Coffee Gold Mine

YESAB Project Proposal

Appendix 8-B Surface Hydrology Intermediate Component Analysis Report

VOLUME II

Prepared for:
Kaminak Gold Corp. a subsidiary of
Goldcorp Inc.
Suite 3400-666 Burrard Street
Vancouver, BC Canada V6C 2X8

Prepared by:
Lorax Environmental Services, Ltd.
2289 Burrard Street
Vancouver, BC V6J 3H9

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1.0 INTRODUCTION

This report, prepared on behalf of Goldcorp Inc. (Goldcorp or Proponent), presents an analysis of potential Project-related changes and cumulative changes on surface hydrology. The analysis pertains to the construction, operation, reclamation and closure, and post-closure of the Coffee Gold Mine (Coffee Project or Project), a proposed gold development project in west-central Yukon, approximately 130 kilometres (km) south of Dawson. The Project is a proposed open pit gold mine using a cyanide heap leach process to extract ore.

The location and general arrangement of facilities associated with the proposed undertaking are shown in **Figure 1.1-1**. The proposed access to the Project site is via the Northern Access Route (NAR), which will extend over a total distance of approximately 190 km south from Dawson. The access route will use both new and existing roads south from Dawson, to reach the mine site. The access route will include crossings over the Stewart and Yukon Rivers on ice roads in winter, and by barge in summer.

Project footprints and associated water management for the Project are shown in **Figure 1.1-2**. Major infrastructure related to the proposed mining and processing operations at the Project area includes: the waste rock storage facilities and open pits; water diversion structures and storage ponds; haul roads; primary and secondary crushing facilities; heap leach facilities; a carbon adsorption plant; a gold refinery; an accommodation complex; and an all-weather airstrip.

Latte, Double Double, Supremo and Kona pits are planned to be mined by open-pit shovel and truck methods. Most waste rock from the open pits is planned to be deposited in the engineered waste rock storage facility (WRSF) adjacent and near to the pits from which the waste is sourced. A portion of waste rock associated with the Project is scheduled to be backfilled in open pits to create causeways and to minimize the WRSF footprint overall.

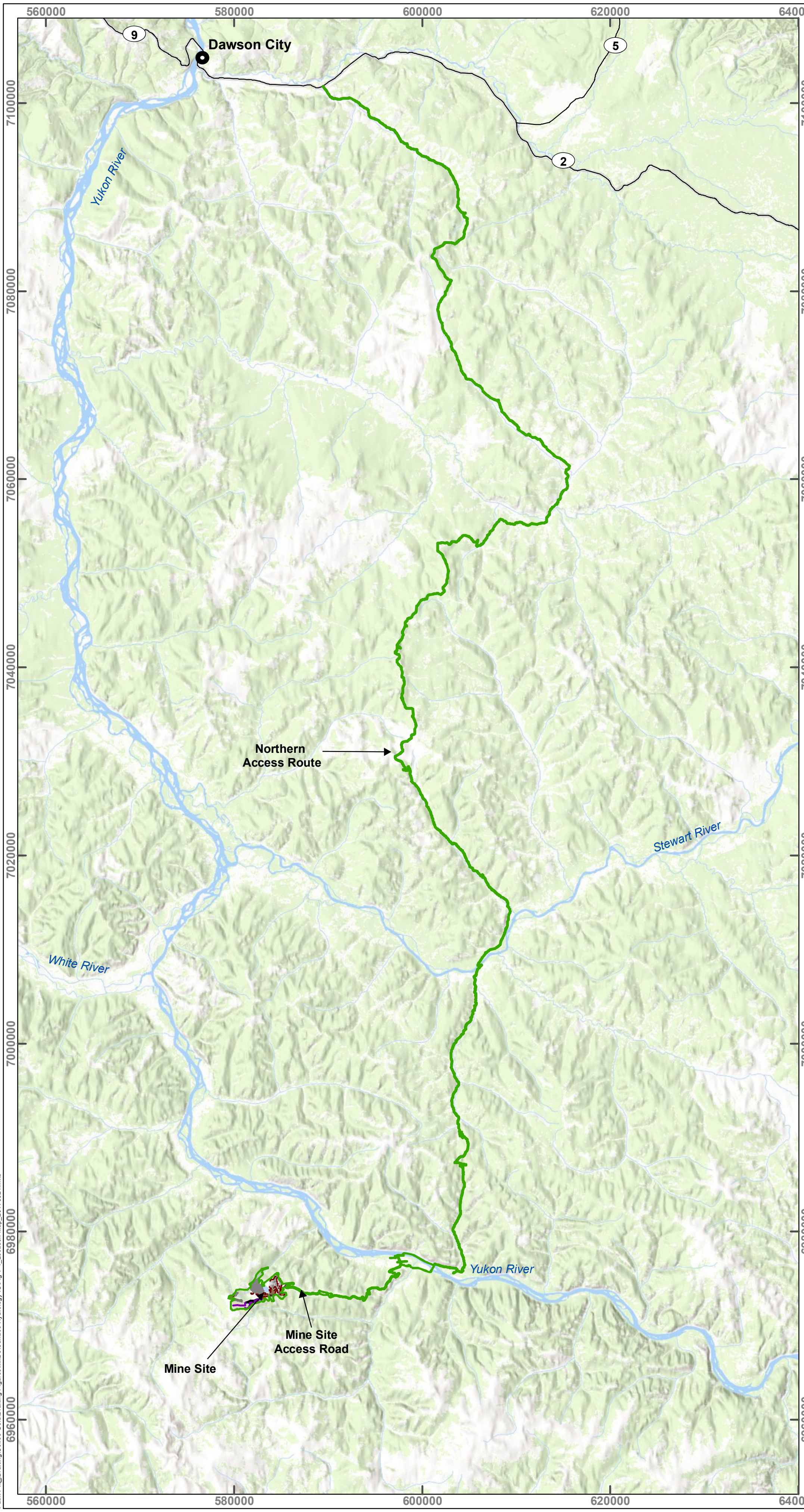
Goldcorp retained Lorax Environmental Services Ltd. to undertake an analysis of the Surface Hydrology Intermediate Component (IC) for the Project. Overall, the information provided herein supports the Project Proposal to be submitted to the Yukon Environmental and Socio-economic Assessment Board (YESAB) Executive Committee for screening under the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA). The information also supports applications to be submitted for a Quartz Mining Licence (QML) and a Type A Water Licence from the Yukon Water Board (YWB).

YESAB defines Valued Environmental and Socio-economic Components (VCs) as elements of environmental and/or socio-economic systems valued for environmental, scientific, social, aesthetic, or cultural reasons. An Intermediate Component (IC) is defined as a component in an intermediate position along a pathway of effects leading to one or more receptors or VCs. Surface Hydrology (used interchangeably with surface water quantity or streamflow herein) forms a key component of the aquatic environment, as the magnitude, frequency, duration and timing of stream discharge is directly linked to other components of the aquatic ecosystem (Poff et al., 1997; Fisheries and Oceans Canada (DFO) 2013). In terms of the physical and biophysical environment, these linkages include groundwater quantity and quality, surface water quality, fish and fish habitat and aquatic resources.

This report includes the following sections:

- Section 1.0 presents the scope of the analysis and the rationale for the selection of Surface Hydrology as an IC. This section also presents the indicators through which the IC will be assessed and introduces the spatial and temporal boundaries for the assessment;
- Section 2.0 of this report identifies IC-specific analysis methods that differ appreciably from the methods set out in **Section 5.0, Assessment Methodology** of the Project Proposal. Specifically, Section 2.0 introduces a GoldSim water balance model (WBM) that was constructed and calibrated to quantify Project-related streamflow changes attributable to mine development at the Project site;
- Section 3.0 summarizes the baseline hydro-meteorological conditions within the local study area (LSA) and regional study area (RSA) (refer to **Appendix 8-A**);
- Future conditions and changes with the proposed Project are discussed in Section 4.0 to Section 6.0 of this assessment.
    - Section 4.0 identifies and explores potential interactions between Project components, Project-related activities and Surface Hydrology through a screening process. Furthermore, Section 4.0 proposes and evaluates mitigation measures that reduce or avoid changes to Surface Hydrology from Project-related activities;
    - Section 5.0 assesses potential cumulative changes on Surface Hydrology from the Project in combination with past, present, and reasonably foreseeable future projects;
    - Section 6.0 provides a summary discussion of future conditions and changes associated with the Project.
- Section 7.0 outlines, at high level, the monitoring program to be implemented to verify predicted changes and the effectiveness of proposed mitigation measures for the IC. Section 8.0 also describes any adaptive management strategies that will be in place to address changes falling outside the range of prediction presented in this application.

The Surface Hydrology IC analysis also addressed potential changes attributable to the Project as aligned with **Section 28.0 Accidents and Malfunctions Assessment in the Project Proposal**. Relevant results for the Surface Hydrology IC are presented in **Section 28.0** and identify the cause, type, nature, likelihood and predicted consequence of accidents or malfunctions associated with Project components by Project phase, and mitigation measures (e.g., design standards, preventative measures, management plans, emergency response and contingency plans and procedures) to be implemented to manage risk and prevent or reduce the incidence and magnitude of such unplanned events.



COFFEE PROJECT

Location Map, General Arrangement for the Coffee Project

Legend

- Municipality
- Highway
- Project Footprint

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Figure 1.1-1	Date: Mar 21, 2017	Drawn by: G.M.	Reviewed: J.S./L.F.

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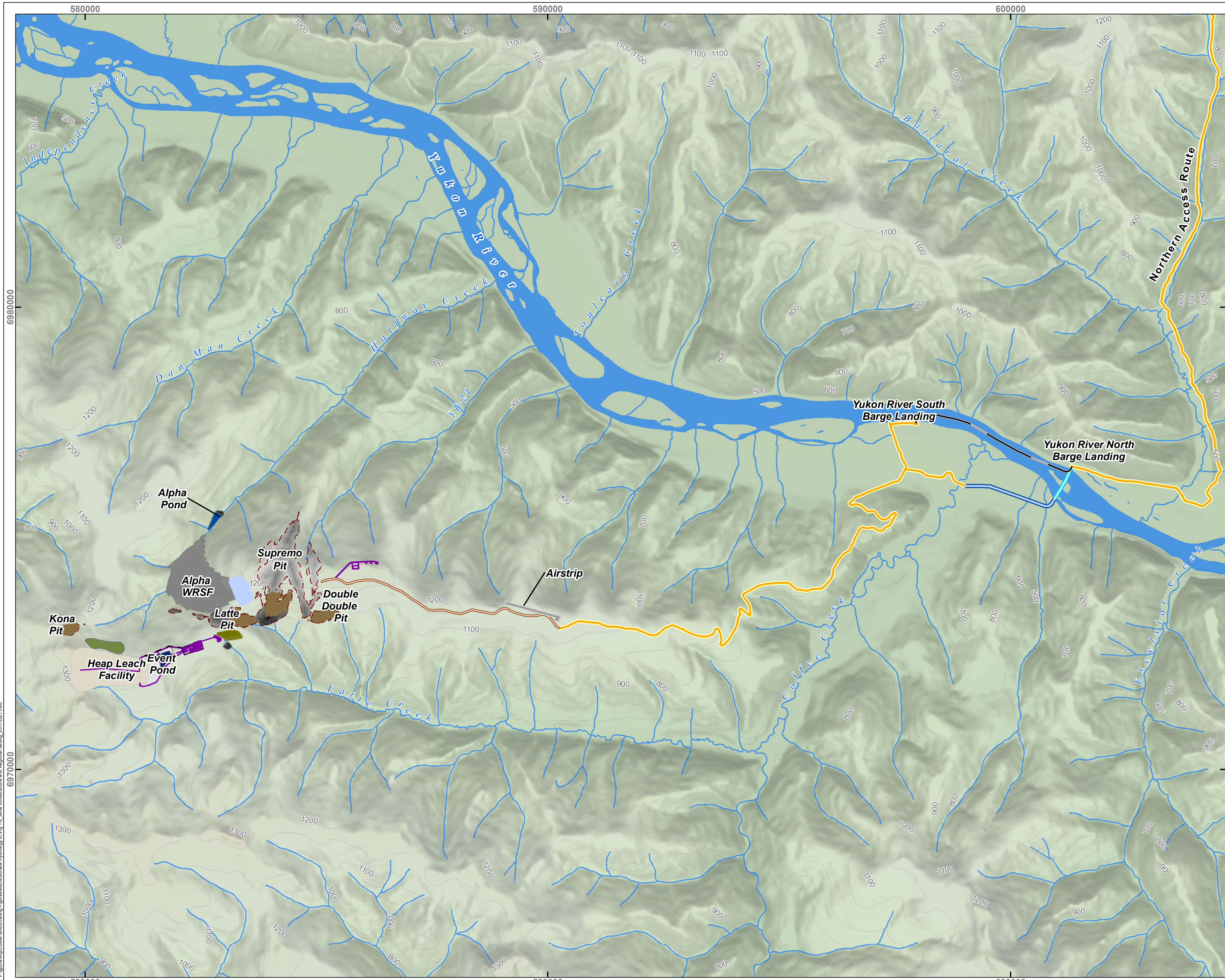
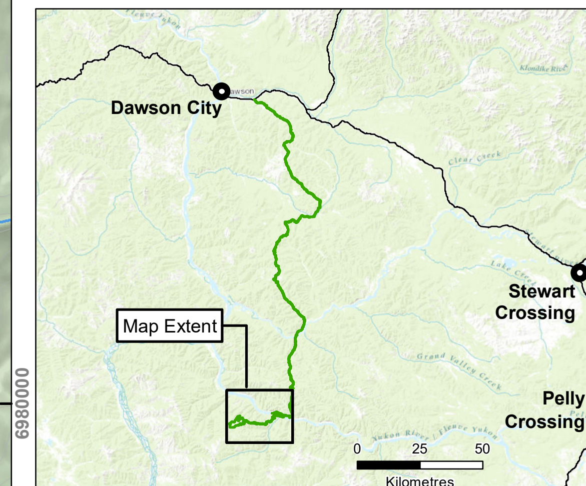


COFFEE GOLD MINE

Mine Site Infrastructure and Regional Setting



Legend

- Municipality
- Project Footprint
- Highway
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route
- Watercourse
- Waterbody

Proposed Infrastructure

- WRSF
- Backfill
- Total Pit Outline
- ROM Stockpile
- Organics Stockpile
- Heap Leach Pad Base
- Event Pond
- Heap Leach Access Disturbance Footprint
- Frozen Soil Storage Area
- Support Infrastructure

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1.1 Issues Scoping

The selection process for ICs is supported by an identification of issues scoped through a review of traditional knowledge, the regulatory environment and consideration of potential Project-related changes in the context of Surface Hydrology and mining projects.

1.1.1 Traditional Knowledge

Central to the issues scoping process for this IC assessment was a review of available Traditional Knowledge for the Project area. The Project overlaps with the asserted area or established traditional territories of the:

- Tr’ondëk Hwëch’in
- Selkirk First Nation
- First Nation of Na-cho Nyäk Dun
- White River First Nation.

Goldcorp has undertaken an engagement and consultation process, as defined under **section 50 (3)** of YESAA, to support the scoping of issues for the Project (see Project Proposal **Sections 3.0 Consultation and Engagement**). Goldcorp continues to consult and engage with affected First Nations and communities, government agencies, and persons or other stakeholders who may be interested in the Project and its related activities. The consultation and engagement process, including formation of technical working groups established with First Nations, government departments, community meetings, one-on-one and small group meetings, and ongoing communications such as print communication, newsletter, and website updates, including specific presentations and discussions regarding key themes of interest relating to the Project, was central to the selection and analysis of the Surface Hydrology IC.

An initial assessment of available Traditional Knowledge confirms a First Nations tenet that air, land, and water resources are inextricably linked, and furthermore, the maintenance and protection of these resources is highly important to people and biota (fish, wildlife and plants) alike. For example, many of the First Nations interviewed indicate the importance of the Coffee Creek corridor, and the salmon runs that it supported, to their people. Traditional use of the area is well documented and fish camps were set up annually near the mouth of Coffee Creek by multiple First Nations groups (e.g., Bates and DeRoy 2014, Tr'ondëk Hwëch'in 2012, Dawson Indian Band 1998, Easton et al. 2013). Overall, the themes identified through the engagement and consultation process provide a supporting basis for including Surface Hydrology as an IC for the Project.

1.1.2 REGULATORY ENVIRONMENT

As part of the issues scoping for the proposed Surface Hydrology IC, federal and territory regulations, pertaining to the protection and management of land and water resources, were reviewed.

Described in more detail in Section 3.0, the management, use and discharge of water from a mine site is governed by several pieces of territorial and federal legislation. The primary territorial acts are the *Quartz Mining Act* and the *Waters Act* (**Table 3.1-1**). The application information requirements for a licence under both acts overlap substantially, and the regulation of mining activities is integrated across all environmental disciplines. Thus, the change assessment for the Surface Hydrology IC must take these regulatory requirements into account, through the mine plan, water management plans (including discharge of effluent), and operational monitoring and reporting plans. As an extension, some of the mitigation measures proposed to offset a change on the proposed IC are informed by the regulatory requirements.

At the federal level, the effects assessment is informed by YESAA, which co-ordinates the assessment of major projects under a single review that is jointly administered by both the federal and territorial governments. The discharge of mine effluent is governed under the *Fisheries Act*, and specifically by the *Metal Mining Effluent Regulations* (**Table 3.1-1**), which impose limits on the discharge of deleterious substances for any mine that exceeds a discharge rate of 50 m^3/day (from all final discharge points). As the management of mine water discharge often focuses primarily on the effluent water quality, the effluent discharge rates (and thus the potential change to the Surface Hydrology IC) are determined based on a combination of the effluent discharge limits, and the resultant water quality in the receiving streams.

The *Navigation Protection Act* regulates activities that may affect the navigability of those water bodies listed in the Schedule of Navigable Waters, including dewatering (s.23). The Yukon River is listed in this schedule, and thus is subject to the provisions of the act.

1.1.3 PROJECT ACTIVITIES AT THE COFFEE GOLD MINE

The construction, operation and closure of a mine site invariably involves some degree of alteration to adjacent landscapes and local watercourses. Land disturbance, the management of water (e.g., diverting, storing and pumping of water), and consumptive uses of water have the potential to alter the volume, timing and spatial distribution of surface runoff at- and downstream of the Project site.

The Construction Phase for the Project is proposed to span roughly a three-year period, and activities that will commence and remain ongoing throughout this phase are:

- Upgrading and construction of road sections and crossings between Dawson and the mine site
- Clearing and grubbing of mine infrastructure areas
- Development of Latte and Double Double pits

- Development and use of the Alpha WRSF
- Development and use of stockpiles for temporary storage of organics/topsoil and remaining overburden, run-of-mine ore (ROM) and crushed ore
- Heap Leach Facility (HLF) construction, including water management infrastructure
- Loading of ore on the HLF pad
- Development and use of water management infrastructure external to the WRSF (e.g., diversion ditches, sediment control ponds, sumps)
- Construction of the crusher, process plant, airstrip, mine site service and haul roads, power generation facility and camp.

The Operation Phase of the Project will span twelve years, with activities below having the potential to alter surface water quantity:

- Development of Kona Pit and Supremo Pit and continued development of the Double and Latte Pits (and associated temporary closures)
- Backfilling of waste rock to open pits
- Continued development of the Alpha WRSF
- Continued use and development of all soil stockpiles and mine access roads
- Operation of the crusher and process plant and continued staging of HLF construction
- Progressive reclamation and closure of the HLF
- Ongoing contact and non-contact water management, pit dewatering as required
- Installation of a water treatment facility for the HLF.

The Reclamation and Closure Phase will span a 10-year time period and activities showing potential to alter surface water quantity are:

- Progressive reclamation of disturbed areas within the mine site footprint
- Progressive reclamation of the Alpha WRSF and HLF
- Closure of Supremo and Kona Pits
- Dismantling of ROM stockpile, crusher facility, process plant and all support infrastructure
- Closure of the HLF and related water management structures, including operation of water treatment facility for HLF rinse water
- Decommissioning of sediment ponds and HLF water treatment facility
- Decommissioning of road sections as required.

1.2 SELECTION OF THE SURFACE HYDROLOGY IC

This section of the assessment describes the IC selection process and builds a rationale for including Surface Hydrology as an IC within the Coffee Gold Mine Project Proposal. The ICs and VCs that were selected for the Project are summarized in **Section 5.0 Assessment Methodology of the Project Proposal**. The selection process followed the guidelines set up in **Section 5.1.2**, and ultimately determined that the Surface Hydrology component would be most effectively assessed as an IC. There was a single candidate IC (Surface Hydrology) considered in this analysis, and a single IC was selected. The evaluation of Surface Hydrology as an appropriate IC is summarized in **Table 1.2-1.**

A motivating factor for the selection of the IC was Traditional Knowledge. Specifically, the importance of local watercourses to First Nations played a role in the selection of this IC:

> *We value our natural environment with healthy fish and wildlife populations, clean water, clean air and the natural state of the land. The Na-Cho Nyák Dun Traditional Territory is the headwaters for rivers flowing to the Arctic as well as the Pacific Ocean. It is part of the migratory corridor for the Porcupine Caribou and home to a diversity of fish and wildlife populations. Historically it was traveled far and wide by Na-Cho Nyák Dun ancestors who lived off the land.* (Na-Cho Nyak Dun 2008).
>
> *No water, No world. It is more precious than gold.* (T. Campbell, 2012).

Secondly, Surface Hydrology (streamflow) is linked to other aquatic ecosystem components core to the Project Proposal (refer to **Table 5.1-3 Intermediate Component and Valued Component Linkages**). The Surface Hydrology IC is directly linked to the Groundwater IC in the following ways:

- Precipitation abstracted to groundwater recharge is not available for surface runoff
- Groundwater discharge to valley bottoms contributes to baseflows year-round, and the formation of channel ice (aufeis) in the winter months
- Leakage from future pit lakes and/or sediment ponds may report to nearby streams via shallow groundwater flow pathways.

The Surface Hydrology IC is directly linked to the Surface Water Quality VC in the following ways:

- Concentrations of parameters of concern (e.g., arsenic, uranium) in the receiving streams are a function of the load (mass) multiplied by the flow (volume/time)
- Some chemical parameters are controlled by the rate of groundwater discharge, which forms the majority of surface flow during the winter months (and during extended dry periods in the open water season). This represents a three-way linkage between Surface Hydrology, Groundwater and Surface Water Quality
- The relative timing and direction (routing) of mine contact waters (e.g., pit dewatering, WRSF seepage) in relation to the timing (peak and low flows) of discharge in receiving streams will influence surface water quality (the rate of contact water discharge divided by the flow in the

receiving stream equals the dilution ratio) conditions during Construction, Operation, Reclamation and Closure and Post-closure Phases of the Project.

The Surface Hydrology IC is directly linked to the Fish and Fish Habitat VC in the following ways:

- Fish habitat is defined in part by the volume of water in a watercourse during critical times (e.g., over-wintering, rearing, spawning)
- Streamflow is linked to the wetted channel width, which is a key habitat indicator
- Timing of melt (snow and aufeis) plays a role in the timing of potential fish access to the Project area streams
- Altered rainfall-runoff responses (e.g., flashier runoff as a potential result of stripping and grubbing of Project footprint) can alter stream channel morphology (e.g., remove pools).

The Project mine plan schedules development of four open pits and a WRSF, and envisions a comprehensive water management layout comprised of two sediment control ponds and associated conveyance structures to manage contact water generated by the Project. Owing to the likelihood of these interactions, the Surface Hydrology discipline is routinely included in environmental assessment applications, and several federal and territorial water regulations and policy instruments are in place to guide the management and use of surface waters at mine sites.

Lastly, the measurement of streamflow is a well-established scientific discipline, with well-defined and internationally accepted measurement practices and standards. Watershed and water balance modelling are also well-developed disciplines, and form an integral component of mine project design and environmental impact assessment. Given primary concerns of the identified First Nations were sustainability of their way of life, access to clean water, and the ability to harvest food from their territory (fish, in this specific example), a robust assessment of potential residual changes as they relate to Surface Hydrology is critical to address these concerns.

Table 1.2-1 Surface Hydrology Intermediate Component – Evaluation Summary

Candidate IC	Project Interaction			Third Party Input		Supports the Analysis Other IC or VC?	Selected as IC?	Decision
	Interactions?	Project Phase / Project Component / Project Activity	Nature of Interaction	Sources	Input			
Surface Hydrology	Yes	Several Project activities expected to interact with the proposed IC. Interactions with IC expected for all phases of the Project. See Section 1.1.3 and **Table 4.1-2**.	The Project has the potential to alter the timing and magnitude of streamflow at a local scale.	Tr'ondëk Hwëch'in Selkirk First Nation First Nation of Na-cho Nyäk Dun White River First Nation Yukon Territorial Government Federal Government Public Stakeholder	While Traditional Knowledge available for assessment made no specific reference to Surface Hydrology, many entries underscore the value and importance First Nations place on air, land and water resources. Many Traditional Knowledge references acknowledge the interconnectedness of water and biota (fish, wildlife) and the value place on healthy fisheries on Coffee Creek and the Yukon River. Several pieces of territorial legislation govern the management and use of surface waters (see **Table 3.1-1**). No public stakeholder comments were received.	Yes. The Surface Hydrology IC assessment supports the assessment of the Surface Water Quality and Fish and Fish Habitat VCs, as well as the Groundwater IC.	Yes	Surface Hydrology was selected as an IC due to its importance to stakeholders, strong linkages with other ICs/VCs, and the potential for Project-related activities to alter the existing streamflow regime in the Project area.

1.3 INDICATORS

The document *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* (DFO 2013) describes the various methods used to assess the potential impact of flow alterations on fish habitat. The hydrological methods category of analysis seeks to characterize the natural flow paradigm, where "…the management goal is maintenance of the many natural or historic characteristics of the hydrograph (amplitude, timing, frequency, duration, variability, *etc*.)."

Following this guidance, the indicators chosen to quantify the Surface Hydrology IC describe the key components of the streamflow regime (**Table 1.3-1**). Standard metrics are included and the baseline conditions for each are described in **Appendix 8-A**. An additional metric included in this analysis is the duration and frequency of daily flows less than 30% of the mean annual discharge (MAD), which is strongly correlated to basin size, and serves as a cut-off limit for flow reductions during low-flow periods (DFO 2013).

Table 1.3-1 Indicators for Surface Hydrology

Indicator	Rationale for Selection
Annual Runoff	Project activities (e.g., pit dewatering, water diversions, water use) have the potential to change the proportion of precipitation that reports as surface runoff on an annual basis.
Monthly Runoff Distribution	Water management ponds, open pits, pit lakes and WRSFs are known to alter (e.g., attenuate, enhance) the runoff signatures of mine-affected catchments on a monthly and seasonal basis.
Low Flows	Alterations to the existing groundwater regime and shallow interflow may result from Project development (e.g., pit development, waste rock placement).
Peak Flows	Alteration of the land surface and diversion of water via ditches may increase peak flows in the vicinity of the Project. Conversely, reductions in basin area may have the potential to reduce peak flows via reduction in contributing areas.
Duration and Frequency of Flow < 30% MAD	Flow alterations resulting in instantaneous flows less than 30% of MAD increase risk of changes to ecosystems that support fisheries.

Specific examples of Project activities along with examples of linkages to the chosen indicators are provided below:

- Construction of the Project – stripping, grubbing, compaction, road construction and pit development will increase the impervious portion of each mine-affected catchment. The increase in impervious area has the potential to reduce infiltration to the shallow (and subsequently deep) groundwater systems, which may affect annual runoff volumes, the distribution of monthly runoff, reduce baseflows and increase peak flows.
- Operation of the HLF – water will be required for the leaching process and will be stored within the closed-circuit heap leach system until the rinsing and treatment begins in the Reclamation and Closure Phase. This will require mainly the use of and recycling of contact water, but may require some makeup water from nearby locations. Abstractions for the HLF have the potential to reduce

annual runoff volumes, low flows and high flows, and alter the monthly distribution of flow in local creeks.

- Development of Open Pits – As open pits are developed, the non-contact area within mine catchments decreases while contact areas will increase in magnitude. Runoff coefficients will increase as the pit walls are expected to be largely impervious, which may increase annual runoff. Low flows may be affected in the watersheds that contain pits that intersect the groundwater table. Later in the mine life, open pits may become temporary sinks as they start to fill, which may reduce annual runoff volumes, alter the monthly distribution of flows (increased winter flows and reduced summer flows) and dampen peak flow magnitudes to some degree.
- Development of WRSF – Placement of waste rock will serve to attenuate flows within mine basins and has the potential to alter the monthly runoff regime and increase low flows and moderate peak flows in some months (e.g., late summer, autumn).

The indicators selected will be used to evaluate potential adverse changes, the subsequent effectiveness of mitigation measures, and to characterize potential residual adverse changes. The indicators selected are common metrics used to describe the streamflow regime, and each has a direct physical linkage to the proposed Project activities, as well as the previously mentioned VC or ICs (e.g., low flows may be altered by waste rock placement, both of which are linked to surface water quality, and fish and fish habitat) unto which the Surface Hydrology IC is related.

1.4 Establishment of Analysis Boundaries

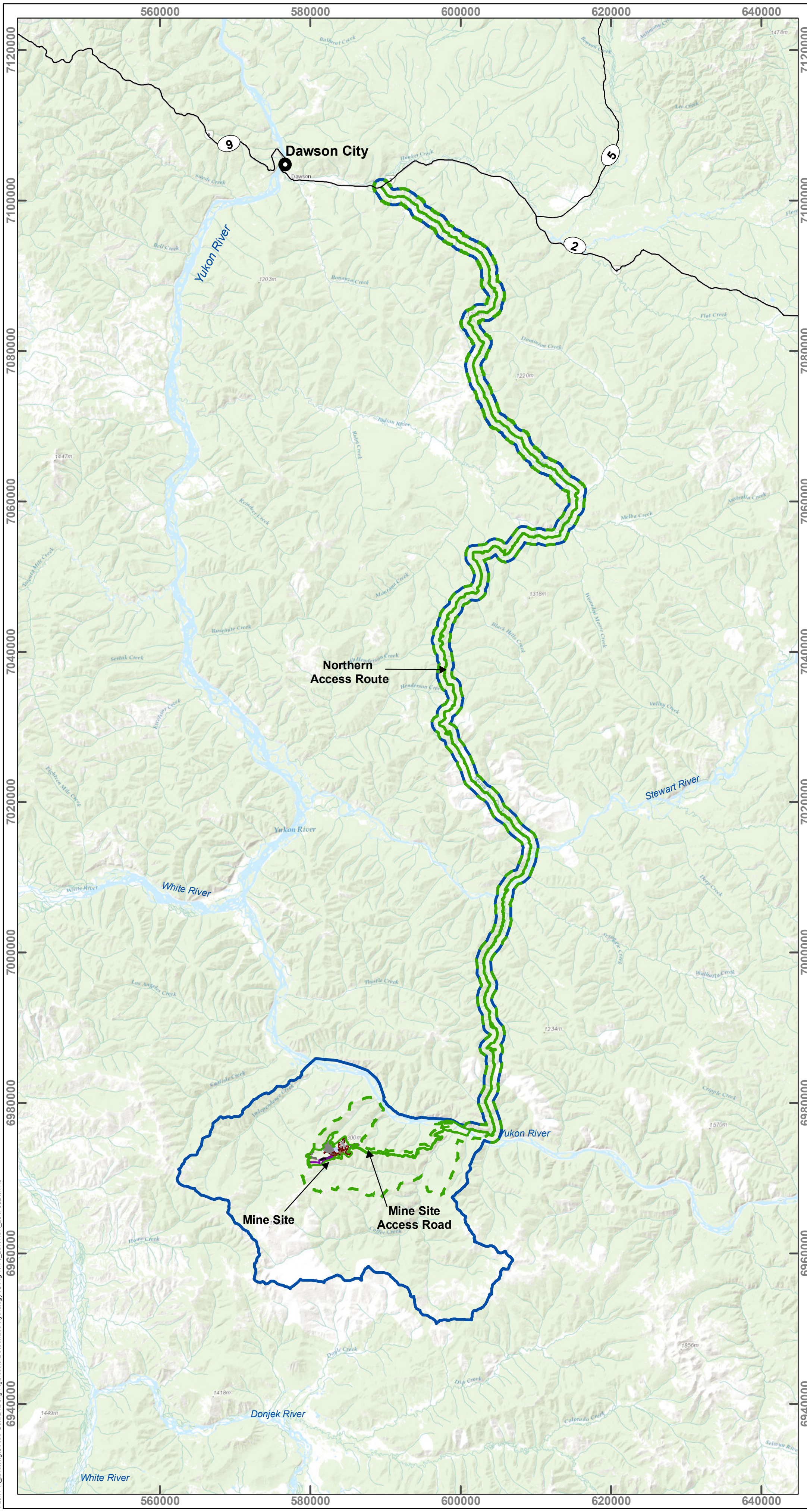
The analysis boundaries define the limits within which the assessment of changes and supporting studies (e.g., baseline monitoring, predictive modelling) for the Surface Hydrology IC were conducted. These boundaries encompass where and when the Project is reasonably expected to interact with streamflows. The boundaries consider administrative or technical constraints encountered in the baseline characterization as well as limitations in predicting or measuring Project-related changes (e.g., modelling or measurement accuracy relative to magnitude of predicted change).

1.4.1 Spatial Boundaries

Spatial boundary definitions for the Surface Hydrology IC are summarized in **Table 1.4-1** and shown on **Figure 1.4-1. Figure 1.4-2** provides the hydrological setting for the Coffee Gold Mine project footprints, including stream names. The LSA encompasses the maximum geographical area within which the Project is likely to interact with, and potentially result in a direct or indirect change to Surface Hydrology (see **Figure 1.4-1**). The RSA, which encompasses the LSA, is established to provide broader context for the analysis of Project-related changes (see **Figure 1.4-1**). The cumulative changes study area encompasses the area within which residual changes due to the Project are likely to interact with residual changes resulting from other past, present, or future projects or activities to result in a cumulative change or changes. A map is presented in Section 5.0 of this report that describes this area in more detail.

