grab, (Figure 2), are used the majority of the time and collect surface sediments to assess the horizontal distribution of sediment quality/characteristics. These grabs are also used for the collection of benthic invertebrate samples from depositional habitats. Core samplers (Figure 2) are used to collect a depth profile of sediments, allowing assessment of vertical distribution of variables and long-term changes in sediment quality/characteristics. Core samplers are used infrequently, but are useful for studies focusing on time trends in chemicals and sedimentation rates. Sampling equipment should be chosen based on survey objectives, site conditions and the volume of sediment required for analysis. The advantages and disadvantages of common grab devices are outlined in Table 1 (Environment Canada 2005). All equipment should be made of stainless steel, particularly when sampling for the analyses of metals or organic compounds.

Step-by-step instructions for the collection of grab samples (using an Ekman or Ponar grab) are as follows:

1. Prior to collecting the sample, rinse/clean the grab sampler (jaws open) and all other equipment (i.e., stainless steel pans and spoon) that will come into contact with the sample (see Section 1.3.3) to prevent contamination;

2. Set the grab into the open position. Using a graduated rope attached to the top of the sampler, slowly lower the grab until it touches the bottom. If using an Ekman grab, ensure the messenger (small weight used to trigger the sampler) remains at the surface;

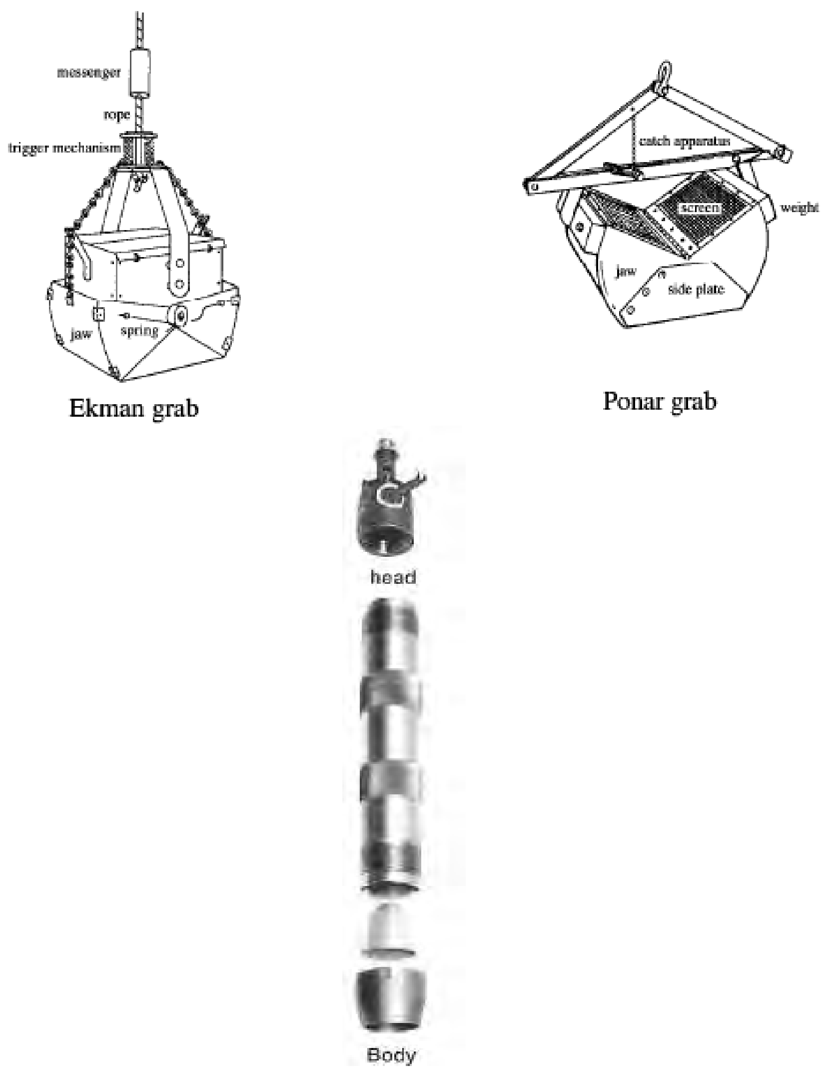
3. Trigger the sampler. The Ponar grab will trigger automatically as soon as it contacts the sediment bed; however, for the Ekman grab, release the messenger while ensuring the graduated line is as vertical as possible; maintain some tension in the line so that the messenger falls freely and trips the jaws of the grab;

4. Once the jaws of the sampler have been triggered closed, begin to slowly raise the sampler off the bottom (fine sediments may be lost if the sampler is raised too quickly);

5. Ensure the sample meets acceptability criteria (e.g., desired depth of penetration has been achieved, no loss of sediment sample due to incomplete closure or tilting of the grab sampler). If the criteria are not met, the sample should be discarded in a bucket and another sample collected from the site; and

6. If the sample is acceptable, completely open the jaws and put the sample into a flat-bottomed stainless steel pan. Repeat the collection process until sufficient sediment volume has been collected. Mix all sediments material to obtain a homogenous sample for the labeled, sterilized glass jars and/or re-sealable plastic bags (depending on analyses).

Figure 2 Diagrams of an Ekman and a Ponar sediment grab (BC WLAP 2003) and the Ogeechee sand corer.



Ogeechee Sand Corer

Table 1 Characteristics, advantages, and disadvantages of grab devices and corer(s) used for sediment sample collection.

Grab Sampler/ Dimension	Use	Sediment Depth Sampled (cm)	Volume of Sediment Sample (cm^3)	Advantages	Disadvantages
Smith-McIntyre Grab	Deep Lakes, Rivers, Estuaries	0-30	10,000-20,0000	Designed for sampling hard substrates (rubble or coarse/very coarse unconsolidated bottom).	Loss of fine-grained sediment; heavy – require motorized winch; possible metal contamination.
Ekman Grab – Small	Lakes, Marine Areas Soft Sediments Silt, Sand	0-10	≤ 3,400	Designed for fine-grained soft sediments and mixtures of silt and sand; lightweight and therefore easy to operate manually.	Restricted to low current conditions.
Ekman Grab – Large	Lakes, Marine Areas Soft Sediments, Silt, Sand	0-30	≤ 13,300	Designed for fine-grained soft sediments and mixtures of silt and sand; large sample obtained, permitting subsampling.	Restricted to low current conditions; penetration depth exceeded by weight of sampler in very soft sediment.
Ponar Grab – Standard	Deep Lakes, Rivers, Estuaries Useful for sand, silt, and clay	0-10	7,250	Most universal grab sampler; adequate on most substrates; large sample obtained intact, permitting subsampling; good for coarse and firm bottom sediments.	Shock wave from descent may disturb fine-grained sediment; possible incomplete closure of jaws results in sample loss; possible contamination from metal frame construction.
Petersen Grab	Deep Lakes, Rivers, Estuaries Useful on most substrates	0-30	9,450	Large sample; can penetrate most substrates.	Heavy, likely requires winch; no cover/lid to permit subsampling; all other disadvantages of Ekman and Ponar.
Ogeechee Sand Corer	Bottom sands, shallow waters	0-50	800	Effectively samples bottom sands; made of stainless steel.	Difficult to use in clays, heavy soils.

4.3 GENERAL SAMPLING CONSIDERATIONS

The following protocols should be followed to prevent sample contamination:

- Conduct sampling sequentially from the least to the most contaminated sites (degree of contamination is estimated by site conditions, professional knowledge, etc.);
- Clean all sampling equipment (spoons, pans, grab sampler) before use, following three steps:
  - Rinse equipment with environmental grade hexane and environmental grade acetone (to remove any organic residues);
  - Clean equipment with a solvent, metal-free soap (e.g., Liquinox) to remove any metal residues; and
  - Rinse equipment three times with ambient water downstream of the sampling site.
- Sampling equipment for organics analyses must not be plastic; the container must be a glass bottle provided by the laboratory. Sampling equipment for metals analyses must be stainless steel or plastic (for sample homogenization);
- Wear disposable non-powdered latex gloves throughout the sample collection process;
- Use only grab samples that do not contain large, foreign objects, obtain an adequate penetration depth, and are not overfilled or leaking;
- Transfer sediments from the grab sampler to a cleaned stainless steel pan for compositing using a clean, stainless steel spoon. Avoid direct contact between sediments and gloves;
- During collection of composite samples, keep the composite container covered between grab collections;
- Store sample containers appropriately (i.e., capped and away from potential contamination) in office or storage facilities; and
- Keep sample containers capped at all times except during sample collection. Store sample containers in a clean shipping container (cooler). Vehicle (boat, truck) cleanliness should be maintained at all times to avoid potential sources of contamination.

4.4 DEPOSITIONAL HABITATS

In depositional habitats, the collection of water quality samples from a monitoring site should be completed PRIOR to sediment sampling to avoid disturbing overlying waters.

Grab Samples

The following protocols should be followed when collecting sediment samples for benthic invertebrate, toxicity, and/or chemical analyses:

- Collect the top 2 to 5 cm of each grab sample and transfer to a stainless steel tray using a stainless steel spoon. If required, collect additional grab samples until a sufficient volume of surficial sediment is collected (approximately 1 L of sediment);
- Record the following information on the field datasheet:
  - The number of grab samples collected for composite samples;
  - The general appearance of the sediments, including grain size, presence of a hydrocarbon or biogenic sheen, and presence of debris, plant material, or biota; and
  - Other general information described in Section 3.0.
- Homogenize the sediments and transfer to heat-treated, wide-mouth glass jars with Teflon® lids lined with aluminum foil as needed. Typically, a small jar (125 mL) is collected for analysis of total organic carbon and pH analyses, and a larger jar (250 mL) of sediment is collected for grain size and chemical analyses.
  - For toxicity samples, collect a larger volume of sediment (approximately 3 L of sediment). Transfer the sediments to two 1 L jars or laboratory-supplied sealable plastic bags;
  - For concurrent chemical and grain size analyses, transfer sediments to 125 mL and 250 mL glass jars, as described above; and
  - Each analytical laboratory will have its own protocols, and it is advisable to confirm specifications with each laboratory prior to conducting the sediment survey.
- Place an adhesive label with the sample ID on each jar and secure it with clear tape. Write sample IDs and other relevant information (e.g., type of analyses requested, station ID) on the lid of the jar using a waterproof marker. Attach the duplicate ID label to the field datasheet for each sample collected;
- Double bag toxicity samples and label both bags with an indelible marker; and
- Store all samples in a cooler with ice packs to avoid exposure to heat and light, and ship to the appropriate laboratory for analysis.

Core Samples

Use the Ogeechee sediment corer with the stainless steel liner.

Each core sample consists of a single core, which can be partitioned into 3 samples, 0-15 cm, 15-30 cm and 30+ cm.

Detailed Ogeechee Sand Corer sample collection procedure:

- Clean the stainless steel corer, liner and slide hammer, using techniques outlined in Section 1.3.3;
- Seat the corer at the desired sample collection location (attach enough additional lengths of core handle extensions to ensure the top is above the water surface);
- Either sink the corer into the sample using body pressure, or utilize the slide hammer to pound the corer into the substrate;
- Remove the corer by hand, or use the slide hammer if manual removal is difficult;
- Using gloved hands, remove the core tip and slide the core liner out of the corer;
- Hold the corer at a proper angle to ensure sample is not lost. The liner should be held over a cleaned stainless steel tray at all times;
- Using the cleaned core sample slide plunger, push the required volume of sample out of the liner, and place it into a labeled sample jar. A trowel, knife or spoon may be required to section off the appropriate sample volume from the liner; and
- Store all samples in a cooler with ice packs to avoid exposure to heat and light, and ship to the appropriate laboratory for analysis.

4.5 EROSIONAL HABITATS

In erosional habitats, where substrates with large particle sizes are present (e.g., large gravel, cobble, or boulder), sediments generally are not collected for chemical analyses due to particle size limitations. However, information regarding the bed structure should be collected, including the dominant particle size, degree of embeddedness, matrix, and texture of the substrate. A substrate score, which takes into consideration the particle type/size and degree of embeddedness, is derived using criteria described in Table 2.

Table 2 Criteria used to characterize substrates (adapted from Reynoldson *et al.* 1998).

Particle Type/Size		Embeddedness	
Category	**Score**	**Category**	**Score**
Organic cover (> 50% of surface)	1	Completely embedded	1
< 0.1 to 0.2 cm	2	¾ embedded	2
0.2 to 0.5 cm	3	½ embedded	3
0.5 to 2.5 cm	4	¼ embedded	4
2.5 to 5 cm	5	Unembedded	5
5 to 10 cm	6		
10 to 25 cm	7		
> 25 cm	8		

The substrate score is derived by summing the scores for:

- Size of predominant particle;
- Size of 2^{nd} most predominant particle;
- Size of remaining material; and
- Embeddedness.

In addition, a photographic record should be taken at each station to illustrate the substrate within a 30 x 30 cm grid.

4.6 SAMPLING FROM A BOAT

The collection of deep-water samples requires that at least one member of the sampling group be very familiar with boat operation and safety. If the sampling trip involves the use of a boat, then the weather forecast should be obtained prior to departure; if conditions are poor, the sampling trip should be postponed. Each crewmember must wear a personal flotation device (PFD) at all times.

Collecting river samples from a boat should ideally utilize three people: one to operate the boat and maintain the position during sampling, one to collect the sample from the bow, and one to collect field measurements and take field notes. Samples should be collected moving from the most contaminated sites to least contaminated sites and from downstream to upstream sites. Samples are to be collected using methods described above.

4.7 SOIL SAMPLE COLLECTION

Surface soil sampling will is the same as for sediment (see Section 1.3.3). Each soil sample will consist of a composite of 10 sub-samples. Each sample will utilize a standardized area coverage and spacing system, as follows:

- 5 x 5 m square plot; and
- 2 rows of 5 sub-samples collected at 1m intervals. Rows will be spaced 5 m apart.

All ten samples will be transferred to a clean stainless steel tray, homogenized with a clean stainless steel spoon, and then transferred to a laboratory-supplied sample jar.

Below-surface soil samples will be collected using a soil corer in softer ground, and using stainless steel digging instruments (e.g., spade, chisel) in harder ground.

4.8 SAMPLE SHIPPING

In most cases, samples should be kept cool (e.g., on ice, 4 °C) and dark. Samples should not be allowed to freeze and should be shipped in coolers (with ice-packs) as soon as possible to the appropriate laboratory (keeping in mind appropriate holding times). Avoid use of cube or block ice; the water that leaks with melting may ruin sample labels.

Chain of Custody (COC) and Analytical Request forms must accompany all samples submitted for analysis. These forms are usually combined as a single document and are available in triplicate. The form should be completed and one copy be retained by the field personnel (after the shipper has signed the COC); the remaining two copies are to be sent with the water samples, either inside the shipping container or attached firmly to the outside of the container. The COC forms should be enclosed in a sealed, waterproof bag.

It is important that each person having custody or control of the samples is identified on the COC forms. Typically, this will include the crew who collected the sample, any intermediate persons involved in storing, packaging or transporting the sample, the shipper, and the analytical laboratory that will receive the samples.

5.0 FIELD MEASUREMENTS

Routine field water quality measurements should be taken at each sampling station. Dissolved oxygen, temperature, and specific conductivity are commonly measured in the field using a multi-variable probe (e.g., YSI 85 meter); pH is measured using a pH meter (e.g., Piccolo ATC pH meter [HI 1280]). Dissolved oxygen can also be measured by Winkler titration; the LaMott portable Winkler titration kit has often been used in the field.

Additional information on water quality field measurements can be found in SOP 8 (Water Quality).

6.0 SEDIMENT QA/QC SAMPLES

QA/QC samples are collected to evaluate environmental heterogeneity and to assess potential contamination from sample preparation, handling, or analysis. Sediment QA/QC samples include cross-contamination samples and field duplicates. Gloves must be changed prior to collection of QA/QC samples, as well as between stations. A complete set of QA/QC samples is to be collected from a randomly selected station(s). The number of QA/QC samples collected must be equal to 5% to 10% of the total number of composite samples collected (e.g., collect one set of QA/QC samples for every 5 or 10 stations sampled).

Cross-contamination blanks are used to ensure that procedures used to clean equipment between stations are effective. Two different methods can be used for cross-contamination blanks, depending on the size of the grab sampler used for sample collection.

- **Small grab samplers (e.g., Ekman or Petite Ponar)** – Equipment must be cleaned as described in Section 1.3.3. Place sampling equipment, including the grab sampler and spoon, in a metal tray and rinse a fourth time with de-ionized, distilled water. Collect rinsate in the tray for analysis to evaluate possible cross-contamination between stations. Rinsate samples are treated and analyzed as water samples;
- **Large grab samplers (e.g., Standard Ponar, Smith-McIntyre)** – Equipment must be cleaned as described above. Swipe the entire inside and outside of the grab sampler and spoon with 2”X 2” cotton gauze pads (i.e., swabs). For PAH or dioxin and furan samples, presoak the swab in a 1:1 acetone/hexane mixture. Place the swab in a sample container and treat it like a sediment sample. Place samples collected for PAH or dioxin and furan analysis in an amber glass jar; and
- **Rinsate blanks**, comprised of de-ionized, distilled water, **or swab blanks**, comprised of a clean swab placed in a sample container, should be collected prior to sample collection (analogous to trip blanks). The number of cross-contamination samples and blanks collected should be equal to 5% to 10% of the total number of stations.

To identify potentially contaminated samples, the cross-contamination swab/rinsate and swab/rinsate blanks are compared to each other. Concentrations of analytes in the cross-contamination blanks and filter blanks should be similar. Analyte concentrations in these blanks are also compared to detection limits; however, the swabs may contain some analytes at concentrations greater than detection limits. For most analytes, blanks with contaminant concentrations greater than 5 times the detection limits represent samples that were potentially contaminated during sample collection, shipping, or analysis.

Field duplicates are used to assess the precision of the field sampling and heterogeneity of sediments collected from the same location by collecting a replicate sample. The relative percent difference (RPD) between field duplicates is determined to assess the precision of the analyses and heterogeneity of the sample. Relative percent difference is calculated as:

$$|(A–B) / [(A+B)/2] * 100\%|$$

Analyte concentrations differing by more than 20% between samples and at least five times above detection limits are considered to exhibit higher variability than expected due to analytical error.

7.0 GENERAL EQUIPMENT AND SUPPLIES FOR SEDIMENT OR SOIL QUALITY SURVEYS

The following is a list of sampling equipment and supplies generally recommended for collecting sediment or soil samples:

Sampling and Documentation

- Pre-cleaned field sample containers (obtained from the analytical lab) of appropriate type and number for desired analyses, including containers for cross-contamination samples and blanks;
- Latex gloves;
- Sample preservatives;
- Ice packs/coolers;
- Waterproof labels, permanent markers and pencils;
- Field logbooks/binders;
- Maps, air photos, GPS unit, compass;
- Written protocols and procedures for sample collection and equipment operation, including FWIs;
- Field equipment (e.g., grab sampler or corer, sampling tools, water quality meters), spare parts, and repair equipment (duct tape, silicon lubricant, toolbox, socket set, etc.);
- Camera or video equipment as required;
- Laboratory Chain of Custody/Analytical Request forms; and
- Transportation (truck, ATVs, boat, snowmobile, helicopter).

