Volume 2, Section 12 Snake Lake Reservoir Expansion Project
Environmental Impact Assessment
Climate Change

Submitted to:

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On behalf of:

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Executive Summary

The Eastern Irrigation District (EID) is applying for approval under the *Environmental Protection and Enhancement Act* (EPEA) to construct the proposed Snake Lake Reservoir (SLR) Expansion Project (the Project). The Project, located between Bassano and Brooks in Alberta, involves the construction of a roughly 8 km long, up to 20 m high dam to increase the storage capacity of the reservoir system from 19.25 million m^3 to 87.4 million m^3. The purpose of this expansion is to provide continued and enhanced irrigation support for existing irrigated land downstream of the SLR and any new lands that may be serviced in the future.

This Environmental Impact Assessment (EIA) section addresses greenhouse gas emissions and climate change based on requirements provided in the Final Terms of Reference (FTOR; Volume 2, Appendix A) for the Project issued by Alberta Environment and Protected Areas (Alberta EPA), and following the Guide to Preparing Environmental Impact Assessments in Alberta (Government of Alberta, 2013). This document also contains a residual impacts assessment for effects of climate change. A literature review of carbon sequestration was completed as part of this assessment.

Greenhouse gas (GHG) emissions are known to contribute to climate change. Emissions from construction vehicles, including CO_2, methane (CH_4), and nitrous oxide (N_2O), will add to emissions already occurring in the area from vehicle and railway traffic, cattle grazing, and natural emissions from other sources. Emissions from shipping of aggregate materials and construction of the reservoir expansion will add an estimated 12,000 to 28,000 new tonnes of CO_2 (equivalent [eq]) per year from 2025 to 2028, before decreasing to 8,000 tonnes per year in 2029. These projections are based on planned equipment use and shipping needs over the five-year period. Over the five years, this adds up to a total project-related 93,484.6 tonnes of CO_2eq, or 43% of total emissions in the Project study areas (including baseline amounts). After construction, emissions from the reservoir expansion will decrease, leaving only the baseline emissions and reservoir outputs (about 28,000 tonnes per year).

In the context of climate change, the viability and long-term benefits of the Project to the agricultural sector and other water uses downstream of SLR in the EID was assessed. Climate changes will likely have both positive and negative effects on agricultural and natural systems in southern Alberta. Development of the Project will nevertheless provide an overall benefit during this period of change, as water reliability mitigates drought, and other predicted effects of climate change. No field studies were performed as part of this climate change assessment, so discussions are based on simulations from the modelling community and general knowledge of climate change impacts. Modelling results were obtained from the Prairie Climate Centre, as well as the Government of Canada's publicly available data sources.

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Abbreviations

ac-ft	Acre-ft
Alberta EPA	Alberta Environment and Protected Areas
AR5	Fifth assessment report (IPCC)
AR6	Sixth assessment report (IPCC)
CH_4	Methane
CMIP5	Coupled Model Intercomparison Project Initiative
CO_2	Carbon dioxide
CPKC	Canada Pacific Kansas City
ECCC	Environment and Climate Change Canada
EIA	Environmental Impact Assessment
EID	Eastern Irrigation District
ENSO	El-Niño Southern Oscillation
eq	Equivalent
FTOR	Final Terms of Reference
GDP	Gross Domestic Product
GHG	Greenhouse gas
GOA	Government of Alberta
GOC	Government of Canada
GWPs	Global Warming Potentials
IDF	Intensity-duration-frequency
IO	Instream objective
IPCC	Intergovernmental Panel on Climate Change
LCSA	Local Climate Study Area
N_2O	Nitrous oxide
norms	normals
PDO	Pacific Decadal Oscillation
PNA	Pacific North American (jet stream) pattern
$PM_{2.5}$	Fine particulate matter
RCPs	Representative Concentration Pathways
RCSA	Regional Climate Study Area
SLR	Snake Lake Reservoir
SO_2	Sulfur dioxide
SPEI	Standardized Precipitation Evapotranspiration Index
SSPs	Shared Socioeconomic Pathway
TCH	Trans-Canada Highway

12.1 INTRODUCTION

12.1.1 Background

The Eastern Irrigation District (EID) is applying for approval under the Environmental Protection and Enhancement Act (EPEA) to construct the proposed Snake Lake Reservoir (SLR) Expansion Project (the Project). The Project, located between Bassano and Brooks in Alberta, involves the construction of a roughly 8 km long, up to 20 m high dam to increase the storage capacity of the reservoir system from 19.25 million m^3 to 87.4 million m^3.This is in response to the anticipated changes in the local and regional water balance due to climate change that will affect the amount and timing of on-field and headwater precipitation and associated runoff in the Bow River, as well as effects on irrigated farming areas in the EID due to higher temperatures. As temperatures rise the hydrological cycle tends to intensify, leading to changes in precipitation patterns, timing of river peaks and low flow events, and total river discharge. Increasing temperatures can also result in more frequent and intense storms as well as prolonged periods of drought. These changes can affect both water availability for storage and variable water needs, necessitating adaptive measures to manage water resources effectively (Crossman et al., 2013; NASA, 2024).

The effects of climate change are a considerable threat to many industries, including agriculture. In Alberta, the following changes include but are not limited to increasing temperatures (average temperatures and number of days >30°C), increase in evaporation and evapotranspiration, a shorter winter season, declining snowpacks, earlier and shorter spring runoff, with extended low flow periods, increased intensity, duration, and frequency of severe weather events impeding access to croplands and damaging crops (e.g. hail), increased frequency and duration of droughts, increased growth of weeds and invasive species, and increased insect activity resulting in damage to crops. There are, however, some benefits to the agricultural sector that may occur due to increasing atmospheric carbon dioxide (CO_2) levels and generally warming conditions, at least in the short-term (Herring, 2020). These include an extended growing season, increased drought-tolerance for some crops, enhanced crop productivity and yield, and greater variety of crops that can be grown in Alberta.

To build climate resilience for agricultural producers in the EID, additional water storage is necessary to address rainfall deficits that typically occur during the summer months and may continue throughout the growing season before harvest. The Project is therefore an adaptation strategy by the EID to provide climatic resilience against periods of water scarcity.

Although flows in the Bow River have varied over the years, the post-1930s era has seen a significant moderating of river flows due to the presence of upstream control structures and storage reservoirs. The presence and the management of these structures has served to stabilize river flow variability from both peak and low flows. The existence of these management structures significantly reduces the risk that low flows will restrict the diversion of water for the EID at Bassano Dam. Currently, the EID can withdraw water for irrigation at a rate that allows other water obligations to be met, those being maintenance of the 11.3 m^3/s instream flow objective for Bow River below Bassano Dam and ensuring (along with other water users) that apportionment requirements are met: one-half of the South Saskatchewan River's discharge must cross the border into Saskatchewan.

The following sections highlight the greenhouse gas (GHG) emissions that are anticipated to be associated with the Project, the baseline climate of the study region, and the climate changes that are projected to occur within this century based on simulation results generated by the global climate modelling community.

12.1.2 Regulatory Context

On July 4, 2024, Alberta Environment and Protected Areas (Alberta EPA) issued a Final Terms of Reference (FTOR) for this Project. The FTOR (Volume 2; Appendix A) requires that Climate Change be assessed, including a review of Baseline Conditions and an Impact Assessment.

12.2 STUDY AREA

The Local Climate Study Area (LCSA) is represented by lands surrounding the existing SLR as well as the Project area serviced by the irrigation water to be stored in those structures. The closest major population centre to the Project is the City of Brooks. The Regional Climate Study Area (RCSA) represents a larger area located upstream of the LCSA extending from the City of Calgary back to the eastern slopes of the Rocky Mountains and encompassing the headwaters area of the Bow River. Figure J1-1 (Appendix J1) shows these study areas, with the approximate area influenced by regional climate conditions outlined in purple. These areas were selected to be consistent with the climate model output referenced later in this section.

12.3 ISSUE SCOPING

At the onset of the EIA, resources and indicators for the climate change discipline were identified that could be affected by the Project (FTOR Section 3.9.1). Included in the effects assessment are potential challenges posed by construction and operation phases relating to various climate change factors. The likelihood of these being realized has been used to screen-out those effects that are likely to be neutral or negligible and focused on SLR (FTOR Section 3.9.2).

Projected changes to the future climate of the LCSA and RCSA will have implications for the Project. The screening process included the following steps:

- a review of climate normals (i.e., “norms”) and variability in the LCSA;
- a summary of baseline climatic conditions including type and frequency of meteorological events (e.g., length of dry spells, days over 30ºC);
- identifying the risks, issues, and/or concerns regarding these effects;
- determining what assessments to include (ones where high effects are likely), and which to exclude (effects are likely to be negligible or trivial);
- the types of data/information available for the assessment to determine if the issue can be assessed locally or regionally; and
- determining a final list of resources and indicators for baseline and impact assessment.

An issues scoping table (Table 12-1) outlines the various climate change effects that are likely to occur, identifies indicators or measures that can be assessed, determines the risk that climate change may have on these indicators, determines if the effects on the indicators are likely and whether there is sufficient data to assess baseline conditions and impacts, and determines if the assessment can be done quantitively or qualitatively. Climate change categories included temperature and precipitation, growing conditions, extreme weather events, river water supply, surface and groundwater quality, ecosystem conditions, and economic considerations.

Table 12-1: Climate change issue scoping

Climate Effect Categories	Indicators or Measures	Climate Change Issues/Benefits	Screening
Temperature and Precipitation	Mean annual and seasonal temperatures	Changes to temperatures will influence crop yield, growing season, and irrigation needs	Likely: Assess baseline and impacts
	Timing and amount of precipitation	More water may be available for capture in spring and fall leading to reduced need for irrigation; reduced summer precipitation along with warmer temperatures will influence summer irrigation needs	Likely: Assess baseline and impacts
	Evaporation and transpiration loss	More evaporative losses will influence the need for additional irrigation storage and use	Likely: Assess baseline and impacts
Growing Conditions	Extreme heat events	Longer, hotter, dryer conditions may increase crop damage due to heat stress, pests, increase the need for irrigation to promote crop shading, and change optimal growing and harvest dates	Likely: Assess baseline and impacts
	Growing degree days	Changes will result in improved growing conditions for same or new crops, possibly affecting yield	Likely: Assess baseline and impacts
	Frost-free days	Reduced frost-free days will lengthen growing season, crop types and yield	Likely: Assess baseline and impacts
Extreme Weather Events	Drought	Increased occurrence, intensity, and length of droughts	Likely: Assess baseline and impacts
	Frequency of wet periods	Increased intensity of precipitation events	Likely: Assess baseline and impacts
	Wind and Hail events	Increased severity of wind and hail events from convective storm activity	Qualitative assessment only
River Water Supply	Precipitation in late fall / winter months	Less stored water to release during the spring freshet due to declining snowpacks after winters with low snowfall	Likely: Assess baseline and impacts
	Upstream precipitation	Altered precipitation timing and intensity in eastern slopes / headwater areas	Likely: Assess baseline and impacts
	Upstream river flows	Increase in low flow periods reducing withdrawal rates despite upstream storage and regulation of Bow River flows by numerous control structures	Qualitative assessment only
	Reduced river flow at diversion location	Less water available to store for irrigation despite upstream water management	Qualitative assessment only
	Rain on snow events	More rain-on-snow events leading to earlier depletion of stored water in headwater areas and extended low flow period	Qualitative assessment only
Surface and Groundwater Quality	Nutrient concentrations in surface water and groundwater	Increased need for fertilizers to enhance crop development leading to impacted agricultural runoff or groundwater recharge	Qualitative assessment only
	Presence of detectable pesticides	Increased need for pesticide use to address invasive weed species and insect impacts	Qualitative assessment only

Climate Effect Categories	Indicators or Measures	Climate Change Issues/Benefits	Screening
	Change to trophic status of a nearby waterbodies	Negative effects on aquatic and terrestrial habitat	Unlikely – most waterbodies currently dry in summer; no information to suggest this will occur in reservoirs and natural deep waterbodies
	Changes to baseline groundwater chemistry	Negative effects on local groundwater users due to increased agricultural loadings	Unlikely – most groundwater users access water from confined bedrock aquifers
Ecosystem Conditions	Changes to native grassland, shrub and tree communities	Grassland, shrub and tree species prone to drought stress may be reduced in abundance altering community composition	Qualitative assessment only
	Changes to wildlife habitat suitability	Altered communities may affect habitat availability of species, especially those restricted to tree or shrub conditions	Qualitative assessment only
Economic Conditions	Yield per hectare	Longer growing season and frost-free days may lead to increased crop yield/harvests per year. Increased drought frequency, wildfire, flooding events, or wind/hailstorms, may result in economic losses and increased insurance rates	Qualitative assessment only
	Agricultural Gross Domestic Product	Increased yields may improve financial returns; losses may impede agricultural viability	Qualitative assessment only
	Insect activity and crop damage	Warmer day and night temperatures may facilitate crop pests to multiply and adversely affect crops	Qualitative assessment only
	Crop Failure	Crop loss may occur due to an unreliable water supply during severe drought conditions	Unlikely – due to enhanced water supply potential from offstream reservoirs
	Reduced field access	Spring or fall flooding in fields due to increased rainfall may reduce access during critical periods for crop planting and harvesting	Qualitative assessment only
	Increased wildfire risk	Dryer conditions due to droughts and severe wind events will increase probability of wildfire events	Qualitative assessment only
	Erosion of reservoir berms	Higher rainfall events may saturate reclaimed berms leading to runoff and erosion	Qualitative assessment only
	Overtopping of reservoir	Extreme rain and wind events may combine to affect reservoir water levels and significantly reduce freeboard provided	Unlikely: Engineering design has considered worst case precipitation and wind events to design dams with sufficient freeboard; Assessment included in Volume 1, Section 6 (Dam Safety)

12.4 GREENHOUSE GAS ASSESSMENT

12.4.1 Baseline

GHG assessment for the Project was based on the Air Emissions Local Study Area: a roughly 5 km buffer around the Project (7.5 km from approximate centre of the Project area; see Volume 2, Section 4). Activities that could affect GHG emissions include grazing, oil and gas facilities (9), a feedlot, and some acreages (4) (Appendix J1, Figure J1-2). Baseline GHG emissions and sequestration estimates were made for the following categories within the LCSA (Appendix J1, Figure J1-1):

Trees: GHG emissions and sequestration were assessed for trees removed from the Project area. Other trees within the LCSA were assumed to remain unchanged. Estimates were based on Environment and Climate Change Canada's (ECCC) National Inventory Report 1990 to 2022 *Greenhouse Gas Sources and Sinks in Canada* (Government of Canada [GOC], 2024a). Project area trees were estimated from aerial imagery, using the emission factor for semi-arid prairie lands. Per ECCC methodology, other types of vegetation (e.g., grassland) were not considered in the assessment of GHGs (GOC, 2024a).

