7 April 2017

BURNCO AGGREGATE PROJECT, HOWE SOUND, BC

Water Management Plan - Draft

DRAFT

Submitted to:
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BURNCO Rock Products Ltd

REPORT

Report Number: 1114220046-669-R-RevA

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1.0 INTRODUCTION

The Proposed BURNCO Rock Products Ltd. (BURNCO) aggregate facility is located approximately 22 kilometres (km) southwest of Squamish and 35 km northwest of Vancouver with geographic coordinates of 49° 34’ 00”N, 123° 23’ 20”W (the Project, Figure 1).The Project will be developed within a 70 ha clear cut (in 2004 to 2005) area in the southern portion of a 320 ha, privately-owned Property (“the Property”) that has been owned since 2008 by 0819042 BC Ltd and BURNCO Rock Products Ltd. The aggregate mine will be located on a 30 hectare (ha) portion of the Property. The major Project components include the aggregate pit, the McNab Creek Flood Protection Dyke, the Fines Storage Area, the pit lake Containment Berm, conveyor system, electric powered floating clamshell dredge, temporary soil stockpiles, crusher, wash plant, water tanks, silt press, site offices and welfare facilities, marine loading conveyor and a barge load-out and walkway Figure 2.

The management, mitigation, and monitoring of water resources during the Project construction, operation, reclamation, and closure are outlined in this Water Management Plan (WMP). This includes:

- The water management strategy;
- The water mitigation plan; and
- The water monitoring program.

1.1 Background

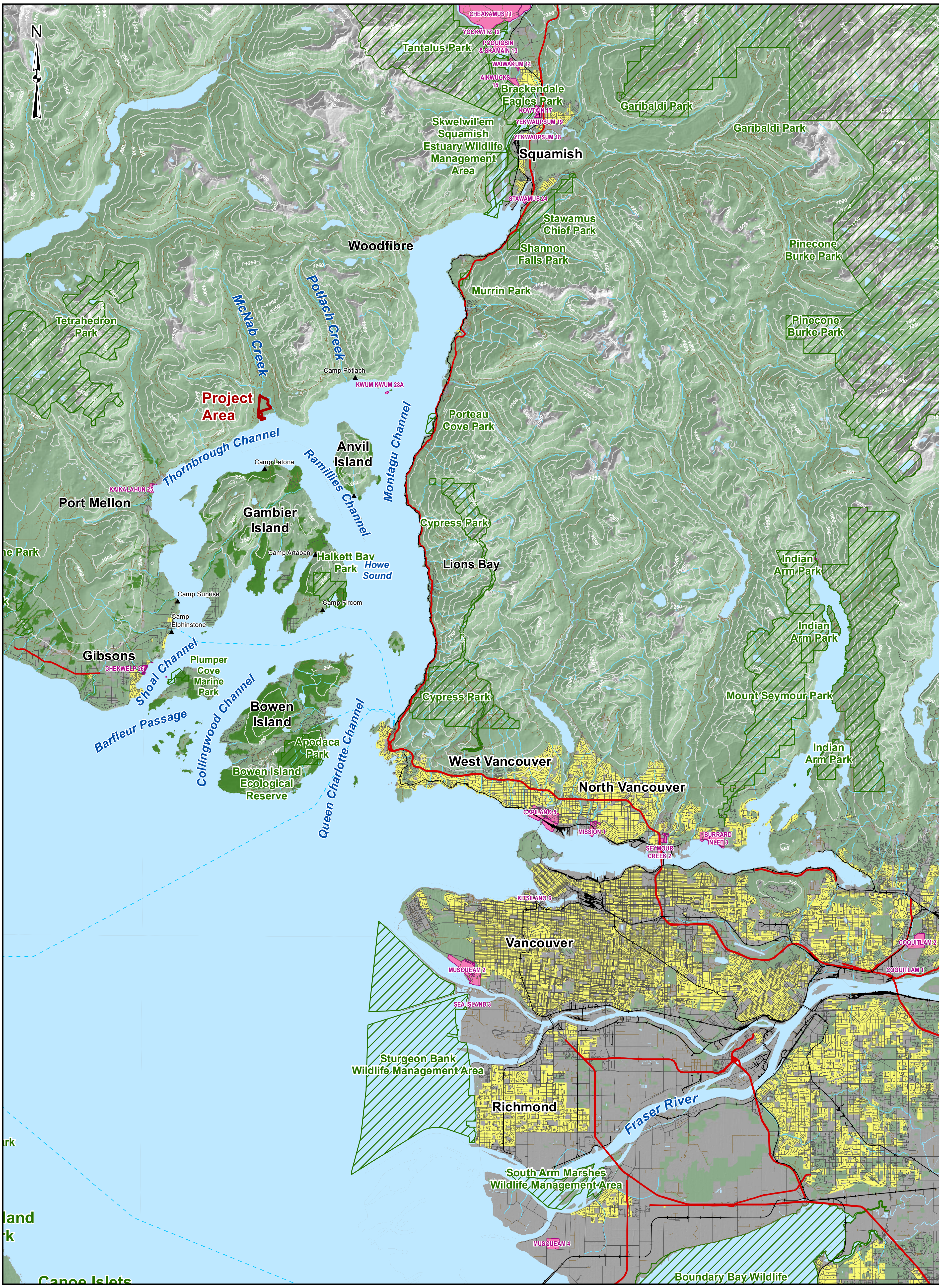
An Environmental Assessment Certificate Application/Environmental Impact Statement (EAC Application/EIS) for the Proposed BURNCO Aggregate Project was prepared in accordance with requirements for an environmental assessment (EA) under the British Columbia *Environmental Assessment Act*, SBC 2002, c.43 (BCEAA) and the former *Canadian Environmental Assessment Act* (CEAA) and submitted in July of 2016 to the B.C. Assessment Office (BCEAO) and the Canadian Environmental Assessment Agency (The Agency). The Application is currently under review.

A Mines Act Permit Application (MAPA) is also required and will be submitted to satisfy the requirement of the *Mines Act.* The Project will also be submitting a *Water Sustainability Act* License application concurrently with the MAPA. This Licence will include any works that involve the use or diversion of water on the same parcel of private land owned by the Proponent. In addition, a separate groundwater well license will be required for the usage of water during processing and will be submitted concurrently.

1.2 Objectives and Scope

The WMP was developed to provide a long-term water management strategy that includes the management of water resources, a mitigation plan to reduce potential effects to water resources, and an effects monitoring plan to monitor water resources in the receiving environment. The plan is designed to meet the preliminary mitigation measures, and commitments and assurances outlined in the EAC Application/EIS and those required by the *Water Sustainability Act*. The plan is expected to be refined based on discussion and consultation with regulatory agencies and First Nations.

Management of water on the site will occur through the management strategy defined below as well as details laid out in the Erosion and Sediment Control Plan (ESCP). Section 3.0 provides mitigation measures by phase to be implemented and monitored by a Qualified Environmental Professional (QEP) during the Project. The mitigation measures were developed to minimize the potential effects outlined in the EAC Application/EIS. The surface water and groundwater monitoring programs and potential aquatic resources monitoring program are described in Section 4.0 and were developed in order to confirm the findings of the impact assessment and provide on-going monitoring of water resources as the Project progresses. The plan also provides the mechanisms for the initiation of adaptive management techniques outlined in Sections 8.1 and 8.0.



LEGEND

Project Area	Highway
Park / Protected Area	Road
Sensitive Environmental Area	Resource Road
Vegetation	Railway
Indian Reserve	Ferry
Residential Area	Watercourse
Waterbody	Contour (250m)
	Camp

10 0 10

SCALE 1:250,000 KILOMETRES

REFERENCE

Parks/protected areas and sensitive areas from the Province of British Columbia. Elevation and indian reserves from Geobase.
Base data from CanVec. Projection: UTM Zone 10 Datum: NAD 83

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PROJECT

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

TITLE

LOCATION OF BURNCO AGGREGATE PROJECT

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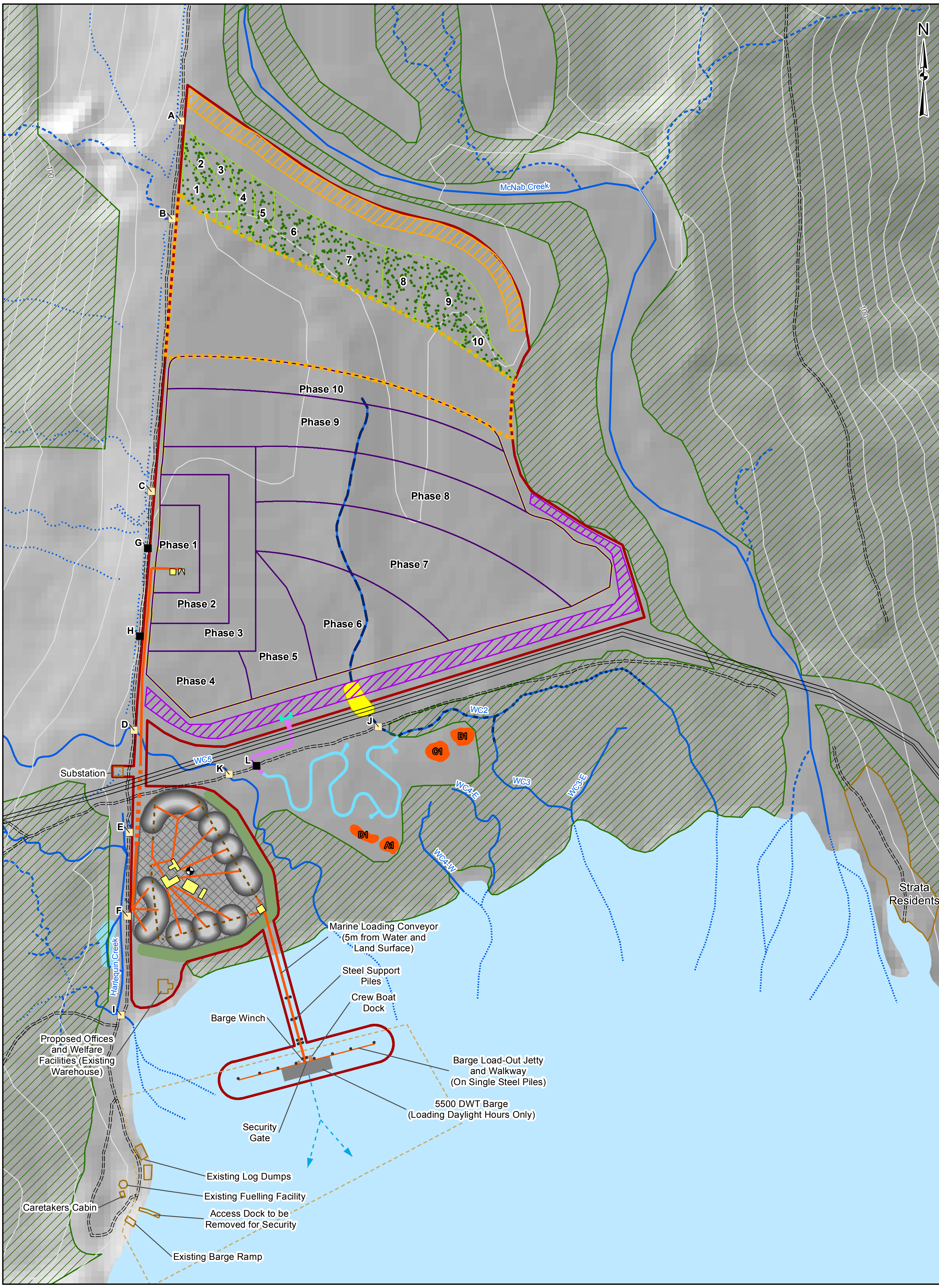
PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	KZ	5 Dec. 2016	SCALE AS SHOWN	REV. 0
GIS	JP	5 Dec. 2016		
CHECK				
REVIEW				

FIGURE 1

Path: Y:\Vancouver\Spatial Data\Project Data\BC\McNab\Figures\MXD\Surface Water\Annex9\Figure_1_Location_of_Burnco_Aggregate_Project.mxd



