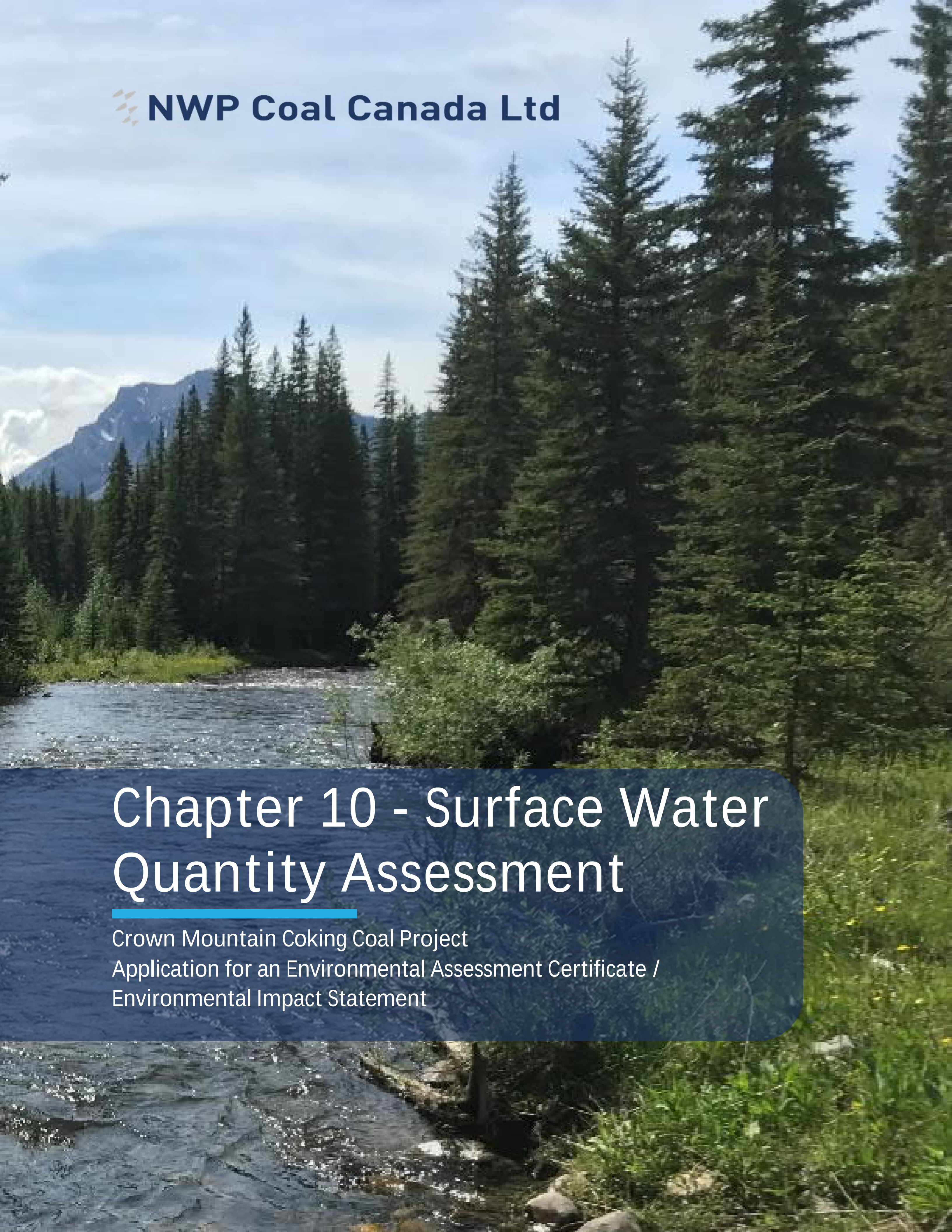

NWP Coal Canada Ltd

Chapter 10 - Surface Water Quantity Assessment

Crown Mountain Coking Coal Project
Application for an Environmental Assessment Certificate / Environmental Impact Statement

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10. Surface Water Quantity Assessment

10.1 Introduction

Surface water is a key component of the biophysical environment. The timing and magnitude of surface water flows (hydrology) are essential to the maintenance of surface water quality and quantity that are essential to the health and well-being of all living things including aquatic ecosystems, vegetation, and wildlife through direct influences on physical habitat and water quality. Surface water quantity also influences other environmental conditions including groundwater availability and quality and climate feedbacks (e.g., albedo effect; Bonsal et al., 2019).

The hydrologic cycle is primarily governed by natural processes such as precipitation, water storage in ice and snow, surface runoff, evaporation, and evapotranspiration; however, many anthropogenic activities also influence hydrology, including agriculture, industry, hydroelectricity generation, drinking water provisions, and recreational activities (Bonsal et al., 2019). Climate change is also increasingly recognized as a factor that affects hydrology and surface water availability through alterations of the climatic conditions that influence the hydrologic cycle.

Given the complex relationship between hydrology and the natural environment, surface water quantity (as represented by hydrology) was identified as an intermediate valued component (VC) for the Project in the Application Information Requirements (AIR; Environmental Assessment Office [EAO], 2018) and as a component of the physical environment in the Guidelines for the Preparation of an Environmental Impact Statement for the Crown Mountain Coking Coal Project (EIS Guidelines; Canadian Environmental Assessment Agency, 2015). An understanding of hydrologic characteristics within and downstream of the Project area is critical to the Project design, engineering, and assessment of potential environmental effects.

Surface water quantity effects have linkages with intermediate and receptor VCs; these effects are primarily assessed in the following chapters:

- Chapter 9: Groundwater Assessment;

- Chapter 11: Surface Water Quality Assessment;
- Chapter 12: Fish and Fish Habitat Assessment;
- Chapter 13: Landscapes and Ecosystems Assessment;
- Chapter 14: Vegetation Assessment;
- Chapter 15: Wildlife and Wildlife Habitat Assessment; and
- Chapter 22: Human and Ecological Health Assessment.

10.1.1 Regulatory and Policy Setting

Applicable provincial and federal legislation and guidance documents related to hydrology and the management of surface water quantity are summarized in Table 10.1-1.

Table 10.1-1: Regulatory Considerations and Guidance Documents for Surface Water Quantity

Legislation/Guideline Name	Year	Description
Federal Legislation		
Canada Water Act	1985	The Canada Water Act legislates water resources by providing a framework for collaboration among federal, provincial, and territorial governments in matters relating to water resources, including programs relating to research, conservation, development, and utilization of water resources.
Fisheries Act	1985, amended 2019	The Fisheries Act provides protection against the death of fish other than by fishing, release of deleterious substances, and the harmful alteration, disruption, or destruction of fish habitat, among others.
Provincial Legislation		
Water Sustainability Act	2014	The Water Sustainability Act manages the use and diversion of water resources in the province and aims to ensure a sustainable supply of fresh, clean water is available to meet the needs of B.C. residents.
Water Protection Act	1996	The Water Protection Act confirms the Province's ownership of surface and groundwater, defines limits for bulk water removal, and prohibits large-scale diversions of water between major provincial watersheds and/or to locations outside the province.
Mines Act	1996	The Mines Act and its associated Health, Safety and Reclamation Code for Mines (2021) require mines to have programs for the environmental protection of land and watercourses throughout the mine life, including plans for prevention of erosion and sediment release. Watercourses are required to be reclaimed, and the Ministry of Energy, Mines and Low Carbon Innovation has the authority to require monitoring and/or remediation programs to protect watercourses.

Legislation/Guideline Name	Year	Description
Provincial Guidance Documents		
Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators	2016	The guidance document outlines and defines the baseline study requirements and information considerations required to propose a mineral development in B.C. (B.C. MOE, 2016).
Manual of British Columbia Hydrometric Standards	2018	The guidance document outlines procedures for acquiring water quantity data, assessing the data, and qualifying and quantifying data grades (Resources Inventory Standards Committee, 2018).

10.2 Scope of the Assessment

10.2.1 Valued Components and Measurement Indicators

Hydrologic conditions may be impacted by reduction in streamflows associated with alteration of natural flow regimes that could potentially result from the proposed water withdrawal and other mine development activities. Changes to surface water hydrology have the potential to impact aquatic and terrestrial ecosystems, vegetation, wildlife, and human receptors through direct influences on physical habitat and water quality. Measurement indicators for surface water quantity are summarized in Table 10.2-1.

Table 10.2-1: Measurement Indicators and Effects Pathways for Surface Water Quantity

Valued Component	Measurement Indicators	Effects Pathways
Surface Water Quantity (Hydrology)	Surface water levels and flow rates (e.g., maximum/minimum flows, seasonal and event driven flows)	VCs or VC groups for which surface water quantity is an effects pathway include: • Groundwater quantity and quality; • Surface water quality; • Landscapes and ecosystems; • Vegetation; • Fish and fish habitat; • Wildlife and wildlife habitat; • Benthic invertebrates; and • Human and wildlife health.

10.2.2 Indigenous and Stakeholder Consultation

NWP engaged with Indigenous groups and conducted consultation with public stakeholders and regulators. A summary of all consultation and engagement activities undertaken to date is presented in Chapter 4. No specific consultation feedback on surface water quantity was received in the Pre-Application phase.

10.2.3 Assessment Boundaries

10.2.3.1 Spatial Boundaries

Three study areas were considered in the surface water quantity assessment: the Project footprint, the Aquatic Local Study Area (LSA), and the Aquatic Regional Study Area (RSA). As detailed in Chapter 5, Table 5.3-2, the spatial boundaries for the surface water quantity VC have changed from the study areas presented in the AIR. A discussion on the spatial boundaries used in the assessment is provided below.

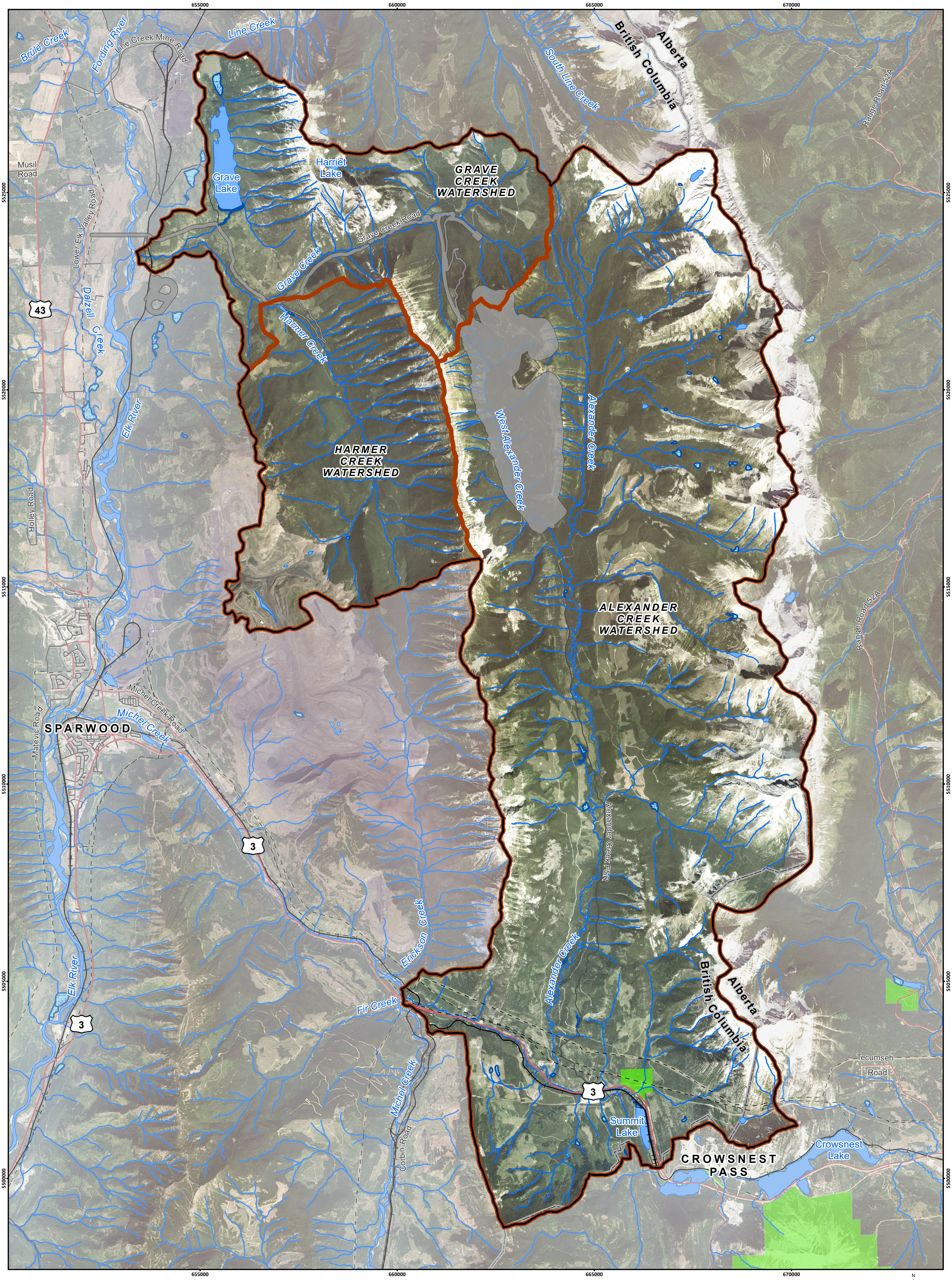
The Project footprint encompasses the location of temporary and permanent works associated with the Project and covers approximately 13 km^2 (square kilometres) or 1,283 hectares (ha; Figure 10.2-1). The centre of the Project is positioned approximately 12 km northeast of the District of Sparwood and approximately 5 km west of the provincial boundary between B.C. and Alberta (Figure 10.2-1). The Project footprint consists of the proposed surface extraction areas (three pits - North Pit, East Pit, and South Pit); Mine Rock Storage Facility; mine infrastructure and support facilities, including the plant area (raw coal stockpile area and processing plant); clean coal transportation route; rail loadout facility and rail siding; and ancillary facilities (i.e., water supply, power supply, natural gas supply, water, sewage treatment, fuel storage and explosives storage). The Project footprint is located within portions of two watersheds, Grave Creek and Alexander Creek. The majority of the Project footprint is located within the Alexander Creek watershed, while the access roads leading to the mine are generally located within the Grave Creek watershed.

The Aquatic LSA includes the Project footprint and the surrounding area where potential impacts associated with Project activities could directly affect hydrologic conditions. The Aquatic LSA covers an area of approximately 228.6 km^2 and extends to the catchment boundaries for the Grave Creek watershed (including Harmer Creek) and Alexander Creek watershed areas (including West Alexander Creek; Figure 10.2-1). The Aquatic LSA can be thought of as the “zone of influence” of the Project on surface water quantity.

The Aquatic RSA generally encompasses the full extent of the Elk River watershed and the portion of Lake Koocanusa located north of the Canada-USA border (Figure 10.2-2). The RSA extends beyond the LSA and covers a total geographic area of approximately 4,387 km^2. The RSA comprises the area where changes in the hydrological environment could potentially be indirectly impacted by the Project in the regional area. The headwaters of the Elk River watershed originate within Elk Lakes Provincial Park and the River flows in a southerly direction to its outlet into Lake Koocanusa, approximately 20 km north of the Canada-USA border. Streamflows in the lower reaches of the Elk River are regulated by a hydroelectric dam near Elko (Elko Dam), which is operated by BC Hydro. The RSA is the main study area for conducting the cumulative effects assessment.

10.2.3.2 Temporal Boundaries

Temporal boundaries include the time periods during which the Project is anticipated to result in potential effects on VCs (Environmental Assessment Office [EAO], 2013). The temporal limits of the Project used in the effects assessment include the timing of Project phases and activities, as outlined in Table 10.2-2. Additional detail of the phases and activities related to the Project are outlined in Chapter 3.



Crown Mountain Coking Coal Project

Figure 10.2-1
Aquatic Local Study Area (LSA)

LEGEND

- Aquatic Local Study Area
- Watershed
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

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Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada. Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

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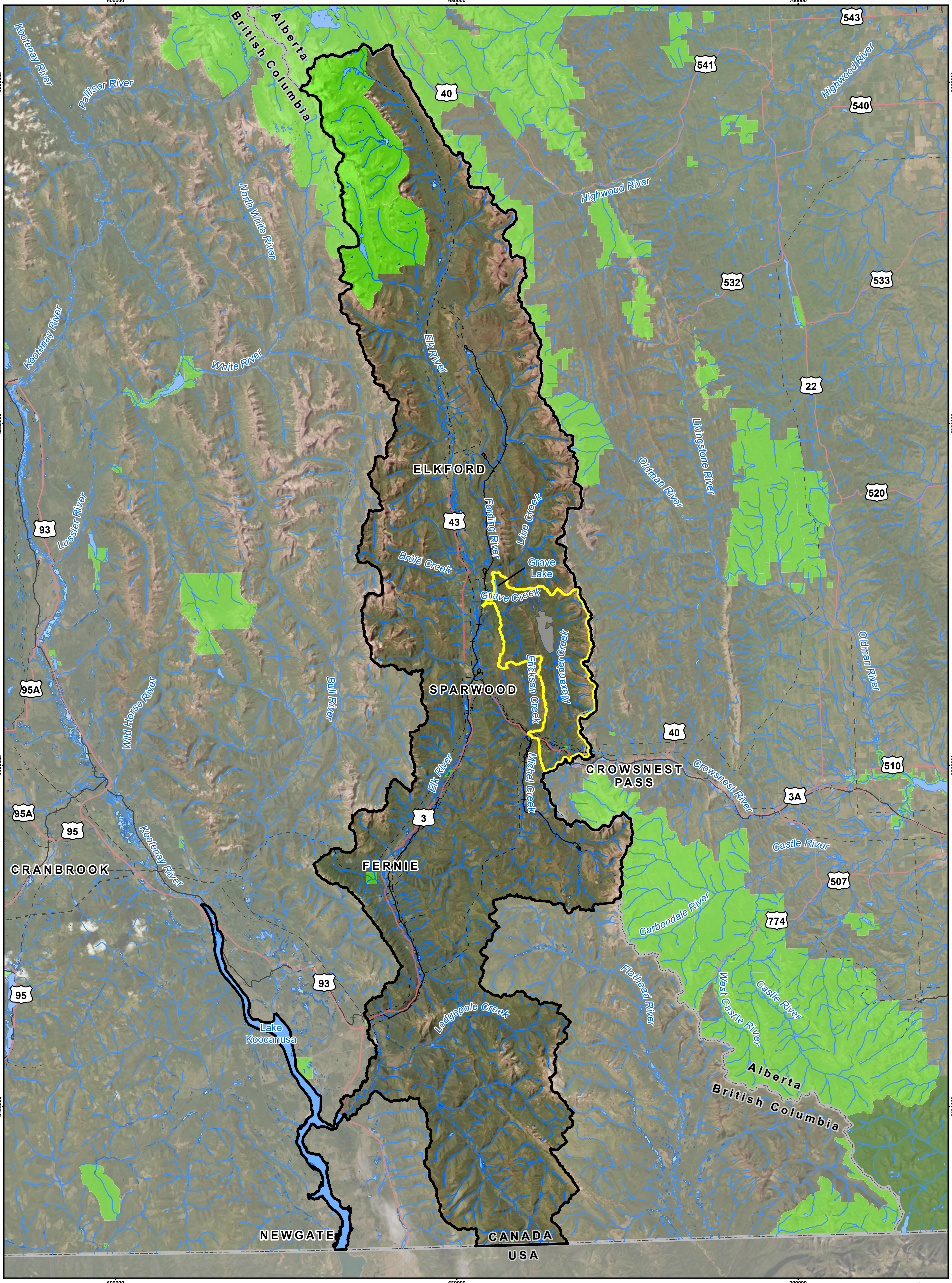
Project: 12-6231
Status: FINAL
Date: 2021-02-25



Crown Mountain Coking Coal Project

Figure 10.2-2
Aquatic Regional Study Area (RSA)

LEGEND

- Aquatic Regional Study Area
- Aquatic Local Study Area
- Project Footprint
- Highway
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- National Park
- British Columbia/ Alberta Border

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Table 10.2-2: Temporal Boundaries for the Effects Assessment

Phase	Project Year	Length of Phase (Years)
Construction and Pre-Production	1 – 2	2
Operations	3 – 17	15
Reclamation and Closure	18 – 19	2
Post-Closure	20 – 34	15

10.2.3.3 Administrative Boundaries

Administrative boundaries refer to the limitations imposed on the assessment by political, economic, or social constraints and consider the jurisdiction in which the Project is located. In addition to the applicable regulatory and policy framework as outlined in Table 10.1-1, the Project is situated over the dividing line of Upper Kootenay Basin and the Central Kootenay Basin hydrologic zones (Zone Numbers 19 and 20, respectively) and within the Designated Area of the Elk Valley Water Quality Plan (Teck Resources Limited, 2014).

10.2.3.4 Technical Boundaries

Technical boundaries represent constraints imposed on the assessment due to limitations in the ability to predict the effects of the Project (EAO, 2013). Technical boundaries for the assessment of potential effects to surface water quantity include:

- Limitations imposed by the constraints of the baseline data collection, data coverage, and lack of historically available flow data for Alexander Creek; and
- Assumptions required in the predictive models, specifically the water and load balance model (Appendix 10-A).

For the purposes of this assessment, notable levels of conservatism are built into the assessment methodology to minimize/eliminate under-prediction. Details on the modelling, including assumptions and limitations, are provided in the Crown Mountain Flow and Water Quality Impact Assessment Modelling Technical Memo (Appendix 10-A; SRK Consulting, Inc. [SRK], 2021).

10.3 Regional and Local Overview

Current land uses within the Aquatic LSA and RSA include: residential; recreational (e.g., hunting, ATV trails, fishing, hiking, etc.); exploration; resource; industrial; rangeland; agriculture; and forestry. Mining in the East Kootenay region has been ongoing for well over a century, with coal being the dominant resource extracted in the area. Additional information on past and present land use is provided in Chapter 1, Section 1.3.2.

The hydrologic conditions in the Aquatic RSA and LSA are controlled by natural factors (e.g., climate; relief; geology; vegetation) and anthropogenic factors (e.g., mining; forestry; agriculture; hydroelectric dams; climate change).

10.3.1 Regional Environment

The Aquatic RSA for the Project is situated over the dividing line of Upper Kootenay Basin and the Central Kootenay Basin hydrologic zones (Zone Numbers 19 and 20, respectively). This area is characterized by low precipitation and dry summers, cold and dry winters, and low-to-moderate snow pack (Columbia Basin Trust, 2017). As noted in Section 10.2, the Aquatic RSA is comprised of the full extents of the Elk River and extends downstream to include the portion of Lake Koocanusa located north of the Canada-USA border. The Elk River watershed covers an area of approximately 4,381 km^2 and is generally oriented in a north to south direction. The current land cover of the Elk River watershed is coniferous, shrub, and barren (68.4%, 14.8%, and 8.9%, respectively; Ministry of Forests, Lands, Natural Resource Operations and Rural Development [FLNRORD], 2019).

The Elk River has many significant tributaries, including the Fording River, Line Creek, Wigwam River, and Michel Creek (Figure 10.2-1). A summary of watershed information for the Elk River and its major tributaries from the Kootenay Boundary Water Tool (FLNRORD, 2019) is provided in Table 10.3-1.

Table 10.3-1: Summary of the Elk River Watershed

Watercourse	Watershed Area (km^2)	Elevation (m asl) [min – mean – max]	Mean Annual Discharge (m^3/s)	Annual Runoff (m^3/yr)	Current Allocations (m^3/yr)
Elk River	4,381.0	981 – 1,820 – 3,124	75.373	542,936	99,303,917
Fording River	621.0	1,299 – 2,009 – 3,031	8.780	445,932	36,876,538
Line Creek	138.0	1,361 – 2,008 – 2,924	2.130	487,149	2,948,951
Michel Creek	646.0	1,234 – 1,813 – 2,735	10.845	529,806	29,760,249
Lodgepole Creek	177.0	1,034 – 1,697 – 2,526	3.690	656,633	0
Wigwam River	813.0	998 – 1,725 – 2,614	18.200	705,946	0

Source: FLNRORD, 2019

10.3.2 Local Environment

The Project is situated in an area of steep topography of the Front Ranges Rocky Mountains of B.C. The relief on the Project footprint generally ranges from 1,850 to 2,200 metres above sea level (m asl). The area is characterized by rugged ridges with moderate to steep-sloping sides at higher elevations and gentle slopes at lower elevations. The west side of the Project footprint is characterized by steep sided ridges and subdued mountains, while those on the east are rugged with many cirques and U-shaped valleys. The setting is truly mountainous, underlain mostly by structurally deformed sandstone, siltstone, mudstone, and coal.

Key watercourses in the Aquatic LSA include the Elk River, Michel Creek, Alexander Creek, West Alexander Creek, Harmer Creek, and Grave Creek (Figure 10.2-1). Waterbodies in the immediate vicinity include Grave Lake, Harriet Lake, Mite Lake, and Barren Lake. A summary of the watersheds in the Aquatic LSA is provided in Table 10.3-2.

Table 10.3-2: Summary of Watersheds in the Aquatic LSA

Watercourse	Watershed Area (km^2)	Elevation (m) [min – mean – max]	Mean Annual Discharge (m^3/s)	Annual Runoff (m^3/yr)	Current Allocations (m^3/yr)
Alexander Creek	184.9	1,352 – 1,878 – 2,656	2.952	93,151,224	8,302
West Alexander Creek	14.7	1,589 – 1,958 – 2,368	0.286	9,017,614	0
Grave Creek	80.9	1,254 – 1,764 – 2,463	1.088	34,331,932	0
Harmer Creek	39.0	1,389 – 1,783 – 2,450	0.530	16,716,113	0

Source: FLNRORD, 2019

The Alexander Creek watershed is the largest drainage basin in the Aquatic LSA and covers a watershed area of approximately 184.9 km^2, which is oriented in south facing aspect (Figure 10.2-1). The land cover of the Alexander Creek watershed is coniferous, shrub, and barren (69.9%, 15.4%, and 8.7%, respectively; FLNRORD, 2019). Alexander Creek flows in a southerly direction from its headwaters to its confluence with Michel Creek, approximately 10.7 km southeast of Sparwood. Michel Creek flows north-westerly along Highway 3 and ultimately discharges to the Elk River near Sparwood. The total length of Alexander Creek is approximately 25 km.

Alexander Creek has numerous tributaries that generally consist of high-gradient mountain streams, with the most significant tributary being West Alexander Creek. The West Alexander Creek watershed covers an area of approximately 14.7 km^2 within the boundaries of the Alexander Creek watershed. West Alexander Creek flows in a south to southeast direction over a distance of approximately 6 km to its confluence with Alexander Creek. The watercourse has several tributaries that generally consist of small, high-gradient mountain streams.

The Grave Creek watershed covers an area of approximately 80.9 km^2 and is oriented in an east to west direction (Figure 10.2-1). The current land cover of the Grave Creek watershed is coniferous, shrub and barren (88.1%, 7.7%, and 2.5%, respectively), with the remainder of the watershed generally consisting of waterbodies (Grave Lake and Harriet Lake; FLNRORD, 2019). Grave Creek generally flows westerly and drains into the Elk River, approximately 12.5 km north of Sparwood. Several tributaries drain into Grave Creek, the largest of which being Harmer Creek. The Harmer Creek watershed covers an area of approximately 39.0 km^2 within the boundaries of the Grave Creek watershed. Harmer Creek generally flows northerly and drains into Grave Creek approximately 12 km northeast of Sparwood.

10.4 Existing Conditions

This section describes the existing conditions in the Aquatic LSA and RSA in sufficient detail to enable potential effects of the Project on surface water quantity to be identified, understood, and assessed.

10.4.1 Existing Regional and Local Information

10.4.1.1 Hydrology

Existing local and regional hydrologic data were compiled by conducting a desktop assessment of background information on long-term regional hydrology data in the Project study areas (i.e., the Project footprint, the Aquatic LSA, and the Aquatic RSA). Data sources included:

- Available regional Water Survey of Canada (WSC) data;
- Federal databases and mapping sites (e.g., Environment and Climate Change Canada);
- Provincial databases and mapping sites (e.g., B.C. Water Resources Atlas);
- Scientific research from local non-governmental organizations (NGOs); and
- Other environmental assessments (EAs) undertaken near the Project.

Teck Resources Limited (Teck) conducted the Baldy Ridge Extension Project (Baldy Ridge) EA in 2014 for the expansion of Teck's Elkview Operations located approximately 8 km southwest of the proposed Project (Golder Associates, 2015). As part of the EA, hydrological surveys were conducted to determine the existing hydrological conditions in relation to the project and the project's effects on hydrology. A baseline study was conducted to characterize the climate and streamflows under long-term conditions, using long-term data sets to account for climatic variability for seven watercourses in its project LSA and RSA, including Grave Creek. The existing climate conditions for the RSA were:

- 1.4 degrees Celsius (°C) mean annual temperature;
- 761 millimetres (mm) mean annual precipitation;
- 818 mm mean annual potential (1 m – depth) evaporation; and
- 803 mm mean annual (potential) evapotranspiration.

The existing stream flow characteristics for Grave Creek (at the mouth) were:

- 1.1 cubic metres per second (m^3/s) mean annual discharge;
- 409 mm mean annual water yield;
- 11 m^3/s 10-year flood peak discharge; and
- 0.16 m^3/s 7Q10 low flow.

Teck also conducted an EA in 2011 for a proposed extension of the existing Line Creek Operations - Line Creek Operations Phase II Project (Line Creek) located approximately 15 km north of the proposed Project (Teck Coal Limited, 2011). As part of the 2011 EA, hydrological surveys were undertaken to determine the existing hydrological conditions in relation to the project and the project's effects on hydrology.

The existing climate conditions for its LSA were:

- -1.2 °C mean annual air temperature;
- 814 mm mean annual precipitation;
- 814 mm mean annual lake (1 m-depth) potential evaporation; and
- 793 mm mean annual (potential) evapotranspiration.

10.4.1.2 Climate Change

Available documentation related to the hydrologic impacts of climate change were compiled and reviewed with the objective of identifying historical and projected trends in the Aquatic RSA. This included several studies, reports, and publications that have been undertaken in recent years to assess climate trends and variability in the region. The climate and hydrology of the Columbia River basin have been the subject of several documents published by the Pacific Climate Impacts Consortium (PCIC), including:

- Climate Extremes in the Columbia Basin Summary Report (PCIC, 2014);
- Hydrologic Impacts of Climate Change on B.C. Water Resources – Summary Report for the Campbell, Columbia and Peace River Watersheds (Zwiers et al., 2011);
- Preliminary Analysis of Climate Variability and Change in the Canadian Columbia River Basin: Focus on Water Resources (Murdock et al, 2007); and
- Climate Change in the Canadian Columbia Basin – Starting the Dialogue (Columbia Basin Trust, 2006).

10.4.1.2.1 Historical Trends

A review of available documentation related to climate and hydrology trends in the upper Columbia River Basin identified the following key findings with respect to historical trends:

- During the 90 year period from 1913 to 2002:
    - Annual mean temperature rose by 1.4 °C, with increases occurring primarily in the winter season;
    - Annual minimum and maximum temperatures increased by 1.6 and 0.9 °C, respectively;
    - Annual precipitation rose by 26%, with annual rainfall increasing by 32% and annual snowfall decreasing by 6%; and
    - Snowpack is declining with increasing temperatures, particularly at lower elevations.
- Glaciers in the Canadian Columbia River Basin have diminished in size; and
- Historical streamflow records show a general trend towards earlier and larger spring freshet and smaller summer flows.

Climate

A review of historical data was undertaken for three climate stations in the Aquatic RSA (Sparwood, Fernie, and Fording River Cominco) to identify trends in air temperature and precipitation since 1970 at various locations and elevations in the region (Environment and Climate Change Canada [ECCC], 2019). The available historical data for the three subject climate stations generally indicate that:

- There has been an overall increase in mean annual air temperatures over the 34 year assessment period, most notably at lower elevations;
- An increasing trend for rainfall occurred at the Sparwood and Fernie climate stations, while annual rainfall trended downwards at the Fording River Cominco climate station;
- Annual snowfall has decreased significantly at the Fernie and Fording River Cominco climate stations and increased at the Sparwood climate station; and
- Overall, the historical climate data demonstrates that air temperatures have increased in the Aquatic RSA and that there is considerable variability with respect to precipitation conditions.

Further information regarding historical climate trends in the Aquatic RSA is provided in the Hydrology Baseline Report in Appendix 10-B.

Streamflows

An assessment of historical streamflow data (WSC, 2019) was carried out to identify long-term trends at select hydrometric stations located in the RSA. The assessment involved a review of unit area mean annual, mean summer (July-September), and mean winter flows (January-March) for the following stations and years:

- Grave Creek at the Mouth - Station 08NK019 (1970-1998);
- Michel Creek below Natal - Station 08NK020 (1970-1994);
- Elk River near Natal - Station 08NK016 (1951-2018); and
- Elk River at Fernie - Station 08NK002 (1970-2018).

There was a declining trend in mean annual flows at all four of the hydrometric stations over their respective period of record, with the most noteworthy decline at Michel Creek near Natal and the smallest decline at Elk River near Fernie. There was also a decreasing trend in mean summer flows, with the most substantial decline at Grave Creek at the mouth and the smallest decline at Elk River near Fernie. There was an increasing trend in mean winter flows at all stations, with the exception of Grave Creek at the Mouth. The most substantial increase in mean winter flows occurred at Elk River near Fernie.

10.4.1.2.2 Projected Trends

Climate

Future climate projections have been developed for the Columbia River Basin by the Pacific Climate Impacts Consortium through detailed modelling using an ensemble of Global Climate Models. The climate projections are for the period of 2041–2070 relative to a baseline period of 1971–2000. The results of the projections include the following (PCIC, 2014):

- Annual mean temperature is projected to increase, with increases projected in all seasons;
- The annual total basin-averaged precipitation is projected to increase;
- Most projections show an increase in precipitation in the winter months and decreased precipitation in the summer; and
- Future projections indicate a potential increase in precipitation extremes.

Streamflows

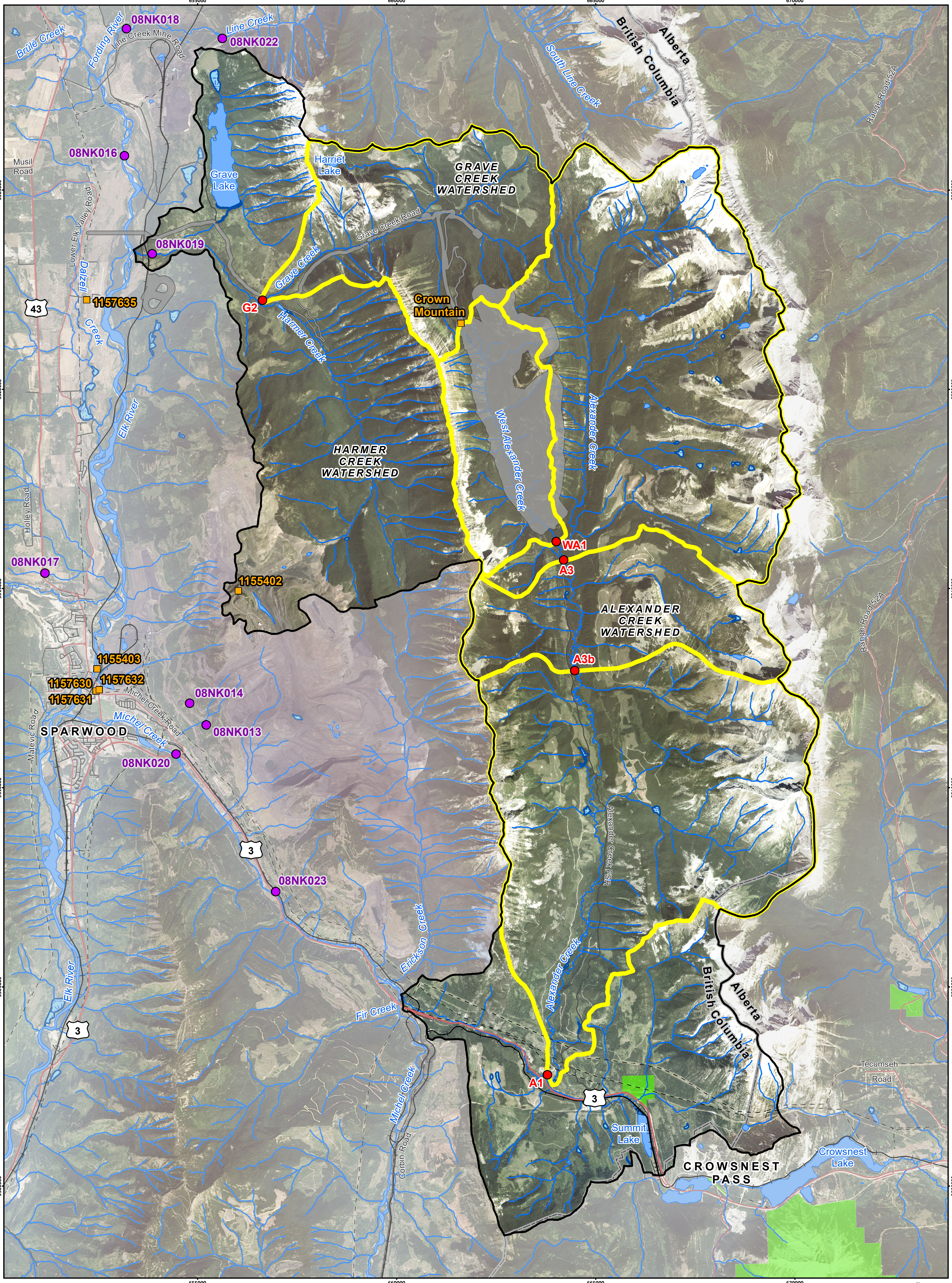
Recent studies indicate that increasing temperatures and altered precipitation patterns will impact the hydrology of western North America (Zwiers et al., 2011). Estimates of future streamflow were undertaken by PCIC for the 2050s period, which resulted in the following findings:

- Annual streamflows are expected to increase in the Upper Columbia River for the 2050s;
- Monthly streamflows are projected to increase during the late fall and winter; and
- Monthly streamflows are projected to lower in the late summer and early fall.