Health and Safety

- Personal gear for all possible field and weather conditions (e.g., survival suits, rainjackets/rainpants, appropriate footwear, waders, gloves, hat, change of clothes);
- First aid kit and survival kit;
- Personal floatation device for each crew member for deep water or boat work;
- Boat safety equipment including paddles, painters, bailer, throw-bag and whistle;
- Communication device (satellite phone when access is other than helicopter) and list of emergency phone numbers;
- Wool blankets and emergency food and clothing;
- Buggy whip, hard hats, blue light, reflective vests if accessing oil sands mine site; and
- Spare jerry can of fuel, tow-rope, shovel and pick if access is by truck.

8.0 REFERENCES

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Reynoldson TB, Logan C, Milani D, Pacoe T, Thompson SP. 1998. Protocols for reference condition data bases: Field sampling, sample, and data management of benthic community structure and environmental attributes in aquatic ecosystems. NWRI Report No. 98-129. Environment Canada, Burlington, Ontario. 69 pp.

Appendix A2

Marine Organisms Identified During Field Survey

	TR 1			TR 2			TR 3			TR 4			TR 5			TR 6		
	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	South	Mid	North	West	Mid	East
SUBSTRATE (%)																		
Boulder						5	5	5	70			80			85	85	85	70
Cobbles		10		10	30	25	25	45	10	10	10	10	25	40	5	5	5	10
Gravel	10	30	30	60	40	50	25	30	10	50	50	5	50	35				10
Fines	90	60	70	30	30	30	45	20	10	40	40	5	25	25	10	10	10	10
VEGETATION																		
Brown Algae (Phaeophyta spp.)				Throughout	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal	Abundant*	Trace	Minimal	Abundant	Abundant	Abundant	Abundant
Red Algae (Rhodophyta spp.)				Trace	Trace	-	Trace	Trace	Minimal	-	-	Abundant*	-	-	Abundant	Abundant	Abundant	Abundant
Green Algae (Chlorophyta spp.)			trace ulva	Throughout	Minimal	Throughout	Minimal	Minimal	Minimal	Minimal	Minimal	Abundant*	-	-	Abundant	Abundant	Abundant	Abundant
Other/notes		trace		OM on bottom	OM on bottom	Ulva on rocks at N end		Growth concentrated on rocks	Algae concentrated on riprap			*on Riprap features			RipRap features	RipRap features	RipRap features	RipRap features
CRA FISHERY SPECIES																		
Salmonids																		
Pink salmon (Oncorhynchus gorbuscha)																		
Chum salmon (O. keta)																		
Coho salmon (O. kisutch)																		
Chinook salmon (O. tshawytscha)																		
Sockeye salmon (O. nerka)																		
Steelhead trout (O. mykiss)																		
Cutthroat trout (O. clarkii)																		
Rough fish																		
Lingcod (Ophiodon elongatus)																	1	
Rockfish (Sebastes spp.)																		
Kelp greenling (Hexagrammos decagrammus)															1		1	
Pacific herring (Clupea pallasii)																		
Northern anchovy (Engraulis mordax)																		
Flatfish																		
English sole (Pleuronectes vetulus)																		
Rock sole (Lepidopsetta bilineata)																		
Dover sole (Microstomus pacificus)																		
Starry flounder (Platichthys stellatus)																		
Crustaceans																		
Red rock crab (Cancer productus)				3				1	1	4		1			3	1	1	
Dungeness crab (Cancer magister)	5			7	14	10	3	9	2	9	7	6	11	12	9	4	1	1
Shrimp (Pandalus spp.)											1	1		1				
Bivalves (Bivalvia)																		
Bivalvia Spp.	21					5					1	2						
Invertebrates																		
Asteroidea				2		1		1	2			3			2		1	
Polychaeta																		
oligochaeta																		
aplacophora																		
scphopoda																		
isopoda																		
cumacea																		
decapoda																		
mysidacea																		
amphipoda																		
sipunculida																		
nemerta																		
holothuroidea																		
Ophiuroidea																		
OTHER AQUATIC SPECIES																		
Cnidaria Spp. (Jellyfish/anemone)										2	1	2	2	1				
Shiner surfperch (Cymatogaster aggregate)												8			11	11		
Blackbelly eelpout (Lycodopsis pacifica)																		
Staghorn Sculpin (Leptocottus armatus)																		
Arrow goby (Ptereleotris evides)																		
Gunnels (Pholis lata, Apodichtys flavidus, P. ornate)							1											
Three-spined stickleback (Gasterosteus aculeatus)							1											
Sculpins (Clinocottus acuticeps, Oligocottus maculosus)											1							
Bay pipefish (Sygnathus leptorhynchus)					1													
AQUATIC SPECIES AT RISK																		
Bluntnose Sixgill Shark																		
Green Sturgeon																		
Grey Whale																		
Harbour Porpoise																		
Humpback Whale																		
Killer Whale																		
Leatherback Sea Turtle																		
Nooksack Dace																		
Northern Abalone																		
Rougheye Rockfish type I																		
Rougheye Rockfish type II																		
Steller Sea Lion																		
Yelloweye Rockfish																		
Yelloweye Rockfish																		

Appendix A3

Habitat Assessment Photos

FIELD PHOTOS

Transect 1

Photo 1 East Infill basin looking east from end point of Transect 1

Photo 2 East Infill basin looking north from end point of Transect 1

Photo 3 East Infill basin looking west from end point of Transect 1

Photo 4 Transect 1 sea bottom start of video survey

Photo 5 Transect 1 sea bottom middle of video survey

Photo 6 Transect 1 sea bottom end of video survey

Transect 2

Photo 7 Pier pilons connecting permanently moored barge to eastern spit at start p of transect 2

Photo 8 East Infill basin looking south from end of Transect 2

Photo 9 Transect 2 Sea bottom start of video survey

Photo 10 Transect 2 sea bottom middle of video survey.

Photo 11 Transect 2 moderate quality habitat

Photo 12 Transect 2 sea bottom end of video survey

Transect 3

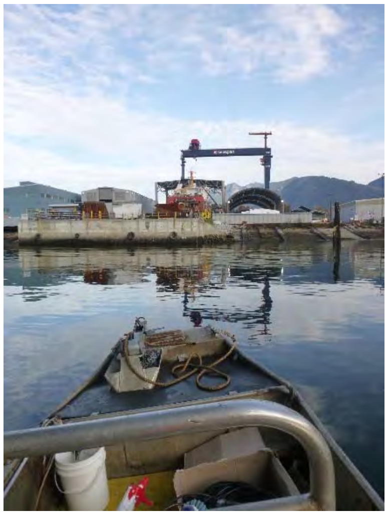

Photo 13 Looking north to load out quay from start point of Transect 3

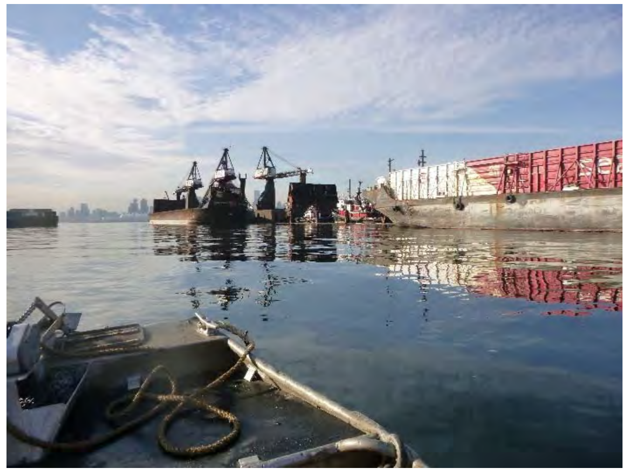

Photo 14 Looking southwest of Study Area from end point of Transect 3

Photo 15 Transect 3 sea bottom start of video survey

Photo 16 Transect 3 sea bottom middle of video survey

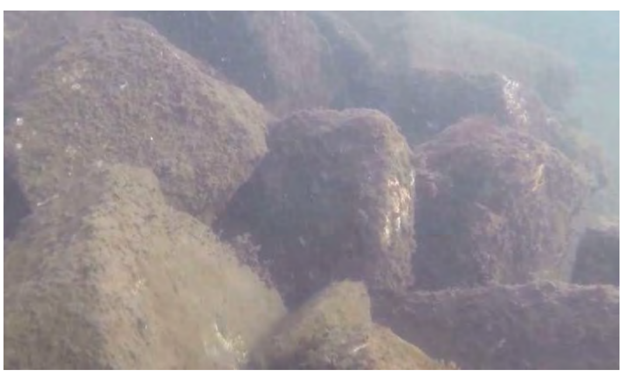

Photo 17 Transect 3 sea bottom end of video survey

Photo 18 Transect 3 moderate quality habitat

Photo 19 Transect 3 bay pipefish

Photo 20 Transect 3 Starfish

Transect 4

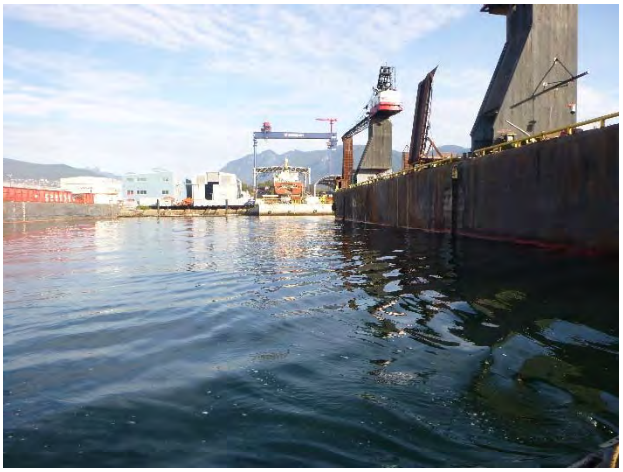

Photo 21 Transect 4 looking north from start of video survey

Photo 22 Transect 4 sea bottom start of video survey

Photo 23 Transect 4 sea bottom middle of video survey

Photo 24 Transect 4 sea bottom end of video survey against the base of the load out quay

Photo 25 Transect 4 Sawn off pier pilon near endpoint of video survey

Photo 26 Transect 4 moderate quality habitat near endpoint of video survey

Transect 5

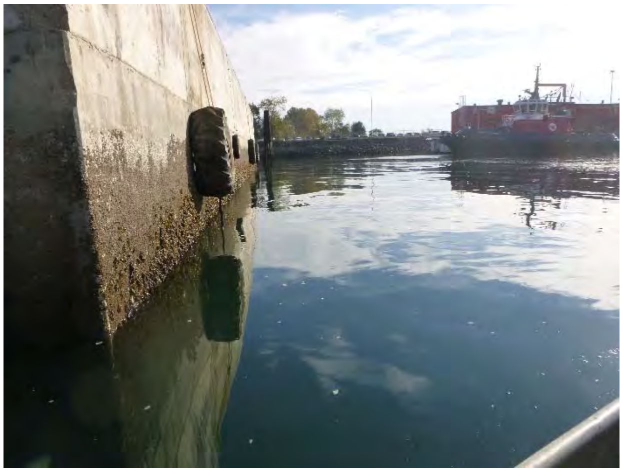

Photo 27 Transect 5 looking east along base of load out key end point of video survey

Photo 28 Transect 5 sea bottom start of video survey

Photo 29 Transect 5 sea bottom middle of video survey

Photo 30 Transect 5 sea bottom end of video survey

Photo 31 Transect 5 moderate quality habitat at base of load out quay

Tansect 6

Photo 32 Transect 6 looking north along western edge of load out quay at start of video survey

Photo 33 Transect 6 sea bottom at start of video survey

Photo 34 Transect 6 kelp bed

Photo 35 Transect 6 sea bottom at middle of video survey

Photo 36 Transect 6 sea bottom at end of video survey

Appendix A4

Sediment Sampling Results Measured Against CCME ISQGs

ALS		Sample ID		SS1	SS2	SS3	SS4	SS5	SS8	SS9	SS10	DUP	SS11	SS12
10/29/2018		ALS ID		L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10	L2183716-11
L2183716		Date Sampled		10/18/2018 11:10:00 AM	10/18/2018 11:58:00 AM	10/18/2018 12:25:00 PM	10/18/2018 12:16:00 PM	10/18/2018 12:44:00 PM	10/18/2018 1:15:00 PM	10/18/2018 1:31:00 PM	10/18/2018 1:44:00 PM	10/18/2018 12:00:00 AM	10/18/2018 1:50:00 PM	10/18/2018 2:01:00 PM
Moisture+A1:E16	Units	LOR	CCME ISQGs	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Moisture	%	0.25	-	16.1	20.2	24.4	51.7	30.6	29.3	33.2	30.9	28.8	21.9	71.2
pH (1:2 soil:water)	pH	0.1	-	8.42	8.29	8.11	7.98	8.03	7.96	8.07	7.97	7.93	7.94	7.44
Aluminum (Al)	mg/kg	50	-	8460	9830	10000	11100	9870	9090	9210	9450	9250	8470	11800
Antimony (Sb)	mg/kg	0.1	-	13.2	25.8	2.11	0.9	0.3	0.34	0.45	1.04	0.68	0.62	1.19
Arsenic (As)	mg/kg	0.1	7.24	53.6	51.7	9.61	5.8	2.6	2.8	2.77	4.02	3.04	12.7	12
Barium (Ba)	mg/kg	0.5	-	34.7	33.6	37.7	34	25.1	19.8	21.3	20	20.1	17.6	45.4
Beryllium (Be)	mg/kg	0.1	-	<0.10	<0.10	<0.10	0.16	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.24
Bismuth (Bi)	mg/kg	0.2	-	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	mg/kg	5	-	6.7	10.1	12.6	22.3	9.6	9.5	9.5	8.3	9.2	8.3	100
Cadmium (Cd)	mg/kg	0.02	0.7	0.434	0.296	0.685	1.01	0.612	0.358	0.307	0.318	0.275	0.094	2.06
Calcium (Ca)	mg/kg	50	-	32000	7450	43900	15300	8100	4980	4680	4360	3810	4110	30400
Chromium (Cr)	mg/kg	0.5	52.3	17.8	27.7	14.5	19	10.7	9.63	8.81	15.9	21.6	24.4	27.3
Cobalt (Co)	mg/kg	0.1	-	5.33	6.31	4.9	4.93	3.6	3.67	3.48	3.46	3.91	4.7	5.73
Copper (Cu)	mg/kg	0.5	18.7	69.2	50.7	41.6	64.6	39.2	21.7	29.8	37.3	30.4	58	135
Iron (Fe)	mg/kg	50	-	19100	35000	16600	16200	10700	10400	9930	10900	10700	18900	21200
Lead (Pb)	mg/kg	0.5	30.2	33.2	34.1	14.2	18.8	12.7	8.76	9.95	11.5	9.59	10.1	43.1
Lithium (Li)	mg/kg	2	-	9.3	11.8	12.1	13.5	12.9	10.6	12.2	10.7	11.7	11.1	13.7
Magnesium (Mg)	mg/kg	20	-	4800	4910	5320	5950	4340	3920	4220	3990	4800	4050	9290
Manganese (Mn)	mg/kg	1	-	228	325	203	219	183	187	179	170	185	235	204
Mercury (Hg)	mg/kg	0.05	0.13	<0.050	<0.050	<0.050	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.155
Molybdenum (Mo)	mg/kg	0.1	-	4.58	5.27	1.68	1.76	0.89	0.88	0.61	0.83	0.66	3.59	4.33
Nickel (Ni)	mg/kg	0.5	-	8.06	13.5	9.15	10.2	5.37	4.53	4.86	6.05	9.17	19.1	15.9
Phosphorus (P)	mg/kg	50	-	501	533	437	483	331	314	343	353	326	283	810
Potassium (K)	mg/kg	100	-	1150	1300	1480	1300	910	870	870	920	880	760	2270
Selenium (Se)	mg/kg	0.2	-	<0.20	<0.20	<0.20	0.24	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.68
Silver (Ag)	mg/kg	0.1	-	<0.10	0.36	0.1	0.19	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.28
Sodium (Na)	mg/kg	50	-	3610	4620	5650	7130	4090	3530	3980	3590	4130	3600	21700
Strontium (Sr)	mg/kg	0.5	-	104	46.9	237	97.5	61.6	36.5	38.4	35.7	30.6	38	174
Sulfur (S)	mg/kg	1000	-	2200	2300	4000	4700	2000	2100	1600	<1000	1200	<1000	14900
Thallium (Tl)	mg/kg	0.05	-	0.072	0.071	0.089	0.095	0.066	<0.050	0.06	0.05	<0.050	<0.050	0.18
Tin (Sn)	mg/kg	2	-	3.5	4.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.4
Titanium (Ti)	mg/kg	1	-	517	506	614	657	608	548	557	527	553	482	676
Tungsten (W)	mg/kg	0.5	-	0.97	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.71
Uranium (U)	mg/kg	0.05	-	0.911	0.858	0.937	0.756	0.64	0.456	0.435	0.477	0.453	0.35	1.86
Vanadium (V)	mg/kg	0.2	-	37.5	34.9	38	37.3	27.5	26.5	25.6	31.3	29.5	25.6	48.9
Zinc (Zn)	mg/kg	2	124	296	182	160	208	140	88	81.8	94.7	75.6	62.2	361
Zirconium (Zr)	mg/kg	1	-	1.6	1.1	1.7	1.9	1.1	<1.0	1.1	1.1	<1.0	<1.0	4.9
EPH10-19	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
EPH19-32	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	530
LEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
HEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	520
2-Bromobenzotrifluoride	%	Surrogate	-	159.4 *	158.6 *	159.6 *	96.5	98	94.1	96.8	94.6	94.7	173.8 *	96.8
Acenaphthene	mg/kg	0.005	0.00671	0.0114	0.0437	0.369	0.308	0.0179	0.0206	0.0236	<0.017 DLCI	0.0724	<0.0050	0.293
Acenaphthylene	mg/kg	0.005	0.00587	<0.0050	<0.0050	0.021	0.0461	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.0129	<0.0050	0.134
Anthracene	mg/kg	0.004	0.0469	0.0368	0.0633	0.307	0.501	0.0387	0.0748	0.0987	0.0241	0.0623	0.0148	1.24
Benz(a)anthracene	mg/kg	0.01	0.0748	0.075	0.149	0.668	1.11	0.142	0.119	0.228	0.093	0.366	0.038	2.7
Benzo(a)pyrene	mg/kg	0.01	0.0888	0.042	0.092	0.274	0.647	0.137	0.093	0.185	0.081	0.407	0.03	1.54
Benzo(b&j)fluoranthene	mg/kg	0.01	-	0.079	0.159	0.526	1.11	0.23	0.162	0.312	0.149	0.652	0.06	2.87
Benzo(b+j+k)fluoranthene	mg/kg	0.015	-	0.11	0.223	0.73	1.55	0.322	0.236	0.438	0.206	0.922	0.083	3.94
Benzo(g,h,i)perylene	mg/kg	0.01	-	0.014	0.035	0.085	0.218	0.068	0.045	0.085	0.036	0.24	0.013	0.465
Benzo(k)fluoranthene	mg/kg	0.01	-	0.031	0.063	0.204	0.433	0.092	0.074	0.126	0.057	0.27	0.023	1.07
Chrysene	mg/kg	0.01	0.108	0.079	0.175	0.621	1.02	0.163	0.204	0.256	0.104	0.526	0.054	2.54
Dibenz(a,h)anthracene	mg/kg	0.005	0.00622	0.0058	0.0135	0.0356	0.0866	0.0212	<0.020 DLCI	0.0271	<0.017 DLCI	0.0606	<0.0050	0.177
Fluoranthene	mg/kg	0.01	0.113	0.242	0.497	2.79	3.82	0.432	0.467	0.651	0.275	1.14	0.09	9.54
Fluorene	mg/kg	0.01	0.0212	0.013	0.035	0.335	0.291	0.02	0.031	0.034	<0.017 DLCI	0.073	<0.010	0.351
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01	-	0.018	0.049	0.121	0.292	0.086	0.053	0.114	0.049	0.285	0.018	0.646
1-Methylnaphthalene	mg/kg	0.05	-	<0.050	<0.050	<0.050	0.063	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	mg/kg	0.01	0.0202	<0.010	<0.010	0.049	0.088	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.02	<0.010	0.074
Naphthalene	mg/kg	0.01	0.0346	0.011	0.011	0.094	0.164	0.012	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.032	<0.010	0.135
Phenanthrene	mg/kg	0.01	0.0867	0.051	0.199	1.12	1.6	0.156	0.143	0.231	0.069	0.699	0.024	1.71
Pyrene	mg/kg	0.01	0.153	0.128	0.295	1.57	2.37	0.329	0.24	0.447	0.189	0.845	0.055	5.13
Quinoline	mg/kg	0.05	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthene d10	%	Surrogate	-	72	75	72.5	110.9	108.6	75.7	112	93.5	89.3	82.8	121.3
Chrysene d12	%	Surrogate	-	85.5	85	84.6	117.9	117.6	69.6	118.7	96.4	97.1	95.4	129.4
Naphthalene d8	%	Surrogate	-	68	76.5	69	115.1	111.5	73.8	115.4	94.7	94.5	84.3	123.3
Phenanthrene d10	%	Surrogate	-	80	81	80	118.3	114.7	76	116.8	98.4	98.3	90.6	129.1
B(a)P Total Potency Equivalent	mg/kg	0.02	-	0.07	0.149	0.469	1.04	0.215	0.146	0.294	0.126	0.633	0.047	2.47
IACR (CCME)	mg/kg	0.15	-	1.1	2.25	7.84	15.8	3.02	2.25	4.23	1.9	8.63	0.76	39.3

* = Result Qualified — Mouse-over the result to see the qualification.