Table 1.4-1 Spatial Boundary Definitions for Surface Hydrology

Spatial Boundary	Description of Assessment Area
Local Study Area (LSA)	The Halfway Creek and Yukon Tributary (YT-24) watersheds, Latte Creek and Coffee Creek downstream of the confluence with Latte Creek to the Yukon River. The LSA also includes the alignment of the proposed Northern Access Route (including barge crossing) from the mine site to the highway junction situated to the east of Dawson.
Regional Study Area (RSA)	The entirety of the LSA, the Coffee Creek watershed (including the portion upstream of the confluence with Latte Creek), Independence Creek and the section of the Yukon River that spans the confluences with Independence and Latte Creeks, with a 100 m buffer.
Cumulative Changes Study Area	Includes the extent of the proposed RSA that is south of the Yukon River, as well as local drainage on the north side of the Yukon River extending from Ballarat Creek downstream to Kirkman Creek.



COFFEE PROJECT

Surface Hydrology IC Local and Regional Study Areas

Legend

- Municipality
- Highway
- Project Footprint
- Local Study Area
- Regional Study Area

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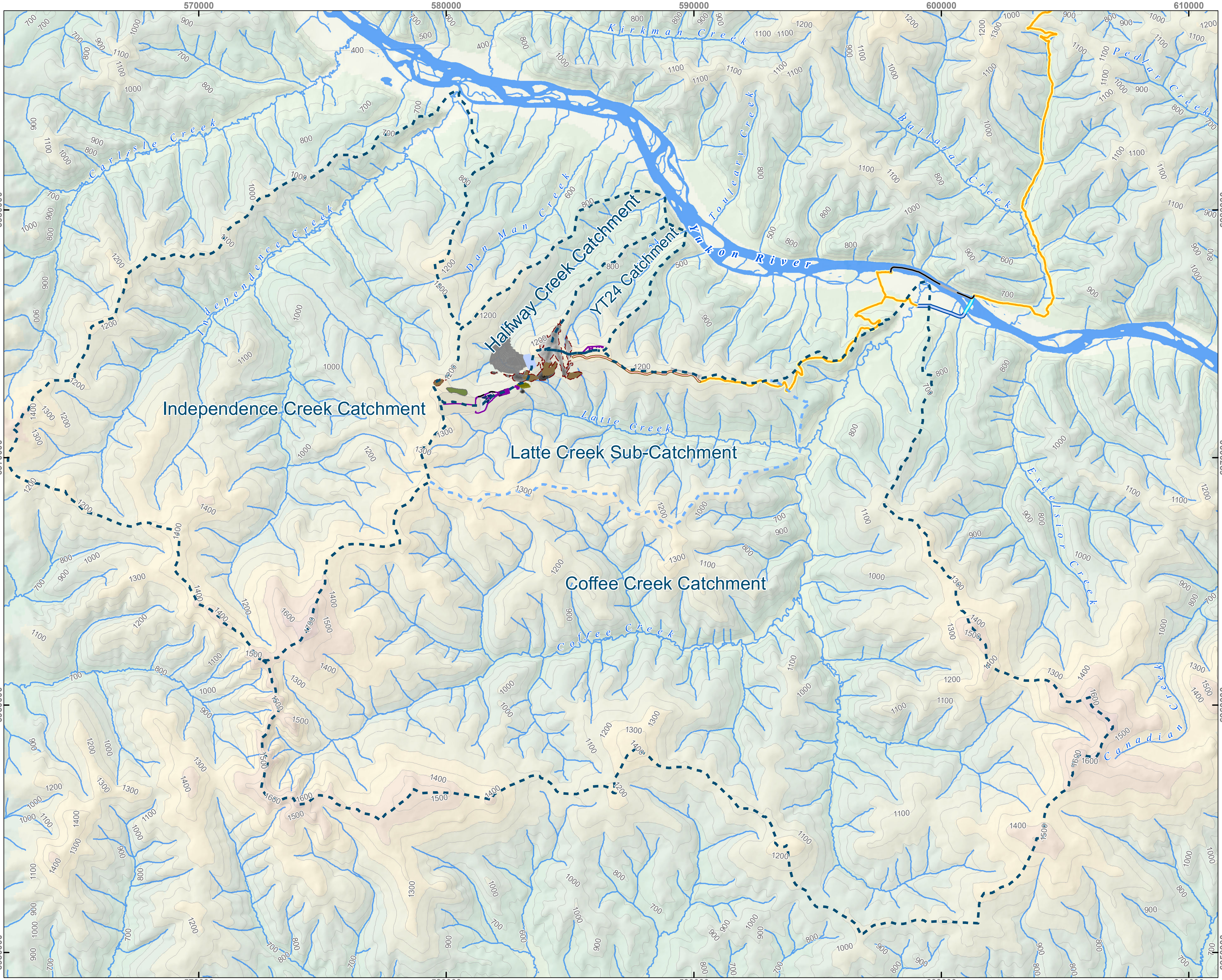
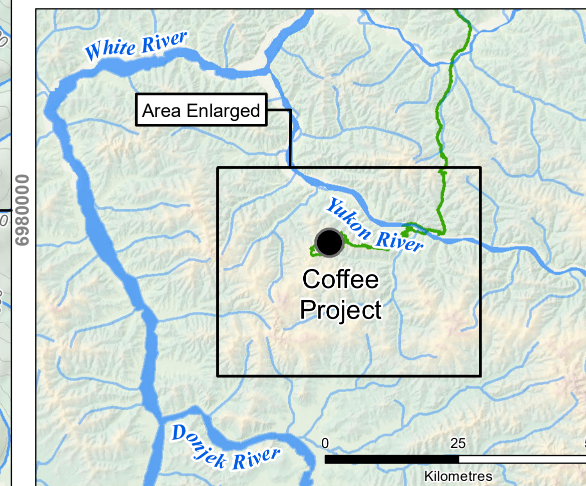
COFFEE GOLD MINE

Coffee Project Mine Site Footprint and Hydrological Setting





Legend

- Catchment
- Sub-Catchment
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1.4.2 TEMPORAL BOUNDARIES

The specific details pertaining to the Project's Construction, Operation, Reclamation and Closure, and Post-closure Phases are described in the Project Proposal (**Section 2.0 Project Description**). The temporal boundaries of the Surface Hydrology IC assessment reflect those periods during which the planned Project activities may reasonably be expected to potentially affect this IC. As such, the temporal boundaries of the Surface Hydrology change assessment span the entire Project life, beginning with the Construction Phase (Year -3, calendar year 2018) and ending with the Post-closure Phase (beginning Year 23).

Temporal boundaries for the Project are shown in **Figure 1.4-3**. For the IC assessment, Operation and Reclamation and Closure Phases are assumed to take place over 12-yr and 10-yr time horizons respectively. Closure is envisioned to consist of two phases – post-mining closure and active closure – with each phase assumed to be approximately five years in duration. The Post-closure Phase has been modelled out to the year 2100, although monitoring activities are not expected to continue for the duration of this Project phase. This end-point was selected because the climate change projections that were incorporated into the WBM terminate in this year.

The Surface Hydrology IC naturally exhibits temporal variations that are summarized in Section 3.0 of this report. Examples are the seasonal variation in streamflows (winter low flows and channel icing, spring snow melt freshet, summer low flows and rainfall-driven peak flow events); long-term cyclical (i.e., inter-annual) fluctuations resulting in wetter and drier than average years; and long-term trends (e.g., increasing winter flows over time). The Surface Hydrology IC assessment is based on the following data and modelling exercises:

- Two to five years of baseline streamflow data (11 stations)
- Four years of site climate record
- Reconstructed site climate records (28 years) and daily discharge records (33 years)
- Regional climate change analyses to inform long-term water balance scenarios
- A site-wide WBM run at a daily time-step that predicts potential changes to Surface Hydrology (presented as monthly summaries and described in detail in **Appendix 12-C**).

This long-term and well-defined data set allowed for a robust characterization of the baseline condition and the range of expected changes resulting from Project development are well constrained.

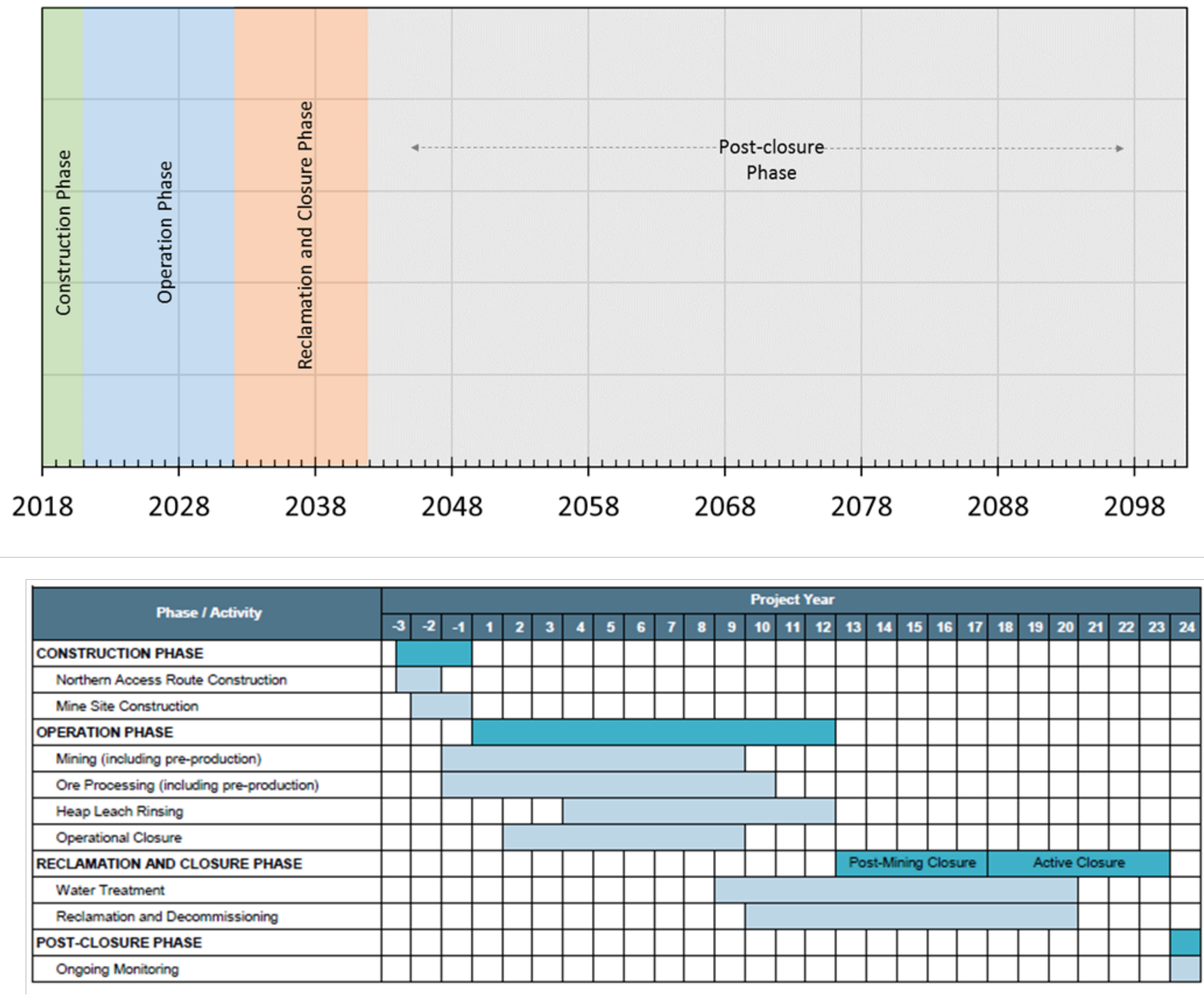


Figure 1.4-3 Temporal Boundaries for the Surface Hydrology IC Analysis.

Notes: Shading in the upper and lower panels demarcates the main phases of the Project. The temporal boundaries in the schematic are scaled in calendar years (upper panel) and Project year (lower panel) where year 2018 is assumed to equate to Year -3 of the Coffee Gold Mine Plan.

1.4.3 ADMINISTRATIVE BOUNDARIES

No administrative boundaries (e.g., political issues) were encountered during the collection of baseline stream flow data, or during the modelling and prediction of potential Project-related changes to Surface Hydrology.

1.4.4 TECHNICAL BOUNDARIES

For the open water season, no technical boundaries (e.g., sampling constraints) were encountered during the collection of baseline stream flow data or during the modelling and prediction of potential Project-related changes to Surface Hydrology. However, during the winter season (October through April), creeks in the LSA and RSA experience extensive stream channel icing. While flow is still present at some stations in winter as a result of groundwater discharge, it is often split between the channel edges, between ice laminae, and through the bedload. Therefore, standard streamflow measurement techniques (e.g., current meter, salt dilution) are not applicable in these circumstances, and where measurements exist, they are subject to a much higher range of measurement error than those taken under open water conditions. A strong relationship exists between most water quality parameters and streamflow in the Project area streams (see **Appendices 12-A through 12-C**). Given the higher uncertainty in the winter discharge measurements and the robust water quality and quantity relationship for this season, the water balance and water quality model calibration focused more on replicating the water quality signature during this period.

2.0 ANALYSIS METHODS

2.1 BACKGROUND

The Surface Hydrology IC assessment, including the analysis of Project-related changes, cumulative changes, and changes due to accidents and malfunctions, was conducted according to the methods set out in **Section 5.0 Effects Assessment Methodology** of the Project Proposal. An initial screening of the potential interaction between activities associated with the NAR and the Surface Hydrology IC showed negligible interaction overall. However, the initial screening of potential interactions between activities local to the Project site (e.g., open pit development, construction and operation of the HLF, management of waste rock, active water management) and the Surface Hydrology IC showed a much higher degree of potential interaction. Given the potential for Project interaction, at and downstream of mine footprints, a detailed and site-specific WBM was constructed and calibrated using GoldSim modelling software. This Coffee Gold Mine WBM serves as a means to quantify any residual changes associated with the Construction, Operation, Reclamation and Closure and Post-closure Phases of the Project, and is introduced in the sections below.

2.2 COFFEE GOLD MINE WATER BALANCE MODEL

To predict potential changes to the Surface Hydrology IC resulting from the Project, a detailed water balance modelling exercise was undertaken. Building on the baseline streamflow and climate data collected at the Project site (**Appendix 8-A**), a site-wide WBM was assembled using GoldSim modelling software. The model is constructed and calibrated to predict streamflow conditions in local watercourses for a Natural Flow case (i.e., a baseline scenario that considers no Project). A Base Case module (Project activities turned on) within the WBM also encodes the mine plan and all associated major Project footprints (e.g., open pit and waste rock storage facility footprints) and water-related activities (i.e., pit dewatering, diversions, storage and release of water (and loads) from sediment control ponds) associated with the Construction, Operation, Reclamation and Closure and Post-closure Phases of the Project. The Natural Flow and Base Case modules of the WBM are described at high level in **Table 2.2-1** and **Table 2.2-2** and discussed in detail in the next sections.

Table 2.2-1 Coffee Gold Mine Water Balance Model Description – Natural Flow Module

Coffee Gold Mine Water Balance Model (WBM) – Natural Flow Module	
Purpose	• To estimate monthly, natural (i.e., baseline, no Project) streamflows at nodes on local watercourses (Latte, Coffee, YT-24 and Halfway Creek) and the Yukon River.
Modelling Platform	• GoldSim simulation software (V11). • GoldSim is a graphical and object-oriented modelling platform.
GoldSim WBM Module	• The Coffee Gold Mine WBM (**Appendix 12-C**) was constructed using the three-reservoir water balance model core to the GoldSim software. • Surface runoff, baseflow, snowfall/melt processes and aufeis production from winter baseflow are all represented in the Coffee Gold Mine WBM which is a modified version of the Birkenes model (Christophersen and Seip, 1982; Seip et al., 1985; Stone and Seip, 1989). • The natural flow module of the Coffee Gold Mine WBM was calibrated at daily time-step using long-term, daily- synthetic streamflow data as the calibration targets.
Catchment Boundaries, Elevation Data	• Watershed boundaries and hypsometric outputs (i.e., curves and representative bands of elevation data) for local catchments were generated from 1:25,000 mapping data. • To encode elevation dependent climate parameterizations into the WBM, drainages were separated into three elevation bands (400-800 m, 800-1200 m and >1200 m).
Climate	• The natural flow module of the Coffee Gold Mine WBM was driven by a 28-year daily precipitation, air temperature and potential evaporation record. • As required, precipitation and air temperature inputs are scaled by elevation using gradients reported in **Appendix 8-A**. • To represent the Project timeline (2018-2101), the 28-year climate record was looped three times to produce an 84-year record. • Monthly climate change scenario data (from Scenario Network for Alaska and Arctic Planning, SNAP) for the A2 emission scenario (2-km resolution) were used to scale daily precipitation and air temperature inputs over the long term.
Hydrology	• Baseline hydrology data from autumn 2010 to Dec 2015 were combined with regional streamflow data to generate long-term synthetic streamflow records for model nodes. • Long-term synthetic streamflow records for Latte, Coffee, YT-24 and Halfway Creek served as targets for the natural flow module WBM calibration.
Water Quality	• The Coffee Gold Mine Water Quality Model (WQM) is also presented in full in **Appendix 12-C**, and it is notable that the WQM was constructed on top of the architecture of the Coffee Gold Mine WBM. • Like the WBM, the WQM was calibrated to appropriately represent baseline water quality conditions in local receiving streams.
Outputs	• For the natural flow condition (i.e., no project, baseline), 84-year long predicted streamflow records are generated by GoldSim. Flow records are produced for seven local tributaries and three WBM nodes on the Yukon River at monthly time step. • For this IC assessment and reporting procedures in general, Monte Carlo simulation capabilities are turned on within GoldSim. The resulting outputs per WBM node consist of 28 unique iterations (i.e., 28-year climate record is time stepped) each extending for the 84-year timeframe. • Natural flow outputs from the model used to estimate percent change metric (i.e., where %change = ((Base Case – Natural Flow)/Natural Flow)*100)

Table 2.2-2 Coffee Gold Mine Water Balance Model Description – Base Case Module

Coffee Gold Mine Water Balance Model – Base Case Module	
Purpose	• To estimate monthly, Base Case (i.e., Project affected) streamflows at nodes on local watercourses (Latte, Coffee, YT-24 and Halfway Creek) and the Yukon River.
Overview	• The modelling platform and WBM module used to estimate Base Case flows were fundamentally the same as those described for the natural flow module. ▫ Same catchment boundaries, elevation data, climate and hydrology inputs described for the natural flow module were used to populate the undisturbed portions of local watersheds in the Base Case module. • Mine plan, water management details and outputs from the Coffee Gold Mine Groundwater Model were encoded into the Base Case module to represent future conditions at the Project site with development.
Mine Plan	• Mine footprints for proposed open pits, WRSFs, the HLF, soil stockpiles and related Project infrastructure were encoded into the Base Case module. • Mine plan data issued February 2017, were used to populate the Base Case module. Data entered into GoldSim included year-by-year representations of: ▫ Open pits – Kona, Latte, Supremo and Double Double ▫ Backfilled pits and causeways ▫ WRSFs – Alpha and Beta (temporary) ▫ The HLF, including water management infrastructure.
Water Management Layout	• Sediment control ponds and conveyance structures (e.g., toe drains, interception ditches) described within the Coffee Gold Mine Water Management Plan (refer to **Appendix 31-E**) were also encoded into the Base Case model. • Conceptually, the Water Management Plan conveys contact waters associated with Project footprints to one of three watersheds: Latte/Coffee Creek drainage, YT-24 drainage and Halfway Creek drainage.
Groundwater	• A groundwater model was constructed and calibrated for the Project (**Appendix 7B-1**). • The groundwater model was first calibrated for baseline conditions, then run with Project footprints (WRSFs, open pits) in place to assess end of Operation and long-term Closure water level distributions, creek baseflows and pit seepage losses to the groundwater system. • Estimates of seepage losses from the pits to groundwater predicted by the groundwater model were incorporated into the base case module of the WBM.
Outputs	• As per the natural flow module, 84-year predicted flow records for seven local tributaries and three nodes on the Yukon River are outputted from the base case module of the WBM and account for future climate change (A2 emission scenario). • Consistent with water quality reporting and the natural flow module, flow outputs for base case are monthly. • Monte Carlo simulation capability is turned on within GoldSim, resulting in output of 28 unique iterations (i.e., climate year is time stepped) of predicted streamflow, each iteration being 84-years in length. • Base case flow records used as inputs to estimation of percent change metric (i.e., % change = ((Base Case – Natural Flow)/Natural Flow)*100.

2.2.1 CLIMATE INPUTS

A full description of the climate inputs entered into the WBM are provided in **Appendix 8-A** and **Appendix 12-C**, respectively and summarized here briefly for context. The GoldSim model performs a deterministic 84-year simulation using a reconstructed synthetic precipitation and temperature record to drive the Natural Flow and Base Case modules of the WBM. The use of a synthetic daily climate record as an input to the model allows it to be run on a daily time-step from the start of Construction through the Post-closure Phase of the Project. This is desirable for tracking temporally variable flows (e.g., freshet) and rapidly changing storage in smaller ponds and pit lakes, as well as to remain coordinated with the modelling approach adopted by the heap leach design team. The HLF water balance model forms a sub-component of the site-wide water balance model, and the climate inputs are consistent between the site- and HLF water balance models ensuring that discrepancies are not introduced by differing time-steps or assumptions (refer to **Appendix 12-C-1 – Operations Heap Leach Facility Water Balance Model, Appendix 12-C-2 – Draindown Heap Leach Facility Water Balance Model**).

Climate inputs for the period 2018 through 2101, which amount to three loops of a 28-year synthetic climate record, were prepared for entry into the WBM, and it is important to note that the climate data were trended upward for air temperature and precipitation as dictated by 2-km resolution down-scaled climate change scenario data for the Project. Trending of the climate data was governed by datasets produced by the Scenario Network for Alaska and Arctic Planning, and for an aggressive and worst case climate change scenario (A2 emission scenario). Climate change projections, observed and predicted climate trends and the rationale for the selection of the A2 emission scenario for Base Case is described in **Appendix 8-A** (refer to **Appendix D, Climate Change** in that document). Air temperature and precipitation inputs entered into the Natural Flow and Base Case sub-models are shown in **Figure 2.2-1**, superimposed on top of the temporal boundaries for the IC assessment.

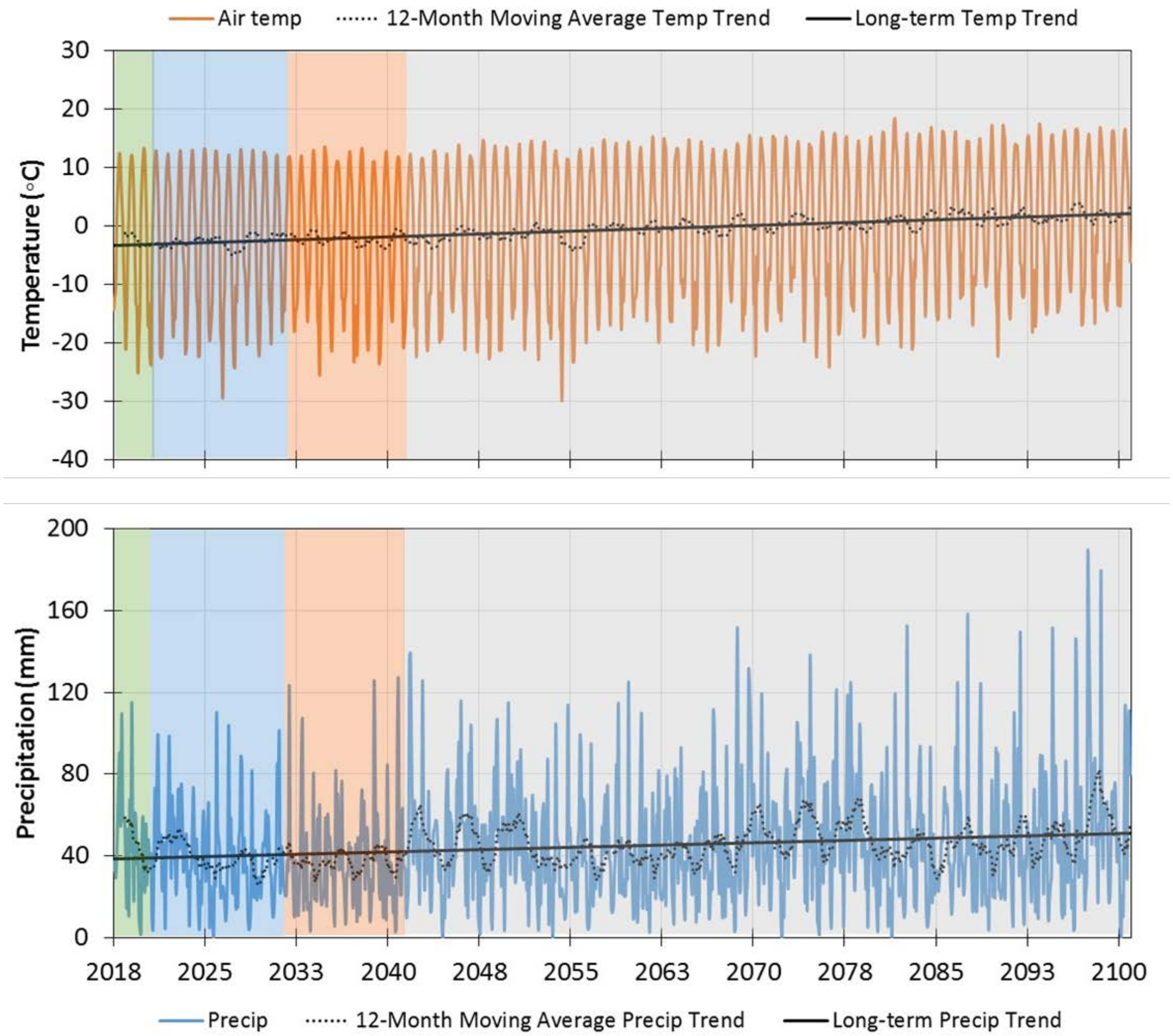


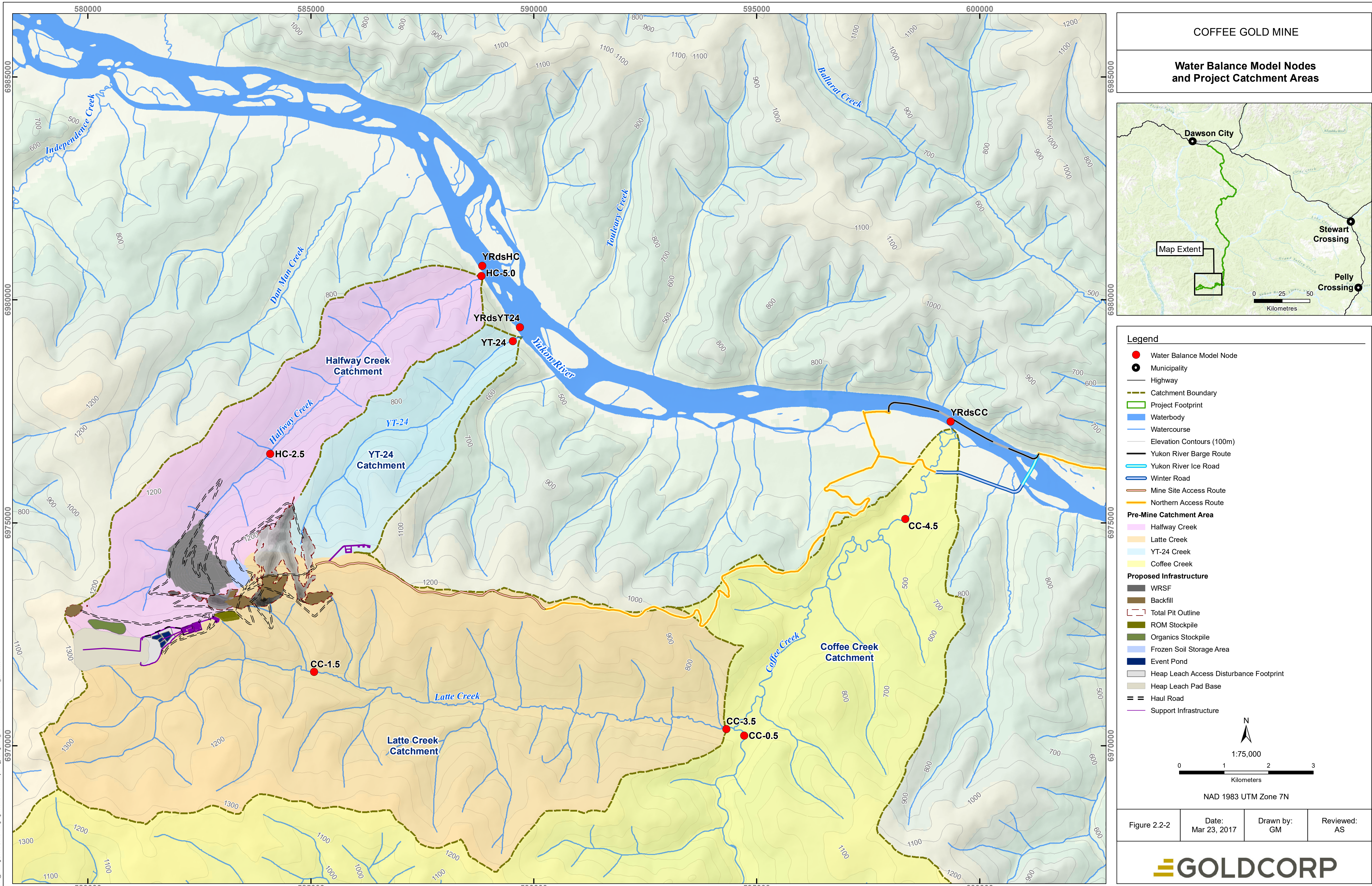
Figure 2.2-1 Air Temperature and Precipitation Inputs to the Coffee Gold Mine Water Balance Model.

Notes: Temperature and precipitation variables were trended upward using a 2-km gridded climate change scenario for the A2 emission scenario. Shading on the plot (i.e., green, blue, pink and grey) correspond to temporal boundaries introduced in **Figure 1.4-3**.

2.2.2 WATER BALANCE MODEL NODES

The WBM is configured to represent relevant physical processes that drive streamflow at the Project site. Rainfall, surface runoff, baseflow, snowfall/melt processes and aufeis production are all represented in the WBM, as are the elevational dependence of the temperature and precipitation inputs. The current configuration of the site-wide water balance considers ten receiving environment nodes (**Figure 2.2-2**), each situated downstream of the contact water storage ponds in the Latte Creek, YT-24 and Halfway Creek drainages. Listed below are descriptions of these receiving environment water balance nodes:

- Latte/Coffee Creek – several of the proposed mine footprints report in the direction of Latte Creek, a headwater drainage to Coffee Creek. Coffee Creek is a large watershed (~500 km^2) that reports to the Yukon River.
  - CC-1.5 – The CC-1.5 water balance node is situated immediately downstream of the principle points of discharge from the Supremo Pit (SU1, SU4S).
  - CC-3.5 - The CC-3.5 water balance node is situated immediately upstream of the Latte Creek-Coffee Creek confluence. Mine water discharges that report to CC-1.5 (drainage area ~23 km^2) will become more dilute prior to reaching CC-3.5 (drainage area ~70 km^2) given that the drainage between CC-1.5 and CC3-5 is for all intents and purposes pristine.
  - CC-0.5 – The Project does not influence flow (or water quality) at this water balance node. Therefore, the flows represented by this node are background or natural flows only in both the Natural Flow and the Base Case sub-models.
  - CC-4.5 - The CC-4.5 water balance node is situated on Coffee Creek proper, upstream of the confluence with the Yukon River. The combined drainage area reporting to this location is approximately 500 km^2.
- Yukon Tributary 24 (unnamed tributary that reports directly to the Yukon River).
  - This water balance node is situated immediately upstream of the confluence with the Yukon River. The natural drainage reporting to this node is approximately 12 km^2.
  - For Operation, Closure and Post-closure Phases of the Project, SU3N and SU5N/SU5S mine footprints are assumed to report in the direction of YT-24.
  - For the Operation Phase of the Project only, the SU3W pit is assumed to be dewatered to SU3N and therefore reports to YT-24 for this phase. During the Closure and Post-closure Phases of the Project, the SU3W pit is assumed to discharge to Halfway Creek drainage once full.
- Halfway Creek - proposed mine footprints in the Alpha WRSF and Kona pit sub-watersheds report in the direction of Halfway Creek. Halfway Creek reports directly to the Yukon River.
  - HC-2.5 - The HC-2.5 water balance node is situated roughly mid-drainage on Halfway Creek (catchment area ~15 km^2). The water balance node is downstream of the principle points of discharge from the Alpha WRSF and Kona Pit/Beta temporary WRSF and the proposed diversion around the Alpha WRSF.
  - HC-5.0 - The HC-5.0 water balance node is situated immediately upstream of the Halfway Creek-Yukon River confluence. Drainage area reporting to HC-5.0 is approximately 30 km^2.
- Yukon River
  - The WBM accounts for flow and tributary mixing at three locations on the Yukon River: Yukon River downstream of Coffee Creek, Yukon River downstream of YT-24 and Yukon River downstream of Halfway Creek.