10.4.2 Baseline Programs

10.4.2.1 Methods

The hydrology baseline study was conducted in the Aquatic LSA within the Alexander Creek, Harmer Creek and Grave Creek watersheds (Figure 10.4-1) to determine existing hydrologic conditions within key waterbodies. The baseline hydrology study involved the compilation and synthesis of available



Crown Mountain Coking Coal Project

Figure 10.4-1
Climate and Hydrometric Monitoring Stations

LEGEND

- Baseline Stream Flow Monitoring Station
- Regional Hydrometric Station
- Climate Station
- Stream Flow Monitoring Station Catchment Area
- Aquatic Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

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Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada, Environment and Climate Change Canada, 2019.
Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: RB
Map Checked By: HEB
Map Coordinate System: NAD 1983 UTM Zone 11N

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Project: 12-6231
Status: FINAL
Date: 2021-02-24

Document Path: G:\GIS\2012 and Prior\126231 Crown Mountain\EA_Report\ExistingConditions\Hydrology\126231_EC_HYD_ClimateHydrometricMonitoringStations.mxd background information, the development and implementation of a hydrometric monitoring program, and the analysis of long-term regional hydrology and climate data.

The data collection protocol for the hydrology baseline study was developed and conducted in accordance with the B.C. Ministry of Environment's Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (B.C. MOE, 2016) and Manual of British Columbia Hydrometric Standards (Resources Inventory Standards Committee, 2018). For additional details on the hydrology baseline program, refer to Appendix 10-B.

The climate conditions in the Project footprint and Aquatic LSA were determined by collecting data at the Project-specific Crown Mountain Climate Station located within the coal license area in the headwaters of the Alexander Creek/West Alexander Creek watershed (Figure 10.4-1). The climate station was installed at an elevation of 1,920 m asl, and operated from January 2013 to May 2016. Climate conditions in the Aquatic RSA were determined by collecting data obtained from 14 ECCC climate stations and 7 snow sampling stations operated by FLNRORD (Figure 10.4-1). Additional details on climate data collection and analysis are available in Appendix 6-B, Meteorology Baseline Report. The climate stations recorded continuous and seasonal climate data related to temperature, precipitation, and wind speed and direction. The snow sampling stations obtained data for snow depth and snow-water equivalent from Automated Snow Pillow and Manual Snow Course surveys.

The hydrologic conditions in the Aquatic LSA were determined by collecting hydrology data at five project-specific hydrometric monitoring stations that were installed to collect water level data at locations where potential impacts associated with the Project activities could directly affect the hydrologic conditions (Table 10.4-1, Figure 10.4-1). Four of the stations were initially installed in May 2012 (A1, A3, G2, and WA1). Hydrometric station A3 was relocated in July 2014 to a more favourable location (A3B) to better capture the representative flows along Alexander Creek. The hydrometric stations were decommissioned in May 2016. Stations A1 and G2 were re-installed in November 2017 and operated until December 2019.

All of the hydrometric stations were installed on watercourses located down-gradient of the proposed Project footprint. Hydrometric monitoring was not conducted up-gradient of the Project footprint, as there are no up-gradient watercourses. At each hydrometric station, continuous water level measurements were collected at 15 minute intervals using a combination of pressure transducer/water level loggers models. Bathymetry studies were not conducted as part of the baseline studies because large rivers and lakes were not monitored as part of the baseline program.

Table 10.4-1: Summary of Hydrometric Stations in the Aquatic LSA

Station Name	Creek	Latitude	Longitude	Monitoring Began	Monitoring Ended	Substrate
A1	Alexander	49°39'19.7"N	-114°43' 51.6"W	May 15, 2012	December 7, 2019	Gravel/cobble
A3	Alexander	49°46'17.5"N	-114°43'12.0"W	May 16, 2012	July 18, 2014	Gravel/cobble
A3B	Alexander	49°44'47.0"N	-114°42'57.6"W	July 18, 2014	May 2, 2016	Gravel/cobble
WA1	West Alexander	49°46'32.4"N	-114°43'19.2"W	May 16, 2012	May 2, 2016	Gravel/cobble/ boulder

Station Name	Creek	Latitude	Longitude	Monitoring Began	Monitoring Ended	Substrate
G2	Grave	49°49'55.7"N	-114°49'19.2"W	May 15, 2012	December 7, 2019	Gravel/cobble/ boulder

Manual hydrometric stream gauging was also conducted to measure discharge rates at each of the Aquatic LSA hydrometric monitoring stations, approximately two to four times a year, based on seasonal freeze-up and runoff schedule. Stream gauging was performed by area-velocity methods using a portable acoustic doppler velocity meter and followed the Manual of British Columbia Hydrometric Standards (B.C. MOE, 2018) for "Grade A data".

The baseline hydrologic conditions in the Aquatic RSA were determined through the compilation and review of hydrology data from seven hydrometric stations operated by ECCC (Figure 10.2-2; Table 10.4-2).

Table 10.4-2: Summary of Hydrometric Stations in the Aquatic RSA

Parameter	Elk River at Fernie	Elk River near Natal	Fording River at the Mouth	Hosmer Creek above Diversions	Grave Creek at the Mouth	Michel Creek below Natal	Line Creek at the Mouth
Station ID	08NK002	08NK016	08NK018	08NK026	08NK019	08NK020	08NK022
Drainage Area (km^2)	3,090.0	1,840.0	621.0	6.4	83.9	637.0	138.0
Period of Record	1919-2019	1950-2019	1970-2019	1981-2019	1970-1999	1970-1998	1971-2019
Regulation Type	Natural	Natural	Natural	Natural	Natural	Natural	Natural

10.4.2.2 Results

10.4.2.2.1 Climate

The mean daily average, minimum, and maximum air temperature values for the Aquatic LSA were derived for January 2014 to May 2016 based on continuous data collected at the Crown Mountain climate station. Mean daily average temperatures ranged from -8.1 to 14.9 °C, with an overall average of 2.3 °C. Mean monthly air temperatures were calculated for the Aquatic LSA and Aquatic RSA. The Aquatic LSA baseline conditions were represented by data from the Crown Mountain Climate Station, while Aquatic RSA baseline conditions were represented by the climate stations operated by ECCC (i.e., Sparwood station, Fernie station, and Fording River Cominco station). A summary of monthly air temperatures at the Project area between January 2014 and May 2016 is provided in Appendix 10-B.

To characterize the precipitation conditions for the Project footprint and Aquatic LSA, a regression analysis was undertaken using data collected at nearby climate stations to identify a relationship for the mean summer (May to September) and mean winter (October to April) seasonal precipitation, and the corresponding elevation at the climate stations. The Sparwood (11557630) and Natal Harmer Ridge (1155402) climate stations were selected for the analysis, given their proximity to the Project area, elevation, and available period of record. Highest mean precipitation occurred in November and the lowest mean total monthly precipitation occurred in August. A summary of the total monthly precipitation at the Aquatic LSA for the period of January 2014 to May 2016 is provided in Appendix 10-B.

10.4.2.2.2 Hydrology

Key hydrologic indices and statistics for the Aquatic LSA and Aquatic RSA were calculated to provide context to annual movement of water through the Project study areas.

Aquatic Local Study Area

Water Level Data

The minimum, mean, and maximum water levels recorded at each station (Figure 10.4-1) are summarized in Table 10.4-3, which are based on average daily data collected during the open water season (April 1 – November 30).

Table 10.4-3: Summary of Average Water Level Data (m) at Hydrometric Stations

Hydrometric Station	Period	Water Level (m)		
		Min	Mean	Max
A1	05/15/2012 – 05/02/2016	0.00	0.23	0.89
	11/14/2017 – 11/30/2019	0.24	0.35	0.73
G2	05/15/2012 – 05/02/2016	0.06	0.27	0.77
	11/14/2017 – 11/30/2019	0.07	0.21	0.84
WA1	05/15/2012 – 05/02/2016	0.18	0.33	0.57
A3B	06/27/2014 – 05/02/2016	0.04	0.19	0.70

Note: Water levels for open water season (April 1 – November 30).

Discharge Hydrographs

Discharge hydrographs for stations A1, A3B, WA1, and G2 are provided in Figure 10.4-2 to Figure 10.4-5. The annual hydrographs for each of the four stations demonstrate the variability of flow conditions over the monitoring periods. Notably, minimal to near zero flows are annually observed in the late-fall to early-spring months at the four stations. The onset of annual freshet conditions has been noted to occur as early as the beginning of April in some years (e.g., 2016) across the stations. The freshet periods over the course of stream flow monitoring were found to generally persist into early July with low summer flows typically occurring at least by the end of August.

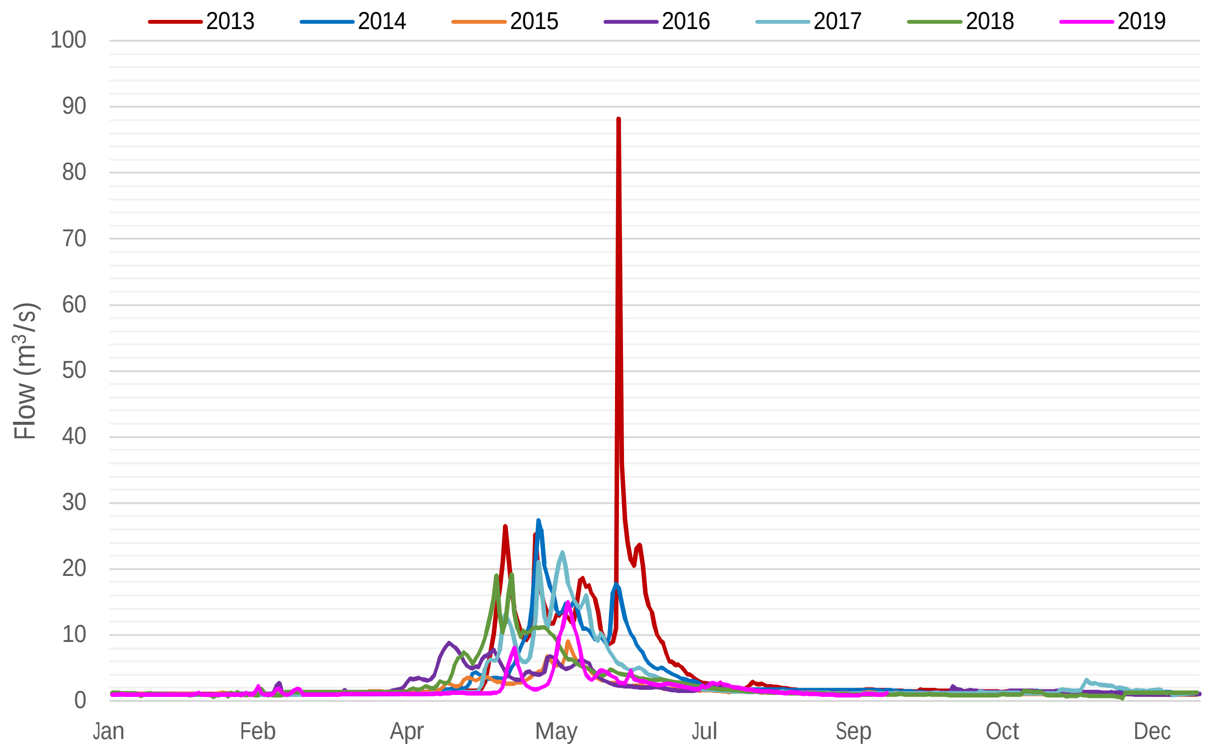


Figure 10.4-2: Discharge Hydrograph for Station A1

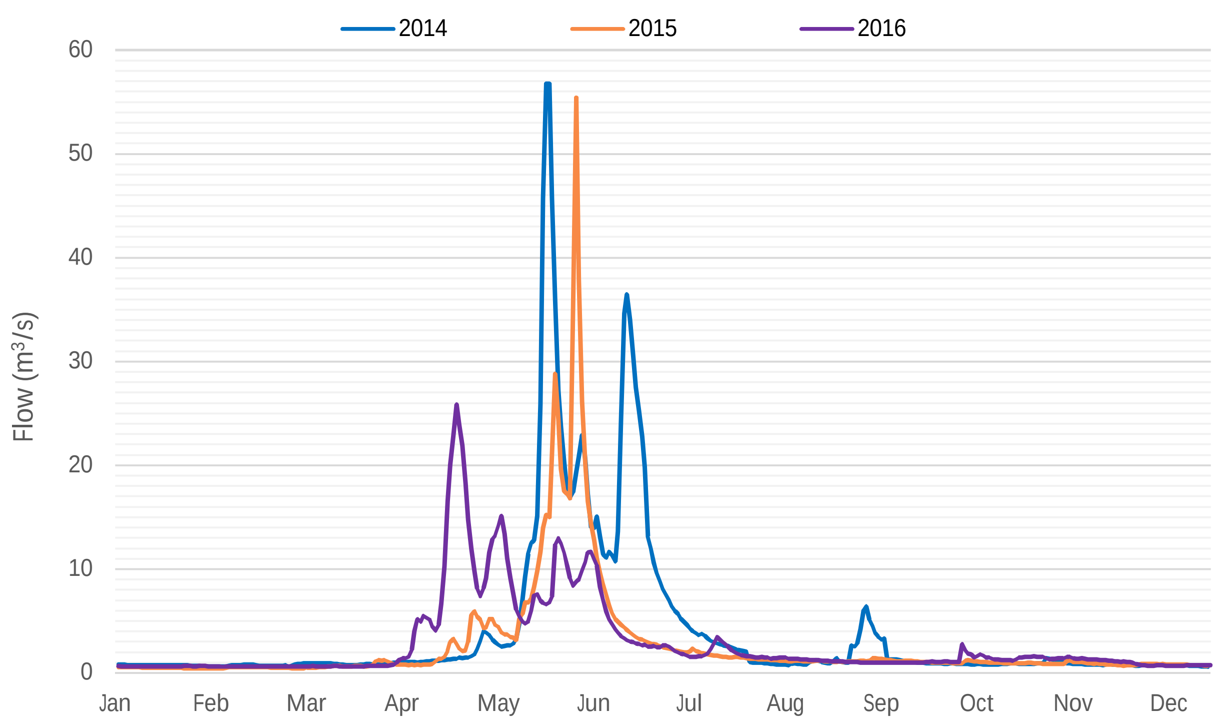


Figure 10.4-3: Discharge Hydrograph for Station A3B

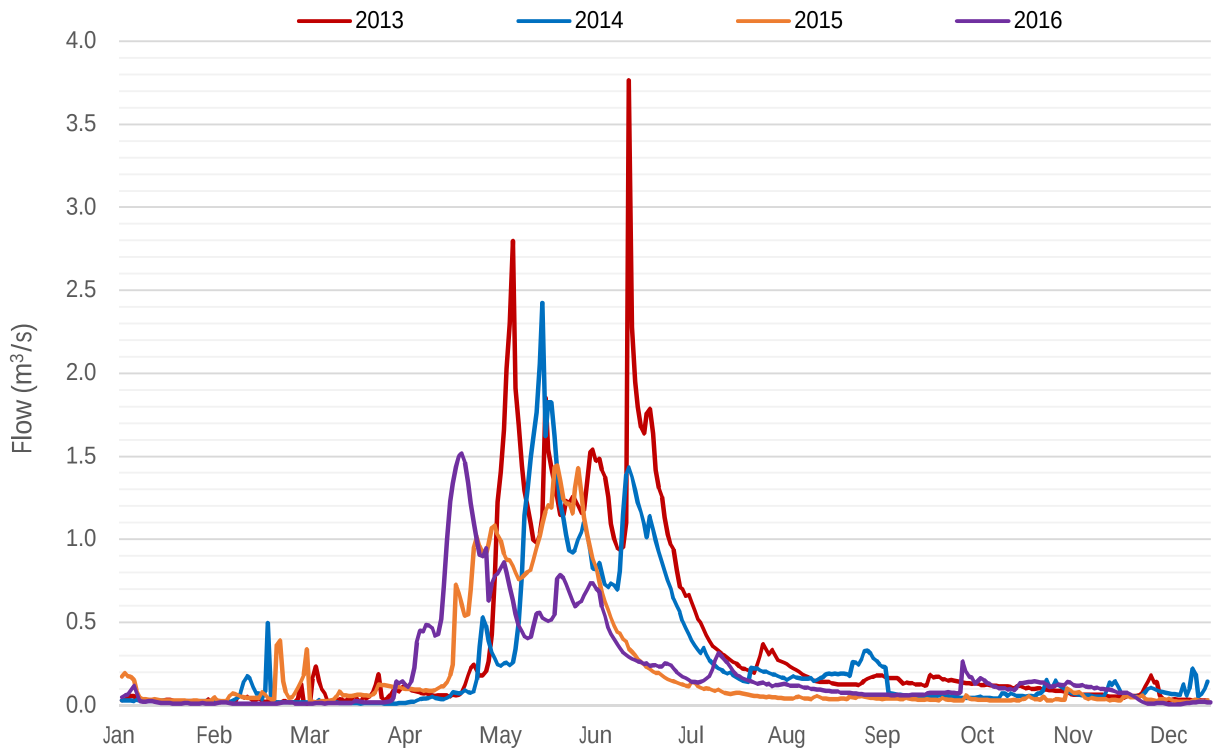


Figure 10.4-4: Discharge Hydrograph for Station WA1

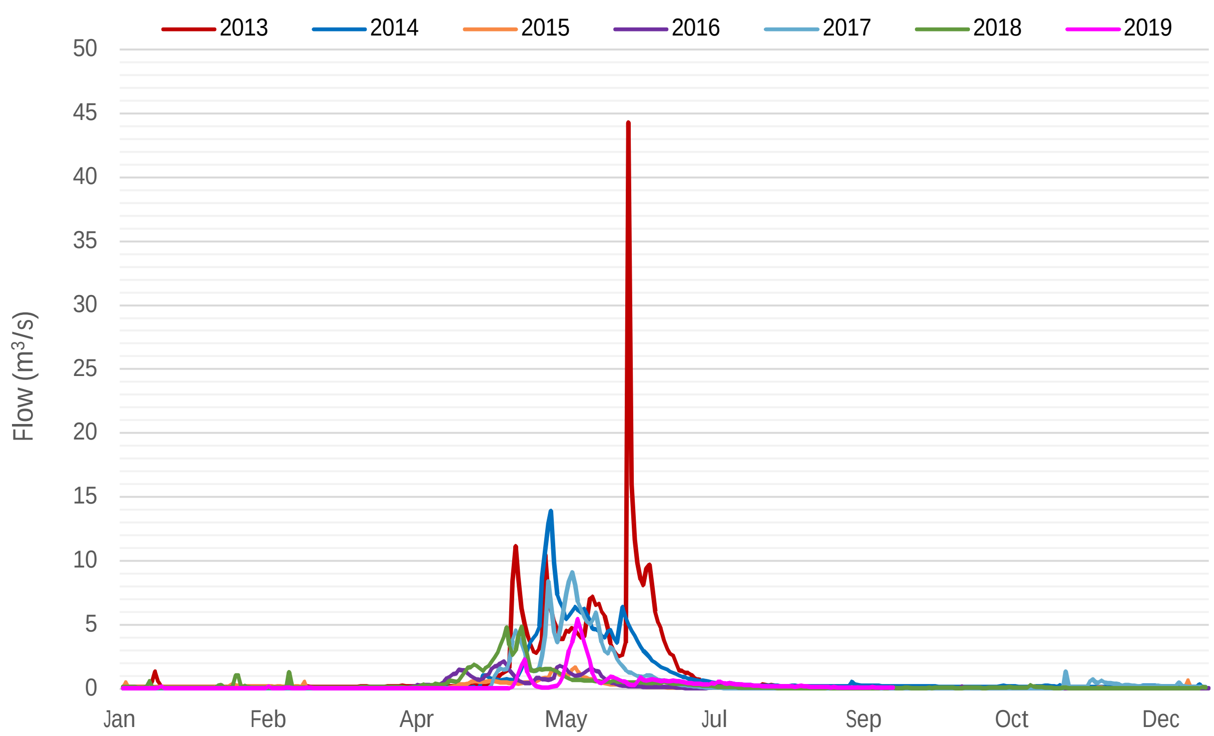


Figure 10.4-5: Discharge Hydrograph for Station G2

Annual and Monthly Runoff

Annual and monthly runoff depths for each of the hydrometric monitoring stations from 2013 to 2019 are provided in Table 10.4-4. Through a review of the annual and monthly runoff data for the common period of assessment (2014-2016), the following observations are noted:

- Most of the runoff occurred between April and July at all of the hydrometric stations, with a significant portion of the runoff generated in the months of June and July;
- Mean annual and monthly runoff was generally highest at Station A3B, with the greatest annual value in 2014 (1,367.3 mm). This can likely be attributed to the higher average elevation of the A3B watershed in comparison with the other stations, which would expect to result in an increase in precipitation and snowmelt; and
- The lowest proportion of runoff typically occurred in the late summer, winter, and early spring months at all of the hydrometric monitoring stations.

Additional observations noted for the extended period of monitoring (2013 and 2017-2019) at Stations A1 and G2 indicate that the highest runoff depth occurred at G2 in June 2013 (786.1 mm), which accounted for 55% of the annual runoff for that year. Similarly, the highest runoff depth at A1 during the same month (332.9 mm), which is equivalent to 40% of the 2013 annual runoff.

Peak Flows

Peak flows and unit area yield values for each of the hydrologic monitoring stations are summarized in Table 10.4-5. As noted above, peak flows typically occur during the freshet in the summer months (June to August). Of the five monitoring stations, the highest peak flow occurred at Station A1 in 2013, while the highest yield values during the common monitoring period occurred at Station A3B in 2014.

Mean, Minimum, and Maximum Daily Flows and 7 Day Low Flows

Table 10.4-6 provides a summary of the average, minimum, and maximum daily flows, together with the minimum average 7-day low flows, for the hydrometric monitoring stations, which demonstrate the variability of flows over the assessment period. The highest maximum flows in the Alexander Creek (A1) and Grave Creek (G2) occurred in 2013, while the lowest minimum flows occurred in 2018 (not including 2019 as it is a partial year of data). The highest average mean and maximum flows are associated with Station A3B and the lowest corresponding values occurred at Station WA1.

Table 10.4-4: Monthly and Annual Runoff Depth (mm) at Hydrometric Monitoring Stations

Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
A1 (147.6 km^2)	2013	19.1	17.0	19.8	24.2	214.1	332.9	83.2	34.9	27.7	27.0	22.0	19.7	841.7
	2014	18.5	16.2	20.0	24.8	173.2	200.6	54.7	30.8	27.2	21.9	21.6	23.3	632.7
	2015	18.7	17.7	21.2	30.8	68.4	69.0	31.2	23.7	20.3	19.3	18.6	19.4	358.2
	2016	17.3	18.4	19.4	76.1	93.8	62.1	33.3	25.2	21.3	26.4	25.1	19.2	437.5
	2017	18.0	16.1	18.8	20.5	167.8	174.0	40.2	24.0	20.7	22.2	29.6	27.7	579.6
	2018	19.2	16.1	24.7	48.2	200.3	81.0	42.7	22.7	17.6	16.9	17.0	20.4	526.9
	2019	18.2	18.5	19.7	19.3	55.1	96.2	41.8	23.3	16.8	-	-	-	309.1
	Mean	18.4	17.2	20.5	34.8	139.0	145.1	46.7	26.4	21.7	22.3	22.3	21.6	536.0
WA1 (14.6 km^2)	2013	5.5	4.4	11.6	16.9	227.2	263.3	95.6	38.4	26.2	23.8	13.5	10.6	737.0
	2014	4.9	11.1	2.8	8.4	176.8	177.1	67.1	32.9	27.0	9.4	15.0	15.9	548.4
	2015	10.2	12.6	13.9	48.6	186.8	106.9	19.4	8.2	7.4	6.2	8.2	6.4	434.6
	2016	4.8	2.1	2.8	123.5	117.6	76.1	35.8	19.7	11.7	22.1	20.5	4.4	441.1
	Mean	6.3	7.6	7.8	49.4	177.1	155.8	54.5	24.8	18.1	15.4	14.3	9.3	540.3
A3B (90.8 km^2)	2014	21.4	18.4	25.1	34.3	447.8	535.1	118.6	28.2	64.4	25.4	26.7	21.9	1,367.3
	2015	14.6	13.5	19.7	48.2	280.3	323.4	55.2	34.6	33.2	29.6	26.4	23.0	901.8
	2016	18.7	16.5	19.1	251.8	269.5	161.7	62.0	38.4	28.9	41.9	38.9	23.0	970.3
	Mean	18.2	16.1	21.3	111.5	332.5	340.1	78.6	33.7	42.2	32.3	30.7	22.6	1,079.8
G2 (24.9 km^2)	2013	25.0	15.3	18.3	24.0	416.4	786.1	111.9	14.8	7.2	6.2	6.7	8.3	1,440.0
	2014	7.8	6.6	7.0	10.3	424.0	461.8	77.3	24.3	23.9	18.5	48.1	41.6	1,151.3
	2015	17.0	19.4	6.9	16.0	77.4	53.9	12.0	7.8	7.0	6.6	7.6	9.1	240.9
	2016	6.0	5.2	6.0	60.5	123.7	64.0	12.4	5.1	3.6	6.2	5.3	3.8	301.6
	2017	4.0	3.7	3.8	3.6	322.9	336.4	23.2	4.4	3.5	3.8	26.9	25.1	761.2
	2018	14.0	23.9	13.7	58.0	241.0	59.4	29.3	8.1	7.4	10.0	10.4	7.4	482.5
	2019	6.5	7.1	4.5	3.5	58.5	148.7	49.5	19.6	11.6	-	-	-	309.6
	Mean	11.5	11.6	8.6	25.1	237.7	272.9	45.1	12.0	9.2	8.5	17.5	15.9	675.6

Table 10.4-5: Peak Discharges and Unit Area Yields for Hydrometric Monitoring Stations

Hydrometric Station	Drainage Area (km²)	Year	Peak Flow (m^3/s)	Yield ($L/s/km^2$)
A1	147.62	2013	88.25	597.8
		2014	27.40	185.6
		2015	9.04	61.2
		2016	8.82	59.7
		2017	22.52	152.6
		2018	19.20	130.0
		2019	15.00	101.6
		Mean	27.17	184.1
WA1	14.60	2013	3.77	257.9
		2014	2.42	166.1
		2015	1.45	99.1
		2016	1.52	103.9
		Mean	2.29	156.74
A3B	90.77	2014	56.77	795.2
		2015	55.43	776.5
		2016	25.85	362.2
		Mean	46.02	644.6
G2	24.87	2013	44.3	1780.2
		2014	13.9	559.7
		2015	1.69	68.1
		2016	2.17	87.1
		2017	9.14	367.3
		2018	4.87	195.6
		2019	5.46	219.5
		Mean	11.65	468.2

Table 10.4-6: Minimum, Average, and Maximum Daily Flows and 7 Day Low Flows

Hydrometric Station	Drainage Area (km^2)	Year	Mean (m^3/s)	Minimum (m^3/s)	Maximum (m^3/s)	7 Day Low (m^3/s)
A1	147.62	2013	3.94	1.02	88.25	1.03
		2014	2.96	0.93	27.40	0.93
		2015	1.68	0.94	9.040	0.98
		2016	2.05	0.91	8.82	0.93
		2017	2.71	0.86	22.52	0.97

Hydrometric Station	Drainage Area (km^2)	Year	Mean (m^3/s)	Minimum (m^3/s)	Maximum (m^3/s)	7 Day Low (m^3/s)
		2018	2.47	0.36	19.20	0.67
		2019*	1.98	0.84	15.00	0.86
		Average	2.54	0.84	27.17	0.91
WA1	14.60	2013	0.34	0.01	3.77	0.02
		2014	0.25	0.01	2.42	0.01
		2015	0.20	0.02	1.45	0.02
		2016	0.20	0.01	1.52	0.01
		Average	0.25	0.01	2.29	0.02
A3B	90.77	2014	3.94	0.56	56.77	0.61
		2015	2.60	0.40	55.43	0.44
		2016	2.79	0.59	25.86	0.60
		Average	3.11	0.52	46.02	0.55
G2	24.87	2013	1.14	0.04	44.28	0.04
		2014	0.87	0.04	13.92	0.06
		2015	0.19	0.03	1.70	0.03
		2016	0.24	0.03	2.17	0.03
		2017	0.60	0.03	9.14	0.03
		2018	0.38	0.05	4.87	0.05
		2019*	0.34	0.03	5.46	0.03
		Average	0.54	0.04	11.65	0.04

Note: * partial year of data

Aquatic Regional Study Area

Long-term hydrologic analyses were completed for seven hydrometric stations located within the Aquatic RSA (Figure 10.4-1) to provide long-term regional context for streamflow trends. Table 10.4-7 provides a summary of mean seasonal and annual flow information for the regional hydrometric stations. In the Aquatic RSA, the highest flows generally occur in the late spring and summer months, which coincides with the timing of the annual freshet. The mean annual yield values are greatest for the Hosmer Creek, Michel Creek, and Line Creek stations, while the lowest mean annual yields occurred at the Grave Creek station.

With respect to 7-day low flow conditions, the lowest unit area values occurred at the Michel Creek and Hosmer Creek stations, with the highest values at the Line Creek and Elk River at Fernie stations (Table 10.4-7). Unit area peak discharge rates were highest at the Hosmer Creek and Michel Creek stations, and lowest at the Grave Creek and Elk River at Fernie station.

Table 10.4-7: Summary of Regional Hydrometric Station Information

Parameter	Elk River at Fernie	Elk River near Natal	Fording River at the Mouth	Hosmer Creek above Diversions	Grave Creek at the Mouth	Michel Creek below Natal	Line Creek at the Mouth
Station ID	08NK002	08NK016	08NK018	08NK026	08NK019	08NK020	08NK022
Drainage Area (km^2)	3,090	1,840	621	6.4	83.9	637	138
Period of Record	1919-2019	1950-2019	1970-2019	1981-2019	1970-1999	1970-1998	1971-2019
Mean Annual Flow (m^3/s)	47.73	26.20	8.09	0.12	1.08	10.72	2.14
Mean Winter Flow (m^3/s)(1)	17.24	7.89	2.61	0.05	0.39	4.00	0.72
Mean Summer Flow (m^3/s)(2)	77.52	44.34	13.53	0.19	1.77	18.62	3.54
Mean Annual Yield (mm)	487	447	411	596	406	531	694
10-Year Unit Area 7-Day Low Flow ($L/s/km^2$)	2.3	1.9	1.9	1.7	2.0	1.6	2.4
10-Year Unit Area Peak Discharge ($L/s/km^2$)	152.8	142.4	164.3	296.9	135.9	215.1	189.9

Notes:
1. Winter season period is from October 1 to March 31.
2. Summer season period is from April 1 to September 30.

10.5 Project Effects Assessment

10.5.1 Thresholds for Determining Significance of Residual Effects

The thresholds for determining the significance of residual effects for the surface water quantity assessment are based on changes in water quantity (i.e., streamflow) conditions within the receiving drainage environment. The assessment includes an examination of streamflow conditions at multiple locations along key watercourses within the Aquatic LSA and Aquatic RSA.

There are no prescribed federal or provincial guidelines or regulations to serve as thresholds for determining the significance of residual effects can be evaluated for the surface water quantity assessment. Accordingly, for the purpose of the assessment, a significant residual adverse environmental effect is defined as a change in surface water quantity that would result in the following:

1. An increase in streamflows within the receiving watercourses which would cause a higher potential for flooding or erosion and related impacts to downstream lands or infrastructure; or
2. A reduction in streamflows within the receiving watercourses which would cause changes to the fluvial regime and geomorphic conditions.

An assessment of the significance of potential residual effects related to surface water quantity on fish and fish habitat is provided in Chapter 12.

The thresholds for establishing the potential for residual adverse effects on surface water quantity consider the characterizations described in Section 10.5.4 to make a determination of significance.

10.5.2 Project Effects

Project activities and components have the potential to result in adverse effects to surface water quantity within the receiving watercourses during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. The primary objective of this section is to identify the potential effects related to surface water quantity that could result from the interaction of the Project components and activities with the VCs noted in Chapter 5.

10.5.2.1 Project Interactions

Project activities that are expected to interact with surface water quantity, with a potential for adverse effects, are presented together with the associated ranking in Table 10.5-1. Specific details on Project activities and components are discussed in Chapter 3. Project activities and components are assessed independently for each temporal phase to identify the potential pathways that could result in adverse effects on surface water quantity.

Table 10.5-1: Project-Surface Water Quantity Interaction and Ranking Matrix

Project Phase	Project Component	Description of Activities	Surface Water Quantity
Construction and Pre-Production	Transportation	Use of Highway 43, Line Creek Mine Road, Valley Road, and Grave Creek Road by highway transport trucks, light duty vehicles, and crew busses to transport personnel, materials, and consumable items	I
	Logging of Merchantable Timber	Merchantable timber will be logged from the infrastructure and pre-production development footprint	I
	Clearing and Grubbing	After the merchantable timber has been removed, the remaining vegetation will be cleared and grubbed from the infrastructure and pre-production development footprint	II
	Stockpiling Wood Waste	Wood waste will be stockpiled and used for reclamation as a source of coarse woody debris	I
	Quarry for Construction Materials	Excavation of road bed materials from the North Pit footprint for use on Grave Creek Road	II
	Water Management of Water Management Structures	Water management structures to support initial construction activities will be built prior to soil being salvaged from the run of mine (ROM) and plant site	I
		Interim Sediment Pond will be built prior to the soil removal and stockpiling from the pit access road and initial phase of the North Pit	II
		Grave Creek Reservoir will be constructed to act as a back-up source of process water	II
	Soil Salvage	Soil will be salvaged from the footprint of the infrastructure	I

Project Phase	Project Component	Description of Activities	Surface Water Quantity
	Road Upgrading and Construction	Branch C Road will be widened and upgraded to facilitate construction and mine traffic to plant site area	I
		Grave Creek Road will be widened to facilitate the clean coal haul	I
		A new road will be constructed off the Valley Road to access the rail loadout for construction and operation	I
	Linear Infrastructure	Installation of the powerline	I
		Installation of the natural gas line	I
	Overland Conveyor	Clearing, grubbing, and construction of overland conveyor from the plant site to Grave Creek Road	I
	Coal Handling Process Plant Construction	Excavating and pouring of foundation	I
		Transportation of materials and personnel to site	I
		Constructing of the Coal Handling Process Plant (CHPP)	I
		Commissioning of the CHPP	I
	Workshop / Mine Dry Construction	Excavating and pouring of foundation	I
		Transportation of materials to site	I
		Construction of workshop / mine dry	I
		Equipment wash bay and heavy equipment parking	I
		Administration, first aid, and mine dry building	I
		Diesel tank farm	I
		Warehouse	I
		Potable water system	I
		Septic system	I
		Water supply pipelines from Grave Creek and West Alexander Creek	I
		Commissioning of the facilities	I
	Explosives Factory Construction	Construction of the explosives factory	I
	Rail Loadout Construction	Excavation and preparation of the rail bed	I
		Excavation and preparation of foundation stockpiling and coal handling systems	I
		Transportation of materials and personnel to site	I
		Construction of rail loadout	I
		Connection to the CP Fording Sub-line	I
		Commissioning of the rail loadout	I
	Labour	Hiring of personnel for the mine, CHPP operations, administration, and coal haul	I
		Training of personnel	I

Project Phase	Project Component	Description of Activities	Surface Water Quantity
	Construction Waste Materials	Collection and transfer to a recycling facility or other approved facility	I
Operations	Transportation	Use of Highway 43, Line Creek Mine Road, Valley Road, and Grave Creek Road by highway transport trucks, light duty vehicles, and crew busses to transport personnel, materials, and consumable items	I
	Explosives Factory	Ammonium nitrate / emulsion storage facilities which have the ability to load explosive agents into delivery trucks	I
		Wash facility to decontaminate the bulk explosive delivery trucks	I
		Storage of explosives (detonators and boosters)	I
	Fuel Storage	Receiving bulk fuel deliveries	I
		On-site storage of fuel	I
		Dispensing fuel	I
		Transferring fuel to on-site delivery trucks	I
	Mine Roads Development	Building roads from material sourced on-site	I
	Mining	Progressive clearing	II
		Removal of unconsolidated material	
		Loading, hauling, and stockpiling of soil	
		Drilling and loading of blastholes	
		Detonating the explosives	
		Loading, hauling, and dumping of mine rock	
		Loading, hauling, and stockpiling of coal	
	Site Water Requirements	Using contact water as the primary process make-up water from Interim Sediment Pond (Year 1 to 5)	II
		Using contact water as the primary process make-up water from the North Pit (Year 5 to 15)	II
		Backup reservoir in Grave Creek as a secondary source of process make-up water	III
	Coal Processing	Run of mine coal sizing	I
		Washing coal	II
		Mechanical and thermal drying of coal	I
		Coal reject disposal (part of loading, hauling, and dumping of mine rock activities)	I
		Conveying clean coal	I
	Sewage Treatment	Sewage will be treated by a septic system constructed at the plantsite which will support the administration, mine dry, and CHPP facilities	I

Project Phase	Project Component	Description of Activities	Surface Water Quantity
	Main Sediment Pond	Construction of Main Sediment Pond in Year 4	III
		Management of the Main Sediment Pond discharge	III
	Reclamation	Reclaiming available areas as soon as possible to achieve reclamation objectives	I
Reclamation and Closure	Transportation	Use of Highway 43, Line Creek Mine Road, Valley Road, and Grave Creek Road by highway transport trucks, light duty vehicles, and crew busses to transport personnel, materials, and consumable items	I
	Dismantling Infrastructure and Buildings	Dismantling CHPP, maintenance facilities, administration, and other facilities	I
		Dismantling, salvaging, collecting, and transferring materials to a recycling facility or other approved facility	I
	Removal of Linear Infrastructure	Removal of the powerline	I
		Removal of the natural gas line	I
	Reclamation	Reclaiming available areas as soon as possible to achieve reclamation objectives	III
	Monitoring	Reclamation monitoring	I
		Geotechnical monitoring	I
		Aquatic effects monitoring	I
	Water Management	Management of the Main Sediment Pond discharge	II
Post-Closure	Water Management	Decommissioning the Main Sediment Pond once water quality objectives have been	III
	Road Use	Branch C Road will remain as a permanent access road for commercial and recreational use	I
	Rail Line	The rail line will remain as a permanent feature	I
	Monitoring	Reclamation monitoring	I
		Geotechnical monitoring	I
		Aquatic effects monitoring	I

Notes (after EAO, 2013):
I = No or negligible effect (positive or adverse) is anticipated; not carried forward in the assessment
II = Potential adverse effects requiring additional mitigation or substantive positive effects are expected; carried forward in the assessment
III = Key interaction resulting in potential significant adverse effect or significant concern; carried forward in the assessment

In general, the Project has the potential to adversely affect surface water quantity in the receiving watercourses through the changing of streamflow characteristics (flows, volume, timing) attributed to modifications to topography and surface cover, alterations of natural drainage pathways, and surface water withdrawals.

