

***Mount Nansen
Hydro-meteorology Baseline Report***

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1. Introduction

1. Introduction

Yukon Government, Assessment and Abandoned Mines (AAM) is preparing an assessment of proposed care and maintenance activities at the Mount Nansen Site (the Site), an abandoned gold and silver mine located approximately 45 km (70 km by road) west of Carmacks, Yukon as shown in Figure 1-1.

As part of the project proposal process, Lorax Environmental (Lorax) was retained by AAM to describe existing environmental conditions related to hydrology and meteorology at the Site for the purpose of informing the assessment process. This report describes the results of that work.

1.1 Scope of Report

For the meteorology discipline, this report presents air temperature, precipitation (rain and snow) and potential evaporation estimates for the Site. Air temperature, precipitation and potential evaporation estimates are compared to long-term regional climate records where appropriate to do so. Additionally, relative humidity, wind, atmospheric pressure and radiation data (*i.e.*, net longwave, net shortwave and net radiation) are summarized to the extent required to inform evaporation estimates. For the hydrology discipline, this report presents a summary of recent streamflow data collected at the Site, with a focus on the continuous data collected from 2014 to 2016. This time period was selected as it represents the most recent monitoring data, the collection and analysis of which is considered to be of high quality (*i.e.*, a mostly continuous streamflow record, and rating curves with low error; < 10% on average). Like the meteorology discipline, Site hydrology is characterized by drawing upon regional streamflow data from stations near Mount Nansen.

An overview of the climate and streamflow monitoring programs is provided in Section 2.1 and Section 2.2. Methodologies and assumptions related to the collection, analysis and presentation of climate and streamflow data are presented in Section 2.3. Methods for the measurement of streamflow and stage (*i.e.*, both spot and continuous) are presented in Appendix A, along with the approach used to develop the rating curves for each station, paired stage-discharge measurements, and associated rating curve error. Stage record corrections (*e.g.*, due to station relocation, staff gauge frost jacking, channel aggradation, *etc.*) are also presented in Appendix A.

In Section 3.1, the following information is presented:

- Air temperature data for the Site and a comparison of these data to long-term air temperature record for two regional climate stations (Pelly Ranch, Carmacks);

- Precipitation data (*i.e.*, snowfall, rainfall) for the Site and a comparison of these data to records collected at Pelly Ranch, Carmacks and Carmacks CS;.
- Continuous snow depth and ablation (snowpack melt) data collected at the Site climate station since October 2011;
- A brief discussion of relative humidity, wind speed, barometric pressure and radiation (*i.e.*, net longwave, net shortwave and net radiation) collected at the property; and
- A summary of regional evapotranspiration and lake evaporation estimates and presentation of potential evaporation estimates from the Site that were computed with Site-specific climate data.

In Section 3.2, streamflow data is presented in the following formats:

- Monthly tables showing average, maximum and minimum 15-minute discharge values (m^3/s);
- Monthly tables showing average discharge (m^3/s), average unit yields ($\text{L}/\text{s}/\text{km}^2$) and total runoff (mm);
- Time-series plots of continuous average daily discharge (m^3/s) and spot flow measurements (m^3/s);
- Time series plots of average daily unit yields ($\text{L}/\text{s}/\text{km}^2$), by year, and;.
- Regional analyses and recurrence interval estimates for mean annual runoff, peak flows and low flows (annual and June to September), presented in tabular and graphical formats.

1.2 Project Area Drainage Characteristics

The Mount Nansen Site is situated within the Victoria Creek watershed, a tributary of the Nisling River, which in turn, is a medium sized basin located in the larger Donjek/White Rivers basin. The White River flows north into the Yukon River, which flows northwest into Alaska and into the Bering Sea. Carmacks is the nearest town, located approximately 45 km east of the Site.

The streamflow regime at the Site is dominated by spring snowmelt-driven freshet, followed by a rapid recession to summer low-flows maintained by groundwater and interflow discharging to the local stream channels. Low-flows are punctuated by intermittent rainfall-driven peak flow events that generally last for several days and are followed by a rapid recession. Icing begins in the smaller stream channels in October, and some sections of Dome Creek freeze to the bed (*e.g.*, DC-DX). The lower sections of Dome

Creek freeze to bed slightly later in the year (e.g., DC-B and DC-R, in November), while other sections still show some flows throughout the winter season (e.g., DC-DX+105 and DC-U). The exception to this freezing regime is the discharge from the seepage collection pond (herein referred to by its station identifier SEEP), where discharges are more constant year-round. In the winter, seep discharge subsequently freezes and glaciates a portion of Dome Creek downstream of SEEP. The channel icing (shelf ice, as well as sporadic aufeis) melts during the freshet, and contributes to streamflows into May and at some years into June.

1.2.1 Study Area

The Order In Council (OIC) boundary encompasses the upper portion of the Pony Creek Watershed, the entirety of the Dome Creek Watershed, and a small portion of Victoria Creek, upstream of the confluence with Dome Creek, to just upstream of the Back Creek confluence. The Local Study Area (LSA) boundary is generally coincident with the OIC boundary, as is the case for the Surface Water Quality baseline study. For the purposes of the hydrology baseline report, the Project site drainages (described below) are of greatest interest, followed by Victoria Creek, which forms the receiving environment for all Project related drainage.

The Site itself is drained primarily by two small creeks – Dome Creek (4.5 km²) and Pony Creek (1.7 km²) (Figure 1-2). Most of the Site footprint is located within the Dome Creek watershed. The headwaters of Dome Creek are located above the mill site where the creek flows eastward past the Tailings Storage Facility (TSF) via a diversion channel (on the northern side of the TSF) and continues eastward and then southeastward to its confluence with Victoria Creek. The lower portion of Dome Creek receives flow from the diversion channel, as well as from the TSF seepage pond, which is pumped into the creek upstream of the confluence with the diversion channel. Channel icing (aufeis) is extensive throughout the Dome Creek drainage, and the stream channel is typically frozen to bed throughout the winter. The seepage pond continues to accumulate water throughout the winter and is continuously pumped to Dome Creek where it freezes. At the Mount Nansen access road crossing of the creek, this accumulation of aufeis often leads to ice blockage in the culvert and build-up on the road. The melt of this aufeis, including the accumulated ice formed from the seepage pond outflows, typically leads to high flows in May and at times in June.

Pony Creek is a small ephemeral stream located to the north of the Dome Creek drainage, and drains part of the Site north of the Brown-McDade Pit. This creek flows southeast to its confluence with Back Creek via a poorly defined channel that freezes to the bottom during the winter. Pony Creek has been modified by historical mining activity, including ongoing placer mining (EDI, 2014a), trenching, exploration roads, waste rock piles, earth

berms, gravel quarries, and old adit and core shacks (EDI, 2012a). Upstream of the confluence with Back Creek, Pony Creek flows through a fan, and the stream is characterized by both gaining (re-emergence of sub-surface flow) and losing (to sub-surface flow paths) reaches. A previous study (AECOM, 2010b) provided evidence for shallow groundwater flow paths via fractured bedrock between the Pony Creek and Brown-McDade Pit. These pathways were noted to activate during high flow events in response to rainfall and spring snowmelt events. When activated, surface flows in Pony Creek recharge shallow groundwater flowpaths which discharge to the Brown-McDade Pit via the north wall (AECOM, 2010b). More recently, placer mining activity and associated water diversions in Pony Creek have diverted this flowpath, removing a source of water reporting to the pit, and resulting in historically low pit water levels. Information for Pony Creek is not presented in this report because very little continuous data is available for the stream. Further, its flow path (i.e. outside of most Project components) and physical characteristics (described above) made it not useful to the water quality modelling component of the Project.

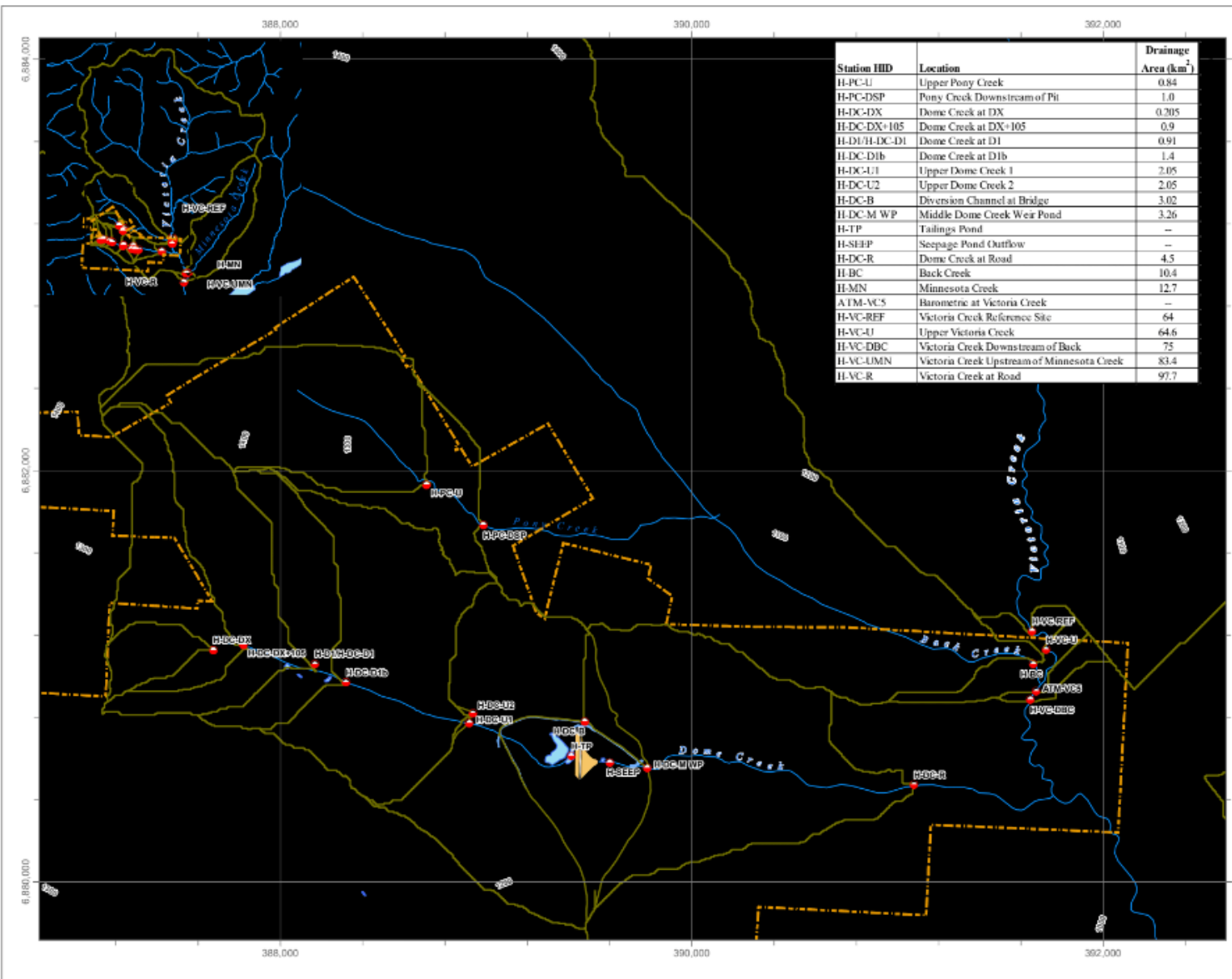
Victoria Creek is the largest watershed considered in this assessment, and has a drainage area of 112 km² at its confluence with the Nisling River. In the context of the local drainages, Back Creek, Dome Creek, Dry Creek (located downstream of the Site), and Minnesota Creek are all tributaries of Victoria Creek.

Back Creek is a small drainage (10.4 km²) located north of the Site, and flows southeast to the eastern edge of the Order In Council (OIC) boundary and into Victoria Creek upstream of the pumphouse (artesian well water source). The upper and mid-sections of Back Creek are influenced by active placer mining operations, resulting in high suspended sediment loads in this stream during the open water period. These high sediment loads have resulted in the water level logger located at the H-BC station being silted in on several occasions (AECOM, 2010a). Back Creek is also subject to aufeis formation, and the channel typically freezes to substrate by mid-October, until it melts in early May.

South of the Dome Creek confluence, Minnesota Creek (having a drainage area of 12.7 km²) joins Victoria Creek on the eastern side, upstream of the Mount Nansen access road crossing. This drainage is not influenced by the Mount Nansen mining activities, and is gauged primarily as a reference stream. Data from this station are not presented in this report, as they are not directly relevant to the water balance and water quality modelling effort completed in support of this application.



Figure 1-1: Mount Nansen Location Map



Station ID	Location	Drainage Area (km ²)
H-PC-U	Upper Pony Creek	0.84
H-PC-DSP	Pony Creek Downstream of Pit	1.0
H-DC-DX	Dome Creek at DX	0.205
H-DC-DX+105	Dome Creek at DX+105	0.9
H-DU/H-DC-D1	Dome Creek at D1	0.91
H-DC-D1b	Dome Creek at D1b	1.4
H-DC-U1	Upper Dome Creek 1	2.05
H-DC-U2	Upper Dome Creek 2	2.05
H-DC-B	Diversion Channel at Bridge	3.02
H-DC-M WP	Middle Dome Creek Weir Pond	3.26
H-TP	Tailings Pond	--
H-SEIP	Seepage Pond Outflow	--
H-DC-R	Dome Creek at Road	4.5
H-BC	Back Creek	10.4
H-MN	Minnesota Creek	12.7
A1M-VC5	Barometric at Victoria Creek	--
H-VC-REF	Victoria Creek Reference Site	64
H-VC-U	Upper Victoria Creek	64.6
H-VC-DBC	Victoria Creek Downstream of Back	75
H-VC-UMN	Victoria Creek Upstream of Minnesota Creek	83.4
H-VC-R	Victoria Creek at Road	97.7

LEGEND

- Hydrometric Station
- Mount Nansen OIC Boundary
- Catchment Boundary
- Mill Area
- Mine Camp Area
- Tailings Dam
- Tailings
- Pond
- Pit Outline
- Waste Rock Area
- 100m Contour
- 20m Contour

Coordinate System: NAD 1983 UTM Zone 8N
 Projection: Transverse Mercator
 Datum: North American 1983
 Units: Meter
 1:17,500

DATE SAVED: Mar 10, 2017
 DRAWN BY: GM
 REVIEWED: SJ
 VERSION: 1



PROJECT:

**Mount Nansen
Project Proposal**

TITLE:
Hydrology Monitoring Catchments
and Hydrometric Station Network

PROJECT # A422-1 FIGURE 1-2

2. Climate and Streamflow Monitoring Programs

2. Climate and Streamflow Monitoring Programs

2.1 Baseline Meteorological Study

Over the years, climate data have been collected at the Site by several entities, including Gartner Lee, AECOM and AMEC). Most recently, climate data were collected by Northern Avcom and Environmental Dynamics Inc. (EDI), who were retained by Yukon Government, Assessment and Abandoned Mines Branch (AAM) beginning in 2011. EDI has submitted monitoring reports (*e.g.*, annual reporting for 2011 and 2012; monthly reporting for 2015-16) to AAM since the initiation of their contract in 2011, and the reader is referred to these reports for more detail on the annual conditions at Site and monitoring network status and changes. Additionally, the baseline meteorological study draws upon the following data sources and/or technical summaries:

- Environmental Dynamics Inc. (EDI) (2016). *Mount Nansen Water Resources Investigations 2016/17: Methodology*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. July 2016.
- AMEC (2014) Mount Nansen Site Characterization Report. Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, YT.
- AECOM (2010c). Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation (Appendix D) in LORAX 2011 Mount Nansen Options for Closure. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon.

2.1.1 Site Meteorological Data

A climate station (ATM-ROAD AAM) was installed to specifically support this phase of permitting at Mount Nansen. The climate station was installed by EDI Environmental Dynamics Inc. in October 2011 and is situated at elevation 1,255 meters above mean sea level (m asl). Figure 2-1 shows the location of several Site-specific snow course stations sampled during the period of baseline study, as well as the location of a nearby long-term snow course monitoring station (SC-AIR or 09CA-SC01) maintained by the Yukon Government. The 09CA-SC01 snow course is situated approximately 5 km from the ATM-ROAD AAM climate station.

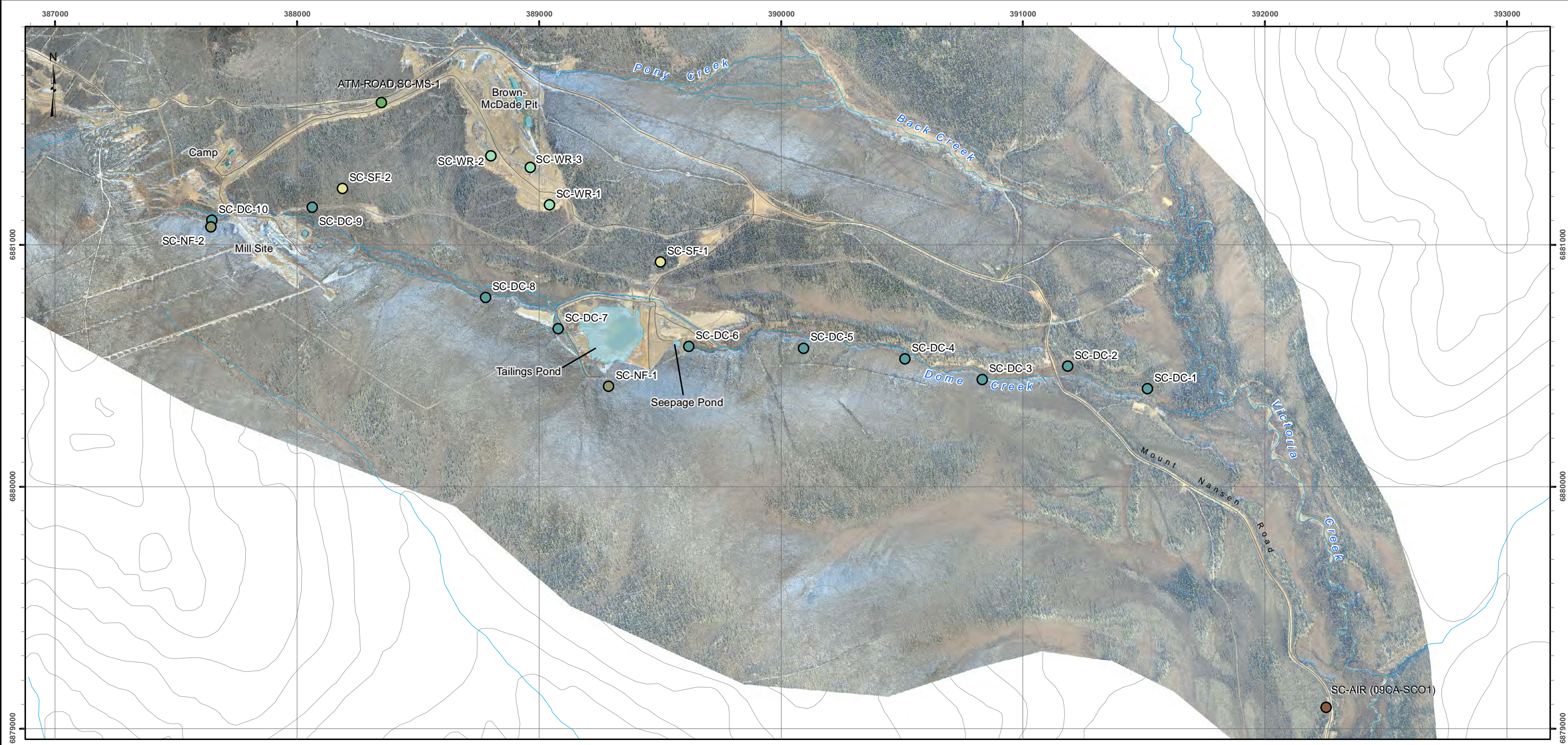


Figure 2-1: Map of Mount Nansen Climate Station (ATM-ROAD AAM) and Snow Course Locations

Legend

- Airport
- Met Stn
- North Facing
- South Facing
- Valley Transect
- Waste Rock
- Unpaved Road/Access
- Contours
- Watercourse
- Waterbody (pit pond and tailings)

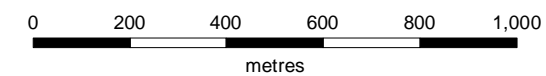
1:250,000 topographic spatial data: Canvec and National Topographic Database (NTDB); courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

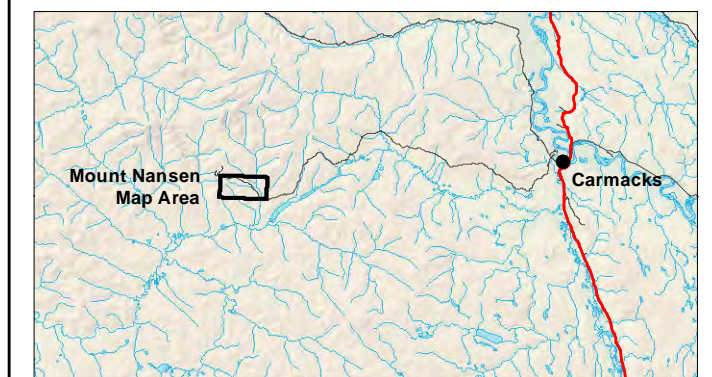
Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2011) was obtained using Garmin GPS technology.

This document is not an official land survey and the spatial data presented is subject to change.

Modified from:
Figure 3. Dome Creek Snow Sampling Stations in the Mount Nansen Site Area. Mount Nansen Snow Survey Program 2011-12(p.17). Environmental Dynamics Inc. July 2012



Map Scale = 1:16,000 (printed on 11 x 17)
Map Projection: North American Datum 1983 UTM Zone 8N



A Campbell Scientific climate station was established at ATM-ROAD AAM to measure air and ground temperature, relative humidity, rainfall, snow depth, net shortwave and longwave radiation, net radiation, wind speed, and wind direction. Additionally, a barometric logger is installed at ATM-ROAD AAM which collects barometric pressure and air temperature data that is relevant to the baseline hydrology program. Table 2-1 is reproduced from EDI (2015) and summarizes climate data parameters, sampling frequencies and reporting protocols for the measurements collected at the Mount Nansen climate station.

The period of record at ATM-ROAD AAM presented within this report covers October 20, 2011 through to October 31, 2016 excluding a data gap in 2014 (January 3 to April 8, 2014) during which time climate sensors were factory calibrated. Routine maintenance of the climate station (*e.g.*, checking sensor cables for wear, cleaning solar panel and sensors of snow/debris, calibrating sensors, replacing and upgrading hardware as required) was performed by Northern Avcom during regularly scheduled Site visits. Offloaded data from the ATM-ROAD AAM datalogger were compiled to a central database with basic quality control/quality assurance performed following protocols outlined in EDI (2015).

2.1.2 Site Snow Course Stations

For one winter (*i.e.*, November 2010 through May 2011), an intensive set of snow depth and snow water equivalent (SWE) measurements were made across the property (EDI, 2012b). Specifically, snow course stations established at 19 locations were sampled on eight occasions (Table 2-2). Selected snow course stations spanned an elevation gradient of ~250 m (*i.e.*, stations elevations ranged from 1,000 to 1,250 m asl) and represented various aspects (*e.g.*, north facing versus south facing slopes) and representative cover types (*e.g.*, natural/undisturbed versus exposed waste rock). Included in the list of 19 locations was a snow course established adjacent to the ATM-ROAD AAM climate station (labelled ATM-ROAD, SC-MS-1 on Figure 2-1).

Snow course measurements were carried out at the Site following the British Columbia Ministry of Environment (BC MOE, 1981) protocols (*i.e.*, sampling locations along a transect were each sampled for depth and snow water equivalent [SWE] then averaged to a composite value). Maximum SWE accumulation is typically realized in the Yukon, and at Mount Nansen, by the end of March of each year. Therefore, to enable direct comparisons between Site and regional SWE data, March 1 and April 1 snow course measurements at the Site were scheduled to correspond closely with timing of snow course sampling dates at stations maintained by the Yukon Government.

**Table 2-1:
 Summary of climate data parameters, sampling frequencies and reporting protocols for measurements collected at Mount Nansen climate station (ATM-ROAD AAM) – modified from EDI (2015).**

Reporting Time-step	Meteorological Parameter	Units	Notes
Daily	Air temperature (Maximum)	°C	Measured every 5 minutes; Daily maximum value is reported
	Air temperature (Minimum)	°C	Measured every 5 minutes; Daily minimum value is reported
	Relative humidity (Maximum)	%	Measured every 5 minutes; Daily maximum value is reported
	Relative humidity (Minimum)	%	Measured every 5 minutes; Daily minimum value is reported
	Snow depth	cm	Reports the depth of snow at the end of the day
	Battery voltage	V	Measured every 5 minutes; Daily minimum value is reported
Hourly	Net shortwave radiation	W/m ²	Measured every 5 minutes; Hourly average is reported
	Net longwave radiation	W/m ²	Measured every 5 minutes; Hourly average is reported
	Net total radiation	W/m ²	Measured every 5 minutes; Hourly average is reported
	Wind speed	m/s	Measured every 5 minutes; Hourly average is reported
	Wind direction	degrees	Measured every 5 minutes; Hourly average is reported
	Rainfall	mm	Total hourly rainfall
	Snow depth	cm	Hourly sample recorded
	Air temperature	°C	Measured every 5 minutes; Hourly average is reported
	Relative humidity	%	Measured every 5 minutes; Hourly average is reported
	Ground temperature at the surface	°C	Hourly sample recorded
	Barometric pressure	mbar	Hourly sample recorded

**Table 2-2:
Snow Course Stations – Mount Nansen Mine Site (2010-11)**

Station ID	Elevation (m)	Northing UTM	Easting UTM	2010		2011					
				Nov	Dec	Jan	Feb	Mar	Apr	Mid-Apr	May
SC-DC-01	1,015	391514	6880404	x	x	x	x	x	x	x	x
SC-DC-02	1,022	391184	6880497	x	x	x	x	x	x	x	x
SC-DC-03	1,034	390832	6880442	x		x	x	x	x	x	x
SC-DC-04	1,044	390513	6880527	x		x	x	x	x	x	x
SC-DC-05	1,068	390094	6880572			x	x	x	x	x	x
SC-DC-06	1,074	389619	6880578	x	x	x	x	x	x	x	x
SC-DC-07	1,104	389080	6880653	x	x	x	x	x	x	x	x
SC-DC-08	1,118	388780	6880782	x	x	x	x	x	x	x	x
SC-DC-09	1,181	388063	6881155		x	x	x	x	x	x	x
SC-DC-10	1,225	387649	6881101		x	x	x	x	x	x	x
SC-NF-1	1,117	389350	6880450		x	x	x	x	x	x	x
SC-NF-2	1,232	387670	6881070		x	x	x	x	x	x	x
SC-SF-1	1,134	389503	6880928			x	x	x	x	x	x
SC-SF-2	1,186	388189	6881231		x	x	x	x	x	x	x
SC-WR-1	1,191	389044	6881164	x	x	x	x	x	x	x	x
SC-WR-2	1,212	388802	6881366	x	x	x	x	x	x	x	x
SC-WR-3	1,214	388965	6881319	x	x	x	x	x	x	x	x
SC-Met	1,248	388350	6881586		x	x	x	x	x	x	x
SC-AIR	986	392251	6879088					x		x	

Notes:

x indicates the snow course station was sampled in 2010 and 2011.

2.1.3 Regional Meteorology Data

Climate data are available for the Yukon from monitoring networks operated by both Federal and Yukon Governments (Table 2-3, Table 2-4 and Figure 2-2). Regional climate data and snow course measurements are invaluable to place shorter climate records into a broader context.

Nearest climate stations to the Site include Pelly Ranch, Carmacks and the Carmacks CS climate stations (Table 2-3). There is a long history of monitoring (*i.e.*, 50+ years of record) at the Pelly Ranch and Carmacks climate stations. However, it is notable that neither station is actively reporting weather data (*i.e.*, Carmacks record ends in 2008, Pelly Ranch record ends in 2015). The Carmacks CS climate station remains operational in 2017, although precipitation data are available from July 2013 onward and the record for other parameters (*e.g.*, air temperature) dates to 2000 only.

There are five regional snow course stations within proximity to the Site (Table 2-4, Figure 2-2). The Williams Creek, Mount Berdoe, Satasha Lake, McIntosh and Mount Nansen snow course stations are operated by the Yukon Government and show record lengths that vary from 20 to 40 years. The Mount Nansen snow course station (09CA-SC01, elevation 1,021 m asl) is closest to the Site (~5 km away from ATM-ROAD AAM). Snow depth and SWE measurements are typically sampled four times each year at regional snow course stations (January 1, February 1, March 1, and April 1).

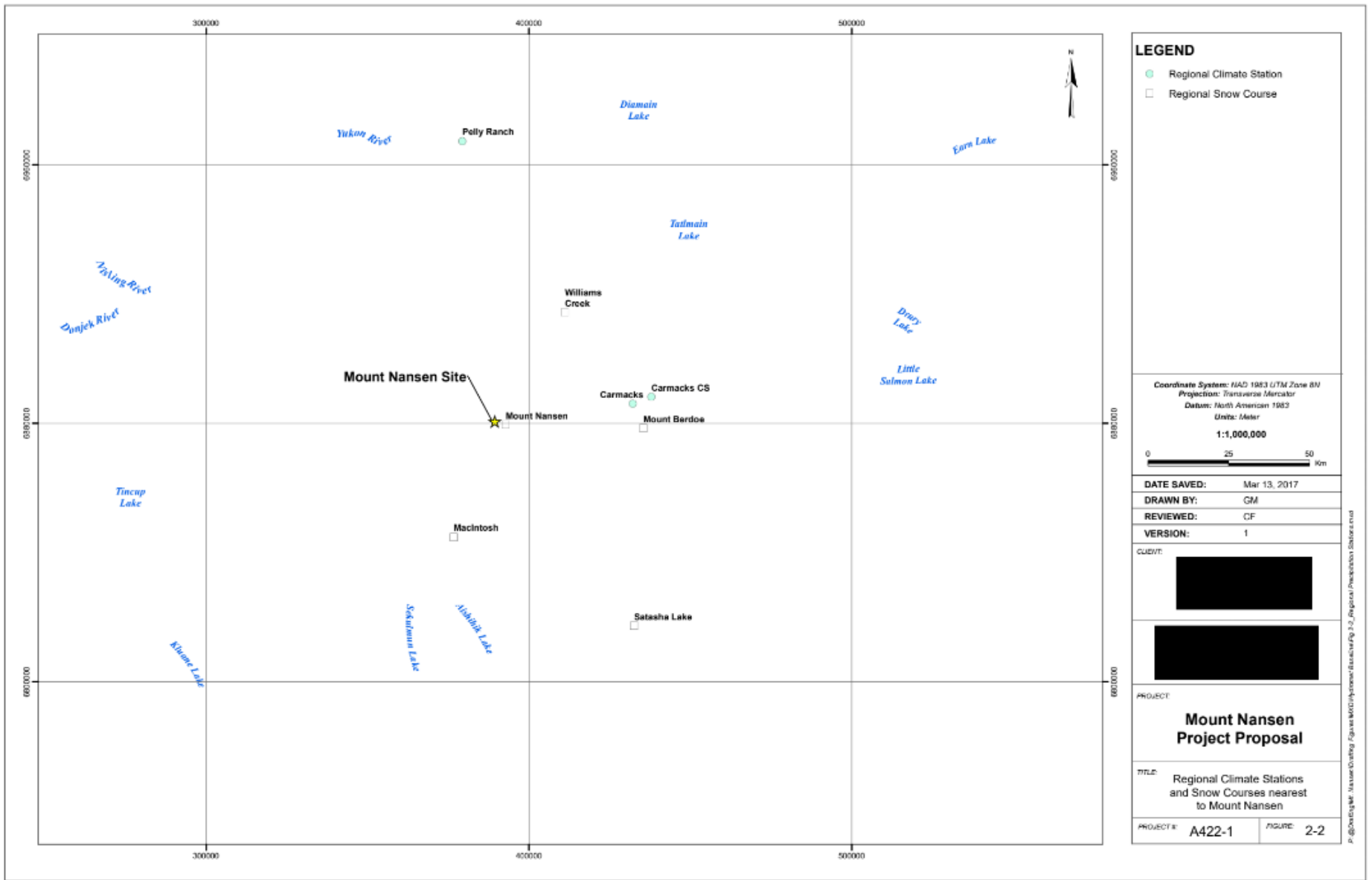
**Table 2-3:
Regional Climate Stations nearest Mount Nansen.**

Station Name	Distance to Site (km)	Latitude	Longitude	Elevation	Climate Identifier	Parameters	Frequency	Period of record
PELLY RANCH	90	62.83	-137.31	445	2100880	Air temperature (Min, Max, Avg), Total rain, Total snow, Total precip	Monthly, daily	1951 to 2015
CARMACKS	80	62.1	-136.3	525	2100300	Air temperature (Min, Max, Avg), Total rain, Total snow, Total precip	Monthly, daily	1963 to 2008
CARMACKS CS*	60	62.12	-136.19	543	2100301	Air temperature (Min, Max, Avg), Total rain, Total snow, Total precip	Hourly, daily	2000 to 2017

*Total precip data are limited at Carmacks CS (i.e., July 2013 to present).

**Table 2-4:
Regional Snow Courses nearest Mount Nansen.**

Station	ID	Distance to Site (km)	Elevation (m)	Latitude	Longitude	Record
Mount Berdoe	09AH-SC01	50	1,035	62° 02'	136° 14'	1976 to present
Satasha Lake	09AH-SC03	77	1,106	61° 29'	136° 16'	1987 to present
Williams Creek	09AH-SC04	41	914	60° 21'	136° 43'	1995 to present
Mount Nansen	09CA-SC01	5	1,021	62° 02'	137° 03'	1976 to present
MacIntosh	09CA-SC02	39	1,160	61° 43'	137° 20'	1976 to present



P:\04045\04045\Map\04045\Map\MCD\Hydro\Basin\Fig 2-2_Regional/Proposed/Station.mxd

2.2 Mount Nansen Site Hydrometric Network

2.2.1 Data Sources

Streamflow data has been collected by AECOM from 2009 to 2011 (AECOM, 2011), and most recently by Environmental Dynamics Inc. (EDI), who were retained by Yukon Government and Abandoned Mines (AAM) beginning in 2011. EDI has submitted monitoring reports (annual for 2011 and 2012, quarterly for 2013 to 2015, monthly for 2015/16) to AAM since the initiation of their contract in 2011, and the reader is referred to these reports for more detail on the annual conditions at Site and monitoring network status and changes.

The streamflow data collected at the Mount Nansen Site from 2009 up to and including 2014, has been previously summarized in the following reports:

- AECOM (2010). *Memorandum Re: Mount Nansen Hydrology Program Progress Summary (2009)*. Prepared for Assessment and Abandoned Mines Branch, Yukon Government. February 4, 2010.
- AECOM (2011). *Mount Nansen 2010 Hydrology Monitoring*. Prepared for Assessment and Abandoned Mines.
- AMEC (2014) Mount Nansen Site Characterization Report. Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, YT.
- AMEC (2014) Mount Nansen Remediation Project 30% Design Phase Report. Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, YT.
- Environmental Dynamics Inc. (EDI) (2012). *Mount Nansen Site Hydrologic Monitoring 2011-2012*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. May 2012.
- Environmental Dynamics Inc. (EDI) (2013). *Mount Nansen Site Data Report: Surface Water and Meteorological Monitoring 2012/13*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. March 2013.
- Environmental Dynamics Inc. (EDI) (2013). *Mount Nansen Water Resource Investigations Quarterly Report April-June 2013*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. October 2013.

- Environmental Dynamics Inc. (EDI) (2014). *Mount Nansen Water Resource Investigations Quarterly Report July-September 2013*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. February 2014.
- Environmental Dynamics Inc. (EDI) (2014). *Mount Nansen Water Resource Investigations Quarterly Report October-December 2013*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. March 2014.
- Environmental Dynamics Inc. (EDI) (2014). *Mount Nansen Water Resources Investigations Quarterly Report January to March 2014*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. April 2014.
- Environmental Dynamics Inc. (EDI) (2014). *Mount Nansen Water Resources Investigations Quarterly Report (Q1) April-June 2014*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. September 2014.
- Environmental Dynamics Inc. (EDI) (2015). *Mount Nansen Water Resources Investigations Quarterly Report (Q2) July to September, 2014*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. February 2015.
- Environmental Dynamics Inc. (EDI) (2015). *Mount Nansen Water Resources Investigations Quarterly Report Q3 October to December*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. February 2015.
- Environmental Dynamics Inc. (EDI) (2015). *Mount Nansen Water Resources Investigations Quarterly Report (Q4) January-March 2015*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. April 2015.
- Environmental Dynamics Inc. (EDI) (2015). *Mount Nansen Water Resources Investigations 2015-2016: Methodology*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. September 2015.
- Environmental Dynamics Inc. (EDI) (2016). *Mount Nansen Water Resources Investigations 2016/17: Methodology*. Prepared for Yukon Energy, Mines and Resources, Assessment and Abandoned Mines, Whitehorse, Yukon. July 2016.

2.2.2 Hydrometric Network

The hydrometric network at the Site has been in continuous operation since 2009, but has undergone changes throughout this period in response to optimization of monitoring objectives. The full list of hydrometric stations that have been monitored at Site is provided in Table 2-5, and shown in Figure 1-2 and Figure 2-3. Note that several of these stations are no longer monitored, thus the currently operating stations are highlighted in the table for reference.

A fulsome description of the monitoring network in its current state is presented in *Appendix A: Mount Nansen Water Resources Investigations 2016/17: Methodology*, and the reader is referred to this document for details on the following:

- Monitoring network description;
- Discharge measurement methods (including velocity-area mid-section, salt dilution, volumetric and v-notch weir);
- Winter streamflow measurements;
- Levelling surveys;
- Data validation, QA/QC and management;
- Rating curve development; and
- Calculation of continuous stage and discharge time-series.

In summary, the manual streamflow measurement program is conducted on a monthly basis, year-round at the Site. During freshet, an additional monitoring event is scheduled, resulting in one month (typically April or May) where two manual hydrometric measurements are made. Continuous water levels are recorded at the stations denoted as a Type ‘C’ in Table 2-5, and these continuous readings are carried through into the winter months at those stations denoted as Type ‘CW’. While instantaneous discharge measurements are collected throughout the winter, no rating curves are developed using these measurements, or applied to the winter water level readings, due to the known influence of channel ice on the hydraulic relationship.

2.2.2.1 Tailings Storage Facility Seepage Pond

Water is pumped year-round from the seepage pond located down gradient of the tailings storage facility. In 2012, a new flow gauge was installed to measure the outflows from the seepage pond (see Section 3.2.2.9 in EDI 2013a for further detail). The data collected by the flow gauge was compared to concurrent volumetric measurements for a period of 7 months in 2012 (Figure 2-4). There was good agreement between the two methods for this period (see Table 3-13), and therefore the data collected from 2006 to 2011 was adjusted upwards using the regression relationship obtained from the overlapping data collected in 2012.

Table 2-5:
Mount Nansen hydrometric stations. Highlighted rows indicate the stations for which data are presented in this report.

Drainage	Station HID ¹	Location	Type ²	UTM E ³	UTM N ³	Drainage Area (km ²)	Record Period
Pony Creek	H-PC-U	Upper Pony Creek	C	388,709	6,881,930	0.84	2010-2013
	H-PC-DSP	Pony Creek Downstream of Pit	C	388,986	6,881,734	1.0	2009-2016
Dome Creek	H-DC-DX	Dome Creek at DX	I	387,674	6,881,127	0.2	2012-2013
	H-DC-DX+105	Dome Creek at DX+105	I	387,820	6,881,150	0.9	2012-2016
	H-D1/H-DC-D1	Dome Creek at D1	I	388,167	6,881,059	0.91	2011,2012
	H-DC-D1b	Dome Creek at D1b	I	388,262	6,881,000	1.4	2012-2016
	H-DC-U1	Upper Dome Creek 1	C	388,919	6,880,772	2.1	2010-2013
	H-DC-U2	Upper Dome Creek 2	C	388,937	6,880,819	2.1	2011-2013
	H-DC-B	Diversion Channel at Bridge	C/I	389,480	6,880,780	3.0	2014-2016
	H-DC-M WP	Middle Dome Creek Weir Pond	C/CW	389,788	6,880,565	3.3	2011-2015
	H-TP	Tailings Pond	I	389,427	6,880,625	--	2012
	H-SEEP	Seepage Pond Outflow	I	389,604	6,880,598	--	2006-2015
	H-DC-R	Dome Creek at Road	C	389,817	6,880,561	4.5	2009-2016
Back Creek	H-BC	Back Creek	C	391,626	6,880,901	10.4	2009-2016
Minnesota Creek	H-MN	Minnesota Creek	C	392,540	6,879,249	12.7	2012-2013
Victoria Creek	ATM-VC5	Barometric at Victoria Creek	ATM	391,626	6,880,872	--	2011-2016
	H-VC-REF	Victoria Creek Reference Site	C	391,650	6,881,113	64	2011-2013
	H-VC-U	Upper Victoria Creek	C/CW	391,667	6,880,882	64.6	2009-2016
	H-VC-DBC	Victoria Creek Downstream of Back	C/CW	391,627	6,880,840	75	2012-2016
	H-VC-UMN	Victoria Creek Upstream of Minnesota Creek	C/CW	392,413	6,879,244	83.4	2012-2016
	H-VC-R	Victoria Creek at Road	C/CW	392,305	6,878,755	97.7	2011-2015
	H-VC-R+290 ⁴	Victoria Creek at Road + 290	C/CW	392,295	6,878,638	97.7	2015-2016

Notes:

1. HID = unique station identifier that corresponds with hydrometric database tables.
2. Station Type: ATM = atmospheric pressure monitoring; C = continuous water level monitoring with instantaneous discharge rating measurements; I = instantaneous stage and/or discharge measurement; CW = continuous winter water level monitoring with instantaneous discharge rating measurements.
3. NAD 83, UTM Zone 8.
4. This station was installed in 2015 due to icing conditions at H-VC-R preventing accurate discharge measurements.