COFFEE GOLD MINE
Water Balance Model Nodes and Project Catchment Areas
Dawson City
Stewart Crossing
Pelly Crossing
Map Extent
0 25 50
Kilometres
Legend
Water Balance Model Node
Municipality
Highway
Catchment Boundary
Project Footprint
Waterbody
Watercourse
Elevation Contours (100m)
Yukon River Barge Route
Yukon River Ice Road
Winter Road
Mine Site Access Route
Northern Access Route
Pre-Mine Catchment Area
Halfway Creek
Latte Creek
YT-24 Creek
Coffee Creek
Proposed Infrastructure
WRSF
Backfill
Total Pit Outline
ROM Stockpile
Organics Stockpile
Frozen Soil Storage Area
Event Pond
Heap Leach Access Disturbance Footprint
Heap Leach Pad Base
Haul Road
Support Infrastructure
N
1:75,000
0 1 2 3
Kilometers
NAD 1983 UTM Zone 7N
Figure 2.2-2
Date: Mar 23, 2017
Drawn by: GM
Reviewed: AS
GOLDCORP
580000
585000
590000
595000
600000
6985000
6980000
6975000
6970000
Yukon River
Independence Creek
Dan Man Creek
Halfway Creek
Toulouse Creek
Ballarat Creek
YT-24
Latte Creek
Coffee Creek
YRdsHC
HC-5.0
YRdsYT24
YT-24
HC-2.5
YRdsCC
CC-4.5
CC-1.5
CC-3.5
CC-0.5
Halfway Creek Catchment
YT-24 Catchment
Latte Creek Catchment
Coffee Creek Catchment

2.2.3 BASE CASE MODEL AND SENSITIVITIES

For the Surface Hydrology IC analysis, the model was first run for a Natural Flow case to produce a baseline streamflow time-series. Next, the WBM was run again with mine footprints and associated water management turned on in the WBM (refer to **Figure 1.1-2**, mine footprints), to represent the year-over-year influence on the Project. These two outputs (Natural Flow vs. Base Case) may then be compared to one another with Project-related streamflow changes being assessed against Natural/baseline conditions. As outlined in **Appendix 12-C**, WBM model outputs were averaged on a monthly basis, and the predicted streamflow alterations were calculated as a percent change from the Natural Flow condition, as follows:

$$\%\Delta Flow = \left(\frac{Base\ Case\ Flow - Baseline\ Flow}{Baseline\ Flow}\right) x\ 100 \qquad \text{[Equation 2]}$$

Natural- and Base Case flow predictions are compared to one other in this IC assessment, with streamflow changes summarized using indicators. The indicators selected are common metrics used to describe the streamflow regime (e.g., Direction, Magnitude, Timing, Frequency; refer to Poff et al., 1997), and each has a direct physical linkage to the proposed Project activities, as well as associated VC or ICs (e.g., low flows may be altered by waste rock placement, both of which are linked to surface water quality, and fish and fish habitat) unto which the Surface Hydrology IC is related. Overall, the basis of the change characteristic ratings was informed by measurement error for the surface hydrology discipline and instream flow assessment methods/directional documents:

- Measurement error associated with the surface hydrology discipline was assumed to be +/-5%. Therefore, predicted changes lesser in magnitude than +/-5% were assigned a rating of Negligible (NG) as those predicted changes fall within measurement error. The highest data grade described by the British Columbia Manual of Hydrometric Standards is assigned to data gathered by a rated structure (e.g., flume, weir), with a rating accuracy of <5% (error) (Resources Information Standards Committee (RISC) 2009). The next highest data grade is for an ideal stream cross-section, and assumes that the rating accuracy is <7% (error).
- Magnitude ratings of Low (greater than 5% but less than 10%) Moderate (greater than 10% but less than 20%) and High (greater than 20%) were established in the Surface Hydrology IC Report accordingly. Instream flow needs literature informed the selected rating. For example, the AB Desktop IFN method (Government of Alberta, 2011) recommends that in the absence of site-specific information and to achieve an ecologically protective flow regime that no more than a 15% reduction in natural flow (for months seeing appreciable runoff) should occur. DFO 2013 indicates that the probability of degradation to ecosystems sustaining fisheries increases with increasing alteration to the natural flow conditions. Further, the document indicates that cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river relative to a “natural flow regime” have a low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries.

It is important to note that all streamflow output from the water balance model were provided to water quality and fish and aquatic habitat discipline leads for additional assessment. Thus, the High, Moderate and Low ratings used in the Surface Hydrology IC Report are screening level values intended to guide assessments completed by others – but are not intended to represent the results of a detailed WQ-flow or fish-flow assessment.

3.0 EXISTING CONDITIONS

The information in this section establishes the context for the analysis of Project-related changes to the Surface Hydrology IC, specifically within the LSA, but also within the context of the broader RSA. It describes the pre-Project or baseline condition (i.e., conditions prior to interaction with the Project) of the Surface Hydrology IC. This information includes the regulatory and legislative structure that will guide the Project assessment and licensing processes as well as guidance and technical standards published by both the territorial and federal governments that informs the work undertaken to support the relevant applications. Also relevant is the information collected as part of the Traditional Knowledge surveys conducted on Goldcorp's behalf in support of the Project Proposal. Finally, several sources of scientific information were relied upon to characterize the baseline conditions at the Project site. An extensive baseline streamflow dataset exists for the project, with record up to five years in length available for some basins. This data allowed a highly-detailed characterization of the baseline streamflow regime and its linkages to the site climate data, basin physiography, etc. to be elucidated. This data was extended over a longer time period using the regional datasets from the territorial and federal hydrometric networks.

A growing body of literature is available that summarizes hydro-climatic conditions in the Yukon River basin, peak flow analyses for the Yukon and conterminous basins in Alaska, climate change projections for the Yukon out to the year 2100, current trends in temperature, precipitation and streamflow, and the drainage response of waste rock storage facilities in cold climates. Much of this information was drawn on to produce the Baseline Hydrometeorology Report (**Appendix 8-A**), and to conceptualize and calibrate the site-wide WBM (**Appendix 12-C**), both of which form the foundation of the Surface Hydrology analysis. Highlights from those documents are presented in this section of the report.

3.1 REGULATORY CONTEXT

The management, use and discharge of water from a mine site is governed by several pieces of territorial and federal legislation. The primary territorial acts are the *Quartz Mining Act* and the *Waters Act* (**Table 3.1-1**). The application information requirements for a licence under both acts overlap substantially, and the regulation of mining activities is integrated across all environmental disciplines. Thus, the analysis for the Surface Hydrology IC must take these regulatory requirements into account, through the mine plan, water management plans (including discharge of effluent) and operational monitoring and reporting plans. As an extension, some of the mitigation measures proposed to offset a change in this IC will be informed by the regulatory requirements.

At the federal level, the assessment of Project-related changes is informed by YESAA, which co-ordinates the assessment of major projects under a single review that is jointly administered by both the federal and territorial governments. The discharge of mine effluent is governed under the *Fisheries Act*, and specifically by the *Metal Mining Effluent Regulations* (**Table 3.1-1**), which impose limits on the discharge of deleterious substances for any mine that exceeds a discharge rate of 50 m^3/day (from all final discharge points). As the management of mine water discharge often focuses primarily on the effluent water quality, the effluent discharge rates (and thus the potential changes to Surface Hydrology) are determined based on a combination of the effluent discharge limits, and the resultant water quality in the receiving streams. The *Navigation Protection Act* regulates activities that may affect the navigability of those water bodies listed in the Schedule of Navigable Waters, including dewatering (s.23). The Yukon River is listed in this Schedule, and thus is subject to the provisions of the act.

Table 3.1-1 Summary of Applicable Legislation and Regulatory Frameworks for Surface Hydrology, Coffee Gold Mine

Territorial Acts and Regulations	Citation
Public Health and Safety Act • Drinking Water Regulation (OIC 2007/139)	RSY 2002, c. 176
Quartz Mining Act • Quartz Mining Land Use Regulation (OIC 2003/64) • Security Regulation (OIC 2007/77) • Quartz Mining Fees and Forms Regulation (OIC 2009/28)	SY 2003, c. 14
Waters Act • Waters Regulation (OIC 2003/58)	SY 2003, c. 19
Federal Acts and Regulations	**Citation**
Canada Water Act	R.S.C 1985, c. C-11
Navigation Protection Act	R.S.C 1985 c. N-22
Canadian Environmental Protection Act, 1999 • Pollutant Discharge Reporting Regulations (SOR/93-351)	S.C. 1999, c. 33
Fisheries Act • Metal Mining Effluent Regulations (SOR/2002-222)	R.S.C. 1985, c.F-14
Yukon Environmental and Socio-Economic Assessment Act • Accessible Activities, Exceptions and Executive Committee Projects Regulations (SOR/2005-379) • Decision Body Time Periods and Consultation Regulations (SOR/2005-380)	S.C. 2003, c. 7
Guidance Documents	**Citation**
Plan Requirement Guidance for Quartz Mining Projects	Yukon Water Board 2012
Guidance Document on Water and Mass Balance Models for the Mining Industry	Golder 2011
Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada	DFO 2013
Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators	BC Ministry of Environment 2012
Manual of Standard Operating Procedures for Hydrometric Surveys in British Columbia	RISC 2009

3.2 BACKGROUND INFORMATION AND STUDIES

The next sub-sections present traditional knowledge, scientific information and baseline monitoring results relevant to the Surface Hydrology discipline.

3.2.1 TRADITIONAL KNOWLEDGE

As outlined in Section 1.0, Goldcorp has undertaken an engagement and consultation process, as defined under section 50 (3) of *YESAA*, to support the scoping of issues for the Project (see **Section 3.0 Consultation and Engagement** of the Project Proposal for details on the consultation program). Goldcorp continues to consult and engage with affected First Nations and communities, government agencies, and persons or other stakeholders who may be interested in the Project and its related activities.

Clear from the consultation and engagement process is a strong supporting basis for including Surface Hydrology as an IC for the Project. However, as the measurement and characterization of Surface Hydrology is primarily a numerical exercise, there was limited quantitative information in the Traditional Knowledge database that could be incorporated into either the baseline hydrology report or the analysis of Project-related changes.

3.2.2 SCIENTIFIC AND OTHER INFORMATION

Multiple additional sources of scientific information were relied upon to inform the baseline characterization of the Project area, the projected future climatic and streamflow conditions that may result from ongoing climatic change, and the conceptualization and calibration of the site wide WBM.

Relevant regional streamflow and climate data have been collected near the Coffee Gold Mine for decades. Twenty-two regional climates stations with daily records that are located in both Alaska and the Yukon were incorporated into the baseline study. The longest record available is from Dawson, beginning in 1901. Sixteen hydrometric stations from the Water Survey of Canada (WSC) and Yukon Hydrometric networks were also incorporated in the baseline analysis. Three of these stations have daily records beginning in the 1950s (Stewart River, Pelly River and the Yukon River). These data sets were relied upon to set the context for the site-specific baseline data, and specifically to do the following (refer also to **Appendix 8-A**):

- Extend the site records using statistical methods to produce reconstructed daily records of streamflow and climate for input to the WBMs (i.e., site-wide WBM and HLF)
- Generate recurrence interval estimates of peak flows, rainfall and snow melt events
- Produce trend analyses of the relevant streamflow and climate metrics to inform scenarios run for the Post-closure Phase.

Several examples are provided below of where existing peer-reviewed literature and government guidance documents were relied upon to describe:

- The winter aufeis formation at site (e.g., Yoshikawa et al. 2007)
- Infiltration to waste rock storage facilities in cold climates (e.g., Neuner et al. 2013)
- Peak flow estimates (e.g., Curran et al. 2003, Janowicz 1989)
- Low flow estimates (e.g., Smakhtin 2001, WMO 2009)
- The synoptic drivers of the regional precipitation regime (e.g., Cassano and Cassano 2010)
- Regional climate and winter temperature inversions (e.g., Wahl et al. 1987)
- Current and projected climatic changes for the Yukon (e.g., Werner et al. 2009)
- The conceptualization of a watershed model for small drainages (e.g., Christophersen and Seip 1982).

3.2.3 BASELINE STUDIES CONDUCTED DURING THE PROJECT'S FEASIBILITY PROGRAM

Summarized in **Table 3.2-1,** several studies have been undertaken to inform the Feasibility Study (JDS, 2016), YESAB application and subsequent Quartz Mining Licence and Water Use Licence. These studies employed current best practices for streamflow monitoring as outlined in the *Manual of British Columbia Hydrometric Standards – Version 1.0* (RISC 2009), and water balance modelling as detailed in the *Guidance Document on Water and Mass Balance Models for the Mining Industry* (Golder 2011).

Table 3.2-1 Summary of Desktop and Field Studies Related to Surface Hydrology

Study Name	Study Purpose, Duration and Spatial Boundaries
Hydro-meteorology baseline study	Baseline climate and streamflow data were collected from a climate station (4 year record), 18 snow courses (4 year record) and 11 hydrometric stations (2-5 year records) located at the Project site (within the RSA). Refer to **Appendix 8-A**.
Heap Leach Water Balance Model	A modelling exercise specific to the HLF footprint was undertaken for the Feasibility Study (JDS, 2016) to determine make-up water requirements, pond volume requirements, drain down period, water treatment requirements, *etc*.
Site-wide Water Balance Model	A site-wide WBM was assembled that incorporates the HLF water balance model, all Project area drainages, and all mine components (e.g., WRSFs, open pits, water conveyance and storage infrastructure). This model was calibrated to the baseline climate and streamflow data, and runs on a daily time-step, from pre-mine condition, through to the Post-closure Phase. Refer to **Appendix 12-C**.

Overall, the objectives of the baseline hydro-meteorology study were to:

- Collect high-quality climate and streamflow data from a suite of Project area watersheds
- Describe runoff generation processes in the context of local climate conditions (e.g., snow accumulation, timing of snowmelt, basin response to summer rainfall) and physiography (e.g., basin size, basin storage, the influence of permafrost, land cover, elevation and aspect)
- Calculate relevant metrics for local watersheds, including annual/monthly runoff depths, low flows, peak flows and unit yields by drainage basin
- Combine site-specific climate/hydrometric data with regional data sources (i.e., Alaska/Yukon climate and flow monitoring data), to better estimate inter-annual streamflow variability and recurrence intervals for low and peak flows
- Generate the synthetic climate and hydrology datasets that will inform economic/engineering studies (e.g., HLF design) and be used to construct and calibrate the site-wide water balance and water quality model being developed for the Project environmental impact assessment and licensing processes
- Place the existing baseline data and reconstructed climate and discharge records into the context of ongoing and projected climate change.

Surface hydrology is likely to be directly affected to some degree by the construction, operation, reclamation and closure of the Project. The measurement (i.e., amount of flow, timing) of surface water discharge is a well-established science, and is governed by rigorous standards (e.g., RISC 2009). A robust, high-quality and relatively long-duration streamflow dataset was established within the Project LSA and RSA and is fully described in **Appendix 8-A**. Data used to characterize the baseline Surface Hydrology regime for the Project LSA and RSA was sourced from the following hydrology and climate stations:

- Eleven Project-specific hydrometric stations spanning a wide range of drainage areas
- Three Project-specific climate stations at various elevations (two tipping bucket rain gauges were installed in 2015 to define the precipitation/elevation gradient at site)
- Eighteen Project-specific manual snow courses
- Twenty-two regional climate stations operated by various agencies
- Two regional snow courses and six snow pillows operated by the Yukon Territorial Government and the National Oceanic and Atmospheric Administration, respectively, and
- Sixteen regional hydrometric stations operated by the WSC.

The baseline Surface Hydrology monitoring study was initiated at the Coffee Gold Mine in autumn 2010 with three stations (HC-5.0, CC-3.5 and IC-4.5) instrumented to collect continuous water level data. The network of continuously recording stations was expanded in 2014 to include an additional eight stations where spot flow measurements had been made coincident with water quality sampling since 2010. In general, new stations were located in close proximity to the resource and downstream of proposed mine footprint areas. **Table 3.2-2** summarizes station nomenclature and drainage characteristics for Coffee Gold Mine surface water monitoring stations. Furthermore, **Figure 3.2-1** shows the location of these monitoring stations with respect to proposed Project infrastructure and mine footprints.

Table 3.2-2 Coffee Gold Mine Surface Water Monitoring Stations and Drainage Basin Characteristics

Station ID	Drainage Area (km^2)	Mean Elevation (m) above asl)	Min Elevation (m)	Max Elevation (m)
CC-0.5a	385.6	1,023	446	1,707
CC-1.0lw	3.4	1,017	732	1,302
CC-1.5a	23.1	1,120	712	1,379
CC-3.5a	69.8	969	447	1,379
CC-4.5a	484.0	993	427	1,708
CC-5.0ls	6.2	1,221	1,042	1,394
CC-5.5ls	3.4	1,236	1,056	1,394
CC-6.0l	9.6	1,225	1,042	1,394
CC-7.0lrs	124.7	1,010	514	1,656
CC-8.0lrs	18.2	1,300	1,008	1,666
CC-8.5lrs	214.8	1,058	512	1,707
HC-2.5a	14.8	1,043	664	1,343
HC-5.0a	27.0	885	428	1,344
IC-0.5as	68.9	1,048	522	1,529
IC-1.5a	81.1	1,077	522	1,708
IC-2.5a	17.3	1,003	493	1,344
IC-3.0as	18.3	905	465	1,299
IC-4.5a	222.3	989	427	1,708
YT-24l	11.8	838	428	1,293

Notes:

[a] Monitoring station established by Access Consulting Group in autumn 2010.

[l] Monitoring station established by Lorax Environmental in spring 2014.

[w] Discharge measured by V-notch weir

[r] Monitoring stations located south of the Project. Stations monitored between August 2014 and August 2015 only.

[s] Spot flow monitoring station only.


COFFEE GOLD MINE
Surface Water Monitoring Stations
Dawson City
Stewart Crossing
Pelly Crossing
Map Extent
Kilometres
Legend
Surface WQ Monitoring Station
Surface and Hydrology Monitoring Station
Weather Station
Municipality
Project Footprint
Highway
Yukon River Barge Route
Yukon River Ice Road
Winter Road
Mine Site Access Route
Northern Access Route
Watercourse
Waterbody
Proposed Infrastructure
WRSF
Backfill
Total Pit Outline
ROM Stockpile
Organics Stockpile
Heap Leach Pad Base
Event Pond
Heap Leach Access Disturbance Footprint
Haul Road
Frozen Soil Storage Area
Support Infrastructure
N
1:125,000
Kilometres
NAD 1983 UTM Zone 7N
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Figure 3.2-1
Date: Mar 21, 2017
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Reviewed: CF
GOLDCORP
YUK-5.0
IC-4.5
IC-3.0
IC-2.5
IC-0.5
IC-1.5
HC-5.0
YT-24
HC-2.5
Airstrip
KAM-MET-STN
YUK-2.0
CC-4.5
CC-3.5
CC-0.5
CC-1.0
CC-1.5
CC-5.5
CC-6.0
CC-5.0
Yukon River
Kirkman Creek
Carlisle Creek
Independence Creek
Dan Man Creek
Halfway Creek
Latte Creek
Coffee Creek
Excelsior Creek
Canadian Creek
Discovery Pup
Toule Creek

Gauged watersheds at the Coffee Gold Mine range in size from approximately 3 to 500 km^2; eight of the watersheds being monitored have drainage areas of less than 25 km^2. Watercourses potentially affected by the Project, including Halfway Creek, Latte Creek, Independence Creek, Coffee Creek and YT-24 (unnamed tributary to Yukon River), were all gauged as part of the baseline study. In addition to capturing a range of drainage areas, the watersheds gauged for the baseline hydrology study differ in elevation characteristics (i.e., mean catchment elevations range 800 to 1,300 m asl) and represent varying aspects as well.

3.2.3.1 Hydrometric Methods and Extension of Site Data

Continuously-recording hydrometric stations were instrumented with metric staff gauges, and surveyed to three benchmarks on an annual basis. Pressure transducers were housed in perforated stilling wells, and recorded water level at 15-minutes intervals. Manual measurements of stage and discharge were made on a monthly basis to coincide with the water quality sampling campaign, and these measurements were used to construct rating curves. Using these curves, a continuous discharge record was computed for each hydrometric station using the stage-discharge relation and the continuous water level record.

As part of the baseline hydrology study, site- and regional hydrometric data were analyzed in combination to: place the relatively short period of record for Coffee Gold Mine drainages into a broader context; generate long-term (i.e., 30+ year) synthetic discharge records for the Project area, and; to compute robust flow metrics (e.g., instantaneous peak flows, low flows for various return periods) from the combined site and regional information. These metrics were used to inform engineering and design studies related to the mine and the Water Management Plan (**Appendix 31-E**), and to construct and calibrate a site-wide water balance and water quality model for the Project.

Frequency analysis was used to estimate the recurrence of discharges of a particular magnitude for all regional hydrometric stations near the Project. As outlined in **Appendix 8-A**, the annual time-series of instantaneous maximum discharge values for the regional stations was assembled for the peak flow analysis. For the low flow analysis, daily discharge data from eleven of the selected regional hydrometric stations were downloaded from the WSC data portal and seven-day rolling averages were computed from the daily discharge data. The annual minima time-series of the winter and June-September 7-day average low flows were then assembled for the frequency analysis.

The high-quality discharge records available for the Project site allowed synthetic discharge time series to be constructed for 11 project hydrometric stations using regional streamflow data as a driver. Synthetic streamflow records allow the site-specific characteristics of the Project basins to be retained in a longer-term record, while preserving any regional inter-annual variability in discharge. This allows for more robust recurrence interval estimates of critical discharge regime metrics (e.g., mean annual runoff, seasonal runoff distribution, low-flow metrics), and also maintains the regional inter-annual variability in streamflows resulting from multi-decadal climate cycles (e.g., Pacific Decadal Oscillation, Arctic Oscillation) and trends (e.g., increasing winter low flows).

As described in **Appendix 8-A**, statistical methods were used to assemble the synthetic streamflow records. The hydrometric record from the Indian River above the Mouth WSC gauge (09EB003) was used as the predictor basin for all synthetic hydrographs, and was selected based on the following criteria: the drainage basin is situated north of Coffee Creek, but south of Dawson; record period of sufficient length and completeness to capture the full-range of inter-annual streamflow variability over the last 30 years; and the record provides a good representation of all relevant components of the site hydrographs (i.e., rapid freshet, multiple rainfall driven peaks during the summer and early fall, and extended winter base flows of <1 L/s/km^2). These data were then used as the calibration targets for the site-wide water balance model. This approach confirms that the conceptual model accurately represents the physical processes that drive the local streamflow regime, and by extension, the expected changes to the Surface Hydrology IC resulting from Project development.

The regional hydro-climatic data are also descriptive of the proposed NAR alignment. The proposed road lies within the area represented by the regional data, and two of the barge crossings are situated on rivers gauged by the WSC (Yukon River and Stewart River). Information on peak flows and high-magnitude storm events presented in **Appendix 8-A** informed the design criteria for all stream crossings (e.g., sizing of culverts and bridges). Finally, the road crosses the Indian River, which was used as the surrogate discharge record from which to extend the Project site hydrometric data, as discussed above.

3.3 DESCRIPTION OF EXISTING CONDITIONS

At the Project site, local patterns of streamflow are dominated by a snowmelt freshet that typically occurs late-April to mid-June, and punctuated by multiple rainfall-induced high-flow events that occur throughout the summer and autumn. In general, these high-flow events are short lived, often persisting for a duration of one or two days. A plot showing the unit yields for all Project drainages, for their periods of record, is presented in **Figure 3.3-1**.

Average unit yields across the Project site are 9 L/s/km^2 for the open water season (May to October), ranging from 4.5 to 15 L/s/km^2, depending on the drainage. The YT-24 and CC-1.0 drainages that drain the proposed north and south mine area catchments respectively have lowest yields, while Upper Latte Creek (CC-6.0 and CC-1.5) and Independence Creek at the Mouth (IC-4.5) have the highest yields.

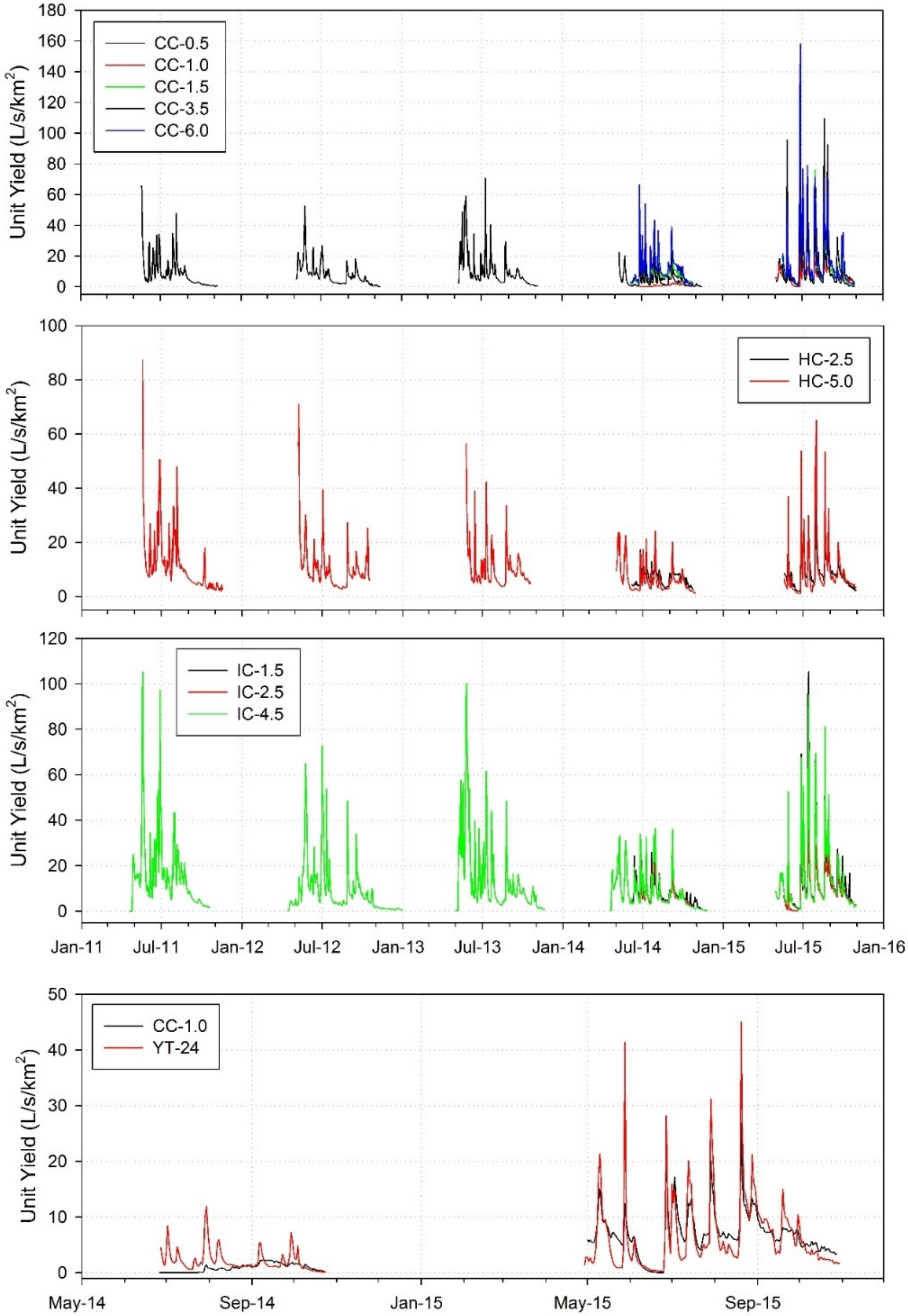


Figure 3.3-1 Unit Yield Hydrographs for Gauged Project Basins

3.3.1 Annual Runoff

Table 3.3-1 presents the annual runoff data in tabular format, for both the measured period of record (2011-2015) and the synthetic record (1982-2015).

Mean annual runoff (MAR) estimates at the Project site vary from basin to basin. For example, the runoff generated by YT-24 is low and approximately 60 mm based on measurements recorded in 2014 and 2015 (**Appendix 8-A**). In contrast, runoff generated in the headwaters of Latte Creek are comparatively high and estimated to be 160 mm based on the 2014 and 2015 field campaigns. MAR for CC-6.0, a high-elevation headwater station within the Latte Creek drainage shows an even higher MAR value. It is clear from the data presented in **Table 3.3-1** that 2014 was an abnormally dry year, and the average runoff values from stations with shorter records will be skewed as a result.

The reconstructed annual runoff values in **Table 3.3-1** represent a longer record (33 years), and therefore a wider range of wet and dry years. As a result, the reconstructed average annual runoff values tend to be higher than average runoff calculated from the measured data. The stations with two years of measured data have reconstructed averages that are 56% higher than the measured values, while the stations with five years of measured data have reconstructed averages that are 7% lower than the measured values. The annual runoff varies by three to seven times over the period of record, depending on the station. This reconstructed series was used to calibrate the site-wide WBM, and so that the model represented the inter-annual runoff variability faithfully, and by extension, provided a robust estimate of the likely changes to the existing streamflow regime resulting from Project development.

Table 3.3-1 Mean Annual Runoff for Coffee Gold Mine Gauged Watersheds

Station ID	Measured Annual Runoff (mm)						Reconstructed Annual Runoff (mm)		
	2011	2012	2013	2014	2015	Average	Minimum	Average	Maximum
CC-0.5		--	--	99	236	167	74	231	446
CC-1.0		--	--	9	110	60	27	76	147
CC-1.5		--	--	123	210	166	120	272	494
CC-3.5	134	132	168	70	156	132	56	126	232
CC-6.0		--	--	148	264	206	196	382	670
HC-2.5		--	--	81	127	104	98	191	326
HC-5.0	183	155	131	97	133	140	54	141	263
IC-1.5		--	--	114	207	160	100	240	444
IC-2.5		--	--	74	135	104	60	153	276
IC-4.5	253	200	255	156	216	216	70	179	342
YT-24		--	--	23	97	60	26	92	180
Average		162	185	90	172	136	80	189	347

MAR estimates were regressed against mean basin elevation (m), and a robust relationship between runoff and elevation was ascertained. This relationship is shown for Project site drainages in **Figure 3.3-2**. Overall, these data underscore the importance of elevation as a control on runoff generation at the Project site.

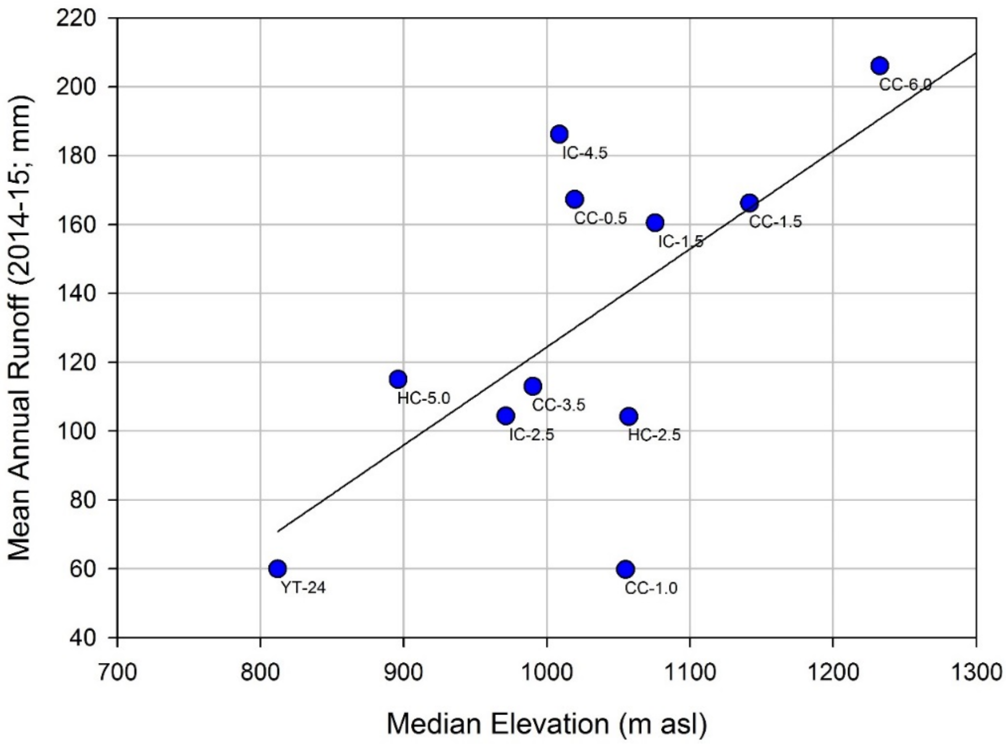


Figure 3.3-2 Mean Annual Runoff for the Open Water Season Plotted Against Median Basin Elevation (2014-2015).

3.3.2 MONTHLY RUNOFF DISTRIBUTION

At the Project site, the dominant drivers of runoff during the open water season are the spring snowmelt during the months of May and June, and intense convective rainfall that occurs frequently during the months of June through September. During the open water season, the recession limbs of local hydrographs are often steep following the passage of a large rain event and the associated peak flows. Low-flow conditions can occur intermittently during the summer and early autumn across the Project site, with unit yields during early summer often approaching those measured during the winter months. The average monthly runoffs as a percentage of the annual total are presented in **Figure 3.3-3**.

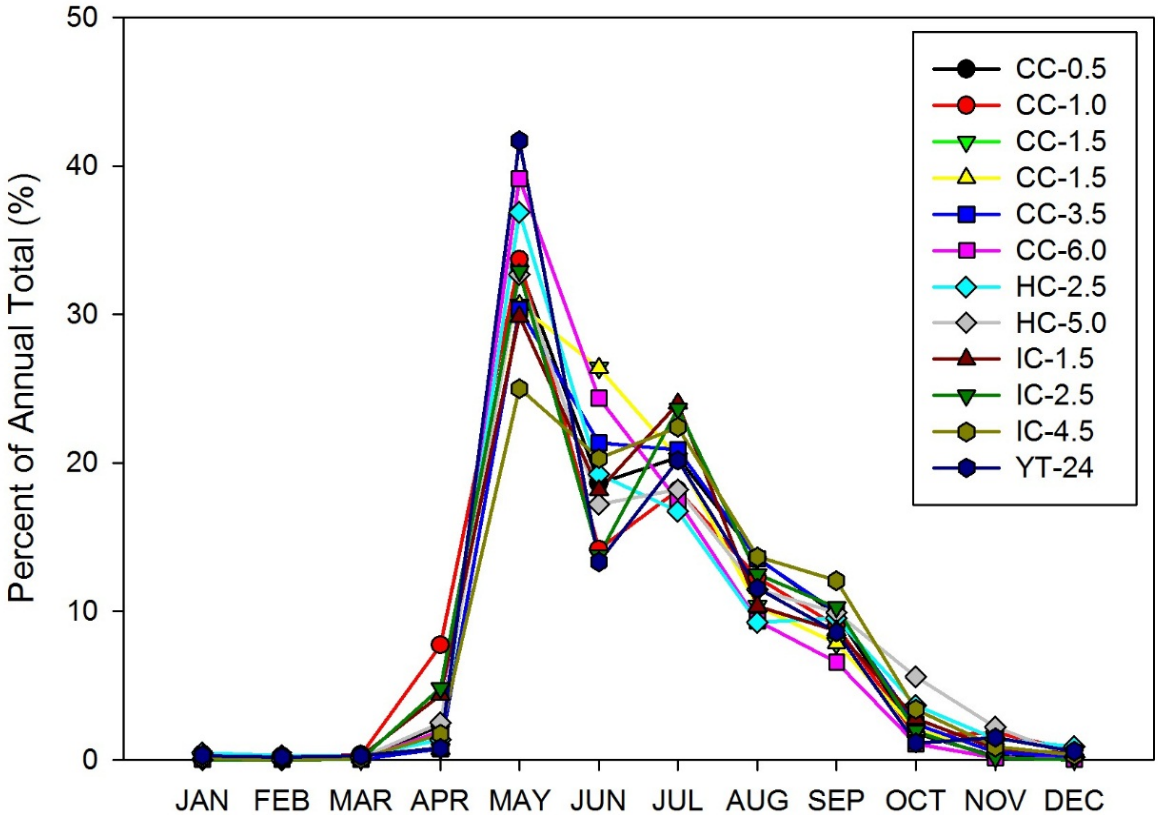


Figure 3.3-3 Monthly Runoff Distribution as Percent of Annual Total for Project Hydrometric Stations.

