BC EAO EAC Application – Tenas Project

Section 10.0 Effects of the Environment on the Project

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VERSION 1.0

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Tenas Project

Section 10.0 Effects of the Environment on the Project

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Abbreviations and Acronyms

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
7Q10	7-day low flow for a 1-in-10-year return period
7Q2	average annual 7-day low flow
AIR	Application Information Requirements
AQMP	Air Quality Management Plan (S13.0-C2)
AR5	Fifth Assessment Report
BC	British Columbia
BC MFLNRORD	British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development
BC MOE	British Columbia Ministry of Environment
C	Chapter
CCOHS	Canadian Centre for Occupational Health and Safety
CMIP5	Coupled Model Intercomparison Project
CNFDB	Canadian National Fire Database
CNR	Canadian National Railway
CO^2	carbon dioxide
CPP	Coal Processing Plant
DCP	dry chemical powder
EAC	Environmental Assessment Certificate
ECCC	Environment and Climate Change Canada
EMP	Explosives Management Plan (S13.0-C6)
ERT	Emergency Response Team
EOC	Emergency Operations Centre
FSR	Forest Service Road
GCMs	Global Circulation Models
GHG	greenhouse gas
GovBC	Government of British Columbia
g	gravity
ICLR	Institute of Catastrophic Loss Reduction
IPCC	Intergovernmental Panel on Climate Change
LSA	Local Study Area
MAAT	mean annual air temperature
MAP	mean annual precipitation
MERP	Mine Emergency Response Plan (S13.0-C9)
MIC	Mine Infrastructure Complex
MWMP	Minesite Surface Water Management Plan (S13.0-C11)

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
NLSI	National Lightning Safety Institute
NOAA	National Oceanic and Atmospheric Administration
NRCAN	Natural Resources Canada
OHSP	Occupational Health and Safety Program (S13.0-C13)
PAG	potentially acid generating
PCIC	Pacific Climate Impacts Consortium
PPE	personal protective equipment
Project	Tenas Project
PGA	Peak Ground Acceleration
PMF	probable maximum flood
PVC	polyvinyl chloride
Q50	1-in 50-year return period
RDBN	Regional District of Bulkley-Nechako
ROW	right-of-way
RCP	Representative Concentration Pathway
S	Section
SRK	SRK Consulting (Canada) Ltd.
TAC	Tenas Access Corridor
TARP	Trigger Action Response Plan
TSC	terrain stability classes
USGS	United States Geological Survey
VC	Valued Component
VMP	Vegetation Management Plan (S13.0-C18)
WGEN	weather generator
WRSA	Wildlife Regional Study Area
WSC	Water Survey of Canada

Units of Measure

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
°	degree
°C	degrees Celsius
%	percent
cm	centimetre
>	greater than
ha	hectare

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
ka BP	kilo annum (1,000 years) Before Present
km	kilometre
km/hr	kilometres per hour
kPa	kilopascal
<	less than
m	metre
m/s	metres per second
m^3	cubic metres
m^3/s	cubic metres per second
mm	millimetre
masl	metres above sea level
mm	millimetres
W/m^2	watts per square metre

EXECUTIVE SUMMARY

This section of the Environmental Assessment Certificate (EAC) Application evaluates the potential effects of the environment on the Tenas Project (Project) which may be associated with effects to a Project Valued Component (VC).

The potential for the environment to affect the Project has considered the frequency of environmental events, as described in the approved AIR for the Project, in the region and the Project Area. The events deemed to have possible consequences on the proposed Project included the following:

- potential impacts of climate change;
- extreme weather and weather-related events (e.g., heavy precipitation, extreme temperatures, and high winds);
- flood events;
- lightning strikes;
- geohazards;
- seismic activities/events; and
- forest fire.

The risks to VCs from potential effects to the Project were evaluated using a risk approach that considers the Likelihood (probability of occurrence) of Project effects on VCs and the consequences (severity of occurrence) of Project effects on VCs. The overall risk for each scenario was evaluated based on a combination of probability and consequence. A conclusion on the overall risk to the Project and the risk to VCs was determined.

The evaluation of the risk to VCs from effects to the Project was based on the implementation of the design and management measures proposed for each of the environmental events. Design standards for buildings, structures, infrastructure, and Minesite landforms have been implemented to avoid or minimize the risks to the Project, and the layout of the Project has avoided geohazards to the extent possible. Design standards have considered predicted extreme weather events due to climate change. Where risks have been identified, measures are in place to monitor for the occurrence of the event where possible, and initiate preparatory measures, for example for forest fires. The **Mine Emergency Response Plan (Section [S] 13.0-Chapter [C] 9) (MERP)** addresses a response system and measures to implement should the event occur, and TCL has initiated engagement with local emergency service providers to coordinate capacity to respond to potentially large events.

With mitigation to avoid effects of the environment on the Project, the Likelihood of effects to VCs is considered **Rare** or **Unlikely**, with the exception of geohazard risk for the Goathorn Creek crossing (a necessary access point) where active and historic landslide escarpments are present, and stability issues are likely. Mitigation and monitoring are in place to manage this risk. Consequences to the Project and to VCs as a result of the effects on the Project were evaluated as **Negligible** to **Major**, with the highest consequences evaluated where there was a potential for employee injury or a closure of the Minesite (Human Health, and Economic Development VCs). Based on the Likelihood and Consequences, no high risks were determined, and the evaluated risks ranged from **Very Low** to **Moderate**.

1. INTRODUCTION

This section of the Environmental Assessment Certificate (EAC) Application evaluates the potential effects of the environment on the Tenas Project (Project) which may be associated with effects to a Project Valued Component (VC).

Effects on VCs as a result of potential environmental events will be mitigated by Project design measures, the mitigation provided by TCL for the Project-related effects for each of the VCs discussed in the **EAC Application Section (S) 4.0** through **8.0**, and the environmental management plans in **S13.0**. In addition, the mitigation in **S9.0 Accidents and Malfunctions** is applicable where environmental events trigger effects similar to an accident and/or malfunction.

In particular, the **Mine Emergency Response Plan (S13.0-C9) (MERP)** sets up a response system and identifies responsibilities for emergencies related to onsite events and environmental emergencies. The MERP includes responses for casualties, forest fires, and floods, as well as evacuation plans, emergency aid agreements, consultation with potentially impacted parties and development of notification policies, communication protocols and post-event reporting.

Where possible, TCL will support emergency response efforts initiated by local government to manage the effects of environmental events in the Project Area and vicinity. For example, the Protective Services Department of the Regional District of Bulkley-Nechako (RDBN) is responsible for facilitating the RDBN's Emergency Management Program, 911 Service, Rural Fire Protection, and Emergency Response. During an emergency, the RDBN activates its Emergency Operations Centre (EOC) to support residents. (RDBN 2021). Additional information on local and regional emergency services is provided in **S6.0-C3 Infrastructure and Services VC**.

1.1 Scope of the Evaluation

The scope for the assessment of the effects of the environment on the Project is described in the Project's approved Application Information Requirements (AIR) (BC EAO 2022). The AIR states that the EAC Application must consider:

- the environmental factors deemed to have possible consequences on the proposed Project, including, but not necessarily limited to, consideration of natural hazards such as:
  - potential impacts of climate change (e.g., temperature rise, and trend of increasing precipitation);
  - extreme weather and weather-related events (e.g., heavy precipitation, extreme temperatures, and high winds);
  - flood events;
  - lightning strikes;
  - geohazards including slope stability (debris torrents, rock fall and avalanche);
  - seismic activities/events;
  - forest fire;
- a description of any changes or effects on the proposed Project that may be caused by the above-mentioned environmental factors;
- the Likelihood and Consequence of the changes or effects to relevant VCs;

- practical mitigation measures, including design strategies and environmental contingency plans, to avoid or minimize the Likelihood and Consequence of the effects of the environment on the proposed Project; and
- a conclusion about the potential risk of an effect of the environment on the proposed Project and to relevant VCs.

The region is located 150 kilometres (km) east of the closest active volcanic zone, the Stikine Volcanic Belt, which extends northward from Prince Rupert (Natural Resources Canada [NRCAN] 2021a). Therefore, effects from volcanic activity are not expected to occur for the Project and volcanic events were excluded from the scope.

The risk evaluation in this EAC Application presents mitigation measures prior to the determination of the Likelihood and Consequence of the effects to VCs. The mitigation measures, including design strategies, are drawn from the measures integrated into the Project design and environmental management plans presented in **S13.0**, Project Description as presented in **S1.0 Overview of Project Proponent Description**. Because they are integral to the Project, the evaluation assumes their implementation for the determination of Likelihood and Consequence. No contingency mitigation over and above that proposed for the Project and the management plans included in this EAC Application is considered necessary to address the effects of the environment to relevant VCs.

1.2 Methods

The Project may be affected by environmental factors and associated natural events. The risks to VCs from these effects is evaluated using a risk approach that parallels the risk assessment method applied in **S9.0 Accidents and Malfunctions**. The approach to determining the risks to VCs from the effects to the Project includes these steps for each factor:

- The environmental factor or event is described;
- Effects to the Project that may be caused by an environmental factor are described;
- Effects to the VCs that may be caused by the effects to the Project (referred to herein as “Project effects”) are described;
- Mitigation measures based on integrated Project design strategies and environmental management plans are identified;
- Risks to VCs are assessed:
  - The Likelihood (probability of occurrence) of Project effects on VCs is evaluated;
  - The Consequences (severity of occurrence) of Project effects on VCs are evaluated;
  - The overall risk for each scenario is evaluated by selecting the risk category based on a combination of probability and consequence; and
- A conclusion on the overall risk to the Project and the risk to VCs is presented.

Risk is derived from the product of Likelihood and Consequence. Likelihood is based on an assessment of the frequency of events based on experience and professional judgment. Likelihood is ranked from Rare to Almost Certain. The severity of the consequence is based on the description of effects to VCs based on mitigation and management measures, and the characteristics of the VCs. Likelihood and Consequence are combined in a risk matrix to establish risk categories ranging from Negligible to Severe (**Figure 1.2-2**). Risks in the highest categories are considered non-routine and would receive additional planning, employee training, and management scrutiny, as appropriate.

Figures 1.2-1 and 1.2-2 below provide the Likelihood and Consequence definitions used for the risk assessment. The risk assessment ratings are summarized in **Figure 1.2-3**.

Likelihood	**Almost Certain**	The unwanted event has occurred frequently: occurs in order of one or more times per year and is likely to reoccur within one (1) year
	Likely	The unwanted event has occurred infrequently: occurs in order of less than once per year and is likely to reoccur within three (3) years
	May	The unwanted event has happened in the business at some time or could happen within five (5) years
	Unlikely	The unwanted event has happened in the business at some time or could happen within 15 years
	Rare	The unwanted event has never been known to occur in the business or it is highly unlikely that it will occur within 25 years.

Figure 1.2-1: Summary of Likelihood definitions

Consequence Rating	Harm to people	Environmental Impact	Business Interruption/ Material Damage	Legal & Regulatory	Impact on Reputation/Social/ Community	Effects on Environment
Negligible	First aid case/exposure to minor health risk	Minimal environmental harm	No disruption to operation, 5% loss of budgeted operating profit	Low level legal issue	Slight impact – public awareness may exist but no public concern	**Biophysical Environment:** Resulting adverse effects are barely to not detectable, of very limited extent, and can be reversed in two days or less. **Human Environment:** Resulting adverse effects are not detectable or are in the normal range of variability in the human environment.
Minor	Medical treatment case/exposure to major health risk	Material environmental harm – incident remediable short term	Brief disruption to operation, 10% loss of budgeted operating profit/listed assets	Minor legal issue, noncompliance and breeches of the law	Limited impact – local public concern	**Biophysical Environment:** Resulting adverse effects are barely detectable, and can be reversed in one month or less, or are low extent. **Human Environment:** Resulting adverse effects are detectable but are not likely to be experienced at the community level.
Moderate	Lost time injury/reversible impact on health	Serious environmental harm – incident remediable within LOM	Partial shutdown, 15% loss of budgeted operating profit/listed assets	Serious breach of law/investigation/repo rt to authority prosecution and/or moderate penalty	Considerable impact - regional public concern	**Biophysical Environment:** Resulting in lethal and/or sub-lethal effects at the individual level indistinguishable from natural variation or resulting adverse effects are detectable and can be reversed in one year or less. **Human Environment:** Adverse effects would result in demonstrable change and are possible at the community-wide level but remain within historic norms and present no or a minor management challenge.
Major	Single fatality or loss of quality of life/irreversible impact on health	Major environmental harm – incident remediable post LOM	Partial loss of operation, 20% loss of budgeted operating profits/listed assets	Major breech of the law, considerable prosecution and penalties	National impact – national public concern	**Biophysical Environment:** Resulting in some structural and functional changes at the population level above natural variation, or resulting adverse effects occur regionally and can be reversed in 10 years or less. **Human Environment:** Adverse effects would result in changes beyond historical norms and present a moderate management challenge.
Severe	Multiple fatalities/impact on health ultimately fatal	Extreme environmental harm – incident irreversible	Substantial or total loss of operation, 25% loss of budgeted operating profit/listed assets	Very considerable penalties and prosecutions. Multiple law suits and jail terms	International impact – International public concern	**Biophysical Environment**: Resulting in structural and functional changes at the population level to an extent which could potentially result in severe changes at the community and ecosystem levels, or resulting adverse effects occur regionally and will take more than 10 years to reverse. **Human Environment:** Adverse effects would result in changes beyond historical norms and present a major management challenge. One or more fatalities may occur.

Figure 1.2-2: Summary of Consequence definitions

		Hazard Effect/Consequence				
		SEVERE	**MAJOR**	**MODERATE**	**MINOR**	**NEGLIGIBLE**
Likelihood	**ALMOST CERTAIN**	CRITICAL	VERY HIGH	HIGH	MEDIUM	LOW
	LIKELY	VERY HIGH	HIGH	MEDIUM	MEDIUM	LOW
	MAY	HIGH	MEDIUM	MEDIUM	MEDIUM	VERY LOW
	UNLIKELY	MEDIUM	MEDIUM	MEDIUM	LOW	VERY LOW
	RARE	MEDIUM	LOW	LOW	VERY LOW	NEGLIGIBLE

Figure 1.2-3: Summary of Risk Assessment ratings

2. CLIMATE CHANGE

2.1 Climate Change Conditions

Climatic proxy records such as lake sediments, ice cores, and tree rings are used to reconstruct climate before instrumental records exist. At the last glacial maximum, from 25 to 14 thousand years before present (ka BP), ice sheets covered the entirety of northern North America (Bradley 1999). British Columbia (BC) was largely covered by the Cordilleran Ice Sheet until deglaciation began around 14 ka BP. Deglaciation ended around 10 ka BP, and temperatures largely cooled until the end of the Little Ice Age, which ended in the mid-19th century (Walker and Sydneysmith 2007). Air temperatures have warmed since the end of the 600-year long Little Ice Age, which initiated continuing widespread glacial retreat at lower elevations in the province.

Beginning in the early-to-mid-20th century, instrumental meteorological data sets were of sufficient number and quality to produce province-wide climatic records. From 1900 to 2013, air temperature increased by 1.4 degrees Celsius (˚C) per century (British Columbia Ministry of Environment [BC MOE] 2016).

Increases in global air temperatures have been documented over the last several decades and this warming is expected to continue (Intergovernmental Panel on Climate Change [IPCC] 2013). Trends in precipitation show an increase in mean annual precipitation (MAP) as well as an increase in the intensity and frequency of heavy precipitation events. However, confidence in precipitation trends is lower than for air temperature. There is increased uncertainty associated with projections of local-scale effects and changes associated with vegetation, streamflow, glaciers, and wildfire.

Climate change assessment for the Project was completed using the fifth version of the Coupled Model Intercomparison Project (CMIP5). The purpose of CMIP5 is to provide a database of global coupled ocean-atmosphere general circulation model simulations using standardized boundary conditions and provide simulations for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013, 2014).

Climate change scenarios were evaluated considering three (3) different Representative Concentration Pathways (RCP): 2.6; 4.5; and 8.5. The RCPs are defined based on how much greenhouse gases are expected to be emitted in the years to come where the possible range of radiative forcing values for RCP 2.6, RCP 4.5, and RCP 8.5 by year 2100 is 2.6, 4.5 and 8.5 Watts per square metre (W/m^2) respectively. These three (3) scenarios are among the RCPs adopted by the IPCC for the Fifth Assessment Report and assume that global anthropogenic forces are not constant in time (IPCC 2014).

Environment and Climate Change Canada (ECCC) provides access to monthly gridded global climate data (precipitation and air temperature) from 29 CMIP5 models for the period of 1900 to 2100, with historical results from 1900 to 2005 and forecast results from 2006 to 2100. The median response of the ensembled models, for each RCP, is also provided and was used for this analysis. Note that the CMIP5 ensemble results do not differentiate between emission scenarios (RCPs) prior to 2006. Data for the Project location were obtained and processed to evaluate predicted trends up to year 2100, deemed the maximum reasonable prediction range (IPCC 2014).

2.1.1 Climate Change and Air Temperature Conditions

Projected climate change effects were evaluated on an annual basis, relative to a defined baseline period for three (3) consecutive 30-year forecast periods, defined as follows:

- baseline period from 1981 to 2010 (CMIP5), centred on 1995;
- first forecast period from 2011 to 2040 (CMIP5), centred on 2025;
- second forecast period from 2041 to 2070 (CMIP5), centred on 2055; and
- third forecast period from 2071 to 2100 (CMIP5), centred on 2085.

The mean annual air temperature (MAAT) from the Project record during the baseline period, as well as the historical CMIP5 ensemble results over the same period and the forecasted MAAT for the three (3) different RCP scenarios are presented in **Figure 2.1 1.**

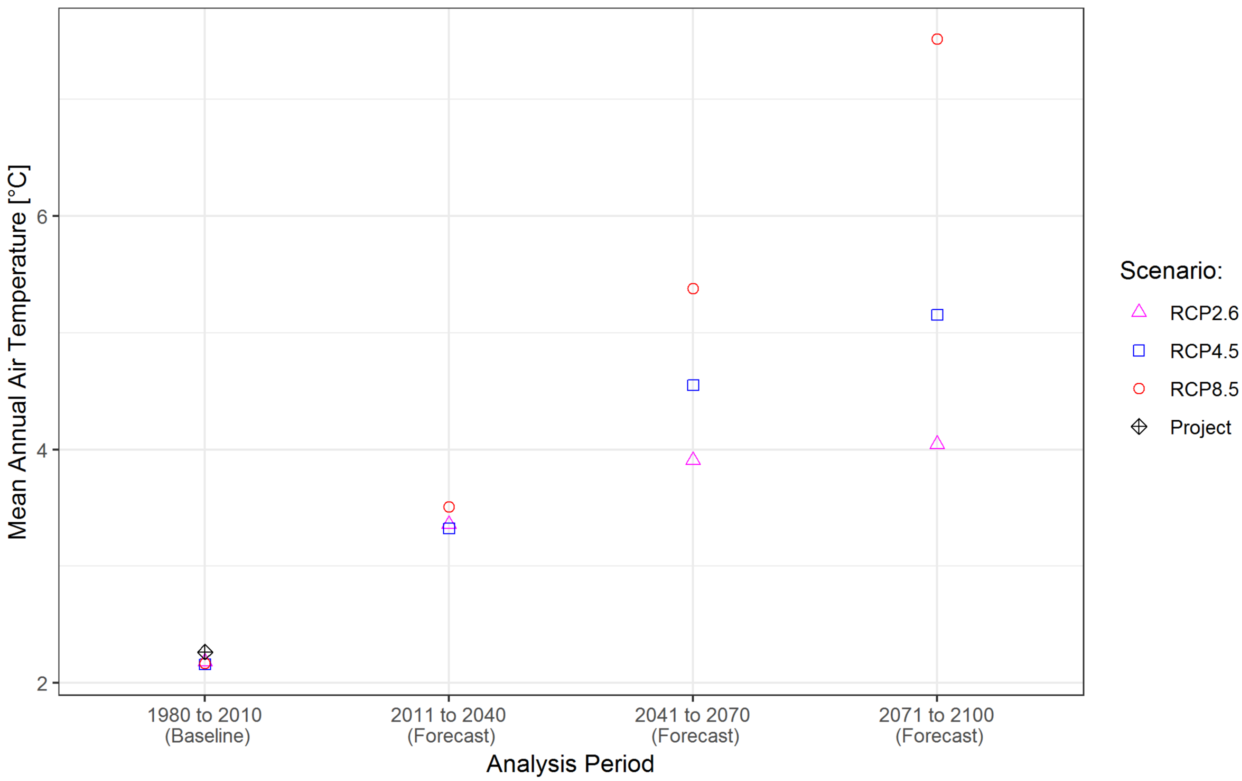


Figure 2.1-1: Forecast of climate change effect on mean annual air temperature

The rates of change relative to the baseline results for the three (3) RCPs up to year 2100 using CMIP5 ensemble data are presented in **Table 2.1-1**.