Applied Guideline: **British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water(Typical)**

Color Key: Within Guideline | Exceeds Guideline

HATFIELD CONSULTANTS
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North Vancouver BC V7P 0A3

Date Received: 18-OCT-18
Report Date: 29-OCT-18 13:31 (MT)
Version: FINAL

Client Phone: 604-926-3261

Certificate of Analysis

Lab Work Order #: L2183716
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 17-720221
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18
	Sampled Time	11:10	11:58	12:25	12:16	12:44
	Client ID	SS1	SS2	SS3	SS4	SS5
SOIL						
Physical Tests	Moisture (%)	16.1	20.2	24.4	51.7	30.6
	pH (1:2 soil:water) (pH)	8.42	8.29	8.11	7.98	8.03
Metals	Aluminum (Al) (mg/kg)	8460	9830	10000	11100	9870
	Antimony (Sb) (mg/kg)	13.2	25.8	2.11	0.90	0.30
	Arsenic (As) (mg/kg)	53.6	51.7	9.61	5.80	2.60
	Barium (Ba) (mg/kg)	34.7	33.6	37.7	34.0	25.1
	Beryllium (Be) (mg/kg)	<0.10	<0.10	<0.10	0.16	0.11
	Bismuth (Bi) (mg/kg)	0.21	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	6.7	10.1	12.6	22.3	9.6
	Cadmium (Cd) (mg/kg)	0.434	0.296	0.685	1.01	0.612
	Calcium (Ca) (mg/kg)	32000	7450	43900	15300	8100
	Chromium (Cr) (mg/kg)	17.8	27.7	14.5	19.0	10.7
	Cobalt (Co) (mg/kg)	5.33	6.31	4.90	4.93	3.60
	Copper (Cu) (mg/kg)	69.2	50.7	41.6	64.6	39.2
	Iron (Fe) (mg/kg)	19100	35000	16600	16200	10700
	Lead (Pb) (mg/kg)	33.2	34.1	14.2	18.8	12.7
	Lithium (Li) (mg/kg)	9.3	11.8	12.1	13.5	12.9
	Magnesium (Mg) (mg/kg)	4800	4910	5320	5950	4340
	Manganese (Mn) (mg/kg)	228	325	203	219	183
	Mercury (Hg) (mg/kg)	<0.050	<0.050	<0.050	0.067	<0.050
	Molybdenum (Mo) (mg/kg)	4.58	5.27	1.68	1.76	0.89
	Nickel (Ni) (mg/kg)	8.06	13.5	9.15	10.2	5.37
	Phosphorus (P) (mg/kg)	501	533	437	483	331
	Potassium (K) (mg/kg)	1150	1300	1480	1300	910
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20	0.24	<0.20
	Silver (Ag) (mg/kg)	<0.10	0.36	0.10	0.19	<0.10
	Sodium (Na) (mg/kg)	3610	4620	5650	7130	4090
	Strontium (Sr) (mg/kg)	104	46.9	237	97.5	61.6
	Sulfur (S) (mg/kg)	2200	2300	4000	4700	2000
	Thallium (Tl) (mg/kg)	0.072	0.071	0.089	0.095	0.066
	Tin (Sn) (mg/kg)	3.5	4.7	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	517	506	614	657	608
	Tungsten (W) (mg/kg)	0.97	<0.50	<0.50	<0.50	<0.50
	Uranium (U) (mg/kg)	0.911	0.858	0.937	0.756	0.640
	Vanadium (V) (mg/kg)	37.5	34.9	38.0	37.3	27.5
	Zinc (Zn) (mg/kg)	296	182	160	208	140
	Zirconium (Zr) (mg/kg)	1.6	1.1	1.7	1.9	1.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18
	Sampled Time	13:15	13:31	13:44		13:50
	Client ID	SS8	SS9	SS10	DUP	SS11
SOIL						
Physical Tests	Moisture (%)	29.3	33.2	30.9	28.8	21.9
	pH (1:2 soil:water) (pH)	7.96	8.07	7.97	7.93	7.94
Metals	Aluminum (Al) (mg/kg)	9090	9210	9450	9250	8470
	Antimony (Sb) (mg/kg)	0.34	0.45	1.04	0.68	0.62
	Arsenic (As) (mg/kg)	2.80	2.77	4.02	3.04	12.7
	Barium (Ba) (mg/kg)	19.8	21.3	20.0	20.1	17.6
	Beryllium (Be) (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	9.5	9.5	8.3	9.2	8.3
	Cadmium (Cd) (mg/kg)	0.358	0.307	0.318	0.275	0.094
	Calcium (Ca) (mg/kg)	4980	4680	4360	3810	4110
	Chromium (Cr) (mg/kg)	9.63	8.81	15.9	21.6	24.4
	Cobalt (Co) (mg/kg)	3.67	3.48	3.46	3.91	4.70
	Copper (Cu) (mg/kg)	21.7	29.8	37.3	30.4	58.0
	Iron (Fe) (mg/kg)	10400	9930	10900	10700	18900
	Lead (Pb) (mg/kg)	8.76	9.95	11.5	9.59	10.1
	Lithium (Li) (mg/kg)	10.6	12.2	10.7	11.7	11.1
	Magnesium (Mg) (mg/kg)	3920	4220	3990	4800	4050
	Manganese (Mn) (mg/kg)	187	179	170	185	235
	Mercury (Hg) (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Molybdenum (Mo) (mg/kg)	0.88	0.61	0.83	0.66	3.59
	Nickel (Ni) (mg/kg)	4.53	4.86	6.05	9.17	19.1
	Phosphorus (P) (mg/kg)	314	343	353	326	283
	Potassium (K) (mg/kg)	870	870	920	880	760
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	3530	3980	3590	4130	3600
	Strontium (Sr) (mg/kg)	36.5	38.4	35.7	30.6	38.0
	Sulfur (S) (mg/kg)	2100	1600	<1000	1200	<1000
	Thallium (Tl) (mg/kg)	<0.050	0.060	0.050	<0.050	<0.050
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	2.2
	Titanium (Ti) (mg/kg)	548	557	527	553	482
	Tungsten (W) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Uranium (U) (mg/kg)	0.456	0.435	0.477	0.453	0.350
	Vanadium (V) (mg/kg)	26.5	25.6	31.3	29.5	25.6
	Zinc (Zn) (mg/kg)	88.0	81.8	94.7	75.6	62.2
	Zirconium (Zr) (mg/kg)	<1.0	1.1	1.1	<1.0	<1.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2183716-11				
	Description	Soil				
	Sampled Date	18-OCT-18				
	Sampled Time	14:01				
	Client ID	SS12				
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	71.2				
	pH (1:2 soil:water) (pH)	7.44				
Metals	Aluminum (Al) (mg/kg)	11800				
	Antimony (Sb) (mg/kg)	1.19				
	Arsenic (As) (mg/kg)	12.0				
	Barium (Ba) (mg/kg)	45.4				
	Beryllium (Be) (mg/kg)	0.24				
	Bismuth (Bi) (mg/kg)	<0.20				
	Boron (B) (mg/kg)	100				
	Cadmium (Cd) (mg/kg)	2.06				
	Calcium (Ca) (mg/kg)	30400				
	Chromium (Cr) (mg/kg)	27.3				
	Cobalt (Co) (mg/kg)	5.73				
	Copper (Cu) (mg/kg)	135				
	Iron (Fe) (mg/kg)	21200				
	Lead (Pb) (mg/kg)	43.1				
	Lithium (Li) (mg/kg)	13.7				
	Magnesium (Mg) (mg/kg)	9290				
	Manganese (Mn) (mg/kg)	204				
	Mercury (Hg) (mg/kg)	0.155				
	Molybdenum (Mo) (mg/kg)	4.33				
	Nickel (Ni) (mg/kg)	15.9				
	Phosphorus (P) (mg/kg)	810				
	Potassium (K) (mg/kg)	2270				
	Selenium (Se) (mg/kg)	0.68				
	Silver (Ag) (mg/kg)	0.28				
	Sodium (Na) (mg/kg)	21700				
	Strontium (Sr) (mg/kg)	174				
	Sulfur (S) (mg/kg)	14900				
	Thallium (Tl) (mg/kg)	0.180				
	Tin (Sn) (mg/kg)	2.4				
	Titanium (Ti) (mg/kg)	676				
	Tungsten (W) (mg/kg)	0.71				
	Uranium (U) (mg/kg)	1.86				
	Vanadium (V) (mg/kg)	48.9				
	Zinc (Zn) (mg/kg)	361				
	Zirconium (Zr) (mg/kg)	4.9				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18
	Sampled Time	11:10	11:58	12:25	12:16	12:44
	Client ID	SS1	SS2	SS3	SS4	SS5
Grouping	**Analyte**					
SOIL						
Hydrocarbons	EPH10-19 (mg/kg)	<200	<200	<200	<200	<200
	EPH19-32 (mg/kg)	<200	<200	<200	<200	<200
	LEPH (mg/kg)	<200	<200	<200	<200	<200
	HEPH (mg/kg)	<200	<200	<200	<200	<200
	Surrogate: 2-Bromobenzotrifluoride (%)	SURR-ND 159.4	SURR-ND 158.6	SURR-ND 159.6	96.5	98.0
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	0.0114	0.0437	0.369	0.308	0.0179
	Acenaphthylene (mg/kg)	<0.0050	<0.0050	0.0210	0.0461	DLCI <0.017
	Anthracene (mg/kg)	0.0368	0.0633	0.307	0.501	0.0387
	Benz(a)anthracene (mg/kg)	0.075	0.149	0.668	1.11	0.142
	Benzo(a)pyrene (mg/kg)	0.042	0.092	0.274	0.647	0.137
	Benzo(b&j)fluoranthene (mg/kg)	0.079	0.159	0.526	1.11	0.230
	Benzo(b+j+k)fluoranthene (mg/kg)	0.110	0.223	0.730	1.55	0.322
	Benzo(g,h,i)perylene (mg/kg)	0.014	0.035	0.085	0.218	0.068
	Benzo(k)fluoranthene (mg/kg)	0.031	0.063	0.204	0.433	0.092
	Chrysene (mg/kg)	0.079	0.175	0.621	1.02	0.163
	Dibenz(a,h)anthracene (mg/kg)	0.0058	0.0135	0.0356	0.0866	0.0212
	Fluoranthene (mg/kg)	0.242	0.497	2.79	3.82	0.432
	Fluorene (mg/kg)	0.013	0.035	0.335	0.291	0.020
	Indeno(1,2,3-c,d)pyrene (mg/kg)	0.018	0.049	0.121	0.292	0.086
	1-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	0.063	<0.050
	2-Methylnaphthalene (mg/kg)	<0.010	<0.010	0.049	0.088	DLCI <0.017
	Naphthalene (mg/kg)	0.011	0.011	0.094	0.164	0.012
	Phenanthrene (mg/kg)	0.051	0.199	1.12	1.60	0.156
	Pyrene (mg/kg)	0.128	0.295	1.57	2.37	0.329
	Quinoline (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: Acenaphthene d10 (%)	72.0	75.0	72.5	110.9	108.6
	Surrogate: Chrysene d12 (%)	85.5	85.0	84.6	117.9	117.6
	Surrogate: Naphthalene d8 (%)	68.0	76.5	69.0	115.1	111.5
	Surrogate: Phenanthrene d10 (%)	80.0	81.0	80.0	118.3	114.7
	B(a)P Total Potency Equivalent (mg/kg)	0.070	0.149	0.469	1.04	0.215
	IACR (CCME) (mg/kg)	1.10	2.25	7.84	15.8	3.02

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10
	Sample ID	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18	18-OCT-18
	Sampled Time	13:15	13:31	13:44		13:50
	Client ID	SS8	SS9	SS10	DUP	SS11
Grouping	**Analyte**					
SOIL						
Hydrocarbons	EPH10-19 (mg/kg)	<200	<200	<200	<200	<200
	EPH19-32 (mg/kg)	<200	<200	<200	<200	<200
	LEPH (mg/kg)	<200	<200	<200	<200	<200
	HEPH (mg/kg)	<200	<200	<200	<200	<200
	Surrogate: 2-Bromobenzotrifluoride (%)	94.1	96.8	94.6	94.7	SURR-ND 173.8
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	0.0206	0.0236	DLCI <0.017	0.0724	<0.0050
	Acenaphthylene (mg/kg)	DLCI <0.020	DLCI <0.017	DLCI <0.017	0.0129	<0.0050
	Anthracene (mg/kg)	0.0748	0.0987	0.0241	0.0823	0.0148
	Benz(a)anthracene (mg/kg)	0.119	0.228	0.093	0.366	0.038
	Benzo(a)pyrene (mg/kg)	0.093	0.185	0.081	0.407	0.030
	Benzo(b&j)fluoranthene (mg/kg)	0.162	0.312	0.149	0.652	0.060
	Benzo(b+j+k)fluoranthene (mg/kg)	0.236	0.438	0.206	0.922	0.083
	Benzo(g,h,i)perylene (mg/kg)	0.045	0.085	0.036	0.240	0.013
	Benzo(k)fluoranthene (mg/kg)	0.074	0.126	0.057	0.270	0.023
	Chrysene (mg/kg)	0.204	0.256	0.104	0.526	0.054
	Dibenz(a,h)anthracene (mg/kg)	DLCI <0.020	0.0271	DLQ <0.017	0.0606	<0.0050
	Fluoranthene (mg/kg)	0.467	0.651	0.275	1.14	0.090
	Fluorene (mg/kg)	0.031	0.034	DLCI <0.017	0.073	<0.010
	Indeno(1,2,3-c,d)pyrene (mg/kg)	0.053	0.114	0.049	0.285	0.018
	1-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	DLCI <0.020	DLCI <0.017	DLCI <0.017	0.020	<0.010
	Naphthalene (mg/kg)	DLCI <0.020	DLCI <0.017	DLCI <0.017	0.032	<0.010
	Phenanthrene (mg/kg)	0.143	0.231	0.069	0.699	0.024
	Pyrene (mg/kg)	0.240	0.447	0.189	0.845	0.055
	Quinoline (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: Acenaphthene d10 (%)	75.7	112.0	93.5	89.3	82.8
	Surrogate: Chrysene d12 (%)	69.6	118.7	96.4	97.1	95.4
	Surrogate: Naphthalene d8 (%)	73.8	115.4	94.7	94.5	84.3
	Surrogate: Phenanthrene d10 (%)	76.0	116.8	98.4	98.3	90.6
	B(a)P Total Potency Equivalent (mg/kg)	0.146	0.294	0.126	0.633	0.047
	IACR (CCME) (mg/kg)	2.25	4.23	1.90	8.63	0.76

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2183716-11				
	Description	Soil				
	Sampled Date	18-OCT-18				
	Sampled Time	14:01				
	Client ID	SS12				
Grouping	**Analyte**					
SOIL						
Hydrocarbons	EPH10-19 (mg/kg)	<200				
	EPH19-32 (mg/kg)	530				
	LEPH (mg/kg)	<200				
	HEPH (mg/kg)	520				
	Surrogate: 2-Bromobenzotrifluoride (%)	96.8				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	0.293				
	Acenaphthylene (mg/kg)	0.134				
	Anthracene (mg/kg)	1.24				
	Benz(a)anthracene (mg/kg)	2.70				
	Benzo(a)pyrene (mg/kg)	1.54				
	Benzo(b&j)fluoranthene (mg/kg)	2.87				
	Benzo(b+j+k)fluoranthene (mg/kg)	3.94				
	Benzo(g,h,i)perylene (mg/kg)	0.465				
	Benzo(k)fluoranthene (mg/kg)	1.07				
	Chrysene (mg/kg)	2.54				
	Dibenz(a,h)anthracene (mg/kg)	0.177				
	Fluoranthene (mg/kg)	9.54				
	Fluorene (mg/kg)	0.351				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	0.646				
	1-Methylnaphthalene (mg/kg)	<0.050				
	2-Methylnaphthalene (mg/kg)	0.074				
	Naphthalene (mg/kg)	0.135				
	Phenanthrene (mg/kg)	1.71				
	Pyrene (mg/kg)	5.13				
	Quinoline (mg/kg)	<0.050				
	Surrogate: Acenaphthene d10 (%)	121.3				
	Surrogate: Chrysene d12 (%)	129.4				
	Surrogate: Naphthalene d8 (%)	123.3				
	Surrogate: Phenanthrene d10 (%)	129.1				
	B(a)P Total Potency Equivalent (mg/kg)	2.47				
	IACR (CCME) (mg/kg)	39.3				

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Antimony (Sb)	DUP-H	L2183716-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Calcium (Ca)	DUP-H	L2183716-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Benz(a)anthracene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Benzo(a)pyrene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Benzo(b&j)fluoranthene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Benzo(k)fluoranthene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Fluoranthene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Indeno(1,2,3-c,d)pyrene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Phenanthrene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Duplicate	Pyrene	DUP-H	L2183716-11, -4, -5, -6, -7, -8, -9
Matrix Spike	Fluoranthene	MS-B	L2183716-11, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLCI	Detection Limit Raised: Chromatographic Interference due to co-elution.
DLQ	Detection Limit raised due to co-eluting interference. GCMS qualifier ion ratio did not meet acceptance criteria.
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
SURR-ND	Surrogate recovery marginally exceeded ALS DQO. Reported non-detect results for associated samples were deemed to be unaffected.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EPH-TUMB-FID-VA	Soil	EPH in Solids by Tumbler and GCFID	BC MOE EPH GCFID

Analysis is in accordance with BC MOE Lab Manual method "Extractable Petroleum Hydrocarbons in Solids by GC/FID", v2.1, July 1999. Soil samples are extracted with a 1:1 mixture of hexane and acetone using a rotary extraction technique modified from EPA 3570 prior to gas chromatography with flame ionization detection (GC-FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAAS	EPA 200.2/1631E (mod)

Soil samples are digested with hot nitric and hydrochloric acids, followed by CVAAS analysis. This method is fully compliant with the BC SALM strong acid leachable metals digestion method.