Table 3.3-2 presents the same information as **Figure 3.3-3** in the standard runoff, discharge and unit yield metrics. For reference, the mean annual discharge and 30% MAD metrics are presented for each station, and the months where streamflows naturally drop below this threshold are highlighted. A key finding for the Project area is that months of November through March fall below the 30% MAD threshold, while months of April through October exceed the 30% MAD threshold at each monitoring location shown. As discussed in Section 3.2.2.3 of **Appendix 8-A**, channel icing (aufeis) is extensive in the LSA during the winter months, and serves to limit or exclude fish during this period. This information is used to focus the Surface Hydrology change assessment, as the winter months currently experience severe flow reductions as the result of natural processes. It is challenging to collect data on streamflows during the winter months, assuming that flow is even present, and as discussed in Section 3.4.2, where available, these measurements are subject to a high degree of potential error. Therefore, the primary focus of this change analysis will be on potential flow alterations during the open water season.

Table 3.3-2 Monthly Streamflow Metrics for the Coffee Gold Mine Area

Station	Area (km^2)	Units	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAD	30% MAD
CC-1.5	23.1	mm	0.70	0.74	1.39	23.45	77.92	32.20	35.36	27.13	23.34	11.71	2.47	1.39		
		m^3/s	0.01	0.01	0.01	0.21	0.67	0.29	0.31	0.23	0.21	0.10	0.02	0.01	0.17	0.06
		$L/s/km^2$	0.26	0.30	0.52	9.05	29.09	12.42	13.20	10.13	9.00	4.37	0.95	0.52		
		% annual	0%	0%	1%	9%	31%	14%	16%	12%	10%	5%	1%	1%		
CC-3.5	69.8	mm	0.65	0.64	1.10	17.24	44.56	20.28	22.23	16.48	14.19	6.32	1.47	0.99		
		m^3/s	0.02	0.02	0.03	0.46	1.16	0.55	0.58	0.43	0.38	0.16	0.04	0.03	0.32	0.10
		$L/s/km^2$	0.24	0.26	0.41	6.65	16.64	7.82	8.30	6.15	5.47	2.36	0.57	0.37		
		% annual	0%	0%	1%	11%	29%	14%	16%	12%	10%	5%	1%	1%		
CC-4.5	484	mm	0.04	0.16	0.81	31.92	57.30	19.10	26.86	20.74	17.97	6.35	0.33	0.16		
		m^3/s	0.01	0.03	0.15	5.96	10.35	3.57	4.85	3.75	3.35	1.15	0.06	0.03	2.77	0.83
		$L/s/km^2$	0.01	0.07	0.30	12.31	21.39	7.37	10.03	7.74	6.93	2.37	0.13	0.06		
		% annual	0%	0%	1%	15%	24%	13%	17%	12%	11%	5%	1%	1%		
YT-24	11.8	mm	0.23	0.21	0.45	24.82	21.79	10.32	12.94	10.21	9.23	2.50	0.44	0.23		
		m^3/s	0.00	0.00	0.00	0.11	0.10	0.05	0.06	0.05	0.04	0.01	0.00	0.00	0.03	0.01
		$L/s/km^2$	0.08	0.08	0.17	9.58	8.14	3.98	4.83	3.81	3.56	0.93	0.17	0.08		
		% annual	0%	0%	1%	25%	22%	12%	15%	12%	11%	3%	0%	0%		
HC-2.5	14.8	mm	1.27	0.99	1.45	12.78	51.58	25.04	26.78	21.72	19.62	10.68	3.50	2.17		
		m^3/s	0.01	0.01	0.01	0.07	0.29	0.14	0.15	0.12	0.11	0.06	0.02	0.01	0.08	0.03
		$L/s/km^2$	0.47	0.41	0.54	4.93	19.26	9.66	10.00	8.11	7.57	3.99	1.35	0.81		
		% annual	1%	1%	1%	7%	28%	14%	16%	12%	11%	6%	2%	1%		
HC-5.0	27.0	mm	0.53	0.43	0.76	14.08	46.63	21.95	24.50	19.72	17.86	8.15	1.94	0.97		
		m^3/s	0.01	0.00	0.01	0.15	0.47	0.23	0.25	0.20	0.19	0.08	0.02	0.01	0.13	0.04
		$L/s/km^2$	0.20	0.18	0.29	5.43	17.41	8.47	9.15	7.36	6.89	3.04	0.75	0.36		
		% annual	0%	0%	0%	8%	29%	14%	16%	13%	12%	5%	1%	1%		

Notes: Months where average discharge falls below the 30% of mean annual discharge threshold are highlighted for reference.

Peak flows at the Project site are driven primarily by the intense convective rainfall events that are common in the summer months, with secondary peaks occurring in late-May, as a result of melting snowpacks. Instantaneous peak flows (as unit yields) are typically between 120 and 200 $L/s/km^2$, although some drainages have recorded peak flows that are much lower and in the 60 $L/s/km^2$ range (e.g., CC-1.0, HC-2.5 and IC-2.5). Peak flows recorded in Upper Latte Creek (e.g., CC-6.0 and CC-1.5) are much larger in magnitude and on the order of 300 to 400 $L/s/km^2$.

3.3.3 Peak Flows

Peak flows at the Project site are driven primarily by the intense convective rainfall events that are common in the summer months, with secondary peaks occurring in late-May, as a result of melting snowpacks. Instantaneous peak flows (as unit yields) are typically between 120 and 200 L/s/km^2, although some drainages have recorded peak flows that are much lower and in the 60 L/s/km^2 range (e.g., CC-1.0, HC-2.5 and IC-2.5). Peak flows recorded in Upper Latte Creek (e.g., CC-6.0 and CC-1.5) are much larger in magnitude and on the order of 300 to 400 L/s/km^2.

As an extension to the peak flow analysis presented using measured data from site, a regional peak flow analysis was conducted using data from the regional hydrometric network (**Appendix 8-A**). Recurrence interval estimates of annual instantaneous peak flows were plotted against drainage area, and an enveloping power law function was then fit to the data. For reference, the measured peak flows from the site data were also plotted, with a separate function fit to these data. The enveloping power law functions derived from the regional data for each recurrence interval (e.g., 1:100 year peak flow) were used to estimate the corresponding peak flow for all Project drainages. The results of this analysis are presented as unit yields in **Table 3.3-3**.

Table 3.3-3 Instantaneous Peak Yield Recurrence Interval Estimates for Project Basins Derived From Regional Analysis (L/s/km^2)

Station	Drainage Area (km^2)	1:2 year	1:5 year	1:10 year	1:25 year	1:50 year	1:100 year	1:200 year	Measured Maximum Peak Yields
CC-0.5	385.6	118	195	288	398	462	570	639	192
CC-1.0	3.4	241	489	805	1,261	1,597	2,132	2,579	50
CC-1.5	23.1	181	337	531	790	966	1,249	1,465	396
CC-3.5	69.8	153	272	418	603	723	918	1,057	141
CC-6.0	9.6	206	400	643	979	1,216	1,596	1,899	310
HC-2.5	14.8	193	368	585	881	1,086	1,415	1,671	81
HC-5.0	27	176	327	514	761	928	1,196	1,399	118
IC-1.5	81.1	149	264	405	582	695	880	1,012	161
IC-2.5	17.3	189	357	566	848	1,042	1,354	1,596	66
IC-4.5	222.3	128	217	325	455	534	664	751	147
YT-24	11.8	200	384	615	931	1,152	1,507	1,786	127

3.3.4 LOW FLOWS

As the summer progresses, baseflows are enhanced by active layer melt and soil moisture recharge. By November, unit yields were observed to drop to 0.5 to 1.5 L/s/km^2 in all Project drainages, and zero flow conditions become widespread by late January and are accompanied by extensive aufeis formation. Aufeis (i.e., frozen groundwater seepage that accumulates within and adjacent to local watercourses) is pervasive in creeks and streams at the Project site. Aufeis melts during the freshet, but may persist into the early summer (mid- to late-June).

A robust characterization of the low flow regime is required to inform potential water quality sensitivities, as well as the potential for shortfalls in water required for process makeup or dust control, for example. Recurrence interval estimates of the minimum 7-day average flow ($7Q_2$ [median], $7Q_5$, $7Q_{10}$ and $7Q_{20}$; subscript indicates recurrence interval in years) for the summer period (June-September) were derived from the synthetic discharge records (**Table 3.3-4**). Due to limited site data available for the winter period, and extensive aufeis conditions documented in Project basins, all available spot flow measurements for the winter months are presented in **Appendix 8-A** for the site stations to give an indication of the expected annual low flow condition.

Table 3.3-4 June – September Minimum 7-day Low Flow Recurrence Interval Estimates From Synthetic Site Records With Values in Unit Yields (L/s/km^2).

Exceedance Probability	Return Period	CC-0.5	CC-1.0	CC-1.5	CC-3.5	CC-6.0	HC-2.5	HC-5.0	IC-1.5	IC-2.5	IC-4.5	YT-24
0.5	1:2 (median)	1.79	0.00	2.49	0.80	2.55	2.83	1.72	1.94	0.75	1.64	0.89
0.2	1:5	0.99	0.00	1.89	0.48	1.51	2.05	0.88	1.13	0.45	0.63	0.77
0.1	1:10	0.72	0.00	1.69	0.38	1.15	1.74	0.62	0.87	0.34	0.34	0.71
0.05	1:20	0.55	0.00	1.57	0.33	0.91	1.52	0.46	0.71	0.28	0.19	0.67

An important component of the winter flow regime at the Project site is the extensive icing of the local channels. This ice growth, or aufeis, is the result of shallow groundwater discharge and/or baseflow in the stream channel freezing. This ice impedes subsequent flow, which is forced on top of the existing ice sheet, where it freezes. This process repeats continuously throughout the winter, and results in laminated ice sheets that can approach 2 m in thickness and 50+ m in width in the Project channels. The aufeis process also acts as a storage reservoir for winter baseflows, and can store up to a third of the cumulative annual baseflow in sub-Arctic watersheds (Yoshikawa et al., 2007).

Aufeis often far exceeds the natural stream channel width in the smaller tributaries, and because ice melts much more slowly than the snowpack, much of the freshet occurs while extensive aufeis is still present. This makes accurate measurement of streamflows (where they exist) challenging or impossible during the winter season at most hydrometric stations, and dangerous during the initiation of freshet. Aufeis may also influence the distribution of annual streamflow, since the baseflow stored in aufeis during the winter months is released during the freshet and early summer periods. Further information on this process, examples and an aufeis distribution map for the Project site are presented in **Appendix 8-A**.

3.3.5 YUKON RIVER

As described in Section 2.2.2, contact waters associated with the Coffee Gold Mine will report passively to Halfway Creek, YT-24 (unnamed tributary) or Latte Creek – a headwater tributary of Coffee Creek. Ultimately, these three receiving creeks (i.e*.,* Halfway, Latte, YT-24) report to the Yukon River, and therefore, an understanding of the Yukon River flow regime is critical.

The Yukon River is gauged at a number of locations in Yukon and Alaska. The WSC hydrometric station Yukon River above White River (09CD001) is situated a short distance downstream of the Coffee Gold Mine (~15 km). Period of record for this station is 61 years (1956-2016), and the drainage area for the basin at the location of the gauge is 149,000 km^2.

The drainage area of the Yukon River at locations relevant to the Project is essentially identical in magnitude. For example, the estimated drainage of the Yukon River above Coffee Creek is 147,317 km^2 (i.e., an area 1.2% less than that area at 09CD001). The Yukon River downstream of Halfway Creek compares within 0.8% of the drainage at 09CD001 and is 147,839 km^2.

Average, minimum and maximum discharge data (period of record, daily) for the Yukon River above White River are shown in **Figure 3.3-4**. These data show that winter flows for the Yukon River are typically 400-500 m^3/s, but may reach winter minima on the order of 250 m^3/s upon occasion. Flows for months May through November, can reasonably be expected to range between 1,000 and 3,000 m^3/s at the Project site, with peak flows in summer months reaching period of record maxima on the order of 2,000 to 8,000 m^3/s.

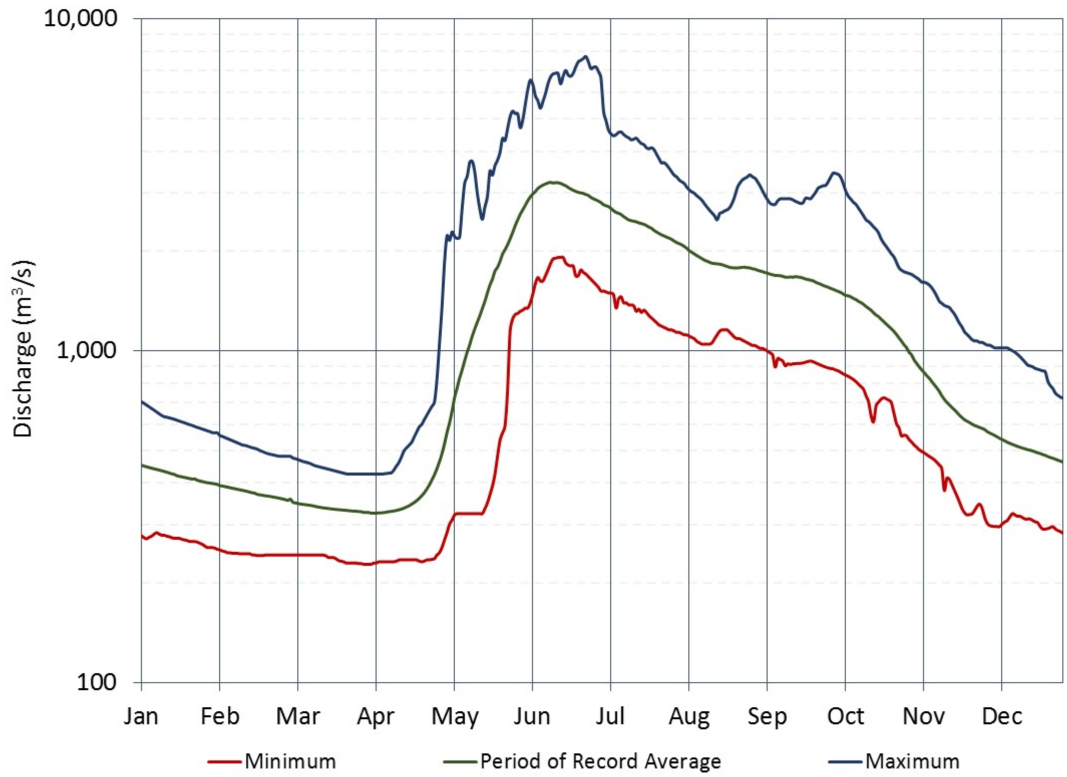


Figure 3.3-4 Daily Average-, Minimum- and Maximum Discharge Data for the Yukon River Above the White River (09CD001; 1956-2015)

3.3.6 NORTHERN ACCESS ROUTE

While the Baseline Hydro-meteorology Study (**Appendix 8-A**) placed emphasis on climate and flow reconstructions for the Coffee Gold Mine Site, the analyses completed under that study are directly applicable to the NAR:

- From **Appendix 8-A**, the monthly climate data shown in **Figure 3.3-5** and **Figure 3.3-6** confirm highly coherent air temperature and precipitation signatures for the regional climate stations within a 200 km radius of the mine site. Monthly magnitudes and annual patterns shown in these plots (e.g., proportionally more precipitation in months June, July and August compared to other months; long cold winters) apply to the NAR and Coffee Project mine site alike.
- Estimates of extreme precipitation (e.g., 1:100 year, 24-hour rainfall), including an estimate of probable maximum precipitation (PMP) for the Project area are presented in appended technical memos (see **Appendix B** and **Appendix C**) to the **Baseline Hydro-meteorology Report (Appendix 8-A)**. A discussion of snowmelt runoff is also included. These outputs were prepared to support design and feasibility studies relating to the Project, including studies at the HLF and along the NAR.

- As summarized in **Section 3.3.3**, a frequency analysis was conducted to estimate the recurrence of discharges of a particular magnitude for all regional hydrometric stations within a 200 km radius of the Project. In the analysis, recurrence interval estimates of annual instantaneous peak flows were plotted against drainage area, and an enveloping power law function was then fit to the data. Much like the extreme precipitation assessments undertaken (**Appendix 8-A**), the peak flow analyses were completed to inform design and feasibility studies, including studies along the NAR.
- A baseline program was initiated along the new section of the proposed NAR beginning in August 2015. Coincident with the collection of water quality samples, spot measurements of streamflow were measured at the proposed road crossings on Ballarat, Maisy May and Blackhills Creeks. These monitoring stations continue to be sampled for flow and water quality on a monthly basis.

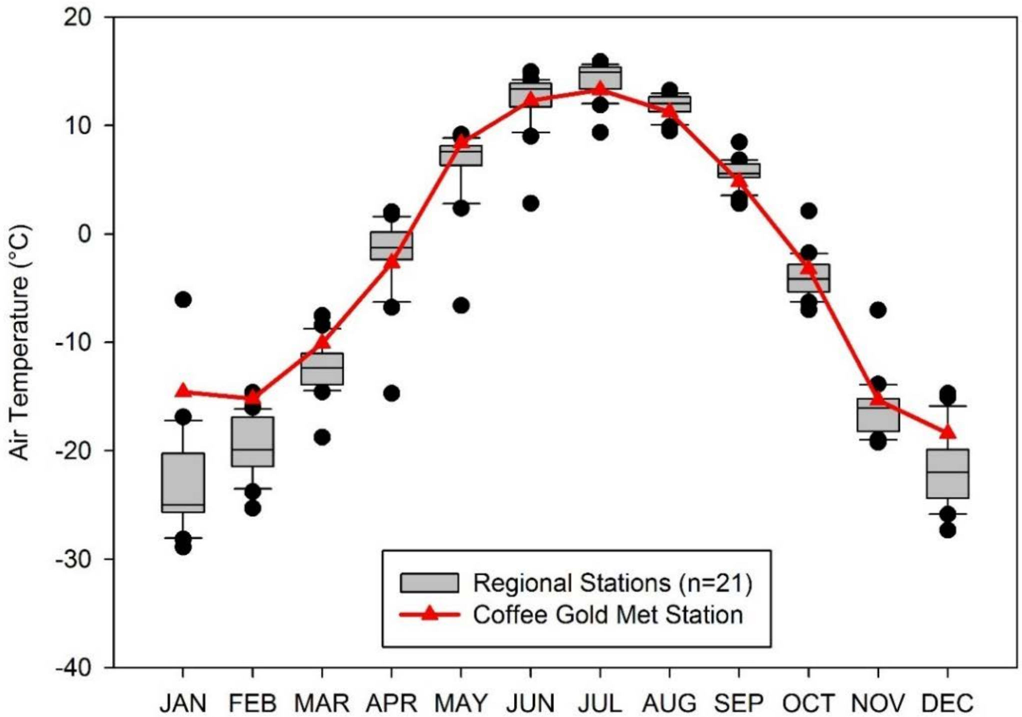


Figure 3.3-5 Monthly Average Temperatures for Coffee Gold Mine (2012-2015) and Surrounding Climate Stations (Period of Record).

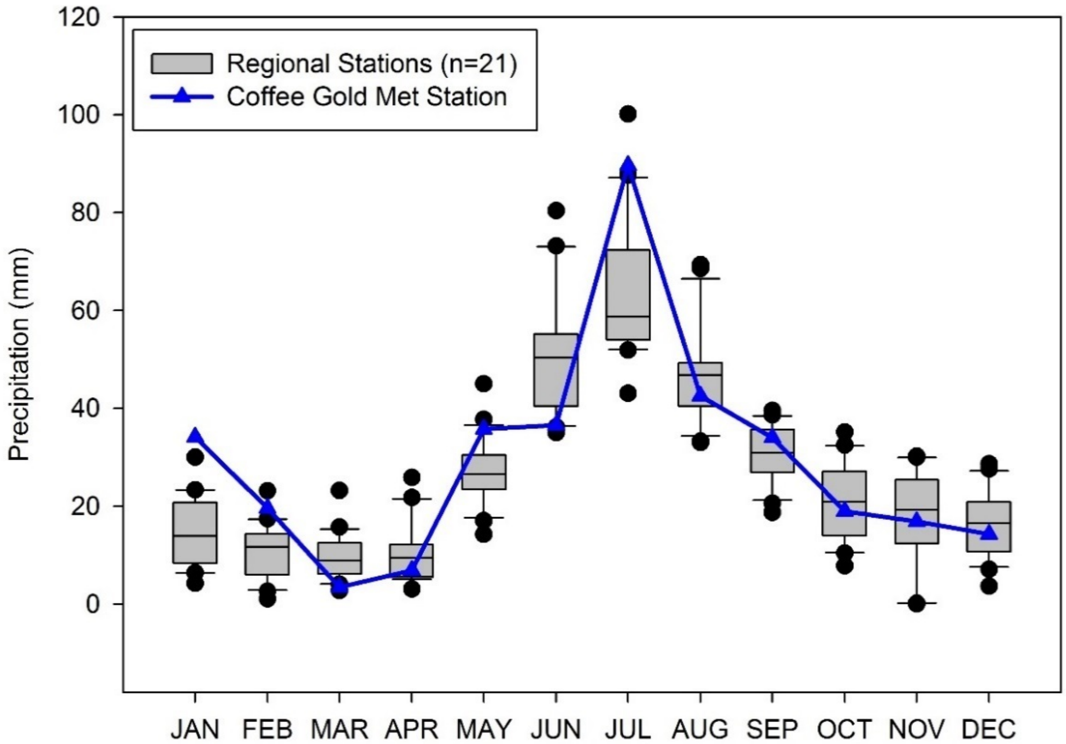


Figure 3.3-6 Monthly Average Precipitation From the Surrounding Climate Stations (Period of Record) and From Coffee Gold Mine (2012-2015)

3.4 SOURCES OF UNCERTAINTY

This section presents a brief overview of the various sources of error and uncertainty that must be considered in the Surface Hydrology IC analysis.

3.4.1 BASELINE STUDY PERIOD

Given the inter-annual variability in natural streamflow regimes and the known relationship between important streamflow metrics and multi-decadal climate cycles (e.g., Arctic Oscillation, Pacific Decadal Oscillation, El Niño Southern Oscillation), the duration of the baseline period is of critical importance when attempting to quantify the baseline condition. As noted in Section 3.3.1, the calculated MAR for the Project watersheds differs markedly depending on whether the station has two or five years of measured data. Thus, streamflow metrics or modelling based on shorter datasets have a higher likelihood of being skewed by anomalous years, as was the case with 2014 (drier than average).

This inherent shortcoming was overcome by employing regional data to extend the site-specific dataset to estimate peak and low flow recurrence intervals. In addition, the Indian River at the Mouth (09EB003) WSC station record was used as the predictor station to create long-term (33 years) records of streamflow for all eleven Project stations. These daily records were then used to calibrate the site-wide WBM, the predictions of which are outlined in this report. These records contain extended periods of wetter and drier than average conditions, which increases the confidence that the WBM can robustly replicate the inter-annual variability in streamflows.

3.4.2 MEASUREMENT ERROR

Measurement of streamflow is a well-defined and rigorous scientific discipline. However, manual measurements are subject to instrument error (e.g., error range of meters, pressure transducer accuracy), and this is particularly true for measurements of flow under ice. The highest data grade described by the British Columbia Manual of Hydrometric Standards is assigned to data gathered by a rated structure (e.g., flume, weir), with a rating accuracy of <5% (error) (RISC 2009). The next highest data grade is for an ideal stream cross-section, and assumes that the rating accuracy is <7% (error). All measurements and hydrometric station installations conform to the highest standard, and all instrumentation was checked and re-calibrated annually. Staff gauges were surveyed on an annual basis, and where necessary, corrections were made to the water level record and rating curves to account for movement of the gauge (e.g., due to frost-jacking).

Due to the extensive channel icing experienced by the Project area streams, the measurement of streamflows is very challenging during the winter months, including the months of April and October. Measurements made under ice cover are subject to increased error due to alterations of the hydraulic relationship present during the open-water season. Additionally, peak freshet flows often occur while there is still ice present in the channels, which in addition to presenting safety concerns, can also alter the water level – discharge relationship. For these reasons, both the measurement and modelling error is assumed to be relatively higher for the months of October through April, and particularly for the November to March period.

3.4.3 RATING CURVES

The rating curves for the Project hydrometric stations are generally quite robust, with most having manual spot flow controls on more than 90% of the measured record. Where the upper end (high-flow) portions of the rating curves were poorly constrained by the manual measurements, the slope-area method was employed to estimate the bankfull discharge associated with the matching water level. Full details of error uncertainty associated with rating curves are provided in **Appendix 8-A**.

3.4.4 MODEL CONCEPTUALIZATION AND ERROR

The exercise of modelling a complex natural system is a fine balance between adequate representation of the processes that drive streamflow (e.g., precipitation-elevation gradients, baseflow partitioning, soil moisture accounting, snow melt), and an intuitive model structure. Simplifying assumptions must be made in the absence of detailed data on some of the processes (e.g., temperature indexed snowmelt algorithms), and predictions made on the potential changes to streamflows resulting from mine development well into the future. A watershed model is considered to be well calibrated if the percent bias is +/-25% for streamflow (e.g., Moriasi et al. 2007). Given that a model is calibrated to the measured data, the errors are assumed to be cumulative. The modelling approach outlined in Section 2.2.3 (and in more detail in **Appendix 12-C**), allows the variability in the model predictions to be quantified, and removes the potential for an erroneous assumption related to the distribution of the input series, or the specific year of the mine life in which a high magnitude wet- or dry-year occurs to affect the predictions. Further detail on the WBM assumptions and inputs is provided in **Appendix 12-C**.

3.5 CLIMATE CHANGE

A large body of research exists on the rate and extent of streamflow changes within Canada's North, and the Yukon River basin in particular. Environment Yukon published *Yukon Water: An Assessment of Climate Change Vulnerabilities* in 2011, which states that:

> "It is clear, however, that Yukon's climate is changing, and so is its hydrologic regime. Over the last several decades, winter and summer temperatures have increased in all regions, and the forecast is for continued warming. Most projections for precipitation suggest increases, particularly in winter. Snowmelt has been starting earlier, particularly in Yukon's mountain streams. The period of snow cover is decreasing, and a continued trend of earlier snowmelt and associated earlier peak flows can be expected. An analysis of global evaporation trends found that higher temperatures could result in greater evaporation, particularly in the North."

Two key documents that provide assessments of climate change for the Project area include The Yukon Climate Change Indicators Report by Streicker (2016) and Climate Change Projections for Coffee Creek Region, Yukon (**Sub-Appendix D1 of Appendix 8-A**). The Streicker (2016) report outlines climate change indicators (objective measures of climate change) and provides ten key findings (simple, high-level conclusions of current research and Traditional Knowledge) as they apply to Yukon Territory. Both the Streicker (2016) and Goldcorp reports present climate projections based on climate forcing scenarios that were published by Intergovernmental Panel on Climate Change in the Special Report on Emissions Scenarios in 2000 (IPCC 2000). The Special Report on Emissions Scenarios A2 scenario, which defines the most rapid increases in emissions trajectories over the next 100 years, was used for projections in both reports. Modeled historical climate averages and future projections are from the Scenarios Network for Alaska and Arctic Planning at the University of Alaska. The main findings of these reports, as they relate to groundwater are summarized below.

Annual precipitation has increased by 6% over the past 50 years in Yukon (Streiker, 2016). Average annual precipitation is projected to increase only marginally to for a valley location modelled at the project site by 2100; however, a larger increase of 20% is forecast for the broader region by 2100 (**Appendix 8-A**). Most of the increase in precipitation is likely to occur in summer and winter, with little change occurring in spring or fall. Streiker (2016) indicates that there is medium confidence that evapotranspiration will increase over the foreseeable future, and that this increase may outpace increases in precipitation. A forecast for evapotranspiration for the Project area has not been conducted; therefore, it is unclear whether increased precipitation will result in increased annual runoff.

Streiker (2016) indicates that the average annual temperature in Yukon has risen by over 2°C over the past 50 years. The current annual average temperature at the Project site is -3°C and is forecast to rise by 3°C to 5°C by the year 2100 (**Appendix 8-A**). The warming is anticipated to be particularly pronounced in the summer and will lead to a later freeze-up in the fall and earlier thaw in the spring. This increase in temperature is likely to have implications on permafrost integrity, which in turn, has implications on groundwater flow paths and baseflow in the regional streams. Streicker (2016) cites this as a key finding – that permafrost is degrading and more thaw is projected, typically resulting in an increase in the depth of the active layer. Streiker (2016) further concludes that climate change is altering streamflow and groundwater flow patterns, and that degrading permafrost increases pathways for groundwater, increasing winter low flows.

A recent study examined the sensitivity of a northern mountainous basin to climate change, and the results are particularly pertinent to the Project watershed. The Wolf Creek Research Basin, located in the headwaters of the Yukon River near Whitehorse, is 179 km^2 in area, and exhibits similar physiographic characteristics to the Project basins, including the proportion that contains permafrost (~43%). Rasouli et al. (2014) used a distributed hydrologic model to estimate the impacts of a changing climate (warming up to 5°C and precipitation changes up to +/- 20%) on the runoff response of the research basin. The authors found that the snow regime was the most sensitive to temperature, and warming of 5°C could not be balanced by a corresponding 20% increase in precipitation. Basin discharge was more sensitive to changes in precipitation, and a 20% increase combined with 5°C warming resulted in snow accumulation, and peak flows decreasing by 20%, annual runoff increasing by 20% and a corresponding increase in the snow-free period, and therefore the evapotranspiration season.

Annual Runoff

In general, annual discharge has remained fairly constant at many of the stations in the Yukon River Basin, albeit with several exceptions – largely related to increased melt of extensive glaciers. However, small changes in headwater systems that may not be statistically significant at the point of measurement are cumulative, and can result in significant positive shifts at a downstream location (Brabets and Walvoord 2009). Janowicz (2008) noted that there was a slight positive trend (not statistically significant) in most of the basins analyzed within both the continuous and discontinuous permafrost zones. This is attributed to a corresponding slight increase in annual precipitation. However, there was a pattern of decreasing annual runoff in the sporadic permafrost zone, which potentially resulted from an increase of evapotranspiration driven by increasing temperatures.

Monthly Distribution

A consistent finding of streamflow trend analyses in Canada's north and North America in general is that the spring freshet is occurring earlier, winter low flows are increasing over time, and summer flow are generally decreasing, albeit at lower rates than the changes in winter and April discharges (e.g., Stewart et al. 2005; **Appendix 8-A**). Brabets and Walvoord (2009) noted significant increases in April streamflow volumes across the Yukon River Basin, and attributed these to a combination of increased winter baseflows, higher winter snowpacks and earlier melt. Related to the thawing of permafrost and the deepening of the active layer during the summer months is the extension of the flow paths from the point of infiltration to point of discharge in surface waters. One result of increased soil water residence time is an increase of autumn flows during the period when streamflows are receding from the open water season, as water infiltrated during the summer months finally discharges to surface. Five of the 12 stations analysed for trends in **Appendix 8-A** showed significant positive trends in streamflow for the month of September, lending support to this hypothesis.

Peak Flows

The trend analysis conducted in support of the Project Proposal (**Appendix 8-A**) found no significant trends for the annual maximum daily discharge at the 12 stations included in the analysis. Janowicz (2008) found a weak trend towards decreasing annual peak flows in the discontinuous permafrost zone. Two possible mechanisms for this were postulated: reduced winter snowpacks and therefore lower volumes of water available for melt during the freshet; or increased infiltration and flow path lengths as a result of degrading permafrost. It was noted in **Sub-Appendix B** of **Appendix 8-A** that the largest snowmelt events in the regional snow pillow record occurred later in the season, when large snowpacks persisted into a period where they are exposed to higher temperatures and solar radiation inputs. Therefore, it is also possible that warming spring temperatures, while resulting in earlier melt, also reduce both the magnitude of the melt as day lengths are shorter, and the volume of snow water equivalent remaining for melt later in the season.

Winter Low Flows

Increases in winter low flows have been observed in streamflow records in the Canadian Northwest Territories (St. Jacques and Sauchyn 2009), and in the Yukon River Basin (Walvoord and Striegl 2007, Brabets and Walvoord 2009). Walvoord and Striegl (2007) analysed long-term streamflow records along the Yukon River Basin and found that winter low flow (i.e. groundwater baseflow) had demonstrated an upward trend of 0.4% to 2.6% per year (normalized to the mean) with an average of 0.9% increase in low flows per year. The increase in winter low flows was not accompanied by an increasing trend in annual flow or precipitation and was consequently attributed to enhanced groundwater pathways arising from melting permafrost. The largest increases were observed in the Porcupine and Koyukuk watersheds, large portions (90-100%) of which are underlain by permafrost. Note that the Project lies in an area of discontinuous permafrost (NRCAN, 2015), and permafrost mapping indicates that 62% of the mapped Project area is underlain by permafrost (EBA, 2016). While positive trends were noted for winter flows for the entire record period analyzed by Brabets and Walvoord (2009), the spatial extent of these trends grew during the warm phase of the Pacific Decadal Oscillation (Mantua et al. 1997). Further analysis indicated that below average winter flows persisted during the cold phase of the Pacific Decadal Oscillation, and above average winter flows during the warm Pacific Decadal Oscillation; however, the long-term trend is consistently towards increasing winter discharges. The analysis presented in **Sub-Appendix D2 of Appendix 8-A** includes several hydrometric records from smaller headwater basins (and with shorter record periods) that were not included in Brabets and Walvoord (2009). The trends toward increasing winter low flows were noted in the analysis completed for the Project submissions for all stations with winter discharge data (n =11).