Specifically, the Project has the potential to affect surface water quantity through:

- Construction of the Grave Creek Reservoir and backup reservoir to act as a source of process make-up water;

- Water withdrawals from Grave Creek for use as process make-up water;
- Clearing and grubbing of vegetation from the infrastructure and pre-production development footprint;
- Modifications to the contributing watershed area for West Alexander and Alexander Creeks due to mining in the upper watershed;
- Site water management and discharge to the receiving environment, including construction, operation, and decommissioning of the Interim and Main Sediment Ponds;
- Mining operations including loading, hauling and stockpiling of soil, removal of unconsolidated material, and loading, hauling and stockpiling/dumping of coal and mine rock;
- Sequestering of mine contact water in sediment ponds and to a lesser extent in the open pit during Operations and upon closure, thereby reducing downgradient streamflow, as well as release of treated wastewater potentially increasing downgradient streamflow;
- Surface water-groundwater interactions; and
- Reclamation activities for the mine rock dump area.

Potential effects on surface water quantity as a result of the Project that are carried forward in the discussion of potential effects are identified in Table 10.5-2.

Table 10.5-2: Potential Effects on Surface Water Quantity

Potential Effect	Rationale for Selection of Environmental Effect
Change to Surface Water Quantity due to Site Construction Activities	Potential for streamflows to be affected as a result of changes to hydrologic characteristics (land use, surface cover, drainage pathways) related to site construction activities.
Change to Surface Water Quantity due to Surface Water Withdrawals	Potential for reduced flows in downstream reaches of Grave Creek due to water withdrawals.
Change to Surface Water Quantity due to Operational Activities	Potential for streamflows to be affected as a result of changes to drainage pathways and introduction of water management structures as well as sequestration and treatment of mine contact water.
Change to Surface Water Quantity due to Mine Closure and Reclamation Activities	Potential for streamflows to be affected as a result of changes to hydrologic characteristics (land use, surface cover, drainage pathways) related to site reclamation activities. Potential positive effects to streamflows once the sediment ponds are decommissioned, as a result of no longer sequestering incoming water flows.

10.5.2.2 Discussion of Potential Effects

The potential effects identified in Table 10.5-1 are discussed in the context of each Project phase (Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure) in the following subsections.

10.5.2.2.1 Change to Surface Water Quantity due to Site Construction Activities

The Construction and Pre-Production and Operations phases involve activities that will influence the hydrologic characteristics within portions of the Grave Creek and West Alexander/Alexander Creek watersheds. These activities include the removal of trees (timber), clearing and grubbing, site grading, and the construction of mine site facilities and transportation and drainage infrastructure, which will alter local topography and cause localized changes to surface water hydrology.

There is a potential for streamflows to be affected during the Construction and Pre-Production phase as a result of the above-described activities due to changes to the existing land use, surface cover, and drainage pathways. Potential effects related to site construction and operation activities are not anticipated during the Reclamation and Closure or Post-Closure phases.

10.5.2.2.2 Change to Surface Water Quantity due to Surface Water Withdrawals

The Grave Creek Reservoir is proposed to be constructed during the Construction and Pre-Production phase. Surface water withdrawals from Grave Creek will occur on an ongoing basis during the Operations phase to provide a source of process water. Withdrawals of surface water from Grave Creek will cease at the end of the Operations phase.

There is a potential for streamflows to be reduced within the downstream reaches of Grave Creek during the Construction and Pre-Production and Operations phases as a result of the construction of the reservoir and subsequent surface water withdrawals. The potential effects during the Reclamation and Closure phase will be limited to the decommissioning of the reservoir and associated infrastructure.

10.5.2.2.3 Change to Surface Water Quantity due to Operational Activities

Surface water runoff within the Project footprint will be achieved through a combination of drainage infrastructure and water management facilities that will evolve and adapt throughout the duration of the Project phases, as outlined below.

<u>Construction and Pre-Production</u>

The initial Project phase will involve the construction of drainage infrastructure to collect, convey, and divert surface runoff along transportation infrastructure (mine roads and railway lines), mine facilities, and operational areas including excavation, stockpile, and waste placement areas. In addition, the Interim Sediment Pond will be constructed for surface water quality purposes and to provide a source of process water, thereby sequestering water for use by the Project that could reduce downgradient streamflows. Outflows from the Interim Sediment Pond will discharge via a controlled outlet structure to West Alexander Creek.

Operations

Drainage and water management infrastructure will continue to be constructed and modified to collect, convey, and divert surface runoff within the mine area, along linear infrastructure, and around mine facilities. The Main Sediment Pond is scheduled to be constructed in Year 5, after which the Interim Sediment Pond will be decommissioned. During the remaining period of the Operations phase, contact water from the North Pit will serve as the primary source of process water. Outflows from the Main Sediment Pond will discharge via a controlled outlet structure to West Alexander Creek, partially restoring streamflow that would otherwise result from sequestering water in the pond.

Reclamation and Closure

Following the end of operational mining activities, the drainage and water management infrastructure will be modified and decommissioned as part of the reclamation works in preparation for site closure. Drainage pathways will be established to reflect the final layout and grading plan within the Project footprint. The Main Sediment Pond will continue to operate during this phase of the Project, and will continue to outlet to West Alexander Creek.

Post-Closure

Much of the drainage and surface water management system implemented during the Reclamation and Closure phase will continue to operate in a similar manner with respect to drainage pathways and boundaries. The primary change during the Post-Closure phase is the decommissioning of the Main Sediment Pond. Water that would otherwise be sequestered in the pond will restore streamflow in downgradient watercourses, and there should no longer be any influence of the Project on surface water hydrology (in other words, surface water inputs to the former Project footprint will then equal outputs from the former Project footprint, with no further accumulation) - a positive effect with respect to hydrology.

10.5.2.2.4 Change to Surface Water Quantity due to Mine Closure and Reclamation Activities

Site reclamation activities will involve several changes within the Project footprint, including site grading and surface cover modifications within the Mine Rock Storage Facility area. In addition, mine site infrastructure and water management facilities will be decommissioned. There is a potential for streamflows within the Alexander Creek system to be affected by site reclamation and decommissioning activities during the Reclamation and Closure and Post-Closure phases. As mentioned above, positive effects are expected to surface water hydrology upon closure as streamflow is restored following decommissioning of water retention structures.

10.5.2.3 Transboundary Effects

The Project is located approximately 5 km west from the Alberta border and 85 km north from the Montana border in the United States of America. As discussed in Chapter 1, Section 1.3.3, the nearest federal lands to the proposed Project are the ?aq'am First Nation Bummer's Flat 1 Reserve (approximately 69 km southwest), Stoney Nakoda Edan Valley 216 Reserve (approximately 70 km northeast), Tobacco Plains 2 (approximately 80 south), Piikani Nation Peigan Timber Limit 147B (approximately 52 km east in Alberta), and Parcels 73 and 82 of the Dominion Coal Blocks (approximately 20 and 40 km southwest, respectively). Federal land is not required to facilitate the Project and the Project does not overlap with any federal land. Of the federal lands listed above, only Parcel 73 and a small portion of Parcel 82 of the

Dominion Coal Blocks are located with the Aquatic RSA; the other federal lands are located outside the Elk River watershed and therefore surface water quantity effects will not occur within these lands. Although Parcel 73 and a small portion of Parcel 82 are located within the Aquatic RSA, changes to surface water quantity within these federal lands are not expected as the watercourses that have the potential to be affected by the Project (i.e., West Alexander Creek, Alexander Creek, the lower reaches of Michel Creek, and the Elk River) do not overlap with the Dominion Coal Blocks.

Transboundary effects to surface water quantity in Lake Koocanusa south of the B.C./Montana border during the Operations, Reclamation and Closure, and Post-Closure phases are not anticipated, as the Project footprint accounts for a very small portion of the contributing watershed area of the Kootenay River at the Canada-U.S. border (i.e., less than 0.06%). Transboundary effects into Alberta will not occur as a result of the Project as all watersheds within and surrounding the Project footprint are located on the western side of the Continental Divide.

10.5.3 Mitigation Measures

The proposed mitigation strategy has been developed to reduce or minimize adverse effects on surface water quantity though the incorporation of practical best management practices (BMPs) and procedures. These have been identified based on relevant provincial and federal guidance documents together with available information for mitigation measures implemented for similar projects.

Mitigation measures were identified for each potential effect on surface water quantity. For the purposes of this assessment, mitigation measures are defined to include project design feature, procedure, or practice that will reduce or eliminate Project-related effects to surface water quantity. Potential Project-related changes to surface water quantity will be reduced through design mitigation, regulatory requirements, BMPs, including management plans, monitoring, and adaptive management.

The proposed strategy is intended to mitigate adverse effects for the following potential Project effects on surface water quantity:

- Change to Surface Water Quantity due to Site Construction Activities;
- Change to Surface Water Quantity due to Surface Water Withdrawals;
- Change to Surface Water Quantity due to Operational Activities; and
- Change to Surface Water Quantity due to Mine Closure and Reclamation Activities.

Implementation of the operational practices and procedures that are prescribed in the Site Water Management Plan (Chapter 33, Section 33.4.1.8) will be the primary means by which adverse effects to surface water quantity will be addressed. The Site Water Management Plan includes a combination of mitigation measures that will be executed and adapted to accommodate site conditions throughout the various phases of the Project.

In general, the Site Water Management Plan will include a range of drainage features and facilities for the conveyance, diversion, and storage of surface water runoff within the Project footprint. One of the principal goals of the Site Water Management Plan is to minimize disruptions to streamflow conditions in the receiving watercourses, which will be achieved through the following mitigation objectives:

- Segregation and diversion of non-contact surface runoff around mine disturbed areas and water control facilities;

- Controlling outflows from water management facilities to maintain streamflow conditions in the receiving watercourses to the extent possible, particularly during low flow conditions;
- Limiting surface water withdrawals to minimize impacts on streamflows;
- Implementation of progressive contouring and reclamation of dump site areas to minimize changes in land use and hydrological characteristics; and
- Decommissioning and reclaiming water management facilities to restore natural streamflow conditions in the receiving watercourses to the extent possible.

Table 10.5-3 provides a summary of the proposed mitigation measures for each of the potential effects on surface water quantity.

Table 10.5-3: Summary of Proposed Mitigation Measures on Surface Water Quantity

Potential Effect	Mitigation Measures	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
Change to Surface Water Quantity due to Site Construction Activities	Site Water Management Plan	To maintain streamflow conditions (flows and water levels) within the receiving watercourses	Construction and Pre-Production	Moderate	Yes
Change to Surface Water Quantity due to Surface Water Withdrawals	Application of limitations on water withdrawals	To maintain flows and water levels in the downstream reaches of Grave Creek	Operations	High	No
Change to Surface Water Quantity due to Operational Activities	Site Water Management Plan	To maintain streamflow conditions (flows and water levels) within the receiving watercourses	Operations	Moderate	Yes
Change to Surface Water Quantity due to Mine Closure and Reclamation Activities	Site Water Management Plan, Site Reclamation, and Reclamation Monitoring	To maintain streamflow conditions (flows and water levels) within the receiving watercourses	Reclamation and Closure, Post-Closure	Moderate	Yes

Further information regarding the Site Water Management Plan is provided in Chapter 33, Section 33.4.1.8, including details related to the proposed water withdrawal operation for Grave Creek.

10.5.4 Characterization of Residual Effects, Significance, Likelihood and Confidence

Based on the evaluation of potential Project effects on surface water quantity, potential residual effects that may remain after implementation of proposed mitigation measures include:

- Change to Surface Water Quantity due to Site Construction Activities;
- Change to Surface Water Quantity due to Operational Activities; and
- Change to Surface Water Quantity due to Mine Closure and Reclamation Activities.

Potential effects resulting from surface water withdrawals from Grave Creek can be mitigated though the implementation of withdrawal restrictions to allow for environmental flow requirements to be met during period of low flow conditions. Accordingly, changes to surface water quantity due to surface water withdrawals is not identified as a residual effect for surface water quantity.

10.5.4.1 Hydrology Assessment Methods

Methodology

A water and load balance model was developed by SRK using the software program GoldSim version 12.1 to simulate the generation, movement, and storage of water throughout the proposed Crown Mountain Project. The Goldsim model is designed as a probabilistic, dynamic simulator running continuously from pre-production to life-of-mine (LOM) and into closure/reclamation, for a total simulation duration of 34 years, in a sequence of quarter day to one day time-steps with select climate inputs being allowed to vary within manually defined stochastic distributions.

The water balance component of the model simulates the climate of the region through the use of stochastic precipitation, temperature, and solar radiation elements, developed to mimic the historical climate observed at the site and in the nearby climate monitoring station of Sparwood, B.C. The uncertainty introduced by these stochastic inputs is propagated through the model with the simulation of snowpack and snow melt, icepack formation and melt, runoff, infiltration, and evaporation into the various facilities of the Project. The flows of water into and out of the facilities, as well as any water stored within the facilities, are calculated at a minimum time step of daily through the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases.

For the purpose of the surface water quantity effects assessment, the GoldSim model was simulated for multiple long-term scenarios to evaluate streamflow (water quantity) characteristics at key locations within the Aquatic LSA and RSA under existing and proposed (i.e., mine development) land use conditions, in addition to climate change conditions. A summary of the model scenarios is provided in Table 10.5-4.

Table 10.5-4: Surface Water Quantity Effects Assessment Model Scenarios

Assessment Scenario	Land Use	Climate Conditions
A.1	Existing (Baseline) Conditions	Historical
B.1	Mine Development	Historical
B.2	Mine Development	With Climate Change (RCP8.5)

Further information regarding the model development and simulation methodology is outlined below:

- The model reflects the change in land use and water management at the mine site over the Project phases:
  - Construction and Pre-Production;
  - Operations;
  - Reclamation and Closure; and
  - Post-Closure;

- The water and load balance model was developed to address all major facilities associated with the Project. Each facility has been developed as an individual module that contains all calculations performed on a sub daily time-step from Pre-Production through the projected life of the mine (LOM) and into closure/reclamation;
- The model was simulated for the 34 year assessment period based on historical daily climate data for 1985 through 2018 to represent pre-development (baseline) conditions; and
- The climate change scenarios are based on the Representative Concentration Pathway (RCP) 8.5 trajectory used in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5; IPCC, 2014).

Additional information regarding the GoldSim model is available in the Crown Mountain Flow and Water Quality Impact Assessment Modelling Technical Memo (Appendix 10-A; SRK, 2021).

For the purpose of the surface water quantity effects assessment, streamflow conditions were evaluated at multiple flow node locations along the receiving watercourses located in the Aquatic LSA (i.e., Grave Creek and West Alexander/Alexander Creeks), which are listed in Table 10.5-5 and shown on Figure 10.5-1.

Table 10.5-5: Surface Water Quantity Effects Assessment Local Study Area Flow Nodes

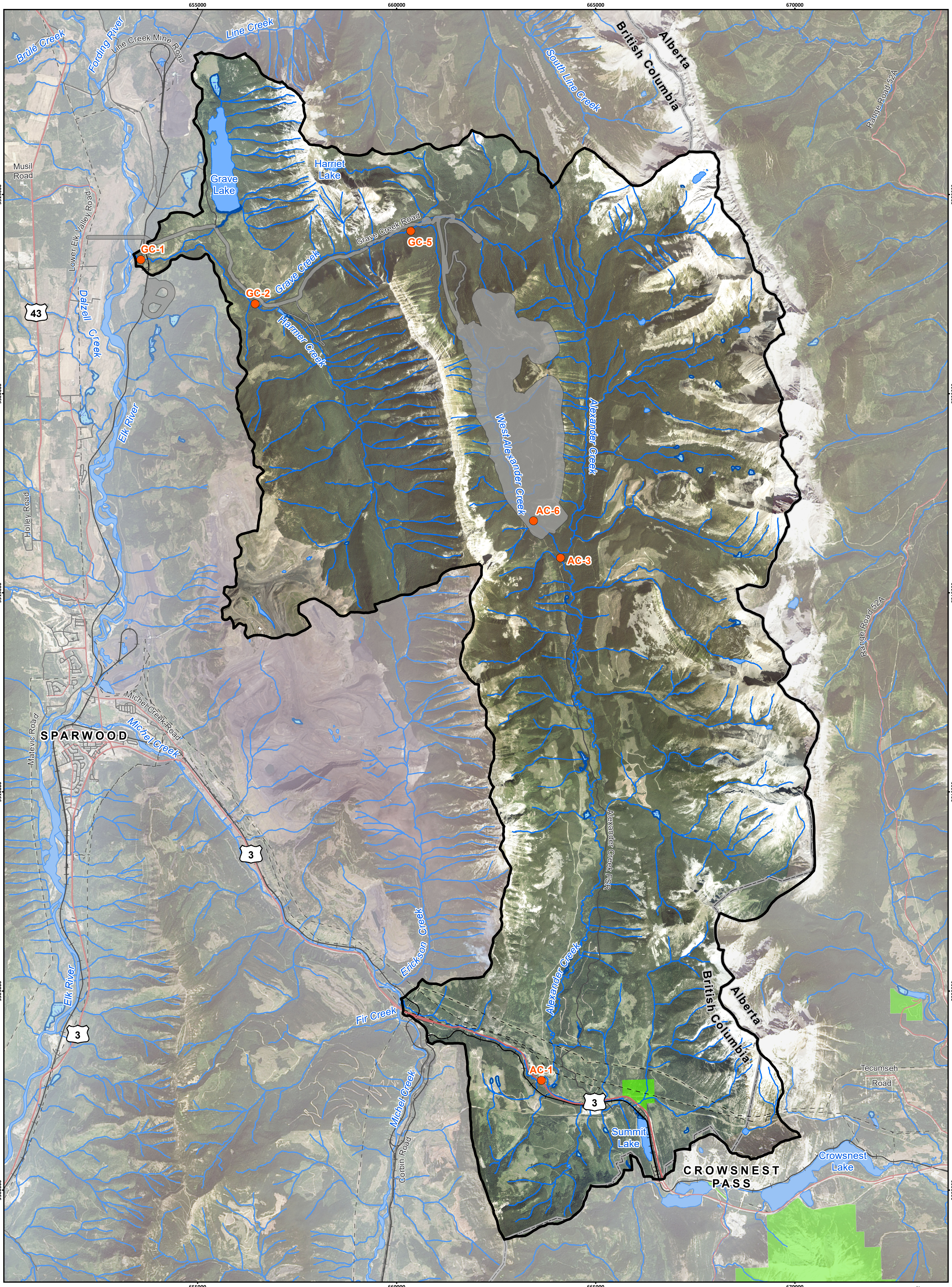
Grave Creek Watershed		Alexander Creek Watershed	
Node ID	Location Description	Node ID	Location Description
GC-1	Grave Creek upstream of confluence with Elk River	AC-1	Alexander Creek upstream of Hwy 3
GC-2	Grave Creek downstream of confluence with Harmer Creek	AC-3	Alexander Creek downstream of confluence with West Alexander Creek
GC-5	Grave Creek downstream of withdrawal location	AC-6	West Alexander Creek downstream of Main Sediment Pond outlet

The location of the flow nodes for each watercourse were purposefully selected to provide an opportunity to assess potential surface water quantity effects independently for the upper, middle, and lower reaches of each of the subject watercourses in the Aquatic LSA.

In addition, the surface water quantity assessment examined the potential effects on water quantity at various locations within the Aquatic RSA, including flow nodes along the Elk River and at Lake Koocanusa. The Aquatic RSA flow nodes are listed in Table 10.5-6 and shown on Figure 10.5-2.

Table 10.5-6: Surface Water Quantity Effects Assessment Regional Study Area Flow Nodes

Node ID	Location Description
EV_ER1	Elk River Downstream of Michel Creek
RG_ELKORES	Elk River at Elko Reservoir
RG_DSELK	Lake Koocanusa downstream of Elk River



Crown Mountain Coking Coal Project

Figure 10.5-1
Aquatic Local Study Area Flow Nodes

LEGEND

- Flow Node
- Aquatic Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

Scale 1:90,000

N W E S

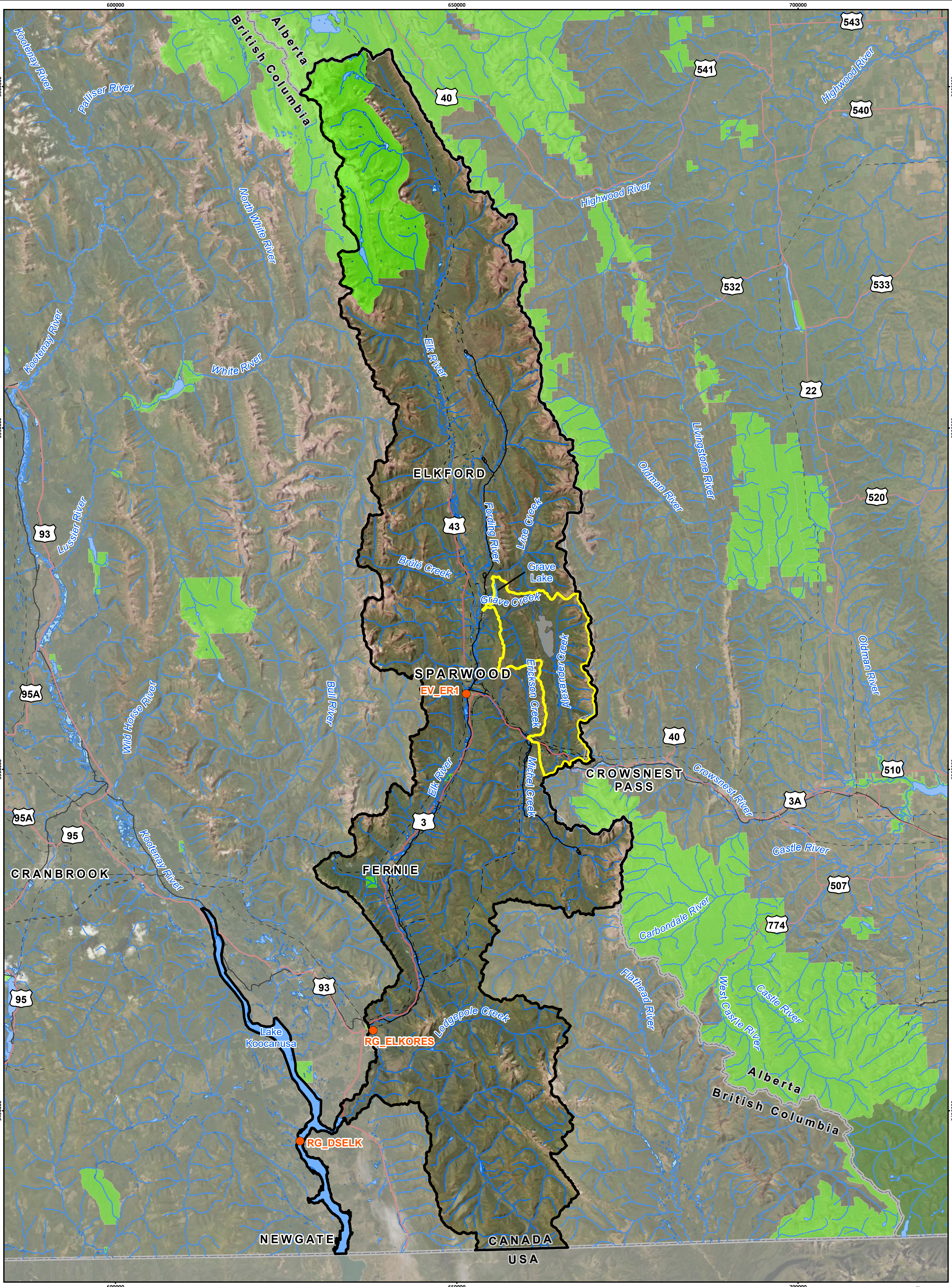
Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada. Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: LMM
Map Checked By: JNW
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2021-02-24

Document Path: G:\GIS\2012 and Prior\126231 Crown Mountain\EA_Report\EffectsAssessment\Hydrology\126231_EA_HYD_LocalStudyAreaFlowNodes.mxd



Crown Mountain Coking Coal Project

Figure 10.5-2
Aquatic Regional Study Area Flow Nodes

LEGEND

- Flow Node
- Aquatic Regional Study Area
- Aquatic Local Study Area
- Project Footprint
- Highway
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- National Park
- British Columbia/ Alberta Border

0 10 20
Kilometres

Scale 1:525,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada, Elk Valley Water Quality Plan.
Imagery Provided By ESRI.

Map Created By: LMM
Map Checked By: JNW
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2021-02-24

Assumptions and Limitations

The water balance model is based on a series of expected and conservative assumptions developed to be representative of the water and chemical mass conditions observed at the current, undeveloped site or conditions expected during future development of the Project. The water and load balance by necessity includes the simplification of a number of complex natural phenomena, including, but not limited to: climate, runoff, snow melt, ice formation, infiltration, and seepage attenuation. The model uses physical models that are only representations of these processes and are calibrated to observed baseline data, where possible. However, many of these processes do not exist in the current, undeveloped conditions and as such future behaviour cannot be predicted with precision.

Understanding that the model is an estimation of the actual behaviour that will potentially occur in the future, observed behaviour of physical processes and the system as the Project is developed will be compared with the modelling results to refine the model, physical processes, and inputs to improve the model performance.

10.5.4.2 Potential Residual Effects Assessment

The results of the Project residual effects assessment on surface water quantity are presented in the following subsections.

10.5.4.2.1 Baseline Conditions Characterization

Baseline conditions were characterized for the purpose of establishing a benchmark to which the magnitude and significance of potential effects on surface water quantity of the Project study areas could be assessed. The methodology for characterizing baseline conditions involved the development of a long-term water balance model to simulate surface water quantity (runoff) characteristics over a period of 34 years to coincide with the temporal boundaries (i.e., time periods) during which the Project is anticipated to result in potential effects on VCs.

For ease of reference, the results of the baseline conditions characterization are presented together with the residual effects characterization below in Section 10.5.4.2.2.

10.5.4.2.2 Residual Effects Characterization

As discussed in Section 10.5.2, the potential effects identified through the assessment of the proposed Project phases were associated to changes in surface water quantity related to the following activities:

- Site Construction Activities involving changes to the existing land use, surface cover, and drainage pathways;
- Surface Water Management Activities, including the construction and operation of drainage infrastructure and water management facilities; and
- Mine Closure and Reclamation Activities, including changes in land use, surface cover, drainage pathways, and decommissioning of water management facilities.

A continuous long-term water balance model was developed to assess the potential effects on surface water quantity (i.e., streamflows) within the receiving drainage environment. The modelling methodology is outlined in Section 10.5.4.1 and discussed in further detail in the Crown Mountain Flow and Water Quality Impact Assessment Modelling Technical Memo (SRK, 2021; Appendix 10-A).

The residual effects characterization involved an assessment of surface water quantity characteristics under baseline and proposed mine development conditions. The assessment included an examination of annual and monthly streamflows at multiple locations along the receiving watercourses over the 34 year assessment period. For the purpose of the effects assessment, the predicted changes to surface water quantity are presented separately for the Aquatic LSA and RSA watercourses.

Change to Surface Water Quantity for Local Study Area Watercourses

A summary of the projected mean annual and monthly flow conditions over the 34 year assessment period for Grave Creek, Alexander Creek, and West Alexander Creek is presented below.

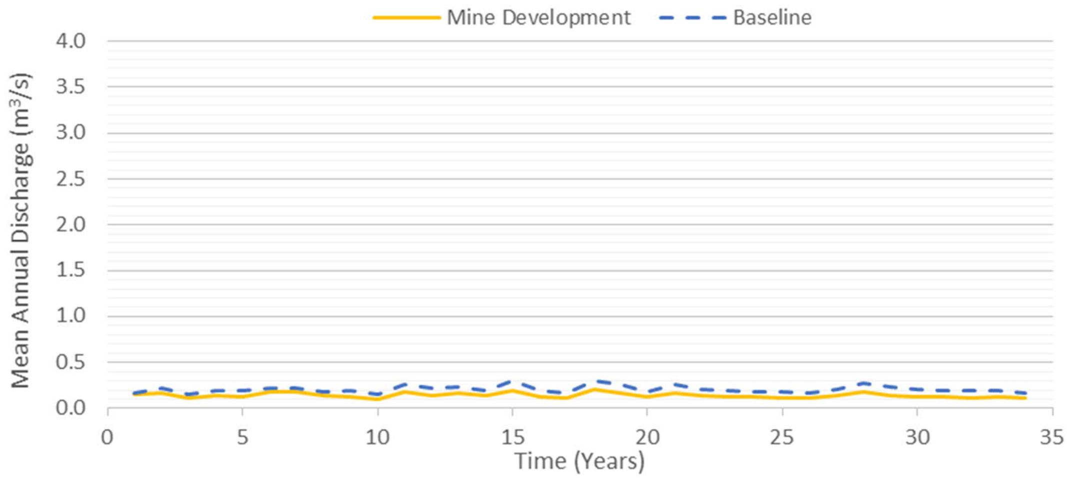
Alexander Creek and West Alexander Creek

The projected 34 year continuous annual flow hydrographs for the baseline and mine development scenarios at each of the assessment nodes are presented on Figure 10.5-3, which are based on historical climate conditions. A consistent scale was applied for the axes to illustrate the relative magnitude of flows between the three assessment nodes.

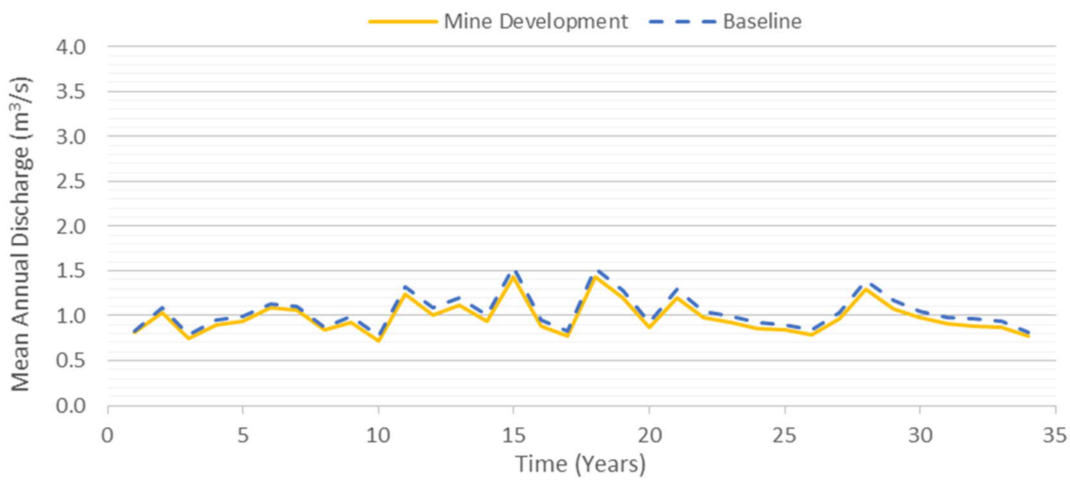
The 34 year continuous annual hydrographs indicate that there is a reduction in annual flows between the mine development scenario compared with the baseline simulations over the duration of the assessment period. The most notable changes occur on West Alexander Creek downstream of the Main Sediment Pond (AC-6), while the differences are much less significant in the downstream reaches as found at Alexander Creek downstream of West Alexander Creek (AC-3) and Alexander Creek Upstream of Highway 3 (AC-1).

A summary of the average minimum, mean, and maximum annual flows at the assessment nodes on Alexander and West Alexander Creeks, which illustrates the variability of flows and potential changes during the individual Project phases is presented in Table 10.5-7. The table includes the projected flows for existing land use conditions together with the mine development scenario and the percent change during the respective timeframe for each of the individual Project phases. The full set of long-term flow data for the 34 year assessment period is provided in Appendix 10-C.

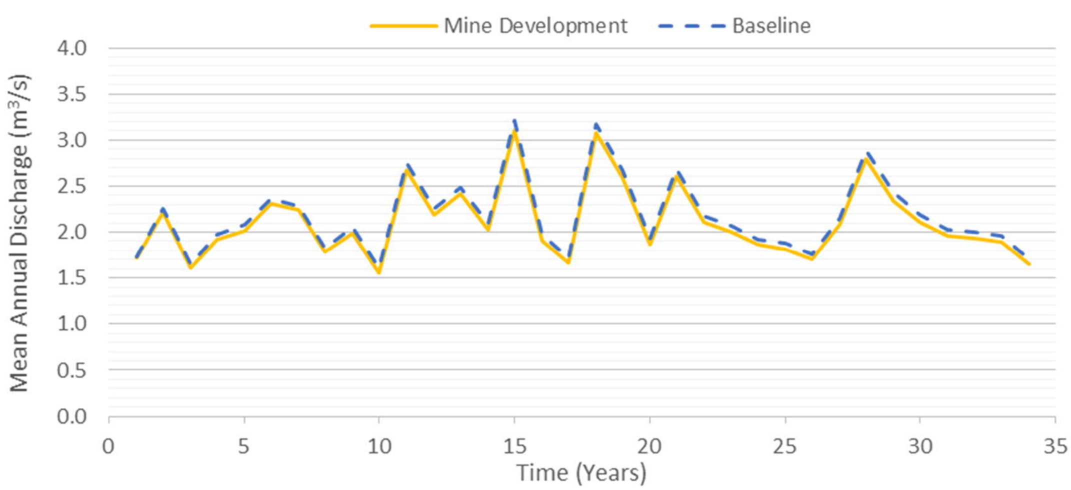
The projected annual flow data indicate that there will be a decrease in the minimum and average annual flows at all of the assessment nodes (AC-1, AC-3, and AC-6) during all of the Project phases. The maximum annual flows generally also show a decrease at all of the nodes through the Project phases with the exception of a moderate increase being detected immediately downstream of the decommissioned Main Sediment Pond site during the Post-Closure phase only. The magnitude of the respective annual flow changes shows a trend of substantially reducing in the downstream direction of flow within Alexander Creek, with changes in annual flow generally less than 3.5% from the baseline values at the lower reaches of Alexander Creek (AC-1) for all phases.