Grazing Cattle: Because data on cattle in the nearby feedlot or farms were not available, GHG emissions were estimated for cattle based on carrying capacity of the Project area (i.e., 269 cow/calf pairs, per the Dry Mixedgrass Range Plant Community Guide; (Adams, et al., 2013)). This is meant to approximate the number that have been, or would be, grazing on the Project site prior to construction. It was conservatively assumed that these cattle would be grazing in the Project area throughout the entire year.

Existing SLR: Emissions from the existing SLR were based on the first year of operations (i.e., 1998) and Baseline year of 2023 using the ECCC methodology (GOC, 2024a).

Vehicles: GHG emissions from vehicles were estimated also using the ECCC methodology and the same assumptions previously indicated for the air quality dispersion modelling of vehicles on the Trans-Canada Highway (TCH; see Volume 2, Section 4). GHG emissions were estimated using the annual average daily traffic.

Railway: GHG emissions were estimated also using the ECCC methodology, and the same assumptions assumed for the air quality dispersion modelling (see Volume 2, Section 4).

Oil Batteries: GHG emissions from the Journey Countess Oil Battery could not be estimated because appropriate data for the facility were not available.

12.4.2 GHG Emissions Estimates

Values for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were converted to carbon dioxide equivalent (CO_2eq) using the current Global Warming Potentials (GWPs) in the Government of Canada Gazette, Part 1, Volume 157, Number 4: *Supplement Notice with Respect to Reporting of Greenhouse Gases (GHGs) for 2022 and 2023* (GOC, 2023a) (Table 12-2).

Table 12-2: Current global warming potentials for greenhouse gas emission estimations

Substance	Global Warming Potential
CO_2	1
CH_4	28
N_2O	265

GHG emissions from the Baseline Air Quality Assessment are provided in Table 12-3. GHG emissions from construction vehicles, including CO_2, CH_4, and N_2O will add to those already occurring in the area from cattle grazing, vehicular traffic on the TransCanada Highway and the Canada Pacific Kansas City (CPKC) rail line north of the proposed reservoir expansion area, accounting for current uptake from living plants (trees). Additional details are provided in the Air Quality section (see Volume 2, Section 4).

Table 12-3: Summary of baseline greenhouse gas emissions

Source	Emissions (tonnes per year)			
	CO_2	CH_4	N_2O	CO_2eq
Trees	-227.0	-	-	-227.0
Existing SLR	398.3	-	-	398.3
Cattle	-	2.0	-	56.0
Vehicles (TCH)	16,010.3	1.1	0.3	16,191.0
Trains	11,107.1	0.6	4.6	12,263.4
TOTAL	**27,288.7**	**3.7**	**4.9**	**28,681.7**

Values for CO_2, CH_4, N_2O are converted to CO_2eq following the Canada GHG Notice (GOC, 2023a) (Table 12-2)

12.4.3 Project Construction Phase

Project construction emissions were quantified (Table 12-4) based on the monthly equipment usage provided in Volume 1, Section 2.15 (Overview) for the Project Construction period. In addition, the following other sources were considered:

Existing SLR: GHG emissions from reservoirs tend to follow a decreasing trend for approximately 42 years, after which time they begin sequestering carbon (GOC, 2024b). Emissions for the Construction Case are lower than those from the 2023 Baseline year.

Worker Vehicles: GHG emissions from worker vehicles were calculated assuming 80 round trips per day of 50 km each (i.e., 25 km each way) to the Project site from Brooks, five days per week. It is assumed the workers would all drive pickup trucks. The pickup truck fuel consumption rate was obtained from the 2021 Fuel Consumption Guide (GOC, 2021).

Flatbed Trucks: GHG emissions from flatbed trucks were assumed based on one flatbed truck per industrial vehicle travelling 8 km from the TCH to the Project, including the return trip. Emissions also assumed a total travel distance of 32 km per industrial vehicle used on site. The flatbed truck fuel consumption rate was obtained from the 2019 Fuel Efficiency Benchmarking in Canada's Trucking Industry (GOC, 2019).

Vehicles on Trans-Canada Highway (TCH): GHG emissions assumed the number of gasoline-fuelled passenger vehicles reduces by 4.7% each year per Statistics Canada, which indicates that electric vehicles increased by 8.6% between 2023 and 2024, and 55% of those vehicles were battery operated with the rest being hybrids (GOC, 2023b). It was assumed that hybrid vehicles would be operating on gasoline at the speed limit of 110 km/h. The total gasoline-fuelled passenger vehicles were also assumed to increase by 1.59% per year (GOC, 2024c).

Railway/Trains: GHG emissions were assumed to be unchanged from the Baseline year of 2023.

Table 12-4: Summary of greenhouse gas emissions for Project construction case

Year	Emission Category	Emissions (tonnes per year)			
		CO_2	CH_4	N_2O	CO_2eq
2025	**Project Only**				
	On-Site Construction Equipment	11,253.0	0.3	0.6	11,415.0
	Existing SLR	334.9	-	-	334.9
	Sub-Total	*11,587.9*	*0.3*	*0.6*	*11,749.9*
	Other Emission Sources in LCSA				
	Vehicles on Trans-Canada Hwy	15,623.3	1.0	0.3	15,730.8
	Trains	11,107.1	0.6	4.3	12,263.4
	Sub-Total	*26,730.4*	*1.6*	*4.6*	*27,994.2*
	TOTAL	**38,318.3**	**1.9**	**5.2**	**39,744.1**
2026	**Project Only**				
	On-Site Construction Equipment	11,605.3	0.3	0.6	11,775.5
	Existing SLR	304.8	-	-	304.8
	Sub-Total	*11,910.1*	*0.3*	*0.6*	*12,080.3*
	Other Emission Sources in LCSA				
	Vehicles on Trans-Canada Hwy	15,406.2	1.0	0.3	15,513.7
	Trains	11,107.1	0.6	4.3	12,263.4
	Sub-Total	*26,513.3*	*1.6*	*4.6*	*27,777.1*
	TOTAL	**38,423.4**	**1.9**	**5.2**	**39,857.4**
2027	**Project Only**				
	On-Site Construction Equipment	22,737.7	0.6	1.5	23,165.1
	Existing SLR	275.7	-	-	275.7
	Sub-Total	*23,013.4*	*0.6*	*1.5*	*23,440.8*
	Other Emission Sources in LCSA				
	Vehicles on Trans-Canada Hwy	15,198.1	1.0	0.3	15,305.6
	Trains	11,107.1	0.6	4.3	12,263.4
	Sub-Total	*26,305.2*	*1.6*	*4.6*	*27,569.0*
	TOTAL	**49,318.6**	**2.2**	**6.1**	**51,009.8**
2028	**Project Only**				
	On-Site Construction Equipment	27,271.3	0.8	1.9	27,803.1
	Existing SLR	247.6	-	-	247.6
	Sub-Total	*27,518.9*	*0.8*	*1.9*	*28,050.7*
	Other Emission Sources in LCSA				
	Vehicles on Trans-Canada Hwy	15,001.0	1.0	0.3	15,108.5
	Trains	11,107.1	0.6	4.3	12,263.4
	Sub-Total	*26,108.1*	*1.6*	*4.6*	*27,371.9*
	TOTAL	**53,627.0**	**2.4**	**6.5**	**55,422.6**
2029	**Project Only**				
	On-Site Construction Equipment	7,501.4	0.2	0.3	7,576.0
	Existing SLR	220.4	-	-	220.4
	Sub-Total	*7,721.8*	*0.2*	*0.3*	*7,796.4*

Year	Emission Category	Emissions (tonnes per year)			
		CO_2	CH_4	N_2O	CO_2eq
	Other Emission Sources in LCSA				
	Vehicles on Trans-Canada Hwy	14,813.1	1.0	0.3	14,920.6
	Trains	11,107.1	0.6	4.3	12,263.4
	Sub-Total	*25,920.2*	*1.6*	*4.6*	*27,184.0*
	TOTAL	**33,642.0**	**1.8**	**4.9**	**34,980.4**
	FIVE YEAR TOTAL	**213,329.2**	**10.2**	**27.9**	**221,014.3**

Values for CO_2, CH_4, N_2O have been converted to CO_2eq using the current GWPs presented in the Canada GHG Notice (GOC, 2023a) (Table 12-2)

12.4.4 Project Operations Phase

When the reservoir is in operation, there will be no significant emissions of NO_2, sulfur dioxide (SO_2) or fine particulate matter (i.e., $PM_{2.5}$), noting that the sides of the expanded portion of the SLR will be rip-rapped to prevent soil erosion even during drawdown periods. Only GHG emissions for the year 2030 have been quantified, noting the following:

Existing Reservoir: As indicated previously, GHG emissions tend to decrease annually from reservoirs that have been in operation for up to 42 years, after which they begin to sequester carbon.

SLR Expansion: This analysis assumes that, in 2030, the Project will have been in operation for one year.

Vehicles on Trans-Canada Highway (TCH): The number of vehicles on the TCH was adjusted as indicated for the Project Case.

Trains: The number of trains was conservatively assumed to remain constant from previous years, since data are not available for future projections of activity.

The results of estimated emissions are provided in Table 12-5.

Table 12-5: Greenhouse gas emissions from Project operations case in year 2030

Source	Emissions (tonnes per year)			
	CO_2	CH_4	N_2O	CO_2eq
SLR Expansion	885.5	-	-	885.5
Existing SLR	194.0	-	-	194.0
Vehicles (TCH)	14,635.1	1.0	0.3	14,750.1
Trains	11,107.1	0.6	4.3	12,263.4
TOTAL	**26,821.7**	**1.6**	**4.6**	**28,093.0**

12.4.5 Project Decommissioning Phase

The dam and reservoir will be permanent features – there will be no decommissioning phase.

12.4.6 Carbon Sequestration Capacity

The Project area has a certain capacity for GHG sequestration, which may be impacted by construction and expansion activities. Changes in land use and water management practices can affect soil carbon levels. Native grasslands have extensive root systems that can be effective for carbon storage (Tracey, 2020). However, this is not included in the ECCC methodology, as they assume a neutral effect of grasslands (GOC, 2024a). Trees have carbon sequestration capacity, until they die and decay or are burned in a forest fire, at which time they are a carbon emission. The treed area in the Project area does not represent a considerable sequestration capacity. Sequestering related to increased crop production due to the enhance irrigation security provided by the Project is a possibility but is also not included in the ECCC methodology.

Freshwater reservoirs have been shown to be carbon sinks and sequester carbon due to high rates of burial and sedimentation (Li, et al., 2024). The long-term carbon storage ability of reservoirs may decrease as more carbon is sequestered when the reservoir is first flooded (Li, et al., 2024). However, the long-term carbon sequestering ability of reservoirs is dependent on the management of ecologic and hydrologic conditions (Li, et al., 2024). The prime management strategy for protecting carbon release from sediment in reservoirs is reducing the drawdown of stored water and not exposing the contained sediment to an oxygen rich environment, thus enhancing biological decomposition (Council of Canadian Academies, 2022). Although reservoirs have been shown to be carbon sinks, many lakes and reservoirs are supersaturated with carbon and act as sources rather than sinks (Council of Canadian Academies, 2022). The expanded SLR is expected to be a carbon sink as most of the topsoil and organic matter will be removed prior to flooding, reducing the initial source of carbon for decomposition.

12.4.7 Mitigation Measures

In addition to water level management of the reservoir, mitigation strategies to reduce GHG emissions may include the use of energy efficient machinery and implementing carbon offset projects. Also, logistical planning to reduce vehicular activity (e.g., delivery planning, ride sharing) – a large source of GHGs related to this Project – can serve to reduce emissions. These measures are considered best management practices that could be employed.

12.5 CLIMATE CHANGE ASSESSMENT

Climate change effects are assessed for the SLR and Project area, based on:

- a review of climate norms and variability in the LCSA and RCSA;
- a summary of baseline climatic conditions including type and frequency of meteorological events (e.g. length of dry spells, days over 30ºC);
- identifying the risks, issues, and/or concerns regarding these effects;
- determining what assessments to include (ones where effects are likely to occur), and which to exclude (effects that are likely to be negligible or trivial);
- the types of data/information available for the assessment to determine if the issue can be assessed locally or regionally; and
- adaptation strategies to deal with anticipated effects of climate change.

12.5.1 Assessment Methodology

12.5.1.1 Data Sources

Several data sources have been examined to determine the baseline climate conditions for the LCSA and RSA as well as projections for future conditions based on reasonable scenarios used by the climate modelling community (Weatherstats, 2024; Prairie Climate Centre, 2024; GOC, 2024d; 2024e). Projections for climate change have been derived from statistically downscaled model data (10 km x 10 km grid cells) from 24 climate models obtained from the Coupled Model

Intercomparison Project initiative (CMIP5). This data has been made available through the Pacific Climate Impacts Consortium climate service centre at the University of Victoria (2024).