Table 2.1-1: Mean Annual Air Temperature (MAAT) Increase from Baseline

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5
2011-2040	1.2°C	1.2°C	1.3°C
2041-2070	1.7°C	2.4°C	3.2°C
2071-2100	1.9°C	3.0°C	5.3°C

Notes: *°C=degrees Celsius; RCP=Representative Concentration Pathways*

Based on the ensembled median data, the MAAT for the Project is expected to increase by 2°C to 5°C by year 2085. Monthly impacts to temperature due to climate change were evaluated using the same methodology as described above. RCP 4.5 projections are shown below for application to the water balance model. The monthly change in temperature relative to monthly baseline data for the RCP 4.5 up to year 2100 using CIMP5 ensemble data is presented in **Table 2.1-2**.

Table 2.1-2: Monthly Average Temperature Increase from Baseline for Representative Concentration Pathway (RCP) 4.5 (in degrees Celsius [°C])

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011-2040	1.25	1.23	1.16	1.13	1.35	1.44	1.35	1.21	1.00	0.97	1.02	0.86	1.2
2041-2070	2.89	2.16	2.42	2.30	2.60	2.51	2.45	2.39	2.11	2.07	2.26	2.48	2.4
2071-2100	3.45	2.79	3.01	3.04	3.14	3.13	3.24	2.99	2.72	2.56	2.85	2.97	3.0

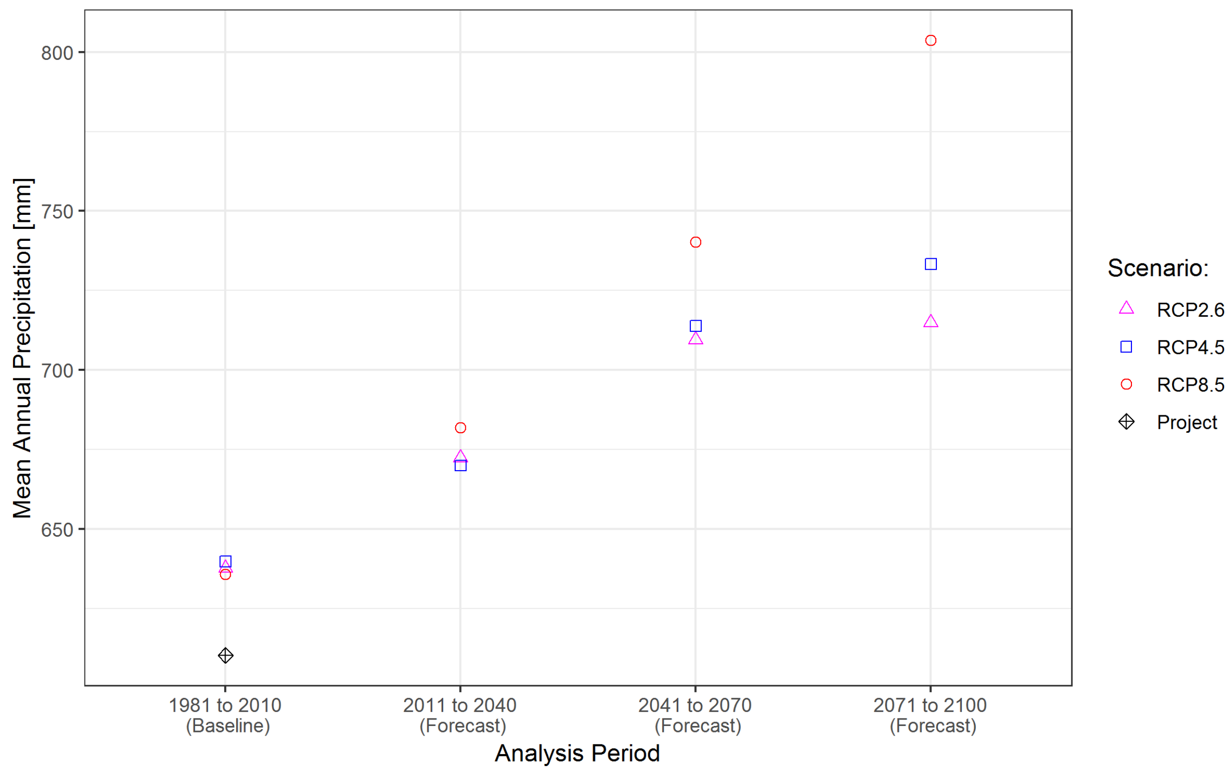
Results show a consistent increase in temperature for all months and can be applied to the monthly average temperature data for the Project.

2.1.2 Climate Change and Precipitation Conditions

As with temperature, projected climate change effects were evaluated relative to a defined baseline period for three (3) consecutive 30-year forecast periods, defined as follows:

- baseline period from 1981 to 2010 (CMIP5), centred on 1995;
- first forecast period from 2011 to 2040 (CMIP5), centred on 2025;
- second forecast period from 2041 to 2070 (CMIP5), centred on 2055; and
- third forecast period from 2071 to 2100 (CMIP5), centred on 2085.

The MAP from the Project record during the baseline period, as well as the historical CMIP5 ensemble results over the same period, and the forecasted MAP for the three (3) different RCP scenarios, are illustrated in **Figure 2.1-2.**



Source: *Appendix 1.0-R SRK, Tenas Project Hydrometeorological Report*

Figure 2.1-2: Forecast of climate change effect on mean annual precipitation (MAP)

The percent (%) increase of MAP for the three (3) RCPs up to year 2100, where changes are calculated relative to the modelled baseline period is presented in **Table 2.1-3**.

Table 2.1-3: Mean Annual Precipitation (MAP) Percent (%) Increase from Historical Baseline Average

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5
2011-2040	+5%	+5%	+7%
2041-2070	+11%	+12%	+16%
2071-2100	+12%	+15%	+26%

Notes: *+=increase; %=percent; RCP= Representative Concentration Pathway*

Based on the ensembled median data, the MAP for the Project is expected to increase by 75 millimetres (mm) to 175 mm by year 2085.

Monthly impacts to precipitation due to climate change were evaluated using the same methodology as described above. RCP 4.5 projections for application to the water and load balance model based are shown below.

The monthly rate of change to precipitation relative to monthly baseline data for the RCP 4.5 up to year 2100 using CIMP5 ensemble data is presented in **Table 2.1-4**.

Table 2.1-4: Monthly Average Precipitation Variation from Baseline for Representative Concentration Pathway (RCP) 4.5 (in %)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011-2040	5%	7%	6%	0%	14%	2%	1%	-1%	5%	7%	4%	3%	+5%
2041-2070	12%	8%	14%	14%	34%	33%	-5%	0%	10%	12%	11%	12%	+12%
2071-2100	12%	11%	16%	9%	48%	23%	-23%	2%	14%	18%	16%	18%	+15%

Notes: *%=percent*

Results indicate a net increase in precipitation for all months except July and August, which are expected to decrease up to year 2070, after which August will begin to increase and July will continue to decrease through year 2100. Rates of change can be applied to the monthly average precipitation rates for the Project.

Extreme precipitation under climate change conditions was estimated using the IDF_CC Tool (Version 3) (Institute of Catastrophic Loss Reduction [ICLR] 2018), similar to the baseline depth-duration-frequency curve, for return periods 2 to 100 years.

The Pacific Climate Impacts Consortium (PCIC) (PCIC 2014) attach no probability or Likelihood of occurrence to the different RCPs and leave it up to each designer/stakeholder to judge. The rationale adopted for the Project for selecting RCP 4.5 as the most representative for climate change based on guidance provided by Baisley et al. (2016) is summarized in **Table 2.1-5**.

Table 2.1-5: Adopted Representative Concentration Pathway (RCP) Qualitative Probabilities

Scenario	Likelihood	Reasoning
RCP 2.6	Rare	Emission values are relative to pre-industrial levels requiring stringent global climate change policies to limit emissions.
RCP 4.5	May	Current proposed climate change policies are achieved.
RCP 8.5	Unlikely	Continue current trend of increasing emissions without applying any climate change policies.

Note: *RCP=Representative Concentration Pathway*

Post-closure depth-duration-frequency curves for the Project were developed using bias corrected RCP 4.5 Global Circulation Models (GCMs) for the time-period 2006 to 2100 as summarized in **Table 2.1-6.**

Table 2.1-6: Project Post-closure Depth-Duration-Frequency Curves (Precipitation Depth-millimetres [mm])

Duration (minutes)	Return Period in Years								
	2	5	10	25	50	100	200	1000	PMP
5	4.7	7.3	8.9	10.5	11.8	12.7	15.7	19.7	29.1
10	6.7	10.4	12.8	15.3	17.3	18.8	23.4	29.2	43.2
15	8.1	12.3	14.9	17.4	19.5	20.9	25.8	32.2	47.7
30	11.3	16.5	19.5	22.4	24.7	26.1	32.0	40.0	59.3
60	15.4	22.7	26.9	30.9	33.9	35.7	43.6	54.6	80.9
120	20.1	29.0	33.9	38.2	41.6	43.3	52.3	65.8	97.4
360	32.8	45.9	52.2	56.7	59.8	61.6	72.3	91.5	135.5
720	40.4	57.7	67.0	75.0	81.2	84.3	101.4	127.5	188.8
1,440	49.2	70.6	84.2	98.4	110.6	119.7	150.7	187.0	277.0

Notes: *PMP=Probable Maximum Precipitation*

2.1.3 Climate Change and Lake Evaporation Conditions

Changes to lake evaporation were assessed by updating the Morton methodology evapotranspiration model with the temperature changes obtained for RCP 4.5 and presented in **Table 2.1-2**. The maximum temperature, minimum temperature and dew temperature Project time series were updated using the same net increase rates. **Table 2.1-7** presents the monthly rates of change relative to the baseline lake evaporation for RCP 4.5 up to year 2100.

Table 2.1-7: Monthly Lake Evaporation Variation from Baseline for Representative Concentration Pathway (RCP) 4.5 (in percent [%])

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011-2040	1%	1%	3%	3%	3%	4%	3%	3%	3%	1%	1%	1%	+2%
2041-2070	2%	2%	6%	6%	6%	6%	6%	6%	6%	2%	2%	2%	+4%
2071-2100	2%	3%	7%	8%	8%	8%	8%	8%	8%	2%	2%	2%	+5%

Results indicate a net increase in lake evaporation for all months of the year and can be applied to the Project monthly evaporation rates.

2.1.4 Climate Change and Stream Flow Conditions

A hydrologic model was used to evaluate climate change impacts on streamflow. The model was calibrated to the Water Survey of Canada (WSC) hydrometric stations on Telkwa River, Bulkley River and Goathorn Creek, along with local hydrometric data on Tenas Creek and Four Creek. The model consists of a daily precipitation and temperature input with monthly runoff coefficients and baseflow values. Monthly flows from historic climate were compared against monthly flows projected in 2100 based on the monthly climate change variability presented previously in **2.1.1** and **2.1.2.**

Historic temperature and precipitation inputs were developed using a daily weather generator (WGEN) which was calibrated to the Project climate statistics and adjusted for each hydrometric station based on the median elevation of the associated watershed. A daily snowmelt model was incorporated to convert daily precipitation to rain and snow and produce snowmelt in the spring. The calibrated monthly runoff coefficients along with a recession and baseflow value were included for each river, producing a baseline flow record.

Climate change streamflow were calculated by adjusting the climatic inputs (precipitation and temperature) using the monthly adjustment factors (RCP 4.5) presented above. The updated climate variables were then incorporated into the same snowmelt and runoff model to produce streamflow in 2100.

The runoff model was simulated for 100 realizations under historic conditions and projected climate change conditions (Year 2100). The 50th percentile (median), 10th percentile (low flow) and 90th percentile (high flow) statistics were extracted from the realization record and are compared in each creek for historic conditions versus 2100 climate change conditions for RCP 4.5.

Historic monthly streamflow for each percentile and both historic and climate change conditions are presented in **Figure 2.1-3** for Tenas Creek, **Figure 2.1-4** for Four Creek, **Figure 2.1-5** for Goathorn Creek**,** **Figure 2.1-6** for Telkwa River, and **Figure 2.1 7** for Bulkley River, where dashed lines represent climate change conditions and solid lines represent historic conditions, for a range of percentiles shown in different colours.

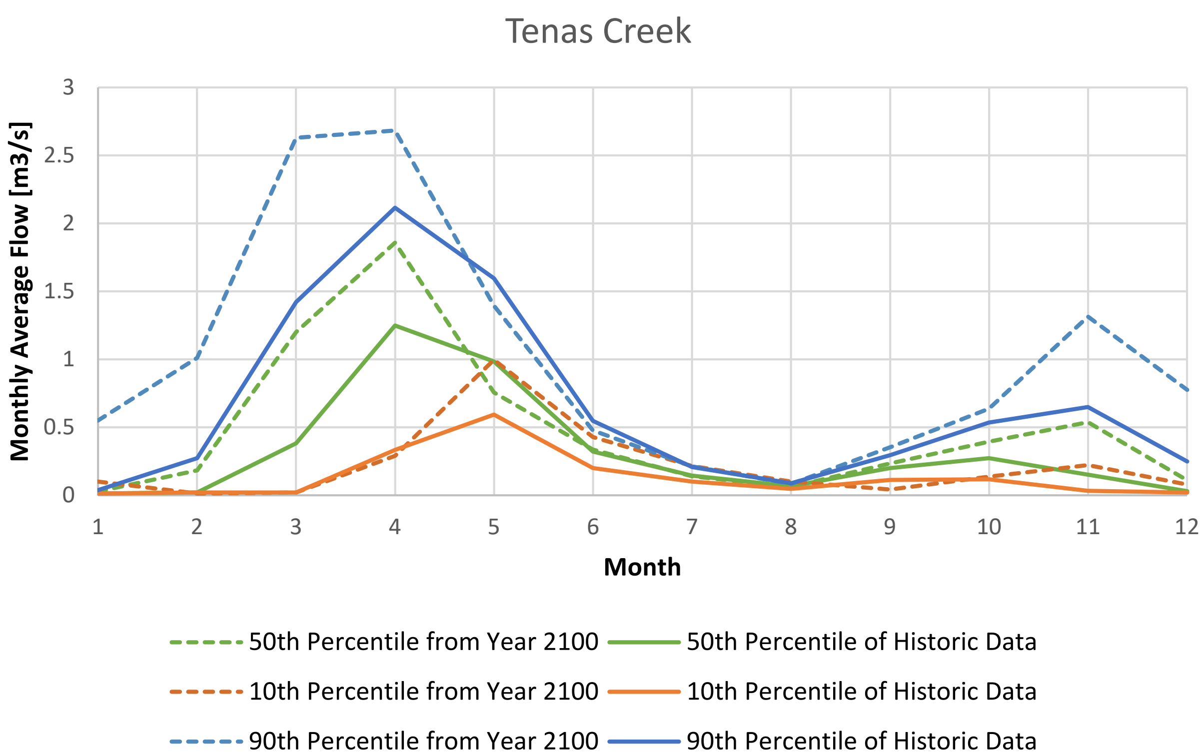


Figure 2.1-3: Tenas Creek monthly streamflow summary for historical conditions and climate change conditions in 2100 with Representative Concentration Pathway (RCP) 4.5

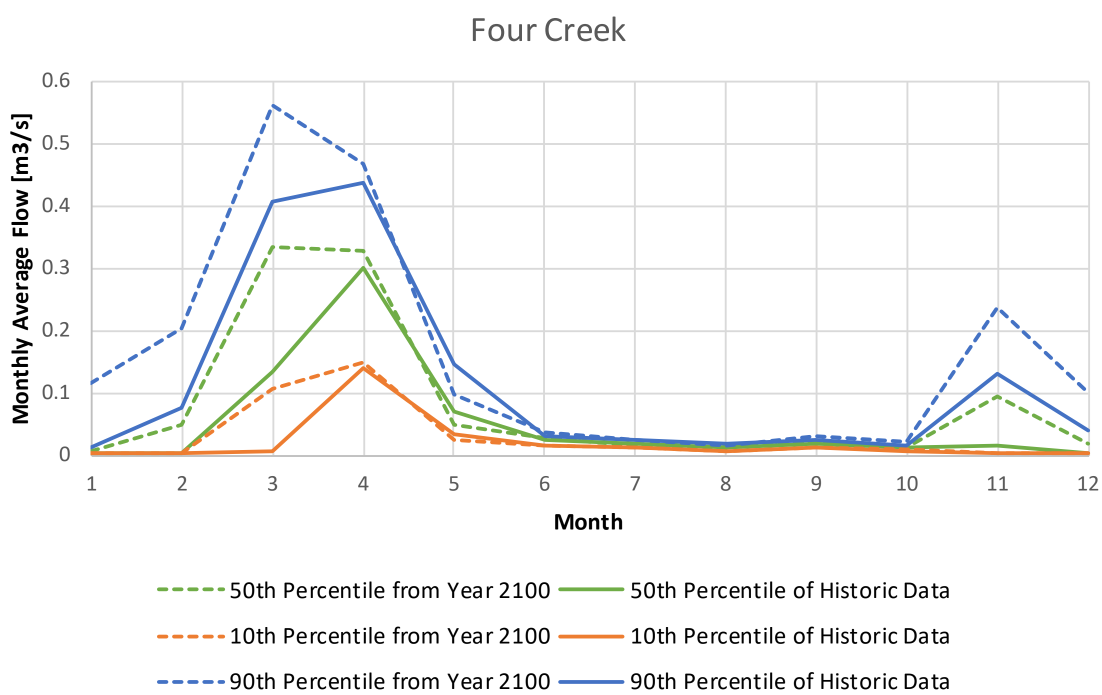


Figure 2.1-4: Four Creek monthly streamflow summary for historical conditions and climate change conditions in 2100 with Representative Concentration Pathway (RCP) 4.5