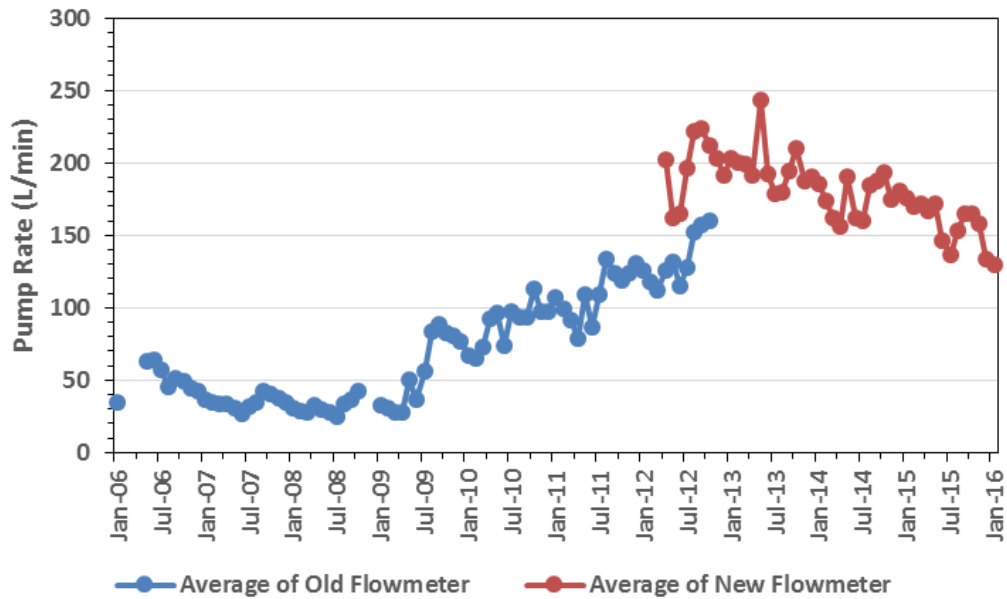


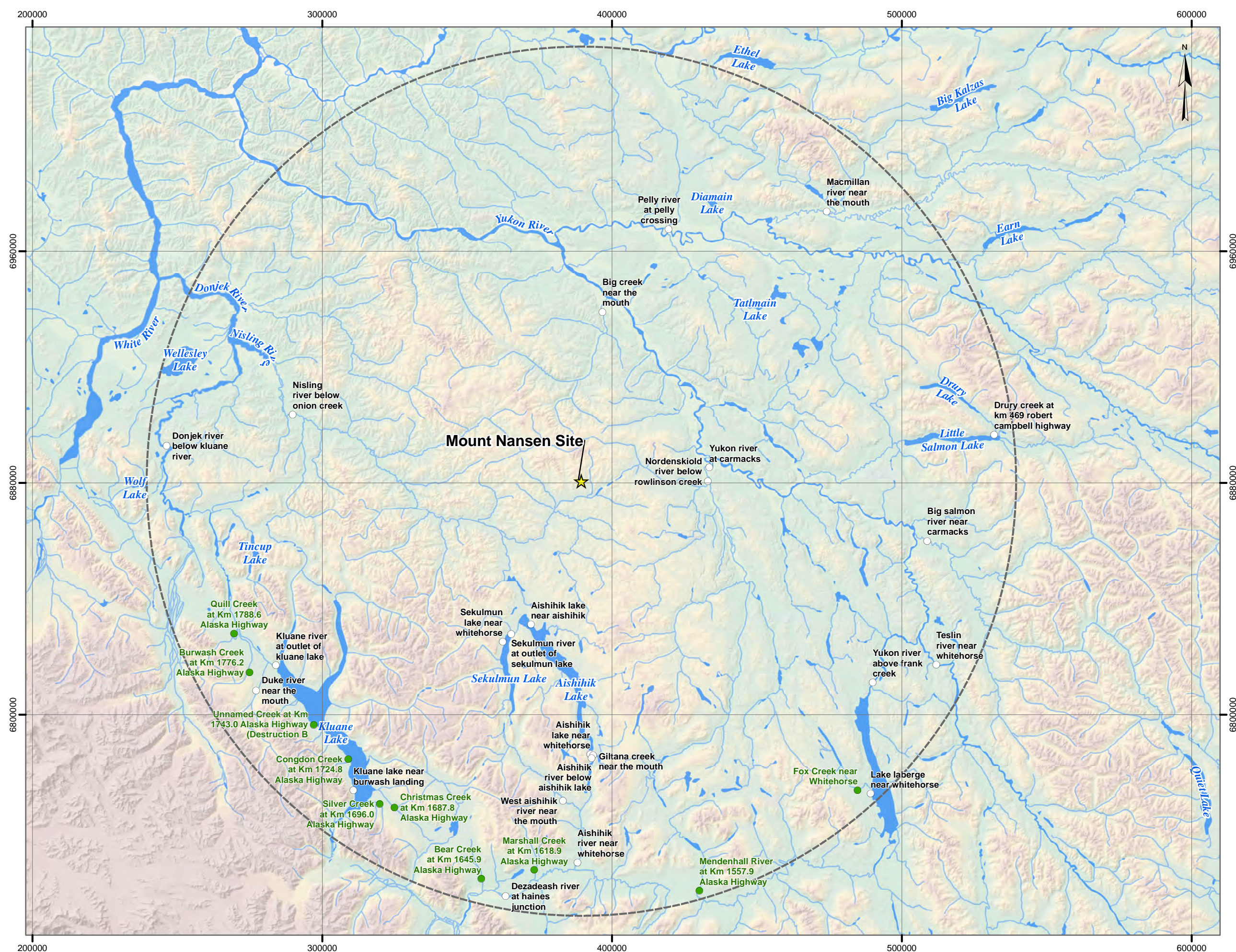
Figure 2-4: Monthly tailings storage facility seepage pond outflows.

2.2.3 Regional Hydrometric Network

As per the meteorology discipline, regional hydrometric data were assembled as part of the baseline hydro-meteorology characterization. The regional stations selected and their basin characteristics are summarized in Table 2-6 below and are also shown in Figure 2-8 for reference. Note that while 10 stations in the Yukon Hydrometric Network (YHN) fall just inside of this radius, most of them are located along the eastern foothills of the St. Elias mountain range, and are thus not considered representative of the streamflow regime at the Mt. Nansen Site. As a result, these stations were not included in the regional analysis.

**Table 2-6:
Regional Hydrometric Stations within 150 km of the Mt. Nansen Site**

Station ID	Station Name	Drainage Area (km ²)	Period of Record	Agency	Feasibility Study Comments	Latitude	Longitude
08AA001	Aishihik River near Whitehorse	4,300	1950-1986	WSC	Used for the regional peak and low flow analyses	60°51'40" N	137°03'40" W
08AA003	Dezadeash River at Haines Junction	8,450	1952-2015	WSC	Used for the regional peak and low flow analyses	60°44'53" N	137°30'30" W
08AA009	Giltana Creek near the Mouth	190	1980-2015	WSC	Used for the regional peak and low flow analyses	61°11'42" N	136°58'55" W
08AA010	Aishihik River below Aishihik Lake	3,000	1980-2016	WSC	Used for the regional peak and low flow analyses	61°11'06" N	136°59'29" W
09AB009	Yukon River above Frank Creek	30,800	1953-1994	WSC	Not representative of Site streamflow regime, not used in regional analyses	61°26'04" N	135°11'18" W
09AF001	Teslin River near Whitehorse	36,500	1955-1973	WSC	Used for the regional peak and low flow analyses	61°29'21" N	134°46'35" W
09AG001	Big Salmon River near Carmacks	6,760	1953-1996	WSC	Used for the regional peak and low flow analyses	61°52'21" N	134°50'10" W
09AH001	Yukon River at Carmacks	81,800	1951-2015	WSC	Used for the regional peak and low flow analyses	62°05'40" N	136°16'20" W
09AH003	Big Creek near the Mouth	1,800	1974-2015	WSC	Used as the regional predictor station to generate long-term, Site-specific synthetic discharge records for the Project area, and in the regional peak and low flow analyses	62°34'4"	137°0'34"
09AH004	Nordenskiold River below Rowlinson Creek	6,410	1982-2015	WSC	Used for the regional peak and low flow analyses	62°03'4"	136°16'49"
09AH005	Drury Creek at km 469 Robert Campbell Highway	552	1995-2015	WSC	Used for the regional peak and low flow analyses	62°12'00"	134°23'16"
09BB002	MacMillan River near the Mouth	13,800	1984-1996	WSC	Used for the regional peak and low flow analyses	62°53'36" N	135°30'36" W
09BC001	Pelly River at Pelly Crossing	48,900	1951-2015	WSC	Used for the regional peak and low flow analyses	62°49'47"	136°34'50"
09CA002	Kluane River at Outlet of Kluane Lake	4,950	1952-1995	WSC	Not representative of Site streamflow regime, not used in regional analyses	62°04'56" N	139°51'35" W
09CA003	Donjek River below Kluane River	12,400	1979-1994	WSC	Not representative of Site streamflow regime, not used in regional analyses	62°4'56"	139°51'35"
09CA006	Nisling River below Onion Creek	7,910	1995-2015	WSC	Used for the regional peak and low flow analyses	62°12'17"	139°2'33"
09DD004	McQuesten River near the Mouth	4,750	1979-2015	WSC	Used for the regional peak and low flow analyses	63°36'40"	137°16'10"



LEGEND

- Mount Nansen Site
- Hydrometric Station**
 - Canada-Yukon Network
 - Yukon Network
- 150 Km Radius around Mount Nansen Site

Coordinate System: NAD 1983 UTM Zone 8N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:1,250,000

DATE SAVED: Jul 11, 2017

DRAWN BY: GM

REVIEWED: SJ

VERSION: 1

CLIENT:

PROJECT:

Mount Nansen Project Proposal

TITLE:

Regional Hydrometric Stations

PROJECT #: A422-1	FIGURE: 2-2
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2.3 Data Analyses and Outputs

The sections below describe data analyses and outputs assembled in support of the baseline meteorology and hydrology studies. Descriptions are provided to explain a recurrence interval analysis approach for SWE, seasonal rainfall, and the calculation of potential evaporation estimates from Site climate data. Methods and approaches to assemble regional streamflow metrics are also discussed below.

2.3.1 Recurrence Interval Analysis – SWE and Rainfall

Long-term regional climate records were used to create synthetic datasets for SWE and seasonal rainfall. Creation of synthetic datasets and the recurrence interval analyses were undertaken as follows:

- Synthetic datasets were computed for April 1 SWE and seasonal rainfall. A synthetic dataset was computed for April 1 SWE as regional data confirm water stored in snow packs reach a maximum by April 1 and this storage excludes snowfall lost through winter sublimation. The reader is referred to Figure 3-5 (upper panel) and related text for more detail. Seasonal rainfall considered any rainfall realized between April 1 and October 31. Considered in aggregate, April 1 SWE and seasonal rainfall are a robust measure of effective precipitation.
 - The nearby 09CA-SC01 snow course served as the predictor station for the April 1 synthetic SWE record for Site. Period of record at this monitoring station is extensive and covers the 1976 to 2016. A comparison with data collected on-Site is provided in Section 3.1.2.1.
 - The Pelly Ranch and Carmacks climate stations were considered as predictor stations for the seasonal rainfall recurrence interval analysis. Both records exceed 40 years in duration, noting the Pelly Ranch station is the longer of the two.
- For both the April 1 SWE and seasonal rainfall assessments, mine Site data were compared to regional observations for corresponding time periods. Based on the comparison, data scalars were calculated and then applied to the long-term regional record. In this regard, the data scalars were used to adjust the regional climate record upward or downward to be representative of conditions at the Site.
 - Site and regional data used to generate data scalars for April 1 SWE and seasonal rainfall (April to October) are presented and discussed in Section 3.1.
- Adjusted climate records were next exported to Mathwave EasyFit statistical software. Using EasyFit, an array of continuous probability distributions were fitted to the input datasets. For a suite of wet and dry conditions (*i.e.*, 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year events), recurrence interval estimates for April 1 SWE and

seasonal rainfall were computed from the GEV (generalized extreme value) continuous probability distribution.

2.3.2 Potential Evaporation Estimates

Hourly potential evaporation rates were computed using Mount Nansen climate station data and the Ref-ET calculator which is a compiled, stand-alone computer program that calculates reference evapotranspiration and potential evaporation (ASCE, 2005). For the period of available record, an hourly climate input file was prepared from the Mount Nansen climate station database. The input variables required by Ref-ET include date and time stamps, air temperature, relative humidity, net radiation, wind speed, and atmospheric pressure data.

From the assembled climate inputs, Ref-ET returned potential evaporation (PE) computations at hourly time step for several standard evaporation models (*e.g.*, Penman-Monteith model, Priestley-Taylor formulation). Hourly results from Ref-ET for a standard Penman-Monteith model were aggregated to daily time-step using pivot tables in MS-Excel. Daily potential evaporation estimates were then summarized (*i.e.*, plots, monthly data table) and compared to PE values reported for other Yukon mining projects.

2.3.3 Regional Streamflow Summary Statistics

To obtain the input data required for the regional streamflow analyses (annual runoff, monthly distributions, peak and low flow recurrence interval estimates, *etc.*), the daily time-series (in m^3/s) from the hydrometric stations listed in Table 2-6 were run through a customized routine to extract the relevant metrics. Extracted metrics included the following:

- Average annual (calendar year and water year [October to September]) discharge;
- Annual maximum and minimum daily discharge;
- Annual and June-September minimum 7-day average discharge;
- Average monthly discharge (m^3/s) and runoff (mm).

Section 3.6.1 presents the results of the annual runoff assessment, along with recurrence interval estimates of annual runoff for the Site stations of interest. The statistical methods used to generate the recurrence interval estimates are the same as those used for the regional peak and low flow analyses, described in Sections 2.3.4 and 2.3.5 below.

2.3.4 Regional Peak Flow Analysis

A frequency analysis was used to estimate the recurrence of discharges of a particular magnitude for all regional hydrometric stations within a 150 km radius of the Mt. Nansen

Site. In a frequency analysis, a time-series of annual flow events are viewed as being a set of events sampled from a population of all events that is infinitely long and therefore continuous. Continuous probability distributions (*e.g.*, Log Pearson Type III, Generalized Extreme Value, Log Logistic 3P) are then fitted to the observations and future and/or extreme events (*e.g.*, 1:200 year flood) are estimated from best fitting probability distributions. Statistical tests (*e.g.*, Kolmogorov Smirnov; Anderson Darling) may be used to isolate the probability distributions that best fit the observations or return a conservative result (Meylan *et al.*, 2012). The frequency analysis may also be based *a priori* on a probability distribution conventionally applied in hydrology studies (*e.g.*, Log Pearson Type III).

Annual time-series of instantaneous maximum discharge values from the regional stations listed in Table 2-6 were compiled. Where the instantaneous maximum value was missing, the maximum daily discharge for that year (assuming a complete record was available) was scaled by the average ratio of instantaneous to daily peak flow from the other years in the station record (*per* Ahmed and Jackson 2013). This ratio ranged from 1.01 to 1.24, with the ratio generally increasing with decreasing basin size (*i.e.*, smaller basins show flashier runoff characteristics). The final datasets were then input to the EasyFit Professional (v5.5) software and a range of distributions were fit. The Log Pearson (Type III) distribution was used for most stations, with the Log Logistic 3P distribution providing the best fit (using the Anderson Darling test) for several of the smaller drainage basins.

2.3.5 Regional Low Flow Analysis

As per the peak flow analysis, the same set of regional stations were assessed in a low flow analysis. To process datasets for the low flow analysis, daily discharge data from eleven of the selected regional hydrometric stations were downloaded from the Water Survey of Canada data portal and seven-day rolling averages were computed from the daily discharge data. Next, annual minima time-series of the winter and June-September 7-day average low flows were assembled for each station. These data were then exported to the EasyFit software for further evaluation.

Through an inspection of the statistics and ranking data output by EasyFit, no single probability distribution could be identified that consistently provided a best fit to the station observations of low flow. However, the Log Pearson Type III (LP3), Weibull and Log Normal distributions were, in general, high ranking distributions for each hydrometric station inspected. Furthermore, estimated low flows based on these three probability distributions were very similar. Consistent with guidance from the BC Ministry of Environment (see BC MOE, 2012), low flow values returned by the LP3 distribution are reported in Section 3.2, noting that recurrence interval estimates were derived for the $7Q_2$

(median), 7Q₅, 7Q₁₀ and 7Q₂₀ events. Where the LP3 distribution did not provide a good fit to the data, the Weibull distribution was used following the guidance provided in WMO (2009).

As a final step in the low flow analysis, estimated low flows for each station were plotted against their respective drainage areas. This plot in effect allows a low flow metric to be estimated for a location of interest based on drainage area information alone. Summer and winter manual low flow measurements collected from the Project drainages were added to these regression plots, in an effort to validate the low flow-drainage area relationship for the smaller spatial scale (*i.e.*, drainage areas on the order of 1 to 100 km²).

2.3.6 Long-term Synthetic Streamflow Records

The high-quality discharge records available for the Site allowed synthetic discharge time series to be constructed for four project hydrometric stations (DC-B, DC-R, VC-DBC and VC-UMN) using regional streamflow data as a driver. Synthetic streamflow records allow the site-specific characteristics of the Project basins to be retained in a longer term record, while preserving any regional inter-annual variability in discharge. This allows for more robust recurrence interval estimates of critical discharge regime metrics (*e.g.*, mean annual runoff, seasonal runoff distribution, June-September 7Q₁₀, *etc.*), and also maintains the regional inter-annual variability in streamflows resulting from multi-decadal climate cycles (*e.g.*, PDO, AO) and trends (*e.g.*, increasing winter low flows). An excerpt from Appendix A of the Water Balance and Water Quality Model Report (Lorax 2017) is provided below to describe the process of generating synthetic discharge records for the Site drainages, to be used as the primary streamflow inputs to the site-wide water balance model. The reader is referred to Lorax (2017), which provides a fulsome description of these synthetic data, and their incorporation into the site-wide water balance model.

Four regional stations from the Water Survey of Canada (WSC) network were assessed for use as the predictor dataset, all of which gauge watersheds located near to the Site, and are under 10,000 km² in area, and thus are more likely to contain streamflow responses that are similar to the Site watersheds:

- Big Creek near the Mouth (09AH003; 1,800 km²; 1974-2015)
- Nordenskiold River below Rowlinson Creek (09AH004; 6,410 km²; 1982-2015)
- Drury Creek at KM 469 Robert Campbell Highway (09AH005; 550 km²; 1995-2015)
- Nisling River below Onion Creek (09CA006; 7,910 km²; 1995-2015)

The comparison focused on whether the progression of streamflows was reflective of Site conditions, and in particular, whether the magnitude and timing of freshet, periodic rainfall

event drive peak flows, recession curve shape, and low flow regimes matched those measured at Site. Following this comparative exercise, the hydrometric record from the Big Creek near the Mouth WSC gauge was used as the predictor basin for all synthetic hydrographs. A plot showing the unit yields for the Site stations in Table 2-5 overlaid on the Big Creek yields is presented in Figure 2-6 for reference.

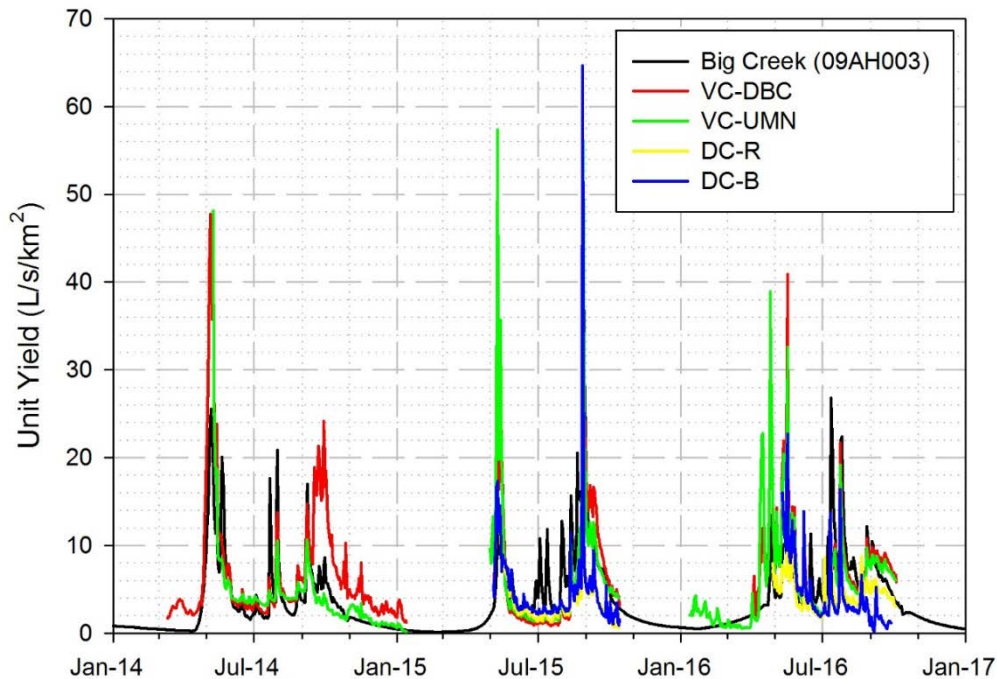


Figure 2-6: Site watershed and Big Creek (09AH003) unit yield time-series (2014-2016)

Following the Empirical Frequency Pairing (EFP) methodology described by Butt (2013), the overlapping periods of record were selected for the Site station and the representative regional station. Data were discretized by month, and all available daily average flows for each month were ranked. For example, if there were data available for the month of April over three years, then the number of paired observations was 90. The paired and ranked observations were then plotted, with the regional station set as the predictor variable (x-axis). Due to the limited availability of continuous winter flow data, all data for the months of October through April were grouped to represent the winter low-flow regime. Additionally, all available spot flow measurements were included in the analysis to buttress the continuous low flow discharge data.

The methodology described in Butt (2013) was modified to improve the predictive power of the EFP method. A piece-wise linear regression approach was employed to estimate flow values that fall between each Site-regional data pair. For cases where the minimum/maximum daily flow in the record fell outside of the Site data record, the

relationships were extrapolated using a linear relationship between at least 10 data pairs, and an understanding of the regional peak and low flow unit yields.

An example of the EFP relationship for the Dome Creek at the Road (DC-R) hydrometric station is provided in Figure 2-7.

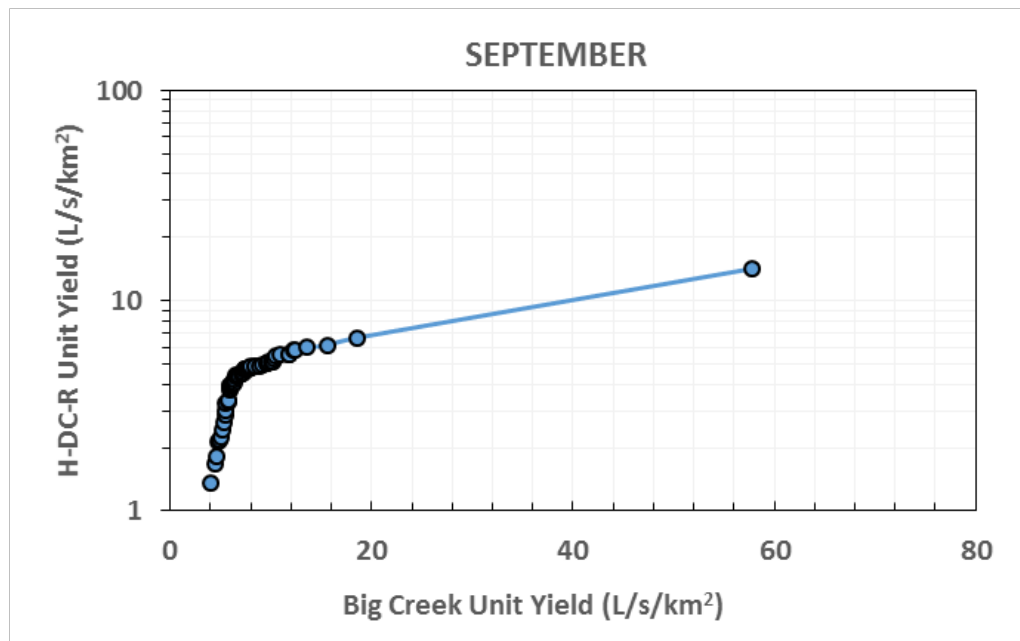


Figure 2-7: Empirical frequency pairing relationship for September at hydrometric station DC-R

The first attempt to construct a synthetic discharge series for the VC-DBC node resulted in higher discharges than those measured at the downstream VC-UMN station, which has a larger contributing area, and would therefore be expected to generate relative more runoff in the winter. No losing reaches are thought to exist between these monitoring points, and the water quality record is indicative of lower winter flows at the upstream (VC-DBC) station. Finally, an inspection of the available continuous water level data from the VC-DBC station during the winter months indicated that these measurements were likely artificially elevated due to channel icing alteration of the hydraulic relationship between flow and stage at the gauging station. Accordingly, the VC-UMN synthetic record was scaled by a simple drainage area ratio (0.9), for all months due to issues with winter low flow data at VC-DBC. This record resulted in much improved model calibration to measured water quality during the winter.

The synthetic discharge records generated for the four Site stations span the period of 1975 to 2016 (42 years), which allows the shorter-term Site discharge records to be placed in a broader historical context.

3. Results

3. Results

3.1 Meteorology

3.1.1 Air temperature

Air temperatures measured at the Site between October 2011 and October 2016 are presented in Figure 3-1, Figure 3-2 and Table 3-1. Typically, warmest air temperatures are recorded in the summer (June, July and August) in a given year and coldest air temperatures are recorded in the winter (December, January, February). For the period of baseline monitoring at ATM-ROAD AAM, the maximum and minimum daily air temperature measurements were 26.8°C (Jun 23, 2013) and -36.6°C (January 29, 2013) respectively (Figure 3-1).

Mount Nansen air temperature data are compared to regional climate station data in Figure 3-2 and Table 3-1 at monthly time steps. Overall, Site temperatures are generally consistent with regional stations (Table 3-1), where mean annual air temperature values range from values -3.8 to -1.4°C for the locations (Site and regional) and time periods reported. For the period of record at ATM-ROAD AAM, July was confirmed as the warmest month (mean monthly temperature was 11.2°C), whereas November, December and January were the coolest months and each approximately -13°C on average.

3.1.1.1 Winter Temperature Inversions and Monthly Varying Lapse Rates

At the elevation of the ATM-ROAD AAM climate station (1,255 m asl), a notable departure from the regional temperature signature occurs during winter months (Figure 3-2). These data show that air temperatures recorded at the mine Site may be 5 to 10°C warmer than measurements recorded at valley bottom stations (*e.g.*, Carmacks, Carmacks CS, and Pelly River). As described by Wahl (1987), this reversal of the normal lapse rate (*i.e.*, the intuitive decrease in temperature with increase in elevation, typically reported as -6.0 °C/1,000 m elevation gain) and are commonly caused by cold Arctic air masses pooling in the valley bottoms from November to March.

In Table 3-2, monthly lapse rates (*i.e.*, the temperature difference between two stations expressed in units °C/1,000 m elevation gain) have been computed using monthly air temperature data from ATM-ROAD, Carmacks CS and Pelly Ranch climate stations, with months of the year indicating a reversal of the normal lapse (*i.e.*, temperature increases with increase in elevation). Winter reversals of the normal lapse are noted at the Site between November and March with magnitude of the reversals greatest for months December, January and February (*e.g.*, Table 3-2; +11.2 °C/1,000 m for January, computed against Carmacks CS climate data).

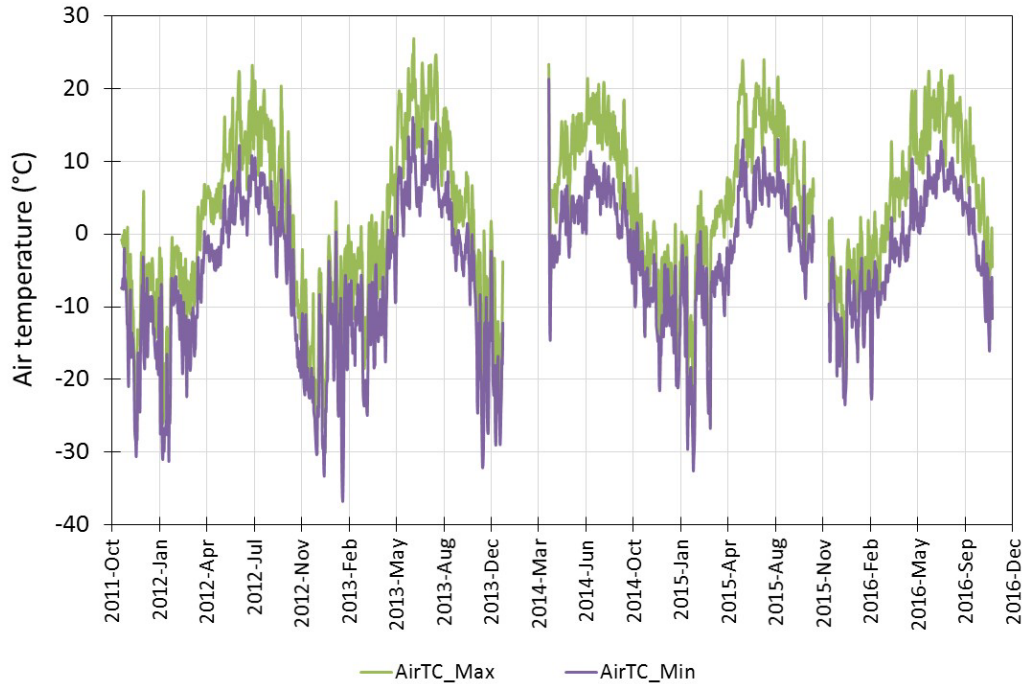


Figure 3-1: Daily minimum and maximum temperature data from the Mount Nansen climate station (ATM-ROAD AAM, elevation 1,255 m asl) for the period October 2011 to October 2016.

Table 3-1: Mean monthly and annual air temperature summaries for ATM-ROAD AAM and nearest regional climate stations to Mount Nansen.

ATM-ROAD AAM													
Year, Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2011	nd	nd	nd	nd	nd	nd	nd	nd	nd	-4.4	-15.9	-8.9	nd
2012	-17.7	-8.0	-9.8	0.1	2.8	8.8	10.0	9.3	4.2	-6.2	-16.6	-18.4	-3.5
2013	-13.3	-8.4	-10.9	-7.7	4.4	12.1	11.9	11.6	4.6	0.0	-13.7	-15.9	-2.1
2014	nd	nd	nd	1.9	6.6	8.5	11.3	9.4	4.0	-3.1	-7.5	-8.0	nd
2015	-11.8	-10.4	-7.0	-1.1	9.8	10.1	11.0	8.1	3.0	-0.5	-10.2	-11.8	-0.8
2016	-7.5	-7.5	-3.6	1.8	6.8	10.4	11.8	10.7	4.8	-4.5	nd	nd	nd
Average (2011-2016)	-12.5	-8.6	-7.8	-1.0	6.1	10.0	11.2	9.8	4.1	-3.1	-12.8	-12.6	-1.4
Regional Climate Stations													
Year, Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Carmacks CS (2011 to 2016)	-20.5	-12.9	-7.8	1.3	9.1	13.8	15.4	13.3	7.6	-1.5	-15.1	-21.0	-1.5
Carmacks (1963 to 2008)	-25.4	-17.9	-10.1	0.5	7.6	13.5	15.3	12.9	6.8	-1.8	-13.9	-22.0	-2.9
Pelly Ranch (1951 to 2015)	-26.5	-20.4	-11.7	0.2	8.0	13.6	15.4	12.7	6.6	-2.5	-16.0	-24.3	-3.8
Pelly Ranch (2011 to 2015)	-20.8	-18.3	-11.5	-0.1	9.2	14.7	16.0	13.8	7.9	-1.4	-16.4	-20.7	-2.3

Note:
'nd' indicates that no data is available for this month.

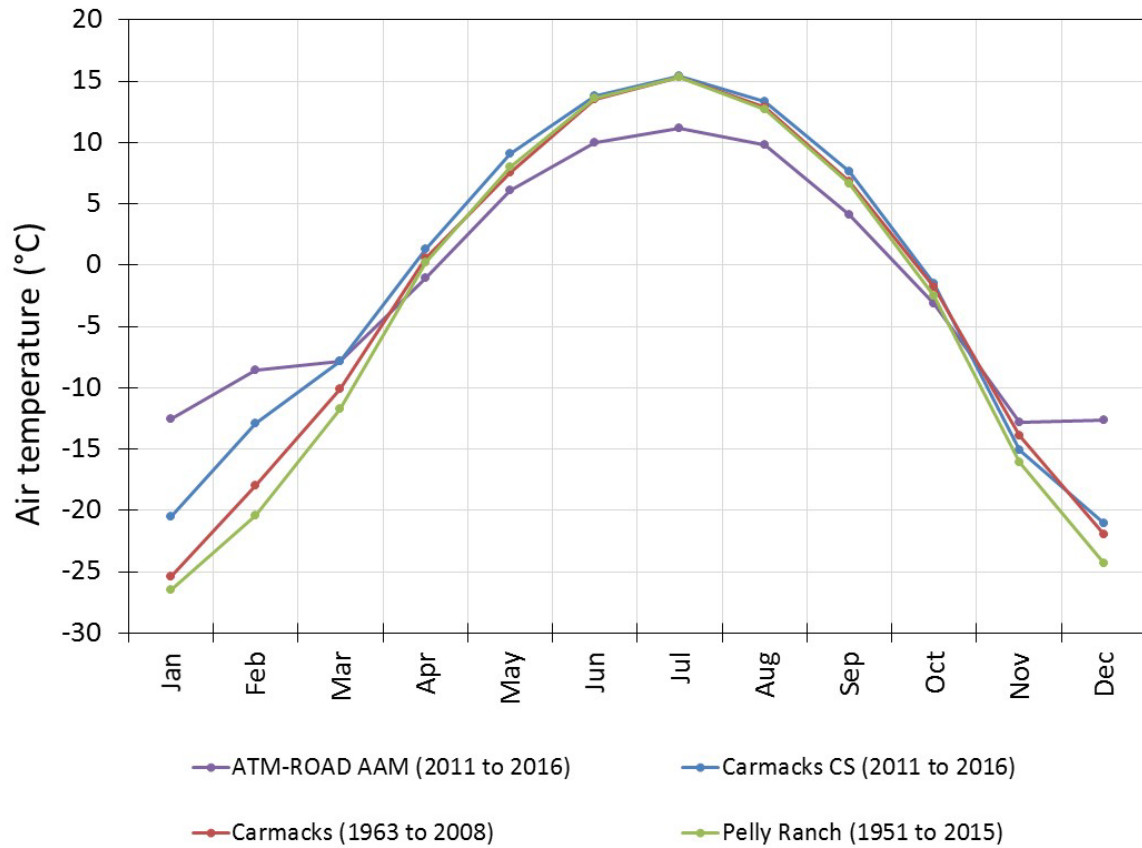


Figure 3-2: Monthly temperature signatures for ATM-ROAD AAM and regional climate stations nearest the Site.

Table 3-2: Monthly lapse rates derived for the mine Site using data recorded at ATM-ROAD, Carmacks CS and Pelly Ranch climate stations.

Derivation	Average Lapse Rate (°C/1,000m elevation gain)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carmacks CS (2011-16) used as low elevation station	11.2	6.0	0.0	-3.2	-4.2	-5.3	-5.9	-4.9	-4.9	-2.2	3.2	11.8
Pelly Ranch CS (2011-15) used as low elevation station	10.4	12.1	4.6	-1.1	-3.9	-5.9	-6.0	-5.0	-4.8	-2.1	4.5	10.1

Note: Grey shading indicates those months showing lapse rate $\geq 0^\circ\text{C}/1,000\text{ m}$.

For months May through September, the local lapse rates reported in Table 3-2 are generally consistent with a normal lapse rate or the saturated adiabatic lapse rate (*i.e.*, SALR; typical rate of cooling of ascending saturated air) of $-5.0^\circ\text{C}/1000\text{ m}$. Referring to Figure 3-2 and Table 3-1, May to September air temperatures may be 3 to 4°C lower at

ATM-ROAD AAM than measured at closest regional climate stations (Figure 3-2, Table 3-1). The ATM-ROAD climate station is roughly 700 to 800 m higher than nearest regional climate stations, and thus the measured temperature difference between the mine Site and closest regional stations equates to lapse rates on the order of -4.0 to -6.0°C/1,000 m for these months.

3.1.2 Precipitation

Figure 3-3 shows the spatial distribution of annual precipitation across the Yukon River basin. Marked with a yellow star in this figure, the Site is situated in the headwaters of the Yukon River basin, with flows emanating from the Site reporting ultimately to the Yukon River via the White River sub-basin. Annual precipitation is reported by Brabets *et al.* (2000) to range from 250 to 375 mm/yr near Mount Nansen.

Precipitation data from two nearby climate stations indicate the following: mean annual precipitation for Carmacks and Pelly Ranch are 296 and 320 mm respectively; these two mean annual precipitation values fall roughly at the mid-point of the Brabets *et al.* (2000) precipitation band that contains the mine Site and the regional stations; and the proportions of rainfall and snowfall reporting at Carmacks and Pelly River are dominated by rainfall on an annual basis (*i.e.*, Rain%/Snow% at Carmacks is 66/34 and at Pelly Ranch the proportions are 64/36).

Period of record precipitation data for Carmacks and Pelly Ranch are summarized in Figure 3-4 to give indication of the typically dry and wet months in the region on an annual basis. Overall, Figure 3-4 indicates that low precipitation accumulation is expected on average for the months of March and April (*i.e.*, 3-4% of annual precipitation is expected in each month), whereas summer months see proportionally more precipitation (*i.e.*, 50-55% of annual precipitation typically reports during June, July, August and September).

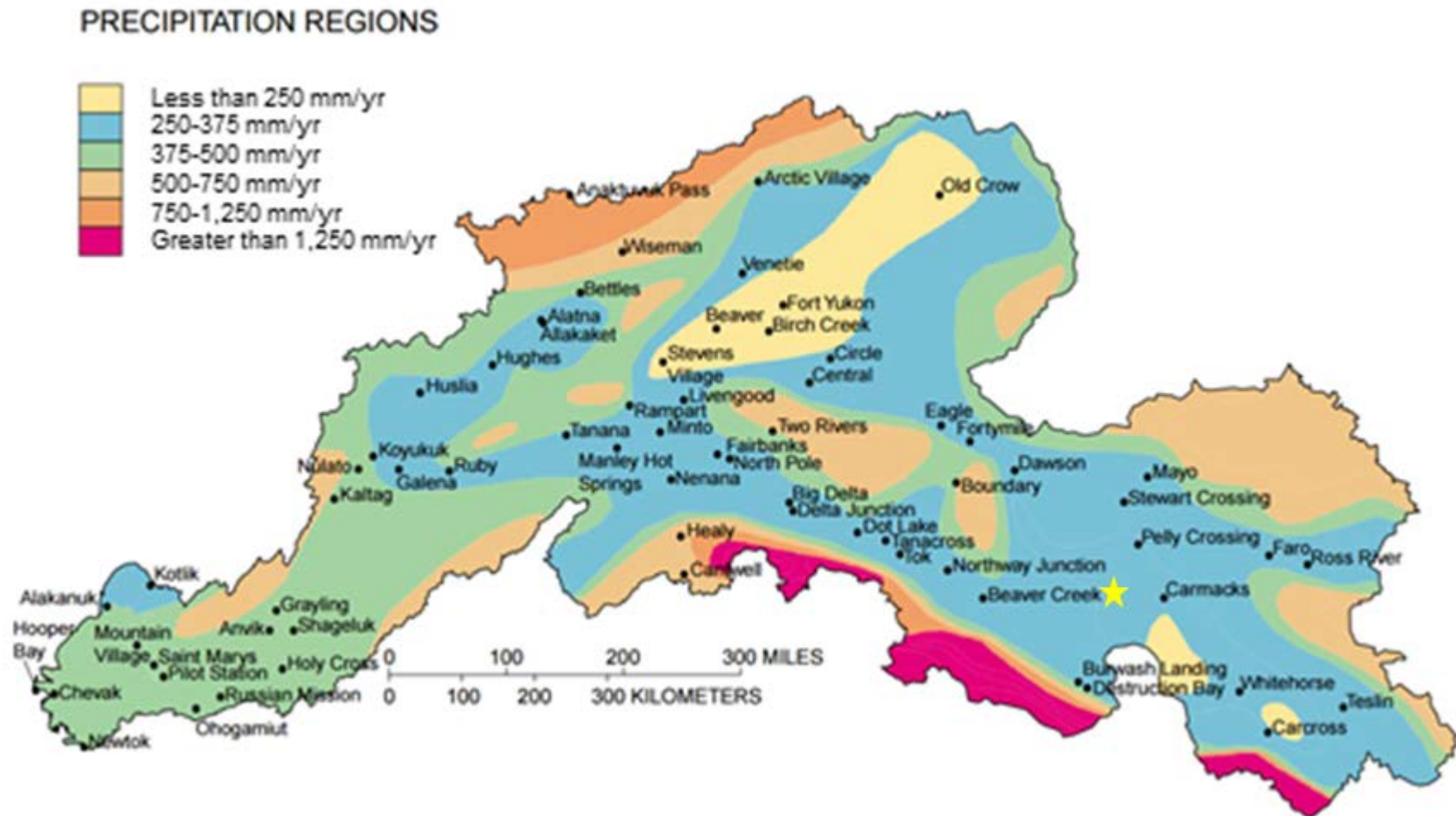


Figure 3-3: Distribution of annual precipitation across the Yukon River basin (modified from Brabets, 2000). The Mount Nansen location is approximated by the yellow star.

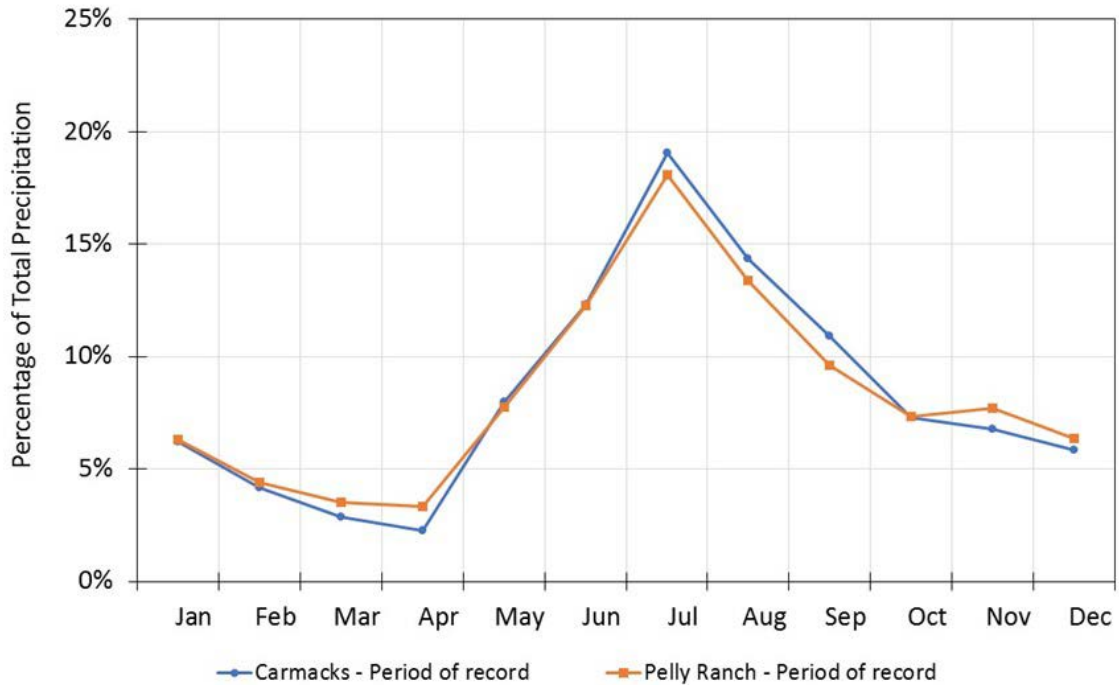


Figure 3-4: Long-term precipitation distributions for the Carmacks and Pelly Ranch climate stations. Monthly values represent proportions of total annual precipitation for the available period of record per station.

3.1.2.1 Regional and Site SWE Measurements, Snow-depth relationship

Regional snow course data are presented in Figure 3-5, Table 3-3, Table 3-4 and Figure 3-6. The upper panel of Figure 3-5 compares the relative magnitude of March 1 vs. April 1 SWE estimates at the Mount Nansen 09CA-SC01 monitoring station. X-axis and Y-axis scaling is the same in this plot and a 1:1 line (diagonal dashed line) is indicative that snow course measurements recorded on the April 1 survey are the best proxy for maximum SWE at the onset of snowmelt. The lower plot of Figure 3-5 also shows snow course data from Mount Nansen (09CA-SC01). In this figure, a robust predictive relationship between April 1 SWE and snow depth is illustrated and is based on 40 years of record.

Table 3-3 summarizes long-term average March 1 and April 1 snow course measurements at five regional snow course stations near the Site (refer to Figure 2-2). As per Figure 3-5 (upper), data in Table 3-3 confirm April 1 SWE estimates are 10 to 20% higher than March 1 SWE estimates. Further, the data show that April 1 SWE estimates range from 80 to 110 mm (elevations range from approximately 900 to 1,150 m asl) across the five stations. For the Mount Nansen (09CA-SC01) snow course, Table 3-4 summarizes period of record SWE and snow depth statistics (minimum, maximum, average, and standard deviation) for March 1 and April 1 in more detail.