12.5.1.2 Climate Scenarios

The model output from the Prairie Climate Centre refers to previous climate scenarios known as Representative Concentration Pathways (RCPs), which are projections of GHG emissions over time under differing global development conditions. Two have been chosen from those modelled results, RCP 4.5 (low effect case) and RCP 8.5 (high effect case), based on scenario pathways related to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) released in 2014 (IPCC, 2013). RCP 4.5 represents a stabilization in GHG emissions, without an overshoot, leading to a radiative forcing of 4.5 W/m^2 in the year 2100. RCP 8.5 represents a rise in radiative forcing to 8.5 W/m^2 in the year 2100. Climate scenarios related to the IPCC's sixth and most recent assessment report (AR6), release in 2023, now refer to Shared Socioeconomic Pathways (SSPs) (IPCC, 2023). RCP 4.5 is similar to SSP2-4.5, and RCP 8.5 is similar to SSP5-8.5. These more recent pathways for global development include a wider range of socioeconomic factors including the implications of population growth and global Gross Domestic Product (GDP). Regardless of the refinements made in the AR6, there are similarities between the AR5 and AR6 scenarios. Figure 12-1 compares the two pathways.

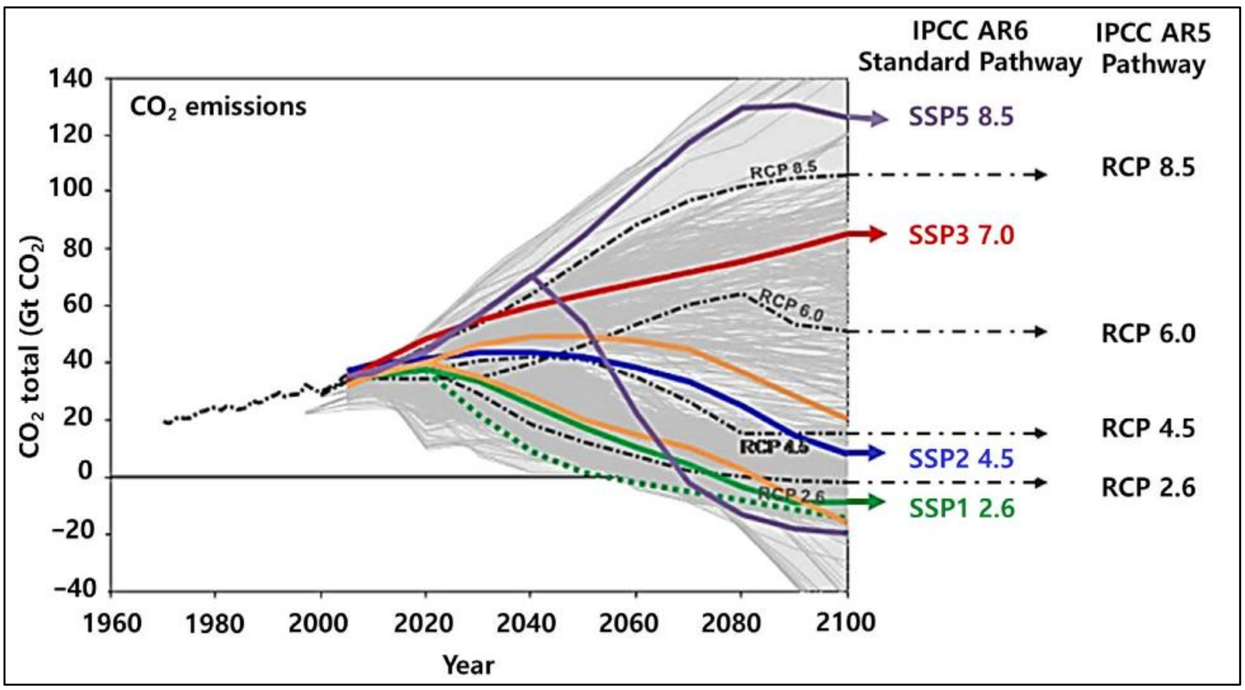


Figure 12-1: Comparison between carbon dioxide (CO_2) emission trajectories of IPCC assessment scenarios from fifth and sixth assessment report
(National Institute of Water and Atmospheric Research, 2024)

Given uncertainties regarding the absolute scale of global GHG emissions in the future, the differences between the RCP 4.5 and SSP2-4.5, as well as the RCP 8.5 and SSP5-8.5, are of minor significance. As such the modelled results from the Climate Atlas of Canada for RCP 4.5 and RCP 8.5 scenarios (Prairie Climate Centre, 2024) best represent the possible future climate conditions for the Project.

12.5.2 Baseline Conditions

The Project is located in southern Alberta, in an area known as the "Palliser Triangle", which is some of the driest territory in Canda. The physiography is characterized by semi-arid grassy plains with fertile soils extending across southern Alberta, Saskatchewan, and the southwest corner of Manitoba (Nkemdirim & Weber, 1999). Originally deemed unsuitable for crop development due to the consistently arid conditions and frequent droughts, the area experienced a transformation with the implementation of irrigation projects in the early 1900s, leading to flourishing agricultural development (Nkemdirim & Weber, 1999; Government of Alberta [GOA], 2013). This Project is a continuance of this adaptation strategy to address increasingly arid conditions in the future and mitigate drought events that have hindered agricultural development in the region.

12.5.2.1 Climate Norms

The goal of this Project is to ensure agricultural productivity through access to sufficient quantities of irrigation water. To establish a baseline of current conditions for comparison with anticipated climate change impacts, the climate norms for the study area from 1991 to 2020 were obtained from ECCC (GOC, 2024f). Previous normal periods including 1971-1990 and 1981-2010 have been provided for comparative purposes. Table 12-6 is a summary of values for parameters relevant to the agricultural sector, as accessed from the Brooks station (Climate ID 3030QLP).

Table 12-6: Climate norms for the Brooks, Alberta area

Climate parameter	1971-1990	1981-2010	1991-2020	Δ (%) Between 1971-1990 and 1991-2020
Temperature (annual average ºC)	4.2 (277.4 K)	-	4.8 (278.0 K)	+0.2
Days with minimum temperature ≥0ºC	170.5	-	170.8	+0.2
Days with maximum temp >30ºC	14.0	-	19.4	+38.6
Growing degree days (above 5 ºC)	1,712.9	-	1,753.4	+2.4
Annual precipitation (average mm)	348.0	347.5	299.4	-14.0
Days with precipitation ≥0.2 mm	103.6	88.5	96.6	-6.8
Days with precipitation ≥5 mm	19.9	21.0	16.0	-19.6
Days with precipitation ≥10 mm	7.8	8.8	6.6	-15.4
Days with precipitation ≥25 mm	1.3	1.0	1.2	-7.7
Days with precipitation ≥50 mm	-	-	0.13	-
Extreme daily precipitation (mm)	88.9 (Jun)	55.5 (Sep)	60.6 (Jun)	-31.8

Note: "-" means data not available

Since the 1971-1990 normal period, the average annual temperature has increased by 0.6ºC, with growing degree days increasing by about 2.4% from 1,712.9 to 1,753.4. Although days with temperatures above 0ºC have not changed much during that time, the days above 30ºC have increased by 5.4 days (almost 39%).

As for precipitation, the average annual precipitation has declined roughly 14% since the 1971-1990 normal period and has averaged about 299 mm during the 1991-2020 timeframe. A comparison of days with precipitation exceeding certain thresholds also shows a decline since the 1971-1990 normal period, with the greatest changes occurring for the days with precipitation ≥5 mm (-19.6%) and ≥10 mm (-15.4%).

12.5.2.2 Flooding

Runoff that supplies water for the existing and proposed reservoir expansion originates in the eastern slopes of the Rocky Mountains and flows eastwards towards the Project area. After it passes the Project area is flows into the South Saskatchewan River and across the provincial boundary. This runoff comprises snowmelt from seasonal snowpack and rainfall received during the late spring/early summer to fall seasons. Under certain conditions, flooding events can occur, much like what happened in the Calgary region during 2005 and 2013. This is characterized by spring to early summer upslope conditions and orographic rainfall effects leading to rain-on-snow events along the eastern slope of the Rocky Mountains and enhanced, and rapid, runoff.

The flooding history for the Bow River at Calgary station (upstream of the Elbow River confluence) is provided in Figure 12-2. This historical record has data extending back to the late 1800s and predates the installation of control structures on the river, which commenced in 1929 with construction of the Ghost Dam and an associated storage reservoir (Imbrogno, 2024). Figure 12-2 and the accompanying Table 12-7 illustrates that most major flood events occurred before the construction of the Ghost Dam, with fewer events occurring thereafter.

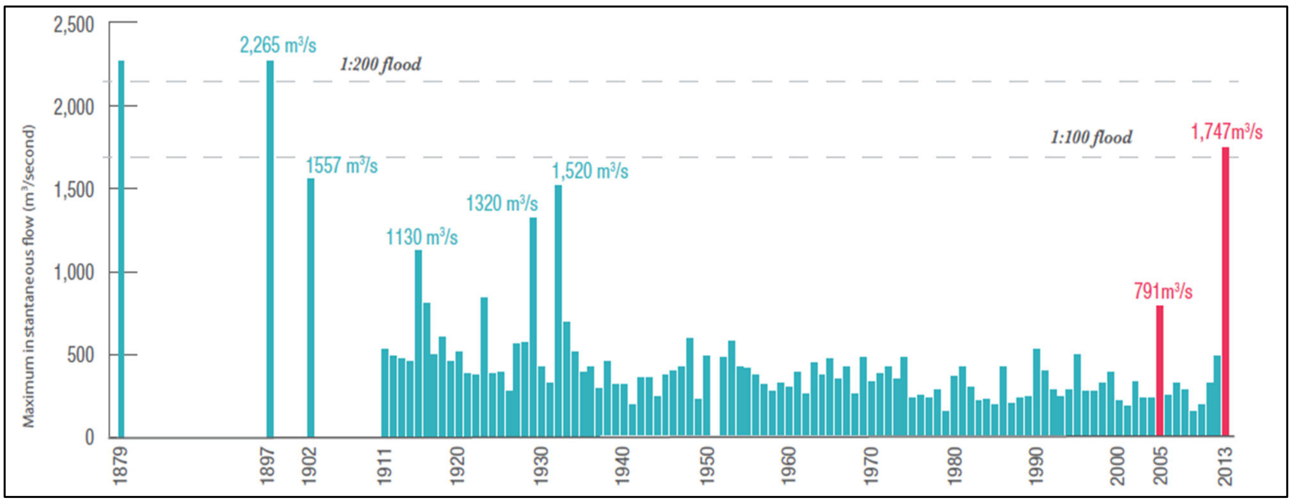


Figure 12-2: Historical flood events for the Bow River at Calgary: above the Elbow River confluence **(City of Calgary, 2024)**

Table 12-7: Probability of flood events for the Bow River above the Elbow River confluence

Return period (years)	Probability of occurrence in any given year (%)	Bow River above Elbow River (m^3/s)
2	50	369
5	20	659
10	10	927
20	5	1,230
50	2	1,660
100	1	2,020
500	0.2	2,920

(City of Calgary, 2024)

Effective water management has largely prevented river flooding since the early 1930s. However, the 2005 flood did occur, classified by the City of Calgary engineering department as a 1 in 10 year event (10% chance of occurring in any given year), and was followed by the 2013 flood. The 2013 event was estimated to be between a 1 in 50-year (2% chance) and a 1 in 100-year (1% chance) event, indicating that significant flooding is still possible despite the presence of current control structures and river management practices.

In the coming decades, changes in the timing of spring runoff are expected to increase the frequency of high flow and low flow events, including changes to flooding events. This is the result of a shorter winter season and a higher risk of rain-on-snow events by more winter precipitation falling as rain instead of snow.

12.5.2.3 Minimum Flows

Historical minimum flows for the Bow River at Bassano Dam have been documented since 1910 but the dataset suffers from large gaps in monthly measurements. Therefore, a review of minimum monthly flows for the Bow River at Calgary station provides a more contiguous dataset to assess how minimum flows have changed over time. Based on the historic record, the typical low flow period for the river extends from late October to early April (GOC, 2024e).

Figure 12-3 shows the history of minimum annual flow extending back to 1911. Since the construction of the Ghost Dam, and other control structures on the Bow River system upstream of Calgary, the minimum flow has increased consistently above 20 m^3/s since the 1950s, reaching as high as nearly 50 m^3/s in the mid-2000s. A period of minimum flows of 10 m^3/s or less (reaching a low of 3.48 m^3/s in 1930) is also evident prior to that time (Figure 12-3).

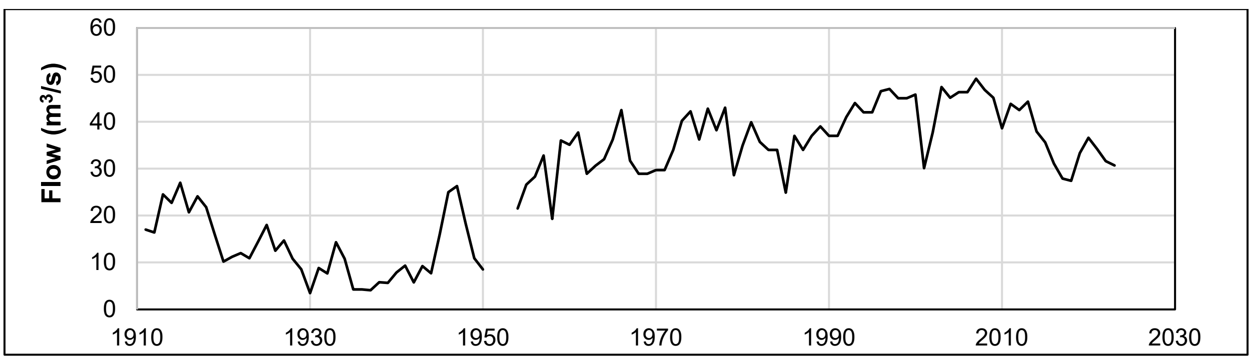


Figure 12-3: Historical minimum yearly flow conditions in the Bow River at Calgary

The establishment of control structures and water management efforts on the Bow River upstream of the EID diversion point have resulted in increased minimum flows as more water can be held back in the spring and released through the year. This management strategy will continue into the future as long as there is sufficient water to capture in spring. Table 12-8 provides a monthly summary of historical flow conditions for the Bow River at Bassano Dam station (Water Survey of Canada [WSC] Station 05BM004) (GOC, 2024g). The period of record extends for 112 years from 1910 to 2022, and pre-dates the first dam installed on the river upstream of Bassano Dam. Except for the period of 1915 to 1933, average monthly flow records have only been documented for the months of April through to October.