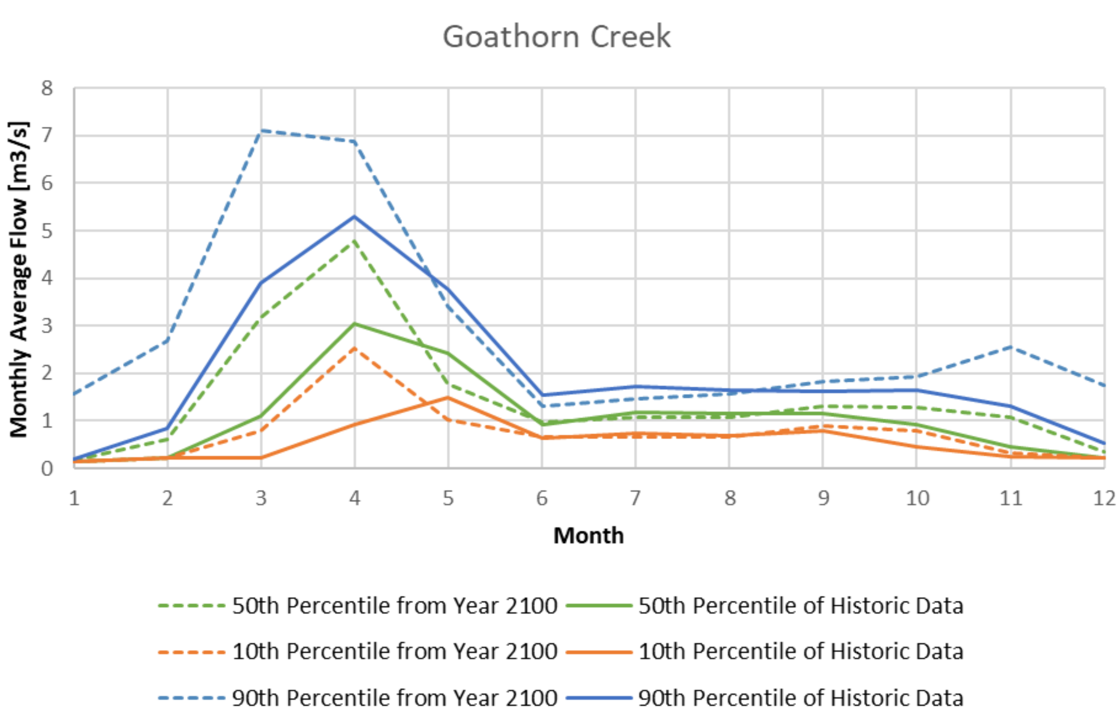


Figure 2.1-5: Goathorn Creek monthly streamflow summary for historical conditions and climate change conditions in 2100 with Representative Concentration Pathway (RCP) 4.5

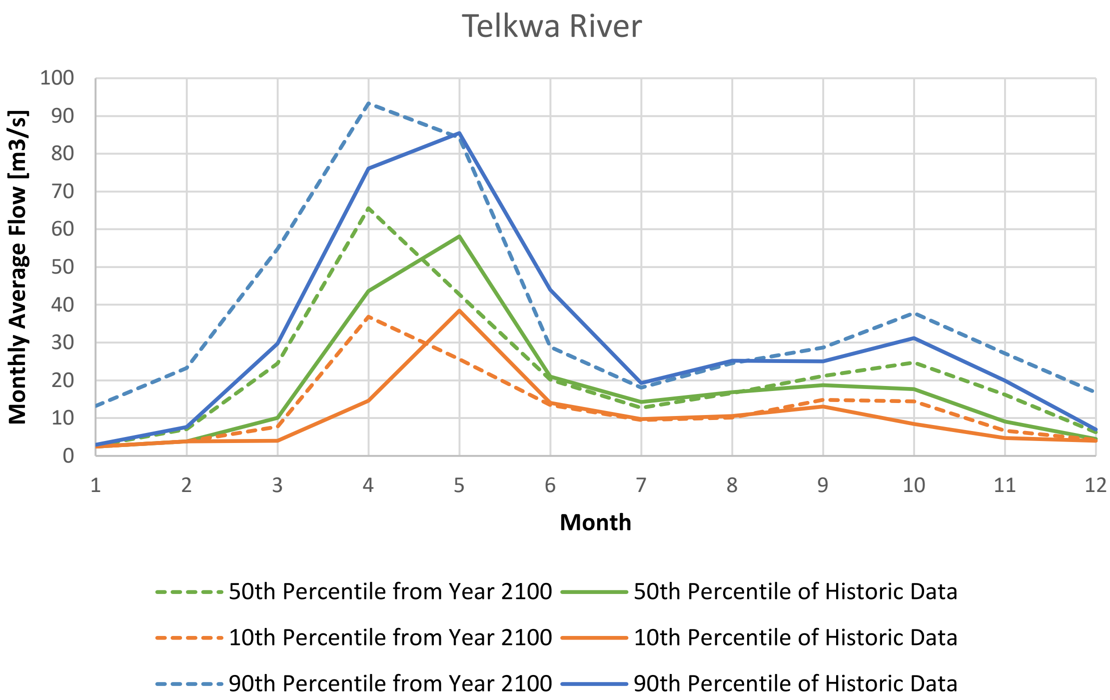


Figure 2.1-6: Telkwa River monthly streamflow summary for historical conditions and climate change conditions in 2100 with Representative Concentration Pathway (RCP) 4.5

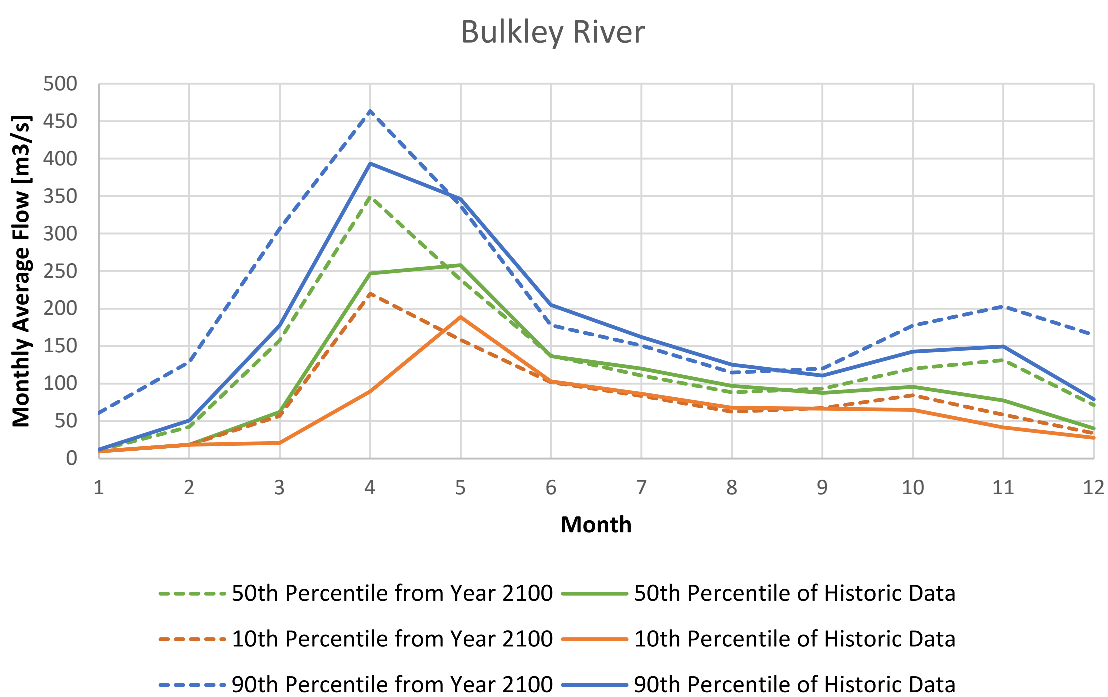


Figure 2.1-7: Bulkley River monthly streamflow summary for historical conditions and climate change conditions in 2100 with Representative Concentration Pathway (RCP) 4.5

The general tendency when comparing historic and climate change monthly streamflow is an overall increase in flow magnitude and a shift to an earlier spring freshet. These observations coincide with the climate change projections in **Table 2.1-3**, showing a 15% increase in annual precipitation by 2100 under RCP 4.5, and a 48% increase in precipitation in May, as shown in **Table 2.1-4**.

Note that the runoff model relies on a constant unit baseflow value for each river, which was not adjusted for climate change in these predictions. Precipitation is anticipated to decrease during the drier summer months (namely July, in **Table 2.1-4**), which, in combination with the higher evaporation rates shown in **Table 2.1-4**, would be expected to decrease streamflow during the low-flow summer period.

2.2 Potential Effects on the Project and Valued Components (VCs)

The potential effects to the Project from climate change are discussed below, noting the risk of the Project components to the change. The risk assessment for the effects of climate change on the Project and subsequent effects on VCs is included in the assessment of extreme weather events, (**3.1 Temperature Risk Assessment**, **3.2 Precipitation Risk Assessment**) and the assessment of surface water flows (**3.3 Surface Water Flows Risk Assessment**).

Project components are designed to withstand a wide range of air temperatures, including the temperature ranges projected by GCMs for various greenhouse gas (GHG) scenarios. Increasing the number of freeze-free days would be beneficial to the Project in some respects, such as reducing heating costs, and reducing the exposure of personnel to extreme cold. Climate change is predicted to induce milder winters in this region, which would likely produce more freeze-thaw cycles. If not accounted for during design and construction, this increase would accelerate roadway, railway, and pipeline deterioration, and increase maintenance costs. More frequent freeze-thaw cycling also has the potential to compromise the strength of other site infrastructure, including powerlines, building foundations, and bridges.

2.3 Project Mitigation Measures for Climate Change

Mitigation measures for extreme weather events presented in **3. Extreme Weather Events** are also applicable to managing effects of climate change on the Project. Specific mitigation measures for climate change are:

- parameters for Project design specifications address increased risks and safety factors to account for climate change;
- ongoing review of climate change conditions and adequacy of Project components to manage changed conditions; and
- monitoring and adaptive management for Project components and personnel for safety to address concerns and update management plans.

2.4 Likelihood and Consequence of Potential Effects of Climate Change

With appropriate Project design and the implementation of mitigations measures, the Likelihood of climate change affecting the Project and resulting in an adverse effect to the Project VCs is **Unlikely**. Appropriate maintenance and management procedures will be in place to avoid or minimize environmental consequences of climate change on the Project. With the implementation of the design, Construction Phase, and Operation Phase measures, the Consequence of the effects of climate change on the Project affecting the environment is considered **Negligible**.

2.5 Conclusions on Potential Risks for Climate Change

The risk assessment for the effects of climate change on the Project and secondary effects on VCs is included in the assessment of extreme weather events **(3.1, 3.2**) and the assessment of surface water flows (**3.3**), however, based on the assessment of Likelihood and Consequence, the risk is assessed as very low overall (additional detail provided in **3.1** to **3.3**).

3. EXTREME WEATHER EVENTS

Extreme weather events occur in many forms, including windstorms, thunderstorms, heat waves and heavy precipitation. Of the extreme weather events likely to occur in the future, this subsection focuses on extreme warmth, extreme cold, and low and high precipitation. Extreme events occur because of variability in weather conditions. Weather refers to atmospheric conditions on time scales ranging from days to weeks, whereas climate refers to longer term atmospheric conditions. Long-term climatic conditions are important to consider in the context of extreme weather events since future variability is expected to be impacted by climate change.

This subsection provides risk assessments for temperature, precipitation, and surface water flow events. Future climate variability and extremes are presented. Trends and projections reported in the literature, as well as those obtained for the Project Area are presented.

3.1 Temperature Risk Assessment

3.1.1 Temperature Conditions

This subsection provides a description of typical and extreme air temperatures, and freeze-thaw cycles.

3.1.1.1 Typical Air Temperatures

The average annual air temperature between 30 September 2017 and 9 December 2019 at the Tenas Meteorological Station was 2.5˚C. The coldest month was February 2019 when the mean minimum daily air temperature was -11.3˚C. The warmest month was July 2019 when mean maximum daily air temperature was 14.2˚C.

ClimateWNA (Centre for Forest Conservation Genetics 2021) was used to generate a “Climate Normal” for the Tenas Meteorological Station location and elevation. For the 30-year period 1981-2010, the average annual air temperature was 2.2 ˚C. The month with the coldest mean minimum daily air temperature was January (-10.9 ˚C) and the warmest was July (18.1 ˚C). The MAT for the period of 1961-1990 was slightly lower at 1.7 ˚C.

Local and regional air temperature have been collected at several locations around the Project. **Table 3.1-1** provides monthly summaries of air temperature measured at some of these locations as well as Climate Normals computed by Environment Canada for 1981-2010.

Table 3.1-1: Monthly Air Temperature Summaries from Relevant Sources

Month	Tenas Project Station (2017-2019) (993 masl)	Smithers A (2017-2019) (523 masl)	Smithers A (1980-2010) Climate Normals (521.8 masl)	Suskwa Valley (1981-2010) Climate Normals (534 masl)	Topley Landing (1981-2010) Climate Normals (722 masl)	Equity Silver (1981-2010) Climate Normals (1,280 masl)
January	-5.7	-4.9	-7.2	-6.4	-8.5	-8.4
February	-11.3	-8.9	-4.4	-3.5	-6	-6.8
March	-2.3	-0.2	0.1	0.4	-1.6	-4
April	1.8	6.3	4.8	4.9	3.6	0.9
May	9.9	13.8	9.4	9	8.4	4.9
June	10.8	14.7	13	12.6	12.4	9.5
July	14.2	17.1	15.2	14.5	14.6	11.6
August	14.1	17.4	14.6	13.9	14.1	11.5
September	7.0	10.8	9.9	9.6	9.7	7.3
October	1.9	4.5	4.4	4.1	4	1.6
November	-2.8	-0.6	-2.1	-2.5	-2.6	-4.4
December	-7.5	-5.7	-7.1	-5.1	-6.9	-7.5
Average	2.5	6.3	4.2	4.3	3.4	1.3
Daily Maximum	23.9	26.5	21.6	20.8	20.7	16.6
Daily Minimum	-22.6	-23.6	-11.0	-9.3	-12.0	-11.

Notes: *masl=metres above sea level*
Measurement period begins 30 September 2017 and ends 9 December 2019 so incomplete months (more than 5 days missing) were removed from the analysis.

3.1.1.2 Extreme Air Temperatures

Given the climatic setting of the Project, effects on the Project might be expected from both extremely cold and extremely warm air temperatures. Historical data from the nearby weather stations show a wide range of air temperatures with a range from 36.5˚C to -44.0˚C. These extremes are more likely to affect workers exposed to the elements, compared to the workers housed inside structures.

Table 3.1-2: Extreme Air Temperature Summaries from Relevant Sources (degrees Celsius [⁰C])

	Tenas Project Station	Smithers A	Smithers A	Suskwa Valley	Topley Landing	Equity Silver
	(2017-2019)	(2017-2019)	(1981-2010)	(1981-2010)	(1981-2010)	(1981-2010)
			Climate Normals	Climate Normals	Climate Normals	Climate Normals
	(993 masl)	(521.8 masl)	(521.8 masl)	(534 masl)	(722 masl)	(1,280 masl)
Extreme Maximum Date	31.8ºC 29 July 2018	34.2ºC 30 July 2018	36.0ºC 30 July 2009	36.5ºC 12 August 1990	34.4ºC 31 July 1971	30.0ºC 23 July 1994
Extreme Minimum Date	-24.9ºC 28 December 2017	-31.9ºC 3 February 2019	-43.9ºC 13 January 1950	-33.0ºC 27 November 1985	-41.7ºC 25 January 1972	-44.0ºC 4 January 1982

Notes: *⁰C = degrees Celsius; masl = metres above sea level*

3.1.1.3 Freeze-Thaw Cycles

At high elevations in northern BC (greater than [>] 1,000 masl), freeze-thaw is likely a concern in spring, summer and fall; at lower elevations in northern BC (less than [<] 1,000 masl), it is more of a concern in the fall, winter, and spring. Freeze-thaw cycles are a causal factor of cracked pavement and road surfaces and can cause damage to power and other utility lines.

3.1.2 Potential Effects on the Project and Valued Components (VCs)

The potential effects of extreme weather events on the Project are listed in **Table 3.1-3**, and are discussed separately for extreme warmth, extreme cold, and freeze-thaw cycles in the following subsections.

3.1.3 Project Mitigation Measures for Extreme Temperatures

The Project will be designed and constructed in accordance with federal and provincial standards to minimize the potential for structural damage resulting from extreme weather events. The ranges in weather events stated by the current BC Building Code (Government of British Columbia [GovBC] 2018) is expected to encompass climate change impacts predicted for the next 25 years.

Weather forecasts will be monitored, which will provide time to prepare for air temperature extremes. Health and safety policies will be implemented, and risk assessments will be undertaken before working in adverse weather conditions. Staff will be educated through formal training programs so that they understand the risks of working under extreme high and low temperatures, and to provide them with a good knowledge of the related procedures. Daily job risk analysis will be conducted. Personnel will be required to wear appropriate personal protective equipment (PPE), including cold weather gear, while working outside. Radio communication will be maintained with anyone working away from the Minesite.

Suitable equipment and design systems will be purchased for the Project to enable operation under both extreme high and low temperatures. Equipment will be maintained to allow for proper operation. Potentially vulnerable infrastructure will be built to withstand freeze-thaw cycles, especially infrastructure related to transportation and utilities.

Air temperature-related effects to the Project and mitigation measures are presented in **Table 3.1-3** and discussed in the following sections. Mitigation for the temperature-related effects includes:

- preventative maintenance and prompt repair of damaged Project components;
- monitoring of weather forecasts to better anticipate potential extreme heat, extreme cold and freeze-thaw events;
- implementation of the **Occupational Health and Safety Program (S13.0-C13) (OHSP)**;
- proper training and education programs will be formalized to provide staff with sufficient training and knowledge to make informed decisions regarding risks related to extreme temperatures as well as related procedures to mitigate these risks;
- conducting daily job safety and hazard analyses;
- requiring staff to incorporate weather-appropriate PPE for outdoor work; and
- constructing infrastructure related to transportation and utilities to withstand extreme weather events. Any damage to infrastructure will be reported and information will be made available to staff (e.g., road conditions).

Table 3.1-3: Air Temperature-related Effects to the Tenas Project and Mitigation Measures

Category	Component	Potential Project Effects Extreme Warmth	Potential Project Effects Extreme Cold and Freeze-Thaw Cycles	Mitigation Measures
Open Pit	Open pit workers	Effects to workers from warmth: heat exhaustion, dehydration, heat stroke.	Effects to workers from cold, e.g., frostbite, hypothermia, distraction, accidents	Staff will wear appropriate clothing and be trained in risks and risk-mitigation relating to extreme temperatures
Mine Infrastructure	▪ Material storage/stockpiles ▪ Surface Water Management Infrastructure and raw water supply ▪ Tenas Control Pond and sedimentation ponds	Effects to infrastructure from warmth: increased air conditioning (& power) demands.	Effects to infrastructure from cold, e.g., increased heating (and power) demands, freeze-thaw damage	Suitable equipment will be used in Mine Infrastructure to withstand extremes of heat and cold for the region.