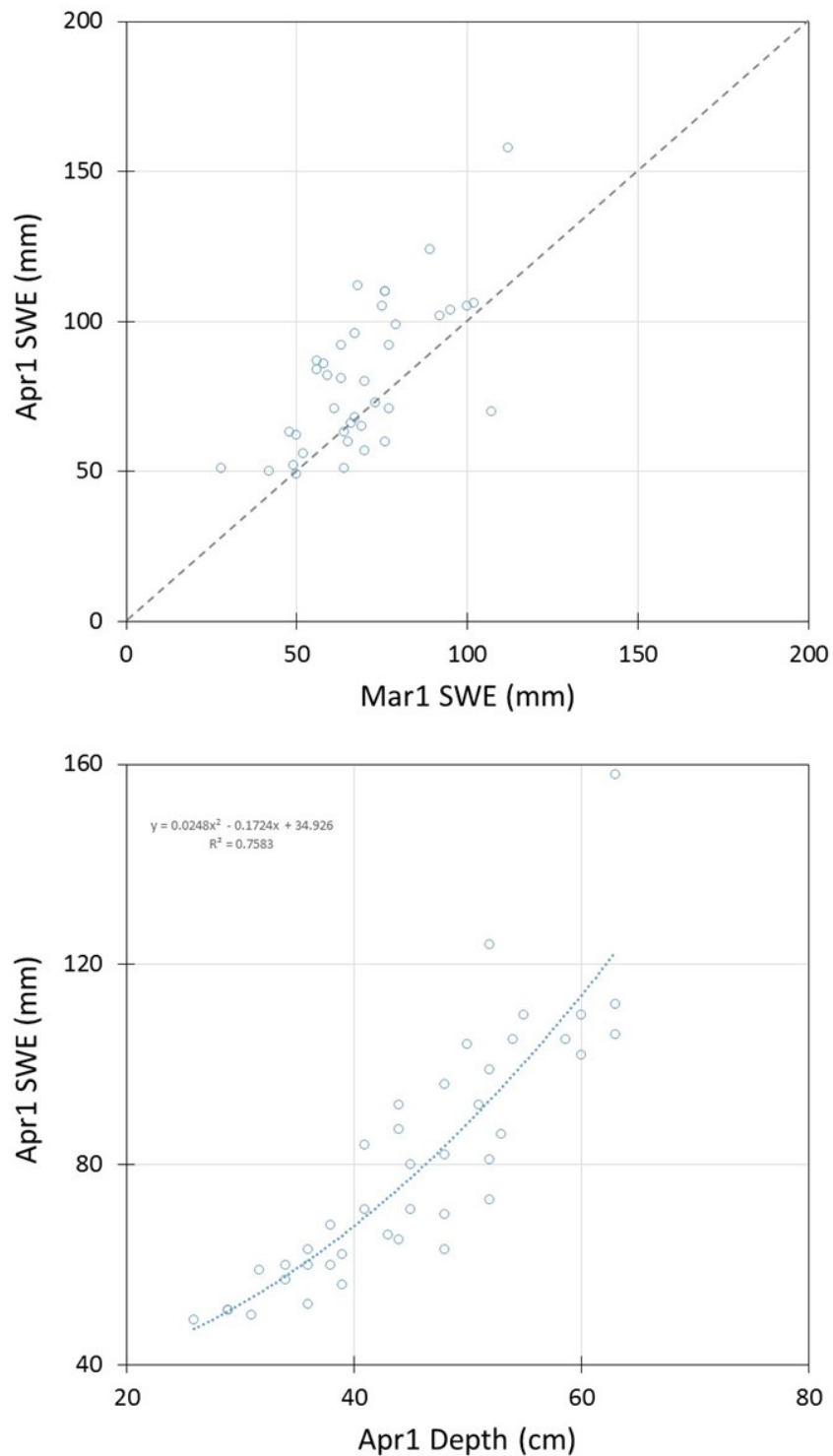


Figure 3-5: Period of record (1976 to present) snow course data for Mount Nansen (09CA-SC01). The upper plot shows the relationship between Apr1:Mar1 SWE, whereas the lower plot shows a predictive relationship between Apr1 SWE and Snow Depth at the Mount Nansen snow course.

**Table 3-3:
 March 1 and April 1 SWE Measurements at Regional Snow Course Stations**

Station	ID	Elevation (m)	Avg SWE for March 1 (mm)	Avg SWE for April 1 (mm)
Mount Berdoe	09AH-SC01	1,035	97	110
Satasha Lake	09AH-SC03	1,106	85	100
Williams Creek	09AH-SC04	914	89	102
Mount Nansen	09CA-SC01	1,021	69	80
MacIntosh	09CA-SC02	1,160	81	100

**Table 3-4:
 Period of record (n = 40 yrs) snow depth and SWE statistics for Mount Nansen (09CA-SC01) snow course.**

Metric	Mount Nansen (09CA-SC01)			
	Mar Depth (cm)	Mar SWE (mm)	Apr Depth (cm)	Apr SWE (mm)
Average	43	69	45	80
Max	61	112	63	158
Min	20	28	26	49
St Dev	9.1	18.1	10.1	24.3

A time series plot (1976 to 2016) showing patterns and variability in SWE and snow depth at the Mount Nansen (09CA-SC01) snow course is presented as Figure 3-6. In this figure, the timeframe corresponding to the period of baseline study is shown with grey shading. Furthermore, average SWE (orange) and average snow depth (blue) are shown with dashed lines in the plot for reference. Overall, Figure 3-6 confirms four consecutive years of above average snow accumulation (2010 to 2013) were followed by three consecutive years of below average SWE accumulation (2014 to 2016) at Mount Nansen. Calendar year 2011 returned the period of record maximum SWE for the 09CA-SC01 station.

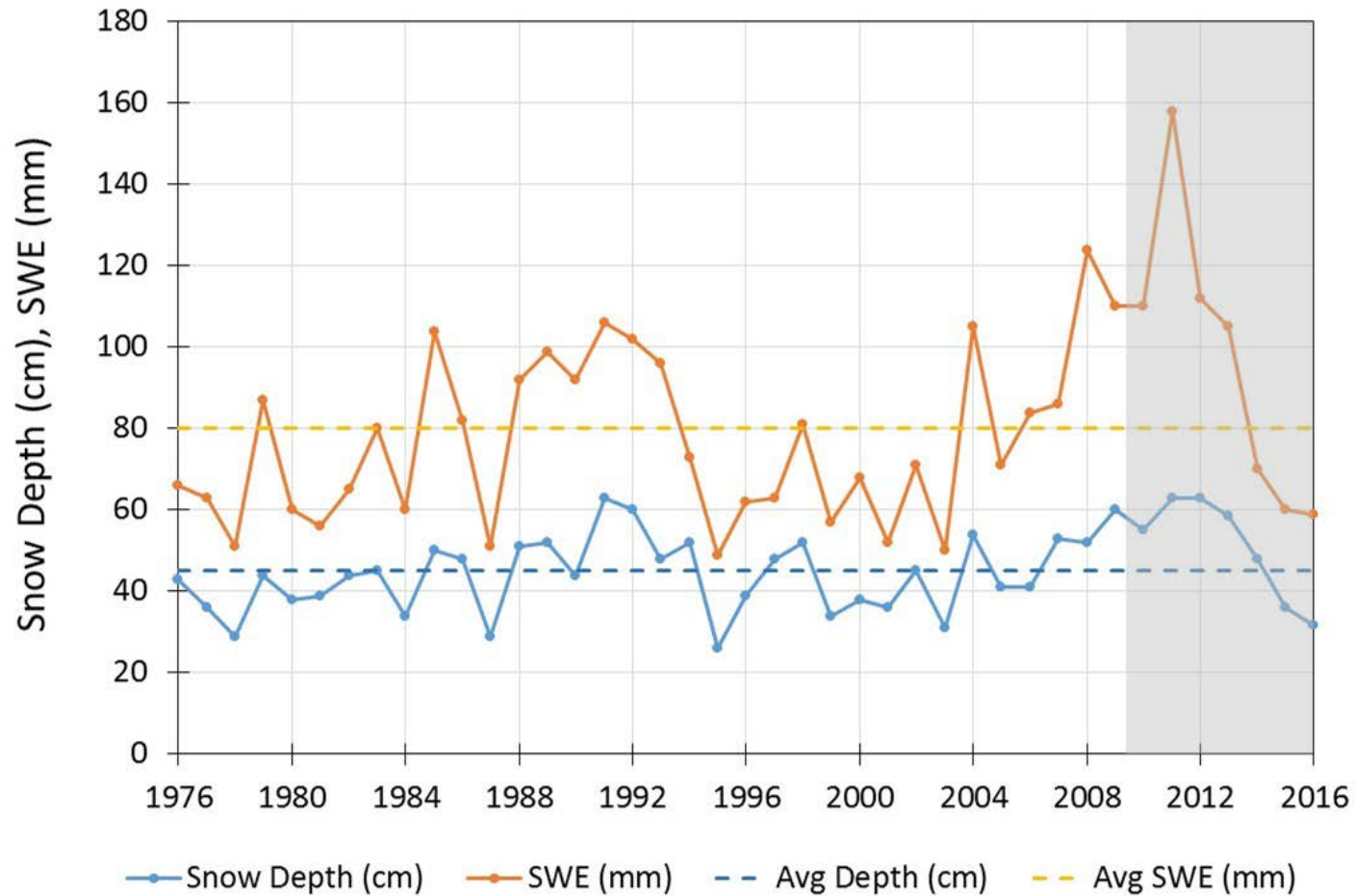


Figure 3-6: Time-series plot (1976 to 2016) showing patterns and variability in SWE and snow depth at the Mount Nansen (09CA-SC01) snow course. The timeframe corresponding to the period of baseline study is shown with grey shading. Average SWE (orange) and average snow depth (blue) are shown with dashed lines in the plot.

Figure 3-7 shows the available snow course data collected at the mine Site. Specifically, the figure shows March 1 and April 1 snow course data for the Dome Creek watershed plotted against monitoring station elevation for calendar year 2011. Also shown on the plot are SWE measurements recorded at 09CA-SC01 (Mount Nansen, Yukon Government) and the snow course established adjacent ATM-ROAD AAM for the March 1 and April 1 sample dates for 2011. Time series data presented in Figure 3-6 for the Mount Nansen snow course show April 1 SWE measurements for this year (2011) are the period of record maximum.

These data show the following with respect to patterns of SWE at the property in 2011: April 1 SWE measurements at sampling locations are consistently higher (by ~30% on average) than SWE measurements recorded on the March 1 survey; across an elevation change of ~250 m, the Dome Creek SWE measurements show some evidence for increasing value with increase in elevation (on the order of 8 to 10% increase in SWE per 100 m increase in elevation) for data collected both March 1 and April 1; and for the March 1 and April 1 sampling periods in 2011, the 09CA-SC01 SWE measurements (blue and grey squares, Figure 3-7) equate reasonably closely (within 10% of one another, but higher at 09CA-SC01) to the SWE measurements recorded at the ATM-ROAD AAM snow course station (blue and grey circles, Figure 3-7).

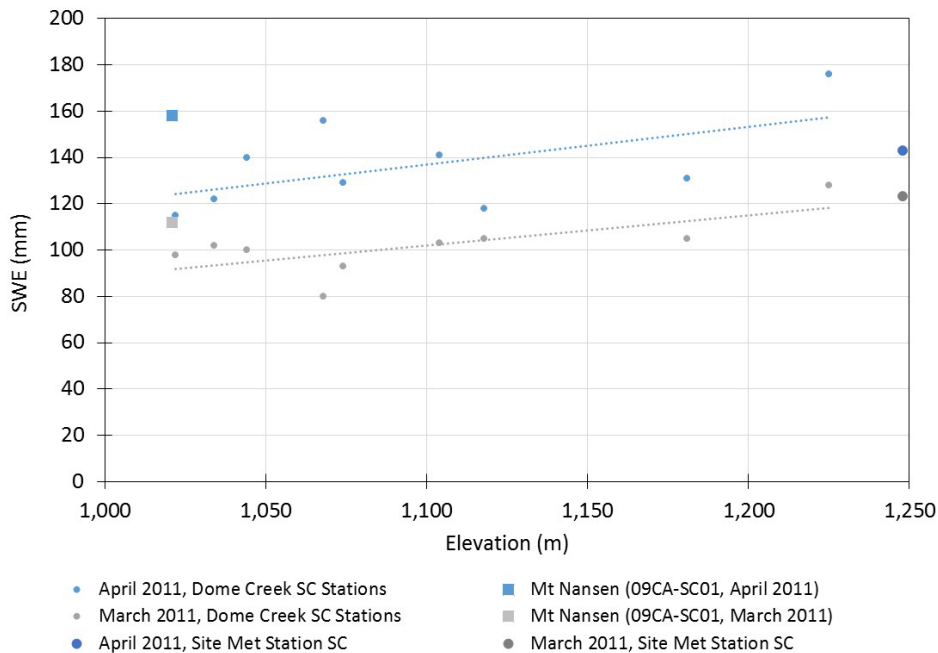


Figure 3-7: Plot showing 2011 snow course SWE results for the Site (Dome Creek Stations, Met Station) and the adjacent 09CA-SC01 monitoring station. SWE measurements are shown for March 1 and April 1 and plotted versus station elevation.

To compliment the 2011 SWE comparison (*i.e.*, Figure 3-6, Figure 3-7) between mine Site and the regional snow course station, snow depth data recorded at the ATM-ROAD climate station corresponding to dates of snow surveys completed at 09CA-SC01 were converted to estimates of SWE then compared. This comparison was possible for the period 2012-16. Overall, the snow depth comparison reported in Table 3-5 confirmed that snow depths recorded at ATM-ROAD AAM for multiple years (*i.e.*, 2012-16, n = 5) were approximately 20% greater at the ATM-ROAD station, a finding indicative that SWE measurements at the mine Site may exceed the values (Figure 3-5, Table 3-4) returned by long-term monitoring at 09CA-SC01.

Recurrence interval estimates for April 1 SWE are reported for the Site in Table 3-6. To compute these values, period of record SWE measurements for April 1 at 09CA-SC01 were first adjusted upward by 20% then a frequency analysis was conducted on the resulting synthetic data. The frequency analysis was conducted using EasyFit (Mathwave) statistical software, where the data were fit with a GEV (generalized extreme value) continuous probability distribution. Estimates of SWE were computed using the GEV distribution for a range (1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 yr) of dry and wet conditions. Results presented in Table 3-6 indicate a 1:2 year April 1 SWE of 94 mm, with SWE estimates being approximately 50 mm (1:100 yr dry) and 200 mm (1:100 yr wet) for the Site for extreme conditions.

**Table 3-5:
Comparison of April 1 snow depth and SWE data for Mount Nansen (09CA-SC01)
and ATM-ROAD for 2012-16.**

April 1, Year	Mount Nansen (09CA-SC01)		ATM-ROAD Station	
	Depth (cm) ^a	SWE (mm) ^a	Snow Depth (cm) ^b	Estimated SWE (mm) ^c
2012	63	112	70	121
2013	59	105	63	109
2014	48	70	62	107
2015	36	60	51	87
2016	32	59	45	77
Avg	47	81	58	100

Notes:

- a) Snow depth and SWE measurements recorded during the April 1 snow survey
- b) Average daily snow depth recorded at the ATM-ROAD climate station for date corresponding to snow survey at 09CA-SC01
- c) Estimated SWE computed from a simple linear regression using 2012-16 depth and SWE measurements from 09CA-SC01 (*i.e.*, $SWE = 0.024(\text{Depth})^2 - 0.1724(\text{Depth}) + 34.926$; $R^2 = 0.92$)

Table 3-6:
Recurrence interval estimates of SWE for the Site (elevation 1,255 m asl)

Probability	Event	April 1 SWE (mm)*
0.01	1:100 dry	49
0.02	1:50 dry	53
0.05	1:20 dry	59
0.1	1:10 dry	65
0.2	1:5 dry	74
0.5	1:2 median	94
0.8	1:5 wet	122
0.9	1:10 wet	140
0.95	1:20 wet	158
0.98	1:50 wet	180
0.99	1:100 wet	197

*Notes: To compute these SWE estimates April 1 measurements from the 09CA-SC01 monitoring station were first adjusted upward by a factor of 1.24 then fitted with a GEV (Generalized Extreme Value) continuous probability distribution. Predicted SWE estimates for a range of probabilities were computed using Mathwave EasyFit statistical software. The reported values in this table represent April 1 SWE for elevation 1,255 m asl.

3.1.2.2 Site Snow Depth and Snow Melt Summary

Figure 3-8 shows continuous snow depth data for the ATM-ROAD AAM climate station for the available period of record. Four complete winter records were recorded at the Site (2011-12, 2012-13, 2014-15 and 2015-16).

Snow accumulation begins in earnest at the Site by mid- to late October. In general, snow packs reach their maximum depths for the season by the middle of February. Figure 3-8 shows pack depth is relatively stable between mid-February and the onset of snow melt in the spring. While pack depths are constant during this time period, SWE values continue to increase since maturing and weathering of the snow pack increases its density with time.

Data in Figure 3-8 indicate the onset of melt conditions varies from year to year. For example, snowmelt and pack ablation was early and rapid in spring 2016 (light blue line), with much of the pack being lost by the first week of April. In contrast, onset of melt conditions began by May 1 in the spring of 2013. Based on the data collected thus far, melt out of snow packs occurs over a 20 to 30 day period.

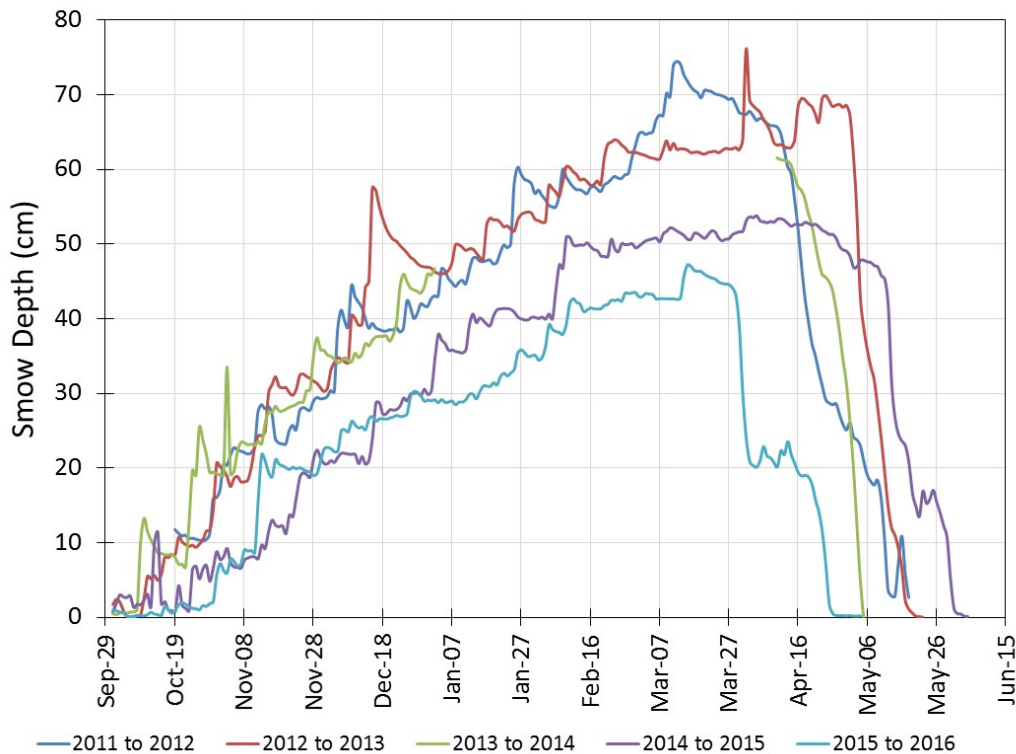


Figure 3-8: Summary of continuous snow depth data collected at ATM-ROAD AAM climate station for the available period of record.

3.1.3 Regional and Site Rainfall Summary

3.1.3.1 Rainfall – Mount Nansen Site Data

Rainfall data collected at the Site are presented in Table 3-7 and Table 3-8. The rainfall data reported in Table 3-7 were collected previously by Gartner Lee and span the 2000 to 2005 timeframe. The rainfall data reported in Table 3-6 were collected at ATM-ROAD AAM and show coverage between April 2012 and October 2016. In both Table 3-7 and Table 3-8, seasonal (*i.e.*, either April to September or April to October) rainfall totals for the Site are compared to regional climate stations (Carmacks, Pelly Ranch, Carmacks CS) for corresponding years where possible to do so.

As per Figure 3-4, Site rainfall data confirm a similar distribution with months showing appreciable precipitation accumulation including June, July and August. These rainfall data also show that rainfall accumulation at the Site exceeds the depths recorded at nearest regional stations. For example, rainfall for the period from 2000 to 2005 was approximately 12% higher at the Site than at the Pelly Ranch climate station. More recently, rainfall data collected at the Site between 2012 and 2014 exceeded rainfall accumulation at Pelly Ranch by roughly 20%.

**Table 3-7:
Comparison of corresponding rainfall data collected at the Site and nearest regional climate stations (2000 to 2005)**

Year	Rainfall (mm)								
	Apr	May	Jun	Jul	Aug	Sep	The Site (Apr-Sep)	Carmacks (Apr-Sep)	Pelly Ranch (Apr-Sep)
2000	10	48	47	88	118	85	396	409	354
2001	2	nd	nd	nd	7	51	nd	179	248
2002	5	20	29	52	70	5	181	182	236
2003	6	24	68	61	38	13	210	160	163
2004	13	32	45	61	24	45	220	152	173
2005	1	21	107	93	29	38	289	221	236
Average	6	29	59	71	48	40	259	217	235

Notes:

Site rainfall data April to September reported above are values reported by Gartner Lee (AMEC, Characterization Report); nd = no data.

**Table 3-8:
Comparison of corresponding rainfall data collected at ATM-ROAD AAM climate station and nearest regional climate stations (2012 to 2016)**

Year	Rainfall (mm)									
	Apr	May	Jun	Jul	Aug	Sep	Oct	ATM-ROAD (Apr-Oct)	Pelly Ranch (Apr-Oct)	Carmacks CS (Apr-Oct)
2012	3	21	61	63	79	21	10	256	196	nd
2013	11	18	39	77	36	52	22	256	232	nd
2014	5	24	26	71	41	57	13	236	193	160
2015	6	8	25	57	98	26	17	238	nd	198
2016	23	50	42	107	41	29	2	294	nd	198
Average	10	24	39	75	59	37	13	256	nd	nd

Note:

'nd' indicates that no data is available for this month.

3.1.3.2 Regional rainfall data and recurrence interval estimates

A summary of regional rainfall data is presented in Figure 3-9 and Figure 3-10. In the upper panel of Figure 3-9, period of record seasonal rainfall data are presented for Pelly Ranch, Carmacks and Carmacks CS. For the Pelly Ranch and Carmacks stations, long-term averages for the period of record are shown in the figure with dashes lines. These data confirm that long-term seasonal rainfall is roughly the same at Pelly Ranch and Carmacks (193 mm and 190 mm respectively), and ranged from 100 mm to 400 mm over the past five decades. While the long-term average rainfall is the same for the two stations, the lower panel of Figure 3-9 illustrates the variability that exists between the stations on an

annual basis. A close inspection of the data indicates rainfall totals can vary on an annual basis often by 50%, yet the data plot 1:1 overall.

Figure 3-10 compares period of record seasonal rainfall data for the Site (2000-2005, 2012-2016) to period of record measurements at Pelly Ranch and Carmacks. As per results presented in Table 3-7 and Table 3-8, Figure 3-10 indicates seasonal rainfall totals at Mount Nansen exceed those measurements at Pelly Ranch and Carmacks by approximately 15-20%. To generate recurrence interval estimates for seasonal rainfall representative of the Site, period of record rainfall totals for Pelly Ranch and Carmacks were adjusted upward by factors of 1.15 and 1.19 respectively.

Next, the resulting time series (Pelly Ranch, $n = 56$ years; Carmacks, $n = 40$ years) were fitted with continuous probability distributions in EasyFit (results for GEV distribution are presented here). Finally, representative estimates for dry and wet year events (1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year) were computed with results presented in Table 3-9. The recurrence interval analysis for seasonal rainfall returned 1:2 year values roughly 220 mm, with extreme dry and wet estimates (1:100 year) spanning a range 120 mm to approximately 400 mm respectively. For most events, recurrence interval estimates were similar in magnitude whether predicted from the Pelly Ranch or Carmacks adjusted time series. However, extreme wet year (*e.g.*, 1:50 and 1:100 year) seasonal rainfall estimates were more conservative (*i.e.*, larger) when predicted from the Carmacks time series.

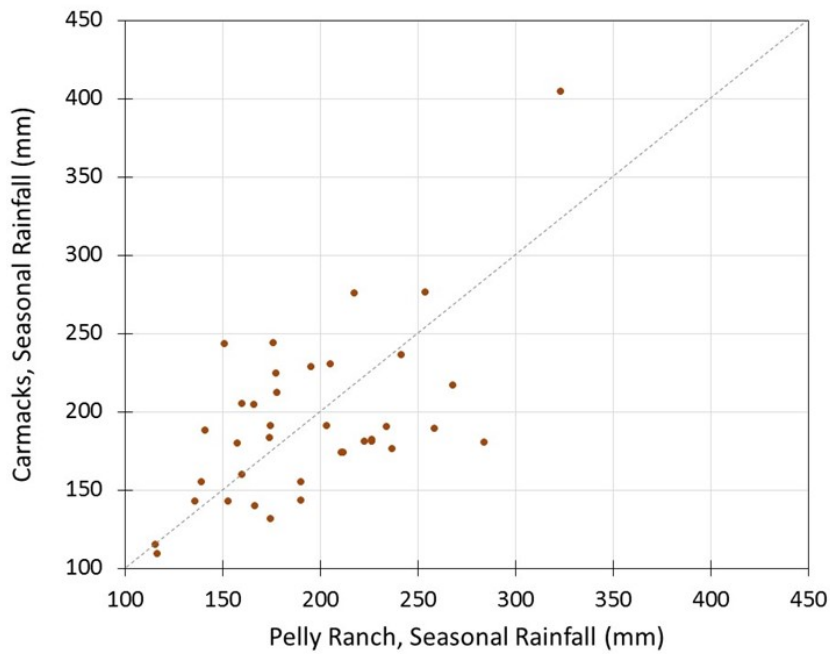
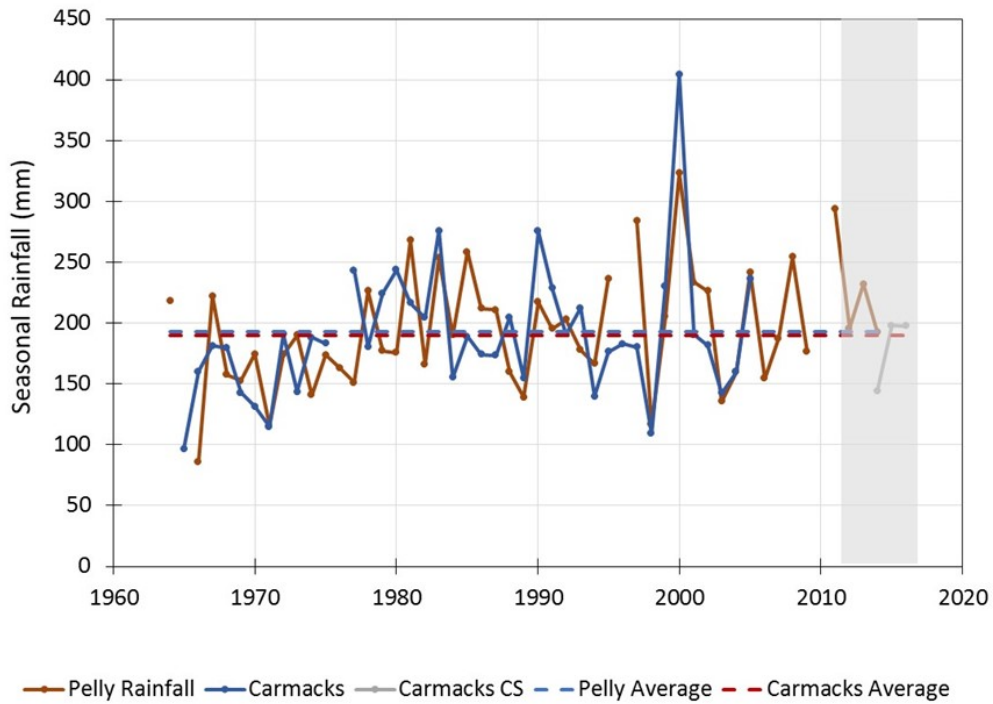


Figure 3-9: Seasonal rainfall summaries for Pelly Ranch, Carmacks and Carmacks CS for available periods of record. Data are presented as time-series (upper) and regression plot (lower). Long-term averages and 1:1 lines are shown on the plots with dashed lines.

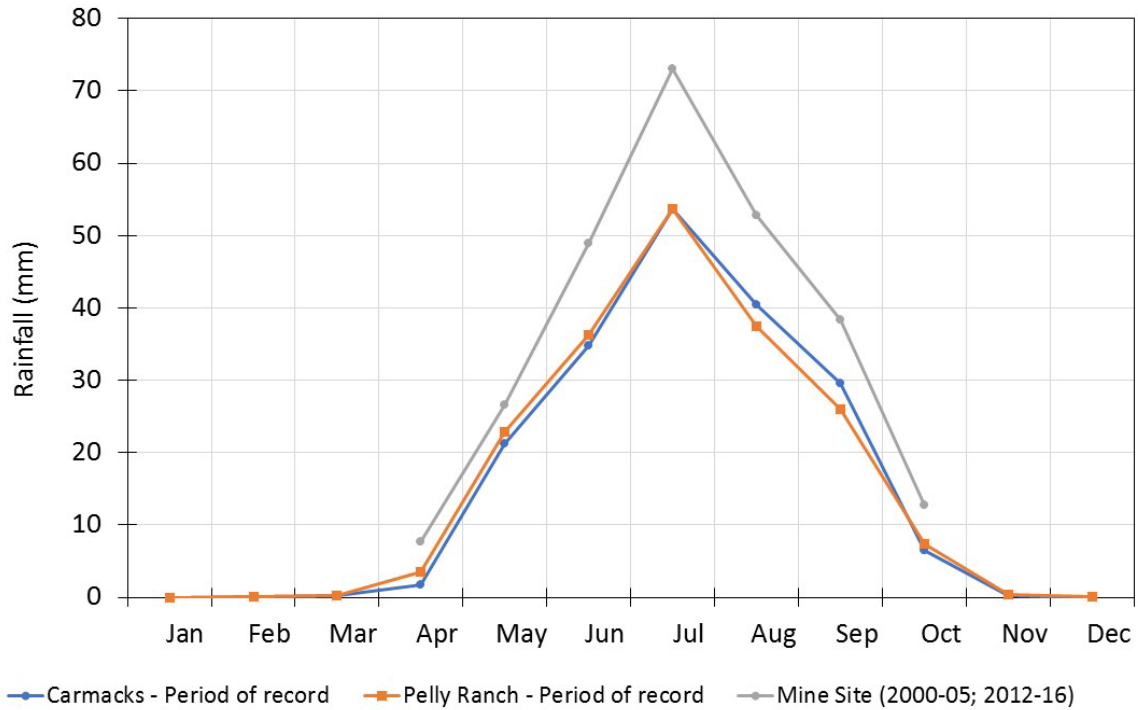


Figure 3-10: Comparison of rainfall data for available periods of record at the Site, Carmacks and Pelly Ranch.

**Table 3-9:
Recurrence Interval Estimates for Site Rainfall (Apr to Oct)**

Probability	Event	Seasonal Rainfall (Pelly Ranch Predictor)	Seasonal Rainfall (Carmacks Predictor)
0.01	1:100 dry	114	123
0.02	1:50 dry	124	131
0.05	1:20 dry	140	145
0.1	1:10 dry	155	158
0.2	1:5 dry	174	175
0.5	1:2 median	217	216
0.8	1:5 wet	266	271
0.9	1:10 wet	294	306
0.95	1:20 wet	318	340
0.98	1:50 wet	347	383
0.99	1:100 wet	365	414

Notes:

Based on an assessment of corresponding rainfall data available for Mount Nansen (Table 3-7 and Table 3-8) and nearest regional stations, monthly rainfall data for Pelly Ranch and Carmacks were adjusted upward by factors of 1.15 and 1.19 to represent the Site. The adjusted time series (Pelly Ranch, n = 56 years; Carmacks, n = 40 years) were then analyzed using Mathwave-EasyFit.

3.1.4 Relative Humidity, Wind Speed, Atmospheric Pressure and Radiation Data

Four plots (Figure 3-11 Figure 3-12, Figure 3-13 and Figure 3-14) are shown below to summarize observations at ATM-ROAD AAM for relative humidity (daily maximum, daily minimum), wind speed (daily average, 30-day average), atmospheric pressure (daily average) and radiation (daily average) data. Measurements and trends for these parameters are discussed briefly in the paragraphs below.

Minimum relative humidity measurements at the Site climate station were lowest between April and October each year (*i.e.*, 30-50%), but closer to saturation (80-100%) during the winter (Figure 3-11). In the summer, minimum relative humidity values are inversely proportional to air temperature data. This means that on an hourly basis, relative humidity minima typically occur in the late-afternoon and correspond with the time of temperature highs for the day.

The 30-day average (black dashed line) shown in Figure 3-12 indicates that daily wind speeds of 1 to 3 m/s were typical for the period of baseline study. However, daily average wind speed data showed considerable variability with time, noting that daily average wind speeds on the order of 4 to 6 m/s were not uncommon at the mine Site. While not shown in Figure 3-12, inspection of the hourly wind record for Site indicates that only 3% of the measurements recorded during the baseline study at ATM-ROAD AAM exceeded 6 m/s, whereas the maximum hourly wind measurement for the period of record was 15 m/s.

Barometric pressure measured at the Site climate station ranged from a daily low of 840 to a high of 890 mb (Figure 3-13). Overall, barometric pressures were notably higher in the summer months compared with pressure lows that characterized winter months (*e.g.*, December, January).

Figure 3-14 shows daily average radiation data for three variables: net shortwave radiation; net longwave radiation; and net radiation (the balance of net shortwave and net longwave radiation). Net shortwave radiation signatures are highest (and positive; 200 to 300 W/m²) in the summer, a function of the abundant incoming shortwave radiation and long daylight hours that characterize the Yukon summer. In contrast, net shortwave radiation signatures are negligible (*i.e.*, 0 to 15 W/m²) for extended time periods during the winter owing to minimal incoming radiation and shorter days. Net longwave radiation (heat losses) signatures are essentially negative year-round at the Site, with values being most negative in the summer (-25 to -100 W/m²).

In the winter, net radiation (*i.e.*, balance of net longwave and net shortwave) is slightly negative (0 to -50 W/m² typically) with magnitude of flux a function of net longwave losses. In the summer, net radiation is strongly positive at the Site as heat losses via net longwave radiation are typically minor compared to net shortwave radiation inputs.

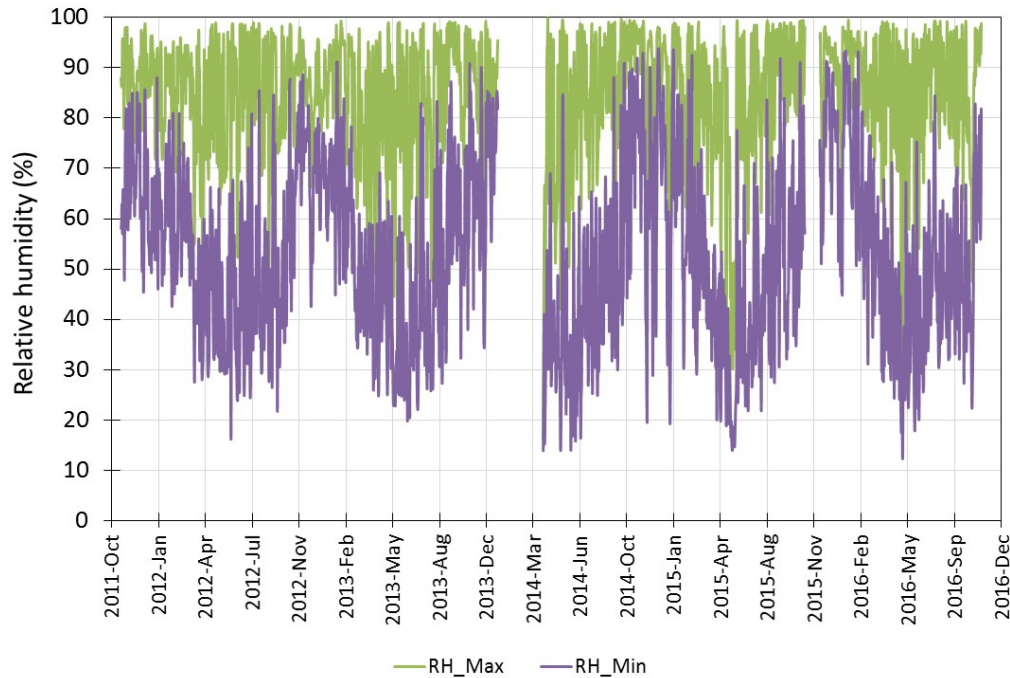


Figure 3-11: Daily maximum and minimum relative humidity measurements at ATM-ROAD AAM for available period of record.

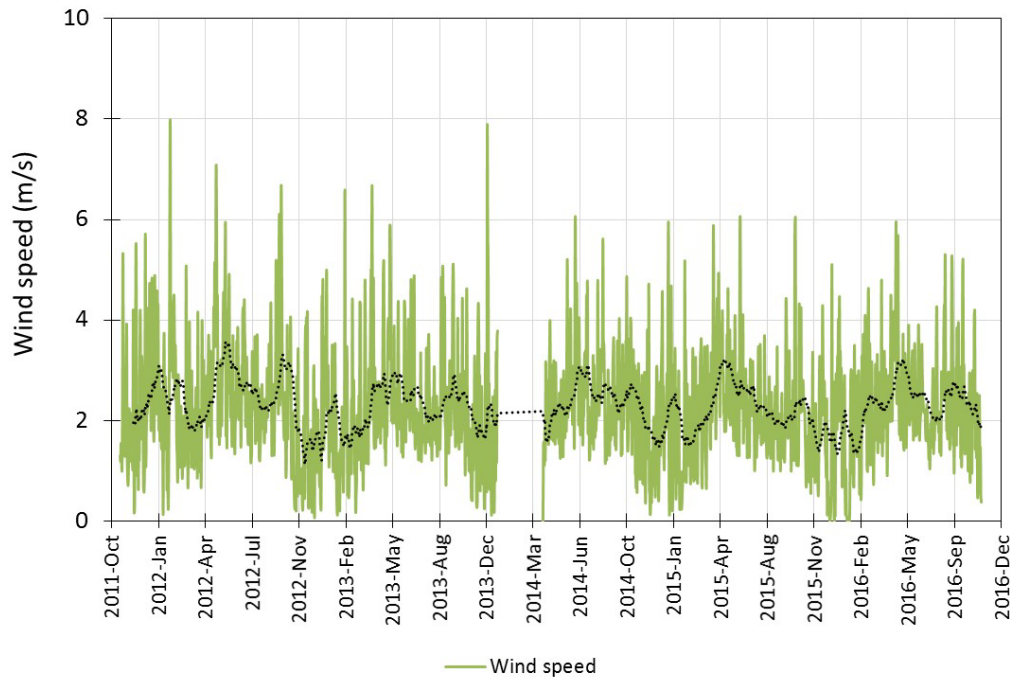


Figure 3-12: Daily average wind speed measurements at ATM-ROAD AAM climate station for available period of record. A rolling 30-day average wind signature is shown on the plot with a dotted black line.

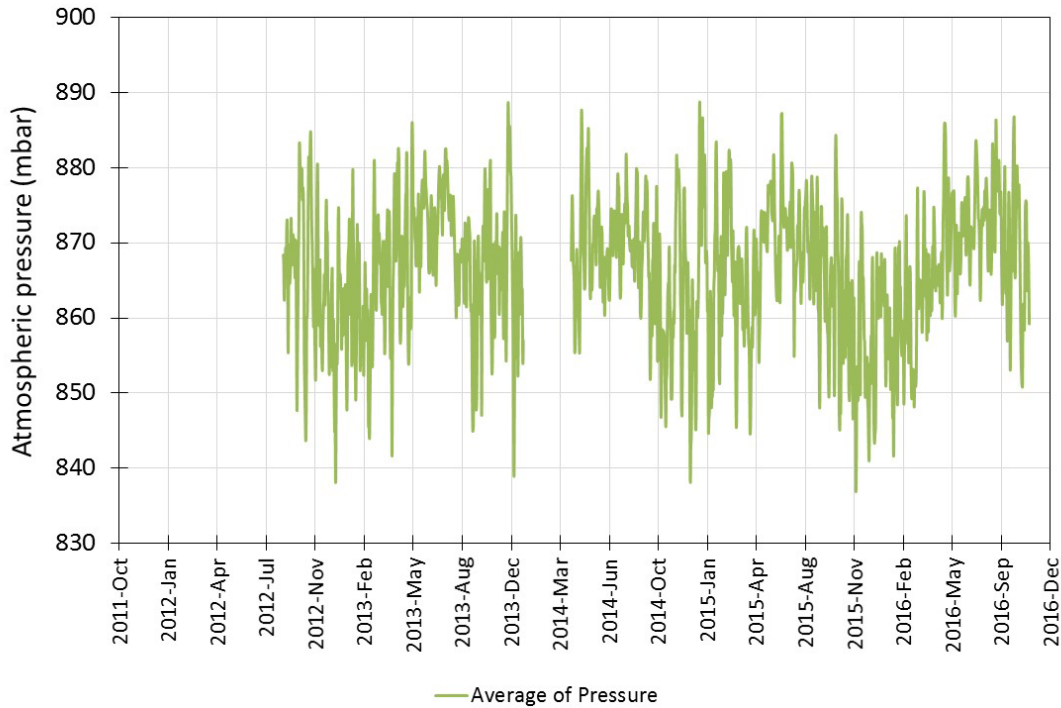


Figure 3-13: Daily average barometric pressure data recorded at ATM-ROAD AAM for available period of record.

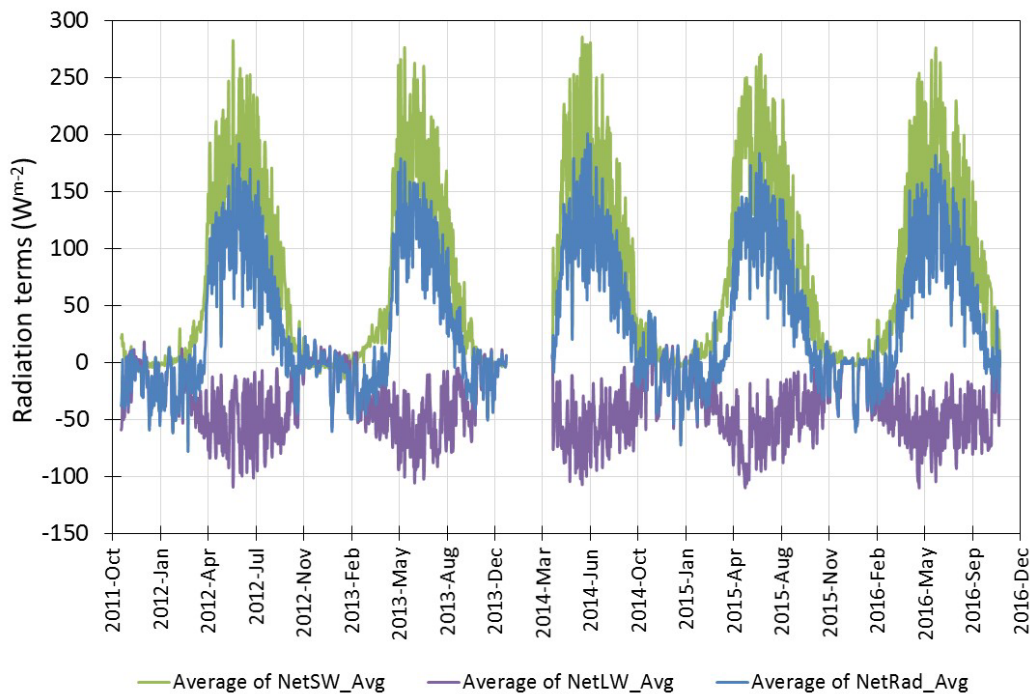


Figure 3-14: Summary of daily average- net shortwave, net longwave and net radiation measurements at ATM-ROAD AAM for the available period of record.

3.1.5 Evapotranspiration and potential evaporation (PE)

Regional estimates of evapotranspiration and potential evaporation are presented in Table 3-10. The regional estimates were computed by Clearwater Consultants for various territorial mining assessments (CC, 2006). Table 3-8 (upper) data indicates that May-September evapotranspiration rates may be expected to be on the order of 140 to 200 mm for the Site. Table 3-10 (lower) presents six long-term estimates of mean annual lake evaporation (modelled and by pan) for Yukon stations. Overall, May to September lake evaporation totals are similar at these locations and ranges from 414 to 483 mm. Williams Creek and Pelly Ranch are situated nearest Mount Nansen and reported long-term lake evaporation is approximately 450 mm (May to September) for these stations.