Overall, the largest trends in winter low flows are noted in basins with continuous permafrost, while the signal in the discontinuous permafrost zone (where the Project is located) is more variable (albeit, still increasing; Janowicz 2008).

Summer Low Flows

Information on summer streamflow trends for the Yukon River Basin is somewhat limited; however, the available research indicates that summer discharge exhibits a decreasing trend in the upper and middle Yukon basins (Brabets and Walvoord 2009). While the correlation between trends in summer flows and the Pacific Decadal Oscillation phase was weaker than for the winter flows, the summer months showed the reverse – above-average flow during the cold Pacific Decadal Oscillation and below-average flow during the warm Pacific Decadal Oscillation.

The streamflow trend analysis presented in **Sub-Appendix D2 of Appendix 8-A** found that trends in summer low flows, where present, were variable. Generally, trends were negative for the months of June through August, although not statistically significant.

3.6 OTHER PROJECTS INFLUENCE ON EXISTING CONDITIONS (PAST AND PRESENT)

While there are placer activities and quartz mining exploration activities in the general vicinity of the Project, there are currently no known projects located within close proximity (i.e., within ~5 km of the Mine Site) that would have the potential to appreciably alter the streamflow regime from the natural condition. Therefore, the baseline data collected in support of the Project Feasibility Study (JDS, 2016), YESAB and licensing submissions is assumed to reflect the true natural streamflow regime. Past, present and future projects are discussed in more detail in Section 5.0 of this IC analysis.

4.0 FUTURE CONDITIONS WITH THE PROJECT

The Surface Hydrology IC may change in the future with the development of the Project. This section of the IC analysis identifies and describes potential interactions between Project activities and Surface Hydrology during Project Construction, Operation, Closure and Post-closure. Furthermore, the section evaluates the potential for adverse Project-related changes to Surface Hydrology arising from each of these interactions.

The focus of the assessment presented in this section of the report is upon those interactions of greatest potential consequence to the Surface Hydrology IC. In terms of scope, the assessment considers discipline interactions with upgrades and construction associated with the NAR, as well those interactions associated with mining (pit development, waste rock storage, gold recovery, and water management) at the Coffee Gold Mine property. The Project Interaction Matrix in the Project Proposal (**Section 5.0 Assessment Methodology**) is formally screened in this section of the report and provides a full inventory of the drivers of change for the Project in the context of the Surface Hydrology IC.

As summarized in **Section 5.0 Assessment Methodology** of the Project Proposal, the Surface Hydrology IC is closely linked to two VCs identified for the Project – Fish and Fish Habitat (Biophysical VC) and Surface Water Quality (Physical Environment VC). Surface Hydrology is also linked to the Groundwater IC (Physical Environment) and two Human Environment VCs (Land and Resource Use, Community Health and Well-being). In this regard, the evaluation of potential Project-related changes on Surface Hydrology forms an integral component of several other effects and change assessments evaluated under this Project Proposal.

In Section 4.1, definitions for potential interaction are introduced and Project activities showing potential Project interaction with the Surface Hydrology IC are screened and discussed. Section 4.2 screens and discusses potential Project interaction associated with the NAR activities, whereas Construction, Operation, Reclamation and Closure and Post-closure Phases Project interactions associated with mine development form the focus of Sections 4.3. This section concludes with a summary of the residual changes that are predicted to result from Project development in Section 4.4.

4.1 POTENTIAL PROJECT INTERACTIONS WITH SURFACE HYDROLOGY

For the Surface Hydrology IC analysis, potential Project interaction is assessed in the context of the terminology presented in **Table 4.1-1.** Definitions provided for *No Interaction*, *Negligible Interaction* and *Potential Interaction* are formally presented in **Section 5.0 Assessment Methodology** of the Project Proposal, and are applied to all activities listed in the Project Activities Matrix and considered all phases of the proposed undertaking. In **Table 4.1-2**, the Project Activities Matrix is screened for the Surface Hydrology IC. Notable in the screening methodology and outcome is that where *No Interaction* between the Project and IC is anticipated, or the interaction is considered *Negligible Interaction* (i.e., not expected to have a substantive influence on the short- or long-term integrity of the IC), the interaction is not considered further in the assessment.

Table 4.1-1 Potential for an Interaction Between Surface Hydrology and the Project

Term	Definition
No Interaction	Project activity will not interact with the IC. The activity/interaction is not considered further in the assessment.
Negligible Interaction	Interaction with the Project activity will not have a substantive influence on the short or long-term integrity of the IC (i.e., not measurable / not detectable).
Potential Interaction	Interaction between the Project activity and the IC may have a substantive influence on the short- or long-term integrity of the IC (i.e., measurable or detectable using an identified indicator). The potential change due to the interaction is considered further in the change analysis.

Table 4.1-2 Identification of Potential Project Interactions with Surface Hydrology

Project Component	#	Project Activity	Groundwater Quantity	
			Interaction Rating	Nature of Interaction and Potential Effect
Construction Phase				
Overall Mine Site	C-0	Confirmatory geotechnical drilling in select areas at the mine site, as necessary	Negligible Interaction	Minimal surface disturbance by drill pads, water withdrawals expected to range from 0.6 to 1.3 L/s.
	C-1	Mobilization of mobile equipment and construction materials	No Interaction	None
	C-2	Clearing, grubbing, and grading of areas to be developed within the mine site	Negligible Interaction	Will require construction of diversions, settling ponds which will alter local runoff patterns, and clearing of vegetation will alter existing evapotranspiration regime, leading to locally increased runoff coefficients.
	C-3	Material handling	No Interaction	None
Open Pits	C-4	Development of Latte pit and Double Double pit	Potential Interaction	May alter the existing monthly streamflow distribution, low flow and peak flow regimes due to land surface changes.
	C-5	Dewatering of pits (as required)	Potential Interaction	Abstraction of water to open pits will moderate peak flows locally, and particularly during freshet. Dewatering may increase flows during the remaining open water season.
WRSFs	C-6	Development and use of Alpha WRSF	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the WRSF than for natural ground. A rock drain will be constructed at the base of the WRSF to allow up-gradient water to pass freely through the base of the dump.
Stockpiles	C-7	Development and use of temporary organics stockpile for vegetation and topsoil	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
	C-8	Development and use of frozen soils storage area	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
	C-9	Development and use of ROM stockpile for temporary storage of ROM ore	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
Crusher System	C-10	Construction and operation of crushing circuit	No Interaction	None
	C-11	Construction and operation of crushed ore stockpile	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
Heap Leach Facility	C-12	Staged heap leach facility (HLF) construction, including associated event ponds, rainwater pond, piping, and water management infrastructure	Potential Interaction	HLF will operate as a closed system, effectively removing runoff from the uncovered (no raincoats) footprint. Will reduce annual runoff and alter monthly flow distributions. The portion of the HLF that is covered by raincoats will allow all precipitation to convert to runoff via the rainwater collection pond, increasing runoff coefficients locally.
	C-13	Heap leach pad loading	Potential Interaction	Moisture entrained in ore will be unavailable for discharge, as HLF operates as a closed system.
Plant Site	C-14	Construction and operation of process plant	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
	C-15	Construction and operation of reagent storage area and on-site use of processing reagents	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
	C-16	Construction and operation of laboratory, truck shop, and warehouse building	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
	C-17	Construction and operation of power plant	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
	C-18	Construction and operation of bulk fuel/LNG storage and on-site use of diesel fuel or LNG	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
Camp Site	C-19	Construction and operation of dormitories, kitchen, dining, and recreation complex buildings; mine dry and office complex; emergency response and training building; fresh (potable) water and fire water use systems; and sewage treatment plant	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.
	C-20	Construction and operation of waste management building and waste management area	Negligible Interaction	Redistribution of water around Project site, may alter low flows locally. Relative volumes are very low, and this activity is not considered further in this assessment.

Project Component	#	Project Activity	Groundwater Quantity	
			Interaction Rating	Nature of Interaction and Potential Effect
Bulk Explosive Storage Area	C-21	Construction of storage facilities for explosives components and on-site use of explosives	No Interaction	None
Mine Site and Haul Roads	C-22	Upgrade, construction, and maintenance of mine site service roads and haul roads	Negligible Interaction	May slightly alter the local runoff regime as vegetation is removed and surfaces compacted, but changes are not expected to be discernible. This activity is not considered further in this assessment.
Site Water Management Infrastructure	C-23	Development and use of sedimentation ponds and conveyance structures, including discharge of compliant water	Potential Interaction	Alteration of local drainage patterns, changes to runoff coefficients (higher than for natural ground).
	C-24	Initial supply of HLF process water	Potential Interaction	Abstraction of water from nearby creeks will result in lower streamflows and may potentially alter monthly distribution of flow.
	C-25	Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water	Potential Interaction	Reduced volume of runoff routed to streams, potentially reduce peak flows, low flows and annual runoff.
Ancillary Components	C-26	Upgrade of existing road sections for Northern Access Route (NAR), including installation of culverts and bridges	Negligible Interaction	Will lead to slight alterations in channel gradient on a local scale. This activity is not considered further in this assessment.
	C-27	Construction of new road sections for NAR, including installation of culverts and bridges	Negligible Interaction	Has the potential to slightly increase runoff from the new road surface, and straighten the stream channel at road crossings. This activity is not considered further in this assessment.
	C-28	Development, operation, and maintenance of temporary work camps along road route	Negligible Interaction	Will alter natural ground conditions, with potential to slightly alter existing runoff regimes at a local scale. This activity is not considered further in this assessment.
	C-29	Vehicle traffic, including mobilization and re-supply of freight and consumables	No Interaction	None
	C-30	Development, operation, and maintenance of barge landing sites on Yukon River and Stewart River	Negligible Interaction	May alter stream channel form slightly (armouring, instream works) at a local scale. This activity is not considered further in this assessment.
	C-31	Barge traffic on Stewart River and Yukon River, including barge mobilization of equipment for NAR construction	No Interaction	None
	C-32	Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads	Negligible Interaction	Construction and removal may result in slight changes to the local ice breakup patterns. No measureable substantial change to Surface Hydrology is anticipated to result from this activity, and is not considered further in this assessment.
	C-33	Annual construction and operation of winter road on the south side of the Yukon River	Negligible Interaction	May alter stream channel form slightly (armouring, instream works) at a local scale. This activity is not considered further in this assessment.
	C-34	Construction, operation, and maintenance of permanent bridge over Coffee Creek	Negligible Interaction	May alter stream channel form slightly (armouring, instream works) at a local scale. This activity is not considered further in this assessment.
	C-35	Construction and maintenance of gravel airstrip	Negligible Interaction	May slightly alter the local runoff regime as vegetation is removed and surfaces compacted, but changes are not expected to be discernible. This activity is not considered further in this assessment.
	C-36	Air traffic	No Interaction	None
	C-37	Use of all laydown areas	No Interaction	None
	C-38	Use of Coffee Exploration Camp	No Interaction	None

Project Component	#	Project Activity	Groundwater Quantity	
			Interaction Rating	Nature of Interaction and Potential Effect
Operation Phase				
Overall Mine Site	O-1	Material handling	No Interaction	None
	O-2	Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal	No Interaction	None
	O-3	Progressive reclamation of disturbed areas within mine site footprint	Potential Interaction	Progressive reclamation of disturbed areas will result in greater volumes of non-contact water being discharged to the environment. This will reduce the changes to streamflow expected to result from the full mine footprint.
Open Pits	O-4	Development of Kona pit and Supremo pit and continued development of Double Double pit and Latte pit	Potential Interaction	Double Double and Latte pits will extend below the groundwater table, and thus will likely require dewatering as they become groundwater sinks. Exposure of pit walls will increase runoff coefficients within pits, and dewatering of meteoric water inputs could alter monthly distribution of streamflow and low flow regimes, and potentially annual runoff volumes.
	O-5	Cessation of mining at Double Double pit, Latte pit, Kona pit, and Supremo pit	Potential Interaction	Meteoric water abstracted to filling pits will reduce runoff available to receiving streams, potentially reducing annual runoff and altering monthly runoff regime, peak flows and low flows.
	O-6	Partial backfill of Latte pit and Supremo pit	Potential Interaction	Meteoric water abstracted to filling pits will reduce runoff available to receiving streams, potentially reducing annual runoff and altering monthly runoff regime, peak flows and low flows.
	O-7	Backfill of Double Double pit and Kona pit	Potential Interaction	Meteoric water abstracted to filling pits will reduce runoff available to receiving streams, potentially reducing annual runoff and altering monthly runoff regime, peak flows and low flows. All water that accumulates in the Kona pit during operations (this water will only be meteoric water entering the pit and not groundwater) will be used in the process plant as make-up. Kona pit will be backfilled during winter, when the waste rock is frozen so that the backfill process will re-establish the permafrost. As such, water will not enter the backfilled pit voids, but rather run off the waste rock in the active zone. No measurable changes in streamflows from the baseline condition are expected.
	O-8	Dewatering of pits (as required)	Potential Interaction	Abstraction of water to open pits will moderate peak flows locally, and particularly during freshet. Dewatering may increase flows during the remaining open water season.
WRSFs	O-9	Continued development and use of Alpha WRSF	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and slightly increased runoff coefficients due to higher infiltration into the WRSF than for natural ground. A rock drain will be constructed at the base of the WRSF to allow up gradient water to pass freely through the base of the dumps. Baseflows may increase downstream of the WRSF as a result of increased residence time of infiltration within the dump.
	O-10	Development and use of Beta WRSF	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and slightly increased runoff coefficients due to higher infiltration into the WRSF than for natural ground. A rock drain will be constructed at the base of the Alpha WRSF to allow up gradient water to pass freely through the base of the dumps. Baseflows may increase downstream of the Alpha WRSF as a result of increased residence time of infiltration within the dump.
Stockpiles	O-11	Continued use of temporary organics stockpile for vegetation and topsoil	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
	O-12	Continued use of frozen soils storage area	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
	O-13	Continued use of ROM stockpile for temporary storage of ROM ore	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
Crusher System	O-14	Crusher operation	No Interaction	None
	O-15	Continued use of crushed ore stockpile	Potential Interaction	Will alter natural ground cover, changing local runoff regimes. Attenuation of peak flows is likely, and increased runoff coefficients due to higher infiltration into the stockpiles than for natural ground.
Heap Leach Facility	O-16	Continued staged HLF construction, including related water management structures and year-round operation	Potential Interaction	HLF will operate as a closed system, effectively removing runoff from the uncovered (no raincoats) footprint. Will reduce annual runoff and alter monthly flow distributions.

Project Component	#	Project Activity	Groundwater Quantity	
			Interaction Rating	Nature of Interaction and Potential Effect
	O-17	Progressive closure and reclamation of HLF	Potential Interaction	Progressive reclamation of the HLF will result in greater volumes of non-contact water being discharged to the environment. This will reduce the HLF operation changes to streamflow.
Plant Site	O-18	Process plant operation	Negligible Interaction	The volumes of water necessary for the process plant operation are negligible, and will be sourced from the HLF, which operates as a closed system.
	O-19	Continued on-site use of processing reagents	No Interaction	None
	O-20	Continued on-site use of diesel fuel or LNG	No Interaction	None
Camp Site	O-21	Continued use of facilities	No Interaction	None
Bulk Explosive Storage Area	O-22	Continued on-site use of explosives	No Interaction	None
Mine Site and Haul Roads	O-23	Use and maintenance of mine site service roads and haul roads	Negligible Interaction	May slightly alter the local runoff regime as vegetation is removed, but changes are not expected to be discernible. This activity is not considered further in this assessment.
Site Water Management Infrastructure	O-24	Continued use of sedimentation ponds conveyance structures	Potential Interaction	Alteration of local drainage patterns, changes to runoff coefficients (higher than for natural ground). Potential for slight alterations to timing of runoff and reductions in peak flows, due to attenuation (storage) within ponds.
	O-25	Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water	Potential Interaction	HLF will operate as a closed system, effectively removing runoff from the uncovered (no raincoats) footprint. Will reduce annual runoff and alter monthly flow distributions.
	O-26	Installation and operation of water treatment facility for HLF rinse water	Potential Interaction	Discharge of treated water will increase flows locally as the HLF is rinsed.
Ancillary Components	O-27	NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal)	No Interaction	None
	O-28	NAR vehicle traffic, including mobilization and re-supply of freight and consumables	No Interaction	None
	O-29	Operation and maintenance of barge landing sites on Stewart River and Yukon River	Negligible Interaction	May alter stream channel form slightly (armouring, instream works) at a local scale. This activity is not considered further in this assessment.
	O-30	Barge traffic on Stewart River and Yukon River	No Interaction	None
	O-31	Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads	Negligible Interaction	Construction and removal of ice roads may result in slight changes to the local ice breakup patterns. No measurable change to Surface Hydrology is anticipated to result from this activity, and this activity is not considered further in this assessment.
	O-32	Annual construction and operation of winter road on the south side of the Yukon River	Negligible Interaction	Construction and removal of winter road may result in slight changes to the local ice breakup patterns. No measurable change to Surface Hydrology is anticipated to result from this activity, and this activity is not considered further in this assessment.
	O-33	Operation and maintenance of gravel air strip	No Interaction	None
	O-34	Air traffic	No Interaction	None
	O-35	Use of all laydown areas	No Interaction	None
	O-36	Use of Coffee Exploration Camp if required	Negligible Interaction	May slightly alter the local runoff regime as vegetation is removed, but changes are not expected to be discernible. This activity is not considered further in this assessment.

Project Component	#	Project Activity	Groundwater Quantity	
			Interaction Rating	Nature of Interaction and Potential Effect
Reclamation and Closure Phase				
Overall Mine Site	R-1	Reclamation of disturbed areas within mine site footprint	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state.
	R-2	Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal	No Interaction	None
Open Pits	R-3	Reclamation of Double Double pit, Latte pit, Supremo pit, and Kona pit	Potential Interaction	Water abstracted to filling pits will reduce runoff available to receiving streams, potentially reducing annual runoff and altering monthly runoff regime, peak flows and low flows. Once pits are full (with the exception of Kona Pit), they will serve as reservoirs that will moderate streamflows locally as they spill.
WRSFs	R-4	Reclamation of Alpha WRSF	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state. The rock drain at the base of the WRSF will be preserved as the dumps are re-contoured.
	R-5	Reclamation of Beta WRSF	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state. The waste rock in the Beta WRSF will be backfilled to the Kona Pit in Year 12, and thus the WRSF footprint will return to a natural flow regime.
Stockpiles	R-6	Reclamation of temporary organics stockpile, frozen soils storage area, and ROM stockpile	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state.
Crusher System	R-7	Dismantling and removal of crusher facility and stockpile	No Interaction	None
Heap Leach Facility	R-8	Closure of HLF and related water management structures	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state.
Plant Site	R-9	Dismantling and removal of process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage	Negligible Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state. This activity is not considered further in this assessment.
Camp Site	R-10	Dismantling and removal or dormitories and kitchen, dining, and recreation complex buildings, mine dry and office complex, emergency response and training building, fresh (potable) water and fire water systems, sewage treatment plant, and waste management building	No Interaction	None
Bulk Explosive Storage Area	R-11	Dismantling and removal of explosives storage facility	No Interaction	None
Mine Site and Haul Roads	R-12	Decommissioning and reclamation of mine site service roads and haul roads	Negligible Interaction	This will alter the runoff regime from the Operation Phase condition, and return runoff to a state more similar to the baseline condition.
Site Water Management Infrastructure	R-13	Decommissioning and reclamation of selected water management infrastructure, construction of long-term water management infrastructure, including water deposition to creek systems	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state.
	R-14	Operation and maintenance of HLF water treatment facility	Potential Interaction	Discharge of treated water will increase flows locally as the HLF is rinsed.
	R-15	Decommissioning and removal of HLF water treatment plant	Potential Interaction	As mine site areas are reclaimed, the runoff regime will begin to return to its natural state.
Ancillary Components	R-16	NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal)	No Interaction	None
	R-17	NAR vehicle traffic	No Interaction	None
	R-18	Operation and maintenance of barge landing sites on Stewart River and Yukon River	Negligible Interaction	May alter stream channel form slightly (armouring, instream works) at a local scale. This activity is not considered further in this assessment.
	R-19	Annual resupply of consumables and materials for active closure via barge on the Yukon River	No Interaction	None
	R-20	Annual construction, maintenance, and decommissioning of Stewart River and Yukon River ice roads	Negligible Interaction	Construction and removal of ice roads may result in slight changes to the local ice breakup patterns. No measurable change to Surface Hydrology is anticipated to result from this activity, and this activity is not considered further in this assessment.
	R-21	Decommissioning of new road portions	Negligible Interaction	This will alter the runoff regime from the Operation Phase condition, and return runoff to a state more similar to the baseline condition.
	R-22	Air traffic	No Interaction	None
	R-23	Decommissioning and reclamation of airstrip	No Interaction	None
	R-24	Operation of Coffee Exploration Camp to support monitoring activities	Negligible Interaction	May slightly alter the local runoff regime as vegetation is removed, but changes are not expected to be discernible. This activity is not considered further in this assessment.
Post-closure Phase				
Overall Mine Site	P-1	Long-term monitoring	No interaction	Monitoring activities by their nature are not expected to have a measurable effect on Surface Hydrology.

4.2 NORTHERN ACCESS ROUTE

4.2.1 OVERVIEW

The proposed access to the Project mine site is via the NAR, which will extend over a total distance of approximately 190 km south from Dawson. The access route will use both new and existing roads south from Dawson, to reach the mine site. The access route will include crossings over the Stewart and Yukon Rivers on ice roads in winter, and by barge in summer. The NAR is included within the LSA and RSA boundaries defined for the Surface Hydrology IC.

The NAR begins at the Hunker Creek road turnoff from the Alaska Highway a short distance southeast of Dawson. From the Alaska Highway, the first 60 km of the access route is a publicly maintained road that will require little or no modification. From this point, the road will extend for approximately 131 km to the mine site. Of this distance, roughly 80 km will be comprised of existing roads and trails that will be upgraded, 15 km of existing roads used with little or no modification, and approximately 36 km of new road will need to be constructed.

New road sections will follow existing trails that were established mainly to service historic and current placer mining operations. To minimize number of crossings and interaction with sensitive habitat (e.g., fish bearing streams, wetlands), the proposed road alignment often follows the height of land. The proposed access route will cross 43 streams, from the Sulphur Dominion junction to the Project mine site, and a total of 12 bridges and 9 major culverts will be installed in support of the Project.

4.2.2 ROAD DESIGN AND STREAM CROSSINGS

The road alignment will extend from the terminus of the existing public road southeast to cross the Indian River, crossing new bridges over Sulphur Creek and the Indian River. It will then run west, parallel with, and on the south side of Indian River, and then turn south up the Eureka Creek drainage. From here it will go up onto the height of land to the west of Eureka Creek, and remain on the height of land, travelling south through the headwaters of Henderson Creek (to the west) and Dome Creek (to the east). It will then travel south down the Maisy May drainage, crossing bridges over a tributary and Maisy May main stem, to the confluence of Maisy May at Stewart River.

From the south side of the Stewart River crossing, the road will travel up the Barker Creek drainage, crossing four new bridges, approach the height of land, and descend the Ballarat Creek drainage, crossing two new bridges. It will then cross Ballarat Creek main stem via a new bridge to reach the Yukon River west of the Ballarat confluence. The last section of road extends west from the landing on the south side of the Yukon River, crosses Coffee Creek via a new bridge, to reach the mine site. A total of 12 bridges and 9 major culverts will be installed.

4.2.3 POTENTIAL PROJECT-RELATED INTERACTIONS WITH SURFACE HYDROLOGY

As summarized in **Table 4.1-2**, road construction activities include, but are not limited to, the following: equipment staging; clearing and grubbing in advance of earthworks related to road preparation; cutting (excavation) and filling to stabilize slopes/banks adjacent to road; opening and closure of borrow pits and quarries along the road route; the installation/construction of watercourse crossings and drainage features (e.g., drains, culverts, ditches); and instream works and activities associated with the construction and operation of barge landings on the Stewart and Yukon River crossings.

The influence of road(s) on hillslope hydrology and watershed response has garnered some attention in the open scientific literature (Spellerberg, 1998; Forman and Alexander, 1998). For example, fisheries and surface water quality issues related to road development (e.g., changes in water temperature, turbidity, contaminant loading, potential for spills) are well documented (e.g., Jones et al., 2000; Gibson et al., 2005), so too are road-related issues relating to slope failures, sediment production and transport, groundwater discharge, peak flows and flooding, riparian and wetland health, land use planning and climate change (Daigle, 2010). Potential changes to Surface Hydrology attributable to road upgrade, construction, maintenance and reclamation (refer to **Table 4.1-2**) include the following:

- Compacted road surfaces, including soil/rock cuts, fill and adjacent ditching, may limit infiltration and alter pre-development surface and groundwater flow paths (Pike et al., 2010).
- Road sections that intersect or re-direct shallow groundwater flow paths may alter local streamflow regimes (e.g., increase annual surface runoff to a minor degree) or alter groundwater-controlled environments (such as springs or seepage areas) down gradient of the road section (Hancock, 2002).
- Runoff from a section of road may flow into a local watercourse directly, potentially enhancing peak flows at the point of discharge. Alternatively, local road runoff may be conveyed by ditches and culverts to an adjacent drainage. In this regard, flows may be reduced in the tributary down-gradient of the road section, yet be enhanced in the adjacent drainage (Pike et al., 2010).
- Standing waters attributable to a blocked culvert (debris, beaver activity, and icing) may alter local groundwater flow paths, in essence, increasing baseflow to a local tributary. Episodic discharge of standing water may enhance peak flows in an adjacent watercourse if release coincides with a runoff event (enhance peak flows). Alternatively, the discharge of standing water may enhance baseflow conditions in the local watercourse, if it reports out of sync with the local hydrograph.

Noting the potential changes outlined above, several of the Project activities associated with the NAR were assigned a rating of No Interaction (e.g., Activities C-29 and C-31). These activities are associated with barge and vehicle traffic. No changes to Surface Hydrology are anticipated to result from these activities, and thus these Project activities are not considered further in this assessment.

For the envisioned phases of the Project, thirteen activities were assigned a rating of negligible interaction with the Surface Hydrology IC. These activities include:

- C-26: Upgrade of existing road sections for Northern Access Route (NAR), including installation of culverts and bridges
- C-27: Construction of new road sections for NAR, including installation of culverts and bridges
- C-28: Development, operation, and maintenance of temporary work camps along road route
- C-30, O29, R-18: Development, operation, and maintenance of barge landing sites on Yukon River and Stewart River
- C-32, O-31, R-20: Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads
- C-33, O-32: Annual construction and operation of winter road on the south side of the Yukon River
- C-34: Construction, operation, and maintenance of permanent bridge over Coffee Creek
- R-21: Decommissioning of new road portions

Activities that are expected to have a negligible interaction are not carried forward in detail in this assessment.

4.2.4 MITIGATION MEASURES

The construction, operation, maintenance and decommissioning of the NAR will be performed in accordance with accepted best practices. Best management practices (BMPs) related to the construction and operation of resource roads have been incorporated into several of the management plans are relevant to the NAR, and are listed below:

- Access Route Construction Management Plan (**Appendix 31-A**)
- Access Route Operational Management Plan (**Appendix 31-B**)
- Conceptual Reclamation and Closure Plan (**Appendix 31-C**)

Potential adverse changes resulting from the road can be minimized and controlled by implementing standard operating procedures and BMPs. Notably, monitoring and surveillance of the surface water drainage system in close proximity to stream crossings and sensitive habitats/areas will be carried out by the Proponent over the life of the Project (refer to Section 8.0).

With respect to Access Route Management Plans (**Appendix 31-A** and **Appendix 31-B), t**he proposed stream crossings along the NAR include:

- Standard non-fish stream culverts
- Embedded culverts in small, low habitat value fish streams
- Pipe-arches on small, low habitat value fish streams
- All steel portable bridges over larger water courses or higher value fish habitat.

All stream crossing structures will be designed to pass a peak flow event appropriate for the design life of the access road. 100-year flood events were estimated at each crossing site using the rational, regional, cross-sectional manning equation and USGS peak flow estimation methods. Estimates were adjusted for changes in localized watershed characteristics, such as infiltration rates and localized rainfall intensity. Site observations, existing structures, and historic high water evidence were also used to estimate peak flow.

Additional access route mitigation measures that pertain to the Surface Hydrology IC are listed below, noting that enhancements to management plans and refinements of BMPs in the context of the Surface Hydrology IC will be undertaken as required over the Project timeline:

- Clearing widths through riparian areas will be minimized to the extent possible. This will reduce the potential for erosion and subsequent bedload changes.
- In areas underlain with undisturbed, shallow, ice rich permafrost, the existing surface material will be left intact, with the road constructed by filling over a geotextile separation layer. This will serve to reduce active layer melt and subsequent changes to low flows.
- Ditch water will be redirected away from the stream at stream crossing sites by use of cross drain culverts and off take ditches. Instream work on all watercourses is to be minimized and completed at times of low flow.
- Barge landings - the industrial site will be sloped away from the river with surface runoff directed to a settling pond. The pond will attenuate surface flows from the site.
- Bridges will be sized so that the abutments do not impinge on the stream channel or floodplain, and therefore will not constrict the bankfull channel width. All bridge deck elevations will be set to accommodate high water flows.
- If the road approaches require fill on floodplains, relief culverts will be placed to minimize damming effects during over bankfull flood flows. This will reduce the potential for backed up water to cut through the road bed and increase peak flow discharges downstream.

4.2.5 RESIDUAL CHANGES SUMMARY FOR THE NAR

With the implementation of BMPs and standard operating procedures, the Northern Access Route is not expected to result in any residual changes to Surface Hydrology.

4.3 MINE SITE ASSESSMENT

This section presents the potential project-related changes to the Surface Hydrology IC, the mitigation measures proposed to reduce or remove these changes, and the residual change assessment for the potential Project-related changes to the existing streamflow regime as it relates to the Project mine site.

4.3.1 POTENTIAL PROJECT-RELATED CHANGES

The Construction, Operation, Reclamation and Closure and Post-closure Phases of the Project have the potential to alter the extent of watershed boundaries as water from various mine components will be routed to central management locations (e.g., open pits, sediment control ponds). In addition, ground surface characteristics will change as pits are developed, ore is stockpiled and placed on the HLF, waste rock is deposited in WRSFs and water management infrastructure is constructed and operated.

These alterations within the Project drainages have the potential to change flow conditions in local creeks and streams from their baseline condition. Open pits will store water and reduce runoff while the pits are filling, whereas surface water diversions have the potential to remove flow from one drainage and increase flow in an adjacent watershed. The HLF will operate as a closed loop for most of the Operation Phase, and will remove runoff from the headwaters of both Latte and Halfway Creeks. Sediment ponds located downgradient of the Project infrastructure will collect runoff and may attenuate peak flows (i.e., delay runoff response and moderate peak flows). Finally, the WRSFs are anticipated to store and release water differently from the natural areas they once were (e.g., attenuate the snowmelt freshet signature and enhance summer low flows).

The degree to which the natural streamflow regime might be altered must be quantified, as this information is an integral component of the environmental assessment process that is mandated by *YESAA*. A quantification of the potential residual changes to the existing streamflow regime is also required as an input to site-wide water quality modelling efforts, fish and fish habitat impact assessments, site-wide water management planning and groundwater modelling exercises.

4.3.2 MITIGATION MEASURES

Many of the mitigation measures that are relevant to the Surface Hydrology IC are built into the Project design, and are also directly relevant to the Surface Water Quality VC and Groundwater IC. These include a combination of Project phasing and development schedules, waste handling options, and water management infrastructure and planning commitments. As the WBM incorporates all components of the mine plan, including design mitigation measures, the model predictions presented in Section 4.3.5 through 4.3.7 represent residual changes (following mitigation), from an EA perspective. The design mitigation measures proposed for the Project, and relevant to the Surface Hydrology IC are listed in the sections below.

4.3.2.1 Phased Mine Development and Progressive Reclamation

In addition to providing flexibility in the schedule, maximizing ore grade, and allowing the HLF to be maintained at full production capacity, phased development of the mine will reduce pre-stripping requirements in the early years. By reducing pre-stripping, the development footprint is reduced, thereby limiting the potential alteration to surface runoff and groundwater recharge. Progressive reclamation and closure activities will begin as soon as mining at the Double Double pit has been completed in Year 2 and will continue throughout the mine life.

4.3.2.2 Alpha WRSF Site Selection and Design

Mine waste that is not backfilled into pits will be stored in the Alpha WRSF. Placement of the majority of mine waste in a single ex-pit dump minimizes the extent of ground disturbance. By minimizing ground disturbance, alteration to the runoff and groundwater recharge regimes is limited. Minimizing ground disturbance also minimizes potential footprint areas generating mine contact water.

Waste rock benches will be designed to slope inwards from the WRSF crest and runoff will be collected in a ditch and conveyed to ditches along the perimeter of the WRSF. In addition, a flow-through rock drain will be installed at the base of the Alpha WRSF to route all flows emanating from the upgradient catchment through the base of the WRSF, thus limiting the contact time with WRSF contact flows.

Water that infiltrates the WRSF will preferentially flow towards the sediment ponds and not recharge the groundwater system. Given the topographic relief of the sites and permafrost occurrence underlying the proposed Alpha WRSF, it is believed that the rock drain will be highly effective. Furthermore, it is more conservative to assume that WRSF seepage reports to the sediment ponds rather than to groundwater for the purpose of assessing surface water quantity effects.

4.3.2.3 ROM Stockpile Design

To minimize potential effects of ARD associated with the ROM stockpile, the ROM pad will be lined and the drainage will be collected throughout LOM. Runoff collection ditches and sediment basins will be constructed along the down-gradient boundary of the ROM stockpile footprint. The ROM stockpile will have a diversion channel downhill to convey water to the Facility Pond. Collected drainage will be used as process make-up water to minimize contact water that reports to the receiving environment.