Category	Component	Potential Project Effects Extreme Warmth	Potential Project Effects Extreme Cold and Freeze-Thaw Cycles	Mitigation Measures
	▪ Coal Processing Plant (CPP) and buildings and coal handling systems ▪ Explosive and fuel storage ▪ Water supply - contingency wells			
Roads	▪ Access roads ▪ Tenas Access Corridor (TAC)	Increased fugitive dust due to higher temperatures	Blowing snow, frost heave.	▪ Frequent snow clearing. Use of appropriate design ▪ Water addition and/or addition of chemical agents for the roads and Coal Processing Plant (CPP) stockpiles if required for fugitive dust. ▪ Standards to minimize frost heave.
Rail Infrastructure	▪ Rail Infrastructure Sedimentation Pond ▪ Rail Infrastructure Fueling Station ▪ Rail Loadout ▪ Rail Loop ▪ scales	Increased fugitive dust due to higher temperatures.	Delays in loading trains due to snow falls	▪ Equipment for snow clearing ▪ Chemical agents and water addition at the Rail Infrastructure and CPP if required for fugitive dust.
Powerline	Powerline and substation	n/a	n/a	n/a

Note: *n/a=not applicable*

3.1.4 Extreme Heat Risk Assessment

3.1.4.1 Potential Effects on the Tenas Project and Valued Components of Extreme Heat

The effects of extreme heat to the Project may include:

- Workers' health may be negatively impacted due to conditions such as heat exhaustion, dehydration, and heat stroke;
- Workers can be more distracted and error-prone under conditions of extremely high air temperature;
- Equipment does not run as smoothly under extreme high temperatures and can be more prone to malfunctions, and these malfunctions increase the risk of exposure and accidents;
- More power may be needed onsite to keep air conditioning systems running;

- Sustained high temperatures will cause more precipitation to fall as rain rather than snow. Earlier melting of the snowpack is also likely leading to an earlier freshet as well as increases in runoff during late winter (early snowmelt). If precipitation falls more often as rain, more rapid runoff throughout freshet and summer is possible, which could increase erosion. The cost of maintenance for diversion channels and roadways may increase (high precipitation events are addressed in **3.2.2**); and
- In dry years, higher temperatures may lead to an increased Likelihood of wildfires in the project area (wildfires are assessed in **7.0)**.

Potential effects to VCs from the effects to the Project are limited to the Human Health VC. Extreme heat events may affect employee health. Effects to public health are not anticipated. An increased potential for accidents and malfunctions through error may result in effects to VCs, depending on the event, as described in **S9.0 Accidents and Malfunctions** of the **EAC Application**.

3.1.4.2 Likelihood and Consequence of Extreme Heat

Extended periods of extreme heat are **Unlikely** under current conditions, but extremely high air temperatures have occurred in the past. The Likelihood of incidences of extreme heat is expected to increase under climate change in the Post-closure Phase of the Project.

The Likelihood for the effects of extreme heat on the Project to affect the Human Health VC is considered **Rare**. Consequences to VCs are considered Minor due to the short nature of extreme heat events.

3.1.4.3 Conclusions on Potential Risk of Extreme Heat

Risk assessment for extreme heat was guided by the BC climate risk assessment, which focuses on provincially significant climate risks, and adapted to the Project region. The risk associated with extremely high air temperatures is considered high. ClimateWNA showed a 6-11 ˚C increase in June and July average maximum monthly temperatures under RCPs 4.5 and 8.5 in 2085.

While the climate risk associated with extreme warmth is high, the effects of extreme warmth to the Project are managed by the Project design and mitigation and the risk to the Project is considered very low. With the mitigations in place, the Likelihood of effects to VCs is considered **Rare**, the Consequence is considered **Minor**, and the risk assessed as **Very Low**.

3.1.5 Extreme Cold Risk Assessment

3.1.5.1 Potential Effects on the Project and Valued Components (VC) of Extreme Cold

The effects of extreme cold to the Project may include:

- Worker’s health may be negatively impacted due to conditions such as frostbite and hypothermia;
- Workers may become more distracted and prone to accidents;
- Equipment and machinery do not function optimally at extremely low temperatures, which can increase the exposure of workers to cold conditions as well as increase accidents. If extremely low temperatures occur in tandem with snowfall, conditions such as blowing snow can slow Minesite operations by decreasing visibility and slowing transport;
- Power consumption will increase if heating requirements are greater than under typical conditions;

- Extended periods of extreme cold could extend winter and result in more precipitation falling as snow rather than rain. If snow accumulation increases substantially, roadways and diversion channels could require additional clearing; and
- Freshet could be delayed leading to a later increase in runoff.

Effects to VCs from the effects of extreme cold on the Project may include effects to the Surface Water VC with changes in flow characteristics, Economic Development VC should the Minesite need to slow down or close, and Human Health VC for employees. An increased potential for accidents and malfunctions through error may result in effects to VCs, depending on the event, as described in **S9.0 Accidents and Malfunctions** of the **EAC Application**.

3.1.5.2 Likelihood and Consequence of Extreme Cold

Extended periods of extreme cold are unlikely under current conditions, but extremely cold air temperatures have been documented in the past. The Likelihood of incidences of extreme cold may increase under climate change.

Consequences to VCs from the effects of extreme cold on the Project are considered **Unlikely** with the mitigation in place. Consequences to VCs are assessed as **Minor**, due to the seasonal temporary duration of the effects.

3.1.5.3 Conclusions on Potential Risk of Extreme Cold

Risk assessment for temperature was guided by the BC climate risk assessment, which focuses on provincially significant climate risks, and adapted to the Project region. The risk associated with extremely low air temperatures is considered low. ClimateWNA showed a 2-4˚C increase in average monthly winter air temperatures under RCPs 4.5 and 8.5 in 2085.

With mitigation by design of Project components to withstand low temperatures, the risk of effects to the Project from predicted potential increases in low temperature are considered **Low**. With the mitigation in place, the Likelihood of consequent effects to the Surface Water, Economic Development, and Human Health VCs is assessed as **Unlikely**, the Consequence is considered **Minor**, and the risk is assessed as **Low**.

3.1.6 Freeze-thaw Cycle Risk Assessment

Given that air temperatures in winter transition above and below the freezing point, freeze-thaw cycles and frost heave in winter will occur during the Project’s lifecycle.

3.1.6.1 Potential Effects on the Project and Valued Components (VC) from Freeze-thaw Cycles

The effects of freeze-thaw cycles to the Project may include:

- damage to transportation routes, including haul roads, the Tenas Access Corridor (TAC), and the rail line; and
- damage to Project infrastructure, including drainage infrastructure (spillways, pipelines, culverts, berms), powerline and natural gas pipeline if applicable.

Effects to VCs from the effects to the Project may include effects to the Surface Water VC from damage to road drainage infrastructure and other drainage infrastructure, resulting in unanticipated changes in flow and flow direction. Effects are expected to be very localized and not to extend to Aquatic Resources, and Fish and Fish Habitat VCs. Effects to other VCs are not anticipated.

3.1.6.2 Likelihood and Consequence for Freeze-thaw Cycles

The average temperature increase in winter across BC is 2.2˚C per 100 years with 2.6˚C to 2.9˚C increase in the north-central region of the province (BC MOE 2016). The Likelihood of freeze-thaw cycles is greater for the Project region under climate change conditions as winter temperatures are projected to continue to increase while enhanced variability in air temperatures is also expected.

Effects to Surface Water VC from the effects of freeze-thaw cycles on the Project are considered **Unlikely**, due to design standards, monitoring and prompt repair of potential damage. Consequences to Surface Water from the effects to the Project are considered **Negligible**, as they will be Short-term due to prompt repairs before damage is extensive, and therefore of limited extent.

3.1.6.3 Conclusions on Potential Risk of Freeze-thaw Cycles

The risk of freeze-thaw cycles is not explicitly stated in the BC climate risk assessment, but it is likely increased. Although the region may experience a generally milder winter, the season will be punctuated by extreme cold days and greater fluctuation around zero degrees that may adversely affect roads, equipment and create challenging conditions for workers.

The effects of extreme cold to the Project are managed by the Project design and mitigation and the risk of effects to the Project is considered **Very Low** as potential effects will be identified and managed prior to damage to Project components. With the mitigation in place, the Likelihood of effects to Surface Water VC is assessed as **Unlikely**, the consequence is considered **Negligible**, and the risk **Very Low**.

3.2 Precipitation Risk Assessment

This subsection reviews the risks from high and low precipitation events only. Risks from surface water flows including flooding are addressed in **3.3.**

3.2.1 Precipitation Conditions

3.2.1.1 Typical Precipitation

Annual precipitation measured from 2017 to 2019 for the Tenas Meteorological Station was 672 mm, based on 2018, which was the only full period of record available. A large amount of rainfall occurs in summer and fall months while snowfall is significant in winter months. The proportion of rain to snow was variable across years when the Tenas Deposit Station record was gap-filled using regressions from Smithers A regional station (SRK Consulting (Canada) Ltd. [SRK] 2021). The Tenas Deposit Station record showed that large rainfall events can occur during summer and particularly, fall. Overall, precipitation was not found to increase significantly with elevation, while snow depth at the Project meteorological station showed similar patterns to the Tsai Creek automated regional station operated by Environment Canada and similar magnitudes to the Hudson Bay manual snow records (SRK 2021). Peak snow depths for the Project typically occurred in February and March (79-119 cm) with snow-free conditions in June.

Tenas Deposit Station records were extended using Smithers A regional station, producing an expected MAP for the Project of 608 mm (SRK 2021).

The monthly and annual average precipitation for the Tenas Deposit Station, the extended Project record using Smithers A (SRK 2021), nearby meteorological regional stations and associated 30-year Climate Normals for regional stations in the area are shown in **Table 3.2-1**. Data from the Smithers A regional station is not available from November 2018 to present. Smithers Auto regional station has a precipitation record spanning 2017 to 2019 and was included in **Table 3.2-2**.

Table 3.2-1: Monthly and Annual Precipitation Summaries from Relevant Sources

Month	Tenas Deposit Station (2017-2019) (993 masl)	Tenas Project, Synthetic (1942-2019) SRK 2021 (993 masl)	Smithers A (2017-2018)	Smithers Auto (2017-2019)	Smithers A (1980-2010) Climate Normals (521.8 masl)	Suskwa Valley (1981-2010) Climate Normals (534 masl)	Topley Landing (1981-2010) Climate Normals (722 masl)	Equity Silver (1981-2010) Climate Normals (1,280 masl)
January	55	70	31.8	44.6	42.7	60.6	54.4	64.7
February	85	46	34.5	40.7	23.4	36.3	34.5	40.8
March	44	32	23.3	26.5	20.6	37.9	29.6	39.6
April	14	26	8.1	22.3	23.8	40.6	25	28.1
May	20	37	57	35.8[2]	38.1	62.9	42.2	46
June	50	46	55.2	50.3	55.2	75.6	58.5	71.9
July	67	48	26	36.5	45.6	70.4	46.4	69.8
August	11	43	9	23.2	43.8	60.5	42.1	53.7
September	49	51	53.1	43.3	53.8	81	43.1	56.4
October	98	72	86	78.9	64.8	89.9	54.4	70.6
November	86	69	61[2]	89.5	55	77.5	57	62.8
December	61	68	9.2[3]	36.1[2]	41.9	64.1	51.1	57.2
Annual Total	672[1]	608	579[4]	528	508.5	757.1	538.1	661.3

Notes: *masl = metres above sea level*
Measurement period begins 30 September 2017 and ends 9 December 2019 so incomplete months (more than 5 days missing) were removed from the analysis.
[1]Only one (1) full calendar year was recorded. 672 millimetres (mm) was the total precipitation for 2018.
[2]More than five (5) days missing from record. Incomplete month during a single year.
[3]Entire month missing.
[4]Only one (1) full calendar year was recorded. 579 mm was the total precipitation for 2017.

3.2.1.2 Extreme Precipitation

Concurrent with gradual warming across BC, the historical record reveals an increase of 12% in average precipitation across the province over the past century (BC MOE 2016). Trends across seasons were not statistically significant due to high climate variability and topographical differences across the province. A large body of the scientific literature suggest that the documented increases in average global air temperature should lead to an intensification of the freshwater cycle (Ziegler et al. 2003; Dery et al. 2009, Zhang et al. 2013).

The change in precipitation regimes is complex and typically implies a shift in the proportion of rain and snow, timing, and an increase in convective or higher-magnitude rainfall events for the Northern Hemisphere. From 1910 to 2001 in B.C., heavy precipitation events (defined by the threshold depth of the top 5% of all observed events, or 26 mm) increased by 16% (Groisman et al. 2005). The increases in observed total and heavy precipitation were linked to precipitation changes simulated by GCMs for overlapping time periods. Given that GCMs incorporate the intensification of the hydrologic cycle, this study supports that GCMs may be useful in predicting future changes in heavy precipitation.

Precipitation records from regional meteorological stations provide information on precipitation extremes. Nearby regional weather stations with 30-year climate normals are listed in **Table 3.2-2** with associated maximum recorded daily precipitation values**.** The extremes for snow and rain are available for these stations from Environment Canada. Available extremes from the Tenas Deposit Station are also presented.

Table 3.2-2: Extreme Precipitation Summaries from Relevant Sources

Station	Tenas Project Station	Smithers A	Suskwa Valley	Topley Landing	Equity Silver
Years of Record	2017-2019	1942-2018	1982-2021	1962-2017	1981-2021
Elevation [mas]	993	523	534	722	1280
Maximum Recorded Daily Rainfall (mm)	73	68[1]	64	55	58
Date of Maximum Recorded Daily Rainfall	24 October 2017	24 October 2017	28 September 1988	25 July 1970	30 July 2006
Maximum Recorded Daily Snowfall (cm)	65	61	26	74	82
Date of Maximum Recorded Daily Snowfall	7 February 2018	16 January 1947	6 February 2011	27 October 2006	28 October 2006

Notes: *mm=millimetres. cm=centimetres, masl=metres above sea level*
Smithers A also recorded 6 mm of precipitation as snowfall, producing a total precipitation depth of 74 millimetres (mm) on 24 October 2017.

Extreme precipitation values generated for the Project with climate change for a range of probabilistic return periods and storm durations are presented in **2.1.2**. Results with climate change suggest that the October 2017 storm experienced at Smithers A and on site was similar to a 1 in 5-year to 1 in 10-year event by 2100 with effects of climate change. This suggests that more extreme events than those previously experienced at regional stations could be expected.

3.2.2 High Precipitation Assessment

This assessment considers the potential effects to the Project from high precipitation and consequent effects to VCs. Effects from high stream flow leading to flooding are addressed separately in **3.4.2** (including damage to management ponds).

3.2.2.1 Potential Effects on the Tenas Project and Valued Components (VCs) of High Precipitation

The effects of high precipitation-related events on the Project include potential damage to buildings, site infrastructure, and roadways. Potential effects are summarized in **Table 3.2-3.**

Table 3.2-3: Summary of Effects to the Tenas Project from High Precipitation

Category	Component	Potential Project Effects
Minesite	Open pits	Increased demand for water removal
	Access roads	▪ Effects to drainage leading to erosion, sedimentation, flooding ▪ Greater potential for large snowfall amounts during the winter could result in periods of high snow accumulation on roads ▪ Heavy precipitation events could lead to road damage and/or erosion ▪ Increased maintenance could be required to access various Project sites in winter and maintain road integrity ▪ Reduced access to Minesite and reduced productivity due to downed trees, snow drifts, damaged roads
	Material storage/stockpiles	Effects from erosion
	Surface Water Management Infrastructure and raw water supply	Exceedance of capacity of ponds and overflow to spillways
	Tenas Control Pond and sedimentation ponds	▪ Exceedance of pond capacity and overflow to spillways ▪ Damage to system
	Coal Processing Plant (CPP) and buildings and coal handling systems	▪ Increased precipitation in solid forms, such as sleet or hail, may damage building roofs. Damage from high precipitation ▪ Snow loading leading to damage of infrastructure and reduced mine productivity
	Explosive and fuel storage	▪ Damage from high precipitation ▪ Snow loading leading to damage of infrastructure and reduced mine productivity
	Water supply - contingency wells	No effects
Tenas Access Corridor (TAC)	Road surface, ditches, culverts, Goathorn Creek bridge, and other bridges	▪ Infrastructure effects: erosion, sedimentation, flooding ▪ Damage to bridges due to increased debris flows ▪ Access effects: reduced access to Minesite and reduced productivity due to downed trees, snow drifts, damaged roads
Rail Infrastructure	▪ Rail Infrastructure Sedimentation Pond	▪ Flooding hazard in 200-year flood ▪ Increased moisture levels in processed coal causing handling issues

Category	Component	Potential Project Effects
	▪ Rail Infrastructure Fueling Station ▪ Rail Loadout ▪ Rail Loop ▪ scales	▪ Exceedance of Rail Infrastructure Sedimentation Pond capacity and overflow to spillways. Damage to system
Powerline	Powerline and substation	Failure due to erosion at footings

Potential effects to VCs may include:

- temporary effects to Surface Water VC from potential damage to diversion ditch network, management pond systems, control and sedimentation ponds, pond spillways, and road drainage infrastructure. With the management pond design capacities, a high precipitation event is not expected to result in containment failures (such as considered in **S9.0 Accidents and Malfunctions** of the **EAC Application**);
- unanticipated changes in water flow from damaged Project components may result in soil erosion, changes in aquatic resources and fish habitat, and loss of vegetation and wildlife habitat (Aquatic Resources, Fish and Fish Habitat, Vegetation, and Wildlife VCs); and
- reduced access may affect Project productivity (Economic Development VC).

3.2.2.2 Project Mitigation Measures for High Precipitation Events

A regular inspection and maintenance program will be established for review of water management infrastructure, other infrastructure and building integrity. Identified areas of concern will be repaired on an ongoing basis. Damage to Project infrastructure from a high precipitation event will be repaired promptly.

Mitigation measures relating to periods of high precipitation and potential water quantity changes include:

- shovelling snow off roofs after heavy snowfalls if required to prevent roof collapse from excessive loads;
- applying construction design criteria for the Coal Processing Plant (CPP) site and other buildings to withstand periods of heavy precipitation (rainfall and snow);
- implementing design criteria for roads and buildings to take into account high precipitation events;
- diverting non-contact water around the Project;
- using the excavated pit for storage of water in high precipitation events;
- designing spillways to handle flows 2/3 of the way between a 1 in 1000 and the probable maximum flood (PMF) event on the management and control ponds;
- Designing spillways for a 1 in 200-year storm event for all sedimentation ponds; and
- Tenas Control Pond contains additional storage capacity of 210,000 cubic metres (m^3) beyond the target operating level to manage the 1 in 10-year 24-hour inflow event without overtopping

Mitigation for high rainfall events resulting in high stream flow with flooding is presented in **3.3.2** for high stream flow.

3.2.2.3 Likelihood and Consequence of Potential Effects of High Precipitation

The impacts of high precipitation events in Project catchments could lead to extremely high flows and flooding (see **3.3** for flooding). Effects are anticipated to be more severe when they occur during the snowmelt period and may trigger additional melt from the remaining snowpack.

Effects to the Surface Water VC from the effects of high precipitation on Project buildings, site infrastructure and roads are considered **Unlikely**, due to design standards, monitoring and prompt repair of potential damage. The Likelihood of effects from the changes to Surface Water on aquatic resources and fish habitat, and loss of vegetation and wildlife habitat is considered **Rare** (Aquatic Resources, Fish and Fish Habitat, Vegetation, Wildlife VCs), as is the Likelihood of loss of access (Economic Development VC). Consequences to these VCs from the effects to the Project are considered **Negligible** to **Minor**, as they will be short term due to the prompt repairs, and the biophysical effects are expected to be within the Project Area.

