5.5 Surface Water Resources

5.5.1 Introduction

This section of the Environmental Assessment Certificate (EAC) Application/Environmental Impact Statement (EIS) (hereafter referred to as the EA.) has been prepared by Golder Associates Ltd. (Golder). It addresses the effects of the Proposed BURNCO Aggregate Project (hereafter referred to as the 'Proposed Project') identified in the construction, operation, reclamation and closure phases on valued components (VCs) related to surface water resources. Consideration has been given to mitigation measures proposed to mitigate any identified effects to acceptable levels and any residual effects have been characterized. Additionally consideration has also been given to cumulative effects of other reasonable foreseeable future projects in combination with the residual effects of the Proposed Project.

This section should be read in conjunction with the following technical reports provided in Volume 4, Part G – Section 22.0:

- Appendix 5.5-A - Surface Water Hydrological Baseline. BURNCO Aggregate Project;
- Appendix 5.5-B - Pit Lake Hydrodynamic Model BURNCO Aggregate Project Closure Plan;
- Appendix 5.5-C - Baseline Data Report: McNab Valley Surface Water Quality, 2009 to 2014;
- Appendix 5.5-D - Water Quality Modelling of the BURNCO Aggregate Project, BC;
- Appendix 5.5-E - Water Quality Screening Tables;
- Appendix 5.1-A - Fisheries and Freshwater Habitat Baseline Report; and
- Appendix 5.6-A - Hydrogeological Modelling to Assess Proposed Mine Plan. McNab Creek Valley Aggregate Project, Howe Sound, BC.

5.5.2 Regulatory and Policy Setting

The regulations and policies applicable to the Proposed Project relating to surface water resources are provided in Table 5.5-1.

Table 5.5-1: Applicable Provincial and Federal Regulations and Policies: Surface Water Resources

Applicable Provincial and Federal Regulations and Policies	Description
British Columbia *Mines Act*	Legislation that governs mining and mineral exploration activities in British Columbia and specifically governs all activities that occur on mines sites.
British Columbia *Environmental Management Act* (EMA; Waste Discharge Regulations)	EMA prohibits the introduction of waste to the environment unless the introduction of that waste is conducted in accordance with a permit, approval, order, or regulation (EMA sections 6([2] and 6[3]). The requirement of the EMA is that "*a person must not introduce waste into the environment in such a manner or quantity as to cause pollution"* (EMA section 6[4]). Pollution is defined in EMA as "*the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment*".
Federal *Fisheries Act*	The Government of Canada is responsible for managing fisheries resources in Canada through the *Fisheries Act* and its supporting regulations. The *Fisheries Act* (1985) protects the quality and integrity of fish habitats in commercial, recreational, and Aboriginal fisheries. Recently, the *Fisheries Act* has been revised. As of November 25, 2013, the Section 35 prohibition against the harmful alteration or disruption, or the destruction of habitat (HADD) has been combined with the Section 32 prohibition against the killing of fish by means other than fishing, to become a prohibition against the serious harm of fish, which is defined as death of fish or any permanent alteration to, or destruction of, fish habitat. Section 36 of the Act continues to contain a general prohibition against the deposit of deleterious substances to water frequented by fish.
*Canadian Environmental Protection Act R.S.C., 1999 (*Environment and Climate Change Canada)	An Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.
British Columbia *Water Sustainability Act*	In the Province of British Columbia legislation of matters relating to use and flow of surface water and groundwater, and protection of water resources are governed by the *Water Sustainability Act* (WSA) (SBC 2014). On February 29, 2016, the Regulations of the *Water Act* (RSBC 1996) were repealed and the WSA was brought into force, along with five new regulations, including the *Water Sustainability Regulation* (B.C. Reg 36/2016), the *Water Sustainability Fees, Rentals and Charges Tariff Regulation* (B.C. Reg. 37/2016), the *Dam Safety Regulation* (B.C. Reg. 40/2016), and the new *Groundwater Protection Regulation* (GWPR) (B.C. Reg. 39/2016). The *Water Sustainability Regulation* includes requirements for the licensing, diversion and use of groundwater and surface water to protect water resources and ecosystems, while the GWPR specifically addresses protection of the groundwater resource and identifies requirements for the construction of wells (discussed in detail in Volume 2, Part B – Section 5.6). The *Dam Safety Regulation* includes design standards and requirements and obligations for dam owners including minor dams.
Federal *Species at Risk Act*	The *Species at Risk Act* protects at-risk wildlife species by mandating recovering planning and, in some cases, prohibiting harm to individual animals or their habitats (*Species at Risk Act* 2002). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is a scientific panel that assesses and ranks species status based on conservation concern (i.e., extinct, extirpated, endangered, threatened, special concern, not at risk, or data deficient). In BC, the Conservation Data Centre assigns a provincial rank to a species, which is based solely on its status within British Columbia. In order to simplify interpretation of species ranks in British Columbia, three categories have been created: Red (extirpated, endangered, or threatened), Blue (special concern), and Yellow (secure and not at risk of extinction), which provides a foundation for managing and protecting species at risk in the province.

5.5.3 Assessment Methodology

This section provides a description of the assessment methodology used in preparing the EA related to surface water resources.

Please refer to Volume 2, Part B - Section 4.0: Assessment Methods of this EA for the general assessment methodology and scope including: selection of VCs, establishing boundaries, describing existing conditions, identification of Proposed Project VC interactions, identifying mitigation measures, evaluating residual effects and assessing cumulative effects. The assessment methodology presented below is specific to the assessment of surface water resources.

5.5.3.1 Valued Component Selection and Rationale

This section describes the VCs and measureable indicators identified for this assessment related to surface water resources. The VCs identified reflect issues and guidelines, potential Aboriginal concerns, issues identified by BC EAO and CEA Agency, First Nations, other stakeholders, professional judgment and key sensitive resources, species or social and heritage values. All identified candidate surface water resources VCs were carried forward in the effects assessment (e.g. no surface water resources VCs were excluded from the assessment). Additional details regarding the methods used to select VCs is provided in Part B, Volume 2 – Section 4.2.4.

The following attributes were also considered in selecting VCs:

- relevance to the area associated with the Proposed Project;
- potential for interaction with the Proposed Project;
- availability of data to support the EA; and
- Sensitivity to potential Proposed Project effects and use as a key indicator of Proposed Project effects.

Using the information above the following VCs were selected for the assessment of surface water resources:

- Surface water flow;
- Surface water quality; and
- Aquatic health (i.e., the health of aquatic life indicators present in the study area).

The Proposed Project may cause changes to surface water flow and water quality on the Site that can affect the health of aquatic life indicators present in the study area. Indicators for surface water flow identified include changes to baseflows. Key aquatic life indictors identified within the Local Study Area (LSA) included periphyton, benthic invertebrates, and fish species. These indicators are discussed in more detail below.

Changes to flow: The development of the proposed pit could potentially alter the local groundwater water levels which could influence flows in McNab Creek, WC 2 and the foreshore minor streams.

Surface water quality: Planned mining activities, and potential accidents and malfunctions (spills) can cause changes to water quality, which can affect aquatic health.

Periphyton: Primary producers such as periphyton, phytoplankton, and macrophytes form the base of the aquatic food chain. Periphyton communities develop in close association with hard substrates (rocks, woody debris, and plant cover) and are common in flowing environments where wetted substrate serves as a supporting habitat for these organisms. Periphyton is a complex matrix of algae and heterotrophic microbes and serves as an important food source for invertebrates and certain fish species. It can also be an important sorption matrix for contaminants.

Benthic invertebrates: Benthic invertebrates (e.g., aquatic insect larvae, molluscs, and worms) are important intermediate links in aquatic food chains because they graze on periphyton or detritus, or prey on other aquatic organisms. They also serve as food for stream-dwelling fish and bird species. Benthic invertebrates are also commonly used as biological indicators because they are ubiquitous and respond to a wide range of stressors. Benthic invertebrate communities inhabit both erosional (hard bottom substrate) and depositional (soft bottom substrate) habitats. Erosional habitats such as riffles are predominant within creeks in the LSA. In the largest LSA stream, McNab Creek, the benthic invertebrate community is dominated by chironomids (non-biting midges) followed by EPT taxa (i.e., mayflies (Order *Ephemeroptera*), stoneflies (*O. Plecoptera*), and caddisflies (*O. Trichoptera*).

Fish: Fish dominate many freshwater food webs as the top predator and can also be sensitive indicators of water quality. Six salmon and trout fish species were identified within the Proposed Project Area including Chinook (*Oncorhynchus tshawytscha*), Chum (*O. keta*), Coho (*O. kisutch*), and Pink Salmon (*O. gorbuscha*), and Cutthroat (*O. clarkii*) and Rainbow Trout (*O. mykiss*). The LSA (specifically McNab Creek and WC 2) provides spawning, overwintering, and juvenile rearing habitat for salmon and trout species. Chum, Coho, and Pink Salmon and Cutthroat Trout have significant value as commercial, recreational, and Aboriginal (CRA) fisheries. Other fish species, such as sculpin (*Cottus* spp.), gunnelfish (Family *Pholidae*), Threespine Stickleback (*Gasterosteus aculeatus*), and White Spotted Greenling (*Hexagrammos stelleri*) were also noted within the LSA.

Sediment quality at the water quality assessment nodes, in terms of grain-size and trace element concentrations, is not expected to change significantly as a result of the Proposed Project and so was not assessed further in the aquatic health assessment.

Table 5.5-2 provides a summary of identified VCs, rationale for their inclusion in the assessment, and measureable parameters or endpoints that will be considered in the assessment.

Table 5.5-2: Valued Components and Measurable Indicators: Surface Water Resources

Valued Component	Indicator	Rationale	Measurable Indicators
Surface Water Flow	Changes to Baseflow	The development of the proposed pit could potentially alter the groundwater levels at the site, which could influence baseflow in McNab Creek, WC 2 and the Foreshore Minor Streams.	Modelled average rate flow from McNab Creek to the groundwater system; Average annual daily baseflow in WC 2, Foreshore Minor Streams based on numerical modelling; and Wetted area and average flow depth in WC 2 and Foreshore Minor Streams were evaluated through numerical modelling.
	Changes to extreme low flow	The development of the proposed pit could potentially alter the groundwater levels at the site, which could influence extreme low flows in McNab Creek.	The duration and frequency of periods of no surficial flow in the segment of McNab Creek adjacent to the Proposed Project will be estimated using a regional analysis and numerical modelling of flow from McNab Creek to the Groundwater system.
Surface Water Quality	Surface Water Quality	Mining activities including accidents and malfunctions (spills) can cause changes to water quality, which can affect aquatic health. The importance of characterizing and predicting changes to water quality was identified through consultation with regulators, the public, and First Nations.	Water quality monitoring during the Proposed Project, site sediment and erosion control and spill prevention and response practices will be compared to applicable regulatory and industry guidelines and best management practices.
Aquatic Health (the health of aquatic life indicators present in the study area).	Periphyton	Important food source for invertebrates and certain fish species. It can also be an important sorption matrix for contaminants.	Assessed by comparing predicted water quality concentrations to applicable WQGs and the baseline condition. For parameters without WQGs but greater than 10% above the baseline condition, an assessment of the magnitude of potential effects was undertaken based on toxicity information in the available literature.
	Benthic Invertebrates	Important intermediate link in aquatic food chains. Benthic invertebrates graze on plant material and serve as food for fish, amphibians and birds.	
	Fish	Dominate many freshwater food webs as the top predator and can be sensitive indicators of water quality. The importance of evaluating residual effects of the Proposed Project on fish species was identified through consultation with regulators, the public, and First Nations.	

Notes:
n/a: not applicable; WQG: water quality guideline

5.5.3.2 Assessment Boundaries

5.5.3.2.1 Spatial Boundaries

The spatial boundaries for the EA have been selected to take into account the physical extent of the Proposed Project, related effects and key environmental systems. The spatial boundaries for surface water resources are consistent with assessments of hydrology (Volume 2, Part B - Section 5.5) and fisheries and freshwater habitat (Volume 2, Part B - Section 5.1).

The spatial boundaries for surface water resources include a LSA and a Regional Study Area (RSA).

5.5.3.2.1.1 Local Study Area

The LSA is the immediate area surrounding the proposed pit, as shown in Figure 5.5-1. The LSA encompass the Proposed Project Area that is expected to interact with and potentially change the conditions of surface water quantity and quality. The LSA was defined as an area bounded to the north and east by McNab Creek, to the south by Howe sound, and to the west by a line approximately 10 m beyond (i.e., west of) the access road that runs in the north-south direction.

5.5.3.2.1.2 Regional Study Area

The RSA was established to provide a regional context for the consideration of changes to surface water resources that could cause adverse Proposed Project effects to the health of aquatic life indicators. The RSA was also established to encompass the area within which the residual effects of the Proposed Project are likely to overlap with the residual effects of other existing or reasonably foreseeable projects and activities. The RSA was defined as all watersheds that flow into McNab Creek and the LSA, as shown in Figure 5.5-1.

5.5.3.2.2 Temporal Boundaries

Based on the Proposed Project schedule, the temporal boundaries for the effects assessment for surface water quality and aquatic health are as follows:

- Project construction – up to 2 years;
- Project operations – 16 years; and
- Project reclamation and closure – on-going and 1 year beyond operations.

Surface water resources predictions were made during Proposed Project operations and reclamation and closure. For a full description of the temporal boundaries of the Proposed Project please refer to Volume 2, Part B - Section 4.0.

5.5.3.2.3 Administrative Boundaries

These boundaries refer to the limitations on the assessment imposed by political, economic or social constraints. No administrative boundaries are applicable to the surface water resources assessment.

5.5.3.2.4 Technical Boundaries

These boundaries refer to constraints on the assessment imposed by limitations in the ability to predict effects. The technical boundaries of the surface water resources assessment include:

- The assessment of the Proposed Project's potential effects and residual effects on baseflow and extreme low flow were based on numerical modelling with limited calibration.
- The climate and hydrological baselines conditions used in this assessment were largely based on available long term regional data as limited onsite historic were available.
- The Proposed Project's potential effects and residual effects on surface water quality and aquatic health are limited to the extent of the water quality modelling (Volume 4, Part G – Section 22.0: Appendix 5.5-D), which is restricted to within the LSA.

5.5.3.3 Assessment Methods

5.5.3.3.1 Existing Conditions

The methods used to characterize existing surface water hydrological conditions in the Proposed Project Area are detailed in Volume 4, Part G – Section 22.0: Appendix 5.5-A (Surface Water Resources Hydrological Baseline Report).

A characterisation of existing baseline conditions related to surface water quality and Fisheries and Freshwater Habitat is provided in the McNab Valley Surface Water Quality, 2009-2014 Baseline Data Report (Volume 4, Part G – Section 22.0: Appendix 5.5-C) and Fisheries and Freshwater Habitat Baseline Report (Volume 4, Part G – Section 22.0: Appendix 5.1-A) based on the baseline sampling program for the Proposed Project. The main findings are summarised in this Section to describe existing baseline conditions.

All appendices are provided in Volume 4, Part G – Section 22.0.

5.5.3.3.2 Identifying Project Interactions

A preliminary evaluation of identified interactions between the various physical works and activities and surface water quality and aquatic health, across all spatial and temporal phases of the Proposed Project, was undertaken to characterize interactions as:

a) Positive, none or negligible, requiring no further consideration; or

b) Potential effect requiring further consideration and possibly additional mitigation.

This evaluation is presented in Section 5.5.5. Rationale is provided for determinations where positive, no or negligible interactions were identified and therefore no further consideration is required. For those Proposed Project-VC interactions that may result in a potential effects requiring further consideration, the nature of the effects (both adverse and positive) arising from those interactions is described. Potential effects include direct, indirect, and induced effects.

5.5.3.3.3 Evaluating Residual Effects

Proposed Project-related residual effects were characterized as the basis for determining the significance of any potential residual effects on surface water resources. The residual effects assessment was primarily based on an evaluation of potential effects on aquatic indicators exposed to predicted water quality for the Proposed Project, or changes to flows, after the implementation of the appropriate mitigation measures. The assessment of water quality-related Proposed Project effects on aquatic health is based on water quality predictions presented in Volume 4, Part G – Section 22.0: Appendix 5.5-D.

Potential residual effects were characterized using the following standard residual effects criteria:

- **Context** – the current and future sensitivity and resilience of the VC to change caused by the Proposed Project as described in Table 5.5-3;
- **Magnitude** – the expected size or severity of the residual effect. Amount or category of change relative to baseline (including natural variations) or relative to toxicity-based benchmarks (i.e., regulatory guidelines, risk-based screening values) as described in Table 5.5-3;
- **Extent** – the spatial scale over which the residual effect of a defined magnitude is expected to occur as described in Table 5.5-3;
- **Duration** – the length of time the residual effect persists as described in Table 5.5-3;
- **Reversibility** - indicating whether the effect is fully reversible, partially reversible, or irreversible. The likelihood of a return to baseline conditions is described in Table 5.5-3; and
- **Frequency** – how often the residual effect occurs during the Proposed Project or a specific Proposed Project phase as described in Table 5.5-3.

Where possible, definitions have taken into account the technical guidance. The following documents are considered to be relevant to an assessment of surface water resources:

- Guideline of the Selection of Valued Components and Assessment of Potential Effects (EAO 2013);
- Application Requirements for a *Mines Act* Permit and an *Environmental Management Act* Permit for proposed mining projects (MEMPR 2012);

- Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. (BC MOE 2012); and
- Guidance on Applications for Permits under the *Environmental Management Act* – Technical Assessment (BC MOE 2010).

Table 5.5-3: Criteria for Characterizing Potential Residual Effects: Surface Water Resources

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Surface Water Flow	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system is moderately susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible**: <1% change; **Low:** 1 to 10% change; **Medium:** 10% to 30% change; or **High:** >30% change.	**Local:** Effect restricted to the LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term:** <5 years; **Medium-term:** 5 years to life of Proposed Project; or **Long-term:** >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.
Surface Water Quality – Suspended Sediments Surface Water Quality – Accidental Chemical Spills	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system is moderately susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** No significant effect on surface water quality. Peak concentrations less than applicable WQGs or not distinguishable from the baseline conditions; **Low:** Potential for effects on the most sensitive components of the receiving environment. Peak concentrations extend above applicable WQGs; or **Medium:** Greater potential for effects on the most sensitive components of the receiving environment. Peak concentrations extend above applicable WQGs. **High:** Potential for effects on a wider range of components of the receiving environment. Peak concentrations extend above applicable WQGs.	**Local:** Effect restricted to the LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term:** <5 years; **Medium-term:** 5 years to life of Proposed Project; or **Long-term:** >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

VC	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Surface Water Quality and Aquatic Health	**Resilient:** The system has low susceptibility to potential changes caused by the Proposed Project; **Moderately Resilient:** The system is moderately susceptibility to potential changes caused by the Proposed Project; or **Sensitive:** The system is susceptible to potential changes caused by the Proposed Project.	**Negligible:** *No significant effect on surface water quality and aquatic health*. Peak concentrations less than applicable WQGs or not distinguishable from the baseline condition[1]; **Low:** *Potential for effects on the most sensitive indicator species and life-stages present within mine-influenced receiving waters.* Peak concentrations extend above applicable WQGs and are more than 10% higher than the median baseline concentration. • A risk-based assessment concludes that the magnitude of effect on aquatic health is low. Populations and communities are expected to remain self-sustaining and ecologically functional; **Medium:** *Greater potential for effects on the most sensitive indicator species and life-stages present within mine-influenced receiving waters.* Peak concentrations extend above applicable WQGs and are more than 10% higher than the median baseline concentration. • A risk-based assessment concludes that the magnitude of effect on aquatic health is medium. Populations and communities are expected to remain self-sustaining and ecologically functional; or **High:** *Potential for effects on a wider range of indicator species and life-stages present within mine-influenced receiving waters.* Peak concentrations extend above applicable WQGs and are more than 10% higher than the median baseline concentration. • A risk-based assessment concludes that the magnitude of effect on aquatic health is high. Possible impairment of the ability of aquatic indicator populations and communities to remain self-sustaining and ecologically functional.	**Site-Specific:** Effect restricted to one station or to stations on the same waterbody; **Local:** Effect restricted to the LSA; **Regional:** Effect extends beyond the LSA into the RSA; or **Beyond Regional:** Effect extends beyond the RSA.	**Short-term:** <5 years; **Medium-term:** 5 years to life of Proposed Project; or **Long-term:** >life of Proposed Project.	**Fully reversible:** Effect reversible with reclamation and/or over time; **Partially Reversible:** Effect can be reversed partially; or **Irreversible:** Effect irreversible and cannot be reversed with reclamation and/or over time.	**Low:** Occurs rarely or during a specific period; **Medium:** Occurs intermittently; or **High:** Occurs continuously.

Notes:
[1] Predicted concentrations of modelled parameters not higher than 10% above median baseline concentrations for those parameters.
VC: valued component; WQG: water quality guideline; LSA: local study area; RSA: regional study area.

The likelihood of the potential residual effect occurring was also characterized for surface water resources. To derive a likelihood rating that indicates the probability of a certain effect to occur, implementation of mitigation measures were considered. For example, the likelihood of a certain effect is low, if there is a low potential of the event leading to the effect to occur, or if there are effective controls in place that can eliminate or reduce the magnitude or frequency of the effect. The following criteria were used to define likelihood:

- Low - likelihood of occurrence (0 to 40%) – Residual effect is possible but unlikely;
- Medium - likelihood of occurrence (41 to 80%) - Residual effect may occur, but is not certain to occur; and
- High - Likelihood of occurrence (81% to 100%) - Residual effect is likely to occur or is certain to occur.