Lining of the ROM stockpile and the collection and use of its runoff and drainage will limit the opportunity for ROM contact water to recharge the groundwater system or report as an uncontrolled release to the surface water system.

4.3.2.4 Kona Pit

The Kona pit is completed tens of metres above the ambient groundwater table. Meteoric water that collects in the pit during operations will be pumped and used as make-up water for HLF. Likewise, seepage collected from the temporary Beta WRSF will also be used as make-up water. These measures limit the opportunity for Kona contact water to recharge the groundwater system or report as an uncontrolled release to the surface water system.

Backfill of the Kona pit is slated to occur during the winter which will trap cold air into the backfilled pit. This will aid in preservation of permafrost and facilitate freezing of subsequent infiltration. This will also limit the opportunity for Kona pit wall and waste rock contact water to recharge the groundwater system.

4.3.2.5 Backfilling of Pits

Waste rock will be used to backfill mined out pits at Latte, Supremo, and Double-Double, to create causeways that shorten the ore haul distance to the crusher (compared to having to haul material around the pits), and to minimize contact water catchment area. By minimizing ground disturbance and associated footprints, alteration to the runoff and groundwater recharge regimes is limited. Minimizing ground disturbance and size of ex-pit WRSFs also minimizes potential footprint areas generating mine contact water.

4.3.2.6 Surface Water Protection and Management

As a contingency measure, the Alpha WRSF benches will be sloped inward. The benches will be crowned at the centreline to direct any potential runoff to either the north or south edge of the WRSF, where it will be routed to the Alpha Pond on the north edge of the WRSF, and to the head of the rock drain on the southern edge of the WRSF. Minor runoff volumes may be directed down the WRSF face via a variation of channels and berm cuts. Diverting concentrated flow down the WRSF face will be avoided to prevent erosion on the slope. Interim water management structures will be built, as required.

4.3.2.7 HLF Design to Facilitate Progressive Closure

The heap leach pad will be constructed in 5 stages, separated into cells, and closed progressively. Each pad stage will be separated from the adjacent stage by a ditch or berm and drainage pipe, providing hydraulic (solution) isolation between stages. In addition, cells will be created within each stage by constructing a drainage ditch or berm with a drainage pipe every 100 m. The berms and ditches will allow high-resolution tracking of solution chemistry (especially gold tenor) and will aid in progressive closure by allowing rinsing of the older portions of the heap beginning by Year 4. Progressive reclamation of the heap leach pad will entail rinsing individual sections of the heap leach ore once they have undergone the complete gold recovery cycle. The heap will be rinsed (via solution from the rinse pipelines) and capped in stages; as each stage is capped, the raincoats for that area will be removed and used in other areas or incorporated as part of the closure capping.

Progressive closure of the HLF reduces the footprint area available to generate contact water and also presents an opportunity to test water treatment efficacy prior to full buildout of the HLF. Both measures are directly protective of surface water quality and indirectly protective of groundwater quality.

4.3.2.8 HLF Liner System

Liner system design will provide for collection of process and rinse solutions and protection of surface and groundwater quality through heap leach pad operation and active closure. The liner system is comprised of a 2.0-millimetre (mm)-thick linear low density polyethylene (LLDPE) geomembrane over a reinforced geosynthetic clay liner (GCL) liner. The bottom side of the LLDPE liner will be aggressively textured to provide a close bond with the GCL. A 500-mm-thick drainage layer composed of crushed gravel and drainage pipes will be installed over the synthetic liners. This overliner system will protect the geomembrane liner from damage during ore stacking and operations, and will drain process and rinse waters out of the system in a manner that will minimize hydraulic head over the liner.

Leak detection will be accomplished by three separate systems: electrical leak location surveys performed after construction of each stage of the leach pad, horizontal wick drains installed under each collection ditch or berm to operate as large-scale lysimeters, and monitoring wells installed away from the pad.

The HLF liner system is designed to maximize recovery of pregnant solution by minimizing any losses to the groundwater system. To account for the presence of multiple liners under the HLF, recharge to groundwater through the liners is assumed to equal zero in the Groundwater Model and site-wide WBM.

4.3.2.9 HLF Water Balance

The HLF water balance will be operated to minimize demand for withdrawal of make-up water from external sources and to avoid need to treat surplus water until near the end of the mine life. Process water for use in heap pad leaching will be preferentially sourced from site contact water. Geomembrane covers referred to as raincoats will be used over the heap to reduce the volume of meteoric water infiltrating into the heap and entering the process solution. Water diverted by the raincoats will be temporarily stored in the rainwater pond and used for makeup water during drier periods, as well as for freshwater for rinsing during progressive reclamation of the pad stages. The mine and HLF water balance will be actively managed through best management practices regarding raincoat use and timing of use, thereby , reducing the need to withdraw water from area creeks.

4.3.2.10 Management of Non-Contact Water

Surface water and rainwater will be kept away from the HLF and process circuit to the maximum extent possible through:

- Installation of permanent and interim perimeter diversion channels and berms around perimeter of heap leach pad.
- Starting in Year 3, placement of raincoats (i.e., exposed geomembrane covers) over portions of the heap leach pad to minimize infiltration of rainwater and snowmelt into the heap leach pad and process circuit, and to increase heat retention in the winter.
- Progressive closure of HLF will reduce length of time that HLF is at its maximum footprint size.

4.3.2.11 HLF Event Ponds

Three event ponds (EP-1S, EP-1N and EP2) and a rainwater pond will be built between the heap leach pad and the process plant. The event ponds are designed to contain a combination of upset conditions, including:

- Heap draining during an extended power or pumping outage
- Extreme precipitation and freshet events
- Cumulative water storage during wet years or temporary shut-downs.

The rainwater pond is designed to temporarily store clean water diverted by the raincoats for use as makeup water during drier periods, as well as for freshwater for rinsing during progressive reclamation of the pad stages. All ponds will be lined with two HDPE geomembranes, separated by a drainage layer and underlain by a GCL.

Pond design will minimize the potential for HLF contact water to infiltrate groundwater. All lined ponds associated with the HLF are assumed to provide zero recharge to the groundwater system in the Groundwater Model and in the site-wide WBM.

4.3.2.12 Sediment Pond Design, Capacity and Discharge

Runoff from the mine site will be routed to two sediment retention ponds located downstream of proposed mining areas (Alpha Pond and the Facility Pond). The ponds will serve 2 purposes: 1) settlement of TSS load prior to discharge, and 2) reduction in peak discharge rate of a storm by attenuating (storing and releasing) runoff and discharging it at a lower peak rate.

Each sediment retention pond will be sized to retain runoff volumes by controlling outflow, and will also allow runoff volumes for the 10-year, 24-hour storm event to remain for a minimum of 48 hours. Due to the large influx of runoff during spring freshet, it is anticipated that the pond will fill to capacity, and the overflow will discharge through the emergency spillway. The Alpha Pond also has the capacity to hold the 100-year freshet flow while discharging water at a maximum rate of 5,000 GPM. This will give flexibility to the site to manage water. Runoff volumes greater than the 10-year event, but less than or equal to the 100-year event, will be routed through the riser structure. Storms up to the 200-year event will be routed through the emergency spillway. Peak discharge (m^3/s) from the ponds will be at a rate less than or equal to the pre-development rates for storms less than or equal to the 10-year, 24-hour event.

4.3.2.13 Rock Drains

Flow-through drains, or rockcut spillways will be installed to drain pit lakes that may develop during the Operation Phase or form at the end of mine life. These drains will be capable of conveying flows up to the 100-year, 24-hour storm event, plus snowmelt for up to four times the calculated peak runoff. Channels will be located near the spill point of the pit lakes (near the connection with the flow-through drains) to accommodate overflow should the flow-through drains clog or freeze. In addition, a flow-through rock drain will be installed at the base of the Alpha WRSF to route all flows emanating from the upgradient catchment through the base of the WRSF, thus limiting the contact time with WRSF contact flows. The Alpha WRSF rock drain will be designed to accommodate up to 2 times the 100-year, 24-hour flow.

4.3.2.14 Summary of Mitigation Measures

As listed above, the mitigation measures incorporated into the Project design are extensive, and in concert, they serve to substantially reduce the potential changes to streamflows that might otherwise be expected to result from the development of a mine. In addition to the various mitigation measures listed above, surface water monitoring (see Section 8.0) will inform the day-to-day operation of the site and associated water management activities. This section outlines the monitoring network that will track the movement and storage of water on the site, the rates and points of discharge, and the monitoring thresholds that will trigger additional mitigating action to reduce the changes to local streamflows resulting from the mine operations in a timely manner.

The predictions presented here, combined with the extensive mitigation measures built into the Project and the monitoring and adaptive management plans, present the best efforts of the Project proponent to mitigate potential Project related changes to the Surface Hydrology IC. As such, no further mitigation measures are proposed.

4.3.3 RESIDUAL CHANGES TO THE SURFACE HYDROLOGY IC

The study of Surface Hydrology is a highly quantitative science, and as such, the change characteristics typically employed in a residual effects assessment for a VC were employed. These same change characteristics are commonly used in hydrology studies when characterizing the streamflow regime of a given area - either changes that are presently occurring in response to some driver (e.g., mine impacts), or are predicted to occur (e.g., climate change). The definition and use of the change characteristics also allows a consistent approach to be taken when describing the residual changes likely to occur as a result of Project development, across watersheds or Project phases. This enables the reader to quickly and effectively understand how the predicted residual changes are linked to the mine plan, expected future climate change and reclamation activities.

4.3.4 RESIDUAL CHANGE CHARACTERISTICS

Residual change characteristics, ratings, nomenclature (symbols) and qualifiers for the Surface Hydrology IC analysis are presented in **Table 4.3-1**. Results for this assessment are presented in Sections 4.3.5 to 4.3.7 for each phase of the Project (Construction, Operation, Reclamation and Closure, Post-closure Phases), where IC indicators are used to characterize residual changes. The Residual Change Characteristics selected are common metrics used to describe the streamflow regime (e.g., Direction, Magnitude, Timing, Frequency; refer to Poff et al., 1997), and each has a direct physical linkage to the proposed Project activities, as well as associated VC or ICs (e.g., low flows may be altered by waste rock placement, both of which are linked to surface water quality, and fish and fish habitat. The numerical outputs from the WBM were analyzed to determine the magnitude of expected change from the baseline condition, and this metric is divided into Low, Moderate and High classifications. The rationale for the thresholds assigned to these classifications was informed by measurement error for the surface hydrology discipline and instream flow assessment methods/directional documents.

Measurement error associated with the surface hydrology discipline was assumed to be +/-5% (e.g., RISC, 2009). Therefore, predicted changes lesser in magnitude than +/-5% were assigned a rating of Negligible (NG) as those predicted changes fall within measurement error. For Low, Moderate and High thresholds, instream flow needs literature informed the selected rating. For example, the AB Desktop IFN method (Government of Alberta, 2011) recommends that in the absence of site-specific information and to achieve an ecologically protective flow regime that no more than a 15% reduction in natural flow (for months seeing appreciable runoff) should occur. DFO 2013 indicates that the probability of degradation to ecosystems sustaining fisheries increases with increasing alteration to the natural flow conditions. Further, the document indicates that cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river relative to a "natural flow regime" have a low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries. Magnitude ratings of Low (greater than 5% but less than 10%) Moderate (greater than 10% but less than 20%) and High (greater than 20%) were established in the Surface Hydrology IC Report accordingly.

Table 4.3-1 Residual Change Characteristics, Ratings, Nomenclature and Qualifiers for the Surface Hydrology IC assessment

Residual Change Characteristics	Rating	Symbol	Qualifiers	Indicators
Direction Identifies the direction of change associated with residual effect	***Positive***	+	*>5% change from natural condition*	*Annual Runoff* *Monthly Distribution* *Low Flow* *High Flow* *Duration and Frequency of flow <30% MAD*
	Negative	-	*<-5%change from natural condition*	
	Varied	-/+	*Direction of change associated with residual change varies and may be positive or negative*	
	No Change	*NC*	*Magnitude of change within +/-5% change from natural condition*	
Magnitude Describes the magnitude of the residual effect relative to the natural condition of the Surface Hydrology IC.	***High***	*H*	*≥20% change from natural condition*	
	Moderate	*M*	*≥10% and <20% change from natural condition*	
	Low	*L*	*<10% change from natural condition*	
	Negligible	*NG*	*Magnitude of change within +/-5% change from natural condition*	
Timing Identifies the temporal attribute(s) of the residual effect	***Change Detected***	*CD*	*Timing of flow events (i.e., as shown by time series plots) materially affected by Project*	
	No Change	*NC*	*Timing of flow events (i.e., as shown by time series plots) not materially affected by Project*	
Frequency Describes how often the residual effect is likely to occur	***Infrequent***	*I*	*Decadal return period*	
	Frequent	*F*	*Expected to occur most years*	
	Continuous	*C*	*Occurs all years*	
Reversibility Describes the degree to which the residual effect can be reversed once causal factors cease. Irreversible changes are considered to be permanent	***Fully Reversible***	*FR*	*Reversible on time step of months, year(s)*	
	Partially Reversible	*PR*	*Reversible on time step of decade(s)*	
	Irreversible, permanent	*IR*	*Residual change persists on time scale of centuries*	
Probability of occurrence Describes the likelihood that the residual effect will occur	***Likely***	*LK*	*>10% chance of occurring*	
	Unlikely	*UL*	*<10% change of occurring*	

As described in Section 2.0 and **Appendix 12-C**, a site-wide WBM was used to predict potential alterations to streamflows that may result from the Project. **Table 4.3-2** summarizes the Project components and activities that were incorporated into the WBM, and a complete description of the model setup, parameterization and calibration is provided in **Appendix 12-C**. The percent changes that are presented for each station (see Section 4.5 through 4.7) are based on 28 climate iterations that were run through the WBM and the statistics presented (i.e., mean, 10^{th} and 90^{th} percentile) were computed using the complete output for each phase. For example, the Closure Phase spans ten years, with 28 iterations for each year. Therefore, the monthly sample size that these percent change statistics are based on is n = 280 for the Closure Phase. Analysis and discussion of the residual changes are presented by drainage for Latte/Coffee, YT-24 and Halfway Creeks, with a focus on the headwater stations that will experience the greatest residual changes (i.e., CC-1.5, YT-24, HC-2.5 and HC-5.0).

Table 4.3-2 WBM – Project Activities Checklist

Project Component/Activity and WBM Component Checklist		
Facility	**Project Component/Activity**	**Encoded in GoldSim Model**
Non-contact Areas	• Undisturbed areas within mine drainages are reduced (clearing, grubbing) in magnitude over time as Project footprints expand.	Yes
Open Pits	• Year-by-year development of open pits (including Latte, Kona, Supremo and Double Double pits) represented in the GoldSim model.	No
	• Partial (Latte and Supremo) and full backfilling (Double Double and Kona) of open pits accounted for in the WBM.	Yes
	• GoldSim model accounts for progressive reclamation of disturbed areas (e.g., the closure of Kona and Double Double pits).	Yes
	• Functionality allowing the dewatering of open pits during Construction and Operation Phases of the Project encoded into the WBM.	Yes
	• GoldSim model configured to allow pit lakes to passively fill (and spill if they fill) through Reclamation and Closure and Post-closure Phases.	Yes
	• Pit lake recharge/discharge functionality (as informed by the Coffee Gold Mine GW model) built into the GoldSim model.	Yes
Waste Rock Storage Facilities	• Year-by-year development of the Alpha and Beta temporary WRSFs are encoded in the GoldSim model.	No
	• GoldSim model accounts for progressive reclamation of disturbed areas (e.g., the closure of Beta temporary WRSF).	Yes
	• WRSF attenuation factor (i.e., lag in WRD hydrograph) incorporated into the WBM.	Yes
Heap Leach Facility	• Staged HLF construction and related water management structures incorporated into the GoldSim model.	Yes
	• Ore-wetting, make-up water requirements and management of non-contact water related to the HLF accounted for in the GoldSim model.	Yes
	• Discharge of effluent from a water treatment plant, during Operation and Reclamation and Closure Phases of the Project, encoded into the WBM.	Yes
	• GoldSim model considers the closure of the HLF and related water management structures, and the dismantling and removal of the water treatment plant.	Yes

Project Component/Activity and WBM Component Checklist		
Facility	**Project Component/Activity**	**Encoded in GoldSim Model**
Stockpiles	• Water management associated with engineered stockpiles for temporary storage organics/topsoil, overburden, ROM ore and crushed ore built into the WBM.	Yes
Water Management Structures and Activities	• Sediment control ponds situated downstream of the Alpha WRSF and open pits encoded into the GoldSim model.	Yes
	• Major water conveyance structures (i.e., interception ditches, diversion ditches, toe drains beneath waste rock piles) envisioned for mine catchments encoded into the WBM.	Yes
	• GoldSim model may be configured to account for consumptive uses such as potable water use, water stored for fire protection and dust suppression.	Yes

The model predictions for the Operation Phase were compared to the baseline data for all stations to determine whether the proposed Project would alter the proportion of the year that experiences flows below the 30% MAD threshold. **Table 3.3-2** presents the existing condition, where all Project area streams drop below 30% of the MAD in the months of November through March due to extensive channel icing. Given the sharp contrast between the winter and open-water season flows, the relative changes in the existing streamflow regime would have to be substantial to extend the period of time that streamflows remain below this threshold. While some Project related residual changes are predicted to occur, they are not of sufficient magnitude to extend the period of reduced flow beyond its current state. As a result, this indicator is not assessed further in this section.

In **Appendix 12-C-3**, summary tables and plots are presented for key nodes represented of the WBM. Results in **Appendix 12-C-3** are organized by WBM node and provide added context to the summary information presented in this section.

4.3.5 LATTE CREEK AND COFFEE CREEK

A summary of water balance model outputs relevant to Latte Creek and Coffee Creek is presented in **Figure 4.3-1**, **Table 4.3-3, Table 4.3-4**, **Table 4.3-5** and **Table 4.3-6**. As a compliment to this information, detailed water balance model screenings are provided for four Latte Creek and Coffee Creek water balance nodes (i.e., CC-1.5, CC-3.5, CC-0.5 and CC-4.5) in **Appendix 12-C-3**, noting that the CC-0.5 model node is situated upstream of the Latte-Coffee confluence and therefore experiences no change in streamflow regime following Project development.

Table 4.3-3 summarizes percent change predictions for the Latte and Coffee Creek water balance nodes for End of Operation, Closure and Post-closure. Predictions are reported in the table for three metrics (i.e., 10th percentile, mean, 9th percentile) and for months of the year with reliable surface water flow (i.e., April through end-October). Percent change estimates in the table are screened to highlight values exceeding magnitudes of ±5%, with pink formatting indicating positive percent change values and blue indicating negative percent changes in this analysis. These data indicate positive percent change data for April at CC-1.5 and CC-3.5, but minor flow reductions overall for Latte Creek.

For the Operation Phase, **Figure 4.3-1** summarizes 10th percentile, mean and 90th percentile discharge data at CC-1.5 for the Natural/baseline and Base Case model runs. Taken in aggregate with Table 4.3-3, these discharge data are indicative that future flow changes attributable to the Project are predicted to be relatively minor for Latte Creek at the CC-1.5 water balance node. Furthermore, the natural drainage of CC-1.5 is 23.1 km^2 and with increased distance downstream (i.e., CC-3.5: 70 km^2 drainage area; CC-4.5: approximately 500 km^2) any discernible flow changes in Upper Latte Creek are anticipated to become increasingly muted at the Latte Creek confluence with Coffee Creek and Coffee Creek below Latte Creek.

By drawing on the water balance model results summarized in **Appendix 12-C-3**, a detailed indicator assessment for CC-1.5 is presented by Project Phase in **Table 4.3-4**. Direction, Magnitude and Timing indicators for CC-1.5 show similar results for Operation, Closure and Post-Closure Phases, although flow changes for the Operation Phase appear worst case. During the Operation Phase, active pits are being dewatered, small volumes of water are being abstracted from pit sumps as needed for process make-up water and dust suppression activities, and backfilled WRSFs (e.g., Double Double and SU1 pits), serve to alter the local flow regime. At CC-1.5, the Low Flow indicator for the Magnitude residual change characteristic returns a consistent high (H) rating for each Project Phase, whereas as other indicators for change characteristics consistently return ratings that are low, moderate or associated with negligible or no change.

Exposed pit walls are assumed to generate pit wall runoff more efficiently than natural drainage area and additional runoff from these areas has the potential to enhance future low flow regimes compared to the baseline condition. Any change at CC-1.5 associated with pit wall runoff will be greatest during the Operation Phase when actively mined pits are efficiently being dewatered. By comparison, in Closure and Post-Closure open pits passively fill and eventually spill and thus the proportion of exposed pit wall is reduced in these later Project Phases. Backfilled waste rock in the Latte Creek drainage also has the potential to enhance low flow signatures given that WRSFs are assumed to attenuate (reduce freshet peak, enhance summer and autumn flows) the natural hydrograph.

CC-3.5 is the next node located downstream of the proposed Project. As a result, any Project related change discernible at CC-1.5 becomes substantially reduced at this node further downstream. **Table 4.3-5** provides an indicator summary at CC-3.5 for Operation, Closure and Post-Closure Phases of the Project. The same activities that serve to alter streamflows at CC-1.5 have a similar effect at CC-3.5, though they are muted by the larger watershed. For example, the Low Flow indicator for the Magnitude residual change characteristic returns a consistent moderate (M) rating for each Project Phase at CC-3.5, whereas as other indicators for change characteristics consistently return ratings that are low (L) or associated with negligible or no change.

Finally, at the CC-4.5 node (which represents a watershed area 21 times larger than the CC-1.5 node), none of the model runs predict discernible changes to the Natural/baseline streamflow regime. This node represents Coffee Creek just upstream of its confluence with the Yukon River, and as discussed in Section 1.3, is also a site of substantial cultural and historical significance with a long history of use by the First Nations of the region.

Table 4.3-3 presents the statistical summary of the predictive model runs for this location. In general, the alterations to streamflow are predicted to be less than 1% at CC-4.5, which is well below the assessment threshold selected for this exercise, and much lower than the highest hydrometric measurement standards. As such, there are no changes predicted to occur to the existing streamflow regime at CC-4.5 as a result of the proposed Project (**Table 4.3-6**).

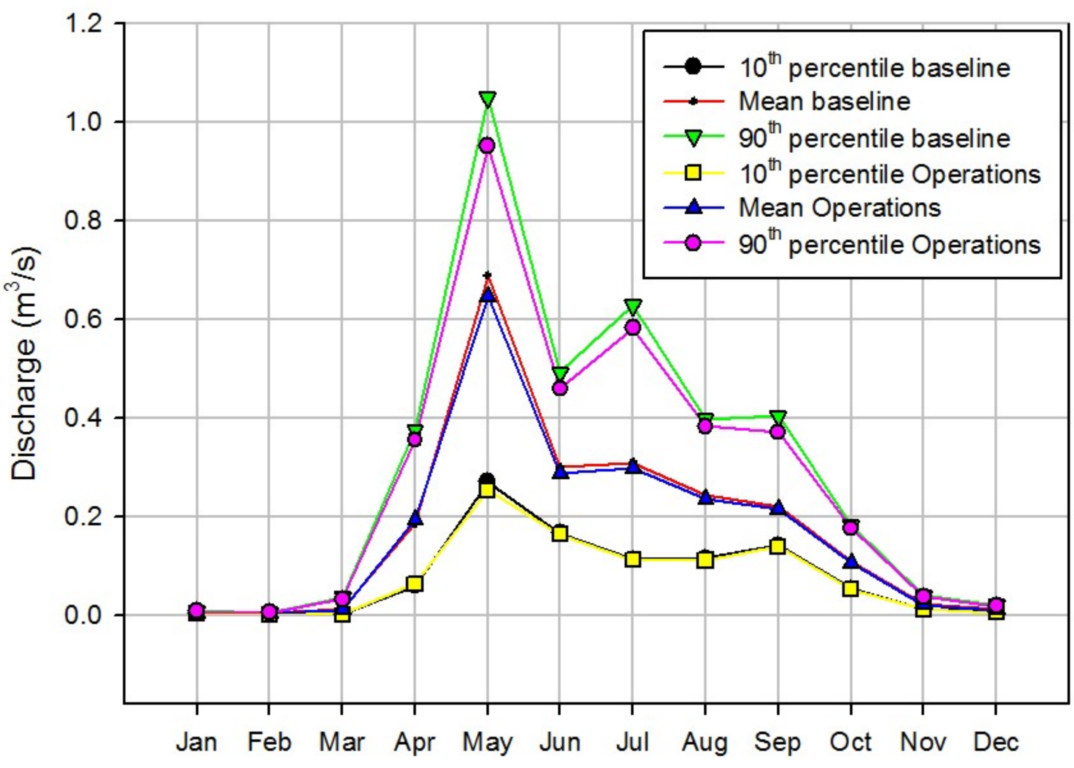


Figure 4.3-1 Predicted Monthly Discharges at Station CC-1.5 for the End of Operation Phase

Table 4.3-3 Latte Creek and Coffee Creek – Percent Change Summary

			Percent Change from Reference Condition (%)						
Location	**Phase**	**Metric**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
CC-1.5 (23.1 km²)		10th Percentile	-7.3	-11.0	-8.3	-8.1	-7.5	-7.7	-8.3
	End Operations	Mean	8.1	-6.4	-4.2	-3.5	-3.2	-2.9	-3.4
		90th Percentile	27.8	-1.0	-0.4	0.4	0.4	0.4	0.2
		10th Percentile	-1.2	-6.7	-4.0	-4.2	-3.6	-3.6	-5.0
	Reclamation and Closure	Mean	13.0	-4.6	-2.7	-2.8	-2.5	-2.0	-2.4
		90th Percentile	25.7	-2.6	-1.3	-1.0	-1.5	0.3	0.8
		10th Percentile	-2.0	-4.4	-2.1	-2.1	-1.7	-1.7	-2.3
	Post-closure	Mean	5.9	-1.1	-1.0	-0.8	-0.6	-0.1	-0.6
		90th Percentile	20.2	1.9	0.0	0.2	0.4	1.2	1.1
CC-3.5 (69.8 km²)		10th Percentile	-3.0	-5.8	-3.7	-3.6	-3.4	-3.6	-4.3
	End of Operations	Mean	4.1	-3.0	-1.5	-1.1	-1.0	-0.9	-1.2
		90th Percentile	11.9	0.2	0.5	0.9	1.0	1.0	1.3
		10th Percentile	0.0	-3.4	-1.4	-1.5	-1.1	-1.2	-2.4
	Reclamation and Closure	Mean	6.3	-1.9	-0.7	-0.7	-0.7	-0.3	-0.5
		90th Percentile	12.1	-0.8	0.1	0.2	-0.1	0.9	1.8
		10th Percentile	-0.6	-2.1	-0.4	-0.4	-0.2	-0.2	-0.5
	Post-closure	Mean	3.3	0.1	0.2	0.4	0.4	0.7	0.6
		90th Percentile	9.7	2.0	0.8	0.9	1.0	1.5	1.7
CC-4.5 (484 km²)		10th Percentile	-0.2	-0.8	-0.6	-0.4	-0.4	-0.4	-0.6
	End of Operations	Mean	0.3	-0.4	-0.2	-0.1	-0.1	-0.1	-0.1
		90th Percentile	0.9	0.0	0.1	0.1	0.1	0.1	0.2
		10th Percentile	0.0	-0.4	-0.2	-0.2	-0.1	-0.1	-0.3
	Reclamation and Closure	Mean	0.5	-0.2	-0.1	-0.1	-0.1	0.0	-0.1
		90th Percentile	1.0	-0.1	0.0	0.0	0.0	0.1	0.3
		10th Percentile	0.0	-0.3	-0.1	0.0	0.0	0.0	-0.1
	Post-closure	Mean	0.3	0.0	0.0	0.0	0.0	0.1	0.1
		90th Percentile	0.7	0.4	0.1	0.1	0.1	0.2	0.2

* Drainage area reported alongside site location is the pre-development (baseline) estimate
Values in table are the percent change in monthly average streamflow from the baseline condition (Without Project). Blue shaded cells represent predicted negatives changes (i.e., flow reductions) greater than the 5% threshold and grey shaded cells represent predicted positive changes (i.e., flow increases) greater than the 5% threshold.

Table 4.3-4 Residual Change Characteristics and Indicator Ratings for CC-1.5

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive Negative Varied No Change*	Annual Runoff	-	-	-
	Monthly Distribution	-	-	NC
	Low Flows	+	+	+
	High Flows	-	-	-
Magnitude *High Moderate Low Negligible*	Annual Runoff	NG	NG	NG
	Monthly Distribution	M	L	NG
	Low Flows	H	H	H
	High Flows	M	L	L
Timing *Change Detected No Change*	Monthly Distribution	NC	NC	NC
	Low Flows	NC	NC	NC
	High Flows	CD	CD	NC
Frequency *Infrequent Frequent Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible Partially reversible Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Timing: Change Detected (CD), No Change (NC); Frequency: Infrequent (I), Frequent (F), Continuous (C)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

Table 4.3-5 Residual Change Characteristics and Indicator Ratings for CC-3.5

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive* *Negative* *Varied* *No Change*	Annual Runoff	-	-	NC
	Monthly Distribution	-	-	NC
	Low Flows	+	+	+
	High Flows	-	-	NC
Magnitude *High* *Moderate* *Low* *Negligible*	Annual Runoff	NG	NG	NG
	Monthly Distribution	L	NG	NG
	Low Flows	M	M	M
	High Flows	L	NG	NG
Timing *Change Detected* *No Change*	Monthly Distribution	NC	NC	NC
	Low Flows	NC	NC	NC
	High Flows	NC	NC	NC
Frequency *Infrequent* *Frequent* *Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible* *Partially reversible* *Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely* *Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Timing: Change Detected (CD), No Change (NC); Frequency: Infrequent (I), Frequent (F), Continuous (C)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

Table 4.3-6 Residual Change Characteristics and Indicator Ratings for CC-4.5

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive* *Negative* *Varied* *No Change*	Annual Runoff	NC	NC	NC
	Monthly Distribution	NC	NC	NC
	Low Flows	NC	NC	NC
	High Flows	NC	NC	NC
Magnitude *High* *Moderate* *Low* *Negligible*	Annual Runoff	NG	NG	NG
	Monthly Distribution	NG	NG	NG
	Low Flows	NG	NG	NG
	High Flows	NG	NG	NG
Timing *Change Detected* *No Change*	Monthly Distribution	NC	NC	NC
	Low Flows	NC	NC	NC
	High Flows	NC	NC	NC
Frequency *Infrequent* *Frequent* *Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible* *Partially reversible* *Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely* *Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

4.3.6 YT-24 TRIBUTARY

Similar to the outputs presented in Section 4.3.5 for Latte and Coffee Creeks, monthly percent change statistics are presented in **Table 4.3-7** for YT-24, with representative flow data (Operations; 10th percentile, mean, 90th percentile) shown for this tributary in Error! Reference source not found.. For months with appreciable discharge (April through October, streamflow predictions generally indicate that enhancements of flows are anticipated at YT-24, throughout the phases of mine life assessed. Using mean percent change results to summarize main patterns and trends (**Table 4.3-7**) the following is noted for YT-24: percent change values for the Operation Phase range from 2.6% (April) to 34% (October); mean percent change predictions for months June through September are intermediate to April and October predictions, and range from 9 to 23%; and mean monthly percent change predictions are slightly worst case for the Operation Phase as compared to predictions returned for Closure and Post-Closure Phases.

The widespread predicted increases in streamflows at YT-24 are attributable to several factors. First, as outlined in **Appendix 8-A**, the YT-24 basin has the lowest median elevation of all Project area gauged basins, and therefore receives relatively lower precipitation amounts overall. The natural runoff coefficient for this station is also quite low, and averages 0.17 for the two years of gauged record, compared to the Project area average of 0.34. Secondly, the relationship between precipitation and elevation is well established for the Project site, with higher elevations receiving proportionately more precipitation than lower elevations. Project infrastructure in the YT-24 drainage is located at, or near, the height of land in the basin, which proportionately receives more precipitation. Thirdly, development of the mine is predicted to result in more of the meteoric water being transformed into runoff. Specifically for YT-24, stripping of overburden and development of open pits will result in lower rates of infiltration and evapotranspiration and more runoff. And lastly, the post-development drainage area for YT-24 slightly exceeds that for the pre-mine condition since a portion of the Supremo sitting in the Latte Creek watershed is predicted to drain northward following Project development. Although this additional contributing area is small (<5% of the pre-mine drainage area), the change occurs at high elevation, where the potential for additional precipitation and runoff potential is realized.

Accordingly, the magnitude of the predicted residual changes is rated as either moderate or high for all indicators (i.e., Direction, Magnitude, Timing) and all phases of the Project (**Table 4.3-8**). As described for Latte Creek, exposed pit walls are assumed to generate pit wall runoff more efficiently than natural drainage area and additional runoff from these areas has the potential to enhance future low flow regimes compared to the baseline condition. This is apparent at YT-24, with Magnitude (Low Flow) ratings being high for Operation, Closure and Post-closure. The Magnitude (High Flow) residual change screenings confirm increased basin productivity following mine development with rating being high for the Operation phase and moderate for Closure and Post-closure. The higher rating for the Operation phase occurs as actively mined pits are efficiently being dewatered during this phase, rather than passively filling and/or spilling later in the Project timeline. The residual changes for YT-24 are predicted to be continuous, irreversible (permanent) and the probability of occurrence is rated as likely.

Table 4.3-7 YT-24 Percent Change Summary

			Percent Change from Reference Condition (%)						
Location	Phase	Metric	Apr	May	Jun	Jul	Aug	Sep	Oct
YT-24 (11.8 km²)	End of Operations	10th Percentile	-7.6	4.1	0.2	-2.2	-0.7	-0.8	11.1
		Mean	2.6	23.3	9.9	11.0	10.0	9.1	34.1
		90th Percentile	14.2	47.9	17.7	18.5	18.2	16.7	62.3
	Reclamation and Closure	10th Percentile	-5.7	5.5	2.3	2.3	1.4	0.5	8.5
		Mean	-2.0	14.3	4.1	3.5	2.9	3.8	26.4
		90th Percentile	3.9	30.2	5.9	4.7	3.9	7.4	39.2
	Post-closure	10th Percentile	-3.2	3.5	2.7	2.2	2.3	2.5	6.8
		Mean	6.7	14.6	5.7	6.3	5.4	6.6	20.2
		90th Percentile	15.1	31.5	10.2	11.3	10.6	11.4	38.7

* Drainage area reported alongside site location is the pre-development (baseline) estimate.

