Figure 1.2-4
WSC Hydrometric Stations Near the Regional Study Area with >5 Year Records

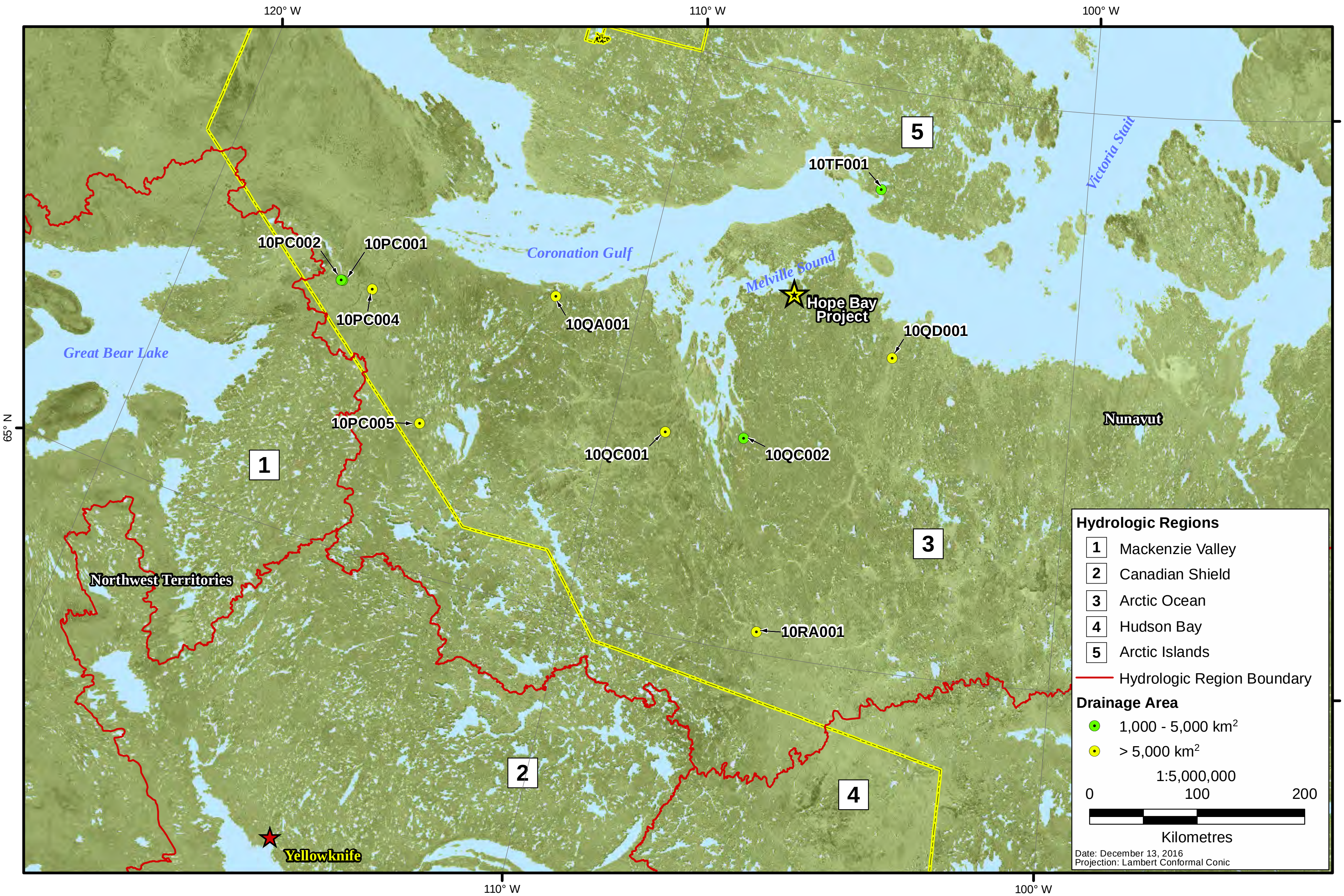


Table 1.2-2. Water Survey of Canada Stations Relevant to the Region

WSC Station ID	Station Name	Latitude	Longitude	Drainage Area (km^2)	Period of Record
10PC001	Kendall River near outlet of Dismal Lakes	67°12'31" N	116°34'20" W	2,790	1969-2008
10PC002	Atitok Creek near Dismal Lakes	67°12'52" N	116°36'32" W	217	1979-1990
10PC004	Coppermine River above Copper Creek	67°13'44" N	115°53'12" W	46,200	1987-present
10PC005	Fairy Lake River near outlet of Napaktulik Lake	66°15'7" N	113°59'7" W	6,442	1993-present
10QA001	Tree River near the mouth	67°38'6" N	111°54'8" W	5,810	1968-present
10QC001	Burnside River near the mouth	66°43'34" N	108°48'47" W	16,800	1976-present
10QC002	Gordon River near the mouth	66°48'36" N	107°06'04" W	1,530	1977-1994
10QD001	Ellice River near the mouth	67°42'30" N	104°8'21" W	16,900	1971-present
10RA001	Back River below Beechey Lake	65°11'14" N	106°05'09" W	19,600	1978-present
10TF001	Freshwater Creek near Cambridge Bay	69°7'52" N	104°59'26" W	1,490	1970-present

1.2.3.1 Hydrometric Data Collection and Analysis

Water Level Monitoring

The hydrometric stations operated during the open-water season, from June to late-September. Hydrometric stations consist of a staff gauge, pressure transducer, and data logger. The staff gauge is a semi-permanent installation that provides a visual indication of water level in the stream or lake. The pressure transducer and datalogger automatically record water level at 10 to 15 minute intervals.

The basic assumption of hydrometric monitoring is that for a given channel cross section, there is a direct relationship between observed water level (stage), and the streamflow (discharge). This relationship is site-specific, and must be developed by collecting manual measurements of discharge over a range of observed stages. An empirical stage-discharge relationship is developed and used to convert the recorded water levels to streamflow and produce an annual hydrograph (record of discharge versus time).

Streamflow Measurement

Manual streamflow measurements were completed at all the hydrometric stations during the open-water season. Where streamflow allowed, velocity measurements were obtained with the area-velocity technique, using either a vane or propeller driven current meter (Swoffer 2100™) or an electromagnetic velocity flow meter (Marsh-McBirney Flo-mate™ or Hach FH950). This technique involves wading across the channel and measuring the depth and velocity (perpendicular to the direction of flow) at regular intervals. Hence, the cross-sectional area of the stream (m^2), with the velocity of the water (m/s), is used to calculate discharge (m^3/s; Herschy 2009).

Where water depth or velocity conditions were too high to allow for safe wading, velocity was determined using a StreamPro™ (Teledyne RD Instruments) Acoustic Doppler Current Profiler (ADCP). An ADCP uses acoustic-Doppler technology to measure both water depths and current velocities as the instrument is ferried across the channel. The results are sent via Bluetooth to a laptop and can be viewed in real-time. Flow velocities were measured at a single section or transect across the channel. Multiple traverses of the section were completed during each site visit to reduce the effects of turbulence, directional bias, or other random errors. The standard for both the United States

Geological Survey (USGS; 2005) and WSC (2004) with a minimum of four transects (two in each direction) were followed.

Stage-discharge Relationship

Rating curves were developed using standards outlined by the USGS (Rantz et al. 1982) and the International Organization for Standardization (ISO 2010). Once developed, the rating curve can to be used to convert water level data recorded by a hydrometric monitoring station into a continuous discharge time-series, otherwise known as a discharge hydrograph. The quality of a rating curve is a function of the number and accuracy of the individual data points (measurements) that are used to generate the curve. To develop a robust rating curve for each hydrometric station, a minimum of 10 manual streamflow measurements, well distributed through the range of flows, should be collected.

It is common to have limited measurements corresponding to high flow conditions, and the rating curve is often extrapolated to a high flow value that is beyond the range of the observed data used to generate the curve. In general, rating curves can be reliably extrapolated to a value equal to 1.5 times the greatest measured discharge. Any discharge extrapolation beyond that limit is not recommended as the resulting value will have greater uncertainty (ISO 2010).

Rating curves were developed using Aquarius™ Time Series Hydrologic Software (Aquatic Informatics Inc.). The software uses standard methods outlined by the USGS and ISO (Kennedy 1984, ISO 2010). Rating curves are typically represented as a power function equation of the form:

$$Q = C \times (h - a)^n$$

Where Q is the discharge [m^3/s], C and n are regression coefficients, h is the stage [m], and a is the stage at zero flow (datum correction) [m]). Normally, channel cross-sectional information at each monitoring site is used to determine the stage at zero flow.

Rating curves can be exceptionally complicated, with changes to curves being common and occurring as a result of many factors. For example, erosion of channel beds and banks can cause a change in the rating curve. Such alterations are called shifts and result in rating curves having a finite temporal period of applicability. Alterations can occur gradually over time such as a progressive degradation of a channel, while others can be instantaneous as in the case of a high flow causing a slump in the bank. Other complications arise when the geometry of a channel is such that the rating curve is not a single curve, but a combination of multiples curves, with applicability at different ranges of stage. The change from one curve to another usually corresponds to a notable change in channel geometry, or in downstream channel controls. These factors, among many others, rarely occur in isolation and are frequently inter-related, thereby complicating rating curve development and sometimes increasing uncertainty.

Monthly and Annual Runoff

The annual hydrograph of daily discharge estimates were used to calculate mean monthly and annual discharge for hydrometric stations. Mean annual discharge values were divided by drainage area to estimate annual runoff (as a depth), which is a measure of the hydrological response of a drainage basin. Because it is normalized by drainage area, annual runoff is a useful index for comparing the hydrologic response of different sized basins.

1.2.3.2 Water Balance Modelling Approach for Baseline Characterization

A water balance for the Hope Bay Project, including the Phase 2 project as well as existing and approved projects, was developed to simulate both baseline and project-affected flows at

13 assessment nodes (Table 1.2-3; Figure 1.2-5) using a long-term precipitation dataset that was generated for the life of project (Appendix V3-2D).

Table 1.2-3. Surface Hydrology Assessment Nodes

Assessment Node	Latitude	Longitude	Drainage Area (km^2)
Wolverine Lake Outflow East*	68° 1' 1"	106° 32' 47"	3.1
Wolverine Lake Outflow North*	68° 1' 49"	106° 33' 48"	3.1
Patch Lake Outflow	68° 2' 51"	106° 31' 35"	30.0
PO Lake Outflow	68° 3' 31"	106° 31' 7"	34.9
Ogama Lake Outflow	68° 6' 11"	106° 33' 1"	74.8
Doris Lake Outflow	68° 8' 40"	106° 35' 10"	89.8
Little Roberts Lake Outflow	68° 10' 23"	106° 34' 52"	197
Windy Lake Outflow	68° 6' 13"	106° 38' 51"	14.1
Glenn Lake Outflow	68° 9' 51"	106° 40' 16"	33.6
Trout Lake Outflow	67° 38' 40"	106° 21' 16"	33.7
Stickleback Lake Outflow	67° 38' 49"	106° 22' 6"	2.7
Aimaokatalok Lake Outflow	67° 41' 25"	106° 26' 40"	1,293
Koignuk River 1	67° 48' 6"	106° 31' 51"	1,472
Koignuk River 2	67° 53' 56"	106° 37' 23"	2,171

** Wolverine Outflow East and North were modelled as one outflow node (Appendix V3-2D).*

The model was calibrated using observed streamflows between 2010 and 2015. The water balance was run using probabilistic simulations, with multiple realizations and variable hydrology. This approach allowed for simulating baseline and project-affected flows under average hydrological conditions, as well as the 1-in-20-year dry and wet conditions (Appendix V3-2D).

Climate change was accounted for in the water balance model with predicted increases to temperature and precipitation. The values incorporated into the model were based on the results of the climate change analysis (Appendix V3-2A) and interpolated between years within the model (Table 1.2-4).

Table 1.2-4. Climate Change Trends, Compared to 1979-2005 Conditions

	Doris and Madrid Watersheds		Boston Watersheds	
Year	Temperature Increase[1]	Precipitation Increase	Temperature Increase[1]	Precipitation Increase
2020	1.0%	6.4%	0.8%	6.4%
2050	1.8%	13.0%	1.4%	13.0%
2080	2.6%	19.0%	2.1%	18.0%

[1] *Temperature increases are applied in Kelvin*

Figure 1.2-5
Surface Hydrology Assessment Nodes

1.2.4 Characterization of Baseline Conditions

1.2.4.1 Hydrological Processes

The hydrologic regime of the Project is typical of high latitude regions of the continental Canadian Arctic and is strongly influenced by long cold winters, relatively low precipitation, and low relief topography generally with high watershed storage (i.e., lakes and wetlands). Extremely cold temperatures in the region, combined with permafrost, result in a short period of runoff that typically occurs from June to October. Compared to non-permafrost regions, permafrost watersheds tend to have higher peak flow and lower base flow (Kane 1997).

The physiography of the region is dominated by vegetated tundra hillslopes with lakes and scattered wetlands. The presence of permafrost is hydrologically significant, as it has very low hydraulic conductivity, and thus acts as a barrier to deep groundwater recharge. This physical restriction tends to increase surface water runoff and decrease sub-surface flows.

A number of factors influence the volume of freshet runoff and temporal and spatial variation of annual flows in Arctic watersheds:

- *Amount of snowpack in spring*. Snowpack depth is dependent on the amount of snowfall during the previous winter and the amount of snow remaining in each watershed prior to freshet. Snow can be lost or redistributed due to sublimation, melting, or wind.
- *Air temperature*. Above freezing air temperatures combined with a rapid air temperature increase can produce a high melt rate and streamflow. Different melt rates occur on north and south facing slopes, which may affect the timing of melt and size of the contributing area. Warm air temperatures can increase evapotranspiration and sublimation, reducing surface water availability.
- *Timing for opening of stream channels at lake outlets*. Snowmelt from hillslopes surrounding lakes can occur before the stream channels draining the lakes become ice free. In this case, meltwater can be stored in the lake and then released once the channels are open to flow.
- *Soil moisture conditions and lake levels at the end of the previous summer*. A dry summer in the previous year can lead to a significant soil moisture deficit and lower lake levels. As a result, a portion of the annual runoff will recharge the lakes and soil moisture before surface waters are transmitted as streamflow from a drainage area.
- Other watershed-specific physiographic controls include watershed size, slope, substrate type, and vegetation.

Arctic hydrographs are characterized by a steep rising limb leading to a peak flow discharge that occurs during the spring, shortly after air temperature rises above freezing (Figure 1.2-6). During freshet, water that is stored in the winter snowpack melts and is released quickly, generating high flows that are typically the annual peak. In small basins, high flows can last as little as a few days. Peak flow typically occurs immediately after ice break-up in lakes and channel reaches, especially in smaller basins. Due to the presence of permafrost, small streams do not receive groundwater contributions, and flow discharges from these basins may cease after freshet until late summer rains (Figure 1.2-6). For rivers draining larger watersheds, the freshet peak may be delayed relative to smaller drainages as snowmelt from upper portions of the watershed is routed through the drainage network. Precipitation events in the late summer and early fall may lead to a second hydrograph peak, but this peak is generally lower magnitude than the freshet peak (Figure 1.2-6). This secondary rain-driven peak is not visible when daily flow hydrographs are averaged into monthly runoff values (Figure 1.2-7).