LEGEND

PROJECT COMPONENTS

- Project Area
- Proposed Aggregate Pit Phases
- McNab Creek Flood Protection Dyke
- Pit Lake Containment Berm
- Soil Deposit Area (Salvaged Soil Stockpiles)
- Fines Storage Area
- Processing Area
- Elevated Conveyor
- Underground Conveyor
- Below Pile Conveyor
- Barge Route
- Proposed Groundwater Use Well
- Proposed Culvert
- Existing Culvert
- Existing Feature
- Chanel Infill (WC 2 Plug) Riprap and Filter Zone
- WC 2 Extension - Year 1 Construction
- WC 2 Extension - Closure Construction
- Outlet Structure with Spillway and Low-Level Outlet (Post-Closure)
- Final Pit Lake Boundary
- Amphibian Compensation Pond
- Product Stockpiles
- Possible Processing Infrastructure Configuration
- Processing Area Berm

BASEMAP DATA (TRIM / McElhanney)

- Mature Forest
- Existing Road
- Existing Log Tenure Area
- Existing Transmission Lines
- Contour (20m)
- Permanent /Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse
- Ephemeral Watercourse
- Constructed Watercourse Phase 1 (1985)
- Constructed Watercourse Phase 2 (1996)
- Constructed Watercourse Phase 3 (2001-2003)

200 0 200

SCALE 1:6,000 METRES

REFERENCE

DEM from Geobas. Base data from the Province of British Columbia. Contours from TRIM positional data. Additional detailed site features provided by McElhanney. Projection: UTM Zone 10 Datum: NAD 83

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PROJECT

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TITLE

PROJECT COMPONENTS

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PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	KZ	2 Nov. 2016	SCALE AS SHOWN	REV. 0
GIS	JP	7 Mar. 2017		
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FIGURE 2

Path: Y:\Vancouver\Spatial Data\Project Data\BC\McNab\Figures\MXD\Surface Water\Annex9\Figure_2_Proposed_Project_Components.mxd

2.0 MANAGEMENT STRATEGY

Water on site will be managed through the following main mechanisms:

- Collection and infiltration;
- Runoff collection and conveyance through a system of ditches and valved culverts;
- Wash water recycling;
- Pit Lake Containment Berm and the McNab Creek Flood Protection Dyke; and
- The adaptive management strategy outlined in Section 8.0.

During the operational phase of the Project, the primary mechanism for water management at the Project site will involve the collection and infiltration of excess surface water. This approach is viable due to the high permeability of the surficial soils. The northern area of the Project Area will be graded such that runoff will be directed to the pit and away from salvaged soil stockpiles in the Soil Deposit Area, the Fines Storage Area, the McNab Creek Flood Protection Dyke and the pit lake Containment Berm. Surface run-off from the slope to the west of the Project Area (referred to as Western Slopes) will be collected in a ditch at the toe of the slope on the west side of the existing north/south access road. These flows will be conveyed to the pit through three culverts during the dry season (Figure 2). Within the Processing Area, runoff water will be collected in settling pond(s) which will be formed by the site grading. The majority of this water collected in this area is expected to infiltrate to groundwater. When excess stormwater is collected in this area, a backup stormwater management system will pump water from settling pond(s) into either the aggregate washing system (e.g., storage tanks) or the pit lake.

Project-related water use will be limited to a 95% efficient wash plant and emergency use for fire suppression. The wash plant will use approximately 110 litres per second (1,450 gpm), of which 106 litres (3,052,800 to 3,816,000 litres per day) will be recycled water supplied from two large storage tanks located in the processing area shown on Figure 2. The 5% loss (via retention, evaporation and absorption; 4 litres per second (50 gpm or 115,200 to 144,000 litres per day) will be supplemented with make-up water by a groundwater well (Figure 2). The recycled wash water will be processed, screened and pressed to remove the fines and silt. Fines and silt will be mechanically dried and deposited in the Fines Storage Area (Figure 2).

Figure 3 provides a depiction of the Project wash water cycle.

No point source discharges of surface water are proposed during construction and operations phases of the Project. After closure an outlet structure from the pit lake will be constructed and excess surface water will be permitted to discharge from the pit lake during high precipitation events. Controlled flows from a low level outlet valve may also be used to provide flows into the proposed fish offset habitat post-closure (see the Fish Habitat Offset Plan – Appendix C of the water license application). Water in the pit will be monitored and tested prior to controlled discharges as described in Section 4.1.3.3.

Aggregate Project Washwater Cycle

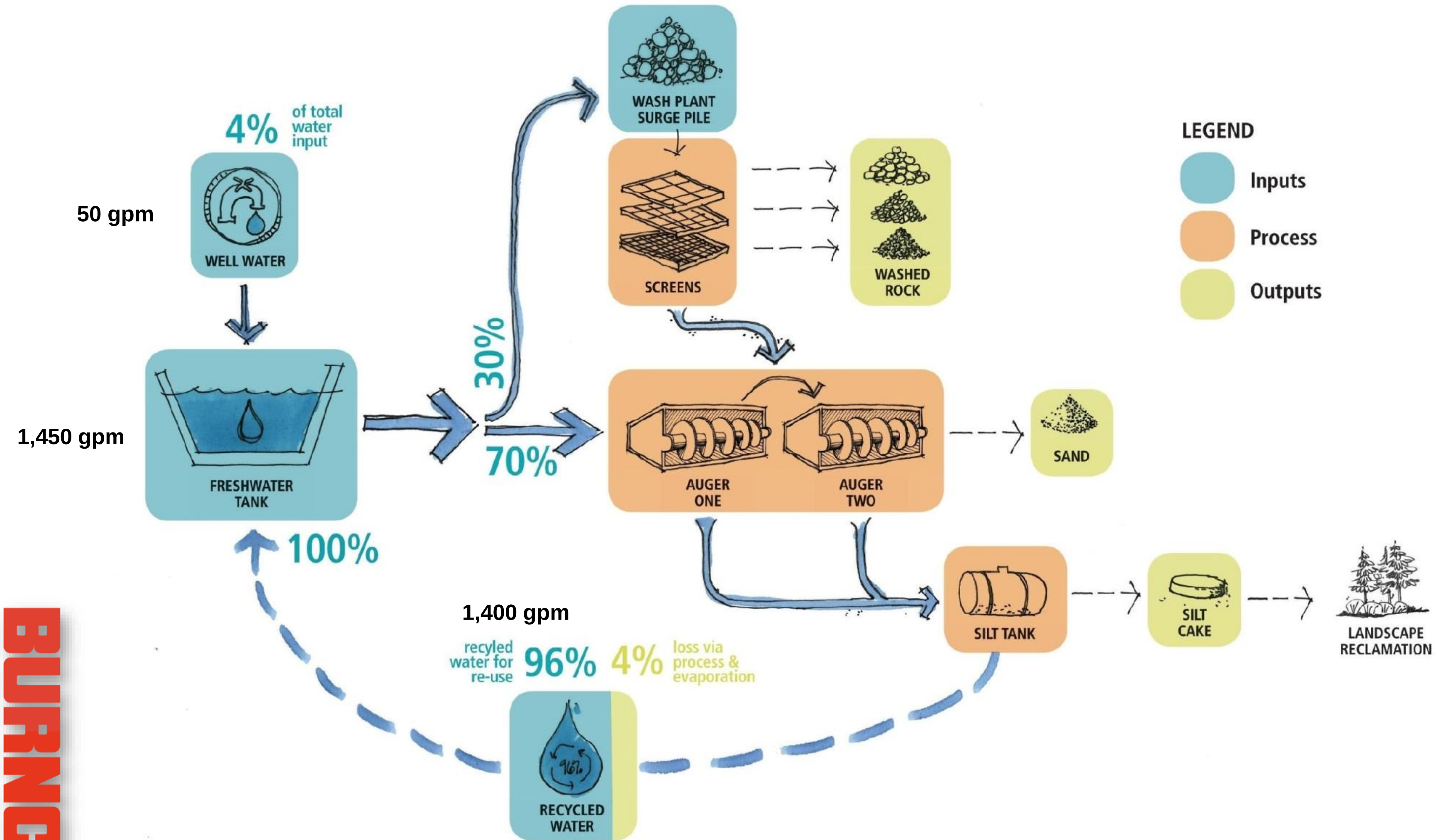


Figure 3: Wash Water Cycle

3.0 MITIGATION

The mitigation strategy outlines the mitigation measures, commitments and assurances outlined in the EAC Application/EIS. This section will be updated as necessary once the Conditions of the Project have been finalized. Additional mitigation measures related to the control and monitoring of erosion is outlined in the ESCP and those related to the monitoring of TSS are provided in the Fisheries Habitat Protection Mitigation Plan. Adaptive management measures to be implemented are discussed in Section 8.0.

3.1 Construction

Mitigation during construction that relate to surface water, groundwater, and aquatic resources have been laid out in the ESCP and the Fisheries Habitat Protection Mitigation Plan. No additional construction mitigation measures are suggested for water resources.

3.2 Operations

Mitigation measure to be carried out during operations of the Project are:

- 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 during operations. Water accumulating within the pit area would infiltrate into the ground 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 Processing Area storm water management system. Conveyor crossings of any watercourses will be designed and constructed to prevent runoff from the conveyors being discharged to watercourses.
- 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. Periodically the cakes will be moved to the Fines Storage Area. Fines cakes will also be used for progressive reclamation as possible. Further details are provided in the Reclamation and Effective Closure Plan and the Vegetation Management Plan.
- The design of the pit footprint was limited to the southern portion of the alluvial delta/fan (e.g., the current proposed extent of pit) so that while the pit is being developed and when it is fully developed the water loss from McNab Creek to the groundwater system would less than losses under the baseline conditions.
- During the operational phase of the Project, the amount of surface flow from the western slopes can be controlled to either increase or decrease the amount of surface flow reporting to the pit lake. By allowing more flow or less flow into the pit from the western slopes the operator can influence pit lake water levels. This will be achieved through the installation of flow control works on ditches and culverts (e.g., valves) at the toe of the western slope.

- Areas progressively reclaimed during the operational phase will be re-vegetated to minimize the exposure of fines to chemical dissolution and to control erosion. This is further detailed in the Reclamation and Effective Closure Plan and the Vegetation Management Plan.
- During the operational phase of the project, if water levels in the pit lake become higher than the design level, the culverts which drain the west slopes into the pit lake (Figure 7) will be blocked and the flows will be diverted to reduce the amount of water reporting to the pit.

3.3 Reclamation and Closure

An outlet structure will be constructed within the Pit Lake Containment Berm (see Figure 2) at closure at an elevation of about 5.0 m. This structure will allow water to be retained in the pit lake at the design water level. The analysis has indicated that the design water level will maintain baseflows in McNab Creek above baseline conditions. The outlet structure has been designed to be adjustable based on monitoring data collected and the trigger action response plan for maintaining baseflows in McNab Creek. Adaptive management may be undertaken which would involve altering the elevation of the crest of the outlet structure, either by raising or lowering it (e.g., adding or removing stop logs. It is anticipated that monitoring of the pit lake water levels and adjustments to the outflow elevation undertaken as part of adaptive management in the 2 to 3 years after closure will be sufficient to refine the program for the long term.

Additional details regarding reclamation activities are provided in the Reclamation and Effective Closure Plan.

4.0 MONITORING

The objectives of the monitoring program are to:

- Systematically collect data to evaluate whether or not potential Project-related changes in the aquatic environment may be occurring; and,
- Guide the development and implementation of effective adaptive management.

The monitoring program has been designed to include the following:

- Description of the approach for monitoring triggers;
- Summary of baseline monitoring information;
- Summary of predictions;
- Description of the monitoring strategy;
- Identification of sampling locations and frequency of sampling for each component;
- Description of the conceptual ecological model for aquatic resources;
- Define the trigger action response plan for each component;
- An overview of the proposed sampling methodology and data analysis for each of the study components;
- An overview of the quality assurance/quality control (QA/QC) procedures; and
- An overview of the adaptive management framework.

4.1.1 Approach to Monitoring Triggers

The water quantity and water quality effects assessments were based primarily on model evaluations of the Projects water balance and water quality. The models evaluated the potential effects of the Project on surface water flows, wetted areas, flow depths, and also potential effects on water quality in the receiving environment. The model results were used as the basis for the development of this WMP and are summarized in the sections below.