3.2.2.4 Conclusions on Potential Risks of High Precipitation

Intensity and frequency of high precipitation events are expected to change for the Project region under climate change conditions. Current construction design criteria for buildings, roads and conveyance infrastructure consider these projected changes and therefore the Likelihood of an effect to the Project occurring is considered **Rare**. The consequence of effects to the Project due to high precipitation exceeding the parameters used for design may be **Moderate** to **Severe**. However, with mitigation in place, the consequences to the Project can be reduced to **Moderate** or **Minor**, resulting in an overall risk profile to the Project of **Low** to **Very Low**.

With the mitigation in place, the Likelihood of effects to the Surface Water, Aquatic Resources, Fish and Fish Habitat, Vegetation, Wildlife, and Economic Development VCs from the effects to the Project is assessed as **Unlikely**, the consequence to these VCs is considered **Minor** due to their limited extent, and the risk **Low**.

3.2.3 Low Precipitation Assessment

This assessment considers the potential effects to the Project from low precipitation and consequent effects to VCs.

3.2.3.1 Potential Effects on the Project and Valued Components (VCs) of Low Precipitation

Effects to the Project from low precipitation may include:

- insufficient water cover for management ponds;
- insufficient water supply from the Tenas Control Pond for firefighting; and
- insufficient water supply for the CPP.

Effects to VCs from the effects to the Project could include changes in water quality released from the management ponds, however per the **Minesite Water Management Plan (S13.0-C11) (MWMP)**, surface water releases will not be undertaken during water supply shortages when water quality is most likely to be affected. Effects to Surface Water, and consequently Aquatic Resources and Fish and Fish Habitat, may also result from withdrawals from Goathorn Creek or reduced flows from the contact water collection in the watershed during low flows due to low precipitation. However, as stated in the **MWMP**, water withdrawals from Goathorn Creek are capped at a maximum of 3% which is below the value where effects would be expected for this creek.

3.2.3.2 Project Mitigation Measures for Low Precipitation Events

Mitigation measures relating to periods of low precipitation and potential water quality declines include:

- collecting all contact water from the Project for use by the Project;
- developing a **Minesite Surface Water Management Plan (S13.0-C11) (MWMP)** that accounts for low-runoff years; option for a 2.5-metre (m) water cover on management ponds when 1 m is sufficient to stop oxidization of potentially acid generating (PAG) material;
- the ability to reduce water consumption of the Project from 15,000 m^3 per month to 10,000 m^3 with additional dewatering equipment in the CPP;
- the ability to change from using Goathorn Creek for emergency water supply to using the Telkwa River where the planned water use would be less than 0.1%;
- capping withdrawals from Goathorn Creek at a maximum of 2.5% which is below the value where effects would be observed; and
- flexibility to pump water between management ponds and Tenas Control Pond and the open pit.

3.2.3.3 Likelihood and Consequence of Potential Effects for Low Precipitation

Effects to the Surface Water, Aquatic Resources, and Fish and Fish Habitat VCs from the effects of low precipitation on Project water management are considered **Rare**, due to the design of the water management system for the Project and the measures in place to conserve and recycle water within the Project (see **S1.0 Overview of Project Proponent Description** of the **EAC Application**, and the **MWMP**). Consequences to these VCs from the effects to the Project are considered **Negligible** to **Major**. No release of water to watercourses during times of low precipitation is considered a **Negligible** consequence, however water withdrawal, or reductions from runoff to fish-bearing streams may be of **Major** consequence.

3.2.3.4 Conclusions on Potential Risks of Low Precipitation

For any given year, MAP varies by tens to hundreds of mm. Compared to the Project MAP, a decrease of approximately 300 mm of precipitation was estimated as a 1 in 1,000 dry year. However, variation from the average precipitation may be enhanced under climate change even if the MAP is expected to increase and month-to-month variability may increase.

The effects of low precipitation to the Project are managed by the Project design and operating practices in management plans and the risk to the Project is considered **Low**.

With the mitigation in place, the Likelihood of effects to VCs is assessed as **Rare**, however the worst-case consequence is considered **Major** due to possible effects on fish habitat, while the overall risk assessment is **Low**.

3.3 Surface Water Flows Risk Assessment

This subsection presents information on typical and extreme surface water flows, the potential effects to the Project from high and extreme low flows and consequent effects to VCs. Normal flows will not have substantial effects on the Project and are therefore not considered further.

3.3.1 Surface Water Conditions

This subsection presents information on surface water conditions based on historical datasets, the potential effects to the Project from the extreme high and low conditions, and consequent effects to VCs. Effects from climate change to surface water are discussed in **2. Climate Change**. For detailed information about surface water conditions and effects, see **S4.0-C3 Surface Water VC** of the **EAC Application**.

3.3.1.1 Typical Stream Flows

The Project is situated within the catchments of the following watercourses:

- Tenas Creek: bordering the western and northern extents of the Minesite;
- Four Creek: bordering the eastern extent of the Minesite;
- Goathorn Creek: downstream of both Tenas Creek and Four Creek on the eastern extent of the Minesite;
- Telkwa River: downstream of Goathorn Creek and north of the Project; and
- Bulkley River: downstream of Telkwa River, northeast of the Project and adjacent to Rail Infrastructure.

Fluvial hazards have been identified along the Bulkley River, the Telkwa River, Goathorn Creek and Helps Creek. The hazards include flooding, lateral bank erosion, channel bed aggradation and widening, and channel avulsion (abandonment of an old channel and formation of a new one). Floodplain hazard mapping is presented in the **Terrain and Soils Baseline Report** (**Appendix 4.2-A** of **S4.0-C2 Terrain and Soils VC** of the **EAC Application**.

A hydrometric baseline program involved monitoring a network of hydrometric stations in the identified watercourses in the vicinity of the Project to provide site-specific hydrologic data. Detailed methodologies and results from the Project Area hydrometric program are provided in baseline studies and the Project hydrometeorology report (SRK 2021).

Discharge from the nearby regional stations as well as the local hydrometric stations follow a snowmelt-dominated flow regime with an initial increase in discharge observed in April followed by annual maximum flows in response to snowmelt during May. Discharge response to rainfall events throughout the summer and a recession to annual low flows is observed in the late fall and winter. Mean annual runoff for the Project is 224 mm but varies based on the median catchment elevation due to the orographic effect of precipitation and temperature.

The typical yield and baseflows per unit catchment area varies between the major streams, creeks, and rivers within the Project Area, where the larger systems, namely Telkwa River and Bulkley River, produce a higher yield than the smaller Goathorn, Tenas Creek and Four Creek. A summary of flow regime details for each watercourse potentially affected by the Project, including drainage area, mean annual unit discharge and average winter unit baseflow is presented in **Table 3.3-1**.

The Four-Hydro station was installed in April 2020 with continuous data through October 2020. Additional data will be required to develop accurate flow statistics, however comparisons with overlapping Goathorn Creek Water Survey of Canada suggest that Four Creek exhibits a faster and peakier snowmelt period followed by a longer low flow period through the summer months and minor responses to rainfall events throughout the fall. SRK also completed a review of Piteau data collected in 1997 and 1998 for Four Creek and it confirmed this finding. Additional commentary on Four Creek is provided in SRK 2021.

Table 3.3-1: Project Hydrometric Station Summary

Hydrometric Station	Drainage Area	Mean Annual Unit Discharge	Average Winter Unit Baseflow
	(km^2)	($L/s/km^2$)	($L/s/km^2$)
Tenas-Hydro (2)	47	11.0	0.43
Four-Hydro (5)	11	5.2	0.30
Goathorn-Hydro (1)	124	13.2	1.8
Telkwa-Hydro (3)	967	28.2	4.1
Bulkley River at Quick (4)	7340	19.0	3.0

Notes: *km^2=square kilometres; $L/s/km^2$=litres per second per square kilometre*

[1]Tenas-Hydro is a local hydrometric station installed for the purpose of baseline monitoring of the Tenas Project in 2017 and was extended using a regression with long-term WSC 08EE008 Goathorn Creek Near Telkwa.

[2]Four-Hydro is a local hydrometric station installed for the purpose of baseline monitoring of the Tenas Project in April 2020. Additional data will be required to develop a regression model and extended time series. The average winter baseflow represents the average of three (3) low-flow measurements collected in February 2021 while the mean annual discharge represents the mean of data recorded between April 2020 and October 2020. Additional details are provided in SRK 2021.

[3]Goathorn-Hydro is a local hydrometric station installed for the purpose of baseline monitoring of the Tenas Project in 2017 and was extended using a regression with long-term WSC 08EE008 Goathorn Creek Near Telkwa.

[4]Telkwa-Hydro is a local hydrometric station installed for the purpose of baseline monitoring of the Tenas Project in 2017 and was extended using a regression with long-term WSC 08EE020 Telkwa River below Tsai Creek.

[5]Bulkley River at Quick is a Water Survey of Canada station (WSC 08EE004).

3.3.1.2 Extreme High Stream Flows

The effect of extreme high flow events is an important consideration for the Project to evaluate and mitigate the risk of flooding. Flooding events in the Project region are typically produced by rapid snowmelt during freshet conditions in May or June or high-intensity rainfall events in late summer or early autumn.

A peak flow analysis was performed using the extended Project hydrometric records for Goathorn, Tenas and Telkwa, along with the WSC record at Bulkley River at Quick (08EE004). The peak-flows for each watercourse are presented in **Table 3.3-2**. The return period refers to the probability of occurrence of the flood event. For example, a 1-in 50-year return period (Q50) event is a flow magnitude that has a 2 percent (%) chance of being exceeded in any given year. Additional data will be required to generate peak flow statistics using the Four-Hydro record.

Table 3.3-2: Project Watercourses Peak Flows (cubic metre per second [m^3/s])

Return Period (years)	Tenas-Hydro	Goathorn-Hydro	Telkwa-Hydro	Bulkley River at Quick (WSC 08EE004)
1000	50	48	600	1211
500	42	44	499	1174
200	32	39	391	1123
100	2716	35	325	1079
50	22	31	269	1028
25	19	27	222	976
20	18	25	209	954
10	15	21	172	895

Return Period (years)	Tenas-Hydro	Goathorn-Hydro	Telkwa-Hydro	Bulkley River at Quick (WSC 08EE004)
5	12	17	139	815
2	9	12	102	668

The probability of a 1-in-100-year event occurring during the Construction Phase is 1%, during the Operation Phase is 20%, and during the Decommissioning, Reclamation and Post-closure Phase there is a 44% chance (**Table 3.3-3).**

Table 3.3-3: Probabilities Associated with Extreme Events Throughout Project Phases

Event	Probability for Any Single Year (%)	Probabilities for Project Phases		
		Construction (2021)	Operation (2022 to 2043)	Decommissioning, Reclamation and Post-closure (2044 to 2100)
1-in-10-year	10%	10%	90%	100%
1-in-20-year	5%	5%	68%	95%
1-in-50-year	2%	2%	36%	68%
1-in-100-year	1%	1%	20%	44%
1-in-200-year	0.5%	0.5%	10.4%	24.9%
1-in-500-year	0.2%	0.2%	4.3%	10.8%
1-in-1000-year	0.1%	0.1%	2.2%	5.5%

Notes: *%=percent*

3.3.1.3 Extreme Low Flows

Low flows are an important consideration for this Project because they could affect aquatic communities. While the annual low flow will occur during winter months, flow volumes during the summer season (June to September) also occur. Low flows are characterised using different indices than high flows, with the most common measure being the seven (7)-day low flow over a given period of time. For example, the average annual 7-day low flow (7Q2) provides an estimate of the average base flow conditions of a stream. Another measure, the 7Q10, is the 7-day average minimum flow that is expected to occur once every 10 years.

Seven-(7) day low flow statistics were developed using the extended hydrometric records for Goathorn, Tenas and Telkwa, along with the WSC record at Bulkley River at Quick (08EE004). Frequency analyses were performed to estimate the seven (7)-day low flow conditions for a range of return periods, as shown in **Table 3.3-4**.

Additional data will be required to generate low flow statistics for Four-Hydro. For the assessment, an average low flow in Four Creek was developed based on the available monitoring from 2020. Extreme low flows, as presented in **Table 3.3-4** for other streams, will be developed once additional local data are available.

Table 3.3-4: Project Watercourses Seven (7)-day Low Flows (cubic metre per second [m^3/s])

Hydrometric Station	Watershed Area (km²)	7-Day Low Flow (m^3/s) for Return Periods (years)				
		5	10	20	50	100
Tenas-Hydro	48	0.005	0.004	0.003	0.003	0.002
Goathorn-Hydro	124	0.23	0.22	0.21	0.19	0.19
Telkwa-Hydro	997	3.7	3.4	3.2	2.9	2.8
Bulkley River	7340	17	15	13	12	11

Notes: *km² =square kilometres m^3/s=cubic metres per second*

3.3.2 High Stream Flow Risk Assessment (Flooding)

3.3.2.1 Potential Effects on the Project and Valued Components (VCs)

Effects to the Project from high stream flow events may include:

- disruption to operations;
- loss of life or injury;
- damage to diversion ditches, collection ditches and management pond spillways;
- damage to Minesite roads and the TAC;
- damage to river crossings, including Goathorn Creek bridge, and culverts. Rapid channel avulsion could cause damage to any infrastructure in the new channel; and
- damage to the Rail Infrastructure.

Most collection channels at the Project are required during the Post-closure Phase to provide a water cover in the management ponds. Over time, vegetation is expected to become established within the collection channels. Therefore, channels were sized to convey the design peak flow with climate change with the addition of vegetation growth. Should design flows be exceeded, the channels will overflow, causing excess water to flow through the Minesite with potential damage as noted above. Such an occurrence would be relatively short-lived (several days following the precipitation event).

Floods occurring along the Minesite roads and TAC could result in road closures caused by excess water on the road surface, erosion of the road surface, damage to stream crossings, or debris blocking the roads. Under the most extreme flood events there is the potential for drainage structure washouts (bridges, culverts, and cross-drains).

For floods in excess of the design criteria, it is likely that road closures will be put in effect as there is potential for crossings to partially obstruct flows, resulting in elevated upstream water levels (backwatering) and overtopping onto the road surface. Road closures under these conditions would be temporary and the road would re-open once water levels recede, and structural checks of the crossings have been made.

The Rail Infrastructure may be affected by flooding of the Bulkley River as it is within the 1 in 200-year floodplain, as is the entire main Canadian National Railway (CNR) rail line. Flooding in this area has not disrupted the CNR rail line within its 100 year history. Closures of the main CNR rail line due to flooding would halt operations in the Project Rail Infrastructure area.

Effects to VCs from the Project effects may include:

- changes to erosion rates and deposition of sediment, affecting stream morphology and water quality, affecting the Surface Water VC;
- consequent effects to Fish and Fish Habitat, Aquatic Resources, and Wildlife VCs; and
- temporary Project closures, affecting the Economic Development VC.

3.3.2.2 Project Mitigation Measures for Extreme High Stream Flows

Project infrastructure will be designed to withstand flood events. To minimize the potential effects from floods on the Project, most of the key Project components (e.g., diversions channels, and road stream crossings) have been designed to accommodate at least the 100-year flood event. Flooding will be mitigated by:

- monitoring weather forecasts to anticipate and prepare for large rainfall events;
- slowing or stopping work if rainfall runoff is anticipated to cause unsafe working conditions;
- placing Project-related infrastructure above high water marks wherever possible;
- appropriately reinforcing stream channels at road crossings and stream crossings to minimize sediment movement:
  - The 1-in-100-year or a 1-in-200-year flood event is included in the design for diversion and collection channels, depending on the risks to downstream infrastructure or the environment and the expected design life of each structure;
  - Stream crossings on site roads are designed to pass the 1-in-100-year event. Appropriately sized riprap will be placed at the inlet and outlet of bridges and culverts to protect structures from erosion;
  - A regular inspection and maintenance program will be established to ensure that the channels and stream crossings are free of obstructions and able to convey design flows efficiently. This will be especially important during early spring before freshet conditions, in early fall ahead of potential fall rainstorms and following any major flood event;
- diverting site runoff from mining areas into ponds that are sized and designed appropriately for flood events:
  - The Tenas Control Pond will be sized to control average freshet flows with an additional capacity to manage the 100-year 24-hr storm event;
  - The discharge rate to Goathorn Creek is based on the average annual inflow into the Tenas Control Pond multiplied by a safety factor of 1.2, and discharge was assumed to occur over a period of five (5) months (May to September);
  - Runoff volumes greater than the design capacity are discharged through the emergency spillway. Given the proximity to Tenas and Goathorn creeks, the spillway was sized for an event 2/3 between the 1,000-year event and the PMF event;
- implementing a Trigger Action Response Plan (TARP) (see **MERP**) to weather conditions:
  - Operations will cease at the Rail Infrastructure if a flood event greater than a 1 in 100-year event is forecast in the upcoming 48 hours;
  - The temporary diversion dams will be inflated with water to divert flows away from the coal stockpiles and loading area;

- Rail cars could be moved to the Ridley Port area for storage and operations will stop temporarily at the Rail Infrastructure;
- Rail cars could be moved to the CNR rail yards in Prince George;
- Damage due to flooding to the Rail Infrastructure will be repaired and ready for when other infrastructure in the region recovers from this event; and
- following the measures in the **MERP** for preparation for a potential flood event to minimize effects to the Project.

3.3.2.3 Likelihood and Consequence for High Stream Flow Events

During the lifespan of the mine there is a 44% chance of a 1-in-100-year flood (see **3.3.1**), as well as lesser volume floods, which could affect Project components. The Likelihood of effects to VCs from a flood of this size is therefore conservatively considered **Unlikely**, occurring up to twice during the life of the Project. With Project mitigation measures in place to manage potential flood events, consequences of the effects to the Project on surface water quality and linked VCs are considered to range from **Minor** (i.e., for culvert repair), to **Moderate** (failure of a water crossing). Economic consequences may be **Moderate** if access is constrained, and the mine is closed until road, rail and bridge repairs are completed.

3.3.2.4 Conclusions on Potential Risk for High Stream Flows

The effects of high stream flows to the Project are managed by the Project design and mitigation to address high flow situations and climate change, and risk to the Project is considered low. With the Project mitigation in place, in the worst-case situation, the Likelihood of effects to VCs is assessed as **Unlikely**, the consequence is considered **Moderate** (less than one (1) year), and the risk assessment is **Medium**.

3.3.3 Extreme Low Stream Risk Flow Assessment

3.3.3.1 Effects on the Project and Valued Components (VCs)

Effects to the Project from low precipitation may include:

- insufficient water cover for control pond and management ponds;
- insufficient water supply from the control pond for firefighting; and
- insufficient water supply for coal processing.

Effects to VCs from the effects to the Project could include changes in water quality released from the management ponds, however per the **MWMP**, surface water releases will not be undertaken during water supply shortages when water quality is most likely to be affected. Effects to Surface Water, and consequently Aquatic Resources, and Fish and Fish Habitat VCs, may also result from withdrawals from Goathorn Creek or reduced flows from the contact water collection in the watershed during low flows. While the annual low flow will occur during winter months, flow volumes during the summer season (June to September) are also important as they can strongly influence species presence. However, as stated in the **MWMP**, water withdrawals from Goathorn Creek are capped at a maximum of 2.5% which is below the value where effects would be observed.