Figure 1.2-6

A Typical Example of Discharge and Runoff in an Arctic Nival River (Atitok Creek near Dismal Lake, 1988), with Air Temperature and Precipitation

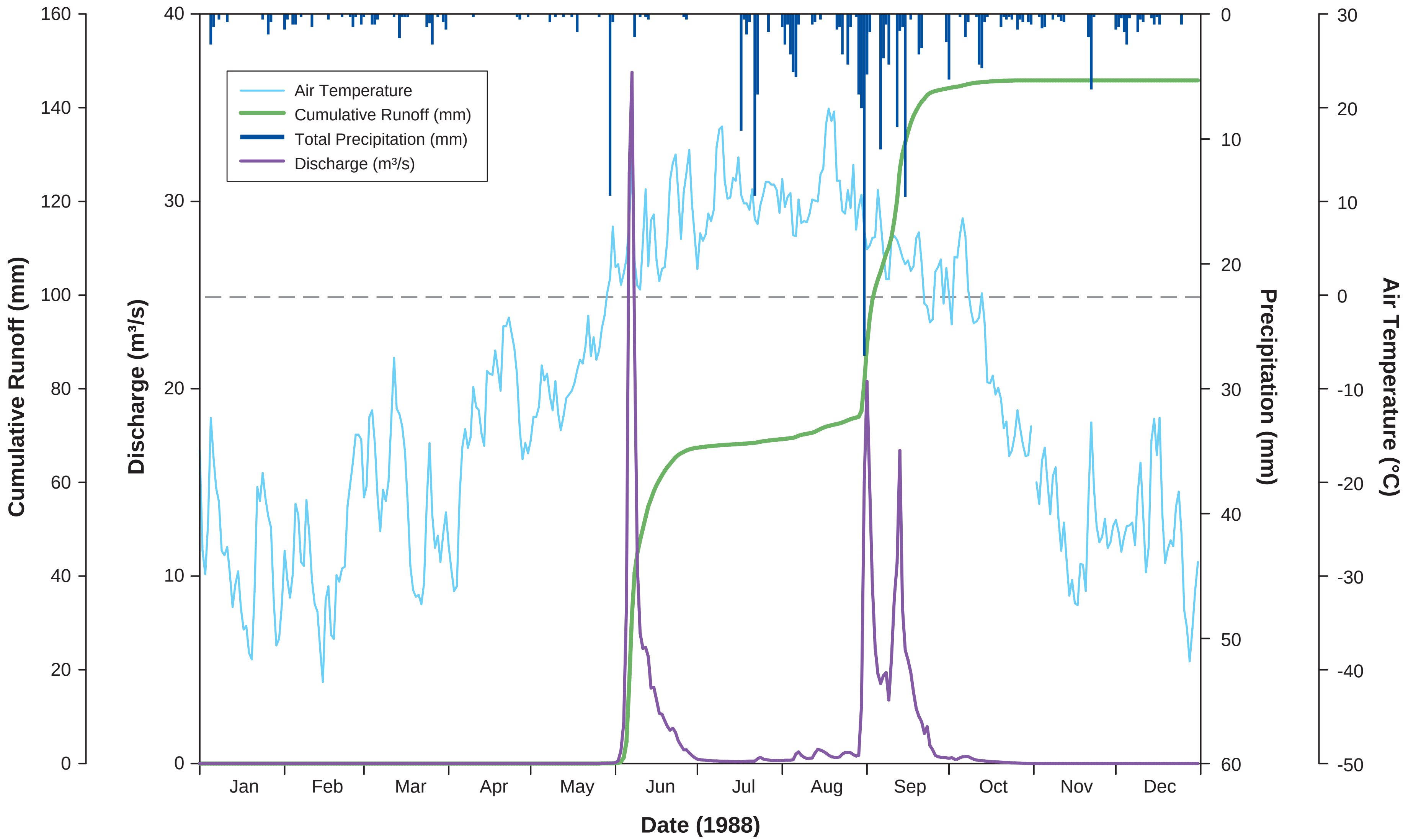
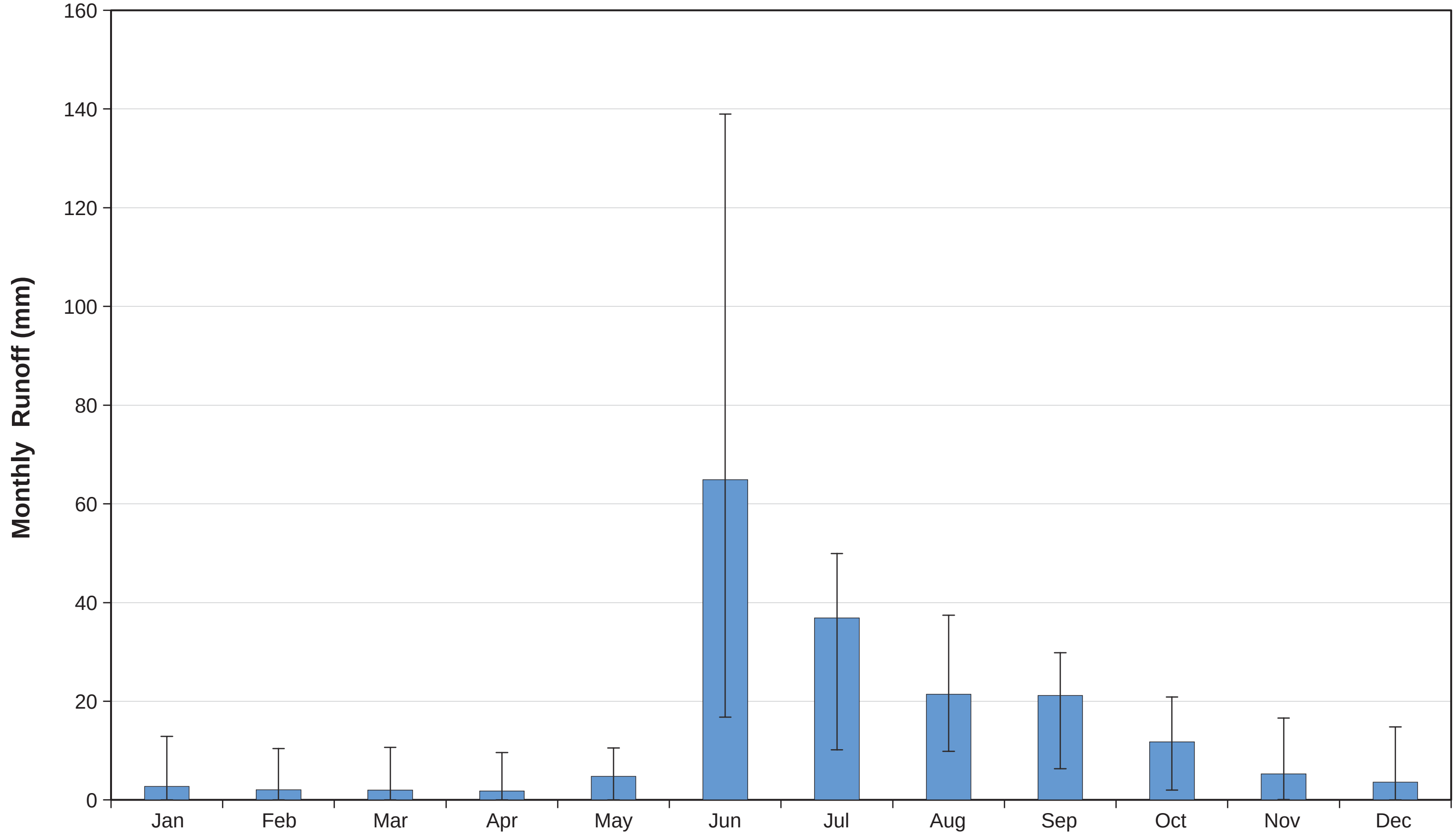


Figure 1.2-7

Historical Monthly Runoff at Regional Water Survey of Canada Stations - Average Monthly Runoff during Period of Record



Notes: Bars represent the average value of 10 regional stations.
Whiskers show the variation of average monthly runoff among 10 regional stations.

After snowmelt-generated runoff ends in summer and fall, the remaining runoff is controlled by rainfall, evaporation, and release of stored water in lakes and the active layer of soil. Smaller basins with minimal lake area tend to exhibit a more rapid response to precipitation than larger basins. Open-water evaporation rates in the summer often exceed total rainfall, causing soil moisture deficits in the shallow active layer of the soil. In October, air temperature normally dips below freezing, precipitation begins to fall as snow, and streamflow ceases for the winter except in rivers with very large watersheds.

1.2.4.2 Baseline Data Collection Results

Streamflow data collected from hydrometric stations (Section 1.2.2.1) were analyzed based on the methods described in Section 1.2.3. Annual runoff estimates for hydrometric monitoring stations and annual fluctuation of lake levels are summarized in Tables 1.2-5 and 1.2-6, respectively. Details, including analyses and further hydrologic indices are available in Appendices V5-1A to V5-1K. These results were used in Appendix V3-2D to generate long-term estimates for monthly baseline flow estimates at different assessment nodes within the Project area. These estimates are presented in the following section.

1.2.4.3 Baseline Streamflow Estimates

Long-term baseline monthly streamflow estimates for the average, 1-in-20-year wet, and 1-in-20-year dry runoff conditions at 13 modelling nodes, based on the methodology described in Section 1.2.3.2 (Appendix V3-2D), are summarized in Table 1.2-7. These baseline streamflow estimates represent natural flows under existing climate conditions.

Baseline flow projections (i.e., future natural flows if no project were developed in the region), incorporating the climate change trends (described in Section 1.2.4.6; Appendix V3-2A), are provided in Appendix V5-1M. These baseline streamflow estimates are used for effects assessment in this section.

In addition, long-term average baseline monthly lake elevation and volume estimates for five lakes, are summarized in Appendices V5-1N and V5-1O. These baseline lake elevation and volume estimates are used in the fish habitat effects assessment (Volume 5, Section 6).

1.3 VALUED COMPONENTS

1.3.1 Potential Valued Components and Scoping

VECs are those components of the biophysical environment considered to be of scientific, ecological, economic, social, cultural, or heritage importance (Volume 2, Section 4). The selection and scoping of VECs considers biophysical conditions and trends that may interact with the proposed Project, variability in biophysical conditions over time, and data availability as well as the ability to measure biophysical conditions that may interact with the Project and are important to the communities potentially impacted by the Project. For an interaction to occur there must be spatial and temporal overlap between a VEC and Project component and/or activities. The selection and scoping of VECs also considers their importance to the communities potentially impacted by the Project.

Table 1.2-5. Annual Runoff Estimates for Hydrometric Monitoring Stations (2004 to 2015)

Hydrometric Station	Drainage Area (km^2)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Roberts Hydro	98	61	100	72	72	170	98	146	162	99	61	138	168
Little Roberts Hydro	199	64	90	68	83	158	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Doris Hydro and TL-2	95	62	83	73	80	153	99	129	191	107	41	113	187
Doris TL-3	95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	190	109	47	120	190
Ogama Hydro	75	n/a	n/a	78	97	136	99	129	160	n/a	n/a	n/a	n/a
Patch Hydro	32	n/a	n/a	40	n/a	150	95	98	175	n/a	n/a	n/a	n/a
PO Hydro	68	n/a	n/a	n/a	n/a	n/a	125	120	213	n/a	n/a	n/a	n/a
Tail Hydro	4.4	42	84	53	82	152	109	168	n/a	n/a	n/a	n/a	n/a
Windy Hydro	14	n/a	n/a	n/a	n/a	n/a	168	222	n/a	118	43	98	n/a
Glenn Hydro	32	n/a	n/a	63	n/a	132	130	n/a	n/a	n/a	n/a	n/a	n/a
Koignuk Hydro	2,937	n/a	n/a	n/a	n/a	n/a	137	140	191	n/a	n/a	n/a	n/a
Aimo Out Hydro	1,224	n/a	n/a	n/a	n/a	n/a	n/a	144	206	n/a	n/a	n/a	n/a
Aimo In Hydro	725	n/a	n/a	n/a	n/a	n/a	n/a	n/a	134	n/a	n/a	n/a	n/a
East Aimo Hydro	363	n/a	n/a	n/a	n/a	n/a	n/a	147	172	n/a	n/a	n/a	n/a
East Tailings Hydro	8	n/a	n/a	n/a	n/a	n/a	n/a	46	113	n/a	n/a	n/a	n/a
Trout Hydro	27	n/a	n/a	n/a	n/a	n/a	n/a	n/a	147	n/a	n/a	n/a	n/a
Stickleback Outflow	2.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	197	n/a	n/a	n/a	n/a

Notes:
Lake level fluctuation values were not provided in the baseline reports prior to 2004.
n/a = Either data were not collected or total runoff value for the year was not provided in the baseline report.

Table 1.2-6. Recorded Ranges of Seasonal Lake Levels for Lake Monitoring Stations (2004 to 2015)

Lake Monitoring Station	Water Level Fluctuation (m)											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Wolverine Lake	n/a	n/a	0.16	n/a	0.06	0.25	0.24	0.26	n/a	n/a	n/a	n/a
Monitoring Period	n/a	n/a	Jun 1 - Sep 7	n/a	Jun 18 - Sep 9	Jun 20 - Jul 26	Jun 13 - Sep 28	Jun 21 - Sep 21	n/a	n/a	n/a	n/a
Patch Lake	n/a	n/a	0.20	0.10	0.23	0.18	0.30	0.44	n/a	n/a	n/a	n/a

Lake Monitoring Station	Water Level Fluctuation (m)											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Monitoring Period	n/a	n/a	Jun 1 - Sep 9	Jun 25 - Sep 12	Jun 23 - Sep 9	Jun 19 - Sep 22	Jun 14 - Sep 29	Jun 22 - Sep 22	n/a	n/a	n/a	n/a
PO Lake	n/a	n/a	n/a	0.34	0.58	0.22	0.34	0.64	n/a	n/a	n/a	n/a
Monitoring Period	n/a	n/a	n/a	Jun 18 - Sep 14	Jun 23 - Sep 9	Jun 18 - Sep 21	Jun 14 - Sep 29	Jun 8 - Sep 22	n/a	n/a	n/a	n/a
Ogama Lake	n/a	n/a	0.46	0.23	0.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Monitoring Period	n/a	n/a	Jun 31 - Sep 8	Jun 19 - Sep 14	Jul 2 - Sep 9	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Doris Lake	0.40	0.58	0.59	0.29	0.66	0.35	0.68	0.74	0.63	0.35	0.68	0.42
Monitoring Period	Jun 12 - Sep 10	Jun 8 - Dec 31	Jan 1 - Dec 31	Jan 1 - Dec 31	Jan 1 - Sep 12	May 27 - Sep 21	May 30 - Oct 4	Jan 1 - Sep 29	Jan 1 - Sep 7	May 22 - Sep 10	Jan 1 - Sep 21	Jul 15 - Sep19
Tailings Impoundment Area (Tail Lake)	0.17	0.19	0.25	0.23	0.20	0.14	0.17	0.63	0.50	0.34	0.41	0.36
Monitoring Period	Jun 13 - Dec 31	Jan 1 - Dec 31	Jan 1 - Dec 31	Jan 1 - Dec 31	Jan 1 - Sep 12	Jan 1 - Sep 21	Jun 2 - Oct 4	May 12 - Sep 29	Jan 1 - Sep 12	May 22 - Sep 9	Mar 16 - Sep 18	Jul 15 - Sep 19
Little Roberts Lake	0.44	0.59	0.49	0.55	0.63	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Monitoring Period	Jun 6 - Sep 7	Jun 7 - Sep 29	Jun 30 - Sep 8	Jun 13 - Sep 14	Jun 19 - Sep 12	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Roberts Lake	0.36	0.26	0.58	0.52	0.36	0.20	0.40	0.56	n/a	n/a	n/a	n/a
Monitoring Period	Jun 18 - Sep 13	Jun 29 - Sep 17	Jun 3 - Sep 6	Jun 15 - Sep 14	Jun 22 - Sep 12	Jun 17 - Sep 20	Jun 14 - Oct 2	Jun 21 - Sep 25	n/a	n/a	n/a	n/a
Windy Lake	n/a	n/a	n/a	0.24	0.06	0.23	0.10	0.24	0.18	0.10	0.13	0.21
Monitoring Period	n/a	n/a	n/a	Jun 21 - Aug 4	Jul 2 -Sep 9	Jun 16 - Sep 23	Jun 10 - Sep 24	Jun 21 - Sep 22	Jun 7 - Sep 13	Jun 5 - Sep 8	Jun 5 - Sep 8	Jun 12 - Sep 19
Glenn Lake	n/a	n/a	0.19	0.22	0.18	0.26	n/a	n/a	n/a	n/a	n/a	n/a
Monitoring Period	n/a	n/a	Jun 1 - Sep 11	May 24 - Jul 3	Jun 23 - Sep 9	Jun 17 - Sep 19	n/a	n/a	n/a	n/a	n/a	n/a
Aimaokatalok Lake	n/a	n/a	n/a	1.99	3.04	2.23	2.13	n/a	n/a	n/a	n/a	n/a
Monitoring Period	n/a	n/a	n/a	n/a	n/a	n/a	Jun 1 - Sep 26	n/a	n/a	n/a	n/a	n/a

Notes:
Lake level fluctuation values were not provided in the baseline reports prior to 2004.
n/a = Either data were not collected or total runoff value for the year was not provided in the baseline report.