Values in table are the percent change in monthly average streamflow from the baseline condition (Without Project). Blue shaded cells represent predicted negatives changes (i.e., flow reductions) greater than the 5% threshold and grey shaded cells represent predicted positive changes (i.e., flow increases) greater than the 5% threshold.

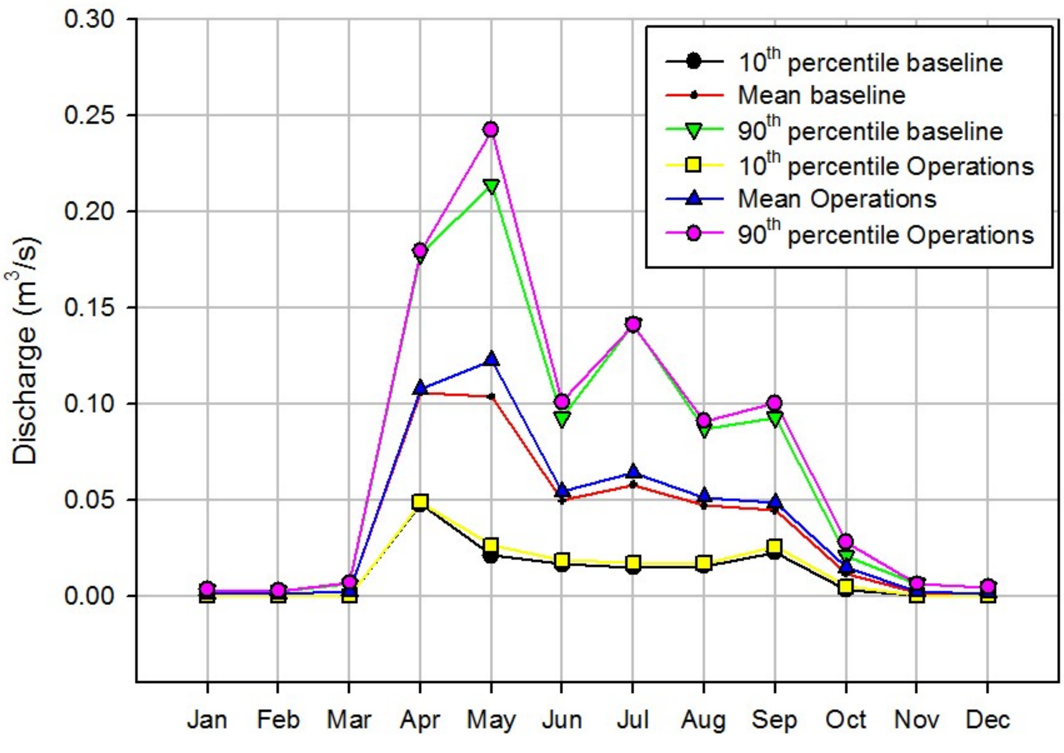


Figure 4.3-2 Predicted Monthly Discharges at Station YT-24 for the End of Operation Phase

Table 4.3-8 Residual Change Characteristics and Indicator Ratings for YT-24

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive* *Negative* *Varied* *No Change*	Annual Runoff	+	+	+
	Monthly Distribution	+	+	+
	Low Flows	+	+	+
	High Flows	+	+	+
Magnitude *High* *Moderate* *Low* *Negligible*	Annual Runoff	M	M	M
	Monthly Distribution	H	H	H
	Low Flows	H	H	H
	High Flows	H	M	M
Timing *Change Detected* *No Change*	Monthly Distribution	CD	CD	CD
	Low Flows	CD	CD	CD
	High Flows	CD	CD	CD
Frequency *Infrequent* *Frequent* *Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible* *Partially reversible* *Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely* *Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

4.3.7 HALFWAY CREEK DRAINAGE

Similar to the outputs presented in Section 4.3.5 (Latte and Coffee Creeks) and Section 4.3.6 (YT-24), monthly percent change statistics are presented in **Table 4.3-9** for the HC-2.5 and HC-5.0 nodes on Halfway Creek. The predicted changes for this location are also shown in **Figure 4.3-3**. With the Project, approximately 3.1 km^2 of the 14.8 km^2 Upper Halfway Creek drainage will contain mine infrastructure, and therefore 21% of the natural watershed area will generate contact water. At the End of Operations Phase, flows are predicted to increase from the baseline condition beyond the 5% threshold for May through September at HC-2.5. The 10th percentile changes range from 6% to 12% for these months, the mean predicted changes range from 19% to 26% and the 90th percentile predicted increases range from 36% to 47% above the baseline monthly streamflows. The months of April and October show greater variability in the range of predicted alterations, ranging from -27% (10th percentile) to 0% (90th percentile) for April, and -16% (10th percentile) to 20% (90th percentile) for October. Similar to the other basins, data for April and October is subject to larger measurement error due to ice effects, and therefore the model results likely have a larger range of variability. Additionally, the relative streamflow rates are much lower in April and October, and therefore relatively small absolute changes in predicted flows result in larger relative changes.

Exposed pit walls are assumed to generate pit wall runoff more efficiently than natural drainage area and additional runoff from these areas has the potential to enhance future low flow regimes compared to the baseline condition. Any change at HC-2.5 associated with pit wall runoff will be greatest during the Operation Phase when actively mined pits are efficiently being dewatered. By comparison, in Closure and Post-Closure open pits passively fill and eventually spill and thus the proportion of exposed pit wall is reduced in these later Project Phases. Piled waste rock in the Halfway Creek drainage also has the potential to enhance low flow signatures given that WRSFs are assumed to attenuate (reduce freshet peak, enhance summer and autumn flows) the natural hydrograph. Finally, the commissioning and operation of the Alpha Pond has the potential to alter the distribution of streamflow timing. All contact water emanating from the upgradient mined areas eventually reports to this pond, which is dewatered at a rate of 300 L/s during the open water season. Depending on the magnitude of a freshet or large rainfall event, some water may leave this pond later than it would have under the baseline condition. Once this pond is removed in the Post-closure phase, this potential attenuation effect is removed, however the alterations due to the presence of the WRSF will are expected to still be present.

A similar pattern (i.e., flow enhancements at HC-2.5) is evident in the Closure Phase predictions, with mean predicted changes for the months of May through September ranging from 22% to 29%. Slightly larger alterations are realized during this phase as a direct result of treated discharge from the HLF drain-down being directed to Halfway Creek over a period of several years during this phase. (**Table 4.3-9**). A similar range of predicted flow alterations (-22% to 59% exists for April and October. This variability about the mean, and inconsistent direction (increase or decrease) of flow alteration suggests that the predicted changes are driven by climate as much as by mine operations, and are also a result of small changes due to Project operations being superimposed on the existing low flows. Thus, a small absolute change in flow will result in relatively larger flow alterations when expressed as a percent change.

During the Post-Closure Phase, the predicted alterations are weighted toward the positive side of the distribution, and range from 12% to 32% for the months of May to September. No predicted changes below the -5% screening threshold are predicted to occur in this phase. The slight increase in predicted flow changes (relative to the End of Operations and Closure periods) is largely due to the passive spill of the SU3W pit to Halfway Creek, and the routing of passively treated water from the HLF to the Latte pit, which subsequently spills to the Alpha WRSF rock drain.

Table 4.3-10 presents the residual change assessment for the HC-2.5 node. The magnitude of predicted flow alterations is high for all four indicators (Annual Runoff, Monthly Distribution, Low Flows and High Flows), in all phases. The timing of streamflows in Halfway Creek are predicted to change as the Alpha WRSF is expected to both attenuate streamflows (lagged) and increase the runoff coefficient above the background condition (particularly during wet-years). The changes are predicted to occur continuously, will be irreversible (permanent) and the probability of occurrence is rated as likely.

The HC-5.0 node represents the entirety of the Halfway Creek watershed at its confluence with the Yukon River. The drainage area reporting to this node is 27 km^2, and similar to the downstream stations on Latte Creek (from CC-1.5), all additional runoff from the intervening basin is non-contact. Therefore, the mine affected area comprises only 11% of the total basin area at HC-5.0. The predicted streamflow alterations at the HC-5.0 are similar in both direction and magnitude to those for HC-2.5, but are of lower magnitude due to the larger contribution non-contact drainage area (**Table 4.3-9**). Only the 10^{th} percentile predictions for April and October show predicted reductions that exceed the -5% screening threshold, for the End of Operations and Closure phases.

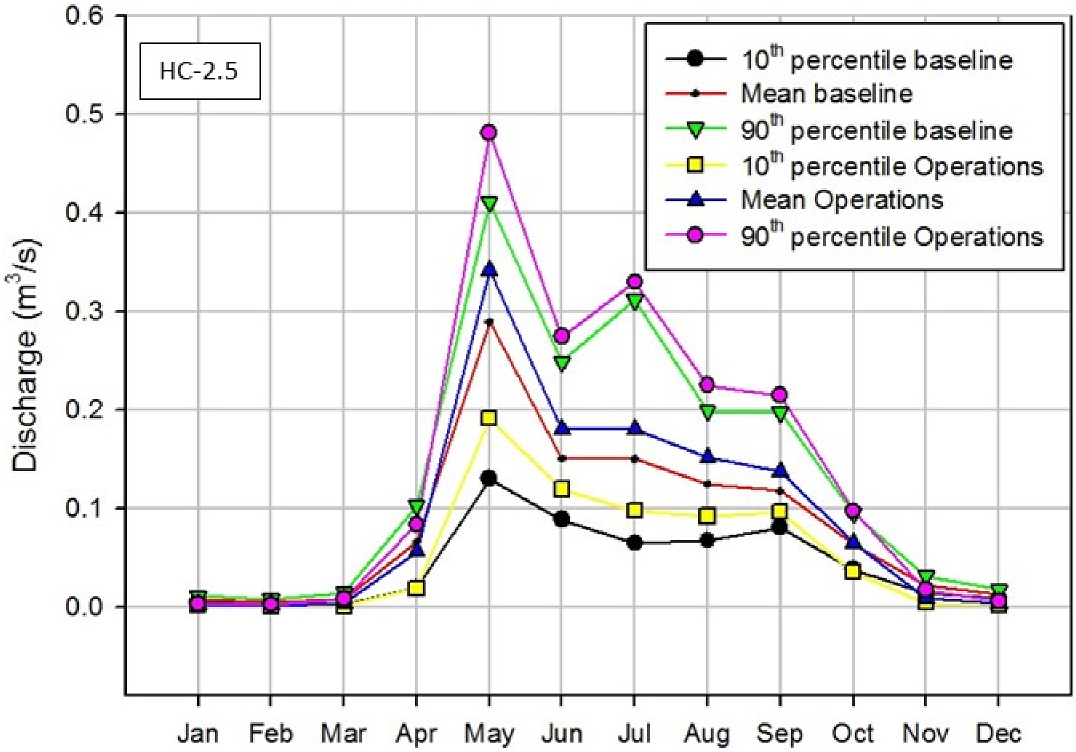
Table 4.3-11 presents the residual change assessment for the HC-5.0 node. The magnitude of predicted flow alterations is high for the Annual Runoff, Monthly Distribution and Low Flows indicators, and moderate for the High Flows indicator in all phases. As for HC-2.5, the timing of streamflows is expected to change due to the Operation and Closure of the Project. The changes are predicted to occur continuously, be irreversible (permanent) and the probability of occurrence is rated as likely.

Table 4.3-9 Halfway Creek Drainage Percent Change Summary

Location	Phase	Metric	Percent Change from Reference Condition (%)						
			Apr	May	Jun	Jul	Aug	Sep	Oct
HC-2.5 (14.8 km²)	End of Operations	10th Percentile	-27.0	9.1	8.5	9.1	11.8	5.6	-15.7
		Mean	-15.1	22.2	24.4	26.3	24.6	19.1	2.0
		90th Percentile	-0.2	47.3	39.1	46.9	40.6	35.7	19.6
	Reclamation and Closure	10th Percentile	-22.4	4.2	9.7	10.2	14.1	7.6	-18.1
		Mean	3.2	21.5	27.6	29.3	29.2	23.2	2.4
		90th Percentile	59.1	49.8	43.4	51.7	46.0	40.6	20.5
	Post-closure	10th Percentile	6.5	-3.3	18.6	12.5	16.0	9.1	-1.0
		Mean	37.8	11.9	31.9	28.9	26.8	22.9	14.5
		90th Percentile	80.5	37.7	45.9	50.4	40.4	38.1	30.1
HC-5.0 (27 km²)	End of Operations	10th Percentile	-12.4	5.4	5.2	5.4	6.9	3.6	-7.3
		Mean	-6.3	14.1	15.3	16.3	15.1	11.8	4.6
		90th Percentile	1.3	31.1	25.0	29.6	25.7	21.9	17.1
	Reclamation and Closure	10th Percentile	-10.8	2.5	6.2	6.0	8.3	4.4	-9.3
		Mean	2.7	13.6	17.3	18.1	18.0	14.3	4.7
		90th Percentile	29.1	34.0	27.5	32.4	29.2	25.3	19.7
	Post-closure	10th Percentile	3.8	-2.1	11.4	7.4	9.4	5.3	-0.4
		Mean	19.4	7.6	19.9	17.8	16.4	14.0	10.3
		90th Percentile	41.1	24.1	29.2	32.0	25.7	23.9	21.8

* Drainage area reported alongside site location is the pre-development (baseline) estimate.

Values in table are the percent change in monthly average streamflow from the baseline condition (Without Project). Blue shaded cells represent predicted negatives changes (i.e., flow reductions) greater than the 5% threshold and grey shaded cells represent predicted positive changes (i.e., flow increases) greater than the 5% threshold.



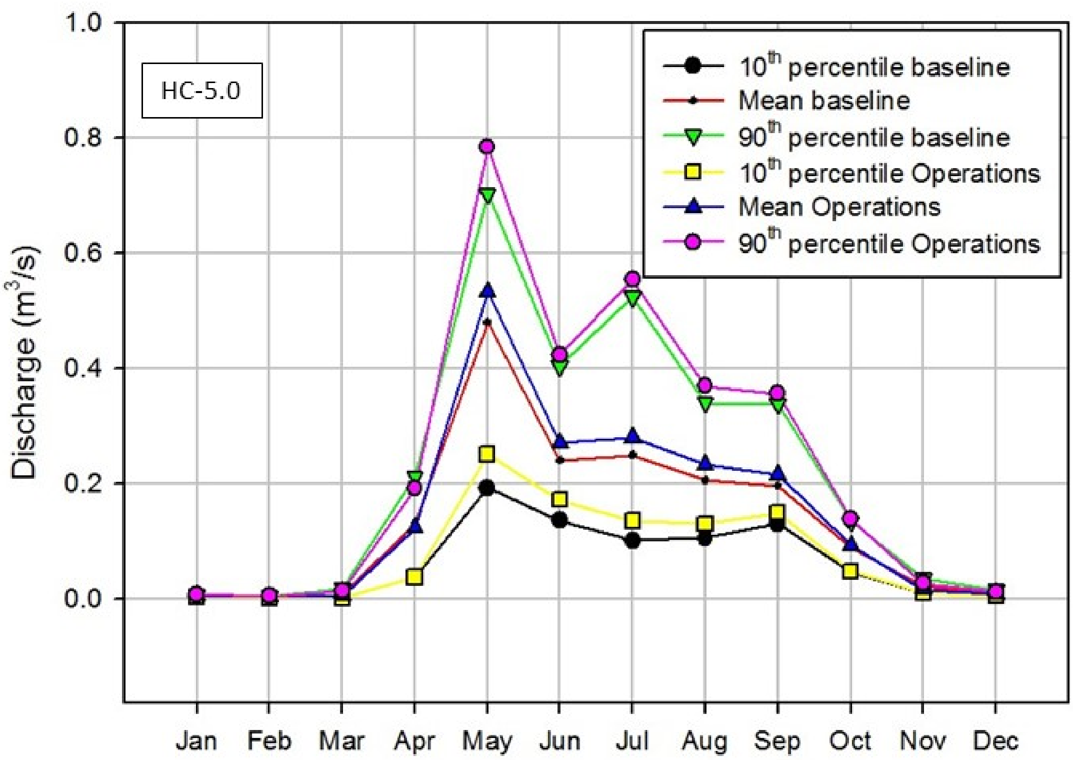


Figure 4.3-3 Predicted Monthly Discharges at Station HC-2.5 (upper) and Station HC-5.0 (lower) for the End of Operation Phase

Table 4.3-10 Residual Change Characteristics and Indicator Ratings for HC-2.5

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive* *Negative* *Varied* *No Change*	Annual Runoff	+	+	+
	Monthly Distribution	+	+	+
	Low Flows	-/+	-/+	-/+
	High Flows	+	+	+
Magnitude *High* *Moderate* *Low* *Negligible*	Annual Runoff	H	H	H
	Monthly Distribution	H	H	H
	Low Flows	H	H	H
	High Flows	H	H	H
Timing *Change Detected* *No Change*	Monthly Distribution	CD	CD	CD
	Low Flows	CD	CD	CD
	High Flows	CD	CD	CD
Frequency *Infrequent* *Frequent* *Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible* *Partially reversible* *Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely* *Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Timing: Change Detected (CD), No Change (NC); Frequency: Infrequent (I), Frequent (F), Continuous (C)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

Table 4.3-11 Residual Change Characteristics and Indicator Ratings for HC-5.0

Residual Change Characteristics	Indicator	End of Operation	Reclamation and Closure	Post-closure
Direction *Positive* *Negative* *Varied* *No Change*	Annual Runoff	+	+	+
	Monthly Distribution	+	+	+
	Low Flows	-/+	-/+	-/+
	High Flows	+	+	+
Magnitude *High* *Moderate* *Low* *Negligible*	Annual Runoff	H	H	H
	Monthly Distribution	H	H	H
	Low Flows	H	H	H
	High Flows	M	M	M
Timing *Change Detected* *No Change*	Monthly Distribution	CD	CD	CD
	Low Flows	CD	CD	CD
	High Flows	CD	CD	CD
Frequency *Infrequent* *Frequent* *Continuous*	Annual Runoff	**C**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Reversibility *Fully reversible* *Partially reversible* *Irreversible, permanent*	Annual Runoff	**IR**		
	Monthly Distribution			
	Low Flows			
	High Flows			
Probability of occurrence *Likely* *Unlikely*	Annual Runoff	**LK**		
	Monthly Distribution			
	Low Flows			
	High Flows			

Notes:

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Timing: Change Detected (CD), No Change (NC); Frequency: Infrequent (I), Frequent (F), Continuous (C)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

4.3.8 YUKON RIVER

The estimated drainage of the Yukon River above Coffee Creek is 147,317 km^2, while the combined drainage area of all Project area watersheds (Coffee/Latte, Halfway and YT-24 Creeks) is approximately 530 km^2, or 0.4% of the Yukon River drainage.

In order for flow alterations to be detectable in the Yukon River at the +/- 5% change threshold, the predicted streamflow alterations for the Project area watersheds would need to be several orders of magnitude higher than what is presented in this exercise. Therefore, the Project is assumed to cause no discernible change to the streamflow regime of the Yukon River.

4.4 SUMMARY OF FUTURE CONDITIONS WITH THE PROJECT

An assessment of residual changes attributable to the proposed Project is presented in Section 4.2 for the NAR and Section 4.3 for the Coffee Gold Mine Site. With the implementation of the design mitigations and BMPs included in management plans, no residual changes to the Surface Hydrology IC are expected from the construction, operation and decommissioning of the NAR.

Future residual changes to the hydrologic regime at the Coffee Gold Mine Site have been predicted using a GoldSim WBM, which incorporates Project design measures to avoid and minimize potential changes to streamflows. Residual changes are limited mainly to the CC-1.5, YT-24, HC-2.5 and HC-5.0 WBM nodes. Residual changes are summarized for Operation phase, the phase returning worst case flow changes, in **Table 4.4-1**. Predicted changes to the existing streamflow regime at CC-3.5 and CC-4.5 are considerably lower magnitude, with mean values (of all WBM runs) often fall below the +/-5% change from baseline that was selected as the assessment threshold. It is notable that flow changes and ratings at CC-1.5 and HC-2.5 improve with distance downstream and by CC-3.5 and HC-5.0 model nodes respectively. A final summary of potential Project-related residual changes to Surface Hydrology is provided as **Table 4.4-2**.

Table 4.4-1 Summary of Predicted Project-related Residual Changes to Surface Hydrology during Operation Phase

	Annual Runoff	Monthly Distribution	Low Flows	High Flows	Annual Runoff	Monthly Distribution	Low Flows	High Flows	Monthly Distribution	Low Flows	High Flows	Frequency	Reversibility	Probability of occurrence
WBM Node	**Direction**				**Magnitude**				**Timing**					
CC-1.5	-	-	+	-	NG	M	H	M	NC	NC	CD	C	IR	LK
CC-3.5	-	-	+	-	NG	L	M	L	NC	NC	NC	C	IR	LK
CC-4.5	NC	NC	NC	NC	NG	NG	NG	NG	NC	NC	NC	C	IR	LK
YT-24	+	+	+	+	M	H	H	H	CD	CD	CD	C	IR	LK
HC-2.5	+	+	-/+	+	H	H	H	H	CD	CD	CD	C	IR	LK
HC-5.0	+	+	-/+	+	H	H	H	M	CD	CD	CD	C	IR	LK

Notes:

Residual changes are presented for the Operation phase, as this is when the largest changes are predicted to occur.

Direction: Positive (+), Negative (-), Varied (-/+), No Change (NC)

Magnitude: High (H), Moderate (M), Low (L), Negligible (NG)

Timing: Change Detected (CD), No Change (NC); **Frequency:** Infrequent (I), Frequent (F), Continuous (C)

Reversibility: Fully Reversible (FR), Partially Reversible (PR), Irreversible/permanent (IR)

Probability of occurrence: Likely (L), Unlikely (UL)

10th and 90th percentile percent change data used for Direction and Magnitude screenings

Table 4.4-2 Summary of Potential Project-related Residual Changes to Surface Hydrology

Project Component / Activity	Potential Change to Surface Hydrology	Proposed Mitigation Measures	Potential Residual Adverse Change
Northern Access Route	Refer to **Section 4.2.3**: • Increased sediment production and transport • Increased flooding due to blocked culverts, increased runoff from road surfaces and ditches • Reduced infiltration through road surfaces • Altered shallow groundwater flow paths.	Implementation of BMPs in mitigation plans: • Access Route Construction Management Plan • Access Route Operational Management Plan • Dust Management Plan • Conceptual Reclamation and Closure Plan • Erosion and Sediment Control Plan	No residual adverse changes anticipated.
Mine Site			
Latte Creek (CC-1.5)	Potential changes: • Reductions in runoff due to storage in HLF, pits and WRSFs • Increases in runoff due to clearing and stripping activities, pit development, etc. • Alteration of monthly streamflow distribution due to land surface alterations, attenuated runoff through WRSFs and pond storage and release • Reductions in runoff due to operation of HLF as closed system for most of Operation Phase	Mitigation measures are listed in **Section 4.3.2**, and include: • Progressive reclamation and backfilling of pits • WRSF site selection and inclusion of rock drains • HLF operated as closed system for first part of Operation phase and progressive reclamation beginning in Year 4 • Management of non-contact water • Sediment pond, event pond and rainwater collection pond design.	Moderate changes (reductions) in annual runoff, monthly distribution, low flows and high flows.
Latte Creek (CC-3.5)			Low changes (reductions) in annual runoff and high flows, and moderate changes in monthly distribution and low flows.
Coffee Creek (CC-4.5)			No residual adverse changes anticipated.
YT-24			High magnitude changes (increases) in annual runoff, monthly distribution, low flows and high flows.
Halfway Creek (HC-2.5)			High magnitude changes (increases) in annual runoff, monthly distribution, low flows and high flows.
Halfway Creek (HC-5.0)			Moderate/high changes (increases) in annual runoff, monthly distribution, low flows and high flows.

5.0 FUTURE CONDITIONS WITH THE PROJECT AND OTHER PAST, PRESENT, AND FUTURE PROJECTS AND ACTIVITIES

This section of the report presents an analysis of potential cumulative changes to the Surface Hydrology IC and the Project's contribution to these changes. For the purposes of this assessment, cumulative changes are assumed to result from interactions between Project-related changes and the incremental changes to the IC resulting from other past, present, and future potential projects and activities.

Surface hydrology is by its nature a cumulative discipline in that a watercourse gathers additional flow with distance travelled and areal increase within a watershed context. Therefore, streamflow at a given point on a watercourse is an accumulation of all surface water reporting from the watershed above – whether cumulative flow is attributable to natural processes, human-induced change or a combination of factors. If there are residual changes to Surface Hydrology upstream of a point of interest, they will manifest in the accumulated flow downstream should the residual changes be of sufficient magnitude.

Guidance documents specific to this Cumulative Change Analysis are identified below:

- Draft Technical Guidance for Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012 (CEA Agency, December 2014);
- Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act 2012, Operational Policy Statement (CEA Agency 2013 a);
- Practitioners Glossary for the Environmental Assessment of Designated Projects under the Canadian Environmental Assessment Act, 2012 (CEA Agency 2013b); and
- Reference Guide: Addressing Cumulative Environmental Effects (CEA Agency 1994a).

Project related changes were assessed for the IC in Section 4.0, with screening guided by the Projects and Activities Inclusion List (refer to **Section 5.0 Assessment Methodology, Appendix 5-B**).

5.1 SPATIAL AND TEMPORAL SCOPE OF THE CUMULATIVE CHANGE ANALYSIS

Section 5.1 outlines the spatial and temporal scope of the Cumulative Change Analysis for the Surface Hydrology IC.

5.1.1 SPATIAL SCOPE OF THE CUMULATIVE CHANGE ANALYSIS

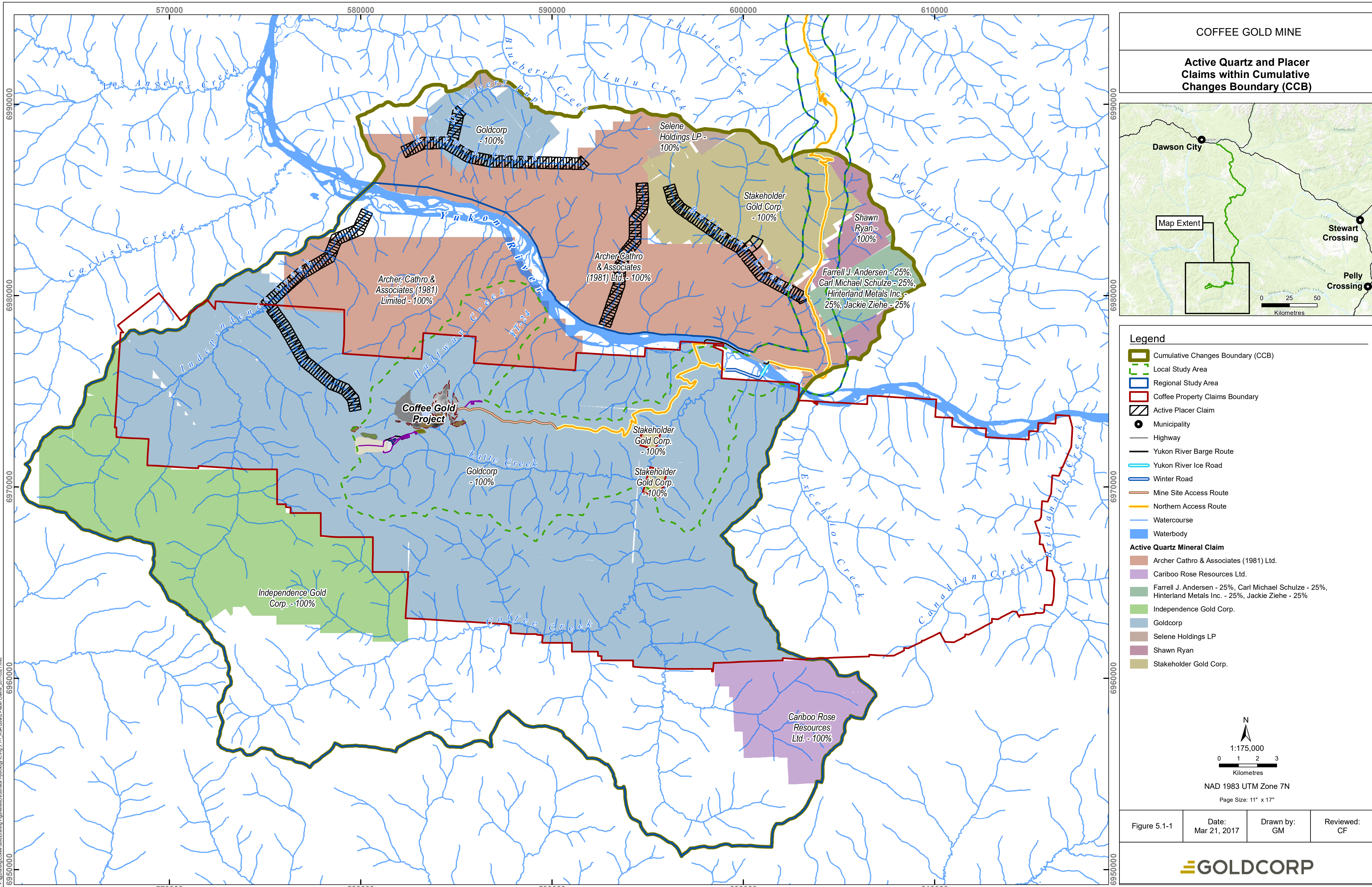
All past, present and potential future Projects in the vicinity of the Coffee Gold Mine (i.e., proposed pits, waste rock storage facilities, HLF, and water management structures associated with the mine site) are shown in **Figure 5.1-1.** A Cumulative Change Boundary (CCB) is proposed as the spatial scope for the Cumulative Change Analysis and is also shown in **Figure 5.1-1** (heavy black line). Project-related residual changes to Surface Hydrology identified in Section 4.0 were carried forward into the Cumulative Change Analysis. With respect to the NAR, no residual changes are carried forward in the Surface Hydrology IC assessment and accordingly, cumulative changes are not evaluated for the extent of the NAR situated north of the Coffee Gold Mine Site.

Specific to the Mine Site, Project-related residual changes were considered for their potential to interact with future Projects and activities identified within the CCB. Therefore, discussion in this chapter focuses on potential cumulative changes and the Latte Creek, YT-24 Creek and Halfway Creek watersheds.

As indicated in Section 4.0, Project-related changes in streamflow are not detectable in the Yukon River given the scale of the Yukon basin (147,000 km^2) compared to local watersheds (i.e., drainage areas on the order of 10-100s of km^2). It is notable that residual changes from the Project are not explored in detail at the scale of the Yukon River for this reason.

5.1.2 TEMPORAL SCOPE OF THE CUMULATIVE CHANGE ANALYSIS

The Cumulative Change Analysis considers the same timeline and Project Phases as presented in Section 1.5 of this report. Relevant also to the temporal scope of the Cumulative Change Analysis is the time of year that past, present and potential future activities are assumed to take place. For this assessment, it is assumed that potential future quartz exploration and placer mining activities occurring within the CCB will be constrained to summer and early autumn (i.e., May to end-September) when local creeks are flowing freely and not iced over.


COFFEE GOLD MINE
Active Quartz and Placer Claims within Cumulative Changes Boundary (CCB)
Dawson City
Map Extent
Stewart Crossing
Pelly Crossing
0 25 50
Kilometres
Legend
Cumulative Changes Boundary (CCB)
Local Study Area
Regional Study Area
Coffee Property Claims Boundary
Active Placer Claim
Municipality
Highway
Yukon River Barge Route
Yukon River Ice Road
Winter Road
Mine Site Access Route
Northern Access Route
Watercourse
Waterbody
Active Quartz Mineral Claim
Archer Cathro & Associates (1981) Ltd.
Cariboo Rose Resources Ltd.
Farrell J. Andersen - 25%, Carl Michael Schulze - 25%, Hinterland Metals Inc. - 25%, Jackie Ziehe - 25%
Independence Gold Corp.
Goldcorp
Selene Holdings LP
Shawn Ryan
Stakeholder Gold Corp.
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Lulu Creek
Thistle Creek
Pedlar Creek
Carlisle Creek
Yukon River
Independence Creek
Halfway Creek
YT-24
Latte Creek
Coffee Creek
Excelsior Creek
Canadian Creek
Britannia Creek
Goldcorp - 100%
Selene Holdings LP - 100%
Stakeholder Gold Corp. - 100%
Shawn Ryan - 100%
Farrell J. Andersen - 25%, Carl Michael Schulze - 25%, Hinterland Metals Inc. - 25%, Jackie Ziehe - 25%
Archer, Cathro & Associates (1981) Limited - 100%
Archer Cathro & Associates (1981) Ltd. - 100%
Coffee Gold Project
Stakeholder Gold Corp. - 100%
Goldcorp - 100%
Stakeholder Gold Corp. - 100%
Independence Gold Corp. - 100%
Cariboo Rose Resources Ltd. - 100%

5.2 CHANGES DUE TO OTHER PAST, PRESENT, AND FUTURE PROJECTS AND ACTIVITIES

Residual changes to Surface Hydrology identified in Section 4.0 are carried forward into this Cumulative Change Analysis. No residual changes attributable to the Northern Access Route are carried forward in the Surface Hydrology IC assessment. Residual changes attributable to the Mine Site are carried forward into the analysis and are generally determined to be most pronounced during the Operation Phase and are low-to moderate- in magnitude overall.

An inventory of future Projects and activities was assembled from a wide variety of information sources, including municipal, regional, provincial, and federal government agencies; other stakeholders; and companies' and businesses' websites. A comprehensive listings other past, present and potential future Projects that could foreseeably interact with already identified residual changes are provided in **Table 5.2-1** and **Table 5.2-2** and discussed in the next sections.