3.3.3.2 Project Mitigation Measures for Extreme Low Stream Flows

Mitigation measures relating to reducing drought-induced water quality declines include:

- collecting non-contact water around Minesite Infrastructure;

- developing a **MWMP** that accounts for low-runoff years; option for a 2.5-m water cover on management ponds when 1 m is sufficient to stop oxidization of PAG material;
- reducing Project water requirements from 15,000 m^3 per month to 10,000 m^3 per month through additional dewatering equipment in the CPP and through additional water conservation efforts which will require approximately one (1) year to purchase and commission;
- the ability to change from using Goathorn Creek for emergency water supply to using the Telkwa River where the planned water use would be less than 0.1%; and
- flexibility to pump water between management ponds and Tenas Control Pond.

3.3.3.3 Likelihood and Consequence for Extreme Low Stream Events

Low flows are anticipated to be a frequent seasonal occurrence at the Project Minesite. The water management system for site run-off, management ponds and spillways has been designed to function during low flow periods and extreme low flow periods through strategic conservation of water in the management plans and minimizing water extraction from water courses during low flow periods in summer and winter. As such low and extreme low flows are not anticipated to interact with mining activities, and the Likelihood of effects to the Surface Water, and consequently Aquatic Resources, and Fish and Fish Habitat VCs, as a result of extreme low flow is considered **Unlikely**. With the Project design measures in place, consequences to these VCs are conservatively considered **Moderate**.

3.3.3.4 Conclusions on Potential Risk for Extreme Low Flows

The effects of extreme low flows to the Project are managed by the Project design and mitigation which are implemented through the **MWMP**; risks to the Project are considered **Low**.

With the mitigation in place, the Likelihood of effects to the Surface Water, Aquatic Resources, and Fish and Fish Habitat VCs is assessed as **Unlikely**, the consequence is considered **Moderate**, and the risk assessed as **Medium**.

3.4 Wind Risk Assessment

This subsection presents information on typical and extreme wind conditions, the potential effects to the Project from extreme winds, and consequent effects to VCs.

3.4.1 Wind Conditions

3.4.1.1 Typical Wind Levels

Based on the 27-month dataset from the Tenas Project Station, 1 to 2 metres per second (m/s) winds were the most frequent, occurring 45% of the time. The average daily wind speed from 30 September 2017 to 9 December 2019 was 1.5 m/s. The frequency of calm winds (less than 1 m/s) was 35%, and daily average wind speeds did not exceed 4 m/s.

3.4.1.2 Extreme Wind Levels

The maximum gust speed recorded on-site was 14.9 m/s (53.6 kilometre per hour [km/hr]) on 22 March 2018. This is classified as a near gale force wind on the Beaufort scale (rated 7 on a scale of 1 to 12 from low to high (National Oceanic and Atmospheric Administration [NOAA] 2021). A gale force wind is described as when whole trees are in motion and inconvenience felt when walking against wind.

3.4.2 Potential Effects on the Project and Valued Components (VCs)

Overall, as described above, winds in the Project Area are generally low velocity and are unlikely to have effects on the Project. However, high velocity winds do occur. High winds during below-freezing air temperatures would contribute to wind chill and blowing snow. Blowing snow would reduce visibility, limiting access to and from the Minesite. High winds could also:

- dislodge roofing;
- destabilize covered walkways;
- damage or remove equipment shrouds and covers, which could then present a safety hazard;
- cause downed trees, which could temporarily block roads and the rail line;
- damage powerlines and building services if improperly designed or installed;
- increase fugitive dust from coal storage areas;
- increase fugitive dust from topsoil stockpiles;
- increase fugitive dust from non-PAG and overburden storage piles and backfills; and
- create electrical blackouts.

The potential effects to the VCs are:

- air quality effects from dust (**S4.0-C1 Atmospheric Environment VC** of the **EAC Application**);
- temporary short-term effects to the Economic Development VC should blockages to roads and Rail Infrastructure temporarily halt transport of processed coal or the powerline fails; and
- injury to employees from falling trees or wind-blown material (**S8.0-C1 Human Health VC** of the **EAC Application**).

3.4.3 Project Mitigation for Extreme Wind Events

The meteorological station is recording onsite winds on an ongoing basis to guide construction techniques necessary to mitigate potential damage by wind. Mitigation measures include:

- Weather forecasts will be monitored to anticipate and prepare for severe winds;
- Project components damaged by wind will be promptly repaired and wind-blown material will be collected and transported or covered to minimize potential hazards;
- The Minesite will have a comprehensive fugitive dust mitigation strategy which is further detailed in the **Air Quality Management Plan (S13.0-C2) (AQMP)**. At high wind speeds, both water and/or chemical agents will be used to limit fugitive dust emissions from stockpiles, haul roads, the TAC, and backfills. Some activities can be curtailed during extreme wind events, such as loading of processed coal at the Rail Infrastructure, to reduce fugitive dust emissions;
- During a powerline failure due to wind (see **S9.0 Accidents and Malfunctions** of the **EAC Application**), non-essential machinery will be shut down until power is re-established. Danger trees will be removed from the powerline route, and from the TAC right-of-way (ROW) to minimize electrical blackouts and potential injury from vehicle accidents on the TAC; and
- Mitigation for extreme low temperatures would be applicable for potential wind chill and blowing snow effects (**3.2.3**).

3.4.4 Likelihood and Consequence for High Winds

The occurrence of high wind effects to the Project affecting VCs is considered **Unlikely**, as most effects to the Project are minimal and will be promptly repaired. Curtailed coal loading will minimize dust concerns at the Rail Infrastructure site, and the comprehensive **AQMP** will mitigate fugitive dust emissions from the Minesite. With the implementation of the **OHSP**, and prompt repair to damaged infrastructure, injuries to employees are not anticipated. The potential consequences to the Economic Development VC from temporary shut-downs due to wind are considered **Negligible**, as Project mining activities will continue with power from generators for the short time that power may be out, and blockages to transportation routes will be repaired within days. Consequences to the VCs are therefore considered **Negligible**.

3.4.5 Conclusions on Potential Risk for High Winds

The overall risk to the Project from high winds is considered **Very Low**, as the area is not prone to high winds.

Effects to the Atmospheric Environment, Economic Development and Human Health VCs are **Unlikely**, and the consequences are assessed as **Negligible**, therefore the potential risk to VCs from wind effects to the Project is considered **Very Low**.

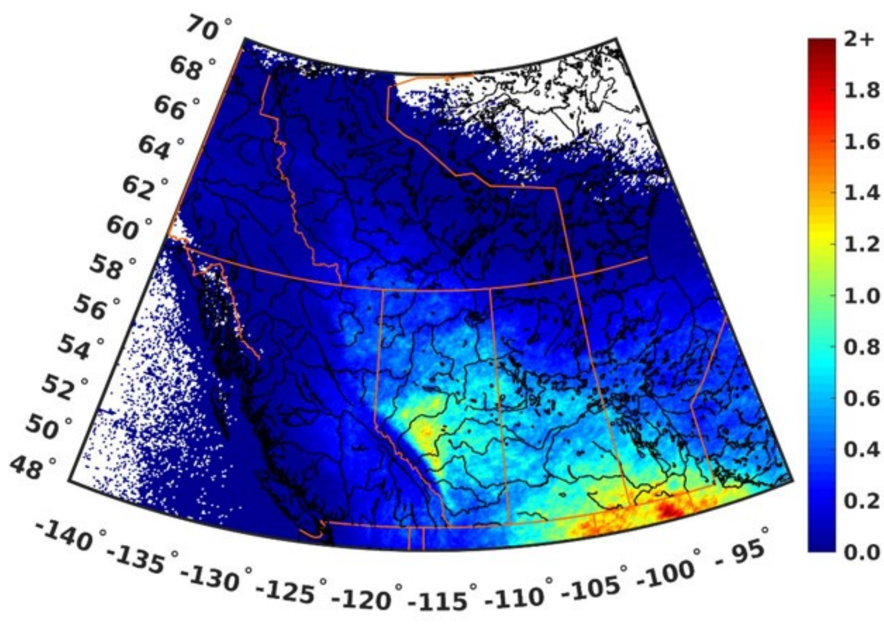
4. Lightning Strike Risk Assessment

This subsection presents information on lightning conditions, the potential effects to the Project from the lightning, and potential consequent effects to VCs.

4.1 Lightning Conditions

The earth's electrical balance is maintained through thunderstorms and lightning. The downward leader (gas plasma channel) from a thundercloud strikes the earth. The voltage is broken down by ground-based air terminators that emit varying degrees of induced electric activity, by forming upward streamers. This "switch" is then closed and the current flows resulting in lightning flashes (National Lightning Safety Institute [NLSI] 2014). Lighting is a stochastic, irregular and unpredictable occurrence which is difficult to predict and forecast; however, scientists have determined that there has been a general increase in lightning strikes due to climate change and global warming, as much as 10% increase per degree of global warming (Price et al. 2009). Further, lightning strike frequencies can be related to regions of greater instability in the atmosphere which is patterned and caused by the differential heating of the Earth's surface by the sun (Price et al 2009).

In Canada, lightning events usually occur outside snowfall seasons in April to October with most ground lightning strikes occurring in July (Canadian Centre for Occupational Health and Safety [CCOHS] 2021), and most lightning-related fatalities and injuries occur in the June to August summer months (Mills et al. 2006). **Figure 4.1-1** describes the average lightning flash density in Western Canada from 1999 to 2018 and **Table 4.1-1** features the numeric values of the average lightning flash density in Western Canada from 1999 to 2018 (ECCC n.d.).



Source: *Environment and Climate Change Canada (ECCC) n.d.*

Figure 4.1-1: Average Lightning Flash Density (per square kilometre per year [km^2/yr]) in Western Canada from 1999-2018

Table 4.1-1: Average Lightning Flash Density (per square km per year [km^2/yr]) in Western Canada from 1999-2018

Area in Province or Territory	Average flash density per km^2/yr	Colour Representation in Figure 4.1-1
British Columbia (BC) – offshore west of Haida Gwaii	(too few for detection)	White
BC – North and South Coast and Northern BC	0.1	Dark Blue
BC – Central Interior	0.25	Blue
BC – Peace Region – Small Areas	0.5	Light Blue
BC – Southeast Small Areas	0.5	Light Blue
Yukon	0.1	Dark Blue
Northwest Territories – South	0.25	Blue
Northwest Territories – Northeast	0.1	Dark Blue
Nunavut	0.1	Dark Blue

Source: *Environment and Climate Change Canada (ECCC) n.d.*
Note: *km^2/yr=square kilometre per year*

BC observes significantly fewer ground lightning strikes compared to the eastern provinces based on the statistics shown by **Figure 4.1-1** and **Table 4.1-1**.

Summer thunderstorms occur within the Project Area. Thunderstorms may be accompanied by lightning strikes, hail, and occasionally tornadoes. A thunderstorm is classified as severe when it contains hail larger than ¾ inch (1.9 centimetre [cm]) in diameter, winds gusting more than 50 knots (92.6 km/hr) and/or a tornado. Thunderstorms frequently accompany severe rainstorm events, but the severity of the damages is often greater than what would have been caused by the precipitation event alone (Mills et al. 2006).

Lightning strikes and flashes are monitored on an ongoing basis through the Canadian Lightning Detection Network (ECCC 2020). Although there is no data for Telkwa, data does exist for Smithers (22 km northwest of the Project) and Terrace (102 km west of Project). On average, Terrace experienced 756 (0.10 per day) lightning strikes, and Smithers experienced 1,858 (0.26 per day) for the 10-year period between 1999 and 2018 (Mills et al. 2006). Lightning strikes are defined as the sum of both cloud-to-cloud and cloud-to-ground strikes. It is expected that the frequency of lightning strikes at the Project site will be similar to that for Smithers, the closest location with data.

4.2 Potential Effects on the Project and Valued Components (VCs)

Lightning may cause significant damage to the Project site and infrastructure if an event were to occur on or near the Project site, during the Project's lifetime. Effects from lightning may include thermal stress of materials, radial acoustic shock wave (thunder) causing mechanical damage, magnetic pressures up to 6,000 atmospheres, voltage sparking and dielectric breakdown (failure of insulating material), and rapid heating of air in enclosed spaces resulting in fracture of large dense objects (i.e., concrete and or rock structures) (National Lightning Safety Institute [NLSI] 2014). Sparks from exploding high current arcs or powerlines have the potential to start fires as well.

The direct effects of lightning strikes on the Project include initiating fires and electrical failures. Fires resulting from lighting strikes could include buildings, infrastructures, equipment and machinery, stockpiled waste materials for disposal such as lubricants, and the forested area within, or adjacent to, the Project

Area. Lighting can also cause detonation of holes loaded with explosives. Radio communications and computer systems may fail if not sufficiently protected from electrical surges associated with lightning. Damage to the Project components from lightning events could therefore include (NLSI 2014):

- failure of radio communications if surge protection inadequate;
- worker injury;
- damage to computer systems if inadequate grounding;
- damage to electrical equipment, including substation, transmission line, and pumping systems for management ponds;
- fire initiation and damage to buildings, infrastructure, equipment and machinery and vehicles and offsite areas;
- damage to mobile equipment; and
- consequent Minesite shutdowns and loss of production.

The resultant effects to VCs will depend on the location, type, and level of damage to the Project. Effects will be similar to those discussed in **S9.0 Accidents and Malfunctions** of the **EAC Application**, for example for fire and explosions, containment failures and power failures. There may be effects to Human Health VC due to an employee injury from direct strikes or indirectly from damage to vehicles and equipment in use. Minesite shutdown will affect the Economic Development VC.

4.3 Project Mitigation Measures for Lightning

Mitigation of lightning strikes primarily includes maintaining compliance with building codes (electrical standards and fire suppression systems) and fire control standards. The BC Building Code (GovBC 2018) will be adhered to ensure that electrical and fire detection systems are adequate for the structures. Appropriate fire fighting equipment will be readily available, and personnel will be trained to use it, as described in the **MERP**. The **Explosives Management Plan (S13.0-C6) (EMP)** provides a detailed procedure for dealing with lighting in relation to explosives use. Vegetation will be cleared far enough away from infrastructure to give time for Project personnel to react to a fire. Lighting detection devices will be provided onsite to monitor the Likelihood of a lighting strike with subsequent actions taking by the blasting and drilling operations.

Some protection measures that may be included in Project infrastructure or site design include (NLSI 2014):

- indirect air terminal designs that utilize inductive and capacitive coupling from lightning-energized conductors and overhead shield wires or mast systems next to or above the Project infrastructure;
- upward leader suppression by breakdown of voltages using interior faraday shielding such as rebar and inner-wall screening;
- surge protection devices for all electrical wired configurations in Project site;
- use of down-counters installed outside and away from Project infrastructure or building structural steel to emulate a faraday cage to protect infrastructure from direct lightning strikes;
- bonding by electrical referencing of metallic conductors entering structures to the same ground potential to assure the lightning protection systems in place; and
- grounding systems such as ground rings or Ufer grounds connected around Project infrastructure to reduce AC impedance and DC resistance.

4.4 Likelihood and Consequence for Lightning

Effects to the Project that affect VCs from lightning strikes within the Project Area are expected to be a **Rare** event as the Project is not in a high lightning area given the low number of lighting strikes in both Terrace and Smithers which are the nearest areas with records.

Consequences of the effects from a lightning strike to the Project Area will be managed by the implementation of design measures, however risks remain, and consequences are uncertain. The consequence of the effects from a lightning strike to the Project has been rated as **Major**, as it may require more than one (1) year but less than 10 to return to existing conditions from a fire caused by lightning (see **S9.0 Accidents and Malfunctions** of the **EAC Application** for related risks). However, in a worst-case scenario, where there is a possibility of a fatality due to a direct lightning strike, consequences may be rated as **Severe**.

4.5 Conclusions on Potential Risk for Lightning

Although the occurrence of lightning in the Project area is low, the potential risk to the Project is evaluated as **Medium**, as risks may remain for employee injury even with the implementation of the design mitigation which will avoid most other risks to the Project. Production loss is also a factor in the risk assessment for the Project. Worst-case risks to VCs, should there be fatalities, are evaluated as medium, as the Likelihood is **Rare**, and the consequence is assessed as **Severe**.

5. GEOHAZARDS RISK ASSESSMENT

This subsection presents information on geohazard conditions, the potential effects to the Project from the hazards, and consequent effects to VCs.

5.1 Geohazard Conditions

Hazard assessments have been developed for snow avalanches, terrain stability (debris torrents, rock fall), and surface erosion potential (see details in **S4.0-C2 Terrain and Soils VC** of the **EAC Application**).

The extent of snow avalanche hazards is primarily influenced by a combination of terrain and climatic conditions. Generally, snow avalanches occur where there are steep, open slopes or gullies covered with deep snowpack. The initiation zone of an avalanche typically has an incline slope of greater than 60% (58 degrees [º]). Avalanches will begin to decelerate in the runout zone and stop on slopes less than 30% (17º).

Avalanche magnitude relates to the destructive potential of an avalanche, which is a function of its mass, speed, and density, as well as the length and cross section of the avalanche path. It is defined according to the Canadian avalanche size classification system. Risks associated with avalanches are due to exposure to the high impact forces and the potential for extended burial.

The Terrain and Soils Local Study Area (LSA) does not contain avalanche prone terrain with slopes greater than 60%. No snow avalanche tracks were identified in the study area. For these reasons it is not anticipated that avalanches will affect the Project, and they are not considered further.