Table 1.2-7. Baseline Monthly Streamflow Estimates under the Average, 1-in-20-Year Wet, and 1-in-20-Year Dry Conditions

Assessment Node	Drainage Area (km^2)	Climate Condition	Monthly Flow (m^3/s)												Annual Flow (m^3/s)	Annual Runoff (mm)
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Wolverine Lake Outflow	**3.1**	Average	0	0	0	0	0	0.072	0.002	0	0	0	0	0	**0.006**	**62**
		Dry[1]	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
		Wet[2]	0	0	0	0	0.080	0.095	0.008	0.003	0.011	0.014	0.001	0	**0.018**	**181**
Patch Lake Outflow	**30.0**	Average	0	0	0	0	0.121	0.332	0.154	0.088	0	0	0	0	**0.058**	61
		Dry[1]	0	0	0	0	0.101	0.196	0.085	0.060	0	0	0	0	**0.037**	39
		Wet[2]	0	0	0	0.003	0.763	0.486	0.223	0.156	0	0	0	0	**0.137**	144
PO Lake Outflow	**34.9**	Average	0	0	0	0	0.110	0.415	0.130	0.180	0	0	0	0	**0.070**	63
		Dry[1]	0	0	0	0	0.102	0.165	0.063	0.057	0	0	0	0	**0.032**	29
		Wet[2]	0	0	0	0.014	0.843	0.473	0.303	0.256	0.111	0	0	0	**0.168**	152
Ogama Lake Outflow	**74.8**	Average	0	0	0	0	0.089	1.101	0.085	0.771	0.003	0	0	0	**0.171**	72
		Dry[1]	0	0	0	0	0.082	0.108	0.018	0.052	0	0	0	0	**0.022**	9
		Wet[2]	0	0	0	0.100	3.623	0.696	1.036	1.101	0.930	0	0	0	**0.631**	266
Doris Lake Outflow	**89.8**	Average	0	0	0	0	0.053	1.520	0.546	0.225	0.252	0.111	0.014	0	**0.226**	79
		Dry[1]	0	0	0	0	0.016	0.699	0.255	0.063	0.109	0.059	0.013	0	**0.101**	35
		Wet[2]	0	0	0	0	1.570	1.944	0.742	0.627	0.557	0.471	0.211	0	**0.513**	180
Little Roberts Lake Outflow	**197**	Average	0	0	0	0	0.350	5.216	1.463	0.734	0.830	0.246	0.028	0	**0.736**	118
		Dry[1]	0	0	0	0	0.059	1.525	0.640	0.441	0.357	0.138	0.026	0	**0.265**	42
		Wet[2]	0	0	0	0.056	6.246	6.493	2.143	1.899	1.677	1.763	0.459	0	**1.737**	278
Doris LSA Outflow	**198**	Average	0	0	0	0	0.352	5.235	1.466	0.737	0.833	0.246	0.028	0	**0.739**	118
		Dry[1]	0	0	0	0	0.059	1.527	0.640	0.443	0.358	0.138	0.026	0	**0.266**	42
		Wet[2]	0	0	0	0.056	6.276	6.512	2.151	1.906	1.681	1.770	0.459	0	**1.744**	278
Windy Lake Outflow	**14.1**	Average	0	0	0	0	0	0.169	0.094	0.026	0.018	0	0	0	**0.025**	57
		Dry[1]	0	0	0	0	0	0.088	0.040	0.007	0.004	0	0	0	**0.011**	26
		Wet[2]	0	0	0	0	0	0.323	0.133	0.063	0.055	0	0	0	**0.048**	107
Glenn Lake Outflow	**33.6**	Average	0	0	0	0	0.053	0.625	0.095	0.038	0.071	0.005	0	0	**0.073**	69
		Dry[1]	0	0	0	0	0.004	0.177	0.011	0	0	0.004	0	0	**0.016**	15
		Wet[2]	0	0	0	0.011	0.598	0.822	0.217	0.173	0.173	0.165	0.007	0	**0.181**	170

Assessment Node	Drainage Area (km²)	Climate Condition	Monthly Flow (m³/s)												Annual Flow (m³/s)	Annual Runoff (mm)
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Madrid LSA Outflow	**37.5**	Average	0	0	0	0	0.062	0.707	0.109	0.048	0.083	0.006	0	0	**0.084**	71
		Dry[1]	0	0	0	0	0.005	0.186	0.014	0.009	0.012	0.005	0	0	**0.019**	16
		Wet[2]	0	0	0	0.014	0.709	0.909	0.249	0.212	0.188	0.196	0.008	0	**0.208**	175
Trout Lake Outflow	**33.7**	Average	0	0	0	0	0.081	0.725	0.109	0.082	0.108	0.008	0	0	**0.092**	86
		Dry[1]	0	0	0	0	0.007	0.040	0.017	0.040	0.039	0.007	0	0	**0.013**	12
		Wet[2]	0	0	0	0.019	0.974	0.845	0.269	0.249	0.176	0.266	0.011	0	**0.236**	221
Stickleback Lake Outflow	**2.7**	Average	0	0	0	0	0	0.058	0.001	0	0	0	0	0	**0.005**	57
		Dry[1]	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0
		Wet[2]	0	0	0	0.000	0.065	0.084	0.006	0	0.007	0.010	0.001	0	**0.014**	169
Aimaokatalok Lake Outflow	**1,293**	Average	0	0	0	0	3.10	27.87	4.01	3.02	4.16	0.30	0	0	**3.52**	86
		Dry[1]	0	0	0	0	0.27	1.50	0.57	1.48	1.44	0.27	0	0	**0.46**	11
		Wet[2]	0	0	0	0.71	37.37	32.53	10.20	9.51	6.78	10.20	0.44	0	**9.04**	220
Koignuk River 1	**1,472**	Average	0	0	0	0	3.52	31.67	4.66	3.52	4.72	0.34	0	0	**4.01**	86
		Dry[1]	0	0	0	0	0.31	1.73	0.74	1.73	1.67	0.31	0	0	**0.54**	12
		Wet[2]	0	0	0	0.81	42.52	36.95	11.68	10.85	7.70	11.60	0.50	0	**10.29**	220
Koignuk River 2	**2,171**	Average	0	0	0	0	5.15	46.49	7.21	5.47	6.94	0.51	0	0	**5.95**	86
		Dry[1]	0	0	0	0	0.46	2.64	1.41	2.71	2.52	0.46	0	0	**0.85**	12
		Wet[2]	0	0	0	1.19	62.54	54.20	17.45	16.11	11.32	17.05	0.73	0	**15.15**	220
Boston LSA Outflow	**2,918**	Average	0	0	0	0	6.90	62.35	9.93	7.56	9.30	0.68	0	0	**8.02**	87
		Dry[1]	0	0	0	0	0.61	3.61	2.12	3.76	3.41	0.62	0	0	**1.18**	13
		Wet[2]	0	0	0	1.59	83.89	72.65	23.61	21.72	15.18	22.88	0.98	0	**20.35**	220

[1] *1-in-20-Year Dry Condition*
[2] *1-in-20-Year Wet Condition*

1.3.1.1 The Scoping Process and Identification of VECs

The scoping of *VECs* follows the process outlined in the Assessment Methodology (Volume 2, Section 4). VECs proposed in the EIS guidelines (NIRB 2012a) were further informed through consultation with communities, regulatory agencies, available TK, and professional expertise. The EIS guidelines (NIRB 2012a) propose that surface hydrology be considered for inclusion in the effects assessment. The selection of surface hydrology as a VEC was also informed by:

- review of recently completed Nunavut EAs (e.g., Back River, Mary River);
- consultation and engagement with local and regional Inuit groups (e.g., the KIA); and
- public consultation and open house meetings held in the Kitikmeot communities in May 2016 (see Volume 2, Section 3, Public Consultation and Engagement).

1.3.1.2 NIRB Scoping Sessions

Scoping sessions hosted by NIRB (2012b) with key stakeholders and local community members (i.e., the public) focused on identifying the components that are important to local residents, as related to the Project. Comments made during these sessions were compiled and analysed as part of *VEC* scoping. No remarks were made about surface hydrology.

1.3.1.3 TMAC Consultation and Engagement Informing VEC Selection

Community meetings for the Phase 2 Project were conducted in each of the five Kitikmeot communities as described in Section 3 of Volume 2. The meetings are a central component of engagement with the public and an opportunity to share information and seek public feedback. Overall, the community meetings were well attended. Public feedback (questions, comments, and concerns) about the proposed Project was obtained through open dialogue during Project presentations, through discussions that arose during the presentation of Project materials and comments provided in feedback forms. No specific feedback was provided about surface hydrology.

1.3.2 Valued Components Included in the Assessment

The scoping analysis identified the surface hydrology VEC for inclusion in the assessment (Table 1.3-1). The surface hydrology VEC was selected as a component of the assessment of the potential effects of the Project on freshwater environment because of the following:

- the potential to interact with the activities and components of the Project;
- importance identified in the TK report;
- identification as a potential VEC by government regulators and the NIRB;
- inclusion in recently completed Nunavut EISs (e.g., Back River, Mary River); and
- professional judgement.

Table 1.3-1. Valued Ecosystem Components Included in the Surface Hydrology Assessment

Species or Group	Identified by: TK	Identified by: NIRB Guidelines	Identified by: Government	Rationale for Inclusion
Surface Hydrology	x	x	x	Key component of the biophysical environment Essential to the integrity of fish and aquatic habitat

1.4 SPATIAL AND TEMPORAL BOUNDARIES

The spatial boundaries selected to shape this assessment are determined by the Project's potential impacts on the freshwater environment. Spatial and temporal boundaries were defined as the maximum limits within which the effects assessment was conducted. The boundaries were determined by the criteria specified in the EIS guidelines (NIRB 2012a), and described in the Effects Assessment Methodology (Volume 2, Section 4).

Temporal boundaries are selected that consider the different phases of the Project and their durations. The Project's temporal boundaries reflect those periods during which planned activities will occur and have potential to affect the freshwater environment.

The determination of spatial and temporal boundaries also takes into account the development of the entire Hope Bay Greenstone Belt. The assessment considers both the incremental potential effects of the Phase 2 Project as well as the total potential effects of the additional Phase 2 Project activities in combination with the existing and approved projects including the Doris Project and advanced exploration activities at Madrid and Boston.

1.4.1 Project Overview

Through a staged approach, the Hope Bay Project is scheduled to achieve mine operations in the Hope Bay Greenstone Belt through mining at Doris, a bulk sample followed by commercial mining at Madrid North and South, and mining of the Boston deposit. To structure the assessment, the Hope Bay Project is broadly divided into: 1) the Approved Projects (Doris and exploration), and 2) the Phase 2 Project (this application).

1.4.1.1 The Approved Projects

The Approved Projects include:

1. the Doris Project (NIRB Project Certificate 003, NWB Type A Water Licence 2AM-DOH1323);
2. the Hope Bay Regional Exploration Project (NWB Type B Water Licence 2BE-HOP1222);
3. the Boston Advanced Exploration Project (NWB Type B Water Licence 2BB-BOS1217); and
4. the Madrid Advanced Exploration Project (NWB Type B Water Licence under Review).

<u>The Doris Project</u>

Following acquisition of the Hope Bay Project by TMAC in March of 2013, planning and permitting, advanced exploration and construction activities have focused on bringing Doris into gold production in early 2017. In 2016, the Nunavut Impact Review Board and Nunavut Water Board (NWB) granted an amendment to the Doris Project Certificate and Doris Type A Water Licence respectively, to expand mine operations to six years and mine the full Doris deposit. Mining and milling rates were increased to a nominal 1,000 tpd to 2,000 tpd.

The Doris Project includes the following:

- the Roberts Bay offloading facility: marine jetty, barge landing area, beach and pad laydown areas, fuel tank farm/transfer station, and quarries;
- the Doris Site: 280 person camp, laydown area, service complex (e.g., workshop, wash bay), quarries, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerators, explosives storage, and diesel power plant;
- Doris Mine works and processing: underground portal, temporary waste rock pile, ore stockpile, and processing plant;
- water use for domestic, drilling and industrial uses, and groundwater inflows to underground development;
- Tailings Impoundment Area (TIA): Schedule 2 designation of Tail Lake with two dams (North and South dams), roads, pump house, and quarry;
- all-weather roads and airstrip, winter airstrip, and helicopter pads; and
- water discharge from the TIA will be directed to the outfall in Roberts Bay.

Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been ongoing since the 1990s. Much of the previous work for the program was based out of the Windy Lake (closed in 2008) and Boston sites (put into care and maintenance in 2011). All exploration activities are currently based from the Doris Site with plans for some future exploration at the Boston Site. Components and activities for the Hope Bay Regional Exploration Project include:

- staging of drilling activities out of Doris or Boston sites; and
- operation of exploration drills in the Hope Bay Belt area, which are supported by helicopter.

Boston Advanced Exploration

The Boston Advanced Exploration Project, which operates under a Type B Water Licence, includes:

- the Boston exploration camp, sewage and greywater treatment plant, fuel storage and transfer station, landfarm, and a heli-pad;
- mine works consisting of underground development for exploration drilling and bulk sampling, temporary waste rock pile, and ore stockpile;
- potable water and industrial water taken from Aimaokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

Since the construction of Boston will require the reconfiguration of the entire site, construction and operation of all aspects of the Boston Site will be considered as part of the Phase 2 Project for the purposes of the assessment.

Madrid Advanced Exploration

In 2014, TMAC applied for an advanced exploration permit to conduct a bulk sample at the Madrid North and Madrid South sites, which are approximately 4 km south of the Doris Site. The program includes extraction of a 50,000 tonne bulk sample, which will be trucked to the mill at the Doris Site for processing and placement of tailings in the TIA. All personnel will be housed at the Doris Site.

The Water Licence application is currently before the NWB. Madrid advanced exploration includes constructing and operating of the following at each of the sites:

- Madrid North and Madrid South: workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station, contact water pond, and quarry;
- Madrid North and Madrid South mine works: underground portal and works, waste rock pad, ore stockpile, compressor building, brine mixing facility, saline storage tank, air heating facility, and vent raises; and
- a road from the Doris Site to Madrid with branches to Madrid North, Madrid North vent raise, and the Madrid South portal.

1.4.1.2 The Phase 2 Project

The Phase 2 Project includes the construction and operation of commercial mining at the Madrid (North and South) and Boston sites, the continued operation of Roberts Bay and the Doris Site to support mining at Madrid and Boston, and the Reclamation and Closure and Post-Closure phases of all sites. Excluded from the Phase 2 Project, for the purposes of the assessment, are the reclamation and closure and post-closure of unaltered components of the Doris Project as currently permitted and approved.

<u>Construction</u>

Phase 2 construction will use the infrastructure associated with Approved Projects.

Additional infrastructure to be constructed for the proposed Phase 2 Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of West Dam, and development of a west road to facilitate access);
- construction of an off-loading cargo dock at Roberts Bay (including a fuel pipeline, expansion of the fuel tank farm and laydown area);
- construction of infrastructure at Madrid North and Madrid South to accommodate mining;
- complete development of the Madrid North and Madrid South mine workings;
- construction of a process plant, fuel storage, power plant, and laydown at Madrid North;
- all weather access road (AWR) and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston with associated quarries;
- all infrastructure necessary to support mining activities at Boston including construction of a new 200-person camp at Boston and associated support facilities, additional fuel storage, laydown area, ore pad, waste rock pad, process plant, airstrip, diesel power plant, and dry-stack tailings management area (TMA) at Boston; and
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston.

<u>Operation</u>

Phase 2 Project represents the staged development of the Hope Bay Belt beyond the Doris Project (Phase 1). Phase 2 operations includes:

- mining of the Madrid North, Madrid South, and Boston deposits;

- transportation of ore from Madrid North, Madrid South and Boston to Doris for processing, and transportation of concentrate from process plants at Madrid North and Boston to Doris for final gold refining once the process plants at Madrid North and Boston are constructed;
- use of Roberts Bay and Doris facilities, including processing at Doris and maintaining and operating the Robert's Bay outfall for discharge of water from the TIA;
- operation of a process plant at Madrid North to concentrate ore, and disposal of tailings at the Doris TIA;
- operation of a process plant at Boston to concentrate ore, and disposal of tailings to the Boston TMA; and
- ongoing use and maintenance of transportation infrastructure (cargo dock, jetty, roads, and quarries).

Reclamation and Closure

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Section 5.5):

- Camps and associated infrastructure, laydown areas and quarries, buildings and physical structures will be decommissioned. All foundations will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Using non-hazardous landfill, facilities will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered rock. Once the water quality in the reclaim pond has reached the required discharge criteria, the North Dam will be breached and the flow returned to Doris Creek.
- The Madrid to Boston All-Weather Road and Boston Airstrip will remain in place after Reclamation and Closure. Peripheral equipment will be removed. Where rock drains, culverts, or bridges have been installed, the roadway or airstrip will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure that natural drainage can pass without the need for long-term maintenance.
- A low-permeability cover, including a geomembrane, will be placed over the Boston TMA. The contact water containment berms will be breached. The balance of the berms will be left in place to prevent localised permafrost degradation.

1.4.2 Spatial Boundaries

1.4.2.1 Project Development Area

The Project Development Area (PDA) is shown in Figure 1.4-1 and is defined as the area which has the potential for infrastructure to be developed as part of the Phase 2 Project. The PDA includes engineering buffers around the footprints of structures. These buffers allow for refinement in the final placement of a structure through detailed design and necessary in-field modifications during construction phase. Areas with buildings and other infrastructure in close proximity are defined as pads with buffers whereas roads are defined as linear corridors with buffers. The buffers for pads varied depending on the local physiography and other buffered features such as sensitive environments or riparian areas. The average engineering buffer for roads is 100 m on either side.

Since the infrastructure for the Doris Project is in place, the PDA exactly follows the footprints of these features. In all cases, the PDA does not include the Phase 2 Project design buffers applied to potentially environmentally sensitive features. These are detailed in Volume 3, Section 2 (Project Design Considerations).

1.4.2.2 Local Study Area

The Local Study Area (LSA) is shown in Figure 1.4-1 and is defined as the PDA and the area surrounding the PDA within which there is a reasonable potential for immediate effects on the freshwater environment due to an interaction with a Project component(s) or physical activity. The LSA includes the watersheds for key waterbodies that have a potential for interaction with the Project. The same LSA was used for the freshwater water quality and fish and fish habitat VECs.

1.4.2.3 Regional Study Area

The Regional Study Area (RSA) is shown in Figure 1.4-1 and is defined as the broader spatial area representing the maximum limit where potential direct or indirect effects may occur. The RSA includes the PDA, the LSA, and additional areas within which there is the potential for indirect or cumulative effects. The RSA for the surface hydrology VEC includes portions of the Angimajuq watershed and sections of the Koignuk River watershed located to the west of the PDA and is the same used for the freshwater water quality and fish and fish habitat VECs.