Each of the models were used to inform the effects assessments based on a number of inputs and assumptions, some of which were directly measured, some of which were interpreted, and some were the result of model calibration. There is a moderate level of confidence in the magnitude of the water quantity effects caused by the project, but a high level of confidence in the relative effects. These positive relative effects become less in the latter phases of mining. Therefore, the approach to address uncertainty in these later phases of mining is through real-time monitoring in the early phases of mining, and refinement and re-calibration of the model if necessary to provide an accurate predictive tool for the later phases of mining. Uncertainty in the later phases will be managed by erring on the side of positive effects to the McNab Creek baseflow compared to current conditions.

The hydrogeological model also provided input to the site water quality model. This model erred on the side of conservatism with respect to model inputs and assumptions such there is a high level of confidence that the actual water quality effects will be less than predicted.

The hydrogeological and site wide water quality models represent the current understanding of the Project site and provide useful indicators of environmental conditions that can be used to inform monitoring triggers. Monitoring triggers can be set at various times and locations throughout a system. These monitoring triggers will be used to confirm/refute model predictions. They may trigger an adjustment to future phases of the mine plan.

Monitoring triggers are proposed for each of the following components and are provided in the following sections:

- Water quantity – pit lake levels and hydraulic gradient;
- Water quantity – surface water levels in downstream watercourses;
- Surface water quality.

Mitigation strategies that will be applied, should the triggers be exceeded, are presented in Section 8.1.

4.1.2 Water Quantity

4.1.2.1 Summary of Baseline

The baseline study involved collection and review of regional historical climate and stream flow data, as well as local data. A detailed baseline study of the surface water system is provided in Appendix 5.5-A (provided in Appendix D of the Water license application) and summarized below.

Based on the BC Stream flow Inventory (Coulson and Obedkoff 1998), the 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 near the Project Area are shown on Figure 4. 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 hydrological characterization of the Project Area was also performed to derive the following McNab Creek stream flow baseline characteristics. Baseline flow characteristics included:

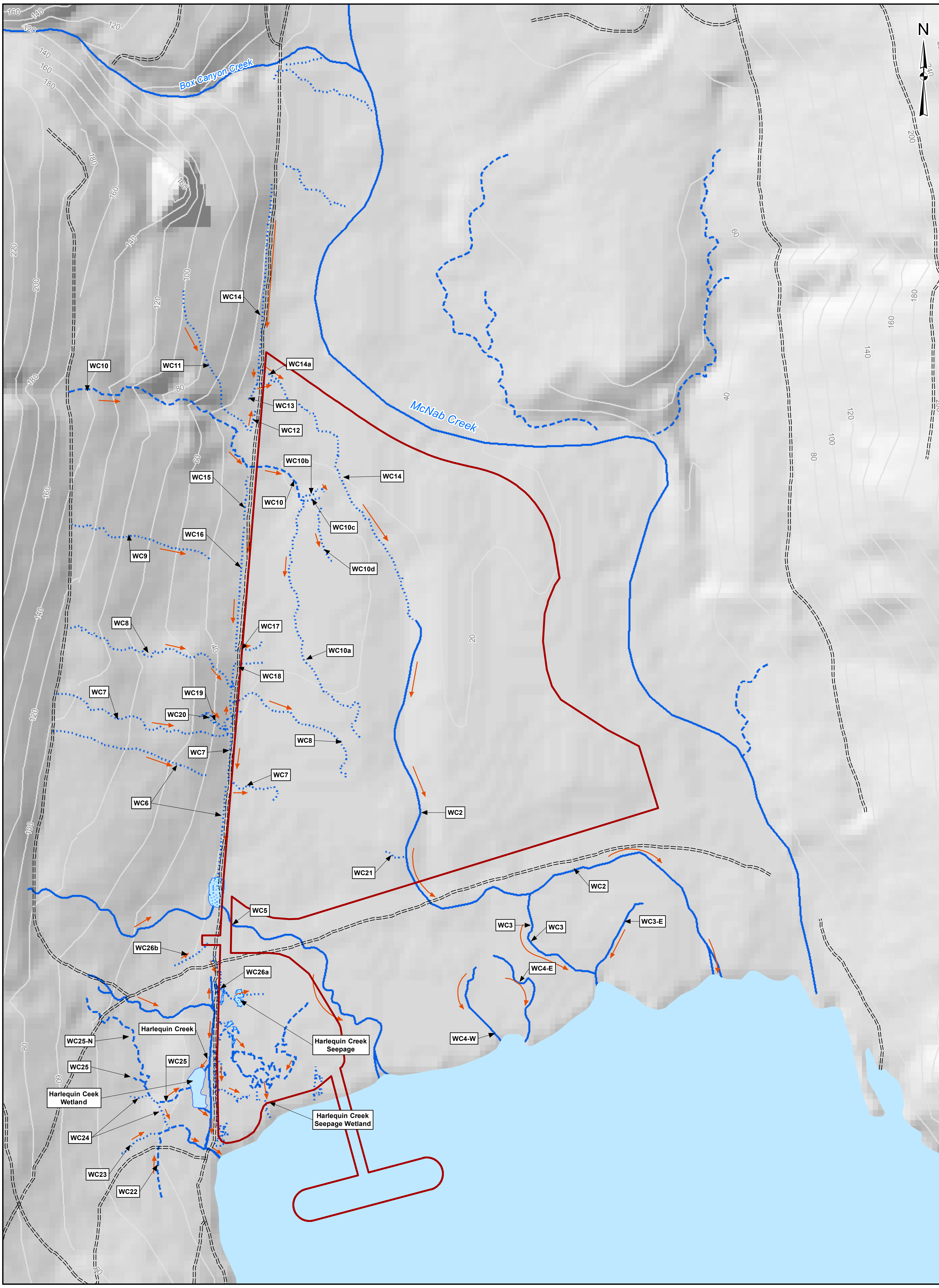
- McNab Creek mean annual and monthly flows;
- McNab Creek extreme low flow with a return period of 5 and 10-years. An additional extreme low flow analysis will also be completed based on data provided by Box Canyon at the request of FLNRO to better characterize the baseline and extreme low flow; and
- McNab Creek extreme high daily flow with a return period of 200 years.

No historical flow records for WC 2 were 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. Details regarding flows in WC 2 are presented in Table 2.

No historical records of flow in the Foreshore Minor Streams were identified. Characterization of flows in the foreshore minor streams was performed using results from the hydrogeological assessment presented in Appendix 5.6-A (provided in Appendix D of the Water license application). Details regarding flows in the Foreshore Minor Streams are presented in Table 2.

A Project Area climate characterization was also completed to support the hydrological analysis presented in Appendix 5.5-A (provided in Appendix D of the Water license application).

Surface water level data (until October 2014) was collected by automated pressure transducers and the resulting water level data converted to equivalent elevations using the staff gauges as datum. The resulting continuous elevation record for surface waters in both McNab Creek and WC 2 are summarized in Attachment C of Appendix 5.6-A. This data will be used in combination with the proposed additional sampling described in Section 4.1.2.3.2 during the monitoring program to support the trigger action response plan (Table 7).



LEGEND

- Project Area
- Low Lying Wetted Area
- Beaver Impounded Wetted Area
- Waterbody
- Road (Existing)
- Contour (20m)
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Ephemeral Watercourse
- Direction of Flow

200 0 200

SCALE 1:7,000 METRES

REFERENCE

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

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PROJECT

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

TITLE

WATERCOURSES

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PROJECT NO. 11-1422-0046			PHASE No.
DESIGN	DC	01 May 2015	SCALE AS SHOWN REV. 0
GIS	DL	10 Mar. 2016	FIGURE 4
CHECK			
REVIEW			

4.1.2.2 Summary of Predictions

The Project is anticipated to have an influence on the groundwater levels within the LSA. This would have the potential to alter baseflow and extreme low flows in McNab Creek and average flow rates in WC 2, and the Foreshore Minor Streams. The Project's potential effect on baseflow and extreme low flows was evaluated based on hydrogeological modelling results (Appendix 5.6-A (provided in Appendix D of the Water license application)), professional judgement and guidance received from representatives of regulatory agencies. Below is a summary of the methods used to determine the surface water flows in the affected watercourses. The results of these analyses are provided in Table 2.

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. The 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. 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.

In general, the following predictions were made based on the results of the assessment:

- There will be an increase in the local groundwater levels.
- There will be a flattening of the groundwater gradient between McNab Creek and the Project Area.
- There will be a reduction in the rate of flow from McNab Creek (i.e., seepage) to the groundwater system in the Project Area (e.g., a positive effect during periods of low flow in McNab Creek).
- The average flow rate in the lower segment of WC 2 will be reduced by 19% at closure when compared to the baseline conditions. Despite the reductions in flow, 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 Project.

Table 1: Annual Average Predictions for Pit Lake Elevations, McNab Creek Flow Loss and Change of McNab Creek Flow Loss from Current Conditions (Year 0)

Year	Pit Lake Elevation (m)	McNab Creek Loss (m^3/day)	% Change from Year 0
Year 0	n/a	17,800	n/a
Year 5	5.5	10,900	-39%
Year 10	4.5	12,500	-30%

Notes: Negative losses (e.g., -39% in year 5) indicated more flows in McNab Creek from current conditions

Table 2: Seasonal Average Predictions for Pit Lake Elevations, McNab Creek Flow Loss and Change of McNab Creek Flow Loss from Current Conditions (Year 0)

Year	End of Wet Season		End of Dry Season		
	McNab Creek Loss	Change From Year 0	Pit Lake Elevation	McNab Creek Loss	Change From Year 0
	m^3/day	%	m	m^3/day	%
Year 0	**16,200**	**-**	**n/a**	**18,500**	**-**
Year 1	6,600	-59%	4.4	13,000	-30%
Year 2	7,200	-56%	4.3	13,800	-25%
Year 3	8,100	-50%	4.3	13,400	-28%
Year 4	7,500	-54%	4.2	13,500	-27%
Year 5	7,500	-54%	4.2	13,800	-25%
Year 6	8,600	-47%	3.8	14,400	-22%
Year 7	9,700	-40%	3.7	15,000	-19%
Year 8	10,100	-38%	3.7	14,900	-19%
Year 9	9,600	-41%	3.8	14,500	-22%
Year 10	10,200	-37%	3.7	15,000	-19%

Notes: Negative losses (e.g., -30% in year 5) indicated more flows in McNab Creek from current conditions

4.1.2.3 Monitoring Strategy

Monitoring for groundwater levels and surface water levels and flow rates will be carried out throughout the life of the Project as presented Table 3. This monitoring will include the following:

- Monitoring of the surface water levels in the pit lake (trigger);
- Collection of the surface water levels in the downstream watercourses (trigger and supplemental baseline data);
- Monitoring surface water flow rates and surface water levels in McNab Creek upstream from the Project Area (monitoring/supplemental baseline data);
- Monitoring of the hydraulic gradient between McNab Creek and the pit lake; and
- Monitoring of groundwater levels in wells located both up-gradient and downgradient of the pit (Figure 7). This will include monitoring at existing wells which will be retained for as long as feasible based on phase of development shown in Table 3 and at additional newly constructed wells (monitoring/supplemental baseline data).

The objective of the water quantity monitoring is to confirm the result of the modelling (provided in Appendix D of the water license application) and the surface water analyses (Table 2) which will be periodically checked, new simulations undertaken particularly if triggers are exceeded as outlined in Section 4.1.2.3.2 or if consideration is being given to altering the mine plan.

The monitoring will be used to:

- Inform the trigger action response plan (e.g., compliance/effectiveness);
- Provide on-going monitoring data for input into the models (e.g., monitoring); and
- Supplement the previously collected baseline data (e.g., baseline).

Table 3: Groundwater and Surface Water Quantity Monitoring Locations and Reporting Schedule

Parameter	Station ID	Monitoring Type	Frequency	Duration	Reporting
Groundwater Levels[1]	MW05-01 MW05-02 MW05-05 DH10-01 DH10-02 DH10-05 DH10-06 DH10-07 DH17-01 DH17-02 DH17-03 DH17-04 DH17-05 DH17-06	Baseline	Continuous	Pre- construction and Construction (as possible – prior to disturbance)	Annually
	MW05-01 MW05-02 MW05-05 DH10-01 DH10-02 DH10-05 DH10-06 DH10-07	Compliance/ effectiveness	Continuous	Retain as long as feasible based on phase of development	Annually
	DH17-01 DH17-02 DH17-03 DH17-04 DH17-05 DH17-06	Compliance/ effectiveness	Continuous	Pre-construction and life of Project	Annually
Surface Water Flow	MC-US-01 (McNab Creek)	Baseline/monitoring	Continuous	Pre- construction and life of Project	Annually

[1] Groundwater level data collection will occur continuously pre-construction and through the lifetime of the Project and will be downloaded every 3 months.