LEPH/HEPH-CALC-VA	Soil	LEPHs and HEPHs	BC MOE LEPH/HEPH

LEPHs and HEPHs are measures of Light and Heavy Extractable Petroleum Hydrocarbons in soil. Results are calculated by subtraction of applicable PAH concentrations from EPH10-19 and EPH19-32, as per the BC Lab Manual LEPH/HEPH calculation procedure.

LEPHs = EPH10-19 minus Naphthalene and Phenanthrene.

HEPHs = EPH19-32 minus Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and Pyrene.

MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)

Soil/sediment is dried, disaggregated, and sieved (2 mm). Strong Acid Leachable Metals in the <2mm fraction are solubilized by heated digestion with nitric and hydrochloric acids. Instrumental analysis is by Collision / Reaction Cell ICPMS.

Limitations: This method is intended to liberate environmentally available metals. Silicate minerals are not solubilized. Some metals may be only partially recovered (matrix dependent), including Al, Ba, Be, Cr, S, Sr, Ti, Tl, V, W, and Zr. Elemental Sulfur may be poorly recovered by this method. Volatile forms of sulfur (e.g. sulfide, H2S) may be excluded if lost during sampling, storage, or digestion.

MOISTURE-VA	Soil	Moisture content	CWS for PHC in Soil - Tier 1

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-TMB-H/A-MS-VA	Soil	PAH - Rotary Extraction (Hexane/Acetone)	EPA 3570/8270

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation. Because the two isomers cannot be readily chromatographically separated, benzo(j)fluoranthene is reported as part of the benzo(b)fluoranthene parameter.

Benzo(a)pyrene Total Potency Equivalents [B(a)P TPE] represents the sum of estimated cancer potency relative to B(a)P for all potentially

Reference Information

carcinogenic unsubstituted PAHs, and is calculated as per the CCME PAH Soil Quality Guidelines reference document (2010).

PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

17-720221

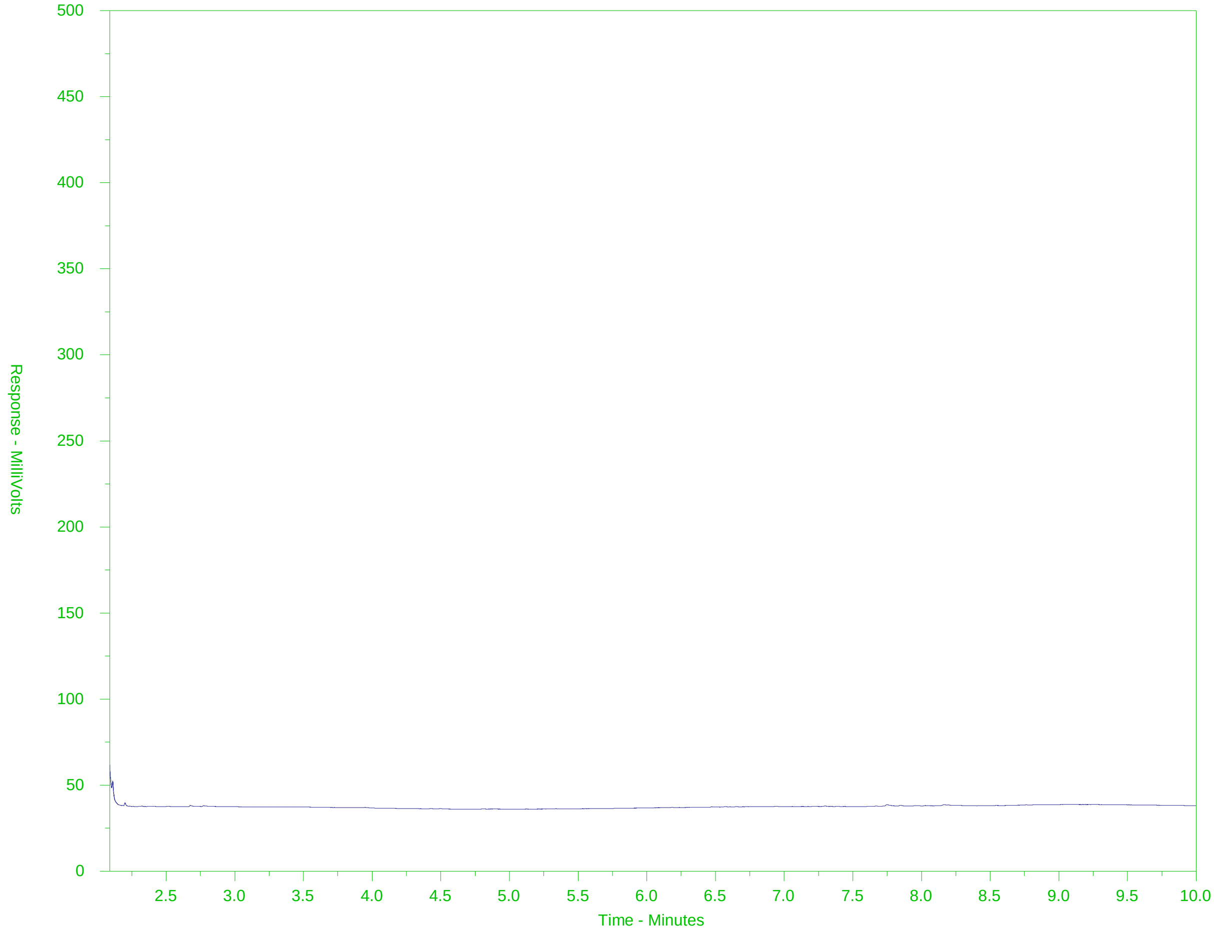
GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-1
Client Sample ID: SS1



EPH10-19		EPH19-32
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F

← Gasoline → ← Motor Oils/ Lube Oils/ Grease →
← Diesel/ Jet Fuels →

The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

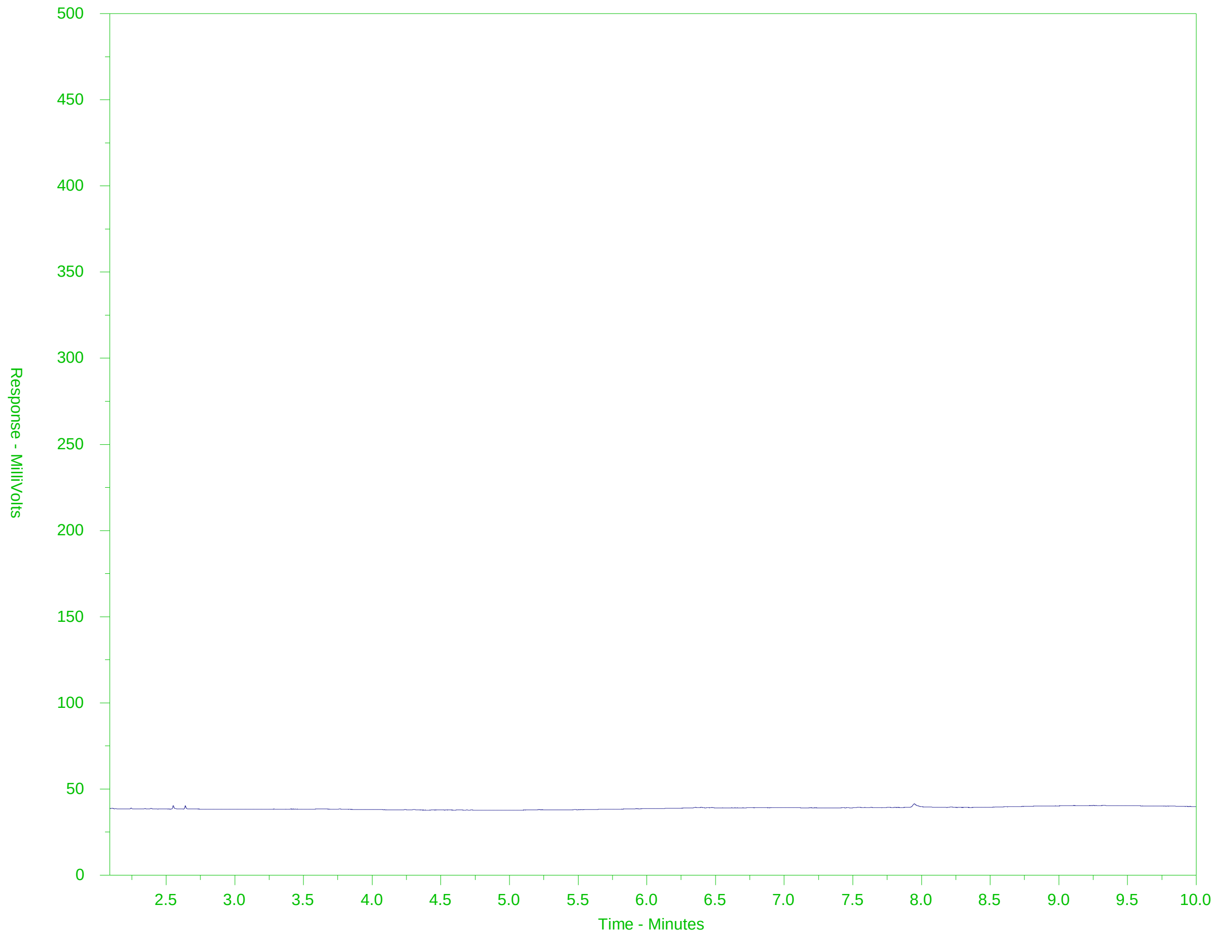
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-2
Client Sample ID: SS2



← EPH10-19 →	← EPH19-32 →	
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →		

The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

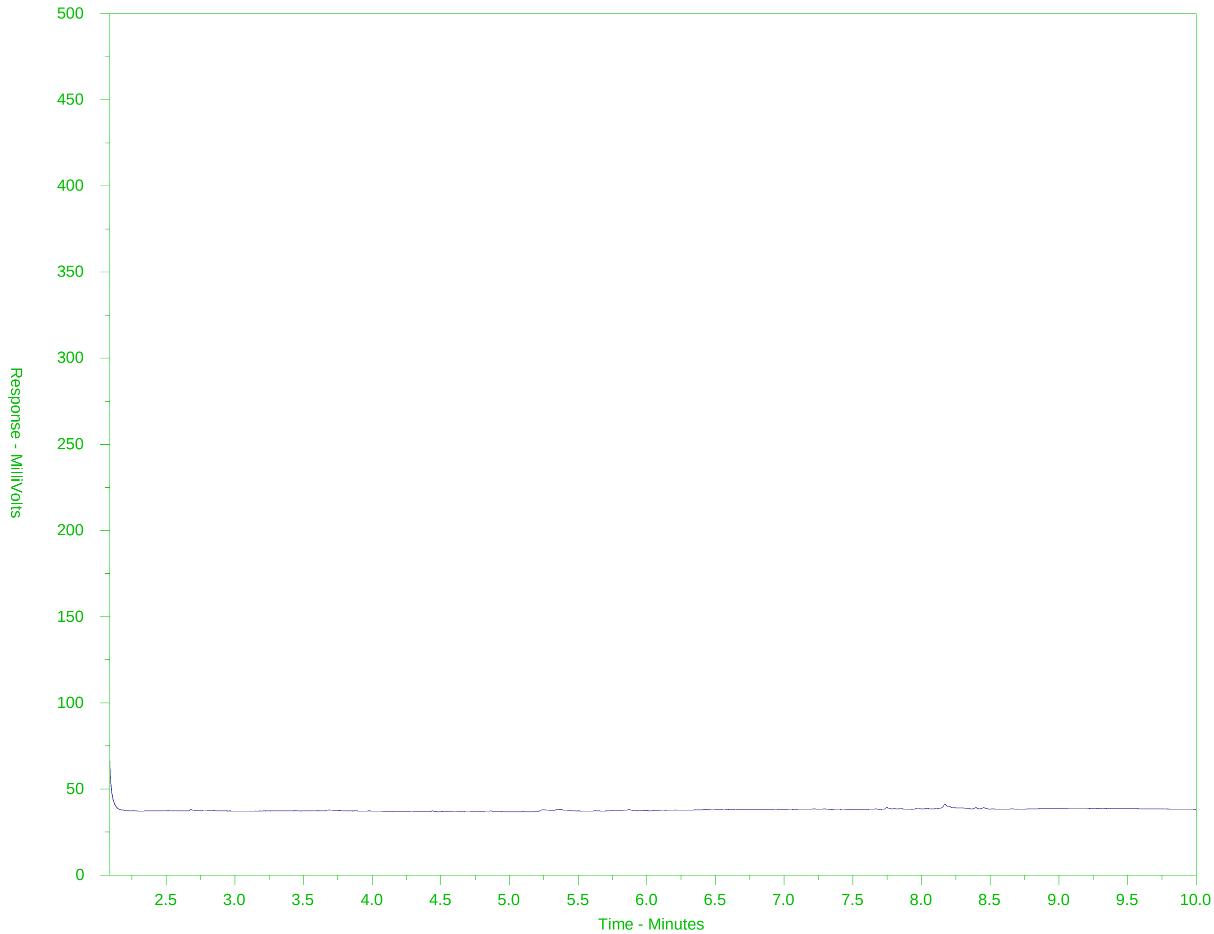
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

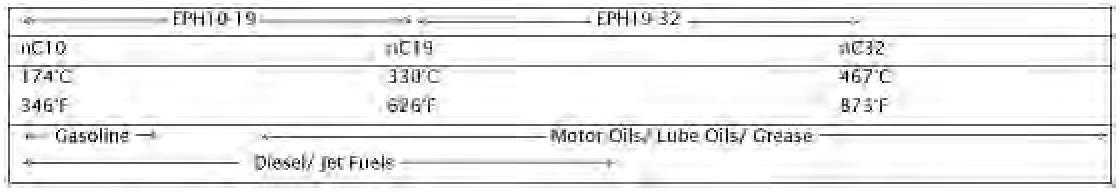
A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-3
Client Sample ID: SS3





The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

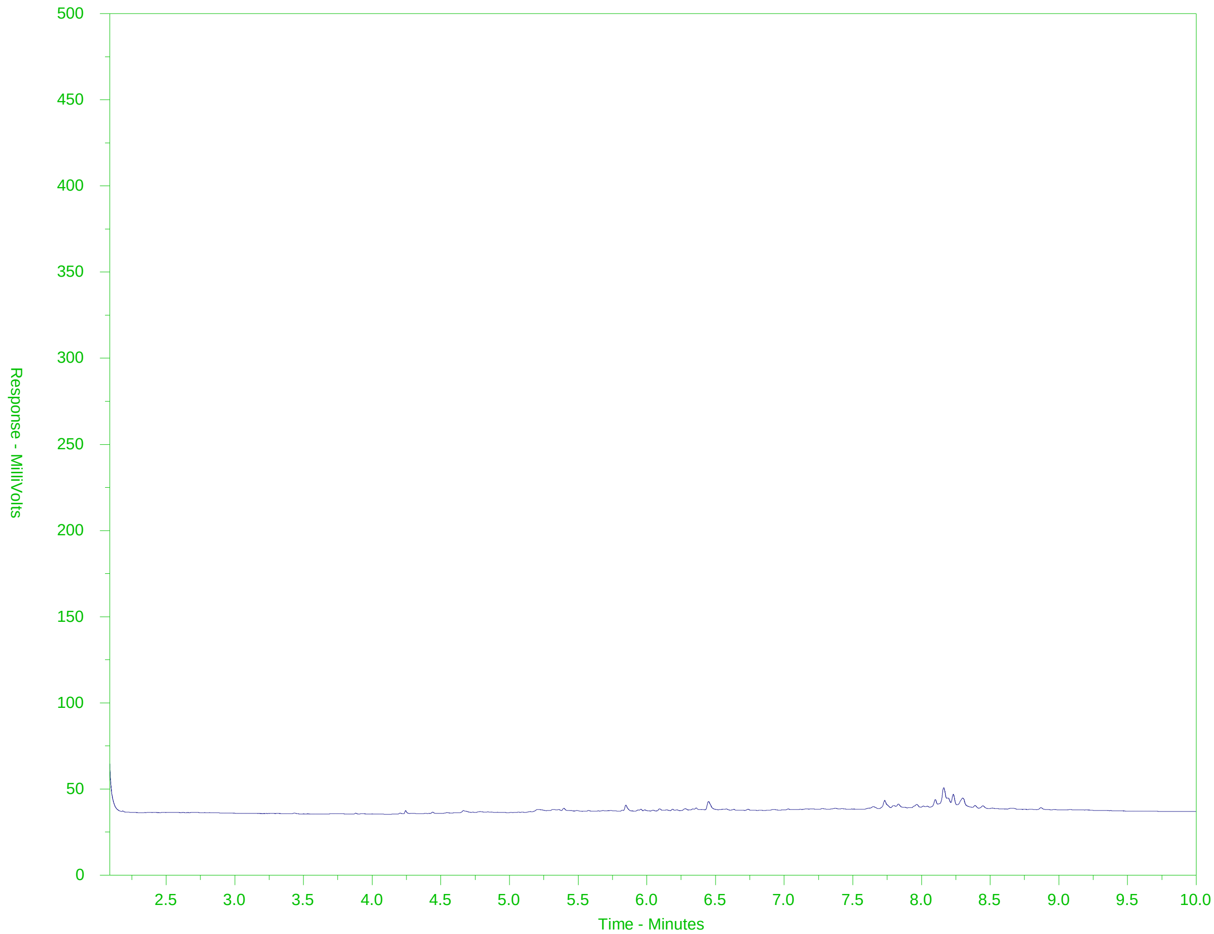
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-4
Client Sample ID: SS4