5.5.3.3.3.1 Surface Water Flow Assessment

5.5.3.3.3.1.1 Baseflow

The Proposed Project is anticipated to have an influence on the groundwater levels within the LSA. This would have the potential to alter baseflow in McNab Creek, WC 2, and the Foreshore Minor Streams. The Proposed Project's potential effect on baseflow was evaluated based on hydrogeological modelling results (Volume 4, Part G – Section 22.0: Appendix 5.6-A), professional judgement and guidance received from representatives of regulatory agencies.

The hydrogeological assessment used DHI-WASY's Finite Element subsurface flow system (FEFLOW), a computer program for simulating groundwater flow, mass and heat transfer in porous media under saturated and unsaturated conditions. FEFLOW model inputs included climate and stream flow baseline conditions presented in the Surface Water Hydrological Baseline (Volume 4, Part G – Section 22.0: Appendix 5.5-A). Changes resulting from Proposed Project activities during different phases were also incorporated into the model (i.e., the phased development of the aggregate pit). FEFLOW was used to estimate the Proposed Project's effect on the baseflow in McNab Creek, WC 2, and the Foreshore Minor Streams. The baseflows were estimated for pre-Proposed Project conditions, Proposed Project construction, operation, and closure phases as discussed in Section 5.5.5.2.1. For details of the hydrogeological modelling, refer to Volume 4, Part G – Section 22.0: Appendix 5.6-A.

The Proposed Project's potential effects on flow characteristics in McNab Creek, WC 2 and the Foreshore Minor Streams were also evaluated by estimating the change in wetted area and average flow depth in these systems based on baseflow estimates. The change in wetted area and average flow depth was estimated using the Hydrologic Engineering Centers River Analysis System (HEC-RAS), a one-dimensional hydraulic model developed by US Army Corps of Engineers. The McNab Creek geometry was modelled based on surveyed channel cross-sections and LiDAR mapping of the overbank areas. WC 2 and the Foreshore Minor Streams geometry was represented with simplified trapezoidal cross-sections developed based on observations of geometry made during aquatic habitat mapping investigations.

5.5.3.3.3.1.2 Extreme Low Flows

The Proposed Project has the potential to impact the extreme low flows in McNab Creek. Commonly, a natural stream gains flow from the groundwater system as it flows downstream through its watershed. However, McNab Creek currently loses flow to the groundwater system in the reach adjacent to the north and east sides of the Proposed Project Area. This is due to a combination of variables, including: the alignment of the watercourse, the nature of the surficial soils, and the presence of WC 2. As a result, the creek has been observed to periodically have no surface flow in isolated segments during dry periods of the year. Due to this existing pattern of flow loss to the groundwater system resulting in occasional periods of no surficial flow in segments of the stream adjacent to the Proposed Project Area, a conventional statistical low flow analysis was not the preferred tool for assessing the potential impacts of changes in groundwater levels. Instead, a drought analysis was completed to evaluate the duration of these periods of no flow in order to provide a quantifiable metric to support the assessment. The drought analysis is not intended to be provided as a quantification of the frequency or duration of periods of no flow in McNab Creek but as a means to indicate the degree and direction of potential impacts relative to baseline conditions.

A regional statistical frequency analysis to estimate the extreme low flows in McNab Creek immediately upstream from the Proposed Project Area was performed. The 5 and 10-year return period extreme low flows were estimated using data from the WSC Station Chapman Creek above Sechelt Diversion. The running average flows over durations of 1 to 20 days were estimated for the months of August and September, when the lowest flows in McNab Creek are expected. The annual minima time series was populated using the lowest running average flows from each year for the different event durations. Several standard statistical distributions, including 3 Parameter Log-normal, Log Pearson III, Extreme Value, and Weibull (Gumbel III), were compared to the data, and the most suitable distribution was selected. The data population and the selected distribution were then used to estimate the extreme low flows during each time period.

The Proposed Project's impact on low flow was evaluated by assessing the duration and frequency of periods when the creek has no surface flow (i.e., drought) in this segment. This drought analysis was carried out by estimating the rate of surface flow loss to the groundwater system in this segment of the creek, and comparing it to the estimated extreme low flows. When the rate of groundwater loss was greater than the extreme low flow rate, the creek was considered to be dry or without any surficial flow. By comparing the estimated rate of loss to the low flow rates of various durations, the anticipated duration of a dry period, for a given recurrence interval was estimated.

5.5.3.3.3.2 Surface Water Quality –Suspended Sediments

Changes to suspended sediments in surface water runoff that could potentially result from Proposed Project activities were evaluated qualitatively with respect to the Water Quality VC. The assessment focused on activities that could potentially change suspended sediments levels in surface water.

5.5.3.3.3.3 Surface Water Quality –Chemical Spills

Accidental chemical spills related to the Proposed Project have the potential to effect surface water quality. Proposed Project activities were evaluated qualitatively with respect to the Water Quality VC. The assessment focused on activities that could potentially result in chemical spills affecting surface water quality.

5.5.3.3.3.4 Aquatic Health Assessment

The aquatic health effects assessment was guided by two common expectations under the *Fisheries Act* and the *Environmental Management Act*:

- A discharge to the aquatic environment should not be acutely lethal; and
- Chronic sublethal effects should not occur outside of the initial dilution zone (IDZ). A lack of chronic sublethal effects are (conservatively) predicted when the parameter of concern has a concentration lower than the ambient water quality guidelines (WQGs). The applicable guidelines were BC MOE WQGs for the protection of aquatic life (BC MOE 2015a, b) and Canadian Council of Ministers of the Environment (CCME) WQGs for the protection of aquatic life (CCME 1999).

Potential environmental impact was identified by evaluating predicted concentrations of effluent (from the pit lake) quality, as well as predicted water quality at the edge of the IDZ and further downstream in the receiving environment. The IDZ is the initial portion of the larger effluent mixing zone. The extent of an IDZ is defined on a site-specific basis and allows for mixing between effluents and the receiving water (BC MOE 2013a). For the purposes of this effects assessment, the edge of the IDZ was assumed to be station MCF-6 located within WC 2, downstream of the pit lake discharge.

The aquatic health assessment relied on water quality modelled predictions presented in Volume 4, Part G – Section 22.0: Appendix 5.5-D. Water quality predictions were modelled for the following nodes during operations and at closure (Figure 5.5-*2*):

- Two nodes on McNab Creek (MCF-1 and MCF-7);
- Pit lake (MCF-5);
- Downstream of the pit lake and within WC 2 (MCF-6); and
- Downstream of the pit lake along a permanent watercourse (MCF-12).

The following two water quality model scenarios were developed for the Proposed Project as described in Volume 4, Part G – Section 22.0: Appendix 5.5-D.

- **Base Case:** Median baseline water quality inputs were used to estimate water quality in the pit lake and at the four LSA receiving environment locations; and

- **Conservative Case:** A combination of 95th percentile, maximum and stochastic baseline water quality inputs were used to evaluate a conservative quality scenario. The conservative case scenario was developed to establish an upper bound on predictions based on sensitivity to input water qualities. Two sources of conservatism exist: water quality predictions assumed that all input water parameters will occur at 95th percentile or maximum concentration simultaneously throughout the course of operations and closure, or the water quality predictions evaluate the 95th percentile water quality from the probabilistic model.

Predicted water concentrations were modelled for the pit lake (MCF-5); however, it is not considered to be part of the receiving environment. The pit lake will not provide suitable habitat for fish due to its steep banks, lack of cover, and limited food supply. Consequently, the pit lake was not formally evaluated in the aquatic health assessment but is discussed in Section 5.5.5.6.1.

5.5.3.3.3.4.1 Identification of Exposure Pathways

Exposure pathways for aquatic life are routes by which indicators could potentially be exposed to water quality parameters in various environmental media. Pathways that could be applied to aquatic indicators include the following:

- Direct contact with water by periphyton, benthic invertebrates, and fish; and
- Ingestion of dietary items with elevated concentrations of some parameters (such as trace metals) by benthic invertebrates and fish.

5.5.3.3.3.4.2 Conceptual Model

This model describes how a stressor might affect the ecological components of an environment, and provides a graphical representation of exposure pathways. Figure 5.5-*3* provides a diagrammatic representation of the relationships between the water quality parameters, pathways, and aquatic health indicators. The stressors considered in this assessment are the potential for toxicity-related effects of some water quality parameters on aquatic life and the potential for nutrient enrichment related effects.

5.5.3.3.4 Evaluating Significance of Residual Effects

The significance of potential residual adverse effects was determined for surface water resources based on residual effects criteria and the likelihood of a potential residual effect occurring described in Section 5.5.3.3.3, a review of background information and available field study results, consultation with government agencies and other experts, and professional judgement.

The significance of predicted residual effects of the Proposed Project on surface water resources was characterized as negligible (and not significant), not significant or significant.

- **Negligible (and not significant).** Negligible residual effects are either not measurable, within the range of natural variability, or so small they may be safely disregarded. They do not warrant further consideration and are not carried forward into a cumulative effects assessment.
- **Not Significant.** Residual effects may be characterized as not significant if they are determined to be measurable but do not exceed established environmental standards, guidelines, or objectives and/or are not beyond the natural variability of the environmental conditions and/or are not likely to result in substantial changes to the viability of aquatic health (i.e., the ability of the population, ecosystem or community to work and function over time within the defined spatial and temporal boundary).
- **Significant**. Residual effects may be characterized as significant if there is a reasonable expectation that the effect of the Proposed Project would:
  - exceed established environmental standards, guidelines, or objectives and be beyond the natural variability of environmental conditions; and/or
  - Affect the viability of aquatic health (i.e., the ability of the population, ecosystem or community to work and function over time within the defined spatial and temporal boundary).

The rationale and determination of the significance of potential residual effects on surface water resources are provided in Section 5.5.5. All non-negligible residual adverse effects (i.e., significant and non-significant) will be considered for inclusion in a cumulative effects assessment.

5.5.3.3.5 Level of Confidence

The level of predictive confidence to determine the probability of an effect was assessed to characterize the level of confidence associated with the significance determinations. Predictive confidence was defined based on confidence that the assessment of significance was appropriately conservative with respect to the flow modelling, water quality predictions, site-specific and toxicological considerations, and the status of scientific information available.

Level of predictive confidence was characterized as:

- Low: Limited evidence is available, models and calculations are highly uncertain, and/or evidence about potential effects is contradictory.
- Moderate: Sufficient evidence is available and generally supports the prediction.
- High: Sufficient evidence is available and most or all available evidence supports the prediction.

Low confidence suggests a higher level of uncertainty in the significance determinations compared to moderate or high confidence ratings.

5.5.4 Baseline Conditions

The baseline surface water hydrology, surface water quality report, Fisheries and Freshwater Habitat baseline is provided in Volume 4, Part G – Section 22.0: Appendix 5.5-A, Appendix 5.5-C, and Appendix 5.1-A. Baseline information regarding wetlands is provided in Volume 4, Part G – Section 22.0: Appendix 5.3-A. Brief summaries of baseline conditions are provided below based on these reports.

5.5.4.1 Traditional Ecological and Community Knowledge Incorporation

TEK/CK information was gathered from a Project-specific study undertaken by *Sḵwx̱wú7mesh* (Squamish Nation) and from publicly-available sources.

TEK/CK sources were reviewed for information that could contribute to an understanding of surface water resources. The main sources of this information include:

- Occupation and Use Study (OUS) undertaken by S*ḵwx̱wú7mesh* (Traditions 2015 a,b)
- An expert report produced on behalf of Tsleil-Waututh Nation for another project (Morin 2015)
- Regulatory documents for other projects in close proximity to the Proposed Project Area (e.g., Eagle Mountain – WGP 2015 a,b; PMV 2015; WLNG 2015).

TEK/CK sources available at the time of writing provided no specific information on harvest locations, abundance or quality of, or other environmental knowledge regarding resources potentially affected by Project-related activities in the RSA, including changes to these resources over time. Following is a general discussion of Aboriginal Groups' harvesting of resources potentially affected by Project-related effects on surface water resources within Howe Sound.

Aquatic Health (i.e., the health of aquatic life indicators present in the study area) was considered as a valued component in the assessment of effects on surface water resources. Fish and benthic invertebrates were considered as indicators in the assessment that focused on freshwater streams in the local study area. S*ḵwx̱wú7mesh* reports harvesting the following fish species in freshwater: all five species of salmon, steelhead and Dolly Varden char.

S*ḵwx̱wú7mesh* previously reported harvesting a total of twenty bird species, including, but not limited to, red throated loons, geese, grebes, and ducks (surf scooters, mallards, mergansers) (Eagle Mountain – WGP 2015b, Kennedy and Bouchard 1976b in Millennia 1997, SN 2001). Tsleil-Waututh Nation also reports harvesting waterfowl throughout Howe Sound at locations where larger flocks gather (Eagle Mountain – WGP 2015b; WLNG 2015).

For a full summary of Aboriginal Group use of lands and resources for traditional purposes and occupancy of Howe Sound refer to Part C.

5.5.4.2 Surface Water Flow

The main objective of the surface water hydrological baseline evaluation was to characterize the hydrologic setting as it relates to the Proposed Project and to support the assessment of potential impacts on surface water resources. The baseline study involved collection and review of regional historical climate and stream flow data, as well as local data.

Based on the BC Stream flow Inventory (Coulson and Obedkoff 1998), the Proposed Project is located in hydrologic subzone 9B, Southern Coastal Mountains. The McNab Creek watershed is further classified as part of the Southern Pacific Ranges Ecosection (BC MOE 2011), which is characterized by glaciated U-shape valleys. Upper valley slopes are generally steep, with a mantle of till glacial material or exposed bedrock, and the lower valley slopes are generally flatter with predominantly coarse substrate in the valley bottoms along the mainstream watercourses.

Based on available aerial imagery, much of the McNab Creek watershed is covered by thick forest, while the upper slope areas have limited vegetative cover, consistent with steep slopes nearing the alpine limit of forests.

Surface water systems which could be potentially impacted by the Proposed Project were identified and characterized, as describe in Volume 4, Part G – Section 22.0: Appendix 5.5-A. Figure 5.5-*2* shows the location of these systems with reference to the Proposed Project. The systems identified are:

- McNab Creek;
- WC 2 (upper and lower segments); and
- Foreshore Minor Streams WC 3, WC 3-E, WC 4-W, WC 4-E, and a portion of WC 5.

A Proposed Project Area climate characterization was completed to support the hydrological analysis. The local Fire Weather Station TS_MCNABB, located adjacent to the Proposed Project Area, had a relatively short period of record and could not be used to derive long-term climate trends. Environment and Climate Change Canada (formerly Environment Canada; ECCC) meteorological stations within the vicinity of the Proposed Project were identified and evaluated for their potential to represent local climatic conditions. The Port Mellon Station (ECCC Station No. 1046330 and No. 1046332) was selected for the Proposed Project Area climate characterization for its location and relatively long period of record (1942 to 2012). To confirm Port Mellon Station's ability to represent local climate conditions at the Proposed Project Area, Port Mellon Station temperature and precipitation records were compared to TS_MCNABB records and were found to have similar trends.

The Port Mellon Station records were used to derive the following climate baseline characteristics at the Proposed Project Area:

- Average, mean maximum and mean minimum monthly temperature;
- Annual, seasonal (wet/dry) and monthly precipitation;
- 200-year return period extreme high precipitation for various durations; and

- Average monthly and annual evapotranspiration and evaporation.

A hydrological characterization of the Proposed Project Area was also performed. The Water Survey Canada (WSC) hydrometric station located at Chapman Creek above Sechelt Diversion (Sta.No. 08GB060) was selected as the representative regional station for the Proposed Project Area hydrology. The 18 years of records at Chapman Creek hydrometric station (1970 to 1988) were used to derive the following McNab Creek stream flow baseline characteristics:

- McNab Creek mean annual and monthly flows;
- McNab Creek extreme low flow with a return period of 5 and 10-years; and
- McNab Creek extreme high daily flow with a return period of 200 years.

No historical flow records for WC 2 have been identified. A flow monitoring station was installed in the upper segment of WC 2 and recorded flows from September 2010 to November 2012. Water levels and flow records from this station were used to characterize flows in WC 2.

No historical records of flow in the Foreshore Minor Streams have been identified. Characterization of flows in these streams has been performed using results from the hydrogeological assessment presented in Volume 4, Part G – Section 22.0: Appendix 5.6-A.

5.5.4.3 Surface Water Quality

Surface water sampling was conducted monthly between November 2009 and December 2010 at two sites (MCF-7 on McNab Creek and MCF-11 on Harlequin Creek). Water sampling was also conducted during three additional events in September and October 2012, and March 2014 at 15 sites throughout the LSA to capture seasonal and spatial variability in water quality. Samples were analyzed for general parameters, metals, nutrients, and hydrocarbons. Measured concentrations were compared to applicable WQGs, specifically BC MOE WQGs for the protection of aquatic life (BC MOE 2015a, b) and Canadian Council of Ministers of the Environment (CCME) WQGs for the protection of aquatic life (CCME 1999).

Surface water in the LSA generally had low trace metal and nutrient concentrations, with the exception of aluminum, and hydrocarbons were not detectable. Total aluminum consistently exceeded the CCME WQG with the highest concentrations coinciding with elevated suspended sediments measured at sites downstream or alongside the road that runs north/south within the LSA on its west side. Dissolved aluminum also consistently exceeded the maximum and 30-day BC Ministry of Environment (BC MOE) BC WQGs. The aluminum content of the water likely reflects the natural mineralogy of the area.

5.5.4.4 Aquatic Health

5.5.4.4.1 Fish and Fish Habitat

The Proposed Project is located in the lower portion of the McNab Creek watershed on the western shore of Howe Sound's Thornbrough Channel. The Proposed Project will be situated on the glacial fan-delta between the mouths of Harlequin Creek and McNab Creek. Thirty-five watercourses (i.e., streams, ditches, groundwater-fed watercourses) are present on the Property in the vicinity of the Proposed Project. Fisheries and Freshwater Habitat assessments of the perennial, ephemeral and intermittent watercourses within or adjacent to the footprint of the Proposed Project components were undertaken (Volume 4, Part G – Section 22.0: Appendix 5.1-A). The objectives of the habitat assessments were to collect information regarding the location and extent of available fish habitats and to assess the characteristics of these habitats. A multi-year fish sampling program that included electrofishing, minnow trapping, adult salmon counts and beach seining was also undertaken within the fish bearing portions of the identified water courses. The objective of the fish sampling program was to collect information regarding the fish community present in the Proposed Project Area. The fish sampling information collected included distribution, relative abundance and habitat use for fish species potentially affected by the Proposed Project.

The majority of the identified watercourses located on or near the Proposed Project site do not flow continuously and many of them are not connected to fish-bearing watercourses. The main fish-bearing watercourses in the area include McNab Creek, Harlequin Creek, WC 2, and several natural watercourses below the proposed pit for the Proposed Project.

The upper portions of McNab Creek are relatively small and steep, whereas the lower 1.7 km of the watercourse where it flows north and west of the Proposed Project is wider and lower gradient. The lower segment contains numerous gravel and cobble bars and deep pools. The lower portion of the watercourse provides an abundance of suitable salmonid spawning habitat with more limited potential for juvenile rearing.

Harlequin Creek and its tributaries are situated in the south-west corner of the Property. The main watercourse flows parallel along the west side of the existing access road on the Property. Upstream of the road Harlequin Creek has steep cascade-pool and step-pool type habitats while it has lower gradient riffle-pool and wetland habitats adjacent to the access road. Harlequin Creek and its tributaries provide a diversity of habitats including adequate cover, suitable substrates for spawning and deep pools that provide suitable overwintering habitats for salmonids.

Watercourse 2 is located near the center of the Proposed Project site. Watercourse 2 is divided into two distinct segments separated by the hydro power line Right-of-Way (ROW) and culvert for an access road. The upper segment of WC 2 consists of a straight, excavated channel flowing from north to south for approximately 520 m through the area of the proposed pit. The majority of the upper segment of WC 2 mainly contains lower gradient pool and run habitats, with the exception of a short segment of steeper riffle-pool habitat near the top of the watercourse that contains exposed gravels and cobbles. The upper portion of the watercourse mainly provides habitat suitable for juvenile salmonid rearing. Below the culvert the lower segment of WC 2 consists primarily of a slow-flowing water with low-gradient run and pool habitats. The last segment of the watercourse drains into the historically natural groundwater-fed watercourse where it enters the foreshore. The lower segment of the watercourse is tidally influenced with backwatering effects all the way up to the culvert and brackish conditions extending approximately 100 m upstream from the mouth. The lower portion of the watercourse provides an abundance of suitable juvenile salmonid rearing habitat with some spawning habitat.