Parameter	Station ID	Monitoring Type	Frequency	Duration	Reporting
Surface Water Levels[2]	MCF-15 (WC 2) MCF-6 (WC 2) MC-US (McNab Creek) MC-DS (McNab Creek)	Baseline	Continuous	Pre- construction and Construction (prior to disturbance)	Annually
	MCF-15 (WC2) MCF-14 (WC 2 Extension) MCF-6 (WC 2) MCF-12 (WC5) MC-US McNab Creek) MC-DS (McNab Creek)	Compliance/ effectiveness/ monitoring	Continuous	Construction (post disturbance) to life of Project	Annually
	MCF-16 (pit lake)	Compliance/ effectiveness	Continuous	Operations through the life of Project and post-closure s	Annually

4.1.2.3.1 Pit Lake Water Levels and Groundwater Gradient

As the pit lake expands to the north during operations, the hydraulic gradient within the groundwater will start to trend towards the baseline conditions (Table 2). The rate of loss of flow from McNab Creek to the groundwater system is proportional to the hydraulic gradient in the groundwater between McNab Creek and the Project Area. This hydraulic gradient is essentially the difference between the water level in McNab Creek and that in the pit lake divided by the distance between these two points. Continuous water level will be undertaken in the Pit Lake and McNab Creek. These data will be supplemented by water level measurements in wells located in the active mining area, which will be retained for as long as possible (e.g., well DH10-02 will be retained until Phase 7 and well DH10-07 which will be retained until year/phase 3) and replaced at a location outside the active mining area and by additional wells located outside the active mining area.

This data will be used to confirm/refute the model predictions (provided in Appendix 5.6-A, provided in Appendix D of the water license application) that will be periodically checked and additional simulations may be undertaken, if the monitoring results in a trigger being met (see Table 6 and Table 5). If the hydrogeological model is revised than it will used as a predictive tool to assess the relative effects future phases of the project on water quantity compared to the current conditions. If it is found that the effects are greater than the current conditions, then adaptive management such as adjustment of the future mine plan will be undertaken.

[2] Surface water level data collection will occur continuously pre-construction and through the lifetime of the Project and will be downloaded every 3 months.

4.1.2.3.2 Downstream Surface Water Levels

Surface water levels will be monitored in:

- WC 2 (MCF-6, MCF-15);
- the WC 2 Extension (MCF-14); and
- WC 5 (MCF-12).

As indicated in Table 3 several monitoring sites will be used to augment previously collected baseline data or establish baseline conditions in locations where data has not been collected. In locations where new monitoring sites are being established to collect baseline data (MCF-6, MCF-12 and MCF-15), it is anticipated that baseline data will be collected over a period of at least one year prior to Project activities having the potential to influence surface water levels.

Surface flows will also be monitored at the upstream site in McNab Creek (MC-US-01). It is not anticipated that the McNab Creek flow data recorded upstream from the site will be used directly to evaluate the potential effects of the project but these data will serve to improve the understanding of the overall system.

4.1.2.4 Trigger Action Response

4.1.2.4.1 Pit Lake Water Levels and Groundwater Gradient

A two-fold trigger action response plan is proposed:

- The pit lake water levels will be monitored and compared to dry season predicted levels in Table 6; and
- The hydraulic gradient will be monitored and compared to the triggers presented in Table 5.

In the event that the water level in the pit lake is lower than the trigger level or the hydraulic gradient is higher than the trigger level, an action response plan will be initiated. Firstly this will involve confirmation of that the data did indeed constitute a trigger. If values are confirmed then additional water actions could include review of water levels in the groundwater monitoring wells, McNab Creek and downstream creeks (described below), and atmospheric data. The source of the trigger will be assessed (e.g., natural causes [e.g., such as periods of drought, extreme precipitation, etc.] or the Project). The numerical hydrogeological model will be re-simulated using measured data (including atmospheric data) to assess the rate of loss of flows from McNab Creek to the Project Area and compare those values to losses that would occur under current conditions. If the revised model predictions deviate from the original predictions, adaptive management will be implemented (described in Section 3.4).

The objective related to the monitoring of water quantity triggers is to validate model predictions as outlined in Table 4.

Table 4: Components of the Water Quantity Monitoring Program

Component	Description
Objective	Confirm the result of the modelling (Appendix 5.6-A provided in Appendix D of the Water license application) and the analysis (Table 2).
Description	Water levels will be monitored in the groundwater and surface water to refine and re-calibrate the model, if necessary.
Comparison Criteria	Trend towards baseline conditions on McNab Creek. See trigger response threshold in Table 5, Table 6 and Table 7.
Location	See Table 3
Duration	Baseline prior to construction and throughout the life of the Project.
Methods	Transducers installed in monitoring wells and surface water
Sample area	The Project Area as well as groundwater inputs to the north and west to capture the groundwater flows from McNab Creek
Parameters	Groundwater and surface water levels
Sensitivity/accuracy	TBD
Sample No.	Continuous record at a 15 minute interval with direct field measurements taken every 3 months
Frequency	Data will be downloaded every 3 months.
Timing	Pre-construction, construction, operations, closure and post closure
Measure Constraints	TBD
Analytical test	Comparison of the pit lake water levels and groundwater levels to those predicted. Comparison of the average depth in the WC 2, WC 2 Extension and WC 5 to the average depth during baseline conditions.

Trigger levels for water quantity have been set relative to either A) the baseline monitoring results or B) the model predictions corresponding to the relevant operational phase of the Project. Monitoring results which indicate a lower than predicted rate of loss from McNab Creek to the groundwater system will not be considered a trigger as this would increase the flows in McNab Creek and would therefore be considered a positive effect on the system. The triggers represent our current understanding of the water balance at the site and the future conditions that are predicted to result in the downstream environment. To verify that water levels remain within these ranges, water level data will be collected continuously and compared to the trigger values outlined in Table 5, Table 6 and Table 7 to observe if values are trending within an acceptable range of the predicted results.

Table 5: Response Trigger for and Groundwater Gradient during Operations

Year	Phase	Unit (m/m)	Trigger	Response
0	n/a	n/a	Hydraulic gradient greater on average over a two week period	▪ For an single trigger: - Review water levels in monitoring wells and McNab Creek to confirm trigger value - Identify source or cause of the trigger exceedance, such as Project, periods of drought, extreme precipitation, etc. - Confirm trigger exceedance is the result of natural causes or the Project ▪ If confirmed: - Use numerical model to assess losses from McNab Creek from Project and compare to losses that would occur under current conditions - Implement adaptive management strategy ▪ If trigger is a result of natural causes - Continue to monitor for triggers
1	1	0.02		
2	2	0.022		
3	3	0.024		
4	4	0.025		
5	5	0.025		
6	6	0.026		
7	6	0.026		
8	7	0.026		
9	7	0.026		
10	7	0.025		

Table 6: Response Trigger for Pit Lake Water Levels during Operations

Year	Phase	Unit – pit lake Elevation (m)	Trigger	Response
0	n/a	n/a	Water level lower on average over a two week period	▪ For an single trigger: - Review water levels in monitoring wells and McNab Creek to confirm trigger value - Identify source or cause of the trigger exceedance, such as Project, periods of drought, extreme precipitation, etc. - Confirm trigger exceedance is the result of natural causes or the Project ▪ If confirmed: - Use numerical model to assess losses from McNab Creek from Project and compare to losses that would occur under current conditions - Implement adaptive management strategy ▪ If trigger is a result of natural causes - Continue to monitor for triggers
1	1	4.4		
2	2	4.3		
3	3	4.3		
4	4	4.2		
5	5	4.2		
6	6	3.8		
7	6	3.7		
8	7	3.7		
9	7	3.8		
10	7	3.7		

4.1.2.4.2 Downstream Surface Water Levels

Table 7: Response Trigger for Water Quantity – Surface Water Levels

Parameter	Phase	Unit	Trigger	Response
Surface Water Level in WC 2 and WC 5	Operations		A deviation from the predicted change exceeding 10% of the average annual flow depth at the monitoring site.	■ For an single trigger: - Review sampling and analytical methods. - Confirm values. ■ If confirmed: - Identify source or cause of the trigger value. - Implement adaptive management strategy (described in Section 8.1).

Notes: * baseline surface water levels program is described in Section 4.1.2.5.2.

4.1.2.5 Field Methods

4.1.2.5.1 Pit Lake Water Levels and Groundwater Gradient

Pit lake water levels and water levels in McNab Creek north of the project (near the location of MC-US) will be monitored using the field methods described below for the downstream surface water levels.

Monitoring Well Installation

Boreholes for monitoring wells will be drilled by a registered well driller who is classified as a geotechnical / environmental driller per the *Groundwater Protection Regulations*. Borehole locations will be hydro-excavated prior to drilling. Cuttings and/or the slurry from hydro vac operations will be placed in drums and stored on-Site pending disposal.

Wells will be installed at the stations identified in Table 3 to allow for the collection of groundwater samples and measurement of groundwater levels. The groundwater monitoring wells will be constructed of 51 mm diameter washed and wrapped Schedule 40 PVC pipe with 0.25 mm (0.010 inches) slotted screens. The annulus between the screen and borehole will be backfilled with clean silica sand to approximately 0.6 m above the screen to form a filter pack, while the annulus above the filter pack will be filled with bentonite chips to 0.3 m below ground surface (bgs). To protect the monitoring wells, cemented-in flush-mount well protectors or well risers to prevent access.

Groundwater Monitoring Well Development and Sampling

Following drilling and monitoring well installation, the newly-installed monitoring wells will be developed in order to remove the fine sediments and water that may have been affected by the drilling or well installation and to improve the hydraulic connection between the wells and the surrounding aquifer. The monitoring wells will be developed by purging and removing groundwater using 5/8 in. polyethylene tubing and a Waterra® brand foot valve. To prevent cross-contamination, each monitoring well was developed using dedicated high-density polyethylene (HDPE) tubing. Typically, at least six well volumes, and a maximum of 44 well volumes, will be removed from the monitoring wells and field parameters including electrical conductivity, pH, dissolved oxygen, and redox will be recorded during development. The well volumes removed will be determined based on obtaining stable field measurements and silt removal. Where six well volumes cannot be removed the well will be purged dry at least one time.

Where existing groundwater monitoring wells are found to be silty, they were redeveloped prior to sampling. In addition, based on observed condition existing wells will be redeveloped to improve the hydraulic connection and remove sediments that may have built up over time.

Groundwater levels will be monitored through the installation of individual pressure transducers with automated dataloggers in all proposed and existing monitoring wells (both shallow and deep) shown in Table 3. All devices will be programmed to record water pressures in a synchronized manner at a 15-minute interval.

Resulting water level data will be converted to equivalent elevations (as metres geodetic) using monitoring well collar elevations provided by a Registered BCLS.

Borehole logs, monitoring well construction details and groundwater monitoring well purge records, will be provided in the annual reports to FLNRO and other regulators as required.

4.1.2.5.2 Downstream Surface Water Levels

Surface water levels will be monitored at the stations outlined in Table 3. Station installation works included installation of pressure transducer probes inserted below the water surface to measure water level. Barologgers will be secured onsite to measure the atmospheric pressure to compensate for the total pressure readings recorded by the transducers installed below the water surface. The pressure transducers will be set to record at 15-minute intervals, and the barometric loggers will be set to record at hourly intervals.

Water level and atmospheric pressure records from the pressure transducers will be downloaded and checked every 3 months at which time the water surface will be measured relative to the local benchmark and any equipment maintenance will be performed. At MC-US-01 where the recorded water levels will be used to estimate flow rates, manual flow measurements and will be carried out on an annual interval using methodologies derived from Coulson (1991) to confirm and augment the existing stage-discharge rating curve. The frequency of manual flow rate measurements should be increased to two measurements per year if the recorded flow is found to disagree with the established rating curve.