Mount Nansen climate station data were also used to compute Site-specific estimates of potential evaporation (PE) for the Site. A daily time series of the resulting PE estimates is shown in Figure 3-15 and summarized monthly in Table 3-11. Consistent with lake evaporation estimates presented for Yukon stations (Table 3-10), months showing highest rates of PE include May, June, July and August, whereas rates of PE for April and October are roughly one half those computed for warmest months. Figure 3-15 is indicative that rates of PE are variable from day to day, a function of the specific radiation/temperature, humidity and wind regime the Site may experience.

During warmest months (May, June, July, and August) daily rates of PE may range from 2 to 6 mm/day at ATM-ROAD AAM. Seasonal summaries in Table 3-11 (*i.e.*, April to October or May to September) return average PE estimates for the period of baseline study in the range 430 to 490 mm/yr, which are similar to those reported for regional stations (see Table 3-10, lake evaporation). Furthermore, the PE total for May to September on average accounts for 90% of the annual estimate, the total PE for Apr and October accounts for roughly 10% of the annual estimate and PE for months not reported in Table 3-11 (Nov-Mar) are assumed to be negligible.

Table 3-10:
Estimates of evapotranspiration and potential evaporation from past studies in the Yukon

	Average Monthly Areal Evapotranspiration (mm)													
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	May-Sep
Williams Creek	0	0	17	17	27	41	38	18	15	5	0	0	177	140
Mayo A	0	0	0	19	33	50	56	39	17	6	0	0	220	195
Whitehorse A	0	0	13	24	35	45	45	24	15	8	0	0	209	164
Minto Camp (adjusted)	0	0	6	20	32	40	35	22	16	4	0	0	174	144
	Average Monthly Lake Evaporation (mm)													
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	May-Sep
Williams Creek (WREVAP)	0	0	22	62	100	119	111	77	34	4	0	0	528	440
Mayo A (WREVAP)	0	0	0	48	91	111	108	78	26	6	0	0	467	414
Whitehorse A (WREVAP)	0	0	15	58	97	119	113	81	34	10	0	0	528	444
Whitehorse A (Adjusted Class A pan)	-	-	-	-	104	125	110	96	48	-	-	-	-	483
Pelly Ranch (Adjusted Class A pan)	-	-	-	-	108	120	108	80	37	-	-	-	-	453
Minto Camp (Adjusted)	0	0	5	56	95	119	112	80	24	4	0	0	495	431

Notes:

For adjusted Class A pan estimates reported in the table, the symbol (-) indicates no measurements available for month.

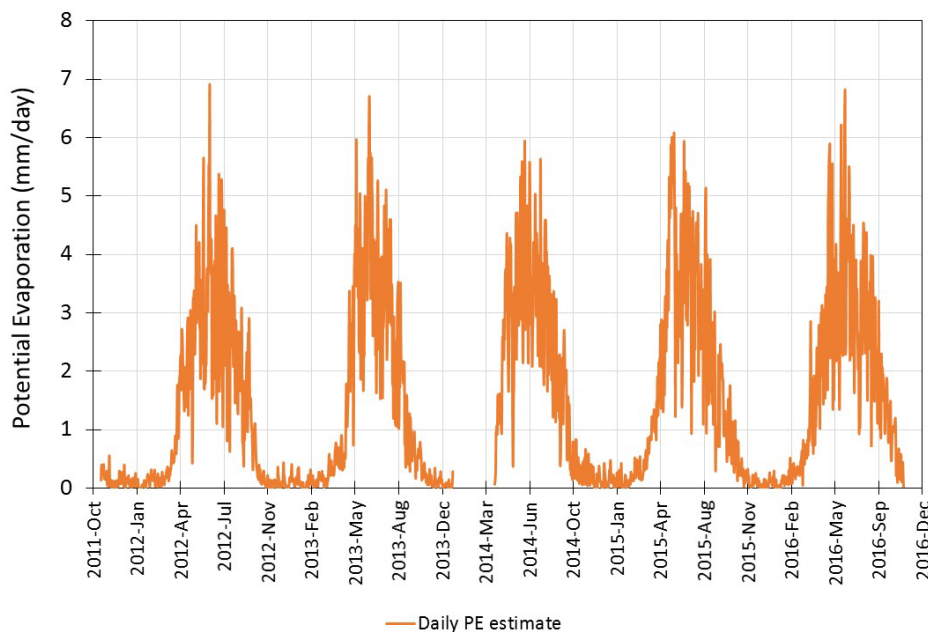


Figure 3-15: Daily potential evaporation estimates for climate station (ATM-ROAD AAM) for the period of baseline study.

**Table 3-11:
Summary of potential evaporation estimates for the Mount Nansen climate station (ATM-ROAD AAM) for the period of baseline study.**

Year	Potential Evaporation (in mm)								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr to Oct	May to Sep
2012	43	82	99	102	80	47	11	463	410
2013	14	84	119	103	90	42	15	466	437
2014	32	95	112	101	80	43	11	474	431
2015	46	127	110	98	71	40	16	508	446
2016	56	101	115	95	87	45	17	516	443
Average	38	98	111	100	82	43	14	486	433

3.2 Manual Streamflow Measurements

This section presents the available manual streamflow measurements that have been made at the Site by EDI from 2011 to 2016, in tabular format. The discharge value calculated from the rating curve and the associated error relative to the manual measurement are presented as well. A negative error value indicates that the rating curve derived discharge is under-estimated relative to the manual measurement, and vice-versa. Overall, the average rating error for each station ranges from -1% to 8% for the stations that gauge the smaller Site watersheds (*e.g.*, Dome Creek). The average rating curve errors are higher for

the hydrometric stations located on the larger streams (e.g., Victoria Creek). However, the error metrics for three of these stations (H-BC, H-VC-DBC and H-VC-R) are skewed substantially higher by potential measurement error and/or bias. The first two station rating curves are influenced by the inclusion of measurements collected under channel icing conditions, where the hydraulic relationship is affected by the presence of ice, and the latter rating curve is influenced by two erroneous measurements made in June and July of 2015. If these measurements are removed, the average error for these three stations is 9%. Error associated with under-ice discharge measurements is much less of an issue for Dome Creek in particular, due to the extensive icing in the channel, which means that many of the hydrometric stations are located in spots that freeze to bed during the winter (i.e., no flow measurement is possible).

**Table 3-12:
Station H-DC-B (Dome Creek Diversion Channel at the Bridge) – Discharge
Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
06/05/2013	17:00	SS	0.022	NA	NA
15/05/2013	11:20	SS	0.119	NA	NA
21/05/2013	14:44	SS	0.107	NA	NA
27/05/2013	15:40	SS	0.304	NA	NA
10/06/2013	16:31	SS	0.427	NA	NA
24/06/2013	14:36	SS	0.021	NA	NA
15/07/2013	15:21	SS	0.016	NA	NA
13/08/2013	14:24	SS	0.005	NA	NA
23/09/2013	15:18	SS	0.028	NA	NA
15/10/2013	15:17	SS	0.012	NA	NA
12/11/2013	16:20	SS	0.000	NA	NA
14/04/2014	16:15	N	NA	NA	NA
08/05/2014	14:37	SS	0.119	NA	NA
20/05/2014	15:17	SS	0.040	NA	NA
24/06/2014	10:40	SS	0.010	NA	NA
15/07/2014	13:19	SS	0.004	NA	NA
12/08/2014	10:51	SS	0.010	NA	NA
16/09/2014	15:59	SS	0.014	NA	NA
15/10/2014	8:22	SS	0.027	NA	NA
13/11/2014	13:00	N	NA	NA	NA
15/12/2014	16:00	N	NA	NA	NA
16/02/2015	17:15	N	0.000	NA	NA
21/04/2015	9:45	SS	0.009	NA	NA
05/05/2015	18:20	SS	0.032	NA	NA
14/05/2015	8:18	SS	0.037	0.035	-5%
16/06/2015	15:00	SS	0.008	0.015	82%
14/07/2015	10:00	SS	0.005	0.006	26%
19/08/2015	15:18	SS	0.017	0.019	12%
15/09/2015	16:45	SS	0.023	0.015	-34%
14/10/2015	15:00	SS	0.009	NA	NA
10/05/2016	13:22	SS	0.0424	NA	NA
06/06/2016	19:18	SS	0.0168	NA	NA
05/07/2016	15:10	SS	0.0054	0.005	-2%
02/08/2016	18:42	SS	0.008	0.005	-30%
07/09/2016	15:25	SS	0.017	0.007	-58%
04/10/2016	13:15	SS	0.005	NA	NA
AVERAGE RATING CURVE ERROR					-1%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-13:
Station H-SEEP (Seepage Pond Outflow) – Discharge Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Flow Meter Discharge (m ³ /s)	Flow Meter Error (%)
17/04/2012	17:38	V/SG	0.0070	0.0034	-52%
01/05/2012	14:42	V/SG	0.0030	0.0031	4%
15/05/2012	15:36	V/SG	0.0026	0.0029	13%
30/05/2012	7:58	V/SG	0.0027	0.0028	2%
11/06/2012	15:18	V/SG	0.0030	0.0027	-10%
25/06/2012	14:45	V/SG	0.0020	0.0030	51%
09/07/2012	12:26	V/SG	0.0029	0.0028	-1%
23/07/2012	13:47	V/SG	0.0036	0.0033	-10%
06/08/2012	13:48	V/SG	0.0035	0.0034	-2%
21/08/2012	13:38	V/SG	0.0036	0.0036	1%
04/09/2012	13:45	V/SG	0.0033	0.0038	16%
17/09/2012	14:42	V/SG	0.0035	0.0037	8%
02/10/2012	14:25	V/SG	0.0036	0.0038	5%
15/10/2012	14:30	V/SG	0.0034	0.0034	-1%
13/11/2012	17:01	V/SG	0.0030	0.0036	19%
12/12/2012	12:45	V/SG	0.0040	0.0033	-19%
14/01/2013	17:30	V/SG	0.0030	0.0034	13%
12/02/2013	14:40	V/SG	0.0030	0.0033	10%
17/04/2013	12:04	V	0.0030	0.0025	-17%
08/05/2013	9:47	V	0.0029	0.0034	17%
15/05/2013	11:00	V	0.0026	0.0033	27%
11/06/2013	16:53	V	0.0024	0.0021	-11%
25/06/2013	15:07	V	0.0026	0.0024	-7%
16/07/2013	15:45	V	0.0028	0.0026	-7%
13/08/2013	13:05	V	0.0030	0.0029	-4%
24/09/2013	15:55	V	0.0039	0.0033	-14%
16/10/2013	18:58	V	0.0050	0.0038	-24%
13/11/2013	17:05	V	0.0033	0.0030	-7%
17/12/2013	10:00	V	0.0026	0.0031	21%
13/01/2014	15:13	V	0.0024	0.0031	32%
10/03/2014	13:00	V	0.0029	0.0027	-6%
14/04/2014	15:40	V	0.0025	0.0025	-1%
09/05/2014	13:03	N	NA	0.0048	NA
21/05/2014	13:15	V	0.0009	0.0032	252%
24/06/2014	9:28	V	0.0030	0.0026	-12%
16/07/2014	10:25	V	0.0030	0.0026	-13%
12/08/2014	10:00	V	0.0030	0.0030	1%
16/09/2014	15:21	V	0.0030	0.0031	3%
14/10/2014	18:07	V	0.0030	0.0032	5%
14/10/2014	18:07	NA	NA	0.0032	NA
13/11/2014	14:00	V	0.0028	0.0026	-7%
15/12/2014	16:40	V	0.0030	0.0030	0%
12/01/2015	17:20	V	0.0020	0.0030	49%
16/02/2015	15:55	V	0.0025	0.0028	14%
17/03/2015	8:25	V	0.0029	0.0040	37%
20/04/2015	18:57	V	0.0041	0.0024	-41%
05/05/2015	16:30	V	0.0027	0.0030	10%
13/05/2015	17:56	V	0.0030	0.0037	22%
16/06/2015	13:38	V	0.0020	0.0027	33%
14/07/2015	9:45	V	0.0023	0.0023	-2%
19/08/2015	14:10	V	0.0022	0.0022	-2%
15/09/2015	15:50	V	0.0027	0.0028	6%
14/10/2015	13:47	V	0.0027	0.0027	1%
AVERAGE RATING CURVE ERROR					8%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SG = Staff Gauge; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-14:
Station H-DC-M WP (Middle Dome Creek Weir Pond) – Discharge Measurement
Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
23/06/2011	12:17	SS	0.041	NA	NA
23/06/2011	12:17	F	0.080	NA	NA
07/07/2011	9:25	CM	0.024	NA	NA
03/08/2011	15:00	CM	0.175	NA	NA
17/08/2011	11:25	CM	0.038	NA	NA
31/08/2011	8:30	SS	0.039	NA	NA
31/08/2011	8:30	F	0.091	NA	NA
31/08/2011	8:30	CM	0.000	NA	NA
28/09/2011	23:24	CM	0.030	NA	NA
12/10/2011	11:06	SS	0.018	NA	NA
16/11/2011	14:20	SS	0.004	NA	NA
09/01/2012	13:20	SS	0.017	NA	NA
30/01/2012	14:30	SS	0.002	NA	NA
05/03/2012	15:38	SS	0.005	NA	NA
15/04/2013	16:18	SS	0.000	NA	NA
06/05/2013	15:53	N	NA	NA	NA
15/05/2013	10:58	SS	0.131	NA	NA
21/05/2013	13:55	SS	0.456	NA	NA
27/05/2013	14:30	SS	0.210	NA	NA
10/06/2013	15:48	SS	0.104	NA	NA
24/06/2013	14:00	SS	0.019	NA	NA
15/07/2013	14:25	SS	0.009	NA	NA
13/08/2013	13:34	SS	0.007	NA	NA
23/09/2013	14:41	SS	0.073	NA	NA
15/10/2013	14:31	SS	0.0174	NA	NA
12/11/2013	15:28	SS	0.0141	NA	NA
17/12/2013	9:12	SS	0.0067	NA	NA
13/01/2014	14:15	SS	0.007	NA	NA
10/02/2014	16:50	SS	0.007	NA	NA
10/03/2014	16:45	SS	0.0041	NA	NA
23/06/2014	18:49	V	0.009	NA	NA
15/07/2014	14:30	V	0.005	NA	NA
12/08/2014	9:15	V	0.01	NA	NA
16/09/2014	14:15	W	NA	NA	NA
16/09/2014	14:15	V	0.014	NA	NA
15/10/2014	10:41	V	0.014	NA	NA
13/11/2014	13:14	W	NA	NA	NA
13/11/2014	13:14	V	0.004	NA	NA
20/04/2015	18:20	N	NA	NA	NA
05/05/2015	15:50	N	NA	NA	NA
13/05/2015	17:40	SS	0.118	0.126	7%
16/06/2015	13:25	V	0.007	0.009	22%
14/07/2015	8:54	V	0.005	0.005	5%
19/08/2015	13:46	SS	0.017	0.014	-18%
19/08/2015	13:46	V	0.013	0.014	7%
15/09/2015	15:10	V	0.021	0.020	-5%
14/10/2015	13:20	V	0.011	0.008	-27%
AVERAGE RATING CURVE ERROR					-1%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-15:
Station H-DC-R (Dome Creek at the Road) – Discharge Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
12/05/2011	12:00	F	0.133	NA	NA
25/05/2011	12:00	SS	0.088	NA	NA
25/05/2011	12:00	CM	0.119	NA	NA
07/06/2011	16:45	SS	0.067	NA	NA
07/06/2011	16:45	F	0.032	NA	NA
22/06/2011	18:00	CM	0.081	NA	NA
06/07/2011	12:40	CM	0.032	NA	NA
03/08/2011	10:26	SS	0.078	NA	NA
03/08/2011	10:26	F	NA	NA	NA
17/08/2011	17:55	SS	0.127	NA	NA
17/08/2011	17:55	F	0.232	NA	NA
31/08/2011	14:15	SS	0.042	NA	NA
14/09/2011	10:04	SS	0.026	NA	NA
14/09/2011	10:04	F	0.069	NA	NA
28/09/2011	14:10	SS	NA	NA	NA
28/09/2011	14:10	F	0.087	NA	NA
12/10/2011	9:06	SS	0.030	NA	NA
16/11/2011	13:30	V	0.000	NA	NA
31/08/2011	14:15	F	0.087	NA	NA
06/05/2013	14:58	N	NA	NA	NA
10/06/2013	14:41	SS	0.064	NA	NA
24/06/2013	13:10	SS	0.024	NA	NA
15/07/2013	13:27	SS	0.013	NA	NA
13/08/2013	12:50	SS	0.012	NA	NA
23/09/2013	13:45	SS	0.0849	NA	NA
15/10/2013	13:27	SS	0.0113	NA	NA
12/11/2013	14:08	SS	0.0043	NA	NA
14/04/2014	13:58	N	NA	NA	NA
08/05/2014	13:24	SS	0.1521	NA	NA
20/05/2014	13:48	SS	0.056	NA	NA
23/06/2014	17:17	SS	0.014	NA	NA
15/07/2014	11:18	SS	0.009	NA	NA
11/08/2014	16:26	SS	0.023	NA	NA
16/09/2014	8:58	SS	0.024	NA	NA
14/10/2014	16:02	SS	0.022	NA	NA
12/11/2014	15:30	N	NA	NA	NA
15/12/2014	NA	N	NA	NA	NA
20/04/2015	NA	N	NA	NA	NA
05/05/2015	NA	N	NA	NA	NA
13/05/2015	9:22	V	0.005	NA	NA
13/05/2015	9:22	SS	0.051	NA	NA
15/06/2015	16:49	SS	0.015	0.014	-4%
13/07/2015	16:21	SS	0.008	NA	NA
18/08/2015	16:43	SS	0.012	0.021	72%
18/08/2015	16:43	V	0.013	0.021	54%
14/09/2015	19:25	SS	0.035	NA	NA
13/10/2015	15:00	SS	0.024	NA	NA
28/04/2016	14:10	SS	0.055	NA	NA
10/05/2016	9:42	SS	0.034	0.027	-22%
06/06/2016	15:13	SS	0.015	0.014	-5%
04/07/2016	17:20	SS	0.040	0.037	-7%
01/08/2016	15:32	SS	0.019	0.015	-19%
06/09/2016	17:23	SS	0.024	0.022	-5%
03/10/2016	17:16	SS	0.016	NA	NA
07/11/2016	NA	N	NA	NA	NA
AVERAGE RATING CURVE ERROR					-1%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-16:
Station H-BC (Back Creek) – Discharge Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
12/05/2011	15:32	CM	0.125	NA	NA
25/05/2011	16:30	CM	0.334	NA	NA
07/06/2011	15:55	SS	0.051	NA	NA
07/06/2011	15:55	F	0.564	NA	NA
23/06/2011	14:30	CM	0.036	NA	NA
07/07/2011	14:30	CM	0.056	NA	NA
03/08/2011	12:16	CM	0.339	NA	NA
18/08/2011	16:55	CM	0.004	NA	NA
30/08/2011	16:20	CM	0.104	NA	NA
14/09/2011	12:18	CM	0.080	NA	NA
28/09/2011	15:05	CM	0.045	NA	NA
12/10/2011	10:02	SS	0.022	NA	NA
16/11/2011	11:00	N	NA	NA	NA
21/07/2011	13:11	VH	0.198	NA	NA
21/07/2011	13:11	F	0.300	NA	NA
16/05/2013	13:20	ADV	0.340	NA	NA
16/05/2013	13:20	SS	0.180	NA	NA
22/05/2013	12:25	SS	0.616	NA	NA
28/05/2013	15:33	ADV	0.292	NA	NA
11/06/2013	12:42	SS	0.110	NA	NA
25/06/2013	11:54	SS	0.017	NA	NA
16/07/2013	12:36	SS	0.003	NA	NA
14/08/2013	10:45	SS	0.015	NA	NA
24/09/2013	12:20	SS	0.053	NA	NA
16/10/2013	13:48	SS	0.006	NA	NA
15/04/2014	11:50	N	0	NA	NA
09/05/2014	11:25	SS	0.3729	NA	NA
21/05/2014	12:10	SS	0.047	NA	NA
24/06/2014	20:38	N	0	NA	NA
14/07/2014	15:33	N	0	NA	NA
11/08/2014	19:28	N	0	NA	NA
16/09/2014	12:44	SS	0.07	NA	NA
15/10/2014	12:50	SS	0.0451	NA	NA
13/11/2014	10:00	N	NA	NA	NA
16/12/2014	10:30	N	NA	NA	NA
20/04/2015	17:51	N	0.000	0.000	NA
05/05/2015	12:20	N	0.000	0.000	NA
13/05/2015	10:33	N	0.000	0.000	0%
16/06/2015	10:45	N	0.000	0.000	0%
13/07/2015	18:47	N	0.000	0.004	0%
19/08/2015	10:28	SS	0.037	0.040	7%
15/09/2015	9:25	SS	0.099	0.000	NA
14/10/2015	11:35	SS	0.009	0.000	NA
19/04/2016	11:50	ADV	0.074	0.000	NA
27/04/2016	15:10	ADV	0.179	0.141	-21%
09/05/2016	18:26	ADV	0.076	0.094	24%
07/06/2016	15:04	ADV	0.104	0.070	-33%
05/07/2016	12:15	SS	0.006	0.025	318%
02/08/2016	13:08	SS	0.041	0.051	25%
07/09/2016	11:15	SS	0.075	0.075	0%
04/10/2016	18:56	SS	0.034	0.000	NA
AVERAGE RATING CURVE ERROR - All measurements					2%
AVERAGE RATING CURVE ERROR – Under ice measurements removed					32%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-17:
Station H-VC-U (Upper Victoria Creek) – Discharge Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
12/05/2011	14:30	CM	0.780	NA	NA
25/05/2011	15:30	CM	2.259	NA	NA
07/06/2011	14:15	SS	0.490	NA	NA
07/06/2011	14:15	F	1.279	NA	NA
23/06/2011	3:00	CM	0.527	NA	NA
07/07/2011	15:06	CM	0.409	NA	NA
03/08/2011	12:58	CM	2.623	NA	NA
18/08/2011	15:15	CM	1.260	NA	NA
30/08/2011	15:35	CM	0.648	NA	NA
14/09/2011	11:15	CM	0.390	NA	NA
28/09/2011	16:04	CM	0.312	NA	NA
11/10/2011	16:07	CM	0.223	NA	NA
16/11/2011	11:43	CM	0.316	NA	NA
11/01/2012	10:26	SS	0.005	NA	NA
31/01/2012	13:46	SS	0.002	NA	NA
06/03/2012	17:30	CM	0.059	NA	NA
21/07/2011	14:20	F	2.342	NA	NA
16/04/2013	15:59	ADV	0.062	NA	NA
16/04/2013	15:59	SS	0.020	NA	NA
07/05/2013	14:12	ADV	0.125	NA	NA
16/05/2013	12:33	ADV	2.136	NA	NA
22/05/2013	11:30	ADV	0.727	NA	NA
28/05/2013	14:51	ADV	2.7011	NA	NA
11/06/2013	11:43	ADV	0.4882	NA	NA
25/06/2013	11:11	ADV	0.208	NA	NA
16/07/2013	11:46	ADV	0.1145	NA	NA
14/08/2013	10:20	ADV	0.2783	NA	NA
24/09/2013	11:30	ADV	0.7413	NA	NA
16/10/2013	12:40	ADV	0.4047	NA	NA
13/11/2013	14:30	SS	0.4991	NA	NA
17/12/2013	17:01	SS	0.0637	NA	NA
14/01/2014	13:52	ADV	0.087	NA	NA
14/01/2014	14:12	SS	0.134	NA	NA
11/02/2014	12:20	SS	0.061	NA	NA
11/03/2014	14:14	ADV	0.013	NA	NA
11/03/2014	14:14	SS	0.034	NA	NA
09/05/2014	11:37	ADV	1.929	NA	NA
21/05/2014	11:21	SS	0.392	NA	NA
21/05/2014	11:21	ADV	0.556	NA	NA
24/06/2014	20:05	ADV	0.172	NA	NA
14/07/2014	13:09	ADV	0.144	NA	NA
11/08/2014	18:52	ADV	0.261	NA	NA
16/09/2014	11:20	ADV	0.571	NA	NA
15/10/2014	12:18	ADV	0.422	NA	NA
16/12/2014	10:15	ADV	0.127	NA	NA
13/01/2015	18:00	SS	0.057	NA	NA
13/01/2015	18:00	ADV	0.051	NA	NA
17/02/2015	13:58	ADV	0.020	NA	NA
17/02/2015	13:58	SS	0.018	NA	NA
16/03/2015	19:20	SS	0.009	NA	NA
16/03/2015	19:20	ADV	0.010	NA	NA
20/04/2015	17:25	ADV	0.130	NA	NA
05/05/2015	13:15	ADV	0.368	NA	NA
13/05/2015	14:14	ADV	1.290	NA	NA
16/06/2015	10:00	ADV	0.100	0.091	-8%
13/07/2015	18:34	ADV	0.090	0.092	2%
19/08/2015	8:41	ADV	0.379	0.372	-2%
19/08/2015	8:41	ADV	0.379	0.372	-2%
15/09/2015	8:30	ADV	0.856	0.766	-10%
14/10/2015	10:10	ADV	0.192	NA	NA
19/04/2016	10:30	ADV	0.263	NA	NA

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
27/04/2016	13:35	ADV	1.367	1.410	3%
09/05/2016	17:37	ADV	0.775	0.755	-3%
07/06/2016	14:08	ADV	0.359	0.370	3%
05/07/2016	10:35	ADV	0.170	0.185	9%
02/08/2016	12:12	ADV	0.503	0.461	-8%
07/09/2016	10:00	ADV	0.583	0.540	-7%
04/10/2016	17:14	ADV	0.447	0.474	6%
08/11/2016	14:35	ADV	1.664	NA	NA
AVERAGE RATING CURVE ERROR					-1%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-18:
Station H-VC-DBC (Victoria Creek downstream of Back Creek) – Discharge
Measurement Summary**

Date	Time		Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
11/01/2012	9:20	NA	SS	0.047	NA	NA
11/01/2012	9:20	NA	CM	0.554	NA	NA
01/02/2012	14:30	NA	SS	0.002	NA	NA
06/03/2012	17:12	NA	SS	0.056	NA	NA
16/04/2013	13:46	NA	ADV	0.061	NA	NA
16/04/2013	13:45	NA	SS	0.030	NA	NA
07/05/2013	12:18	NA	ADV	0.210	NA	NA
07/05/2013	12:19	NA	SS	0.150	NA	NA
16/05/2013	11:50	NA	ADV	2.612	NA	NA
22/05/2013	10:40	NA	ADV	0.801	NA	NA
28/05/2013	14:05	NA	ADV	2.080	NA	NA
11/06/2013	11:10	NA	ADV	0.565	NA	NA
25/06/2013	10:30	NA	ADV	0.230	NA	NA
16/07/2013	11:00	NA	ADV	0.114	NA	NA
14/08/2013	9:53	NA	ADV	0.313	NA	NA
24/09/2013	10:50	NA	ADV	0.785	NA	NA
16/10/2013	11:56	NA	ADV	0.385	NA	NA
13/11/2013	12:57	NA	ADV	0.237	NA	NA
13/11/2013	12:58	NA	SS	0.200	NA	NA
17/12/2013	15:00	NA	SS	0.204	NA	NA
14/01/2014	12:30	12:30	ADV	0.104	NA	NA
14/01/2014	12:37	12:37	SS	0.170	NA	NA
11/02/2014	11:10	11:10	SS	0.148	NA	NA
11/03/2014	12:00	12:00	ADV	0.0447	NA	NA
11/03/2014	12:00	12:00	SS	0.0179	NA	NA
15/04/2014	9:50	9:50	SS	0.044	0.168	282%
15/04/2014	9:50	9:50	CM	0.047	0.168	257%
09/05/2014	11:40	11:40	ADV	2.388	2.499	5%
21/05/2014	10:25	10:25	ADV	0.6273	0.720	15%
24/06/2014	19:28	19:28	ADV	0.1767	0.231	31%
14/07/2014	14:40	14:40	ADV	0.1037	0.165	59%
11/08/2014	17:45	17:45	ADV	0.2876	0.287	0%
16/09/2014	10:07	10:07	ADV	0.670	1.589	137%
15/10/2014	11:20	11:20	ADV	0.478	0.543	14%
16/12/2014	9:25	9:25	ADV	0.178	0.513	189%
13/01/2015	16:14	16:14	ADV	0.058	NA	NA
13/01/2015	16:14	16:14	SS	0.052	NA	NA
17/02/2015	12:46	12:46	ADV	0.023	NA	NA
17/02/2015	12:46	12:46	SS	0.034	NA	NA
16/03/2015	17:57	17:57	SS	0.017	NA	NA
16/03/2015	17:57	17:57	ADV	0.013	NA	NA
20/04/2015	16:23	16:23	ADV	0.192	NA	NA
05/05/2015	11:32	11:32	ADV	0.317	NA	NA

Date	Time		Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
13/05/2015	11:10	11:10	ADV	1.163	1.049	-10%
16/06/2015	8:45	8:45	ADV	0.085	0.104	23%
13/07/2015	17:28	17:28	ADV	0.085	0.095	12%
19/08/2015	7:50	7:50	ADV	0.433	0.409	-6%
15/09/2015	7:45	7:45	ADV	0.962	NA	NA
14/10/2015	8:20	8:20	ADV	0.216	NA	NA
19/04/2016	9:35	9:35	ADV	0.268	0.696	159%
27/04/2016	11:55	11:55	ADV	1.536	1.425	-7%
09/05/2016	16:54	16:54	ADV	0.852	0.835	-2%
07/06/2016	13:02	13:02	ADV	0.520	0.472	-9%
05/07/2016	9:45	9:45	ADV	0.164	0.179	9%
02/08/2016	10:48	10:48	ADV	0.539	0.540	0%
07/09/2016	9:00	9:00	ADV	0.650	0.713	10%
04/10/2016	15:37	15:37	ADV	0.547	0.581	6%
08/11/2016	13:40	13:40	ADV	0.166	NA	NA
AVERAGE RATING CURVE ERROR - All measurements						53%
AVERAGE RATING CURVE ERROR – Under ice measurements removed						16%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

Table 3-19:
Station H-VC-UMN (Victoria Creek Upstream of Minnesota Creek) – Discharge Measurement Summary

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
16/04/2013	10:44	ADV	0.059	NA	NA
16/04/2013	10:44	SS	0.120	NA	NA
07/05/2013	10:11	ADV	0.162	NA	NA
16/05/2013	10:06	ADV	2.062	NA	NA
16/05/2013	10:06	SS	1.970	NA	NA
22/05/2013	9:15	ADV	0.448	NA	NA
28/05/2013	10:45	ADV	3.283	NA	NA
11/06/2013	9:56	ADV	0.662	NA	NA
25/06/2013	8:31	ADV	0.247	NA	NA
16/07/2013	9:11	ADV	0.126	NA	NA
14/08/2013	8:26	ADV	0.321	NA	NA
24/09/2013	10:07	ADV	0.783	NA	NA
16/10/2013	10:20	ADV	0.538	NA	NA
13/11/2013	10:28	SS	0.788	NA	NA
17/12/2013	13:30	SS	0.252	NA	NA
14/01/2014	10:30	ADV	0.091	NA	NA
14/01/2014	10:38	SS	0.157	NA	NA
11/02/2014	9:40	SS	0.109	NA	NA
11/03/2014	10:04	SS	0.003	NA	NA
15/04/2014	8:40	SS	0.019	NA	NA
15/04/2014	8:40	CM	0.022	NA	NA
09/05/2014	8:30	ADV	2.605	NA	NA
21/05/2014	8:51	SS	0.741	0.762	3%
21/05/2014	8:51	ADV	0.702	0.762	9%
24/06/2014	18:29	ADV	0.1879	0.289	54%
15/07/2014	9:00	ADV	0.1204	0.266	121%
11/08/2014	15:00	ADV	0.2832	0.334	18%
15/09/2014	16:10	ADV	0.6602	0.480	-27%
14/10/2014	14:30	ADV	0.5108	0.179	-65%
12/11/2014	14:35	ADV	0.1989	0.195	-2%
15/12/2014	14:38	ADV	0.1396	0.080	-43%
13/01/2015	13:17	SS	0.018	NA	NA
13/01/2015	13:17	ADV	0.036	NA	NA
17/02/2015	9:12	SS	0.009	NA	NA
16/03/2015	15:15	SS	0.002	NA	NA

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
20/04/2015	14:43	N	NA	NA	NA
04/05/2015	16:10	ADV	NA	0.646	NA
14/05/2015	12:39	ADV	2.052	2.961	44%
15/06/2015	15:10	ADV	0.109	0.161	48%
13/07/2015	14:55	ADV	0.104	0.142	37%
18/08/2015	15:23	ADV	0.480	0.437	-9%
14/09/2015	18:20	ADV	1.105	0.792	-28%
13/10/2015	16:50	ADV	0.336	NA	NA
19/04/2016	13:30	ADV	0.195	0.338	73%
27/04/2016	19:15	ADV	1.460	1.925	32%
09/05/2016	15:17	ADV	0.997	0.893	-10%
07/06/2016	11:25	ADV	0.534	0.505	-5%
04/07/2016	15:55	ADV	0.210	0.205	-2%
02/08/2016	8:38	ADV	0.606	0.515	-15%
06/09/2016	15:40	ADV	0.624	0.623	0%
03/10/2016	15:06	ADV	0.416	0.461	11%
08/11/2016	11:25	ADV	0.166	NA	NA
AVERAGE RATING CURVE ERROR					11%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-20:
Station H-VC-R (Victoria Creek at the Road) – Discharge Measurement Summary**

Date	Time	NA	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
06/07/2011	10:30	10:30	CM	0.637	NA	NA
03/08/2011	7:56	7:56	CM	3.673	NA	NA
17/08/2011	16:25	16:25	CM	1.841	2.036	11%
30/08/2011	13:45	13:45	CM	0.963	1.113	16%
14/09/2011	8:40	8:40	CM	0.498	0.869	75%
27/09/2011	17:30	17:30	CM	0.468	0.313	-33%
11/10/2011	14:54	14:54	CM	0.277	NA	NA
16/11/2011	9:15	9:15	CM	0.210	NA	NA
16/11/2011	9:15	9:15	SS	0.077	NA	NA
14/12/2011	17:00	17:00	N	NA	NA	NA
20/07/2011	10:40	10:40	CM	1.707	2.581	51%
11/01/2012	16:20	16:20	SS	0.061	NA	NA
12/01/2012	13:25	13:25	SS	0.159	NA	NA
01/02/2012	9:15	9:15	SS	0.057	NA	NA
06/03/2012	14:45	14:45	SS	0.043	NA	NA
15/04/2013	13:00	13:00	ADV	0.034	NA	NA
15/04/2013	13:00	13:00	SS	0.040	NA	NA
06/05/2013	13:05	13:05	ADV	0.122	NA	NA
06/05/2013	13:05	13:05	SS	0.100	NA	NA
15/05/2013	8:15	8:15	ADV	3.208	NA	NA
21/05/2013	12:23	12:23	ADV	1.221	NA	NA
27/05/2013	12:53	12:53	ADV	3.597	NA	NA
10/06/2013	13:23	13:23	ADV	0.735	NA	NA
24/06/2013	12:02	12:02	ADV	0.289	NA	NA
15/07/2013	12:23	12:23	ADV	0.1598	NA	NA
13/08/2013	11:45	11:45	ADV	0.3696	NA	NA
23/09/2013	12:30	12:30	ADV	0.949	NA	NA
15/10/2013	12:09	12:09	ADV	0.3786	NA	NA
12/11/2013	12:54	12:54	ADV	0.2959	NA	NA
16/12/2013	16:05	16:05	SS	0.253	NA	NA
13/01/2014	13:04	13:04	SS	0.17	NA	NA
10/02/2014	15:00	15:00	SS	0.063	NA	NA
10/03/2014	14:54	14:54	ADV	0.0296	NA	NA
08/05/2014	11:54	11:54	ADV	3.204	NA	NA
08/05/2014	11:54	11:54	ADV	3.204	NA	NA

Date	Time	NA	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
20/05/2014	13:03	13:03	ADV	0.758	0.971	28%
23/06/2014	16:03	16:03	ADV	0.179	NA	NA
14/07/2014	16:46	16:46	ADV	0.121	0.098	-19%
11/08/2014	12:40	12:40	ADV	0.329	0.273	-17%
15/09/2014	14:39	14:39	ADV	0.770	0.541	-30%
14/10/2014	13:20	13:20	ADV	0.577	0.148	-74%
15/12/2014	13:33	13:33	ADV	NA	0.068	NA
12/01/2015	14:45	14:45	ADV	0.014	NA	NA
16/02/2015	13:00	13:00	ADV	0.009	NA	NA
16/03/2015	13:00	13:00	ADV	0.002	NA	NA
20/04/2015	13:03	13:03	ADV	0.145	NA	NA
04/05/2015	13:57	13:57	ADV	0.450	0.544	21%
04/05/2015	13:57	13:57	ADV	0.450	0.544	21%
12/05/2015	16:50	16:50	ADV	2.328	2.283	-2%
15/06/2015	13:25	13:25	ADV	0.146	0.557	283%
13/07/2015	13:17	13:17	ADV	0.076	0.481	533%
18/08/2015	13:30	13:30	ADV	0.542	1.037	91%
14/09/2015	15:30	15:30	ADV	1.315	1.198	-9%
13/10/2015	13:40	13:40	ADV	0.464	NA	NA
AVERAGE RATING CURVE ERROR – all measurements						56%
AVERAGE RATING CURVE ERROR – June and July 2015 measurements removed						9%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

**Table 3-21:
Station H-VC-R+290 (Victoria Creek at the Road+290)– Discharge Measurement Summary**

Date	Time	Method	Discharge (m ³ /s)	Rating Curve Discharge (m ³ /s)	Rating Curve Error (%)
14/09/2015	15:30	ADV	1.315	1.198	-9%
13/10/2015	13:35	ADV	0.398	NA	NA
18/04/2016	13:35	ADV	0.559	0.688	23%
27/04/2016	17:10	ADV	1.754	2.144	22%
09/05/2016	13:44	ADV	0.912	1.027	13%
06/06/2016	13:21	ADV	0.334	0.422	27%
04/07/2016	14:05	ADV	0.221	0.277	25%
01/08/2016	13:18	ADV	0.699	0.733	5%
06/09/2016	14:05	ADV	0.719	0.812	13%
03/10/2016	13:01	ADV	0.484	0.651	34%
07/11/2016	14:27	ADV	2.451	0.651	-73%
AVERAGE RATING CURVE ERROR					8%

Notes:

1. Measurement Method: ADV = Acoustic Doppler Velocity Profile; CM = Current Meter; F = float; N = No Measurement; SS = Salt Slug Dilution; V = Volumetric; VH = Velocity Head; W = Weir.

3.3 Streamflow Records – Discharge

The computed flow records for the highlighted Site stations listed in Table 2-5 are presented as average daily discharge time-series and plotted with spot discharge measurements in Figure 3-16 through Figure 3-25. The highlighted stations are those that have continuous flow data of sufficient duration to allow monthly and annual summaries of discharge, runoff and unit yields to be calculated. The same flow records are also presented as unit yield plots, with each plot showing annual data for all stations on a single plot (refer to Figure 3-25 to Figure 3-29).

While discharge magnitude varies with watershed area (*i.e.*, larger basin areas result in higher discharge values), it is more often instructive to compare runoff and/or unit yields to remove the influence of watershed area. The variation in runoff and yields across the gauged basins at the Project Site is relatively low, with unit yields averaging 5.9 ± 1.5 L/s/km² and an average runoff of 104 ± 37 mm for the open water season (Table 3-22). The Site sub-watersheds, and Dome Creek in particular, exhibit relatively lower average runoff (62 ± 6 mm) in 2015 and 2016 than the stations located on Victoria Creek (133 ± 15 mm).

Table 3-23 through Table 3-41 present the monthly summaries of streamflow as discharge, unit yields and runoff, by station.

3.4 Streamflow Records – Unit Yields

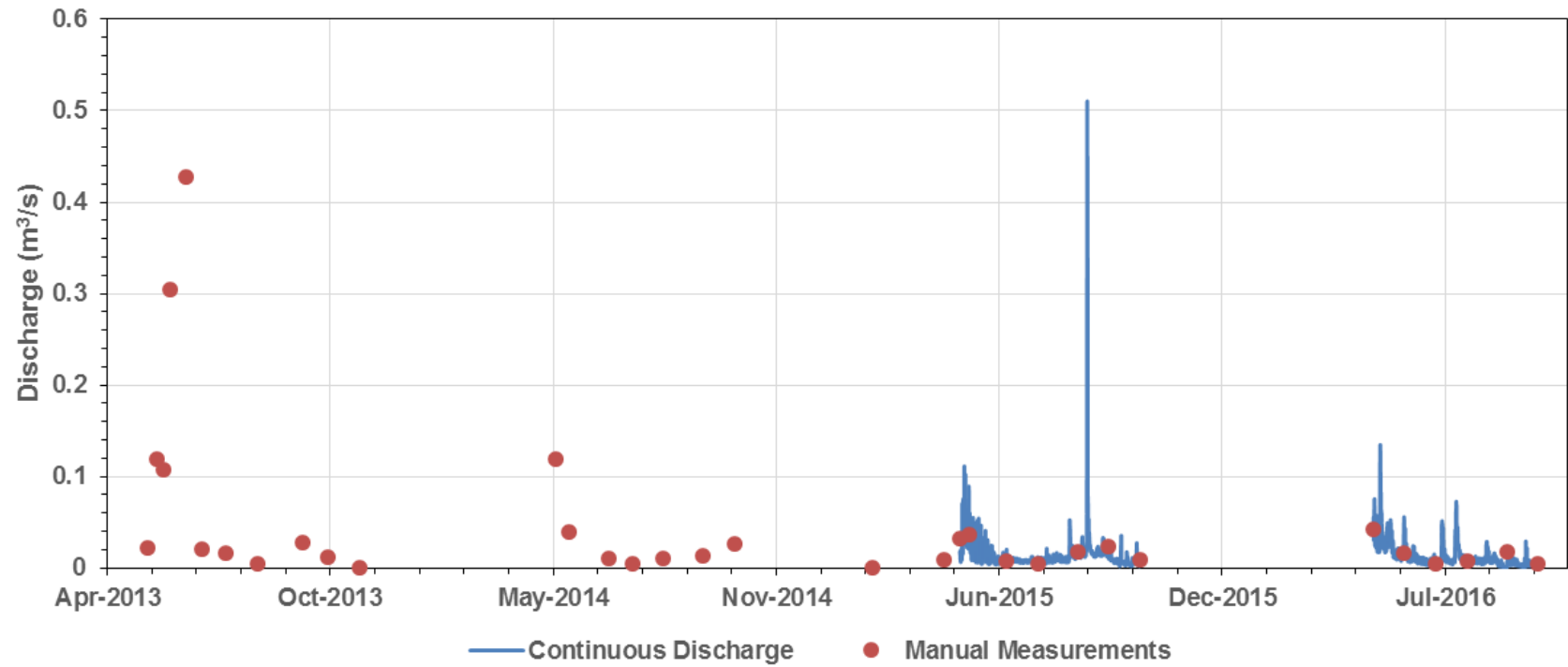
Period of record (Figure 3-26) and unit yield plots per year (Figure 3-27 through Figure 3-30) are presented for nine of the continuously recording hydrometric stations in this section. The H-SEEP station gauges the outflows from the TSF seepage pond, and does not have a specific drainage area. Therefore, unit yield and runoff values are not calculated for this station.

Table 3-22:
Summary of monthly average discharge, unit yield and runoff for Project Site hydrometric stations.