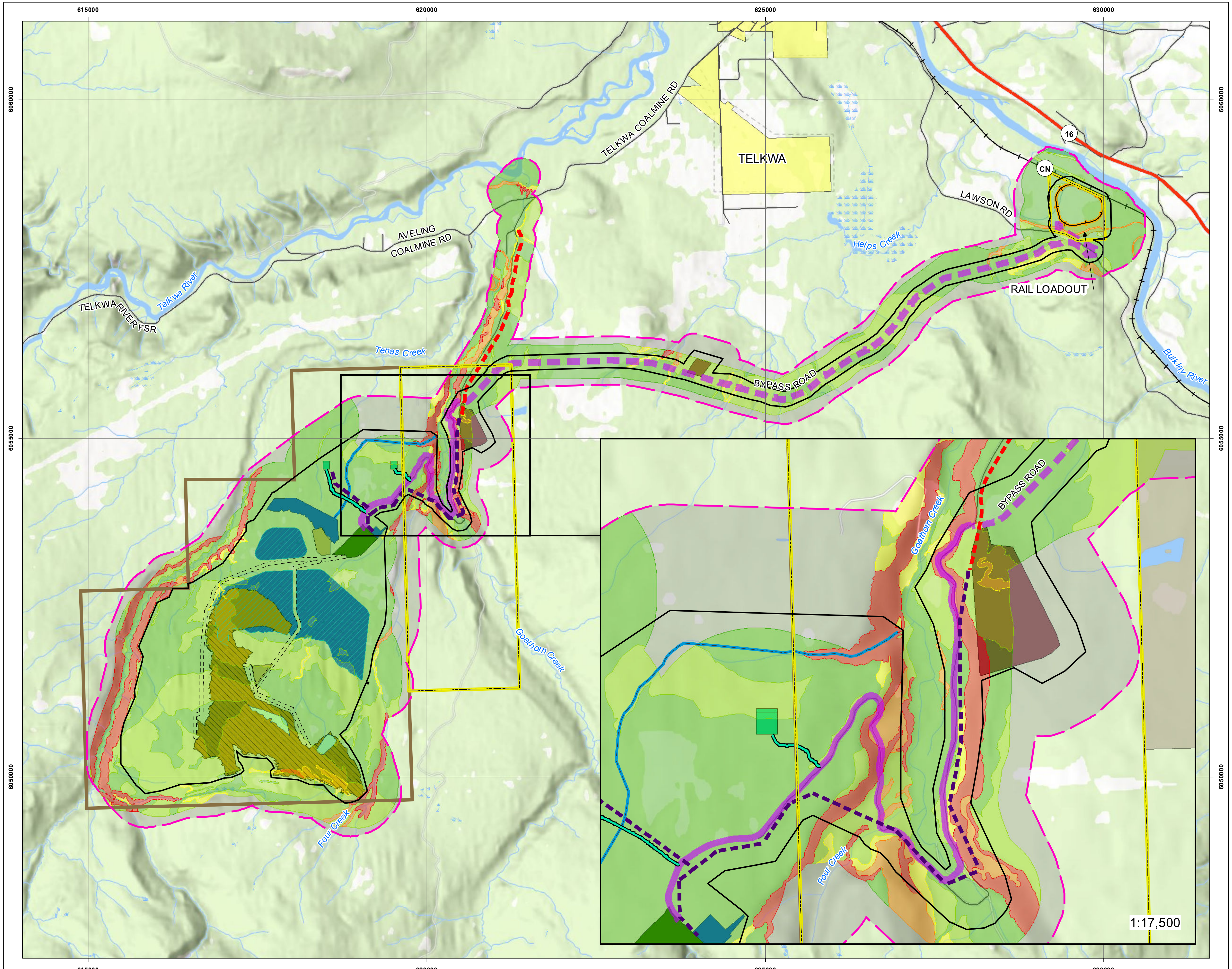
Terrain stability classes (TSC) indicate the likelihood of any landslide of any type, size, or character initiating in the polygon. The TSC delineate the relative slope stability of the polygon following Minesite development. Surface erosion potential is a highly qualitative rating of the potential for generating sediment during Minesite Construction, and Operation phases. Both analyses consider general land development activities associated with Minesite development such as land clearing, excavation along roads, trails, pipelines, drainage ditches and test pits, and deposition of excavated material for storage, fill or as side cast. Slope stability related to activities in the open pit are considered in the design of the Project (see **S1.0 Overview of Project Proponent Description** and **S9.0 Accidents and Malfunctions** of the **EAC Application**.

The five (5) TSC range from TSC I (stable terrain) to TSC V (unstable terrain). Stable terrain mapped as TSC I and II dominates the LSA and makes up over 90% of the LSA. The remainder of the LSA is dominated by unstable terrain mapped as TSC V which comprises approximately 5% of the LSA. TSC V (unstable) and IV (potentially unstable) makes up approximately 7% of the LSA and occurs predominantly along the steep valley sidewalls of Tenas Creek, Goathorn Creek, and some sections of Four Creek (**Figure 5.1-1**). TSC V terrain units typically have moderately steep to steep slope gradients and show evidence of active or recent slope movement[1]. TSC IV terrain typically has similar slope angles or is located adjacent to TSC V terrain, and commonly shows signs of historic mass movement. Landslides or soil creep are expected to occur during excavation or following cut-and-fill road construction. TSC IV and V terrain units may include small sites of stable terrain. A subsequent geotechnical investigation is required to determine the site-level landslide hazard associated with proposed development and to design mitigative measures that reduce or eliminate the landslide hazard.

[1] TSC IV and V are assigned to the initiation zones of slope movement. Landslide run-out areas on gentle terrain were typically assigned to TSC I, II or III.

Tenas Project

Terrain Stability Classes in the Local Study Area



Legend

- Rail Line
- Highway
- Road
- Watercourse
- Wetland
- Waterbody
- Municipal Area
- Project Area
- Terrain and Soils Local Study Area

Terrain Stability Class

- I
- II
- III
- IV
- V
- No Data

Project Features

- Existing 25 kV Power Line
- 25 kV Power Line
- Haul Road
- Rail Loop
- Discharge Path
- Tenas Access Corridor
- Backfill Area
- Control and Plant Sedimentation Pond
- Explosive Infrastructure
- Management Pond
- Mine Infrastructure Complex
- Open Pit
- Pit Lake
- Quarry
- Rail Infrastructure
- Topsoil Stockpile
- Tenas Coal Licenses
- Telkwa Coal Limited Private Property

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Project line features are for display only.

Sources

- Project Features: Allegiance Coal, April 21, 2021.
- Basedata: Government of British Columbia
- Basemap: World Topo Base

N

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Kilometers

NAD 1983 UTM Zone 9N

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TELKWA COAL LIMITED

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In the Goathorn Creek Valley, much of the valley sidewall terrain was assigned a TSC IV or V. Slopes above and below the existing Telkwa Coalmine Road and/or Caribou Forestry Service Roads (FSR) are subject to active debris slides or accelerated creep in glacial till leading to deep, open tension cracks. Thick sand deposits overlying impervious glacial till promote seepage horizons on the valley wall, contributing to soil saturation, creep, and occasional, natural, shallow debris slides. Along the Caribou FSR, the slope instability includes: rockfall and ravelling in steep colluvium above the road; shallow debris slides and slumping in thick glacial till above the road; and tension cracks due to settling and creep in 2 to 5 m thick, clay-bearing mine rock.

The valley walls of Tenas Creek, to the west of the Minesite, and portions of Four Creek, were mapped as TSC IV and V. Steep slope angles, active toe slope undercutting by Tenas Creek, the fine texture of the thick quaternary sediments and seepage surfacing on the valley wall at stratigraphic contacts all contribute to active and potential slope instability. No active landslides were identified at Four Creek.

Surficial materials in and surrounding the Minesite area, along the Bypass Road and along the shoulder above the valley wall of Goathorn Creek have a low surface erosion potential, reflecting the low slope gradients and the cohesive soil textures as well as presence of coarse fragments in glacial till. At the southern edge of the Minesite area, thin veneers of glacial till or weathered rock over hummocky bedrock also have a low erosion potential. Areas of high or very high surface erosion potential were identified on the steep and moderately steep, fine-textured valley side walls of Goathorn Creek and Tenas Creek. In addition, the units include unstable and potentially unstable sites and have a greater potential for exposure of disturbed mineral soil in landslides. Fluvial fans consisting of sand and gravels are highly susceptible to surface erosion along existing and potentially new distributary channels. Floodplain units with silty overbank deposits were also assigned a high erosion potential rating; while slope gradients are typically <5%, the sandy soils lack cohesion and overland flow during peak run-off events or along spring-fed back channels may easily entrain any mineral soil exposed by construction or land clearing. Any development on areas of high and very high surface erosion potential requires erosion control planning and installation

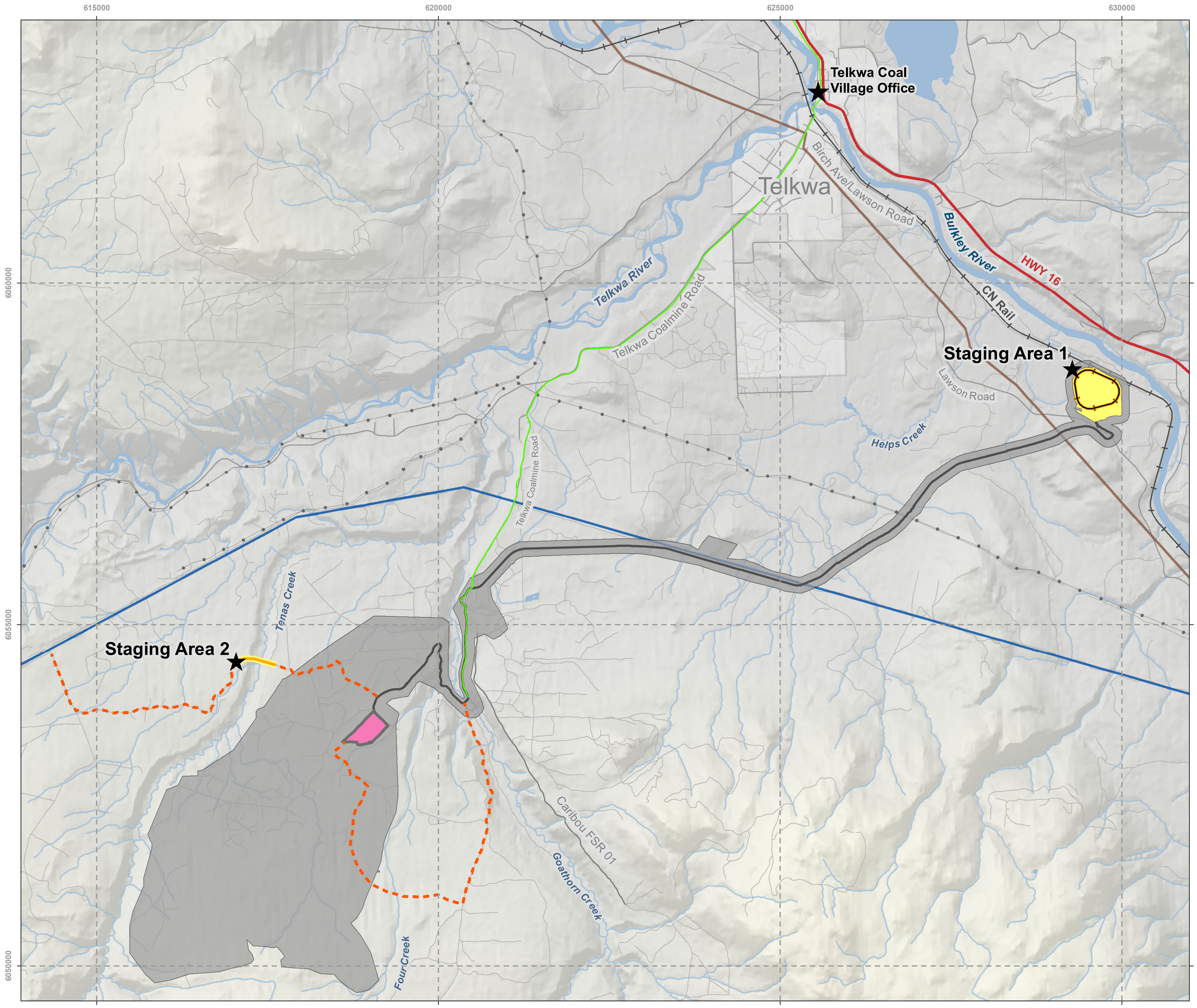
Rockfalls occur through mechanical action on unstable (and occasionally stable) rock. In the Project Area, rockfalls would likely be the result of seismic activity, freeze-thaw activity, or unsecure overhead hazards, within the open pit. Seismic activity could result in the release of small or large sections of rock. Freeze-thaw is a mechanical trigger for rock with existing cracks and fissures. When water or snow is introduced into cracks and fissures of rocks (cliffs and outcrops primarily), and is then exposed to free-thaw cycles, the contraction and expansion of solid-state water acts to progressively ratchet the rock loose. This process could be relatively fast or occur over a long period of time, depending on the site-specific circumstances.

5.2 Potential Effects on the Project and Valued Components (VCs)

Slope stability concerns in the vicinity of Goathorn Creek have the potential to affect the TAC, and the Goathorn Creek bridge.

The combined effects of the existing conditions, and potential increased instability not entirely mitigated by Project design, may lead to damage and destruction of sections of the TAC and bridge in the vicinity of Goathorn Creek. These slope instability effects to the TAC and bridge in the vicinity of Goathorn Creek may increase erosion and sedimentation in the creek, and in turn change morphology of Goathorn Creek and affect water quality. Aquatic resources in the creek, and fish and fish habitat at the site and downstream may be affected. The Surface Water, Aquatic Resources, and Fish and Fish Habitat VCs would have the potential to be affected.

The direct effect of a large landslide is temporary closure of the TAC with the inability to move personnel, equipment, and processed coal between the Rail Infrastructure and the Minesite. If a landslide occurs on the west side of Goathorn Creek, there is a secondary egress route along the public access trail to the Hunter Basin as illustrated by **Figure 5.2-1** below. If a landslide occurs on the east side of Goathorn Creek, access to the Minesite will be temporarily cut off until the debris can be removed, and safe access is established. In a worst-case situation, an alternative access could be constructed across Tenas Creek on the west side of the Project as illustrated by **Figure 5.2-1** below. Closure of the TAC could result in temporary Minesite closures and effects to the Economic Development VC.



TELKWA COAL LIMITED

Figure 5.2-1

Tenas Project

Evacuation routes

Tenas Access Corridor Features

- Project Area
- Mine Infrastructure Complex (Coal Processing Plant, Maintenance Facility, and Pit Fueling Station, Administration and Mine Dry Building, Mine Rescue and Light Vehicle Maintenance Buildings)
- Rail Infrastructure
- Rail Loop
- Tenas Access Corridor
- Evacuation Routes
- Section of Evacuation Route that is on foot (From Trail to Staging Area)

Base Features

- Rail Line
- Highway
- Secondary Roads and Trails
- Pacific Natural Gas Pipeline
- 25 kV Powerline
- 138 kV Transmission Line
- 500 kV Transmission Line
- Watercourse
- Waterbody
- Telkwa Village Boundary

NAD 83 UTM Zone 9N
Date Created: Jun 14 2021
Last updated: July 08 2021
Version: 2
Created by NB
Base Data: Geogratis, Allegiance Coal 2021

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5.3 Project Mitigation Measures for Geohazards

Mitigation measures presented in **S4.0-C2 Terrain and Soils VC** of the **EAC Application** for effects to terrain stability are applicable to managing the environmental effects on the Project. Project design measures include:

- construction design specifications (e.g., abutments, water management systems, erosion and sediment controls) to eliminate and/or minimize further direct and indirect effects;
- Project design and sequencing that emphasize progressive reclamation (if/where possible) during the Operation Phase;
- locating the TAC in areas of little geotechnical risk, with the exception of the Goathorn Creek Valley section the road has little to no geotechnical risks (see **S1.0 Overview of Project Proponent Description** of the **EAC Application)**;
- installation of slope measuring devices on the Goathorn Creek section of the TAC to record slope movements and feed into a TARP;
- locating equipment onsite and offsite to assist with removal of any landslide materials on the TAC;
- Project design for road crossings at bridges and culverts considered an assessment of creek bank stability and debris flow potential; and
- locating Minesite buildings, infrastructure, machinery, and work zones at a distance from overhead hazards to mitigate against rockfalls.

5.4 Likelihood and Consequence of Potential Effects

Active and historic landslide escarpments are present in the vicinity of Goathorn Creek (**Figure 5.2-1** and **S4.0-C2 Terrain and Soils VC** of the **EAC Application**). Stability issues are therefore considered likely to occur; however, with design mitigation the Likelihood of changes to VCs may occur. The Consequences to Surface Water, Aquatic Resources, and Fish and Fish Habitat VCs are considered **Minor**, as the existing conditions are already unstable, and the effects may be indistinguishable from natural variation. The consequence of this event to the Economic Development VC is rated as a **Minor** due to business interruption reasons as it is expected that the Project's annual production could be negatively impacted if the road is blocked.

5.5 Conclusions on Potential Risk for Geohazards

There is little potential for a geohazard to affect the Project's Minesite and most of the TAC as they are located on shallow-dipping terrain. There is the potential that geohazards related to instability and erosion may affect a section of the TAC only in the Goathorn Creek valley. Design mitigation is anticipated to reduce the risks to the Project.

With the mitigation, the effects from the Project to VCs may occur and the consequences to the environment are considered **Minor**, because potential environmental effects may be indistinguishable from natural variation. There are also potential economic effects of **Minor** consequence from a temporary closure of access to the Minesite. The resultant risk to the Surface Water, Aquatic Resources, Fish and Fish Habitat, and Economic Development VCs is considered medium.

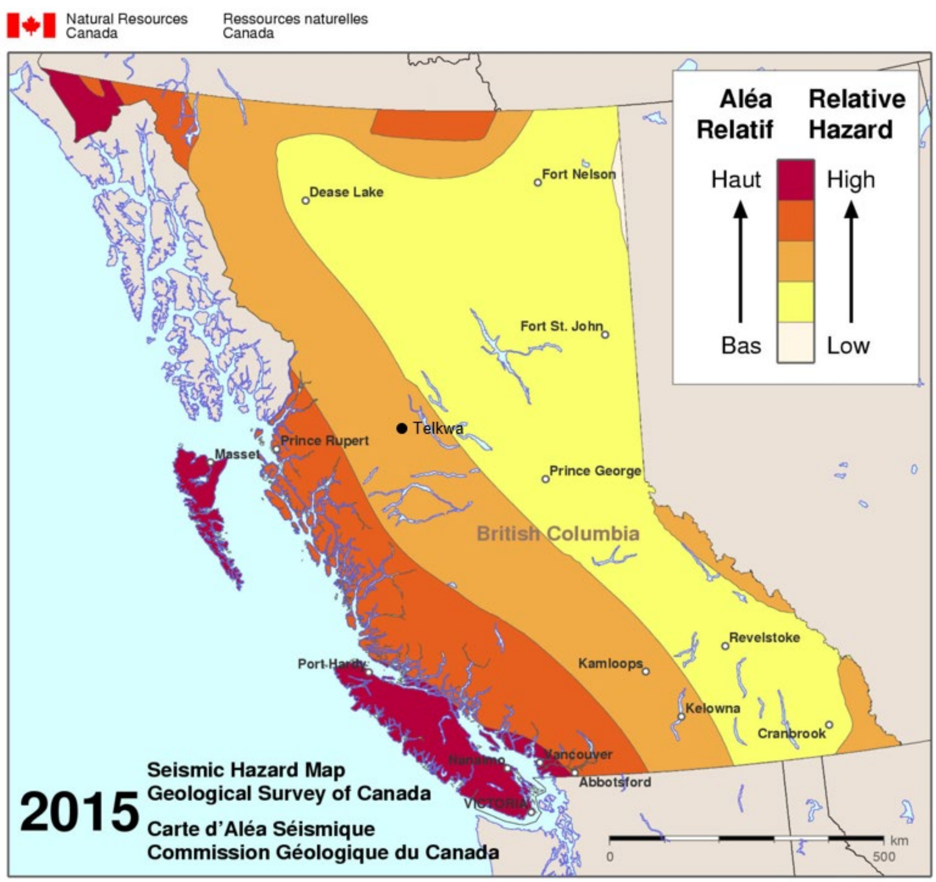
6. SEISMIC EVENT RISK ASSESSMENT

6.1 Seismic Conditions

This subsection discusses effects and mitigation measures relating to seismic activity.

The Project is situated inland and to the east of the BC coastal mountains within a moderate relative seismic hazard zone as defined by NRCAN (2020) (**Figure 6.1-1**). The highest seismic risk in BC lies offshore where the Pacific Plate relative to the North American Plate collide. Effects related to seismic-induced rapid mass-movements are expected to be restricted to the portion of the TAC which lies within the Goathorn Creek Valley, as the remainder of the Project is located within relatively flat ground with acceptable terrain stability (i.e., stable terrain makes up over 90% of the LSA).