4.1.2.6 Natural Factors that May affect Observations

At the time of writing this plan, several monitoring sites do not have an established baseline data record of water levels. The results of the baseline data collection and consideration of the specific physical conditions at each monitoring site will be required to provide meaningful response trigger values. As preliminary metric for a response trigger it has been proposed that of a deviation from the predicted value exceeding 10% of the annual average depth at the monitoring site be used. However, it is recommended that the response trigger values be reviewed and revised as appropriate in consultation with the regulator after the monitoring sites have been established and one year of baseline data has been collected.

4.1.3 Water Quality and Aquatic Health

Surface water quality and aquatic health were evaluated in the effects assessment as part of the EAC Application/EIS (Section 5.5). A summary of the indicators and exposure pathways are provided in Table 8.

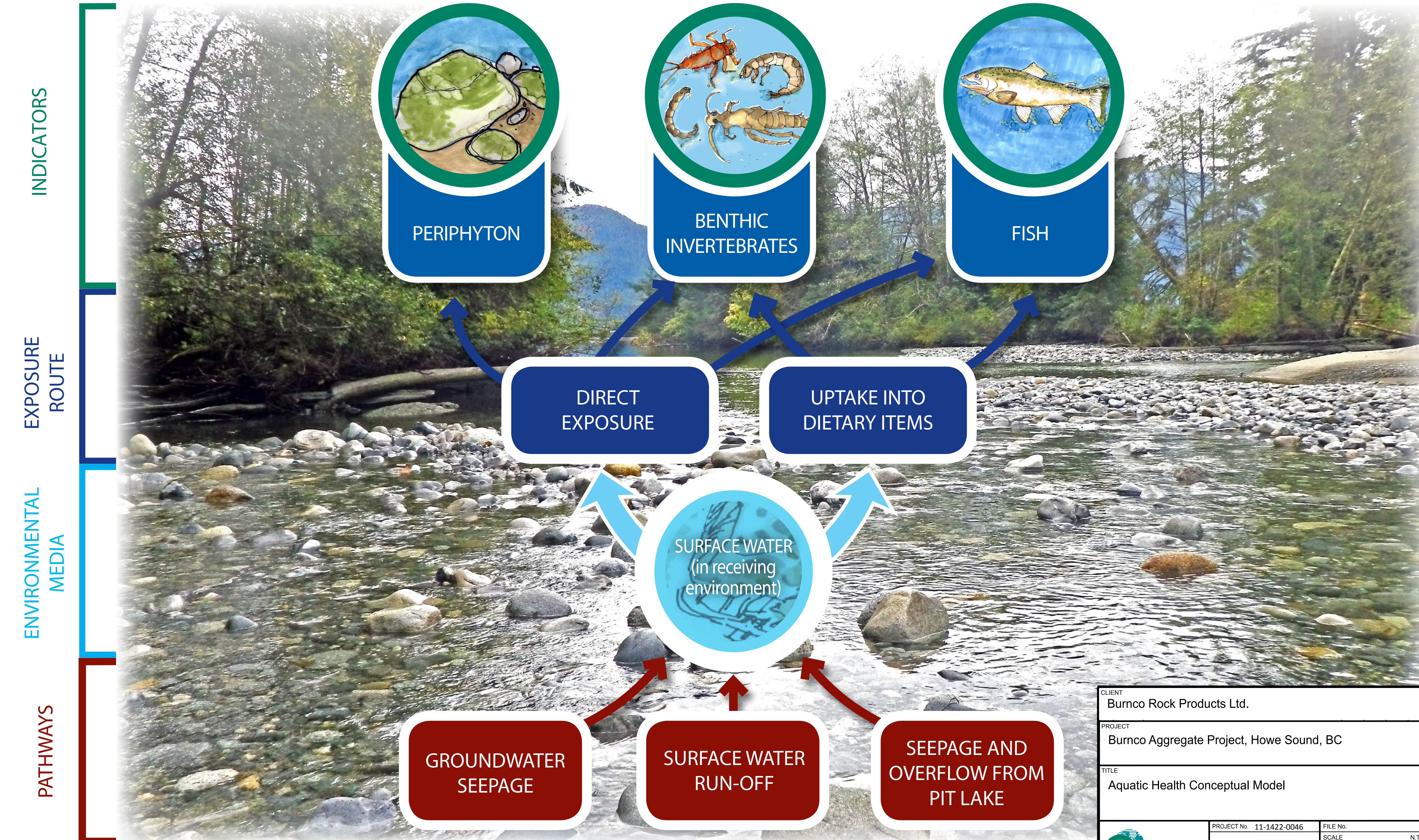
Table 8: Surface water and aquatic health indicators and exposure pathways

Valued Component	Indicator	Exposure Pathway
Surface water quality	Surface water quality	N/A
Aquatic Health	Periphyton	Direct contact with surface water
	Benthic Invertebrates	■ Direct contact with surface water ■ Ingestion of dietary items with elevated concentrations of some parameters
	Fish	■ Direct contact with surface water ■ Ingestion of dietary items with elevated concentrations of some parameters

Notes: N/A – not applicable

Figure 5 provides a diagrammatic representation of the relationships between the water quality parameters, exposure pathways, and aquatic health indicators. The stressors considered in this assessment are:

- potential for toxicity-related effects of some water quality parameters on aquatic life; and
- potential for nutrient enrichment related effects.



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

A summary of baseline information, predictions, adaptive management strategies, and monitoring for surface water quality, groundwater quality and aquatic health are provided in the sections below.

4.1.3.1 Summary of Baseline

4.1.3.1.1 Groundwater Quality

Based on the results of groundwater samples collected at the Project site, it was found that the local groundwater chemistry was influenced by the geographic location, depth from which the sample originates and lithology in which the wells are completed. The baseline groundwater quality was defined as either the median or 95 percentile of all groundwater samples. The 95 percentile concentrations were then compared to British Columbia Water Quality Guidelines (BCWQG) and the Canadian Council of Ministers of the Environment Environmental Quality Guidelines (CCME). It should be noted that dissolved metals were considered for groundwater quality. In this 95 percentile baseline the following parameters were found to have exceedances:

- Dissolved fluoride concentrations of 0.16 mg/l, exceeding the CCME guideline of 0.12mg/L.
- Dissolved aluminium concentration of 0.049 mg/L, exceeding the BCWQ guideline of 0.011 mg/l and exceeding the CCME hardness dependent guideline of 0.005 mg/L.

4.1.3.1.2 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[3]). 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 2017 and 2015) 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.

A detailed surface water quality baseline report is provided in Appendix 5.5-C (provided in Appendix D of the water license application).

[3] Harlequin Creek is hydraulically disconnected from the Proposed Project Area. No potential effects to this watercourse are anticipated therefore, monitored of this watercourse has not been proposed.

4.1.3.1.3 Aquatic Health

Baseline information for aquatic health indicators (fish, benthic invertebrates, and periphyton) are summarized below.

Fish

Fisheries and Freshwater Habitat assessments of the perennial, ephemeral and intermittent watercourses within or adjacent to the footprint of the Project components were undertaken (EAC Application, Volume 4, 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 Project Area. The fish sampling information collected included distribution, relative abundance and habitat use for fish species potentially affected by the Project.

The majority of the identified watercourses located on or near the Project Area 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 Project (Figure 4).

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 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 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 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.

Benthic Invertebrates

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

Periphyton were not sampled as part of the baseline benthic sampling program in 2013 but if the Project is initiated they will be sampled as part of the additional baseline program prior to construction (additional details provided in Section 4.1.3.3.2)

4.1.3.1.4 Additional Baseline Monitoring

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. Algal biomass data will also be collected at MCF-6 and MCF-12 downstream of the pit lake under baseline conditions prior to construction of the fish offset habitat (Figure 7). These data will represent baseline data in a future biological monitoring program should a program be initiated.

4.1.3.2 Summary of Predictions

Water quality predictions presented in Appendix 5.5-D (provided in Appendix D of the Water license application) were modelled during operations and at closure for the following assessment nodes located in the downstream receiving environment within the LSA (Figure 7):

- The pit lake
- Downstream receiving environment:

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

Two water quality model scenarios were developed for the Project, as described in Appendix 5.5-D (provided in Appendix D of the water license application).

- **Base Case:** Median baseline water quality inputs were used to estimate water quality at the four LSA receiving environment nodes; 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.

4.1.3.2.1 Pit Lake

During operations, a pit lake will form. Surficial overflow and groundwater seepage from the pit lake will report to the receiving environment. A direct surface connection between the receiving environment and the pit lake will only be constructed at closure when the offset habitat is connected to the pit lake. A direct surface connection between the pit lake and the receiving environment is not expected during operations given that the pit lake containment berm has been designed to contain extreme flood events.

Sources of the water quality in the pit lake are groundwater flow from McNab Creek, infiltration through the fines in the Fines Storage Area, groundwater flow from the west slope and surface water inflow from precipitation. Predicted concentrations when all sources of groundwater are under median conditions were compared to baseline, B.C. Water Quality Guidelines (BCWQG) and to CCME water quality guidelines.

All water quality parameters modelled were predicted to be less than baseline, BCWQG or CCME guidelines during operations. At closure, a direct surface connection between the receiving environment and the pit lake will be constructed. Water quality predictions at closure were modelled to determine the potential for pit lake water to be a considered a deleterious substance or cause pollution in the downstream receiving environment. Predicted concentrations of major ions, nutrients and trace metals in the pit lake water indicate that the lake water would not be considered a deleterious substance, and would be unlikely to cause pollution in the downstream receiving environment. In addition, predicted lake water quality met long-term BC and CCME WQGs indicative of chronic exposure.

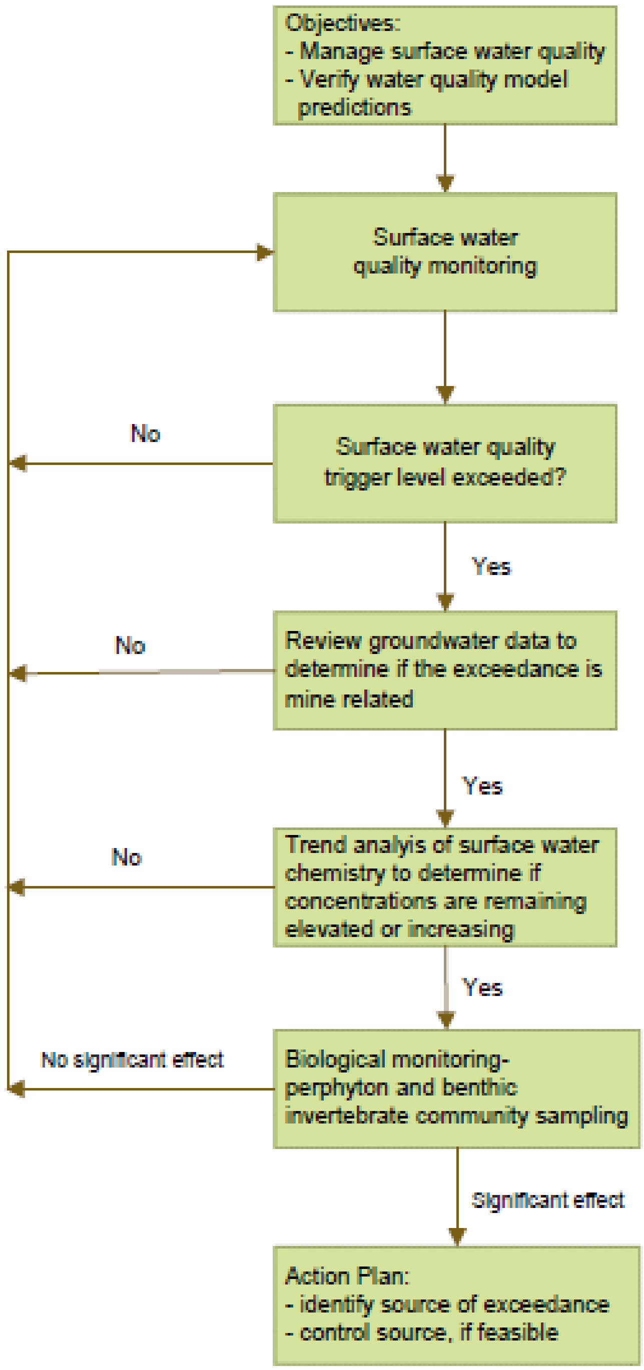
4.1.3.2.2 Downstream Receiving Environment

Predicted concentrations were 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; or were not distinguishable from background baseline conditions.