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)



Alexander Creek Downstream of West Alexander Creek (AC-3)



Alexander Creek Upstream of Highway 3 (AC-1)

Figure 10.5-3: Projected Mean Annual Flows for Multiple Locations on Alexander/West Alexander Creeks (Years 1 – 34)

Table 10.5-7: Projected Minimum, Mean, and Maximum Average Annual Flows (m^3/s) by Project Phase at Multiple Locations on Alexander/West Alexander Creeks

Project Phase	Annual Flow Parameter	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
		Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	0.79	0.77	-2.6	0.38	0.36	-5.4	0.08	0.06	-27.3
	Mean	1.99	1.96	-1.5	0.96	0.93	-3.1	0.19	0.16	-15.4
	Max	10.15	9.95	-2.0	4.87	4.68	-3.9	0.97	0.80	-17.8
Operations (Years 3-17)	Min	0.79	0.78	-2.3	0.38	0.36	-6.0	0.08	0.01	-82.1
	Mean	2.16	2.09	-2.8	1.03	0.97	-5.9	0.21	0.15	-29.6
	Max	16.49	16.14	-2.1	7.91	7.59	-4.1	1.58	1.50	-4.8
Reclamation and Closure (Years 18-19)	Min	0.80	0.78	-1.7	0.38	0.37	-3.8	0.08	0.00	-100.0
	Mean	2.93	2.84	-3.0	1.40	1.32	-6.3	0.28	0.19	-31.5
	Max	25.18	24.51	-2.7	12.09	11.44	-5.4	2.41	1.84	-23.8
Post-Closure (Years 20-34)	Min	0.80	0.78	-2.7	0.38	0.36	-6.3	0.08	0.00	-97.7
	Mean	2.12	2.05	-3.3	1.02	0.95	-6.9	0.20	0.13	-34.5
	Max	16.31	16.01	-1.9	7.83	7.62	-2.6	1.56	1.62	3.4

A comparision of the projected mean annual runoff yield for the baseline and mine development scenarios at the Alexander Creek assessment nodes during each of the Project phases in presented in Table 10.5-8. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C. In general, the results illustrate a varying level of decline in the mean annual yield between the baseline and mine development scenarios, with the magnitude of change diminishing in the downstream direction of flow but increasing over the timeline of mine development at all locations.

Table 10.5-8: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations on Alexander/West Alexander Creeks

Project Phase	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	433	427	-1.5%	433	420	-3.1%	433	367	-15.4%
Operations (Years 3-17)	469	456	-2.8%	469	441	-5.9%	469	330	-29.6%
Reclamation and Closure (Years 18-19)	637	617	-3.0%	637	597	-6.3%	637	436	-31.5%
Post-Closure (Years 20-34)	461	446	-3.3%	461	429	-6.9%	461	302	-34.5%

Statistical frequency analyses were performed to estimate the peak flows for a range of recurrence intervals (return periods) – based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were undertaken using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-9.

Table 10.5-9: Return Period Peak Flows (m^3/s) at Multiple Locations on Alexander/West Alexander Creeks

Return Period (Years)	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	14.6	14.3	-2.1%	7.0	6.8	-2.4%	1.4	1.4	0.7%
5	21.8	21.3	-2.3%	10.5	10.1	-3.8%	2.1	2.0	-3.3%
10	27.0	26.3	-2.6%	12.9	12.3	-4.7%	2.6	2.4	-5.8%
20	32.1	31.2	-2.8%	15.4	14.6	-5.2%	3.1	2.8	-7.8%
50	39.0	37.8	-3.1%	18.7	17.6	-5.9%	3.7	3.4	-9.6%
100	44.5	43.0	-3.4%	21.3	19.9	-6.6%	4.3	3.8	-11.0%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

In gereral, the frequency analysis results suggest that a reduction in the return period peak flows is projected at all of the assessessment nodes, with the percentage change from baseline conditions declining in the downstream direction of flow within the Alexander Creek system.

An assessment of projected low flow conditions was also undertaken at the Alexander Creek flow nodes. Table 10.5-10 presents the 7-day low flows for a range of return periods.

Table 10.5-10: Return Period 7-Day Low Flows (L/s) at Multiple Locations on Alexander/West Alexander Creeks

Return Period (Years)	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	798	781	-2.1%	383	364	-5.0%	76.5	44.3	-42.1%
5	791	772	-2.4%	380	358	-5.8%	75.8	36.1	-52.4%
10	787	768	-2.4%	378	355	-6.1%	75.5	32.4	-57.1%
20	784	764	-2.6%	376	352	-6.4%	75.2	29.6	-60.6%
50	780	760	-2.6%	375	349	-6.9%	74.8	26.8	-64.2%
100	778	757	-2.7%	373	347	-7.0%	74.6	25.1	-66.4%

Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

Similar to the high flow statistics, the return period low flow projections indicate an overall reduction between the baseline and mine development assessment scenarios. The percentage change from baseline conditions follows a declining trend in the downstream direction of flow within the Alexander Creek system.

The temporal differences were also examined further through an assessment of the mean monthly flows at the Alexander/West Alexander Creek assessment nodes. Figure 10.5-3 illustrates the percent change in the mean monthly flows for each Project phase when compared to baseline conditions (i.e., with no mine development) over the respective timeframes. Mean monthly flow data for the 34 year model simulations are included in Appendix 10-C.

A review of the temporal percent change in projected mean monthly flows and runoff yield for the Alexander/West Alexander Creek nodes indicates the following:

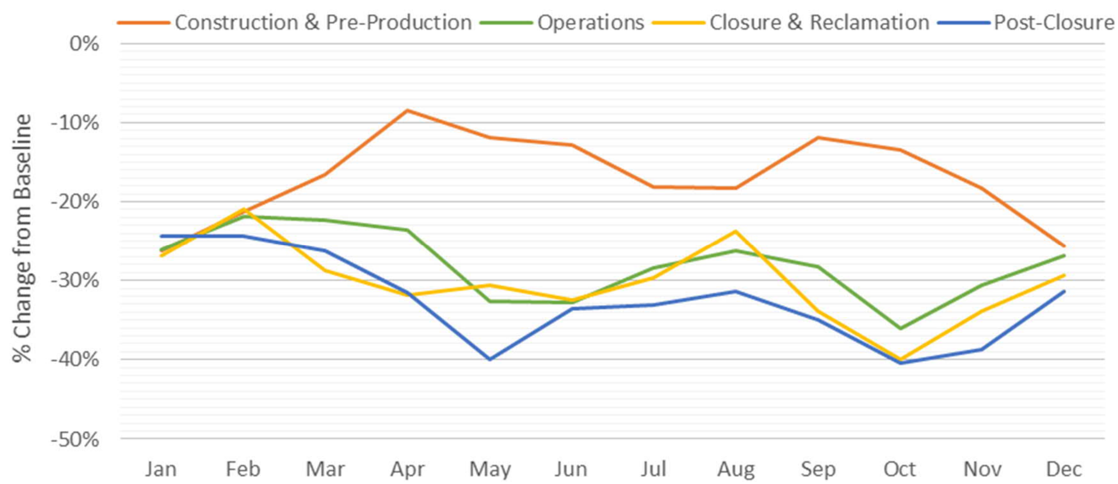
- The temporal change in mean monthly flows and runoff yield is most prominent at AC-6, with the percent change declining substantially at the downstream of the confluence of Alexander Creek (AC-3) and even more so further downstream at Highway 3 (AC-1);
- The temporal percent changes are most notable during the Reclamation and Closure and Post-Closure phases and comparatively lower during Construction and Pre-Production and Operations; and
- The Post-Closure phase generally illustrates the larger reduction in monthly flows and yields in late spring and fall months.

The percent temporal change values at each of the assessment nodes were applied to the baseline flow statistics for the purpose of estimating the mean monthly flows during each Project phase. The monthly hydrographs for each of the assessment nodes on Alexander/West Alexander Creek are presented in Figure 10.5-5. Mean monthly flow data are included in Appendix 10-C.

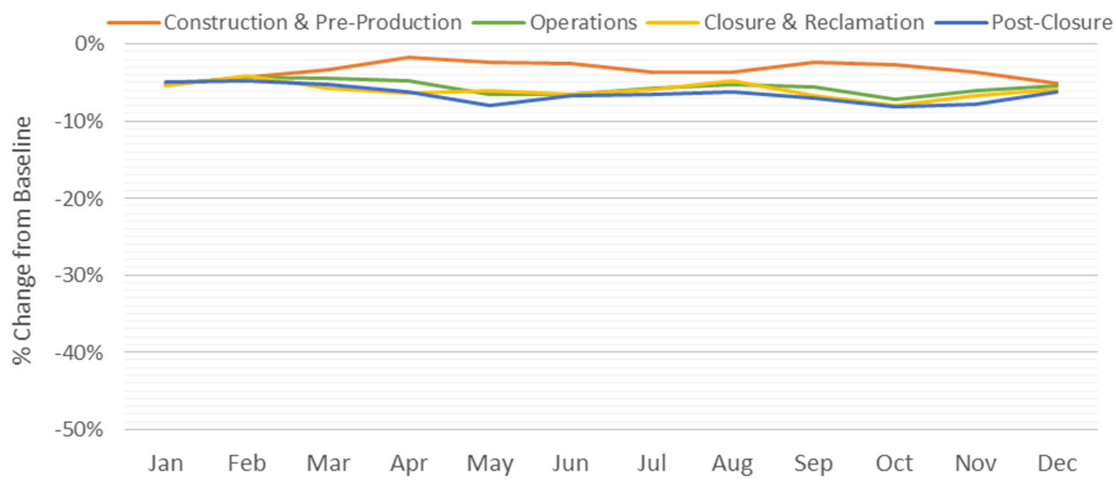
Through a comparison of the projected mean monthly flow data for the baseline and mine development scenarios, the following notable findings are evident:

- For the Alexander Creek Upstream of Highway 3 (AC-1) node, the reduction in mean monthly flows varies based on the Project phase and are in the range of approximately -4% to -1%;
- For the Alexander Creek downstream of West Alexander Creek (AC-3) node, the reduction in mean monthly flows is relatively comparable with respect to the Project phase and generally in the order of double the AC-1 values (approximately -8% to -2%); and
- The reduction in mean monthly flows are most pronounced at the West Alexander Creek downstream of the Main Sediment Pond Outlet (AC-6) node, where the percent change varies between up to approximately -12% during Construction and Pre-Production to as much as -40% during the Post-Closure phase.

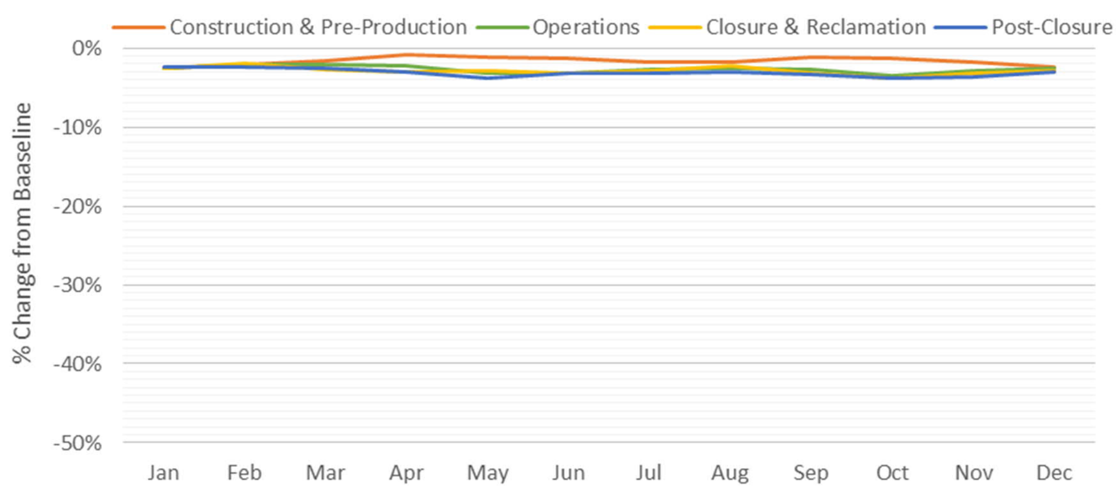
The projected average monthly hydrographs corresponding to baseline conditions in addition to each Project phase are provided in Figure 10.5-5 for the Alexander Creek flow nodes. The hydrographs are presented on consistent vertical axes to illustrate the relative magnitude between the flow notes. As shown and as discussed above, the results indicate that there is a reduction in average monthly flows for all of the Project phases, and that flow reductions are most notable in the spring and fall months during the Reclamation and Closure and Post-Closure phases, and to a lesser extent the Operations Phase. The magnitude of the projected reduction in average flows declines substantially between AC-6 and AC-3, and more so between AC-3 and AC-1.



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)

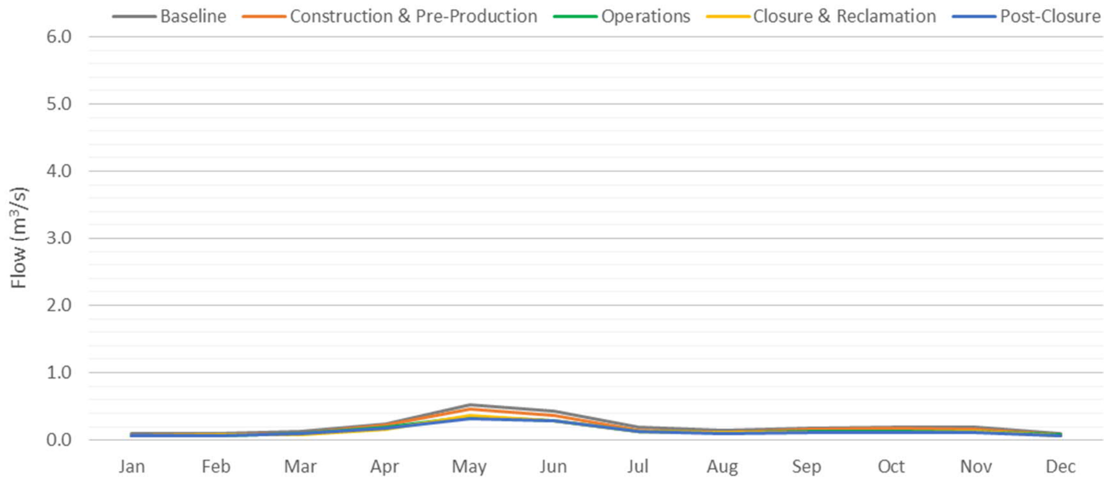


Alexander Creek Downstream of West Alexander Creek (AC-3)

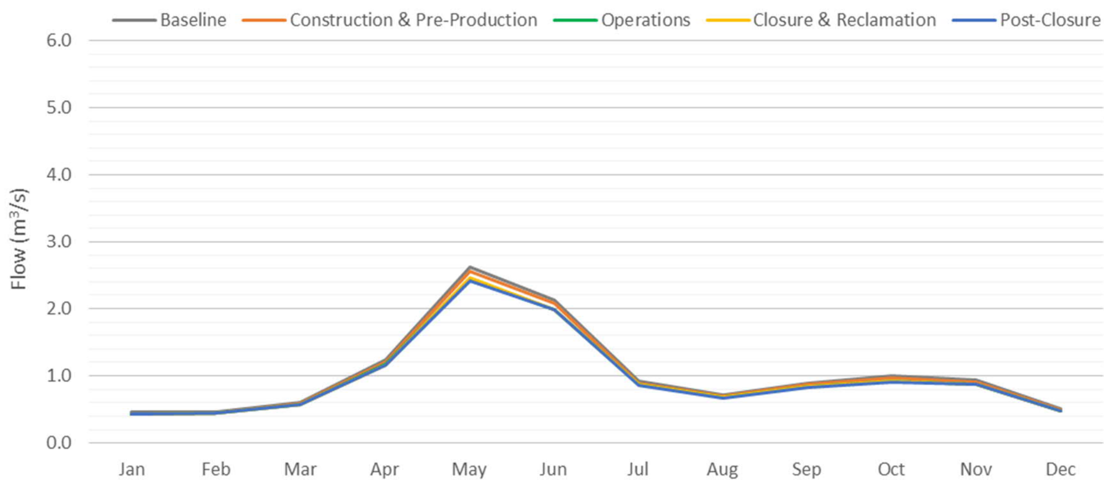


Alexander Creek Upstream of Highway 3 (AC-1)

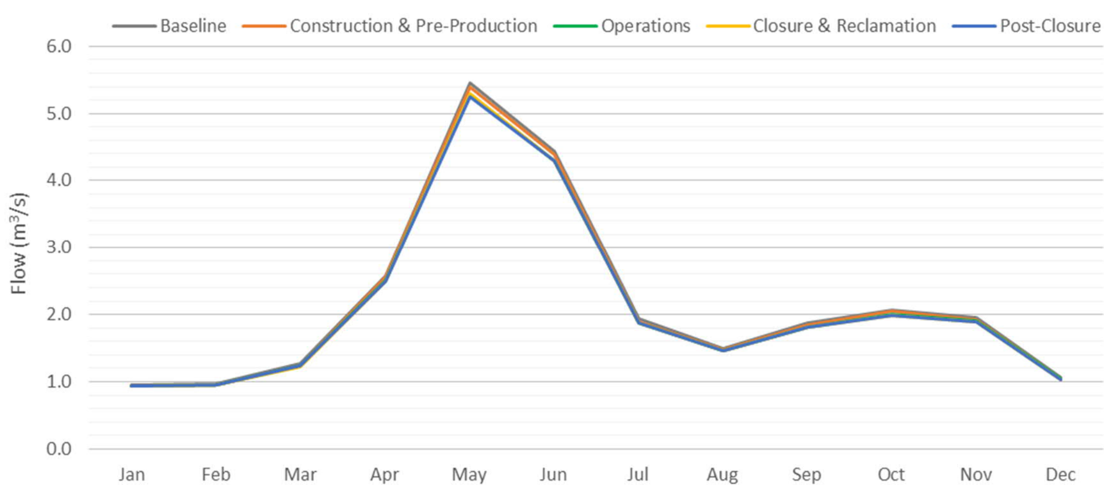
Figure 10.5-4: Temporal Percent Change in Projected Mean Monthly Flows for Multiple Locations on Alexander/West Alexander Creeks (Years 1 – 34)



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)



Alexander Creek Downstream of West Alexander Creek (AC-3)



Alexander Creek Upstream of Highway 3 (AC-1)

Figure 10.5-5: Projected Mean Monthly Hydrographs for Multiple Locations on Alexander/West Alexander Creeks (Years 1 – 34)

Climate Change

The long-term water balance model was also simulated with meteorological data which was adjusted to account for projected changes in climate conditions over the 34 year assessment period. Further details regarding the assessment methodology are provided in Section 10.5.4.1 and the accompanying technical memo in Appendix 10-A (SRK, 2021).

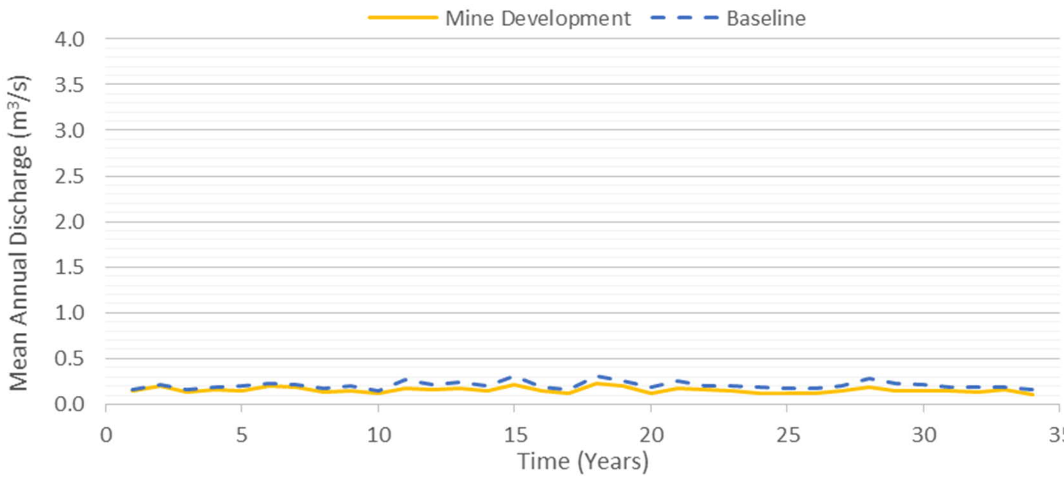
A summary of the projected minimum, mean, and maximum average annual flows for the assessment nodes on Alexander/West Alexander Creeks is provided in Table 10.5- 11. Annual flow data for the climate change assessment is included in Appendix 10-C.

The projected mean annual flows at AC-1, AC-3, and AC-6 for the baseline and mine development scenarios under climate change conditions for the 34 year assessment timeline are presented on Figure 10.5-6.

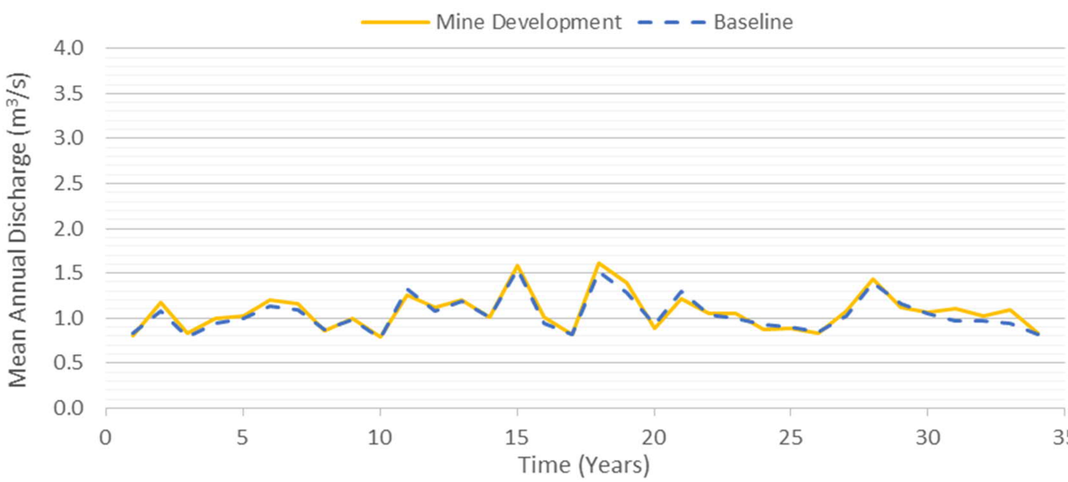
Similar to the assessment that was undertaken to evaluate historical climate conditions, a reduction in the minimum and mean average flows is projected at all of the assessment nodes during each of the Project phases, while an increase in maximum average flows is projected at most locations during the Operations, Reclamation and Closure, and Post-Closure phases.

Table 10.5-11: Projected Minimum, Mean, and Maximum Mean Average Annual Flows by Project Phase at Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions

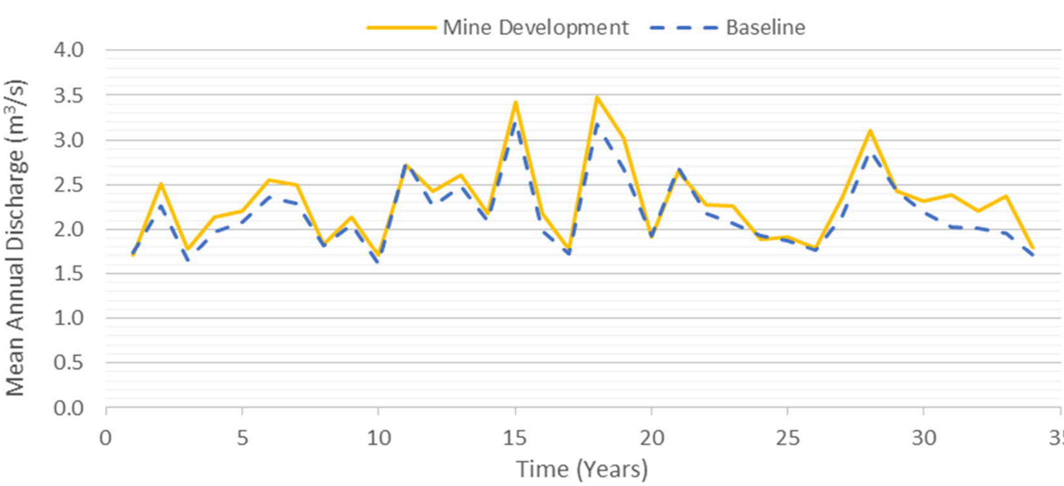
Project Phase	Annual Flow Parameter	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
		Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	0.79	0.77	-2.3	0.38	0.36	-5.1	0.08	0.06	-26.8
	Mean	1.99	2.11	5.9	0.96	1.00	4.2	0.19	0.17	-8.6
	Max	10.15	12.16	19.8	4.87	5.73	17.7	0.97	0.99	1.7
Operations (Years 3-17)	Min	0.79	0.78	-1.7	0.38	0.36	-5.5	0.08	0.01	-87.4
	Mean	2.16	2.28	5.6	1.03	1.06	2.3	0.21	0.16	-23.1
	Max	16.49	17.61	6.8	7.91	8.32	5.2	1.58	1.74	10.0
Reclamation and Closure (Years 18-19)	Min	0.80	0.79	-0.4	0.38	0.37	-2.7	0.08	0.00	-100.0
	Mean	2.93	3.25	11.1	1.40	1.50	7.1	0.28	0.21	-23.7
	Max	25.18	37.47	48.8	12.09	17.15	41.9	2.41	2.42	0.4
Post-Closure (Years 20-34)	Min	0.80	0.79	-1.0	0.38	0.37	-4.1	0.08	0.00	-100.0
	Mean	2.12	2.24	5.9	1.02	1.04	1.9	0.20	0.15	-28.4
	Max	16.31	17.79	9.1	7.83	8.47	8.1	1.56	1.79	14.5



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)



Alexander Creek Downstream of West Alexander Creek (AC-3)



Alexander Creek Upstream of Highway 3 (AC-1)

Figure 10.5-6: Projected Mean Annual Flows for Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions (Years 1 – 34)

A comparision of the projected mean annual runoff yield is provided in Table 10.5-12 for the baseline and mine development scenarios under climate change. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C. The results demonstrate a varying level of change in the mean annual yield between the baseline and mine development scenarios. Increases in the yield are projected at AC-1 and AC-3, while decreases with a greater magnitude are forecasted at AC-6.

Table 10.5-12: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions

Project Phase	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	433	459	5.9%	433	452	4.2%	433	396	-8.6%
Operations (Years 3-17)	469	495	5.6%	469	480	2.3%	469	361	-23.1%
Reclamation and Closure (Years 18-19)	637	707	11.1%	637	682	7.1%	637	486	-23.7%
Post-Closure (Years 20-34)	461	488	5.9%	461	470	1.9%	461	330	-28.4%

Peak flows for a range of recurrence intervals (return periods) were estimated through a statistical frequency analyses, which are based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were conducted using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-13.

Table 10.5-13: Return Period Peak Flows (m^3/s) at Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions

Return Period (Years)	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	14.6	16.7	14.4%	7.0	7.9	13.3%	1.4	1.7	18.6%
5	21.8	24.5	12.4%	10.5	11.5	9.5%	2.1	2.3	8.6%
10	27.0	29.9	10.7%	12.9	14.0	8.5%	2.6	2.7	3.5%
20	32.1	35.3	10.0%	15.4	16.4	6.5%	3.1	3.1	-1.0%
50	39.0	42.5	9.0%	18.7	19.6	4.8%	3.7	3.6	-5.1%
100	44.5	48.1	8.1%	21.3	22.1	3.8%	4.3	3.9	-7.7%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

The frequency analysis results predominately indicate that there would be an increase in the projected peak flows for all return periods, although reductions are predicted for the longer recurrence intervals at

AC-6. Overall, there is an increasing trend in the magnitude of change in peak flows moving in the downstream direction of flow within Alexander Creek. These increases are primarily attributed to the effects of climate change, as the mine development scenario (without climate change) is generally projected to reduce the peak flows.

Table 10.5-14 provides a summary of the projected return period low flows for the Alexander Creek assessment nodes under the climate change scenario.

Table 10.5-14: Return Period 7-Day Low Flows (L/s) at Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions

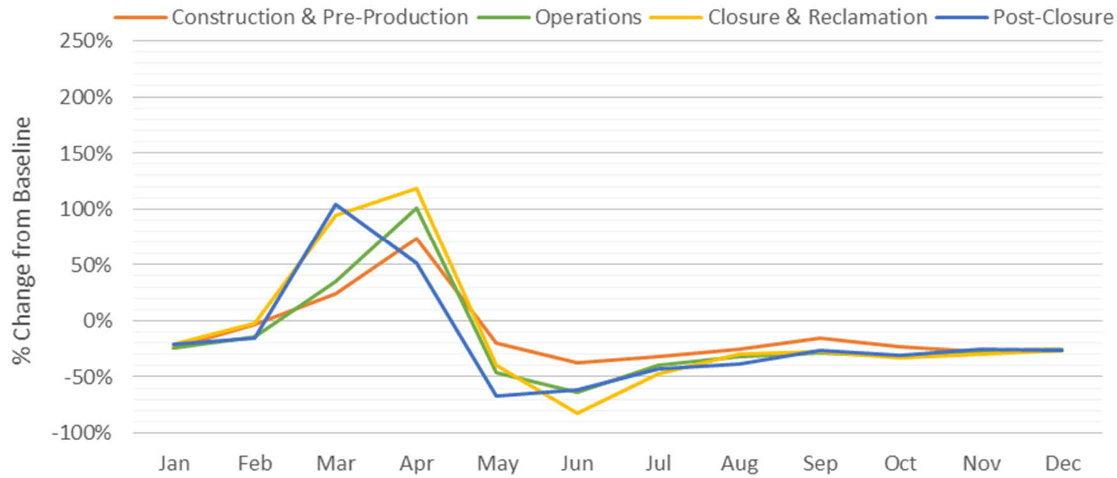
Return Period (Years)	Alexander Creek Upstream of Hwy 3 (AC-1)			Alexander Creek Downstream of West Alexander Creek (AC-3)			West Alexander Creek Downstream of Sediment Pond (AC-6)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	798	791	-0.9%	383	369	-3.7%	76.5	40.6	-46.9%
5	791	771	-2.5%	380	359	-5.5%	75.8	25.6	-66.2%
10	787	760	-3.4%	378	354	-6.3%	75.5	20.1	-73.4%
20	784	752	-4.1%	376	350	-6.9%	75.2	16.5	-78.1%
50	780	743	-4.7%	375	346	-7.7%	74.8	13.2	-82.4%
100	778	737	-5.3%	373	343	-8.0%	74.6	11.3	-84.9%

Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

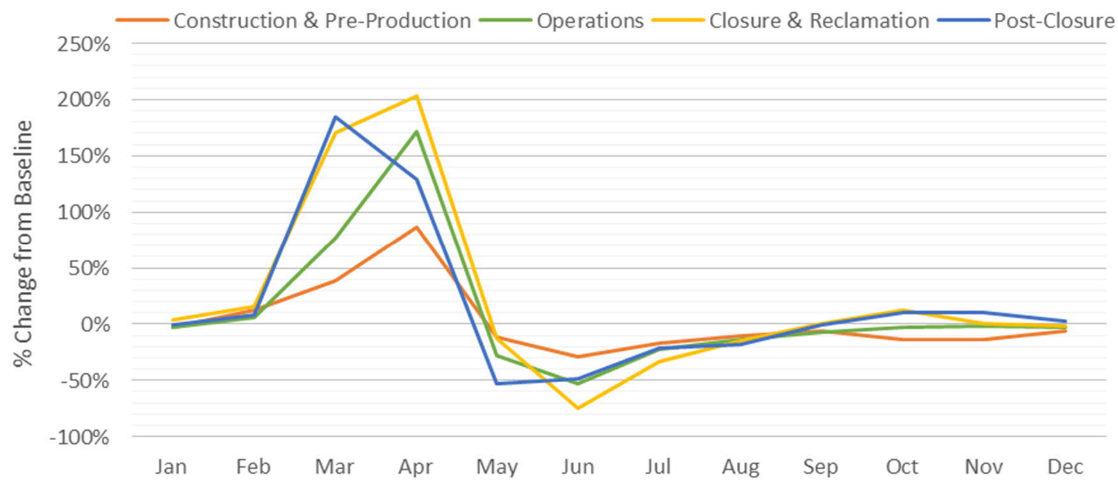
The return period low flow projections indicate an overall reduction between the baseline and mine development assessment under climate change scenarios with the percentage change following a declining trend in the downstream direction of flow within the Alexander Creek system. The relative magnitude of change in the return period low flows is greater when accounting for the effects of climate change. The variability, magnitude and timing of temporal changes in mean monthly flows under climate change conditions for each Project phase when compared to existing conditions (i.e., with no mine development) is illustrated in Figure 10.5-7. Mean monthly flow data for the Alexander/West Alexander Creek assessment nodes under climate change conditions are included in Appendix 10-C.

Overall, the temporal changes (percent change from baseline) in monthly flows are similar at the three Alexander/West Alexander Creek assessment nodes, which involve substantial positive differences in the late winter/early spring and negative differences in the late spring/early summer in comparison with the existing land use assessment results. The temporal changes vary depending on the Project phase, with the most prominent changes occurring in the Reclamation and Closure and Post-Closure timeframes.

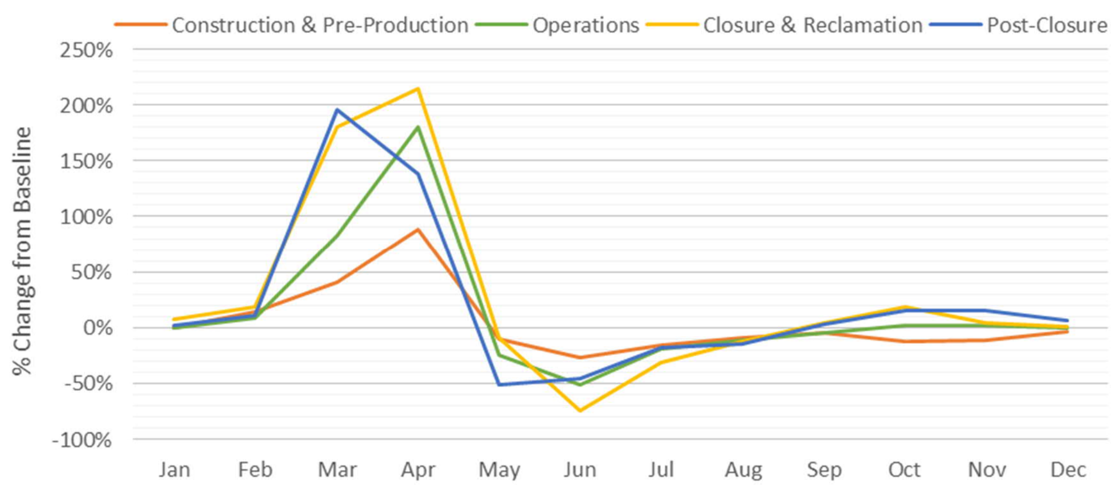
The percent change factors derived from the climate change model results were applied to the baseline flow projections to establish the mean monthly flow hydrographs at each of the Alexander/West Alexander Creek assessment nodes (Figure 10.5-8).