There are four natural groundwater-fed watercourses located south and west of the lower segment of WC 2. These natural groundwater-fed watercourses are identified, east to west, as 3, 3-E, 4-E, and 4-W. Watercourse 3 is the only one of these watercourses that is actually connected to the lower segment of the WC 2. This watercourse is slow-flowing with run and pool habitats that mainly provide suitable conditions for rearing juvenile salmonids. This watercourse is fresh water however it is tidally influenced and the lower segment is brackish. The remaining groundwater watercourses are dead-end channels that are more tidally influenced. Watercourse 3-E is a dead-end, marshy watercourse that connects with Watercourse 3 near its outlet to the foreshore. Watercourses 4-E and 4-W are low gradient marshy watercourses entering the intertidal flats along the shoreline of the property. These watercourses are characterized by fine substrates and moderate growths of marsh vegetation. Closer to the foreshore stable substrate in these watercourses support intertidal algae (e.g., *Fucus* sp.). The more brackish conditions in these watercourses tend to provide marginal habitat for freshwater rearing juvenile salmonids. However, these watercourses are used during higher tides by fish species including salmonids inhabiting the estuary.

The last natural watercourse below the proposed pit is identified as Watercourse 5 and it is located in the south-west corner of the Proposed Project site. The watercourse flows off of the slope next to the main access road and continues south-east to the foreshore between the proposed pit and the proposed processing facility. Watercourse 5 has cascade-pool/ riffle-pool morphology in its upstream reaches above the road with moderate gradients and substrates dominated by gravel and cobble. The lower portion of the watercourse is lower gradient with riffle-pool morphology and a substrate composition of primarily fines and gravel. The lower segments of this watercourse provide high value habitat for rearing and overwintering salmonids. Gravels found in the lower portion of the watercourse provide suitable spawning substrates for trout and salmon. The upper segments of the watercourse above the road provide moderate value habitats for rearing and overwintering salmonids with pockets of suitable spawning gravels.

5.5.4.4.2 Benthic Communities

Benthic invertebrate communities in perennial watercourses McNab Creek (six stations), Watercourse 2 (two stations) and Harlequin Creek (one station) were sampled in August, 2013 to provide a baseline characterization of invertebrate abundance and community composition in watercourses within the vicinity of the Project. McNab Creek and Harlequin Creek are natural watercourses; Watercourse 2 is located on a constructed groundwater-fed watercourse in the center of the proposed Project Area. Details regarding sampling methodology, taxonomic identification, and data analysis and interpretation are provided in Appendix 5.1-A, along with descriptions of the stream habitat in each watercourse. A brief summary of the main findings is provided here to support the surface water quality and aquatic health assessment.

Habitat variables measured indicated that habitat throughout McNab Creek was fairly similar, and characteristic of a wide, fast flowing creek with larger coarse substrates (cobbles and boulders). Watercourse 2 upstream station (T-08) had features of a small alpine creek (e.g., narrow, fast flowing, large, coarse substrate), and the downstream station (T-09) had features indicative of recent disturbance. Harlequin Creek exhibited conditions indicative of a fast-flowing creek with smaller substrate (silt/clay, gravel) and moderate canopy cover. Overall, stations were similar within all three watercourses and were typical of lotic habitats throughout BC.

Measures of benthic community composition (or relative abundance) provide information based on the relative contributions of different taxa (Barbour et al. 1999). Key taxa can provide important information about the condition of the benthic community. Percent EPT (Order Ephemeroptera [mayflies], Order Plecoptera [stoneflies], and Order Trichoptera [caddisflies]), percent Chironomids (non-biting midges) and percent Tombidiformes (mites) were calculated at each station. EPT taxa are characteristic of fast flowing, lotic habitats in BC and are generally considered to be sensitive to environmental disturbances including changes in water chemistry, sedimentation and scouring of the stream bed due to high flow events (Resh and Jackson 1993; Barbour et al. 1999). The baseline benthic invertebrate sampling program concluded the following with regard to baseline conditions in McNab Creek, Watercourse 2, and Harlequin Creek.

- Taxa richness was low to moderate at the stations sampled, with 10 to 20 families observed.
- In general, organisms were unevenly distributed among the taxonomic groups observed with the community dominated by relatively few species at each station.
- Relative abundance and percent composition analysis indicated that at the majority of stations the invertebrate community was dominated by the Family Chironomidae, with the exception of the community at station T-03 (McNab Creek), T-08 (upstream station on WC 2) and T-09 (Harlequin Creek), where EPT taxa were dominant, and at station T-06 (upstream station on McNab Creek) where the Order Trombidiformes were the most dominant taxa. In this study, the site with lowest total abundance of invertebrates (T-06) also had the highest proportion of Trombidiforms.

Periphyton were not sampled as part of the baseline benthic sampling program in 2013.

5.5.5 Effects Assessment

5.5.5.1 Project-VC Interactions

A preliminary evaluation of identified interactions between the various physical works and activities and the selected VCs across the spatial and temporal phases of the Proposed Project is presented in Table 5.5-4, Table 5.5-5, and Table 5.5-6. Potential Proposed Project-VC interactions are characterized as:

a) Positive, none or negligible, requiring no further consideration; or

b) Potential effect requiring further consideration and possibly additional mitigation.

Rationale is provided for all determinations where no or negligible interactions were identified and therefore no further consideration was required.

For those Proposed Project-VC interactions that may result in a potential direct, indirect and induced effects requiring further consideration, the nature of the effects (both adverse and positive) arising from those interactions is described in Section 5.5.5.2 below.

Table 5.5-4: Project-VC Interaction - Surface Water Resources VC – Surface Water Flow

Project Activities	Description	Surface Water Flow	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed).
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed).
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed).
5. Marine loading facility installation	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.

Project Activities	Description	Surface Water Flow	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor	○	▪ The area of disturbed land (potential changes in land cover) during dry excavation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed). ▪ The dry excavation works and the installation of the clamshell and floating conveyor are not expected to significantly affect the groundwater table, and therefore have negligible impact on the baseflow.
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to flow (i.e., McNab Creek watershed).
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.

Project Activities	Description	Surface Water Flow	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Operations			
9. Crew transport	▪ Daily water taxi	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	●	▪ Development of the aggregate pit and the associated pit lake will result in a relatively flat water surface in an area where the groundwater surface is currently sloped. This will result in raising the groundwater levels in some areas and lowering it in others. This change in the local groundwater levels would have the potential to influence the baseflow for McNab Creek and the foreshore surface water systems. ▪ Development of the aggregate pit will necessitate the blockage of the upper segment of WC 2 near the edge of the proposed pit area. This activity would have the potential to affect the baseflow rate in WC 2 downstream from the pit area due to the reduction in the length of watercourse which gains flow from the groundwater system.
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well. ▪ Drying and storage of fines and silt	●	▪ For plant operation, approximately 4% of the aggregate washing water is from make-up water extracted from local groundwater well. This extraction of groundwater would affect groundwater levels near the well with the potential to affect baseflows in nearby streams.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed). ▪ Activities have no direct interaction with groundwater table, which controls baseflow. ▪ These activities are expected to have negligible impact on the baseflow.

Project Activities	Description	Surface Water Flow	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	○	▪ The stockpile storage has no interaction with surface water baseflow.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
16. Refuelling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ Refueling and maintenance of on-site equipment has no interaction with surface water baseflow.
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	○	▪ The area of disturbed land (potential changes in land cover) for site preparation is relatively small compared to the watershed area of the sources contributing to baseflow (i.e., McNab Creek watershed).

Project Activities	Description	Surface Water Flow	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	●	▪ Site reclamation activities have not direct interaction with baseflow. ▪ As part of the proposed mine plan, the completion of the pit lake will include the commission of an outflow structure, which is expected to govern the water level in the pit. This will affect the groundwater table and will have the potential to impact baseflows in McNab Creek and the foreshore surface water systems.

Notes:
○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.
● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.5-5: Project-VC Interaction - Surface Water Resources VC - Water Quality

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery may be transported by runoff into surface water systems.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery may be transported by runoff into surface water systems. ▪ Accidental release of concrete mix materials or curing water to watercourses.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery may be transported by runoff into surface water systems. ▪ Potential accidental release of concrete mix materials or curing water to watercourses.
5. Marine loading facility installation	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
6. Pit development	▪ Dry excavation to remove overburden/topsoil ▪ Installation of clamshell and floating conveyor ▪ Direct removal of upper segment of WC 2	●	▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery may be transported by runoff into surface water systems.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
7. Other ancillary land-based construction works	▪ Temporary construction infrastructure set up (trailers, temporary power, etc.) ▪ Upgrades to the existing heavy equipment maintenance shop and warehouse ▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment ▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad ▪ Install contained washroom facilities ▪ Construct pump room for well/stream intake water distribution and fire-fighting	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery may be transported by runoff into surface water systems. ▪ Potential accidental release of concrete mix materials or curing water to watercourses
8. Other ancillary marine construction works	▪ Removal of existing small craft dock; install temporary dock for worker access ▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power ▪ Barge household and industrial solid waste off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Operations			
9. Crew transport	▪ Daily water taxi	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
10. Aggregate mining	▪ Use of electric powered floating clamshell dredge ▪ Primary screening and conveyance of extracted material to processing area ▪ Install channel plug in WC 2	●	▪ Potential sediment laden run-off from conveyor during and after precipitation events would have the potential to impact nearby watercourses. ▪ Surface runoff from the immediate area surrounding the mining area will be directed into the pit and no surface runoff to any surrounding watercourses is anticipated. ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation or maintenance of machinery during the decommissioning of the upper segment of WC 2 may be transported by runoff into surface water systems. ▪ It is not anticipated that the use of the electric powered floating clamshell dredge or the primary screening and conveyance of extracted material would have the potential to result in a chemical spill which could affect surface water quality.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
11. Processing (screening, crushing, washing)	▪ Screening to separate aggregate sizes ▪ Oversized gravels crushed ▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well. ▪ Drying and storage of fines and silt	●	▪ Potential release of dust from crushing activities and storage of fines/silt to surrounding surface water systems may impact the surface water quality by increasing the suspended sediments concentration. ▪ Runoff from crushed aggregate and stored fines/silt may potentially carrying sediment-laden water to nearby watercourses. ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Surface water run-off and seepage into groundwater may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation of machinery used to support the operation of the crusher or wash plant may be transported by runoff into surface water systems.
12. Progressive reclamation	▪ Ongoing earth works (including site clearing, surface material removal) ▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Potential release of dust to surrounding surface water systems through wind action on exposed soils ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ All surface runoff from the immediate area surrounding the mining area including the areas where fines will be used for re-vegetation and landscaping will be directed into the pit mitigating the potential for impacts related to suspended sediments. ▪ Dissolved constituents in surface water run-off, seepage into groundwater and re-emergence in watercourses may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation of machinery used to support the operation of the crusher or wash plant may be transported by runoff into surface water systems.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
13. Stockpile storage	▪ Processed sand and gravel conveyed to stockpile area ▪ Storage of processed materials in stockpiles	●	▪ Potential release of dust to surrounding surface water systems through wind action on conveyor. ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Potential sediment laden run-off from conveyor and stockpiles during and after precipitation events. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation of machinery used to maintain stockpiles of material may be transported by runoff into surface water systems.
14. Marine loading	▪ Transfer of stored material using marine conveyor system ▪ Barge loading ▪ Site and navigational lighting	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
15. Shipping	▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel, Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs
16. Refuelling and maintenance	▪ Refueling and maintenance of on-site equipment	●	▪ Transport of contaminants from chemical spills related to the fueling or maintenance of onsite machinery via run-off to surface water systems.

Project Activities	Description	Water Quality	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation of machinery used to remove the land based infrastructure may be transported by runoff into surface water systems.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	●	▪ Areas of newly planted soils may be subject to surface erosion. ▪ Precipitation on exposed soil may cause erosion resulting in the suspension of sediments in run-off water. ▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health. ▪ Accidental chemical spills or other fugitive releases related to the operation of machinery used to for site reclamation.

Notes:

○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.

● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

Table 5.5-6: Project-VC Interaction - Surface Water Resources VC - Aquatic Health

Project Activities	Description	Aquatic Health	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
Construction			
1. Crew and equipment transport	▪ Daily water taxi ▪ Tug and barge transport of machinery/materials (est. 8 loads) ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.
2. Site preparation, including construction of the berms and dyke	▪ Logging, clearing and grubbing ▪ Grading ▪ Construction of the berms and dyke ▪ Compaction and laying of gravel base ▪ Limited improvements to existing on-site road infrastructure	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off and leaching to groundwater.
3. Processing area installation, including conveyors and materials handling system)	▪ Installation and use of portable concrete batch plant for construction ▪ Installation of concrete foundations ▪ Installation of screens, crushers, wash plant, conveyor system and automated materials-handling system (i.e., reclaim tunnels) ▪ Installation of groundwater well as a source of make-up water for the wash plant	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off and leaching to groundwater.
4. Substation construction and connection	▪ Construct electrical substation adjacent to existing BC Hydro transmission line ▪ Construct outdoor switchyard, electric building, and 100 m transmission line	●	▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off and leaching to groundwater.
5. Marine loading facility installation	▪ Remove existing mooring dolphins ▪ Steel pile installation ▪ Installation of conveyor, barge movement winch and mooring dolphins	○	▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.

<table>
<tr><th rowspan="2">Project Activities</th><th rowspan="2">Description</th><th colspan="2">Aquatic Health</th></tr>
<tr><th>Potential Interaction (See Notes)</th><th>Potential Effect / Rationale for Exclusion</th></tr>
<tr><td>6. Pit development</td><td>▪ Dry excavation to remove overburden/topsoil
▪ Installation of clamshell and floating conveyor
▪ Direct removal of upper segment of WC 2</td><td>●</td><td>▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off and leaching to groundwater.</td></tr>
<tr><td>7. Other ancillary land-based construction works</td><td>▪ Temporary construction infrastructure set up (trailers, temporary power, etc.)
▪ Upgrades to the existing heavy equipment maintenance shop and warehouse
▪ Upgrades to the existing fuelling facility for the storage of diesel and gasoline for on-site equipment
▪ Construct site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility and helipad
▪ Install contained washroom facilities
▪ Construct pump room for well/stream intake water distribution and fire-fighting</td><td>●</td><td>▪ These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off and leaching to groundwater.</td></tr>
<tr><td>8. Other ancillary marine construction works</td><td>▪ Removal of existing small craft dock; install temporary dock for worker access
▪ Construct new floating small craft dock, the with tie-up area for a float plane, serviced with 30 amp (A) 125 volt (V) shore power
▪ Barge household and industrial solid waste off-site</td><td>○</td><td>▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.</td></tr>
</table>

<table>
<tr><th rowspan="2">Project Activities</th><th rowspan="2">Description</th><th colspan="2">Aquatic Health</th></tr>
<tr><th>Potential Interaction (See Notes)</th><th>Potential Effect / Rationale for Exclusion</th></tr>
<tr><td colspan="4">Operations</td></tr>
<tr><td>9. Crew transport</td><td>▪ Daily water taxi</td><td>○</td><td>▪ This is a marine-based activity and has no interaction with the surface water (freshwater) VCs.</td></tr>
<tr><td>10. Aggregate mining</td><td>▪ Use of electric powered floating clamshell dredge
▪ Primary screening and conveyance of extracted material to processing area
▪ Install channel plug in WC 2</td><td>●</td><td>▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health.
▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health.</td></tr>
<tr><td>11. Processing (screening, crushing, washing)</td><td>▪ Screening to separate aggregate sizes
▪ Oversized gravels crushed
▪ Operation of wash plant fed using recycled water from two large storage tanks, supplemented with make-up water by a groundwater well.
▪ Drying and storage of fines and silt</td><td>●</td><td>▪ Potential release of dust from crushing activities and storage of fines/silt to surrounding surface water systems may impact the surface water quality by increasing the suspended sediments concentration.
▪ Runoff from crushed aggregate and stored fines/silt may potentially carrying sediment-laden water to nearby watercourses.
▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health.
▪ Surface water run-off and seepage into groundwater may affect water quality and aquatic health.</td></tr>
<tr><td>12. Progressive reclamation</td><td>▪ Ongoing earth works (including site clearing, surface material removal)
▪ Fines and silt mixed with organic overburden material and used for infilling, re-vegetation and landscaping</td><td>●</td><td>▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health.
▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health.</td></tr>
<tr><td>13. Stockpile storage</td><td>▪ Processed sand and gravel conveyed to stockpile area
▪ Storage of processed materials in stockpiles</td><td>●</td><td>▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health.
▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health.</td></tr>
<tr><td>14. Marine loading</td><td>▪ Transfer of stored material using marine conveyor system
▪ Barge loading
▪ Site and navigational lighting</td><td>○</td><td>▪ This is a marine-based activity. Activities will not affect surface water quality and aquatic health.</td></tr>
<tr><td>15. Shipping</td><td>▪ Barge traffic (delivery/collection) in Howe Sound, Ramillies Channel,</td><td>○</td><td>▪ This is a marine-based activity. Activities will not affect surface water quality and aquatic health.</td></tr>
</table>

Project Activities	Description	Aquatic Health	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
	Thornbrough Channel, and Queen Charlotte Channel ▪ Tug and barge transport of fuel and consumables ▪ Navigational lighting		
16. Refuelling and maintenance	▪ Refueling and maintenance of on-site equipment	○	▪ Potential effects related to this activity are captured above in Table 5.5.5.
Reclamation and Closure			
17. Crew and equipment transport	▪ Daily water taxi movements ▪ Tug and barge transport of machinery/materials ▪ Barge household and industrial solid waste barged off-site	○	▪ This is a marine-based activity. Activities will not affect surface water quality and aquatic health.
18. Removal of land-based infrastructure	▪ Remove surface facilities, including clamshell dredge, conveyor system, screens, crushers, wash plant, automated materials-handling system, heavy equipment maintenance shop and warehouse, fuelling facility, site office, communications building, workers lunch/dry room, caretaker's cabin, first aid facility, helipad and contained washroom facilities	●	▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health.
19. Removal of marine infrastructure	▪ Remove marine facilities, in marine load out facility, jetty, conveyors and piles	○	▪ This is a marine-based activity. Activities will not affect surface water quality and aquatic health.

Project Activities	Description	Aquatic Health	
		Potential Interaction (See Notes)	Potential Effect / Rationale for Exclusion
20. Site reclamation	▪ Final completion of the pit lake, landscaping and re-vegetation to develop a functional ecosystem in the freshwater pit ▪ Landscaping and re-vegetation of processing area, berms and dyke	●	▪ Particulate from air emissions may be deposited on water bodies affecting surface water quality and aquatic health. ▪ Surface water run-off and leaching to groundwater may affect water quality and aquatic health. ▪ Overflow from the pit lake and seepage of groundwater from the pit lake may affect surface water quality.

Notes:

○ = Potential effect of Proposed Project activity on VC is positive, none or negligible; no further consideration warranted.

● = Potential effect of Proposed Project activity on VC that may require mitigation; warrants further consideration.

5.5.5.2 Potential Project-Related Effects

Anticipated Proposed Project activities for each Proposed Project phase, as listed in Table 5.5-4, Table 5.5-5, and Table 5.5-6 were evaluated for their potential to interact with identified VCs. Potential interactions are described in the sections below.

5.5.5.2.1 Changes in Surface Water Flow

5.5.5.2.1.1 Construction

No potential interactions between the construction phase activities and baseflow in local watercourses were identified.

5.5.5.2.1.2 Operations

The following activities to be carried out as part of the operation phase of the Proposed Project were identified as having potential interactions with baseflow in local watercourses:

Aggregate mining:

BURNCO proposes to mine approximately 1.6 million tonnes of material from the pit area each year. The upper segment of WC 2 is within the footprint of the proposed pit area, and will be removed at the initial stages of the Proposed Project, including the culvert that connects the upper to the lower segment of WC 2. These activities have the potential to influence groundwater levels in the area of the proposed pit, and potentially influence baseflows in McNab Creek, WC 2, and the Foreshore Minor Streams.

Aggregate processing:

The aggregate processing operation is expected to involve the screening, crushing, and washing of mined aggregate. The majority of the water used in the aggregate washing process (i.e., approximately 96%) will be recycled and reused. However, approximately 4% of the water required for the process will be extracted from a local groundwater well. This proposed extraction of groundwater may potentially impact surface water baseflow in the Foreshore Minor Streams.

To provide the means to assess potential impacts on aquatic habitat, the potential effects related to baseflow were assessed in terms of changes in wetted area and average flow depth in the watercourses in addition to changes in flow rate. A summary of the results are presented in this section. The interpretation of the analysis and a discussion of the significance of potential changes, as they relate to aquatic habitat are presented in Volume 2, Part B – Section 5.1: Fisheries and Freshwater Habitat assessment.

Potential effects of identified operations phase activities were evaluated separately for each of the surface water systems, and described in the sections below.

5.5.5.2.1.2.1 McNab Creek - Baseflow

The Proposed Project has the potential to impact baseflows in McNab Creek. Commonly during periods of no precipitation or runoff, a natural stream gains baseflow from the groundwater system as it flows downstream. However, McNab Creek currently loses baseflow to the groundwater system in a segment adjacent to the Proposed Project Area (to the north and east). This is due to a combination of variables including the alignment of the watercourse, the nature of the surficial soils, and the presence of WC 2. The rate at which baseflow is lost from McNab Creek to the groundwater system is influenced by the gradient between the creek water surface and the groundwater table. A steeper gradient between the creek and the groundwater system would result in a higher rate of groundwater loss from McNab Creek.