Liquefaction is defined as the transformation of granular material from a solid state into a liquid state because of increased soil saturation. Liquefaction is the primary cause of landslides and other ground failures associated with earthquakes. Based on the results of the 2018 and 2019 field investigations (SRK 2018, SRK 2019), it is appropriate to generally classify the existing ground conditions at the site as a Class C Site in accordance with the 2015 National Building Code: Table 4.1.8.4.A (NRCAN 2020) indicating that the Project site is located in a relatively stable seismic area. Liquefaction of the native soils is unlikely due to their well graded soils, relatively high fines content and the moderate seismic risk for the area.



***Source**: Natural Resources Canada [NRCAN] 2020*

Figure 6.1-1: Seismic hazard map for British Columbia

6.2 Effects on the Project and Valued Components (VCs)

Earthquakes may cause damage to workers and Project infrastructure, particularly where infrastructure is not built on firm ground, or where unconsolidated material is deposited on slopes. There may also be damage to buildings, infrastructure, water management system and Minesite components resulting from liquefaction of natural soils and material storage piles.

Minesite landforms may also be affected by a seismic event (see design mitigation in **6.3**). With consideration to the open pit slopes, experience from mines throughout the world have showed that seismicity has caused few, if any, recorded instances of instability in harder rock pit slopes (Read and Stacey 2009). As a result, the completed pseudo-static analysis is considered conservative for the operational stability conditions**.** However, as with most sites in BC, there remains a risk that an earthquake event may adversely affect an engineered landform at the Project site.

Business may be interrupted if the TAC is rendered impassable. Depending on the length of the interruption the Project's annual production could be negatively impacted by a large seismic event even though the seismic risk is moderate.

The resultant effects to VCs from damage to the Project will depend on the strength of the earthquake and level of damage to the Project. Earthquake-induced slope failures are a potential concern on the steeper slopes of the Goathorn Creek watershed (potential rockfall, slumping and mass-movements – see **5.0** for the geohazards risk assessment).

Effects associated with a seismic event will be similar to those discussed in **S9 Accidents and Malfunctions** of the **EAC Application**, for example fire and explosions, containment failures and power failures. There may be effects to demand for emergency services during the event (Infrastructure and Services VC), and effects to employee health due to result of injury from failing structures (Human Health VC). Minesite shutdown would affect the Economic Development VC.

6.3 Project Mitigation Measures for a Seismic Event

The geotechnical design of the mine landforms (i.e., embankments, piles, backfills, pit slopes) consider stability conditions under static and pseudo-static conditions. Pseudo-static conditions incorporate a probabilistic seismic event using guidance from the 2015 National Building Code of Canada - Seismic Hazard Calculator (NRCAN 2020). Peak Ground Acceleration (PGA) is a measure of how hard foundations displace or shake and is measured in units of acceleration due to gravity (g). PGA was calculated for the Project Area for two (2) return periods, assuming firm ground (**Table 6.3-1**). Typically, a 1-in-475 return period event is considered for design stability considerations through the operational life of the Project. The engineered landforms at the Project were evaluated with a 1-in-2,475 event which normally represents long-term or closure conditions. The United States Geological Survey (USGS) has developed a table of intensity descriptions for PGA (Worden et al 2020, Larsson 2004). A PGA of 0.02 g would be felt indoors and windows and doors would be disturbed. PGA of 0.06 g to 0.07 g would be felt by all, and structural damage would be slight (Larsson 2004).

Table 6.3-1: Exceedance Probability, Risk, and Peak Ground Acceleration (PGA) for Seismic Events at the Project

Event	PGA (g) (NBC 2020)	Probability for Any Single Year (%) (NBC 2020)	Probabilities for Project Phases[1] (%)		
			Construction + Operation (Years 1 to 23)	Operation + Decommissioning and Reclamation (Years 1 to 27)	Operation + Decommissioning and Reclamation + Post-closure (Years 1 to 52)
1-in-475-year	0.023	0.21	4.8	5.7	10.9
1-in-2,475-year	0.049	0.0004	0.01	0.01	0.02

Notes: *%=percent; NBC=National Building Code; PGA=Peak Ground Acceleration*
1 The probabilities of events-occurring Project phases are calculated using the hydrology frequency analysis formula:
Probability (risk) = 1 – (1 – P)n where P is the probability for an event in any single year, and n is the Project phase length.

The above analysis suggests that the Project is at lower risk of a damaging seismic event. For example, there is a 10.9% chance of a 1:475-year event occurring, with a PGA of 0.023 during Operation, Decommissioning and Reclamation, and Post-closure phases which would cause light structural damage at the surface. However, where infrastructure is not built on firm ground, or where unconsolidated material is deposited on slopes, damage to infrastructure and risk to workers could be greater.

The **MERP** will include procedures for managing possible seismic events. The **MERP** will require that trained, first response personnel are present when workers are onsite. The number and type of First Responders depends on the number of workers employed. There will also be personnel onsite trained in First Aid, firefighting, emergency response, and hazardous material handling and clean-up. Appropriate emergency equipment will be onsite. For more details, please refer to the **MERP**.

Site infrastructure is located in areas that avoid or minimize exposure to weak, unconsolidated soils or soils that are assessed to be potentially liquefiable, where practical. Where infrastructure is to be built on weak, compressible, or potentially liquefiable foundation soils, deep foundation support or foundation treatment (soil replacement, preloading, dynamic compaction, vibro-compaction, vibro-replacement, or deep soil mixing) will be incorporated into the design. All structures will be thoroughly assessed for stability and integrity after seismic events. Mine infrastructure, such as the CPP, has been structurally engineered and includes loading from earthquakes as part of the design criteria.

With consideration to the engineered landforms for the Project, the design stability conditions are based on achieving a Factor of Safety (FOS) greater than typically 1.3 to 1.5 (static conditions) and 1.05 to 1.15 (pseudo-static conditions) which complies with the design requirements for the landform under review. Please see **Appendix 1.0-L SRK, Tenas Project Management and Control Pond Stability Assessment,** and **Appendix 1.0-O SRK, Tenas Project Foundation Assessment** of **S1.0 Overview of Proponent Project Description** for further information on the geotechnical stability analysis performed for the open pit slopes, backfilled piles, management ponds, and sedimentation ponds. There is a level of redundancy built into the engineering design to mitigate the effect of an earthquake event should one occur during the operational and post-closure lifespan of these structures.

Slope and groundwater monitoring strategies established by the Minesite Operations, Engineering and Environmental team members should support the identification of slower landform deformations that may be exhibited following an earthquake event. Where rapid deformations occur, it will be challenging to firstly identify and then evacuate Minesite personnel.

6.4 Likelihood and Consequence of Seismic Events

A substantial seismic event for the Project area is expected to be a rare event as the area is in a moderate seismic hazard zone. A 1-in-475 return period event has been considered in the Project design. With design mitigation implemented, the Likelihood of effects to the Project, and consequently to VCs, is also considered to be **Rare**. While the Likelihood is **Rare**, the consequences to the Project are dependent on the scale of the event. The VCs that are affected, and their consequences, are also dependent on the scale of the event. In a worst-case scenario, consequences may be **Moderate** due to injuries sustained by employees during the event (Human Health VC) and the length of time to return to normal operations (Economic Development VC).

6.5 Conclusions on Potential Risk for Seismic Events

The Project is at a lower risk of a damaging seismic event. For example, there is a 10.9% chance of a 1:475-year event occurring, with a PGA of 0.023, which would cause light structural damage at the surface. However, where infrastructure is not built on firm ground, or where unconsolidated material is deposited on slopes, damage to infrastructure and risk to workers could be greater and the risk to Project from a seismic event is considered medium. The overall risk to the Project is considered **Low**.

Using the **Moderate** consequence and **Rare** Likelihood ratings developed above for potentially affected VCs, seismic events have a risk assessment rating of **Low**.

7. Wildfire Risk Assessment

7.1 Wildfire Conditions

Wildfires are common throughout most of BC and are an important natural disturbance of BC's ecosystems. The effects of wildfires are observable over large spatial and temporal scales with evidence of previous fires detectable decades, and in some cases centuries, after a burn. In natural settings, wildfires are an ecological process that shapes forested ecosystems by creating mosaics of forest types and ages, which increases the diversity of flora and fauna across the landscape. In areas occupied by humans, wildfires pose a risk to human infrastructure that have potentially catastrophic consequences; the insurance claims due to the 2017 wildfire season in BC were estimated to total $137 million (Tymstra et al. 2020).

The severity, cause, and extent of wildfires is influenced by local conditions of the forests and is dependent on summer weather (e.g., temperature, precipitation, and wind) and the quantity of available fuel (i.e., combustible material). The cause of wildfires is most often lightning strikes during the summer. In areas occupied or seasonally used by people, human-caused wildfires are a common occurrence as humans cause nearly half of the wildfires in BC (British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development [BC MFLNRORD], BC Wildfire Service 2021). The size of wildfires is related to the severity of the fires and whether fires are actively suppressed. Fires in remote locations are commonly monitored and left to burn; therefore, wildfires in remote areas tend to be larger. Climate change is actively altering the frequency and severity of wildfires in BC, resulting in more frequent and more severe fires (Wotton et al. 2010). Future climate changes that result in increased temperature or reduced summer precipitation, are expected to increase the risk of wildfires in BC.

7.1.1 Wildfire History

During the lifetime of the Project, wildfires are likely to occur within the region and potentially near the Project. The history of wildfires is summarized at the scales of the Wide-ranging Wildlife Regional Study Area (WRSA) and LSA. The WRSA was used to summarize the frequency of wildfires because it is the largest of the regional study areas used to describe environmental conditions in the Project Area. The history of wildfires was accessed from the Canadian National Fire Database (CNFDB), a geospatial database that provides the spatial boundaries and attributes of the wildfires across Canada (NRCAN 2021).

A total of 22 wildfires have intersected the WRSA since 1970 with 17 of the fires caused by humans, and 15 of the fires occurring since 2000. The fires that intersected the WRSA have burned a total area 23,295 hectares (ha). The largest wildfire that intersected the WRSA burned 21,577 ha during the summer of 1983; however, only a small part of this fire occurred within the WRSA. Excluding this fire, the mean size of wildfires that intersected the WRSA is 88 ha and most wildfires measured less than 20 ha in size. Only four (4) wildfires have occurred within the LSA since 1970, and all were caused by humans. The total area burned by wildfires that intersect the LSA during this period is 70 ha. See **Table 7.1-1**.

The small size of most wildfires that have burned within the WRSA and LSA reflect BC's wildfire management that actively suppresses fires that put communities or human infrastructure at risk. Due to the proximity of the Project to communities, residences, and existing infrastructure, all wildfires have been and will continue to be suppressed during the life of the Project.

Table 7.1-1: Summary of Wildfire Frequency and Amount of Burned Area by Decade for Fires that Intersect the Wide-ranging Wildlife Regional Study Area (WRSA) and the Local Study Area (LSA) between 1970 and 2019

	Wide-ranging Wildlife Regional Study Area (WRSA)		Local Study Area	
Decade	**Count of Fires***	**Area (ha)[1]**	**Count of Fires**	**Area (ha)**
1970-1979	0	0	0	0
1980-1989	4	21,669	1	65
1990-1999	3	383	0	0
2000-2009	8 (3)	509	1	0.4
2010-2019	7 (2)	734	2	4
Total	**22**	**23,295**	**4**	**70**

Notes: ** Values in brackets indicate the number of lightning caused fires.*
1 The area presented may not be entirely within the Wide-ranging Wildlife Regional Study Area (WRSA)

7.2 Potential Effects on the Project and Valued Components (VCs)

Wildfires have the potential to cause considerable damage to or destroy Project infrastructure and delay construction or cause a stoppage of operations during the 22-year mine life. Buildings and other structures are susceptible to fires as they may contain or be constructed with flammable materials. Roads, bridges, and powerlines required for operation of the Project, including public infrastructure, could be damaged by fires. Project operations could be halted until such time as damaged Project components are repaired and access is available.

Damage to Project components from fire could result in:

- effects to air quality from damage to fuel storage tanks, explosives areas, other chemical storage areas, vehicles, and buildings (Atmospheric Environment VC);
- effects to surface water quality from damage to fuel storage tanks, explosives storage areas, and other chemical storage areas, in flow that is not contained by the water infrastructure system (e.g., management ponds) (Surface Water VC);
- consequent effects to Aquatic Resources, Fish and Fish Habitat, and Wildlife VCs from air quality and water quality effects;
- effects to demand for emergency services during the event (Infrastructure and Services VC);
- effects to Visual Resources VC from the effects to the Project infrastructure;
- effects from halt of Project operations to Economic Development VC; and
- effects to public health from injuries during firefighting and from effects to air and water quality (Human Health VC)

7.3 Project Mitigation Measures for Wildfire Events

The Project was planned and designed based on its location in an area of seasonal wildfire risk. The **MERP** includes actions to initiate in the event of a wildfire in the vicinity of the Minesite and will include information on regional resources to respond to wildfires. Wildfires are regionally managed by the Northwest Fire Center in Smithers. The Project is located within the Bulkley subdivision, which is based in Telkwa and Hazelton. Project staff will be trained to properly respond to emergency situations like wildfires.

The fire suppression system onsite will consist of the following:

- hand activated manual alarms and fire protection activation subpanels located throughout the following buildings (CPP, Maintenance Facility, Mine Rescue, Light Vehicle Maintenance, Tire Shop, Administration and Mine Dry);
- fire hose reels and dry chemical powder (DCP) portable fire extinguishers with polyvinyl chloride (PVC) clear cover;
- carbon dioxide (CO_2) portable fire extinguishers located adjacent to electrical service facilities;
- point type smoke and heat detection buildings as required;
- carbon monoxide detection in buildings as required;
- fire water supplied from the Tenas Control Pond and pumps;
- a maximum system operating pressure, not less than 1,035 kPa for a period of 12 hours;
- fire water ring main servicing hydrants near the Mine Infrastructure Complex (MIC) and CPP facilities;
- sounder and beacons installed throughout the site;
- Class II hose station complete with foam depot boxes for hazard areas; and
- sufficient water storage to sustain one (1) full hour of both hydrants being activated.

In the event of wildfire, the guidance in the **MERP** will be followed. This guidance includes monitoring of forest fires within 300 km of the Minesite, and staged actions depending on the distance of the wildfire from the Project, such as construction of firebreaks. As the fire approaches, personnel will be evacuated, except for volunteers from the Emergency Response Team (ERT) and others to form a site firefighting team. The ERT will conduct a final sweep of the site, and a Roll Call will be conducted to verify that all employees, visitors, and contractors are evacuated. The Project has an **EMP** that deals specifically with lightning that may initiate fires, and there are other controls in place such as clearing vegetation far enough away from infrastructure to give sufficient time for Project personnel to react to a fire.

The **Vegetation Management Plan (S13.0-C18) (VMP)** includes actions to manage debris that could increase the risk of wildfire in the Project Area. The **VMP** was guided by the *Wildfire Act*, SBC 2004, c 31 (GovBC 2004), and associated guidance to mitigate wildfire risk. In addition, the **VMP** identifies numerous mitigation measures for proper disposal of woody debris during Construction through Post-closure phases. The **VMP** also includes prescriptive mitigation measures to reduce vegetation growth and encroachment on Project infrastructure, partly to mitigate the risk of wildfires. Danger trees (i.e., trees that may fall and spread fire) will be removed from work areas and near Project infrastructure reducing the risk of trees falling and spreading fire or damaging Project facilities.

The Project equipment and facilities will be designed, placed, and managed to reduce the potential of the Project causing fires, as summarized in **S9.0 Accidents and Malfunctions** of the **EAC Application**. The mitigation to reduce the risks on fires due to the Project will also mitigate and reduce the risk of wildfire affecting the Project.

7.4 Likelihood and Consequence of Potential Effects

Given the small size of most wildfires, the history of fires, and fire suppression capabilities within the LSA, and the mitigation measures in place for the Project, the Likelihood of effects to VCs from the effects of forest fires on the Project is considered **Rare**. The consequences of the effects of a wildfire to the Project will depend on size of the fire and the ability to minimize the effects within the Project Area.

The suppression of the fire within the Project Area is expected to limit its extent, with the implementation of the mitigation described in **7.3** of this section, and **S9.0 Accidents and Malfunctions** of the **EAC Application**. Consequences from effects to VCs may be moderate, with effects to biophysical VCs from air and water quality changes reversed in about one (1) year or less. Not all Project components are expected to be affected. Damaged Project components would be replaced or reconstructed in a short time frame, and where possible temporary structures would be provided to reduce the shutdown timeframe.

7.5 Conclusions on Potential Risk for Fire

The risk of wildfires causing damage to Project infrastructure or delays to the Project is considered low. Mitigation measures are in place to reduce the risk to the Project from wildfires and regionally the Province of BC actively manages forests to reduce the risk of wildfires causing damage to communities and infrastructure. The risks of wildfires affecting the Project are partly related to the size and severity of the fires, with larger fires resulting in the greatest risk to the Project. Were a wildfire to occur in the vicinity of the Project, local wildfire management crews would be deployed quickly, and a fire is very likely to be effectively suppressed.

Because the frequency of fire in the LSA is expected to be low, the Likelihood of effects to VCs is considered **Rare**. The potential Consequences are conservatively estimated as **Moderate** and the resultant risk to VCs is evaluated as **Low**.

8. Summary of Risks to Valued Components (VCs) from Effects of the Environment on the Project

The evaluation of potential for the environment to affect the Project has considered the frequency of environmental events in the region and the Project Area. Design standards for buildings, structures, infrastructure, and Minesite landforms have been implemented to avoid or minimize the risks to the Project, and the layout of the Project has avoided geohazards to the extent possible. Design standards have considered predicted extreme weather events due to climate change. Where risks have been identified, measures are in place to monitor for the occurrence of the event where possible, and initiate preparatory measures, for example for forest fires. The **MERP** addresses a response system and measures to implement should the event occur, and TCL has initiated engagement with local emergency service providers to coordinate capacity to respond to potentially large events.

With mitigation to avoid effects of the environment on the Project, the Likelihood of effects to VCs is considered **Rare or Unlikely**, with the exception of geohazard risk for the Goathorn Creek crossing (a necessary access point) where active and historic landslide escarpments are present, and stability issues are **Likely**. Mitigation and monitoring are in place to manage this risk. Consequences to the Project and to VCs as a result of the effects on the Project were evaluated as **Negligible to Major**, depending in most cases on the potential for employee injury or a closure of the Minesite (Human Health, and Economic Development VCs). A summary of the risk to VCs from the effects of an environmental event on the Project is presented in **Table 8-1**. The evaluation is based on the implementation of the design and management measures proposed for each of the environmental events.

Table 8-1: Summary of Risks from Environmental Effects to the Project to Valued Components (VCs)

Environmental Event	Likelihood of Effects to VCs with Mitigation	Worst Case Consequence to VCs with Mitigation	Risk Assessment
Climate Change - Overview	Unlikely	Negligible	Very Low
Extreme Heat	Rare	Minor	Very Low
Extreme Cold	Unlikely	Minor	Low
Freeze-thaw Cycle	Unlikely	Negligible	Very Low
High Precipitation	Unlikely	Minor	Low
Low Precipitation	Rare	Major	Low
High Stream Flow (Flooding)	Unlikely	Moderate	Medium
Extreme Low Stream Flow	Unlikely	Moderate	Medium
Wind	Unlikely	Negligible	Very Low
Lightning	Rare	Severe	Medium
Geohazards	May	Minor	Medium
Seismic Events	Rare	Moderate	Low
Wildfire	Rare	Moderate	Low

Note: *VC=Valued Component*

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