1.4.3 Temporal Boundaries

The Project represents a significant development in the mining of the Hope Bay Greenstone Belt. Even though this Project spans the conventional Construction, Operation, Reclamation and Closure, and Post-closure phases of a mine project, Phase 2 is a continuation of development currently underway. Phase 2 has four separate operational sites: Roberts Bay, Doris, Madrid (North and South), and Boston and three mine sites: Madrid North, Madrid South and Boston. Development, operation and closure of the Phase 2 Project will overlap mining and post-mining activities at the existing Doris mine. As such, the temporal boundaries of this Project overlap with a number of Existing and Approved Authorizations (EAAs) for the Hope Bay Project and the extension of activities during Phase 2.

For the purposes of the EIS, distinct phases of the Project are defined (Table 1.4-1). It is understood that construction, operation and closure activities will, in fact, overlap among sites; this is outlined in Table 1.4-1 and further described in Volume 3, Section 2 (Project Design Considerations).

The assessment also considers a Temporary Closure phase should there be a suspension of Project activities during periods when the Project becomes uneconomical due to market conditions. During this phase, the Project would be under care and maintenance. This could occur in any year of Construction or Operation with an indeterminate length (one to two year duration would be typical).

Figure 1.4-1
Project Development Area, Local Study Area, and Regional Study Area for Surface Hydrology

Table 1.4-1. Temporal Boundaries for the Effects Assessment for Surface Hydrology

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Construction	1 - 4	2019 - 2022	4	• **Roberts Bay:** construction of marine dock and additional fuel facilities (Year 1 – Year 2); • **Doris**: expansion of the Doris TIA and camp (Year 1); • **Madrid North:** construction of process plant and road to Doris TIA (Year 1); • **All-weather Road**: construction (Year 1 – Year 3); • **Boston**: site preparation and installation of all infrastructures including process plant (Year 2 – Year 5).
Operation	5 - 14	2023 - 2032	10	• **Roberts Bay**: shipping operations (Year 1 – Year 14) • **Doris**: mining (Year 1 - 4); milling and infrastructure use (Year 1 – Year 14); • **Madrid North:** mining (Year 1 – 13); ore transport to Doris mill (Year 1 -13); ore processing and concentrate transport to Doris mill (Year 2 – Year 13); • **Madrid South:** mining (Year 11 – Year 14); ore transport to Doris mill (Year 11 – Year 14); • **All-weather Road**: operational (Year 4 – Year 14); • **Boston**: winter access road operating (Year 1 – Year 3); mining (Year 4 – Year 13); ore transport to Doris mill (Year 4 – Year 5); processing ore (Year 6 – Year 13); and concentrate transport to Doris mill (Year 6 – Year 13).
Reclamation and Closure	15 - 17	2033 - 2035	3	• **Roberts Bay**: facilities will be operational during closure (Year 15 – Year 17); • **Doris**: camp and facilities will be operational during closure (Year 15 – Year 17); mining, milling, and TIA decommissioning (Year 15 – Year 17); • **Madrid North:** all components decommissioned (Year 15 – Year 17); • **Madrid South:** all components decommissioned (Year 15 – Year 17); • **All-weather Road**: road will be operational (Year 15 – Year 16); decommissioning (Year 17); • **Boston**: all components decommissioned (Year 15 – Year 17).
Post-Closure	18 - 22	2036 - 2040	5	• **All Sites:** Post-closure monitoring.
Temporary Closure	NA	NA	NA	• **All Sites:** Care and maintenance activities, generally consisting of closing down operations, securing infrastructure, removing surplus equipment and supplies, and implementing on-going monitoring and site maintenance activities.

1.5 PROJECT-RELATED EFFECTS ASSESSMENT

1.5.1 Methodology Overview

This assessment was informed by a methodology used to identify and assess the potential environmental effects of the Project and is consistent with the requirements of Section 12.5.2 of the Nunavut Agreement and the EIS Guidelines. The effects assessment evaluates the potential direct and indirect effects of the Project on the environment and follows the general methodology provided in Volume 2, Section 4 (Effects Assessment Methodology), and comprises a number of steps that collectively assess the manner in which the Project will interact with the surface hydrology VEC defined for the assessment (Section 1.3).

To provide a comprehensive understanding of the potential effects for the Project, the Phase 2 components and activities are assessed on their own as well as in the context of the Approved Projects (Doris and exploration) within the Hope Bay Greenstone Belt. The effects assessment process is summarized as follows:

1. Identify potential interactions between the Phase 2 Project and the VECs or VSECs;
2. Identify the resulting potential effects of those interactions;
3. Identify mitigation or management measures to eliminate or reduce the potential effects;
4. Identify residual effects (potential effects that would remain after mitigation and management measures have been applied) for Phase 2 in isolation;
5. Identify residual effects of Phase 2 in combination with the residual effects of Approved Projects; and
6. Determine the significance of combined residual effects.

After the identification of potential interactions effects (Steps 1; Section 1.5.2), mitigation and management measures were considered (Step 2, Section 1.5.3). Alteration of streamflow was used as an indicator for assessment of the potential effects of the Project on surface hydrology. Streamflow predictions of a water balance model (Appendix V3-2D) were used to quantify the potential effects of the Project on surface hydrology (Steps 3 and 4; Section 1.5.4). If results of Steps 3 and 4 predicted residual effects on surface hydrology, such effects were characterized in terms of *direction*, *magnitude*, *duration*, *frequency*, *geographic extent*, and *reversibility*, (Step 5, Section 1.5.5), and the significance of residual effects was determined (Step 6, Section 1.5.5).

1.5.2 Identification of Potential Effects

The Project has the potential to interact with surface hydrology through a number of activities and pathways. Project activities that have the potential to interact with surface hydrology and alter baseline streamflows were identified and shown in Table 1.5-1. These components were judged to have probable or likely interactions with surface hydrology, and this screening step did not consider application of mitigation and management measures. These interactions can cause the following potential effects on surface hydrology:

- *Alteration of streamflow in Doris Watershed*: Streamflow at assessment nodes Wolverine Lake Outflow, Patch Lake Outflow, PO Lake Outflow, Ogama Lake Outflow, Doris Lake Outflow, and Little Roberts Lake Outflow are considered in the Doris Watershed (Figure 1.2-5) category for the purpose of this effects assessment.

- *Alteration of streamflow in Windy Watershed*: Streamflow at assessment nodes Windy Lake Outflow and Glenn Lake Outflow are considered in the Windy Watershed (Figure 1.2-5) category for the purpose of this effects assessment.
- *Alteration of streamflow in Aimaokatalok Watershed*: Streamflow at assessment nodes Trout Lake Outflow, Stickleback Lake Outflow, Aimaokatalok Lake Outflow, Koignuk River 1, and Koignuk River 2 are considered in the Aimaokatalok Watershed (Figure 1.2-5) category for the purpose of this effects assessment.

The activities that have the potential to interact with surface hydrology (Table 1.5-1) can be grouped into the following three broad categories:

1. *Water withdrawal from lakes*: Water withdrawal from Doris, Windy, and Aimaokatalok lakes for domestic and industrial uses could affect lake outflows by lowering the water level in these lakes. Therefore, streamflows at Doris, Windy, and Aimaokatalok watersheds can be affected.
2. *Construction and use of underground mines*: Doris, Madrid North, and Madrid South mines are expected to intercept talik (Appendix V3-2D). Water level in Doris, Windy, Patch, and Wolverine lakes are predicted to drawdown through talik and, therefore, streamflows at Doris and Windy watersheds can be affected.
3. *Modification of natural drainages*: Contact water diversion and discharge (e.g., water transfer to, and discharge from, the TIA), modification of runoff coefficient at disturbed surfaces (e.g., stockpiles), and access roads where crossings are not sized to pass natural flows could affect drainage pathways. Therefore, these activities have the potential to alter streamflows at Doris, Windy, and Aimaokatalok watersheds.

The water balance model (Appendix V3-2D) collectively characterized the potential effects of all these activities on surface hydrology.

Table 1.5-1. Project Interaction with Surface Hydrology VEC

Project Component/Activity	Surface Hydrology		
	Alteration of Doris Watershed Streamflows	Alteration of Windy Watershed Streamflows	Alteration of Aimaokatalok Watershed Streamflows
Roberts Bay			
Construction and Operation - use of existing approved and permitted infrastructure			
Marine discharge for TIA water	X		
Roberts Bay - Doris road use and maintenance	X		
Site roads use and maintenance	X		
Water management system	X	X	X
Reclamation and Closure - use of existing approved and permitted infrastructure			
Site surface infrastructure	X		
Roberts Bay - Doris road	X		

Project Component/Activity	Surface Hydrology: Alteration of Doris Watershed Streamflows	Surface Hydrology: Alteration of Windy Watershed Streamflows	Surface Hydrology: Alteration of Aimaokatalok Watershed Streamflows
***Roberts Bay** (cont'd)*			
Reclamation and Closure - proposed Phase 2 infrastructure			
Site surface infrastructure	X		
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring	X		
Doris			
Construction - proposed Phase 2 infrastructure			
Expansion of camp (280 person capacity, expanded to 400 person capacity)	X		
Raising the TIA South Dam	X		
TIA West Dam	X		
Operation - use of existing approved and permitted infrastructure			
Camp	X	X	
Camp facilities (sewage treatment facilities, potable water treatment, fire suppression)	X	X	
Mill	X		
Ore stockpile	X		
Site roads use and maintenance	X		
Water discharge to the receiving environment	X		
Water management system	X		
Water use from Doris Lake	X		
Water use from Windy Lake		X	
Operation - proposed Phase 2 infrastructure			
Camp (expanded)	X	X	
TIA road use and maintenance	X		
TIA storage	X		
Reclamation and Closure - use of existing approved and permitted infrastructure			
Site surface and mining infrastructure	X		
Reclamation and Closure - proposed Phase 2 infrastructure			
Camp (expanded)	X	X	
TIA roads (perimeter and South Dam)	X		
TIA	X		
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring	X		

Project Component/Activity	Surface Hydrology Alteration of Doris Watershed Streamflows	Alteration of Windy Watershed Streamflows	Alteration of Aimaokatalok Watershed Streamflows
Madrid North			
Construction - use of existing approved and permitted infrastructure			
Site roads	X	X	
Surface infrastructure (shop, compressor building, laydown area, office, emergency shelter)	X	X	
Underground mine (drilling, blasting, excavation, ventilation)	X	X	
Waste rock pile	X	X	
Water management system	X	X	
Construction - proposed Phase 2 infrastructure			
Expansion of site pad (waste rock stockpile)	X	X	
Water discharge to the receiving environment	X	X	
Water management system (including expanded CWP)	X	X	
Operation - use of existing approved and permitted infrastructure			
Doris - Madrid road use and maintenance	X	X	
Madrid North access road use and maintenance	X	X	
Ore stockpile	X	X	
Site roads use and maintenance	X	X	
Waste rock pile	X	X	
Operation - proposed Phase 2 infrastructure			
Water discharge to the receiving environment	X	X	
Water management system (including CWP)	X	X	
Reclamation and Closure - proposed Phase 2 infrastructure			
Inter-site roads	X	X	
Site surface and mining infrastructure	X	X	
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring	X	X	
Madrid South			
Construction - use of existing approved and permitted infrastructure			
Site roads	X	X	
Water management system	X	X	
Construction - proposed Phase 2 infrastructure			
Water discharge to the receiving environment	X	X	
Water management system (including expanded CWP)	X	X	

Project Component/Activity	Surface Hydrology		
	Alteration of Doris Watershed Streamflows	Alteration of Windy Watershed Streamflows	Alteration of Aimaokatalok Watershed Streamflows
***Madrid South** (cont'd)*			
Operation - use of existing approved and permitted infrastructure			
Doris - Madrid road use and maintenance	X	X	
Ore stockpile	X	X	
Site roads use and maintenance	X	X	
Underground mine (drilling, blasting, excavation, ventilation)	X	X	
Waste rock pile	X	X	
Water management system - Type B licence	X	X	
Operation - proposed Phase 2 infrastructure			
Water discharge to the receiving environment	X	X	
Water management system (including CWP)	X	X	
Reclamation and Closure - proposed Phase 2 infrastructure			
Inter-site roads	X	X	
Site surface and mining infrastructure	X	X	
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring	X	X	
Madrid-Boston All-Weather Road			
Construction - use of existing approved and permitted infrastructure			
Madrid-Boston winter road	X	X	X
Construction - proposed Phase 2 infrastructure			
All weather road (grading, backfill, excavation, drainage)	X	X	X
Water crossings	X	X	X
Operation - use of existing approved and permitted infrastructure			
Madrid-Boston winter road	X	X	X
Operation - proposed Phase 2 infrastructure			
All weather road use and maintenance	X	X	X
Water crossings	X	X	X
Reclamation and Closure - use of existing approved and permitted infrastructure			
Madrid-Boston winter road	X	X	X
Construction camps	X	X	X
Reclamation and Closure - proposed Phase 2 infrastructure			
All-weather road, quarries and associated infrastructure	X	X	X
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring	X	X	X

Project Component/Activity	Surface Hydrology: Alteration of Doris Watershed Streamflows	Surface Hydrology: Alteration of Windy Watershed Streamflows	Surface Hydrology: Alteration of Aimaokatalok Watershed Streamflows
Boston			
Construction - use of existing approved and permitted infrastructure			
Camp (65 person)			X
Construction - proposed Phase 2 infrastructure			
Camp (sewage treatment facilities, potable water treatment, fire suppression)			X
Ore stockpile			X
Overburden pile			X
Site roads			X
Surface infrastructure (exploration office, core storage facility, laydown area, office, emergency shelter, office, warehouse, reagent storage, workshop, waste management facility)			X
Underground mine (drilling, blasting, excavation, ventilation)			X
Waste rock pad and pile			X
Water discharge to the environment			X
Water management system			X
Water use from Aimaokatalok Lake			X
Dry-stack TMA			X
TMA roads			X
TMA water management system			X
Operation - proposed Phase 2 infrastructure			
Camp (sewage treatment facilities, potable water treatment, fire suppression)			X
Ore stockpile			X
Overburden pile			X
Site roads and maintenance			X
Underground mine (drilling, blasting, excavation, ventilation)			X
Waste rock pile			X
Water discharge to the environment			X
Water use from Aimaokatalok Lake			X
Water management system			X
Dry-stack TMA			X
TMA roads use and maintenance			X
TMA water management system			X
Reclamation and Closure - proposed Phase 2 infrastructure			
Site surface and mining infrastructure			X
TMA and associated infrastructure			X
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring			X

Project Component/Activity	Surface Hydrology		
	Alteration of Doris Watershed Streamflows	Alteration of Windy Watershed Streamflows	Alteration of Aimaokatalok Watershed Streamflows
Boston Airstrip			
Construction - proposed Phase 2 infrastructure			
Access road			X
Operation - proposed Phase 2 infrastructure			
Access road use and maintenance			X
Reclamation and Closure - proposed Phase 2 infrastructure			
Site surface infrastructure			X
Post Closure - proposed Phase 2 infrastructure			
Post closure monitoring			X

Notes:
X= interaction
Blank = no interaction

1.5.3 Mitigation and Adaptive Management

1.5.3.1 Mitigation by Project Design

Mitigation measures, considered in the design of the project to minimize or eliminate potential effects of the Phase 2 Project on surface hydrology, include:

- Mine areas are constructed to minimize contact water. Facilities are designed with consideration of footprint minimization and are located, where possible, in areas of reduced runoff. Where necessary, runoff is diverted upstream of mine areas to further reduce the amount of contact water created.
- Contact water pond storage capacity, freshet flows, and expected storm event volumes are determined based on site-specific conditions. The sizing and design of these facilities is such that they can hold water during unusual storm events and contain freshet flows for prescribed periods.
- The TIA has been designed with substantial additional capacity to store both natural and Project-related inputs in exceedance of routinely expected volumes. The TIA will routinely be operated at a water level that provides availability of contingency capacity.
- Existing infrastructure associated with the Doris Project will be used to minimize the footprint of the Phase 2 Project.
- Climate change projections for key climatic and hydrologic design details have been considered.
- Routes of roads and pipelines have been minimized, and routing has been made as far as is practical from stream channel crossings and wet, boggy areas where fish habitat may be disturbed.
- Erosion potential will be reduced by working during periods of low runoff (e.g., winter) as much as possible.

- Water will be recycled and reused where possible.

The design of the Phase 2 Project also included adherence to regulatory requirements and guidelines relevant to the mitigation of potential effects on surface hydrology. These regulatory requirements included the following:

- Culvert maintenance will be conducted following the guidance provided in *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016), which adheres to the *Fisheries Act (1985)*.
- In-water work will be conducted during approved timing windows presented in *Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat* (DFO 2013a).
- Water withdrawal will follow permit conditions.

1.5.3.2 Best Management Practices

Avoidance is an effective mitigation measure to reduce the potential effects on surface hydrology. Best management practices are described in relevant management plans provided as annexes to Volume 8. Management plans directly relevant to surface hydrology include:

- Doris Project Domestic Wastewater Treatment Management Plan (Annex 5);
- Hope Bay Project Groundwater Management Plan (Annex 6);
- Water Management Plan: Madrid Advanced Exploration Program, North and South Bulk Samples (Annex 7);
- Water Management Plan, Hope Bay Project (Annex 8);
- Water and Ore/Waste Rock Management Plan (Annex 9);
- Sewage Treatment Plan Operation and Maintenance Plan (Annex 10);
- Hope Bay Project Doris Tailings Impoundment Area Operations, Maintenance, and Surveillance Manual (Annex 11);
- Hope Bay Project Phase 2 Aquatic Effects Monitoring Plan (Annex 21); and
- Hope Bay Project, Phase 2 Conceptual Closure and Reclamation Plan (Annex 27).