In the initial years of the operational phase of the Proposed Project (assumed Year 1), the upper segment of WC 2 and the culvert immediately downstream (see Figure 5.5-2) will be decommissioned. The analysis indicates that this will result in an increase in the groundwater levels in the area of the pit. This would flatten the groundwater table gradient between McNab Creek and the pit area, resulting in a reduction in the rate of baseflow loss from McNab Creek to the groundwater system when compared to the baseline conditions (i.e., increased baseflow). The potential effect of a reduction in loss to groundwater is expected to last throughout the operational phase of the Proposed Project.

Table 5.5-7 shows the Proposed Project's estimated potential effects on the rate of baseflow loss from McNab Creek to the groundwater system. The Proposed Project's potential effects to the McNab Creek groundwater loss for Years 0, 5, 10, 15, and 16, were modelled in the hydrogeological assessment. Linear interpolation was used to estimate the potential effects between the modelled years. The details of the hydrogeological model used to derive these results are discussed in Volume 4, Part G – Section 22.0: Appendix 5.6-A and Volume 2, Part B – Section 5.6: Hydrogeological assessment.

As shown in Table 5.5-7, the analysis indicates that the reduced loss of baseflow from McNab Creek to the groundwater system would be between 1% and 39% when compared to baseline conditions (Year 0). As this reduction in the rate of baseflow loss would result in higher baseflow rates in McNab Creek, this was considered as a **positive** potential effect for the aquatic habitat in the creek and therefore will not be carried forward in the effects assessment.

Table 5.5-7: Change in Rate of Baseflow Loss from McNab Creek during Project Operation

Year	Pit Lake Elevation (m)	McNab Creek Baseflow Loss	
		m^3/day	% change from Baseline - Year 0-
Year 0* (Baseline)	**n/a**	**17,800**	**n/a**
Year 1	5.50	16,420	-8%
Year 2	5.50	15,040	-16%
Year 3	5.50	13,660	-23%
Year 4	5.50	12,280	-31%

Year	Pit Lake Elevation (m)	McNab Creek Baseflow Loss	
		m^3/day	% change from Baseline -Year 0-
Year 5*	**5.50**	**10,900**	**-39%**
Year 6	5.30	11,220	-37%
Year 7	5.10	11,540	-35%
Year 8	4.90	11,860	-33%
Year 9	4.70	12,180	-32%
Year 10*	**4.50**	**12,500**	**-30%**
Year 11	4.58	13,380	-25%
Year 12	4.66	14,260	-20%
Year 13	4.74	15,140	-15%
Year 14	4.82	16,020	-10%
Year 15*	**4.90**	**16,900**	**-5%**
Year 16*	**5.00**	**17,600**	**-1%**

* Modelled results from FEFLOW (Refer to Volume 4, Part G – Section 22.0: Appendix 5.6-A)

The estimated changes in McNab Creek baseflow presented in Table 5.5-7 were used to estimate potential changes in wetted area and average flow depth within the segment of McNab Creek adjacent to the Proposed Project Area during periods of base flow. The results of this assessment are presented in Table 5.5-8 and Table 5.5-9.

Table 5.5-8: McNab Creek Estimated Changes in Wetted Area - Operational Phase

Year	Estimated Wetted Area (m^2)	Change in Wetted Area Compared to Baseline -Year 0- (m^2)
Year 0 (Baseline)	32,769	n/a
Year 1	32,808	40
Year 2	32,847	78
Year 3	32,884	115
Year 4	32,918	149
Year 5	32,957	188
Year 6	32,957	188
Year 7	32,941	172
Year 8	32,933	165
Year 9	32,933	165
Year 10	32,918	149

Year	Estimated Wetted Area (m^2)	Change in Wetted Area Compared to Baseline -Year 0- (m^2)
Year 11	32,891	123
Year 12	32,868	99
Year 13	32,843	74
Year 14	32,817	49
Year 15	32,793	24
Year 16	32,775	6

The expected increase in wetted area is considered a **positive** potential effect and therefore will not be carried forward in the effects assessment. Estimates of increased wetted area ranged from 6 m^2 to 188 m^2 through the operational phase of the Proposed Project.

Table 5.5-9: McNab Creek Estimated Changes in Flow Depth – Operational Phase

Year	Estimated Average Flow Depth (m)	Change in Average Flow Depth Compared to Baseline -Year 0- (m)
Year 0 (Baseline)	0.369	n/a
Year 1	0.370	0.000
Year 2	0.370	0.001
Year 3	0.370	0.001
Year 4	0.371	0.002
Year 5	0.371	0.002
Year 6	0.371	0.002
Year 7	0.371	0.002
Year 8	0.371	0.002
Year 9	0.371	0.002
Year 10	0.371	0.002
Year 11	0.370	0.001
Year 12	0.370	0.001
Year 13	0.370	0.001
Year 14	0.370	0.000
Year 15	0.369	0.000
Year 16	0.369	0.000

The increase in average flow depth is considered a **positive** potential effect and therefore will not be carried forward in the effects assessment. Estimates of increased average flow depth reached up to 0.002 m through the operational phase of the Proposed Project.

5.5.5.2.1.2.2 McNab Creek – Extreme Low Flows

As a result of existing pattern of flow loss to the groundwater system in the Proposed Project Area, McNab Creek has been observed to periodically have no surface flow in an isolated segment adjacent to the Proposed Project Area during prolonged dry periods. For this reason, a statistical low flow frequency analysis alone was not considered adequate for assessing the potential impacts of changes in groundwater levels, and therefore a drought analysis was also completed. The drought analysis allowed the evaluation of the potential duration of periods with no surficial flow within the watercourse segment adjacent to the Proposed Project Area.

The 5-year and 10-year return period extreme low flows in McNab Creek immediately upstream from the Proposed Project Area were estimated using data from the WSC Station at Chapman Creek above Sechelt Diversion. One to 20 days running average flows were estimated for the months of August and September, when the lowest flows in McNab Creek are expected. The drought analysis was carried out by estimating the rate of surface flow loss from McNab Creek to the groundwater system, and comparing this rate to the estimated extreme low flows. Whenever the rate of loss to the groundwater system was greater than the extreme low flow rate, the creek was considered to be dry with no surficial flow within the affected segment. The anticipated duration of dry periods for different return periods was estimated by subtracting the estimated rate of loss from the estimated low flow rates of various durations (a negative result indicating no surficial flows). Further explanation of the methodology used to evaluate the potential impact to the McNab Creek extreme low flows is presented in Section 5.5.3.3.3.1.

The results of the analysis are presented in Table 5.5-10 in terms of total dry period duration corresponding to the specified recurrence intervals. As this reduction in predicted dry periods would result in greater water availability for aquatic habitat in McNab Creek, this was considered as a **positive** potential effect of the Proposed Project and therefore was not carried forward in the effects assessment.

Table 5.5-10: McNab Creek Dry Period Duration – Operational Period

Year	Dry Period Duration (days)	
	5-year Low Flow	10-Year Low Flow
Year 0 (Baseline)	**4 days**	**17 days**
Year 1	0 day	14 days
Year 2	0 day	9 days
Year 3	0 day	3 days
Year 4	0 day	0 day
Year 5	0 day	0 day
Year 6	0 day	0 day
Year 7	0 day	0 day
Year 8	0 day	0 day
Year 9	0 day	0 day
Year 10	0 day	0 day
Year 11	0 day	2 days

Year	Dry Period Duration (days)	
	5-year Low Flow	10-Year Low Flow
Year 12	0 day	6 days
Year 13	0 day	9 days
Year 14	0 day	12 days
Year 15	1 day	15 days
Year 16	4 days	17 days

Hydrologic and hydrogeologic monitoring will be carried out throughout the operational phase of the Proposed Project and the analysis presented here will be periodically calibrated and refined. The extent of the proposed pit will be re-evaluated if the calibrated and refined results suggest that a negative impact to aquatic habitat in McNab Creek is anticipated.

5.5.5.2.1.2.3 Watercourse 2

Several activities associated with the Proposed Project have the potential to influence baseflow rates in WC 2. These include:

- Decommissioning of the upper segment of WC 2;
- Construction of the extension (habitat offset); and
- Changes in groundwater levels and gradients.

Under baseline conditions, surface runoff and groundwater flows are collected and conveyed by WC 2 and discharged into Howe Sound. WC 2 consists of an upper and a lower segment, which are connected with a culvert (refer to Figure 5.5-2). In the early stages of the operational phase of the Proposed Project (assumed by the end of Year 1) the upper segment of WC 2 will be decommissioned and the connecting culvert will be removed. This proposed change has the potential to reduce the flows in the lower segment of WC 2 because the flow contribution from upper segment would be lost.

To capture additional groundwater inflows and compensate for the loss of habitat and flows from the lost upper segment of WC 2, the Proposed Project includes an extension of WC 2 of approximately 670 m (as shown in Figure 5.5-2). This extension would mimic the features of the lower segment of the existing WC 2, with bends, pools and riffles that are suitable for aquatic habitat. The conceptual design includes a trapezoidal channel with a base width of 5 m, and 2 horizontal to 1 vertical sideslopes.

The groundwater level around the southern portion of the proposed pit area will be higher during the operational phase of the Proposed Project than under baseline conditions. This would result in a steeper groundwater gradient and higher contribution to baseflows along the lower segment of WC 2.

The loss of the upper segment of WC 2, the extension of WC 2 and the elevated groundwater levels were considered in the evaluation of the overall potential effects of the Proposed Project on baseflow rates in the lower segment of WC 2. Potential effects were modelled for years 0, 5, 10, 15 and 16, and effects on other years were estimated through linear interpolation. The assessment results (Table 5.5-11) indicate that during the operational phase, the Proposed Project would result in a reduction in baseflows in the lower segment of WC 2 of between 19% and 37%, compared to baseline conditions (Year 0).

The details of the hydrogeological model used to derive these results are discussed in a separate report (Volume 4, Part G – Section 22.0: Appendix 5.6-A).

Table 5.5-11: Estimated Changes in WC 2 Baseflow – Operational Phase

Year	Pit Lake Elevation (m)	WC 2 Baseflow	
		m^3/day	% change from Baseline -Year 0-
Year 0* (Baseline)	**n/a**	**36,500**	**n/a**
Year 1	5.50	23,100	-37%
Year 2	5.50	23,100	-37%
Year 3	5.50	23,100	-37%
Year 4	5.50	23,100	-37%
Year 5*	**5.50**	**23,100**	**-37%**
Year 6	5.30	23,540	-36%
Year 7	5.10	23,980	-34%
Year 8	4.90	24,420	-33%
Year 9	4.70	24,860	-32%
Year 10*	**4.50**	**25,300**	**-31%**
Year 11	4.58	25,960	-29%
Year 12	4.66	26,620	-27%
Year 13	4.74	27,280	-25%
Year 14	4.82	27,940	-23%
Year 15*	**4.90**	**28,600**	**-22%**
Year 16*	**5.00**	**29,600**	**-19%**

* Modelled results from FEFLOW (Volume 4, Part G – Section 22.0: Appendix 5.6-A)

The reduction in baseflow in the lower segment of WC 2 as a result of the Proposed Project activities is considered as a **negative** potential effect for the aquatic habitat in WC 2 requiring further consideration in the residual effects assessment.

The wetted area and average flow depth in the lower segment of WC 2 were estimated using the methodology presented in Section 5.5.3.3.3.1 for the operational phase of the Proposed Project. The results are shown in Table 5.5-12 and Table 5.5-13. Although the Proposed Project is expected to reduce flow rates in WC 2, it is expected to increase the wetted area and average flow depth. These potential effects are primarily related to the proposed 670 m groundwater-fed extension, which is longer and of different geometry than the 550 m of upper segment WC 2 that would be eliminated as a result of the Proposed Project.

Table 5.5-12: Estimated Changes in WC 2 Wetted Area – Operational Phase

Year	Wetted Area (m^2)	Change in Wetted Area compared to Baseline -Year 0- (m^2)
Year 0 (Baseline)	6,080	n/a
Year 1-5	7,311	1,231
Year 6	7,324	1,244
Year 7	7,338	1,258
Year 8	7,351	1,271
Year 9	7,365	1,285
Year 10	7,378	1,298
Year 11	7,397	1,317
Year 12	7,416	1,337
Year 13	7,435	1,356
Year 14	7,454	1,374
Year 15	7,473	1,393
Year 16	7,501	1,421

The analysis indicated a **positive** potential effect during the operational phase of the Proposed Project and therefore will not be carried forward in the effects assessment. The estimated increases in wetted area within WC 2 range from 1,231 m^2 to 1,421 m^2.

Table 5.5-13: Estimated Changes in WC 2 Average Flow Depth – Operational Phase

Year	Average flow depth (m)	Change in Depth compared to Baseline -Year 0- (m)
Year 0 (Baseline)	0.232	n/a
Year 1-5	0.304	0.072
Year 6	0.308	0.076
Year 7	0.310	0.078
Year 8	0.313	0.081
Year 9	0.316	0.084
Year 10	0.319	0.087
Year 11	0.323	0.091

Year	Average flow depth (m)	Change in Depth compared to Baseline -Year 0- (m)
Year 12	0.327	0.095
Year 13	0.331	0.099
Year 14	0.336	0.104
Year 15	0.339	0.107
Year 16	0.346	0.114

The analysis indicated a **positive** potential effect on average flow depth in WC 2 and therefore will not be carried forward in the effects assessment. Estimated increases in average flow depth range from 0.072 m to 0.114 m.

5.5.5.2.1.2.4 Foreshore Minor Streams

In the early stages of the operational phase of the Proposed Project, the connection between the upper and lower segments of WC 2 will be decommissioned. The analysis indicates that this would result in the groundwater level rising in the proposed pit area and an increased groundwater table gradient towards the foreshore area to the south. These conditions would increase groundwater inflow to the Foreshore Minor Streams (WC 3, WC 3-E, WC 4-E, WC 4-W, and WC 5).

Table 5.5-14 through Table 5.5-17 show the anticipated potential effects of the Proposed Project's on the Foreshore Minor Streams baseflow rates, wetted areas and average flow depths during the operational phase. These potential effects were modelled for Year 0, 5, 10, 15, and 16, and estimates for other years were derived through linear interpolation. The details of the hydrogeological model used to derive these results are provided in Volume 4, Part G – Section 22.0: Appendix 5.6-A.

Table 5.5-14: Estimated Changes in Foreshore Minor Streams Baseflow – Operational Phase

Year	Pit Lake Elevation (m)	Minor Streams Baseflow Gain	
		m^3/day	% change from Baseline -Year 0-
Year 0* (Baseline)	**n/a**	**5,900**	**n/a**
Year 1	5.50	8,400	42%
Year 2	5.50	8,400	42%
Year 3	5.50	8,400	42%
Year 4	5.50	8,400	42%
Year 5*	**5.50**	**8,400**	**42%**
Year 6	5.30	8,360	42%
Year 7	5.10	8,320	41%
Year 8	4.90	8,280	40%

Year	Pit Lake Elevation (m)	Minor Streams Baseflow Gain	
		m^3/day	% change from Baseline -Year 0-
Year 9	4.70	8,240	40%
Year 10*	**4.50**	**8,200**	**39%**
Year 11	4.58	8,320	41%
Year 12	4.66	8,440	43%
Year 13	4.74	8,560	45%
Year 14	4.82	8,680	47%
Year 15*	**4.90**	**8,800**	**49%**
Year 16*	**5.00**	**9,000**	**53%**

* Modelled results from FEFLOW (Volume 4, Part G – Section 22.0: Appendix 5.6-A).

Table 5.5-15: Foreshore Minor Streams Estimated Flows – Operational Phase

Year / Stream name (Length, m)	WC 3 (210)	WC 3-E (153)	WC 4-W (118)	WC 4-E (179)	WC 5 (348)
Estimated Flows (m^3/day)*					
Year 0 (Baseline)	**1,229**	**896**	**691**	**1,048**	**2,037**
Year 1	1,750	1,275	983	1,492	2,900
Year 2	1,750	1,275	983	1,492	2,900
Year 3	1,750	1,275	983	1,492	2,900
Year 4	1,750	1,275	983	1,492	2,900
Year 5	**1,750**	**1,275**	**983**	**1,492**	**2,900**
Year 6	1,742	1,269	979	1,485	2,886
Year 7	1,733	1,263	974	1,477	2,872
Year 8	1,725	1,257	969	1,470	2,859
Year 9	1,717	1,251	965	1,463	2,845
Year 10	**1,708**	**1,245**	**960**	**1,456**	**2,831**
Year 11	1,733	1,263	974	1,477	2,872
Year 12	1,758	1,281	988	1,499	2,914
Year 13	1,783	1,299	1,002	1,520	2,955
Year 14	1,808	1,318	1,016	1,541	2,997
Year 15	**1,833**	**1,336**	**1,030**	**1,563**	**3,038**
Year 16	**1,875**	**1,366**	**1,054**	**1,598**	**3,107**

* Pro-rated flows from hydrogeological model results (Volume 4, Part G – Section 22.0: Appendix 5.6-A) and stream length.

The assessment results (shown in Table 5.5-15) indicate that the Proposed Project will have a **positive** effect on the flows in the minor stream WC 3, WC 3-E, WC 4-E, WC 4-W, with a flow increase between 39% and 53% during the operational phase; and therefore this effect will not be carried forward into the effects assessment.

Table 5.5-16: Foreshore Minor Streams Estimated Changes in Wetted Area – Operational Phase

Year	WC 3		WC 3-E		WC 4-E	
	Wetted Area (m^2)	Change in Wetted Area compared to Year 0 (m^2)	Wetted Area (m^2)	Change in Wetted Area compared to Year 0 (m^2)	Wetted Area (m^2)	Change in Wetted Area compared to Year 0 (m^2)
Year 0 (Baseline)	738.8	n/a	178.9	n/a	413.1	n/a
Year 1 to 5	743.8	5.0	183.1	4.2	417.0	3.9
Year 6	741.5	2.7	183.1	4.2	416.9	3.8
Year 7	741.5	2.7	183.0	4.1	416.9	3.8
Year 8	741.4	2.6	182.9	4.0	416.8	3.7
Year 9	741.4	2.6	182.9	4.0	416.8	3.7
Year 10	741.3	2.5	182.8	3.9	416.7	3.6
Year 11	741.5	2.7	183.0	4.1	416.9	3.8
Year 12	741.6	2.8	183.2	4.3	417.1	4.0
Year 13	741.7	2.9	183.4	4.5	417.2	4.1
Year 14	741.8	3.0	183.6	4.7	417.4	4.3
Year 15	741.9	3.1	183.8	4.9	417.6	4.5
Year 16	742.1	3.3	184.1	5.2	417.9	4.8

Year	WC 4-W	WC 5		
	Wetted Area (m^2)	Change in Wetted Area compared to Year 0 (m^2)	Wetted Area (m^2)	Change in Wetted Area compared to Year 0 (m^2)
Year 0 (Baseline)	450.3	n/a	935.8	n/a
Year 1 to 5	452.6	2.3	945.9	10.1
Year 6	452.6	2.3	945.8	10.0
Year 7	452.5	2.2	945.6	9.8
Year 8	452.5	2.2	945.5	9.7
Year 9	452.5	2.2	945.3	9.5
Year 10	452.4	2.1	945.1	9.3
Year 11	452.5	2.2	945.6	9.8
Year 12	452.6	2.3	946.1	10.3
Year 13	452.7	2.4	946.6	10.8
Year 14	452.8	2.5	947.0	11.2
Year 15	453.0	2.7	947.5	11.7
Year 16	453.1	2.8	948.2	12.4

The assessment results (shown in Table 5.5-16) indicate that the Proposed Project will result in an increase in wetted area, ranging from 2.1 m^2 to 12.4 m^2 for the Foreshore Minor Streams during the operational phase of the Proposed Project. This is considered a **positive** effect, and therefore this effect will not be carried forward into the effects assessment.

Table 5.5-17 Foreshore Minor Streams Estimated Changes in Average Flow Depth – Operational Phase

Year	WC 3		WC 3-E		WC 4-E	
	Average flow depth (m)	Change in Average flow depth compared to Year 0 (m)	Average flow depth (m)	Change in Average flow depth compared to Year 0 (m)	Average flow depth (m)	Change in Average flow depth compared to Year 0 (m)
Year 0 Baseline	0.021	n/a	0.021	n/a	0.019	n/a
Year1-5	0.028	0.007	0.026	0.005	0.023	0.004
Year6	0.024	0.003	0.025	0.004	0.023	0.004
Year7	0.024	0.003	0.025	0.004	0.023	0.004
Year8	0.024	0.003	0.025	0.004	0.023	0.004
Year9	0.024	0.003	0.025	0.004	0.023	0.004
Year10	0.023	0.002	0.025	0.004	0.023	0.004
Year11	0.024	0.003	0.025	0.004	0.023	0.004
Year12	0.024	0.003	0.026	0.005	0.023	0.004
Year13	0.024	0.003	0.026	0.005	0.024	0.005
Year14	0.024	0.003	0.026	0.005	0.024	0.005
Year15	0.025	0.004	0.026	0.005	0.024	0.005
Year16	0.025	0.004	0.027	0.006	0.025	0.006

Year	WC 4-W		WC 5	
	Average flow depth (m)	Change in Average flow depth compared to Year 0 (m)	Average flow depth (m)	Change in Average flow depth compared to Year 0 (m)
Year 0 Baseline	0.011	n/a	0.024	n/a
Year1-5	0.015	0.004	0.028	0.004
Year6	0.015	0.004	0.028	0.004
Year7	0.015	0.004	0.028	0.004
Year8	0.015	0.004	0.027	0.003
Year9	0.015	0.004	0.027	0.003
Year10	0.015	0.004	0.027	0.003
Year11	0.015	0.004	0.028	0.004
Year12	0.015	0.004	0.028	0.004
Year13	0.015	0.004	0.028	0.004
Year14	0.015	0.004	0.028	0.004
Year15	0.015	0.004	0.028	0.004
Year16	0.016	0.005	0.028	0.004

The potential effect of increased average flow depth ranged from 0.002 m to 0.007 m for the Foreshore Minor Streams during the operational phase of the Proposed Project (Table 5.5-17) was considered **positive** and therefore will not be carried forward in the effects assessment.