4.1.3.3 Monitoring Strategy

As outlined conceptually in Volume 3, Part E of the Environmental Assessment Certificate Application, the monitoring strategy will be implemented to verify the findings of the environmental impact assessment and determine the potential for adverse effects to aquatic life in the downstream receiving environment. Event based monitoring of suspended solids will be undertaken at specific times during construction and operations in accordance with the Fisheries Habitat Protection and Monitoring Plan and the ESCP. Additional recommendations for water quality monitoring in relation to the offset habitat to be constructed is provided in Appendix 5.1-B (provided in Appendix C of the Water license application).

Water quality data will be collected in the receiving environment as shown on Figure 7 and outlined in Table 9 and Table 10. Water quality data will be screened against available BC and CCME WQGs, and compared to the relevant baseline condition. The Surface Water Quality and Aquatic Health Response Framework outlined in Figure 6 will be applied and biological monitoring of aquatic resources according to the program described in Section 4.1.3.3.2 will be implemented as appropriate according to the trigger action response plan. To satisfy the trigger action response plan, on-going water quality sampling will also be conducted in the groundwater wells as shown in Table 10. This data will be used to determine the potential origin of a water quality trigger exceedance.



DRAFT

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

TITLE
FLOWCHART OF SURFACE WATER QUALITY AND AQUATIC HEALTH RESPONSE FRAMEWORK

Golder Associates

PROJECT No.	11-1422-0046		PHASE No.	
DESIGN	EI	7APR17	SCALE AS SHOWN	REV. A
CADD	ASD	7APR17	**FIGURE 6**	
CHECK				
REVIEW				

O:\Final\2011\1422\11-1422-0046\1114220046-669-R-RevA\Figs

The water quality monitoring program also includes sampling and toxicity testing of the pit lake at closure to determine if the pit lake water represents a deleterious substance as per the *Fisheries Act* or if release of this water to the receiving environment would constitute pollution as defined in the *Environmental Management Act* (EMA).

4.1.3.3.1 Water Quality Monitoring Program Design

The water quality monitoring program for the Project will include the collection of water samples for analytical chemistry and in situ water quality measurements as described in Table 9 and Table 10. The monitoring schedule will be refined in consultation with regulators and First Nations.

During construction and the first two years of operations, surface water quality monitoring effort will be focused on watercourses downstream of the Project Area and samples will be collected at:

- McNab Creek (MCF-1 and MCF-7);
- Downstream of the pit lake and within WC 2 (MCF-6 and MCF-15);
- Downstream of the pit lake in WC 5 (MCF-12); and
- Downstream of the pit lake within the new fish offset habitat (MCF-14).

After two years of operational sampling, the frequency will be re-evaluated in consultation with regulators and First Nations MoE and other regulatory agencies.

At closure and as required prior to a release event during post-closure, pit lake water samples will be collected from MCF-13 and analyzed for a suite of parameters to characterize water quality. Toxicity testing will also be undertaken at closure and as required prior to release into the downstream environment. Acute toxicity testing with rainbow trout is proposed to determine if pit lake water would be considered a deleterious substance as per the federal *Fisheries Act.* (96 hr. acute rainbow trout LC50 test). An additional 48 hr. acute *Daphnia* (water flea) LC50 test will also be undertaken to determine if the pit lake water would be acutely lethal to aquatic invertebrates.

The following chronic tests are also recommended to confirm that release from the pit lake to the offset habitat would not result in long-term chronic effects to fish or invertebrates:

- 7 day chronic fish swim up test (survival and growth endpoints); and
- 7 day chronic *Ceriodaphnia* test (survival and reproduction endpoints).

Table 9: Surface Water Quality Monitoring and Reporting Schedule

Parameter	Station ID	Monitoring Type	Frequency	Duration	Reporting
Surface Water Quality	MCF-1 (McNab Creek)	Baseline and Compliance/ effectiveness	Quarterly	Prior to construction and life of Project	Annually
	MCF-6 (WC 2) MCF-12 (WC 5) MCF-14 (extension/offset) MCF-15 (WC 2)	Baseline and Response	Monthly or Quarterly	Monthly during Year 1 and 2 of operations. Monthly or quarterly prior to construction and for the remainder of the life of Project. Frequency will determined based on a review of the data from Year 1 and 2.	Annually
	MCF-7 (McNab Creek)	Baseline and Response	Quarterly	Prior to construction and life of Project	Annually
	MCF-13 (pit lake)	Compliance/ effectiveness	Once at closure and then as required prior to discharge into receiving environment.	Water chemistry and toxicity testing at closure and then as necessary prior to discharge into receiving environment	Once at closure and then as required prior to discharge into receiving environment.

Table 10: Groundwater Quality Monitoring and Reporting Schedule

Parameter	Station ID	Monitoring Type	Frequency	Duration	Reporting
Groundwater Quality	MW05-01 DH10-01 DH10-02 DH10-07 MW05-02 DH10-05 DH10-06 MW05-05 DH17-01 DH17-02 DH17-03 DH17-04 DH17-05 DH17-06	Baseline and Response	As required based on trigger action response plan	Life of Project	As required based on trigger action response plan.

Notes: Monitoring wells located both up-stream (north), down-stream (south) and east of the open pit. This will include existing wells that will not be removed as part of the aggregate extraction and additional wells installed to monitor groundwater levels during operations; and additional monitoring wells installed at the bottom of the east facing slopes to monitor water quality inputs from the west.

Table 11: Components of the Water Quality Monitoring Program

Component	Description
Objective	To verify that actual Project-related changes in water quality in the downstream receiving environment are consistent with the findings of the surface water quality and aquatic health assessment that was based on modelled water quality predictions.
Description	A suite of surface water quality parameters will be measured at representative stations in the downstream receiving environment and in pit lake water.
Comparison Criteria	Parameter concentrations will be compared to available BC MoE and CCME short and long term WQGs protective of aquatic life. Concentrations will also be compared to the baseline condition plus 20%. The baseline condition will be updated with supplementary water quality data collected prior to construction.
Location	Receiving Environment: McNab Creek, WC 2, WC 5, new fish offset, and the pit lake water (only at closure and as required during post-closure; see Table 3).
Duration	Supplementary baseline data for the receiving environment: Prior to construction. Receiving environment: Throughout the life of the Project. Pit lake water: At closure and as required during post-closure.
Methods	Surface water samples will be collected in accordance with procedures described in the British Columbia Field Sampling Manual 2013 (BC MoE 2013). Samples will be sent for analysis to an analytical laboratory accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA).
Sample area	Receiving environment (see Table 9 and Figure 6) and pit lake.
Parameters	In situ water quality, conventional parameters, total suspended and dissolved solids, major ions, nutrients, organic carbon, and total and dissolved metals.
Sensitivity/accuracy	Varies by parameter
Sample No.	One sample per location. A field replicate sample will also be collected at one location during each sampling event.
Frequency	Monthly during the first two years of operations at MCF-6, MCF-12, MCF-14, and MCF-15. Sampling frequency will be re-evaluated following a review of water quality data collected during the first two years of operations. Quarterly at sampling locations in McNab Creek. The pit lake water will be sampled once at closure and then as required.
Timing	N/A
Measure Constraints	N/A
Data Analysis	Monthly or quarterly concentrations of water quality parameters will undergo a quality assurance/quality control evaluation (see Section6.1), be screened against available BC and CCME WQGs, and compared to the relevant baseline condition. As part of the trigger action response plan described in Section 4.1.3.3.2, trend analysis will be undertaken to identify if concentrations of a flagged parameter are consistently increasing over time.

4.1.3.3.2 Trigger Action Response

The objective related to the monitoring of water quality triggers is to validate model predictions and determine the potential for adverse effects to aquatic life in the downstream receiving environment as outlined in Table 11 and to understand the cause and implications as described in Table 12.

Surface water quality data will be screened against short and long-term water quality guidelines for the protection of aquatic life from BC MOE (BC MOE 2016) and CCME (CCME 1999). Surface water concentrations will also be compared to background baseline concentrations. Observed increases in contaminant concentrations in environmental media do not necessarily represent adverse effects and may not, in themselves, warrant additional adaptive management actions.

The response plan outlined in Table 12 will be triggered if changes in surface water quality are identified in the monitoring results.Trigger levels for surface water quality are set at:

- Concentration(s) of one or more parameters above 80% of a BC or CCME WQG and greater than 20% over baseline concentrations.
- Concentration(s) of one or more parameters where the baseline condition was already above the WQG and increased to greater than 20% over the baseline concentration.

The surface water triggers, responses, and the response plan framework are provided in Table 12 and Figure 6.

Table 12: Response Trigger for Water Quality

<table>
<tr><th>Parameter</th><th>Trigger</th><th>Response within the Response Framework shown in Figure 6</th></tr>
<tr><td>Water quality parameters with available BC or CCME WQGs where the baseline condition is below these guidelines</td><td>Within 80% of the guideline and greater than 20% over baseline concentrations</td><td rowspan="4">■ Review sampling and analytical methods
■ Review groundwater quality monitoring data to determine potential origin of exceedance
■ Increase sampling frequency to monthly if current sampling frequency is being conducted quarterly
■ Trend analysis
■ If an increasing trend is determined:
- Identify source or cause of the trigger exceedance.
- Monitoring of periphyton biomass and benthic invertebrate communities to determine potential effects to these aquatic health indicators.</td></tr>
<tr><td>Water quality parameters with available BC or CCME WQGs where the baseline condition is already above these guidelines</td><td>Greater than 20% over baseline concentrations</td></tr>
<tr><td>Water quality parameters with no available BC or CCME WQGs</td><td>Greater than 20% over baseline concentrations</td></tr>
<tr><td>Phosphorus</td><td>An increasing trend in phosphorus concentrations that indicates a potential shift in trophic status</td></tr>
</table>

4.1.3.3.3 Aquatic Resources Monitoring Program Design

Section in-progress

4.1.3.4 Overview of Monitoring Program Field Methods

4.1.3.4.1 Water Quality

Surface water quality 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 for analysis of physical tests (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 metals 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. All samples will be will be submitted to laboratory accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA), for analysis.

Chain of Custody forms and laboratory analytical reports will be provided in annual reports to the FLNRO and other regulators as required.

Groundwater quality samples will be collected from newly installed and selected existing wells following low flow sampling methods using a peristaltic pump and dedicated 1/4 in. diameter HDPE tubing. Field parameters to be collected include electrical conductivity, pH, dissolved oxygen and redox measured with an YSI 556 multi-parameter instrument and flow through cell until parameters stabilize prior to sampling. Groundwater samples will be collected in laboratory supplied bottles and filtered and preserved as required.

4.1.3.4.2 Aquatic Resources

Periphyton Biomass

Six replicate samples will be collected from each sampling location. For each replicate, the sampled substrate will be photographed and water depth and near-bottom velocities will be measured and recorded. Periphyton will be scraped from a specified area (18.1 cm^2 for all stations) of natural substrate using a clean scalpel blade and scrub brush, and transferred to a filtration unit with deionized water. A mixed cellulose ester filter membrane (0.45 µm) will be used in the filter apparatus and the water-periphyton mixture will be filtered through the membrane. The membrane should then be folded in half, placed in a sampling tube, and labelled. Chlorophyll can degrade rapidly when exposed to heat and light. Samples to be submitted for chlorophyll *a* analysis should be kept in the dark and frozen to minimize degradation. Samples are to be stored in the dark and shipped on ice to the analytical laboratory for analysis of chlorophyll *a*.