EPH10-19		EPH19-32
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →		

The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

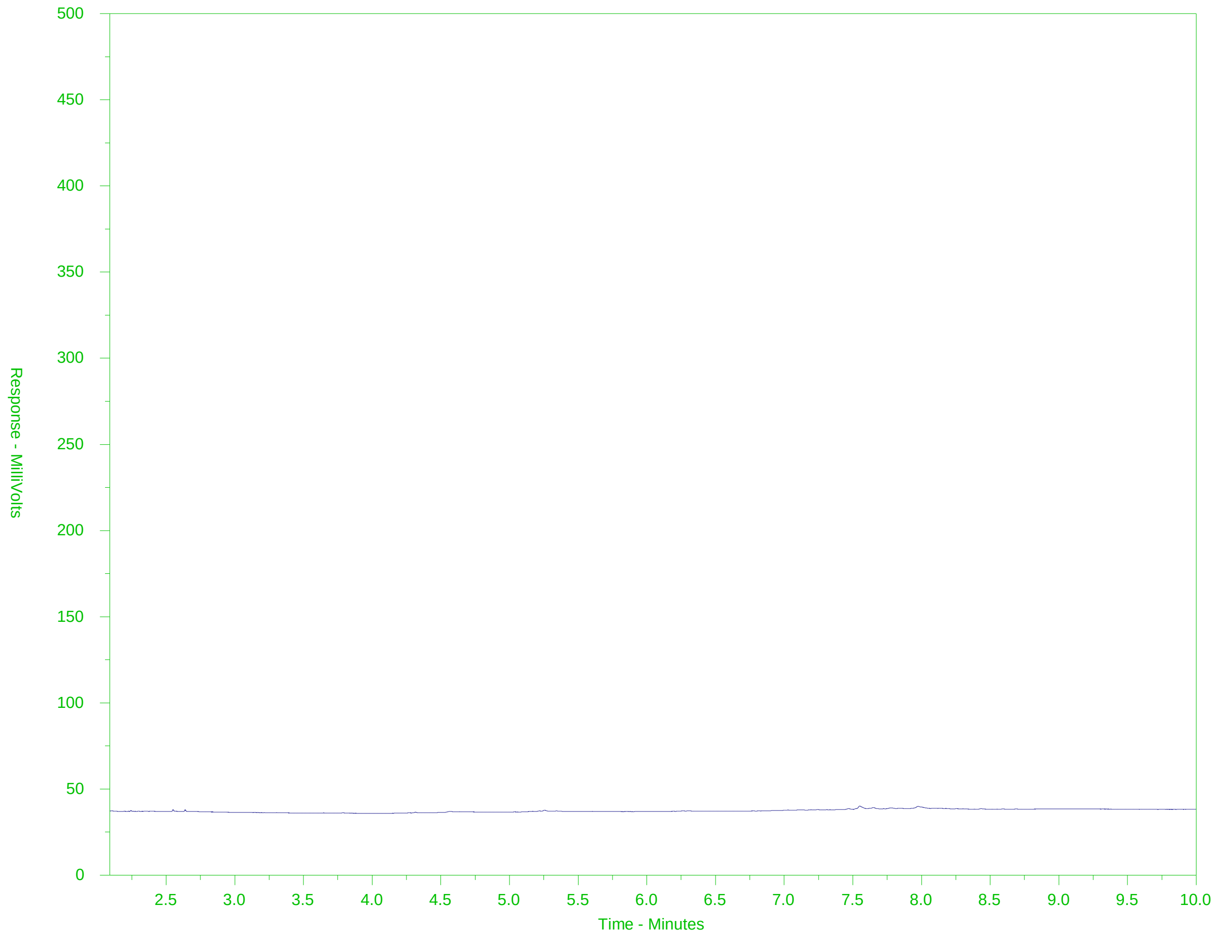
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-5
Client Sample ID: SS5



← EPH10-19 →	← EPH19-32 →	
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →		

The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

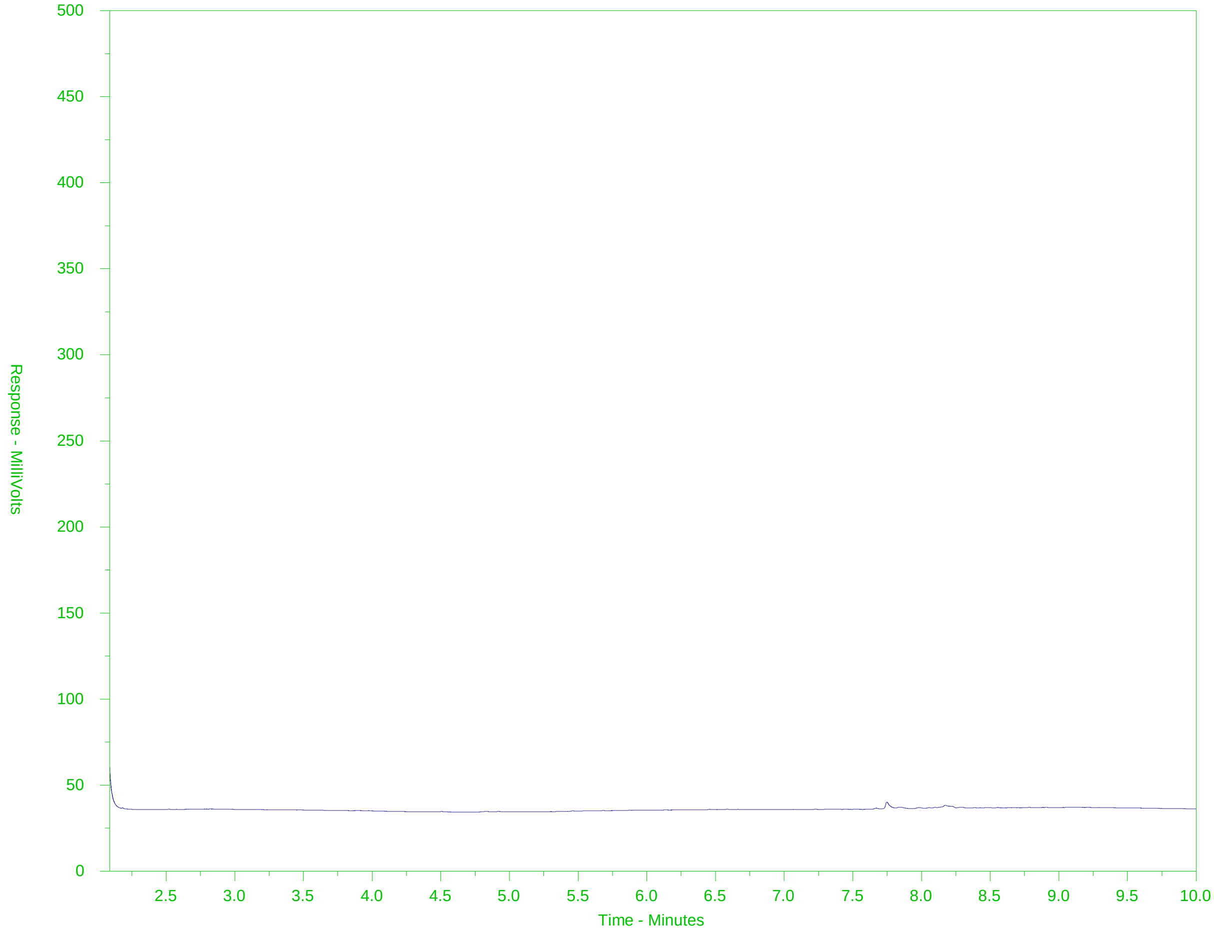
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

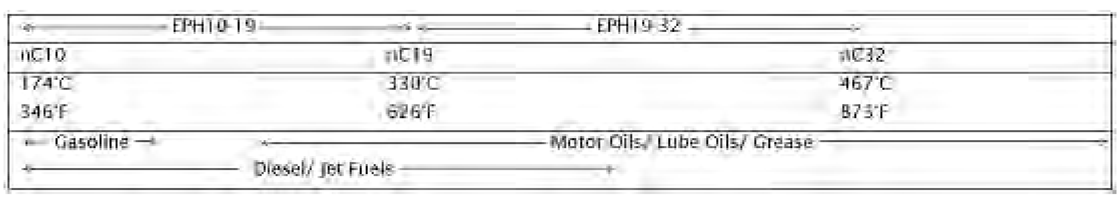
A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-6
Client Sample ID: SS8





The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

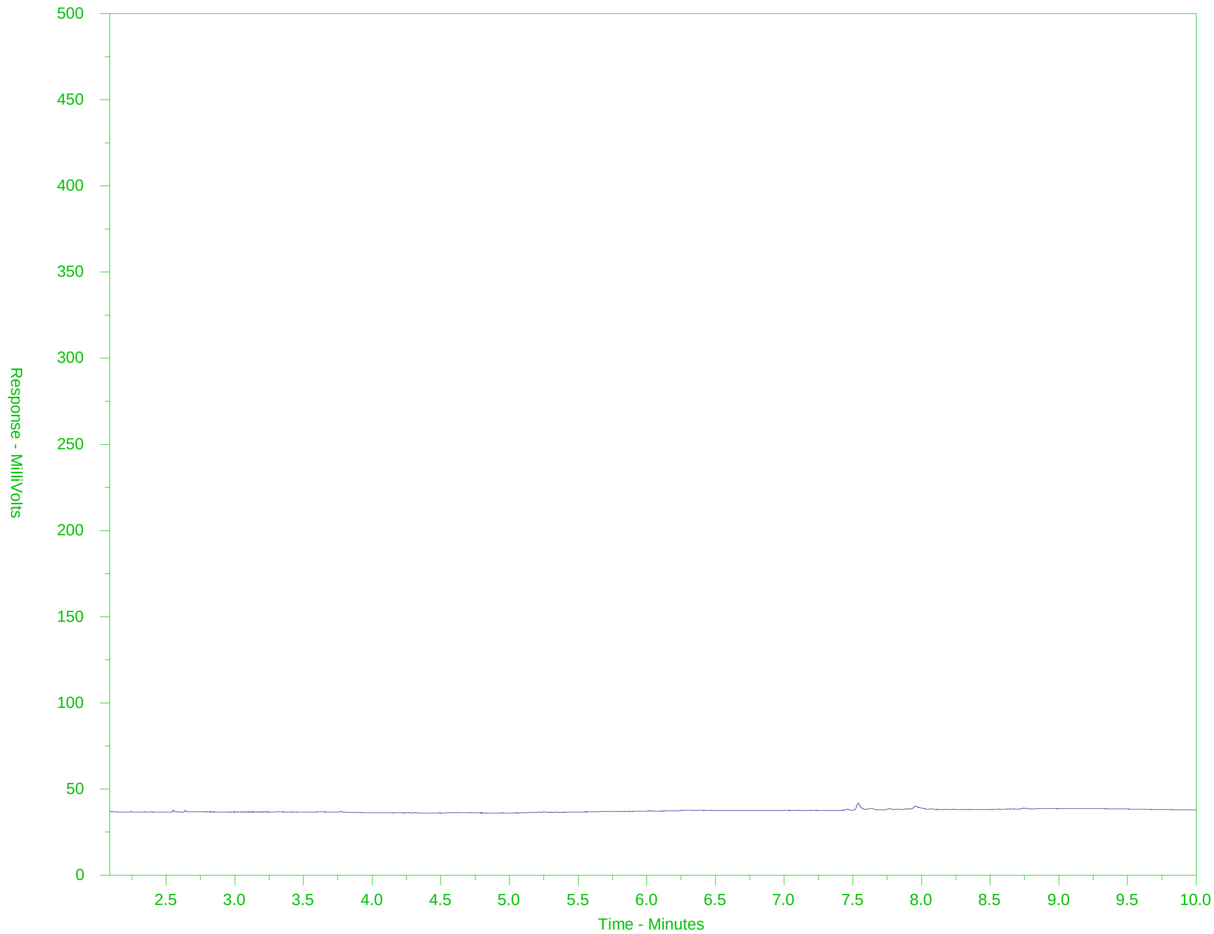
A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

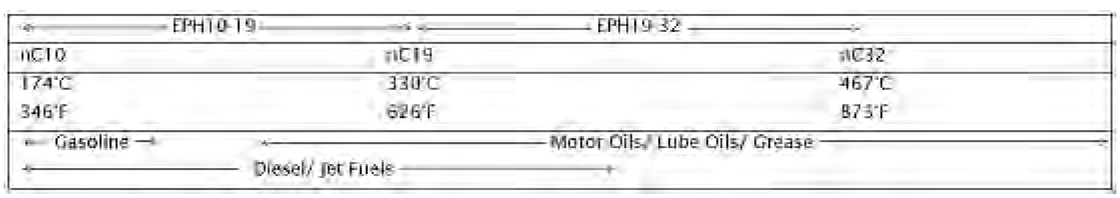
Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: WG2911383-3#L2183716-6

Client Sample ID: SS8





The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

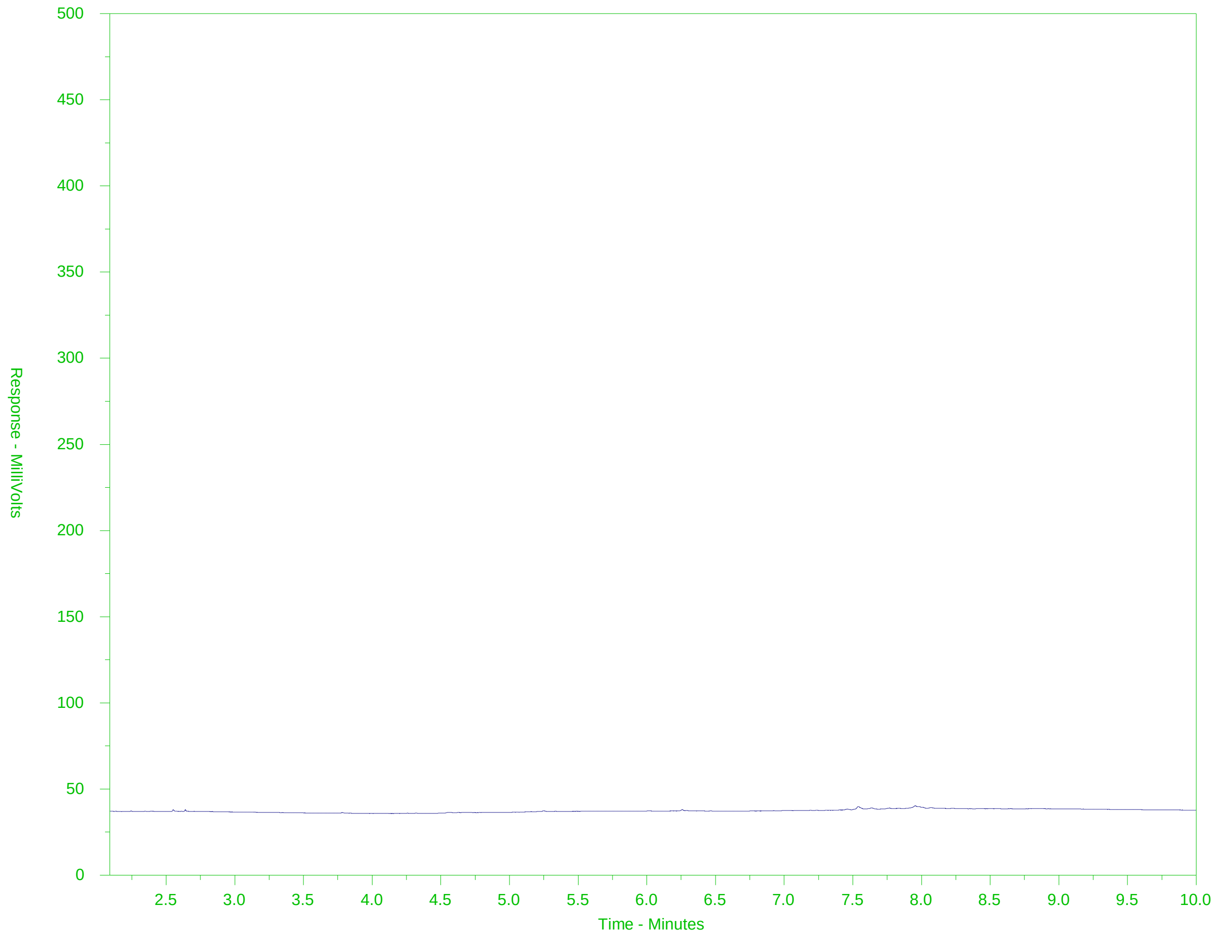
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

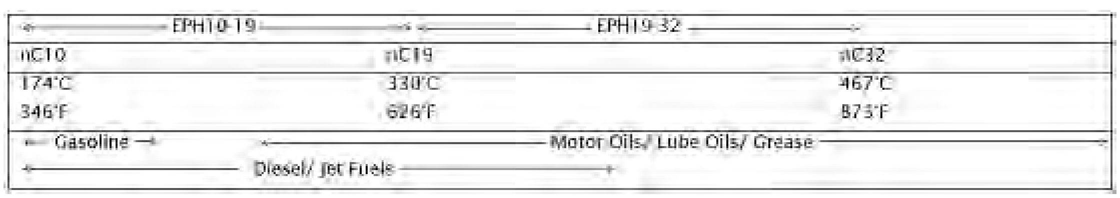
A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-7
Client Sample ID: SS9





The BC EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

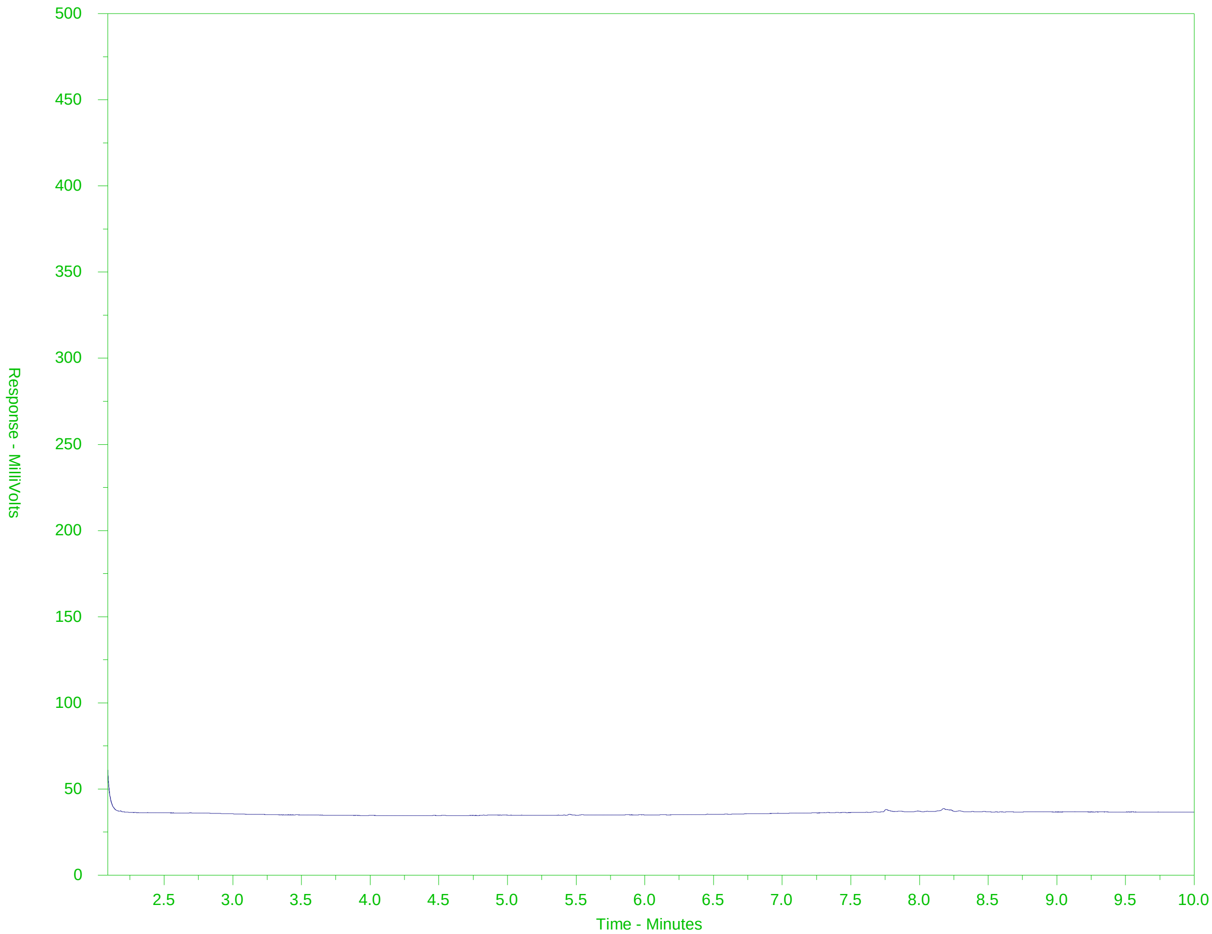
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-8
Client Sample ID: SS10