It is proposed that groundwater will be withdrawn from an onsite well located within the plant area to support the operation of the aggregate processing plant. The aggregate plant is anticipated to recycle and reuse 96% of the aggregate washing water. The remaining 4% of the water is would be obtained from the groundwater well. The plant will process aggregate for a maximum 14 hour per day, and 300 days per year, at an estimated groundwater withdrawal rate of 50 US gallons per minute or 159 m^3/day (D. Holmes, 2013, pers. comm., 19 July). The drawdown from this well is estimated to extend approximately 120 m away from the pumping well. Minor stream WC 5 is closest to the proposed groundwater withdrawal location and its flows could potentially be impacted; however; when considered in combination with the other anticipated impacts of the Proposed Project on WC 5 (elevated groundwater levels) the analysis indicates that baseflow rates will increase. The analysis indicated that the Proposed Project related increases in the groundwater levels would increase baseflow rates in WC 5 in the range of 863 m^3/day to 1,070 m^3/day. The net projected-related potential effect is **positive** and therefore is not considered further in the assessment.

5.5.5.2.1.3 Reclamation and Closure

The aggregate pit is proposed to remain in place after the Proposed Project closure is completed, it will continue to have potential effects on the baseflows of McNab Creek, WC 2, and Foreshore Minor Streams. Potential changes to baseflow as a result of reclamation and closure activities are shown in Table 5.5-18 and discussed in the sections below.

Table 5.5-18: Estimated Change to Baseflow - Reclamation and Closure Phase

Year	Pit Lake Elevation (m)	McNab Creek Baseflow Loss to Groundwater		WC 2 Baseflow		Minor Stream Gain from Groundwater	
		m^3/day	% change from Year 0	m^3/day	% change from Year 0	m^3/day	% change from Year 0
Year 0*	n/a	17,800	n/a	36,500	n/a	5,900	n/a
Closure*	5.00	17,600	-1%	29,600	-19%	9,000	53%

* Modelled results from FEFLOW.

5.5.5.2.1.3.1 McNab Creek

Closure plans for the Proposed Project include the construction of an outflow structure for the pit lake. This structure will allow water to be retained in the pit lake at the design water level. The design water level will be selected to maintain baseflows in McNab Creek slightly above baseline conditions. The design of the outflow structure will be refined at the closure phase of the Proposed Project, based on groundwater level and pit lake water level monitoring data collected throughout the operational years of the Proposed Project.

The assessment results (Table 5.5-18) indicate that during the reclamation and closure phases of the Proposed Project, the potential impact to McNab Creek baseflow would be slightly **positive** and was not carried forward in the assessment.

5.5.5.2.1.3.2 Watercourse 2 (WC 2)

The hydrogeological assessment results shown in Table 5.5-18 indicate that the baseflow rate in the lower segment of WC 2 will be reduced by 19% in the closure phase when compared to the baseline conditions. This is considered to be a **negative** potential impact of the Proposed Project warranting further consideration in the effects assessment.

5.5.5.2.1.3.3 Foreshore Minor Streams

The assessment results shown in Table 5.5-18 indicate that the baseflows in the Foreshore Minor Streams will be increased by 53% in the closure phase relative to baseline conditions. This is considered to be a **positive** potential impact of the Proposed Project and therefore was not carried forward in the assessment.

5.5.5.2.2 Changes in Water Quality

Activities that were expected to be undertaken during the different phases of the Proposed Project (Table 5.5-5), which may have effects on the surface water turbidity were identified and are discussed below.

5.5.5.2.2.1 Construction

The following activities related to the Proposed Project construction phase could potentially affect suspended sediment concentrations in surface water:

- Site preparation, including construction of the berms and dyke;
- Processing area installation, including conveyors and materials handling system;
- Substation construction and connection;
- Pit development; and
- Other ancillary land-based construction works.

Surface runoff from disturbed areas would have the potential to carry fine-grained materials to receiving waters resulting in increased turbidity. The mobilization of fine-grained materials may occur during earthworks, adherence and transportation on construction equipment or as a result of land clearance operations. In addition, lands cleared of vegetation would be more susceptible to erosion and subsequently transport of fines into waterways. Increases in runoff turbidity could potentially result in a deleterious impact on fish habitat if it were to reach fish-bearing streams which are discussed in detail in Volume 2, Part B - Section 5.1.

5.5.5.2.2.2 Operations

The following activities related to the operational phase of the Proposed Project could potentially have effects on suspended sediment concentrations in surface water:

- Aggregate mining;
- Processing (screening, crushing, washing);
- Stockpile storage; and
- Progressive reclamation.

Potential effects related to increases in turbidity during the operations phase will be similar to those described above for construction in Section 5.5.5.2.2.1.

Some components in the design of the Proposed Project will assist in mitigating the potential effects of elevated suspended sediment concentrations in surface water. Some of these measures include:

- During aggregate mining operations, runoff from within the active mining area will be directed to the pit. The proposed pit has been designed such that all runoff would be retained within the pit without a discharge of surface flows. Water accumulating within the pit area during storm events would infiltrate into the pit wall and be filtered naturally through the native granular soils.
- The potential for sediment laden runoff from the conveyor system would be managed by directing runoff either to the pit or the process area storm water management system. Conveyor crossing of any watercourses will be designed and constructed to prevent runoff being discharged to watercourses.
- Drainage works surrounding the pit will be constructed such that clean runoff originating in areas unaffected by the Proposed Project will be directed around the active mining area.
- The processing of aggregate involves crushing, screening, washing and stockpiling material. The fines generated by these activities will be extracted from the wash water and compressed into sediment cakes. The dried sediment cakes will be stored in a covered onsite containment facility and re-used for progressive reclamation.
- Areas progressively reclaimed during the operational phase will be re-vegetated to control erosion.

5.5.5.2.2.3 Reclamation and Closure

The following activities related to the reclamation and closure phase of the Proposed Project could potentially have effects on suspended sediment concentrations in surface water:

- Removal of land-based infrastructure; and
- Site reclamation.

Potential effects related to increases in turbidity during the reclamation and closure phase will be similar to those described above for construction in Section 5.5.5.2.2.1.

5.5.5.2.2.4 Accidents and Malfunctions: Spills

Activities that have the potential to result in an accidents and malfunction, in relation to chemical spills, during the different phases of the Proposed Project are identified in Table 5.5-5. Accidental chemical spills related to the uses of heavy equipment, the storage of fuel or the storage of other chemicals on-site could have a potential impact on surface water quality.

5.5.5.2.3 Aquatic Health

Activities that were expected to be undertaken during the different phases of the Proposed Project (Table 5.5-6), that may have effects on surface water quality and consequently aquatic health were identified and are discussed below. These Proposed Project-VC interactions relate to changes in water chemistry, including water quality parameters with the potential to result in direct toxicity-related effects on aquatic indicators in the receiving environment and parameters that have the potential to result in nutrient enrichment-related effects, and are further assessed in Section 5.5.5.4.1.4.

5.5.5.2.3.1 Construction

Based on Table 5.5-6, the following activities during the construction phase may have potential effects on surface water quality and aquatic health, including:

- Site preparation, including construction of the berms and dyke;
- Processing area installation, including conveyors and materials handling system);
- Substation construction and connection;
- Pit development; and
- Other ancillary land-based construction works.

These activities may result in the creation of areas of exposed soil with the potential to be subject to surface water run-off. Water quality constituents associated with these exposed materials may enter surface waters directly through run-off or indirectly via leaching to groundwater.

With effective implementation of the proposed erosion and sediment control measures during the construction phase, no effects to surface water quality and aquatic health from run-off or leaching to groundwater are expected.

5.5.5.2.3.2 Operations

Based on Table 5.5-6, the following activities during the operations phase were evaluated to have potential effects on surface water quality and aquatic health, including:

- Aggregate mining;
- Processing (screening, crushing, washing);
- Stockpile Storage; and
- Progressive Reclamation.

During aggregate mining, it is expected that fine-grained materials will be excavated along with the aggregate materials. Fines could be mobilized by adhering to the construction equipment and precipitation events may result in run-off from construction equipment. Water quality constituents (e.g., metals, nutrients, major ions) associated with the fine materials may enter surface waters directly through run-off and/or indirectly via leaching to groundwater. In addition, fines could be mobilized into air particulates and deposited onto water bodies.

Stockpiled materials on site, either temporary or long-term, may contain fines and water quality constituents associated with those fines can be mobilized by precipitation or wind.

During operations, ongoing progressive reclamation activities include site clearing, surface material removal, berm and dyke construction, infilling, re-vegetation and landscaping. Generation and mobilization of fine materials and exposure of soil are expected from site clearing and surface material removal activities. Water quality constituents associated with these materials may enter surface waters directly through run-off, air deposition, or indirectly via leaching to groundwater.

5.5.5.2.3.3 Reclamation and Closure

The following Proposed Project reclamation and closure phase activities in Table 5.5-6 were evaluated to have potential effects on surface water quality and aquatic health:

- *Removal of Land-based Infrastructure*: may create areas of exposed soil that are susceptible to increased erosion and run-off as well as potential for leaching to groundwater.

- *Site Reclamation:* Site reclamation works includes the landscaping and re-vegetation of the completed pit lake, processing areas, and berms and dyke. The restoration and re-vegetation of the landscape will have a positive effect in terms of decreasing erosion and surface run-off, as well as leaching to groundwater. Site reclamation will also include further development of the pit lake which may affect groundwater quality. Overflow from the pit lake or seepage from groundwater may potentially result in changes to surface water quality.

5.5.5.2.4 Geochemical Testing for ML-ARD Potential

The results of the geochemical testing program for the Project are presented in Appendix 5.6-C.

Geochemical testing was conducted on 3 composite samples collected from two test pits at the Project site. The geochemical testing program included acid base accounting, whole rock and trace metal analysis, and sequential leach tests. The objective of acid base accounting was to determine the material's potential to generate acidity. The acid base accounting results confirmed that the materials contained no sulphide minerals; oxidation of sulphide minerals is the primary source of long-term acid generation potential. Therefore, the materials are considered to have a low potential for long-term acid generation.

The results of whole rock and trace metal analysis were used to identify parameters that may require further consideration in the context of metal leaching potential. Sequential leach testing was used to evaluate the metal leaching potential of the materials. Sequential leach testing is appropriate for evaluating the potential for metal leaching in the absence of reactive sulphide minerals, therefore this test method was used in place of the humidity cell test method (HCT). Testing according to the HCT protocol is not necessary to determine the long-term metal leaching potential of the materials. The results of the sequential leach tests were screened in the context of the BCWQ and CCME Guidelines for the protection of Freshwater Aquatic Life in order to identify parameters of potential environmental concern. The results of the sequential leach tests were used to develop inputs to the water quality predictions for the Proposed Project.

5.5.5.3 Mitigation

The sections below describe the mitigation measures that are proposed to be implemented to mitigate potential Project-related effects to surface water. A summary of these measures is presented in Table 5.5-19 for surface flow, Table 5.5-20 for surface water quality and Table 5.5-21 for aquatic health.

The mitigation strategy outlined below forms the basis for the commitments that the Proposed Project is making with respect to surface water. A detailed list of all commitments of the Proposed Project are provided in Volume 3, Part F – Section 19.

5.5.5.3.1 Construction

5.5.5.3.1.1 Suspended Sediment

In addition to the components included within the design of the Proposed Project presented in Section 5.5.5.2.2 which will partially mitigate potential suspended sediment related impacts on surface water quality and subsequently aquatic health, task-specific Sediment, Erosion and Drainage Control Plans will be developed to guide preventive measures to reduce the potential release of sediment laden water from the Proposed Project Area. Plans will be prepared in accordance with:

- the Land Development Guidelines for the Protection of Aquatic Life (DFO 1993);
- BC Water Quality Guidelines (BC MOE 2001);
- *Fisheries Act;*
- Aggregate Operators Best Management Practices Handbook for BC (Ministry of Energy and Mines 2002); and
- Other relevant BMPs.

The plans will be reviewed and implemented by a qualified environmental professional. Adherence with the objectives of the plans will be determined based on performance. Water quality will be monitored by a qualified Environmental Monitor during Proposed Project construction phase. If water quality is unsatisfactory, additional mitigation measures will be implemented.

Sediment and erosion control measures that may be used during construction include, but are not limited to, the following:

- No work will be undertaken within riparian areas (i.e., 15 m from top of bank) of existing stream or watercourse except in favorable weather and low water conditions and in accordance with the recommendations of the Environmental Monitor and as permitted in the Proposed Project regulatory approvals;
- Erosion prevention measures, such as silt fences, filter fabric, straw bales, gravel filter dikes, sedimentation ponds, or other preventative measures implemented will be monitored, maintained and repaired as required;
- Construction wastes, overburden, soil, or any other substances potentially deleterious to riparian or aquatic habitat will be stored and/or disposed of in such a manner as to prevent entry to riparian areas, or any streams or watercourses;
- No materials will be stockpiled within 15 m of the top of bank of a watercourse. Soil stockpiles will be diked, sloped and seeded or tarped to minimize erosion. If temporary stockpiles are constructed, then appropriate erosion and sediment control mitigation measures will be installed and regularly maintained until these stockpiles are decommissioned or seeded. Spoil will be managed in accordance with the appropriate Proposed Project regulatory approvals, or applicable legislation, regulations, and guidelines prior to the completion of construction activities;

- Vegetation cover will be maintained wherever possible. Buffer strips will be left around watercourses by the Contractor, in accordance with terms and conditions of the Proposed Project approvals and in accordance with recommendations from the Environmental Monitor;
- Surface drains and ditches constructed as part of the Proposed Project will be graded according to applicable BMPs, and vegetated or otherwise stabilized by placing biodegradable, straw or coconut fiber erosion control blankets along the watercourse;
- Disturbed areas adjacent to watercourses will be re-vegetated as soon as possible to prevent surface erosion and/or sediment transport. Any watercourses affected during construction will be maintained and restored to their pre-construction or equivalent condition in accordance with recommendations from the Environmental Monitor; and
- Water quality will be monitored for turbidity in adherence to the BC water quality guidelines for the protection of aquatic life (fresh, marine, estuarine). Details on these mitigation measures are provided in Volume 2, Part B - Section 5.1.

With the effective implementation of Proposed Project design and these task-specific mitigation measures, the identified activities are not expected to result in increased suspended solid content and adverse effects to surface water quality.

5.5.5.3.2 Operations

5.5.5.3.2.1 Changes in Surface Water Flow

The predicted Proposed Project-related reduction in baseflow in the lower segment of WC 2 would not be mitigated as part of the Proposed Project and this potential impact was carried through to the residual effects section of this assessment.

5.5.5.3.2.2 Changes in Water Quality – Suspended Sediment

Mitigation measures associated with suspended sediment concentrations in surface water during the operations phase of the Proposed Project shall include Sediment, Erosion and Drainage Control Plans and BMPs consistent with those described within the assessment of the construction phase in Section 5.5.5.3.1. With the effective implementation of Proposed Project design and these mitigation measures, the identified activities are not expected to result in adverse effects to suspended solid content in surface water quality.

5.5.5.3.3 Reclamation and Closure

5.5.5.3.3.1 Changes in Surface Water Flow

The predicted Proposed Project-related reduction in baseflow in the lower segment of WC 2 would not be mitigated as part of the Proposed Project and this potential impact was carried through to the residual effects section of this assessment.

5.5.5.3.3.2 Water Quality – Suspended Sediment

Mitigation measures associated with suspended sediment concentrations in surface water during the reclamation and closure phase of the Proposed Project shall include Sediment, Erosion and Drainage Control Plans and BMPs consistent with those described within the assessment of the construction phase in Section 5.5.5.3.1 as well as adherence to the Reclamation and Effective Closure Plan (provided in Volume 4, Part G – Section 22.0: Appendix 4. With the effective implementation of Proposed Project design and these mitigation measures, the identified activities are not expected to result in adverse effects to suspended solid content in surface water quality.

5.5.5.3.4 Accidents and Malfunctions

Potential impacts on surface water quality from spills of hazardous or toxic materials will be mitigated through the development and implementation of task-specific Materials Storage, Handling and Waste Management Plan(s) (MSHWMP) and a site-specific Spill Prevention and Emergency Response Plan(s) (SPERP; details provided in Volume 3, Part E – Section 16.0). These plans will be prepared by a QEPI and developed in accordance with applicable regulations, guidelines and BMPs. An environmental monitor will monitor the implementation and performance of the chemical handling, spill prevention and emergency response plans.

Spill control measures and hazardous waste management will include, but will not be limited to, the following:

- Environmental Construction Specifications (ECS) will be developed as performance-based standards and recommendations to be met during the construction and operation of the Proposed Project. These ECS will be included in the Proposed Project Environmental Management Plans (EMP) and will be based on existing legislation and regulations, where applicable, as well as BMPs.
- A SPERP available for inspection and posted at conspicuous locations on the Site;
- A readily available supply of appropriate spill emergency response material and equipment, maintained on site at and in effective working condition at all times;
- All machinery used on-site would be in good repair and power washed prior to its arrival onsite;
- Appropriate measures will be taken to prevent any fuels, lubricants or construction wastes from entering any watercourse or water supply well. No discharge of wash water to the ground or to surface watercourses at the site from trucks and equipment related to Proposed Project activities;

- Hazardous materials including, but not limited to, fuels, bitumens, cement, paints, solvents, cleaners, dust suppressants, used fuel and oil filters, and other construction materials will be stored and handled to avoid loss and allow containment and recovery in the event of a spill;
- Maintenance operations will be confined to specific areas such that spills can be contained and collected before contaminants reach any watercourses. Designated areas will identified for the transfer and limited temporary storage of hazardous materials and wastes, as required. These areas will be clearly labeled and appropriately controlled. Hazardous wastes and hazards materials not in active use would be removed promptly from the site;
- Proper Workplace Hazardous Material Information Systems (WHMIS) labels and Material Safety Data Sheets (MSDS) will be maintained for any hazardous materials used and stored on site;
- Any Special Waste generated will be disposed of in compliance with the *British Columbia Special Waste Regulation*. Inventories of types and quantities of Special Wastes generated, stored, or removed will be maintained, including manifests identifying Special Waste haulers, disposal destinations and disposal certification documents; and
- All equipment and the designated hazardous material storage site(s) will be inspected daily and results of this inspection recorded in a log. Daily inspections will include looking for signs of leakage, and checking that emergency response equipment is in place.

Table 5.5-19: Identified Mitigation Measures: Baseflow

Potential Effect	Mitigation	Anticipated effectiveness
Construction		
No mitigation suggested.		
Operations		
No mitigation suggested.		
Reclamation and Closure		
No mitigation suggested.		

Table 5.5-20: Identified Mitigation Measures: Surface Water Quality

Potential Effect	Mitigation	Anticipated effectiveness
Construction		
Changes to Water Quality – Suspended Sediments	▪ Proposed Project design elements ▪ Erosion and Sediment Control Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Changes to Water Quality – Spills	▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0) ▪ Site specific Spill Prevention and Emergency Response Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Operations		
Changes to Water Quality – Suspended Sediments	▪ Proposed Project design elements ▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Changes to Water Quality – Spills	▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0) ▪ Site specific Spill Prevention and Emergency Response Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Reclamation and Closure		
Changes to Water Quality – Suspended Sediments	▪ Proposed Project design elements ▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.

Potential Effect	Mitigation	Anticipated effectiveness
Changes to Water Quality – Spills	▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0) ▪ Site specific Spill Prevention and Emergency Response Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.

Table 5.5-21: Identified Mitigation Measures: Aquatic Health

Potential Effect	Mitigation	Anticipated effectiveness
Construction		
Direct Toxicity-Related Effects	▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3) ▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Nutrient Enrichment-Related Effects	▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Operations		
Direct Toxicity-Related Effects	▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3) ▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Nutrient Enrichment-Related Effects	▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 30)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Reclamation and Closure		
Direct Toxicity-Related Effects	▪ Erosion and Sediment Control Pan (Volume 4, Part G – Section 22.0: Appendix 3) ▪ Material Storage, Handling and Waste Management Plan (Volume 3, Part E – Section 16.0)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.
Nutrient Enrichment-Related Effects	▪ Erosion and Sediment Control Plan (Volume 4, Part G – Section 22.0: Appendix 3)	Mitigation plans will be prepared in accordance with applicable provincial and federal guidelines and BMPs and by and QEP. The mitigation is expected to be effective in reducing the potential impact of the residual effect.

5.5.5.3.5 Monitoring

5.5.5.3.5.1 Surface Water Quality

The surface water quality monitoring program for the Proposed Project will include the collection of surface water samples for analytical chemistry and *in situ* measurements of water quality parameters. Samples will be collected at the following locations:

- McNab Creek (MCF-1 and MCF-7);
- Pit lake (MCF-5);
- Downstream of the pit lake and within WC 2 (MCF-6); and
- Downstream of the pit lake along a permanent watercourse (MCF-12).