Table 12-8: Historical flow conditions (m^3/s): Bow River at Bassano Dam (1910-2022)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Mean	37.8	37.6	53.1	70.1	114	277	165	91.6	69.3	68.6	53.9	38.9	89.7
Max	68.4	52	119	153	273	851	772	352	292	188	84.7	63.7	272
Min	28.2	27.2	28.5	7.99	4.63	17.8	4.64	7.73	6.95	7.09	34.7	25.3	16.7

Note: Typical months where flow less than the current 11.3 m^3/s instream objective (IO) have been highlighted in blue. Note that these flows are upstream of Bassano Dam, and do not represent low flow resulting from EID water withdrawals. Also note that IOs have changed over the years as different methods to determine these objectives have been used (Epp & Ealey, 2006).

The recorded flows for the Bow River at Bassano station (GOC, 2024e) show minimum flows have remained above the 11.3 m^3/s IO for 98.7% of the time. This represents a total of 1,327 months over the entire 1,344-month period. Except for 4 months during 1984-1992, flows below the IO cutoff value have generally occurred during the July-October period, and this low-flow condition has not been recorded at the Bassano Dam station since 2001. Open flow conditions have been recorded in the past for the low-flow months extending from November to April during the 1915-1933 period, and at no time did the conditions decrease below 11.3 m^3/s; the lowest value recorded in that period was 25.3 m^3/s in December 1922.

The history of flow conditions for the Bow River indicates that ample water remains in the river during the time needed to divert water into the expanded reservoir for irrigation storage and subsequent use. This may change, however, due to anticipated shifts in seasonality associated with the timing and duration of the spring freshet as well as changes to late season precipitation. This is explored further in the following subsections.

12.5.2.4 Extreme Weather Events

Figure 12-4 provides a historical view of precipitation changes in the Brooks area since 1950. Also provided are the 10^{th} and 90^{th} percentiles, which are commonly used to represent periods of drought and excess moisture when assessing climate records.

There have been several periods of drought (i.e., years below the 10^{th} percentile) in the Brooks area in the last 74 years (Figure 12-4). These periods of a precipitation deficit occurred during 1960-62, 1987-89, 1997, 2000-2002, and 2011, and appear to have been occurring more frequently from 2015 onward based on measured values reported at the Brooks station. Further analysis of the data indicates that these drought events have occurred in 16.2% of the analyzed years and have been more prevalent since 1990.

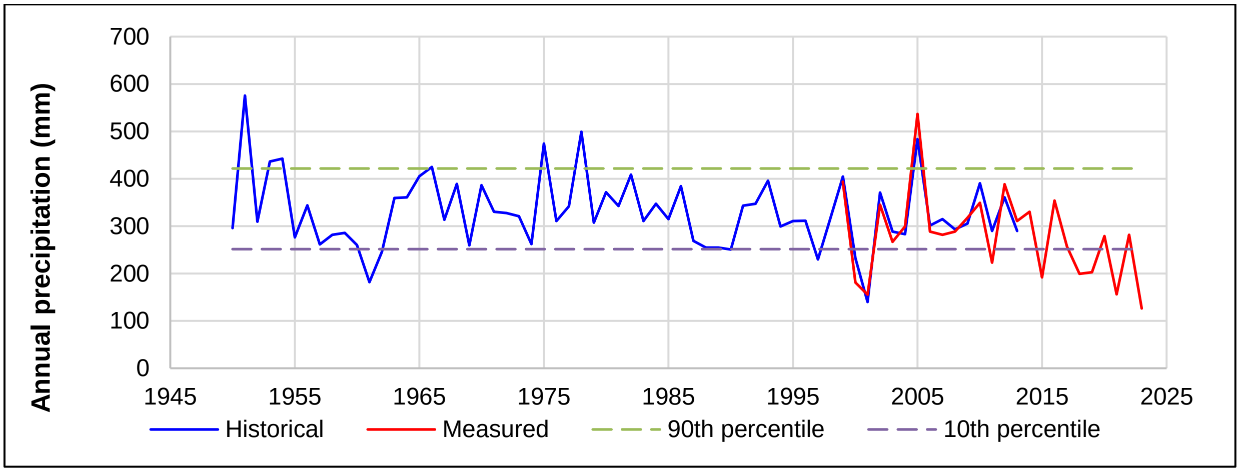


Figure 12-4: Historical and measured precipitation for Brooks, AB
(Prairie Climate Centre, 2024)

Excess precipitation (considered in this assessment to be above the 90th percentile) has occurred less frequently (i.e., 9.5% of the time), and almost entirely precedes the year 1980. Years where these excess events have occurred are as follows: 1951, 1953-54, 1966, 1975, 1978, and 2005.

12.5.2.5 Intense Rainfall

Heavy rainfall events (7 mm/h or more, per ECCC's definition; (GOC, 2024b)) are known to occur in the area (usually during thunderstorm events). Information pertaining to the magnitude of these events is shown in intensity-duration-frequency (IDF) data provided by ECCC for various climate stations across the country (GOC, 2024b; Prairie Climate Centre, 2024). The nearest station to the Project area with historical IDF data is Brooks.

Table 12-9 summarizes the IDF data assessed for the last 36 years for various return periods (in total millimeters that could be expected to fall). Figure 12-5 presents this data graphically, showing the expected precipitation rate in mm/h. Reconciling the table of values with the graph is a simple process. For example, the 10 minutes 2-yr return period value is multiplied by 6 to get the 1 hour reading on the graph (e.g. 7.1 x 6 = 42.6 mm/hr), and the 2 hr 2-yr return period value is divided by 2 to get the 1 hour reading on the graph (e.g. 17.4 ÷ 2 = 8.7 mm/hr), and so on.

Table 12-9: Historical intensity-duration-frequency data for the Brooks, AB station (in mm), 1965-2021

Duration of Event	Return period						1965 – 2021
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	No. of years
5 min	5.0	7.4	8.9	10.9	12.4	13.9	36
10 min	7.1	10.8	13.3	16.3	18.6	20.9	36
15 min	8.6	13.2	16.3	20.2	23.1	25.9	36
30 min	10.9	16.9	20.8	25.7	29.4	33.1	36
1 hr	13.9	21.6	26.8	33.2	38.0	42.8	38
2 hr	17.4	25.4	30.8	37.5	42.5	47.5	38

Duration of Event	Return period						1965 – 2021
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	No. of years
6 hr	23.9	32.6	38.4	45.7	51.1	56.5	38
12 hr	29.3	39.4	46.1	54.5	60.8	67.0	38
24 hr	34.9	48.4	57.3	68.6	77.0	85.3	38

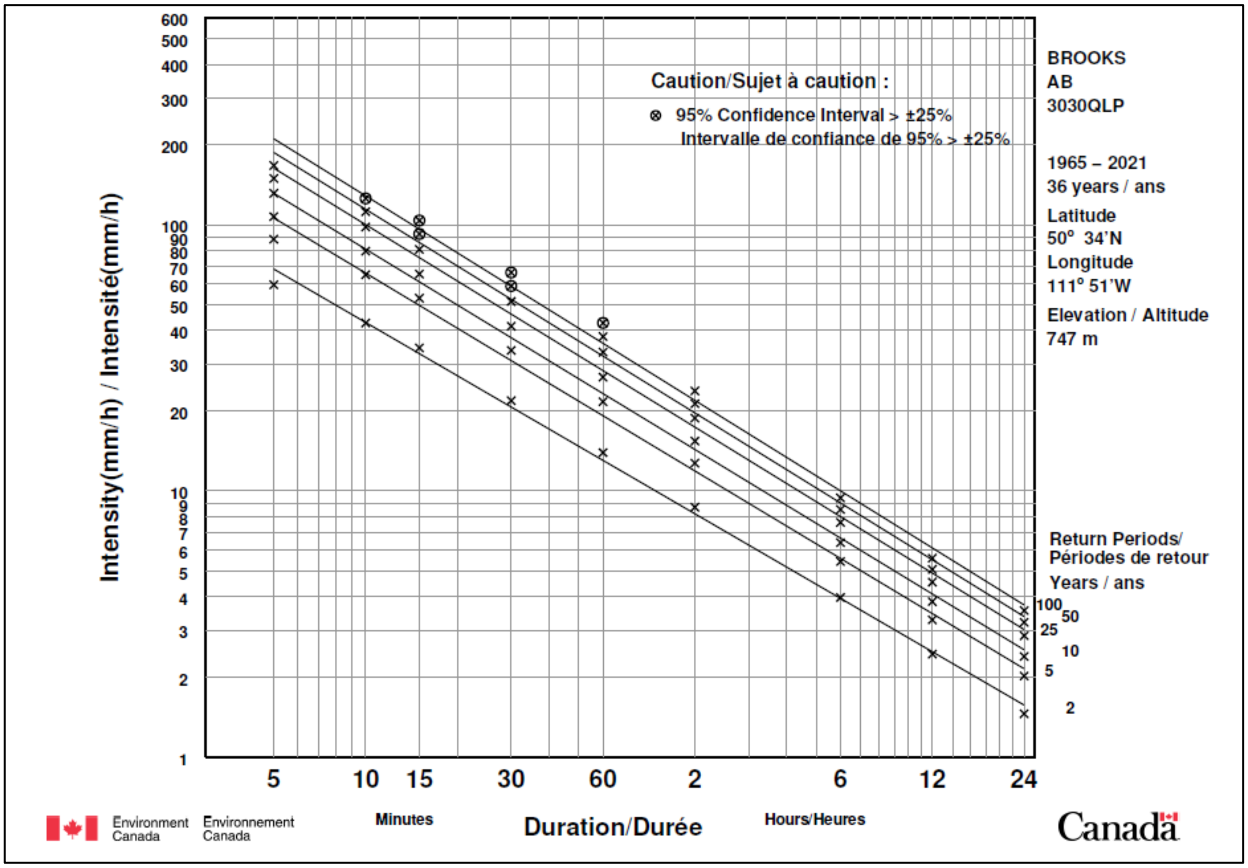


Figure 12-5: Intensity-duration-frequency graph, in mm/hr, for the Brooks, AB climate station
(Prairie Climate Centre, 2024)

12.5.2.6 Evaporation and Evapotranspiration

Evaporation and evapotranspiration are two important variables to consider when assessing the water budget of an area. Evaporation, which is the transformation of liquid water to vapour, and transpiration, which is the water vapour emissions from plants, serve to reduce the amount of moisture in the soil and available for plant uptake or groundwater recharge. If extreme enough, this can lead to water stress on vegetation and aquatic systems, potentially causing adverse effects. Figure 12-6 shows the changes in shallow lake evaporation, potential evaporation, and areal evapotranspiration for the Brooks area since the mid-1900s (GOA, 2013).

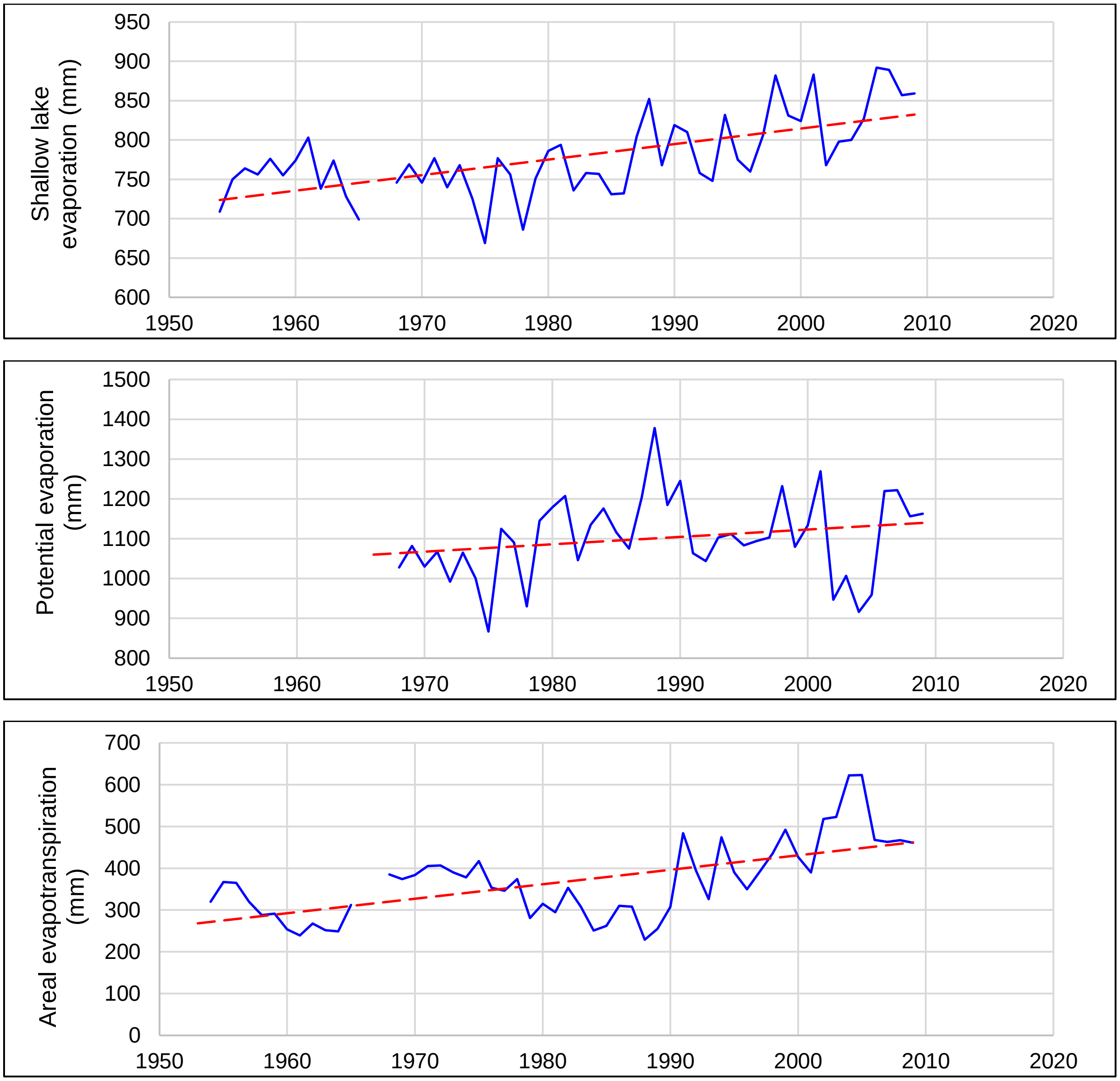


Figure 12-6: Historical evaporation and evapotranspiration in the Brooks area
(GOA, 2013)

Over time, historical evaporation and evapotranspiration has been variable but has shown a general increasing trend since measurements began (Figure 12-6). Comparison of climate norms from the 1971-2000 and 1991-2020 periods (Table 12-6) indicate a 0.6ºC temperature increase and 14% reduction in precipitation, which is consistent with these trends. Under continued warming due to climate change, the expectation is for increased growing season dryness across the prairie region (Basu & Sauchyn, 2022).