Station	Drainage Area (km ²)	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average/Total	
H-DC-B	3.0	Average Discharge (m ³ /s)	--	--	--	--	<i>0.03</i>	0.01	0.01	0.02	0.01	<i>0.01</i>	--	--	0.014	
		Average Yield (L/s/km ²)	--	--	--	--	<i>9.71</i>	3.59	3.67	5.26	2.78	<i>2.01</i>	--	--	4.50	
		Runoff (mm)	--	--	--	--	<i>20</i>	9	10	14	7	2	--	--	62	
H-SEEP ¹	NA	Average Discharge (m ³ /s)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	
		Average Yield (L/s/km ²)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Runoff (mm)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H-DC-M WP	3.3	Average Discharge (m ³ /s)	--	--	--	--	<i>0.04</i>	0.01	0.01	0.03	0.02	0.01	--	--	0.018	
		Average Yield (L/s/km ²)	--	--	--	--	<i>12.92</i>	2.90	1.79	7.81	4.62	2.46	--	--	5.42	
		Runoff (mm)	--	--	--	--	<i>20</i>	8	5	21	12	3	--	--	68	
H-DC-R	4.5	Average Discharge (m ³ /s)	--	--	--	--	<i>0.030</i>	0.012	0.016	0.021	0.019	0.004	--	--	0.017	
		Average Yield (L/s/km ²)	--	--	--	--	<i>6.60</i>	2.73	3.57	4.62	4.30	0.99	--	--	3.80	
		Runoff (mm)	--	--	--	--	<i>14</i>	7	10	12	11	1	--	--	55	
H-BC	10.4	Average Discharge (m ³ /s)	--	--	--	<i>0.125</i>	<i>0.085</i>	<i>0.026</i>	<i>0.029</i>	<i>0.065</i>	<i>0.083</i>	--	--	--	0.069	
		Average Yield (L/s/km ²)	--	--	--	<i>12.03</i>	<i>8.20</i>	<i>2.51</i>	<i>2.84</i>	<i>6.30</i>	<i>7.95</i>	--	--	--	6.64	
		Runoff (mm)	--	--	--	<i>12</i>	<i>22</i>	<i>6</i>	<i>8</i>	<i>17</i>	<i>17</i>	--	--	--	81	
H-VC-U	64.6	Average Discharge (m ³ /s)	--	--	--	<i>0.860</i>	<i>0.695</i>	<i>0.309</i>	<i>0.342</i>	<i>0.593</i>	<i>0.550</i>	<i>0.369</i>	<i>0.202</i>	<i>0.146</i>	0.452	
		Average Yield (L/s/km ²)	--	--	--	<i>13.31</i>	<i>10.76</i>	<i>4.79</i>	<i>5.30</i>	<i>9.18</i>	<i>8.51</i>	<i>5.71</i>	<i>3.12</i>	<i>2.26</i>	6.99	
		Runoff (mm)	--	--	--	<i>13</i>	<i>23</i>	<i>11</i>	<i>12</i>	<i>23</i>	<i>22</i>	<i>7</i>	<i>8</i>	<i>1</i>	121	
H-VC-DBC	75.0	Average Discharge (m ³ /s)	<i>0.174</i>	--	<i>0.225</i>	<i>0.449</i>	<i>1.102</i>	<i>0.225</i>	<i>0.311</i>	<i>0.519</i>	<i>0.843</i>	<i>0.497</i>	<i>0.329</i>	<i>0.195</i>	0.443	
		Average Yield (L/s/km ²)	<i>2.32</i>	--	<i>3.00</i>	<i>5.99</i>	<i>14.69</i>	<i>3.00</i>	<i>4.14</i>	<i>6.91</i>	<i>11.24</i>	<i>6.63</i>	<i>4.39</i>	<i>2.60</i>	5.90	
		Runoff (mm)	<i>2</i>	--	<i>5</i>	<i>13</i>	<i>38</i>	<i>8</i>	<i>11</i>	<i>19</i>	<i>29</i>	<i>10</i>	<i>11</i>	<i>7</i>	154	
H-VC-UMN	83.4	Average Discharge (m ³ /s)	<i>0.137</i>	--	<i>0.066</i>	<i>0.819</i>	<i>1.025</i>	<i>0.267</i>	<i>0.351</i>	<i>0.527</i>	<i>0.604</i>	<i>0.363</i>	<i>0.192</i>	<i>0.084</i>	0.403	
		Average Yield (L/s/km ²)	<i>1.64</i>	--	<i>0.79</i>	<i>9.83</i>	<i>12.29</i>	<i>3.20</i>	<i>4.21</i>	<i>6.32</i>	<i>7.25</i>	<i>4.35</i>	<i>2.30</i>	<i>1.01</i>	4.84	
		Runoff (mm)	<i>2</i>	--	<i>2</i>	<i>21</i>	<i>30</i>	<i>8</i>	<i>11</i>	<i>17</i>	<i>19</i>	<i>4</i>	<i>6</i>	<i>3</i>	123	
H-VC-R	97.7	Average Discharge (m ³ /s)	--	--	--	<i>0.28</i>	<i>1.32</i>	<i>0.437</i>	<i>0.736</i>	<i>1.14</i>	<i>0.772</i>	<i>0.394</i>	<i>0.168</i>	<i>0.073</i>	0.591	
		Average Yield (L/s/km ²)	--	--	--	<i>2.86</i>	<i>13.51</i>	<i>4.47</i>	<i>7.53</i>	<i>11.67</i>	<i>7.90</i>	<i>4.04</i>	<i>1.72</i>	<i>0.75</i>	6.05	
		Runoff (mm)	--	--	--	<i>5</i>	<i>32</i>	<i>12</i>	<i>13</i>	<i>29</i>	<i>20</i>	<i>6</i>	<i>4</i>	<i>2</i>	124	
H-VC-R+290	97.7	Average Discharge (m ³ /s)	--	--	--	<i>0.876</i>	<i>1.449</i>	<i>0.493</i>	<i>0.621</i>	<i>1.005</i>	<i>0.998</i>	<i>0.654</i>	--	--	0.871	
		Average Yield (L/s/km ²)	--	--	--	<i>8.97</i>	<i>14.83</i>	<i>5.04</i>	<i>6.35</i>	<i>10.29</i>	<i>10.22</i>	<i>6.70</i>	--	--	8.91	
		Runoff (mm)	--	--	--	<i>23</i>	<i>32</i>	<i>13</i>	<i>17</i>	<i>28</i>	<i>26</i>	<i>4</i>	--	--	143	

Notes:

1. The H-SEEP station gauges the TSF seepage pond outflows via a flow meter. There is no drainage area associated with this monitoring station, therefore unit yields and runoff are not calculated.
2. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.



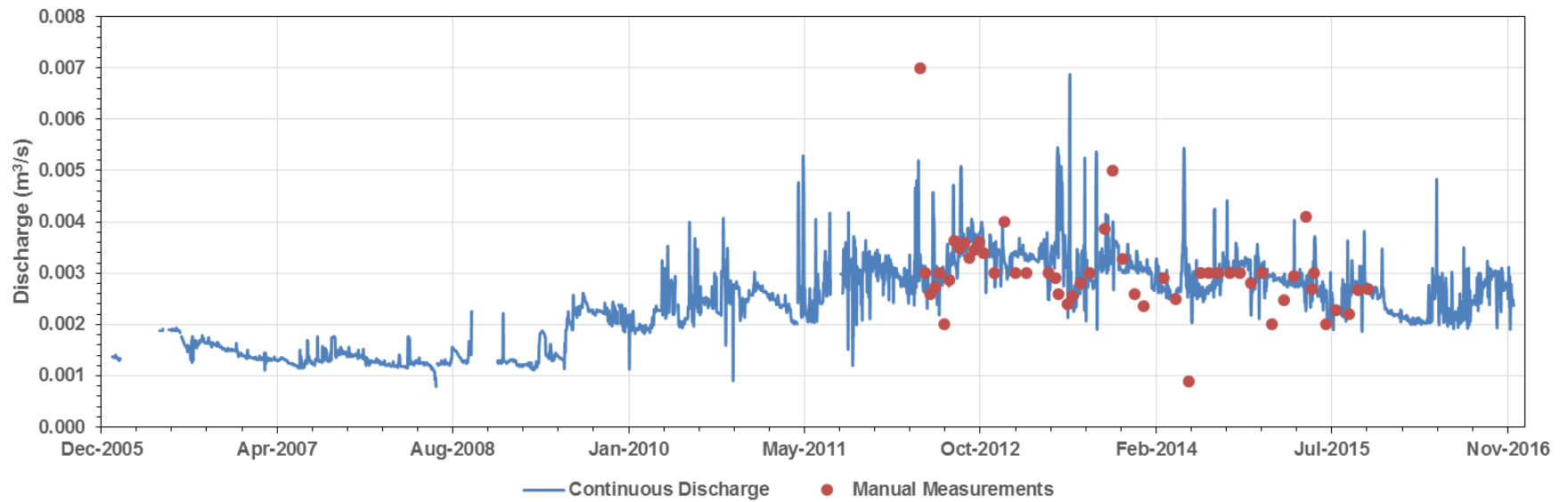


Figure 3-17: H-SEEP Average daily discharge record (2006-2016)

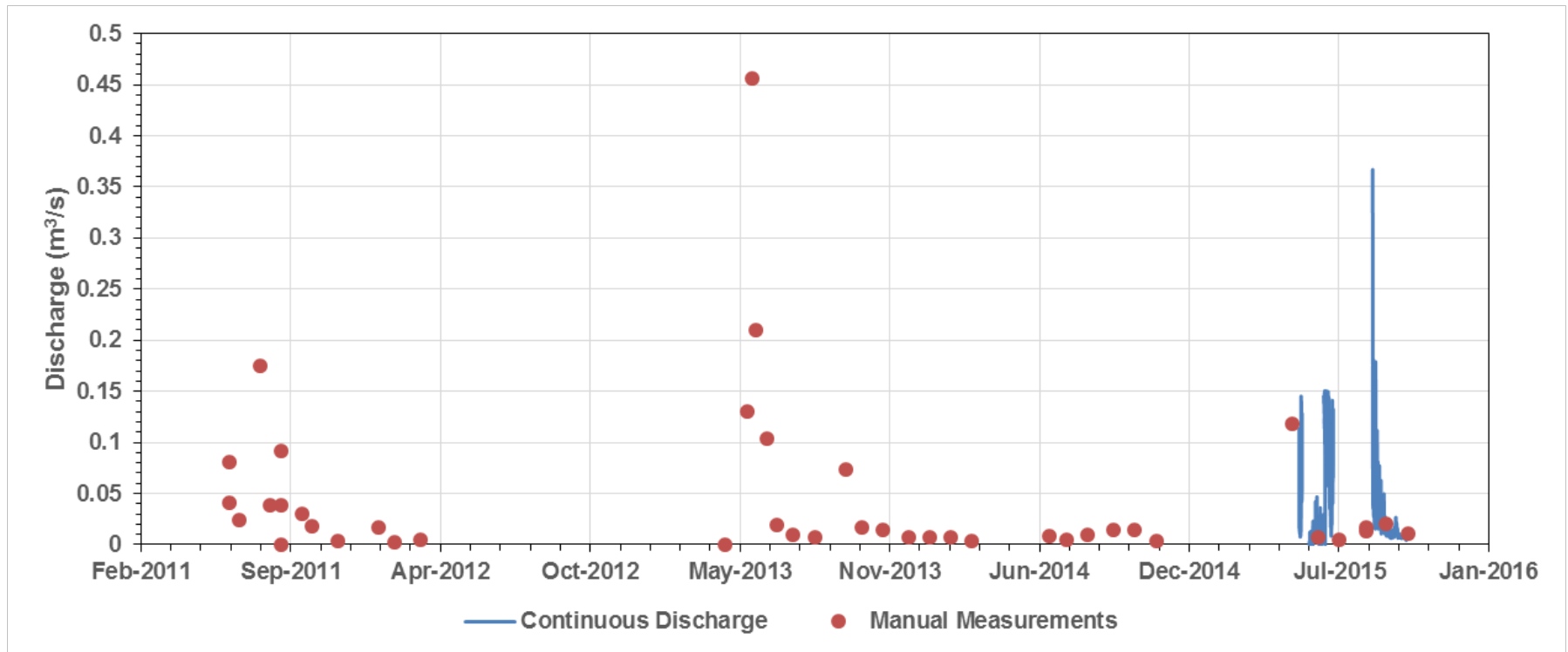


Figure 3-18: H-DC-M WP Average daily discharge record (2011-2016)

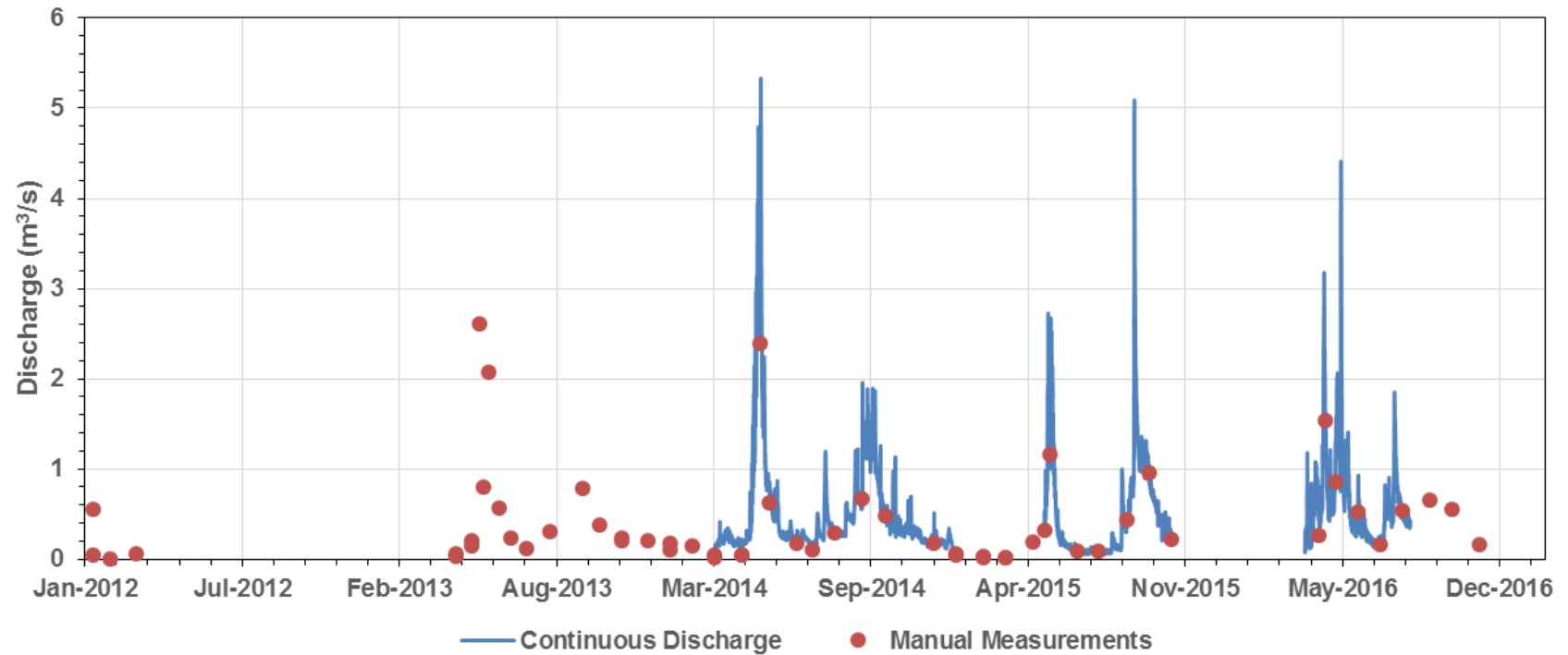


Figure 3-22: H-VC-DBC Average daily discharge record (2012-2016)

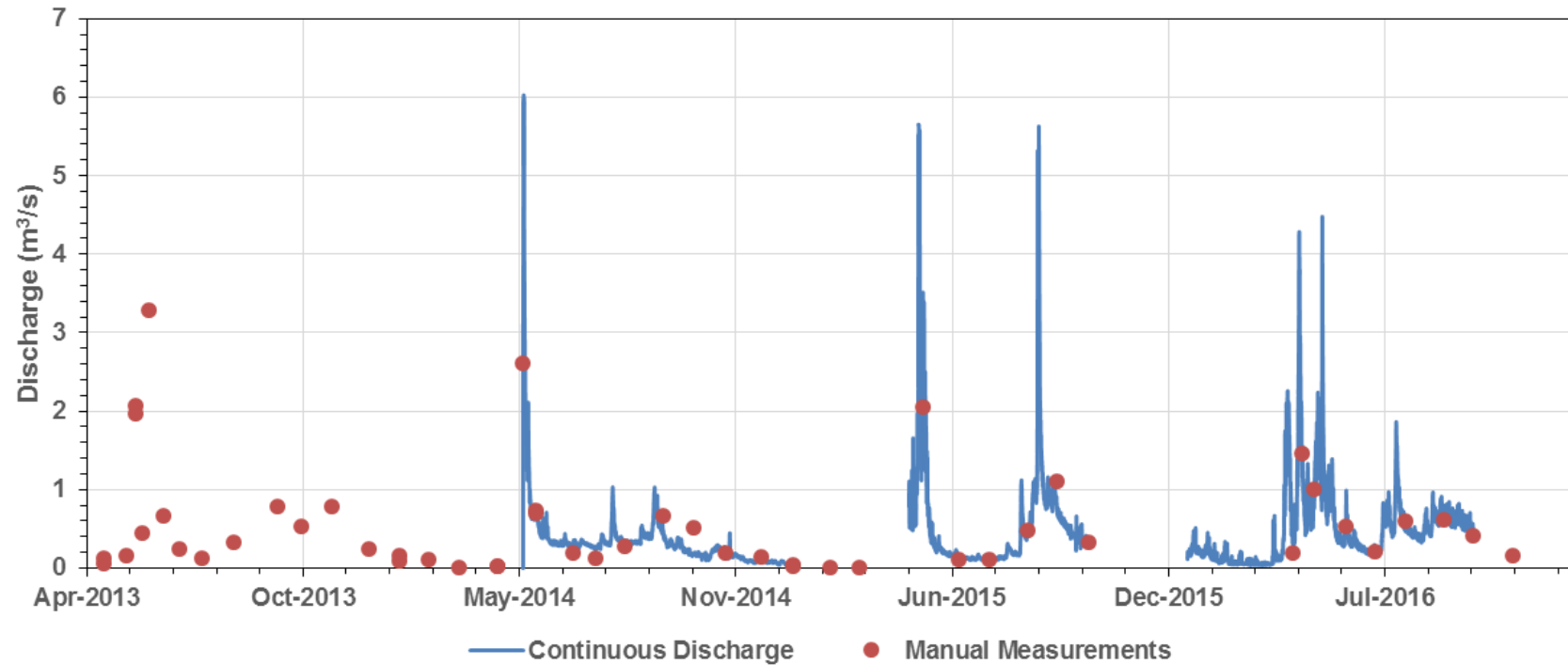


Figure 3-23: H-VC-UMN Average daily discharge record (2013-2016)

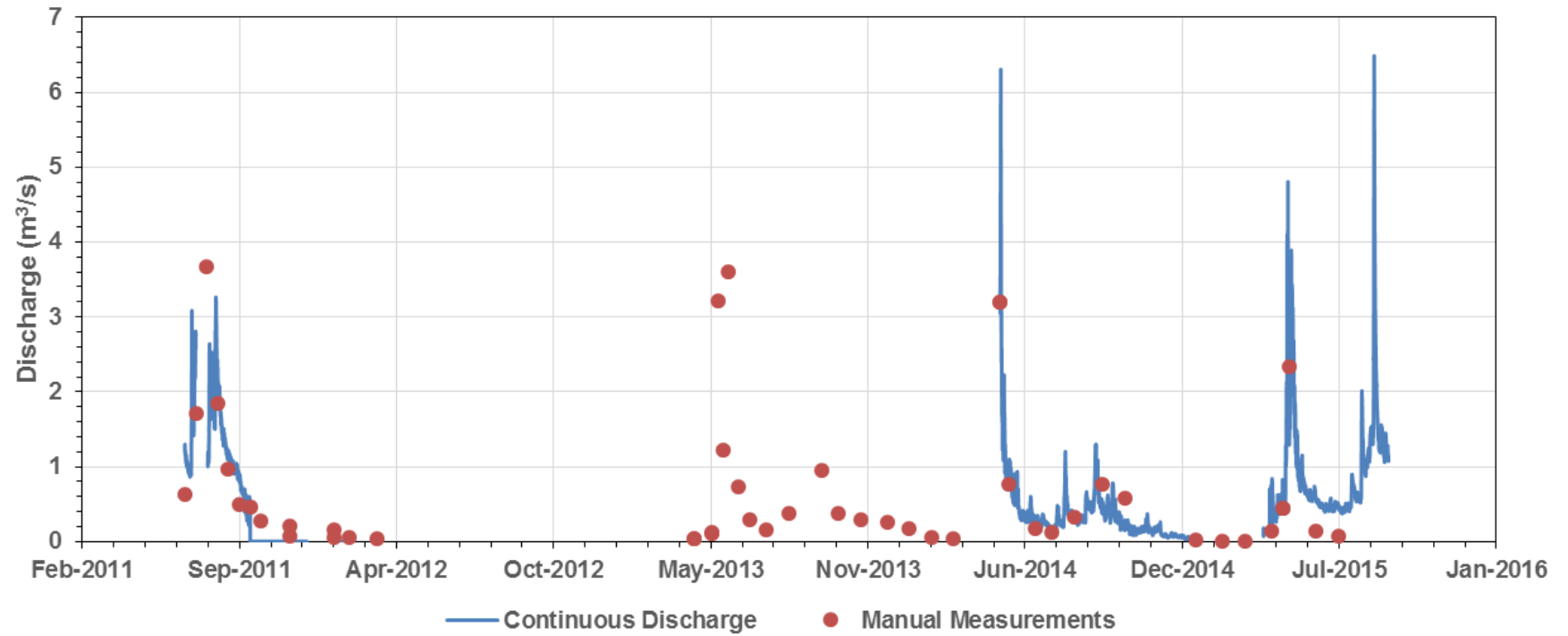


Figure 3-24: H-VC-R Average daily discharge record (2011-2015)

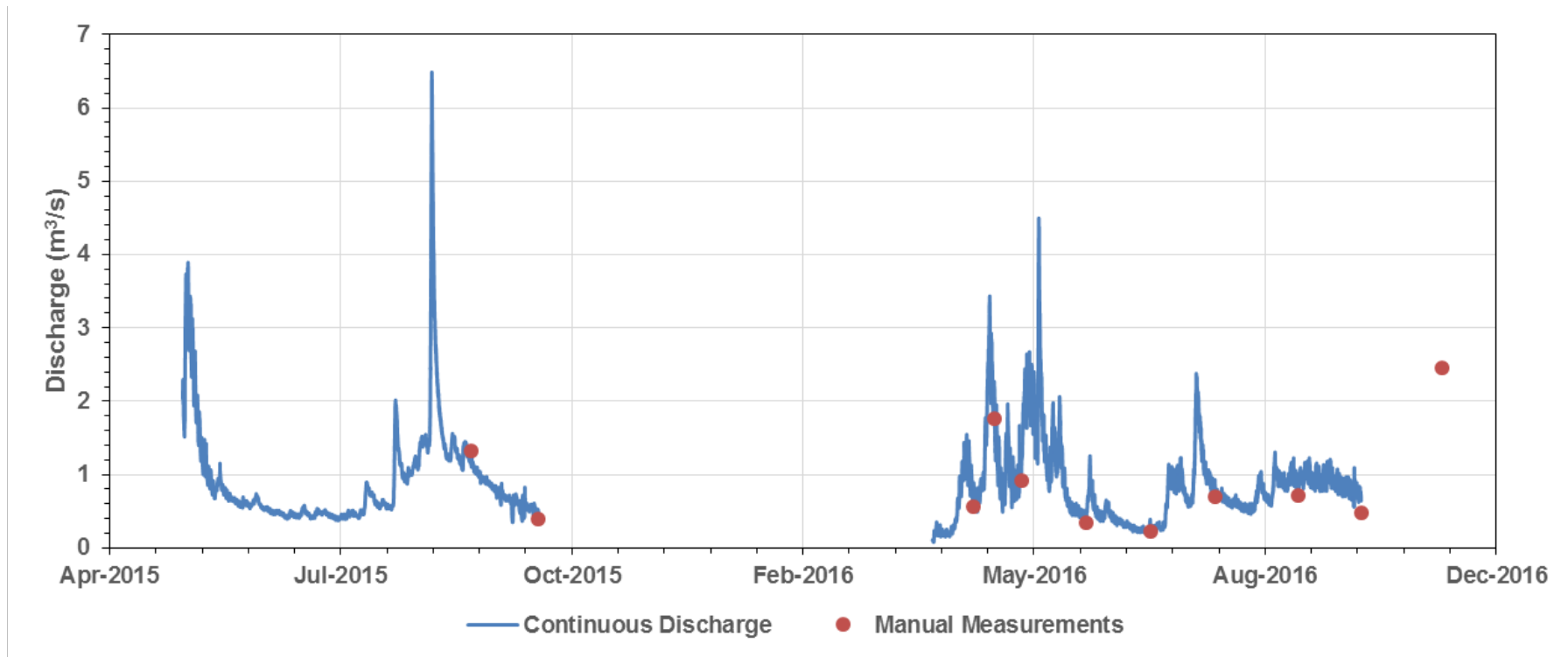


Figure 3-25: H-VC-R+290 Average daily discharge record (2015-2016). Station established in 2015 due to prohibitive ice conditions at HC-VC-R.

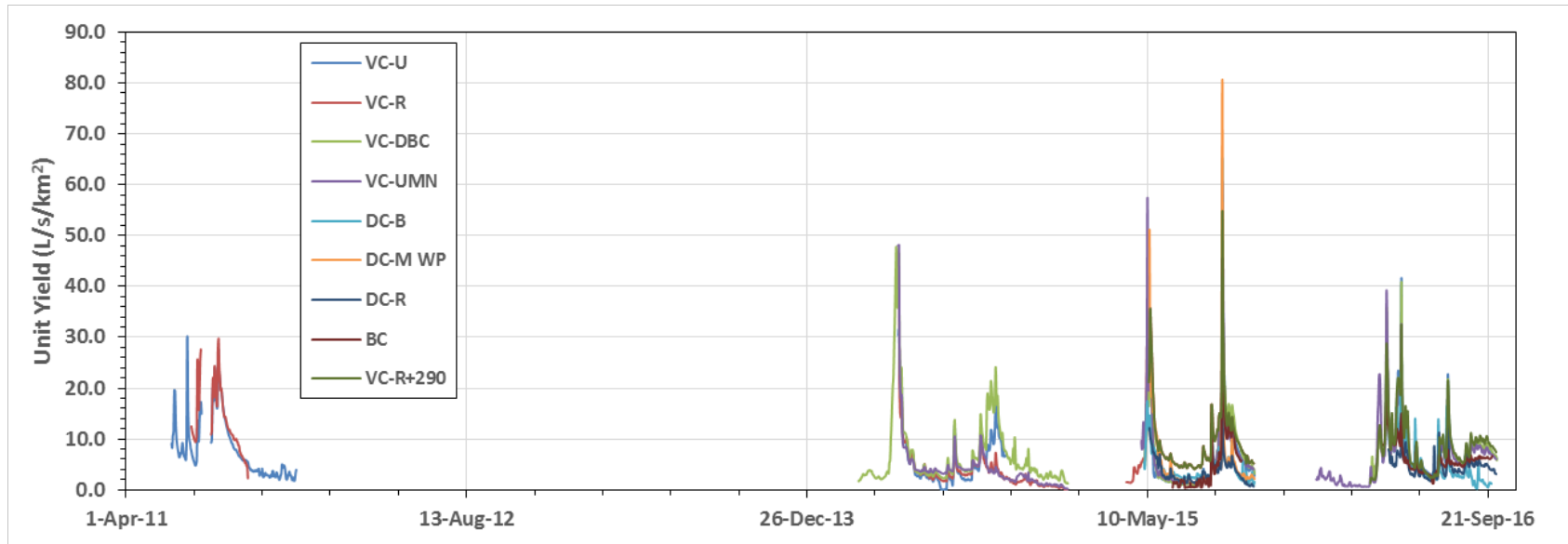


Figure 3-26: Average daily unit yield time-series for select Project stations (2011-2016)

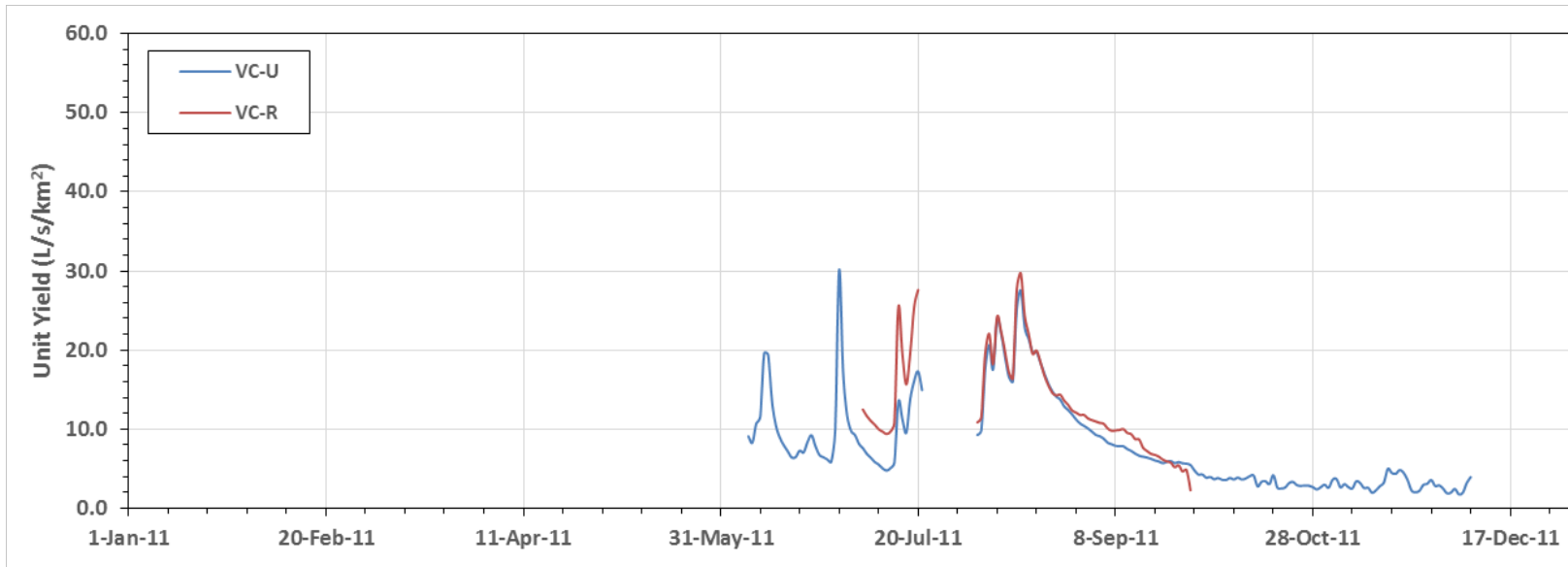


Figure 3-27: Average daily unit yield time-series for select Victoria Creek stations (2011)

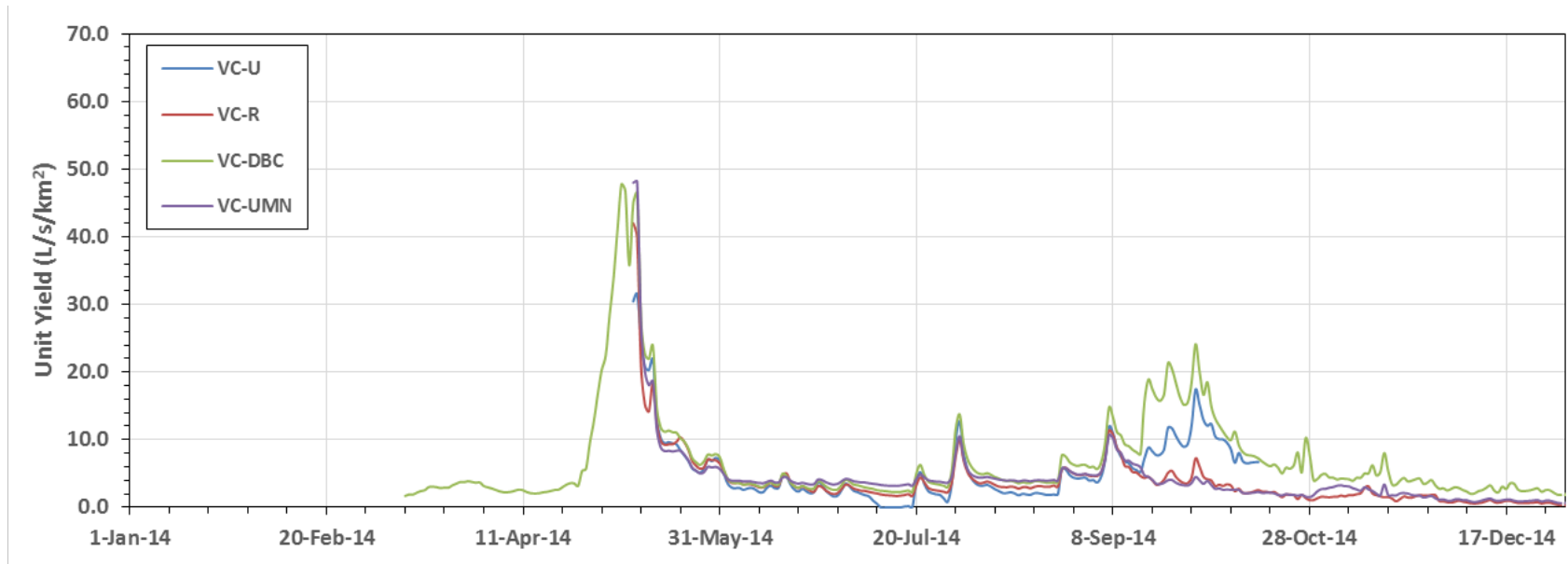


Figure 3-28: Average daily unit yield time-series for select Project stations (2014)

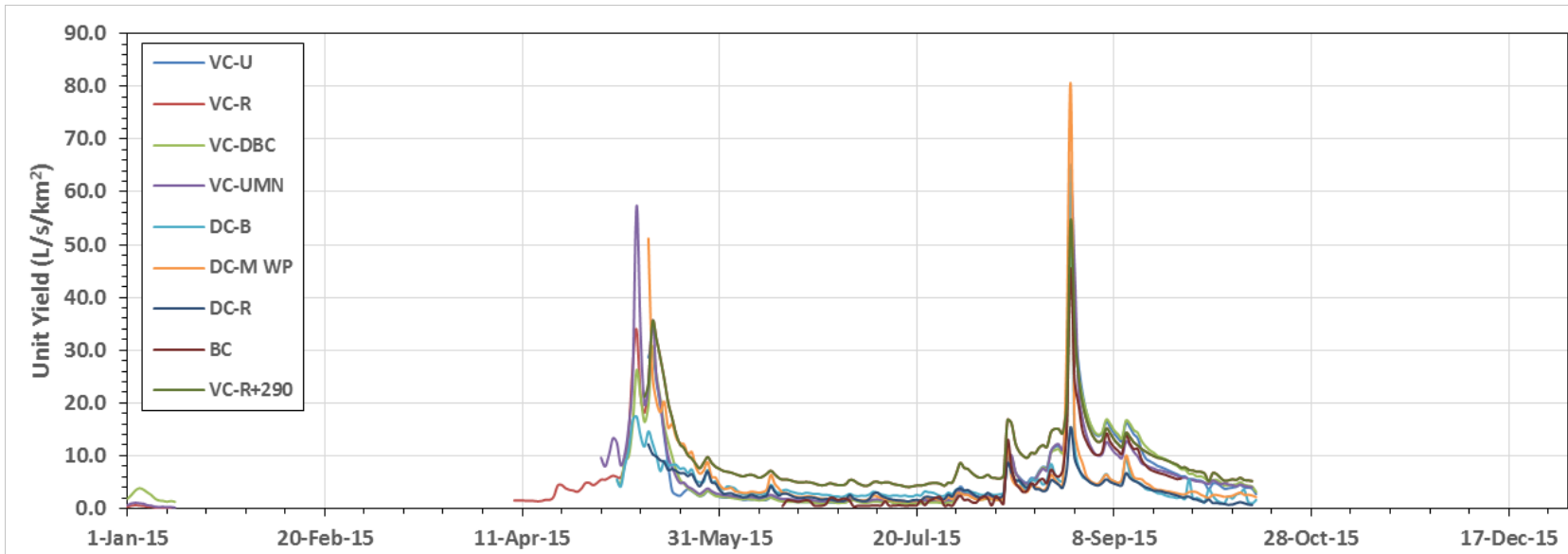


Figure 3-29: Average daily unit yield time-series for select Project stations (2015)

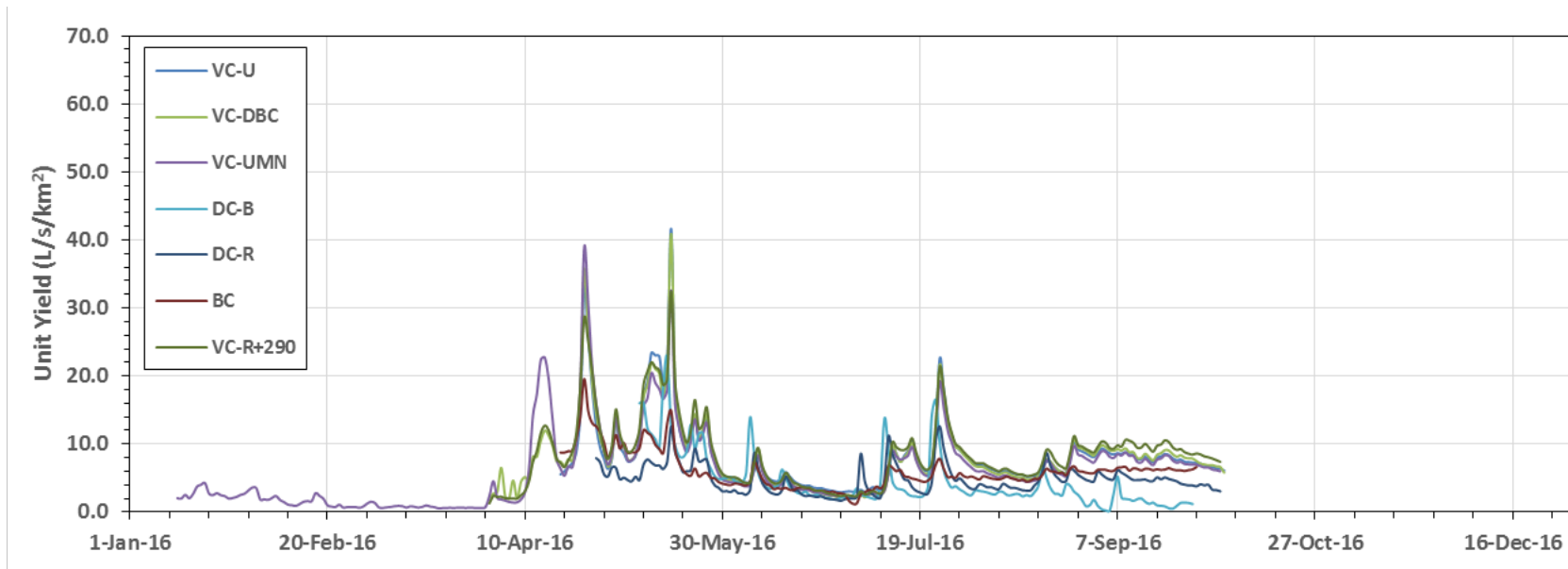


Figure 3-30: Average daily unit yield time-series for select Project stations (2016)

3.5 Streamflow Records – Monthly Summary Tables

Summary tables of average monthly discharge, unit yields and runoff are presented for ten hydrometric stations in this section.