Benthic Invertebrate Community

Benthic invertebrate samples will be collected per the following methods:

- One invertebrate composite sample will be collected in riffle habitats according to CABIN protocols (Environment Canada 2012b)[4]. A kicknet (400-µm mesh) will be used to collect a single time-integrated

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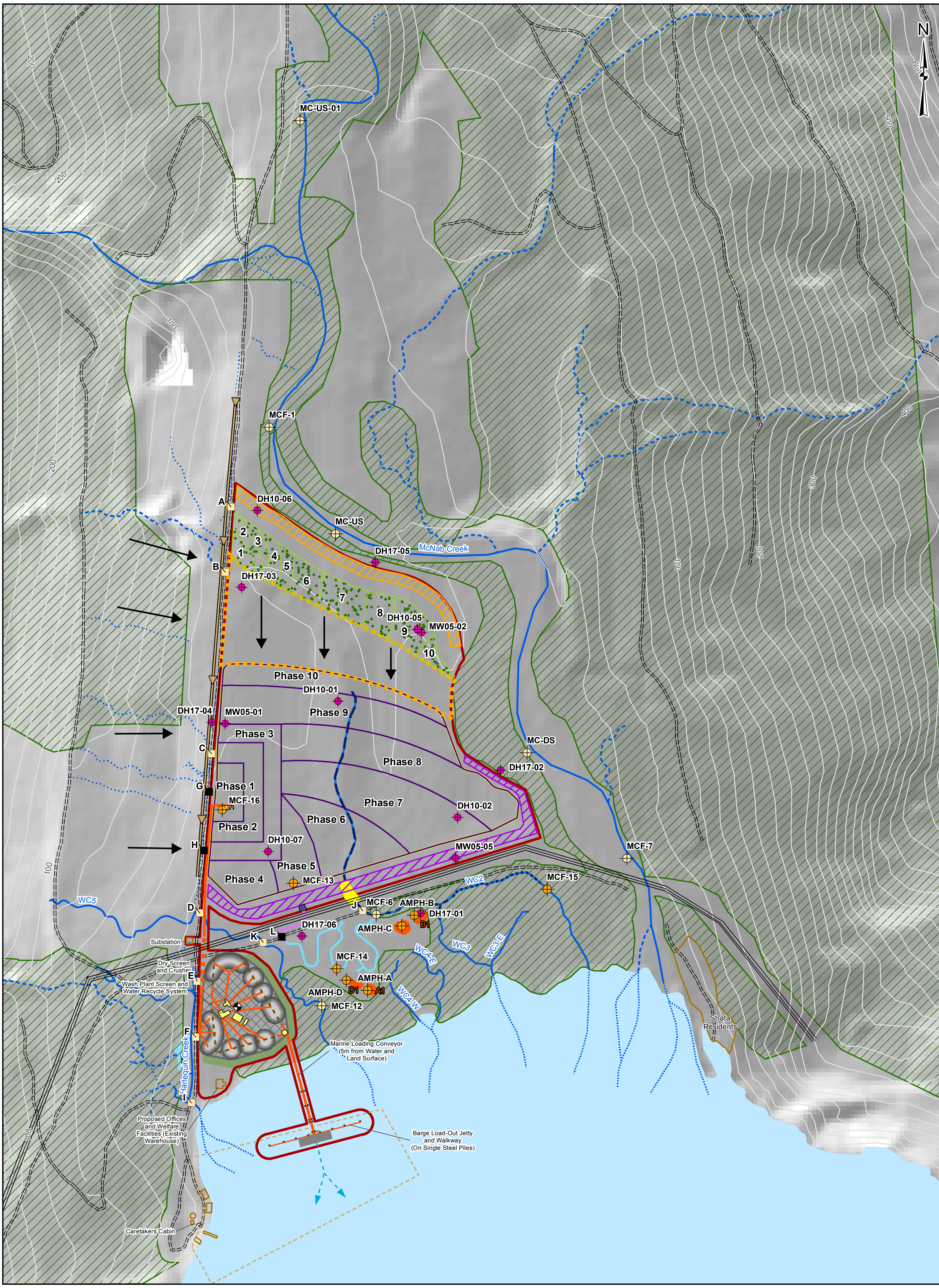
[4] The CABIN study design relies on the reference condition approach (RCA) to assess the benthic invertebrate communities in the region. The RCA compares benthic invertebrate assemblages at a series of stations within the zone of influence to a suitable reference condition given the particular characteristics of the test site. With this study design, replication occurs at the site level rather than the multiple replicates within a site typically used in traditional control/impact study designs (Bailey et al. 2004).

benthic invertebrate community sample from mainstream riffle habitat throughout each sampling station. The reach sampled will be traversed in a zigzag pattern from bank to bank in an upstream direction for a collection time of three minutes.

- The collected material and benthos will be washed into labelled containers using filtered site water and preserved with 10% phosphate-buffered formalin in a 1:3 ratio (formalin to sample). The samples will be submitted for taxonomic identification and enumeration to the lowest practical level (typically genus or species).

A habitat assessment will be conducted at each sampling location following CABIN field sampling protocols to measure field-based habitat variables (Environment Canada 2012b), including weather conditions, general site description, reach data (including habitat type, canopy coverage, macrophyte coverage, periphyton coverage, and vegetation types), channel characteristics (including stream order, water clarity, and channel gradient, width, depth, and velocity), substrate characteristics (including composition of stream bed material, surrounding material and embeddedness), disturbance indicators, surrounding land use, and erosion potential. GIS-based landscape-scale habitat variables will be provided by the BC MOE, including watershed area, stream length, stream order, percent lakes, percent rivers, percent wetlands, percent ice, slope, and site elevation. VAFS on dried tissues, and percent moisture if sufficient tissue volume is available.



LEGEND

PROJECT COMPONENTS

- Project Area
- Proposed Aggregate Pit Phases
- McNab Creek Flood Protection Dyke
- Pit Lake Containment Berm
- Soil Deposit Area (Salvaged Soil Stockpiles)
- Fines Storage Area
- Processing Area
- Non-Contact Water Diversion Ditch
- Elevated Conveyor
- Underground Conveyor
- Below Pile Conveyor
- Barge Route
- Proposed Groundwater Use Well
- Proposed Culvert
- Existing Culvert
- Existing Feature
- Chanel Infill (WC 2 Plug) Riprap and Filter Zone
- WC 2 Extension - Year 1 Construction
- WC 2 Extension - Closure Construction
- Outlet Structure with Spillway and Low-level Outlet
- Final Pit Lake Boundary
- Amphibian Compensation Pond
- Product Stockpiles
- Possible Processing Infrastructure Configuration
- Processing Area Berm

BASEMAP DATA (TRIM / McElhanney)

- Mature Forest
- Existing Road
- Existing Log Tenure Area
- Existing Transmission Lines
- Contour (20m)
- Permanent /Perennial Watercourse
- Intermittent Watercourse
- Intertidal Watercourse
- Ephemeral Watercourse
- Constructed Watercourse Phase 1 (1985)
- Constructed Watercourse Phase 2 (1996)
- Constructed Watercourse Phase 3 (2001-2003)
- Direction of Flow / Runoff

Monitoring Locations

- Proposed Surface Water Monitoring Location
- Surface Water Monitoring Location
- Goundwater Monitoring Well

DRAFT

300 0 300

SCALE 1:9,000 METRES

REFERENCE

DEM from Geobas. Base data from the Province of British Columbia. Contours from TRIM positional data. Additional detailed site features provided by McElhanney. Projection: UTM Zone 10 Datum: NAD 83

PROJECT

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

TITLE

WATER MANAGEMENT MONITORING PLAN

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	KZ	2 Nov. 2016	SCALE AS SHOWN	REV. 0
GIS	JP	21 Feb. 2017		
CHECK				
REVIEW				

FIGURE 7

Path: Y:\Vancouver\Spatial Data\Project Data\BC\McNab\Figures\MXD\Surface Water\Annex9\Figure_7_Water_Management_Monitoring_plan2.mxd

5.0 GROUNDWATER WELL DECOMMISSIONING

Monitoring wells will be located both upstream and downstream of the pit and include existing wells which will be retained for as long as feasible based on phase of development shown in Table 13. New groundwater monitoring wells will also be constructed to support the groundwater monitoring program. The groundwater usage well will be decommissioned during reclamation and closure activities and will be permitted under a separate licence. The remaining groundwater monitoring wells will be retained as necessary for the groundwater monitoring program and decommissioned once no longer needed. The decommissioning of all groundwater wells will follow the Part 9 – Well Deactivation and Decommissioning of the *Groundwater Protection Regulations.*

Table 13: Groundwater Well Decommissioning

Well ID	Decommissioning Year
MW05-01	Year 3 of Operations (Phase 3)
MW05-02	Year 9 of Operations (Phase 7)
MW05-05	Year 1 to 2 of Construction (e.g., once the pit lake Containment Berm is constructed)
DH10-01	Year 9 of Operations (Phase 7)
DH10-02	Year 7 of Operations (Phase 6)
DH10-05	Year 9 of Operations (Phase 7)
DH10-06	Year 1 to 2 of Construction (e.g., once the McNab Creek Containment Berm is constructed)
DH10-07	Year 3 of Operations (Phase 3)
Groundwater Usage Well	Year 1 or 2 of Reclamation and Closure
All other wells	As necessary for the groundwater monitoring program

6.0 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The water monitoring program will incorporate a quality assurance/quality control (QA/QC) program. QA includes a range of management and technical practices designed to assure that the delivered product is suitable for the intended use (BC MoE 2013). QC includes collection of data to assess data quality, statistical assessment of data quality, and remedial measures taken when the objectives were not realized (BC MoE 2013).

6.1 Quality Assurance

Quality assurance protocols will be diligently followed so data are of known, acceptable, and defensible quality. There are three areas of internal and external management, which are outlined in more detail below.

6.1.1 Field

Samples will be collected by the experienced crews, by trained field staff proficient in standardized field surface, aquatic and groundwater sampling procedures, to help minimize investigator bias among stations. The procedures will be consistent with standard methods (e.g., Environment Canada 1993), which refer to standard sample collection, preservation, handling, storage, and shipping protocols. They also will provide specific guidelines for field record keeping and sample tracking. Sampling staff will also use specific work instructions (SWIs), which are standardized documents that detail specific sampling instructions, equipment needs and operational requirements, required technical procedures, sample labelling and shipping protocols, laboratory contacts, and estimated time required to complete the specified field work.

Water samples will be collected in laboratory-supplied, certified-clean bottles. Water quality meters will be maintained and tested daily, and calibrated as per manufacturer's instructions. Reusable equipment will be decontaminated between sites. Care will be taken to minimize the introduction of foreign material into the samples or loss of material of interest from the samples prior to analysis. Field notes will be maintained to document the field sampling program, including date and location of sample, sampler's initials, and method of sample collection. Each sample will be labelled with a unique identifier and the date sampled. Chain-of-custody forms will be updated as samples are collected, and will be checked to verify the information recorded before samples are submitted.

6.1.2 Laboratory

Chemistry samples will be submitted to a laboratory accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for the parameters for which analysis is requested. Standard QA practices employed by the laboratory will consist of the following:

- Sample tracking from receipt at the lab through to final reporting;
- Calibration of measuring and testing equipment using established procedures;
- Documentation of test methods and support procedures to ensure consistency of application, repeatability of test results and traceability of analyses;

- Relation checks to highlight anomalous relationships between test parameters;
- Data validation through several reviews prior to release of final reports;
- Method validation to confirm the test method used is the latest version of published standard methods and is fit for the intended use; and
- Experimental and statistical procedures to establish method detection limits (MDL) and limits of reporting (LOR).

Taxonomy samples will be submitted to a taxonomist certified by the Society for Freshwater Science (SFS). Standard QA practices employed by the laboratory will include the following:

- Sample tracking from receipt at the lab through to final reporting;
- Check that samples were delivered with appropriate preservative; and
- Documentation of test methods and support procedures to ensure consistency of application.

6.1.3 Desktop

Sample receipts and analytical reports provided by the lab will be checked for errors (e.g., sample names entered incorrectly, samples not analyzed for all requested compounds). Analytical reports will also be reviewed to confirm that laboratory objectives had been met and the appropriate QA information reported. If necessary, the laboratory will be contacted to make corrections. Throughout data preparation and analysis, data tables, calculated values, and statistical analyses will undergo internal review to identify potential errors and make corrections as necessary.

6.2 Quality Control

6.2.1 Pit Lake Water Levels and Groundwater Gradient

Section in-progress

6.2.2 Downstream Surface Water Levels

The QC program for the surface water level monitoring stations will include the regular confirmation of recorded water levels using observations of water surface elevations on a staff gauge established at each monitoring site. Deviation between water levels recorded using the pressure transducers and those observed on the staff gauge will be investigated by:

- Verifying the datum of the staff gauge using a secondary monument established nearby;
- Checking the water level record from the pressure transducer for an obvious shift in the monitoring station; and
- Correcting the error either through correcting the datum on the staff gauge or on the transducer.