12.5.3 Impact Assessment

As effects of climate change continue, and the water balance adjusts, several changes are expected to occur to hydrometeorological conditions. These changes may impact agricultural productivity in the Project area and the surrounding communities that depend on this activity. The construction of the proposed reservoir is a climate adaptation strategy designed to address these evolving risks and ensure the agriculture sector's economic viability by providing irrigation water throughout the growing season for sustained agricultural development.

No field studies were performed as part of this climate change assessment, so the reliance has been placed on simulations from the modelling community and general knowledge of climate change impacts. Modelling results were obtained from the Prairie Climate Centre, as well as the Government of Canada publicly available data sources.

12.5.3.1 Mitigation/Adaptation Measures

Reservoir Expansion

The development of the Project serves as a major climate adaptation measure against climate change impacts. For example, the existing reservoir, with a capacity of 19.25 million m^3 was able to mitigate the negative impacts of the 2023 drought. The expanded reservoir, with a capacity of 87.4 million m^3 (almost 5 times), would significantly enhance this capability and ensure sufficient water storage for future drought conditions. Under drier conditions, the long-term viability of local agriculture will be challenged by increased water scarcity and reduced crop yields. The expanded reservoir will help mitigate these effects by providing a reliable source of water during extended deficit periods. Potential adverse effects of excess rainfall events, such as water-logging and negative impacts on crop quality or the reservoir structure itself, will be managed through efficient reservoir operations and infrastructure adaptations and maintenance.

Operational Adaptations

Future diversions from the Bow River at Bassano Dam, managed within the IO cutoff flow rate of 11.3 m^3/s, will protect the river during low flow conditions and safeguard the reservoir infrastructure during excessive water flow conditions. Proper operation of headgate structures and management of water allocations from the expanded reservoir will be crucial for addressing future climate conditions.

12.5.4 Predicted Project Effects (Application Case)

The predicted Project effects will have a positive impact on the agricultural sector (and other activities relying on water from the EID) based on the greater storage and water availability leading to increased drought resiliency.

Project impacts were assessed by comparing baseline conditions (Baseline Case) to Project conditions (Project Case), including a full construction (maximum impact scenario), and a future operations scenario (including all mitigation, reclamation, and any offsets), for assessing residual impacts. This section is an assessment of the climate change projections and associated potential impacts related to the Project including the receptors affected by those impacts, the risks and effects associated with climate change in the region. The benefits provided by the reservoir expansion are also included.

12.5.4.1 Temperature, Precipitation, and River Flows

Temperature and Precipitation

The two main drivers of impacts related to changing climatic conditions are temperature and precipitation. Changes in both variables affect the water balance of an area and the viability of agricultural productivity and other related activities. Projected changes for these two variables under the RCP 4.5 and RCP 8.5 scenarios are summarized in Table 12-6, along with the percentage change from the 1976-2005 baseline period. Figure 12-7 shows the results of various model simulations over the 2021-2050 and 2051-2080 time periods. Although there is variability among the differing climate models as to the magnitude of change to temperature and precipitation, the general trend is for an increase in both variables, which has implications for the local and regional water balance.

Both assessed scenarios show predicted increases in temperature and precipitation for the Project area, with precipitation increases ranging from -10 to +30% (a mean of about 10%) for the low effect scenario, and with no noticeable increase from the first 30-year (2021-2050) to the second 30-year (2051-2080) period. In contrast, the temperature increases from about 2 degrees to 3 degrees higher over the two periods. Similar results are shown for the high scenario with similar increases in precipitation; however, temperature increases are projected to be from 2 degrees to about 4.5 degrees from the first to second period (Figure 12-7).

Evaporation and Evapotranspiration

Evaporation and evapotranspiration are by-products of warming temperatures due to the changes in various climate indices and the water balance of the Project area. Following a review of climate model information, Basu and Sauchyn (2022) indicate that potential impacts to agricultural lands of Canada, including the Project area, are as follows:

- decreases in the net water balance index indicate enhanced dryness over Western Canada in all future periods;
- increased total evapotranspiration surpasses the increase in total precipitation by 100 mm to 300 mm resulting in more dryness;
- increased transpiration (10 to 20% in the future) compared to the historical baseline results in higher evapotranspiration;
- total evaporation decreases by 15% to 20% as the fractional contribution of evaporation from soil decreases by 20% to 25% as well; and
- total evaporation from vegetation increases by 10% to 15%.

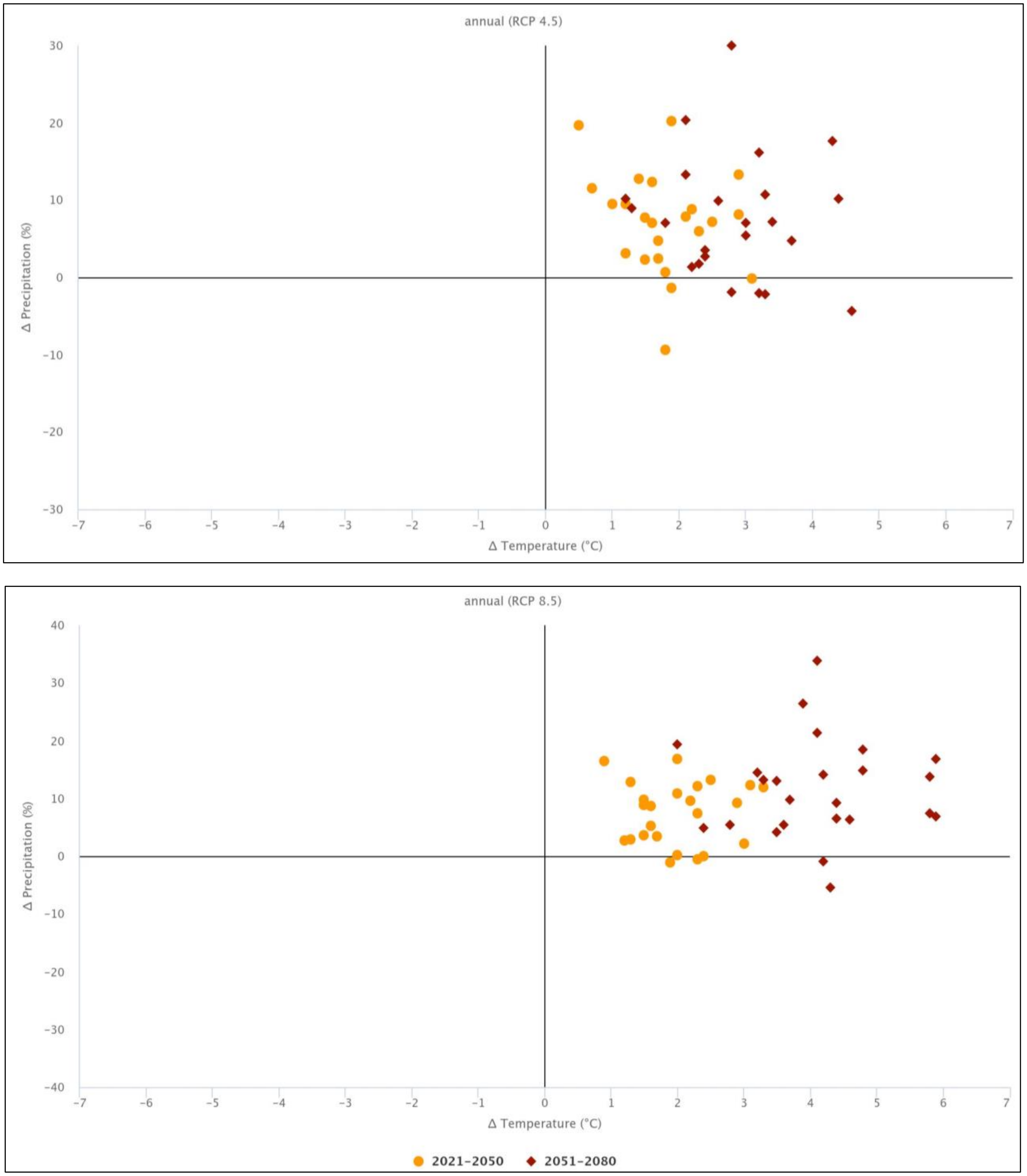


Figure 12-7: Projected changes to average annual temperature and precipitation in the Project area for multiple climate models relating to representative concentration pathway 4.5 and 8.5 scenarios
(Prairie Climate Centre, 2024)

Basu and Sauchyn's (2022) findings are consistent with the general expectation of the climate modelling community and underscores the risk posed to the local agricultural community to water balance deficits in the future.

Impacts: The anticipated changes to evaporation and evapotranspiration and expected to enhance growing season dryness over the prairie region in the coming decades and adversely affect agricultural productivity. The major impacts include:

- enhanced risk of water scarcity; and
- the likelihood of more frequent and sustained drought conditions and their adverse effects on crop productivity.

River Flows

Ensuring availability and reliability of water can be a significant challenge. The Project has been designed to build climate change resiliency into the area's water supply by capturing and storing water from the Bow River and using it for irrigation activities to support sustained agricultural development. The supply of water to the Bow River is, however, heavily dependent on the snowmelt generated from seasonal snowpacks in the eastern front ranges of the Rocky Mountains, plus late spring/early summer rainfall events in the upper headwater areas. Modelled results for projected changes to precipitation in the headwater regions of the Bow River are provided in Figure 12-8 for the RCP 4.5 (low effect) and RCP 8.5 (high effect) scenarios.

As indicated in Figure 12-8, changes in the timing and magnitude of precipitation in the headwaters of the Bow River, and consequently, runoff in the Bow River are expected in the future. Identified changes are presented in all graphs as predicted % change from the 1976-2005 baseline period. As discussed in the methods section (i.e. Section 12.5.1), the RCP 4.5 and RCP 8.5 are two climate scenarios examined to represent a low (4.5) and high (8.5) change. Also examined are two time periods, the 30-year period from 2021 to 2050, and the next period from 2051 to 2080. All the graphs show that monthly precipitation is expected to increase in winter (January to March), spring (April to June), and autumn (October to December) periods, followed by a decrease during the summer months (July to September).

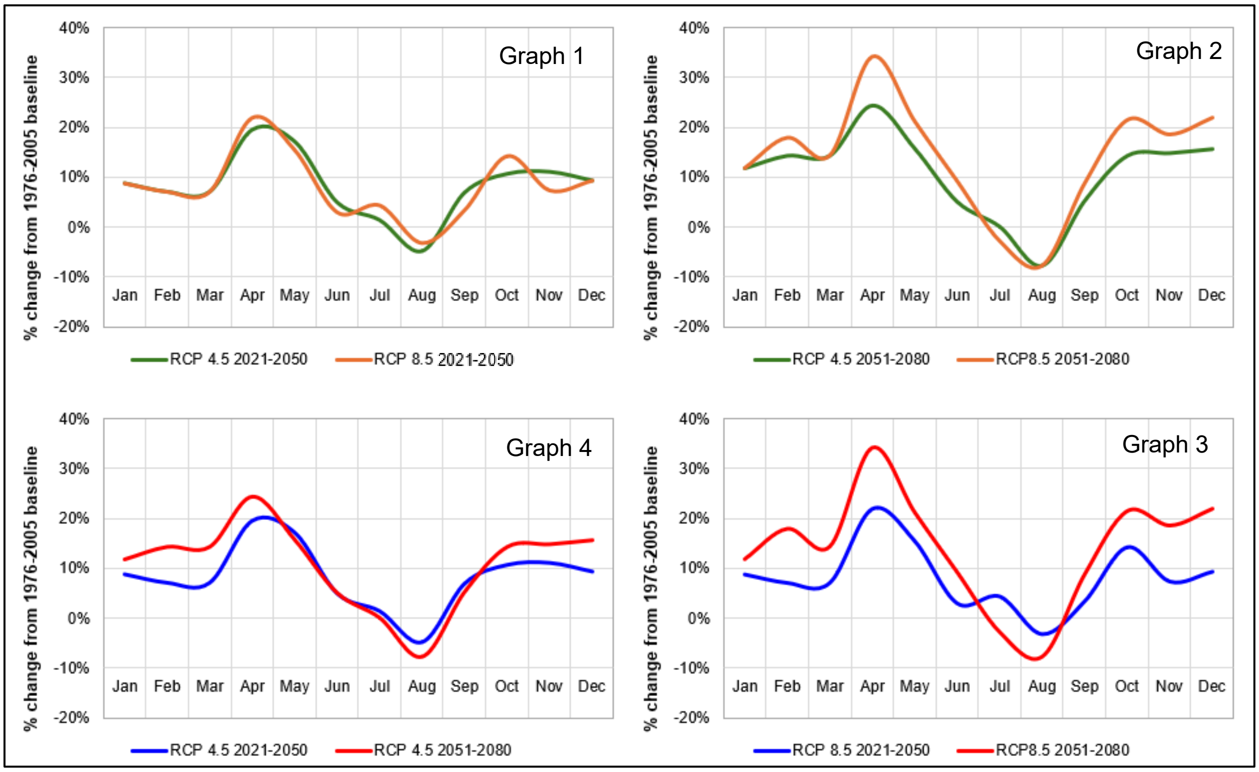


Figure 12-8: Projected percent change in monthly precipitation from 1976-2005 baseline period in the Calgary region and headwater areas for the Bow River
(Prairie Climate Centre, 2024)

The top two graphs compare data for RCP 4.5 and RCP 8.5 to each other for the same time periods, the top left showing 2021-2050 and the top right show 2051-2080, whereas the bottom two graphs each compare the RCPs (4.5 for the graph on the bottom left and 8.5 for the graph on the bottom right) in different time periods. Starting at the top left and moving in a clockwise direction the graphs may be numbered 1 through 4:

- Graph 1: In the first 30 years, there is expected to be a 7-10% increase in precipitation in winter, 10-22% increase in spring, +5 to -5% change in summer and 7-13% increase in fall. Graph 1 also shows there is little difference between the two scenarios for the first 30 years.
- Graph 2: In the next 30 years, the high effects scenario is predicted to result in even more intense winter, spring, and fall precipitation, without much change in the summer.
- Graphs 3 and 4 compare the two 30-year periods to show how much change is expected over time. Graph 3 shows the worst-case scenario, and in this comparison the next 30 years are expected to see a large increase in precipitation: roughly 12-20% in winter, 5-35% in spring, -10 to +15% in autumn and 15-22% in fall.
- Graph 4 results are similar for the low scenario, but are muted in comparison.