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)

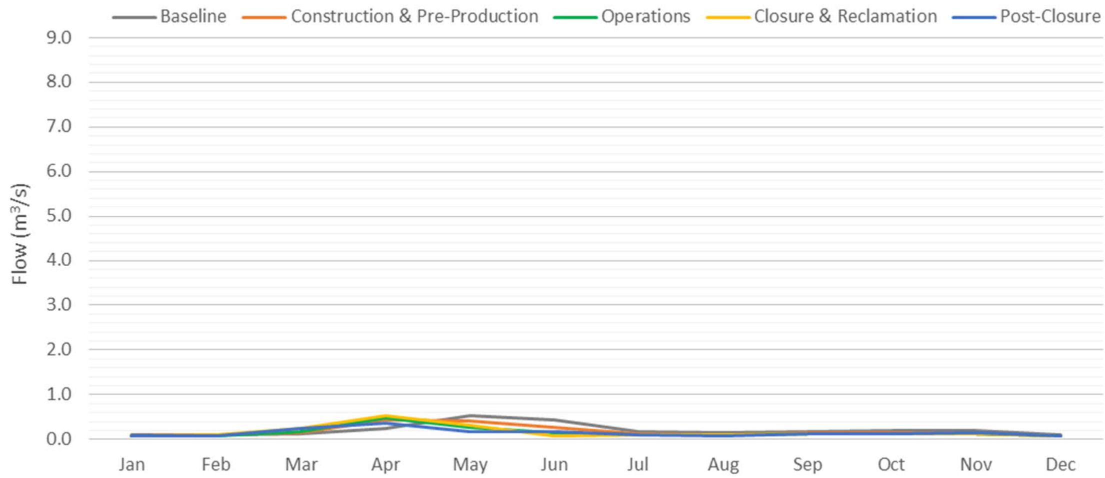


Alexander Creek Downstream of West Alexander Creek (AC-3)

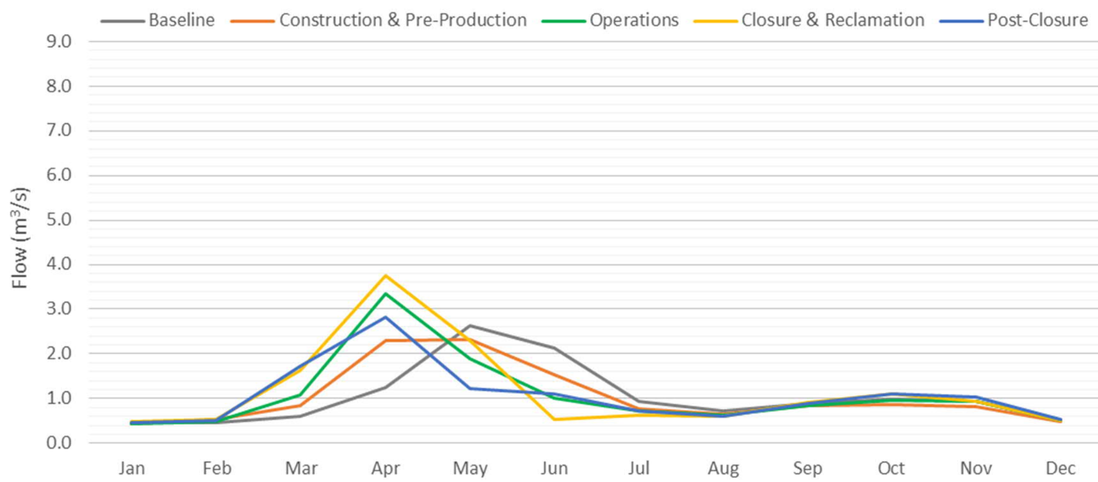


Alexander Creek Upstream of Highway 3 (AC-1)

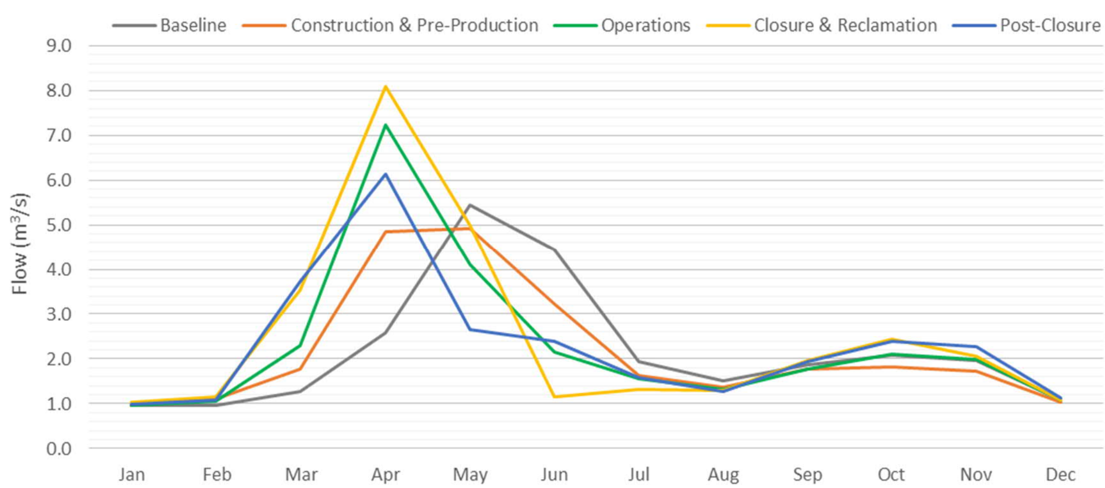
Figure 10.5-7: Temporal Percent Change in Predicted Mean Monthly Flows for Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions (Years 1 – 34)



West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)



Alexander Creek Downstream of West Alexander Creek (AC-3)



Alexander Creek Upstream of Highway 3 (AC-1)

Figure 10.5-8: Projected Mean Monthly Hydrographs for Multiple Locations on Alexander/West Alexander Creeks under Climate Change Conditions (Years 1 – 34)

Through a comparison of the projected mean monthly flow data for the baseline and mine development (with climate change) scenarios, the following notable findings were conclusions were identified at the Alexander/West Alexander Creek assessment nodes:

- At all of the locations, there is a distinct change in the shape of the hydrograph resulting from a shift in the timing of the peak of the freshet from late spring (May-June) to mid-spring (April-May), together with changes to the magnitude of mean monthly flows;
- The increase in the magnitude of mean monthly flows during the freshet is most notable at the Alexander Creek nodes (AC-1 and AC-3) for the Operations and Reclamation and Closure phases. At the West Alexander Creek downstream of the Main Sediment Pond (AC-6) node, there is a reduction in the magnitude of the mean monthly flows during the freshet period for all phases with the exception of Reclamation and Closure; and
- Overall, it is evident that the impacts of climate change will have a substantial influence on the timing and magnitude of streamflows with Alexander/West Alexander Creeks.

Grave Creek

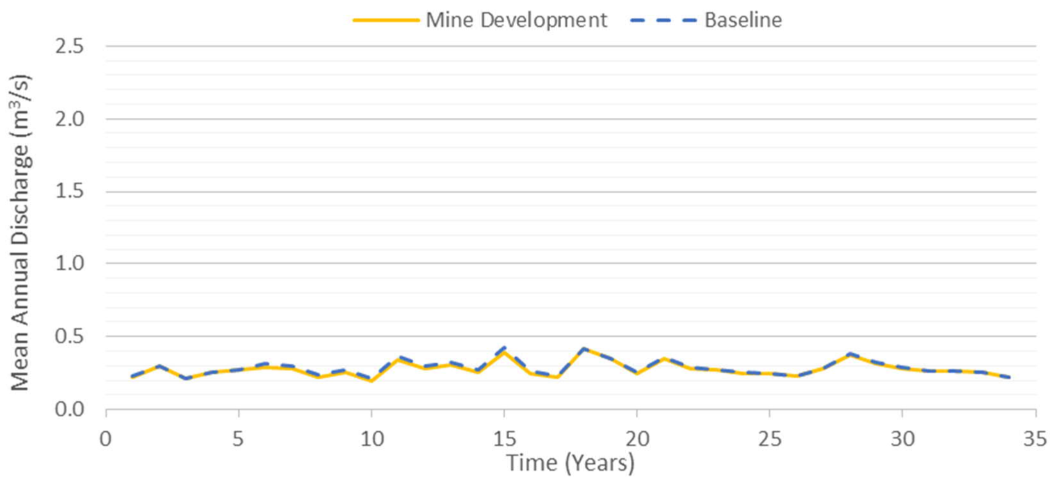
The projected annual flows for the baseline and mine development scenarios at each of the Grave Creek assessment nodes are presented on Figure 10.5-9, which are based on historical climate conditions. A consistent scale was applied for the axes to illustrate the relative magnitude of flows between the three assessment nodes.

The hydrographs show that there is a minor reduction in mean annual flows for Grave Creek associated with the mine development scenario over the duration of the assessment period. The most notable changes occur downstream of the water withdrawal location (GC-5), while the differences are much less significant downstream of the confluence with Harmer Creek (GC-2) and upstream of the Elk River (GC-1).

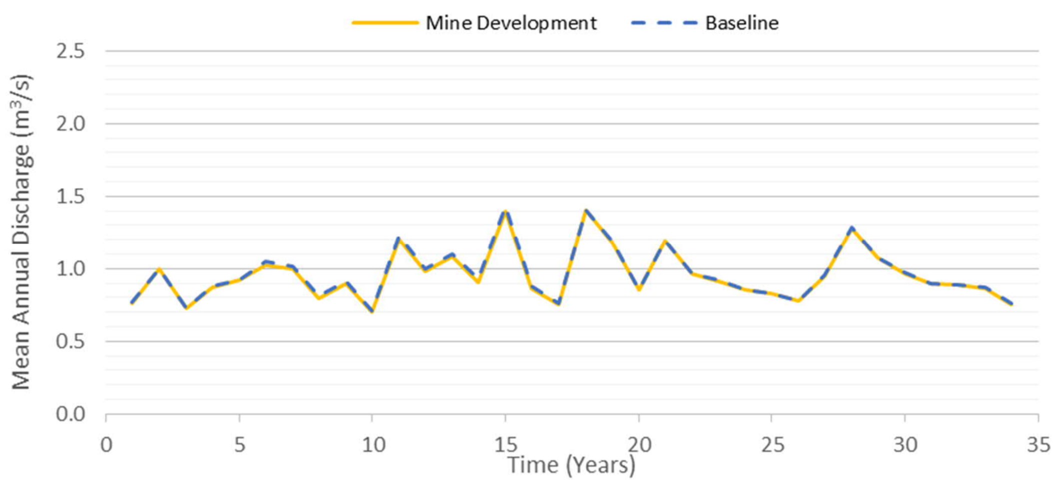
A summary of the minimum, mean, and maximum average annual flows at the assessment nodes on Grave Creek, to illustrate the variability and potential changes during the individual Project phases are presented in Table 10.5-15. The table includes the projected flows for existing land use conditions together with the mine development scenario and the percent change during the respective timeframe for each of the individual Project phases. Annual flow data for the full assessment period are provided in Appendix 10-C.

The projected mean annual flow data indicate that there will generally be a reduction in the annual minimum and average flows at all of the assessment nodes (GC-1, GC-3, and GC-6) during all of the Project phases. The maximum annual flows generally shows a decrease at all of the nodes, with the exception of the Post-Closure phase where a minor increase is noted. The magnitude of the respective changes is substantially lower at the downstream nodes within Grave Creek.

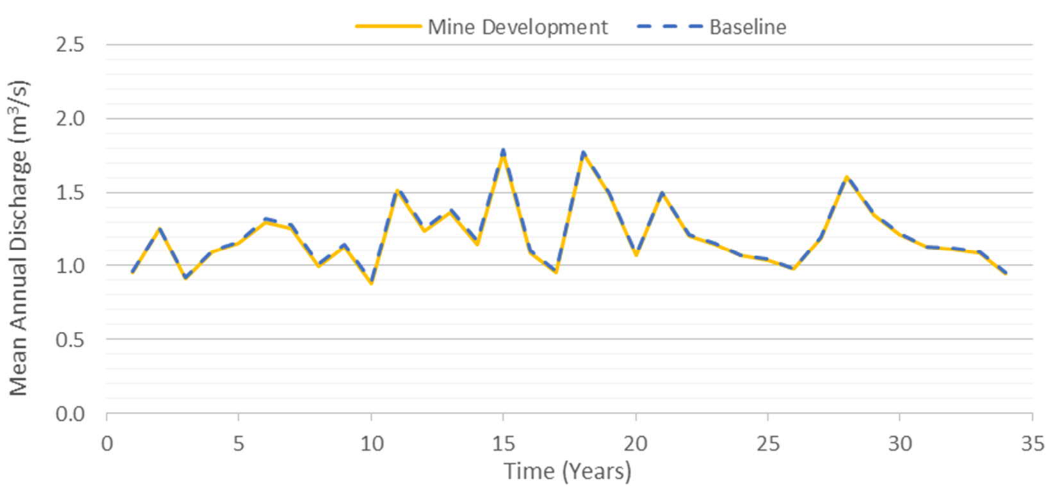
A comparision of the projected mean annual runoff yield for the baseline and mine development scenarios at the Alexander Creek assessment nodes during each of the Project phases is presented in Table 10.5-16. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C. In general, the results illustrate a varying level of decline in the mean annual yield between the baseline and mine development scenarios, with the magnitude of change diminishing in the downstream direction of flow but increasing over the timeline of mine development at all locations.



Grave Creek Downstream of Withdrawal Location (GC-5)



Grave Creek Downstream of Harmer Creek (GC-2)



Grave Creek Upstream of Elk River (GC-1)

Figure 10.5-9: Projected Mean Annual Flows for Multiple Locations on Grave Creek (Years 1 – 34)

Table 10.5-15: Predicted Minimum, Mean, and Maximum Average Annual Flows by Project Phase at Multiple Locations on Grave Creek

Project Phase	Annual Flow Parameter	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
		Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	0.44	0.44	-1.5	0.35	0.35	-1.7	0.10	0.10	-5.4
	Mean	1.11	1.10	-0.7	0.88	0.88	-0.7	0.26	0.26	-1.9
	Max	5.66	5.61	-0.9	4.51	4.46	-1.0	1.34	1.30	-2.8
Operations (Years 3-17)	Min	0.44	0.43	-1.7	0.35	0.35	-2.0	0.10	0.10	-6.5
	Mean	1.20	1.18	-1.5	0.96	0.94	-1.8	0.28	0.27	-5.4
	Max	9.20	9.06	-1.5	7.32	7.19	-1.8	2.17	2.05	-5.5
Reclamation and Closure (Years 18-19)	Min	0.45	0.44	-1.0	0.35	0.35	-1.2	0.11	0.10	-3.8
	Mean	1.63	1.63	-0.4	1.30	1.29	-0.4	0.39	0.38	-0.8
	Max	14.05	14.01	-0.3	11.18	11.16	-0.2	3.32	3.31	-0.3
Post-Closure (Years 20-34)	Min	0.44	0.44	-1.0	0.35	0.35	-1.2	0.10	0.10	-4.0
	Mean	1.18	1.18	-0.5	0.94	0.94	-0.5	0.28	0.28	-1.2
	Max	9.10	9.10	0.0	7.25	7.25	0.1	2.15	2.17	0.8

Table 10.5-16: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations on Grave Creek

Project Phase	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	433	430	-0.7%	433	430	-0.7%	433	425	-1.9%
Operations (Years 3-17)	469	462	-1.5%	469	461	-1.8%	469	444	-5.4%
Reclamation and Closure (Years 18-19)	637	634	-0.4%	637	634	-0.4%	637	631	-0.8%
Post-Closure (Years 20-34)	461	459	-0.5%	461	459	-0.5%	461	456	-1.2%

Statistical frequency analyses were performed to estimate the peak flows for a range of recurrence intervals (return periods) – based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were undertaken using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-17.

Table 10.5-17: Return Period Peak Flows (m^3/s) at Multiple Locations on Grave Creek

Return Period (Years)	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	8.1	8.1	-0.6%	6.5	6.4	-0.6%	1.9	1.9	-1.6%
5	10.0	9.9	-0.7%	8.0	7.9	-0.8%	2.4	2.3	-2.1%
10	12.2	12.1	-0.8%	9.7	9.6	-0.9%	2.9	2.8	-2.8%
20	15.0	14.9	-0.7%	12.0	11.8	-1.7%	3.6	3.4	-3.1%
50	17.9	17.7	-1.1%	14.3	14.1	-1.4%	4.2	4.1	-3.5%
100	21.8	21.5	-1.4%	17.3	17.1	-1.2%	5.1	4.9	-3.9%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

The frequency analysis results generally suggest that a reduction in the return period peak flows is projected at all of the assessessment nodes, with the percentage change from baseline conditions declining in the downstream direction of flow within Grave Creek.

Low flow conditions were also assessed for the Grave Creek flow nodes, which are based on the projected 7 day low flow data. The results are presented in Table 10.5-18 for a range of return periods.

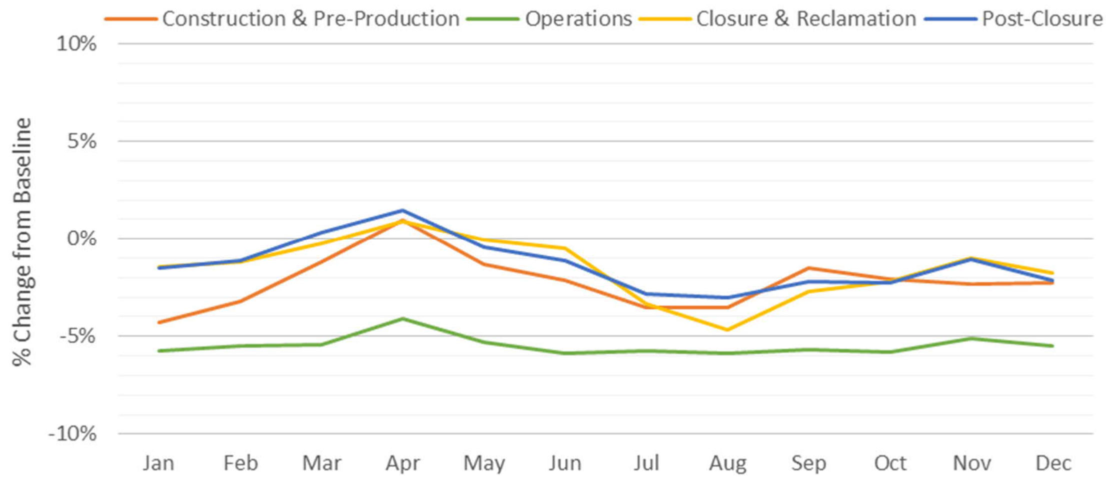
Table 10.5-18: Return Period 7-Day Low Flows (L/s) at Multiple Locations on Grave Creek

Return Period (Years)	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	445	451	1.3%	355	359	1.1%	105	106	1.0%
5	441	439	-0.5%	351	350	-0.3%	104	104	0.0%
10	439	433	-1.4%	350	345	-1.4%	104	102	-1.9%
20	437	428	-2.1%	348	341	-2.0%	103	101	-1.9%
50	435	423	-2.8%	347	337	-2.9%	103	99.9	-3.0%
100	434	420	-3.2%	346	334	-3.5%	102	99.1	-2.8%

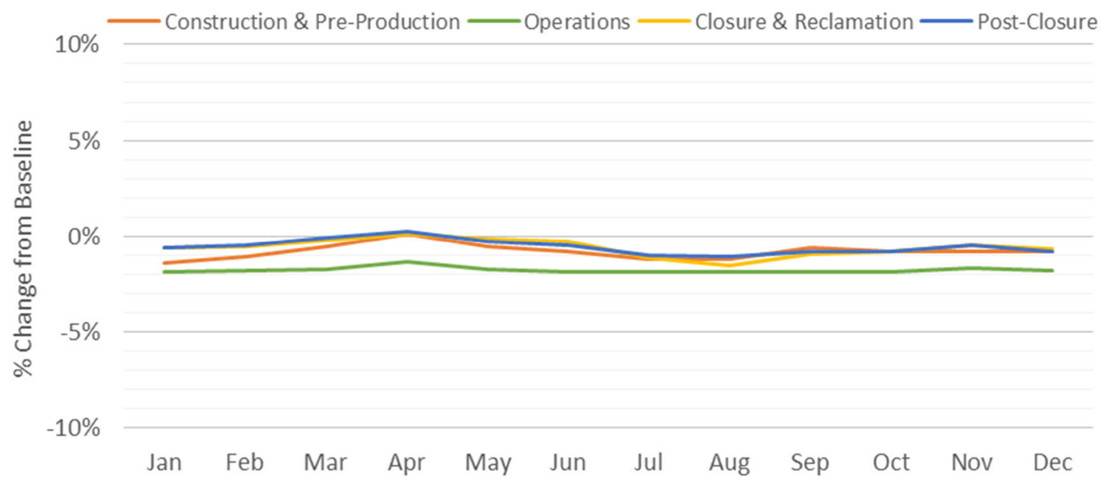
Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

The return period low flow projections indicate a minimal increase for the 2 year return period and a varying degee of reduction for all other recurrence intervals when comparing the baseline and mine development assessment scenarios. The percentage change from baseline conditions follows a slight decline in the downstream direction of flow within the Grave Creek system.

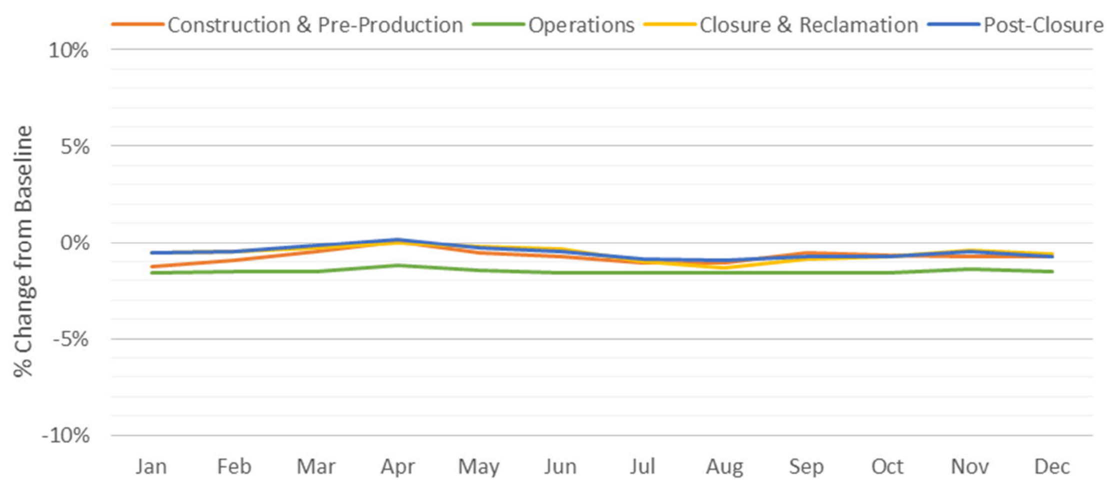
The percent temporal change (% change from baseline) in the mean monthly flows for each Project phase when compared to existing conditions (i.e., with no mine development) over the respective timeframe is illustrated in Figure 10.5-10. Mean monthly flow data are included in Appendix 10-C.



Grave Creek Downstream of Withdrawal Location (GC-5)



Grave Creek Downstream of Harmer Creek (GC-2)



Grave Creek Upstream of Elk River (GC-1)

Figure 10.5-10: Temporal Percent Change in Projected Mean Monthly Flows for Multiple Locations on Grave Creek (Years 1 – 34)

The temporal percent change in projected mean monthly flows for the Grave Creek assessment nodes demonstrate the following:

- The temporal percent changes are most notable during the Operations phase and are comparatively lower during all other phases, with the least change generally corresponding to the Reclamation and Closure and Post-Closure phases; and
- The temporal change in mean monthly flows is most prominent at GC-5 during (in the range of up to approximately -5.9% to -4.1% during Operations and less for other phases), with the percent change declining substantially at the downstream of the confluence of Harmer Creek at nodes GC-2 and GC-1 (approximately -1.9% or less).

The monthly hydrographs for each of the assessment nodes on Grave Creek are presented in Figure 10.5-11. Mean monthly flow data are included in Appendix 10-C.

In comparing the projected mean monthly flow data for the baseline and mine development scenarios, the following conclusions are noted:

- For the Grave Creek Upstream of Elk River (GC-1) node, the reduction in mean monthly flows varies based on the Project phase and is in the range of approximately -1.6% to 0.1%;
- For the Alexander Creek downstream of Harmer Creek (GC-2) node, the reduction in mean monthly flows is relatively comparable with respect to the Project phase and generally in the order of double the GC-1 values (approximately -1.9% to 0.3%); and
- The reductions in mean monthly flows are more pronounced at the Grave Creek Downstream of the Withdrawal Location (GC-5) node during the Operations phase (up to approximately -5.9%).

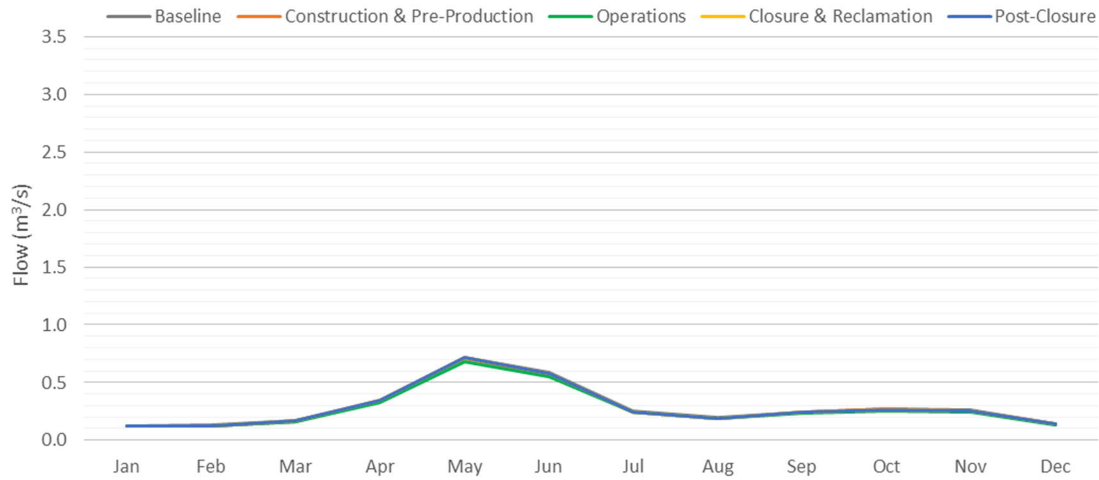
Climate Change

A summary of the projected minimum, mean, and maximum annual flows for the assessment nodes on Grave Creek is provided in Table 10.5-19. Annual flow data for the climate change assessment are included in Appendix 10-C. Further details regarding the assessment methodology are provided in Section 10.5.4.1 and the accompanying technical memo in Appendix 10-A (SRK, 2021).

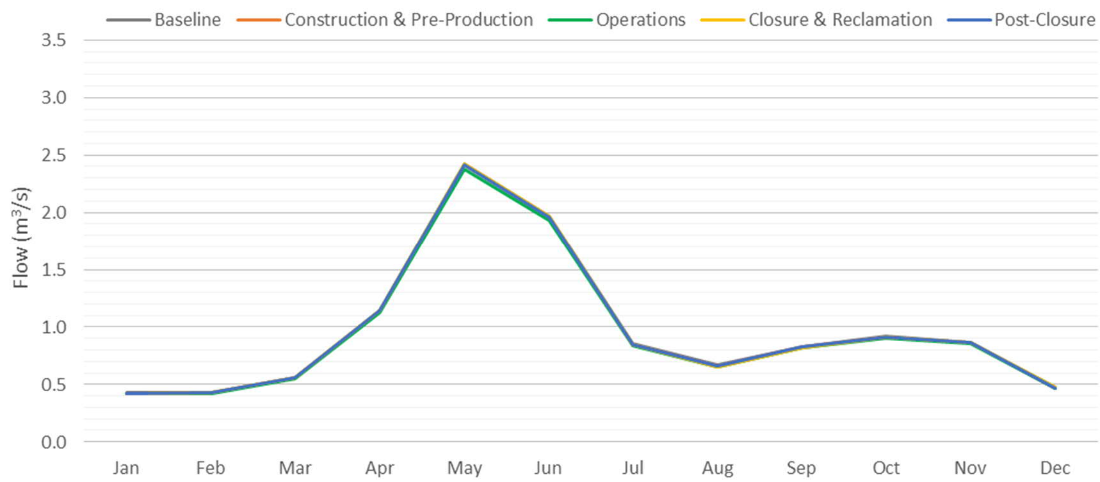
A reduction in the mean minimum annual flows is projected at all of the assessment nodes during each of the Project phases, while a substantial increase in mean and maximum average flows is projected at most locations during the Operations, Reclamation and Closure, and Post-Closure phases.

The projected mean annual flows at GC-1, GC-3, and GC-5 for the existing land use and mine development scenarios under climate change conditions for the 34 year assessment timeline are presented in Figure 10.5-12. As illustrated, there is an increase in mean annual flows associated with the mine development scenario at all of the assessment nodes. The relative magnitude of the increased mean annual flows is comparable at the three nodes.

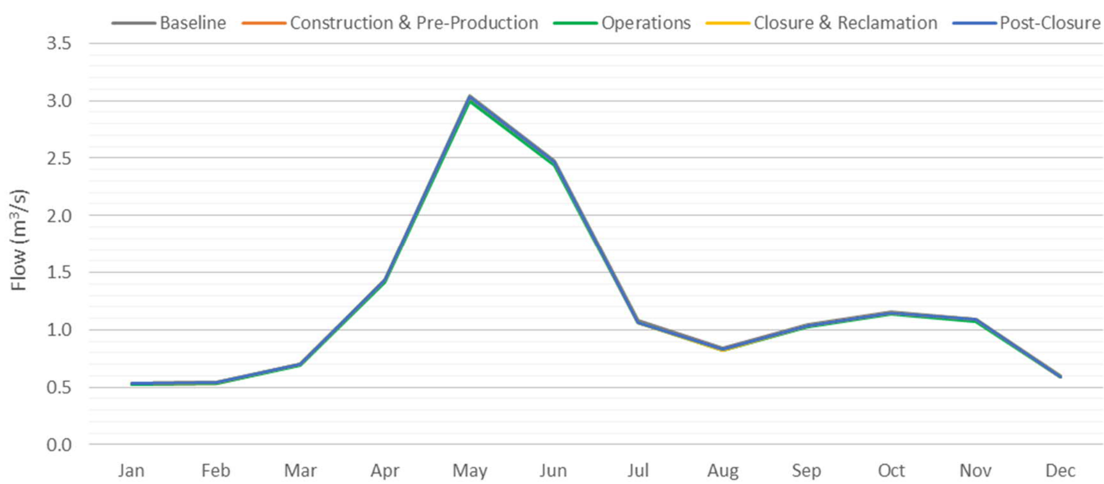
The projected mean annual runoff yield for Grave Creek is provided in Table 10.5-20 for the baseline and mine development scenarios under climate change. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C. The results show a varying level of change in the mean annual yield between the baseline and mine development scenarios. Increases in the yield are projected at all of the assessment flow nodes, with the highest increases occurring during the Reclamation and Closure phase (Years 18-19).



Grave Creek Downstream of Withdrawal Location (GC-5)

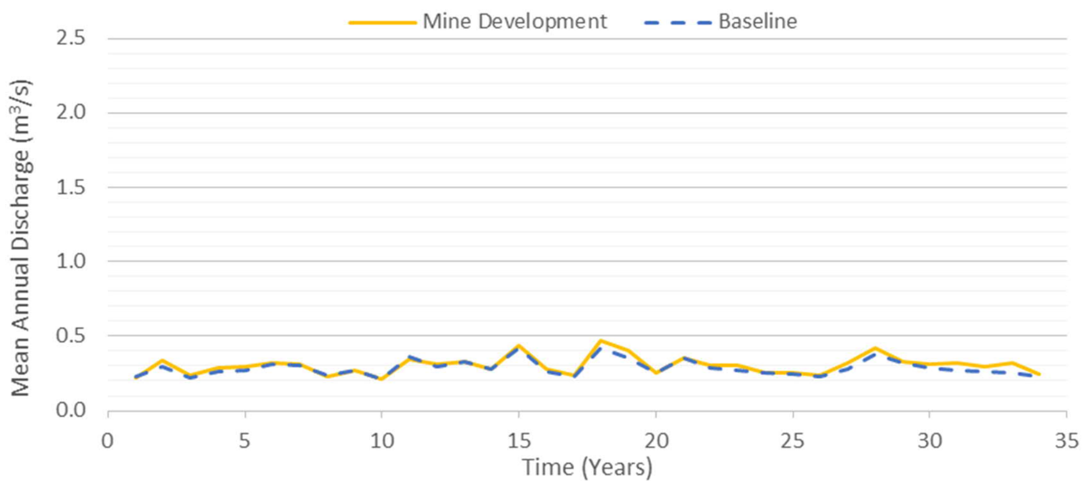


Grave Creek Downstream of Harmer Creek (GC-2)

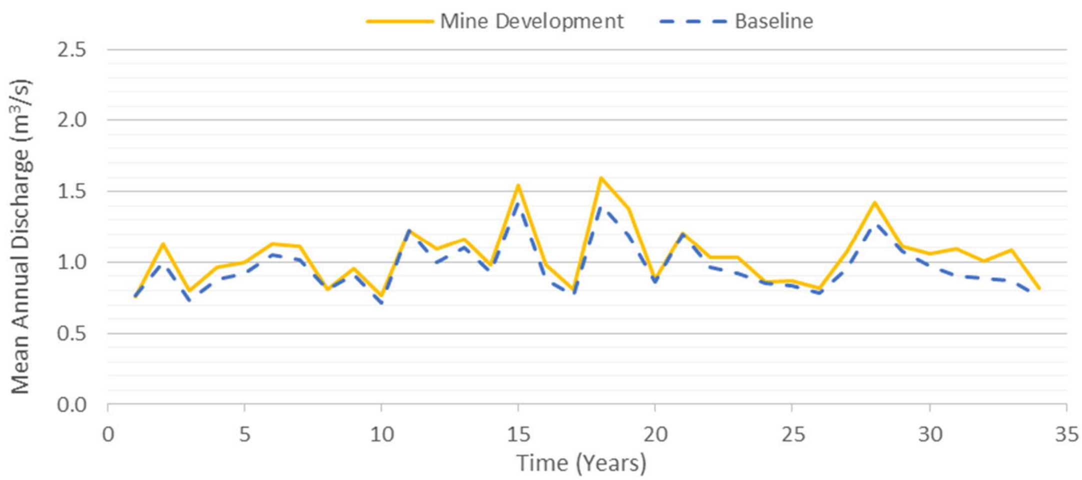


Grave Creek Upstream of Elk River (GC-1)

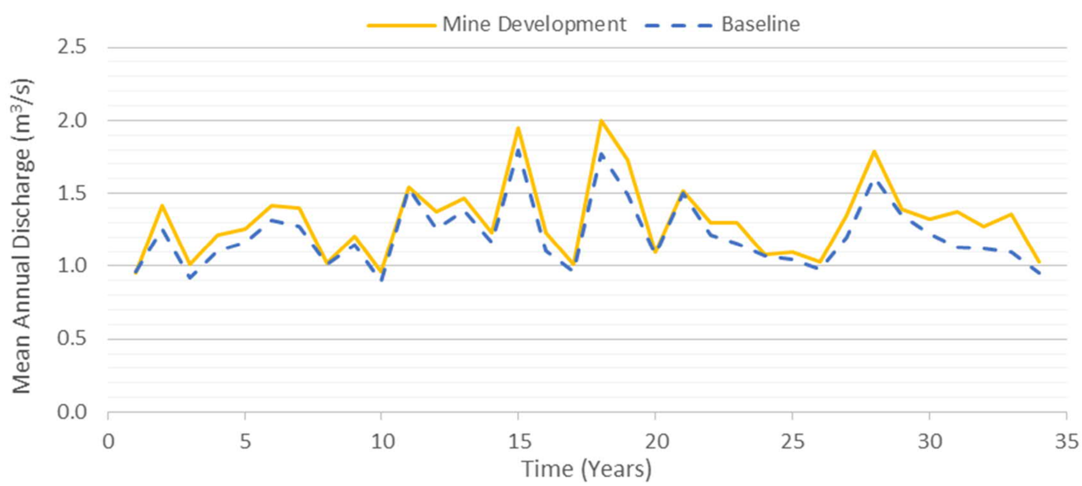
Figure 10.5-11: Projected Mean Monthly Hydrographs for Multiple Locations on Grave Creek (Years 1 – 34)



Grave Creek Downstream of Withdrawal Location (GC-5)



Grave Creek Downstream of Harmer Creek (GC-2)



Grave Creek Upstream of Elk River (GC-1)

Figure 10.5-12: Predicted Mean Annual Flow for Multiple Locations on Grave Creek under Climate Change Conditions (Years 1 – 34)

Table 10.5-19: Predicted Minimum, Mean, and Maximum Average Flows by Project Phase at Multiple Locations on Grave Creek under Climate Change

Project Phase	Annual Flow Parameter	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
		Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	0.44	0.44	-1.0	0.35	0.35	-1.2	0.10	0.10	-4.7
	Mean	1.11	1.19	6.7	0.88	0.94	6.7	0.26	0.28	5.5
	Max	5.66	6.83	20.5	4.51	5.43	20.4	1.34	1.58	17.9
Operations (Years 3-17)	Min	0.44	0.44	-1.1	0.35	0.35	-1.4	0.10	0.10	-5.7
	Mean	1.20	1.29	7.0	0.96	1.02	6.7	0.28	0.29	2.9
	Max	9.20	9.88	7.4	7.32	7.84	7.1	2.17	2.25	3.6
Reclamation and Closure (Years 18-19)	Min	0.45	0.45	0.1	0.35	0.35	-0.1	0.11	0.10	-3.3
	Mean	1.63	1.87	14.3	1.30	1.49	14.3	0.39	0.44	13.9
	Max	14.05	21.76	54.9	11.18	17.33	55.0	3.32	5.15	55.3
Post-Closure (Years 20-34)	Min	0.44	0.45	0.5	0.35	0.35	0.3	0.10	0.10	-2.7
	Mean	1.18	1.29	9.0	0.94	1.02	9.0	0.28	0.30	8.3
	Max	9.10	10.06	10.5	7.25	8.01	10.6	2.15	2.39	11.2

Table 10.5-20: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations on Grave under Climate Change Conditions

Project Phase	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	433	462	6.7%	433	462	6.7%	433	457	5.5%
Operations (Years 3-17)	469	502	7.0%	469	501	6.7%	469	483	2.9%
Reclamation and Closure (Years 18-19)	637	728	14.3%	637	728	14.3%	637	725	13.9%
Post-Closure (Years 20-34)	461	502	9.0%	461	502	9.0%	461	499	8.3%

Peak flows for a range of recurrence intervals (return periods) were estimated through a statistical frequency analyses, which are based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were conducted using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-21.