5.2.1 OTHER PROJECTS WITHIN THE CCB

Currently, there are two quartz mining claims located south of the Yukon River and near the Coffee Gold Mine Site (**Table 5.2-1**). Little information is available on the mineral claim attributed to the Stakeholder Gold Corporation, and the company website only lists their Ballarat property as undergoing active exploration. The locations of the Stakeholder Gold Corporation claims indicate potential interaction with Coffee Creek along the mainstem of the watercourse and downstream of the confluence with Latte Creek. The website for the Dan Man Project indicates no active exploration program at this tenure since 2011. However, the Dan Man Project includes targets in the Dan Man watershed, a drainage that is situated between Halfway Creek and Independence Creek watersheds. The Dan Man claim also extends into the Halfway Creek and YT-24 drainages, and thus there is potential for exploration of these claims in the future.

Farther afield, there is potential for mineral exploration in the headwaters of Coffee Creek (i.e., upstream of the Latte/Coffee Creek confluence) (refer to **Figure 5.1-1** and **Table 5.2-1**). In addition to claims held by Goldcorp, titles held by Independence Gold Corp., Rimfire Minerals/AuRico Gold, and Cariboo Rose Resources Ltd., are situated within the Coffee Creek drainage. In the Independence Creek drainage, titles held by Arcus Development Group Inc., Rimfire Minerals/AuRico Gold and Independence Gold Corp., are also noted. Quartz exploration activities that may affect Surface Hydrology include mainly the abstraction of water (from creeks, shallow groundwater) to support seasonal (May-Sep) drilling operations and work camp domestic needs. There are no known placer mining claims situated within the extent of the CCB that is situated south of the Yukon River (**Table 5.2-2**).

North of the Yukon River, the CCB extends to the height of land and includes the Ballarat Creek, Touleary Creek and Kirkman Creek drainages. As shown in

Figure 5.1-1 and summarized in **Table 5.2-1** and **Table 5.2-2**, there are both placer mining and quartz claims within the extent of the CCB north of the Yukon River. Like Coffee Creek and Independence Creek watersheds, there is potential for mineral exploration in these northern drainages given the holdings of Goldcorp, Arcus Development Group Inc., Selene Holding LP, Stakeholder Gold Corp., Hinterland Minerals Inc. and Shawn Ryan. A number of placer mining claims are held within the Ballarat Creek and Kirkman Creek drainages, as well as on a minor tributary just east of the Touleary Creek watershed.

Table 5.2-1 Quartz Mining Activity Within the Cumulative Change Boundary

Status	Claim/Tenure	Extent of CCB South of Yukon River	Extent of CCB North of Yukon River
Active	TL		X
Active	DM	X	X
Active	ANA	X	X
Active	BERG	X	X
Active	BERG F	X	X
Active	ICE	X	X
Active	KANA	X	X
Active	KOFFEE	X	X
Active	MAYA	X	X
Active	TAK		X
Active	BDW	X	X
Active	GRT	X	X
Active	GRT F	X	X
Active	HAN	X	X
Active	SOL	X	X
Active	TIGER	X	X
Active	VIP	X	X
Active	XT	X	X
Active	XY	X	X
Active	XZ	X	X
Active	COFFEE	X	X
Active	COFFEE NW	X	X
Active	CREAM	X	X
Active	LION	X	X
Active	KIRKMAN		X
Active	AVE	X	X
Active	BLVD	X	X
Active	DRIVE	X	X

Status	Claim/Tenure	Extent of CCB South of Yukon River	Extent of CCB North of Yukon River
Active	BC		X
Active	Black Fox		X
Active	Cub		X
Active	PEDLAR		X
Active	BA		X
Active	EX		X
Active	KIT	X	X
Active	TIK		X
Pending	DM	X	X
Active	Redfox		X
Pending	Bal		X

Table 5.2-2 Placer Mining Projects Within the Cumulative Change Boundary (CCB)

Status	Claim/Tenure	Extent of CCB South of Yukon River	Extent of CCB North of Yukon River
Active	Claim		X
Active	Co-Disc		X
Active	Fischer		X
Active	FON		X
Active	Jake		X
Active	Kai		X
Active	Kirkman		X
Active	KK		X
Active	Oro		X
Active	Pegasus		X
Active	Rat		X
Active	Tara		X
Active	Tie		X
Active	Independence	X	

5.3 Potential Cumulative Changes

Potential cumulative changes are summarized in **Table 5.3-1** for locations and watercourses situated within the CCB defined for the Surface Hydrology IC. Where appropriate, **Table 5.3-1** summarizes residual changes attributable to the Coffee Gold Mine alongside potential residual effects assigned to past, present and future activities. A combined rating (Project residual changes + Other Projects residual changes) is assigned to locations and watercourses of interest in **Table 5.3-1.**

With respect to quartz claims in the CCB, it is conceivable that exploration activities may occur in the future and therefore plausible that there may be cumulative changes to Surface Hydrology as a result of future mineral exploration. However, exploration is a predominately seasonal activity that takes place during the snow free season of May through end-September. Relatively minor amounts of water may be abstracted from a local watercourse or shallow groundwater well to meet domestic supply needs of a temporary work camp. Water may also be abstracted from a local watercourse or groundwater well in support of a drilling and exploration campaign.

Typically, surface disturbance associated with an exploration program is relatively minimal. A drill pad (or station) may be approximately 15 m^2 or less in size and connecting roads between drill pads are assumed to be on the order of 4 m wide and up to several 100's metres in length. Water requirements for a standard diamond drill program typically range from 0.6 to 1.3 L/s, depending on the drill type being used, depth of hole, rock type, etc. (Kaminak, pers. comm. 2015). To place this flow rate in context of local hydrology, 0.6 to 1.3 L/s equates to approximately 2% to 5% of the June-September $7Q_{10}$ (7-day summer low flow, 1:10 year return period) low flow estimate for the Halfway Creek drainage.

Potential residual changes associated with future quartz exploration was assigned a low rating overall, noting that this rating may be high locally (e.g., at spatial scale 1 km^2), but negligible (within measurement uncertainty) at large spatial scale (i.e., >10-15 km^2). Compared to locations at the Coffee Gold Mine showing residual changes (e.g., HC-2.5, CC-1.5, YT-24), residual effects attributable to exploration are assumed to be very minor. As such, no additional measures are proposed to reduce a future Project's contribution to an adverse cumulative change on the Surface Hydrology IC.

5.3.1 Latte Creek/Coffee Creek

With the exception of the Coffee Gold Mine, there are no known quartz exploration activities in the Latte Creek watershed. Therefore, residual changes at CC-1.5 and CC-3.5 are attributed exclusively to the Coffee Gold Mine and show cumulative residual change ratings of medium and low-medium respectively.

There is potential for future quartz exploration activities in the lower reaches of Coffee Creek. With any abstraction from a tributary adjacent to Coffee Creek (i.e., at small spatial scale (<1 km^2), immediately downstream of a point of extraction), there may be measurable residual change associated with the exploration activity. However, at the spatial scale of Coffee Creek, or assuming the abstraction is from Coffee Creek proper (e.g., at CC-4.5, drainage area ~500 km^2) residual changes from an exploration activity are assumed to be negligible as they will be masked by the streamflow signature of the greater watershed. Overall, the cumulative residual change rating for lower Coffee Creek (CC-4.5) is assigned as negligible.

5.3.2 YT-24 CREEK

There is potential for future quartz exploration activities to take place in the lower reaches of the YT-24 watershed. At this spatial scale (i.e., drainage area is approximately 12 km^2), the abstraction of water for domestic supply or drilling purposes (0.6 to 1.3 L/s) equates to approximately 7-15% of a June-September $7Q_{10}$ (7-day summer low flow, 1:10 year return period) low flow for this tributary. Exploration-related potential residual changes are assumed to be negligible since to some degree they will be masked by the streamflow signature of the greater watershed. Overall, the cumulative residual change rating for this location is assigned as high, noting that the direction of change attributable to the Coffee Gold Mine is positive (i.e., overall, flows at YT-24 are anticipated to be enhanced because of the Project).

5.3.3 HALFWAY CREEK

With exception of the Coffee Gold Mine, there are no known quartz exploration activities in the headwaters of the Halfway Creek watershed. Therefore, residual changes at HC-2.5 are attributed exclusively to the Coffee Gold Mine and show a cumulative residual change rating of high.

Further downstream at HC-5.0 (lower reaches of Halfway Creek), there is potential for future quartz exploration activities. At this spatial scale (i.e., drainage area is approximately 30 km^2), the abstraction of water for domestic supply or drilling purposes (0.6 to 1.3 L/s) equates roughly to <5% of a June-September $7Q_{10}$ (7-day summer low flow, 1:10 year return period) low flow for the Project area. These potential residual changes are assumed to be negligible as they will be largely masked by the streamflow signature of the greater watershed. Overall, the cumulative residual change rating for this location is assigned as moderate-high.

5.3.4 COFFEE CREEK HEADWATERS

There is potential for future quartz exploration activities in the headwaters of Coffee Creek. Local to any future exploration activity in the Coffee Creek watershed (i.e., at small spatial scale (<1 km^2) and immediately downstream of a point of extraction), there may be measurable residual changes associated with the exploration activity. However, at distance downstream (e.g., at CC-4.5, drainage area ~500 km^2) from a potential future exploration activity, these residual changes are assumed to be negligible as they are masked by the streamflow signature of the greater watershed.

5.3.5 INDEPENDENCE CREEK

There is potential for future quartz exploration activities throughout the Independence Creek watershed. Like Coffee Creek, Independence Creek is a large (~225 km^2 drainage at the mouth) and relatively pristine watershed. There may be measurable residual changes associated with the exploration activity in the headwaters of the drainage. However, at distance downstream (i.e., once drainage area exceeds 10-15 km^2) any local residual changes from quartz exploration are assumed to be negligible as they will be masked by the streamflow signature of the greater watershed. Overall, the cumulative residual change rating for this location is assigned as negligible and it is notable that no residual changes are anticipated in this drainage from the Coffee Gold Mine.

5.3.6 NORTH SHORE OF YUKON RIVER

North of the Yukon River, the proposed CCB extends to a height of land and includes the Ballarat Creek, Touleary Creek and Kirkman Creek drainages. As shown in **Figure 5.1-1** there are some placer mining and quartz claims situated in the northern reaches of the CCB. Placer mining techniques are used to recover precious metals that are associated with sediment in a stream bed or floodplain. Bulldozers, backhoes, dredging machinery or hydraulic jets (delivery of water under high pressure) may be used to extract the metal of interest.

While notable that quartz exploration and placer mining activities will likely be ongoing to some degree in Ballarat, Touleary and Kirkman Creek drainages, these potential future activities show no interaction with the watercourses likely to be influenced by the Coffee Gold Mine (i.e., Latte Creek, YT-24 and Halfway Creek). As indicated in Section 4.0, Project-related changes in streamflow are not detectable in the Yukon River given the scale of the Yukon basin (147,000 km^2), and it follows that potential future activities North of the Yukon River would not be detectable either. Accordingly, no measurable cumulative changes to the Yukon River streamflow regime are reported in **Table 5.3-1** as part of this analysis.

Table 5.3-1 Summary of Potential Project-related Residual Adverse Cumulative Changes to Surface Hydrology

Project Component/ Activity	Potential Cumulative Change to Surface Hydrology	Proposed Mitigation Measures	Potential Residual Adverse Cumulative Change
Northern Access Route	No cumulative changes anticipated for all indicators.	Implementation of best management practices in mitigation plans: • Access Route Construction Management Plan • Access Route Operational Management Plan • Dust Management Plan • Reclamation and Closure Plan • Sediment and Erosion Control Plan	No residual adverse cumulative changes anticipated.
Within the Extent of the CCB			
Latte Creek (CC-1.5)	No cumulative changes anticipated for all indicators.	Mitigation measures that are incorporated into the mine plan are sufficient to limit potential residual adverse cumulative changes.	No residual adverse cumulative changes anticipated for all indicators.
Latte Creek (CC-3.5)	No cumulative changes anticipated for all indicators.	Therefore, additional mitigation measures are not warranted.	No residual adverse cumulative changes anticipated for all indicators.
Coffee Creek (CC-4.5)	Negligible or no cumulative changes anticipated for all indicators.		Negligible or no residual adverse cumulative changes anticipated for all indicators.
YT-24	Negligible or no cumulative changes anticipated for all indicators.		Negligible or no residual adverse cumulative changes anticipated for all indicators.
Halfway Creek (HC-2.5)	No cumulative changes anticipated for all indicators.		No residual adverse cumulative changes anticipated for all indicators.
Halfway Creek (HC-5.0)	Negligible or no cumulative changes anticipated for all indicators.		Negligible or no residual adverse cumulative changes anticipated for all indicators.

Project Component/ Activity	Potential Cumulative Change to Surface Hydrology	Proposed Mitigation Measures	Potential Residual Adverse Cumulative Change
Coffee Creek Mainstem	No cumulative changes from the Project upstream of Latte Creek for all indicators. Negligible cumulative changes are expected from the Project below confluence with Latte Creek for all indicators.	Mitigation measures that are incorporated into the mine plan are sufficient to limit potential residual adverse cumulative changes. Further, many of the assessment nodes in the LSA returned residual change ratings of negligible or low. Therefore, additional mitigation measures are not warranted.	No residual adverse cumulative changes from the Project upstream of Latte Creek for all indicators. Negligible residual adverse cumulative changes are expected from the Project below confluence with Latte Creek for all indicators.
Independence Creek	No cumulative changes from the Project are anticipated for all indicators.		No residual adverse cumulative changes from the Project are anticipated for all indicators.
Yukon River between Ballarat Creek and Independence Creek	No detectable cumulative changes from the Project are anticipated for all indicators.		No detectable residual adverse cumulative changes from the Project are anticipated for all indicators.

5.4 MITIGATION MEASURES FOR CUMULATIVE CHANGES

Quartz mining exploration activities typically involve small scale footprints and water management is not on a scale sufficient to alter the distribution and magnitude of stream flows (*e.g.*, diversions or impoundments). Furthermore, exploration activities are typically seasonal in nature and constrained to summer months May through end-September.

Within the CCB, there is potential for interaction between those residual changes estimated for the Coffee Gold Mine, and those that may be realized via quartz mining exploration in the future. For two reasons, no specific mitigation measures are proposed to manage cumulative changes in the LSA. Firstly, and for locations showing residual changes (e.g., high (HC-2.5 and YT-24)), residual changes attributable to the Coffee Gold Mine largely influence the final rating. Therefore, the mitigation measures inherent in the Project mine plan (refer to Section 4.3) are assumed most efficient as a means to limit cumulative changes resulting from future exploration activities. Secondly, many of the assessment locations in the CCB and situated south of the Yukon River returned cumulative residual change ratings that were negligible or low, suggesting additional mitigation measures are not warranted.

For the extent of the CCB situated north of the Yukon River, a general finding of the analysis for cumulative changes is that where residual changes from the Project may interact with potential residual changes from a future activity (placer mining, quartz exploration), cumulative residual change characteristics were rated as negligible and suggestive that no additional mitigation measures are necessary. Therefore, further analysis of residual changes is not required.

6.0 SUMMARY OF ANALYSIS OF CHANGES TO SURFACE HYDROLOGY

This section of the IC analysis highlights overall results of the change analysis completed for the Surface Hydrology IC. The scope of the analysis, including the rationale for IC selection, the indicators selected to measure potential changes to the IC, and the spatial and temporal boundaries relevant to the analysis are summarized in Section 1.0. The analysis considers future activities and potential interactions associated with the NAR and the Project mine site (Section 4.2 and 4.3 respectively), as well as potential interactions associated with past, present and future activities within a CCB defined specifically for the Surface Hydrology IC (Section 5.0). For the residual change analysis at the Project mine site, Section 2.0 introduces a GoldSim WBM that was constructed and calibrated to quantify Project-related changes attributable to mine development, and this model was populated with baseline and regional hydro-meteorological information (Section 3.0; **Appendix 8-A**). In **Section 28.0**, potential accidents and malfunctions (i.e., cause, type, nature, likelihood and predicted consequences) associated with Project components by Project phase are discussed and residual changes associated with pre-defined upset conditions are qualified for the Surface Hydrology IC.

6.1 NORTHERN ACCESS ROUTE

An assessment of IC interaction with Project activities related to the NAR is presented in Section 4.2. No residual changes resulting from the construction-, operation or decommissioning of the NAR are predicted to occur, assuming that BMPs and standard operating procedures are followed as outlined in the associated management plans (Section 4.2; **Appendices 31-A and 31-B**).

6.2 COFFEE GOLD MINE SITE

For the Coffee Gold Mine Site, a detailed, site-wide WBM was used to estimate the potential changes to the Surface Hydrology IC resulting from the proposed Project for the local watersheds within the mine site portion of the LSA (i.e., south of the Yukon river). This assessment included the likely results of a changing climate in the base case scenario, and encompassed all phases of the mine life, extending out into the Post-closure Phase. The design mitigation measures that are proposed to limit the extent of changes to the Surface Hydrology IC are presented in Section 4.3. In general, many of the mitigation measures that have been incorporated into the Project design serve to limit the Projects interaction with the surrounding environment. As a result, any residual changes are largely confined to the headwater drainages at the Project site, represented by the CC-1.5, YT-24 and HC-2.5 WBM nodes. As the assessment progresses downstream, additional non-contact runoff is added to the drainage, and the residual changes are shown to decrease in magnitude accordingly.

Flow reductions are predicted to occur in Upper Latte Creek as a result of Project development, with the largest magnitude changes predicted to occur during the Operation phase. The magnitude of change predicted for the four indicators used in this assessment ranged from low to high at CC-1.5, with ratings at downstream locations CC-3.5 and CC-4.5 generally being low and/or consistent with negligible or no change form natural/baseline condition. Flow enhancements are predicted generally for the YT-24, HC-2.5 and HC-5.0 model nodes. For YT-24, the relatively larger proportion of the drainage area that will contain mine infrastructure (open pits only), the elevation of mine footprints, and increase in overall contributing area (due to water management activities), is predicted to result in moderate and high magnitude changes to the streamflow regime. Like results for CC-1.5, streamflow changes are predicted to be greatest at YT-24 during the Operation Phase, when pits are actively dewatered. Results for HC-2.5 show high magnitude change ratings for selected indicators (Annual Runoff, Monthly Distribution, Low Flow, Peak Flow) over Project life, with improvement (i.e., flow enhancements diminish) in indicator ratings (e.g., Magnitude, High Flow – moderate) further downstream at HC-5.0. For all nodes assessed as part of the Coffee Gold Mine site analysis, predicted changes to the Surface Hydrology IC are expected to be continuous in nature, irreversible and are likely to occur.

6.3 CUMULATIVE CHANGE ANALYSIS

The Cumulative Change Analysis examined potential interactions between the proposed Project, and other nearby past, present and reasonably foreseeable future projects (Section 5.0). A total of two recent (within the last 5 years) active mineral exploration projects, and no known placer projects are located within the portion of the LSA defined for the Surface Hydrology IC that sits south of the Yukon River. Potential exploration activity at these sites in the future is assumed to require very small water abstractions (e.g., for drilling), and therefore future exploration activities are not anticipated to result in measurable incremental changes to the Surface Hydrology IC within local watercourses such as Halfway Creek and YT-24 Creek.

Within the larger CCB, there is the potential for future mineral exploration to interact with the proposed Projects residual changes. The areas where this activity has the potential to occur are the mainstem of Coffee Creek and Independence Creek. However, the residual changes that may result from these potential activities are of low magnitude, duration, extent, and therefore not predicted to result in detectable cumulative changes to the Surface Hydrology IC. The mitigation measures that are proposed to limit the extent of changes on the Surface Hydrology IC are the same as those presented in Section 4.0, since the residual changes likely to be realized are attributable mainly to the Project.

7.0 MONITORING AND ADAPTIVE MANAGEMENT

Streamflow predictions presented in this chapter are considered robust. However, it will be necessary to implement a strategic and flexible water monitoring program at the mine site for the following reasons:

- Enhance baseline understanding of local hydro-meteorological processes
- Verify the accuracy of the residual change and residual cumulative change prediction
- Assess the efficacy of proposed mitigation measures and the need for modifications to those measures
- Identify analysis discrepancies that may arise related to the Surface Hydrology IC
- Implement additional mitigation measures as per adaptive management plans as required.

7.1 MONITORING SYSTEM OVERVIEW

The relevant monitoring and management plans that will inform adaptive management and future water monitoring program at the Coffee Gold Project are:

- Access Route Construction Management Plan (**Appendix 31-A**)
- Access Route Operational Management Plan (**Appendix 31-B**)
- Conceptual Reclamation and Closure Plan (**Appendix 31-C**
- Waste Rock and Overburden Management Plan (**Appendix 31-D**)
- Water Management Plan (**Appendix 31-E.**

A generic water monitoring program is discussed below for the Coffee Gold Project, with focus below on monitoring concepts as they relate to: Mine Site Monitoring; Effluent Monitoring; and Receiving Environment Monitoring. During Construction, water monitoring is anticipated to evolve and expand as mine design concepts, construction schedules and permitting details become certain, whereas during Operation and Closure Phases additional water specific monitoring initiatives may be required to inform mitigative actions.

Following successful reclamation and closure of the mine site, water monitoring directives for Post-closure are envisioned, albeit with reduced scope compared to preceding mine phases. Design and delivery of future monitoring activities will require the involvement of the regulatory agencies that have jurisdiction over water related issues, affected First Nations and coordinated efforts by mine site staff.

7.1.1 MINE SITE MONITORING

Mine site monitoring is intended to record the quantity and quality of both surface and groundwater that is affected by the various mine facilities. It is required primarily to verify geochemical 'source terms', (quantitative assumptions and predictions made to anticipate the effects of bedrock disturbance that will occur in the course of mine development, that underlie the ML/ARD Management Plan), and to confirm that site-wide water management systems are effective and functioning as intended. As such, Mine Site Monitoring includes measurement of flow and water quality associated with contact water such as seepage from waste rock storage facilities (WRSFs) and runoff from pit walls that reports to in-pit sumps.

7.1.2 EFFLUENT MONITORING

Effluent monitoring is intended to record the quantity and quality of surface water that collects in sediment control ponds and sumps, located downgradient of mine infrastructure, and is discharged to the receiving environment. For Construction and Operation phases, two ponds (Facility, Alpha WRSF) are currently proposed for the Project and surface water quantity will be monitored at each of them. Additionally, contact water that reports southward to Latte Creek (i.e., south Supremo pits and associated backfill) and northward to YT-24 (north Supremo pits, no backfill features) is proposed to be managed to dedicated sumps which will require flow measurement capability.

Effluent water quality and flow monitoring will also occur on water treatment plant effluent. Surplus rinse water from the heap leach facility will require discharge and therefore treatment starting in Year 9 and is anticipated to continue into active closure. Monitoring to ensure compliance with appropriate discharge limits for treated effluent pond discharges are important components of the plan and are expected to be subject to certain regulatory requirements. Following reclamation and drain-down of the HLF, seepage from the closed facility is proposed to be directed to Latte Pit. Measuring discharges and water quality from the future pit lake will be a requirement following spillover.

7.1.3 RECEIVING ENVIRONMENT MONITORING

Receiving environment monitoring includes both surface water and groundwater. Monitoring is intended to record the quantity and quality of water in the receiving environment, downstream of mine inputs in both groundwater and surface water. Surface water flow monitoring will include monitoring at selected stations on Latte Creek, Coffee Creek, YT-24, Halfway Creek, as well as Independence Creek, the latter of which serves as the undisturbed control drainage, as noted above. Flows in the receiving environment downstream of the mine will reflect the ultimate effects of the mine on the relevant intermediate and valued components (ICs and VCs, respectively).

7.2 METHODS

Flow monitoring will ultimately be undertaken to measure surface water discharges from mine facilities, from sediment control ponds, and to measure flows in the receiving environment. This section provides an overview of current monitoring methods employed at the Project, which focuses currently on receiving environment monitoring and collection of baseline data. Flow measurement procedures and key findings associated with baseline climate and hydrology studies are described in detail in the *Coffee Gold Project: Hydro-meteorology Baseline Report* (**Appendix 8-A**).

Hydrology methods observe the standards and procedures outlined in the *Manual of British Columbia Hydrometric Standards – Version 1.0* (RISC, 2009). This document defines standards and detailed procedures for the acquisition of water quantity data, and provides specific direction on monitoring site selection, station construction and benchmarking, recording discharge measurements, developing stage-discharge relationships, and reporting and presenting hydrometric data.

These standard methods have been employed since 2010 as part of the baseline monitoring program, and will continue to be used through the construction and operation phases of the Coffee Gold Project.

7.3 Monitoring Locations and Frequency

A robust and spatially representative hydrometric monitoring program is currently in place, and a high-quality baseline dataset exists from which to measure Project-related changes to streamflow and to confirm the predictions of the water-balance-modelling exercise. The monitoring program is currently structured to provide high-resolution (i.e., temporal – water level data at a 15-minute time-step; spatial – 11 stations spanning all relevant Project area watersheds) data that will allow potential changes to all indicators used in this change assessment to be robustly measured and re-evaluated.

Station names, locations, period of record and watershed metrics are summarized for the current hydrometric network in **Table 8.3-1**, which is complimented by a high-elevation climate station (air temperature, precipitation, relative humidity, solar radiation, wind speed and direction, barometric pressure) and stand-alone tipping bucket rain gauges and snow courses established at various elevations. The baseline hydrometric monitoring network is also depicted in **Figure 3.2-1** and described in detail in **Appendix 8A**.

A baseline hydrometric monitoring program will continue throughout environmental assessment and permitting processes, into Operation, and beyond into the Post-closure phase. Continuation of a baseline hydrometric program will presumably form a requirement of both the Quartz Mining and Water Use Licenses for the Project, and the data collected will be included in the annual reporting requirements associated with these licenses. During Construction, water monitoring is anticipated to evolve and expand as mine design concepts, construction schedules and permitting details become certain. Accordingly, additional sampling locations and measurement protocols will be re-evaluated and updated at that time.

Table 7.3-1 Summary of Receiving Environment Hydrometric Stations

Station Name	Location	Catchment Area (km^2)	Mean Elevation (m asl)	Period of Record
Latte and Coffee Creeks				
CC-5.0	Tributary to upper Latte Creek (south tributary)	6.2	1,221	2014-Present (spot)
CC-5.5	Tributary to Upper Latte Creek (west tributary)	3.4	1,236	2014-Present (spot)
CC-6.0	Upper Latte Creek (upstream of South mine basin confluence)	9.6	1,225	2014-Present
CC-1.0	Tributary to Latte Creek draining South mine basin (near Latte Creek confluence)	3.4	1,017	2014-Present
CC-1.5	Latte Creek (downstream of South mine basin)	23.1	1,120	2010-Present (spot) 2014-Present (continuous)
CC-3.5	Lower Latte Creek (upstream of Coffee Creek confluence, downstream of all mine influence)	69.8	969	2010-Present (spot); 2011-Present(continuous)
CC-0.5	Upper Coffee Creek (above Latte Creek confluence, not mine influenced)	385.6	1,023	2010-Present (spot) 2014-Present (continuous)
CC-4.5	Lower Coffee Creek (near confluence with Yukon River)	484	993	2010-Present (spot)
YT-24				
YT-24	Yukon River Tributary (YT) 24 (near confluence with Yukon River)	11.8	838	2014-Present
Halfway Creek				
HC-2.5	Upper Halfway Creek	14.8	1,043	2010-Present (spot) 2014-Present(continuous)
HC-5.0	Lower Halfway Creek (near confluence with Yukon River)	27.0	885	2010-Present (spot); 2011-Present(continuous)
Independence Creek (Control)				
IC-0.5	Upper Independence Creek	68.9	1,048	2010-Present (spot)
IC-1.5	Tributary to Independence Creek (southernmost tributary)	81.1	1,077	2010-Present (spot) 2014-Present (continuous)
IC-2.5	Tributary to Independence Creek (middle tributary)	17.3	1,003	2011-Present (spot); 2014-Present (continuous)
IC-3.0	Tributary to Independence Creek (northernmost tributary)	18.3	905	2010-Present (spot)
IC-4.5	Independence Creek (near confluence with Yukon River)	222.3	989	2010-Present (spot); 2011-Present (continuous)

7.4 MONITORING PROCEDURES

Climate and hydrometric installations will be frequented by field technicians at monthly intervals, year-round. During each sampling event, field staff will perform the following tasks:

- Note the time, weather, general flow conditions, presence/absence of ice and staff gauge reading (before and after manual flow measurement to capture changes in stage during visit)
- Note any channel form changes (e.g., scouring at station, sediment buildup, altered hydraulic control, undercutting of banks)
- If station includes a weir or other rated structure (e.g., flume or discharge pipe outfall), inspect the site for signs of leakage or erosion around or under the structure, sediment buildup, changes in the hydraulic relationship, damage from ice or equipment, and algae growth or other obstruction
- Inspect the instrumentation and logger for damage, moisture buildup, or any condition that could cause or lead to malfunction
- Change desiccant packs as necessary
- Download the data logger and visually inspect data for abnormalities
- Make a manual measurement of flow, using a current meter, salt dilution, or other method as appropriate
- If necessary and time permits, make a second measurement to constrain the measurement error
- Estimate possible sources of error (fluctuating stage, inadequate salt slug dilution, etc.)
- Take photos of the staff gauge, upstream and downstream views, and anything else of note.

In addition to the monitoring procedures above, a benchmark survey will be completed at least once a year, or following a large flow event and/or following the spring breakup.

7.5 IMPLEMENTATION

The monitoring system will be implemented in a systematic manner to ensure that reliable and consistent data is obtained. Key considerations include assignment of responsibilities, data management, and data interpretation and reporting.

7.5.1 RESPONSIBLE PERSONS

Responsibilities associated with the hydrologic monitoring program are to be assigned to site personnel or qualified professionals.

7.5.1.1 Site Personnel

Site personnel will be responsible for the following tasks related to the hydrologic monitoring plan:

- Scheduled site sampling visits, sensor and meter maintenance and calibration
- Personal health and safety, including hazard identification and avoidance, wearing appropriate personal protective equipment (PPE), etc.

- Initial data management activities including QA/QC of data, archiving and backup
- Compilation of data for dissemination to other qualified professionals
- Training of other site staff to ensure redundancy in the monitoring program
- Review and updates of the monitoring protocols, manuals, etc. as necessary, and/or as required by permit and license conditions.

7.5.1.2 Qualified Professionals

External consultants (i.e., qualified professionals engaged by Goldcorp) will be responsible for the following tasks related to the collection and interpretation of meteorological data:

- Secondary QA/QC of data collected by the program
- Updates of existing analyses and new analyses that utilize the site data, as required
- Maintaining a record of changes made to the data following the QA/QC exercise, and a record of suggested alterations to the monitoring program (including frequency, sensor types, monitoring locations, monitoring and data management protocols, etc.)
- Maintaining backups of all data and associated maintenance records, field notes, reports, etc. on a corporate server.

7.5.2 DATA MANAGEMENT

Once the data has been collected from the site monitoring stations, it will be entered by the responsible site personnel into a standardized hydro-meteorological database. This will form the primary record, and any adjustments or corrections that are performed on this data will be saved as separate files, to ensure that the original data records remain unaltered. All data and associated field notes will be stored in standard electronic format.

Following every site visit, the manual discharge and stage measurements will be checked against the existing rating curve to ensure the quality of the measurement, and the stability of the curve. The continuous water level data will be reviewed to ensure that the sensors are functioning properly, and that the offset between the staff gauge and transducer readings hasn't changed. Following each benchmark survey, the data will be checked for indications that the staff gauge has shifted (e.g., frost jacking), and if necessary, offsets for the future staff gauge measurements will be calculated and applied.

At the conclusion of each open water season, the rating curves will be checked for consistency, and the continuous water level record will be corrected using the appropriate offsets and archived, along with the updated discharge record. Hydrometric stations and climate installations will be winterized in late-Autumn.

7.5.3 DATA ANALYSIS AND REPORTING

Reporting of the data collected under this monitoring plan will be a requirement for both site operational tracking and optimization, and of the associated permits and licenses that will be required for the proposed Project. Reporting will occur internally on a quarterly basis, and externally on an annual basis. The latter will presumably be linked to permitting and/or licensing requirements.

7.5.3.1 Quarterly Data Reports

As part of site management activities, quarterly reports will be produced for internal use. The reports will summarize all data collected as part of the hydro-meteorological monitoring program. These reports will also note any changes that have been made to the monitoring network, including sampling location, frequency, parameters, and rating curve adjustments.

7.5.3.2 Annual Interpretive Reports

Annual interpretive reports will presumably be a permit or licence requirement for the proposed Project. It is anticipated that annual interpretive hydrometric reports will encompass data from the meteorology, surface and ground water, heap leach and waste rock monitoring programs. These reports will summarize the data collected for the previous year in tabular and graphical format, as well as providing summary statistics (e.g., monthly rainfall and temperature summaries, precipitation (snow and rain) as a percent of the long-term average, discharge and water quality, etc.).

For the water quantity monitoring program, the following data will be included in the Annual Interpretive Report:

- Final daily discharge / streamflow records for the year for all monitoring sites
- Manual discharge measurements from all sites
- Up-to-date corrected water level records
- Benchmark surveys and adjustments made to the staff gauge-pressure transducer offsets
- Dates of transducer installation / removal
- Updated rating curves, with discussion of adjustments made, discrepancies and errors
- Summary statistics for water quantity (averages, peak flows, low flows)
- Relationships with site and regional climate data.

Any significant changes to the monitoring network, such as changes to instrumentation, or location of monitoring points will be noted, along with a rationale for the changes. If necessary, recommendations will be made concerning upgrades or changes that are deemed necessary for the following year, along with the rationale.

7.6 SUMMARY

A strategic and flexible water monitoring program is necessary to: enhance baseline understanding of local hydro-meteorological processes; verify the accuracy of the residual change and residual cumulative change predictions; assess the efficacy of proposed mitigation measures and the need for modifications to those measures; and implement additional mitigation measures as per adaptive management plans as required. Design and delivery of future monitoring activities will require the involvement of the regulatory agencies that have jurisdiction over water related issues, affected First Nations and coordinated efforts by mine site staff.

A generic water monitoring program is discussed in this section that addresses meteoric and flow measurement in relation to mine facilities, points of effluent release and downstream and receiving streams. Climate and flow monitoring at the Coffee Gold Mine presently focuses on the collection of baseline hydrometric data in receiving steams. However, during Construction, the monitoring network will evolve and expand as mine design concepts, construction schedules and permitting details become certain, For Operation and Closure Phases, additional water specific monitoring initiatives may be required to inform mitigative actions.

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