These projections suggest that greater precipitation is expected in the Bow River basin in future winter months (more likely as rainfall than snow), and greater rainfall is expected in spring and fall, resulting in greater river flows and more water available to be captured for off stream storage.

This would help offset the greater deficit in water predicted for summer months, particularly in July and August. Continued ability to store excess water in upstream dams will also help preserve flow conditions for downstream users in low flow conditions.

Impacts: Variable precipitation (timing and amount) can lead to conditions that adversely affect agricultural productivity, such as:

- decreased river flows due to reduced snowpacks and shorter/earlier spring freshet (resulting in longer low-flow period and reduced access to irrigation water);
- waterlogging of fields leading to access difficulty during critical times of the year (seeding and harvest); and
- negative impacts to crop quality and yields due to excessive moisture.

Water supply impacts will be unlikely to change with the development of the Project. The new reservoir storage size will allow increased capture of water, and as there is predicted to be increased winter precipitation, with ensuing spring rains and fall rains, ample water should be available to fill the reservoir in most years. No predictions were made for anomalous conditions, but it is likely that some years will see decreased snowpack and rainfall, as occurred in 2023 (see Volume 1, Section 7), such that water may not be plentiful in the early spring. In these cases, if drought occurs in mid-summer most years will be able to rely on stored water from previous years (e.g., higher fall rains prior to the drought year). It is only in the unlikely event that two extreme drought years and low flow years occur back-to-back that lower water availability may occur. In this case, starting the year with low water levels, the EID would rely on existing water management tools such as rationing and encourage planting of more drought resistant/water efficient. Note that there would never be a need to draw water from the Bow River when the IO is not being achieved, and total annual diversion of water will always meet the apportionment requirements and be within the allowable water diversion volume under the EID's water licence. Total water irrigated per acre would also not increase beyond the current range; therefore, no effects would occur downstream of the Project.

12.5.4.2 Growing Conditions

Length of the growing season will be impacted by future temperature changes, as noted in Table 12-10. The frost-free period is projected to increase from 153 days (under RCP 4.5) to 163 days (under RCP 8.5) by 2051-2080.

Impacts: The additional frost-free days, combined with the 34% to 50% increase in growing degree days above 5ºC (i.e., the temperature for cool-season plants like wheat, barley, and rye) will benefit crop production. The projected increase in winter and spring precipitation (9% to 19%) will also benefit crop production during early growth.

Table 12-10: Change in climate indices under RCP 4.5 and 8.5 emission scenarios (compared to 1976-2005 baseline period)

Climate Parameter	Baseline (1976-2005)	RCP 4.5 (2051-2080)	Δ (%) From Baseline	RCP 8.5 (2051-2080)	Δ (%) From Baseline
Mean annual °C	4.5 (277.7 K)	7.4 (280.6 K)	1.0	8.7 (281.9 K)	1.5
Days with max >30°C	16	40	150	53	231
Annual average precipitation (mm)	332	355	7	357	8
Spring	80	94	18	95	19
Summer	143	144	<1	145	1
Fall	65	69	6	69	6
Winter	44	49	11	48	9
Growing degree days (above 5 °C)	1,713	2,291	34	2,577	50
Growing degree days (above 15 °C)	282	603	114	785	178
Average length of heat waves (days)	3.3	7.6	130	8.3	151
Frost-free period (days)	131	153	17	163	24

(Prairie Climate Centre, 2024)

Note: Growing degree days above 5°C are used to assess crop growth potential, while those above 15°C are used to assess insect growth potential. Modeled ensemble results for relevant climate indices, based the two scenarios assessed as part of this review, are summarized in Table 12-6. These projections, along with the baseline period of 1976-2005, and the percentage change from that baseline during the 2051-2080 time frame (starting roughly 25 years from now) have been provided for both the RCP 4.5 and RCP 8.5 scenarios.

Climate change will also have negative effects on crop production. This includes an increase in the number of days above 30ºC (the upper limit to healthy plant growth), expected to be anywhere from 40 to 53 days (150% to 231%), and an increase in the average length of heat wave days (i.e., 3 or more days with maximum temperature of 30 ºC or higher) of 7 to 8 days (130% to 151%) (Prairie Climate Centre, 2024). Additional shading from developed crops or irrigation in these hot periods may be necessary to sustain yields.

Although there is on average ≤ 1% change in summer precipitation (Table 12-10), Figure 12-8 shows July and August are likely to sustain reduced precipitation of about 8% reducing river flows and increasing need for irrigation. Combined with the warming conditions in the same period, the risk of extended drying events could adversely affect crop production if sufficient irrigation water is not available. This, combined with a projected increase anywhere from 603 to 785 (114% to 178%) growing degree days above 15°C (often used to determine if conditions are warm enough for insect development) will enhance the development of pests that may negatively affect otherwise healthy crops. Other negative effects associated with rising temperatures include:

- **Change in river flow seasonality**: shorter winters and early snowmelt can alter the timing and volume of river flows;
- **Increased evaporative losses:** higher temperatures can lead to greater evaporation from water bodies, wetlands, and soil, reducing water availability;
- **Heat stress:** increased number of hot days can stress vegetation and aquatic and terrestrial habitats; and
- **Increased water demand**: both crop production and other water uses will require water under hotter conditions.

12.5.4.3 Extreme Weather Events

Drought

According to the GOC (2024h), droughts are expected to become more frequent as the global temperature continues to increase. This is particularly true for areas prone to dry conditions, such as the Palliser Triangle region of southern Alberta.

Eum et al. (2023) reviewed the potential changes in various climate indices in the natural areas of Alberta, including the risk of drought (i.e. based on a standardized precipitation evapotranspiration index [SPEI]). The study assessed the influence of differing global temperature increases on projections of extreme drought and the related return periods in each natural region. Table 12-11 summarizes those results for the three natural areas relevant to this Project: the Rocky Mountains, the Foothills (i.e. headwater areas of the Bow River), and the Grasslands region (where the Project is situated). The decreasing return periods (i.e. increased probability of droughts) for the increasing temperature scenarios is evident. With respect to the Project area, anywhere from a 6% to 20% increase in the chance of extreme drought occurring is anticipated for the associated temperature increases expected for the RCP 4.5 (mean from 1.4ºC to 1.8ºC) and RCP 8.5 (mean from 2.0ºC to 3.7ºC) scenarios for the 2045 to 2100 timeframe (IPCC, 2013).

Table 12-11: Simulated return periods for extreme drought in natural areas of Alberta

Global Warming Scenario	Natural Area					
	Rocky Mountains		Foothills		Grasslands	
	Return period (yr)	Chance (%)	Return Period (yr)	Chance (%)	Return Period (yr)	Chance (%)
SPEI-12 Baseline (1985-2014)	36	3	33	3	33	3
1.5ºC increase	14	7	16	6	16	6
2ºC increase	9	11	9	11	12	8
3ºC increase	8	13	7	14	8	13
4ºC increase	7	14	6	17	5	20
5ºC increase	6	17	5	20	5	20

Note: SPEI-12 = Standardized Precipitation Evapotranspiration Index for 12-month period over the water-year season (ending in September)

According to the GOC (2024h) the likelihood of droughts occurring is expected to increase, although when they will occur is more difficult to determine. Various factors can increase drought risk, including climate patterns that promote warmer and drier conditions such as the El Niño-Southern Oscillation (ENSO), and the Pacific Decadal Oscillation (PDO), as well as the prevailing position of the jet stream over Western Canada (i.e., the Pacific North American pattern (PNA). Given the right conditions, blocking ridges of high pressure due to a positive phase of the PNA, combined with positive phases of the ENSO and/or PDO can lead to extended drying events (Asong et al., 2018). The fact that southern Alberta is also in a rain shadow of the Rocky Mountains further exacerbates these conditions.

Projecting future conditions in relation to these various climate and atmospheric modes amid changing climate conditions is extremely challenging and remains a key focus of on ongoing research within the climate modeling community. Consequently, drought prediction beyond a general understanding that southern Alberta will likely experience more frequent drought conditions in the future is as far as this assessment can go.

Impacts: Climate change is anticipated to result in drier conditions due to increased temperatures and longer duration of hot spells leading to enhanced evaporation and evapotranspiration. This is anticipated to balance out, and possibly even diminish, the effects of anticipated increases in precipitation. The expectation is increased drought frequency, which will adversely affect the water balance of the region. Impacts from drier conditions will manifest themselves as follows:

- increased risk of water scarcity due to negative effects to the local and regional water balance;
- increased demand for irrigation and other water supply needs;
- reduction in river flows in years with a low snowpack leading to extended low-flow conditions;
- reduction in crop yields; and
- increased insect activity.

Heavy Rainfall

With respect to precipitation, ECCC has developed IDF data related to various climate scenarios to determine how conditions may change in the future. Table 12-12 summarizes the anticipated precent change from the 1965-2021 baseline period by the 2051-2080 time period with respect to total mm and mm/hr for various return periods (Table 12-9 and Figure 12-4, respectively). In all cases, increases above the historic baseline data are anticipated with differences ranging from 17.0% to 37.9% depending on the duration and return period assessed (Prairie Climate Centre, 2024). As noted previously, annual precipitation is projected to increase by up to 8%, on average, by the 2051-2080 timeframe compared to the 1976-2005 baseline, and anywhere from <1% to 19% during the various seasons (Table 12-10). Based on the IDF projections more of this rainfall is anticipated to fall in major storm events (Table 12-12).

Table 12-12: Change in intensity-duration-frequency (IDF) of precipitation events in 2051 to 2080 for RCP 4.5 and 8.5 from 1965-2021 baseline period

Return period	Units	Duration									Δ Median
		5 min	10 min	15 min	30 min	1 hr	2 hr	6 hr	12 hr	24 hr	
2-yr (Baseline)	mm/hr	59.5	42.7	34.4	21.8	13.9	8.7	4.0	2.4	1.5	-
RCP 4.5	mm/hr	72.0	52.0	42.0	26.0	17.0	11.0	4.9	2.9	1.8	-
Δ From Baseline	*%*	*21.0*	*21.8*	*22.1*	*19.3*	*22.3*	*26.4*	*22.5*	*20.8*	*20.0*	*21.8*
RCP 8.5	mm/hr	79.0	57.0	46.0	29.0	18.0	12.0	5.3	3.2	2.0	-
Δ From Baseline	*%*	*32.8*	*33.5*	*33.7*	*33.0*	*29.5*	*37.9*	*32.5*	*33.3*	*33.3*	*33.3*
5-yr (Baseline)	mm/hr	88.8	64.8	52.8	33.8	21.6	12.7	5.4	3.3	2.0	-
RCP 4.5	mm/hr	107.0	79.0	65.0	41.0	26.0	15.0	6.6	4.0	2.4	-
Δ From Baseline	*%*	*20.5*	*21.9*	*23.1*	*21.3*	*20.4*	*18.1*	*22.2*	*21.2*	*20.0*	*21.2*
RCP 8.5	mm/hr	117.0	86.0	70.0	45.0	29.0	17.0	7.2	4.4	2.7	-
Δ From Baseline	*%*	*31.8*	*32.7*	*32.6*	*33.1*	*34.3*	*33.9*	*33.3*	*33.3*	*35.0*	*33.3*
10-yr (Baseline)	mm/hr	106.8	79.8	65.2	41.6	26.8	15.4	6.4	3.8	2.4	-
RCP 4.5	mm/hr	130.0	97.0	79.0	51.0	33.0	19.0	7.8	4.6	2.9	-
Δ From Baseline	*%*	*21.7*	*21.6*	*21.2*	*22.6*	*23.1*	*23.4*	*21.9*	*21.1*	*20.8*	*21.7*
RCP 8.5	mm/hr	142.0	106.0	87.0	55.0	36.0	20.0	8.5	5.0	3.2	-
Δ From Baseline	*%*	*33.0*	*32.8*	*33.4*	*32.2*	*34.3*	*29.9*	*32.8*	*31.6*	*33.3*	*32.8*
25-yr (Baseline)	mm/hr	130.8	97.8	80.8	51.4	33.2	18.8	7.6	4.5	2.9	-
RCP 4.5	mm/hr	160.0	119.0	98.0	63.0	40.0	23.0	9.2	5.5	3.5	-
Δ From Baseline	*%*	*22.3*	*21.7*	*21.3*	*22.6*	*20.5*	*22.3*	*21.1*	*22.2*	*20.7*	*21.7*
RCP 8.5	mm/hr	174.0	130.0	107.0	68.0	44.0	25.0	10.0	6.0	3.9	-
Δ From Baseline	*%*	*33.0*	*32.9*	*32.4*	*32.3*	*32.5*	*33.0*	*31.6*	*33.3*	*34.5*	*32.9*
50-yr (Baseline)	mm/hr	148.8	111.6	92.4	58.8	38.0	21.3	8.5	5.1	3.2	-
RCP 4.5	mm/hr	181.0	136.0	112.0	71.0	46.0	26.0	10.0	6.2	3.9	-
Δ From Baseline	*%*	*21.6*	*21.9*	*21.2*	*20.7*	*21.1*	*22.1*	*17.6*	*21.6*	*21.9*	*21.6*
RCP 8.5	mm/hr	198.0	148.0	123.0	78.0	50.0	28.0	11.0	6.8	4.3	-
Δ From Baseline	*%*	*33.1*	*32.6*	*33.1*	*32.7*	*31.6*	*31.5*	*29.4*	*33.3*	*34.4*	*32.7*
100-yr (Baseline)	mm/hr	166.8	125.4	103.6	66.2	42.8	23.8	9.4	5.6	3.6	-
RCP 4.5	mm/hr	203.0	152.0	126.0	80.0	52.0	29.0	11.0	6.8	4.4	-
Δ From Baseline	*%*	*21.7*	*21.2*	*21.6*	*20.8*	*21.5*	*21.8*	*17.0*	*21.4*	*22.2*	*21.5*
RCP 8.5	mm/hr	222.0	167.0	138.0	88.0	57.0	32.0	12.0	7.4	4.8	-
Δ From Baseline	*%*	*33.1*	*33.2*	*33.2*	*32.9*	*33.2*	*34.5*	*27.7*	*32.1*	*33.3*	*33.2*

Impacts: Coupled with the projected increase in storm IDFs is the potential for more violent weather events to occur due to increased temperatures, enhanced warming of the earth, the formation of convective winds, and the increase in atmospheric moisture due to water losses from the land from increased evaporation and evapotranspiration. The combination of these effects can lead to the following:

- generation of large amounts of rainfall over short periods of time and the related effects due to flooding and waterlogging of field; and
- increased erosive forces due to excessive runoff.