Table 10.5-21: Return Period Peak Flows (m^3/s) at Multiple Locations on Grave Creek under Climate Change Conditions

Return Period (Years)	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	8.1	9.4	15.2%	6.5	7.5	15.1%	1.9	2.2	13.5%
5	10.0	11.4	14.0%	8.0	9.1	14.4%	2.4	2.7	13.1%
10	12.2	13.9	13.9%	9.7	11.0	13.4%	2.9	3.2	12.2%
20	15.0	17.0	13.3%	12.0	13.5	12.5%	3.6	4.0	11.5%
50	17.9	20.1	12.3%	14.3	16.0	11.9%	4.2	4.7	10.9%
100	21.8	24.3	11.5%	17.3	19.3	11.6%	5.1	5.7	10.3%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

The frequency analysis results predominately indicate that there would be an increase in the projected peak flows for all return periods, with an increasing trend in the magnitude of change in peak flows moving in the downstream direction of flow along Grave Creek. These increases are primarly attributed to the effects of climate change, as the mine development scenario (without climate change) is generally projected to reduce the peak flows.

A summary of the projected return period low flows under the climate change scenario for the Grave Creek assessment nodes is provided in Table 10.5-22.

Table 10.5-22: Return Period 7-Day Low Flows (L/s) at Multiple Locations on Grave Creek under Climate Change Conditions

Return Period (Years)	Grave Creek Upstream of Elk River (GC-1)			Grave Creek Downstream of Harmer Creek (GC-2)			Grave Creek Downstream of Withdrawal Site (GC-5)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	445	445	0.0%	355	354	-0.3%	105	101	-3.8%
5	441	433	-1.8%	351	343	-2.3%	104	97.4	-6.3%
10	439	426	-3.0%	350	338	-3.4%	104	95.5	-8.2%
20	437	421	-3.7%	348	334	-4.0%	103	93.8	-8.9%
50	435	415	-4.6%	347	329	-5.2%	103	92.1	-10.6%
100	434	411	-5.3%	346	326	-5.8%	102	90.9	-10.9%

Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

In general, the return period low flow projections for Grave Creek indicate an overall reduction between the baseline and mine development assessment. The percentage change follows a declining trend in the downstream direction of flow. Notably, the relative magnitude of change in the return period low flows is greater when considering the effects of climate change.

The magnitude and timing of temporal changes in mean monthly flows under climate change conditions are illustrated on Figure 10.5-13 for each Project phase when compared to existing conditions (i.e., with no mine development). Mean monthly flow data for the Grave Creek assessment nodes under climate change conditions are included in Appendix 10-C.

The temporal changes (% change from baseline) in mean monthly flows are generally equivalent at the three Grave Creek assessment nodes, which indicate substantial positive differences in the late winter/early spring and negative differences in the late spring/early summer in comparison with the baseline assessment results. The temporal changes vary depending on the Project phase, with the most prominent changes occurring in the Reclamation and Closure and Post-Closure timeframes. It is notable that similar results were calculated for the Alexander/West Alexander Creek assessment nodes.

Figure 10.5-14 presents the mean monthly flow hydrographs at each of the Grave Creek assessment nodes, which were developed based on the percent temporal change factors derived from the climate change model results and applied to the baseline flow projections.

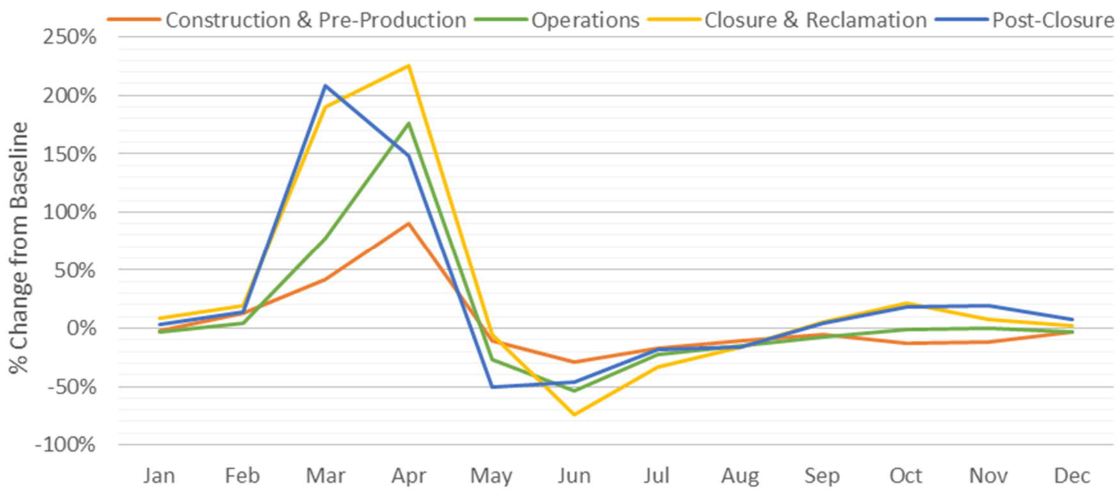
Through a comparison of the projected mean monthly flow data for the baseline and mine development (with climate change) scenarios, the following notable findings were conclusions were identified at the Alexander/West Alexander Creek assessment nodes:

- There is a distinct change in the shape of the hydrograph at all of the assessment nodes resulting from a shift in the timing of the peak of the freshet from late spring (May-June) to mid-spring (April-May), together with changes to the magnitude of mean monthly flows;
- The increase in the magnitude of mean monthly flows during the freshet is most notable for the Operations and Reclamation and Closure phases, and to a lesser extent for the Post-Closure phase; and
- Overall, it is evident that the impacts of climate change will have a substantial influence on the timing and magnitude of streamflows within Grave Creek.

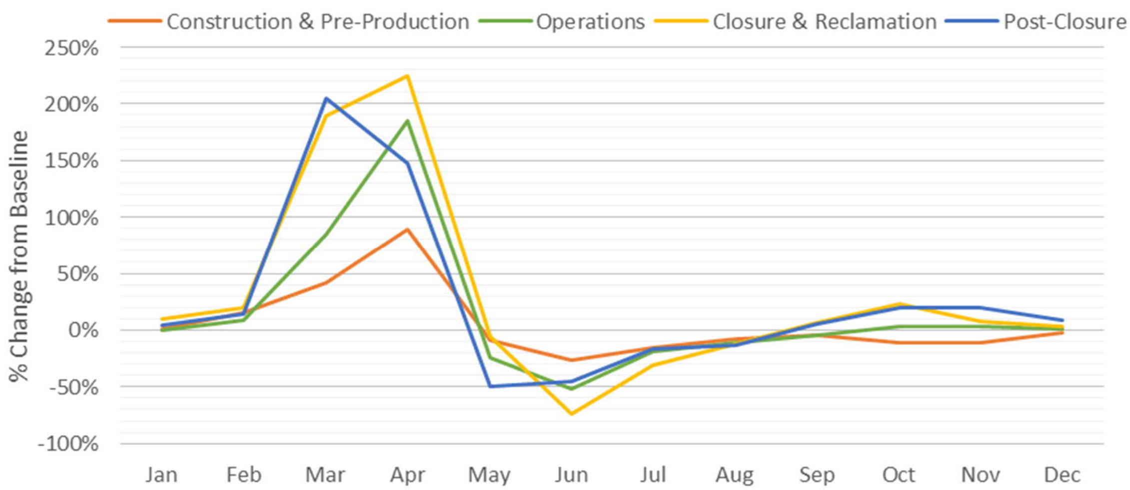
Changes to Surface Water Quantity for the Aquatic Regional Study Area

Table 10.5-23 provides a summary of the projected annual flow conditions over the 34 year assessment period for multiple locations in the Aquatic RSA downstream of the Project footprint. The assessment involved an examination of streamflow conditions at two flow node locations in the Elk River, including downstream of Michel Creek near Sparwood (EV_ER1) and at the Elko Reservoir (RG_ELKORES). In addition, the assessment included a flow node in Lake Koocanusa (RG_DSELK) to evaluate potential transboundary effects. The Aquatic RSA flow node locations are shown on Figure 10.5-2. Annual flow data for the full assessment period are provided in Appendix 10-C.

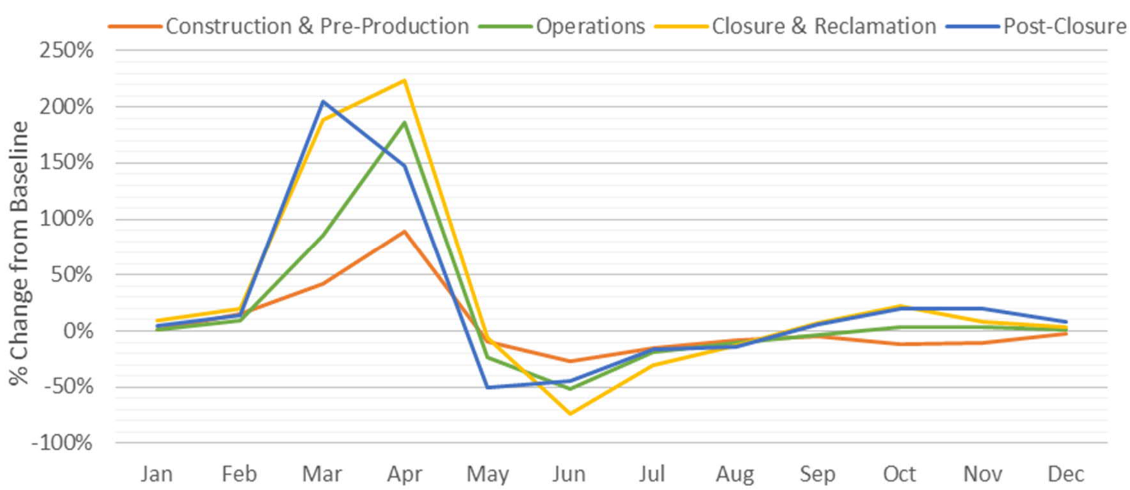
The projected annual flows for the baseline and mine development scenarios at each of the Aquatic RSA assessment nodes are presented on Figure 10.5-15, which are based on historical climate conditions. A consistent scale was applied for the axes to illustrate the relative magnitude of flows between the three assessment nodes.



Grave Creek Downstream of Withdrawal Location (GC-5)

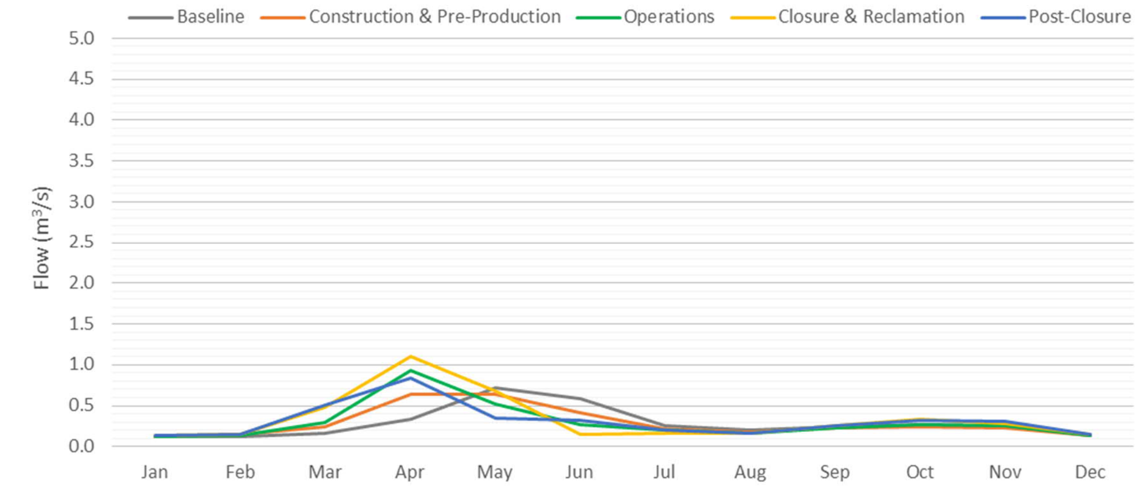


Grave Creek Downstream of Harmer Creek (GC-2)

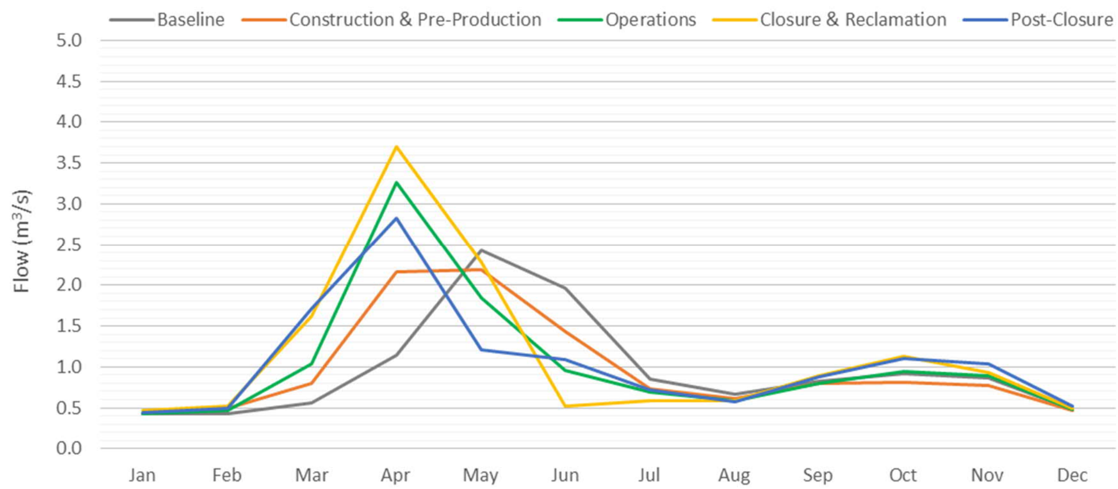


Grave Creek Upstream of Elk River (GC-1)

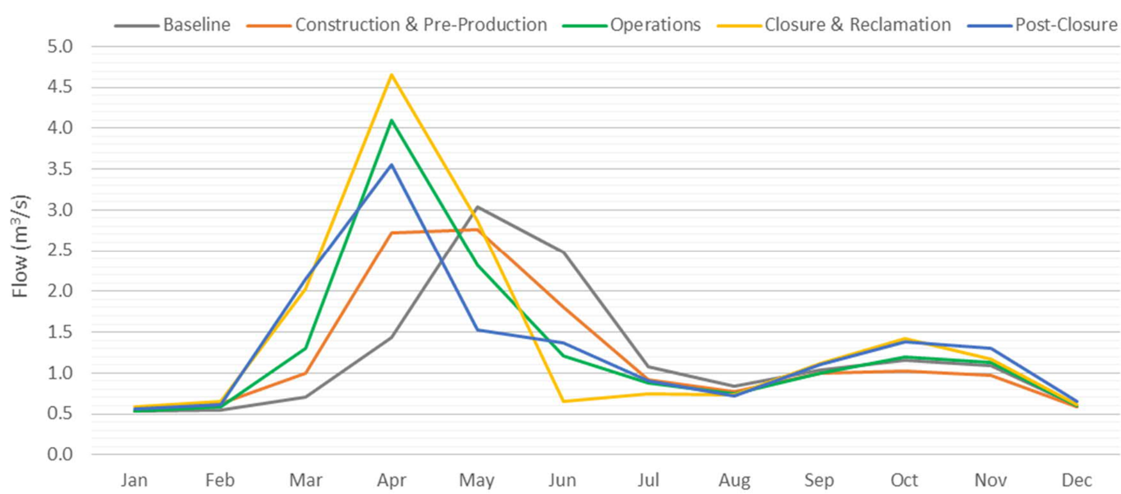
Figure 10.5-13: Temporal Percent Change in Predicted Mean Monthly Flows for Multiple Locations on Grave Creek under Climate Change Conditions (Years 1 – 34)



Grave Creek Downstream of Withdrawal Location (GC-5)

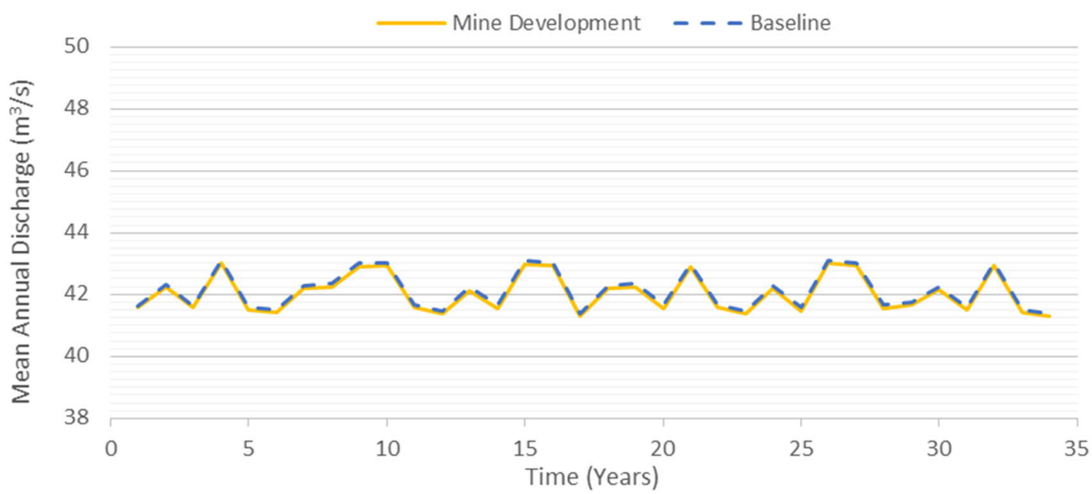


Grave Creek Downstream of Harmer Creek (GC-2)

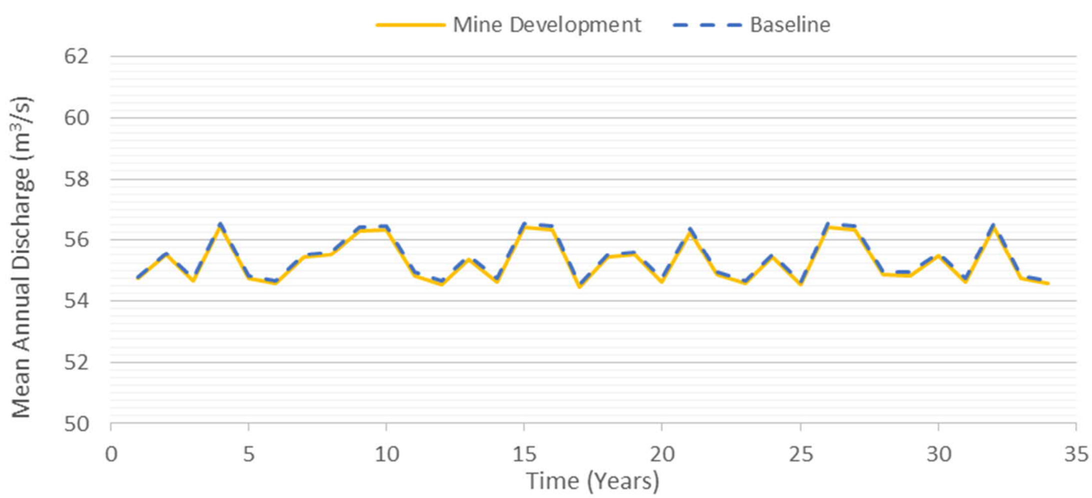


Grave Creek Upstream of Elk River (GC-1)

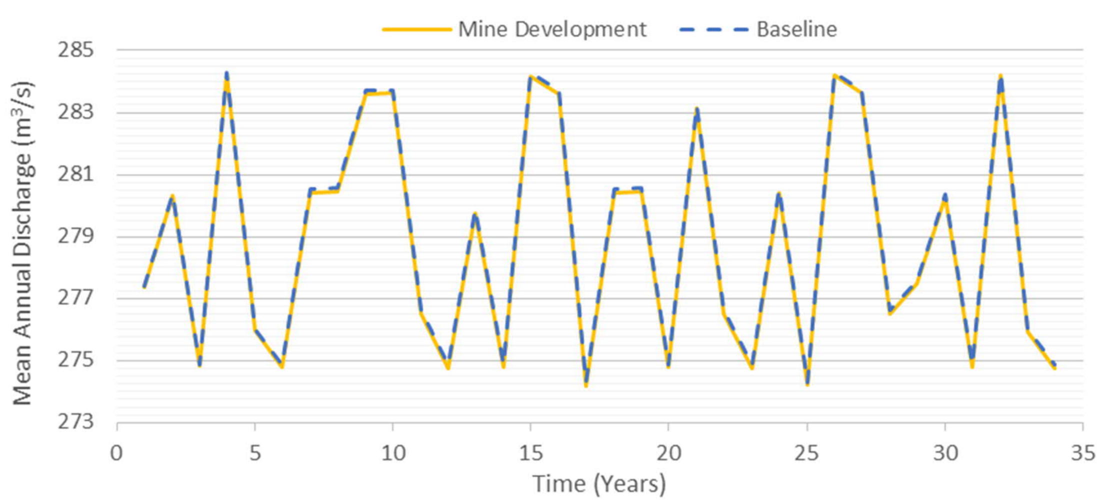
Figure 10.5-14: Projected Mean Monthly Hydrographs for Multiple Locations on Grave Creek under Climate Change Conditions (Years 1 – 34)



Elk River Downstream of Michel Creek (EV_ER1)



Elk River at Elko Reservoir (RG_ELKORES)



Lake Koocanusa Downstream of Elk River (RG_DSELK)

Figure 10.5-15: Predicted Mean Annual Flow for Multiple Locations in the RSA (Years 1 – 34)

Table 10.5-23: Predicted Minimum, Mean, and Maximum Average Annual Flows by Project Phase at Multiple Locations in the Aquatic RSA

Project Phase	Annual Flow Parameter	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
		Base-Line	Mine Dev.	% Change	Base-Line	Mine Dev.	% Change	Base-Line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	10.48	10.45	-0.3	15.38	15.35	-0.2	65.48	65.45	0.0
	Mean	41.96	41.92	-0.1	55.17	55.12	-0.1	278.89	278.84	0.0
	Max	218.47	217.18	-0.6	252.17	250.88	-0.5	1033.3	1032.0	-0.1
Operations (Years 3-17)	Min	10.48	10.44	-0.3	15.40	15.37	-0.2	65.56	65.53	0.0
	Mean	42.20	42.10	-0.2	55.47	55.37	-0.2	279.14	279.04	0.0
	Max	226.51	224.39	-0.9	260.94	258.82	-0.8	1063.8	1061.7	-0.2
Reclamation and Closure (Years 18-19)	Min	10.52	10.49	-0.2	15.49	15.47	-0.1	65.93	65.91	0.0
	Mean	42.31	42.22	-0.2	55.56	55.47	-0.2	280.54	280.44	0.0
	Max	230.52	228.36	-0.9	265.48	263.31	-0.8	1081.3	1079.1	-0.2
Post-Closure (Years 20-34)	Min	10.46	10.43	-0.2	15.40	15.38	-0.1	65.54	65.52	0.0
	Mean	42.06	41.96	-0.2	55.33	55.24	-0.2	278.47	278.37	0.0
	Max	224.98	222.81	-1.0	259.27	257.10	-0.8	1057.5	1055.3	-0.2

The assessment results show that there is a minor reduction in the projected annual flows (minimum, average, and maximum values) at the Aquatic RSA nodes for the mine development scenario, which follow a declining changing trend from upstream to downstream within the receiving drainage system. It is notable that the projected flow reductions are nominal and generally within the precision variability of the assessment methodology and modelling computational procedures.

Table 10.5-24 presents a comparision of the projected mean annual runoff yield for the baseline and mine development scenarios Aquatic RSA assessment nodes during each of the Project phases. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C.

Table 10.5-24: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations in the Aquatic RSA

Project Phase	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	471	471	-0.1%	494	494	-0.1%	378	378	0.0%
Operations (Years 3-17)	474	473	-0.2%	497	496	-0.2%	378	378	0.0%
Reclamation and Closure (Years 18-19)	475	474	-0.2%	498	497	-0.2%	380	380	0.0%

Project Phase	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Post-Closure (Years 20-34)	472	471	-0.2%	496	495	-0.2%	377	377	0.0%

Note: Watershed catchment areas for the Aquatic RSA flow nodes were delineated using the Kootenay Boundary Water Tool (https://kwt.bcwatertool.ca/) developed by the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Watershed reports are included in Appendix 10-D.

In general, the results show that there would be minimal to no change (-0.2% change or less) between the baseline and mine development scenarios.

Statistical frequency analyses were performed to estimate the peak flows for a range of recurrence intervals (return periods) – based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were undertaken using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-25.

Table 10.5-25: Return Period Peak Flows (m^3/s) at Multiple Locations in the Aquatic RSA

Return Period (Years)	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	225	223	-0.9%	260	258	-0.8%	1,060	1,060	0.0%
5	229	227	-0.9%	263	261	-0.8%	1,070	1,070	0.0%
10	232	230	-0.9%	267	265	-0.7%	1,090	1,080	-0.9%
20	235	233	-0.9%	271	268	-1.1%	1,100	1,100	0.0%
50	238	236	-0.8%	274	272	-0.7%	1,110	1,110	0.0%
100	241	239	-0.8%	277	275	-0.7%	1,130	1,120	-0.9%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

The frequency analysis results generally suggest that a minor reduction (-1.1% change or less) in the return period peak flows is projected at all of the assessessment nodes, with the percentage change from baseline conditions declining in the downstream direction of flow within the Aquatic RSA.

Low flow conditions were also assessed for the Aquatic RSA flow node locations, which are based on the projected 7 day low flow data. The results are presented in Table 10.5-26 for a range of return periods.

Table 10.5-26: Return Period 7-Day Low Flows (L/s) at Multiple Locations in the Aquatic RSA

Return Period (Years)	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	10,500	10,500	0.0%	15,400	15,400	0.0%	65,600	65,600	0.0%
5	10,400	10,400	0.0%	15,400	15,300	-0.6%	65,400	65,300	-0.2%
10	10,400	10,400	0.0%	15,300	15,300	0.0%	65,200	65,200	0.0%
20	10,400	10,400	0.0%	15,300	15,300	0.0%	65,200	65,100	-0.2%
50	10,400	10,400	0.0%	15,300	15,200	-0.7%	65,000	64,900	-0.2%
100	10,400	10,400	0.0%	15,300	15,200	-0.7%	65,000	64,800	-0.3%

Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

Similar to the high flow statistics, the return period low flow projections indicate little to no change between the baseline and mine development assessment scenarios for the Aquatic RSA flow nodes.

Figure 10.5-16 presents the percent temporal change (% change from baseline) in the monthly flows at the Aquatic RSA nodes for each Project phase when compared to existing conditions (i.e., with no mine development) over the respective timeframe. Mean monthly flow data are included in Appendix 10-C.

The temporal percent change in projected mean monthly flows for the Aquatic RSA assessment nodes indicate the following:

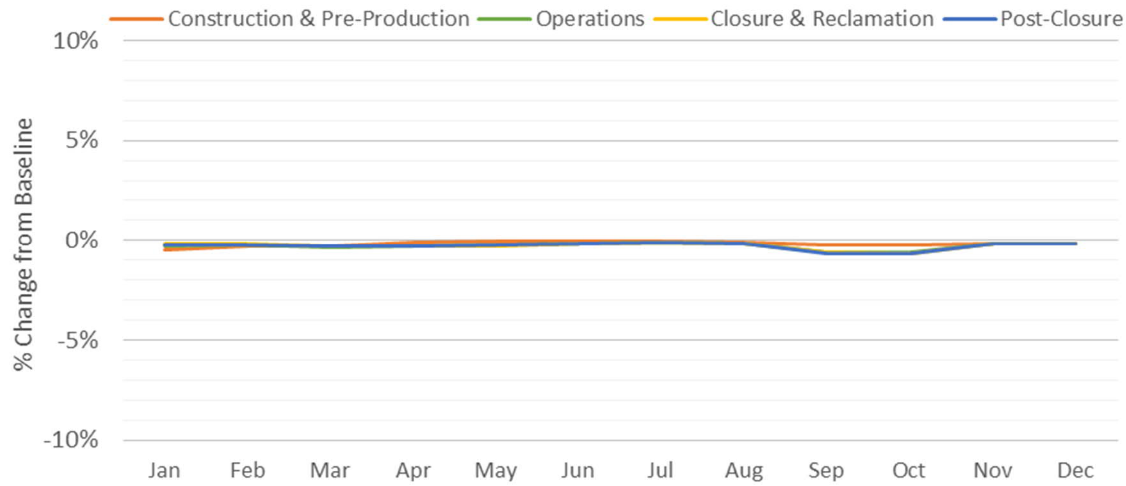
- The temporal percent changes are nominal (less than 1%) and comparatively similar for all Project phases at the Elk River flow nodes (EV_ER1 and RG_ELKORES); and
- At the Lake Koocanusa downstream of Elk River flow node (RG_DSELK), the percent change from baseline is virtually non-detectable for all Project phases.

The percent temporal change values at each of the assessment nodes were applied to the baseline flow statistics for the purpose of estimating the monthly flows during each Project phase. The monthly hydrographs for each of the RSA assessment nodes are presented in Figure 10.5-17. Monthly flow data are included in Appendix 10-C.

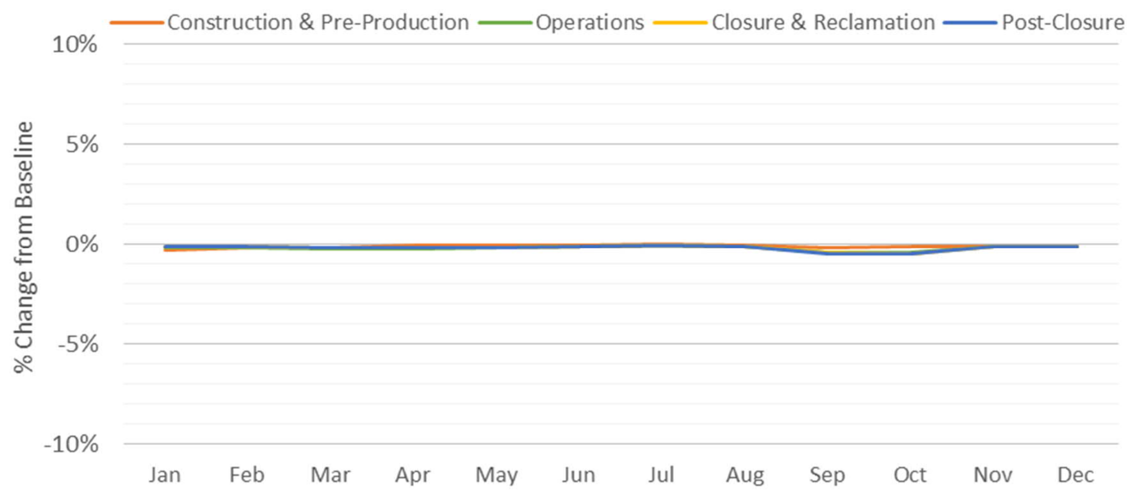
Overall, the difference in the projected mean monthly flow data for the baseline and mine development scenarios at the Aquatic RSA nodes is negligible to non-detectable.

Climate Change

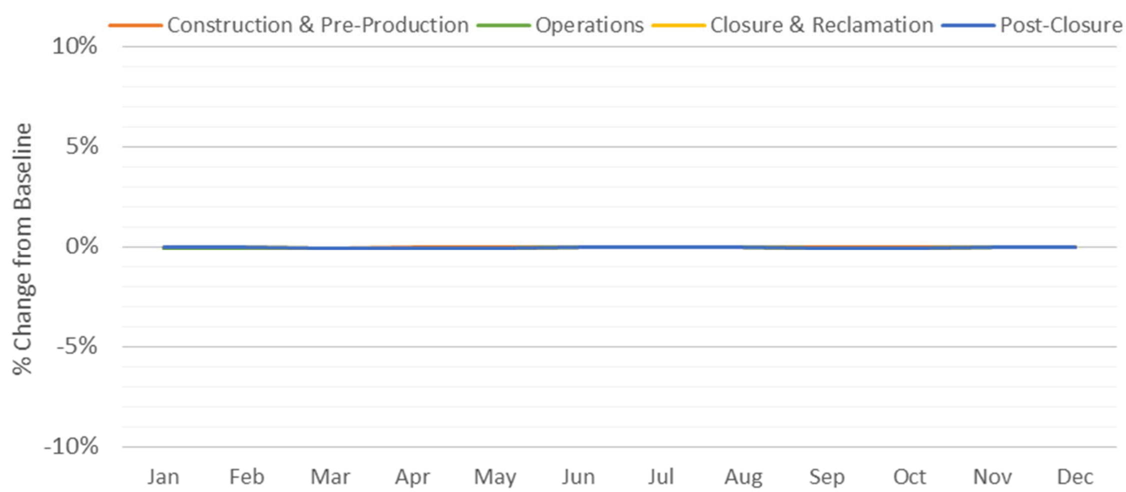
A summary of the projected minimum, mean, and maximum annual flows for the Aquatic RSA assessment nodes is provided in Table 10.5-27. Annual flow data for the climate change assessment are included in Appendix 10-C. Further details regarding the assessment methodology are provided in Section 10.5.4.1 and the accompanying technical memo in Appendix 10-A (SRK, 2021).