EPH10-19	EPH19-32	
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
Gasoline	Motor Oils/ Lube Oils/ Grease	
Diesel/ Jet Fuels		

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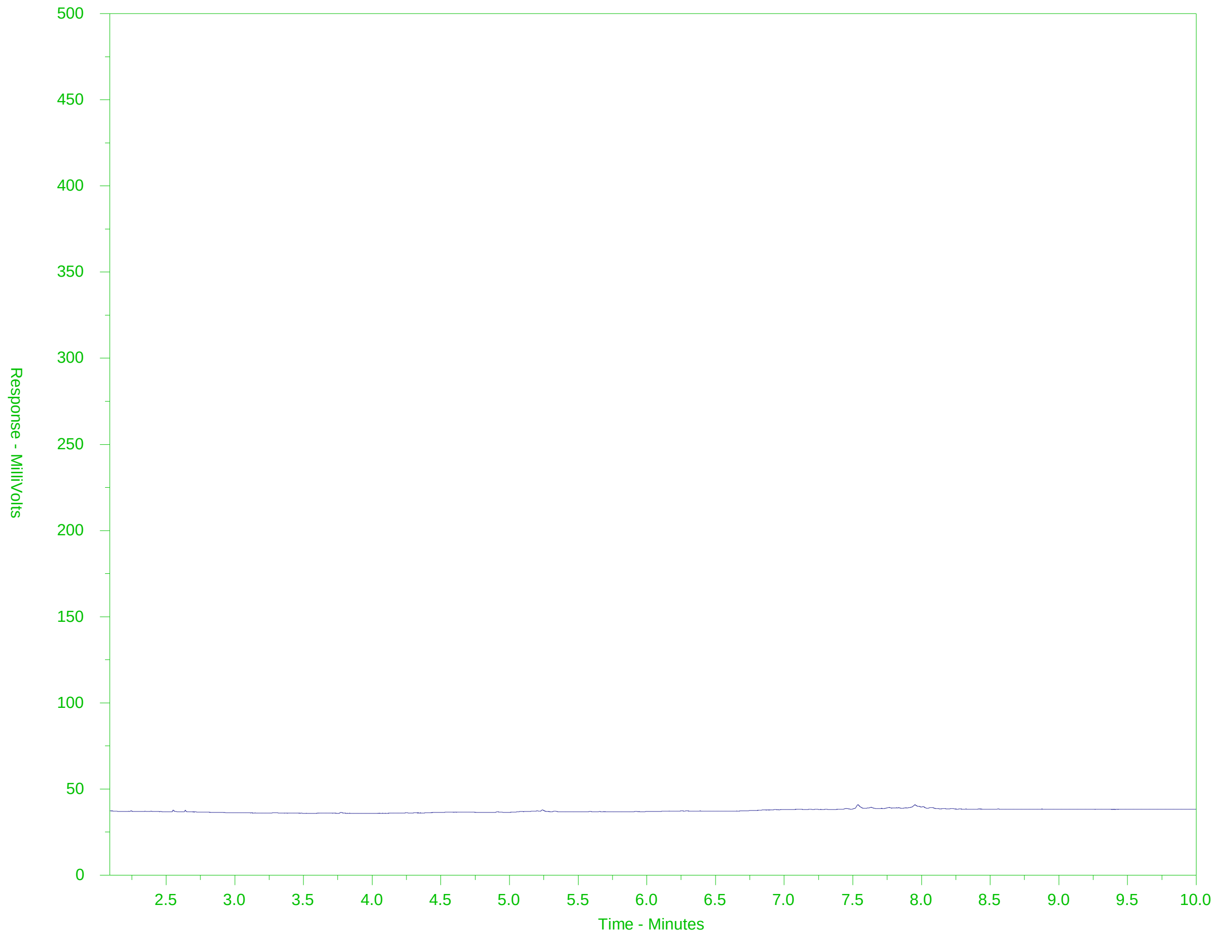
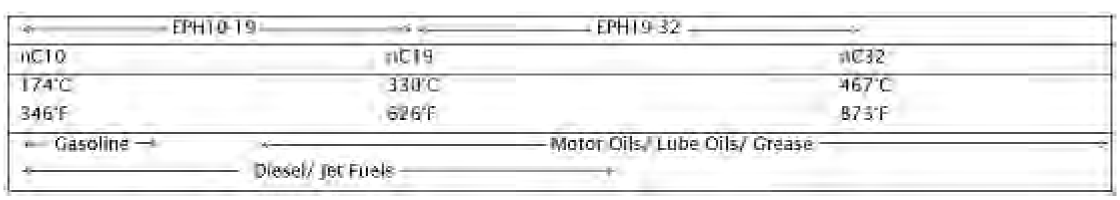
BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-9
Client Sample ID: DUP





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The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

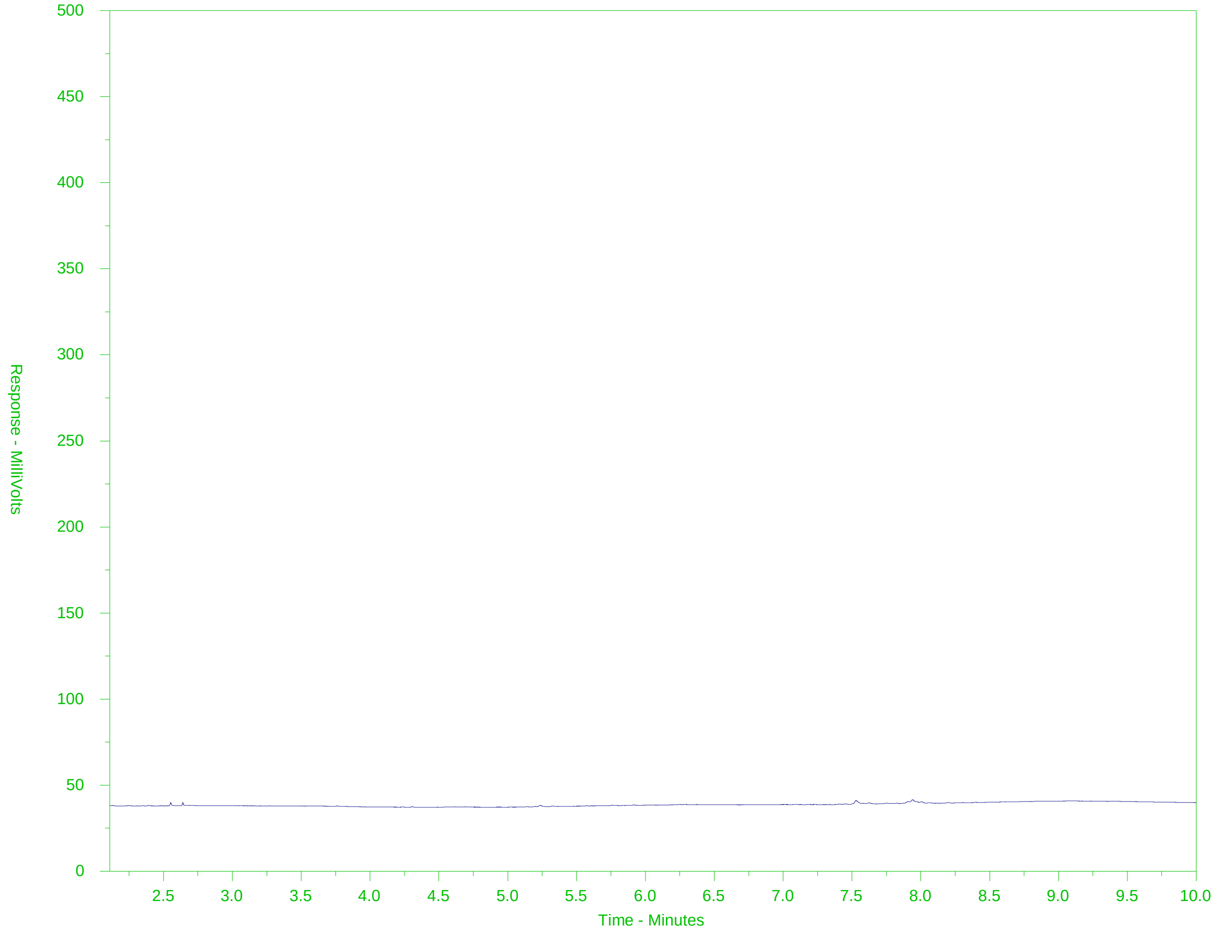
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: WG2908841-3#L2183716-9
Client Sample ID: DUP



← EPH10-19 →	← EPH19-32 →	
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →		

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The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples, but general patterns and distributions will remain similar.

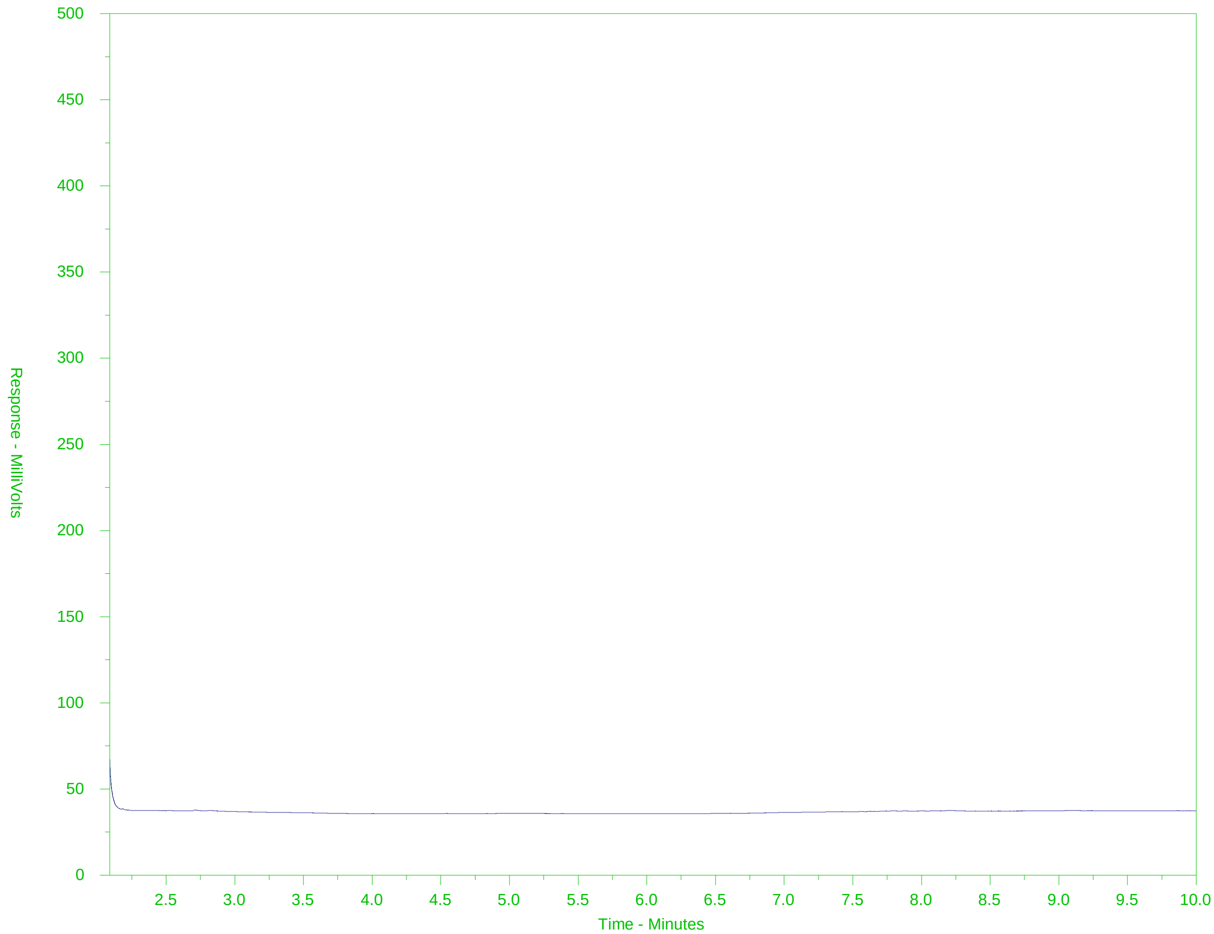
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

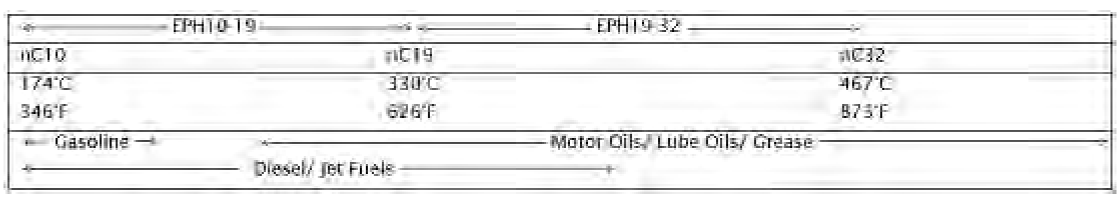
A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-10
Client Sample ID: SS11





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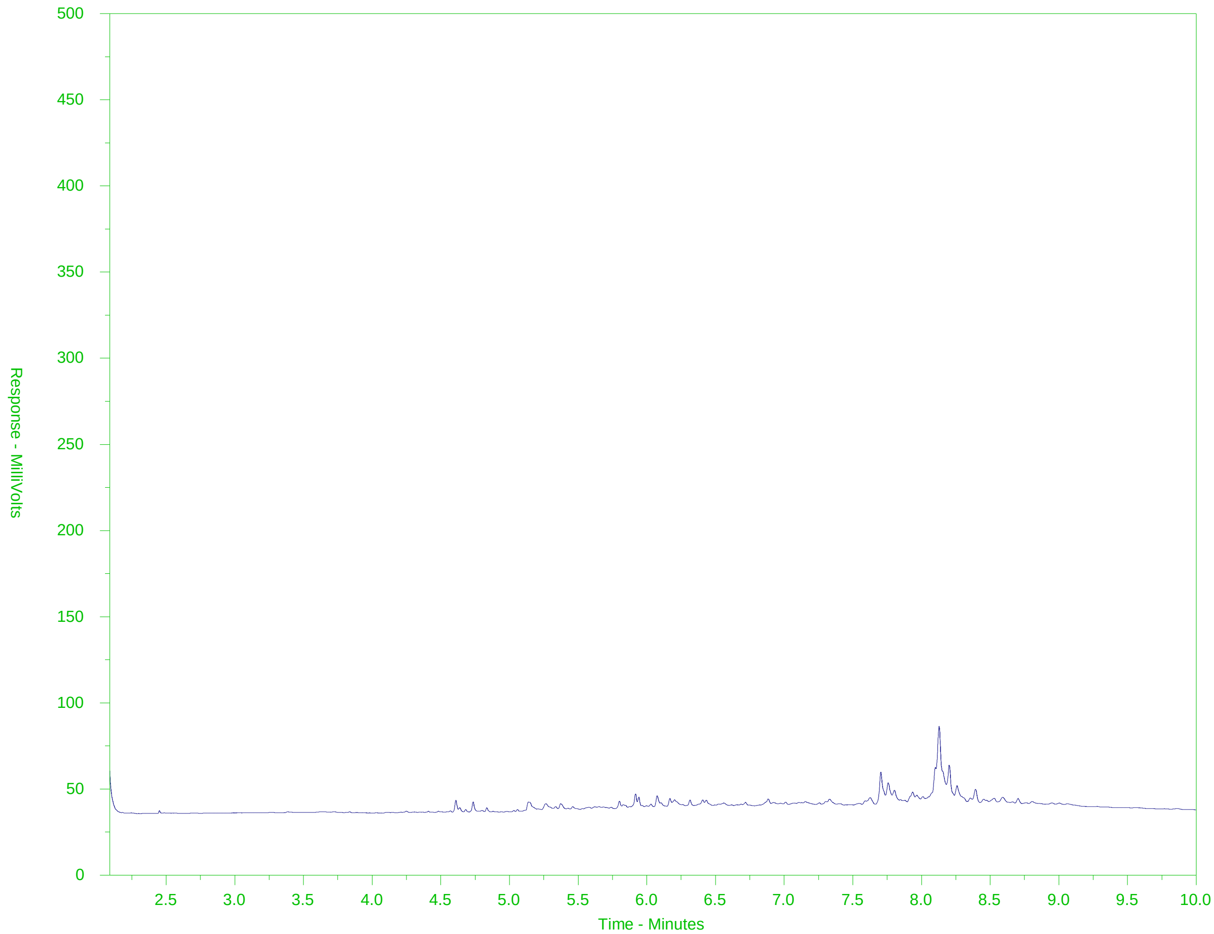
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

Note: This chromatogram was produced using GC conditions that are specific to the ALS Canada EPH method. Refer to the ALS Canada EPH Hydrocarbon Library for a collection of chromatograms from common reference samples (fuels, oils, etc.). The HDR library can be found at www.alsglobal.com.

BC EPH HYDROCARBON DISTRIBUTION REPORT

ALS Sample ID: L2183716-11
Client Sample ID: SS12



← EPH10-19 →	← EPH19-32 →	
nC10	nC19	nC32
174°C	330°C	467°C
346°F	626°F	873°F
← Gasoline →	← Motor Oils/ Lube Oils/ Grease →	
← Diesel/ Jet Fuels →		

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(ALS) Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2183716-COFC

COC Number: 17 - 720221

Page of

Report To	Contact and company name below will appear on the final report
Company:	HATFIELD CONSULTANTS
Contact:	LIANNE LEBLOND
Phone:	604 830 2447
	Company address below will appear on the final report
Street:	#200 - 850 HARBOURSIDE DR
City/Province:	NORTH VANCOUVER BC
Postal Code:	V7P 0A3
Invoice To	Same as Report To [X] YES [ ] NO
	Copy of Invoice with Report [ ] YES [ ] NO
Company:	
Contact:	

Report Format / Distribution	
Select Report Format:	[X] PDF [ ] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report	[X] YES [ ] NO
[X] Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	[X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax	LLEBLOND@HATFIELDGROUP.COM
Email 2	
Email 3	MHOLIN@HATFIELDGROUP.COM
Invoice Distribution	
Select Invoice Distribution:	[X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax	LLEBLOND@HATFIELDGROUP.COM
Email 2	

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)	
Regular [R]	[X] Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days)	4 day [P4-20%] [ ]
	3 day [P3-25%] [ ]
	2 day [P2-50%] [ ]
EMERGENCY	1 Business day [E-100%] [ ]
	Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)] [ ]
Date and Time Required for all E&P TATs:	
For tests that can not be performed according to the service level selected, you will be contacted.	