Surface water samples will be collected in accordance with procedures described in the *British Columbia Field Sampling Manual 2013* (BC MOE 2013). Water samples will be submitted to a laboratory accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA), for analysis of physical parameters (pH, hardness, conductivity (µS/cm), alkalinity, and total suspended and dissolved solids), anions and nitrogen forms (nitrate, nitrite, ammonia, sulphate), phosphorus (total, dissolved and orthophosphate), organic carbon, and total and dissolved metals. Field replicates (i.e., side-by-side samples) will be collected at a different location during each sampling event and the results of analysis will be compared to evaluate the precision of the methods used.

During and prior to construction, water quality samples will be taken on a quarterly basis at the five LSA sampling locations listed above. Additional construction-related monitoring mainly related to suspended sediments will also be undertaken during this time in accordance with the EMP. Additional recommendations for monitoring of water quality in relation to the Fish Habitat Offset Plan are provided in Volume 2, Part B – Section 5.1.

For the first two years of operations, monitoring effort will be focused on the pit lake (MCF-5) and downstream of the pit lake within WC 2(MCF-6), where water samples will be collected on a monthly basis. In McNab Creek (MCF-1 and MCF-7) and downstream of the pit lake along a permanent watercourse (MCF-12), samples collection will be quarterly. After two years sampling, frequency will be re-evaluated in consultation with MOE and other regulatory agencies.

5.5.5.3.5.2 Aquatic Health

Baseline monitoring of periphyton biomass will be undertaken in McNab Creek at stations MC-1 and MC-7 as well as a suitable location upstream of mine influence prior to construction. Samples for analysis of algal biomass will also be collected at MCF-6 and MCF-12 downstream of the pit lake under baseline conditions prior to construction of the extension (habitat offset). These data will represent baseline data in a future biological monitoring program should a program be initiated.

Monitoring of periphyton biomass and benthic invertebrate communities in McNab Creek and WC 2 during operations will be triggered by the following changes in surface water quality:

- Consistent exceedance of BC WQGs for one or more parameters that have the potential to result in toxicity-related effects on aquatic life; and
- An increasing trend in phosphorus concentrations that indicates a potential shift in trophic status in McNab Creek or WC 2 during construction or operations.

Additional recommendations for monitoring of Fisheries and Freshwater Habitat and benthic invertebrate communities in relation to the Fish Habitat Offset Plan are provided in Volume 4, Part G – Section 22.0: Appendix 5.1-B.

5.5.5.4 Residual Effects Assessment

Potential Proposed Project-related effects on surface water resources following the application of the appropriate mitigation measures described in Section 5.5.5.3 were characterized using the assessment criteria described in Section 5.5.3.3.3.

An assessment of the magnitude of any effects on surface water resources is presented first, followed by an evaluation of the other assessment criteria that form the basis for determining significance of effect as described in Section 5.5.5.5. Potential effects on Fisheries and Freshwater Habitat that relate to changes in surface water (flow and quality) are provided in Volume 2, Part B - Section 5.1: Fisheries and Freshwater Habitat assessment.

5.5.5.4.1 Surface Water Flow and Surface Water Quality

5.5.5.4.1.1 Construction

5.5.5.4.1.1.1 Changes in Water Quality – Suspended Sediment

An identified potential impact of the Proposed Project on surface water quality was an increase in suspended sediments in nearby watercourses related to construction activities. Due to the transient nature in surface water flow the receiving environment is considered resilient to this potential change. With the effective implementation of mitigation measures and adherence to WQG the magnitude of potential residual effects on water quality from increased turbidity resulting from Proposed Project construction activities are considered to be negligible (peak concentration less than WQG). The extent of the effect will be confined to the LSA and is therefore considered local with a short-term duration. The reversibility is considered low (the effect can be reversed) as potential impacts to water quality due to increased turbidity would be limited to certain high risk activities and the system would return to pre-activity conditions once the activity ceases or adaptive mitigation is implemented to limit the impacts. The frequency of the effect is considered to be low as the potential for the residual effect would be related to a specific combination of activities and meteorological conditions.

5.5.5.4.1.2 Operations

5.5.5.4.1.2.1 Changes in Surface Water Flow

The following characterization is presented in terms of potential changes in base flow rates in isolation of other hydrologically significant variables. The analysis results indicated that the flow in the downstream segment of WC 2 during the operations phase would be reduced by 19% to 37%. This range was considered to be a residual effect of medium to high magnitude on surface flows. The duration of the residual effect is expected to be medium-term, as reductions in flow within this range would persist throughout the life of the Proposed Project. The frequency of the residual effect was considered continuous and therefore was categorized as high. The reversibility was categorized as irreversible as the effect was considered permanent.

Despite the reductions in baseflow, other hydrologically significant variables including total wetted surface area and average flow depth of WC 2 are expected to increase as a result of the Proposed Project. The resiliency of the system (context) to reductions in baseflow in WC 2 is important only as it affects downstream receptors. The most important receptor identified for the Proposed Project was fish and fish habitat. A detailed assessment regarding the context (resiliency) of Fisheries and Freshwater Habitat to withstand reductions in baseflows in WC 2; taking into consideration habitat offsetting; is presented in Volume 2, Part B – Section 5.1: Fisheries and Freshwater Habitat assessment.

5.5.5.4.1.2.2 Changes in Water Quality – Suspended Sediment

An identified potential impact of the Proposed Project on surface water quality was an increase in suspended sediments in nearby watercourses related to operational activities. Due to the transient nature in surface water flow, the receiver is considered resilient to this potential change. With the implementation of mitigation measures such that WQG are not exceeded the magnitude of potential residual effects on water quality from increased turbidity resulting from Proposed Project operations is considered to be negligible (peak concentration less than WQG). The extent of the effect will be confined to the LSA and is therefore considered local with medium-term duration as potential water quality impacts would be limited to the operational phase of the Proposed Project. The effect is considered fully reversible as water quality can return to baseline conditions with the effective implementation of mitigation measures. The frequency of the effect is considered to be low as the potential for the residual effect would be related to a specific combination of activities and meteorological conditions.

5.5.5.4.1.3 Reclamation and Closure

5.5.5.4.1.3.1 Changes in Surface Water Flow

The following characterization is presented in terms of potential changes in base flow rates in isolation of other hydrologically significant variables. The analysis results indicated that the flow in the downstream segment of WC 2 during the reclamation and closure phase would be reduced by 19% which was considered to represent a residual effect of medium magnitude. The duration of the residual effect is expected to be long-term, as reductions in flow will persist beyond the life of the Proposed Project. The frequency of the residual effect is considered continuous and therefore was categorized as high. The reversibility was categorized as irreversible as the effect is considered permanent. The context was considered sensitive as the flow in WC 2 would have limited other flow inputs.

Despite the reductions in baseflow, other hydrologically significant variables including total wetted surface area and average flow depth of WC 2 are expected to increase as a result of the Proposed Project. As these effects are most significant in the context of aquatic life, this residual effect is discussed and evaluated in more detail within Volume 2, Part B – Section 5.1: Fisheries and Freshwater Habitat assessment.

5.5.5.4.1.3.2 Changes in Water Quality – Suspended Sediments

An identified potential impact of the Proposed Project on surface water quality was an increase in suspended sediments in nearby watercourses related to construction activities during reclamation and closure. Due to the transient nature in surface water flow, the receiving environment is considered resilient to this potential change. With the implementation of mitigation measures and adherence to WQG, the magnitude of potential residual effects on water quality from increased turbidity resulting during the Reclamation and Closure phase of the Proposed Project are considered to be negligible (peak concentration less than WQG). The extent of the effect will be confined to the LSA and is therefore considered local with a short-term duration as potential water quality impacts would be limited to the specific reclamation activities. The effect is considered fully reversible as water quality can return to baseline conditions with the effective implementation of mitigation measures. The frequency of the effect is considered to be low as the potential for the residual effect would be related to a specific combination of activities and meteorological conditions.

5.5.5.4.1.4 Accidents and Malfunctions: Spills

A potential impact on water quality related to spills of hazardous materials during construction activities was identified in this assessment. The impact of an accidental spill would vary significantly based on the nature and details of the spill such as volume and type of material spilled. The context of the potential impact was considered to be sensitive. For the purposes of this assessment it was conservatively assumed that if a spill occurred and was permitted to reach a watercourse unmitigated the WQG would be exceeded; however, with adherence to BMPs and the effective implementation of mitigation measures it is not anticipated that a spill would reach a watercourse and the magnitude of potential residual effects on surface water quality is considered be negligible. The extent of the potential effect will be confined to the LSA and is therefore was considered local. Depending on the nature of the spill, the duration of the potential impact could range from short-term up to long-term as potential effects to water quality could remain post-closure. The effect is considered fully reversible to irreversible depending on the nature of the spill. The frequency of the effect is considered to be low, as the potential for accidental events during construction would be limited to specific periods of high risk activities (re-fueling activities, movement of hazardous materials) and would generally be avoided through planning and mitigation.

5.5.5.4.2 Aquatic Health

Potential Proposed Project-related effects on surface water quality and aquatic health following the application of the appropriate mitigation measures described in Section 5.5.5.3 were characterized using the assessment criteria described in Section 5.5.3.3.3. An assessment of the magnitude of potential effects on surface water quality and aquatic health is presented first, followed by an evaluation of the other assessment criteria that form the basis for determining significance of effect as described in Section 5.5.3.3.4.

Water quality was not modelled for the construction phase, as was done for the other phases, because of the short-term duration of construction (i.e., less than 5 years) and activities that differ from those in the operations and reclamation and closure phases. Activities identified for the construction phase that may affect surface water quality and consequently aquatic health are expected to be mitigated by the Erosion and Sediment Control Plan (Volume 3, Part E - Section 16.0 and provided in Volume 4, Part G – Section 22.0: Appendix 3) implemented during Proposed Project construction, resulting in residual effects of negligible magnitude. Therefore the assessment of magnitude focussed on the operations and closure time periods.

5.5.5.4.2.1 Assessment of Magnitude of Potential Residual Effects

The assessment focussed on water quality parameters with the potential to result in direct toxicity-related effects on aquatic indicators in the receiving environment and parameters that have the potential to result in nutrient enrichment-related effects (Figure 5.5-3). During operations, the potential for residual effects in the downstream receiving environment was assessed based on annual water quality predictions presented in Volume 4, Part G – Section 22.0: Appendix 5.5-E, for base case and conservative case scenarios. The residual effects assessment for the reclamation and closure period was based on corresponding water quality predictions for closure, also presented in Volume 4, Part G – Section 22.0: Appendix 5.5-E.

Water quality predictions at the four LSA assessment nodes were compared to BC WQG and CCME WQGs for the protection of freshwater aquatic life (Volume 4, Part G – Section 22.0: Appendix 5.5-E).

- For water quality parameters with guidelines dependent on pH (i.e., aluminum) or hardness (i.e., cadmium, copper, lead, manganese, nickel, silver, and zinc), the baseline field pH and predicted hardness associated with those water quality parameters were used in the screening. Hardness was calculated based on predicted calcium and magnesium concentrations. Baseline field pH values were used in the screening process because pH values were not simulated in the receiving environment water quality model.

Water quality predictions were also compared to median baseline concentrations for the LSA streams (Volume 4, Part G – Section 22.0: Appendix 5.5-E).

- Site-specific surface water baseline concentrations were used for McNab Creek locations (MCF-1 and MCF-7). MCF-1 represents baseline surface water and is only affected by air deposition. MCF-7 was regularly monitored and will be affected by air deposition, pit lake seepage, and pit overflow.

- Baseline data collected at MCF-2, -3, -4, -5, and -6 were pooled together and were used to compare to the predicted water quality values at MCF-6, and -12. Data were pooled due to the relatively limited data available for these stations and because these locations will be affected by the Proposed Project via air deposition and water quality changes from groundwater (pit lake seepage) or surface water run-off. Median baseline concentrations were used for the base case scenario and 95th percentile baseline concentrations were used for the conservative case scenario.

Predicted concentrations of water quality parameters were considered distinguishable from the baseline condition if predicted concentrations were more than 10% greater than the median baseline concentration. A difference of ≤10% between the median baseline concentration and predicted concentrations was not considered to represent a potential effect to water quality and aquatic health because:

- Analytical uncertainty can be 10% or higher, depending on the laboratory, the analytical technique, and the individual parameter in question;
- A difference of less than 10% is unlikely to be statistically significant; and
- Potential effects to aquatic organisms are unlikely to be detectable or ecologically meaningful for a change in a substance concentration of less than 10%.

5.5.5.4.2.1.1 Direct Toxicity-Related Effects

Water quality parameters modelled at the four LSA assessment nodes with the potential to result in toxicity-related effects on aquatic indicators are trace metals[1], nutrients (nitrogen forms), total dissolved solids and major ions.

5.5.5.4.2.1.1.1 Trace Metals

Metals occur naturally in the environment as geochemical components of sediments, soils and rocks. Weathering processes mobilize these compounds and transport them into streams, rivers, and eventually the ocean. Metals also enter the aquatic environment from anthropogenic sources such as those related to mining operations, fossil fuel combustion and industrial emissions.

Certain metals are essential for maintaining good health because of their importance as components of enzymes or other biologically important proteins (e.g., iron in haemoglobin), and a shortage of those metals can result in adverse effects. Excess concentrations of these metals and concentrations of non-essential metals can result in toxicity-related effects on aquatic life. The toxicity of metals to aquatic organisms ranges widely from slight reductions in growth rates to mortality, and may be acute (after a short-term exposure) or chronic (over a longer term).

Metals in the aquatic environment can exist in dissolved form, adhered to particulates, as part of organic and/or inorganic complexes, and in various oxidation states. The chemistry and behaviour of metals can be complex and are dependent on a various factors that include but may not be limited to the following factors:

- The type of metal;
- Exposure route, duration and concentration;
- The form of the metal at the time of exposure (e.g., inorganic arsenic is more toxic than the organic form, whereas methylmercury is more toxic than inorganic mercury), which can be affected by site-specific physical, chemical, and biological conditions (e.g., pH, redox, microbial transformations);
- External and internal synergistic, additive or antagonistic interactions of co-occurring contaminants;
- Sensitivity of a given organism;
- Physiological ability to detoxify and/or excrete the metal;
- Life stage (e.g., embryonic and larval stages of benthic organisms are generally more sensitive than adult stages); and
- The condition of the exposed organism (e.g., a fish that is stressed by elevated water temperatures or low oxygen levels is potentially more sensitive to toxicant exposure).

For the base and conservative cases during operations and closure, predicted concentrations of trace metals in McNab Creek and downstream of the pit lake at MCF-6 and MCF-12, are within 10% of the baseline condition or are below applicable BC and CCME WQGs reflective of chronic exposure. The only exceptions were predicted vanadium concentrations at both stations during operations and closure for the conservative case when concentrations were more than 10% higher than the baseline condition. There are no available BC or CCME WQGs for vanadium, however, EC and HC (2010) assessed the toxicity of vanadium to aquatic life and derived a predicted no-effect concentration (PNEC) for toxicity to freshwater organisms of 0.12 mg/L through a species sensitivity distribution analysis. This chronic PNEC is more than three orders of magnitude higher than the maximum total vanadium concentration predicted at MCF-6 and MCF-12 (0.00074 mg/L); therefore, chronic toxicity to aquatic life would not be expected at MCF-6 and MCF-12 due to the predicted concentrations.

In consideration of the above assessment, the magnitude of residual effects associated with trace metal concentrations predicted during operations and closure for base and conservative cases is negligible (Table 5.5-22).

5.5.5.4.2.1.1.2 Nitrogen Forms (ammonia, nitrate and nitrite)

Inorganic nitrogen occurs naturally in the aquatic environment and exists predominantly in three forms in the aquatic environment: nitrate, nitrite and ammonia (CCME 2012a). The relative concentrations of these three forms depend on biotic processes within the nitrogen cycle (e.g., assimilation, nitrogen fixation, nitrification, denitrification, ammonification, decomposition of organic matter), the rates of which are mediated by pH, temperature, and dissolved oxygen levels (CCME 2012a). The exposure pathway of greatest relevance is via direct contact with surface water. Exposure to elevated concentrations of these nitrogen forms can result in a variety of effects from slight reductions in growth rates to mortality, and may be acute (after a short-term exposure) or chronic (over a longer term). Larval life-stages tend to be more sensitive than adult life-stages (Environment Canada 2004; CCME 2012b).

- Nitrate occurs naturally in the aquatic environment. Recent studies have demonstrated an ameliorative effect from increased water hardness on nitrate toxicity to sensitive species, suggesting that water hardness influences the fate and toxicity of nitrate (e.g., Nautilus 2011a, b, 2013). However the mechanism(s) of action by which hardness influences nitrate toxicity is not fully known and at present water hardness is not considered in the derivation or application of the BC and CCME WQGs.
- Nitrite is an intermediate product that forms during the bacteria-mediated nitrification of ammonia to nitrate under aerobic conditions, and is influenced by environmental factors such as pH, temperature, dissolved oxygen, the abundance of nitrifying bacteria, and the presence of compounds that can inhibit nitrification (Russo 1985). The conversion of ammonia to nitrite is the rate-limiting step in the nitrification process and nitrite is rapidly oxidized to nitrate. Nitrite therefore tends to be transient in natural oxygenated environments and is generally present at low concentrations, with some exceptions where it is found to be naturally elevated (Russo 1985; Lewis and Morris 1986). Chloride has the most influence on nitrite toxicity and the BC nitrite WQG is dependent on the chloride concentration under the conditions being assessed (Nordin 1986).
- Ammonia exists in two forms or ‘species’: un-ionized ammonia (NH_3) and ionized ammonia (NH_4^+, also known as the ammonium ion). The un-ionized form is generally the more toxic of the two. When a chemistry laboratory measures the ammonia concentration of a sample of water, the ammonia is reported as total ammonia nitrogen (sometimes abbreviated as TAN), which includes the combined total nitrogen concentration of the NH_3 (un-ionized) and the NH_4^+ (ionized) forms. The two forms of ammonia exist in a balance (equilibrium) in water and the ammonia can readily change between the two species. As the pH becomes more basic, the amount of the un-ionized form will increase. As the pH becomes more acidic, the amount of the un-ionized form will decrease. An increased water temperature will also favour an increased amount of the un-ionized form (NH_3) whereas higher salinities favour the ionized form of ammonia. The BC and CCME ammonia WQGs are pH and temperature dependent (Nordin 1986; CCME 2010).

For the base and conservative cases during operations and closure, predicted concentrations of ammonia, nitrate and nitrite in McNab Creek and downstream of the pit lake at MCF-6 and MCF-12, are within 10% of the baseline condition or are below applicable BC and CCME WQGs reflective of chronic exposure. Therefore, the magnitude of residual effects associated with predicted concentrations in these modelled scenarios is negligible (Table 5.5-22).

5.5.5.4.2.1.1.3 Total Dissolved Solids, Major Ions and Water Hardness

Total dissolved solids (TDS) represent the sum of all common dissolved ions (e.g., sodium, calcium, magnesium, potassium, chloride, sulphate, bicarbonate, and nitrate) (APHA 2005). Dissolved solids are naturally present in water, and the concentration and relative composition of individual components are determined by natural factors, such as the geology and soil in the watershed, atmospheric precipitation and the evaporation-precipitation water balance (Weber-Scannell and Duffy 2007). Changes in TDS concentrations can result from many anthropogenic activities; generation and disposal of waste rock and mine effluent, are considered to have primary linkages to geochemistry, with resulting effects on both TDS and concentrations of individual ions.

The mechanisms of TDS toxicity can be divided into two main groups, which are not necessarily mutually exclusive: toxicity from osmotic stress and specific ion toxicity (Davies and Hall 2007; Weber-Scannell and Duffy 2007). Osmotic stress can occur with an increase in TDS, which causes cellular desiccation due to an increased osmotic potential between the organism and the aquatic medium, in which water flows from an area of relatively low solute concentration (the cell) to an area of relatively high solute concentration (the surrounding environment) (Davies and Hall 2007). Specific ion toxicity refers to the uptake of a particular ion by an organism to concentrations that have adverse effects on normal cellular function. Thus, TDS toxicity is dependent on a number of factors, such as overall TDS concentration, the specific ion composition, and the organisms that may be affected.

Neither BC MOE nor CCME have an established WQG for the protection of aquatic life for TDS; however, TDS benchmarks have been established in other jurisdictions:

- In Alaska, TDS may not exceed 1,000 mg/L (ADEC 2009). Moreover, a concentration of TDS may not be present in water that causes an adverse effect to aquatic life. Permits are required for discharges to receiving water that result in an increase of TDS concentration in the waterbody between 500 and 1,000 mg/L. Chapman et al. (2000) reported that studies conducted for Coeur Alaska's Kensington Mine site resulted in the first site-specific TDS permit in Alaska. The permit states that TDS may not exceed 1,000 mg/L in Sherman Creek, the receiving waterbody of Kensington Mine effluent (ADEC 2009). Alaska also granted a site-specific permit for Red Dog Creek, the receiving waterbody for Red Dog Mine effluent (ADEC 2009; Brix et al. 2010). Concentrations of TDS up to 1,500 mg/L are permitted during periods when salmonids are not spawning, provided calcium is greater than 50% by weight of the total cations (ADEC 2009; Brix et al. 2010). During spawning periods, the limit was set at 500 mg/L (Brix et al. 2010).
- In 2004, the Iowa Department of Natural Resources (IDNR) adopted an interim TDS standard that required toxicity testing in situations where discharges resulted in receiving stream TDS concentrations greater than 1,000 mg/L (IDNR 2009). However, IDNR recently recommended replacing the current site-specific TDS approach with numerical sulphate and chloride criteria (IDNR 2009).