Elk River Downstream of Michel Creek (EV_ER1)

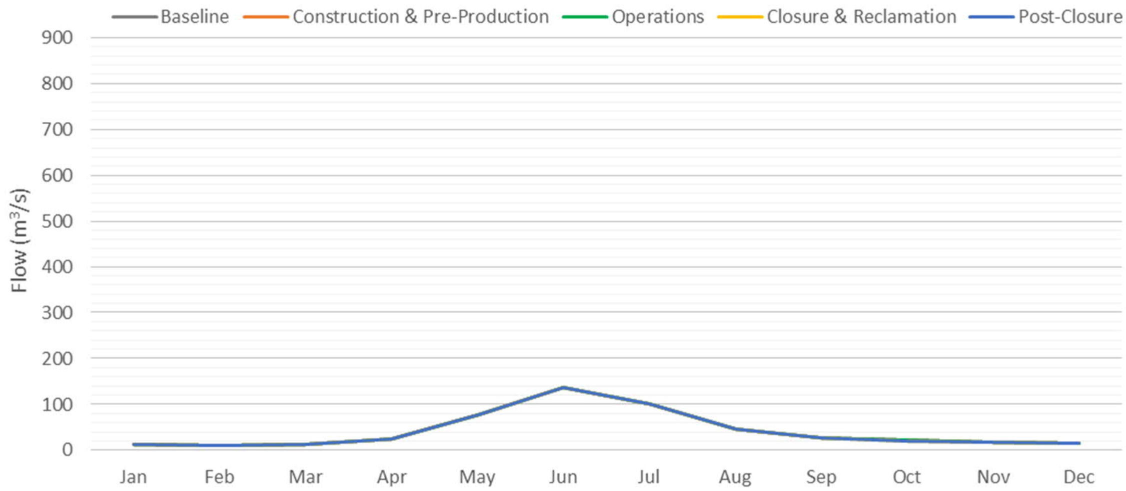


Elk River at Elko Reservoir (RG_ELKORES)

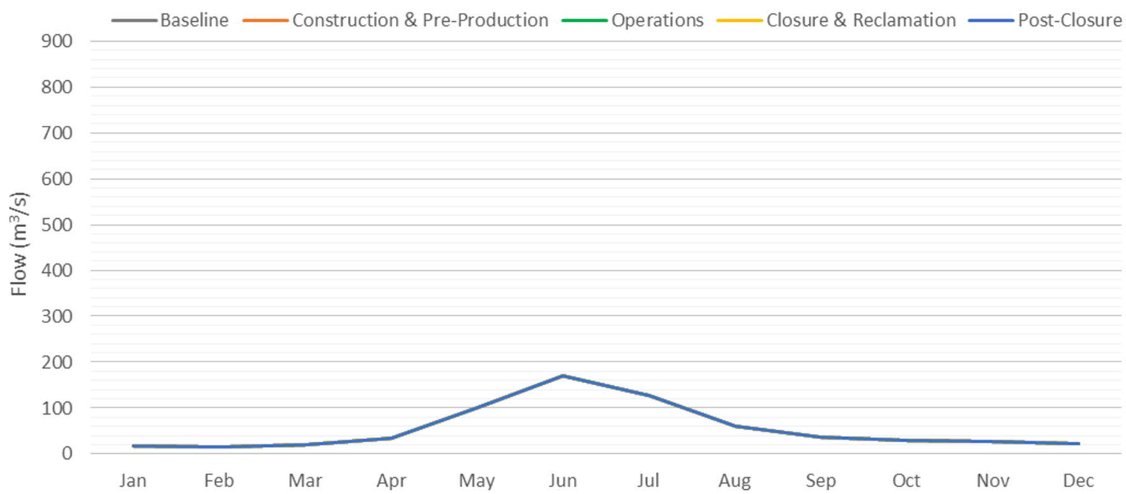


Lake Koocanusa Downstream of Elk River (RG_DSELK)

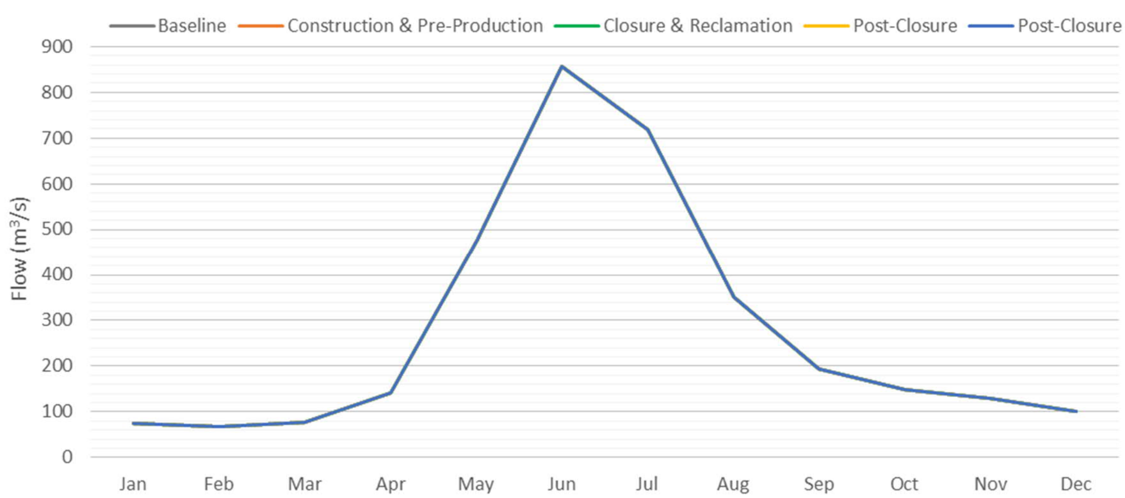
Figure 10.5-16: Percent Change in Predicted Mean Monthly Flows for Multiple Locations in the RSA (Years 1 – 34)



Elk River Downstream of Michel Creek (EV1_ER1)



Elk River at Elko Reservoir (RG_ELKORES)



Lake Koocanusa Downstream of Elk River (RG_DSELK)

Figure 10.5-17: Projected Mean Monthly Hydrographs for Multiple Locations in the RSA (Years 1 – 34)

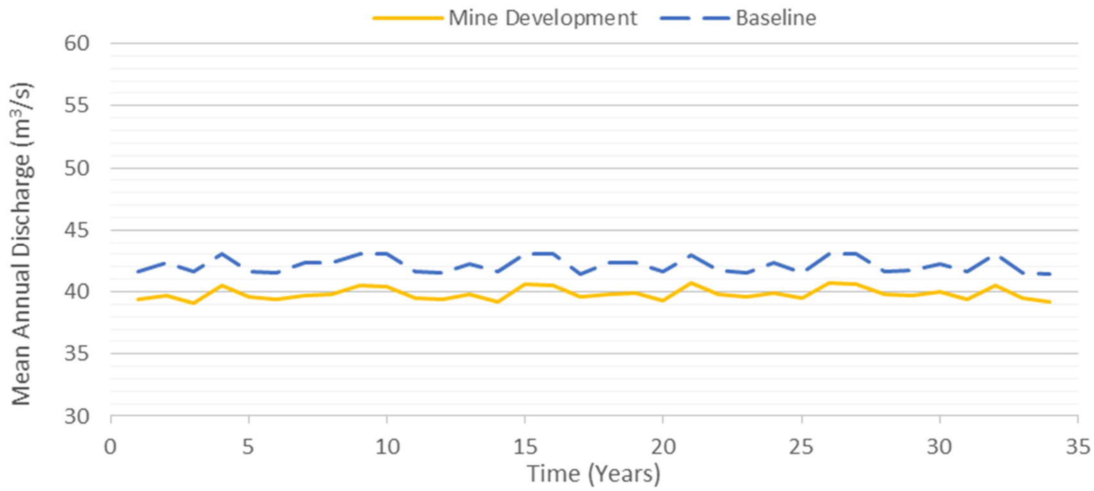
Table 10.5-27: Predicted Minimum, Mean, and Maximum Average Flows at Multiple Locations along the Elk River under Climate Change

Project Phase	Annual Flow Parameter	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
		Base-Line	Mine Dev.	% Change	Base-Line	Mine Dev.	% Change	Base-Line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	Min	10.48	10.46	-0.2	15.38	15.37	-0.1	65.48	65.53	0.1
	Mean	41.96	39.52	-5.8	55.17	52.51	-4.8	278.89	261.50	-6.2
	Max	218.47	158.27	-27.6	252.17	184.33	-26.9	1033.3	907.04	-12.2
Operations (Years 3-17)	Min	10.48	10.44	-0.4	15.40	15.37	-0.2	65.56	65.55	0.0
	Mean	42.20	39.83	-5.6	55.47	52.97	-4.5	279.14	262.50	-6.0
	Max	226.51	160.47	-29.2	260.94	186.69	-28.5	1063.8	938.08	-11.8
Reclamation and Closure (Years 18-19)	Min	10.52	10.47	-0.5	15.49	15.43	-0.4	65.93	65.78	-0.2
	Mean	42.31	39.89	-5.7	55.56	53.10	-4.4	280.54	263.80	-6.0
	Max	230.52	160.74	-30.3	265.48	186.96	-29.6	1081.34	957.17	-11.5
Post-Closure (Years 20-34)	Min	10.46	10.42	-0.4	15.40	15.38	-0.1	65.54	65.61	0.1
	Mean	42.06	39.89	-5.2	55.33	53.25	-3.8	278.47	263.27	-5.5
	Max	224.98	153.46	-31.8	259.27	178.98	-31.0	1057.5	937.07	-11.4

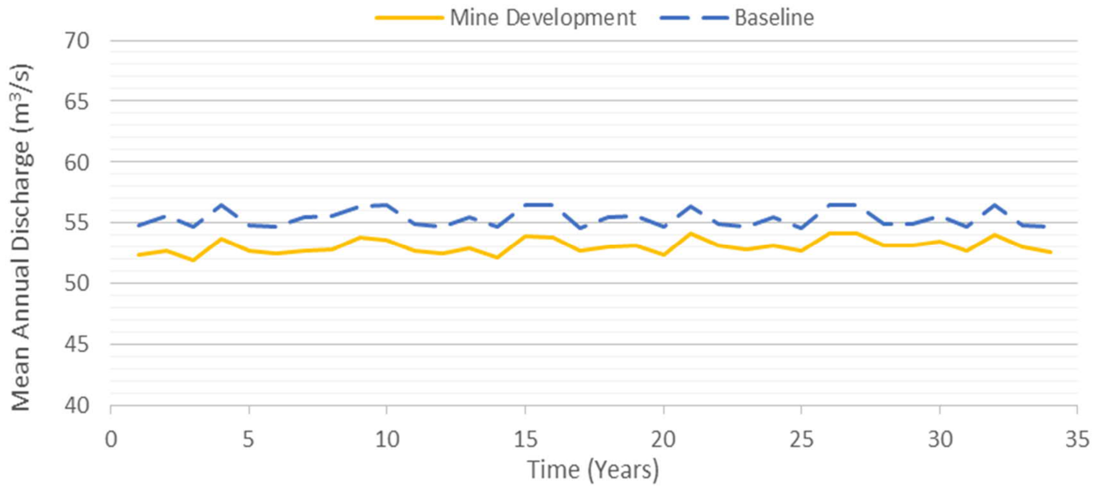
A minor reduction in the minimum annual flows is projected at all of the assessment nodes during each of the Project phases, while a more substantial decrease in average and maximum flows is projected at all of the nodes for all of the Project phases.

The projected annual flows at the Aquatic RSA flow nodes for the existing land use and mine development scenarios under climate change conditions for the 34 year assessment timeline is presented in Figure 10.5-18. As shown, there is a decrease in the mean annual flows associated with the mine development scenario at all of the assessment nodes. The relative magnitude of the reduced mean annual flows is comparable at the two Elk River nodes and a more pronounced reduction at the Lake Koocanusa node.

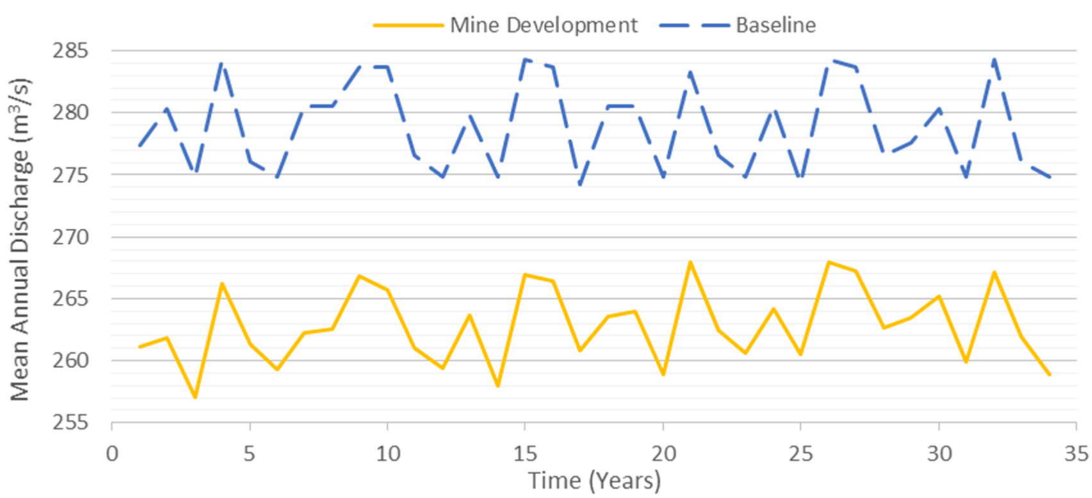
The projected mean annual runoff yield for the baseline and mine development scenarios during each of the Project phases are compared in Table 10.5-28. The mean annual and monthly yield values projected over the 34 year assessment period are included in Appendix 10-C. In general, the results show that there would be minimal to no change (-0.2% change or less) between the baseline and mine development scenarios.



Elk River Downstream of Michel Creek (EV_ER1)



Elk River at Elko Reservoir (RG_ELKORES)



Lake Koocanusa Downstream of Elk River (RG_DSELK)

Figure 10.5-18: Predicted Mean Annual Flow for Multiple Locations in the Aquatic RSA under Climate Change Conditions (Years 1 – 34)

Table 10.5-28: Projected Mean Annual Yield (mm) by Project Phase at Multiple Locations in the Aquatic RSA under Climate Change Conditions

Project Phase	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change	Base-line	Mine Dev.	% Change
Construction and Pre-Production (Years 1-2)	471	444	-5.8%	494	471	-4.8%	378	354	-6.2%
Operations (Years 3-17)	474	448	-5.6%	497	475	-4.5%	378	355	-6.0%
Reclamation and Closure (Years 18-19)	475	448	-5.7%	498	476	-4.4%	380	357	-6.0%
Post-Closure (Years 20-34)	472	448	-5.2%	496	477	-3.8%	377	356	-5.5%

Statistical frequency analyses were performed to estimate the peak flows for a range of recurrence intervals (return periods) – based on the water balance model results projected at each flow node over the 34 year assessment period. The frequency analyses were undertaken using the software program HYFRAN and applied a log-normal distribution. A summary of the results is provided in Table 10.5-29.

Table 10.5-29: Return Period Peak Flows (m^3/s) at Multiple Locations in the Aquatic RSA under Climate Change Conditions

Return Period (Years)	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	225	157	-30.2%	260	183	-29.6%	1,060	936	-11.7%
5	229	160	-30.1%	263	186	-29.3%	1,070	949	-11.3%
10	232	163	-29.7%	267	190	-28.8%	1,090	962	-11.7%
20	235	166	-29.4%	271	193	-28.8%	1,100	975	-11.4%
50	238	169	-29.0%	274	196	-28.5%	1,110	986	-11.2%
100	241	172	-28.6%	277	199	-28.2%	1,130	999	-11.6%

Note: Peak flows estimated through frequency analysis based on annual peak data (daily maximums) over the 34 year assessment period.

The frequency analysis results generally suggest that a reduction in the return period peak flows is projected at all of the assessessment nodes, with the percentage change from baseline conditions declining in the downstream direction of flow within the Aquatic RSA. The Project changes are primarily attributed to the effects of climate change.

Table 10.5-30 provides a summary of the projected return period low flows for the Aquatic RSA assessment nodes under the climate change scenario.

Table 10.5-30: Return Period 7-Day Low Flows (L/s) at Multiple Locations in the Aquatic RSA under Climate Change Conditions

Return Period (Years)	Elk River Downstream of Michel Creek (EV_ER1)			Elk River at Elko Reservoir (RG_ELKORES)			Lake Koocanusa Downstream of Elk River (RG_DSELK)		
	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change	Baseline	Mine Dev.	% Change
2	10,500	10,500	0.0%	15,400	15,400	0.0%	65,600	65,600	0.0%
5	10,400	10,400	0.0%	15,400	15,300	-0.6%	65,400	65,300	-0.2%
10	10,400	10,400	0.0%	15,300	15,300	0.0%	65,200	65,200	0.0%
20	10,400	10,400	0.0%	15,300	15,300	0.0%	65,200	65,100	-0.2%
50	10,400	10,400	0.0%	15,300	15,200	-0.7%	65,000	64,900	-0.2%
100	10,400	10,400	0.0%	15,300	15,200	-0.7%	65,000	64,800	-0.3%

Note: Low flows estimated through frequency analysis based on annual data (7 day low flows) over the 34 year assessment period.

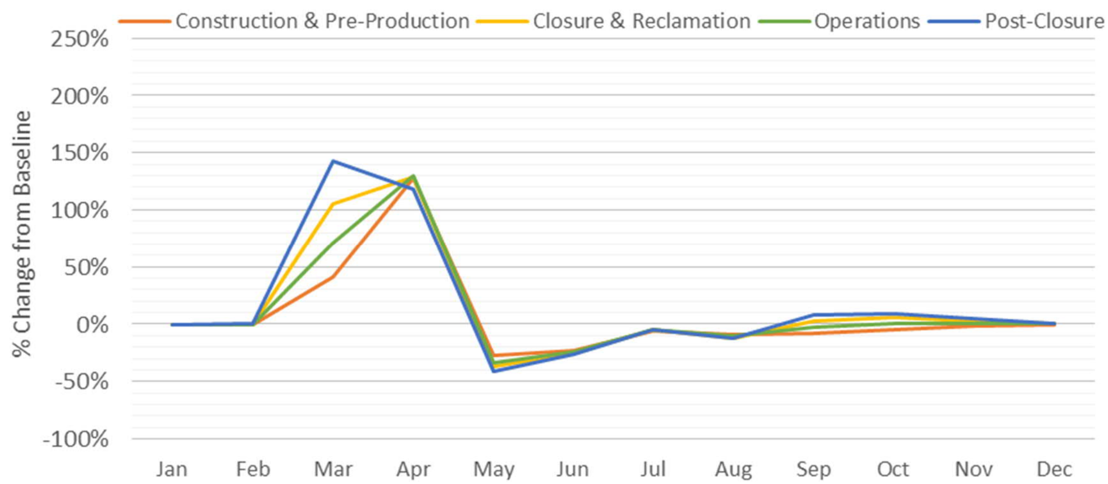
The assessment of return period low flow consitions suggest that the magnitude of projected change between the baseline and mine development assessment scenarios under the climate change scenario is minimal for the Aquatic RSA flow nodes.

The magnitude and timing of temporal changes in monthly flows under climate change conditions are illustrated on Figure 10.5-19 for each Project phase when compared to existing conditions (i.e., with no mine development). Mean monthly flow data for the Aquatic RSA assessment nodes under climate change conditions are included in Appendix 10-C.

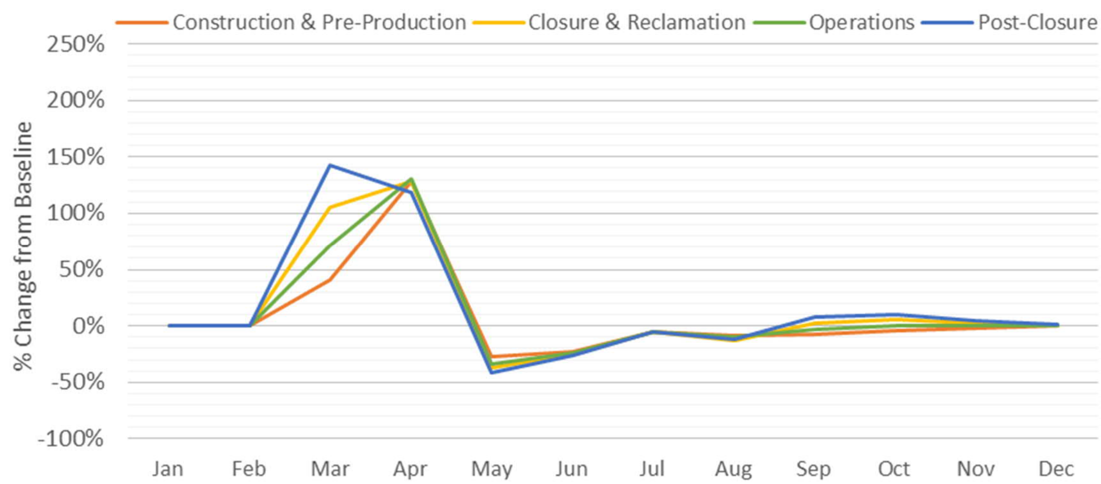
The temporal changes (% change from baseline) in mean monthly flows demonstrate substantial positive differences in the late winter/early spring and negative differences in the late spring/early summer in comparison with the existing land use assessment results. The temporal changes vary depending on the Project phase, with the most prominent changes occurring in the Reclamation and Closure and Post-Closure timeframes. Similar results were calculated for the Alexander/West Alexander Creek and Grave Creek assessment nodes.

The mean monthly flow hydrographs at each of the Aquatic RSA assessment nodes, which were developed based on the percent temporal change factors derived from the climate change model results and applied to the baseline flow projections is presented in Figure 10.5-20. Through a comparison of the projected mean monthly flow data for the baseline and mine development (with climate change) scenarios, the following notable findings were identified at the Alexander/West Alexander Creek assessment nodes:

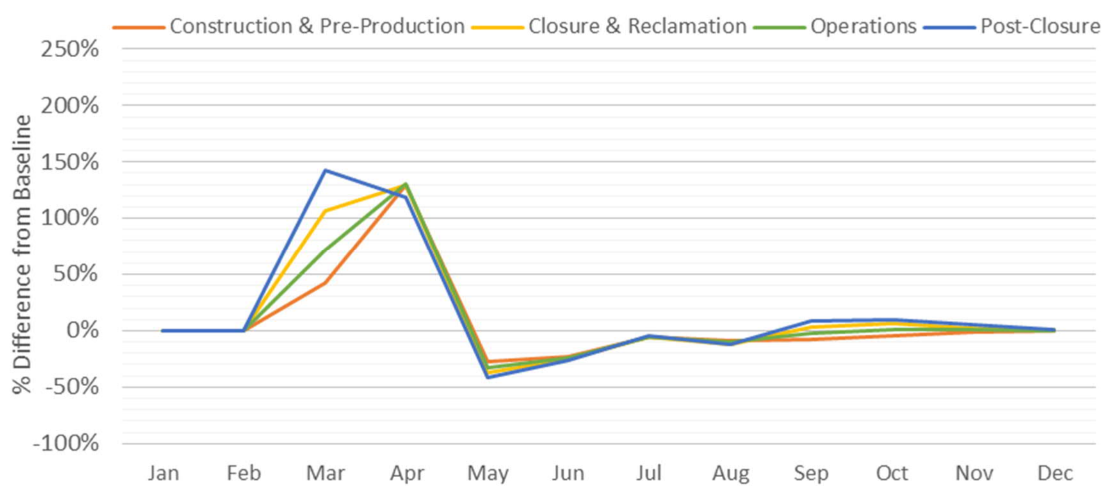
- The increase in the magnitude of mean monthly flows during the freshet is most notable for the Reclamation and Closure and Post-Closure phases;
- There is a change in the shape of the hydrograph at all of the assessment nodes, with an increase in flows in the late winter and early spring months and a reduction in flows in the mid-spring to early summer period. The future climate change projections for the region indicate higher temperatures in the late winter and early spring time period, which would result in an earlier snowmelt and the potential for a reduced magnitude in maximum flows during the freshet; and
- Overall, it is evident that the impacts of climate change will have a substantial influence on the timing and magnitude of streamflows within the receiving watercourses in the Aquatic RSA.



Elk River Downstream of Michel Creek (EV_ER1)

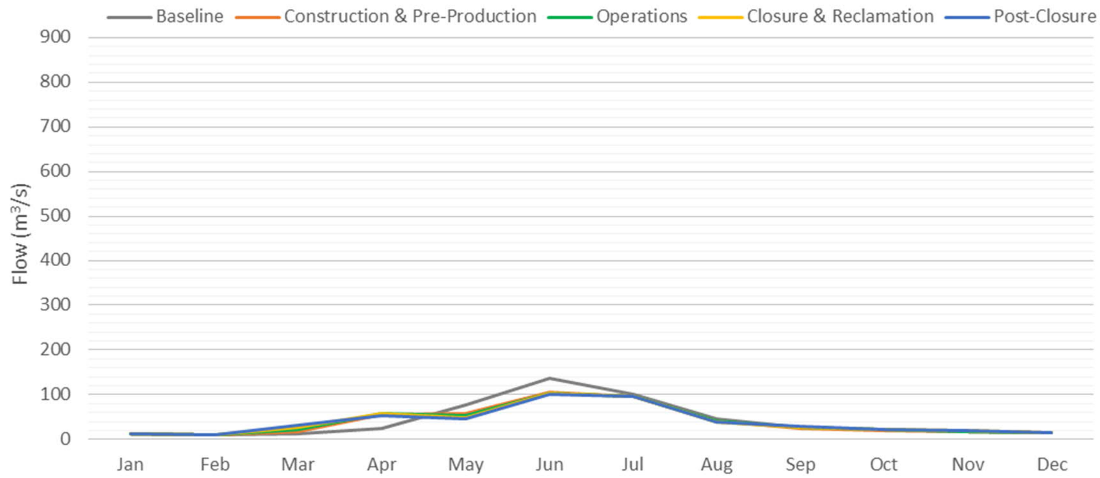


Elk River at Elko Reservoir (RG_ELKORES)

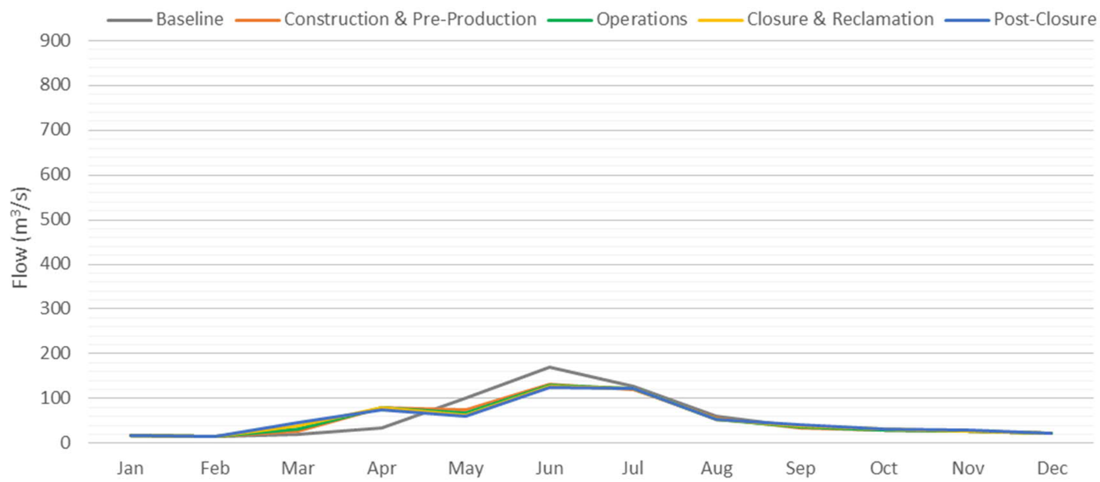


Lake Koocanusa Downstream of Elk River (RG_DSELK)

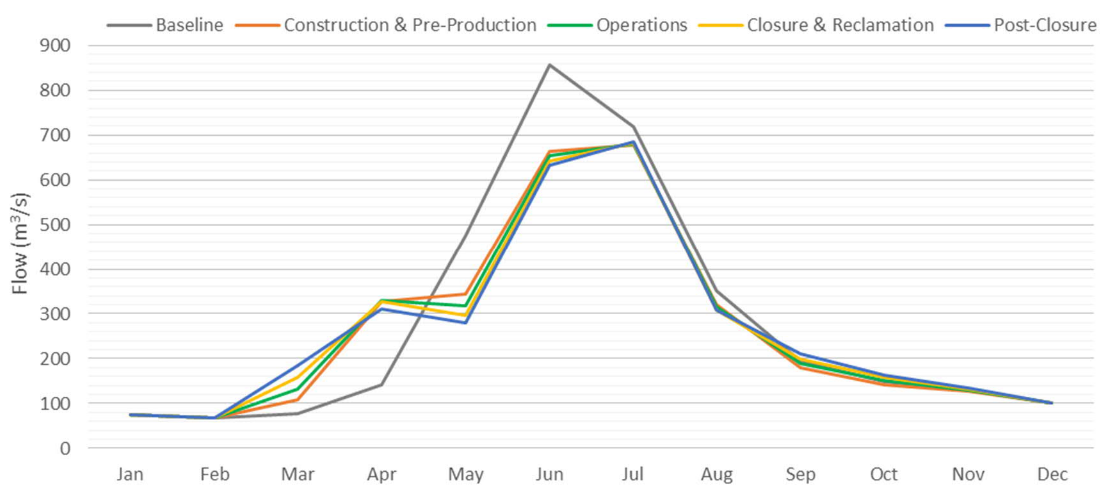
Figure 10.5-19: Percent Change in Predicted Mean Monthly Flows for Multiple Locations in the Aquatic RSA under Climate Change Conditions (Years 1 – 34)



Elk River Downstream of Michel Creek (EV_ER1)



Elk River at Elko Reservoir (RG_ELKORES)



Lake Koocanusa Downstream of Elk River (RG_DSELK)

Figure 10.5-20: Projected Mean Monthly Hydrographs for Multiple Locations in the Aquatic RSA under Climate Change Conditions (Years 1 – 34)

10.5.4.3 Summary of Potential Residual Effects

Table 10.5-31 presents a summary of the predicted changes in surface water quantity at the Aquatic LSA assessment nodes, including the range of projected changes in mean annual and monthly flows during each Project phase. A discussion of the potential effects to surface water quantity for the Aquatic RSA is provided in Section 10.6.

10.5.4.4 Characterization of Residual Effects

The assessment of residual effects on surface water quality involves the consideration and evaluation of specific effects assessment criteria based on the degree (i.e., ‘level’) of potential Project effects. Criteria used to characterize residual effects are defined in Chapter 5, Section 5.3.4.5 and include duration, magnitude, geographic extent, frequency, reversibility, and context.

10.5.4.4.1 Changes to Surface Water Quantity due to Site Construction Activities

The residual effects to surface water quantity due to site construction activities are characterized as follows:

- Duration: Short-term, the potential for adverse effects to surface water quantity will generally be limited to the Construction and Pre-Production phase of the Project (approximately 18 months).
- Magnitude: Low to High, the potential for negative effects to surface water quantity is low in Grave Creek, low to moderate in Alexander Creek, and high in West Alexander Creek.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site construction activities are completed (including timber harvesting, clearing and grubbing, and construction of mine site roads and facilities).
- Reversibility: Reversible long-term, changes in surface water quantity resulting from site construction activities are anticipated to be potentially reversible as the site is reclaimed.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

<u>Determination of Significance</u>

The residual effects on surface water quantity related to site construction activities are considered not significant. In Grave Creek, the projected reduction in surface water quantity will be minimal during the Construction and Pre-Production phase and generally limited to the upper reaches of the watercourse. The change in water quantity is projected to be moderate in West Alexander Creek; however, the resulting influence on the downstream reaches of Alexander Creek is considerably lower during this Project phase.

Table 10.5-31: Summary of Predicted Changes in Surface Water Quantity at Aquatic LSA Nodes

Node Location/ID	Predicted Hydrologic Change	Project Phase			
		Construction and Pre-Production (Years 1-2)	Operations (Year 3-17)	Reclamation and Closure (Years 18-19)	Post-Closure (Years 20-34)
Alexander Creek/West Alexander Creek					
West Alexander Creek Downstream of Sediment Pond Outlet (AC-6)	Change in Mean Annual Flow	-9.3 to -20.1%	-19.5 to -35.0%	-30.2 to -33.1%	-30.7 to -40.0%
	Change in Mean Monthly Flow	-8.5 to -26.3%	-21.9 to -36.1%	-20.9 to -40.0%	-24.3 to -40.4%
Alexander Creek Downstream of West Alexander Creek (AC-3)	Change in Mean Annual Flow	-1.9 to -4.0%	-3.9 to -7.0%	-6.0 to -6.6%	-6.1 to -8.0%
	Change in Mean Monthly Flow	-1.7 to -5.3%	-4.4 to -7.2%	-4.2 to -8.0%	-4.9 to -8.1%
Alexander Creek Upstream of Hwy 3 (AC-1)	Change in Mean Annual Flow	-0.9 to -1.9%	-1.9 to -3.4%	-2.9 to -3.2%	-2.9 to -3.8%
	Change in Mean Monthly Flow	-0.8 to -2.5%	-2.1 to -3.5%	-2.0 to -3.8%	-2.3 to -3.9%
Grave Creek					
Grave Creek Downstream of Withdrawal Location (GC-5)	Change in Mean Annual Flow	-0.7 to -3.5%	-1.2 to -6.6%	-0.7 to -1.0%	-0.8 to -1.5%
	Change in Mean Monthly Flow	+1.0 to -4.3%	-4.1 to -5.9%	+0.9 to -4.6%	+1.5 to -3.0%
Grave Creek Downstream of Harmer Creek (GC-2)	Change in Mean Annual Flow	-0.4 to -1.2%	-0.5 to -2.1%	-0.3 to -0.4%	-0.4 to -0.6%
	Change in Mean Monthly Flow	+0.1 to -1.4%	-1.4 to -1.9%	+0.1 to -1.5%	+0.3 to -1.1%
Grave Creek Upstream of Elk River (GC-1)	Change in Mean Annual Flow	-0.4 to -1.0%	-0.5 to -1.8%	-0.4 to -0.4%	-0.4 to -0.6%
	Change in Mean Monthly Flow	-0.0 to -1.2%	-1.2 to -1.6%	-0.0 to -1.3%	+0.1 to -0.9%

Level of Magnitude:

Low (<5.0% change) Moderate (>5% and <15% change) High (>15% change)

Likelihood and Confidence

Effects from Project activities that are determined to be not significant and do not require a characterization of likelihood. Confidence considers the reliability of data and analytical methods used in the assessment of effects. The long-term water balance and loading (GoldSim) model results are considered to provide a reasonable prediction of the magnitude, timing, and extent of surface water quantity effects related to Project activities. Notwithstanding, the effects assessment characterization does include potential sources of uncertainty, which are summarized below:

- The water balance model development process involved several assumptions and limitations regarding the proposed timeline for the mine site development, water management plan implementation, mine rock seepage, groundwater interactions, and climate related variables (i.e., precipitation, snowpack/melt, evaporation, etc.);
- Limited information was available regarding the current and future operation of the Teck's Elkview Operations (including water management practices), which influences streamflows in Grave Creek;
- The water surface water quantity estimates for the climate change scenarios are based on projected temperature and precipitation conditions, which involve potential uncertainties;
- Uncertainty is considered to be higher in the future over the longer-term, as there are aspects with respect to the mine development operations and water management that are less defined and subject to change; and
- The modelling process for the Aquatic RSA involved integration with the Elk Valley Water Quality Prediction Model, which applied average flow rates for the Elk River watershed hydrology.

As such, this significance prediction is ascribed a moderate level of confidence.

10.5.4.4.2 Changes to Surface Water Quantity due to Operational Activities

The residual effects to surface water quantity due to operational activities are characterized as follows:

- Duration: Long-term, the potential for adverse effects to surface water quantity resulting from operational activities will generally be limited to Operations phase of the Project.
- Magnitude: Low to High, the potential for negative effects to surface water quantity is low to moderate in Grave Creek, low to moderate in Alexander Creek, and high in West Alexander Creek.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site operations activities are ongoing (including mining activities, drainage modifications, and operation of Main Sediment Pond).
- Reversibility: Irreversible, changes in surface water quantity resulting from site operational activities are anticipated to be potentially irreversible until after the Post-Closure phase.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

Determination of Significance

The residual effects on surface water quantity related to site operational activities are considered not significant. In Grave Creek, the projected reduction in water quantity will be minimal during the Operations phase and generally limited to the upper reaches of the watercourse. The change in water quantity is projected to be moderate in West Alexander Creek; however, the resulting influence on the downstream reaches of Alexander Creek is considerably less substantial during this Project phase. The potential reduction in water quantity in West Alexander Creek could result in a change in the natural flow regime, which may cause fluvial/geomorphologic changes (i.e., erosion potential, bedload movement) and sediment transport capacity to downstream reaches of Alexander Creek.

It is notable that the results of the effect assessment indicate that the potential impacts of future climate change will have a substantially greater influence on surface water quantity (i.e., magnitude and timing of streamflows) along the downstream watercourses in the Aquatic LSA and RSA.

Likelihood and Confidence

Effects from Project activities that are determined to be not significant do not require a characterization of likelihood. Confidence considers the reliability of data and analytical methods used in the assessment of effects. The long-term water balance and loading (GoldSim) model results are considered to provide a reasonable prediction of the magnitude, timing, and extent of surface water quantity effects related to Project activities. Notwithstanding, the effects assessment characterization does include potential sources of uncertainty, which are summarized below:

- The water balance model development process involved several assumptions and limitations regarding the proposed timeline for the mine site development, water management plan implementation, mine rock seepage, groundwater interactions, and climate related variables (i.e., precipitation, snowpack/melt, evaporation, etc.);
- There is potential uncertainty with respect to the rate of water movement through mine rock stockpiles and dump areas;
- Limited information was available regarding the current and future operation of the Teck's Elkview Operations (including water management practices), which influences streamflows in Grave Creek;
- The water surface water quantity estimates for the climate change scenarios are based on projected temperature and precipitation conditions, which involve potential uncertainties;
- Uncertainty is considered to be higher in the future over the longer-term, as there are aspects with respect to the mine development operations and water management that are less defined and subject to change; and
- The modelling process for the Aquatic RSA involved integration with the Elk Valley Water Quality Prediction Model, which applied average flow rates for the Elk River watershed hydrology.

As such, this significance prediction is ascribed a moderate level of confidence.

10.5.4.4.3 Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities

The residual effects to surface water quantity due to mine closure and reclamation activities are characterized as follows:

- Duration: Permanent, the potential for adverse effects to surface water quantity is predicted to extend beyond the Post-Closure Phase.
- Magnitude: Low to High, the potential for negative effects to surface water quantity is low in Grave Creek, low to moderate in Alexander Creek, and high in West Alexander Creek.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously to some extent through the Reclamation and Closure and Post-Closure Phases.
- Reversibility: Irreversible, changes in surface water quantity resulting from mine closure and reclamation activities are anticipated to be potentially irreversible until after the Post-Closure phase.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

Determination of Significance

The residual effects on surface water quantity related to mine closure and reclamation activities are considered not significant. In Grave Creek, the projected reduction in water quantity will be minimal during the Reclamation and Closure phase and generally limited to the upper reaches of the watercourse. The change in water quantity is projected to be moderate in West Alexander Creek; however, the resulting influence on the downstream reaches of Alexander Creek is considerably less substantial during this Project phase.

It is notable that the results of the effect assessment indicate that the potential impacts of future climate change will have a substantially greater influence on surface water quantity (i.e., magnitude and timing of streamflows) along the downstream watercourses in the Aquatic LSA and RSA. The climate change related impacts are projected to escalate over time and are most pronounced during the Post-Closure phase.

Likelihood and Confidence

Effects from Project activities that are determined to be not significant do not require a characterization of likelihood. Confidence considers the reliability of data and analytical methods used in the assessment of effects. The long-term water balance and loading (GoldSim) model results are considered to provide a reasonable prediction of the magnitude, timing, and extent of surface water quantity effects related to Project activities. Notwithstanding, the effects assessment characterization does include potential sources of uncertainty, which are summarized below:

- The water balance model development process involved several assumptions and limitations regarding the proposed timeline for the mine site development, water management plan implementation, mine rock seepage, groundwater interactions, and climate related variables (i.e., precipitation, snowpack/melt, evaporation, etc.);

- There is potential uncertainty with respect to the rate of water movement through mine rock stockpiles and dump areas following reclamation;
- Limited information was available regarding the current and future operation of the Teck's Elkview Operations (including water management practices), which influences streamflows in Grave Creek;
- The water surface water quantity estimates for the climate change scenarios is based on projected temperature and precipitation conditions, which involve potential uncertainties;
- Uncertainty is considered to be higher in the future over the longer-term, as there are aspects with respect to the mine development operations and water management that are less defined and subject to change; and
- The modelling process for the Aquatic RSA involved integration with the Elk Valley Water Quality Prediction Model, which applied average flow rates for the Elk River watershed hydrology.