Project Information	
ALS Account # / Quote #:	HAT100
Job #:	
PO / AFE:	
LSD:	
ALS Lab Work Order # (lab use only):	

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	
ALS Contact: JANICE PEARSON	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	LEPH	HEPH	TOTAL METALS	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	SS1	18-OCT-18	11:10	SOIL	↓	↓	↓			
	SS2	"	11:50	"	↓	↓	↓			
	SS3	"	12:25	"	↓	↓	↓			
	SS4	"	12:16	"	↓	↓	↓			
	SS5	"	12:44	"	↓	↓	↓			
	SS8	"	13:15	"	↓	↓	↓			
	SS9	"	13:31	"	↓	↓	↓			
	SS10	"	13:44	"	↓	↓	↓			
	DUP	"		"	↓	↓	↓			
	SS11	"	13:50	"	↓	↓	↓			
	SS12	"	14:01	"	↓	↓	↓			

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] YES [X] NO

Are samples for human consumption/ use? [ ] YES [X] NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ]		SIF Observations	Yes [ ]	No [ ]	
Ice Packs [X]	Ice Cubes [ ]	Custody seal intact	Yes [ ]	No [ ]	
Cooling Initiated [X]					

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
	1.0

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: M. Holz	Date: 18 OCT 2018	Time:	Received by:	Date:	Time:	Received by: HA	Date: 10/18	Time: 3:55P

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

JULY 2017 FRONT

Appendix A5

Sediment Sampling Results Measured Against CCME PEL

ALS		Sample ID		SS1	SS2	SS3	SS4	SS5	SS8	SS9	SS10	DUP	SS11	SS12
10/29/2018		ALS ID		L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10	L2183716-11
L2183716		Date Sampled		10/18/2018 11:10:00 AM	10/18/2018 11:58:00 AM	10/18/2018 12:25:00 PM	10/18/2018 12:16:00 PM	10/18/2018 12:44:00 PM	10/18/2018 1:15:00 PM	10/18/2018 1:31:00 PM	10/18/2018 1:44:00 PM	10/18/2018 12:00:00 AM	10/18/2018 1:50:00 PM	10/18/2018 2:01:00 PM
Moisture+A1:E16	Units	LOR	CCME (PEL)	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Moisture	%	0.25	-	16.1	20.2	24.4	51.7	30.6	29.3	33.2	30.9	28.8	21.9	71.2
pH (1:2 soil:water)	pH	0.1	-	8.42	8.29	8.11	7.98	8.03	7.96	8.07	7.97	7.93	7.94	7.44
Aluminum (Al)	mg/kg	50	-	8460	9830	10000	11100	9870	9090	9210	9450	9250	8470	11800
Antimony (Sb)	mg/kg	0.1	-	13.2	25.8	2.11	0.9	0.3	0.34	0.45	1.04	0.68	0.62	1.19
Arsenic (As)	mg/kg	0.1	41.6	53.6	51.7	9.61	5.8	2.6	2.8	2.77	4.02	3.04	12.7	12
Barium (Ba)	mg/kg	0.5	-	34.7	33.6	37.7	34	25.1	19.8	21.3	20	20.1	17.6	45.4
Beryllium (Be)	mg/kg	0.1	-	<0.10	<0.10	<0.10	0.16	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.24
Bismuth (Bi)	mg/kg	0.2	-	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	mg/kg	5	-	6.7	10.1	12.6	22.3	9.6	9.5	9.5	8.3	9.2	8.3	100
Cadmium (Cd)	mg/kg	0.02	4.2	0.434	0.296	0.685	1.01	0.612	0.358	0.307	0.318	0.275	0.094	2.06
Calcium (Ca)	mg/kg	50	-	32000	7450	43900	15300	8100	4980	4680	4360	3810	4110	30400
Chromium (Cr)	mg/kg	0.5	160	17.8	27.7	14.5	19	10.7	9.63	8.81	15.9	21.6	24.4	27.3
Cobalt (Co)	mg/kg	0.1	-	5.33	6.31	4.9	4.93	3.6	3.67	3.48	3.46	3.91	4.7	5.73
Copper (Cu)	mg/kg	0.5	108	69.2	50.7	41.6	64.6	39.2	21.7	29.8	37.3	30.4	58	135
Iron (Fe)	mg/kg	50	-	19100	35000	16600	16200	10700	10400	9930	10900	10700	18900	21200
Lead (Pb)	mg/kg	0.5	112	33.2	34.1	14.2	18.8	12.7	8.76	9.95	11.5	9.59	10.1	43.1
Lithium (Li)	mg/kg	2	-	9.3	11.8	12.1	13.5	12.9	10.6	12.2	10.7	11.7	11.1	13.7
Magnesium (Mg)	mg/kg	20	-	4800	4910	5320	5950	4340	3920	4220	3990	4800	4050	9290
Manganese (Mn)	mg/kg	1	-	228	325	203	219	183	187	179	170	185	235	204
Mercury (Hg)	mg/kg	0.05	0.7	<0.050	<0.050	<0.050	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.155
Molybdenum (Mo)	mg/kg	0.1	-	4.58	5.27	1.68	1.76	0.89	0.88	0.61	0.83	0.66	3.59	4.33
Nickel (Ni)	mg/kg	0.5	-	8.06	13.5	9.15	10.2	5.37	4.53	4.86	6.05	9.17	19.1	15.9
Phosphorus (P)	mg/kg	50	-	501	533	437	483	331	314	343	353	326	283	810
Potassium (K)	mg/kg	100	-	1150	1300	1480	1300	910	870	870	920	880	760	2270
Selenium (Se)	mg/kg	0.2	-	<0.20	<0.20	<0.20	0.24	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.68
Silver (Ag)	mg/kg	0.1	-	<0.10	0.36	0.1	0.19	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.28
Sodium (Na)	mg/kg	50	-	3610	4620	5650	7130	4090	3530	3980	3590	4130	3600	21700
Strontium (Sr)	mg/kg	0.5	-	104	46.9	237	97.5	61.6	36.5	38.4	35.7	30.6	38	174
Sulfur (S)	mg/kg	1000	-	2200	2300	4000	4700	2000	2100	1600	<1000	1200	<1000	14900
Thallium (Tl)	mg/kg	0.05	-	0.072	0.071	0.089	0.095	0.066	<0.050	0.06	0.05	<0.050	<0.050	0.18
Tin (Sn)	mg/kg	2	-	3.5	4.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.4
Titanium (Ti)	mg/kg	1	-	517	506	614	657	608	548	557	527	553	482	676
Tungsten (W)	mg/kg	0.5	-	0.97	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.71
Uranium (U)	mg/kg	0.05	-	0.911	0.858	0.937	0.756	0.64	0.456	0.435	0.477	0.453	0.35	1.86
Vanadium (V)	mg/kg	0.2	-	37.5	34.9	38	37.3	27.5	26.5	25.6	31.3	29.5	25.6	48.9
Zinc (Zn)	mg/kg	2	271	296	182	160	208	140	88	81.8	94.7	75.6	62.2	361
Zirconium (Zr)	mg/kg	1	-	1.6	1.1	1.7	1.9	1.1	<1.0	1.1	1.1	<1.0	<1.0	4.9
EPH10-19	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
EPH19-32	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	530
LEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
HEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	520
2-Bromobenzotrifluoride	%	Surrogate	-	159.4 *	158.6 *	159.6 *	96.5	98	94.1	96.8	94.6	94.7	173.8 *	96.8
Acenaphthene	mg/kg	0.005	0.0889	0.0114	0.0437	0.369	0.308	0.0179	0.0206	0.0236	<0.017 DLCI	0.0724	<0.0050	0.293
Acenaphthylene	mg/kg	0.005	0.128	<0.0050	<0.0050	0.021	0.0461	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.0129	<0.0050	0.134
Anthracene	mg/kg	0.004	0.245	0.0368	0.0633	0.307	0.501	0.0387	0.0748	0.0987	0.0241	0.0823	0.0148	1.24
Benz(a)anthracene	mg/kg	0.01	0.693	0.075	0.149	0.668	1.11	0.142	0.119	0.228	0.093	0.366	0.038	2.7
Benzo(a)pyrene	mg/kg	0.01	0.763	0.042	0.092	0.274	0.647	0.137	0.093	0.185	0.081	0.407	0.03	1.54
Benzo(b&j)fluoranthene	mg/kg	0.01	-	0.079	0.159	0.526	1.11	0.23	0.162	0.312	0.149	0.652	0.06	2.87
Benzo(b+j+k)fluoranthene	mg/kg	0.015	-	0.11	0.223	0.73	1.55	0.322	0.236	0.438	0.206	0.922	0.083	3.94
Benzo(g,h,i)perylene	mg/kg	0.01	-	0.014	0.035	0.085	0.218	0.068	0.045	0.085	0.036	0.24	0.013	0.465
Benzo(k)fluoranthene	mg/kg	0.01	-	0.031	0.063	0.204	0.433	0.092	0.074	0.126	0.057	0.27	0.023	1.07
Chrysene	mg/kg	0.01	0.46	0.079	0.175	0.621	1.02	0.163	0.204	0.256	0.104	0.526	0.054	2.54
Dibenz(a,h)anthracene	mg/kg	0.005	0.135	0.0058	0.0135	0.0356	0.0866	0.0212	<0.020 DLCI	0.0271	<0.017 DLCI	0.0606	<0.0050	0.177
Fluoranthene	mg/kg	0.01	1.494	0.242	0.497	2.79	3.82	0.432	0.467	0.651	0.275	1.14	0.09	9.54
Fluorene	mg/kg	0.01	0.144	0.013	0.035	0.335	0.291	0.02	0.031	0.034	<0.017 DLCI	0.073	<0.010	0.351
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01	-	0.018	0.049	0.121	0.292	0.086	0.053	0.114	0.049	0.285	0.018	0.646
1-Methylnaphthalene	mg/kg	0.05	-	<0.050	<0.050	<0.050	0.063	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	mg/kg	0.01	0.201	<0.010	<0.010	0.049	0.088	<0.017 DLCI	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.02	<0.010	0.074
Naphthalene	mg/kg	0.01	0.391	0.011	0.011	0.094	0.164	0.012	<0.020 DLCI	<0.017 DLCI	<0.017 DLCI	0.032	<0.010	0.135
Phenanthrene	mg/kg	0.01	0.544	0.051	0.199	1.12	1.6	0.156	0.143	0.231	0.069	0.699	0.024	1.71
Pyrene	mg/kg	0.01	1.398	0.128	0.295	1.57	2.37	0.329	0.24	0.447	0.189	0.845	0.055	5.13
Quinoline	mg/kg	0.05	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthene d10	%	Surrogate	-	72	75	72.5	110.9	108.6	75.7	112	93.5	89.3	82.8	121.3
Chrysene d12	%	Surrogate	-	85.5	85	84.6	117.9	117.6	69.6	118.7	96.4	97.1	95.4	129.4
Naphthalene d8	%	Surrogate	-	68	76.5	69	115.1	111.5	73.8	115.4	94.7	94.5	84.3	123.3
Phenanthrene d10	%	Surrogate	-	80	81	80	118.3	114.7	76	116.8	98.4	98.3	90.6	129.1
B(a)P Total Potency Equivalent	mg/kg	0.02	-	0.07	0.149	0.469	1.04	0.215	0.146	0.294	0.126	0.633	0.047	2.47
IACR (CCME)	mg/kg	0.15	-	1.1	2.25	7.84	15.8	3.02	2.25	4.23	1.9	8.63	0.76	39.3

* = Result Qualified — Mouse-over the result to see the qualification.

Applied Guideline: **British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water(Typical)**

Color Key: Within Guideline | Exceeds Guideline

Appendix A6

Sediment Sampling Results Measured Against DSR

ALS		Sample ID		SS1	SS2	SS3	SS4	SS5	SS8	SS9	SS10	DUP	SS11	SS12
10/29/2018		ALS ID		L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10	L2183716-11
L2183716		Date Sampled		10/18/2018 11:10:00 AM	10/18/2018 11:58:00 AM	10/18/2018 12:25:00 PM	10/18/2018 12:16:00 PM	10/18/2018 12:44:00 PM	10/18/2018 1:15:00 PM	10/18/2018 1:31:00 PM	10/18/2018 1:44:00 PM	10/18/2018 12:00:00 AM	10/18/2018 1:50:00 PM	10/18/2018 2:01:00 PM
Analyte	**Units**	**LOR**	**DSR**	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Moisture	%	0.25	-	16.1	20.2	24.4	51.7	30.6	29.3	33.2	30.9	28.8	21.9	71.2
pH (1:2 soil:water)	pH	0.1	-	8.42	8.29	8.11	7.98	8.03	7.96	8.07	7.97	7.93	7.94	7.44
Aluminum (Al)	mg/kg	50	-	8460	9830	10000	11100	9870	9090	9210	9450	9250	8470	11800
Antimony (Sb)	mg/kg	0.1	-	13.2	25.8	2.11	0.9	0.3	0.34	0.45	1.04	0.68	0.62	1.19
Arsenic (As)	mg/kg	0.1	-	53.6	51.7	9.61	5.8	2.6	2.8	2.77	4.02	3.04	12.7	12
Barium (Ba)	mg/kg	0.5	-	34.7	33.6	37.7	34	25.1	19.8	21.3	20	20.1	17.6	45.4
Beryllium (Be)	mg/kg	0.1	-	<0.10	<0.10	<0.10	0.16	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.24
Bismuth (Bi)	mg/kg	0.2	-	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	mg/kg	5	-	6.7	10.1	12.6	22.3	9.6	9.5	9.5	8.3	9.2	8.3	100
Cadmium (Cd)	mg/kg	0.02	0.6	0.434	0.296	0.685	1.01	0.612	0.358	0.307	0.318	0.275	0.094	2.06
Calcium (Ca)	mg/kg	50	-	32000	7450	43900	15300	8100	4980	4680	4360	3810	4110	30400
Chromium (Cr)	mg/kg	0.5	-	17.8	27.7	14.5	19	10.7	9.63	8.81	15.9	21.6	24.4	27.3
Cobalt (Co)	mg/kg	0.1	-	5.33	6.31	4.9	4.93	3.6	3.67	3.48	3.46	3.91	4.7	5.73
Copper (Cu)	mg/kg	0.5	-	69.2	50.7	41.6	64.6	39.2	21.7	29.8	37.3	30.4	58	135
Iron (Fe)	mg/kg	50	-	19100	35000	16600	16200	10700	10400	9930	10900	10700	18900	21200
Lead (Pb)	mg/kg	0.5	-	33.2	34.1	14.2	18.8	12.7	8.76	9.95	11.5	9.59	10.1	43.1
Lithium (Li)	mg/kg	2	-	9.3	11.8	12.1	13.5	12.9	10.6	12.2	10.7	11.7	11.1	13.7
Magnesium (Mg)	mg/kg	20	-	4800	4910	5320	5950	4340	3920	4220	3990	4800	4050	9290
Manganese (Mn)	mg/kg	1	-	228	325	203	219	183	187	179	170	185	235	204
Mercury (Hg)	mg/kg	0.05	0.75	<0.050	<0.050	<0.050	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.155
Molybdenum (Mo)	mg/kg	0.1	-	4.58	5.27	1.68	1.76	0.89	0.88	0.61	0.83	0.66	3.59	4.33
Nickel (Ni)	mg/kg	0.5	-	8.06	13.5	9.15	10.2	5.37	4.53	4.86	6.05	9.17	19.1	15.9
Phosphorus (P)	mg/kg	50	-	501	533	437	483	331	314	343	353	326	283	810
Potassium (K)	mg/kg	100	-	1150	1300	1480	1300	910	870	870	920	880	760	2270
Selenium (Se)	mg/kg	0.2	-	<0.20	<0.20	<0.20	0.24	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.68
Silver (Ag)	mg/kg	0.1	-	<0.10	0.36	0.1	0.19	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.28
Sodium (Na)	mg/kg	50	-	3610	4620	5650	7130	4090	3530	3980	3590	4130	3600	21700
Strontium (Sr)	mg/kg	0.5	-	104	46.9	237	97.5	61.6	36.5	38.4	35.7	30.6	38	174
Sulfur (S)	mg/kg	1000	-	2200	2300	4000	4700	2000	2100	1600	<1000	1200	<1000	14900
Thallium (Tl)	mg/kg	0.05	-	0.072	0.071	0.089	0.095	0.066	<0.050	0.06	0.05	<0.050	<0.050	0.18
Tin (Sn)	mg/kg	2	-	3.5	4.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.4
Titanium (Ti)	mg/kg	1	-	517	506	614	657	608	548	557	527	553	482	676
Tungsten (W)	mg/kg	0.5	-	0.97	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.71
Uranium (U)	mg/kg	0.05	-	0.911	0.858	0.937	0.756	0.64	0.456	0.435	0.477	0.453	0.35	1.86
Vanadium (V)	mg/kg	0.2	-	37.5	34.9	38	37.3	27.5	26.5	25.6	31.3	29.5	25.6	48.9
Zinc (Zn)	mg/kg	2	-	296	182	160	208	140	88	81.8	94.7	75.6	62.2	361
Zirconium (Zr)	mg/kg	1	-	1.6	1.1	1.7	1.9	1.1	<1.0	1.1	1.1	<1.0	<1.0	4.9
EPH10-19	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
EPH19-32	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	530
LEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
HEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	520
2-Bromobenzotrifluoride	%	Surrogate	-	159.4 *	158.6 *	159.6 *	96.5	98	94.1	96.8	94.6	94.7	173.8 *	96.8
Acenaphthene	mg/kg	0.005	2.5	0.0114	0.0437	0.369	0.308	0.0179	0.0206	0.0236	<0.017 *	0.0724	<0.0050	0.293
Acenaphthylene	mg/kg	0.005	2.5	<0.0050	<0.0050	0.021	0.0461	<0.017 *	<0.020 *	<0.017 *	<0.017 *	0.0129	<0.0050	0.134
Anthracene	mg/kg	0.004	2.5	0.0368	0.0633	0.307	0.501	0.0387	0.0748	0.0987	0.0241	0.0823	0.0148	1.24
Benz(a)anthracene	mg/kg	0.01	2.5	0.075	0.149	0.668	1.11	0.142	0.119	0.228	0.093	0.366	0.038	2.7
Benzo(a)pyrene	mg/kg	0.01	2.5	0.042	0.092	0.274	0.647	0.137	0.093	0.185	0.081	0.407	0.03	1.54
Benzo(b&j)fluoranthene	mg/kg	0.01	2.5	0.079	0.159	0.526	1.11	0.23	0.162	0.312	0.149	0.652	0.06	2.87
Benzo(b+j+k)fluoranthene	mg/kg	0.015	2.5	0.11	0.223	0.73	1.55	0.322	0.236	0.438	0.206	0.922	0.083	3.94
Benzo(g,h,i)perylene	mg/kg	0.01	2.5	0.014	0.035	0.085	0.218	0.068	0.045	0.085	0.036	0.24	0.013	0.465
Benzo(k)fluoranthene	mg/kg	0.01	2.5	0.031	0.063	0.204	0.433	0.092	0.074	0.126	0.057	0.27	0.023	1.07
Chrysene	mg/kg	0.01	2.5	0.079	0.175	0.621	1.02	0.163	0.204	0.256	0.104	0.526	0.054	2.54
Dibenz(a,h)anthracene	mg/kg	0.005	2.5	0.0058	0.0135	0.0356	0.0866	0.0212	<0.020 *	0.0271	<0.017 *	0.0606	<0.0050	0.177
Fluoranthene	mg/kg	0.01	2.5	0.242	0.497	2.79	3.82	0.432	0.467	0.651	0.275	1.14	0.09	9.54
Fluorene	mg/kg	0.01	2.5	0.013	0.035	0.335	0.291	0.02	0.031	0.034	<0.017 *	0.073	<0.010	0.351
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01	2.5	0.018	0.049	0.121	0.292	0.086	0.053	0.114	0.049	0.285	0.018	0.646
1-Methylnaphthalene	mg/kg	0.05	2.5	<0.050	<0.050	<0.050	0.063	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	mg/kg	0.01	2.5	<0.010	<0.010	0.049	0.088	<0.017 *	<0.020 *	<0.017 *	<0.017 *	0.02	<0.010	0.074
Naphthalene	mg/kg	0.01	2.5	0.011	0.011	0.094	0.164	0.012	<0.020 *	<0.017 *	<0.017 *	0.032	<0.010	0.135
Phenanthrene	mg/kg	0.01	2.5	0.051	0.199	1.12	1.6	0.156	0.143	0.231	0.069	0.699	0.024	1.71
Pyrene	mg/kg	0.01	2.5	0.128	0.295	1.57	2.37	0.329	0.24	0.447	0.189	0.845	0.055	5.13
Quinoline	mg/kg	0.05	2.5	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthene d10	%	Surrogate	-	72	75	72.5	110.9	108.6	75.7	112	93.5	89.3	82.8	121.3
Chrysene d12	%	Surrogate	-	85.5	85	84.6	117.9	117.6	69.6	118.7	96.4	97.1	95.4	129.4
Naphthalene d8	%	Surrogate	-	68	76.5	69	115.1	111.5	73.8	115.4	94.7	94.5	84.3	123.3
Phenanthrene d10	%	Surrogate	-	80	81	80	118.3	114.7	76	116.8	98.4	98.3	90.6	129.1
B(a)P Total Potency Equivalent	mg/kg	0.02	-	0.07	0.149	0.469	1.04	0.215	0.146	0.294	0.126	0.633	0.047	2.47
IACR (CCME)	mg/kg	0.15	-	1.1	2.25	7.84	15.8	3.02	2.25	4.23	1.9	8.63	0.76	39.3
Total PAH	mg/kg	0.08	2.5	0.838	1.88	9.19	14.2	1.95	1.73	2.82	1.13	5.78	0.421	30.6
* = Result Qualified	Mouse-over the result to see the qualification.													
Applied Guideline:	**British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water(Typical)**													
Color Key:	Within Guideline	Exceeds Guideline												