Intense Convective Storms (Wind and Hail)

Climate change may also increase the occurrence and intensity of damaging thunderstorms. For this assessment, it is qualitatively predicted that intense storms will increase in occurrence and intensity as these events are strongly coupled to high temperature differentials in the atmosphere, conditions leading to intense rainfall, and high rates of evapotranspiration, all of which are anticipated to increase with continued global warming. Likely effects include:

- creation of conditions favourable for the production of damaging hail and possibly enhanced tornado activity; and
- intense convective storm activity leading crop and property damage.

12.5.5 Surface and Groundwater Quality

Increased temperatures and altered precipitation patterns can lead to higher concentrations of pollutants in surface waters. Predicted increases in rainfall for spring and autumn seasons may lead to increased runoff from fields, transferring a greater amount of nutrients and pesticides to waterbodies before they can attenuate in the surficial soils and underlying deposits. This can potentially affect water quality and aquatic habitats. The two scoped indicators were:

- nutrient concentrations in surface water and groundwater; and
- presence of detectable pesticides.

Evidence from water quality monitoring in the EID (see Volume 2, Section 7) indicates that pesticides and herbicides do show up at detectable levels in return flow monitoring sites in some areas, but not generally in the Bow River water or waters immediately downstream of the existing SLR. Effects may occur to surface water or groundwater; however, the limited connectivity to the groundwater beneath this area (due to the presence of overlying low permeability till deposits) leads to a reduced expectation for effects to be observed (see Volume 2, Section 6 – Hydrogeology). If these chemicals increase their presence in the surface water and groundwater in the future, they will be identified in the existing water monitoring and dealt with accordingly (see Volume 2, Section 7, Appendix E, Figure E1-13).

12.5.6 Ecosystem Conditions

The two scoped indicators included:

- changes to native grassland, shrub and tree communities; and
- changes to wildlife habitat suitability.

Effects of climate change on plant communities may occur through influences on soils or on plant species. Increased rainfall in the spring and fall could lead to increased soil erosion and leaching due to more intense and frequent rainfall events. This can affect soil stability and depth, favoring species adapted to thin topsoils, and where a saline or sodic clay till layer is closer to surface. The leaching of salts and deposition in low lying areas can reduce soil quality. Changes to native grassland, shrub, and tree communities are likely to occur over long time periods, as plant species are conservative by nature and once established take time to be replaced. Shifts in climate conditions can alter plant community composition and productivity. Warmer temperatures and changing precipitation patterns may favour invasive species, altering the native grassland community. Decreased coverage of tree and shrub species can potentially affect habitat quality, nesting areas, and availability of food and shelter for wildlife. This may further result in a shift in the wildlife community.

12.5.7 Economic Conditions

There are certain resources that will be affected by climate change, and indicators that can be tracked to determine their performance. These included the following scoped indicators:

- **Crop yield per hectare:** certain crops may benefit from warmer conditions, leading to higher production and yields (e.g., corn), due to an increase in length of growing season and/or the increased growing degree days. These factors can have a combined effect on increasing the time for some crops to grow and fully mature, and the type of crops grown can be those adapted to warmer climates. An extended growing season may also allow for multiple crop harvests in the same growing season (e.g., forage crops).
- **Economic return (agricultural GDP):** given that higher yield and specialty crops with a higher economic yield have the potential to be grown, economic returns may be increased. More intense droughts could reduce these yields, but development of the Project will ensure irrigation needs are met to address future droughts.
- **Crop failure, insect outbreaks and reduced field access due to flooding:** improved economic return may be offset by increased effects of severe storms, flooding, and insect outbreaks (warmer temperatures can enhance pest proliferation; this can also lead to increased pesticide use, which can impact water quality). Existing or enhanced insurance or assistance programs would also need to support producers and food processers.
- **Increased wildfire risk:** drying conditions will affect native grassland areas that do not received sufficient rainfall and may result in increased frequency and intensity of prairie grass fires. Implementation of the fire control plan (see Volume 1, Section 11) should mitigate these effects, but this plan may need to be updated over time as the risk increases.
- **Erosion of reservoir berms:** due to increased rainfall in spring and fall, soil losses and increased sedimentation due to enhanced erosion may affect surface water quality. Standard mitigation measures (erosion and sediment controls – see Volume 1, Section 11) will ensure these effects are limited.

12.5.8 Residual Impacts Assessment

Residual impacts were assessed for two indicators that will be affected by the Project activities (Table 12-13). It is not expected that there will be any long-term, negative residual impacts to climate change resulting from the reservoir expansion. The impacts from GHGs are only expected to occur during Project construction, and impacts from carbon sequestration are expected to occur over the long-term as carbon sequestration can take many decades.

Table 12-13: Residual impact rating for indicators affected by the Project

Indicator or Resource	Direction	Key Criteria			Modifiers		Residual Impact Rating
		Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
Greenhouse Gas Emissions	Negative	Low	Regional	Short-term	Medium	N/A	Low Negative
Carbon Sequestration	Positive	Low	Local	Long-term	Medium	N/A	Medium Positive

The residual impacts assessment (Table 12-14) considers each indicator from the Issues Scoping in the worst-case scenario impacted by climate change and provides a rating to identify how the effects will likely impact the region. All indicators were assessed considering mitigation measures and Project-related adaptation, and in some cases, the rating criteria were affected. For example, the magnitude rating for drought is reduced to Low, when considering the mitigating effects of the Project, as it will provide a reliable water supply. Other mitigations or Project adaptations include physical effects such as erosion and sediment control and increased irrigation to mitigate effects of higher temperatures and lower rainfall. There are also economic controls such as improved compensation methods for crop losses.

Table 12-14: Effects of climate on the Project and region in an anticipated worst-case climate scenario

Climate Effect Category	Indicator or Resource	Direction	Key Criteria			Modifiers		Residual Impact Rating
			Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
Temperature and Precipitation	Mean annual and seasonal temperatures	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Timing and amount of precipitation	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Evaporation and transpiration loss	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
Growing Conditions	Extreme heat events	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Growing degree days	Positive	High	Regional	Long-term	Medium	N/A	High Positive
	Frost-free days	Positive	High	Regional	Long-term	Medium	N/A	High Positive
Extreme Weather Events	Drought	Negative	Low*	Regional	Long-term	Medium	High Importance	High Negative
	Frequency of wet periods	Negative	High	Regional	Long-term	Medium	High Importance	High Negative
	Wind and hail events	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
River Water Supply	Precipitation in late fall/winter months	Positive	High	Extra Regional	Long-term	Medium	N/A	High Positive
	Upstream precipitation	Negative	Low*	Extra Regional	Long-term	Medium	N/A	Medium Negative
	Upstream river flows	Negative	Low*	Extra Regional	Long-term	Medium	N/A	Medium Negative
	River flow at diversion location	Negative	Low*	Extra Regional	Long-term	Medium	N/A	Medium Negative
	Rain or snow events	Negative	High	Extra Regional	Long-term	Medium	N/A	High Negative

Climate Effect Category	Impact Description	Direction	Key Criteria			Modifiers		Residual Impact Rating
			Magnitude	Geographical Extent	Duration	Confidence	Ecological and Social Context	
Surface and Groundwater Quality	Nutrient concentrations in surface water and groundwater	Negative	High	Regional	Long-term	Medium	N/A	High Negative
	Presence of detectable pesticides	Negative	High	Regional	Long-term	Medium	N/A	High Negative
Ecosystem Conditions	Changes to native grassland, shrub and tree communities	Negative	High	Regional	Long-term	Medium	N/A	High Negative
	Changes to wildlife habitat suitability	Negative	High	Regional	Long-term	Medium	N/A	High Negative
Economic Conditions	Yield per hectare	Positive	High	Regional	Long-term	Medium	N/A	High Positive
	Agricultural gross domestic product	Positive	High	Regional	Long-term	Medium	High Importance	High Positive
	Insect activity and crop damage	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Reduced field access	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Increased wildfire risk	Negative	Low*	Regional	Long-term	Medium	N/A	Medium Negative
	Erosion of reservoir berms	Negative	Low*	Footprint	Long-term	Medium	N/A	Medium Negative

*Magnitude reduced to low given Project activities and mitigation measures.

12.6 CUMULATIVE EFFECTS ASSESSMENT

Since the Project is not expected to have a negative effect on climate change (i.e. assessed residual effects are only due to external factors in and surrounding the Project area) the cumulative effects have not been assessed.

12.7 MONITORING AND MANAGEMENT

Monitoring for climate change in the context of this Project will not be conducted by the EID as this information is already being collected by various provincial and federal agencies at dedicated weather and monitoring stations located near the Project area.

Management of the reservoir filling and water storage, as well as the delivery of water to irrigated lands, will be managed accordingly to ensure sufficient water for the intended needs. Filling of the expanded reservoir will be restricted to periods of flow, as measured at the Bow River at Bassano Dam station, where the IO of 11.3 m^3/s is maintained to protect aquatic habitat in the river below the dam. If the effects of climate change cause this flow rate to be insufficient, it will be up to regulators to adjust this minimum rate, and the EID to adapt to ensure compliance. Delivery of water for irrigation, and other needs, will be managed through the EID's reservoir operations to ensure reliability of supply even during periods of extended drought.

12.8 CONCLUSIONS

GHG emissions will increase slightly and temporarily during the Project construction – mostly from the operation of construction vehicles. Emissions during the construction of the Project are anticipated to range from roughly half of the emission from vehicle movement on the TCH and nearby CPKC rail line to about equal amounts, peaking at roughly equal amounts in 2028, followed by a sharp decline of about 28% in 2029. The five-year combined total for emissions in the LCSA is projected to be on the order of 221,000 tonnes, of which about 43% will be due to construction and shipping activities and the rest due to baseline emissions. Some of this will be offset by growth of vegetation that will consume some of the GHGs (CO_2 in particular) as a result of the water security provided by the Project.

Climate change is anticipated to affect conditions relating to crop productivity and water users in the EID. Most notably, climate projections indicate a continued rise in temperatures and a commensurate increase in precipitation. Growing degree days are also projected to increase, along with the length of the growing season, which should result in increased agricultural productivity but also increased water demand. This, of course, would be countered by increasing drying and heat stress that is expected across the prairie region over the coming decades. Although streamflow characteristics are projected to shift to an earlier and more protracted runoff period with a longer low-flow period, the regulation of the river and presence of upstream control structures has decreased the variability of flow in the Bow River and increased baseflows as a result. This has led to improved and more stable low-flow conditions than would otherwise occur. This provides favourable conditions for the diversion of water from the Bow River at Bassano Dam as long as flows above the IO of 11.3 m^3/s are consistently met.

12.9 REFERENCES

Adams, B., Richman, J., Poulin-Klien, L., France, K., Moisey, D., & McNeil, R. (2013). Rangeland plant communities for the Dry Mixedgrass Natural Subregion of Alberta. *Second Approximation. Rangeland Management Branch, Policy Division, Alberta Environment and Resource Development, Lethbridge, Pub. No. T/040*, 135.

Asong, Z., Wheater, H., Bonsal, B., Razavi, S., & Kurkute, S. (2018). Historical drought patterns over Canada and their teleconnections with large-scale climate signals. *22*(6). Retrieved from https://doi.org/10.5194/hess-22-3105-2018

Basu, S., & Sauchyn, D. (2022). Future changes in the surface water balance over western Canada using the CanESM5 (CMIP6) ensemble for the shared socioeconomic pathways 5 scenario. *14*(5). Retrieved from https://doi.org/10.3390/w14050691

City of Calgary. (2024). *Calgary river flows - historical data*. Retrieved September 25, 2024, from https://www.calgary.ca/water/flooding/calgary-river-flows-historical-data.html

Council of Canadian Academies. (2022). *Nature-based climate solutions.* Retrieved from https://cca-reports.ca/reports/canadas-carbon-sink-potential/

Crossman, J., Futter, M., & Whitehead, P. (2013). The significance of shifts in precipitation patterns: Modelling the impacts of climate change and glacier retreat on extreme flood events in Denali National Park. Retrieved from https://doi.org/10.1371/journal.pone.0074054

Epp, H., & Ealey, D. (2006). Proceedings of the Conference Held by the Alberta Society of Professional Biologists on March 25-28, 2006 in Calgary, AB. Water: Science and Politics.