The maximum predicted concentration of TDS (63 mg/L in MCF-6 and MCF-12, conservative case) is low and well below established standards available for TDS in North America. Therefore although TDS concentrations are predicted to increase to concentrations more than 10% above the baseline condition, predicted concentrations are low, and not expected to result in adverse effects on the aquatic health of indicator species. As a result, the magnitude of effect associated with predicted concentrations for the base and conservative case scenarios is negligible at the four assessment nodes (Table 5.5-22).

5.5.5.4.2.1.1.4 Major Ions

The maximum concentrations of individual constituent ions and their approximate percent contribution (based on standard methods equation [APHA 2005]) associated with this maximum concentration of TDS were: sodium (65% of TDS); calcium (12%); sulphate (10%); alkalinity (6%); and chloride + magnesium + potassium (6%TDS). Mount et al. (1997) reported that the relative ion toxicity to freshwater species was generally potassium > bicarbonate ≈ magnesium > chloride > sulphate, whereas calcium and sodium did not appear to cause significant toxicity. Rather, the toxicity of calcium and sodium was primarily attributable to the corresponding anion.

Predicted concentrations of these major ions are not expected to result in toxicity-related effects on aquatic indicators at the two assessment nodes in McNab Creek and downstream of the pit lake at MCF-6 and MCF-12, during operations and closure, based on the following rationale.

- Predicted concentrations of sulphate, potassium, and chloride are below applicable long-term BC or CCME WQGs.
- The predicted maximum sodium concentration of 38 mg/L is substantially lower than the 680 mg/L sodium effects benchmark[2] referenced by Suter and Tsao (1996) in a review of toxicological benchmarks for screening potential contaminants of concern.

Therefore the magnitude of effect for the base and conservative case scenarios is negligible at the four assessment nodes (Table 5.5-22).

Water Hardness

Water hardness is a property of calcium and magnesium and degrees of hardness are defined as soft water, moderately hard water, hard water and very hard water (McNeely et al. 1979). The available baseline data indicates that water hardness in LSA streams is less than 10 mg/L (as $CaCO_3$) and so is considered to be very soft water (based on McNeely et al. 1979). Although calcium and magnesium concentrations at MCF-6 and MCF-12 during operations and closure are predicted to be higher than 10% of baseline under both modelled scenarios, predicted calcium and magnesium concentrations would still only result in a maximum water hardness of 21 mg/L (as $CaCO_3$), which is still considered to be very soft water (based on McNeely at al. 1979). Therefore, the magnitude of effect for the base and conservative case scenarios is negligible at the four assessment nodes (Table 5.5-22).

Table 5.5-22: Base Case and Conservative Case: Characterization of the Magnitude of Potential Project-Related Residual Effects on Surface Water Quality and Aquatic Health

Project-Related Effect	Magnitude of Effect Rating	Rationale
Construction		
Residual effects of negligible magnitude		
Operations		
Direct Toxicity-Related Effects	Magnitude of effect on aquatic health is expected to be negligible.	▪ Predicted concentrations of trace metals and nitrogen forms are below applicable WQGs for the protection of aquatic health or are not distinguishable from the baseline condition[1]. ▪ Predicted concentrations of TDS and major ions are below applicable WQGs where they exist. ▪ Predicted concentrations of TDS and major ions without WQGs, that are higher than the baseline condition, are not expected to result in adverse effects on aquatic indicators based on an assessment of the available regulatory and toxicity information.
Nutrient Enrichment-Related Effects		▪ Predicted concentrations of phosphorus and nitrogen forms are low, indicative of nutrient poor conditions with no change in trophic status expected.
Reclamation and Closure		
Direct Toxicity-Related Effects	Magnitude of effect on aquatic health is expected to be negligible.	▪ Predicted concentrations of trace metals and nitrogen forms are low and below applicable WQGs for the protection of aquatic health or are not distinguishable from the baseline condition[1]. ▪ Predicted concentrations of TDS and major ions are low and below applicable WQGs where they exist. ▪ Predicted concentrations of TDS and major ions without WQGs, that are higher than the baseline condition, are not expected to result in adverse effects on aquatic indicators based on an assessment of the available regulatory and toxicity information.
Nutrient Enrichment-Related Effects		• Predicted concentrations of phosphorus and nitrogen forms are low, indicative of nutrient poor conditions with no change in trophic status expected.

Notes:
TDS: Total dissolved solids; WQG: water quality guideline
[1] Predicted concentrations of modelled parameters not higher than 10% above median baseline concentrations for those parameters.

5.5.5.4.2.1.2 Nutrient Enrichment-Related Effects

Nitrogen and phosphorus are the two primary nutrients required for plant growth. In freshwater systems plant productivity and associated biomass accumulation are first to respond to an increase in phosphorus and nitrogen water concentrations (Environment Canada 2004). When nitrogen and phosphorus concentrations increase, aquatic plants and algae respond by increasing productivity (i.e., growth of biomass). Whereas primary productivity in freshwater systems tends to be limited by phosphorus and productivity in marine systems tend to be limited by nitrogen (Nordin 1985; CCME 2012a), the extent to which nitrogen forms limit productivity in both environments can vary (CCME 2013). For example, although most freshwater streams are expected to be phosphorus limited, some studies have shown both phosphorus and nitrogen to limit algal growth in streams (e.g., Dodds and Welch 2000, Dodds et al. 2002). Although both nutrients should be considered with respect to algal biomass accrual in streams, the LSA streams are expected to be phosphorus limited.

Regardless of the limiting nutrient, the relationship between nutrient concentrations and periphyton biomass is weaker in rivers and streams than in lakes (Dodds et al. 2002, Wetzel 2001). In rivers and streams, periphyton biomass is influenced to a greater degree by factors other than nutrient concentrations, that include, but are not limited to, light availability, flow velocities, stability and type of substrate, length of the growing season, suspended sediment load, invertebrate grazing, flood and drought frequencies, time since the last freshet and water temperature (Allen 1995, Dodds et al. 2002, Tank and Dodds 2003, Lewis and McCutchan 2010, Wetzel 2001). A BC phosphorus WQG for lakes has been approved, but a similar guideline has not been proposed for streams. Instead, a benthic algal biomass guideline of 100 mg/m^2 chlorophyll has been approved (Nordin 1985).

At the federal level, CCME (2004) and Environment Canada (2004) recommended total phosphorus trigger ranges for Canadian lakes and rivers as part of a national guidance framework for the management of freshwater systems. The trigger values were intended to indicate a change in trophic status from ultra-oligotrophic (<4 µg/L) to oligotrophic (4-10 µg/L) to mesotrophic (10-20 µg/L) to meso-eutrophic (20-35 µg/L) to eutrophic (35-100 µg/L) to hyper-eutrophic (>100 µg/L) conditions.

Aquatic ecosystems initially respond to mild nutrient enrichment with an increase in primary productivity that may not necessarily result in adverse effects on water quality or invertebrate and fish communities. However, beyond a certain point in phosphorus-limited systems, increased productivity due to an increase in phosphorus inputs can result in excess algal growth with adverse effects on water quality and higher trophic levels. Response patterns to nutrient enrichment in freshwater systems can include increased productivity, decreased biodiversity, a shift from sensitive species to more tolerant species, increased organic matter leading to sedimentation and the physical alteration of substrates, including smothering of fish spawning and benthic invertebrate habitat (Nordin 1985; Environment Canada 2004).

Base case total phosphorus concentrations are predicted to be within 10% of baseline conditions and therefore not distinguishable from baseline in McNab Creek. Downstream from the pit lake at MCF-6 and MCF-12 predicted concentrations are more than 10% higher than the baseline condition, with a maximum phosphorus concentration of 0.0032 mg/L predicted for the base case. With respect to trophic status, all the concentrations predicted for the base case scenario can be categorized as ultra-oligotrophic, according to the total phosphorus trigger ranges for Canadian lakes and rivers described in CCME (2004) and Environment Canada (2004). Ultra-oligotrophic conditions also prevailed under baseline conditions at these assessment nodes.

For the conservative case, predicted concentrations are within 10% of the baseline condition at all four LSA stations and can be classified as oligotrophic according to CCME (2004). Predicted concentrations are lower than or within the range of the BC phosphorus WQG for lakes where salmonids are the predominant fish species (i.e., 0.005 to 0.015 mg/L).

Based on this assessment phosphorus concentrations are expected to be low and for the most part not distinguishable from the baseline condition. Where predictions are distinguishable from baseline, predicted concentrations are still reflective of nutrient poor conditions and no trophic change from the baseline condition is expected. Therefore the magnitude of nutrient enrichment effects on aquatic health is expected to be negligible for both the base and conservative cases (Table 5.5-26).

5.5.5.4.2.2 Construction

During construction, direct toxicity-related and nutrient enrichment-related effects on surface water quality and aquatic health are expected to be of negligible magnitude based on the short-term duration of activities and effective implementation of construction mitigation measures. Negligible effects on periphyton, benthic invertebrate communities and fish are local in extent and short-term. The frequency of the residual effect is considered to be low and the effect is expected to be fully reversible (Table 5.5-26). With the application of mitigation measures, the likelihood of occurrence of residual effects on aquatic health related to direct toxicity and nutrient enrichment is considered low (Table 5.5-27).

5.5.5.4.2.3 Operations

During the operations period under the base and conservative case scenarios, effects on surface water quality and aquatic health are expected to be of negligible magnitude based on the assessment of predicted water quality presented in Section 5.5.5.4.2.1. Based on an evaluation of the annual water quality predictions presented in Volume 4, Part G – Section 22.0: Appendix 5.5-E for the two modelled scenarios, negligible effects on periphyton, benthic invertebrate communities and fish are local in extent and medium to long-term. The frequency of the residual effect is considered to be low and the effect is expected to be fully reversible (Table 5.5-26). With the application of mitigation measures, the likelihood of occurrence of residual effects on aquatic health related to direct toxicity and nutrient enrichment is considered low (Table 5.5-27).

5.5.5.4.2.4 Reclamation and Closure

Potential residual effects related to the reclamation and closure phase are similar to those discussed above for operations but over the long-term.

Table 5.5-23: Characterization of Potential Project-Related Residual Effects: Surface Water Flow

Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
No anticipated interaction						
Operations						
Changes in baseflow in WC 2	See Section 5.1 for context related to effects on Fish and Fish Habitat.	M to H	L	MT	IR	H
Reclamation and Closure						
Changes in baseflow in WC 2	See Section 5.1 for context related to effects on Fish and Fish Habitat.	M	L	LT	IR	H

Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR - Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.
N/A: Not Applicable

Table 5.5-24: Characterization of Potential Project-Related Residual Effects: Water Quality – Suspended Sediment

Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Changes in water quality– Suspended Sediment	R	N	L	ST	FR	L
Operations						
Changes in water quality– Suspended Sediment	R	N	L	MT	FR	L
Reclamation and Closure						
Changes in water quality– Suspended Sediment	R	N	L	ST	FR	L

Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR - Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.
N/A: Not Applicable

Table 5.5-25: Characterization of Potential Project-Related Residual Effects: Water Quality - Spills

Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Changes in Water Quality - Spills	S	N	L	ST to LT	FR to IR	L
Operations						
Changes in Water Quality - Spills	S	N	L	ST to LT	FR to IR	L
Reclamation and Closure						
Changes in Water Quality - Spills	S	N	L	ST to LT	FR to IR	L

Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR - Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.
N/A: Not Applicable

Table 5.5-26: Base Case and Conservative Case: Characterization of Potential Project-Related Residual Effects on Surface Water Quality and Aquatic Health

Project-Related Effect	Residual Effect Assessment Criteria					
	Context	Magnitude	Extent	Duration	Reversibility	Frequency
Construction						
Direct Toxicity-Related Effects	S	N	L	ST	FR	L
Nutrient Enrichment-Related Effects	S	N	L	ST	FR	L
Operations						
Direct Toxicity-Related Effects	S	N	L	MT to LT	FR	L
Nutrient Enrichment-Related Effects	S	N	L	MT to LT	FR	L
Reclamation and Closure						
Direct Toxicity-Related Effects	S	N	L	LT	FR	L
Nutrient Enrichment-Related Effects	S	N	L	LT	FR	L

Context: R – Resilient, MR – Moderately Resilient, S - Sensitive;
Magnitude: N – Negligible, L – Low, M – Medium, H – High;
Geographic Extent: L – Local, R – Regional, BR – Beyond Regional;
Duration: ST – Short-tern, MT – Medium-term, LT – Long-term;
Reversibility: FR - Fully Reversible, PR - Partially Reversible, IR - Irreversible;
Frequency: L – Low, M – Medium, H – High.
N/A: Not Applicable

Table 5.5-27: Likelihood of Occurrence of Potential Residual Effects on Surface Water Flow, Surface Water Quality, and Aquatic Health

VC	Residual Effect	Likelihood	Rationale
Construction			
Water Quality - Suspended Sediments	Potential for changes in surface water quality from increases in suspended sediments in runoff.	Low	With the proposed erosion and sediment control implemented, the potential for surface water quality degradation from suspended sediments is reduced significantly
Water Quality – Spills	Potential for changes in surface water quality as a result of accidental spills of hazardous materials.	Low	With the proposed spill prevention and control implemented, the potential for surface water quality degradation from chemical spills is reduced significantly
Water Quality - Aquatic Health	Local, short-term, residual effect of negligible magnitude on surface water quality.	Low	With the application of mitigation measures, the likelihood of occurrence of residual effects on aquatic health related to direct toxicity and nutrient enrichment are considered low.
Operations			
Flow	Reduced baseflow in the WC 2	High	The proposed pit and removal of the upper segment of WC 2 is anticipated to result in decreased baseflow in the WC 2.
Water Quality - Suspended Sediments	Potential for changes in surface water quality from increases in suspended sediments in runoff.	Low	With the proposed erosion and sediment control implemented, the potential for surface water quality degradation from suspended sediments is reduced significantly
Water Quality – Spills	Potential for changes in surface water quality as a result of accidental spills of hazardous materials.	Low	With the proposed spill prevention and control implemented, the potential for surface water quality degradation from chemical spills is reduced significantly
Water Quality - Aquatic Health	Local, long-term, residual effect of negligible magnitude on surface water quality.	Low	With the application of mitigation measures, the likelihood of occurrence of residual effects on aquatic health related to direct toxicity and nutrient enrichment are considered low.
Reclamation and Closure			
Flow	Reduced baseflow in WC 2	High	The proposed pit and removal of the upper segment of WC 2 is anticipated to result in decreased baseflow in the WC 2.
Water Quality - Suspended Sediments	Potential for changes in surface water quality from increases in suspended sediments in runoff.	Low	With the proposed erosion and sediment control implemented, the potential for surface water quality degradation from suspended sediments is reduced significantly

VC	Residual Effect	Likelihood	Rationale
Water Quality – Spills	Potential for changes in surface water quality as a result of accidental spills of hazardous materials.	Low	With the proposed spill prevention and control implemented, the potential for surface water quality degradation from chemical spills is reduced significantly
Water Quality - Aquatic Health	Local, long-term, residual effect of negligible magnitude on aquatic health.	Low	With the application of mitigation measures, the likelihood of occurrence of residual effects on aquatic health related to direct toxicity and nutrient enrichment are considered low.

Notes:
VC: valued component

5.5.5.5 Significance of Residual Effects

The significance of potential residual adverse effects was determined based on the effects criteria ratings and the likelihood of a potential residual effect occurring presented in Table 5.5-3, a review of background information and available field study results, consultation with government agencies, First Nations, and other experts, and professional judgement.. A summary of significance determinations for the base and conservative case scenarios is presented in Table 5.5-28 along with rationale for the determination of significance for the operations and closure time periods.

For all potential interactions, negligible (and not significant) residual effects on surface water resources are expected during construction, operations and during reclamation and closure. Potential residual effects on surface water resources were either:

- Not distinguishable from baseline conditions; or
- Negligible because predicted concentrations are below conservatively-derived WQGs for the protection of aquatic life, or in the absence of water quality guidelines, an assessment of predicted concentrations concluded adverse effects on aquatic life would not be expected.

Based on the negligible significance rating for all residual effects on surface water resources, no residual effects were carried forward into a cumulative effects assessment.

Potential effects related to reductions in surface water flows are related to the most sensitive receiver in WC 2 identified as fish and fish habitat. A comprehensive evaluation of how changes in the hydraulic conditions of the WC 2 will cause effects to Fisheries and Freshwater Habitat and a determination of the significance of these effects is presented in Section 5.1.

Table 5.5-28: Significance of Potential Residual Effects on Surface Water Resources

VC	Residual Effect	Significance	Rationale
Construction			
Water Quality – Suspended Sediments	Changes in Water Quality from Increases in Suspended Sediments	Negligible - Not Significant	With the effective implementation of the proposed erosion and sediment control measures and BMPs, the residual effect was considered negligible (and not significant).
Water Quality – Spills	Changes in Water Quality from accidental spills of hazardous materials.	Negligible - Not Significant	With the effective implementation of the proposed spill prevention and control measures and BMPs, the residual effect was considered negligible (and not significant).
Water Quality - Aquatic Health	Toxicity-related effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).
	Nutrient enrichment effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).
Operations			
Water Quality – Suspended Sediments	Changes in Water Quality from Increases in Suspended Sediments	Negligible - Not Significant	With the effective implementation of the proposed erosion and sediment control measures and BMPs, the residual effect was considered negligible (and not significant).
Water Quality – Spills	Changes in Water Quality from accidental spills of hazardous materials.	Negligible - Not Significant	With the effective implementation of the proposed spill prevention and control measures and BMPs, the residual effect was considered negligible (and not significant).
Surface Water Quality - Aquatic Health	Toxicity-related effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).
	Nutrient enrichment effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).
Reclamation and Closure			
Water Quality – Suspended Sediments	Changes in Water Quality from Increases in Suspended Sediments	Negligible - Not Significant	With the effective implementation of the proposed erosion and sediment control measures and BMPs, the residual effect was considered negligible (and not significant).

VC	Residual Effect	Significance	Rationale
Water Quality – Spills	Changes in Water Quality from accidental spills of hazardous materials.	Negligible - Not Significant	With the effective implementation of the proposed spill prevention and control measures and BMPs, the residual effect was considered negligible (and not significant).
Surface Water Quality - Aquatic Health	Direct Toxicity-related effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).
	Nutrient enrichment-related effects	Negligible - Not Significant	Based on the assessment in Section 5.5.5.3.5, the significance of a potential residual effect on aquatic health is negligible (and not significant).

Notes:
VC: valued component; WQG: water quality guideline; LSA: local study area; CCME: Canadian Council of Ministers of the Environment

5.5.5.6 Level of Confidence

The impact assessment conducted here was an *a priori* predictive exercise with the objective of identifying whether or not the Proposed Project will result in significant effects to the aquatic receiving environment. It is important to identify the major uncertainties associated with the predictive assessment and to consider the implications of these uncertainties on the level of confidence in determination of significance. The identification of uncertainties will assist in focusing a receiving environment monitoring program during operations.

An assessment of the level of confidence in the determination of negligible residual effects on surface water quality and aquatic health is provided in Table 5.5-29.

Table 5.5-29: Level of Confidence in Potential Residual Effect Predictions: Surface Water Quality

Residual Effect	Level of Confidence (LOC) in Residual Effect Prediction	LOC Rationale
Construction		
Potential for changes in surface water quality from increases in suspended sediments	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.
Potential for changes in surface water quality from accidental spills	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.

Residual Effect	Level of Confidence (LOC) in Residual Effect Prediction	LOC Rationale
Operations		
Reduced flow in the lower segment of WC 2	High level of confidence in relative changes in flows. Moderate level of confidence in magnitude of flows.	Projections of baseflow rates were based on hydrogeological modelling of the proposed conditions for Years 0, 5, 10, 15, and 16. The flows between the modelled years were interpolated assuming a linear relationship. Limited calibration data were available to refine this analysis. It is recommended that groundwater, pit water levels, McNab Creek and the lower segment of WC 2 be monitored throughout the operational phase of the Proposed Project with the results being used to calibrate and refine the hydrogeologic model and inform mine planning.
Potential for changes in surface water quality from increases in suspended sediments	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.
Potential for changes in surface water quality from accidental spills	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.
Negligible effect on surface water quality and aquatic health in the downstream receiving environment in terms of the potential for direct toxicity-related and nutrient-enrichment related effects.	Moderate	Because the Proposed Project does not yet exist, it was necessary to make assumptions about the Proposed Project-related inputs to the aquatic environment. The predicted surface water quality was based on conservative assumptions as discussed in Volume 4, Part G – Section 22.0: Appendix 5.5-D. An ongoing monitoring program will be used to verify water quality predictions in the pit lake and the downstream receiving environment. An absence of chronic sublethal effects is conservatively predicted when modelled parameter concentrations are lower than provincial and federal WQGs. These generic WQGs are: ▪ Intended to be protective of sensitive aquatic biota across the province (BC WQGs) and Canada (CCME WQGs). ▪ Derived with the intention of protecting all forms of aquatic life over a chronic exposure period. Screening against the BC WQGs was conservative because these guidelines are generally intended to be applied to the mean concentration of five samples collected over a 30-day period of time (Meays 2012). The assessment has examined the contaminants individually; however, in reality they are discharged in a mixture. Although the most common form of interaction among contaminants is additive, it is possible that more-than-additive (synergistic) or less-than additive (antagonistic) interactions are operable. It is unlikely that the contaminants would all be simultaneously discharged at the maximum concentration and the evidence of contaminant mixture effects generally applies to contaminants at higher concentrations than those near WQG.