Mitigation and management measures relevant to surface hydrology include the following:

- Water collected in the contact water ponds will be routinely discharged to the TIA or tundra (where permitted and in compliance with discharge requirements), to retain maximum pond holding capacity and reduce the possibility of unintentional releases.
- Ponds will be routinely monitored and water will be pumped out of them as soon as the volume they contain is large enough for continuous pumping.
- Where possible, groundwater will be utilized during underground drilling to reduce fresh water and salt consumption, and to minimize groundwater discharge volumes.
- Sediment control measures, such as use of silt fences, will be implemented for works in or near waterbodies and watercourses.
- Erosion control measures, such as capping of soils exposed during construction activities with rock, will be implemented where necessary.
- Seepage and runoff from waste rock and ore stockpiles will be directed to contact water ponds.

- Non-contact water will be diverted around infrastructure, as much as feasible, and directed to the existing drainage networks.
- Groundwater will be collected in mine sumps and may be stored temporarily in the mine, and either pumped to the MOMB located in the mill building and discharged to Roberts Bay or transferred to the TIA. Discharge to Roberts Bay or the TIA may occur year round.
- Exploration drilling water will be recycled to minimize the quantity of freshwater used, and to reduce salt use.
- Vehicular access across a watercourse or waterbody will be by road or bridge, or other acceptable method according to *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016);
- During temporary closure the following will take place to protect freshwater water quantity:
    - Waste rock and ore piles and tailings facilities as well as dams, roads and pipelines will be inspected and maintained.
    - Surface water management and sediment and erosion control will continue as needed.
- During Closure the TIA North Dam will be breached to restore natural drainage.
- During Closure a low infiltration cover will be placed over the dry stack tailings in the Boston TMA. Once the cover is in place, the contract water pond berm will be breached to restore natural drainage. The remainder of the berms will stay in place in order to preserve the permafrost. The closure plan for the Boston TMA will be refined through the operations period through monitoring of water quality in the contact water ponds and updating water quality predictions.

1.5.3.3 Proposed Monitoring Plans and Adaptive Management

A monitoring program, described in Volume 8, Annex 8, will be undertaken to:

- Comply with monitoring requirements outlined in applicable water licences and project certificates;
- Ensure water being discharged to the environment meets the appropriate discharge limits;
- Ensure points of discharge to tundra are not negatively affected by pooling water or erosion; and
- Ensure tracking of water movement and volumes.

Routine visual inspections of all water management structures will be completed to determine whether the facilities are operating as designed and to assess maintenance requirements. Facility inspections are carried out following significant rain events and throughout freshet (Volume 8, Annex 8). In addition, daily inspection of all pads and dykes located throughout the bulk sample infrastructure will be completed (Volume 8, Annex 7).

Adaptive management will be determined on a case-by-case basis. Management activities may include modifications to existing mitigation and management measures or installation of additional control measures.

1.5.4 Characterization of Potential Effects

Project residual effects are the effects that are remaining after mitigation and management measures are taken into consideration. If the implementation of mitigation measures eliminates a potential effect and no residual effect is identified on that VEC, the effect is eliminated from further analyses.

If the proposed mitigation measures are not sufficient to eliminate an effect, a residual effect is identified and carried forward for additional characterization and significance determination. Residual effects of the Project can occur directly or indirectly. Direct effects result from specific Project-environment interactions between Project activities and components and VECs. Indirect effects are the result of direct effects on the environment that lead to secondary or collateral effects on VECs.

Results of the water balance model (Appendix V3-2D) include streamflow predictions at 13 assessment nodes during different phases of the Project (Appendix V5-1P), as well as lake elevation and volume predictions at five lakes during different phases of the Project (Appendices V5-1Q and V5-1R). While streamflow predictions (Appendix V5-1P) are directly used in this section to assess streamflow alterations, lake elevation and volume predictions (Appendices V5-1Q and V5-1R) inform other effects assessment sections (e.g., fish habitat effect assessment in Volume 5, Section 6).

Streamflow prediction of the water balance model show that none of the three potential effects identified in Section 1.5.2 will be fully eliminated after implementation of mitigation measures (Section 1.5.3). Therefore, the following three potential effects are identified as residual effects and carried forward for additional characterization:

- *Alteration of streamflow in Doris Watershed;*
- *Alteration of streamflow in Windy Watershed;* and
- *Alteration of streamflow in Aimaokatalok Watershed.*

Assessment of Phase 2 potential effects in isolation of existing and permitted projects would include comparison of project-affected flows during the Construction, Operation, Closure, and Post-closure phases of the Phase 2 Project, with flows before Construction of Phase 2 (hereafter refer to as Year 0). It is noted that streamflows in Year 0 are not pre-development natural flows since these flows include the predicted effects of the Doris Project.

In contrast, assessment of Phase 2 potential effects in combination with existing and permitted projects included comparison of project-affected flows during the Construction, Operation, Closure, and Post-closure phases of the Phase 2 Project (Appendix V5-1P), with baseline flow projections without any development (Appendix V5-1M).

Assessment of Phase 2 in combination with existing and permitted projects results in higher streamflow effects than those of the Phase 2 in isolation of existing and permitted projects (Table 1.5-2). Therefore, for the purpose of surface hydrology effects assessment, characterization of potential effects and the significance determination are based on Phase 2 in combination with existing and permitted projects relative to baseline flow projections. These effects are referred to as effects of the Hope Bay Project hereafter. This effect assessment provides conservative estimates for Phase 2 in isolation of existing and permitted projects. This is consistent with the natural flow regime paradigm (Poff et al. 2010) and best practices for hydrologic effects assessments.

<u>Streamflow Alteration in Doris Watershed</u>

Effects of the Hope Bay Project on annual flow in Doris Watershed assessment nodes, including average annual effects as well as maximum annual effects during the life of the Phase 2 Project, under the average, dry, and wet climate conditions, are shown in Table 1.5-3. Figure 1.5-1 shows the inter-annual variation of annual effects.

Table 1.5-2. Comparison of Project Effects on Surface Hydrology between the Phase 2 in Isolation of, and Hope Bay Project (Phase 2 in Combination with, Existing and Approved Projects)

	Annual Flow Predictions			Change in Annual Flow (averaged over life of Project)	
Surface Hydrology Assessment Node	Baseline Flows (averaged over life of Project) (m^3/s)	Flow in Year 01 (m^3/s)	Hope Bay Project-Affected Flows (averaged over life of Project) (m^3/s)	Phase 2 in Isolation of Existing and Approved Projects Flow Change (% Year 0 flow)	Hope Bay Project Flow Change (% of baseline)
Doris Watershed					
Wolverine Lake Outflow	0.006	0.006	0.006	**0.4%**	**-5.7%**
Patch Lake Outflow	0.061	0.058	0.055	**-6.1%**	**-10.6%**
PO Lake Outflow	0.073	0.070	0.067	**-4.3%**	**-8.9%**
Ogama Lake Outflow	0.178	0.171	0.172	**0.5%**	**-3.6%**
Doris Lake Outflow	0.238	0.226	0.193	**-14.7%**	**-18.9%**
Little Roberts Outflow	0.771	0.736	0.688	**-6.6%**	**-10.8%**
Windy Watershed					
Windy Lake Outflow	0.027	0.025	0.026	**1.7%**	**-5.0%**
Glenn Lake Outflow	0.077	0.073	0.076	**3.8%**	**-1.7%**
Aimaokatalok Watershed					
Trout Lake Outflow	0.096	0.092	0.096	**4.2%**	**0.0%**
Stickleback Lake Outflow	0.0052	0.0049	0.0050	**3.2%**	**-3.7%**
Aimaokatalok Outflow	3.668	3.518	3.658	**4.0%**	**-0.3%**
Koignuk River 1	4.184	4.014	4.175	**4.0%**	**-0.2%**
Koignuk River 2	6.200	5.949	6.191	**4.1%**	**-0.2%**

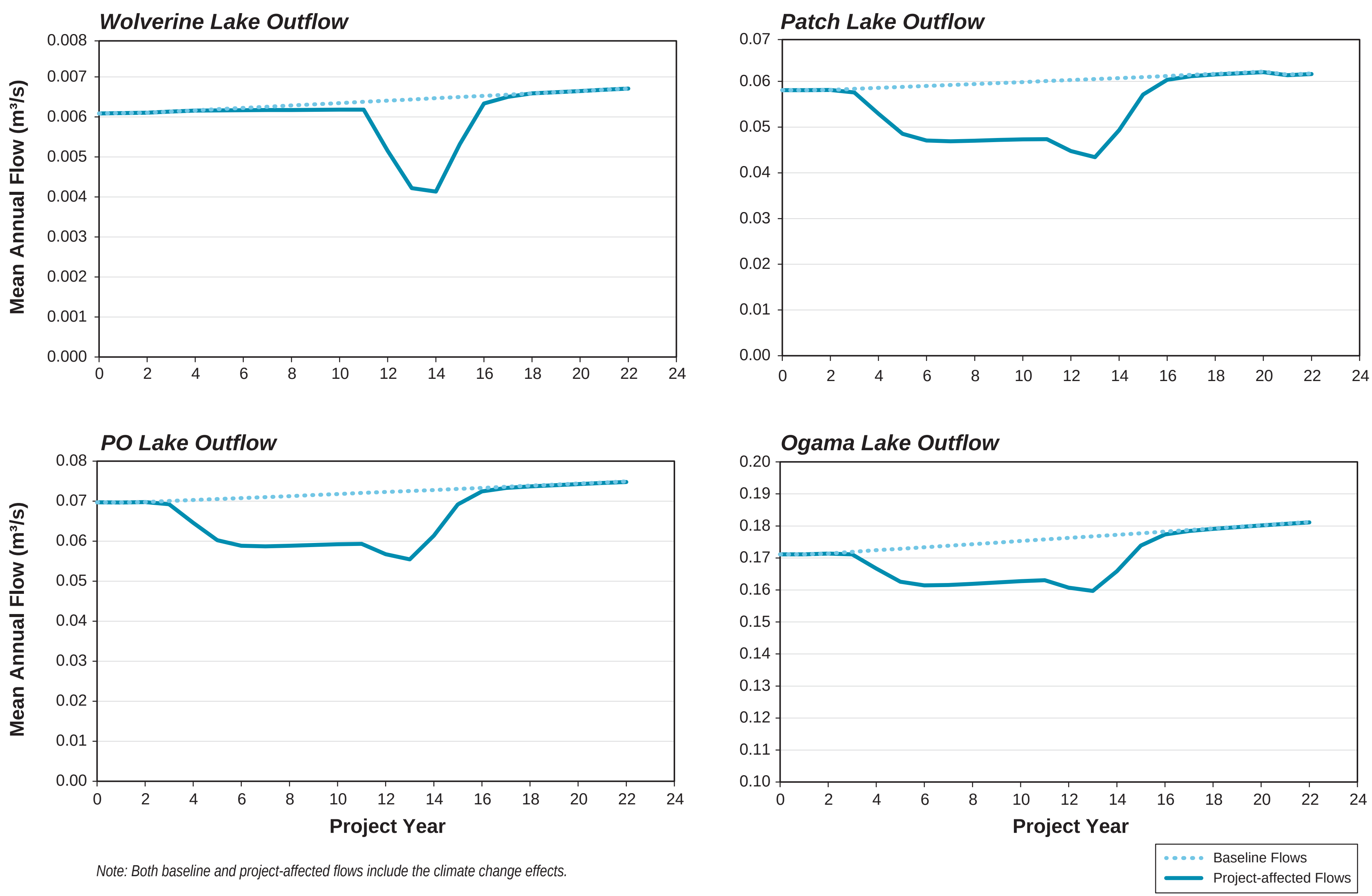
[1] *Year 0 is one year before Construction of Phase 2 Project commences.*

Maximum flow reductions in all Doris Watershed nodes occur in the last years of Operation (Figure 1.5-1). For example, annual Doris Lake Outflow is, on average, reduced by 18.9% during the life of Phase 2 Project, while the maximum annual flow reduction is 43% in the last two years of Operation (Table 1.5-3 and Figure 1.5-1). Percent flow reductions during dry (and wet) years are higher (and lower) than normal years (Table 1.5-3).

Annual streamflows at Doris Lake and Little Roberts Lake Outflow are reduced more than 10% from baseline, which is generally assumed to be the natural variability of riverine systems (DFO 2013b). Exceedance curves for flow reductions at Doris Lake and Little Roberts lakes are provided (Figure 1.5-2) to support the assessment of effects of alteration in streamflow on freshwater fish VECs (Volume 5, Section 6).

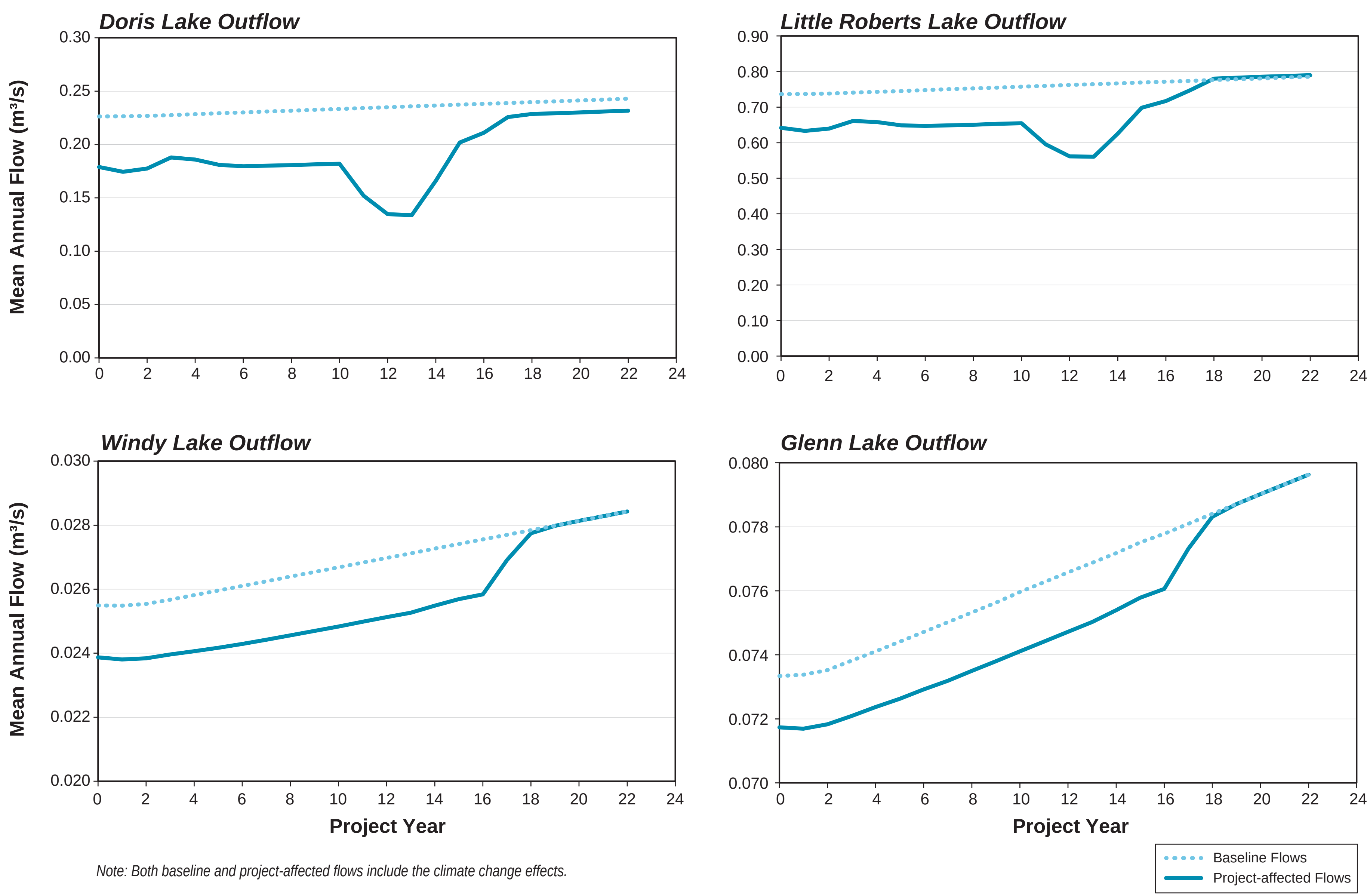
Effects of the Hope Bay Project on monthly flow in Doris Watershed assessment nodes, during project years with maximum flow reduction compared to baseline conditions, are shown in Table 1.5-6 to 1.5-11.

Figure 1.5-1a
Baseline and Project-affected Annual Flows



Note: Both baseline and project-affected flows include the climate change effects.

Figure 1.5-1b
Baseline and Project-affected Annual Flows



Note: Both baseline and project-affected flows include the climate change effects.