At the hydrometric monitoring station located on McNab Creek (MC-US-01) water levels recorded using the pressure transducer will be compared to the concurrent water level observations made on the staff gauge. The methodology for the reconciliation of deviations between the recorded and observed values will be the same as described for the water level monitoring stations. In addition a manual flow measurement will be carried out each year to confirm and augment the station stage-discharge rating curve. If the manual flow measurement is inconsistent with the stage discharge curve additional manual flow measurements will be carried out as required to reconcile deviation and identify any shifts or changes in the rating curve.

6.2.3 Groundwater Quality

The QC component of groundwater monitoring will consist of applicable field and sample handling procedures, and the preparation and submission of two types of QC samples to the various laboratories involved in the program. The QC samples include blanks (e.g., travel, field, equipment) and duplicate/split samples.

Sample bottle preparation, field measurement and sampling handling QC procedures include the following:

- Sample bottles will be kept in a clean environment, capped at all times, and stored in clean shipping containers. Samplers will keep their hands clean, wear gloves, and refrain from eating or smoking while sampling.
- Where sampling equipment must be reused at multiple sampling locations, sampling equipment will be cleaned appropriately between locations.
- pH, and specific conductivity will be measured in the field using hand held meters (e.g., YSI water quality sondes).
- Samples will be cooled to between 4 degrees Celsius (°C) and 10°C as soon as possible after collection. Care will be taken in when packaging samples for transport to the laboratory to maintain the appropriate temperature (between 4°C and 10°C) and minimize the possibility of rupture. Where appropriate, samples will be treated with preservatives to minimize physical, chemical, biological processes that may alter the chemistry of the sample between sample collection and analysis.
- Samples will be shipped to the laboratory as soon as reasonably possible to minimize sample hold times. If for any reason, samples do not reach the laboratory within the maximum sample hold time for individual parameters, the results of the specific parameters will be qualified, or the samples will not be analysed for the specific parameters.
- Chain of custody sample submission forms will be completed by field sampling staff and will be submitted with the samples to the laboratory.
- Only staff with the appropriate training in the applicable sampling techniques will conduct water sampling.

Quality control procedures implemented as part of the Groundwater Monitoring Program will consist of the preparation and submission of QA/QC samples, such as field blanks, trip blanks, and split/duplicate water samples. These are defined as follows:

- Field Blank: A sample will be prepared in the field using laboratory-provided deionized water to fill a set of sample containers, which will then be submitted to the laboratory for the same analysis as the field water samples. Field blanks will be used to detect potential sample contamination during collection, shipping and analysis.
- Travel Blank: A sample will be prepared and preserved at the analytical laboratory prior to the sampling trip using laboratory-provided deionized water. The sample will remain unopened throughout the duration of the sampling trip. Travel blanks will be used to detect potential sample contamination during transport and storage.
- Duplicate Sample: Two samples will be collected from one port using identical sampling procedures. They will be labelled, preserved individually and submitted for identical analyses. Duplicate samples will be used to assess variability in water quality at the sampling site. Duplicate will be collected and submitted for analyses at approximately, 10% of sampling locations. For smaller batches of samples (less than 10), at least one duplicate will be collected and submitted for analysis.
- Split Sample: A sample will collected from one port and submitted to the laboratory where it will be subsequently split into two sets of sample containers. Samples will then be submitted for identical analyses. Split samples will be used to check analytical precision.

6.2.4 Surface Water Quality and Aquatic Health

Quality control for chemistry (water and tissue) will include collection of field duplicates or triplicates, lab duplicates, trip blanks, spiked samples, and laboratory blanks to assess precision, accuracy, and possible contamination due to sampling or methodological bias. Quality control for taxonomic analyses will include a field triplicate, re-sorting checks and re-identification checks to assess precision and accuracy.

For QC purposes, the replicate samples (6 for periphyton) collected at each station will provide a mechanism for assessing intra-station variability in algal biomass.

The purpose and objective for each monitoring component are summarized in Table 14.

Table 14: Purposes and Objectives for Quality Control Components

QC Component	Purpose	Frequency	Data Quality Objectives[1]
Water Chemistry			
Field duplicate	To assess within site environmental variability	With 10% of samples collected	RPD >20% indicate a possible problem, > 50% indicate a definite problem, for values ≥5x MDL
Field blank	To monitor contamination of samples between collection and receipt by laboratory	One per sampling program	<MDL

QC Component	Purpose	Frequency	Data Quality Objectives[1]
Lab duplicate	To assess the precision of analytical methods	One per up to 20 samples submitted	Follow laboratory specified DQOs
Lab control sample/Matrix Spike/CRM	To assess the accuracy of analytical methods	One per up to 20 samples submitted	Follow laboratory specified DQOs
Method blank	To monitor contamination of samples during laboratory analysis	One per up to 20 samples submitted	<MDL
Benthic Invertebrate Taxonomy			
Field triplicate	To assess the precision of sampling methods and local environmental variability	One per habitat type (i.e., creek and wetland) and per sampling program	Within range of normal variability
Lab Re-sorting	To determine sorting efficiency	On 10% of samples submitted	Discrepancy in organism counts between the first and second counts is less than 10%
Lab Re-identification	To determine identification efficiency	On 10% of samples submitted	Error rate is 5% or less for taxonomic identifications

Notes: MDL = Method detection limit; CRM = Certified Reference Material; RPD = relative percent difference between concentrations measured in duplicates, calculated as: ([original – duplicate] ÷ mean) x 100. RSD = relative standard deviation between concentrations measured in triplicates, calculated as: (standard deviation ÷ mean) x 100. Values less than five times the MDL are not included in the RPD or RSD calculations because analytical variability near the MDL is higher and does not provide a good measure of variability associated with the collection of field samples. As applicable, the purpose and objectives of QC components are adopted from the BC Field Sampling Manual (BC MoE 2013) and the CABIN Field Sampling Protocols (Environment Canada 2012b).

1. DQOs may change over time so may need to be revised as appropriate.

7.0 REPORTING SCHEDULE

Following each monitoring cycle, an annual interpretive report will be prepared and submitted to both the Ministry of Forest Land and Natural Resources Operations (FLNRO), by March 31 of the next calendar year, for review (assuming that all field data are available in sufficient time). Additional reporting may be required as laid out in Table 3. The report contents will follow guidance from Environment Canada (2012a) for EEM and will include a description of methods (including QA/QC), presentation of analytical and statistical results and interpretation, and a summary of recommendations for the next cycle of water monitoring.

8.0 ADAPTIVE MANAGEMENT STRATEGY

The Water Management Plan will be dynamic in nature and will follow an adaptive management strategy based on the results of ongoing monitoring. An adaptive management framework will allow an assessment of the effectiveness of the proposed mitigation measures in a timely manner to inform management decisions regarding mitigation. Should the planned mitigations not be sufficient to prevent adverse effects to water resources and aquatic health receptors, then additional contingency measures might be enacted (Section 8.1).

The progressive implementation of the adaptive management framework will include periodic review of mitigation measure performance and monitoring data, as part of ongoing consultation with FLNRO and other regulators as required. The result is a constant feedback of new information into the decision-making process. The framework not only specifies how management will adapt to new conditions (new information, changes to the mine plan, refined modelling and mitigation), but the framework itself will adapt and become a more reliable and robust tool to enable the making of sound and timely decisions regarding management.

Together with the progressive development and implementation of mitigation measures, monitoring is an integral part of adaptive management. The framework provides a constant feedback loop between monitoring of water quantity predictions, water quality predictions, and management decisions. Management actions will be taken to the extent necessary to prevent adverse effects to water resources and aquatic health receptors as outlined in the trigger response plan in Section 4.1.2.4.

Management will be guided by a reasonable level of certainty derived from relevant lines of evidence. Based on the relevant lines of evidence, management actions will be taken sufficiently early to minimize or avoid exposures that could result in significant adverse effects to water resources. The financial and environmental costs of a management action will be considered if there is a material benefit to the protection of populations and communities of ecological receptors.

8.1 Adaptive Management Actions

If the water quantity triggers presented in Table 5 are exceeded and the exceedance is confirmed to be as a result of Project activities then the following management actions would be undertaken:

- Review and adjust mine plan
- If the trigger is attributed to the presence of more permeable material (as a result of historical subsurface channels) then a cut off wall will be installed

8.1.1 Mine Plan

The phased approach of mine development (e.g., starting at phases 1 and working towards phase 10) was selected in order to allow progressive review and adjustments of the mine plan. This approach included the following considerations:

- Plugging the upper segment of WC 2 during construction. This allows for a flattening of the groundwater gradient between McNab Creek and the Project Area and an increase to surface water flows in McNab Creek.
- Starting mining in the western portion of the pit. This area of the mine is the furthest away from where surface water from McNab Creek enters the groundwater system and reports to the pit lake. The rate of loss of flow from McNab Creek to the groundwater system is proportional to the hydraulic gradient in the groundwater

between McNab Creek and the Project Area. This hydraulic gradient is essentially the difference between the water level in McNab Creek and that in the pit lake divided by the distance between these two points. By commencing mining in Phase 1 and moving eastward, the gradient will be increased as the mine progresses, slowly increasing the rate of groundwater reporting to the pit lake from McNab Creek.

- Phases of the mine become progressively larger over the life of the mine.

The groundwater model will be re-simulated to determine the geometry of the mine that would maintain a 10% buffer to the baseflow predictions in McNab Creek at closure. This means the mine plan will be developed throughout operations to cease mining operations when McNab Creek flows reach 10% above baseline values. Adjustments to the mine plan may include adjusting the depth of mine excavation in certain phases (i.e., shallower in some phases and deeper in others), changing the position or order that the phases are developed or elimination of selected phases.

8.1.2 Pit Lake Water Levels

Loss of water from the pit or increased inflow of groundwater to the pit from McNab Creek has been identified as a possible scenario that could result in a water quantity trigger. For example, if a buried natural stream channel filled primarily with gravel and having a higher hydraulic conductivity than the surrounding sand and gravel material was encountered during pit development, disturbance of this feature could theoretically affect the groundwater gradient between McNab Creek and the pit. Based on the known pit stratigraphy and hydrogeologic data on groundwater levels obtained in the proposed pit area, the probability of encountering discrete zones of material with hydraulic conductivities significantly different than those assessed previously is considered to be very low. The proposed phased development of the pit lake and excavation of the extension of the WC 2 habitat offset channel will provide opportunities to identify potential variations in the sand and gravel stratigraphy downstream of the proposed pit.

If a condition of hydrogeologic concern that could affect pit lake levels was identified during pit development, then potential options for hydraulically isolating the pit from McNab Creek or the downstream environment would be reviewed and a suitable option identified based on the particular geologic nature of the issue. Under such circumstances, an option for hydraulically isolating a portion of the pit would be to backfill the area of concern with low permeability materials. The mine plan would be re-evaluated together with actions taken to mitigate the concern.

In general, if higher permeability gravels were encountered along the northern pit perimeter, it is anticipated that an accelerated rate of “flattening” of the groundwater table (i.e., decrease in groundwater gradient) would be expected to occur between McNab Creek and the pit, but with essentially no change to the groundwater model prediction.

8.1.3 WC 2 Extension Water Levels

The proposed WC 2 extension would be a constructed groundwater fed channel which is intended to serve as an offset for the loss of the existing upper portion of WC 2 which is located within the proposed mine footprint. The flow depths in the WC 2 extension will be monitored as one component of determining if the objectives of the offset plan is being met. The water levels in the WC 2 extension channel will be largely controlled by the geometry and invert elevation of the channel. If the depth of flow within the channel is inadequate to support the objectives of the habitat offset plan, structural modifications to the channel such as deepening and/or constricting various points within the channel will be carried out to modify the hydraulic properties of the channel.

9.0 CLOSURE

We trust that this report meets your immediate requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned at 604-296-4200.

GOLDER ASSOCIATES LTD.

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KZ/ EI/CC/DG/asd

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ATTACHMENT A

Water Quality Parameters – In-progress

ATTACHMENT B

McNab Creek Low Flow Analysis - Supplemental Information In-Progress

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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