Eum, H., Fajard, B., Tang, T., & Gupta, A. (2023). Potential changes in climate indices in Alberta under projected global warming of 1.5-5C. *47*(23). doi:10.1016/j.ejrh.2023.101390

Government of Alberta (GOA). (2013). *Evaporation and evapotranspiration in Alberta.* Edmonton: Alberta Environment and Sustainable Resource Development. Retrieved from https://www.acis.alberta.ca/acis/docs/mortons/mortons-evaporation-estimates.pdf

Government of Canada (GOC). (2019). *Fuel efficiency benchmarking in Canada's trucking*. Retrieved from https://natural-resources.canada.ca/energy/efficiency/transportation/commercial-vehicles/reports/7607

GOC. (2021). *2021 Fuel consumption guide*. Retrieved from https://natural-resources.canada.ca/sites/nrcan/files/oee/pdf/transportation/tools/fuelratings/2021%20Fuel%20Consumption%20Guide.pdf

GOC. (2023a). Notice with respect to reporting of greenhouse gases (GHGs) for 2022 and 2023. Canada Gazette. Retrieved from https://canadagazette.gc.ca/rp-pr/p1/2023/2023-01-28/html/sup1-eng.html

GOC. (2023b). *New motor vehicle registrations, first quarter 2023.* Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/230802/dq230802b-eng.htm

GOC. (2024a). Greenhouse gas sources and sinks in Canada: executive summary 2024. Retrieved from https://publications.gc.ca/site/eng/9.816345/publication.html

GOC. (2024b). *Glossary*. Retrieved October 13, 2024, from https://climate.weather.gc.ca/glossary_e.html

GOC. (2024c). *Population projections for Canada (2023 to 2073), Provinces and Territories (2023 to 2048)*. Retrieved from https://publications.gc.ca/site/eng/9.937934/publication.html

GOC. (2024d). *Engineering climate datasets - Intensity-Duration-Frequency (IDF)*. Retrieved September 15, 2024, from https://climate.weather.gc.ca/prods_servs/engineering_e.html

GOC. (2024e). *Historical hydrometric data search*. Retrieved from https://wateroffice.ec.gc.ca/search/historical_e.html

GOC. (2024f). *Canadian climate normals*. Retrieved October 1, 2024, from https://climate.weather.gc.ca/climate_normals/index_e.html

GOC. (2024g). *Real-time hydrometric data graph for Bow River Below Bassano Dam (05BM004) [AB]*. Retrieved from https://wateroffice.ec.gc.ca/search/real_time_e.html

GOC. (2024h). *Drought*. Retrieved October 2024, 12, from https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/impacts-climate-change-forests/drought/17772

Herring, D. (2020). Are there positive benefits from global warming? National Oceanic and Atmospheric Administration. Retrieved from https://www.climate.gov/news-features/climate-qa/are-there-positive-benefits-global-warming

Imbrogno, A. (2024). A short history of Calgary's dams. Calgary Heritage Initiative. Retrieved from https://calgaryheritage.org/wp/a-short-history-of-calgarys-dams/

IPCC. (2013). *Climate Change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intervobernmental Panel on Climate Change.* Cambridge and New York: Cambridge University Press.

IPCC. (2023). *Summary for policymakers.* Geneva, Switzerland. doi:10.59327/IPCC/AR6-9789291691647.001

Li, C., Wang, Y., Yi, Y., Wang, X., Santos, C., & Liu, Q. (2024). A review of reservoir carbon Cycling: Key processes, influencing factors and research methods. *Ecological Indicators, 166*. Retrieved from https://doi.org/10.1016/j.ecolind.2024.112511

NASA. (2024). *How does climate change affect precipitation?* Retrieved from Global Precipitation Measurement: https://gpm.nasa.gov/resources/faq/how-does-climate-change-affect-precipitation

National Institute of Water and Atmospheric Research. (2024). *Climate change scenarios for New Zealand*. Retrieved September 20, 2024, from https://niwa.co.nz/climate-and-weather/climate-change-scenarios-new-zealand

Nkemdirim, L., & Weber, L. (1999). Comparison between the droughts of the 1930s and the 1980s in the southern prairies of Canada. *12*(8), 2434-2450. Retrieved from https://doi.org/10.1175/1520-0442(1999)012<2434:CBTDOT>2.0.CO;2

Pacific Climate Impacts Consortium. (2024). *PCIC Climate Explorer*. (University of Victoria) Retrieved from https://www.pacificclimate.org/analysis-tools/pcic-climate-explorer

Prairie Climate Centre. (2024). *Climate atlas of Canada*. Retrieved September 15, 2024, from https://climateatlas.ca/

Tracey, A. (2020, June 29). *Grasslands: Climate change's unsuspecting heroes .* Retrieved from Nature Conservancy Canada: https://www.natureconservancy.ca/en/blog/archive/grasslands-the-unsuspecting.html

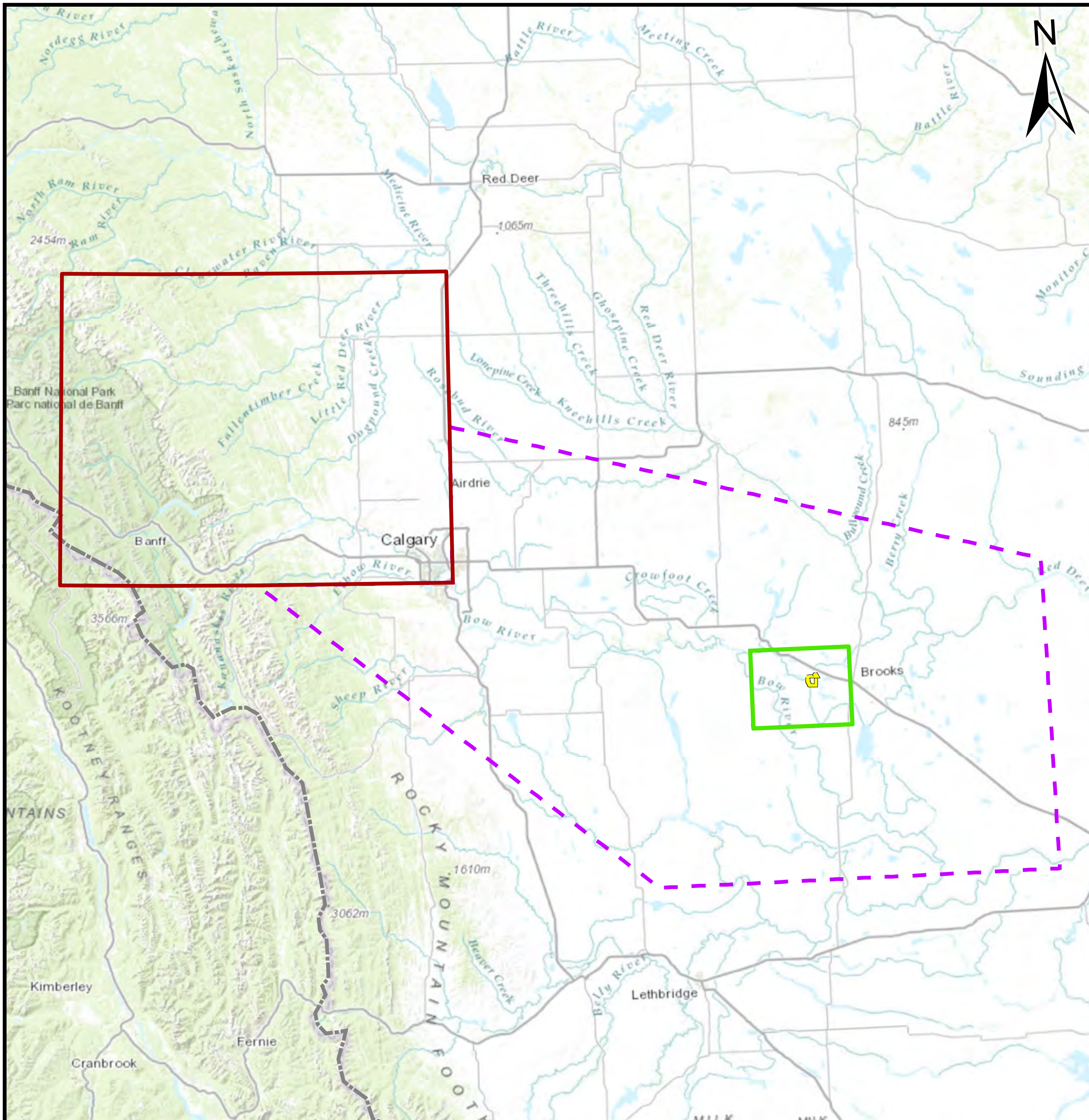
Weatherstats. (2024). *Total Precipitation - Annual data for Brooks*. Retrieved September 25, 2024, from https://brooks.weatherstats.ca/charts/precipitation-yearly.html

Appendix J

Appendices

Figures

Appendix J1: Figures



SCALE: 1:2,000,000

15 0 15 30 Km

Drafted:	JNB	Date:	Mar 19, 2025
Approved:	VL	Revision:	0
Route Source:		Date:	Feb 18, 2025
Sketch		Revision:	0

Data Sources:
ESRI World Topographic Map
ATS Grid: AltaLIS 2007.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the topographic map is from 2010 (NRCAN) and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Snake Lake Reservoir Expansion Project Area
- Bow River Basin Regional Study Area
- Local Climate Study Area
- Approximate Area of Influence

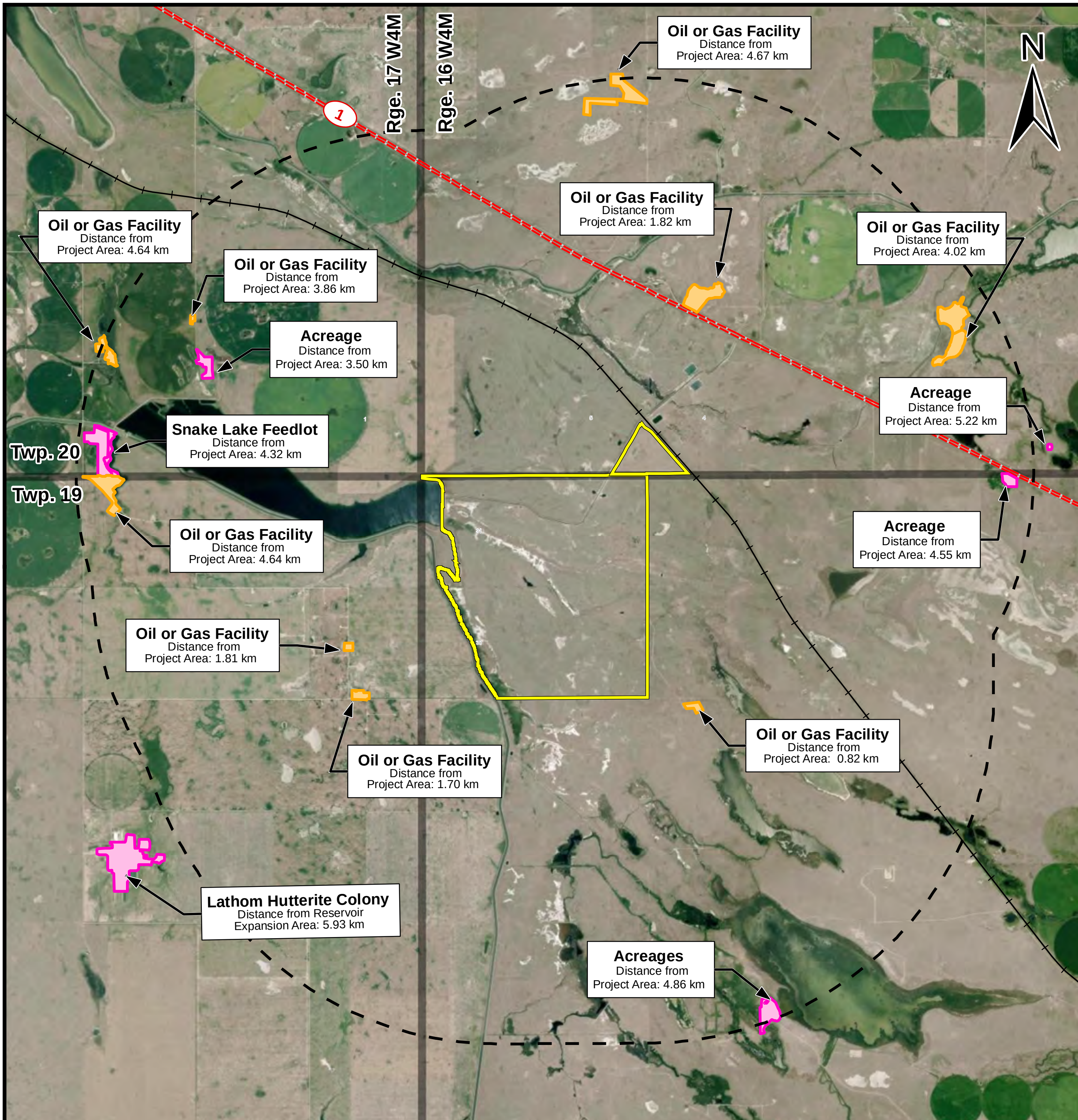
EID

Locations of Climate Data (Modelled and Measured) used to Establish Climate Normals and Influences on Conditions in the Bow River Basin

March 2025

REF.: AARES21-127 (Climate Change)

Figure J1-1



SCALE: 1:80,000

0.5 0 0.5 1 Km

Drafted:	JNB	Date: Mar 19, 2025
Approved:	WB	Revision: 0
Route Source:		Date: Feb 21, 2024
CAD Survey		Revision: 0

Data Sources:
Imagery: ESRI. Date: 07/10/2021.
ATS Grid: AltaLIS 2007.
Noise Contours produced by PMO Global Services.

AAR Environmental Services

Please contact AARES for all other sources.

Please note that the imagery is from 2021 and although we have no reason to doubt the accuracy and completeness of it, users should be aware discrepancies may be present.

Legend

- Snake Lake Reservoir Expansion Project Area
- 5 km Project Area Radius
- Settlement
- Industrial Facility
- Highway
- Railway

EID

Development Within 5 km of the Snake Lake Reservoir Expansion Project Area

March 2025

REF.: AARES21-127 (Climate Change)

Figure J1-2