Figure 1.5-1c

Baseline and Project-affected Annual Flows

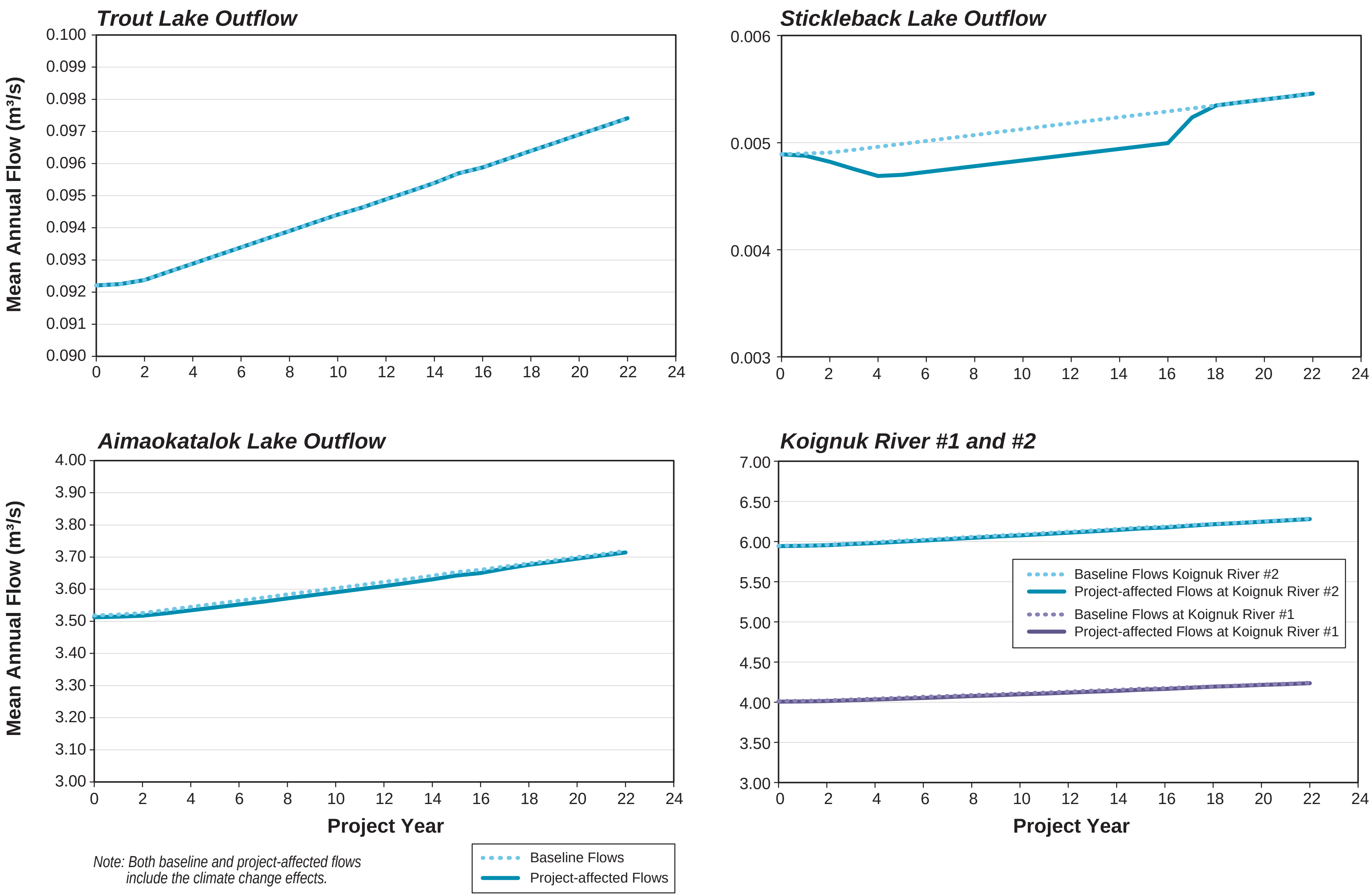
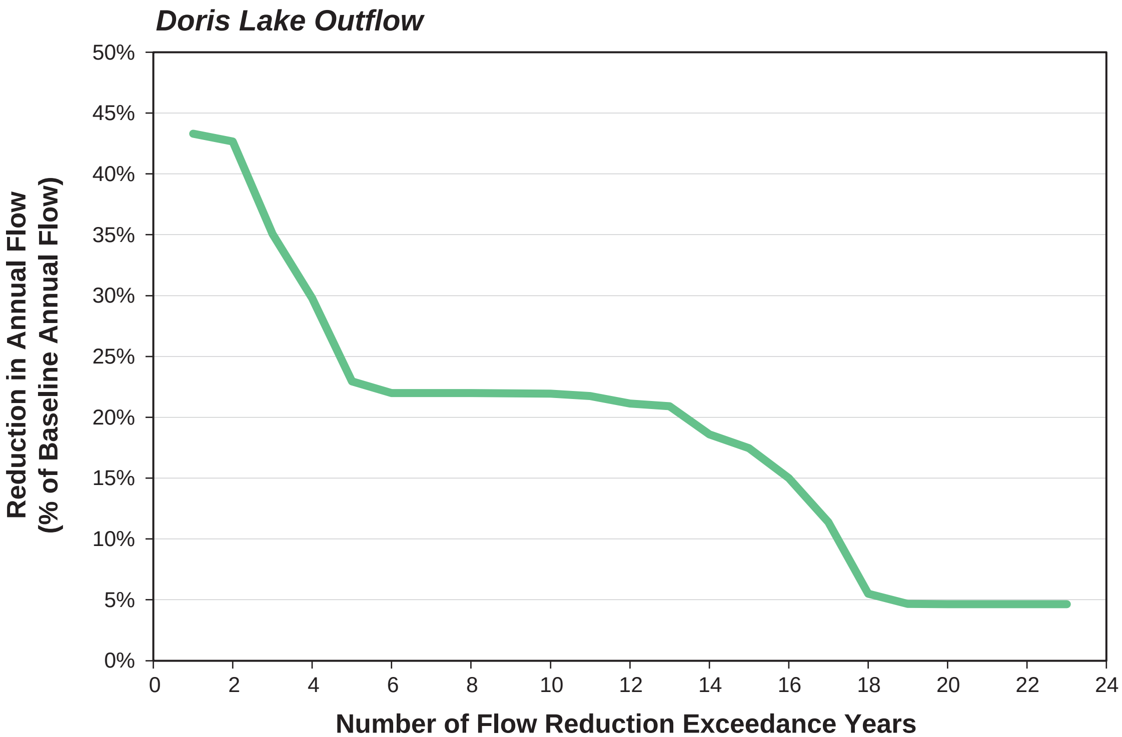


Figure 1.5-2

Exceedance Curve for Annual Flow Reduction at Doris Lake Outflow and Little Roberts Lake Outflow



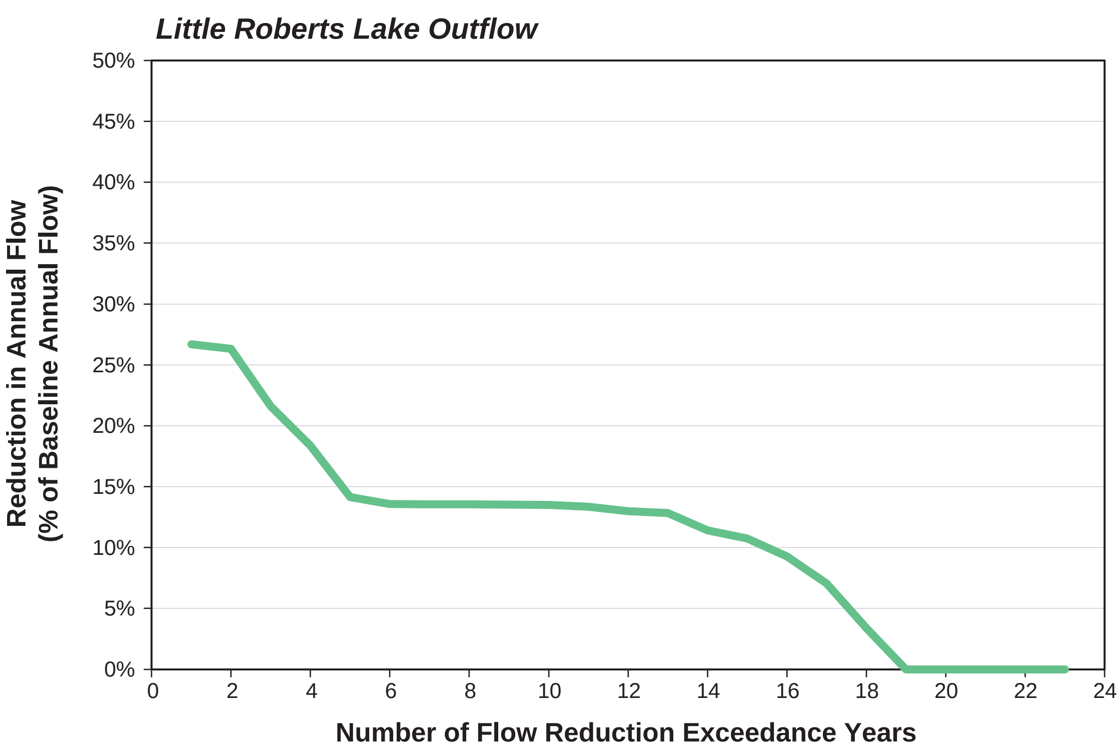


Table 1.5-3. Baseline and Project-affected Annual Flows at Doris Watershed Assessment Nodes during the Life of Project (Average of Years 1 to 22)

Surface Hydrology Assessment Node	Climate Condition	Average Annual Flows during All Project Phases: Baseline flows[1] (m^3/s)	Project-affected Flows[2] (m^3/s)	(% of annual baseline flow)	Maximum Change in Annual Flow (all project phases) (% of annual baseline flow)
Wolverine Lake Outflow	Average	0.006	0.006	**-5.7%**	**-36.1%**
	Dry[3]	0.000	0.000	**0.0%**	**0.0%**
	Wet[4]	0.019	0.018	**-3.5%**	**-20.4%**
Patch Lake Outflow	Average	0.061	0.055	**-10.6%**	**-28.2%**
	Dry[3]	0.041	0.036	**-13.6%**	**-38.0%**
	Wet[4]	0.149	0.138	**-7.3%**	**-19.7%**
PO Lake Outflow	Average	0.073	0.067	**-8.9%**	**-23.6%**
	Dry[3]	0.037	0.031	**-15.6%**	**-42.6%**
	Wet[4]	0.204	0.194	**-4.9%**	**-12.5%**
Ogama Lake Outflow	Average	0.178	0.172	**-3.6%**	**-9.7%**
	Dry[3]	0.028	0.021	**-25.1%**	**-68.6%**
	Wet[4]	0.819	0.810	**-1.1%**	**-3.3%**
Doris Lake Outflow	Average	0.238	0.193	**-18.9%**	**-43.3%**
	Dry[3]	0.104	0.080	**-23.2%**	**-58.6%**
	Wet[4]	0.507	0.429	**-15.4%**	**-34.8%**
Little Roberts Outflow	Average	0.771	0.688	**-10.8%**	**-26.7%**
	Dry[3]	0.283	0.241	**-14.7%**	**-34.7%**
	Wet[4]	1.679	1.541	**-8.2%**	**-19.5%**

[1] Average of simulated baseline flows during the life of Project (i.e., Years 1 to 22) including climate change effects
[2] Average of predicted project-affected flows during the life of Project (i.e., Years 1 to 22) including climate change effects
[3] 1-in-20-Year Dry Condition
[4] 1-in-20-Year Wet Condition

<u>Streamflow Alteration in Windy Watershed</u>

Effects of the Hope Bay Project on annual flow in Windy Watershed assessment nodes, including average annual effects as well as maximum annual effects during the life of the Phase 2 Project, under the average, dry, and wet climate conditions, are shown in Table 1.5-4. Annual flow reduction in Windy Watershed nodes under average climate conditions are less than 10% (Table 1.5-4). Percent flow reductions during dry (and wet) years are higher (and lower) than normal years (Table 1.5-4).

Effects of the Hope Bay Project on monthly flow in Windy Watershed assessment nodes, during project years with maximum flow reduction compared to baseline conditions, are shown in Table 1.5-12 to 1.5-13.

<u>Streamflow Alteration in Aimaokatalok Watershed</u>

Effects of the Hope Bay Project on annual flow in Aimaokatalok Watershed assessment nodes, including average annual effects as well as maximum annual effects during the life of the Phase 2 Project, under the average, dry, and wet climate conditions, are shown in Table 1.5-5. Annual flow reduction in Aimaokatalok Watershed nodes under average, dry, and wet climate conditions are less than 10% (Table 1.5-5).

Effects of the Hope Bay Project on monthly flow in Aimaokatalok Watershed assessment nodes, during project years with maximum flow reduction compared to baseline conditions, are shown in Table 1.5-14 to 1.5-18.

Table 1.5-4. Baseline and Project-affected Annual Flows at Windy Watershed Assessment Nodes during the Life of Project (Average of Years 1 to 22)

Surface Hydrology Assessment Node	Climate Condition	Average Annual Flows during All Project Phases			Maximum Change in Annual Flow (all project phases) (% of annual baseline flow)
		Baseline flows[1] (m^3/s)	Project-affected flows[2] (m^3/s)	(% of annual baseline flow)	
Windy Lake Outflow	Average	0.027	0.026	**-5.0%**	**-7.0%**
	Dry[3]	0.014	0.013	**-7.7%**	**-15.0%**
	Wet[4]	0.052	0.051	**-3.2%**	**-4.8%**
Glenn Lake Outflow	Average	0.077	0.076	**-1.7%**	**-2.4%**
	Dry[3]	0.018	0.017	**-5.4%**	**-9.2%**
	Wet[4]	0.185	0.184	**-0.9%**	**-1.3%**

[1] *Average of simulated baseline flows during the life of Project (i.e., Years 1 to 22) including climate change effects*
[2] *Average of predicted project-affected flows during the life of Project (i.e., Years 1 to 22) including climate change effects*
[3] *1-in-20-Year Dry Condition*
[4] *1-in-20-Year Wet Condition*

Table 1.5-5. Baseline and Project-affected Annual Flows at Aimaokatalok Watershed Assessment Nodes during the Life of Project (Average of Years 1 to 22)

Surface Hydrology Assessment Node	Climate Condition	Average Annual Flows during All Project Phases			Maximum change in annual flow (all project phases) (% of annual baseline flow)
		Baseline flows[1] (m^3/s)	Project-affected flows[2] (m^3/s)	(% of annual baseline flow)	
Trout Lake Outflow	Average	0.096	0.096	**0.0%**	**0.0%**
	Dry[3]	0.014	0.014	**0.0%**	**0.0%**
	Wet[4]	0.235	0.235	**0.0%**	**0.0%**
Stickleback Lake Outflow	Average	0.0052	0.0050	**-3.7%**	**-5.8%**
	Dry[3]	0.0000	0.0000	**0.0%**	**0.0%**
	Wet[4]	0.0155	0.0150	**-3.2%**	**-6.3%**
Aimaokatalok Outflow	Average	3.668	3.658	**-0.3%**	**-0.4%**
	Dry[3]	0.489	0.483	**-1.1%**	**-2.2%**
	Wet[4]	9.020	9.004	**-0.2%**	**-0.3%**
Koignuk River 1	Average	4.184	4.175	**-0.2%**	**-0.3%**
	Dry[3]	0.579	0.574	**-0.9%**	**-1.8%**
	Wet[4]	10.261	10.246	**-0.2%**	**-0.2%**
Koignuk River 2	Average	6.200	6.191	**-0.2%**	**-0.2%**
	Dry[3]	0.928	0.923	**-0.6%**	**-1.1%**
	Wet[4]	15.113	15.097	**-0.1%**	**-0.2%**

[1] *Average of simulated baseline flows during the life of Project (i.e., Years 1 to 22) including climate change effects*
[2] *Average of predicted project-affected flows during the life of Project (i.e., Years 1 to 22) including climate change effects*
[3] *1-in-20-Year Dry Condition*
[4] *1-in-20-Year Wet Condition*

Table 1.5-6. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Wolverine Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0	0.072	0.002	0	0	0	0	0	**0.006**
Baseline 22[b]		22	0	0	0	0	0.000	0.080	0.002	0	0	0	0	0	**0.007**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0	0.072	0.002	0	0	0	0	0	**0.006**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0	0.073	0.002	0	0	0	0	0	**0.006**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-0.1%**
Operation[f]	Flow (m^3/s)	14	0	0	0	0	0	0.049	0.001	0	0	0	0	0	**0.004**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-36.7%	-6.5%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-36.1%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0	0.063	0.002	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-18.5%	-2.3%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-18.1%**
Post-closure[f]	Flow (m^3/s)	19	0	0	0	0	0	0.079	0.002	0	0	0	0	0	**0.007**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**0**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-7. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Patch Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.121	0.332	0.154	0.088	0	0	0	0	**0.058**
Baseline 22[b]		22	0	0	0	0	0.147	0.347	0.161	0.093	0	0	0	0	**0.063**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.121	0.332	0.154	0.088	0	0	0	0	**0.058**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0.102	0.308	0.143	0.081	0	0	0	0	**0.053**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-7.6%	-7.7%	-9.4%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-9.7%**
Operation[f]	Flow (m^3/s)	13	0	0	0	0	0.071	0.257	0.122	0.069	0	0	0	0	**0.043**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-24.3%	-22.5%	-23.9%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-28.2%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.122	0.322	0.151	0.088	0	0	0	0	**0.057**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-5.8%	-4.4%	-3.8%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-6.3%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.141	0.343	0.159	0.092	0	0	0	0	**0.062**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.3%	-0.2%	-0.2%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-0.2%**