Table 3-23:
H-DC-B Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Average	--	--	--	--	0.03	0.01	0.01	0.02	0.01	0.01	--	--
	Maximum	--	--	--	--	0.11	0.02	0.02	0.51	0.04	0.03	--	--
	Minimum	--	--	--	--	0.00	0.00	0.00	0.01	0.00	0.00	--	--
2016	Average	--	--	--	--	0.03	0.01	0.01	0.01	0.00	--	--	--
	Maximum	--	--	--	--	0.13	0.06	0.07	0.03	0.03	--	--	--
	Minimum	--	--	--	--	0.01	0.00	0.00	0.00	0.00	--	--	--
All Years	Average	--	--	--	--	0.03	0.01	0.01	0.02	0.01	0.01	--	--
	Maximum	--	--	--	--	0.13	0.06	0.07	0.51	0.04	0.03	--	--
	Minimum	--	--	--	--	0.00	0.00	0.00	0.00	0.00	0.00	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-24:
H-DC-B Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	# days with data	--	--	--	--	26	30	31	31	30	13	--	--
	Average Discharge (m ³ /s)	--	--	--	--	0.03	0.01	0.01	0.02	0.01	0.01	--	--
	Average Yield (L/s/km ²)	--	--	--	--	8.72	3.05	2.65	7.53	4.13	2.01	--	--
	Runoff (mm)	--	--	--	--	19.8	7.9	7.1	20.2	10.7	2.3	--	--
2016	# days with data	--	--	--	--	21	30	31	31	27	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	0.03	0.01	0.01	0.01	0.00	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	10.71	4.14	4.68	2.99	1.43	--	--	--
	Runoff (mm)	--	--	--	--	19.6	10.7	12.5	8.0	3.3	--	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	--	0.03	0.01	0.01	0.02	0.01	0.01	--	--
	Average Yield (L/s/km ²)	--	--	--	--	9.71	3.59	3.67	5.26	2.78	2.01	--	--
	Runoff (mm)	--	--	--	--	19.7	9.3	9.8	14.1	7.0	2.3	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-25:
H-SEEP Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	Average	<i>0.001</i>	--	--	--	<i>0.002</i>	<i>0.002</i>	<i>0.002</i>	0.002	0.002	0.002	0.002	<i>0.001</i>
	Maximum	<i>0.001</i>	--	--	--	<i>0.002</i>	<i>0.002</i>	<i>0.002</i>	0.002	0.002	0.002	0.002	<i>0.002</i>
	Minimum	<i>0.001</i>	--	--	--	<i>0.002</i>	<i>0.002</i>	<i>0.002</i>	0.001	0.002	0.002	0.001	<i>0.001</i>
	# days with data	24	--	--	--	7	17	26	31	30	31	30	30
2007	Average	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	<i>0.001</i>	0.001
	Maximum	0.002	0.001	0.001	0.001	0.001	0.002	0.002	<i>0.002</i>	0.002	0.002	<i>0.002</i>	0.002
	Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<i>0.001</i>	0.001	0.001	<i>0.001</i>	0.001
	# days with data	31	28	31	30	30	30	31	29	30	31	29	31
2008	Average	0.001	0.001	0.001	<i>0.001</i>	0.001	0.001	<i>0.001</i>	0.001	<i>0.001</i>	<i>0.002</i>	--	--
	Maximum	0.001	0.001	0.001	<i>0.002</i>	0.001	0.001	<i>0.001</i>	0.002	<i>0.002</i>	<i>0.002</i>	--	--
	Minimum	0.001	0.001	0.001	<i>0.001</i>	0.001	0.001	<i>0.001</i>	0.001	<i>0.001</i>	<i>0.001</i>	--	--
	# days with data	31	29	31	29	31	30	29	31	29	20	--	--
2009	Average	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.002	<i>0.002</i>
	Maximum	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.002	<i>0.002</i>
	Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	<i>0.002</i>
	# days with data	30	28	31	30	31	30	31	31	30	31	30	30
2010	Average	0.002	0.002	0.002	0.002	<i>0.003</i>	0.002	0.003	<i>0.002</i>	0.002	0.003	0.003	0.003
	Maximum	0.002	0.002	0.002	0.004	<i>0.003</i>	0.002	0.004	<i>0.003</i>	0.003	0.004	0.003	0.003
	Minimum	0.001	0.002	0.002	0.002	<i>0.002</i>	0.002	0.002	<i>0.002</i>	0.002	0.002	0.001	0.002
	# days with data	31	28	30	30	25	30	31	28	30	31	30	31
2011	Average	0.003	0.003	0.002	0.002	0.003	0.002	0.003	<i>0.003</i>	<i>0.003</i>	0.003	<i>0.003</i>	<i>0.003</i>
	Maximum	0.003	0.003	0.003	0.002	0.005	0.004	0.003	<i>0.004</i>	<i>0.004</i>	0.004	<i>0.004</i>	<i>0.003</i>
	Minimum	0.003	0.002	0.002	0.002	0.002	0.002	0.002	<i>0.003</i>	<i>0.002</i>	0.001	<i>0.002</i>	<i>0.003</i>
	# days with data	31	28	31	30	30	30	31	6	26	31	29	30
2012	Average	0.003	0.003	0.003	<i>0.003</i>	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.003
	Maximum	0.003	0.003	0.003	<i>0.005</i>	0.005	0.003	0.005	0.005	0.004	0.004	0.004	0.004
	Minimum	0.002	0.002	0.002	<i>0.002</i>	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.003
	# days with data	31	29	31	25	31	30	31	31	30	31	30	31
2013	Average	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.003
	Maximum	0.004	0.004	0.004	0.004	0.005	0.007	0.005	0.005	0.005	0.004	0.004	0.003
	Minimum	0.003	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	# days with data	31	28	31	30	31	30	31	31	30	31	30	31
2014	Average	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	Maximum	0.003	0.003	0.003	0.003	0.005	0.003	0.003	0.004	0.004	0.004	0.003	0.004
	Minimum	0.003	0.003	0.003	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.002	0.002
	# days with data	30	28	31	30	31	30	31	31	30	31	30	31
2015	Average	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003	0.002
	Maximum	0.003	0.003	0.004	0.003	0.004	0.003	0.003	0.004	0.003	0.004	0.003	0.002
	Minimum	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002
	# days with data	31	28	31	30	31	30	31	31	30	31	30	31
2016	Average	0.002	0.002	0.002	0.003	0.002	0.002	0.002	<i>0.003</i>	0.003	0.003	<i>0.003</i>	--
	Maximum	0.002	0.002	0.002	0.005	0.003	0.003	0.004	<i>0.003</i>	0.003	0.003	<i>0.003</i>	--
	Minimum	0.002	0.002	0.002	0.002	0.002	0.002	0.002	<i>0.002</i>	0.002	0.002	<i>0.002</i>	--
	# days with data	31	29	31	30	31	30	31	29	30	31	29	--
All Years	Average	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002
	Maximum	0.004	0.004	0.004	0.005	0.005	0.007	0.005	0.005	0.005	0.004	0.004	0.004
	Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-26:
H-DC-M WP Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Average	--	--	--	--	0.043	0.010	0.006	0.026	0.015	0.008	--	--
	Maximum	--	--	--	--	0.367	0.027	0.012	0.492	0.037	0.011	--	--
	Minimum	--	--	--	--	0.010	0.004	0.004	0.005	0.006	0.005	--	--
All Years	Average	--	--	--	--	0.043	0.010	0.006	0.026	0.015	0.008	--	--
	Maximum	--	--	--	--	0.367	0.027	0.012	0.492	0.037	0.011	--	--
	Minimum	--	--	--	--	0.010	0.004	0.004	0.005	0.006	0.005	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-27:
H-DC-M WP Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	# days with data	--	--	--	--	18	30	31	31	30	13	--	--
	Average Discharge (m ³ /s)	--	--	--	--	0.043	0.010	0.006	0.026	0.015	0.008	--	--
	Average Yield (L/s/km ²)	--	--	--	--	12.92	2.90	1.79	7.81	4.62	2.46	--	--
	Runoff (mm)	--	--	--	--	20.4	7.5	4.8	20.9	12.0	2.8	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	--	0.043	0.010	0.006	0.026	0.015	0.008	--	--
	Average Yield (L/s/km ²)	--	--	--	--	12.92	2.90	1.79	7.81	4.62	2.46	--	--
	Runoff (mm)	--	--	--	--	20.4	7.5	4.8	20.9	12.0	2.8	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-28:
H-DC-R Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Average	--	--	--	--	0.031	0.011	0.009	0.021	0.017	0.004	--	--
	Maximum	--	--	--	--	0.066	0.021	0.021	0.083	0.033	0.013	--	--
	Minimum	--	--	--	--	0.009	0.005	0.005	0.008	0.004	0.002	--	--
2016	Average	--	--	--	--	0.028	0.014	0.023	0.020	0.021	--	--	--
	Maximum	--	--	--	--	0.068	0.045	0.065	0.043	0.030	--	--	--
	Minimum	--	--	--	--	0.008	0.007	0.008	0.013	0.009	--	--	--
All Years	Average	--	--	--	--	0.030	0.012	0.016	0.021	0.019	0.004	--	--
	Maximum	--	--	--	--	0.068	0.045	0.065	0.083	0.033	0.013	--	--
	Minimum	--	--	--	--	0.008	0.005	0.005	0.008	0.004	0.002	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-29:
H-DC-R Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	# days with data	--	--	--	--	<i>19</i>	30	31	31	30	<i>13</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	--	0.031	0.011	0.009	0.021	0.017	0.004	--	--
	Average Yield (L/s/km ²)	--	--	--	--	<i>6.92</i>	<i>2.33</i>	<i>1.99</i>	<i>4.74</i>	<i>3.84</i>	<i>0.99</i>	--	--
	Runoff (mm)	--	--	--	--	<i>11</i>	6	5	13	10	<i>1</i>	--	--
2016	# days with data	--	--	--	--	31	30	31	31	30	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	0.028	0.014	0.023	0.020	0.021	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	6.29	3.12	5.14	4.50	4.76	--	--	--
	Runoff (mm)	--	--	--	--	17	8	14	12	12	--	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	--	<i>0.03</i>	0.01	0.02	0.02	0.02	<i>0.00</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	--	<i>6.60</i>	2.73	3.57	4.62	4.30	<i>0.99</i>	--	--
	Runoff (mm)	--	--	--	--	<i>14.0</i>	7.1	9.6	12.4	11.1	<i>1.1</i>	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-30:
H-BC Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Average	--	--	--	--	--	0.013	0.010	0.075	0.100	--	--	--
	Maximum	--	--	--	--	--	0.028	0.036	0.669	0.165	--	--	--
	Minimum	--	--	--	--	--	0.001	0.002	0.002	0.054	--	--	--
2016	Average	--	--	--	0.125	0.085	0.039	0.049	0.056	0.065	--	--	--
	Maximum	--	--	--	0.221	0.280	0.089	0.097	0.079	0.082	--	--	--
	Minimum	--	--	--	0.082	0.035	0.014	0.004	0.038	0.055	--	--	--
All Years	Average	--	--	--	--	0.085	0.026	0.029	0.065	0.083	--	--	--
	Maximum	--	--	--	--	0.280	0.089	0.097	0.669	0.165	--	--	--
	Minimum	--	--	--	--	0.035	0.001	0.002	0.002	0.054	--	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-31:
H-BC Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	# days with data	--	--	--	--	--	15	31	31	24	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	0.013	0.010	0.075	0.100	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	1.26	0.97	7.23	9.63	--	--	--
	Runoff (mm)	--	--	--	--	--	2	3	19	20	--	--	--
2016	# days with data	--	--	--	11	31	30	31	31	27	--	--	--
	Average Discharge (m ³ /s)	--	--	--	0.125	0.085	0.039	0.049	0.056	0.065	--	--	--
	Average Yield (L/s/km ²)	--	--	--	12.03	8.20	3.77	4.70	5.36	6.27	--	--	--
	Runoff (mm)	--	--	--	12	22	10	13	14	15	--	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	0.13	0.09	0.03	0.03	0.07	0.08	--	--	--
	Average Yield (L/s/km ²)	--	--	--	12.03	8.20	2.51	2.84	6.30	7.95	--	--	--
	Runoff (mm)	--	--	--	11.9	21.9	5.7	7.6	16.9	17.5	--	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-32:
H-VC-U Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	Average	--	--	--	--	--	0.660	0.626	1.101	0.443	0.214	0.202	0.146
	Maximum	--	--	--	--	--	2.291	1.435	1.978	0.680	0.502	0.696	0.262
	Minimum	--	--	--	--	--	0.349	0.273	0.559	0.209	0.000	0.109	0.000
2012	Average	--	--	--	--	--	--	--	--	--	--	--	--
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
	Minimum	--	--	--	--	--	--	--	--	--	--	--	--
2013	Average	--	--	--	--	--	--	--	--	--	--	--	--
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
	Minimum	--	--	--	--	--	--	--	--	--	--	--	--
2014	Average	--	--	--	--	0.720	0.187	0.147	0.206	0.543	0.583	--	--
	Maximum	--	--	--	--	2.126	0.506	0.995	0.688	1.197	0.987	--	--
	Minimum	--	--	--	--	0.260	0.000	0.000	0.087	0.197	0.312	--	--
2015	Average	--	--	--	--	0.505	0.100	0.096	0.631	0.695	0.265	--	--
	Maximum	--	--	--	--	2.298	0.170	0.300	4.298	1.322	0.386	--	--
	Minimum	--	--	--	--	0.118	0.064	0.066	0.118	0.267	0.137	--	--
2016	Average	--	--	--	0.860	0.860	0.290	0.499	0.434	0.518	0.414	--	--
	Maximum	--	--	--	2.626	4.367	0.698	1.652	0.766	0.687	0.494	--	--
	Minimum	--	--	--	0.317	0.292	0.172	0.168	0.303	0.352	0.329	--	--
All Years	Average	--	--	--	0.860	0.695	0.309	0.342	0.593	0.550	0.369	0.202	0.146
	Maximum	--	--	--	2.626	4.367	2.291	1.652	4.298	1.322	0.987	0.696	0.262
	Minimum	--	--	--	0.317	0.118	0.000	0.000	0.087	0.197	0.000	0.109	0.000

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-33:
H-VC-U Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	# days with data	--	--	--	--	--	23	21	27	30	31	30	6
	Average Discharge (m ³ /s)	--	--	--	--	--	<i>0.660</i>	0.626	1.101	0.443	0.214	0.202	<i>0.146</i>
	Average Yield (L/s/km ²)	--	--	--	--	--	<i>10.21</i>	9.69	17.05	6.85	3.31	3.12	<i>2.26</i>
	Runoff (mm)	--	--	--	--	--	<i>21</i>	17	40	18	9	8	<i>1</i>
2012	# days with data	--	--	--	--	--	--	--	--	--	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	--	--	--	--	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	--	--	--	--	--	--	--
	Runoff (mm)	--	--	--	--	--	--	--	--	--	--	--	--
2013	# days with data	--	--	--	--	--	--	--	--	--	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	--	--	--	--	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	--	--	--	--	--	--	--
	Runoff (mm)	--	--	--	--	--	--	--	--	--	--	--	--
2014	# days with data	--	--	--	--	22	30	31	31	30	<i>15</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	--	<i>0.720</i>	0.187	0.147	0.206	0.543	<i>0.583</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	--	<i>11.15</i>	2.90	2.28	3.19	8.40	<i>9.02</i>	--	--
	Runoff (mm)	--	--	--	--	<i>21</i>	8	6	9	22	<i>11</i>	--	--
2015	# days with data	--	--	--	--	<i>18</i>	30	31	31	30	<i>13</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	--	<i>0.505</i>	0.100	0.096	0.631	0.695	<i>0.265</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	--	<i>7.82</i>	1.54	1.49	9.77	10.76	<i>4.11</i>	--	--
	Runoff (mm)	--	--	--	--	<i>12</i>	4	4	26	28	<i>5</i>	--	--
2016	# days with data	--	--	--	<i>12</i>	31	30	31	31	30	<i>4</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	<i>0.860</i>	0.860	0.290	0.499	0.434	0.518	<i>0.414</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	<i>13.31</i>	13.31	4.50	7.72	6.72	8.02	<i>6.40</i>	--	--
	Runoff (mm)	--	--	--	<i>13</i>	36	12	21	18	21	<i>2</i>	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	<i>0.860</i>	<i>0.695</i>	<i>0.309</i>	<i>0.342</i>	<i>0.593</i>	0.550	<i>0.369</i>	<i>0.202</i>	<i>0.146</i>
	Average Yield (L/s/km ²)	--	--	--	<i>13.3</i>	<i>10.8</i>	<i>4.8</i>	<i>5.3</i>	<i>9.2</i>	8.5	<i>5.7</i>	<i>3.1</i>	<i>2.3</i>
	Runoff (mm)	--	--	--	<i>13</i>	<i>23</i>	<i>11</i>	<i>12</i>	<i>23</i>	22	<i>7</i>	<i>8</i>	<i>1</i>

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-34:
H-VC-DBC Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Average	--	--	0.225	0.291	1.503	0.261	0.293	0.372	1.009	0.640	0.329	0.195
	Maximum	--	--	0.415	1.832	5.332	0.599	1.196	0.865	1.947	1.866	0.696	0.513
	Minimum	--	--	0.102	0.127	0.419	0.180	0.155	0.242	0.393	0.245	0.185	0.120
2015	Average	0.174	--	--	--	0.804	0.111	0.093	0.688	0.887	0.356	--	--
	Maximum	0.342	--	--	--	2.725	0.187	0.293	5.087	1.484	0.525	--	--
	Minimum	0.086	--	--	--	0.145	0.055	0.052	0.099	0.370	0.197	--	--
2016	Average	--	--	--	0.607	0.997	0.304	0.547	0.496	0.633	0.494	--	--
	Maximum	--	--	--	3.177	4.408	0.928	1.851	0.931	0.846	0.581	--	--
	Minimum	--	--	--	0.075	0.298	0.131	0.119	0.299	0.378	0.350	--	--
All Years	Average	0.174	--	0.225	0.449	1.102	0.225	0.311	0.519	0.843	0.497	0.329	0.195
	Maximum	0.342	--	0.415	3.177	5.332	0.928	1.851	5.087	1.947	1.866	0.696	0.513
	Minimum	0.086	--	0.102	0.075	0.145	0.055	0.052	0.099	0.370	0.197	0.185	0.120

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-35:
H-VC-DBC Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	# days with data	--	--	20	30	31	30	31	31	30	31	30	31
	Average Discharge (m ³ /s)	--	--	0.225	0.291	1.503	0.261	0.293	0.372	1.009	0.640	0.329	0.195
	Average Yield (L/s/km ²)	--	--	3.00	3.87	20.05	3.48	3.90	4.96	13.45	8.53	4.39	2.60
	Runoff (mm)	--	--	5	10	54	9	10	13	35	23	11	7
2015	# days with data	12	--	--	--	27	30	31	31	30	13	--	--
	Average Discharge (m ³ /s)	0.174	--	--	--	0.804	0.111	0.093	0.688	0.887	0.356	--	--
	Average Yield (L/s/km ²)	2.32	--	--	--	10.72	1.48	1.24	9.17	11.83	4.75	--	--
	Runoff (mm)	2	--	--	--	25	4	3	25	31	5	--	--
2016	# days with data	--	--	--	24	31	30	31	31	30	4	--	--
	Average Discharge (m ³ /s)	--	--	--	0.607	0.997	0.304	0.547	0.496	0.633	0.494	--	--
	Average Yield (L/s/km ²)	--	--	--	8.10	13.29	4.05	7.29	6.61	8.44	6.59	--	--
	Runoff (mm)	--	--	--	17	36	10	20	18	22	2	--	--
All Years	Average Discharge (m ³ /s)	0.174	--	0.225	0.449	1.102	0.225	0.311	0.519	0.843	0.497	0.329	0.195
	Average Yield (L/s/km ²)	2.32	--	3.00	5.99	14.69	3.00	4.14	6.91	11.24	6.63	4.39	2.60
	Runoff (mm)	2	--	5	13	38	8	11	19	29	10	11	7

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-36:
H-VC-UMN Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Average	--	--	--	--	1.032	0.320	0.341	0.376	0.443	0.193	0.192	0.084
	Maximum	--	--	--	--	6.025	0.527	1.032	0.766	1.030	0.370	0.448	0.117
	Minimum	--	--	--	--	0.000	0.251	0.165	0.293	0.239	0.099	0.089	0.044
2015	Average	0.048	--	--	--	1.023	0.158	0.138	0.700	0.728	0.382	--	--
	Maximum	0.095	--	--	--	5.651	0.234	0.314	5.627	1.304	0.662	--	--
	Minimum	0.012	--	--	--	0.199	0.101	0.101	0.160	0.376	0.223	--	--
2016	Average	0.226	0.129	0.066	0.819	1.021	0.323	0.574	0.505	0.642	0.514	--	--
	Maximum	0.514	0.452	0.214	4.284	4.477	0.990	1.862	0.967	0.912	0.586	--	--
	Minimum	0.116	0.044	0.037	0.057	0.321	0.172	0.161	0.325	0.385	0.421	--	--
All Years	Average	0.137	--	0.066	0.819	1.025	0.267	0.351	0.527	0.604	0.363	0.192	0.084
	Maximum	0.514	--	0.214	4.284	6.025	0.990	1.862	5.627	1.304	0.662	0.448	0.117
	Minimum	0.012	--	0.037	0.057	0.000	0.101	0.101	0.160	0.239	0.099	0.089	0.044

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available

Table 3-37:
H-VC-UMN Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	# days with data	--	--	--	--	23	30	31	31	30	31	30	31
	Average Discharge (m ³ /s)	--	--	--	--	<i>1.032</i>	0.320	0.341	0.376	0.443	0.193	0.192	0.084
	Average Yield (L/s/km ²)	--	--	--	--	<i>12.38</i>	3.83	4.09	4.51	5.32	2.32	2.30	1.01
	Runoff (mm)	--	--	--	--	<i>24</i>	10	11	12	14	6	6	3
2015	# days with data	<i>6</i>	0	0	0	31	30	31	30	30	<i>13</i>	--	--
	Average Discharge (m ³ /s)	<i>0.048</i>	--	--	--	<i>1.023</i>	<i>0.158</i>	<i>0.138</i>	<i>0.700</i>	<i>0.728</i>	<i>0.382</i>	--	--
	Average Yield (L/s/km ²)	<i>0.58</i>	--	--	--	<i>12.26</i>	<i>1.89</i>	<i>1.66</i>	<i>8.40</i>	<i>8.73</i>	<i>4.58</i>	--	--
	Runoff (mm)	<i>0</i>	--	--	--	<i>33</i>	5	4	22	23	5	--	--
2016	# days with data	<i>19</i>	29	31	24	31	30	31	31	30	3	--	--
	Average Discharge (m ³ /s)	<i>0.226</i>	0.129	0.066	0.819	1.021	0.323	0.574	0.505	0.642	0.514	--	--
	Average Yield (L/s/km ²)	<i>2.70</i>	1.54	0.79	9.83	12.24	3.87	6.88	6.06	7.69	<i>6.17</i>	--	--
	Runoff (mm)	<i>4</i>	4	2	21	33	10	18	16	20	<i>1</i>	--	--
All Years	Average Discharge (m ³ /s)	0.137	--	0.066	0.819	1.025	0.267	0.351	0.527	0.604	0.363	0.192	0.084
	Average Yield (L/s/km ²)	1.64	--	0.79	9.83	12.29	3.20	4.21	6.32	7.25	4.35	2.30	1.01
	Runoff (mm)	2	--	2	21	30	8	11	17	19	4	6	3

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-38:
H-VC-R Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	Average	--	--	--	--	--	--	1.452	1.741	0.704	--	--	--
	Maximum	--	--	--	--	--	--	3.083	3.263	1.160	--	--	--
	Minimum	--	--	--	--	--	--	0.862	1.003	0.000	--	--	--
2012	Average	--	--	--	--	--	--	--	--	--	--	--	--
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
	Minimum	--	--	--	--	--	--	--	--	--	--	--	--
2013	Average	--	--	--	--	--	--	--	--	--	--	--	--
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
	Minimum	--	--	--	--	--	--	--	--	--	--	--	--
2014	Average	--	--	--	--	1.194	0.321	0.284	0.374	0.538	0.232	0.17	0.07
	Maximum	--	--	--	--	6.303	0.704	1.202	0.876	1.296	0.565	0.37	0.12
	Minimum	--	--	--	--	0.449	0.131	0.098	0.219	0.246	0.084	0.08	0.03
2015	Average	0.029	--	--	0.280	1.446	0.552	0.472	1.306	1.073	0.557	--	--
	Maximum	0.065	--	--	0.839	4.805	0.744	0.895	6.485	1.790	0.825	--	--
	Minimum	0.000	--	--	0.070	0.453	0.393	0.373	0.519	0.583	0.346	--	--
All Years	Average	--	--	--	0.280	1.320	0.437	0.736	1.140	0.772	0.394	0.168	0.073
	Maximum	--	--	--	0.839	6.303	0.744	3.083	6.485	1.790	0.825	0.369	0.118
	Minimum	--	--	--	0.070	0.449	0.131	0.098	0.219	0.000	0.084	0.082	0.028

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-39:
H-VC-R Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	# days with data	--	--	--	--	--	--	<i>14</i>	27	30	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	--	<i>1.452</i>	1.741	0.704	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	--	<i>14.86</i>	17.82	7.21	--	--	--
	Runoff (mm)	--	--	--	--	--	--	<i>18</i>	42	19	--	--	--
2012	# days with data	--	--	--	--	--	--	--	--	--	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	--	--	--	--	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	--	--	--	--	--	--	--
	Runoff (mm)	--	--	--	--	--	--	--	--	--	--	--	--
2013	# days with data	--	--	--	--	--	--	--	--	--	--	--	--
	Average Discharge (m ³ /s)	--	--	--	--	--	--	--	--	--	--	--	--
	Average Yield (L/s/km ²)	--	--	--	--	--	--	--	--	--	--	--	--
	Runoff (mm)	--	--	--	--	--	--	--	--	--	--	--	--
2014	# days with data	--	--	--	--	23	30	31	31	30	31	30	31
	Average Discharge (m ³ /s)	--	--	--	--	<i>1.194</i>	0.321	0.284	0.374	0.538	0.232	0.17	0.07
	Average Yield (L/s/km ²)	--	--	--	--	<i>12.22</i>	3.28	2.91	3.83	5.51	2.37	1.72	0.75
	Runoff (mm)	--	--	--	--	<i>24</i>	9	8	10	14	6	4	2
2015	# days with data	6	--	--	22	31	30	31	31	30	<i>13</i>	--	--
	Average Discharge (m ³ /s)	0.029	--	--	<i>0.280</i>	1.446	0.552	0.472	1.306	1.073	<i>0.557</i>	--	--
	Average Yield (L/s/km ²)	<i>0.29</i>	--	--	<i>2.86</i>	14.80	5.65	4.83	13.37	10.98	<i>5.70</i>	--	--
	Runoff (mm)	<i>0</i>	--	--	<i>5</i>	39	15	13	36	28	<i>6</i>	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	<i>0.280</i>	<i>1.320</i>	<i>0.437</i>	<i>0.736</i>	<i>1.140</i>	<i>0.772</i>	<i>0.394</i>	<i>0.168</i>	<i>0.073</i>
	Average Yield (L/s/km ²)	--	--	--	<i>2.86</i>	<i>13.51</i>	<i>4.47</i>	<i>7.53</i>	<i>11.67</i>	<i>7.90</i>	<i>4.04</i>	<i>1.72</i>	<i>0.75</i>
	Runoff (mm)	--	--	--	<i>5</i>	<i>32</i>	<i>12</i>	<i>13</i>	<i>29</i>	<i>20</i>	<i>6</i>	<i>4</i>	<i>2</i>

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-40:
H-VC-R+290 Summary statistics for 15-minute discharge record. All values are in m³/s.

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Average	--	--	--	--	1.541	0.552	0.472	1.306	1.073	0.557	--	--
	Maximum	--	--	--	--	3.890	0.744	0.895	6.485	1.790	0.825	--	--
	Minimum	--	--	--	--	0.674	0.393	0.373	0.519	0.583	0.346	--	--
2016	Average	--	--	--	0.876	1.356	0.433	0.769	0.704	0.924	0.752	--	--
	Maximum	--	--	--	3.430	4.494	1.253	2.377	1.306	1.226	0.889	--	--
	Minimum	--	--	--	0.077	0.442	0.210	0.192	0.460	0.559	0.623	--	--
All Years	Average	--	--	--	0.876	1.449	0.493	0.621	1.005	0.998	0.654	--	--
	Maximum	--	--	--	3.430	4.494	1.253	2.377	6.485	1.790	0.889	--	--
	Minimum	--	--	--	0.077	0.442	0.210	0.192	0.460	0.559	0.346	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

Table 3-41:
H-VC- R+290 Summary statistics for daily discharge, unit yield and runoff

Year	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	# days with data	--	--	--	--	<i>19</i>	30	31	31	30	<i>13</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	--	<i>1.541</i>	0.552	0.472	1.306	1.073	<i>0.557</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	--	<i>15.78</i>	5.65	4.83	13.37	10.98	<i>5.70</i>	--	--
	Runoff (mm)	--	--	--	--	<i>26</i>	15	13	36	28	<i>6</i>	--	--
2016	# days with data	--	--	--	30	31	31	31	31	30	<i>3</i>	--	--
	Average Discharge (m ³ /s)	--	--	--	0.876	1.356	0.433	0.769	0.704	0.924	<i>0.752</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	8.97	13.88	4.43	7.87	7.21	9.46	<i>7.69</i>	--	--
	Runoff (mm)	--	--	--	23	37	12	21	19	25	<i>2</i>	--	--
All Years	Average Discharge (m ³ /s)	--	--	--	0.876	1.449	0.493	0.621	1.005	0.998	<i>0.654</i>	--	--
	Average Yield (L/s/km ²)	--	--	--	8.97	14.83	5.04	6.35	10.29	10.22	<i>6.70</i>	--	--
	Runoff (mm)	--	--	--	23	32	13	17	28	26	<i>4</i>	--	--

Notes:

1. Values in italics indicate months with incomplete records, and fields denoted by '--' indicate that no data is available.

3.6 Regional Analyses

Data from the regional hydrometric stations listed in Table 2-6 were compiled and analyzed to characterize mean annual runoff (MAR), monthly distribution of runoff, peak flow and low flow recurrence interval estimates. The results of these analyses are presented in the following sections. Note that the culmination of the regional streamflow analysis is the development of the synthetic streamflow records that are used as the primary input to the Site water balance and water quality model (WBM/WQM). This process is described in detail in Appendix A of the WBM/WQM report (Lorax 2017).

3.6.1 Annual Runoff

Summaries of the average annual discharge, mean annual runoff (MAR) and average annual unit yields are presented for the regional stations in Table 3-42, and the monthly distribution of runoff is shown in Figure 3-31. In general MAR ranges from ~100 mm/year to 484 mm/year, and the dominant streamflow regime is nival (*i.e.*, snowmelt) driven. The relationship between MAR and geographical position within the regional study area was explored by plotting the MAR values against latitude and longitude. No clear pattern between these variables was noted, however, physiographic characteristics do play a role in MAR and the monthly distribution of runoff. Three of the weather stations captured in the 150 km radius around the Site show a marked divergence from the nival pattern. The Yukon River above Frank Creek (09AB009), Kluane River at the Outlet of Kluane Lake (09CA002) and the Donjek River below Kluane River (09CA003), all display markedly

different hydrographs (Figure 3-31). The first station displays a hydrograph that is representative of a lake outflow regime (Lake Laberge), and the other two stations are dominated by a summer glacier melt pattern, from the extensive icefields located on the eastern flank of the St. Elias Range. These three stations display runoff regimes that are not representative of the Site streamflow regime and were, therefore, not included in the subsequent low flow analyses (Section 3.6.4). If these stations are removed from the regional summary, then the regional average MAR is 205 mm/year, and ranges from 100 to 320 mm/year.

Table 3-42:
Regional peak flow recurrence interval estimates, presented in m³/s (top) and unit yields (L/s/km²)

Station ID	Station Name	Drainage Area (km ²)	Average Annual Discharge (m ³ /s)	Average Annual Unit Yield (L/s/km ²)	MAR (mm)
08AA001	Aishihik River near Whitehorse	4,300	14.36	3.30	105
08AA003	Dezadeash River at Haines Junction	8,450	43.99	5.21	164
08AA009	Giltana Creek near the Mouth	190	0.62	3.27	103
09AB009	Yukon River above Frank Creek	30,800	329.97	10.59	338
09AF001	Teslin River near Whitehorse	36,500	350.81	9.19	303
09AG001	Big Salmon River near Carmacks	6,760	68.53	9.94	320
09AH001	Yukon River at Carmacks	81,800	769.94	9.31	297
09AH003	Big Creek near the Mouth	1,800	7.93	4.42	139
09AH004	Nordenskiold River below Rowlinson Creek	6,410	15.10	2.35	74
09AH005	Drury Creek at km 469 Robert Campbell Highway	552	5.06	9.08	289
09BB002	MacMillan River near the Mouth	13,800	136.78	10.07	313
09BC001	Pelly River at Pelly Crossing	48,900	392.81	8.00	254
09CA002	Kluane River at Outlet of Kluane Lake	4,950	75.92	15.31	484
09CA003	Donjek River below Kluane River	12,400	165.24	13.47	421
09CA006	Nisling River below Onion Creek	7,910	37.02	4.69	148
09DD004	McQuesten River near the Mouth	4,750	38.78	8.14	258

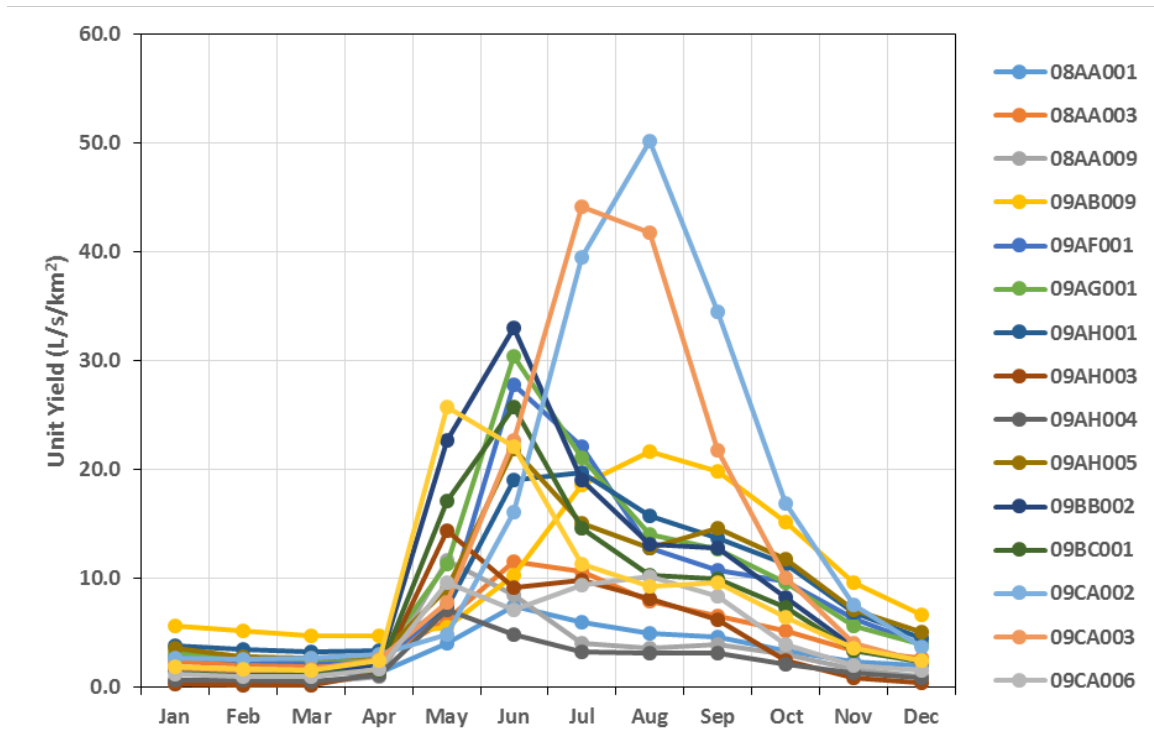


Figure 3-31: Monthly unit yield distribution for regional hydrometric stations.

To quantify the expected runoff that Site basins would generate in a dry- or wet-year, the synthetic streamflow records described in Section 2.3.6 (and in the Water Balance and Water Quality Model Report) were used to generate recurrence interval estimates of dry- and wet-year runoff. The results are listed in Table 3-45, noting that as discussed in Section 2.3.6, values are not provided for the VC-DBC station, as this series was scaled from the VC-UMN series, and thus the runoff values would be the same for the two stations.

Table 3-43:
Recurrence interval estimates of dry- and wet-year runoff. Values are in mm/year.

Exceedance Probability	Recurrence Interval	Big Creek (1,800 km ²)	DC-B (3.0 km ²)	DC-R (4.5 km ²)	VC-UMN (83.4 km ²)
0.995	1:200 year dry	43	24.5	29	45
0.99	1:100 year dry	49	29.8	31	50
0.98	1:50 year dry	56	36.2	35	56
0.96	1:25 year dry	64	44	39	64
0.9	1:10 year dry	78	58	47	77
0.5	1:2 year (median)	130	114	77	126
0.1	1:10 year wet	214	225	132	215
0.04	1:25 year wet	257	295	164	266
0.02	1:50 year wet	290	353	191	306
0.01	1:100 year wet	323	416	219	348
0.005	1:200 year wet	357	487	249	393

For comparison with the precipitation values presented in Section 3.1.2, the Big Creek annual runoff series is presented in Figure 3-34 as a standard anomaly plot that shows standardized deviations from the long-term average. The figure shows the same inter-annual variability in runoff over the Site baseline record period as the precipitation record does. Years 2011 through 2013 had higher than average runoff, while years 2014 and 2015 had lower than average runoff regionally. As the Site synthetic streamflow records are based on the Big Creek record, the same results would hold true for the Site records. The data for 2016 are preliminary, but indicate annual runoff was higher than the long-term average.

To further integrate the long-term estimates of precipitation, snow water equivalent, evapotranspiration and the understanding of Site precipitation/elevation gradients, the Site and regional hydro-climatic data were used to generate Site basin specific annual average water balances, for confirmation purposes. The results are presented in Lorax (2017), in Section 3.1.1.

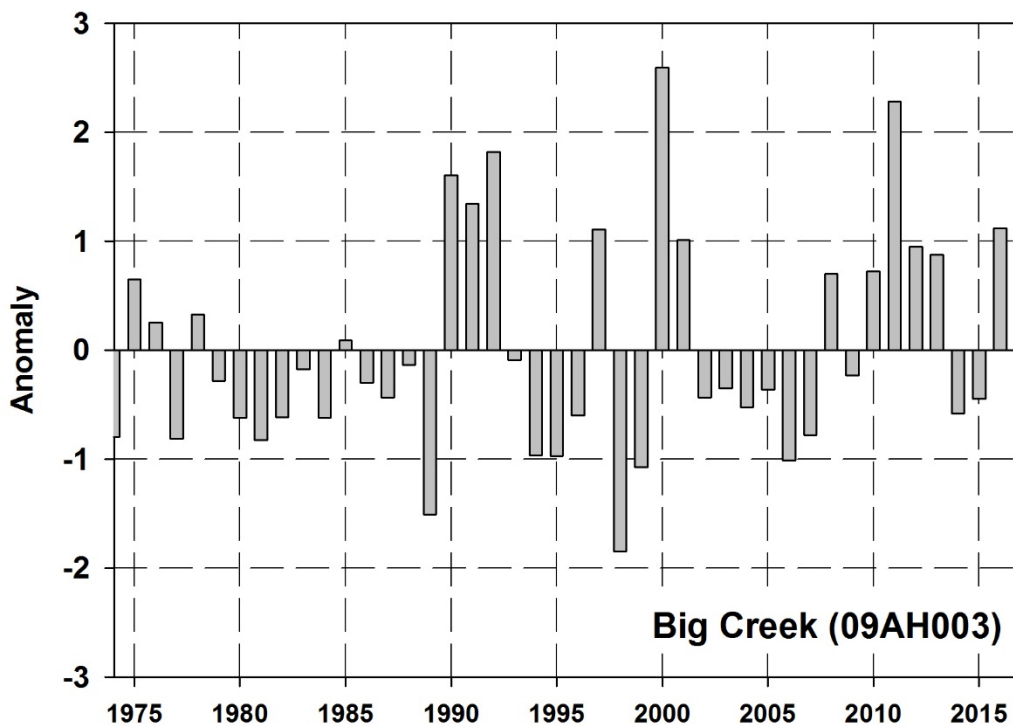


Figure 3-32: Standard anomaly plot of synthetic annual runoff series for the Big Creek hydrometric station.

3.6.2 Peak Flow Estimates

As an extension to the peak flow analysis presented using measured data from site, a regional peak flow analysis was conducted using the stations listed in Table 2-6. Recurrence interval estimates of annual instantaneous peak flows were plotted against drainage area on a log-log plot, and a power law function was then fit to the data (Figure 3-33). For reference, the measured instantaneous peak flows from the Site data were also plotted. The power law functions derived from the regional data for each recurrence interval (*e.g.*, 1:100 year peak flow) were used to estimate the corresponding peak flow for all Project drainages. For reference, the maximum discharges measured in the Site drainages fall below a 1:2 year peak flow recurrence interval, as derived from the regional analysis (Table 3-46) for which the measured instantaneous peak flow values are presented alongside the regionally derived estimates. The two exceptions to this are stations DC-B and DC-M WP, which show measured peak flows between a 1:2 and 1:5 year recurrence interval estimate. Given the relatively short duration of the Site data (2-5 years), this result is not unexpected.

The highest peak discharges measured by the regional hydrometric network (relative to basin area) were recorded at the Big Creek station (WSC; 09AH003), which was used as the predictor station for the synthetic streamflow records (see Section 2.3.6). Given that the regional line of best fit falls below this point, an enveloping approach was employed to generate a second set of power functions for use in estimating peak flows at the Site. Briefly, a second line was drawn parallel to the regional line of best fit and extended through the point with the largest discharge value (plots highest on the y-axis). The new y-intercept was then entered into the power law function to provide an upper-case estimate of peak flows for the Site drainages. The results of the initial regional recurrence interval analyses are presented in Table 3-44, and the two sets of equations are presented in Table 3-45. The two sets of Site peak flow estimates (best-fit and envelope curve) are presented in Table 3-46 and Table 3-47, respectively.

The best-fit curves return peak flow estimates that are approximately three times lower those returned by the envelope curve estimates, a difference that is consistent for all stations and recurrence intervals. This difference between best-fit and envelope values is driven by the difference in the y-intercept, not the slope of the line which do not vary in magnitude or direction.

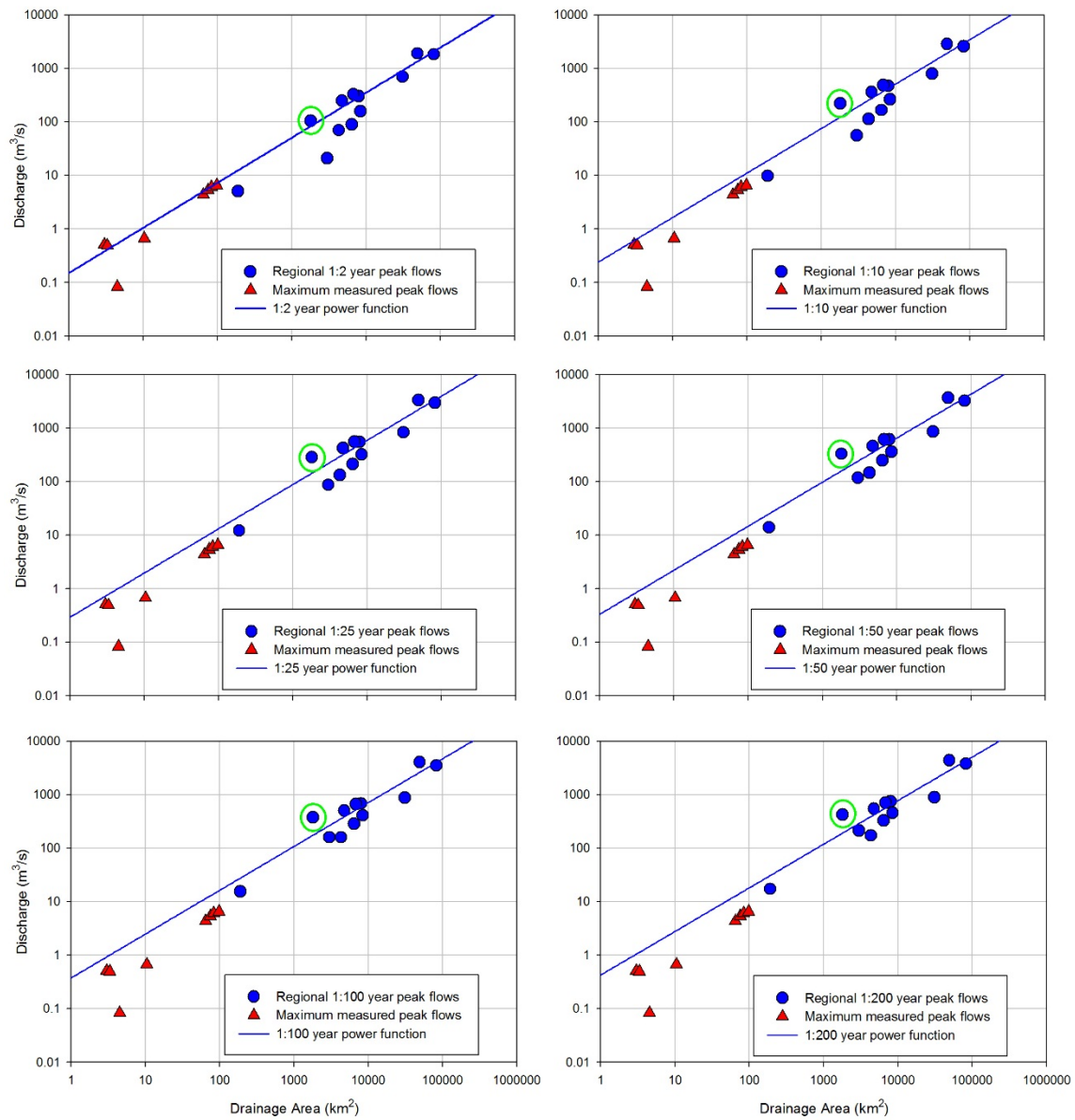


Figure 3-33: Peak flow estimates for regional stations (blue circles) and maximum recorded instantaneous Site discharges (red triangles). Peak flow estimates for the Big Creek (09AH003) station are marked with a green circle.