As such, this significance prediction is ascribed a moderate level of confidence.

10.5.4.5 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence are summarized in Table 10.5-32. As indicated, there are no significant residual effects to surface water quantity anticipated as a result of the Project.

Table 10.5-32: Summary of Residual Effects on Surface Water Quantity

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization	Significance (Significant, Not Significant)	Confidence (High, Moderate, Low)
Changes to Surface Water Quantity due to Site Construction Activities	Construction and Pre-Production	Site Water Management Plan	Duration: Short-term Magnitude: Low to High Geographic Extent: Local Frequency: Continuous Reversibility: Reversible long-term Context: Neutral	Not Significant	Moderate
Changes to Surface Water Quantity due to Operational Activities	Operations	Site Water Management Plan	Duration: Short-term Magnitude: Low to High Geographic Extent: Local Frequency: Continuous Reversibility: Irreversible Context: Neutral	Not Significant	Moderate
Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities	Reclamation and Closure, and Post-Closure	Site Water Management Plan, Site Reclamation, and Reclamation Monitoring	Duration: Permanent Magnitude: Low to High Geographic Extent: Local Frequency: Continuous Reversibility: Irreversible Context: Neutral	Not Significant	Moderate

10.6 Cumulative Effects Assessment

Cumulative environmental effects are the result of Project residual environmental effects interacting with the effects of other past, present, and reasonably foreseeable future projects or activities to produce a combined/overlapping effect. The objective of the cumulative effects assessment is to consider overlapping effects for all residual adverse effects, not only those predicted to be significant (EAO, 2013). The assessment of cumulative effects on the surface water quantity VC requires that:

- The Project results in a residual adverse environmental effect on the surface water quantity VC;
- A residual Project effect interacts cumulatively with effects from other projects or activities (i.e., an effect of the Project overlaps spatially and temporally with those of other projects or activities that have been or will be carried out);
- The other projects or activities have been or will be carried out and are not hypothetical; and
- The cumulative effect is likely to occur.

Further information regarding the cumulative effects assessment methodology is provided in Chapter 5, Section 5.3.5.

10.6.1 Overview of Project Residual Effects

A cumulative effects assessment is required for the surface water quantity VC because there is a possibility that potential Project residual effects may remain after implementation of proposed mitigation measures, which include:

- Change to Surface Water Quantity due to Site Construction Activities (during the Construction and Pre-Production phase);
- Change to Surface Water Quantity due to Operational Activities (during the Operations phase); and
- Change to Surface Water Quantity due to Mine Closure and Reclamation Activities (during the Reclamation and Closure phase).

10.6.1.1 Assessment Boundaries

10.6.1.1.1 Spatial Boundaries

The cumulative assessment for surface water quantity was conducted at a regional scale which includes the Aquatic RSA, as described in Section 10.2.3.1.

10.6.1.1.2 Temporal Boundaries

The temporal boundaries for the cumulative effects assessment are the same as those for Project effects, as defined in Section 10.2.3.2.

10.6.1.1.3 Use of Temporal Cases

The temporal cases used in the assessment of cumulative effects are described as follows:

1. Base Case – Describes the current status of the VC prior to the start of the Project, including all appropriate past and present projects and/or activities. The Base Case for surface water quantity is presented in the existing conditions of the VC assessment chapter, with explicit reference to

the fact that the Base Case generally reflects the contributions of past and present projects and/or activities;

2. Project Case – Describes the status of the VC with the Project in place, over and above the Base Case. For surface water quantity, this is assessed using the peak effect of the Project or the maximum active footprint for the Project; and
3. Future Case – Describes the status of the VC as a result of the Project Case in combination with all reasonably foreseeable future projects and/or activities that could be carried out.

10.6.1.1.4 Administrative Boundaries

Additional administrative boundaries were not considered of the cumulative effects assessment of surface water quantity effects beyond those described in Section 10.2.3.3.

10.6.1.1.5 Technical Boundaries

The technical boundaries for the cumulative effects assessment are associated to constraints imposed on the assessment due to limitations in the ability to predict the effects of the Project (EAO, 2013).

For the purpose of the surface water quantity assessment, the technical boundaries relate to constraints with respect to available baseline data in addition to the limitations and assumptions involved with predictive (water and load balance) models. To undertake the cumulative assessment of surface water quantity effects in the Aquatic RSA, the Site Wide Water Quality (SWWQ) water and load balance model was integrated with the Elk Valley Regional Water Quality Model (RWQM). Due to the different methodologies that were applied to evaluate streamflow in the SWWQ and RWQM models, only the average flow rates and concentrations provided by the RWQM were considered to be suitable for integrating the cumulative effects from the Project into the RWQM results (SRK, 2021).

10.6.2 Identifying Past, Present, and Reasonably Foreseeable Projects and/or Activities

Descriptions of the past, present, and reasonably foreseeable projects and/or activities for consideration in the cumulative effects assessment are provided in Chapter 5, Section 5.3.5.3.

A summary of the past, present, and reasonably foreseeable projects or activities that are expected to interact with surface water quantity, with a potential for adverse cumulative effects is presented in Table 10.6-1. A map showing the location of the past, present, and reasonably foreseeable future projects or activities is presented on Figure 10.6-1.

As noted in Chapter 5, Section 5.3.4.3, the following projects were considered as past, present, or reasonably foreseeable future projects and/or activities in the cumulative effects assessment but were not included:

- Coal Mountain Phase 2 as the environmental assessment was placed on hold by Teck Coal Limited in 2016;
- Mount Brussilof (Baymag Mine) by Baymag due to no temporal overlap;
- Barnes Lake Phosphate Exploration Project by Fertoz International Inc. given that the project is in exploration phase and no project has been proposed; and
- Cabin Ridge Coal by Warburton Group is in exploration and no project has been proposed.

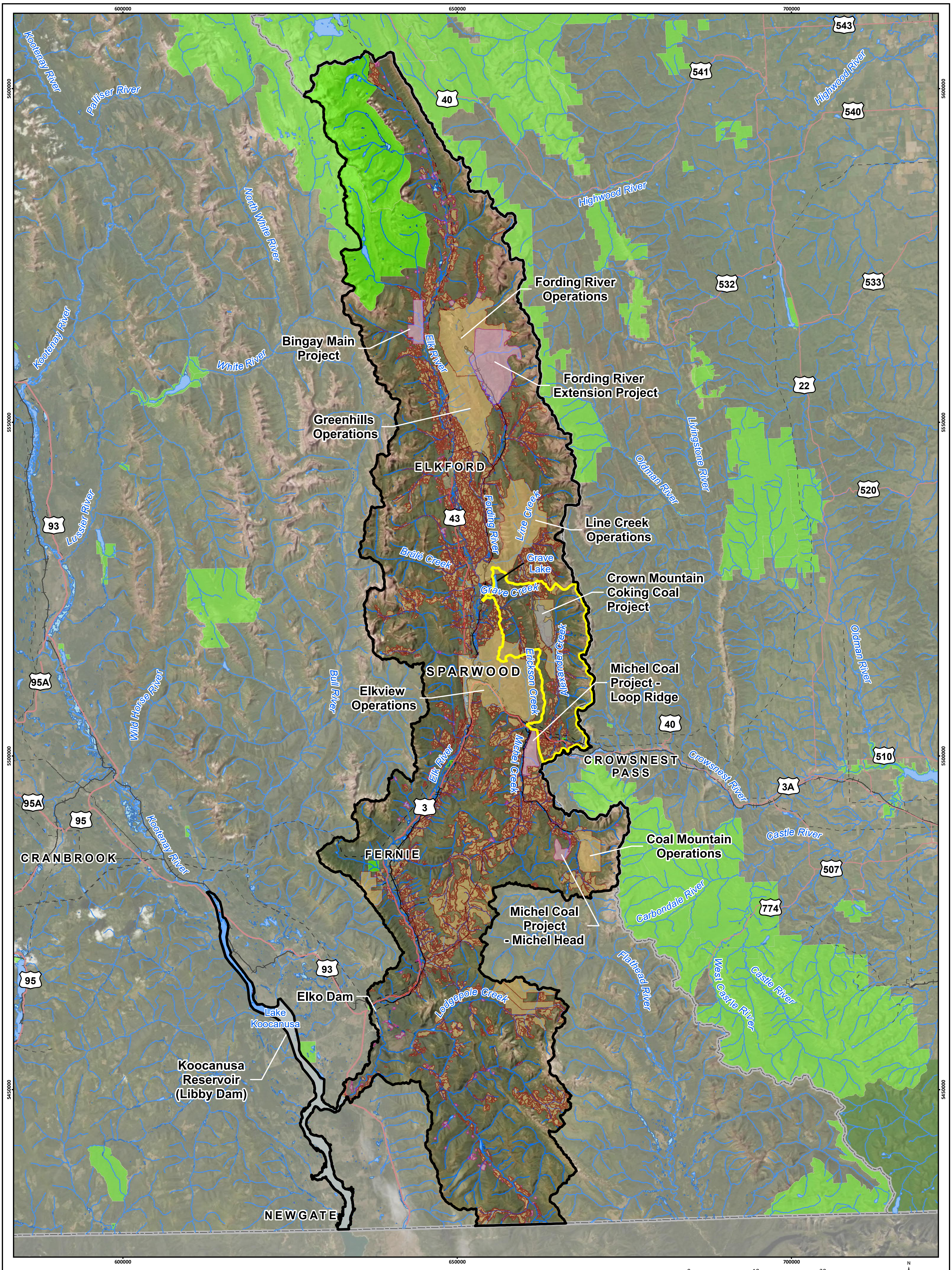
Table 10.6-1: Surface Water Quantity Interactions Matrix for Potential Cumulative Effects

Past, Present, or Reasonably Foreseeable Future Projects or Activities	Ranking of Potential Cumulative Effect	Justification / Rationale
Past or Present Projects or Activities that Have Been Carried Out		
Natural Resource Extraction – Mining (Past Projects)	I	The effects to surface water quantity from past mining projects are reflected in baseline conditions and are therefore implicitly considered in the assessment of cumulative effects.
Coal Mountain Operations	III	Current/ongoing mining operations have a potential for contributing to adverse cumulative effects on surface water quantity within the Aquatic RSA because of the associated land use and hydrologic changes.
Elkview Operations	II	
Line Creek Operations	II	
Fording River Operations	II	
Greenhill Operations	II	
Kootenay West Mine	I	The Kootenay West Mine Project does not spatially overlap with the Elk River watershed or Lake Koocanusa.
Elkhorn Quarry West (Windermere Mining Operations)	I	The Elkhorn Quarry West Project does not spatially overlap with the Elk River watershed or Lake Koocanusa.
Energy - Elko Dam	III	Operation of the Elko Dam has a potential for contributing to adverse cumulative effects on surface water quantity within the Aquatic RSA.
Koocanusa Reservoir	III	The Koocanusa Reservoir has the potential for contributing to adverse cumulative effects on surface water quantity within the southern portion of the Aquatic RSA.
Marten Lake Phosphate Exploration Project	I	This project is not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the project footprint is small and the associated hydrologic implications are understood to be minimal.
Forestry	II	Past and present forestry projects/activities have a potential for contributing to adverse cumulative effects on surface water quantity within the Aquatic RSA because of the associated land use and hydrologic changes.
Energy - Pipelines	I	Past and present pipeline projects/activities are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.

Past, Present, or Reasonably Foreseeable Future Projects or Activities	Ranking of Potential Cumulative Effect	Justification / Rationale
Energy - Electrical Transmission	I	Past and present electrical transmission projects/ activities are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Transportation	I	Past and present transportation projects/activities are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Recreation and Tourism	I	Past and present recreation and tourism projects/ activities are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Commercial, Residential, and Industrial Use	I	Past and present projects/activities related to commercial, residential, and industrial use are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Parks and Protected Areas	I	Past and present projects/activities related to parks and protected areas are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Agriculture	I	Past and present agriculture projects/activities are not expected to contribute to adverse cumulative effects on surface water quantity within the Aquatic RSA because the hydrologic implications are minimal.
Natural Processes or Events	I	Past and present natural processes or events are reflected in baseline conditions and are therefore implicitly considered in the assessment of cumulative effects.
Reasonably Foreseeable Future Projects or Activities That Will Be Carried Out		
Michel Coal Project	III	This proposed future mining project has the potential to contribute to adverse cumulative effects on surface quantity because of the change in land use and hydrology that could result from mine development and operations.
Grassy Mountain Coal Project	I	The Grassy Mountain Coal Project does not spatially overlap with the Elk River watershed or Lake Koocanusa.

Past, Present, or Reasonably Foreseeable Future Projects or Activities	Ranking of Potential Cumulative Effect	Justification / Rationale
Tent Mountain Mine Project	I	The Tent Mountain Mine Project does not spatially overlap with the Elk River watershed or Lake Koocanusa.
Fording River Extension Project	II	This proposed future mining project has the potential to contribute to adverse cumulative effects on surface quantity because of the change in land use and hydrology that could result from mine development and operations.
Bingay Main Project	II	This proposed future mining project has the potential to contribute to adverse cumulative effects on surface quantity because of the change in land use and hydrology that could result from mine development and operations.
Elan Hard Coking Coal Project	I	The Elan Hard Coking Coal Project does not spatially overlap with the Elk River watershed or Lake Koocanusa.
Climate Change	II	Climate change has the potential to impact surface water quantity through alterations to air temperature and precipitation patterns, affecting seasonal and annual stream flows.
Natural Processes or Events	I	Future natural processes or events such as floods have the potential to affect local and regional surface water quantity, as exemplified by the extreme flooding recorded in the Elk Valley in June 2013. These impacts are anticipated to persist for short periods of time and to be fully reversible and as such are not considered further in the assessment of cumulative effects.

Notes:
I – Residual Project effects do not act cumulatively with those of other past, present, or reasonably foreseeable future projects and/or activities. Not carried forward in the assessment.
II – Residual Project effects act cumulatively with those of other past, present, or reasonably foreseeable future projects and/or activities, but are unlikely to result in significant cumulative effects; or residual Project effects act cumulatively with existing significant cumulative effects but the Project will not measurably contribute to these cumulative effects on the VC. Carried forward in the assessment.
III – Residual Project effects act cumulatively with those of other past, present, or reasonably foreseeable future projects and/or activities, and may result in significant cumulative effects; or residual Project effects act cumulatively with existing significant cumulative effects and the Project may measurably contribute to adverse changes in the state of the VC. Carried forward in the assessment.



Crown Mountain Coking Coal Project

Figure 10.6-1
Present and Reasonably Foreseeable Projects and Activities with the Potential to Contribute to Cumulative Effects in the Aquatic RSA

LEGEND

Projects and Activities

- Certain (Present)
- Reasonably Foreseeable Future
- Aquatic Regional Study Area
- Aquatic Local Study Area
- Crown Mountain Coking Coal Project
- Highway
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- National Park
- British Columbia/ Alberta Border

0 10 20
Kilometres

Scale 1:525,000

N W E S

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada, Elk Valley Water Quality Plan.
Imagery Provided By ESRI.

Map Created By: RB
Map Checked By: HEB
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-24

Document Path: \\42dillon\CAD\GIS\2012 and Prior\126231 Crown Mountain\EA_Report\CumulativeEffects\SurfaceWater\SWQuantity\126231_CE_SWQn_PPRFfutureProjectsActivitiesRSA.mxd

10.6.3 Identification of Potential Cumulative Effects

A review of past, present, and reasonably foreseeable future projects or activities was conducted to identify potential cumulative interactions for surface water quantity within the Aquatic RSA. The results of the assessment are summarized as follows:

- Potential effects to surface water quantity from past mining projects are reflected in baseline conditions – therefore, these effects are implicitly considered in the Base Case for the assessment of cumulative effects;
- Existing and proposed linear infrastructure (i.e., electrical transmission, pipelines, and transportation) is not expected to result in a measurable contribution to adverse cumulative effects on surface water quantity;
- Other industries and land uses including agriculture and recreation and tourism account for a very small proportion of the Aquatic RSA and are not identified having the potential to contribute substantially to adverse cumulative effects on surface water quantity; and
- The projects and activities identified as having a potential to interact cumulatively with the predicted residual Project effects primarily include the currently ongoing and proposed mine operations, forestry, hydroelectric generating facilities, and reservoirs in the Aquatic RSA.

In summary, the projects and activities with a potential to adversely contribute to cumulative effects on surface water quantity are summarized in Table 10.6-2.

Table 10.6-2: List of Projects and Activities with Potential to Adversely Contribute to Cumulative Effects on Surface Water Quantity

Project/Activity	Project Life	Proponent	Watershed or Sub-Watershed
Coal Mountain Operations	Currently operating	Teck Resources Limited	Michel Creek
Elkview Operations	Currently operating	Teck Resources Limited	Grave/Alexander Creeks
Line Creek Operations	Currently operating	Teck Resources Limited	Line Creek
Fording River Operations	Currently operating	Teck Resources Limited	Fording River
Greenhill Operations	Currently operating	Teck Resources Limited	Elk/Fording Rivers
Energy - Elko Dam	Currently operating	BC Hydro	Elk River
Koocanusa Reservoir	Currently operating	US Army Corps of Engineers	Kootenay River
Forestry	Ongoing	Various	Various
Michel Coal Project	Proposed	NorthCoal	Michel Creek
Fording River Extension Project	Proposed	Teck Resources Limited	Fording River
Bingay Main Project	Proposed	Centermount Coal Limited	Elk River

10.6.4 Mitigation for Cumulative Effects

The mitigation strategy developed for Project effects is also applicable to the cumulative effects for surface water quantity. As described in Section 10.5.3, the mitigation plan involves a combination of Project design features, procedures, and practices aimed at reducing or eliminating Project-related effects to surface water quantity.

Implementation of the operational practices and procedures that are prescribed in the Site Water Management Plan (Chapter 33, Section 33.4.1.8) will be the primary means by which adverse effects to surface water quantity will be addressed. The Site Water Management Plan includes a combination of mitigation measures that will be executed and adapted to accommodate site conditions throughout the various phases of the Project.

For the purpose of the cumulative effects assessment, it is understood that similar mitigation measures have been adopted to minimize or eliminate potential surface water effects associated with other projects and activities that are currently operating, ongoing, or planned in the Aquatic RSA. In the case of other mine operations in the Elk Valley, this includes the implementation of appropriate best practices and measures that are intended to mitigate changes in surface water quantity. Similarly, the existing hydroelectric dams that have the potential to affect streamflow conditions in the Aquatic RSA (i.e., Elko, Libby Dam/Lake Koocanusa) have incorporated various design and operational mitigation strategies. In fact, the operation of these dams moderates the movement of surface water in the Aquatic RSA through storage and attenuation of streamflows.

Ongoing and continued collaboration between project proponents, government, Indigenous organizations, and other stakeholders is necessary to confirm that appropriate mitigation measures are adopted such that adverse cumulative effects on surface water quantity are minimized to a practical extent. Proactive mitigation strategies, monitoring programs, and data sharing are of critical importance to fulfil regional objectives, which are possible through working groups such as the Elk Valley Cumulative Effects Management Framework (EV-CEMF; 2018). Mitigation and management measures recommended by the EV-CEMF will be considered, as applicable, in the discussion of mitigation measures for cumulative effects on surface water quantity.

To determine whether additional mitigation measures are required to address potential cumulative effects to surface water quantity, a long-term hydrometric monitoring program will be implemented. Further details are provided in Section 10.7.

10.6.5 Characterization of Residual Cumulative Effects

The assessment of residual cumulative effects on surface water quality involves the consideration and evaluation of specific effects assessment criteria based on the degree (i.e., 'level') of potential Project effects. Similar to the Project effects assessment, the criteria used to characterize residual cumulative effects include duration, magnitude, geographic extent, frequency, reversibility, and context, as defined in Chapter 5, Section 5.3.4.5. The residual cumulative effects are determined based on the same significance thresholds as were established for residual Project effects as outlined in Section 10.5.1.

10.6.5.1 Base Case

The Base Case for surface water quantity was established through an assessment of streamflow conditions (i.e., predicted mean annual and mean monthly flows) at multiple locations in the Aquatic RSA. The Base Case accounts for all past and present projects/activities, and is intended to serve as the baseline conditions for the assessment of cumulative effects for surface water quantity. The Base Case for surface water quantity is described in Section 10.5.4.2.1 and further detailed in the Crown Mountain Flow and Water Quality Impact Assessment Modelling Technical Memo (Appendix 10-A; SRK, 2021).

10.6.5.2 Project Case

The Project Case includes all past and present projects or activities which have the potential for contributing to adverse cumulative effects on surface water quantity in the Aquatic RSA in combination with the effects of the Project. As listed in Table 10.6-1, there are multiple currently operating mine projects in the Elk Valley in addition to forestry activities and two hydroelectric dams/reservoirs, which have the potential to contribute to adverse cumulative effects on surface water quantity.

A quantitative assessment of cumulative effects on surface water quantity was undertaken through the preparation of a water balance and loading model for the Project Case. As demonstrated in Section 10.5.4.4, significant residual Project effects for surface water quantity are not predicted to occur beyond limited areas within the Aquatic LSA. A summary of the assessment of cumulative effects related to each of the Project residual effects for surface water quantity is provided below.

10.6.5.2.1 Changes to Surface Water Quantity due to Site Construction Activities

The residual cumulative effects to surface water quantity due to site construction activities in combination with the effects of other past and present projects or activities are characterized as follows:

- Duration: Short-term, the potential for adverse effects to surface water quantity will generally be limited to the Construction and Pre-Production phase of the Project (approximately 18 months).
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site construction activities are completed (including timber harvesting, clearing and grubbing, and construction of mine site roads and facilities).
- Reversibility: Reversible long-term, changes in surface water quantity resulting from site construction activities are anticipated to be potentially reversible as the site is reclaimed.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.5.2.2 Changes to Surface Water Quantity due to Operational Activities

The residual cumulative effects to surface water quantity due to site operational activities in combination with the effects of other past and present projects or activities are characterized as follows:

- Duration: Long-term, the potential for adverse effects to surface water quantity resulting from operational activities will generally be limited to Operations phase of the Project.
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site operations activities are ongoing (including mining activities, drainage modifications, and operation of Main Sediment Pond).
- Reversibility: Irreversible, changes in surface water quantity resulting from site operational activities are anticipated to be potentially irreversible until after the Post-Closure phase.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.5.2.3 Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities

The residual cumulative effects to surface water quantity due to mine closure and reclamation activities in combination with the effects of past and present projects or activities are characterized as follows:

- Duration: Permanent, the potential for adverse effects to surface water quantity is predicted to extend beyond the Post-Closure phase;
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA;
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa);
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously to some extent through the Reclamation and Closure and Post-Closure phases;
- Reversibility: Irreversible, changes in surface water quantity resulting from site operation activities are anticipated to be potentially irreversible until after the Post-Closure phase; and
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.5.3 Future Case

The assessment of cumulative effects for surface water quantity under the Future Case considers the potential for substantial overlapping of effects with reasonably foreseeable future projects or activities. As discussed above, there are four proposed coal mine projects that are currently contemplated within the Elk Valley, together with ongoing/future forestry operations. Sufficient data are not available to facilitate a quantitative assessment of cumulative effects on surface water quantity in the Aquatic RSA. Notwithstanding, it is expected that these proposed mine operations will require appropriate mitigation strategies including best practices to minimize or eliminate effects on surface water quantity.

There is a potential for cumulative surface water quantity effects in the lower reaches of Michel Creek from the following ongoing and proposed projects/activities:

- Elkview Operations – Teck Resources Limited (currently operating);
- Coal Mountain Operations – Teck Resources Limited (care and maintenance);
- Crown Mountain Coking Coal Project – NWP Coal Canada Ltd (proposed); and
- Michel Coal Project – North Coal (proposed).

Portions of the existing Elkview Operations mine and Crown Mountain Project footprint are located within the Alexander Creek watershed, which contributes surface flows to Michel Creek at their confluence (located near the crossing of Highway 3). The existing Coal Mountain Operations and proposed Michel Coal Project are located within the headwater area of the Michel Creek watershed.

In addition to the above mining operations, a considerable amount of forestry activity (i.e., logging) has occurred in the Michel Creek watershed, with the possibility for more in the future. These past, present, and proposed future projects/activities have the potential for cumulative/overlapping surface water quantity effects to Michel Creek and downstream portion of the Elk River.

Several additional currently operating and proposed coking coal mines are located in the northern portion of the Elk Valley, which together with forestry activities, account for much of the major projects/activities with the potential to adversely contribute to cumulative effects on surface water quantity. There is a potential for cumulative/overlapping effects to occur at the confluence of the Elk River and Michel Creek as a result of the following projects/activities, in addition to those listed above:

- Line Creek Operations – Teck Resources Limited (currently operating);
- Fording River Operations – Teck Resources Limited (currently operating);
- Greenhill Operations – Teck Resources Limited (currently operating);
- Bingay Main Project – Centermount Coal Limited (proposed); and
- Fording River Extension Project – Teck Resources Limited (proposed).

The total footprint of the current and proposed projects/activities in the Elk Valley represents a relatively small proportion of the overall Elk River watershed area. Accordingly, the cumulative/overlapping effects on surface water quantity in the Aquatic RSA are expected to be minimal to non-detectable.

The results of the quantitative assessment that was undertaken using the water balance and loading model for the Project Case demonstrate that the impacts of climate change will have a substantial influence on the timing and magnitude of streamflows within the receiving watercourses in the Aquatic RSA. It is anticipated that the potential cumulative effects to surface water quantity that could result from the proposed projects/activities will be minor by comparison.

A summary of the assessment of cumulative effects related to each of the Project residual effects for surface water quantity is provided below.

10.6.5.3.1 Changes to Surface Water Quantity due to Site Construction Activities

The residual cumulative effects to surface water quantity due to site construction activities in combination with the effects of other reasonably foreseeable future projects or activities are characterized as follows:

- Duration: Short-term, the potential for adverse effects to surface water quantity will generally be limited to the Construction and Pre-Production phase of the Project (approximately 18 months).
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site construction activities are completed (including timber harvesting, clearing and grubbing, and construction of mine site roads and facilities).
- Reversibility: Reversible long-term, changes in surface water quantity resulting from site construction activities are anticipated to be potentially reversible as the site is reclaimed.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.5.3.2 Changes to Surface Water Quantity due to Operational Activities

The residual cumulative effects to surface water quantity due to site operational activities in combination with the effects of other reasonably foreseeable future projects or activities are characterized as follows:

- Duration: Long-term, the potential for adverse effects to surface water quantity resulting from operational activities will generally be limited to Operations phase of the Project.
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA.
- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously as site operations activities are ongoing (including mining activities, drainage modifications, and operation of Main Sediment Pond).
- Reversibility: Irreversible, changes in surface water quantity resulting from site operational activities are anticipated to be potentially irreversible until after the Post-Closure phase.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.5.3.3 Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities

The residual cumulative effects to surface water quantity due to mine closure and reclamation activities in combination with the effects of other reasonably foreseeable future projects or activities are characterized as follows:

- Duration: Permanent, the potential for adverse effects to surface water quantity is predicated to extend beyond the Post-Closure phase.
- Magnitude: Low, the potential for negative effects to surface water quantity is low at all of the assessment nodes in the Aquatic RSA.

- Geographic Extent: Local, potential effects to surface water quantity are restricted to the Aquatic LSA and are non-detectable in the Aquatic RSA (Elk River and Lake Koocanusa).
- Frequency: Continuous, the potential for adverse effects to surface water quantity occurs continuously to some extent through the Reclamation and Closure and Post-Closure phases.
- Reversibility: Irreversible, changes in surface water quantity resulting from site operation activities are anticipated to be potentially irreversible until after the Post-Closure phase.
- Context: Neutral, for the purpose of the hydrology/surface water quantity assessment, there is not a defined measure for context – accordingly, a neutral value was assigned. Given that surface water quantity is an intermediate component in the effects pathway, the assessment results presented herein are carried forward for other aquatics related VCs including fish and fish habitat.

10.6.6 Determination of Significance of Residual Cumulative Effects

As discussed in Section 10.5.4, measurable residual Project effects for surface water quantity are not predicted to occur beyond limited areas within the Aquatic LSA. The residual effects of the Project on surface water quantity were found to vary with respect to magnitude and were generally limited to the upper reaches of the receiving watercourses. Accordingly, no measurable residual effects for surface water quantity are predicted beyond the Aquatic LSA boundary, within the remainder of the Aquatic RSA. The residual effects of the Project on surface water quantity during all phases of the Project were therefore rated not significant.

The water balance and loading model that was prepared for the Aquatic RSA includes the cumulative interactions with effects from ongoing mining operations, forestry activities, and hydroelectric dams in the Elk Valley. As summarized in Section 10.5.4.4, the results of model indicate that the predicted change in surface water quantity for the Project Case is negligible to non-detectable (i.e., less than 1% compared to baseline), when considering mean annual and mean monthly flows during all Project phases at multiple nodes in the Aquatic RSA.

With respect to the Future Case, a quantitative assessment was not possible due to the unavailability of adequate information related to the reasonably foreseeable future projects in the Aquatic RSA (i.e., proposed mine site development details, water management plan, etc.). However, it is understood that mitigation measures and appropriate operational practices are in place for all of the current coal mines in the Elk Valley, and similarly it is expected that an appropriate mitigation strategy would be developed and implemented for the proposed future coal mining operations.

In light of the above, and in consideration of planned mitigation and best practices, the residual cumulative effects of the Project in combination with those of other past, present, or reasonably foreseeable future projects or activities on surface water quantity during all phases are considered not significant.

Likelihood and Confidence

A characterization of likelihood is not required for cumulative effects from Project activities that are determined to be not significant.

Confidence considers the availability and reliability of data and analytical methods used in the assessment of effects. The long-term water balance and loading (GoldSim) model results are considered to provide a reasonable prediction of the magnitude, timing, and extent of surface water quantity effects related to past and present projects and activities in the Aquatic RSA.

The availability of information related to reasonably foreseeable future projects and activities in the Aquatic RSA is limited and, thus, a quantitative assessment of cumulative impacts on surface water quantity was not possible. Accordingly, there is lower confidence for the Future Case. This significance prediction is assigned a moderate level of confidence for the Future Case, but a high level of confidence for the Base Case and Project Case.

10.6.7 Summary of Cumulative Effects Assessment

Residual cumulative effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence are summarized in Table 10.6-3. As indicated, there are no significant residual cumulative effects to surface water quantity anticipated as a result of the Project.

Table 10.6-3: Summary of Residual Cumulative Effects on Surface Water Quantity

Residual Cumulative Effect	Project Phase(s)	Mitigation Measures	Summary of Cumulative Residual Effects Characterization	Significance (Significant, Not Significant)	Confidence (High, Moderate, Low)
Changes to Surface Water Quantity due to Site Construction Activities	Construction and Pre-Production	Site Water Management Plan	Duration: Short-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Reversible long-term Context: Neutral	Not Significant	Moderate to High
Changes to Surface Water Quantity due to Operational Activities	Operations	Site Water Management Plan	Duration: Short-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Irreversible Context: Neutral	Not Significant	Moderate to High
Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities	Reclamation and Closure, Post-Closure	Site Water Management Plan, Site Reclamation, and Reclamation Monitoring	Duration: Short-term Magnitude: Low Geographic Extent: Local Frequency: Continuous Reversibility: Irreversible Context: Neutral	Not Significant	Moderate to High

10.7 Follow-up Strategy

As required by the Canadian Environmental Assessment Act (2012), a follow-up program must be defined to verify the effects predictions or the effectiveness of mitigation. In this light, a comprehensive hydrometric monitoring program will be developed and implemented to facilitate an ongoing examination of streamflow conditions within the receiving watercourses downstream of the Project footprint.

The proposed hydrometric monitoring program (Chapter 33, Section 33.4.1.8.9) will involve the installation of a water level gauge station at the locations identified in Table 10.7-1, which will consist of a water level logger and staff gauge. In addition, stream gauging will be conducted periodically to measure discharge rates such that a rating curve (water level vs. flow relationship) can be established at each location.

Table 10.7-1: Summary of Proposed Hydrometric Monitoring Locations

Watercourse	Location	Upstream Mine Project/Activity
Grave Creek	Upstream of Harmer Creek	• Crown Mountain Coal Coking Project (NWP)
	Upstream of Elk River	• Crown Mountain Coal Coking Project (NWP) • Elkview Operations (Teck)
Alexander Creek	Upstream of Erickson Creek	• Crown Mountain Coal Coking Project (NWP)
	Upstream of Michel Creek	• Crown Mountain Coal Coking Project (NWP) • Elkview Operations (Teck)
Michel Creek	Downstream of Alexander Creek	• Crown Mountain Coal Coking Project (NWP) • Elkview Operations (Teck) • Coal Mountain Operations (Teck) • Michel Coal Project (North Coal)

The monitoring program will also involve the installation and operation of a climate station to collect meteorological data that is representative of the Project footprint.

The results of the monitoring program will be relied upon to determine whether additional mitigation measures or adaptive management strategies are needed.

10.8 Summary and Conclusions

The Crown Mountain Coking Coal Project (the Project) will involve changes in land use and hydrology which could result in a residual effect on surface water quantity. The thresholds for determining the significance of residual effects for the surface water quantity assessment are based on changes in water quantity (i.e., streamflow) conditions within the receiving drainage environment.

For the purpose of the assessment, a significant residual adverse environmental effect is defined as a change in surface water quantity that would result in the following:

1. An increase in streamflows within the receiving watercourses which would cause a higher potential for flooding or erosion and related impacts to downstream lands or infrastructure; or
2. A reduction in streamflows within the receiving watercourses which would cause changes to the fluvial regime and geomorphic conditions.

To characterize the residual effects on surface water quantity, a long-term water balance and loading model was developed which examined multiple long-term scenarios to evaluate streamflow characteristics at key locations within the Aquatic LSA and Aquatic RSA under existing and proposed (i.e., mine development) land use conditions, in addition to climate change conditions. The model also incorporated proposed mitigation measures which will impact surface water quantity.

Based on the evaluation of potential Project effects on surface water quantity, potential residual effects that may remain after implementation of proposed mitigation measures include:

- Changes to Surface Water Quantity due to Site Construction Activities;
- Changes to Surface Water Quantity due to Operational Activities; and
- Changes to Surface Water Quantity due to Mine Closure and Reclamation Activities.

Based on the results of the assessment, the residual effects on surface water quantity related to site construction activities, operational activities, and mine closure and reclamation activities are considered not significant. The residual effects assessment characterization includes several potential sources of uncertainty and, therefore, this significance prediction is assigned a moderate level of confidence.

A cumulative effects assessment was undertaken for the surface water quantity VC because there is a possibility that potential Project residual effects may remain after the implementation of proposed mitigation measures. The cumulative effects assessment involved the identification of past, present, and reasonably foreseeable future projects or activities followed by an evaluation to characterize cumulative residual effects on surface water in the Aquatic RSA under various temporal cases (Base Case, Project Case, and Future Case). The assessment of cumulative effects under the Project Case includes all past and present projects/activities which have the potential for contributing to adverse cumulative effects on surface water quantity, while the Future Case considers the potential for substantial overlapping of effects with reasonably foreseeable future projects or activities.

The water balance and loading model that was prepared for the Aquatic RSA includes the cumulative interactions with effects from ongoing mining operations, forestry activities, and hydroelectric and reservoirs dams in the Elk Valley. The results of model indicate that the predicted change in surface water quantity for the Project Case is negligible to non-detectable (i.e., less than 1% compared to baseline), when considering mean annual and mean monthly flows during all Project phases at multiple nodes in the Aquatic RSA.

With respect to the Future Case, a qualitative assessment was not possible due to the unavailability of adequate information related to the reasonably foreseeable future projects in the Aquatic RSA (i.e., proposed mine site development details, water management plans, etc.). However, it is understood that mitigation measures and appropriate operational practices are in place for all of the current coal mines in the Elk Valley, and similarly it is expected that an appropriate mitigation strategy would be developed and implemented for the proposed future coal mining operations.

In summary, the residual cumulative effects of the Project in combination with those of other past, present, or reasonably foreseeable future projects or activities on surface water quantity during all phases are considered not significant. This significance prediction is assigned a moderate to high level of confidence. The availability of information related to reasonably foreseeable future projects and activities in the Aquatic RSA is limited and a quantitative assessment of cumulative impacts on surface water quantity was not possible – accordingly, there is lower confidence for the Future Case. As such, this significance prediction is assigned a moderate level of confidence for the Future Case, but a high level of confidence for the Base Case and Project Case.

A Project-specific follow-up program is necessary to verify the effects predictions and the effectiveness of mitigation measures, which will improve the moderate level of confidence assigned to the prediction of residual effects (Project and cumulative) on surface water quantity. The follow-up program includes the implementation of a hydrometric monitoring program to collect streamflow data at strategic locations within the receiving watercourses downstream of the Project footprint. In addition, monitoring program will involve the installation and operation of a climate station to collect meteorological data that is representative of the Project footprint. The results of the monitoring program will be relied upon to determine whether additional mitigation measures or adaptive management strategies are needed.

10.9 References

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