Notes:
[a] *Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0*
[b] *Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change*
[c] *Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences*
[d] *Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.*
[e] *When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a*
[f] *For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.*

Table 1.5-8. Effects of Hope Bay Project on Surface Hydrology – Maximum Monthly Effects on PO Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.110	0.415	0.130	0.180	0.000	0	0	0	**0.070**
Baseline 22[b]		22	0	0	0	0	0.136	0.435	0.137	0.189	0.000	0	0	0	**0.075**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.110	0.415	0.130	0.180	0.000	0	0	0	**0.070**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	n/a[e]	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	1	0	0	0	0	0.110	0.414	0.130	0.180	0.000	0	0	0	**0.070**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	n/a[e]	n/a[e]	n/a[e]	**0**
Operation[f]	Flow (m^3/s)	13	0	0	0	0	0.060	0.343	0.098	0.163	0.000	0	0	0	**0.055**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-19.4%	-26.5%	-11.8%	0	n/a[e]	n/a[e]	n/a[e]	**-23.6%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.111	0.407	0.127	0.182	0.000	0	0	0	**0.069**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-4.7%	-5.2%	-1.9%	0	n/a[e]	n/a[e]	n/a[e]	**-5.3%**
Post-closure[f]	Flow (m^3/s)	19	0	0	0	0	0.132	0.431	0.136	0.187	0.000	0	0	0	**0.074**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.3%	-0.2%	-0.1%	0	n/a[e]	n/a[e]	n/a[e]	**-0.2%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-9. Effects of Hope Bay Project on Surface Hydrology – Maximum Monthly Effects on Ogama Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.089	1.101	0.085	0.771	0.003	0	0	0	**0.171**
Baseline 22[b]		22	0	0	0	0	0.115	1.154	0.092	0.806	0.004	0	0	0	**0.181**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.089	1.101	0.085	0.771	0.003	0	0	0	**0.171**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	n/a[e]	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0.070	1.083	0.074	0.768	0.003	0	0	0	**0.167**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-2.3%	-13.8%	-1.1%	0	n/a[e]	n/a[e]	n/a[e]	**-3.3%**
Operation[f]	Flow (m^3/s)	13	0	0	0	0	0.039	1.048	0.053	0.770	0.004	0	0	0	**0.160**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-7.3%	-39.9%	-2.7%	0	n/a[e]	n/a[e]	n/a[e]	**-9.7%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.090	1.116	0.083	0.792	0.004	0	0	0	**0.174**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-1.7%	-7.7%	-0.4%	0	n/a[e]	n/a[e]	n/a[e]	**-2.2%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.110	1.142	0.090	0.800	0.004	0	0	0	**0.179**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.4%	0	0	n/a[e]	n/a[e]	n/a[e]	**-0.1%**

Notes:

[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0

[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change

[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences

[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.

[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a

[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-10. Effects of Hope Bay Project on Surface Hydrology – Maximum Monthly Effects on Doris Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.053	1.520	0.546	0.225	0.252	0.111	0.014	0	**0.226**
Baseline 22[b]		22	0	0	0	0	0.085	1.636	0.557	0.241	0.270	0.119	0.015	0	**0.243**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0	1.196	0.493	0.183	0.210	0.071	0	0	**0.179**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-21.3%	-9.7%	-18.7%	-16.9%	-36.0%	n/a[e]	n/a[e]	**-20.9%**
Construction[f]	Flow (m^3/s)	1	0	0	0	0	0	1.142	0.490	0.182	0.210	0.072	0	0	**0.174**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-24.9%	-10.2%	-19.0%	-16.8%	-35.0%	n/a[e]	n/a[e]	**-23.0%**
Operation[f]	Flow (m^3/s)	13	0	0	0	0	0	0.757	0.427	0.164	0.206	0.051	0	0	**0.134**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-52.4%	-22.5%	-29.8%	-21.3%	-55.7%	n/a[e]	n/a[e]	**-43.3%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.023	1.342	0.507	0.210	0.242	0.100	0.004	0	**0.202**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-16.2%	-8.2%	-10.8%	-8.2%	-14.4%	n/a[e]	n/a[e]	**-15.0%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.075	1.500	0.541	0.236	0.265	0.116	0.015	0	**0.229**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-7.1%	-2.4%	-0.7%	-0.3%	-1.2%	n/a[e]	n/a[e]	**-4.7%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-11. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Little Roberts Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.350	5.216	1.463	0.734	0.830	0.246	0.028	0	**0.736**
Baseline 22[b]		22	0	0	0	0	0.558	5.444	1.502	0.779	0.880	0.263	0.030	0	**0.786**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.244	4.568	1.357	0.650	0.745	0.166	0	0	**0.642**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-12.4%	-7.2%	-11.5%	-10.3%	-32.5%	n/a[e]	n/a[e]	**-12.8%**
Construction[f]	Flow (m^3/s)	1	0	0	0	0	0.246	4.460	1.352	0.649	0.745	0.168	0	0	**0.633**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-14.6%	-7.6%	-11.6%	-10.2%	-31.6%	n/a[e]	n/a[e]	**-14.1%**
Operation[f]	Flow (m^3/s)	13	0	0	0	0	0.326	3.688	1.234	0.620	0.745	0.126	0	0	**0.560**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-31.1%	-16.7%	-18.3%	-13.0%	-50.3%	n/a[e]	n/a[e]	**-26.7%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.386	4.857	1.395	0.713	0.821	0.224	0.008	0	**0.698**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-9.6%	-6.1%	-6.7%	-5.0%	-13.0%	n/a[e]	n/a[e]	**-9.3%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.543	5.367	1.500	0.794	0.899	0.259	0.030	0	**0.780**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.6%	0.5%	3.1%	3.3%	-0.3%	n/a[e]	n/a[e]	**0.5%**

Notes:
[a] *Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0*
[b] *Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change*
[c] *Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences*
[d] *Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.*
[e] *When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a*
[f] *For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.*

Table 1.5-12. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Windy Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0	0.169	0.094	0.026	0.018	0	0	0	**0.025**
Baseline 22[b]		22	0	0	0	0	0	0.196	0.097	0.028	0.020	0	0	0	**0.028**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0	0.158	0.089	0.024	0.016	0	0	0	**0.024**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-6.8%	-4.8%	-7.4%	-9.1%	n/a[e]	n/a[e]	n/a[e]	**-6.4%**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0	0.160	0.089	0.024	0.016	0	0	0	**0.024**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-7.3%	-5.1%	-7.8%	-9.6%	n/a[e]	n/a[e]	n/a[e]	**-6.8%**
Operation[f]	Flow (m^3/s)	7	0	0	0	0	0	0.163	0.089	0.024	0.017	0	0	0	**0.024**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-7.5%	-5.2%	-8.0%	-9.8%	n/a[e]	n/a[e]	n/a[e]	**-7.0%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0	0.174	0.091	0.025	0.018	0	0	0	**0.026**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-6.8%	-4.6%	-7.1%	-8.6%	n/a[e]	n/a[e]	n/a[e]	**-6.3%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0	0.190	0.096	0.027	0.020	0	0	0	**0.028**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.4%	-0.2%	-0.3%	-0.2%	n/a[e]	n/a[e]	n/a[e]	**-0.3%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-13. Effects of Hope Bay Project on Surface Hydrology – Maximum Monthly Effects on Glenn Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.053	0.625	0.095	0.038	0.071	0.005	0	0	**0.073**
Baseline 22[b]		22	0	0	0	0	0.085	0.649	0.102	0.042	0.078	0.005	0	0	**0.080**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.053	0.614	0.090	0.037	0.068	0.005	0	0	**0.072**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-1.8%	-4.7%	-3.2%	-3.5%	0	n/a[e]	n/a[e]	**-2.2%**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0.057	0.615	0.091	0.037	0.069	0.005	0	0	**0.072**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-2.0%	-4.9%	-3.3%	-3.7%	0	n/a[e]	n/a[e]	**-2.3%**
Operation[f]	Flow (m^3/s)	7	0	0	0	0	0.062	0.618	0.092	0.037	0.070	0.005	0	0	**0.073**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-2.1%	-5.0%	-3.4%	-3.8%	0	n/a[e]	n/a[e]	**-2.4%**
Closure[f]	Flow (m^3/s)	15	0	0	0	0	0.074	0.628	0.095	0.039	0.073	0.005	0	0	**0.076**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-2.0%	-4.4%	-3.0%	-3.4%	0	n/a[e]	n/a[e]	**-2.2%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.079	0.643	0.100	0.041	0.077	0.005	0	0	**0.078**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.1%	-0.1%	0	n/a[e]	n/a[e]	**-0.1%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-14. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Trout Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0.081	0.725	0.109	0.082	0.108	0.008	0	0	**0.092**
Baseline 22[b]		22	0	0	0	0	0.128	0.723	0.114	0.086	0.114	0.008	0	0	**0.097**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0.081	0.725	0.109	0.082	0.108	0.008	0	0	**0.092**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	0	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0.087	0.724	0.109	0.083	0.109	0.008	0	0	**0.093**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	0	n/a[e]	n/a[e]	**0**
Operation[f]	Flow (m^3/s)	5	0	0	0	0	0.089	0.724	0.110	0.083	0.109	0.008	0	0	**0.093**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	0	n/a[e]	n/a[e]	**0**
Closure[f]	Flow (m^3/s)	16	0	0	0	0	0.115	0.723	0.113	0.085	0.112	0.008	0	0	**0.096**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	0	n/a[e]	n/a[e]	**0**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0.119	0.723	0.113	0.086	0.113	0.008	0	0	**0.096**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	0	0	0	n/a[e]	n/a[e]	**0**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-15. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Stickleback Lake Outflow during different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	0	0.058	0.001	0	0	0	0	0	**0.005**
Baseline 22[b]		22	0	0	0	0	0	0.065	0.001	0	0	0	0	0	**0.005**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	0	0.058	0.001	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**0**
Construction[f]	Flow (m^3/s)	4	0	0	0	0	0	0.056	0.001	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-5.5%	-4.2%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-5.5%**
Operation[f]	Flow (m^3/s)	5	0	0	0	0	0	0.056	0.001	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-5.8%	-4.2%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-5.8%**
Closure[f]	Flow (m^3/s)	16	0	0	0	0	0	0.059	0.001	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-5.7%	-4.1%	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**-5.6%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	0	0.064	0.001	0	0	0	0	0	**0.005**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	0	n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	**0**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-16. Effects of Hope Bay Projecton Surface Hydrology – Maximum Monthly Effects on Aimaokatalok Lake Outflow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	3.095	27.874	4.010	3.021	4.155	0.304	0	0	**3.518**
Baseline 22[b]		22	0	0	0	0	4.936	27.805	4.219	3.184	4.363	0.317	0	0	**3.719**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	3.054	27.867	4.002	3.014	4.151	0.300	0	0	**3.512**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.0%	-0.2%	-0.2%	-0.1%	-1.2%	n/a[e]	n/a[e]	**-0.2%**
Construction[f]	Flow (m^3/s)	4	0.000	0.000	0.000	0.000	3.300	27.813	4.025	3.031	4.171	0.302	0.000	0.000	**3.534**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.4%	-0.4%	-0.3%	-1.3%	n/a[e]	n/a[e]	**-0.3%**
Operation[f]	Flow (m^3/s)	12	0.002	0.002	0.002	0.002	3.984	27.801	4.103	3.091	4.240	0.307	0.002	0.002	**3.610**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.2%	-0.4%	-0.5%	-0.4%	-1.2%	n/a[e]	n/a[e]	**-0.4%**
Closure[f]	Flow (m^3/s)	16	0	0	0	0	4.361	27.774	4.148	3.124	4.294	0.309	0	0	**3.650**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.3%	-0.4%	-0.4%	-1.3%	n/a[e]	n/a[e]	**-0.3%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	4.581	27.778	4.174	3.146	4.321	0.314	0	0	**3.676**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.2%	-0.2%	-0.1%	n/a[e]	n/a[e]	**-0.1%**

Notes:

[a] *Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0*

[b] *Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change*

[c] *Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences*

[d] *Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.*

[e] *When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a*

[f] *For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.*

Table 1.5-17. Effects of Hope Bay Project on Surface Hydrology – Maximum Monthly Effects on Koignuk River 1 Flow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	3.516	31.671	4.661	3.522	4.723	0.345	0	0	**4.014**
Baseline 22[b]		22	0	0	0	0	5.603	31.597	4.900	3.706	4.958	0.360	0	0	**4.242**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	3.474	31.663	4.656	3.514	4.718	0.342	0	0	**4.008**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.0%	-0.1%	-0.2%	-0.1%	-1.1%	n/a[e]	n/a[e]	**-0.1%**
Construction[f]	Flow (m^3/s)	4	0.000	0.000	0.000	0.000	3.752	31.605	4.682	3.533	4.742	0.343	0.000	0.000	**4.033**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.3%	-0.4%	-0.3%	-1.2%	n/a[e]	n/a[e]	**-0.3%**
Operation[f]	Flow (m^3/s)	12	0.002	0.002	0.002	0.002	4.533	31.597	4.772	3.603	4.819	0.350	0.002	0.002	**4.120**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.3%	-0.4%	-0.3%	-1.0%	n/a[e]	n/a[e]	**-0.3%**
Closure[f]	Flow (m^3/s)	16	0	0	0	0	4.954	31.563	4.820	3.639	4.884	0.352	0	0	**4.165**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.4%	-0.2%	-1.2%	n/a[e]	n/a[e]	**-0.3%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	5.201	31.570	4.846	3.664	4.907	0.357	0	0	**4.193**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.2%	-0.2%	-0.0%	n/a[e]	n/a[e]	**-0.1%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

Table 1.5-18. Effects of Hope Bay Project on Surface Hydrology - Maximum Monthly Effects on Koignuk River 2 Flow during Different Phases of the Project under Average Climate Conditions

Project Phase		Project Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline 0[a]		0	0	0	0	0	5.152	46.489	7.206	5.473	6.937	0.508	0	0	**5.949**
Baseline 22[b]		22	0	0	0	0	8.210	46.412	7.557	5.742	7.280	0.530	0	0	**6.285**
Existing and Permitted Projects[c]	Flow (m^3/s)	0	0	0	0	0	5.111	46.489	7.202	5.466	6.933	0.504	0	0	**5.944**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	0	-0.1%	-0.1%	-0.1%	-0.7%	n/a[e]	n/a[e]	**-0.1%**
Construction[f]	Flow (m^3/s)	4	0.000	0.000	0.000	0.000	5.526	46.412	7.243	5.500	6.968	0.507	0.000	0.000	**5.982**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.2%	-0.2%	-0.8%	n/a[e]	n/a[e]	**-0.2%**
Operation[f]	Flow (m^3/s)	12	0.002	0.002	0.002	0.002	6.676	46.412	7.374	5.600	7.083	0.516	0.002	0.002	**6.110**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.3%	-0.2%	-0.6%	n/a[e]	n/a[e]	**-0.2%**
Closure[f]	Flow (m^3/s)	16	0	0	0	0	7.284	46.373	7.441	5.653	7.176	0.520	0	0	**6.176**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.2%	-0.3%	-0.2%	-0.8%	n/a[e]	n/a[e]	**-0.2%**
Post-closure[f]	Flow (m^3/s)	18	0	0	0	0	7.624	46.373	7.482	5.686	7.211	0.526	0	0	**6.215**
	Change (%)[d]		n/a[e]	n/a[e]	n/a[e]	n/a[e]	n/a[e]	-0.1%	-0.1%	-0.1%	-0.1%	0	n/a[e]	n/a[e]	**-0.1%**

Notes:
[a] Baseline flow (natural flows if no infrastructure had been developed) in Project Year 0
[b] Baseline flow (natural flows if no infrastructure had been developed) at the end of mine life (i.e., Year 22), including the effects of climate change
[c] Flows in Project Year 0 with existing and permitted projects, before Construction of Phase 2 infrastructure commences
[d] Percent of baseline flow. Climate change effects are considered in both baseline and project-affected flows. For example, project-affected flows in Year 10 are compared with baseline flows in Year 10.
[e] When baseline flow is zero (i.e., in winter) or monthly-averaged flow is misleading because flow is zero during part of the month (e.g., May and November), percent changes are described as n/a
[f] For each phase of the Project, the year with maximum difference from baseline conditions is shown on the table.

1.5.5 Characterization of Residual Effects

1.5.5.1 Definitions for Characterization of Residual Effects

In order to determine the significance of Project residual effect, each potential negative residual effect is characterized by a number of attributes consistent with those defined in of the EIS guidelines (Section 7.14, Significance Determination for the Hope Bay Project; NIRB 2012a). A definition for each attribute and the contribution that it has on significance determination is provided in Table 1.5-19.