Table 3-44:
Regional peak flow recurrence interval estimates, presented in m³/s (top) and unit yields (L/s/km²)

Station ID	Station Name	Drainage Area (km ²)	m ³ /s						
			1:2 year	1:5 year	1:10 year	1:25 year	1:50 year	1:100 year	1:200 year
09DD004	McQuesten River near the Mouth	4,750	249	318	363	420	461	503	544
09AH003	Big Creek near the Mouth	1,800	105	174	222	284	329	375	420
09AH004	Nordenskiold River below Rowlinson Creek	6,410	89	134	166	211	247	284	324
09BC001	Pelly River at Pelly Crossing	48,900	1905	2476	2852	3325	3678	4032	4390
09CA006	Nisling River below Onion Creek	7,910	302	406	470	553	615	680	747
08AA003	Dezadeash River at Haines Junction	8,450	159	220	262	318	362	408	455
08AA001	Aishihik River near Whitehorse	4,300	70	96	113	132	146	159	171
08AA010	Aishihik River below Aishihik Lake	3,000	21	38	56	87	118	159	212
08AA009	Giltana Creek near the Mouth	190	5.0	7.9	9.8	12.2	13.9	15.5	17.2
09AH001	Yukon River at Carmacks	81,800	1836	2297	2593	2960	3230	3497	3765
09AG001	Big Salmon River near Carmacks	6,760	328	425	484	556	608	658	707
09AB009	Yukon River above Frank Creek	30,800	698	767	800	834	854	872	887

Station ID	Station Name	Drainage Area (km ²)	L/s/km ²						
			1:2 year	1:5 year	1:10 year	1:25 year	1:50 year	1:100 year	1:200 year
09DD004	McQuesten River near the Mouth	4,750	52	67	76	88	97	106	115
09AH003	Big Creek near the Mouth	1,800	58	97	123	158	183	208	233
09AH004	Nordenskiold River below Rowlinson Creek	6,410	14	21	26	33	38	44	51
09BC001	Pelly River at Pelly Crossing	48,900	39	51	58	68	75	82	90
09CA006	Nisling River below Onion Creek	7,910	38	51	59	70	78	86	94
08AA003	Dezadeash River at Haines Junction	8,450	19	26	31	38	43	48	54
08AA001	Aishihik River near Whitehorse	4,300	16	22	26	31	34	37	40
08AA010	Aishihik River below Aishihik Lake	3,000	7	13	19	29	39	53	71
08AA009	Giltana Creek near the Mouth	190	27	42	52	64	73	82	90
09AH001	Yukon River at Carmacks	81,800	22	28	32	36	39	43	46
09AG001	Big Salmon River near Carmacks	6,760	49	63	72	82	90	97	105
09AB009	Yukon River above Frank Creek	30,800	23	25	26	27	28	28	29

Table 3-45:
Regional peak flow equations (best-fit and envelope) in m³/s

Recurrence Interval	Equation	Envelope Equation
1:2 year	$Q = 0.1511*(A)^{0.8421}$	$Q = 0.3997*(A)^{0.8421}$
1:5 year	$Q = 0.2061*(A)^{0.8347}$	$Q = 0.5451*(A)^{0.8347}$
1:10 year	$Q = 0.2429*(A)^{0.8311}$	$Q = 0.6425*(A)^{0.8311}$
1:25 year	$Q = 0.2925*(A)^{0.8265}$	$Q = 0.7736*(A)^{0.8265}$
1:50 year	$Q = 0.3331*(A)^{0.8229}$	$Q = 0.8810*(A)^{0.8229}$
1:100 year	$Q = 0.3778*(A)^{0.8189}$	$Q = 0.9993*(A)^{0.8189}$
1:200 year	$Q = 0.4279*(A)^{0.8145}$	$Q = 1.1318*(A)^{0.8145}$

Table 3-46:
Peak flow recurrence interval estimates for the Site drainage basins, based on the regional best-fit power function. Units are m³/s

Station	Drainage Area (km ²)	Max. Measured Discharge (m ³ /s)	Discharge (L/s/km ²)	1:2 year	1:5 year	1:10 year	1:25 year	1:50 year	1:100 year	1:200 year
H-DC-B	3.0	0.509	169.5	0.381	0.516	0.605	0.725	0.823	0.929	1.047
H-DC_M WP	3.3	0.492	149.0	0.413	0.558	0.655	0.785	0.890	1.004	1.132
H-DC-R	4.5	0.083	18.4	0.536	0.723	0.848	1.014	1.148	1.295	1.457
H-BC	10.4	0.669	64.4	1.086	1.455	1.701	2.026	2.288	2.571	2.882
H-VC-U	64.6	4.367	67.6	5.054	6.685	7.761	9.168	10.285	11.473	12.758
H-VC-DBC	75.0	5.332	71.1	5.731	7.572	8.786	10.372	11.630	12.964	14.407
H-VC-UMN	83.4	6.025	72.2	6.267	8.273	9.596	11.323	12.691	14.142	15.708
H-VC-R	97.7	6.485	66.4	7.161	9.442	10.945	12.905	14.456	16.099	17.869

Table 3-47:
Peak flow recurrence interval estimates for the Site drainage basins, based on the regional envelope power function. Units are m³/s

Station	Drainage Area (km ²)	Max. Measured Discharge (m ³ /s)	Discharge (L/s/km ²)	1:2 year	1:5 year	1:10 year	1:25 year	1:50 year	1:100 year	1:200 year
H-DC-B	3.0	0.509	169.5	1.008	1.364	1.601	1.918	2.176	2.457	2.769
H-DC_M WP	3.3	0.492	149.0	1.092	1.477	1.733	2.075	2.353	2.656	2.993
H-DC-R	4.5	0.083	18.4	1.418	1.913	2.243	2.682	3.037	3.425	3.853
H-BC	10.4	0.669	64.4	2.872	3.849	4.499	5.359	6.052	6.801	7.623
H-VC-U	64.6	4.367	67.6	13.370	17.680	20.529	24.248	27.203	30.346	33.745
H-VC-DBC	75.0	5.332	71.1	15.161	20.026	23.240	27.432	30.758	34.291	38.107
H-VC-UMN	83.4	6.025	72.2	16.579	21.881	25.384	29.947	33.566	37.406	41.549
H-VC-R	97.7	6.485	66.4	18.942	24.971	28.952	34.132	38.235	42.581	47.265

3.6.3 Low Flow Estimates

3.6.3.1 Summer Low Flow Regime

The low flow recurrence interval estimates for the summer period (June to September) are presented in Table 3-48 (regional) and Table 3-49 (Site).

The regional stations represent basins that span three orders of magnitude for area (km²), and, therefore, there is substantial variation in the calculated low flow values. The most representative regional basins are assumed to be those with drainage areas <10,000 km². The regional analysis returns summer 7Q₁₀ yields for each station that range from 0.23 (Giltana Creek) to 9.41 L/s/km² (Yukon River at Carmacks), which is a large range (Table 3-48). There is a strong positive relationship between drainage area and low flows, with the smallest basin included in the analysis having the lowest flows (Figure 3-34). The regional equations are shown in Figure 3-34, and were used to estimate low flow metrics for the Site streams (Table 3-49). The resulting estimates show summer 7Q₁₀ values for the Site stations ranging from 0 to 0.018 m³/s (0.024 to 0.18 L/s/km²; Table 3-49), with an average summer 7Q₁₀ value for the eight Project stations of 0.1 L/s/km². The average June (lowest flow month) discharges have been included for reference.

**Table 3-48:
June – September minimum 7-day low flow (7Q_{year}) recurrence interval estimates
for regional stations. Units are m³/s.**

Station ID	Station Name	Drainage Area (km ²)	Distribution	7Q ₂ (median)	7Q ₁₀	7Q ₂₀
08AA001	Aishihik River near Whitehorse	4,300	LP3	13.03	7.35	6.22
08AA003	Dezadeash River at Haines Junction	8,450	LP3	43.53	29.62	26.36
08AA009	Giltana Creek near the Mouth	190	LP3	0.25	0.04	0.02
09AB009	Yukon River above Frank Creek	30,800	Log-Logistic (3P)	205.51	165.32	154.84
09AF001	Teslin River near Whitehorse	36,500	Log-Logistic (3P)	350.89	245.68	209.90
09AG001	Big Salmon River near Carmacks	6,760	LP3	66.21	48.36	44.35
09AH001	Yukon River at Carmacks	81,800	Log-Logistic (3P)	958.22	769.38	705.16
09AH003	Big Creek near the Mouth	1,800	Log-Logistic (3P)	3.56	2.03	1.78
09AH004	Nordenskiold River below Rowlinson Creek	6,410	LP3	9.65	4.87	4.02
09AH005	Drury Creek at km 469 Robert Campbell Highway	552	LP3	4.63	3.31	3.06
09BB002	MacMillan River near the Mouth	13,800	Log-Logistic (3P)	129.47	96.24	84.93
09BC001	Pelly River at Pelly Crossing	48,900	LP3	348.05	229.90	201.84
09CA002	Kluane River at Outlet of Kluane Lake	4,950	Log-Logistic (3P)	38.86	25.79	21.87
09CA003	Donjek River below Kluane River	12,400	LP3	150.56	89.20	76.30
09CA006	Nisling River below Onion Creek	7,910	LP3	20.14	9.58	7.79
09DD004	McQuesten River near the Mouth	4,750	LP3	28.75	19.40	17.38

The 7Q₁₀ estimate for the Big Creek hydrometric record (09AH003), which was used as the regional predictor for the construction of the Site synthetic streamflow records, is 1.3 L/s/km², which lies on the regional line of best fit (Figure 3-34). A parallel analysis that was conducted using the synthetic streamflow data shows a larger range of estimates than those returned from the regional analysis. For the four stations that synthetic records were assembled for, estimated summer 7Q₁₀ values for the Site stations range from 0 to 0.098 m³/s (0 to 1.2 L/s/km²; Table 3-49), with an average summer 7Q₁₀ value of 0.48 L/s/km².

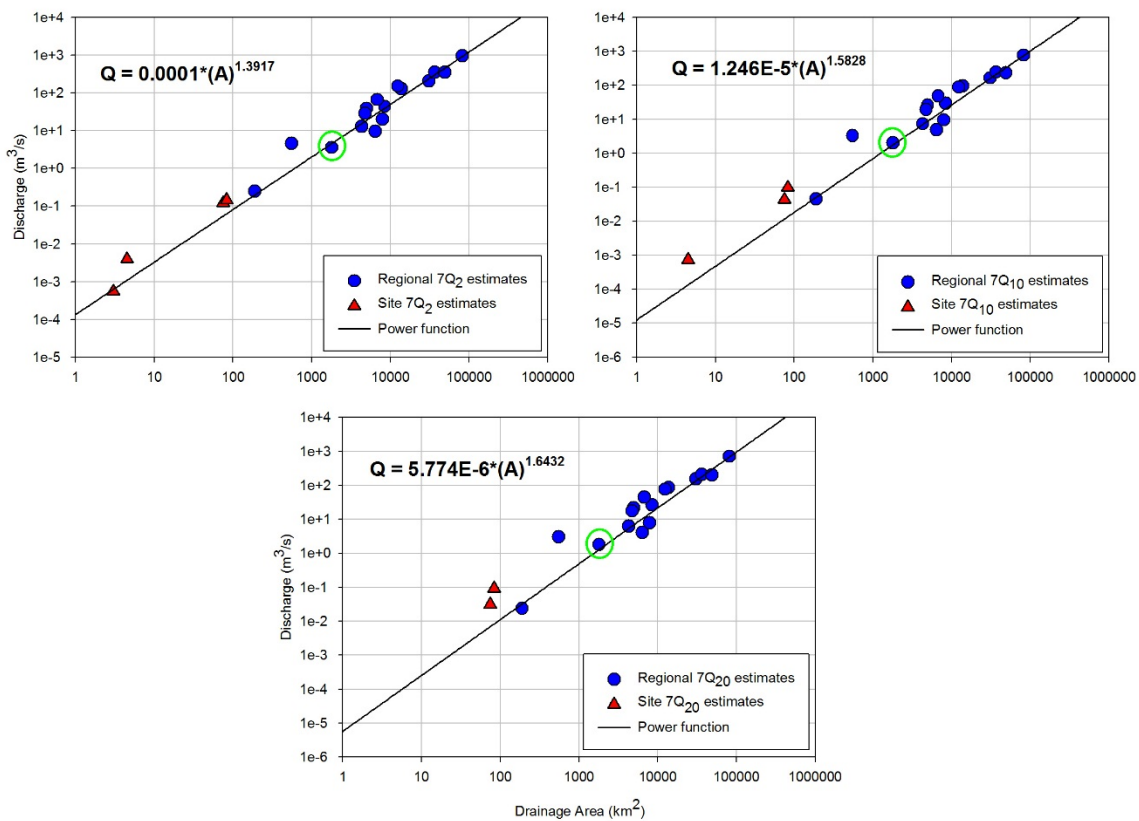


Figure 3-34: June-September 7-day average low flow (7Q_{year}) estimates derived from regional streamflow records (blue circles) and Site synthetic streamflow records (red triangles). Low flow estimates for the Big Creek (09AH003) station are marked with a green circle.

Table 3-49:
June – September minimum 7-day low flow (7Q_{year}) recurrence interval estimates for Site stations. Units are m³/s.

Station	Drainage Area (km ²)	Regional Equations			Average June Discharge	Based on Synthetic Streamflows		
		7Q ₂	7Q ₁₀	7Q ₂₀		7Q ₂	7Q ₁₀	7Q ₂₀
H-DC-B	3.0	0.0005	0.0001	0.00004	0.011	0.001	0.000	0.000
H-DC_M WP	3.3	0.0005	0.0001	0.00004	0.010	NA	NA	NA
H-DC-R	4.5	0.0008	0.0001	0.00007	0.012	0.004	0.001	0.000
H-BC	10.4	0.0026	0.0005	0.00027	0.026	NA	NA	NA
H-VC-U	64.6	0.0331	0.0091	0.00545	0.309	NA	NA	NA
H-VC-DBC	75.0	0.0407	0.0116	0.00696	0.225	0.121	0.043	0.031
H-VC-UMN	83.4	0.0472	0.0137	0.00829	0.267	0.147	0.098	0.091
H-VC-R	97.7	0.0588	0.0176	0.01075	0.437	NA	NA	NA

3.6.3.2 Annual (Winter) Low Flow Regime

The low flow recurrence interval estimates for the summer period (June to September) are presented in Table 3-50 (regional) and Table 3-51 (Site).

Similar to the June-September low flow analysis, there is substantial variation in the calculated annual low flow values. The regional analysis returns annual 7Q₁₀ yields that range from 0 (Giltana Creek) to 3.1 L/s/km² (Yukon River above Frank Creek), which is a large range (Table 3-50). There is a strong positive relationship between drainage area and low flows, and the smallest basin included in the analysis has the lowest flows (Figure 3-35). The regional equations are shown in Figure 3-35, and were used to estimate low flow metrics for the Site streams (Table 3-51). The resulting estimates show annual 7Q₁₀ values for the Site stations ranging from 0 to 0.016 m³/s (0.024 to 0.16 L/s/km²; Table 3-51), with an average annual 7Q₁₀ value for the eight Project stations of 0.1 L/s/km².

The 7Q₁₀ estimate for the Big Creek hydrometric record (09AH003), which was used as the regional predictor for the construction of the Site synthetic streamflow records, is 1.3 L/s/km², which lies well below the regional line of best fit (Figure 3-35). A parallel analysis that was conducted using the synthetic streamflow data shows a larger range of estimates than those returned from the regional analysis. For the four stations that synthetic records were assembled for, estimated annual 7Q₁₀ values for the Site stations range from 0 to 0.016 m³/s (0 to 0.16 L/s/km²; Table 3-51), with an average annual 7Q₁₀ value of 0.1 L/s/km².

Further information on the winter streamflow conditions in the Site drainages with relevance to the Site water balance and water quality model is presented in Section 2.1.1.1 of the Mount Nansen Water Balance and Water Quality Model Report (Lorax 2017).

Table 3-50:
Annual minimum 7-day low flow recurrence interval estimates for regional stations.
Units are m³/s.

Station ID	Station Name	Drainage Area (km ²)	Distribution	7Q ₂ (median)	7Q ₁₀	7Q ₂₀
08AA001	Aishihik River near Whitehorse	4,300	LP3	4.00	2.48	2.21
08AA003	Dezadeash River at Haines Junction	8,450	LP3	15.17	8.39	6.80
08AA009	Giltana Creek near the Mouth	190	NA	0.04	0.00	0.00
09AB009	Yukon River above Frank Creek	30,800	LP3	134.80	95.15	84.63
09AF001	Teslin River near Whitehorse	36,500	LP3	74.45	56.22	52.00
09AG001	Big Salmon River near Carmacks	6,760	LP3	15.54	13.00	12.33
09AH001	Yukon River at Carmacks	81,800	LP3	247.21	182.76	165.29
09AH003	Big Creek near the Mouth	1,800	Lognormal	0.13	0.03	0.02
09AH004	Nordenskiold River below Rowlinson Creek	6,410	LP3	2.78	1.67	1.43
09AH005	Drury Creek at km 469 Robert Campbell Highway	552	LP3	1.31	0.76	0.62
09BB002	MacMillan River near the Mouth	13,800	LP3	15.65	8.05	6.12
09BC001	Pelly River at Pelly Crossing	48,900	LP3	51.00	37.57	34.25
09CA002	Kluane River at Outlet of Kluane Lake	4,950	Weibull (3P)	10.44	4.64	2.89
09CA003	Donjek River below Kluane River	12,400	LP3	17.16	12.29	11.06
09CA006	Nisling River below Onion Creek	7,910	Weibull (3P)	6.60	4.04	3.20
09DD004	McQuesten River near the Mouth	4,750	LP3	6.57	5.02	4.66

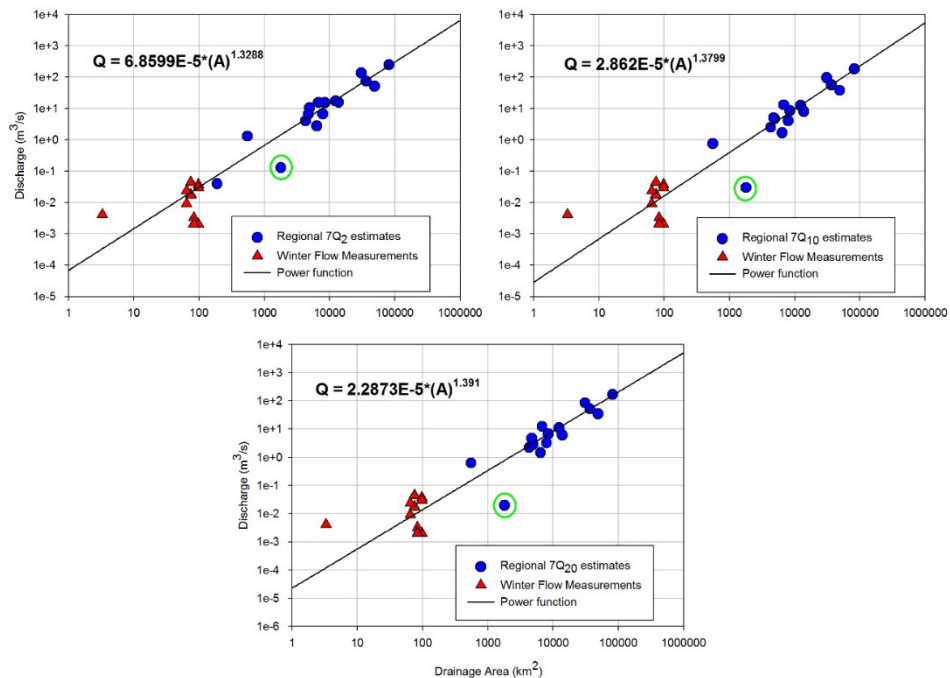


Figure 3-35: Annual (winter) 7-day average low flow estimates derived from regional streamflow records (blue circles) and manual measurements of streamflow (red triangles). Low flow estimates for the Big Creek (09AH003) station are marked with a green circle.

Table 3-51:
Annual minimum 7-day low flow recurrence interval estimates for Site stations.
Units are m³/s.

Station	Drainage Area (km ²)	7Q ₂ (median)	7Q ₁₀	7Q ₂₀
H-DC-B	3.0	0.000	0.000	0.000
H-DC_M WP	3.3	0.000	0.000	0.000
H-DC-R	4.5	0.001	0.000	0.000
H-BC	10.4	0.002	0.001	0.001
H-VC-U	64.6	0.017	0.009	0.008
H-VC-DBC	75.0	0.021	0.011	0.009
H-VC-UMN	83.4	0.024	0.013	0.011
H-VC-R	97.7	0.030	0.016	0.013

For reference, the available manual spot flow measurements (*i.e.*, where channels were not frozen to bed) are presented in Table 3-52. Where flow is present, late-winter yields range from 0.02 to 0.6 L/s/km² in the Victoria Creek drainage. Only one flow measurement is available for the mine Site drainages (in Dome Creek), and this is likely influenced by the pumped discharge from the Tailings Pond (H-SEEP). Also of note is that late-winter flows in Victoria Creek vary substantially along the gauged reach from above the confluence with Back Creek (VC-U; 0.25 L/s/km²) to downstream of Back Creek (VC-DBC; 0.41 L/s/km²), dropping substantially at the VC-UMN station (0.02 L/s/km²) and then increasing again at the VC-R station (0.23 L/s/km²). These average yields are based on only two to four spot measurements, however, and while they provide a useful snapshot of the annual low flow regime they cannot be expected to constrain the full range of variability.

Table 3-52:
Winter spot flow measurements presented as monthly averages for Project area hydrometric stations. Values are unit yields (L/s/km²).

Hydrometric Station	Drainage Area (km ²)	Measurement Date	Month	Discharge (m ³ /s)	L/s/km ²
H-DC-M WP	3.3	15/04/2013	4	0.0004	0.12
H-DC-M WP	3.3	10/03/2014	3	0.0041	1.24
H-DC-R	4.5	12/11/2013	11	0.0043	0.96
H-VC-DBC	75	11/03/2014	3	0.0447	0.60
H-VC-DBC	75	11/03/2014	3	0.0179	0.24
H-VC-DBC	75	15/04/2014	4	0.044	0.59
H-VC-DBC	75	16/03/2015	3	0.017	0.23
H-VC-R	97.7	15/04/2013	4	0.037	0.38
H-VC-R	97.7	10/03/2014	3	0.0296	0.30
H-VC-R	97.7	16/03/2015	3	0.002	0.02
H-VC-U	64.6	11/03/2014	3	0.023	0.36
H-VC-U	64.6	16/03/2015	3	0.009	0.14
H-VC-UMN	83.4	11/03/2014	3	0.0032	0.04
H-VC-UMN	83.4	15/04/2014	4	0.0021	0.03
H-VC-UMN	83.4	16/03/2015	3	0.002	0.02

3.6.3.3 Winter Ice Regime in Dome Creek

All available winter spot flow measurements from the 2011 to 2016 period were summarized to characterize streamflow conditions in Dome Creek. Spot streamflow measurements made in Dome Creek at DC-M (proximal to DC-U) indicate that unit yields can reach lows of 0.1 L/s/km² just prior to the initiation of freshet (mid-April; Table 3-52), but are generally in the range of 1 to 5 L/s/km² for the months of November through April (Table 3-14). DC-B typically freezes to bed during the winter months, supported by observations made by EDI staff on the monthly water quality sampling trips. Extensive icing is also encountered at DC-R, with one manual winter flow measurement taken in November 2013 indicating yields of <1 L/s/km² (Table 3-15; EDI, 2013d). Zero flow conditions become widespread by January and are accompanied by extensive aufeis formation.

Aufeis (*i.e.*, frozen groundwater seepage that accumulates within- and adjacent to local watercourses) is pervasive in creeks and streams in the region and at the Site. Aufeis melts during the freshet, but may persist into the early summer (mid- to late-June). This ice growth, or aufeis, is the result of shallow groundwater discharge and/or baseflow in the stream channel freezing. The ice impedes subsequent flow, which is forced on top of the existing ice sheet, where it freezes (Figure 3-36). This process repeats continuously throughout the winter, and results in laminated ice sheets that have been measured close to 0.5 m in thickness within Dome Creek (Figure 3-37 to Figure 3-41). Liquid flow is thus either not present, or it can still occur between these laminae, and at the edges of the stream channel. It is these flows that the water quality samples are taken from during the winter. The aufeis process also acts as a storage reservoir for winter base flows, and can store up to a third of the cumulative annual baseflow in sub-Arctic watersheds (Yoshikawa *et al.*, 2007).

Aufeis often far exceeds the natural stream channel width in the smaller tributaries, and as ice melts much more slowly than the snowpack, much of the freshet occurs while extensive aufeis is still present. This makes accurate measurement of streamflows (where they exist) challenging or impossible during the winter season at many of the Project hydrometric stations, and dangerous during the initiation of freshet. This process also influences the distribution of annual streamflow, as the baseflow stored in aufeis during the winter months is released during the freshet and early summer periods. This means that proportionately even more of the total annual runoff is expressed during the months of May through October.

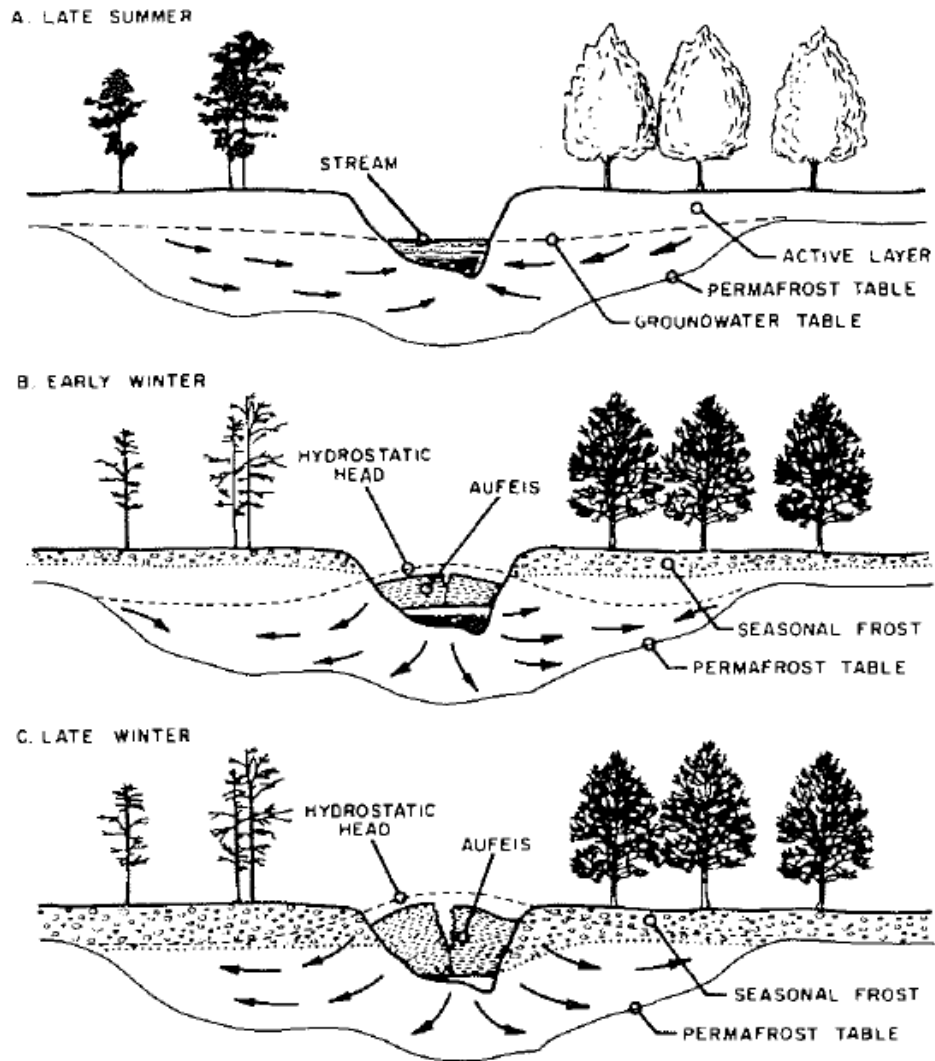


Figure 3-36: Groundwater flow patterns and aufeis formation (from Kane, 1981).



Figure 3-37: Overflow at DC-U, looking upstream (March 17, 2015). Source: EDI 2015a.



Figure 3-38: DC-M, looking upstream (March 10, 2014). Source: EDI 2014d.



Figure 3-39: DC-R, looking downstream (February, 2015). Source: EDI 2015a.



Figure 3-40: DC-B, looking downstream (March 17, 2015). Source: EDI 2015a.



Figure 3-41: DC-B, looking upstream (January 14, 2014). Source: EDI 2014d.

4. Closure

4. **Closure**

We trust that this report meets your expectations at this time. Please contact the undersigned with any questions or comments.

Sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

Prepared by:



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***Appendix A:
Mount Nansen Water Resources
Investigations 2016-2017:
Methodology***

**Mount Nansen Water Resources
Investigations 2016/17:
Methodology**

Prepared For
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EDI Project
16Y0089
July 2016

**Down
to Earth
Biology**



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1 PROGRAM INTRODUCTION

Yukon Government Assessment and Abandoned Mines (AAM) retained the services of EDI Environmental Dynamics Inc. (EDI) in 2016 to conduct the Water Resource Investigations 2016/17 program at the Mount Nansen Site. This program involves three monitoring components: meteorology, surface water hydrology and surface water quality. Monitoring activities are completed on a monthly basis from April 2016 to March 2017, with two trips in April 2016 to capture the freshet period. Trips are typically scheduled for the first week of each month and take place over two to three days.

This report presents the methodology for the current program. Any updates to the program methodology will be provided in the monthly reports with rationale provided. The following sections include descriptions of site/station locations and program methodology for each component.

1.1 MONITORING NETWORK DESCRIPTION

The Mount Nansen Site lies within the Victoria Creek drainage which is a tributary to the Nisling River. The abandoned mine infrastructure includes a mill, a tailings and seepage pond facility, a diversion channel, and the Brown-McDade pit lake and waste rock pile area. Several smaller watercourses drain the mine site area, including Dome Creek and Pony Creek. Dome Creek is a tributary to Victoria Creek and originates upstream of the mill, flows through the valley and is diverted around the tailings pond via the diversion channel. Pony Creek lies within the northern portion of the mine site area to the north of the Brown-McDade pit lake. Pony Creek is a tributary to Back Creek, which flows into Victoria Creek upstream of the Dome Creek confluence. Minnesota Creek lies east of the mine site area and is not within the influence of the mine, flowing into Victoria Creek downstream of the Dome Creek confluence. There are also numerous groundwater seeps around the Site, including seepage sites around the mill area and around the waste rock pile and Dome Creek Valley (Figure 1, Figure 2 and Figure 3).

There are a total of 26 water quality sampling sites and 13 hydrometric monitoring stations (Table 1).

Table 1. List of surface water monitoring locations at the Mount Nansen Site (2016/17 Scope of Work).

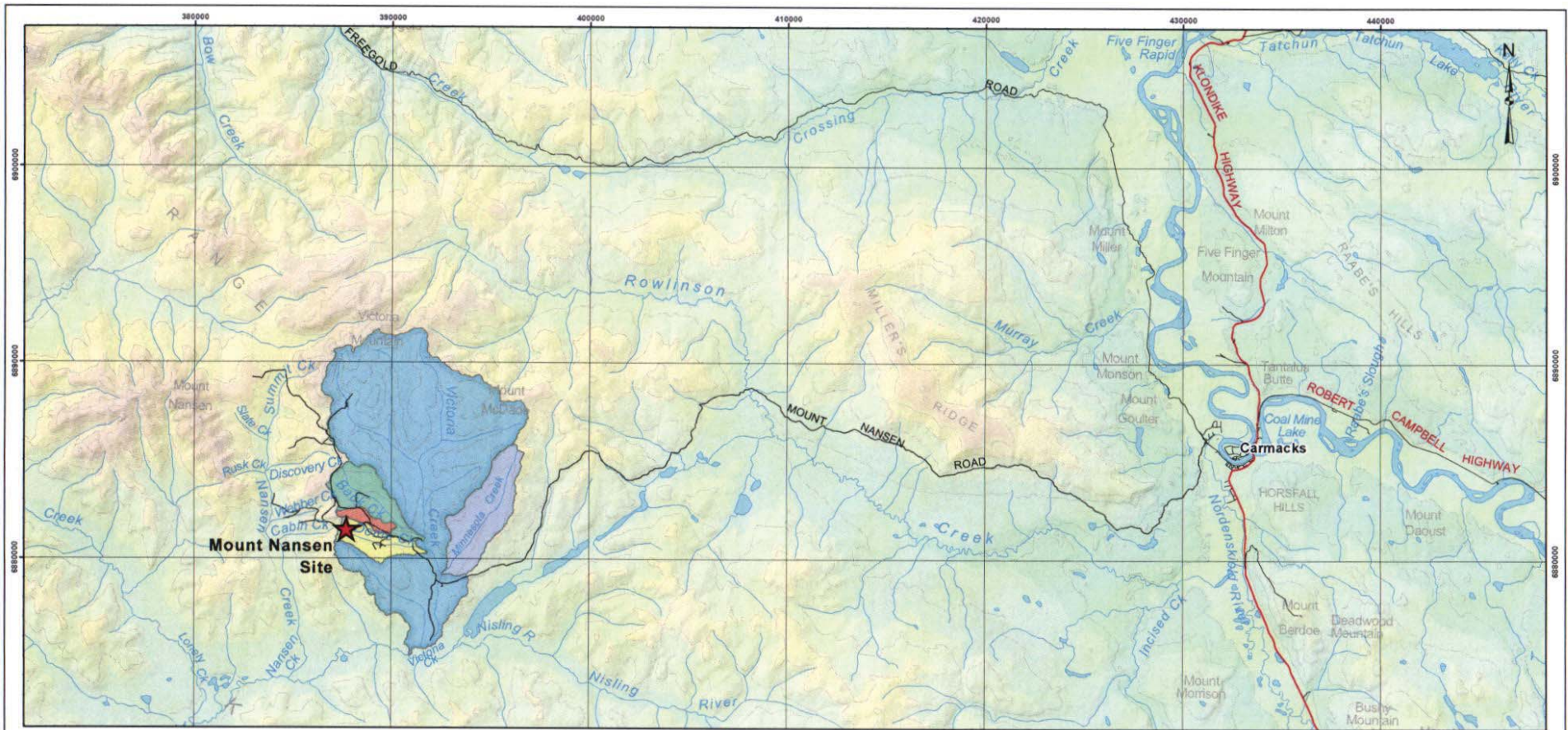
Station/Site Name	Hydrology	Water Quality	Station/Site ID
Upper Pony Creek	-	✓	WQ-PC-U
Pony Creek Downstream of Pit	✓	✓	H-PC-DSP/WQ-PC-D
Dome Creek at DX	-	✓	WQ-DC-DX
Dome Creek at DX+105	✓	✓	H/WQ-DC-DX+105
Dome Creek at D1b	✓	✓	H/WQ-DC-D1b
Diversion Channel at Bridge	✓	✓	H/WQ-DC-B
Middle Dome Creek	✓	✓	H-DC-M WP/WQ-DC-U
Dome Creek at Road	✓	✓	H/WQ-DC-R
Seepage Pond Outflow	✓	✓	H/WQ-SEEP
Tailings Pond	✓	✓	H/WQ-TP



Station/Site Name	Hydrology	Water Quality	Station/Site ID
Brown-McDade Pit Lake	-	✓	WQ-PIT-1,2,3*
Mill Site Seep 08	-	✓	WQ-MS-S-08
Mill Site Seep 03	-	✓	WQ-MS-S-03
Back Creek	✓	✓	H/WQ-BC
Upper Victoria Creek	✓	✓	H/WQ-VC-U
Victoria Creek Downstream of Back Creek	✓	✓	H/WQ-VC-DBC
Victoria Creek Upstream of Minnesota Creek	✓	✓	H/WQ-VC-UMN
Victoria Creek at Road + 290 m	✓	✓	H-VC-R+290/WQ-VC-R**
Pump House Well	-	✓	WQ-PW
Dome East Slope Seep 01	-	✓	WQ-DESS-01
Dome East Slope Seep 02	-	✓	WQ-DESS-02
Dome East Slope Seep 03	-	✓	WQ-DESS-03
CH-P-13-01	-	✓	WQ-CH-P-13-01
Lower West Toe of Waste Rock Dump Seep 01	-	✓	WQ-LW-SEEP-01
East Toe of Northwest Pile Seep 01	-	✓	WQ-NW-SEEP-02
Pony Creek Adit Seep	-	✓	WQ-ADIT-SEEP

*currently suspended pending safety review of pit walls

**winter sampling location at WQ-VC-R+150 due to prohibitive ice conditions upstream of road



Regional Overview Map of Mount Nansen Site

Legend

Local Drainage Area

- Back Creek
- Dome Creek
- Minnesota Creek
- Pony Creek
- Victoria Creek

- Topographic Contour
- Secondary Road
- Highway

Data sources
 1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

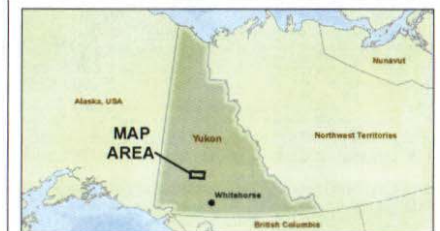
Digital Elevation Model provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.

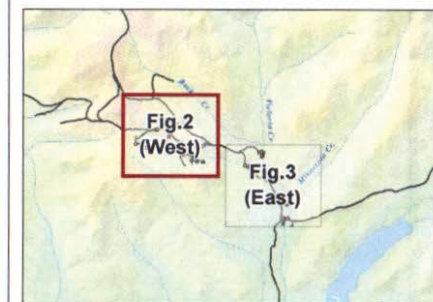
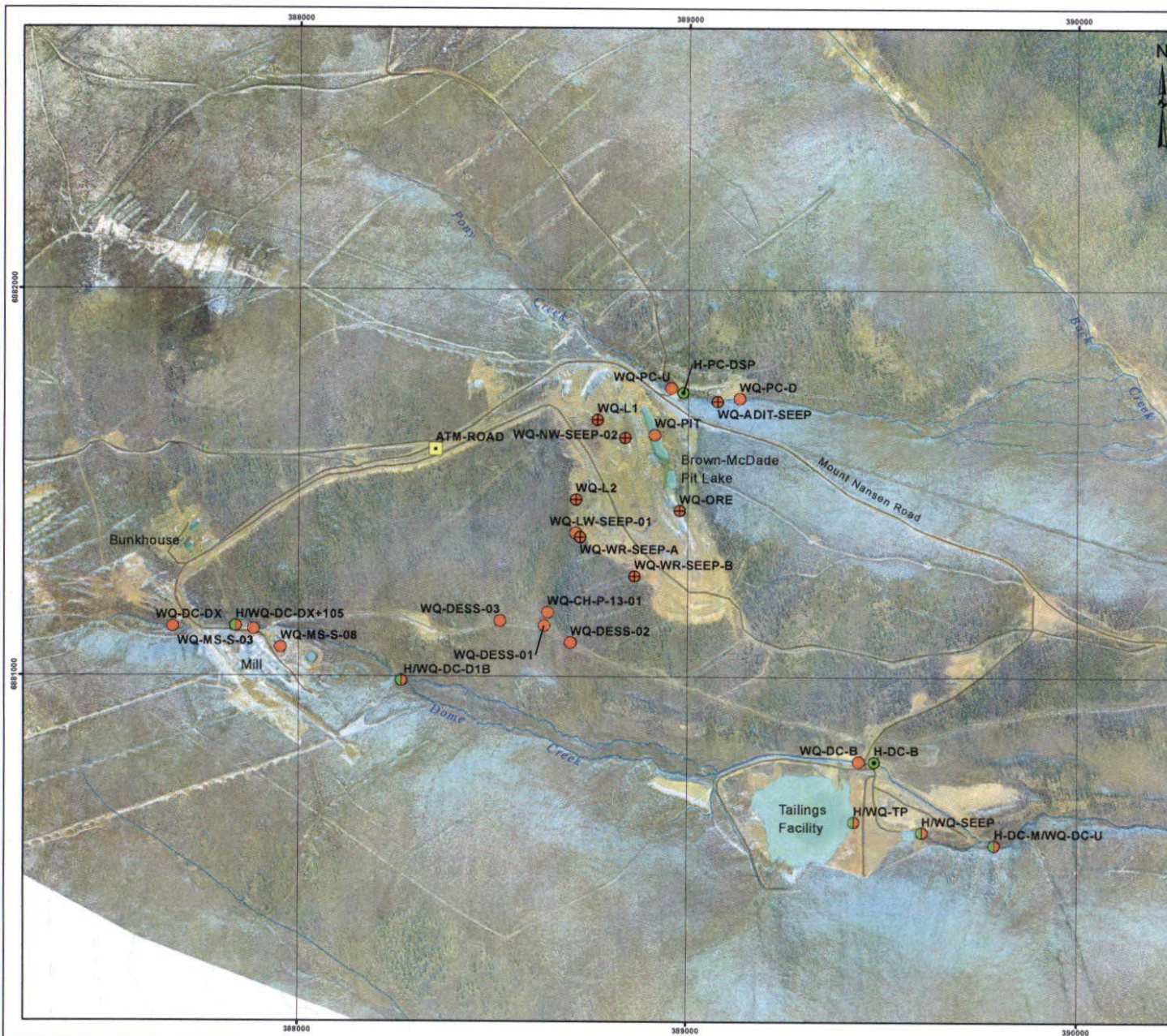
This document is not an official land survey and the spatial data presented is subject to change.



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 Map Projection: NAD 1983 UTM Zone 8N

Drawn: LG	Checked: MM / JB	Date: 14/07/2016	FIGURE 1
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Legend

- Atmospheric Station (label e.g. ATM-ROAD)
- Hydrometric Station and Water Quality Site (label e.g. H/WQ-VC-UMN)
- Hydrometric Station (label e.g. H-VC-R)
- Water Quality Site (label e.g. WQ-PC-U)
- ⊕ Temporary Water Quality Site (label e.g. WQ-MS-S-03)
- Unpaved Road/Access

Mount Nansen Site (West): Hydrometric Stations and Water Quality Sites

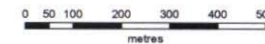
Notes:

1:50,000 and 1:250,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.

Watercourse, drainage areas and Mount Nansen Road layers digitized / modified by EDI (2011) using orthophotos provided by Yukon Government, Energy, Mines and Resources (2011).

Imagery provided by Yukon Government - Energy, Mines and Resources - Abandoned Mines Branch.

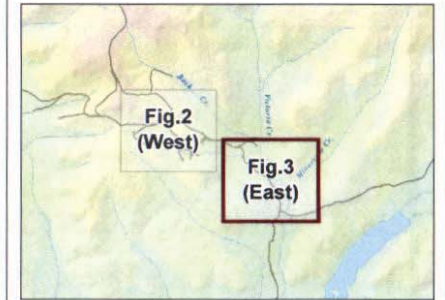
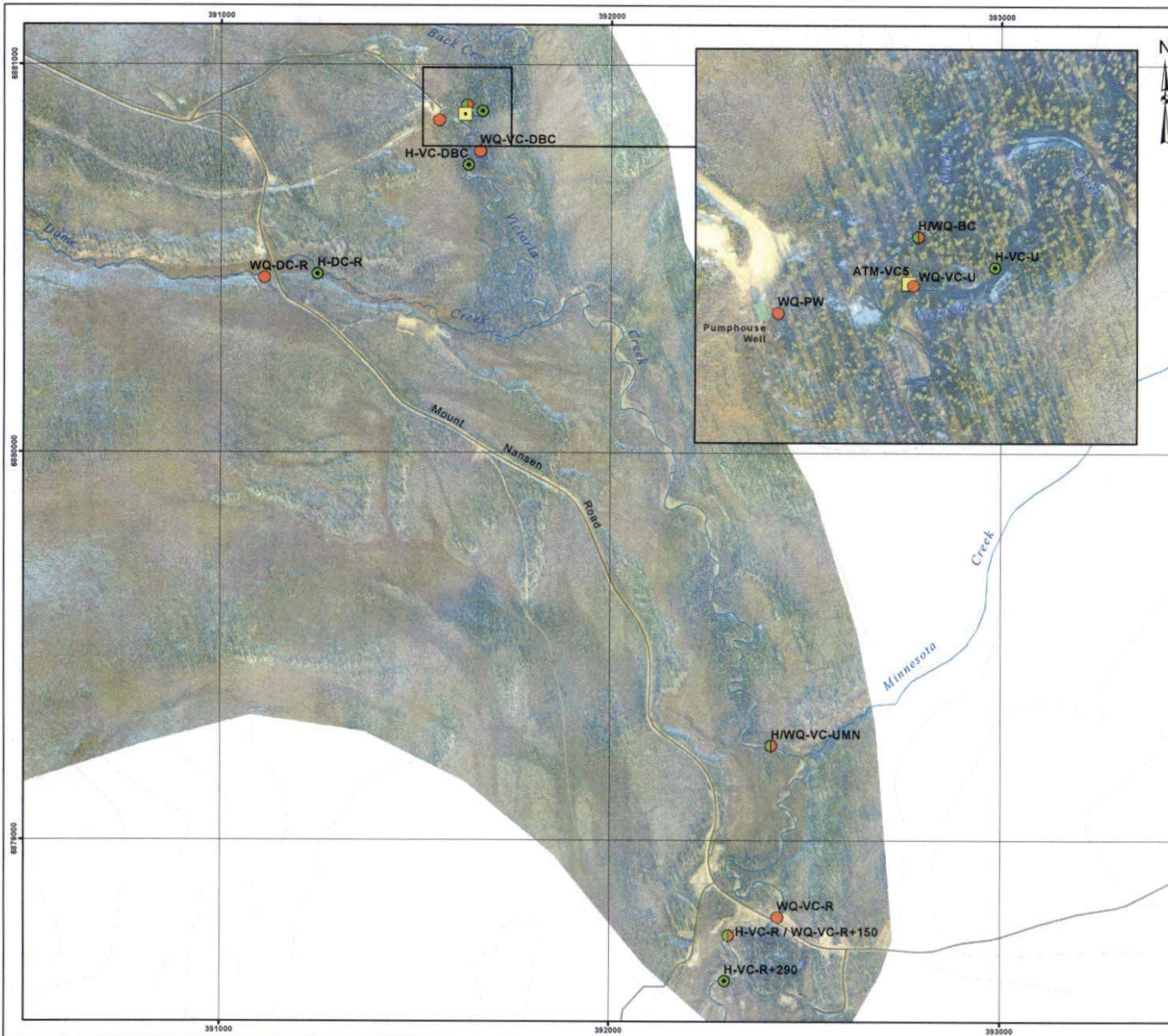
Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2015) was obtained using Garmin GPS technology.