Residual Effect	Level of Confidence (LOC) in Residual Effect Prediction	LOC Rationale
Reclamation and Closure		
Reduced Flow in WC 2	Moderate	Projections of baseflow rates were based on hydrogeological modelling of the proposed conditions at closure. Limited calibration data were available to refine this analysis. It is recommended that groundwater, pit water levels, McNab Creek and the lower segment of WC 2 be monitored throughout the operational phase of the Proposed Project with the results being used to calibrate and refine the hydrogeologic model and inform mine closure design.
Potential for changes in surface water quality from increases in suspended sediments	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.
Potential for changes in surface water quality from accidental spills	High	The conditions, activities, potential impacts and mitigation are similar to many other projects carried out within the region.
Negligible effect on surface water quality and aquatic health in the downstream receiving environment.	Moderate	See the rationale for the operations LOC assessment

Notes:
WQG: water quality guideline; LOC: level of confidence

5.5.5.6.1 Pit Lake Quality

Predicted concentrations of major ions, nutrients and trace metals in the pit lake were compared to maximum BC WQGs and short-term CCME WQGs to assess the potential for the pit lake water to be acutely lethal. It was assumed that if predicted concentrations were lower than these WQGs that the pit lake water would not result in acute lethality. Predicted concentrations of major ions, nutrients and trace metals in the pit lake water during operations and closure were notably lower than maximum BC WQGs and short-term CCME WQGs and were lower than the corresponding longer–term WQGs (i.e., 30-day average BC WQGs and CCME WQGs). The discharge from the pit lake is not considered a deleterious substance, and is unlikely to cause pollution in the downstream receiving environment.

Although the pit lake is not defined as part of the receiving environment for the purposes of this assessment, the water quality in the pit lake was comparable to that predicted for MCF-6 in WC 2 and predicted concentrations would not be expected to result in significant effects on the aquatic health of biota in the downstream receiving environment. This expectation would be verified by monitoring of water quality in the pit lake and the downstream receiving environment (See section 5.5.5.3.5).

5.5.5.7 Cumulative Effects Assessment

All potential Project-related residual adverse effects were determined to be negligible and requiring no further consideration. No residual effects were carried forward to a cumulative effects assessment.

5.5.6 Conclusions

5.5.6.1 Changes in Surface Water Flow

Based on the results of the hydrogeological assessment, the Proposed Project was projected to have **positive** potential effects on the flows in McNab Creek by reducing the rate of flow loss to the groundwater system in the segment of McNab Creek located adjacent to the proposed pit to the north and east.

The Proposed Project was projected to have **positive** potential effects of increased baseflow in the Foreshore Minor Streams. Between Proposed Project operation and closure, the projected increase in flow ranged between 39% and 53% compared to pre-Proposed Project conditions. No negative residual effects are anticipated for the Foreshore Minor Streams' baseflow as a result of the Proposed Project.

It is anticipated that the Proposed Project would have potential effects of reduced baseflow in WC 2. During the operational phase of the Proposed Project the analysis indicated that the baseflow in WC 2 would be reduced in the range of 19% and 37% compared to pre-Proposed Project conditions. At the closure and reclamation phase the estimated reduction in baseflow in WC 2 would be 19%. An extension to the existing lower segment of WC 2, to be completed as part of the Proposed Project, will create additional habitat area to offset the loss of the upper segment of WC 2. The proposed extension would result in an increase in the wetted area in the range of 1,231 m^2 and 1,421 m^2, and the average flow depth would increase between 0.072 m and 0.113 m.

When considered in isolation of other hydrologically significant characteristic such as total wetted surface area and average flow depth, the reduction in baseflow in the operational and reclamation and closure phases of the Proposed Project was characterized as a medium to high in magnitude. The most sensitive receiver related to the hydraulic conditions within WC 2 identified in this assessment was aquatic life. A more detailed and comprehensive evaluation of changes in the hydraulic conditions of WC 2, including changes in flow rates, depths and total wetted area, are presented in Volume 2, Part B – Section 5.1: Fisheries and Freshwater Habitat assessment.

5.5.6.2 Changes in Water Quality

5.5.6.2.1 Suspended Sediments

The Proposed Project has the potential to have negative effects on water quality related to suspended sediments. Throughout the life of the Proposed Project, preventive and mitigative measures are proposed to reduce the potential for sediment erosion, transport and deposition into any stream or watercourse, consistent with the Land Development Guidelines for the Protection of Aquatic Life (DFO 1993), BC WQG (BC MOE, 1998) and applicable Best Management Practices (BMPs). For each Proposed Project phase, site-specific Erosion and Sediment Control Plans (Volume 4, Part G – Section 22.0: Appendix 3) and Environmental Management Programmes would be established. With the effective implementation of erosion and sediment control measures and BMPs the significance for surface water quality degradation from suspended sediments was categorized as negligible-not significant.

5.5.6.2.2 Chemical Spills

The Proposed Project has the potential to have negative effects on water quality related to chemical spills. The potential effects of a chemical spill on water quality are variable and would depend on the nature of the spill. Throughout the entire life of the Proposed Project, preventative and mitigative measures are proposed to reduce the potential effects resulting from chemical spills. Site and Proposed Project phase-specific SPERPs and MSHWMPs will be developed. These plans will be consistent with the *BC Spill Reporting Regulation*, the *BC Special Regulation* and other applicable BMPs. With the effective implementation of the proposed preventative and mitigative measures the significance for surface water quality degradation from chemical spills was categorized as negligible-not significant.

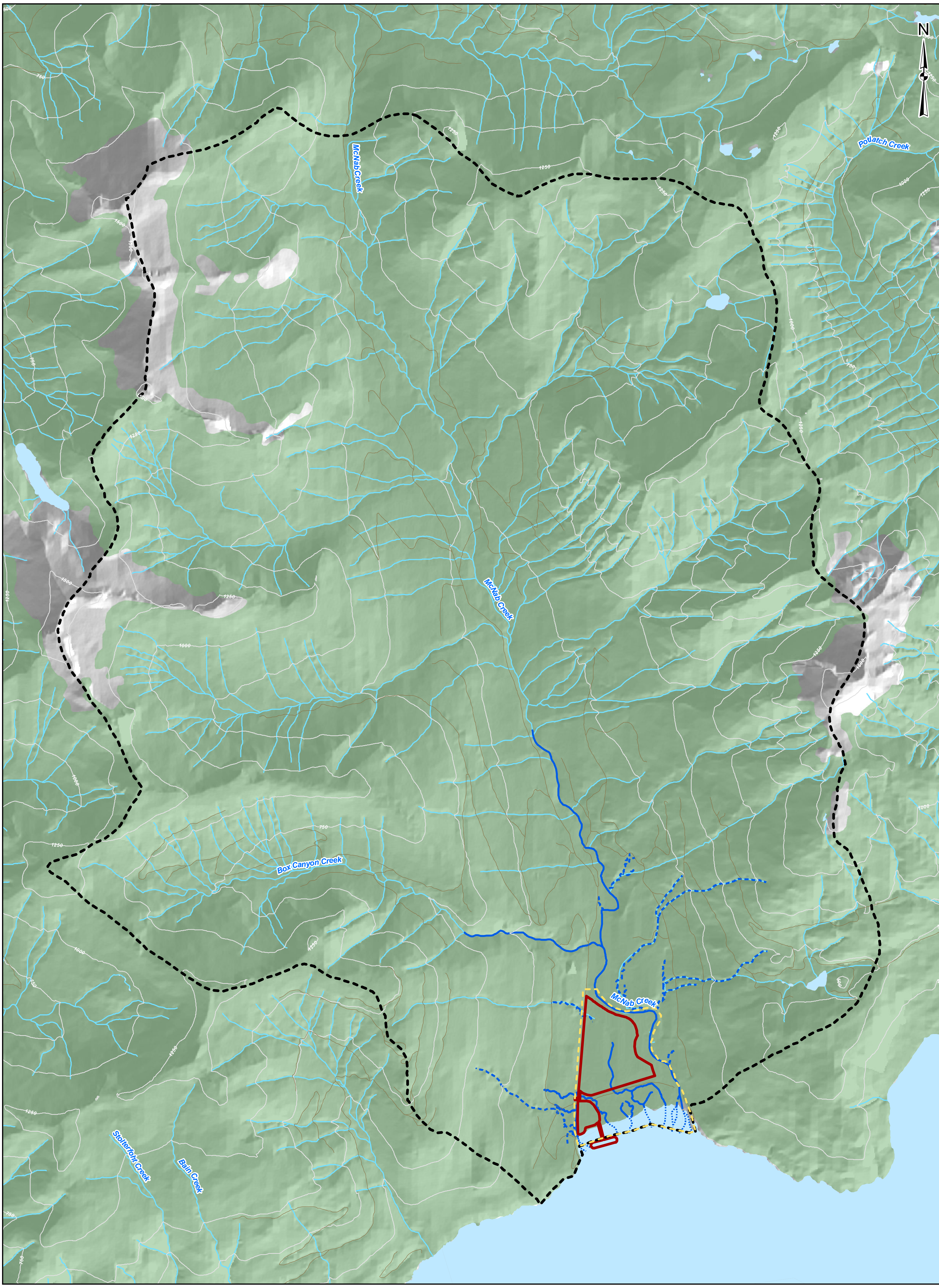
5.5.6.3 Aquatic Health

Based on the residual effects assessment of predicted surface water quality in the aquatic environment downstream of mine influence, the Proposed Project is expected to result in negligible effects on surface water quality and aquatic health indicators (i.e., periphyton, benthic invertebrate communities and fish populations). There is moderate confidence in the determination of negligible effects on surface water quality and aquatic health.

A conceptual surface water quality monitoring program is proposed to collect data in the receiving environment to verify water quality predictions made in Volume 4, Part G – Section 22.0: Appendix 5.5-E that were used as the basis for the Surface Water Quality and Aquatic Health Assessment. Monitoring of periphyton biomass under baseline conditions should be undertaken in the LSA prior to construction of the extension. These data would represent baseline data in a future biological monitoring program should such a program be triggered by water quality changes in the downstream receiving environment.

Recommendations for monitoring of fish and fish habitat and benthic invertebrate communities in relation to the Fish Habitat Offset Plan are provided in Volume 4, Part G – Section 22.0: Appendix 5.1-B.

All potential Project-related residual adverse effects were determined to be negligible and requiring no further consideration. No residual effects were carried forward to a cumulative effects assessment.



LEGEND

- Project Area
- Local Study Area
- Regional Study Area
- Vegetation
- Waterbody
- Resource Road
- Contour (250m)
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse
- Watercourse

1,000 0 1,000

SCALE 1:40,000 METRES

REFERENCE

Contours from TRIM positional data. DEM from Geobase. Vegetation from Canvec. Watercourses from the Province of British Columbia and field data. Resource roads from the Province of British Columbia.
Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

SURFACE WATER RESOURCES
STUDY AREAS

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.
DESIGN	MD	14 May. 2014	SCALE AS SHOWN REV. 2
GIS	DL	08 Mar. 2016	
CHECK	KZ	21 Apr. 2015	**FIGURE 5.5-1**
REVIEW	AC	21 Apr. 2015	

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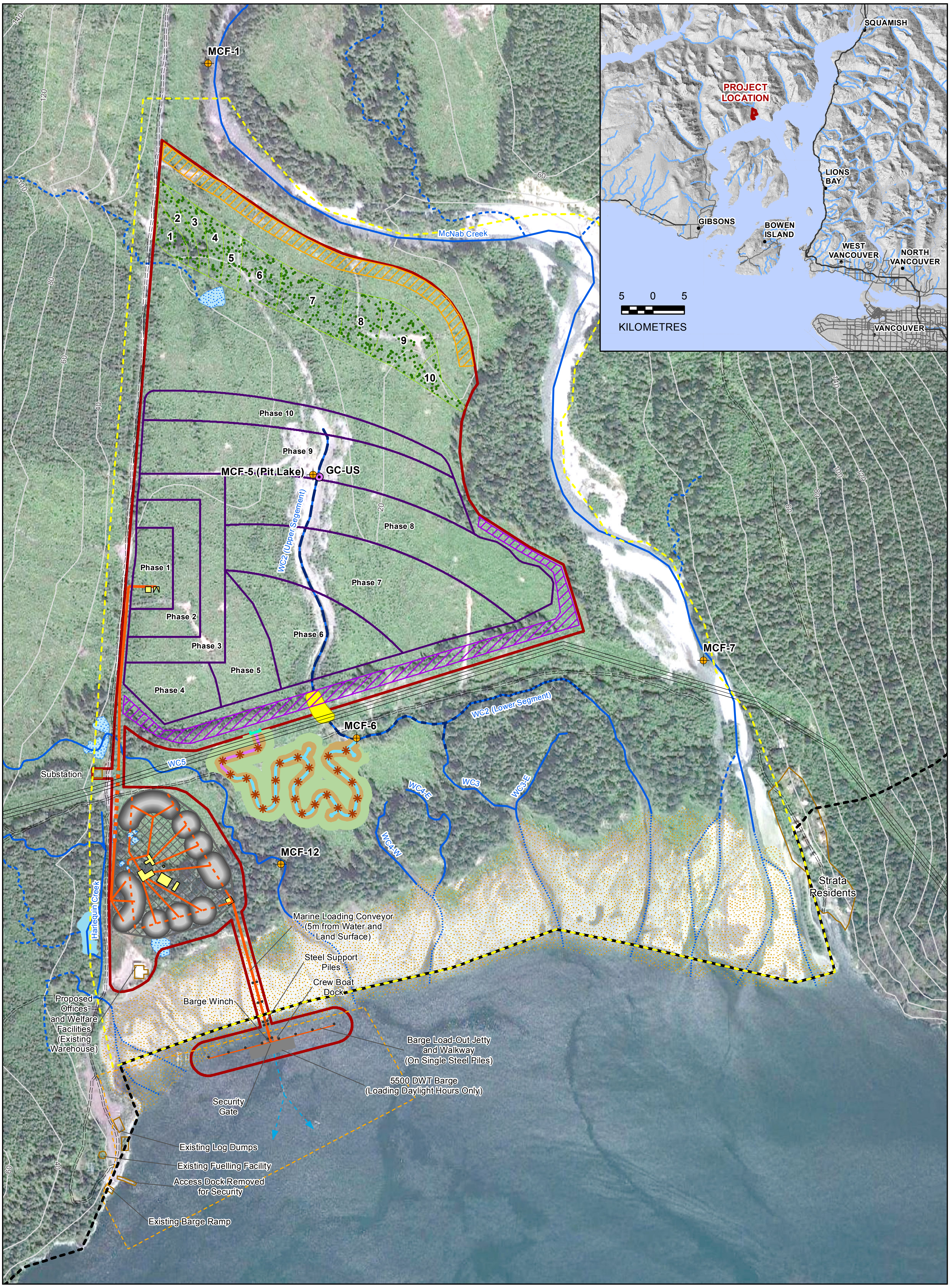

LEGEND

- Predicted Water Quality Location
- Station Locations (ID)
- Project Area
- Local Study Area
- Regional Study Area
- Proposed Aggregate Pit Phase
- Product Stockpile
- Processing Area
- Existing Feature
- Existing Log Tenure Area
- Fines Storage Area
- McNab Creek Flood Protection Dyke
- Pit Lake Containment Berm
- Possible Processing Plant Configuration
- Intertidal Zone
- Waterbody
- Low Lying Wetted Area

Proposed WC2 Extension (~770 m)

- Proposed Channel Extension: Year 1 Channel Construction
- Proposed Channel Extension: Project Closure Channel Construction
- Top of Bank
- Riparian
- Channel Infill, Riprap and Filter Zone
- Outlet Structure with Spillway and Low-Level Outlet
- Above-Ground Conveyor
- Below Pile Conveyor
- Barge Load-out
- Transmission Line
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse

Constructed Watercourse

- Phase 1 (1985)
- Phase 2 (1998)
- Phase 3 (2001 - 2003)
- Contour (20m)
- Road (Existing)
- Barge Route
- Pile
- Wood Debris

210 0 210

SCALE 1:6,500 METRES

REFERENCE

Contours from TRIM positional data. Additional detailed site features provided by McElhanney. Watercourses from the Province of British Columbia and field data. Base data from the Province of British Columbia. Base Imagery from Google Maps 20100807.
Projection: UTM Zone 10 Datum: NAD 83

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

SURFACE WATER RESOURCES SITE PLAN

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No. 4400	
DESIGN	LC	03 Nov. 2014	SCALE AS SHOWN	REV. 0
GIS	DL	08 Mar. 2016	**FIGURE 5.5-2**	
CHECK	CC	08 Mar. 2016		
REVIEW	CC	08 Mar. 2016		

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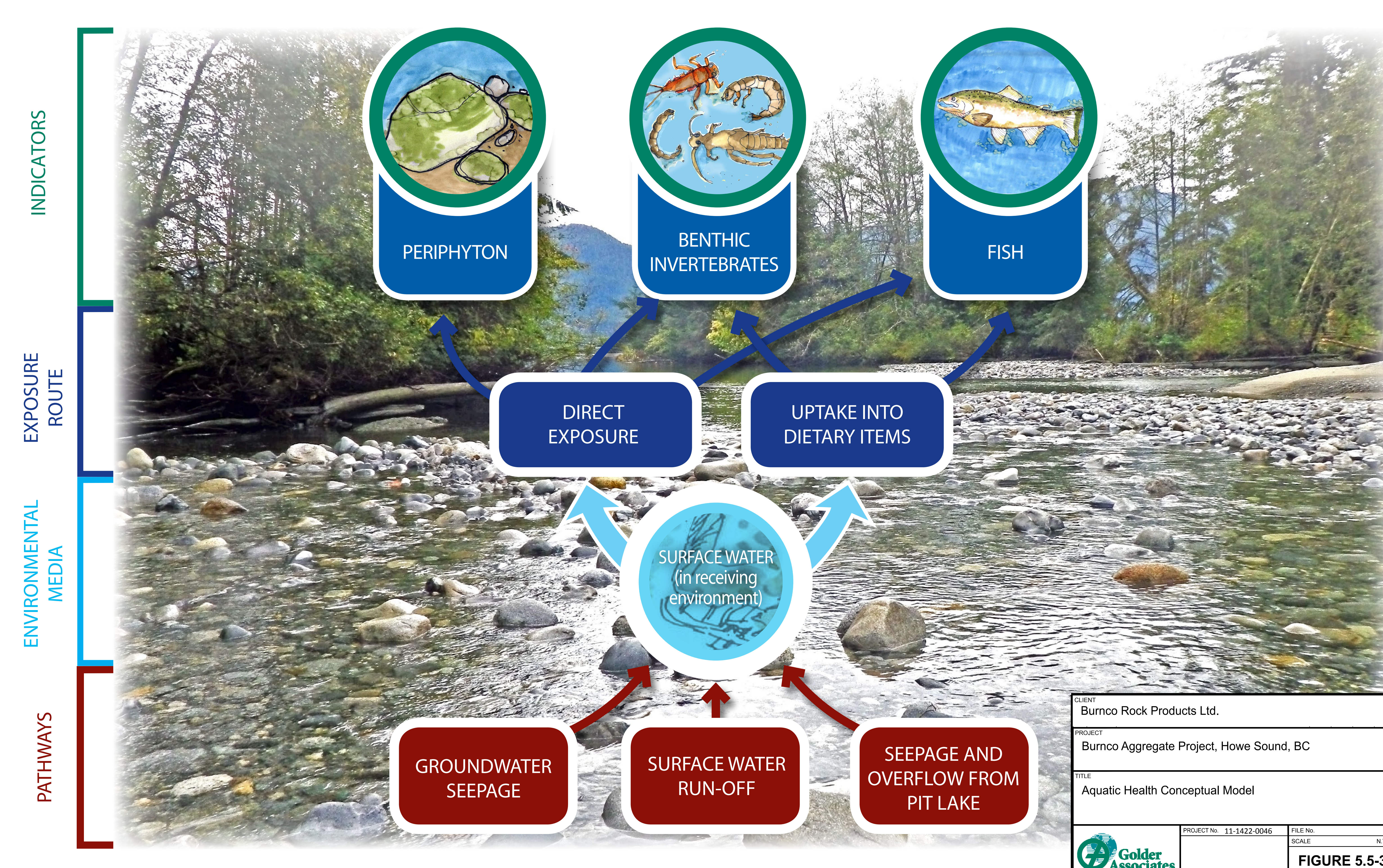

CLIENT
Burnco Rock Products Ltd.

PROJECT
Burnco Aggregate Project, Howe Sound, BC

TITLE
Aquatic Health Conceptual Model

Golder Associates

PROJECT No. 11-1422-0046

FILE No.

SCALE N.T.S.

FIGURE 5.5-3