Appendix A7

Sediment Sampling Results Measured Against CSR SEDQ Study

ALS		Sample ID		SS1	SS2	SS3	SS4	SS5	SS8	SS9	SS10	DUP	SS11	SS12
10/29/2018		ALS ID		L2183716-1	L2183716-2	L2183716-3	L2183716-4	L2183716-5	L2183716-6	L2183716-7	L2183716-8	L2183716-9	L2183716-10	L2183716-11
L2183716		Date Sampled		10/18/2018 11:10:00 AM	10/18/2018 11:58:00 AM	10/18/2018 12:25:00 PM	10/18/2018 12:16:00 PM	10/18/2018 12:44:00 PM	10/18/2018 1:15:00 PM	10/18/2018 1:31:00 PM	10/18/2018 1:44:00 PM	10/18/2018 12:00:00 AM	10/18/2018 1:50:00 PM	10/18/2018 2:01:00 PM
Analyte	**Units**	**LOR**	**Sch. 3.4 Sediment MW(Typical)**	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Moisture	%	0.25	-	16.1	20.2	24.4	51.7	30.6	29.3	33.2	30.9	28.8	21.9	71.2
pH (1:2 soil:water)	pH	0.1	-	8.42	8.29	8.11	7.98	8.03	7.96	8.07	7.97	7.93	7.94	7.44
Aluminum (Al)	mg/kg	50	-	8460	9830	10000	11100	9870	9090	9210	9450	9250	8470	11800
Antimony (Sb)	mg/kg	0.1	-	13.2	25.8	2.11	0.9	0.3	0.34	0.45	1.04	0.68	0.62	1.19
Arsenic (As)	mg/kg	0.1	50	53.6	51.7	9.61	5.8	2.6	2.8	2.77	4.02	3.04	12.7	12
Barium (Ba)	mg/kg	0.5	-	34.7	33.6	37.7	34	25.1	19.8	21.3	20	20.1	17.6	45.4
Beryllium (Be)	mg/kg	0.1	-	<0.10	<0.10	<0.10	0.16	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	0.24
Bismuth (Bi)	mg/kg	0.2	-	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)	mg/kg	5	-	6.7	10.1	12.6	22.3	9.6	9.5	9.5	8.3	9.2	8.3	100
Cadmium (Cd)	mg/kg	0.02	5	0.434	0.296	0.685	1.01	0.612	0.358	0.307	0.318	0.275	0.094	2.06
Calcium (Ca)	mg/kg	50	-	32000	7450	43900	15300	8100	4980	4680	4360	3810	4110	30400
Chromium (Cr)	mg/kg	0.5	190	17.8	27.7	14.5	19	10.7	9.63	8.81	15.9	21.6	24.4	27.3
Cobalt (Co)	mg/kg	0.1	-	5.33	6.31	4.9	4.93	3.6	3.67	3.48	3.46	3.91	4.7	5.73
Copper (Cu)	mg/kg	0.5	130	69.2	50.7	41.6	64.6	39.2	21.7	29.8	37.3	30.4	58	135
Iron (Fe)	mg/kg	50	-	19100	35000	16600	16200	10700	10400	9930	10900	10700	18900	21200
Lead (Pb)	mg/kg	0.5	130	33.2	34.1	14.2	18.8	12.7	8.76	9.95	11.5	9.59	10.1	43.1
Lithium (Li)	mg/kg	2	-	9.3	11.8	12.1	13.5	12.9	10.6	12.2	10.7	11.7	11.1	13.7
Magnesium (Mg)	mg/kg	20	-	4800	4910	5320	5950	4340	3920	4220	3990	4800	4050	9290
Manganese (Mn)	mg/kg	1	-	228	325	203	219	183	187	179	170	185	235	204
Mercury (Hg)	mg/kg	0.05	0.84	<0.050	<0.050	<0.050	0.067	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.155
Molybdenum (Mo)	mg/kg	0.1	-	4.58	5.27	1.68	1.76	0.89	0.88	0.61	0.83	0.66	3.59	4.33
Nickel (Ni)	mg/kg	0.5	-	8.06	13.5	9.15	10.2	5.37	4.53	4.86	6.05	9.17	19.1	15.9
Phosphorus (P)	mg/kg	50	-	501	533	437	483	331	314	343	353	326	283	810
Potassium (K)	mg/kg	100	-	1150	1300	1480	1300	910	870	870	920	880	760	2270
Selenium (Se)	mg/kg	0.2	-	<0.20	<0.20	<0.20	0.24	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.68
Silver (Ag)	mg/kg	0.1	-	<0.10	0.36	0.1	0.19	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.28
Sodium (Na)	mg/kg	50	-	3610	4620	5650	7130	4090	3530	3980	3590	4130	3600	21700
Strontium (Sr)	mg/kg	0.5	-	104	46.9	237	97.5	61.6	36.5	38.4	35.7	30.6	38	174
Sulfur (S)	mg/kg	1000	-	2200	2300	4000	4700	2000	2100	1600	<1000	1200	<1000	14900
Thallium (Tl)	mg/kg	0.05	-	0.072	0.071	0.089	0.095	0.066	<0.050	0.06	0.05	<0.050	<0.050	0.18
Tin (Sn)	mg/kg	2	-	3.5	4.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.4
Titanium (Ti)	mg/kg	1	-	517	506	614	657	608	548	557	527	553	482	676
Tungsten (W)	mg/kg	0.5	-	0.97	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.71
Uranium (U)	mg/kg	0.05	-	0.911	0.858	0.937	0.756	0.64	0.456	0.435	0.477	0.453	0.35	1.86
Vanadium (V)	mg/kg	0.2	-	37.5	34.9	38	37.3	27.5	26.5	25.6	31.3	29.5	25.6	48.9
Zinc (Zn)	mg/kg	2	330	296	182	160	208	140	88	81.8	94.7	75.6	62.2	361
Zirconium (Zr)	mg/kg	1	-	1.6	1.1	1.7	1.9	1.1	<1.0	1.1	1.1	<1.0	<1.0	4.9
EPH10-19	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
EPH19-32	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	530
LEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
HEPH	mg/kg	200	-	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	520
2-Bromobenzotrifluoride	%	Surrogate	-	159.4 *	158.6 *	159.6 *	96.5	98	94.1	96.8	94.6	94.7	173.8 *	96.8
Acenaphthene	mg/kg	0.005	0.11	0.0114	0.0437	0.369	0.308	0.0179	0.0206	0.0236	<0.017 *	0.0724	<0.0050	0.293
Acenaphthylene	mg/kg	0.005	0.15	<0.0050	<0.0050	0.021	0.0461	<0.017 *	<0.020 *	<0.017 *	<0.017 *	0.0129	<0.0050	0.134
Anthracene	mg/kg	0.004	0.29	0.0368	0.0633	0.307	0.501	0.0387	0.0748	0.0987	0.0241	0.0823	0.0148	1.24
Benz(a)anthracene	mg/kg	0.01	0.83	0.075	0.149	0.668	1.11	0.142	0.119	0.228	0.093	0.366	0.038	2.7
Benzo(a)pyrene	mg/kg	0.01	0.92	0.042	0.092	0.274	0.647	0.137	0.093	0.185	0.081	0.407	0.03	1.54
Benzo(b&j)fluoranthene	mg/kg	0.01	-	0.079	0.159	0.526	1.11	0.23	0.162	0.312	0.149	0.652	0.06	2.87
Benzo(b+j+k)fluoranthene	mg/kg	0.015	-	0.11	0.223	0.73	1.55	0.322	0.236	0.438	0.206	0.922	0.083	3.94
Benzo(g,h,i)perylene	mg/kg	0.01	-	0.014	0.035	0.085	0.218	0.068	0.045	0.085	0.036	0.24	0.013	0.465
Benzo(k)fluoranthene	mg/kg	0.01	-	0.031	0.063	0.204	0.433	0.092	0.074	0.126	0.057	0.27	0.023	1.07
Chrysene	mg/kg	0.01	1	0.079	0.175	0.621	1.02	0.163	0.204	0.256	0.104	0.526	0.054	2.54
Dibenz(a,h)anthracene	mg/kg	0.005	0.16	0.0058	0.0135	0.0356	0.0866	0.0212	<0.020 *	0.0271	<0.017 *	0.0606	<0.0050	0.177
Fluoranthene	mg/kg	0.01	1.8	0.242	0.497	2.79	3.82	0.432	0.467	0.651	0.275	1.14	0.09	9.54
Fluorene	mg/kg	0.01	0.17	0.013	0.035	0.335	0.291	0.02	0.031	0.034	<0.017 *	0.073	<0.010	0.351
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01	-	0.018	0.049	0.121	0.292	0.086	0.053	0.114	0.049	0.285	0.018	0.646
1-Methylnaphthalene	mg/kg	0.05	-	<0.050	<0.050	<0.050	0.063	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	mg/kg	0.01	0.24	<0.010	<0.010	0.049	0.088	<0.017 *	<0.020 *	<0.017 *	<0.017 *	0.02	<0.010	0.074
Naphthalene	mg/kg	0.01	0.47	0.011	0.011	0.094	0.164	0.012	<0.020 *	<0.017 *	<0.017 *	0.032	<0.010	0.135
Phenanthrene	mg/kg	0.01	0.65	0.051	0.199	1.12	1.6	0.156	0.143	0.231	0.069	0.699	0.024	1.71
Pyrene	mg/kg	0.01	1.7	0.128	0.295	1.57	2.37	0.329	0.24	0.447	0.189	0.845	0.055	5.13
Quinoline	mg/kg	0.05	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthene d10	%	Surrogate	-	72	75	72.5	110.9	108.6	75.7	112	93.5	89.3	82.8	121.3
Chrysene d12	%	Surrogate	-	85.5	85	84.6	117.9	117.6	69.6	118.7	96.4	97.1	95.4	129.4
Naphthalene d8	%	Surrogate	-	68	76.5	69	115.1	111.5	73.8	115.4	94.7	94.5	84.3	123.3
Phenanthrene d10	%	Surrogate	-	80	81	80	118.3	114.7	76	116.8	98.4	98.3	90.6	129.1
B(a)P Total Potency Equivalent	mg/kg	0.02	-	0.07	0.149	0.469	1.04	0.215	0.146	0.294	0.126	0.633	0.047	2.47
IACR (CCME)	mg/kg	0.15	-	1.1	2.25	7.84	15.8	3.02	2.25	4.23	1.9	8.63	0.76	39.3

* = Result Qualified	Mouse-over the result to see the qualification.
Applied Guideline:	**British Columbia Contaminated Sites Regulation Stage 10 Amendment (NOV, 2017) - Schedule 3.4 Sediment Standards Marine and Estuarine Water(Typical)**
Color Key:	Within Guideline / Exceeds Guideline

Appendix A4

Fisheries Act Authorization Application

*This package will be provided as a separate attachment.

Appendix A5

DFO Letter of Advice

Fisheries and Oceans Canada
Pêches et Océans Canada

Pacific Region
Suite 200 - 401 Burrard Street
Vancouver, British Columbia
V6C 3S4

Région du Pacifique
Pièce 200 - 401 rue Burrard
Vancouver (C.-B.)
V6C 3S4

Your file *Votre référence*

January 17, 2019

Our file *Notre référence*

18-HPAC-01117

Seaspan ULC
Attention: George Geatros; Manager, Special Projects
10 Pemberton Avenue
North Vancouver, BC V7P 2R1

Via Email: ggeatros@seaspan.com

Subject: JSS Load-out Gravel Bed and East Infill – Application for Authorization under the *Fisheries Act* Required, but Prohibited Effects on Listed Aquatic Species at Risk Not Likely.

Dear Mr. Geatros:

The Fisheries Protection Program (the Program) of Fisheries and Oceans Canada (DFO) received your proposal on December 14, 2018. We understand that you propose to:

- Complete upgrades to your shipyard located on Pemberton Avenue in North Vancouver. The proposed upgrades are understood to be occurring in adjacent areas in the eastern portion of the shipyard and consist of:
  - Constructing the JSS Load-out Gravel Bed to allow vessels to be launched from the existing load-out pier using a self-contained dry-dock (Seaspan Careen). The load-out gravel bed will be constructed by depositing gravel over an area of 8,250 m^2 to raise the existing seabed to -1 m chart datum (c.d.) to allow grounding of the dry-dock at an elevation level with the load-out pier.
  - Infilling of an area on the East Spit to create additional storage and laydown space on the landside of the shipyard. The infill will be constructed using either a rip rap berm (9,500 m^2) or a sheet pile wall (8,600 m^2).

Canada

Our review considered the following information:

- Completed *Request for Review* form received by email on January 7, 2019;
- *JSS Load-out Gravel Bed and East Infill Project Habitat Assessment* prepared by Hatfield Consultants received by email on December 14, 2018; and
- *Request for Project Review* letter prepared by Hatfield Consultants received by email on December 14, 2018.

Your proposal has been reviewed to determine whether it is likely to result in serious harm to fish which is prohibited under subsection 35(1) of the *Fisheries Act* unless authorized. Your proposal has also been reviewed to determine whether it is likely to affect listed aquatic species at risk, any part of their critical habitat or the residences of their individuals in a manner which is prohibited under sections 32, 33 and subsection 58(1) of the *Species at Risk Act*, unless authorized.

We understand the following aquatic species listed under the *Species at Risk Act* may use the area in the vicinity of where your proposal is to be located:

- Killer Whale (Northeast Pacific Southern Resident), Northern Abalone, Leatherback Sea Turtle, Basking Shark listed as Endangered;
- Killer Whale (Northeast Pacific Transient) listed as Threatened; and
- Steller Sea Lion, Harbour Porpoise (Pacific Ocean), Humpback Whale (North Pacific), Grey Whale (Eastern North Pacific), Yelloweye Rockfish (Pacific Ocean Inside and Outside Waters), Green Sturgeon, Bluntnose Sixgill Shark, Tope listed as Special Concern.

Based on the review of the above information, the Program has concluded that the following work, undertaking or activity is likely to result in serious harm to fish:

- Placement of gravel and cobble over an area of 8,250 m^2 to raise the seabed elevation to -1 m (chart datum); and
- Infilling an area on the East Spit of 9,500 m^2 if a rip rap berm is used or 8,600 m^2 if a sheet pile wall is used.

Your proposal requires an authorization pursuant to paragraph 35(2) (*b*) of the *Fisheries Act* in order to proceed. As your proposal will not result in prohibited effects on listed aquatic species at risk, no permit will be required under the *Species at Risk Act*.

Please submit the following information and documents to apply for a *Fisheries Act* authorization:

- a completed Application for Authorization under Paragraph 35(2) (*b*) of the *Fisheries Act* Form (www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/authorization-autorisation-eng.html);

- the required information and documentation set out in the *Applications for Authorization under Paragraph 35(2)(b) of the Fisheries Act Regulations* (http://laws-lois.justice.gc.ca/eng/regulations/SOR-2013-191/page-1.html); and
- an irrevocable letter of credit (for requirements see: http://www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/application-eng.html#ch33) to cover the cost of offsetting plan, if you are required to provide one as set out in subsection 3(2) of the Regulations.

Should you choose to relocate or redesign your proposal, this could reduce the potential impacts of your proposal to a level where serious harm to fish can be avoided and a *Fisheries Act* authorization would no longer be required. If you choose to modify your proposal to avoid a need for authorization, please submit your revised Request for Review form.

Please be advised that any unauthorized work, undertaking or activity that contravenes section 35 of the *Fisheries Act* or sections 32, 33 and/or subsection 58(1) of the *Species at Risk Act* could lead to corrective action, such as enforcement. It is also your *Duty to Notify* DFO if you have caused, or are about to cause, serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery. Such notifications should be directed to the DFO-Pacific Region Observe, Record and Report phone line (toll free) at 1-800-465-4336; or in Greater Vancouver at 604-607-4186.

It remains your responsibility to meet all other federal, territorial, provincial and municipal requirements that apply to your project.

If you have any questions with the content of this letter, please contact Andrew MacInnis at our Nanaimo office at 250-756-7266 or by email at Andrew.MacInnis@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Sincerely,

M S Engelsjord

Michael Engelsjord
Team Lead
Fisheries Protection Program

cc: Stewart Wright, Hatfield Consultants, swright@hatfieldgroup.com