Map Scale = 1:10,000 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 8N

Drawn: MP	Checked: MM/SD	Date: 14/07/2016	FIGURE 2
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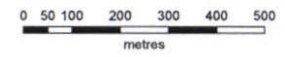




- Legend**
- Atmospheric Station (label e.g. ATM-ROAD)
 - Hydrometric Station and Water Quality Site (label e.g. H/WQ-VC-UMN)
 - Hydrometric Station (label e.g. H-VC-R)
 - Water Quality Site (label e.g. WQ-PC-U)
 - Temporary Water Quality Site (label e.g. WQ-MS-S-03)
 - Unpaved Road/Access

Mount Nansen Site (East): Hydrometric Stations and Water Quality Sites

Notes:
 1:50,000 and 1:250,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (Corporate Spatial Warehouse) www.geomatics.yukon.ca.
 Watercourse, drainage areas and Mount Nansen Road layers digitized / modified by EDI (2011) using orthophotos provided by Yukon Government, Energy, Mines and Resources (2011).
 Imagery provided by Yukon Government - Energy, Mines and Resources - Abandoned Mines Branch.
 Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2015) was obtained using Garmin GPS technology.



Map Scale = 1:10,000 (printed on 11 x 17)
 Map Projection: NAD 1983 UTM Zone 8N

Drawn: MP	Checked: MM/SD	Date: 14/07/2016	FIGURE 3
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2 PROGRAM METHODOLOGY

2.1 METEOROLOGY

A Campbell Scientific meteorological station (ATM-ROAD AAM) was established at the Mount Nansen Site in October 2011. The station is located adjacent to the Mount Nansen Road, east of the camp at an elevation of 1,255 m above sea level (Figure 2).

The ATM-ROAD station records air and ground temperature, humidity, rainfall, snow depth, snow depth measurement quality, net shortwave and longwave radiation, total radiation, wind speed, wind direction and battery voltage (Table 2). There is also a barometric logger, which collects barometric pressure and air temperature for use in the hydrometric program (Section 2.2).

Table 2. Summary of weather data parameters collected at Mount Nansen Meteorological Station (ATM-ROAD AAM).

Meteorological Parameter	Units	Notes
Daily Collection		
Air Temperature Maximum	°C	Measured every 5 minutes; Daily maximum value is reported
Air Temperature Minimum	°C	Measured every 5 minutes; Daily minimum value is reported
Humidity Maximum	%	Measured every 5 minutes; Daily maximum value is reported
Humidity Minimum	%	Measured every 5 minutes; Daily minimum value is reported
Snow Depth	cm	Reports the depth of snow at the end of the day
Battery Voltage	Volts	Measured every 5 minutes; Daily minimum value is reported
Hourly Collection		
Net Shortwave	W/m ²	Measured every 5 minutes; Hourly average is reported
Net Longwave	W/m ²	Measured every 5 minutes; Hourly average is reported
Net Total Radiation	W/m ²	Measured every 5 minutes; Hourly average is reported
Wind Speed	m/s	Measured every 5 minutes; Hourly average is reported
Wind Direction	degrees	Measured every 5 minutes; Hourly average is reported
Rainfall	mm	Total hourly rainfall
Snow Depth	cm	Hourly sample recorded
Snow Depth Quality	-	Hourly measurement recorded
Air Temperature	°C	Measured every 5 minutes; Hourly average is reported
Humidity	%	Measured every 5 minutes; Hourly average is reported
Ground Temperature Surface	°C	Hourly sample recorded
Barometric Pressure	mbar	Hourly sample recorded



2.1.1 DATA DELIVERABLES

The maintenance and calibration of ATM-ROAD AAM sensors and infrastructure is conducted by Northern Avcom and data is accessible through an internet download. EDI is responsible for downloading and compiling these raw data into a database (Table 3) and conducting a basic quality control/quality assurance review to identify issues with the sensors, calibration and general function of the telemetry system. If any corrections are required to the data, changes will be made as required, to the hourly dataset in Aquarius Workstation Time Series Software (Aquatic Informatics Inc.) and exported into a corrected data table in the Microsoft Access database (Table 3). A copy of an updated meteorological database will be provided with each monthly monitoring report. In addition, plots for each parameter will be included in the monthly reports corresponding with end of the open water season and the end of the winter season.

Table 3. Meteorological database tables and content description.

Database Table Name	Description
lut_Met_Parameters	A description of the sensors and infrastructure at the station
lut_Met_Stn_Information	Basic metadata about the station including location and elevation
lut_Met_Stn_Operations	Operational history of the station including calibration dates, time periods where sensors are offline and a summary of data corrections
tbl_RAW_Daily_Weather	Raw daily data with an abbreviated selection of parameters
tbl_RAW_Hourly_Weather	Raw hourly data for the complete selection of station parameters
tbl_RAW_Thermistor	Raw thermistor data
tbl_CORRECTED_Hourly_Weather	Corrected daily weather data, as required

2.2 HYDROLOGY

The Mount Nansen hydrometric program is designed to collect baseline hydrometric measurements and to support engineering design, water balance modeling, water quality modeling and water management planning. The creeks on the project site are relatively small and exhibit channel instability, particularly in Dome Creek. As a result, hydrometric monitoring efforts will be adapted to the dynamics hydraulic conditions to provide the most accurate and appropriate discharge method. The hydrometric program includes four types of stations (Table 4):

1. **Atmospheric:** A continuous barometric data logger is used to compensate water level loggers for atmospheric pressure.
2. **Instantaneous:** Stage and/or discharge measurements are instantaneous and collected manually during each field visit.
3. **Continuous:** Water level loggers measure stage at 15 minute intervals continuously during the open water season. Instantaneous stage and discharge measurements are obtained on each field visit to develop the open water stage-discharge rating curve that converts the continuous stage data to discharge values.



4. **Continuous Winter:** Water level loggers measure stage at 15 minute intervals continuously during the winter season to facilitate an understanding of water level changes in the winter periods. Instantaneous discharge measurements are obtained on each field visit; however, no rating curve is applied to the winter stage data.

Table 4. Mount Nansen hydrometric and atmospheric station information.

HID ¹	Hydrometric Station Name	Type ²	Location ³		Drainage Area (km ²)	Elevation ⁴ (m)
			Easting	Northing		
ATM-VC5	Barometric at Victoria Creek	ATM	391626	6880872	-	1015
H-PC-DSP	Pony Creek Downstream of Pit	I	388986	6881734	1.0	1191
H-DC-DX+105	Dome Creek at DX+105	I	387820	6881150	0.9	1204
H-DC-D1b	Dome Creek at D1b	I	388262	6881000	1.4	1156
H-DC-B	Diversion Channel at Bridge	C	389480	6880780	3.0	1095
H-DC-M WP	Middle Dome Creek Weir Pond	C/CW	389788	6880565	3.3	1065
H-TP	Tailings Pond	I	389427	6880625	-	1093
H-SEEP	Seepage Pond Outflow	I	389604	6880598	-	1072
H-DC-R	Dome Creek at Road	C	392540	6879249	4.5	1020
H-BC	Back Creek	C	391626	6880901	10.4	1021
H-VC-U	Upper Victoria Creek	C/CW	391667	6880882	64.6	1019
H-VC-DBC	Victoria Creek Downstream of Back Creek	C/CW	391627	6880840	75.0	1017
H-VC-UMN	Victoria Creek Upstream of Minnesota Creek	C/CW	392413	6879244	83.4	986
H-VC-R+290	Victoria Creek at Road + 290	C/CW	392295	6878638	97.7	975

Notes:

1 - HID = unique station identifier that corresponds with hydrometric database tables.

2 - Station Type: ATM = atmospheric pressure monitoring; C = continuous water level monitoring with instantaneous discharge rating measurements; I = instantaneous stage and/or discharge measurement; CW = continuous winter water level monitoring with instantaneous discharge rating measurements.

3 - NAD 83, UTM Zone 8.

4 - Elevations for hydrometric stations are estimates based on field data collected by handheld Garmin GPS units and digital spatial data (DEM) provided by AAM.

The barometric sensor and data logger at the meteorological station (ATM-ROAD AAM, Elev. = 1,255 m) is used as a redundant logger for the barometric logger located near Victoria Creek (ATM-VC5). There is an elevation difference of 240 m between ATM-ROAD AAM and ATM-VC5 therefore elevation corrections prescribed by Solinst Canada Ltd. are applied to the ATM-ROAD AAM data in the case that the ATM-VC5



logger malfunctions. (Note: the barometric units collected by ATM-ROAD AAM are millibars whereas ATM-VC5 barometric units are kilopascals; unit conversion is required).

The hydraulic conditions encountered at the Mount Nansen hydrometric stations vary in each watershed and change seasonally. In addition, Back Creek, Dome Creek and Pony Creek are relatively small channels that typically require non-standard discharge measurement methods to be employed (i.e., alternative methods to the velocity-area mid-section method). Hydraulic conditions during the winter months also require alternative hydrometric measurements depending on the ice conditions. The following is a list of hydrometric measurement methods used in the Mount Nansen hydrometric monitoring network that are described in the sections to follow:

- the velocity-area mid-section method (standardized),
- volumetric measurements,
- v-notch weir measurements, and
- salt dilution gauging (brine salt slug injection) method.

The velocity-area mid-section method is standardized by British Columbia's Resources Information Standards Committee (RISC 2009), however many of the channels at the Site are inappropriate for using this method (i.e., too shallow, too narrow or low discharge). In such cases, alternative methods including salt-dilution gauging and volumetric measurements are used. Typically, an elevation survey is completed during each hydrometric station visit where there are continuous data loggers installed; surveys are used to monitor shifts in benchmarks, station, and staff gauge elevations. Surveys are not completed during the winter because stage elevations are affected by ice, changing the relationship between stage and discharge; rating curves are not developed for the winter period.

Given the small channel sizes and low seasonal discharges at many stations, the minimum reportable discharge is set to 0.001 m³/s or 1 L/s; this value is lower than what is typically reported for other hydrometric programs (e.g., Water Survey of Canada uses +/-0.01 m³/s for open water conditions). Field methods used at Mount Nansen can accommodate this higher resolution of discharge under ideal conditions, however measurement uncertainty for each method should be considered when interpreting results. Measurement uncertainty is based on instrument accuracy and channel conditions at the time of measurement. If discharge is calculated to be less than 0.001 m³/s it will be reported as 0.000 m³/s, and flagged as 'Below Reportable Confidence Limits' in the hydrometric database (Section 2.2.10).

The following sections provide details on each method used and the methodology for developing rating curves and continuous stage and discharge hydrographs.



2.2.1 VELOCITY-AREA MID-SECTION

The velocity-area mid-section method will be used to determine discharge at hydrometric stations where channel criteria meet those outlined in standard guidance documents (RISC 2009; WSC 1999). Cross-section locations will be established for each hydrometric station where this method is applied; these cross-sections will be located in close proximity to continuous data logger installations.

The current meter used to obtain the velocity measurements is a 2-dimension, side looking, FlowTracker Handheld Acoustic Doppler Velocimeter (ADV) (Sontek/YSI Inc. 2009). The FlowTracker is used by both the Water Survey of Canada and the U.S. Geological Survey. The FlowTracker computer calculates discharge using the mid-section method and calculates the statistical discharge uncertainty based on methods developed by the U.S. Geological Survey (Cohn et al. 2006). This method of calculating uncertainty accounts for the uncertainty associated with width, depth and accuracy of the FlowTracker calibration and the effects of channel variability on depth and velocity across the cross-section (Sontek/YSI 1999). The statistical discharge uncertainty calculated by the FlowTracker at Mount Nansen is typically less than $\pm 5\%$. An uncertainty of $\pm 10\%$ is considered by industry as acceptable for the velocity-area mid-section method. The statistical uncertainty was applied for all velocity-area discharge measurements obtained with the ADV. The ADV also provides a variety of quality control and assurance assessments in real-time, reducing field measurement error. The absence of moving parts on the acoustic sensor also decreases measurement error during winter conditions.

The ADV automatically calculates discharge using the following standard velocity-area mid-section equations; the continuity relationship for discharge (Q),

$$Q = v \cdot A = b \quad [1]$$

Where depth (d), velocity (v) and width (b) measurements will be obtained for at least 20 panels across the metering cross-section; in some cases where low flow or winter conditions are non-ideal, measurements will be obtained twice with 10 panels or alternative discharge methods will be considered (*e.g.*, salt tracer or volumetric). The cross-section panel width and depth are multiplied by the velocity (averaged over 40 seconds) to obtain an instantaneous discharge measurement (q) for each panel (RISC 2009). Panel discharges are subsequently summed to obtain total discharge. The discharge for the first and last panels is calculated using half the distance from the edge to the first and last mid-panel verticals.

The velocity-area discharge calculation is described by the following equations:

$$q_n = v_n d_n \frac{(b_{n+1} - b_{n-1})}{2} \quad [2]$$

$$Q = q_1 + q_2 + q_3 + q_4 + q_5 + \dots + q_n \quad [3]$$

Where SI units of m^3/s , m/s , and m are used for discharge, velocity and depth respectively.



2.2.2 SALT DILUTION GAUGING

Salt dilution gauging will be used at hydrometric stations where the channel conditions are not suitable for using a velocimeter and the velocity-area mid-section method. Typically this occurs when water depths are less than 0.05 m, channel widths are less than 3.0 m, or during winter months when ice conditions are inappropriate for conducting velocity-area measurements beneath the ice.

This method requires the selection of an input (injection) site and a downstream electrical conductivity measurement site. The distance between these sites (mixing length) is optimized for the minimum distance required for complete mixing of the fully dissolved salt tracer vertically throughout the water column and across the channel. Specific channel conditions during open water and winter periods will be required for successful salt dilution gauging. These criteria ensure that complete lateral and vertical mixing occurs in as short a distance as possible: minimal pools; no backwater areas; no braiding; little to no in-stream vegetation; and no losses or gains of water such as tributaries or groundwater fluxes (Moore 2004a; Moore 2004b; Laberge Environmental Services 1999; Kite 1994). The tracer methods and calculations provided by Moore (2004a; 2004b; 2005) will be employed as they are thought to be significantly more robust and adaptable to site-specific stream conditions than those presented in the other salt tracer references. There are three different salt dilution gauging methods presented in the literature: constant rate injection (brine); slug injection (brine) and dry salt injection. The slug injection (brine) method was selected for use because this method was most practical for the monitoring program and winter conditions.

A conductivity meter (YSI ProPlus Multi-Meter, calibrated daily) records electrical conductance at two second intervals the downstream location during the measurement. Background electrical conductivity is logged for several minutes before the salt is injected to measure the variability of the background EC. Electrical conductance (EC) and water temperature are logged rather than the temperature compensated value, specific conductance (SPC) parameter that is available on the YSI ProPlus. The collection of the uncompensated EC allows for a more robust analysis of the data.

A known mass of salt (NaCl) is dissolved into a graduated bucket of stream water at the injection site. Once fully dissolved, the salt solution is injected at the upstream site and the electrical conductivity of the salt wave is measured at the downstream location at two second intervals depending on the stream velocity. Two trials are conducted at each station. When possible, a secondary method of discharge measurement is used to validate the salt dilution measurement (i.e., ADV measurement) due to the non-standard nature of the method.

The formula used to calculate discharge for the Mount Nansen salt slug injections is:

$$Q = \frac{V_{si}}{1 \cdot k \cdot \tau \cdot \sum (E_m - E_b)} \quad [4]$$



Where Q is discharge (m^3/s), V_{slug} is the volume of salt slug injection (in litres), τ is the time interval in seconds and E_m and E_b are the measured and background conductivity at time interval t , respectively. The k value is the calibration factor that accounts for the non-linearity of electrical conductance and salt concentration in stream water. The k value is taken as the slope of the line of EC and relative concentration of the salt slug in a sample stream water. The target peak specific conductance for the salt wave is an increase of at least ten-times the resolution of the conductivity meter used. Typically, an increase between 10% and 50% of E_b is achieved, above the required increase of 2 to 5 $\mu\text{S}/\text{cm}$.

Stream discharge is calculated for each salt slug trial using Equation [4] and averaged to provide a discharge estimate. The average estimated measurement accuracy for the salt dilution gauging method is $\pm 20\%$. However, salt dilution gauging accuracy will vary between each station due to differences in individual channel conditions and stream water velocities.

2.2.3 VOLUMETRIC

Channel constrictions created by culverts, pipes and weirs provide an opportunity to measure stream flow by measuring the time to fill a graduated container; this is the volumetric method of discharge measurement. Volumetric discharge measurement is ideal for low flows because all of the stream flow is captured in a container of a known volume at a confined outlet or constriction in the channel. The volumetric method for measuring discharge will be used periodically at several stations at Mount Nansen where a culvert v-notch weir or pipe is available (H-PC-DSP; H-SEEP; H-DC-M WP). During extreme low flows it is also possible to obtain volumetric estimates at H-DC-DX+105 and H-DC-D1b.

The volumetric measurement is completed using a graduated 20 L bucket and a timing device. The time required to fill the volume is recorded over five separate volumetric trials. All five volumetric trials are averaged to provide a discharge estimate. The estimated measurement accuracy is $\pm 10\%$.

The volumetric measurement method that is employed at H-SEEP (Tailings Dam Seepage Pond pump pipe outlet) is used to validate daily instantaneous measurements read at the flow meter attached to the pump that is used to manage water levels in the Seepage Pond. Daily flow meter readings are collected by the site maintenance staff and data is maintained by AAM. EDI staff collects concurrent flow meter readings when volumetric measurements are made at the pipe outlet.

2.2.4 WINTER HYDROMETRICS

Instantaneous hydrologic measurements will be completed year round for all stations that are not frozen to the channel bed. Measurements completed during periods when the channel is ice covered have lower accuracy than open channel measurements because the standard hydrometric methods are based on open channel hydraulic relationships between the impelling and resisting forces of flow. Ice increases the resistance to flow, slowing velocities and increasing the water surface elevation (backwater effect). Frazil ice, anchor ice, slush and ice jams influence the water surface profile and effective depth of flow in the channel. As a result, the relationship between stage and discharge changes during the winter. Cold temperatures



frequently cause problems with measurement equipment, including continuous water level loggers. In the Yukon, winter measurement instruments are usually working at or beyond the cold temperature operating limits of the instrumentation and resultant data will be carefully analyzed for quality. All measurements collected during ice conditions will be flagged in the data record with 'B'; the standard data flag used by the WSC indicating backwater or ice effects. Measurements influenced by ice are not included in the open water stage-discharge rating curve development.

Hydrometric measurement methods are selected on a site by site basis to determine which method will provide the highest quality data and will be based on professional judgment of the channel hydraulics and ice conditions. In many of the streams at the Mount Nansen Site, multiple layers of ice are present with flow travelling through complex networks within and on the surface of the ice. In such conditions, discharge measurements become increasingly uncertain and are not performed. Typically in Victoria Creek, the velocity-area and salt dilution methods are both feasible during ice-cover periods when ice thicknesses and ambient air temperatures are not prohibitive. Salt dilution can be used on the smaller channels if they are not frozen to the bed and there is sufficient flow.

2.2.5 HYDROMETRIC LEVELING SURVEYS

Hydrometric leveling surveys are performed during each open water season visit to stations where continuous data loggers are installed. The purpose of these surveys is to tie the data logger water levels to the local station datum. Each station has a local, relative datum defined by benchmarks in close proximity to the data logger and stilling well. Three benchmarks are installed at each continuous station as per RISC (2009) Data Grade A guidelines. Each survey includes a survey with a level and rod for Benchmark 1 (BM1), Benchmark 2 (BM2), Benchmark 3 (BM3), the top of the staff gauge (TOS), the water surface elevation (WATER) and the elevation of the fixed-length logger apparatus (TOR). The elevation of Benchmark 1 at every station defines a local elevation of 3.000 m above datum. The local datum is always located below the elevation of zero flow. The benchmarks and the top of the staff gauge are regularly checked for shifting as a result of periglacial processes and survey error. While there is some apparent movement in the benchmark elevations and occasionally anomalous survey data, the water surface elevation data will be carefully reviewed using staff gauge readings and the field records of stilling well maintenance (logger or staff gauge shifts) before applying local datum offsets to the raw data logger record. All suspect data is excluded from the corrected data. All stage data is presented in metres referenced to the local datum unless otherwise noted.

2.2.6 HYDROMETRIC VALIDATION & QA/QC PROGRAM

The velocity-area, weir and volumetric hydrometric measurement methods used for the Mount Nansen hydrometric program are standardized by the WSC and the USGS. Several stations do not meet standardized criteria; alternative methods (*e.g.*, salt dilution gauging) are used at these stations. In some cases, concurrent standardized methods (*e.g.*, velocity-area measurements) allow for the validation and calibration



of alternate methods. Concurrent measurements also facilitate uncertainty estimates for stream discharge measurements and will be collected where feasible and appropriate.

Quality control and quality assurance (QA/QC) checks begin during field visits. The Flow Tracker ADV provides numerous QA/QC checks in real-time during velocity measurements that allow the field crew to increase the precision of the measurements. Upon return from the field, data entry hydrometric technicians perform preliminary checks and reviews of the raw data and discharge calculations prior to the production of trip and monthly reports. A third round of QA/QC is completed during data entry into the hydrometric database. A final QA/QC is completed during the development of rating curves and hydrographs for each hydrometric station.

2.2.7 RATING CURVE DEVELOPMENT

Rating curves are based on open channel hydraulic relationships between stage (water level) and discharge. They are based on open-water conditions only and are not representative of ice-cover channel conditions. The y-axis represents the recorded stage level at the gauge and the x-axis the discharge. The rating curve equation represents the hydraulic reaction of flow through a smoothly varying channel with increasing stage (or a constant control point at all stages) (Maidment 1993). The rating curve equation [6] has the form:

$$Q = C(h + a)^N \quad [6]$$

Where Q is discharge in m^3/s , C is typically proportional to the channel width, $(h+a)$ represents the depth of water above the stage of zero flow (water level where flow becomes zero) and the value of N is a function of the channel geometry (Maidment, 1993). If the pressure transducer is below the point of zero flow, the value of ' a ' is negative; conversely a positive ' a ' value indicates that it is above. Typically as the stage increases, the hydraulic control shifts from low flow hydraulic control to channel friction control or to ice related controls. As a result multiple rating curve expressions for a single channel and various stages are often required to accurately represent the full range of flows.

By taking the log of both sides of the rating curve in equation [6], we obtain:

$$\log Q = \log C + N \log (h + a) \quad [7]$$

the rating curve equation [8] takes the linear form $y=mx+b$ and can be fit to the discharge rating points as a straight line. Rating curves may be developed using several different methods including fitting the calibration points by eye and the maximum likelihood solution. Given the small size of the channels at the Mount Nansen Site, the narrow range of stage changes, and channel instabilities, each rating curve is developed by fitting by eye within the Aquarius Time-Series Software environment (Aquarius Informatics Inc. 2014).

Rating curves are developed for stations with continuous water level loggers using surveyed water levels (stage) and instantaneous discharge measurements. A rating curve is considered preliminary if the following conditions are met: there are less than 10 reliable rating measurements (RISC 2009), if rating measurements



do not capture an acceptable range of flows (i.e., 10 %-200 % of mean discharge [MD]), or, if there is a high rating curve error.

Rating curves are developed with rating measurements obtained when the channel is ice free. Any rating measurement obtained during ice conditions are reported simply as instantaneous measurements. Rating curves are valid only for a defined rating period. A rating period represents a section of time where both the channel and hydrometric installation are stable.

Timely monitoring events during the spring freshet period allow the capture of higher spring flows. A conservative approach was adopted for presenting the continuous hydrometric record in the report deliverables. Predicting flood or low flows can introduce error into hydrologic analysis and should be carefully considered in the context of channel hydraulic geometry.

2.2.8 CONTINUOUS STAGE & DISCHARGE

There are nine continuous Solinst Edge pressure transducers installed at Mount Nansen and one barometric pressure transducer to compensate the water level loggers for atmospheric pressure (Table 4). Continuous stage records are collected at 15 minute intervals. The pressure transducers are downloaded on each site visit. Continuous discharge is calculated using the stage-discharge rating curve developed for the rating period at each respective station. The continuous stage record (rather than discharge record) is presented for stations where developing reliable rating curves is considered unsuitable due to channel conditions and available measurement techniques. Examples of this occur at H-DC-M-WP and H-DC-B.

2.2.9 DATA MANAGEMENT

Hydrometric data is compiled into a Microsoft Access database after each visit to the Mount Nansen Site. The hydrometric database is designed to hold raw and corrected field data including hydrometric station metadata, station history, field measurements, survey data and data logger files. The hydrometric database is also used for QA/QC and generating report summaries.

2.2.10 DATA DELIVERABLES

The deliverables for the hydrometric monitoring component of the water resources investigation includes:

- Monthly Report
 - Instantaneous discharge values and hydrographs for each station
 - Notation of QA/QC issues and corrections (if required)
 - Up to date hydrometric database
- Open Water / End of Winter Enhanced Monthly Report



- Instantaneous discharge values and hydrographs for each station
- Notation of QA/QC issues and corrections (if required)
- Up to date hydrometric database
- Rating curves and equations for applicable
- Continuous stage and discharge hydrographs

If any corrections are required to the data, changes will be made as required to continuous stage, discharge records in Aquarius Time Series Software (Aquatic Informatics Inc.) and exported into a corrected data table in the database (Table 5). A copy of an updated hydrological database will be provided with each monthly monitoring report. In addition, rating curves and continuous hydrographs will be included in the monthly reports corresponding with end of the open water season and the end of the winter season.

Table 5 Hydrological database tables and content descriptions.

Database Table Name	Description
lut_hydrometric_data_flags	List of hydrometric data flags associated with the discharge measurements
lut_hydrometric_Qmeas_type	List of the hydrometric measurement method used for each discharge value
lut_hydrometric_station_ID	Unique hydrometric station identifier (HID)
lut_hydrometric_survey_flags	List of data flags for the hydrometric survey data
lut_hydrometric_survey_points	List of hydrometric survey points captured in hydrometric surveys
tbl_hydrometric_station_history	Operational history for each hydrometric station including data logger serial numbers, installation locations and dates.
tbl_Q_Measurement	Master summary of all discharge measurements and methods for each site visit. Unique measurement identifier (MID).
tbl_site_visit_MID	Unique measurement identifier assigned to each station for each site visit. If multiple measurement methods are used at a station during a single site visit the measurements have a single MID
tbl_survey_data	Hydrometric level survey data.

2.3 WATER QUALITY

Water quality sampling will occur on a monthly basis from April 2016 to March 2017, with two trips in April 2016 to capture the freshet period. There are a total of 26 water quality sites in the 2016/17 scope of work, with the potential for additional sites during freshet and at the request of AAM (Table 6). The water quality program includes collecting water samples at each site depending on suitable conditions for laboratory analysis, as well as collection of in situ water quality data, site photographs, and a description of site conditions. The sampling frequency varies by site, as some sites are sampled monthly, during freshet only, on a seasonal basis, or only up to two to three times per year. In addition to the sampling schedule, samples are only collected when conditions are suitable. During the summer months, some sites become dry for short periods of time (e.g., portions of Pony Creek flow underground when weather conditions are hot and



dry). During the winter period, many sites on Dome Creek, Pony Creek and Back Creek freeze to substrate as early as November and can remain frozen into May. Aufeis conditions commonly develop within Dome Creek, with thick ice developing in layers. Overflow ice build-up is also common on Victoria Creek upstream of the Mount Nansen Road crossing, which prevents sampling at the WQ-VC-R site during the winter. Since this site represents the most downstream receiving environment, a more suitable winter sampling location is used downstream of the road crossing (WQ-VC-R+150).

Table 6. Mount Nansen water quality site and sampling information.

Water Quality Site Name	Site ID	Site Location ¹		Sampling Frequency	Type of Lab Analysis ²
		Easting	Northing		
Pony Creek upstream	WQ-PC-U	388955	6881745	Monthly	Standard Package
Pony Creek downstream	WQ-PC-D	389131	6881719	Monthly	Standard Package
Pit Lake (3 samples)	WQ-PIT-1,2,3	388913	6881625	Monthly	Pit Lake Package
Dome Creek at DX	WQ-DC-DX	387674	6881127	Monthly	Standard Package
Dome Creek at DX+105	WQ-DC-DX+105	387820	6881150	Monthly	Standard Package
Dome Creek at D1b	WQ-DC-D1b	388264	6880989	Monthly	Standard Package
Diversion Channel at Bridge	WQ-DC-B	389439	6880781	Monthly	Standard Package
Upper Dome Creek	WQ-DC-U	389788	6880565	Monthly	Standard Package
Dome Creek at Road	WQ-DC-R	391111	6880449	Monthly	Standard Package
Tailings Pond	WQ-TP	389427	6880625	Monthly	Standard Package
Seepage Pond Outlet Pipe	WQ-SEEP	389604	6880598	Variable ³	Standard Package, LC50
Mill Site Seep 03	WQ-MS-S-03	387884	6881121	3X Per Year	Standard Package
Mill Site Seep 08	WQ-MS-S-08	387954	6881073	3X Per Year	Standard Package
Back Creek	WQ-BC	391626	6880901	Monthly	Standard Package
Upper Victoria Creek	WQ-VC-U	391626	6880872	Monthly	Standard Package
Victoria Creek downstream Back Creek	WQ-VC-DBC	391633	6880740	Monthly	Standard Package
Victoria upstream of Minnesota	WQ-VC-UMN	392413	6879244	Monthly	Standard Package
Victoria Creek at Road	WQ-VC-R	392431	6878802	Monthly	Standard Package



Water Quality Site Name	Site ID	Site Location ¹		Sampling Frequency	Type of Lab Analysis ²
		Easting	Northing		
Victoria Creek at Road (winter location)	WQ-VC-R+150	392305	6878755	Monthly	Standard Package
Pump House Well	WQ-PW	391558	6880856	Monthly	Drinking Water Package, Bacteriological Sample
Dome East Slope Seep 01	WQ-DESS-01	388632	6881131	Seasonal ⁴	Standard Package
Dome East Slope Seep 02	WQ-DESS-02	388699	6881087	Seasonal ⁴	Standard Package
Dome East Slope Seep 03	WQ-DESS-03	388518	6881143	Seasonal ⁴	Standard Package
Upwelling near CH-P-13-01	WQ-CH-P-13-01	388640	6881165	Monthly	Standard Package
Lower West Toe of Waste Rock Pile Seep	WQ-LW-Seep-01	388711	6881371	Seasonal ⁴	Standard Package
Pony Creek Adit Seep	WQ-ADIT-SEEP	389081	6881709	2X per Year	Standard Package
NW-SEEP-02	WQ-NW-SEEP-02	388837	6881617	Freshet ⁵	Standard Package

Notes:

1 - NAD 83, UTM Zone 8.

2 - Parameters included in various sampling packages are explained in greater detail in Table 7.

3 - Sampling frequency for this site was variable as the WQ-SEEP site is sampled on a monthly basis for the standard package samples and every second month for the LC50 sample.

4 - Sampling frequency for these sites is seasonal as these seeps are to be sampled during freshet and then once during the summer, fall, and prior to winter freeze-up.

5 - Freshet sampling only during April 2016.

2.3.1 FIELD SAMPLING METHODS

Water samples are collected at each sample site from the same location each month. Laboratory-cleaned bottles are filled using clean techniques (i.e., nitrile gloves, appropriate bottle handling) and samples are filtered and preserved on site, as per instructions by accredited lab. Samples are kept in coolers immediately following collection, and later transferred to the Mount Nansen Site sample refrigerator until they can be transferred to Whitehorse on the final day of each sampling event. Chain of Custody forms, supplied by the lab, are included in each sample cooler, and samples are delivered to the accredited lab upon arrival back in Whitehorse, YT to ensure lab holding times were met. The bacteriological sample collected at the pump house well each month is submitted to Yukon Government Environmental Health Services in Whitehorse, YT for analysis. More details on lab analysis are included in Section 2.3.2.

Sampling from the pit lake has currently been suspended pending a safety assessment associated with rock fall from the pit walls. Once the site has been determined 'safe', sampling will re-commence. Samples from the pit lake are taken from the same general location in the middle of the lake from the deepest location, at



three different depths, from the surface, at mid depth and just off the bottom. When the pit lake is ice free, a row boat is used to access the sampling location, and samples are collected using a Kemmerer sampler. In the event that ice covers the water surface, an ice auger is used to access the water column.

In situ water quality parameters collected at each site include turbidity, water temperature, specific conductivity (SPC) and pH. Dissolved oxygen is only collected at the pit lake as well as from fish bearing streams year round (Victoria Creek and Back Creek). An Oakton T100 turbidity meter is used to collect in situ turbidity (NTU). This meter is calibrated on a monthly basis according to instrument specifications. A YSI ProPlus multi-meter is used to collect in situ water temperature (degrees Celsius), pH (pH units), specific conductivity ($\mu\text{S}/\text{cm}$). Field crews calibrate the YSI meter prior to each trip and as required in the field. A YSI ProODO meter is used to measure dissolved oxygen (mg/L) from the pit lake (this probe does not require any calibration).

Field data is recorded on standard field data forms (either on a field tablet or hard copy datasheets); this information includes station name, sample date and time, water temperature, SPC, pH, DO, turbidity, photo numbers and a record of site conditions including flow stage (low, moderate, high), turbidity (clear, light, moderate, high), and any other qualitative observations

2.3.2 LABORATORY ANALYSIS

There are several lab analyses packages used for the water resources investigations program (Table 7). A 'standard site package' includes lab analysis of cyanides, routine physical tests, anions and nutrients, total metals, and dissolved metals. The 'pit lake package' is similar to the standard package, but excludes cyanide parameters. The 'drinking water package' includes physical tests, anions and nutrients, total metals and bacteriological tests (total coliforms and *E. coli*). The detection limits for the various parameters can vary between packages based on the standard lab testing procedures.

A toxicity test for rainbow trout (LC50) is completed for one sample at one site (WQ-SEEP) every second month.

Table 7. Laboratory analysis parameters included in various 'packages' created for surface water quality sampling at Mount Nansen.

Analysis Package	Parameters Included
Standard Site Package	<p>Cyanides: Cyanate, Total Cyanide (as Strong Acid Dissociable), Weak Acid Dissociable, Thiocyanate</p> <p>Physical Tests: Conductivity, Hardness, pH, Total Dissolved Solids, Total Suspended Solids</p> <p>Anions and Nutrients: Bicarbonate, Carbonate, Hydroxide, Total Alkalinity, Total Ammonia, Chloride, Fluoride¹, Nitrate, Nitrite, Sulphate</p> <p>Total Metals: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium,</p>



Analysis Package	Parameters Included
Pit Lake Package	<p>Vanadium, Zinc.</p> <p>Dissolved Metals: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc.</p> <p>Physical Tests: Conductivity, Hardness, pH, Total Dissolved Solids, Total Suspended Solids</p> <p>Anions and Nutrients: Bicarbonate, Carbonate, Hydroxide, Total Alkalinity, Total Ammonia, Chloride, Fluoride¹, Nitrate, Nitrite, Sulphate</p> <p>Total Metals: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc.</p> <p>Dissolved Metals: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc.</p>
Drinking Water Package	<p>Physical Tests: True Colour, Conductivity, Hardness, pH, Total Dissolved Solids, Turbidity</p> <p>Anions and Nutrients: Alkalinity, Total, Chloride, Fluoride¹, Nitrate, Nitrite, Sulphate</p> <p>Total Metals: Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Potassium, Selenium, Sodium, Uranium, Zinc.</p>
LC50 Package	LC50 test conducted with rainbow trout.

Note: 1- The instrumentation used for the fluoride analysis is typically done with ion chromatography (IC) with the other anions (chloride, nitrate, nitrite, sulphate, etc.). However, in some cases where there is high specific conductivity and sulphates, the samples must be diluted to protect instrumentation with detection limits adjusted. When the detection limit for fluoride is adjusted, it is adjusted above the interim guideline value. When this case occurs, the fluoride sample will be analyzed using the selective electrode method (SIE) to ensure that the reporting limit does not increase beyond the 0.12 mg/L guideline value.

2.3.3 QA/QC SAMPLE PROGRAM

The water quality field program also includes collection of QA/QC samples, including: replicate samples, field blanks, and travel blanks. These are described in detail below:

- Replicate samples are essentially sample replicates collected at the same date, time and location as the regular sample. All sampling methodology is the same, as if it is a separate site. Replicates are collected from one to three sites, randomly selected, during each trip, depending on the total number of sites per trip, to cover approximately 10% of the total sites sampled. The replicate



samples are collected to check the accuracy and precision of the laboratory analysis, as well as a measure of the variability in water quality at a site for a given time.

- The field blank samples are collected on site, where a set of sample bottles is filled with deionized water at some point during the sampling trip. Sampling methodology is the same as if sampling from a stream, with filtering and preserving as required. The purpose of a field blank is to identify any contamination introduced to the sample during the act of field sampling (i.e., sample filling/handling, exposure to questionable air quality) or via the supplies (filter, syringe, bottle, or preservative).
- The travel blank is a sample set provided by the laboratory to be carried by the staff to and from site during the field work. The travel blank is not opened at any time during the trip. The purpose of including a travel blank is to identify any contamination of the sample caused during transportation or storage.

Following receipt of the laboratory analysis results, a review of the QA/QC sample results is completed. Field and travel blank sample data is also reviewed to ensure that concentrations of all potential contaminants are low to below detection limits. For replicate samples, relative percent difference (RPD) is calculated to express precision of the sample and its replicate using the formula below:

$$\%R = \left(\frac{(x_1 - x_2)}{\left(\frac{x_1 + x_2}{2} \right)} \right) \times 100\%$$

Where replicate results were less than 5-times the detection limit, the difference between the sample and the duplicate should be no greater than 2-times the detection limit to be considered precise. If the difference between the sample and replicate are greater than 2-times the detection limit, the RPD value must be reported. For analytical results greater than 5-times the detection limit, RPD values less than 20% are considered precise. RPD values greater than 50% indicate problems or errors that affect precision of the analytical result (Table 8).

Table 8. QA/QC assessment categories and results wording.

Category	QA/QC Result
<DL	Adequately Precise
<2XDL	Adequately Precise
RPD<20%	Adequately Precise
RPD>20%	Imprecise or Intrinsically High Variability
RPD>50%	Error or Problem

Notes: DL = detection limit and RPD = relative percent difference



2.3.4 DATA MANAGEMENT & ANALYSIS

Once field crews return from the field, all in situ data is revised and entered into the project water quality database (Microsoft Access). Ten percent of the data entered into the database is reviewed on the raw field sheets for QA/QC purposes. Upon receipt of the lab data, it is also appended to the project database.

Data are reviewed and parameters of concern are compared with the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of freshwater 'aquatic life' (CCME-AL; CCME 2015; Table 9), and with the Effluent Quality Standards (EQS) outlined in Yukon Water Board Water license No. QZ94-004, issued to BYG Natural Resources Inc. on February 13, 1996 (Table 10). Drinking water quality from the WQ-PW site is compared to the applicable Guidelines for Canadian Drinking Water Quality (Health Canada 2012; Table 11).

Table 9. CCME-AL guidelines applicable to Mount Nansen surface water quality sampling program (CCME 2015).

Water Quality Parameter	CCME AL Guideline	Comments
Aluminum	0.1 mg/L	CCME is 0.1 at pH \geq 6.5, if pH is lower than 6.5, guideline is set at 0.005 mg/L
Ammonia	0.75 mg/L	Guideline is temperature and pH dependent. This represents a highly conservative guideline calculated for a pH of 8.5 and a water temperature of 0°C. Guideline decreases with increasing pH and temperature.
Arsenic	0.005 mg/L	-
Cadmium	0.00009 mg/L	Guideline is hardness dependent; this value is for a sample water hardness of 50 mg/L. A hardness dependent guideline of 0.04 μ g/L is used when water hardness is >0 to <17 mg/L. At hardness >280 mg/L the guideline is 0.37 μ g/L. At hardness ≥ 17 to ≤ 280 mg/L the guideline in μ g/L is calculated using the following equation: Hardness Adjusted Guideline = $10^{[0.83(\log[\text{hardness}]) - 2.46]}$
Chloride	120 mg/L	-
Chromium	0.0089 mg/L	Interim guideline
Copper	0.002 mg/L	Guideline is hardness dependent; this value is for an unknown hardness or hardness between 0 to <82 mg/L. At hardness >180 mg/L, the guideline is 4 μ g/L. At hardness ≥ 82 to ≤ 180 mg/L, the guideline in μ g/L is calculated using the following equation: Hardness Adjusted Guideline = $e^{0.8545 (\text{LN}[\text{hardness}] - 1.465) * 0.2}$
Fluoride	0.120 mg/L	Interim guideline
Iron	0.3 mg/L	-
Lead	0.003 mg/L	Guideline is hardness dependent; this value is for a hardness of 100 mg/L. When hardness is 0 to ≤ 60 mg/L the guideline is 1 μ g/L. At hardness >180 mg/L, the guideline is 7 μ g/L. At hardness >60 to ≤ 180 mg/L the guideline in μ g/L is calculated using the following equation: Hardness Adjusted Guideline = $e^{[1.273 (\text{LN}[\text{hardness}] - 4.705]}$



Water Quality Parameter	CCME AL Guideline	Comments
Molybdenum	0.0073 mg/L	-
Nickel	0.1 mg/L	Guideline is hardness dependent; this value is for a hardness of 100 mg/L. When hardness is 0 to ≤60 mg/L the guideline is 25 µg/L. At hardness >180 mg/L, the guideline is 150 µg/L. At hardness >60 to ≤180 mg/L the guideline in µg/L is calculated using the following equation: Hardness Adjusted Guideline = $e^{[0.76 (LN[hardness]+1.06)]}$
Nitrate	13 mg/L	-
Nitrite	0.06 mg/L	-
pH	6.5 - 9.0	-
Selenium	0.001 mg/L	-
Silver	0.00025 mg/L	-
Thallium	0.0008 mg/L	-
Uranium	0.015 mg/L	-
Zinc	0.03 mg/L	-

Table 10. Mount Nansen Effluent Quality Standards outlined in Yukon Water Licence #QZ94-004.

Water Quality Parameter	Effluent Discharge Standard
pH	6.0 to 8.5 pH
Total Suspended Solids (TSS)	50 mg/L
Toxicity (LT50 – 96 hr. for rainbow trout, pH non-adjusted)	100%
WAD Cyanide	0.1 mg/L
Total (SAD) Cyanide	0.3 mg/L
Antimony (Total)	0.15 mg/L
Arsenic (Dissolved)	0.15 mg/L
Barium (Total)	1.0 mg/L
Cadmium (Total)	0.02 mg/L
Chromium (Total)	0.04 mg/L
Copper (Total)	0.2 mg/L
Iron (Total)	1.0 mg/L
Lead (Total)	0.1 mg/L
Manganese (Total)	0.5 mg/L
Mercury (Total)	0.005 mg/L
Nickel (Total)	0.3 mg/L
Silver (Total)	0.10 mg/L
Zinc (Total)	0.3 mg/L



Table 11. Applicable guidelines for Canadian Drinking Water Quality for WQ-PW (Health Canada 2012).

Water Quality Parameter	Health Canada Guideline
Antimony	0.006 mg/L
Arsenic	0.010 mg/L
Barium	1.0 mg/L
Boron	5.0 mg/L
Cadmium	0.005 mg/L
Chromium	0.05 mg/L
Fluoride	1.5 mg/L
Lead	0.010 mg/L
Mercury	0.001 mg/L
Nitrate	45 mg/L
Selenium	0.01 mg/L
Uranium	0.02 mg/L

2.3.5 DATA DELIVERABLES

All water quality data is entered into a Microsoft Access database, as mentioned in Section 2.3.4, including lab data results and in situ data results (Table 12). A copy of an updated water quality database is provided with each monthly monitoring report.

Table 12. Water quality database tables and content description.

Database Table Name	Description
Tbl_WQ_Site_Info	List of sites and locations of water quality sites at Mount Nansen from 2013 to present. Updated when new sites are added to the program or when sites are discontinued.
TBL_WQ_Sampling_Data	List of sites where samples were collected each trip, including WQID (site name) and the corresponding EDI identifier (unique sample ID). There are check boxes for whether an LT50/LC50, bacteriological sample, or QA/QC sample were collected.
TBL_WQ_InSitu_Data	Record of in situ data collected each trip. Includes WQID, date, temperature, specific conductivity, pH, turbidity, dissolved oxygen, flow level, water clarity, and other comments.
TBL_WQ_Result_Data	Lab results for each sample (identified with unique EDI identifier). EDI identifier is linked to site WQ ID through the TBL_WQ_Sampling_Data.
TBL_BacT_Data	Lab results for the bacteriological sample collected at WQ-PW.



Database Table Name	Description
TBL_LT50_LC50_Data	Lab results for the LT50 or LC50 collected at WQ-SEEP.
LUT_Flow_Level	Lookup table for list of flow level values (used in drop down list for above TBL_WQ_InSitu_Data).
LUT_Water_Clarify	Lookup table for list of water clarity values (used in drop down list for above TBL_WQ_InSitu_Data).



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