Table 1.5-19. Attributes to Evaluate Significance of Potential Residual Effects

Attribute	Definition and Rationale	Impact on Significance Determination
Direction	The ultimate long-term trend of a potential residual effect - positive, neutral, or negative.	Positive, neutral, and negative potential effects on the surface hydrology VEC are assessed, but only negative residual effects are characterized and assessed for significance.
Magnitude	The degree of change in a measurable parameter or variable relative to existing conditions. This attribute may also consider complexity - the number of interactions (Project phases and activities) contributing to a specific effect.	The higher the magnitude, the higher the potential significance.
Duration	The length of time over which the residual effect occurs.	The longer the length of time of an interaction, the higher the potential significance.
Frequency	The number of times during the Project or a Project phase that an interaction or environmental/ socio-economic effect can be expected to occur.	Greater the number times of occurrence (higher the frequency), the higher the potential significance.
Geographic Extent	The geographic area over which the interaction will occur.	The larger the geographical area, the higher the potential significance.
Reversibility	The likelihood an effect will be reversed once the Project activity or component is ceased or has been removed. This includes active management for recovery or restoration.	The lower the likelihood a residual effect will be reversed, the higher the potential significance.

For the determination of significance, each attribute is characterized. The characterizations and criteria for the characterizations are provided in Table 1.5-20. Each of the criteria contributes to the determination of significance.

Due to inherent data and modelling uncertainty in hydrologic studies, it is reasonable to account for at least a 5% error in hydrologic estimates. Therefore, it was assumed that any streamflow change less than 5% of the baseline flows could be an artifact of data and/or modelling uncertainty, and hence, was considered as a negligible change (Table 1.5-20). A variation of 10% from baseline conditions was assumed to be within the natural variability of the riverine system and, therefore, streamflow effects of less than 10% are *low* magnitude. This is in agreement with recommendations from the Science Advisory Secretariat, Fisheries and Oceans Canada (DFO 2013b), and with recent EIS studies in the region (e.g., Back River and Mary River). The relative values of *high* and *low* magnitude effects (i.e., 50% and 10%) were aligned with recent EIS studies in the region (e.g., Back River and Mary River).

Table 1.5-20. Criteria for Residual Effects for Environmental Attributes

Attribute	Characterization	Criteria[1]
Direction	Positive	Beneficial
	Variable	Both beneficial and undesirable
	Negative	Undesirable
Magnitude	Negligible	The change in streamflow is not detectable (i.e., less than 5% of the baseline flow)
	Low	The change in streamflow is less than 10% of the baseline flow[1]
	Moderate	The change in streamflow is between 10% and 50% of the baseline flow
	High	The change in streamflow is greater than 50% of the baseline flow
Duration	Short	Up to 4 years (Construction phase)
	Medium	Greater than 4 years and up to 17 years (4 years Construction phase, 10 years Operation phase, 3 years Reclamation and Closure phase)
	Long	Beyond the life of the Project
Frequency	Infrequent	Occurring only occasionally
	Intermittent	Occurring during specific points or under specific conditions during the Project
	Continuous	Continuously occurring throughout the Project life
Geographic Extent	Project Development Area (PDA)	Confined to the PDA
	Local Study Area (LSA)	Beyond the PDA and within the LSA
	Regional Study Area (RSA)	Beyond the LSA and within the RSA
	Beyond Regional	Beyond the RSA
Reversibility	Reversible	Effect reverses within an acceptable time frame with no intervention
	Reversible with effort	Active intervention (effort) is required to bring the effect to an acceptable level
	Irreversible	Effect will not be reversed

[1] *Established by fish habitat requirements (DFO 2013b)*

1.5.5.2 Determining the Significance of Residual Effects

Section 7.14 of the EIS guidelines provided guidance, attributes, and criteria for the determination of significance for residual effects (NIRB 2012a). Also, the Canadian Environmental Assessment Agency's

Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects (CEA Agency 1992) guided the evaluation of significance for identified residual effects. The significance of residual effects is based on comparing the predicted state of the environment with and without the Project, including a judgment as to the importance of the changes identified.

Probability of Occurrence or Certainty

Prior to the determination of the significance for negative residual effects, the probability of the occurrence or certainty of the effect is evaluated. For each negative residual effect, the probability of occurrence is categorized as unlikely, moderate or likely. Table 1.5-21 presents the definitions applied to these categories.

Table 1.5-21. Definition of Probability of Occurrence and Confidence for Assessment of Residual Effects

Attribute	Characterization	Criteria
Probability of occurrence or certainty	Unlikely	Some potential exists for the effect to occur; however, current conditions and knowledge of environmental trends indicate the effect is unlikely to occur.
	Moderate	Current conditions and environmental trends indicate there is a moderate probability for the effect to occur.
	Likely	Current conditions and environmental trends indicate the effect is likely to occur.
Confidence	High	Baseline data are comprehensive; predictions are based on quantitative predictive model; effect relationship is well understood.
	Medium	Baseline data are comprehensive; predictions are based on qualitative logic models; effect relationship is generally understood, however, there are assumptions based on other similar systems to fill knowledge gaps.
	Low	Baseline data are limited; predictions are based on qualitative data; effect relationship is poorly understood.

Determination of Significance

Significance of a residual effect on surface hydrology depends on the magnitude and other attributes of the effect. If the magnitude is *negligible* or *low*, the effect will be characterized as **not significant**, because streamflow alteration will be within the natural variation. If the magnitude is *high* and the effect is beyond the LSA, the effect will be characterized as **significant**, because such an effect would mean substantial change in hydrologic regime beyond the LSA.

If the magnitude is *moderate*, significance determination will depend on other attributes, and will become more subjective. Key attributes to consider are reversibility, duration, and geographic extent. A key consideration that can further qualify a *moderate* magnitude effect is its pathway to other VECs. For example, a *moderate* magnitude streamflow reduction that has a potential for fish habitat loss can be characterized differently depending on whether the application of fisheries offsetting has the potential to mitigate effects on the freshwater fish VECs of fish habitat and fish community.

Confidence

The knowledge or analysis that supports the prediction of a potential residual effect, in particular with respect to limitations in overall understanding of the environment and/or the ability to foresee future events or conditions, determines the confidence in the determination of significance. In general, the lower the confidence, the more conservative the approach to prediction of significance must be. The level of confidence in the prediction of a significant or non-significant potential residual effect qualifies the determination, based on the quality of the data and analysis and their extrapolation to the predicted residual effects. *Low* is assigned where there is a low degree of confidence in the inputs, *medium* when there is moderate confidence and *high* when there is a high degree of confidence in the inputs. Where rigorous baseline data were collected and scientific analysis performed, the degree of confidence will generally be *high*. Table 1.5-21 provides descriptions of the confidence criteria.

The water balance model used industry standard modelling software to support the assessment process, including the investigation of dry and wet climate sensitivities. Therefore, there is *high* confidence in the results of this residual effects assessment for predicted effects on surface hydrology.

Residual effects identified in the Project-related effects assessment are carried forward to assess the potential for cumulative interactions with the residual effects of other projects or human activities and to assess the potential for transboundary impacts should the effects linked directly to the activities of the Project inside the Nunavut Settlement Area (NSA), which occurs across provincial, territorial, international boundaries or may occur outside of the NSA.

1.5.5.3 Characterization of Residual Effect for Surface Hydrology VEC

Streamflow Alteration in Doris Watershed

Residual effects on streamflow are anticipated during the Construction and Operation phases, with maximum effects during the last two years of Operation. Streamflows are predicted to be 10 to 50% lower than baseline flows (Table 1.5-3). Therefore, magnitude of the residual effect is *moderate*.

The *negative* effects are expected to be *regional*, *medium-term* in duration, and *continuous* as water withdrawal from lakes and water loss to talik are continuous. Surface hydrology has the capacity to recover and the effects are expected to be fully *reversible*. The probability of occurrence is estimated to be *likely*, and confidence was *high* because of the quantitative input from the baseline environmental data and water balance model, and the confidence in the mitigation and management strategies.

Streamflow reduction in Doris Watershed has the potential to affect fish habitat in Doris Lake Outflow and Little Roberts Outflow. However, fisheries offsetting may feasibly be applied to mitigate effects on freshwater fish VECs (including fish habitat and fish community) through the implementation of a Fisheries Offsetting Plan, as deemed necessary by DFO (Volume 5, Section 6). Therefore, the residual effect of the Project is concluded to be **Not Significant** on surface hydrology.

As previously mentioned (Section 1.5-4) this characterization was based on the Hope Bay Project (Phase 2 in combination with existing and permitted projects), but is conservatively also used for Phase 2 in isolation of existing and permitted projects.

Streamflow Alteration in Windy Watershed

Residual effects on streamflow are anticipated during the Construction and Operation phases. Streamflow reductions compared to baseline are predicted to be less than 10% under average climate conditions (Table 1.5-4). Therefore, magnitude of the residual effect is *low*.

The *negative* effects are expected to be *local*, *medium-term* in duration, and *continuous* as water withdrawal from lakes and water loss to talik are continuous. Surface hydrology has the capacity to recover and the effects are expected to be fully *reversible*. The probability of occurrence is estimated to be *likely*, and confidence was *high* because of the quantitative input from the baseline environmental data and water balance model, and the confidence in the mitigation and management strategies.

Based on the abovementioned attributes, the residual effect of the Project is concluded to be **Not Significant** on surface hydrology.

As previously mentioned (Section 1.5-4) this characterization was based on the Hope Bay Project (Phase 2 in combination with existing and permitted projects), but is conservatively also used for Phase 2 in isolation of existing and permitted projects.

<u>Streamflow Alteration in Aimaokatalok Watershed</u>

Residual effects on streamflow are anticipated during the Construction and Operation phases. Streamflow reductions compared to baseline are predicted to be less than 10% (Table 1.5-5). Therefore, magnitude of the residual effect is *low*.

The *negative* effects are expected to be *local*, *medium-term* in duration, and *continuous* as water withdrawal is continuous. Surface hydrology has the capacity to recover and the effects are expected to be fully *reversible*. The probability of occurrence is estimated to be *likely*, and confidence was *high* because of the quantitative input from the baseline environmental data and water balance model, and the confidence in the mitigation and management strategies.

Based on the abovementioned attributes, the residual effect of the Project is concluded to be **Not Significant** on surface hydrology.

As previously mentioned (Section 1.5-4) this characterization was based on the Hope Bay Project (Phase 2 in combination with existing and permitted projects), but is conservatively also used for Phase 2 in isolation of existing and permitted projects.

1.6 CUMULATIVE EFFECTS ASSESSMENT

The potential for cumulative effects arises when the potential residual effects of the Project affect (i.e., overlap and interact with) the same surface hydrology VEC that is affected by the residual effects of other past, existing or reasonably foreseeable projects or activities.

1.6.1 Methodology Overview

1.6.1.1 Approach to Cumulative Effects Assessment

The general methodology for cumulative effects assessment (CEA) is described in Volume 2, Section 4, and focuses on the following activities:

1. Identify the potential for Project-related (Phase 2 and the complete Hope Bay Project) residual effects to interact with residual effects from other human activities and projects within specified assessment boundaries. Key potential residual effects associated with past, existing, and reasonably foreseeable future projects were identified using publicly available information or, where data was unavailable, professional judgment was used (based on previous experience in similar geographical locations) to approximate expected environmental conditions.
2. Identify and predict potential cumulative effects that may occur and implement additional mitigation measures to minimize the potential for cumulative effects.
3. Identify cumulative residual effects after the implementation of mitigation measures.
4. Determine the significance of any cumulative residual effects.

Table 1.5-22. Summary of Residual Effects and Overall Significance Rating for Surface Hydrology - Phase 2

Residual Effect	**Attribute Characteristic**						**Overall Significance Rating**		
	Direction *(positive, variable, negative)*	**Magnitude** *(negligible, low, moderate, high)*	**Duration** *(short, medium, long)*	**Frequency** *(infrequent, intermittent, continuous)*	**Geographic Extent** *(PDA, LSA, RSA, beyond regional)*	**Reversibility** *(reversible, reversible with effort, irreversible)*	**Probability** *(unlikely, moderate, likely)*	**Significance** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Alteration Streamflow in Doris Watershed	Negative	Moderate	Medium	Continuous	RSA	Reversible	Likely	Not significant	High
Alteration Streamflow in Windy Watershed	Negative	Low	Medium	Continuous	LSA	Reversible	Likely	Not significant	High
Alteration Streamflow in Aimaokatalok Watershed	Negative	Low	Medium	Continuous	LSA	Reversible	Likely	Not significant	High

Table 1.5-23. Summary of Residual Effects and Overall Significance Rating for Surface Hydrology - Hope Bay Project

Residual Effect	Attribute Characteristic						Overall Significance Rating		
	Direction *(positive, variable, negative)*	**Magnitude** *(negligible, low, moderate, high)*	**Duration** *(short, medium, long)*	**Frequency** *(infrequent, intermittent, continuous)*	**Geographic Extent** *(PDA, LSA, RSA, beyond regional)*	**Reversibility** *(reversible, reversible with effort, irreversible)*	**Probability** *(unlikely, moderate, likely)*	**Significance** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Alteration Streamflow in Doris Watershed	Negative	Moderate	Medium	Continuous	RSA	Reversible	Likely	Not significant	High
Alteration Streamflow in Windy Watershed	Negative	Low	Medium	Continuous	LSA	Reversible	Likely	Not significant	High
Alteration Streamflow in Aimaokatalok Watershed	Negative	Low	Medium	Continuous	LSA	Reversible	Likely	Not significant	High

1.6.1.2 Assessment Boundaries

The CEA considers the spatial and temporal extent of Project-related residual effects on the surface hydrology VEC combined with the anticipated residual effects from other projects and activities to assist with analyzing the potential for a cumulative effect to occur.

Spatial Boundaries

The spatial boundary for the CEA was the assessment Regional Study Area (RSA; Figure 1.4-1). This study area contains the LSA and was determined to cover the extent of direct and indirect effects of the Project on the freshwater environment.

Temporal Boundaries

The temporal boundaries of the CEA were defined by the timelines for Past, Existing, and Reasonably Foreseeable Projects as described in the CEA methodology (Volume 2, Section 4). These timelines were compared to the Project timeline (Section 1.4.3).

1.6.2 Potential Interactions of Residual Effects with Other Projects

The mining industry is the main source of industrial activity in Nunavut, which is being explored for uranium, diamonds, gold and precious metals, base metals, iron, coal, and gemstones. In addition to major mining development projects, other land use activities are also present in the territory and, as required under Section 7.11 of the Project EIS guidelines, were considered for potential interactions with the Project (see Volume 2, Section 4 for more details).

No past, present, or foreseeable projects that could potentially interact with the residual effects of the Hope Bay Project lie within the freshwater assessment RSA. Therefore, no cumulative effects to the surface hydrology VEC were predicted.

1.7 TRANSBOUNDARY EFFECTS

The Project EIS guidelines define transboundary effects as those effects linked directly to the activities of the Project inside the NSA, which occur across provincial, territorial, international boundaries or may occur outside of the NSA (NIRB 2012a). Transboundary effects of the Project have the potential to act cumulatively with other projects and activities outside the NSA.

The watersheds that have potential interaction with a Project component(s) or physical activity drain into Roberts Bay and Hope Bay; these watersheds lie entirely within Nunavut, and therefore no potential for transboundary effects was identified.

1.8 IMPACT STATEMENT

The surface hydrology VEC was identified because surface water flow is a key component of the biophysical environment. It is linked to other components of the aquatic ecosystem including surface water quality, fish, fish habitat, and aquatic resources. The Inuit identify rivers and lakes as important sources of drinking water and fish habitat. Surface water is also protected by the *Canada Water Act* (1985).

Baseline studies included monitoring streamflow during the open-water season using hydrometric stations. A water balance model was developed to simulate both baseline and project-affected flows; the water balance model accounted for climate change with predicted increases to temperature and precipitation.

The Project has the potential to interact with surface hydrology through a number of activities including water withdrawal from lakes, construction and use of underground mines, and modification of natural drainages. These activities have the potential to alter streamflow in Doris, Windy, and Aimaokatalok watersheds.

Mitigation measures include use of existing infrastructure, minimization of Project footprint, recycle and reuse of contact water, adherence to regulatory requirements and permit conditions, sufficient contact water storage capacity, implementation of erosion control plans, water management inspections, and use of groundwater to minimize freshwater use.

Residual effects on surface hydrology, after implementation of mitigation measures, are:

- *Alteration of streamflow in Doris Watershed*
- *Alteration of streamflow in Windy Watershed*
- *Alteration of streamflow in Aimaokatalok Watershed*

Water balance modelling results showed that the alteration of streamflow at Windy and Aimaokatalok watersheds would be within the natural variation of streamflow.

Streamflow alteration at Doris watershed would be beyond the natural variation of flow, and has the potential to affect fish and fish habitat. However, as described in the freshwater fish effects assessment (Volume 5, Section 6), fisheries offsetting may feasibly be applied to mitigate effects on freshwater fish VECs due to flow reduction through the implementation of a Fisheries Offsetting Plan, as deemed necessary by DFO. Therefore, effects of the Project on surface hydrology would be **Not Significant**.

No cumulative effects are predicted to occur because the surface hydrology residual effects are not predicted to overlap spatially with any other past, existing, or reasonably foreseeable project. Similarly, no transboundary effects are identified.

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